Nuclear Power in the Middle East Following Fukashima

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Abstract

This paper comments on the significance of Fukashima both technically and with regard to public opinion. On the former, it is argued that the culture of the industry and resultant history are overwhelmingly more important indicators of the safety of nuclear power. Although in the wake of Fukashima, safety improvements are being made, in the resultant politics, it is probable that costs are being increased to address combinations of events of negligible probability and attention diverted from more proactive assessments. However, the effect on public opinion has been decisively negative and lasting .

The MENA context of rationale, cost and political environments are discussed. The impending crisis of domestic use of hydrocarbon resources in the Gulf States is presented and the alternative path of sustainable energy is demonstrated using the example of Kuwait. It is suggested that the concentration on supply solutions, whilst expedient, is not optimum and that the much more challenging, and ultimately more significant issue of demand control through tariff increase and sustainable energy policy must be addressed. The requirement for a nuclear contribution to the resultant reduced energy mix in these countries and to address more fundamental energy shortfalls and security issues elsewhere in the region remains strong. Nuclear power programs are summarized and the most significant in UAE, Saudi Arabia, Turkey, Jordan and Egypt, in order of certainty, discussed.

1 Lessons of Fukashima

It has now been admitted [2] by the Japanese Government that the Fukashima accident was caused by failure to design for known tsunami conditions. It is also probable that seismic design, known to be inadequate, was a contributory factor in accident response.

The tsunami design basis chosen was 5.7 M, while 20M events had occurred in the previous century. TEPCO Internal reports to this effect and practical experience of the vulnerability of emergency generators to flooding were available before the accident. The event on 11th March was 14 M. Fukashima was designed in the late 1960's before rigorous seismic design was possible.

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In 2006 NISA required a general seismic re–evaluation. No significant assessments were performed. Reports submitted were limited. It was known that appropriate seismic reinforcements of safety related pipework were not in place at Fukashima . Following an earthquake in 2007, the more recent Kashiwazaki Kariwa plant was shut down for 21 months for reassessment and modification.

Thus both TEPCO and more seriously, NISA were fully aware of the possibility of core damage consequent on flooding, inadequacy of seismic design and of the need for safety improvements but that no action was taken. The latter organization did not monitor nuclear safety. A succession of inadequate disclosure and falsification of information by the Japanese nuclear industry is well publicized.

Kiyoshi Kurokawa, chairman of the commendably frank and courageous report by the National Diet of Japan Nuclear Accident Independent Investigation Commission has stated [2]

"The accident was a profoundly man made disaster that could and should have been foreseen and prevented"
" Its fundamental causes are to be found in the ingrained conventions of Japanese culture"
He explains that this culture led to a mindset, which in extreme placed corporate interest above safety and which managed to avoid learning the lessons of Three Mile Island and Chernobyl.

1.1 Safety and Regulatory Significance
To a first order, Fukashima is a uniquely Japanese failure in both the safety culture and regulation essential for the safe use of Nuclear Power. In the US and Europe, the Three Mile accident in 1979 proved the integrity of containment of Light water reactors, despite failures of instrumentation and operation leading to a partial meltdown. It also transformed safety culture and regulation, resulting in orders of magnitude improvement in reliability and availability. Figure 1 shows fleet averages of availability and significant incidents for the 104 US reactors. The latter values are per reactor year and defined as events with a core damage probability of 10^{-5} or higher. There is therefore a strong trend of improvement in both operational performance and safety despite the ageing of the fleet. There are no discernable radiological health effects from operations and incidents.

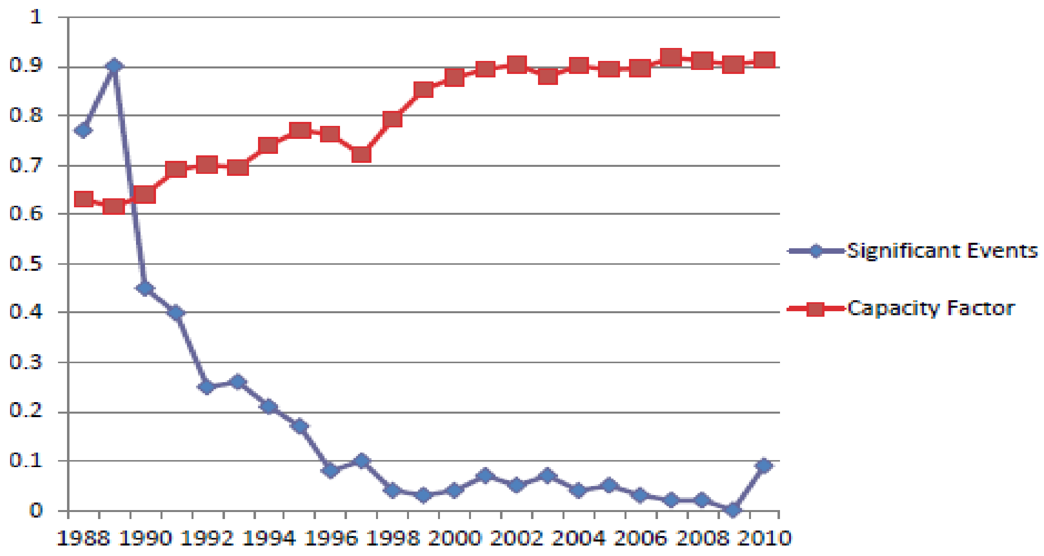


Figure 1 Availability and Significant Events [4]

Had these standards of safety culture and regulation been applied in Japan, safe shutdown at Fukashima would have been achieved. However this has not resulted in complacency in the world nuclear industry. It has recognized the risks of the inevitable balance between safety and cost, and the possibility of design shortfalls, and has undertaken reassessment of all reactors by stress testing. Its position is well expressed by Mike Weightman, UK Chief Inspector of Nuclear Installations [3]

"We see no reason to curtail operation of nuclear power plant. Once work is completed proposed improvements will be considered in line with our normal regulatory approach" ……. "We need to continue to adhere to the principle of continuous improvement. No matter how high the standards are, the quest for improvement should never stop ".

This culture of safety-in-depth against realistic operational, fault and emergency design conditions has been rigorously practiced for 3 decades making increasing use of probabilistic assessments in a strong independent regulatory environment. It is unlikely that major functionally justified changes or safety improvements will result from Fukashima However, in the prevailing climate of opinion, there is a strong possibility of major cost escalation due to counter-measures against deterministically imposed combinations of events of negligible probability. There is also a danger that excessive emphasis on earthquake and flooding will obstruct the quest for other causes of accident by the more proactive normal safety culture.

While it is unlikely to materialize in the foreseeable future, an enforceable international safety regime, (similar to international safety regime in commercial air transport) could contribute tangibly to assure public opinion and policy makers. The concept was raised by France and others and discussed briefly within IAEA following the accident, but was opposed strongly by most other nuclear states.

1.2 Public Relations and Political Significance

Public opinion is conditioned by perceptions of nuclear weapons, explosions and fear of radiation and waste disposal, exacerbated by the sometimes alarmist and uninformed media coverage. It is influenced by anti nuclear movements, initially focused on weapons but now extended to nuclear power which they maintain is an unsafe and because of sustainable energy unnecessary technology propounded by an untrustworthy industry and establishment. These views are strengthened by major accidents but are intolerant of the facts of those accidents. Despite inadequate instrumentation and gross operator failure, Three Mile Island proved the safety of containment of an early PWR without public harm. Both Chernobyl and Fukashima were solely caused by willful disregard of the safety in depth culture routinely practiced in the US, Europe and South Korea. They are also intolerant of the fact that existing nuclear power plants in these countries are the safest, cheapest and least polluting source of electricity currently available.

Also, although the largest technically feasible and economically justifiable renewable energy component in the energy mix is required, very large-scale deployment is beset with difficulty, and its cost trajectories and the extent of deployment remain uncertain. For the next two decades, a renewable share of around 20-30% appears to be a limiting practical ceiling on economic (cost of storage) and technical (grid stability) for most countries.

These influences have already achieved have their objectives. Public opinion is shown in Figure 2. Before Fukashima, in all countries, only a large minority considered that nuclear power was a safe and important source of electricity and that new plants should be built.

Fukashima is catastrophically and permanently damaging to the vital role of nuclear power in the world economy and in reducing carbon emissions. Recognition of this is evident in the following statement by the Japanese Government, immediately prior to IAEA Ministerial conference on nuclear safety in June 2011 [1] , evidently seeking to mitigate the damage:

"Japan takes it very seriously and with remorse that this accident has raised concerns around the world about the safety of nuclear power generation and above all, Japan feels severe regret for causing anxiety among people all over the world about the safety of nuclear power and release of radioactive materials." [1]

This statement and those from [2]quoted above are too late. Japan is deeply respected by the public worldwide because of its excellence in high public profile technology such as cars and consumer electronics and because of its perceived integrity. The facts of the gross design and regulatory failures will remain incredible to the public, leaving a lasting perception that safe nuclear power is beyond the capability of even such a respected nation.

The response of Germany, similarly respected, is seen to endorse this perception and is equally damaging. The hasty acquiescence to anti nuclear public opinion for political expediency, abandoning the considered views of the executive which produced it is not recognized.

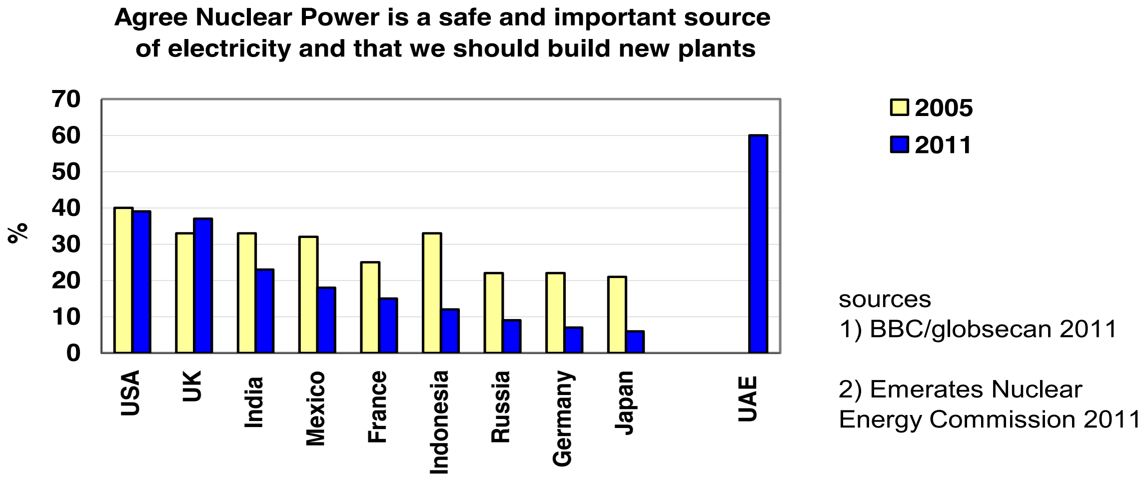
Actions by the industry, intended to recover public opinion may have the opposite effect. Emphasis on Generation III+ designs with passive or multi-redundant systems, and the declared expectation that the reassessment process and stress tests following

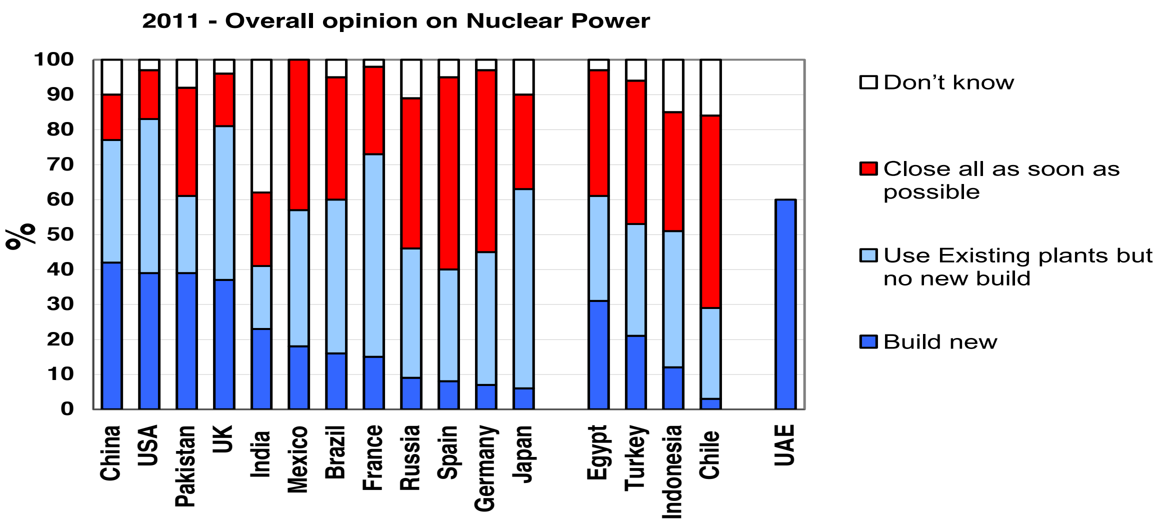
Fukashima will yield major safety improvements, leaves the public perception that the previous safety process and existing reactor stock are unsafe.

Mitigation of socio-political impacts of accidents is essential but overt emphasis implies an establishment accepting their possibility and the requirement for as remote siting as possible. In fact, size of exclusion zones is dependant on the severity of the accident postulated. The only basis on which Nuclear Power can be responsibly proposed is that it is engineered and regulated in a manner which renders the probability of such accidents negligible. The history of U.S. and European reactors and their siting relative to major centers of population supports this basis.

Post Fukashima opinion is also shown on Figure 2. With the exception of US and UK, public support in nations with nuclear power is sharply reduced. The position of the segment supporting continued use of existing plant but opposing new, despite its lower risk, appears inconsistent.

Few opinion surveys in the Middle East are available. That for the UAE, conducted for the Emirates Nuclear Energy Commission by an independent polling organization is remarkable.





.Figure 2 Public Opinion Before and After Fukashima

GCC states are monarchies with either no or limited participatory democracies. Kuwait and Bahrain are most advanced with legislatures in which a majority of members are elected. Other countries in the wider MENA region, have, both monarchies with elected legislation (Jordan and Monarchy) but with limited power, and pseudo "democratic" republics , with presidents of chiefs for life. The storms of the Arab spring are sweeping the region promising transformative but bumpy and long pathways to true democracies. It is notable that in the Gulf states nuclear programs are certain where political power is most strongly vested in ruling monarchy elites (the UAE and Saudi Arabia) and have been abandoned in response to public opinion by governments in countries with strong legislatures (Kuwait and Bahrain) In Jordan, public opinion may yet have the same effect. Its significance in Egypt is as yet uncertain.

2 Rational For Nuclear Power in MENA

2.1 The Gulf States

The primary rationale is to counter the domestic use of national hydrocarbon resources and consequent reduction of national income. With the exception of Bahrain, the GCC are rentier states with national income dependant on hydrocarbon exports - ranging from about 70% in the UAE to 93% in Kuwait. Historically, these revenues and small populations provided budget surpluses which allowed governments to provide citizens with material benefits, including heavily subsidized electricity and water, transport fuel, public sector employment, welfare, free education and housing without taxation. This has become the basis of a de facto social contract between the government and its people, and the basis of popular support for the former. Tariffs are shown in Figure 3.

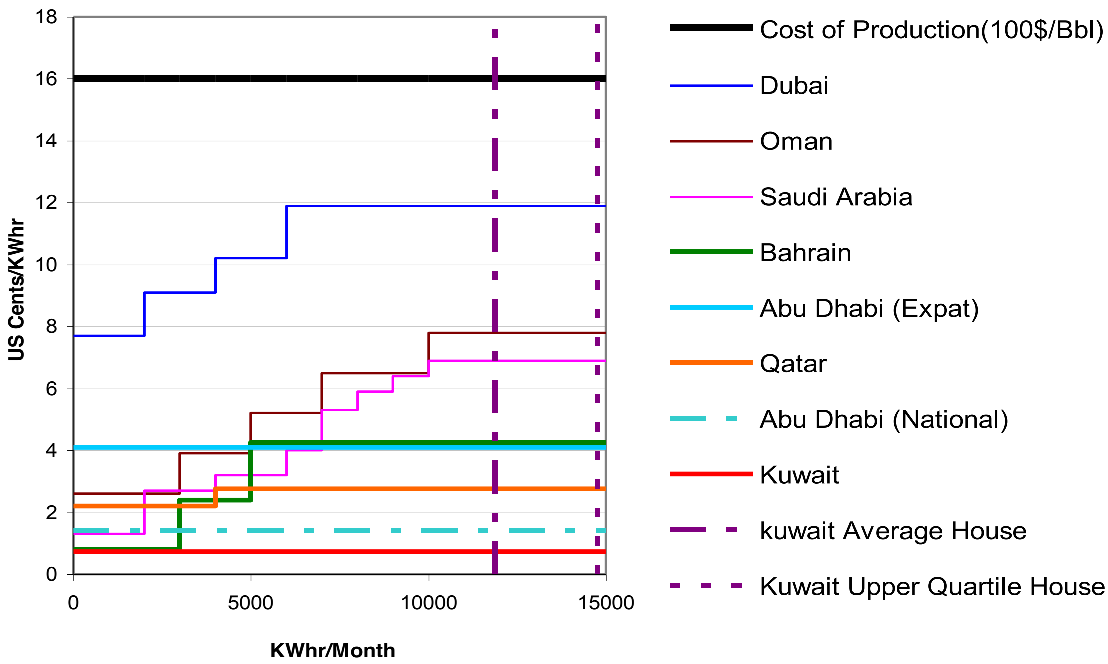


Figure 3 GCC Tariffs relative to cost of production @ 100 4/Bbl

These levels of subsidy lock in a consumer base of buildings, equipment and vehicles chosen with little consideration of efficiency and eliminate conservation in their operation. Together, with the absence of taxation, they have also eliminated the financial instruments normally used to incentivise efficiency and conservation.

These effects, more than severity of the environment, are responsible for the situation shown in Figure 4. Although they are not industrial economies, the 3 wealthiest Gulf States, including Kuwait have the highest per capita fossil generated electricity demand, and therefore emissions in the world. Resultant consumption of domestic hydrocarbon resource is shown in Figure 5.

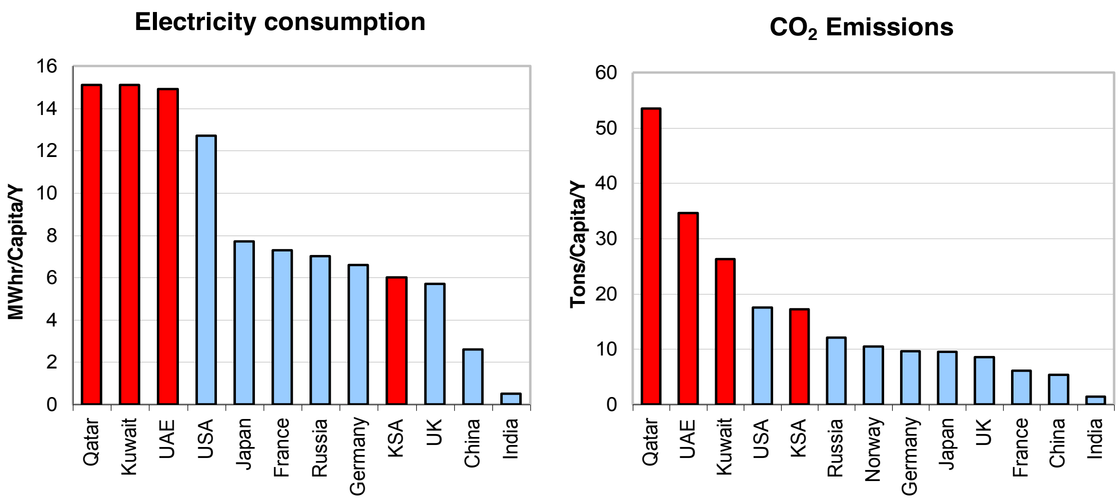
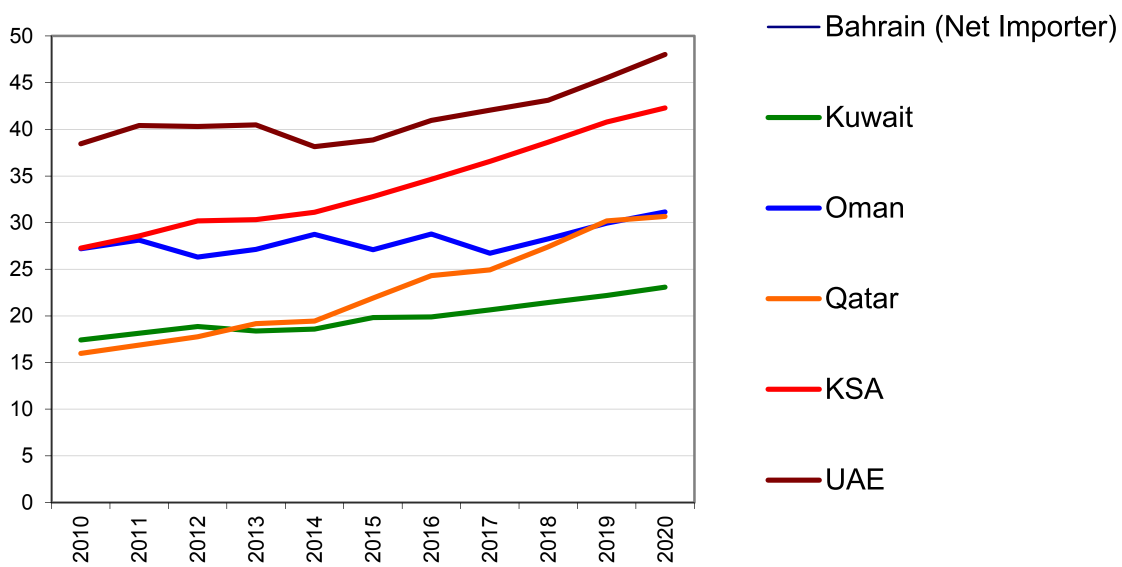


Figure 4 Per Capita Electricity & Carbon Emissions [5] & [6]



Domestic Energy consumption as % Maximum Possible Total production (source EIU , National Bank of Kuwait)

Figure 5 Domestic Hydrocarbon Consumption as a % of Total Production [7]

The decade of rising oil prices and increasing budget surpluses from 1998 to 2008 diverted attention from these issues and encouraged the postulation of ambitious national development plans, but now they are a major cause for concern.

Saudi Arabia is the most serious case. Despite exceptional sustained diversification efforts, the economy remains almost 90% dependant upon oil exports. Raising oil production is increasingly difficult and more costly. Per capita demand is rising rapidly because of its present relatively low levels and urbanization. A recent study by an international independent research body [8] gives the following forecasts of the development of the energy economy under present policies.

The implications are declining revenue and inability to meet the increasing expectations of a rising young population leading to economic unsustainability and, in the new Arab trend to expectations of democratization, political unrest. Because of the social contract and the resultant political difficulties of demand management, attention is concentrated on supply. Major programs of Nuclear and Renewable Energy have been announced, as yet without official detail - nuclear first but with increasing emphasis on Renewables post Fukashima and as their costs reduce.

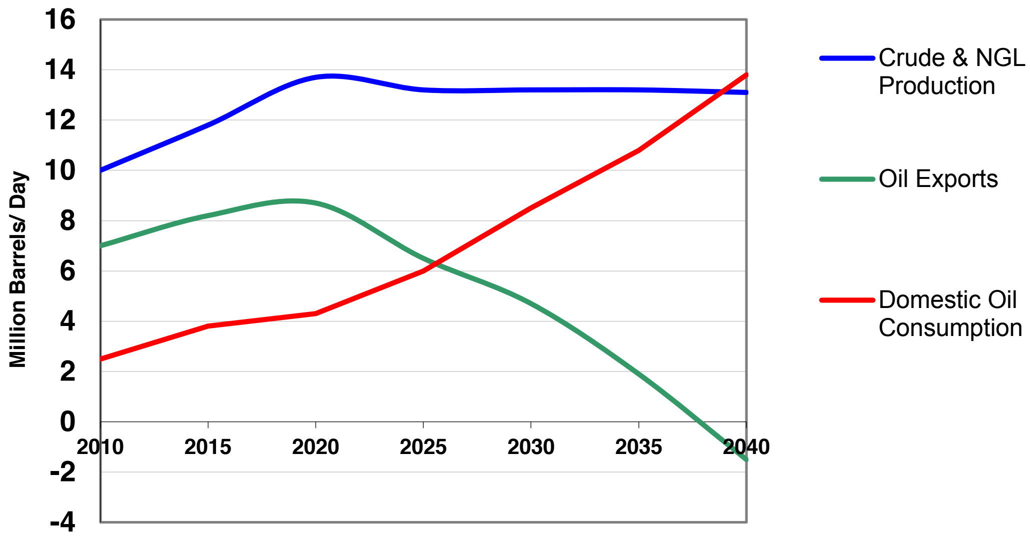


Figure 6 Oil Balance in Saudi Arabia on Business as Usual Trajectory [8]

Although this is an extreme case, it illustrates the general problem, which to various extents and timescales, faces all the Gulf States, and the policies being adopted.

The economic competitiveness of nuclear power is discussed below in 3.1. Financing has always been problematic, because of high capital cost, risk of delays and cost overruns, slow returns on investment and decommissioning commitments. Now these difficulties are exacerbated by the consequences of Fukashima, both in cost escalation and investor confidence. The MENA region's policy of following the world trend to merchant power industry is now almost impossible to apply to a nuclear power program because of these superimposed risks. However, the advantages of nuclear power in reducing domestic hydrocarbon consumption, and providing low cost electricity for operating lives of more than 40 years as now proven in the USA and France, remain attractive as a contribution to economic sustainability of the Gulf States. Combinations of a majority of direct state funding, together with loan guarantees and mitigation of risks to encourage private sector investment, is one of the optimum uses of present fiscal reserves.

2.2 Energy Security

This is a significant consideration in the Gulf States, particularly for Kuwait, which to avoid the use of high value exports at high official demand scenarios will rely on LNG imports for over 30% of its energy requirements. However, it is the primary rationale for Bahrain and Jordan, which are entirely dependant on imports, Turkey: and Egypt.

2.3 The Knowledge Based Economy

All of the MENA Countries recognize the imperative to transition toward knowledge based economy and envisage nuclear technology as a contribution to doing so. Some, notably Iran, regard it as a matter of national prestige. Many of the countries, except the Gulf States, operate research reactors, Egypt for 40 Years. However, all with power programs intended to lead to Power will outsource training and have entered into suitable international agreements.

3 Alternative Paths

3.1 The Effect of Fukashima on Generation Economics

Overnight costs must increase but the extent is yet uncertain. Figure 7 compares nuclear with fossil and renewable technologies and shows the effect of up to 30% increase on the anticipated 4.5 $/W pre Fukashima. The effect of various levels of state participation are indicated by discount rates of 5%, (state ownership), 8% (major state participation, loan guarantees and absorption of major risks) and 12% (IPP). Because of the present world economic situation, and the climate of opinion on nuclear power, the IPP model is considered unlikely. Major state participation either by the host, or the technology providing country, is considered the only probable financing model, justified as discussed above and is now the model for the UAE Barakah plant.

Unlike the US, competitiveness of CCGT is set by the Middle East /Asia LNG market in which, for the foreseeable future, prices will be near fuel oil parity. The Fossil results are for an IPP with 10% discount rate and fuel prices benchmarked to crude. Assuming a 30% cost escalation, fully state supported nuclear power is competitive with CCGT in MENA above a crude benchmark of 50 $/Bbl and Joint Ventures above 70$/ Bbl. For some countries, including Kuwait and Saudi Arabia, CCGT may not be possible because of gas and LNG shortage. Reheat steam plant shown is then the most efficient plant available for heavy fuel oil firing but is uncompetitive. The RE results use a consensus of IEA and NREL costs, an IPP model with a 10% discount rate and resource data for Kuwait. RE competitiveness is time dependant . By 2020 Wind is so with all alternatives other than State supported nuclear and CCGT with benchmark crude@ < 100 $/Bbl. The same is predicted to apply to utility PV by 2025l.

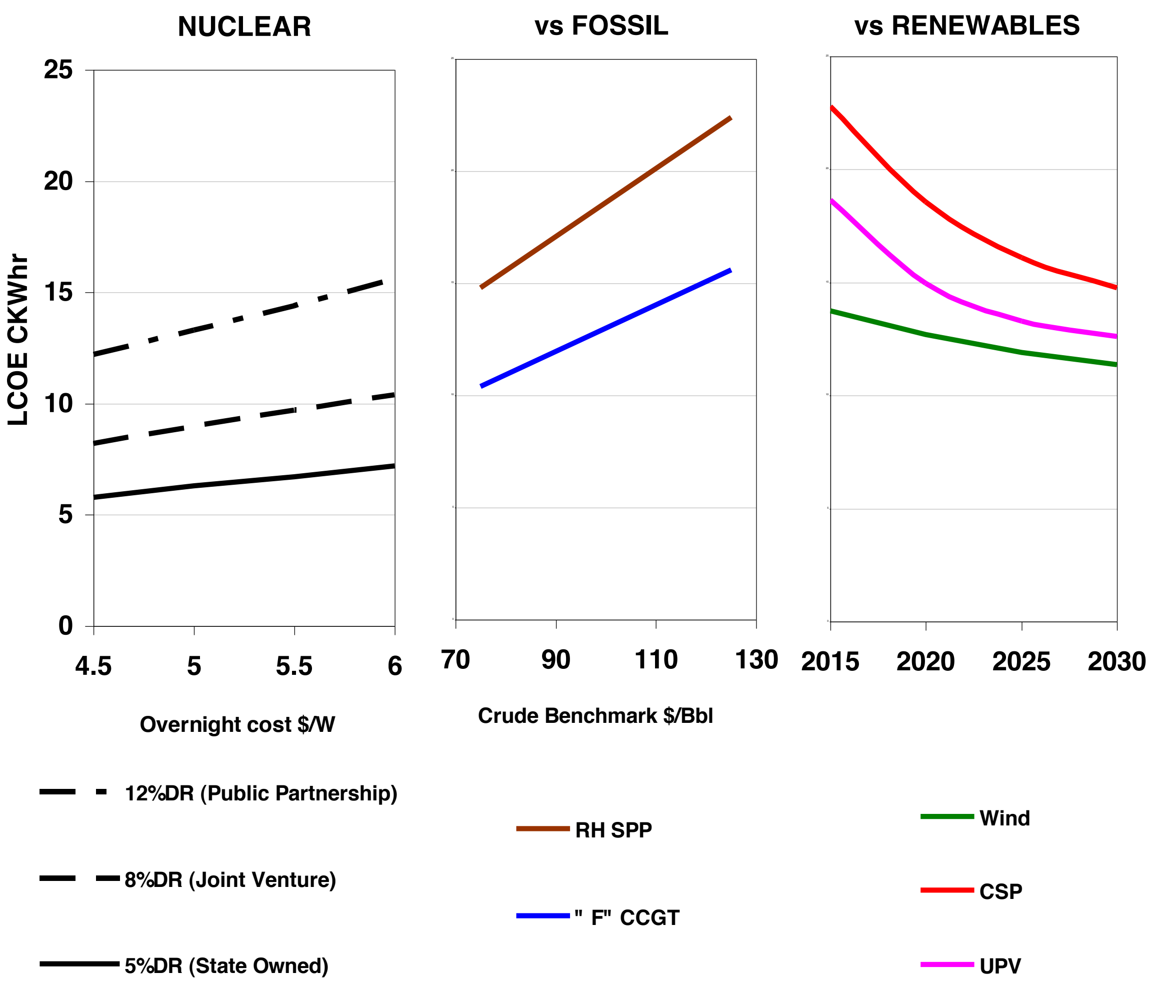


Figure 7 Comparison of Generating Costs

3.2 Conservation

Because of previous neglect of conservation resulting from state subsidies of electricity, potential for conservation, particularly in the Gulf States is almost certainly the largest in the world. Residential is the largest demand sector. Figure 8 shows estimates of technically feasible savings on grid energy consumption of a typical Kuwaiti villa with rooftop PV. Recent unpublished studies show that using current technology, on existing buildings retrofitting windows and sealing, use of efficient energy appliances and partial use of efficient lighting has potential to save 36% and rooftop PV a further 14%. Envelope improvements, and further use of efficient lighting in new buildings included in a recent building code, could save a further 8%. District Cooling is transformative, projecting a further 17% saving. Thus, including 14% due to PV, savings of 50% on air cooled and 75% on district cooled buildings are now possible. With some building envelope development, increased appliance and A/C plant efficiency and design to accommodate larger PV arrays, within less than a decade further savings of more than 10% are possible. Saving potential in large buildings with lower ratios of roof and exterior wall to occupied floor area, which already utilize water cooled AC, are less.

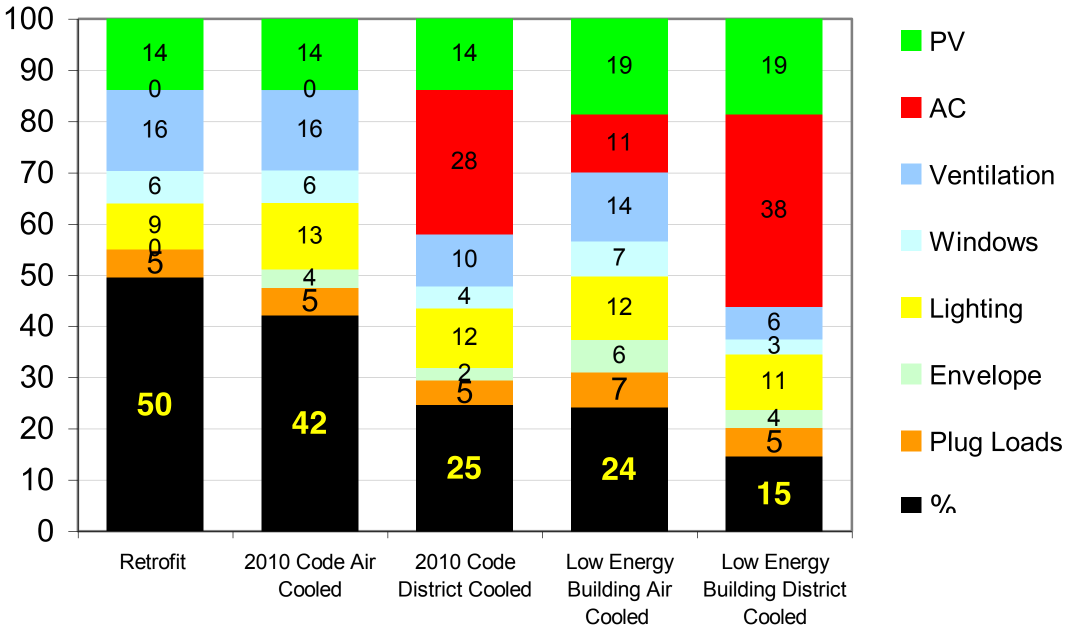


Figure 8 Potential % Saving on Energy Demand of Kuwaiti Villas

Difficulties in realization of such potential are the absence of consumer incentive and the levels of national coordination and resource required.

The consumer considers only first cost. Unless tariffs are greatly increased, retrofits and the additional cost of energy efficiency measures mandated in codes for new buildings must be state subsidized. However, irrespective of efficiency of design, tariff increase is the only consumer motivation to operate his building efficiently and is ultimately inevitable. In the present political climate, this is a major challenge to governments.

Conservation requires the declaration of saving targets in law and national development policy. It must be included in the mandates of all relevant government entities and the planning and technology requirements accepted. Cash incentives (rebates) for consumer saving of excessive use of electricity have the potential to be a win-win solution, meriting serious consideration.

Human resource requirements are large to design, implement and audit sustainable energy throughout national economies. This has larger potential for the national knowledge base than nuclear power.

These challenges are the most important for national sustainability, they offer the largest potential for reduction in domestic energy consumption, for industrial diversification, quality employment and development of national capability. They are fundamentally more appropriate that the concentration on supply measures presently apparent in the Gulf States. They are the only solution to the problem discussed in 2.1 and, must be confronted in the near future.

3.3 The Example of Kuwait

Figure 9 is a typical example of the uncertainty of energy planning in the Gulf States. It shows three demand scenarios: A optimistic official estimates including national development plans funded by fiscal reserves implying more than 60% increase in per capita consumption, B based on estimates of national income, without significant conservation initiatives and C, as B assuming half of the conservation potential shown in Figure 8 is achieved. Two fuel availability scenarios covering uncertainty in realization of domestic gas resources are shown. The supply and demand scenarios range from requirements of between 50 and 15% imports in case A, depending on domestic gas realization, to balance at certain fuel availability in case C.

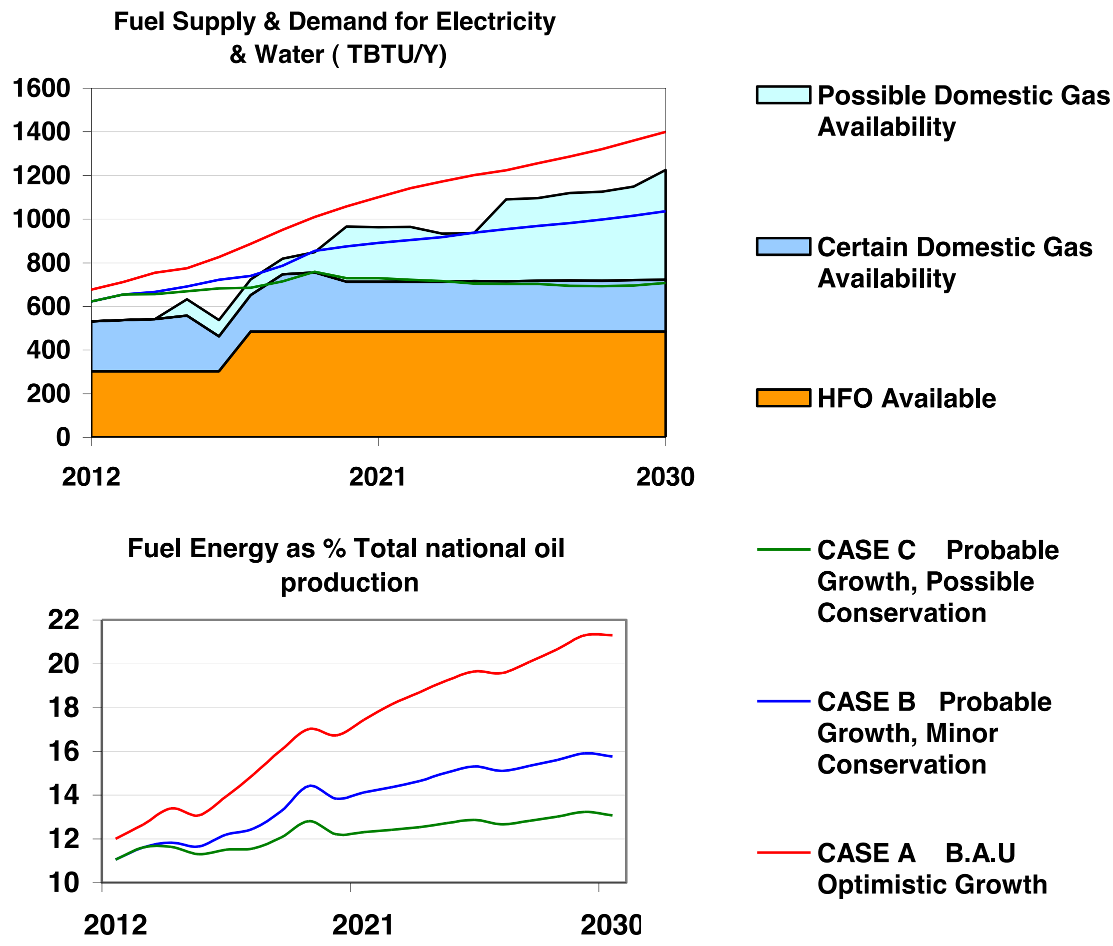


Figure 9 Kuwait Example – Energy Supply and Demand [9]

Case A was the primary justification for the now terminated Kuwait Nuclear Program. A secondary justification extending to cases B & C depended on the generation economics as discussed in 3.1.

4 Middle East Nuclear Programs

Programs are shown in Figure 10 and summarized in Table 1 [10] [11}. The most significant are discussed below.

4.1 United .Arab. Emirates

The program was initiated in 2008 to counter forecast 50% shortfalls in availability of gas which is used almost exclusively for power generation in the UAE. Plans are for 5 GW of nuclear power by 2020 with up to 20 GW by 2032, depending on growth, a consortium led by Korean electric Power Company and involving Samsung, Hyundi & Doosan has been selected to build 4 AP 1400 reactors. A site at Barakah, 300 Km West of Abu Dhabi was chosen. Licenses for component construction were issued in 2010, for site preparation, followed by ground breaking in 2011 and for construction of the first two units in 2012. The licensing process included review post Fukashima.

The program is on schedule to commission the 4 reactors between 2017 and 2020 the first less than 10 years after commencement. There is expectation that the consortium will have a major role in operation for 60 years. The program sets a world standard and model for fast tracked, efficient implementation. International expertise is used in key posts in the national regulator and nuclear corporation whilst development of national resource is pursued in parallel. Policy is based on full cooperation with the non proliferation treaty, an IAEA safeguards agreement and the Additional Protocol. First fuel loads are provided by the consortium. Long term arrangements for uranium supply and fuel manufacturing are being pursued. In country enrichment is banned by the law which established nuclear infrastructure. In county HLW repositories are being considered. The UAE has been complimented on its good practice, safety culture, independence of regulation and human resource development by the IAEA. The financing Model has evolved to increasing state participation and support of equity partners .

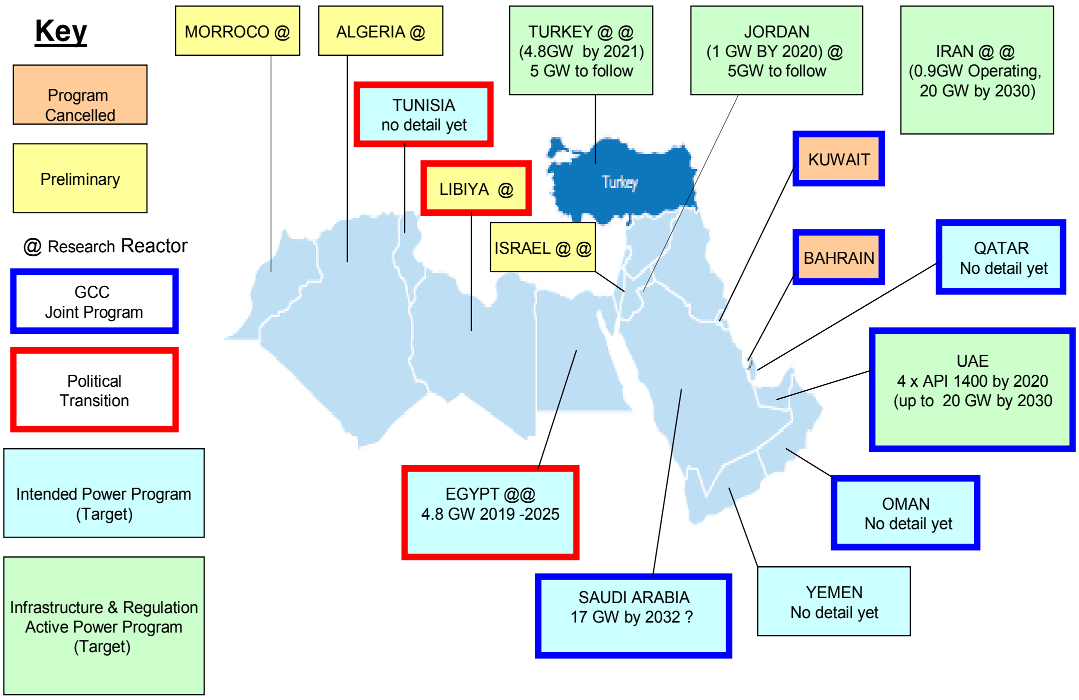


Figure 10 Middle East Nuclear Power Programs

4.2 Saudi Arabia

Because of the imperative of the problem outlined in 2.1 above, the current availability of huge financial resources and an absolute monarchy this will certainly be the largest MENA program. However, it was initiated only in 2009 with a royal decree establishing the King Abdullah Centre for Atomic and Renewable Energy (KACARE) in 2010 as the responsible entity. Multiple international agreements have been signed, notably with Argentina for small modular reactors with emphasis on desalination, and with China including fuel fabrication. High level strategy and definitive plans are still under consideration. Statements are that generating capacity will double to over 100 GW by 2032, that 2 reactors will be built by 2022 and 16 by 2032. Intent of 40 GW of solar and 4GW from waste and geothermal have been stated. The remit of KACARE is an energy mix, evidently of the order of 15: 45:40, nuclear, fossil and RE.

4.3 Turkey

Rationale is energy independence and to meet demand growth. At present, 33% of the energy slate is Russian gas and 17% Iranian. Turkey is industrializing rapidly and, per capita, demand has trebled in 2 decades. Nuclear power has been considered to be a key component of economic growth since 1970 but the program has been characterized by delayed and cancelled tenders partly due to concerns about finance. In 2008, only Atomstroyexport bid for 4 x 1200 MW reactors for the Akkuyu site on the Mediterranean with required COD 2017 -2009. This was cancelled after lengthy delays by the Government but cooperation agreements with Russia were signed. In 2010, Rosatom, as part of an aggressive policy to establish Russia in the international nuclear industry offered, and Turkey signed, an intergovernmental agreement to Build, Own and Operate the Akkuyu plant using the AES 2006 reactor and to provide100% initial equity in a Turkish company established for the purpose. The licensing process is on course for COD in 2020.

Attempts to develop a further 4 x 1400 MW plant at Sinop on the Black sea have seen bids by KEPCO in 2010 for construction, using the AP1400 and part ownership, cancelled over electricity sales guarantees and a subsequent bid by TEPCO using ABWR cancelled as a result of Fukashima. A further round to find a BOO partner involving Mitsubishi, Areva, Candu Energy and a possible re-entry by KEPCO is now in progress. Two further sites have also been identified.

Turkey is pursuing development of its relatively small Uranium resources and the Rosatom Akkuyu agreement includes the possibility of fuel fabrication in country but Turkey has signed IAEA safeguards agreements and the additional protocol.

4.4 Jordan

Jordan is dependent on imported energy, 10 % of electricity is imported from Egypt and Syria. The fuel slate for generation of the balance is 25% gas from Egypt with the remainder; heavy fuel oil and light distillated from the GCC. Energy requirement is predicted to double by 2030. Jordan has also considered Nuclear power and developed infrastructure for more than 40 years. Throughout it has sought to link development of its Uranium resources with power A Joint venture ventures with Areva have been formed for this purpose but a similar arrangement with China was terminated in 2011. Non proliferation safeguards and an additional protocol are in place. Current nuclear power strategy is for first plant by 2020 and 30% nuclear generation by 2030, with intent to become a net exporter. It has International agreements with France, Russia, and Canada involving power and desalination and uranium resource development. In 2009, a contract for a 5 MW university research reactor was signed with a consortium of Korean universities and Daewoo. Construction will start in 2012 and operation is expected in 2016, to serve as the basis of training for the national program.

In 2008, a CANDU reactor to utilize domestic natural uranium was considered. From 2009, Jordan has been evaluating bids for 2 x 1 GW reactors, finally short listing an Areva MHI consortium and Atomstroyexport. It has also evaluated bids for investor operators for the plant from potential Spanish, Russian and Korean Partners. These are based on 70:30 Debt Equity ratios and 45 year power purchase agreements. There is also the possibility of an asset exchange involving part of the Uranium resources.

Separately, Rosatom has offered B.O.O. of 4 x 1200 MW reactors for longer term development in a deal similar to that in Turkey.

The program is affected by a shortage of suitable sites. Jordan only has about 30 Km of coastline on the Gulf of Aqaba. This location has been rejected because of seismicity and inland sites proposed. Initially, a site 40 Km N of Amman, with cooling from a municipal wastewater treatment plant was chosen. This has now been changed to one 100 KM from Amman. Cooling arrangements have not been described. Jordan has a growing anti-nuclear movement and in 2012 the lower house of the Legislature suspended the power program and uranium resource development pending re-evaluation of costs, quantity and quality of uranium resources and safety studies by the Jordan Atomic Energy Commission.

Despite the clear rationale and decades of commitment, this development superimposed on uncertainties of finance, siting, linkage to uranium production and processing make the program increasingly uncertain.

4.5 Egypt

From a low base of per capita consumption, high demand growth rates are inevitable. Fuel slate is predominantly domestic gas which is expected to be depleted in 20 years. The incentive for nuclear power is strong and Egypt has pursued it for more than 40 years. Research reactors have been operated and infrastructure established over this period. A succession of plant projects including desalination for sites west of Alexandria and on the Gulf of Suez, have been attempted since 1964 but they were interrupted because of Chernobyl. The program was restarted in 2004 by cooperation agreements with Russia and China. Since then it has been subject to continuous change. Proposals for a 1000 MW cogeneration plant at Al Dabaa, 250 Km W of Alexandria were developed in 2006. In 2008 preconstruction contracts were placed for a 1.2 GW plant with COD in 2017 on a site to be determined. This was extended in 2010 to 4 x 1200 MW by 2025.

Since then Egypt has been dominated by political change. The rationale for a nuclear program is clear, strengthened by expectations of economic development following that change. However, its future depends on newly empowered public opinion and the availability of finance, possibly via the partnering policies now established by Russia and China in Turkey and Jordan.

4.6 GCC

Saudi Arabia was one of the main proponents of a GCC program. Given its, and the UAE’s independent programs and the supply limited situation of all the member states, the future of a GCC program, other than cooperation on nuclear emergencies and probably, regional grid development to provide system security under large reactor trip conditions is uncertain.

The GCC Secretariat continues to pursue the preparation of feasibility studies for a regional program. The Saudi nuclear program, could be the nucleus in which other Member states participate in investments and manpower requirements and share production proportionally, leaving regulation to Saudi Arabia

A regional HLW managed repository, accepting waste from GCC and outside, probably located in Saudi Arabia, eventually followed by a reprocessing facility is an attractive but very long term possibility.

5 Conclusions

In general, MENA has so far responded rationally, apparently recognizing the economic and environmental benefits of nuclear power and it long term record of safety and reliability in South Korea US and France rather than the specifically Japanese events at Fukashima and the political expediency in Germany.

The significance in MENA of these latter events depends on the empowerment of public opinion to affect national policy. It is notable that in two of the most democratized countries, Kuwait and Bahrain, nuclear intent has been dropped by the executive before encounters with the legislature. Programs in UAE and Saudi Arabia, with effectively absolute rule by heredity elites, and that in Turkey are certain, Jordan is encountering increasing opposition in addition to siting difficulty. Egypt depends on as yet unknown political response.

The UAE has established a very impressive benchmark for implementation by a developing country, making maximum use of international expertise in executive roles, whilst simultaneously developing national resource, rejecting lengthy programs of prior development of national resource, research reactors and involvement in fuel production.

Build Own and Operate Policy by Russia in Turkey and Jordan demonstrates an aggressive intent to develop as a dominant provider of nuclear technology and may be very significant in MENA.

The Gulf States have chosen to address the looming energy supply/demand imbalances which threaten national sustainability and ultimately, political unrest, predominantly by attention to alternative supply sources. Although this is expedient because of the political dangers of breaking or severely modifying the social contract for massively subsidized energy and the challenges of national coordination and

Table 1 -1

Country	Pre Fukashima	Post Fukashima
UAE	Rationale: Partially compensate fuel (predominantly gas) shortfall 50% in 2020, increasing thereafter Strategy: 5 GW by 2020. Up to 20 by 2032. Standardize technology Fast track. Outsourced expertise. Parallel indigenous development. First plant state financed with small contractor equity. Subsequent by JV's (Government / investor/ contractor) 2008 – 2010 Regulator, Nuclear Energy Corporation, Safety Review board 2009 KEPCO Selected from 3 bids. 4 x AP1400. COD 2017 -2020 2010 Site: Barakah 300 Km W of Abu Dhabi	2011 public outreach, polls 2012 Construction license delayed by additional safety reviews 2013 Possibility of early follow on plant depending on demand
Kuwait	Rationale: Minimize use of crude & GO to meet 50% fuel slate shortfall by 2030.	"Kuwait is no longer pursuing NPP". Fuel issue not addressed
KSA	Rationale: unsustainable domestic oil and gas consumption(25% production in 2009, 60% predicted in 2032 for B.A.U) Strategy: 2 reactors by 2022, 16 by 2032. Interest in small reactors for desalination. No plant/ site details yet 2009 Royal decree stating NPP essential to meet energy demand and prevent depletion of hydrocarbon resources and establishing King Abdullah City for Nuclear and renewable energy KACARE	Evidence of shift of emphasis to Solar
Bahrain	Rationale Minimal hydrocarbon resources, net importer, urgent requirement for alternative generation, energy security	2012 Minister "Plans abandoned"
Qatar	Rationale Maximize gas availability for petrochemicals and GTL. Constraints on gas production. 8% electricity demand increase 2008 Feasibility studies with EDF 2010 Cooperation with Rosatom. Interest in Russian Floating Nuclear Power and desalination plants.	2012 studies: viability at crude > 55$/bbl. No changes in policy announced but go ahead not imminent.
Oman	2009 Cooperation agreement with Rosatom for technology transfer and preliminary studies Various statements of intent but no firm proposals	

Table 1-2

Country	Pre Fukashima	Post Fukashima
GCC Joint	Rationale Shares costs, technology, human resource requirements. Allows Optimum siting for emergency exclusion zones and cooling conditions. Optimum use of GCC grid to ensure electrical network stability under reactor trip 2007 IAEA study shows Economic viability. 2010 Consultant studies on siting, knowledge sharing, safety and regulation	2012 Consultant studies on emergency response. No detailed proposals No changes in policy announced
Turkey	Rationale Energy independence. (Present Energy Slate 33% Russian gas, 17% Iranian gas, 25% Coal, 25% Hydro. Demand growth 8% Several projects proposed , tendered and cancelled since 1970 2010 Intergovernmental agreement for Rosatom to B.O.O. 4 x VVER 1200. For Mediterranean site at Akkuyu. Includes Fuel Supply and spent fuel return. 100 % Initial Rosatom equity, retaining 51%. Construction start 2013 C.O.D 2018 -2021 2010 Toshiba/ TEPCO Bid for 5 GW at Black Sea site at Sinop	2012 TEPCO Sinop bid withdrawn. 2012 Renewed discussions with France, South Korea, Japan and China on Sinop No changes in policy
Iran	Rationale Conserve hydrocarbons for export and petrochemicals Strategy 23 GW by 2030 1975 KWU contract for 2 x 1.2 GW PWR at Bushehr 1979 50 & 85% completion, KWU withdrew 1995 Atomstroyexport to replace 1 reactor with 915 MW VVER. 2005 Fuel Supply and spent fuel return agreement with Russia 2011 Completion & commencement of operation	2011 Grid connection Operation by Russians under IAEA supervision No changes in policy. Plans for unit 2 construction
Jordan	Rationale: Energy security. Fuel (Gas 28%, HFO 36%, GO 36%), 11% of Electricity all imported. Concerns re Egyptian gas. Uranium reserves. Interest as fuel vendor with enrichment partner Strategy: 1GW by 2020, 5 by 2030, Part financing by operator partners. 2007 Atomic Energy commission (JAEC), Regulator (JNRA) 2009 Contract for 5MW research reactor for technology centre 2009 Areva/MHI, SNC Laval. Atomstroyexport bids for 1 GW. 2010 Concern re. seismicity of Aquaba site. Inland location 40Km N of Amman chosen. Cooling from wastewater plant 2011 Investor operator Bids received 2011 Rosatom offer BOO for 4 reactors	2012 Selection of contractors for 1GW. Start 2014, COD 2020 2012 Site moved to100 Km N of Amman 2012 Political opposition. Suspension by parliament pending studies by JAEC 2012 Possible Delays associated with Syrian Civil War

Table 1-3

Country	Pre Fukashima	Post Fukashima

Egypt	Rationale Energy security. Fuel slate (Gas 72%, HFO 16%, 14 % hydro). Gas expected to be depleted in 20 years. Demand growth 7%. 1956 Atomic energy Commission. 1976 Nuclear Power Plant Authority. 1976 -1986 Various projects and tenders. Program cancelled because of Chernobyl. 2004 – 2008 Cooperation agreements with Russia & China 2008 Preconstruction contract for 1.2 GW plant COD 2017 2010 .plan extended to 4 plants COD 2019- 2025 2011 delayed because of political instability	No policy changes announced Muslim brotherhood statements supportive of nuclear power program
Israel	No Civil Nuclear Power Program	
Tunisia	1981Agency for Nuclear Safety, Centre for Radiation Protection, 2008 Nuclear law revised with IAEA 1990 Atomic Energy Commission 2006 Cooperation agreement with France, extended in 2008	Evaluating 0.6 to 1 GW plant No policy changes announced
Algeria	2008 various international cooperation agreements 2009 Declared intent to build reactor in 2020 and then 1 per 5 years	No policy changes announced
Morocco	Study with Atomstroyexport for building first plant in 2017 Study with China on 10 MW , 2MG/D desalination plant 2010 2 x 1 GW reactors under CDM to be tendered 2014	No policy changes announced
Yemen	Developing proposals with IAEA for 300 MW reactors in 2025 -2030 and 1.5 GW about 2035	No policy changes announced

Financial instruments to implement sustainable energy policy, it is shortsighted. The latter policy has greater long-term potential for reducing demand, and creating

Industrial diversification and quality employment than any solely supply side measure and must be addressed. Because of locked in demand and implementation timescales of sustainable energy, the rationale for early construction of a nuclear component of the energy mix remains for many of the MENA countries, but the longer-term extent of deployment now being proposed appears unlikely
.
The serious and advanced plans for nuclear power in all MENA region countries have not adequately addressed the fuel cycle challenge: planning and implementing redundant approaches to assured practical nuclear fuel cycle services. The UAE, and Kuwait before it abandoned its nuclear plan, pursued multiple approaches including participation in and support to regional and international arrangements for assured fuel procurement and services. Such arrangements need to be pursued and encouraged by all those who believe in the role of safe and secure nuclear power in the future energy mix of the MENA region.

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