Nuclear power in Saudi Arabia

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The paradox of the world's foremost oil exporting country struggling to provide enough energy for itself is by now well known. On the face of it, it does not make much sense to spend time prioritizing alternative approaches: whether consumption should be reined in or alternative sources of electricity developed; or whether among the latter, priority should be given to renewables or nuclear. All of the above need to be pursued in parallel: hence my argument is not that nuclear power should be preferred to other solutions, but simply that it is likely to be part of the solution.

Diversifying the Kingdom's energy mix

No energy system should depend on a single energy source: individual sources of energy have different characteristics which complement each other, and only a diversified system can offer the most appropriate source for each of a wide variety of uses. Nuclear energy is a source of concentrated heat, which can be used to produce electricity but also, intrinsically, in other industrial contexts – a consideration especially important to the hydrocarbons industry.

The main characteristics of nuclear energy are well known:

- Investment costs are high, while running costs are relatively low; the final cost of the energy produced depends crucially on (a) the cost of construction of the plant (including the time for construction); (b) the cost of capital (the interest rate or hurdle rate of return); and (c) the degree of utilization;
- Fuel costs are limited; the fuel is easy to store and procure in advance, so even if it is not produced domestically it allows for a considerable degree of security of supply;
- GHG emissions are very low, even if one considers the full life cycle – in other words, emissions in the construction phase, including the materials used for construction;
- On the other hand, nuclear energy can be mishandled and lead to major accidents, although opinions on the exact impact of accidents, in terms of human lives, are far from convergent

(but no one disputes the fact that coal is a much worse killer than nuclear). Safety can be enhanced through improved technology (entailing added cost), careful siting, and strict adherence to established procedures (human error is the foremost cause of accidents – but humans do err).

So far, an overwhelming share of heat and electricity needs in Saudi Arabia has been procured through burning hydrocarbons. Light crude oil or residual fuel oil yields a controlled and potentially continuous source of heat, which is desirable for industrial uses and for meeting base load electricity demand when burned in conventional thermal power plants. The cost of the fuel may be regarded as being either: very low if, at any given moment in time, we ask what is the marginal cost of taking a barrel out of the ground for burning in a power plant (assuming that export demand has been satisfied already); or very high, if we consider that crude oil burned in power plants could have been exported (not immediately, but rather at some future time; but to calculate this you would need a view of future prices and the discount rate).

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That said, if we consider that there is a ceiling on Saudi crude oil production, then obviously an increase in domestic consumption will eventually compress crude availability for export. Nuclear energy can neatly substitute for crude oil in providing steady heat or base load electricity.

The characteristics of gas powered generation are different from those of nuclear energy:

- The investment cost per MW of capacity is lower and economies of scale are also lower, meaning that smaller plants may reach top efficiency;
- The opportunity cost of the fuel is obviously higher (considerable repressed demand for gas exists in the Kingdom, and the cost of producing gas from non-associated or even non-conventional formations is considerably higher than current gas prices);
- Depending on whether an open gas turbine or a combined cycle configuration is chosen, flexibility in output is gained and the plant is suitable for meeting medium or peak load (also due to lower investment cost and greater modularity).

Nuclear energy does not make a good substitute for gas – there are ways in which a nuclear power plant can be used for medium or even peak load, but it is a very expensive way of solving the problem.

The strategic value of Saudi Arabia's nuclear programme is high

Among other renewable sources, hydro is a convenient and flexible source of electricity, but obviously does not have a chance in Saudi Arabia. Wind is intermittent and highly variable, so it eats into the base load but cannot be relied upon for continuous operation. Photovoltaic (PV) is intermittent, although less variable than wind, but similarly must be combined with a back-up source. Concentrated solar power (CSP) may in theory be coupled with heat storage, enabling the provision of round-the clock-power, but would still not be available in cloudy or even hazy conditions.

Greater penetration of wind and solar can certainly help in reducing the burning of gas for power generation, less so for reducing the burning of oil (flexibility is an issue); but neither can entirely substitute for hydrocarbons, while nuclear potentially can. Thus, if the strategic problem of Saudi Arabia is to create a position where the country can survive in a future – however distant – when hydrocarbons might no longer be available, nuclear must be part of the picture (I am now excluding imported coal or gas as an alternative).

The requirements of desalination must be considered in this context. Solar desalination has been proposed, but the production of desalinated water in the volumes needed to satisfy demand (which admittedly is wasteful and should be reined in) would require the devotion of huge spaces to solar ponds or distillation units. Alternatively, concentrated solar power can be used for distillation: water, unlike electricity, can be stored and therefore direct CSP distillation is more promising than CSP power generation. But nuclear works even better for a combination of desalination and power generation for base load.

Desalination can also 'support' nuclear if an appropriate mix of technologies that will allow maximum flattening of the load is adopted. This is because some desalination technologies absorb electricity, and could be run when excess power is available; while others may be coupled with electricity generation. Again, water can be stored while electricity cannot, although some very large seasonal storage might be needed in order to achieve a significant flattening of the load in the presence of extreme seasonal demand excursion, as we have in Saudi Arabia. Such storage might be very expensive, but after all it could be a good strategic move, considering the extreme vulnerability of the country to a potential collapse in desalinated water supply.10

Thus the strategic value of acquiring a nuclear component of total primary energy supply appears to be very strong for Saudi Arabia. Only CSP comes close to giving the same degree of confidence and sustainability in the long run, although the issue of intermittency has not yet been completely solved. Which of these solutions is economically more attractive is a moot question, as the answer depends entirely on the assumptions we may formulate on construction costs, cost of capital, and degree of utilization. Nuclear energy from standardized plants that do not face delays in construction (the South Korea–UAE model), at a time when the Saudi Government sits on a large accumulated surplus (invested in US Treasury bonds), and with the prospect of such nuclear plants being used in excess of 8000 hours per year, is very likely to be comparatively very cheap.

'NUCLEAR ENERGY CAN NEATLY SUBSTITUTE FOR CRUDE OIL IN PROVIDING STEADY HEAT OR BASE LOAD ELECTRICITY.'

The potential for space concentration of power generation capacity is much greater for nuclear than for CSP or other renewable sources. The literature frequently sees spatial distribution of power generation as a positive element, but in fact in Saudi Arabia both population and industrial activities are concentrated in a limited number of large clusters. CSP will probably be preferable for serving dispersed smaller agglomerations, while the major cities are better served by large nuclear energy parks.

A further important aspect is the potential use of nuclear or renewable sources in the hydrocarbon industry. The latter requires considerable heat inputs at all stages: in EOR if steam-assisted gravity drainage is required, and also in refining and petrochemicals. Decarbonizing the production of fossil fuels and petrochemicals is an important consideration which affects the acceptability of the products in an environmentally conscious world. Although in the end the burning of fossil fuels always generates emissions, the minimization of the carbon footprint of the hydrocarbons and petrochemicals industry should be a strategic concern for a major oil producer like Saudi Arabia. Use of nuclear energy to assist in hydrocarbon production, refining, and transformation is of strategic importance in this respect. Use of CSP might also be contemplated but – apart for the much greater land use required – intermittency is likely to be viewed as a major problem, because no one would consider shutting down a distillation column or a cracker because of a cloudy day.

Decision-making and the geopolitical dimension

Finally, we need to consider the decision-making process: who decides which solution is adopted? Most decisions about energy efficiency need to be made by literally millions of individual consumers or households, and the government is limited to adopting policies that may encourage these millions to take the right decisions. Such policies are frequently unpopular, and are vulnerable to procrastination. Similarly, photovoltaic solar installations are mostly very small scale and also require investment decisions from a large number of private investors. Nuclear energy is at the opposite extreme: it is a technology that requires centralized decision making and control, careful institution-building, and justifies securitization. In this respect, it is very well adapted to regimes where decision-making is strongly centralized, and in turn it helps to justify the centralization of power. Hence nuclear energy is not very well suited to democratic regimes where power is distributed and public acceptance is paramount, but is very well suited to regimes – democratic or authoritarian – where power is concentrated and whoever holds it enjoys a considerable degree of autonomy with respect to public opinion.

'… NUCLEAR WORKS EVEN BETTER FOR A COMBINATION OF DESALINATION AND POWER GENERATION FOR BASE LOAD.'

This point is also likely to be paramount when considering the country's international relations. There is a way of thinking that tends to present interest in nuclear energy as necessarily a cover or preliminary for an eventual attempt to acquire nuclear weapons. This attitude has hindered the uptake of nuclear energy around the world and is fundamentally flawed. Surely, in the face of the almost total bankruptcy of the non-proliferation regime, the temptation for non-nuclear weapon countries to acquire weapons capability is growing – but the correct response is to re-establish the credibility of the Non-Proliferation of Nuclear Weapons Treaty (NPT), not to hinder the uptake of peaceful nuclear technology.

At the same time, a regime considering the acquiring of a nuclear energy component, possibly including some eventual enrichment and reprocessing capability, knows very well that if it goes ahead, its own stability becomes much more important to the rest of the world, and it will see this as a welcome by-product. To all sorcerers' apprentices who still argue that the Saudi monarchy is part of the problem, not of the solution, the consideration that the country will have significant access to nuclear technology in the future may be quite sobering. The Kingdom's decision makers surely take this into account.

The author's most recent book
The Political Economy of Energy Reform: the Clean Energy – Fossil Fuel Balance in the Gulf States *(co-edited with R. Ferroukhi) was published in March 2014. He further discusses the challenges of nuclear power in his chapter 'The Political Economy of Gulf Energy Reform'.*