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Renewable Energy Policies in the GCC: Challenges and Prospects

Imen Jeridi Bachellerie

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Soaring Energy Demand in the GCC Countries

Rapid population growth, increasing urbanization, the vital need for air-conditioning and water desalination, as well as energy-intensive industries are driving the Gulf Cooperation Council (GCC) countries to burn growing amounts of their hydrocarbon production, or become importers of natural gas to sustain their fast economic development.[1]

The region's total domestic energy consumption reached 375 Mtoe in 2013; a 27-percent increase compared to 2008,[2] and is projected to grow by a further 40 percent by 2020.[3] Domestic consumption amounted to about 28 percent of the region's energy production in 2014, compared with 17 percent in 2000.[4]

In this context, the demand for heavily subsidized electricity and water has been growing substantially too. Between 2004 and 2013, electricity consumption grew by 88 percent.[5] It hit 496.62 TWh in 2013 and is expected to reach 662 TWh in 2020.[6]

Similarly, desalination capacity in the GCC region, which stood at 32 million cubic meter/day (MCM/d) in 2014, is estimated to reach 36 MCM/d by end of 2016, and 43 MCM/d in 2020.[7] In 2008, it amounted to 25.5 MCM/d.[8]

Table 1 - Electricity generating capacity (GW) - installed and projected

	Electricity Generating Capacity (GW)		
	Installed	Projected (BAU scenario)	Projected (BAU scenario)
	2012	2020	2030
Bahrain	3.9	4.5	6.5
Kuwait	14.7	18	25
Oman	5.8	7	15
Qatar	7.9	9	17.5
Saudi Arabia	53.6	100	135
UAE	27.2	42	85
GCC	113.1	180.5	284
Sources:	EIA	Youssef Almulla, 2015	Youssef Almulla, 2015

Note: UAE figures comprise those of Abu Dhabi, Dubai and other Emirates. Sources: EIA International Energy Statistics; and Youssef Almulla, "Gulf Cooperation Council Countries 2040 Energy Scenario for Electricity Generation and Water Desalination," (MSc thesis 2015), KTH School of Industrial Engineering and Management (2015).

[1] All GCC countries, except Qatar, are dependent on gas imports; Kuwait and UAE are net importers. See GOIC, *Energy Efficiency Guidebook for Industries* (Doha, 2013); Energy Information Administration, International Energy Statistics, https://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=7,- (accessed in January 2016).

[2] International Energy Agency, *Key World Energy Statistics for 2015 and 2010.*

[3] The Economist Intelligence Unit, "The GCC in 2020," 2010.

[4] IRENA, *Renewable Energy Market Analysis: The GCC Region*. IRENA, Abu Dhabi, 2016.

[5] IEA, *Key World Energy Statistics* 2015 and 2010.

[6] IEA *Key World Energy Statistics* and the Economist Intelligence "The GCC in 2020."

[7] Global Water Intelligence, "GWI 2015: Desalination Markets," 2016.

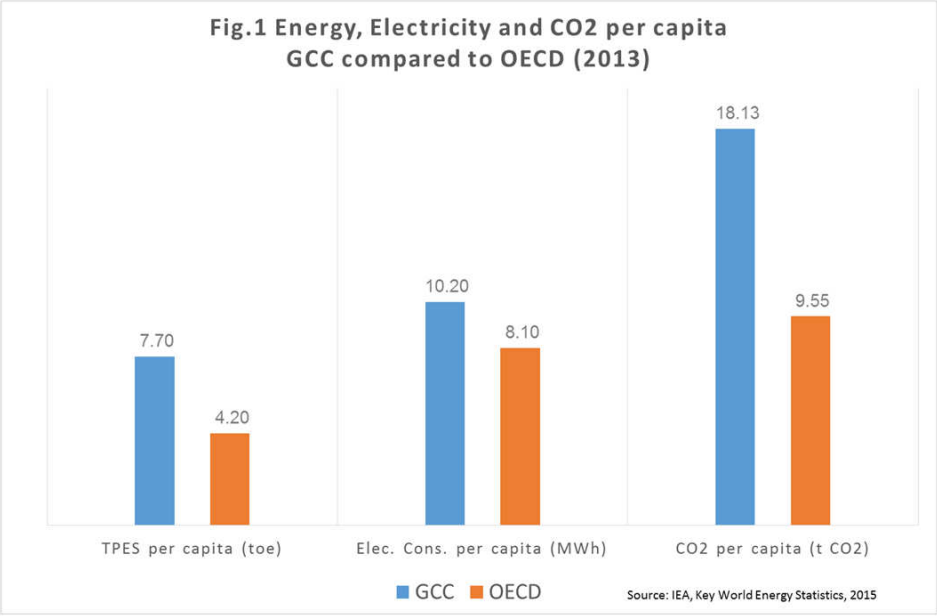
[8] ESCWA, "Sustainable Production and Consumption Patterns in Energy and Water Sectors in the ESCWA Region," 2011.

Such trends in power and water demand in the region are unsustainable. Utility production of these commodities accounted for an average of 40 percent of the total primary energy supply (TPES) of the GCC region in 2008, which then represented 16 percent of its total net exports of fossil fuels. These utilities consumed an average of 50 percent of TPES in 2011.[9]

The growing energy demand in the region is accompanied by energy-intensive consumption patterns (Fig.1) and low energy-efficiency records. This challenges the competitiveness of the GCC economies and adds pressure on their future prospects of hydrocarbon exports and related revenues, which is even more constraining in a context of low hydrocarbon prices that restricts government budgets.

The sustainability of the region's growth is certainly at stake, as continuously expanding population and industries as well as the low cost of fuel will lead it to experience significant shortage of energy and, subsequently, significant increase in its price.[10] Hence, the GCC governments need to further both their energy conservation programs and diversification plans so to reduce waste, brace for future increases in demand, and minimize the environmental impact of their socio-economic expansion. In this sense, the power and water – supply and demand – sectors offer a vast untapped potential for energy-efficient, clean and RE technologies, which would affect the GCC energy markets at large.

Figure 1: Energy, electricity and CO_2 per capita in the GCC compared to OECD (2013)



Note: In 2013, the GCC energy consumption per capita was at 7.70 toe, 83 percent higher than the OECD average and 6.5 percent higher than in 2008. Source: IEA, Key World Energy Statistics, 2010 and 2015.

[9] GOIC, *Gulf Statistical Profile 2008,* 2009; GOIC Doha 2009; Laura Al-Katiri, Laura and Muna Husain (2014) "Prospects for Renewable Energy in GCC States: Opportunities and the Need for Reform," OIES PAPER: MEP 10 Oxford Institute for Energy Studies (September 2014)- based on IEA statistics.

[10] Given that the majority of the power and water capacity is powered by gas, the gas supply deficit was expected to reach 7 billion cubic feet per day by end of 2015. See GOIC, *Energy Efficiency Guidebook* (Doha, 2013).

Nevertheless, concern about these challenges has been repeatedly expressed during the last decade. In particular, the GCC governments have become gradually attentive to the economic, strategic, and technology opportunities related to a clean and renewable energy (RE) transition in their countries as well as to the costs of delaying it. This has driven them to explore – and, albeit to a lesser extent, deploy – most suitable renewable energy (RE) applications, particularly for electricity and desalinated water production. All the same, the present context still presents some institutional and technical challenges that need to be overcome, should the governments wish to maximize deployment, achieve their announced targets, and reap the associated benefits.

Renewable Energy Context in the GCC Countries

The recent debate on the role of renewables in the future energy mix has taken place in parallel to plans for nuclear power in the GCC countries. Bahrain, Kuwait, Saudi Arabia, and the UAE have all considered the nuclear option. However, due to various socio-political factors these plans have been abandoned in Bahrain and Kuwait, but they continue to be pursued in Saudi Arabia through the King Abdullah City for Atomic and Renewable Energy (KA-CARE) and are certainly well on the way to being established in the UAE through the Federal Authority for Nuclear Regulations (FANR).[11]

Interestingly, some GCC countries – mainly Saudi Arabia and Kuwait – had, as early as the mid-1970s, allocated funds to investigate RE potential and applications in the local conditions; but these early research programs did not spur the deployment of RE sources in the region. They were then not economically and politically viable enough to gain a footing within a local socio-technical system or be adopted widely.[12]

However, whereas the 1970s and 1980s RE programs were confined to academic research – with no involvement of the local industrial sector – the region's initiatives of the last decade have been motivated by energy sustainability imperatives and economic diversification. Hence, they involved several actors and partnerships among governmental, private, scientific, industrial, local and international organizations. This shift was also accompanied by institutional reforms and new investments in RE technologies made both abroad and locally.

RE Potential, R&D and Deployment Projects

Physical Potential

The GCC region is situated between 35°N and 35°S, a geographic area that is characterized by high solar irradiation. It has thus an enormous solar energy potential. Indeed, a 2005 study by DLR has estimated that the total economic solar potential for both photovoltaic (PV) and Concentrated Solar Power (CSP) in the region is many multiples above the power demand of all the GCC countries.[13] Associated with this research, scientists have also shown

[11] Four nuclear plants with a total capacity of 5.6GW are expected to be completed between 2017 and 2020 in Abu Dhabi. See Federal Authority for Nuclear Regulations, UAE Government White Paper on Nuclear Energy, 2008.

[12] Total investment reached $250 million, but installed capacity did not exceed 2 MW of demonstration projects. For a synthesis of these programs, see Imen Jeridi Bachellerie, "Framework for a Renewable Energy Transition in the GCC: Finding the Right Paradigms," *The Gulf Monitor* 3, no. 3 (March 2010).

[13] DLR, *Concentrating Solar Power for the Mediterranean Region* (2005).

a high potential for coastal CSP energy, particularly in Saudi Arabia. This specific potential is considered to be particularly advantageous for water desalination based on solar thermal energy technologies (Table 2).[14]

Table 2: Solar economic potential and coastal potential in the GCC countries

	Solar Economic Potential CSP+PV (TWh/y)	Coastal Potential for CSP (TWh/y)
Bahrain	33	21
Kuwait	1,528	134
Oman	19,408	497
Qatar	793	324
Saudi Arabia	124,574	2,055
UAE	1,991	538
GCC	148,327	3,569
Sources:	DLR (2005)	Alnaser, Trieb, and Knies (2007)

More recent investigations affirm the excellent suitability of the GCC region for solar PV deployment, estimating that developing just one percent of this area could create almost 470 gigawatts (GW) of power generation capacity. The same study has also claimed the high offshore wind potential in the region.[15]

Nevertheless, earlier investigations had concluded that the GCC region has a moderate potential for wind power. Indeed, only in Oman and Saudi Arabia does wind energy yield the economically viable potential of 1,400 of full load hours per year for each country. The highest full load hours per year reaches 2,463 in Oman and, more modestly, 1,789 in Saudi Arabia.[16]

R&D and Deployments

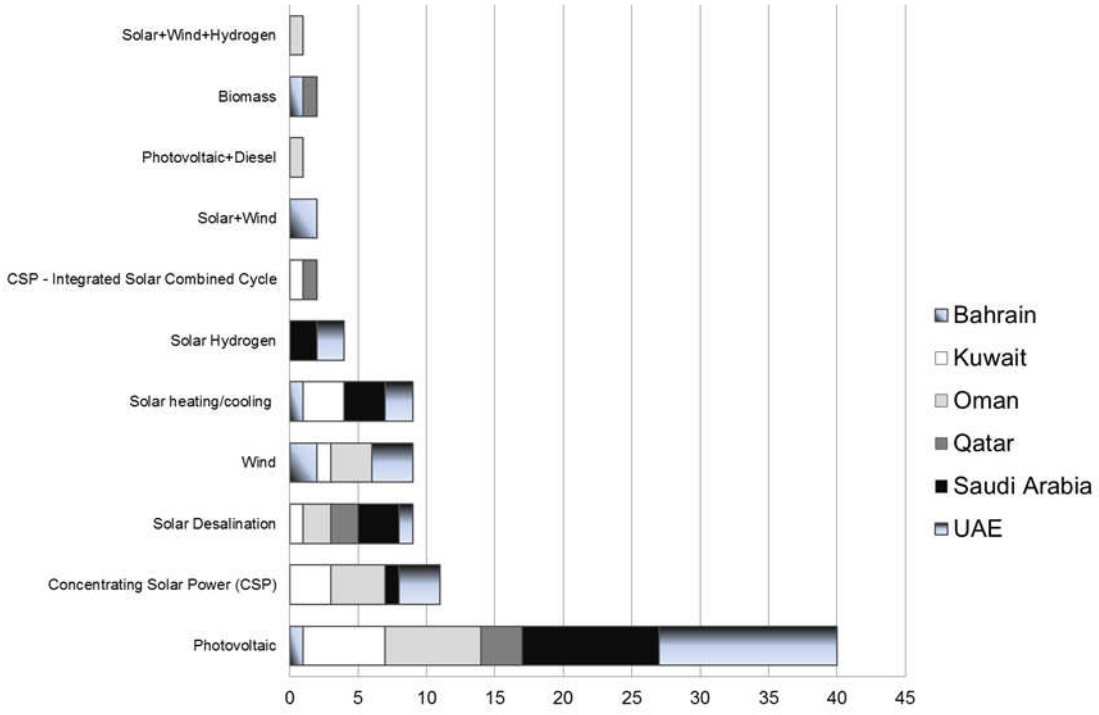
In general, the region's aggregate experience shows that the UAE and Saudi Arabia are now leading the way in terms of RE energy R&D and deployment projects, but despite a sharp difference in the extent of deployment and investment efforts between the GCC countries, research, feasibility studies, and pilots have multiplied in the entire region.[17] In addition to pioneering KACST (Saudi Arabia) and KISR (Kuwait), research has taken place in University of

[14] W.E. Alnaser, F. Trieb and G. Knies. "Solar Energy Technology in the Middle East and North Africa (MENA) for Sustainable Energy, Water and Environment," In *Advances in Solar Energy: An Annual Review of Research and Development* ed. D.Y. Goswami (UK: Oxford, 2007), 261-305.
[15] IRENA, *Renewable Energy Market Analysis.*
[16] W.E. Alnaser, N.W. Alnaser, "Solar and Wind Energy Potential in GCC Countries and Some Related Projects," *Journal of Renewable and Sustainable Energy* 1, no. 2 (2009): 1-28.
[17] For more details on RE R&D and deployments in each GCC country, see Imen Jeridi Bachellerie, *Renewable Energy in the Gulf Cooperation Council Countries: Resources, Potential, and Prospects* (Gulf Research Center 2012); Imen Jeridi Bachellerie, "Sustainability and Competitiveness : A Pragmatic Approach to Solar Energy Transition in the GCC Countries" (GRC Reports, September 2013) ; Rabia Ferroukhi, Haris Doukas, Stella Androulaki
Emanuela Menichetti, Andrea Masini and Arslan Khalid, "EU-GCC Renewable Energy Policy Cooperation: Exploring Opportunities," GRC Gulf Papers (December 2013); and IRENA, *Renewable Energy Market Analysis*.

Bahrain (Bahrain), Sultan Qaboos University (Oman), King Fahd University (Saudi Arabia), Qatar Science and Technology Park, and Masdar Institute (UAE), to cite but a few. This was conducted locally or in cooperation with international organizations.

In parallel, deployments – mainly solar owing to the region's enormous potential – have multiplied across the GCC countries. Among the most significant projects arethe Masdar CSP Shams1 (100MW) in Abu Dhabi; Princess Nora University solar water heating (17MW) Saudi Arabia; Dubai's MBRAM Solar park (13 MW); Qatar Exhibition Center building (12MW); PV plants by Aramco (10.5; 3.5 and 1.8 MW) Saudi Arabia; Masdar City PV plant (10MW); BAPCO (5MW) Bahrain; solar thermal plant by Petroleum Development Oman (7MW); KAUST buildings in Thuwal, Saudi Arabia (2MW); rooftop PV systems in Masdar City (1MW); Shoya Shell and Saudi Electricity Company in Farazan Island, Saudi Arabia (0.5 MW).

Figure 2 - Completed RE R&D and deployment projects per technology and per GCC country



Source: IJB 2013, updated by the author.

These initiatives confirm that both photovoltaic power and solar thermal technologies like CSP could be appropriate and that the region can have several possible openings to develop potential related markets and technology sectors.

For instance, thanks to Global Horizontal Irradiance (GHI) in the GCC – ranging between 4.5 and 6.5 KWh/square meter – PV technologies, whether integrated into buildings, deployed in remote areas, or used in utility-scale projects, are poised to play a significant role in addressing growing electricity demand. Moreover, PV power generation technology is considered to be most suitable to mitigate the peak electricity demand during the summer months – such peak load occurs at the same hours of the day where GHI is highest in the entire GCC region.

On the other hand, CSP potential in the GCC countries (due to high Direct Normal Irradiance – DNI) indicates that such a technology should be further developed and deployed in the region; its applications include thermal water desalination, integrated solar combined cycle

(ISCC) plants, and thermal enhanced oil recovery (EOR); its advantages in terms of production cost or industrial flexibility (power and thermal output) are evident.

RE Institutional Context, Plans and Legislative Frameworks

Institutions

The recent RE initiatives in the GCC region were accompanied by governments' efforts to establish supervisory and regulatory bodies in charge of the energy sustainability of their countries.[18] Their approaches to promoting renewables differ according to the level of affiliation they have with existing ministries (or authorities) or to the specific objectives they pursue. The latter include:

- Policy making (Ministry of Energy, Ministry of Foreign Affairs' Directorate of Energy and Climate Change (DECC), UAE; Masdar - Abu Dhabi Future Energy Company (ADFEC), Abu Dhabi; Prime Minister's Office, Dubai)
- Designing RE development plans or national strategies (Committee for Renewable Energies in Bahrain; KA-CARE in Saudi Arabia; Masdar ADFEC; Authority for Electricity Regulation in Abu Dhabi; AER in Oman; Dubai Supreme Council of Energy (DSCE)
- Supervising the procurement process of RE (Sustainable Energy Procurement Company (SEPC), KSA; Dubai Supreme Council of Energy (DSCE); Kuwait MEW; AER Oman
- Regulating RE deployments or defining RE power purchase agreements (Ministry of Electricity and Water, Kuwait; Electricity and Cogeneration Regulation Authority (ECRA), Saudi Arabia; Abu Dhabi Urban Planning Council (UPC); Abu Dhabi Regulation and Supervision Bureau; or Dubai Supreme Council of Energy (DSCE); Kahrama utility, - Qatar.
- Developing RE power generation plants (Saudi Aramco; BAPCO; Masdar Power; Kahrama; ACWA).
- Identifying opportunities for RE investments regionally and internationally (KA-CARE; Masdar City Masdar Fund; Masdar Power).
- Promoting cooperation among energy stakeholders, utilities, R&D institutions, and the business environment (Committee for Renewable Energies in Bahrain).

Such progress at the institutional level reflects the enhanced capability of the GCC countries to advance the RE agenda in the region. Yet, this has unfortunately not been complemented by a systematic adoption of national RE policies or financial and regulatory frameworks that maximize actual deployments.

Legal and Financial Frameworks

All GCC governments have announced mid to long-term RE targets or projected future RE projects. In fact, these targets range from 5 to 25 percent of their future power generation capacities, by 2020 or 2030 (Table 3), and – if completed – would represent an enormous leap in deployments (Table 4 and Fig. 3)

[18] This covers energy efficiency programs, alternative energy sources like nuclear, clean coal, etc. For details on the GCC Institutions, see Jeridi Bachellerie, *Renewable Energy in the Gulf Cooperation Council Countries*; Jeridi Bachellerie, "Sustainability and Competitiveness"; Ferroukhi et al., "EU-GCC Renewable Energy Policy Cooperation"; IRENA, *Renewable Energy Market Analysis*.

Table 3 Renewable Energy GCC national targets – 2020 and 2030

	RE national targets		
	2020-2021	2030	Sources
Bahrain	5%	5%	RCREEE, Arab Future Energy Index™(AFEX) Renewable Energy 2015
Kuwait	5%	15%	RCREEE, Arab Future Energy Index™(AFEX) Renewable Energy 2015
Oman	10%	15%	2020: Imen Jeridi Bachellerie, GRC 2012 ; 2030: IRENA, 2016.
Qatar	20%	20%	RCREEE, Arab Future Energy Index™(AFEX) Renewable Energy 2015
Saudi Arabia	23-30%	23-30%	KACARE, 2013 - Scenario, not an official target.
UAE - Abu Dhabi	7%	7%	IRENA, 2012
UAE - Dubai	7%	15%	DEWA, 2015

So far, the GCC governments' approaches for RE development follow a project-based pattern – sometimes as a public infrastructure initiated by public enterprises – or as public private partnerships (PPP), where independent power production (IPP) schemes are complemented by power purchase agreements with national authorities or utilities.

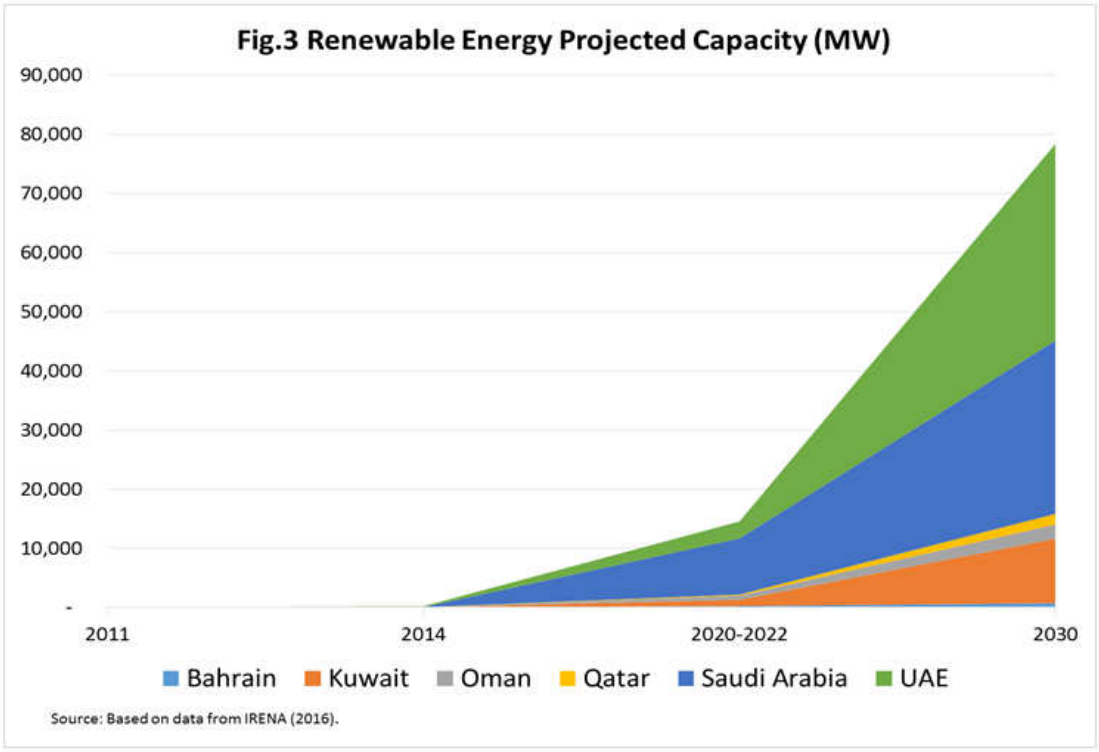
Thus, in general, the region's governments are currently opting for focused financial solutions like public competitive bidding or auction or public funding such as grants and subsidies designed for fixed quantities of deployments.[19]

Such specific measures were first developed for the financial frameworks of the grid-connected Abu Dhabi's 100MW CSP plant Shams1 and Muhammad bin Rashid Al Maktoum (MBRAM) solar park phase 1 (13 MW). Then, building on this institutional experience, the MBRAM solar park phase 2 (100MW), benefited from reverse-auction mechanisms and the Riyadh-based ACWA Power bid for a record low PV power tariff of just under 6 cents/kWh.[20] This price, that has been made possible thanks to the falling costs of thin film PV technology, is even competitive with oil and gas-based electricity in the region.[21] Will this prompt the conventional power order to adapt to such RE procurement, implemented through these auctions?[22] According to IRENA, these tenders have already triggered the progress of some RE projects in the region (namely in Kuwait, Abu Dhabi and Oman).

Table 4 - Renewable Energy electricity capacity (MW), installed and projected, based on national targets (2020 – 2030)

	Renewable Energy Electricity Capacity (MW)			
	Installed		Projected, based on national targets	
	2011	2014	2020-2022	2030
Bahrain	1	1	225	700
Kuwait	0	0	1,050	10,900
Oman	-	1	700	2,400
Qatar	25	28	180	1,800
Saudi Arabia	-	25	9,500	29,300
UAE	20	135	2,870	33,300
GCC	45	190	14,525	78,400
Source: IRENA (2016), 'Renewable Energy Market Analysis: The GCC Region'. IRENA, Abu Dhabi.				

[19] Ferroukhi et al.,"EU-GCC Renewable Energy Policy Cooperation."
[20] Capital Business, http://www.capitalbusiness.me/news/details/567 (accessed in December 2015).
[21] IRENA, *Renewable Energy Market Analysis.*
[22] Such hypothesis was formulated by an executive of the Dubai Multi Commodities Centre and quoted by Capital Business.



Note: The absence of dedicated policies and legal and financial frameworks for utility-scale or smaller deployments could jeopardize such projections

Challenges for RE Development in the GCC Region

Progress of RE initiatives has been significant for the last decade, especially in Saudi Arabia and the UAE, which are the most active GCC countries in terms of energy diversification plans and institutional reforms. Nevertheless, the GCC governments' commitments are still considered to be insufficient. A set of institutional, regulatory, economic, and technical barriers still inhibit large-scale deployment, and the GCC countries' energy stakeholders still need to work on alleviating them.

The design and implementation of RE policies require mature and well-coordinated institutions.[23] However, some institutional and policy challenges to RE development exist in the region. These include weak national strategies to evaluate the impact of RE technologies or encourage their systematic take-up; inadequate capacity and coordination between the different national (nascent) agencies within the same country, as well as insufficient monitoring and enforcement of the clean energy plans and measures that already exist.[24]

In this sense, public monopolies of energy and electricity markets in the GCC countries are considered barriers to RE development. The region's governments have not implemented a systematic RE legislation and utility market policy frameworks that govern issues such as a feed-in tariff or grid access for RE technologies. Such reforms, however, are required to harness the potential for private sector investments in RE-based electricity.

Certainly, one of the most significant economic challenges to the systematic RE uptake in the region remains the inappropriate energy pricing. This issue ties energy supply-side policy

[23] IRENA, *Renewable Energy Market Analysis.*
[24] Ferroukhi et al., "EU-GCC Renewable Energy Policy Cooperation."

success, such as the promotion of RE power, to further reforms on the demand side, particularly in utility energy pricing subsidies.[25]

In the hydrocarbon-rich GCC countries, with established subsidizing mechanisms for conventional energy domestic consumption, this factor artificially causes a financial unattractiveness for RE investments, as it exacerbates the cost competitiveness of these technologies and the high initial capital cost of related projects and infrastructure.

Considering the cost-effectiveness (and efficiency) of the energy systems in the GCC countries, the energy-pricing schemes in the region are certainly not conducive to rational energy consumption; they minimize awareness about the values of energy resources being wasted, their environmental impact, or the real costs of the hydrocarbon-based electricity and desalinated water. This, in turn, does not help limit the region's excessive power consumption, in general, or the related losses in its production and distribution systems, in particular.[26]

On this aspect, however, it is deemed necessary to enhance the efficiency and cost-effectiveness of the existing power networks, and hence the information monitoring along with them, in order to optimize the connection of distributed electricity supply into the wider electric network. The region's networks need to deploy smart grid technologies to enhance the overall flexibility of their power transmission infrastructure and, eventually, to allow the monitoring of electricity supply fluctuations from distributed – and intermittent – RE sources.[27]

Besides its intermittent nature, another technical challenge to solar power in the region arises from the dusty and humid local climate conditions, which lower the efficiency of both the photovoltaic panels and the CSP troughs. Moreover, experts have also pinpointed the vulnerability of PV modules, inverters, and storage devices under the region's high temperatures. In this regard, R&D efforts remain necessary to search for new materials and to enhance the techno-economic viability of solar power systems in the local environment.

Prospects for a Renewable Energy Transition in the GCC

According to IRENA,[28] should the GCC countries meet their RE targets by 2030, the projected 80GW of RE based power capacity could bring far-reaching socio-economic benefits:

- Reduce water usage by 16 percent (equivalent to 11 trillion liters per year)
- Save 2.5 billion barrels of oil equivalent over 2015-2030 (leading to cumulative savings worth $55-87 billion)
- Create more than 200,000 jobs
- Reduce CO_2 emissions per capita by 8 percent (equivalent to 1 gigatonne (Gt) over 2015-2030)

However, from the current 190MW of RE installed capacity (Table 4 and Fig. 3) – less than 0.2 percent of the region's total electricity capacity – to the projected 30-50GW in five years'

[25] El-Katiri and Hussain, "Prospects for Renewable Energy in GCC States."
[26] Due to falling oil and gas prices, the issue of reforming hydrocarbons subsidies is increasingly topping the energy political agenda. Relatedly, restricted reforms of electricity price subsidies have already been initiated by some GCC governments.
[27] S. Chodimella, "Middle East Catching up on Smart Grid Technologies," Siemens.com 2013, April 9, 2013.)
[28] IRENA, *Renewable Energy Market Analysis.*

time or 80 GW by 2030, the challenge for the GCC region would be to scale up the current deployment efforts to completely different levels. For this to happen, a disruptive approach to the region's energy context should, theoretically, be required.

Yet, the GCC governments have not yet devised road maps to achieve their objectives, nor have they introduced policy instruments such as loans, loan guarantees by governments, or feed-in-tariffs to incentivize the private sector to invest in RE projects.[29] More fundamentally, to promote the integration of RE technologies into the future energy mix of the GCC countries, the restructuring of the domestic utility market, including the reform of fossil fuel prices and electricity tariffs, remains paramount, as this would give the right incentives for utilities to make investment choices based on clear economic benefits. Otherwise, RE deployments could turn into a major money drain. [30]

More generally, energy conservation and diversification plans go hand in hand in the betterment of the current GCC energy context, as the margins to reduce consumption and the monetary value associated with the hydrocarbons savings (or fuel and electricity tariff reforms) resulting from energy efficiency would help finance a more diversified energy mix and lead to enhanced competitiveness and more diversified economies. On the other hand, spending more on expanding assets (energy capacity) while keeping intact costly wasteful demand, would be unsustainable, economically and environmentally, destroying rather than creating value to society.

Nevertheless, the potential for solar energy technology in the GCC countries remains very high, and a set of intrinsic and extrinsic factors point to a strong strategic and economic case for its development in the region. The GCC region has obvious advantages in terms of solar irradiation, raw material (silicon), and cheap access to energy. Hence, it appears plausible that, in the long run, the GCC markets for PV solar will become very attractive and a full-fledged solar industry will be built in this part of the world.

The risk though is that it would be a market where value will be mostly captured by foreign industries. So beyond deploying solar energy capacity, national strategies should ensure that such expenditure translates largely into money spent within their economies. This suggests that deployment of existing solar technologies in the near term, along with any learning-by-doing and induced industrial innovation from this deployment, is a real opportunity for solar energy know-how to be embedded in the country's socio-technical system.

At the same time, as PV power generation is expanding globally, the poly-silicon industry ventures and their prospective downstream development in the region[31] can effectively benefit from the region's comparative advantages (access to cheap energy and raw materials). So, beyond merely localizing the manufacturing processes, these industries should also encourage research, development, and embedment of new solar energy science in the region – namely through access to and creation of intellectual property – leading to the engineering of upgraded PV cell technologies that are both globally competitive and relevant to the region's specific technical challenges. The deployment of solar technologies in local conditions still asks for the identification of the most appropriate applications, the development of materials, and the enhancement of the efficiency of collection and storage devices.

[29] For instance, the delay in implementing the feed-in Tariff policy, announced in 2013, continues to hinder investments in the rooftop solar PV installations of the "Shams Dubai" net-metering program (IRENA, *Renewable Energy Market Analysis*).
[30] El-Katiri and Husain "Prospects for Renewable Energy in GCC States."
[31] For a list of solar PV manufacturers in the GCC countries, see IRENA, *Renewable Energy Market Analysis*, fig. 3.12, 66.

The latter point emphasizes two strategic objectives: first, industrial development should be tuned with national deployment strategies; otherwise it would only exacerbate energy demand and the CO_2 footprint. And second, R&D capability should be built to prevent the GCC countries from being fully dependent on technology imports and foreign know-how.

For this to happen, human capital development policies should be more deliberately introduced to persuade individuals to acquire RE technical know-how and organizations to train people into relevant skills. Such a learning process could contribute to transforming the indigenous energy market. This may take a decade or two.

Realization of the solar energy potential in the region requires political will as well as knowledge at the national, municipal, and individual levels, for RE technology concentrates multiple challenges and opportunities that go beyond the boundaries of academic laboratories or the affordability of foreign machines and expertise. It flows into societies through the geo-political challenges (energy security), the techno-social endeavors (human capital and R&D capability), and the environmental stresses (climate change) it raises.

About the Author

Imen Jeridi Bachellerie is a researcher on Science and Technology (S&T) policies in the Arab countries, based in Dubai. Imen Jeridi's professional experience led her to coordinate projects, and write reports and research papers related to knowledge production and diffusion in this part of the world. She particularly focused her research for some years on the GCC countries.

Imen Jeridi holds a degree in Electro-Mechanical Engineering from Ecole Nationale d'Ingénieurs of Tunis (Tunisia), a Master of Science in Mechanics from Ecole Normale Supérieure de Cachan (France), and a Master of Science in Epistemology and History of Science and Scientific Institutions from Université Denis Diderot-ParisVII (France).

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Her publications include: "Sustainability and Competitiveness: A Pragmatic Approach to Solar Energy Transition in the GCC Countries" (GRC Gulf Papers 2013), Renewable Energy in the GCC Countries: Resources, Potential, and Prospects (GRC books 2012), "Knowledge Creation and Diffusion: the Role of UAE Universities" (GRC Gulf Papers 2010), and "Science and Technology: Future Applications, Trends and Impact," (Papers of the Jeddah Economic Forum 2010). Her current research interests include University Industry Linkages and National Innovation Systems in the Arab World.