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A review and assessment of energy policy in the Middle East and North Africa region

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ABSTRACT

The energy landscape of the Middle East and North Africa (MENA) region has undergone a significant transformation in recent years as a result of intersecting technological, economic and political trends, both regional and international. The evolving dynamics of international energy markets, increased diversification of energy sources, global concerns for climate change, and regional conflict are among the leading factors impacting the evolution of MENA energy policy. This paper provides an assessment and outlook for energy policy in the MENA region within the context of the myriad factors impacting policy design and implementation. A review and analysis of the social, political and economic factors that are impacting regional energy policy is provided and followed by analysis of regional energy policy with consideration of hydrocarbon exploration and production, regional energy trade, demand management and clean energy production. The findings show that the MENA region is in the midst of an energy transition that has uncertain outcomes but will undoubtedly have long lasting impacts on the global energy system.

1. Introduction

The global energy landscape has been rapidly evolving in recent years. Of particular importance to this evolution has been the rise of cost-competitive new sources of oil and gas supply, dramatic volatility in international oil and gas prices, the emergence of various types of renewable energy as cost-competitive energy sources, and increasingly coordinated global efforts to address climate change. The Middle East and North Africa (MENA[1]) region plays a key role in the global energy system and hence is particularly sensitive to many of these factors. Sustained weakness in oil prices starting mid-2014 and continuing into 2016 has had a negative impact on the finances of MENA oil-exporting countries, requiring them to initiate or intensify the reform of energy subsidies and taxation. Although MENA energy-importing countries benefit from lower global energy prices, many of these countries are at the epicenter of wars and political struggles that have greatly impacted their ability to take advantage of lower energy prices. Libya, Syria and Yemen are confronted by ongoing civil wars and Iraq remains unstable amidst political dysfunction. Jordan and Lebanon have been dealing with a refugee crisis from the Syrian conflict and Egypt's population is disillusioned with the stagnating economy and political repression. Iran offers more promise as the economy emerges from international sanctions, but the future remains unclear given the country's still-difficult diplomatic relations with the West and its GCC neighbors, and years of underinvestment across almost all sectors.

It is against this backdrop of international and regional developments that MENA energy policy is being shaped. Although energy policy is context-dependent (Hoppe et al., 2016), it is generally concerned with political decisions for implementing programs that achieve energy-related societal goals, including universal access to reliable and affordable energy sources that spur economic development. Hence, MENA energy policy must account for interrelated social, economic and political factors that are at the foundation of energy systems. This paper therefore begins with a review of the MENA regional context, as well as assessment of both global and regional factors shaping the region's energy policy. Evolution of the MENA energy system is then considered with particular focus on the key issues concerning energy supply, demand and trade. Finally, policy conclusions and implications are drawn from a synthesis of the issues discussed.

2. The MENA region context

The MENA region does not have a single, uniform definition, although the World Bank defines MENA to include the following regions and countries:

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[1] In this paper we define MENA as including the North African Countries (Morocco, Algeria, Tunisia, Libya and Egypt), the Levant countries (Jordan, Israel , Lebanon, Syria and Palestine), the Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Saudi Arabia, Qatar and United Arab Emirates), Iraq and Iran).

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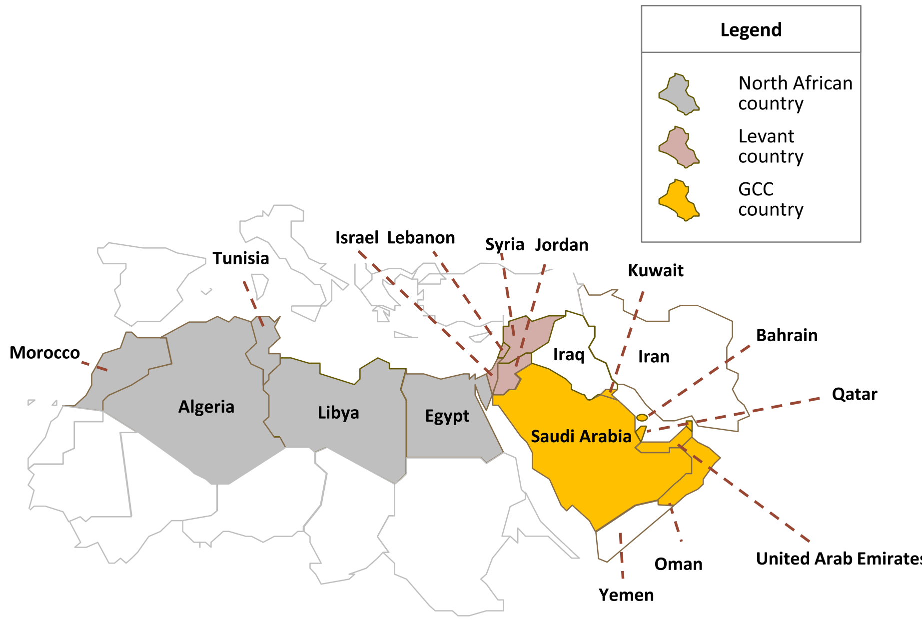


Fig. 1. Countries of the MENA Region.

- North Africa (or Maghreb): Morocco, Algeria, Tunisia, Libya and Egypt
- Mediterranean (or Levant): Jordan, Israel, Palestine (West Bank and Gaza), Lebanon and Syria
- Gulf Cooperation Council (GCC): Bahrain, Kuwait, Oman, Saudi Arabia, Qatar and United Arab Emirates
- Other Middle East: Iran, Iraq (sometime considered in the Levant), Djibouti and Yemen

For the purpose of this work we follow the World Bank definition of MENA with the exception of Djibouti given its location in East Africa (Fig. 1).

It is essential to consider these MENA countries' social, political and economic circumstances as these elements impact their energy systems. The forces that drive energy system change, namely energy security, economic development, energy access and concern for climate and health, have differing levels of influence based on context. Although the MENA region has significant renewable and fossil energy resources, country-specific circumstances lead to very different current states and potentials of the energy system. The following MENA country classifications[2] are useful in identifying these circumstances (Apergis and Payne, 2014; Devarajan et al., 2016; IMF, 2016b; REN21 et al., 2013; The Economist, 2016):

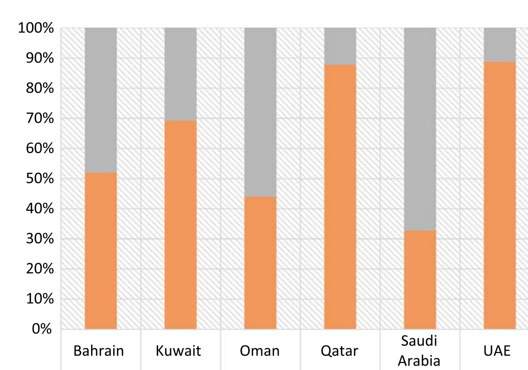
- Developing countries that are net oil-exporters[3] and labor-importing (Bahrain, Kuwait, Oman, Saudi Arabia, Qatar and United Arab Emirates)
- Developing countries that are net oil-exporters and labor-abundant (Algeria, Libya, Syria, Iraq, Iran and Yemen)
- Developing countries that are net oil-importers and labor-abundant (Morocco, Tunisia, Egypt, Jordan and Lebanon)

Within this classification scheme, "labor-importing" refers to a country with small indigenous population that relies on a substantial expatriate population to meet its labor force needs, particularly in the private sector. As shown in Fig. 2, the labor-importing GCC countries all have populations consisting of greater than 30% expatriates.

The net-oil exporting countries are largely reliant on hydrocarbon exports for overall economic activity and fiscal revenue. According to the IMF's recent assessment of this group of countries (IMF, 2016b):

- The share of hydrocarbon revenue as percentage of total government revenue in 2014 ranged from 47% in Yemen to 94% in Iraq and averaged 77% across the group.

- Hydrocarbons were the main 2014 export goods, accounting for more than 80% of total exports in half of the countries, and above 60% in all of them except the UAE. For the UAE, non-hydrocarbon exports contributed nearly 70% of total exports but this number included a large share of re-exports.



	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE
Nationals in Population	630,990	1,281,712	2,323,954	278,000	20,708,462	1,062,609
Expats in Population	683,572	2,879,692	1,825,963	1,991,672	10,061,913	8,324,395

Fig. 2. Population Demographics of the GCC Countries.
Sources: Gulf Labor Markets and Migration and BQ Magazine (Gulf LabourMarkets and Migration (GLMM), 2013; Snoj, 2013, 2015)

[2] The only country considered in this work that does not fit within this classification system is Israel, which is a developed, net oil-importing country.

[3] For simplicity and in accordance with the approach taken by the International Monetary Fund, the term "oil" is used to mean hydrocarbons, acknowledging that some MENA countries, such as Algeria and Qatar, produce and export a significant amount of natural gas.

The result of such natural resource dependence is macroeconomic volatility and lack of incentive for the establishment of regulatory and institutional frameworks supportive of strong private sectors. Although reforms have been gradually taking place over the course of the past decade, a legacy of centralized control financed by hydrocarbon revenues can be difficult to displace. Many countries with rich resource endowments have struggled with governance, economic growth and conflict (Friedrichs and Inderwildi, 2013). At the present time, Syria, Iraq, Libya and Yemen are all in the midst of civil wars resulting in damage to human and physical capital that will take years to remedy and have severely hindered energy system development. Libya, Syria and Yemen will almost certainly see minimal, if any, energy infrastructure investment through the end of the decade (APICORP Energy Research, 2016c). According to the World Bank, MENA has experienced a dramatic increase in violence during the past two years and today has the highest number of terrorist incidents and casualties in the world. Libya, Syria, the Palestinian Territories, Lebanon, Iraq and Yemen are all countries included in the World Bank's Harmonized List of Fragile Situations (The World Bank, 2016) while Algeria, Tunisia, Egypt and Jordan are considered fragile from the spillover of neighboring conflicts (Fig. 3). Violence and instability greatly constrain economic growth and make energy system development very difficult.

The underlying causes of regional instability and conflict have been cited as failing social contracts and lack of regional cooperation (Devarajan, 2016). In the context of MENA oil-exporters, social contracts are based on the exchange of state-provided jobs, free health and education, and subsidized food and fuel in exchange for citizen allegiance to the government. Although the notion of the social contract is commonly associated with the oil-exporting countries, social contracts developed in the region before the discovery of oil and hence have been problematic for oil-importing countries as well (Chatham House, 2016; Rougier, 2016). For the net oil-exporters, however, the social contract is typically associated with the narrower constructs of the rentier state and the resource curse (Abulof, 2015; Ansari, 2016; Beblawi and Luciani, 1987; Reiche, 2010; Sachs and Warner, 2001; van der Ploeg, 2011). Natural resource wealth has in fact played a major role in the social contracts of GCC countries, exemplified by substantial social spending increases in GCC countries during and following the Arab Spring of 2011 (Karshenas et al., 2014).

Consistent with the context described, the World Energy Council provides a useful and encompassing summary of the MENA region's critical uncertainties, which are issues yet to have clear paths of action in the region but are extremely important, and action priorities, which are highly impactful issues that are currently being addressed by regional national agendas (World Energy Council, 2016a):

- **Critical Uncertainties**: Middle East geopolitical and socioeconomic dynamics, energy efficiency, energy-water nexus, regional interconnection
- **Action Priorities**: commodity prices, energy subsidies, renewable energy, liquefied natural gas (LNG)

These uncertainties and priorities are examined from global and regional perspectives in the following sections.

3. Global factors influencing MENA energy policies

3.1. Developments in oil and gas markets

From 2011 to early 2014, Brent crude oil prices hovered above US $100 per barrel and liquefied natural gas (LNG) prices achieved similarly high price levels. This period of stable but high oil prices lasted until June 2014 when oil prices began a precipitous decline that resulted in prices of less than US $50 per barrel by early 2016. The steep price decline was catalyzed by the rise of shale oil production in the United States, shifting demand patterns in major oil consuming nations and OPEC resistance to oil production cuts to curtail supply (Fattouh, 2016). At the present time it is not clear whether these factors are structural and will permanently cap the price of traded oil or whether they are more cyclical in nature, and supply and demand balances will ultimately lead to longer-term price increases. The important issue for MENA energy policy is that all countries must be prepared for an uncertain future where oil prices may remain below US $60 per barrel thru 2020 (Devarajan et al., 2016; World Bank Group, 2016).

Natural gas markets have similarly been in flux during the period of falling oil prices. Between 2011 and 2014, LNG prices import prices were above US $14 per MMBtu and as high as $18 per MMBtu across Asia, and in Europe gas prices were between US $8 and US $10 per MMBtu, leaving gas uncompetitive to coal in power generation (Corbeau et al., 2016). By early 2016, however, LNG prices in Japan were less than US $5 per MMBtu (MEES, 2016e) and all regional

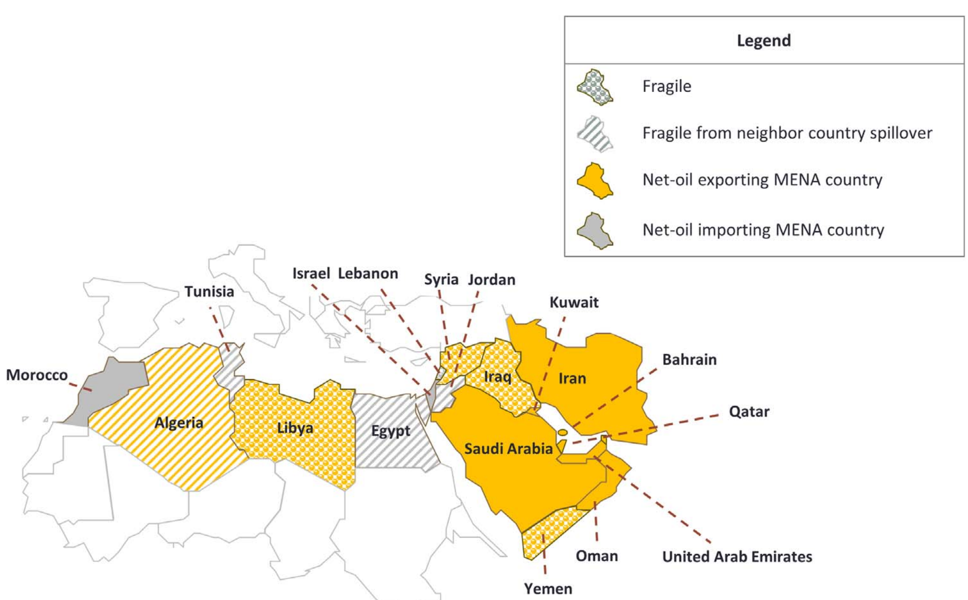


Fig. 3. Conflict status of MENA countries. MENA country classification according to the World Bank harmonized list of fragile situations 2015.

natural gas prices are expected to converge to such low levels with regional spreads within US $0.60 per MMBtu (APICORP Energy Research, 2016e). This fall in global gas prices has been driven by the fall in oil prices (to which LNG prices are often contractually linked), and by the completion of new LNG export facilities. During the recent period of very high LNG prices, investment in LNG export capacity rose sharply, particularly in the US and Australia, and now 150 billion cubic meters (bcm) of LNG export capacity is under construction in 2016 (MEES, 2016e) relative to the entire LNG global market of 338 bcm in 2015 (BP, 2016). LNG supply and demand imbalance is therefore positioned to depress LNG prices at least until 2020.

3.2. Climate change and sustainability

More than two decades after the U.N. Framework Convention on Climate Change (UNFCCC) was established, in 2015 the UNFCCC mechanism brought together 195 countries to sign into a new international climate agreement (the Paris Agreement) (Dagnet et al., 2016). The majority of countries globally have now committed to scaling up renewable energy and energy efficiency through Intended Nationally Determined Contributions (INDCs), which outline the climate actions countries intend to take under the Paris Agreement and become Nationally Determined Contributions (NDCs).

INDCs submitted have different levels of ambition for greenhouse gas (GHG) emission mitigation. Mitigation contributions can be in the form of GHG targets, non-GHG targets, proposed actions or a combination of these elements. As shown in Table 1, MENA countries are divided in their approaches. The GCC countries, although increasingly proactive in the global climate change agenda (Luomi, 2014), have not made any unconditional GHG emissions reduction commitments, while all of the North African countries, with the exception of Egypt, have made at least some form of unconditional commitment. Likewise, Israel, Jordan, Lebanon, Iraq, Iran and Yemen have made unconditional commitments with Israel being the most ambitious, proposing to reduce GHG emissions by 2030 to 26% below the 2005 level. Neither Syria nor Libya, both war-torn nations, have submitted INDCs. The conditional commitments that have been made primarily indicate a need for international support and financing in order to achieve significant levels of carbon reduction. The modest or complete lack of unconditional INDCs from many MENA countries suggests that GHG abatement will not likely be a driving force for regional energy policy. Consistent with this idea, no MENA country has expressed the intention to implement a climate policy related to carbon taxes or emissions trading (World Bank, 2016). The position of MENA countries, particularly those in the GCC, is perhaps not surprising considering that recent work (McGlade and Ekins, 2015) has suggested that 33% of global oil reserves and 50% of global gas reserves, both vital contributors to government revenues in oil-exporting countries, should remain unused in the coming decades in order to meet the Paris Agreement climate targets.

3.3. Evolution of renewable energy as a cost-competitive energy source

Biomass for power, hydropower, geothermal, utility-scale solar PV and onshore wind are now all renewable energy sources that can compete with fossil-fuel based power generation in a number of geographies globally (Frankfurt School - UNEP Collaborating Centre and BNEF, 2016; IRENA, 2015c; Lazard, 2015). Although costs vary depending on geography and application, advances in the economics of solar and wind energy have been particularly impressive. The average cost of solar photovoltaic (PV) modules fell by nearly 80% between 2009 and 2014, while wind turbine average costs declined by nearly 33% over the same period (IRENA, 2015d). Such cost reductions are a key reason that more than 60% of all new power generation capacity in 2015 came from renewable energy, led by solar and wind (REN21, 2016). Within the MENA context, one of the world's lowest-cost utility-scale solar PV power plants is being built in Dubai, UAE and will provide electricity under a power purchase agreement (PPA) for US $0.0584 per kWh (IRENA, 2016d). This was the record low cost for utility scale solar PV when originally announced but now is actually much more expensive than the most recent utility-scale solar PV PPAs signed in Peru (US $0.048 per kWh), Mexico (US $0.045 per kWh), again Dubai (US $0.0299 per kWh) (Europe, 2016; IRENA, 2016b). The record-low tender bid of US $0.0242 per kWh for a utility-scale solar project has been recorded in Abu Dhabi, UAE in 2016 (MEES, 2016a). However, the actual bid price is likely closer to US $0.029 per kWh because the record-low price announced includes a summer multiplier factor that artificially reduces the calculated price (Chase, 2016).

It is important to consider that while renewable energy policy has shaped the deployment trends seen today, the dynamics of renewable energy deployment are now shaping renewable energy policy. Consistent with renewable energy technology deployment trends, renewable energy policies have been predominantly focused on the power sector. Through 2015, 114 countries had adopted power sector policies as opposed to 66 countries with transport sector policies in place and only 21 countries with heating and cooling policies in place (REN21, 2016). This focus on renewable energy policy for the power sector has brought solar PV and onshore wind energy to the point that policy design must now shift away from a focus on bridging the cost gap between renewables and fossil-based power generation towards frameworks that support investment for further scale-up and integration of renewables into energy systems (IEA-RETD, 2016; IEA, 2015b; Shell, 2016). As intermittent renewable energy sources achieve higher levels of electricity system penetration, system-level costs must be evaluated and not just the levelized cost of electricity (LCOE) considered to the boundary of the generation source. System level assessments are geographically specific and bring a more realistic understanding of the true lifecycle costs of intermittent renewable energy sources (Hirth, 2013; Khatib and Difiglio, 2016).

4. Regional factors influencing MENA energy policies

4.1. Natural resource endowments

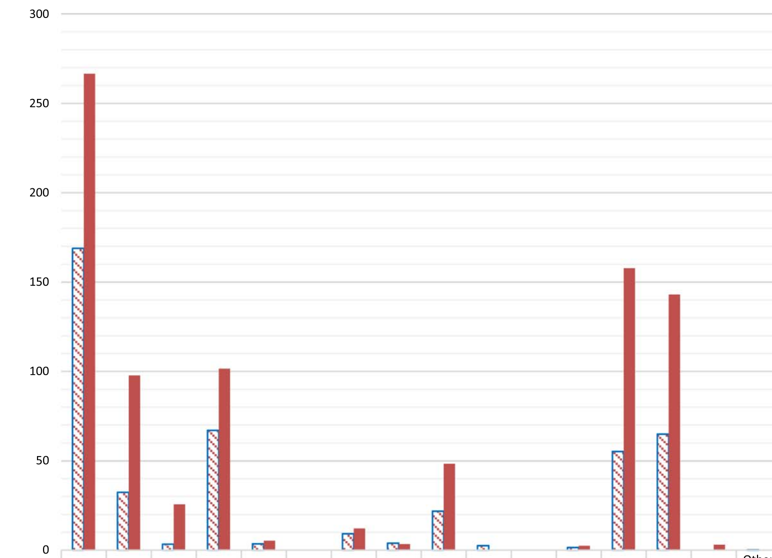
4.1.1. Hydrocarbon resources

The MENA region has extremely limited coal reserves but abundant oil and gas reserves in certain countries (World Energy Council, 2013). MENA proved oil reserves are estimated at 860 billion barrels (bbl), representing 52% of the global total, and MENA proved natural gas reserves are estimated at 88 trillion cubic meters (Tcm), representing 42% of the global total (Khatib, 2014). As shown in Fig. 4, Saudi Arabia has the largest regional proved oil reserves (266.6 bbl), followed by Iran (157.8 bbl), Iraq (143.1 bbl), Kuwait (101.5 bbl) and the UAE (97.8 bbl). Iran has the largest regional proved gas reserves at 34 Tcm and is followed by Qatar (24.5 Tcm) (Fig. 5). Beyond these proved reserves, the Levant Basin in the offshore areas of the Eastern Mediterranean possesses natural gas resources that may exceed 3.5 Tcm (EIA, 2013) and Israel is particularly well-positioned to exploit these resources for meeting domestic energy demand as well as exporting natural gas to neighboring MENA countries should political dimensions of such trade prove viable (Shaffer, 2011; Siddig and Grethe, 2014). The MENA region also contains abundant unconventional oil and natural gas resources in selected countries. Estimates are that Algeria has 20 Tcm of shale gas resources and 6 bbl of tight oil, Saudi Arabia has 17 Tcm of shale gas resources and the UAE has 5.8 Tcm of shale gas resources (World Energy Council, 2016b). At the present time, Saudi Arabia is the regional leader with regard to strategic intent as well as technical potential for exploitation of shale gas resources such that they become proved reserves (World Energy

Table 1
MENA Intended Nationally Determined Contributions (INDCs).

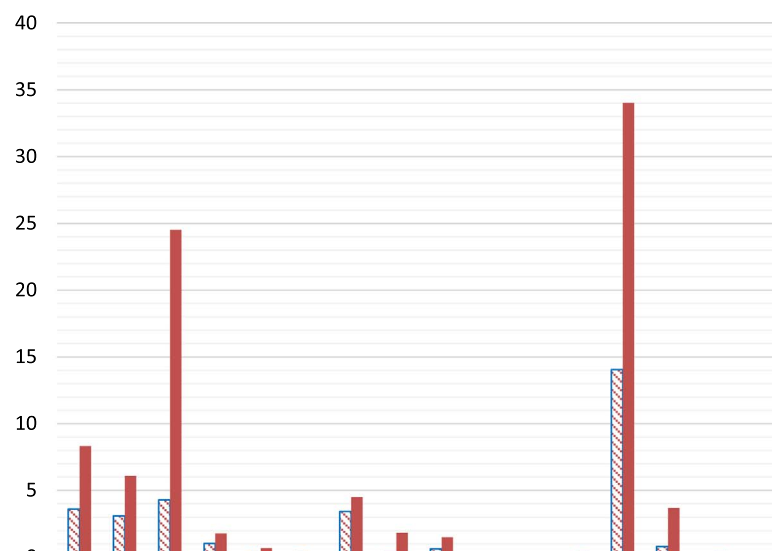
Country	Region	Unconditional target	Conditional target	Target year	Reference year	Conditions for implementation / financial support required
Bahrain	GCC			N/A	N/A	Commitment depends highly on the level of international support in means of implementation
Kuwait	GCC			N/A	N/A	
Oman	GCC		2%	2030	Business as Usual (BAU)	Implementation conditional to the assistance that will be provided by the UNFCCC on finance, capacity building and transfer of technology
Qatar	GCC	Economic diversification of the economy away from hydrocarbons		2030	N/A	N/A
Saudi Arabia	GCC	Economic diversification that will have mitigation co-benefits of up to 130 million tons of CO_2eq avoided annually by 2030		2030	N/A	N/A
United Arab Emirates	GCC	Pursuit of a portfolio of actions, including an increase of clean energy to 24% of the total energy mix			N/A	
Israel	Levant	26%		2030	2005	N/A
Jordan	Levant	2%	14%	2030	Business as Usual (BAU)	Upper bound conditional to availability of international financial aid and support for implementation
Lebanon	Levant	15%	30%	2030	Business as Usual (BAU)	Upper bound implemented upon the provision of additional international support
Iran	Middle East	4%	12%	2030	Business as Usual (BAU)	Subject to termination and non-existence of sanctions, availability of international resources in the form of financial support and technology transfer, exchange of carbon credits, accessibility of bilateral or multilateral implementation mechanisms, transfer of clean technologies as well as capacity building
Iraq	Middle East	13%	15%	2035	Business as Usual (BAU)	
Algeria	North Africa	7%	22%	2030	Business as Usual (BAU)	High end of the range conditional to support in terms of external financing, technology development and transfer and capacity building
Egypt	North Africa		Aims to achieve “high CO_2 mitigation levels”	2030	N/A	Financial contributions required for implementing the INDCs for both adaptation and mitigations
Morocco	North Africa	13%	32%	2030	Business as Usual (BAU)	The high end of the range is conditional on gaining access to new sources of finance and enhanced support, compared to that received over the past years, within the context of a new legally-binding agreement under the auspices of the UNFCCC
Tunisia	North Africa	13%	41%	2030	2010	The upper bound of the range is conditional on the support of the international community for funding, capacity building and technology transfer
Yemen	North Africa	1%	13%	2030	Business as Usual (BAU)	Significant support in terms of capacity building and technology development and transfer in addition to financial assistance

The stated Unconditional Target and Conditional Target for each country are expressed as the percentage GHG emission reduction relative to GHG emissions in the stated Reference Year. The targets are to be achieved by the stated Target Year.



	Saudi Arabia	UAE	Qatar	Kuwait	Oman	Bahrain	Algeria	Egypt	Libya	Tunisia	Israel	Syria	Iran	Iraq	Yemen	Other Middle East
1984 Proved Oil Reserves (billion barrels)	168.8	32.3	3.3	67.0	3.5		9.2	4.0	21.8	2.5		1.5	55.3	65.0	-	0.2
2015 Proved Oil Reserves (billion barrels)	266.6	97.8	25.7	101.5	5.3		12.2	3.5	48.4	0.4		2.5	157.8	143.1	3.0	0.2

Fig. 4. Proved oil reserves history in MENA countries.
Source: (BP, 2016)



	Saudi Arabia	UAE	Qatar	Kuwait	Oman	Bahrain	Algeria	Egypt	Libya	Tunisia	Israel	Syria	Iran	Iraq	Yemen	Other Middle East
1984 Proved Natural Gas Reserves (tcm)	3.6	3.1	4.3	1.0	0.2	0.2	3.4	0.2	0.6	-	-	0.1	14.0	0.8	-	-
2015 Proved Natural Gas Reserves (tcm)	8.3	6.1	24.5	1.8	0.7	0.2	4.5	1.8	1.5		0.2	0.3	34.0	3.7	0.3	^

Fig. 5. Proved gas reserves history in MENA countries.
Source: (BP, 2016)

Council, 2016b).

In the assessment of MENA oil and gas reserves it is very important to be clear on what is considered a proved reserve. The certainty of recovering discovered and commercially viable oil and gas resources with current technology ranges from proved reserves that have a 90% probability of being produced with existing technologies and under current economic and operating conditions to possible reserves with a 10% certainty of being developed under favorable circumstances (Chapman, 2014; McGlade et al., 2013; Verbruggen and Al Marchohi, 2010). However, assumptions about current technologies and market conditions can yield discrepancies in results for proved reserves. As shown in Figs. 4 and 5, proved reserve estimates in MENA OPEC countries[4] increased dramatically between 1984 and 2015. This may be due to a change in reported reserve estimates that are closer to the definition of 2P reserves, which are proved reserves in addition to probable reserves that have a 50% probability of being developed using current or imminent technologies and assuming favorable economic and political conditions. Such a change by OPEC countries would be motivated by the fact that OPEC quotas are set at a percentage of estimated proved reserves and so higher estimates would allow for

[4] The Organization of the Petroleum Exporting Countries (OPEC) countries include Algeria, Angola, Ecuador, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, UAE and Venezuela.

more production (Chapman, 2014). Consistent with this argument, it has been suggested that Kuwait's proved reserves may be closer to 24 billion barrels and Saudi Arabia's reserves may have been overstated by as much as 40% (Chapman, 2014).

Although this question about proved reserves in MENA OPEC countries does not necessarily imply an imminent shortage of oil, it does raise the question about peak conventional oil (Jefferson, 2012). Oil extraction costs in the MENA region, particularly the GCC, are the lowest in the world and so uncertainty regarding regional proved reserves makes the evolution of global energy prices uncertain as more expensive resources increasingly are needed to meet demand (Brecha, 2012). Further, MENA countries that have historically relied on resource rents to support social, political and economic agendas face risks regarding their actual timelines for implementing reforms needed for their "post-oil" economies. Regional oil-exporting economies face the dual risks of reduced demand for hydrocarbon exports due to a global energy transition that is characterized by reduced dependence on hydrocarbon resources as well as potentially less economically exportable hydrocarbon resources than is suggested by published reserves to production ratios.

Natural gas in the MENA region provides a salient example of the fact that resource abundance is not equivalent to an abundance of exploitable energy. Although the MENA region has substantial amounts of natural gas, subsidized or administered gas prices, unattractive investment terms for partners, and challenging extraction conditions have led to underinvestment in reserves development that has many MENA countries not only unable to monetize their reserves for export, but more fundamentally unable to utilize their reserves to meet domestic energy demands (Darbouche, 2013a). Similarly, despite the large low-cost gas reserves of Iran and Qatar, regional political disagreements and unattractive gas prices have prevented robust levels of intra-regional gas pipeline trade. The GCC countries, for instance, have substantial associated and non-associated natural gas reserves but all GCC countries with the exception of Qatar are now faced with a shortage of domestic natural gas supply (Crown Prince Court and UAE Ministry of Foreign Affairs, 2014; Komabargi et al., 2010; Krane and Wright, 2014; Lahn, 2016). This is again an indication that stated proved hydrocarbon reserves in the MENA region can be misleading with regard to the outlook for regional energy self-sufficiency.

4.1.2. Renewable energy resources

The MENA region has a rich endowment of renewable energy resources, particularly solar and wind resources (Alnaser and Alnaser, 2011; Bhutto et al., 2014; IRENA, 2016d; IRENA and League of Arab States, 2014; Nematollahi et al., 2016). Direct Normal Radiation (DNR), which is a measure of suitability for concentrated solar applications, ranges between 2,050 and 2,800 kWh/m^2/year in the MENA region where cloud cover is rare (IRENA and League of Arab States, 2014). These DNR levels are among the best in the world and so solar heating and cooling, Concentrated Solar Power (CSP) and Concentrated Photovoltaic (CPV) technologies are highly relevant for the region. Regional solar conditions are also generally very good for photovoltaic (PV) technologies with Global Horizontal Irradiance (GHI), a measure of suitability for PV, ranging between 1920 kWh/m^2/year in Lebanon to 2450 kWh/m^2/year in Egypt. For reference, 2100 kWh/m^2/year is a lower threshold for optimal solar PV power generation (IRENA, 2016a). It must be noted however, that regional environmental conditions, particularly dust, can significantly impact the performance of solar technologies (Costa et al., 2016; Sarver et al., 2013) and so resource assessments must be appropriately calibrated to account for this during solar project development (Gherboudj and Ghedira, 2016).

Wind resources in the MENA region are good, although more specific to selected MENA countries than solar resources. The Atlantic and Red Sea coasts of Morocco, Egypt and Saudi Arabia have very good wind potential with wind speeds in these areas often exceeding 7 m/s, which is the lower threshold wind speed for optimal wind power generation (IRENA, 2016a). IRENA has assessed solar and wind opportunities for the GCC, for both grid-connected and off-grid systems based on resource intensity, distance to power grids, population density, land cover, topography, altitude, and protected areas (IRENA, 2016d). IRENA's findings show technical potentials in the GCC for 65 GW of grid-connected wind energy, 34 GW of off-grid wind energy, 505 GW of grid-connected solar PV and 283 GW of off-grid solar PV for a total 888 GW of potential power generation, which is more than 6 times the current GCC installed power generation capacity.

Beyond solar and wind energy, MENA countries additionally have hydro, geothermal and bio-based renewable energy sources, including waste-to-energy (Hawila et al., 2014). However, these resources are expected to play a more limited role in regional renewable energy relative to solar and wind. Most of the region's hydro resources and installed capacity are in Iran (11.2 GW), Egypt (2.8 GW), Iraq (2.7 GW), Morocco (1.77 GW) and Syria (1.5 GW) with small installations in Algeria, Tunisia, Israel, Lebanon and Jordan (IHA, 2015). However, the hydropower resources in these countries have been almost fully exploited already except for Iran (Fragkos et al., 2013; IRENA and League of Arab States, 2014). Iran does have further technical potential for hydropower; the country has set no further targets for hydropower and economically exploitable hydropower potential in the country is unclear (World Energy Council, 2013). Notably, pumped storage hydro (PSH) capacity has been deployed in Iran (1.04 GW), Morocco (464 GW) and Iraq (240 GW) and this provides these countries with capacity for energy storage that can support large-scale deployment of intermittent solar and wind resources (IHA, 2015). Dubai has also announced a plan for 250 MW of PSH to be coupled with solar energy, which will be a first-of-kind project in the GCC (MEES, 2016b).

Geothermal energy does not currently play a significant role in MENA energy systems with only Israel having 23 MW of geothermal capacity, which is used for direct heating (World Energy Council, 2013). However, Algeria, Morocco, Saudi Arabia, and Yemen do have geothermal sites with temperatures that exceed 200 °C at 5000 m and so these countries could potentially leverage geothermal energy for power applications (IRENA and League of Arab States, 2014). Low-temperature geothermal heat may additionally have regional applications in desalination (Loutatidou and Arafat, 2015) as well as district cooling.

Although assessment of regional resource potentials is informative, it is perhaps more useful to consider technical and economic potentials as well. As show in Table 2, work from the 100% renewable energy project (Delucchi and Jacobson, 2011; Jacobson and Delucchi, 2011; Jacobson et al., 2016) suggests an interesting view of the enormous opportunity for solar energy and, to a lesser extent, wind energy in the region if all the social, political and economic factors required to realize this potential could be aligned.

4.2. Energy-water nexus

Although the MENA region contains more than 60% of the world's proven crude oil reserves, it has only about 1.4% of the world's fresh water supply. All MENA countries, with the exception of Iran and Iraq, are subjected to water scarcity, which is a condition where renewable water resources are less than 1000 m^3/year/capita. Siddiqi and Anadon have reviewed the MENA energy-water nexus (Siddiqi and Anadon, 2011) and shown that the regional dependence on energy for fresh water is substantial and this dependence is related not only to desalination, but the entire water value chain including abstraction, purification (including wastewater treatment for reuse), distribution, utilization, and disposal. In fact, 14% or more of the total fuel consumption in Libya is due to groundwater pumping and in Egypt up to 1% of total electricity consumption is associated with wastewater

Table 2
MENA renewable energy potentials for power production.
Source: (Jacobson et al., 2016)

Country	Onshore Wind	Offshore Wind	Wave	Geothermal	Hydro	Tidal	Solar (Residential Rooftop)	Solar (Government Rooftop)	Solar (Utility)	Solar (CSP)
Algeria	1.3%	0.0%	0.0%	0.0%	0.2%	0.0%	10.9%	12.1%	60.5%	15.0%
Egypt	20.0%	0.3%	0.2%	0.0%	1.3%	0.0%	13.7%	9.5%	40.0%	15.0%
Libya	26.5%	3.5%	1.0%	0.0%	0.0%	0.0%	6.7%	9.3%	38.0%	15.0%
Morocco	22.5%	5.0%	0.6%	0.0%	2.7%	0.0%	9.9%	8.8%	45.5%	5.0%
Tunisia	23.0%	4.0%	0.6%	0.0%	0.2%	0.0%	6.0%	6.6%	54.5%	5.0%
Bahrain	1.0%	8.0%	0.2%	0.0%	0.0%	0.0%	3.8%	6.3%	60.7%	20.0%
Kuwait	5.0%	6.8%	0.2%	0.0%	0.0%	0.0%	1.6%	3.7%	54.7%	28.0%
Oman	18.0%	3.8%	0.5%	0.0%	0.0%	0.0%	1.8%	2.3%	58.6%	15.0%
Qatar	3.5%	7.9%	0.2%	0.0%	0.0%	0.0%	1.4%	3.2%	77.3%	6.5%
Saudi Arabia	11.0%	0.0%	0.2%	0.0%	0.0%	0.0%	3.8%	5.1%	45.0%	35.0%
United Arab Emirates	4.0%	4.0%	0.1%	0.0%	0.0%	0.0%	0.9%	1.5%	79.4%	10.0%
Israel	6.0%	1.0%	0.1%	0.0%	0.0%	0.0%	17.1%	16.2%	39.5%	20.0%
Jordan	30.0%	0.0%	0.0%	0.0%	0.1%	0.0%	11.1%	10.8%	33.0%	15.0%
Lebanon	10.0%	8.0%	0.3%	0.0%	2.1%	0.0%	5.2%	10.2%	59.2%	5.0%
Syria	35.0%	1.5%	0.0%	0.0%	5.9%	0.0%	13.9%	6.8%	29.9%	7.0%
Iran	11.0%	2.5%	0.1%	0.0%	2.2%	0.0%	2.9%	2.7%	60.6%	18.0%
Iraq	25.0%	0.0%	0.0%	0.0%	4.5%	0.0%	12.9%	7.7%	39.0%	10.9%
Yemen	4.0%	5.0%	2.0%	1.2%	0.0%	0.1%	27.3%	8.3%	39.1%	13.0%

For each MENA country, the share of proposed renewable energy technology is shown. The highest technology shares are shown in green and the lowest shares in red.

treatment (Siddiqi and Anadon, 2011). Hence, the energy-water nexus is a key area of uncertainty and concern for MENA countries (World Energy Council, 2016a).

Although the dominant use of water in the MENA region is for agriculture (AFED, 2015), potable and industrial water consumption is the driver for the very high reliance on seawater desalination across the region. GCC countries are particularly prominent in desalination, having 26 million m^3/day of seawater desalination capacity, approximately 36% of total worldwide capacity (IRENA, 2016d). The impact on the GCC power and water sector from this substantial desalination need is substantial. An average of 12% of total sector fuel consumption across the GCC is spent on desalination with the range being from 10% in Saudi Arabia to approximately 30% in Qatar (IRENA, 2016d). The GCC countries are globally unique in their heavy reliance on thermal desalination technologies, which were historically necessary to desalinate water in the Arabian Gulf because of the Gulf's very high level of total dissolved solids. Thermal desalination technologies were also convenient for coupling with thermal-based power generation technologies because waste-heat from fossil energy combustion could be used for multi-stage flash (MSF) or multiple-effect desalination (MED). The GCC's dependence on thermal desalination is apparent from the region's installed desalination capacity, which in 2014 was 53% MSF, 11.3% MED, 34.5% reverse-osmosis (RO) and 1.2% other technologies (IRENA, 2016d). In contrast, only 30% of desalinated water is produced by thermal processes on a global level (Ghaffour et al., 2015). Now, however, GCC countries are moving away from thermal desalination in order to decouple power and water systems. Advancements in membrane-based technologies, such as reverse osmosis, allow Arabian Gulf water to be desalinated at lower cost than thermal approaches. This is important as GCC countries require clean water production technologies that support a shift toward alternative energy sources, such as nuclear and renewables, which is a global interest (Ghaffour et al., 2015; Shatat et al., 2013).

While energy policy in the GCC is clearly linked with water policy due to the structure of the power and water system, integrated energy and water policy planning is a key issue throughout the rest of the MENA region as well. As a specific example, lack of coordinated energy and water planning in Jordan has been assessed and shown to put the Jordanian energy system at risk as new requirements for water from oil-shale development were not adequately considered due to lack of coordinated energy and water policy formulation (Siddiqi et al., 2013).

5. MENA energy system transition

The literature on energy transitions suggests that energy system evolution is one of the central policy challenges facing industrial countries (Miller et al., 2013). This is certainly true for MENA countries as well and has been discussed in the context of regional energy strategy and policy formation (Griffiths and Weijermars, 2013). Key issues for regional energy transition include diversification of energy supply, energy demand management and energy trade, particularly intra-regionally.

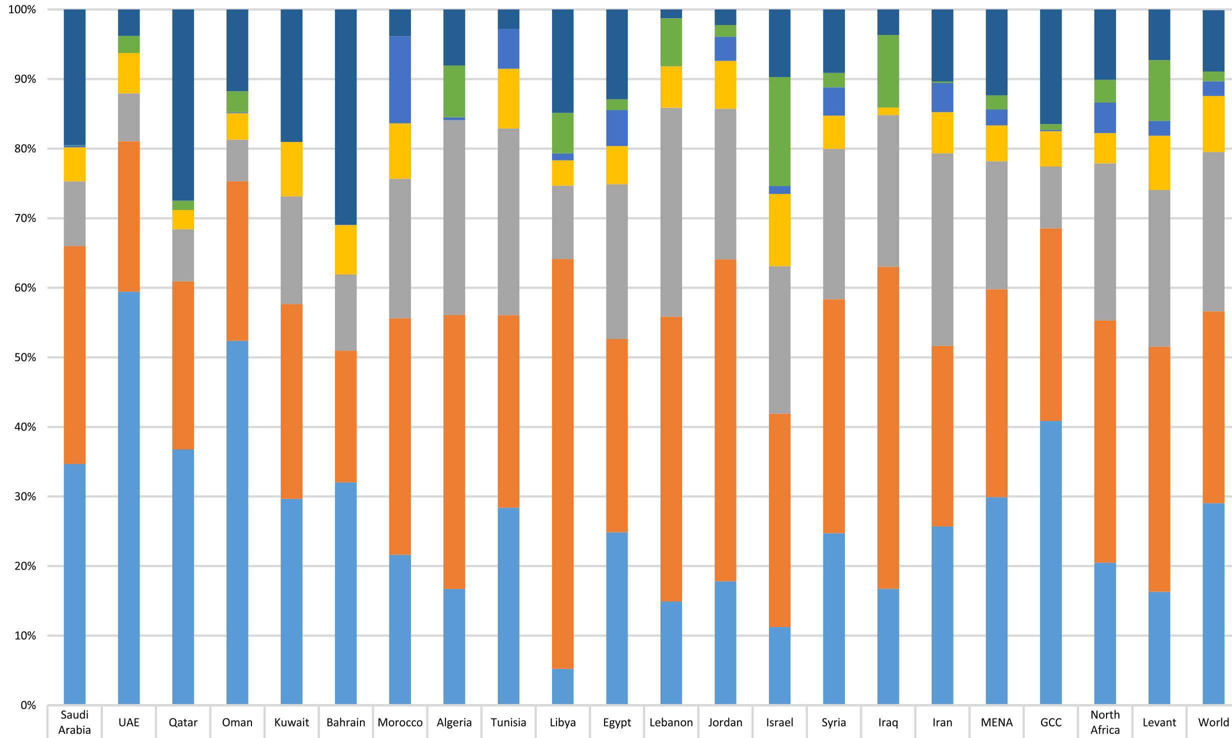
Table 3
MENA energy strategies and targets.

Country	Energy supply strategy				Renewable energy targets						
	Nuclear energy	Coal	LNG import	Renewable energy (strategy/action plan/ program)	Primary energy from renewable resources	Final energy from renewable resources	Electricity generation from renewable resources	Technology-specific share of electricity generation	Renewable power installed capacity and/or generation	Heating and cooling from renewable resources	Transportation energy from renewable resources
Bahrain			X	X			5% by 2030				
Kuwait			X	X			15% by 2030		Solar PV : 4.6 GW by 2030 CSP : 5.7 GW by 2030 Wind power : 700 GW by 2030		
Oman			X	X							
Qatar				X			2% by 2020; 20% by 2030		Solar PV : 1.8 GW by 2014		10% by 2020
Saudi Arabia	X			X Saudi Arabia Vision 2030*		4% by 2020			Unspecified Renewable Energy : 3.45 GW by 2020		
UAE	X	X	X	X Dubai: Dubai Integrated Energy Strategy 2030		24% by 2021	No national target Abu Dhabi - 7% by 2020; Dubai - 7% by 2020 and 25% by 2030				
Israel		X		X		13% by 2025; 17% by 2030	17% by 2030; 10% by 2020				
Jordan	X	X	X	X Master Strategy of Energy Sector in Jordan for the period (2007–2020) adopted in 2007		11% by 2025	15% by 2015		Electricity : 1 GW by 2018; Solar PV : 300 MW by 2020; CSP : 300 MW by 2020; Wind power : 1.2 GW by 2020	Solar water heating systems for 30% of households by 2020	
Lebanon			X	X Policy Paper for Electricity Sector (2010); NEEAP (2011–2015)		15% by 2030	12% by 2020		Bio-power from biogas : 15–25 MW by 2015; Hydropower : 40 MW by 2015; Wind power : 60–100 MW by 2015; 400–500 MW by 2020	15% renewables in gross final consumption in power and heating by 2030	
Palestine			X	X National Energy Strategy (2012–2020); Palestinian Solar Initiative							
Syria				The 11th Five-Year Plan for 2011–2015							
Iran	X			X					Solar power and wind power : 5 GW (no date)		
Iraq				X Renewable Energy Plan 2013–2017, adopted in 2012			10% by 2030		Solar PV : 240 MW by 2016; CSP : 80 MW by 2016; Wind power : 80 MW by 2016		
Yemen				X					Bio-power : 6 MW by 2025; Geothermal power : 200 MW by 2025; Solar PV : 4 MW by 2025; CSP : 100 MW by 2025; Wind power : 400 MW by 2025		
Algeria				X National Program for Renewable Energy and Energy Efficiency 2030		37% by 2030	27% by 2030		Electricity : 22 GW by 2030; Bio-power from waste-to-energy : 1 GW by 2030; Geothermal power : 15 MW by 2030; Solar PV :		

(continued on next page)

Table 3 *(continued)*

	Energy supply strategy				Renewable energy targets						
Country	Nuclear energy	Coal	LNG import	Renewable energy (strategy/action plan/ program)	Primary energy from renewable resources	Final energy from renewable resources	Electricity generation from renewable resources	Technology-specific share of electricity generation	Renewable power installed capacity and/or generation	Heating and cooling from renewable resources	Transportation energy from renewable resources
				adopted in 2011					13.5 GW by 2030; CSP : 2 GW by 2030; Wind power : 5 GW by 2030		
Egypt	**X**	**X**	**X**	**X** National RE Strategy 2020 adopted in 2008, updated in 2012; Feed-in Tariff Program; Master plan for RE 2025	14% by 2020		20% by 2020	Wind power : 12% and 7.2 GW by 2020	Hydropower : 2.8 GW by 2020; Solar PV : 220 MW by 2020,700 MW by 2027; CSP : 1.1 GW by 2020, 2.8 GW by 2017; Wind power : 7.2 GW by 2020		
Libya				**X** National Plan for developing RE in Libya (2013–2025)	10% by 2020		7% by 2020; 10% by 2025		Solar PV : 129 MW by 2015, 344 MW by 2020, 844 MW by 2025; CSP : 125 MW by 2020, 375 MW by 2025; Wind power : 260 MW by 2015, 600 MW by 2020, 1 GW by 2025	Solar water heating: 80 MWth by 2015; 250 MWth by 2020	
Morocco		**X**	**X**	**X** New National Energy Strategy Assessment Report, 2013			52% by 2030		Hydropower : 2 GW by 2020; Solar PV and CSP : 2 GW by 2020; Wind power : 2 GW by 2020	Solar water heating: 1.2 GWth (1.7 million m^2) by 2020	
Tunisia				**X**					Electricity : 1 GW (16% of capacity) by 2016, 4.6 GW (40% of capacity) by 2030; Bio-power from solid biomass : 40 MW by 2016, 300 MW by 2030; Solar power : 10 GW by 2030 ; Wind power : 16 GW by 2030		



	Saudi Arabia	UAE	Qatar	Oman	Kuwait	Bahrain	Morocco	Algeria	Tunisia	Libya	Egypt	Lebanon	Jordan	Israel	Syria	Iraq	Iran	MENA	GCC	North Africa	Levant	World
Non-energy use	19%	4%	27%	12%	19%	31%	4%	8%	3%	15%	13%	1%	2%	10%	9%	4%	10%	12%	16%	10%	7%	9%
Non-specified (other)	0%	2%	1%	3%	0%	0%	0%	7%	0%	6%	2%	7%	2%	16%	2%	10%	0%	2%	1%	3%	9%	1%
Agriculture/forestry	0%	0%	0%	0%	0%	0%	13%	0%	6%	1%	5%	0%	3%	1%	4%	0%	4%	2%	0%	4%	2%	2%
Commercial and public services	5%	6%	3%	4%	8%	7%	8%	0%	9%	4%	5%	6%	7%	10%	5%	1%	6%	5%	5%	4%	8%	8%
Residential	9%	7%	7%	6%	15%	11%	20%	28%	27%	11%	22%	30%	22%	21%	22%	22%	28%	18%	9%	23%	23%	23%
Transport	31%	22%	24%	23%	28%	19%	34%	39%	28%	59%	28%	41%	46%	31%	34%	46%	26%	30%	28%	35%	35%	28%
Industry	35%	59%	37%	52%	30%	32%	22%	17%	28%	5%	25%	15%	18%	11%	25%	17%	26%	30%	41%	21%	16%	29%

Fig. 6. Distribution of Total Final Energy Consumption (TFEC) in MENA Countries. TFEC data are for 2013. Non-energy use covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel. Source: (IEA, 2015a).

In 2015, MENA primary energy consumption was more than 97% based on oil and natural gas (BP, 2016) with the significant use of coal by Morocco and Israel being among the few instances of regional primary energy diversification. However, as shown in Table 3 and discussed in sections that follow, energy supply diversification is a strategic priority in the region.

Unlike primary energy supply, however, there is significant regional diversity in the sectoral distribution of total final energy consumption (TFEC, Fig. 6). Industry dominates TFEC in the GCC countries while transportation and buildings playing a larger role in TFEC within North African and Levant countries. This distribution of energy demand is extremely important because the power and buildings sectors globally have a much better outlook for transition to low carbon energy supply than either the industrial or transportation sectors (IRENA, 2016c; Shell, 2016). For both industry and transportation, demand management from energy efficiency, reduced consumption via appropriate price signals and a shift to low carbon energy supply will all need to play a prominent role.

5.1. Demand management

Energy consumption in the MENA region has grown twice as fast as GDP between 2000 and 2011 with an average annual GDP growth of approximately 4% versus primary energy and electricity demand growth of approximately 8% each (RCREEE, 2015a). Further, the growth rate of MENA electricity production capacity was 2.5 times the regional GDP growth rate in 2014 (APICORP Energy Research, 2015) and planned power production capacity to 2020 suggests that this massive growth in demand for electricity is not abating (Fig. 7). The

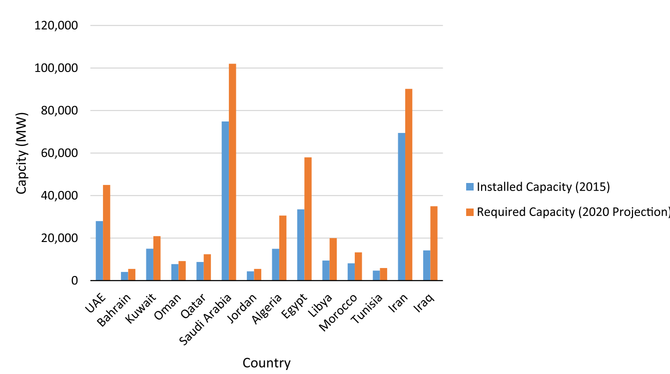


Fig. 7. Power Generation Capacity in the MENA Region. Power generation capacity in 2015 and projected requirements for 2020. Sources: (APICORP Energy Research, 2016d; MEED Insight, 2015).

high demand for electricity across the MENA region is perhaps not surprising given that 56% of the regional population lives in cities and by 2050 this percentage is expected to reach 68% (AFED, 2015). Furthermore, the region's climate and general lack of fresh water resources leads to a heavy dependence on energy-intensive air-conditioning and desalination. These demographic and consumption factors indicate that a decoupling of economic growth and energy consumption is essential for MENA countries to move toward sustainable economic development. The resource-rich MENA countries, such as those in the GCC, have particularly been at the forefront of the region's energy and carbon intensity given their high income levels and reliance on energy-intensive industries for economic growth (Friedrichs and Inderwildi, 2013; Lahn and Preston, 2013; Lahn et al., 2013; Stevens and Lahn, 2011).

5.2. Energy efficiency

In 2010, the Arab Energy Efficiency Guidelines were adopted based on the European Directive 2006/32/EC with the intent for Arab states to develop national energy efficiency action plans (NEEAPs) that target comprehensive energy savings by 2020 (RCREEE, 2015a). By 2015, the majority of North African and Levant countries had adopted the NEEAP framework while GCC countries, as well as Israel and Iran, which are not Arab states, have largely taken their own approaches. In all cases, the focus of efficiency measures has been mainly on the power sector and more specifically residential buildings where demand for electricity is highest in the region. Given the emphasis on buildings, key efficiency measures to consider are building energy codes, appliance standards, energy labeling, energy audits (particularly relevant for commercial and industrial buildings), metering and efficiency in urban planning. With regard to electricity supply, other than the UAE, Qatar, Bahrain and Saudi Arabia, losses in the transmission and distribution of electricity exceed 10% in all MENA countries, averaging nearly 20% across the region (Emtairah and Chaaban, 2013; RCREEE, 2015a). Hence, rehabilitating transmission and distribution networks is a key measure for regional energy efficiency. Although not directly an energy efficiency measure, reduction of electricity peak demand through demand management approaches, such as time-differentiated tariffs, is an essential further consideration.

Within the buildings sector, in 2014 the UAE had the highest share of green buildings in the region serving as home to 70% of the 1170 Leadership in Energy and Environmental Design (LEED)-registered buildings in the GCC (Asif, 2016). Both the UAE and Qatar have implemented sustainable building rating systems tailored to the regional context, namely the Pearl Rating System (PRS) in Abu Dhabi and the Global Sustainability Assessment System (GSAS) in Qatar. Across the rest of the MENA region, mandatory and voluntary building standards and codes are implemented or under preparation (Emtairah and Chaaban, 2013). However, enforcement of the standards and codes has been weak, suggesting challenges with institutional capacity that policy makers must address. As the implementation of building codes is addressed, policy makers must additionally consider integrated climate responsive strategies for the buildings sector that recognize a hierarchy of efficiency measures, starting with urban planning and progressing through building morphology, architectural design, building construction, installation and finally building integrated renewables (Visser and Yeretzian, 2013). As regional urbanization progresses, holistic city and building designs must be pursued that account for regionally specific climate factors that make optimal urban design principles far different from those used in regions with very different heat, humidity, dust, temperature cycling and precipitation profiles.

Appliance standards in the region focus on minimum energy performance for the devices that consume the most energy. In the GCC, peak energy demand occurs during summer days and so air conditioning accounts for up to 70% of the GCC's annual peak electricity consumption and is a key target for energy efficient technologies (RCREEE, 2015a). Properly tailored minimum energy performance standards (MEPS) are vital as research has shown that chillers in the GCC with optimal MEPS could reduce peak electricity consumption demand by nearly 15% (Afshari and Friedrich, 2016). MEPS for air conditioning systems are now implemented across the GCC but only since 2013–2014 in Saudi Arabia, the UAE and Qatar. District cooling networks, an option being pursued in the UAE, can cut energy usage in a typical residential unit by 40–45% compared to traditional climate control systems (IRENA, 2016c) and so should be a priority for GCC policy makers in addition to MEPS for standard air conditioning units. Lighting is a significant consumer of energy outside of the GCC where peak electricity demand occurs at night. Lighting accounts for more than 20% of electricity consumption in Egypt and Jordan and up to 56% of peak electricity demand in Morocco (RCREEE, 2015a). Hence, MEPS for lighting is important and readily available via commercially available and increasingly cost effective lighting technologies such as light emitting diodes (LEDs). Jablonski and Tarhini (Jablonski and Tarhini, 2013) have shown that in the Mediterranean Partner Countries[5] (MPC), indoor lighting efficiency, street lighting efficiency and refrigerator efficiency are the most economically attractive energy efficiency measures, which is consistent with the general notion that lighting and cooling efficiency need to be regional priorities. Importantly, however, the economic viability for such energy efficiency technologies is based on the cost of energy saved and so almost no efficiency technology will be viable in countries with heavily subsidized energy prices.

Beyond energy efficiency in buildings, greater regional emphasis must be placed on the transportation and industrial sectors. As shown in Fig. 6, these two sectors make up 51% of final energy consumption in the Levant countries, 56% of final energy consumption in the North African countries and a massive 69% of final energy consumption in the GCC countries. Despite such significant contributions to energy consumption, no MENA country currently has a comprehensive policy for transportation efficiency (RCREEE, 2015a) with only Tunisia setting a transportation efficiency target in its NEEAP. In the GCC, industrial energy consumption is a major challenge but no GCC countries have established legislation for industrial energy efficiency and energy intensity targets for the sector are absent (Lahn and Preston, 2013). This is a gap that requires urgent attention from policy makers.

5.3. Energy efficiency best practices

Energy efficient economic growth in MENA and elsewhere requires the proper framework, including adequate energy price signals, supportive policies, institutional capacity for implementing demand management measures and, in the power sector, efficient utility operations. The Regional Centre for Renewable Energy and Energy Efficiency (RCREEE) has ranked Tunisia as the MENA country that has achieved the best progress toward developing each of the stated framework conditions for energy efficient development[6] (RCREEE, 2015a). This ranking is consistent with Tunisia having the highest conditional GHG mitigation target among MENA countries (Table 1). Analysis of the Tunisian energy system indicates the importance of the following factors:

- Clear national energy efficiency strategies and action plans
- Energy efficiency policy frameworks that consist of a wide range of measures including regulatory, fiscal and financial instruments that cover electricity as well as other forms of energy Implementation of impactful energy subsidy reform measures
- Strong institutional support consisting of strategic leadership, dedicated resources and competent staff

Tunisia shows particular strength in having a structured approach to energy efficiency policy design and implementation. Importantly, Tunisia has established the National Agency for Energy Conservation (ANME) to take accountability for the country's energy efficiency strategies and implementation processes with consideration of the industry, buildings and transportation sectors. Establishment of such a dedicated institution is a best practice for other countries in the region to consider. So far, other MENA countries are generally lacking clear demand-side strategies that are accompanied by action plans with

[5] The MPC countries are Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Syria, Tunisia, and West Bank/
Gaza.

[6] Israel was not included in the assessment but is additionally advanced in energy efficiency (Jablonski, S., Tarhini, M., 2013; Meir et al., 2012).

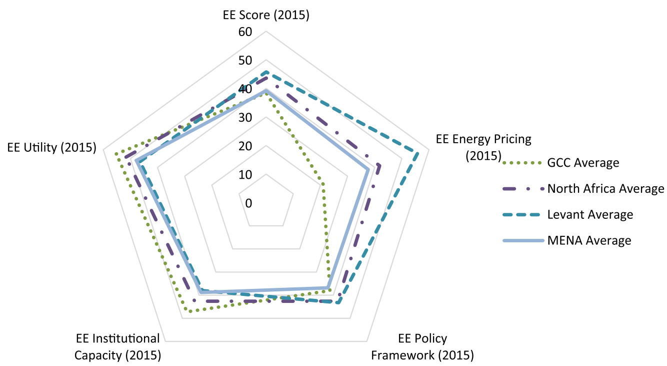


Fig. 8. Energy efficiency framework conditions in the MENA region. Scoring of energy efficiency (EE) frameworks in MENA countries along the dimensions of energy pricing, energy efficiency policy frameworks, institutional capacity to implement energy efficiency measures and energy efficiency within power and water utilities. The EE Score is the overall composite score accounting for each separate dimension.
Source: (RCREEE, 2015a).

time-bound targets and supported by robust regulatory frameworks and incentives.

Fig. 8 shows that Levant countries in general perform best in the MENA region with regard to energy efficiency. North Africa comes in second behind the Levant countries followed by the GCC countries. The only dimension of energy efficiency with substantial disparity among the MENA countries is energy pricing, where GCC countries have historically done very poorly due to substantial subsidies for electricity as well as gasoline and diesel fuels.

5.4. Energy subsidies

The need for energy subsidy reform in MENA has been a widely documented and is a critical issue for energy demand management as well as fiscal stability (APICORP Energy Research, 2016a; El-Katiri and Fattouh, 2015; Fattouh and El-Katiri, 2013; Sdralevich et al., 2014; World Energy Council, 2016a). According to the IMF, in 2011 pretax energy subsidies[7] in the region amounted to US $237 billion, which was approximately 48% of global subsidies in the same year and 8.6% of regional GDP (Sdralevich et al., 2014). The ramifications of heavy energy subsidization in the MENA region include the formation of energy intensive industries that rely on cheap energy for competitiveness, lack of incentives for efficiency in the industrial, power and water sectors, rapid growth in demand for primary fuels and electricity, fuel shortages and smuggling, unequal distribution of benefits with the wealthiest segments of society benefiting the most, growth in carbon dioxide emissions and rapidly rising fiscal burdens (Fattouh and El-Katiri, 2013; Sdralevich et al., 2014). It is rising fiscal burdens, however, that have stimulated subsidy reforms in both net-oil importing and net-oil exporting MENA countries in the past several years (Fattouh et al., 2016; Verme, 2016). Falling global oil and gas prices have also eased the task of subsidy reform by narrowing the differential with domestic prices (Benes et al., 2015).

Energy subsidy reform efforts have taken place in the net-oil importing countries of Egypt, Jordan, Morocco and Tunisia with the focus on fuel products and electricity tariffs (Sdralevich et al., 2014; Verme, 2016). The reform efforts in Jordan, Morocco and Tunisia have been successful in achieving reform measures without sparking serious protests. This has been through context-appropriate implementation of best practice measures that include adequate preparation, gradual price adjustments, sufficient breadth of reform, consensus building, communication and provision of adequate mitigation measures (Fattouh and El-Katiri, 2013; Sdralevich et al., 2014; Whitley and van der Burg, 2015). Morocco has perhaps been the most successful overall in eliminating price controls across energy products and Jordan has done very well with petroleum product reforms but still is coping with the financial burden from remaining electricity subsidies (Verme, 2016). Subsidy reform in Tunisia has been gradual but steady since 2012 and reform in Egypt is still a work in progress as the country continues pushing forward with reform efforts out of fiscal and economic necessity (El-Katiri and Fattouh, 2015; Fattouh et al., 2016).

Among the net-oil exporting MENA countries, Yemen has struggled in its reform efforts with the most recent attempt at reform in 2014 being done in a hasty fashion that led to substantial social backlash and reversal of the reform effort (El-Katiri and Fattouh, 2015). Algeria announced increases in value added taxes on diesel, electricity, and natural gas at the end of 2015 but the efforts to date have been insufficient to help reverse the country's fiscal deterioration as substantial energy subsidies remain in place (IMF, 2016a). Iran initiated major energy subsidy reforms in 2010 (Fattouh et al., 2016) but has had difficulties in subsequent years as the failure to remove price controls completely, inflation, currency depreciation, and institutional challenges in achieving targeted and cost effective compensation measures for citizens allowed substantial subsidies to again accrue by 2014 (Verme, 2016). Nonetheless, the Iranian government has sustained its reform initiatives and continued with a further price adjustment in 2014, presenting a positive albeit mixed example for subsidy reform efforts (El-Katiri and Fattouh, 2015).

In the wealthier GCC countries subsidy reform had long been considered a near impossibility as subsidies have served as a means of redistributing natural resource wealth to citizens (e.g. the social contract) (Krane and Hung, 2016) and enhancing the competitiveness of energy intensive industries. Now, however, all GCC countries have carried out reform measures due to fiscal pressures resulting from falling oil revenues (APICORP Energy Research, 2016a; Benes et al., 2015; Boersma and Griffiths, 2016; Fattouh et al., 2016; Lahn, 2016). Even in Kuwait, where parliamentary influence over energy policy has made the social contract much more difficult to adjust than in the rest of the GCC, subsidy reform has occurred. Kuwait's cabinet approved increases to gasoline prices ranging from 42–83% depending on grade and the increases took effect in September 2016. However, unlike gasoline pricing reforms in the rest of the GCC, Kuwait is partially compensating citizens with up to 75 liters of free gasoline each month. Even with this concession in place, the move has been met with considerable resistance from Kuwait's parliament, resulting in the Kuwaiti Emir dissolving the parliament in October 2016 (MEES, 2016d). Kuwait's electricity and water subsidy reforms, which are planned to take effect in 2017 are expected to be less contentious than the gasoline price increases because they will target expat citizens and businesses and exempt national citizens.

Subsidy reforms in the GCC have been broad, covering natural gas, transport fuels, electricity and water and a detailed review of the specific pricing reforms and the timeline for reforms is provided by Lahn (Lahn, 2016). Subsidy reforms in the power and water sectors generally adhere to rising consumption-based slab tariffs that are different across sectors (residential, commercial, industrial). Nationality is a factor in the residential sector with expatriates paying more than nationals for electricity and water in the UAE, Bahrain and Qatar. Time-of-use pricing is additionally implemented for industrial electricity tariffs in Abu Dhabi and Oman. Unlike electricity and water price reforms, however, transport fuel price reforms in GCC countries, with the exception of Kuwait, are being applied uniformly across sectors and nationalities.

[7] Pre-tax subsidies are defined as the difference between the price consumers pay and the cost of supplying energy. Post-tax subsidies include the estimated cost of environmental damage and foregone consumption taxes that may rightfully be applied to energy products.

5.5. Energy supply diversification

5.5.1. Renewable energy

There have been several comprehensive reports from international agencies on the opportunities for renewable energy in the MENA region (IRENA and League of Arab States, 2014; RCREEE, 2015b; REN21 et al., 2013) as well as focused reports on Africa (with inclusion of North Africa) (IRENA, 2015a) and the GCC (IRENA, 2016d). Renewable energy in the GCC has been an ongoing topic of academic interest with many authors considering policies that could stimulate renewables adoption (Abdmouleh et al., 2015; Al-Amir and Abu-Hijleh, 2013; Alnaser and Alnaser, 2011; Atalay et al., 2016; Bhutto et al., 2014; Lilliestam and Patt, 2015; Mezher et al., 2012) and further developing economic top-down and technological bottom-up models to simulate the impacts of implementing various clean energy policies (Matar et al., 2015b; Mondal et al., 2014; Sgouridis et al., 2016, 2013). The potential of renewable energy in North Africa has garnered similar interest (Boubaker, 2012; Brand, 2016; Carafa et al., 2016; Hawila et al., 2014; Marktanner and Salman, 2011; Vidican, 2016).

As shown in Table 3, MENA countries have largely followed the global trend of prioritizing the power sector in renewable energy plans and targets. Only Qatar has a target for transportation and only Lebanon, Jordan, Libya and Morocco have national solar heating targets despite the excellent regional solar resources. Solar water heating (SWH) requires special consideration as an impactful renewable energy source since it receives much less attention than solar power yet is a low cost and effective means of improving energy performance in the buildings sector (Jablonski and Tarhini, 2013; REN21 et al., 2013). Both Jordan and Dubai in the UAE require installation of solar water heaters in new buildings and both Morocco and Tunisia have successful programs (RCREEE, 2015a; REN21 et al., 2013). In the emirate of Dubai in the UAE, installation of solar water heaters is required in all new villas and labor accommodations to provide 75% of domestic hot water requirements (RCREEE, 2015a; Sgouridis et al., 2016). The largest regional deployment of solar water heating, however, is in Israel where 3.2 GW_{th} was deployed by the end of 2014 and regulations enforcing SWH in every residential unit in Israel has been enforced since 1976 (Meir et al., 2012).

Regional targets for electricity generation from renewable energy range from no defined target in Oman to 52% in Morocco by 2030. As would be expected based on regional renewable energy resources, capacity targets primarily relate to solar and wind energy technologies. Only Morocco, Egypt and Lebanon specify incremental hydropower capacity targets while Lebanon, Yemen, Algeria and Tunisia specify modest bioenergy targets. Yemen is the single country that specifies a geothermal target.

Although renewable energy for the MENA power sector has promise, renewable energy is expected to play a minimal role in industry and transportation. IRENA's REMap 2030 includes assessment of renewable energy opportunities in the UAE, Kuwait, Saudi Arabia, Egypt and Morocco (IRENA, 2016c) and shows that the transportation sector is unlikely to have any significant contribution from renewable energy by 2030. This result is consistent across the MENA region with the national and sub-national policy targets shown in Table 3 as well as the results of IRENA's more detailed GCC and North Africa assessments (IRENA, 2014, 2015a, 2016d). While renewable fuels for transportation are unlikely in the region, solar thermal energy for process heat, particularly in the GCC countries, may be viable (Sgouridis et al., 2016). North African countries could see renewable energy contribute to up to 23% of industrial sector energy demand by 2030 with solar thermal process heat complimenting biomass and hydropower energy (IRENA, 2015a). Opportunities for solar thermal in the GCC industrial sector is limited, however, as the energy-intensive industries present in the region require substantial amounts of electricity and/or high-temperature process heat that solar thermal cannot provide.

It is clear that MENA countries are moving toward adoption of renewable energy, primarily in their power sectors. In order to do this, however, a structured approach must be adopted to policy development, starting from a political vision that is followed closely by concrete energy strategies that are implemented through roadmaps, actions plans and appropriate policy tools (IRENA, 2015b; IRENA and League of Arab States, 2014; Vidican, 2016). Published strategic and implementation plans for renewable energy are largely absent in the GCC countries while such documents are more readily available in the North African and Levant countries. It therefore naturally follows that renewable energy policies are much more prominent in North Africa and the Levant as shown (Table 4). As indicated in Table 4, Israel is the MENA leader with regard to the number of policies implemented and is followed by Jordan. The UAE, and Dubai in particular, is a standout in the GCC with regard to renewable energy policy implementation. The most widely implemented renewable energy policy in the MENA region is tendering, which is logical given the dominance of this approach for the region's procurement of power capacity. Morocco has been a regional in renewable energy with 13% of power production from renewables already by 2013 (MEED Insight, 2015), 797 MW of wind energy capacity installed as of 2014 (MEED Insight, 2015) and 180 MW of CSP capacity by the end of 2015 (REN21, 2016). With such experience in utility-scale renewable energy and more projects in the pipeline (APICORP Energy Research, 2016f), Morocco provides a strong regional model for renewable energy tendering or auctions[8] (Carafa et al., 2015; IRENA, 2013, 2015b) with best practices relevant to many other MENA countries (Åberg et al., 2016).

Although competitive bidding via auctions is a mechanism well suited to utility-scale projects within existing MENA electricity market structures and is a broader trend in renewable energy policy design (REN21, 2016), the mechanism can have drawbacks. Specifically, private sector and consumer engagement is limited, administrative and transaction costs can be high and projects may fail to be delivered if awarded bidders end up unable to meet their delivery obligations (del Río and Linares, 2014). Hence, additional policy measures, such as feed-in-tariffs (FiTs) and net metering to support particularly distributed renewables are relevant when the context is appropriate, such as the emirate of Dubai in the UAE where solar PV net-metering policy coupled with sufficiently high electricity tariffs is a key part of the emirate's energy strategy (Griffiths and Mills, 2016). Jordan is another MENA country committed to renewables where the electricity market structure, energy pricing, policies, regulations and access to financing make distributed solar attractive towards meeting the country's target of 12% power generation capacity from solar by 2020 (Hadjipanayi et al., 2016; MESIA, 2016). Israel will additionally benefit from distributed solar given the excellent potential for rooftop solar in the country (Vardimon, 2011), supportive FiT and net-metering policies in place (Hadjipanayi et al., 2016) and low likelihood of participating in regional electricity markets (Boffa and Sapio, 2015).

Egypt, Algeria and Iran are all cases where the ambition and potential for distributed solar power and solar power in general are high (MESIA, 2016) but context will be a major hindrance to realization of ambitions. The social and political challenges in Algeria make financing for renewable energy projects a great challenge (Hawila et al., 2014; RCREEE, 2015b). Iran has a very good ambition for solar as well as a supportive FiT framework for distributed solar but short term and long term political, economic and operational risks remain high (Aguilar et al., 2016). This again highlights the need to assess context when considering the timeline and potential for MENA countries to evolve and transition their energy systems.

[8] The terms auction and public tendering or competitive tendering are used interchangeably. In this paper, the scheme is referred to as an auction.

Table 4
MENA renewable energy policies.

Country	Regulatory							Fiscal Incentives and Public Financing				
	Feed-in tariff / premium payment	Electric utility quota / obligation / RPS	Net metering / Net billing	Transport obligation / mandate	Heat obligation/ mandate	Tradable REC	Tendering	Capital subsidy, grant, or rebate	Investment or production tax credits	Reductions in sales, energy, VAT or other taxes	Energy production payment	Public investment, loans, or grants
Bahrain												○
Kuwait							○					
Oman												
Qatar												
Saudi Arabia												
UAE		•	▪*		•		▪*				•	•
Israel	○	○	○		○		○	○	○	○		○
Jordan	○		○	○	○		▪			R		○
Lebanon			○							○		○
Palestine												
Syria	○		○				○		○			
Iran	○								○		○	○
Iraq							▪					
Yemen												
Algeria	○						○	○			▪	○
Egypt	R		○				○	○		○		
Libya										○		
Morocco			○				▪					○
Tunisia			○					○		○		○

○ EXISTING NATIONAL (could also include subnational), • EXISTING SUB-NATIONAL (but no national), ▪ NEW (one or more policies of this type), R REVISED (one or more policies of this type), ▪ * NEW SUB-NATIONAL

5.5.2. Nuclear energy

Renewable energy is not the only clean energy source being considered in MENA. Nuclear energy has been a topic of numerous studies (Ahmad and Ramana, 2014; George, 2012; Jewell, 2011; Marktanner and Salman, 2011; Ramana and Ahmad, 2016; Rogner and Eldin, 2013; Supersberger and Führer, 2011) and the UAE has taken a leading role with 5.6 GW under construction and the first of four planned reactors scheduled to come online in 2017. According to the World Nuclear Association, many MENA countries have expressed nuclear intentions, including the UAE, Saudi Arabia, Qatar, Kuwait, Yemen, Israel, Syria, Jordan, Egypt, Tunisia, Libya, Algeria and Morocco (World Nuclear Association, 2016). However, Kuwait, Oman and Qatar are no longer pursuing nuclear power following the Fukushima Daiichi Nuclear Power Station accident in Japan in 2011 and there is a degree of public opposition to nuclear in certain MENA countries, such as Jordan, that maintain their nuclear ambitions (Nakhle, 2016).

As shown in Table 5, only Iran currently has operational nuclear capacity in the region but the UAE will soon follow. Although Saudi Arabia had developed the region's most ambitious nuclear plan, planning for 16 nuclear reactors to begin coming online by 2022 and providing a total capacity of more than 18 GW by 2032 (Nakhle, 2016), the Saudi Vision 2030 now suggests that 3 GW of nuclear capacity will be developed in the country by 2030 (APICORP Energy Research, 2016b). Jordan has signed an agreement with Russia's state nuclear corporation, Rosatom, to build a 2 GW nuclear power plant in Jordan by 2023 and Egypt has likewise signed a deal with Rosatom to build four reactors of 1.2 GW capacity each for delivery between 2024 and 2028 (Nakhle, 2016). Morocco, Tunisia, and Algeria are continuing to express interest in nuclear energy with Algeria running two research reactors for over two decades now. Again it is Rosatom that has agreed to construct a 1 GW reaction in Algeria by 2030 and that has signed a memorandum of understanding with Tunisia for the establishment of nuclear capabilities (APICORP Energy Research, 2016b).

Regardless of national ambitions, nuclear energy in the MENA region faces numerous challenges (Jewell, 2011), including high upfront capital costs that often increase over time when construction delays occur (Ahmad and Ramana, 2014), incompatibility of large nuclear reactors with small national electricity grids[9] (Ramana and Ahmad, 2016) and, perhaps most importantly, a geopolitical environment that puts nuclear plants at risk of terrorist attacks and creates suspicion that civilian nuclear programs will have a military purpose as well. The Iranian nuclear program is a very clear example of this latter issue (Sukin, 2015). The potentially positive aspects of nuclear energy in MENA countries are the provision of low-carbon baseload electricity supply to meet rapidly growing power and water demand, good alignment with state-planned electricity systems (Khatib and Difiglio, 2016) and, in selected cases, access to necessary government financing. Less obvious but nonetheless relevant considerations for nuclear power in the MENA region are the potential for strengthened state control and security when nuclear power plants are deployed, as well as the creation of stronger allegiances with countries that have nuclear technology transfer capabilities (Krane et al., 2016). Although the UAE's nuclear program has been developed with South Korean technology and has additional political support from the United States, Japan, Britain and France (Krane et al., 2016), the infiltration of Russia into regional nuclear programs makes the geopolitical dimension of nuclear power an important consideration.

5.5.3. Coal

No MENA country has significant coal reserves and so coal has played a limited role in the MENA energy system with the exceptions of Morocco (IEA, 2014) and Israel (Shaffer, 2011). In Israel, coal currently accounts for 48% of power generation but this is expected to fall as the country increases its reliance on domestically produced natural gas. Morocco relies on coal for approximately 32% of power generation capacity (MEED Insight, 2015).

Subcritical coal-fired power generation represents approximately 80% of global coal-fired capacity and is characterized as low efficiency (approximately 25–37% (Enerdata, 2013)) and highly polluting (IRENA, 2015d). Hence, coal-fired power generation in its most widely

[9] Power system planners generally recommend that the capacity of any single power plant should not be larger than 10% of the grid's total capacity to avoid major system problems in the case of reactor shut down.

Table 5
Current and planned nuclear power plants in the MENA region.

Country	Site	Capacity (GW)	Units	Cost (US $B)	Status
Iran	Bushehr-1	1	1	3.5	Start-up in 2011 with intermittent operation until 2013
	Bushehr-2,3	2	2	11	Russia's Rosatom to build for start-up in 2023 and 2025
UAE	Barakah	5.6	4	20	Under construction by Korea's Kepco with plants to come online annually between 2017 and 2020
Egypt	Dabaa	4.8	4	29.4	Egypt has agreed to a US $25bn Russian loan for Rosatom construction and delivery between 2024 and 28
Jordan	Qusayr Amra	2	2	10	Rosatom seeking to build for startup in 2024 and 2026

adopted form is one of the least favored choices for new power capacity when resource efficiency and environmental matters are factored. However, international coal prices fell approximately 80% between 2008 and 2015, thus reviving interest in coal for power generation particularly where policy frameworks are not in place to price in the health and environmental externalities of coal-fired power generation (Corbeau et al., 2016). Consistent with this trend, MENA countries other than Morocco and Israel are now exploring coal-based power generation. Egypt plans to deploy 12.5 GW of coal-fired generation into its energy mix by 2022 (MEED Insight, 2015) and Jordan is planning for 5% of its power to be generated by coal by 2025. In the GCC, Dubai (UAE) is investing in 2.4 GW of coal-fired generation that will start to come online by 2020 (MEES, 2016c) and coal is increasingly used in the UAE's cement plants, replacing gas (Matar et al., 2015a). The use of coal for power generation in Saudi Arabia has been modeled and was found to be economically viable in the Kingdom's overall future energy mix if coal prices remain near current levels out to 2030 and sufficient increases in competing gas and oil prices occur (Matar et al., 2015a). To date, however, Saudi Arabia has made no commitments to coal.

Dubai has positioned its coal-fired generation as "clean coal" that uses supercritical boilers and steam generators (37–45% plant efficiency (IEA, 2015b)) as well as flue gas desulfurization to comply with stringent emissions standards (MEES, 2016c). Although Dubai has secured its clean coal capacity at a very low PPA of US $0.045 per kWh over 25 years, such pricing is not likely to be possible in MENA countries where financing is more expensive. Similar to recent solar PV PPAs in Dubai, highly favorable circumstances are present in the UAE that will not easily be replicated in a country like Egypt. Hence, "clean coal" may have limited viability in the region with many countries potentially adopting highly polluting but less expensive subcritical generation technologies.

5.5.4. LNG

The challenges faced by many MENA countries in developing their domestic natural gas reserves is moving the region toward becoming one of the world's most attractive LNG markets. Although the MENA region accounted for just 1% of global LNG demand in 2013, this figure will rise to roughly 6.5% of global demand by 2017 (APICORP Energy Research, 2016e). While not surprising that net-oil importing countries such as Egypt, Jordan, Lebanon and Morocco are moving toward LNG imports, LNG import has also become central to the energy strategies of several regional net-oil exporting countries, including the UAE, Kuwait and Bahrain (APICORP Energy Research, 2016e). Saudi Arabia is also considering LNG import while working toward better exploitation of domestic reserves (MEES, 2016g). The substantial fall in global LNG prices in recent years and an LNG supply excess at least until 2020 makes it strategically attractive for MENA countries to meet their near-term energy demands via LNG imports.

5.6. Regional energy trade

5.6.1. Natural gas trade

Natural gas trade within MENA has been very limited and Qatar has been the dominant player regarding exports from the region and to neighboring countries. In 2015, Qatar exported 106 bcm as LNG primarily to Asia Pacific countries and approximately 20.1 bcm as piped gas to UAE and Oman via the Dolphin pipeline (BP, 2016). All the remaining gas exports from MENA countries were through pipelines (about 25 bcm from Algeria, 6.5 bcm from Libya and 8.4 bcm from Iran) and LNG (approximately 20 bcm from UAE, Oman, and Yemen) were to markets outside MENA. Pipeline and LNG gas trade within MENA represented only 12% of total MENA gas exports in 2011 (Darbouche, 2013b) and this is little changed in recent years. Within the region, the Arab Gas Pipeline connects Egypt with Jordan, Syria and Lebanon (with a separate branch to Israel) but is of little value while Egypt lacks gas to export and the pipeline has repeatedly suffered sabotage in Sinai. The Dolphin pipeline connects Qatar with the UAE and Oman and has capacity for 33 bcm per year, of which approximately 20 bcm is utilized to supply the UAE and Oman. Trans-continental gas deliveries are via the Trans-Med pipeline linking Algeria to Tunisia and ultimately Italy, the GME pipeline that links Algeria to Morocco and ultimately Spain (Crown Prince Court and UAE Ministry of Foreign Affairs, 2014; Darbouche, 2013b), and Iranian pipelines to Turkey with small volumes to Azerbaijan and Armenia. Iran is also unique in importing pipeline gas from outside MENA, from Turkmenistan (Crown Prince Court and UAE Ministry of Foreign Affairs, 2014).

Although greater intra-regional pipeline gas trade is a worthy concept, the incentive for making necessary investments is limited and any plans by Iran and Qatar to export to neighboring countries have been stymied by political disputes, as well as by unattractive regulated gas prices.

Instead, MENA countries are moving to import low cost LNG via floating storage and regasification units (FSRUs) that are a relatively quick, flexible solution for exploiting current and foreseen very low LNG pricing (APICORP Energy Research, 2016e). Iran is, however, actively seeking to exploit its abundant gas reserves via regional pipelines given the challenges faced in the economics of LNG export. Engineering and design work is presently underway to establish a subsea pipeline between Iran and Oman that will have capacity to supply Oman with 1 billion cubic feet per day (Bcf/d) by 2017 (Ibrahim, 2016). The pipeline would help Oman address its growing gas supply deficit while providing Iran with supply credibility that could open up further opportunities for pipeline gas exports to Kuwait and the UAE, as well as elsewhere in the region, should the political dimensions of such activity prove viable (Ibrahim, 2016).

5.6.2. Electricity interconnections

The integration of regional electricity markets for the purposes of increased electricity system efficiency and enhanced welfare has been a key part of European energy policy (Glachant and Ruester, 2014) and has great importance to regional energy systems around the world (Boffa and Sapio, 2015; Oseni and Pollitt, 2016). However, the MENA region presently has one of the world's lowest levels of traded electricity production despite estimates that investment costs to meet the growing electricity demand could be reduced by up to 35% with a fully integrated MENA electricity grid (Devarajan, 2016). In North Africa, integration of energy markets with Europe has been a topic of discussion with many modeling studies developed to assess the opportunity. Similarly, the integration of GCC electricity markets via the GCC grid continues to be a live discussion.

5.6.3. Inter-regional electricity market integration between North Africa and Europe

The interconnection of energy markets to exploit comparative advantage and enhance energy system security and reliability has been widely considered within the MENA context as well as for other regions of the world (Van de Graaf and Sovacool, 2014). Of particular interest has been connection between the MENA region and Europe via a "supergrid" powered by renewable energy sources. This supergrid concept involves using High Voltage Direct Current (HVDC) grids to transport renewable electricity across geographic regions, thus maximizing the utilization of renewable energy resources from regions such as North Africa that have the best renewable energy resource potential (Elliott, 2013). Such exchange of renewable electricity between North Africa and Europe is particularly attractive given the importance placed on renewable energy by the member states of the European Union (EU). The EU envisages a renewable energy share of 20% in final energy consumption by 2020 and this share can be at least partially achieved by imports of electricity generated from renewable energy sources in non-EU countries (Karakosta et al., 2013). As such, several national regulatory authorities and international private or governmental initiatives have conducted feasibility studies and cost benefit analyses for the idea, including the Desertec Foundation, MEDGRID, EUROMED and the Fraunhofer Institute for Solar Energy Systems (Fragkos et al., 2013; Platzer et al., 2016).

The Desertec Industrial Initiative (DII)[10] is perhaps of the best known scheme for massive integration of inter-regional electricity systems. DII was announced by a consortium of German investors in July 2009 with the target of making EUR 440 billion of investments in renewable power in North Africa mainly for export to Europe. DII's target was to meet as much as 15–20% of Europe's electricity needs by 2050 through North African electricity exports (Komendantova et al., 2012; Van de Graaf and Sovacool, 2014). While studies conducted on such an electricity trading scheme generally indicate techno-economic feasibility (Boie et al., 2016; Fragkos et al., 2013; Platzer et al., 2016), numerous factors have continued to hinder progress. These factors include energy subsidy differences across borders, administrative barriers, the lack of availability of local value chains and difficult conditions for renewable energy project financing. A fundamental question then is whether an initiative such as DII is at all feasible given the MENA region's current social, economic and political conditions. Van de Graaf and Sovacool have described five dimensions of possible failure for energy mega projects such as Desertec initiative – social, technical, economic, political and psychological – and considered each dimension with the Desertec context (Van de Graaf and Sovacool, 2014). Their work shows that the sheer size of the project has led to intractable stakeholder fragmentation within MENA and Europe and this fragmentation is further hindered by the technical challenges from required grid connections and lack of access to technology financing given the unstable social, economic and political context of North Africa. On the latter point, investors in North African countries have particular concern about regulatory, political and force majeure events[11] (Komendantova et al., 2012), consistent with the fact that other than Morocco, all North African countries are considered Fragile states (see Fig. 3). The non-technical risks in North Africa are therefore very real and likely to create an indefinite delay in the realization of electricity market megaprojects such as Desertec. Indeed, the most stable country in North Africa, Morocco, has now developed the strongest frameworks in MENA for renewable energy (RCREEE, 2015b) but outside of Desertec.

[10] DII was inspired by the Desertec concept to harness solar and wind energy in the deserts of North Africa, a concept developed by the German Trans-Mediterranean Renewable Energy Cooperation (TREC) of the Club of Rome.

[11] Particularly terrorist attacks in the North African context.

5.6.4. GCC grid

Integration of electricity markets within the GCC is becoming increasingly important as regional demand for electricity grows. The GCC countries have an estimated 148 GW of installed power generation capacity representing nearly 50% of total MENA power-generating capacity (APICORP Energy Research, 2016d). It is further estimated that the region will require investment in generation, transmission and distribution infrastructure totaling more than US $130 billion over the next 5 years to meet new demand. Although efforts in demand management may ultimately lessen this requirement, it is far from optimal for each GCC country to build new capacity with no consideration of electricity trade. In May 2001, the GCC Interconnection Authority (GCCIA) was formally established with the explicit intention of supporting electricity trade among all GCC member states. The evolution of the GCCIA, covered in detail in other work (El-Katiri, 2012), indicates that the GCC grid was created initially with the intention of emergency power trade rather than as the basis for an electricity trading market. Now, however, electricity trading is a GCCIA ambition with recent work showing that a GCC electricity market could create US $23.57 billion in economic benefits by 2038 via reduction in fuel, operation and maintenance costs (KAPSARC, 2016) and provide additional savings of US $5.66 billion in power generation capacity over the same timeframe along with abatement of 190–225 million tons of regional carbon dioxide emissions (Al-Shahrani, 2016). Further benefits of integration would be shared access to large-scale nuclear power generation within the region and a better ability to integrate growing shares of intermittent renewable energy sources. Importantly as well, the GCC grid can be expanded beyond the GCC to include Jordan and ultimately the North African grid, enabling a MENA-wide system of electricity trade. Jordan has in fact signed a memorandum of understanding in 2016 with the GCCIA to connect with the GCC grid via Saudi Arabia as early as 2018 and Saudi Arabia has indicated plans to connect to Egypt by 2019. Oman additionally is prioritizing the establishment of an electricity spot market with clear plans for electricity trading through the GCC grid in the near future (MEES, 2016f). The moves of both Jordan and Oman are signs that MENA energy cooperation is an urgent matter that will necessarily factor into regional energy strategies and policies moving forward. Challenges for GCC electricity trade that need to be addressed, however, include energy price distortion due to different levels of energy subsidies across GCC countries, differences in local regulations towards cross border power trading and differences in national power sector structures (Al-Ebrahim, 2016). As a positive indication, however, GCC countries are undertaking energy subsidy reforms and do possess the commitment to free trade and adequate transmission capacity that are pre-requisites for electricity market integration (Oseni and Pollitt, 2016).

6. Conclusions and policy implications

Although the MENA region will continue to be a major oil and gas producer, consumer and exporter for years to come, a global transition to new sources of energy supply is underway and this will continue to impact all MENA countries. Specifically, the increasing adoption of alternative energy internationally as well as greater focus on the decoupling of economic growth from energy consumption will have a lasting impact on export revenues for net-oil exporting countries. Rapidly increasing regional energy demand coupled with increasingly limited low-cost oil and gas supply in some MENA countries, and the global shift towards low-carbon energy, necessitate an energy system transition across the region. This transition must place emphasis on regional energy cooperation, demand management and sustainable energy supply. History tells us, however, that such transitions pose great challenges for energy policy design (Jefferson, 2014). The challenge is all the greater given social and political turmoil prevalent in the region. Countries such as Syria, Iraq, Libya and Yemen will not be able to progress their energy systems while they are in the midst of civil wars. Likewise, MENA countries directly impacted by turmoil in neighboring countries will continue to face spillover impacts that hinder the realization of their energy system potentials.

Assessment of the current MENA region context suggests that driving forces for the evolution of energy policy are energy security and energy cost minimization. Although arguments have been made that job creation should be a driving force for regional clean energy and renewables in particular (IRENA, 2016d; Sooriyaarachchi et al., 2015; van der Zwaan et al., 2013), the arguments are not compelling for the majority of MENA countries. MENA clean energy targets to date have generally lacked sufficient substance and stability to assume that the clean energy sector will be central to regional economic diversification and employment strategies. Likewise, the INDCs submitted by MENA countries so far suggests that energy policy with not be strongly coupled to climate policy. Greenhouse gas and other climate matters will of course benefit from energy demand management measures and deployment of clean energy technologies. The means by which the energy system transitions take place in the region are, however, unlikely to be policies directly targeting carbon emissions.

Regional energy security and energy cost minimization will ideally be met through policy evolution that emphasizes demand management through continued efforts on energy subsidy reforms and energy efficiency in all sectors. Critically, however, political announcements and visions regarding clean energy must be translated into strategies and action plans that lead to the design and implementation of tailored policies and regulations. Each MENA country should in fact aim to develop a National Renewable Energy Action Plan that follows best practices for the creation of such plans. Furthermore, energy strategies must be integrated with water strategies given the very strong link between these sectors in the MENA region.

With regard to specific and near-term energy policy actions, continued subsidy reform and progress toward the ultimate elimination of subsidies is particularly pressing because these measures relate to all end-use sectors and impact fiscal stability in many countries. However, the expectations from currently implemented subsidy reform initiatives must be realistic in order to guide further policy developments on energy demand management. Even though subsidy reforms are now occurring in the GCC where energy demand growth is most significant, energy prices in the GCC remain low even after reform efforts and this is a key reason for evidence of inelastic energy demand (Algunaibet and Matar, 2016; Atalla and Hunt, 2016). Therefore, subsidy reform measures, while important, need to be considered as complementary to policies aimed at energy efficiency in sectors where price signals may not be sufficient to mitigate energy demand growth. In the buildings sector, MEPS for appliances that are tailored to regional environmental conditions, particularly air conditioners, are critical for the GCC countries. Stringent and enforced building standards and codes, integrated with regionally tailored urban planning, are a priority across the entire MENA region. Energy efficiency in the industrial sector is a key issue for regional policy makers since clean energy supply for industry is challenging given the lack of regional hydro and bioenergy resources. Further, the extremely energy intensive industries in the GCC, such as aluminum smelting, already have captive fossil-based power generation that will not be replaced anytime soon. Energy efficiency and modal alternatives in the transport sector also require regional attention given the lack of commercially viable clean energy options for transportation in the MENA region.

Although renewable energy is a central topic of energy system diversification globally, there is significant interest regionally in nuclear energy and coal to complement greater use of natural gas in the power sector. Renewable energy and coal capacity can be realized through well implemented auctions that establish large-scale energy generation at lowest cost. Auctions are becoming a favored approach globally for renewable energy and electricity markets in the MENA region are compatible with this approach. Importantly, however, regional policy makers must place emphasis on auction designs that address the weaknesses of this policy tool, namely high transaction costs associated with administrative procedures and the underbuilding and delays in construction that can result from aggressive bidding that results in auction prices are that too low for project viability and/or disincentivizes project developers from participating in regional auctions due to unrealistic price ceilings. Furthermore, it is unlikely that the majority of coal capacity developed in the region will be “clean” and so the long-term environmental ramifications must be considered.

Nuclear energy requires substantial financial investment and places a great burden on the human resources and institutional structures necessary to ensure that adequate safety and security measures are in place. The UAE has set the standard regionally for nuclear power but, although Jordan has established the necessary regulatory authority in 2014, it is unclear that other countries in the region can be as successful. The commitment by the UAE to establish the required regulatory structures and safeguards against non-civil uses of nuclear technology will be challenging in other countries where the political and economic context is less stable. The debate over nuclear energy as part of national energy policies in the MENA region is sure to continue, with considerable geopolitical consequences now that Russia has become deeply involved.

As a final policy consideration, regional energy cooperation is essential but must be approached in a thoughtful and realistic manner. Iran has strong interest in regional pipeline trade of natural gas although there may be limited political viability of Iran playing a key role in regional energy supply, particularly when alternatives for natural gas exist via low-cost LNG imports. Regarding electricity trade, energy megaprojects such as Desertec seem far too ambitious given the current socioeconomic and geopolitical context of the region. However, electricity market integration in the GCC may be viable within the next several years if GCC countries maintain their current focus on least-cost energy system development and make further strides in electricity price normalization. As the GCC electricity market makes progress, further connections to North Africa may eventually be possible. However, a truly integrated electricity market across the MENA is hard to foresee in the near future.

In sum, evolution and transition of the MENA energy system will be challenging but will progress out of necessity. Advances for now will mainly be based on transactional exploitation of easier opportunities, including on a bilateral basis when relations are good. Wider success will be realized by policymakers becoming increasingly aware of the integrated set of challenges and opportunities they face and then implementing a cohesive set of strategies, action plans and policies aimed at not just evolving the regional energy system, but developing the energy, political and social systems that collectively define the energy system possibilities. This, in turn, opens up a rich set of research concerns for the energy policy community.

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References

Abdmouleh, Z., Alammari, R.A.M., Gastli, A., 2015. Recommendations on renewable energy policies for the GCC countries. Renew. Sustain. Energy Rev. 50, 1181–1191.
Åberg, E., Myrsalieva, N., Emtairah, T., 2016. Power Mark. Struct. Renew. Energy Deploy. Exp. MENA Reg., 199–215.
Abulof, U., 2015. Can't buy me legitimacy: the elusive stability of Mideast rentier regimes. J. Int. Relat. Dev..
AFED, 2015. Arab Environment: Sustainable Consumption. Annual Report of Arab Forum for Environment and Development, 2015. Technical Publications, Beirut, Lebanon.
Afshari, A., Friedrich, L., 2016. A proposal to introduce tradable energy savings certificates in the emirate of Abu Dhabi. Renew. Sustain. Energy Rev. 55, 1342–1351.

Aguilar, L.A., Mayer, J., Ghafouri, M.H., Khosroshahi, N., Grundner, C., Vasaf, E., Haid, S., Mahdavi, S., Mahmoudi, A., Jafarkazemi, D.F., 2016. Enabling PV Iran: The Emerging PV Market in Iran German Solar Association – BSW-Solar / Bundesverband Solarwirtschaft e.V., Berlin,.

Ahmad, A., Ramana, M.V., 2014. Too costly to matter: economics of nuclear power for Saudi Arabia. Energy 69, 682–694.

Al-Amir, J., Abu-Hijleh, B., 2013. Strategies and policies from promoting the use of renewable energy resource in the UAE. Renew. Sustain. Energy Rev. 26, 660–667.

Al-Ebrahim, A., 2016. GCC Interconnection: Opportunities and Challenges Working towards an Electricity Trade Price, ReformingEnergy Prices in GCC Countries: Opportunities and Challenges, Riyadh, Saudi Arabia.

Al-Shahrani, N., 2016. Current status in the GCC: electricity interconnections and regional market integration prospects and potential for collaboration, EU-GCC Clean EnergyNetwork II: Working Groups Consultation Workshop, Dubai, UAE.

Algunaibet, I.M., Matar, W., 2016. The Responsiveness of Fuel Demand to Gasoline Price in Passenger Transport: A Case Study of Saudi Arabia. The King Abdullah Petroleum Studies and Research Center (KAPSARC), Riyadh, Saudi Arabia.

Alnaser, W.E., Alnaser, N.W., 2011. The status of renewable energy in the GCC countries. Renew. Sustain. Energy Rev. 15 (6), 3074–3098.

Ansari, D., 2016. Resource curse contagion in the case of Yemen. Resour. Policy 49, 444–454.

Apergis, N., Payne, J.E., 2014. The oil curse, institutional quality, and growth in MENA countries: Evidence from time-varying cointegration. Energy Econ. 46, 1–9.

APICORP Energy Research, 2015. MENA power investment: set to keep fast growth despite a lull in other energy sectors. APICORP Res. Econ. Comment. 10, 4.

APICORP Energy Research, 2016a. Energy price reform in the GCC: long road ahead. APICORP Res. Econ. Comment. 1, 4.

APICORP Energy Research, 2016b. Fiscal restraints to keep MENA nuclear power on side lines. APICORP Res. Econ. Comment. 1, 8.

APICORP Energy Research, 2016c. MENA energy investment outlook? Big plans in uncertain times. APICORP Res. Econ. Comment. 1, 6.

APICORP Energy Research, 2016d. MENA power investment: finance and reform challenges. APICORP Res. Econ. Comment. 1, 7.

APICORP Energy Research, 2016e. MENA: LNG's top growth target. APICORP Res. Econ. Comment. 1, 9.

APICORP Energy Research, 2016f. Renewables in the Arab world: a new phase. APICORP Res. Econ. Comment. 1, 5.

Asif, M., 2016. Growth and sustainability trends in the buildings sector in the GCC region with particular reference to the KSA and UAE. Renew. Sustain. Energy Rev. 55, 1267–1273.

Atalay, Y., Biermann, F., Kalfagianni, A., 2016. Adoption of renewable energy technologies in oil-rich countries: explaining policy variation in the Gulf Cooperation Council states. Renew. Energy 85, 206–214.

Atalla, T.N., Hunt, L.C., 2016. Modelling residential electricity demand in the GCC countries. Energy Econ..

Beblawi, H., Luciani, G., 1987. The Rentier State. Croom Helm.

Benes, K., Cheon, A., Urpelainen, J., Yang, J., 2015. Low Oil Prices: An Opportunity for Fuel Subsidy ReformColumbia School of International and Public Affairs.

Bhutto, A.W., Bazmi, A.A., Zahedi, G., Klemeš, J.J., 2014. A review of progress in renewable energy implementation in the Gulf Cooperation Council countries. J. Clean. Prod. 71, 168–180.

Boersma, T., Griffiths, S., 2016. Reforming Energy Subsidies: Initial Lessons from the United Arab Emirates. The Brookings Institution and The Masdar Institute of Science and Technology.

Boffa, F., Sapio, A., 2015. Introduction to the special issue "The regional integration of energy markets". Energy Policy 85, 421–425.

Boie, I., Kost, C., Bohn, S., Agsten, M., Bretschneider, P., Snigovyi, O., Pudlik, M., Ragwitz, M., Schlegl, T., Westermann, D., 2016. Opportunities and challenges of high renewable energy deployment and electricity exchange for North Africa and Europe – Scenarios for power sector and transmission infrastructure in 2030 and 2050. Renew. Energy 87, 130–144.

Boubaker, K., 2012. Renewable energy in upper North Africa: Present versus 2025-horizon perspectives optimization using a Data Envelopment Analysis (DEA) framework. Renewable Energy.**43**, 364-369.

BP, 2016. BP Statistical Review of World Energy June 2016, 65th Edition.

Brand, B., 2016. Chapter 5 - The Renewable Energy Targets of the MENA Countries: Objectives, Achievability, and Relevance for the Mediterranean Energy Collaboration. In: Campi, M.T.C., Lenzi, V., Ozturk, I. (Eds.), Regulation and Investments in Energy Markets. Academic Press, 89–100.

Brecha, R.J., 2012. Logistic curves, extraction costs and effective peak oil. Energy Policy 51, 586–597.

Carafa, L., Frisari, G., Vidican, G., 2015. Electricity transition in the Middle East and North Africa: a de-risking governance approach. J. Clean. Prod..

Carafa, L., Frisari, G., Vidican, G., 2016. Electricity transition in the Middle East and North Africa: a de-risking governance approach. J. Clean. Prod. 128, 34–47.

Chapman, I., 2014. The end of peak oil? Why this topic is still relevant despite recent denials. Energy Policy 64, 93–101.

Chase, J., 2016. Abu Dhabi sets new solar record of $24.2/MWh - or does it? Bloomberg New. Energy Financ..

Chatham House, 2016. The Social Contract in the GCC.

Corbeau, A.-S., Shabaneh, R., Six, S., 2016. The Impact of Low Oil and Gas Prices on Gas Markets: A Retrospective Look at 2014-15. The King Abdullah Petroleum Studies and Research Center (KAPSARC), Riyadh, Saudi Arabia.

Costa, S.C.S., Diniz, A.S.A.C., Kazmerski, L.L., 2016. Dust and soiling issues and impacts relating to solar energy systems: literature review update for 2012–2015. Renew. Sustain. Energy Rev. 63, 33–61.

Crown Prince Court, UAE Ministry of Foreign Affairs, 2014. Natural Gas: An Assessment of Global Trends and UAE Development, United Arab Emirates.

Dagnet, Y., Waskow, D., Elliott, C., Northrop, E., Thwaites, J., Mogelgaard, K., Krnjaic, M., Levin, K., Mcgray, H., 2016. Staying On Track From Paris: Advancing The Key Elements Of The Paris Agreement. World Resources Institute.

Darbouche, H., 2013a. MENA's growing natural gas deficit and the issue of domestic prices. Energy Strategy Rev. 2 (1), 116–121.

Darbouche, H., 2013b. Natural Gas and Arab Energy Transition. In: Gelil, I.A., El-Ashrey, M., Saab, N. (Eds.), Arab Environment: Sustainable Energy. Annual Report of Arab Forum for Environment and Development, 2013. Technical Publications, Beirut, Lebanon.

del Río, P., Linares, P., 2014. Back to the future? Rethinking auctions for renewable electricity support. Renew. Sustain. Energy Rev. 35, 42–56.

Delucchi, M.A., Jacobson, M.Z., 2011. Providing all global energy with wind, water, and solar power, Part II: reliability, system and transmission costs, and policies. Energy Policy 39 (3), 1170–1190.

Devarajan, S., 2016. An exposition of the new strategy, promoting peace and stability in the Middle East and North Africa. World Bank Group, Washington, D.C.

Devarajan, S., Mottaghi, L., Do, Q.-T., Jelil, M.A., 2016. Syria: reconstruction for peace, Middle East and North Africa (MENA) Economic Monitor. World Bank Group, Washington, D.C..

EIA, 2013. Overview of oil and natural gas in the eastern Mediterranean region. U.S. Energy Inf. Adm. (EIA).

El-Katiri, L., 2012. Opportunities and Challenges of GCC Electricity Market Cooperation. Oxford Institute for Energy Studies.

El-Katiri, L., Fattouh, B., 2015. A Brief Political Economy of Energy Subsidies in the Middle East and North Africa. Oxford Institute for Energy Studies.

Elliott, D., 2013. Emergence of European supergrids – Essay on strategy issues. Energy Strategy Rev. 1 (3), 171–173.

Emtairah, T., Chaaban, F., 2013. Energy Efficiency. In: Gelil, I.A., El-Ashrey, M., Saab, N. (Eds.), Arab Environment: Sustainable Energy. Annual Report of Arab Forum for Environment and Development, 2013. Technical Publications, Beirut, Lebanon.

Enerdata, 2013. The state of global energy efficiency Global and sectorial energy efficiency trends. ABB Ltd.

Europe, S., 2016. Global Market Outlook for Solar Power: 2016-2020.

Fattouh, B., 2016. Adjustment in the Oil Market: structural, Cyclical or Both?. Oxford Institute for Energy Studies.

Fattouh, B., El-Katiri, L., 2013. Energy subsidies in the Middle East and North Africa. Energy Strategy Rev. 2 (1), 108–115.

Fattouh, B., Sen, A., Moerenhout, T., 2016. Striking the Right Balance? GCC Energy Pricing Reforms in a Low Price Environment. Oxford Institute for Energy Studies.

Fragkos, P., Kouvaritakis, N., Capros, P., 2013. Model-based analysis of the future strategies for the MENA energy system. Energy Strategy Rev. 2 (1), 59–70.

Frankfurt School - UNEP Collaborating Centre, BNEF, 2016. Global Trends in Renewable Energy Investment 2016. Frankfurt School of Finance & Management, Frankfurt.

Friedrichs, J., Inderwildi, O.R., 2013. The carbon curse: are fuel rich countries doomed to high CO_2 intensities? Energy Policy 62, 1356–1365.

George, R., 2012. Why are the GCC states turning to Nuclear Power?, ORF Issue Brief. Observer Research Foundation.

Ghaffour, N., Bundschuh, J., Mahmoudi, H., Goosen, M.F.A., 2015. Renewable energy-driven desalination technologies: a comprehensive review on challenges and potential applications of integrated systems. Desalination 356, 94–114.

Gherboudj, I., Ghedira, H., 2016. Assessment of solar energy potential over the United Arab Emirates using remote sensing and weather forecast data. Renew. Sustain. Energy Rev. 55, 1210–1224.

Glachant, J.-M., Ruester, S., 2014. The EU internal electricity market: done forever? Uti. Policy 31, 221–228.

Griffiths, S., Mills, R., 2016. Potential of rooftop solar photovoltaics in the energy system evolution of the United Arab Emirates. Energy Strategy Rev. 9, 1–7.

Griffiths, S., Weijermars, R., 2013. Introduction to Energy Strategy Reviews theme issue "Strategy options and models for the Middle East and North Africa (MENA) energy transition". Energy Strategy Rev. 2 (1), 1–4.

Gulf Labour Markets and Migration (GLMM), 2013. GCC: Total population and percentage of nationals and non-nationals in GCC countries (latest national statistics, 2010-2015), ⟨http://gulfmigration.eu/total-population-and-percentage-of-nationals-and-non-nationals-in-gcc-countries-latest-national-statistics-2010–2015/⟩

Hadjipanayi, M., Koumparou, I., Philippou, N., Paraskeva, V., Phinikarides, A., Makrides, G., Efthymiou, V., Georghiou, G.E., 2016. Prospects of photovoltaics in southern European, Mediterranean and Middle East regions. Renew. Energy 92, 58–74.

Hawila, D., Mondal, M.A.H., Kennedy, S., Mezher, T., 2014. Renewable energy readiness assessment for North African countries. Renew. Sustain. Energy Rev. 33, 128–140.

Hirth, L., 2013. The market value of variable renewables, the effect of solar and wind power variability on their relative price. Energy Econ. 38, 218–236.

Hoppe, T., Coenen, F., van den Berg, M., 2016. Illustrating the use of concepts from the discipline of policy studies in energy research: an explorative literature review. Energy Res. Soc. Sci. 21, 12–32.

Ibrahim, R., 2016. Middle East the emerging new LNG player – as a consumer, Qamar Energy Newsletter. Qamar Energy, 6–7.

IEA-RETD, 2016. RE TRANSITION – Transitioning to Policy Frameworks for Cost-Competitive Renewables, In: Jacobs et al. IET – International Energy Transition GmbH(Ed.). IEA Technology Collaboration Programme for Renewable Energy Technology Deployment (IEA-RETD), Utrecht.

IEA, 2014. Morocco 2014, Energy Policies Beyond IEA countries. OECD/IEA (Int. Energy Agency), (Paris).

IEA, 2015a. Energy balances of non-OECD countries 2015. OECD/IEA.
IEA, 2015b. Energy technology perspectives 2015. OECD/IEA (Int. Energy Agency), (Paris).
IHA, 2015. 2016 Hydropower Status Report. International Hydropower Association Limited (IHA), London.
IMF, 2016a. Algeria: selected IssuesInternational Monetary Fund (IMF).
IMF, 2016b. Economic Diversification in Oil-Exporting Arab Countries, Annual Meeting of Arab Ministers of Finance. International Monetary Fund (IMF).
IRENA, 2013. Renewable Energy Auctions in Developing Countries. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2014. Sultanate of Oman: Renewables Readiness Assessment. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2015a. Africa 2030: Roadmap for a Renewable Energy Future. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2015b. Renewable Energy Target Setting. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2015c. Renewable Power Generation Costs in 2014. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2015d. REthinking Energy: Renewable Energy and Climate Change. I. nternational Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2016a. Investment opportunities in the GCC: suitability maps for grid-connected and off-grid solar and wind projects. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2016b. Letting in the Light: how solar PV will revolutionise the electricity system. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2016c. REmap: Roadmap for a Renewable Energy Future, 2016 Edition. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, 2016d. Renewable Energy Market Analysis: the GCC Region. International Renewable Energy Agency (IRENA), Abu Dhabi.
IRENA, League of Arab States, 2014. Pan-Arab Renewable Energy Strategy 2030.
Jablonski, S., Tarhini, M., 2013. Assessment of selected energy efficiency and renewable energy investments in the Mediterranean Partner Countries. Energy Strategy Rev. 2 (1), 71–78.
Jacobson, M.Z., Delucchi, M.A., 2011. Providing all global energy with wind, water, and solar power, Part I: technologies, energy resources, quantities and areas of infrastructure, and materials. Energy Policy 39 (3), 1154–1169.
Jacobson, M.Z., Delucchi, M.A., Bauer, Z.A.F., Goodman, S.C., Chapman, W.E., Cameron, M.A., Bozonnat, C., Chobadi, L., Erwin, J.R., Fobi, S.N., Goldstrom, O.K., Harrison, S.H., Kwasnik, T.M., Lo, J., Liu, J., Yi, C.J., Morris, S.B., Moy, K.R., O'Neill, P.L., Redfern, S., Schucker, R., Sontag, M.A., Wang, J., Weiner, E., Yachanin, A.S., 2016. 100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for 139 Countries of the World, In: University, T.S.P.-S. (Ed.).
Jefferson, M., 2012. Oil & Gas modelling: some "pre-determined" elements and building blocks, Oil and Gas Modelling. Research Centre for Energy Management (RCEM) at ESCP Europe Business School and the Centre of International Business and Sustainability (CIBS) at London Metropolitan Business School (LMBS). Energy Institute, London.
Jefferson, M., 2014. Closing the gap between energy research and modelling, the social sciences and modern realities. Energy Res. Soc. Sci. 4, 42–52.
Jewell, J., 2011. A nuclear-powered North Africa: just a desert mirage or is there something on the horizon? Energy Policy 39 (8), 4445–4457.
KAPSARC, 2016. Opportunities and Challenges in Reforming Energy Prices in Gulf Cooperation Council Countries. The King Abdullah Petroleum Studies and Research Center (KAPSARC), Riyadh, Saudi Arabia.
Karakosta, C., Marinakis, V., Psarras, J., 2013. RES cooperation opportunities between EU and MENA countries: the case of Morocco. Energy Strategy Rev. 2 (1), 92–99.
Karshenas, M., Moghadam, V.M., Alami, R., 2014. Social policy after the Arab spring: States and social Rights in the MENA region. World Dev. 64, 726–739.
Khatib, H., 2014. Oil and natural gas prospects: Middle East and North Africa. Energy Policy 64, 71–77.
Khatib, H., Difiglio, C., 2016. Economics of nuclear and renewables. Energy Policy.
Komabargi, R., Waterlander, O., Sarraf, G., Sastry, A., 2010. Gas Shortage in the GCC: how to Bridge the Gap. Booz & Company.
Komendantova, N., Patt, A., Barras, L., Battaglini, A., 2012. Perception of risks in renewable energy projects: the case of concentrated solar power in North Africa. Energy Policy 40, 103–109.
Krane, J., Hung, S.Y.E., 2016. Energy Subsidy Reform in the Persian Gulf: The End of the Big Oil Giveaway. Rice University's Baker Institute for Public Policy, Houston, Texas.
Krane, J., Jaffe, A.M., Elass, J., 2016. Nuclear energy in the Middle East: Chimera or solution? Bull. At. Sci. 72 (1), 44–51.
Krane, J., Wright, S., 2014. Qatar 'Rises Above' Its Region: Geopolitics and the Rejection of the GCC Gas Market. Kuwait Programme on Development, Governance and Globalisation in the Gulf States.
Lahn, G., 2016. Fuel, Food and Utilities Price Reforms in the GCC: A Wake-up Call for Business. Royal Institute of International Affairs, London.
Lahn, G., Preston, F., 2013. Targets to promote energy savings in the Gulf Cooperation Council states. Energy Strategy Rev. 2 (1), 19–30.
Lahn, G., Stevens, P., Preston, F., 2013. Saving Oil and Gas in the Gulf. Chatham House.
Lazard, 2015. Lazard Lev. Cost. Energy Anal. 9, 0.
Lilliestam, J., Patt, A., 2015. Barriers, Risks and Policies for Renewables in the Gulf States. Energies 8 (8), 8263–8285.
Loutatidou, S., Arafat, H.A., 2015. Techno-economic analysis of MED and RO desalination powered by low-enthalpy geothermal energy. Desalination 365, 277–292.
Luomi, M., 2014. Mainstreaming Climate Policy in the Gulf Cooperation Council States. Oxford Institute for Energy Studies.
Marktanner, M., Salman, L., 2011. Economic and geopolitical dimensions of renewable vs. nuclear energy in North Africa. Energy Policy 39 (8), 4479–4489.
Matar, W., Echeverri, R., Pierru, A., 2015a. The Prospects for Coal-fired Power Generation in Saudi Arabia. The King Abdullah Petroleum Studies and Research Center (KAPSARC), Riyadh, Saudi Arabia.
Matar, W., Murphy, F., Pierru, A., Rioux, B., 2015b. Lowering Saudi Arabia's fuel consumption and energy system costs without increasing end consumer prices. Energy Econ. 49, 558–569.
McGlade, C., Ekins, P., 2015. The geographical distribution of fossil fuels unused when limiting global warming to 2 [deg]C. Nature 517 (7533), 187–190.
McGlade, C., Speirs, J., Sorrell, S., 2013. Unconventional gas – A review of regional and global resource estimates. Energy 55, 571–584.
MEED Insight, 2015. MENA power 2016: Investing in the future. Mena Power Proj. 2016.
MEES, 2016a. Abu Dhabi Looks To Break Dubai's Solar Cost Record. Middle East Econ. Surv. (MEES) 59, 38.
MEES, 2016b. Dubai Adds CSP, Hydro To Renewables Mix; Northern Emirates. Eye Coal. Middle East Econ. Surv. (MEES) 59, 45.
MEES, 2016c. Dubai's Dewa Doubles Coal-Fired Plan. Middle East Econ. Surv. (MEES) 59, 23.
MEES, 2016d. Kuwait Dissolves Parliament Amidst Subsidy Reform Uproar. Middle East Econ. Surv. (MEES) 59, 42.
MEES, 2016e. LNG Supply Glut To Depress Prices For Years To Come. Middle East Econ. Surv. (MEES) 59, 24.
MEES, 2016f. OPWP Pushing Spot Market Development, Eyes GCC electricity trading. Middle East Econ. Surv. (MEES) 59, 18.
MEES, 2016g. Will The 'Golden Age Of Gas' Ever Arrive? Middle East Econ. Surv. (MEES) 59, 24.
Meir, I.A., Peeters, A., Pearlmutter, D., Halasah, S., Garb, Y., Davis, J.-M., 2012. An assessment of regional constraints, needs and trends. Adv. Build. Energy Res. 6 (2), 173–211.
MESIA, 2016. Middle East Solar Outlook for 2016. Middle East Solar Industry Association (MESIA), United Arab Emirates.
Mezher, T., Dawelbait, G., Abbas, Z., 2012. Renewable energy policy options for Abu Dhabi: drivers and barriers. Energy Policy 42, 315–328.
Miller, C.A., Iles, A., Jones, C.F., 2013. The social dimensions of energy transitions. *Science as.* Culture 22 (2), 135–148.
Mondal, M.A.H., Kennedy, S., Mezher, T., 2014. Long-term optimization of United Arab Emirates energy future: policy implications. Appl. Energy 114, 466–474.
Nakhle, C., 2016. Nuclear Energy's Future in the Middle East and North Africa. Carnegie Moscow Center.
Nematollahi, O., Hoghooghi, H., Rasti, M., Sedaghat, A., 2016. Energy demands and renewable energy resources in the Middle East. Renew. Sustain. Energy Rev. 54, 1172–1181.
Oseni, M.O., Pollitt, M.G., 2016. The promotion of regional integration of electricity markets: Lessons for developing countries. Energy Policy 88, 628–638.
Platzer, W., Boie, I., Ragwitz, M., Kost, C., Thoma, J., Vogel, A., Fluri, T., Pfeiffer, W., Burmeister, Frank, Tham, N., Pudlik, M., Bohn, S., Agsten, M., Bretschneider, P., Westermann, D., Kranzer, D., Schlegl, T., 2016. Supergrid – Approach for the integration of renewable energy in Europe and North Africa, Fraunhofer Topics of the Future. Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany.
Ramana, M.V., Ahmad, A., 2016. Wishful thinking and real problems: small modular reactors, planning constraints, and nuclear power in Jordan. Energy Policy 93, 236–245.
RCREEE, 2015a. Arab Future Energy Index 2015: Energy Efficiency. Regional Center for Renewable Energy and Energy Efficiency (RCREEE), Cairo, Egypt.
RCREEE, 2015b. Arab Future Energy Index 2015: Renewable Energy. Regional Center for Renewable Energy and Energy Efficiency (RCREEE), Cairo, Egypt.
Reiche, D., 2010. Energy Policies of Gulf Cooperation Council (GCC) countries—possibilities and limitations of ecological modernization in rentier states. Energy Policy 38 (5), 2395–2403.
REN21, 2016. Global Status Report. REN21 Secretariat, Paris.
REN21, IRENA, the United Arab Emirates, 2013. A, the United Arab Emirates, 2013. MENA Renewables Status Report. REN21 Secretariat, Paris
Rogner, H.-H., Eldin, A.S., 2013. Nuclear Power Option. In: Gelil, I.A., El-Ashrey, M., Saab, N. (Eds.), Arab Environment: Sustainable Energy. Annual Report of Arab Forum for Environment and Development, 2013. Technical Publications, Beirut, Lebanon.
Rougier, E., 2016. "Fire in Cairo": Authoritarian–Redistributive Social Contracts, Structural Change, and the Arab Spring. World Dev. 78, 148–171.
Sachs, J.D., Warner, A.M., 2001. The curse of natural resources. Eur. Econ. Rev. 45 (4–6), 827–838.
Sarver, T., Al-Qaraghuli, A., Kazmerski, L.L., 2013. A comprehensive review of the impact of dust on the use of solar energy: history, investigations, results, literature, and mitigation approaches. Renew. Sustain. Energy Rev. 22, 698–733.
Sdralevich, C., Sab, R., Zouhar, Y., Albertin, G., 2014. Subsidy Reform in the Middle East and North Africa: Recent Challenges and Progress Ahead. International Monetary Fund (IMF), Washington, D.C.
Sgouridis, S., Abdullah, A., Griffiths, S., Saygin, D., Wagner, N., Gielen, D., Reinisch, H., McQueen, D., 2016. RE-mapping the UAE's energy transition: an economy-wide assessment of renewable energy options and their policy implications. Renew. Sustain. Energy Rev. 55, 1166–1180.
Sgouridis, S., Griffiths, S., Kennedy, S., Khalid, A., Zurita, N., 2013. A sustainable energy transition strategy for the United Arab Emirates: evaluation of options using an integrated. Energy Model. Energy Strategy Rev. 2 (1), 8–18.
Shaffer, B., 2011. Israel—New natural gas producer in the Mediterranean. Energy Policy

39 (9), 5379–5387.
Shatat, M., Worall, M., Riffat, S., 2013. Opportunities for solar water desalination worldwide: review. Sustain. Cities Soc. 9, 67–80.
Shell, 2016. A Better Life with a Healthy Planet: Pathways to Net-Zero Emissions Shell's New Lens Scenarios. Shell Int. BV.
Siddig, K., Grethe, H., 2014. No more gas from Egypt? Modeling offshore discoveries and import uncertainty of natural gas in Israel. Appl. Energy 136, 312–324.
Siddiqi, A., Anadon, L.D., 2011. The water–energy nexus in Middle East and North Africa. Energy Policy 39 (8), 4529–4540.
Siddiqi, A., Kajenthira, A., Anadón, L.D., 2013. Bridging decision networks for integrated water and energy planning. Energy Strategy Rev. 2 (1), 46–58.
Snoj, J., 2013. Population of Qatar by nationality. BQ Mag., June 11, 2016 ⟨http://www.bq-magazine.com/economy/2013/12/population-qatar⟩.
Snoj, J., 2015. UAE´s population – by nationality. BQ Mag., June 11, 2016 ⟨http://www.bq-magazine.com/economy/socioeconomics/2015/04/uae-population-by-nationality⟩.
Sooriyaarachchi, T.M., Tsai, I.T., El Khatib, S., Farid, A.M., Mezher, T., 2015. Job creation potentials and skill requirements in, PV, CSP, wind, water-to-energy and energy efficiency value chains. Renew. Sustain. Energy Rev. 52, 653–668.
Stevens, P., Lahn, G., 2011. Burning Oil to Keep Cool: The Hidden Energy Crisis in Saudi Arabia. Chatham House, 49.
Sukin, L., 2015. Beyond Iran: Containing Nuclear Development in the Middle East. Nonproliferation Rev. 22 (3–4), 379–400.
Supersberger, N., Führer, L., 2011. Integration of renewable energies and nuclear power into North African Energy Systems: an analysis of energy import and export effects. Energy Policy 39 (8), 4458–4465.
The Economist, 2016. Black Gold., White Gold..
The World Bank, 2016. FY16 List Fragile Situations June. 3, 2106 ⟨http://www.worldbank.org/en/topic/fragilityconflictviolence/overview⟩.
Van de Graaf, T., Sovacool, B.K., 2014. Thinking big: politics, progress, and security in the management of Asian and European energy megaprojects. Energy Policy 74, 16–27.
van der Ploeg, F., 2011. Natural resources: curse or blessing? J. Econ. Lit. 49 (2), 366–420.
van der Zwaan, B., Cameron, L., Kober, T., 2013. Potential for renewable energy jobs in the Middle East. Energy Policy 60, 296–304.
Vardimon, R., 2011. Assessment of the potential for distributed photovoltaic electricity production in Israel. Renew. Energy 36 (2), 591–594.
Verbruggen, A., Al Marchohi, M., 2010. Views on peak oil and its relation to climate change policy. Energy Policy 38 (10), 5572–5581.
Verme, P., 2016. Subsidy Reforms in the Middle East and North Africa Region: A Review. World Bank Group.
Vidican, G., 2016. Chapter 4 - Scaling Up Renewable Energy Deployment in North Africa. In: Campi, M.T.C., Lenzi, V., Ozturk, I. (Eds.), Regulation and Investments in Energy Markets. Academic Press, 73–87.
Visser, F., Yeretzian, A., 2013 Energy Efficient Building Guidelines for MENA region. MED-ENEC.
Whitley, S., van der Burg, L., 2015. Fossil Fuel Subsidy Reform: From Rhetoric to Reality. New Climate Economy, London and Washington, DC.
World Bank, 2016. . State and Trends of Carbon Pricing 2016 (October). World Bank, Washington, DC.
World Bank Group, 2016. Commodity Markets Outlook, October. World Bank, Washington, DC.
World Energy Council, 2013. World Energy Resources: 2013 Survey. World Energy Council, London.
World Energy Council, 2016a. 2016 World Energy Issues Monitor. World Energy Council, London.
World Energy Council, 2016b. World Energy Resources: unconventional gas, a global phenomenon. World Energy Council, London.
World Nuclear Association, 2016. Emerging Nuclear Energy Countries, June 15, 2016, ⟨http://www.world-nuclear.org/information-library/country-profiles/others/emerging-nuclear-energy-countries.aspx⟩.