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# Clean and Alternative Energy in the U.A.E.

Overview and Opportunities for Business: An Update



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## INTRODUCTION

Over the past decade, the U.A.E. has demonstrated a serious commitment to the development of clean and alternative energy. The U.A.E. is currently installing four major nuclear power plants in the emirate of Abu Dhabi. It is also playing a leading role in solar, wind, and other renewable energy projects both in the U.A.E. and abroad.

These initiatives are strategic choices by the U.A.E.'s leadership to promote the economic wellbeing of the country and its people. After all, these programs:

- Help meet the U.A.E.'s growing demand for power. The U.A.E.'s energy demand is forecasted to increase at an annual rate of about 9% (three times the global average), due largely to population growth and expanding industrial capacity.<sup>1</sup>
- Reduce the U.A.E.'s dependence on natural gas imports. The U.A.E. is currently a net importer of natural gas, which it relies on for both electricity and enhanced oil recovery.<sup>2</sup>
- Preserve the U.A.E.'s lucrative oil exports. The U.A.E. is the seventh-largest petroleum producer in the world, with hydrocarbon export revenues projected to reach \$65 billion in 2017, accounting for roughly 20% of all export revenue.<sup>3</sup>
- Protect the U.A.E.'s environment and promote the health and wellbeing of its citizens.
- Diversify the economy and create employment opportunities for U.A.E. nationals.

This final point is particularly important. Since its independence, the U.A.E. has made great strides in diversifying its economy away from oil, emerging as a regional hub for trade, travel, tourism, finance, healthcare, and education. As a result, U.A.E. Minister of Economy His Excellency Sultan bin Saeed Al Mansoori noted in September 2017 that the U.A.E.'s non-oil sector contributes to 70% of the country's GDP. By 2020, this figure is expected to rise to 80%.<sup>4</sup>

The development of clean and alternative energy is one of the next pillars of the U.A.E.'s economic diversification strategy. As such, it will help the country realize the shared vision of His Highness Sheikh Khalifa bin Zayed Al Nahyan, President of the U.A.E., His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the U.A.E. and Ruler of Dubai, and His Highness Sheikh Mohamed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of the U.A.E. Armed Forces, to have the U.A.E. "celebrate" the export of its last barrel of oil.<sup>5</sup>

This new and updated report begins by reviewing the U.A.E. leadership's stated commitments to developing clean and alternative energy. It then provides an overview of key institutions, projects, research, events, and funding mechanisms that are helping the U.A.E. realize these commitments. Finally, it concludes by highlighting opportunities and resources for businesses interested in this sector. Throughout, this report references the long history of successful U.S.-U.A.E. partnerships that have helped make the U.A.E. a regional leader in this field.

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## NATIONAL AND INTERNATIONAL COMMITMENTS

The U.A.E. has made ambitious national-level commitments for the adoption of clean and alternative energy. In January 2017, U.A.E. Vice President and Prime Minister and Ruler of Dubai His Highness Sheikh Mohammed bin Rashid Al Maktoum unveiled a U.A.E. Energy Strategy for 2050. This strategy aims for the U.A.E.'s energy mix in 2050 to comprise 44% renewable energy, 38% gas, 12% clean coal, and 6% nuclear. As of early 2017, 90% of the U.A.E.'s energy needs were reportedly met by natural gas.<sup>6</sup>

This commitment to expanding clean and alternative energy sources over the coming decades is built on the U.A.E.'s national vision – Vision 2021. Vision 2021 is a long-term plan first launched in 2010 to make the U.A.E. one of the “best countries in the world” by the year 2021, when the U.A.E. will celebrate its Golden Jubilee or the 50<sup>th</sup> anniversary of its formation. One of the six pillars of this vision is creating a “sustainable environment and infrastructure.” A key performance indicator for this particular pillar is increasing the contribution of clean energy to the U.A.E.'s total energy mix from 0.23% in 2015 to 27% by 2021.<sup>7</sup>



These national-level initiatives are complemented by Emirate-level plans, such as the Dubai Clean Energy Strategy 2050. This strategy, unveiled in November 2015 by His Highness Sheikh Mohammed bin Rashid Al Maktoum, has five main pillars: infrastructure, legislation, funding, training, and creating an environmentally friendly energy mix. It calls for clean energy to account for 7% of Dubai's energy needs by 2020, 25% by 2030, and 75% by 2050. Meeting this target will require a capacity of 44,000 MW of clean and renewable energy by 2050.<sup>8</sup>

The above national and Emirate-level initiatives are in keeping with the U.A.E.'s international commitments. In September 2016, the U.A.E. ratified the Paris Agreement on Climate Change under which 196 nations resolved to limit global warming to a maximum of 2 degrees Celsius. In ratifying this agreement when it did, the U.A.E. became the first country in the Middle East to do so, demonstrating its leadership role on this important issue.<sup>9</sup>

## KEY INSTITUTIONS

While all U.A.E. federal government institutions are playing a role in implementing the above plans, certain ministries have taken the lead. Namely, the U.A.E. federal government has entrusted the U.A.E. Ministry of Energy and Industry (renamed in October 2017 from the Ministry of Energy) and the U.A.E. Ministry of Cabinet Affairs and Future (renamed from Ministry of Cabinet Affairs in 2016) with supervising the implementation of its 2050 Energy Strategy.<sup>10</sup> The U.A.E. Ministry of Climate Change and Environment (renamed from the Ministry of Environment and Water in February



UNITED ARAB EMIRATES  
MINISTRY OF CLIMATE CHANGE  
& ENVIRONMENT



UNITED ARAB EMIRATES  
MINISTRY OF ENERGY & INDUSTRY

2016) also plays an important role in promoting a green economy and sustainability.<sup>11</sup>

Beyond these ministries, certain other governmental institutions are also of note. The Emirates Nuclear Energy Corporation (ENEC) has overseen the design, construction, and operation of all U.A.E. nuclear power plants.<sup>12</sup> Meanwhile, the Dubai Electricity and Water Authority (DEWA), the Abu Dhabi Electricity and Water Authority (ADWEA), the Sharjah Electricity and Water Authority (SEWA), and the Federal Electricity and Water Authority (FEWA) have led the development of pioneering renewable and clean energy projects in their respective Emirates.



A final U.A.E. institution that plays an outsized role in the country is the Abu Dhabi Future Energy Company (Masdar), which is a developer and investor in renewable energy globally and sustainable real estate projects in Abu Dhabi. Established by the Mubadala Development Company (now the Mubadala Investment Company) in 2006, Masdar has – with the help of U.S. companies such as CH2M, SolarOne, and SunPower – built a sustainable urban development and economic free zone in Abu Dhabi called Masdar City.<sup>13</sup> From this city, which serves as a “greenprint” for future cities, Masdar has advanced the development, commercialization, and deployment of renewable energy and clean technologies through businesses focusing on clean energy deployment and sustainable real estate.



In addition to these U.A.E. institutions, the International Renewable Energy Agency (IRENA) has since 2009 been based in the U.A.E. IRENA, which was the first intergovernmental organization to be headquartered in the Middle East region and the first intergovernmental institution dedicated to renewable energy, supports countries in their transition to a sustainable energy future by serving as a “platform for international cooperation, a center of excellence, and a repository of policy, technology, resources, and financial knowledge.”<sup>14</sup> IRENA officially inaugurated its 32,000 square-meter permanent headquarters at Masdar City in 2015.<sup>15</sup>



## PROJECTS IN THE U.A.E.

With the support of the above institutions, the U.A.E. has begun transforming its energy mix, particularly with respect to nuclear and solar energy.

## A. Nuclear

The U.A.E.'s nuclear energy program first took shape in 2009 with the creation of both the Emirates Nuclear Energy Corporation (ENEC) and the Federal Authority for Nuclear Regulation (FANR). While FANR regulates the U.A.E. nuclear program, ENEC oversees the design, construction, and operation of the country's nuclear power plants. It also ensures the U.A.E.'s nuclear power program is coordinated with the U.A.E.'s industrial infrastructure plans, builds the human resource capacity among Emiratis for this program, and informs the public about the program.<sup>16</sup>



Soon after its creation, ENEC awarded two important contracts. First, it gave U.S. engineering company CH2M (now Jacobs Engineering) a long-term contract to help manage the nuclear program.<sup>17</sup> Then, it charged a consortium led by Korea Electric Power Corporation (KEPCO) with building four 1,400 MW reactors in Abu Dhabi's Western region.<sup>18</sup> These reactors are known as the Barakah Nuclear Energy Plant.



In 2013, the KEPCO-led consortium broke ground on the first reactor at this plant. Since then, construction has proceeded steadily such that, as of the end of September 2017, the overall completion rate for the plant was 84.92%, with Unit 1 96.83% complete, Unit 2 89.21% complete, Unit 3 78.84% complete, and Unit 4 59.47% complete. To date, this has entailed more than 1.4 million cubic yards of concrete, 250,000 tons of reinforcing steel, and 1,559 kilometers of cable.<sup>19</sup>



*Barakah Nuclear Power Plant*

The first reactor of the Barakah plant is expected to become operational in 2018.<sup>20</sup> Another reactor is then due to come online every year for the next three years. When all four reactors are completed in 2021, they will collectively provide for one-quarter of the U.A.E.'s total electricity needs.<sup>21</sup> The plants are expected to be operational for around 60 years.<sup>22</sup>

As these reactors are completed, they will be operated and maintained by the Nawah Energy Company, which is an ENEC subsidiary that is 18% owned by KEPCO.<sup>23</sup> As part of its commitment to Emiratization, Nawah Energy Company will be comprised 60% of U.A.E. nationals.<sup>24</sup>

While KEPCO has led the consortium building these reactors, U.A.E. companies have played a prominent role. As of November 2017, more than 1,400 U.A.E.-based companies had been contracted for delivery of products and services for the Barakah plant, with contracts worth over 13 billion AED [\$3.5 billion]. These companies include cable manufacturer Ducab, which is jointly held by the Investment Corporation of Dubai and U.A.E. industrial conglomerate Senaat.<sup>25</sup>

U.S. companies have also played important roles in this project. For instance, Bechtel has won design and project management support contracts.<sup>26</sup> Moreover, Westinghouse has built cooling pumps and a digital control center as well as conducted large-scale training of Emirati staff.<sup>27</sup>



This extensive involvement of U.S. companies in the U.A.E. nuclear program has been made possible by the 123 Agreement for Peaceful Civilian Nuclear Energy Cooperation that the U.S. and U.A.E. signed in late 2009.<sup>28</sup> Importantly, under this agreement, the U.A.E. committed to not enrich uranium and not reprocess spent fuel to extract plutonium. In foreswearing these fuel cycle activities that pose the most serious proliferation risks, the U.A.E. has been held up as a model for regional countries pursuing responsible civil nuclear energy development.<sup>29</sup>

## B. Solar

The U.A.E.'s pursuit of solar energy began with Masdar. In 2009, Masdar completed a 10 MW solar photovoltaic (PV) power plant to provide electricity to Masdar City, with 50% of the panels coming from a U.S. company, First Solar. Masdar subsequently partnered with Total and Abengoa Solar to construct a 100 MW concentrated solar power (CSP) plant called Shams 1 in the Western region of Abu Dhabi. After its completion in 2013, this plant became the largest renewable energy project in the Middle East, generating enough electricity to power 20,000 homes.<sup>30</sup>



*Shams 1 Solar Plant*

From there, the U.A.E.'s solar ambitions only grew, especially with the launch of the Mohammed bin Rashid Al Maktoum Solar Park at Seih Al Dahal in Dubai. This 50 billion AED [\$13.6 billion] project, which is overseen by Dubai Electricity and Water Authority (DEWA), is a key component of the Dubai Clean Energy Strategy 2050. The park currently has 213 MW of PV in service and another 800 MW of PV under construction. When fully completed in 2030, it will have a capacity of 5,000 MW, making it the largest single-site solar park in the world based on the IPP model and accounting for 25% of the estimated total energy production of Dubai.<sup>31</sup> It will also feature the world's largest CSP project, which will generate 700 MW of power at a cost of 7.3 cents per kilowatt hour using a 260 meter solar tower.<sup>32</sup> CSP is more expensive than PV, but it has advantages in terms of energy storage.

One of the most notable aspects of the Mohammed bin Rashid Al Maktoum Solar Park has been its ability to generate record-low bids for the estimated cost of producing electricity.

- In 2015, Saudi Arabia's ACWA Power and its Spanish partner TSK won a contract to build the second phase of this park, a 200 MW plant, with a then-record-breaking bid of 5.84 cents per kilowatt-hour.<sup>33</sup> Notably, ACWA and TSK awarded U.S. panel manufacturer First Solar (which was also involved in the park's first phase) a \$200 million engineering, procurement, and

construction contract, and it awarded General Electric a contract to provide inverters, transformers, and switchgears.<sup>34</sup>

- In 2016, DEWA awarded a contract to a Masdar-led consortium to build the third phase of this solar park, an 800 MW solar PV plant, with an even lower record-breaking bid of 2.99 cents per kilowatt-hour. Unlike conventional solar power arrays, the third phase of this park will use tilting panels that track the sun, thereby maximizing output.<sup>35</sup>

Since then, the U.A.E. has embarked on another project that set new record-low bids for the cost of electricity generation. The Abu Dhabi Water and Electricity Authority (ADWEA) signed a contract with Japan's Marubeni and China's JinkoSolar to build and operate a 1,177 MW solar project in Suwaihan, approximately 120 kilometers southeast of Abu Dhabi city. This project, which is named "Noor Abu Dhabi," is expected to be completed by 2019 at a total cost of 3.2 billion AED [\$870 million].<sup>36</sup> Notably, Marubeni and JinkoSolar submitted a record-low bid for the cost of electricity generation at a weighted 2.42 cents per kilowatt hour, although the actual price that ADWEA will pay for power generated during peak months will reportedly be 1.6 times higher than that.<sup>37</sup> This project is part of broader plans by ADWEA to generate 5,700 MW of solar power by 2026.<sup>38</sup>

At the same time that the U.A.E. has undertaken these landmark utility-scale solar projects, Dubai has encouraged households and businesses to adopt solar power through its "Shams Dubai" initiative. In late 2015, DEWA set up a net metering system allowing private home owners and businesses to install PV panels to generate electricity equivalent to the amount they consumed on average. Any excess electricity produced by these panels could then be fed into the electric grid to offset their utility bills, providing a significant incentive for the installation of solar rooftops on residential and commercial establishments.<sup>39</sup> By mid-December 2017, DEWA completed connecting solar panels to 548 buildings, with a total capacity of 20.1 MW. DEWA aims to increase this number to cover all buildings in the Emirate by 2030.

Many leading U.A.E. businesses have embraced solar power as part of initiatives like these.

- DP World announced in October 2016 that it would install 88,000 solar panels on its facilities in Jebel Ali Free Zone and Mina Rashid.<sup>40</sup> Moreover, in October 2017, DP World launched a crowdfunding project with Dubai Carbon Center of Excellence to help retrofit warehouses in Mina Rashid.<sup>41</sup>
- Emirates National Oil Company (ENOC) announced in October 2017 that all future ENOC service stations would be powered by solar energy. Earlier in 2017, ENOC piloted the first solar-powered service station in the country in Dubai Internet City.<sup>42</sup>
- Majid Al Futtaim, the builder of the Mall of the Emirates and other malls, vowed in August 2016 to produce 5% of its total energy in the next two years using solar PV technology.<sup>43</sup> In June 2017, Majid Al Futtaim and Veolia of France signed a deal to install 12,500 solar panels at four Majid Al Futtaim malls. Two of its other malls began generating some of their electricity from solar panels the previous year.<sup>44</sup>



- Intercontinental Hotels Group (IHG) broke ground in November 2017 on Dubai's first fully solar-powered hotel, Hotel Indigo Dubai.<sup>45</sup>

### C. Other

Although the U.A.E.'s energy diversification efforts have thus far centered on nuclear and solar energy, the U.A.E. has sought to harness other sources of clean or alternative energy as well, such as clean coal and hydropower.

- In October 2017, the Federal Electricity and Water Authority (FEWA) announced that Ras Al Khaimah would build a clean coal power station by the first quarter of 2021. This 8 billion AED [\$2.18 billion] plant would reportedly generate 1,800 MW per year.<sup>46</sup>
- In June 2017, DEWA signed an agreement with Electricité de France (EDF) to consult on a planned hydroelectric power station at Hatta Dam. This 250 MW hydroelectric power station would be the first of its kind in the Gulf Cooperation Council (GCC).<sup>47</sup>
- In June 2016, DEWA signed an agreement with a consortium including China's Harbin Electric and Saudi Arabia's ACWA Power to build and operate a 2,400 MW clean coal plant (the Hassyan clean coal power station) that should be fully operational by 2023.<sup>48</sup> Through a partnership with Harbin Electric, General Electric will provide this plant with its ultra-supercritical (USC) technology and advanced environmental control systems (ECS).<sup>49</sup>

In addition, the U.A.E. has embarked on a number of waste-to-energy projects.

- In January 2018, Tadweer (the Center for Waste Management in Abu Dhabi) signed a contract for the first landfill gas-to-energy investment project in the Middle East. This project will produce approximately 5 MW of power by September 2018 from gas at Al Dhafra Landfill, which is the largest landfill in Abu Dhabi.<sup>50</sup>
- In January 2017, Masdar signed an agreement with Sharjah Environment Company (Bee'ah) to develop a waste-to-energy plant in Sharjah. When this facility opens in 2020, it will incinerate around 37.5 tons of municipal solid waste per hour, diverting around 300,000 tons of solid waste from landfills each year and producing around 27 MW of electricity. This project is in keeping with Sharjah's "zero waste-to-landfill" target for 2020.<sup>51</sup>
- In June 2016, Dubai Municipality announced that it is building a 2 billion AED [\$540 million] facility to convert solid waste into energy in Warsan District 2, with operations expected to commence in the second quarter of 2020. The first phase of this project will receive 2,000 metric tons of municipal solid waste per day and produce 60 MW of power.<sup>52</sup>



*Masdar Chairman HE Sultan Al Jaber and Bee'ah Chairman HE Salim Al Owais sign partnership agreement*

## Reducing Greenhouse Gas Emissions

The U.A.E. Energy Strategy 2050 calls not just for increasing the U.A.E.'s production of clean and alternative energy. In addition, it calls for the U.A.E. to improve its energy efficiency 40% by the middle of the century. It also calls for the U.A.E. to reduce its carbon dioxide emissions 70% by 2050.<sup>53</sup>

The U.A.E. has already taken bold steps to reduce energy consumption. For instance, in August 2015, the U.A.E. removed longstanding subsidies on the price of gas and diesel that had led to inefficient consumption patterns. More recently, in August 2017, Abu Dhabi announced that it would replace more than 350,000 street fixtures across the Emirate over the next five years with energy-efficient LED lights.<sup>54</sup>

One of the key U.A.E. institutions in promoting energy efficiency has been the Emirates Authority for Standardization and Metrology (ESMA), which is the U.A.E.'s national standardization body. Among other things, this body has developed standards for fuel-efficient motor vehicles and energy-efficient appliances and lighting.



At the same time that the U.A.E. has strived to reduce energy consumption, the country has gone to great lengths to reduce greenhouse gas emissions in other ways.

- DEWA launched its Green Charger initiative in April 2014 to install and manage electric vehicle charging infrastructure and thereby encourage the public to switch to electric vehicles. By December 2015, DEWA had installed over 100 electric vehicle stations throughout Dubai and will have 200 such stations by 2018. In order to incentivize the adoption of electric vehicles, DEWA announced in September 2017 that all Green Charger initiative registered users would be able to charge their electric vehicles for free at all DEWA Green Charger electric vehicle charging stations through the end of 2019.<sup>55</sup>
- Abu Dhabi National Oil Company (ADNOC) and Masdar created Al Reyadah, the Middle East's first specialized company focused on exploring and developing commercial-scale Carbon Capture, Utilization, and Storage. In November 2016, Al Reyadah launched a 450 million AED [\$122 million] facility in Musaffah that is designed to capture up to 800,000 metric tons of carbon dioxide emitted from an Emirates Steel factory every year and transfer it to oilfields for enhanced oil recovery. In January 2018, ADNOC acquired Masdar's 49% share in Al Reyadah.<sup>56</sup>



*Inauguration of Al Reyadah Facility*

## PROJECTS ABROAD

While transforming its energy mix at home, the U.A.E. has simultaneously invested in renewable energy projects abroad, particularly solar and wind projects.

### A. Solar

Masdar has made major investments in utility-scale solar power plants in the Middle East region. Masdar is the majority shareholder of a 200 MW solar plant in Jordan, the Baynouna Solar Energy Project, which will become Jordan's largest solar plant when completed in 2019.<sup>57</sup> Masdar and EDF Energies Nouvelle also submitted a bid in October 2017 to supply power from a 300 MW photovoltaic plant in Saudi Arabia for as little as 1.79 cents per kilowatt hour. Although ultimately not accepted, this bid was still notable in that it would have set another world record for the lowest cost of producing solar electricity.<sup>58</sup>

Masdar has also engaged in large-scale solar projects outside the region.

- Through a joint venture with Spanish engineering firm Sener called Torresol Energy, Masdar has built three concentrated solar power plants with a total capacity of 120 MW in Spain: the 20 MW Gemasolar plant, the 50 MW Valle 1 plant, and the 50 MW Valle 2 plant. The Gemasolar plant is unique in that it is the world's first utility-scale solar power plant to combine a central tower receiver system and molten salt storage technology to enable a constant, 24-hour-per-day electricity supply.<sup>59</sup>
- Masdar signed a project development agreement in November 2017 with PT Pembangkitan Jawa-Bali (PT PJB), a subsidiary of Indonesian state electricity company Perusahaan Listrik Negara (PLN), to develop a floating solar photovoltaic power plant. This 200 MW plant in the West Java province of Indonesia will sit atop a reservoir powering a 1 GW hydroelectric power station. Besides producing clean power, this innovative plant will thereby reduce evaporation from the reservoir and limit the growth of algae there by providing shading from the sun.<sup>60</sup>



*Gemasolar Plant*

In addition to these utility-scale ventures, Masdar has embarked on smaller solar energy projects throughout the world, often in remote and complex locations. For instance, it has installed a 10 MW PV power plant in Siwa, Egypt and 31.6 MW of solar power in Mauritania.<sup>61</sup> It has also installed solar home systems in over 500 houses and 50 public facilities in Helmand, Afghanistan, and it has deployed approximately 19,500 such systems in rural Morocco.<sup>62</sup>

Masdar has often partnered with the U.A.E. government and associated development agencies to implement such projects.

- In 2013, U.A.E. Foreign Minister His Highness Sheikh Abdullah bin Zayed Al Nahyan set up the U.A.E.-Pacific Partnership Fund. As part of this effort, Masdar used funding from the Abu Dhabi

Fund for Development (ADFD) and assistance from the U.A.E. Foreign Ministry to implement 11 renewable energy projects in Pacific nations. These projects, which helped those nations save on costly diesel fuel imports, spanned the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, Palau, the Solomon Islands, Tonga, Tuvalu, and Vanuatu.<sup>63</sup>



*Masdar Project in the Marshall Islands*

- In January 2017, U.A.E. Minister of State for International Cooperation Her Excellency Reem Al Hashimy announced a \$50 million grant fund for renewable energy projects in Caribbean island countries. Similar to the Pacific Partnership Fund, grant funding is being provided by the ADFD, with the U.A.E. Ministry of Foreign Affairs managing the initiative and Masdar leading its implementation.<sup>64</sup>

The ADFD has been active in supporting solar energy projects beyond these two funds. In fact, ADFD has vowed to provide concessional loans worth a total of \$350 million over seven annual funding cycles to promising renewable energy projects in developing countries identified as such by IRENA. Since 2012, ADFD has already allocated \$214 million in loans to 21 solar projects, including projects in Antigua & Barbuda, Burkina Faso, Cape Verde, Cuba, Mali, Mauritius, Niger, Rwanda, Senegal, the Seychelles, and Sierra Leone.<sup>65</sup>



## **B. Wind**

Masdar has also invested heavily in regional wind projects. In 2013, Masdar invested in a 117 MW, 38-turbine, \$290 million wind farm in Jordan's southern governorate of Tafila, which was the Middle East's first commercial utility-scale wind power project.<sup>66</sup> More recently, Masdar announced that it is partnering with General Electric and Spain's TSK to build Oman's first large-scale wind farm, a 13-turbine 50 MW wind farm in Dhofar.<sup>67</sup> Moreover, in January 2018, Masdar signed a collaboration agreement to deliver a wind power portfolio of more than 800 MW in Egypt alongside Elsewedy Electric and Marubeni Corporation.<sup>68</sup>

Beyond the region, Masdar has invested in several major wind projects including:

- The 630 MW London Array, which is the world's largest offshore wind farm in operation;
- The 402 MW Dudgeon Offshore Wind Farm in East Anglia, United Kingdom;
- The 158 MW Cibuk 1 Wind Farm outside Belgrade, Serbia, which comprises 57 wind turbines supplied by GE Renewable Energy;



*The London Array*

- The 72 MW Krnovo onshore Wind Farm in Montenegro, which is the country's first wind project;<sup>69</sup> and
- The 30 MW Hywind floating offshore wind farm in Scotland, which is the world's first commercial-scale floating offshore wind farm.<sup>70</sup>

In addition to these utility-scale projects, Masdar has installed smaller-scale wind farms in remote locations. For instance, it installed a 6 MW, 8-turbine farm in the Seychelles thanks to a grant from the ADFD.<sup>71</sup> It also built a wind farm in Samoa as part of the aforementioned UAE-Pacific Partnership.<sup>72</sup>

## RESEARCH

The U.A.E. is home to a number of institutions that are embarking on pioneering research in the area of clean and alternative energy, perhaps above all Masdar Institute. Located at the heart of Masdar City and established in partnership with MIT, this Institute was the first institution dedicated to research on renewable energy and sustainable technologies in the region. Since its inception in 2007, it has grown to comprise a student body of 450 students. Moreover, its students, faculty, and researchers have been responsible for over 1,200 publications in peer-reviewed journals as well as 14 U.S. patents and a further 90 patent applications.<sup>73</sup> Looking ahead, the Institute is set to continue down its promising path following its merger with two of the U.A.E.'s other leading universities – the Khalifa University of Science, Technology, and Research and the Petroleum Institute – to form a single world-class, research-intensive institution called Khalifa University of Science and Technology.<sup>74</sup>



*Masdar City*

The Masdar Institute has engaged in a wide variety of research into solar energy in particular.

- In August 2017, a team of researchers led by a Masdar Institute professor developed a solar absorber that is capable of absorbing nearly all light in the ultraviolet to visible range.<sup>75</sup>
- In January 2016, Masdar Institute researchers demonstrated that desert sand could be a possible thermal energy storage material.<sup>76</sup> This demonstration was thanks in part to the Masdar Solar Hub, which is a state-of-the-art solar testing and R&D hub that was launched in January 2015 to allow for research on PV and concentrator photovoltaic (CPV) modules as well as CSP components, solar thermal equipment and solar receivers, and thermal energy storage systems.<sup>77</sup>
- In 2013, Masdar launched a renewable energy desalination pilot program to test innovative energy-efficient desalination technologies based on solar energy. Five commercial partners



*Masdar Solar Hub*

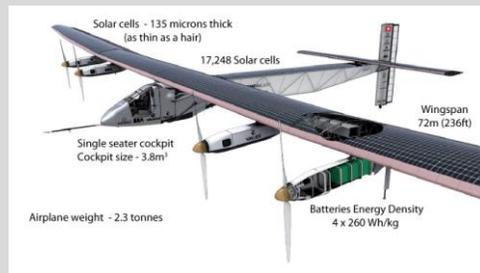
were selected to each develop a next-generation pilot seawater desalination plant. One of these partners was U.S.-based Trevi Systems.<sup>78</sup>

- The Masdar Institute's Research Center for Renewable Energy Mapping and Assessment has long supported the U.A.E. and the International Renewable Energy Agency (IRENA) in their creation of a publicly-accessible atlas of solar and wind resources.<sup>79</sup>

The Masdar Institute has also led important research on biofuels. At the beginning of the decade, the Masdar Institute formed the Sustainable Bioenergy Research Consortium (SBRC) with Boeing, Etihad, and UOP Honeywell as founding members.<sup>80</sup> This consortium – which has since grown to include Takreer, Safran, and General Electric – has sought to advance research on sustainable aviation biofuels, with a focus on alternative fuels derived from halophytic (saltwater tolerant) plants. In 2016, the Consortium broke ground on an integrated seawater, energy, and agriculture facility at Masdar City that was designed with technical support from CH2M.<sup>81</sup> The next year, it harvested its first crop of the biofuel feedstock *Salicornia*, which is a local salt-tolerant and oil-rich plant.<sup>82</sup>

### Solar Impulse

One of the most publicized demonstrations of the U.A.E.'s commitment to solar energy research and development was the Solar Impulse 2 project, which was hosted by Masdar. Solar Impulse 2 is a 2,300 kilogram plane designed to fly day and night entirely on solar power generated from the 17,240 solar cells on its wings. In 2015, this plane embarked on the first-ever round-the-world solar journey, departing Abu Dhabi in March 2015 and successfully returning to the U.A.E. capital in July 2016.<sup>83</sup>



Masdar City is now also home to the region's first sustainability-focused startup accelerator, The Catalyst. In January 2018, Masdar and BP launched this joint initiative, which will run two cycles per year, recruiting six startups per cycle. It will prioritize businesses at the commercialization stage, offering expenditures, training, mentoring, and office space.<sup>84</sup>



In addition to Masdar City, the Mohammed bin Rashid Solar Park is another center of research into renewable energy. In 2014, DEWA launched a Research & Development Center there that is expected to be completed by 2020. This center will focus its work around four main areas: solar power, smart grid innovation, energy efficiency, and water. The center will include indoor and outdoor laboratories including a PV solar testing facility and a CSP testing facility.<sup>85</sup> In November 2015, His Highness Sheikh Mohammed bin Rashid Al Maktoum inaugurated construction works on

the DEWA Innovation Center, which will serve as a platform to showcase the latest solar and renewable energy technologies.<sup>86</sup>

Masdar and DEWA are not the only institutions working to develop renewable energy in the U.A.E. Ras Al Khaimah hosts a graduate-level campus of the École Polytechnique Fédérale de Lausanne that is focused on energy and sustainability.<sup>87</sup> Researchers at U.A.E. University have also undertaken promising research into renewable energy, perhaps most notably about the potential use of geothermal energy in the U.A.E.<sup>88</sup>

## CONFERENCES AND EVENTS

The U.A.E. has emerged as a regional hub for clean and alternative energy events such as Abu Dhabi Sustainability Week (ADSW). Every January, Masdar hosts this global forum, which brings public and private sector stakeholders together to address challenges and celebrate achievements in sustainable development and clean energy. Beginning with the IRENA General Assembly, ADSW includes a large number of events, ranging from the Zayed Future Energy Prize Awards Ceremony to the World Future Energy Summit, the International Water Summit, the EcoWaste Exhibition, and the Solar Expo. In 2017, ADSW had 38,000 visitors and 639 exhibiting companies from 30 countries.<sup>89</sup>

Every October, the U.A.E. is also host to the Water, Energy, Technology and Environment Exhibition (WETEX). This exhibition – under the patronage of His Highness Sheikh Hamdan bin Rashid Al Maktoum, Deputy Ruler of Dubai, Finance Minister of the U.A.E., and President of DEWA – spans nine large halls at the Dubai International Convention and Exhibition Center that showcase the latest products, solutions, and technologies from almost 2,000 exhibitors.<sup>90</sup>

WETEX is immediately followed by the World Green Economy Summit, which is one of the leading global forums on the green economy. This Summit is held under the patronage of His Highness Sheikh Mohammed bin Rashid Al Maktoum and organized by DEWA and the World Green Economy Organization in cooperation with the Dubai Supreme Energy Council and WETEX. One of the key milestones of this Summit has been the creation of the World Green Economy Organization, which seeks to drive green economy transitions through coalitions, unlocking investments, and scaling up innovations in energy, infrastructure, and water.<sup>91</sup>



*U.A.E. Vice President and Prime Minister and Ruler of Dubai HH Sheikh Mohammed bin Rashid Al Maktoum, Abu Dhabi Crown Prince and Deputy Supreme Commander of the U.A.E. Armed Forces HH Sheikh Mohamed bin Zayed Al Nahyan, and other dignitaries attend Abu Dhabi Sustainability Week*



*DEWA Exhibition at WETEX*

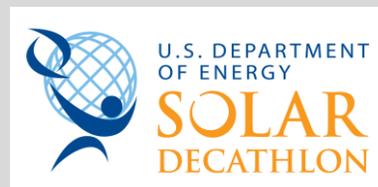
On top of these annual events, the U.A.E. will soon be host to Expo 2020 Dubai, or the World's Fair. Expo 2020's theme is "Connecting Minds, Creating the Future," and one of its subthemes is "Sustainability."<sup>92</sup> In keeping with this theme, Expo 2020 Dubai has partnered with DEWA as its Official Sustainable Energy Partner and committed to ensuring that half the energy used by the Expo will come from renewable sources, with 400 MW of electricity coming specifically from the Mohammed bin Rashid Al Maktoum Solar Park.<sup>93</sup> Expo 2020 Dubai will also have a Sustainability Pavilion that will produce 4 GWh of electricity per year through solar panels – more than the building needs to operate, allowing it to feed excess power into the electric grid.<sup>94</sup> Meanwhile, Masdar was appointed program manager for the U.A.E. Pavilion at Expo 2020 on the basis of its track record of successfully delivering highly innovative and sustainable projects. The winning design, which is in the shape of a Falcon, will embrace sustainable building principles.<sup>95</sup>



*Expo 2020 U.A.E. National Pavilion*

### **Solar Decathlon Middle East**

The U.S. Department of Energy Solar Decathlon is a collegiate competition made up of 10 contests that challenge student teams to design and build full-size, solar-powered houses. In June 2015, the U.S. Department of Energy and DEWA signed an agreement to create the Solar Decathlon Middle East. This Decathlon is due to take place in November 2018 in Dubai.<sup>96</sup>



## **FINANCING**

The U.A.E. government has played an important role in financing the above institutions, projects, research, and events. Moreover, it will continue to play a central role in doing so in future. In March 2017, U.A.E. Energy Minister His Excellency Suhail Al-Mazrouei said that the U.A.E. plans to invest no less than \$150 billion in clean power by 2050.<sup>97</sup>

In addition to directly funding clean energy projects through official government channels, the U.A.E. government indirectly funds such projects through sovereign wealth funds like Mubadala Investment Company. Masdar, which is one of Mubadala's portfolio companies, has, according to Masdar CEO Mohamed Al Ramahi, built a total renewable energy portfolio of \$8.5 billion (its share of which is \$2.7 billion) as of 2017.<sup>98</sup>

While the U.A.E. has funded many projects itself, it has also turned to public private partnerships (PPP) for financing, including for three of the aforementioned utility-scale PV solar projects. In these PPP arrangements, the private sector partner has led the design, construction, operation, maintenance, and financing of the project and will be remunerated on the future power it

generates. According to Nathan Weatherstone, the former Head of Sustainable Business at the National Bank of Abu Dhabi (now First Abu Dhabi Bank), the U.A.E.'s PPP model has "been at the forefront of unlocking private sector capital in the early stages of the transition to a more sustainable global economy and provides a blueprint for others to tailor to their own circumstances."<sup>99</sup>

U.A.E. financial institutions such as First Abu Dhabi Bank have also played important roles in financing projects.

- In November 2017, First Abu Dhabi Bank (FAB) became the first U.A.E. bank to sign the United Nations Global Compact, a U.N. policy initiative encouraging businesses to adopt sustainable and socially responsible policies.<sup>100</sup>
- In March 2017, the National Bank of Abu Dhabi (NBAD), which merged with First Gulf Bank to become FAB in April 2017, issued the region's first green bond totaling \$587 million to fund environmental projects.<sup>101</sup>
- In October 2016, eight U.A.E. Banks - NBAD, the Commercial Bank of Dubai, Dunia Finance, Emirates NBD, HSBC, the National Bank of Fujairah, RAKBank, and Union National Bank – signed the "Dubai Declaration" to expand sustainable financing over the next five years given what they saw as a potential 10 billion AED [\$2.7 billion] financing gap for sustainable projects.<sup>102</sup>



Finally, it is of note that the U.A.E. government has created funding mechanisms to encourage the widespread adoption of clean energy. In November 2015, as part of the launch of the Dubai Clean Energy Strategy 2050, His Highness Sheikh Mohammad bin Rashid Al Maktoum announced the establishment of the 100 billion AED [\$27.2 billion] Dubai Green Fund to provide, through its financial resources, loans for investors in the clean energy sector in the Emirate at reduced interest rates.<sup>103</sup> In October 2017, DEWA announced a joint collaboration with National Bonds to launch the Green Fund with an initial 2.4 billion AED [\$650 million] in capital.<sup>104</sup>

#### **Jumeirah Energy International Silicon Valley Company**

In October 2017, DEWA launched an investment company based in Silicon Valley called Jumeirah Energy International (JEI) Silicon Valley Company. JEI Silicon Valley will identify and build strategic relationships with U.S. R&D centers, universities, and research bodies; promote relations with existing U.S. partners; and provide access to industry information. It will also create links with the startup community in Silicon Valley.<sup>105</sup>

## **BUSINESS OPPORTUNITIES AND RESOURCES**

The U.A.E.'s ambitious plans for the development of clean and alternative energy mean myriad opportunities for U.S. companies. The U.A.E. will be looking for companies to bid for and execute renewable energy projects. These companies will then be searching for sub-contractors to design and build these projects, provide key technologies (such as wind turbines, solar panels, and transformers), and offer legal advice and consulting services. There will also be opportunities for banks and other institutions to lend financing for such projects.

The scope of such projects is potentially enormous. In January 2018, at Abu Dhabi Sustainability Week, U.A.E. Energy Minister His Excellency Suhail Al-Mazrouei said that the U.A.E. expects to tender at least 1,000 MW of projects every year to meet a target of 44 GW of clean and renewable energy by 2050. His Excellency commented, "I think it is achievable because it makes sense economically and most of that is going to be for the private sector."<sup>106</sup>

Outside of these projects, U.S. companies will find Abu Dhabi Sustainability Week (ADSW), the Water, Energy, Technology and Environment Exhibition (WETEX), Expo 2020 Dubai, and other U.A.E. events to be important avenues to showcase their products to a global audience, meet potential partners, learn about industry trends, and explore new markets.

Finally, U.S. students, researchers, and entrepreneurs will find fertile ground at the Masdar Institute and elsewhere in the U.A.E. to utilize cutting-edge research facilities, forge meaningful research partnerships, and test innovative new ideas.

For companies or individuals interested in exploring opportunities in this sector, they can turn to numerous U.S. and U.A.E. government agencies and trade councils for guidance.

### **A. U.S. Government Institutions**

Firms can rely on the assistance of U.S. government institutions, located both in the U.A.E. and Washington, D.C.

#### ***U.S. Government Contacts in the U.A.E.***

Regional Senior Commercial Officer for the Gulf and Commercial Counselor: Dao M. Le  
U.S. Embassy, Commercial Section  
P.O. Box 4009, Abu Dhabi, U.A.E.  
Tel: +971-2- 414-2665 Fax: +971-2- 414-2228  
E-mail: Dao.Le@trade.gov

Commercial Attaché: Rachel Duran  
U.S. Embassy, Commercial Section  
P.O. Box 4009, Abu Dhabi, U.A.E.  
Tel: +971-2-414-2530 Fax: +971-2-414-2228  
E-mail: rachel.duran@trade.gov

Principal Commercial Officer: Shakir Farsakh  
U.S. Consulate General, Commercial Section  
P.O. Box 121777, Dubai, U.A.E.  
Tel: +971-4-309-4963 Fax: +971-4-309-4841  
E-mail: shakir.farsakh@trade.gov

***U.S. Government Contacts in Washington, D.C.***

U.A.E. Desk Officer: James Cramer  
U.S. Department of Commerce  
U.S. and Foreign Commercial Service  
International Trade Administration  
14<sup>th</sup> St. & Constitution Avenue, N.W.  
Washington, D.C. 20230  
Tel: +1 (202) 482-0879 Fax: +1 (202) 482-0878  
Email: James.Cramer@trade.gov

**B. U.A.E. Government Institutions**

Firms can also turn to U.A.E. government institutions in both the United States and the U.A.E.

***U.A.E. Government Contacts in the United States***

Commercial Counselor: His Excellency Saud H. Al Nowais  
U.A.E. Embassy, Trade & Commercial Office  
3522 International Court, NW  
Washington, DC 20008  
Tel: +1 (202) 243-2425 Fax: +1 (202) 243-2408  
Email: trade@uaeembassy-usa.org

Consul General of the U.A.E. in Los Angeles: His Excellency Abdulla Alsaboosi  
1999 Avenue of the Stars, Suite 1250  
Los Angeles, CA 90067  
Tel: +1 (310) 551-6534  
Email: protocol.la@mofa.gov.ae

Consul General of the U.A.E. in New York: His Excellency Majid Al-Suwaidi  
535 5th Ave., 32nd Floor  
New York, N.Y. 10017  
Tel: +1 (212) 419-7670  
Email: nycon@mofa.gov.ae

Consul General of the U.A.E. in Boston: His Excellency Salem Alshamsi

One International Pl, Suite 2901  
Boston, MA 02110  
Tel: +1 (617) 948-8800  
Email: consboston@uaeembassy-usa.org

***U.A.E. Government Contacts in the U.A.E.***

Ministry of Finance  
P.O. Box 433, Abu Dhabi, U.A.E.  
Tel: +971-2-698-7500 Fax: +971-2-698-7414  
P.O. Box 1565, Dubai, U.A.E.  
Tel: +971-2-698-7500 Fax: +971-4-393-9724  
Website: [www.mof.gov.ae](http://www.mof.gov.ae)

Ministry of Economy  
P.O. Box 901, Abu Dhabi, U.A.E.  
Tel: +971-2-613-1111 Fax: +971-2-626-0000  
P.O. Box 3625, Dubai, U.A.E.  
Tel: +971-4-314-1555 Fax: +971-4-358-1811  
Website: [www.economy.ae](http://www.economy.ae)

Abu Dhabi Department of Economic Development (DED)  
P.O. Box 12, Abu Dhabi, U.A.E.  
Tel: +971-2-815-8888 Fax +971-2-672-7749  
Website: <https://ded.abudhabi.ae/>

Dubai Department of Economic Development  
P.O. Box 13223, Dubai, U.A.E.  
Tel: +971-4-445-5555 Fax: +971-4-445-5554  
Website: [www.dubaided.gov.ae](http://www.dubaided.gov.ae)

Sharjah Department of Economic Development  
P.O. Box 829, Sharjah, U.A.E.  
Tel: +971-6-512-2222 Fax: +971-6-528-7999  
Website: [www.sedd.gov.ae](http://www.sedd.gov.ae)

Ras Al Khaimah Department of Economic Development  
PO Box 10510, Ras Al Khaimah  
Tel: +971-7-227-1222  
Website: <http://www.ded.rak.ae>

Ajman Department of Economic Development  
P.O. Box 870, Ajman, U.A.E.  
Tel: 971-800 70

Website: <https://www.ajmanded.ae>

Umm Al Quwain Department of Economic Development  
Al Roudah, Shaikh Rashid Bin Saeed Al Maktoum Street  
Tel: 971-6-765-2200  
Website: <http://ded.uaq.ae/>

### **C. Trade Associations**

Finally, firms can consult major U.S. trade associations and chambers of commerce and their counterparts in the U.A.E.

#### ***U.S. Trade Associations/Chambers of Commerce***

U.S.-U.A.E. Business Council  
505 Ninth Street, NW  
Washington, D.C. 20004  
Tel: +1 (202) 863-7285 Fax: +1 (202) 863-7289  
Email: [info@usuaebusiness.org](mailto:info@usuaebusiness.org)  
Website: [www.usuaebusiness.org](http://www.usuaebusiness.org)

AmCham Abu Dhabi  
P.O. Box 43710, Abu Dhabi, U.A.E.  
Tel: +971-2-631-3604 Fax: +971-2-633-0489  
Email: [admin@amchamabudhabi.org](mailto:admin@amchamabudhabi.org)  
Website: [www.amchamabudhabi.org](http://www.amchamabudhabi.org)

The American Business Council of Dubai and Northern Emirates  
P.O. Box 74648, Dubai, U.A.E.  
Tel: +971-4-379-1414 Fax: +971-4-379-1515  
Email: [director@abcdubai.com](mailto:director@abcdubai.com)  
Website: [www.abcdubai.com](http://www.abcdubai.com)

#### ***U.A.E. Trade Associations/Chambers of Commerce***

Federation of U.A.E. Chambers of Commerce & Industry  
P.O. Box 3014, Abu Dhabi, U.A.E.  
Tel: +971-2-621-4144 Fax: +971-2-633-9210  
Email: [info@fcciuae.ae](mailto:info@fcciuae.ae)  
Website: [www.fcciuae.ae](http://www.fcciuae.ae)

Abu Dhabi Chamber of Commerce and Industry  
P.O. Box 662, Abu Dhabi, U.A.E.  
Tel: +971-2-621-4000 Fax: +971-2-621-5867

Email: [contact.us@adcci.gov.ae](mailto:contact.us@adcci.gov.ae)  
Website: [www.abudhabichamber.ae](http://www.abudhabichamber.ae)

Dubai Chamber of Commerce & Industry  
P.O. Box 1457, Dubai, U.A.E.  
Tel: +971-4-228-0000 Fax: +971-4-202-8888  
Email: [customercare@dubaichamber.com](mailto:customercare@dubaichamber.com)  
Website: [www.dubaichamber.com/](http://www.dubaichamber.com/)

Sharjah Chamber of Commerce & Industry  
P.O. Box 580, Sharjah, U.A.E.  
Tel: +971-6-530-2222 Fax: +971-6-530-2226  
Email: [scci@sharjah.gov.ae](mailto:scci@sharjah.gov.ae)  
Website: [www.sharjah.gov.ae](http://www.sharjah.gov.ae)

Ajman Chamber of Commerce & Industry  
P.O. Box 662, Ajman, U.A.E.  
Tel: +971-600-595-959 Fax: +971-6-747-1222  
Email: [info@ajmanchamber.ae](mailto:info@ajmanchamber.ae)  
Website: [www.ajmanchamber.ae](http://www.ajmanchamber.ae)

Fujairah Chamber of Commerce and Industry  
P.O. Box 738, Fujairah, U.A.E.  
Tel: +971-9-223-0000 Fax: +971-9-222-1464  
Email: [chamber@fujcci.ae](mailto:chamber@fujcci.ae)  
Website: [www.fujcci.ae](http://www.fujcci.ae)

Ras Al Khaimah Chamber of Commerce and Industry  
P.O. Box 87, Ras Al Khaimah, U.A.E.  
Tel: +971-7-207-0222 Fax: +971-7-226-0112  
Email: [info@rakchamber.ae](mailto:info@rakchamber.ae)  
Website: [www.rakchamber.ae](http://www.rakchamber.ae)

Umm Al Quwain Chamber of Commerce & Industry  
P.O. Box 436, Umm Al Quwain, U.A.E.  
Tel: +971-6-765-1111 Fax: +971-6-765-5055  
Email: [uaqcci1@eim.ae](mailto:uaqcci1@eim.ae)  
Website: <http://www.uaqchamber.ae/>

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<http://www.masdar.ae/en/energy/detail/masdar-city-solar-pv-plant>
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<http://www.thenational.ae/business/energy/costs-tumble-as-dubais-mohammed-bin-rashid-al-maktoum-solar-park-sets-the-mark>;  
<http://www.thenational.ae/business/energy/dubais-mohammed-bin-rashid-al-maktoum-solar-park-shatters-world-record-again>;  
<http://www.thenational.ae/business/energy/dubai-ruler-wants-solar-panels-on-every-roof-by-2030>;  
<https://www.dewa.gov.ae/en/customer/innovation/renewable-energy/facts-about-the-solar-park>;  
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