Electricity Markets in the Resource-Rich Countries of the MENA: Adapting for the Transition Era

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Abstract

The Middle East and North Africa's (MENA) resource-rich economies are pursuing two parallel strategies in their electricity sectors: (i) increasing and integrating renewables into their power generation mix to mitigate the impact of rising domestic oil and gas demand on their economies and boost hydrocarbon export capacities; and (ii) undertaking power sector reforms to attract investment in generation capacity and networks, remove subsidies, and improve operational efficiency. These goals imply that the design of reforms (including regulations governing wholesale and retail markets and networks) needs to be carried out with a view to a rising share of non-dispatchable resources. The lack of an integrated approach to simultaneously address these two strategies is likely to lead to several misalignments between renewables and various components of future electricity markets, as the share of intermittent resources increases in the generation mix. The key challenge is that the 'ultimate model' capable of reconciling these two goals is as yet unknown, and is still evolving, due to uncertainties around the development of technologies, institutions, and consumer preferences. We argue that resource-rich MENA countries can, however, move towards adopting a transition model of electricity markets, the individual elements of which can be adapted to suit either centralized or decentralized future electricity sector outcomes. We outline the key components of this model for the wholesale market, retail market, and network regulation, considering governments' objectives and the specific contexts of the countries in the region.

Keywords: energy transition; MENA; renewables; future electricity sector evolution; technology; institutions

1. Introduction

Resource-rich economies in the Middle East and North Africa (MENA) have strong motivations, beyond decarbonization, to increase the share of renewables in their power mix. They are at a stage of development where economic and population growth, rapid urbanization and economic prosperity have led to soaring domestic electricity demand, with increasing amounts of crude oil, fuel oil, diesel and natural gas being diverted to the power sector at prices below international levels (Lilliestam and Patt, 2015). The rapid rise in domestic energy consumption results in suboptimal utilization of the resource base and puts many of these countries on a fiscally unsustainable path given their dependence on oil and gas export revenues. This is exacerbated by underpriced energy vectors, inefficient state-owned utilities, and power sectors heavily reliant on government budgets for investment and operation. Therefore, governments need to increase the share of renewables in the generation mix not only to boost hydrocarbon export revenues, but also to enhance security of supply,[1] diversify the energy mix, and restructure the power sector in order to attract private capital and improve efficiency.[2] In the long term, renewables can help reduce the region's per-capita emissions which is amongst the world's highest (Poudineh et al., 2018), as well as contribute to economic diversification.

Parallel to renewables policy, several MENA countries have begun undertaking power sector reforms, with the aim of restructuring the energy sector, allowing private-sector participation, removing energy subsidies, and reducing reliance on the public budget. However, renewables targets complicate the process of reform, especially if governments wish to move the electricity sector towards market-based approaches. The key challenge is how to design a reform model that helps them attract investment and improve efficiency, while simultaneously integrating a rising proportion of intermittent resources. Failure to find the right model is likely to frustrate reform efforts and governments may find themselves in need of making significant changes to the electricity market at later stages. For example, inadequate tariff design structure, following the removal of subsidies, could lead to difficulty in recovering the power systems' fixed costs, and also to the regressive distribution of costs among ratepayers. Furthermore, introducing significant renewables without a proportionate increase in power system flexibility (both in

[1] Some of these countries, such as the United Arab Emirates and Kuwait, are already net importers of natural gas.
[2] Blazquez et al. (2018) show that renewables deployment (along with shifting power generation from oil to natural gas and increasing the administered price of oil) is among the most cost-effective ways of reducing oil consumption in Saudi Arabia, with significant net benefits to society.

generation and in the grid) typically leads to curtailment and/or lower system reliability. Moreover, integrating demand-side resources faces a significant hurdle when ownership and operation of the national electricity grid are not decoupled. There are many examples of potential friction if reforms are designed independently of renewables policies (see Peng and Poudineh et al. [2017]).

Experience around the world has typically been of reforming countries adopting the 'OECD model' of reforms,[3] namely unbundling the electricity sector from a state-owned, vertically integrated monopoly into its functional components—generation, transmission, distribution, and retail supply—and introducing competition into generation and retail supply (for example through wholesale markets, retail competition, and privatization).

In many jurisdictions that pioneered power sector liberalization (Europe, Australia and the United States (Texas) among others), energy is the only commodity traded in liberalized electricity markets.[4] Prices in energy-only markets are set according to the system marginal cost (Sen, 2014), relying on market price signals to organize both short-term coordination for dispatching, and long-term coordination for investment in generation capacity (Roques and Finon, 2017; UKERC, 2010). In practice it is difficult to achieve both objectives through price signals in energy-only electricity markets, for two principal reasons:

First, such a design ignores market imperfections around short- versus long-term coordination (Roque and Finon, 2017). The interests of market participants are not aligned, weakening their incentive to contract forward and share risk. Retail competition allows consumers to switch suppliers at short notice; even if this does not happen, it constrains retail companies' ability to sign contracts with generators exceeding the duration of their contracts with customers. There is also no financial market for forward hedging. These imperfections increase the cost of capital for investors, potentially leading to inadequate or suboptimal generation mix and frequent price volatility.

Second, decarbonization (a major objective in OECD countries) has exposed weaknesses in the wholesale market model around its compatibility with the intermittency of renewables. Marginal-cost-based price formation in energy-only markets has little relevance for renewable

[3] Pioneered in the 1980s/1990s by countries of the Organisation for Economic Co-operation and Development (OECD).
[4] As opposed to capacity or services.

generation technologies, as what distinguishes renewable plants (in a market for dispatch) is their location and ability to provide flexibility and balancing services, rather than their marginal costs which are close to zero (Keay, 2016). Zero marginal cost renewables in energy-only markets also lead to price volatility (and sometimes to zero or negative prices).[5] The simultaneous operation of renewables and traditional generation within competitive wholesale markets has led to market breakdown and distortion of electricity price signals, especially when renewables receive out-of-market payments. Furthermore, the decentralized nature of small-scale renewables implies that assets are transferred away from utilities to 'prosumers' or private on-site generators, impacting the earnings (return on assets) of traditional utilities.

The issue is not limited to wholesale market design; the entire package of reforms practiced in the OECD is under question. There is a growing consensus that imposing the OECD reform model onto countries with no regard to contextual heterogeneity creates further complexity. The original objectives of the OECD model were to achieve higher efficiency, lower consumer prices and enhance consumer choice, whereas in non-OECD countries the model was implemented to resolve the inadequacy of investment and removal of the electricity supply constraint on growth (Williams and Ghanadan, 2006). Context is particularly important for resource-rich MENA countries, as the adoption of more market-based approaches results in political challenges (for example if prices were to be based on marginal costs, this would require the removal of subsidies and would lead to much higher electricity prices), whereas moving towards a fully subsidized renewables programme (in addition to existing fossil fuel subsidies) increases fiscal and economic pressures, especially at times of low oil prices (Poudineh et al., 2018).

Electricity markets are effectively in transition around the world, with considerable uncertainty around the development of future markets and business models that will reconcile the goals of market liberalization and renewables integration. Multiple options are available, whether for market structure, utility business models, or consumer engagement, with each model having its own advantages and disadvantages (Robinson and Keay, 2017). Approaches based on centralized coordination are effective for security of supply and risk mitigation, but not with coping with inefficiencies and information asymmetry when compared to markets; they are also susceptible to political pressures (Robinson and Keay, 2017). In contrast, systems with

[5] Storage could resolve intermittency issues, but has yet to achieve commerciality.

decentralized coordination are effective at addressing informational asymmetry and promoting efficiency, but not in dealing with risks and uncertainties. This implies that resource-rich MENA countries need to design their own model of power sector reform on the basis of their energy system objectives, the energy transition, and their distinct contexts. In this paper, we propose a *transition model of electricity markets* for these countries. Such a model needs to:

- combine the effective features of various successful designs;
- balance the roles of the market versus the government;
- be compatible with the current technology mix and institutions in the region;
- allow for the further development of renewables;
- be flexible enough to adapt to future developments in the electricity sector;
- encourage efficiency and security of supply; and
- promote consumer preference.

Section 2 analyses the main features of electricity markets in a resource-rich MENA countries, Section 3 describes what a transition model would look like for these countries, Section 4 discusses how the model could be adapted to possible scenarios for future evolution of electricity markets, and Section 5 concludes.

2. The Electricity Sector Structures of MENA Resource-Rich Economies: Basic Features

In this paper, we focus on major resource-rich economies of the MENA region which are locked into a cycle of dependency on fossil fuels, due to two primary interconnected factors: rising domestic hydrocarbon consumption on the back of underpriced and plentiful fossil fuel reserves (oil/gas); and, rising dependence on oil and gas export revenues to finance domestic economic activities and maintain rent distribution (Poudineh et al, 2016). We use an indicator of resource dependency (oil rents[6] as a percentage of GDP at 10% or higher) to identify the relevant countries. As seen in Figure 1, nine countries fit this criteria. We exclude Libya, Iraq and Oman due to problems with data availability. This leaves us with six key MENA countries on which we draw for our analysis: Algeria, Kuwait, Iran, Qatar, Saudi Arabia and United Arab Emirates (UAE).

[6] As per The World Bank (2019) oil rent is defined as the difference between the value of crude oil production at international prices and total costs of production.

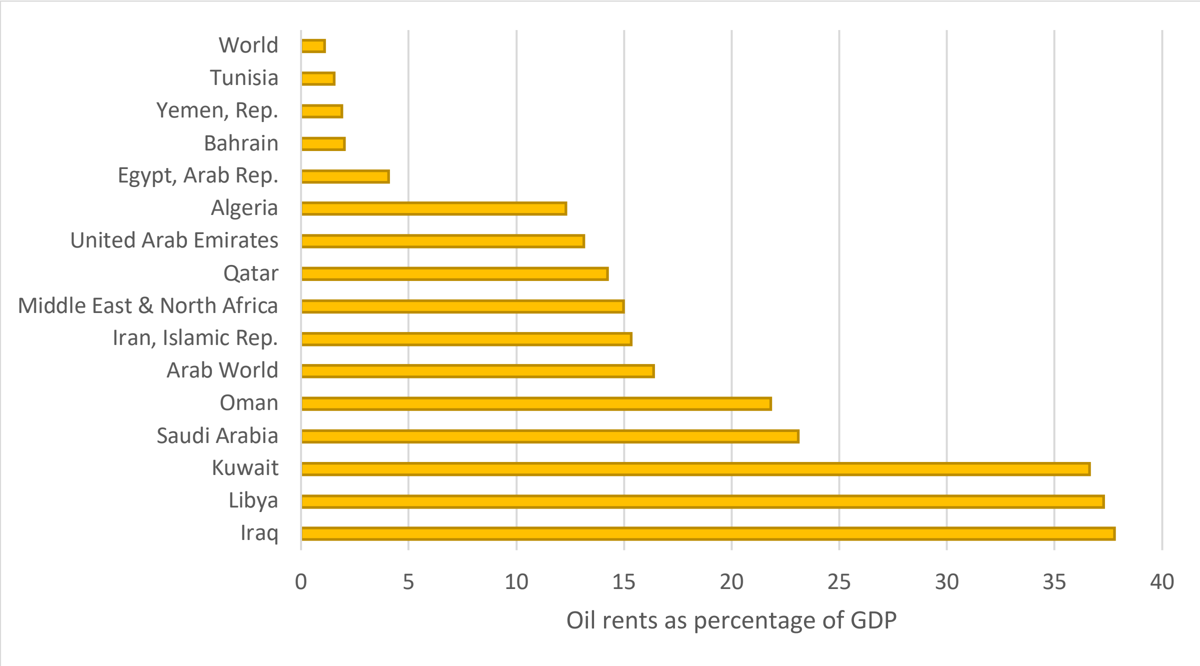


Figure 1: Oil rents as percentage of GDP

Source of data: The World Bank (2019)

MENA resource rich countries have a high potential for renewable energy, especially for solar PV (see Figure 2), which benefits from high levels of solar irradiation. Prominent regional solar projects that are active or in the pipeline include: Abu Dhabi's 100 megawatt (MW) Shams concentrating solar power (CSP) plant (operational since 2014); Dubai's Mohammed bin Rashid Al Maktoum Solar Park (photovoltaic [PV]), of which Phase 1 (13 MW) was completed in 2013, Phase 2 (200 MW) was completed in 2017 and Phase 3 (800 MW) is due for completion in 2020; Kuwait's Shagaya solar thermal project (50 MW); Iran's 20 MW Mokran solar PV project, Saudi Arabia's Al-Aflaj 50 MW solar PV plant, and Oman's 500 MW Ibri-2 utility-scale solar project.

Although there is potential for wind in some MENA countries, with the exception of Iran which has 288 MW wind capacity, renewables are biased towards solar energy. As seen in Table 1, the share of CSP and Biomass and Waste is also negligible in the power mix.

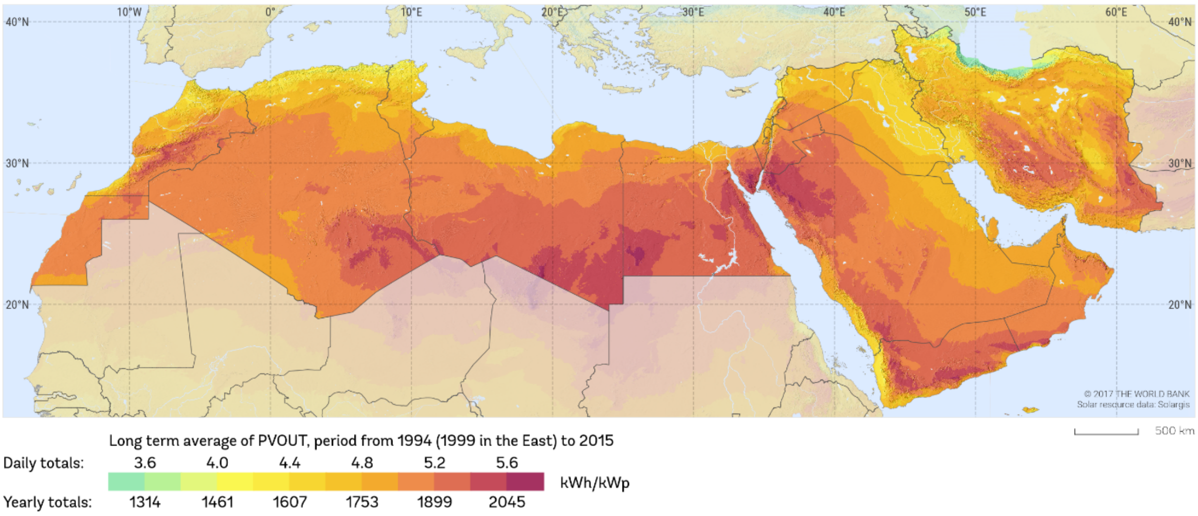


Figure 2: Photovoltaic electricity potential in the MENA

Source: Adapted from © 2017 The World Bank, Solar resource data: Solargis

https://solargis.com/maps-and-gis-data/download/middle-east-and-north-africa

Table 1: Installed Renewable Capacity in Resource Rich MENA Countries (2017)

Country	**Solar PV**	**CSP**	**Wind**	**Biomass and Waste**	**Other technologies**	**Total RE (in MW)**	**% of installed capacity**
Kuwait	19	50	10	0	0	79	0.4%
Qatar	5	0	0	38	0	43	0.4%
Saudi Arabia	89	50	3	0	0	142	0.2%
UAE	487	100	1	1		589	2.0%
Iran	260	0.25	288	18.8	72.95	640	0.8%
Algeria	345	25	10.2	0	0	380.2	2.11%

Source: IRENA (2019), IRNA (2017), Bargozideha (2018), YJC (2019), CEEG (2017), Helioscsp (2019), Zistonline (2018)

Existing renewable capacity in these countries is less than 6% of installed capacity. However, most have introduced fairly ambitious long-term renewable energy targets (see Figure 3). For instance, Kuwait is targeting 15% of electricity demand to be met by renewables by 2030 and the UAE's target is 24% clean energy (including nuclear) in the energy mix by 2021. Saudi Arabia is targeting 9.5 gigawatts (GW) of solar capacity by 2023, while Iran is pursuing 5 GW of solar and wind capacity by 2020. Oman is targeting 16% of total electricity demand by 2025 to be met from renewables, and 30 per cent by 2030.

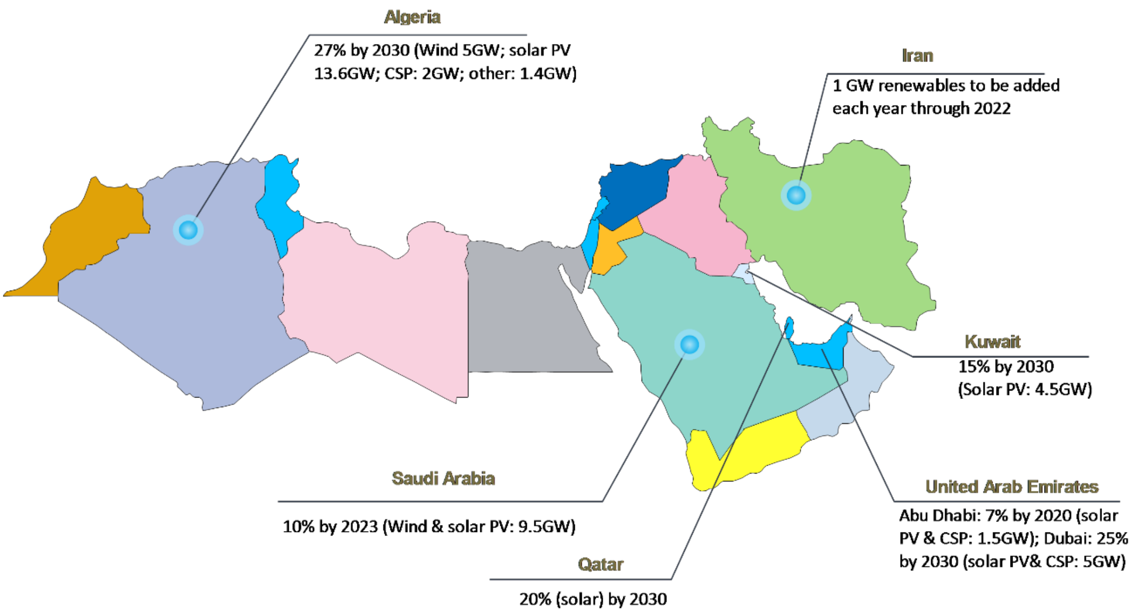


Figure 3: Renewable energy targets in MENA resource-rich countries (% of power mix or gigawatts)

Source: Authors

The key instrument to meet their renewable targets is auctions, some of which have yielded the world's lowest prices for solar energy. Examples include Phase 2 of Mohammed bin Rashid Al Maktoum Solar Park at 5.85 US cents per kilowatt hour (kWh), and the Dubai Electricity and Water Authority reportedly receiving five bids from international firms to build the third phase of the park in 2016, the lowest of which was 2.99 US cents/kWh. In February 2018, ACWA Power was awarded rights to develop the 300 MW Skaka IPP solar PV project in Saudi Arabia at a record low tariff of 8.782 halala/kWh (2.34 US cents/kWh).

Low auction prices are partly due to technology cost declines and low risk finance, and partly due to favourable solar irradiation which allows for high yield solar PV plants. This has made renewables almost cost competitive with fossil fuels. However, the extent to which these countries can achieve their renewable targets is constrained by the characteristics of these countries' electricity sectors, and by the contexts within which they operate. There are five key features related to the region's electricity sector that will affect not only the design of instruments to achieve renewable targets but also future developments of these countries' power sectors.

First, historically, electricity sectors in resource-rich MENA countries have been organized around vertically integrated, state-owned utilities endowed with a statutory or *de facto* monopoly over generation, transmission and distribution (Dyllick-Brenzinger and Finger, 2013). For instance, in Kuwait the monopoly is the Ministry of Electricity and Water (MEW), in Saudi Arabia it is the Saudi Electricity Company (SEC), and in Iran it is Tavanir, the holding company for generation, transmission and distribution. These state monopolies historically owned and operated all assets and infrastructure in the electricity sector.

Although legislation has been introduced to reform the electricity sector structure in many of these countries, implementation has been slow. Reform laws in Iran (1999), Saudi Arabia (2005), and Algeria (2002) envisage wholesale markets; Abu Dhabi (UAE) reform legislation (1998) envisages disaggregated single buyers with bilateral trading and third-party access, and reform laws of Kuwait (2008; 2010) and Qatar limit changes to allowing Independent Power Producers (IPPs) in generation, alongside unbundling (for Qatar) (Dyllick-Brenzinger and Finger, 2013).

Second, electricity markets in resource-rich MENA countries are all currently variants of the single-buyer model (see Tables 2 and 3), with differences in the levels at which competition plays out. Private investment in generation is mainly facilitated through auctioning tenders for IPPs and IWPPs (Integrated Water and Power Producers) based on long-term contracts. Iran is the only MENA country where competition is introduced through bid-based auctions in the spot market for generation, with the electricity price for the single buyer in the pool determined by the interaction of competing generators (Poudineh et al., 2018).

Third, these countries' electricity sectors feature highly subsidized tariffs, which often do not reflect the production cost. The global oil price downturn prompted several resource-rich MENA countries, including Kuwait and Saudi Arabia, to raise retail electricity prices to shift their economies towards a more fiscally sustainable path, with mixed success. For example Kuwait, which was the last Gulf Cooperation Council (GCC) country to move on electricity reforms, proposed to more than triple its retail electricity price for certain consumers, but this faced resistance in the country's parliament.

As a consequence of subsidized tariffs, utilities' revenues are insufficient, requiring them to fall back on national budgets for their investment requirements. Subsequently, resource-rich MENA countries have tended to pursue the cheapest (in terms of capital cost) and quickest options for investment in generation, such as oil-fired boiler plants or open-cycle gas turbines, which are also technologies with low conversion efficiencies and thus high running costs (Poudineh et al., 2018).

Fourth, despite the potential compatibility in these countries' electricity load profiles and regional pattern of solar irradiation, in reality there is a mismatch created by inefficiencies in consumption. For instance in Kuwait, despite the temperature drop in the evenings, the electrical load remains relatively unchanged through the day due to inefficient buildings consumption (and distorted electricity prices)—primarily to meet demand for air conditioning.

Fifth, the state has a very strong presence in the electricity sectors, which cannot be easily or quickly circumvented in favour of more decentralized institutions, limiting the potential for radical innovation in the foreseeable future. Resource-rich MENA countries have struggled to establish independent regulatory and other institutions. For instance, Abu Dhabi's Regulation and Supervision Bureau, its notional electricity regulator, sets bulk supply tariffs and applies incentive regulation (for example RPI-X)[7] to networks, but still has direct government representation (Dyllick-Brenzinger and Finger, 2013). Studies suggest that these countries' institutional feasibility should include the existence of renewable energy ministries and regulators, and definition of their resources, competencies, laws, existing strategies and activities in renewable energy (DIE, 2012). However, current institutional frameworks for

[7] A price-capping formula, RPI-X stands for Retail Prices Index less expected efficiency savings of X.

energy are largely dominated by the oil and gas sector, and renewables have yet to be integrated (Poudineh et al., 2018).

Any structural design for the electricity sector in the region needs to consider the above context.

3. A Transition Model for Resource-Rich MENA Countries

Currently, most resource-rich MENA countries are at an early stage of electricity sector reform (that is, vertically integrated or single-buyer structures). In a way, this constitutes an advantage when designing their own reform packages to fit with their unique circumstances, whilst avoiding OECD countries' mistakes. The transition model proposed in the section below is supported by this premise. Various possible models of electricity sector structure are evident, progressively evolving from a *vertically integrated monopoly* (VIM), which owns and operates generation, transmission, distribution, and retail supply, to full wholesale and retail competition (see Figure 4). Each model resolves different issues in the functioning of the sector.[8] The first step from a VIM is a *bundled single-buyer model*, which allows for competition (private companies) in generation, but transforms the VIM into a monopsony—creating perverse incentives for the latter to prioritize its own generation assets in the dispatch. The *unbundled single-buyer model* corrects for this distortion, through the unbundling (accounting and/or ownership separation) of generation from transmission and distribution.

As seen in Table 2, MENA resource-rich countries are currently at the stage of either single buyer model or single buyer model and unbundling. IPPs are prevalent in generation. This is similar to the experience in South and Southeast Asian countries, where private sector IPPs were given a guaranteed rate of return on their investments in an effort by governments to attract private investment (Sen et al., 2018). However, unlike the utilities in resource-rich MENA which can fall back on national budgets and hydrocarbon export revenues, Asian state-owned utilities did not have the resources to meet these guarantees, leading to the collapse of IPPs (in part also due to the Asian financial crisis) in many of these countries.

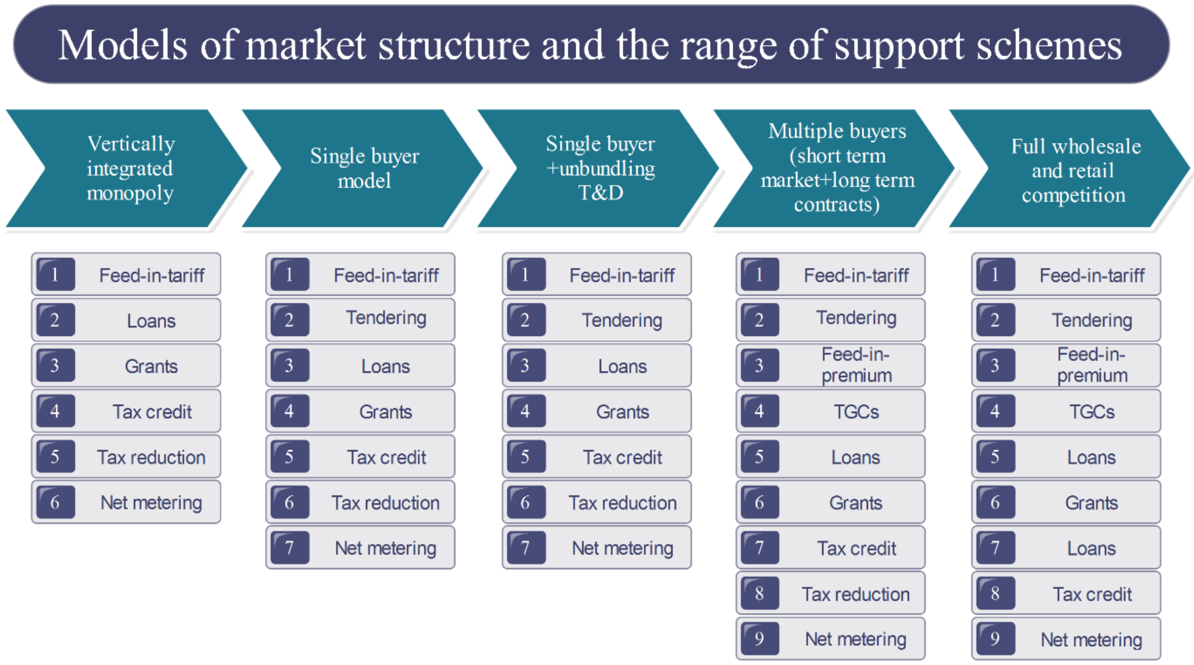
[8] Poudineh et al. (2018) provide a taxonomy.

Table 2: The current stage of reform in selected resource-rich MENA countries

	Existing power sector structure
Algeria	Single buyer market structure with unbundled transmission and distribution. Sonelgaz, formerly a vertically integrated company, was restructured into a holding company driving an industrial group consisting of several companies and trades, including electricity generation, transmission and distribution, including Joint Venture with Sonatrach to form Algerian Energy Company.
Kuwait	Bundled single-buyer market structure with IPPs, IWPPs and captive power plants in generation. The MEW was solely responsible for the development of the electricity sector.
Iran	Unbundled (legally) single buyer. A law was passed in 2004 which allowed Tavanir (Iran's vertically integrated Power Generation, Transmission and Distribution Company) to incorporate new companies and sell 65% of their share in Tehran Security Exchange (TSE). A new company named the Iran Electricity Grid Management Company (IEGMC) was established in the same year (fully owned by Tavanir) to operate and manage the transmission network.
Qatar	Bundled single-buyer market structure with IPPs in generation. Generation carried out by a range of private and public sector players. Qatar Electricity and Water Company (QEWC) is the largest generation utility (with 52% state ownership) and also holds part-ownership in several other local utilities. State-owned enterprise Qatar General Electricity & Water Company (Kahramaa) is sole purchaser of all electricity generated, which is sold on to end-consumers; it is also responsible for transmission and distribution.
Saudi Arabia	Bundled single-buyer market structure, with IPPs/IWPPs in generation. Vertically-integrated SEC owns most generation assets plus nearly all transmission & distribution networks. SEC is the only wholesale purchaser and is responsible for selling electricity to final consumers. IPPs have long-term contracts with SEC plus feedstock price & availability guarantees.
UAE	Single buyer market structure with unbundled transmission and distribution. For e.g. in Abu Dhabi, Emirates Water & Electricity Company (EWEC, formerly Abu Dhabi Water & Electricity Company-ADWEC) is the single buyer which purchases all electricity, Abu Dhabi Transmission & Dispatch Co is responsible for transmission, and two state companies (Abu Dhabi Distribution Company and Al Ain Distribution Company) are responsible for distribution and retail supply.

However the single buyer (undertaking transmission and possibly distribution, if integrated with transmission) may abuse its dominant position, or may default on its payments given the risk involved in monopsony markets. Hence, the *multiple-buyer model* allows more than one offtaker (for example large electricity consumers, regional transmission companies, and distribution or retail companies) with grid operation carried out by an independent system operator, or by the largest transmission system operator. At this stage it is also possible to create a short term wholesale electricity market for dispatch. This market can complement the market for long term contracts that already existed in the single buyer model. The fifth model allows for *full wholesale and retail competition* with markets usually but not necessarily organized around day-ahead transactions, bilateral contracts and balancing. Poudineh et al. (2018) review the compatibility of renewables support mechanisms with each model, showing that tendering is compatible with all structures that have moved away from a VIM (Figure 4).

Figure 4: Models of market structure



Notes: ISO = independent system operator; TGC = tradable green certificates.

Source: Poudineh et al. (2018, 147).

3.1 Components of the transition model

On a global scale, decarbonization and renewables integration are catalysing a shift in the technological fundamentals of the electricity system, opening up possibilities for new commercial and business models around which markets need to reorganize. The uncertainty over the end-point of this shift implies that the 'ultimate' model is as yet unknown. Resource-rich MENA countries can adopt a transition model, which deals with the problem of attracting investment in renewables while balancing the competitive functioning of electricity markets with investment incentives. This model would be more adaptable to the eventual outcome of the electricity transition in these countries. We describe its main features below.[9]

3.2 Unbundling

The unbundling of the electricity sector into generation, transmission, distribution, and retail supply is a basic structural measure required to address various perverse incentives that encourage anti-competitive behaviour by integrated monopolies. Most resource-rich MENA countries have not undertaken complete unbundling – in terms of both the separation of

[9] We focus on the design of wholesale and retail markets and network regulation, but it goes without saying that there is a need for an independent regulatory body to regulate networks and monitor competition in the market.

accounts, and structural unbundling (creation of separated legal entities). Out of the countries discussed in Table 2, Kuwait and Qatar have not unbundled. In countries where some degree of structural unbundling has taken place, separated companies remain part of the same legal entity. Examples include Algeria's Sonelgaz and Iran's Tavanir, which are holding companies for their generation, transmission and distribution subsidiaries. In the UAE, which has arguably progressed the most towards structural reform, EWEC is the single buyer, with a separate transmission company and two distribution-cum-retail supply companies – but these are all wholly owned subsidiaries of the state-owned Abu Dhabi Power Corporation (ADPC). As UAE generators sign long-term Power Purchase Agreements (PPAs) with EWEC and also have confirmed fuel supply agreements to reduce both credit off-taker and fuel price risk, this structure prevents competition from developing in the wholesale market for power generation (Hasan et al., 2019).[10]

Even when complete unbundling to facilitate competition is part of official policy, governments have not been able to carry this out due to resistance from incumbents. For instance, Saudi Arabia's Electricity and Cogeneration Regulatory Authority's (ECRA) had planned to unbundle SEC into four private generation, one independent transmission and one distribution company, with a view to attracting private investment into the sector, by end-2016, but this has not yet been achieved (MEES, 2018b). As the bundled state-owned utility often receives large subsidies from low priced hydrocarbons and revenue supplements to manage a large generation fleet and extensive networks, it resists plans that undermine this position. Unbundling with a view to injecting competitiveness in the sector may imply that some parts of the state utility, when unbundled, may no longer be eligible for receiving these rents, creating inherent resistance to reform from the beneficiaries of these rents.

Power sector reform on its own cannot entirely resolve these issues; rather, they need to be part of the wider discourse on economic diversification. Malik (2019) for instance argues that this requires ruling elites to concede greater space to the private sector, on economic grounds. Economic arguments have been made for the need for these concessions, for instance with a view to making the utilities sector more efficient. For example, Camos et al. (2018) using a survey of utilities in 14 MENA countries argue that a quasi-fiscal deficit exists in their power sectors that exceeds 4 per cent of their GDP, representing more than the average investment

[10] Although IPPs and IWPPs are incentivised to consume fuel efficiently through a bonus-penalty mechanism in the PPAs.

urgently needed in the region's electricity sector, estimated at 3 per cent of GDP. A third of this can be attributed to inefficiencies in utilities' operations, including collection losses, transmission and distribution losses and overstaffing (in relation to what 'efficient' utilities of the same size and characteristics would do) (Camos et al. (2018). If unaddressed, it can be argued that the ensuing (and preventable) investment gap could reduce the rents upon which the political elites who resist reform have come to depend.

The eventual aim of unbundling is to make the network a separate unit and a neutral market facilitator, with generators competing on a level playing field. In such a system, access to the grid is regulated and not negotiated. There are various models that can be adopted here. One is the independent Transmission System Operator (TSO), which is fully unbundled from the rest of the system (the previous model in the United Kingdom). The second is a legally unbundled TSO, such as that of RTE in France, in which the TSO operates separately to the rest of the system, but transmission assets remain under the ownership and control of the partially public-owned French utility company Électricité de France (EdF). The third model is the Independent System Operator (ISO), which does not own any transmission assets.

Resource-rich MENA countries can consider options based on their own contexts: for instance, in countries where legal or ownership unbundling has proved difficult to achieve, the TSO model (in which the assets remain with state ownership but the TSO operates separately from the rest of the system) could be adopted alongside accounting separation. In Saudi Arabia for instance, ECRA already plans to have grid transmission assets operated by an independent firm. Other countries (such as Kuwait and Qatar) could begin with accounting separation in order to infuse efficiency into the operation of various segments of the electricity supply chain, and continue towards legal or ownership unbundling alongside adopting the TSO model. In the long-term, based on their success with these procedures, MENA countries could move towards the ISO model. With regard to the distribution network, in theory the same unbundling rule would apply as for the transmission grid. However, in most OECD countries with liberalized electricity markets, the remit of distribution network operators (DNOs), which was previously restricted to network operations, requires expanding in a system with decentralized renewables into areas such as demand response and storage, smart grids and metering, and customer data management. This would effectively transform DNOs into distribution system operators (DSOs), which share some of the traditional responsibilities of TSOs, but at a distribution level.[11] Most resource-rich MENA countries have not separated the operation of the distribution network from retail supply – in countries which have not unbundled (e.g. Kuwait and Qatar), the vertically integrated entity carries out both functions. Whereas in countries where limited unbundling has been carried out (e.g. UAE) distribution companies are responsible for distribution and retail supply in specific geographical areas. This implies that these countries are in a relatively favourable position to adapt to a changing and more decentralized electricity system with regards to distribution networks.

3.3 Innovation-oriented network regulation

Network regulation needs to be in line with wider objectives in the power sector (such as liberalization and decarbonisation) and evolve with change of technology. In many resource-rich MENA countries, fully-fledged network regulation is absent. Even in those countries which have 'unbundled' their networks (e.g. Abu Dhabi (UAE), where reforms have progressed considerably) some key issues such as Third Party Access (TPA) are not very well established.

For competitive markets to develop, network companies need to provide open (non-discriminatory) Third Party Access for potential users, other than the state entity, within these countries. In most of these countries, 'open access' is either loosely defined or non-existent. Abu Dhabi's transmission company permits open access to its network (upon payment of a wheeling charge) but the terms are not very well defined. In Saudi Arabia only those non-utility generators connected to the grid that have a generation license from ECRA are allowed to use the transmission network to meet their own captive demand at different locations, paying the wheeling charges as set by the regulator (KAPSARC, 2018). In Algeria, regulation 02-01 grants IPPs the right to access the grid, which is regulated by Décret Executive 07-293. However, according to existing regulation in Algeria, the TSO is only responsible for building the connection infrastructure up to 50 km. In Iran, since 2005, a regulated TPA regime for transmission network has been adopted which obliges Iran Grid Management Company (IGMC) to connect new generation facilities; however, the process is lengthy and IGMC has significant discretionary power due to its responsibility with respect to network security.

[11] See Poudineh et al. (2017).

The other issue is interconnection and regional cooperation. For resource-rich MENA countries, an important element of network modernization is the development of regional grid interconnections, which can aid in the sharing of reserves, lower the need for capacity investments and for maintaining national spinning reserves, export low cost solar power to other regions and engender competition.

MENA countries already have some level of interconnection (see Figure 5) under three blocks: EIJLLPST interconnection, GCC interconnection and Maghreb interconnection. EIJLLPST interconnects Egypt, Libya, Jordan, Iraq, Syria, Palestine and Lebanon. Iran and Turkey are connected to this clock through Iraq and Syria. Maghreb interconnector connects Morocco, Algeria and Tunisia to EIJLLPST interconnects on east and to European power grid on the west through Spain. The GCC interconnector connects the power markets of members of the Gulf Cooperation Council countries via the 400 kV Gulf Cooperation Council Interconnection Authority (GCCIA)[12] transmission link. Saudi Arabia, Kuwait, UAE and Qatar are part of this network but with different level of capacities (see Figure 6).

The GCCIA interconnector has historically been underutilized, with members drawing on it mainly to bridge power outages. However, evidence suggests that its use for electricity trading is increasing in recent years (although absolute volumes remain small). Traded power comprised 48 per cent of electricity transfers in 2016, and 54 per cent in 2017 (MEES, 2018c). Around 878 GWh of electricity was traded in 2017 over 184 days, at an average price of US Cents 12.4/kWh, which is considerably higher than the region's heavily subsidized power prices (e.g. Saudi Arabia's highest electricity tariff equates to US Cents 8.5/kWh) (MEES, 2018c). This implies that utilities not only can benefit from trading power but also from network optimization opportunities that interconnection provides. The barriers to full utilization of the interconnection include a lack of enabling regulations (for instance, current regulations do not require members to provide support for more than 30 minutes) and a lack of accurate price signals (which would require information on the marginal costs of electricity production in member countries) (MEES, 2018c).

[12] Established in 2001; operation of the interconnector commenced in 2009.

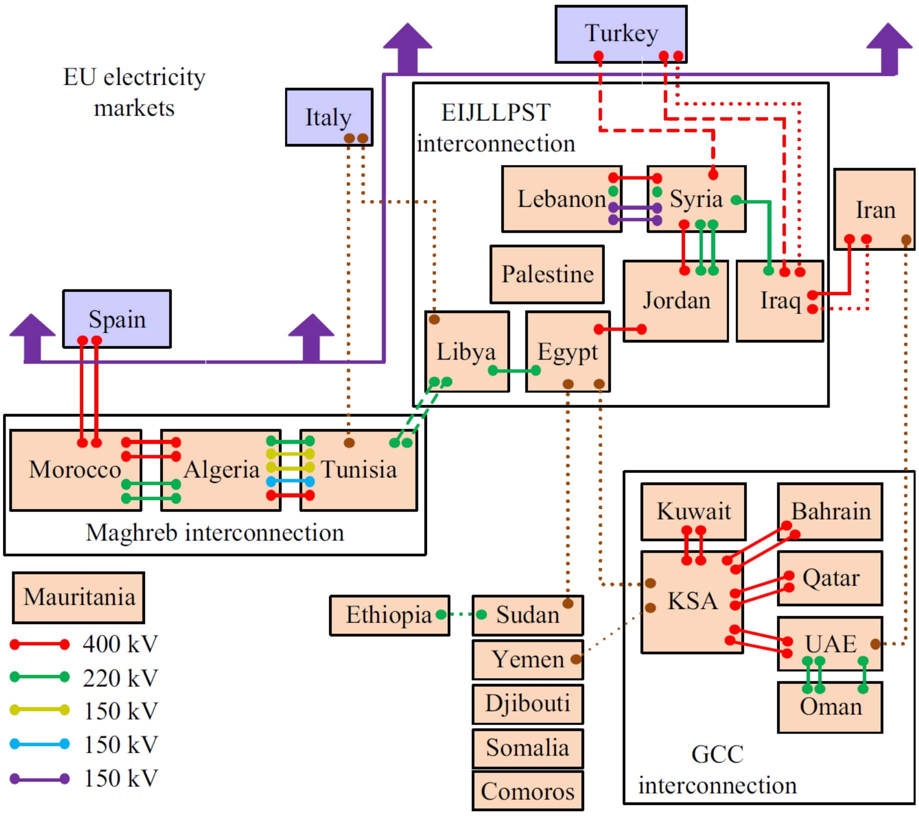


Figure 5: Middle East and North Africa Interconnections (solid line represents existing interconnectors whereas dash line and dotted line represent "not operational/island operation" and "under consideration/construction" respectively)

Source: Zhang et al (2017)

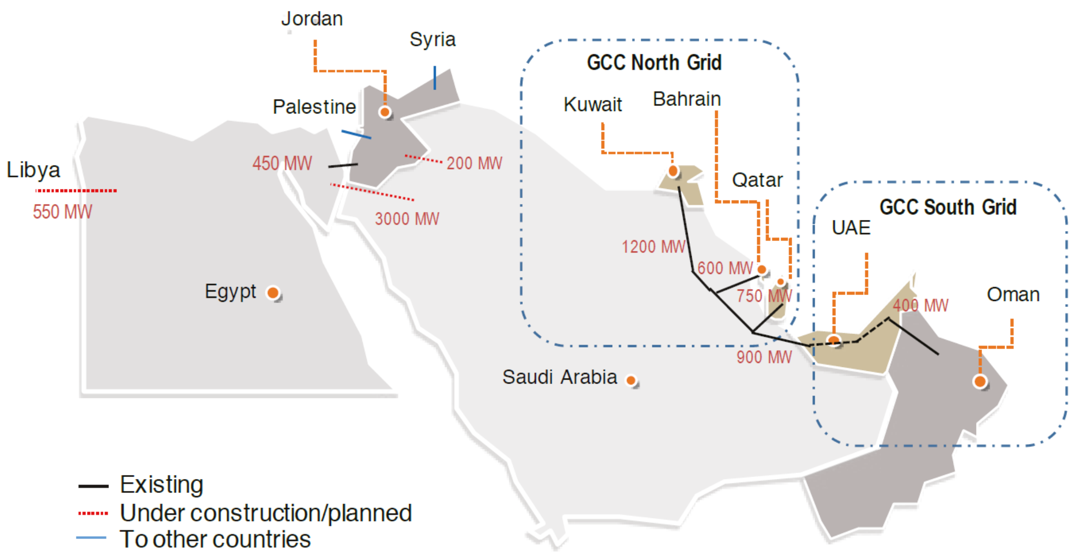


Figure 6: the GCC interconnector

Source: KAPSARC (2018)

There is also a need for a compensation plan that remunerates network firms for their cost of efficient investment and operation as well as innovation, while sharing the risks between firms and their customers in an efficient manner (Poudineh et al., 2017). Regulators in these countries can adopt a combination of an *input-based approach*, which includes the costs of network services in regulatory expenses, *output-based regulation*, which allows firms to benefit from the full value of successful investment and innovation outcomes (for example by allowing for additional revenues or extending the regulatory period), and tendering in order to regulate innovation and business-as-usual expenses of the firms.

3.4 Retail market: competition for large consumers, regulation for small consumers

In contrast to the original liberalization model in which retail supply was proposed to be fully competitive for all consumers, in our proposed transition model retail competition applies only to large consumers whereas smaller consumers pay regulated prices. There are two reasons for such a differentiation. First, the experience of OECD economies (e.g. UK) shows that retail consumers typically do not engage with the market as anticipated, creating an opportunity for suppliers to exploit small consumers through their unilateral market power. The lack of engagement by small users is caused by consumer inertia, transaction costs, lack of information, negligible gain from switching supplier and internet illiteracy. Frequent switching, on the other hand, creates another problem. Most suppliers in liberalized markets are unwilling to enter into long-term contracts with generators in order to hedge against the volatility of wholesale market prices.[13] This is because they cannot rely on a consumer base, which can easily switch suppliers. This absence of a forward market is one of the reasons that short-term energy-only wholesale markets do not provide sufficient incentives for investment. A regulated retail market for small consumers means that the government sets the retail price as the combination of generation costs, network fees, and a fixed margin for suppliers. It might also want to hold annual auctions in order to identify least-cost suppliers for serving small electricity customers. This averts the need of designing the retail market based on the assumption of fully engaged consumers.

[13] They thus remain unhedged or use alternative methods such as acquiring generation facilities (an internal hedge through vertical integration).

A regulated retail market, however, must not lead to governments distorting retail electricity prices through heavy subsidies or taxes. In essence, the final price of electricity needs to reflect the efficient costs of consumption. The experience of OECD countries shows that distorting the retail price signal has several side effects including load and grid defection through self-generation, inequity in recovering the fixed costs of the power system from a smaller pool of users, inefficient decentralization and lack of incentive to invest in electric vehicles and other low carbon electricity-based equipment.

Unlike OECD countries in which retail prices of electricity are high due to tax and other social and policy costs, resource-rich MENA countries have historically heavily subsidized their retail consumers. The average electricity prices across the countries studied in this paper is USD cent 4.3/kWh whereas the world average is USD cent 14/kWh (see Figure 7). Furthermore, the average electricity price is far below the average cost of production in the region, which is more than USD cent 10/kWh. Even in the UAE, which has carried out extensive energy price reforms, final electricity prices are not cost reflective. Due to extensive use of liquid fuels, and contrary to conventional wisdom, electricity production is costly in MENA resource-rich countries. Camos et al. (2018) in their survey of MENA utilities conclude that two-thirds of the inefficiencies of the region's utilities can be attributed to 'underpricing' of electricity (tariffs set below the cost of supply), and a 2013 IMF study concluded that all MENA countries spend on average 2 per cent of GDP on poorly targeted electricity subsidies (IMF, 2013).

Whether there is a tax or subsidy, the distortionary effect is the same from an economic perspective. In developed economies where retail prices are artificially high due to taxes and other charges, sometimes an inefficient level of decentralization occurs. On the contrary, in resource-rich countries, there is an inefficient level of centralization. When consumers can have electricity from the grid for a trivial price, there is little incentive for them to invest in solar PV, energy efficiency, demand response or storage. This makes the uptake of distributed energy resources very difficult, given the extent of support that would be required from governments to make them attractive. It has also pushed up and encouraged wasteful electricity consumption.

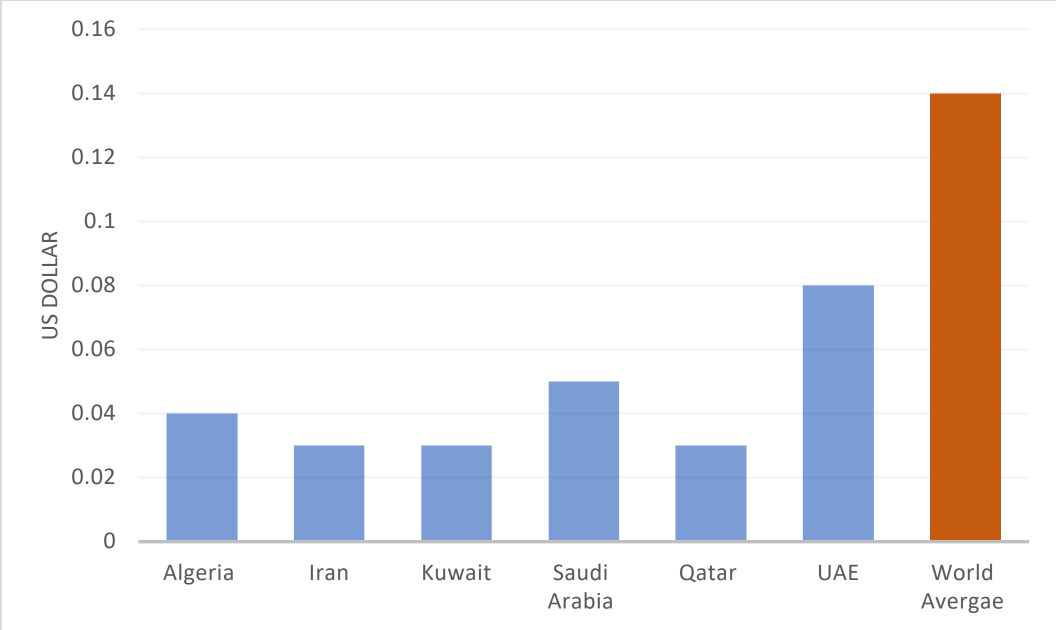


Figure 7: Retail electricity prices in MENA resource-rich countries (June 2018)

Source of data: Globalpetrolprices.com (2019)

Resource-rich MENA countries are aware of the need for energy price reform, not least because of pressure on public budgets during the low oil price cycles. Saudi Arabia for instance, revised its electricity tariffs upwards beginning in 2016, with the launch of the 'Citizen's Account' that aimed to mitigate the adverse impact of higher prices on specific consumers through providing monthly direct cash transfers to eligible citizens (which began in 2017).[14] These dual policies have had several knock-on effects, the first of which is higher revenues for SEC (which in 2017 reported a 52 per cent increase over 2016 in its net profits, to $1.84 billion) (MEES, 2018b). Following the tariff increases, peak electricity consumption supplied by SEC also fell from 214.6 TWh in 2014 to 204.6 TWh in 2017 – or by around 4.6 per cent (MEES, 2018b). The revenue increases could make SEC assets more attractive to private investors as the country proceeds with implementing reforms. Saudi generation capacity has also continued to grow since 2015, as demand has plateaued/fallen, creating a 'supply cushion' – estimated at around 20GW (MEES, 2018d). Iran also embarked on an ambitious energy price reform in 2010. It initially led to reduction in subsidies and energy consumption; however, the price reform was later undermined by wider economic issues such as inflation and depreciation of national currency. Most of the other countries (barring Kuwait, where reforms have been held up by opposition from its Parliament) have similarly adopted a regulated adjustment of electricity

[14] Roughly 3.7 million citizens are registered for these accounts.

tariffs. This component of the transition model is therefore in alignment with the existing contexts of resource-rich MENA countries, provided it is implemented alongside mitigation measures.

3.5 Hybrid wholesale markets: short-term energy markets with long-term contracts

Given the issues associated with short-term wholesale markets providing sufficient incentives for investment—for example due to the absence of a forward market in which generators can hedge risks[15]— and the misalignment of incentives due to short-term consumer 'switching', we suggest a transition model of wholesale markets for resource-rich MENA countries in the form of a hybrid structure that decouples long-term investment from short-term system optimization. This entails a combination of 'interventionist' and market mechanisms as follows:

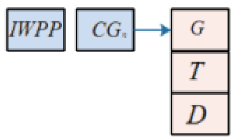
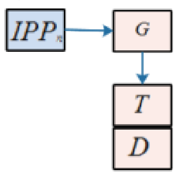
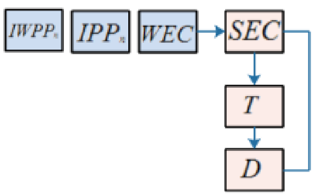
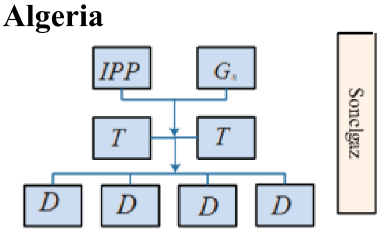
- *A short-term energy market* for short-term coordination and optimization (dispatch) based on spot electricity prices.
- *Long-term contracts* to support long-term coordination, reduce risks for new entrants, facilitate project financing and ensure resource adequacy. Long-term contracts decouple investment decisions from price movements in the short-term energy market (Roques and Finon, 2017).

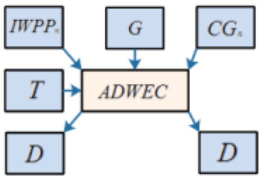
The operation of the short-term market is a very well-known process in the power industry, and MENA countries can easily accommodate this. Long-term energy contracts are usually allocated through auctions. Designing auctions that deliver the optimal outcome, considering the context and government objectives, is not a trivial task. It entails significant government coordination alongside dealing with associated risks and unintended outcomes (such as over- or under-procurement). The upside is that most of these countries have already had a programme of renewable and non-renewable generation technology procurement through auctions. In the past auctions were held in the form of Engineering, Procurement and Construction (EPC) model but in recent years these countries have moved towards the IPP model with PPAs. The UAE has led in the adoption of auctions but others such as Kuwait, Saudi Arabia, Iran, Qatar, Oman and Algeria are also using tendering for renewable

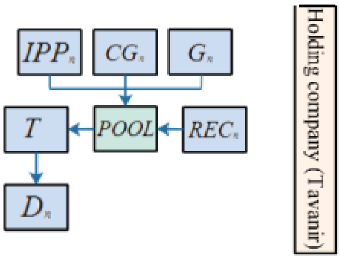
[15] Exacerbated by caps on the wholesale price, for example due to political reasons, or concerns over market power during scarcity periods. Scarcity pricing helps generators recover fixed costs from the energy-only market and caps may prevent this.

procurement. The existence of auctions, long term contracts in the form of IPPs and associated institutions and regulations facilitate the process of restructuring the existing power markets towards the hybrid model. The existing state of market in MENA resource-rich countries along with steps toward hybrid structures are summarized in Table 3.

Table 3: Steps towards a transition model for selected MENA countries

Power sector model	Steps towards hybrid market structure
Kuwait  Single-buyer	Kuwait aims to increase private investments into IPPs/IWPPs through public-private partnerships (PPP) facilitated by Kuwait Authority for Partnership Projects (KAPP). The IPP model with PPAs can be adapted to hybrid model by establishing a spot market in which long term contracts are connected to its price.
Qatar  Single-buyer	Reform and privatisation has already started and functional separation of generation, transmission and distribution is planned. The Qatar General Electricity and Water Corporation (Kahramaa) is responsible for the transmission and distribution parts of value chain whereas generation is the responsibility of the newly formed Qatar Electricity & Water Company (QEWC). The government is envisioning the possibility of privatising Kahramaa and establishing a transmission and distribution company. Similar to other GCC countries, in Qatar, most power generation plants are in the form of IWPPs and IPPs but with the QEWC holding majority shares. Although power sector reform is currently at its early stage it can be shaped towards a hybrid structure.
Saudi Arabia  Single-buyer + unbundled transmission	The Electricity Industry Restructuring Plain requires SEC to be broken up into 4 generation, 1 transmission and 1 distribution company. Competition between wholesale buyers to purchase power from generators is a possibility. Following Vision 2030 the Saudi Company for Energy Purchase was established as the 'principal buyer' of electricity. Saudi Arabia already heavily relies on IPP and PPAs to enhance its generation capacity. The IPP model also plays a crucial role in the Kingdom's latest 3.5GW renewable-energy target by 2020, and 9.5GW by 2030. The existing reforms along with IPPs and PPAs can be incorporated in a future hybrid power market.
Algeria  Single-buyer + unbundled transmission and distribution	Reform envisaged breakup of Sonelgaz into generation, transmission and distribution, with wholesale market competition and partial privatisation (the latter has been opposed by the country's Unions). Algeria has been traditionally using IPPs to deploy new capacity in the power sector. In 2013, around 54% of Algeria's power generation was produced by IPPs. In recent years renewable IPPs were also introduced. Furthermore, the regulatory framework governing the electricity sector in Algeria envisions establishment of a market operator and creation of a wholesale market for electricity. It is planned that initially large consumers and suppliers would be able to participate directly in the

<table>
<tr><td></td><td>wholesale market. This market structure then would be adaptable to a hybrid model.</td></tr>
<tr><td>United Arab Emirates (Abu Dhabi)


Single-buyer + unbundled transmission and distribution</td><td>UAE's power sector is arguably one of the most advanced among GCC countries in terms of the creation of competitive market structures which facilitate procurement of electricity through competitive bidding. Open access to the TransCo's network is permitted for all potential users in Abu Dhabi. More than 90% of power generation in Abu Dhabi is provided by IPPs today although the Abu Dhabi Water and Electricity Authority retains majority stake in them. The Dubai Electricity and Water Authority (DEWA) is also increasing its reliance on IPPs. Given the existing plans for creation of a short term market, UAE's power sector naturally moves towards a hybrid model.</td></tr>
<tr><td>Iran


Limited wholesale market</td><td>In terms of reform, Iran's power sector is at a more advanced stage compared with other six countries studied in this paper. Iranian Grid Management Company (IGMC) is responsible for operating the wholesale market known as Iran Power Pool (IRPP). IRPP operates based on merit order, taking bids from regional electricity companies and generators. Furthermore, forward contracts can be traded in the Iran Energy Exchange. The IRPP is the first spot electricity market operating in the Middle East. Adaptation of Iran's power pool to a hybrid model is easier given the existence of forward market and long term contract along with a spot market.</td></tr>
</table>

Notes: G = generation; T = transmission; D = distribution; CG = captive generation; WEC = Saudi Water & Electricity Co.; SEC = Saudi Electricity Co.; Sonelgaz = Algerian electricity holding company; ADWEC = Abu Dhabi Water & Electricity Co.; POOL = Iranian mandatory power pool; REC = regional electricity company; Tavanir = Iranian electricity holding company; subscript *n* = multiple entities; LT = long-term; ST = short-term.
Source: Authors.

Useful lessons can be learnt from international experience in relation to auctions and long term contracts. The standard process of auctions for allocation of long-term contracts requires developers who meet predetermined financial and technical criteria to submit bids to develop their generation technology, with the power offtaker signing a contract with the lowest bidder (Hochberg and Poudineh, 2018). These auctions can be technology-specific (to scale up a specific technology), technology-neutral (where technologies compete on a level playing field), or multi-technology (competition among several technologies, with the proportion of energy contracted from each determined by the auction outcome). Long-term contracts can facilitate secure revenue streams for investors,[16] whilst competitive auctions ensure lower consumer prices for electricity. The product to be auctioned can be capacity (measured in megawatts, for example) or energy (megawatt hours). While conventional generation can be contracted

[16] Partly depending on the organization of electricity markets.

through energy or capacity auctions, the variability of renewables and underdevelopment of storage technologies or other forms of flexibility services imply that renewables are more suited to energy auctions (they can be moved to capacity auctions once the market is established and new sources of flexibility emerge that allow intermittent resources to firm up).

The long-term energy contracts are an effective approach for attracting investment in generation technology, they are not free of distortions. This is specifically an issue in capacity-constrained power systems. The coexistence of long-term contracts and short-term energy-only markets risks pricing distortions—most transactions occur in the long-term market, undermining the relevance of the short-term market (market foreclosure) (Peng and Poudineh, 2017). As a result, generators may limit their participation in the short-term market, affecting competition in the short market, and hence prices.

As the economics of renewables improve over time and a market for flexibility is developed, resource-rich MENA countries can transition from hybrid structures with a long-term energy market to a long-term capacity market for renewables alongside the short-term energy market.[17] This truly separates markets for investment from markets for energy and decisions related to long-term investment from operational decisions on short-term generation choices.

4. Future Evolution of Resource-rich MENA Electricity Markets

An 'ultimate' model of electricity market reform, which reconciles liberalization and renewables integration, is still evolving. The direction that this takes will broadly depend on three factors: development of technologies; development of institutions; and, public acceptance and consumer preference. The transition model discussed in this paper is flexible to adapt to future scenarios in the power sector.

4.1 Development of technologies

Technological advances—on generation, grid, metering infrastructure and digitalization—will shape the future of electricity markets. Resource-rich MENA countries are in the unique position of having the natural climatic conditions and resources required for testing new

[17] We acknowledge that there is a trade-off here between market compatibility and investment incentive. Energy-based long-term contracts provide the strongest incentive for investment in generation capacity, but they can be incompatible with operation of the short-term market. Capacity-based long-term contracts are market compatible, but they may not sufficiently incentivize renewable generators to invest in new capacity.

renewable and storage technologies, as is evident by a number of demonstration projects in the region. One such example of an evolving technology which has been taken up in various countries is Concentrated Solar Power (CSP) – plants which produce electricity by converting concentrated direct solar irradiation into energy. An advantage of CSP over other renewable technologies such as PV and wind is the quality of being dispatchable and the option of energy storage; solar thermal power plants can be equipped with thermal energy storage with a full-load storage capacity in the range of several hours (storage is filled during the day and discharged at night) (ESMAP, 2011). However, the drawback is that it is a nascent technology and thus there are challenges to bring it to the market. Despite this, initiatives such the MENA-CSP Scale-Up Investment Plan (co-financed by multilateral institutions) focuses on mobilizing concessional financing and grants to help CSP scale up in MENA. In the UAE, DEWA has around 700MW of CSP under development; Saudi Arabia has the Duba 1 and Waad Al Shamal CSP projects (43MW and 50MW respectively), and Kuwait has the 50MW Shagaya CSP project with further projects planned (Al Abdaliyah 60MW).

On the electricity transmission side are supergrid technologies that aim to connect power systems, as well as integrate renewables from remote locations to the grid, through long-distance high-voltage direct current cables that overlay the existing grid (Peng and Poudineh, 2017). For example, attempts to connect Europe's grid with the MENA are related to the development of a supergrid. These developments will change the configuration of national markets and necessitate new market design, new operating models and a revised view of the issue of security of supply as cyber security becomes the key in an interconnected power system.

On the distribution side are the 'smart grid' and smart meters which enable active network management, real-time load balancing and giving consumers the option to actively manage consumption. Smart grids initiatives in the region are not prevalent compared with smart meter programmes which are emerging as a key element of MENA countries' efforts to improve the efficiency of energy consumption– the UAE and Saudi Arabia are leading efforts in this regard. For instance, DEWA plans to install one million smart meters across the emirate by 2020, replacing all mechanical and electromechanical meters. Abu Dhabi's ADWEA has fully completed the phase-one rollout of smart meters for electricity and water. Similarly, Saudi Arabia aims to install around 12 million smart meters across the Kingdom by 2025, as part of SEC's energy efficiency efforts. In 2017, Kuwait's MEW announced a plan to replace old meters with 1.2 million smart meters within seven years (Asaba, 2018). The barriers to the scaling up of smart metering technologies remain the willingness of utilities to change their business models to fully leverage the benefits of smart metering (including dynamic pricing, and customer engagement), and the communication of information to consumers.

4.2 Development of institutions

Future electricity markets will need entirely new supporting institutions that complement the characteristics of a sector predominantly based on renewable energy. One aspect of this includes the existence of renewable energy entities and regulators, their resources, competencies, laws, strategies and activities in renewable energy (DIE, 2012). In recent years, many of the MENA's resource-rich countries have established dedicated agencies to oversee the scaling up of renewable energy. Examples include Renewable Energy and Energy Conservation Directorate at the Ministry of Energy and Mines in Algeria, the Department of Energy (established in 2018) in UAE (Abu Dhabi), Saudi Arabia's Renewable Energy Project Development Office (REPDO) and the Renewable Energy Organization of Iran (SUNA). The key weakness of these institutions is that they are not sufficiently integrated with the other energy institutions in these countries, which have been historically dominated by oil and gas (Poudineh et al., 2016). For instance, the role of these institutions is often confined to administering tenders for private renewable project developers (e.g. REPDO in Saudi Arabia administers contracts under the National Renewable Energy Programme). These agencies also have to contend with powerful state owned electricity companies which oversee generation, transmission and distribution assets, and to whom widespread renewables deployment may be seen as a disruption to their business models, rather than an opportunity. Renewable policy institutions on their own arguably do not yet have sufficient influence over these companies to the extent that renewables could be favoured within the energy mix (Poudineh et al., 2016).

Institutions in the electricity sector refer not just to traditional top-down structures, but also to universally accepted interfaces, protocols, and standards to ensure a common communication vocabulary among system components within and between networks and the development of appropriate regulations and operating procedures in conjunction with the development of technologies (Peng and Poudineh, 2017). The UAE's 'smart cities' initiative, for instance, seeks to deploy decentralized and digitized applications and technologies including smart meters, remote terminal units and advanced distribution management systems for smart grids through an umbrella of collaborating institutions including technology firms, the Ministry of Infrastructure Development, DEWA, and the Sharjah Electricity and Water Authority.

The lack of regulatory independence is also a major concern for renewables deployment in these countries, as governments often overturn regulatory decisions and in many cases tariffs are set inflexibly. For instance, Saudi Arabia's 2005 reform legislation envisaged competitive market structures, yet its regulator ECRA has no control over tariffs, and is thus unable to engender competitive forces and incentive regulation in the industry (Poudineh et al., 2016). Institutions also require a rethinking of the scope and purpose of regulation as new actors may enter the system or existing actors may change their role, and this requires modification to the institutional setting of the power system. For example, DNOs may need to evolve their roles outside of the traditional network business into DSOs. A step ahead of this would be DSOs' evolution into distribution system platforms (DSPs): intermediaries that convert data to accessible information—aiding consumers and suppliers alike to make efficient consumption/production choices—connect participants, and reduce transaction costs (Poudineh et al., 2017).[18] As distribution and retail supply have remained integrated in the resource-rich MENA countries (including countries which have progressed the furthest with reforms, such as UAE), such changes would be very slow unless institutional settings are adapted accordingly.

4.3 Public acceptance and consumer preference

Public acceptance and consumer preference will be critical to influencing the future shape of electricity markets. In the initial stages of renewables deployment, public acceptance is needed for support schemes (for example consumption-based levies). At later stages, the uptake of technologies such as smart grids implies that consumers willingly make proactive decisions in changing their consumption patterns (and possibly their daily routines). This, however, requires dealing with the issues such as privacy and customer data management in a proper manner. Currently, there is no evidence, given the perverse incentives created by subsidized tariffs, that consumers in these countries are likely to engage in sophisticated forms of consumer participation. However, there is evidence that they might respond to price signals (e.g. as witnessed following the upward revision of SEC's electricity tariffs since 2016). The implementation of mitigating measures to offset the adverse impacts of any price-based policy

[18] With business models similar to aggregation software services, DSPs could facilitate peer-to-peer markets.

measures (e.g. the Saudi Citizen's Account) also made public acceptance of these measures an easier process. It may be argued that some of these countries (e.g. UAE and Saudi Arabia) are on the cusp of launching widespread rollouts of smart meters and will need to do so in a gradual manner that does not jeopardize their public legitimacy. Similarly, the uptake of supergrids needs widespread political support and hence public backing, requiring their positive externalities to be highlighted (including energy security, complementarity with economic policy, job creation, and equitable distribution of benefits).

Finally, with decentralization and the emergence of self-generators as competitors to traditional utilities, there are multiple paths to the liberalization of retail markets that might emerge from preference that consumers exercise. A case in point is California, in which self-generation and the promotion of community choice aggregators have introduced fierce competition with traditional utility companies. With the increase of self-generation especially roof top solar PV there is a possibility that alternative paths to retail choice emerge which are based on private provision of reliability as opposed to the current public provision of reliability based on centralised grid.

4.4 Compatibility of the transition model with future scenarios

The transition model described above is largely compatible with potential outcomes in the future evolution of the electricity sector, which reduce to either greater centralization or more decentralization (or their combination), depending on the three factors identified above (i.e., technology, institutions and consumer preference) and their associated transaction costs.

In a *centralized* scenario, the power sector in the region moves towards large-scale renewable plants (desert-based CSP plants, utility-scale solar PV plants, and onshore and offshore wind farms) and battery storage technologies, with conventional generation technologies (oil and gas) becoming a minority in the system. As renewable technologies create zero marginal costs, a part of short-term market (that is, day ahead) loses its significance, while the long-term capacity component of the market, along with real-time energy and the ancillary service market, remain significant. The transition model is therefore easily adaptable to such a scenario and electricity markets do not have to be redesigned. Large-scale network technologies dominate in this scenario, with regional balancing through the supergrid (for example the GCCIA interconnector and the MENA interconnection with Europe). This scenario would require centralized coordinating institutions and widespread public backing for greater regional interconnection and trading among MENA countries.

In a *decentralized* scenario, consumers transform into prosumers, with smart-grid technologies and their integration with smarter appliances and devices (Internet of Things) resulting in consumers self-selecting their consumption, selling electricity to each other and to the grid. We argue that the transition model is easily adaptable to this scenario as well, as a reliability insurance element can be introduced into the retail market; that is, consumers can opt for a protection level against power outage that best suits them and communicate this to the insurer (which can be the same as supplier) who purchases capacity on their behalf. This insurance-based decentralized market structure also allows generators/investors to recover their fixed costs, as consumers need to pay reliability premiums if they wish to rely on centralise grid for reliability. This decentralized structure also opens up potential new markets, such as for flexibility services (Boscan and Poudineh, 2016).

A combination of the above two scenarios is also possible, but differences in transaction costs, incentives of market participants and consumer preference imply that one will eventually predominate, or outweigh the other. Given the complex political economy of the region and emphasise on self-sufficiency, *centralized* supergrids, which require an enormous amount of cooperation, standardization and market coordination between different countries, are unlikely to emerge as dominant, although there will still be a role for interconnectors in system optimization (and the volume of electricity traded relative to electricity supplied for local outages, may continue to increase). On the other hand, given the phenomenal success in the MENA countries with low-priced solar PV, combined with the conduciveness of natural climatic conditions, and the fact that solar PV installations are a heavy government priority in many MENA countries, the *decentralized* scenario is likely to constitute a major share of the transition process.

5. Conclusion

The tension between liberalization and decarbonization in pioneering electricity markets, such as in the EU, has arisen partly because renewables were imposed upon a market designed for conventional fossil fuel electricity. Resource-rich MENA countries, by contrast, have the opportunity to design their electricity markets around the incorporation of renewables at the outset and tap into years of international experience gained through trial and error. These countries can adopt market structures that avoid the risk of market breakdown under fully liberalized electricity systems with a high share of non-dispatchable resources.

On wholesale market design, we have argued that a hybrid structure of short-term coordination (through energy-only markets) combined with long-term contracts is proved to be the way forward for resource-rich MENA countries during the transition period, particularly given the contexts within which they operate (for example rigid governance structures and underdeveloped institutions as compared with OECD Europe). In medium to long term, these countries could move towards long-term contracts for capacity, when storage technologies and other form of low carbon flexibility resources become commercialized and competitive, and participants in the market gain experience.

For the network segment, these countries can adopt an innovation-oriented regulatory model, as opposed to traditional incentive regulation with a focus on cost efficiency. The difference between these two approaches is in the incorporation of risk in the model for regulating network companies, given the high degree of uncertainty in the outcome of innovation activities. These countries also benefit significantly from regional integration of their power markets and electricity trade. Future network regulations should account for the risk involved in the investment in interconnections.

The retail market can be opened to competition for large consumers, but for small users it can be regulated without the government distorting retail prices through subsidies. The structure of final electricity prices must not lead to inequitable distribution of system fixed costs or encourage grid defection.

Finally, the advent of prosumers, along with fall in the cost of batteries and advances in information and communication technology, may open up a new path for consumer involvement in the electricity sector. It also may provide a new design for restructuring the power sector in the form of prosumer-network-prosumer as an alternative or complement to the traditional liberalization model of wholesale-network-retail.

A key argument in this paper is that there is no one path to market liberalization, as combinations of technological advances, consumer preference, and institutional changes can offer alternative or complementary approaches to the 'classical' model of power sector reform.

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