

Abu Dhabi Electricity Sector: Features, Challenges and Opportunities for Market Integration

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Key Points

The emirate of Abu Dhabi was the first in the Gulf Cooperation Council (GCC) to design and implement reforms aimed at moving away from a wholly government-owned vertically-integrated electricity market structure. From 1998, several policy, legislative, structural and institutional reforms were introduced to Abu Dhabi's electricity sector and the related water desalination industry. The key features of the emirate's electricity market and the challenges and opportunities associated with increased participation in cross-border electricity trading are summarized as follows:

Maintaining national self-sufficiency in power on an economically competitive basis is likely to remain the core criterion for the emirate's supply-side planning. Accordingly, any possible reduction in the overall cost of electricity procurement for Abu Dhabi by using regional interconnections is seen as a big emerging driver for market integration. This is in addition to the savings that could accrue at the regional level.

With lower peak demand growth projections for the near future and the commissioning of a 5.6 gigawatt (GW) nuclear power plant scheduled for 2021 or 2022, Abu Dhabi's electricity sector is likely to produce larger power surpluses, particularly during the winter months. Abu Dhabi sees many opportunities from developing an integrated electricity market in the Gulf region. Providing open access to the transmission grid should encourage electricity trading opportunities. The existing regulatory provisions in Abu Dhabi allow for the use of its transmission network for cross-border electricity trading on the same terms as for other eligible users within Abu Dhabi.

The current single-buyer (SB) model provides limited 'implicit' competition in the procurement of bulk supply. As power generation companies (generators) do not have direct market access (i.e., whereby they can also sell their power to any buyer other than the SB, this creates little or no pressure on generators to compete with others in day-to-day operations.

The prospects of undertaking electricity trading are also hampered by the lack of volume and time-specific marginal costs for trading opportunities. However, for facilitating cross-border electricity trade, the realistic assessment of volume and time-specific marginal costs assumes significance. Efforts are being made to develop and test a robust system for determining the volume and time-specific marginal costs that would enable the SB (or generators as the case may be) to offer bids for trading surplus electricity.

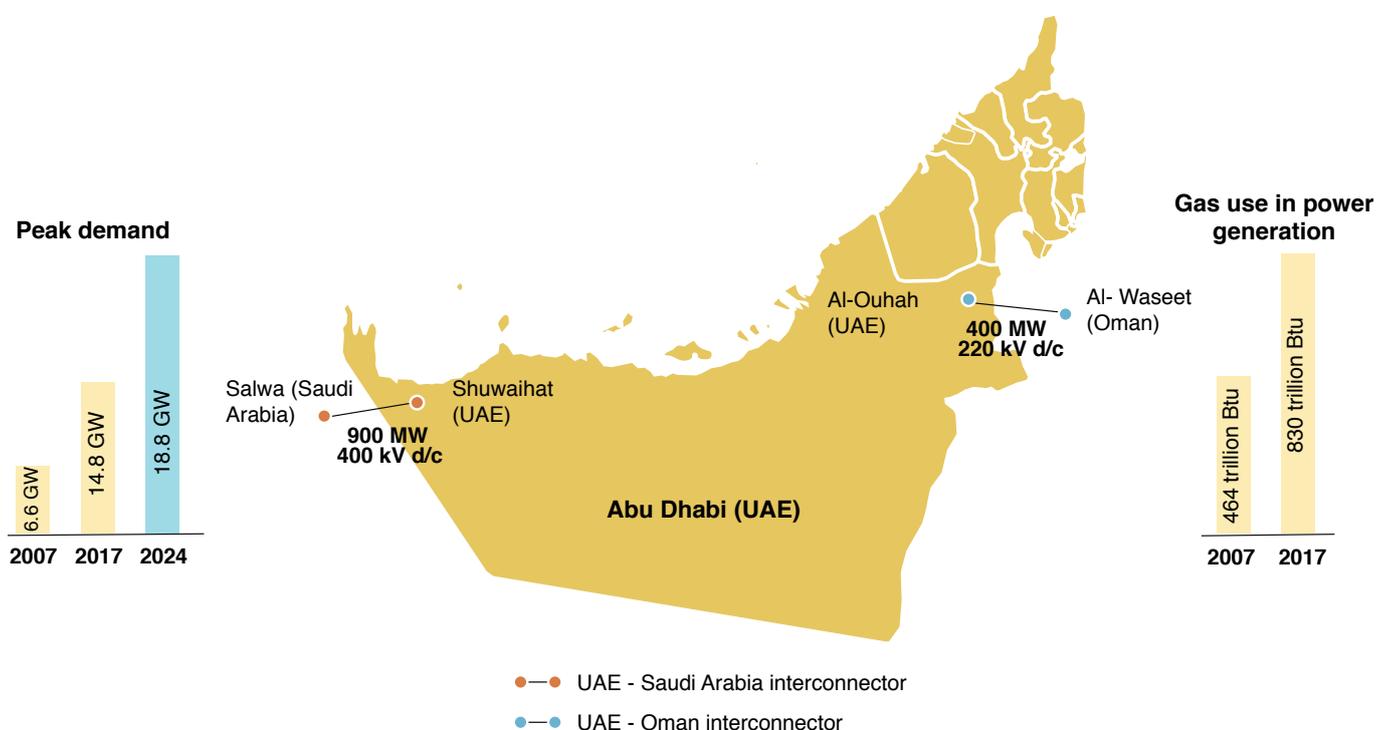
At the generation end, the emirate's electricity and water producers do not receive explicit fuel (natural gas) subsidies. However, despite significant reforms to Abu Dhabi's electricity sector and the introduction of higher and, in some cases, cost-reflective tariffs for various customer categories over the past two decades, electricity tariffs are still heavily subsidized for many residential consumers.

Abu Dhabi is exploring several options to further liberalize its electricity market. These include relaxing the conditions of 100% off-take guarantees offered to generators through SBs. Another option is to allow generators to participate in future wholesale markets when their contracts expire.

Key Points

Electricity trading is likely to be recognized as a separate licensed activity, which is expected to give fresh impetus to electricity trading within Abu Dhabi, across the United Arab Emirates (UAE) and throughout the Gulf region. To encourage the effective utilization of surplus capacity through electricity trading, a future price discovery process, such as a forward electricity market (both medium term and long term) would complement the current day-ahead scheduling for wholesale electricity.

Figure 1. Abu Dhabi electricity demand and fuel consumption.



Source: Collated from multiple sources based on information available in the public domain. The map showing regional interconnections is for representational purposes and does not show the exact transmission corridor between the countries.

Introduction

KAPSARC has initiated a research project to develop insights that can facilitate the creation of a well-functioning integrated electricity market comprising the member states of the Gulf Cooperation Council (GCC). This project aims to identify and examine the key issues affecting electricity market integration within GCC countries and the wider Middle East and North Africa (MENA) region and suggests potential enablers that could facilitate market integration. Policy, legislative, regulatory, market design, system operation and governance aspects of the electricity market will be examined for each GCC country, to identify good practice arrangements that can encourage efficient regional electricity trade. A number of power systems around the world have combined to form regionally-integrated electricity markets. Their experiences will also be studied for their potential application in the GCC region. This research project will help to fill existing knowledge

gaps for policymakers in the region and to facilitate ongoing efforts toward regional electricity market integration.

The first phase of the project addresses the features of, and the challenges and opportunities for, the electricity sectors of several countries in the region. The analysis discusses reform initiatives, restructuring activities, key market players and associated issues. It provides a deep analysis of the main themes of the electricity sectors and will serve as the backbone for a subsequent comprehensive study focusing on aspects of market design. The subsequent study will also propose a pragmatic approach to guide the transition towards more effective regional market integration. This report focuses on Abu Dhabi's electricity sector. Future reports will look at market design-related and market structure-related issues in the context of developing an integrated regional electricity market.

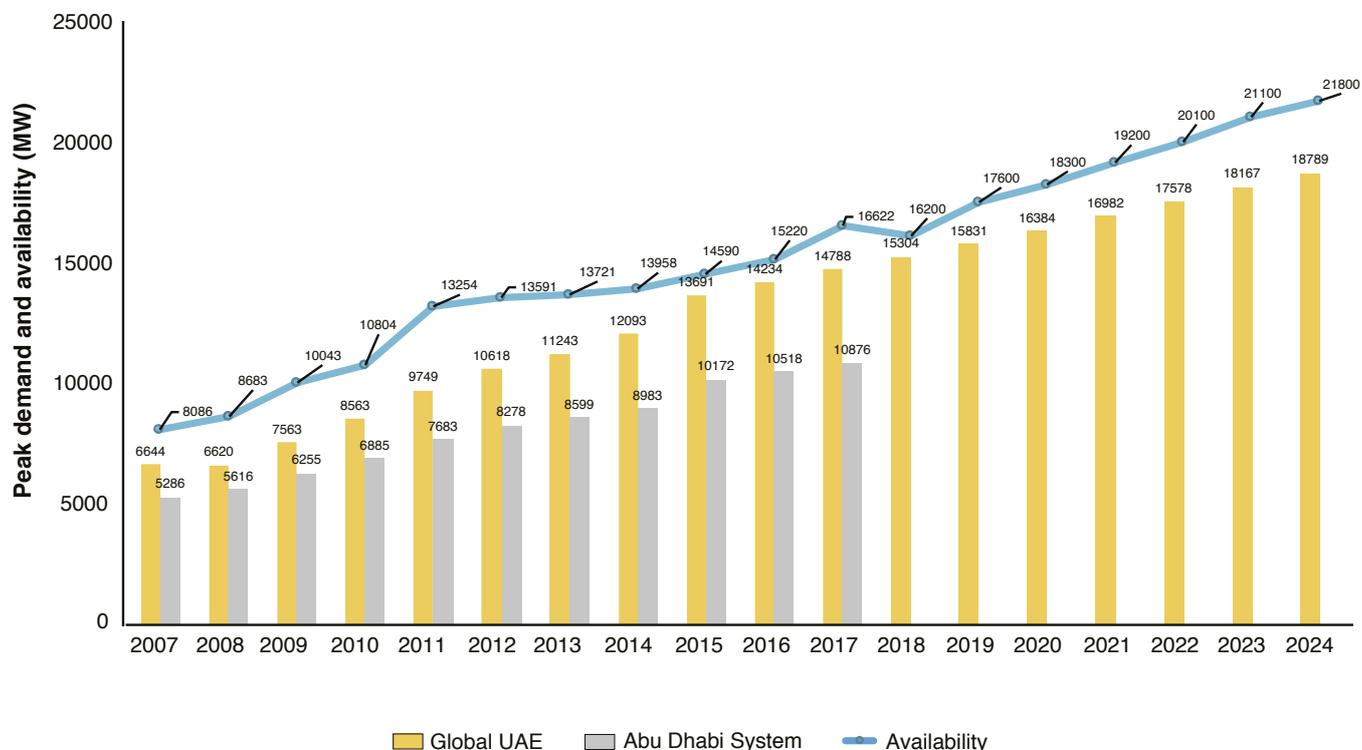
Demand and Supply Outlook

With nearly 16,622 megawatts (MW) of generation capacity and 14,788 MW of peak demand in 2017, Abu Dhabi ranks first among the United Arab Emirates (UAE) and third among GCC countries in terms of generation assets and peak demand. Abu Dhabi's rising population and growing economy have been the key factors driving the increase in peak demand (Figure 2), which grew by an average of 8.33% per year between 2007 and 2017. The growth in demand has largely come from a range of industrial and business sector activities (OBG 2014) and increased exports to the smaller Northern Emirates of Ajman, Umm Al Qaiwain, Ras Al Khaimah, and Al Fujairah. Real peak demand growth has been close to the projection made by the Abu Dhabi Water and Electricity Company (ADWEC) for 2009-2030, which

forecasted electricity demand in the emirate would grow by 7% to 8% per year until 2020.

The Abu Dhabi Transmission and Despatch Company (TRANSCO) expects the compounded future annual growth rate of peak demand to be 3.4% (base case scenario) for the period 2016-2030, significantly lower than the actual increase in the past 10 years. Lower expectations for gross domestic product (GDP) and population growth, increased energy efficiency and reduction in subsidies are likely to be potential factors behind the lower peak demand growth forecast. The electricity peak demand (including supplies to Abu Dhabi and the Northern Emirates) is projected to increase from 14.2 gigawatts (GW) in 2016 to 20 GW-26 GW by 2030 (TRANSCO 2017).

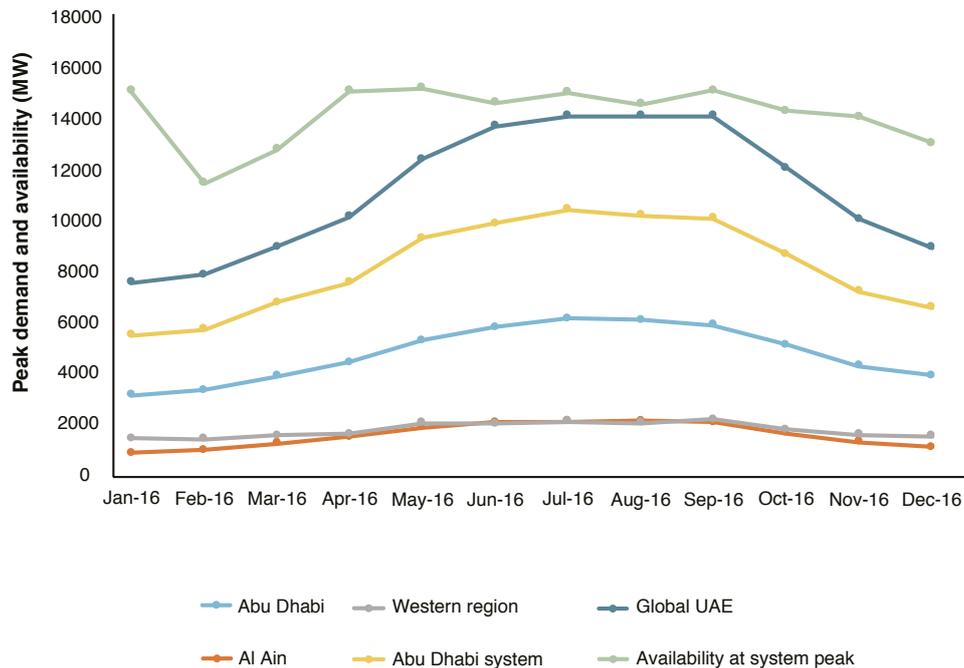
Figure 2. Historical and projected electricity peak demand.



Source: (i) ADWEC Statistical Report 1999-2016, (ii) ADWEC Statistical Leaflet 2017, and (ii) 2017 Electricity Seven Year Planning Statement (2018-2024) Main Report by TRANSCO

Note: Yellow bars indicate peak demand projections.

Figure 3. Historical variations in demand.



Source: ADWEC Statistical Report 1999-2016

Note: Abu Dhabi system demand represents the combined peak demand of Abu Dhabi municipality (also referred as Abu Dhabi region), Al Ain municipality (also referred as Al Ain region) and the Western region (also known as Al Gharbia municipality). Global UAE peak demand also includes the peak demand that is served by the emirate of Abu Dhabi in the Federal Electricity and Water Authority (FEWA) and Sharjah Electricity and Water Authority (SEWA) regions. In line with the presidential decree in 2010 the majority of all customer demand in the Northern Emirates is now met by Abu Dhabi's generation fleet and supplied through TRANSCO's transmission network. Likewise, total availability at the time of system peak also includes generation facilities located in FEWA and SEWA regions.

With 15.22 GW of available capacity in 2016 and a predictable pattern of seasonal variations in peak demand (Figure 3), surplus power capacity exists during the winter months of November to February. With the commissioning of a 5.6 GW nuclear power plant and other renewable energy projects under development, plus a moderate increase in peak demand, Abu Dhabi's surplus available capacity will further increase in the coming years. The effective utilization of this surplus capacity will require the exploration of electricity trading opportunities in the region. The share of the residential sector in Abu Dhabi's electricity consumption declined from 45.3% in 2007 to 25.6% in 2016. This decline has been compensated for by a steady increase in electricity consumption by the commercial and industry sectors over the same period (Figure 4). The commercial

sector now represents the highest electricity consuming category in Abu Dhabi, at 52.1%.

Maintaining internal self-sufficiency in power generation through competitive tendering has been core to supply-side planning in the emirate of Abu Dhabi, and is likely to be an important consideration for future growth strategies. The current fuel mix for electricity generation in the emirate is heavily dominated by natural gas, which accounts for 99.7% of the fuel used for power generation and water desalination in Abu Dhabi (ADWEC 2017). While natural gas consumption for electricity and water production has increased sharply, from 360.9 billion cubic feet (Bcf) in 2005 to 807.2 Bcf in 2017, domestic natural gas production has shown a smaller increase, rising from 2,069.6 Bcf in 2005 to 3,096.2

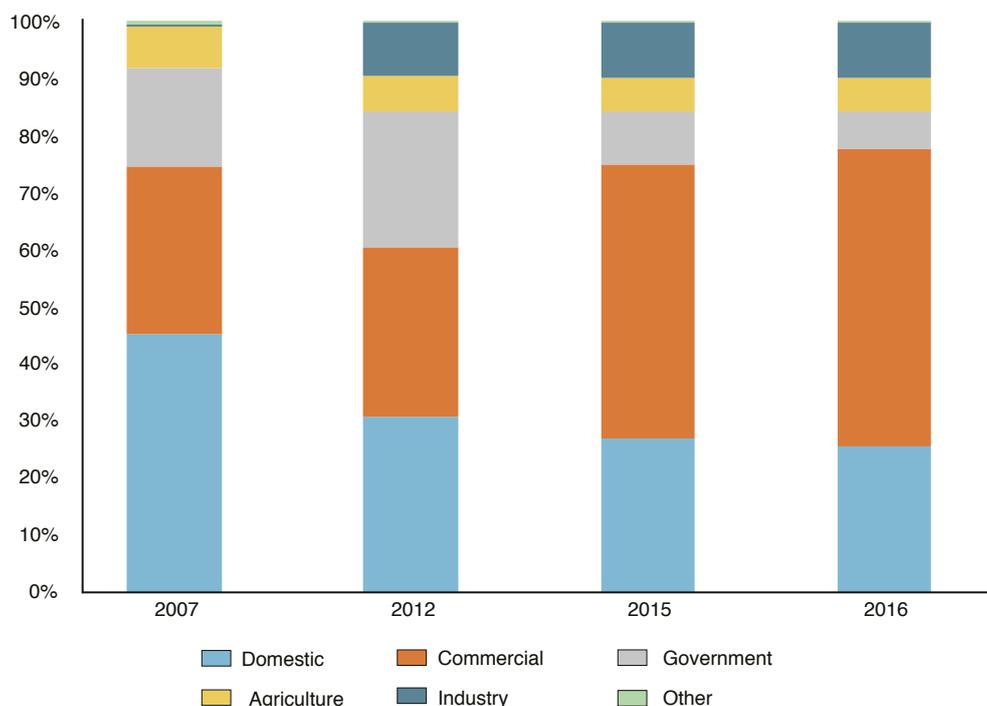
Demand and Supply Outlook

Bcf in 2017 (SCAD 2017). Abu Dhabi's growing reliance on natural gas imports for its gas-based power generation and to improve its environmental credentials has made energy diversification a national priority, with clean energy becoming an important part of the government's energy strategy. The government plans to reduce the dominance of gas in its energy mix by expanding into renewable and nuclear energy resources. In 2007, Plan Abu Dhabi 2030 acknowledged the need to use the emirate's available hydrocarbon resources cautiously, and to explore the use of non-hydrocarbon resources (mainly solar and wind) to augment the growing energy needs of its economy (ADUPC 2007). The Shams 1 (100 MW) concentrated solar power (CSP) project and the Masdar City (10 MW solar photovoltaic [PV]) project are both operational, while the 800 MW Sweihan PV project is under development. Abu Dhabi is committed to increasing its renewables-based production capacity to 7% of the country's total production capacity by 2020. To support this

objective, the Abu Dhabi Department of Energy (DoE) (formerly the Regulation and Supervision Bureau [RSB]) has emphasized the need to develop regulations and the necessary sector initiatives to encourage and integrate non-conventional power generation, including renewable energy technologies, in the coming years.

Abu Dhabi is also developing the four-unit 5.6 GW Barakah nuclear power plant. The first of the four reactors is likely to be commissioned in mid 2019. According to the Emirates Nuclear Energy Corporation, the new nuclear power plant will supply up to 25% of the UAE's electricity needs once it is fully operational in 2021/2022 (ENEC 2018). When fully commissioned, the electricity generated from the facility's four nuclear reactors will require it to explore trading opportunities for excess power capacity, both within and outside the UAE, in particular during the winter months when power demand is lower in the Gulf region (Trichakis et al. 2018).

Figure 4. Share of electricity by consumption categories.



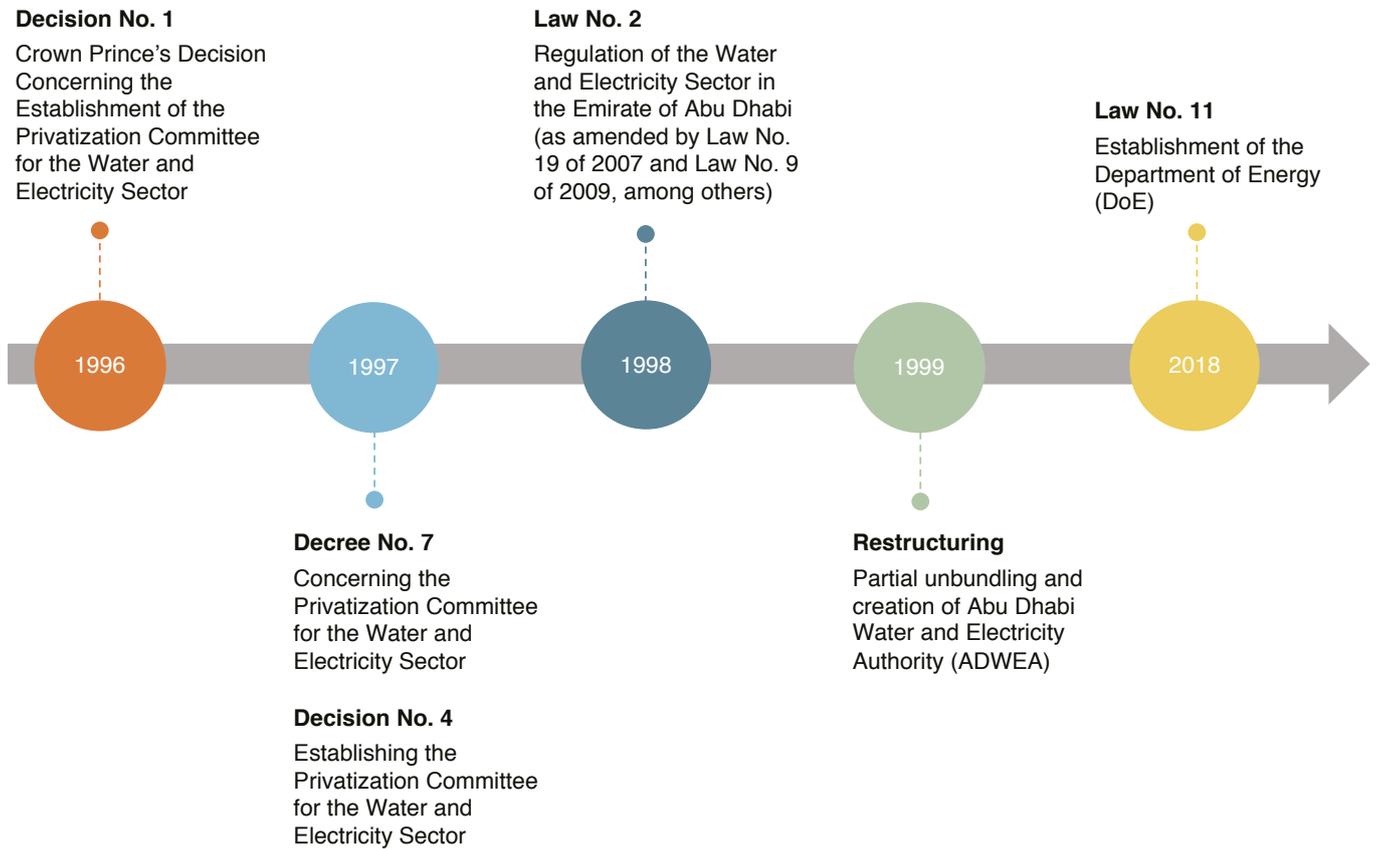
Source: Energy and Water Statistics 2016, Statistics Centre, Abu Dhabi

Reform Initiatives and Timelines

Abu Dhabi was the first in the GCC to initiate power sector reforms, moving away from the traditional state-owned vertically integrated monopoly model. Recognizing the need for private sector participation in the electricity sector amid growing power demand, the government of the emirate created the Privatization Committee in

1997, leading to the enactment of a new law for the power and water desalination sectors in 1998, and partial deregulation of those utilities in 1999. Private sector participation in power generation and water desalination was encouraged as an alternative to government-financed plants, freeing up public resources for use in other growth areas.

Key reform milestones



Restructuring of the Electricity Sector: Roles and Entities

Until February 2018, Abu Dhabi's electricity sector was governed and regulated by Law No. 2 of 1998. This legislation paved the way for the creation of various entities responsible for activities across the supply chain (Figure 5), initially owned by the Abu Dhabi government through the Abu Dhabi Water and Electricity Authority (ADWEA).

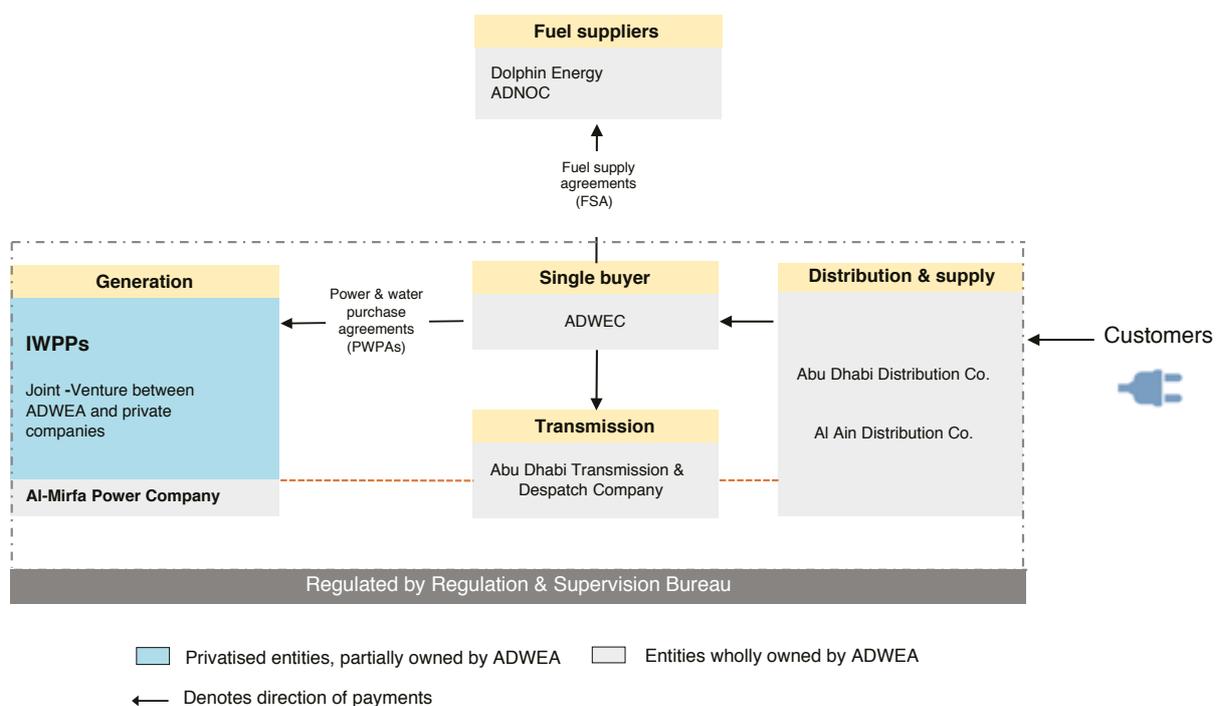
Policy, development and privatization

ADWEA replaced Abu Dhabi's Water and Electricity Department and is responsible for all matters relating to the formulation, development and implementation of policy relating to Abu Dhabi's water and electricity sector, including privatization. ADWEA was created as a government-owned entity with legal and administrative independence. Its remit was to ensure a sustainable supply of

power and water in the emirate while improving the cost-efficiency of the sector through private sector participation and other demand-side interventions.

ADWEA retained ownership of the share capital of the Abu Dhabi Power Corporation (ADPC). In addition to managing the emirate's public sector entities, as part of the privatization program, ADWEA was allowed to form joint ventures under the build-operate-transfer (BOT) or build-operate-own (BOOT) models for water and electricity production. Article 19 of the 1998 legislation exempted ADWEA from the public tendering and procurement laws applicable in Abu Dhabi and empowered it to issue its own regulations to regulate tenders and procurement activities. Its other functions included (i) the promotion of research, conservation and the efficient use of electricity and water, and (ii) the publication of information or advice on matters of public interest.

Figure 5. Abu Dhabi electricity industry structure (1999-February, 2018)



Source: Abu Dhabi Transmission & Despatch Company (TRANSCO).

The single buyer

The state-owned Abu Dhabi Water and Electricity Company (ADWEC), was created in 1998 to ensure sufficient potable water and power capacity in the emirate and to buy all water and electricity produced in the Emirate of Abu Dhabi. In late 2018, the Emirates Water and Electricity Company (EWEC) was established to replace ADWEC, with a wider mandate to cover the Northern Emirates in addition to the emirate of Abu Dhabi. EWEC is wholly-owned by the government-owned ADPC. EWEC is responsible for procuring and supplying natural gas to all water and power generation companies. The single-buyer (SB) model encapsulated by ADWEC created a high level of certainty for producers and for ADWEC through long-term power and water purchase agreements (PWPAs), commonly referred to as off-take agreements. These agreements are awarded through a competitive tendering process based on the lowest levelized unit cost of electricity production. However, such PWPAs also eliminate the possibility of developing a competitive bulk supply market as ADWEC purchased all power output. The costs of purchasing power, water and natural gas, plus EWEC's operational costs, form the basis of the bulk supply tariff (BST). This tariff is in effect the wholesale power and water tariff for the sector, and is calculated by EWEC and approved by the DoE each year. The BST represents between 50% and 60% of total sector costs. EWEC calculates the BST, including the cost of electricity imports, and it is then reviewed and approved by the regulator as per the tariff determination process.

Transmission and despatch

The Abu Dhabi Transmission and Despatch Company (TRANSCO), a wholly owned subsidiary of ADPC, carries out the transmission and despatch of power in the emirate. TRANSCO owns and

operates Abu Dhabi's power transmission network, which comprises a mixture of 400-kilovolt (kV), 220-kV and 132-kV lines. TRANSCO also operates the load despatch center and is responsible for developing (i) procedures for the economic and technical despatch of production facilities, and (ii) a system for the settlement of payments for the providers of production capacity, delivered electricity output and ancillary services.

Planning for the transmission infrastructure is carried out by TRANSCO, based on the investment requirements consistent with the government's vision. A seven-year electricity planning statement (known by the abbreviation E7YPS) is prepared annually for network development and presents a forward view of an integrated generation transmission system expansion plan. While preparing the network development strategy, TRANSCO (i) relies on the assessment of the demand forecast and commensurate generation capacity requirements by EWEC, which are part of its duties under the law, and (ii) undertakes its own techno-economic and risk analysis in accordance with the relevant grid codes and standards, consistent with international best practice. Ensuring system security in grid operation is the basic criterion in assessing the bulk transmission system capabilities. It also solicits feedback from users seeking the use of the transmission system. E7YPS is reviewed by the Abu Dhabi electricity regulator and amended as required. Existing transmission facilities with no significant additional cost may be able to accommodate the first large-scale solar power projects being developed at Sweihan in Al-Ain region of the emirate (TRANSCO 2017). The transmission capacity reinforcement needed to enable power evacuation from the under-construction 5.6 GW Barakah nuclear power plant (located in the western region) was included in TRANSCO's 2017 E7YPS.

Restructuring of the Electricity Sector: Roles and Entities

Abu Dhabi's power transmission system is connected to the Northern Emirates and Dubai through the Emirates National Grid, referred to within the UAE as regional grid interconnections. Abu Dhabi is also connected to the electricity grids of Saudi Arabia and Oman through international grid interconnections established through the GCC Interconnection Authority (GCCIA). The GCCIA grid provides an alternative source for operating reserves and support during power shortages or emergencies. These regional and international grid interconnections offer yet untapped electricity trading opportunities between neighboring countries in the Gulf region, lowering power procurement costs for participating countries, and offering additional savings such as reducing and/or deferring investment in new generation capacity at the regional level due to the further integration of the electricity market (TRANSCO 2017).

Abu Dhabi's electricity market has been designed under the capacity market model, where electricity generators are paid their capital recovery and fixed operation and maintenance (O&M) costs on the basis of committed or declared power availability from a power plant, irrespective of whether and how much the plant produces. This addresses the perceived risks associated with under-recovery of investors' fixed costs. Additionally, a variable O&M cost is paid by TRANSCO to cover the generating plant's variable costs and other cost elements such as back-up fuel costs.

The expected fuel consumption for a range of loading conditions and efficiency norms over the plant's life is provided by generators through PWPAs. Their performance and actual fuel cost are monitored regularly by EWEC with inputs from TRANSCO. This cost (i.e., fuel cost) is paid directly by EWEC to the Abu Dhabi National Oil Company (ADNOC) and to Dolphin Energy, the two main

suppliers of natural gas to the emirate's IWPPs. However, IWPPs are incentivized to consume fuel efficiently through a bonus-penalty mechanism under the PWPAs, based on benchmark (or reference) heat rates, and minimum requirements as set by the regulator, where applicable. No subsidies are included in the assessment of the fuel cost. Gas is offered at a competitive price, but below the market price for power production (Graves 2016).

TRANSCO prepares a day-ahead generation schedule for various generating units, largely within the bounds of power purchase agreements between EWEC and the IWPPs, and takes note of other relevant technical considerations. There is an implicit competition in day-ahead scheduling as the most efficient plants are despatched first in the unit commitment schedule, wherein it optimizes the production costs for the next 24-hours. Operational timescales for system operation and despatch follow day-ahead generation schedules with hourly scheduling. There are no separate ancillary and balancing services markets as the existing power producers are required to provide these services under the main power purchase contracts, which define the conditions and requirements for providing such services.

Unlike many wholesale electricity markets that follow a single market clearing price (i.e., the price of the highest accepted offer), each generator in Abu Dhabi is paid a separate price based on its power contract or PWPA, when despatched according to TRANSCO's economic scheduling model. Conceptually, a truly competitive wholesale market (where no single buyer or seller is large enough to influence the market) can incentivize both short-run efficiency (i.e., efficient despatch with electricity production at least-cost throughout the day) and long-run efficiency (i.e., investments in new generation to maximize profits). However,

such competitive pressures are not present in a market design characterized by a SB model with guaranteed power off-take, a feature common in most Gulf countries.

Currently, the SB buys all the power, the system operator follows a day-ahead scheduling process aimed at the aggregate optimization of electricity procurement costs in accordance with the relevant PPAs, and the SB pays the fuel cost directly. Therefore, the need to accurately know the volume and time-specific marginal costs of electricity production for trading opportunities is considered unimportant. However, in order to facilitate cross-border electricity trade, it is important to have a realistic assessment of volume and time-specific marginal costs.

The lack of accurately determined marginal costs of electricity production for specific trading opportunities has been highlighted as one of the key barriers to Abu Dhabi (and other GCC member states) undertaking cross-border electricity trades. From both buyers' and sellers' perspectives, knowing the marginal costs of production is an important enabler of cross-border electricity trading. Efforts are being made to design and test a more robust pricing system that would help SBs (or generators as the case may be) when placing their bids, and which would be more reflective of the opportunity costs linked to specific volumes and times of providing electricity for export.

Moreover, the existence of either implicit or explicit fuel subsidies for electricity production continues to distort the real cost of electricity production in the region. Therefore, the current approach of supply-side pricing may be unsuitable for trading purposes and may send incorrect price signals to potential competitors. As a result, the nodal agencies in GCC member states that are

responsible for the import and export of electricity are often reluctant to disclose and share their marginal costs with counterparts across borders and actively engage in cross-border electricity trading. Given this reluctance, there is a good case for the establishment of a regional, neutral, entity that can help member states develop a robust methodology for assessing the marginal cost of electricity production, reflecting the fair value of the commodity for trading purposes. Designing and implementing an acceptable and transparent regulatory approach for cost-reflective marginal pricing will be an important enabler for cross-border electricity trade.

Distribution/supply

Electricity distribution and supply functions in Abu Dhabi are carried out by two companies, the Abu Dhabi Distribution Company (ADDC) and the Al Ain Distribution Company (AADC), also wholly-owned by ADPC (formerly ADWEA). Their responsibilities include the ownership, operation and maintenance of the country's water and electricity distribution network assets, meter reading, and services relating to the supply of water and electricity in their respective areas. AADC is the sole distributor and supplier of water and electricity in the eastern region of the emirate, focusing on the city of Al Ain and surrounding rural areas. ADDC supplies water and electricity to customers in the rest of the emirate and is the largest of the two electricity distribution companies in Abu Dhabi.

Independent water and power producers (IWPPs): selection, ownership and PPAs

A number of independent water and power producers (IWPPs) have been established in the emirate since the start of electricity and water sector liberalization in 1998, and they account for nearly all

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of Abu Dhabi's power generation and desalination capacity. The privatization of these utilities had strong political support from the emirate's leadership (Ameri 2017). This political support and the business-friendly environment of Abu Dhabi boosted the confidence of potential private players, leading to the successful privatization of the emirate's power generation business.

The greenfield power generation and water desalination projects are awarded through a competitive bidding process based on the lowest levelized tariffs for the sale of water and electricity to EWEC (formerly ADWEC). The divestment of existing projects relies on maximizing the asset value for a given tariff (RSB 2013). The levelized tariff is calculated based on the given assumptions about availability, production, fuel prices and other factors. In the past, a nominal internal rate of return (IRR) of 13% on equity was guaranteed to prospective private producers in the base case scenario. This rate has been reduced in recent tendering processes for new IWPPs, reflecting current market conditions. However, a reasonable IRR is assured to ensure the financial viability to private investors.

EWEC (formerly ADWEC) uses a two-part tariff structure for making payments to IWPPs under PWPAs. The capacity (or availability) payments cover the fixed costs of the plant comprising of return on capital, depreciation and fixed operating and maintenance (O&M) costs, to be paid against the declared availability of power, irrespective of whether and how much the plant produces. The second component of the tariff allows for the recovery of variable O&M costs, payable only for the electricity produced by the plant. Various payment rates are subject to annual indexation against United States and UAE inflation and/or the dollar-dirham exchange rate. Other supplemental

payments, such as start-up and shut-down costs, and back-up fuel costs are also paid to the producers by EWEC. EWEC pays gas suppliers for the natural gas consumed by each IWPP, insulating power producers from market- and gas supply-related risks. Once the projects are awarded, the sale price of electricity, off-take obligations and the gas price are defined in the contractual agreement between each IWPP and EWEC. The power and water purchase agreements usually have a term of 20 to 25 years from the start of commercial operations.

In daily operational scheduling, the current market design does not allow IWPPs to compete for their dispatch at shorter operational (e.g., a sub-hourly basis) timescales, and does not incentivize them for offering various other products/services linked with the time and scarcity of resources (e.g., ancillary services and demand response). It was noted that investors "might simply walk away" if they had to compete in the day-ahead market (Al-Sunaidy 2011). EWEC (formerly ADWEC) manages the entire bidding process for power and water desalination projects through the pre-qualification of bidders, issuing requests for proposals and selecting successful bidders for water and power projects, which can be a single company or a consortium of companies. The ownership of the IWPPs is split 60:40 between the government (through its subsidiaries) and private sector (domestic and/or foreign) investors. The 60% government shareholding is 10% held by ADPC (formerly ADWEA) and 90% held by the Abu Dhabi National Energy Company (more commonly known as TAQA). A few project companies have other ownership structures. To limit market concentration, joint venture partners are not allowed to collectively own more than 25% of the market capacity.

Regulation, price control and price reforms

RSB was established as an independent regulator, and its powers, duties and functions were set out in Law No. 2 of 1998 and subsequent amendments. RSB's key functions included: (i) price control covering EWEC, TRANSCO, ADDC and AADC, (ii) issuing licenses to conduct regulated activities, (iii) monitoring the performance and compliance of licensees, and (iv) making regulations as it saw fit for the regular, efficient and safe supply of electricity in the emirate. Law No. 19 of 2007 changed the bureau's reporting structure and expanded its authority to license and regulate entities carrying collecting, treating and disposing of sewage and wastewater.

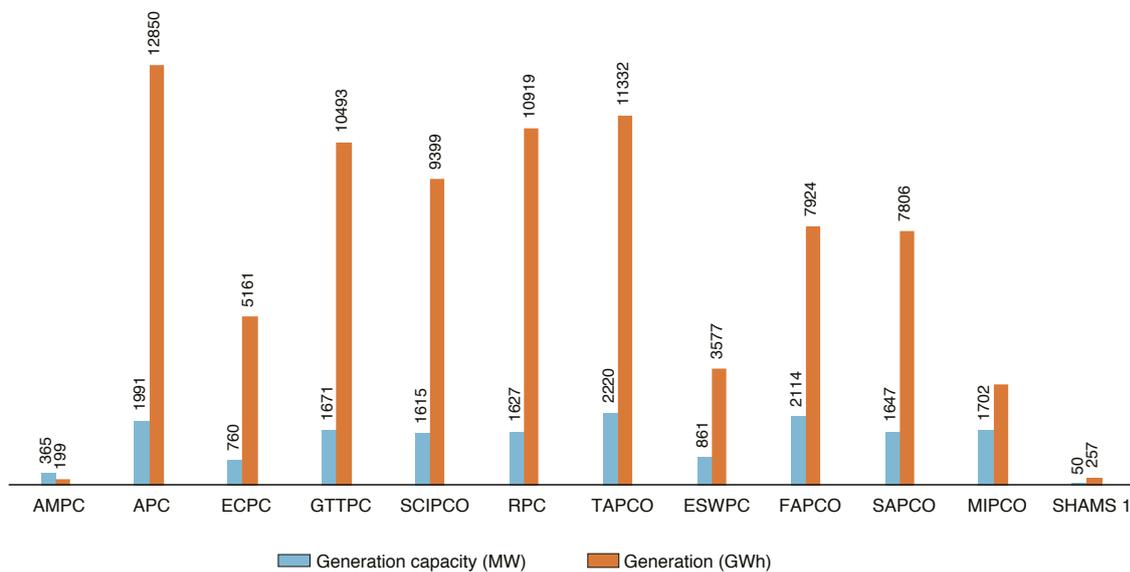
The price controls for the network companies have been in the form of the consumer price index-X factor (CPI-X) revenue caps. The RSB set the maximum allowed revenue (MAR) for each company or business for each year of the price control period. MAR is made up of an estimate of operating costs, regulatory depreciation and regulatory returns (i.e., return on capital). Despite making progress in reforming the emirate's electricity sector, retail tariffs are still heavily subsidized for local citizens. However, Abu Dhabi's residential electricity tariffs for expatriates have increased significantly in the past decade and are now close to the cost of supply (Figure 7). The UAE is almost unique in having a very large expatriate population and a relatively wealthy, small, population of nationals (Boersma and Griffiths 2017).

Open access to transmission and distribution network

In the current market arrangement, all generators of electricity are connected to the transmission grid and are only allowed to sell their electricity to the SB. Further, companies that intend to generate power and/or desalinate water primarily for their own consumption may offer for sale surplus electricity or water in excess of their requirements to the SB only under a 'self-supply' license. While access to the transmission and distribution network is available to all potential users within Abu Dhabi, TRANSCO's network can also be utilized by intended users (single/principal buyers and/or any other eligible party) from across the border for any potential cross-border electricity trading activities on payment of wheeling charges, subject to the availability of the transmission network. Further, in all such cases, intended users from outside Abu Dhabi are required to pay the same level of wheeling charges as paid by other eligible users in Abu Dhabi. TRANSCO calculates the transmission wheeling charges, which are then approved by the DoE (formerly RSB). This is a positive first step, indicating a willingness to provide non-discriminatory access to transmission to encourage cross-border electricity trading. However, unless the current SB model is changed to a multi-buyer and multi-seller wholesale market design, open access to the transmission grid will have limited relevance in promoting competition and facilitating electricity trading within or outside the country.

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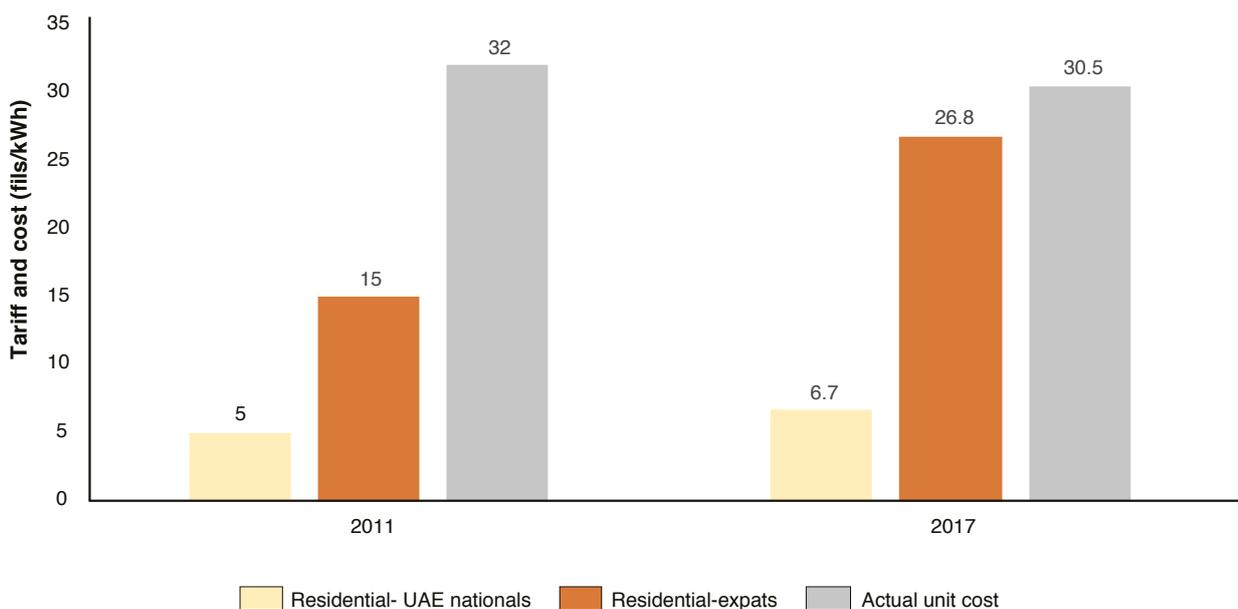
Figure 6. Abu Dhabi generation capacity by company.



Source: ADWEC Statistical Leaflet 2017

AMPC (Al-Mirfa Power Company), APC (Arabian Power Company), ECPC (Emirates CMS Power Company), GTTPC (Gulf Total Tractebel Power Company), SCIPCO (Shuweihat CMS International Power Company), RPC (Ruwais Power Company), TAPCO (Taweelah Asia Power Company), ESWPC (Emirates SembCorp Water and Power Company), FAPSCO (Fujairah Asia Power Company), SAPCO (Shuweihat Asia Power Company PJSC), MIPCO (Mirfa International Power & Water Company), Shams 1 (Shams Power Company)

Figure 7. Abu Dhabi: Power supply cost versus residential electricity tariffs.



Source: (i) (Collins 2012), and (ii) Water & electricity tariffs 2017 for ADDC and AADC.

Recent Developments – The Establishment of the Department of Energy (DoE)

Law No. 2 of 1998 provided the mandate to ADWEA and the RSB to deal with policy matters and to regulate the water and electricity sector. Hydrocarbon sector activities were administered by other concerned state-owned entities and the Supreme Petroleum Council (SPC). In February 2018, a series of new laws was issued by the government of Abu Dhabi to revamp past economic reforms. This included Law No. 11 of 2018 to revamp earlier energy reforms in the emirate through the establishment of the Abu Dhabi Department of Energy (DoE) and consolidating all energy policy and regulatory functions under one entity. The DoE replaced ADWEA and RSB. In addition to the electricity and water sector, the DoE's mandate also includes the production, processing, storage, transmission, distribution, supply, sale and purchase of natural gas, petroleum, and related by-products without prejudice to the SPC's mandate. The DoE's mandate is to develop and implement public policies that drive the future direction and provisioning of the emirate's energy sector in all its forms. It is tasked with developing strategic initiatives aimed at diversifying and securing energy sources for economic, environmental, and social sustainability in Abu Dhabi. Its responsibilities include:

- Developing strategic plans to grow the energy sector and monitoring the execution of these plans.

- Regulating all aspects of the energy sector through developing policies, codes, standards, rules, resolutions and circulars.

- Licensing activities in the energy sector and monitoring their compliance.

- Proposing fees, tariffs, and prices and submitting them to the Executive Council for approval.

- Encouraging investment from and partnership with the private sector.

- Representing the energy sector within and outside the UAE.

- Promoting energy and water efficiency initiatives and programs.

(DoE 2018)

At the time of writing, Law No. 11 of 2018 was not yet available in the public domain, so further details on its scope and approach for the energy sector are unclear. However, we understand that all of RSB's and ADWEA's assets, rights and obligations have been transferred to the DoE, and that the DoE will henceforth be responsible for executing all the functions previously carried out by ADWEA and the RSB. The Abu Dhabi Power Corporation now owns all the subsidiaries of the former ADWEA. It is also possible that electricity trading may be recognized as a separate licensed activity and that TRANSCO may be granted the license to carry out such activities in addition to its continuing role as owner and operator of the transmission infrastructure. Other entities such as the SB (now through EWEC), TRANSCO, ADDC and AADC will continue to perform their respective roles.

Summary and Insights

The reform initiatives that started in Abu Dhabi in 1998 seeking to promote a bigger role for the private sector in the emirate's electricity production and to improve the regulation and governance of the country's electricity sector, have come a long way. The introduction of the Law No. 2 of 1998 was a key first step which provided direction for the liberalization of Abu Dhabi's power industry and future market design. Law No. 11 of 2018 has further expanded the scope of reforms to provide an objective and coherent approach to the development of the emirate's energy sector. The key features, challenges and opportunities for further market integration are summarized below:

Policy, legislation and governance

Law No. 2 of 1998 presented the new design for the electricity and water sector and clearly articulated the functions and powers for the new entities to be created under the law, stipulating roles ranging from policy design and implementation, to regulation and governance, and the planning, production and supply of electricity and water. The enactment of this law arguably helped build confidence among prospective private investors in the Abu Dhabi power and water industry and supported the government's vision for the privatization of the utility sector in the emirate. The RSB also contributed to matters related to sector policies by developing policy proposals for expanding private sector involvement and implementing economic tariffs. The DoE has now assumed the wider policymaking role for the energy sector. However, the SPC continues to be responsible for setting and regulating petroleum-related policies, objectives and activities in Abu Dhabi.

Regulation

The 1998 law paved the way for the establishment of the regulator, the RSB (now DoE). The new

regulator was assigned the sole and exclusive authority to regulate the emirate's electricity and water sector, covering the economic and technical aspects of all licensed power and water operators. In regulating the electricity sector, the RSB followed the CPI-X revenue cap regulation model, defining the MAR for each year of the price control period, and adjusting it by CPI inflation less factor X to reflect various considerations including revenue profiling and potential cost savings.

Challenges to the price control regime have been addressed through changes to the regulatory price control mechanism over the years, but the basic form of price control has remained broadly unchanged since it was established. Various regulations framed by the RSB for regulating the sector were designed to drive improvements in sectoral efficiency. These include capital cost efficiency, operational efficiency, and customer service. In addition to the typical roles discharged by electricity regulators around the world, Abu Dhabi's RSB also on occasion prepared and presented its vision for the electricity sector, identifying priority areas for the coming five years and the initiatives required to drive progress in these areas. The RSB encouraged competition through competitive tendering, benchmarking, market share limits (to protect the sector from market dominance by one or a few companies) and private sector investment.

While access to the transmission and distribution network is available to all potential users within the emirate, TRANSCO's network is also made available for use in any potential cross-border trading activities on payment of the same level of wheeling charges as paid by other eligible users in Abu Dhabi, subject to the availability of network capacity. Such regulatory provisions should encourage cross-border electricity trading.

As part of the 2018 restructuring of Abu Dhabi's electricity industry, as set out in that year's Law No. 11, ADWEA and the RSB were replaced by the newly-created DoE. The DoE is now responsible for the overall development of the emirate's energy sector and performs all of the policy and regulatory functions previously carried out by ADWEA and the RSB. The 2018 reform aimed to consolidate all energy sector policy and regulatory functions under one government entity and to formulate coherent strategic plans for developing the emirate's energy sector, including oil, gas and renewable energy.

Market design

In line with the provisions of the electricity law and RSB's vision, all new generation projects are awarded through a competitive bidding process based on the lowest levelized tariffs for the sale of electricity to EWEC (formerly ADWEC), a SB. The levelized tariff is calculated based on the assumptions of availability, production, generator fuel prices and other factors. As competition is restricted at the entry level, optimization of the production cost for various generating units is largely done within the bounds of PPAs between EWEC and IWPPs, subject to demand and other technical constraints.

Abu Dhabi's electricity market design is based on the capacity market model. The electricity generators are paid capital recovery and fixed O&M costs on the basis of committed availability of their production facilities, in addition to the variable O&M and fuel costs. While this market model has been able to address the perceived risks associated with under-recovery of the IPPs' fixed costs, the exclusivity provisions in single buyer PPAs could make developing a more competitive wholesale electricity market more challenging.

Regarding the timescales for system operation and despatch, TRANSCO prepares only day-ahead generation schedules based on the declared availability received from generators for each generating unit. The day-ahead scheduling creates implicit competition as the most efficient plants are despatched first in the unit commitment schedule. The schedule aims to optimize the aggregate electricity procurement cost in accordance with the relevant PPAs for the next 24 hours. There is a need to develop a future price discovery process, such as a forward electricity market, where forward electricity contracts with delivery and withdrawal obligations can be traded (both medium term and long term) to complement the existing day-ahead scheduling for wholesale electricity and to encourage the effective utilization of surplus capacities through electricity trading. A shorter-term market, i.e., intra-day, can help in addressing intermittency issues by offering greater flexibility in an electricity market that is expected to have a larger share of renewables in the future.

Access to the transmission network at reasonable prices is important not only to encourage cross-border electricity trading but also to utilize any surplus power capacity effectively. In this regard, allowing access to TRANSCO's transmission network for cross-border electricity trading on the same terms as other eligible users within Abu Dhabi is a positive step. Moreover, the transparent mechanism followed in publishing the transmission use of system charges makes it easier for any intended users (within and outside Abu Dhabi) to evaluate the economics of open access.

Market integration

With lower peak demand growth projections for the near future and the commissioning of a 5.6 GW nuclear power plant, the Abu Dhabi electricity sector

Summary and Insights

will likely witness bigger power surpluses in future, particularly during the low-demand winter months. The surplus capacity will provide an incentive to trade electricity both within the UAE and across the wider Gulf region. Electricity trading is likely to be recognized as a separate licensed activity, which is expected to give fresh impetus to electricity trading both within the country and throughout the region.

Natural gas in Abu Dhabi is offered at a competitive price for industrial users but the price remains below free-market levels for power production. Although this does not equate to an explicit gas subsidy for electricity producers, the concern that power exports from Abu Dhabi represent an implicit wealth transfer is unlikely to arise as a barrier to cross-border electricity trade.

In the current market arrangement where electricity is sold to the SB, the fuel cost is paid by the SB directly to gas suppliers and day-ahead scheduling aims to optimize costs over the next full-day. The need to accurately determine the marginal costs of electricity production for specific trading opportunities is considered unimportant. However, in order to facilitate cross-border electricity trade, the realistic assessment of volume and time-specific

marginal cost becomes important. In this regard, efforts are being made to develop and test a robust system to determine the volume-specific and time-specific marginal costs that can enable SBs (and generators as the case may be) to make bids for trading their surplus electricity. More efficient price signals (or at least clear bilateral contracts) will likely be needed to facilitate cross-border electricity trade. Further, the nodal agencies in Gulf states that are responsible for exporting electricity have typically been reluctant to disclose and share their marginal costs with their counterparts across the borders due to implicit or explicit fuel subsidies offered for electricity production.

In this regard, a case can be made for the establishment of a neutral regional entity that can help harmonize necessary regulations, wherever relevant, to encourage cross-border electricity trade. This may also include developing a robust methodology for assessing the marginal cost of electricity production, reflecting the fair value of the commodity for trading purposes. Designing and implementing an acceptable and transparent regulatory approach for cost-reflective marginal pricing is expected to be an important enabler for cross-border electricity trade in the region.

References

Abu Dhabi Department of Energy. 2018. "Laws and Regulations." Accessed January 2019. <http://www.doe.gov.ae/en/laws-regulations>

Abu Dhabi Transmission & Despatch Company (TRANSCO). 2017. "2017 Electricity Seven Year Planning Statement (2018-2024), Main Report." http://www.transco.ae/media/pdf/2017%20Electricity%20Seven%20Year%20Planning%20Statement_Main%20Report.pdf

Abu Dhabi Urban Planning Council (ADUPC). 2007. "Plan Abu Dhabi 2030." <https://government.ae/en/about-the-uae/strategies-initiatives-and-awards/local-governments-strategies-and-plans/plan-abu-dhabi-2030>

Abu Dhabi Water & Electricity Company (ADWEC). 2017. "Statistical Leaflet 2017." http://www.adwec.ae/Documents/Leaflet/Statistical_Leaflet_Final_Flat_2017.pdf

Al Ameri, Hamad, and Bakhit, Al Ameri. 2017. "Privatization of the Utilities Sector of Abu Dhabi, UAE." *Journal of Economics and Sustainable Development*.

Al-Sunaidy, Ali Masoud Ali. 2011. "Electricity service utilities in the GCC: Steps towards a common regulatory reform." Ph.D. thesis, Business School, The University of Hull. Hydra. <https://hydra.hull.ac.uk/resources/hull:6232>

Boersma, Tim, Griffiths, Steve. 2016. "Reforming Energy Subsidies – Initial lessons from the United Arab Emirates." Brookings Energy Security and Climate Initiative. https://www.brookings.edu/wp-content/uploads/2016/01/esci_20160119_uae_energy_subsidies.pdf

Collins, Laura. 2012. "The real cost of water and electricity will shock you." *The National*, April 7, 2012, Abu Dhabi, UAE. <https://www.thenational.ae/arts-culture/the-real-cost-of-water-and-electricity-will-shock-you-1.354574>

Emirates Nuclear Energy Corporation (ENEC). 2018. "Barakah Nuclear Energy Plant." <https://www.enec.gov.ae/barakah-npp/>

Graves, LeAnne. 2016. "Industrial companies in Abu Dhabi to face higher gas bill." *The National*, December 29. <https://www.thenational.ae/business/industrial-companies-in-abu-dhabi-to-face-higher-gas-bill-1.217224>

Oxford Business Group (OBG). 2014. "The Report: Abu Dhabi 2014." <https://books.google.com.sa>

Trichakis, Pavlos, Nicholas Carter, Stephen Tudhope, Ilesh Patel, Sgouris Sgouridis, and Steve Griffiths. 2018. *Enabling the UAE'S Energy Transition - Top Ten Priority Areas for Renewable Energy Policymakers*. Abu Dhabi: EWS-WWF. https://www.moei.gov.ae/assets/download/2db7770e/Enabling%20the%20UAE%E2%80%99s%20energy%20transition_%20F3_EWSWWF_WEB.pdf.aspx

Regulation and Supervision Bureau (RSB). 2013. "Independent water and power producers." <http://rsb.gov.ae/assets/documents/231/infoiwpp.pdf>

Statistics Centre Abu Dhabi (SCAD). 2017. "Energy and Water Statistics 2016." <https://www.scad.ae/Release%20Documents/Energy%20and%20Water%20Statistics%202016%20-%20EN.pdf>

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About the Project

Mindful of the potential opportunities that could be harnessed by developing a common electricity market in the GCC and wider MENA region, KAPSARC has initiated a regional electricity market integration research project. It examines a range of issues relating to electricity market integration, including experiences of other power pools and their potential application for this region. The project will focus on understanding and examining the policy and legislative, market design and structure, regulatory and system operation dimensions of electricity markets, to identify good practice arrangements and to provide insights into policy and regulatory issues. The various outputs are intended to fill existing knowledge gaps and facilitate ongoing efforts toward regional electricity market integration.

Notes



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