Middle East Energy Dubai

Role of Energy Storage
in GCC's Clean Energy Transition

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Middle East's focus on the transition toward clean energy

Around the world, a remarkable movement is taking shape, as nations, organizations, and individuals come together to tackle some of the most pressing issues facing our planet such as global warming reduction, decreasing dependence on fossil fuels, and transitioning to clean energy. To track progress and discuss efforts towards these goals, the Conference of Parties (COP) is held annually.

This year, COP28 will be held in the United Arab Emirates (UAE) to recognize the crucial role of Middle Eastern countries in this journey toward decarbonization. According to IRENA, the Gulf Cooperation Council (GCC) countries, including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE, are among the world's top hydrocarbon-producing nations.

CO_2 Emissions by GCC countries

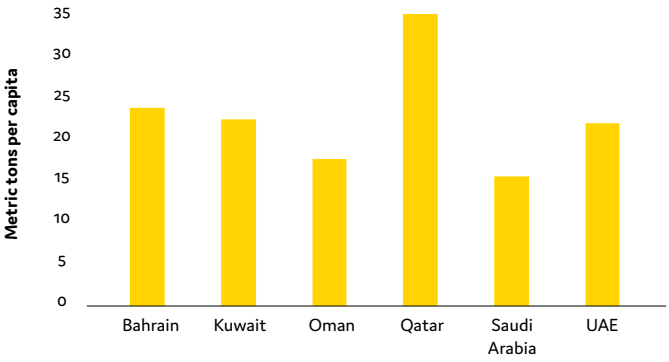


Figure 1: Carbon Emissions in the GCC Region in 1] 2019]
Source: World Bank

Hence, their efforts to introduce decarbonization targets have significant importance. Moreover, holding COP28 in the UAE also highlights the importance of the GCC region in global efforts toward a sustainable future.

Middle Eastern countries depend heavily on their fossil fuel resources to meet their rapidly increasing energy demand and consumption. According to a report by published by World Bank in 2022, the GCC region's GDP growth is expected to reach US$ 6 trillion by 2050, however, if GCC implements a green growth strategy, then its GDP would have the potential to reach US$ 13 trillion by 2050. [2]

As of 2021, the renewable energy share in the GCC region was relatively low compared to other regions of the world. The cumulative capacity of renewable energy is around 3,352 MW in the GCC region [3]. The majority of the GCC countries' electricity still comes from fossil fuels, primarily oil and natural gas. Looking forward, GCC countries have strategies in place to include renewable and clean energy sources in their electricity generation mix that entails the addition of solar, nuclear power, biomass, and hydrogen.

Cumulative Renewable Installation in the GCC Countries

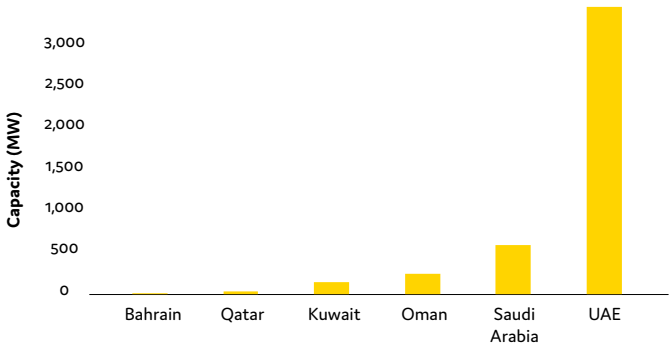
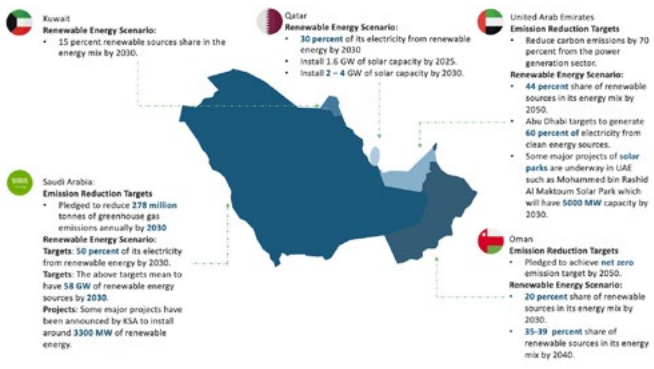


Figure 2: Cumulative Renewable Installation in the GCC Countries [2]
Source: IRENA

In recent years, GCC is ambitiously acknowledging the need to diversify the energy mix and transition to cleaner forms of energy. The GCC countries have set ambitious targets and introduced strategies to increase the share of renewables in their energy mix.



Saudi Arabia, the UAE, and Oman are leading the GCC region in the transition to renewable energy. Saudi Arabia aims to have a 50% share of renewable sources in its energy mix by 2030 [6], while the UAE also intends to have a 44% share by 2050 [7]. Oman also plans to add a 39% share of renewable sources to its energy mix by 2040. The UAE is also building the largest solar park in the world, with a capacity of 5,000 MW by 2030. This transition to renewable energy will help GCC countries diversify their energy mix, boost their economies by creating new jobs, and ensure energy security.

Challenges associated with renewables & potential solutions

Intermittency of renewables (wind & solar): To effectively meet targets set by countries, it is crucial to increase the availability of renewable energy sources and ensure that the grid can accommodate the added energy. Moreover, these renewable energy sources have intermittent nature due to which becomes necessary to ensure the availability of flexible assets in the electricity grid.

Storage as a solution: Energy storage has emerged as one of the potential solutions to address the challenge of balancing supply and demand that arises from the intermittent nature of renewable energy sources.

Deploying energy storage in the power grid can offer several key benefits such as [8]:

- Increases the reliability and stability of the power grid by smoothing out fluctuations in supply and demand.
- Enables the integration of renewable energy sources, such as wind and solar, into the grid.
- Provides backup power during power outages.
- Helps to reduce greenhouse gas emissions by enabling the use of cleaner energy sources.
- Supports the development of smart grid technologies.
- Increases the efficiency of the energy system by allowing excess energy to be stored for later use.

Application of energy storage systems

Level	Category	Application
Grid-Scale	Electric Supply	Energy Time Shifting Supply Capacity
	Ancillary Services	Frequency Regulation Voltage Support
	Transmission	Deferral Congestion Relief Transmission Support
End-user	Commercial Industrial	Renewable Energy Shifting Backup Peak-Hour Consumption

Table 1: Energy Storage Applications [9]
Source: Analysis and Comparison of Battery Energy Storage Technologies for Grid Applications (IEEE)

Why GCC needs BESS?

The battery energy storage systems would become a crucial part of the GCC region in the future as they would help maintain a balance between electricity supply and demand, integrate more clean and renewable energy sources, and enable efficient use of electricity as consumption continues to rise. A few factors that could potentially drive the market for BESS include:

Electricity energy consumption

Energy consumption in commercial, industrial, and residential sectors has been growing rapidly across the GCC region. There are various factors such as economic development, population growth, industrial growth, and lower electricity prices which are resulting in higher consumption. It would be important for countries in the GCC region to introduce measures for efficient usage of energy and avoid wasteful consumption to reduce emissions and reliance on fossil fuels.

The amount of electricity consumed during peak-demand hours is also increasing gradually in this region. The use of electricity from renewable energy plus battery energy storage systems can help in meeting the peak demand with clean energy instead of using fossil-fuel-based power plants.

Emission reduction targets

The GCC region›s transition towards a green economy is crucial for reducing emissions and supporting the global shift toward clean energy. To achieve this goal, countries like UAE and Saudi Arabia have set targets for emission reduction. A key component of this transition is reducing reliance on diesel generators for backup power and replacing it with battery energy storage systems. This shift would present a significant market opportunity for battery energy storage solutions.

Electricity Energy Consumption

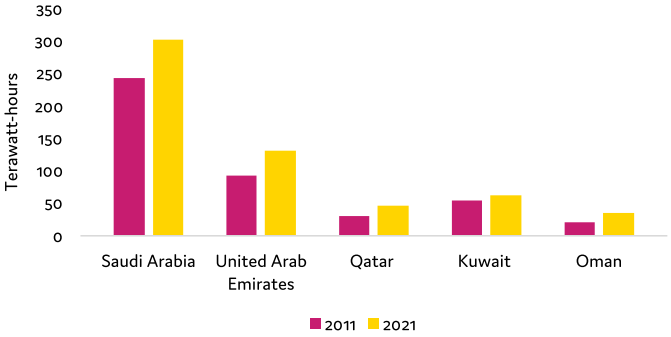


Figure 4: GCC's Electricity Energy Consumption [10]
Source: Our World in Data

Renewable energy integration

In the following years, we can expect that the share of renewable energy sources would increase significantly in the energy mix which would arise the flexibility requirements. To reduce the emissions, it would be more sensible to meet these flexibility requirements through clean energy technologies such as battery energy storage systems. The addition of renewable energy sources would drive the growth of BESS in the GCC region.

Countries are using energy storage as a solution to provide flexibility to the electricity grid

United States

In the U.S., to overcome the difficulties brought on by its growing reliance on renewable energy sources, California has been at the forefront of implementing energy storage systems.

The "duck curve," a phenomenon that happens when solar power output peaks in the middle of the day and results in a sharp decline in energy consumption at night, is one of the biggest problems that California faced due to the increased rollout of renewable energy. As a result, there was an imbalance between the supply and demand of energy since conventional power plants cannot quickly vary their production to match fluctuations in demand.

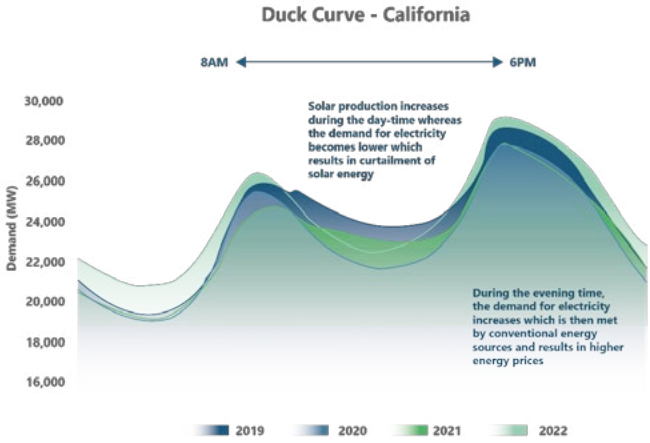


Figure 5: Duck Curve – California [11]
Source: CAISO

To address this issue, California resorted to technologies such as energy storage systems (ESS) that could provide energy time shifting i.e., storing the energy during the daytime and utilizing it in the later part of the day. The state has been installing large-scale ESS to store excess renewable energy generated during the day and release it in the evening when demand is high. This helps to smooth out the duck curve and ensure a more reliable and stable power supply.

Energy storage has allowed California to integrate more renewables into its grid system, as it allows for more flexible management of energy supply and demand and enables efficient use of grid capacity. It also allows California to reduce its dependence on peaker natural gas power plants, which helps to reduce emissions.

United Kingdom:

The United Kingdom has the largest installed capacity of offshore wind in the world, moreover, it has also been installing solar and onshore wind in large numbers. The country has installed around:

- Onshore Capacity: 14,690 MW
- Offshore Capacity: 13,848 MW
- Solar Capacity: 14,114 MW

The abovementioned numbers indicate that the United Kingdom has integrated significantly high amounts of renewable energy sources into its electricity system, which also implies that the requirements for energy time shifting have been raised. Since the mid of 2020s, battery energy storage systems (BESS) emerged as a solution for providing fast firming. The United Kingdom has recognized energy storage as a solution to further increase the integration of renewable energy sources.

To enable the development of BESS, the United Kingdom has made several progresses in terms of including its definition in legislation, removing the capacity limit barriers, awarding funds, and introducing revenue streams such as frequency response, balancing mechanisms, and wholesale arbitrage markets.

Cumulative Installed Capacity of BESS in the UK

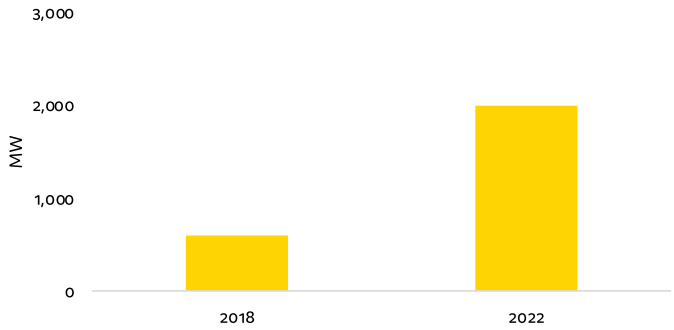


Figure 6: Cumulative Capacity of BESS in the United Kingdom [12]
Source: PTR Energy Storage Database

Australia

Australia is one of the leading countries to shift towards clean energy technologies and accelerate the deployment of renewable energy sources. In 2021, renewable energy share grew to 29% in its energy mix. This has led to the challenge of maintaining grid flexibility due to the intermittent nature of renewables which could expose the grid to the frequent fluctuation between supply and demand.

Australia is adopting battery energy storage systems as a solution to these challenges where it has deployed around 700 MW BESS capacity and has plans to install over 5 GW capacity by 2030. The addition of the energy storage systems would help:

- Energy Time Shifting: As batteries help to shift the energy for use at a later time and hence Australia is installing it as a solution to store the overproduction of renewable energy during the day and use it at a later time when the demand is high.
- Grid Forming: Batteries can also provide grid-forming services to provide inertia to a grid that has less dependence on conventional or natural-gas power plants. Australia has installed batteries to provide inertia to the grid and has provided funding to new eight projects which will provide inertia through grid-forming batteries.

Key takeaways for GCC

The United States, Australia, and the United Kingdom are among the top leading economies that have accelerated the deployment of renewables and energy storage. Energy storage is playing a crucial role in this transition by providing the network with the necessary flexibility to avoid curtailments, balance supply, and demand, and maintain grid stability through the provision of ancillary services and inertia.

The problems faced by the abovementioned countries and the solutions implemented by them offer valuable key takeaways for the emerging markets of renewables. Following the best practices of these countries, the GCC countries could explore the following options to ensure a smooth integration of renewables into their energy mix and power grid.

a. Conduct thorough studies of energy storage's role in providing grid flexibility.
b. Regulate energy storage as a separate asset and integrate it into the regulatory framework.
c. Establish targets or roadmaps for energy storage deployment.
d. Restructure the electricity market to attract private investment in the energy storage sector.

e. Hold auctions to incentivize the installation of energy storage in co-location with renewable energy technologies.

f. Implement clear regulations for participation in existing business cases, such as the ancillary services market, and create new business cases such as the capacity market, and wholesale arbitrage market to make energy storage a profitable and attractive investment.

Energy storage present scenario and existing use-cases in GCC Countries

Present scenario

The chart below presents an overview of the GCC countries' existing market of energy storage systems. The historical landscape of BESS in the GCC indicates that the energy storage market for technologies such as battery energy storage systems has been at a nascent stage.

Battery Energy Storage Systems - Annual Additions

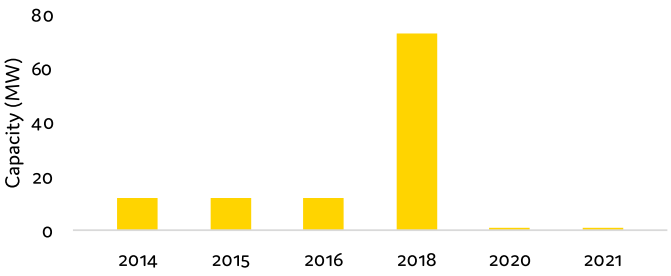


Figure 7: Overview of Annual Additions of BESS in the GCC Region [12]
Source: PTR Energy Storage Database

The UAE has installed most of the energy storage systems in the GCC region. In 2016, Abu Dhabi Water & Electricity Authority announced the deployment of around 108 MW of sodium-sulfur-based BESS with an individual capacity of around 4 MW and 8 MW at different locations to support their distribution network. The batteries were supplied by NGK Insulators [13]. Since then, this has been one of the biggest development for BESS projects in the GCC region. In 2021, the Dubai Electricity and Water Authority installed a pilot BESS of 1.21 MW at a solar park. Qatar installed its first grid-scale pilot BESS project in 2020. The BESS had a capacity of 1 MW and could be operated for four hours. The purpose of this BESS project in Qatar was to provide capacity during peak-demand hours.

In the remaining countries of the GCC region, the installation capacity for the BESS system is still non-existent. Majorly because these countries committed to the acceleration of renewable energy and emission reduction just around three to four years ago due to which deployment of BESS is yet to be experienced.

Battery Energy Storage Systems - Annual Additions

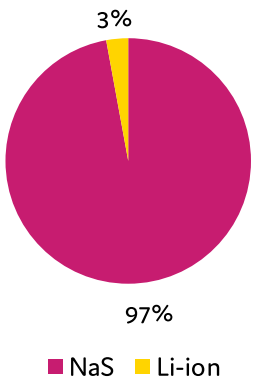


Figure 8: Chemistry Mix Split [12]
Source: PTR Energy Storage Database.

Installed Base - Country Split

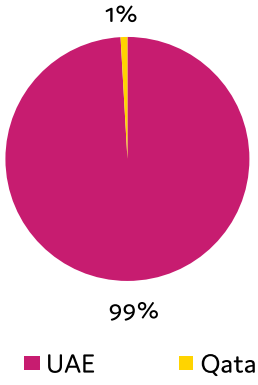


Figure 9: Country Split – Installed Base [12]
Source: PTR Energy Storage Database

Battery Energy Storage Systems - Annual Additions

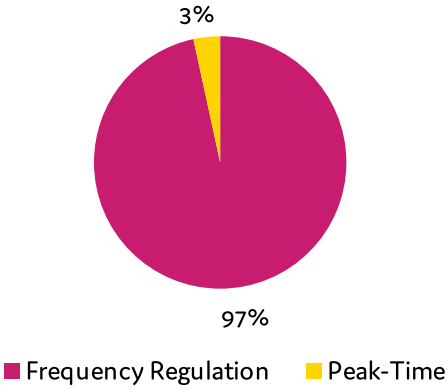


Figure 10: Applications Split – Installed Base [12]
Source: PTR Energy Storage Database

Which applications installed-base BESS projects are catering to in the GCC region:

The electricity markets in the GCC region are based on the single-buyer model. The single-buyer model means the existence of vertically integrated companies that are all owned by the state. In the generation sector, the Independent Power Producers (IPP) can participate and sell their energy, but the state would have a major share in these private investments. Moreover, all the transmission and distribution companies are state-owned. which limits the possibility of a competitive wholesale arbitrage market for energy storage systems in this region.

The existing application for installed-based ESS are [14]:

Applications	Definitions	Use-Cases Presence in GCC countries
Ancillary Services	The ancillary market services such as frequency regulation and voltage support can be provided by the grid-connected battery energy storage systems.	BESS projects are serving this application in Dubai and Abu Dhabi
Energy Time Shifting	Energy storage is charged during the time when renewable energy generation is in excess to use it at a later time when the electricity demand is high.	BESS projects are catering to this application in Qatar and the UAE
Backup Power	Backup power is an existing market in which battery energy storage system solutions are being explored and deployed in co-location with diesel generators and solar energy. This is being achieved by pairing energy storage with local power generation such as solar PV panels, enabling the maintenance of power quality for commercial or industrial applications and reducing the cost of electricity consumption.	Backup power solutions are being used in C&I sector of these countries.

Figure 11: Existing Use-Cases of BESS in the GCC
Source: PTR

GCC region has the potential for growth of the BESS market

United Arab Emirates

The ambitious targets for renewable energy sources set by the emirates in UAE have the potential to drive the growth of BESS development. As discussed in the present scenario section, the two main emirates, Dubai and Abu Dhabi already have experience in installing BESS. The main objective of installing those BESS projects was to understand their technical and economic viability.

BESS has the potential to be a critical component in the integration of renewable energy in the UAE. By providing flexibility, BESS can help ensure a stable and reliable energy supply. However, the full potential of BESS at the utility-scale level will depend on the regulatory landscape in the UAE. The government's stance on energy storage, specifically concerning ownership and investment, will play a crucial role in determining the future of BESS in the country. If the state decides to own and develop all BESS assets, it will have a positive impact on the growth of the sector. However, if the government allows also private investment in BESS projects, it will lead to lower prices, competition, and innovation in the sector.

Aside from the BESS, UAE is also planning to build a 250 MW pumped hydro project.

In addition to utility-scale projects, the commercial and industrial sectors of Dubai, Abu Dhabi, and Northern Emirates are actively incorporating battery energy storage systems into their operations. These BESS are being installed in hybrid configurations with solar and diesel generators, providing a reliable and flexible energy supply for these sectors. This trend highlights the growing recognition of the benefits of BESS, and the proactive approach being taken by the commercial and industrial sectors in the UAE to adopt this technology.

Saudi Arabia

The potential for energy storage in the Kingdom of Saudi Arabia (KSA) is significant, given the country's abundant resources and growing demand for energy.

With a rapidly expanding population and economy, KSA is facing increasing energy demand.

KSA has significant potential for renewable energy sources, such as solar and wind, and energy storage systems can support the integration of these sources into the grid. Additionally, energy storage can help address the challenges posed by the variability of renewable energy sources, ensuring a stable and reliable energy supply.

ACWA Power is set to develop 1.2 GWh BESS at its Red Sea Project [15]. This is an off-grid energy storage system that would be co-located with solar. Moreover, ACWA Power also plans to install 600 GWh BESS at Neom smart city project. We can expect that similar developments can take place in the future for different commercial projects.

Other than these developments, the energy storage market hasn't developed in KSA because regulations and potential to operate in the electricity market are still non-existent in the country. However, it could be expected that the integration of renewables and KSA's plan to reform the electricity market would drive the development of a utility-scale energy storage market. Similar to UAE, the C&I sector of the KSA has the potential to combine BESS with solar and diesel generators to meet the energy consumption demands at these sites.

Qatar

In 2020, state-owned Qatar General Electricity and Water Corporation installed first-grid scale pilot BESS in the country.

As Qatar plans to install 2 – 5 GW of renewable energy sources capacity by 2035 [16], energy storage would be needed to increase the flexibility and reliability of the electricity grid. The country already has experience installing BESS which would be beneficial to further developments in the country. Currently, there are no significant developments in the utility-scale energy storage market in terms of regulations, electricity market, or projects.

Oman and Kuwait

The energy storage market in Oman and Kuwait, including batteries, is expected to grow in the coming years due to the increasing demand for renewable energy and the need for backup power solutions. The government is promoting the use of renewable energy sources and has set targets for the integration of renewables into the energy mix. However, the market is still in its early stages and the adoption of energy storage systems may be limited by the high cost of these systems and the lack of infrastructure and regulations.

The GCC region has a high potential for the installation of BESS projects due to its rapid renewable energy integration, increasing energy consumption, and carbon emissions reduction targets.

Utility Scale BESS Market Forecast in GCC

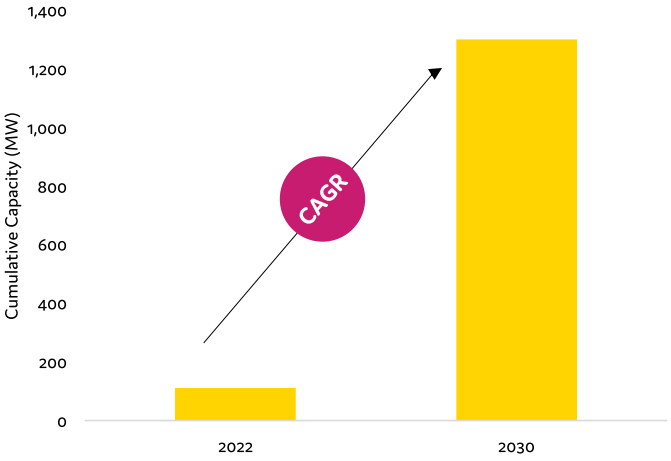


Figure 12: Forecast of Utility-Scale Battery Energy Storage Systems
Source: PTR Energy Storage Database

Possible Use-Cases

The following are some of the potential use cases which will be catered by the battery energy storage systems in the GCC region.

Transmission Deferral
The BESS could be used as an alternative to traditional network reinforcement. It can help in increasing the capacity of the transmission grid.

Reserve Capacity
A capacity reserve is the additional generating capacity that is available to the electric power system, BESS can provide this capacity instead of peaker natural gas power plants.

Ancillary Market
The BESS market can provide ancillary services in primary and secondary reserve markets. It will help in maintaining stability within a very short time.

Wholesale Arbitrage Market
The BESS projects can participate in this market by charging their storage at lower prices and discharging during peak hours.

ESS landscape in backup power applications in the ME

Carbon emissions from the C&I sector and net-zero targets.

The GCC region is facing a rise in energy consumption due to growth in the commercial and industrial sectors. Several factors contribute to this higher energy demand such as population growth, rising living standards, economic development, large fossil fuel resources, and the developed industrial sector. The C&I sector meets this increasing energy demand during peak hours through distributed energy sources such as diesel generators. Diesel generators have become a reliable backup power source for industries and businesses in the GCC region also because of their access to large oil reservoirs.

However, as discussed in the previous sections, the GCC countries are targeting to achieve net-zero emissions in the next couple of decades. This would imply that these countries would need to find solutions to replace the diesel generators if not fully then partly with low-carbon emissions technologies such as BESS.

As diesel fuel releases 2.6 kg of carbon dioxide per liter, which could add up to a significant cumulative figure due to the developed market of diesel generators in the GCC. Moreover, it is expected that the diesel generators market sales are subjected to grow by 4.3 percent in 2023 which shows significant adoption of diesel generators in the Middle East.

Hybrid solution (Solar PV + Batteries + Diesel Generators)

The GCC countries are already exploring innovative hybrid solution which combines solar PV and batteries with diesel generators to meet the energy demand or to act as a backup power source. Solar PV has the advantage of very lower operating costs as compared to diesel generators. Moreover, the C&I sector can use this solution to meet their demand through solar PV during the daytime and store the excess energy generated from solar PV in batteries. Batteries would enable the user to use renewable energy and meet the remaining

demand through diesel generators. This kind of solution reduces the run-time and maintenance for diesel generators.

Below is a brief example of this kind of solution which is being used by Atlas Copco in UAE [17]

This daily load graph shows the requirement of power to meet the needs of any commercial or industrial site. The daily load always fluctuates according to the needs throughout the day. However, diesel generators are designed to operate at either full load which means the remaining generated energy would be lost or they could operate at partial load, however, that would be insufficient to fulfill the required power demand.

Daily Load Diagram

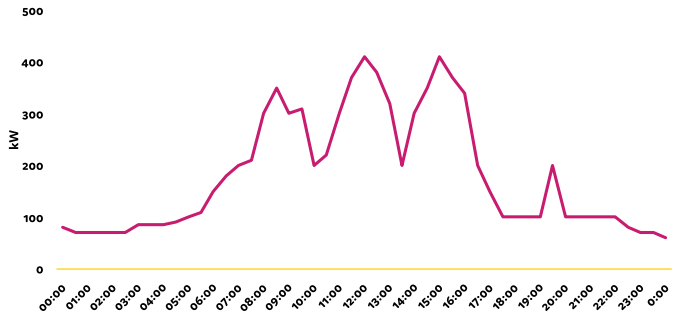


Figure 14: Daily Load Curve of an Industrial Site
Source: Atlas Copco

In this case, the commercial and industrial sites make use of two diesel generators in parallel. One diesel generator is operated at partial load whereas the second diesel generator is used only to meet the peak demand during the day. This kind of solution can result in less fuel consumption, saving costs, and increased efficiency.

Daily Load Diagram

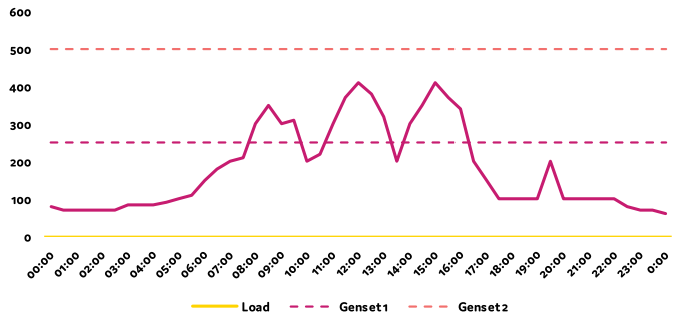


Figure 15: Use of Parallel Generators
Source: Atlas Copco

However, there is a more efficient and innovative way to solve this problem which is to use the hybrid solution of combining battery energy storage and a diesel generator. The BESS can be charged at times when the load on the diesel generator is less, and the stored energy can later be used to meet the demand while turning off the generator. This kind of solution can also be combined with solar where BESS is charged through solar and can alone provide energy during low-demand hours. This would reduce the overall use of fuel, increase efficiency, reduce noise, and also help in saving costs.

Daily Load

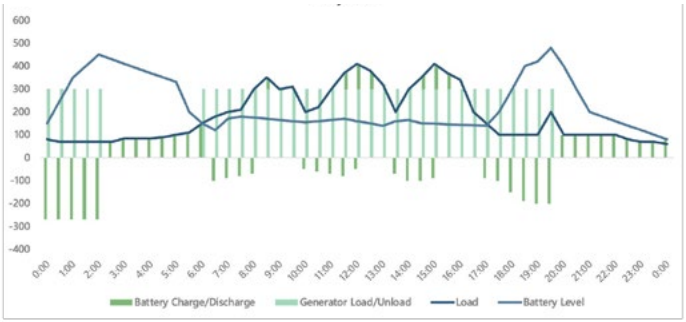


Figure 16: Use of BESS + Diesel Generators
Source: Atlas Copco

Aside from the technical and financial advantages, the adoption of this solution would also help reduce the emissions from the commercial and industrial sectors which contribute significantly to the total carbon emissions.

Looking Forward

A strong policy and collaboration across the value chain will lead to accelerated growth of the BESS market in the GCC region. It would require collaborative efforts from utility companies, regulatory bodies, investment companies, and players across the energy storage value chain to accelerate the development of BESS.

Below are mentioned a few of the suggestions which could help with the development of the energy storage market in the GCC:

Electricity model

The development of BESS in the GCC region faces challenges due to the prevailing electricity model, which relies on regulated tariffs rather than market-driven wholesale electricity prices. This makes it difficult to leverage BESS to provide grid services, as it requires higher revenues to become profitable. [18] To overcome these challenges, the current electricity model needs to be revised and policies for energy storage need to be introduced. Despite the decline in the cost of energy storage in recent years, the investment required for BESS remains substantial, and it is only possible if the electricity prices are higher than the current regulated tariffs. By making changes to the existing electricity model, the GCC region can effectively promote the development of BESS and tap into its potential benefits such as lowering the share of fossil-fuels-based power plants in providing grid balancing services.

Regulations Fostering BESS

One of the main reasons for the slow growth in the development of energy storage is the lack of regulations. It would be crucial to introduce regulations that are favorable for energy storage such as defining it as a separate asset and clarifying the ownership regulations and regulations for participating in the electricity market.

Incentivization

The battery energy storage market has not experienced any significant growth in this region hence it is still seen as a new technology and the costs are relatively high compared to the parts of the world. The financing or incentivization for battery energy storage in form of tax credits for C&I and residential customers might help in boosting the growth of this technology.

Technology

The battery-based energy storage systems market in the GCC region is in its early stages, lacking experience in technology, cost, installation, and safety regulations compared to developed markets. However, the involvement of government and private investors through incentivization or tax credit schemes can drive innovation and lead to growth in the BESS market.

Net-metering Scheme

In GCC countries, to boost the development of residential solar, the customers are offered remuneration for the amount of electricity that is fed back into the grid at a specific time. Hence, this kind of scheme and incentives might need to be revised to cater to the development and growth of the residential energy storage market. [3]

Financing

The governments in the GCC region could collaborate with energy storage developers to introduce favorable regulations and provide capital investments to support the development of a utility-scale energy storage market and eliminate the financing risk and uncertainty factor for the projects by providing long-term contracts through auctions.

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