CHAPTER 3

Pairing Coal with Solar: The UAE’s Fragmented Electricity Policy

Jim Krane

INTRODUCTION

The United Arab Emirates’ transformation over the past decade into an interventionist player in regional and global politics has bled into domestic energy policy, incentivizing the diversification of fuels and technology choices for electricity generation. A country that once depended overwhelmingly on a single electricity source—thermal generation using domestic natural gas—is quickly building out a diversified power sector leveraging imports of gas in various forms, along with coal, nuclear, and solar power.

The UAE’s fast-evolving power portfolio appears to have been assembled in a fragmented way, outside the reach of centralized planning and without fully exploiting the national electricity grid. Instead, changes in domestic energy policy revolve around questions of subnational autonomy, comparative cost, and political risk.

J. Krane (✉)
Rice University’s Baker Institute, Houston, TX, United States
e-mail: jkrane@rice.edu

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Oil-rich Abu Dhabi has spent huge sums on clean power from nuclear and renewables, while investing in domestic natural gas production to replace imports from rival Qatar. Neighboring Dubai seeks to avoid dependence on Abu Dhabi with a cost-driven pairing of cheap and dirty Chinese coal with even cheaper photovoltaic solar. Sharjah, like Dubai, pursues autonomy from the national grid, while the four northern emirates move in the opposite direction, reinforcing dependence on power supplied by Abu Dhabi.

The inconsistent power sector strategy is reflected in the UAE’s disunity in foreign relations, with Dubai’s long-held neutrality and associations with Iran and Qatar coming under challenge from Abu Dhabi’s increasingly interventionist role in the region. Energy policy in Abu Dhabi aims to increase freedom of maneuver in foreign policy through US-style ‘energy independence’ aspirations, which protect unfettered nationalist policies from being restrained by dependence on imports.

Further factors are coloring negative views of gas:

- The UAE has enjoined—or, arguably, instigated—regional political disputes with Iran and Qatar, the two countries holding the largest gas reserves in the region. Ongoing imports from Qatar are exposed to risk of cutoff or changes in contractual terms. Imports from Iran would be similarly exposed, had they started.
- Cost of solar power and battery storage continues to fall. Reduced costs, along with geographical advantages, have encouraged the UAE to leverage renewables for an increasing role in current generation and future plans.
- The UAE’s natural gas imports have exposed it to fluctuating market prices on fuels that it sells domestically at low, fixed prices. Increases in domestic supply, until recently, were made more difficult by complex geology. Recent discoveries and increasing production of associated gas have moderated these factors.¹

To mitigate the uncertainties associated with natural gas, utility planners have designated coal, nuclear, and solar to assume more than half of gas’ current share in the national generation mix. If plans in Abu Dhabi and Dubai are followed through to fruition, utility planners forecast that
natural gas demand would flatten or even decline. Ultimately, policymakers aim to end the UAE’s status as a net importer of natural gas by 2030.

This paper examines the political and strategic drivers for the UAE’s shift toward coal, nuclear, and solar power. It finds that while coal and solar appear competitive with gas on the basis of cost, and nuclear and coal provide reliability of supply, the policy is also being driven by higher priority strategic rationales around power projection, external image enhancement, energy supply security, and ultimately the security and stability of the regime.

**BACKGROUND ON UAE POWER SECTOR**

Electricity policy in the UAE is of vital importance due to two extremes: high average temperatures and high levels of demand. Per capita electricity consumption in the UAE is near world-leading levels, at 13,000 kilowatt-hours per capita in 2017. Likewise, primary energy consumption averaged nearly 500 gigajoules per person in 2018, the world’s 4th highest and nearly 7 times the world average (Fig. 3.1). High rates

![Primary energy consumption per capita 2018 (GJ/person)](Image)

**Fig. 3.1** Primary energy consumption per capita 2018 *(Source BP 2019)*
of demand are driven by high incomes, low fixed prices, high ambient temperatures, and inefficient designs of buildings and communities. Cooling buildings accounts for roughly 60% of power consumption.

Major disparities in demand occur between UAE nationals and generally poorer expatriates who make up 90% of the population. Emirati households in Abu Dhabi consume around three times more electricity than (typically smaller) expatriate households, and about five times more than a household in the US state of Arizona. Further discrepancies exist among residents in the poorer northern emirates of Sharjah, Ajman, Umm al-Quwain, Ras al-Khaimah and Fujairah, and the dominant emirates of Dubai, the UAE financial capital, and Abu Dhabi, the political and economic capital. The disparities are bound up in constitutional provisions enshrining ownership of natural resources in individual emirates.

In 2018, fossil fuels made up 99% of primary energy consumption in the UAE. Oil, the dominant transportation fuel and a backup feedstock for power generation, held 40% of the overall energy market while gas retained nearly 60%.

Coal use, once nearly nonexistent in the UAE, rose by 22% per year over the decade to 2018, driven by substitution for natural gas in cement and ceramics manufacture outside Abu Dhabi. The UAE is destined to become a much more significant coal consumer upon the 2020 startup of Dubai’s 2.4-gigawatt Hassyan coal-fired power plant. A planned expansion of the $3.4 billion Hassyan plant would push its capacity to 3.6 GW.

The UAE’s aspirational power mix calls for expanding coal-fired power to generate 12% of the country’s electricity, an installation estimated at 11.2 GW of capacity, more than coal capacity operating in Canada or Malaysia in 2019. A quadrupling of coal capacity is unlikely, however, given the associated environmental and reputational damage, as well as the falling cost of competing technologies. Since little coal is found in the Middle East, and none on the Arabian Peninsula, Middle Eastern coal is imported, mainly from Colombia (3.5 mtoe in 2018), Russia (1.7), and South Africa (1.5) (Fig. 3.2).

Much of the diversification referenced in the introduction was yet to arrive at the time of writing. Some 98% of the UAE’s electricity in 2018 was produced by combusting fossil fuels, nearly all of it from natural gas (41 bcm of a total 77 bcm consumed in the UAE 2018) with small
Fig. 3.2  Share of fossil fuels in electricity production. The UAE’s electricity production is dominated by fossil fuels, in comparison with smaller amounts used in other high per capita consuming countries. However, much of the non-fossil generation depicted here depends on large hydropower and nuclear resources which are less intermittent than competing renewable technologies (IEA 2019).

amounts of oil-based fuel and an even smaller amount of solar power (Table 3.1/Fig. 3.3).

The power sector was to have been diversified by 2018 with the startup of Abu Dhabi’s $25 billion Barakah nuclear power plant. However, problems emerged that delayed construction for three years. These included discovery of counterfeit parts supplied using forged safety documents as

Table 3.1  UAE primary energy and power generation by fuel

|                     | % of 2018 primary energy consumption | % of 2018 power generation |
|---------------------|-------------------------------------|-----------------------------|
| Natural gas         | 59                                  | 98                          |
| Oil                 | 40                                  | 1.2                         |
| Coal                | 0.94                                | 0                           |
| Renewables          | 0.19                                | 0.7                         |

Source  BP 2019
well as voids found in the concrete walls of two of the four units. These issues prevented licensing and operation of the four 1.4 gigawatt nuclear generation reactors, the first of which was completed in 2018. Startup of the first reactor was achieved in 2020.

Dubai and Abu Dhabi have also developed growing amounts of solar-powered generation (a combination of photovoltaic and concentrating solar power). These sources provided less than 1% of the UAE’s electricity in 2018. Even so, growth in capacity nearly doubled over 2017, from 350 MW to almost 600 MW. By 2019, capacity reached nearly 2.1 GW. A negligible amount of wind-generated electricity in the UAE is provided by a single 850 kilowatt turbine on Sir Bani Yas Island.

As in other aspects of the UAE’s energy profile, the national power sector is dominated by Abu Dhabi, with more than half the country’s 30 GW of installed capacity, mainly gas-fired combined cycle gas turbine (CCGT) plants (Table 3.2). Abu Dhabi also supplies power to most of the other emirates, via the fully interconnected UAE national grid. Dubai, however, is fully self-sufficient in power generation. Once the Hassyan...
coal plant is complete, Dubai will have a generation-reserve margin that reaches 25% beyond 2020 peak demand. Dubai is not expected to import power from Abu Dhabi, even after the nuclear plants are online. Sharjah, too, is developing new CCGT plants that will allow it to become independent of Abu Dhabi power imports as soon as 2021.17

As may be apparent, planning for power generation expansions in Dubai, Sharjah and Abu Dhabi has been conducted independently and not coordinated through the central government. Dubai’s decision to invest in coal was made when LNG prices were over $10 mmbtu and did not consider the scenario of falling LNG prices or a gas glut materializing in the region. Meanwhile, Abu Dhabi’s 2008 decision to pursue nuclear power acknowledged that nuclear was not the most cost-competitive form of generation available at the time, and others—including coal—were cheaper.18

Table 3.2 UAE installed power generation capacity by type, 2019

| Power authority                              | Total installed capacity | Solar | CCGT     | Steam turbine | Gas turbine | Diesel |
|----------------------------------------------|-------------------------|-------|----------|---------------|-------------|--------|
| EWEC Abu Dhabi (10 gas-fired, 3 solar*)      | 16,740                  | 1780  | 14,678   | 1027          | 867         | 0      |
| Dubai Electricity and Water Authority (DEWA) (10 gas-fired, 4 solar**) | 10,703                  | 713   | 7574     | 340           | 2076        | 0      |
| Sharjah Electricity and Water Authority (SEWA) (6 gas/diesel) | 2846                    | –     | –        | 432           | 2382        | 32     |
| Federal Electricity and Water Authority (FEWA) (3 gas/diesel) | 703                     | –     | –        | –             | 703         | 0      |
| Total (MW)                                   | 30,871                  | 2493  | 22,252   | 1799          | 6028        | 32     |
| %                                            | 8.1%                    | 72.1% | 5.8%     | 19.5%         | 0.1%        |        |

*50 MW CSP, 1.28 GW PV; **713 MW PV
Source Baker Institute, Ministry of Energy and Industry, MEES 2019
Clean Energy Goals Versus Reality

The onset of coal-fired power in the UAE runs counter to the ‘green’ energy narrative that policy elites have cultivated. In 2006, Abu Dhabi launched a strategic campaign to champion environmental initiatives, announcing it would build the world’s first ‘zero-carbon city’. Masdar City, as the development was called, was to receive $15 billion in government funding for zero-carbon housing for 40,000 residents and 1500 businesses, a carbon management unit, a clean technology investment fund, and a graduate school affiliated with the Massachusetts Institute of Technology, and sundry clean energy projects.19 Amid worldwide accolades over the ambitious project, then-CEO Sultan Ahmed al-Jaber said in 2007 that Masdar enjoyed ‘an unlimited budget for renewable energy projects.’20

Energy policymakers went further in 2009, declaring that Abu Dhabi would leverage its ample sunshine and vacant land to join the European clean energy vanguard. By 2020, the Abu Dhabi government announced, renewable energy sources were to account for at least 7% of the emirate’s total electric power generation capacity (Table 3.3).21 When bundled with its concurrent nuclear plans, Abu Dhabi pledged that zero-carbon sources would account for 24% of its electricity generation capacity. The

Table 3.3 Various ‘green energy’ targets announced in the UAE since 2006

| Clean energy targets by emirate |
|-------------------------------|
| **Abu Dhabi**                  |
| Create zero-emission city Masdar, operating on 100% renewable power |
| 2020: Renewable power 7% of power mix |
| 2021: Clean energy (solar + nuclear) 27% of power mix |
| **Dubai**                      |
| 2020: 7% of power generation from renewables |
| 2030: Reach 5000 MW solar capacity (25% of power mix) |
| 2030: Burn waste to produce power, eliminate waste to landfill |
| 2050: 75% of power from “clean” sources |
| **Ras Al Khaimah**             |
| 2040: 25–30% of power from “clean” sources |
| **UAE**                       |
| 2050: 44% of UAE power generation capacity from renewables; 70% reduction in power sector carbon emissions from “business as usual” case |

Source Compiled by author
two pledges appeared aimed to transform global public perceptions of the UAE from an autocratic petrostate that was an outsized producer, exporter, consumer, and subsidizer of fossil fuels, to a progressive haven for ambitious environmental goals.

The Masdar announcement came at a time when domestic production of associated natural gas—that produced in tandem with oil—began to lag growth in demand, and when oil prices were breaching new highs, driven by new consumption in China. Abu Dhabi was receiving an enormous windfall in oil profits while simultaneously grappling with a shortage of its main power generation feedstock.

Clean energy exuberance in Abu Dhabi was short-lived. Masdar’s ambitions were scaled back after the 2009 recession, and several projects were cancelled or downsized. Among the victims was Masdar City itself, which saw its zero-carbon promise dropped as too expensive. The city’s size was reduced and completion date pushed back. Also shelved was a 400 MW hydrogen power plant that was to have been built jointly with BP. Construction and operating costs for concentrating solar power plant Shams 1 (50 MW of solar augmented by 50 MW of gas-fired generation) were so high that LCOE for the plant was estimated at 40 US cents per kilowatt-hour. Two follow-on phases were cancelled.

The downsizing of Masdar, Shams, and Abu Dhabi’s renewables ambitions did not reduce the reputational benefits that the emirate would accrue. In 2009, before virtually any of Abu Dhabi’s clean energy plans had been realized, the emirate was selected for the prestigious opportunity to host the headquarters of a new United Nations agency, the International Renewable Energy Agency. IRENA, as it is known, remains the first and only UN agency with a permanent headquarters based in the Middle East.

On the other hand, the UAE’s PV solar power ambitions turned out to have been underestimated in 2009. As panel prices fell, utilities in Dubai and Abu Dhabi secured ultra-low tariffs from developers—after providing free land and grid connections—and came close to meeting the 2020 renewables goal, in capacity terms at least. As 2020 arrived, Abu Dhabi’s renewables installation had reached nearly 1 GW, 6% of its installed capacity of 16.7 GW, and sufficient to provide about 2–4% of the emirate’s electricity. Installed renewables capacity in the UAE overall reached 2.1 GW by December 2019, equal to 7% of the country’s roughly 30 GW of installed capacity, but—given the lower capacity factor for intermittent renewables versus thermal generation—producing 2–3% of nationwide power.
Clean Energy Aspirations and Credibility

In 2017, the UAE launched an updated set of power sector goals, the National Energy Strategy 2050. The strategy is focused on altering the electricity generation mix, rather than the overall energy balance including transport and industry. A full 50% of future electricity production is to be provided by ‘clean’ sources, i.e., nuclear and renewable power. The remaining 50% is to be split between fossil fuels, gas (38%), and coal (12%). The strategy implies a tripling in 2019 power capacity to 93 GW, including 11.2 GW of coal and 41 GW of renewables (Fig. 3.4). As mentioned above, these targets remain aspirational and do not pertain to currently understood plans or proposals.

Given the high capacity factors of nuclear, coal, and gas—where plants typically produce power above 70% of their full capacity rating—the actual electricity output will differ markedly. Non-dispatchable solar, by contrast, produces power at about 20–25% of its peak output rating. If the UAE reaches its clean energy aspirations, gas, coal, and nuclear plants will produce around 78% of electricity in 2050 with solar, biomass, and wind producing the remaining 22%. Therefore, fossil fuels will still produce around 70% of the UAE’s electricity.

The 2050 strategy also envisions a 70% reduction in power sector carbon emissions from the business as usual level, an unattainable goal alongside such an enormous buildout of fossil capacity. Rather than a

![UAE electricity capacity: Current and planned](image)

**Fig. 3.4** UAE electricity capacity: current and planned. Natural gas-fired generation drops from 98% of capacity in 2017 to 38% by 2050 under the UAE’s latest plan
decline in carbon emissions, adhering to the 2050 strategy implies the UAE’s carbon emissions would rise well beyond 2018’s level of 277 million tonnes. The environmental NGO Climate Action Tracker has calculated that the UAE’s GHG emissions, including those of transport and industry, would grow by 50% between 2010 and 2030.

However, the list of planned and tendered projects, based on capacity, presents a different story (Fig. 3.5; see Annex for a full list). Gas appears certain to retain its dominance in the electricity mix, with some 7 GW of forthcoming capacity in the planning stages. Meanwhile, published plans suggest that nuclear, solar, and coal reach levels of capacity between 5 and 7 GW apiece. Again, the far lower capacity factor of solar versus coal and nuclear suggests that solar will play a smaller role in electricity provision than that suggested by ‘installed capacity’ figures.

**Diversification Away from Gas**

Why would utility planners in the UAE trouble themselves to push through a diversification of the power sector, particularly one that includes a large commitment to renewables? Survey results in the Middle East suggest there is little grassroots pressure from society to embrace...
environmental goals or move away from fossil fuels, while civil society pressure groups are generally banned.  

Further, the UAE holds proven gas reserves of 6 trillion cubic meters of natural gas, roughly 3% of the global total and enough to produce at current rates for 90 years, according to BP. Even if domestic supply became an issue, the UAE lies within pipeline distance of some of the world’s largest natural gas fields that happen to be controlled by neighboring states. These include the North Field/South Pars Field of Qatar and Iran; the Qeshm (Salakh and Gavarzin), Saru, Tabnak, Assaluyeh, Kish, Sarkhun, and Sirri fields of Iran; and the North and South Kidan fields of Saudi Arabia. All lie within a 250-mile radius of the UAE’s main pipeline termini.

Examined from the perspective of a domestic electricity security standpoint, the state of natural gas supply looks more fraught.

First, the cost of producing gas in the UAE is rising. Marginal production costs for new fields were $3/mmbtu in 2015, rising to $7—the highest in the GCC—by 2030. Costs for new sour gas projects in the UAE were particularly high. Mills estimates a cost of $7–8/mmbtu for one forthcoming offshore sour gas project.

Second, the UAE has since 2008 been a net importer of natural gas, importing nearly 20 bcm in 2017, nearly as much gas as the total consumed in Kuwait that year. The cost of imports is pushing up the overall cost of electricity. Between 2007 and 2014, Dubai paid an average $3.72 per mmbtu for fuels burned to generate power.

Third, the UAE may lie within cost-effective pipeline range of major low-cost gas producers, including Iran and Qatar, but imports of gas from those countries have only been partly successful. Diplomatic relations with both have worsened under the more assertive regional policies of Mohammed bin Zayed al-Nahyan, the Abu Dhabi crown prince and de facto UAE ruler. Qatar supplies gas to the UAE through the undersea Dolphin Pipeline, but those imports eventually face the expiration in 2032 of the production sharing contract between the Dolphin Energy consortium and the Qatari government.

Fourth, regional gas trading is hampered by long-running government policies of fixing local prices below international benchmarks. Price levels in the UAE’s six emirates vary widely, as do those in neighboring countries. These discrepancies could be overcome if the Gulf region developed a pricing hub that encouraged cross-border gas trading at prices based on an index that included futures pricing. But consumers in the GCC are
unused to paying world market prices for natural gas. Most wholesale natural gas sales are done below the marginal cost of production, at fixed prices that range from $1.25 to $2.50/mmbtu.

Thus, while the average cost of gas looks reasonable, marginal increases in domestic production are increasingly costly, while import prices—and Qatari supplies—are uncertain.

**REGIONAL GAS POLITICS**

As mentioned, the UAE lies close to two major potential suppliers, Iran—the world No. 2 holder of gas reserves—and Qatar, the No. 3 reserves holder. Both countries have long histories of commercial trade with the sheikhdoms that now make up the UAE. Dubai, in particular, harbors close ties to Tehran and Doha. However, the UAE’s deteriorating relationship with both countries makes it unlikely that utility planners would choose to deepen their reliance on either state for critical energy needs.

**Relations with Iran**

The UAE has had shifting relations with Iran since the 1979 Islamic revolution. Dubai’s historically warmer ties with Iran have been counterbalanced by those of Abu Dhabi, where initial estrangement was tempered in the 1990s when the UAE joined a collective agreement to reduce GCC-Iran tensions. At the time, Tehran developed its most constructive working relations with Qatar, Oman, and the UAE, although ties with Abu Dhabi were hampered by a territorial dispute over three Gulf islands. A high point came in 2007 when Iranian President Mahmoud Ahmadinejad made the first-ever state visit by an Iranian head of state to the UAE. Ahmadinejad gave a major public address in a stadium in Dubai, home to nearly half a million Iranian expatriates and thousands of Iran-owned businesses.

Since then, UAE relations with Iran have plummeted as Abu Dhabi’s Crown Prince Mohammed bin Zayed has countered inroads of political Islam and Iran-backed Shia paramilitaries across the Middle East. The Abu Dhabi leadership opposed the US diplomatic outreach to Iran under US President Obama that resulted in the 2015 nuclear agreement. Abu Dhabi supported the Trump administration’s pullout of the agreement and the re-imposed US trade embargo on Iran.
By late 2019, the UAE had backed away from confronting Iran, perhaps due to inconsistencies in the Trump administration approach of stoking conflict with Iran while seeking to avoid a major US role in any resulting war. The UAE therefore made concessions aimed at reducing the likelihood that the UAE would bear the brunt of any Iranian retaliation.

**UAE-Iran Gas Trade**

The UAE-Iran gas trade has paralleled the political relationship, with signs of promise undermined by dispute. Under a 25-year export agreement signed in 2001, Iran was supposed to supply a Sharjah-based firm with 600 million cubic feet of gas per day by 2005, via undersea pipelines between the UAE and multiple gas fields off Iran’s Sirri Island. But Iranian parliamentarians protested what they saw as overly generous terms for UAE-based Crescent Petroleum. Iranian gas would have been sold at prices near $1/mmbtu, based on a crude-linked formula drawn up when oil prices were $18/bbl.36

Other than a brief test of the Sharjah leg of the pipeline in 2010— which found leaks during transmission—the pipeline has remained unused. Attempts to renegotiate have failed. An international tribunal in 2014 found in favor of Crescent Petroleum, which has begun pursuing damages from the National Iranian Oil Co.37 Discussions revived in 2017 yielded hopes that Iran would finally start its exports.38 But trade opportunity evaporated when the UAE backed Trump administration sanctions on Iranian exports.

**Relations with Qatar**

UAE relations with Qatar, like those with Iran, vary by emirate. Dubai’s traditionally strong ties—cemented through ruling family inter-marriage39—contrast with the historically cooler relationship between Doha and Abu Dhabi. Overall UAE-Qatar ties have deteriorated since the 1995 coup that brought Sheikh Hamad bin Khalifa al-Thani to power. Relations continued to decline as Qatar involved itself in regional politics that included support for opposition groups such as the Muslim Brotherhood during the Arab Spring. The dispute has continued under Sheikh Tamim bin Hamad al-Thani, who came to power in 2014.

In 2017, the UAE broke off diplomatic relations and launched a surprise trade embargo on Qatar, joined by Saudi Arabia, Bahrain, and
Egypt. The four closed airspace and borders, banned trade and travel, and ejected Qatari from their national territories. In the UAE, even Qatari married to Emirati citizens were forced to flee.40

One factor that appears to have prevented the UAE-Qatar conflict from escalating is the dependence of the UAE on imports of Qatari natural gas via the Dolphin Pipeline, a 50-mile undersea link that delivers about 2 bcf/day or 20 bcm/year, roughly half the UAE’s annual requirement for power generation.

Despite the UAE-led blockade, Qatar has treated the gas exports as outside the bounds of the dispute, keeping the gas flowing at contracted prices around $2/mmbtu, below normal prevailing rates at most international hubs.41 In fact, Dolphin’s uninterrupted provision of gas has allowed Abu Dhabi to maintain its lucrative LNG exports at much higher prices. Qatari officials have long complained about the terms of the long-term contract (expiring in 2032), which, they argue, leaves Qatar in the position of cross-subsidizing the UAE.

Perhaps as a result, the UAE has never fully leveraged its access to Qatar’s massive gas reserves. A third of the volume of the Dolphin Pipeline, with a capacity of 3.2 bcf/d, remains unused (Fig. 3.6). In the 1990s and 2000s, Qatar was unwilling to commit to increases in long-term supply at prices then on offer from the UAE.42 But Doha has since sold so-called interruptible shipments during the UAE’s peak summer demand period at prices around $5/mmbtu and has agreed to further higher-priced shipments to Ras al-Khaimah and Sharjah until 2026.43

The UAE’s role in the blockade of Qatar leaves both countries cautionous on the risks of expanding trade. Qatar appears unwilling to export further gas at prices inconsistent with its LNG netbacks. And the UAE’s critical dependence on Qatari gas has exposed a weakness, while providing Doha a strategic trump card to deter the UAE from escalating hostilities against Qatar directly, and perhaps, against some Qatari interests in the region. In short, UAE dependence on Qatar serves as a dampener on Abu Dhabi’s freedom of foreign policy maneuver in the Gulf region and therefore provides another rationale for the UAE’s program of diversification in power generation.

Gas Trade with Saudi Arabia?

Another potential future source of supply that is often overlooked lies in neighboring Saudi Arabia. For the time being, the kingdom neither
exports nor imports natural gas, but Saudi Aramco has invested heavily over the past decade to raise domestic output to supplant oil in power generation. Saudi energy officials have made suggestions about Saudi gas being exported via a GCC-wide gas grid.

Two major sour gas fields, North and South Kidan, sit in the Saudi Empty Quarter near the Abu Dhabi border, making them prime sites for future UAE-bound exports. The Kidan fields hold little in the way of valuable liquids to assist with costs, leaving lifting costs around $6/mmbtu, which makes the fields uneconomic sources of supply (albeit cheaper than LNG imports, at times) for any GCC state, all of which administer gas prices at lower levels.

**Why Diversify?**

Abu Dhabi’s 2007–2008 Interagency Working Group on Energy laid out several reasons for diversifying the mix of power generation fuels and technologies, driven by a 13% increase in power demand in 2006
amid gas shortages that required expensive diesel backup. Criteria for the diversification included:

- Economic performance (including reducing the use of expensive backup fuels, particularly diesel, and reducing exposure to volatile commodity prices)
- A preference for domestic fuels (based on energy security concerns about potential for supply disruption)
- Dispatchability and flexibility of generation (versus intermittent or inflexible sources)
- Environmentally clean sources, technologies involving technical knowledge transfer and quality jobs.\(^{45}\)

After the 2017 breakdown in UAE-Qatar relations, the UAE announced its intention to achieve self-sufficiency in natural gas prior to the 2032 expiration of the main Dolphin contract. Preexisting plans to diversify toward nuclear, coal, and renewables fit well within the self-sufficiency mandate and the UAE’s more forceful regional and international political stance.

Further, for oil and gas exporters like the UAE, reduced gas demand at home—where prices are subsidized—allows more to be sold abroad at full international prices. At a minimum, the Gulf monarchies have been subject to enormous opportunity costs in providing subsidized domestic power, and in some cases, the domestic price for gas is insufficient even to cover costs.

Every gigawatt of solar power capacity offsets consumption of some 3 million barrels of oil equivalent, or roughly 0.5 bcm gas, per year.\(^{46}\) For each gigawatt of dispatchable generation, the hydrocarbon savings are larger: 6 million barrels of oil equivalent/year (or 1 bcm/y) saved per gigawatt of coal-fired capacity (at 50% capacity usage) and as much as 10 million boe/y (2 bcm/y) per gigawatt for nuclear plants.

**Regime Security and Nuclear Power**

As mentioned, the first of Abu Dhabi’s four 1.4 GW nuclear power plants was expected to begin providing power to the UAE grid in 2020. Levelized cost of electricity (LCOE) for Abu Dhabi’s South Korean-built nuclear plants (including decommissioning costs) is estimated at the low
end of the typical scale for nuclear of between 7.3 and 14 US cents per kWh.47

Abu Dhabi’s experience with nuclear power has been difficult, and it appears that it will not be repeated in its current form. The emirate’s ambitious completion deadlines fell by the wayside, while the complexity and cost of the Barakah plant have rendered them uncompetitive with competing options. However, mastery of the development process frees Abu Dhabi to consider a future array of nuclear options, such as small modular reactors, which might help the emirate cope with challenges from international climate action.

Nuclear power confers further benefits to Abu Dhabi beyond the 5.6 GW of firm, zero-carbon power generation capacity. These range from freeing domestic hydrocarbons for export, transfer of complex technology, and creating high-value employment.48 Abu Dhabi’s nuclear investment allows the state to leverage an oil windfall to meet essential long term power needs.49 Nuclear power’s long time horizon—the Barakah reactors may provide electricity until 2080—allows the state to transfer today’s oil wealth to future generations.

From the perspective of an autocratic regime, there are further benefits from civil nuclear power. The nuclearization process tends to encourage a strengthening of the central state and the regime’s control over society, through increased internal security measures and enhanced coercive apparatus, ostensibly justified by the technology’s inherent hazards.50 Vulnerabilities in nuclear systems also create new requirements for secrecy and surveillance, and less tolerance for dissent.51 Protecting the fuel cycle does double duty in bolstering regime security.

Finally, for Abu Dhabi, ‘going nuclear’ may also increase the West’s stake in the survival of the regime because a shift to anti-US governance could open the door to proliferation of nuclear technology. Gulf Arab rulers have had reason to fear that Washington may eventually seek to end its role as the GCC’s long-term guardian. Nuclearization under those circumstances may offer an alternate path to maintaining the strategic interest of the United States and other global powers.52

The Political Economy of Gulf Solar Power

Early ambitions for solar technology to contribute materially to the UAE’s power supply fell far short of initial expectations. But precipitous cost declines in solar reached a threshold by 2016 that allowed the technology
to compete favorably in the Gulf. Reforms of subsidies on competing fuels also increased the relative attractions of solar.

In the UAE, solar is viewed as a clean power source that frees the state from dependence on imported fuel and associated political risks, while providing reputational benefits. But even in the sunny Gulf climate solar generation’s intermittency requires backup from thermal generation or grid storage to render it a substitution option for gas.

The drop in cost has been dramatic. In 2016, solar bids came in under 6 US cents per kWh. A year later, bids halved to just under 3 cents/kWh and halved again in 2019 to around 1.5 cents/kWh. By comparison, gas purchased for $5/mmBtu produces electricity in a modern CCGT at 3.5–4.5 cents/kWh. Current prices allow solar investments to underprice gas-fired generation on the basis of fuel savings alone.

In unsubsidized markets with privately held gas generation—such as in parts of the United States—the idling of gas-fired power in favor of solar serves to reduce the capacity factor of the plants whose output is displaced. The idling undercuts the displaced plant’s profitability and leaves investors holding a partially stranded asset. In the UAE, however, reducing demand for subsidized gas relieves government spending on imports. Amendments to subsidy accounting rules in 2016 provided further advantage to solar by requiring utility planners to consider the full opportunity cost of forgone hydrocarbon exports, rather than valuing gas as a waste product.

In the UAE and Saudi Arabia, numerous PV solar installations—planned and under construction—have achieved power sales tariffs under 3 US cents per kWh. For instance, the Mohamed bin Rashid Solar Park Phase II array in Dubai reached a power purchase price of 2.99 cents per kWh, while the Sweihan solar project in Abu Dhabi reached 2.94 cents and Saudi Arabia’s Sakaka project achieved 2.34 cents. In October 2019, Dubai announced it had accepted a bid to build 900 MW of solar PV within the fifth phase of the MbR plant selling power for just 1.7 cents per kWh. Abu Dhabi was reported to have received a bid of 1.35 cents per kWh for a planned 2 GW PV installation.

Ultra-low solar power purchase prices in the Gulf are a factor of the state bearing the costs of land and transmission, while reaping the effects of falling costs that have rendered PV modules just a third of the cost of a typical project. Apostoleris et al. have added further factors to this list for the Gulf, including zero sales tax, zero cost for environmental permits or grid connections, labor costs less than half those in developed states,
low-cost financing, and high rates of debt to equity, all of which combine to achieve an LCOE in the UAE of 2.85 US cents, where a comparable US plant’s LCOE would only reach 7.38 cents per kWh (including a 10% return for the developer). It bears mentioning that LCOE estimates typically do not encompass the full costs of solar generation, including paying for backup generation to cover demand when solar is unavailable, along with required reinforcements to transmission networks.

Regardless, these cost advantages allowed the UAE’s installed capacity to reach 2.1 GW by December 2019, meaning that 7% of the country’s roughly 30 GW of installed capacity was renewable. However, given the lower capacity factor for intermittent renewables versus thermal generation, 2.1 GW of solar can be expected to produce around 2–3% of the UAE’s electricity output.

Solar’s unaccounted-for costs are balanced by off-books benefits in the form of reduced political risk. Once generating, solar plants produce electricity at zero variable cost, because the fuel (solar energy) is free. Solar ‘fuel’ is also not subject to embargo or trade risk, which provides an advantage over gas, coal, and nuclear, which involve fuel imports.

The Dash for Coal—To Replace Gas

The first-ever coal-fired power plant in the GCC was in the late stages of construction in late 2020. The first 2.4 GW phase of Dubai’s Hassyan plant is scheduled to open in 2020 or 2021. If the Hassyan plant reaches its full 3.6 GW capacity as planned, it would be larger than the 2.8 GW Afsin-Elbistan Power Station in Turkey, currently the largest coal plant in the Middle East.

The nearby emirate of Ras al-Khaimah has also announced a pair of coal-fired plants, as has neighboring Oman. Neither had reached final investment decision.

The Dubai coal plant represents a contrarian watershed in Persian Gulf energy policy. The project leverages the only fossil fuel not found on the Arabian Peninsula to mitigate dependence on natural gas, a fuel so plentiful in the surrounding region that it is estimated to hold 40% of the world’s proven reserves. Dubai’s power sector diversification will shift it away from the cleanest of the fossil fuels toward the dirtiest. In so doing, Dubai effectively reverses the ‘dash for gas’ pursued by the United Kingdom, United States and elsewhere that have achieved carbon and pollution benefits by replacing coal with gas.
Coal combustion in power generation emits roughly double the carbon per unit of electricity delivered versus natural gas, along with local pollutants such as sulfur dioxide, nitrogen oxides, and mercury. Coal ash is often mildly radioactive. Coal soot drifting in the atmosphere becomes an agent of climate change when deposits darken surfaces of glaciers, ice caps, and sea ice, reducing the Earth’s reflectivity while promoting warming and melting of those surfaces.

Dubai’s investment in coal runs counter to more than a decade of ‘clean energy’ image-building and rhetoric from the highest levels of the UAE government. Abu Dhabi in particular has sought to establish itself as a ‘green petro-state’ through projects like low-carbon Masdar City, the hosting of the UN’s renewable energy agency, and the solar power initiatives described above.

Perhaps accordingly, Dubai’s embrace of coal is being done discreetly, with none of the fanfare afforded the UAE’s investments into renewables or real estate. The discretion suggests that ruling elites are uncomfortable with coal.

Normally Dubai’s media outlets can be counted on to trumpet the superlatives of the city’s energy milestones. But coverage of Hassyan has been muted, overshadowed by solar projects and their record-low tariffs—even though the power output of Dubai’s coal plant, if operated anywhere near nameplate capacity, will dwarf that of all the UAE’s planned solar arrays combined. Hassyan’s 3.6 GW of coal capacity operated 60% of the time would generate almost 19 GWh of electricity in a year. That is nearly double the 11 GWh of power produced from the UAE’s eventual 5 GW of solar installations operating at a 25% capacity factor.

An indicator of the diverging levels of prestige between Dubai’s solar parks and its coal plant is evident in their names. Dubai’s ruler, Mohammed bin Rashid Al-Maktoum, has named the solar development after himself, seeking to associate his legacy with clean energy. The uncommon name accorded the coal plant—Hassyan—suggests that Emirati elites were unwilling to be linked with it. Its location, too, is suggestive. Hassyan is being built on the least populated and furthest reach of Dubai’s coastline, directly abutting the Abu Dhabi border.

The UAE government’s energy policy documentation keeps Dubai’s coal plant at arm’s length. The government’s online energy portal devotes multiple paragraphs to nuclear, solar, wind, and waste-to-energy projects. Coal is dismissed in just two sentences, with no links to further detail,
even though the national Energy Strategy 2050 strategy envisions coal taking a 12% share of the UAE’s power output. 62

When official reports must mention the coal project, it is described as ‘clean coal.’ Although ‘clean coal’ is an ambiguous term, when used in energy circles it typically refers to plants equipped with carbon capture and storage (CCS) infrastructure, such as the W. A. Parish plant outside Houston or the Boundary Dam plant in Saskatchewan. The Hassyan plant will not be equipped with CCS. In Hassyan’s case, ‘clean’ appears to be a reference to its use of ultra-supercritical boilers, contemporary technology, which operate with greater efficiency and lower particulate emission than those found in older plants. Since Hassyan’s design requires it to be retrofitted for any future connection to CCS infrastructure, the plant does not meet standard criteria for ‘clean coal.’ 63

The downplaying of coal in the UAE may become official policy. Disagreements between Abu Dhabi and Dubai over the wisdom of coal have cast doubt on the likelihood that coal capacity will be further expanded beyond Hassyan’s 2.4 GW first phase, despite plans on record. 64

**Questions Around Coal**

Why would a wealthy, energy-endowed country venture into imported coal at a time when the climate and pollution consequences are universally understood? Most commercial and development banks have halted coal lending, considering it inappropriate other than in very limited circumstances in energy-poor countries without alternatives. Besides not meeting these criteria, the UAE, and Dubai in particular, depend heavily on tourism, an industry sensitive to negative publicity and pollution. A 2015 World Bank statistical ranking found the UAE already had higher mean average particulate (PM 2.5) air pollution, mainly from airborne dust, than any other country in the world, including China and India, where coal combustion has created serious public health issues 65 (Fig. 3.7). Even low-particulate ‘clean coal’ will worsen air quality.

Why coal, then? There appear to be at least five reasons behind the UAE’s ‘dash for coal.’

The first is based on strategic calculations about energy security and diversity of supply and technology. The Middle East may hold the world’s largest repository of natural gas, but it is also an arena for competition among great powers and regional autocracies, replete with ongoing
conflicts and proxy wars. The fact that Abu Dhabi has begun taking an active role in these conflicts exacerbates risks to its gas supply. Global coal reserves by contrast are so large and geographically dispersed that opportunities for political interference are limited. The fact that 99.9% of the world’s coal is produced outside the Middle East\textsuperscript{66} may actually enhance its attractiveness.

Cost factors are coal’s second advantage. Dubai has managed to procure an extraordinarily low power purchase price for dispatchable coal-fired power. The tariff promised by the Hassyan plant’s Chinese-led consortium was just 4.24 US cents per kWh at 2015 coal prices.\textsuperscript{67} That price is slightly lower than those obtained in recent tenders for CCGT plants.\textsuperscript{68} Estimates of Abu Dhabi’s Barakah nuclear plant’s LCOE, by contrast, run around 7 or 8 US cents per kWh.\textsuperscript{69} As mentioned, however, Hassyan’s cost analyses looked competitive with higher priced gas and renewables at the time planners made the final investment decision.

Third, coal can provide a source of baseload generation that can substitute for the UAE’s natural gas-fired plants. Intermittent renewables cannot provide firm, dispatchable capacity without expensive add-ons, such as battery storage, pumped hydro storage, or gas backup. As such, coal represents an attractive alternative for times when gas is expensive or unavailable.

Coal may be dispatchable, but it does present a major disadvantage. Modern gas turbines can vary output within minutes. A gas ‘peaker’ plant can start up and dispatch power with an hour’s notice. Coal’s typical 8-hour startup makes it less appropriate for synergizing with renewables which vary their production based on weather.

Fourth, the Hassyan project represents a major overture to China, part of a growing strategic bilateral engagement. Political elites in the UAE

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**Fig. 3.7** UAE air quality data from The World Bank’s “Little Green Data Book,” p. 219 (2015); https://openknowledge.worldbank.org/bitstream/handle/10986/22025/9781464805608.pdf
have long felt comfortable with top-down Chinese autocratic state capitalism. That admiration now extends to the Chinese coal-driven energy backbone. China was the UAE’s largest trading partner from 2014 to 2016, with some 300,000 Chinese residents and 4000 Chinese-owned businesses in the UAE in 2018.\textsuperscript{70} The Chinese government has encouraged its construction and engineering firms to seek markets for new coal plants abroad due to declining demand in China.\textsuperscript{71}

Fifth, diversification to coal either reduces gas imports or frees it up for higher-value uses in the UAE economy. These uses include those in industry, where gas is both feedstock and heat source and as exportable LNG.\textsuperscript{72} Abu Dhabi exported 7.4 bcm as LNG in 2018.\textsuperscript{73}

**Discussion and Conclusion**

The project mix shaping the UAE’s electricity sector presents a fragmented mix of generation technologies, fuels, and geo-environmental messaging. The glaring disconnect in policymaking between Abu Dhabi’s clean energy push and Dubai’s more price-driven strategy raise the possibility of future inter-emirate disputes. While both emirates pursue diversification away from natural gas, Abu Dhabi’s power mix appears to align with the future possibility of carbon taxation and border adjustment tariffs. Dubai’s does not. Coal-driven carbon emissions from Dubai pose risks for the entire UAE, conceivably penalizing national exports by rendering them less competitive than those from countries with smaller footprints.

The Dubai-Abu Dhabi disconnect is the largest manifestation of a misalignment in electricity policy that has Abu Dhabi and the Northern Emirates ranking environmental criteria highly in their technology choices, while Dubai and Sharjah prioritize cost-driven solutions that increase autonomy from the central state. Also shaping the power portfolio are political rivalries with gas-rich Qatar and Iran, which appear to be predisposing the UAE’s turn away from gas.

As these new power sources come online over the first half of the 2020s, one envisions the UAE increasing contributions from zero-carbon nuclear and solar power, with natural gas eventually relegated to peak periods and backup, a mix that comports well with the international climate action agenda. Indeed, Abu Dhabi plans to reduce the gas consumed by its power sector by as much as half, between 2018 and 2030.\textsuperscript{74} However, if difficulties with intermittency and complexity cannot
be overcome, the UAE appears destined to continued dependence on fossil fuel, including coal.

Solar installations have received outsized attention but had not, as of the end of 2019, contributed a material part of the UAE’s power output. Going forward, contributions of solar will increase as plants under construction are completed and connected to the grid. If plants produce as advertised over the current decade, the realization of investment plans could push the UAE into a clean energy leadership position in the Middle East, albeit one tarnished by coal. It remained to be seen whether the response to COVID-19 resulted in project delays or cancellations.

The UAE’s domestic solar projects have brought reputational and soft-power benefits, as have its overseas renewables investments. Continued cost reductions in renewable energy, alongside flattening growth in domestic power demand, should enable PV solar to act as a fuel-saving daytime substitute for imported natural gas. It will take improvements to solar’s dispatchability to allow it to substitute for the UAE’s fossil generation capacity, particularly during peak periods after dark.

The prestige aspects of solar power are evident in Dubai’s naming of a large solar initiative after its ruler, while the emirate’s even larger coal-fired power investments are downplayed and misleadingly labeled as ‘clean.’ The ‘greenwashing’ of a carbon-intensive electricity strategy carries risks. The specter of an oil-rich emirate free-riding on climate actions elsewhere could generate sufficient opprobrium among the global public to expose the UAE to hostile actions such as boycotts, sanctions, trade penalties and other types of political and regulatory action from governments, non-government organizations, or international agencies.

Elsewhere, coal firms and government backers are coming under pressure from climate change movements to halt coal investment and reduce use of existing assets. It is hard to imagine the UAE evading international pressure over its coal pursuits, given the typical 40-year operating lifetime that could see Hassyan producing electricity until 2060. By that date, continued warming in the Gulf region could present life-threatening summer temperatures that might even trigger domestic opposition to coal use. The combined trajectories of technological change in the power sector, physical changes in the climate, and pressure from the international public for action, could render carbon-intensive assets stranded.

High carbon intensity could also reduce the UAE’s competitiveness in attracting foreign direct investment. As large multinationals pursue carbon reductions in their supply chains, they are igniting competition among
countries to reduce emissions intensity of manufacturing sectors and electricity grids. Adding coal-fired capacity to an already fossil fuel-dominated power mix only reduces the UAE’s carbon competitiveness.

Finally, the fragmentation of the UAE’s 2050 energy strategy appears likely to undermine its longevity. A revision in strategy, particularly in regards to stated goals for expanded coal use, would be less painful if achieved before sunk costs increase the barriers to change.

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**Annex: Future Power Plant Projects in the UAE**
| Project                                      | Fuel type | Planned capacity (MW) | Location                  | Status                  | Expected year online | Investment (million USD) |
|----------------------------------------------|-----------|-----------------------|---------------------------|-------------------------|-----------------------|--------------------------|
| Ajman 100 MW solar power plant               | Solar     | 100                   | Ajman                     | Planned                 | est. 2019             | 136                      |
| Barakah nuclear power plant                  | Nuclear   | 5600                  | Al Dhafra, Abu Dhabi      | Under construction      | 2020                  | 18,700                   |
| Al Warsan waste-to-energy power plant        | Biomass   | 171                   | Al Warsan, Dubai          | Under construction      | 2020                  | 681                      |
| Jebel Ali K Station phase III expansion      | Natural gas| 590                   | Jebel Ali, Dubai          | Under construction      | 2020                  | 218                      |
| Al Aweer natural gas power plant Unit H phase IV | Natural gas| 815                   | Dubai                     | Under construction      | 2020                  | 300                      |
| Sharjah 30 MW multi-fuel waste to energy power plant | Biomass | 30                    | Al Saj’ah, Sharjah        | Under construction      | 2020                  | 220                      |
| Al Sajah Bee’ah 20 MW solar power plant     | Solar     | 20                    | Sharjah                   | Planned                 | 2020                  | 22                       |
| RAK FEWA coal fired power plant              | Coal      | 1800                  | Ras Al Khaimah            | Planned                 | 2021                  | 2177                     |
| Jebel Ali E Station gas turbine extension    | Natural gas| 300                   | Jebel Ali, Dubai          | Planned/under construction | 2021                  | 53                       |
| Al Layyah combined cycle power plant         | Natural gas| 1026                  | Layyah, Sharjah           | Planned                 | 2021                  | 550                      |
| Al Sajah 35 MW waste to energy power plant  | Biomass   | 35                    | Sharjah                   | Planned                 | 2021                  | 39                       |
| RAK Utico clean coal power plant            | Coal      | 270                   | Khorkhowir, Ras Al-Khaimah| Planned                 | 2022                  | 400                      |

(continued)
| Project                                                   | Fuel type                  | Planned capacity (MW) | Location          | Status                           | Expected year online | Investment (million USD) |
|----------------------------------------------------------|----------------------------|-----------------------|-------------------|----------------------------------|-----------------------|--------------------------|
| RAK natural gas power plant                              | Natural gas                | 2200                  | Ras Al Khaymah    | Planned                          | 2022                  | 2420                     |
| Sharjah 1.8 GW CCGT natural gas power plant              | Natural gas                | 1800                  | Sharjah           | Planned                          | 2022                  | 1000                     |
| Hassyan coal power station                              | Coal                       | 3600                  | Dubai             | Under construction               | 2023                  | 3400                     |
| Hatta Hydroelectric (pumped storage) plant 400 MW        | Hydro                       | 250                   | Dubai             | Planned                          | 2023                  | 523                      |
| Hydroelectric plant island in the Gulf                  | Hydro                       | 400                   | N/A               | Planned                          | 2024                  | 840                      |
| Mohammed bin Rashid Al Maktoum Solar Park (MBR solar park)| Solar                      | 5000                  | Dubai             | Partially operating/under construction | 2030                  | 13,600                   |
| RAK Utico solar power plant*                             | Solar                      | 40                    | Ras Al Khaimah    | Under construction               | N/A                   | 250                      |
| RAK Utico hybrid landfill gas-solar-agro power plant*    | Hybrid gas-solar-agro      | 16                    | Ras Al Khaimah    | Planned                          | N/A                   | 100                      |
| Jebel Ali M Station expansion*                           | Natural gas                | 700                   | Jebel Ali, Dubai  | Under construction               | N/A                   | 400                      |
| Umm Al Qaiwain solar power plant                         | Solar                      | 200                   | Falaj Al Mu’alla, UAQ | Planned                          | N/A                   | N/A                      |
| Museum of the future solar power plant                   | Solar                      | 3                     | Dubai             | Planned                          | N/A                   | N/A                      |
| Project                                           | Fuel type | Planned capacity (MW) | Location          | Status            | Expected year online | Investment (million USD) |
|--------------------------------------------------|-----------|-----------------------|-------------------|-------------------|----------------------|--------------------------|
| Al Dhafra 2 GW solar power plant                  | Solar     | 2000                  | Al Dhafra, Abu Dhabi | Planned          | N/A                  | N/A                      |
| RAK FEWA hydro power plant                        | Hydro     | N/A                   | Ras Al Khaimah     | Planned          | N/A                  | N/A                      |
| Sajja 80 MW waste to energy power plant           | Biomass   | 80                    | Sajja, Sharjah     | Under construction | N/A                  | 505                      |

*Expected to be online by 2018 based on the most recent source
Source UAE government and company press releases