

# The Politics of Low-Carbon Energy in Iran and Iraq

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## INTRODUCTION

Iran and Iraq present curious paradoxes in their use—in fact—their lack of use of low-carbon energy. Both have suffered over the past forty years from well-reported wars, sanctions and political upheaval. Both, though in different ways, have experienced fast-rising electricity demand which has been a challenge to meet. Through a mix of circumstances and choice, they have relied primarily on domestic, and usually state, investment to build their power sectors. Both have large-scale, low-cost oil and gas resources, but also significant hydroelectric, solar and wind potential. Yet the use of the ‘modern’ renewables, solar and wind, has made little progress.

On closer examination, though, there are sharp differences in the underlying reasons for this limited penetration of low-carbon energy. Low domestic energy prices and a hydrocarbon-dominated mindset are part of

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the story. But institutional capacity, high-level government strategic priorities, the interests of key players, and the ease or difficulty of accessing international finance and technology, differ between the two. Even if the raw statistics in terms of renewable deployment look quite similar, the processes of getting there have been unlike.

## IRAN

### *Background*

Despite its large land-mass, wealth of renewable resources, heavy energy demand and technically-skilled population, Iran has made relatively little progress in renewables, with the exception of hydroelectricity. This is in sharp contrast with regional neighbours such as the UAE and Turkey.

On the other hand, it was the first Middle Eastern country to begin generating nuclear power. Nuclear forms only a small part of its future planned energy mix, yet has received disproportionate political attention and funding. Nuclear's low-carbon nature has not been an important factor in Iran's choice to adopt it.

By 2019, Iran's installed generation capacity amounted to 81 GW of gas and oil-fired generation, 16 GW of hydropower, 1 GW of nuclear, 0.35 GW of solar photovoltaic, 0.02 GW of solar thermal and 0.3 GW of wind. There are some limited plans for coal power in the Tabas mining area in eastern Iran.

Electricity generation growth was exceptionally rapid following the Iran-Iraq war (1980–1988), with a compound average growth rate of 7.6%, driven by economic reconstruction, fast population growth, the extension of the grid to more remote locations and low, subsidised prices. Annual growth slowed to 3.5% from 2010 to 2018, as most population centres had been connected to power, population growth slowed, the economy suffered two intense phases of sanctions, and subsidies were sharply reduced in late 2010. Nevertheless, keeping up with such fast growth without major nationwide power shortages was a significant achievement.<sup>1</sup>

Iran's complex and factionalised political system features a number of loosely organised groupings, which compete for power and financial resources under the supervision of the supreme leader, Ayatollah Ali Khamenei. Apart from material and social interests, ideological differences

between these groups include statist versus more private enterprise-focussed approaches to the economy; self-sufficiency and the 'resistance economy' favoured by the supreme leader versus international openness and engagement; priority to national and regime security versus the economy; and looking to Europe as Iran's main trade partner versus China and Russia.<sup>2</sup> Note however that all factions co-opt the rather vague rhetoric of the 'resistance economy' since its promulgation by the supreme leader.<sup>3</sup> The 'moderniser' faction (grouping those often termed 'reformists' and 'moderates', including President Hassan Rouhani) is increasingly blamed for failing to deliver prosperity following the signature of the Joint Comprehensive Plan of Action (JCPOA), the 'nuclear deal' or 'Barjam' in Farsi in October 2015 and the US withdrawal in May 2018. The modernisers lost out heavily in the parliamentary elections of February 2020 to the 'Principlist' and 'Securocrat' (Islamic Revolutionary Guards Corps) groupings. This suggests a further shift towards economic self-sufficiency and trade with Russia and China. This was emphasised by the trade and political deal with China announced in July 2020, a purported text of which was 'leaked', but which originated with Chinese President Xi Jinping's visit to Tehran in January 2016. However, these countries are not willing, and Russia is not able, to replace Europe as a trade partner. The new Islamic Republic of Iran inherited after the revolution a large state-dominated energy sector. Its constitution, adopted in December 1979, has a statist orientation, with socialist influences.<sup>4</sup> It states (Article 44): 'The economy of the Islamic Republic of Iran is to consist of three sectors: state, cooperative, and private, and is to be based on systematic and sound planning. The state sector is to include all large-scale and mother industries, foreign trade, major minerals, banking, insurance, *power generation, dams* and large-scale irrigation networks...' [Author's emphasis]. Tavanir, the Iran Generation and Transmission Management of Electric Power Company, had been established in 1970 as a vertically-integrated, monopoly state utility, and continued in that role after the revolution.

This orientation changed somewhat following the Iran-Iraq War, in which 2210 MW of generating capacity was damaged, and under the administrations of then President Ali Akbar Hashemi Rafsanjani (1989–1997). Foreign investment in the upstream oil and gas sector, though not ownership of reserves or production, was allowed by a creative interpretation of the constitution and the introduction of 'buyback' contracts from 1997,<sup>5</sup> effectively a service contract. Widespread blackouts in the early

1990s strengthened awareness of the need for power sector expansion and reform. A wholesale electricity market with a regulator was established in 2003,<sup>6</sup> and in 2004, Tavanir was allowed to list 65% of subsidiaries on the Tehran Stock Exchange, and a separate (though 100%-Tavanir) entity was established to operate the electricity transmission system.<sup>7</sup> The privatisation decree of July 2008 permitted privatisation of major enterprises,<sup>8</sup> albeit excluding the upstream oil and gas sector. Electricity transmission and distribution remain state-owned, but private investment has been encouraged in independent power producers (IPPs) from about 2003, with investors entering the sector from 2005, including for renewable projects, and the majority of power plants have been privatised.<sup>9</sup> However, much of this privatisation, particularly under then President Ahmadinejad, was really pseudo-privatisation, with insiders and parastatal organisations taking control of state assets.<sup>10</sup> Though Quest Energy of Dubai was negotiating for an IPP in 2008, it was not until 2016 that the first foreign company, Unit Group of Belgium, was successful in signing an IPP agreement in Iran (in this case, 6020 MW of gas-fired plants).<sup>11</sup>

There have been attempts to privatise dams and their hydroelectric facilities, but these did not succeed because water resources are strictly property of the state, so they continue to be owned by the Iran Water and Power Resources Development Company, established in 1989.

By 2017, the Energy Ministry owed private producers the equivalent of \$6.8 billion, because of non-payment by some of its users, particularly industries, and because of the gap between electricity supply costs and regulated prices.<sup>12</sup> Political opposition and fears of protests have prevented prices being increased sufficiently to cover costs.

From the late 1990s onwards, there was a lively debate in Iran concerning the best way to use the country's massive gas reserves, which the discovery of South Pars and other fields had by then elevated to the largest or second-largest (after Russia) in the world. This was reminiscent of the policy question in the 1970s concerning depletion of Iran's oil reserves (see below). Options for gas use including domestic power generation and industry (including petrochemicals), transport (compressed natural gas or CNG for vehicles), residential distribution for heating and cooking, reinjection in mature fields for improved oil recovery, and export either by pipeline or as liquefied natural gas (LNG).

This debate was partly couched in economic terms, but largely resolved by political exigencies. In rough descending order of priority, the competition at times of shortage was resolved as residential, transport, power,

industry, reinjection, pipeline exports (with LNG exports last, had there been any). Residential use had the attraction of bringing gas even to relatively small and remote communities, and winning electoral support for local members of the Majles (parliament). The grid expansion also benefited IRGC-linked construction and steel companies, a positive point for then President Ahmadinejad. The length of gas distribution pipelines rose from 120,852 km in 2005 to 286,756 km in 2015,<sup>13</sup> before the growth rate slowed down as gasification was largely completed.

In transport, key aims were to reduce pollution, and to limit reliance on petrol (gasoline), and CNG use really accelerated from 2005.<sup>14</sup> Iran had to import gasoline and this vulnerability was targeted by US sanctions, though subsequently new refining capacity has eliminated imports. For power, gas was displacing oil which could then be exported. In industry, well-connected business groups were able to secure allocations, particularly under the administrations of then President Mahmoud Ahmadinejad (2005–2013). However, when at times gas supplies were limited, particularly during cold winters, industry has often suffered cut-offs.

Reinjection was lower-priority and fell far below planned rates (achieving only 40% in 2015<sup>15</sup>), affecting the country's oil export capacity, though when production was limited by the periods of US sanctions, this did not matter so much. The economic attractiveness of higher oil production was outweighed by the relatively long response time of the reservoirs, and therefore the temptation to divert gas to more urgent needs elsewhere.

Exports by pipeline to Turkey began in 2001 and to Iraq in 2017<sup>16</sup>; small amounts are also exported to Azerbaijan and Armenia. Iran has imported gas from Turkmenistan to serve its northern provinces, due to limited capacity to move gas from southern fields. These imports ceased in late 2016<sup>17</sup> due to a commercial dispute and Iran's own rising output and expanded pipeline and storage capacity to the north. But again, when domestic gas has been short, Iran has cut exports to Turkey and Iraq despite incurring commercial and reputational penalties. A pipeline was completed to the UAE emirate of Sharjah, but never functioned commercially after technical problems, sanctions delays and allegations of corruption and underpricing. Plans for pipelines to Pakistan and Oman have similarly been stymied by long commercial negotiations and American opposition. In this way, with the exception of Iraq, Iran lost its opportunity to create some mutual dependence with neighbours, which

might have dampened down tensions and would have been hard for the USA to target with sanctions.

Finally, LNG exports have made little progress, despite long negotiations with Shell, Repsol, Total and China National Petroleum Corporation (CNPC), as well as smaller firms. The difficulty of accessing specialised equipment and financing under sanctions, a lack of commercial realism, shortages of gas until quite recently, and domestic political opposition, has made LNG exports particularly intractable.

Thus, most of growing gas output was directed to the domestic market, which grew rapidly because of deliberate policies and because of low, subsidised prices. Under the 2010 subsidy reform, gas prices were intended to rise to 65% of the export price, after taxes and transport costs, for industry and 75% for domestic use,<sup>18</sup> and electricity prices were also raised. With careful planning and the deposit of compensation in special bank accounts, this passed off with little unrest. Inflation and currency devaluation have required several subsequent rounds of price rises, while the improvement in the government budget has been limited by rising non-payment of residential bills. Despite or because of the difficulty of procuring equipment under sanctions, Iran's domestic industry became quite capable at building offshore gas production platforms and domestic pipelines. By 2019, its domestic primary energy mix was 65% gas, amongst the highest rates in the world. As a medium-sized country in economy and population, the volume of domestic gas consumption was the fourth highest in the world, behind only the USA, Russia and China.

Because of this rapid demand growth, Iran did suffer gas shortages, usually during the winter high-demand period. These mostly eased by 2017, due to the delayed completion of several phases of the South Pars development. However, shortages recurred in January 2020, possibly because of technical problems at South Pars, and potentially also because of the need to shut-in gas production to avoid over-production of condensate, which cannot be exported due to US sanctions or refined due to delays in refinery upgrades. In view of these issues, and the high reliance of the power sector on gas, alternative generation has again gained attractiveness.

Climate policy has not been a major contributor to Iran's energy plans. Its Nationally Determined Contribution (NDC) under the Paris Agreement (2015) refers to renewable and nuclear power quite generally.<sup>19</sup>

On the whole, the energy transition might be expected to favour a state with large gas resources, such as Iran, over neighbours whose hydro-carbon endowment is biased more to oil, such as Saudi Arabia, Kuwait and Iraq. Iran could indeed, in the longer term, expand gas exports by pipeline to neighbours, and perhaps develop some LNG exports. But because of internal bureaucracy and debate, high domestic consumption and the likely continuing impact of at least some level of sanctions and regional tensions, it is unlikely that Iran will become a major exporter of gas on the scale of Russia, Qatar or the USA.<sup>20</sup>

### *Nuclear Power*

Iran's civil nuclear power plans date back to the 1950s, with the establishment of a programme under US President Eisenhower's 'Atoms for Peace' initiative. The Tehran Research Reactor was set up in 1967, and Shah Mohammad Reza Pahlavi launched a programme to build nuclear generation in 1974.

This was at a time of optimism over nuclear's future in Western countries (and the Soviet bloc<sup>21</sup>); nuclear power was seen as a sign of technological advance. The Shah was in a hurry to build his 'great civilisation', had ample oil revenues following the 1973–1974 price surge and had been diagnosed with cancer in 1974, although it is not entirely clear how aware he was of the seriousness of his condition.<sup>22</sup> Iran's crude oil production reached its all-time high of 6.02 million barrels per day in 1974,<sup>23</sup> and there were concerns its reserves would be depleted by the 1980s.<sup>24</sup> They were estimated at 58.8 billion barrels in 1979, which at the 1974 production level would have been totally exhausted within 27 years.

The country was flaring large quantities of associated gas, but again it was expected that would be captured and used productively by the 1980s, and major projects were planned to use gas for reinjection for improved oil recovery. The supergiant South Pars field, Iran's share of the structure known as North Field in Qatar, would not be discovered until 1990.<sup>25</sup>

The Atomic Energy Organization of Iran (AEOI) was set up in 1974 under Akbar Etemad,<sup>26</sup> and received lavish funding, with a budget in 1976 of \$1.3 billion, larger than any public institution other than the oil industry.<sup>27</sup> Alumni of its training programmes include Ali Akbar Salehi, later head of the AEOI under the Islamic Republic (2009–2010, 2013–present). The plans were for 23 gigawatts (GW) of nuclear generation, via deals with France, West Germany and the USA. However, the

Ford administration was concerned about nuclear weapons proliferation, following some ambiguous statements from the Shah and India's first nuclear test, also in 1974.<sup>28</sup> At this point, Iran's installed generating capacity was only 14 GW, and observers questioned the very large size of the planned power programme.<sup>29</sup>

Iran also acquired an indirect 10% stake in the Eurodif enrichment consortium in France. The USA, at this point, was not particularly concerned about uranium enrichment, but was opposed to Iran's having a reprocessing facility, which could have allowed it to extract plutonium from spent fuel for possible use in weapons. Concepts were floated for Iran to invest in an enrichment plant in the USA, or somewhere else as part of an international consortium. Etemad felt from the start that the USA could be ruled out as a partner; a deal was initialled in 1978, when the Shah conceded on reprocessing, but then fell foul of the revolution. Yet Iran's insistence on its nuclear 'rights', including enrichment, and its view of nuclear power as a corollary of modernity have continued through into the post-revolutionary period.

Agreement had been reached in 1974 with Germany's Kraftwerk (which became Siemens) to build two pressurised water reactors of 1293 MW each at Bushehr on the northern end of the Persian Gulf. The first reactor was substantially complete and the second about half-complete when work was abandoned in 1979 as payment ceased after the revolution. Framatome of France had just started construction of two 910 MW reactors at Darkhovin, in the Khuzestan province near the Iraqi border, but this was abandoned in April 1979. AEOI continued in existence but many trained nuclear professionals also left the country at this time. Ayatollah Khomeini saw the nuclear programme as an expensive legacy of the Shah's programme of Westernisation, and annulled the power plant contracts, though nuclear work with a possible aim of developing weapons did resume in 1983.<sup>30</sup> The Iran-Iraq war denied the nuclear programme further resources, and the Bushehr site was severely damaged in Iraqi air raids during 1984–1988.<sup>31</sup>

Following the war's end in 1988, Iran's nuclear activities picked up again. However, the USA strongly opposed them because of concerns over proliferation, and persuaded Russia, China and Argentina to drop cooperation plans. Iran was reimbursed for its investment in Eurodif in 1991, but lost its right to enriched uranium from the plant. Instead, it began to develop a clandestine enrichment programme from about 1986, with the help of A. Q. Khan, the leader of Pakistan's nuclear weapons

effort. Russia did commit in 1995 to complete the Bushehr-1 plant, using the Russian-model VVER-1000 but reusing the remaining infrastructure as far as possible. Russia agreed to supply fuel and to take back spent fuel, so that enrichment in Iran would not be required. After numerous technical problems, the reactor started up in May 2011 and began commercial operations in September 2013.<sup>32</sup>

Iran also pursued a variety of plans for additional nuclear power plants. This included up to four more VVER-1000 reactors at Bushehr and four at another unspecified site, to be built by Rosatom. Limited work on the site for the first two reactors was carried out between March 2017 and November 2019.<sup>33</sup> In March 2019, it was announced that construction of Bushehr-2 and Bushehr-3 was underway, to be operational by October 2024 and April 2026, respectively,<sup>34</sup> at a cost of \$10 billion, financed by Iran.

A further string of announcements has come out between 2007 and 2014 for an indigenous 360 MW light water reactor at Darkhovin, two 100 MW reactors to be built by the China National Nuclear Corporation on the Makran (southern) coast, and possibly others on the Caspian Sea coast. Under the JCPOA, China also committed to reconstruct Iran's Arak reactor so that it could not produce or reprocess weapons-grade plutonium.

Russia and China are, of course, the two main diplomatic supporters of the Islamic Republic, and China is its sole remaining paying customer for oil. This presents an opportunity for Rosatom to market its reactors with little competition. Deals with China allow Iran to use barter or renminbi-denominated trade offset against oil sales. Iranian officials are frustrated with the actual practical support from these countries, which has done little to shield them from the effect of unilateral US sanctions, but have few alternatives.

During this period, Iran also carried out numerous nuclear activities not directly related to power production, including construction of a heavy water plant, the Arak research reactor and uranium enrichment. Various revelations of these projects led to growing international pressure, particularly from 2003 onwards, for more inspections and restrictions. Some of the justification for Iran's indigenous enrichment effort, and related endeavours such as domestic uranium mining, has been the need to guarantee a fuel supply for its reactors, partly because of the Eurodif experience, partly because of mistrust of various international offers to

provide fuel or third-country enrichment and partly because of the experience of struggling for survival in the face of international isolation during the Iran-Iraq War. But Iran's own uranium resources do not appear sufficient in quality or quantity to fuel a large power generation fleet, and it still has difficulty manufacturing usable fuel rods, making imports of some kind a necessity.<sup>35</sup>

Iran's nuclear power programme has thus taken some forty years, of which about 22 years were spent in active work, to construct 1 GW of generating capacity, at an estimated direct cost in current dollars of \$11 billion,<sup>36</sup> and a much higher cost in terms of sanctions and lost economic opportunities. For comparison, the country's total installed capacity as of 2019 amounted to about 99 GW and peak demand to about 61 GW. The UAE's nuclear programme started construction in 2012 and should have 5.6 GW operational by about 2024, a period of 12 years, at a construction cost of \$24.4 billion. This can be seen either as a story of Iran's remarkable persistence in the face of revolution, war and sanctions, giving it a nuclear capacity that will now be able to yield a significant number of new reactors; or an odd and indecisive commitment to a very expensive programme which will eventually meet only a small part of the country's electricity needs.

However, the nuclear programme since its revival in the late 1980s, and indeed from its inception in 1974, has been about much more than power generation. Barzegar notes that, 'the Iranian nuclear program exceeds mere access to nuclear energy and economic growth and is concerned with more substantial issues, like mastering indigenous knowledge of nuclear technology; in other words, having access to an "independent nuclear fuel cycle"'. This is the embodiment of progress and regional and international prestige for Iran, as the nuclear program has become a symbol of national unity, the country's desire for development and advancement, as well as resistance to foreign powers' unacceptable demands'.<sup>37</sup> Li-Chen Sim, in this volume, further addresses the regional geopolitical implications of nuclear power programmes.

Indeed, technology transfer and the training of Iranian nuclear engineers have been an important part of the agreements with Russia. This narrative is therefore convenient for the leadership of the Islamic Republic, as it plays into the ideology of self-sufficiency and the 'resistance economy', while it also finds favour on nationalist grounds with Iranians who would not otherwise be supportive of the regime. In polling in October 2019, 75% said that Iran should not accept a deal requiring it to

cease permanently any enrichment on its territory, even in return for the lifting of additional US sanctions.<sup>38</sup> Some influential groups within the country, notably the Islamic Revolutionary Guards Corps (IRGC), benefit from a continuing level of sanctions, which allows them to exploit lucrative smuggling opportunities and keep out foreign competitors. Their engineering firms have also benefited from contracts connected to the nuclear power programme.<sup>39</sup>

And, of course, although debate continues on Iran's past and current intentions, enrichment allows it to progress towards potential nuclear latency—the ability to produce a nuclear weapon on short order, as a means of ensuring regime survival. The fate of Saddam Hussein in Iraq (discussed below) and Muammar Qaddafi in Libya, who both gave up nuclear weapons ambitions, contrasts here with the continued survival of the nuclear-armed Kim dynasty in North Korea. Under the Joint Comprehensive Plan of Action (JCPOA), agreed in 2015 with the USA under the Obama administration, the other UN security council permanent members and the EU, Iran accepted stringent restrictions on enrichment, to the point of being useless either for weapons or reactor fuel, but it achieved international recognition of its right to domestic enrichment, a nationalist win for the regime.

### *Hydropower*

Hydropower in Iran also has strong domestic and international political implications, if not to the same level as nuclear energy. These implications relate more to its control of water than of electricity. It is a major part of the power mix, reaching 1.8 GW immediately before the revolution,<sup>40</sup> and now standing at 12.252 GW of installed capacity, generating 9.1% of total electricity in 2019 (this was unusually high due to strong rainfall; the average over the past decade has been 5.3%). Hydro generation is highly variable because of changes in precipitation.

Domestic political factors have led Iran to overbuild dams in the 1990s and 2000s, with the process accelerating particularly under former President Ahmadinejad. These include the drive for food security and national self-sufficiency<sup>41</sup>; rural employment; and lobbying from local MPs. The IRGC, with whom Ahmadinejad was closely associated, has lobbied to build excessive numbers of dams to benefit from contracts awarded to its engineering subsidiary, Khatam Al Anbiya, often under its construction affiliate Sepasad. For instance, in 2012, a Chinese company building the

Bakhtiari Dam in Lorestan was muscled aside by Khatam Al Anbiya.<sup>42</sup> Similar stories have been noted in the conventional power sector, where the IRGC held up a deal for five gas-fired power plants with international investors until Ghadir Holdings, one of its affiliates, was given a stake in an oil-field development.<sup>43</sup> Saeed Mohammed, who became head of Khatam Al Anbiya Construction Base in 2019, earlier led an IRGC company that built dams in western Iran.<sup>44</sup> The poor location and construction of dams built by the IRGC not only wastes water through leakage and evaporation, and dries up fertile areas, but limits the amount of electricity they can generate.

Drought, urbanisation and over-abstraction have led to water shortages and drying out of water bodies such as Lake Orumiyeh in the north-west.<sup>45</sup> It is possible that growing awareness of the negative consequences of dams, and an increase in water tariffs, will lead to a slowdown in future construction. Farmers, who tend to be politically conservative, have come under increasing pressure from water shortages, which may turn opinion against more impoundments. The administration of President Hassan Rouhani, in his first term, did stop some dam projects, in line with its objective to reduce the role of the IRGC in the economy,<sup>46</sup> but dam-building still benefits from the self-sufficiency narrative and powerful political backing.

Dams also have international political consequences, most notable on Iran's western and northern borders. In October 2017 and June 2018, the Kurdistan Region of Iraq (KRI) announced that Iran had interrupted the flow of the Lesser Zab. Kurdish media claimed the first cut-off was to put pressure on the KRI over its referendum on independence, held in September 2017.<sup>47</sup> In October 2018, Iran interrupted flows from the Karun and Karkheh rivers into southern Iraq.<sup>48</sup> In the face of water and power shortages at home, exacerbated by a heatwave, and also possibly because of non-payment by Iraq, Iran also reduced its electricity exports. These factors contributed to the protests centred on Basra, and to Prime Minister Haidar Al Abadi's failure to win a second term in the 2018 elections.

Dam-building has extended into Iranian diplomacy. For instance, in December 2011, its government agreed to fund the Balaa Dam in Lebanon on the condition that an Iranian company was awarded the construction contract. This requirement was dropped due to concerns about links to Khatam Al Anbiya.<sup>49</sup> In May 2020, Iran completed two hydropower projects on the Aras River, forming part of the border

between it and Azerbaijan. The construction sites were on Azerbaijani territory occupied by Armenia, and, in addition to their practical use, they form part of Tehran's complicated diplomacy with its Caucasus neighbours.<sup>50</sup> Iran has also contributed to building the controversial Roghun Dam in Tajikistan, as well as dams in Kyrgyzstan.

### *Non-hydro Renewable Energy*

Iran's progress in non-hydro renewable energy presents a sharp contrast with its efforts in nuclear and hydropower. It has excellent solar and wind resources, and a strong base of technical skills and local industry. There is also domestic pressure for more renewable energy to improve air quality and save on the use of scarce water in thermal and hydroelectric power plants. Renewable energy would also address its concerns over self-sufficiency and the depletion of fossil fuel resources.

Renewable energy appeared in the 20-Year Economic Perspective, put forward in 2005, where the target was to meet 18% of energy (probably meaning electricity) from renewables, likely including hydropower.<sup>51</sup> The Third Development Plan (2000–2005) included plans for a 250 MW wind farm, while the Fourth Development Plan envisaged 1000 MW of wind.<sup>52</sup> The Fifth Development Plan (2010–2015) introduced 20-year power purchase agreements for renewables with feed-in tariffs, and bonuses for higher local content. The Sixth Development Plan (2016–2021) envisages installation of 5000 MW of renewables by 2021 and a further 2500 MW by 2030.<sup>53</sup> In 2017, the country planned to reach about 4 GW of non-hydro renewables by 2021.

Yet by 2019, it had an installed capacity of 'modern' renewables of only 302 MW of wind, 367 MW of solar photovoltaic (PV) and 12 MW of bioenergy. This contrasts strongly to a much smaller country such as Jordan, which had in 2019 374 MW of wind, 998 MW of solar PV and 13 MW of bioenergy.<sup>54</sup> The solar plants in Iran are also mostly of small size, 10 MW or less. The 20 MW Mokran plant was the country's largest when it was opened in the Kerman province in July 2017, financed by a Swiss company and supervised by a German firm.<sup>55</sup> Of course, renewables have struggled to compete economically against low-priced gas,<sup>56</sup> until dropping in cost over the last few years, but the same applies to nuclear power. Various scenarios can meet Iran's power needs with a mix of improved efficiency, gas and renewables with lower costs and CO<sub>2</sub>

emissions than either the current system or with the planned 10 GW of nuclear power.<sup>57</sup>

Renewable energy installation has accelerated recently. The Ministry of Energy Renewable Energy and Energy Efficiency Organisation (SATBA) has signed power purchase agreements (PPAs) for 1427 MW of wind, 2685 MW of solar, 31 MW of biomass and 15 MW of small hydropower. Still, the average size of these projects (32 MW wind and 9 MW solar) is very small compared to the plants of hundreds of megawatts up to 2 GW being constructed in neighbouring countries such as Pakistan, the UAE, Oman and Saudi Arabia. Plans for larger plants, such as a 1 GW solar PV plant near Saveh in the central Markazi province announced in January 2019, and a July 2018 memorandum of understanding for a 0.5–1 GW plant near Yazd with an Italian-Chinese joint venture, are backed by foreign investors.<sup>58</sup> Progress must remain doubtful given the problems posed by sanctions and financing. The feed-in tariffs offered by SATBA apply only to wind, solar or small hydropower projects of up to 10 MW,<sup>59</sup> given limited financial resources. 25% of value-added tax on electricity bills is allocated to SATBA, but this amounts to only \$25 million annually.<sup>60</sup> In 2016, state-owned organizations were obliged to install solar panels to cover at least 20% of their electricity needs, but again take-up has been limited.<sup>61</sup>

There are several reasons for slow progress in renewables. Despite government efforts to promote renewables, the investment environment in Iran for foreign investors remains bureaucratic, slow and opaque. The increasingly tight international and US sanctions established under President Obama during 2010–2015, then the greatly intensified US sanctions imposed by Donald Trump's administration after its withdrawal from the JCPOA in 2017, have deterred foreign investment and made access to international equipment more difficult. International financial institutions such as the European Bank for Reconstruction and Development and the World Bank, which had been important in establishing renewables frameworks in countries such as Morocco, Jordan and Egypt, were not able to bring financing and expertise to Iran. This increased the financial requirement and risk on investors.

There was considerable interest in the brief period the JCPOA was fully operational, including from Danish, Norwegian, Swedish, French, German, Austrian, Spanish, Italian, Greek, Turkish, Indian, South Korean and Chinese companies, who completed solar plants totalling more than 100 MW.<sup>62</sup> But following 2017, most of this activity ceased; for instance,

UK firm Quercus withdrew in August 2018 from plans to build a 600 MW solar plant.<sup>63</sup> The Trump-era sanctions are said to have tripled the price of imported photovoltaic panels, inverters and cables.<sup>64</sup> The governance of the PPA under Iranian law is a further deterrent for international companies. Additional problems have been caused by the Covid-19 outbreak, with suggestions that the high concentration of initial cases around the city of Qom, south of Tehran, was due to the presence of Chinese engineers who are building a 30 MW solar plant there.<sup>65</sup>

All of Iran's non-hydro renewables have been developed with private-sector investment,<sup>66</sup> during a period that non-state companies have generally been squeezed for finance and/or concentrating on short-term, high-return projects. Iranian banks do not offer project financing and corporate finance is at high rates and directed to politically-favoured entities. The National Development Fund (NDF) has very limited resources and these are focussed on high-priority projects. The Renewable Energy Organisation of Iran, SUNA (which was merged into SATBA in December 2016) committed to issue letters of credit, but these do not have a credit rating or sovereign guarantee. The high resulting cost of capital for developers contrasts with the very low cost of capital achieved by developers in the Gulf Cooperation Council countries, a major contributor to their extremely low reported levelised cost of electricity (LCOE).

Instead of the increasingly popular tender model, SUNA offered a range of feed-in tariffs to offset the low electricity sales prices. In 2018, these ranged from 3200 Iranian rials (IRR) per kWh for large projects up to 8000 IRR/kWh for very small projects, which were to be adjusted based on inflation and exchange rates. At the then prevailing exchange rate,<sup>67</sup> this was equivalent to 7.5–18.8 USc/kWh, which should have been attractive. However, the requirement for payments under the power purchase agreement to be made in rials would be unacceptable to most international investors. The feed-in tariff has fallen because of depreciation of the rial; although payment is meant to be made at the official rate, rather than the much lower market rate, this raises the uncertainty of investors about access to hard currency. The Central Bank of Iran had reportedly offered payment to foreign investors in yuan rather than euros, again unattractive to most.<sup>68</sup>

Bureaucracy and unclear regulations hamper projects, with an indicated seven months for the initial stages of qualification with SUNA in reality taking about a year, and the developer has to obtain all licences and pay the associated costs. The developer is responsible for grid connection, a



difference with the typical GCC projects. Acquisition of land is also a slow and expensive process, although this is meant to be provided by the government.<sup>69</sup>

There have been turf wars between the Ministry of Energy, responsible for electricity, and the Ministry of Environment. The Ministry of Energy has less institutional power than the Ministry of Oil and the National Iranian Oil Company (NIOC), who have historically produced most of export earnings. Other organizations have also been active in renewables and receiving part of the allocated budget, including the Renewable Energy Initiative Council (REIC) under the Research Institute of Petroleum Industry, part of NIOC; the Iranian Fuel Conservation Company; the Iranian Research Organization for Science and Technology; and the Ministry of Industry and Mines. This dispersal of responsibility and budget is also likely to have retarded progress.<sup>70</sup>

Despite several rounds of subsidy reform, electricity prices remain very low in international terms because of inflation and currency depreciation. In 2019, power cost a reported 2 US¢/kWh to generate (with gas priced at about \$1/MMBtu, a low figure by international standards) but was sold at 0.7 ¢/kWh.<sup>71</sup> This makes private installation of solar power unattractive. Mohammad Ali Pouramiri, a board member of the Iran Renewable Energy Association, said that subsidies had to be lifted to make renewables attractive.<sup>72</sup> However, given the difficulties in exporting oil and gas, social unrest at rising prices and the attempt to export products such as petrochemicals instead, there are countervailing pressures to retain subsidies.

Chinese firms could take a larger role in the market, given that they could be paid in yuan, they have the expertise and remain relatively willing to take on sanctions risk. As noted, Chinese firms have been developing projects in Qom, as well as the central city of Yazd. But Iran has recently been disappointed with the lack of support provided from China to help it withstand the intensified American sanctions.

These obstacles could, of course, be partly overcome with different government policies, at least to encourage domestic investors. But with a smaller size, lower rents and less domestic manufacturing capacity than for hydropower and the oil and gas sector, renewables have not so far attracted so much political attention from influential business groups, including those linked to the IRGC. There are some exceptions. For instance, in 2017, a Greek engineering firm, Metka, and its Iranian partner, Ghadir Electricity, completed a 10 MW solar plant near

Esfahan.<sup>73</sup> Ghadir has also built solar plants at Yazd, Qom and Kerman, each about 10 MW.<sup>74</sup> Ghadir Energy Investment Company is owned 60% by Ghadir Electricity and Energy Investment Company and 40% by MAPNA. The ultimate parent, Ghadir Investment Company, has been identified by the US's Office of Foreign Assets Control (OFAC) as affiliated with the Execution of Emam Khomeini's Order (EIKO), also known as SETAD.<sup>75</sup> MAPNA, meanwhile, listed on the Tehran Stock Exchange, is mostly involved in building thermal power plants and is also on OFAC's list because of its part-ownership by Iranian government entities.

## IRAQ

### *Background*

Iraq's power sector has experienced exceptional difficulties over the past thirty years. The lack of progress on low-carbon energy despite major resources and desperate need is one small part of an overall damaged and dysfunctional sector. However, there are also particular reasons why renewable energy has made less progress than fossil-fuelled power.

Before 1990, Iraq had 10.2 GW of generating capacity, which was more than adequate to meet demand.<sup>76</sup> The power infrastructure was significantly damaged and deteriorated during the 1990–1991 Gulf War and subsequent sanctions up to 2003, then by looting following the US-led invasion of that year. After the invasion, power demand has grown rapidly because of a rising population, reconstruction and the growing availability of modern appliances, particularly air-conditioning.

The electricity system in Iraq is effectively split in two, with the autonomous Kurdistan Region of Iraq (KRI) operating its own sector. Both 'federal' (non-KRI) Iraq and the KRI have a state-owned sector run by a ministry of electricity with a monopoly of transmission and distribution. However, most generation in the KRI is via independent power producers (IPPs) contracted to the ministry, whereas the federal Ministry of Electricity (MOE) operates most of its own generation, with a limited use of IPPs, which started to generate in 2017.

Generation rose from 30.7 TWh in 2004 to 131.5 TWh in 2019.<sup>77</sup> Of this, 2.5 TWh was hydropower, down significantly from the post-invasion peak of 5.7 TWh in 2004; solar was 0.057 TWh. Of the remainder, slightly more than half was generated from gas, and the rest from oil (fuel oil, diesel and limited amounts of crude oil). Despite progress in

capturing associated gas, flaring has continued at high levels, an estimated 16.8 billion cubic metres (BCM) in 2018, with 11.5 BCM captured and used, because of inadequate facilities to process the gas, and lack of pipeline capacity to power plants.<sup>78</sup> Iraq also imports gas from Iran, reaching about 32 million cubic metres daily in April 2020.<sup>79</sup> The USA has repeatedly granted waivers for Iraq to import Iranian gas and electricity, recognising its indispensability, but has shortened the period of these waivers at times to give it leverage on Iraqi politicians, and repeatedly pressured Baghdad to find alternative supplies. In July 2020, Iraq completed its side of a 1 GW link to Kuwait which would enable it to tap into the GCC grid.<sup>80</sup>

The KRI had managed to establish reasonably reliable electricity service, mostly powered by gas and some diesel, but the fiscal burden has been heavy, with diesel for the Dohuk power plant estimated to cost \$100 million per month more than gas would.<sup>81</sup> By 2020, fuel and generating capacity shortages and power theft had led electricity provision to fall to 14–15 hours daily, with completion of the new Khabat fuel oil-powered plant hoped to boost that to 16–17 hours.<sup>82</sup>

Federal Iraq has suffered from severe and continuing power shortages, as significant growth in generation and fuel supply has still failed to keep up with demand. Peak generation was about 18 GW in summer 2019, plus 1.4 GW of imports from Iran, compared to estimated peak demand of about 25.3 GW.<sup>83</sup> The difference is met by power cuts and the use of distributed neighbourhood diesel generators, which receive fuel at subsidised prices. Technical losses, mostly in the distribution networks, are estimated at 40% and non-technical losses (unofficial connections/theft) at 20%, exceptionally high levels that compromise the ability to meet demand.<sup>84</sup> For comparison, transmission and distribution losses in Iran are about 15% and the world average is around 8%.<sup>85</sup> Even customers who pay their bills are only covering about 10% of the real cost of electricity provision,<sup>86</sup> making it impossible for the MOE to stand on a commercial basis. In April 2019, the World Bank considered a \$200 million loan to improve transmission, distribution and billing in four southern governorates.<sup>87</sup>

Subsidy reform has been almost impossible, because of political and public opposition. Political parties and influential individuals seek a cut of spending on MOE projects, and block them if corrupt payments are not forthcoming. They also have a strong influence on personnel choices at

MOE and other ministries, making it hard to place competent individuals in the right roles and empower them.

Climate policy has not been a major part of Iraq's plans. Its NDC under the Paris Agreement mentions solar equipment and appliances, but the only quantitative target for renewables is to raise hydroelectric plant capacity by 3.3%, a very unambitious goal.<sup>88</sup>

### *Renewable and Nuclear Energy*

Iraq has a good variety of renewable resources, including exploitable hydropower, abundant sunshine on unused land and, in some areas, good wind speeds. Given endemic power and gas shortages, and frequent insurgent and criminal sabotage of transmission lines, distributed renewables should be an economic and practical part of the generation mix.

Iraq has had significant **hydropower** capacity since the 1950s. Its dams are all intended for flood control and irrigation water provision, and all the large ones except Duhok have hydropower generation attached, totalling 2.1 GW. The Dokan (1959) and Darbandikhan (1961) Dams, in what is now the KRI, the Hamrin (1981) and Adhaim (2000) Dams are on tributaries of the Tigris, and the Samarra Dam is on the Tigris itself. The Haditha Dam is on the Euphrates and was finished in 1987.

The Mosul Dam on the Tigris accounts for the largest share of generation capacity with 1062 MW nominal capacity. It was built between 1981 and 1984, but has significant safety concerns because of dissolution of the gypsum bedrock, requiring continuous application of grouting to prevent collapse. The Badush Dam downstream was intended to absorb any flood from Mosul, and began construction in 1989 but work stopped in 1991 because of the UN sanctions. The US suspected in 1991 that the unfinished dam could have been supplying power to a supposed secret uranium enrichment plant nearby.<sup>89</sup> Completion of the dam would cost \$300 million, but expansion to hold any flood from Mosul has been costed at \$10 billion.<sup>90</sup> Work did, however, resume in the summer of 2019, with the possibility of including 170 MW of generation capacity.

The Darbandikhan Dam also suffers from poor construction and was bombed both in the Iran-Iraq and First Gulf wars. Following the US-led invasion of 2003, these dams were partly rehabilitated. However, in August 2014, the Islamic State of Iraq and Syria (ISIS), or Da'esh in its Arabic nickname, seized control of the Mosul Dam, before being driven

out. During their occupation of large parts of northern Iraq, they inflicted severe damage on the electricity generation and transmission networks.

The Bekhme Dam, on the Greater Zab river in what is now the KRI, was begun in 1986, but halted in 1991 by the First Gulf War. It would have 1500 MW of generation capacity. In 2005, Baghdad promised to fund the required \$5 billion. However, no work has commenced, reportedly because it would flood the Barzan area, historic home to the Barzani family which heads the Kurdistan Democratic Party, the region's leading party.<sup>91</sup> Additional dams have been planned in the KRI, including Mandawa (764 MW), Taq Taq (270 MW), Bakrman (52.5 MW) and Deralok (37.6 MW).<sup>92</sup> These have not progressed, although a number of small dams have been built for water storage.<sup>93</sup> The KRG has repeatedly suffered from budgetary crises, particularly following its loss of the Kirkuk area to federal government control in 2017, and during the coronavirus pandemic and sharp drop in oil prices in 2020, and these constrain its ability to fund such large projects. The central government is unlikely to come up with the finance either, since most lucrative subcontracting opportunities would go to politically-connected KRI companies.

Iraq's dams have also suffered from falling water availability, because of regional drought and upstream dam construction by Turkey and Iran,<sup>94</sup> although this improved somewhat with higher rainfall in 2019. Iraqi MPs and the minister of water resources have complained over water shortages because of the filling of Turkish dams,<sup>95</sup> and Turkey did agree to slow down the filling. This was a contrast to the situation in the late 1980s and early 1990s, when Iraqi and Syrian tensions with Turkey over dams escalated almost to the point of military action,<sup>96</sup> but neither country is in any position to coerce Turkey today. The KRI and the federal government in Baghdad have several outstanding disputes, including over territory, the national budget and the KRI's management of oil resources on its territory.<sup>97</sup> The construction of further dams controlling water flows into the Tigris could give the KRI more leverage in these disputes, another reason for Baghdad to drag its feet on funding them.

Repair and rehabilitation of the dams has been slow, both post-2003 and post-ISIS. By early 2019, the maximum operational capacity of the federal Iraq dams appeared to be about 867 MW from a nominal total of 1904 MW.<sup>98</sup> After the initial post-invasion repairs, the hydroelectric sector has received little attention either from the Iraqi government or the international community, except with respect to water. The IEA report on Iraq of April 2019,<sup>99</sup> for instance, only mentions dams in

the context of water shortages, while discussing solar and wind power at length, while the Iraqi government's post-ISIS list of investment projects has five solar opportunities but nothing in hydroelectricity.<sup>100</sup> This may also reflect some opinion in the international community against large hydropower because of its negative social and local environmental impacts, for instance in the withdrawal of Western financial institutions from supporting Turkey's Ilisu Dam. Yet hydropower remains by far the largest source of renewable energy in Iraq, with considerable room for rehabilitation and expansion.

Iraq's **nuclear** programme started in 1956, and it acquired a 2 MW research reactor from the USSR. However, from the early 1970s, under the direction of then vice-president Saddam Hussein, its efforts were solely directed towards gaining nuclear weapons. The country's power generation relied on its oil, gas and about 10% of hydropower, while large amounts of associated gas continue to be flared, so civil nuclear power was never required. Iraq bought two research reactors from France, as well as a plutonium separation laboratory. However, Israel bombed the larger reactor in June 1981 before it could come online. After that, Iraq relied on more clandestine approaches towards uranium enrichment, but its nuclear infrastructure was entirely dismantled during the 1990–1991 Gulf War and subsequent IAEA inspections.<sup>101</sup>

There has been no serious attempt to revive nuclear power in Iraq after the 2003 US-led invasion. In 2009, the government approached France about the possibility of rebuilding one of the research reactors destroyed during the First Gulf War,<sup>102</sup> and it repeated this call to the UN in 2017.<sup>103</sup> But the continuing availability of flared gas, concerns over instability, Iraq's lack of financial resources and institutional capacity, and the growing competitiveness of renewables, make it very unlikely a nuclear power generation programme would make progress.

Iraq has seen a number of plans to expand its use of **non-hydro renewables**. Global horizontal irradiation (GHI) is about 1900–2000 kWh/m<sup>2</sup>/year over the central part of the country, and more than 2100 kWh/m<sup>2</sup>/year in the western desert. This is not as good as some neighbouring countries such as Jordan, Egypt or the UAE, but is still as good or better than southern Spain or the south-western USA, and presents very attractive conditions for solar PV.

A small amount (36.5 MW) of solar photovoltaic was installed during 2013–2014,<sup>104</sup> and parts of Baghdad feature solar street-lighting. The Integrated National Energy Strategy of 2012 foresaw 2 GW of renewables

by 2030, including new hydro,<sup>105</sup> amounting to 3% of total generation. However, it rejected large-scale solar on the grounds that it was (then) too expensive compared to Iraq's cheap and abundant gas, although the MOE planned at that point 50 MW of solar/wind hybrid plants in remote locations where they would be competitive with diesel generators. In October 2012, the MOE announced plans for 400 MW of solar and wind, but these did not proceed.<sup>106</sup>

Following the defeat of ISIS, in 2018 the Iraqi government issued a long list of projects for international investment and reconstruction, which including 410 MW of solar power in various sites, as well as a solar research and manufacturing centre.<sup>107</sup> MOE's own projections showed 2695 MW of solar PV being installed between 2017 and 2020, spread across most provinces of the country, though excluding the KRI and the northern provinces of Kirkuk, Ninewa and Salahuddin, which were still affected by ISIS activities.<sup>108</sup> Projects were awarded to some regional companies: 465 MW in five locations to Sama Baghdad, and 230 MW in four locations to Kuwait-based Al Dana International. However, in the absence of a clear plan, priorities and investment model, these also did not go ahead. MOE has consistently suffered from a high turnover of ministers, because of changes of government and because of dismissal following allegations of corruption (Raad Shalal in 2011) and summer power cuts and protests (Karim Waheed in 2010 and Qassim Al Fahdawi in July 2018).

During this period, numerous companies approached the MOE with offers for solar projects, but these were generally rejected as too expensive. A feed-in tariff of 3.5 USc/kWh was set, inspired by the low prices achieved in some neighbouring countries, but given the early stage of solar power in Iraq and its particular challenges, this was not attractive. For comparison, bids in Jordan in 2015 were around 6–7 USc/kWh,<sup>109</sup> and its Risha project tendered in 2017 was awarded at 5.9 USc/kWh. The Iraqi projects offered were individually relatively small, so not achieving economies of scale. Part of the intention appeared to be to spread development across most provinces, particularly poorer rural provinces with limited other investment and weak grid connections, as well as widening the opportunity for insiders to benefit through land leases and contracts. Although security in most parts of Iraq has improved significantly, it remains a concern, along with high levels of corruption. Importantly, because of low electricity tariffs, theft and very high levels of non-payment, the MOE is reliant on budget transfers (the same applies to

the MOE in the KRI). This creates the concern for investors that they will experience delays and difficulty in receiving payment, particularly in the absence of a sovereign guarantee. Officials at the MOE, meanwhile, were concerned that awarding projects at prices significantly above those achieved in neighbouring countries would attract political scrutiny and allegations of corruption.

The government of Adel Abdel Mehdi, with the highly-regarded Luay Al Khatteeb as electricity minister, came into power in October 2018, and intended to add 1.5–2 GW of renewables during its 3–4 year term.<sup>110</sup> A Renewable Energy Law was drafted, and institutions and individuals have been given the right to generate renewable power for their own use, to 'wheel' it through the state grid to their other facilities, or to sell to MOE under a PPA. Low-interest loans are offered for rooftop solar installations.<sup>111</sup>

In May 2019, the MOE abandoned the feed-in tariff for projects above 10 MW, and instead launched a competitive tender for 755 MW of solar PV across several sites, and pre-qualified 45 bidders,<sup>112</sup> with interested companies including Total, Siemens and Acwa Power, a private Saudi developer with a strong regional track record and significant state backing. In November 2019, a Ministry adviser revealed plans for another 750 MW,<sup>113</sup> or 1000 MW to be launched in the first quarter of 2020. The longer-term intention was for renewables to account for 20% of generation (probably meaning capacity) by 2030. In late 2019, Acwa Power and Amea Power, a private UAE developer, were reportedly encouraged by their home governments to look at investments in Iraq as part of supporting the government and offsetting Iranian influence. Acwa Power proposed two 1 GW solar projects; one would be based in Saudi Arabia and export to Iraq at a tariff of 1.65 c/kWh; the other would be in Iraq with a tariff of 6.5 c/kWh.<sup>114</sup> This illustrates the difference in business risk between the two countries, given that the solar resource is very similar.

However, Iraq has experienced major turmoil since, with widespread anti-corruption protests starting in October 2019, the resignation of Abdel Mehdi's government and the lengthy process of selecting a new prime minister, involving the replacement of Al Khatteeb who had been in office for barely a year, then the arrival of the coronavirus pandemic and the crash in oil prices of March 2020. In this environment, the solar projects have not advanced.

Distributed solar power would seem to be an ideal initiative for Iraq, given its frequent power cuts and the high cost of electricity from generators. There has been some degree of adoption in the KRI in particular, where small private companies offer installations.<sup>115</sup> But in practice, 'rooftop' solar has made little progress. Part of this could be due to opposition from the 'generator mafia', politicians with stakes in the local diesel generators, who have been blamed for ending pilots of electricity tariff reform.<sup>116</sup>

### CONCLUSIONS

The political and financial capital the Iranian state has invested in its nuclear programme, and in totemic features such as its right to domestic enrichment, make it extremely difficult to back down. Its nuclear activities have incurred very heavy diplomatic and economic costs, but at the same time, they have been convenient to some elements of the regime, particularly the IRGC. Similarly, hydropower offers rent-seeking opportunities to developers, and temporarily satisfies the demands of constituents such as farmers. Non-hydro renewables have not yet attracted the same level of interest, though they may as the sector grows. They have suffered from a lack of suitable incentives, the limited scale and experience of local developers, US-imposed sanctions and continuing subsidies.

Iraq's lack of progress in renewables is more straightforward. It is mostly a story of ineffective organisation and capacity, overbearing bureaucracy, unworkable financing and investment models, insecurity and war damage, vested political interests and corruption, government instability, and cheap, subsidised electricity and gas. The renewables sector is not unusual in these regards; most parts of the Iraqi economy post-2003 have similarly failed to attract international or domestic private investment.

Yet objectively, both countries could realise enormous benefits from exploiting their abundant solar and wind resources, given the vast improvements in performance and cost of renewable technologies over the past few years. They have several regional examples of success that could be used as models. Their lack of progress is also not unique; several other neighbours, under apparently more favourable conditions, such as Bahrain, Lebanon, Tunisia and Algeria, have also not managed to install much renewable capacity. Only one other Middle Eastern state, the UAE, has succeeded in completing a civil nuclear power programme.

For Iran, the key to developing large amounts of non-hydro renewables could proceed through an easing of sanctions via negotiations with the USA, and depending on the state of American politics. That would at least allow European, Indian and East Asian firms, and possibly even Middle Eastern neighbours, to get involved. International support for a large renewables programme would reduce the rationale for further growth in nuclear generation. Or, a decision by major politically-connected business groups to get involved in renewables could foster a more supportive set of policies, using a mix of locally-manufactured and imported, particularly Chinese, equipment. Key policy improvements would include reducing subsidies, simplifying procedures and improving access to finance at lower costs. These two routes are not necessarily mutually-exclusive, though as noted, the presence of IRGC-linked companies tends to deter and exclude foreign competition. Estimates of the IRGC's share in the economy range from one-sixth to two-thirds of the economy,<sup>117</sup> though references tend to be circular, with unclear methodology, and the higher figures are implausible given that most of the large oil, agricultural and services sectors are not under IRGC control.

For Iraq, domestic capability and finance is much more limited. Large-scale international investment is crucial. There is substantial interest from a wide range of firms and countries, including GCC neighbours with a political interest in building bridges to Baghdad. By starting with some smaller projects, the MOE could build confidence in its payment model and bring down costs before awarding larger projects,<sup>118</sup> so avoiding the risk of being locked into a big and high-priced PPA, or being accused of corruption for accepting bid prices much higher than those of regional neighbours. The IEA's report proposed 21 GW solar PV and 5 GW wind by 2030, generating 30% of Iraq's electricity. This pace of progress looks unattainable now, but Iraq's renewable sector could still advance quickly under the right contractual model and with sustained and consistent policies. This, in turn, would require the new government of Mustafa Al Kadhimi, or a successor, to be able to overcome vested interests and statist positions, in the face of the political and economic emergency engulfing Iraq since mid-2019.

## NOTES

1. There have been episodic power cuts, as in 2001 and again in 2019 and 2020, caused by technical faults, shortages of gas and low water levels at hydroelectric dams (Fallahi 2019).
2. (Geranmayeh 2020)
3. (Iranian Students' News Agency 2013)
4. (Arjomand 2020)
5. (Ebrahimi and Shiroui Khouzani 2003)
6. (Yousefi et al. 2017)
7. (Poudineh et al. 2021)
8. 5 Iran Privatization Organization, "General Policies of Article 44 of the Constitution of the Islamic Republic of Iran", <http://www.en.ipo.ir/index.aspx?siteid=83&pageid=822>.
9. (Chitchian 2017)
10. (Harris 2013)
11. (Parris 2016)
12. (Tasnim News 2016)
13. (Omidvar 2019)
14. (Sharifi and Gougerdchian 2012)
15. (Chow et al. 2018)
16. (Dehghanpisheh 2017)
17. (Eurasianet 2017)
18. (Iran Data Portal 2009)
19. (National Climate Change Committee 2015)
20. (Jalilvand 2013)
21. (Higginbotham 2019)
22. (Khoshnood and Khoshnood 2016)
23. (OPEC 1999)
24. (Fesharaki 1976)
25. (Esrafil-Dizaji and Rahimpour-Bonab 2013)
26. (Esfandiari 2015)
27. (Milani 2010)
28. (Burr 2009)
29. (Quester 1977)
30. (Coughlin 2009)
31. (Nuclear Threat Initiative 2017)
32. (World Nuclear Association 2020)
33. (Slivyak 2019)
34. (*Financial Tribune* 2019a)
35. (Vaez and Sadjadpour 2013)
36. (Vaez and Sadjadpour 2013)
37. (Barzegar 2012)
38. (Gallagher et al. 2019)
39. (AFP 2008)
40. (Mossavar-Rahmani 1981)
41. Iran became a net wheat exporter in 2018 (Badawi 2018).
42. (DW 2018)
43. (Bazoobandi 2019)
44. (Faucon and Rasmussen 2019)
45. (Embassy of the Kingdom of the Netherlands in Tehran 2019)
46. (Bozorgmehr 2017)
47. (Homa 2017)
48. (Aldroubi 2018)
49. (Sneddon 2015)
50. (Rahimov 2020)
51. (Kalehsar 2019)
52. (Atabi 2004)
53. (CMS Law 2016)
54. (International Renewable Energy Agency [IRENA] 2020)
55. (Euronews 2017)
56. (Azadi et al. 2017)
57. (Mills 2019)
58. (Bhambhani 2019)
59. (Ministry of Energy Renewable Energy and Energy Efficiency Organization (SATBA), n.d.)
60. (*Financial Tribune* 2020a)
61. (*Financial Tribune* 2016)
62. (Arefmanesh 2018)
63. (Karagiannopoulos 2018)
64. (Eghtesadonline.com 2019)
65. (AP 2020)
66. (Chitchian 2017)
67. (XE.com, n.d.)
68. (Arefmanesh 2018)
69. (Taherian 2018)
70. (Fadai et al. 2011)
71. (*Financial Tribune* 2019b)
72. (*Financial Tribune* 2020b)
73. (Al Bawaba 2017)
74. (Ghadir Energy Investment Company, n.d.)
75. (El Nakib 2018)
76. (Ahmad-Rashid 2017)
77. (BP 2020)
78. (International Energy Agency 2019b)
79. (Tehran Times 2020)

80. (Middle East Economic Survey 2020a)
81. (World Bank 2015)
82. (Wali 2020; Middle East Economic Survey 2020b)
83. (Ashwarya 2020)
84. (International Energy Agency 2019a)
85. (Poudineh et al., *Advancing Renewable Energy in Resource-Rich Economies of the MENA*, 2016)
86. (Al Khatteeb 2020)
87. (World Bank 2019)
88. (World Bank 2016; Government of Iraq 2015)
89. [https://books.google.ae/books?id=EGlOBbPQpdYC&pg=PA99&clpg=PA99&dq=badush+megawatts&source=bl&ots=h88-YE7Lv2&sig=ACfU3U1NqvtZfbFoTC7lArvk19i4C-RpdQ&hl=en&csa=X&ved=2ahUKEwiUvI-R0P\\_pAhVtCWMBHYWEAl0Q6AEwAHoECAoQAQ#v=onepage&q=badush%20megawatts&f=false](https://books.google.ae/books?id=EGlOBbPQpdYC&pg=PA99&clpg=PA99&dq=badush+megawatts&source=bl&ots=h88-YE7Lv2&sig=ACfU3U1NqvtZfbFoTC7lArvk19i4C-RpdQ&hl=en&csa=X&ved=2ahUKEwiUvI-R0P_pAhVtCWMBHYWEAl0Q6AEwAHoECAoQAQ#v=onepage&q=badush%20megawatts&f=false), p. 99.
90. <https://www.washingtonpost.com/wp-dyn/content/article/2007/10/29/AR2007102902193.html?hpid=topnews>.
91. (Qader and Hamid 2018)
92. (Kareem 2012)
93. (Abdullah 2019)
94. (Habib 2019)
95. (Karadeniz and Aboulenein 2018)
96. (Jongerden 2009)
97. E.g. (Mills, *A Rocky Road: Kurdish Oil and Independence*, 2018).
98. Qamar Energy analysis of Ministry of Electricity reported generation.
99. (International Energy Agency 2019a)
100. (Government of Iraq 2018)
101. (Nuclear Threat Initiative 2015)
102. (Chulov 2009)
103. (Nichols 2017)
104. <https://public.tableau.com/views/IRENARETimeSeries/Charts?:embed=y&:showVizHome=no&publish=yes&:toolbar=no>.
105. (booz&cco 2012)
106. (Kami 2012)
107. (Government of Iraq 2018)
108. (Ministry of Electricity 2018)
109. (Maccagli 2015)
110. (Al Khatteeb 2020)
111. (Al Maleki 2020)
112. (Bellini 2019a)
113. (Bellini, Iraq Plans Second 750 MW Solar Tender, 2019b)
114. (MEED 2020)
115. (Fairley 2018)

116. (Al-Mawlawi 2020)
117. (Forozan and Shahi 2017)
118. (International Energy Agency 2019a)

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