Energy Sustainability in the Gulf States: The Why and the How

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March 2013

MEP 4

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The author thanks Bassam Fattouh, Jonathan Stern, David Robinson, Lavan Mahadeva, and William Yong for their helpful comments on earlier drafts of this paper; Christian Bruhn for his help and comments on the logarithms drawn up for this paper; as well as a number of unnamed friends, the discussion with whom has proven invaluable for this research. All remaining errors are the author's.

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ISBN 978-1-907555-70-1

Abstract

For many decades, the Gulf states' significant oil reserves have rendered the region among the most important energy suppliers in the world, and there is similar potential for the region's natural gas reserves. However, the Gulf states' rapidly rising regional consumption has begun to play a critical role in the region's future export prospects, including the size and longevity of domestic oil and gas production, both for domestic and export market supply. This paper aims to discuss the current and future challenges evolving from the Gulf region's growing domestic energy use, coupled to its continued, almost exclusive, reliance on oil and natural gas, on the region's future export potential, as well as the security of its domestic energy supplies. It suggests that only a more proactive Gulf policy response to rising domestic energy consumption can help safeguard the stability of the Gulf's role as a global energy supplier as well as its domestic long-term energy security; such a policy response would include the diversification of the region's energy base and the effective management of domestic demand.

1. INTRODUCTION

For many decades, the significant oil reserves of the Gulf region[1] have rendered the region among the most important energy suppliers in the world. Similarly vast natural gas reserves suggest a potential future Gulf role as a major regional and global supplier of gas – at least in principle. It is, however, the rapidly rising regional consumption of the Gulf states which is drawing increasingly on the region's future energy prospects, affecting confidence in the security of Gulf oil and gas exports and its domestic long-term energy supply. Slowly but surely, the Gulf is moving away from being primarily a supply centre for global energy markets, turning instead into a major demand growth market for energy.

The Gulf states' growing energy demand is not yet a cause for crisis, for the region's oil and natural gas reserves are still – in most cases – plentiful and allow the region to leverage for its domestic energy supply on the available domestically produced fossil fuels. The implications of unabated domestic demand growth, coupled to the continued primary reliance on regional oil and natural gas resources, however, could severely impact the economic future of the Gulf in what would undoubtedly be a negative manner. At the level of exports: the growing draw on domestic oil and gas production for domestic consumption will gradually diminish the region's energy exports if no measures are taken to diversify domestic supply sources while also managing domestic demand; the losses in revenues resulting from growing domestic consumption of regional fossil fuel resources would be substantial, in view of the region's low domestic market prices for energy, at a fraction of export prices. At the same time, a more rapid depletion of domestic oil and gas reserves – following production increases now and in the future in response to growing Gulf demand – threatens to deprive future Gulf generations of the region's most valuable natural resource. Both implications promise wider, negative ramifications for the region's long-term socio-economic stability.

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[1] The Gulf region in this paper comprises the six members of the Gulf Cooperation Council (GCC) – Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) – plus Iraq and Iran.

This paper aims to discuss the current and future challenges evolving from the Gulf region's growing domestic energy use, coupled to its continued, almost exclusive, reliance on oil and natural gas, on the region's future export potential, as well as the security of its domestic energy supplies – the *ability of governments to ensure the long-term supply of domestic markets with reliable, stably sourced and affordable energy*. It ties this question of domestic energy security in the Gulf states intrinsically to the sustainability of its use of domestic oil and gas resources, reinforcing the region's ability to meet its *energy needs of the present without compromising the ability to meet those of the future.*[2]

The paper begins by reviewing the history of the Gulf region's energy demand growth, and includes different underlying causes (Section 2). It then looks at the current energy reserve base and different depletion scenarios (Section 3); the separate problem of maintaining sufficient yet sustainable investment in existing energy sources, particularly natural gas (Section 4); followed by a discussion of the whys and hows of increasing regional energy imports (Section 5). Finally, it discusses options of diversifying the region's energy mix, through greater reliance on renewables and – in some cases – nuclear power (Section 6).

2. GULF ENERGY CONSUMPTION IN PERSPECTIVE

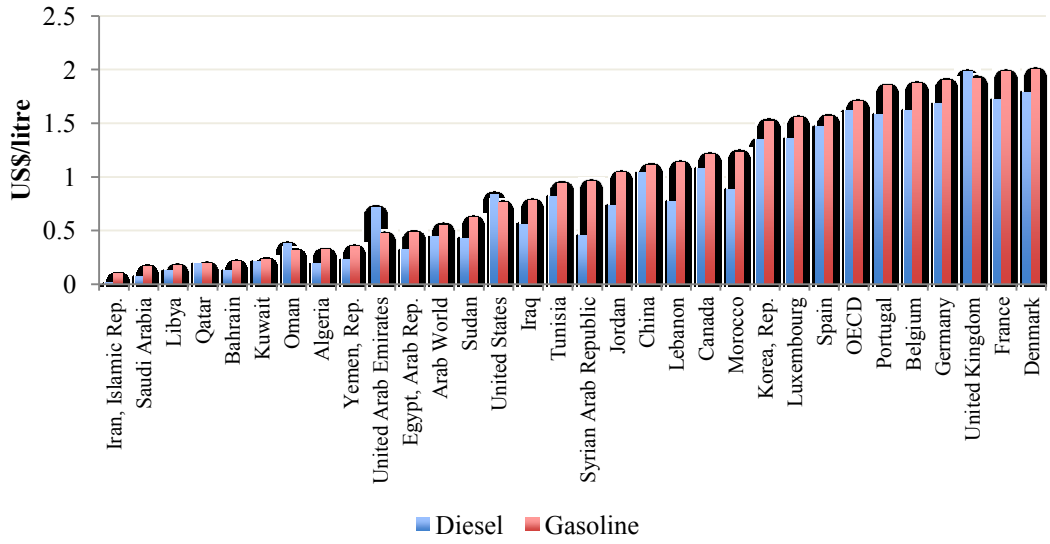
That the Gulf region, over recent decades, stood at the margins of demand-focused attention has, to a large extent, been due to the Middle East's historically small role as an energy consumer – one whose energy needs were entirely met by its own low-cost supplies of oil, and to some extent gas. With a relatively small population in comparison with the traditional major demand markets of Europe, Eurasia, and North America, as well as with the newly emerging demand markets of south and east Asia, during the 1980s and 1990s the Middle East was barely expected to lead any trend in regional demand growth. The region's slow per capita income growth since the late 1970s – standing in stark contrast with that of east Asia's tiger economies during the 1980s and early 1990s – would have done little to predict the region's stellar energy demand growth over this period of time.[3]

Part of an explanation for the Gulf states' relentlessly growing demand for energy comes from their industrial structures. The availability of low-cost hydrocarbon resources, primarily oil but more recently natural gas, has precipitated a series of national policies aimed at diversifying the Gulf's economies towards energy-intensive industries, such as steel, aluminium, and petrochemicals. While successful in boosting value-added output in their national energy sectors, these industries are large energy consumers in proportion to the Gulf states' predominantly small populations – which also explains, to a certain extent, the region's generally high per capita consumption rates for both primary and secondary energy.[4] Meanwhile, the Gulf states' population has more than doubled since the 1980s – due to substantial labour migration flows that have poured into the region since the 1960s – accompanied by a dramatic rise in living standards across the entire region.[5]

Implicit to the supply of the Middle East's domestic markets with local, low-cost hydrocarbon production, has been a historical pricing environment for domestically used energy that can well be seen as being amongst the lowest in the world (see Figure 1 for transport fuels). Gulf oil producers feature among the lowest-price suppliers in various energy price comparisons, indicating a substantial gap between prices paid by energy consumers in the Middle East and in most other parts of the world.

[2] WCED (1987, Point 49).
[3] See Fattouh and El-Katiri (2012b, 20–3).
[4] The four Gulf emirates Qatar, Kuwait, the UAE, and Bahrain display among the highest rates of per capita primary energy consumption in the world, ranging from nearly 9,000 kg of oil equivalent (Bahrain) to over 17,000 kgoe (Qatar). In all four cases, per capita energy and electricity consumption growth has surpassed both population and per capita GDP growth over the past 30 years. Fattouh and El-Katiri (2012a, 280).
[5] World Bank (2012).

Figure 1: Average Retail Prices for Gasoline and Diesel in Selected Countries (US$/litre), 2010



Source: World Bank (2012)

The implications of domestic pricing on energy demand in the Gulf have been significant: low prices for energy have encouraged industrialization into energy-intensive industries, underlining the competitive price-advantage in Gulf downstream production; the Gulf states have singled out domestically produced hydrocarbons above all other sources of energy for their sheer price advantage; and for many decades traditional pricing practices have shielded the Gulf economies from price swings in oil and natural gas supplies, which have shaped long-term demand responses in the shape of declining demand growth and moves to alternative energies seen elsewhere.[6] At the same time, the Gulf states' low domestic pricing environment for energy has had many, initially unintended, consequences: a rapid rise in residential and commercial energy consumption (particularly of electricity and transport fuel) resulting from the lack of price incentives to conserve energy; the Gulf's states' high rate of technical losses and low rates of energy efficiency, by all international comparisons, in the absence of incentives for industry to invest in energy-efficiency measures.[7] Low-cost energy – in the form of electricity, petrol, and other fuels – is, today, frequently perceived as a Gulf citizen's birthright, reflecting a largely distorted cost–price relationship behind energy supplies throughout the region.

This intricate relationship between demand, supply, and pricing stands at the centre of the Gulf states' growing energy demand over the past decades. Starting from relatively low demand figures during the 1960s and 1970s, when domestic energy markets in the region were relatively underdeveloped outside Iran and Iraq, the Gulf region's consumption has nearly doubled in each subsequent decade, rising five-fold since the 1980s.[8] If 'the Gulf' was

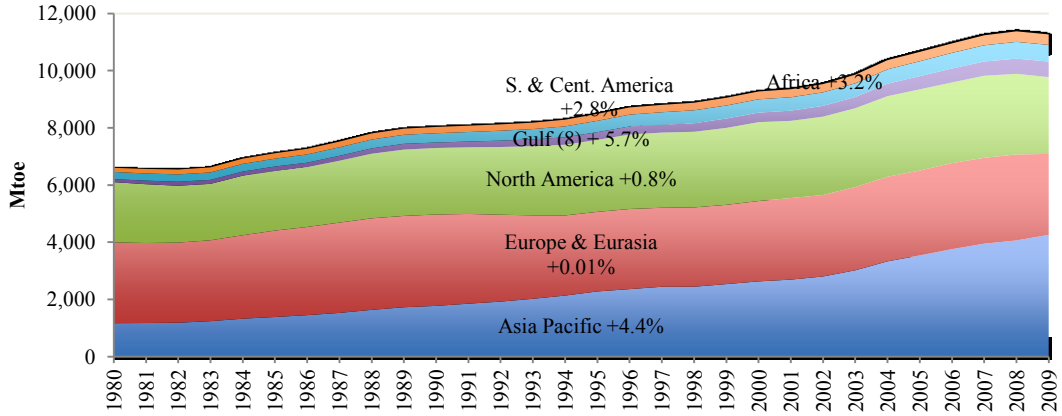
[6] Mati (2008) shows 2006/2007 pass-through rates for domestic fuel prices for several world regions. The Middle East's pass-through rates are the lowest in the world, owing to mostly static domestic fuel prices, which insulate domestic energy markets from price developments on world markets. The IEA's future energy demand scenarios depend in part on heavy-subsidy regions' reductions in domestic fossil fuel subsidies. For instance, see IEA (2012a, 57).

[7] Fattouh and El-Katiri (2012a, 24–36).

[8] A look at Table 8 in Appendix D shows Gulf primary energy demand rose most quickly during the 1970s and thereafter rose at high but declining growth rates in each subsequent decade.

a specific world region, it would have been the world's fastest growing energy market over the last 30 year-period (see Figure 2).[9]

Figure 2: Primary Energy Consumption by Region with 30-Year Compound Annual Growth Rate (CAGR), 1980–2009



Source: BP (2012), World Bank (2012), author's calculations

Shifting Roles for Oil and Natural Gas

Petroleum and petroleum products have, for a long time, been the principal source of energy for the Gulf states, for use in energy-intensive industry such as petrochemicals and fertilizer production, as the main fuel for power generation, and for use in the region's transport sector. The low production cost of Gulf crude oil reserves, coupled to its plentiful availability, rendered oil a logical, and under most perceptions low-cost, energy source for domestic consumption and for the development of the Gulf's own industries, in addition to its value as an export product. The gradual rise in oil prices on international markets, and the Gulf states' own rapidly rising levels of domestic consumption, however, have increasingly changed this perception of oil and its best possible use, from the Gulf economies' point of view. The real cost – in the form of foregone export revenues – of burning crude oil and petroleum products domestically in industry, power generation, and the transport sector has become blatantly high in the Gulf, particularly where alternatives with a lower opportunity cost than oil are available.[10]

The region's natural gas consumption has therefore been rising faster over the last decade than has been the case anywhere else in the world (see Table 1 and Table 8 in Appendix C for disaggregated 10-year data by region). Natural gas, originally produced as a by-product during the process of oil production, has over the past decades also been increasingly produced in non-associated form, to help Gulf producers substitute oil with natural gas, and hence free more valuable oil for export. Total Gulf gas consumption has more than doubled over the last ten years. Saudi Arabia and Iran were the region's largest natural gas consumers, with a rapidly rising share in natural gas consumption by the two countries' power sectors and their industries.[11] The UAE, Bahrain, Qatar, and Oman rely on natural gas for close to 100 per cent of their domestic power generation.[12]

[9] Only over the last ten years, throughout the 2000s, did Asian demand growth begin to exceed demand growth in the Gulf states. Regional aggregated data can be found in Table 7 in Appendix C.
[10] For a detailed discussion, see Fattouh and El-Katiri (2012). For a discussion of the Saudi Arabian context, see Fattouh (2011).
[11] According to Saudi Arabia's Electricity and Cogeneration Regulatory Authority, the Kingdom's gas consumption for power generation between 2000 and 2009 grew by 94% to reach 22.1mn cubic metres/d. Kiyasseh (2012).
[12] UAE: ADWEC (2008–10).

Table 1: Energy Consumption by Type of Energy in the Gulf Economies, 2000–10

	Oil ('000 b/d)*		Natural Gas (Bcm)		Electricity (GWh)	
	2010	*CAGR 2000–10*	*2010*	*CAGR 2000–10*	*2009*	*CAGR 2000–9*
Bahrain	47	6.6%	12	3.4%	10,777	6.5%
Kuwait	354	2.7%	15	7.0%	46,601	4.9%
Oman	106	6.6%	18	10.8%	15,524	7.4%
Qatar	152	11.0%	22	8.2%	23,041	10.5%
Saudi Arabia	2,650	5.1%	88	5.3%	199,117	5.5%
UAE	546	4.7%	61	6.2%	79,544	7.5%
Iran	1,800	3.4%	145	7.9%	163,645	4.9%
Iraq	694	3.8%	1	–7.0%	33,223	1.3%
Total Gulf (8)	**6,349**	**4.4%**	**360**	**6.7%**	**571,472**	**5.4%**
World	87,439	1.2%	3,216	2.5%	18,390,440	2.7%

Notes: *Includes crude oil and imported petroleum products consumption.

Source: EIA (oil); Cedigaz (natural gas); World Bank (electricity); author's own calculations (CAGR)

Oil and natural gas remain the Gulf's only significant source of energy so far; renewables account for less than 1 per cent of overall energy supply, with no use of coal or nuclear power in the region as yet. In part, these circumstances explain why the Gulf has grown to be a far from insignificant oil and gas consumer in absolute terms. With less than a third of Latin America's population, the Gulf states today consume more oil and more than double the amount of natural gas consumed in Latin America (see Table 8 in Appendix C) – which hints at some of the world's highest per capita energy consumption rates in the world.[13]

Saudi Arabia, with some 2.9 mbpd of oil consumption, was the world's sixth largest crude oil consumer in 2011, consuming as much as one quarter of its own production domestically.[14] In 2010, the Kingdom's rapidly rising domestic oil consumption prompted Saudi Aramco CEO Khalid Al-Falih to raise public concerns over his country's future export potential for crude oil, suggesting Saudi crude oil exports could fall by as much as 3 million b/d by 2028 should domestic crude oil consumption grow at unabated rates much into the future.[15] A recent Chatham House paper that includes a simulation of Saudi Arabia's demand outlook based on current demand growth rates concludes that Saudi Arabia could cease to be an exporter of oil by 2038 under a business-as-usual scenario;[16] while a Citibank report suggests that the Kingdom could become a net importer of oil as early as 2030.[17]

Iran's current energy situation is already more severe than that of Saudi Arabia. As the world's fourth largest oil and natural gas producer, which alone holds more than a tenth of world oil and more than a sixth of global natural gas reserves, Iran consumed nearly half of its

[13] Fattouh and El-Katiri (2012a).
[14] Numbers from EIA (2012a).
[15] The Kingdom at the time burnt as much as 1mn b/d in summer in power plants, out of a total production of some 8–8.5mn b/d in 2010. Financial Times (2010). See also Fattouh and El-Katiri (2012b).
[16] Lahn and Stevens (2011).
[17] Bloomberg (2012).

own oil production domestically in 2011, and has been a net natural gas importer since the 1990s.[18] Natural gas shortages, both in Iran and Saudi Arabia, have also affected the development of additional crude oil resources; natural gas is a critical input factor used for Enhanced Oil Recovery (EOR) in the Gulf's maturing oil fields. Both countries have been affected by gas shortages within the sector, reflecting growing competition between different economic sectors (power production, petrochemicals and other energy-intensive industries, and the upstream sector) for first priority allocation of existing production of natural gas. This has resulted in production declines rather than increases in Iranian oil fields,[19] and delays in planned production expansion on the Saudi side.[20]

3. GULF OIL AND GAS RESERVES IN PERSPECTIVE

The Gulf's increasing call on its own energy reserves does raise questions, and not just about immediate production bottlenecks; it also provides a context in which to revisit the question of how durable Gulf oil and gas resources are expected to be, and whether current regional consumption patterns could threaten conventional understanding of the longevity of Gulf oil and gas reserves, assuming no policy and consumption changes crystallize over the coming years or decades. This question is not only of immense importance for the region's long-term role as a primary energy supplier for international markets – where the Gulf's reserve outlook is of fundamental importance to long-term projections of energy supply security – it is also of enormous consequence for future generations of Gulf citizens, for whom oil and natural gas reserves constitute their most important form of capital stock.[21]

A word of advice here: there is no reason to return to age-old debates surrounding a looming depletion of the Gulf's oil and natural gas reserves, as advocated by followers of 'peak oil'[22] theory, and its corresponding gas-market equivalent, of 'peak gas'.[23] Gulf aggregate oil and natural gas reserves, as reported by EIA and its peers, suggest a continuing and plentiful hydrocarbon resource base, a matter reflected in the Gulf's – and the Middle East's – continuing pivotal role as a long-standing key hydrocarbon reserve holder and producer. Oil remains the region's most important energy resource, followed by its natural gas reserves. In 2011, the eight Gulf states – Saudi Arabia, Iran, Iraq, Kuwait, the UAE, Qatar, Oman, and Bahrain – together held just over 789 billion barrels of oil, some 48 per cent of proven world crude oil reserves. Their combined exports account for 40 per cent of traded world crude oil, more than any other producing region.[24]

The region contains several large reserve holders of crude oil – mainly Saudi Arabia, Iran, Iraq, Kuwait, and the UAE. Saudi Arabia alone had proved reserves amounting to 267 billion barrels in 2012, representing the world's largest crude oil reserves, some 16 per cent of world's total.[25] The Gulf's three largest reserve holders – Saudi Arabia, Iran, and Iraq –

[18] According to EIA statistics, in 2011 Iran produced 4.234 mbpd and consumed 2.028 mbpd. EIA (2012a).
[19] EIA (2012b).
[20] For instance, it had been planned that the Neutral Zone, whose output is shared between Saudi Arabia and Kuwait, would see a considerable boost in its production. Final investment decisions have been delayed, however, owing amongst other things to lack of natural gas availability in both Saudi Arabia and Kuwait for the reinjection schemes envisaged for the area. Energy Compass (2012a).
[21] There are good reasons to regard the consumption of non-renewable resource revenues as the consumption of *capital* rather than the consumption of *income*. If all revenues are consumed, the economy's total capital stock declines (Humphreys et al. (2007); Stiglitz (1974)).
[22] For a small sample of the economic basis literature, see Abelson (1974); Attarian (2002); Henderson (1979); Hubbert (1962); Hubbert (1981); Kerr (1984); Hirsh, Besdek and Wending (2005); Nehring (1982); Warman (1972).
[23] The 'peak gas' debate began much later and has, so far, produced fewer works than has been the case for 'peak oil', which by now entertains something of an industry by and of itself. For literature around 'peak gas', see for instance Aleklett and Campbell (2003); Bakhtiari (2001); Naill (1973).
[24] EIA (2012a).
[25] EIA (2012a).

combined hold more than a third of proven world oil reserves, illustrating the enormous concentration of resources within the region.[26] The region's long-term importance as a crude oil exporter stems not only from its size but also from the quality of its reserves, and on historically low levels of domestic demand for oil. Gulf oil reserves are conventional – in contrast to North America's recent high-profile reserve additions for example – which enables the region to be cost-competitive with most other oil reserves in the world. Historically low domestic consumption rates have allowed the region to gain dominance on global trade markets, as well as the ability to dominate the market for functioning critical spare oil capacity – primarily in Saudi Arabia but to a lesser extent in the UAE and Kuwait.[27]

The Gulf also holds significant reserves of natural gas – some 79 Tcm at the end of 2011 – around 38 per cent of proved world gas reserves, although the region's total production of a mere 500 Bcm/a, a sixth of the world's total, does not match its importance on global oil markets.[28] Nor is the Gulf region a large natural gas exporter – with the exception of Qatar (which accounts for more than 80 per cent of aggregate regional gas exports) most Gulf gas reserves are consumed domestically, with additional imports being required in the cases of Iran, the UAE, and Kuwait.[29] Natural gas has historically played a secondary role to oil; its discoveries, including that of Qatar's giant North Field (today the world's single largest non-associated natural gas field) initially triggered disappointment where crude oil reserves had been expected.[30] In reality, natural gas has proved to be something of an economic blessing to the region, despite its under-utilized potential in view of the region's comparably modest production rates. In Qatar today, natural gas exports generate more revenues than do oil exports, saving the micro-state from a previously anticipated decline in export revenues, alongside its declining oil reserve rates.[31]

A distinguishing feature of both Gulf oil and natural gas reserves vis-à-vis those of other regions is the longevity of the region's expected aggregate supply horizon. Table 4 and Table 5 in Appendix A show regional and individual country Reserve-to Production (R/P) ratios, which indicate the number of years at which current production can be maintained, assuming no new reserves are added and production remains at present levels. The region's aggregate R/P ratio for oil has remained relatively constant for the past ten years, despite a slight downward trend owing to significant production increases in the Gulf over the same period of time. At a currently estimated reserve life of 80 years, the region is expected to produce oil comfortably into the next century at current rates of production. It is estimated that currently known conventional Gulf reserves of natural gas will last for at least 157 years at current production, and substantially longer for some of the region's largest reserve holders – Iran, Iraq, and Qatar.

Particularly in relation to the region's oil reserves, the substantial crude reserve additions, mainly during the 1980s, by the large oil producers Saudi Arabia, Kuwait, and the UAE (shown in Table 4, Appendix A) have, in the past, been met by critical voices doubting the accuracy of these figures.[32] During the 2000s, an official parliamentary enquiry in Kuwait followed the publication of a *Petroleum Intelligence Weekly* report about the reserve estimates, which supposedly stand at less than half the levels officially stated. The report

[26] Shares for 2011 based on BP (2012).
[27] E.g. see Fattouh (2010).
[28] Calculation of shares based on EIA (2012a).
[29] The Gulf's total contribution to world traded gas in 2011 amounted to 14%, or 4.9 Tcf, 80% of which is accounted for by Qatar. Calculation of shares based on EIA (2012a). See Section 5 below for a more detailed discussion.
[30] Flower (2011).
[31] The respective shares in government revenues are available at World Bank (2012).
[32] Amongst others, Iranian, Iraqi, and Saudi Arabian officials have in the past accused each other of inflating their reserve figures. These accusations have also formed part of wider intra-regional disputes over shared, or bordering, reserves for instance Iraq's claim under Saddam Hussein that Kuwait 'stole' Iraqi crude, or between Iran and Qatar around the two countries' shared giant North Field/South Pars from which Qatar produces.

referred to issues in Gulf oil reserve accounting, including many OPEC producers' practice of publishing only opaque official reserve numbers that 'do not distinguish between proven, probable and possible reserves.'[33] Similar doubts relating to the reliability of Saudi reserve numbers have been stirred up by Matthew Simmon's controversial study of the Kingdom's reserves in 2006.[34]

Even in the absence of reserve uncertainty, Gulf oil and gas reserves are subject to considerable changes in their production outlook in relation to current and future plans to expand, rather than predominantly maintain, current output. The past ten years of Gulf oil and gas production have seen tremendous production increases, particularly in natural gas; further large increases in the region's oil and gas production are planned (primarily by its large producers Saudi Arabia, Iraq, Iran, Kuwait, and the UAE) in response to both rising international demand, in the case of oil, and growing domestic demand, in the case of natural gas.[35] Initial proposals, unrealistic as these targets were – such as that by Iraq to raise the country's production capacity from its 2011 level of 2.6 mbpd up to 12 mbpd by 2020 – underline the threat that current policy objectives could supersede long-term interests such as sustainable long-term management of reserves in oil producing countries.[36] A simple calculation of a semi-dynamic R/P ratio for the region illustrating this effect is presented in Table 9 and Table 10 in Appendix E.

A different kind of challenge confronts those Gulf oil and natural gas producers whose significantly smaller oil and gas reserves already dictate the pace of current resource depletion rates in their countries. Qatar's oil reserves are, at 24 billion barrels, considerably smaller than those of some of its Gulf neighbours, and falling production means that natural gas, rather than oil, has become the country's most important export commodity. Even smaller are the oil and natural gas reserves of Oman and Bahrain. With a mere 120 million barrels of recoverable oil, and less than 0.3 Tcm of natural gas reserves left, Bahrain in particular faces the depletion of its hydrocarbon resources within a few decades at most. The island state is likely to continue to receive crude oil produced from the Abu Safah field (shared with Saudi Arabia as part of a long-term agreement between the two states) which will save Bahrain from effectively 'running out' of crude oil any time soon, but this option is not available in the case of natural gas.[37] Oman similarly faces a tightening resource base, serving existing long-term natural gas export contracts at the cost of importing small volumes of natural gas from Qatar during the summer to overcome the increasing gap between production and the sum of exports and consumption in Oman's domestic gas market, while the country is increasingly reluctant to burn its declining oil production in domestic industries.[38]

[33] PIW (2006a). For a detailed discussion of Kuwait's reserve accounting, see PIW (2006b). See also MEES (2007).
[34] Simmons (2006).
[35] Saudi Arabia, during the late 2000s, increased its production capacity, though not its gross production, to 12.5 mbpd, up from the previous figure of 10 mbpd. Kuwait has had plans to raise production capacity from around 3 mbpd during the late 2000s to 4 mbpd by 2020. Iran, currently hindered by sanctions in pursuing its ambitious production targets, had planned production rates for crude oil of 4.5 mbpd by 2010 (not achieved) and 5 mbpd by 2015. Iraqi decision-makers initially planned a crude oil output target of 12 mbpd, later informally adjusted to 10 mbpd. Informally, the most widely expected output target by 2020 looks to be some 6 mbpd, significantly less than initially planned. Energy Compass (2012b); Interviews conducted by the author with Iraqi decision makers, September 2012.
[36] For a full discussion of the Iraqi production outlook and government plans, see IEA (2012b).
[37] The Abu Safah field is located between the two countries' boundaries; production has been shared between Saudi Arabia and Bahrain, with Saudi Arabia producing the oil and sending Bahrain's share via a subsea pipeline to the island state.
[38] Ledesma (2011).

4. INVESTMENT CHALLENGES

The continued need to invest in existing and new production capacity, to serve both domestic and international markets, is a challenge faced by the Middle East and other producing regions. The structural long-term challenge of deciding how fast and by how much to react to changes in market consumption patterns has affected the Gulf states and other producing regions in similar ways, in relation to investment choices into their domestic energy sectors.[39] However, the paradox of the region's shortage of natural gas supplies, associated with that of electricity, in the presence of what are in principle sufficient natural gas reserves, remains. And while there may be good reasons why natural resources are left undeveloped for a time, the Gulf states' continued expensive reliance on oil as the only available substitute for natural gas suggests that the use of its gas reserves to replace oil in domestic consumption should be a fundamental policy objective in and of itself.

The Gulf states' natural gas sectors differ in several important respects from oil, which explains the fundamentally different investment dynamics within the two sectors. The majority of Gulf gas reserves are held in associated form with oil, and were for a long time neglected and flared rather than captured and processed. Iraq remains, so far, the most under-explored part of the Gulf for natural gas, having developed no capturing systems, and continuing to flare most of its natural gas production.[40] Associated gas carries an important regulatory disadvantage in the Gulf, for the production of associated gas is tied to production schedules for oil, limited in most Gulf states, at least in theory, by OPEC quotas.[41]

The biggest hopes for increased production are hence tied to Gulf gas production from non-associated gas fields, and indeed their role in boosting regional gas production has been growing significantly during the 2000s. The majority of the region's most important current and future development projects in gas are therefore to be found in non-associated gas fields, such as South Pars in Iran, Saudi Arabia's Karan field, and Abu Dhabi's Shah and Bab field developments. The majority of the Gulf's non-associated gas resources are sour gas reserves, some of which are furthermore found in technically complex reservoir environments, rendering Gulf gas reserves considerably more difficult, and more costly to develop, than the region's oil reserves. Oman and Saudi Arabia are currently exploring unconventional gas resources, including tight- and deep-sea gas reserves, adding further complexity to their field development.[42]

Policy objectives to develop non-associated gas to serve domestic markets – as in Kuwait, the UAE, and Saudi Arabia – have rendered the investment process more difficult. With domestic markets as the target, it is domestic Gulf prices for natural gas, rather than international export prices, which determine the commercial feasibility of company investments into the region's gas reserves. Domestic market prices at around $1.50/MMBtu across the Gulf constitute a mere a fraction of the expected investment cost for non-associated sour gas reserves, which is in the range of $5–6/MMBtu. While this expected investment cost is below the development cost for unconventional resources in other parts of the world, the Gulf states' domestic pricing framework sets a low ceiling for investment returns from development projects, a particularly painful truth for international oil and gas companies.[43] Unattractive

[39] For a thorough discussion, see Fattouh and Mabro (2006).
[40] Different estimates have put Iraq's natural gas reserves potential at between 7.3 Tcm and 10.6 Tcm. The IEA's most recent estimate is 7.3 Tcm, 30% of which is thought to consist of non-associated gas, other authors such as Yacoub and Rutledge suggest reserves of up to 10.6 Tcm. IEA (2012b, 69); Yacoub and Rutledge (2011).
[41] Only Oman and Bahrain are not OPEC members.
[42] IOD (2012b); Times of Oman (2011).
[43] See Fattouh and Stern (2011).

development projects which are not expected to recover their initial investment costs have delayed investment into the Gulf gas sector – this includes projects already underway.[44]

Political indecision and a series of deadlocks have also contributed significantly to the delay of Gulf gas investment. Controversies include: the involvement of foreign oil and gas companies in upstream gas operations, for example, in Kuwait and Saudi Arabia; the financial terms to be offered to contractors, for example in Abu Dhabi and Oman; and the use of gas production within domestic markets for reinjection, power production, or other industries on the one hand, or for exports on the other, for example, in Iran.[45] Long-term parliamentary stalemate and governmental changes in Kuwait have now led to the shelving of 'Project Kuwait' which, in the late 1990s, had been intended to boost the country's non-associated gas production with the help of foreign companies; the policy of instead importing LNG via contracts with Shell and Vitol since 2010 has, by contrast has gained political acceptance, despite respectively higher costs than for the development of domestic resources.[46] Sanctions and domestic conflict, such as has been seen in Iraq and Iran since the 1980s, have further delayed and at times prevented much-needed investment into domestic gas reserves.[47]

Investment delays in the region's natural gas sector, together with their consequences, have shown very visibly throughout the Gulf. Despite sizeable reserves the region, apart from Qatar's contribution, has shown little sign of any imminent role as a major new supplier of natural gas, be it for domestic use or for exports to international markets. Lacking gas as a fuel for power generation has led to the type of leveraging on crude oil burning for peak power that has led above-mentioned analysts to forecast a looming self-consumption of Gulf oil reserves in the future, should demand continue to grow unabated.[48] In the absence of alternative fuels, natural gas shortages have resulted in structural underinvestment in new power generation capacity, leading to recurring power shortages in a region supposedly immune to domestic energy supply disruptions.[49] Natural gas has also been lacking in

[44] Project delays, such as that affecting Abu Dhabi's high-profile Shah-gas development in the late 2000s, are primarily blamed on the lack of commercial feasibility in the eyes of Abu Dhabi's initial development partner ConocoPhillips, now replaced by Occidental at similar contract terms. The compensation per MMBtu produced under Abu Dhabi's Shah gas field deal, for instance, was said to have been placed at $1.50/MMBtu for Occidental, Abu Dhabi's contracted development partner. This agreement follows a previous deal between ADNOC and Conoco-Phillips; the latter organization withdrew from the project at the last minute, due to what Conoco considered to be unrealistic profit margins. Personal interviews by the author with involved parties, August 2012. For a summary of Abu Dhabi's Shah gas woes, see IOD (2011c).

[45] Razavi (2009).

[46] Kuwait's original plans in 1997 were to develop its northern gas fields, with the involvement of IOCs, a proposition later blocked by parliament. A more recent agreement with Shell to develop some of the resources under an Enhanced Technical Service Agreement (ETSA) has been subject to more delay following a 2011 parliamentary enquiry into the legitimacy of the award process. IOD (2011b).

[47] Iran's energy sector is at the heart of economic sectors currently targeted under US and EU sanctions. General international trade relations (including trade in technology, and energy sector inputs) is subject to UN sanctions through UNSCR 1737 (23 December 2006), UNSCR 1747 (March 2007), UNSCR 1803 (March 2008), and UNSCR 1929 (June 2010). The USA and EU additionally imposed sanctions against Iranian individuals, organizations, and Iran's Central Bank in 2011/2012, rendering investment or financial transactions with Iranian institutions currently sanctionable under US and EU law. For an overview of US and EU sanctions, see the US Treasury website at www.treasury.gov/resource-center/sanctions/Programs/pages/iran.aspx and the EU Commission's most recent report on EU sanctions against Iran: European Union (2012)

[48] Refer to fn 15 and 16.

[49] For example, see some recent reports: Business Maktoub (2010b); The National (2010); Business Maktoub (2009); Business Arabia (2009); Business Maktoub (2010a); The Saudi Gazette (2010); MEES (2012a). See also El-Katiri (2011, 11–12); Kombargi, Waterlander, Sarraf, and Sastry (2010).

upstream oil operations – such as EOR operations where gas is used as an essential feedstock.[50]

5. RISING ENERGY IMPORT DEPENDENCE

The Gulf states' rising energy consumption, coupled to slow domestic investment in new resources, has led to a rising volume in Gulf energy imports, primarily of natural gas and petroleum products. But while the import of petroleum products has been a long-term policy, driven in part by commercial decisions based on the lack of profits from refining back at home, natural gas imports are a relatively recent phenomenon, starting as late as the 1990s in Iran, and the late 2000s in parts of the GCC, in response to actual production shortages and expected future shortcomings, due to the domestic investment and production outlook. In particular, Kuwait's decision to import LNG, which came after Dubai's initial LNG terminal during the late 2000s, underlines the approach of most Gulf importers of initially being a stop-gap measure aimed at overcoming short-term gas shortages, which gradually became a permanent measure in the absence of a forecast of sufficient domestic production in the near future.

Currently, some 10 per cent of the Gulf states' natural gas demand is met by imports, the bulk of which is consumed by the UAE, followed by Iran, Kuwait, and Oman. The reliance of individual Gulf economies on imported natural gas is far more significant: the UAE imports more than a third of its aggregate gas needs; the emirate of Dubai itself, however, relies for nearly 90 per cent of its annual demand on imports (see Table 2 below). Dubai emirate has no other choice, for it holds no own significant natural gas or oil reserves; by contrast, Abu Dhabi, Kuwait and (not an importer) Saudi Arabia hold the option to leverage on crude oil and product supplies to compensate for domestic shortages in natural gas.

Table 2: Natural Gas Imports and Consumption, 2000–10

	Consumption (Bcm)		**CAGR**	**Imports (Bcm)**		**CAGR**	**% of Imports in Total Consumption**	
	2000	*2010*	*2000–10*	*2000*	*2010*	*2000–10*	*2000*	*2010*
Bahrain	8.5	12.3	3.4%	0	0	-	-	-
Kuwait	6.9	14.5	7.0%	0	2.8	-	-	19.2%
Oman	5.7	17.5	10.8%	0	1.9	-	-	10.8%
Qatar	9.2	21.8	8.2%	0	0	-	-	-
Saudi Arabia	49.8	87.7	5.3%	0	0	-	-	-
UAE	31.4	60.8	6.2%	4.4	22.9	16.2%	14.0%	37.7%
of which								
Abu Dhabi	20.6	38.1	5.8%	0.0	8.5	-	-	22.3%
Dubai	6.0	16.1	9.4%	4.4	14.4	11.4%	73.3%	89.3%
Iran	62.9	144.6	7.9%	2.7	10.6	13.2%	4.3%	7.3%
Iraq	2.9	1.3	-7.0%	0.0	0.0	-	-	-
Total Gulf (8)	**177.3**	**360.4**	**6.7%**	**7.1**	**38.2**	**16.5%**	**4.0%**	**10.6%**

Notes: Numbers for Oman, the UAE, and Iran are gross imports. Imports include some sport gas purchases by Kuwait, Dubai. *Source:* BP, Cedigaz

[50] Natural gas is the typical medium used for recycling and reinjection into existing producing fields to maintain or raise reservoir pressure. Producers with large, mature oil fields, such as Kuwait and Iran, face the dilemma of increased oil output targets but with insufficient levels of natural gas. This has delayed the achievement of output targets in both countries, as well as elsewhere within the region, for a number of years. For instance, see MEES (2011b); IOD (2012a).

Some Gulf gas importers are also gas exporters, mostly in consequence of ambitious export policies dating back, in part, to the 1970s when Abu Dhabi became the region's first liquefied natural gas (LNG) exporter.[51] Long-term contracts bind Abu Dhabi, Oman, and Iran to agreed export volumes. The UAE and Iran are net-importers, whilst Oman remains a net-exporter but relies on small volumes of Qatari gas to cover summer demand peaks. Iran is the region's most long-standing importer of natural gas, with its first imports dating back to 1997; the UAE and Oman followed, with the opening of the Dolphin pipeline from Qatar in 2008 and subsequent LNG import projects; Kuwait was next, with the completion of its LNG terminal in 2010.[52]

Commercially speaking, it must be assumed that the Gulf states make savings by importing natural gas, as this results in lower crude oil consumption and hence larger crude oil exports. Assuming that the supply security under such import agreements is guaranteed, natural gas – and potentially other alternative energy imports – provides an important second-best solution, in view of the available alternatives such as electricity blackouts or the burning of more valuable crude oil. At the same time, however, those Gulf states with their own domestic reserves are almost certain to pay a substantial premium for imports over the development of their own reserves, whose development costs – conservatively estimated at around $4–5/MMBtu for non-associated sour gas – compare likely favourably with international LNG prices seen during 2012 (probably beyond the $10/MMBtu range).[53] The absurdity of this situation appears more startling in view of the political unwillingness of many Gulf governments to compensate those same oil and gas companies that supply them with flexible LNG with what would be a far smaller, although above domestic pricing ceilings, fee for the development of their very own gas reserves.

Reflected in this absurdity is the Gulf states' high reliance on extra-regional supply sources. Despite the traditionally regional nature of natural gas trade, only about half of the Gulf's current natural gas imports originate within the region: Iran imports pipeline gas from neighbouring Azerbaijan and Turkmenistan, and more than 80 per cent of the UAE's imports are covered by pipeline gas from its GCC neighbour Qatar. The commercial price of regional pipeline imports remains, in most circumstances, considerably lower than that of more flexible LNG.[54] Political obstacles within the region have largely hampered past initiatives to further intra-regional energy trade – such as a GCC-wide natural gas pipeline grid transporting Qatari gas to other GCC neighbours, or pipeline exports from Iran to GCC neighbours.[55] Most new Gulf importers' dependence on more flexible LNG imports reflects this regional reality, ridding LNG importers from many political headaches associated with the dependence on energy supplies from neighbours. In turn, however, they expose Gulf LNG

[51] See Flower (2011).

[52] Iran has, since its first Turkmen imports in the 1990s, added Azerbaijan as a natural gas trading partner and receives all gas imports via pipeline. The UAE has, since 2008, diversified its supply sources of natural gas with an LNG terminal at Dubai (which received its first cargoes in 2011), and is currently building a second LNG regasification terminal at Fujeirah (owned by Abu Dhabi). Oman imports small amounts of pipeline gas from Qatar, Kuwait relies for 100% of its imports on LNG. See Table 6 in Appendix B for details.

[53] The author would like to thank Jonathan Stern for pointing this out.

[54] In the cases of Kuwait and Abu Dhabi, expensive LNG imports have been contracted under international pricing frameworks that link LNG prices to oil, translating into a cost price range of around $10/MMBtu since the late 2000s. The same outlook includes Bahrain for its planned LNG imports after 2014. The only regional example of a fixed price agreement for gas imports is coupled to Qatar's pipeline exports to the UAE and Oman under Dolphin Energy's supply contracts. Dolphin gas exports are linked to a base price of between $1.25 and $1.35/MMBtu (c.i.f., subject to an annual escalation), a price which is a multiple below the current costs of the LNG imports of Dubai and Kuwait. Dargin (2008).

[55] On the failed GCC gas grid, see for instance, Hashimoto, Elass, and Eller (2004). One of the latest communications from the failed Iran–Sharjah gas export deal is from its ongoing arbitration case. MEES (2011a).

importers Kuwait, Dubai, Abu Dhabi and, presumably soon, Bahrain, to geopolitical supply risks such as a closure of the Straits of Hormuz, their most important energy trade route.[56]

Other Energy Imports

Has rising Gulf energy consumption driven up other energy imports? Lacking energy source diversification implies that the Gulf states rely on oil and natural gas for virtually all of the region's energy needs. While the region remains self-sufficient in crude oil supply, some petroleum product supplies were imported as early as during the 1970s. Unlike the case of natural gas, imports of petroleum products have historically been mostly the result of missing profits from refining, and hence profitability. Renewed Gulf interest in new refining capacity in recent years, especially in the large oil producers Saudi Arabia, Kuwait, and Abu Dhabi, does not necessarily reflect a reversal of this reality, but the economics of burning crude oil vis-à-vis products in the place of regionally short natural gas.

The Gulf region relies on imports of petroleum products for about 15 per cent of its consumption, while the UAE and Oman have considerably larger import shares (see

Table **3** below). Only Bahrain and, in the late 2000s, Kuwait did not import petroleum products.

Table 3: Refined Products Imports and Consumption, 1999–2009

	Refined Petroleum Consumption by Type ('000 b/d)		**CAGR**	**Imports of Refined Petroleum Products ('000 b/d)**		**CAGR**	**Share of Imports in Consumption**	
	2000	*2009*	*2000–9*	*2000*	*2009*	*2000–9*	*2000*	*2009*
Bahrain	23.3	45.0	6.8%	0	0	-	-	-
Kuwait	264.4	372.0	3.5%	10.0	0.0	-100.0%	3.8%	-
Oman	52.5	100.2	6.7%	4.1	33.1	23.4%	7.7%	33.1%
Qatar	48.2	135.4	10.9%	0	11.9	-	-	8.8%
Saudi Arabia	1,537.1	2,460.0	4.8%	0	160.1	-	-	6.5%
United Arab Emirates	330.5	524.6	4.7%	99.0	377.3	14.3%	30.0%	71.9%
Iran	1,248.3	1,770.0	3.6%	62.0	187.2	11.7%	5.0%	10.6%
Iraq	462.3	636.0	3.2%	26.0	144.1	18.7%	5.6%	22.7%
Total Gulf (8)	**3,966.6**	**6,043.2**	**4.3%**	**201.1**	**913.9**	**16.3%**	**5.1%**	**15.1%**

Source: EIA (2012a)

Petroleum product imports, once more, exemplify the pivotal problem faced by many Gulf states in relation to their domestic pricing framework. In Summer 2011, the UAE encountered recurring, sporadic, small-scale supply disruptions at petrol stations across the northern emirates.[57] Although initially blamed on maintenance operations, Emirates National Oil Co. (ENOC), one of the UAE's product suppliers, soon shed light on the disruptions. ENOC, like

[56] For an assessment of the risk, see El-Katiri and Fattouh (2012).
[57] IOD (2011a).

other public fuel providers in the UAE and other Gulf countries, buys petroleum products such as gasoline on international markets at market prices, but needs to sell its products at domestically regulated prices, which, according to the company, are a multiple below price levels that would enable fuel suppliers to make profits.[58]

The supposed 'gasoline crisis'[59] in the UAE's petroleum product sector is hence not the consequence of import-related supply disruptions, but of the region's very own domestic pricing policies for imported products. The LNG imports of both the UAE and Kuwait involve a similar dilemma for LNG import companies, suggesting that more of the same domestic conflict over energy pricing is likely to follow, in the absence of a thorough review of these countries' domestic pricing policies.

6. ENERGY SOURCE DIVERSIFICATION OPTIONS

The depletability of the region's oil and gas resources in the long run – having such important consequences on the region's long-term export potential and its domestic energy security – increases the strategic incentives for the region to diversify its domestic energy mix. What options do the Gulf states have as alternatives to their traditional sources of energy supply – oil and natural gas? What challenges do they face in increasing the share of alternative energies in the region's energy mix? Two major options appear on the horizon: increasing investment in renewable forms of energy; and moving towards nuclear power. Nuclear power raises a number of separate security concerns, which is why it is discussed here in greater length.[60]

Renewables

The most common source of energy associated with sustainable energy policies is renewable energy. The Gulf region's geography suggests primarily solar power, but to a lesser extent wind and geothermal power could also be pursued. Renewables offer the Gulf a potential window of future supply security, coupled to positive effects along the economic value chain including the creation of high-technology jobs, and the provision of energy free from the continuing import dependencies entailed by other alternative energies such as nuclear, in addition to various environmental advantages. The first initiatives within the region – the notable examples of Abu Dhabi's Masdar City and Saudi Arabia's plans for the world's first solar-powered industrial desalination plant – have shown the viability of the relevant technology and have furthermore created a new value chain, including high-technology jobs for the local labour market.

In principle, renewables offer the Gulf many economic and strategic benefits. Renewables-fuelled power generation capacity can be built relatively quickly – a substantial advantage in comparison with the multi-year process of acquiring and constructing nuclear facilities. Renewables make use of existing geographical advantages, for example solar power can take advantage of the Gulf's sun-hours, which are comparably longer than those of many European countries where solar technology has to function with considerably fewer sun-hours per day. Demand can be covered at both base- and peak-load by renewables, offering a level of flexibility only fossil fuels otherwise afford.[61] Peak production from solar power,

[58] ENOC is wholly owned by Investment Corporation of Dubai (ICD), an investment arm of the government of Dubai. The company is run, in principle, as a commercial company, but its ownership structure forces ENOC to continue to buy and sell products in spite of making losses. ENOC released a statement in October 2011 explaining: 'The current scenario, where Enoc has to bear the burden of higher international fuel prices while at the same time distributing fuel at subsidized rates, is clearly not sustainable or viable for the company.' Hall (2011).

[59] Reflecting various media reporting at the time, e.g. Hamdan (2011).

[60] For a more detailed comment on the matter, see El-Katiri (2012).

[61] Nuclear power generation requires considerably longer times for starting and shutting down, rendering it preferable as a supplier of base load.

moreover, coincides conveniently with peak demand times, during those hours of intense summer sun when the use of air conditioning across the GCC and other parts of the Gulf peaks.

Many of these factors render renewables, above all, a potent short- and long-term solution for at least part of the Gulf states' future power sector energy needs. Renewables could in this way also help Gulf producers to re-prioritize their non-renewable oil and gas resources to those domestic industries that do not have alternative inputs, and create value-added to energy exports, for instance existing petrochemicals manufacturing. The use of solar power in Enhanced Oil Recovery emerges as another possible long-term option for the Gulf states,[62] offering these countries valuable long-term research – and hence skilled job opportunities – and the option to become frontrunners in the development of different types of energy technologies.

Currently, the share of renewables in the Gulf energy mix remains marginal, with no notable contribution at the time of writing. Many of the challenges faced by renewables in the Gulf resemble those in other parts of the world: their financial cost vis-à-vis traditional, mainly fossil fuels; their technological features, including the dependence of wind and solar technology on optimal climatic conditions; the relatively small-scale capacity additions which renewables offer at present, for instance in comparison to nuclear; and, perhaps most importantly, the lack of political interest in renewables vis-à-vis the more appealing nuclear power, on political grounds – quite in the contrary to more recent trends in Europe and North America.

The financial aspect of technologies such as solar in the Gulf region is, as elsewhere, crucial; the timeframe, as well as the volume of regional investment in renewables technology (making use of economies of scale associated with the cost framework of currently available renewables technology), and the local cost framework against which the cost of renewables is compared (the local production cost or the opportunity cost of lost barrels for export) are likely to determine the financial long-term viability of renewables in the Gulf. With globally falling renewables costs, the financial background of renewables in the region should be expected to be favourable in the future. One of the many benefits of using the technology in the Gulf is also the region's relative abundance of capital, as well as the presence of potential fiscal measures such as subsidies, which could promote this technology much more in the region than is currently the case.

The Nuclear Option

In view of the Gulf states' determined interest in finding alternatives to conventional fossil fuels as energy sources, the region could indeed become one of the world's last new markets for nuclear power, notwithstanding the dismantling of the technology in other parts of the world.[63] Proponents see it as a clean, reliable, and – in the long run supposedly – low-cost source of energy and electricity,[64] now safe enough to employ in the region.[65] Capable of providing the region with baseload power, nuclear energy offers the option to free more valuable crude oil and natural gas for use in other industries, and for peak load. With a planned capacity of 1.4 GW per plant in the case of the UAE – which currently holds the most advanced plans for nuclear power in the region outside Iran – nuclear power also offers significantly larger capacity additions than the region's (as yet) small and episodic renewables

[62] Oman is the first Gulf country to commission a solar EOR project, contracts having been awarded in July 2011 to US firm GlassPoint Solar for a 7 MW solar project. The estimated cost of around $3/MMBtu compares favourably price-wise to Oman's alternative option of importing LNG. Wilson (2011).

[63] This is also reflected in the limited growth forecast for nuclear power generated under various policy scenarios, for instance by the IEA's most recent World Energy Outlook. See IEA (2012a, 182). For a comment in the UK context, see Keay (2007). For a discussion of the German case, see Buchan (2012) and Wettman (2011). For a North American outlook, see Robinson (2009), especially fn35, page 22.

[64] For instance, see Squassoni (2009, 14). See also Jackson (2009).

[65] For a comprehensive discussion, see Luciani (2012). For a technical discussion, see El-Genk (2008).

plants, which so far range between 40 and 100 MW. Like renewables technology, nuclear power is also seen as making an important contribution to wider economic development – for example through the acquisition of technical know-how, the creation of highly skilled jobs for Gulf nationals, and the possible creation of a nuclear research value-chain, a point certain to have influenced policymakers' attraction to the technology.[66]

Nuclear power seems to be an attractive technology for the region on political grounds, at least at first sight. Domestically, access to sensitive nuclear technology afforded by Western partners represents a small political victory for national governments. The symbolic value of nuclear power is also a significant factor in a country's foreign relations, including those with its direct neighbours. However, whilst all of the Gulf states currently interested in, or pursuing, nuclear plans have repeatedly stated their intent to rely entirely on civilian, non-military uses of the technology, a policy shift from one objective to the other is a remaining risk which can never be entirely excluded. Iran has the Middle East's longest-standing nuclear programme, with original plans for nuclear power dating back to the early 1970s. The country's first electricity-generating reactor went online in September 2011, as part of the country's highly controversial nuclear programme aimed, according to official accounts, at securing Iran's future power generation needs.[67] Plans for civilian nuclear power have also been discussed on the Arabian side of the Gulf, with existing plans for nuclear programmes both in the UAE and Saudi Arabia.[68]

There are nevertheless important caveats to the view that nuclear power could indeed be a long-term solution to the region's rising power needs. Economically, nuclear power draws its comparative cost advantage vis-à-vis alternative sources of energy (including imported fossil fuels and some renewables technologies) from the economies of scale achieved using reactor models similar to those proposed for the region, in large power markets such as North America and parts of central Europe, especially France. Whether the Gulf's comparably small individual electricity markets can offer these economies of scale is more than questionable given the absence of alternative options such as intra-regional electricity trade. This makes it likely that the levelized cost of energy (LCOE) for nuclear power in the Gulf, which reflects the average long-run cost per kWh including both fixed and variable costs, will be high compared to costs observed in other industrialized countries.[69] With some of the world's lowest electricity tariffs, which have struggled in the past to recover production costs even for existing, domestically supplied oil- and gas-fired power production, the outlook for commercial cost recovery for nuclear power in the region remains bleak.

Nuclear power in the Gulf also entails a range of economically unquantifiable political and security risks. Iran's controversial nuclear programme serves as a prime lesson to other Gulf states, in relation to to the political and economic damage an ambiguous nuclear programme may entail. Despite reiterated statements by GCC leaders that they are interested in nuclear power merely for civilian uses, the entry of such technology to the Arabian side of the Gulf raises the possibility of a nuclear arms race between the GCC and Iran (which may in turn also confront a nuclear-armed Israel) in the future, although the proponents of nuclear power argue that the logic of mutually assured destruction (MAD) prevented such a race from turning into a war between the Soviet Union and NATO countries.

Nuclear power also raises some very real security concerns from the domestic Gulf perspective. The densely populated Gulf coastline provides little space for evacuation in the case of a serious technical accident. The proximity of many Gulf states to each other implies that one country's nuclear programme affects all other neighbours as well. The region itself

[66] Luciani (2012).
[67] Iran has also had a nuclear research reactor located in Teheran since 1967, but decades of political tensions with several Western nations following the 1979 revolution meant uranium deliveries have dried up, with the reactor understood to have run out of fuel in past years. MEES (2011c); MEES (2012b).
[68] MEES (2012c).
[69] See a more detailed discussion in El-Katiri (2012).

has been volatile, and has been subject to repeated conflict between the neighbours Iraq and Iran, with the invasion of Kuwait in 1990/91 drawing in a GCC member. Current tensions between the West and Iran over the latter's nuclear programme have sparked threats of military attacks against a close-by GCC neighbour, resulting in Iranian threats to close the Straits of Hormuz or to lay mines along its coastline.[70] Even without the threat of military attacks, Iran is known to be an earthquake zone, an uncomfortable truth for the GCC countries also, whose nuclear plans would be fully exposed to the region's fragile coastline. Kuwait notably shelved her nuclear plans following the Fukushima incident of 2011, owing to the weight of security concerns on her side.[71] The relatively large share that nuclear power would have within these countries' national systems also increases the vulnerability of their grids to systematic disruptions, for instance through a technical fault at one or two nuclear plants.[72]

In sum, alternative sources of energy in the Gulf bear a number of significant costs and caveats, seen particularly in the introduction of nuclear power in Iran and on the other side of the Gulf. While it seems that renewable energy could entail a smaller economic and political cost, it remains only at its very beginnings in the region. Nuclear power, politically more appealing in the region – even though, paradoxically, this contradicts trends in nuclear power perception elsewhere – entails foreseeably higher economic, political, and security-related risks to the region than any other technology.

7. CONCLUSION

More than a decade into the new millennium, the Gulf states face many challenges, both old and new, in the management of their energy resources. For reasons explained above, this paper does not subscribe to the increasingly frequently stated views that suggest, over-excitedly, the (looming) presence of a Gulf 'energy crisis'[73] in the shape, principally, of insufficient long-term supplies or supply capacity. Rather, it places sensible policy choice at the centre of the region's long-term energy fate, in view of current and potential supply shortcomings. Supply-based solutions form one important part of any national or regional energy solution for the Gulf states over the long-term. The diversification of the Gulf states' fuel base – towards renewables and, potentially, nuclear power – constitutes a major step which would be capable of reducing the region's dependence on its depletable fuel stock, and hence of prolonging the lifetime of these resources for future generations. Such a step would also establish an important, and currently under-utilized, opportunity – that of raising the region's profile as a modern energy technology hub along the entire energy chain.

Overcoming the Gulf states' long-term challenges will probably also involve ending the long-standing laissez-faire in the region's domestic energy sector that has characterized most Gulf states' demand management policies for decades. More pro-active policies would include: a more comprehensive promotion and enforcement of energy efficiency and energy saving targets; increasingly systematic regulation of efficiency standards for technology used in the industrial, commercial, and household sectors; and – perhaps governments' most powerful tool in managing domestic demand in the long term – a gradual reform of the region's domestic energy pricing frameworks. Such a reform would include a reconsideration of domestic subsidy policies, their beneficiaries, and the way in which alternative measures such as cash transfers and 'citizens' dividends' can help achieve the same objectives while avoiding the, by now, endemic waste of energy in many parts of the Gulf. Iran's 2010/2011 reform of domestic energy prices, coupled to an overhaul of social security and the

[70] El-Katiri and Fattouh (2012).
[71] Energy Compass (2011).
[72] For a comprehensive discussion, see El-Genk (2008).
[73] E.g. Dargin (2010); Dargin and Flower (2011); Lahn and Stevens (2011); Hamdan (2011); Hertog and Luciani (2012).

reallocation of fiscal savings into the pockets of its citizens, demonstrates the feasibility and political benefits of reform efforts.[74]

Many of the Gulf states' lessons could be extended to other parts of the developing world, including their immediate neighbourhood, the wider Middle East. Reflecting shifting patterns in energy consumption and supply in the wider region, the Gulf states stand to gain and lose most from any upward or downward shift in accompanying regional energy policy. Even in the presence of proactive policy changes, the region is unlikely to reverse the existing shift in its role on international energy markets, away from being merely the world's most important supply source of oil (and potentially gas), towards being a rapidly growing demand centre for energy (which includes a probable rising reliance on imports of natural gas and, potentially, other sources of energy). None of this constitutes a crisis. It is, rather, a gradual evolution which can be to the benefit, or the detriment of the Gulf economies.

[74] For a discussion of the reform progress, see Tabatabai (2011); Guillaume, Zytek, and Farzin (2011); and IMF (2011). See also: Fattouh and El-Katiri (2012).

APPENDIX A. HISTORICAL PROVED OIL AND NATURAL GAS RESERVES IN THE GULF, 1980–2011

Table 4: Proved oil reserves at end-year, in billion barrels (R/P ratio), 1980–2011

	1980	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*	*2011*	*2011 % of world total*
Bahrain	0.24 (12)	0.17 (10)	0.11 (6)	0.21 (11)	0.15 (8)	0.12 (7)	0.12 (7)	0.12 (7)	N/A
Kuwait	67.9 (*)	92.45 (*)	97 (*)	96.5 (*)	96.5 (*)	101.5 (*)	101.5 (*)	101.5 (97)	6.1%
Oman	2.5 (24)	4.1 (22)	4.4 (17)	5.2 (16)	5.9 (17)	5.6 (20)	5.5 (17)	5.5 (17)	0.3%
Qatar	3.6 (21)	4.5 (39)	3 (19)	3.7 (22)	16.8 (61)	27.9 (74)	24.7 (43)	24.7 (39)	1.5%
Saudi Arabia	168 (45)	171.5 (*)	260.3 (*)	261.5 (79)	262.7 (76)	264.2 (66)	264.5 (73)	265.4 (65)	16.1%
UAE	30.4 (48)	33 (72)	98.1 (*)	98.1 (*)	97.8 (*)	97.8 (90)	97.8 (93)	97.8 (81)	5.9%
Iran	58.3 (*)	59 (73)	92.8 (78)	93.7 (69)	99.5 (71)	137.5 (90)	151.2 (95)	151.2 (96)	9.1%
Iraq	30 (31)	65 (*)	100 (*)	100 (*)	112.5 (*)	115 (*)	115 (*)	143.1 (*)	8.7%
Total Gulf (8)	**361.0 (53)**	**429.7 (*)**	**655.8 (*)**	**658.9 (94)**	**692.0 (84)**	**749.6 (84)**	**761.2 (85)**	**789.3 (80)**	**47.8%**
World	683.4 (30)	802.6 (38)	1027.5 (43)	1066.1 (43)	1257.9 (46)	1357.0 (46)	1622.1 (54)	1652.6 (54)	100.0%
Gulf share of world reserves	*52.8%*	*53.5%*	*63.8%*	*61.8%*	*55.0%*	*55.2%*	*46.9%*	*47.8%*	-

Notes: (*) R/P ratio above 100 years

Source: Reserves: BP (2012); Bahrain: EIA (2012a) R/P Ratios (static): Author's calculations based on BP (2012) and EIA (2012a)

Table 5: Proved natural gas reserves at end-year, Tcm (R/P ratio), 1980–2011

	1980	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*	*2011*	*2011 % of world total*
Bahrain	0.2 (*)	0.2 (46)	0.2 (30)	0.1 (20)	0.1 (13)	0.1 (8)	0.2 (17)	0.3 (27)	0.2%
Kuwait	1.1 (*)	1.1 (*)	1.5 (*)	1.5 (*)	1.6 (*)	1.6 (*)	1.8 (*)	1.8 (*)	0.9%
Oman	0.1 (*)	0.2 (*)	0.3 (*)	0.5 (*)	0.9 (99)	1 (50)	0.9 (35)	0.9 (38)	0.5%
Qatar	2.8 (*)	4.4 (*)	4.6 (*)	8.5 (*)	14.4 (*)	25.6 (*)	25 (*)	25 (*)	12.0%
Saudi Arabia	3.2 (*)	3.7 (*)	5.2 (*)	5.5 (*)	6.3 (*)	6.8 (*)	8 (*)	8.2 (*)	3.9%
UAE	2.4 (*)	3.1 (*)	5.6 (*)	5.9 (*)	6 (*)	6.1 (*)	6.1 (*)	6.1 (*)	2.9%
Iran	14.1 (*)	14 (*)	17 (*)	19.4 (*)	26 (*)	27.6 (*)	33.1 (*)	33.1 (*)	15.9%
Iraq	0.8 (*)	0.8 (*)	3.1 (*)	3.4 (*)	3.1 (*)	3.2 (*)	3.2 (*)	3.6 (*)	8.7%
Total Gulf (8)	**24.5 (*)**	**27.5 (*)**	**37.5 (*)**	**44.7 (*)**	**58.4 (*)**	**72.0 (*)**	**78.4 (*)**	**79.0 (*)**	**38.0%**
World	81.0 (56)	95.4 (58)	125.7 (63)	137.3 (65)	154.3 (64)	172.3 (62)	196.1 (62)	208.4 (64)	100.0%
Gulf share of world reserves	*30.4%*	*28.9%*	*29.9%*	*32.6%*	*37.8%*	*41.8%*	*40.0%*	*37.9%*	-

Notes: (*) R/P ratio above 100 years; Production numbers are marketed gas, excluding flaring and reinjection.

Source: Reserves: BP (2012); R/P Ratios: Author's calculations based on BP (2012)

APPENDIX B. CURRENT AND PLANNED GAS IMPORT PROJECTS IN THE GULF

Table 6: Current and Prospective Gulf Gas Import Projects, at End-2012

Importing Country	*Type*	*Supplier*	*Contract Type*	*Contract Volume*	*Contract Duration*
Current					
Kuwait	LNG	Shell, Vitol; others (spot only)	MT	3.8 Bcfa (2011) plus spot sales (400–700 MMcf/d (4–7 cargos per month), 500MMcf/d average (38 cargos in 2011))	2010–13
Oman	Pipeline	Dolphin Energy/Qatar Gas	LT	3.5 Bcm/a (agreement in place with UAE for the UAE to take unwanted contract volumes by Oman)	2008–23
UAE	Pipeline	Dolphin Energy/Qatar Gas	LT	17.25 Bcm/a	2008–23
UAE (Dubai)	LNG	Shell; others (spot only)	LT	1 mt/yr (48 BBcf/d) – contract allows up to 3mt/yr (400mn cfd)	2011–26
UAE (Northern Emirates)	Pipeline	Dolphin Energy/Qatar Gas	ST	90–400mn cfd	2009
Iran	Pipeline	Socar (Azerbaijan)	MT	1 Bcm/a (max. 5 Bcm/a by 2015)	2011–16 (formerly already supply contract in place)
	Pipeline	Turkmenistan	LT	8 Bcm/a (max. 20 Bcm/yr)	1997–2022
Planned					
Bahrain	LNG	-	MT	400–800mn cfd for 15 years	Expected 2014/2015
UAE (Abu Dhabi)	LNG	-	-	Initially 4 mt/a (530 MMcf/d) under provisional terminal, with the prospect of increasing to 8 million tons/yr with a permanent facility (1.2 bcf/d)	Expected 2014/15

Source: Author's research; Iran–Turkmenistan trade: Henderson, Pirani and Yafimava (2012)

Table 7: World Energy Consumption by Region, 2000–2010

	Primary Energy (Mtoe)		**Oil* ('000 b/d)**		**Natural Gas (Bcm)**	
	2010	*CAGR 2000–10*	*2010*	*CAGR 2000–10*	*2010*	*CAGR 2000–10*
Asia/Pacific	4,558	5.1%	27,563	2.4%	591	6.7%
Europe/Eurasia	2,939	0.4%	19,039	–0.2%	1,101	1.0%
North America	2,764	0.0%	23,491	0.0%	864	0.8%
Middle East	716	5.0%	7,217	3.2%	403	7.2%
Central & Latin America	619	2.6%	6,079	2.0%	155	4.4%
Africa	382	3.1%	3,377	2.9%	110	5.9%
World	**11,977**	**3.1%**	**87,439**	**1.2%**	**3,216**	**2.5%**

Notes: *Crude Oil and Petroleum Products

Source: BP

APPENDIX D. HISTORICAL PRIMARY ENERGY CONSUMPTION GROWTH IN THE GULF

Table 8: Ten-Year Compound Annual Growth Rates for Primary Energy Consumption in the Gulf-8, 1971–2009

	1971–9	*1980–99*	*1990–99*	*2000–9*
Oil	n/a	5.1%	2.8%	4.1%
Natural Gas	n/a	10.5%	6.0%	6.2%
Primary Energy	11.7%	5.1%	4.9%	4.3%
Electricity	18.3%	9.7%	5.7%	5.3%

Source: Author's calculations based on World Bank (2012), EIA (2012a)

APPENDIX E. A SIMPLE CALCULATION OF A SEMI-DYNAMIC R/P RATIO FOR THE GULF STATES

A simple calculation of a semi-dynamic R/P ratio, based on static current reserves and dynamic production changes over the coming decades of Gulf oil and gas production illustrates the potential challenges facing the region's hydrocarbon resources (Table 9 and Table 10). These calculations are based on a logarithm that assumes constant-rate, cumulative production increases on an annual basis until each country's reserve base is exhausted. The assumed annual production growth rate is based on the average 10-year annual compound growth rate, except for Iraqi oil, where a compound annual growth rate (CAGR) of 8.7 per cent is used; this is based on the assumption of a production ramp-up to 6 mbpd by 2020 as projected by the EIA. This is not a realistic forecast; it merely provides a set of data for illustrative purposes, showing what enormous impact even slight gradual production increases may have on reserve longevity in the region under the assumption that no new reserves are added to current reserve figures.

In the case of Saudi Arabia, for instance, a relatively small annual production growth rate of +1 per cent per annum can reduce the Kingdom's oil production horizon by 20 years, assuming accurate current reserves and no new reserve additions. Iran's oil production, growing by 1.1 per cent per annum, implies a decrease of nearly 30 years of its production horizon assuming no reserve additions are made. Annual production increases of the magnitude seen in the past ten years in natural gas producers Qatar and Iran could, on the other hand, curtail the two countries' production outlooks from 280 and 252 years to 30 and 40 years respectively. Iraq's most recent intention to ramp up domestic oil production from its current figure of around 3 million barrels per day to the (unrealistic) target of over 10 mbd would certainly cripple its reserves outlook, but even the IEA's recently published, more moderate, case of a capacity expansion up to 6 mbd[75] at a constant rate of production growth of 8.7 per cent would still entail the depletion of Iraq's oil reservoirs within a mere 30 years.

Table 9: Oil, Static and Dynamic Reserve-to-Production Ratios

	Reserves (billion barrels), 2010	*Production ('000 b/d), 2010*	*Static R/P Ratio*	*Assumed annual compound production growth rate*	*Dynamic R/P Ratio*
Bahrain	0.12	46.4	7	–0.6%	7
Kuwait	101.5	2,450.4	110	1.0%	77
Oman	5.5	867.9	17	–1.0%	19
Qatar	24.7	1,437.2	43	4.6%	26
Saudi Arabia	264.5	10,521.1	73	1.0%	53
UAE	97.8	2,812.8	93	0.8%	71
Iran	151.2	4,251.6	95	1.1%	66
Iraq	115	2,408.5	127	8.7%*	30

Notes: *Based on CAGR under the assumption of a production rise to 6 mn b/d by 2020, the EIA's moderate-case production scenario, implying a CAGR of 8.7%.

Source: BP, author's calculation

[75] IEA (2012b).

Table 10: Natural Gas, Static and Dynamic Reserve-to-Production Ratios

	Reserves (Tcm), 2010	*Production (Bcm), 2010*	*Static R/P Ratio*	*Assumed annual compound production growth rate*	*Dynamic R/P Ratio*
Bahrain	0.3	12.8	27	3.8%	6
Kuwait	1.8	12.5	143	2.4%	62
Oman	0.9	24.8	38	10.4%	13
Qatar	25.0	89.3	280	13.0%	30
Saudi Arabia	8.2	77.5	105	4.1%	41
UAE	6.1	48.8	125	2.2%	61
Iran	33.1	131.2	252	7.3%	40
Iraq	3.6	3.5	1025	1.7%	164

Source: BP, author's calculation

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