The Need for Climate Resilient Energy Sector

Ibrahim Abdel Gelil

The Arab energy sector is playing and will continue to play a vital role in socioeconomic development in most Arab countries, especially; those endowed with vast hydrocarbon resources. These hydrocarbon resources have been, for decades, fueling, as well, the global economy. In addition, some Arab countries are blessed with huge potential of renewable energy resources such as solar and wind that have not been fully utilized yet. Though, there are nearly 35 million Arabs with no access to modern energy services. Renewable energy resources could play a major role in improving energy access and eradicating poverty particularly in rural and remote areas.

As a major contributor to GHGs emissions, discussions on climate change and energy usually focus on mitigation efforts; however, energy infrastructure must be also resilient to climate change. Climate change will have direct impacts on both the supply and demand of energy, which require specific responses. Energy infrastructure must also be resilient to climate change and natural disasters. Extreme weather events can result in devastating economic and social impacts on infrastructure. This is especially the case for energy because centralized energy systems tend to serve large populated areas and might be vulnerable to climatic changes.

On the demand side, the Arab region is expected to be warmer and drier, which will increase the use for domestic air-conditioners and desalination plants. In turn, this will have unforeseen effects on energy consumption, for example through rises in summer peaks for cooling. Thus, the impacts of extreme weather events will place further pressure on the electricity distribution networks. A report by the World Bank (World Bank, 2012) predicts that the region faces the worst water scarcity in the world—up to 100 million people could be under water stress by 2050. The Arab countries are expected to see increased temperatures of at least 2° Celsius in 15-20 years; and an increase of +4° C by 2100 is also likely. The region is facing increased risk of floods, droughts, and landslides. Moreover, increases in temperature will exacerbate these climate-related hazards.

Thus, in a changing climate, it is highly recommended to:

Systematically assess and monitor energy systems to ensure that they are robust enough to adapt to anticipated climate-related impacts.

- *Mainstream climate impact assessment into EIA and SEA for new energy systems expansion plans.*
- *Address energy poverty as an integral part of adaptation strategies.*
- *Promote shifting toward decentralized, renewable energy supply system in remote and rural areas.*
- *Implement energy demand management as an adaptation measure.*
- *Develop a new holistic approach to deal with the energy-water-climate nexus in the Arab region*
- *Building awareness and institutional capacity at the regional, national and local levels to minimize climate and other risks.*

I. INTRODUCTION

The Arab energy sector is playing and will continue to play a vital role in socioeconomic development in most Arab countries, especially those endowed with vast hydrocarbon resources. These hydrocarbon resources have been, for decades, fueling, as well, the global economy. In addition, some Arab countries are blessed with huge potential of renewable energy resources such as solar and wind that have not been fully utilized yet. Though, there are nearly 35 million Arabs with no access to modern energy services. Renewable energy resources could play a major role in improving energy access and eradicating poverty particularly in rural and remote areas.

The 2012 International Energy Agency's (IEA) world energy outlook projected Saudi Arabia to remain the largest oil liquids producer in the Organization of Petroleum Exporting Countries (OPEC), with total production reaching 15.1 million barrels per day in 2035. In addition to Iran, Qatar, Saudi Arabia, and the United Arab Emirates produced together 80 percent of the world natural gas supply in 2007, with Qatar projected to lead natural gas producers and exporters in 2035 (IEA, 2012).

Thus, for the coming few decades, resilience of the Arab energy facilities to potential risks of climate change and other natural disasters is vital for both achieving sustainable development for the Arab population as well as ensuring global energy security of supply.

As a major contributor to greenhouse gases (GHGs) emissions, discussions on climate change and energy usually focus on mitigation efforts; however, energy infrastructure must be also resilient to climate change. This chapter will discuss vulnerability and adaptation of the energy infrastructure in the Arab region. It so does by 1) highlighting the vital importance of the resiliency of the Arab energy system to avoid any potential catastrophic disruption of energy supply to the global energy market, 2) assessing vulnerability of the Arab energy system to climate change, 3) discussing the role of energy in community adaptation, particularly for the poor, and 4) identifying available adaptation options to improve resilience of energy infrastructure.

II. IMPORTANCE OF THE ARAB ENERGY SECTOR

As discussed in chapters (1) and (2), Arab countries held around 43 percent of the world's

proven oil reserves and nearly 29 percent of the world's gas reserves. Qatar has the largest Arab's gas reserves amounting to 46.6 percent of total Arab and 13.6 percent of world reserves respectively. Further, Qatar ranked the fourth largest exporter of natural gas and the world's largest exporter of liquefied natural gas (LNG) (OAPEC, 2010).

The Arab world's combined production in 2011 amounted to over 26 million barrels per day (b/d), or nearly a third of world oil supply, making the Arab world the world's largest producing region. Four of the world's ten largest producers of oil (Saudi Arabia, UAE, Kuwait, and Iraq) are Arab producers. Given that key position in the global oil market, securing Arab oil supplies has been vital to major global economies. In addition to their high dependency on Arab oil, an underlying security concern for those importers is that the regular flow of oil may be subject to physical disruptions leading to dramatic economic impacts such as those occurred during the first energy shock of the early 1970s.

In addition, Oil and gas revenues, estimated at about US$ 719 billion in 2010 have been the major source of income in most of the Arab countries, especially in the GCC region (table 2, Chapter 1). According to the Arab Monetary Fund, the oil and gas sector makes up about 35.4 percent of the total Arab GDP (AMF, 2011). Additionally, the petroleum industry plays an important role in the social and economic development of many Arab countries, both exporters and others that benefit indirectly, either through worker remittances, trade, or bilateral or joint Arab projects (OAPEC, 2009). The Arab Oil and Gas sector offers a tremendous number of job opportunities in different fields, through its exploration, production, transportation, refinery and distribution activities. Over the past three decades the GCC countries, the major oil exporters, have witnessed an unprecedented economic and social transformation. Oil proceeds have been used to modernize infrastructure, create employment, and improve human development indicators. Thus, the GCC countries have become an important center for regional economic growth.

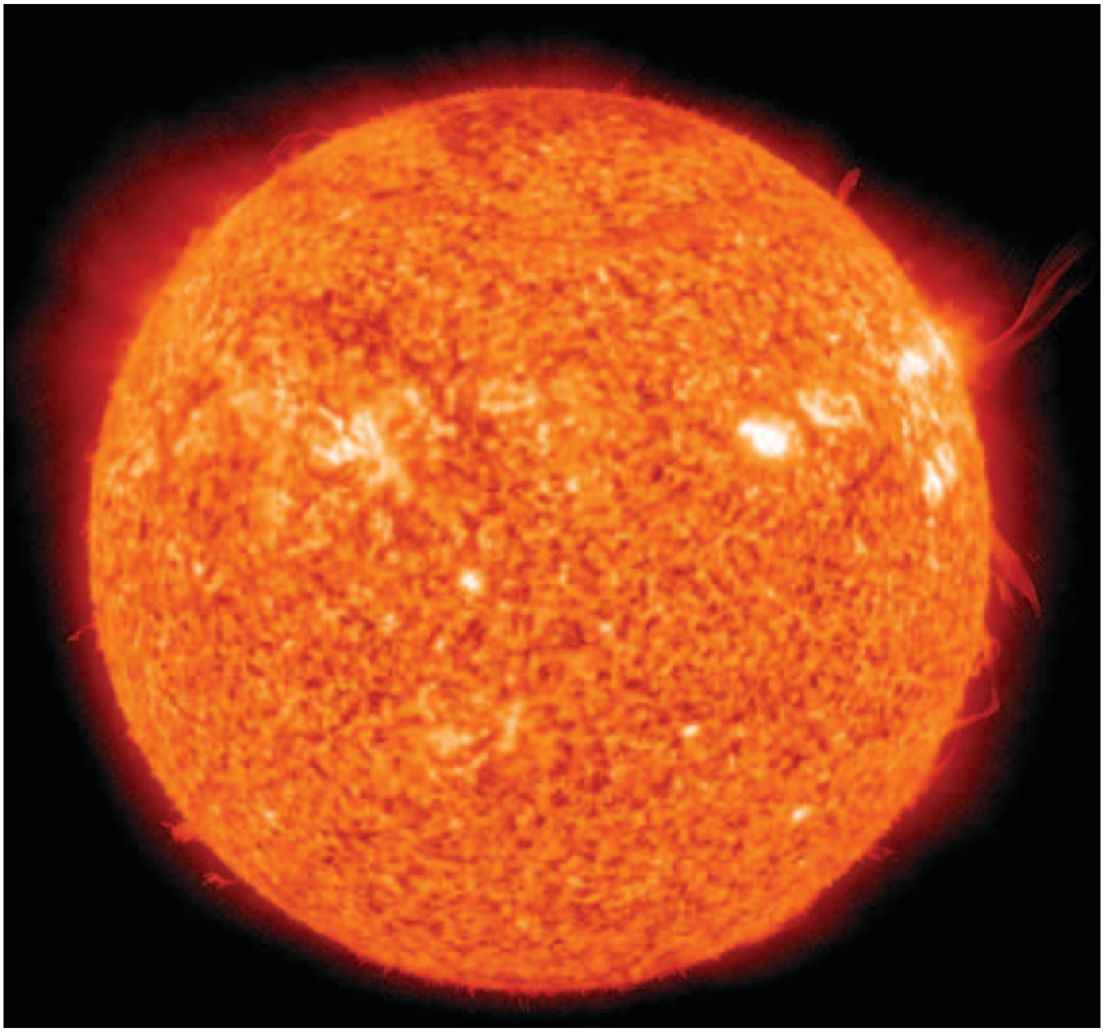
In addition, the Arab countries rely heavily on oil and gas to meet domestic energy demand, they both account for nearly 98.2 percent of the total

Arab energy consumption in 2009. It is worth noting that the energy sector has been playing a major role in addressing the water scarcity issue in the region. Fossil-based combined heat and power thermal plants are commonly used for water desalination in the Arab region, which hosts nearly 50 percent of the world's desalination capacity (AFED, 2010). Saudi Arabia is already producing 18 percent of the world's desalinated water, and this is projected to double to meet growing demand (KACST).

Potential impacts of climate change or any other natural disasters on the energy system would have devastating impacts on both the Arab and the global economies.

III. CLIMATE CHANGE IMPACTS ON THE ENERGY SYSTEM

Discussions on climate change and energy usually centre on mitigation efforts because fossil fuels represent nearly 81 percent of the global primary energy supply and the single major contributor to the global GHG emissions (IEA, 2010). Climate change will have direct impacts on both the supply and demand of energy, which require specific responses. Energy infrastructure



must also be resilient to climate change and natural disasters. Extreme weather events can result in devastating economic and social impacts on infrastructure. This is especially the case for energy because centralized energy systems tend to serve large populated areas and might be vulnerable to climatic changes.

On the demand side, the Arab region is expected to be warmer and drier, which will increase the use for domestic air-conditioners and desalination plants. In turn, this will have unforeseen effects on energy consumption, for example through rises in summer peaks for cooling. Thus, the impacts of extreme weather events will place further pressure on the electricity distribution networks. A report by the World Bank (World Bank, 2012) predicts that the region faces the worst water scarcity in the world—up to 100 million people could be under water stress by 2050. The Arab countries are expected to see increased temperatures of at least 2°C in 15-20 years; and an increase of +4°C by 2100 is also likely. The region is facing increased risk of floods, droughts, and landslides. Moreover, increases in temperature will exacerbate these climate-related hazards. Details of the climate impacts on the energy system will follow below.

A. Impacts on Energy Resources

i. Oil and Gas Resources

Oil and gas resources are not likely to be impacted by climate change. On the other hand, climate change may force the shutting down of oil and gas producing facilities in some coastal low-lying areas vulnerable to see level rise. Further, offshore facilities might also be vulnerable to extreme weather events such as storms, which would lead to their shutting down.

RESPONSE OF ARAB STATES TO CLIMATE CHANGE

Although the Arab region is affected by periodic earthquakes and droughts, Disaster Risk Management (DRM) has not been a priority for the region's governments until recently (UNISDR 2011). At the regional level, the League of Arab States (LAS), the Council of Arab Ministers Responsible for the Environment (CAMRE), the United Nations International Strategy for Disaster Reduction (UNISDR), the Regional Office for the Arab States, and the Arab Economic and Social Council have approved a number of recent DRM and CCA initiatives, including the 2007 Arab Ministerial Declaration on Climate Change and the Arab Strategy for Disaster Risk Reduction (ASDRR).

ASDRR is a 10-year strategy with the aim of reducing disaster losses through identification of strategic priorities and enhancement of institutional and coordination mechanisms and monitoring arrangements at the regional, national, and local levels. The key priorities of ASDRR are to integrate DRM into national development planning and policies; strengthen commitment for comprehensive disaster risk reduction (DRR) across sectors; develop capacities to identify, assess, and monitor disaster risks; build resilience through knowledge, advocacy, research, and training; improve accountability for DRM at the sub-national and local levels; and integrate DRR into emergency response, preparedness, and recovery. To achieve these goals, ASDRR aims at entrusting a ministry with strong political power with the DRM mandate. Local initiatives will be prioritized on the basis of their effectiveness in reducing risks to organizations such as grassroots women's organizations.

Meanwhile, individual Arab economies are making progress on the Hyogo Framework for Action (HFA). Egypt, Jordan, Morocco, Syria and Yemen are making advances in systematically reporting disaster losses for 2010. Jordan, Syria, and the Republic of Yemen have recently published national disaster inventories, and other countries are expected to soon follow. Nine Arab economies have completed their HFA progress reports for 2011: Algeria, Bahrain, the Comoros, Egypt, Lebanon, Morocco, the West Bank and Gaza, Syria and Yemen.

LAS, in coordination with a number of Arab regional and international partners, has prepared a draft Arab action plan to address climate change issues in the Arab region. The cross-cutting program on DRM aims to follow up HFA through the integration of DRR in all programs related to adaptation, building and strengthening cooperation with UNISDR at the national and regional levels, and identifying mechanisms and capacities to reduce disaster risk in the planning and implementation of adaptation programs.

World Bank, 2012

ii. Renewable Energy Resources

Renewable energy plays a key role in future low carbon-emission development aimed at limiting global warming. However, its dependence on climate conditions makes it also susceptible to climate change. Although the first part of this "paradox" has been thoroughly studied (IPCC, 2007), the formal knowledge base is still at an early stage of development (Wilbanks, 2007). The Arab region is blessed with huge potential of renewable energy resources especially wind and solar. With average daily sunlight exceeding 8.8 hours, low cloud covers, limited rainfall and abundant free land space, the region has optimal potential for the construction of large-scale concentrated solar power plants (CSP). According to the International Energy Agency, CSP plants in the region could cater to 100 times the combined electricity consumption of MENA and Europe (Khaleej Times, 2011).

iii. Hydropower Generation

Climatic changes are expected to impact river runoffs and will change hydroelectric output. This is particularly significant for countries such as Egypt and Iraq with large hydroelectric capacity. The total installed hydroelectric capacity in the region is 11,683 MW. The amount of electricity that can be generated from hydropower plants depends on the variation in water inflows to the plant's reservoirs. Changing climate conditions can affect the operation of these existing hydropower systems. This is especially valid for those countries, which receives most of their renewable water resources across their borders. For instance, countries that share the Nile have long argued over the use of its waters, repeatedly raising fears that the disputes could eventually boil over into war. This pending water crisis is compounded by water scarcity in Arab region, raising regional concerns about shared water resources and its implications on the energy system. The Energy-water-climate nexus should be paid special attention in the region; this issue will be further discussed below.

iv. Solar Energy

Most of the Arab countries are blessed with huge potential of solar energy resources. A large part of the Arab region falls within the so-called ‘sun belt’, which benefits from the most energy-intensive sunlight on the globe (in terms of both heat and light). Solar energy resources in the region vary between 1460-3000 KWh/m^2/year. Solar energy generation can be affected by extreme weather events and increased air temperature that can alter the efficiency of photovoltaic (PV) cells and reduce PV electrical generation (Bull, 2007). For example, a 2 percent decrease in global solar radiation will decrease solar cell output by 6 percent overall. The efficiency of CSP generation can be impacted by temperature change. In addition, CSP requires increased water use, and would be vulnerable to aggravated water scarcity due to climate change. Most parts of the Arab region have been identified as well placed to provide huge amount of solar electricity using CSP technology enough to meet the region’s electricity demand as well as Europe’s. In addition, there are plans to generate large amounts of solar electricity in Arab countries and export portions of it to Europe. The “DESERTEC Industrial Initiative” aims to generate up to 550 GW of electricity over the next 40 years, from installations that will initially be located in Algeria, Morocco, Tunisia, Libya and Egypt and later in the deserts of the Middle East from Turkey to Saudi Arabia and Jordan (DESERTEC Foundation, 2010). Climate-induced water scarcity would severely impact these plans.

Another factor to consider while planning for PV solar systems is the impacts of severe sand storms on the system efficiency. For example, the solar power production at the first and largest solar power plant of the UAE and the region was hit badly due to a weeklong extreme sandstorm that occurred in the summer of 2009. It had reduced the solar energy production by almost 40 percent (Greentecmedia, 2010). More frequent sandstorms would demand for more water for cleaning the PV panels, and thus contribute to water and energy shortages. An issue that needs to be further investigated in planning for solar energy development in the Arab region.

v. Wind Energy

Grid connected wind power at commercial scale of 550 MW exists in Egypt and 280 MW in Morocco (NREA, 2011), while standalone wind units are in use for small applications in Morocco, Jordan, and Syria. Natural seasonal variability of wind speed has a significant impact on the energy produced from wind turbines. Alterations in the wind speed frequency distribution can affect the optimal match between power availability from natural resources and the output of wind turbines. Numerous studies discuss the impacts of climate change on wind power. In this context, climate impact studies on wind power systems should focus on the total exploitable wind resource, indicating the future availability of power generation and identifying/prioritizing areas for site-specific viability assessments. Shifts in the geographical distribution and the variability of wind fields are the main mechanisms by which global climate change impacts wind energy endowments (World Bank, 2011).

B. Impacts on Energy Supply

Energy transformation facilities can be affected by climate change in a variety of ways, as discussed in the following sections. It is worth noting that a major share of the current energy system (and even the energy facilities under construction or planned to be built in the next years) will likely be impacted by potential climate changes given the long life span of energy infrastructure.

i. Oil and Gas Production

Oil and gas production from offshore facilities, as well those located in low-lying coastal areas, can be disrupted by extreme events, such as more intense storms, floods or hurricanes, that can lead to production shutdowns for evacuation to avoid loss of life or environmental damage (API, 2008). Hurricanes in the Gulf of Mexico in 2004 and 2005 resulted in a large number of destroyed and damaged offshore oil and gas structures: more than 125 platforms were destroyed (Oil Rig Disasters). An increase in the frequency, duration, and intensity of such extreme events can therefore have significant impacts on oil and gas production. With more than 120 oilrigs working in the region, potential climate risks need to be cautioned.

ii. Oil Refining

The Arab region hosts about 7.9 million barrel/day of oil refining capacity to meet domestic demand of petroleum products and exports around 3.5 million barrel a day to international market (OAPEC, 2012). Oil refining is also a large water consumer and is thus affected by water shortage. Total water consumption in an average U.S. refinery is estimated at 65 to 90 gallons of water per barrel of crude oil (Energetics, Inc. , 1988). Water demand in oil refineries can also rise as a result of higher temperatures and its use in cooling units. Climate-induced disruptions in Arab refineries would severely impact domestic supply of petroleum products as well as the global energy market.

iii. Thermal Power Plants

Large number of thermal power plants in the Arab region especially in the GCC is located within or near the coastal areas. Additional measures will be needed in vulnerable areas to protect them from sea level rise and the increased threat of flooding. Typically lower levels of precipitation and high temperatures in those areas have a negative influence on the cooling processes of power plants. This effect will be exacerbated due to climate change;

GREEN BUILDINGS IN THE ARAB COUNTRIES: CODES, STANDARDS AND RATING SYSTEMS

Samir R. Traboulsi

Public in the Arab countries is becoming more familiar with the term of Green Building, at different levels. While codes are mandatory, the standards and rating systems remain voluntary tools. There are several parameters that affect the preparation of the legalization process to decide for a code, and the development of standards and rating systems.

On the other hand, the world has been crippled with ongoing financial crisis, coupled with issues of resources depletion. Focus on energy and water sectors, as they are becoming scarce, in addition to environmental degradation, prompted the construction industry to seek avenues of solutions through the construction law, energy efficiency standards, water efficient use and standards, environmental air and indoor quality and other standards related to the environment, and various social and economic factors.

Different types of buildings require different tools to facilitate consistent application of sustainable design principles and to serve as a measure of accomplishment resulting in certifying into categories.

Buildings account to about 35 percent of the total energy consumption in the world. Hence the energy efficiency has led the process for modifying the construction codes in different countries. The price of energy varies between one country and another, which meant that affinity for energy efficiency (mandatory or voluntary) is not the same.

Construction laws or codes are usually old, in most countries dating back to the 1970s, and any attempt to change them usually faces opposition. Clauses of the codes describe generally the followings: footprint of the building, zoning and total built up area and day view glazing.

Recent moves in certain Arab countries attempted to introduce new clauses such as: envelope, mass and glazing, and insulation. Egypt, Tunisia, Jordan, Lebanon, Syria and Bahrain introduced codes which stipulated the construction of multi-layer of outside walls aiming at creating additional barriers against heat gains or heat losses.

Other clauses limiting the ratio of glazing over the façade area to a certain percentage are being considered, also to control heat exchange. Certain buildings were required to provide solar hot water systems, such as in Lebanon and Jordan, as part of the permit application. Secretariats of Ministerial Councils of Electricity and Housing within

even a modest variation in ambient temperature may represent a significant drop in energy supply. The significant amounts of water that are needed to cool thermal power facilities make them vulnerable to fluctuations in water supplies. As discussed earlier, water availability is an issue in the Arab region, which means that some power stations are vulnerable to the aggravated water scarcity in the region. Studies show that in the United States, for example, each KW of electricity generated by a steam cycle process requires around 94.6 liters of water. Adding the potential rise in temperature, more cooling would be required to compensate for losses, mainly caused by evaporation. Heat waves and similar extreme weather conditions may place additional severe limitations on power plant operations. This was exemplified during the heat wave of 2003 in Europe, when availability of cooling water was reduced restricting, when most needed, the energy supply. GCC plans to invest US$ 100 billion for power and desalination system expansions over the next decade (Middle East Economic Engineering Forum), these new plants will have to be carefully designed to comply with climate vulnerable conditions.

iv. Nuclear Power Plants

As discussed in Chapter (4), nuclear power is among the energy sources and technologies available today that could help address the challenge of reducing GHG emissions and mitigate climate change. GHG emissions from nuclear power plants are relatively negligible on life cycle basis compared to other energy supply options.

As such, nuclear power plants are often touted as a solution to climate change; however, the Fukushima accident serves as a warning that far from solving the climate change problem, nuclear power may be highly vulnerable to it. In addition to the different safety aspects of nuclear power plants, which were discussed earlier in this the League of Arab States issued energy efficiency guidelines, and are considering green building codes.

In countries facing shortages in the electricity supply, energy efficiency standards which are published by several organizations become useful tools which encourage voluntary action- mainly as cost-saving measure. They typically address envelope, lighting, appliances and HVAC equipment, in addition to solar collectors for hot water and PV panels. The Energy Efficiency Handbook published by AFED in 2012 is an example of such contributions.

A Kuwaiti version of the ASHRAE 90.1-2010 standard, covering residential low buildings, has been issued. Other countries were indirectly complying with the standards when developing their rating systems. Qatar's QSAS, Jordan's Labeling of Appliances and Lebanon's Thermal Standards are examples of the introduction of energy efficiency standards.

Building rating systems are developed as tools that examine the performance of existing buildings or expected performance of the new building when constructed, and translate that into an overall assessment that allows for comparison.

Several building evaluation tools are either copied and pasted, or developed to focus on different areas of sustainable development components, and are designed for different types and uses of buildings. These mostly use scoring points systems, including energy consumption assessments, water efficiency and water efficient use, life cycle assessment, life cycle costing, energy systems design, performance evaluation, productivity analysis, indoor environmental quality assessments, recycling and other economic and social values, operations and maintenance optimization, whole building design and operations, among others.

The green sustainable building rating system considers several values including the technical basis and assumptions, scoring point methodology to measure building performance, and aspects of a sustainable society.

Lebanon, Jordan, Egypt, Qatar, Saudi Arabia, and U.A.E. green building councils are in different stages to develop such green building rating systems. Success will pave the way to collect the benchmark data enabling the implementation of labeling sustainable buildings in other Arab countries.

Dr. Samir R. Traboulsi is Consultant and Senior Lecturer in Electrical Engineering at the American University of Beirut. Former President of Lebanon Green Building Council (LGBC).

report (see chapter 4), the accident at TEPCO's Fukushima–Daiichi Nuclear Power Plant, which was caused by the earthquake and tsunami that struck Japan in 2011, signaled an additional concern related to the impacts of natural hazards, including extreme weather events, on nuclear power plants. Although the accident in Japan was caused by an earthquake and tsunami, yet the effects of potential climate change could cause very similar problems. Nuclear power plants need access to large volumes of water for cooling that is why nuclear power plants are typically sited near large bodies of water, such as coastal areas.

Coastal areas are generally highly vulnerable to sea level rise. This already poses additional problems for the safety of nuclear plants. Moreover, water scarcity and rising water temperatures can disrupt nuclear power. For instance, during the 2003 heat wave in Europe, reactors at inland sites in France were shut down or had their power output reduced because the water receiving the discharge was already warmer than the environmental regulations allowed (Kopytko, 2011). In another instance in 2012, the cooling water temperatures at a twin-unit nuclear power plant in Illinois exceeded the temperatures originally allowed by four degrees Fahrenheit (~2.22°C). Craig Nesbit a spokesman for Exelon, which owns the plant, stated the following about the incident: "I'm not a climatologist. But clearly the calculations when the plant was first operated in 1986 are not what is sufficient today, not all the time." (Schueneman, 2012).

Climate models predict that droughts will become longer and larger. This is already debated in the US over scarce water resources in regions with nuclear power plants, such as river basins in Georgia, Florida and Alabama.

Another cause for concern is floods. All nuclear power plants are designed to withstand a certain level of flooding based on historical data, but these figures do not take climate change into account. Floods due to sea-level rise, storm surges and heavy rain are projected to increase in frequency and severity.

Within the Arab region's context, the World Bank report concluded that climate change is already happening in many parts of the Middle East and North Africa (World Bank, 2012). Further, the region is projected to be drier and hotter, and vulnerable to rising sea levels. The report cited the 2006 flooding of the Nile River Basin, as well as the record five-year drought in the Jordan River Basin that ended in 2008. Of the 19 record temperatures in 2010, almost a quarter was from the Arab world, including Kuwait where temperatures reached 52.6 °C in 2010 and 53.5 °C in 2011. In 2010, the Arabian Sea experienced its second-strongest cyclone on record, with winds as strong as 230 kilometers per hour that killed 44 people and caused US$ 700 million in damages in Oman. As previously stated, the region is already the world's most water scarce, and with climate change, droughts are expected to turn more extreme, further exacerbating water scarcity.

Thus, most forms of energy generation are vulnerable in some way to the effects of climate change, and nuclear power is among those. The bottom line is that if nuclear power is to be used to mitigate the effects of climate change, it must also be capable of adapting to them. There are serious doubts that it can.

v. Energy Transmission and Distribution

Extreme variations of weather and climate situations can impact the transmission and distribution of power, and the transfer of oil, gas, and other fuels. Distribution systems are vulnerable to extreme weather events such as falling trees for example, due to storms. Falling of power transmission and distribution lines can cause power outages and severe consequences thereof, especially in cases of emergency.

This is also true in the case of oil and gas pipelines, which are extended thousands of kilometers in the Arab region and exposed to storms, storm-related landslides and erosion processes, as well as floods. For example, the Suez-Mediterranean pipeline (Sumed pipeline) is an oil pipeline in Egypt, running from a terminal on the Gulf of Suez to offshore terminal in the Mediterranean Sea. It provides an alternative to the Suez Canal for transporting oil from the Gulf region to the international market. Transports of oil products by road or rail are similarly exposed.

The transfer of energy by sea may face increasing challenges and opportunities. For instance, as the Arctic Sea ice melts at unprecedented rates, new shipping routes will open up. The world's ships are already sailing past western and northern Alaska. In fall 2009, two container ships traveled north through the Bering Strait, escorted by Russian icebreakers. These new routes might have far reaching economic impacts on the Suez Canal, a major contributor to Egypt's foreign revenues (Rogoff, 2011).

C. Impacts on Energy Demand

In addition to climate impacts on energy supply infrastructure, unexpected changes in energy demand may impose stresses on these systems. For example, excessive demand for air conditioning in hot weather may affect the efficiency of energy distribution. Rising temperatures can affect final energy use. The most direct and obvious effect relates to higher temperatures. This can increase demand for cooling (or air conditioning). The performance of motors and engines can also vary with changes in climate parameters.

Climate change can also affect the demands on water and electricity in industries that use refrigeration and cooling, and in agriculture, for irrigation purposes.

i. Cooling in Buildings

In the Arab region, households consume more than a third of all end-use energy. In some parts of the Arab countries, especially in the GCC, excessive use of air conditioning is consuming more than half of final energy consumptions in the residential and commercial sectors. Various empirical studies have found that total energy demand depends on outdoor temperature in a U-shaped fashion: low temperatures correspond to relatively high energy demand (higher energy demand for heating), intermediate temperatures correspond to lower energy demand, and high temperatures correspond

to higher energy demand again (Guan, 2009). More studies need to be conducted to further investigate the impacts of temperature increases on the end use levels, across different economic sectors. Potential climate change and global warming should be factored in when forecasting energy demands in vulnerable regions, including the Arab's.

ii. Energy Poverty

Improved access to energy resources and services plays a crucial role in eradicating poverty, achieving sustainable development, and therefore in improving adaptation capacity of developing countries. Energy and technology choices toward a low carbon energy mix are crucial in addressing climate change in the developing countries as the foundation for their adaptation to climate change. Lack of electricity deprives people of many vital needs, in particular food conservation, education, communication, and health care.

Nearly 35 million people in the Arab countries have no access to modern energy services.
This is strongly associated with poverty in rural areas. The lack of access to reliable and affordable essential energy services is primarily not a result of "underdevelopment", but rather a causal factor of economic poverty, malnutrition, chronic health vulnerability, and insecurity.

Affordable access to energy resources and services impacts positively the quality of life, sustains livelihood, increases the economic opportunities, and consequently reduces demographic pressure on ecosystems, thereby improving adaptation capacity. It is one of the reasons why a more equitable distribution of energy supply in the Arab countries must be seen as an important component of sustainable development and climate change adaptation. Public energy policies are hence urged to focus their efforts on advocating for a more equitable distribution of energy services, allowing communities to equally benefit from them.

In this regard, the long lead-time and high costs needed to extend central energy grids to currently off-grid populations often makes centralized distribution of energy a cost-ineffective option. Decentralized renewable energy systems such as home solar systems and local micro grids, on the other hand, offer a golden opportunity to address the lack of access to energy services in rural and remote areas. Such solutions can thus allow developing adaptive capacity of these communities, while drastically reducing GHG emissions.

Further, renewable energy options create more energy independence, in particular from fossil fuels, and their price volatility. This constitutes a vital issue for many Arab oil importing countries such as Lebanon, Jordan, and Morocco.

The Global Rural Electrification Program (PERG), launched in 1996 by the National Electricity Office (ONE) in Morocco is an exemplary Arab project of scaling up renewable energy use for rural development. The project that came as a public-private partnership (PPP) between ONE and TEMSAOL, a French renewable energy service company, aimed to provide PV solar electricity to over 34,000 rural villages by 2007.

Because of the elevated costs in connecting rural households to central electricity grids, individual photovoltaic Solar Home System (SHS) was the best choice, and communities supplied in that case have become better prepared to meet the challenge of climate change.

IV. ENERGY-WATER-CLIMATE NEXUS

Energy and water systems are dynamically linked. The production, supply and transportation of one resource cannot be achieved without making use of the other (see Box). Further, there is growing scientific consensus that climate change is affecting the supply and quality of both. Thus, more needs to be done to ensure that climate adaptation is integral to future planning, to provide sustainable water and energy futures.

A significant share of energy is used across the Arab world for groundwater abstraction, desalination, treatment, transfer, and distribution. Projected climate change-induced declines in fresh water supplies and increase in demand in the region would increase energy requirements for all these activities. Projected increases in average air and water temperatures and limited availability of adequate cooling water supplies are expected to affect the efficiency, operation, and development of new power plants.

This strong interdependency between energy, water, and climate change makes it imperative that policy formulation be coordinated, particularly with respect to mitigation and adaptation to climate change.

In most cases in the region, energy and water policies are fragmented, spanning across many institutions with little coordination between them; this situation surely requiring an urgent reform. The shift from fossil fuel with considerable water use towards renewable sources would reduce demand for water in the energy sector, which makes it more resilient to climate change.

V. ADAPTATION OPTIONS

Energy systems must be climate-proof, withstanding anticipated climate change and its impacts. This can be achieved by increasing the resilience of the energy system. Options include diversifying energy supply options to ensure security of supply, proper sitting of energy facilities away from vulnerable geographic areas, promoting regional energy integration to share energy resources during emergency situations, and disaster preparedness planning and risk management.

The Region has started to respond to the climate risks. The latter was manifested in the 2007 Arab Ministerial Declaration on climate change and the Arab Strategy for Disaster Risk Reduction (ASDRR) (see Box). In this context, improving energy efficiency and scaling up renewable energy technologies would also be considered to further expand the portfolio of energy options.

Given the slow rate of capital stock turnover in the energy sector and the long lifetime of technology, it is important that energy planners, policy makers, and consumers be well prepared so that necessary adaptation measures are taken.

Climate impact assessment and adaptation should be mainstreamed in the Environmental Impact Assessments (EIA) as well as the Strategic Environmental Assessment (SEA) of the energy sector. Infrastructure projects including energy should take climate proofing into account. This would need developing methodologies for climate-proofing infrastructure.

VI. RECOMMENDATIONS

In a changing climate, it is highly recommended to:

1. Systematically assess and monitor energy systems, to ensure that they are robust enough to adapt to anticipated climate-related impacts.
2. Mainstream climate impact assessment into EIA and SEA for new energy systems expansion plans.
3. Address energy poverty as an integral part of adaptation strategies.
4. Promote shifting toward decentralized, renewable energy supply system in remote and rural areas.
5. Implement energy demand management as an adaptation measure.
6. Develop a new holistic approach to deal with the energy-water-climate nexus in the Arab region

Building awareness and institutional capacity at the regional, national and local levels is essential to minimize climate and other risks.

REFERENCES

AFED. (2010). Water: sustainanble mangement of a scarce resource. Beirut. Arab Forum for Environment and Development (AFED).

AMF. (2011). Arab Monetary Fund report. (AMF).

API. (2008). Considering the offshore industry's hurricane response. Retrieved 2011 25-June from http://global.ihs.com/?RID=API1.

Bull. (2007). Report by the US climate change science program.

DESERTEC Foundation. (2010). Retrieved 2011 20-May from http://www.desertec.org/

Energetics, Inc. (1988). Energy and environmental profile of the U.S. petroleum refining.

Energetics, Inc. (2010). Greentecmedia.. Retrieved 2011 29-June from http://www.greentechmedia.com/articles/read/masdar-update/

Guan. (2009). Preparation of future weather data to study the impact of climate change on buildings. Building and Environment , 793—800.

IEA. (2012). International Energy Outlook. International Energy Agency (IEA).

IEA. (2010). Key world energy statistics. International Energy Agency (IEA).

IPCC (2007). Intergovernmental Panel on Climate Change fourth assessment report.

KACST. (n.d.). King Abdulaziz City for Science and Technology (KACST). Retrieved 2011 13-May from http://www.kacst.edu.sa/en/about/media/news/Pages/news49.aspx

Khaleej Times. (2011). Retrieved 2011 13-May from MENA renews focus on green tech: http://www.khaleejtimes.com/DisplayArticle.asp?xfile=data/business/2011/February/business_February194.xml&section=business&col=

Kopytko, N. (2011 24-March). The climate change threat to nuclear power. Retrieved 2013 8-June from NewScientist: http://www.newscientist.com

Middle East Economic Engineering Forum. (n.d.). Retrieved 2011 25-June from http://www.eng-forum.com/News/Mar07/110307a.htm

New and Renewable Energy Authority. (2011). NREA. Retrieved 2013 9-June from http://www.nrea.gov.eg/english1.html.

OAPEC. (2012). OAPEC annual statidtical report. Organization of Arab Petroleum Exporting Countries (OAPEC).

OAPEC . (2010). OAPEC annual statistical report. Organization of Arab Petroleum Exporting Countries. (OAPEC).

OAPEC. (2009). OAPEC annual statistical report. Organization of Arab Petroleum Exporting Countries (OAPEC).

Oil Rig Disasters. (n.d.). Retrieved 2013 7-May from Hurricane Damage Offshore: http://home.versatel.nl/the_sims/rig/h-rita.htm

Rogoff, A. (2011). Retrieved 2011 15-June from Melting Arctic: Think of the Bering Strait as the next Panama Canal: http://www.alaskadispatch.com/article/melting-arctic-think-bering-strait-next-panama-canal?page=0,1

Schueneman, T. (2012 29-August). How climate change may affect nuclear power plants. Retrieved 2013 8-June from theenergycollectives: http://theenergycollective.com

Wilbanks, T. J. (2007). Introduction. In Effects of climate change on energy production and use in the United States. a report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Washington, D.C.

World Bank . (2011). Climate Impacts on Energy Systems. World Bank.

World Bank. (2012). Adaptation to a changing climate in the Arab countries. Washington, DC: The World bank.