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Powering Kuwait into the 21st century: Alternatives for power generation

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Executive Summary

Kuwait is facing a surge in the consumption of power. The current power fuel mix, based on oil, appears unsustainable. Yet Kuwait has a large number of assets. The power fuel mix can be optimized and diversified to include alternatives to oil such as gas or renewables, so as to benefit from the opportunity cost of oil (the price at which this oil could be sold on international market). The country has gas reserves and a good potential in renewable technologies. If energy efficiency can be considered as a potential resource, then much can be achieved in this area as well, given Kuwait's current power and water per capita consumption rates, which are among the highest in the world.

The present tendency has been to go for step-by-step fixes, adding emergency power plants which have increased power generation costs and a non optimized system. Kuwait is on the verge of defining a new power fuel mix, with more gas, and developing new R&D projects.

In this context, this memorandum looks at alternatives, and concludes that in the long term a diversified power mix has to be developed. The current gas glut at the world level, resulting both from the production of unconventional gas resources and the economic recession hitting Europe, offers a sizable opportunity for gas imports. A transition strategy for the power sector could make use of gas imports. In the longer term, however, Kuwait should not make a one-way bet and develop its domestic gas resources. This paper urges the adoption of a common gas strategy integrated into a power sector strategy, through consultation with all actors. It would include reserves, costs, feasibility and potential uses, as well as economic opportunities.

As the region is facing gas shortages and Kuwait ranks independency of supply among its policy priorities, renewable, and in particular solar have their own place in the power mix. The country indeed disposes of substantial and relatively predictable renewable energy resources. Those are well fitted to Kuwait's electricity consumption patterns. They can first contribute to peak demand and seasonal variations shaving. In

the medium term, dedicated applications and distributed (such as Building Integrated Photovoltaic, solar cooling etc.) could also help to relieve the power system of residential and air conditioning load. Power price subsidies for consumers will block their development. The drafting of policies will actually be decisive to ensure the roll out and the sustainability of renewable power. The current 10% renewable target still remains to be defined. Finally, the building of an industry to diversify the economy appears more challenging.

Nuclear power plants projects have been scrapped by the government for security reasons despite the competitiveness of this technology and the availability of liquid funds. The country hopes to import electricity from its neighbors, which will soon benefit from this technology. The creation of a regional electricity market could help to decrease costs, increase the security of power supply, and lead to an optimization of national power systems. However, the size of interconnections is too small and legislation about electricity trade still incomplete. Regional integration would require price reforms at some point, or at least a clear evaluation of costs. Multiple prices and costs, inside Kuwait and across the region, act as a significant bottleneck.

Whatever the choices made, the sustainability of the system cannot be achieved without an underlying energy efficiency strategy. This strategy needs to focus on both the consumption and production side and rely on a clear cost-benefit analysis to serve the interest of the country.

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Introduction

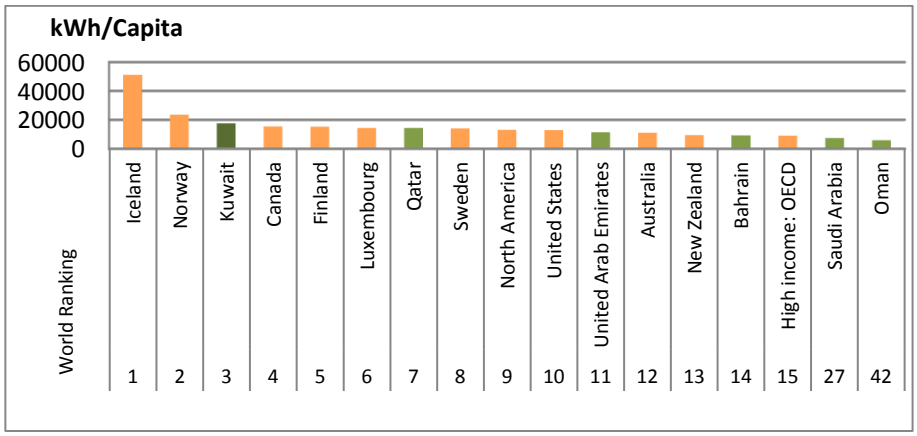
Kuwait faces increasing and unsustainable domestic power consumption: its per capita power consumption level is above that of most advanced industrial countries, including the United States. Power demand is forecast to double in the next ten years. In this context, the country's power fuel mix sustainability is questionable, as it relies on high-value oil. The country's economic sustainability relies to a large extent on revenues from oil exports. Ramping up the production of oil is proving more difficult as Kuwait's fields are ageing and as foreign investment and technology inflows, though needed, are being slowed down by internal politics. Fossil fuels are more difficult to substitute in other sectors than electricity generation (such as transport or petrochemicals), where many alternatives exist including gas, renewables or nuclear energy. The country has such resources, and Kuwait's consumption rates also offer substantial prospects for an energy efficiency strategy.

This study looks at alternatives for the power sector in terms of alternative fuels and generation technologies, the efficiency of the power system, electricity imports, and demand side measures targeting more sustainable consumption. Options are analyzed in three areas: technology feasibility, opportunity cost and political acceptability (social, geopolitical, institutional). Side benefits such as regional integration, economic diversification or job creation are examined qualitatively.

An Overview of Kuwait's Power Sector

Kuwait's power consumption has increased substantially in recent years, close to a rate of 8% per annum, to reach one of the highest levels of consumption per inhabitant worldwide.[1]

Graph1: Power Consumption Per Capita, Worldwide



Source: World Bank data 2011

Demographic growth and the expansion of housing are the main factors behind the surge in power consumption. This is reflected in the consumption breakdown. According to the Kuwait Institute for Scientific Research, buildings consume over 75% of electricity in Kuwait, 65% going for air conditioning[2]. This induces large seasonal fluctuations, with demand in summer months (July and August) being twice as high as winter months (December and January). The consumption peak is quite sharp in the summer (about 9,960GW out of 13,273MW of capacity). There are little incentives for consumers to reduce

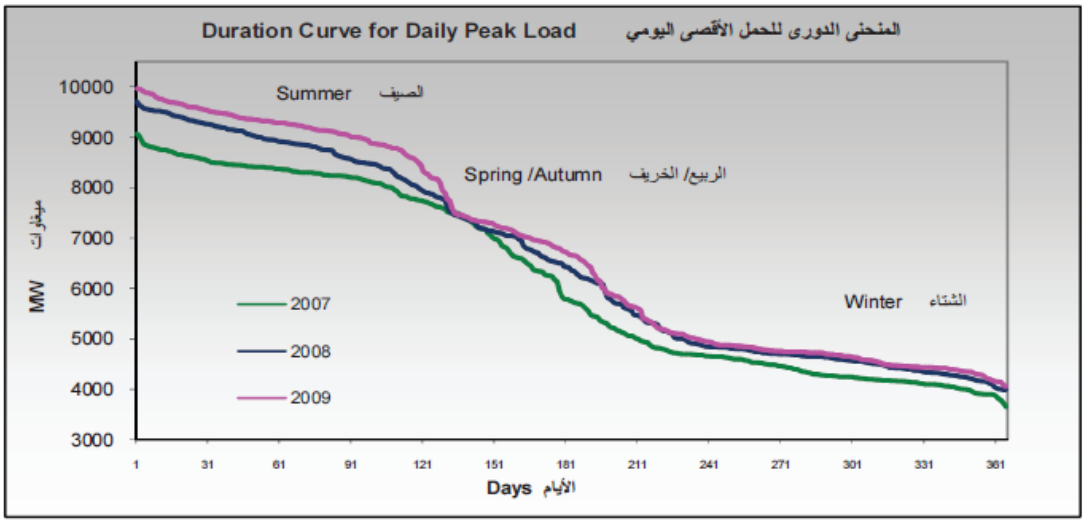
[1] Kuwait's power generation has increased at 6% per year, over the last ten years (MEW data for 2009), from 31,576GWh in 1999 up to 53,216GWh in 2009. Please refer to Maïté de Boncourt's previous IFRI study, *Powering Kuwait into the 21st Century*, (January 2012).

[2] Sa'adAl Jandal, KIRS, Lebanon Sustainability Week, June 2011

consumption, and Kuwait suffers from a clear efficiency strategy on the demand side.

The country also has a high rate of water consumption per capita (470.29l/capita/day) but scarce water resources. Therefore 93% of the water consumed in Kuwait is desalinated, requiring about 8% of the power generated each year.[3] Power and water are interlinked strategic needs. Both water and power consumptions are forecasted to increase at high rates, at least 6% for power. Graph 2 reveals Kuwait's power load curve.

Graph 2: Kuwait's Power Load Curve



Source: MEW, 2010 Statistics

Kuwait's fleet of power stations is composed of six fossil fuel power plants. Most of Kuwait's power plants are dual fuel (they can burn either gas or oil) and are associated with desalination capacity. They are therefore situated along the coast, near to inhabited areas.

Kuwait's power fuel mix is still largely based on oil (73%) heavy fuel, fuel oil and diesel to a lesser extent. Due to the increase in power generation, the share of diesel in the power fuel mix has increased from 4% to up to 7% over the last ten years. The sector therefore currently consumes around 200,000 barrels of its production of 2.5 million barrels of oil per day.[4] Gas power plants are cheaper to run and their fuel cost are lower. From an

[3] As a matter of comparison, around 30% of power is used to desalinate water in Saudi Arabia.

[4] Kuwait oil production is subject to OPEC quotas. It is common knowledge that the country is producing above this quota, at around 2.7 mb/d.

economic perspective, they should be prioritized over oil power plants. In liberalized power sector markets, power plants are used according to a merit order. They are brought into production according to their marginal cost of production, i.e. the most expensive plants are brought in last. The Ministry of Water and Electricity's statistics[5] show that gas power plants are however used to meet summer demand, peak demand and in winter to cover for the maintenance of steam turbines. The choice to use gas as secondary fuel has been made because Kuwait has limited domestic gas production. In other words, priority has been given to security of supply, over cost.

The Opportunity Cost of Oil

The opportunity cost of oil is commonly referred to as the difference with oil market prices and the price at which the power sector buys its oil. It can also include the value oil would have if it is refined. For Saudi Arabia for instance, where the purchase price is $5/barrels, the opportunity cost of selling oil on the market is $125, and the opportunity cost of refining it is around $1,000. This is even more so as the value of refined products has increased significantly in the last years. This argument is debatable, as developing the petrochemical sector is not always a successful operation. Developed consumer countries used to be keen at refining oil themselves and making their own products. Downstream transformation is now moving to Asia. Buying shares in the petrochemical sector instead might end up being a more successful operation. A presentation made by the KNNEC (Kuwait Nuclear Energy Committee) suggest that fuel cost for the power sector in 2010 were around $6 billion, and that they will increase to $13 billion and $20 billion in 2020 and 2030 respectively.

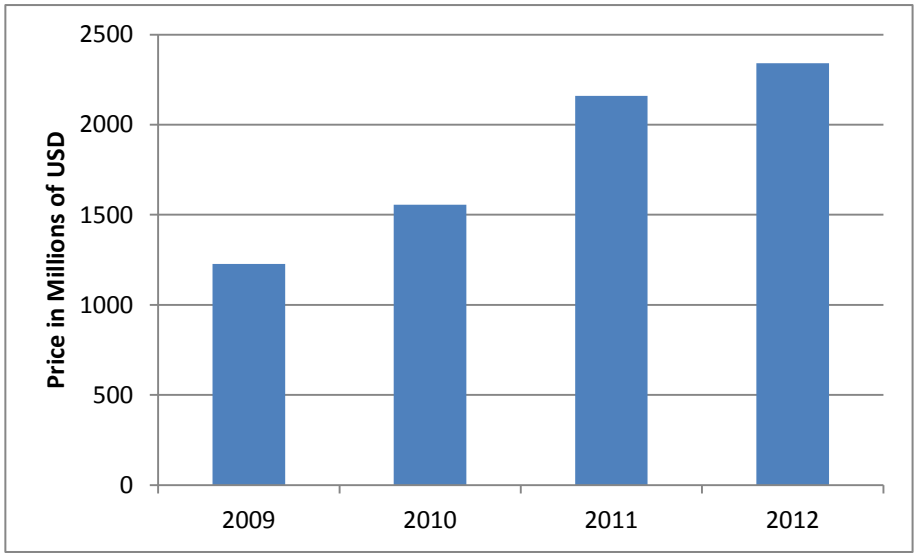
The oil bill for the power sector has therefore increased substantially in recent years. Power plants are currently buying

[5] MEW statistics on fuel use in the power sector, 2010.

their oil at around $50/barrel, which is considered as the price at which the budget of the Kuwaiti government is in balance. The fuel bill of the power sector has been evaluated at $2billion for 2010. The opportunity cost of oil — tells a different story about Kuwait power sector fuel bill (Graph 3). Current international oil prices indeed fluctuate around $120/barrel.

As it was stated in a previous IFRI study, Kuwait's power fuel mix is locking the country into an unsustainable economic path.[6] The fuel mix means that any increase in power and water consumption will result in substantial increases in the country's fuel bill, not even considering the opportunity cost of oil. The country is said to have increased the oil breakeven point from 50$ to $70-80 in one go. Additionally, the attribution of oil to the power sector competes with oil for exports, on which 95% of the state revenues are based.

Graph 3: Kuwait's power sector oil bill at the opportunity cost of oil 2008-2012*

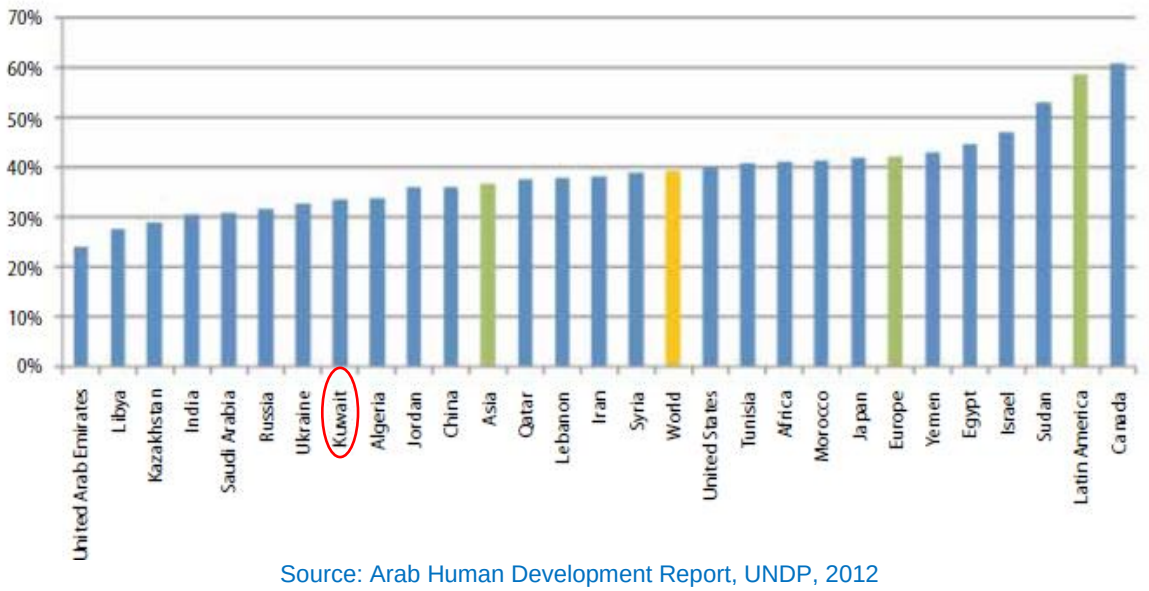


Source: Author's estimates, OPEC prices, MEW 2009 statistics[7]
*This graph merges crude oil, heavy oil and diesel. It is an author's estimate and only gives an order of magnitude. The real opportunity cost is likely to be much higher.

[6] This study developed conclusions on the basis of a very conservative power consumption growth rate (6%) based on compound average growth of the last ten years. Recent consumption growth rates have fluctuated around 8-10%. Consumption has always exceeded the forecasts.
[7] The graph is based on the number of barrels of oil burned at the price of oil on international markets (OPEC basket prices).

Kuwait has a clear interest to replace its oil in the power fuel mix, so as to curb its power sector fuel bill and keep a sustainable level of exports. According to the International Energy Agency, oil prices, could keep rising in the short term, reaching $140/barrel in the current policy scenario mostly driven by the Asian demand,[8] and possibly peak at $150/barrel in 2015/2016 (in real price – 2010 dollars) if investments are being delayed in the MENA region.[9] The Agency forecasts the prices to be increasingly volatile. In the longer term however, producer countries could lose market share.

Graph 4: Energy Efficiency in Power Generation in Selected Arab Countries



Source: Arab Human Development Report, UNDP, 2012

The low efficiency and limited load factor of Kuwait's power plants are due to the fact that most of them are composed of old steam turbines, sometimes exceeding life expectancy, thus requiring more maintenance. Last but not least, differences in seasonal consumption mean that the power

[8] World Energy Outlook 2011, p105.

[9] Under the deferred investment case scenario, the WEO studies the impact of the Arab Spring and deferred investment in the MENA region's oil and gas sector. MENA countries should represent 90% of growth in world oil production by 2035. $100 billion are needed annually. Some countries are decreasing their oil production levels, and this is not attractive for FDI. This might lead in an increase in crude prices up to $150 per barrel in the short term.

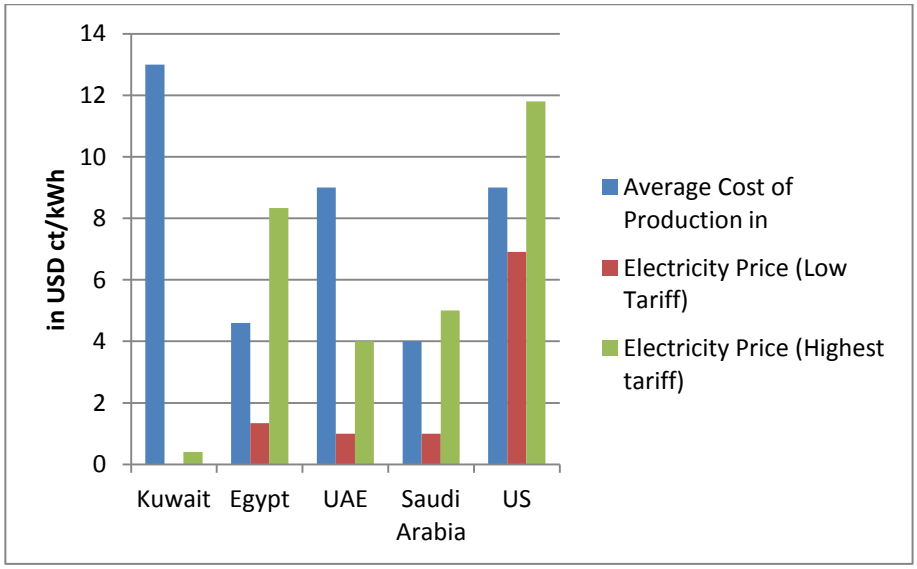
sector is *de facto* oversized in winter and suffers efficiency losses in summer due to high temperatures.[10] To face the surge in power consumption and add capacity reserve margins to meet temperature peaks in the summer, the Ministry of Electricity and Water has added sporadically small emergency gas fired plants or emergency gas turbines in existing power plants. These plants, like Shuwaikh,[11] have a limited life expectancy (around five years) and are quite costly to run despite low initial capital costs.

Peak loads have led to the installation of costly gas turbine with a low utilization rate (i.e. capacity load).[12] New projects are built to increase Kuwait's capacity reserve margins. This small step strategy was launched with no vision of the power fuel mix. Initially, it had been decided to build a fourth refinery so as to distill heavy fuel into fuel oil for the power sector.[13] Then 35Tcf of gas were discovered, offering another opportunity. Yet, both the exploration of gas reserves and the building of the fourth refinery have been delayed or suspended. The urgency of the situation left few options but to build emergency gas turbines.

Consequently, Kuwait's production costs are among the highest in the region, while on the other hand consumer prices and subsidies have not changed since the 1980s. In a business as usual scenario, the state budget will therefore be increasingly unbalanced. Graph 4 shows the difference between electricity generation costs and consumer prices across selected countries. Some of these countries buy their fuel at different prices (oil for power generation is subsidized in the Gulf countries in particular in Saudi Arabia), which distort the generation price.

[10] The seasonal differences in Kuwait between winters and summers are double, with an intermediary season (about one fifth of the time).
[11] The 252MW Shuwaik gas station was commissioned in 2006 as an emergency plant. Its efficiency is as low as 11% compared to 35% for the Sabiya oil and gas fired plant.
[12] Kuwait power fleet's capacity utilization rate in summer is 96%.
[13] Heavy fuel is harmful for power plants, and the Ministry of Electricity and Water has opposed it

Graph 5: Power Production Costs and Consumer Prices Across Selected Countries



Source: Author's own compilation, Arab Union of Electricity Producers, UPDEA (Union Des Producteurs, Transporteurs et Distributeurs D'énergie Éléctrique d'afrique), Saudi Arabia's Electricity ,Co-Generation Regulatory Authority ECRA[14]

The Ministry has now decided to install new power plants, and plans to increase the current capacity up to 16,000MW by 2014, and targets 20,000MW by 2020. The government has decided to go ahead with the partial privatization of the sector. The MEW is now tendering power and water plant projects (the so-called IWPP or Independent Water and Power Production projects). Given delays and complex tendering procedures, the country is now ranked behind Algeria in BMI's updated Power Business Environment Rating, as the size of the market is modest and the regulatory environment complicated.[15] By 2014, almost all new projects will be Combined Cycle Gas Turbines (CCGT). After that year, nothing has been decided yet.

[14] Saudi Arabia has three different types of tariffs (consumers (1), industries (2) and charities, mosques and agriculture (3)) and bracket tariffs. Generation cost include fuel costs. However in many countries, power plants buy their fuel at a subsided price. Saudi power plants buy oil at $5 to $10 / barrel, in Kuwait and the UAE oil is bought at $45-50 per barrel. ECRA does not state whether the price of electricity generation includes the price of oil, at market price. The graph gives therefore more an indication of the level of subvention than real prices.

[15] http://www.prlog.org/11046202-recently-released-market-study-kuwait-power-report-q4-2010.html

This snapshot of Kuwait power sector already leads to a few conclusions.

First, Kuwait's power fuel mix has to be changed. Most of the countries in the region, which are facing very similar challenges in their power sectors, are diversifying their power fuel mix. The United Arab Emirates and Saudi Arabia have opted for nuclear plants. They are simultaneously investing in renewables and look at possibilities of increasing their gas production.

Secondly, the need for new capacity, which of course requires significant investments, appears as a good opportunity to increase efficiency, develop capacity to deal with demand peaks and summers, and restructure the sector. Capacity and technologies adapted to the power load can be developed to decrease the peak and summer load, in particular of air conditioning. Water desalination needs have to be taken into account when adding new capacity and the efficiency of desalination plants can also be increased. The sector could be restructured from a regulatory perspective as well, so as to attract private investments.

Thirdly, given the high consumption rate, the country has an excellent potential for energy efficiency. Lastly, the country first needs a long term strategy so as to stop short term, expensive fixes. This will lead to a positive environment for investment, maintain the sustainability of the economy and help optimize the country's resources. The following sections will explore the possibilities of optimizing and rationalizing Kuwait's power sector.

Exploring Natural Gas Options

This chapter discusses the advantages and challenges of increasing the share of gas into the power fuel mix.

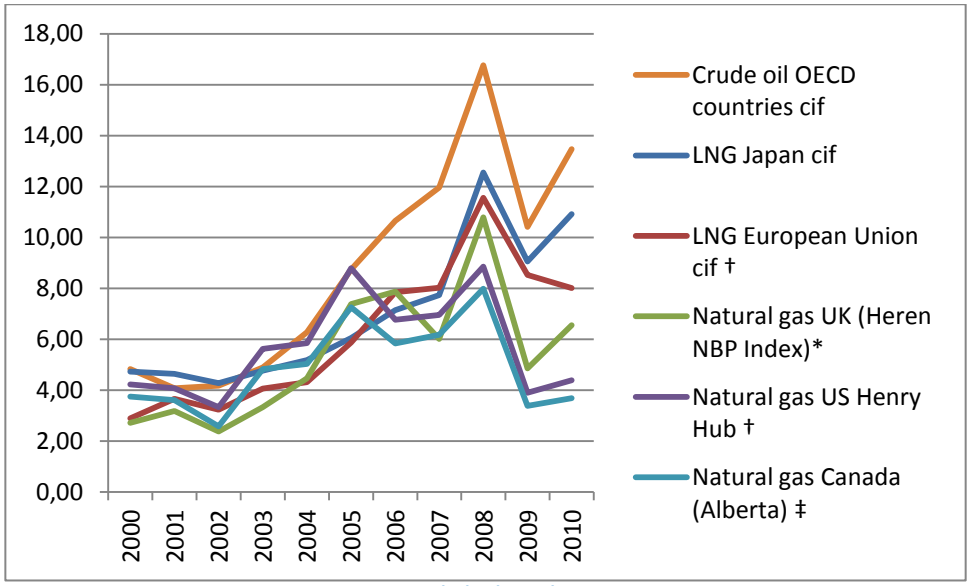
Economics pleads for the displacement of oil by gas in the power mix

Economics pleads the case for the displacement of oil by gas in the power fuel mix. Gas is indeed cheaper than oil as shown in Graph 5. For power production, LNG, the most expensive gas resource, is said to be competitive down to $70/barrel of oil[16] and the current international oil prices are above $120/b. Graph 5 shows that gas is less expensive for the same energy efficiency and the same cost of capital investment than oil power plants. The internal pricing of oil in Kuwait, at around $50 per barrel, is already making LNG more competitive contrary to other countries like SA where oil is sold at $5/barrel.

Export prospects for gas are also more complicated than for oil, requiring pipelines or liquefaction plants for maritime transport. This resource is therefore more interesting for domestic use. Recent developments in the petrochemical industry have renewed interest in gas across the Gulf countries for refining purposes, competing with use for power generation.

[16] ICIS. Kuwait buys its LNG at Asian market prices.

Graph 6: The Evolution of Oil and Gas Prices (in $/MBtus)



Source: BP Statistical Review 2011

Given Kuwait's Ministry of Electricity and Water's plan to introduce 10,000 MW of capacity, gas power plants are an interesting option for Kuwait's power mix. The introduction of new capacity will be challenging from a project management perspective, as the government decided to go for a partial privatization of the sector through procurements. Several projects have already been delayed. In this context, single gas turbines or Combined Cycle turbines (CCGT plants) are cheaper, easier to build and operate, and use less water than other power generation technologies (see Annexes 1 and 2).

Most GCC countries, including in the Emirates or Saudi Arabia which hold large reserves of oil, have therefore switched to gas as a source of power generation. But Kuwait is still getting the lay of the land. The country has so far been reluctant to switch its power sector to gas. This hesitation has to be understood from three different perspectives.

First, there are doubts surrounding the availability of domestic gas. The country has indeed very little gas production and the power sector already consumes now more than half of the country's production.[17] Gas consumption in the industrial sector has as a result fallen to 18%. Gas is also needed for

[17] Sources: EIA Data 2010. Arabianbusiness.com Interview of Kuwait Oil Company Chairman Mr. Al Rushaid, August 2011.

other uses, by the petrochemical industry and or for oil exploration and production. The growing maturity of some Kuwaiti oil fields has resulted in the development of Enhanced Recovery Techniques, for which gas is needed. Since 2008, Kuwait has therefore had to import 7% of its gas as LNG (Liquefied Natural Gas).[18] Most countries worldwide, including of course importing countries but also the United Arab Emirates (a regional oil and gas exporter) import fuel for power production. Security of supply can indeed also be achieved through the diversification of sources, routes and technologies. But Kuwait has a conservative understanding of security of supply, in the sense of independency. This question is political and cannot be solved, but could be partially answered through the development of indigenous resources.

There are also concerns as regards the actual availability of pipeline gas in the region, and subsequently regarding the evolution of regional gas prices.

Third, the country has so far been forced to import expensive Liquefied Natural Gas (LNG), and Kuwait fears LNG prices will further increase in the future. The development of LNG infrastructures has consequently been delayed, and the government has conditioned it on the results of a feasibility study.

This chapter argues that Kuwait should adopt a diversified strategy. Importing gas, to fuel the power sector and develop the petrochemical industries, is and will still be in the short a better economic option than burning oil. The current gas glut resulting both from the production of unconventional gas resources and the economic recession hitting Europe offers a sizable opportunity. Fears about increasing gas prices have to be reassessed from this perspective. On the other hand, the country should start to develop its gas resources for the long term. This is even more true as gas needs are always underestimated. Recent developments of the petrochemical industry in Saudi Arabia suggest that gas can also be used to produce high value products. Whatever the choices made, the sustainability of the system cannot be achieved without an underlying energy efficiency strategy.

[18] Kuwait imported 31Bcf of gas in 2010 according to the EIA, 2010.

Developing indigenous natural gas resources

Kuwait has quite substantial gas reserves (1.78Tcm),[19] and the country is 21st on a worldwide ranking before Egypt, a natural gas exporter.[20] Kuwait produces 11.72 Bcm[21] of natural gas annually, which only 3681-3964cm is non-associated gas. The gas sector clearly has production potential.

In 2006, an important non-associated gas field with an estimated 0.991 Tcm (35Tcf of reserves, was discovered). Initially, the government projected the production of 4.95Bcm (175MMcf/d) and 50,000 bbl/d of condensate by 2008, but the production is now leveling off at 3.9Bcm (140MMcf/d). The field presents difficulties (pressure is excessively high, the gas is highly toxic and at high temperatures) and the country lacks the current technological input. The government has been trying since the 1990s to find ways to open up its oil and gas sector after complete nationalization in 1975, through the so-called Kuwait Project, so as to decrease the economic risk for KOC,[22] to facilitate the exploration and development of northern oil fields and non-associated gas fields as well as the access to Enhanced Oil Recovery technologies in the mature fields (including Great Burgan, Kuwait's major oil field). It initially proposed Operational Service Agreements to International Oil Companies (IOCs) but these contracts were ruled out as not being in phase with the constitution which establishes the sovereignty of the country over oil and gas reserves. To circumvent the problem, Enhanced Technical Service Agreements (ETSAs) have been offered to foreign companies since 2010. However, the ongoing struggle between the parliament and the government has sharpened since 2006, and contractual conditions have not appeared as very appealing.[23] The parliament and the State Audit bureau have been very suspicious of the higher fees proposed as compared to classical Technical Service Agreements, given the climate of strong concerns over corruption. This has resulted in very

[19] 63 Tcf
[20] BP Statistical Review 2010
[21] 414Bcf
[22] The exploration and production arm of the umbrella energy company Kuwait Petroleum Corporation
[23] IOCs usually engaged in Technical Service Agreements, or even Enhanced Technical Service Agreement, where they are paid a fee per barrel produced instead of having production shares, in the hope of better contracts. The Dow Chemical affair which was stopped by the Parliament concerned about corruption, has given a clear negative signal.

heavy and long administrative approval procedures, taken on a project by project basis and not for the Kuwait project as a whole. The master Kuwait Project which foresees the exploration of northern oil fields, and in particular the exploration and production of the Jurassic gas field has therefore been constantly delayed. This climate and the resulting case-by-case approval procedures also more generally hamper the establishment or successful development of a gas strategy for the country. This has forced the government into a step-by-step strategy, and has raised costs of investments due to political risk and delays.

Today, the second phase of the exploration of the non-associated gas field has been allocated to Kharufi National and Saipem with a projected capacity of 500 MMcf/d by 2013. Shell has been developing the Jurassic project through its 2010 ETSA. However, the production target set by KOC of 1 Bcf/d and 350,000 bbl/d of light crude or condensate is seen as highly unlikely by industry experts.[24]

While the Jurassic gas fields are being explored, more short term opportunities should come from both the Khafji and Dorra fields. Kuwait announced, jointly with Saudi Arabia, its plan to start the production at the Dorra offshore gas field (311Bcm) by 2017, which should provide an additional 14-22.6 Mcm/day (500-800 MMcf/d) or 42 Mcm/day (1.5 bcf/day) depending on the estimates, for a $4-5 billion investment. fThis ield is shared by Kuwait, Saudi Arabia, and Iran.[25] However, this will depend on the resolution of a maritime dispute with Iran, which is unlikely to be solved in the current tense political context. The development of both the northern gas field and of Dorra offshore gas field conditions the achievement of the government target of 0.11bcm per day (4Bcf/day),[26] four times the current production level of 1.13 bcf.

Saudi Arabia and Kuwait also aim at producing the Khaji field in the partitioned zone. A $300 million LNG project is planned, as well as a gas pipeline connecting the field to Kuwait city, for which the feasibility study and engineering design were

[24] EIA, 2012
[25] Dorra offshore gas field is named Arash by Iran.
[26] According to http://www.platts.com/RSSFeedDetailedNews/RSSFeed/NaturalGas/6150862. KOC sets a 1 bcf non associated gas production by 2015-2016.

made in 2010 by KGOC.[27] Bids by EPC contractors are awaited.[28] This gas is planned for use in power generation.

The lack of domestic gas has resulted in an increasing amount of gasoil being fueled into power plants to meet demand peaks in summer, impacting negatively on the petrochemical sector.

Gas imports: a viable and reliable strategy for Kuwait?

Regional gas resources and gas shortages

The Gulf region disposes not only of substantial oil resources, but also of gas resources. Iran and Qatar have amongst the larger reserves in the world: Saudi Arabia disposes of significant gas reserves as well, despite lower reserves per person which offer less export prospects (see Table 3).

Table 1: Gas Reserves in the Gulf Region

Country	in Tcm	*R/P ratio*
1. Iran	30	*214*
2. Qatar	25	*217*
3. Saudi Arabia	8	*95*
4. United Arab Emirates	6	*118*
5. Iraq	3	*2 534*
6. Kuwait	2	*154*
7. Oman	1	*25*
8. Yemen	0	*78*
9. Bahrain	0	*17*
Total **Gulf Reserves**	**74**	

Source: BP Statistical Review 2011

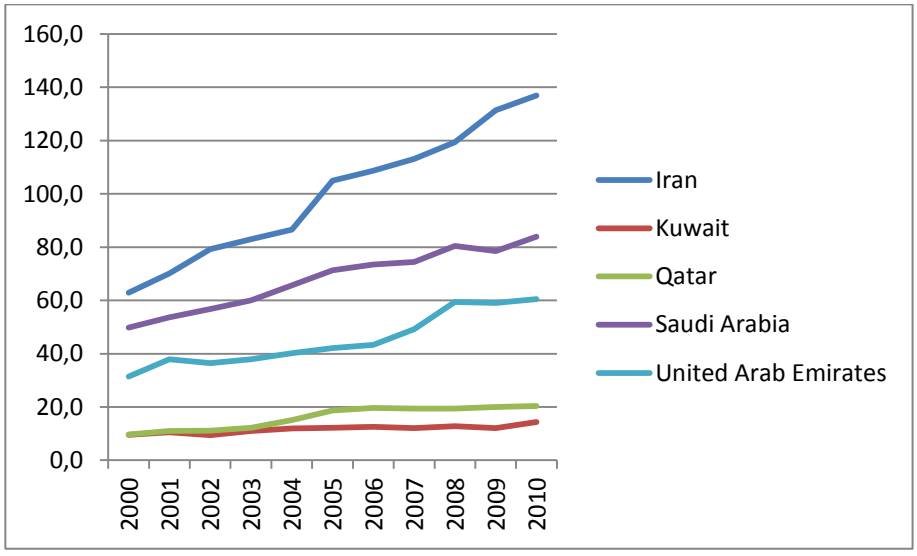
The prospects for intra-regional gas trade are not promising. Most of Kuwait's neighbours have to feed their increasing domestic demand (see Graphs 6 and 7). GCC Countries have a growing appetite for gas. Domestic gas consumption across the GCC has been driven by high GDP

[27] KGOC is KPC arm for the exploration and production in the partitioned zone.

[28] Kuwait Oil and Gas Sector Report, April 2011, Kingdom of the Netherlands

growth and subsequent power generation purposes, enhanced oil recovery techniques for oil fields as well as attempts to diversify the economy through the development of heavy and petrochemical industries. In the future, Gulf countries are expected to be major consumers of gas. The Energy Information Agency forecasts that consumption of gas in the Middle East will grow at an annual rate of 2.4%, hence four times the OECD countries' consumption rate. The following section looks at prospects country-by-country.

Graph 7: Evolution of Domestic Consumption of Gas in selected Gulf Countries 2000-2010 (in Bcm)



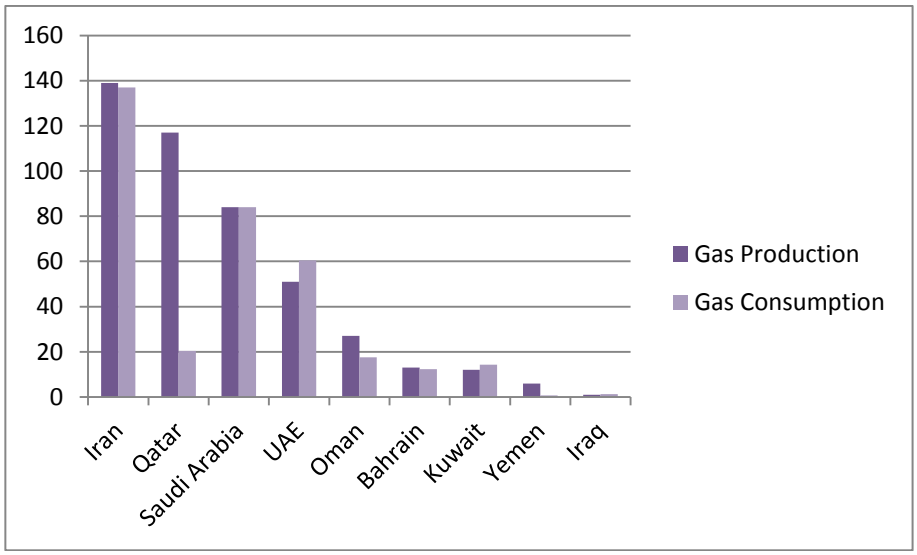
Source: BP Statistical Review.

The second biggest gas reserves in the region are held by Qatar (see Table 2). Past attempts to import gas from Qatar by pipeline (the GCC gas grid project, now relabeled the Dolphin Gas Pipeline) have been blocked by Saudi Arabia.[29] Consequently only the Emirates now benefit from Qatari gas piped exports. Several attempts have been made to negotiate gas imports from Qatar, which has a strategic interest in

[29] In 1990, countries agreed on everything but prices. Kuwait then had to focus on reconstruction, and little was done to revive the project. On the other hand, Saudi Arabia, which had just discovered its own gas, started to oppose the project probably as it gave Qatar too much political influence in the region. The country withdrew from the negotiations in 1992 and successively launched its own gas initiative. Since 2005, Saudi Arabia has refused to approve the construction of the pipeline which is necessary as the pipes would pass through its territorial waters.

exporting gas to the region.[30] The country is now concerned with meeting domestic needs. More recently, Qatar postponed its 2005 moratorium on the production from South Pars until 2014, so that both reserves and the impact of massive production which could damage the reservoir has been reevaluated.

Graph 8: Consumption versus Production of Gas in the Gulf Countries in 2010



Source: BP Statistical Review 2011, EIA 2011.

Kuwait has also signed a memorandum of understanding for the importation of natural gas from South Pars in Iran.[31] The two countries could engage into a sea bed pipeline. The 2005 memorandum of understanding was actually blocked due to a dispute over maritime boundaries, specifically as regards the exploration of the Dorra offshore gas field. The prospect of importing gas from Iran is highly compromised. The current political context due to the Iranian nuclear program makes any resumption of relations among the two countries highly

[30] In 2002, a deal was negotiated for a price of 1.5$/Mbtu while the current price of LNG is around 12-13$/MBtu (interview with a former Kuwaiti minister)

[31] Iran disposes of the worlds' third largest conventional gas reserves. In 2010 the production of Iranian gas was about 139 bcm (BP Statistical Review 2011) and has increased at a constant rate over the last years.[31]

unlikely.[32] On the other hand, Iran has to face increasing domestic demand for gas, while the other several upstream projects have been delayed. As a matter of fact, up to 98% of the current Iranian gas production is currently consumed domestically mostly by households and enhanced oil recovery in oil fields (up to 20%). Domestic consumption of gas has doubled in the last years. The country is now forced to import gas from Turkmenistan so as to cover around 10% of its total domestic consumption. So far the strategy of the country was to maximize oil exports at the expense of gas exports; gas has remained unexplored. The Iranian South Pars field is far less exploited than the field on the Qatari side, North Field.[33] The country needs investments in upstream projects and technologies to develop its gas reserves. Yet, both the modification of gas exploration contracts and the non-transparent allocation of the first development phase of gas fields to national companies are responsible for multinationals' hesitations about investing.[34] Despite announcements over the last ten years, no pipeline has been built so far, and the current embargo has put a definitive halt to any projects. Last but not least, Iran faces financial risks as many countries have stopped their oil imports, and pressure is placed on the remaining importers. Prospects of Iranian gas imports are currently dead.

Since 2003, Iraq has gradually reopened its oil and gas market. Iraq is developing its gas fields, and its gas infrastructure.[35] For this purpose, the country has launched

[32] The relations between the two countries are also tense due to internal politics. Kuwait has a large Shiite minority, and the Arab revolutions, in particular events in Bahrain have called for caution on the government side. The press has also kept up developing an anti-Shiite rhetoric, according to Michel Makinsky, *L'Iran et ses voisins du Sud,* OutreTerre, 2, 2011

[33] The offshore gas field across Qatari and Iranian maritime borders is called South Pars on the Iranian side and North Dome on the Qatari side. The field extends on a 6,000km² on the Qatari side and 3700 km² on the Iranian side and holds around 53 Tcm of natural gas. The current production is considerably higher on the Qatari side (455 mcm), compared to 216 mcm on the Iranian side.

[34] The arrival of Ahmadinejad in August 2005 led to a more protectionist tendency. Several steps of the field's development have been cancelled or delayed. This was the case for the Phase 11 with Total, 13 and 14 with Shell and Repsol for the so called "Persian LNG" or for Phase 22 with the Turkish company TPAO. Phases 15 and 16 were allocated to companies close to the regime in 2005.

[35] Recently, Royal Dutch Shell, Mitsubishi and Iraqi state-owned Southern Oil Company (SOC) have been developing infrastructure to gather associated natural gas from Iraq's southern oil fields.

several tenders. The Kuwait Energy Company has expressed its interest by participating in Iraq's gas fields' third bidding round, jointly with the Turkish company TPAO. The company was awarded 20 year gas development contracts in south west Iraq, for the 4.5 Tcf Siba and Mansuriya fields.[36]

Several doubts remain about the feasibility of gas exports from Iraq in the short and medium term. The advancement of projects depends on the stability of the country, not yet achieved.[37] The government is moreover prioritizing gas for power generation, forecasted to grow tremendously, in order to support the country's reconstruction and industrial development. The possibility of pipeline imports will in the end depend on the reconciliation of the two countries: Iraq still needs to complete reparations through the UN war compensation fund for its 1990 invasion;[38] an agreement on shared oil field exploration is still pending; and the two countries are developing competitive port projects.[39] Officials in Kuwait, and senior level staff of the Kuwait energy sector, are willing to see the situation evolve, but resentment among the population is still high.

Saudi Arabia is also developing its gas sector. The country's natural gas output is projected to grow from 73.6 bcm (2.6 Tcf) in 2007 up to 135.9 bcm (4.8 Tcf) by 2035.[40] Yet, pressures on gas supplies are high. The country is facing the same challenge as Kuwait: its electricity consumption is rising at 8% per year; and its petrochemical sector is growing.

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[36] The tenders offered a remuneration in USD per barrel of oil equivalent, in a so-called TSA (technical service contract) with a plateau production level of dry gas. The remuneration fee for Siba was USD7.50 per boe with a plateau production target of 100 MMSCFD. For Mansuriya, the successful bid was USD7.00 per boe with a plateau production target of 320 MMSCFD. Source:http://www.kuwaitenergy.com.kw/Default.aspx?nid=3736&pageId=139

[37] The project allocated to Shell to reduce gas flaring has for instance recently been scaled down.

[38] The UN Security Council Resolution 1956 (2010) states that Iraq needs to pay Kuwait five percent of the proceeds from all export sales of petroleum, petroleum products and natural gas; as well as five percent of the value of any non-monetary payments of petroleum, petroleum products and natural gas. According to Khaled Al-Mudhaf, the Chairman of the Public Authority for Assessment of Compensation for Damages Resulting from the Iraqi Aggression, the sum remaining to be paid is about $16 billion (source: Arabtimesonline 21st May 2012).

[39] Kuwait plans the so-called Bubiyan terminal which is a few kilometers from Iraq's planned Grand al-Faw terminal.

[40] EIA 2010

Accordingly, the government started to develop a gas strategy at the end of 1990s, which is now being significantly accelerated. New gas fields have been discovered, and Saudi Aramco is increasing both its non-associated and associated gas production. Nevertheless new fields are harder and more expensive to produce.[41] The government has therefore put a moratorium on gas exports until 2030. Any exports by pipeline to Kuwait are thus unlikely to happen before 2030.[42]

Table 2: Domestic Gas Prices in Gulf Countries

Country	Domestic Gas Prices (USD/Mmbtu)
Iran	0.35
Oman	0.90
Qatar	0.95-2.35
Saudi Arabia	0.75
UAE	0.75
Kuwait*	1.3
Bahrain**	0.75 (industrial price)

Source : Oxford Energy Institute 2010, Rasmala, ICIS.
*prices given during an interview at the Ministry of Oil.
**Bahrain is currently decreasing its natural gas subsidies.

Pipeline imports of gas are unlikely to occur due to Kuwait's neighbors' growing domestic demand and unresolved territorial disputes. Beside any strategically defined interest, regional gas producers would have little incentive to sell their gas on the regional markets where prices pale compared to European and in particular Asian prices, even more so as gas production costs are increasing. Qatar is already cross-subsidizing the UAE's petrochemical industries through the Dolphin Gas pipeline; contracts are now being renegotiated. The UAE has so far found it more attractive to import gas from

[41] Saudi Arabia has the world fourth largest gas reserves, at 283 Tcf: 55% of these reserves are associated gas, constrained indirectly by OPEC quotas on oil production, 15% are flared gas, and the remaining are non-associated gas reserves. Among these, 75% have a high sulfur content. Most of the new discoveries happen to be sour gas fields, such as Arabiyah and Hasba (EIA 2010).

[42] The IEO 2010 reference case scenario from the Energy Information Agency assumes that Saudi Arabia will keep its natural gas production for domestic use until 2035.

Qatar rather than develop its own gas resources.[43] Low gas prices slowed down the development of natural gas resources in other gulf countries, discouraging upstream investment in more technically challenging gas fields, such as the Oman tight gas project or sour non-associated gas fields in the UAE. The UAE is facing power black outs due to gas shortages. In the longer term, Kuwait could look to imports from Iran, Iraq and Qatar, which would however require the development of infrastructures.

Buying LNG: an expensive option?

The lack of possibility of importing gas from the region via pipelines and the lack of development of the country's own resources have left Kuwait with two short term power fuel mix options: burning more oil in its power sector or importing Liquefied Natural Gas.

The country has opted temporarily for the second solution. Initially the Kuwait project planned both the development of the country's non-associated gas fields and the building of a fourth refinery to distill heavy fuel, so as to provide fuel oil for the power sector. In the end, as the plan was delayed, Kuwait actually started to import LNG on a seasonal basis in 2009 to cover power summer demand.[44] Since then the country has increased its LNG demand: 11 cargoes in 2009, 33 cargoes were imported in 2010 (i.e. approximately 100 Bcf) and 43 to 47 cargoes in 2011.[45] LNG spot cargoes cost around $15/million Btu in September 2011.[46] This high cost is

[43] The country has developed its gas production in the past, and is now facing sour gas fields.

[44] The country is using Excelerate tankers as a floating import terminal. These vessels can regasify onboard, and tankers have a capacity of about 600mcf/day. The Mina al-Ahmadi LNG terminal became operational in late August 2009. The regasification capacity of al-Ahmadi is approximately 500MMcf/d of LNG.

[45] LNG is mainly imported from regional neighbors, Egypt Yemen, Oman and Qatar via Abu Dhabi, under four-year contracts completed with spot cargoes from the Caribbean. Kuwait signed a four year contract with Shell in August 2009, and a three year contract with Vitol in April 2010. Additionally, every summer around 67 Bcf of LNG are received from Qatar. For LNG imports by country, please refer to http://www.rasmala.com/equity_report/Mena_Strategy_14Oct11.pdf and http://www.petroleum-economist.com/Article/2912531/Kuwaits-growing-need-for-LNG-imports.html)

[46] The country could be forced to buy spot LNG cargoes, which are more than seven times higher than subsidized domestic gas prices. Source:

associated with fears of further gas price increases, and explains why the Ministry of Water and Electricity has not yet clearly positioned itself in favor of gas as a preferred fuel for its power sector.[47]

The context actually provides good opportunities in the short and medium term. The world is currently facing an oversupply of gas. The simultaneous development of unconventional resources (shale and tight gas), the roll out of LNG capacity worldwide, and the economic recession's downward impact on gas demand, means prospects for LNG imports have been significantly scaled down, leading to a glut of natural gas worldwide and the softening of the LNG market.[48] Prospects for increasing natural gas production are significant. While conventional resources of gas of around 400Tcm equal about 120 years of production, unconventional resources bring this figure to nearly 250 years according to the IEA.[49] The shale gas production has revolutionized the world ranking of countries' gas reserves worldwide.

This oversupply of gas has led naturally to the significant drop in gas prices and renegotiation of gas prices. Prices fell to $2.23/Mbtu, the lowest level since 2002 on the Henry Hub, although Asian LNG market prices have remained relatively high.[50] There are significant differences in gas market prices worldwide, as shown in Graph 5 (Chapter 1).

This LNG glut has also freed more gas regionally. Qatar is now facing strong competition on LNG markets[51].

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http://www.petroleum-economist.com/Article/2912531/Kuwaits-growing-need-for-LNG-imports.html

[47] A study assessing the need for permanent LNG import facilities and expanding the current LNG import volumes was to be completed by the end of 2011. So far the country is renting floating LNG terminals.

[48] From OECD countries

[49] World Energy Outlook 2011, IEA.

[50] The differential between Asian oil indexed LNG prices and Henry Hub prices led to a desire to change the indexation from crude oil to gas market price among buyers in both the European and Asia Pacific market. In the end of 2010, there was a differential of around 9$/Mbtu between the Asian oil indexed LNG market and US gas prices. For more information on gas market prices, refer to M. Kanai "Decoupling the Oil and Gas Prices Natural Gas Pricing in the Post-Financial Crisis Market", Ifri Note, May 2011 at www.ifri.org. In 2008 Gasprom gas export to Europe were estimated around $1000/Mbtus (Bloomberg 2012). The company agreed to add more flexibility to its long term contracts with European importers, with a 15% flexibility clause.

[51] The country had to divert its US exports to Asia, where it is also facing competition from both Australia Coal Bed Methane (CBM) production.

Competition will also come from new entrants, like Mozambique, and offshore gas in the Mediterranean. Australia is developing eight new LNG ventures, and its capacity will reach 70 million tonnes, strongly competing with Qatar's planned capacity of 77 million tonnes.[52] The country is worried about overproducing from its North field, and fears low and fluctuating gas prices. The country has therefore started to switch its strategy for gas exports and among other things, to invest in Australian unconventional gas, through Qatar Petroleum International.

Gas markets are not integrated yet, nor are they organized. There is no efficient gas producers' organization as resources are spread. Qatar would surely be interested in regional export prospects. In the short and medium term therefore, Kuwait could benefit from the situation by fueling its power sector with LNG gas. It would be more attractive for Kuwait to fuel its power sector with LNG rather than oil, in the short and medium term, despite the fact that LNG prices are more expensive than Dolphin gas prices.

In the longer term, however, domestic gas resources can be developed. Independency includes the diversification of energy sources and long term prospects for gas will depend on a lot of factors: Asia will import gas massively;[53] policies developing renewables and decreasing the share of nuclear power in Europe will lead to the development of gas power plants. The IEA forecasts that the world reserves can comfortably meet the projected global gas demand to 2035 and well beyond, though prices are more uncertain. Last but not least, gas needs are always underestimated.[54] Other sectors will make good use of gas. So far, KPC has decided to base its petrochemical complex operations on oil, as most of Kuwait's non-associated gas has been of low quality. Since the

China's (unproven) unconventional shale gas reserves are larger than the US, but still not in production.

[52] The country's 14th liquefaction plant is due to come on-stream in 2014, and should increase LNG capacity to 77 million tonnes.

[53] The impact of the Fukushima disaster in March 2011 has already resulted in a 51% increase of gas imports from Japan, and more will come. This has directly impacted on prices in Asian LNG markets, which rose by $16.66/Mbtus in December 2011. By 2030, Korean gas imports will have increased already by 30%, and Chinese imports will have grown fourfold.

[54] The Oxford Energy Institute estimates demand could climb to 6.36 billion cf by 2015, but with domestic gas production is unlikely to keep pace, pricey LNG imports are the only option – to meet the supply deficiencies in 2015 would require 4.6 million tonnes of LNG imports. Most scenarios are conservative.

discovery in the north of the country, KPC has developed a more ambitious gas strategy, and expects the need for gas to grow by almost 300% in the coming 20 years, compared to 25% growth in oil demand.[55]

The result of the study ordered by Kuwait's government on the opportunity of LNG imports and the development of gasification capacity should soon be published. Given the difficulties to find an agreement with neighboring countries, the country could import LNG as a transition solution while developing its domestic resources.

[55] Oil and Gas Report, Kingdom of the Netherlands, 2011

Renewable: green dreams or real potential?

Renewable energy presents a good opportunity in Kuwait to diversify the power mix. The country belongs to the so-called world's Sun Belt, and its Gulf neighbors are more aggressively developing renewable and solar technologies in particular. According to IRENA (the International Renewable Energy Agency), each square meter of the Gulf receives each year an amount of solar energy equivalent to 1.5 million barrels of crude oil. For countries controlling today's oil resources, the perspective of having a grip on tomorrow's energy is indeed quite appealing.

Renewables are nothing but new for Kuwait. The country indeed started to develop renewables in the 1970s, when oil prices were booming at $47/barrel, a high price at the time. In the eighties, about 140 pilot projects were developed covering different solar and wind technologies, as well as desalination and electricity storage. Projects were thus finally stopped. The context has now changed: oil prices are on the rise again, the cost of renewable technologies has substantially decreased, the climate for investments in upstream oil and gas is on a negative track, and the country seeks way to diversify its economy. Renewable are politically more in line with the country's concern over energy independency than gas imports.

Based on scientific studies, this chapter argues that renewables will a role to play in the diversification of Kuwait's power mix, in particular to reduce peak load, in the medium term. However, the development of a renewable industry is still a long way ahead.

An overview of the technologies and Kuwait resources

Kuwait has an obvious potential for solar technologies. It benefits of a clear sky and strong sunlight, and consequently

has a high level of Global Solar Radiation (GRS) (refer to Annex 3: World Insolation Map). Solar resources are measured in terms of Global Horizontal Irradiance (GHI). The GHI is the total amount of shortwave radiation received from above by a horizontal surface to the ground. It includes both the Diffuse Horizontal Irradiance (DHI) and the Direct Normal Irradiance (DNI).

Solar power can be developed in the form of photovoltaic panels, transforming light into electric power, or concentrated solar power CSP (or thermal power), concentrating light and transforming it into heat so as to drive an engine connected to an electrical generator.[56] PV can take advantage of direct or indirect (diffuse) radiation (i.e. GHI) whereas CSP uses only direct insolation (DNI), using tracking systems. CSP becomes viable above 2000kwh/m². Table 4 below shows that Kuwait has a high level of both diffuse and direct insolation[57].

Table 3: Solar Radiation in the Gulf Countries[58]

	Global Horizontal Irradiance	Direct Normal Irradiance kWh/m²/day
Kuwait	5.6	6.2
UAE	5.5	5.5
Egypt	6.0	6.7
Germany	2.7	2.6
USA (California)	4.7	5.1

Source: KISR[59]

Photovoltaic is the most developed solar technology. PV technology can be applied at the scale of a utility, or be

[56] All commercial plants currently rely on synthetic oil as the heat transfer fluid from the collector pipe to the heat exchanger, where the water is preheated, evaporated and then superheated. The superheated steam then runs a turbine which drives a generator producing electricity (IEA Deploying Renewable, 2011)

[57] The US GHI ranges between 1000 in Alaska and Washington, and 2500 kwh/m²/year in the south; Spain ranges between 1300 and 2000 kwh/m²/year; and Germany around 1000-1400 kwh/m²/year according to the US National Renewable Energy Laboratory NREL.

[58] Lower estimates are presented in the status of renewable energy in the GCC countries, Alnaser *et al*. (2011)

distributed for residential and commercial uses. CSP is to be used at the level of utilities, and is on average 15% more expensive. Several CSP technologies are being developed worldwide, some of which offer thermal storage, which is better for ancillary grid services.

Renewables have generally lower efficiencies than conventional fuel or nuclear power plants. Their capacity factor (the ratio of the energy generation system's actual energy output on the energy output If the system run at full time capacity) is affected particularly by the intermittency of the resource (sun or wind). Wind is the most efficient renewable technology today, with a capacity factor ranging from 20% to 40%; PV has a load factor around 15%, depending on the technology considered;[60] and CSP from 20% to 50% (storage can add significantly with the use of storage)[61]. Consequently, renewable generally need to be backed up with fuel-fired stations, which adds to the final cost substantially. For instance the development of renewable in Europe led to rising electricity prices.

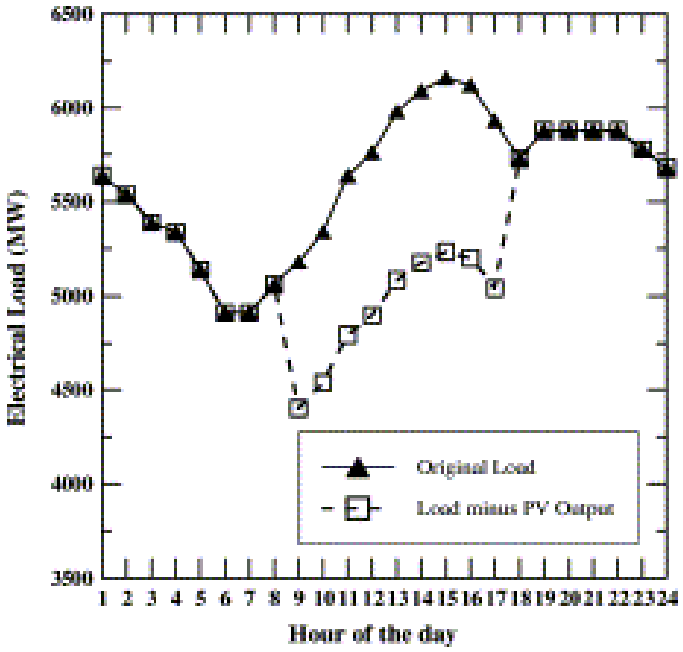
Generally though, Kuwait not only has a very high level of direct and diffuse irradiance compared to other countries worldwide,[62] but also stable insolation and wind patterns, at peak electricity demand hours. Renewables could therefore be used during peak load periods. This makes the use of solar technology interesting to optimize the load pattern. Moreover, the introduction of renewable into the power mix should not be as difficult as in Europe as Kuwait's power plants are conventional power plants, which are flexible. The Kuwaiti system can therefore better cope well with intermittencies.

[60] The IEA estimates PV crystalline silicon at 14-22% for single crystalline, and 12-19% for multiple, PV thermal panel around 80% efficiency, thin film ranges between 12-20% efficiency, and a tracking axis can add up to 30% efficiency. IEA solar technologies, 2011.

[61] US Energy Department

[62] Kuwait has a high level of DNI (around 2100 KWh/m²/year) including sand storms in last 10 years, according to KISR, and a high GHI (Global Horizontal Irradiance: around 1900 KWh/m²/year), according to a study released by the German Aerospace Centre.

Graph 9: PV Output Moderating the Electrical Load (September 4th, 1999)



Source: A.Y. Al-Hasan & all, optimizing load patterns in Kuwait (2003).

Weather conditions in Kuwait could however paradoxically affect the efficiency of solar technologies. The amount of data on wind and solar resources available for Kuwait is currently incomplete, due to limited spatial coverage, a limited record length, and lack of availability of both global radiation data and sunshine duration. Several aspects can however be mentioned.

High temperature would probably reduce PV performance,[63] both in the short and medium term, as the panels are being gradually damaged.[64] The dust combined humidity also decreases the efficiency of PVs as it forms a coat on the panel surface. Some experts affirm that there is less humidity in Kuwait compared to other Gulf countries (to the exception of Saudi Arabia inland). Others, such as the led the German Aerospace center, to concluded that the economic potential for CSP was around 1,525 TWH/y while it was 2.5TWh per year for PV, compared to Kuwait's annual consumption of

[63] PV crystalline silicon panels achieve an efficiency ranking of between 12% and 19% according to the IEA, Energy Technology Perspective, p62. While new technologies, such as cooling systems which allow airflows to decrease temperature are being developed, panels could lose an additional 2 to 3% of efficiency under high temperatures.
[64] Interview KASCT, Riyadh.

51 TWh in 2008.[65] Dust is also a problem for CSP, as it decreases the amount of direct radiation.[66] In Kuwait DNI data suggest that CSP will be better off in the south and desert areas, this would require interconnections lines.

Today, wind is the most mature renewable technology. From 1985 to 1988, Kuwait collected wind data from its demonstration project. The Kuwait Institute for Scientific research concluded that the speed of wind was on average quite low 4.5m/s (around 16km/h), while onshore wind turbines work with wind speed comprised between 15km/h and 90km/h.[67] More interestingly, wind data matches Kuwait's power demand curve, peaking at around 2-3pm in the summer. Recent data and the advancement of technology consider wind turbines to be economically viable at a load of 1,400hours per year (16% capacity factor). Kuwait's capacity factor is 18.3%.

Table 4: Wind Speed and Capacity Factor in the Gulf countries

	Full load of wind/year (average speed 6m/s)	Capacity Factor %
Bahrain	1360	15.5
Kuwait	1605	18.3
Oman	1463	16.7
Qatar	1421	16.2
Saudi Arabia	1789	20.4
UAE	1170	13.3

Source: IRENA, UNDP meeting

Distributed renewables

Distributed technologies, in particular solar technologies such as PV integrated in buildings (BiPV), solar cooling or solar heating, applied to building could significantly contribute to reduce the power load on conventional fossil fuels power

[65] KISR, Sustainable Energy in Kuwait, Challenges and Opportunities, 6th October 2010.
[66] Low level dust is a problem for soling and tower systems as the light has to travel long distances from the heliostat to the tower in the low atmosphere. A scientist from Masdar city estimates that dust can weaken the efficiency of a CSP plant by 20%.
[67] Enerpresse, 21st June 2011. In 2006, the Kuwait Institute for Scientific Research released the results of its demonstration project. At a standard high of 10m, in inland flat desert area (at Al Wafra and Al Taweel), the average wind speed of 3.7 to 5.5 m/s.

plants. Indeed, power demand in Kuwait is mostly driven by residential consumers (up to 65%) and in particular air conditioning, accounting for up to 70% of the demand peak in summer. Additionally, distributed technologies bypass the constraint of space and of the electric grids. In Europe, the hectic development of distributed renewables, supported by feed-in tariffs and subsidies has led to problems of grid management as the Transmission System Operators could not anticipate the needs. This risk is to some extent limited in Kuwait, given the high consumption of houses and the more regular sunlight and wind speeds.

In terms of technology maturity and feasibility, solar water heating is a mature, efficient and low cost technology, already competitive in southern countries. Solar cooling is not mature yet, but has an interesting market potential in Gulf and southern countries.[68] Integrated Photovoltaic in buildings also has the advantages of increasing the efficiency of the building as such. The PV becomes part of the house's envelop, replacing windows, walls, roofs or eaves. This increases the efficiencies of old buildings, in particular those built in the 1970s with little consideration for energy consumption.[69]

Costly energy sources

Kuwait presents good opportunities for the development of renewable. They remain however quite expensive technologies. Fossil fuel power plants are more flexible, they do have higher capacity load factors, a low CAPEX and a limited financial risk as they can be built in a few years. Additionally renewables cannot be developed for base load power. The initial investment cost (CAPEX) of renewable is on the contrary in particular very high (please refer to Annex 1).

[68] Solar Water Heating reaches efficiencies of 80%. Consumption of houses is around 4,000kwh in summer and 2,000kwh in winter in SA. (Average consumption is 128,000KWh per year in Kuwait). There are different solar cooling technologies: passive solar, solar thermal energy conversion and photovoltaic conversion. The US is financing research since 2008 through 2012.

[69] Kuwait developed a pilot project at the English School in the 1980s. KISR also more recently tested the technology on average houses in Kuwait, and found out that on average 50% of the electricity consumption of 52% of the houses could be produced and that building Integrated PV can reduce consumption up to 15-25%[69].

Nevertheless, high oil prices have significantly increased the operation costs of oil fired power plants, even more so as their efficiency has been so far limited. At oil market prices, renewable technologies are thus gradually becoming competitive. Some renewable technology costs have decreased substantially in the last years, and are now becoming affordable. For each doubling of installed capacity, costs have dropped by 20% according to the IEA.[70] Efficiency has increased on the other hand substantially. CSP is not as competitive as PV, yet the value of storage is not properly taken into account. The costs of renewable technologies should further decline in the future.

While most renewable markets still heavily rely on subsidies, the International Energy Agency considers that renewables are competitive already in many off-grid situations or remote islands; PV generation costs in sunny locations where power is generated with expensive fuels is attractive, and should soon become competitive in California (2000h of sun per year), the South of Italy and the Middle East. The IEA considers that for a price of $80 per barrel, both utility scale PV with the same building costs in Germany and the Middle East, solar source, and CSP are already competitive with oil fired generation.[71] The availability of the resource has a substantial impact on the price of generating electricity. According to the European PV Industry Association, the Levelised Cost of Generation (see Annex 1) of PV is around 38$/MWh in Northern Europe, while it is 20$/MWh in Southern Europe and about 16$/MWh in the Middle East. It is generally cheaper to generate renewable on a large scale, small scale power generation such Integrated Building PV have a higher generating cost. In the US the real cost of producing electricity with PV ranges from $9/MWh (utility scale PV in California) to up to $27/MWh (commercial or residential PV)[72].

In Kuwait in particular, sun and wind can cover peak load periods. This gives them an additional competitive advantage as the marginal cost of peak power production is higher. Renewables' high up-front costs are less problematic for Gulf

[70] The production of Chinese panels have divided costs by almost two. Bloomberg, Q1 PV market outlook, 2011

[71] International Energy Agency, Solar Energy Perspective, p64. Bloomberg considers that PV is already competitive with oil fired generation, but not yet with gas fired generation. Their oil price assumption is nevetherless higher than IEA forecasts (high nominal oil prices than IEA 247$ instead of 211$ for the IEA).

[72] US Department of Energy, Solar Technologies Market Report, 2010

countries than OECD countries given their sufficient capital base (linked to oil revenues). In budget terms, renewables also ensure stable generation costs, independent of oil and gas price fluctuations.

System costs: grid connection and intermittency

Beside investment costs, system costs can hamper the massive roll out of renewables in the short term. The achievement of a 10% renewable target, with no major improvement in efficiency, could have an impact on the stability of the grid and network costs. Kuwaiti power plants are spread along the coast, near cities and distribution centers. Developing CSP or PV in the desert areas could end up in mismatches in grid transmission between the installations and the end use. This would raise further grid costs, which are harder to evaluate.

The grid model of Kuwait is conventional, and will have difficulties to integrate distributed resources. No smart grids and no code nor standard exist for residential renewables. Distributed resources could decrease the voltage quality of the system.[73] The development of policies supporting renewables promoting exchanges of electricity within the grid, by giving an advantage to households or utilities to sell renewables into the grid (through priority access or feed-in tariffs) has to take into account their implications for the network. This would require the step-by-step development of renewables, along standards for PVs and smarter grids.

Due consideration has also to be paid to the country's water desalination capacity. Most power plants are coupled with desalination plants to provide around 70% of total consumption. Taking capacity off the coast will have implications for the desalination capacity of the country. Saudi Arabia, which faces the same challenge, has therefore included a substantive programme for water desalination with PV.

[73] Under 1kw per house, there is no impact on voltage. In Germany this is more around 5kw. Cherelle Eid report on PV available at www.ifri.org

Prospects for Kuwait

Renewables clearly have their place in the power. Kuwait's political system offers little prospects for a sudden jump in renewables. The achievement of the 10% target will hardly be feasible without achievements in energy efficiency. Larger development can be however planed for the medium term.

So far, the government is mostly developing pilot Research and Development projects, but no renewable policy or development plan has been set to match the 10% target. The Kuwait Institute for Scientific research is now testing a large variety of technologies so as to find the best applications for the country, and the country is engaging gradually in international cooperation to try to import renewable technology with a very long term approach. Some of the projects could overcome the systemic costs. For instance, hybrid plants (like in Turkey) can avoid feeding intermittent electricity to the grid, solar cooling would soften the power needed for air conditioning etc.[74] These new applications are nevertheless more longer term prospects as the technologies are not yet all mature.

Generation prices of electricity are not heavily distorted by subsidized fuels in Kuwait. Power plants buy their oil at around $50 compared to $5 in Saudi Arabia. Utilities might therefore have an interest in developing and investing in renewables, and will increasingly have one as prices further decrease. Distributed generation, in particular consumer end technologies are on the other hand blocked by the current consumer price of electricity. From a consumer perspective, either residential or commercial, there is little incentive to invest either in renewable applications so as to produce its own electricity, or to decrease their energy consumption. A study analyzing the competitiveness of Building Integrated PV in Kuwait concluded that with the current power consumer tariffs, the net pay back period is of 41 years while it is of 13 with power generation cost.[75] Despite favorable prospects for renewable costs, subsidized electricity prices which are set well

[74] Kuwait's hybrid solar and gas power plant, in Abdalyiah, is expected to deliver 228 MW of power when ready, 65 MW of which comes from solar power and 163 MW from gasfired installations.
. The solar/gas facility will be 100% owned by the developer, the project is said to be worth roughly $720 million.

[75] Decentralized PV in Kuwait.

below long run marginal costs prevent the market from taking off.

Renewable are highly capital intensive and therefore need an appropriate and well defined regulation framework. As the European Union's experience shows this is not always very easy. Any delay in projects will also be costly. According to the IEA, a one year delay increases the cost by 5 to 10% in the LCOE.[76] The development of an industrial field is a long process. It will heavily depend on market conditions, the development of know-how and adequate human resources, regulatory and policy reliability, transparent procedures for encouraging dedicated institutions. But first and foremost it will require the removal of market barriers such as the reform of price structures which are highly uncertain.

The reform and diversification of Kuwait power fuel mix is indirectly and paradoxically not supported by the current oil prices. Indeed high oil prices are increasing Kuwait's oil export revenues. High oil export revenues and the resulting budget surpluses offers a good window of opportunity to make the appropriate investments, and develop the renewable. On the contrary, large budget surpluses hide the need for long term reforms so as to maintain a sustainable level of oil exports. The higher the price of oil, the lesser the export volume is needed to maintain the same amount of revenues. State led projects have usually been very sensitive to the price of oil. The lack of a long term vision for the power sector's future, the lack of vision and budget surpluses are not inductive to the development of renewables.

The development of renewables will probably remain limited in the short and medium term. In the long term, the drafting of policies will be decisive to ensure the roll out and the sustainability of renewable power. The building of an industrial field to diversify the economy appears challenging.

[76] Deploying renewable, IEA, 2011.

Energy Efficiency: a Substantial and Unexplored Resource

There is a large potential for power and water savings in Kuwait both at the consumer end, and on the power sector side. Most of power is consumed in buildings and in particular with air conditioning. Studies have shown that energy efficiency measures could reduce forecast demand by 5 to 10% and save up to $3 billion in the next years. Technologies applied to buildings, such as district cooling and low energy building technologies, could decrease energy consumption of new buildings by 50%; retrofitting of old buildings could save up to 20% in energy consumption.[77] The 5% energy efficiency target would save 300MW each year. Kuwait, like most neighboring countries, developed a building code law in the 1980s. This has led to some decrease in energy consumption already, according to the Kuwait Institute for Scientific Research, although more can still be achieved as implementation has been poor.[78] This responsibility has so far been left to the Ministry of Municipalities. The public sector is responsible for 40 to 50% of power consumption. Electronic equipment is said to be at international norms already, as there is no domestic production. However exporting countries have different energy efficiency standards for their products.

Consumer end measures are however hard to implement given the low water and power prices. The cost of water is now 12 fills for consumers while the cost of producing it is about 50 fills.[79] The government has tried several times to introduce different prices according to the level of consumption or the level of income. Subsidies are actually distorting Kuwait's power sector. The revenues from oil should benefit the population but so far direct subsidies of electricity and water have distorted the

[77] Michael B. Wood, nuclear option for Kuwait.
[78] The National Housing Authority project is an interesting place to start. Individual houses have not complied to a large extent with the law as there was poor enforcement.
[79] Interview with Kuwait Oil Ministry

sector and threaten the sustainability of the system while they could be better off elsewhere. Subsidies also send the wrong signals to the population, unaware of sustainability issues. The current tariffs make investment in building retrofits and optimization unattractive. Kuwait has decided to make the payment of bills compulsory, but this will not apply to nationals who represent the largest consumption share. The unpaid bill is around KD9 to 10 million.

The optimization of the power and water sector can also contribute. The first chapter has shown the low efficiency of the power sector, and the potential for new and more efficient capacity. Also, the water desalination sector has a significant energy efficiency potential. Consumption of water is high. Similar measures could be targeted: adequate information on pricing and new tariff structures as well as the development of new technologies. Additionally, water could be produced during off peak hours and then stored. Kuwait has a low efficiency thermal desalination system (i.e. water is boiled at less than atmospheric pressure). Other systems are more efficient such as reverse osmosis i.e. water filtration through membranes, which is more energy efficient. The technology has been developed in the last years and is now mature and less costly to operate than thermal power plants. This technology is nevertheless more complex to operate compared to thermal distillation plants, and the osmotic pressure is proportional to the salt concentration which is very high in the Gulf Sea (1.5 times higher than in the Mediterranean). Kuwait is currently launching tenders for thermal MSF (Multi Stage Flashing), the most widespread technology worldwide.

Nuclear Power Left Aside

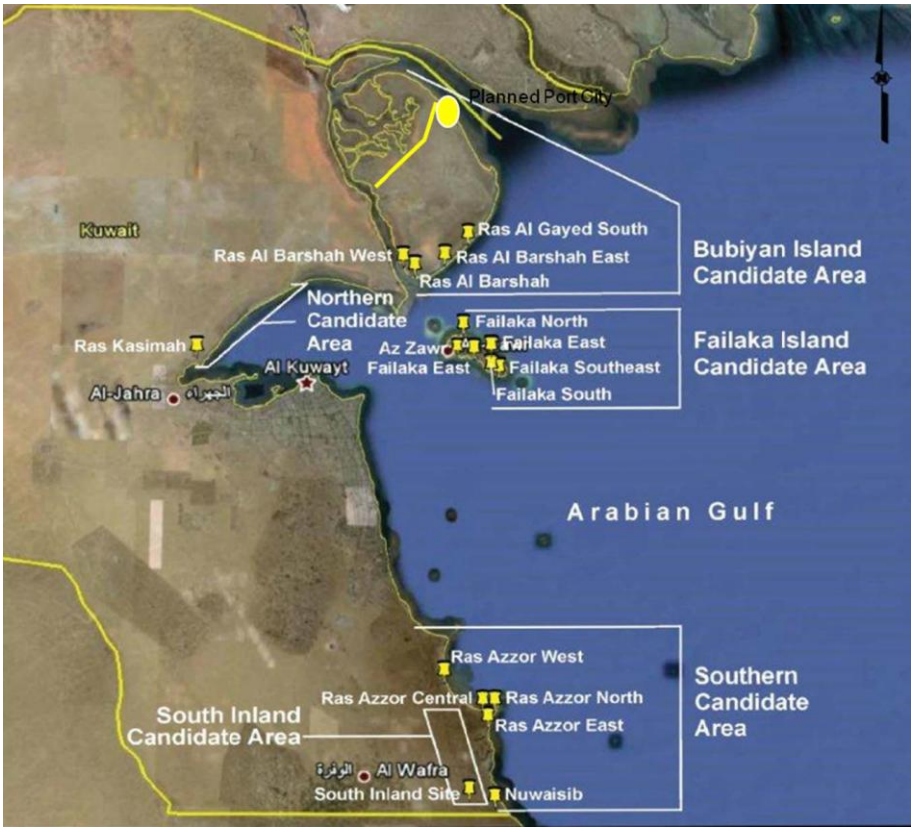
Many Gulf countries are considering or investing in the development of nuclear technologies to displace fossil fuel energy sources and decrease pollution while they struggle to face increasing power demand. Gulf countries have in particular been looking at alternatives to high sulfur gas,[80] crude oil and diesel. The UAE has decided to build four nuclear reactors with a total capacity of 5.6GW under a consortium led by the Korea Electric Power Corporation. Saudi Arabia has launched a $112 billion nuclear program, and plans 16 power plants by 2030, with a total capacity of 14GW.[81] According to the Saudi Arabia Electricity and Co-Generation Regulatory Authority, power capacity is expected to triple by 2032 and reach 121,000MW. The country expects 5% of its electricity to come from nuclear power by 2020.[82] Kuwait has also considered the development of nuclear power capacity. It established the Kuwait National Nuclear Energy Committee in 2009 to prepare the building of four nuclear reactors by 2022 in terms of policy regulations, project management and the long term development of know how. A nuclear law was prepared and an economic feasibility study completed by 2011. Three areas were identified on the coast, as shown in Map 1. In partnership with the IAEA (International Atomic Energy Agency), all plans were scrapped following the Fukushima disaster.

[80] Non-associated gas reserves in the GCC have a high sulfur content, around 20-30%. This is a technical challenge for production and processing. Luciani, 2011

[81] Saudi Arabia's total capacity is 57.4 GW according to ECRA.

[82] The kingdom burns 320 million of crude barrel per year.

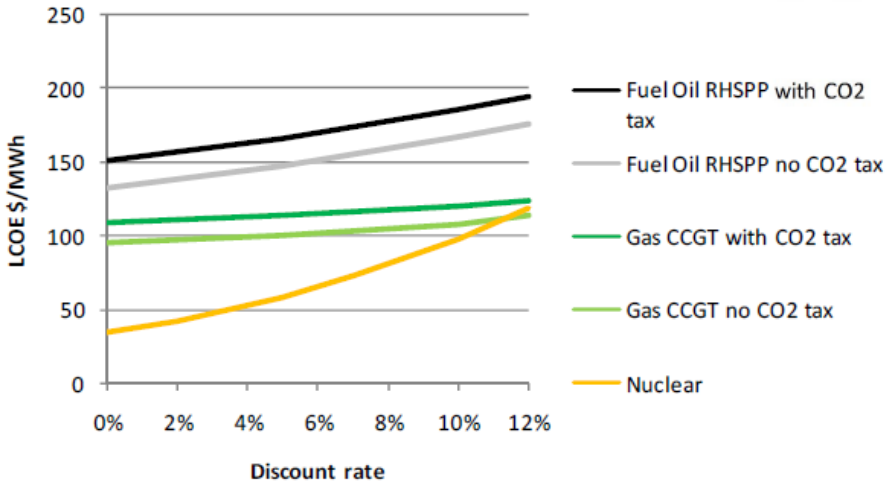
Map 1: Kuwait's Candidate Areas for Nuclear Power Plants



Source: KNNEC

Nuclear power is a competitive source of electricity generation. The KNNEC has studied the economic feasibility of the scheme under several scenarios, including using different construction costs, oil and gas feedstock prices, and nuclear generation capacity. They concluded that the Levelised Cost of Electricity Generation (LCOE) was lower than any other technologies in most cases, leading to significant savings (from $3.8 to $4.7 billion per year): in an extreme case costs at least break even. The discount rate nevertheless plays an important role, as CAPEX costs are higher than for other technologies.

Graph 10: The Competitiveness of Nuclear Power in Kuwait



Source: KNNEC, Vienna February 2011

The high upfront investment of nuclear technologies (around $5,400/KW compared to $1,145/KW for CCGT),[83] which is a real challenge for most countries, is less of a problem for Gulf countries as they have positive liquid financial balances. In liberalized markets, utilities are short of investment funds and must rely on debt or external financing. Nuclear energy offers returns only in the long term.[84] The process of implementing nuclear power has benefited from simplified processes and strong leadership in the UAE and Saudi Arabia. Institutions to support the development have been created and appointed rapidly, and permits (to build etc.) have closely followed political decisions. In Kuwait however, any investment has to pass through the Central Tender Committee, and the development of nuclear power could face the opposition of nationalists in the parliament who oppose the dependence on foreign technology and threats to the environment. Additionally, Law 39 stipulates that any future projects with a capacity greater than 500MW must be tendered as independent water and power projects. This induces further checks through complex tendering procedures, except if the project is considered as an emergency measure, which cannot happen in the case of long term planning of nuclear facilities. Thus, the

[83] Michael B. Wood Nuclear Options for Kuwait, 2009. The International Energy Agency considers CAPEX costs in 2010 for OECD countries to fluctuate between $3000-3700/KW for nuclear technologies and $2400/KW for CCGT (Combined Cycle Gas Turbines)

[84] For a more detailed analysis on the availability of finance in the Gulf countries, refer to Luciani, 2011.

development of nuclear capacity would probably not benefit from the same administrative cost reductions as in other Gulf countries.

Security is also challenging. Kuwait signed the Treaty of Non-Proliferation in 1968. The current Iranian nuclear threat has induced a tense climate in the region. This risk as regards GCC countries is however limited by several factors. The development of nuclear capacity is made in close cooperation with the AIEA, and through a collective approach in the GCC framework. The technology has to be imported, and is usually done so through bilateral agreements with the technology exporting country. For instance, Kuwait signed bilateral cooperation agreements with France, and Saudi Arabia with the US. This allows the international community to maintain a close surveillance over the technology and knowhow transferred, reassuring regional neighbours and the international community at large which heavily depends on fuel exports from the Middle East and thus on its stability.

Safety is also a major concern. The country blocked all projects after the Fukushima disaster. Several countries decided otherwise (the US, China or the UK as well as Saudi Arabia and the UAE). Any problem could yet have widespread negative consequences given the small size of the country and in particular the inland Gulf sea. The management of waste necessitates adequate skills and regulations[85], and the country would rely on foreign companies services, at least to begin with. The development of nuclear electricity generation requires both long term planning and safety and control authority. The ability of the country to provide for insulated technocratic management and proper regulation and safety standards are key to ensuring security.

[85] Michael B. Wood considers that 22 tonnes of fuel generates 15m3 of waste disposal for a power plant working 90% of the time, with a thermal efficiency of 33%.

The GCC Grid: Straying From Market Integration to Being an Emergency Support Mechanism

The Gulf Cooperation Council (GCC) was formed in 1981 among the United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar and Kuwait. The main objective of the GCC is known to be the security of its member countries through regional integration. The idea of a common electricity grid arose at a time of economic growth, leading to industrial and residential development in the late 1970s and early 1980s. Initially the project was thought of as an emergency exchange mechanism. The project was revived in the early 2000s. The utility sector needs to be strengthened as economies are expanding, and power consumption is surging and expected to triple by 2020. In 2004, GCC ministry of energy agreed to finance the grid in three phases for a total amount of $3 billion. Phase 1 (called the GCC North Grid) interconnects Kuwait, Saudi Arabia, Bahrain and Qatar: Phase II connecting the UAE independent system and Oman has been suspended so far; Phase III interconnects the GCC south grid to the GCC North Grid (see map below). The grid is based on plans from the 1980s.[86]

[86] The GCC grid consists of a double 400KV circuit and a 50HZ line, back to back Saudi Arabia is connected with an HVDC and runs asynchronous from the Grid. This is due to the country's eastern electricity transmission system.

Map 2: The GCC Interconnection Scheme

Source: GCC website

The grid allows for emergency exchange and has so far been reduced to this function. Small countries in particular have a limited number of power plants, and therefore face a higher risk of power outage. Commercial trading of electricity is being discussed, but has not been achieved yet despite the many advantages of developing a regional electricity market. The first benefit would be to alleviate the financial burden of building new capacity through an optimization of power sector capacity, leading to efficiencies and cost cuts. Larger base load power plants, such as nuclear plants, could be built and benefit from export prospects. Conventional fuel power plants could also increase their load factor. Competition is further believed to bring costs down. Cost efficient plants will drive out less efficient plants, reducing both costs and the environmental impact of electricity generation. GCC countries have different power fuel mixes. Bahrain, Qatar, UAE and Oman have a high share of gas (75-87%) while Kuwait and Saudi Arabia a high share of oil (crude, heavy oil and even diesel). The price of producing electricity (at international fossil fuel market prices) is therefore higher in the later; electricity trading between GCC countries could transform and diversify their power mix to the extent of the network size. Table 7 shows the cost of producing electricity at peak hours.

Kuwait could for instance reduce its generation cost by buying power from Qatar at peak load. The interconnection can provide Kuwait an extra amount of power from other countries, reduce the risks of blackouts and the necessity of new power

plants for peak loads. A liberalized electricity market is a good prospect for investors and private sector development. The interdependency of countries based on electricity trading could also reinforce the region's stability. The GCC has nevertheless faced crises, like with the Dolphin pipeline, as Saudi Arabia in particular shown its willingness to retain its strategic influence over neighboring countries.

Table 5: Peak Power Generation Cost Across the GCC (at September 2008 fuel international market prices)[87]

	$/MW
Kuwait	188
Bahrain	100
Saudi Arabia	218
Oman	225
Qatar	88
UAE	104

Source: Interconnection in the GCC, Richard D. Tabors

The GCC grid has potential, but suffers from numerous shortcomings. The interconnection capacity among countries is actually quite limited, as displayed in Table 7.

Table 6: Size of the GCC Grid Interconnections Capacity

	Installed Capacity (MW)	Interconnection Size (MW)	Share %
Kuwait	12579	1200	9.5
Bahrain	2800	600	21,4
Saudi Arabia	44490	1200	2,7
Oman	4200	400	9,5
Qatar	3890	750	19
UAE	23250	900	3,9

Source: IEA 2009, MEW 2010

The 1,200MW interconnection to the GCC grid covers currently less than 10% of Kuwait's installed capacity. According to EU estimations, this is the minimum capacity size to cover emergency purposes. Kuwait's peak load is around 30%. The interconnection will not however cover a sufficient

[87] The fuel cost taken into account in the analysis are as follow: $8/MBTU (natural gas), $2.95 Gallon (FO2) and $2.09 Gallon (FO6). The heat rate of the power plants was estimated according the construction year.

share of Kuwait's 20 GW capacity planned by 2020. With no additional trading capacity in the next years, the entire project is going to be reduced to emergency uses. This cannot cover the share margin capacity. The simultaneity of peak hours across the GCC is also a concern for the efficiency of the emergency mechanism.[88] All countries are facing electricity consumption increases but have limited capacity investment so far. Capacity plans match generation needs tightly. Before nuclear power comes on stream in Saudi Arabia by 2030, the potential for electricity exports will be limited. Kuwait has already been refused electricity by Saudi Arabia.

To create a regional electricity market, the GCC is pushing for the liberalization of the participants' power sectors. The IWPP (Independent Water and Power Producers) tenders are now flourishing in the Gulf, and they represent a transitional state to a wholesale market. Kuwait is however a step behind regarding market liberalization and private sector participation. This process is long, as revealed by the experience of the EU electricity market which will still not be completed 15 years from now. The development of commercial trading will require clearer regulations.

The lack of competition and homogeneous legal framework will reduce the benefits of developing interconnections. The pricing difference among the state will most probably hamper the proper functioning of the network.

The creation of a regional electricity market is long and costly and will depend on the political willingness of countries. The $3 billion cost of the project nevertheless pales compared to the $2 billion fuel bill in Kuwait each year. While no short term electricity input from neighbor countries is ensured, in the long term the development of nuclear power plants could benefit an integrated grid.

[88] There are two types of transfer: unscheduled trading in real time or scheduled trading. Payment is mostly in-kind.

CONCLUSION

So far the availability of cheap oil and energy subsidies have prevented the optimization of Kuwait's power system. Kuwait's power choices have also been highly influenced by the country politics and policy objectives. Security of supply concerns has led to the choice of steam turbines over more efficient and less costly solutions. The social redistribution system is also central to the country power generation framework. Both objectives have played against considerations of direct cost and opportunity cost, although these are not contradictory. Both the country security of supply and the social redistribution system could benefit from a better management of resources, a long term vision, and better use of oil. Finally concerns over safety and regional relations have resulted in the development of a regional grid, and the rule out of nuclear power. These two objectives would also benefit from a cost-benefits strategic and long term vision.

The diversification of the power mix is needed. The power fuel mix can be optimized and diversified to include alternatives to oil such as gas or renewables, so as to benefit from the cost opportunity of oil. From an economic perspective, the import of gas in the short term could be used as a transition strategy, while domestic gas resources can be developed in the medium to long term. Renewables can also be used to cover the peak load. Clear policies and pricing and an adequate legislative framework will be key to support the development of renewable and the creation of a regional electricity markets. Interconnections among countries could help to decrease power generation costs, use fuels in a sustainable way, increase security of power supply, and lead to an optimization of national power systems, the size of interconnections is too small and legislation of electricity trade still incomplete.

Efforts should be made to improve efficiency. On the consumer side, many technologies could help decrease consumption (such as improving the energy consumption of buildings). Revenues from oil could be redistributed in a form

that encourages energy consumption. Low power and water low prices support consumption growth, and hamper the development of consumer alternatives (renewables, building retrofitfing). On the production side, the system would gain from being renewed and optimized. The country needs a long term strategy so as to stop short term expensive fixes. This will lead to a positive environment for investment, to maintain the sustainability of the economy and help to optimize the country's resources. Introducing alternatives will contribute to enhancing efficiency. Departing from centralized fossil fuel power generation units, increasing the efficiency of the system and introducing demand side management will require a subtle management system. Yet, these options could confront constrains from a regulatory and institutional perspective.

The country political ability to redefine its strategic objectives will be key to ensure its security of supply and its longer term economic viability. Otherwise, the system will result from short term fixes, maintaining a large share of oil in the power mix and some ad hoc renewable projects. This would miss the cost opportunity of developing a comprehensive strategy.

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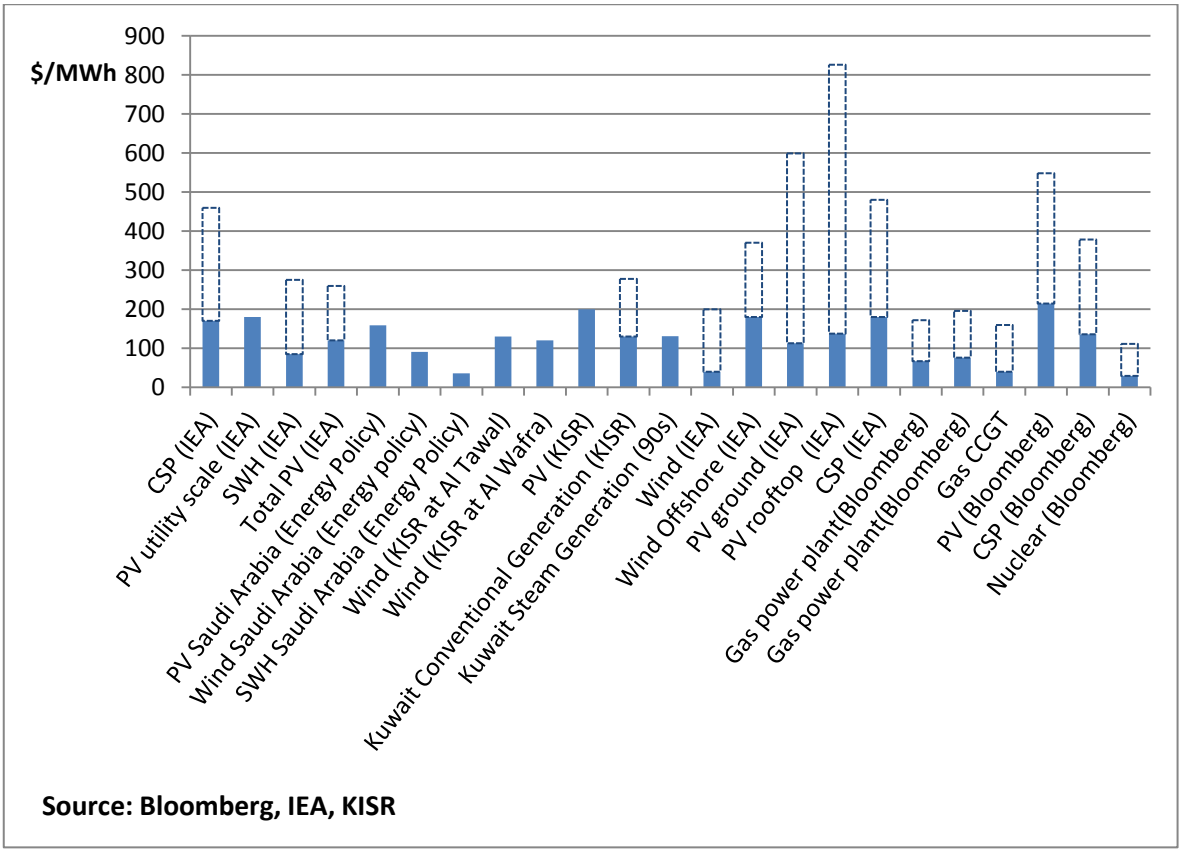
Annexe 1: LCOE Cost of Power Generation Technologies in Kuwait

The table below presents the generating cost of the different technologies from different studies. The cost of different power generation technologies is compared through the so-called LCOE (Levelized Cost of Energy) tool. The LCOE reflects the electricity generation cost at the interconnection to the grid. It includes the capital expenditure (CAPEX), the return on investment, the cost of maintenance and operation (including the fuel cost). Today, costs are levelized by their value of money and interest rates. LCOE prices are not real prices: they do not include market costs and risks. They are closer to reality in monopolistic markets like Kuwait. The LCOE prices however do not take into account system costs i.e. the cost of connecting renewables to the grid.



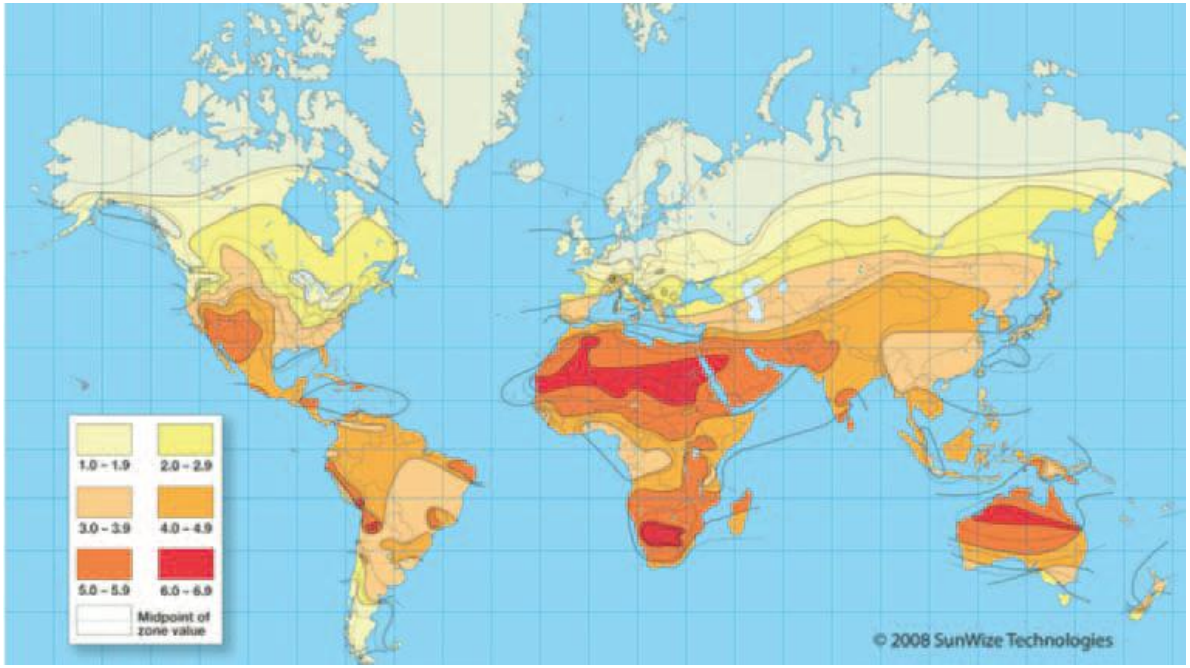
Source: Bloomberg, IEA, KISR

Annex 2: Water Needs of Different Technology Options

Technology	Water Needs
NGCC	200/300 litres per hour for 400 MW at full capacity
Nuclear	1/2 million litres per hour for a 1000 MW power plant operating at full capacity
Solar CSP	Dry cooling technology reduces water needs by 90% as compared to other solar technologies for an energy efficiency penalty of 1-5% CSP still uses more water than coal power plants
Solar PV	Less water than CSP as there are no turbines

Source: IEA Energy Technology Perspectives, 2010

Annex 3: World Insolation Map



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