EWEC

Statement of Future Capacity Requirements

2024-2037

Summary Report

Emirates Water and Electricity Company

Contact

Directorate of Strategy and Planning

Emirates Water and Electricity Company
EWEC Building,
603 Saeed Bin Ahmed Al Otaiba Street,
Al Danah,
PO Box 51111,
Abu Dhabi, United Arab Emirates

Contact Person: Luke Sumner
luke.sumner@ewec.ae

Document Changes and Release History

Version	1.0
Date	28 November 2023
Description	Public version prepared

Acknowledgment

The production of this report has required the input and guidance from the Department of Energy, TRANSCO and the energy sector. All capacity recommendations are subject to regulatory approval. This report represents the views, opinions and recommendations of EWEC unless otherwise specified.

Table of Contents

Acronyms

BESS	Battery Energy Storage Systems
BNEP	Barakah Nuclear Energy Plant
CCGT	Combined Cycle Gas Turbine
CEST	Clean Energy Strategic Target
CH_4	Methane
CO_2	Carbon Dioxide
COD	Commercial Operation Date
DoE	Department of Energy
DoF	Department of Finance
EWEC	Emirates Water and Electricity Company
GHGs	Greenhouse Gases
GW	Gigawatt
GDP	Gross Domestic Product
IPP	Independent Power Project
kg	Kilogram
Mm^3	Million cubic metres
MIGD	Million Imperial Gallons per Day
MTPA	Million Tonnes Per Annum
MW	Megawatt
MWh	Megawatt-hour
m^3	Cubic metres
OCGT	Open Cycle Gas Turbine
PV	Photovoltaic
RO	Reverse Osmosis
SFCR	Statement of Future Capacity Requirements
TRANSCO	Abu Dhabi Transmission and Despatch Company
UAE	United Arab Emirates

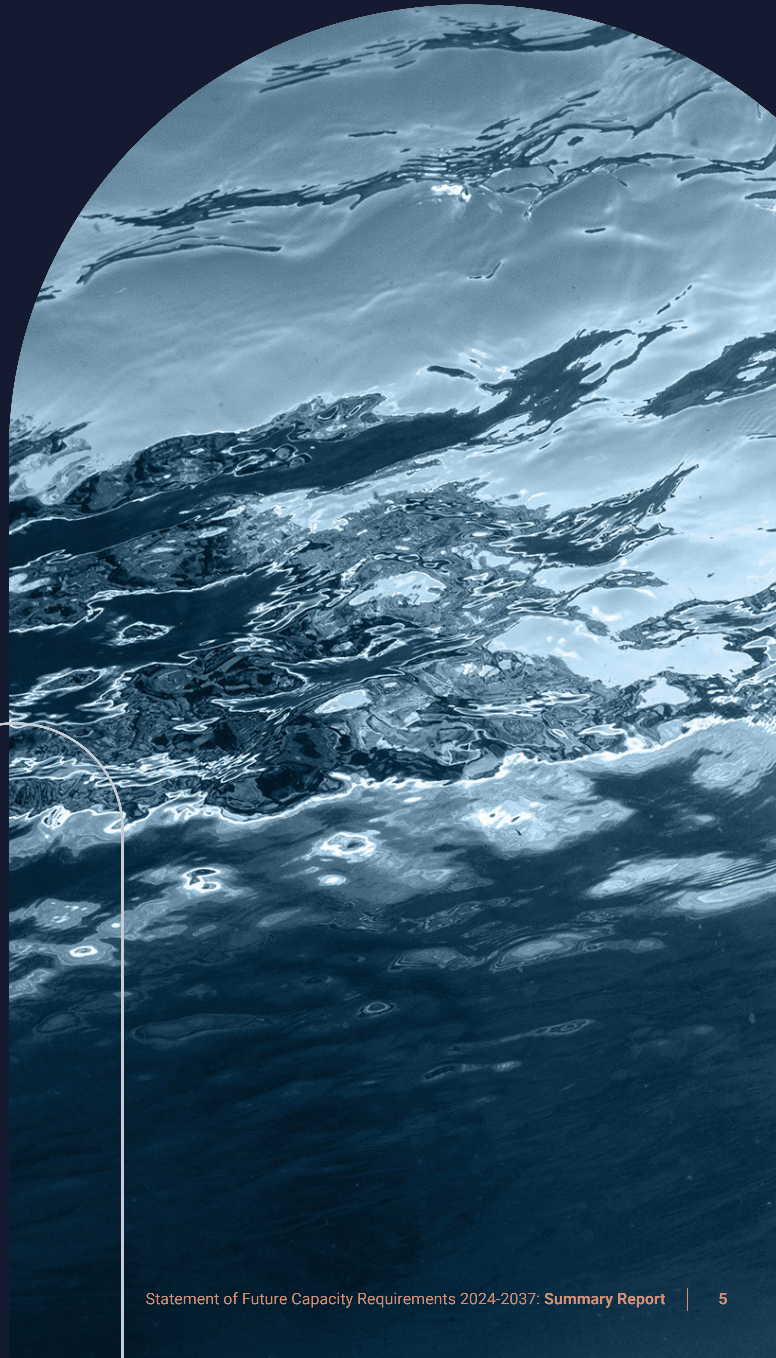
1. Introduction

The Emirates Water and Electricity Company (EWEC) is responsible for providing power and water securely and at the least cost to our customers in Abu Dhabi and the Northern Emirates.

According to Abu Dhabi Government-mandated targets, we are required to achieve 60 per cent clean energy, i.e., from renewable and nuclear energy, by 2035. To add further complexity to the challenge of decarbonisation, both power and water demand is set to increase by around five per cent per year in the period to 2035, due to underlying economic growth and electrification of other sectors such as transportation and industry to support decarbonisation. **This demand growth projection does not account for projects that are currently in the early stages of conceptualisation or due diligence with our primary stakeholders.**

The Statement of Future Capacity Requirements (SFCR) presents our recommendations for the generation and desalination infrastructure required to realise our sustainability targets and meet growing power and water demands securely at least cost.

Our strategy is developed and aligned with the principles of the energy trilemma. This involves balancing three key factors; energy security, affordability and environmental sustainability, which are aligned with our core responsibilities and the government-mandated target.



The challenge of decarbonisation

The proportion of total energy demand served by electricity is widely expected to increase from around 20 per cent today to 50-70 per cent by 2050 to attain net zero.[1,2] Achieving net zero emissions necessitates the electrification of the transportation sector and the provision of lower-carbon alternatives for power and water production in traditionally emissions-intensive industries such as steel, aluminium, cement and chemicals. This has significant implications for power and water systems, which will require extensive further development in terms of transmission and the addition of clean energy projects, set against a backdrop of a five per cent per annum growth rate in power and water demand in Abu Dhabi to 2035.

EWEC is committed to Abu Dhabi being a leader in decarbonisation. We have made significant investments in the infrastructure necessary to reduce our emissions, developing clean energy projects using solar photovoltaics (PV), nuclear power and reverse osmosis (RO) for desalination and implementing energy storage technologies like batteries. We will continue to develop these clean energy projects to 2035 and beyond. We also need to consider how we can safely operate a decarbonised power and water system while maintaining the security of supply at the least cost to consumers.

Gas is a key transition fuel

Like many other countries worldwide, we are utilising gas as a transition fuel. Current gas-based production capacity provides the system with the flexibility in energy generation needed to allow the progressive addition of clean production technologies such as nuclear, solar and wind. The ability of gas plants to start and stop quickly and adapt their output in response to variations in both demand and supply is the key enabler to a decarbonised power and water system. Over the next decade, we anticipate that battery storage costs will continue to fall and gigawatt-scale battery storage solutions will increasingly replace this existing gas-powered generation.

Where we can, we are reconfiguring existing gas assets that are reaching their contract expiry where there is demonstrable benefits to consumers when compared to building new gas projects. Reconfiguring these plants will improve efficiency and operating flexibility, increasing their value to the system. We typically expect these plants to operate at a low capacity factor and primarily operate to ensure power system security. The underlying growth in total demand, even before considering the electrification of industrial and transportation sectors is such that new gas capacity will be required in addition to reconfiguring suitable existing assets to support the transition to decarbonisation.

[1]Energy Transitions Commission (2023), available at: https://www.energy-transitions.org/energy/electricity/
[2]International Energy Agency, 2022. *World Energy Outlook*. p239,
available at: https://iea.blob.core.windows.net/assets/830fe099-5530-48f2-a7c1-11f35d510983/WorldEnergyOutlook2022.pdf

Solar PV is key to meeting our emissions targets

The development of additional solar PV is central to our decarbonisation strategy. The United Arab Emirates (UAE) is well-positioned with abundant solar resources. Solar PV reduces carbon dioxide (CO_2) emissions from electricity generation whilst simultaneously reducing costs, as it is the cheapest form of electrical generation available today. The cost of solar PV panels has decreased nearly 90 per cent over the past 12 years whilst their efficiency has increased. Additionally, the levelised cost of electricity (LCOE) from utility-scale solar PV plants has decreased by about 90 per cent since 2010.[3] For these reasons, the development of solar PV is currently seen as the most cost-effective solution for decarbonising power and water systems, as reflected in this year's SFCR power recommendations (outlined in Section 4.1). We continually assess alternative technologies, such as wind and other renewables, which will likely form part of our recommendations in the future.

[3]IRENA (2023) Renewable Power Generation Costs in 2022.
Available at: https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022.

Decarbonising the power sector with reverse osmosis

The transition from thermal desalination to RO as the primary desalination technology is playing a critical role in the decarbonisation of the power and water systems. Reverse Osmosis is more efficient, cheaper and produces less emissions than existing thermal desalination. In this year's SFCR, we recommend the development of RO projects to meet additional demand and to enable the decoupling of power from water in older gas-fired plants, where water production is energy-intensive and incompatible with our 2035 targets.

Looking to the future

Section 4 outlines our recommendations for power and water to 2037. These recommendations stem from our latest modelling and analysis, which aligns with our mandate of ensuring reliable and least-cost power and water supply and achieving our target of 60 per cent clean energy by 2035.

We currently prioritise the deployment of solar, nuclear, gas and battery technologies to drive our decarbonisation efforts. Nevertheless, as a company committed to remaining technology-agnostic, we recognise that as other clean and renewable energy sources and innovative technologies evolve and become economically feasible, they may feature in our future recommendations.

2. EWEC's Planning Objectives

The UAE started its renewables journey in 2009 when Abu Dhabi was connected to the Masdar City Solar PV plant, the first grid-connected renewable energy project in the country.

Since then, Abu Dhabi has become a global leader in the development of solar PV with 2.5 gigawatts (GW) operational and a further three projects totalling 4.5GW under development by 2028 and more to follow. The emirate has also expanded its expertise into nuclear power, battery energy storage systems (BESS), RO and, most recently, wind energy.

Since taking on the role of system operator in 2022 following the integration of the load dispatch function, we have focused on advancing the integration of clean and renewable energy into the generation portfolio. Managing the system securely with increasing amounts of variable renewable energy is technically more challenging than operating a system based on gas-fired generation and requires the development and deployment of new measurement and control systems. Maintaining system operability as the characteristics of the generating assets change is the defining challenge facing system operators globally, even more than the challenge of building large quantities of clean generating capacity. We recognise the need for careful consideration and planning to address these hurdles. We have crafted a roadmap to realise our decarbonisation objectives, underpinned by the highlights below.

60% total clean energy by **2035**

By **2035**, solar and nuclear will provide the majority of our energy needs

We will integrate batteries and implement control systems that further enable the electrification of the grid

Gas will be the transition fuel to help us achieve our decarbonisation targets for **2035**

We will progressively reduce gas-fired generation with the aim of eliminating its use by **2050**

By **2030**, our system will be run predominantly using solar and nuclear during daylight hours throughout the year

We are working to increase the industrial load served by grid-based supply

We will continue to monitor the potential of other clean and renewable energy sources and technologies, and deploy them where they can help us to achieve our decarbonisation and net zero targets

3. Methodology

The 2023 SFCR uses the 2023 Week Seven power and water demand forecast, which considers a range of up-to-date assumptions and inputs, including the latest information from the Department of Finance (DoF) regarding updated gross domestic product (GDP) projections. The Statement provides a Base Case view of demand, as well as assessing several demand sensitivities for their impact on our capacity expansion recommendations.

3.1 Industrial Sector Demand Growth

As mentioned earlier, the industrial sector is one area which will have a significant impact on demand growth and our decarbonisation goals. Efforts to reduce emissions in this sector have begun, supported by the UAE's net zero strategic target. To bolster these efforts, we are actively engaging with Abu Dhabi's emissions-intensive industries to advance initiatives to reduce carbon emissions.

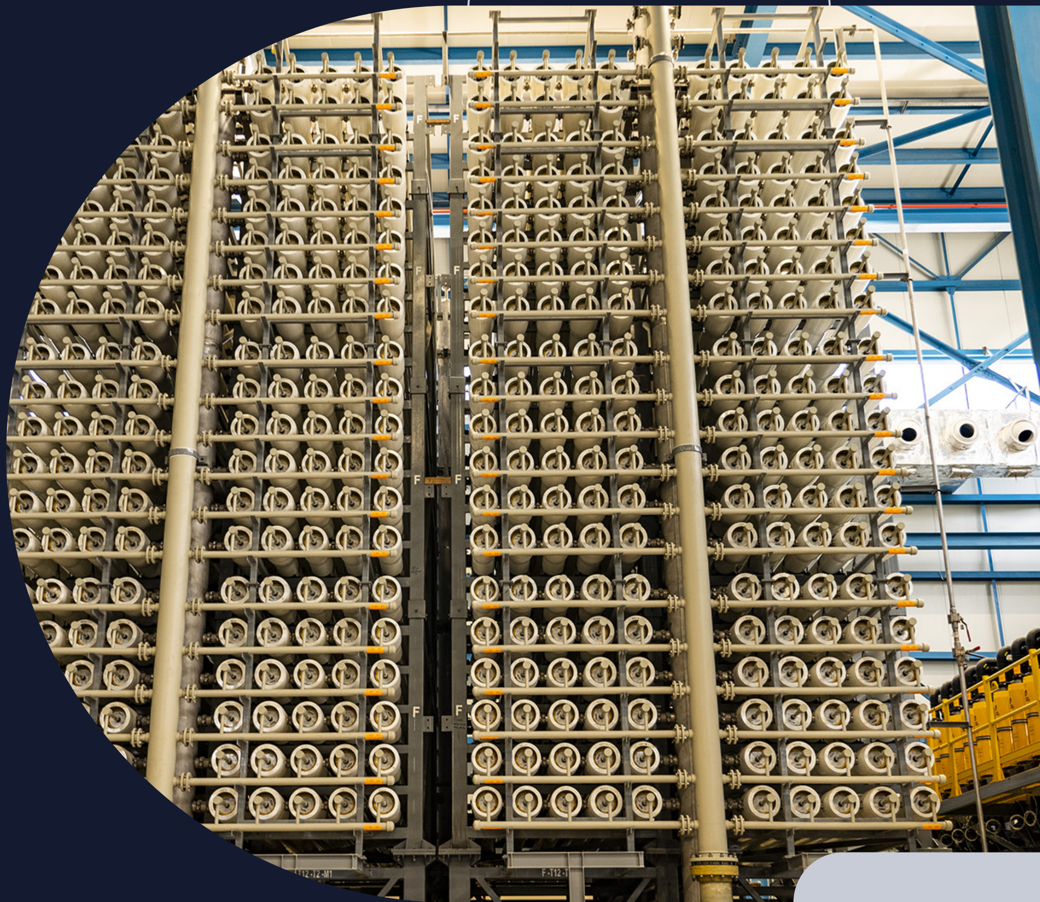
When developing the demand forecast, we need to consider the industrial sector has the potential to double the size of the system by 2037, which would impact our decarbonisation efforts. To ensure that we are informed of developments in this area, we are in ongoing collaboration with key entities in the sector. This enables the building of realistic scenarios of future demand and allows for the planning of adequate power and water capacity additions that ensure security of supply. Our engagement with these critical stakeholders also facilitates the monitoring of sector developments to assess the potential for industrial demand exceeding our forecast.

4. Recommendations

4.1 New Power Recommendations

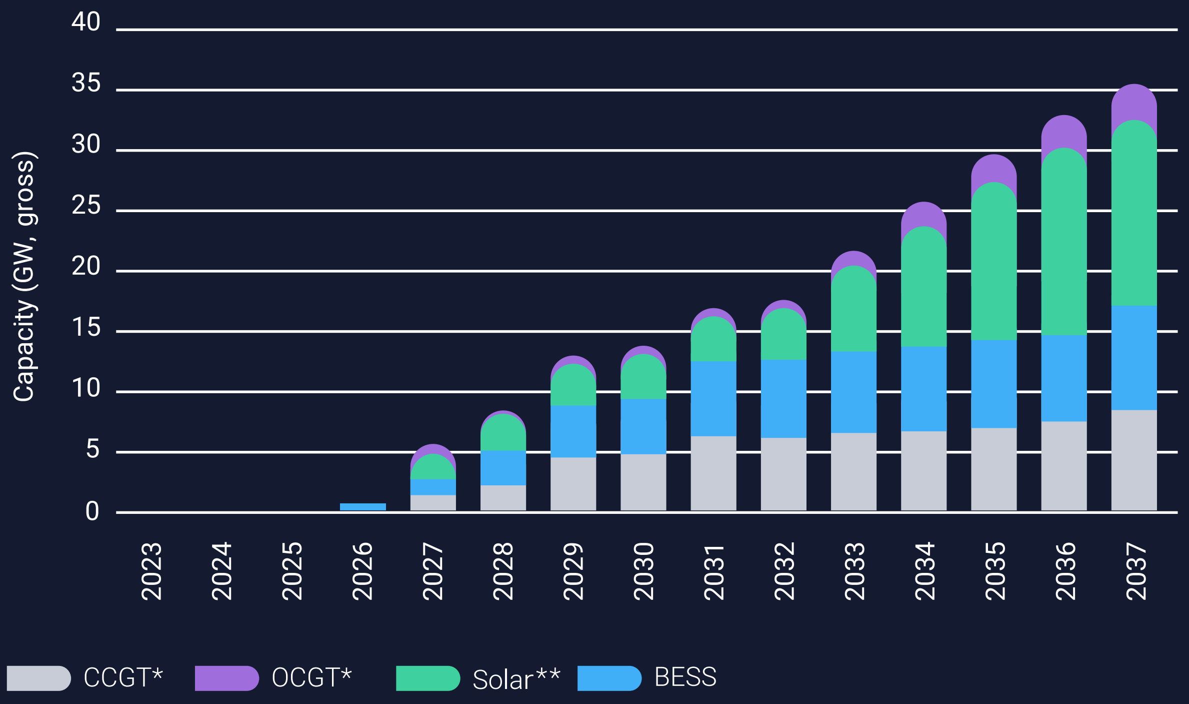
In this year's plan, we recommend the following, as shown in Figure 4.1:

- **Solar PV:** Underlying demand growth supports the development of a further 1.5GW of solar capacity by 2027 following the development of Al Ajban Solar PV Independent Power Project (IPP) in 2026.
- **BESS:** we recommend the development of 400 megawatts (MW) of one-hour depth of storage for the provision of grid stability services by 2026.
- **Thermal:** 5.1GW of gas capacity is required, primarily as a transitional fuel to support the integration of renewable energy projects into the system. The addition of this gas capacity will provide supplementary support as we transition to a decarbonised system. The 5.1GW comprises of:
    - 2.6GW of flexible low-cost Open Cycle Gas Turbine (OCGT) capacity or equivalent, to be available by 2027. OCGT capacity is required to ensure security of supply on a small number of very high-demand days where its role is to provide reserve capacity rather than energy, and correspondingly, it is expected to run with very low capacity factors (less than five per cent per annum). We will specify the option to retrofit to include carbon capture, usage and storage (CCUS) as part of the procurement process.
    - 2.5GW of Combined Cycle Gas Turbine (CCGT) capacity, to be available by 2028 which will serve the increase in underlying demand as well as replace less efficient contract expiring gas-fired capacity where this cannot be reconfigured and the contracts extended. We will specify the option to retrofit to include CCUS as part of the procurement process.



The planning recommendation to proceed with the immediate development in 2023 of each of these battery, solar PV and gas generation projects reflects the varying times to implement and achieve commercial operation for these different technologies.

Figure 4.1: Base Case power recommendations by technology type (GW), 2023-2037



*Up to 7GW of OCGT and CCGT capacity might be provided by contract extension of existing assets. New CCGT in 2027 is unlikely to be achievable but could be procured through reconfiguration or extension of the Shuweihat S1 Power Plant.

**The above capacities do not include projects that are currently under construction such as Al Ajban 1.5GW Solar PV IPP.

We recommend building an additional 2.2GW of solar PV in 2027 and a further 0.8GW of solar PV in 2028. The rate of solar development in the Base Case increases after 2032. This year's recommendation is based on the need to meet our clean energy targets. We suggest an average of 1.4GW of new solar PV is required annually from 2027-2037, following the development of the 1.5GW Al Ajban Solar PV IPP in 2026, which is currently under procurement. We stress test this recommendation via sensitivity analysis and the recommendation is robust when considered against a wide variety of different outcomes.

The integration of 400MW of battery energy storage systems (BESS) by 2026 will provide operating reserves and will be critical in providing flexibility in the system, particularly over the winter periods. The addition of BESS will become more valuable as more solar PV is added to the grid.

As discussed in Section 1, even with the requirement to meet the clean energy target, we continue to see a crucial role in both the short- and medium-term for gas generation. Gas will increasingly be used as a transition fuel that will enable the integration of large amounts of renewable energy into the system. The Base Case forecast indicates that an approximately equal share of new CCGT and OCGT (totalling the 5.1GW recommended) delivers the least-cost to the system.

4.2 New Water Recommendations

Consistent with the planning statements of the past seven years, the 2023 SFCR recommends significant additional RO deployment is needed, as shown in Figure 4.2. We recommend procurement of at least an additional 0.28Mm^3/day (62MIGD) of RO by 2029 to meet demand growth.

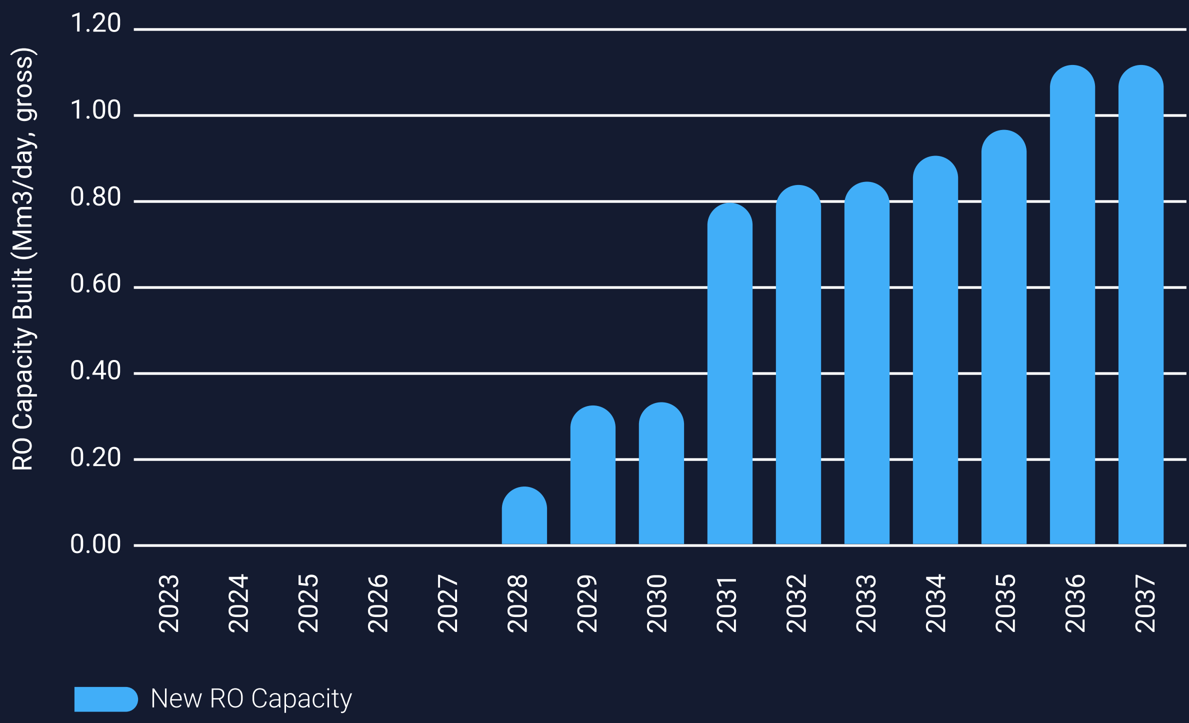
In addition to our recommendations in this year's Statement, we are also in the process of proceeding with developing the following RO projects, which were recommended in the 2021 SFCR:

- 540,000m^3/day (120MIGD) at Mirfa, currently under construction and assumed to reach COD by November 2025
- 320,000m^3/day (70MIGD) at Shuweihat, currently under construction and assumed to reach COD by May 2026
- 450,000m^3/day (100MIGD) total capacity at Abu Dhabi Islands (located on Hudayriyat and Saadiyat), assumed to reach COD by September 2027

By 2029, RO will be 85 per cent of total installed water capacity. This uptick in RO development is primarily driven by RO's significant cost advantage over existing cogeneration assets.

By 2031, we recommend developing a further 0.8Mm³/day of capacity further to the projects described above. This will bring the total RO capacity to over 3.5Mm³/day out of a total available capacity of 4.3Mm³, serving over 92 per cent of total projected demand.

Figure 4.2: Recommended RO capacity (millions of cubic metres per day), 2023-2037



4.3 Existing Fleet Recommendations

4.3.1 Focus on Flexibility

Adding large amounts of nuclear and solar capacity introduces system operability challenges, particularly in winter. The intermittency of solar power makes it difficult to match electricity demand with supply, whilst the constant and reliable nuclear output can also be an issue due to the challenges of adjusting to lower electricity demands. Nuclear power is unable to respond quickly to changes in demand. Therefore, other flexible sources of generation are needed. Solar also causes additional operability challenges because of its variability in generation. Whilst it can significantly reduce the demand needed from other sources of generation during the day, it can result in a rapid increase in the demand required from these other generation sources in the evening, causing large fluctuations. For this reason and to maintain grid reliability, energy storage and different forms of generation are critical for decarbonisation. In addition to developing battery storage to deal with the variability of solar, we have also put in place a range of other measures to improve operability, including increasing the technical flexibility of the cogeneration fleet through upgrades and the rapid decoupling of power and water production through the addition of RO capacity.

There will be a radical shift in how gas assets will operate in the future. As mentioned in section 4.1, gas will primarily be used as a supporting fuel to bolster the system during increased demand. Gas will also increasingly play a vital role in 'two-shifting' operations as the share of PV increases. This change is indicative of the increasing intra-day variability in our gas usage. Consequently, there is a growing need to enhance the flexibility of our gas systems to manage these variations adeptly.

4.3.2 Life Extensions

Several plants will reach the end of their existing contracts during the 2024-2037 planning period. This results in the expiry of over 7GW of power capacity and over 2Mm^3/day of water capacity. EWEC's strategy is to reconfigure and extend those plants reaching contract expiry before the end of 2030. We assess the benefits of each extension against the benefits offered by a replacement with new technology as we approach each closure and where an extension is possible. By 2030, we expect contract extensions will provide nearly 3.5GW of power capacity, rising to just over 6GW by 2035.

5. Emissions

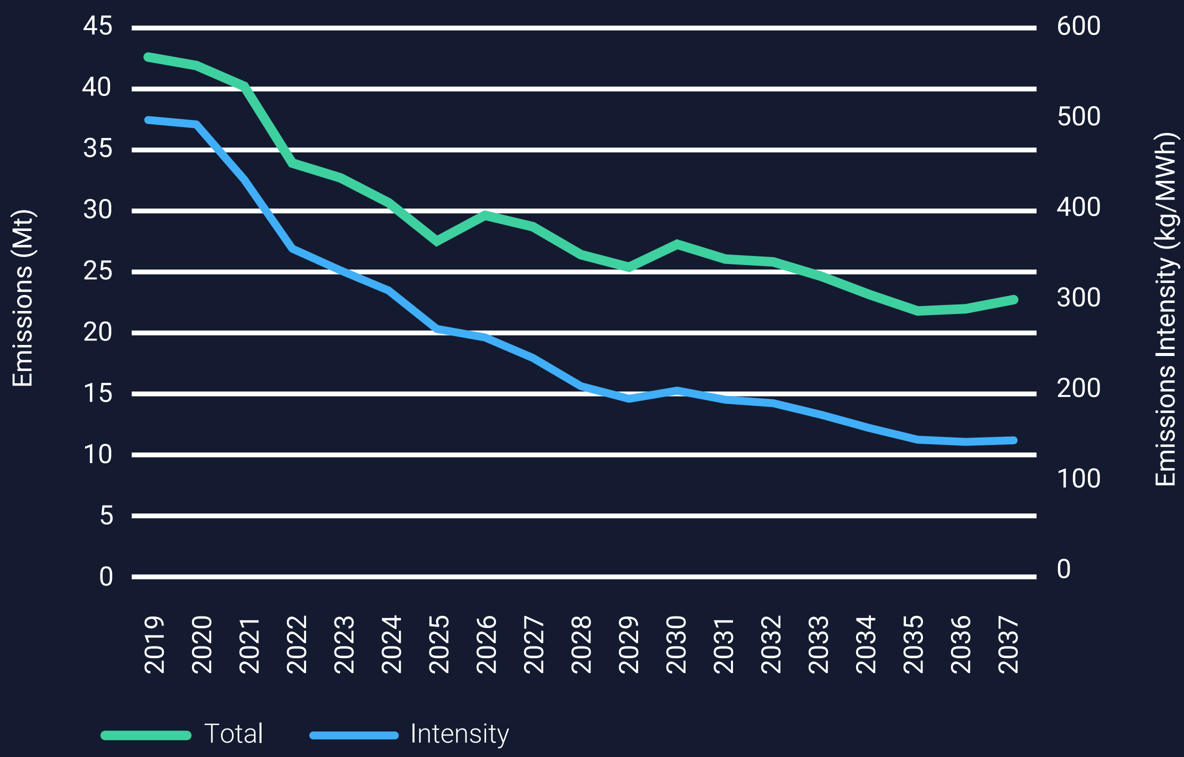
Despite the average 5 per cent per year increase in demand over the forecast period, total emissions from power and water continue to decline due to the marked reduction in emissions intensity of power and water.[4]

The reduction in emissions to date has been driven primarily by the addition of nuclear, solar and RO capacity. Over the next ten years, the further declines will be driven by the addition of large amounts of PV and the provision of grid stability services by batteries rather than gas plants. In addition, remaining gas generation will become more efficient following the further decoupling of power and water cogeneration in favour of electrically powered RO.

[4]Emissions intensity refers to the amount of CO_2 emitted per unit of power or water produced.

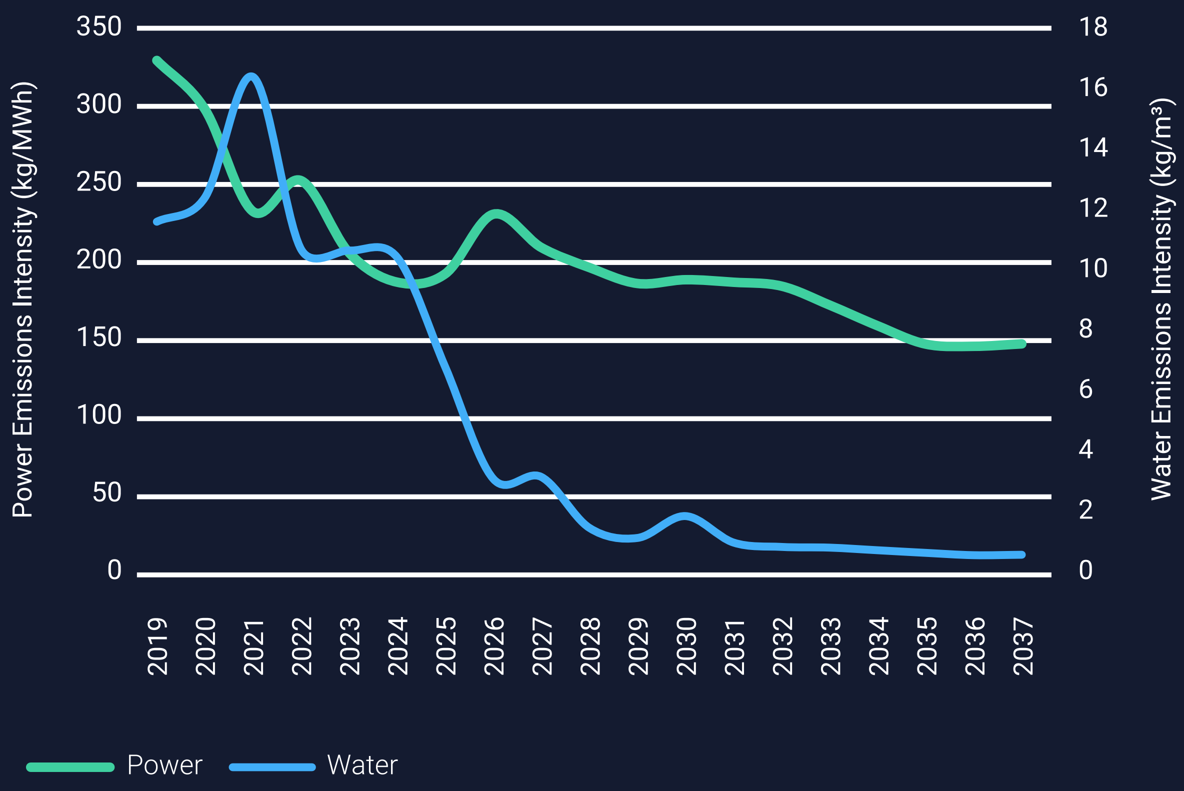
Projected total CO_2 emissions decrease by nearly 50 per cent from 42 million tonnes per annum (MTPA) in 2019 to approximately 22 MTPA by the mid-2030s, as shown in Figure 5.1.

Figure 5.1: Total CO_2 emissions (MTPA) and intensity (kg/MWh): EWEC including Exports, Base Case, 2019-2037



The decreasing emissions intensity of power and water is shown in Figure 5.2. The power emissions intensity falls from 330kg/MWh in 2019 to 190kg/MWh by 2030. The transition from a predominantly thermal desalination-based system to one based on RO directly reduces the carbon intensity of water production from 16kg/m³ in 2021 to less than 1kg/m³ in 2031. In addition, it supports a reduction in the carbon intensity of power production by replacing gas-fired power, previously cogenerated with water, with nuclear and solar energy.

Figure 5.2: EWEC emissions intensity of power and water production: Base Case, 2019-2037



6. Purpose of the Statement

The purpose of this Statement is to provide EWEC's planning outlook and recommendations for the development of infrastructure and systems to meet the power and water demands of our customers.

It outlines our recommendations for the next seven years, but our modelling horizon extends up to and including 2037. The SFCR is produced annually to ensure that our modelling and recommendations remain robust and achieve our current core planning objectives, outlined in Section 2.

Regulatory oversight of EWEC's activities is provided by the Abu Dhabi Department of Energy (DoE). The DoE review and approve the demand forecast and the SFCR, including the assumptions used in the modelling for the Statement.

6.1 Approach to Identifying Efficient Investment

We use a power and water system production cost model called PLEXOS to produce our planning recommendations, underpinned by the objective of achieving the least cost system and in accordance with our mandated reliability standards and sustainability targets.

We have applied this modelling approach across several sensitivities around power and water system supply-demand fundamentals, reflecting the key uncertainties and choices we face as we plan the Sector's production capacity. Our recommendations regarding future capacity expansions are primarily founded on a 'Base Case' scenario in which we plan to meet demand growth within Abu Dhabi emirate as well as the contracts for the supply of power and water that are in place today or that are in the process of being negotiated.

Our modelling approach seeks to optimise decisions to invest in new capacity, to reconfigure or augment existing production facilities, engage in trading opportunities with other entities both within and outside the UAE and retire older production facilities on contract expiry when they are no longer economical or required to maintain security of supply.

Glossary

Absolute Emissions refer to the total amount of greenhouse gases emitted into the atmosphere from a source, sector, region or entity over a defined period of time.

Base Case: The Base Case is the result obtained from running a model with the most likely or preferred set of assumptions and input values.

Capacity factors measure how efficiency an energy source or power plant generates electricity. For example, if a plant has a high capacity factor (i.e. close to 100 per cent), it means that it is running nearly all of the time and generating electricity efficiently.

Carbon Capture, Utilisation and Storage (CCUS) is a process by which CO_2 from industrial processes and power production is captured rather than released into the atmosphere. This CO_2 is then used in other processes such as enhanced oil recovery or the production of products such as concrete. Any excess CO_2 is then stored underground in depleted oil or gas reservoirs.

Carbon-free energy refers to energy sources and technologies that produce no carbon dioxide emissions. Examples include renewable energy sources such as solar, wind, hydropower and geothermal energy, as well as nuclear power.

Clean energy is energy derived from renewable energy, such as solar, wind, hydropower and geothermal energy, and nuclear energy.

Cogeneration Fleet: Power stations or heat engines that use a combination of heat and power to generate electricity and heat at the same time.

Decarbonisation is the reduction of greenhouse gas emissions (GHGs), such as CO_2 and methane (CH_4), generated from human activity. It is achieved through the use of low-carbon energy sources like wind and solar.

Desalination is the process of removing impurities from seawater to produce potable water.

Electrification of the grid refers to the process of expanding and improving the electrical grid infrastructure. It aims to extend the reach of the electrical system.

Emissions Intensity: Emissions intensity refers to the amount of greenhouse gas emissions produced per unit of another factor, for example per unit of energy generated.

Levelised Cost of Electricity (LCOE) measures the cost of generating electricity from a particular power source (such as solar, wind, gas, etc.) over its entire lifetime. It provides an average number for the generation of one unit of electricity from an energy source over its lifespan, considering the cost of building and operating a power plant as well as the production of electricity.

PLEXOS: A market simulation platform that provides unified energy modelling and forecasting.

Sensitivity: A sensitivity is a factor, issue, or impact that is tested against the Base Case. For example, for the purposes of this report, we tested how the introduction of a carbon tax (the sensitivity) would change the Base Case recommendations.

Sensitivity analyses are used to explore how the sensitivities impact the Base Case results or what deviation from the Base Case is shown when the input values and/or modelling assumptions are altered.

Net zero refers to a state whereby the amount of GHGs going into the atmosphere are balanced by those removed from the atmosphere. This is achieved by using carbon-free sources of energy like renewables or nuclear and other technologies such as CCUS.

Renewable energy is energy that is created by natural resources that can be naturally replenished or restored by themselves. Examples include solar, wind, hydropower and geothermal energy.