A Multilevel Perspective for an Energy Transition in the Power Generation Sector of the GCC Countries

HAMEDI, ZOHEIR

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by Zoheir Hamedi

ABSTRACT

As a result of a combination of concerns related to the climate change issue, energy security, and the inevitable depletion of fossil fuels, the energy system of the world economy is, indeed, at the early stage of a gradual and sustained energy transition.

The future of the energy system of the GCC economies will strongly depend on this world tendency, as they are one of the main producers and providers of hydrocarbons to the world economy, and their economies rely almost entirely on the hydrocarbons on two aspects: first of all, as a source of revenue and therefore a core element of their political economy and secondly, hydrocarbons constitute the only energy source fuelling the economic engine of the GCC countries. Moreover, the economies of the Gulf are under an increased pressure to diversify their energy mix for the following reasons: they have one of the largest carbon footprint per capita in the world, and the ever-increasing domestic consumption of electricity is putting an increasing pressure on the available reserves of hydrocarbons to the export market.

Grounded on this new international energy environment and the challenges facing the GCC countries to diversify their energy sources in the long-term, it is proposed through this study to explore through scenarios the possible transition pathway for engaging the GCC economies into an energy transition in their power generation sector up to 2050 and how this objective could be shaped within the context of a hydrocarbon-rich rentier economic system. The scenario methodology will be used within the concept of energy transitions and the multi-level perspective (MLP) framework of analysis, which will allow for a systemic analysis of the energy system of the GCC countries and for identifying the forces that will be at work for potential future energy transitions.

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by

Zoheir Hamedi

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DECLARATION

I hereby confirm that this thesis is the result of my original work. All references, citations or quotes which are not my original work have been duly acknowledged. None of the materials in this thesis has previously been submitted for any other degrees in this or in any other university.

STATEMENT OF COPYRIGHT

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Introduction

BACKGROUND TO THE RESEARCH PROJECT

When economies of the Gulf Cooperation Council (GCC) countries started to emerge from a status of poverty to a status of plenty beginning in the 1930s, but more essentially as an aftermath of the oil crisis of the 1970s, the concept of an energy transition was not a subject of discussion or of interest among the policy-makers of the region, the general public at large, or even in the academic circles. Despite knowing that oil and gas were finite resources, the general belief was that the level of wealth underground was so immense that there was no reason to think about introducing new or alternative energy sources to oil and gas in the energy mix of the region for many decades ahead or more.

In the present time, this situation has started to change as a result of a number of factors related to the political economy of the region, in addition to the indeed slow but steadily growing pressure from the climate change issue on the international relations agenda. Indeed, the unsustainable way humanity has been producing and consuming its energy is now being questioned, and awareness regarding the necessity to engage the world economies into an energy transition away from fossil fuels is growing with time, albeit at different levels from one country to another and from one region to another.

Presently, fossil fuels still remain the main energy sources fuelling the world economy with a dominant status for oil as a result of its relative low cost of production and its liquid nature that makes it easy to process and transport. However, never since the introduction of oil as a source of energy has humanity been so concerned about two main issues related to the extensive use of oil in the world economy; namely, oil depletion and climate change. The problem of oil depletion concerns the availability of sufficient levels of energy resources in terms of oil reserves needed to sustain the ever-increasing world demand for energy, especially in light of the rise of emergent economies including China and India. Indeed, one of the main characteristics of fossil fuels, including oil, is that they are finite resources, and the current level of their consumption is higher than the natural process that has produced them over millions of years. The second, relatively more recent issue is climate change, a process that is related to increasing greenhouse gas (GHG) emissions resulting from the combustion process of hydrocarbons, and viewed by the scientific community as the main cause of global warming.

These two concerns have led humanity to reconsider its relationship to nature and its approach to development, and have raised a number of central questions, namely: Can we continue consuming finite energy resources without serious consideration of transition towards new and clean sources of energy? Can we continue following a model of development that is harmful to the environment, compromising thereby the future needs of coming generations? These questions, and the debate that has followed them, have laid the basis for a new approach to economic growth known as 'sustainable development'. This approach was first defined by the World Commission on Environment and Development (also known as the Bruntland Commission) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p.15). Undoubtedly, energy stands at the heart of a sustainable development approach, one impossible to achieve without reliance on clean and renewable energy sources not only safe for the environment but also able to meet the needs of future generations. This necessary and inescapable relation between clean energy and sustainable development led the United Nations to declare 2012 to be "The Year of Sustainable Energy for All". The acknowledgment of this reality was the result of a steady and gradual shift that began in the seventies with the Declaration of the United Nations Conference on the Human Development in Stockholm in 1972, followed by the *Bruntland Report* in 1987, and culminating in The Earth Summit in Rio in 1992, a shift that placed the debate about climate change on the agenda of the international relations once and for all.

Humanity is, indeed, at the early stage of a gradual and sustained transition in the energy system of world economy, and the 21st century will witness–at the very least–a far higher proportion of energy supplied from clean and renewable sources, which will pave the way to a new economy based on new clean and renewable energies away from fossil fuels.

Indicators of the global energy transition can be found in a number of factors. Firstly, although oil and gas still remain dominant fuels, representing in 2010 32% and 22% (International Energy Association, 2012, p. 53) respectively of the world primary energy supply, there has been a steady and continuous development of the share of renewable energy sources (RES) in the global energy mix, accounting for 19% of the global primary energy consumption in 2011 (REN21, 2013b, p. 19). Despite the global economic recession that started in 2008, the installed capacity of RES has continued to expand, with the fastest growth occurring in the power generation sector. During the period 2008-2012, the installed capacity of solar photovoltaic (PV) grew at an annual average rate of 60%, installed capacity of concentrating solar power (CSP) grew at an average annual rate of 40%, and wind installed capacity grew at an average annual rate of 25% (REN21, 2013b, p. 19). Most of this increase has taken place in China, the United States, Brazil, Canada and Germany, where the BRICS[1] region alone accounted for 36% of the total (with 27% of non-hydro energy), and the EU[2] 44% of the total global renewable power capacity (REN21, 2013b, p. 22). In the EU, during the period 2000-2012, RES accounted for more than half of the total power capacity that was added, primarily solar PV and wind, with around 70% of this addition taking place in 2012 alone (REN21, 2013b, p. 22).

Secondly, the cost of RES, especially solar and wind has been steadily declining for the past four decades. This decline has resulted from technological developments and governmental policy actions in favour of the rapid deployment of RES, economies of scale, and a simultaneous increase in the price of fossil fuels and the capital costs related to them (REN21, 2013b, p. 20).

We are no longer in an environment where conventional energy technologies have an absolute economic advantage over renewable energy

[1] A group of emerging economies that include Brazil, Russia, India, China, and South Africa.

[2] The 27 countries of the European Union.

technologies in every setting. In addition, "monetizing the external costs of energy supply would [significantly] improve the relative competitiveness of RE" (Intergovernmental Panel on Climate Change, 2012, p. 40).

Thirdly, notwithstanding the global financial crisis, investments in RES have reached a record level of US$ 211 billion in 2010, increasing by 32% from US$ 160 billion in 2009 with developing countries investing more than developed countries, and China taking the lead with more than a third of the global investments (REN21, 2011, p. 35). Investments in renewable energy sources have steadily increased since the beginning of this century, moving from US$ 22 billion in 2004 (REN21, 2011, p. 35) to more than US$ 285 billion at the end of 2012 (REN21, 2013b, p. 15). It is true that investments in RES have slowed down in the past two years as a result of uncertainties about support policies in a number of major developed economies; however, investments in 2012 were still 8% higher than the 2010 level, and global investments in renewable power generation were higher than the investments in fossil fuel power generation for a third consecutive year (REN21, 2013b, p. 15).

Fourthly, from a policy perspective in 2011, 118 countries adopted renewable energy targets at different levels—more than double the 2005 figures of 55 countries (REN21, 2011, p. 49). By the end of 2012, 138 countries had adopted renewable energy goals, and of these, 127 of them had renewable energy support policies with more than two-thirds representing emerging economies (REN21, 2013b, p. 14). Most of the support policies for the development of future energy supply are found in the power generation sector, with feed-in tariffs (FIT) and renewable portfolio standards (RPS) as the main policy instruments (REN21, 2013b, p. 15). Even in the Gulf Cooperation Council (GCC)[3] region, a number of member countries have recently adopted renewable energy goals in the power generation sector. For example, in 2008, the Electricity and Water Authority (EWA) in Bahrain set a goal of developing two solar and wind projects in order to generate electricity from renewable sources by 2012 ("Bahrain to Use Renewable Energy", 2009). In 2009, Kuwait officially declared its objective of producing 5% of its electricity from renewables by 2020 (Bachellerie, 2012, p. 63). In Saudi

[3] By the GCC, we mean the Gulf Cooperation Council that includes Bahrain, Kuwait, Oman, Qatar, the Kingdom of Saudi Arabia (KSA), and the United Arab Emirates (UAE).

Arabia, the Electricity and Cogeneration Regulatory Authority (ECRA) has set a target of generating 10% of its electricity from RES by 2020 (Goulding & Bush, 2009, p. 15). The UAE is considered the leading country in developing RES with very ambitious targets. Abu Dhabi, for instance, projects to produce 7% of its electricity from RES by 2030 and has launched a US $2 billion project for the construction of Masdar City, a zero carbon city that would produce all of its electricity from RES. The Dubai Supreme Energy Council has set the target of producing 22% of its electricity from RES by 2030 and 11% of its electricity from nuclear energy (Dubai Global Energy Forum, 2013). These figures are given as examples of policy targets for the development of RES by a number of GCC countries. However, this issue will be discussed in more detail in chapter 4, including the latest policy support policies and targets for the deployment of renewable and nuclear energies in the power generation sector of the GCC countries.

Fifthly, as far as the energy mix is concerned, when looking at the energy outlook produced by research institutions, organizations and energy companies, a general consensus suggests that in the mid- to long-term future, the energy mix will be much more diversified, with an increasing share for renewable and alternative clean energies—even if there are variations in that share from one study to another.

According to the long-term scenarios developed by the IPCC, “a significant increase in the deployment of RES by 2030, 2050 and beyond is indicated in the majority of the 164 scenarios reviewed”, including in the business as usual scenario (2011, p. 24). We can find the same trend in the last BP *Energy Outlook 2030* (2012), which clearly states that the energy mix of the world economy will be more diversified with an expected global growth in energy production coming from non-fossil fuels where “renewables, nuclear and hydro together account for 34% of the growth, [which is] for the first time, larger than the contribution of any single fossil fuel” (p. 13). The growing share of renewable and alternative energy sources in the future energy mix is projected to be even stronger “in the following decade to 2030, with 75% of the growth coming from these sources and very little from coal” (BP, 2012, p. 17). As far as the power generation sector is concerned, the focus of this research project in the GCC energy system, it will be the main driver for the diversification of energy sources and remains the fastest growing sector, with 57% of the projected growth in the primary energy consumption to 2030, compared to 54% for the period from 1990-2010 (BP, 2012, p. 15).

The Arab monarchies of the Persian Gulf are directly concerned by this global trend, and their vulnerability regarding climate change is to be found on two levels. The first level concerns the impact it will have on the ecological and human systems of GCC societies; the second is related to the objective and potential outcomes of the climate regime negotiations on their political economies, knowing that the climate regime being negotiated seeks as an ultimate objective to phase out fossil fuels from the global economy as a result of their direct responsibility in global warming.

Indeed, on the ecological front, it is expected that the adverse effects of climate change will significantly affect the GCC economies, as we will see in more details in the course of this research thesis. In addition, the GCC countries have one of the largest carbon footprints in the world and are classified among the highest CO_2 emitters, as their economies contribute 2.4% of the global greenhouse gas emissions, while their populations represent only 0.6% of the world population (Reiche, 2010, p. 2395).

As far as the impact on their political economies is concerned, the objective of phasing out the world economy from the use of fossil fuels, and oil in particular, represents a direct threat to the main source of revenue of the GCC countries and to their existing political economy. Such a trend can be considered an existential threat to the Arab monarchies of the Gulf but also a very strong motivation to diversify their economies away from oil wealth.

Moreover, there are also a number of other concerns related to the political economy of the region that should be pushing for an energy transition in the GCC countries.

Firstly, oil and gas resources are finite resources and should be replaced by new energies in order to sustain their economies in the long term. Indeed, the depletion of oil and gas resources is inevitable, and these countries must begin their preparations for the post-oil era in order to spread the necessary investments in a long-term perspective and achieve a well-planned, successful energy transition. Secondly, the share of the domestic energy consumption is increasing at the expense of the share of the exports, which represents a direct threat to the level of GCC government revenues. It is therefore in the interest of the GCC governments to save the use of domestic energy by adopting renewable and alternative energies in order to increase their export capacity and monetize their cash earning resources.

AIM AND OBJECTIVES

Grounded on this new international energy environment and the challenges facing the GCC countries in diversifying their long-term energy sources away from hydrocarbons, this study focuses on the power generation sector of the energy system of the GCC countries and will propose a number of possible scenarios regarding an energy transition towards a more diversified energy mix in that sector until the year 2050. The scenario methodology will allow an exploration of the possible future pathways for diversifying the energy sources of the GCC power generation sector, and how the energy transition process could be influenced and shaped within the context of the rentier state theory. In this perspective, this research will analyse the interaction between the three levels of the GCC energy system as proposed by the multilevel perspective (MLP) framework of analysis selected for conducting this research project, and will question the role and the possible evolutions of the central level of the MLP; namely, the socio-technical regimes level, which includes the regimes actors that are in command of the whole energy system. In this regard, the research project will first identify the key variables that will drive the energy transition of the GCC economies in the power generation sector, and then analyse how these key variables may be affected, either positively (as an opportunity), or negatively (as an obstacle), by the rentier nature of the region's social-political contract. In this respect, we hypothesize that the classical rentier state theory as developed in the 1970s (Mahdavy, 1970) and 1980s (Beblawi & Luciani, 1987), even if its main assumptions are still valid, has also proven to be incorrect in a number of its assumptions and superficial in others, and that late rentier theory (Gray, 2011) is a better theoretical framework for analysing rentier states. Indeed, we hypothesize that even if the rentier nature of the GCC states presents structural obstacles to the energy transition of their economies, a rentier state also provides structural characteristics that could become potential opportunities for a successful energy transition in the long run. The hypothesis will be tested through a critical analysis of the rentier state theory grounded in a historical analysis of the development of GCC economies and how they have been performing until now. Further analysis will explore a number of key variables of the energy landscape and their relation to the political economy of the region as they play a central role in the transition of the GCC energy mix of the power generation sector.

Selecting the key variables that will have a determining impact on the future of the energy mix of the region will be necessary for building our scenarios until 2050. These variables will be selected using the MLP, framework of analysis for studying socio-technical energy transitions to sustainability that has been essentially used in the context of developed economies, but with no prior known use in the GCC countries or in the Arab world in general. Briefly defined, the MLP is a "systemic model of three inter-connected levels that are defined by the metaphorical notions of 'niche', 'regime' and 'landscape'" (Jørgensen, 2012, p. 997). In this respect, the 'niche' or micro-level is where the technological variable is found; the 'regime' or meso-level is where the social, cultural and political variables are found; and finally, the 'landscape' or macro-level is where the policies and international environment variables are found. Following the analysis phase of the energy system of the GCC countries within the MLP framework, we will propose a number of relevant energy transition pathways in the power generation sector of these countries up to 2050, based on one or more tentative assumptions regarding the possible future evolution of a number of variables found at the three levels of the MLP.

RESEARCH DESIGN

Given the complexity of the problem under study and the use of the multilevel perspective (MLP) approach, selected for studying energy transitions in the GCC economies, this research is grounded in the systems thinking framework of analysis. Systems thinking is defined as “a process of understanding how things influence one another within a whole” (Konkarikoski, Ritala, & Ihalainen, 2010, p. 1), and as an approach for dealing with complex systems, where ‘system’ refers to a “complex whole of related parts” (Cabrera, Colosi, & Lobdell, 2008, p. 301). It has also been defined as “a formal, abstract, and structured endeavour” (Cabrera et al., 2008, p. 301) where there is a balance between the whole and the parts, and where the multiple levels of the system are taken into consideration. Before we go any further, it is necessary to expand on defining the concept of systems thinking and its relationship to this research project.

Systems Thinking

Systems thinking emerged in the first half of the twentieth century as a result of the limitations of Descartes’s analytic reasoning, also known as reductionism, and following the 1950’s work of Ludwig von Bertalanffy in the field of biology as he developed a theory of open systems. According to Bertalanffy, *“open systems theory* employs functional and relational criteria to study the whole, rather than principles of reductionism to study simple elements” (as cited in Flood, 2010, p. 271). The principles of open systems theory have been generalized to other fields of study and given birth to what Bertalanffy called the general systems theory (GST), from which emerged systems thinking considered “as the basis of a new form of social theory” (as cited in Flood, 2010, p. 271). However, it is important to highlight the difference between systems theory and systems thinking prior to any further developments in order to clarify the foundations of this research thesis.

As defined by Floyd (2008), “systems theory is a set of abstract conceptual frameworks or models for describing . . . systemic perspectives” (p. 140), and as such, it acts as a representational tool used to help describe the world around us;

whereas “systems thinking is first and foremost an epistemology” (Checkland, 1981, p. 318), one according to which social systems are constructed from an “interpretation made through cognitive processes of the human brain” (Flood, 2010, p. 270). In other words, systems thinking rejects the idea of a world composed of ‘real’ social systems, and describes instead a world composed of social systems that are constructed. Such social construction is systemic, and it is based on this understanding of systems thinking that this research project will be grounded.

Systems thinking focuses on the ‘whole’ with the belief “that the world is systemic, which means that phenomena are understood to be an emergent property of an interrelated whole” (Flood, 2010, p. 269). The expression *an emergent property of a whole* refers to the fact that a phenomenon is much more than the properties of its constituent parts, or in other words, that “the whole is greater than the sum of its parts” (Flood, 2010, p. 269). As a consequence, valid knowledge cannot be produced from the process of breaking up phenomena into separate parts and “seeing the parts” only, but rather from the process of building pictures of social phenomena under study and “seeing the whole” (Floyd, 2008, p. 138).

The concept of emergent properties, which is an intrinsic characteristic of the idea of complexity in physical, chemical, and sociocultural systems, has been defined by Checkland (1985) in the following terms: “in an organization there is a hierarchy formed by levels in such a way that each level is more complex than the level below it and it is characterized by emergent properties, which are nonexistent at the level below” (as cited in Mannermaa, 1988, p. 289). For example, chemistry can explain certain biological mechanisms but cannot explain the existence of biology or replace it as such.

The literature about systems thinking is very diverse and reveals a plurality of meanings and claims about the necessary conditions for performing the task of a systems thinker. To help achieve some clarity in this varied literature, Henning and Chen (2012) have performed a content analysis of 14 popular books about systems thinking. While these books were written to explain systems thinking to public laypeople, we have found that the conclusions from their content analysis are also valid for explaining systems thinking in an academic context. Henning and Chen (2012) have thus revealed a common ground among systems thinking scholars, which they have linked to Kruglanski's theory of lay epistemics[4] (1989, 2004 as cited in Henning & Chen, 2012, p. 471). In this respect, Henning and Chen (2012) have used two dimensions of the theory in order to classify a common ground among systems scholars and systems thinkers, which Kruglanski has named "the knowledge domains of a system thinker, and welcoming cognitive conditions for systems thinkers" (1989, as cited in Henning & Chen, 2012, p. 471).

This knowledge domain, which is the first requirement for systems thinkers, has been defined by Henning and Chen "as an understanding of the key characteristics all systems possess" (2012, p. 473), and consists of a definitional task of the system under study; i.e., a description of the characteristics of the system as a whole and its tangible and intangible properties in the people and the ideas, beliefs, and values they hold, as well as the goals, declared or undeclared, of the people who compose the system and the necessary techniques to analyze and understand them.

In order to define and uncover the key characteristics of a given system, the systems thinker must understand a number of key characteristics of systems as summarized by Henning and Chen (2012) in the following points: *Human systems are purposeful* and they exist in order to achieve goals, individual or collective, conscious or unconscious; *members of a system require one another to achieve their goals,* and it is through this interdependency that the system achieves its goals; *people exist in relationship,* or in other words, it is more important to understand the way people relate to each other than to understand the characteristics of people; *the way a system is organized arises from interactions among its members,* meaning that it is the structure of the system that determines how interactions will happen within the system, which in turn determines the outcomes achieved by the system; and *systems are rife with tensions and dichotomies,* as they are characterized by plurality and unity, where every member of the system seeks individual as well as collective objectives (Henning & Chen,

[4] The theory of lay epistemics, as developed by Kruglanski, "account[s] for the process whereby [non-academic] people form their knowledge of various matters" (Kruglanski, 1989; 2004, as cited in Henning & Chen, 2012, p. 471).

2012, p. 474). Consequently, systems thinkers have recognized that systems thinking demands a transdisciplinary approach requiring a variety of techniques or methodologies (Henning & Chen, 2012, p. 477).

According to Kruglanski (1989), possessing the knowledge domain is a necessary requirement for systems thinkers but not sufficient in itself, as the systems thinker needs also “particular modes of thinking conductive to perceiving something accurately” (as cited in Henning & Chen, 2012, p. 471). In his theory of lay epistemics, Kruglanski calls these mental attitudes and cognitive skills the “welcoming cognitive conditions” (1989, as cited in Henning & Chen, 2012, p. 471); they also appear under a variety of different names in the literature, including “systems thinking mindset” (Haines, 1999, p. 1) and “a type of thinking” (Boardman & Sauser, 2008, p. xvii). According to Henning and Chen (2012), the ‘type of thinking’ required for a systems thinker should be based on a number of mental orientations summarized as the following: an orientation towards causality, as a system’s behavior is intimately linked to the multitudes of causally linked variables that make up the structure of the system; an orientation towards logic, even when this logic is not apparent; and an orientation towards particular data sources in order to unveil the logic within a system. The data sources must be found in the incidents and/or problems that occur in patterns of events, and also found in the patterned behavior which is indicates the presence of a structure. Also necessary is an orientation towards the explicit and implicit structures required to understand the behavior of a system, and an orientation towards subjectivity that is “a particularly potent feature of human systems” (Jackson, 2003, as cited in Henning & Chen, 2012, p. 480), and which form the judgments and values that people hold about issues, predisposing them to a certain behavior. Finally, an orientation towards self-reflection is also to be found in the systems thinker himself in order to challenge his own subjectivity and bring to the surface his own worldviews (Henning & Chen, 2012, p. 482).

The common ground for systems thinkers as summarized by Henning and Chen will be the foundation of this research, which is grounded in a systems thinking approach given the complexity of the research project. Indeed, energy transitions are complex processes that involve several levels of analysis, and since systems thinking promotes holism as its primary intellectual strategy for handling complexity, it is very well placed for analyzing and understanding the process of energy transitions. In this respect, the multilevel perspective (MLP) will be applied as a theoretical framework to allow us to model as well as analyze and describe the energy transition process within a system as a first step before building the scenarios.

As far as systems thinking and the MLP are concerned, the only study that has been found in the literature combining these two approaches is a paper by Papachristos under the title "A System Dynamics Model of Socio-Technical Regime Transitions" (2011), which builds a system for an energy transition based on the MLP theory. The objective of this research is not to engage in a modeling study to shed light on the energy transition process, but to shed insight on the process of an energy transition with a perspective of prospecting the future of the energy system of the GCC countries in the power generation sector. Dealing with the future engenders the relationship between systems thinking and futures studies.

Systems Thinking and Futures Studies

Futures studies involve a multidisciplinary approach, and as such, a systems thinking approach is highly recommended for dealing with complex social problems and futures studies (Floyd, 2008, p. 138). Indeed, Mannermaa (1988) argues that "multidisciplinarity and systemic thinking are . . . important scientific criteria of futures research" (p. 281), and according to Emery (1967), a major condition for the validity of any futures approach is that it must originate from an analysis of the broader systems (p. 217).

Futures studies and building scenarios, according to Mannermaa (1996), requires a necessary shift to a new paradigm away from the reductionist Newtonian understanding of reality, towards an evolutionary paradigm that takes into consideration the holistic and systemic nature of natural as well as social systems (p. 620). As a consequence of the holistic and systemic nature of futures studies, there is a need for a multidisciplinary approach built on a consistency between the different levels of hierarchies or explanations (Mannermaa, 1988, p. 294).

In regards to the literature combining systems thinking with futures studies, a limited number of studies have been found, as summarized in the following main references: in the work of Ervin Laszlo, the editor of *World Futures: The Journal of General Evolution* (Floyd, 2008, p. 138); in the work of Hjorth and Bagheri (2006), who have implemented a system dynamics modeling approach to sustainable development in a futures study; in the work of Hames, Oliver, and Saliba in Australia (Floyd, 2008, p. 139); in the work of Hayward (2004); in the work of Inayatullah (2002) using the causal layered analysis (CLA); and finally, in Sarkar’s progressive utilization theory into futures thinking and practice (Floyd, 2008, p. 139). Studies combining systems thinking with futures studies remain limited; they are mainly focused on a western context, and none on developing countries in general or the GCC countries in particular. In this respect, this research proposal is the first of its kind, combining both approaches in the context of the Arab world and the GCC countries, and as such will contribute to shedding a new light on the complex process of energy transition in the Arab countries of the Gulf with a futures perspective.

Due to the complex nature of the research and its long-term perspective, this research will adopt a combined quantitative-qualitative approach. The first part of the research, which deals with the present of the system, will explore a thorough quantitative analysis of the energy landscape and the selected key variables. A qualitative narrative approach will be employed to build the scenarios, as we will be dealing with the long-term future of the energy mix of the GCC countries until 2050, and thus with very little reliable quantitative data that extends as far as the time horizon of this research. In this respect, it is important to mention the personal motivations that are behind this research. There is, first of all, a motivation that stems from my professional background of almost nine years experience in the energy industry, first as an executive in different departments of SONATRACH, the Algerian public oil and gas company, from 2001 to 2007, and as an energy officer at the British Embassy in Algiers, from 2007 to 2008, just before I started this PhD research project in January 2009. The second motivation is based on my personal belief that oil and gas economies, or rentier economies, need to engage in an energy transition as soon as possible if they want to ensure the smooth transition of their societies to a post-oil economy and still remain active actors of the international community. Coming from the energy industry, I am very much aware of the central role of energy in the modern world, and that engaging in an energy transition is more than a technical issue, but rather an existential and vital one that will determine the future of not only the oil and gas exporting societies, but of all humanity.

In addition, this study will build scenarios by using an intuitive-logics approach that relies essentially on information of a qualitative nature. However, the narratives of the scenarios built through 2050 will be based on a detailed qualitative as well as quantitative analysis of the available data about the power generation sector of the GCC countries in addition to the long term energy targets that they have set for themselves. The information as represented by the key variables and selected through the MLP and their corresponding assumptions will be generated through a thorough review of the available literature about energy policy more broadly and more narrowly, the power generation sector of the GCC countries.

SIGNIFICANCE AND CONTRIBUTION OF THE STUDY

Nearly all research concerning the political economy of the GCC countries has dealt almost exclusively with the issue of the economic diversification policies or with strategies in order to diversify the sources of revenues away from the hydrocarbon exports. There are numerous studies about the potential of selected alternative or renewable energy technologies in the context of the GCC countries; however, studies that have dealt with the issue of the diversification of their energy sources with a future perspective are very limited. In this respect, we have found a future research by Al-Saleh under the title “Renewable Energy Scenarios for Major Oil-producing Nations: The Case of Saudi Arabia” (Al-Saleh, 2009), in which the author has used the scenario methodology through the Delphi technique, and a study by Hepbasli and Alsuhaibani titled “A Key Review on

Present Status and Future Directions of Solar Energy Studies and Applications in Saudi Arabia" (2011), which reviews the present status of solar energy in Saudi Arabia and its future possible applications in the power generation sector through scenarios based on narratives. A research paper by Kazem (2011) under the title "Renewable Energy in Oman: Status and Future Prospects" (2011), focuses on the present and future of renewable of energy in Oman for producing electricity but without the use of the scenario methodology. The book edited and published by the Emirates Center for Strategic Studies and Research (2008), *Future Arabian Gulf Energy Sources: Hydrocarbon, Nuclear or Renewable?* (2008), consists of a selection of papers regarding the potential of renewable and alternative energy sources in the GCC power generation sector and future prospects from a technical perspective, and again without proposing scenarios. The book by Bachellerie (2012) published by the Gulf Research Center under the title *Renewable Energy in the GCC Countries: Resources, Potential, and Prospects* (2012), is mainly a review of the present situation and the technical potential of renewables energies in the future energy mix of the GCC region, but with no scenarios developed. There are also numerous studies that have dealt with the subject of renewable and nuclear energies in the GCC context from purely technical or policy perspectives but without a futures perspective, and which will be cited as references in the course of the research, as they are too numerous to be listed at this stage of the study.

Futures studies that rely on the scenario methodology in the context of the GCC countries in general are very limited. Moreover, there are no studies that have used the scenario methodology in combination with the MLP framework of analysis, as proposed by this study for building future energy scenarios for the GCC countries.

Furthermore, Al-Saleh's future study mentioned above focuses on the single case of Saudi Arabia, and no project has used the scenario methodology for the GCC countries as a whole on the issue of the diversification of energy sources, including renewable energies and nuclear energy. This research proposes to contribute toward addressing this issue by building scenarios that will focus on the upstream of the economic system of the Gulf region; namely, the energy sources in the power generation sector, and the role and place of the rentier states in this perspective for making the economies of the region continue to function in the long run in a sustainable way.

Moreover, transition studies have been primarily undertaken in developed societies with almost no studies focusing on other regions. Indeed, according to Lachman (2013), despite its wide use in other parts of the world, it would appear that the transition concept has not been used in any other project about the GCC region or Arab countries, with the exception of a few recent studies in Asian countries (Berkhout et al., 2010, I. H. Rehman et al., 2010; Romijn, Raven, & de Visser, 2010; Verbong, Christiaens, Raven, & Balkema, 2010). In this regard, this research thesis is the first of its kind using the transition concept and the MLP approach for the study of energy transitions in the GCC region and the Arab world in general, and will constitute the foundation for further studies dedicated to the subject of energy transitions.

The outcomes and benefits of this research to the GCC countries can be summarised in the following points: Firstly, it will fill an apparent gap in the academic field by undertaking a future study of the power generation sector of the GCC countries from a regional perspective. Secondly, it will introduce the scenario methodology and transition studies using the MLP approach in the region and their benefits as tools for future studies and forward-looking policy-making. Thirdly, it will help policy makers in government and decision makers in industry achieve a better understanding of the risks and opportunities inherent in each of the scenarios and thus better able to act effectively and proactively. Finally, it will contribute to raising the public profile of energy and climate change among the actors and stakeholders of the energy industry at large.

Before we introduce the outline of the research, it is necessary to define a number of terms and concepts that will be used in the course of this thesis.

When referring to electricity or power generation in this research it should be understood along the International Energy Association's (IEA) definition "as the total amount of electricity generated by power only or combined heat and power plants" (2012, p. 645).

The energies that will compose the focus of this research are oil and gas, defined as ‘conventional energy sources’, renewable energies that include solar, wind, and nuclear energy defined as ‘alternative energy’. When using the expression ‘new and/or clean energies’, we mean the renewable energies selected for this research in addition to nuclear energy. The expression ‘unconventional energies’ will refer to shale oil and/or gas.

OUTLINE OF THE RESEARCH

This research thesis will be structured around six chapters, in addition to an introduction and conclusion. The first chapter will introduce the concept of futures studies and the scenario methodology. The second chapter will be devoted to introducing the energy transitions theory and the multilevel perspective (MLP) for studying the process of an energy transition. The third chapter will begin the process of analysing the energy system of the GCC countries using the MLP framework of analysis, starting at the landscape level. The fourth chapter will focus on the political economy of the GCC through a combined macro- and meso-level analysis. The fifth chapter will review the available niche-innovation technologies for power generation in the context of the GCC countries. Finally, based on the findings of the previous chapters, the sixth chapter will be dedicated to our proposed scenarios regarding the possible transition pathways in the power generation sector of the GCC countries until 2050.

Chapter 1

FUTURES STUDIES: THE SCENARIO METHODOLOGY

1.1. DEFINITION AND SCOPE

According to the Oxford English Dictionary (1991), the word ‘future’ is defined in its adjective form as “that is to be, or will be, hereafter [and] [o]ften qualifying a substantive, with the sense: The person or thing that is expected to be (what the substantive denotes)” (p. 295). As a noun, ‘the future’ is defined as a “time to come; future time” (p. 295).

As far as futures activities are concerned, according to Garret (1993), they can be classified into two main categories: ‘futures studies’ and ‘futures projects’, with the first category being essentially an academic activity that “aim[s] at building futures as a *discipline”* (p. 255) and they involve gathering data and scenario building. Futures projects are grounded on futures studies, but are carried out by groups larger than academic research teams, within the framework of public or private organizations from which the demand for a futures project originates. This distinction has also been proposed by Slaughter (1993a), who distinguishes between *futures research*—equivalent to a *futures project* according to Garret (1993)—and *futures studies,* “where teachers, critics, writers and academics can be found” (Slaughter, 1993a, p. 291)[5]. As far as this research project is concerned, given its academic grounding, it should be classified as a futures study[6].

[5] In addition to the above mentioned two categories, Slaughter (1993a) adds a third one coined *futures movements,* which includes NGOs such as peace movements, green movements, women’s movements, etc. (p. 292).

[6] In order to avoid any misunderstanding, when the expressions ‘research project’, ‘futures research’, or ‘futures research project’ are used, this should be understood to refer to this PhD thesis, which is classified as a futures study.

1.2. THE PHILOSOPHICAL AND EPISTEMOLOGICAL DEBATE IN FUTURES STUDIES

According to Mannermaa (1988), "a short way to outline futures research is to say that it is the study of the present from the point of view of a special interest in comprehending the future" (p. 280). Indeed, futures alternatives imply present choices, or in other words, as stated by Slaughter (1993a), it is "clear that, to the extent that we become aware of different future alternatives, we gain access to new choices in the present" (p. 290). The main interest in studying the future lies in understanding the possible future alternatives and the choices they pose in the present. Consequently, Mannermaa concludes that futures research needs a multidisciplinary approach in addition to systemic thinking, and shares with the social sciences the same criteria that determine what is scientific from what is not (1988, p. 281). The multidisciplinary approach is justified by the use of complexity for describing futures studies, which necessarily involves different levels of analysis—past, present, and future—and needs different theoretical frameworks.

Futures research and scenario building are defined as a 'technical norm' composed of two distinct parts. The first part consists of the analysis work undertaken in order to understand the present through the use of different scientific disciplines. The second part consists of value considerations about the future (Mannermaa, 1988, p. 281). Including value considerations as an intrinsic component of futures studies brings to the surface a debate about objectivity, in particular a strong tendency to aim for objectivity at the expense of normativity. In this sense, futures studies are "basically a normative activity [where] the role of values . . . is even more emphasized than in social sciences generally" (Mannermaa, 1988, p. 285). Indeed, Mannermaa (1988) adds that present day economics is strongly influenced by values as is the case concerning the debate about the desirability of economic growth, illustrated in the famous book commissioned by the Club of Rome under the title *The Limits to Growth*[7] (1972). Considering certain value loaded factors as "objective facts" is a very common

[7] It is worth mentioning in this respect that *The Limits to Growth* is considered one of the first major works that initiated the discipline of futures studies.

mistake in the social sciences in general and in futures studies in particular, and has been “strongly criticized by the ideas of multiverse realities” (Mannermaa, 1988, p. 286), which questions “the idea of one (and only one) universal reality and truth, which is thought to be discoverable by the means of scientific methods and reality” (Mannermaa, 1988, p. 286).

1.2.1. The Concept of Multiverse Realities

The concept of a multiverse of realities implies rejecting the artificial distinction that is made between the subject observing the reality and the object of observation, as the researcher is considered an integral part of the process of observation and conceptualization. As a consequence, “the subject and the object together form a ‘reality’ where both are needed” (Mannermaa, 1988, p. 286). As far as futures studies are concerned, the idea of a multiverse of realities has become a dominating concept in futures research, following the decline of the tendency to forecast the future into single realities and the rise to prominence of the ‘scenario era’, which argues that “the future consists of several essentially different alternatives instead of one ‘dominating trend’; i.e., the future is a multiverse of ideas” (Mannermaa, 1988, p. 286). In this respect, it should be noted that this shift in futures studies took place for practical, not theoretical, reasons, as a consequence of the increasing uncertainty in the international arena during the seventies. This uncertainty included the oil crisis of 1973, uncertainty about the international monetary system, rapid technological progress, the rise of popular movements such as the green movements, the anti-nuclear movements, and the debate about poverty within the framework of north-south widening gap (Mannermaa, 1988, pp. 286-287).

The concept of a multiverse of realities should be understood not only applicable to the future part of a futures research, but also to the present as well, which consists of “several realities or ‘alternatives’” (Mannermaa, 1988, p. 287), depending on the nature of the observer. These realities or ‘alternatives’ are more or less scientific with a certain dose of subjectivity that has to be understood within the framework of the personal ideas and values of the researcher and the motivations that are driving the research, in addition to his or her intuitions. Whether aware of it or not, willingly or unwillingly, the researcher is an active anticipator in the research process, and as such, will definitely leave a personal impact on the outcomes of his or her research.

At this stage of the discussion, it is difficult to mention the concept of the multiverse of realities and the intuitions of the researcher without briefly mentioning the philosophical and theoretical debate that has been always present in the backyard of the science of knowledge production between modern and postmodern research methodologies. Postmodern methodologies are based on an understanding of the knowledge production process that should equally rely on the use of rationalism as well as on intuition. As rightly put by Lacey (1996), "poetry is as important as quantification" (p. 7). In this respect, postmodern research methods "rely on and involve discourse and narrative explanation" (Lacey, 1996, p. 134), and as a consequence of the above debate, the use of the scenario methodology can be very easily considered a post-modern research tool in the field of futures studies.

Discussing the future raises a number of philosophical as well as epistemological issues about the capacity of humankind to know what cannot be known, as the future has not materialized yet. As stated by Mitroff and Turoff (1973), the real concern when dealing with the future is not about how we can have a perfect knowledge of the future—because we cannot—or if we can happen to know all that there is to know about the present with certainty, but rather, "what can we know of the future, and, even more to the point, how can we justify what we think we know" (Mitroff & Turoff, 1973, p. 116). The answer to this question is philosophical as well as epistemological with the issue of role of prediction in futures studies. In other words, are futures studies about making predictions?

As Bell and Olick (1989) have defined it, the word 'prediction' refers to "things that under certain circumstances, will, could, or would happen or *vary in the future*" (Bell & Olick, 1989, p. 116). In this definition, predictions are about the possibility for certain events or outcomes to take place in the future. In the literature, these have also been found under different terms such as forecasts if they refer to concrete events to take place at a precise date; prophecies when used with a mystical or religious perspective; prognostication; foresight; prevision; or anticipation (Bell & Olick, 1989, p. 116). There is no consensus among futurists regarding the definition of these terms; however, in this research, and based on Bell and Olick's work (1989), predictions will be understood to mean a statement or assertion about some future outcome, whether accurate or inaccurate, absolute or probabilistic, in the long or short term.

Making predictions about the future and projecting ourselves in the future is an intrinsic human activity and an everyday exercise for individuals as well as organizations for the purpose of planning and decision-making. As defined by Bell and Olick (1989), the role of the futurists, engaged in futures studies from an academic perspective,

> is in part to make this process more conscious [and] can explicate what often remains implicit or taken for granted about anticipative thinking, and he or she can critically examine and possibly improve the grounds by which the accuracy and usefulness of anticipations are judged. (Bell & Olick, 1989, p. 117)

In other terms, the futurist makes predictions consciously in a structured and critical manner in such a way that it could be verified and improved.

Despite the fact that prediction is an intrinsic component of science, including the social sciences, and knowing that futures studies are essentially involved in exploring the future, there is no agreement among the futurists regarding the role of prediction in futures studies. However, as we will see, the disagreement is more apparent than real. Indeed, on one hand, some futurists consider prediction the main goal of their discipline and engage fully in the exercise of making predictions; for example, Martino, Bardis, Toffler, and Van Vught (Bell & Olick, 1989, p. 119). On the other hand, other futurists either minimize or altogether deny any role for prediction in futures studies, while yet others are ambiguous or have contradictory views about the subject—as is the case with Daniel Bell, who claims that it is impossible to predict the future, yet at the same time "claims that forecasting (as distinct from predicting) is possible under some circumstances" (Bell, 1973, as cited in Bell & Olick, 1989, p. 119).

There has always been a philosophical debate about the role of making predictions in science in general and the social sciences in particular. As far as the philosophers of knowledge are concerned, according to Popper, the trustworthiness of a theory is judged based on its capacity to produce “reliable predictions and instrumental utility” (Weimer, 1979, p. 52, as cited in Bell & Olick, 1989, p. 118). Neurath considers successful prediction a benchmark of the usefulness of a science (Neurath, 1959, as cited in Bell & Olick, 1989, p. 118); while according to Scheffler, the “prevalent view of science is that when a prediction is borne out by experience, the set of beliefs in question has passed a critical test” (Scheffler, 1967, as cited in Bell & Olick, 1989, p. 118). In a more extreme statement, Reichenbach questions the validity of “knowledge if it does not include the future?” (Reichenbach, 1951, p. 89).

In the social sciences, making predictions is already an objective for the founder of sociology, Auguste Comte, who is very well known for his statement *savoir pour pouvoir* (Bell & Olick, 1989, p. 118). Schuessler considers that “American sociologists have more or less taken for granted that prediction is one of their main objectives” (Schuessler, 1971, as cited in Bell & Olick, 1989, p. 118). It is generally accepted by most social scientists that prediction is an integral part of the social scientific enterprise; however, it must be recognized that many social scientists who share this belief do not necessarily make predictions, as they are content with systematic associations between variables in past and present situations without making projections in the future. Another argument for making predictions in futures studies is found in the human tendency to control its present and future, as rightly described by Henshel (1976) when he states that “man tends to predict by controlling” (as cited in Bell & Olick, 1989, p. 130). In other words, there is no control without prediction, and the human tendency for control leads ultimately to performing the exercise of prediction.

Prediction starts from the knowledge of the past and present, which raises a philosophical issue regarding our capacity in knowing them, especially when we take into consideration the attacks on positivism and the validity of knowledge, and the debate that has emerged as a consequence. The post-positivist period that emerged following the work of Kuhn (1962) and Feyerabend (1975) does agree with the positivists regarding the pursuit of objective truth; however, post-positivists recognize the role of the biases that can be brought by the researcher from his or her background and found in the values, ideas, and theories he or she holds. Post-positivism is not a rejection of positivism; rather, it is an amendment of logical positivism and a recognition of the conjectural nature of knowledge, but without advocating relativism.

1.2.2. Critical Realism

As far as futures studies are concerned, Bell (1980) has recommended futurists to adopt the post-post-positivist philosophy known as critical realism, which argues in favour of the possibility of knowing the past and present, and that the limitations to this knowledge are to be found "in human capacities and methodologies" (Bell & Olick, 1989, p. 124). Critical realism advocates the existence of a real world to be known and discovered objectively, but as a result of limited human capacities, certain aspects of reality go beyond the capacity of humans to sense or observe. These limitations to knowing the past and present are the main obstacles for knowing the future[8], as knowledge of the latter is based, partly, on knowledge of the former (Bell & Olick, 1989, p. 124).

Grounded in the critical realism theory, and in order to clarify the epistemological foundations of futures research, Reichenbach (1951) states that "in any event, inductive inference is the best method we have of making assertions about the future" (Reichenbach, 1951, p. 246). In this respect, Reichenbach proposes the concept of a 'posit', where a posit is defined as "a statement [about the future] which we treat as true although we do not know whether it is so" (Reichenbach, 1951, p. 240). From a practical perspective, the concept of a posit means that futurists advance (or posit) likely and unlikely alternative possibilities for the future in order to assess the probability and impact of each alternative. As our knowledge of the past and present is incomplete and/or inaccurate, Coddington (1975) refers to the obstacles to knowing the past and

[8] It is necessary to remind ourselves that while we do not know the future, as it has not yet unfolded, we can explore the future by constructing images or scenarios of the future based on a number of assumptions.

present as ‘knowledge deficiencies’, which include “risk, uncertainty, mistakenness, ignorance, deception and delusion” (p. 152). As far as knowledge of the future is concerned, Coddington (1975) refers to it as ‘knowledge surrogates’, which include “conjecture, expectation, perception, learning, adaptation and so on” (pp. 152-153). Knowledge surrogates describe a knowledge of the future based on ‘as if’ and ‘what if’ statements in order to build alternative images of the future; in other words, they are hypotheses grounded on our actual knowledge of the past and present, and as such, they substitute for the knowledge of the future that we cannot know, but that is necessary for projecting ourselves in the future.

Most futurists agree on the fact that the role of futures studies is not to make precise predictions or to make one single prediction. Indeed, as stated by Fleonora Masini, the ex-president of the World Futures Studies Federation, “futures research should rather reveal the alternative possibilities, and analyse the risks concomitant of these possibilities and their consequences’” (Masini, 1987 as cited in Bell & Olick, 1989, p. 119). There is a shared understanding among most futurists that some form of prediction should be found in futures studies: not one single, precise prediction, but a multitude of images of possible futures with the objective to highlight the probable risks and consequences of the choices that could be made today regarding the future, as well as highlighting the probable opportunities available with other choices. In this respect, John and Magda Cordell McHale rightly stated that “futurists do not aim to ‘prophesy what a specific future will be, but rather more to explore the plurality of future(s) states, which may be contingent upon our actions or accessible to our choice” (J. Cordell & M. C. Cordell McHale (n.d.), as cited in Bell & Olick, 1989, p. 120). The future should be considered open, and as stated by Amara, “the futurists role [is to raise] people’s consciousness of time and [to increase] their awareness of the openness of the future” (1981, p. 25).

As a concluding note, it appears that there are no fundamental disagreements among futurists regarding prediction. Indeed, in one way or another, and depending on the approach, there is a certain level of agreement that prediction is a necessary exercise for futurists, with the understanding that the role of the futurists is not to make specific and precise predictions, but to construct different images of possible futures; i.e., to conceive scenarios that describe alternative images of the future based on our knowledge of the past and present, in addition to different assumptions or models regarding future developments. Prediction is, therefore, a central component of a futures study, one that must be multiple and contingent, although it may be true, false, or uncertain. Knowledge of the past and present is justified, but knowledge deficiencies that may threaten validity must be recognized in order to reduce them through scientific techniques, and thereby improve the quality of prediction. As far as knowledge of the future is concerned, it cannot be justified, as it has not yet unfolded. As proposed by Reichenbach, we can only make posits of the future, which Coddington refers to as knowledge surrogates—or in other words, knowledge of the future based on 'as if' and 'what if' statements for conceiving multiple scenarios.

1.3. PRACTICAL FOUNDATIONS OF A FUTURES STUDY

When reviewing the literature dealing with futures studies in a search for a general or standard approach for undertaking a futures study, a very large diversity of concepts and approaches appears. Concerning these concepts, Slaughter (1993a) has identified 20 that according to him "form an important part of the core of futures studies" (p. 289). Among them, foresight is considered one of the most powerful and highly elaborate concepts of futures studies (Slaughter, 1993a, p. 290). Foresight is first and foremost a basic human skill that materializes in different ways in everyday life to protect ourselves or to avoid making mistakes—for example, checking the weather forecast to know whether we should take a raincoat or not. On a social level, foresight work has now become a necessity in order to prepare for contingencies and assess the likely implications of decisions and choices made in the present time (Slaughter, 1993a, pp. 304-305).

Regarding the approaches for undertaking a futures study, the literature has shown a very significant diversity, as the approach depends on the subject under study as well as the nature and needs of the utilizer. In this respect, according to Garret (1993), “there is simply no standard approach for futures studies, despite the claims of vociferous advocates” (p. 259). However, the lack of a standard approach can be compensated by focusing on the basic components of a futures study, as proposed by Garret (1993), who summarizes them in the following points:

- *Limiting the scope,* which should clarify the purpose of the study by answering the question: what is to be studied? Limiting the scope of the study should also identify the time frame of the study and “whether the study will look just at the ‘end states’ or also with the behaviour of the system over the whole timespan” (p. 260). In this respect, Slaughter (1993a) adds to Garret’s approach on this issue that the time frame of a study depends on the nature of the subject under study; indeed, for subjects related to social policy, economics or education an extended time frame is necessary and could extend to 100 years and beyond (Slaughter, 1993a, p. 305). As far as this study is concerned, the system under study includes political, social, and economic perspectives, with a timespan extending as far as 2050 and representing nearly 40 years. In this respect, it is worth mentioning that the transition process of an energy system is a very large structural change requiring long time frames.

- *Gathering information*, which involves gathering information about the system under study. Different methods are available for building this knowledge base, spanning from the use of computer-based tools to simple desk research. The information gathered could be quantitative as well as qualitative or a mixture of both. In this respect, it should be noted that “qualitative information obtained through public surveys, in-depth interviews, and the collection of items from books, journals, and newspapers is often just as valuable [as information of quantitative nature]” (Garret, 1993, p. 260). As already stated in the introduction, the design of this futures study will be essentially qualitative but will rely on a thorough quantitative analysis of the past and present of the system under study; namely, the power generation sector of the GCC countries.

- *Determining the key variables* by focusing on the relevant variables that will play a central role in the evolution of the system under study. For this study, the multilevel perspective has been selected as an approach to analyse the power generation sector of the GCC countries and help us determine the key variables of the system. As will be explained in detail in chapter 2, the transition theory and the MLP approach provide a very useful framework for bringing to the surface the main actors as well as the relevant variables at work in an energy transition process at the three levels of a given energy system.

- *Examining the past and present,* which could also be considered part of the more general task of *gathering information*, but with a focus on the history of the system under study. The value of a retrospective look lies in its natural foundation for discussing the future, but also for the clues that it could provide about the future (Garret, 1993, p. 261).

- *Identifying the actors,* which could also be considered part of the task of *gathering information*, as it will also rely on the MLP approach and will include information that is mainly focused on the main actors of the system and their respective roles within it.

- *Choosing the assumptions,* which precedes the scenario construction and is concerned with the "conditions, forces and events shaping a particular future" (Garret, 1993, p. 262). At this stage, and as far as this futures study is concerned, the assumptions on which the scenarios will be built will rely on a selection of relevant transition pathways that will be introduced in chapter 3. Indeed, the transition pathways are built on a number of assumptions about what could happen in the landscape environment and the innovations-niche levels, as well as their implications on the regimes level: how it might react to them and how the overall system could evolve. As stated by Garret (1993), the assumptions "include on-going trends and unique occurrences, welcome and undesired factors that are beyond control and ones that can be decided or influenced, things that can happen inside the system and things that are external to it" (p. 262), which is exactly how the transition pathways operate, and the reason why we are proposing to use them as a starting point for building the scenarios. The assumptions are chosen based on their *probability*, where 'very likely' and 'very unlikely' shaping events are considered from an objective approach; as well as their *desirability*—in this case, events that we want to see happen—are considered from a normative approach.

- *Constructing the scenarios* based on the selected relevant assumptions and transition pathways. In this respect, the typology of transition pathways as defined by Geels and Schot (2007) proposes different transition pathways, or developments in the system under study, based on different assumptions.

- *Evaluating the choices*, which involves a judgment about the different scenarios built. This stage, and the one that will follow, are not necessary components of a futures study, as they could be carried out by the specific users concerned by the study or proposed to the public for consideration and debate (Garret, 1993, p. 264). In this respect, this study will not make an evaluation of the choices, but aims to trigger a debate about the future of the energy system of the GCC countries.

- *Selecting strategies and tactics*, in order to determine what actions will be needed to achieve the selected scenario. As already mentioned in the paragraph above, such selection is not a necessary component of a futures study, and accordingly, this research project will not make a selection of strategies and tactics, but rather propose a number of policy recommendations in the conclusion.

Based on these components, we will use the scenario methodology to explore the future of the energy system of the GCC countries concerning the diversification of the energy sources of the power generation sector. In this respect, before building the scenarios, it is necessary to introduce the scenario methodology in the following section.

1.4. THE SCENARIO METHODOLOGY: HISTORY AND SCHOOLS

Scenario thinking has always been a cornerstone of human thought, as humanity has always explored the future and its uncertainties through imagining stories, or scenarios, built around the question of what *could* happen. In time, such imagined scenarios took the form of treatises on utopias and dystopias. Documented evidence about the use of scenario thinking in order to imagine ideal, utopic, future societies goes back as far as Plato's *Republic*, written around 380 BC, Thomas More's *Utopia* in 1516, Francis Bacon's *New Atlantis* in 1627, and Henry Nevill's *Isle of Pine* (1668). Grounded in a dystopian fiction approach, works such as George Orwell's *Nineteen-Eighty-Four* (1949), Aldous Huxley's *Brave New World* (1931), and Margaret Atwood's *The Handmaid's Tale* (1985), imagined the consequences to the world if there were no change in the existing trends, and as such, aimed at giving early warning signs about the evolution of their societies (Hughes, 2009a, p. 2).

Scenarios moreover have a very well established historical tradition in the military through the form of war game simulations. The first documented frameworks of scenarios are attributed to two 19th century Prussian military strategists, von Clausewitz and von Moltke, who were the first to articulate the principles of strategic planning (von Reibnitz, 1988, as cited in Bradfield et al., 2005, p. 797). In modern times, the term 'scenario' was introduced into futures studies by Herman Kahn in the second half of the 1940s in connection with military and strategic studies conducted by the Rand Institute in the U.S., and it was further developed by the Hudson Institute, established by Herman Kahn, after his resignation from Rand in 1961.

Simultaneously to Kahn's work with Rand in the U.S., Gaston Berger, a French philosopher, created the *Centre International de Prospective* in 1957 (Godet, Durance, & Gerber, 2008, p. 12) and conceived an original approach to scenario building for the purpose of long-term planning, which he named *La*

Prospective, and which was first implemented by a French interdepartmental government organization known as DATAR (Office for Regional Planning and Development) (Godet, Monti, Meunier, & Roubelat, 2004, p. 35). As in France, in the U.S., scenarios have initially been used as tools for public policy planning before they were adopted by the private sector at corporate levels, as planning became more complex and sophisticated. The Royal Dutch Shell oil company (Shell) was a pioneer in the field and became the benchmark for corporate scenario planning. Shell's scenario planning delivered the 'Year 2000' study in 1967 which concluded that the predictable, surprise-free environment for the oil business would not continue, and that a shift in power from the oil companies to the oil producers in the Middle East would create major discontinuities in the oil price. The conclusions of this study enabled Shell to anticipate the oil crisis of 1973 and 1985 and adapt to the new environment better than its competitors. Since then, scenarios have been used by the financial services industry, banks, and insurance companies, given their value as a tool for analysing and understanding key competitive decisions. Nowadays, almost all types of private organizations (especially multinational companies) use scenarios to develop their business strategies.

In the present time, the scenario is the most prominent method used in order to undertake a future or foresight study for medium-term to long-term strategic planning in public and private sector organizations. Indeed, "foresight is seen as the attempt to explore alternative futures by taking into account uncertainties [and] scenario analysis is a foresight method" (Rijkens-Klomp, 2012, p. 431).

Scenarios are "stories" or "narratives" illustrating visions of possible or desired futures. The objective of these representations is to highlight the driving forces and the early indicators of the breaking points of the general environment. Scenarios are not predictions or forecasts about the future but rather simulations of various possible futures[9]. Scenarios do not predict the future so much as they illuminate it, preparing us for the unexpected; they are multiple approaches to the

[9] As we have already seen in the section above, prediction is a necessary component of a future study and defined as multiple visions of the future rather than one precise prediction.

future, stories of the inevitable and necessary recombined with the unpredictable and matters of choice (Mc Corduck & Ramsey, 1996, p. 18). It has been rightly said that scenarios are not meant to necessarily “reflect any empirical objective reality, but rather serve as heuristic tools to elucidate the possibility (threat) space for certain objectives and policy options” (Söderholm, Hildingsson, Johansson, Khan, & Wilhelmsson, 2011, p. 1113). In addition, qualitative scenarios can be complementary to qualitative approaches and can lay the foundations for qualitative modeling and analysis.

According to Hughes (2009a), “scenario thinking is about the use of imagination to consider possible alternative futures, as they may evolve from the present, with a view of improving immediate and near-term decision making” (p. 4). The significance of the scenario method lies in its capacity to go beyond the mental, cultural, political and organizational limitations and constraints that tend to hinder creative thinking by developing critical and challenging mental attitudes. Schwartz rightly defines scenarios as “a tool for ordering one’s perceptions about alternative future environments, in which one’s decision might be played out [or in other words] a set of organised ways for us to dream about the future” (1991, p. 4).

In this respect, the scenario method is an invaluable tool for identifying the early signs of change and its implications for an organization, consequently enabling it to be proactive and able to detect and adapt to change in a timely and organised manner before the event occurs. Indeed, the scenario methodology is based on the fact that the future is unpredictable, and that it is necessary to accept, understand, and integrate uncertainty in our thinking about the future.

Scenarios provide multiple views of the future, and as such, offer a powerful framework for organizational learning, allowing the different components of the organization to share and to understand information about risk. Decision-makers will often reject projections of the future that deviate from what they expect or what they regard as comfortable. Diverse scenarios help overcome this mental barrier by developing diversified scenarios that will include those with which the decision-makers are comfortable in addition to those that challenge them. In addition, the diversification of the scenarios allows for introducing the idea that many alternative futures are possible.

Based on the above definitions of scenarios, we can clearly see the fundamental link between scenario thinking and action for decision making, and that building scenarios is a necessary undertaking in order to achieve a number of objectives, which are summarized by Hughes (2009a) in the following points:

- To improve the *protective decision making* process in order to be prepared for dealing with possible external developments that could unfold;

- To improve the *proactive decision making* process in order to be able to act pro-actively, take advantage of possible opportunities, and influence and act upon the external environment;

- To achieve *consensus building* through the engagement of the relevant stakeholders in the scenario building process (Hughes, 2009a, p. 4).

There is a very large, and sometimes confusing, variety of approaches for building strategic scenarios in the literature, to the extent that it has been described as a "methodological chaos" (Simpson, 1992; Martelli, 2001 as cited in Hughes, 2009a, p. 4), which makes it necessary to propose in the following sections a presentation of the different schools and approaches regarding the scenario methodology.

From the very specific American and French experiences mentioned above, two main schools for scenario building emerged: the American school and the French school. In the sections that follow, a short description of these schools and the approaches that have emerged from them will be described.

1.4.1. The American School and its Approaches

The American school for building scenarios emerged following a demand from the US Department of Defense, which was in need of developing new defense systems after the second world war, and more particularly, with the new challenges that emerged with the beginning of the cold war in 1949 (Bradfield, Wright, Burt, Cairns, & van der Heijden, 2005, p. 797). The complexity of decision making in the new post war international environment gave rise to two specific needs: the need for a new methodology capable of addressing the diversity of opinions and experts and achieving consensus among them; and the need for a methodology to explore and simulate the consequences of various policy alternatives.

The American experience and its developments gave birth to two distinct approaches: *the intuitive logics* approach and *the probabilistic modified trends* approach.

1.4.1.1. The intuitive logics approach

The intuitive logics approach is the result of the combination of Kahn's work and his followers with the work of Shell, using the scenarios which have since become the standard for scenarios in the private sector, "which is why the intuitive logics methodology is sometimes referred to as the 'shell approach' to scenarios" (Bradfield et al., 2005, p. 800). The main features of the intuitive logics approach are: first, its flexibility, as it uses an openly intuitive approach in the elaboration of scenarios comparatively to the probabilistic modified trends approaches that rely heavily on computer-based mathematical models, and are discussed in the following sections. Second, "the perspective of intuitive logics scenario work can be either descriptive or normative and the scope extremely broad as in the development of global scenarios or narrowly focused on a particular issue" (Bradfield et al., 2005, p. 806). Third, the intuitive logics methodology is more process oriented and relies essentially on the insights learned from the process than from the output of the scenarios. Fourth, this approach toward building scenarios is subjective, "relying fundamentally on what Jungermann and Thuring refer to as 'disciplined intuition'" (Jungermann & Thuring, 1987, as cited in Bradfield et al., 2005, p. 806). Fifth, the members of the scenario team are essentially "individuals from within the organisation undertaking the scenario work" (Bradfield et al., 2005, p. 808), in addition to experts represented by an experienced scenario practitioner in charge of designing and facilitating the scenario process, as well as "outside experts in the form of 'remarkable people' who have some knowledge of the industry and are acute observers of the environment . . . in order to challenge and stimulate the thinking of the scenario team" (Bradfield et al., 2005, p. 809).

Finally, the final output of the process using the intuitive logics methodology consists of two to four scenarios that are logically linked, presented in a discursive narrative form, and all of equal value. In other words, no probability should be assigned to the scenarios, as they are all equally probable (Bradfield et al., 2005, p. 809).

Under this methodology, the initiation phase is subject to the purpose of the scenario exercise, which could be related to a specific management problem or a very general issue, and "which in turn determines the focus in terms of the driving forces to be examined" (Bradfield et al., 2005, p. 809). The process and the tools can vary from one practitioner to the other, however, as

> they are basically generic and include desk research, individual and group brainstorming and clustering techniques, contextual environment analysis using the Societal, Technology, Economic, Environment, Technology (PESTEL) framework or its derivatives, matrices, systems dynamics, stakeholder analysis and discussions with remarkable people. (Bradfield et al., 2005, p. 809)

1.4.1.2. The probabilistic modified trends approach (PMT)

From the American experience and the work done by Gordon and Helmer et al. at Rand Corporation, emerged the Probabilistic Modified (PMT) approach for scenario techniques, which relies on "the probabilistic modification of extrapolated trends" (Bradfield et al., 2005, p. 800) and includes two distinctive methodologies: trend-impact analysis (TIA) and cross-impact analysis (CIA).

Trend-impact analysis (TIA) appeared in the early 1970s from the field of forecasting studies undertaken by the Futures Group in Connecticut. It is a forecasting technique in which a team of external experts conceive a baseline scenario using trend exploration. Future events that may affect this scenario are identified and evaluated on the basis of their probability of occurrence and degree of impact, and the combined effect of these events are applied to the baseline scenario to create future scenarios. According to Gordon, TIA evolved as a consequence of the criticism of traditional forecasting methods that relied on the extrapolation of historic data—from time-series techniques to econometrics—without considering "the effects of unprecedented future events" (T. J. Gordon, 1994, p. 1). Determining the surprise-free extrapolation is, indeed, the first step of the process, followed by the second step in which the surprise-free extrapolation is modified in order to take into consideration significant unprecedented future events which "should be plausible, potentially powerful in impact, and verifiable in retrospect" (T. J. Gordon, 1994, p. 3). Finally, expert judgments are used to determine the probability of incidence of the unprecedented events, as identified in the previous step and relatively to their expected impact, to generate accustomed extrapolations.

According to Bradfield, following a literature search, "references to TIA in context of scenarios are relatively few in the literature" (Bradfield et al., 2005, p. 801).

As far as the cross-impact analysis (CIA) is concerned, it refers to a family of forecasting techniques designed in 1966 by Gordon and Helmer et al. at the Rand Corporation, which involves identifying and evaluating the impact of trends or events on each other by a team of external experts through the use of a matrix. Similarly to the TIA, "the CIA methodology attempts to evaluate changes in the probability of occurrence of events which might cause deviations in the naïve extrapolations of historical data" (Bradfield et al., 2005, p. 801). The TIA and the CIA follow a similar process in addition to another layer of analysis for the CIA that attempts to connect relationships between events and variables in order "to move from a system of 'unprocessed initial probabilities' to a set of corrected probabilities'" (Bradfield et al., 2005, p. 801). The scenarios are built from the combination of narratives and judgments with the extrapolation of historical data.

1.4.2. The French School: 'La Prospective'

As mentioned previously, Gaston Berger initiated the French scenario work in the 1950s with a focus on the socio-political foundation of France itself, whereas the scenario work simultaneously initiated in the U.S. was of a global nature within the framework of the cold war. Grounded on the work done by Berger, Michel Godet conceived his own approach to building scenarios in the 1970s while he was the head of the Department of Future Studies at SEMA (a defence firm) and developing scenarios for a number of French organizations, such as EDF (Electricité de France), the public electricity company, and Elf, a petroleum products company. The methodology developed by Godet for the development of scenarios is an essentially mathematical and computer-based probabilistic approach, which includes a combination of systems analysis tools and procedures.

According to Bradfield et al. (2005):

> La Prospective approach to scenarios incorporates certain features of the intuitive logics methodology [and] is a more elaborate, complex and more mechanistic rather than an openly intuitive approach to scenario development, relying heavily on computer-based mathematical models which have their roots in TIA and CIA. (p. 801)

In this respect, *La Prospective School* is a mixture of intuitive logics and probabilistic modified trend methodologies, and relies on a team composed of key internal managers led by an external expert consultant for its conduct. It is necessary to mention that the methodological contribution made by Godet is quite different from the more philosophical thinking of Berger and de Jouvenel (Hughes, 2009a, p. 7). Indeed, the work done by Berger and de Jouvenel was conducted within a national public planning perspective, whereas Godet's work extended the field of scenario applications to the industrial sector as well as private companies.

As a result, the methodological approach developed by Godet relies heavily on a number of quantitative and probabilistic tools. In this respect, the process to conceive scenarios based on *La Prospective School*, as developed by Godet (2007a), starts by formulating the problem and analysing the system under study by a group of relevant stakeholders—moderated by an external consultant—before using a number of computer based programmes specific to every stage of the process, which can be described as follows:

- The first stage of the process is dedicated to the search for key internal and external variables. An inventory of the key variables is established with a description of the relationships amongst them through a structural analysis and the use of a software called MICMAC (Matrice d'Impacts Croisés Multiplication Appliqués à un Classement) (Godet, 2008, p. 61);

- In the second stage, an analysis of the stakeholders analysis is undertaken by which the positions and strategies of the relevant actors are identified and analysed through the use of the software MACTOR (Methode Acteurs, Objectifs, Rapports de force) (Godet, 2008, p. 65);

- The third stage is dedicated to exploring the field of possible combinations between the constituting elements of the system under study through the use of the morphological analysis and the software MORPHOL (an abbreviation of morphological analysis) (Godet, 2008, p. 69). This method is essentially used for conceiving scenarios, and is also used for technological forecasting.

- Finally, based on the results of the morphological analysis, the scenarios are then built. In order to delimit the most probable scenarios, it is possible to use the Smic-Prob-Expert software in order to evaluate the probability of certain events occurring in the future (Godet, 2008, p. 77).

According to Godet (2007a), computer programmes are simple tools that help deal with complexity and are necessary for allowing the users to appropriate the system under study and the process (p. 16). When compared to the American school, the French school is mainly focused on the socio-political dimensions of the future of France, whereas the American approach is essentially of a more global nature. In addition, the French approach has a strong bias towards normative scenarios of ideal futures and tends to neglect the exploratory approach to the future (van der Heijden, Bradfield, Burt, Cairns, & Wright, 2002, p. 129).

1.4.3. Comparing the Two Schools

Following this review of the three major schools for building scenarios, it is important to compare between the salient features of each of them in order to choose a specific methodology for our research subject and justify our choice. The success and failure of a scenario project lies in the degree to which a scenario work achieves one or more of the four purposes (van der Heijden et al., 2002, p. 234):

- Making sense of a particular puzzling situation;
- Developing strategy;
- Anticipation; and
- Adaptive organisational learning.

The literature relating to scenario work reveals that the intuitive-logics methodology has been used to achieve all of the four purposes identified due to its great flexibility (Bradfield et al. 2005, p. 806). However, as far as La Prospective and PMT methodologies are concerned, they have been essentially used to achieve the first and second of the above mentioned purposes in order "to determine the most likely evolutionary development of a particular phenomenon with a view of improving the effectiveness of policy and strategic decisions" (Bradfield et al., 2005, p. 806). In this respect, the intuitive-logics methodology relies mainly on subjective and qualitative information to a greater extent than La Prospective and the PMT methodologies, where subjective information is taken into consideration but within a pre-established framework of "complex mathematical, extrapolative forecasting and computer simulation models in their development of scenarios" (Bradfield et al., 2005, p. 806).

A scenario project undertaken using the intuitive-logics methodology can be either descriptive/exploratory or normative and with a very comprehensive scope ranging from global scenarios to scenarios focusing on a specific issue. La Prospective and PMT methodologies are mainly used, however, for the development of descriptive scenarios with a limited scope as they "focus on a specific phenomenon and the set of key variables which bear on the future of that particular phenomenon" (Bradfield et al., 2005, p. 806). In addition, the PMT methodologies are even more limited as far as the scope is concerned, as they "need to have detailed and reliable time series data" (Bradfield et al., 2005, p. 806).

Regarding the time horizon of the scenario project, all three methodologies offer the possibility to consider a period of between 3 and 20 years or more, especially if the scenarios have a very wide focus. As has been noted previously, the intuitive-logics methodology is mainly process oriented, while La Prospective and PMT methodologies are primarily concerned with the output.

There are also differences concerning the composition of the scenario team and the role played by external experts. In the case of the intuitive-logics methodology, the scenario process is generally carried out by a team composed of members from within the relevant organisation with the possibility of including an outside expert to play the role of the 'remarkable person' in order to challenge and stimulate thinking. The La Prospective and PMT methodologies rely on teams composed of key internal managers in addition to an external expert who has the necessary skills and knowledge for using a number of sophisticated tools to conceive and run the scenario exercise. The final and main difference is that, unlike the two other methodologies that attach probabilities to their scenarios, no probabilities are attached to the scenarios produced using the intuitive-logics methodology.

There are objective and visible differences between the intuitive-logics and the PMT methodologies, but fewer differences between the intuitive-logics and La

Prospective methodologies, as “the range and sophistication of tools advocated in some of the more recent variants of the intuitive-logics models are similar in nature to those on which the La Prospective functions” (Bradfield et al., 2005, p. 810)—despite the essential differences that still exist between thee two methodologies in methodological orientation, the composition of the teams, and the role of external experts in the course of the scenario exercise.

From a comparison between the two main schools, two types of scenarios can be identified: *exploratory* scenarios and *normative* scenarios.

Exploratory scenarios: Starting from a present situation with its dominant trends, explorative scenarios describe a succession of events that would logically and necessarily lead to a possible future. Such a scenario can be trend-based, and in this case, focuses on the driving forces of the system under study. They can also focus on the breaking points in relation to the trend-based scenario in order to explore contrasted hypothesis at the limit of the possible. The objective of exploratory scenarios is to scan the most likely possible futures.

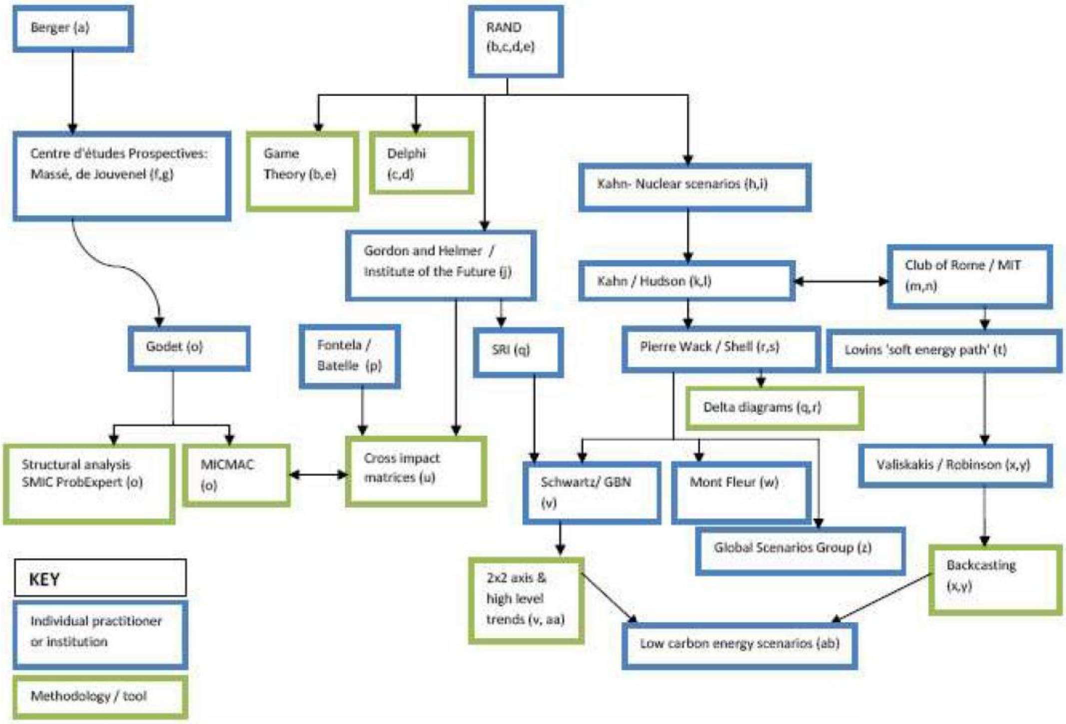
Normative scenarios: Often called anticipation scenarios, these do not begin from the present, but from the image of a desired future which is composed of a number of objectives to be achieved, and from there, they describe the course that links this desired future to the present. The normative scenario is, in general, established in relation to the exploratory scenarios: either as the outcome a selected one, or conceived as a synthesis of them.

As far as this research project is concerned, the choice has been made to build explorative scenarios.

1.5. SCENARIO METHODOLOGIES AND TYPOLOGIES

Grounded in the schools discussed in the sections above, a very large variety of scenario methodologies and typologies have been found in the literature—to an extent that gives rise to a sense of chaos and a great difficulty to find a standard methodology for building scenarios. Indeed, it has been rightly noted that “the literature reveals a large number of different and at time conflicting definitions, characteristics, principles and methodological ideas about scenarios” (Bradfield et al., 2009, p. 796). Moreover, the schools mentioned earlier do not have clear-cut boundaries to separate them, despite the work endeavored in some studies to construct ‘typologies of scenarios’ (Hughes, 2009a; Bradfield et al., 2005; see also International Energy Administration [IEA], 2003; McDowall and Eames, 2006; van Notten et al., 2003, as cited in Bradfield et al., 2005). The confusion is mainly due to the diversity of the users as well as the contexts and objectives for which it has been used; however, and in order to have some clarity in the overall confusion about scenarios and their methods, this research will consider the work by Bradfield et al. (2005) and Hughes (2009a) as the main sources for reviewing the scenario methods found in the literature. Following this clarification, a customized approach for building the scenarios of this research thesis will be suggested.

In this regard, Figure 1 below is a representation in the form of a family tree of the main figures and institutions that have been involved in scenario development, and the main methodologies attributed to them.



a	Berger (1957)	h	Kahn (1960)	o	Godet (1987)	v	Schwartz (1991)
b	Williams (1954)	i	Kahn (1962)	p	Duval et al (1975)	w	le Roux, et al. (1992)
c	Brown and Helmer (1964)	j	Helmer (1972)	q	Bradfield et al (2005)	x	Valiskakis (1988)
d	Dalkey (1967)	k	Kahn et al (1967)	r	Wack (1985a)	y	Robinson (1990)
e	Dresher (1961)	l	Kahn et al (1977)	s	Wack (1985b)	z	Raskin et al (2002)
f	Massé (1966)	m	Forrester (1971)	t	Lovins (1977)	aa	Scearce and Fulton (2004)
g	de Jouvenel (1967)	n	Meadows et al (1972)	u	Dalkey (1972)	ab	Hughes et al (2009a)

Figure 1: Family tree of scenario practitioners and approaches. Adapted from *Transition pathways to a low carbon economy: A historical overview of strategic scenario planning*, by N. Hughes, 2009a, p. 6.

The blue boxes represent the key personalities that have been involved in scenario work, and the green boxes represent the main methodological tools that have been developed for building scenarios. As described by Bradfield et al. (2005), we can clearly see the beginnings of scenario work from the American (RAND) and French (Berger) schools, and the different approaches and tools that have emerged as a result.

In this respect, the line linking Berger and Godet represents the French school already described above. Whereas the line starting from Herman Kahn and passing by Pierre Wack at Shell, and Peter Schwartz at the Global Business Unit (GBU), represents the intuitive-logics school, which is more based on qualitative techniques and intuitions in comparison to the French school, which is more quantitative. However, there is also a convergence between the two schools that has evolved from the work done by Gordon and Helmer at RAND, known as the

Probabilistic Modified Approach, and from which has emerged the two distinctive methodologies known as: the trend-impact analysis (TIA) and cross-impact analysis (CIA) discussed above in the section dealing with the American school. Indeed, this school shares similar characteristics with the approach developed by Godet in the French school. Other common characteristics between the American and French schools can be found in the work of Kahane (1999) in South Africa, who initially came from Shell, and the work of Berger and de Jouvenel, as it has a strong normative public policy orientation, comparatively to the exploratory perspective done at Shell (as cited in Hughes, 2009a, p. 7).

Another important branch of scenario methodologies based on the ‘backcasting’ concept for locating low carbon energy scenarios, and developed by a group of Canadian researchers including Robinson and Valiskakis, proposed a synthesis between the American and French schools (Hughes, 2009a, p. 8). According to this approach, in order to locate the desired low carbon energy scenarios, the starting point of the process should be a description of the desirable future followed by a retrospective identification of the necessary steps and conditions to reach it.

As a concluding note, we can see that the diversity of the scenario methodologies is explained by the diversity of the users and the contexts in which it has been used, and that every use of the scenario method requires the user to conceive a customized approach depending on the subject, the context, and the available means to achieve it. Indeed, as stated by Hughes:

> It follows from the start of a scenario development process, understanding the perspective and bounds of influence of the potential scenario user (whether implicitly or explicitly defined), and from this understanding the objectives of the process, is key to understanding which type of approach, from the numerous variations available to draw on, is the most appropriate for that particular process. (Hughes, 2009a, p. 8)

Accordingly, a specific approach will be proposed for building the scenarios of this research project based on the typology of scenarios as defined by Slaughter (1993a), and combined with the typology of transition pathways as defined by Geels and Schot (2007). In this respect, it is worth noting that prior works linking scenarios and transition pathways have been found in a number of working papers: Hughes (2009a) *A Historical Overview of Strategic Scenario Planning and Lessons for Undertaking Low Carbon Energy Policy*, Hughes (2009a) *Transition Pathways and Low Carbon Energy Scenarios*, and Hughes, Mers, and Strachan (2009) *Review and Analysis of UK and International Low Carbon Energy Scenarios*. As far as the MENA region and the GCC in particular are concerned, no studies have been found linking the transition concept to the scenario methodology, and in this respect, this study could be considered the first attempt for the region. However, the approach used in this research project for linking scenarios and transition pathways is new and will be explained in the following section.

1.5.1. A Scenario Typology

In the course of studying the future, a choice has to be made between different future alternatives. Building the scenarios helps imagine the future, but more importantly, it contributes in providing a road map about the different routes to the future. In this respect, Slaughter (1993a) has recommended building contrasting images of the future by considering a range of alternative future developments, generated through a set of five broad scenarios rooted in our present: a *breakdown scenario*; a *repressive or managed societies* scenario; a *business as usual* scenario; the *ecological decentralist* scenario; and the *transformational societies* scenario.

The breakdown scenario represents a scenario where a major negative, triggering event occurs, such as a sudden environmental degradation, a nuclear accident, or a chronic rise in political and social conflict (Slaughter, 1993a, p. 295).

The repressive or managed societies scenario represents a scenario where there is a return of totalitarian and fascist types of political regimes which could be triggered by a number of different economic and/or political factors.

The business as usual scenario assumes continuity in the present policies and the planned projects. In this scenario, the present situation with all its challenges and the unsustainable way of managing the resources remain unchanged, which could lead to a *breakdown* scenario in the future as a result of the incapacity to adapt to the changing realities.

The ecological decentralist scenario assumes a departure from the actual aggressive ideology of economic growth towards a new approach to nature, based on decentralized 'soft energy paths' and a deep commitment to ecological reconstruction (Slaughter, 1993a, p. 296). This scenario requires a radical ideological shift with a very significant civilizational change; as such, it is highly unlikely that any government would consciously and deliberately engage in such a scenario unless without significant external pressure.

The transformational societies scenario could evolve from two main routes: either from a process that leads humanity to a new stage of development, or through "the benign operation of a new form of technology" (Slaughter, 1993a, p. 296).

The scenarios typology as proposed by Slaughter (1993a) provides for a useful framework or a starting point for building the scenarios of this futures study. The following chapter will be dedicated to the energy transitions theory and the MLP framework of analysis that will be used in order to make a thorough and systematic analysis of the energy system of the GCC countries, in addition to helping us determine the possible future scenarios for an energy transition in the power generation sector of the GCC countries, based on Slaughter's (1993a) scenario typology.

Chapter 2

ENERGY TRANSITIONS: A MULTILEVEL PERSPECTIVE

An energy transition is briefly defined as the process of a qualitative and/or quantitative transformation of the energy system. A qualitative energy transition involves shifting from one source of energy to another source of energy, whereas a quantitative energy transition involves a study of the historical changing patterns of energy consumption between different fuels. However, the concept of energy transitions mainly implies a shift from one or a group of energy sources that dominate the market to another major energy source or sources. The following sections will necessarily define the concept of energy transition and its history before dealing in detail with the multilevel perspective (MLP) approach that has emerged from the study of transitions.

2.1. ENERGY TRANSITIONS DEFINED

Historically, humanity has witnessed local and global, qualitative and quantitative energy transitions, with the first global qualitative energy transition taking place between the 17^{th} and 19^{th} centuries—shifting from wood to coal as a source of energy in the first industrial revolution. The second global qualitative energy transition occurred at the beginning of the 20^{th} century when oil replaced coal, becoming the major energy source of the world energy mix of which coal still remains a component (Solomon & Krishna, 2011, p. 7424). Based on human history and the literature dealing with energy transitions, it can be concluded that energy transitions take place when a number of the following factors are present:

- A depletion of the energy source;
- An increase in the price of the dominant energy as a result of the first factor;

- The existence of environmental and/or health consequences of the energy used, as for example happened with coal at the end of the 19th century;

- The introduction of a new source of energy that is price competitive and more efficient than the existing dominant source of energy, as happened at the beginning of the 20th century when oil replaced coal;

- New geopolitical and economic factors that influence national security.

The 1973 oil crisis was the result of the oil embargo imposed by the Arab oil exporting countries on the major consumers represented by the U.S., Western Europe, and Japan for their support to Israel. As a result of the embargo, the price of oil suddenly increased by 70% on the world energy markets and was one of the reasons that led the world economy into a period of economic recession[10]. The significant increase in the price of oil has burdened the budget of all the importing countries of oil and petroleum fuels, which ultimately led to new policies for saving energy through a wiser and more economic consumption of energy at an individual micro-level and a more efficient energy system at the macro-level. In addition, a number of new measures and policies were implemented in order to decrease the dependency on oil through the development of alternative and/or renewable energy sources. In this respect, the Brazilian and French experiences are considered the most prominent of successful qualitative energy transitions in the twentieth century. The U.S. has also launched a policy for a qualitative energy transition following the 1973 oil crisis, The Independence Project, but it did not lead to a successful outcome.

In the academic literature, the term 'transition' has been mainly used in the context of research conducted about sustainable development. The first book containing both terms was published in 1998 under the title *The Politics of Agenda 21 in Europe*, edited by Timothey O'Riordan and Heather Voisey, and followed by two other books under the titles *Our Common Journey: A Transition*

[10] It is very difficult to identify the real reasons that have led to the economic recession after the oil crisis of 1973, as it was concomitant to a number of monetary and financial policies implemented in western countries, which had an aggravating role.

Toward Sustainability, published in 1999 by the U.S. National Research Council, and *Sustainable Development: The Challenge of Transition*, edited by Jurgan Schmandt and C.H. Ward in 2000 (Kemp, 2010, pp. 291-292). At this stage, the term 'transition' is used in order to describe a general process without any theoretical background. However, in the last decade and more, as a result of historical studies dealing with past energy transitions, a number of descriptive models and concepts have been developed in order to propose a general theory explaining the transitions processes. In this respect, a system level theory emerged, known as the multilevel perspective (MLP), which included concepts drawn from ecology (niches, landscapes), political science (regimes), and evolutionary biology (evolution, selection) (Hughes, 2009b, p. 1). In the literature, the MLP gradually emerged from a number of studies: Kemp et al. (1998), Rotmans, Kemp, & van Asselt (2001); Geels (2002, 2004, 2005a, b, 2006); Perez (2002), Berkhout et al. (2003); Smith et al. (2005); Grin (2006); Kemp, Rotmans, and Loorbach (2007); Geels and Schot (2007); Melosi (2010); Solomon and Krishna (2011). The theory about transitions that emerged from this debate was concerned with transformative change where multiple levels and drivers interact and mutually influence each other in a transition process, and represented a major shift from the traditional perspective of transitions based on a single and linear causality as a result of a 'technological push'.

Transitions theory emerged from the need for a general framework in order to understand the processes through which significant technological and social transformations take place in a given society. Indeed, a transition from present energy sources to new alternative energy sources implies that a paradigm shift will occur (Nader, Cesarino, & Hebdon, 2010, p. 1) and involve political, economic, and security issues that are fundamentally political in nature (Nader, et al., 2010, p. 3). As noted by Melosi, through the examination of the mechanism of change we can reach the conclusion that "potentially, energy transitions can help to clarify how energy development and use influences and is influenced by the technical, economic, political, environmental and social forces that shape society" (2010, p. 45). Finally, "if history teaches us anything on this subject it is that energy transitions are not simply exercises in swapping fuels and technologies, but disruptive events with the potential to remake societies in fundamental ways"

(Melosi, 2010, p. 58). It is based on this historical conclusion that the multilevel perspective (MLP) was developed as an 'appreciative theory' (Nelson & Winter, 1982, as cited in Geels, 2002, p. 1259) that integrates findings from different literatures (Geels, 2002, p. 1259).

Transition studies have used different approaches, and the more frequently used can be summarized as the following: the multilevel perspective (MLP); strategic niche management (SNM); transition management (TM); innovation systems (IS); techno-economic paradigm (TEP); and socio-metabolic transitions (Lachman, 2013, p. 270) approach. The strategic niche management approach (SNM) shares some elements of the multilevel perspective (MLP) and focuses on the niche level and the necessary conditions for a technological niche to operate a breakthrough in the regime level. The transition management (TM) approach is interested in the management aspect of a transition and how to influence the speed and direction of a transition process. The TM approach has proven to be difficult to implement despite its theoretical attractiveness (Lachman, 2013, p. 272). The innovation systems (IS) approach developed in the mid-1980s seeks to uncover the bottlenecks in a transition process by breaking down the system into its constituents and "tends to marginalize cultural and demand side aspects" (Lachman, 2013, p. 273). The techno-economic paradigm (TEP) approach, based on the long wave theory, is a macro view that comprises the whole economy and "argues that major technological shifts are the basis of macro-economic cyclical movements, and together with this shift in technology, the other subsystems within society co-evolve" (Lachman, 2013, p. 273). The TEP approach has been mainly criticized for its deterministic understanding of macro-economic phenomena and for its incapacity to determine the causes of long wave cycles (Geels 2006; van den Bergh & Oosterhius, 2008, as cited in Lachman, 2013, p. 273). Finally, the socio-metabolic approach focuses on a society's general metabolism for studying transitions, but without including the actors and their background represented by their culture, belief systems and political interests (Lachman, 2013, p. 274). Comparatively to the above mentioned approaches, the MLP has been considered as encompassing all the factors relevant in a transition process, and a powerful tool for policy-makers as it "does not employ linear cause-and-effect relationships or simple drivers . . . [and] is well suited to study uncertain and messy processes such as transitions" (Geels, 2012, p. 474).

Based on these arguments, and as far as this research is concerned, the choice has been made to rely on the MLP approach in order to study energy transitions in the context of the GCC countries with a futures perspective. The section below will expand further on the MLP approach and its relevance to this research project.

2.2. THE MULTILEVEL PERSPECTIVE: A CRITICAL ANALYSIS

The debate about transitions, and more particularly technological transitions, has led to the development of a specific approach to analysing the process of technological transitions known as the multilevel perspective (MLP), which draws "on evolutionary economics, the sociology of technology, political economy and other factors" (Solomon & Krishna, 2010, p. 7427). The MLP consists "of three inter-linked dimensions in a nested hierarchy" (Solomon & Krishna, 2010, p. 7427), known as 'niche innovations' at the micro-level; 'sociotechnical regimes' at the meso-level; and 'sociotechnical landscapes' at the macro-level.

According to the MLP framework of analysis, the transition of a new technology (generated and developed at the niche level) from the niche level to the sociotechnical regimes level essentially results from combined, successful developments at the three levels of the MLP. In this respect, in addition to the analysis of the MLP and the different levels involved, it is essential to understand the process through which a niche technological innovation succeeds in moving from niche to regime level and how the reconfiguration process of the regime is managed.

As far as the transition from niche to regime level is concerned, it is mainly the result of a gradual accumulation process, also called *niche accumulation*, which involves "experimentation, learning processes, adjustments and reconfigurations" (Geels, 2002, p. 1271). Based on previous historical experiences, niche technological innovations have been able to break through into the regime level through the mechanism of technological *add-on* and *hybridisation* whereby new technologies link up with already established technologies as a result of a specific need (Geels, 2002, p. 1271). Such was the case of gas turbines in the power generation sector. First introduced in order to improve the productivity of steam turbines in combined steam power stations, gas turbines soon replaced steam as the main technology for electricity production, and steam turbines became the auxiliary add-on (Islas, 1997 as cited in Geels, 2002, p. 1272). In this respect, it should be noted that reconfiguration processes in the regime occur as a result of a gradual and stepwise evolution while the technological transition takes place, and where a new regime grows out of an old regime (Van Den Ende & Kemp, 1999 as cited in Geels, 2002, p. 1272), which involves all the dimensions of the sociotechnical regime.

The significance and value of the MLP lies in its usefulness as an analytical framework for dealing with the complexity of real world situations—which also, however, happen to be its primary weakness. In addition to the difficulty of drawing borders between the different units of analysis that compose it, the MLP requires many data that are essentially of a qualitative nature (Geels, 2002, p. 1273).

As explained in Figure 2 below, the MLP is a process whereby the three levels mentioned above work together according to an ordered dynamic:

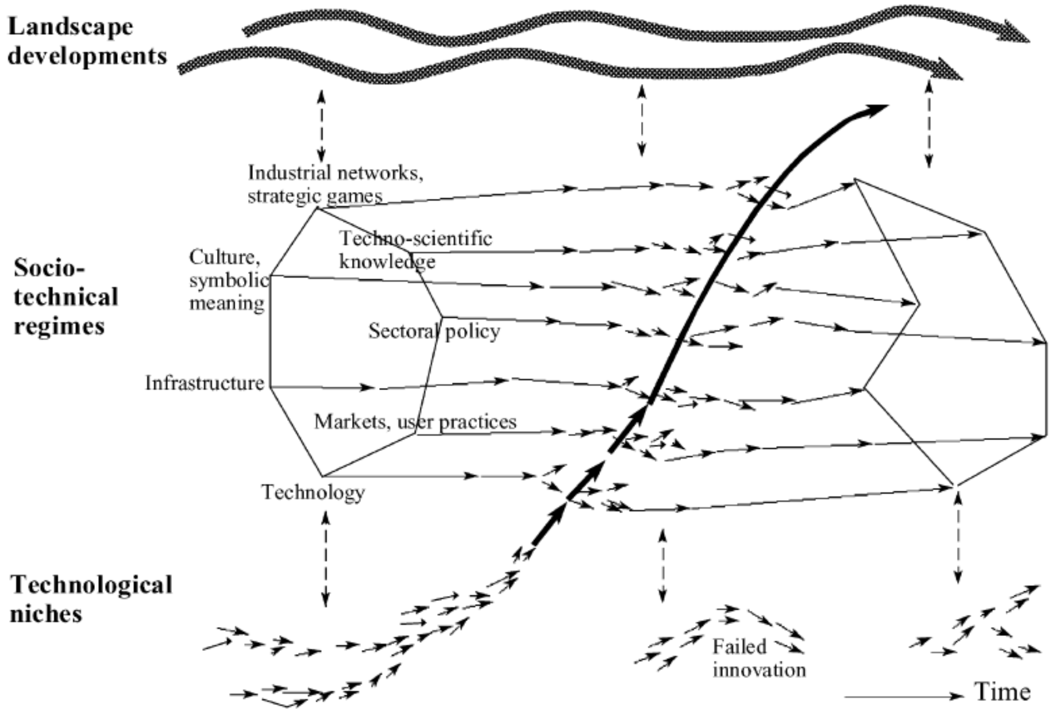


Figure 2: Multilevel perspective on transitions. Adapted from "Technological Transitions as Evolutionary Reconfiguration Processes", by F. W. Geels, 2001, *Research Policy, 31*, p. 1263.

According to the MLP, the dynamic of a transition follows the following pattern: first, a technological niche innovation gradually evolves as a result of technical improvements, cost reduction, and a learning process, in addition to support from interest groups. Second, an increased pressure is placed on the sociotechnical regime as a result of major changes at the sociotechnical landscape, which leads, in a third stage, to destabilizing the regime level who is pushed towards adopting the niche innovations (Geels & Schot, 2007, p. 400).

This standardised conceptualisation of the MLP has been criticised on three main points. The first criticism questions the level of the empirical analysis as "it is unclear how these conceptual levels should be applied empirically" (Berkhout et al., 2004, p. 54). In other words, in the case of the electricity sector—the subject of interest of this research—different regimes are involved at the level of primary fuel (oil, gas, coal, nuclear, or renewables), or at the level of the entire system. This includes the aspects of production, transport, distribution, and consumption, and it is unclear if the focus should be on the whole system or just at one level of the system. In order to overcome this criticism of the MLP, Geels and Schot (2007) suggest to "first demarcate the empirical level of the object of analysis, and then operationalize the MLP" (p. 402). In this respect, and according to DiMaggio and Powell (1983), transitions in sociotechnical regimes are found at the organisational fields, which are defined as:

> Those organisations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organisations that produce similar services or products. The virtue of this unit of analysis is that it directs our attention . . . to the totality of relevant actors. (DiMaggio & Powell, 1983, p. 148)

Based on this definition, as far as this research is concerned, the organisational field of the electricity, or power generation, sector of the GCC countries is composed of a selection of relevant primary energy technologies for electricity production, the institutions and organizations involved in the policy-making process of the power generation sector, and the consumption patterns of electricity as related to demographic growth and economic development, in addition to the international oil market and the climate change issue.

The second criticism of the MLP suggests that it is over-functionalist and too descriptive and structural (Smith et al., 2005, p. 1492). This criticism mainly arises from the use of Figure 2 above, which does not include or mention the role of actors in the transition process. However, the MLP is much more sophisticated than suggested by this figure, as it takes into consideration the nature of the levels and the actors involved, as well as the relationship of the levels to agency.

The third criticism involves the focus of the MLP on the niche innovations level, or micro-level, considered the central level responsible for a regime change. Indeed, the MLP favours the bottom-up approach and explains a regime change as a consequence of changes at the niche innovations level (Berkhout et al., 2004, p. 62). However, it should be noted that this early bias of the MLP has since been addressed in more recent works and can be easily overcome through greater focus on the regime and landscape levels (Geels, 2002, p. 1261).

2.2.1. The Technological Niche Innovations Level

At the niche innovations level (i.e., the micro-level), new niche technological innovations appear on the market and are promoted by governments through subsidies, taxes, or regulation. Indeed, in Brazil following the first oil crisis of the seventies, biofuels have benefited from "strong support and subsidies for the sugarcane industry, [and] funded R&D with rapid payoffs for ethanol production" (Solomon & Krishna, 2010, p. 7427). In France, again following the first oil crisis, nuclear energy benefited from a similar type and level of support. When a significant and fundamental technological innovation takes place, it can have a triggering effect for a major energy transition. An example of a historical niche technological innovation is the discovery of oil and the techniques to produce it, leading to a shift from coal to oil. More recently, another example of a niche innovation can be seen in the Shale gas revolution that took place lately in the U.S. as a result of a major technological breakthrough in the shale gas extraction technology. It is at this level that technical novelties developed by small network of actors emerge (Geels & Schot, 2007, p. 400), as will be seen later in this research in chapter 3 regarding the development of techniques for the extraction of shale gas; namely, horizontal drilling and fracking.

Regarding our research thesis, a thorough review will be undertaken of a selected number of energy technologies—solar, wind, nuclear energy, oil and gas—in order to evaluate their present technological status, their costs in the international markets, and standing in the context of the GCC countries. This work is essential in order to make projections about the level and scope of their potential future deployment.

2.2.2. The Socio-technical Regimes Level

The meso-level, also known as the *socio-technical regimes* level, consists of three intertwined dimensions: “a network of actors and social groups, formal normative and cognitive rules, and material and technical elements” (Solomon & Krishna, 2010, p. 7427). According to Geels (2002), “the term ‘sociotechnical regimes’ . . . refer[s] to the semi-coherent set of rules carried by different social groups” (p. 1260) that are responsible for the stability of the sociotechnical regime as they are the providers of orientation and co-ordination among the relevant actor groups (p. 1260). As shown in Figure 1 above, Geels (2002) distinguished seven interlinked “dimensions in the sociotechnical regime: technology, user practices and application domains (markets), symbolic meaning of technology, infrastructure, industry structure, policy and techno-scientific knowledge” (p. 1262). According to Rip and Kemp:

> A technological regime is the rule-set or grammar embedded in a complex of engineers’ practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures. (Rip & Kemp, 1998, p. 340)

In this respect, the sociotechnical regime (the meso-level) is a deep structure that is relatively stable; however, this stability is not static but rather dynamic, as it allows for innovation to take place through an incremental process. In other terms, the sociotechnical regimes represent a deep structure that “in evolutionary terms, . . . function[s] as [a] selection and retention mechanism” (Geels, 2002, p. 1260) for novel technologies that are being generated and developed at the niche level and actively looking for an opportunity to emerge.

It is worth noting that at this regime level, path dependency and technological lock-in are strongly present in energy systems, which cannot be overcome without a “thinking outside of the box” attitude from the concerned network of actors and social groups mentioned earlier. Given the centrality of the regime level, technological transitions have been defined by Geels and Schot (2007) “as changes from one sociotechnical regime to another” (p. 399). Indeed, the importance of this level is related to the central role of the *formal normative and cognitive* rules in shaping social behaviour and policies within the context of a specific socio-political contract. The *formal normative* rules include values, behavioural norms, and role relationships, whereas *cognitive* rules include belief systems, innovation agendas, problem definitions, guiding principles, and search heuristics. Consequently, at this level are found the policy makers and interest groups who, depending on the socio-political context in which their own values, belief systems, and interests have evolved, will make choices and conceive policies that can either foster a technological transition or hinder it.

2.2.3. The Socio-technical Landscape Level

The macro-level, or the socio-technical landscape level, is represented by the external "environment that usually changes very slowly, over many decades, and influences the dynamics at the niche and regime levels (though not vice-versa)" (Solomon & Krishna, 2010, p. 7427). The macro-level can be summarized in the following factors: "the macro-economy, deep cultural patterns, and [global] political developments" (Solomon & Krishna, 2010, p. 7427). The sociotechnical landscape is relatively static and is similar "to the historian Braudel's concept of *longue durée*" (Geels & Schot, 2007, p. 403). However, the relative stability of the socio-technical landscape does not exclude dynamic aspects, which as elaborated by Van Driel and Shot (2005), can be classified around three types: firstly, "factors that do not change or that change only slowly, such as climate; secondly, long term changes, such as the German industrialization in the late 19th century; thirdly, rapid external shocks, such as wars or rapid fluctuations in the price of oil" (Geels & Schot, 2007, p. 403). These factors are classified at the socio-technical landscape because they represent an external environment that cannot be influenced by actors in the short run.

Developments at the sociotechnical landscape do not necessarily have an immediate impact on the niche-innovations and regimes; rather, they "need to be perceived and translated by actors to exert influence" (Geels & Schot, 2007, p.

404), whereas niche-innovations and regimes have the capacity of leading to action through sociological structuration (Geels & Schot, 2007, p. 404).

2.2.4. A Typology of Environmental Change

In an effort in order to establish a typology of environmental or landscape change, four dimensions of environmental change have been proposed by Suarez and Olivia (2005) that can be summarized as the following: frequency, which represents the number of environmental changes per unit of time; amplitude, or the extent of deviation from the initial circumstances as a result of the disturbance; speed, or rate of change of the disturbance; and finally scope, which represents the number of environmental dimensions that have been affected by the simultaneous disturbances (p. 1022). From the various combinations of these four dimensions, Suarez and Olivia (2005) have identified five typologies of environmental change, as shown in Table 1 below:

Table 1

Attributes of Change and Resulting Typology

Frequency	Amplitude	Speed	Scope	Type of environmental change
Low	Low	Low	Low	Regular
High	Low	High	Low	Hyperturbulence
Low	High	High	Low	Specific shock
Low	High	Low	Low	Disruptive
Low	High	High	High	Avalanche

Note: Adapted from "Environmental Change and Organizational Transformation", by F. Suarez and R. Olivia, 2005, *Industrial and Corporate Change, 14*(6), p. 1022.

The resulting typology generated by the different ways of combining the four attributes of change have been defined by Suarez and Olivia (2005) in the following terms:

- *Regular change* refers to a regular low intensity environmental change.

- *Hyperturbulance change* refers to environments that witness a high frequency of high-speed change in one or a few dimensions.

- *Specific shock* corresponds to rapid and high intensity environmental changes. Their occurrence is rare and they are narrow in scope.

- *Disruptive change* refers to changes that are not very frequent. They develop gradually but have a high intensity effect on the system and require significant adaptation efforts.

- Finally, *avalanche change*—the most extreme typology—does not occur very frequently but is of high speed and intensity and simultaneously affects multiple dimensions of the system. Following an avalanche change, radical transformations are needed, which in turn will lead to a radical change at the regime level (pp. 1022-1023).

Based on Suarez and Olivia's (2005) typology of environmental change, Geels and Schot (2007) have proposed a typology of transition pathways, with the exception of hyperturbulance, as according to them, such a change is found only in markets and is very unlikely in the case of landscape dynamics (p. 404).

2.3. A Typology of Transition Pathways

In order to address the above mentioned criticisms of the MLP, and more particularly the bottom-up bias of the MLP, Geels and Schot (2007) have proposed a 'typology of transition pathways' describing different multilevel interactions that combine two criteria: the first is the criteria of 'timing of interactions', and the second is the criteria of 'nature of interaction' (p. 405).

The timing of interventions criteria argues that "different *timings* of multilevel interactions have different outcomes" (Geels & Schot, 2007, p. 405), which is a significant evolution from earlier MLP descriptions found in the literature that highlighted a simultaneous unfolding process between the different levels. The timing of the pressure originating from the landscape is of particular importance, as the outcome of the transition process will depend from the level of maturity of niche innovations. In this respect, this point refers to another difficulty with the MLP, which is to evaluate the level of development or maturity of technological niches present at the micro-level and whether they are ready to achieve a breakthrough at the meso- or regimes level. Indeed, as regime actors and niche actors can have different opinions about the level of maturity of niche innovations, Geels and Schot (2007) have proposed the following indicators:

(a) Learning processes have stabilized in a dominant design;

(b) Powerful actors have joined the support network;

(c) Price/performance have improved and there are strong expectations of further improvements (e.g., learning curves);

(d) The innovation is used in market niches, which cumulatively amount to more than 5% market share (p. 405).

These indicators will serve as the benchmark to evaluate the maturity of the new energy technologies selected for this research.

The second criteria, ‘nature of interaction’, questions the nature of relationships shared between the niche-innovations and landscape levels with the regime level and whether they are *reinforcing* or *disruptive* relationships through pressure or competition. It is argued that *reinforcing* landscape developments that stabilize the existing regime are not considered drivers for transitions (Geels & Schot, 2007, p. 406). Conversely, *disruptive* landscape developments are a push for change at the regime level. As far as niche-innovations are concerned, their relationships to the existing regime are described as competitive when they aim at replacing it, and symbiotic when they are introduced as competence-enhancing add-ons in the existing regime (Geels & Schot, 2007, p. 406).

Depending on the nature and strength of relationships between niche-innovations and landscape developments with the existing regimes, Geels and Schot (2007) have proposed different transition pathways that can be summarized as follows:

Reproduction process creates no pressure on the sociotechnical regime (meso-level) from the landscape (macro-level), and no significant technological breakthrough at the technological niches level (micro-level); even if they exist, the stability of the regimes level does not allow them to materialize. In this situation, the regime reproduces itself. This pathway can be considered as a 'business as usual' scenario. However, while this pathway does not exclude a transition from taking place, the transition will occur only through an incremental, very long-term process without any destabilizing effect on the sociotechnical regime.

Transformation path results from a moderate pressure from the landscape level on the regime level, whereas the niche-innovations have not yet matured. In this case, the pressure has a disruptive effect on the regime, which reacts by engaging in a reorientation and innovation strategy. It is important to note that the regimes actors do not react immediately to landscape pressure, as it takes some time before they internalize this pressure and consider outside criticism that can originate from social or interest groups as well as the scientific community. This path does not threaten the existence of the regime actors, although some changes may occur at the level of the social networks. In fact, the change in the regime structure takes place from within the regime itself (Geels & Schot, 2007, p. 407).

De-alignment and re-alignment path appears when the pressure from the landscape is rapid and sudden with a resulting disruptive effect on the whole regime architecture. This triggers a high risk of a collapse leading to de-alignment, as no ready technological niche exist to fill the vacuum, but instead a variety of niche innovations who compete for access to the regime level. As a result of this competition, one innovation niche becomes dominant over time and leads to a re-alignment into a new sociotechnical regime (Geels & Schot, 2007, p. 408).

Technological substitution takes place when there is a sudden and disruptive pressure from the landscape level, also described as 'avalanche change', simultaneously to the presence of a ready and mature technological niche waiting for the opportunity to be adopted by the regime actors. Without the landscape pressure, the situation would otherwise resemble the *reproduction process* as a result of the entrenchment and stability of the regime structure. The *technological substitution* path ultimately leads to the replacement of the old regime by a new one, as the old regime actors did not pay attention to the technological developments that were taking place at the niche level. Rather, they reacted only at the last minute as a consequence of a sudden and rapid pressure from the landscape level.

Reconfiguration pathway is the result of "symbiotic innovations, which developed in niches, [and] initially adopted in the regime to solve local problems [and as a result] they subsequently trigger further adjustments in the basic architecture of the regime" (Geels & Schot, 2007, p. 411). Similarly to the *transformation path*, the new regime emerges from the old regime, with substantial changes in the architecture of the regime as the only difference.

Finally, a fifth transition pathway has been proposed by Geels and Schot (2007) which would start as one path before shifting to another path, or a successive combination of other paths (p. 406). This can happen especially if the pressure from the landscape takes the form of 'disruptive change' which is initially perceived as slow and moderate by the regime actors, before it gradually builds and becomes disruptive, leading the regime actors to react to the increasing pressure by shifting from one path to the other before finding a new equilibrium. This transition pathway allows for a greater flexibility in the use of the MLP and for imagining different possible scenarios that will depend on the nature and strength of the pressure that is exerted on the regime.

It should be noted that the proposed pathways are not deterministic or automatic, and that their application to specific cases requires care and adaptation to the specific context in which it is used. Based on this typology of transition pathways, it is proposed in the section below, that the scenarios regarding the transition of the power generation sector of the GCC will consist of relevant combinations between the scenarios typology, as proposed by Slaughter (1993a), and reviewed in chapter 1, and transitions pathways, as proposed by Geels and Schot (2007) typology, and reviewed in this chapter.

As we have already seen in chapter 1, *The breakdown* scenario represents a scenario where a major negative, triggering event occurs, such as a sudden environmental degradation, a nuclear accident, or a chronic rise in political and social conflict (Slaughter, 1993a, p. 295). By comparing this scenario with the typology of transition pathways as elaborated by Geels and Schot (2007), we find that it could correspond to the *de-alignment and re-alignment path*, in case there are no fully matured technological niche-innovations ready to replace the existing technology, or the *technological substitution* path, in case a mature technological niche-innovation is available and waiting to be adopted by the regimes actors.

The repressive or managed societies scenario, reviewed in chapter 1, represents a scenario where there is a return of totalitarian and fascist types of political regimes which could be triggered by a number of different economic and/or political factors. There seems to be no equivalent to this scenario in the typology of transition pathways reviewed in this chapter.

The business as usual scenario, reviewed in chapter 1, assumes continuity in the present policies and the planned projects. In this scenario, the present situation with all its challenges and the unsustainable way of managing the resources remain unchanged, which could lead to a *breakdown* scenario in the future as a result of the incapacity to adapt to the changing realities. This scenario seems to be equivalent to the *reproduction process* transition pathway, reviewed in this chapter, which could evolve into the fifth transition pathway in case a *breakdown* scenario is materialized halfway into the *business as usual* scenario.

The ecological decentralist scenario, reviewed in chapter 1, assumes a departure from the actual aggressive ideology of economic growth towards a new approach to nature, based on decentralized ‘soft energy paths’ and a deep commitment to ecological reconstruction (Slaughter, 1993a, p. 296). This scenario requires a radical ideological shift with a very significant civilizational change; as such, it is highly unlikely that any government would consciously and deliberately engage in such a scenario unless without significant external pressure. In this case, a *breakdown* scenario will correspond either to the *de-alignment and re-alignment* transition pathway or the *technological substitution* pathway, depending on the availability of a mature technological niche-innovation waiting to be adopted by the regimes actors.

The transformational societies scenario, reviewed in chapter 1, could evolve from two main routes: either from a process that leads humanity to a new stage of development, or through “the benign operation of a new form of technology” (Slaughter, 1993a, p. 296). This scenario is very similar to the *transformation path* transition pathway as defined by Geels and Schot (2007) where a disruptive pressure from the landscape takes place at a moment where a niche-innovation is not yet completely mature. In this case, the regime actors react belatedly to the landscape pressure but will ultimately manage to engage in a reorientation and innovation strategy, leading to changes from within the regimes structure.

Chapter 3

THE LANDSCAPE LEVEL: CLIMATE CHANGE AND THE INTERNATIONAL OIL MARKET

As previously defined in previous chapter 3, the macro-level, or the socio-technical landscape level, is represented by the external environment which characterized by its stability, as changes are very slow and can take decades in certain circumstances, in addition to its capacity to influence the dynamics at the niche and regime levels (Solomon & Krishna, 2011, p. 7427). Grounded on the above definition and a desk research focused on the GCC energy system, the following relevant factors have been identified as belonging to the socio-technical landscape of the GCC energy system.

First of all, in the category of factors that do not change or that change very slowly, climate change has been identified as the main potential impact on the future course of the GCC energy system and even on the whole structure of the regimes actors in the advent of an international legally binding climate regime. Climate change has been one of the main factors that have been pushing for the diversification of the energy mix away from the hydrocarbons driven mainly by national or regional (the EU case) considerations and in the absence of international obligations. In this respect, it is necessary to note that the energy diversification efforts have been originally and essentially undertaken by energy importing countries and not by oil and gas producing and exporting countries. In fact, the oil and gas producing countries perceive the energy diversification efforts away from the fossil fuels as a threat to their interests and to their main source of revenue. To date, there are no global legally binding GHG emissions obligations, but this situation could change if the threat of climate change to the global political and economic order leads to a paradigm shift in the global energy system. In this respect, and for the purpose of this research project, it will be necessary to evaluate the possibility of such developments in order to see how it could affect the energy diversification efforts and strategies of the GCC countries between now and 2050.

Given the centrality of oil revenues to the GCC economies, and as a result, to their political stability, the price of oil in the international markets has been identified as a variable that can also have a significant impact on the socio-technical regimes level, with the potential to exercise a rapid external shock on the regimes level of the GCC countries due to the fluctuating nature of energy markets.

The following sections will analyze the past and present of each of these factors before projecting their possible future developments, or 'knowledge surrogates,' as defined by Coddington (1975) and based on 'what if statements', as discussed in chapter 1.

3.1. THE CLIMATE CHANGE FACTOR: A GAME CHANGER?

Climate change issue has gradually emerged as a central issue on the international relations agenda, moving from a subject of interest limited to scientists and environmental circles, to an issue debated in international arenas as well as in domestic political debates about policy choices. This section will first discuss the science that is behind the climate change factor and giving it its '*raison d'être'*, before focusing on the development of the international climate change negotiations and their possible outcomes within the time framework of this research project, i.e., between now and 2050.

3.1.1. What the Science Has to Say About it

Since the seventies, a very large body of scientific studies dealing with the climate change issue has been produced by various academic governmental international and private institutions. On this subject, the most prominent international institution is the Intergovernmental Panel on Climate Change (IPCC), which summarizes the findings of the scientific community's current knowledge of climate science and is considered "the standard reference for all concerned with climate change in academia, government and industry worldwide" (Intergovernmental Panel on Climate Change [IPCC], 2007a, p. i). In this respect, it is necessary to mention that "the IPCC does not conduct new research . . . its mandate is to make policy-relevant—as opposed to policy-perspective—assessments of the existing worldwide literature on the scientific, technical and socio-economic aspects of climate change" (IPCC, 2007a, p. v), which makes it very relevant to our research. Due to the central role played by the IPCC in the scientific as well as political debates related to climate change, we will briefly review its history and role in the next paragraph.

The IPCC is an intergovernmental scientific body established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) with the objective of providing an authoritative international statement of scientific understanding of climate change (IPCC, 2011, p. viii). The scientific reports published by the IPCC are in support of the United Nations Framework Convention on Climate Change (UNFCCC) work, and since its establishment, the IPCC has produced five comprehensive Assessment Reports in addition to a number of Special Reports on specific subjects. The *First Assessment Report* (AR1) was published in 1990, in addition to a *Supplementary Report* in 1992; the *Second Assessment Report* (AR2) was published in 1995; the *Third Assessment Report* (AR3) in 2001; the *Fourth Assessment Report* (AR4) in 2007; and the *Fifth Assessment Report* (AR5) in 2013. The 2007 report considers all published, peer-reviewed "relevant scientific literature available to the authors in mid-2006" (IPCC, 2007a, p. vii).

According to the IPCC's *Special Report on Renewable Energy Sources and Climate Change Mitigation* (2011):

> Climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that article 1 of the

UNFCC defines 'climate change' as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The UNFCC thus makes a distinction between 'climate change' attributable to human activities altering atmospheric composition, and 'climate variability' attributable to natural causes. (IPCC, 2011, p. 956)

In other words, climate change is defined as a significant statistically verifiable change in either the variability of the climate or its mean state, which traces its origins in the significant greenhouse gases released in the atmosphere during the past 150 years. Since the pre-industrial period, CO_2 emissions from fossil fuel use[11] have been considered the largest known source responsible for the increased concentrations of carbon dioxide (CO_2) in the atmosphere. Indeed, according to the IPCC Fourth Assessment Report (AR4), since 1750, "it is estimated that 2/3rds of anthropogenic CO_2 emissions have come from fossil fuel burning" (IPCC, 2007a, p. 25). Indeed, this report concluded that "Most of the observed increase in global average temperature since the mid-20th century is very likely [12] due to the observed increase in anthropogenic greenhouse gas concentrations" (p.10). In this respect, the choice has been made to consider only the emissions of carbon dioxide, as they are directly relevant to the combustion of fossil fuels, whereas other greenhouse gas emissions have a comparatively lower impact on the atmosphere and are not relevant to the burning of oil and gas. Human activities are responsible for the emission of four main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the halocarbons (a group of gases containing fluorine, chlorine and bromine) (IPCC, 2007a, p. 135), with each one of them having a different Radiative Forcing Effect[13] on the

[11] In IPCC usage, "fossil carbon dioxide emissions include those from the production, distribution and consumption of fossil fuels and as a by-product from cement production (2011, p. 2).

[12] According to the formal uncertainty language used in the AR4, the term 'very likely' refers to a >90% assessed probability of occurrence (IPCC, 2011, p. 7).

[13] In IPCC usage, it refers to:

atmosphere, as detailed in Figure 3 below. It has been scientifically established that carbon dioxide is the main anthropogenic[14] greenhouse gas[15] (GHG) and has seen its concentration in the atmosphere increase from a pre-industrial value of about 280 ppm[16] to 379 ppm in 2005 (IPCC, 2007a, p. 2). In addition, the annual growth of carbon dioxide concentration was higher during the last ten years (1995–2005 average: 1.9 ppm per year), than it has been since direct atmospheric measurements began in the 1950s (1960–2005 average: 1.4 ppm per year) (IPCC, 2007a, p. 2).

> The influence of a factor that can cause climate change, such as greenhouse gas, [and] is often evaluated in terms of its radiative forcing. Radiative forcing is a measure of how the energy balance of the Earth-atmosphere system is influenced when factors that affect climate are altered. The word radiative arises because these factors change the balance between incoming solar radiation and outgoing infrared radiation within the Earth's atmosphere. This radiative balance controls the Earth's surface temperature. The term forcing is used to indicate Earth's radiative balance is being pushed away from its normal state.
>
> Radiative forcing is usually quantified as the 'rate of energy change per unit area of the globe as measured at the top of the atmosphere', and is expressed in units of 'Watts per square meter' . . . When radiative forcing from a factor or group of factors is evaluated as positive, the energy of the Earth-atmosphere system will ultimately increase, leading to a warming of the system. In contrast, for a negative radiative forcing, the energy will ultimately decrease, leading to a cooling of the system. Important challenges to for climate scientists are to identify all the factors that affect climate and the mechanisms by which they exert a forcing, to quantify the radiative forcing of each factor and to evaluate the total radiative forcing from the group of factors. (IPCC, 2007a, p. 136)

[14] In IPCC usage, it refers to CO_2 "resulting from or produced by human beings" (IPCC, 2007a, p. 941).

[15] In IPCC usage, "greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds" (IPCC, 2007a, p. 947).

[16] In IPCC usage, "ppm (parts per million) or ppb (parts per billion, 1billion = 1000 million) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. For example, 300 ppm means 300 molecules of a greenhouse gas per million of molecules of dry air" (IPCC, 2007a, p. 2).

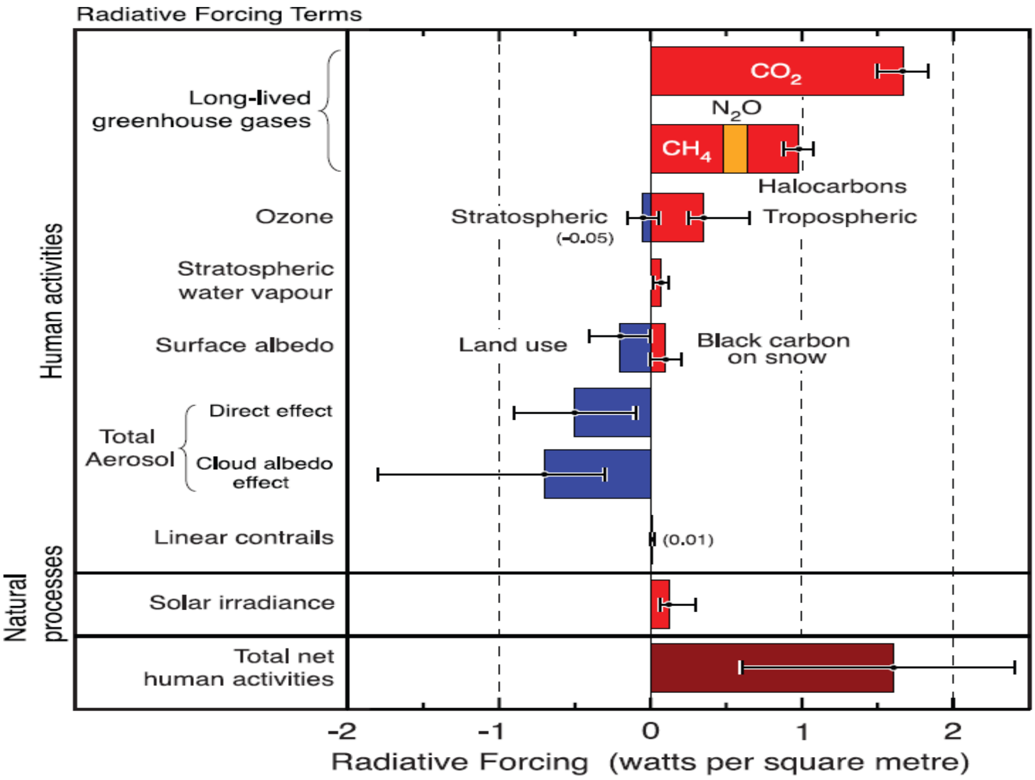


Figure 3: Radiative forcing of climate between 1750 and 2005[17]. Adapted from *Climate Change 2007: The Physical Science Basis,* by IPCC, 2007a, p. 136.

It is clear from the figure above that, among the greenhouse gases, carbon dioxide has caused the largest forcing on the climate from 1750 to 2005.

In fact, carbon dioxide emissions from the power generation sector alone account for 41% of global energy-related CO_2 emissions, as the electricity production sector is highly energy intensive and has reached 4839 Mtoe in 2010, which represented two thirds more than the building sector and double the transportation sector for the same year (International Energy Agency [IEA], 2012,

[17] Per IPCC:

> Summary of the principal components of the radiative forcing of climate change. All these radiative forcings result from one or more factors that affect climate change and are associated with human activities or natural process . . . .The values represent the forcings in 2005 relative to the start of the industrial era (about 1750). Human activities cause significant changes in long-lived gases, ozone, water vapor, surface albedo, aerosols and contrails. The only increase in natural forcing of any significance between 1750 and 2005 occurred in solar irradiance. Positive forcings lead to warming of climate and negative forcings lead to a cooling. The thin black line attached to each colored bar represents the range of uncertainty for the respective value. (IPCC, 2007a, p. 136)

p. 351). In the Current Policies Scenario (a 'business as usual' scenario), CO_2 emissions from the power generation sector are expected to remain at the same level in the future[18], as the share of fossil fuels (coal, oil and gas) in the power generation sector is expected to remain the dominant source of energy at 66% for the coming decades until 2035 (IEA, 2011, p. 188).

Given the fact that the levels of GHG and CO_2 are expected to continue rising, it will be necessary for the sake of this study to review the climate projections for the period between now and 2050, in order to determine the quality and magnitude of the pressure that could originate from the climate change issue at the landscape level and on the socio-technical regimes level. Answering this question will allow us to determine which transition pathway could originate from climate change pressure. Accordingly, the following sections will deal with the climate projections in the short-term as well as in the long-term.

3.1.1.1. Near-term climate change expectations[19]

Existing scientific knowledge does not allow for accurate predictions about future global or regional climates as "the innate behaviour of the climate system imposes limits on the ability to predict its evolution" (IPCC, 2013, p. 962). As a consequence, predictability studies have limitations intimately linked to the state of scientific knowledge and on the quality and number of variables used for representing the climate system. In the absence of major environmental accidents, such as volcanic eruptions or secular changes in total solar irradiance before 2035,

[18]According to the International Energy Agency (IEA) definition, "The Current Policies Scenario embodies the effects of only those government policies and measures that had been enacted or adopted by mid-2012. Without implying that total inaction is probable, it does not take into account any possible, potential or even likely future policy actions" (IEA, 2012, p. 34).

[19] According to the IPCC *Fifth Assessment Report* (AR5): "Unless otherwise stated, 'near-term' change and the projected changes . . . are for the period 2016-2035 relative to the reference period 1985-2005" (2013, p. 955).

it is likely[20] that the Global Mean Surface Temperature (GMST)[21] anomaly[22] for the period 2016-2035, relative to the reference period of 1986-2005, will be in the range 0.3°C to 0.7°C (*medium confidence*)" (IPCC, 2013, p. 955). However, when compared to the mean of the period 1850-1900, it is *more likely than not* that the increase in the global mean surface air temperature will be more than 1°C (*medium confidence*) (IPCC, 2013, p. 955). As a consequence, we can assume that the climate change issue, at the landscape level, will continue to exercise a moderate but mounting pressure on governments globally, including the GCC governments in the short-term. However, can we exclude a climate accident, or an *abrupt climate change*[23] taking place during this period?

The factors that could lead to an *abrupt climate change* are the strength of the Atlantic Meridional Overturning Circulation (AMOC)[24], an increase in CO_2 and/or methane (CH_4) concentrations in the atmosphere as a result of permafrost thawing, and changes in the cryosphere, which is defined as a loss of sea ice (IPCC, 2013, pp. 70-71). However, "in general there is *low confidence*[25] and little

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[20] According to the IPCC (2013), the term *likely* refers to a probability of 66-100% (p. 142).

[21] According to the IPCC (2013), Global Mean Surface Temperature (GMST) is defined as: "An estimate of the global mean surface air temperature" (p. 1455).

[22] According to the IPCC (2013), an anomaly is defined "as [a] departure from a climatology" (p. 1455). The term *climatology* is to be understood as "an estimate of mean climate" (IPCC, 2013, p. 967).

[23] According to the IPCC AR5, *abrupt climate change* is defined "as a large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades and causes substantial disruptions in human and natural systems" (2013, p. 70).

[24] Meridional Overturning Circulation (MOC) is defined as:

> Meridional (north-south) overturning circulation in the ocean quantified by zonal (east-west) sums of mass transports in depth or density layers. In the North Atlantic, away from the subpolar regions, the MOC (which is in principle an observable quantity) is often identified with the *thermohaline circulation* (THC), which is a conceptual and incomplete interpretation. (IPCC, 2013, pp. 1457-1458)

[25] According to the IPCC (2013), "Confidence in the validity of a finding, [is] based on the type, amount, quality, and consistency of evidence (e.g., data, mechanistic understanding, theory, models, expert judgment) and the degree of

consensus on the likelihood of such events over the 21st century (IPCC, 2013, p. 70). Consequently, we can assume that during the time frame of this research project—i.e., between now and 2050—there will be no *disruptive change* originating from the climate change factor at the landscape level which could lead to a *technological substitution transition pathway* as defined by Geels and Schot (2007) according to their proposed typology of transition pathways, as discussed in chapter 2.

3.1.1.2. Long-term climate change expectations[26]

Beginning from the mid-21st century, the projections regarding the evolution of the global mean temperature start to be more dependent on the scenario methodology as a result of the long-term framework of analysis and the uncertainty about the climate mitigation policies that will be implemented by governments globally. In this respect, it is projected that the "global mean temperature will continue to rise over the 21st century under all the RCPs"[27] (IPCC, 2013, p. 90). Indeed, for the period between 2046-2065, relative to the 1986-2005 period, the mean temperature increase will *likely*[28] range between a minimum of 1°C to a maximum of 2°C; while during the period between 2081-2100, relative to the 1986-2005 period, the mean temperature increase will *likely* range between a minimum of 0.3°C to 3.7°C (IPCC, 2013, p. 90).

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agreement. Confidence is expressed qualitatively" (p. 139). For further details regarding the treatment of uncertainty in the IPCC AR5, please read pages 139 to 142.

[26] According to the IPCC AR5, long-term projections concern the period from the end of the 21st century and beyond where "changes are expressed with respect to a baseline period of 1985-2005, unless otherwise stated" (2013, p. 1031).

[27] RCP stands for *Representative Concentration Pathway*, defined as "scenarios that include time series of emissions and concentrations of the full suite of *greenhouse gases and aerosols* and chemically active gases, as well as *land use*/land cover" (Moss et al., 2008, as cited in IPCC, 2013, p. 1461).

[28] According to the IPCC AR5 (2013), the term *likely* refers to a probability of 66-100% (p. 142).

The increase of the global mean sea level (GMSL)[29] will have a significant impact on human societies and especially on the human presence and activities on shores where the majority of the global population and economic activity is located. The 21st century, especially its second half, will witness an increase in the GMSL as relative to the 1986-2005 period, that will *likely* range between 0.24 to 0.30 meters during the period 2046-2065; while it is projected that it will *likely* increase between 0.40 to 0.63 during the period 2081-2100.

The increase of the global mean sea level has *likely* lead to an increase of the magnitude of extreme high sea level events since 1970, as it was very obvious in the case of hurricane Katrina in 2005, where flooding of the city of New Orleans caused the death of at least 1833 persons (Knabb, Rhome, & Brown, 2005, p. 11), in addition to an estimated total damage cost of US$ 108 billion (Knabb et al., 2005, p. 13). As far as the future is concerned, "it is *very likely*[30] that there will be a significant increase in the occurrence of sea level extremes and similarly to past observations, this increase will primarily be the result of an increase in mean sea level" (IPCC, 2013, p. 112).

The increase in the global mean sea level is already being felt, and measures have been taken by advanced economies in a number of projects—including in the UK with the Thames barrier; in the Netherlands with human-made dikes, dams, and floodgates that protect the coast and inland from the sea; in Italy with the Mose project to protect the city of Venice from the rising sea level; and in the U.S. with the Great Wall of Louisiana to protect the coast of Louisiana from the rising sea level and from extreme storm surge. However, poor and developing countries, like Bangladesh and the Small Island States,[31] are already

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[29] According to the IPCC (2013), "Sea level can change, both globally and locally due to (1) changes in the shape of the ocean basins, (2) a change in ocean volume as a result of a change in the mass of water in the ocean, and (3) changes in ocean volume as a result of changes in water density" (p. 1462).

[30] According to the IPCC AR5 (2013), the term *very likely* refers to a probability of 90-100% (p. 142).

[31] Organized within the Alliance of Small Island States (AOSIS), these are composed of "a coalition of small islands and low-lying coastal countries that share similar development challenges and concerns about the environment,

feeling the impact of sea level rise and will be most affected by this phenomenon, as they lack the scientific and financial capacities to mitigate the already existing and future expected sea level rise.[32]

As a consequence, we can assume that the pressure from the climate change issue at the landscape level, during the time frame of this study between now and 2050, will increase over time, potentially leading to a transformation transition pathway as described by Geels and Schot (2007). This pressure on global governments, including the GCC, can yet be described as moderate, as no legally binding international GHG reduction targets currently exist. The reasons for this will be discussed in the following section.

3.1.2. Climate Change: A Central issue in the Global Agenda

The choice of climate change as one of the main factors of the macro-level stems from its position as a global problem—with potential negative impact on worldwide economy, society, and security—requiring a global solution, and as such, climate change is a central issue in the international agenda. While global mitigation efforts remain slow, they are increasing worldwide and are expected to gain in speed as scientific evidence regarding anthropogenic responsibility in global warming accumulates. As a consequence, in recent years, climate change

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especially their vulnerability to the adverse effects of global climate change. It functions primarily as an ad hoc lobby and negotiating voice for small island developing States (SIDS) within the United Nations system" (AOSIS, 2014, para. 1).

[32] In this respect, it is necessary to mention the following clarification regarding sea level rise as per the IPCC *Fourth Assessment Report of Working Group II* (AR4):

> Many coastal regions are already experiencing the effects of relative (local) sea-level rise, from a combination of climate-induced seal level rise, geological and anthropological-induced land subsidence, and other local factors. A major challenge, however, is to separate the different meteorological, oceanographic, geophysical and anthropogenic processes affecting the shoreline in order to identify and isolate the contribution of global warming. An unambiguous attribution of current sea-level rise as a primary driver of shoreline change is difficult to determine at present. (IPCC, 2007b, p. 92)

has been integrated into the national security agenda of a number of countries that consider it a source of potential future instability and a security threat.

In the United Kingdom's 2008 National Security Strategy, climate change is described as "potentially the greatest challenge to global stability and security, and therefore to national security" (Cabinet Office, 2008, p. 18). This challenge is described in the following terms:

> Rising sea levels and disappearing ice will alter borders and open up new sea lanes, increasing the risk of territorial disputes. An increase in the frequency and intensity of extreme weather events—floods, droughts, storms—will generate more frequent and intense humanitarian crises, adding further stresses on local, national and international structures. Rising temperatures together with extreme weather will increase pressures on water supplies." (Cabinet Office, 2008, p. 18)

In France, the 2008 National Security White Paper clearly recognized climate change and its potential impacts as a source of national and international security threats (Blanc, 2008, pp. 25-26).

In the U.S., the Center for Naval Analysis (CNA) Military Advisory Board, a federally funded research center for the United States Navy and Marine Corps, issued a report in 2007 under the title *National Security and the Threat of Climate Change*. In this report, former U.S. Chief of Staff Gordon Sullivan, drawing from his military experience, urges for immediate climate mitigation policies before it is too late, even without total certainty regarding the evaluation of climate change risk:

> We never have a 100 percent certainty. We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield. That's something we know. You have to act with incomplete information. You have to act based on the trend line. (Center for Naval Analysis, 2007, p. 10)

Moreover, since 2010, all Quadrennial Defense Reviews published by the U.S. Department of Defense have mentioned the potential security risk of climate change and the necessity of understanding its implications on military operations and installations, especially coastal, which could be threatened by the rising sea levels. The 2014 *Quadrennial Defense Review* describes the security challenges posed by climate change in detail:

> Climate change poses another significant challenge for the United States and the world at large. As greenhouse gas emissions increase, sea levels are rising, average global temperatures are increasing, and severe weather patterns are accelerating. These changes coupled, with other global dynamics, including growing, urbanizing, more affluent population, and substantial economic growth in India, China, Brazil and other nations, will devastate homes, land and infrastructure. Climate change may exacerbate water scarcity and lead to sharp increases in food costs. The pressures caused by climate change will influence resource competition while placing additional burdens on economies, societies and governance institutions around the world. These effects are threat multiplier that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions – conditions that can enable terrorist activity and other forms of violence. (U.S. Department of Defense, 2014, p. 8)

In the 2010 *National Security Strategy* of the U.S. White House, climate change is clearly defined as a danger to national and international security requiring action from the United States and the international community at large:

> The danger from climate change is real, urgent, and severe. The change wrought by a warming planet will lead to new conflicts over refugees and resources; new suffering from drought and famine; catastrophic natural disasters; and the degradation of land across the globe. The United States will therefore confront based upon clear guidance from the science, and in cooperation with all nations – for there is no effective solution to climate change that does not depend upon all nations taking responsibility for their own actions and for the planet we will leave behind. (White House, 2010, p. 47)

Climate change is now an integral part of the agenda of regional and international organizations. The European Union Commission published a *Climate Action* document that describes the actions the EU countries should take in order to reduce the GHG emissions and gradually transition to a low carbon economy. In this document, the EU urges the member countries to act quickly in order to adapt to climate change as "the cost of not adapting to climate change is estimated to reach at least €100 billion a year by 2020 for the European Union as a whole" (European Commission, 2013, p. 4).

In Asia, the Association of Southeast Asian Nations (ASEAN), very clearly identified climate change among other major "non-traditional security threats, such as terrorism, natural disasters, drug trafficking . . . and infectious diseases [that] are increasing in complexity and require enhanced cooperation among themselves as well as with ASEAN's external partners" (2013, p. 4).

In November 2009, the North Atlantic Treaty Organization (NATO) published a special report titled *Climate Change and Global Security*, summarizing the debate within the NATO Parliamentary Assembly (NATO Parliament Assembly, 2009). Climate change has already been an integral element of all NATO's strategic concepts since at least 2010 (NATO, 2010, p. 13). In addition, in its *Chicago Summit Declaration* in May 2012, climate change was considered as a concern among other "environmental risks . . . that have the potential to significantly affect NATO planning and operations" (NATO, 2012, para. 53).

The climate change issue is intimately linked to the sustainable development debate and requires the mobilization of the international community. According to the Secretary General of the United Nations (UN), climate change is "the defining issue of our time" (United Nations, 2011, para. 36) and a main component of his Five-Year Action Agenda (United Nations, 2012). During the last World Economic Forum at Davos in January 2014, the UN Secretary-General urged world leaders to intensify climate action ahead of the Climate Summit in New York in September 2014—convened to mobilize the international community toward reaching a global legal climate agreement by 2015, when the

UN Framework Convention on Climate Change will meet in Paris for COP21 (United Nations, 2014, para. 1-3).

In a resolution adopted during its 64th session in December 2009, the UN General Assembly recognized "that climate change poses serious risks and challenges to all countries, particularly developing countries . . . and calls upon states to take urgent global action to address climate change in accordance with the principles identified in the Convention" (United Nations General Assembly, 2009, p. 4).

A statement of the UN Security Council in July 2011 recognized "that the possible adverse effects of climate change could, in the long run, aggravate certain existing threats to international peace and security" (United Nations Security Council, Department of Public Information, 2011, para. 1). Moreover, during the last World Economic Forum at Davos in January 2014, action on the climate change front was a major focus of the meeting (United Nations, 2014).

In addition, and parallel to the international climate negotiation process under the umbrella of the UN, other international and regional initiatives have also been launched recently. Major initiatives in that respect include the European Union's Emissions Trading Scheme (EU-ETS), which is the world's first and largest GHG cap and trade program. In addition, the EU has also launched a complementary measure represented by the "20-20-20" directive which requires reducing the overall EU's GHG emissions by 20% and reaching a level of 20% of renewable energy consumption in the EU by 2020. During the Major Economies Meeting on Energy Security and Climate Change, launched by the United States in September 2007, the largest GHG emitters met to discuss a global response to climate change.[33] In July 2005, the meeting of the Group of Eight (G8) nations, also known as the Gleneagles Leaders Summit, launched the Gleneagles Dialogue on Climate Change and discussed issues of finance and technology for dealing with climate change. In September 2007, the Asia Pacific Economic Cooperation

[33] The participants of the meeting included the United States, Australia, Brazil, Canada, the European Union, France, Germany, Indonesia, India, Italy, Japan, Mexico, Russia, South Africa, South Korea, the United Kingdom, and the United Nations.

(APEC) Leaders Meeting in Sydney, Australia, agreed on an action plan that would reduce the energy intensity of their economies by at least 25% by 2030 (with 2005 as the base year) and increase the forest cover of their region by at least 20 million hectares by 2020 (Asia-Pacific Economic Cooperation, 2007, p. 3).

Many international organizations are also involved in climate change mitigation and/or adaptation efforts, among them UN agencies such as the World Bank Group (WBG), the International Monetary Fund (IMF), the Organization for Economic Cooperation and Development, and other institutions including regional banks and the International Energy Agency (IEA).

3.1.2.1. The evolving international framework for addressing climate change

From a historical perspective, the international climate change negotiations can be divided into five major phases summarized in the following three periods: the first period, during which the climate change issue first emerged as a global issue, began with the First World Climate Conference in Geneva, Switzerland, in February 1979—an essentially scientific conference sponsored by the World Meteorological Organization (WMO). This period witnessed the organization of the 1988 Toronto conference, which placed the climate change agenda in the global policy agenda and saw the creation of the IPCC.

The second period, spanning between 1991 and 2001, saw the establishment of the treaties and legal instruments of the climate change agenda. The main achievements of this period are the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, the Kyoto Protocol in 1997, and the Marrakesh Accords in 2001.

Finally, the current period beginning from 2002 until the present time has seen competition between the emerging group of BRICS[34] on one side, and the rich industrialized nations on the other. In addition to the competition, both groups

[34] BRICS refers to Brazil, Russia, India, China and South Africa.

have acted as two leaders of the international climate negotiations, but a leadership that has failed to reach an agreement on a post-2012 treaty as a result of their conflicting interpretations of the principle of “common but differentiated responsibility” regarding climate change.

The following sections will analyze the historical development of the international climate negotiations, the international organizations involved in the negotiation process, the outcomes of these negotiations up to the present time, and their outlook within the future up to 2050 (the time frame of this thesis). The interest in the past, present, and future of the international climate negotiations logically derives from the requirements of a futures study. Indeed, this approach is necessary to determine the future potential pressures—originating from climate change—on the landscape level and on the socio-technical regimes level, and whether these pressures may trigger an energy transition in the power generation sector of the GCC countries.

The section below will describe the UNFCCC with a focus on key steps of their process, before moving on to the Kyoto Protocol and the key steps of climate negotiations and their future outlook.

3.1.2.1.1. The United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992, entered into force on the 21st of March 1994, and has been ratified by 195 governments to date. The UNFCCC is a ‘Rio Convention’[35] adopted at the ‘Rio Earth Summit’ in 1992, which provides the framework within which the international collaborative efforts take place in order to mitigate and adapt to climate change (United Nations Framework Convention on Climate Change [UNFCCC], 2014a). The main objective of these efforts is to

[35] The sister ‘Rio Conventions’ of the UNFCCC are the UN Convention on Biological Diversity and the Convention to Combat Desertification (UNFCCC, 2014b, para. 2).

achieve a global goal of “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system[36]” (UNFCCC, 1992, Article 2, p. 9).

All the parties to the Convention have a commitment to report their mitigating efforts and policies in addition to their commitment to “formulate, implement, publish and regularly update national, and where appropriate, regional programs containing measures to mitigate climate change by addressing anthropogenic emissions” (UNFCCC, 1992, Article 4.1(b), p. 10).

According to the Convention, the allocation of the mitigation efforts is divided among Annex 1 and Annex II countries based on their commitments. Annex I countries include the industrialised members of the OECD (Organization for Economic Development and Cooperation) in 1992, as well as the economies in transition, and are required to extend more efforts on the “basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities” and “developed country parties should take the lead in combatting climate change and the adverse effects thereof” (United Nations Framework Convention on Climate Change, 1992, Article 3.1, p. 9). Moreover, Annex I countries, in addition to other developed countries included in Annex II, also have the responsibility of providing for “new and additional financial resources to meet the agreed full costs incurred by developing country parties in complying with their obligations under Article 12, paragraph 1 . . . including for the transfer of technology needed by developing countries” (United Nations Framework Convention on Climate Change, 1992, Article 3.1, pp. 13-14).

The international climate change negotiations are organized under the umbrella of the UNFCCC through the periodic United Nations Climate Change Conference or the Conference of the Parties (COP). The first Conference of the Parties (COP1) took place in Berlin from March 28 – April 7, 1995. The meetings of the COPs serve as a framework for assessing the progress made in dealing with climate change, in addition to negotiating an internationally binding agreement

[36] The climate system is defined in the UNFCCC convention as “the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions” (United Nations Framework Convention on Climate Change, 1992, Article 1, p. 7).

that would place limits on GHG emissions. Until now, the main achievement of the COPs meetings is the Kyoto Protocol, to be discussed in detail below. Nineteen COPs have taken place to date, with COP20 planned for December 2014 in Peru, and COP21 planned for December 2015 in Paris.

The following sections will review the main instruments and landmark steps of the international climate negotiations under the umbrella of the UNFCCC before discussing the future outlook of the international climate change negotiations.

3.1.2.1.2. The Kyoto Protocol

The Kyoto Protocol is an international agreement adopted in Kyoto, Japan, on the 11th of December 1997, at the third session of the Conference of the Parties (COP3) to the 1992 UNFCC. It entered into force on the 16th of February 2005 and includes 192 Parties[37] to the Protocol, "which commits its Parties by setting international binding emission reduction targets" (UNFCC, 2014c, para. 1). The rules regarding the implementation of the Protocol were adopted during COP7 in Marrakesh in 2001 and are referred to as the "Marrakesh Accords," (UNFCCC Conference of the Parties, 2002, FCCC/CP/2001/13/Add) with the first commitment period starting in 2008 and ending in 2012. In December 2012, the Kyoto Protocol was extended until the upcoming meeting in Paris in December 2015, and the "Doha Amendment to the Protocol" (Kyoto Protocol, C.N.718.2012) was adopted.[38] During the Durban Climate Change Conference in December 2011,

[37] The Parties include 191 countries in addition to the EU. As far as the countries are concerned, they include almost all UN members with the exception of Andorra, Canada, South Sudan and the United States. The United States signed the treaty but did not ratify it.

[38] The Doha Amendments included:

> New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to December 2020; A revised list of greenhouse gases (GHG) to be reported on by Parties in the second commitment period; and, Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which

Canada officially notified the Secretary General of the United Nations of its decision to withdraw from the Kyoto Protocol, a decision that became effective on the 15th of December 2012. (Kyoto Protocol, C.N.796.2011)[39]

According to Article 3 of the Protocol, quantified emission reduction targets are imposed on Annex I Parties in order to reduce the overall GHG emissions "by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012" (Kyoto Protocol, 1998, Article 3, p. 3.1). In order to give some flexibility to help countries reach their emission reductions targets, three market based mechanisms were introduced: International Emissions Permit Trading,[40] the Clean Development Mechanism,[41] and Joint Implementation.[42] In order to be able

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> needed to be updated for the second commitment period. (UNFCCC, 2014c, para. 5-7)

[39] Please read the withdrawal notification: https://unfccc.int/files/kyoto_protocol/background/application/pdf/canada.pdf.pdf

[40] According to Article 17, the Kyoto Protocol "allows countries that have spare units to spare—emissions permitted to them but not used—to sell this excess capacity to countries that are over their limits" (UNFCCC, 2014d, para. 2).

[41] The Clean Development Mechanism:

> Allows emission-reduction projects in developing countries [Parties not included in Annex I] to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO_2. These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction limitation targets. The CDM is the main source of income for the UNFCC Adaptation Fund, which was established to finance adaptation programmes in developing country Parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change. The Adaptation Fund is financed by a 2% levy on CERs issues by the CDM. (UNFCCC, 2014e, para. 1-3).
> For more details, please read Article 12 of the Kyoto Protocol, page 11.

[42] According to Article 6, the Kyoto Protocol:

> Allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex B Party, each equivalent of one tonne of CO_2, which can be counted towards meeting its Kyoto target. Joint Implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their

to account and follow the emission targets of the Parties, the Kyoto Protocol has established a Compliance Committee[43] in addition to specific rules concerning the accounting and reporting of emissions.

3.1.2.1.3. The Bali Road Map

In December 2007, the "Bali Action Plan" was adopted at the13th Conference of the Parties (COP13), and the Third Meeting of the Parties. The adopted document launched the negotiation process regarding the succession to the first Kyoto commitment period post-2012 that was supposed to be signed at the 15th Conference of the Parties in Copenhagen in December 2009. The "Bali Action Plan" consisted of "a set of forward looking decisions that represent the work that needs to be done under various negotiation 'tracks' that is essential for reaching a secure climate future" (UNFCCC, 2014g, para. 1). In addition to agreeing on a second commitment period post 2012, the Protocol track is also meant to achieve an agreement on quantified reduction targets for UNFCCC Annex I Parties. In the history of climate change negotiations, the Bali meeting represents a major landmark, as it is at this meeting that the U.S. "has moved from a position of climate denial a few years ago to participation in an international dialogue on tackling climate change" (Ott, Sterk, & Watanabe, 2008, p. 93).

3.1.2.1.4. COP15, the Copenhagen set back

Initially, the objective of the COP15 meeting at Copenhagen in December 2009 was to sign a new treaty in order to replace the Kyoto Protocol by a new climate treaty for a second period of commitment post-2012. However, as a result of divergent views between developed and industrialized countries regarding the

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commitments, while the host Party benefits from foreign investment and technology transfer. (UNFCCC, 2014f, para. 1-2)

[43] For more information regarding the Compliance Committee please go to: https://unfccc.int/bodies/body/6432.php

principle of "common but differentiated responsibility"[44] (UNFCCC, 1992, Article 3.1, p. 9), which is a key principle of climate change negotiations, COP15 failed to reach its initially declared objective, despite the wave of optimism during the build-up phase of the meeting. The final agreement was reached following last minute intense negotiations between the U.S., Brazil, China, India, and South Africa. Many countries were upset by their exclusion from the negotiations and decided not to support it. This was the case for Kuwait, which objected to the agreement reached at the end of the conference (State of Kuwait, Environment Public Authority, 2010) and as a consequence, the agreement had no legal standing under the UN convention, with the participating countries merely recognizing its existence but without necessarily supporting it.

3.1.2.1.5. Doha COP18: The GCC on the climate regime map

The significance of COP18 lies in the fact that it took place, for the first time, in a country that is an Organization of the Petroleum Exporting Countries (OPEC) member, and more specifically in a GCC country. This is another

[44] According to Rajamani,

> The principle of common but differentiated responsibility brings together several strands of thought. First, it establishes unequivocally the common responsibility of States to protect the global environment. Next, it builds on the acknowledgement by the industrial countries that they bear the primary responsibility for creating climate change by taking into account the historical (rather than future) contributions of States to climate change by determining their responsibility under the regime. In doing so it recognizes broad distinctions between States, whether on the basis of economic development, natural vulnaribility or consumption levels. The principle proceeds to cast emphasis on the ability of States to respond to the environmental crisis at hand and 'accordingly' carves out a leadership role for industrialized countries within the climate regime. (Rajamani, 2000, p. 121)

In other words, according to this principle, it is acknowledged that industrialized nations have a historical responsibility in most of the GHG emissions that are causing climate change, that the emissions from the developing countries are likely to rise in order to meet their developmental needs; and as a consequence, while the goal of limiting the GHG is the same the means and the burden on each side in order to tackle climate change are different.

indicator of the recent interest of the GCC countries in the international climate debate, in an attempt to change their image as countries that are blocking or slowing down advancements in the climate change negotiations. This interest could also be explained by the fact that the GCC countries have made the strategic choice to be active members of the international climate negotiations process in order to influence it and be in a better position to defend their interests. In this respect, it is noteworthy that during COP18, a number of GCC countries took a very important step, as Bahrain, Qatar, Saudi Arabia, and the UAE submitted a note in which they informed the Parties of the conference of their "readiness . . . to put forward their current actions and plans in pursuit of economic diversification that have co-benefits in the form of emissions reductions, adaptation to the impacts of climate change and response measures" (UNFCCC, 2014h, Economic Diversification Initiative section, para. 1). This is, again, another significant development within the framework of the new climate diplomacy most of the GCC countries have adopted in the past few years.

The UNFCCC COP18 meeting at Doha, Qatar, in December 2012, adopted the Doha Amendment to the Protocol (Kyoto Protocol, C.N.718.2012) and confirmed the pledge taken at the COP17 meeting at Durban, South Africa, in December 2011. This pledge officially launched a process to conceive "another legal instrument or an agreed outcome with legal force applicable to all countries" concerning global climate change mitigation policies, which should be completed by 2015 for the post-2020 period (IEA, 2012, p. 242).

3.1.2.1.6. A critical review of the climate negotiations: An international relations perspective

Grounded on the past evolution of international climate negotiations, it is now necessary to question the future course of these negotiations. Are we heading towards more binding international obligations, or are we going to witness a continuation in the existing debate and conflict between developed and developing economies regarding the responsibility of each side in global warming and how to share the burden? The answer to this question will determine whether there will be a mounting international pressure on developed and developing countries, including the GCC, to reduce their GHG emissions and engage in an energy transition by diversifying their energy mix away from the fossil fuels.

The most recent scientific findings “plainly indicate that global emissions must peak as soon as possible and then decline as rapidly as possible to avoid potentially catastrophic impacts on the climate system” (Mace, 2010, p. 231). As rightly said by Ed Miliband in a speech delivered at the London School of Economics in November 2009, “The world requires a comprehensive agreement that is consistent with the science and the need to limit climate change to no more than 2 degrees of warming . . . that means a deal which will ensure that global emissions will peak by 2020 at the latest” (Miliband, 2011, p. 194). There is therefore, an urgent necessity to reach a post-Kyoto global treaty that will include binding measures; however, despite this global necessity, the question remains whether this objective will be achieved and to what extent respected and implemented its Parties. In this respect, it is necessary to recall that the conferences of Copenhagen, Cancun, and Durban have failed to produce a new legally binding treaty despite the repeated pledge to achieve this objective at every meeting of the Conference of the Parties (COP). This present incapacity to move forward undermines the ability of the existing multilateral negotiation framework to achieve the long sought objective of avoiding an increase of the global temperature above 2 degrees in a timely and effective manner.

There are, indeed, serious doubts regarding the possibility of agreeing on a new post-Kyoto Protocol “because it requires the impossible: consensus decision-making by 194 parties on every line of a complex and lengthy treaty” (Eckersley, 2012, p. 24), in addition to the North-South deadlock regarding the implementation of the principle of Common but Differentiated Responsibility. Since the early stages of international climate negotiations, the focus has been on an approach that favors the global deal strategy in order to achieve a comprehensive treaty with binding commitments on mitigation and adaptation funding—a strategy based on five main elements, and:

- It prescribes, in a top-down way, generally applicable policies that are based on commonly understood principles;

- It strives to develop targets and instruments of climate governance (regarding mitigation measures, carbon sinks, adaptation efforts) in a comprehensive manner;
- It is intended to be universal in its application, applying to all countries according to agreed principles of burden-sharing;
- It is universal in its negotiation and decision-making process, being based on the primacy of the UN framework; and
- It seeks to establish legally binding international obligations. (Falkner, Stephan, & Vogler, 2011, p. 204)

The global deal strategy finds its origin in the established model of environmental regime-building since the 1970s, which has dealt with environmental issues "in a compartmentalized way by negotiating issue-specific treaties and building institutions around them" (Susskind 1994, as cited in Falkner, Stephan & Vogler, 2011, p. 204), and has proven to be successful on a growing and significant number of issues reaching over a thousand environmental treaties today (International Environmental Agreements Database Project, 2014). The most prominent example of this successful strategy, and the model for climate diplomacy, is the 1985 Vienna Convention for the Protection of the Ozone Layer, with its attached Montreal Protocol on Substances that Deplete the Ozone Layer adopted in September 1987 (Parson, 2003, as cited in Falkner, Stephan & Vogler, 2011, p. 204).

It is by building on this successful trend that the international climate change negotiations were launched with the establishment of the UNFCCC at the Rio Earth Summit in 1992, despite the fact that "climate change was widely recognized to pose a more complex and costlier challenge than ozone depletion, and early on there was some debate about a universal approach versus regional or sectoral ones" (Nitze 1990, as cited in Falkner, Stephan & Vogler, 2011, p. 205). Despite the absence of binding commitments, as a result of the U.S. opposition, the Convention did establish the norm regarding the issues of global stabilization and the principle of 'common but differentiated responsibility,' paving the way for the establishment of the Kyoto Protocol in 1997. However, comparative to the Montreal Protocol, the Kyoto Protocol was limited in scope, did not extend to developing countries, and the United States failed to ratify the deal, despite the fact that they initially signed it, which has seriously undermined the long term course of the Protocol.

The Kyoto Protocol has been successful in establishing the first climate agreement that included quantitative emission targets, in addition to introducing innovative market based mechanisms for achieving the mitigation objective in a cost-effective manner such as the International Emissions Permit Trading, the Clean Development Mechanism (CDM), and Joint Implementation. However, it also suffered from a number of built-in shortcomings as a consequence of the necessary compromises that had to be done in order for the Protocol to be adopted. These compromises can be summarized in the following points: First, based on the principle of 'common but differentiated responsibility and respective capabilities,' all developing countries were exempted from emission targets obligations, which has greatly contributed toward creating a sharp dividing line between Annex I and non-Annex I countries, and without questioning or putting in place a mechanism that would ultimately include in the future the developing countries—whose emissions are growing—into the global mitigation efforts. Second, as a consequence of the first point, the U.S., the largest GHG emitters at that time, has refused to ratify the Protocol, which has greatly reduced the effectiveness of the mitigation efforts and has discouraged other industrialized countries from taking the economic and political burden without the participation of the U.S. Third, the Kyoto Protocol suffered from design shortcomings that included the "the short-term nature of its emission targets, the ability of countries to withdraw from the agreement and a weak compliance system" (Falkner, Stephan & Vogler, 2011, p. 208). For this reason, the Copenhagen Conference of the Parties (COP15) in December 2009 attempted to deliver a new compromise that would include all the major emitters in Annex I and non-Annex I countries—but without success.

Obviously, there is a very clear lack of political will from the major emitters, which represents a serious obstacle for moving forward with the international climate negotiations. The reasons behind this lack are found in domestic pressures, as well as the in the consequences of the changing global political economy. Indeed, the United States lacks the necessary domestic support for accepting any international climate change commitments, despite agreeing and ratifying the UNFCCC, because of the entailing cost and a fear of negative impacts on the competitiveness of its economy, especially if developing countries such as China, India, or Brazil are exempted from any emission targets commitments—which brings to the discussion the changing global political economy factor. Indeed, since the signature of the Convention in 1992, the world has witnessed a structural shift in the international political economy with the emergence of new economic powers, especially in Asia, that are becoming large GHG emitters as a result of their rapid economic growth. This has brought about a significant change in the map of global emissions, with China becoming the largest CO_2 emitter, ahead of the U.S.,[45] in 2007 (Falkner, Stephan & Vogler, 2011, p. 211). This structural shift is a major argument used by the U.S. and a number of industrialized countries in order to call for the participation of the emerging economies in the global emissions commitments, and one of the main reasons for the successive failures since Copenhagen in achieving a new post-2020 treaty.

Given that the global deal strategy has reached its limitations, it is therefore necessary to question whether alternatives are available to climate change negotiators and in which direction the international climate negotiations will be heading in the future, especially within the time frame of this research project—i.e., between now and 2050. Is the climate change agenda heading towards a new legally binding global post-2020 treaty that will include emissions targets commitments on all the major emitters? Or is it moving towards increased national and regional initiatives—with the risk that this approach, even if proven more effective from a practical perspective, will not reach the long sought objective of less than two degrees increase of the global temperature?

In this respect, it is worth noting that when looking at the developments on the front of national climate mitigation policies and strategies, an argument exists for the national and regional approach. Indeed, based on the findings of a survey

[45] However, it should be noted that the U.S. is still the largest CO_2 emitters per capita.

study covering almost all United Nations countries between 2007 and 2012, three main conclusions have emerged: First, during this time frame, there has been an increase in climate legislation and strategies, as 67% of GHG global emissions are now under national climate legislation or strategy, compared to 45% in 2007; second, most of the increase took place in non-Annex I countries and mainly in Asia and Latin America; and third, there is a significant global trend in the number of countries that are adopting climate mitigation policies, rising from 23% in 2007 to 39% in 2012, which is equivalent to an increase in the percentage of the global population from 36% in 2007 to 73%. The increase in climate mitigation and strategy is significant and expected to continue expanding despite the very slow pace of the international climate change negotiation process. In this respect, an increase in national and regional negotiations and non-binding climate legislation has been observed, as opposed to international climate negotiations and binding legislation (Dubash, Hagemann, Höhne, & Upadhyaya, 2013).

It is in this context that "the George W. Bush administration explicitly set up the Major Economies Meeting in 2007 as an alternative forum for discussing and coordinating climate change issues within a select group of major emitters" (Terhalle & Depledge, 2013, p. 578), which was rebranded in 2009 by President Obama as the Major Economies Forum on Energy and Climate (MEF). Since Copenhagen, the U.S. has repeatedly shown its frustration with the UN-based climate negotiations and its intention to move its focus on other arenas on the model of the MEF (Goldenberg & Vidal, 2010; Nelsen, 2012, as cited in Terhalle & Depledge, 2013, p. 578). On the other side, even if China, similarly to the U.S., has resisted being drawn into a deeper institutionalization of the climate change issue, "it remains, however, a strong supporter of the UN, and notably the climate change regime, as the only legitimate forum for taking international action on the issue" (Terhalle & Depledge, 2013, p. 578).

From a theoretical perspective, it is worth mentioning that the institutionalization tendency is referred to as the theory of 'institutional enmeshment', which is a theoretical framework in international relations aimed to conceptualize a "process of engaging with a state so as to draw it into deep involvement into international and regional society, enveloping it in a web of sustained exchanges and relationships, with the long term goal of integration" (Goh, 2007, as cited in Terhalle & Depledge, 2013, p. 576). From this theoretical framework, both the U.S. and China have constantly insisted that a greater enmeshment from their side will depend on that of the other side as

> the U.S. has consistently claimed, for economic reasons, that it will not sign up to legally binding commitments that do not apply to other 'major emitters' (i.e., China) . . . [and on the other side] China is well versed in the refrain that developed countries (i.e., the US) bear the most responsibility for the cumulative emissions in the atmosphere, and thus must take the lead in addressing the problem before developing countries (i.e., China itself) take on stronger obligations. (Terhalle & Depledge, 2013, pp. 578-579)

There is no doubt that the failure to reach a globally legally binding climate treaty is not only due to the complexity of the issue, but also to a change in the balance of power since the nineties "and of diverging normative world views [between developed and developing countries]" (Terhalle & Depledge, 2013, p. 583). Despite the increase in domestic legislation and measures in the U.S. and China to limit their GHG emissions and the recent wave of optimism (Jacobs, 2014), it is very difficult to imagine how the objective of signing a legally global binding climate regime that would include clear emissions commitments with an efficient enforcement mechanism, could be achieved in the forthcoming COP21 in Paris in December 2015, in the absence of an agreement between the major emitters (especially the U.S. and China) on a new international relations order.

Therefore, it is assumed for the sake of this research that the international climate negotiations will continue evolving slowly before they can eventually achieve a post-Kyoto agreement that would be enforced between 2020 and 2025, in conjunction with an increase in national legislation and measures in order to reduce the GHG emissions, and regional non-binding climate mitigation commitments. As a result, as we have already concluded in this chapter in the section dedicated to climate change science, it is reasonable to assume that the pressure that will originate from the climate change issue at the landscape level, on the regimes level, will be a moderate pressure in the mid-term, and could become much stronger in the long-term (2020 and 2025), leading to a transformation transition pathway as described by Geels and Schot (2007).

3.1.3. The GCC and Climate Change: A Gradual and Sustained Involvement

As we have already seen in the previous sections, climate change is definitely an integral issue of the global agenda, and as such, the GCC countries have been exposed to climate change as an emerging and growing external pressure on their political economy as well as on their energy consumption patterns. Indeed, they are considered among the countries with the highest per capita carbon emissions with Qatar, the UAE, and Kuwait, holding the first three positions in the 2012 WWF/Ecological Footprint report, which is a very good indicator of the severity of the situation in the GCC region, especially when the data shows that carbon emissions represent the bulk of their total per/capita emissions (WWF, 2012, p. 43). This status is a very clear indicator of the unsustainable model of development in the GCC countries, which is related to the central role of oil in their political economy, in addition to geographic and climatic factors that generate very high levels of demand for air conditioning and water from desalination plants.

The following sections will deal first with the potential impacts of climate change on the GCC countries, before moving on to the GCC response to the international climate regime negotiations and the level of their interest in them.

3.1.3.1. Adverse climate change impact on GCC countries

The GCC region will not be immune from the predicted dangerous consequences of climate change on their environment, societies and economies. Indeed, rising sea levels will have an immediate impact on the coast where the majority of the GCC populations and industrial infrastructures are located, including the desalination plants that provide the bulk of water needs of the region. In this respect, Bahrain alone could potentially lose up to 15 kilometers of coastline (Raouf, 2008, p.4). Furthermore, rising sea levels will also increase the salinity of underground water and consequently the water stress in the region. Rising temperatures will also increase the demand on desalinated fresh water and add another pressure on already very scarce water resources, in addition to an increased demand for air conditioning, which in turn will increase their energy consumption and put more pressure on their available and limited oil and gas reserves.

Indeed, according to the findings of a study that has assessed the critical impact elements (land, population, agriculture, urban extent, wetlands and GDP) of a 1 meter sea level rise that is expected to occur by the end of this century on 84 developing countries, including the GCC, Qatar, and the UAE, count among the 10 most impacted on several critical elements, as shown in Table 2 below:

Table 2

Top 10 Most Impacted Countries With a 1-M Sea Level Rise

Rank	Land area	Population	GDP	Urban areas	Agricultural land	Wetlands
1	The Bahamas (11.57)	Vietnam (10.79)	Vietnam (10.21)	Vietnam (10.74)	A.R. Egypt (13.09)	Vietnam (28.67)
2	Vietnam (5.17)	A.R. Egypt (9.28)	Mauritania (9.35)	Guyana (10.02)	Vietnam (7.14)	Jamaica (28.16)
3	Qatar (2.70)	Mauritania (7.95)	A.R. Egypt (6.44)	French Guiana (Fr) (7.76)	Suriname (5.60)	Belize (27.76)
4	Belize (1.90)	Suriname (7.00)	Suriname (6.35)	Mauritania (7.50)	The Bahamas (4.49)	Qatar (21.75)
5	Puerto Rico (1.64)	Guyana (6.30)	Benin (5.64)	A.R. Egypt (5.52)	Argentina (3.19)	The Bahamas (17.75)
6	Cuba (1.59)	French Guiana (Fr) (5.42)	The Bahamas (4.74)	Libya (5.39)	Jamaica (2.82)	Libya (15.83)
7	Taiwan, China (1.59)	Tunisia (4.89)	Guyana (4.64)	United Arab Emirates (4.80)	Mexico (1.60)	Uruguay (15.14)
8	The Gambia (1.33)	United Arab Emirates (4.59)	French Guiana (Fr) (3.02)	Tunisia (4.50)	Myanmar (1.48)	Mexico (14.85)
9	Jamaica (1.27)	The Bahamas (4.56)	Tunisia (2.93)	Suriname (4.20)	Guyana (1.16)	Benin (13.78)
10	Bangladesh (1.12)	Benin (3.93)	Ecuador (2.66)	The Bahamas (3.99)	Taiwan, China (1.05)	Taiwan, China (11.70)

Note: Percentage impact in parenthesis. Adapted from Dasgupta et al., 2009, p. 385.

In the case of a scenario with a 1 meter sea level rise, we can clearly see from Table 2 that regarding the impact on land area, Qatar is in the third position with a potential loss estimated at 2.70% of its land area; regarding the impact on population, the UAE is at the eight position with a potential impact that will affect 4.59% of its population; regarding the impact on urban areas, the UAE is on the seventh position with a potential impact that will affect 4.80% of its urban areas; and finally, regarding the impact on wetlands, Qatar is at the 4th position with a potential impact that will affect 21.76% of its wetlands. Based on the most recent scientific findings, as already explained in the section dedicated to the climate change issue in this chapter, thermal expansion and deglaciation would continue to raise the sea level even if the GHG emissions were stabilized in the near future (Dasgupta et al., 2009, p. 387).

Bahrain is a small island state where most of the unban and economic infrastructure is located on the coast line with very limited capacity to adapt to sea level rise, as most of the coastal areas "do not exceed 5 meters above current main sea level and it will be physically and economically difficult, if not impossible, to establish zoning setbacks for new development or for marine habitats to migrate toward higher land elevation" (Kingdom of Bahrain Public Commission for the Protection of Marine Resources, Environment and Wildlife, 2012, p. 23).

Table 3

Long-term Inundation Scenarios for Bahrain up to 2050[46]

		No accelerated deglaciation				Low deglaciation rate				Extreme deglaciation rate			
		2050 *(SLR=0.3 m)*		2100 *(SLR=1.5 m)*		2050 *(SLR=0.5 m)*		2100 *(SLR=2.0 m)*		2050 *(SLR=1.0 m)*		2100 *(SLR=5.0 m)*	
Land use type	**Total area (km2)**	**Inundation (km2)**	**(%)**	**Inundation (km2)**	**(%)**	**Inundation (km2)**	**(%)**	**Inundation (km2)**	**(%)**	**Inundation (km2)**	**(%)**	**Inundation (km2)**	**(%)**
Built Up	209	10	5%	46	22%	10	5%	64	31%	46	22%	126	60%
Industrial	46	8	17%	29	63%	8	17%	32	69%	29	63%	38	82%
Vacant	79	5	7%	24	30%	5	7%	27	34%	24	30%	38	48%
Agriculture	71	5	7%	15	21%	5	7%	23	32%	15	21%	57	80%
Wetland	2	1	69%	1	77%	1	70%	1	80%	1	74%	2	100%
Barren	304	29	10%	52	17%	29	10%	68	22%	51	17%	122	40%
Heritage	2	0	0%	0	0%	0	0%	0	0%	0	0%	0	1%
Sabkhs	35	26	75%	33	97%	26	76%	34	98%	33	97%	35	100%
Total	**748**	**83**	**11%**	**200**	**27%**	**84**	**11%**	**248**	**33%**	**199**	**27%**	**418**	**56%**

Note: Adapted from *Bahrain's Second National Communication Under the United Nations Framework Convention on Climate Change*, by Kingdom of Bahrain Public Commission for the Protection of Marine Resources, Environment and Wildlife, 2012, p, 25.

As very clearly shown in the table above, Bahrain will be severely impacted by sea level rise in all the scenarios, with the prospect of losing 11% of its total land area by 2050 in case of the no accelerated deglaciation or low

[46] The results in the table are based on the Geographic Information Systems (GIS) mapping analysis. The values represent projected impact of permanent submergence of low-lying lands on the main islands of the Kingdom of Bahrain as associated with the three sea level rise scenarios, disaggregated by land use type. Percentages in the rows corresponding to the eight land use types refer to the share inundated for those land types.

deglaciation scenarios, which considered a sea level rise of only 0.3 metre by 2050. In terms of land use type, this scenario will lead to a loss of 5% of its built up area and 17% of its industrial infrastructure.

In the case of an extreme deglaciation scenario, with a 1 metre sea level rise, Bahrain faces the prospect of losing 27% of its total land up to 2050, which represents 22% of its built up area and 63% of its industrial infrastructure.

It is worth noting that these scenarios conform to the long-term projections of the IPCC AR5, as discussed above in this chapter in the section dealing with the long-term sea rise expectations.

Rising sea levels will also increase the vulnerability of ground water and the aquifers of Bahrain and the GCC countries as a whole (Kingdom of Bahrain Public Commission for the Protection of Marine Resources, Environment and Wildlife, 2012, p. 33).

Temperature projections in Kuwait expect that it will continue to rise from the current annual average of 26.1°C (according to 2010 figures) (State of Kuwait, Environment Public Authority, 2012, p. 28), to an annual average of 28.7°C during the 2010-2035 period (State of Kuwait, Environment Public Authority, 2012, p. 30). During the month of July, the temperatures are expected to rise in most of the Arabian Peninsula and to reach an average above 36°C by 2050 (State of Kuwait, Environment Public Authority, 2012, p. 30). There are no doubts that the rising temperatures will increase electricity consumption and aggravate the water stress in the region.

The coastline of Kuwait spans over 350 km and is where most of the population and critical infrastructure is located (Al-Bakri and Kittaneh, 1998, as cited in State of Kuwait, Environment Public Authority, 2012, p. 31). As a consequence,

> the climate change induced sea level rise could lead to serious adverse impacts on future socioeconomic development . . . [as] [t]here is ample evidence from the international research literature that rising seas will likely flood low-lying urban infrastructure, threaten coastal lagoons and

salt marshes, and contribute to the deterioration of groundwater quality". (State of Kuwait, Environment Public Authority, 2012, p. 31-32)

Indeed, according to sea level rise scenarios ranging from 0.5 and 2 meters, Kuwait would lose between 1.4% and 3% of its total land area, which would impact between 1.8% to 4.8% of the population (State of Kuwait, Environment Public Authority, 2012, p. 37).

Regarding the Sultanate of Oman, according to future projections, temperature is expected to increase by a range between 1°C and 2°C during the period between 2011 and 2040, and by a range of 2°C to 3°C during the period between 2041 and 2070 (Sultanate of Oman, Ministry of Environment & Climate Affairs, 2013, p. 54).

According to the latest findings, the Sultanate of Oman is highly vulnerable to rising sea levels, as it is estimated that "nearly 400 km2 of total land area is projected to be inundated under the smallest sea level rise . . . and over 900 km2 [under the highest sea level rise scenario]" (Sultanate of Oman, Ministry of Environment & Climate Affairs, 2013, p. 57), which will claim between 3% and 4% or rare arable land, but without affecting the urban and industrial areas (Sultanate of Oman, Ministry of Environment & Climate Affairs, 2013, p. 58).

Coming to the case of Saudi Arabia, as a consequence of sea level rise and based on the IPCC scenarios, "biophysical impacts were identified [such] as salt water intrusion, coral reef bleaching, and costal inundation and erosion" (Kingdom of Saudi Arabia Presidency of Meteorology and Environment, 2011, p. 93), which could have adverse effects on water supply and agriculture (Kingdom of Saudi Arabia Presidency of Meteorology and Environment, 2011, p. 102). Concerning temperature trends, results from running a General Climate Model (GCM) have shown that by the year 2041, general warming in Saudi Arabia will be higher than the global average (Darfaoui & Al Assiri, 2010, p. 1).

As a consequence, climate change is now a reality the GCC countries will have to deal with, as there is an urgent necessity for their involvement in the climate regime. Even public opinion regarding climate change has changed; according to a survey conducted in 2008 in 128 countries by the Gallup poll, "49%

of the surveyed individuals in Saudi Arabia were aware of climate change and 40% perceived it as a threat to their country" (Darfaoui & Al Assiri, 2010, p. 2).

3.1.3.2. The GCC and the international climate regime

Since the beginning of the 21st century, GCC countries have started to show more interest in climate change and the international negotiations related to it, as it becomes increasingly clear that they will face an increasing pressure that "would come in two main forms: through changing international energy demand patterns and policies, and through the politics of the international climate regime" (Luomi, 2012, p. 47). As a first indicator of this emerging interest in the international climate regime negotiations, all the GCC countries are now parties to the UNFCCC Convention in their quality of non-Annex I countries[47] in addition to the Kyoto Protocol, which they have all ratified in the past few years as shown in Table 4 below:

[47] According to the UNFCC Convention:

> Non-Annex I parties are mostly developing countries. Certain groups of developing countries are recognized by the convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer. (UNFCCC, 2014i, para. 4)

Table 4

Status of Accession of GCC to UNFCC and Kyoto Protocol

Country	UNFCC	KYOTO PROTOCOL
Bahrain	Ratified in December 1994	Ratified in January 2006
Kuwait	Ratified in December 1994	Ratified in March 2005
Oman	Ratified in February 1995	Ratified in January 2005
Qatar	Ratified in April 1996	Ratified in January 2005
Saudi Arabia	Ratified in December 1994	Ratified in January 2005
United Arab Emirates	Ratified in December 1995	Ratified in January 2005

Note: Adapted from "Status of Ratification of the Convention", by UNFCC, 2014j (treated by the author).

As shown in Table 4 above, all GCC countries have ratified the UFCC Convention and the Kyoto Protocol as well as established a Designated National Authority (DNA) (UNFCCC, 2014k) the organization that is granted the authority by a country party to the Kyoto Protocol in order to authorize and approve participation in Clean Development Mechanism (CDM) projects. Another indicator of the GCC interest in the climate regime is their involvement in CDM projects as shown in Table 5:

Table 5

Clean Development Mechanism Projects in the GCC

COUNTRIES	REGISTERED CDM PROJECTS
BAHRAIN	No CDM projects registered to date.
KUWAIT	Central Gas Utilization Project (CGUP), in Al Wafra, the neutral zone. Recovery and utilization of gas from oil wells that would otherwise be flared or vented. The Project Design Description has been submitted in August 2012.
OMAN	Oman Waste Water Services Company (OWSC), in Muscat governorate. Sludge management in order to avoid dumping. Applied for the project in January 2013.
QATAR	Al Shaheen oil field gas recovery and utilization project. In effect as of July 2004.
SAUDI ARABIA	North Park Building solar power plant project, 10.5 MW photovoltaic plant project in Dhahran. In effect as of December 2006.
UAE	Abu Dhabi Future Energy Company (ADFEC), 100 MW Abu Dhabi solar thermal power plant project in Madinat Zayed. In effect as of July 2006. ADFEC, 10 MW solar power plant project in Masdar City. In effect as of December 2006. Abu Dhabi Gas Industries (GASCO), Implementing energy efficiency measures to reduce fuel gas consumption at GASCO. In effect as of 22nd of December 2006. Dubai Electricity and Water Authority (DEWA), 10 MW photovoltaic plant project in Dubai. In effect as of December 2006. Dubai Aluminum (DUBAL), emission reduction project at DUBAL. In effect as of July 2006.

Note: Adapted from “Clean Development Mechanism (CDM)”, by UNFCC, 2014l (treated by the author).

To date, with the exception of Bahrain, all GCC countries have either submitted a CDM project (Kuwait) or are already the execution phase of the project, which is a very clear indication of the engagement of GCC countries in climate mitigation policies and actions. In addition, it also shows their interest in taking advantage of the financial and technological benefits of CDM projects. In this respect, it is worth noting that in 2011, Saudi Arabia was among the winners of the 2011 DNA Communicators of the Year Showcase, with Spain, Côte d'Ivoire, and Columbia, in recognition of the work of their respective DNAs in promoting the CDM in their countries (UNFCCC, 2014m).

Another indicator of the growing GCC interest and involvement in the international climate regime can be found in the fulfillment of their UNFCCC obligations by submitting National Communication Reports. These reports review the scientific findings regarding climate change in each respective countries, as well as the measures and policies taken in order to mitigate the impact of climate change.

After Bahrain's ratification of the UNFCCC convention in 1994, as a party to the Convention and in fulfillment of its obligations, Bahrain submitted two National Communication reports reviewing the state of scientific findings regarding climate change in Bahrain and the measures being undertaken. The *Initial National Communication* was presented in March 2005 (Kingdom of Bahrain General Commission for the Protection of Marine Resources, Environment and Wildlife, 2005), and the *Second National Communication* in February 2012 (Kingdom of Bahrain Public Commission for the Protection of Marine Resources, Environment and Wildlife, 2012).

Kuwait submitted its one and only *Initial National Communication* (State of Kuwait, Environment Public Authority, 2012) to the Conference of the Parties under its UNFCCC Convention obligations in November 2012. In October 2013, Oman submitted its first and only *Initial National Communication* to the Conference of the Parties under its UNFCCC Convention obligations (Sultanate of Oman Ministry of Environment & Climate Affairs, 2013). Qatar submitted its first and only *Initial National Communication* to the Conference of the Parties under its UNFCCC Convention obligations in 2011 (State of Qatar, Ministry of Environment, 2011). Saudi Arabia submitted two national communications to the Conference of the Parties under its UNFCCC Convention obligations: the *First National Communication* in November 2005 and its *Second National Communication* in October 2011 (Kingdom of Saudi Arabia Presidency of Meteorology and Environment, 2005, 2011). Finally, the UAE submitted three National Communications to the Conference of the Parties under its UNFCCC Convention obligations: the first *National Communication* was submitted in

January 2007, the second in April 2010, and the third in August 2013 (United Arab Emirates Ministry of Energy 2007, 2010, 2013).

From a policy perspective, until the present time the GCC countries have not yet elaborated a national climate legislation[48] or strategy[49] as shown in Map 2 below:

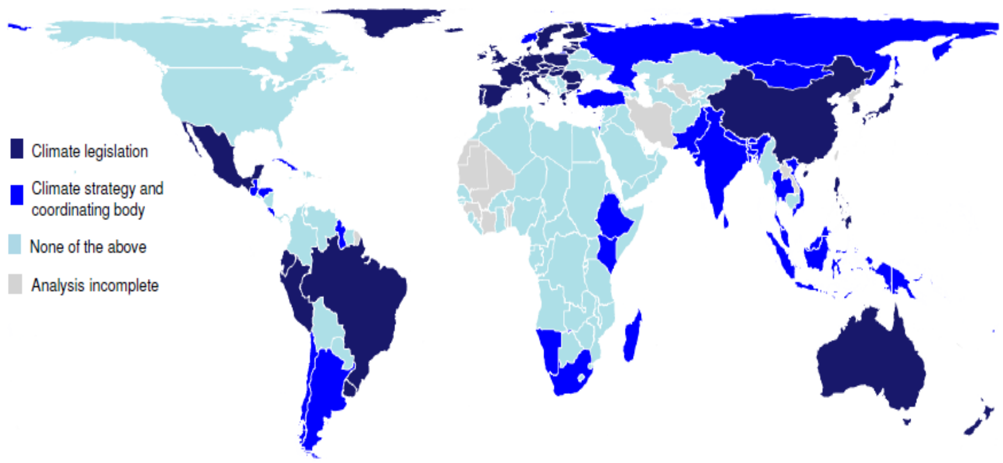

Figure 4: World map of climate legislation and strategies in 2012. Adapted from *Developments in National Climate Change Mitigation, Legislation and Strategy*, by Dubash et al., 2013, p. 656.

Despite some significant actions taken by the GCC governments as described above, the climate change agenda has not yet materialized into a subject of national policy or strategy, which could mean that the climate change issue has

[48] A 'climate legislation' is defined as:

> An act that has been passed by a national parliament, that is in force, and that includes in its title or in its statement of objectives limits or reductions in greenhouse gas emissions. This legislation may include a national climate goal, but this is not necessarily a condition. If a parliament does not exist, the equivalent government act necessary to pass legally enforceable measures should be used as the benchmark. (Dubash, et al., 2013, p. 659).

[49] A 'climate strategy' is defined as: "One or more documents or statements passed by a national government to promote climate change mitigation, but not passed by a national parliament or through any other formal lawmaking process" (Dubash, et al., 2013, p. 659).

not matured enough within the policy making establishment. This may be due to the central role of oil and gas revenues in the GCC budgets, in addition to the absence of a bottom-up pressure from the society at large as a result of the rentier culture—a by-product of the rentier nature of the economy and the state, and will be discussed in detail in chapter 4.

As we have mentioned at the outset of this section, the GCC countries are characterized by an unsustainable energy consumption pattern that is intimately related to the political economy of the region in addition to the significant economic and population growths they have witnessed since the discovery of oil in the region in the 1930s, and that are expected to continue growing in the future. According to the scenario developed in the MED-CSP study, the GDP per capita of the GCC region will grow from US$ 10,000 to 20,000/capita/year to around US$ 30,000 to 50,000/capita/year in the period between 2000 and 2050 (German Aerospace Center, 2005, p. 88).

In this respect, it will be interesting to review the historical developments of the GCC populations and the impact on electricity consumption in the region and how they are likely to evolve in the future. This historical analysis, with an outlook perspective, will also need to include a discussion regarding the energy subsidies issue, which is central to the political economy of the region and closely related to the wasteful energy consumption pattern of the GCC countries.

3.2. THE INTERNATIONAL OIL MARKET

The price of oil is, without any doubt, one of the most important global economic indicators, its evolution closely monitored by producers and policy-makers as well as consumers. As far as the producers are concerned, and the GCC countries in particular, the price of oil is a major concern knowing that oil is at the heart of their political economies and the *raison d'être* of their economic growth as well as political stability. In this respect, it has been selected as the second factor at the landscape level that has historically been the source of the most important pressure on the regimes level of the GCC countries.

The objective of this section is to review the historical developments of world oil markets and how it has affected the GCC economically and politically; to review past and recent oil price forecasts; and finally, to explore future oil demand, supply, and prices and how it could affect the GCC countries based on past experiences. The main objective of this study is to offer a view on long-term oil prices within the time framework of this research project, which is between now and 2050.

It is necessary to mention that the objective is not to make predictions about the future oil prices, but to attempt exploring the most probable trends within the time frame of this research. There have been several consistent attempts by private and state owned companies to predict the future of the energy markets using minute and complex economic models. However, international energy expert Jean-Marie Chevalier asserts that despite the existence of these sophisticated analytic tools, predicting the behavior of the oil markets remains an impossible task. All of the predictive models that have been formulated have mistaken the size of the oil and gas reserves, the cost of their extraction, the evolution of pricing, and the global levels of energy demand, as well as other factors affecting the energy markets in general and the oil and gas market in particular (Chevalier, 2004, p. 25).

Before we engage in the analysis of the oil market, it should be noted that this section will focus on the oil market and its price only, and not the gas markets —as even Qatar, which is mainly a gas exporting country, derives the bulk of its revenues from the export of oil and not from the export of gas (Hertog & Luciani, 2009, p. 8). Indeed, according to 2012 figures, out of the total revenues of US$ 133.717 billion from the export of oil and gas in Qatar, US$ 116.209 billion came from the export of petroleum products[50] alone (OPEC, 2013a, p. 16-17),

[50] According to the U.S. Energy Information Administration,

> Petroleum products are obtained from the processing of crude oil (including lease condensate) [and they] include unfinished oils, liquefied petroleum gases, pentanes plus, aviation gasoline, motor gasoline, naphtha-type jet fuel, kerosene-type jet fuel, kerosene, distillate fuel oil, residual fuel oil, petrochemical feedstocks, special naphthas, lubricants, waxes, petroleum coke, asphalt, road oil, still gas, and miscellaneous products. (IEA, 2007, p. 8).

which represents around 87% of its revenues from petroleum products exports. Moreover, it should be noted that the development of gas fields is much more costly than the development of oil fields and “has been undertaken in conjunction with confirmed [long term] agreements for the off-take of the gas either as liquefied natural gas (LNG) or as piped gas” (Abi-Aad, 2008, p. 68), and in these agreements, the price of gas is indexed on the price of oil. Based on these facts, the choice therefore has been made to focus only on oil and the factors that could affect its prices in the long term, especially the development of unconventional oil, in order to assess the future possible trends of GCC governments’ revenues for building the scenarios.

3.2.1. The Fundamentals of Oil Markets: A Historical Perspective

Since the beginning of the industrial revolution in the 18^{th} century, fossil fuels—first coal, followed by oil and gas at the beginning of the 20^{th} century—have become the world’s principal energy sources, the engine of economic activity, and a pillar of global growth. In less than three decades, the global energy regime switched to using oil as the world’s main energy source, primarily because of its low production cost and its liquid nature, which facilitates its production and transport, making it a vital commodity.

The oil industry’s early history was marked by the discovery of the largest reserves of crude oil in specific and limited geographic locations—primarily, the Middle East and Latin America—by Western companies based in Western Europe and the U.S., which has given to oil a strategic value and a source of geopolitical conflict and competition that has greatly affected its prices on the international markets. Indeed, as a result of the economics and geopolitics that characterize the oil industry, the price of oil has been marked by a chronic instability and volatility, which has made the task of predicting its future price an almost impossible endeavor. Nevertheless, within the framework of a futures study, it is necessary to undertake a detailed analysis of the oil market from a historical perspective and identify the main factors and circumstances that have historically influenced oil prices in the international markets, in order to be able to make assumptions about the most probable evolutions or trends regarding oil prices.

3.2.1.1. Cycles and trends in the oil market

The oil market is an international market where the prices are determined according to the conjunction of two main factors, firstly, the supply and demand factor, which remains the most influential factor and explains the oil market behaviour; and secondly, the geopolitical factor, which threatens oil supply and influences its prices in the international markets, as was the case with the 1973 oil crises, the Iranian revolution in 1979, the Iran-Iraq war until 1988, and the invasion of Kuwait and its liberation by a coalition under the U.S. leadership between 1991 and 1992.

The past decade has witnessed a sharp volatility in oil prices. In July 2008, the price of oil reached US$ 147 per barrel before falling to less than US$ 40 per barrel in December 2008 as a consequence of the unfolding of the global financial crisis. It took two years for oil prices to increase again, reaching US$ 90 per barrel at the beginning of 2011, and picking up again with the beginning of the Arab Spring and especially following the loss of the Libyan production.

Figure 5 below summarizes the historical fluctuations the price of oil has witnessed since the birth of the oil industry in the 19th century, whereas Figures 6-8 highlight the three main cycles of oil price history and the main organizations or forces that had a major role in influencing the oil market.

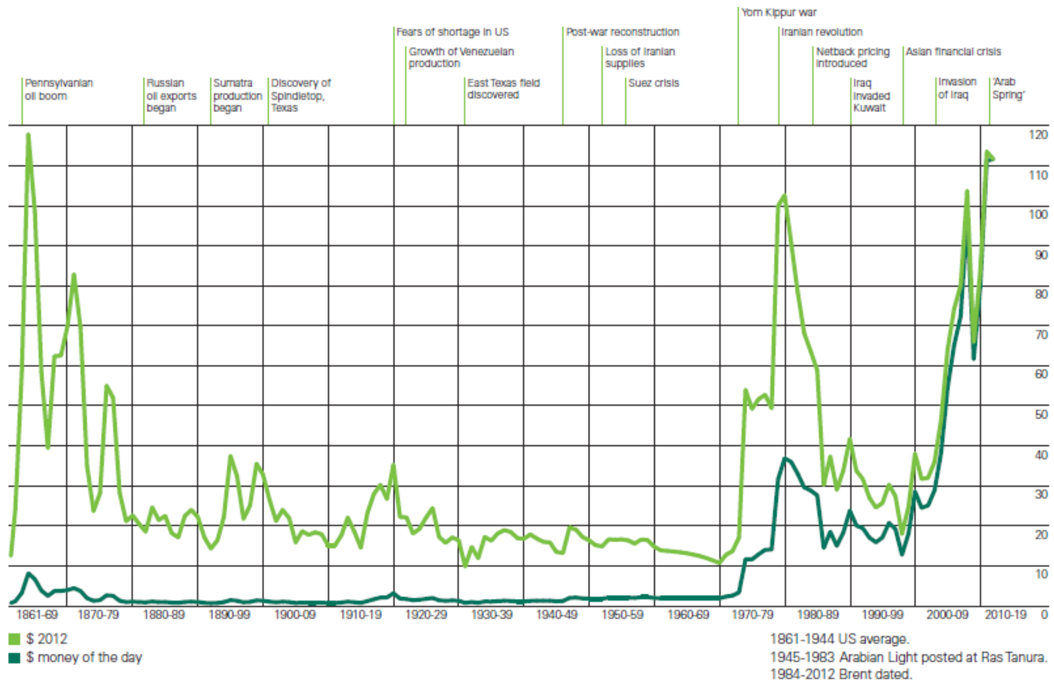

Figure 5: Historical Oil Price Fluctuations 1861-2012. Adapted from *BP Statistical Review of World Energy June 2013,* by BP, 2013, p. 15.

The details of this long history of nominal oil prices (2012 $) can be divided into three main cycles as per the three figures below:

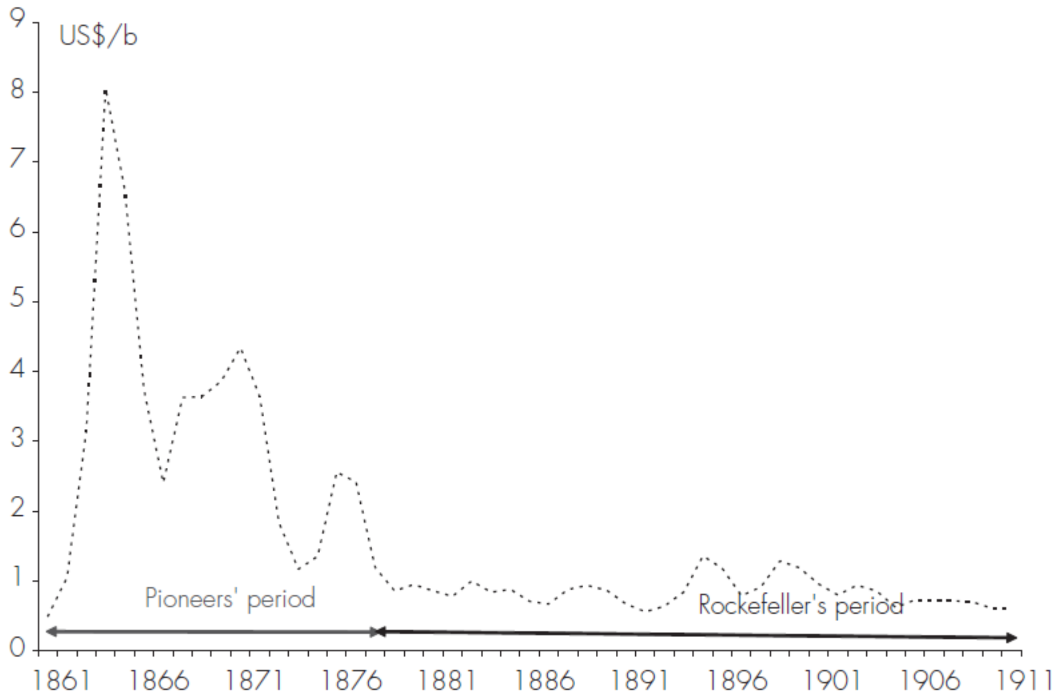

Figure 6: First cycle. Adapted from *BP Statistical Review 2009* as cited in "The Petroleum Market: The Ongoing Oil Price 'Shock' and the Next 'Counter-Shock'", by F. Lescaroux, 2010, p. 102.

The first cycle starts with the birth of the oil industry in Pennsylania, United States, and is divided into two main periods: the pioneer's period from 1861 until 1876, followed by the Rockefeller's period until the first decade of the 20th century.

Figure 7: The second cycle. Adapted from *BP Statistical Review 2009* as cited in "The Petroleum Market: The Ongoing Oil Price 'Shock' and the Next 'Counter-Shock'", by F. Lescaroux, 2010, p. 103.[51]

The second cycle starts in 1911 and is also divided into two main periods. The first period runs from 1911 until 1928, and is defined as a competitive period between the main oil companies. The second period, the Seven Sister's period, begins in 1928 with the Achnacarry Agreement[52] signed between the main oil producers known as the Seven Sisters[53], until just before the first oil crisis in 1973.

[51] The surge in 1947 is the result of a monetary shock.

[52] The Achnacarry Agreement, also known as the "As-I" agreement, refers to a secret pact signed on the 17th of September 1928 between main oil companies the Anglo-Persian Oil Company (later BP), Royal Dutch Shell, and Standard Oil of New Jersey (later Exxon), agreeing on quotas and the price of oil in the international market. The agreement came as a result of a price war between major oil companies in the 1920s that led the price of oil to fall. The pact agreed on limiting the excessive competition responsible for over-production by establishing a system of quotas and division of markets among the major oil companies, fixing prices, and limiting the expansion of over-capacity.

[53] The expression "Seven Sisters" refers to the companies that controlled the world oil market prior to the first oil crisis in 1973. The group included the Anglo-Persian Oil Company (now BP), Standard Oil of California (SoCaL), Texaco and

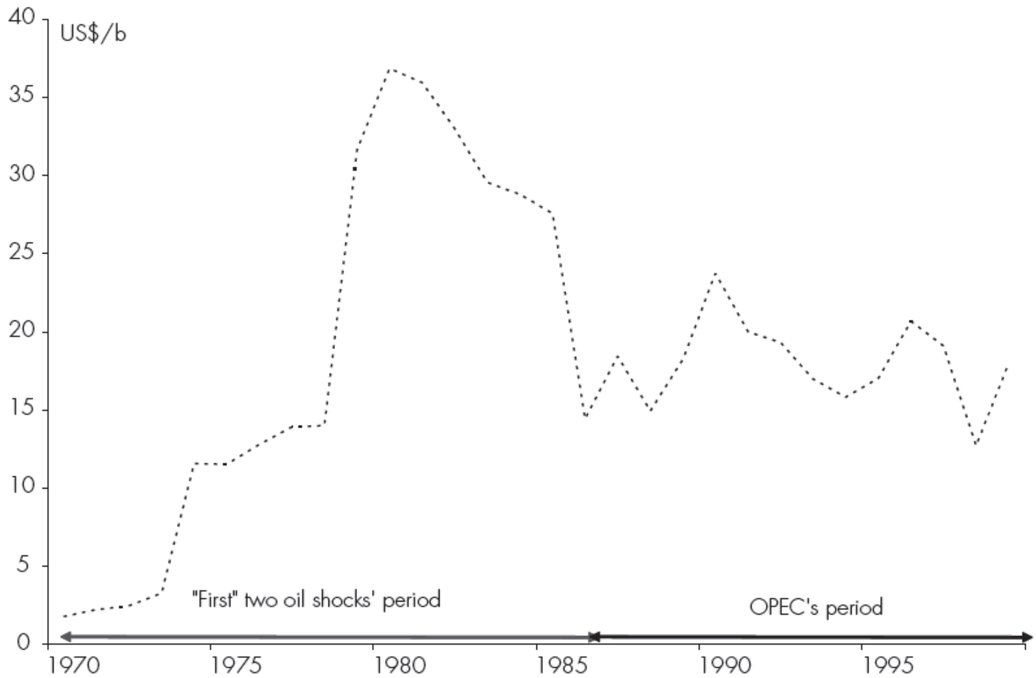

Figure 8: The third cycle. Adapted from *BP Statistical Review 2009* as cited in "The Petroleum Market: The Ongoing Oil Price 'Shock' and the Next 'Counter-Shock'", by F. Lescaroux, 2010, p. 103.

The third cycle is divided into two main periods: from 1973 until 1986, the period of the two oil shocks in 1973 and 1979; and after the collapse of oil prices in 1986, which is defined as OPEC's period.

We can clearly see from the figures above that the oil market has been moving from one phase to another. Indeed,

> historically, the nominal oil price exhibits a series of long and irregular 'cycles' made of two periods, one of turbulence and one of stability . . . or *an entrepreneurial* period and a *cheeseparing* one in non-physicist's terms - with periodicities varying from thirty to sixty years. (Lescaroux, 2010, p. 101).

Such a periodicity is mainly explained by the long investment cycles of the oil industry and is materialized by a succession of over and under-capacity periods

Gulf Oil (these three companies merged and are known today as Chevron), Royal Dutch Shell, Standard Oil of New Jersey (Esso, now part of ExxonMobil), and Standard Oil Company of New York (Socony, now ExxonMobil).

"as well as the market's natural tendency to turn into oligopoly or some other form of control during periods of excess capacity" (Lescaroux, 2010, p. 101). As rightly noted by Paul Frankel in 1946:

> As there is always either too much or too little oil, the industry, not being self- adjusting, has an inherent tendency to extreme crises . . . As no individual unit can evolve a rational production policy on its own, some sort of communal organization is almost inevitable. Paradox though it may appear, oil, competitive par excellence, is usually controlled by some 'leading interests'". (Frankel, 1946, as cited in Lescaroux, 2010, p. 101)

Even today, as stated by Francisco Parra (2004), "the important players in the industry have policies on price . . . [and] [t]he market is not characterized by the kind of intense competition where price for one and all is a 'given', set by the forces of supply and demand, and every one is a price-taker who must accept what he finds" (Parra, 2004, p. 335). However, this does not exclude altogether market forces from the oil price mechanism, as they remain powerful forces in the industry and in fact, "the battle with them is what it's all about" (Parra, 2004, p. 335). In this respect, one of the main subjects of this battle has been to manage the significant disparity between costs and reserves in the Middle East on one side and everywhere else on the other side, a concern which was explicitly expressed by the U.S. Interior Secretary Harold Ickes, who in the 1940s, wondered "how to fit low-cost Saudi Arabia into a structure dominated at the time by high-cost Texas" (Parra, 2004, p. 335).

However, while recognizing that this fact is still valid to a certain extent—as the cost for producing one barrel of oil in the Middle East and North Africa and particularly the Gulf remains the lowest in the oil industry—another factor has in the past decade become of primary importance to OPEC, including the GCC governments. When discussing what they have termed as the "fair price", it is the break-even fiscal oil price that allows for the GCC budgets to remain in equilibrium and to sustain their very large expenditure policy that stands at the core of the socio-political contract of the region. As a result, even if the cost of producing oil in the GCC countries is still very low compared to the high end within the range of costs for producing tight oil in the U.S., tar sand oil in Canada, or the ultra-deep pre-salt oil in the Brazilian offshore, the GCC budgets will have great difficulties keeping the equilibrium between their revenues and expenses with a barrel of oil below US$ 90, an issue that be analyzed with in more details in chapter 4 dealing the political economy of the GCC countries. Consequently, there seems to be a consensus among the major players of the oil industry to keep the prices high in order to allow the GCC budgets to remain in equilibrium on the one hand, and to allow for the development and production of expensive unconventional oil on the other. Nevertheless, the uncertainty about future oil prices remains high, as in the long run, "advances in energy production from shale and other unconventional sources could depress prices of hydrocarbons, as has already been seen in the U.S. market for natural gas" (International Monetary Fund, 2012, p. 11), without forgetting uncertainties of geopolitical nature that could disrupt this unwritten consensus and lead to another oil crisis—either upward or downward.

3.2.2. Current and future outlook of oil markets

Currently, and for many years to come, there is no objective reason to fear for the availability of energy sources to satisfy global demand. This was reconfirmed by the 2012 World Energy Outlook (WEO) of the International Energy Agency (IEA) regarding the future of energy in the world. According to the report and its assumptions regarding the future price of energy and developments in extraction technologies, there are sufficient energy reserves to satisfy the projected global demand for energy until 2035 and beyond (IEA, 2012, p. 63). Indeed, fossil fuel reserves, including oil, gas, and coal, are available in quantities capable of fulfilling the global demand for energy for decades to come, and this is especially true regarding coal. Proven coal reserves exceed the combined global reserves of oil and gas, with the ability to power the international economy for 132 years—based on 2011 production levels (IEA, 2012, p. 63). On the other hand, global proven natural gas reserves—half of which are concentrated in just three countries: Russia, Iran, and Qatar—are capable of fulfilling the projected global gas demand, with combined proven reserves of over 232 billion square feet of natural gas (IEA, 2012, p. 63).

Globally, oil reserves should be able to supply global demand for 55 years based on 2011 production rates. Importantly, OPEC's production alone represents 71 percent of the proven oil reserves around the world (IEA, 2012, p. 63). All available data on proven conventional oil reserves show that there are no objective reasons to worry about potential supply shortages. In addition, more than 70 percent of the increases in the proven global oil reserves since the year 2000 have originated from revisions of data on existing oil fields, a process known as "reserves growth"[54], and only 30 percent of new oil reserves is attributed to new discoveries (IEA, 2012, p. 98).

Moreover, the global oil sector has witnessed an unprecedented level of investment in the domain of oil exploration and production since 2003, reaching US$ 1.5 trillion between 2010 and 2012 alone, and these investments are capable of increasing the production capacity in most oil-producing countries in the coming years (Maugeri, 2012, p. 2). Notably, in the medium and long term, recoverable conventional resources are much larger than proven reserves, and with the changing conditions of the global energy market and advancement in exploration and production technologies, a large share of these resources have been included in the 'proven reserves' category. Moreover, the advancement in exploration and production technologies have also allowed for the production of new forms of oil and gas[55].

Though the production costs of these new forms of oil and gas deposits will undoubtedly be higher than those of conventional resources, the exhaustion of conventional reserves will likely force energy companies to seek new resources that require a more complex process of exploration and production. However, this cost will decrease over time and with the expansion of energy projects, as is the

[54] Reserves growth is defined as the estimated increases in crude oil, natural gas, and natural gas liquids that can be added to existing reserves through expansion, revision, and recovery enhancement technologies, in addition to discovering new oil layers and oil-bearing formations connected to main oil reservoirs. This refers to a revision of the size of previously discovered reservoirs, rather than new discoveries (Maugeri, 2012, p. iii).

[55] This specifically refers to large quantities of unconventional oil and gas reserves that are available in many parts of the world, as evidenced by the American experience with shale gas.

case with all investments in new domains and technologies—bearing a high cost initially before gradually decreasing. Even so, the era of cheap oil is well behind us, as the cost of producing high-quality oil and gas from unconventional sources will never be as low as that of conventional oil and gas.

In developing its productive capacity of shale oil and gas, the U.S. offers a unique experience that might redraw the global energy map, especially if it is reproduced in other parts of the world. These developments are attributed to technological breakthroughs in the production of new types of natural gas, such as shale gas, that are considered unconventional. These breakthroughs may constitute a qualitative leap in the long-run production capacity of shale oil in the U.S., and probably in other regions of the world. Based on these premises, the long-term trends in the international energy system can be summarized in the following points:

- All studies indicate that there is no structural deficiency in the sources of energy, and that the global oil supply—estimated at 93 million barrels of oil per day—is higher than global demand, which is estimated at 88 million barrels per day. Furthermore, there is a consistent increase in proven global oil reserves (BP, 2012, p. 3).

- Fossil fuels (oil, gas, and coal) continue to dominate the international energy mix, reaching 87 percent of global energy consumption. Renewable energy represents no more than 2 percent of the global consumption of energy (BP, 2012, p. 3).

- Oil remains the dominant fuel source, representing 33.1 percent of global energy consumption. However, there has been a decrease in the percentage of oil consumption for 12 successive years in favor of gas and coal, both of which have witnessed a brisk growth estimated at 5.4 percent annually in 2011 (BP, 2012, p. 5).

- Data covering energy consumption in the world indicates that the focus of global consumption is shifting away from the OECD member countries toward developing economies, especially in Asia, headed by China and India. According to a 2012 IEA report, 96 percent of the expected increase in global energy demand will come from outside the OECD region from 2010-2035 (IEA, 2012, p. 56).

- The oil revolution witnessed in the U.S. is not a temporary phenomenon; rather, it is the most important revolution the oil sector has seen in decades, and it can be replicated in other parts of the world. It is possible for this revolution to produce spectacular results in the long term (Maugeri, 2012, p. 6).

- Though it may be true that the age of cheap oil is over, technology and the scaling of projects can lower costs, as the experience of oil and gas production from the North Sea has demonstrated [56]

Given the scale and significance of the shale oil and gas revolutions in the U.S., it is necessary to shed some light on this experience, which has the potential to redraw the global oil map, especially if replicated successfully in other parts of the world.

3.2.2.1. The U.S. revolution of unconventional resources

As explained above, during the past decades, the oil market has been characterized by the emergence of new areas for the exploration and/or production of unconventional oil, such as in Canada (oil sands and tar oil), Venezuela (extra-heavy oil), Brazil (oil produced from the pre-salt formations in the very deep offshore), and above all, the shale gas revolution in the U.S., which has benefited

[56] When oil was discovered under the North Sea in the 1970s, the extraction of the oil deposits was initially deemed to be an extremely arduous, complex, and expensive task as production took place in waters that were 100 to 200 meters deep and over a kilometer under the seabed. Nevertheless, due to the rise in oil prices and the political will of Western countries, the production of North Sea oil became an economically viable operation. After 10 years of exploration, production, and infrastructure construction, the cost of producing oil in the North Sea decreased by 50 percent. Today, major oil companies can economically produce oil in waters that are more than 3,000 meters deep, and from oil reservoirs that lie more than 6 kilometers under the seabed. North Sea oil production, which was previously seen as extremely complex and expensive, has now become a routine operation. Oil that is seen today as too difficult and too expensive to extract will likely become easy and cost-efficient in the future.

from new extraction technologies and is being duplicated for the production of shale oil. Before we deal with the American unconventional oil and gas revolution, it will be useful to shed some light on the technical terminology used to define different types of oil.

3.2.2.1.1. Defining the different forms of oil

Oil is a dense liquid found in the upper layer of the earth's crust and is composed of a complex mixture of hydrocarbons; its appearance, composition, and purity vary widely depending on its origin. Oil and its derivatives are used to generate electricity and to fuel various means of transportation. Over half of the total global oil consumption goes to the transportation sector, a percentage that is expected to increase in the coming decades (IEA, 2012, p. 88). Oil is also the main feedstock for many chemical products, including fertilizers, plastics, and various forms of textiles.

The Society of Petroleum Engineers defines traditional crude oil as oil that is found in a liquid state that can flow naturally ("Conventional Crude Oil," 2011). This means that oil and gas produced through a well should be in a geological formation that has the characteristics of a conventional geological reservoir. The pressure within this reservoir permits the liquids and the gas contained therein to flow easily to the surface. In contrast, the production of unconventional oil and gas takes place under different conditions, either because the geological formation that bears the liquids has low permeability, or because these liquids have a density that is close to, or less than, that of water, requiring different methods of production, transportation, or refining.

The oil industry classifies crude oil according to its relative density or viscosity (light, medium, heavy, or extra heavy). The refining industry also focuses on the level of sulfur in oil, classifying types of crude oil into 'sweet,' when it features a low level of sulfur, and 'sour,' when its sulfur content is high. The refining of crude oil that is rich in sulfur requires refineries that are especially equipped for this process in order to extract high-quality petroleum products.

The U.S. Energy Information Administration (EIA) divides unconventional oil into four categories: heavy oil, extra-heavy oil, bitumen, and shale oil (D. Gordon, 2012). Some analysts argue that oil produced through gas-to-liquid (GTL) or coal-to-liquid (CTL) processes is also a form of unconventional oil (D. Gordon, 2012).

The standards established by the American Petroleum Institute (API) are generally used to gauge the specific density of oil and measure the relative weight of petroleum liquids compared to water. If oil has an API higher than 10, it is lighter than water and can flow on the water's surface; when oil has an API lower than 10, it is heavier than water and is likely to sink. There is a direct inverse relationship between oil's specific density and its API level: the higher the specific density, the lower the API. The oil industry classifies oil types into light oil (with an API lower than 31.1), medium oil (with an API between 22.3 and 31.1), heavy oil (with an API lower than 22.3), and extra-heavy oil (with an API lower than 10). The density of oil, then, indicates its distillate content.

Oil viscosity, on the other hand, is considered the most important characteristic in the oil industry, because it indicates the ease with which the oil will flow from its reservoirs thereby determining the extraction method. Based on this, high viscosity oil is classified as extra-heavy, and oil with extremely high viscosity is classified as bitumen, which is extremely hard to extract using conventional techniques. Oil shale (not to confuse with shale oil), also known as Kerogen oil, is found within rock formations that bear large quantities of Kerogen and similar deposits that produce oil when refined ("Oil Shale," 2011). Given the huge reserves available, oil shale is qualified to become the main source of unconventional oil throughout the world, especially in North America, which contains the largest and richest oil shale formations.

In this regard, 'tight oil'[57] in reality does not differ from conventional oil in quality, since it is light and does not feature high levels of sulfur. However, the

[57] Tight oil refers to the light crude oil confined in shale, limestone, and sandstone formations and can be characterized as having very low porosity and permeability. Even though there are some minor differences between tight oil and shale oil, we will mainly use the term shale oil when referring to these forms of oil.

unconventional nature of the geological reservoirs that contain tight oil or shale oil deposits necessitates the employment of complex and expensive techniques to extract it, leading to its classification as 'unconventional oil'. On the other hand, oil shale is an unconventional form of oil that is trapped in rocks with extremely low permeability. Thus, it is oil that is still in its early stages of geological formation, requiring an expensive heating and refining process for extraction.

It is expected that the production of Kerogen oil will rise from now until 2035. In the U.S. alone, which contains large resources of shale oil (especially in the Green River formation covering Colorado, Utah, and Wyoming), the amount of recoverable oil shale reserves exceed 800 billion barrels of oil, according to a 2011 report by the National Petroleum Council (National Petroleum Council, 2011, p. 46). The mass production of oil shale remains a future potential, but there is no significant production from these resources so far. It is possible that the production of oil shale will increase in the coming years to reach one million barrels per day in 2035, which could be subsequently much higher if economically-viable techniques become available, and if the environmental damage can be minimized (National Petroleum Council, 2011, p. 50). The available reserves of oil shale indicate this form of energy as one of the most important sources of unconventional fossil fuels in the world. In addition to the abundance of oil shale in North America, it is also available in large quantities in Brazil, historical Palestine, Jordan, Indonesia, China, Australia, Estonia, France, Spain, Sweden, Great Britain, and South Africa (D. Gordon, 2012, p. 12).

As indicated above, conventional oil and gas produced in limited geographic regions have dominated the energy system throughout the 20th century. These reserves still represent the majority of oil and gas produced globally today. However, the recent growth in the share of unconventional oil and gas in the global energy mix, especially in the U.S., points to an essential shift in the quality of future oil and gas, as well as a change in the production geography of these resources. By 2040, it is estimated that "about 45% of liquids supply will be from sources other than conventional crude" (ExxonMobil, 2014, p. 37), with the supply from tight oil (shale oil) alone growing faster than the other liquids reaching ten times the 2010 level (ExxonMobil, 2014, p. 38). As far as Canada is concerned, oil sands production will grow by more than 200% over the period between 2010 to 2040 (ExxonMobil, 2014, p. 38).

This ongoing shift is not limited to the use of new types of oil outside the GCC region; this change will also affect the political geography of oil, since the majority of unconventional oil resources are concentrated outside the Middle East and North Africa region, most notably in Eastern Europe and North America. In its 2011 *World Energy Outlook*, the IEA predicted that North America's unconventional petroleum technically recoverable resources could exceed the technically recoverable conventional oil resources in the Middle East by 50 percent (2011, p. 121).

The following sections will be dedicated to the shale gas revolution in the U.S., and how building on this experience, a shale oil (tight oil) revolution in the oil industry is also transforming the entire U.S. energy landscape, with the potential to reshape the global oil map if this experience is duplicated in other regions of the world.

3.2.2.1.2. The shale gas revolution in the U.S.

Throughout the past five years, the significant increase in the production of shale gas in the U.S. has led to a state of national self-sufficiency, and according to the IEA's New Policies Scenario, the U.S., as well as Canada, will emerge as gas exporting countries before 2020 (IEA, 2012, p. 68). This revolution in gas production became possible because of a breakthrough in extraction technology—specifically, the use of horizontal drilling and hydraulic fracturing. The process requires pumping a mixture of water, sand, and chemicals under high pressure to fracture rock layers in order to free the gas confined within them.

In 2000, these techniques were widely employed for the first time in the Barnett shale gas formation in Texas. Oil explorers have known about hydraulic fracturing technology since the 19th century, but it has taken years of development —especially since the 1950s—to reach fruition and increase oil and gas production in the U.S. A second phase in the evolution of this technology began in the mid-1970s, when the U.S. Energy Information Administration sought, along with a number of private partners, to develop technologies that would allow the commercial production of gas from the geological basins in the East. This permitted the development of various technologies, including horizontal drilling, to extract shale gas. The Mitchell Energy and Development Corporation benefited from these technologies in the 1980s and the 1990s by turning the shale gas experiment into a significant economic reality. After their success in producing shale gas in commercial quantities, other companies rushed to replicate its success, spreading to other geological formations across the U.S. After a decade of development and production, the production of shale gas in the U.S. has risen from zero in 2000 to more than 130 billion square meters of natural gas annually (Maugeri, 2012, p. 44). This has resulted in a sharp decrease in the price of natural gas on the American market, where the price of gas reached historic lows. In June 2012, it reached US$ 2.10 per million British Thermal Units (MBTU) at Henry Hub (the leading U.S. trading hub), compared with US$ 9.90 MBTU in the British market, US$ 12 MBTU in the Mediterranean market, and US$ 17.40 MBTU for spot LNG in northeast Asia (IEA, 2012, p. 129).

3.2.2.1.3. The U.S. shale oil revolution

The revolution that America is witnessing in the production of shale oil is a replication of the shale gas revolution. The same techniques have been used to produce shale oil, allowing for the recovery of massive quantities of oil. The U.S. has, in fact, registered successive leaps in its shale oil production since 2008 (IEA, 2012, p. 75). This success is primarily attributed to both new discoveries in extraction technology and the highly competitive environment and the openness of the American market compared to other economies around the world. Given the revolution experienced by the U.S. in the production of unconventional oil and gas, it is clear that the existence of a competitive market and a level playing field have encouraged innovation leading to the exploitation of unconventional resources that were difficult to reach in the past.

The expected decline in U.S. oil imports, from 9.5 million barrels per day in 2011 to 3.4 million barrels per day in 2035, is mainly the result of the increased production of shale oil from now until 2020, and after that time, the decline of imports will primarily be the result of qualitative evolution in the efficiency of vehicle engines, as well as the use of bio-fuels and natural gas in the transportation sector (IEA, 2012, p. 76). The drop of oil imports and the increase in gas exports will positively effect on the U.S. trade deficit, especially if one takes into account that oil imports in 2011 alone constituted two-thirds of the deficit in the trade of goods. In addition, a positive economic stimulus will be provided to the U.S. economy through the export of gas (IEA, 2012, p. 76).

The U.S. became a net oil importer in the mid-1940s, and by the mid-1970s, it was importing 25% of the oil traded globally (IEA, 2012, p. 75)—a situation that has drastically changed since the beginning of the shale gas revolution in the mid-2000s which laid the foundations for the shale oil revolution now taking place. Indeed, according to the IEA (2012), the increase in U.S. unconventional gas over the past five years is equivalent to the current annual gas exports from Russia. As a result of this phenomenal development, and based on the IEA's New Policies Scenario, it is expected that the continuous and combined growth in the production of unconventional oil and gas and biofuels will lead the U.S. to become 97% energy self-sufficient in net terms by 2035 (IEA, 2012, p. 75). In addition, by 2025, the U.S. is expected to become the largest oil producer in the world after Saudi Arabia (Maugeri, 2012, p. 81).

While there are some environmental concerns regarding the production of shale oil or gas, it is not sure that they will represent a serious obstacle to the development of unconventional resources as it is already taking place in the U.S. and Canada. The main obstacle for duplicating the U.S. experience in other parts of the world will be mainly at the regulatory and legal level. As we have the U.S. market benefits from a very specific regulatory environment that is very difficult to find elsewhere, but that can be engineered by governments if they see the necessity to develop their shale resources as an economic and strategic necessity.

Having said this, there is no doubt that the re-emergence of the U.S. energy industry is a key event and a turning point in the history of the global energy sector "that is reshaping the world's energy landscape with far reaching implications" (IEA, 2012, p. 49).

3.2.2.1.4. Early signs of increasing interest in unconventional resources

As a result of the continuous decline in conventional oil resources coupled with an increase in the price of oil in the international markets, "oil shale presents opportunities for supplying some of the fossil energy needs of the world in the years ahead" (World Energy Council, 2010, p. 93). Moreover, following the success of the U.S. shale oil and gas revolutions, a number of governments have demonstrated a serious and rising interest in developing their own resources, as is already the case with the UK (Stevens, 2013, p. 2). In the coming decades, China and Australia have the potential to become one of the major gas producers as, according to the IEA, "unconventional gas [or shale gas] accounts for nearly half of the increase in global gas production to 2035, with most of the increase coming from China, the United States, and Australia" (IEA, 2012, p. 27). In this respect, Tables 6 and 7 below show the top 10 countries in terms of shale oil and shale gas resources globally.

Table 6

Top 10 Countries With Technically Recoverable Shale Oil Resources

RANK	**COUNTRY**	**SHALE OIL (Billion barrels)**
1	Russia	75
2	USA	58
3	China	32
4	Argentina	27
5	Libya	26
6	Venezuela	13
7	Mexico	13
8	Pakistan	9
9	Canada	9
10	Indonesia	8
WORLD TOTAL		345

Note: Adapted from *Technically Recoverable Shale Oil and Shale Gas Resources*, by U.S. Energy Information Administration [EIA], 2013c, p. 10.

Table 7

Top 10 countries with technically recoverable shale gas resources

RANK	COUNTRY	SHALE GAS (Trillion cubic feet)
1	China	1,115
2	Argentina	802
3	Algeria	707
4	USA	665
5	Canada	573
6	Mexico	545
7	Australia	437
8	South Africa	390
9	Russia	285
10	Brazil	245
WORLD TOTAL		7,299

Note: Adapted from *Technically Recoverable Shale Oil and Shale Gas Resources,* by U.S. EIA, 2013c, p. 10.

From Table 6 and 7 above, we can clearly see that China is very well placed in terms of shale oil resources, 3rd globally, and shale gas resources, 1st globally. The interest and focus on China stems from the fact that it has become one of the major energy consumers and importers at the same time and is expected to see its demand in energy grow substantially in the future. Indeed, the last decade has seen very significant growth in the demand for energy from the emerging economies in Asia, and especially China and India, to the extent that the energy markets have witnessed a shift in oil and gas trade directions from the OECD countries to the non-OECD countries. This trend is expected to continue in the coming decades as demand for oil from "North America, Europe and Japan [has] already peaked [as a result of declining] demographics, increased efficiency, and substitution" (Yergin, 2011, p. 712), whereas emerging economies will see their demand in energy increase as a consequence of the significant economic growth they are witnessing and which is expected to last for the foreseeable future.

Given this situation, and since the shale oil and gas revolution in the U.S., the Chinese government has shown an interest in developing its shale gas resources, as according to initial Chinese shale gas resources greatly exceed American reserves by as much as 50 percent and may exceed 1,375 trillion cubic feet of technically-recoverable gas (Gismatullin, 2012). This amount would be enough to fulfill Chinese gas demand for more than 200 years (Evans-Pritchard, 2012). On the same front, Royal Dutch Shell signed a contract to explore and produce shale gas in China in November 2012 with the China National Petroleum Corporation (Gismatullin, 2012). Judging by the American experience, one cannot discount the possibility that shale gas production will lead to shale oil production, which would reduce the proportion of imported oil and gas in China.

However, before being economically produced on a large scale, the development of shale oil and gas in China will most probably face a number of hurdles above the ground—i.e., obstacles of regulatory nature—as well as under the ground—i.e., obstacles of geological nature. Indeed, the success of the American shale gas and oil revolution was made possible especially because of the very specific regulatory environment in the U.S., which is not the case for China at the moment. In addition, from a geological perspective, the Chinese geology will need to adapt the technology used in the U.S. in order to unlock the oil and gas trapped in the geological formations. Moreover, the regions that have great geological potential for shale gas and oil are also regions with much water scarcity, which will increase the cost of production, as water will have to be transported over long distances. However, regions where water and shale formations are present together are also highly populated areas. The latest figures indicate that the Chinese government has been addressing these issues in the past three years, as the production of shale gas in China has already started in certain regions of the country and has risen to 200 million cubic meters in 2013 ("China's 2013 Shale Gas Output", 2014).

In the long run, there are no doubts that the global energy market will be completely different from its current state today. However, in order for the early indicators of a transformation of the energy landscape to take place—as seen in the development of unconventional oil, or in the potential for a technological breakthrough in the transport sector with the development of the electric car—in the climate regime debate as well as the issue of sustainable development, it is only “after 2030 that the energy system could look quite different as the cumulative effect of innovation and technological advance makes its full impact felt” (Yergin, 2011, p. 715).

As far as the GCC region is concerned, there are credible geological indications that the region and in particular Saudi Arabia have significant shale gas resources. Indeed, Saudi Arabia has already launched its domestic unconventional gas program two years ago. At the World Energy Congress held in South Korea in October 2013, the CEO of ARAMCO Khalid Al-Falih declared the Kingdom ready to start producing their shale gas resources and “to commit gas for the development of a 10000 MW power plant which will feed a massive phosphate mining and manufacturing sector” (“Saudi Arabia to Use Shale Gas”, 2013, para. 2).

Grounded on the above survey of the international oil market and the expected future developments, the following sections will review a number of oil price projections elaborated by a selection of energy related institutions.

3.2.3. Oil Price Projections

This section will focus on the oil price projections of the U.S. Energy Information Administration (EIA), the oil price projections elaborated by the International Energy Agency (IEA), and finally, the oil price projections of OPEC. The U.S. EIA was selected as it represents the point of view of the main oil consumer in the global economy and the country where the shale gas and tight oil revolutions are taking place. The IEA was selected as it represents the point of view of the OECD countries that are among the biggest energy consumers. And finally, OPEC’s oil projections were selected as representing the point of view of the main oil producers, including the GCC countries. Given the difficulty to predict the price of oil in the short term and even less in the long term, the longest oil price projection we have been able to find in the literature extends until 2040 only. However, as this research extends until 2050, these projections will be nevertheless very helpful in providing a general trend for the current oil price cycle, given that one cycle could extend between 20 to 30 years as already mentioned in this section. Considering the possible trends between now and the coming 20 years should therefore give us an idea about the possible trends for the next cycle. In any case, as already explained, the objective of this research is not to make predictions, let alone precise predictions, but to explore the most probable trends in the oil market between now and 2050.

3.2.3.1. U.S. Energy Information Administration oil price projections

In its 2013 the long-term oil price projections until 2040, the U.S. Energy Information Administration built three contrasting cases. The first is a reference case which assumes that there are no changes in the current costs of exploration and development and unchanged accessibility conditions to oil resources; in addition to OPEC maintaining their share of the oil market at between 39 and 43% of the world's total production, their planned investments in incremental production capacity are also maintained. It is also assumed that the OECD demand will remain flat between 2010 and 2040, while non-OECD demand will increase by 28 million barrels per day over the same period (U.S. EIA, 2013d, p. 25). In this case, the price of oil will reach US$ 106/barrel in 2020 (real 2011 dollars) and US$ 163/barrel in 2040 as shown in Table 8 and figure 9 below.

The second case is a low price case where oil prices could reach US$ 75/barrel in 2040, as it assumes that average growth in the non-OECD countries will decline from 4.7% (in the reference case) to 4.3% during the period from 2010 to 2040, with growth in the OECD region similar its counterpoint in the reference case and over the same period. On the supply side, OPEC's share increases to 51% of the global oil production by 2040, while the share of non-OPEC production is lower than the reference case, as the low oil prices prevents the production of their more expensive oil (U.S. EIA, 2013d, p. 25).

Finally, the third case is the high price case where oil prices could reach US$ 237/barrel by 2040, as it assumes GDP growth in the non-OECD countries as high as 5.1% during the period between 2010 and 2040, compared to 4.7% in the reference case, which leads to a higher consumption of petroleum liquids and largely offsets the decline in OECD countries as a result of improved energy efficiency and a gradual switch to alternative energy sources. In this case, OPEC's production is lower than the reference case, with a share ranging between 37 and 39% of the global oil production (U.S. EIA, 2013d, p. 26). From past historical patterns, it is expected that in all three cases, OPEC will decrease its production when prices decrease, while non-OPEC countries will increase their production.

Table 8

U.S. EIA Brent Crude Oil Prices in Three Cases 2010-2040 (2011 $/b)

YEAR	**REFERENCE**	**LOW OIL PRICE**	**HIGH OIL PRICE**
2010	81	81	81
2015	96	79	134
2020	106	69	155
2025	117	70	173
2030	130	72	192
2035	145	73	213
2040	163	75	237

Note: Adapted from *International Energy Outlook 2013 with Projections to 2040*, by U.S. EIA, 2013d, p. 25.

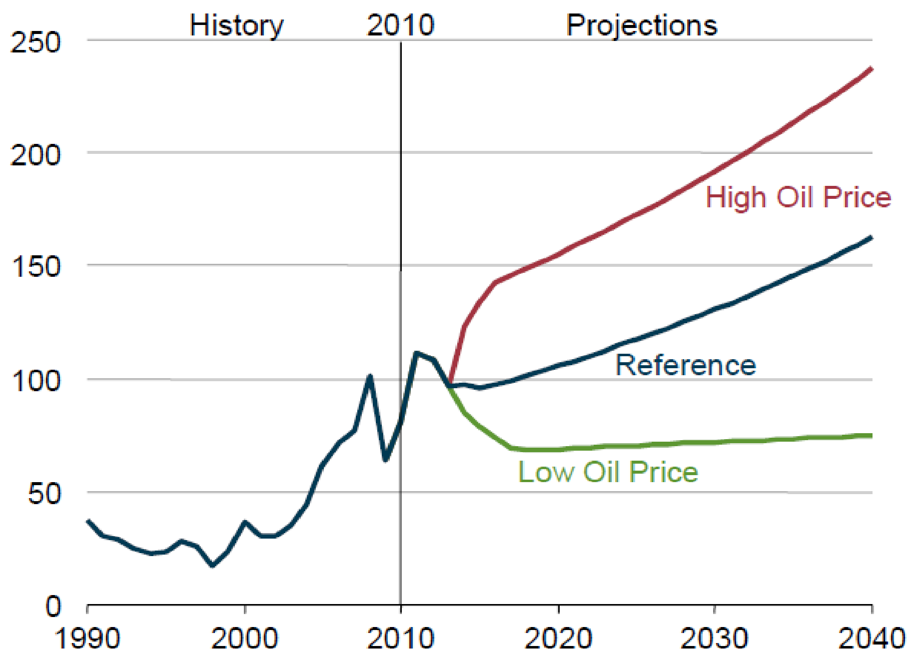

Figure 9: U.S. EIA Brent crude oil prices in three cases 2010-2040 (2011 $/b**)** Adapted from *International Energy Outlook 2013 with Projections to 2040,* by U.S. EIA, 2013d, p. 25.

3.2.3.2. OPEC's oil price projections

According to OPEC's World Oil Outlook (2013), the price of oil can be informed by looking closely at a number of issues including: supply and demand relationship; the behaviour of futures markets, despite its limited predictive content; the way stock accumulation behaves; the expected future supply and demand balances; and finally, the impact of the geopolitical factor. However, in addition to these factors, OPEC's analysis regarding oil price projections considers that

> it is the rising cost of supplying the marginal barrel that has been, and remains, one of the major factors in making revisions to oil price assumptions in the medium- and long-term . . . [and where the marginal cost would be represented by] the costs of producing oil sands projects, tight oil plays, deepwater and Arctic fields. (Organization of the Petroleum Exporting Countries [OPEC], 2013b, p. 26)

The choice of these plays is justified in OPEC's *World Oil Outlook* (2013) by the fact that they represent the high end within the range of costs and as a consequence, the need to have high oil prices in order to keep up with the production economically. Table 26 below summarizes OPEC's reference basket price assumptions according to the reference case.

Table 9

OPEC Reference Basket Price Assumptions in the Reference Case

	NOMINAL PRICES $/b	**REAL PRICES** 2012$/b
2015	110	104
2020	110	94
2025	125	96
2030	141	98
2035	160	100

Note: Adapted from *2013 World Oil Outlook* by OPEC, 2013b, p. 27.

From the table above, according to OPEC's oil price projections, the price of oil is to remain stable in the long run as the nominal OPEC Reference Basket (ORB) price[58], will remain at an average price of US$ 100 per barrel over the period until 2020, before rising to a nominal value of US$ 160/b in 2035, which in real terms will be valued at US$ 100/b due to the increase in the upstream capital costs (OPEC, 2013b, p. 28). As far as the share of renewable energies is concerned, OPEC's projections in the reference case expect an average annual increase "of 7.5% . . . which is faster than any other fuel type" (OPEC, 2013b, p. 53), with the fastest growth taking place in non-OECD countries.

[58] According to OPEC definition:

> The OPEC Reference Basket (ORB) was introduced on January 1, 1987. Up to June 15, 2005 it was the arithmetic average of seven selected crudes . . . As of June 16, 2005, the ORB is calculated as a production weighted average of the OPEC basket of crudes. (OPEC, 2013a, p. 101)

3.2.3.3. IEA's oil price projections

The long-term oil price projections of the IEA are based on three contrasting scenarios that reflect different governmental actions related to energy policy, in addition to different assumptions regarding future oil demand, economic growth, and climate mitigation policies. The first scenario is the Current Policies Scenario, and is based on the policies adopted by mid-2012; the second scenario is the New Policies Scenario, the central scenario of the IEA, which assumes that the existing policy commitments will be implemented in addition to those recently announced; and the third scenario is the 450 Scenario which assumes policy actions that are consistent with the objective of limiting the long-term global temperature increase to 2°C (IEA, 2012, p. 33). Figure 29 below summarizes the oil price projections until 2035 for each scenario.

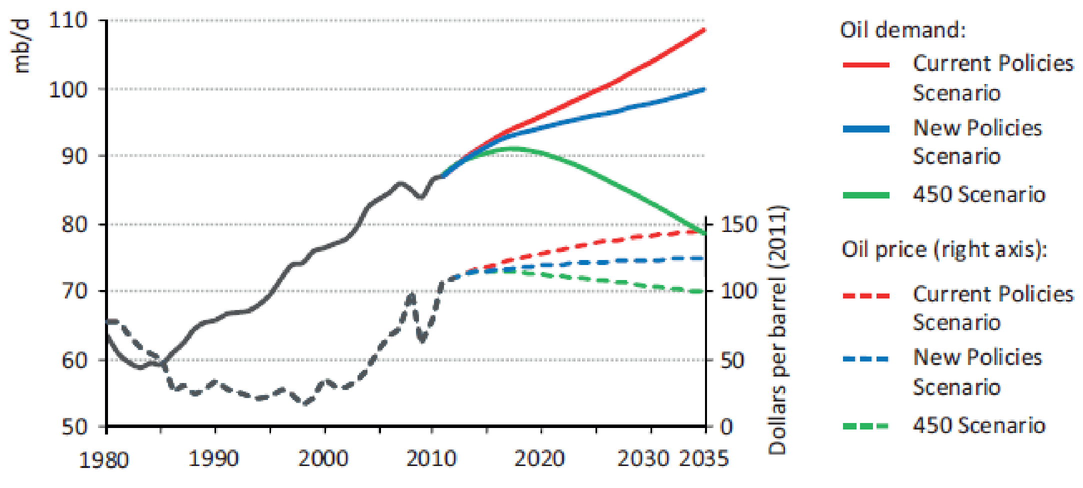

Figure 10: World oil demand and oil price[59] by scenario. Adapted from *World Energy Outlook*, by IEA, 2012, p. 82.

According to the New Policies Scenario, oil demand increases from 87.4 mb/d in 2011 to 99.7 mb/d in 2035 with a price of oil that will rise to US$ 125/b. China alone accounts for around 50% of the net increase (IEA, 2012, p. 81). In this scenario, in the period 2011 to 2015, the share of non-OPEC countries increases to above 53 mb/d as a result of an increase in unconventional oil

[59] Average IEA crude oil import price.

production in the U.S. and Canada, in addition to the production of deep water oil in Brazil. After 2025, the share of non-OPEC countries falls back to 50 mb/d in 2035 (IEA, 2012, p. 81). OPEC's share in the global oil production increases from 42% in 2011 to 48% in 2035 with the biggest absolute increase coming from Iraq (IEA, 2012, p. 81).

The three oil price projections are summarized, for the sake of comparison, in Table 10 below:

Table 10

Comparison of Oil Price Projections $/B

	LOW	**MEDIUM**	**HIGH**
US EIA $2011	US$ 75 in 2040	US$ 163 Reference case in 2040	US$ 237 in 2040
OPEC $2012	US$ 160 Reference case in 2035	n/a	n/a
IEA $2011	US$ 100 450 Scenario in 2040	US$ 125 New Policies Scenario in 2040	US$ 145 Current Policies Scenario in 2040

Note: Adapted from *International Energy Outlook 2013 with Projections to 2040*, by U.S. EIA (2013d); *World Energy Outlook*, by IEA, 2012; *2013 World Oil Outlook,* by OPEC, 2013b (treated by the author).

As we can see from the table above, the projections range from the lowest price at US$ 75/b, to the highest US$ 237/b, depending on the assumptions they are built on, which makes it very difficult if not impossible to know with precision the future destination of oil prices in the international markets. However, grounded on the history of oil price evolution into successive cycles, one of turbulence and one of stability, and for the sake of this research, the most probable trend in the long run will be a cycle of turbulence where the price of oil in the international markets will witness a significant decline after 2030, as explained in more details in the section below.

3.2.3.4. The scenario of a potential price decline

As explained above, the current oil market is characterized by a surplus production of 4 million barrels per day, which is enough to replace the production of any single large oil producer, such as Iran (Maugeri, 2012, p. 64). Furthermore, global oil production capacity exceeds global demand, a situation that will remain the same for at least the next decade due to the latest investments in production capacities. In addition to the developments on the front of the unconventional resources in North America and in other parts of the world, and the possible technological breakthroughs that could occur in the transport sector, there is evidence indicating the real possibility for a significant decline or collapse in the price of oil below the fiscal breakeven oil price after 2030. Historically, the oil market has had a fluid nature, with each "oil boom" usually being followed by an "oil bust". Even if the unconventional resources are more expensive to produce, there is no guarantee that the price of oil will remain high, and this argument is weak when confronted with past historical experiences, as it "does not take into account the fact that learning by doing may significantly lower production costs for now 'frontier' resources, just like it did for North Sea oil or Canadian sands" (Lescaroux, 2010, p. 125).

Indeed, many of the same characteristics as the time period directly preceding the price collapse of the mid-1980s are currently prevalent, primarily:

- There has been a technological breakthrough in the field of unconventional oil production with the shale gas revolution in the U.S., a situation similar to the exploitation of the North Sea oil and gas deposits.
- New discoveries of unconventional oil reserves have been located largely outside of the OPEC countries.
- Governments have the political will to implement policies encouraging the production of unconventional oil in the U.S., Canada and in other

countries. The same public support existed for the development of North Sea resources and for the development of nuclear energy in France for the production of electricity.

- The high prices of oil permit the profitable production of unconventional oil. The cost of producing a barrel of shale oil is usually between US$ 50-65, while the price of oil is currently over US$ 100 per barrel (Maugeri, 2012, p. 54).
- The price collapse in 1986 was preceded by a phase of intense investment in production capacity, benefiting from the rise in oil prices during the 1970s. This investment trend has also been seen since the beginning of the rise of the price of oil in 2000. This dynamic will lead to the expansion of production capacities and the saturation of the global oil market in the long run.

If the repercussions of the U.S. shale gas revolution were projected onto the decreased prices for gas in the North American market, it would be logical to conclude that the shale gas scenario is on the cusp of repeating itself in the production of shale oil followed by a decrease in the price of oil in the international markets[60]. Furthermore, there is a real possibility that this experience will also be replicated in other world regions, such as China. It appears that the long-term price collapse scenario below US$ 100/b is likely to take place between 2030 and 2035, if no other global economic crises occur before this date or if a geopolitical event does not push the prices to another record high level.

In addition to the points above, a potential crisis between OPEC members also looms with the gradual return of Iraq and Iran on the oil market to claim their justified share in OPEC's production, which will inevitably put them in direct confrontation with Saudi Arabia, which has benefited from both nations' long absence from the oil market. The fiscal pressure and the geopolitical environment will make it very difficult for Saudi Arabia to decrease its production in order to

[60] It is worth mentioning that the oil and gas markets are different, and that there is no international market price for gas but instead regional fragmented markets with regional prices that are not linked to each other. Contrary to gas, there is an international oil market with an international price, and therefore any changes in the profile of production in one region of the world can and do have an impact on the price of oil.

allow for the increase of the Iraqi and Iranian oil production without leading to a sharp decline in oil prices.

As far as Iraq is concerned, the IEA's 2012 World Energy Outlook report considers it the future potential big player in the oil industry. However, this prospect will need time to materialize, as there is a need for significant investments requiring at least a decade before any substantial increase in the Iraqi oil production can take place; moreover, there are a number of obstacles that stand in the way of developing Iraq's potential. The first obstacle is the political instability of the country and its security consequences, as it will be very difficult for Iraq to develop its oil industry in the absence of security and political stability. The second potential obstacle could come from Iran, which "regards any substantial expansion in Iraqi output as a threat because that could lead to lower prices . . . [as] [f]rom a geopolitical point of view, Iran does not want Iraq to supplant it as the second largest producer in the Gulf and in OPEC" (Yergin, 2011, p. 297). Iran's calculations in that respect were very clear in 2010, when Iran lifted its own reserve estimates from 138 billion to 150 billion barrels a week after Iraq raised its reserve estimates from 115 to 143 billion, as a result of new bidding rounds and exploration efforts (Yergin, 2011, p. 297).

In the more immediate term, the most probable confrontation could take place between Iran and Saudi Arabia following the signature of the nuclear deal between Iran and the group of P 5+1[61] in Geneva in November 2013 ("Iran Agrees to Curb Nuclear Activity", 2013), which opens the way for signing a permanent agreement in six months and the return of Iran's production and export capacities before the sanctions. In this respect, it is interesting to note that Iran's oil production has been gradually rising since the signature of the Geneva nuclear deal (Lawler & Saul, 2014).

[61] The five permanent members of the Security Council plus Germany.

3.2.3.5. The potential repercussions of an oil price collapse on the GCC

Given the dependency of political economy of the GCC countries on oil revenues, the decrease in the price of oil will undoubtedly have severe repercussions on the GCC economies and societies with possible political implications. On the domestic level, a collapse in the price of oil would doubtlessly have a negative impact on the GCC government budgets, especially if this takes place simultaneously with a shrinking global demand for Gulf oil, given the predictions that other oil-consuming countries, such as China, will develop their unconventional oil and gas resources.

- The financial difficulties that could befall the Gulf states would necessarily impact their ability to satisfy social demands and maintain the state's distributive role, which could engender acute political crises.
- The dearth of financial resources could then push Gulf governments toward external debt, requiring them to submit to the conditions of the lending institutions if the oil bust were to last for more than five years. In fact, because of their massive foreign currency reserves, Gulf economies are capable of surviving an oil price collapse for various periods of time, but it will also lead to more conservative fiscal and budgetary policies, as we will see in chapter 4.
- As far as the subject of this research is concerned, i.e., the diversification of the energy sources in the power generation sector, it is very probable that the materialization of the oil price decline below the fiscal break-even oil price could also probably lead to a decline in the planned investments for deploying renewable and alternative energy sources in the power generation sector, as the GCC governments will be faced by hard policy choices between maintaining their expenditures for social programs, and their investments in diversifying their energy sources.

In short, if the scenario of an oil price collapse takes place, the region will witness the same crises it experienced during the 1980s and the 1990s, but with a greater intensity than the previous oil busts given the growing size of social demands that has been induced by the combination of economic and population growth, in addition to the very instable geopolitical environment represented by the Arab Spring and which is not expected to abate in the short or even long term, and from which the GCC countries will most probably not be completely immune from.

Chapter 4

THE POLITICAL ECONOMY OF THE GCC WITHIN THE RENTIER STATE PARADIGM: A COMBINED MACRO- AND MESO-LEVEL ANALYSIS

This chapter will be dedicated in its first part to a review of the rentier state theory from the classical period in the 1970s and 1980s and its evolution until to the present time. The second part of this chapter will analyse the impact of the rentier nature of the socio-political contract in place in the region on the political economy of the GCC countries. In a third and final part, a special attention will also be given to the power generation sector in the GCC countries with, in a first stage, a detailed analysis of the power industry within the MLP framework of analysis, and in a second stage, we will deal with the economics of power generation in the GCC region and how electricity consumption has been affected by the rentier nature of the regional political economy.

4.1. THE RENTIER STATE THEORY: A CRITICAL REVIEW

The starting point for discussing the concept of an energy transition in the power generation sector of the GCC countries should necessarily start by a review of the rentier state theory as, within the framework of the multilevel perspective, it represents a major landscape shaping factor of the political economy of the GCC countries, the culture and values of the society, as well as the whole energy system of the region and more particularly, the regimes actors at the meso-level.

Indeed, an objective and scientific study of the political economy of the GCC countries with a focus on the energy system of the region coupled with a future outlook perspective must necessarily take into consideration the very specific socio-political context of the rentier, or distributive, state paradigm. The importance of this context, in this respect, is recognized by Tim Niblock when he states that “an understanding of the dynamics affecting policy and development should provide a basis on which to project likely future developments” (Niblock & Malik, 2007, p. 2). Such consideration is necessary in order to build the scenarios and to precisely identify and evaluate the potential obstacles and opportunities that could face the GCC countries in their efforts to engage in a successful energy transition towards a more sustainable and diversified energy system in the power generation sector.

Similarly, the institutional context in which policies are conceived and implemented should also be considered when making policy recommendations for mitigating environmental impact from climate change or transitioning to a more sustainable energy system.

4.1.1. The Main Assumptions of the Classical Period

The concept of economic rent goes back to the classical political economy writings of Adam Smith, David Ricardo, Thomas Robert Malthus and Karl Marx in the late eighteenth and nineteenth centuries. The term was first used by these authors in relation to the pre-capitalist relations of land property in the context of the economy they were living in and which described an unearned income that stems from the physical property of land. According to Adam Smith, a Scottish economist who is considered the father of modern economics and political economy, rent originates from a monopoly situation as in his words “the rent of land . . . considered as the price paid for the use of land, is naturally a monopoly price” (Smith, 2011, p. 225). In Karl Marx’s work, it is used in order to describe a monopoly situation on a limited natural resource that allows for the generation of a ground-rent or a surplus profit. According to Marx, the surplus profit, or the ground rent, generated is not the result of capital invested in the sphere of production, but from “a monopolized force of nature which . . . is only at the command of those who have at their disposal particular portions of the earth and its appurtenances” (Marx, 1959, p. 630). Grounded on this definition, Marx makes a distinction between on one hand, capital investment which is based on a combination of capital, labour and means of production in order to produce goods, and on the other hand, an economy of rent which is based on a situation of monopoly on a natural force or resource

In modern economics, and according to Bannock, rent is defined as “the difference between the return made by a factor of production and the return necessary to keep the factor in its current occupation” (Bannock et al., 1992, p. 129), or in other words, when the difference exceeds normal levels of the owner’s opportunity cost.

As far as the use of the term ‘state’ is concerned, it is worth noting that in the context of the GCC countries, the concept of state as proposed by Weber and Marx are only partially relevant to the region, as according to Weber, one of the main functions of the state is the extraction function, whereas in the case of the GCC, the states are relieved from this function (Beblawi, 1990, p. 89). The Marxist approach regarding the term state emphasizes the concept of class, which does not apply to the region, as the social linkages and identities are based on a variable combination depending on the context, of the family, the tribe and religion. The only class distinction that could be made in the context of the GCC is between the local and expatriate populations (Okruhlik, 1999, p. 295).

State formation in the GCC countries has taken place in two phases. The first phase started before the advent of the oil wealth and saw the creation of various state institutions that allowed for the exercise of power from the ruling elites, and which included the army, the security forces, and the bureaucracy. Simultaneously, based on the pre-existing relations of patronage and clientelism within the historical pattern of ‘sheikhly rule’, a process that took place of “incorporation of one or more groups of social actors into the state, who in turn would become key stakeholders in the maintenance of the evolving political system” (Kamrava, 2012, p. 39). These social groups that included rich merchants and representatives of big families or tribes constituted what can be called the neo-patrimonial network through which the ruling families established their power. The second phase started with the advent of oil wealth, which reinforced the ulterior process and “enabled state actors to deepen their incorporation of the different social groups into the orbit of the state, and to devise new ways in which this incorporation took shape” (Kamrava, 2012, p. 40). It is within this context that the rentier arrangements were devised as an instrument of power and wealth distribution. As rightly stated by Karl (1999), when state-building coincides with petroleum exploitation, the outcome is a self-reinforcing "legacy of overly centralized political power, strong networks of complicity between public and private sector actors, [and] highly uneven mineral-based development subsidized by oil rents" (as cited in Eifert, Gelb, & Tallroth, 2002, p. 5).

It is the specific history and context of the oil producing countries in general, including the monarchies of the Gulf, that the rentier state theory has emerged, as there was a need for a specific theoretical framework in order to understand the state society relations in the oil producing countries and the political economy of an oil based economy.

Since the second half of the twentieth century, the term *rentier state* has been used to define states that derive their revenues from an external source of revenue and especially the states of the oil producing countries of the Persian Gulf. Hossein Mahdavy first developed the rentier state theory in the Iranian context in 1970, but it was only with the publication of Beblawi and Luciani's edited collection, *The Rentier State* (1987) that the theory took shape and the foundation of most of the rentier state literature in the context of the oil producing countries was produced. Beblawi and Luciani make a clear distinction between a rentier state and a rentier economy, as the first is a consequence of the second, and they identify four main characteristics of an ideal rentier state: Firstly, the origin of the rent must be external and generated outside the economy; secondly, at least 40% of the revenues of the state originates from the external rent (Luciani, 1987, p. 70); thirdly, the majority of the population is involved in the consumption and redistribution of the rent instated of producing it (Hanieh, 2011, p. 11); finally, the government is the main beneficiary of the rent and has the responsibility of redistributing it through government expenditures.

From the literature dealing with the concept of the rentier state, we can clearly identify the following key dynamics that characterize the rentier state:

The first dynamic refers to the centrality of the state, as it "becomes the origin of all significant economic and social developments and the determinant of how resources are spread around the population" (Niblock & Malik, 2007, p. 15).

The second dynamic concerns the significant degree of autonomy that a rentier state enjoys from the different sectors or interests groups within the society or economy, as it does not need to extract revenues from them in the form of taxes. The resulting autonomy gives the state the "ability to plan and pursue an economic strategy unfettered by special interests" (Niblock & Malik, 2007, p. 19).

The third dynamic arises in consequence to the two above-mentioned dynamics, and concerns a government independent from local economic forces and therefore uninterested in long-term planning and development policies, needing only an expense policy (Luciani, 1990, p. 76).

In the fourth dynamic, the relations between the ruling family and the political and economic elites take place within a neo-patrimonial network through which the rent is redistributed and the relations with the rest of the society are managed in order to compensate for the lack of a larger political representation (Gray, 2011, p. 7). According to the neo-patrimonial theory, the ruler is at the heart of a dependent network of elites who compete for a share of the rent, and through their own client list network, redistribute the rent to the lower levels of the neo-patrimonial structure in the institutions and the society at large. Through this fully integrated network the rent is redistributed; in addition, the network plays an important role in keeping intact the whole political system.[62]

The fifth dynamic concerns the rentier mentality that characterizes the society and which is reflected in an excessive and wasteful pattern of consumption, especially insofar as energy consumption is concerned. According to Beshara, "the rentier mentality is a corrupt, parasite and unproductive mentality, in addition to being authoritarian and non-ideological" (2012, p. 327).

[62] For a detailed analysis of the neo-patrimonial structure of the Arab countries of the Gulf, please see Bill and Springborg, *Politics in the Middle East* (1990).

In the sixth dynamic, the commercial and service sectors represent a much larger share of the economy and at the expense of the industrial and agricultural sectors. As Niblock points out, “given that the state has the resources to permit substantial imports, and that it has an interest in satisfying popular demands for adequate and reasonably priced food and consumer goods, there is a strong dynamic against production” (2007, p. 17).

The seventh dynamic involves the near-absence or weakness of the civil society, which is not organized enough in order to claim a larger political representation or to have a say in the economic or political choices of their country. According to Beblawi, the financial surplus enjoyed by the rentier state leads to a bargain between political rights and economic welfare, which in turn explains the near absence of democratic institutions in almost all of the Arab countries of the Gulf (1987, p. 59). In this respect, Beshara adds, “the weakness of the civil society is due to the fact that the society is not immune from the state as its immunity is not based on rights but on privileges and on tribal linkages” (2012, p. 328).

The eighth and final dynamic concerns the significant size of the expatriate labour in the economy given the importance of the revenues, the size of the economy, and the very small population of the Arab countries of the Gulf. The issue of the expatriate labour raises the issue of the local labour competitiveness for GCC countries that have recently initiated policies in order to reduce the number of foreign workers and replace them with a local labour. This is, indeed, the case in Saudi Arabia where, according to Niblock, “Saudi governments in the past two decades have sought, no doubt justifiably, to reduce reliance on foreign labour (skilled, unskilled and professional) [and] the impact of these measures has been to raise overall labour costs and reduce labour productivity” (2007, p. 3).

4.1.2. A Critical Perspective of the Theory

Since its first elaboration, the rentier state theory produced an intense academic debate about the validity of some its assumptions about the economic, social, and political context of the oil producing countries, and especially in light of the significant developments the countries of the Gulf have witnessed in these contexts since the seventies. It is worth noting that the critiques to the theory and the changes witnessed by the rentier states of the Gulf have led to a number of changes in the theory that do not undermine its main assumptions or its validity as a theoretical framework for the study of the Arab countries of the Gulf. However, the rentier state theory has gradually evolved through a number of phases and is now mainly known as the 'late rentier state theory', as defined by Gray (2011)[63].

The critiques directed to the rentier state theory can be summarized as follows:

The classical rentier state theory suggests an impression of unrealistic determinism, as if the oil rent is the only factor controlling the destiny of these countries and that their future is predictable. However, as suggested by Niblock, rent is not the only factor that determines the conception of policies and their outcomes, as there are other factors, internal and external, that influence the rentier states and impose on them policies that reduce the unlimited autonomy the classical rentier state theory implies. Domestically, the autonomy of the state can be limited by interests arising from within the state itself represented by high level state officials or members of the ruling family (Niblock & Malik, 2007, p. 19). In addition, the necessary spending on social services as in health and education has ultimately led to higher future expectations in the sectors of employment as a result of the demographical growth and the generalization of education at all levels. The public employment policies implemented by the GCC countries since the seventies have led to the creation of large bureaucracies that represent a significant financial burden to the budgets of their governments and are now increasingly involved and consulted in the decision making process. Internationally, the instability of the international oil market and its influence on the GCC economies, in addition to regional and international geopolitical factors, has greatly reduced the margin of autonomy of the rentier states as assumed by the

[63] For a full and detailed analysis of the stages of developments the rentier state theory has witnessed and especially the last phase known as 'late rentierism', please read Gray (2011), *A Theory of Late Rentierism in the Arab States of the Gulf*.
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classical rentier state theory. As members of the international community, the GCC countries have international obligations that factor into the policy-making process, as mentioned earlier in chapter 3 regarding the climate change issue.

Another critique of the classical theory points out that the centrality of the rentier state does not grant the capacity to induce social changes, as the rentier nature of the socio-political contract in place in these countries deprives the state of the capacity to impose taxes on its citizens. Collecting taxes is one of the tools available to states in order to influence and change social relations and consumption behaviour in the society, and is a very efficient tool for collecting statistical data about the economy. However, the GCC countries are deprived of this tax structure and their governments are therefore limited in their capacity of inducing social change.

The classical theory moreover assumes that the commercial and service sectors represent a much larger share of the economy and at the expense of the industrial sector, whereas the actual context of the GCC countries shows a different reality. Actually, Gulf Arab countries have been able to develop an important petrochemical industrial base in addition to transformation industries that rely on oil and gas as a feedstock. The GCC countries have successfully used their relative advantage of oil and gas availability at low prices in order to build a significant and competitive petrochemical industrial sector.

Finally, the classical theory's assumption that a rentier state is not interested in policy-making and especially long-term and strategic planning has proven to be incorrect. The GCC governments are not only limited to a redistributive role of the rent, as they have shown, since the seventies, an interest and improving capacity in long-term strategic planning in all the sectors of the economy. Indeed, the huge investments made in education, health care, infrastructure, and industrial development, are unmistakably the result of a visionary and developmental approach that has radically changed the societies and economies of the GCC countries that are now much more diversified and integrated into the world economy.

The classical theory has thus ignored the possibility of a gradual evolution of the rentier states of the Gulf into states that, as a result of domestic and international challenges, increasingly share characteristics of 'state capitalism'. This possibility is an important assumption of the late rentier theory, as we will see later in this chapter (Gray, 2011, p. 8).

As a result of these developments, the classical rentier state theory, has also been adapted to the new realities of the oil producing countries, and following the classical phase, which lasted from the end of the 1970s to the early 1990s, the second phase of the theory is defined as the 'specialised and conditional rentier state' theory, and the third actual phase is defined as the 'late rentier state' theory (Gray, 2011).

However, the theory remains valid in its main assumptions. Indeed, the revenues from oil and gas still represent the main source of revenue of the GCC countries, and the rentier nature of the socio-political contract is still in place despite some political reforms at different levels from one country to another. The state is still the main economic and political player, and there are very clear boundaries that define the limits of political as well as economic transformations or developments, limits that are to be found in the socio-political contract at the landscape level.

4.1.3. The New Perspective of Late Rentierism

The classical rentier state theory has evolved through a number of developments and phases that reflected the developments the rentier states have been witnessing since the first oil boom of the seventies. In the academic literature, this evolved theory is known as the theory of late rentierism. In this latest articulation, the main assumption of the classical rentier state theory is still valid as the revenues from oil and gas still represent the main source of state revenue. However, the new theoretical framework takes into consideration the developments and transformations witnessed by rentier states and societies since the seventies and is now more adapted for the study of the actual economic political and social realities of rentier states. In his latest study of the Arab states of the Gulf (2011), Gray describes the main characteristics of the late rentier state as follows:

- *A responsive but non-democratic state.* As a result of the significant economic and population growth the GCC societies have witnessed in the past decades, the GCC societies have been completely transformed. The new reality of the GCC societies has created new domestic and international challenges that have pushed the states of the GCC to be responsive and to adapt to the new realities imposed on them but without reaching the level of a genuine democratic transformation of the political system. Domestically, the GCC governments have been positively responsive to the growing demand for education, employment, health, social services, and communication by investing heavily in the developments of these services. The GCC countries have also been responsive politically by engaging in limited political reforms in varied degrees between countries, but without undermining the status or role of the ruling elites. It is worth noting here the exception of the Kuwaiti political experience, where an elected parliament exists. This is largely due to the very specific history of the Kuwaiti parliament and the nature of the social relationships among the elite. On the international scene, the role and position of the GCC countries in the world economy as providers of energy has put on them an additional pressure and responsibility within the framework of the concept of energy security. There is, indeed, a mutual interdependency between the oil and gas producers of the GCC region and the consumers in the global economy that seriously curtails the assumed autonomy of the rentier state as claimed by the classical rentier state theory.

- *A state that is open to globalization but retains a certain level of economic protectionism.* The classical rentier state theory assumed a tendency to isolationism, which—while potentially true during the period between the thirties and seventies—proved incorrect after the first oil boom. Indeed, the GCC countries have rapidly opted for a certain level of economic open door policy and integration into the world economy in their efforts to diversify their economies. In this respect, it is worth noting that one of the reasons that explains the significant economic growth the GCC countries in the past decades is their success in opening their economies to the global economy. However, they have simultaneously kept a significant level of governmental control on the strategic sectors of the economy represented by the energy sector, through public oil companies. In this respect, the GCC economies are monopoly economies.

- *A dynamic developmental economic policy based on long-term planning.* Since the seventies, the late rentier state has been a dynamic economic player interested in development and long-term planning. Saudi Arabia announced its first five-year plan in 1970 conceived on the basis of a long-term strategic vision. Nowadays, almost all GCC countries plan for the future within the frameworks of long-term visions, as manifested by the "2030 Vision" for Qatar, "Abu Dhabi's 2030 Urban Plan", and "Oman's 2020 Vision". Furthermore, most GCC countries have embarked in long-term economic diversification strategies and policies with significant investments for building an industrial infrastructure as well as in educational infrastructures in order to prepare for the transition of their economies from rentier economies to knowledge economies. Moreover, GCC governments have also invested substantial amounts of their oil revenues into sovereign funds in order to diversify their revenues and prepare for the post-oil period.

- *An 'energy driven' economy vs. an 'energy-centric' economy.* The GCC economies have evolved from a phase where oil wealth was at the centre of the economy (between the fifties and the late eighties), to an economy where the wealth generated by oil is still a major source of its revenues, but is invested as a method of developing the economy in projects in petrochemical and transformative industries (Gray, 2011, p. 31). These investments have been done within the framework of economic diversification policies by using their comparative advantage as oil and gas producers.

- *An 'entrepreneurial state capitalist' structure.* The dominant role played by the GCC states in the economy and their ownership of the means of production have given them, since the nineties, the features of a 'new state capitalist' or 'entrepreneurial state' structure as defined by Bremmer (2010). In the GCC context, the 'entrepreneurial state' has a number of characteristics that we can summarize in the following points: First, the energy companies are owned by the state but are managed professionally; second, the energy policies of the GCC are essentially based on a resource nationalist approach; third, the major companies outside the energy sector are either public companies or majority owned by the state; fourth, the private companies are owned by members of the ruling family or by an elite composed of families or persons closely associated with the ruling families. According to Gray, "there is a friendly-business policy orientation among the new or entrepreneurial state capitalist leadership but this remains subservient to the state" (2011, p. 33).

- *An active and innovative foreign policy.* In opposition to the classical rentier state theory, the rentier Arab states of the Gulf have been able to develop very active regional and international policies and to defend their interests efficiently in international forums. This is the case for the climate change issue, which, if the world economies reduce their consumption of oil, represents a serious potential threat to the rentier Arab states' position as the main supplier of hydrocarbons. This development has been even more noticeable since the beginning of the Arab Spring and the active and influential role the GCC countries have been playing regionally, even if GCC governments have divergent and sometimes conflicting visions or policies regarding the Arab Spring. Furthermore, the GCC countries have established strong strategic and security bonds with the major world powers, with Great Britain in a first stage until the seventies and the U.S. in a second stage following the withdrawal of Great Britain from the region, in order to protect them from regional and international threats.

Concluding this critical review of the rentier state theory, we will now move to an analysis of the political economy of the GCC countries in order to highlight the role of oil and its consequences on the economics and politics of the region.

4.2. THE POLITICAL ECONOMY OF THE GCC: CHALLENGES AND FUTURE OUTLOOK

It is an undisputed fact that oil rents and proceeds have had a central effect on the political economy of GCC countries since the 1930s when oil was discovered in the Arabian Peninsula, but especially following the first oil boom in the 1970s. This wealth has become the main axis of the political economy of the Arabian countries of the gulf, in a manner that has directly or indirectly affected all aspects of life in Gulf societies. On the local level, oil-based economies have contributed to the establishment of a socio-political contract that is characterized by the distribution of benefits to citizens through social services and high government spending in exchange for the citizens' abdication of their right to political participation. Regionally and globally, the Gulf lies at the heart of the geopolitics of energy due to its abundant reserves of oil and gas. The influence of the oil wealth is not limited to the oil-exporting countries of the GCC, but extends to other countries in the Middle East and North Africa as well as Asia through the migrant remittances transferred from the oil-producing countries of the GCC. In 2012 the total outflow of remittances transferred from the GCC countries (excluding the UAE for which there are no data) reached more than US$ 66 billion (World Bank, 2013).

The objective of this section is to undertake an analysis of the political economy of the GCC by focusing on two aspects. The first will highlight the role of oil revenues in the political economy of the GCC countries and how it has been historically affected by the volatility of the oil market. By doing so, the focus will be placed on the circumstances and impact of the oil price collapse in the 1980s on the GCC states in order to evaluate the potential consequences of an oil price collapse on the GCC economies, based on the past historical experience of the economic crisis the GCC countries witnessed as a result of the collapse of oil prices in the mid-1980s. This approach is justified by the fact that some aspects and circumstances of the pre-1986 oil price collapse seem to be taking place now, as can be seen in the development of unconventional oil and gas in North America and discussed in detail in chapter 3. The second point of focus will deal with the political situation in the GCC countries and its relation to their economic performances, within the context of the Arab Spring and how it could affect the GCC political establishments in the long run.

According to Kamrava (2012), the political economy of the GCC region has been characterized by three broad developments: first, the GCC countries have been witnessing a rapid economic growth and massive investments in infrastructural projects that have completely transformed these countries over the past decades. The second development concerns their unprecedented integration into the global economy, which has greatly contributed to their development efforts. Finally, the third trend that characterizes the political economy of the GCC is the emergence of the post-oil era debate and the premise of a sustainable development agenda through the strategic choice of building knowledge-based economies in the long run (Kamrava, 2012, pp. 1-3).

In conjunction with these three main trends in the political economy of the GCC countries, there are, correspondingly, three main structural challenges that are facing the countries of the region (Kamrava, 2012, p. 5). The first structural challenge is found in the rentier nature of their political economy and its political as well as economic consequences. The second challenge involves the population issue, as the GCC countries are characterized by a small indigenous population despite the significant population growth of the last decades, and the reliance of their economies for achieving their developmental goals on imported labor to the extent where imported labor represents around 80% of the overall population in the most extreme cases of the UAE and Qatar. The third challenge comprises the structural deficiencies of their economies, as the economic performance of the GGC states is characterized by its volatility, which has been hampering the development efforts of their governments.

The first structural challenge represented by the rentier nature of the political economy of the region has already been dealt with in the first section of this chapter from a theoretical perspective, knowing that the rentier nature of the

GCC region is a structuring factor that belongs to the macro-level within the MLP framework of analysis. In the following sections, we will first deal in detail with the second structural challenge, namely the population growth and structure of the region, in addition to a future outlook perspective. It should be noted in this respect that the population variable belongs to the macro-level of analysis within the MLP framework, as it is a variable that changes very slowly over time and directly influences the political economy of the region at the meso-level. Following the analysis of the two main macro-level structural challenges, the rentier framework and the population growth variable, we will move, in a second stage, to a meso-level analysis of the political economy of the GCC countries and to its many structural weaknesses and challenges. The first structural weakness is most certainly the role of oil revenues in the GCC political economy and how it affects the economic performance and the economic diversification efforts. In this respect, we will briefly review, in a specific section, the history of economic diversification policies in the GCC their relation to oil revenues and their challenges. In order to highlight the volatile nature of the GCC region, we will analyze the consequences of the oil crisis of the eighties and the nineties, when oil prices collapsed in the international markets, on the GCC economic and political situation. In a third stage, we will be giving a special attention to the power generation sector of the GCC countries in order to highlight the structure of electricity consumption in the GCC countries, as a consequence of the rentier nature of the political economy, and the challenges that it represents to GCC governments. Finally, in a fourth stage, will focus on the political factor in the GCC political economy by examining the role of oil in the regional political equation and how it affects political stability, coupled with the changing regional political map as a result of the Arab Spring, in addition to a future outlook perspective, as we consider that it could have a significant impact on the political future of the GCC region and on the future course of an energy transition.

4.2.1. The Population Factor: Structure and Growth

Since the advent of oil wealth in the Arabian Peninsula in the 1930s, the region has witnessed a very significant economic growth, completely transforming the GCC societies and driving a steady and continuous population growth that is also expected to continue in the future. The relevance of the population growth variable lies in the fact that it is one of the main drivers for electricity demand and consumption (Trieb & Klann, 2006, p. 2), and on the fact that it is also a variable that belongs to the landscape level within the MLP framework of analysis as already explained in chapter 3. However, it should be noted that as far as this research is concerned, the population growth variable will not be considered as a variable that will affect directly the regimes level, but as an explaining factor that sheds light on the growing electricity consumption, the pressure that it puts on the available oil and gas resources, and the GHG emissions of the GCC countries.

As a consequence of the unprecedented economic growth, for the past 50 years, the GCC population has grown ten times, from 4 million in 1950 to 40 million in 2006, and as such, the GCC countries are considered to have the highest population growth in the world (Kapiszewski, 2006, p. 3). Even if the fertility rate of the GCC societies declines in the future, the GCC population is still expected to continue growing as shown in Table 11 and Figure 11 below based on a medium fertility rate[64] growth projection undertaken by the UN population division. Indeed, the fertility rate of GCC societies is expected to decline in the coming years in all fertility projections (low, medium, and high). In the case of the Kingdom of Saudi Arabia, the most populous country of the GCC, the fertility rate for the medium projection is expected to decline from 2.68 for the period between 2010-2015, to 1.64 for the period between 2045-2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2013b).

[64] According to the United Nations, Department of Economic and Social Affairs, fertility rate is defined as: "The average number of children a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. It is expressed as children per woman" United Nations, Department of Economic and Social Affairs, Population Division, 2013b).

Table 11

Population Structure of GCC Countries

	POP. (2010)	POP. (2050)	POP. GROWTH (2010-2050)	URBAN POP.	IMMIG-RATION (2010)	IMMIG % (2010)
BAHRAIN	1,252,000	1,835,000	1.16% (avg. annual)	88.6%	315.4 (thousands)	39.1%
KUWAIT	2,992,000	6,342,000	2.79% (avg. annual)	98.4%	2097.5 (thousands)	68.8%
OMAN	2,803,000	5,065,000	2.01% (avg. annual)	71.7%	826.1 (thousands)	28.4%
QATAR	1,750,000	2,985,000	1.76% (avg. annual)	95.7%	1305.4 (thousands)	86.5%
KSA	27,258,000	40,388,000	1.20% (avg. annual)	82.3%	7288.9 (thousands)	27.8%
UAE	8,442,000	15,479,000	2.08% (avg. annual)	77.9%	3293.3 (thousands)	70.0%
TOTAL	44,497,000	70,442,500	1.45% (avg. annual)	85.7%	15126.6 (thousands)	53.4%

Note: Adapted from *The Migration and Remittances Factbook*, by World Bank, 2011, and *World Population Prospects: The 2012 Revision*, by United Nations, Department of Economic and Social Affairs, Population Division, 2013b (treated by the author).

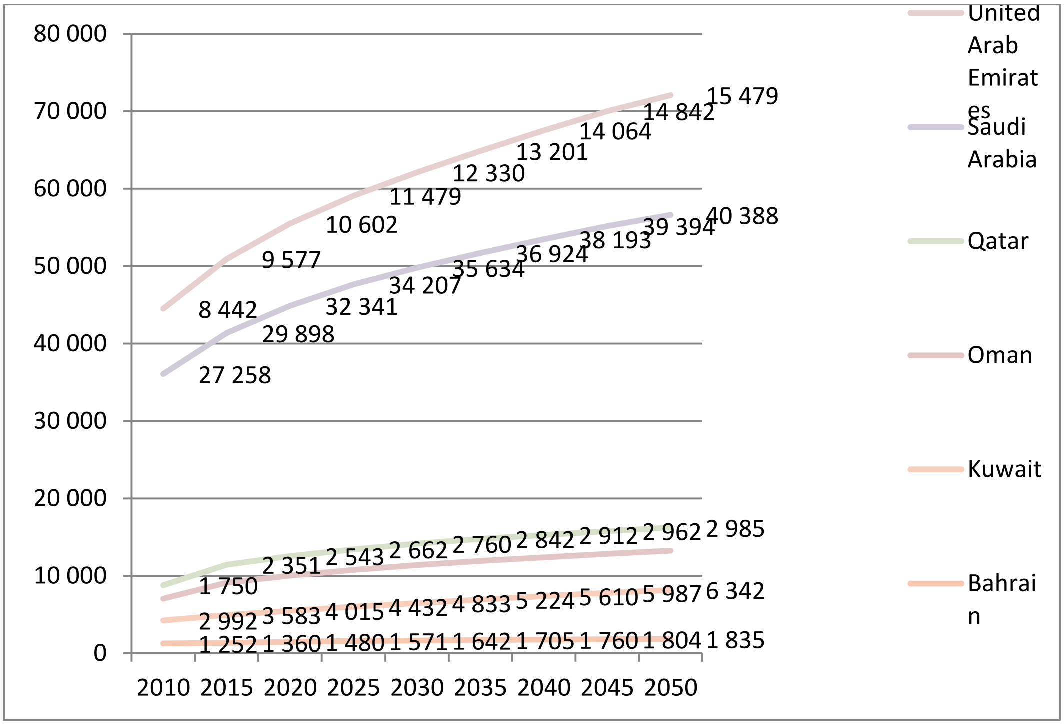


Figure 11: GCC population growth 2010-2050 (Medium Fertility Projection). Adapted from *The Migration and Remittances Factbook,* by World Bank, 2011, and *World Population Prospects: The 2012 Revision*, by United Nations, Department of Economic and Social Affairs, Population Division, 2013b (treated by the author).

According to the United Nations medium fertility growth projection, the GCC population will grow from 44.5 million in 2010 to over 70 million in 2050, which represents a 58.3% increase for the whole period, and an average annual increase of 1.45% per year. In terms of population, Saudi Arabia is the dominating country, accounting for more than 57% of the total GCC population in 2050. This population growth will represent a major challenge to the GCC economies and will put significant pressure on the energy resources of the region.

As far as the GCC employment situation is concerned, it is characterized by a structural imbalance, as foreign labor constitutes the majority of the workforce in the private sector, with high unemployment among GCC nationals despite a policy in place for more than a decade to increase the share of nationals (Economic and Social Commission for Western Asia [ESCWA], 2013, p. 8). Indeed, The public sector is the main employer in the oil producing countries of the Persian Gulf (including Iraq and Iran), as according to official figures, the public sector employs 22% of the active population (Kamrava, 2012, p. 56), whereas according to Michael Herb, in the GCC countries alone, 90% of nationals are employed by the state (Herb, 2009, p. 382).

4.2.2. Oil Dependency of GCC Economies

Thanks to oil revenues, the GCC countries have witnessed a significant economic growth and a radical transformation of their societies and economies, moving them from the status of one of the poorest and less developed regions in the world before the 1970s, to one of the richest, with some of the highest per capita GDPs in the world. Qatar's per capita GDP was estimated at US$ (at PPP) 101,717 in 2013 (The Economist Intelligence Unit, 2014a, p. 8) and the UAE around US$ (at PPP) 54,839 per capita (The Economist Intelligence Unit, 2014b, p. 9). In the long run, the GCC's real GDP is expected to grow by 56% as nominal GDP, as from US$ 341.6 billion in 2000 is expected to be over US$ 2 trillion by 2020 (Economist Intelligence Unit, 2010, p. 2).

The oil dependency of the GCC economies is a fact that can hardly be challenged, even if relative progress has been made for the diversification of the GCC economies since the seventies[65]. This dependency is very obvious in the sensibility of their GDP growth trends to oil price fluctuations in the international markets as can be seen in Figure 12 below:

[65] In political economy, the concept of economic diversification refers to a set of policies that aim at reducing the dependence of the economy on the revenues of a limited, or single, export commodity that are subject to price and volume fluctuations (Diversification, 2001, p. 360).

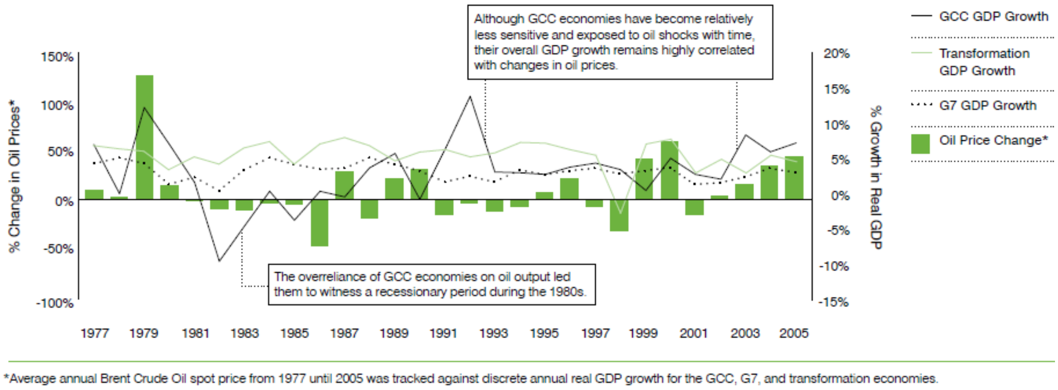


Figure 12: Oil price change versus real GDP growth in the GCC and other economies 1977-2005.[66] Adapted from *Economic Diversification: The Road to Sustainable Development*, by Abouchakra et al., 2008, p. 9.

The high economic concentration in the GCC economies exposes their economies to the exogenous fluctuation of oil price in the international markets and as a consequence, affects the sustainability of their revenues and of their expenditure policies in the long term.

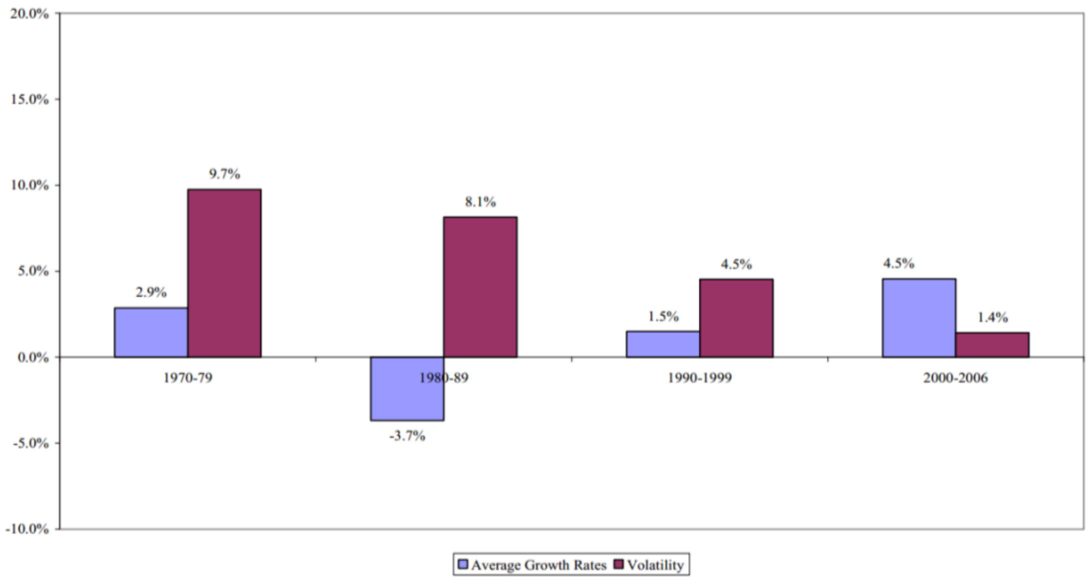
4.2.2.1. The chronic volatility of GCC economies

The economic performance of the GGC states is characterized by its volatility; Figure 13 below presents the average annual growth of GDP per capita and the level of volatility measured on the basis of the standard deviation of the annual growth rate. In this way, one can observe fluctuations, representing instances of "oil shocks," in average growth each decade. Most GCC states, with the exception of Kuwait and Qatar, witnessed significant economic growth during the 1970s, with rates of 12.6 percent in the UAE, 5.7 percent in Saudi Arabia, 5.5 percent in Oman, and 2.9 percent in Bahrain. In the 1980s, all Gulf countries except Oman saw their economies shrink, with rates exceeding -3.6 percent in

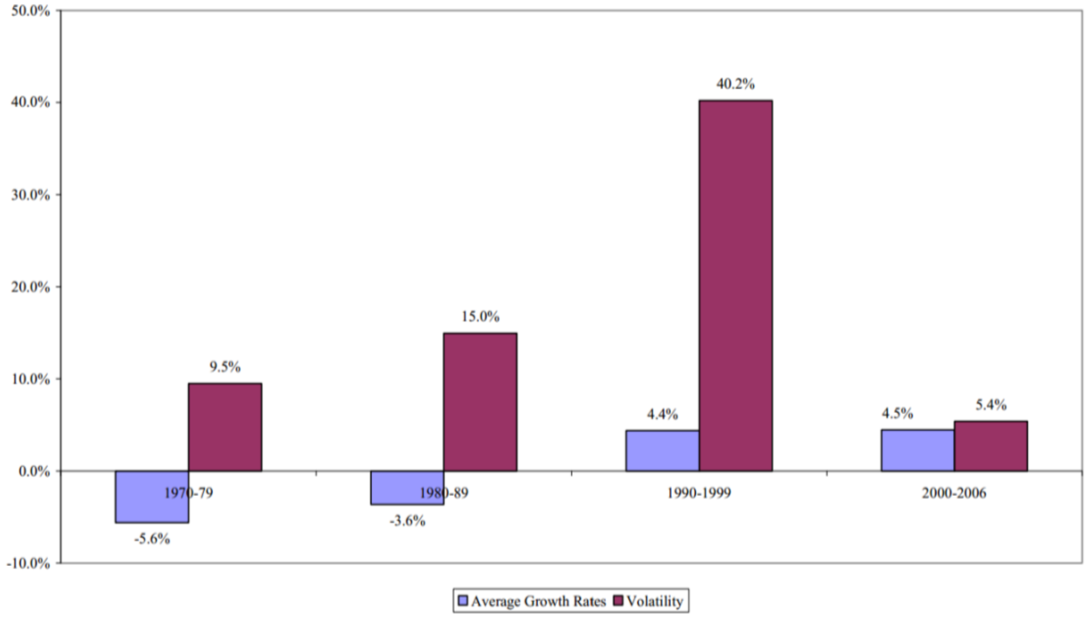
[66] Transformation economies consist of: Hong Kong, Ireland, New Zealand, Norway, Singapore and South Korea. These economies have initiated or completed transformation to an industrialized nation sometime in the second half of the 20th century. Group of Seven (G7) economies consist of Canada, France, Germany, Italy, Japan, the United Kingdom and the United States (Shediac et al., 2008, p. 2).

Kuwait and -6.4 percent in Saudi Arabia (Koren & Tenreyo, 2010, p. 3). With the rebound in oil prices during the late 1990s and the early 2000s, economic growth rates are back on the rise in all GCC states, and they maintain an exceptional economic stability. In sum, the common denominator between all Gulf economies is their extreme instability and the tie between their economies and the oil market's volatility. However, it must be noted that the volatility of GCC economies has been reduced by a factor of 4 since 2005, which is mainly due to two reasons: firstly, the rise of the service economy, as a result of the economic diversification strategies undertaken by GCC governments since the seventies, and secondly, the relative stability of the oil and gas international markets since the 1980s (Koren & Tenreyo, 2010, p. 3).

Bahrain



Kuwait


50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
-10.0%
9.5%
15.0%
40.2%
4.4%
4.5%
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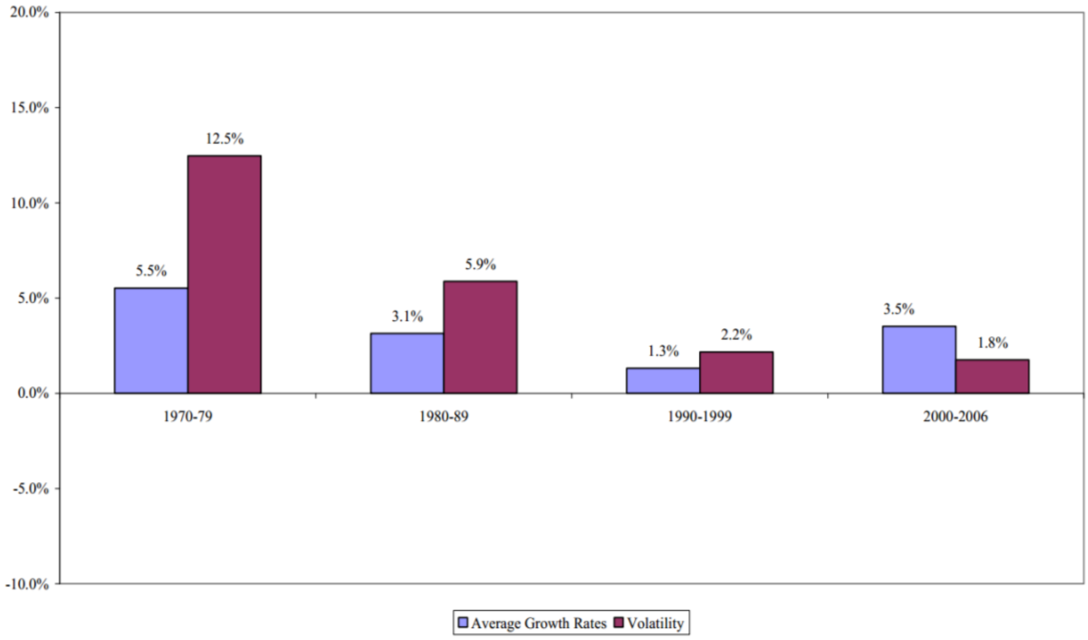
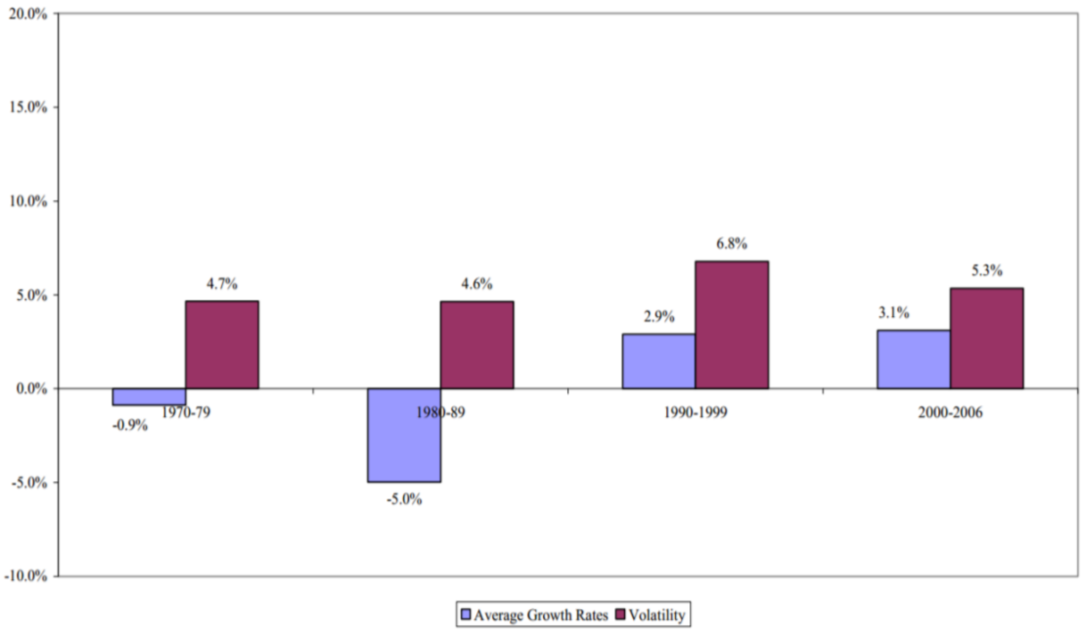
-5.6%
-3.6%
1970-79
1980-89
1990-1999
2000-2006
Average Growth Rates
Volatility

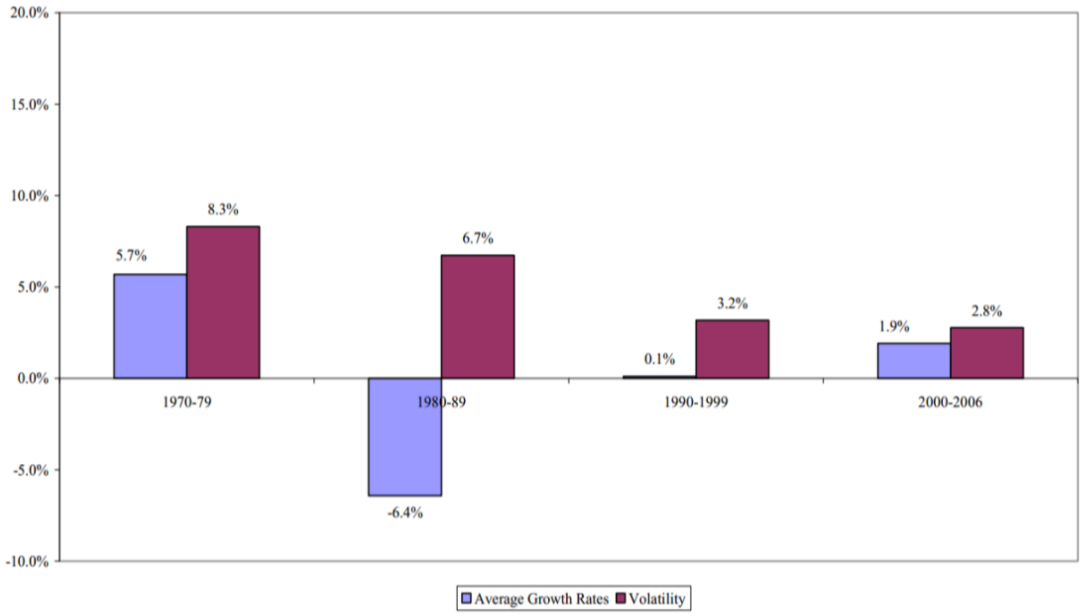
Oman


20.0%
15.0%
10.0%
5.0%
0.0%
-5.0%
-10.0%
12.5%
5.5%
5.9%
3.1%
1.3%
2.2%
3.5%
1.8%
1970-79
1980-89
1990-1999
2000-2006
Average Growth Rates
Volatility

Qatar



Saudi Arabia



The United Arab Emirates

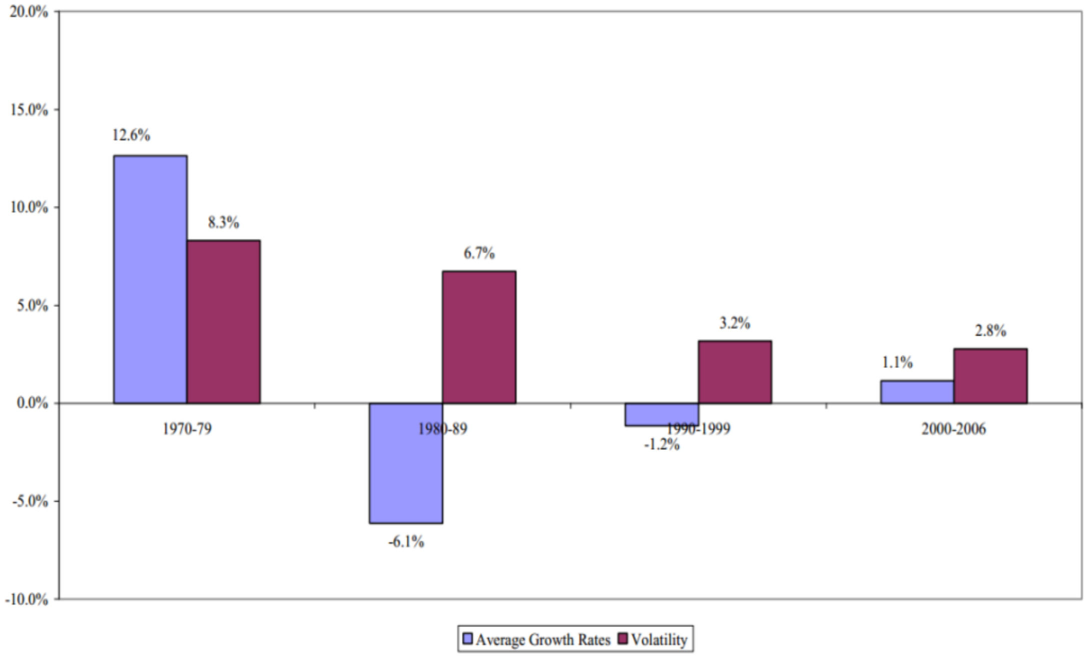


Figure 13: Average yearly growth rates and volatility in the GCC states, 1970-2006. Adapted from UN statistical database from 1970 to 2006 as cited in *Volatility, Diversification and Development*, by Koren & Tenreyo, 2010, pp. 4-5.

The data above is a very clear demonstration of the chronic instability of the GCC economies and their economic vulnerability as a result of their structural dependency on oil export revenues.

4.2.2.2. The financial burden of the energy subsidies

Before engaging in the analysis of energy subsidies, it is first necessary to define the concept of subsidies and how it will be used in the context of this research project. Energy subsidies include consumer subsidies and producer subsidies. The first category "arises when the prices paid by consumers, including both firms (intermediate consumption) and households (final consumption), are below a benchmark price, while producer subsidies arise when prices received by suppliers are above this benchmark" (International Monetary Fund, 2013, p. 6). It is understood that in the context of the GCC countries and this research, we will be dealing with the consumer subsidies. There are different methodologies for calculating subsidies; however, for the sake of this research thesis it has been decided to use the IEA's methodology for calculating subsidies which is based on the price-gap approach, and compares domestic prices to shadow international prices[67].

The rationale behind the energy subsidies in the GCC countries lies in the fact that these countries are endowed with substantial oil and gas wealth, but more particularly in the nature of the social contract of the region or the rentier state structure, which means that political considerations are the main reasons behind energy subsidies in the GCC region. Indeed, as rightly put by Fattouh and El-Katiri, "many Arab Gulf exporters have engaged in providing their citizens with plentiful supplies of cheap energy for decades, as a cornerstone of their citizen's participation in the natural resource wealth of their country" (2012, p. 15). The political aspect of these subsidies make them very resilient to reform, as the local populations consider them rights, and any attempt at bringing reforms to this structure could have a potentially high political price. In addition, there is also an economic rationale for subsidies found in the economic development or industrialization policies of the GCC countries. Indeed, as the countries of the region enjoy a comparative advantage from their status of oil and gas producers, they have pursued policies of industrialization in the energy intensive industries and the petrochemical industries that benefit from subsidized energy prices in order to attract foreign investors and to be competitive on the international markets.

In parallel to their political and economic benefits, energy subsidies have economic as well as environmental consequences. Economically, energy subsidies "create distortive price signals and result in higher energy consumption or production, or barriers to entry for cleaner services" (Vagliasindi, 2012, p. 2). Higher energy consumption will also put pressure on the limited levels of oil and gas reserves, reduce the level of the available quantities for the export market, and

[67] For a detailed account of the IEA's methodology for calculating subsidies please read pages 13 to 15 in: *Analysis of the Scope of Energy Subsidies and Suggestions for the G-20 Initiative*, IEA, OPEC, OECD, World Bank Joint Report. Prepared for submission to the G-20 Summit Meeting Toronto (Canada), 26-27 June 2010.

affect the revenues of the government. On the environmental front, the increased energy consumption induced by energy subsidies will only increase the GHG emissions in the atmosphere.

The tables below summarize the level of subsidies in the GCC countries based on a pre-tax evaluation[68], first as a percentage of their GDP, and second as a percentage of their budget.

Table 12

Pre-Tax Subsidies for Petroleum Products, Electricit,y and Natural Gas, 2011 (Percent Of GDP).

	Petroleum Products	**Electricity**	**Gas**
Bahrain	5.37	2.57	n/a
Kuwait	3.09	2.91	1.29
Oman	3.01	0.76	2.20
Qatar	1.22	1.20	1.07
Saudi Arabia	7.46	2.48	n/a
UAE	0.48	1.86	3.37

Note: Adapted from IMF staff estimates, OECD, IEA, Deutsche Gesellschaft für Internationale Zusammenarbeit, IMF World Economic Outlook, and World Bank as cited in *Energy Subsidy Reform: Lessons and Implications*, by IMF, 2013, p. 50.

[68] According to the IMF:

> Pre-tax subsidies for . . . [petroleum products] are estimated as the difference between international prices adjusted for transport margins [in case of importing countries] and domestic consumer prices . . . between 2000 and 2011. International prices are taken as the monthly average of spot prices from IEA. (International Monetary Fund, 2013, p. 42)

Natural gas pre-tax subsidy estimates "are based on IEA data . . . in 37 countries" (International Monetary Fund, 2013, p. 42). According to the IMF, the pre-tax electricity subsidy estimates

> are based on average domestic prices and cost recovery prices that cover production costs, investment cost, distributional loss and the non-payment of electricity bills. An upward adjustment is also made for the input subsidies that electricity producers may receive through their use of subsidized fossil fuel products. For . . . [most] countries, the last year for which data are available is 2009. (International Monetary Fund, 2013, p. 43)

The level of the subsidies ranges from a minimum of 3.49% of GDP in Qatar to as high as 9.94% of GDP in Saudi Arabia without adding the gas subsidies for which there are no available data. Saudi Arabia is, indeed, considered to be among the largest subsidizers in the world in absolute terms with more than US$ 10 billion of subsidies per year (World Bank, 2009, p. 41). As far as electricity subsidies are concerned, they range from as low as 0.76% of GDP in Oman and as high as 2.91% of GDP in Kuwait.

Table 13

Pre-Tax Subsidies for Petroleum Products, Electricity and Natural Gas, 2011 (Percent of Government Revenues)

	Petroleum Products	**Electricity**	**Gas**
Bahrain	18.96	9.08	n/a
Kuwait	4.57	4.30	1.91
Oman	7.28	1.83	5.31
Qatar	3.17	3.12	2.78
Saudi Arabia	14.00	4.66	0.00
UAE	1.38	5.32	9.61

Note: Adapted from IMF staff estimates, OECD, IEA, Deutsche Gesellschaft für Internationale Zusammenarbeit, IMF World Economic Outlook, and World Bank as cited in *Energy Subsidy Reform: Lessons and Implications*, by IMF, 2013, p. 55.

The figures above are a very clear indication of the burden of subsidies on GCC budgets ranging from the lowest value at 9.07% of the budget in Qatar, to the high level of 28.04% of the budget in Bahrain, and between these two extreme margins, subsidies represent 18.66% of the budget in Saudi Arabia and 16.31% of the budget in the UAE.

The GCC policy of subsidizing energy products in general and electricity in particular has led to an increasing electricity penetration in the GCC countries, and as a consequence, an increased electricity domestic consumption. However, differences exist among the GCC countries in the level of governmental electricity subsidies. Indeed, Kuwait and Qatar offer free electricity to their citizens, whereas the price of electricity is heavily subsidized in Saudi Arabia, Bahrain, and Oman. The UAE is the only exception in the region, as it has a more energy-conscious pricing policy, differing from one state to another, with electricity prices in general double the prices in Bahrain and Oman (Qader, 2009, p. 1203).

Power generation in the GCC countries relies essentially on gas as a source of energy, and given that the international gas market is much more fragmented and regionalized than the oil market, it is very difficult to evaluate accurately the opportunity cost of using gas for power generation in the GCC region. However, as the gas industry is more costly than the oil industry, especially in the case of the LNG industry, and knowing that most of the gas exported outside the region is exported by LNG, which is even more costly than its export by pipelines, we can conclude in general terms that the opportunity cost for using gas in the power generation industry in the GCC region is lower than the opportunity cost of using oil. As a result, there is a significant use of gas among GCC countries for power generation and a tendency toward a growing share in the power generation energy mix. Therefore, we can conclude that gas is the main competitor to other alternative or renewable energy sources. Moreover, electricity subsidies represent in themselves another obstacle to the deployment of renewable energy technologies, as it is very well established fact that "subsidies to electricity reduce the returns to investment in renewable sources" (World Bank, 2009, p. 42).

Building on this conclusion, we can assume that the development of shale gas in the GCC region, which is even more costly to produce and with an even lower opportunity cost than conventional gas, could have a negative impact on the development of renewable energy technologies in the power generation sector of the GCC region, especially if the shale gas resource base is significant as evaluated by different sources.

The burden of the subsidies becomes even more important in case of a post-tax[69] evaluation that takes into consideration the externalities related to the

[69] According to the IMF,

> Post-tax subsidies are estimated as pre-tax subsidies plus *a corrective* (or *'Pigouvian tax')*, reflecting an (excise) tax on energy products to charge for externalities associated with CO_2 emissions, local pollution, and (in the

use of fossil fuels and that are not accounted for in GCC budgets, as we can see from the table below:

Table 14

Post-tax Subsidies for Petroleum Products, Electricity and Natural Gas, 2011 (Percent of GDP).

	Petroleum Products	**Electricity**	**Gas**
Bahrain	10.01	2.96	1.87
Kuwait	6.86	3.12	1.81
Oman	6.54	0.94	3.34
Qatar	5.42	1.26	1.76
Saudi Arabia	13.27	2.79	0.65
UAE	3.49	2.04	4.26

Note: Adapted from IMF staff estimates, OECD, IEA, Deutsche Gesellschaft für Internationale Zusammenarbeit, IMF World Economic Outlook, and World Bank as cited in *Energy Subsidy Reform: Lessons and Implications*, by IMF, 2013, p. 60.

By taking into consideration the externalities that result from subsidizing the fossil fuels, including electricity consumption, the percentage of the subsidies in the GDP almost doubles in almost all GCC countries as it rises from 7.94% of the GDP to 14.84% of the GDP in case of Bahrain, from 5.97% to 10.82% of the GDP in case of Oman, from 3.49% to 8.44% of the GDP in Qatar, and from 9.94% to 16.71% of the GDP in case of Saudi Arabia.

The heavy cost of energy subsidies on GCC economies is an established fact that needs to be tackled through a reform policy of the subsidies system in order to improve the fiscal position of GCC budgets and reduce the domestic energy consumption, which is seriously threatening the export capacity of GCC

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case of gasoline and motor diesel) other externalities such as traffic congestion and accidents; a revenue component, reflecting (ad valorem) tax on energy products that would be consistent with taxation of any other consumer good at the standard value-added tax (VAT) or general sales tax (GST) rate. (International Monetary Fund, 2013, p. 43) countries. Indeed, in the case of Saudi Arabia, for example, as a result of the energy subsidies, energy consumption in Saudi Arabia increases by 5% annually, and in order to maintain its actual export capacity to actual levels, it will need to increase its oil production by 2% annually, which means that by 2030, Saudi oil production will have to be at 15 mb/d with a domestic production that will be as large as the exports (Gately, Al-Yousef, & Al-Sheikh, p. 2012, p. 65). However, given the expected growing expenditures in Saudi Arabia, by 2030 Saudi Arabia will need to export as much as 11 mb/d at the actual prices of oil in the international markets, if it wants to be able to maintain its expenditures levels and to be able to respond to the growing social and economic needs of the society in general, which means that Saudi Arabia should be able to export 11 mb/d by 2030 with an overall oil production of 18 mb/d, which represents a 3% annual increase in its production capacity between now and 2030 and not 2% (Gately, et al., 2012, p. 65). Therefore, reducing the level of energy subsidies in order to reduce the energy consumption of all GCC countries is a vital necessity, assuming that the rentier political system is maintained.

Reforming the subsidies policy in the GCC country will be a challenge both economically and politically. Politically, the subsidies issue is intimately linked to the rentier nature of the socio-political contract in place in the GCC societies, and it is feared that any reform to the subsidies policy, in the absence of political reforms, could have serious political implications on the stability of the regimes in place. Some reforms have been made in a number of GCC countries but on a very limited scope and did not lead to structural changes in the subsidies equation. On the economic front, there are concerns that reducing the level of energy subsidies in the GCC countries could have adverse effects on the competitiveness of its energy intensive industries. It is very well known that the GCC countries in their efforts to diversify their economies have heavily invested in petrochemical and energy intensive energies where they enjoy a relative comparative advantage. Therefore, a reform policy of the subsidies should take into account this concern by implementing specific measures in order to mitigate the impact of higher energy prices on energy intensive industries.

As a result of the heavy burden of the GCC expenditure policies, which includes the subsidies discussed in this section, a major uncertainty regarding the financial sustainability of the existing expenditure policies of GCC governments has become even more evident in the past years, namely the fiscal break-even oil price which depends on the price of oil in the international markets and determines the level of GCC fiscal revenues and their expenditure policy capacities.

4.2.2.3. The fiscal break-even oil price: A major uncertainty

The budgets of the GCC states are currently characterized by a monetary and external surplus due to the elevated oil prices on the world markets. In 2011, financial surpluses reached around 13 percent of the GDP, with the external surplus exceeding 24% of the GDP (International Monetary Fund, 2012, p. 10). The financial situation of these countries is expected to remain the same in the short run; however, the increasing expenditures that have resulted from the rise in the price of oil have caused the fiscal breakeven price[70] for the GCC state budgets to rise to historical levels. Moreover, these expenditures are expected to increase in the future in order to offer extensive social services to their citizens in accordance with the rentier state model, develop their infrastructure, keep up with economic growth in the Gulf, and fund their infrastructural and industrial projects. In addition, demographic growth is increasing due to natural birth rates among the local population and the influx of foreign labor.

This fact in itself engenders a structural weakness and a propensity toward fluctuation. Indeed, Saudi Arabia increased its public "spending by over 100% in nominal terms between 2004 and 2009, and Qatar by almost 300%" (Alkadiri, 2010, p. 76), and as a consequence, the break-even oil price has also increased

[70] As defined by APICORP:

> a fiscal break-even price is the oil price that balances and oil-exporting country's budget . . its determination involves many different parameters [which include] hydrocarbon fiscal revenues (HFR) plus ordinary fiscal revenues (OFS) plus a transfer from a sovereign wealth fund (SWF) or a fiscal stabilization fund (FSF) (Aissaoui, 2013, p. 1).

from US$ 20 per barrel in 2000 to US$ 45 per barrel in 2009 (Alkadiri, 2010, p. 76), to around US$ 90 per barrel in 2013 (Aissaoui, 2013, p. 2), which represents a 100% increase between 2009 and 2013, equivalent to an average annual increase of 25% of the fiscal break-even oil price. Figure 14 below illustrates the increase in the fiscal break-even oil price of GCC budgets between 2012 and 2013.

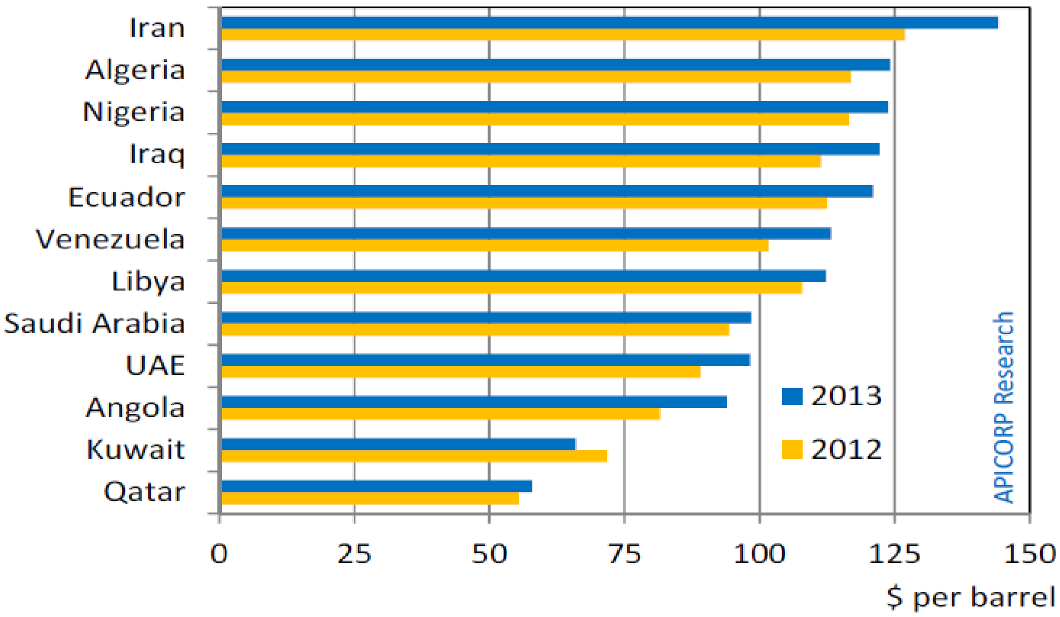


Figure 14: Break-even oil prices for 2012 and 2013 (US$/b). Adapted from "Modeling OPEC Fiscal Break-even Oil Prices", by A. Aissaoui, 2013, p. 2.

From the figure above, we can clearly see that the fiscal break-even prices have increased in 2013 comparatively to 2012, with the exception of Kuwait, which has seen its fiscal break-even price decline to around US$ 65 per barrel in 2013 as a consequence of declining investments in the oil industry. Saudi Arabia has seen its fiscal break-even price increase from US$ 94 per barrel in 2012 to US$ 98 per barrel in 2013. The fiscal break-even price in the UAE has risen from around 90 US$ in 2012 to US$ 98 per barrel. Qatar has also seen its break-even fiscal price increase from US$ 53 per barrel in 2012 to US$ 58 per barrel in 2013 (Aissaoui, 2013, p. 2). Bahrain and Oman are the GCC countries most vulnerable to oil fluctuations, as their fiscal break-even point in 2013 is at US$ 120 and US$ 100 per barrel, respectively (International Monetary Fund, 2012, p. 23). Based on these figures, we can evaluate the average fiscal break-even price of the whole GCC region at around US$ 90 per barrel. Knowing that the average price of oil during the fourth quarter of 2013 averaged US$ 107 per barrel and is expected to decline to US$ 102 per barrel in 2014 (U.S. Energy Information Administration, 2014), we can conclude that the GCC countries, taken as a group, have a very narrow fiscal margin. In the long run, it is thus clear that a significant collapse in the price of oil at US$ 90 per barrel or below would negatively affect the whole economy of the GCC region, and most of the GCC economies taken individually, with the exception of Kuwait and Qatar.

Moreover, a decline of the price of oil to US$ 98 per barrel and below will have very serious implications on the two biggest economies of the GCC region, namely Saudi Arabia and the UAE, with inevitable consequences on the other GCC economies and the region as a whole. Such a scenario is not farfetched, as after rising to historical heights of US$ 147/b in July 2008 for West Texas Intermediate (WTI)—61% higher than six months earlier—the price of oil collapsed to US$ 30/b five months later in December 2008.

A decline in the revenues of Saudi Arabia and the UAE alone will mean that these governments will more likely run budget deficits unless they have a fiscal stabilization fund (FSF) to draw from, and that they will have to reduce their expenditures, which will certainly have implications on their social welfare programs, defence expenditures, and check book diplomacy—i.e., on their regional role in the context of a very unstable regional political environment. Optionally, the GCC countries could increase their oil production in order to increase their revenues, but this option is constrained by the fact that it would have to be done within a collective agreement within OPEC; in addition, we must assume that the incremental production does not affect the price of oil downward in the international markets.

The continuous increase in the fiscal break-even oil price is the major threat to the success of the developmental projects in the GCC economies in general and to the success of the investment plans for the diversification of their energy sources in the power generation sector, knowing that energy transition processes are long-term processes requiring high and long-term investments. This issue is intimately linked to the core of the energy security concerns of the GCC governments and "the sustainability of current crude oil prices into the future"

(Alkadiri, 2010, p. 76). In fact, the growing public expenditures of GCC governments due to the high oil prices may in and of themselves sow the seeds of future economic crises, especially if the price of oil collapses in the global market under the pressure of a number of emerging challenges.

The long-term sustainability of the current oil prices, and the resulting sustainability of the actual levels of oil revenues to the GCC budgets, will be threatened by three main emerging challenges. In the short to medium-term, two main challenges will pressure the price of oil: the consequences of a gradual return of Iran in the oil market following the last nuclear accord with the group of 5+1 at Geneva, and the gradual emergence of Iraq as a major oil producer in the mid-term. The third main challenge is also long-term, and concerns the consequences of the shale oil revolution in the U.S., which is expected to shift from an oil-importing country into a nearly self-sufficient country by 2035 (IEA, 2012, p. 49), and the possibilities of its replication in the major oil consuming nations such as China and India. There is indeed a real possibility that these states will develop their capacities to produce unconventional oil and gas in large quantities, which would doubtlessly not only affect the price of oil in the international markets, but also the level of global demand for oil and gas produced in the GCC states (International Monetary Fund, 2012, p. 10), as already discussed in detail in chapter 3.

In an effort to limit this vulnerability, GCC governments have launched long-term economic diversification strategies that have produced mixed results, as we will see in the section below.

4.2.3. Measuring Diversification in the Context of the GCC

In political economy, diversification "normally refers to exports, and specifically to policies aiming to reduce the dependence on a limited number of export commodities that may be subject to price and volume fluctuations or secular declines" (Diversification, 2001, p. 360).

Economic diversification can be horizontal, i.e., to diversify within the same sector, or vertical, which involves a shift from one sector to the other and generally from the primary to the secondary and tertiary sectors (Hvidt, 2013, p. 5). In the GCC context, the objective of an economic diversification policy would be to reduce the dependency of the GCC budgets on the very heavy dependency on the revenues of oil and gas exports. According to Beblawi, when talking about economic diversification in the GCC countries, it is necessary to divide the manufacturing sector into two categories: *oil based* and *import substitution* industries (Beblawi, 2011, p. 186). In this respect, the GCC countries enjoy a comparative advantage in the petrochemical and energy intensive industries, which explains the development of these industries in the region at the expense of the import substitution industries. However, an economic diversification policy that will focus on the expansion of the oil and gas industry will not help achieve the goal of reducing the structural dependency on oil and gas nor contribute significantly in reducing the cyclical risk to which GCC economies are exposed.

As far as this research project is concerned, measuring the outcome of the economic diversification of the GCC economies will rely on three indicators: first, oil and gas as a percentage of economic indicators in the GCC countries; second, a historical evolution of the GDP breakdown by economic sector in the GCC countries; and finally, a comparison of the GDP breakdown by economic sector between the GCC economies and other economies.

4.2.3.1. The evolving structure of GCC GDP: A historical and comparative analysis

The economic growth of the GCC countries has been made possible mainly and essentially thanks to the oil wealth accrued from the export of oil in the international markets. Some achievements were made to diversify their economies, as they have relatively succeeded in lowering the proportion oil proceeds represent of their gross domestic products (GDP), with the UAE being the most notable example, as it has "seen a steady decline in mining as a share of GDP, from above 70% in the 1970s to around 30% in the 2000s, despite the sharp increase in oil prices in recent years" (Koren & Tenreyo, 2010, p. 6). However, the GCC economies continue to be dependent on oil revenues, as they still play an important role in their state budgets, which represent on average around 40 percent of the GDP and more than 78 percent of their export earnings, and 83 percent of their state budgets as it can be seen in Table 15 below, according to 2008 figures.

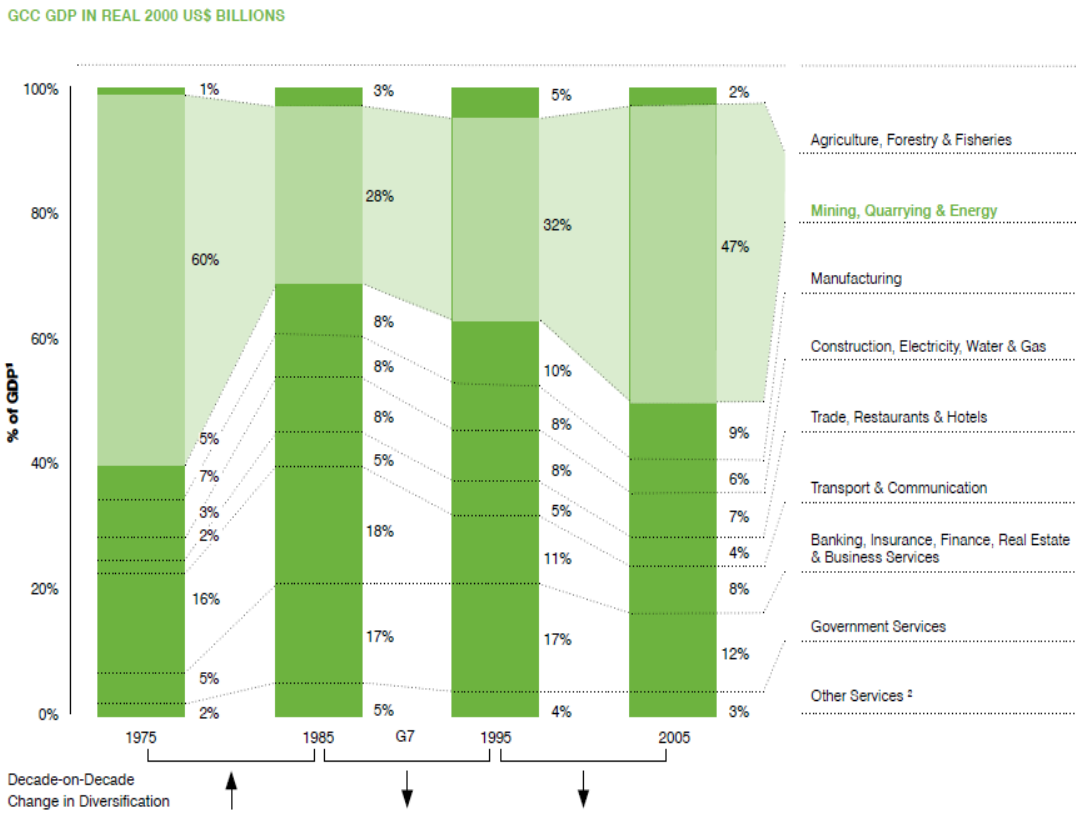
Table 15

Oil and Gas Revenues as a Percentage of Economic Indicators in GCC Countries in 2008

	% of Export Earnings	**% of State Budget**	**% of GDP**
BAHRAIN	69	86	24
KUWAIT	90	93	45
OMAN	65	77	41
QATAR	91	80	46
SAUDI ARABIA	85	85	50
UAE	69	77	32
TOTAL GCC	78.16	83	39.66

Note: Adapted from data calculated in the statistical appendix following each country section in Europa Publications (2011), as cited in Hvidt, 2013, p. 13.

Regarding the second indicator, the figure below reviews the historical evolution of GDP breakdown by economic sector in the GCC countries from 1975 to 2005.



[1] GCC figures are based on a constructed sample of GCC GDP series, subject to data availability.
[2] Other Services include community, social, and personal services; activities of private households as employers; and undifferentiated activities of private households, as well as extraterritorial organizations and bodies.

Figure 15: GCC GDP breakdown by economic sector 1975-2005. Adapted from UAE Ministry of Economy, SAMA, Central Bank of Kuwait, Oman Ministry of National Economy, Central bank of Bahrain, and Qatar Planning Council, as cited in *Economic Diversification: The Road to Sustainable Development*, by Abouchakra et al., 2008, p. 4.

We can clearly see the evolution of the GDP in GCC economies and how intimately linked it is to their revenues from the export of oil in the international markets. However, it is also worth observing that the share of oil sector in the economy has been on decline since the seventies, representing 60% of the GDP in 1975 and declining to 47% in 2005, and according to 2009 figures, declining further to 40.15% (Economic and Social Commission for Western Asia, 2012, p. 183). Historically, the political impetus for economic diversification coincided with periods of low oil prices in the international markets, and as consequence, at times of reduced revenues; however, the recent interest in diversification policies is "atypical in the sense that the diversification coincided with a period of high income" (Hvidt, 2013, p. 2).

When it comes to the third indicator, the picture about the results of energy diversification is even clearer when compared with other economies including resource rich economies like Canada and Norway, as shown in the figure below:

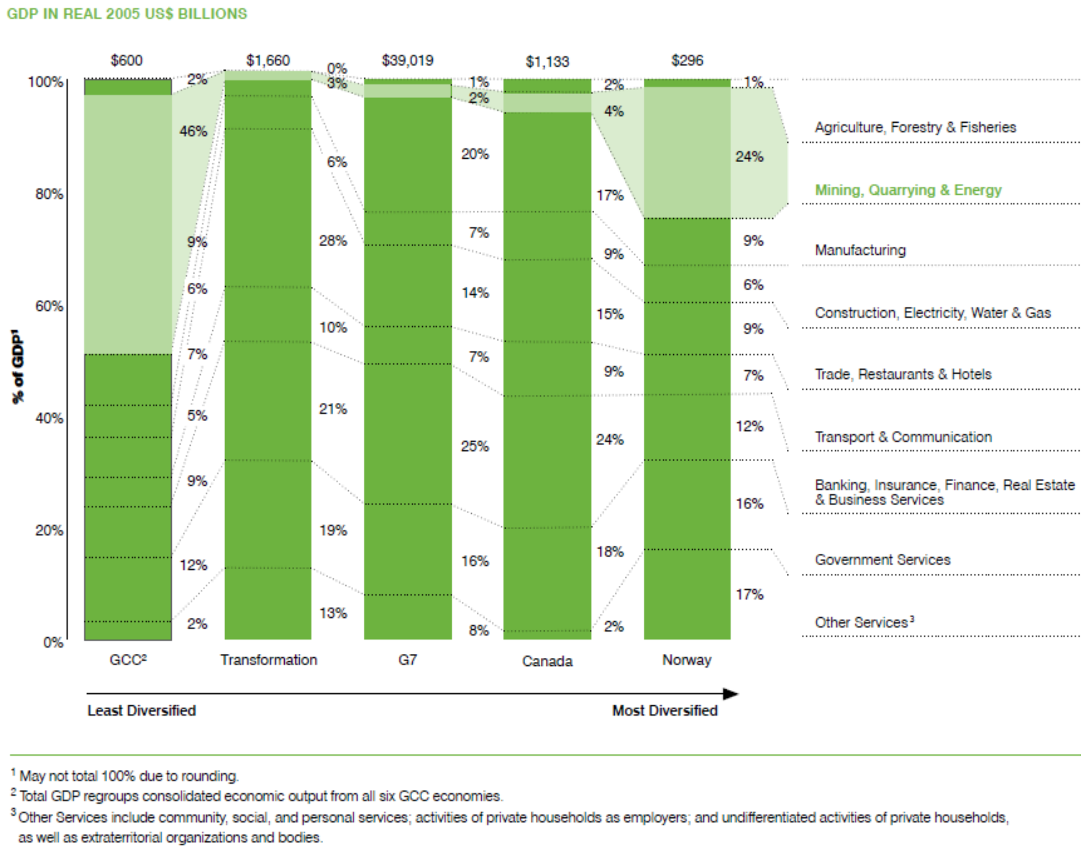


Figure 16: Comparison of GDP breakdown between GCC and other economies. Adapted from UAE Ministry of Economy, SAMA, Central Bank of Kuwait, Oman Ministry of National Economy, Central Bank of Bahrain, Qatar Planning Council, IMF, and OECD official statistics of sampled economies as cited in *Economic Diversification: The Road to Sustainable Development*, by Abouchakra et al., 2008, p. 5.

As a consequence of the dependency of GCC revenues on oil and its price on the international markets, the economies of the Gulf countries are more cyclical in nature than economies with comparable levels of development (Koren & Tenreyo, 2010, p. 19). The over-reliance on oil wealth has negatively impacted the region's development, which suffers from structural deficiencies that hamper its advance toward comprehensive development—the result of an over-reliance on proceeds coming from outside the national economy, which is determined by the global oil market and its constant fluctuations

4.2.3.2. SWFs

Historically, with the exception of two funds established in the U.S. during the second half of the 19th century, the Texas Permanent School Fund in 1854, and the Texas Permanent University Fund in 1876, the first Sovereign Wealth Fund of the world during the 20th century was established in the GCC region by Kuwait in 1953 (Sovereign Wealth Fund Institute, 2014a). A specifically established vehicle was created in that respect called the Reserve for Future Generations (RFFG), which was first managed—very secretively—by the London-based Kuwait Investment Office (KIO) until 1992, when its management was handed over to the Kuwait Investment Authority (KIA) following a parliamentary investigation prompted by doubtful investments in Spain in the mid-1990s (Seznec, 2012, p. 78).

Given the variety of SWFs and the differences that exist between them, it is very difficult to find one definition that can embrace all, but for the sake of this research, it will be useful to use two definitions: the first given by the Sovereign Wealth Fund Institute, and the second by Deutsche Bank. For the former, a SWF is defined in the following terms:

> A Sovereign Wealth Fund (SWF) is a state-owned investment fund or entity that is commonly established for balance of payments surpluses, official foreign currency operations, the proceeds of privatizations, governmental transfer payments, fiscal surpluses, and/or receipts resulting from resource exports. The definition of sovereign wealth fund excludes, among other things, foreign currency reserve assets held by monetary authorities for the traditional balance of payments or monetary policy purposes, state-owned enterprises (SOEs) in the traditional sense, government-employee pension funds (funded by employee/employer contributions), or assets managed for the benefit of individuals (Sovereign Wealth Fund Institute, 2014b).

The definition given by Deutsche bank states that:

> SWFs have the following characteristics: 1- Sovereign, 2- Independently managed from the Central Bank reserves, 3- Have a higher foreign currency exposure, 4- Have no explicit liabilities, 5- Have a higher risk tolerance, 6- Have a long term investment horizon, 7- Potentially could make strategic investments to promote reciprocity to the country. (Seznec, 2012, p. 71)

As far as the size of the GCC SWFs is concerned, here again, we have been confronted with a variety of figures as a consequence of the lack of transparency in the management of these funds, a situation that "has triggered a guessing contest between academics, consultants, and bankers to figure out how much each fund is worth, and what type of instruments are being bought and sold" (Seznec, 2012, p. 71). The table below summarizes the various evaluations according to different institutions:

Table 16

Estimates of GCC SWFs as per Various Institutions in US$ Billions

	Name of Fund and Date of Inception	**Deutsche Bank 2008**	**McKinsey 2008**	**SWF Institute 2014**	**JF Seznec Dec. 2010**
Bahrain	Mumtalakat 2006	10		7.1	
Kuwait	RFFG/KIA[71] 1953	264	200	410	
Oman	SGSF 1980	8		6	
Qatar	QIA[72] 2000	60	40-60	170	
Saudi Arabia	SAMA[73]	365		675.9	392
UAE	ADIA 1976 Mubadala 2002	874 10	500-875 10-15	773	363 27

Note: Adapted from Deutsche Bank: Sovereign Wealth Funds, Overview, October 2008, and McKinsey Global Institute, The Coming Oil Windfall in the Gulf, January 2008, as cited in "The Sovereign Wealth Funds of the Persian Gulf", by J. –F. Seznec, in *The Political Economy of the Gulf*, 2012, p. 72. The data from the SWF Institute was taken from its website (Sovereign Wealth Fund Institute, 2014a). (Treated by the author).

Despite these different estimates, as of today, the GCC SWFs are considered among the wealthiest in the world, with funds close to US$ 1.6 trillion

[71] RFFG stands for The Reserve for Future Generations and KIA stands for Kuwait Investment Authority.

[72] QIA stands for Qatar Investment Authority.

[73] According to the SWFs definitions, SAMA should not be considered a SWF given the fact that SAMA is the Central Bank of Saudi Arabia, and the funds have no independence from it. As rightly defined by Seznec, "SAMA invests its 'Wealth' on behalf of the 'Sovereign' but is not investing as a true SWF" (2012, p. 74).

according to 2007 figures (Shediac & Samman, 2009, p 2), which is already very significant.

The development of SWFs in the GCC countries could be viewed within the framework of the development of State Capitalism with a neo-patrimonial structure. Indeed, it is interesting to note that in the case of the GCC, the management structure of the SWFs follows the general pattern of the neo-patrimonial structure within the overall rentier system as discussed in the theoretical section of this chapter. In Abu Dhabi, for example, concerning the SWFs each "board of directors . . . represent the interests of one or more clans within the royal family . . . [and] [w]thin each board the chairman represents the royal clan that is most vested in the fund" (Seznec, 2012, p. 79). However, the funds are managed in a very professional way while at the same time efforts are made "to include the various clans and the major Abu Dhabi merchant families in all the funds" (Seznec, 2013, p. 79).

Initially, SWFs have essentially been created for macro-economic purposes and in order to "hold, manage, or administer assets to achieve financial objectives" (El-Kharouf, Al-Qudsi, & Obeid, 2010, p. 125) by diversifying their revenues away from the oil revenues. As most of the SWFs have been invested abroad, they do not create jobs locally and do not always contribute to further education and training of the local workforce (Hvidt, 2013, p. 9). Indeed, with the exception of Mubadala[74], and to a certain extent IPIC (International Petroleum Investment Company in Abu Dhabi), most SWFs invest internationally.

The strategic importance of Sovereign Wealth Funds to the GCC economies has significantly changed since the beginning of the 21st century and the rise in the price of oil, as they are now intimately linked "to the GCC's goals of economic diversification and socioeconomic development" (Shediac & Samman, 2009, p. 2), through investments that contribute toward acquiring new knowledge and technologies. In this respect, and with regard to our research subject, Mubadala—the mother company of Masdar city—has invested US$ 8

[74] Mubadala is an exception as it tends to invest in large industrial projects in the emirate, which ultimately benefits all Emiratis (Seznec, 2012, p. 81).

billion with General Electric on a number of projects that include clean energy technologies (Shediac & Samman, 2009, p. 8).

The role of the Sovereign Wealth Funds became evident during the decade long of low oil prices in the international markets in the 1990s. Indeed, during that period in Saudi Arabia, the Saudi Arabian Monetary Agency (SAMA) was able to infuse money into the economy from the excess foreign reserves it accumulated starting from the 1970s (Shediac & Samman, 2009, p. 2). Likewise, in Kuwait, the Kuwait Investment Authority (KIA) has allowed for paying allowances to every exiled family during the occupation of the country by Iraqi forces, and the reconstruction efforts of the oil infrastructure sabotaged by the Iraqi forces following the first Gulf war in 1991 (Seznec, 2012, p. 77).

In case of a future collapse of the price of oil in the international markets, the GCC countries have accumulated reserves that should allow them, to a certain extent and at varying capacity from one country to another, to fill the budgetary deficit for a certain period of time, as we can see from the figure below:

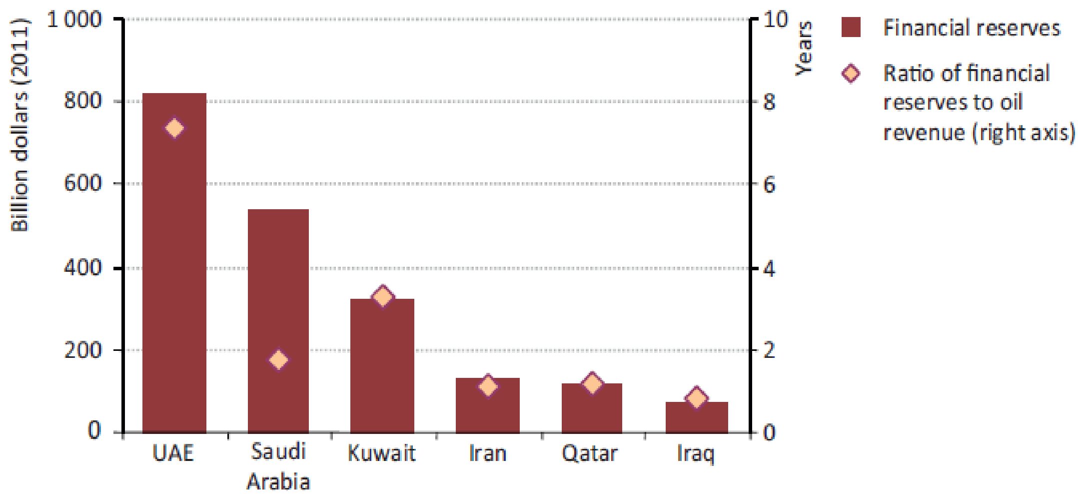


Figure 17: Number of years cover for oil revenues from financial reserves[75] in selected countries. Adapted from IMF, SWF Institute and Development Fund for

[75] Financial reserves estimates include central bank reserves (used primarily for backing a national currency) and, where appropriate, the estimated value of sovereign wealth funds (often used to serve a broader range of government objectives). While Qatar has a relatively low number of years

Iraq databases; IEA analysis as cited in *World Energy Outlook* by International Energy Agency (IEA), 2012, p. 405.

According to the figures above, the UAE's financial reserves can cover the oil revenues for seven years with a fiscal break-even oil price of US$ 98/b; Saudi Arabia's financial reserves can cover the oil revenues for close to two years with a fiscal break-even oil price of US$ 98/b; Kuwait for more than three years, with a fiscal break-even oil price of US$ 65/b; and Qatar for slightly more than one year, but we have to keep in mind that Qatar has the lowest fiscal break-even oil price at US$ 58/b. The comparison between the number of years cover from the SWFs and the fiscal break-even oil price is useful in order to know which countries will be first affected by a decline in the price of oil and how fast their budgets will be placed under stress.

In case of a decline in the price of oil below US$ 98/b, Saudi Arabia and the UAE—the two biggest economies of the region—will be the first affected and will be the first ones to use their financial reserves to fill the gap between their revenues and their expenditures. Kuwait has enough financial reserves to cover for three years of oil revenues but has a low fiscal break-even oil price at US$ 65/b, and Qatar, despite its low level of financial reserves, is favored by a very low fiscal break-even oil price at US$ 58/b. As far as Bahrain is concerned, its budget is already under stress, with a combination of very small SWFs and very high fiscal break-even oil prices at US$ 120/b, and remains afloat only thanks to Saudi financial contributions. Oman is very close to the disequilibrium point with a fiscal break-even oil price at US$ 100/b, and the price of oil ranging between US$ 100.60/b (WTI crude oil) and US$ 109.58/b (Brent crude oil) in the international markets ("Crude Oil," 2014).

Given that the GCC SWFs are now much more diversified than in the past, it is reasonable to expect that their sizes will continue growing in the long term, assuming that the price of oil remains high and that the GCC governments can rely on them for a relatively long period of time—most likely a decade—to balance their budgets in case of fiscal and budgetary deficits resulting from a

cover, it also has the lowest fiscal breakeven oil price of the countries shown. (IEA, 2012, p. 405) sharp decline in the price of oil in the international markets. However, the fiscal pressure will be much higher beyond a decade, especially if we take into consideration the growth of the fiscal break-even oil price.

In the past few years, the GCC governments have diversified the investment destinations of their SWFs towards higher-yielding assets like equity and non-state debt, even if until the present time “public equities represent a significant portion of some SWFs’ investments in the region” (Shediac & Samman, 2009, p. 6). Public equities are more secure; however, their return is very low and could reach less than 1% for a typical 0 to 3 years of dollar denominated Treasury bills, compared to an average annual return of 6% for a portfolio of stocks and bonds (with a 60/40 ratio respectively) (Shediac & Samman, 2009, p. 6). There is indeed a very clear difference in terms of risk between these two different types of investments. Treasury bonds allow for a relative security in the short term; however, “there is a substantial likelihood that real, inflation-adjusted returns over the long term for investments administrated by central banks will be negative” (Shediac & Samman, 2009, p. 7), whereas in the case of more diversified portfolios with private equities, the long term prospects are statistically more favorable, with higher returns and lower losses, than portfolios managed by typical central banks (Shediac & Samman, 2009, p. 7) with returns that are even higher than from the export of oil, as can be clearly seen from the figure below which compares the returns from the oil market to those of the private equities and treasury bonds.

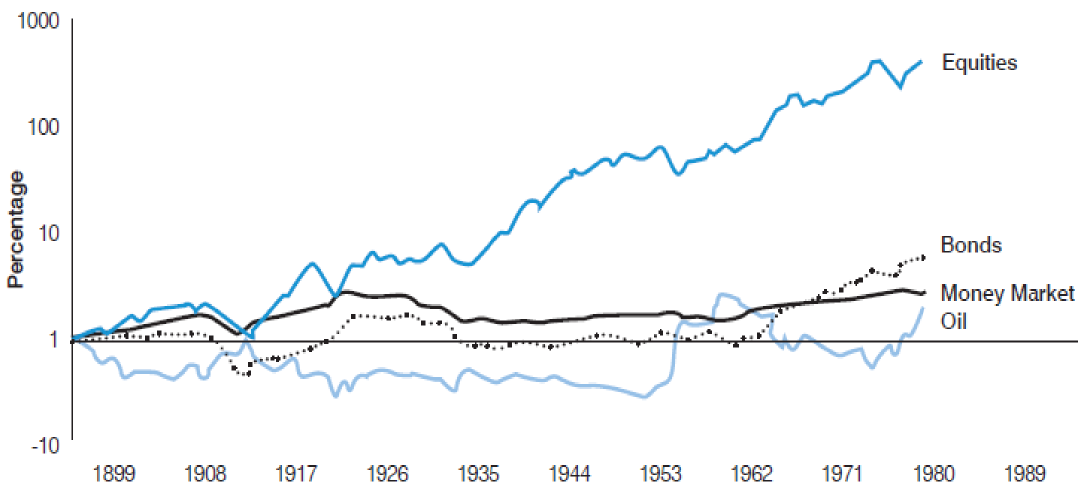


Figure 18: Historical comparison between real returns from the oil market, equities and bonds 1900-1990. Adapted from Morgan Stanley as cited in *The Vital Role of Sovereign Wealth Funds in the GCC's Future*, by Shediac and Samman, 2009, p. 7.

It is true that the recent financial crisis has highlighted the potential risks inherent in investments in the global economy, as during the 2008-2009 financial crisis, "many funds lost from 30 to 60 percent of the value of their investment on the stock markets and in hedge funds" (Seznec, 2012, p. 74). Indeed, Qatar Investment Authority (QIA) "lost very large amounts on its purchases of shares in 2008 and Spring 2009, when the shares of most financial institutions, especially banks like Barclays and Credit Suisse, declined enormously"[76] (Seznec, 2012, pp. 74-75). Between 2008 and 2009, QIA bought a share of 5.8% in Barclays capital, and 10% of Credit Suisse's capital (Seznec, 2012, p. 74). However, in the long term, the outlook of SWFs is expected to remain positive even in the case of future financial setbacks (Shediac & Samman, 2009, p. 4).

The economic diversification strategy of the GCC countries is not limited to the expansion of industry or to the financial aspect represented by the establishment of Sovereign Wealth Funds; it also includes an investment in education within the much broader objective of building knowledge economies in

[76] The values of the shares have by and large come back following the financial crisis: "For example, Credit Suisse, which was worth $78.59 per share on April 27, 2007, plunged to $20.11 on March 6, 2009 but recovered to $46.15 as of February 4, 2011" (Google.com/finance under CS as cited in Seznec, 2012, p. 75).

the long-run and moving from a rentier economy and society to a productive economy and society that produces its wealth from innovation and the production of knowledge, or to what is more commonly known as a knowledge economy. In this respect, it will be interesting to see how the GCC countries have performed until now based on the Knowledge Economy Index produced by the World Bank.

4.2.3.3. The challenge of the knowledge economy in the GCC

In today's global economy, "knowledge (including education, skills, information, and know how) and its renewal and application have become critical factors for sustaining competitiveness and economic growth" (World Bank, 2008: p. 84). In this respect, to measure the progress that countries are making in their transition to a knowledge economy, the World Bank has developed a Knowledge Economy Index that it defines in the following terms:

> The Knowledge Economy Index (KEI) is an aggregate index representing a country's or region's preparedness to compete in the knowledge economy (KE). The KEI is based on a simple average of four sub-indexes which represent the four pillars of the knowledge economy: Economic Incentive and Institutional Regime (EIR); Innovation and Technological Adoption; Education and Training; Information and Communications Technologies (ICT) Infrastructure. (World Bank, 2012, p. 1)

According to the 2012 KEI, the GCC countries are reasonably well ranked comparatively to other economies with three of them (Oman, Saudi Arabia, and the UAE) making significant improvements in their ranking when compared with the year 2000, whereas the three other GCC countries (Bahrain, Kuwait, and Qatar), despite a good ranking in 2012, have seen their ranking decline comparatively to the year 2000, as we can see from Table 17 below:

Table 17

Knowledge Economy Index (KEI) 2012 Rankings of GCC Countries

COUNTRY	2012 RANK	KEI 2012	2000 RANK	CHANGE FROM 2000
UAE	42	6.94	48	6
BAHRAIN	43	6.90	41	-3
OMAN	47	6.14	65	18
SAUDI ARABIA	50	5.96	76	26
QATAR	54	5.84	49	-5
KUWAIT	64	5.33	46	-18

Note: Adapted from *Knowledge Economy Index (KEI) 2012 Rankings*, by World Bank, 2012, p. 2 (treated by the author).

We can clearly see from the table above that the general ranking of the GCC countries is relatively good, as they are placed in the first half of the 146 countries subject of the ranking by the World Bank. Some GCC countries like Oman and Saudi Arabia have witnessed substantial improvements from the year 2000, while others, and especially Kuwait, have witnessed a very significant decline in their ranking comparatively to 2000, which is most probably due to the political instability of its political system and the chronic crisis in the relationship between the parliament and the ruling establishment. However, it is interesting to compare the evolution of the KEI of the GCC countries on a longer time period and with other economies, as shown in Table 18 below, in order to assess how it has been performing until now, and what would be the most probable trend and the pace of development of a knowledge economy in the GCC region in the future. This issue is important, as it will allow us to assess the capacity of the GCC economies to acquire, imbed, and develop energy technologies in the process of energy transition and the diversification of their energy mix in the power generation sector, in the long run.

Table 18

Knowledge Economy Index (KEI) Comparison, GCC & Others 1995-2000

Country	**KEI**		**Economic Incentive and Institutional Regime**		**Innovation**		**Education**		**ICT**	
	Recent	1995	Recent	1995	Recent	1995	Recent	1995	Recent	1995
United States	8.77	9.53	8.41	9.30	9.46	9.55	8.70	9.44	8.51	9.84
United Arab Emirates	6.94	6.39	6.50	6.90	6.60	6.59	5.80	4.46	8.88	7.62
Bahrain	6.90	6.97	6.69	6.95	4.61	6.93	6.78	6.49	9.54	7.52
Oman	6.14	5.34	6.96	6.33	5.88	5.48	5.23	3.65	6.49	5.89
Saudi Arabia	5.96	5.02	5.68	4.45	4.14	5	5.65	4.11	8.37	6.51
Qatar	5.84	5.86	6.87	5.64	6.42	4.79	3.41	5.52	6.65	7.49
Russian Federation	5.78	5.67	2.23	2.60	6.93	5.64	6.79	7.84	7.16	6.60
Brazil	5.58	5.08	4.17	4.83	6.31	5.98	5.61	3.35	6.24	6.17
Kuwait	5.33	5.71	5.86	5.36	5.22	5.50	3.70	4.51	6.53	7.46
South Africa	5.21	6.05	5.49	3.74	6.89	7.26	4.87	6.33	3.58	6.89
China	4.37	3.99	3.79	3.46	5.99	4.07	3.93	3.68	3.79	4.77
India	3.06	3.57	3.57	3.57	4.50	3.70	2.26	2.51	1.90	4.50
Average GCC	6.19	5.88	6.43	5.94	5.48	5.72	5.10	4.79	7.74	7.08
Average BRICS	7.39	4.80	3.85	3.64	6.12	5.33	4.69	5.88	4.53	5.79
Middle East and N. Africa	4.74	n/a	5.41	4.63	6.14	6.39	3.48	n/a	3.92	5.94
World	5.12	n/a	5.45	5	7.72	7.91	3.72	n/a	3.58	7.16

Note: Adapted from *Knowledge Economy Index (KEI) 2012 Rankings*, by World Bank, 2012, p. 2 (treated by the author).

On average, the GCC economies taken as a whole are not very far from the BRICS economies, they are doing much better than the Middle East and North Africa region to which they belong, and are above the world average. However, when we compare the long term evolution of the KEI of the GCC region, with the long term evolution of the KEI of the BRICS, it is interesting to note that the latter have improved their ranking by 53.9% from 1995 to 2012, whereas the GCC economies have only evolved by 5.3%—a clear indication of the very slow process of development of a knowledge economy in the GCC countries despite the very significant financial resources available to them, albeit some progress made during this period. Based on these findings, we can conclude that the GCC countries, given their high level of integration in the global economy, are relatively well prepared for acquiring new energy technologies developed internationally, but their progress in the long run in order to imbed and develop new energy technologies will be very slow. Indeed, from the figures above we can see that the GCC economies have performed very poorly as far as innovation is concerned, as they have not made any positive progress in that respect; on the contrary, they even regressed by 4.2% during the period from 1995 to 2012. Innovation is therefore the main weakness of the GCC countries and it will most probably be the main obstacle they will face in their efforts for a long term energy transition.

This weakness becomes even more manifest in the education sector where "the composition of post-compulsory education programs continues to favor humanities and arts over scientific fields of studies, as on average about two thirds of university students in the GCC countries major in these fields, which is higher than the averages of East Asia at 53.68%[77] and Latin America at 56.8%. Indeed, according to World Bank data, the proportion of students in education, humanities and social sciences reached 60% (per 2002 figures) in Bahrain, 75.3% (per 2003 figures) in Oman, 67.4% (per 2003 figures) in Qatar, 75.6% (per 2003 figures) in

[77] It should be noted in this respect that the average for Asia exceeds the 50% as a result of the average of Indonesia at 76.2%, and Thailand at 71.9%. Without these two countries, the average would have been below 50% at 43.5%. The lowest proportion of students in education, humanities and social sciences is in China with only 32.2% (World Bank, 2008, p. 21).

Saudi, and 57.8 (per 1996 figures) in the UAE, with an average for the region of 67.22% (World Bank, 2008, p. 21).

The GCC countries have certainly made significant efforts in the education sector in the past decades; however, when we compare the outcomes regarding the scientific capacities of the region with other regions of the world, we can see that very significant efforts remain to be made in the long-run. Indeed, according to UNESCO data, the whole MENA region performs very poorly in terms of scientific capacities, as we can see from Table 19 below:

Table 19

Comparison of World Researchers, 2002

	Researchers (thousands)	**% World Researchers**	**Researchers per million inhabitant**	**GERD [78] per Researcher (US$ thousands)**
All Arab States	39.7	0.7	136.0	47.2
Arab States Asia	9.7	0.2	93.5	66.6
Arab States Africa	30.0	0.5	159.4	40.9
Sub-Saharan Africa	30.9	0.6	48.0	113.9
OECD	3414.3	61.8	2984.4	191.9
Latin America and the Caribbean	138.4	2.5	261.2	156.5
Newly Industrialized Asia	291.9	5.3	777.2	183.7
Israel (1997)	9.2	0.2	1395.2	661.1
WORLD	5521.4	100	894.0	150.3

Note: Adapted from UNESCO Institute for Statistics estimations, December 2004, as cited in *UNESCO Science Report 2005*, by United Nations Educational, Scientific and Cultural Organization (UNESCO), 2005, p. 6 (treated by the author).

The data above very clearly shows a structural weakness in the entire MENA region, with an even poorer performance for the Arab states in Asia, where the GCC countries are included. The main indicator in that respect is the last position enjoyed by the MENA region in terms of number of researchers per

[78] GERD stands for Gross Expenditures on R&D.

inhabitants, where all Arab states have a ratio of 136 researchers per million inhabitants, whereas Israel alone has 1395.2 researchers per million inhabitants according to 1997 figures. In addition, despite the investments made in the development of education in the MENA region, the ratio of the Gross Expenditures on R&D (GERD) per researcher in the region remains the lowest in the selected countries in the table and among the lowest in the world. In general, the MENA region does slightly better only comparatively to Sub-Saharan Africa. This poor performance is also found regarding scientific publications, as compared to the global average, "the number of scientific publications originating in the Arab world does not exceed 1.1% of world production (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2005, p. 161).

On the patents indicator, the figures indicate that patents originating from the Middle East and North Africa, including the GCC, illustrate the very poor scientific production and capacities of the region, as shown in the table below:

Table 20

Regional Origin of Patents at the EPO, USPTO and JPO, 2000.[79]

	Total 1991	**Total 2000**	**% World 1991**	**% World 2000**
All Arab States	2	3	0.0	0.0
Arab States Asia	1	3	0.0	0.0
Arab States Africa	1	0	0.0	0.0
OECD	27822	40610	93.0	93.1
Latin America and the Caribbean	1809	2192	6.0	5.0
Newly Industrialized Asia	150	698	0.5	1.6
Israel	104	342	0.3	0.8

Note: Adapted from OECD, Patent Database, September/October 2004, as cited in as cited in *UNESCO Science Report 2005,* by UNESCO, 2005, p. 8 (treated by the author).

The figures above speak by themselves and show the extent of the structural weakness and deficiency of all MENA countries, including the GGG countries.

According to the UNESCO Science Report (2005), the MENA region has failed in delivering the high quality scientists it desperately needs in order to build economic self-reliance and capacity for innovation in the region, and it attributes this situation to a lack of political stability and a low-quality education and inadequate R&D infrastructure (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2005, p. 159).

As already mentioned above, the experience of the GCC countries in the oil and gas sector in regards to technology has mainly relied on importing the needed state of the art technologies and accompanying human knowledge in order

[79] EPO stands for European Patent Office; USPTO stands for United States Patent and Trade Office; JPO stands for Japan Patent Office.

to develop their oil and gas industry (including the petrochemical industry), and it is expected that this model will remain in force for the process of energy transition in the power generation sector up to 2050 or the foreseeable future. As stated by Hertog and Luciani, the GCC countries "have consistently built their development model on strong global integration and reliance on external sources of technology, know-how and manpower" (Hertog & Luciani, 2009, p. 16). This includes managerial best practices, and it is expected that the same model will be applied for the deployment of renewable and nuclear energy technologies in the power generation sector. As a consequence, the efforts of the GCC countries to transform their economies into knowledge economies, in which innovation will be imbedded in the social and economic fabric of their economies, will be a slow process and achieved only in the very long term.

The concept of knowledge economy in the GCC region has resulted in numerous great improvements in a number of indexes but still has a significant structural weakness when it comes to the innovation index and the scientific capacities that are at its core. Despite the important achievements made in the whole MENA region and the GCC in particular, in the past three decades, a long way still remains ahead before they can achieve the long-sought objective of knowledge economies in the GCC region. In this respect, the GCC countries will need to improve the quality of their education system, but "most crucially, the region needs reforms that will help build societies that promote tolerance, allow freedom of expression, encourage free thinking and respect human rights if Arab states are to develop fully their potential" (UNESCO, 2005, p. 175).

Based on the above findings, we can conclude that the GCC economies will need to sustain long-term investments in the education sector in order to develop the necessary scientific and R&D infrastructure and capacities, which will need to be coupled with necessary political reforms that will allow for a transition towards a knowledge economy. In this respect, the investment capacity of GCC governments in the long term will greatly depend on the future outlook of their revenues and the price of oil in the international markets, as any collapse in the price of oil could potentially destabilize the GCC budgets and reduce their investment capacity in all the sectors of the economy, including education and the deployment of new energies in the power generation sectors.

Between the mid-eighties and the end of the nineties, the GCC countries witnessed an economic recession as a result of a sharp decline in the price of oil in the international markets. It will be interesting for the sake of this research and in the perspective of our exploration of the future, to revisit this historical economic crisis and its implications on the GCC countries in order for us to evaluate the investment capacity of the GCC governments in pursuing their economic diversification efforts and for deploying alternative and renewable energies in the long run.

4.2.4. A Historical Perspective on the Oil Crisis of the 1980s and its Repercussions on the GCC

The rise in oil price in the 1970s led to a number of new decisions and policies in the major industrial countries aimed at lowering oil consumption and reliance on OPEC oil producers. These countries encouraged the development of energy-saving technologies and the production of oil from new fields outside of the OPEC countries, such as North Sea oil, despite its high production cost. These decisions, enacted in tandem with the economic recession that hit the global economy during the 1980s, led to a drop in global oil demand and heralded a phase of continuous decline in oil price that lasted until the late 1990s. The price per barrel went down by more than 40% in relative value between 1981 and 1996 and by more than 59% in real value, which negatively impacted the revenues of the GCC countries (Rivlin, 2001, p. 51). For example, GDP per capita in Saudi Arabia went down from USD 18,039 per year in 1981 to USD 7,181 in 1998, a situation that was mainly a result of the significant fall in oil price during the 1980s and the 1990s—as can be seen from Figure 19 below—coupled with fast-paced demographic growth in Gulf countries (Niblock & Malik, 2007, p. 117).

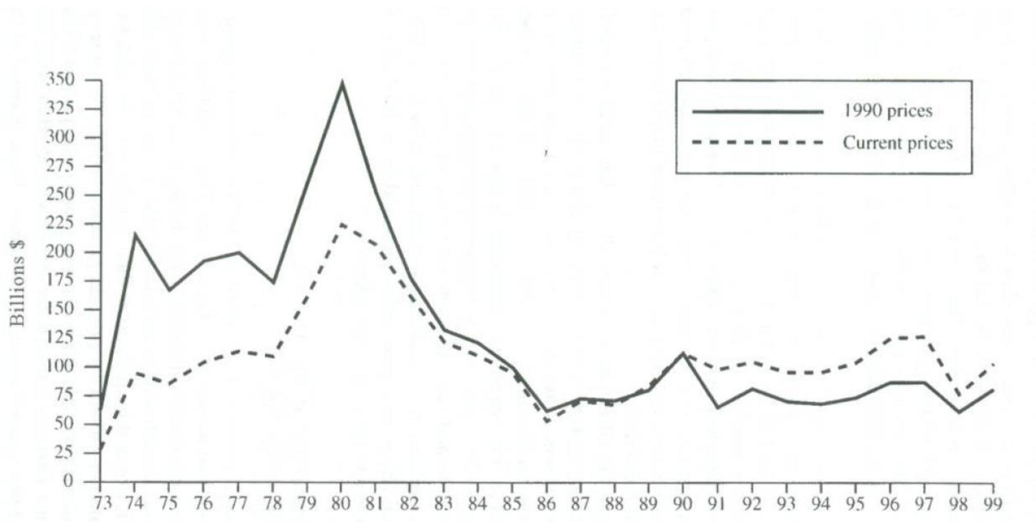


Figure 19: Oil proceeds of OPEC countries between 1973 and 1999. Adapted from *Economic Policy and Performance in the Arab World*, by R. Rivlin, 2001, p. 50.

If analysis is based purely on economic principles, economic rationality should prompt oil-consuming nations to encourage oil production where the cost of extraction is low, such as in the GCC countries. Historically, however, the opposite has taken place. The 1973 oil crisis was spurred by the oil embargo imposed by the Arab oil-exporting countries on the US, Western Europe, and Japan, which came about as a retaliation for these countries' support for Israel during the 1973 October War. This crisis constituted a major shock to the world economy, especially the economies of Western countries. During that time, the price of oil on the international market rose by 70 percent, which gravely affected the global economy, including a protracted worldwide economic recession.[80] The sharp increase in the price of oil affected the cost of importing oil and oil derivatives for the majority of countries around the world, especially Western countries, as they tend to consume the most and are reliant on hydrocarbon imports. Between 1973 and 1987, this led to the adoption of consumption-curbing policies on the one hand—by increasing their energy system's efficiency and changing the consumption habits of society—and on the other, to the enactment of

[80] It would be difficult to determine the real reasons that led to the recession after the oil embargo crisis in 1973, since the crisis took place alongside the adoption of a number of new financial and monetary policies in Western countries that complicated the economic situation.

strategies by a number of countries to lower their reliance on imported oil by turning toward other non-OPEC oil-producing regions, especially outside the Middle East, such as the North Sea and Alaska, despite increased production cost. Moreover, these changes have also led to the encouragement of the development and adoption of alternative or renewable energy sources.

Norway and Great Britain encouraged the exploration and production of oil in the North Sea through tax incentives and new policies. Simultaneously, a technological breakthrough lowered the cost of oil extraction from the North Sea fields, leading to a rise in production from 3.5 million barrels per day in 1988 to 5.9 million barrels of oil per day in 1996 (Rivlin, 2001, p. 52). Based on this historical experience, it appears that governments of energy consuming countries, and especially Western governments, are presumably willing to sacrifice economics in exchange for strategic objectives relating to energy security, especially when they have the technological know-how coupled with a strong political will. These countries are endowed with superior scientific and technological capacities that may permit them to decrease the high cost of production in the early stages, as the production cost is usually seen to drop with the expansion and the scaling up of projects. For this reason, decision makers and experts in oil producing GCC countries rely excessively on an abundance of cheap oil, although it carries a variety of risks; however, history has shown the flaws in this way of thinking.

The spike in oil prices during the 1970s prompted Arab governments to expand their budgets and increase investments in development projects, leading to deficits in the balance of payments and forcing these governments to resort to foreign loans during the 1980s. After the collapse of oil prices in the mid-1980s, oil-producing countries, including the GCC, suffered economically, and as a result, the economic aid sent from rich Arab countries to poor Arab countries was also curbed, forcing some Arab governments to resort to loans from the International Monetary Fund and to undergo its structural adjustment programs.

The economic crisis of the 1980s and 1990s was not solely caused by the collapse of oil prices, but also by the emergence of other factors. Demographic growth, social changes, shifts on the international scene (e.g., the collapse of the

Soviet Union and the Eastern Bloc), and regional security crises—the First Gulf War in 1990-1991, all played a role[81]. The significant and long-term drop in oil price negatively affected the budgets of these governments, limiting their ability to perform their distributive role within the rentier system of the GCC countries.

Oil revenues have also indirectly affected these countries considering the massive investments the Gulf monarchies made in education, health, infrastructure, and industrialization over the last four decades. These improvements have radically changed these economies and societies, which have witnessed the highest rate of demographic growth throughout the world. These countries have also become more diversified and better integrated in the global economy, raising the bar for expected social services, such as employment, health, and education. This is a key issue, as spending on social services engenders higher expectations in terms of future employment, especially because of the expanding demographics and the emergence of mass public education. Moreover, the GCC countries have adopted a public employment policy that has led to the creation of an important financial burden on the budgets of these states. Even the regional crises witnessed in the Gulf and the political and military foreign interventions were directly related to the stature of the Gulf States and their role in the global geopolitical energy map.

During the 1990s, the GCC states suffered economically as a result of their government's financial situation after the collapse of the price of oil in international markets, which began in 1986 when the price of oil went below US$ 10 per barrel (Nonneman, 2001, p. 9). Saudi Arabia was among the countries most affected by this slide in prices, as it was also influenced by external pressures after the First Gulf War and Western military intervention in the region. All of these factors prompted King Fahd to announce political reforms in 1992, including the issuance of the Basic Law of Saudi Arabia, according to

[81] In this context, the economic crises went in tandem with the tenure of Ronald Reagan in the United States and Margaret Thatcher in the United Kingdom, both of whom reoriented the Western—and, subsequently, the global—economy toward liberal economic policies. This was part of their promotion of the Washington Consensus, which called for the reduction of the role of the state in economic development. Furthermore, both Reagan and Thatcher contested the notion of providing monetary aid to the poor countries.

which an appointed Shura Council was founded a year later for the first time since the establishment of the Kingdom in 1932.

4.2.5. The Evolving Political Equation of GCC Power Equilibrium

Political stability is a necessary pre-requisite for any developmental strategy or projects, as recognized by Davidson (2009) when he said that "no amount of careful planning and astute management can sustain Abu Dhabi's economy should there be serious political instability" (Davidson, 2009, p. 94). From our analysis of the political economy in the previous section, we can clearly see that the internal contradictions and vulnerabilities in the political economy of the region reveal signs of weaknesses in the GCC monarchies—weaknesses that were evident in the popular unrest of Oman and Bahrain in 2011. These events are a reminder that the Arab monarchies of the Gulf are not immune from the Arab Spring, and as accurately observed by Kamrava (2012), "the mass-based rebellions that engulfed the Middle East, from Morocco to Algeria in the west, to Bahrain and Oman in the east, all had their roots in fundamental contradictions in the politics and economics of the region" (Kamrava, 2012, p. 1).

Among these contradictions are the population growth issue and its consequences, as the arrival of a rapidly growing young and educated generation to the job market is taking place in a context of labor nationalization policies that in most cases are not necessarily in accordance with the high employment expectations of these generations.

Demographically, the population in the Gulf is currently dominated by youth. In Saudi Arabia, for example, those aged 15 years or younger represent 40 percent of the total population, while those under 25 years of age representing more than 60 percent (Nonneman, 2001, p. 8). A population pyramid of Gulf countries clearly shows that satisfying the demand for new jobs will require additional financial resources and extensive investments in development projects. Furthermore, the quality of the jobs required is an important issue. Due to the immense changes witnessed by Gulf societies in recent years, and the young generation's desire to acquire jobs that fit their academic qualifications, salary expectations, and culture, fulfilling these demands will place an increasingly large burden on the national budgets of these countries. Given the cyclical instability of the revenues from the export of oil and gas, there are very serious doubts that the GCC governments will be able to fulfill the job expectations of future generations. Ultimately, an inevitable equation exists between the resources available and the demand for certain resources: the higher the revenues from oil exports, the higher the demand for social and economic services. Accordingly, Nonneman rightly concludes that the future expansion in the production of oil and gas in the region does not appear sufficient to fully satisfy the expected rise in social demands and demographic growth, which could then undermine the rentier social contract that has historically shaped the policies of this region (Nonneman, 2001, p. 6).

As already discussed in the theoretical section of this chapter, the autonomy of the late rentier state in the GCC, while large, is not absolute, as it has been responsive to social, economic, and—to a certain extent—to political demands and societal pressures. In this respect, the section below will review the historical constitutional as well as political developments in the GCC countries, as required within the framework of a futures study, in addition to a future outlook regarding possible future possible developments or trends regarding the political stability of the region.

4.2.5.1. An overview of constitutional developments in the GCC

Grounded on an analytical historical approach, this section will briefly review the constitutional developments in the GCC since their independence.

4.2.5.1.1. Bahrain: An absolute constitutional monarchy

Bahrain adopted its first constitution on the 26th of May 1973 following the first national election in Bahrain's history, an election that was restricted to native-born male citizens and to which women were excluded. However, as a result of the political repression undertaken under the 1974 State Security Law, the parliament was dissolved in 1975 and the constitution suspended. Between 1994 and 1999, Bahrain witnessed a popular uprising that was the result of political repression coupled with rising unemployment. It is worth noting in this respect that the triggering event of the uprising of the 1990s was a demonstration by unemployed citizens in front of the Ministry of Labour, which developed into an uprising where all political forces, leftists, liberals, and Islamists joined forces to demand a return to the constitutional process interrupted in 1975. The reasons behind the political instability of Bahrain can be found firstly in the erosion of the rentier socio-political contract as a result of the depletion of its oil resources, which created a deficit between the growing population and the dwindling oil revenues of the government; and secondly, in the political equation of the country, where a majority population composed of two thirds Shi'a Muslims is ruled by a ruling family that belongs to the one third Sunni Muslims minority (Peterson, 2006, pp. 11-20).

Following the death of the late Amir Sheikh Isa bin Salman Al Khalifa in 1999 and the arrival to power of his son Amir Sheikh Hamad bin Isa Al Khalifa, a national dialogue was initiated with all the political forces in Bahrain, which ultimately led to the adoption of the 2002 constitution following a referendum which allowed women to vote for the first time. The new constitution established a constitutional monarchy with a bi-cameral legislature, in which a lower-house is elected and the upper-house appointed by the current King. According to written assurances from King Hamad bin Isa Al Khalifa to the opposition leaders, the upper-house would have only an advisory role, with the legislative role remaining the sole responsibility of the elected lower-house, However, following the referendum, King Hamad bin Isa Al Khalifa contradicted his written pledge and promulgated a new constitution granting both houses of the parliament equal legislative powers, and thereby sowed the seeds of the actual uprising in Bahrain during the Arab Spring. Accordingly, the institutional reforms initiated by King Hamad in Bahrain in the 2000s cannot be considered to have changed the power structure, as no evidence exists of genuine political reforms (Ehteshami, 2013, p. 149). As a result, in the wake of the Arab Spring, popular demonstrations demanding political reforms and equality for the Shia majority of the country broke out again in February 2011 and were violently suppressed. A state of emergency was declared, and the military support of Saudi Arabia and the UAE was requested and then delivered through the Gulf Shield force in March 2011. This repressive policy was coupled with the pursuit of a national dialogue in an attempt "to reduce the prospects of total fragmentation between Sunni and Shia" (Ehteshami, 2013, p. 149). In addition, the Bahrain Independent Commission of Inquiry (BICI) was put into place to investigate the brutality of police repression, submitting a report to the King in November 2011. However, until the present time, the long-standing demands of the opposition have yet to see any concrete implementation, and the political stalemate in Bahrain remains in place, with a risk of increasing political violence in the future.

4.2.5.1.2. Kuwait: A rich but unstable parliamentary experience

Of the GCC countries, Kuwait has the oldest constitutional history, as its first constitution was written by a constitutional assembly between 1961 and 1962 and signed into law in November 1962 by Amir Abdullah III Al Salim Al Sabah. The first Majliss Al Umma (National Assembly) members were elected in 1963. However, the parliament has been suspended a number of times—the second time in July 1986, after which it was not reinstated until after the Iraqi invasion and Kuwait's subsequent liberation by a U.S.-led international coalition in February 1992. Only as a result of domestic and international pressures did the Emir finally enact his pledge to resume the constitutional process after liberation. Despite its long history, the constitutional experience of Kuwait is thus characterized by instability and chronic crisis as a result of inter-divisions, manipulations from the ruling family, and a strong opposition that was first led by the liberal MPs and then in more recent times by the Islamists (Peterson, 2006, p. 11-12).

Since the 2000s, long before the Arab Spring wave, the political landscape in Kuwait has been shifting towards "a new political era, where the concentration of power would be reduced as authority moved toward civil society, arguably at the expense of the ruling elite" (Ehteshami, 2013, p. 156). Indeed, the confrontation between the parliament and the Al Sabah rule culminated in November 2011 with the temporary occupation of the parliament by protesters following weeks of street protests under the slogan “new country with a new prime minster”, and the subsequent intervention of the Amir Sheikh Sabah, who described the storming of the parliament as “black Wednesday” (Ehteshami, 2013, p. 156). The changing balance of power in Kuwait became even more apparent following the parliamentary elections of February 2012, where a conservative Sunni Islamist-tribal coalition of Muslim Brotherhood and Salafis won 34 out of the 50 seats of the parliament (Ehteshami, 2013, p. 158). Given the rising tensions between this conservative coalition and the government over economic and public policy issues, there are serious doubts regarding the longevity of the parliament; however, the future outlook regarding the political instability of the country is not positive, and it is reasonable to expect that in the future, the balance of power will continue to change in favour of the civil society and at the expense of the ruling Al Sabah family, thereby redrawing the political map of the country.

4.2.5.1.3. Oman: A firm but responsive Sultan

Oman established its first constitution, The White Book, in November 1996 following a Royal Decree issued by Sultan Qaboos. The White Book, or the Basic Law, created a bicameral legislative body: the Majlis al-Dawla (Council of State), the upper house, and Majlis Al Shura (Consultative Council), the lower house, which were voted in during the 1997 elections. However, both councils were deprived of effective power, as they had no legislative power and could not overturn the Sultan’s decrees or government regulations.

Under the pressure of the popular unrest that took place in many cities of the country during much of 2011 (“Omanis Protest at Slow Pace of Reform”, 2012), Sultan Qaboos reacted with very limited repression combined with political as well as economic reforms. On the political front, two decrees were issued by Sultan Qaboos: the first in March 2011, and the second in October 2011, which included reforms that granted new but limited powers to the legislative bodies, “including approving, rejecting, and amending legislation, and the ability to question ministers who head agencies that provide direct citizen services” (Katzman, 2013, p. 6). As a result, legislative elections took place for the

Consultative Council, the lower house, in October 2011, and for the first time, municipal elections took place in December 2012. On the economic front, "Sultan Qaboos ordered that 50,000 new public sector jobs were created immediately, raised the minimum wage by about one-third (to about US$ 520 per month), and ordered that about US$ 400 be given to job seekers" (Katzman, 2013, p. 4-5). On the political front, the uprising led to the introduction of limited constitutional reforms that do not, however, undermine the powers of Sultan Qaboos. The originality of Oman in this respect is that Sultan Qaboos did not use the same levels of repression as seen in Bahrain and responded positively to the economic demands of the protesters coupled with limited political openings (Esteshami, 2013, p. 161). The future outlook of Oman, despite the 2011 popular protests, looks positive as long as there is no degradation in the economic sphere.

4.2.5.1.4. Qatar: The internal politics of the Al-Thanis

As far as Qatar is concerned, an appointed Consultative Council has existed since 1972, following its independence from the United Kingdom in September 1971, with only consultative powers. In July 1999, the ex-Amir Sheikh Hamad bi Khalifa Al Thani appointed a committee to draft a new constitution (Constitution of Qatar, n.d.) for the country, which was approved in a public referendum in April 2003 and approved by the Amir in June 2004 (Peterson, 2006, p. 11-27). According to the new constitution, the legislative body, the Shura Council, is vested with legislative authority and is composed of two thirds elected members (30) and one third (15) appointed by the Amir. According to the new constitution, its roles include an oversight authority over the Council of Ministers, and it will be able to propose legislation and review budgets. At the local level, municipal elections took place in July 1998, forming the Municipal Council. According to the new electoral law, women are allowed to participate in all elections. The political and constitutional promises of reform by the Amir Sheikh Hamad bin Khalifa Al Thani were mainly the result of "elite factionalism, and more specifically intra-family competition within the Al Thanis" (Kamrava, 2009, p. 403). Indeed, the main reason behind the promised reform agenda was to by-pass the conservative circles within the family that were more favourable to the

Amir's deposed father. As soon as Amir Sheikh Hamad Al Thani consolidated his power domestically and internationally, it became clear that implementation of the promised reforms would take more time than the initially declared calendar, as the first parliamentary elections initially planned to take place in mid-2013 were postponed and the appointed Consultative Assembly's term extended by three years—just before Sheikh Hamad transferred power to his son Sheikh Tamim bin Hamad Al Thani in June 2013. Despite the wave of optimism that followed the arrival of Sheikh Hamad Al Thani to power and his promoted and promised reform agenda, political reforms were not implemented, which led Kamrava (2009) to declare that "meaningful political liberalization remains as elusive as before, and the prospects for the political system becoming democratic do not seem even remotely possible" (Kamrava, 2009, p. 402). It is too soon at the moment to know the intentions of the new Amir, Sheikh Tamim, regarding the political reform agenda. However, it is possible to expect that the recent crisis between Qatar and Saudi Arabia, the UAE, and Bahrain regarding their different and conflicting foreign policies concerning the Arab Spring and their attitudes towards the military coup in Egypt, could probably lead the new and young Amir to resort to the same policies as his father in order to consolidate his power base, which means effectively implementing, and probably accelerating, the reforms agenda.

4.2.5.1.5. Saudi Arabia: An absolute monarchy albeit vulnerable

Saudi Arabia was the last country of the GCC to engage in constitutional reforms, which came only in 1992 and mainly as a consequence of the economic crisis that started following the collapse of oil price in 1986, and the emergence of a strong, Islamist opposition movement known as the Sahwa in reaction to the presence of non-Muslim troops in the Kingdom following Iraq's invasion of Kuwait in August 1990. In January 1992, King Fahd issued a Royal Decree to establish the Shura Council (Majliss Al Shura), whose members are appointed by the King, and which has only a consultative role without any legislative powers. The Saudi constitutional experience is the least developed in the GCC; the King still retains total control over the legislative as well as the executive functions. Indeed, in Saudi Arabia, despite the existence of vibrant social forces, the power and "centrality of the ruling family in national political life has been consolidated rather than diffused even under the guise of a 'reform agenda'" (Tétreault, Okruhlik, & Kapiszewski, 2011, p. 2).

The vibrancy of the social forces in Saudi Arabia became very obvious in the 1990s, when the Sahwa movement led an "opposition campaign against the royal family" (Lacroix, 2011, p. 2) following the call of the Saudi regime on American troops to protect the kingdom from Saddam Hussein, who invaded Kuwait in August 1990. The "Sahwa insurrection", referred to as *intifadat al-Sahwa* in Saudi Islamist circles, was capable of drawing and organizing a large sector of the Saudi public, and especially among the younger generations—a movement that has been described as "the only Islamist mobilization of major magnitude in the history of the country" (Lacroix, 2011, p. 3) that was capable of shaking the Saudi political establishment. The protest was organized through critical sermons in mosques denouncing the presence of non-Muslim foreign troops on the Land of the Two Holy Places, and through petitions that were signed by "some of the intellectual and religious elites of the Kingdom demand[ing] the introduction of radical reforms" (Lacroix, 2011, p. 3). The Saudi regime reacted repressively to the protest campaign, which lasted until late 1994, by arresting several hundred opposition supporters and introducing limited political reforms in January 1992, when King Fahd issued a Royal Decree to establish the Shura Council (Majliss Al Shura) whose members are appointed by the King and which has only a consultative role without any legislative powers.

The significance of this episode of Islamist political grassroots activism to the present situation and to the future political stability of the Kingdom is two-fold. Firstly, the Sahwa movement was an opposition that challenged the monopoly of the Saudi establishment of Islamic legitimacy and its religious base; secondly, the Sahwa movement's "principal originators were the exiled Muslim Brothers" (Lacroix, 2011, p. 38) who came to Saudi Arabia in the 1950s as exiles following the repression campaign they had suffered in Egypt's Gamal Abdel Nasser. The main concern of the ruling establishment in Saudi Arabia regarding the Arab Spring in general, and Egypt in particular, stems essentially from this historical experience and from its fear that Egypt ruled by the Muslim brotherhood could give birth again to a new Sahwa movement and threaten its absolute rule of the country. Even if the prospect of a new “Islamist insurrection” seems improbable in the short term, “it cannot be excluded in the medium term . . . [as] the Saudi Islamists—and the Sahwa—will remain central actors on the Kingdom’s political stage for years, and possibly decades to come” (Lacroix, 2011, p. 270), in addition to the growing pressures originating from the structural weaknesses in its political economy.

By approving and supporting the military coup in Egypt and the repression campaign that followed against the Muslim brotherhood, and labelling it as a terrorist organization in Egypt as well as in Saudi Arabia, the Saudi ruling establishment has opened itself to war with a very large section of Islamists abroad as well as domestically, and the outcome of which will mainly depend on the fate of the new military regime in Egypt, which has not yet consolidated its power, and does not seem to be winning its declared war on the Muslim brotherhood.

4.2.5.1.6. The UAE: Tarnishing its Liberal Capital

Following independence from the United Kingdom, the provisional constitution of the UAE was promulgated in December 1971. Being a federal system, the constitution provided for an executive federal body, the Supreme Council of the Union (SCU), and a legislative body represented by the National Federal Council (NFC) of 40 members, which has only a limited consultative role. The first elections of the NFC took place in 2006 with the participation of a selected electorate of around 7000 persons, representing less than 1% of the UAE’s population; the second elections of the NFC took place in September 2011 with an electorate of 129,274—still inadequately representative of the UAE overall population—and 468 candidates (including 85 women) (Ehteshami, 2013, p. 164). The major development that is worth noting in the context of the Arab Spring is the open petition of 133 intellectuals sent in March 2011 to the federal authorities, demanding an elected national parliament and more accountability. However, the petition did not receive any positive feedback from the federal authorities and any "evidence of major, or even incremental, change has been hard to come by" (Ehteshami, 2013, p. 165).

As a concluding note, the limited legislative and political reforms in the GCC countries came, in most cases, as a result of a combination of domestic and/or international pressures, and not reformist initiatives from the ruling families. Even when pushed to engage in constitutional or political reforms, the ruling establishments in the GCC countries managed to retain most of the powers in a way that did not undermine their authority or the rentier-authoritarian system of rule in force, through a combination of accommodative political methods. Indeed, notwithstanding some scattered limited advances, the GCC countries remain ruled by a combination of rentier and neo-patrimonial authoritarian structures that self-reproduce and are still far from a democratic system of rule and governance.

Despite the diversity of internal mechanisms of political life and developments in the GCC countries, there are still some common features that can briefly describe the actual situation: first, democratization is still a farfetched objective that has not yet materialized in the GCC region; second, in all GCC countries, if at different stages and speed, the balance of power between civil society and the ruling establishment is nevertheless definitely in the process of shifting, and it can be argued that this "is unlikely to be fully controllable by the elites" (Ehteshami, 2013, p. 166).

4.2.5.2. GCC public opinion and the democratic issue

The Arab Spring phenomenon has brought to the surface the emerging role of Arab societies in general and their demands for an increased role in the political and economic equations of their respective countries. In this respect, it will be interesting to use the results of the 2012-2013 Arab Opinion Index[82] survey,

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[82]The Arab Opinion Index (AOI) is a research project that aims to annually and systematically measure Arab opinion on a variety of issues of interest to Arab masses . . . The Arab Center for Research and Policy Studies is conducting this project on representative samples in all Arab countries that permit the

published annually by the Arab Centre for Research and Policy Studies, regarding the Saudi and Kuwaiti public opinion, the only two GCC countries included in the survey and which are a representative sample of the region in every respect, on a number of issues related to the democratic issue and its compatibility with Islam, whether their societies are ready for democracy or not, what is the opinion of their societies on democracy as a system of rule, and finally the public opinion of these two countries of the GCC regarding the Arab Spring.

Table 21 below shows the results regarding the statement: "Democracy is in contradiction with Islam".

Table 21

Results for the Statement: "Democracy is in Contradiction with Islam".

	Strongly Disagree	**Disagree**	**Strongly Agree**	**Agree**	**Do Not Know/Refused to answer**
Saudi Arabia	20%	37%	4%	8%	31%
Kuwait	9%	78%	2%	10%	2%
Arab Average	23%	45%	5%	13%	14%

Note: Adapted from *Arab Opinion Index*, by Arab Center for Research and Policy Studies, 2013, p. 80 (treated by the author).

According to the 2012-2013 Arab Opinion Index, in Saudi Arabia, 57% of the public do not agree with the statement "Islam is in contradiction with

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implementation of survey research. (Arab Center for Research and Policy Studies, 2011).

The 2012-2013 survey (the second since the launching of the Arab Opinion Index project) was conducted in 14 Arab countries including Mauretania, Morocco, Algeria, Tunisia, Libya, Egypt, Sudan, Palestine, Lebanon, Jordan Iraq, Saudi Arabia, Yemen, and Kuwait. The survey included all regions of the Arab world (Maghreb, Mashrek, Nile Valley, and the Arabian Peninsula), representing 89% of the overall Arab population. The survey was based on field questionnaires, with 21,350 respondents divided among the surveyed countries according to population weight. (Arab Opinion Index, 2013, pp. 2-3).

democracy", (divided between 20% who strongly disagree and 37% who simply disagree), while only 12% agree this statement (divided between 4% who strongly agree and 8% who simply agree), with a notable 31% of the respondents refusing to answer the question. In Kuwait, 87% do not agree with the statement (divided between 9% who strongly disagree and 78% who simply disagree), while only 12% agree (divided between 2% who strongly agree and 10% who simply agree), and with only 2% of the respondents refusing to answer the question (Arab Opinion Index, 2013, p. 80). When compared to the Arab world average, the results are to a certain extent in line with the general Arab public opinion, with a noticeably higher result in Kuwait of those surveyed (87% compared to the Arab average of 68%) who do not agree that democracy is in contradiction with Islam.

The second table below shows the results regarding the statement: "Our Society is not Ready for Practising a Democratic System".

Table 22

Results for the Statement: "Our Society is Not Ready for Practising a Democratic System".

	Strongly Disagree	**Disagree**	**Strongly Agree**	**Agree**	**Do Not Know/Refused to answer**
Saudi Arabia	13%	28%	9%	18%	33%
Kuwait	5%	71%	3%	19%	2%
Arab Average	12%	33%	12%	28%	14%

Note: Adapted from *Arab Opinion Index*, by Arab Center for Research and Policy Studies, 2013, p. 81 (treated by the author).

Regarding the statement "Our society is not ready for a democratic system", in Saudi Arabia, only 27% agree with this statement (divided between 9% who strongly agree and 18% who simply agree), while 41% do not agree (divided between 13% who strongly disagree and 28% who simply disagree), with a notable 33% of the respondents refusing to answer the question. In Kuwait, only

22% agree with this statement (divided between 3% who strongly agree and 19% who simply agree), while 76% do not agree (divided between 5% who strongly disagree and 71% who simply disagree), and with only 2% of the respondents refusing to answer the question (Arab Opinion Index, 2013, p. 81). From these figures, we can clearly see that in general, the public opinion in Saudi Arabia and Kuwait, as representative sample of the GGC coutries, consider their societies ready for a democratic system, with a noticeably larger positive opinion in Kuwait compared to Saudi Arabia as a result of the differences in the political and institutional history of both countries. Moreover, the proportion of respondents in Saudi Arabia who refused to answer the question is very high, which could be largely attributed to a much narrower margin for the freedom of expression in Saudi Arabia, as this trend is also found with the other questions of the survey. When compared to the Arab world average, it is interesting to note that in Saudi Arabia, the proportion of those surveyed who agree that their society is not ready for a democratic system (27%) is much lower that the Arab average (40%), and this is in the context of a country that has no democratic experience and where the official political discourse categorically rejects the democratic system of rule.

Table 23 below shows the results regarding the statement: "Democracy, with all its problems, is the best among the regimes".

Table 23

Results for the Statement: "Democracy, with All its Problems, is the Best Among the Regimes".

	Strongly Disagree	**Disagree**	**Strongly Agree**	**Agree**	**Do Not Know/Refused to answer**
Saudi Arabia	2%	10%	19%	38%	30%
Kuwait	1%	28%	61%	7%	3%
Arab Average	4%	14%	23%	45%	14%

Note: Adapted from *Arab Opinion Index*, by Arab Center for Research and Policy Studies, 2013, p. 83 (treated by the author).

In Saudi Arabia, 57% agree with the statement “Democracy, with all its problems, is the best among the regimes” (divided between 19% who strongly agree and 38% who simply agree), while only 12% disagree with this statement (divided between 2% who strongly disagree and 10% who simply agree), and with a noticeable 30% of the respondents who refused to answer the question. In Kuwait, 68% agree with this statement (divided between 7% who strongly agree and 61% who simply agree), while 29% do not agree with this statement (divided between 1% who strongly disagree and 28% who simply disagree), and only 3% of the respondents refusing to answer the question. The comparison with the average results of the Arab world is also interesting in this respect, as we can clearly see that the proportion of those who disagree is lowest in Saudi Arabia (12%) compared to the Arab average (18%) or even Kuwait (29%). In the case of Kuwait, this could be explained by the chronic political instability of the country as a result of the struggle between the ruling establishment and the parliament.

Finally, Table 24 below presents the results of Arab public opinion regarding the Arab Spring.

Table 24

Results of Public Opinion Regarding the Arab Spring

	Very Positive	**Positive to a Certain Extent**	**Very Negative**	**Negative to a Certain extent**	**Do Not Know/Refused to answer**
Saudi Arabia	26%	29%	5%	4%	36%
Kuwait	25%	37%	2%	4%	32%
Arab Average	25%	36%	11%	11%	17%

Note: Adapted from *Arab Opinion Index*, by Arab Center for Research and Policy Studies, 2013, p. 203 (treated by the author).

From the results above, it very clearly appears that public opinions in Saudi Arabia and Kuwait are generally positive regarding the Arab Spring, with 55% reporting positive opinion in Saudi Arabia (divided between 26% “very positive" and 29% "positive to a certain extent"), and 62% reporting positive opinion in Kuwait (divided between 25% "very positive" and 37% "positive to a certain extent"). In both cases, these results are in line with the average results of the Arab world, whereas the negative opinions are much below the Arab world average of 22% (divided between 11% "very negative" and 11% "negative to a certain extent"), with 9% reporting a negative opinion in Saudi Arabia (divided between 5% "very negative" and 4% "negative to a certain extent"), and only 6% reporting negative opinion in Kuwait (divided between 2% "very negative" and 4% "negative to a certain extent"). Again, as in all polls, the percentage of respondents who refused to answer the questions was highest in Saudi Arabia at 36%. The high percentage of respondents who refused to answer the questions of the survey in Saudi Arabia could be explained by the lack of freedom of expression in the country and fear to give their opinion.

The results of the survey above reveal the existence of a public opinion that is very favourable to the democratic idea and that looks forward to changes in the political equation of their countries. It is true that the political systems of the GCC countries are not static and have witnessed some reforms in the past, but it is equally true that these reforms were very limited and did not lead to deep and structural changes in the political equation of the GCC regimes. However, given all the present and future challenges and structural weaknesses discussed in this chapter, will GCC ruling establishments be able to maintain the existing political systems without engaging in a credible process of political transition towards a greater role for popular input in the political and economic decision making process?

4.2.5.3. Political stability in the GCC: Where to?

Thanks to its geographic and demographic as well as economic and political status, Saudi Arabia is, without contest, the largest country of the GCC region, and to a very large extent, the future political developments in Saudi Arabia will determine the fate of the whole region. In turn, the social and political stability of Saudi Arabia will greatly depend on two factors: the first concerns the capacity of the ruling establishment to deal with the structural weaknesses of their respective political economies and be able to provide for the growing social and economic demands of the growing local population; and the second concerns the potential impact of the regional geopolitical developments in the Arab Spring countries—particularly Egypt—on the future political establishments in the GCC countries.

As far as the first factor is concerned, employment is as rightly stated by Niblock and Malik (2007) the central issue for the future stability of the Kingdom, as it will have to be able to create the necessary levels of jobs competitive in skills and ability according to the requirements of the World Trade Organization, of which Saudi Arabia is a member. However, "within the existing framework of policy, there is considerable doubt as to whether current patterns of development in Saudi Arabia will indeed create sufficient and appropriate employment prospects for the growing population in Saudi Arabia" (Niblock & Malik, 2007, p. 228). Indeed, while the labour nationalization policies in Saudi Arabia as well as in Kuwait, Qatar, and the UAE have been conceived in order to absorb the rising unemployment among the new educated generations that are arriving to the job market every year, "in most cases they have avoided addressing the structural problem of citizens being dependent on a distributive economy, and have only served to keep pricing nationals out of the market, which in turn has made them even less attractive employees" (Davidson, 2012, p. 118).

The threat of political instability has grown even more evident with the regional instability consequent to the wave of Arab uprisings. The GCC region has not been immune from the Arab Spring wave, as has been very clear in the events in Bahrain and Oman, where the response to these developments has mainly involved financial hand-outs (Benham, 2011), an increased repression, and a stricter control over the media and especially social media. The human rights record of the GCC monarchies has been severely aggravated, including accusations of torture in the UAE against a young social media activist for a tweet, and accusations formulated by a Geneva-based NGO known as Al Karama ("Smuggles Notes", 2013). In Saudi Arabia, there is a growing popular discontent despite the very large expenditures of the Kingdom in social, educational, and infrastructure projects ("No Satisfaction", 2014). Censorship and the limitations placed on freedom of expression have only increased since the beginning of the Arab Spring, and despite all the efforts of the GCC governments, especially Saudi Arabia and the UAE, to control social media, they are finding great difficulties in that respect.

The Arab Spring has laid the foundations for "a paradigm shift in the political, social and economic structures of the region . . . [where] Arab peoples are being transformed from subjects to citizens" (Chatham House, Middle East and North Africa Programme, 2011, p. 3). As noted by Dr. Rima Khalaf Hunaidi, the Under-Secretary General and Executive Secretary at the United Nations Economic and Social Commission for Western Asia (ESCWA), "the transformations that have taken place in Arab countries are non-linear and irreversible and the theory of 'Arab exceptionalism'—the view that Arabs are somehow congenitally or culturally unsuited for democracy—has been irrevocably shattered" (Chatham House, Middle East and North Africa Programme, 2011, p. 4).

As a result of the Arab Spring, GCC states have reacted through a mixture of populist economic measures such as financial hand-outs, job creation, and salary raises for the nationals in the public sector, as well as an increase in political repression and a strengthening of the security apparatus with the creation of 130,000 new security jobs in the GCC countries in 2011 (Chatham House, Middle East and North Africa Programme, 2011, p. 14). The fiscal and economic measures taken in the GCC countries in the wake of the Arab Spring "have gone against the economic trends of the past decades, during which most GCC governments allowed for a greater role for the private sector . . . [and as a consequence] the Arab Spring also adds to the long-term burden on GCC states' budgets and means they will require higher oil prices in the future to balance their books" (Chatham House, East and North Africa Programme, 2011, p. 14). Moreover, the fiscal pressure has also been increasing as a result of the check diplomacy of GCC governments in the region, and especially Saudi Arabia, in their efforts to stop the wave of the Arab Spring by financially helping the new military regime in Egypt and all the counter-revolutionary forces in the Arab

Spring countries. Indeed, Saudi Arabia's monarch has publicly promised continuous support to the military regime in Egypt (Nordland, 2013).

The ruling establishment in Saudi Arabia perceived the Arab uprisings as a strategic threat to their rule, which is based on an autocratic system that denies its population a say in political as well as economic choices, and as such, could not be in favour of the Arab Spring. In addition, the arrival of the Muslim Brotherhood in Egypt to power through winning all the elections since the fall of Mubarak in February 2011, is in total opposition to the Saudi model of Islamic rule without elections as well as to the democratic principles of people's choice, and also a challenge to the Kingdom's claim as the only legitimate representative of Islam. In this respect, it was not a surprise to see Saudi Arabia, in addition to Kuwait and the UAE, as the first countries to welcome the military coup in Egypt in July 2013 and to immediately offer a financial package of US$ 12 billion in a clear sign of support to the new military rule in Egypt (Hearst, 2013).

There is no doubt that the impact of the Arab Spring on the GCC states has been profound, and it can be argued that the future regional developments in the Arab Spring countries and Egypt particularly will determine the political future of the GCC ruling establishments, and especially Saudi Arabia. Indeed, Saudi Arabia, backed by the UAE and Kuwait, has put all its weight and influence into backing the military coup in Egypt, which is yet quite far from establishing its power over all sectors of Egyptian society, as the country has been in continuous turmoil since the coup, and it is very unlikely that the military regime in Egypt will succeed in maintaining its position. In addition, the branding of the Muslim Brotherhood in Egypt as a "terrorist" organization in December 2013 ("Egypt: Muslim Brotherhood", 2013), followed by Saudi Arabia in 2014 ("Saudi Arabia Declares Muslim Brotherhood", 2014), is a decision strongly criticized by Amnesty International, which considers the new terrorism law in Saudi Arabia a "recipe for systematic torture" (Amnesty International U.K., 2014), and an indication that the repression policy will only increase in the coming years in Saudi Arabia as well as Bahrain and the UAE. This was supported by the 2014 political risk map published by Aon[83], where all GCC countries are classified among the ‘medium-low risk’ category, except Saudi Arabia and Bahrain, which are classified in the ‘medium risk’ (Aon, 2014, p. 5). As far Saudi Arabia is concerned, according to Aon’s 2014 assessment of political risk, the country saw its political violence variable downgraded comparatively to previous years as a result of the “rising level of inequality and moderate increase in political violence” (Aon, 2014, p. 14).

As we have shown in this section, opposition groups are not a new phenomenon in the GCC countries; they existed even before the Arab Spring, but were “successfully contained, as the various regimes were able to co-opt most of the modernizing forces impacting on the region and keep the number of dissents small” (Davidson, 2012, p. 231). However, since the Arab Spring, a new generation of opposition groups have appeared on the Gulf political landscape and are proving to be difficult to co-opt by the Gulf regimes, as these groups benefit from higher education levels than the previous generations, and they are more connected thanks to the technology of social media (Davidson, 2012, p. 231). The regional pressure represented by the Arab Spring is another helping factor for the new generation of opposition compared to their predecessors. In addition, we have clearly seen in this section that public opinion in the GCC countries is very favourable to the idea of democracy, and that the official argument, as in the case of the Saudi political establishment, of incompatibility between democracy and Islam is not a widely shared opinion among the public.

A greater popular input and role in the political decision making process that would ultimately lead to more democratic regimes in the GCC countries “can only increase as the resources-demands equation shifts further: the projected expansion in in hydrocarbons production will not fully compensate for the population explosion and costs of maintenance, hydrocarbon development and welfare—thus undermining the rentier social contract” (Nonneman, 2001, p. 1). In addition, as a result of the very significant social and cultural transformations the GCC societies have witnessed in the past decades, the traditional bases of rule and

[83] Aon is a British multinational consulting company that provides risk management and insurance services.

legitimacy in the GCC countries are less and less relevant in order to insure popular acquiescence (Nonneman, 2001, p. 1).

Given all the structural challenges facing the political economy all GCC countries, in addition to the regional unstable political context and its ramifications on the GCC region, especially on the Saudi domestic political map, it is reasonable to expect that Saudi Arabia could be witnessing a rising political instability with very serious and perhaps radical consequences on its ruling establishment, which will have undeniable consequences on its economic policies, and especially its future plans for an energy transition, the subject of interest of this research thesis. Knowing the centrality of Saudi Arabia in the GCC region, there are no doubts that if such developments should occur, they will certainly impact all GCC countries and their energy diversification policies.

4.3. A MESO-LEVEL ANALYSIS OF THE POWER GENERATION SECTOR OF THE GCC COUNTRIES

In this final section of chapter 4, we propose to undertake an analysis of the power generation sector in the GCC countries at the meso-level within the MLP framework of analysis. In this respect, we will first deal with the structure and organization of the power industry, before moving to the economics of power generation in the GCC region.

4.3.1. The Socio-technical Regimes of the Energy Sector in the GCC

According to the MLP framework of analysis, the policy aspect of the entire system is situated at the meso-level, considered the central level of the MLP where the regimes actors are located and the driving force of the whole energy transition process. As a result, this section will focus on the socio-technical regimes of the energy sector in the GCC countries with a special interest in the power generation industry. Understanding how these regimes and their relevant actors operate in the power generation sector is first necessary in order to understand the dynamics of an energy transition, and before building scenarios based on a combination of a scenario typologies as proposed by Slaughter (1993a), and a typology of transition pathways as proposed by Geels and Schot (2007).

Accordingly, the first step will consist of a review of the existing political and institutional setting within which energy policies in the power generation sector of their respective countries are conceived, and in a second step we will review the energy diversification policy objectives and projects in the GCC countries as far as power generation is concerned.

4.3.1.1. The political and institutional setting of GCC energy policy

Energy policy-making in the GCC countries has gradually evolved from an *ad hoc* informal process controlled by a few influential members of the ruling families, into a more formal bureaucratic and professional policy-making process with a forward policy outlook (Obaid, 2000, p. 5). However, despite this very obvious tendency, energy policy-making in the GCC countries still remains strongly dominated by the state and by political actors closely related to the ruling establishments. Indeed, "most of the successful large state enterprises in the Gulf are under the direct patronage of the ruling elites, and hence are shielded from much of the political interference and rent seeking that happens in other sectors" (Hertog & Luciani, 2009, p. 28). The structure composed by the ruling families and the elites from other big families constitute what has been defined by Gray (2011) as the neopatrimonial ruling structure of the GCC countries where "power [is] closely held at the core by a royal clique, and with elite relationships carefully managed for the sake of regime maintenance and elite enrichment" (p. 25). As already shown in this chapter in the section regarding the rentier state theory, the GCC states are highly centralized and enjoy a relatively significant autonomy from their respective societies; as a consequence, they have a relatively greater freedom in the management of their oil and gas revenues, and conceiving general economic policies and energy policies.

Based on these findings above, we can conclude that the GCC energy sector regimes actors engaged in the process of energy policy-making, including the power generation sector, are found within the ruling elite and their neopatrimonial network.

4.3.1.2. GCC Electricity sector organization

Despite the differences found in the organization of the electricity sectors of the GCC countries, they all share in common the predominant role of the state as the main actor. Indeed, in addition to its role as regulator, the state is also the main owner of the electricity utilities. More recently, efforts have been made by the GCC governments to allow for a greater role of the private sector in the ownership and management of electricity utilities through the establishment of Independent Power Producers (IPPs) and Independent Water and Power Producers (IWPPs). Despite these efforts, however, the state remains the main player. Indeed, according to 2010 figures, IPPs and IWPPs represented only 27% of the generation capacity of GCC utilities (Qahtani, 2011, p. 5), knowing that the GCC governments are also directly or indirectly present in their capital through their national companies. The next section will review the organization of the electricity sector in each GCC country.

4.3.1.2.1. Bahrain

The electricity and water desalination sector of the Kingdom of Bahrain is comprised of the following components:

- The Ministry of Oil and Gas Affairs is in charge of the overall policy of the energy sector in general.
- The Ministry of Electricity and Water is responsible for the policy-making as well as planning aspects of the electricity and water industry in Bahrain.

- The Electricity and Water Authority (EWA) is a governmental body in charge of the production, transmission, and distribution of water and electricity in the Kingdom of Bahrain. The electricity and water industries in Bahrain are under the total control of the government. Energy companies are self-regulated in Bahrain, as there is no independent regulator for the energy sector or the electricity sector.
- Alezl Power Company launched the first Independent Power Project (IPP) in 2006, a gas-fired power plant with a capacity of 950 MW (Bachellerie, 2012, p. 26).
- Al Had Power Company, an Independent Water and Power Project (IWPP), previously state owned, has a power generation capacity of 1006 MW (Bachellerie, 2012, p. 26).
- Al Dur Power and Water Company, an IWPP that started its operations in 2011 with an installed capacity of 1234 MW, is owned by the Gulf Investment Company (GIC), a share holding company equally owned by the governments of the six GCC countries (Gulf Investment Corporation, 2014).
- All the IPPs and IWPPs sell their output to the EWA with which they have a 25-year Power and Water Purchase Agreement.

Bahrain has been connected to the GCC grid since 2009. As a consequence of its dwindling financial resources and chronic political instability, the government of Bahrain has very limited resources to invest in the development of large scale renewable or nuclear energy projects. The renewable energy projects launched by Bahrain so far are mainly pilot solar PV projects. Electricity generation in Bahrain relies on conventional thermal fired power plants by using exclusively natural gas.

4.3.1.2.2. Kuwait

The electricity and water desalination sector of Kuwait is composed of the following components:

- The Ministry of Electricity and Water is in charge of the policy aspects in addition to the production, transmission and distribution of water and electricity in Kuwait. The electricity and water sector is under the total control of the government--the sole supplier of electricity and water in Kuwait. There is no independent regulation authority, and as a consequence, the power and water industry is self-regulated at the level of the Ministry of Electricity and Water, which manages the supply and demand of water and electricity, in addition to setting their prices.
- Al Zour power plant is the first IWPP with a 1500 MW capacity and will be operational in 2015 (Daya, 2012).
- Gas represents only 14.4% of the fuel used for generating electricity and the remaining coming from heavy fuel oil, crude oil and gas oil (Ministry of Electricity and Water in Kuwait, 2009, pp. 59-60).

Despite the very significant revenues enjoyed by the Kuwaiti government, it has been unable to invest in large-scale renewable energy projects as a consequence of the chronic political instability from the ongoing conflict between the parliament and the ruling family. The autonomy of the Kuwaiti ruling elite has been seriously limited by the political activism of the parliament, which often partners with public sector unions in order to block reforms in the economy in general, including the power generation sector. However, we must note that the lack of reforms in Kuwait is not due to the elected origin of the parliament, but rather to the fact that "it has the ability to stymie government action without the responsibility for rule that would come from the formation of the government by parliamentary parties" (Herb, 2009, p. 380).

4.3.1.2.3. Oman

The electricity and water desalination sector of the Sultanate of Oman consists of the following components:

- The Ministry of Oil and Gas is in charge of the overall policy making and planning of the energy sector.

- The Electricity Holding Company (EHC) is a joint stock company that holds the shares of the government in nine power generation, transmission, and distribution companies in Oman. EHC controls 99.9% of the shares of eight subsidiary companies, and 98.10% of the shares of the ninth company, namely Dhofar Power Company (Electricity Holding Company, 2010).
- The Authority for Electricity Regulation (AER) is in charge of regulating the electricity and water sectors, and as such, it has the responsibility of regulating the electricity and water sector, and issuing licenses for public and private companies. It was established in August 2004 (Authority for Electricity Regulation, Oman, n.d.).
- The Oman Power and Water Procurement Company (OPWPC) is the sole buyer of water and electricity produced by private power and desalination plants. Moreover, it is also in charge of the long term planning for electricity and water supply in Oman.
- The Oman Electricity Transmission Company (OETC) is responsible for managing the country's electricity transmission networks.

Oman has a largely autonomous political leadership but limited financial resources, and as a consequence, even if it will do better than Bahrain and Kuwait, it will not be able lead the deployment of large scale RE or nuclear projects at the same level as Saudi Arabia and the UAE.

The fuel mix of the electricity generation industry in Oman relies almost exclusively, or more than 80% in 2013, on natural gas (U.S. EIA, 2013b, p. 9).

4.3.1.2.4 Qatar

The electricity and water desalination sector of Qatar includes the following components:

- The Ministry of Energy and Industry is in charge of policy-making and the overall strategy of the energy as well as industrial sectors. It is worth noting that Qatar has no dedicated independent energy or electricity regulator, as energy companies are self-regulated.

- Qatar Electricity and Water Company (QEWC) was founded in 1990 as a shareholding company in which the government of Qatar owns directly 43% of the shares; the remaining 57% are owned by companies and individuals. QWEC is the main provider of electricity in Qatar with a market share of 62% (Qatar Electricity and Water Company, 2012, p. 8). The government of Qatar also controls 11% of the shares of QEWC indirectly through Qatar Petroleum, the public oil and gas company fully owned by the government, and as a consequence, the government of Qatar has an effective 54% stake in QEWC, without mentioning the 10% share of Qatar National Bank (QNB) in which the government controls 50% of the shares through Qatar Investment Authority (QIA), Qatar's sovereign wealth fund.
- Moreover, QEWC is a shareholder in the following power companies in Qatar, controlling 80% of the Ras Laffan Power Company; 55% of the shares of Qatar Power Company; and 40% shares in Ras Girtas Power Company, which is the largest power plant in the region with a capacity of 2730 MW of electricity (Qatar Electricity and Water Company, 2012, p. 8-9).
- Qatar General Electricity and Water Corporation (QGWEC, KAHRAMAA) was established in 2000 and is in charge of the transmission and distribution of electricity and water in the state of Qatar. It is fully owned by the government of Qatar and is the sole buyer and distributor of water and electricity produced by Qatar Electricity and Water Company and the other electricity providers in Qatar (Qatar General Electricity and Water Corporation, n.d.).

The political leadership in Qatar is in a very comfortable situation, as it has a large political autonomy coupled with significant financial revenues invested in developing significant power generation capacities. The investments in large scale renewable and nuclear energy projects have been limited in Qatar due to its huge gas resources; however, it is investing heavily in RE research through the Qatar Environment and Energy Research Institute (QEERI) based in Qatar

Foundation, the flagship education organization in Qatar. In addition, in 2008, the Qatar Investment Authority (QIA), the financial arm of the Qatari government, funded a Qatari-British fund with ₤ 250 million for the promotion of research dedicated to clean energy technologies (Hertog & Luciani, 2009, p. 37).

The fuel mix of the power generation industry in Qatar is composed exclusively of natural gas.

4.3.1.2.5. Saudi Arabia

The electricity and water desalination sector of the Kingdom is composed of the following components:

- The Supreme Council for Petroleum and Minerals Affairs is the governmental organ that has under its jurisdiction all the ministries and organs in charge of the energy sector, including the Ministry of Water and Electricity (Obaid, 2000, p. 21). The Supreme Council is composed of members of the royal family, government ministers, and industry leaders and is in charge of the overall energy policy-making of the Kingdom (U.S. EIA, 2013a, p. 1).
- The Ministry of Water and Electricity, which is responsible for conceiving overall policies, strategies and plans of the sector.
- The Electricity and Cogeneration Regulatory Authority (ECRA), which is the regulator of the electricity industry and responsible for issuing licenses to entities involved in electricity generation and water desalination. It was established in November 2001, and is financially and administratively independent. In addition to issuing licenses, ECRA is also in charge of reviewing the electricity tariffs periodically and insuring that they are cost-effective, and proposing new tariffs to the government.
- The electricity and water desalination industry, where the Saudi Electric Company (SEC) is the main player, and the Saline Water Conversion Corporation (SWCC), which provides most of the Kingdom's desalinated water.

- King Abdullah City for Atomic and Renewable Energy (K.A.CARE) was established in April 2010 by a Royal Order with the objective to develop nuclear as well as renewable energy technologies and to diversify the energy mix of the Kingdom with a focus on the power generation and seawater desalination sectors (K.A.CARE, 2013). It is dedicated to research in nuclear and renewable energies in addition to the policy making process (Royal Decree, 2010, p. 4), and as such, will play a major role in the coordination of the national and international energy policy of the Kingdom.

From a general policy perspective, “The Science and Technology National Policy” determines the general orientation for the development of science and technology in Saudi Arabia, and as a policy framework, it sets long term objectives and goals within the overall national development plans of the Kingdom. In this respect, King Abdulaziz City of Science and Technology (KACST) plays the role of the national science agency and laboratory of the Kingdom, and as such, is involved in the scientific as well as the policy making aspects of the strategy for the development of solar energy technology.

Regarding electricity production in the Kingdom, the Saudi Electric Company is the dominant player in the electricity production industry in Saudi Arabia as it alone has a share of 77% of the electricity generation capacity in the Kingdom, followed by the state owned Saline Water Conversion Corporation, with a share of 7.6% of electricity generation capacity. Jubail Water and Power Company (JWPC) is the third largest power generation company with an electricity generation capacity of 4.4%. The remaining share of the generation capacity is distributed among eleven other small utilities with a share representing less than 2% per company (Electricity and Cogeneration Regulatory Authority, 2012, p. 21).

On the electricity supply front, the SEC produces 69% of the electricity produced in the Kingdom, SWCC produces 13%, Marafiq 12%, and 17% is produced by the remaining power companies (Electricity and Cogeneration Regulatory Authority, 2012, p. 31).

The mix of the primary fuel used for power generation in Saudi Arabia is composed of 41% gas, 28% crude oil, 20% heavy fuel oil (HFO), and 11% diesel (ECRA, 2012, p. 30). The mix of the backup fuel for power plants, which is available for only 57% of the power plants in the Kingdom, is composed of 44% diesel, 10% crude oil, and 4% HFO (Electricity and Cogeneration Regulatory Authority, 2012, p. 30).

Saudi Arabia, with the UAE, is leading the GCC countries in renewable and nuclear energy investments, as it has a largely autonomous political leadership and important financial surpluses. In addition, with a growing domestic energy consumption pressuring its energy production and particularly its export capacity, Saudi Arabia has the strongest impetus for deploying renewable and nuclear energies in its power generation sector. Moreover, the previous successful experience of the Kingdom in developing an island of efficiency in the energy sector and petrochemical industries will most certainly play in favor of this deployment. The only potential limiting factors to this long term trend could be found in a decrease in the revenues of the Kingdom due to a drop in the price of oil in the international markets, a domestic political crisis in the wake of the Arab Spring, or the development of the very significant shale gas resources available domestically--a development, if materialized, which could redirect investments from RE and nuclear technologies to shale gas production.

4.3.1.2.6. The United Arab Emirates

Whereas the other GCC countries are centralized governments, the UAE is a federation composed of seven emirates where the electricity sector is managed at the state level; i.e., at the level of each individual emirate. When compared with other federal systems, such as in the U.S. and Canada where states have equal powers in the federal system, the main difference lies in that not all the emirates have equal powers in the UAE federal system, as it is based on a power sharing agreement between Abu Dhabi and Dubai. According to this agreement, the president of the federation is the emir of Abu Dhabi, and the prime minister is the emir of Dubai. In addition, only the rulers of Abu Dhabi and Dubai have veto rights in the Supreme Council, the top policy-making body in the UAE. From a demographic perspective, Abu Dhabi and Dubai alone represent more than 65% of the total population and more than 90% of the territory of the UAE. Accordingly, this study will focus on the Emirates of Abu Dhabi and Dubai, as they are the main players involved in the development of renewable and nuclear energy sources in their respective power generation sectors.

The electricity and water desalination sector of the United Arab Emirates is comprised of the following components:

- The Ministry of Energy, which is in charge of coordinating at the federal level the energy policies and planning of the seven emirates, including the electricity sector.
- The Abu Dhabi Regulation and Supervision Bureau as the regulator.
- The Abu Dhabi Water and Electricity Company (ADWEC) as the sole buyer of electricity and water at the level of the emirate, which sells electricity and water to distribution and supply companies based on annually adjusted Bulk Supply Tariff (BST) (Regulation and Supervision Bureau, 2013).
- The publicly owned Mubadala Development Company, established in 2002, is the main promoter of renewable energy projects in the Emirate of Abu Dhabi through its branch Abu Dhabi Future Energy Company (ADFEC), very well known as Masdar (or “source” in Arabic). Khaldoon Al Mubarak is the CEO of Mubadala and the chairman of the Executive Affairs Authority of Abu Dhabi. Ahmad Ali Al Sayegh is the chairman of Masdar and Sultan Al jabber its CEO (Hertog & Luciani, 2009, p. 37).
- In Dubai, the Dubai Supreme Energy Council (DSCE) is in charge of policy as well as general planning for the energy sector, including the power generation sector, in the emirate of Dubai (Dubai Supreme Energy Council, 2013).
- In Dubai, the Dubai Electricity and Water Authority (DEWA), established in January 1992, is in charge of planning, building, and operating electricity and water plants in the emirate of Dubai.

Moreover, it is in charge of their transmission and distribution functions, and as such, it is the sole buyer of electricity and water supply from other independent companies (Dubai Electricity and Water Authority, 2012).

- In Sharjah, the Sharjah Electricity and Water Authority (SEWA) has the responsibility of planning, building and operating electricity and water plants in the emirate of Sharjah, in addition to transmission and distribution tasks (Sharjah Electricity and Water Authority, 2014).
- At the federal level, the Federal Electricity and Water Authority (FEWA), is the regulator responsible for the four other emirates of Ajman, Umm Al Qaiwain, Fujairah and Ras Al Khaimah.

The UAE has been the precursor in the region for the deployment of renewable energy sources in the energy mix of its power generation sector, and as such, it is interesting to see how the regimes actors and their position has adapted to this new situation. In this respect, a good description of how the political structure of the Gulf Monarchies has evolved with the deployment of renewable energy sources in the UAE has been given by Christopher Davidson when talking about the political system in Abu Dhabi which he defines as a "system of 'tribal capitalism'" (Davidson, 2009, p. 2), where "political power . . . [has been] maintained by placing key representatives of other powerful families and loyal clans in directorial roles in the surfeit of new parastatals and private companies charged with overseeing the new economic sectors" (Davidson, 2009, p. 2). This description is to a very large extent also valid in the other GCC monarchies and it is expected that the deployment of renewable energy technologies in GCC countries will most probably lead to a similar path as in the UAE with the same political configuration in which the actual regimes actors will maintain their dominant position in the socio-technical regimes level.

The government of the UAE enjoys a very high level of autonomy in addition to significant fiscal surpluses. Notably, however, unlike the Emirate of Abu Dhabi, the Emirate of Dubai does not individually enjoy significant financial surpluses, and as a consequence, is not and will not be engaged in large-scale energy projects like Abu Dhabi. Politically, the UAE has been a very stable country; nonetheless, signs of potential future political instability exist in the wake of the Arab Spring.

4.3.1.2.7. Energy policy-making and the GCC organization

Although GCC countries share much in common as far as energy policy is concerned, they are not a homogenous entity with a regional energy policy. This is despite of the existence of the GCC organization, which fixed as an objective in its Charter "to effect coordination, integration and inter-connection between Member States in all fields in order to achieve unity between them" (Cooperation Council for the Arab States of the Gulf, 2012, Article 4). After more than three decades, the GCC still remains very far from its initial objectives and has not been able to put into place a common energy policy for the region since its creation in May 1981. The only notable achievement of the GCC organization in the energy field has been the inter-connection of their electricity grid.

There are no common projects regarding renewable energy; however, as far as nuclear energy is concerned, in December 2006, the six heads of state of the GCC countries announced the launch of a collective nuclear energy initiative (Cooperation Council for the Arab States of the Gulf, 2006) to develop peaceful and civilian nuclear energy capacities in the power generation sector. Correspondingly, the Secretariat of the GCC undertook a feasibility study in collaboration with the International Atomic Energy Agency (IAEA) to evaluate the possibilities of establishing a joint nuclear research program under the supervision of the GCC Secretariat (Stracke, 2007, p. 4). However, with the exception of this joint declaration, the cooperation with the IAEA is mainly conducted on a bilateral level, with the actual planning and implementation of the nuclear projects conducted on a national level without any regional collaboration within the GCC organization.

Nonetheless, a number of general conclusions and common characteristics among the GCC countries can be highlighted as far as energy policy-making in the power generation sector is concerned.

4.3.1.2.8. General conclusions

Following the above review and analysis of the electricity sector in the GCC countries, and based on Geels (2002) definition of the socio-technical regimes, which states that these regimes consist of a number of inter-connected dimensions, or "technology, user practices and application domains (markets), symbolic meaning of technology, infrastructure, industry structure, policy and techno-scientific knowledge" (Geels, 2002, p. 1262), we can draw a number of conclusions:

First, the GCC states have a state capitalist structure and are ruled through a regime comprised of the ruling families at the top, and their neopatrimonial networks, who compose the main regimes' actors in the energy sector in general and the power generation sector in particular, and are in charge of the energy policy-making process.

Second, the power generation industry in the GCC region is on the whole vertically integrated, where the GCC governments directly or indirectly control the majority of the shares. The role of the private sector is still limited and has mainly acted as "a follower and policy-taker" (Hertog & Luciani, 2009, p. 39). In this respect, it is worth mentioning the World Bank definition of the private sector, which points to the difficulty of drawing a clear-cut dividing line between the public and the private sectors:

> The private sector is usually defined as the collection of enterprises that are owned by individuals or groups not representing the state, where the public sector comprises government agencies and state owned enterprises. In practice, however, the dividing line between the public and the private sector is always blurred, especially since ownership and control of the state may vary in degree and over time. Furthermore, countries differ in their legal or customary definitions of what is private and what is public. (World Bank, 1989, p. 1).

This definition is even more relevant in the case of the GCC countries, where the state is the major shareholder of all the energy companies of the region, as we have seen above regarding the utilities companies of the respective GCC countries.

Third, power generation technologies in the GCC countries rely exclusively on conventional energy sources--namely, oil and gas--where the industry is vertically integrated under direct control of GCC governments and the ruling elites who compose the regimes actors. In this respect, the power generation infrastructure is exclusively based on these conventional oil and gas sources.

Fourth, it is very difficult to speak of an energy or electricity market in the GCC countries, as no such market exists in the economic sense of the term. Indeed, the prices of energy in general, and electricity in particular, are set by the GCC governments and not by market forces. As a consequence, the introduction of new energy technologies in the energy mix of the GCC power generation sector cannot take place through market forces and will have to be introduced through GCC governments and the existing regimes actors that control it.

Fifth, the increasing economic development and population growth have led to a higher demand on electricity, and as a result, large investments are needed in order to increase the generation capacity of the GCC countries. In response to this challenge, some GCC countries have started to introduce some reforms and to liberalize their electricity markets through the establishment of independent regulatory authorities, as we have seen above, and by encouraging private investments in the power generation sector through long term power purchase agreements with a single buyer or utility at competitive prices for the independent power plants. In this respect, Saudi Arabia, Qatar, the UAE, and Oman are leading the way, whereas the other GCC countries still lag behind. However, discussions are on-going to reform the power generation sector of these trailing countries on the same line as the other leading GCC states. In their phased approach to competitive markets, the GCC governments have allowed for private investments in the generation sector while a regulated monopoly of the public utilities has been maintained in the transmission and distribution sectors. Under this model, the public utility is the single buyer who purchases electricity produced by independent power and power/water producers (IPPs and IWPPs) at competitive prices, determined according to long term purchase agreements, before transmitting and distributing electricity to end-users.

Sixth, the main constraints on the capacity of the GCC governments to invest in large scale power generation projects based on renewable and nuclear primary sources are to be found in the level of political autonomy of respective GCC governments, and the availability of the financial rents (Hertog & Luciani, 2009, p. 38). Indeed, a restriction of the political autonomy of the GCC governments as a result of internal political instability, or/and a limitation in the revenues from the export of oil and gas resulting from price decline in the international markets, will greatly limit the capacity of the GCC governments to diversify their energy sources away from hydrocarbons, and could eventually risk the projects already declared. In this respect, there are signs of potential domestic instability in a number of GCC countries, especially in Saudi Arabia, which suffers from very high unemployment among its young population. Political instability will very likely divert investments from costly large-scale renewable or nuclear projects into social projects in order to buy social peace.

Seventh, energy projects, like other projects in the GCC countries, will be undertaken without input from society; they are, and will continue to be for a relatively long time, initiated by top political elites in a top-down fashion without an impact on the society at large (Hertog & Luciani, 2009, p. 39).

Eighth, in their efforts to diversify their energy sources away from the hydrocarbons, the GCC governments will primarily focus on two fronts. They will first invest in the development of their generation capacities through large scale power generation projects, including renewable and nuclear energies, and the development of islands of efficiency in the power generation sector, but with limited or no actions to curb domestic consumption through taxation or significant price increases, due to the high political cost involved (Hertog & Luciani, 2009, p. 40). The new energies niche-innovations will most probably find their way into the socio-technical regimes through the regimes actors, and will benefit from the concept of islands of efficiencies.

Lastly, the development of the generation capacities in order to cope with the growing domestic demand on electricity will be relatively easier for countries with small populations, such as Abu Dhabi and Qatar, but much more difficult for countries with a large population, such as Saudi Arabia, which will find it very difficult to continue investing on building capacities without working to decrease the local consumption through pricing tools.

4.3.2. The Economics of Power Generation in the Monarchies of the Gulf

The rapid and significant economic growth witnessed by the GCC countries in the past decades has been accompanied by rapidly growing electricity consumption, as shown in Figure 20 below representing the evolution of the GCC electricity consumption comparatively to the evolution of the GDP between 1981 and 2008.

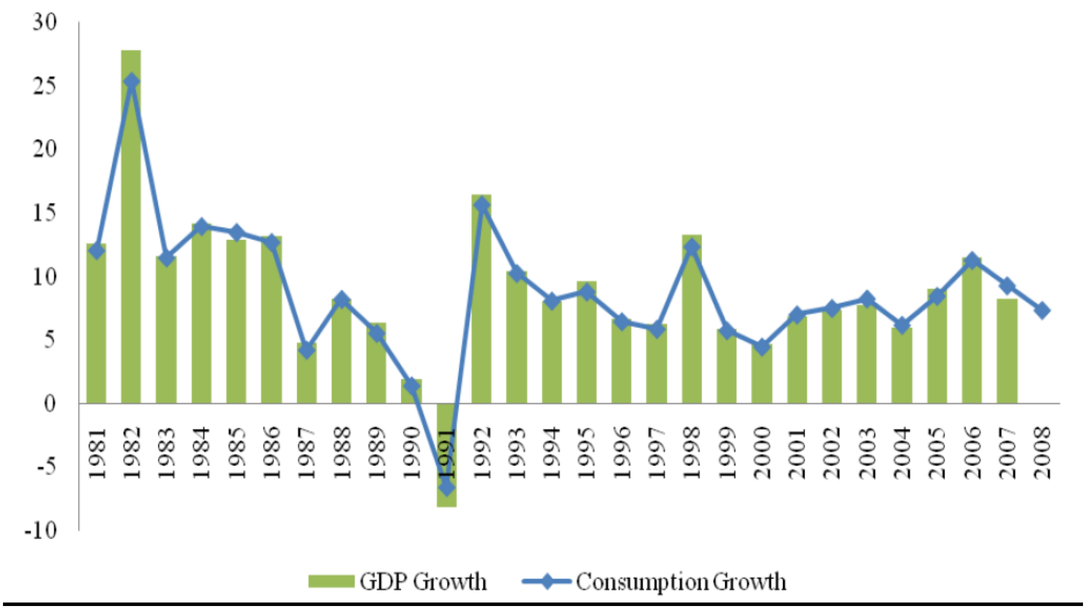

Figure 20: GCC electricity consumption growth. GDP growth 1981-2008. Adapted from *Interlinking the Arab Gulf,* by L. El-Katiri, 2011, p. 6.

The ups and downs of the GDP, and with it electricity consumption, are linked to the fluctuations of the oil price in the international markets, as oil revenues represent a very high proportion of the GCC revenues, and as a consequence, a very significant share of their GDP. Between 2005 and 2009 alone, electricity consumption in the GCC region increased by 8.87% with an average of 3.5% per year—higher than the world average of 2.1% for the same period—and which represented in 2005 an average consumption of 1149 watt per capita. This was higher than the world average of 297 watt per capita, and the EU average of 700 watt per capita, with the exception of the U.S. , which reached 1460 watt per capita (W. E. Alnaser & N. W. Alnaser, 2011, p. 3082). Table 25 below shows a comparison of the watt per capita consumption of the GCC countries with a number of other economies.

Table 25

Watt per capita consumption of the GCC compared to other economies

COUNTRY	**CONSUMP-TION GW/y(2005)**	**CONSUMP-TION GW/y(2009)**	**POPULA-TION 2005**	**W/pers on 2005**	**RAT E %**
BAHRAIN	7614	8742	727,000	1195	12.9
SAUDI ARABIA	146,900	156,800	24,573,000	682	6.3
QATAR	12,520	13,190	813,000	17,57	5.1
OMAN	8661	11,190	2,567,000	385	22.6
UAE	52,620	57,880	4,500,000	1335	9.1
KUWAIT	36,280	39,540	2,687,000	1540	8.2
TOTAL GCC	264,595	287,342	35,867,000	1149	8.87
WORLD	17,109,665	17,480,000	6,464,750,00 0	297	2.1
U.S.	3,872,598	3,892,000	298,213,000	1460	0.4
CHINA	3,3650,600	3.271,000	1,314,844,00 0	277	-11.6
EU	2,950,297	2,926,000	459,387,000	700	-0.8

Note: Adapted from *The Status of Renewable Energy in the GCC Countries*, by W. E. Alnaser & N. W. Alnaser, 2011, p. 3077.

It is worth noting that the generation of electricity in the GCC countries relies entirely on hydrocarbon fuels that benefit from substantial governmental subsidies, which partially explains their very high level of electricity consumption. Indeed, the rentier nature of the state has led to the development of a rentier-like mentality reflected in a very high level of energy consumption, but we also have to take into consideration the extremely harsh environment of the Arabian peninsula and limited water resources, which both imply an intensive use of electricity for air conditioning and water desalination for residential, commercial, and industrial needs.

The breakdown of the electricity consumption in the GCC countries indicates that the residential and commercial sectors represent the biggest share of overall electricity consumption as shown by Figure 21 below:

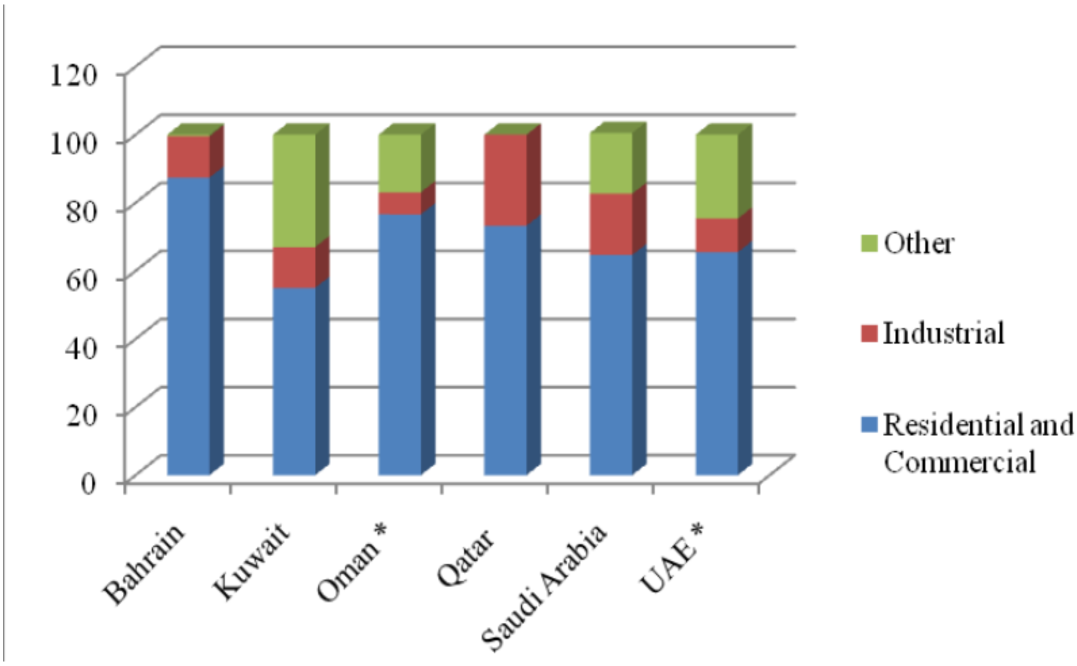

Figure 21: GCC electricity consumption by sector in 2009 (%). Adapted from Arab Union of Electricity, 2009, as cited in *Interlinking the Arab Gulf: Opportunities and Challenges of GCC Electricity Market Cooperation*, by L. El-Katiri, 2011, p. 6.

As far as electricity generation is concerned, in 2012, the installed capacity of the GCC region was estimated to be 117.4 GW, and based on an analysis of peak load demand and reserve capacity requirements, an additional 65.9 GW capacity will be necessary for the period 2014-2018. This is equivalent to more than 56% of the existing capacity, representing an annual rate of capacity growth in the GCC region estimated at 8.7%, and needing a total investment of US$ 72.9 billion in order to be able to respond to the growing domestic demand (Aissaoui, 2013a, p. 2). Moreover, in addition to the investments in the new generation capacity, there will be an additional US$ 48.1 billion of investments needed in transmission and distribution, i.e., a total necessary investment in the whole power sector of the GCC estimated at US$ 121 billion for the period 2014-2018. Based on these estimates for the period between 2014-2018, we can project that for the period between 2014-2050, there will be a need to add a generation capacity of 474.4 GW and to invest US$ 871.2 billion in the whole power sector, if economic and demographic growth continue growing at the same actual levels (corresponding to a medium level fertility rate as discussed in the previous section regarding the population growth variable).

When dealing with the issue of long-term investments in the power sector, we need to determine the source and availability of funding of the expected projects for the selected period of time, i.e., between 2014 and 2050. In the present situation, following the reforms introduced by a number of GCC countries in the power generation sector, it was expected that through IPPs and IWPPs, the private sector will play a major role in funding the power generation projects undertaken on a project finance basis, with the ultimate objective of shifting the financial burden from the public sector to the private sector. However, the experience of the last decade since the first reforms were introduced has proven the expected private sector investments below expectations, which has pushed the GCC governments to maintain a high level of investments in the power generation sector (Aissaoui, 2013a, p. 4). As far as the transmission and distribution (T&D) sectors are concerned, they have been funded essentially from state budgets, in addition to their earnings when available, and eventually by external multilateral bank loans (Aissaoui, 2013a, p. 4).

Unless more reforms are introduced in the whole power sector (Generation, Transmission, and Distribution) on the regulatory as well as on the price of electricity for end-users, the financial burden for future investments in the power sector will remain on the shoulders of the GCC governments with only a limited role for the private sector. In this respect, continued governmental financial support will depend on the revenues of the GCC governments, and consequently on the price of oil and gas in the international markets, which must be maintained above their fiscal break-even price (Aissaoui, 2013a, p. 4).

The availability of fuel—especially gas—in the long term is another major challenge that the GCC governments will have to confront in light of the gas shortages that a number of them have recently been facing. The power generation sector of the region relies heavily on thermal plants fuelled mainly by hydrocarbons in which gas is the main energy source, with the exception of Saudi Arabia and especially Kuwait, where gas represents only 14.4% of the fuel mix (Ministry of Electricity and Water in Kuwait, 2009, p. 59). If there are no new major gas discoveries in the GCC countries currently witnessing gas shortages (Kuwait, Saudi Arabia, and the UAE), given the same levels of population and economic growth and avoiding any change in the price structure of electricity, it is extremely unlikely that the GCC countries, with the exception of Qatar, will find the necessary gas resources domestically.

Indeed, since 1980, the total electricity consumption in the GCC countries has risen nearly tenfold, with the consumption tripling in the 1980s alone, and has been nearly doubling every decade since then (El-Katiri, 2011, p. 3). Despite the comparatively small population of the GCC countries, the consumption of electricity has reached 330TWh, which is slightly less than the consumption of the United Kingdom, according to 2008 figures (El-Katiri, 2011, p. 3).

On the climate change front, the very high electricity consumption in GCC societies has been accompanied by a very high level of CO_2 emissions with an important environmental impact. In 2009 alone, the power generation sector was responsible for an average of 40% of CO_2 emissions reaching even 50% in some GCC countries (Bachellerie, 2012, p. 22). Improving energy efficiency and diversifying the energy mix in the power generation sector are necessary measures to reduce the emission intensity of electricity production while at the same time securing future power supplies for growing needs. The transition to a more diversified energy mix will require strong political will coupled with significant investments for the very large scale deployment of new technologies that will need to be subsidized in their initial launching phases.

As a result of this background and the need to improve the energy security of the GCC countries as whole, the initial idea of interconnecting the electricity grid of the region was conceived (El-Katiri, 2011, p. 17). In May 2001, the GCC Interconnection Authority was officially established with the headquarters in Dammam, Saudi Arabia, and in May 2004, the energy ministers of the GCC approved the public funding of the project for an amount of $3bn, with cost divided among the GCC member countries according to the expected national share of the grid's capacity.

It is worth noting that simultaneous to the discussions about a regional power grid, the issue of diversifying the energy sources in the GCC was also discussed for the first time with an emphasis on nuclear energy, as it became evident that the projected electricity demand will push for the development of alternative energy sources (El-Katiri, 2011, p. 17).

4.4. A REVIEW OF ENERGY DIVERSIFICATION POLICY OBJECTIVES AND PROJECTS IN THE GCC

Since Masdar project was launched in the UAE in 2006, renewable energy policy targets and projects gradually became part of the overall energy policy of a growing number of GCC countries. Historically, energy policy in the GCC countries was limited to oil and gas production and their prices in the international markets with a very limited number of actors involved in the energy policy-making process. In the present time, the energy policy landscape of the GCC countries has since completely changed, becoming more institutionalized and involving numerous actors. Even so, this level of institutionalization has not yet reached parity with western democracies, as it remains a top-down process with almost no input or participation from the larger society.

In the sections below, we will first undertake a short review of the policy tools that have been globally used for the deployment of new energy technologies, before reviewing the policy targets the GCC governments have set for themselves for deploying new energy sources in addition to the policy tools for reaching their objectives. In the final section, we will review the planned renewable and nuclear projects in each GCC country.

Governments have developed a variety of policy tools for the diversification of their energy sources and for energy transition strategies, summarized in the following list:

- Feed-in-tariff (FIT): “The price per-unit of electricity that a utility or power supplier has to pay for distributed or renewable electricity fed into the grid by non-utility generators. A public authority regulates the tariff” (IPCC, 2011, p. 959).
- Renewable Portfolio Standard (RPS): Also known as renewable energy quotas or renewable obligations, it represents “established quotas obligate designated parties (generators or suppliers) to meet minimum (often gradually increasing) renewable energy targets, generally expressed as percentages of total supplies or as an amount of renewable energy capacity, with costs borne by consumers” (IPCC, 2011, p. 964).
- Tax credit: It is a tax reduction or exemption for a certain period in order to encourage investments in renewable energies, within the context of an energy policy for the deployment of RE technologies.
- Pricing laws.
- Production incentives.
- Trading systems, or tradable certificates, also known as tradable green certificates: Under this system, the established renewable energy quotas, produced by the renewable energy producers, are transformed into tradable certificates by the regulatory authority “and assigned to the renewable energy producers to sell or for their own use in fulfilling their quota” (IPCC, 2011, p. 966).
- Subsidies: Direct payment from the government or a tax reduction to a private party for implementing a practice the government wishes to encourage. The reduction of greenhouse gas emissions is stimulated by

> lowering existing subsidies that have the effect of raising emissions (such as subsidies for fossil fuel use) or by providing subsidies for practices that reduce emissions or enhance sinks (e.g., renewable energy projects, insulation of buildings or planting trees). (IPCC, 2011, p. 965)

The feed-in-tariff (FIT) and the Renewable Portfolio Standard (RPS) are the most widely used instruments for the promotion of renewables globally (Solangi, Islam, Saidur, Rahim, & Fayaz, 2011, p. 2152). It should be noted that there is a debate among politicians and academics about the usefulness of these instruments, which varies from one country to another depending on the context of the instruments' implementation and the objectives sought. According to Ekins, there is no standard model that could be used universally as every model must emerge from within the specific cultural and historical context of every country (Etkins, 2004, p. 1903). As a consequence, it is necessary to consider the political as well as the cultural context of the GCC countries, in order to determine the potential instruments available to them for promoting the deployment of RE technologies in their energy mix for the power generation sector.

4.4.1. Policy Tools and RE Objectives in the Context of the GCC

It is worth noting that, as far as the GCC countries are concerned, very significant developments took place recently regarding the deployment of renewable and nuclear energies in the power generation sector. The energy mix of the region is changing, and from the long-term plans declared by Saudi Arabia and the UAE, its future energy landscape will look very different from what exists today. The first section below will review the policy objectives and tools for the deployment of renewable energies, and the second section will concentrate on the nuclear energy policy objectives in the GCC countries.

In their efforts to deploy renewable energy technologies, the GCC governments will need to use a number policy tools in order to achieve their objectives. In this respect, and based on the findings of the previous section, Table

26 below summarizes existing support policies in the GCC countries regarding the diversification of their energy sources:

Table 26

Renewable Energy Support Policies in GCC Countries

			Regulatory Policies		**Fiscal incentives**				**Public Financing**	
	Renewable energy targets	**Renewable energy strategy or plan**	**FIT (Including premium payments**	**Electric utility quota obligation (RPS)**	**Capital subsidy, grant, or rebate**	**Investment/production tax credits**	**Reduction in sales, energy, CO_2, VAT. or other taxes**	**Energy production payment**	**Public investment, loans, or grant (incl. R&D)**	**Public competitive bidding**
Bahrain	Yes	No	No	No	No	No	No	No	No	
Kuwait	Yes	No	No	No	No	No	No	No	Yes	Yes
Oman	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Yes
Qatar	Yes	No	No	No	No	No	No	No	Yes	No
Saudi Arabia	Yes	No	Under discus-sion	No	No	No	No	No	Yes	Yes
UAE	Yes	Yes	Under discus-sion	No	Yes only at state level	No	No	Yes only at state level	Yes only at state level	Yes only at state level

Note: Adapted from *Renewables 2013 Global Status Report,* by REN21, 2013b, p. 17 (treated by the author).

On the front of power generation policies, none of the GCC countries have put in place a Feed-in-tariffs (FIT) system, although it is under discussion in Saudi

Arabia and the UAE. In Saudi Arabia, the discussion involves introducing FIT in small-scale projects, and Abu Dhabi and Dubai are considering introducing green tariffs (REN21, 2013a, p. 21). Although there are no indications about when they will probably implement a FIT system, there are doubts that it will be introduced in the short term due to the fact that it is linked to the pricing of electricity domestically, and the actual political environment in the wake of the Arab Spring does not favor such policies for the moment. So far, none of the GCC countries have implemented minimum price standards (RPS) as a regulatory instrument for deploying renewables, as there is yet no electricity market to introduce it.

In 2012, the emirate of Dubai introduced a regulation regarding new buildings with an obligation to meet at least 75% of their hot water from solar power, whereas the Authority for Electricity Regulation (AER) in Oman has introduced in 2013 an obligation of introducing solar or wind power in every rural project--an obligation that could be suspended only if the company is capable of providing a technical economic infeasibility of the obligation (REN21, 2013a, p. 21).

Fiscal incentives are very poorly used in the GCC region with the exception of Oman on a national level, and the UAE at the state level in Dubai and Abu Dhabi, in the form of energy payments.

However, as far as public financing is concerned, it is present in all the GCC countries, which is a very good indicator of the central role of the GCC states in the political economy of the GCC countries, and of the top-down approach that is in force in the region due to the nature of the existing social contract and to the actual availability of significant financial revenues. Indeed, as we have previously mentioned, the GCC governments have allocated very important budgets for deploying renewable energies in the power generation sector in the long run, and the sustainability of these investments will greatly depend on the continuous flow of substantial revenues from the export of oil and gas, which in turn will depend on the future evolution of energy markets. Further, a decrease in the prices of oil and gas in the international markets will affect the revenues of the GCC governments, which will most probably reduce the level of investments for the deployment of RE technologies in the power generation sector.

All GCC governments have set long-term renewable energy targets, in addition to long-term nuclear projects and targets in Saudi Arabia and the UAE. Indeed, as far as RE technologies are concerned, in 2012, Saudi Arabia unveiled its long-term renewable energy targets for the power generation sector: 25 GW of CSP, 16 GW of solar PV, 9 GW of wind, 3 GW of waste-to-energy, and 1 GW of geothermal by 2032. According to the REN 21 report, "by 2030, Saudi Arabia is expected to become not only the leader of the MENA countries in terms of renewable energy capacity, but also a major player in the world" (2013a, p. 13).

Table 27 below reviews the overall RE targets in the GCC countries, and Table 28 reviews the RE capacity targets by technology in the GCC countries.

Table 27

Overall Renewable Energy Share Targets in GCC Countries

Bahrain	5% by 2020
Kuwait	5% of electricity generation by 2020; 10% by 2030
Oman	10% by 2020
Qatar	At least 2% of electricity generation from solar by 2020
Saudi Arabia	20% of electricity generation from renewables by 2032
UAE	Dubai: 5% of electricity by 2030 / Abu Dhabi 7% of electricity generation capacity by 2020

Note: Adapted from *MENA Renewables Status Report*, by REN21, 2013a, p. 16 and 18 (treated by the author).

Table 28

RE Capacity Targets by Technology in the GCC Countries

	Solar PV	CSP	Wind	Biomass, Geothermal	Total
Bahrain	-	-	-	-	-
Kuwait by 2030	3500 MW	1100 MW	3100 MW		7700 MW
Oman	-	-	-	-	-
Qatar by 2020	640 MW				640 MW
Saudi Arabia by 2022	17350 MW		6500 MW wind/waste to energy/geothermal		23850 MW
by 2032	1600 MW	25000 MW	9000 MW wind; 3000 MW waste to energy; 1000 MW geothermal		54000 MW
UAE	-	-	-	-	-

Note: Adapted from *MENA Renewables Status Report*, by REN21, 2013a, p. 19 (treated by the author).

From the first table above, it appears that by early 2013, all GCC countries had established renewable energy targets for themselves, even if only the UAE has a formal renewable energy strategy or plan at this stage. Almost all GCC countries have set a target for electricity production; these range from between 2% in Qatar by 2020, and 20% in Saudi Arabia by 2032. Kuwait and Oman announced both targets for producing 10% of their electricity from renewables by 2030 and 2020 respectively (REN21, 2013a, p. 16). From a technological perspective, it appears that solar, followed by wind, are the main technological choices of the region, with an advantage for CSP over solar PV despite CSP’s higher cost. It is also very clear that among the GCC countries Saudi Arabia has the most ambitious objectives for deploying renewables in the power generation sector.

The UAE has also been investing in renewable energy domestically and internationally through its government-backed privately structured companies Masdar and Taqa. Masdar has recently inaugurated Shams 1, a CSP power plant with a 100 MW of installed capacity, in addition to the Noor 1 solar PV plant with a 100 MW of installed capacity, and the 30 MW Sir Bani Yas wind farm project. Internationally, Masdar has been involved in funding renewable energy projects on behalf of the UAE government: in the UK in the London Array, the largest offshore wind farm in the world; in Spain in Gemasolar, a CSP power plant project, which will be based on the most advanced storage technologies (REN21, 2013a, p. 33); and in other developing countries such as Afghanistan, the Seychelles, and Mauritania. In addition, the Abu Dhabi fund for Development has allocated US$ 350 million in the form of soft loans for renewable energy projects in developing countries that are members of IRENA (REN21, 2013a, p. 21). In this respect, the Kuwaiti Investment Authority has recently announced that it will be investing in renewable energy projects (REN21, 2013a, p. 21). Saudi Arabia also has been very active on this front, investing in renewable energy projects abroad through its project developer ACWA Power International, which will invest US$ 1.16 billion in a 160 MW CSP plant at Ouarzazate in Morocco (REN21, 2013a, p. 26). Through such investments, Saudi Arabia and the UAE are pursuing a diversification of their international investments portfolio, in addition to an improved international image, as GCC countries are considered among the main blockers of the international climate mitigation negotiations. However, economic incentive is the main driver in their economic diversification strategy.

In order to promote renewable energies, state owned energy companies in the GCC have recently created branches dedicated to renewable energies. In 2012, in Saudi Arabia, Aramco has created an investment unit for renewable energies. It has also funded, entirely or partially, and in partnership with the King Abdullah Petroleum Studies and Research Center, three solar PV projects with a total installed capacity of 17 MW (REN21, 2013a, p. 26). In Qatar, the General Electricity and Water Corporation has declared that it will invest US$ 125 billion in alternative and renewable energy projects (REN21, 2013a, p. 21).

There are also efforts to promote the whole renewable value chain within the local economy, with a notable lead for Saudi Arabia due to the size of its domestic market. The objective behind this policy is to diversify the economy and to create new job opportunities in highly rewarding professions for young university graduate nationals.

As a concluding note, the GCC countries have, overall, made significant progress for the diversification of their energy sources in the power generation sector through significant investment plans for the deployment of renewable energy sources. They have all established renewable energy targets and allocated budgets in that respect; however, this effort is state-driven, and it will take some time before it becomes market-driven with regulatory and financial mechanisms that will enable and encourage investments from the private sector.

4.4.2. Nuclear Energy in the GCC: An Emerging Role

The United Arab Emirates was the first in the GCC region to declare an interest in nuclear power and to conceive a nuclear policy. In April 2008, the UAE government published a comprehensive national policy on nuclear energy with the clearly established objective of building nuclear power plants (Emirates Nuclear Energy Corporation, 2011a). According to this policy the objective is to produce between 20 and 25% of the UAE's electricity from nuclear energy by 2020 (Emirates Nuclear Energy Corporation, 2011b). In 2008, the UAE and the USA signed a nuclear energy cooperation agreement. In October 2008, the UAE established the national nuclear regulatory authority, and at the end of the year, it signed an agreement with a South-Korean consortium for building four APR 1400 reactors. Construction of its first nuclear reactor, Barakah-1, started in July 2012 with commercial operation planned to start by 2017-2018 for the first two units, followed by the two remaining units by 2019-2020.

In December 2009, the Emirates Nuclear Energy Corporation (ENEC) was established by decree and charged with implementing the Emirate's nuclear energy program, and accordingly, in charge of the deployment, ownership and operation of the nuclear plants (Emirates Nuclear Energy Corporation, 2011b).

According to the national nuclear energy policy, the UAE made the choice to deploy nuclear energy for electricity generation in order to cope with the projected electricity demand, because it was the only available option that could help achieve a number of objectives simultaneously. Firstly, nuclear power technology has the potential to deliver the projected demand on electricity, which is projected to grow by 9% annually until 2020 (*Policy of the United Arab Emirates*, 2008, “Background”). Secondly, the available reserves of gas will not be sufficient to generate the projected demand on electricity, whereas oil and coal will lead to an environmental degradation of the Emirate. And finally, for renewable energies, “even aggressive development could only supply 6-7% of peak electricity demand by 2020” (Emirates Nuclear Energy Corporation, 2011, p. 1).

In June 2011, the government of Saudi Arabia declared its plans to develop nuclear energy for the generation of electricity in order to meet growing domestic demand. Following this, King Abdullah City for Atomic and Renewable Energy (K.A.CARE) was created to undertake the task of building 16 nuclear power plants over the next 20 years, with a total investment of around US$ 80 billion dollars. The first two reactors are planned to come online in 10 years, followed by two more each year until 2030 in order to reach the objective of generating 20% of the Kingdom’s needs in electricity (World Energy Council, 2012, p. 32). Saudi Arabia has already signed a number of cooperation agreements with several governments and institutions in the fields of training, safety, and waste management--including building power plants with South Korea, France, Argentina--and is holding talks to explore potential nuclear energy cooperation with Russia, China, the UK, the Czech Republic and the U.S. (Knott, 2012).

Kuwait had plans to build four 1 GW nuclear power plants before abandoning them in the wake of the Fukushima nuclear accident (Knott, 2012).

The deployment of nuclear energy can bring significant advantages to the energy system of the GCC countries, especially as a mature technology with the potential to produce high levels of projected electricity demand in the future. However, the deployment of nuclear power in the GCC could face some constraints. First, it remains unsure that the GCC governments will be financially capable of maintaining their declared plans for long-term significant investments for the deployment of nuclear power, given the growing fiscal pressure—as a result of growing demand coupled with the impact of the Arab Spring—to increase their spending on the social and security fronts. Indeed, the GCC governments could postpone or curtail their nuclear power ambitions in the case of a decline in their revenues due to a drop in the price of oil, or changes in the structure of the global energy market as a result of the duplication of the American oil/gas shale revolution in other parts of the world, especially in China and India. The fiscal pressure faced by the GCC governments raises the cost issue of deploying nuclear power technology, and the extent to which the GCC governments can ably sustain the long-term investments needed for developing nuclear energy in the power generation sector, given the lack of cost-recovering power tariff structure in the GCC (El-Katiri, 2012, p. 2). Indeed, the rentier state structure will not allow for a tariff system to recover the initial investments that the governments will have to undertake in order to deploy nuclear power, in addition to the very high level of expected long-term variable costs inherent to nuclear energy technology. Following the Fukushima nuclear accident, concerns about the security of nuclear plants have led to a review of the security of existing nuclear plants globally and to stronger security measures for existing and future power plants, with a resulting increase in the cost of nuclear power.

Chapter 5

THE TECHNOLOGICAL INNOVATION-NICHES IN THE CONTEXT OF THE GCC

5.1. INTRODUCTION: THE RATIONAL FOR DEPLOYING RENEWABLE ENERGY SOURCES

In order to build future scenarios about the diversification of energy resources in the electricity generation sector of the GCC region, it is first necessary to establish a comprehensive and detailed review of the available niche technologies for the supply of electricity at the micro-level of the MLP. The niche technologies are those projected to replace the dominant conventional energy sources that are presently an integral part of the regimes level. The niche technologies considered in this research are the renewable energy technologies of direct solar energy and wind energy, whereas nuclear technology represents an alternative source of energy.

The choice has been made to limit the scope of this research to these renewable energy sources, as they are the most technically and commercially mature and also the most relevant to the GCC region, as will be seen in the context of this chapter. Moreover, considering all the available commercial renewable energy sources would present a task beyond the scope of a Ph.D. thesis.

The selected renewable energy sources will also be analyzed regarding their climate change mitigation impact, especially as far as carbon dioxide (CO_2) emissions are concerned. This chapter will be based essentially on the scientific findings of the various reports of the Intergovernmental Panel on Climate Change (IPCC), in addition to other academic and industry resources when necessary, especially when dealing with the specific cases of the GCC countries. The decision to rely primarily on the outcomes of the IPCC reports is motivated by two reasons: The IPCC reports are based on a literature review encompassing most of what has been published by the scientific community, and as a consequence, the data and outcomes of these reports are very widely accepted by the world scientific community and thus representative of the actual global scientific knowledge about climate change and renewable energy technologies. The second reason for this choice is linked to the homogeneity of the data and figures in the IPCC reports. Indeed, one of the main problems of dealing with the data in the energy industry stems from its diversity and occasional contradictions. Even the same subject may entail different calculating methods based on various inputs and assumptions. In this respect, IPCC figures allow us to overcome this technical problem.

The focus of this chapter will be a comparison of the technical and commercial aspects of these technologies as far as cost and CO_2 emissions are concerned, in addition to an analysis of their status and technical potential within the context of the GCC region. Finally, the future outlook of each technology will be discussed from a technical as well as a cost perspective within the GCC context, based on the most current information available in the literature in order to determine the long-term trends for building the scenarios.

The focus on the CO_2 emissions factor is motivated by the fact that the largest known source responsible for the increased concentrations of carbon dioxide (CO_2) in the atmosphere since the pre-industrial period is fossil fuel use, as already discussed in detail in chapter 3, in addition to the fact that the power generation sector alone accounts for 41% of global energy-related CO_2 emissions, as the electricity production sector is highly energy intensive and has reached 4839 Mtoe in 2010, which represented two-thirds more than the building sector and double the transportation sector (IEA, 2012, p. 351).

According to the 2012 IEA *World Energy Outlook*, the global demand[84] on electricity has increased by 40% over the period from 2000 to 2010, despite the decline caused by the global financial crisis in 2009, and demand for electricity is forecasted to continue growing more than any other form of final energy over the

[84] Per the IEA calculations, “electricity demand is calculated as the total gross electricity generated less own use in the production of electricity, less transmission and distribution losses” (IEA, 2012, p. 180).

projection period of 2010 to 2035. Indeed, in the scenarios conceived by the IEA, the annual demand growth on electricity will reach 2.6% per year in the Current Policies Scenario, 2.2% in the New Policies Scenario[85] (the central scenario of the WEO), and at only 1.7% in the 450 Scenario[86] (IEA, 2012, p. 180).

Before embarking on the task of surveying the renewable energy technologies available and evaluating their market potential for the production of electricity, as well as their climate mitigation potential, let us first outline "renewable energy" as defined by the IPCC:

> Renewable energy is any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use**.** Renewable energy is obtained from the continuing or repetitive flows of energy occurring in the natural environment and includes low carbon technologies such as solar energy, hydropower, wind, tide and waves and ocean thermal energy, as well as renewable fuels such as biomass. (IPCC, 2011, p. 958)

In other words, renewable energy is a naturally occurring and theoretically inexhaustible source of energy not derived from fossil or nuclear fuel, and that can be produced at equal or higher rates than its actual consumption.

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[85] According to the IEA definition:

> The New Policies Scenario—[the] central scenario— takes into account broad policy commitments and plans that have already been implemented to address energy-related challenges as well as those that have been announced, even where the specific measures to implement these commitments have yet to be introduced (IEA, 2012, p. 34).

[86] According to the IEA definition:

> Rather than being a projection based on past trends, modified by known policy actions, [the 450 Scenario] deliberately selects a plausible energy pathway. The pathway chosen is consistent with actions having around 50% of chance of meeting the goal of limiting the global increase in average temperature to two degrees Celsius (2 ˚C) in the long term, compared with pre-industrial levels. According to climate experts, to meet this goal the long-term concentration of greenhouse gases in the atmosphere needs to be limited to around 450 parts per million of carbon dioxide equivalent (ppm CO_2 eq)—hence the scenario name. (IEA, 2012, pp. 34-35)

All energy sources, including renewable energy sources, flow from primary energy through carriers to services and end uses. As far as renewable energy sources are concerned, the various renewable energy technologies available have the technical capacity to supply the market with the full range of energy services needed by a modern economy as shown in Figure 22 below:

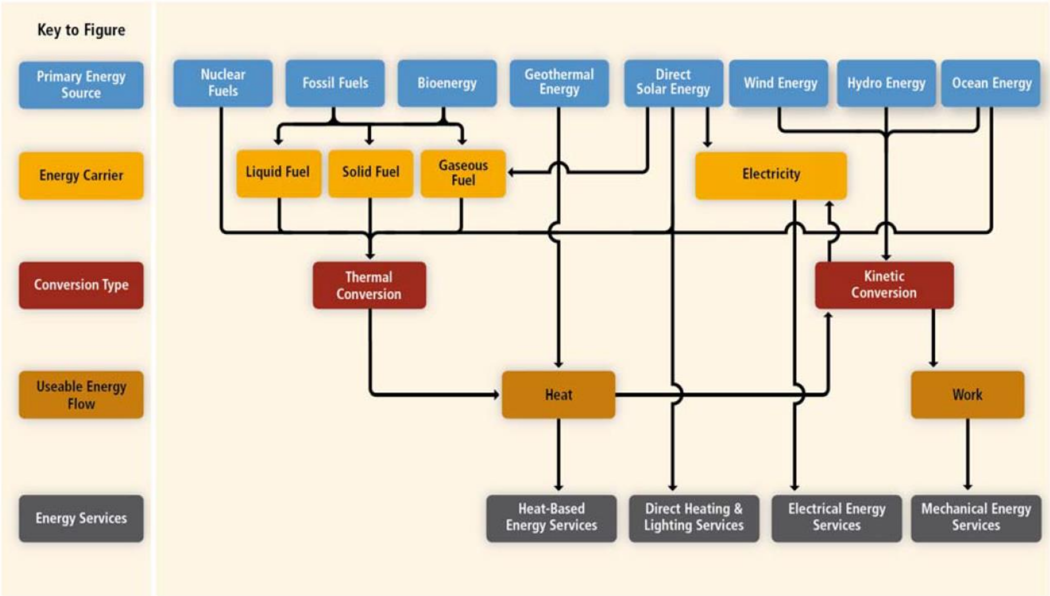

Figure 22: Illustrative paths of energy from source to service [87] Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 38.

It can be clearly seen from the figure above that that RE technologies can produce the full range of energy services needed for human use; however, as this research focuses on the production of electricity in the GCC countries, it will only consider the energy pathways that lead to the production of electricity using RE technologies relevant to the GCC region. In this regard, the relevant renewable energy technologies for the production of electricity in the GCC region are limited to solar energy and wind, as will be seen in subsequent sections of this chapter.

The deployment of RE sources is popular due to their potential role in mitigating climate change; however, they can also have social and economic benefits in addition to positive impacts on the environment and health, as summarized in the following points:

[87] All connected lines indicate possible energy pathways.

Firstly, RE sources do not suffer from the depletion factor, as they are inexhaustible. Indeed, the theoretical potential of RE is much bigger than the projected global energy demand, and the challenge for humanity is to be able to develop the technologies to capture a significant share of that potential in a sustainable way to produce the demanded energy services. From a technical perspective, the potential[88] of RE sources is by far much greater than the projected global energy demand (IPCC, 2011, p. 39).

Figures regarding the depletion of fossil fuel energy sources range from the very optimistic to the very pessimistic, and it is difficult to find any consensus among experts about the time range for the depletion of these resources. As such, it is not the objective of this research to review and analyze in detail the various theories and technical details about this issue. However, consensus ultimately agrees that fossil fuels are finite and will reach depletion sometime in the future—even if significant disagreements remain among the scientific community about the time range of this future.

In the context of the oil and gas rich countries of the GCC, introducing RE into the energy mix of the region, particularly in the power generation sector, will have the additional potential advantage of decreasing the domestic consumption of fossil fuels, and consequently increase its export capacity of cash earning oil and gas. Indeed, the growing domestic consumption of fossil fuel is putting pressure on the export capacity of a number of GCC countries and especially Saudi Arabia, which is already consuming 25% of its oil production domestically and projected to consume 50% of its oil production by 2015, according to the latest figures. The domestic consumption of oil and gas is pressuring available reserves, and some GCC countries have already begun witnessing a gas shortage.

Secondly, when compared to the thermal conversion processes for the production of electricity using conventional energy sources, RE sources are more environmentally friendly, as they are more efficient and require less primary energy conversion, and as a result release much less CO_2 in the atmosphere.

[88] According to IPCC usage, "Technical potential is used in the SRREN as the amount of RE output obtainable by full implementation of demonstrated technologies or practices. No explicit reference to costs barriers or policies is made" (IPCC, 2011, p. 10).

Indeed, “the thermal process to produce electricity (including biomass and geothermal) suffer losses of approximately 40 to 90%, and losses of about 80% occur when supplying the mechanical energy needed for transport based on internal combustion engines (IPCC, 2011, p. 38). In other words, the significant conversion losses of conventional energy technologies mean that they require much more primary energy from fossil fuels for the production of electricity. On the other hand, direct energy conversion from RE sources (with the exception of biomass and geothermal) to produce electricity does not suffer thermodynamic power cycle losses.

Thirdly, RE technologies can improve the level of energy access to the populations living in remote areas that are not connected to the national grid, which will contribute toward meeting the Millennium Development Goals of the United Nations as agreed upon following the Millennium Summit in 2000. The RE technological solutions for remote areas have the advantage of being cheaper and cleaner than the fossil fuel alternatives, such as diesel generators, so long as they are used to provide for basic services such as lighting, heating, drinking water, and cooking at a local level.

Fourthly, economic development has historically been accompanied by increasing energy use with consequential growth in the emissions of GHG. The deployment of RE will ultimately lead to decoupling that correlation and help achieve the goal of sustainable development, thanks to its technical capacity to give access to energy services in geographically remote areas. In addition, with its very low GHG emissions, it will contribute to climate change mitigation and the protection of the environment, with positive health impacts.

Fifthly, especially in the context of the GCC region, RE technologies will help reduce the stress on water availability, as with few exemptions (e.g. some biomass options) they consume much less water than the conventional water-cooled power plants.

5.1.1. The Cost Factor of Renewable Energy Sources

As stated by the last IPCC report, "the levelized cost of energy[89] for many RE technologies is currently higher than existing energy prices, though in various settings RE is already economically competitive" (IPCC, 2011, p. 40). Certain renewable energy technologies can be cost competitive within a given range in very specific environments and conditions related to the characteristics of the technology, regional cost variations, and performance under different environments and climates, as can be seen from Figure 23 below. As a result of the technical as well as the commercial developments RE technologies have witnessed in the past few decades conventional energy technologies do not anymore enjoy an absolute economic advantage over renewable energy technologies in every setting. The cost of RE has tended toward decline for the past decades, and with its expected technological developments—coupled with the economies of scale the future upcoming RE projects worldwide will provide—there is no doubt that in the long-term, RE will be cost competitive in most settings. That goes without mentioning that increases in the price of conventional energy sources will further the cost competitiveness of RE. In addition, when comparing the cost factor between RE and conventional technologies, the externalities and full social cost[90] of the latter are not taken into consideration;

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[89] According to the IPCC report,

> The levelized cost of energy represents the cost of an energy generating system over its lifetime; it is calculated as the per-unit price at which energy must be generated from a specific source over its lifetime to a break even. It usually includes all private costs that accrue upstream in the value chain, but does not include the downstream cost of delivery to the final consumer; the cost of integration, or external environmental or other costs. Subsidies and tax credits are also not included. (IPCC, 2011, p. 13)

[90] According to IPCC usage,

> Externalities arise from a human activity, when agents responsible for the activity do not take full account of the activity's impact on others' production and consumption possibilities, and no compensation exists for such impacts. When the impact is negative, they are called external costs. When positive they are referred to as external benefits. (IPCC, 2011, p. 11)

The energy industry, from extraction to consumption, has had a significant negative environmental and social impact—for example, the environment damage caused by fossil fuel extraction, production, transport, and consumption; the increased probability of wars due to the competition over access and control of energy resources; public health issues and chronic disease linked to the pollution of the environment, et cetera.

therefore, "monetizing the external costs of energy supply would [significantly] improve the relative competitiveness of RE" (IPCC, 2011, p. 13).

As can be seen from Figure 23 below in the case of PV and wind technologies, the cost of PV modules and wind power plants have experienced a declining slope since the end of the seventies, which historically corresponds to the first oil shock between 1973 and 1974.

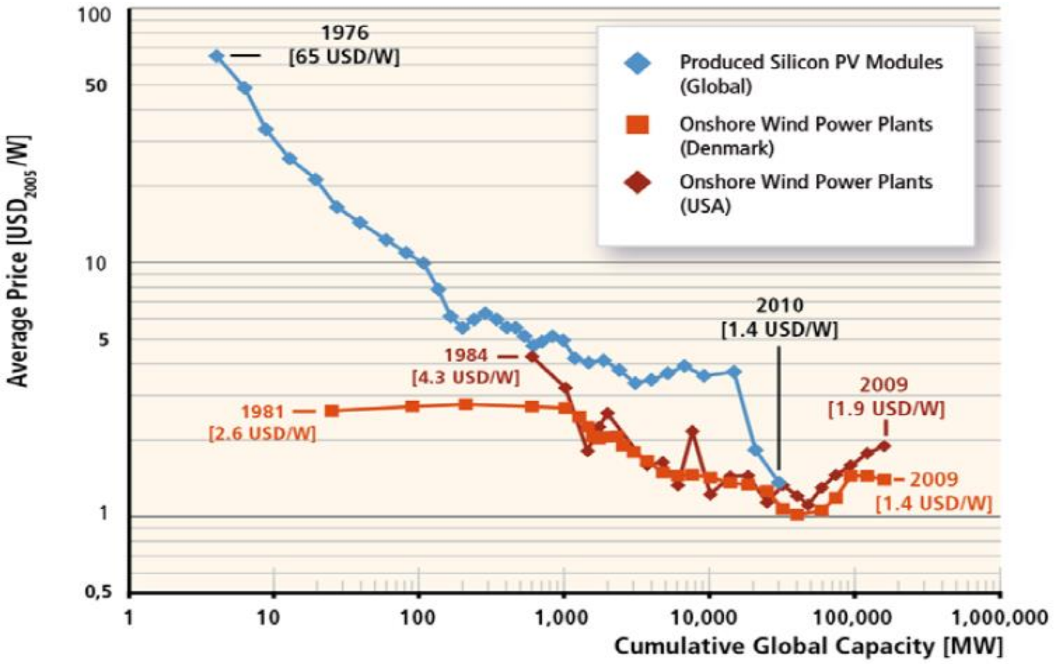


Figure 23: Selected experience curves in logarithmic scale for the price of silicon PV modules and onshore wind power plants per unit of capacity. Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change,* by IPCC, 2011, p.15.

In the electricity production sector, a variety of RE technologies can produce electricity at substantially variable costs. Figure 24 below provides a comparison of LCOE of RE technologies for the production of electricity. The cost ranges of these figures are broad as they are general and do not take into account local costs of investment, the quality of RE technology, and the cost of operation and maintenance that can vary from one technology to the other and from one context to the other.

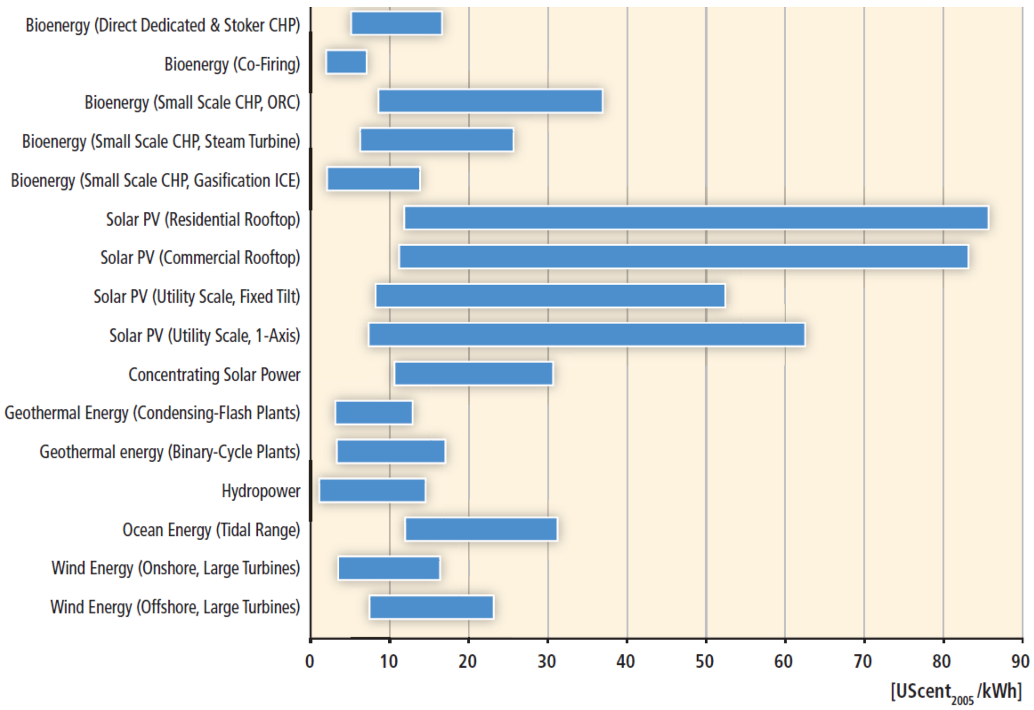


Figure 24: Levelized Cost of Electricity for commercially available RE technologies covering a range of different discount rates.[91] Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 188.

Calculating the cost of RE takes into consideration the investment cost in addition to the operation and maintenance cost (O&M cost), and in the case of RE, they are characterized by very high investment costs relative to O&M and fuel costs.

From a regional perspective, there are substantial variations from one region to another. As far as production of solar PV panels is concerned, China is now the leading global producer user and exporter, and in 2008, in terms of

[91] The lower bound of the levelized cost range is based on a 3% discount rate applied to the low end of the ranges of investment, operations, and maintenance (O&M), and (if applicable) feedstock cost and the high ends of the ranges of capacity factors and lifetimes as well as (if applicable) the high ends of the ranges of conversion efficiencies and by-product revenue. The higher bound of the levelized cost range is accordingly based on a 10% discount rate applied to the low end of the ranges of investment, operations, and maintenance (O&M), and (if applicable) feedstock cost and the high ends of the ranges of capacity factors and lifetimes as well as (if applicable) the high ends of the ranges of conversion efficiencies and by-product.

capacity, it was the largest investor in thermal water heating and third in bioethanol production. In the GCC region, however, the picture is entirely different, as its energy mix completely depends on fossil fuels and has not yet developed any capacity in RE, including the power generation sector. A number of ambitious projects of RE electricity production have been announced in the past few years but yet to materialize, with the exception of the Masdar project in the UAE, which has a 100 MW PV solar plant that has recently been put on line and is providing electricity for Masdar City.

5.1.2. Outlook of Renewable Energy Sources up to 2050

The majority of the reports or studies that have dealt with the future of the RE technologies predict, at different levels, an increasing share of RE sources in the global energy mix.

According to the 2011 IPCC report, "A significant increase in the deployment of RE by 2030, 2050 and beyond is indicated in the majority of the 164 scenarios reviewed in this special report" (p. 20). Although there are substantial variations between regions, all the scenarios indicate that RE will witness a very substantial deployment globally. In the electricity sector, and in the mid-term, the scenarios show a larger share of RE in the energy mix, and a more rapid deployment than the transport or heating sectors (IPCC, 2011, p. 816). The share of RE in the power generation sector varies from one scenario to another in the four reference scenarios. Indeed, in the lowest case of RE electricity development, the market share potential is 9% above the 2008 level, reaching a share of 24% by 2050, whereas the highest share of RE in the power generation sector reaches 95%, 72%, and 35% in the two other remaining scenarios (IPCC, 2011, p. 818). From these figures, it can be confidently assumed that the share of RE in the power generation sector will witness a significant deployment in the future up to 2050, as shown in Figure 25 below, which details the future deployment of RE in the power generation sector and by technology.

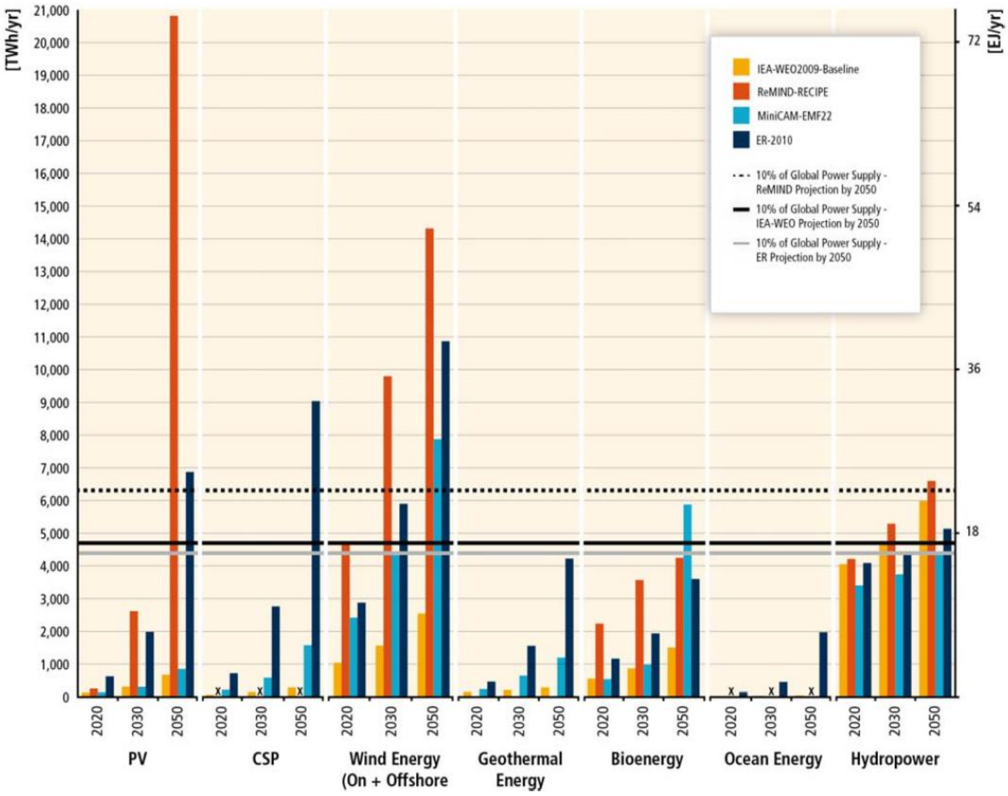


Figure 25: Projected global renewable power generation development by technology[92]. Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 819.

From the figure above, it can be clearly seen that all the projections in the four scenarios indicate a growing role for RE technology in the power generation sector, especially as far as wind and solar energy are concerned. Indeed, PV is expected to witness a very significant increase after 2030 in two scenarios, with a share of more than 10% by 2050, whereas the supply of electricity from wind is expected to overtake hydropower by 2030 (IPCC, 2011, p. 54). The differences in the scenarios can be explained by a number of reasons, but are mainly due to the fact that every scenario follows a different strategy and makes different projections regarding the future demand on electricity, and whether there will be a significant shift towards more electricity in the transport and heating sectors. Finally, on the policy front, the report concludes that "a high RE deployment can

[92] Development projections by technology and shares of global power generation for the four illustrative scenarios selected by the IPCC report for comparison.

only be achieved if system-relevant policy decisions are made many years ahead of the intended market penetration" (IPCC, 2011, p. 54).

As far as future investments in the RE in the power generation sector globally are concerned, the total investments are estimated to USD_{2005} range, depending on the scenarios, between USD_{2005} 1.360 and 5.100 billion between 2011 and 2020, and between 1.490 and 7.180 billion for the decade 2021 and 2030 (IPCC, 2011, p. 54)—investments that will ultimately lead to expanding the deployment of RE in the power generation sector, in addition to further decreases in the cost of RE.

From a regional perspective, the scenarios reviewed by the report provide a projection about the future deployment of RE in a selected number of regional settings that can be summarized in the following Figure 26:

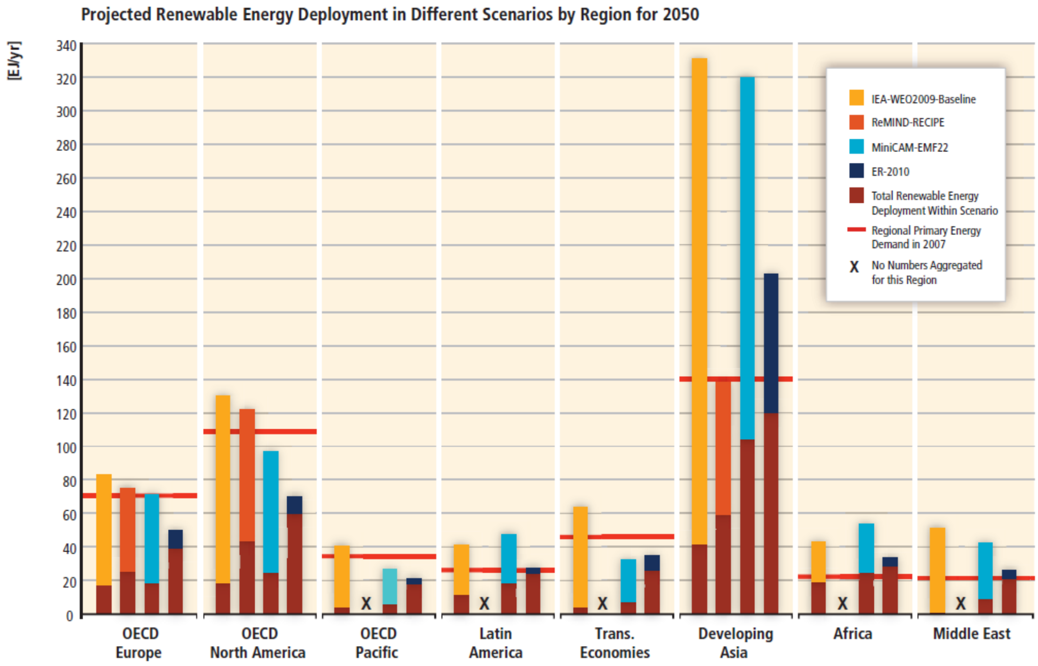


Figure 26: Projected renewable energy deployment in different scenarios by region for 2050[93]. Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 825.

[93] Regional breakdown of possible energy demand and RE potential deployment for the selected set of four scenarios in 2050.

From the figure above, it can be clearly seen that the Middle East, which includes the GCC region, is the region with the lowest level of RE deployment, as less than 4.5% of the available technical potential for RE is exploited, compared to 22.1 for India, 17.7% for China, and 15.3% for the OECD region (IPCC, 2011, p. 825).

From a technological perspective, wind technical potential has been better exploited to a much larger extent than solar energy. The projected weak performance of the Middle East region and the GCC in particular, is mainly due to the structural obstacles to a rapid and substantial deployment of RE in the region, and which are mainly linked to the fact that they enjoy substantial reserves of oil and gas at very low cost. However, according to the 2013 REN21 MENA Renewables Status Report:

> There is growing recognition of the opportunity cost of oil and gas used for domestic purposes, especially electricity production, desalination, and air conditioning, all of which are experiencing rapid increases in demand driven by rising GDP, urbanization, and population growth. (REN21, 2013a, p. 9)

Currently in the GCC region, oil and gas are nearly the only energy sources used for producing electricity on a large scale, but this situation could change in the long-term in light of the renewable energy projects that are in the pipeline for the power generation sector. The following tables will illustrate, in Table 29, the existing installed renewable energy capacity in the GCC countries, and Table 30, the capacity estimates for renewable energy projects in the pipeline, by technology, in the GCC countries.

Table 29

Installed Renewable Energy Capacity (MW) in the GCC Countries

	Solar PV	**Solar CSP**	**Wind**	**Biomass**	**Total**
Bahrain	5 (Year: 2011)	0	0.5 (2012)	0	5.5
Kuwait	1.8 (2010)	0	0	0	1.8
Oman	0.7 (2010)	0	0	0	0.7
Qatar	1.2 (2010)	0	0	40 (2012)	41.2
Saudi Arabia	7 (2013)	0	0	0	7
UAE	22.5 (2012)	100 (2013)	0	3 (2012)	125.5
Total	38.2	100	0.5	43	181.7

Note: Adapted from *MENA Renewables Status Report*, by REN21, 2013a, p. 11 (treated by the author).

Table 30

Capacity (MW) Estimates for Renewable Energy Projects in The Pipeline, by Technology (Number of Projects)[94]

	Solar	**Wind**	**Biomass**	**Total**
Bahrain	0	0	25 (1)	25
Kuwait	0	0	0	0
Oman	407 (2)	0	0	407
Qatar	0	0	0	0
Saudi Arabia	125 (4)			125
UAE	113.8 (3)	30 (1)	101 (2)	244.8
Total	645.8	30	126	801.8

Note: Adapted from *MENA Renewables Status Report* by REN21, 2013a, p. 12 (treated by the author).

From the two tables above, it is very clear that renewable energies are nearly absent from the energy landscape of the GCC region, even if the present situation remains modest and the installed capacity irrelevant to the existing electricity demand. However, the future could be different in the long term depending on a number of drivers that this research aims at selecting and evaluating for building the long-term scenarios of the power generation sector of the GCC countries up to 2050.

In this respect, the following sections will undertake the task of making a detailed technical as well as market analysis of the relevant RE technologies for the GCC region.

[94] The table includes only renewable energy projects in the power generation sector with a capacity greater than 1 MW.

5.2. DIRECT SOLAR ENERGY TECHNOLOGIES

According to the IPCC, solar energy is defined as: "Energy from the sun that is captured either as heat, as light that is converted into chemical energy by natural or artificial photosynthesis, or by photovoltaic panels and converted directly into electricity" (IPCC, 2011, p. 965).

When converted to heat or thermal energy, solar energy can be used to heat water (for use in buildings, homes or swimming pools), to heat spaces in buildings or homes, and it can be converted into electricity through Photovoltaic (PV) cells or Concentrating Solar Plants (CSP) for the production of electricity at different scales.

The concept of solar energy relies on the conversion, directly or indirectly, of solar radiation into energy using a variety of technologies. It is this radiation that plays a central role in producing electricity in two ways: indirectly, by producing heat that powers a mechanical engine which in turn drives an electrical generator, or directly by producing electricity through the use of photovoltaic cells. The average surface irradiance is evaluated at around 170W/m^2 which represents 5.4 GJ per m^2 and per year, equivalent to the energy that can be extracted from one barrel of oil, 200 kg of coal, or 140m^3 of gas (World Energy Council, 2010, p. 410). There are, of course, regional variations in solar irradiation[95], as some regions of the world receive much higher solar irradiance than average.

Solar energy is very abundant, and has a potential that exceeds the potential of all other energy sources as "the rate at which solar energy is intercepted by the Earth is about 10.000 times greater than the rate at which humankind consumes energy" (IPCC, 2011, p. 337). Converting only 0.1% of this energy with an efficiency of only 10% would be equivalent to "four times the world's total generating capacity of about 3000 GW" (World Energy Council, 2010, p. 408).

[95] According to IPCC usage, solar irradiance is defined as "The rate of solar power incidence on a surface (W/m_2). Irradiance depends on the orientation of the surface, with as special orientations: (a) surfaces perpendicular to the beam solar radiation; (b) surfaces horizontal with or on the ground. Full sun is solar irradiance that is approximately 1.000 W/m_2 (IPCC, 2011, p. 965).

From a regional perspective, the Middle East, North Africa, and GCC regions have the highest potential for solar energy, as seen from Table 31 below.

Table 31

Annual Total Technical Potential of Solar Energy for Various Regions of fhe World, Not Differentiated by Conversion Technology

REGIONS	Range of Estimates	
	Minimum, EJ	Maximum, EJ
North America	181	7,410
Latin America and Caribbean	113	3,385
Western Europe	25	914
Central and Eastern Europe	4	154
Former Soviet Union	199	8,655
Middle East and North Africa	412	11,060
Sub-Saharan Africa	372	9,528
Pacific Asia	41	994
South Asia	39	1,339
Centrally planned Asia	116	4,135
Pacific OECD	73	2,263
TOTAL	**1,575**	**49,837**
Ratio of technical potential to primary energy supply in 2008 (492 EJ)	*3.2*	*101*

Note: Adapted from "Table 5.19" by Rogner et al., 2000, as cited in *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 342.

As far as the Arabian Peninsula is concerned, it is ideally located in the sunbelt region and enjoys an annual solar radiation of about 2200 kWh/m^2 (Hepbasli et al., 2011, p. 5022).

Solar technologies are diverse and adapted to different settings, from small scale infrastructure for the production of electricity for local use, to large scale plants for providing electricity to the national and international grids, as exemplified by the Desertec Industrial Intiative (DII)[96] project to export solar electricity from the Middle East and North Africa region to Europe. In the present situation, solar energy in the power generation sector represents only a small fraction of the global electricity production. However, based on the scenarios reviewed by the IPCC, the potential deployment scenarios of solar energy ranges "from a marginal role of direct solar energy in 2050 to one of the major sources of

[96] Please see website: http://www.dii-eumena.com/about-us/mission-vision.html

energy supply" (IPCC, 2011, p. 337). In another study undertaken by the German Advisory Council on Global Change (WBGU), solar energy will have a major contribution to the global energy needs by 2050, as shown in Figure 27 below. In addition, it is worth noting that in the past 30 years, the cost of solar energy has significantly decreased thanks to continuous technical developments and to supportive public policies at the governmental level.

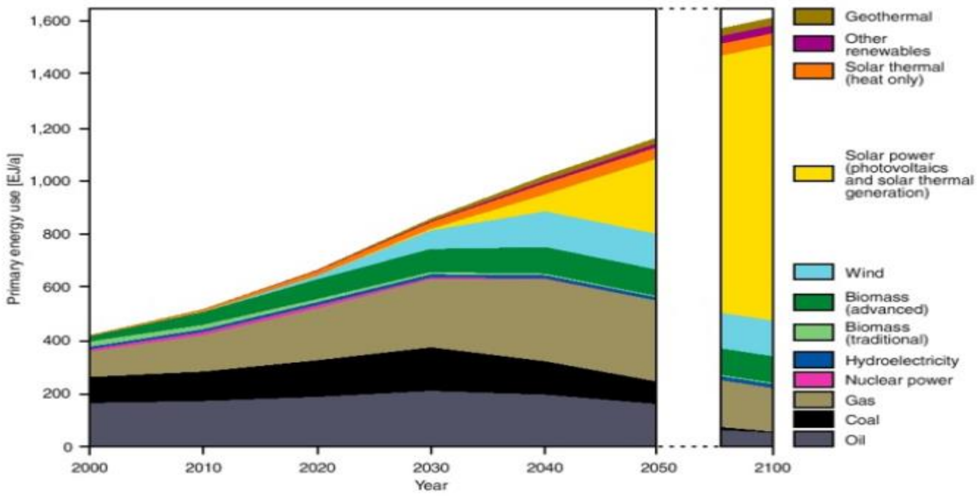


Figure 27: The evolution of the global energy mix up to 2100. Adapted from *World in Transition: Towards Sustainable Energy Systems*, by Germany Advisory Council on Global Change (WGBU), 2003, p. 3.

According to this future projection, it can be clearly seen from the figure above that the inflection point in the energy system is around 2030 when the contribution of RE and solar energy in the global energy mix will start becoming substantial, before representing about 70% by 2100, while oil gas and coal together will only represent around 15% of the global energy mix. According to the German Advisory Council on Global Change (WGBU), this scenario will only materialize in the case of a combination of energy efficiency and energy intensity policies in addition to continuous technological developments in solar energy technologies (2003, p. 3).

As far as electricity generation is concerned, solar energy can produce electricity in two ways: by converting solar energy directly into electricity through photovoltaic cells (PV), or by using solar thermal energy in a Concentrated Solar Power plant (CSP) in order to produce high temperature heat converted into electricity through a heat engine and generator. These are the two actual main techniques used for power generation in addition to other secondary techniques used to deliver heat and cooling. On the development front, researchers are also working on developing solar technologies that will provide for energy carriers such as hydrogen or hydrocarbon fuels, known as solar fuels. For the sake of this research, the focus will be on the PV and CSP technologies as they are the most advanced in the solar technology family and are mainly used in the power generation sector.

The level of maturity of solar technologies varies from one technology to another, “and their applicability depends on local conditions and government policies to support their adoption (IPCC, 2011, p. 337). Solar thermal technology used for comfort heating of buildings, industrial process heat, and domestic hot water, is considered a mature technology and is already cost competitive with conventional fuels in certain settings. Solar thermal technology is growing at annual rate of 16% and has reached an estimated capacity of 180 GW_{th} in 2009 (IPCC, 2011, p. 337). As far as the cost of solar technologies is concerned, it is still higher than the cost of conventional fuels for power generation, with the exception of off-grid applications in remote areas, and it faces additional costs that are linked to the integration of the solar energy power plants to the national grid.

It is worth mentioning, before starting a review of the solar energy technologies for the production of electricity relevant to the GCC region, namely PV and CSP technologies, that various and sometimes significantly different data regarding the technical characteristics of these technologies exist in the solar energy literature, especially regarding their cost and efficiency. This is mainly because these figures depend not only on the industrial process for producing them but also on the geographical characteristics of the site, in addition to the local governmental policies. In this respect, the data used in this research is general and does not necessarily reflect regional variations. However, in order to have the most accurate data, a limited number of sources accepted by governments, industry, and academia for their accuracy will be relied upon.

5.2.1. Photovoltaic (PV) Solar Technologies

The process of creating a voltage or electric current following the exposure of a material to sunlight is described as the *Photovoltaic effect* and is the basis of the photovoltaic (PV) solar technologies. According to the IPCC definition, PV solar technology is based on the process "of converting light energy directly into electricity by mobilizing electrons in solid state devices . . . [that are] specially prepared thin sheet semiconductors [that] are called PV cells" (IPCC, 2011, p. 963). From a historical perspective, the photovoltaic effect was first observed by the French physicist Alexandre-Edmond Becquerel in 1839, but the modern photovoltaic technology was born in 1954 in the United States when the first silicon photovoltaic (PV) cell capable of converting the sun's energy into electricity was developed by the Bell laboratories, with a 6% efficiency (Chapin et al., 1954), and had its first application on an orbiting satellite Vanguard 1 in 1958 (El Chaar, Lamont, & El Zein, 2011, p. 2167).

PV power generation technology is one of the fastest growing renewable energy sources and has witnessed a very substantial expansion in the past years, reaching a compound annual growth rate of more than 50% from 2003 to 2009, thanks to supportive public pricing policies. In addition, the installed capacity for PV power was estimated to be 22 GW in 2009, and an additional 13 GW of additional capacity was added in 2010 alone (IPCC, 2011, p. 338).

The global PV installed capacity reached 22 GW in 2009, capable of generating up to 26 TWh/year, with more than 90% of this capacity installed in three markets: the EU27 with 16 GW (73%), Japan with 2.6 GW (12%), and the USA with 1.7% (8%). As far as 2010 is concerned, the additional installed capacity was estimated to be between 9 and 24 GW (Jäger-Waldau, 2010b, as cited in IPCC, 2011, pp. 338-339). The PV projects in these markets is essentially grid-connected and has benefited from various governmental stimulation programs, including feed-in tariffs, various mechanisms such as buy-down incentives, investment tax credits, performance-based incentives, and RE quota systems. Figure 28 below illustrates the evolution of the cumulative installed capacity for PV from 2000 to 2009.

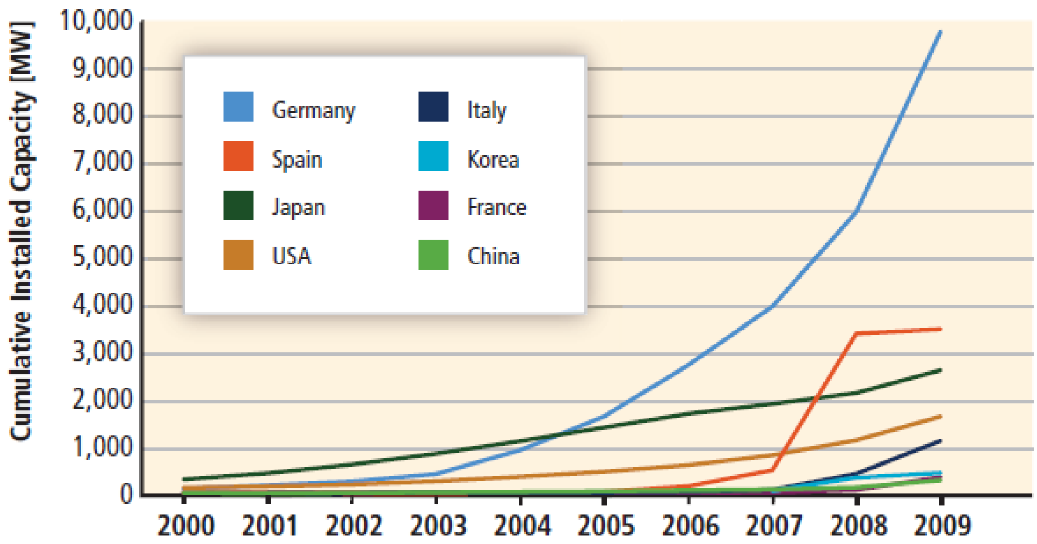


Figure 28: Installed PV capacity in eight markets. Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 361.

Despite its significant expansion and huge technical potential, PV solar technology is not yet a major energy supplier for primarily economic reasons. However, as the price of conventional-powered electricity rises while PV installed prices decline, it will not take very long before PV power will reach grid-parity with conventional-powered electricity. When mentioning the grid-parity concept, it is necessary to define it and to clarify certain points. According to Branker et al.:

> Grid-parity refers to the lifetime generation cost of the electricity from PV being comparable with the electricity prices for conventional sources on the grid often graphically given as the industry average for solar PV electricity generation against the average electricity price for a given country. (Branker et al., 2011, p. 4471)

While certainly a useful benchmark for the industry, its validity is subject to the accuracy of the method used to calculate the lifetime generation-cost of solar PV electricity. In addition, “grid parity is a moving target – as renewable deployment increase, their value in displacing conventional resources decline” (Olson et al., 2012, p. 17). In other words, the value of solar PV, or renewable energies in general, should not be based on the cost factor alone but also on the other benefits it brings to society.

Regarding concentrating PV (CPV), it is still an emerging market that represents around 17 MW of installed capacity globally in 2008, with estimates ranging between 20 to 40 additional capacity installed in 2009 and 2010 (IPCC, 2011, p. 361).

5.2.1.1. The cost factor of PV solar technology

As far as the cost of utility-scale electricity generation is concerned, in the context of Europe and the U.S. with a high solar irradiance, it ranges from 15 to 40 US $cents_{2005}$/KWh at a discount rate of 7% (IPCC, 2011, p. 338). However, when placed in a historical perspective, the cost of PV solar technologies has decreased from 22 USD/Wp in 1980 to 2–5 USD/Wp in 2005 (Margolis, 2003; Shaheen et al., 2005, as cited in Bosetti et al., 2012, p. 309), thanks to investments in R&D and economies of scale provided by the deployment of the technology, in addition to a decrease in the price of silicon.

According to the results of a study based on three scenarios about the long-term possible evolution up to 2050 of the cost of electricity produced using the PV and CSP technologies, it will greatly depend on the level of investments made in research, development, and deployment (RD&D). Indeed, according to the 'current RD&D' scenario, the experts who conducted the study concluded that the price of electricity will range between 7.5 and 14.5 cUSD/kWh, with an average cost of 10.8 cUSD/kWh, and that it will have a 66% probability to be lower than the symbolic level of 11 cUSD/kWh[97], and 10% of probability that it will be at 5.55 cUSD/kWh or even less. In the scenario with an increase of 50% in RD&D, the cost of PV CSP electricity will reach an average cost of 9.3 cUSD/kWh, and it has a 78% of probability that it will reach below the 11 cUSD/kWh by 2030, with a 12% probability that it will reach 5.55 cUSD/kWh. In the third scenario with a 100% increase in RD&D, there is a consensus among experts that the cost of solar electricity has 90% of probability to be lower than 11

[97] This represents the projected cost of producing electricity from coal with a 30 USD per ton of CO_2.

cUSD/kWh, with a 21% probability that it will reach 5.55 cUSD/kWh (Bosetti, Catenacci, Fiorese, & Verdolini, 2012, p. 316).

In order to have a clear idea about the cost of PV solar plants in the GCC region, it is worth reviewing the results of two different studies that have analyzed the energy as well as the financial profiles of two projects. The first study concerns a small-scale 5 MW PV power plant in Saudi Arabia, and the second concerns a study undertaken in 2011 for a large-scale PV power plant in the UAE. The latter project was actually built and inaugurated in June 2009 and is part of the Masdar Project in Abu Dhabi.

Regarding the first study, it concerns a small-scale 5 MW PV installation in Saudi Arabia, where the mean value of the Internal Rate of Return (IRR) of the project has been found to be 13.5% at any location in the Kingdom, with the highest IRR obtained at Bisha in the south-west region, where the IRR reached a maximum of 16.7%, while the Simple Payback Period (SPP) of the project was found to vary between 7.6 and 11.8 years depending on the location of the project (S. Rehman, Bader, & Al-Moallem, 2007, p. 1852). According to the study, the net present value (NPV) of the project is positive and would have a mean value of $51.3 million, making it a profitable project (S. Rehman et al. 2007, p. 1855), while the cost of energy[98] (COE) for a 5 MW PV plant in Saudi Arabia would range between 20 and 30 cents/kWh, i.e. 25 cents on average (S. Rehman et al. 2007, p. 1852).

From these figures, it can be concluded that small-scale solar PV plants in Saudi Arabia have a favorable economic profile, especially when they are located in areas with a high global radiation (GSR) as it is for the site of Bisha.

Regarding the second study, in June 2009, a large-scale PV solar power plant with a 10 MW capacity was inaugurated in Abu Dhabi in order to produce electricity for the project Masdar City. What will follow is an analysis of the main financial indicators of the project. The PV power plant is projected to generate around 24.4 GWh/year of electricity, which according to 2008 figures, represents

[98] It is defined as the avoided cost of energy required for the project to break-even. In the case of this study, it is assumed that all financial parameters other than the avoided cost of energy are kept constant (S. Rehman et al., 2007, p. 1854).

0.07% of Abu Dhabi's total power generation of 34.500 GWh—enough to meet the demand of 1970 persons based on the UAE's consumption of 12.375 kWh/year and per capita (Harder et al., 2006, p. 793).

Table 32

Summary of the Financial Indicators of a 10 MW PV Power Plant

Net present value	$–50.8 million
Energy production cost	16.18 cents/kWh
Benefit-cost ratio	0.45
Annual life cycle savings	$–3.3 million
Internal rate of return	0.5%
Simple payback period	55.4 years
Years to positive cash flow	29.5 years

Note: Adapted from "The Costs and Benefits of Large Scale Solar Photovoltaic Power Production in Abu Dhabi, United Arab Emirates", by E. Harder and J. M. Gibson, 2011, in *Renewable Energy, 36,* p. 793.

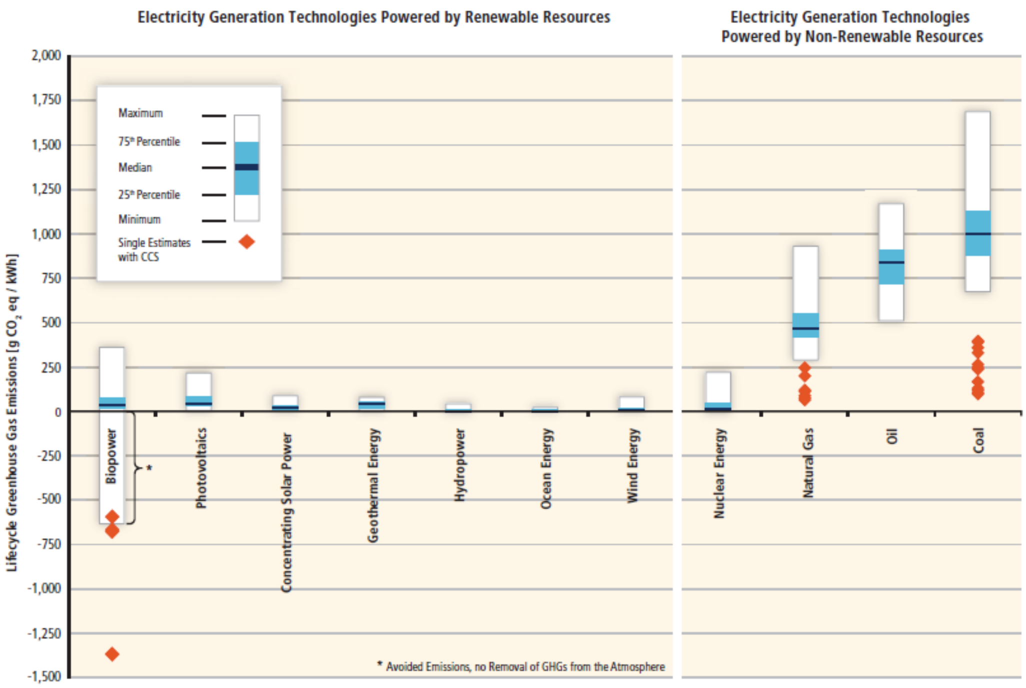
The study concluded that large-scale PV power plants were not profitable as the NPV had a negative value of around $ -50.8 million (see Table 32 above); however, when taking into consideration the negative externalities represented by the environmental cost, the picture was quite different with an estimated NPV of $ 47.4 million (Harder & Gibson, 2011, p. 795). Here again, this is another example of different ways of calculating energy projects and whether externalities of a given project are included or not. These results confirm similar findings that PV solar power plants projects are not profitable for the moment, and that they should be subsidized by governments, as private utilities companies will not take into consideration the cost of the negative externalities represented by the damage caused to the environment by power plants using conventional fossil fuels.

The total cost for producing 1kWh, or the energy cost, is estimated to be 16.18 cents/kWh, whereas the number of years necessary before having a positive cash flow are estimated to be around 29.5 years. All these elements illustrate the long-term nature of large-scale RE projects in the power generation sector and that can only be realized with a strong financial backing from a government.

According to Bloomberg New Energy Finance (BNEF), PV solar technology is already a viable option for power generation in the Gulf region in the case the price of domestic energy is valued at the international market. In other words, the financial profile of a PV project in the GCC will depend on whether comparisons are based on the price it sold at domestically, or are based on the international price of oil. Indeed, when based on the international price of oil, the results of an economic modeling for a 100 MW PV power plant show that "there is a strong economic rationale for Gulf Cooperation Council (GCC) states to build solar capacity today (BNEF, 2011, p. 1). However, when PV is compared to gas, "investment in PV in order to displace gas is still not cost-competitive due to the very low price of gas and the higher efficiency of gas-fired power plants compared with oil-fired power plants" (BNEF, 2011, p. 6), but could become possible in the next 20 years if it is assumed that gas prices will increase and the cost of PV technology will continue to decline.

5.2.1.2. The climate mitigation impact of solar PV

The climate change mitigation potential is the main driver for the development of RE, and an evaluation of the environmental burden of different technologies from upstream to downstream is a necessary step in order to make comparisons between the different energy sources, whether conventional or renewable energy. In this respect, the lifecycle assessment (LCA) concept is a very helpful concept in order to evaluate the full environmental impact of technologies and make comparisons between them. As defined by the IPCC, the "LCA allows a detailed investigation into the environmental consequences that are associated with manufacture, operation and decommissioning of a specific technology evaluated in the context of the current energy system (2012, p. 729). In this respect, Figure 29 below compares the life cycle GHG emissions (g of CO_2) between RE technologies and non-renewable, or conventional, energy technologies in the power generation sector.



Count of Estimates	222(+4)	124	42	8	28	10	126	125	83(+7)	24	169(+12)
Count of References	52(+0)	26	13	6	11	5	49	32	36(+4)	10	50(+10)

Figure 29: Estimates of lifecycle GHG emissions (g CO_2eq/kWh). Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 732.

The figure above illustrates the environmental advantage of RE technologies, especially regarding CO_2 emissions, comparatively to the conventional energy technologies in the power generation sector. It is worth noting that the bulk of CO_2 emissions in the RE technologies takes place in the upstream stage, during the manufacturing process, whereas the emissions from the conventional technologies take place in the downstream phase as a result of the combustion of the fossil fuels.

According to a study undertaken by Kannan et al., which included a life cycle assessment (LCA) and life cycle cost analysis for a 2.7 kWp grid connected monocrystalline solar PV system in Singapore, the GHG emissions from a PV solar power generation plant is "less than one-fourth that of an oil-fired steam turbine plant and one-half that a gas fired combined cycle plant (as cited in Parida, Iniyan, & Goic, 2011, p. 1630).

Based on the results of a study undertaken by S. Rehman et al. for the evaluation of the cost of a 5 MW solar PV plant, it has been estimated that 41 plants with a 5 MW capacity spread in the whole territory of the Kingdom contribute in avoiding the emission of 335.455 tons of GHG in the atmosphere per year, which represents an average of 914 tons of greenhouse gases (S. Rehman et al., 2007, pp. 1854-1855). In the case of a large-scale PV power plant of 10 MW capacity in Abu Dhabi, it has been found that it would contribute in avoiding the emission in the atmosphere of 10.732 tons of CO_2 eq., emitted by 24.4 GWh of electricity produced from a conventional thermal power plant (Harder & Gibson, 2011, p. 795).

5.2.1.3. Future outlook of solar PV

As a result of the continuous technical improvements and the economies of scale provided by the development of PV solar projects worldwide, the cost of PV solar technology will continue to decline, and it is expected that by 2020 or even before, it will reach the status of a cost-competitive energy supply technology (Bagnall et al., 2008, p. 4395), provided with the necessary investments in research and new projects globally, which will allow for PV technology to be deployed more extensively after 2020 and beyond.

5.2.1.4. Status of PV solar technology in the GCC

In the past decade, the UAE has been at the forefront of major solar energy developments and is now considered the leading country in solar energy investments in the region and worldwide with very ambitious long-term objectives. In this respect, the Masdar Project has been the landmark project launched by Mubadala Group, and considered the biggest and most ambitious solar energy project in the Middle East and North Africa. In addition, the Emirate of Abu Dhabi has set the goal to produce 7% of its electricity by 2020. In June 2009, Noor 1, a solar PV plant with a 100 MW of installed capacity, was launched within the overall Masdar project. This is the largest solar PV plant in the entire

Middle East and one of the largest worldwide. The solar PV plant produces around 17500 MWh of electricity and annually offsets 15000 tons of CO_2 (Masdar, n.d.).

Among the GCC countries, Saudi Arabia has the highest potential, and has been engaged in solar energy research since the early sixties, when the first PV beacon was built at the airport of Al Madinnah. In the field of scientific research, the first small-scale research project was launched in 1969, while the first major research and development (R&D) efforts were initiated by the King Abdulaziz City for Science and Technology (KACST) in 1977 (Hepbasli et al., 2011, p. 5022). Following this major step, a significant number of research and pilot projects were undertaken by the Energy Research Institute (ERI) within KACST with the collaboration of renowned research institutions in the world. Table 33 below summarizes the solar energy research projects pursued in Saudi Arabia by ERI and KACST between 1981 and 2000. Based on this historical background, it can be concluded that Saudi Arabia has the longest proven experience in solar energy technology, which is why its technical outcomes and policy aspects can be relied upon in this research dedicated to the future of solar energy in the GCC countries.

Table 33

List of Solar Energy Projects Conducted by the ERI and KACST 1981-2000

Period or year conducted	Location	Description of projects		Application purposes
		Type	Capacity	
1981–1987	Solar Village	PV system	350 kW (2155 MWh)	AC/DC electricity for remote areas
1981–1987	Saudi universities	Solar cooling	–	Developing of solar cooling laboratory
1986–1991	KAU, Jeddah	Solar hydrogen	2 kW (50 kWh)	Testing of different electrode materials for solar hydrogen plant
1986–1994	Solar Village	Solar-thermal dishes	2 pieces, 50 kW	Advanced solar stirling engine
1987–1990	Solar Village	PV test system	3 kW	Demonstration of climatic effects
1987–1993	Solar Village	PV hydrogen production	350 kW (1.6 MWh)	Demonstration plant for solar plant hydrogen production
1988–1993	Dammam	Energy management in buildings	–	Energy conservation
1988–1993	Al-Hassa, Qatif	Solar dryers	–	Food dryers (dates, vegetables, etc.)
1989–1993	Solar Village	Solar hydrogen generator	1 kW (20–30 kWh)	Hydrogen production, testing and measurement (laboratory scale)
Since 1990	Solar Village	Long-term performance of PV	3 kW	Performance evaluation
1993–1995	Solar Village	Internal combustion engine	–	Hydrogen utilization
1993–1997	Solar Village	Solar collectors development	–	Domestic, industrial, agricultural
1993–2000	Solar Village	Fuel cell development	100–1000 W	Hydrogen utilization
1994–1999	Sadous Village	PV water desalination	0.6 m^3	PV/RO interface per hour
1994–2000	12 stations	Solar radiation measurement	–	Saudi solar atlas
1994–2000	5 stations	Wind energy measurement	–	Saudi solar atlas
1996	Southern regions of Saudi Arabia	PV system	4 kW	AC/DC electricity for remote areas
1996	Muzahmia	PV in agriculture	4 kWp	AC/DC grid connected
1996–1997	Solar Village	Solar-thermal desalination	–	Solar distillation of brackish water
1996–1998	Solar Village	PV system	6 kW	PV grid connection
1999–2000	Solar Village	Solar refrigeration	–	Desert application

Note: Adapted from “Evaluation of Solar Energy Research and its Applications in Saudi Arabia: 20 Years of Experience” by S. H. Alawaji, 2001, in *Renewable and Sustainable Energy Reviews, 5*, p. 61.

On the research front, the scientific capacities of Saudi Arabia have also been enhanced by the establishment—six months before the announcement to establish KACARE—of King Abdullah University of Science and Technology (KAUST), which will be dedicated essentially to research for the diversification of the Saudi economy, including the development of renewable energy technologies (KAUST, 2014). King Fahd University of Petroleum and Minerals (KFUPM), established in 1963, has recently established a Center of Research Excellence in Renewable Energy (CoRE-RE) and a Center for Sustainable Energy Technologies (SET) in order to contribute in the national research effort for the development of alternative and sustainable energy technologies.

Saudi Arabia has also conducted a number of research on sea-water desalination using solar technology. The first pilot project was conducted in 1984 within the framework of SOLERAS (Saudi Arabian-United States Program for Cooperation in Solar Energy Projects) at Yanbu on the Red Sea coast with a capacity of 200m^3 per day. In April 2010, Saudi Arabia—in collaboration with IBM—has launched the first step of a three-phase project for water desalination using solar energy technology. In addition, the project includes establishing a research institute dedicated to the development of cost-effective technological solutions for sea-water desalination through solar energy (Hepbasli et al., 2011, p. 5040).

The establishment of the above mentioned research institutions in Saudi Arabia is a clear indication of the Kingdom's political will to be not only a consumer of RE technologies, but also, in the long term, to put the Kingdom on the world map of the technological developers and innovators of RE technologies. It is still too soon to assess the future outcomes of all these investments in solar energy research, and to what extent they will allow Saudi Arabia to become a producer of solar energy technologies and know-how, but there is no doubt that all these efforts fall within the overall strategy of the Kingdom to transform, in the long run, its economy from an oil based rentier economy into a knowledge economy. From the Saudi experience in solar energy research and projects, Alawaji has reached a number of conclusions, of which the most relevant to our research include:

- Seawater desalination through solar energy is currently not cost-competitive with conventional energy sources.

- PV solar technology has proven to be cost-competitive in Saudi Arabia on-grid as well as off-grid. The only drawback with PV solar technology is the necessity to clean the PV panels regularly due to the dusty weather, in order to preserve an acceptable level of efficiency.

- Solar-thermal dishes with a small diameter have proven to be more practical in remote locations due to the maintenance and operational problems faced by large-scale solar-thermal dishes, which are not cost-competitive (Alawaji, 2001, p. 76).

Aramco, the Saudi public petroleum company, is also engaged in the development of renewable energies; in 2012, it created an investment unit for renewable energies, and in partnership with the King Abdullah Petroleum Studies and Research Center, it is funding entirely or partially the construction of three solar PV projects with a total installed capacity of 17 MW (REN21, 2013a, p. 26).

The other GCC countries also have plans for solar PV plants but at a much smaller scale than the UAE and Saudi Arabia, and as already reviewed in chapter 4 in the section dedicated to the energy policies of the GCC countries.

It should be noted that in the context of the GCC region and its dusty weather, that the PV solar panels require periodic cleaning in order to maintain the performance which results in a non-negligible consumption of water.

5.2.2. Concentrating Solar Power (CSP) Systems

Most of the electricity that is produced globally relies on the fossil fuels (coal, gas and oil) that are burned in order to create a hot fluid used in a downstream process for generating electricity. The CSP technology provides an alternative to the fossil fuels for producing heat, and therefore has an interest in building on an existent and proven technology. CSP has a number of advantages as summarised in the following points: (1) It is suitable for a wide range of capacities depending on the conditions and applications, starting from tens of kW (dish/Stirling systems), to multiple MW using tower and trough systems; (2) it is flexible enough to integrate thermal storage for peaking loads, starting from less than an hour to six hours, or use fossil fuels as a back-up to overcome the disadvantage of the intermittency of sunlight; (3) it is composed of flexible modular and scalable components; (4) the materials used for producing the components of a CSP are widely available (IPCC, 2011, p. 355).

As shown in Figure 30 below, four types of concentrating solar plants have been developed worldwide: a) Parabolic trough; b) Central receiver plant; c) Linear fresnal; and d) Dish/engine.

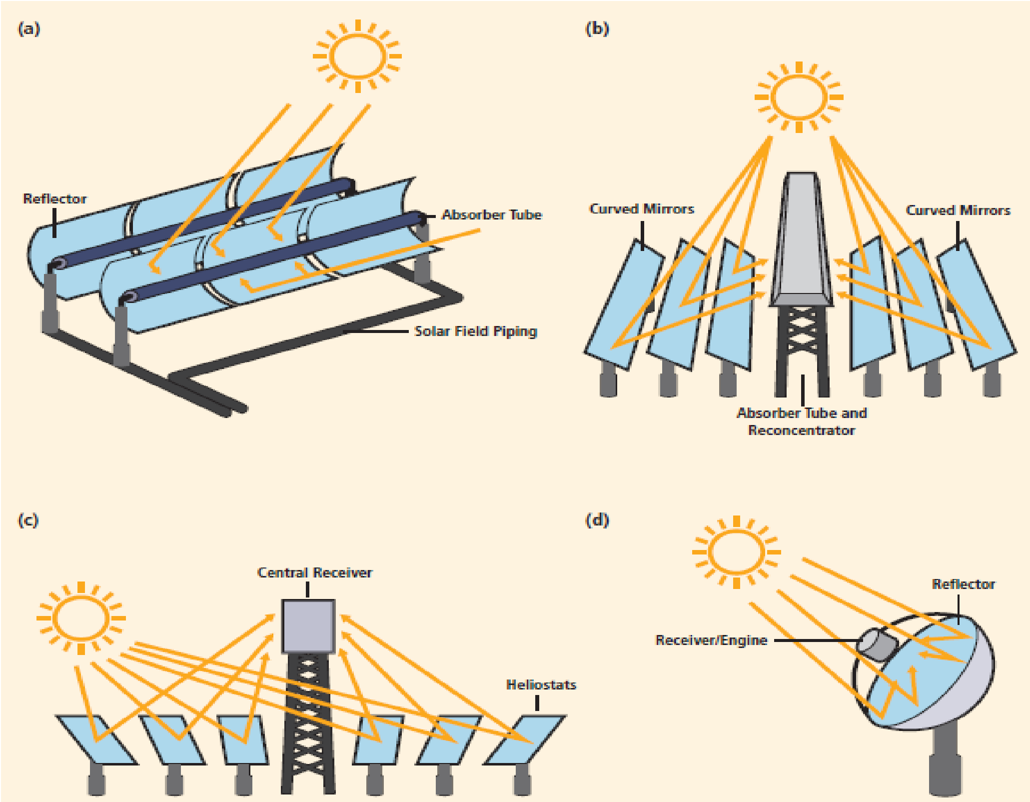


Figure 30: Schematic diagram of the four types of CSP plants. Adapted from *Renewable Energy Sources And Climate Change Mitigation: Special Report Of The Intergovernmental Panel On Climate Change*, by IPCC, 2011, p. 356.

CSP plants depend on direct beam irradiation as opposed to global horizontal irradiation, and accordingly, need to be situated in regions with a high level of direct solar radiation in order to be efficient, such as the sun-belt near equatorial cloud-free regions, as is the case for the GCC. Figure 31 below shows the regions of the world that are appropriate for CSP plants, and it indicates that the GCC region is among the most promising areas for CSP projects.

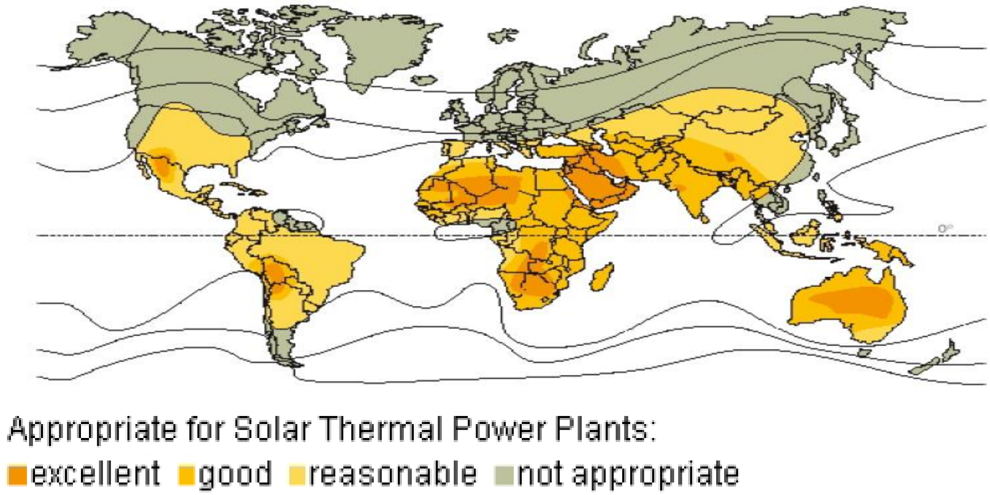


Figure 31: Regions of the world appropriate for CSP plants. Adapted from *2010 Survey of Energy Resources* by World Energy Council, 2010, p. 416.

Globally, CSP electricity generation represented more than 700 MW of grid-connected installed capacity in 2009, in addition to another 1.500 MW_e under construction, with the majority of these plants using the parabolic trough technology. However, the Central-receiver technology is expanding as the bulk of the announced projects use it, most of them located in Spain and the U.S. (IPCC, 2011, p. 361).

5.2.2.1. The cost factor of CSP technology

The data concerning the cost of CSP technology is currently limited, as it strongly depends on the cost of storage technology. According to 2009 figures, the levelized costs of energy for large scale plants with a capacity of six hours of thermal storage was estimated to be around 20 to 30 US $cents_{2005}$/KWh (IPCC, 2011, p. 338).

The efficiency and cost of a CSP plant is intimately linked to the level of solar irradiance, and in this respect, selecting the ideal location is a crucial element of any CSP project. In the case of the MENA region, which includes the GCC, its higher solar irradiance makes the cost of CSP projects in the MENA region lower than in Europe (German Aerospace Center [DLR], 2006, p. 7). However, when compared to the cost of PV solar technology, the cost of CSP technology is higher. As for parabolic trough, it ranges between 3.15 and 4.20 USD/W and rises to 4.90 USD/W when a six hour thermal storage system is included (Denholm et al., 2010; Price et al., 2002, as cited in Bosetti et al., 2012, p. 309).

5.2.2.2. The climate mitigation impact of CSP Systems

As has been seen already in Figure 29 above, all RE technologies have a significant potential for climate change mitigation, including CSP technology that is even better classified than the PV solar technologies. The environmental mitigation impact of CSP technology is very significant, even if there are minor variations from one application to the other. In general terms, each square meter of a CSP plan has the potential of avoiding the emission in the atmosphere between 0.25 and 04 tons of CO2 per year (IPCC, 2011, pp. 370-371).

The first environmental impact of CSP plants is not the GHG emissions aspect of the problem, but in the land use issue, as building a CSP plant requires a large surface of flat land. Indeed, the land requirement of a CSP plant is important—around 2 km^2 for a 100 MW_e plant depending on the technology used for the collectors and without any storage facility (IPCC, 2011, p. 355). This impact is especially relevant if the plant has to be built on agricultural land or on protected natural reserves; however, “sunny deserts close to electricity infrastructure are ideal” locations (IPCC, 2011, pp. 370-371), which is exactly the case for the GCC region. However, the land requirement aspect of CSP plants could become an issue for the small countries of the GCC when taken individually (with the notable exception of Saudi Arabia), but not if the GCC region is considered as an integrated unit. Therefore, we can assume that the feasibility of CSP plants will also depend on the level of integration between the GCC countries within the framework of the GCC organization.

The second environmental concern of CSP technology is water availability and consumption, as it needs substantial quantities of water in order to produce the steam necessary to make the turbines turn and generate electricity. This concern is even more pressing in the case of the GCC region, which already suffers from water scarcity. However, the technology of dry cooling can contribute substantially toward decreasing water consumption.

Finally, the third environmental concern of CSP technology is, as in the case of solar PV technology, associated with the visual impact of the plants.

5.2.2.3. The future outlook of CSP

The future deployment of CSP technology has great potential, even if in the present time its cost still exceeds marketed energy prices—as has been seen in a previous section of this research—and thus continued cost reductions will be necessary for a substantial expansion of CSP technology to become a major contributor to the global energy supply in the long term.

The long-term scenarios concerning the future deployment of CSP technology in the power generation sector vary greatly, depending on the assumptions they make. Table 34 below summarizes the results of four different scenarios concerning the deployment of CSP technology in the mid-term up to 2020 in terms of cumulative capacity.

Table 34

Evolution of Cumulative CSP Capacity Based on Different Scenarios

Cumulative installed capacity	**CSP Electricity (GW)**		
	2009	**2015**	**2020**
Current value	0.7		
EREC Greenpeace (reference scenario)		5	12
EREC Greenpeace (revolution scenario)		25	105
EREC Greenpeace (advanced scenario)		30	225
IEA Roadmaps		N/A	148

Note: Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change,* by IPCC, 2011, p. 386.

As can be seen from the table above, there are large variations between the scenarios as they are based on different assumptions regarding the GHG targets.

5.2.2.4. Status of CSP technology in the GCC

According to a study undertaken by the German Ministry of Environment Natural Conservation and Nuclear Safety in 2006, the GCC region has the potential to become a major producer and exporter of electricity generated through solar energy applications thanks to the region's significant potential. In this respect, and according to the REN21 report about the expected future deployment of solar energy technologies in the MENA region, CSP will have an advantage over solar PV, despite CSP's higher cost (REN21, 2013a, p. 19).

Almost all the GCC countries have declared long-term capacity objectives for CSP power; however, so far, the only CSP power plant in operation in the region is Shams 1, the world's largest CSP power plant with a 100 MW of installed capacity, which entered into operation in March 2013 (REN21, 2013a, p. 10).

5.3. WIND ENERGY TECHNOLOGY

According to the IPCC, wind energy is defined as:

Kinetic energy arising from air currents arising from uneven heating of the earth's surface. A wind turbine is a rotating machine including its support structure for converting the kinetic energy to mechanical shaft energy to generate electricity [. . .]. A wind farm, wind project or wind power plant is a group of wind turbines interconnected to a common utility system through a structure of transformers, distribution lines, and (usually) one substation. (IPCC, 2011, p. 967)

Wind energy has been part of human history since ancient times, with a variety of applications from sailing, to grind grains in windmills, to water pumping. From a historical perspective, it is worth noting that windmills were introduced in Europe by the crusaders as they returned from their campaigns in the Middle East; the Dutch then improved and refined windmills, expanding its uses to other applications. However, the industrial revolution led to a temporary decline of windmills, and the first attempt to use wind for generating electricity is attributed to James Blyth and Charles Bruch in 1887, followed by Poul la Cour in 1891. However, it is only in the 1970s that wind energy began to be used on a commercial level thanks to technical advances and government support, first in Denmark, followed by the U.S. in California in the 1980s, and then Germany and Spain in the 1990s (IPCC, 2011, p. 542).

In recent years, wind energy has been expanding at very high rates; global installed wind capacity has increased from a cumulative capacity of 14 GW in 1999 to 160 GW by the end of 2009, representing an increase of 12 fold in 10 years with most of this addition built onshore. However, offshore capacity is catching up quickly, as 2.1 GW of capacity was added in 2009 alone (IPCC, 2011, p. 539).

It is necessary to note that the figures regarding the assessment of the global or regional technical potential for wind energy are not fixed, as they essentially depend on the level of development of the technology. According to a variety of assessments, the global technical potential for wind energy is much higher than the actual world electricity production, and almost all the regions of the world enjoy variable levels of wind energy potential, even if it is not evenly distributed across all the regions of the globe. According to the latest estimates of the IPCC, based on a synthesized figure from a variety of studies, the technical potential of onshore wind energy is 180 EJ/year, equivalent to 50.000 TWh/year, which represents the double of the global electricity production in 2008 (73 EJ or 20.200 TWh) (IPCC, 2011, pp. 543-544).

As far as the regional onshore wind energy potential is concerned, a number of studies have been undertaken by different organizations and have produced varying figures as they are based on different key input parameters related to the speed of the wind and the performance of the technology. The results of these studies are summarized in Table 35 below:

Table 35

Regional Allocation of Global Technical Potential for Onshore Wind Energy

Grubb and Meyer (1993)		WEC (1994)		Krewitt et al. (2009)[2]		Lu et al. (2009)	
Region	%	Region	%	Region	%	Region	%
Western Europe	9	Western Europe	7	OECD Europe	5	OECD Europe	4
North America	26	North America	26	OECD North America	42	North America	22
Latin America	10	Latin America and Caribbean	11	Latin America	10	Latin America	9
Eastern Europe and Former Soviet Union	20	Eastern Europe and CIS	22	Transition Economies	17	Non-OECD Europe and Former Soviet Union	26
Africa	20	Sub-Saharan Africa	7	Africa and Middle East	9	Africa and Middle East	17
Australia	6	Middle East and North Africa	8	OECD Pacific	14	Oceania	13
Rest of Asia	9	Pacific	14	Rest of Asia	4	Rest of Asia	9
		Rest of Asia	4				

Note: Adapted from *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, by IPCC, 2011, p. 547).

The figure of 8% for the Middle East and North Africa, given by the WEC (1994) study, would be the closest indicative figure about the technical potential of the GCC region, as the other studies include the GCC in much larger geographical regions.

As far as the global deployment of wind energy is concerned, it has been successfully deployed in a number of countries. Since 2006, China has been doubling its turbine installations every year, and in 2009, it was ranked second worldwide in terms of installed capacity. Indeed, China ranks first in renewable power capacity, followed by the U.S., Germany, Spain, and India. India is also becoming a major actor in the RE field, as it is now one of the main producers of wind turbines in the world and among the top five countries in terms of installation (REN21, 2009, 2010). In 2010, wind energy supplied between 10 to 20% of electricity demand in four countries: Denmark, Portugal, Spain, and Ireland (IPCC, 2011, p. 540).

5.3.1. The Cost Factor of Wind Energy

Since the eighties, the cost of wind energy has significantly declined, especially as far as onshore wind technology is concerned, and is cost-competitive with existing energy market prices in many parts of the world (IPCC, 2011, p. 583). However, the cost of a wind energy project will be site dependent, highly depending on the wind potential compared to alternative power sources, and has to be evaluated individually for each project. In this respect, it is worth noting that offshore wind plants investment costs are 50 to 100% higher than for an onshore wind plants (IPCC, 2011, p. 584). The cost of offshore wind plants is highly site-specific and depends on a number of factors, especially the depth at which the plant is located. Until the present time, offshore wind plants have been built in relatively shallow water near to the coast, which means that higher costs should be expected from projects that will be built in deep waters far from the coast (IPCC, 2011, p. 584). However, offshore wind plants have, generally, the advantage of being exposed to a higher wind resource than onshore wind plants, and therefore a higher productivity. This issue is relevant to the GCC, as it will mean that offshore wind power plants built on the Persian Gulf coast will be much more cost-competitive than the wind plants built on the Red Sea or Indian ocean coasts, as the latter two are much deeper than the Persian Gulf, which has a maximum depth of 90 meters. The increased deployment of wind energy is still in need of a strong public financial backing in addition to a “responsive . . . political framework and a wide range of government policies” (IPCC, 2011, p. 559).

In 2009, the levelized cost of energy for an onshore wind power plant varied between US$ $cents_{2005}$ 5 to 15/kWh, depending on the site and the quality of wind resource, whereas for an offshore wind plant, the levelized cost of energy varied between US$ $cents_{2005}$ 10 to more than 20/kWh for plants built on relatively shallow water. However, according to the literature, offshore wind has a greater potential for cost reduction than onshore wind, and which could reach 10 to 40% by 2020 (IPCC, 2011, p. 541). Despite very significant cost reductions in wind offshore technology, it is projected that by 2035, “offshore wind costs [will] remain well above wholesale electricity prices in most countries” (IEA, 2012, p. 227).

5.3.2. The Climate Mitigation Impact of CSP Technology

Especially in the case of onshore wind plants, wind energy can have a limited number of impacts on the environment, including bird and bat fatalities as a result of collision with wind turbines. The environmental impact of offshore wind energy is not yet very well known. In general, the main impact of wind energy is visual, represented by the large-scale onshore wind farms. Hoever, as far as GHG emissions and in particular CO_2, are concerned, wind energy has a very strong potential climate mitigation impact for near-and long-term (IPCC, 2011, p. 541).

5.3.3. The Future Outlook of Wind

According to the IPCC scenarios, the contribution of wind energy “to global electricity supply could rise from 1.8% by the end of 2009 to 13 to 14% by 2050 in the median scenario” (IPCC, 2011, p. 541).

In the New Policies Scenario of the IEA, the share of wind energy in global power generation increases significantly from 1.6% in 2010 to 7.3% in

2035, with the highest increase taking place in the European Union as it will jump from 5% in 2010 to one fifth of total electricity generation by 2035 (IEA, 2012, p. 227).

From a regional perspective, the potential wind energy deployment by region is shown in Table 36 below:

Table 36

Installed Onshore and Offshore Wind Power Capacity by Region in the New Policies Scenario (GW)

	Wind Onshore			Wind Offshore			Total Wind		
	2011	2020	2035	2011	2020	2035	2011	2020	2035
OECD	150	285	441	4	31	113	154	315	555
Americas	53	107	175	-	4	26	53	112	202
United States	47	90	143	-	3	18	47	93	161
Europe	91	161	231	4	24	72	95	184	304
Asia Oceania	6	16	34	0	3	14	6	19	49
Japan	3	8	16	0	2	9	3	9	25
Non-OECD	84	262	482	0	9	62	85	271	544
E. Europe/Eurasia	2	6	16	-	0	3	2	6	19
Asia	79	239	411	0	9	53	79	248	464
China	62	191	280	0	9	46	62	200	326
India	16	44	93	-	-	5	16	44	97
Middle East	0	2	21	-	-	2	0	2	23
Africa	1	4	15	-	-	1	1	4	16
Latin America	2	11	19	-	-	3	2	11	22
World	234	546	923	4	40	175	238	586	1 098
European Union	90	159	218	4	23	70	94	182	288

Note: Adapted from *World Energy Outlook*, by IEA, 2012, p. 227.

In the Middle East and GCC region, the future deployment of wind energy up to 2035 seems to be very modest comparatively to other regions of the world, even if the figures for the Middle East are slightly better than those of Africa, Latin America, and East Europe/Eurasia. While this projection should be taken with care, as it is not specific to the GCC region, the wind potential in the GCC is nonetheless not very high, and a significant deployment of wind energy in the GCC region should not be expected even up to 2050.

5.3.4. Status of Wind Energy in the GCC

As has been seen previously in Table 35 above, the technical potential of wind power in the GCC region is moderate comparatively to other regions of the world or comparatively to other RE sources like solar. Table 37 below illustrates the wind technical potential for every GCC country (at a height of 10 meters), and compares it to the solar energy technical potential.

Table 37

Solar Versus Wind Powers in the GCC Countries

Country	Solar energy (Wh/m^2)	Sunshine duration (h)	Solar power (W/m^2)	Wind power (W/m^2)	Solar/wind
Bahrain	5180	9.2	563	78	7.2
Saudi Arabia	5670	8.7	683	71	9.6
Kuwait	5990	8.9	673	140	4.8
Qatar	5260	9.3	565	85	6.6
UAE	5078	8.8	577	57	10.1
Oman	5410	9.6	564	141	4

Note: Adapted from "The Status of Renewable Energy in the GCC Countries", by W. E. Alnaser and N. W. Alnaser, 2011, in *Renewable and Sustainable Energy Reviews, 15*, p. 3081.

The figures in the table above indicate that Oman has the highest wind potential followed by Qatar and then Kuwait. However, when the wind power potential is compared to the sun power potential, there is no doubt that sun power overtakes wind power by far, which means that when making future projections about the development of RE sources in the GCC region, the share of solar energy should be much greater than the share of wind energy but without excluding the latter. As far as the onshore wind potential of Oman is concerned, it is mainly located on the coastal areas, in addition to the mountains in the north of Salalah. The offshore wind energy potential of Oman is located on the coast, which stretches over around 1700 km from the Strait of Hormuz in the north to the border with Yemen in the south. It is necessary to note that the wind energy potential of the whole GCC region has not yet been evaluated in detail and that further studies are needed in order to be able to determine with accuracy the most favorable locations for potential future wind energy projects. However, the following section will present the available data related to wind energy in a number of GCC countries.

In the case of Qatar, the wind energy potential is suitable enough for small wind turbine generators that could be used to pump water or produce electricity in remote areas not connected to the national grid (Marafia et. al., 2002, p. 1). From a cost perspective, producing electricity from wind power in Qatar has proven to be competitive with conventional gas turbines (Marafia et al., 2002, p. 249).

In Saudi Arabia, the regions with the highest wind potential are located on the western, Red Sea coast and the eastern, Persian Gulf coast as can be seen from Table 38 below.

Table 38

Wind Speed for 20 Locations in Saudi Arabia

Station	**Wind speed (m/s)**	
	Mean	**Maximum**
1. Dahran	4.38	11.8
2. Gizan	3.24	7.7
3. Guriat	4.22	16.5
4. Jeddah	3.71	11.3
5. Turaif	4.33	14.4
6. Ryadh	3.08	8.8
7. Yanbu	3.76	10.03
8. Abha	2.94	14.9
9. Hail	3.24	10.8
10. Al-Jouf	4.02	15.9
11. Al-Wejh	4.43	11.8
12. Arar	3.61	12.9
13. Bisha	2.47	10.3
14. Gassim	2.78	9.3
15. Khamis	3.14	12.9
16. Nejran	2.10	8.8
17. Qaisumah	3.55	11.8
18. Rafha	3.86	12.4
19. Tabouk	2.73	15.5
20. Taif	3.66	10.3

Note: Adapted from *Overview of Energy Storage Systems for Storing Electricity from Renewable Energy Sources in Saudi Arabi,a* by F. Rahman, S. Rehman, S., and M. A. Abdul-Majeed, 2012, p. 276.

The first two locations with the highest wind speed are located on the western and eastern coast (Tabuk and Dahran), followed by one location in central Arabia in the Najd province (Turaif), followed by two locations near the

Jordanian border (Guriat and Al Jouf), and finally the Yanbu and Taif provinces on the Red Sea coast.

According to a study undertaken at King Fahd University of Petroleum and Minerals, the wind potential in four locations of the western coast of the kingdom has been evaluated to range between 3 and 4.5 m/s at 10 meters high with the highest speed during the summer from May to August (Shaahid et. al., 2013, p. 591). The western coast of the kingdom is about 1800 km long from the Gulf of Aqaba in the north to the Yemeni border in the south, and consists essentially of mountains that act as wind deflectors.

So far, the only declared project for a wind power plant in the region is the Sir Bani Yas wind farm project in the UAE with a 30 MW capacity (REN21a, 2013, p. 33).

5.4. NUCLEAR TECHNOLOGY: AN ALTERNATIVE FOR POWER GENERATION

Nuclear energy is defined as the energy released during a nuclear reaction that results from either splitting atoms, also known as fission, or from fusing atoms, also known as fusion. Both reactions release nuclear energy; however, as of the present time, only fission is used in power plants to generate electricity on a large scale, as fusion is still not yet a mature technology and will not be available commercially before 2050 (Smith et al., 2006a; Cook et al., 2005 as cited in IPCC, 2007c, p. 272). Research in fusion nuclear energy is being actively supported by a number of countries as it has a long-term, nearly inexhaustible supply of energy, with helium as the by-product.

Electricity was for the first time generated using a nuclear fission technology in the United States of America, near Arco-Idaho in 1951, at the EBR-1 experimental reactor. The production of nuclear power on a commercial level took place initially in the former USSR in 1954 at Obninsk nuclear power plant, which marked the beginning of nuclear electricity on a commercial scale. Since then, the share of nuclear energy technology in the power generation sector has been gradually increasing, especially after the first oil shock of 1973, which triggered efforts among the major oil consuming countries to diversify their energy mix away from oil and gas. Despite a number of setbacks in the consecutive years that were related to decreases in the price of oil in the international markets, or to nuclear accidents like the Three Mile Island accident in 1979 in the U.S. , or the Chernobyl accident in 1986 in the former USSR, nuclear energy resumed its growth, and with it, its share of electricity in the global electricity mix.

Fission nuclear power has been very successfully used for power generation in a number of countries since the seventies, following the first oil crisis and resulting impetus among oil importing countries to seek alternative routes to diversify their energy sources away from oil. Nuclear energy was chosen as an alternative source of energy by the countries that had developed it for military purposes during the Second World War—namely, the United States, the ex-Soviet Union, the United Kingdom, and France. Significantly and interestingly, France has made a successful energy transition in its power generation sector, shifting from a dependency on fossil fuels without any nuclear role, to nuclear power representing 78% of the electricity supply today, in less than three decades. The United States and the United Kingdom have also witnessed significant increases in the share of nuclear energy in their respective power generation sectors but not to the same extent as the French case.

The main constraints for the deployment of nuclear power are related to the issues of potential nuclear accidents—Chernobyl and Fukushima as very well-known examples—the issues of nuclear waste management, the difficulty to assess the decommissioning cost that has proven to be much higher than what previously estimated, and finally, the proliferation risk posed by nuclear technology

5.4.1. The Cost Factor of Nuclear Power Energy

When first deployed, nuclear power was not yet cost-competitive with conventional energy resources, but thanks to very strong governmental political and financial support, in addition to economies of scale brought about by the deployment of the technology, nuclear power has matured as a technology and become commercially competitive.

Nuclear energy in the power generation sector is cost-competitive with other energy resources, except where there is direct access to abundant fossil fuel reserves, which is the case of the GCC countries. Nuclear plants are expensive to build but relatively cheap to run; indeed, the capital costs are much more important than generating costs in a nuclear power project.

According to a study undertaken by the Energy Information Administration of the US Energy Department, the average levelized cost (2011 $/megawatt hour) of a nuclear power plant brought on line by 2018, comparatively to other 15 technological solutions in the US context, an advanced nuclear power plant is classified at the 8th position, slightly cheaper than a conventional coal power plant and much cheaper than renewable energy, with the exception of hydro and onshore wind. Table 39 below gives the details of the comparison of the levelized cost of a number of generation technologies that will be brought on line in 2018.

Table 39

Estimated Levelized Cost of New Generation Resources in 2018

Plant type	Capacity factor (%)	U.S. average levelized costs (2011 $/megawatthour) for plants entering service in 2018				
		Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system levelized cost
Dispatchable Technologies						
Conventional Coal	85	65.7	4.1	29.2	1.2	100.1
Advanced Coal	85	84.4	6.8	30.7	1.2	123.0
Advanced Coal with CCS	85	88.4	8.8	37.2	1.2	135.5
Natural Gas-fired						
Conventional Combined Cycle	87	15.8	1.7	48.4	1.2	67.1
Advanced Combined Cycle	87	17.4	2.0	45.0	1.2	65.6
Advanced CC with CCS	87	34.0	4.1	54.1	1.2	93.4
Conventional Combustion Turbine	30	44.2	2.7	80.0	3.4	130.3
Advanced Combustion Turbine	30	30.4	2.6	68.2	3.4	104.6
Advanced Nuclear	90	83.4	11.6	12.3	1.1	108.4
Geothermal	92	76.2	12.0	0.0	1.4	89.6
Biomass	83	53.2	14.3	42.3	1.2	111.0
Non-Dispatchable Technologies						
Wind	34	70.3	13.1	0.0	3.2	86.6
Wind - Offshore	37	193.4	22.4	0.0	5.7	221.5
Solar PV[1]	25	130.4	9.9	0.0	4.0	144.3
Solar Thermal	20	214.2	41.4	0.0	5.9	261.5
Hydro[2]	52	78.1	4.1	6.1	2.0	90.3

Note: Adapted from *Levelized Cost of New Generation Resources*, by U.S. EIA, 2013a, p. 4.

The figures in the table above indicate that the cost of a nuclear energy power plant is cost-competitive with almost all the other energy sources, with the exception of gas for conventional energy sources and wind for renewable energy sources, in the US context. However, it must be borne in mind that "as with any projection, there is uncertainty about all [the factors used to calculate the cost, and that] their values can vary regionally and across time as technologies evolve and fuel prices change" (U.S. EIA, 2013b, p. 1). Indeed, in the case of the GCC region, the results of such a comparison will be very different with a larger difference at the advantage of gas, as it is produced locally and enjoys a significant level of energy subsidies. In this respect, the interest of this comparison lies in informing us on the relative cost position of nuclear energy and other energy sources.

Nevertheless, the above figures have to be accepted with a high level of caution, as the cost issue of nuclear energy is highly debatable and can differ depending on how the decommissioning costs are estimated. This is very difficult to predict, as proven in the experience of the USA and the UK[99]. In addition, globally, the cost of nuclear energy witnessed very significant increases long before the Fukushima nuclear accident; in France and Finland, the cost has increased to twice or even three times the original estimates. Nuclear energy projects are mainly funded by substantial governmental funding, as private investors have been reluctant to invest in nuclear projects due to the very high risks involved (Patterson, 2011).

5.4.2. The Climate Mitigation Impact of Nuclear Technology: Mixed Results

According to the 2010 WEC survey of energy resources, the long-term mitigation potential of nuclear energy up to 2030 is the highest at the lowest average cost in the energy supply sector and especially in the power generation sector (WEC, 2012, p. 250). Other studies (Storm Van Leeuwen & Smith, 2005 as cited in IPCC, 2007c, p. 269) give much higher levels of GHG emissions, as they are based on higher emissions from the mining, processing, and decommissioning. However, nuclear power remains a very efficient technology for climate mitigation.

5.4.3. Outlook of Nuclear Energy Technology: The Impact of Fukishima

The Fukushima nuclear incident had a significant impact on the development of nuclear energy, in the short-term as well as in the long-term. In the case of Japan, it is very doubtful that nuclear energy will ever return to its pre-Fukushima share

[99] Please read Nuclear Energy Statistics, House of Commons Library, 2013, and the following article for more details: http://www.theguardian.com/environment/2013/jun/23/britain-nuclear-atomic-clean-up-decommissioning

of 30% in the electricity mix of the country, let alone achieve the objective of 50% by 2030 as previously envisaged. Prior to this nuclear accident, Japan had 54 nuclear reactors in operation, but now it is considering phasing out from nuclear energy and expanding the share of renewables in its energy mix. Germany has also lately adopted a new national energy strategy with the objective of phasing out from nuclear energy by 2020 and increasing renewable energies in its energy mix. It is worth mentioning that before the Fukushima nuclear accident, there were 17 nuclear reactors in Germany providing one quarter of the country's electricity mix (Froggatt, Mitchell, & Managi, 2012, p. 2). Investing in renewable energies for the past decade, Germany has become a world leader in the field with very ambitious long-term objectives. Indeed, according to the German Solar Industry Association (DSW), "the share of solar power in the electricity mix will increase by 70% over the next four years, to 7%, and rise to 10% by 2020" (Froggatt et al., 2012, p. 3). Belgium, Italy, and Switzerland have also decided to phase out from nuclear energy, while other countries in Europe have maintained their nuclear energy objectives, including France, UK, Czech Republic, and Hungary. In Asia, India and Pakistan are moving ahead with their nuclear projects and have already ordered two additional nuclear power plants, while China is building 26 reactors. According to the International Atomic Energy Agency, a number of other countries are considering expanding or embarking in building new nuclear power plants, including Bangladesh, Belarus, Egypt, Indonesia, Lithuania, Malaysia, Nigeria, Poland, the Philippines, Turkey and Vietnam (International Atomic Energy Agency, 2013, p. 35), while others have abandoned their nuclear projects, like Kuwait and Egypt.

The Fukushima nuclear accident has, without doubt, triggered an energy shock in Japan as well as in Germany due to the very radical and bold decisions taken by both countries in phasing out of nuclear energy. On the policy front, if there is one important lesson that can be extracted from these two experiences, it is about the importance of the political will for making radical transformations in the energy system. Indeed, when the political will is strong enough, rapid change can take place in the energy system of a country with significant financial as well as environmental gains to be achieved. This is even more evident in the German case, which started the transition process of its energy system long before the

Fukushima incident reinforced it with additional supporting arguments and impulse (Froggatt et al., 2012, p. 10).

From the German experience in energy transitions, it can be firstly observed that solar and wind technologies are reliable and capable of delivering large quantities of electricity. Secondly, the speed and efficiency of deployment have greatly contributed to the continuous decreases in the cost of solar and wind technologies (Froggatt et al., 2012, p. 11).

According to the New Policies Scenario of the IEA 2012 World Energy Outlook, as a result of the Fukushima accident, by 2035 the share of nuclear power in the global electricity supply will remain almost unchanged comparatively to the 2012 share, or 12% of the global supply (IEA, 2012b, p. 53). By 2035, the installed capacity is projected to increase by around 200 GW to reach around 580 GW, with 94% of the net increase coming from non-OECD countries and mainly in China, which will see its installed capacity rise from 12 GW in 2011 to 128 GW in 2035, followed by South Korea, India, and Russia (IEA, 2012b, p. 53). When compared with the 2011 Outlook of the IEA regarding the deployment of nuclear power in 2035, it has been revised downward by 6% as a result of the Fukushima nuclear accident (IEA, 2012b, p. 67). However, it should be noted that despite this projected decrease in nuclear power investments, nuclear energy in the power generation sector will continue its presence in the global electricity mix and retain its advantage as a mature technology readily usable for increasing the power generation capacity of a given country or for climate mitigation objectives, thanks to its very low level of CO_2 emissions. In addition, based on the experience with the Chernobyl nuclear incident in 1986, it will not take much time before confidence in nuclear power returns, especially as the expected technological improvements regarding the security aspects, as well as the management of nuclear waste, are taken into consideration. This could be commercially available by 2030 as shown in Figure 32 below. Therefore, in 2050, the share of nuclear power in the global electricity mix could be higher than what is expected today, unless there is another major nuclear accident on the same scale or larger than the Fukushima accident. If materialized, this would certainly have a very negative impact on the future deployment of nuclear energy globally.

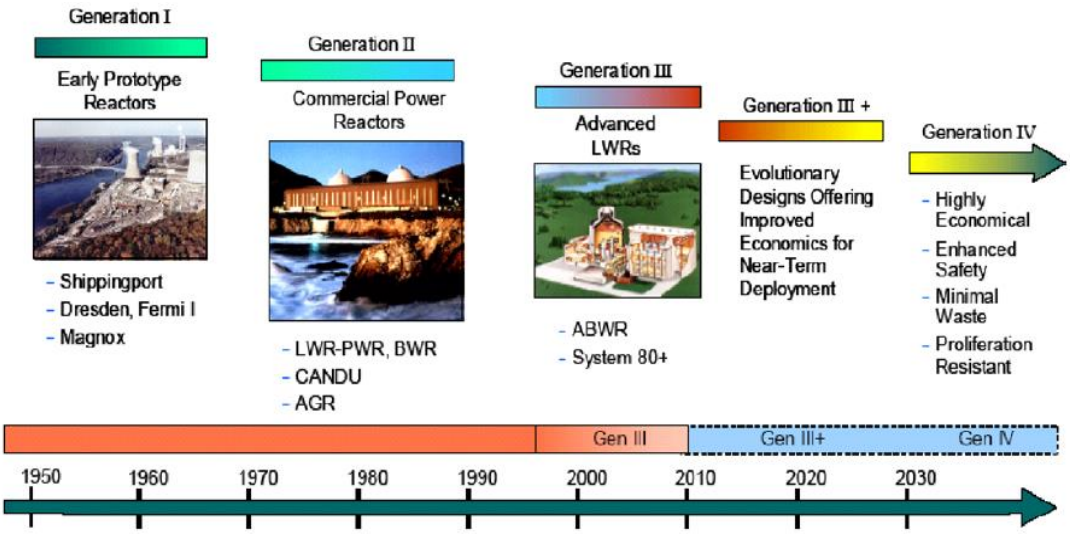


Figure 32: Evolution of nuclear power systems from Generation 1 to the future Generation[100] 4. Adapted from GIF, 2002, taken from IPCC, 2007c, p. 270.

Regarding the uranium reserve, it should remain largely available for a few hundred years at current rates of consumption, depending on the various nuclear technologies used as shown in Figure 33 below (IPCC, 2007c, p. 271).

[100] Notes: LWR=light water reactor; PWR=pressurized water reactor; BWR=boiling water reactor; ABWR=advanced boiling water reactor; CANDU=Canada Deuterium Uranium.

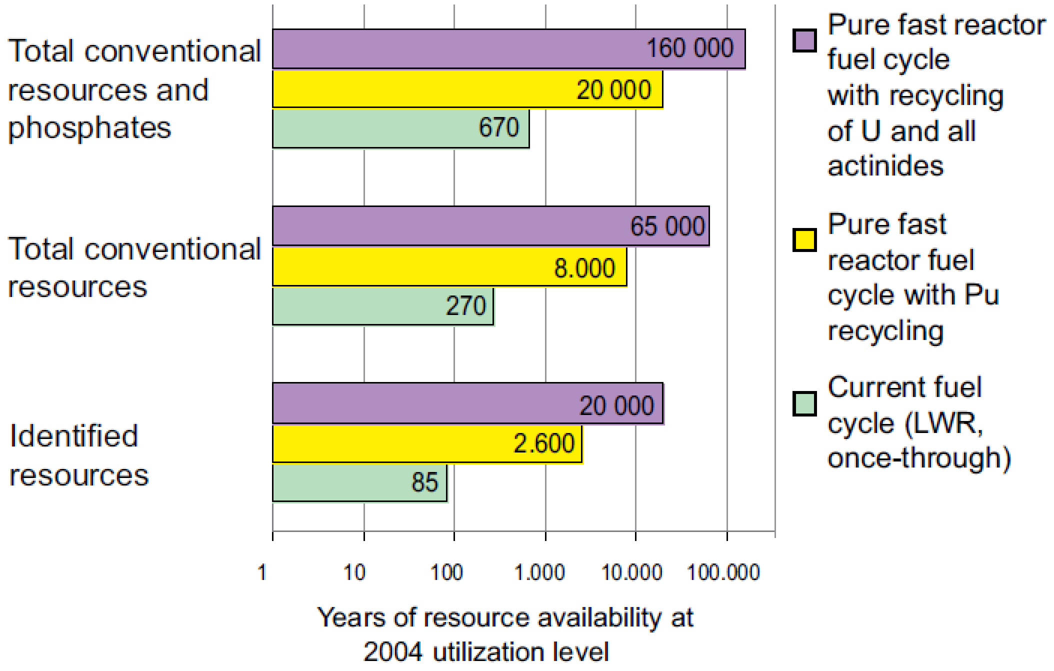


Figure 33: Estimated years of uranium resource availability for various nuclear technologies at 2004 nuclear power utilization levels. Adapted from OECD, 2006b OECD, 2006c, taken from *WB3* by IPCC, 2007c, p. 271.

5.4.4. Nuclear Energy Technology in the GCC: A Promising Future

Until the recent past, the GCC countries made it very clear that they were not interested in nuclear energy and even called for a nuclear-free Gulf as a way to distance and single out Iran and its declared strategy to deploy nuclear energy domestically[101]. However, following the declaration of a joint nuclear initiative by the six GCC leaders in December 2006, in which they highlighted their interest in developing a nuclear program for peaceful purposes, a number of GCC governments have launched nuclear projects for the production of electricity—both individually and on a national basis. The surprising and radical shift in the GCC's policy for the deployment of nuclear energy could be explained in light of geopolitical as well as domestic reasons. From a geopolitical perspective, it has been suggested that this shift in policy towards nuclear energy in the GCC is

[101] In 2006, Prince Saud Al Faisal, Saudi Arabia's foreign minister declared: "We are urging Iran to follow our position, the Gulf and the Middle East should be nuclear-free" (as cited in El-Katiri, 2012, p. 1)

mainly a reaction to the Iranian nuclear program, as stated by Edward Markey, a US congressman in 2008: "Saudi Arabia's interest in nuclear energy can only be explained by the dangerous politics of the Middle East [. . .] Saudi Arabia, a champion and kingpin of the Sunni Arab world, is deeply threatened by the rise of Shiite-ruled Iran" (Markey, 2008). However, it remains unsure whether developing nuclear energy in the GCC countries will allow them to master the technology and attain the levels Iran has reached in the development of nuclear energy and in building indigenous scientific capacities in the field. In addition, the UAE and Saudi Arabia—the two countries that have officially declared their interest in deploying nuclear power—have renounced developing enrichment capacities domestically, which means that they will not have the capacity to control the full nuclear fuel cycle and especially the dual-usage (civilian and military) stages of nuclear energy technology. When comparing the nuclear programs of Iran and the GCC, it must be kept in mind that Iran has been developing its nuclear capabilities since the seventies with corresponding human potential in that respect, whereas as newcomers, the GCC countries will require decades to develop the necessary knowledge and human capacities to match Iran in this field. Therefore, it is primarily for domestic reasons that the GCC have made this strategic shift regarding developing nuclear power. Indeed, from a domestic perspective, it is mainly due to a structural shift in the energy mix—in particular, electricity—that the GCC countries have opted for nuclear power, as well as the increasing pressure of the domestic consumption of energy on available reserves of oil and gas that has pushed a number of GCC countries to consider diversifying their energy mix in the power generation sector, which represents the highest proportion of their overall energy consumption. In this respect, nuclear energy for the generation of electricity has been seriously taken into consideration by GCC governments, as it represents an available mature technology with a proven track record for power generation.

Moreover, deploying nuclear power in the GCC region will have an impact on their energy security as they increase their technological dependency, in addition to a fuel dependency, to foreign markets and countries, and lose the autonomy they now enjoy from their control over oil and gas reserves in their own territories. Indeed, resorting to nuclear power will mean that GCC countries will have to import the nuclear fuel necessary to run the nuclear power plants, and which is produced and processed abroad. In this respect, the UAE has officially "renounced any intention to develop a domestic enrichment and reprocessing capability and . . . to source fuel from reliable and responsible foreign suppliers" (*Policy of the United Arab Emirates*, 2008, p. 9).

The GCC countries entirely lack R&D capacities and the scientific knowledge in nuclear technology. Compared to solar energy, which has been extensively researched since the seventies and especially in Saudi Arabia, there is no prior nuclear scientific experience throughout the GCC region. Consequently, for a long period of time, the GCC countries will have to completely rely on foreign expertise and human resources before it can create a local human and scientific capacity in the field. This will also be reflected on the overall cost of deploying nuclear power technology.

In order to evaluate the cost-competitiveness of nuclear power in the context of the GCC, it will be interesting to make some comparisons with the cost structure of other markets. According to Abu Dhabi Water and Electricity Company (ADWEC), the current domestic price of electricity lies between US$ 0.008 and 0.041/kWh (equivalent to 3 and 5 fils in Emirati currency) (Regulation & Supervision Bureau, 2014), whereas the US levelized cost of electricity from an advanced power plant that will enter into service in 2017, is expected to range between US$ 0.107 and 0.118/kWh (U.S. EIA, 2012). Given the clear and large difference between the two price structures, it is therefore legitimate to have serious doubts about the economic viability of nuclear power in the GCC region after accounting for the extra cost of starting from scratch, as compared to the US market, which has already benefitted from economies of scale due to the long history of nuclear power in the US in addition to the large scale of the US market. It is also worth mentioning that the budgets the UAE and Saudi Arabia have officially declared (US$ 20 and 80 billion respectively) for building 4 nuclear power plants in the UAE and 16 nuclear power plants in Saudi Arabia will have to be reevaluated in light of the Fukushima nuclear accident and the increase in the cost of nuclear power technology it has provoked due to additional security requirements for future nuclear power plants (Schaps, 2013).

Nuclear energy requires very significant capital investments and is considered a risky investment that will yield financial returns only in the long term, in addition to a very low or even negative opportunity discount for the GCC economies (Hertog & Luciani, 2009, p.15). As a consequence, the main source of funding of nuclear energy projects will be local, which will constitute a heavy financial burden on the GCC budgets and depend on the revenues generated from the export of oil and gas and on their prices in the international markets.

All the above points raise the central issue of the cost for deploying nuclear power in the GCC countries. There are, indeed, serious doubts about the economic interest for the deployment of nuclear power in the GCC region, as from a cost issue perspective, it is not certain that nuclear power will be the ideal technological solution for contributing significantly to the projected power demand in the region. As a consequence, the future of nuclear power in the GCC region will greatly depend on the long-term financial capacity of the GCC governments to sustain the very significant initial investments necessary for the deployment of nuclear power. This will be in addition to the long-term subsidies that the governments of the region will have to maintain as long as the rentier state structure of the GCC governments is not reformed to allow for putting a cost-recovering power tariff structure into place.

From a macro-perspective, we cannot understand the actual situation of the energy system in the GCC and explore its future if we don't put it within the context of the social contract that sustains the economic and political system of the GCC countries, as has already been detailed in chapter 4. In this respect, the scenarios will help us see how the future of the electricity mix of the region will evolve depending on the future evolution of the political system of the GCC countries.

Chapter 6

SCENARIOS OF POSSIBLE ENERGY TRANSITION PATHWAYS IN THE GCC COUNTRIES

In this chapter, and at this stage of the research, we can state what are our knowledge surrogates, as defined by Coddington (1975), and discussed in chapter 1, regarding the future of an energy transition in the GCC countries based on our knowledge and analysis of the past and present on the whole energy system of these countries. In this respect, before we engage in building the future scenarios of an energy transition in the power generation sector of the GCC countries, let us first briefly revisit the typology of scenarios as proposed by Slaughter (1993a) and reviewed in chapter 1, and when relevant, their corresponding transition pathways as proposed by Geels and Schot (2007), discussed in detail in chapter 2. Simultaneously, we will also select a number of scenario/transition pathways that we consider relevant to the GCC countries based on our investigation and findings regarding the three levels of the MLP framework of analysis in the context of the GCC region.

In his work about scenarios, Slaughter (1993a), proposed a typology of five possible scenarios that could be used to describe future possible developments in any given context. In parallel, and in the specific context of energy transitions, Geels and Schot (2007) have proposed a typology of energy transition pathways that describe possible transitions pathways depending on the nature and strength of a combination of developments at the three levels of an energy system.

The first scenario, or the *breakdown* scenario, describes a situation where a major negative, triggering event occurs, such as sudden environmental degradation, a nuclear accident, or a chronic rise in political and social conflict (Slaughter, 1993a, p. 295). By comparing this scenario with the typology of transition pathways elaborated by Geels and Schot (2007), we find that in the absence of fully mature technological niche-innovations ready to replace the existing technology, it corresponds to the *de-alignment and re-alignment path*, which takes place when a rapid and sudden pressure emerges from the landscape with a resulting disruptive effect on the whole regimes level architecture. However, in case a mature technological niche-innovation is available and waiting to be adopted by the regimes actors, it corresponds to the *technological substitution* path, which occurs when there is a sudden and disruptive pressure from the landscape but with a mature technological niche that is waiting for an opportunity to emerge.

Within the time framework of this research project, which spans from now through 2050, and based on our findings in chapters 3-5, it is very unlikely that a sudden environmental degradation will take place or that the climate change factor will exert such a disruptive pressure on the global energy system in general or the GCC energy system in particular. As far as the climate regime negotiations are concerned, they have been progressing very slowly in the past decades, and it is very unlikely that there will be radical changes in that respect in the short or medium terms; however, it is very likely that the climate regime negotiations will speed-up and the pressure on the global, including GCC, energy systems will increase between 2025 and 2030, as a result of a climate degradation and an agreement reached between the major industrial countries and the emerging economies regarding a post-Kyoto treaty. At this period of time (between 2025 and 2030), it is expected that the renewable and alternative energies reviewed in the course of this research in chapter 5, solar, wind and nuclear, will be mature enough, cost competitive, and capable of replacing the conventional fossil fuel energies, which means that the energy transition that will take place could be described as a *technological substitution* pathway.

According to our analysis of the political economy of the GCC and the political stability factor, the only situation that could potentially lead to a *breakdown* scenario in one or more countries of the GCC region—particularly Saudi Arabia—would be a sudden rise in political and social conflict as a result of a combination of domestic and geopolitical developments, such as a second revolutionary wave against the Saudi backed military regime in Egypt in addition to an exasperation of the fundamental contradictions in the politics and economics of the region, as explained in chapter 4. Such a development, if it occurs, will have very significant implications on the rentier socio-political contract and will accelerate the already shifting balance of power towards the larger society at the expense of the ruling establishments in the region. It is very difficult to determine with precision the possibility of a *breakdown* scenario in any GCC country; however, in case the GCC political regimes evolve towards a *repressive or managed societies* scenario, then the chances of a *breakdown* scenario will be greatly increased.

The *repressive or managed societies* scenario, the second scenario in the typology, depicts a return of totalitarian and fascist types of political regimes which could be triggered by a number of different economic and/or political factors. There seems to be no equivalent to this scenario in the typology of transition pathways. However, given the existing political situation in a number of GCC countries with the noticeable increase in repression policies and practices in the wake of the Arab Spring and the region, it is a scenario that could materialize in the future with significant consequences on the political stability of the concerned regimes and the sustainability of energy diversification policies. The increased repression, in addition to the impact and pressure from the regional environment represented by the Arab Spring, coupled with an exasperation of the structural weaknesses identified in the political economy of the region, could lead to a destabilization of the existing rentier socio-political contract, and to a *breakdown* scenario with the similar possible developments as already discussed in the previous paragraph. In fact, the *repressive or managed societies* scenario and the *breakdown* scenario are intimately linked, as the second occurs as a logical consequence of the first, and so they will be treated as one general scenario that consists of a combination of both.

Given the fact that such developments could potentially materialize between the mid and long-term, we will consider this general scenario (comprised of a *repressive or managed societies* scenario followed by a *breakdown* scenario) as one possibility. The possibility of such developments are also backed by our findings in chapter 3 regarding the future outlook of oil prices in the international markets that expect a significant decline and maybe a collapse in the price of oil, and as a result, the GCC economies will be put under an additional fiscal pressure. What adds to the possibility of at least, a significant decline in the price of oil, is the fact that the period when the price of oil is expected to take place, 2030 to 2035, corresponds also to the period when the international climate regime negotiations are expected to speed-up and achieve an international legally binding agreement to reduce the GHG emissions, and as a result lead to a decrease in the global demand for oil. These assumptions are in fact the basis of a number of scenarios discussed in chapter 3, such as the *450 scenario* of the IEA (2012), or the scenarios reviewed by the IPCC (2011) that are based on a stabilization of the atmospheric CO_2 concentrations at a level of less than 440 ppm (Parts per million).

The *breakdown* scenario, if materialized, could eventually lead to a new political equation in the region that would be based on a new socio-political contract and power equilibrium in favour of a larger public input in the policy-making process, and as a result, the possibility to use all the policy instruments and tools, including and especially the pricing tool, in order to decrease the energy consumption and to facilitate the deployment of new and alternative energy sources. This development, if it occurs, could push the GCC economies into a succession of *de-alignment re-alignment* energy transition pathways, or even to a *technological substitution* pathway, depending if it takes place in a moment where the renewable energies have reached their maturity or not.

The third scenario, as proposed by Slaughter's (1993a) typology, is the *business as usual* scenario, which assumes continuity in the present policies and the planned projects, and corresponds to the *reproduction transition* pathway according to Geels and Schot (2007) typology of transitions, and which assumes that there is no significant or disrupting pressure emerging from the landscape level. In this scenario, the present situation with all its challenges and the unsustainable way of managing the resources remains unchanged, and the existing socio-political contract is maintained and not threatened by domestic or regional geopolitical events This scenario seems to be equivalent to the *reproduction process* transition pathway and could evolve into a *technological substitution* transition pathway, or to a *reconfiguration* pathway as we will see later in this chapter. This scenario is conform to the *baseline* scenario of the IPCC (2011) and to the *current policies* scenario of the IEA (2012) reviewed in chapters 3 and 5, as they both assume a continuity in the current policies and a materialization of the existing officially declared renewable or/and nuclear energy objectives.

The fourth proposed scenario is the *ecological decentralist* scenario, which assumes a departure from the actual aggressive ideology of economic growth towards a new approach to nature, based on decentralized 'soft energy paths' and a deep commitment to ecological reconstruction (Slaughter, 1993a, p. 296). This scenario requires a radical ideological shift with a very significant civilizational change; as such, it is highly unlikely that any government would consciously and deliberately engage in such a path without significant external pressure, especially in the GCC context, as this scenario would necessarily mean a radical change in the rentier socio-political contract of the region and a total change in the existing regimes architecture. As a consequence, this scenario will not be explored, as it is very unlikely that it could materialize globally or in the context of the GCC countries; in addition, there is no equivalent to this scenario in the typology of energy transition pathways as proposed by Geels and Schot (2007).

Finally, the fifth scenario in the typology is the *transformational societies* scenario, which could evolve from two main routes: either from a process that leads humanity to a new stage of development, or through "the benign operation of a new form of technology" (Slaughter, 1993a, p. 296). This scenario is very similar to the *transformation path* transition pathway defined by Geels and Schot (2007), where a moderate pressure emerges from the landscape at a moment where a niche-innovation is not yet completely mature. In this case, the regime actors react belatedly to the landscape pressure but will ultimately manage to engage in a reorientation and innovation strategy, leading to changes from within the regimes structure. In the present time, it is very difficult to find any indication that the global economy is on its way towards a new stage of development or a new economy that will witness a departure from the intensive use of fossil fuels, as they will still remain essential parts of the global energy mix in the foreseeable future. However, as renewable energies have been witnessing noticeable levels of growth globally in the past decade, it is possible to expect that the global economy, and with it the GCC region, will gradually evolve towards a *transformational* *societies* scenario in the long run and beyond the time frame of this research project; i.e., after 2050. Therefore, even if the *transformational societies* scenario is very unlikely to become a reality within the time frame of this research project, the possibility of such a scenario in the extended future should not be excluded. In addition, in regards to GCC countries, it could be argued that the strategic choice made by their governments to build knowledge economies and reduce their dependency on oil rent is placing the GCC countries on the path of the *transformational societies* scenario; however, as we have seen from our findings regarding the subject of knowledge economies in the GCC in chapter 4, this is a very farfetched objective that most probably will not be realized between now and 2050.

Grounded on Slaughter's (1993a) and Geels and Schot's (2007) work, and on the findings of this research project, in addition to the selected combinations of scenario/transition pathways, the following sections propose to review how the most relevant combinations of scenario/transition pathways selected above could evolve in the future as far as the power generation sector of the GCC countries is concerned. In this respect, only two general scenarios will be considered relevant given the actual global context and to the GCC region, with each one consisting of a combination of transition pathways. The first general scenario will be called the 'Neverland' scenario, as it represents continuity of the existing unsustainable system and without any change, which is closer to fiction; and the second will be called the 'phoenix' scenario, as it describes a rebirth process from the ashes of a breakdown.

6.1. THE NEVERLAND SCENARIO: FROM THE *REPRODUCTION* TRANSITION PATHWAY TO THE *TECHNOLOGICAL SUBSTITUTION* TRANSITION PATHWAY

During the whole phase of this transition process—between now and 2050—it is generally assumed that there will be no domestic, regional or geopolitical developments that could affect the existing ruling establishments in the GCC countries and the rentier socio-political contract in place.

This transition process is divided into two successive periods of transition pathways. The first period begins as a *reproduction* transition pathway according to the Geels and Schot (2007) transitions typology, or a *business as usual* scenario, according to Slaughter's (1993a) typology of scenarios, and will last until the end of the officially declared plans for deploying renewable and nuclear energy technologies in the GCC countries, i.e., between 2030 and 2035. This time frame corresponds also to our conclusion in chapter 3 that climate regime international negotiations will not successfully reach a legally binding post-2020 international treaty until the time frame between 2030 and 2035; or that even if they do, it will be with very minimal objectives that will not lead to a radical restructuring of the global economy, such as moving away the fossil fuels from their dominant status in the global energy mix. It is therefore only after this period that the pressure from the climate change factor at the landscape level will relatively increase on the socio-technical regimes level of the GCC countries, which will push them towards the second period of energy transition until 2050 and beyond, namely the *technological substitution* pathway according to the Geels and Schot (2007) typology of transition pathways.

The main assumptions of the first period, or *business as usual* scenario, are the following: It is assumed that there are no pressures emerging from the landscape level on the regimes level, whether from the climate change issue or the price of oil in the international markets. As for the price of oil, it is assumed that this will be adequately high and above the fiscal break-even oil price in order for GCC governments to be able to maintain their expenditures policies, for keeping the internal social peace, and for sustaining their long-term investments and achieving their planned renewable and nuclear energy objectives for power generation. It is also assumed that during this first period, the actual structure and growth of energy demand and supply in the GCC region will be unchanged until 2030. Regarding the climate change issue, in order for this scenario to materialize it is therefore also assumed that the existing stalemate in international climate regime negotiations will last until 2030-2035 as a result of a continuing disagreement between the major industrial countries and the emerging economies. According to this scenario, for the first period, a legally binding emissions reduction treaty will not be achieved per the UNFCCC objectives and time table, but instead gradually and in the long-term by building on national and regional climate policy developments, which is already currently taking place as discussed in chapter 3.

During the first period, the *business as usual* scenario or the *reproduction* transition pathway, the regimes actors who represent the ruling establishments that control and manage the energy systems of the GCC countries will be able to implement the gradual and very slow integration of new and renewable energy technologies in their respective power generation sectors according to their officially set objectives.

It should be noted that as far as this first period of reproduction transition pathway is concerned, it would be wrong to assume that there are no pressures on the socio-technical regimes level in order to diversify their energy sources and engage in an energy transition, as the pressure already exists, but is moderate and manageable. In addition, there is also another pressure that stems from the structural weaknesses and challenges in their political economy and especially in regards to energy consumption and electricity consumptions, which are posing a real threat to their available oil and gas reserves and to their export capacity of their main cash earning resources. We can assume for this scenario that the main pressure, for the moment and during this first period, comes not from the climate change issue at the landscape level but from within the meso-level itself, or the socio-technical regimes level that is shaped by the rentier nature of the GCC countries' political economy, which is a structuring factor found at the landscape level. As projected by the energy transitions theory and the MLP framework of analysis, it is expected that during this period, the very strong relationship and interaction between the landscape, macro-level, and the socio-technical regimes, meso- level should play a major role in pushing the energy transition process ahead.

During the second period, after 2030, the international climate regime negotiations speed-up and an international legally binding agreement is signed and starts to be implemented, which creates an increasing pressure on the GCC countries to engage in an energy transition and diversify their energy sources away from the hydrocarbons. However, thanks to the investments and efforts made during the first period in deploying renewable and alternative energy technologies, and the now mature and cost competitive renewable and alternative energy technologies, the GCC countries will be well prepared to respond positively to this pressure and maintain or even speed-up their diversification efforts towards a *technological substitution* energy transition pathway. An acceleration of the negotiations process that would lead to a legally binding treaty after 2030 would only add momentum to their diversification efforts starting from now, and encourage their pursuit after 2030. The main impact on the GCC countries of an internationally legally binding emissions reduction agreement would be on the price of oil in the international markets that could decline as a result of a deceased global consumption. Nevertheless, even if a decline in the price of oil should occur in the future, as expected to take place between 2030 and 2035 according to our findings in chapter 3, the reserves accumulated in the SWFs should be high enough by that time to help the GCC governments fill the oil revenues gap and maintain their investments for more than a decade and without compromising the already planned or the future planned renewable and nuclear energy projects after 2030. Concerning energy consumption in the GCC region, the increasing landscape pressure that could originate from the expected international climate regime after 2030 could and should lead to a reduced energy and electricity consumption in the GCC countries, but it will be very difficult to imagine how this could happen without fiscal and policy tools, and without implications on the rentier socio-political contract and the status of the socio-technical regimes actors.

Therefore, as a result of the combination of the two successive transition processes and periods, and based on a number of assumptions, within the time frame from now until 2050, the GCC countries could achieve the following objectives in their energy transition towards a more diversified energy mix in their respective power generation sectors:

- *Bahrain*: 5% of its electricity from renewables by 2020 as already planned, which, given its limited financial capacities, should be equivalent to an additional 5% every decade, in order to reach 20% of its electricity generated from renewables by 2050. As Bahrain has not declared any nuclear energy projects or plans in the time of writing this research thesis, in addition to the very high capital cost necessary for launching nuclear energy projects comparatively to the limited financial capacities of Bahrain, we will assume that nuclear energy will not be included in its power generation energy mix between now and 2050.

- *Kuwait:* As already planned, Kuwait should achieve the objective of 5% of electricity generation from renewables by 2020 and 10% by 2030, which represents an additional 10% by decade, and consequently should be able to produce 30% of its electricity from renewables by 2050 without any nuclear energy input, similar to Bahrain, even if Kuwait could afford the cost of nuclear projects.

- *Oman*: With its already planned objective of producing 10% of its electricity from renewable energy sources by 2020, we can assume that it could be compared to Kuwait, despite its more limited financial resources, and assume that it should be able to produce 30% of its electricity from renewables by 2050 and without any nuclear energy input.

- *Saudi Arabia*: According to its planned objectives, 20% of the Kingdom's electricity will be produced from renewable energy sources and another 20% produced from nuclear energy by 2032 from the planned 16 nuclear power plants to be built in the coming 20 years (the plan was declared in 2011), which represents a total of 40% of its electricity produced from non-fossil fuel sources by 2032. Assuming that the same percentages will be added from nuclear and renewables in the next 20 years after 2032, the total electricity produced from these two sources could reach around 80% of the Kingdom's total electricity production. In this case, Saudi Arabia would have achieved an almost total energy transition in its power generation sector.

- *Qatar:* With only 2% of planned electricity generation from renewables (only solar) by 2020, Qatar is the country of the GCC region that will see the smallest development of electricity generation from renewables, as it should not exceed 10% by 2050, if we assume an addition of only 2% by decade and without any nuclear energy input. Thanks to its significant gas resources, Qatar will have less pressure than the other GCC countries for two reasons: firstly, as a result of its small population compared to its very significant gas resources, there are no threats on its available reserves and export capacity in the long term; secondly, as gas is considered less polluting than the other fossil fuels, even during the second period after 2030, there will not be a significant pressure on Qatar from the expected international climate regime.

- *The UAE*: As far as Dubai is concerned, given its planned objective of 5% of renewable electricity generation by 2030 and its limited financial capacities, electricity generation from renewables should not exceed 10% by 2050, and without any nuclear energy contribution. Whereas in the case of Abu Dhabi, based on its planned objective of 7% of renewable electricity generation by 2020, it could reach around 30% of electricity generation from renewable energies alone by 2050. It is projected that by 2020 the UAE will produce between 20 and 25% of its electricity from nuclear energy. By assuming that it will add 20% of nuclear energy capacity every decade, the UAE should be able to produce 80% of its electricity from nuclear energy by 2050, and as a consequence, successfully operate an energy transition in its power generation sector.

It is, of course, understood that according to the MLP framework of analysis, the socio-technical regimes actors will not be threatened by the transition process, as the new economy that will emerge from the development of renewable and nuclear energy technologies will be managed through the same neo-patrimonial structure that characterizes the socio-technical regimes level in the GCC countries, based on the experience of the UAE in this respect as described by Davidson (2009), and discussed in chapter 4 in the section dealing with the socio-technical regimes of the energy sector of the GCC countries.

This scenario is established on a number of status-quo assumptions that seem very unlikely to be achieved given the structural challenges facing the GCC governments in their respective political economies, in addition to the challenges found on the landscape level regarding the international oil market and its many uncertainties. This is without mentioning the very unstable regional geopolitical environment, which combined with the structural challenges of its political economy, will represent the main uncertainties regarding the future course and fate of GCC ruling establishments. As a consequence, the probability for such a scenario to materialize, even if possible, is still very low.

6.2. THE PHOENIX SCENARIO: FROM A *BREAKDOWN* SCENARIO TO A REBIRTH

The ‘phoenix’ scenario initially begins with a *repressive or managed societies* scenario that is the consequence of a combined pressure originating simultaneously from the landscape level in the form of regional geopolitical developments with regards to the Arab Spring wave and the developments in the Arab Spring countries and especially in Egypt, in addition to pressure from the socio-technical regimes level in the form of an increased political instability as a result of growing incapacity of a number of GCC governments, particularly Saudi Arabia, to respond to the growing social and economic demands of their societies. This scenario develops from the structural deficiencies within the political economy of these countries and the weakening of the rentier socio-political contract. An additional pressure from the landscape could come from a collapse in the price of oil in the international markets, which could take place in the coming years as a result of a return of Iraq and Iran to the oil market, or at the latest, between 2030 and 2035 as a result of the development of unconventional oil and gas resources outside the U.S. as we have seen in chapter 3.

The possible consequence of a *repressive or managed societies* scenario could lead to a *breakdown* scenario that will in turn lead after the consolidation of the newly emerging political equation in the medium-term to a greater popular input in the political and economic decision making process, or to a reconfiguration of the socio-technical regimes level, according to the MLP terminology and framework of analysis. It is difficult to predict the exact outcome of such a development and whether it will materialize in one or more countries of the GCC; however, we will be in the presence of a new political order that will definitely have an impact on the future course of the energy transition process. Should such a development occur, it should not be expected to lead to a radical transformation of the regional political economy; however, the energy transition process will face fewer structural obstacles related to the rentier nature of the political economy, as it will allow the new regime actors within the new ruling establishment to use all the policy tools at their disposal (regulatory policies, such as feed-inn tariffs, or fiscal incentives, such as electric utility quota obligations, or pricing tools), in order to curb electricity consumption and encourage the deployment of renewable and alternative energy sources.

In case the breakdown scenario occurs within the coming decade, the most probable transition pathway followed will be the *de-alignment re-alignment* transition pathway, as according to our findings in chapter 5, it is not expected that renewable energy technologies will be mature and cost competitive enough to readily replace the fossil fuel based technologies before 2020. In addition, it is assumed that during this period (the first decade from now), the pressure from the climate change issue at the landscape level will remain moderate, as no legally binding international agreement will yet be reached, or even if reached will be a minimal agreement with minimal objectives.

However, in case the breakdown scenario occurs later, or between 2030 and 2035, there are enough indications to expect that the most probable energy transition pathway will be a *technological substitution* pathway, according to the transition pathway typology proposed by Geels and Schot (2007). Indeed, during this period of time, renewable energy technologies will have reached a sufficient level of maturity to emerge and fully integrate the socio-technical regimes level that will be restructured accordingly. Moreover, during this period, the pressure from the climate change issue is expected to increase, as it is very probable that the international climate regimes negotiations will gain speed and an internationally binding emissions reduction agreement will become a reality.

It is true that the immediate consequences of a *breakdown* scenario in any GCC country will lead to a period of political instability that could take a number of years before it finally stabilizes; however, it is very probable that the new political system emerging from this breakdown will allow for the birth of a new GCC region with a much larger input from society in the policy making process. In this respect, it is important to note that the *breakdown* scenario does not necessarily mean a fall of the existing regimes in the GCC countries but essentially a significant degradation or rupture in the prevailing rentier socio-political contract that will lead to structural changes in the power equilibrium between the existing ruling elites and the society at large. This development is not impossible given the fact that the power equilibrium of the region has been changing and evolving over the past decades, and that this trend does not favor the ruling elites, as we have already seen in chapter 4.

Within the same scenario, it also very possible that the *repressive or managed societies* scenario will be prolonged over a long period of time without necessarily leading to a *breakdown* scenario but to a situation of long-term political instability during which the energy diversification efforts will be greatly negatively affected and the process of an energy transition significantly slowed down. In this case, the ruling establishments in the GCC countries will be capable of maintaining themselves thanks to the oil and SWFs proceeds in addition to a support from global allies that will not be in favour of a breakdown in the existing political regimes of the region given the centrality of the region in supplying the global economy with energy.

Given the significant uncertainties regarding the outcomes of a *breakdown* scenario, it will be very difficult to make detailed projections regarding the share of renewable or nuclear energy in all GCC countries, once the period of instability has passed and the GCC economies have embarked on an energy transition path. However, it is reasonable to expect that the quantified expectations of the 'neverland' scenario reviewed in the section above will depict the minimum achievable objectives, and probably more, and whether they are engaged in a *de-alignment re-alignment* transition pathway or in a *technological substitution* pathway, depending on when the *breakdown* scenario will occur. Whereas in case of a prolonged *repressive or managed societies* scenario, there are even doubts that the GCC countries will be able to achieve even the already planned targets for 2030 -2035.

As a concluding note for this chapter, it is interesting to observe four main points. The first is that the main factor that will determine the political future of the GCC countries and consequently their energy transition pathways may be found in the combined future evolution of the rentier structure of the GCC political economy and its structural weaknesses, in addition to the regional geopolitical factor and its disturbing influence on the internal political dynamics. Indeed, the sustainability of the emerging energy diversification policies in the GCC countries will depend on their financial capacities as well as their capacities to maintain a certain level of political stability in addition to the future possible regional developments and how the GCC countries will be impacted by them. A situation where the GCC countries will be politically instable and negatively impacted by geopolitical regional developments is not a situation that will be in favour of sustained long-term investments for engaging in an energy transition, as the priority of GCC ruling establishments will be to maintain and increase their social expenditures policies at the expense of investments in restructuring the economy. Such a situation will only maintain and exasperate the existing structure of the GCC political economy, which is the main obstacle to a successful energy transition. Secondly, and as a consequence of the previous point, the future of an energy transition in the GCC countries is intimately linked to the future evolution of the power equilibrium between the ruling establishments and the larger society, as the more it moves in favour of the latter, the faster and deeper will be the energy transition. This concluding point finds its logic in the fact that with a larger input from the society in the socio-political contract of the region the capacity of the GCC governments to use all the policy and fiscal tools will be enhanced and, as a result, the process for the deployment of alternative and renewable energy sources will be speeded-up. Moreover, such an evolution will also create the conditions for a real electricity market to emerge which will allow for more investments from the private sector, and decrease the financial pressure on the GCC budgets. Indeed, for the moment, and as long as the existing rentier socio-political contract will be maintained, all the financial burden for investing in the new energy sources rests essentially on the shoulders of the GCC governments, which represents an additional substantial financial pressure on GCC budgets. As far as the third point is concerned, it is noteworthy that in both scenarios—the 'neverland' scenario and the 'phoenix' scenario—the *technological substitution* pathway is always present half way of the energy transition process, which is an indication that the *technological substitution* pathway is a necessary phase in the overall energy transition process, but also an indication that, in the context of the GCC countries, the *technological substitution* pathway is in need of a preparation phase before it can take place.

Finally, it is in the interest of the existing regimes actors to act proactively and to take the initiative to introduce genuine political reforms given the fact that an energy transition process is a long-term process that needs stability and a continuity in the economic policies in order to achieve two concomitant goals, the first is to curb energy consumption, and especially electricity consumption, through policy and pricing tools, and the second is to achieve a successful energy transition and diversify their energy sources away from the hydrocarbons.

CONCLUSION

Despite a general impression that the GCC countries are not concerned with the climate change issue and alternative energy sources, there are signs of an early awareness. Between 1996 and 2005, all GCC countries signed and ratified the United Nations Framework on Climate Change (UNFCC) and joined the Kyoto Protocol, and have taken seriously their UNFCCC obligations. Furthermore, they have also shown an interest in CDM projects in order to take advantage of the technological as well as financial benefits offered by the mechanism. They have moreover already set long term renewable and nuclear energy objectives and launched a number of renewable and alternative energy projects. However, these steps remain timid, as oil and gas are still the sole energy sources fuelling their economies and power generation sectors, and the renewable and nuclear energy projects have not yet been conceived within the framework of an overall energy policy and/or strategy with the objective of engaging in an energy transition process, and in this respect, the GCC governments face much effort ahead for a successful qualitative energy transition.

Indeed, the GCC governments face a number of structural long-term challenges. Essentially, these are found in their respective political economies, chief among them the diversification of their economy, and within this general framework, engaging in a qualitative energy transition to diversify their energy sources away from the hydrocarbons that fuel their economies, with a particular emphasis on the power generation sector, given its share of energy consumption and its contribution to CO_2 emissions. According to the MLP framework of analysis, as the GCC governments gradually engage in the energy transition process, they will face a number of obstacles but could also potentially benefit from a number of opportunities as well, which can be summarized in the following points:

Obstacles or barriers are defined by the IPCC as “any obstacle to reaching a goal, adaptation or mitigation potential that can be overcome or attenuated by a policy or measure” (2011, p. 44). Using the MLP framework of analysis, we will look at the potential obstacles for a successful energy transition; i.e., at the micro-level first (the technological niche); followed by the meso-level (the socio-technical regimes); and finally, at the macro-level (the landscape environment).

On the micro-level, one of the main features of the technological factor in the GCC region is its dependency on the international market to import technology, as this technology is not home grown. Even in the case of the conventional energy technologies fueled by oil and gas already established at the regimes level, they have been historically imported from the international markets. Indeed, the GCC countries are already consumers of technology in every sector of their economies, especially in the oil and gas industry, and will most probably need to rely on imported technology in their energy transition process and adapt it to the country's specific regime and geographical context. At this level, we can clearly see that there is a structural weakness represented by the strong dependency on technologies developed abroad; however, the experience of GCC countries with conventional energy sources also shows that thanks to their integration within the global economy, they have been successful in developing their energy industry by relying on imported technology, and there are no objective reasons for not duplicating this experience with alternative and renewable energy technologies. Nevertheless, the GCC experience also reveals that importing the technology did not necessarily lead to creating a local value chain or to embedding the technology locally. Indeed, as far as renewable technologies are concerned, their value chain has seen some positive developments, but there remain still a number of challenges that must be overcome in order to build local industries in the field. The main challenge stems from the ownership of intellectual rights by the limited number of companies that own the patents, which they are still reluctant to license, as well as to build industries locally in the GCC countries (REN21, 2013a, p. 32). Furthermore, the local research and scientific capacities are still too weak (or even in some cases, nonexistent) to contribute towards localizing the whole value chain of renewable technologies, despite some progress made on that front by the Masdar Institute, which has recently produced the first clean technology patent of the Middle East and North Africa region (REN21, 2013a, p. 33). Deploying nuclear energy technology will face even greater difficulties in that respect, as access to its technology in the international markets is greatly limited comparatively to other energy technologies, due to its potential military proliferation issue, in addition to its very high capital cost.

To conclude on the micro-level, it is necessary to note that the MLP approach when used in the GCC context needs to take into consideration the fact that technological niche-innovations do not need necessarily to be home grown, that they can be imported from international markets, albeit some difficulties attached to the ownership of intellectual rights by a limited number of companies, which could be an obstacle to creating local value chains and embedding the technology locally.

As far as the meso-level (or the socio-technical regimes level) is concerned, as already defined earlier, it is very clear that it has a central role in any transition strategy and often the driving force of the micro- and macro-levels, but also very strongly influenced and shaped by them. At this level of the analysis, we can identify a number of potential obstacles to a successful energy transition as summarized in the following points:

The rentier nature of the existing socio-political contract and the importance of the oil and gas stakeholders with vested interests in the economy will mostly likely represent the main obstacles to a qualitative energy transition in the GCC region. However, as already seen in the UAE case, the new economy that has emerged from the introduction of renewable energy technologies has been managed by the same old neo-patrimonial structure, or regime actors according to the MLP terminology; therefore, when managed and gradual, and not the result of a *breakdown* scenario, an energy transition process in the context of the GCC does not necessarily represent a threat to the already established regime actors. In fact, when the regime actors act pro-actively, they can insure that they will preserve their interests and position within the socio-technical regimes level.

Once again, as a result of the rentier political economy of the region, there is a near-absence of a civil society with active NGOs and green movements or parties due to the social contract in place in the GCC countries, which limits the possibility of bottom-up advocated policies. Indeed, "apart from a few organizations serving professional and religious (charity) interests, the establishment of functioning civil society by GCC nationals remains underdeveloped" (Jill, 2005, as cited in Spiess, 2008, p. 249). Consequently, there is almost no input from the larger society in the policy-making process, and the rentier nature of the culture of the society has led to the development of wasteful energy consumption patterns that have been placing a significant pressure on their available oil and gas reserves.

Moreover, the rentier redistributive political economy has led to the policy of minimal taxation, which prevents the internalization of external costs and does not allow for using fiscal and policy tools, such as an ecological tax or a feed-in tariff system, in order to curb the domestic consumption and encourage investments in new and alternative energy sources.

Energy subsidies on conventional oil and gas sources reduce considerably the already weak cost competitiveness of nuclear and renewable energy technologies, knowing that the latter will need substantial governmental funding and subsidies in order to be introduced into the energy mix, and before they can compete with the conventional energy sources. There is here, indeed, a very strong structural obstacle, as energy subsidies have allowed for the GCC countries to be very attractive for energy intensive industries, as they enjoy a comparative cost advantage for highly energy intensive industries (cheap energy plus low cost labor), and as a consequence, have contributed to the economic diversification efforts of GCC governments.

On the landscape or macro-level, the main obstacle to a qualitative energy transition is to be found, first of all, in the regional geopolitical instability. Indeed, as we have seen in chapter 4, the Arab Spring wave has led to a strong return of the redistributive practices and policies in order to buy social peace, which reinforces the existing rentier structure considered the main obstacle for an energy transition. The second potential obstacle, albeit to a lesser extent, is the increase in the price of oil in the international market, as the GCC countries have seen their dependency on oil revenues increase since 2002, and as a result, the share of oil in the GCC economies has risen from 30.8% in 2002 to 40% in 2006 (Saif, 2009, p. 3). However, this factor comes double-edged, as the latest increase in the price of oil has also led to reducing the cost gap between conventional energy sources and renewable energy sources, which has then led to growing investments in the RES.

Another potential obstacle at the macro-level is the slow pace of progress in the negotiation process around compulsory climate change regimes due to the conflicting interests between the West in general and the emerging economies regarding the principle of shared but unequal responsibility.

On the other side, there are also a number of opportunities that could contribute positively in a qualitative energy transition. According to the 2011 IPCC report:

Opportunities can be defined as:

> circumstances of action with the attribute of a chance character. In the policy context that could be the anticipation of additional benefits that may go along with the deployment of RE but that are not intentionally targeted. These include four major opportunity areas: social and economic development; energy access; energy security; and climate change mitigation and the reduction of environmental and health impacts. (IPCC, 2011, p. 41)

Based on the above definition, we have identified the following potential opportunities available to the GCC countries for a successful energy transition in the power generation sector.

At the technological niche-innovations level, or micro-level, the GCC countries primarily have been importers of technology, and they lack the necessary scientific network and capacities for developing technologies locally; however, solar technology has been present in the GCC countries since the seventies, especially in Saudi Arabia where a number of pilot projects have taken place. Solar technology is therefore well known in the region, and there are even local if limited scientific capacities in the field, which could be reinforced and developed through governmental investments in training, research, and development. Saudi Arabia and the UAE are taking the lead in this perspective following the creation of King Abdullah City for Nuclear and Renewable Energy, and Masdar Institute, respectively. The technological niche will certainly need further development before it becomes imbedded in the region, but the seeds for developing the solar technological niche are already available and being actively pursued.

Of the GCC region, Saudi Arabia is the most advanced in pursuing the development of local content within its overall strategy for the deployment of renewable energy technologies, an objective that potentially only Saudi Arabia can pursue because of the size of its manpower and market. This objective is very clear in the White Paper released in February 2013, which states that “while K.A.CARE is aggressively pursuing the development of the local value chain, projects will be expected to escalate their local content inclusion accordingly” (K.A.CARE, 2013, as cited by REN21, 2013a, p. 32). Saudi Arabia also requires potential partners to make most of their procurement locally, and it introduced a 1% tax for investments in training and research in solar energy technologies. Finally, they have introduced fiscal incentives for employing local manpower (REN21, 2013a, p. 32).

The objective of such an obligation is clearly to encourage joint ventures with international companies and push them to build local industrial branches that will contribute to training the local manpower and transfer technologies in the long run. In this respect, it appears that Saudi Arabia, a latecomer in the renewable energy market, will be a major player regionally and possibly globally, if the financial effort is sustained in the long term.

The UAE, which has been the first country in the GCC region to take the lead in the development of renewable energies, is also pursuing the objective of increasing the local content; however, the size of its population and market will have a limiting impact on this strategy. There seems to be an awareness of these limitations at the governmental level, and this why the UAE has been more active and present than Saudi Arabia in international investments in renewable energy projects abroad (REN21, 2013a, p. 33).

On the meso-level, or socio-technical regimes level, there are also a number of potential opportunities that could contribute positively to the energy transition process and which can be summarized in the following points:

The rentier state enjoys a certain level of autonomy, which grants him the "ability to plan and pursue an economic strategy unfettered by special interests" (Niblock & Malik, 2007, p. 15). The rentier state theory attributes to the rentier state a central role in the economy and a relative level of autonomy—characteristics that are necessary for conducting a successful energy transition.

Indeed, the existence of a state capitalist and neo-patrimonial structure is a potential advantage that grants the GCC governments the necessary institutional and political factors for engaging in an energy transition. Political will is determinant in a process that needs a state apparatus for planning and implementing the policy. The state capitalist structure, coupled with an inclusive approach in energy policy-making towards the neopatrimonial structure and the relevant energy stakeholders as represented by the major national energy companies, would greatly contribute towards gathering the necessary support for engaging in a successful energy transition.

On the financial front, the GCC governments have at their disposal in the present time significant capital resources that will be necessary, especially in the initial launching phase, in order to make the needed investments for a gradual transition. Following the last increases in the price of oil, the GCC governments have been enjoying substantial revenues from the export of oil and gas, and it would make sense from an economical perspective to invest the available financial wealth in diversifying their energy sources, as it is a long term process that requires long term planning and investments. As demonstrated by the Stern Review, costly adjustments could be avoided in the future if an incremental transformation process was initiated now, rather than radical change later (Stern, 2007). When looking at the international market and the available alternative technologies, such as nuclear technology, or the renewable energy sources, such as solar and wind, they all have high initial costs and a long time period of depreciation of the investment, and will therefore need strong regulatory and financial support from the GCC governments in the initial phases. Regulation and subsidies will be necessary to allow the deployment of the selected technological niche and decrease the cost as a result of economies of scale.

Moreover, investing in RES is an opportunity to diversify the economy and create jobs in knowledge-intensive fields. Very significant investments will be required for the deployment of new energies in the power generation sector, which consequently will need to create fast growing new markets with attending opportunities for growth and diversification.

Engaging in an energy transition process that would lead to an increased share of alternative and renewable energy sources in the energy mix of the GCC countries will, undoubtedly, reduce the pressure on their limited reserves of hydrocarbons, and more oil and gas could be exported with a better financial value.

On the landscape or macro-level, the potential opportunities can be summarized in the following points:

The existence of the GCC organization through which the member countries could potentially coordinate more closely their energy policies and avoid duplication of efforts is a potential advantage that has not yet been fully exploited until the present time, excepting the experience of the grid interconnection. In this respect, it is important to remind that the GCC Interconnection Authority (GCCIA) offers a good example of this available opportunity, as the 7 billion power grid is expected to cut the need for new electricity generation in the GCC countries by 5000 Megawatts (Reiche, 2010, p. 2400). The European Union experience has been built on steel and coal industries, and the GCC countries could use the energy industry as the building block for a greater regional integration, which will certainly allow for larger economies of scale and a lower level of investments when projects are done collectively It is true, however, that the GCC countries have not made significant achievements in their cooperation and integration process until now, especially regarding the objectives set in the Charter by the member states when the GCC organization was created in 1981, but its existence is an asset that could be further developed and improved.

At the international level, the GCC countries could take advantage of the Kyoto Protocol for investments in clean energy projects and benefit from technology transfer, training and technical assistance, and energy diversification. As seen in chapter 3, the GCC countries have been actively seeking this opportunity, and it should be expected that this trend will be reinforced in the future.

While there are a number of structural weaknesses at all levels, in the GCC countries, there are also a number of opportunities available to the governments of the region to engineer a successful energy transition within three to five decades, if the political will is strong enough. Let us not forget that the classical rentier state theory initially assumed that a rentier state would not be capable of developing an industry, which has since proven wrong, as demonstrated by the very significant industrial development in the petrochemical industry. As stated by Tim Niblock, the GCC countries have been able to push forward a number of industrial projects through the concept of "islands of efficiency" (Niblock & Malik, 2007, p. 20). Accordingly, it is not impossible to implement the same concept toward a strategy for an energy transition within the framework of the multi-level perspective, where all the levels will reinforce each other, with the meso-level playing a central role in the process. Indeed, the political will at the level of the policy-makers, in addition to the engagement and support of the neopatrimonial network, will be key factors for engineering a successful energy transition. While the GCC countries lack the efficient and independent bureaucratic structure present in a developmental state and are limited in their capacity to collect taxes, their societies are not static, as they are undergoing gradual political reforms that could in the long run transform the state structure and lead to a change in the minimal taxation policy. Indeed, political reforms in the GCC countries have already taken place in the past, and we should expect the possibility of further reforms in the political equation of the region, especially if we consider the regional context of the Arab Spring—which is now only at its first stages and in the long run, could potentially reconfigure the whole political map of the region. This development, if it should occur, will gradually change the society's role and create a new equilibrium between the top-down and bottom-up approaches—an equilibrium that is lacking for the moment.

From a policy perspective energy transition processes have to be considered within the more general framework of economic diversification policies and strategies and the success of both is based on an essential political determinant. Indeed, political legitimacy and social consensus constitute fundamental pre-requisites for undertaking the necessary disruptive reforms, and a successful energy transition will greatly depend on a gradual and simultaneous process of phasing out from the unsustainable social-political social contract based on oil rent. Moreover, as it has been demonstrated in chapter 4, the Arab Spring has only reinforced the existing social contract as GCC governments have retracted from the process of economic reforms for political considerations.

The assumption of the transition theory and the MLP framework of analysis that an energy transition will lead to a reconfiguration of the regimes actors is proving correct to a certain extent in the GCC countries. There is indeed a process of reconfiguration of the regimes actors that is taking place in the power structure of the GCC monarchies, and this process is expected to continue and increase in intensity as the energy transition accelerates; however, the regimes actors in the GCC monarchies have also shown a certain capacity to adapt to the process of change in a way that has not undermined their power status in the political system. This capacity to adapt has been very well described by Davidson in the following terms:

> The hybrid, semi-formal, political system of the oil era that witnessed family patriarchs becoming cabinet ministers or other officials at the helm of seemingly modern public sector institutions, has evolved once more. Impressively reinvigorated for the post-oil era, Abu Dhabi’s elites, still forged from centuries-old alliances, have been reconfigured as development-focused boardroom executives alongside their roles as tribal sheikhs. (Davidson, 2009, p. 2)

Finally, it is of course recognized that, as for any human endeavor, this research project is a limited and imperfect work that will surely need to be improved and further developed. The main limitation of this work is most probably to be found in the fact that the proposed scenarios are the outcome of personal desk research and not the result of a larger participatory effort. There are, of course, no methodological objections for building scenarios through desk research; however, there is no doubt that this work would greatly benefit from a participatory research work including a sample of relevant policy-makers from the region, academics, and members of the public in order to think collectively about the future of the energy system of the GCC countries.

It is hoped that this research thesis will constitute a modest contribution to scientific knowledge in general and to the discourse about energy transitions in the GCC countries in particular, which will hopefully create an impulse to use the transitions theory and the MLP framework of analysis by other researchers working on the GCC region and the greater Arab world.

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