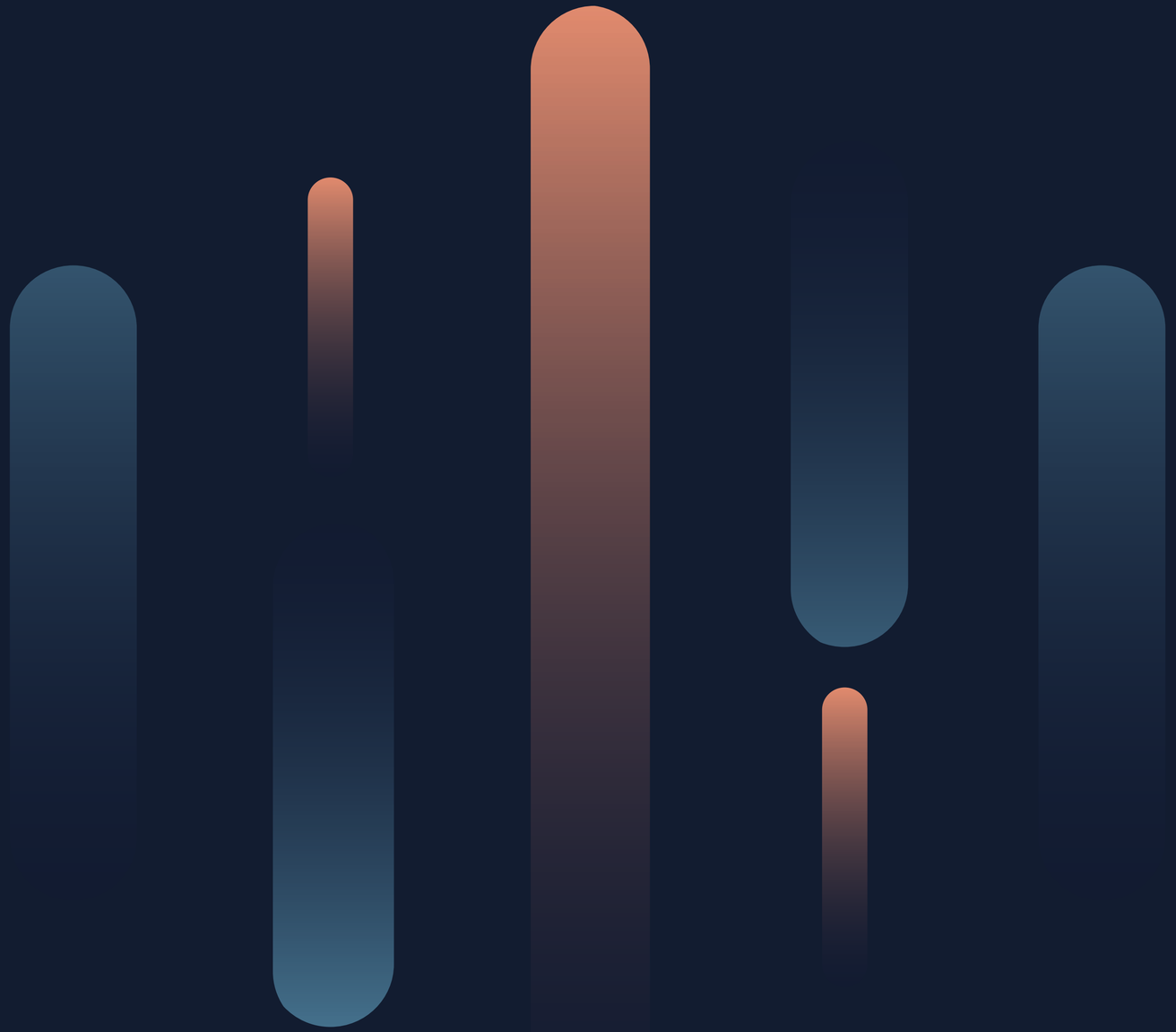
EWEC

Statement of Future Capacity Requirements

2023-2029

Summary Report

Emirates Water and Electricity Company



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The production of a report of this complexity has required the input and guidance from many people within EWEC, the Department of Energy, TRANSCO and across the sector, whose support has been invaluable. This report represents the views, opinions and recommendations of EWEC unless otherwise specified.

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Acronyms

ADNOC	Abu Dhabi National Oil Company
BESS	Battery Energy Storage Systems
CCGT	Combined Cycle Gas Turbine
CO_2	Carbon Dioxide
COD	Commercial Operation Date
DoE	Department of Energy
EWE	Etihad Water and Electricity
EWEC	Emirates Water and Electricity Company
GW	Gigawatt
IPP	Independent Power Producer
MIGD	Million Imperial Gallons per Day
MTPA	Million Tonnes Per Annum
MW	Megawatt
OCGT	Open Cycle Gas Turbine
PCOD	Project Commercial Operation Date
PV	Photovoltaic
RO	Reverse Osmosis
SEWA	Sharjah Electricity and Water Authority
SFCR	Statement of Future Capacity Requirements
UAE	United Arab Emirates

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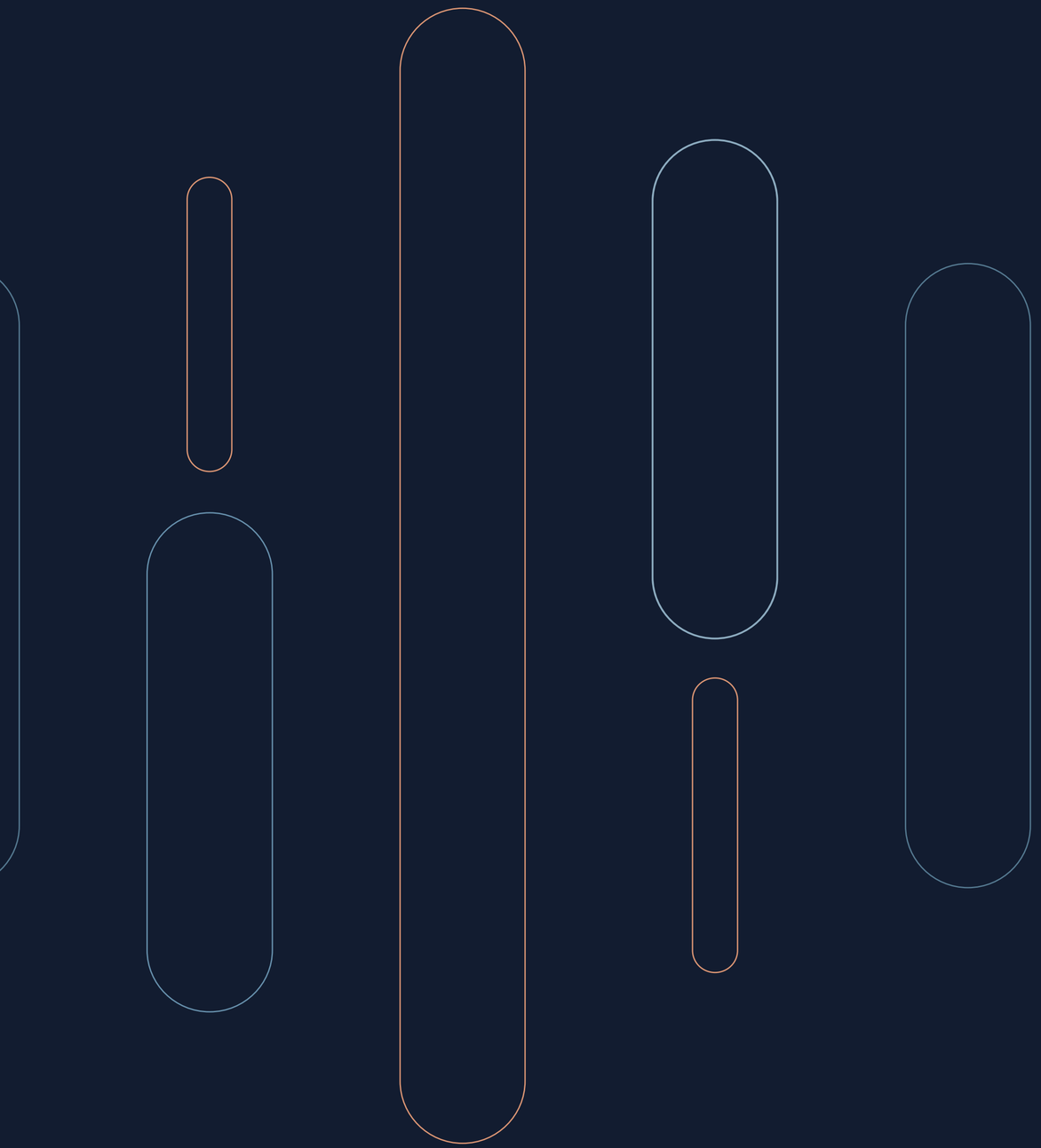
SUMMARY OF RECOMMENDATIONS



Based on our techno-economic modelling, the 2022 Statement of Future Capacity Requirements (SFCR) recommends the following:

Reverse Osmosis

- Urgently proceed with the development of two reverse osmosis (RO) desalination plants, Mirfa M2 120 Million Imperial Gallons per Day (MIGD)[1] and Shuweihat S4 70MIGD, to improve system operability and achieve economic benefits as soon as possible.
- Finalise sites and acquire the necessary approvals to develop an additional 100MIGD RO capacity provisionally identified on Abu Dhabi Islands to ensure timely deployment ahead of the retirement of the power and water complex at Sas Al Nakhl.

Battery Energy Storage Systems

- Procure battery capacity of 300 megawatts (MW) with a one-hour depth of storage to provide the operating reserves required to maintain system operability following the commissioning of the full nuclear capacity.
- In collaboration with TRANSCO, undertake power studies to identify optimal network locations and finalise capacities to ensure secure power system operation.

Solar Photovoltaic

- Immediately procure 1.5 gigawatts (GW) of solar photovoltaic (PV) projects in 2026 to realise gas-saving benefits fully.
- Since the Statement was published, the Abu Dhabi Government has established a 60% clean energy target. This drives the requirement for a total PV capacity of at least 16 gigawatts (GW) by 2035 and requires that sites for this capacity are identified and secured.

Thermal Capacity

- Secure 1.5GW of gas-fired capacity to meet peak demand in 2026 and the capacity shortage from 2027 onwards due to the retirement of Sas Al Nakhl, comprising a combination of either new-build, contract-extension or reconfiguration of existing assets.
- Identify sites for additional combined-cycle gas turbine (CCGT) and open-cycle gas turbine (OCGT) capacity, particularly to support the retirement of the power and water complex at Sas Al Nakhl.

[1] This capacity was recommended due to economies of scale from upgrading the project to 120MIGD from 80MIGD.

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INTRODUCTION

2.1 Purpose of Statement

The Emirates Water and Electricity Company (EWEC) is the single buyer and seller of water and electricity in the Emirate of Abu Dhabi. Under our licence, we are required to:

- Ensure that there is sufficient production capacity to meet all reasonable demands for water and electricity;[2]
- Engage in the economic purchase of water and electricity production capacity; and
- Engage in the economic purchase of ancillary services and fuel.

We develop and publish a Statement of Future Capacity Requirements ('the Statement' or 'SFCR') annually, which details our recommendations for achieving these obligations. This report summarises the recommendations for new capacity to be added to the system over the period 2023 to 2029 made in the full 2022 Statement of Future Capacity Requirements. We interpret our 'economic purchase' obligations as requiring the procurement of water and electricity (including ancillary services) to minimise the overall costs of the power and water systems in Abu Dhabi Emirate.

In minimising total system costs, we seek 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 United Arab Emirates (UAE), and retire older production facilities on contract expiry when they are no longer economical or required to maintain security of supply.

[2] EWEC needs to adhere to two key security of supply standards: (1) Demand for power must be met, with a loss of load expectation not to exceed five hours per year, as defined in the Generation Security Standard (GSS) and approved by the DoE in its capacity of sector regulator; and (2) Demand for water must be met with a loss of load expectation not to exceed one day in 10 years, as defined in the Desalination Security Standard (DSS) and approved by the DoE in its capacity of sector regulator.

2.2 Approach to Identifying Efficient Investment

Our approach to identifying the least cost system expansion plan in 2022 is based on the PLEXOS power and water system production cost model developed and refined over the past five years combined with a reserve margin requirement sufficient to meet the reliability standards required by our licence.

We have applied this modelling approach across several sensitivities around power and water system supply-demand fundamentals, reflecting the key uncertainties and choices facing EWEC as it plans 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 (consistent with the obligations in our licence), 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.

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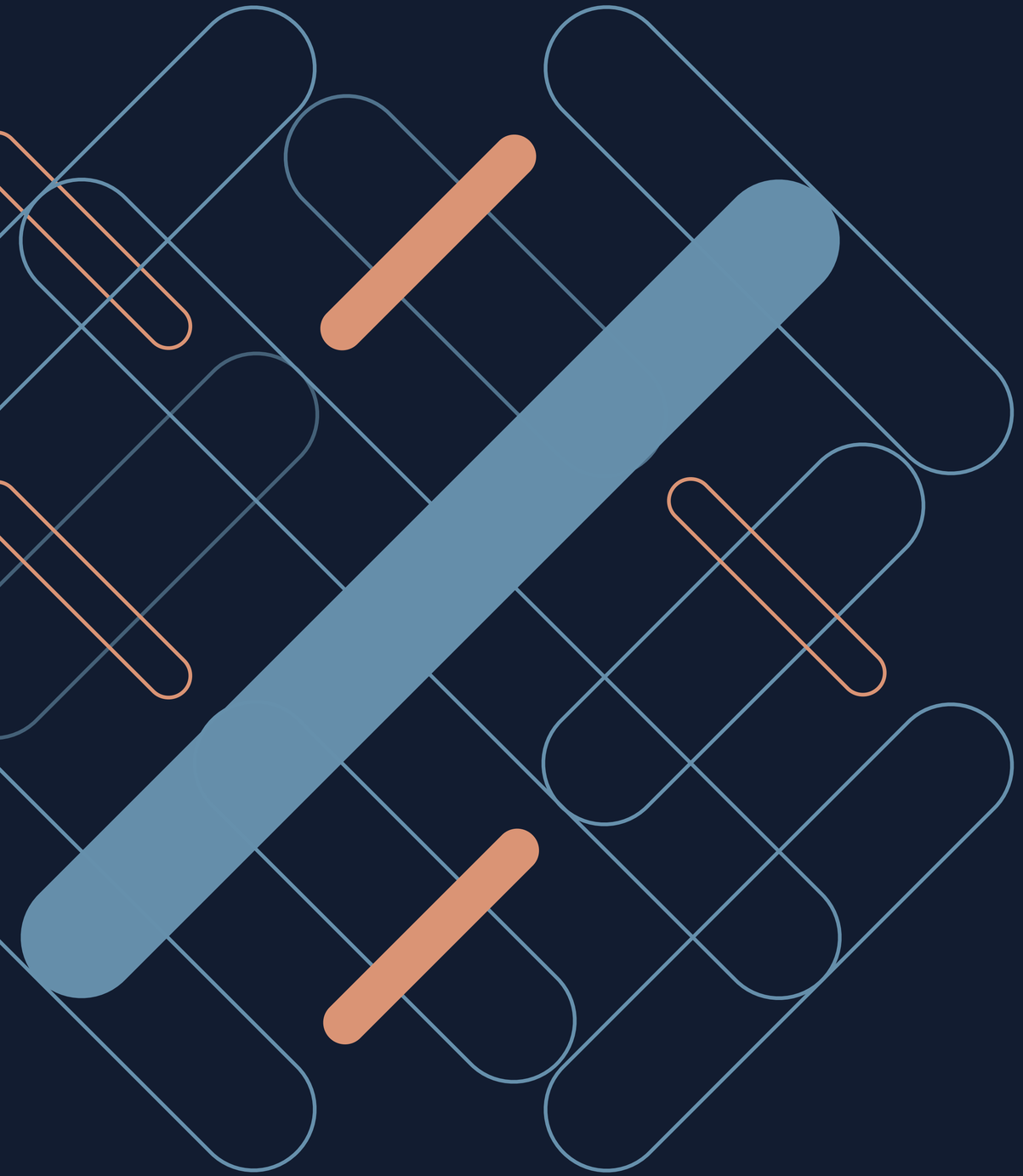
SUMMARY OF MODELLING ASSUMPTIONS



Recent geopolitical events combined with the impact of COVID-19 have dominated the global economic outlook and created uncertainty and disruption across supply chains and within markets. This has materially impacted the power and water sector by increasing the uncertainty of economic growth and the associated short- and mid-term demand forecasting for both sectors. Additionally, these impacts have heightened timing risk for the completion of construction and subsequent commercial operation dates for projects under construction. Finally, whilst there have been considerable recent increases in global energy prices, our existing contracted gas position has meant that we have minimal exposure to this increase with correspondingly minor knock-on effects on short-term sector costs. Nevertheless, we continue to monitor the ongoing global situation to mitigate risks where possible.

3.1 Demand Growth

For the 2022 SFCR, we use the 2022 February Week 7 power and water demand forecast that takes into account updated GDP projections provided by the Department of Finance. This indicates a faster than previously expected rebound in demand growth following the COVID-19 pandemic.

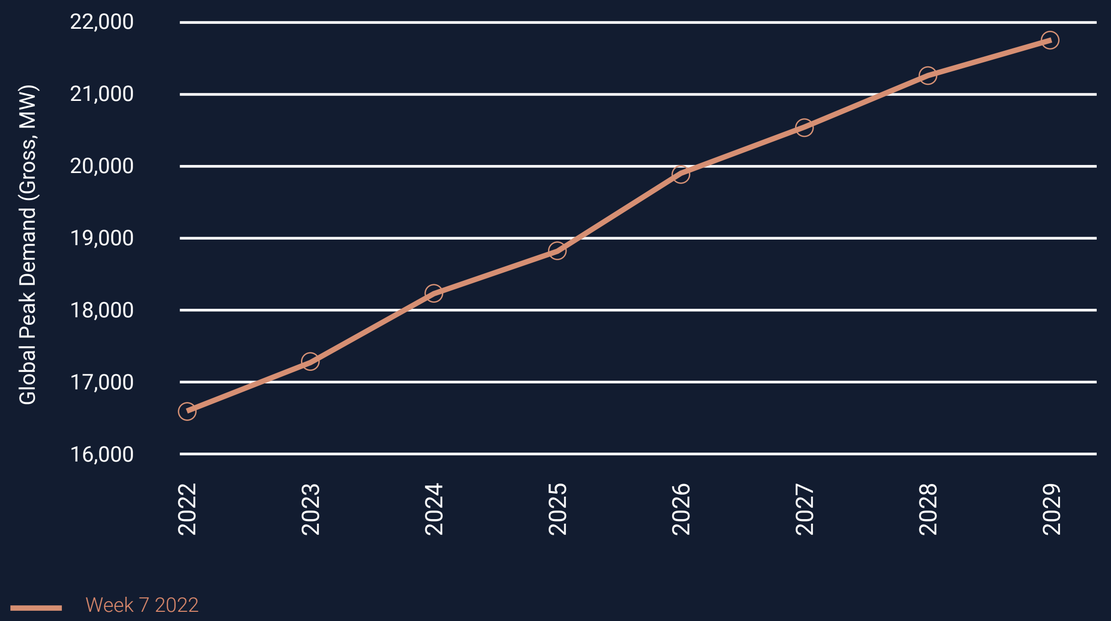
In addition to our Base Case view of demand, we also assess several demand sensitivities for their impact on our capacity expansion recommendations.

3.1.1 Power

Gross peak power demand is forecast to increase ~30% between 2022 and 2029 and is expected to rise from 16.7GW in 2022 to 21.6GW in 2029. The otherwise consistent increase in peak and total energy demand from 2022 is impacted, on the one hand, by a reduction in exports to Sharjah Electricity and Water Authority (SEWA) over 2022-2023 due to the commissioning of their new power plant, whilst being offset, on the other, by the addition of new Abu Dhabi National Oil Company (ADNOC) Offshore demand from 2026.

As Figure 3-1 illustrates, this forecast reflects an underlying increase in demand from 2023 onwards.

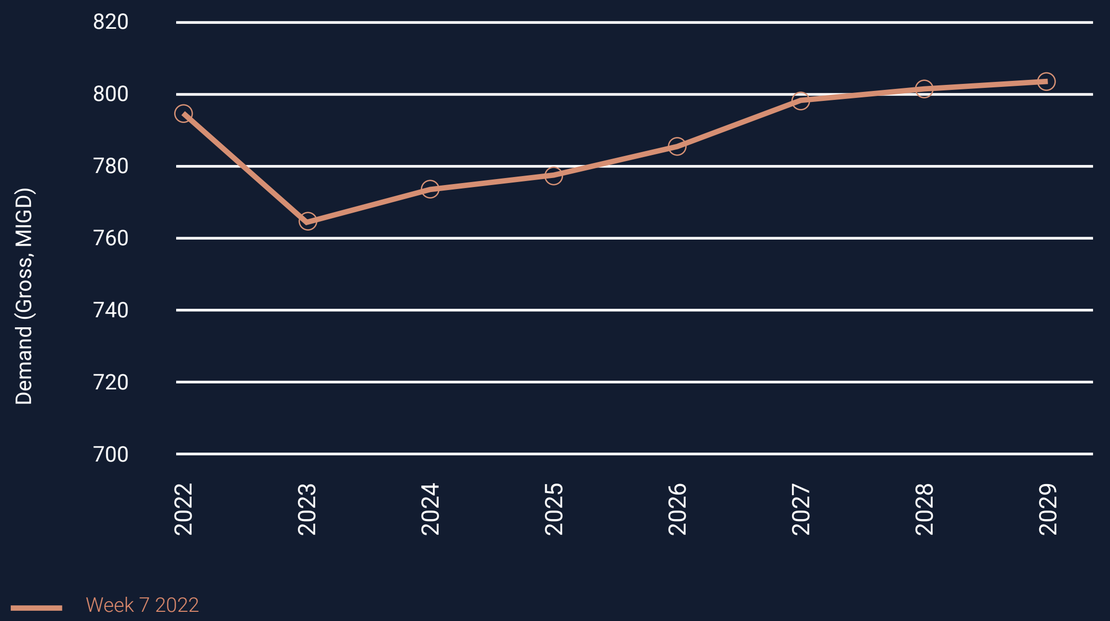
Figure 3.1: Base Case peak power demand (Gross, MW)



3.1.2 Water

Projected water demand is expected to be less sensitive to uncertainties posed by COVID-19. Projected demand is expected to reach 764MIGD (3.47Mm^3/day) in 2023 and starts rising from 2024 to reach 805MIGD (3.66Mm^3/day) in 2029 as shown in Figure 3.2. The demand will reduce from 2022 to 2023 because of a decrease in exports to Etihad Water and Electricity (EWE) resulting from the commissioning of their RO plant at the end of 2021. The decrease in demand in the Abu Dhabi region until 2024 is predominantly due to substituting desalinated water with recycled water for irrigation purposes.

Figure 3.2: Base Case peak water demand (Gross, MIGD)



3.2 Upcoming Retirements and Existing/Committed Supply

As in the 2021 SFCR, we assume in our Base Case modelling that all existing assets will retire at the end of their contracts. New assets are then selected by size and type based on their ability to contribute towards minimising the total system cost over the planning horizon. In practice, where existing assets can be contract extended, either 'as is' or in a reconfigured mode and result in a lower overall system cost, this option will be chosen. However, for modelling purposes, approximately 30% of water and power capacity is assumed to retire across the planning horizon to 2029.

Since the 2021 SFCR, major milestones have been realised on several projects:

- Barakah Unit 2 successfully completed commissioning and achieved commercial operation in March 2022, with Unit 3 expected to reach commissioning in Q2 2023.
- Al Dhafra Solar PV project's commissioning is anticipated to occur in Q1 2023.
- Fujairah F3 has reached financial close with Project Commercial Operation Date (PCOD) expected by Q4 2023.
- Taweelah RO has reached a significant milestone and is now at 50% production capacity, supplying up to 100MIGD (450,000m^3/day) into the network since December 2021. Full PCOD of 200MIGD (910,000m^3/day) is expected by Q2 2023.

We have received proposals for new reverse osmosis projects at Mirfa (M2) and Shuweihat (S4). In addition, we have also started receiving expressions of interest for the development of a new solar PV project, Al Ajban Solar PV Independent Power Producer (IPP). These three projects are expected to be operational by 2026.

3.3 The Costs of New Generation and Desalination Facilities

A key assumption that affects our capacity recommendations is the cost of new generation and desalination capacity. Under our Base Case scenario, we have updated our new build cost assumptions based on recent tender experiences and with reference to the latest market developments. We project these current costs into the future without speculating on potential future changes in technology costs.

3.4 Fuel

Our PLEXOS modelling accounts for the pricing and volumes of different tranches of gas available to the sector under current contracts.

To the extent that we need to procure gas outside of its existing contracts, we have formed an assumption through discussion with our suppliers regarding the long-term pricing of additional gas.

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RECOMMENDATIONS

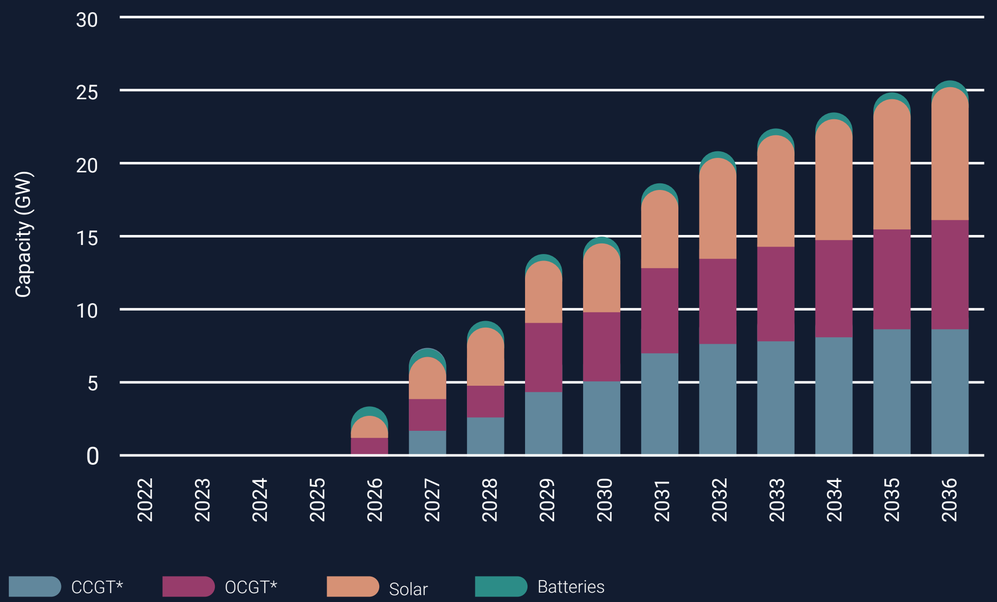
4.1 New Power Recommendations

Figure 4.1 shows our recommendations for new power capacity under the Base Case. Our modelling results indicate the following:

- Battery Energy Storage Systems (BESS): a minimum of 300MW x one-hour of reserve-optimised BESS by 2026.
- Solar PV: following Al Ajban Solar PV in 2026, we recommend another 1.5GW of PV by 2027 (or as early as possible).
- Thermal:
  - 1.5GW of new peaking gas generation or the extension or reconfiguration of existing assets for summer 2026.
  - A further 1.8GW of new CCGT or the extension or reconfiguration of existing assets for summer 2027.

We recommend BESS, solar PV and thermal generation capacity in the earliest complete year we assume each technology type can be deployed.

Figure 4.1: Base Case power recommendations by technology type (GW), 2022-2036



*OCGT and CCGT plants could be extended or reconfigured as well as developing new plants.

As the underlying demand increases, we have also identified a significant system cost and emissions reduction benefit from adding more solar PV capacity. In addition to the 1.5GW required from Al Ajban Solar PV in 2026, we project a need for a further 3GW of PV by 2029.

All recommendations in the 2022 SFCR for future capacity beyond that in the current year are, to some extent, dependent on future technology and market cost changes. The majority of sensitivities recommend up to 4.1GW of PV by 2029, which will grow rapidly after that. Accordingly, we must secure sites and develop business cases for materially more PV than recommended in the Base Case to deploy additional capacity quickly should the need arise.

Our recommendation to develop 300MW of BESS by 2026 will provide operating reserves. In addition, procuring 1.5GW of thermal capacity by 2026 will help meet reserve margin requirements. This recommendation rises to 9GW of OCGT or CCGT or asset extension by 2029 to replace 7GW of contract-expiring cogeneration assets and meet growing demand.

4.2 New Water Recommendations

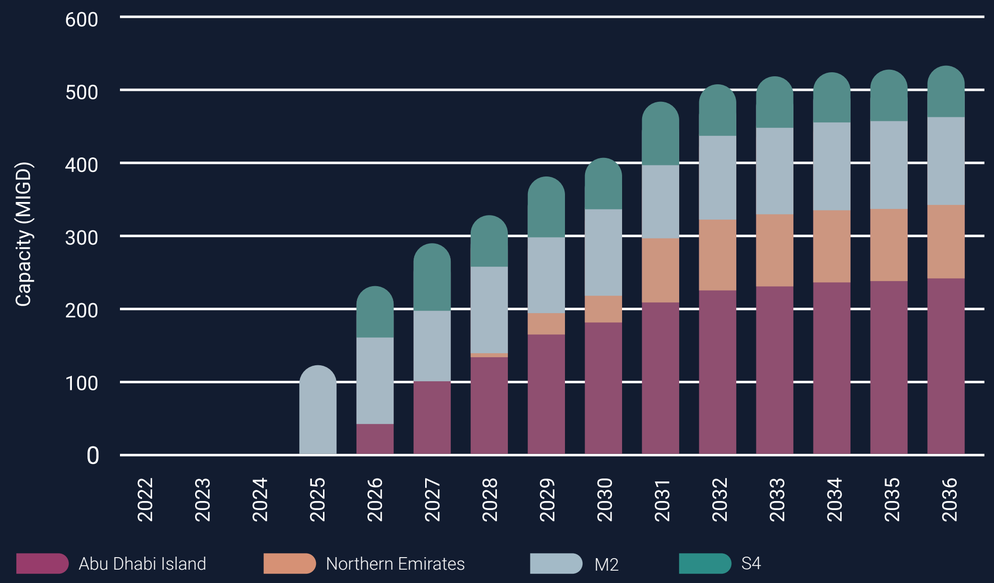
The 2022 SFCR recommends significant additional RO deployment in our Base Case. As confirmed in the 2021 SFCR, we are proceeding with the procurement of:

- 120MIGD[3] (540,000m^3/day) at Mirfa, assumed to reach Commercial Operation Date (COD) by July 2025; and
- 70MIGD (320,000m^3/day) at Shuweihat, assumed to reach COD by October 2025.

Our results show that the new Taweelah RO plant will provide sufficient capacity to ensure security standards are met following the decommissioning of Taweelah A2 in 2021.

The new Taweelah RO plant decouples water from power production, which alleviates security of supply challenges during periods of low electrical demand conditions in winter. Our modelling indicates that the system has adequate capacity up to 2027, even before the addition of an extra 190MIGD (860,000m^3/day) currently being procured at Mirfa and Shuweihat. The planned development of a total of 100MIGD across two sites on Abu Dhabi Islands, one at Hudayriyat Island and one at Saadiyat Island, will also facilitate the replacement of Sas Al Nakhl, due to retire in 2028.

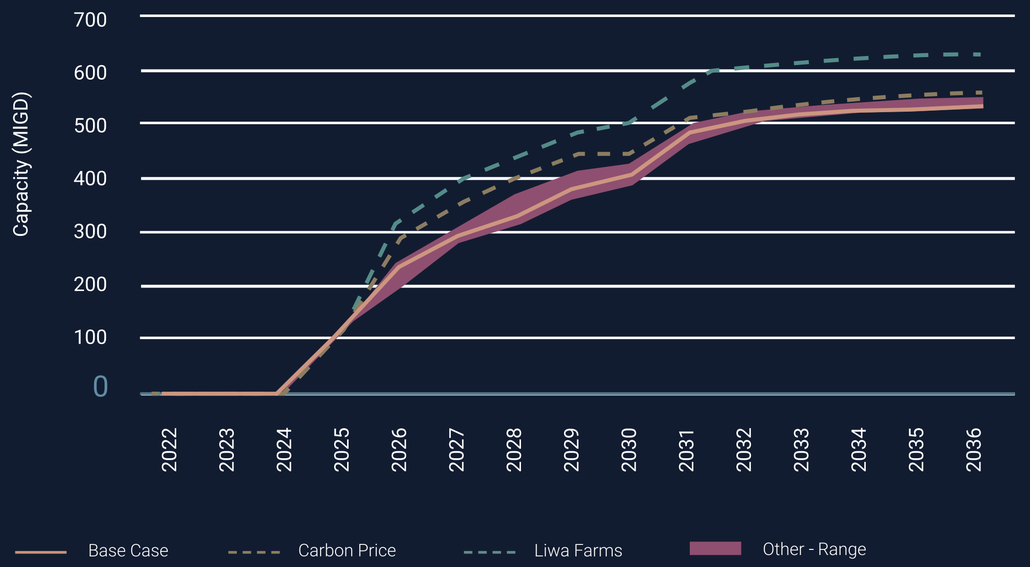
Figure 4.2: Recommended RO capacity by region (MIGD), 2022-2036



[3] See Footnote 1

The recommendation to develop at least 200MIGD (0.91Mm³/day) RO by 2026 (or as soon as possible) is resilient across all sensitivities, while sensitivities related to higher demands highlighted the potential need to deploy significantly more. In the scenario that assessed the impact of a tax on carbon, an additional 170MIGD (0.77Mm³/day) is required. By 2036, most sensitivities modelled indicate a total build-out projection of approximately 500MIGD-600MIGD (2.27Mm³/day-2.73Mm³/day).

Figure 4.3: Projected new RO capacity by sensitivity (MIGD), 2022-2036 (including Mirfa M2 and Shuweihat S4*)



*M2 is included in modelling from 2025, with expected Q4 2025 commissioning of S4 rounded to 2026.

4.3 Existing Fleet Recommendations

4.3.1 Focus on Flexibility

The addition of large amounts of nuclear and solar capacity introduces a number of system operability challenges, particularly in winter. We have put in place a range of measures to mitigate these, 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.

4.3.2 Life Extensions

Several plants will reach the end of their existing contracts during the 2023-2029 planning period:

- Shuweihat S1 (1,615MW, 101MIGD) expires in June 2025;
- Sas Al Nakhl (1,670MW, 95MIGD) expires in July 2027;
- Taweelah B (2,220MW, 160MIGD) expires in October 2028; and
- Taweelah A1 (1,671MW, 85MIGD) expires in July 2029.

Recognising the resulting need for replacement capacity after the retirement of Sas Al Nakhl in 2027, we are working with the operators of these plants to explore the economic viability of various extension and reconfiguration options compared with the procurement of new capacity.

5

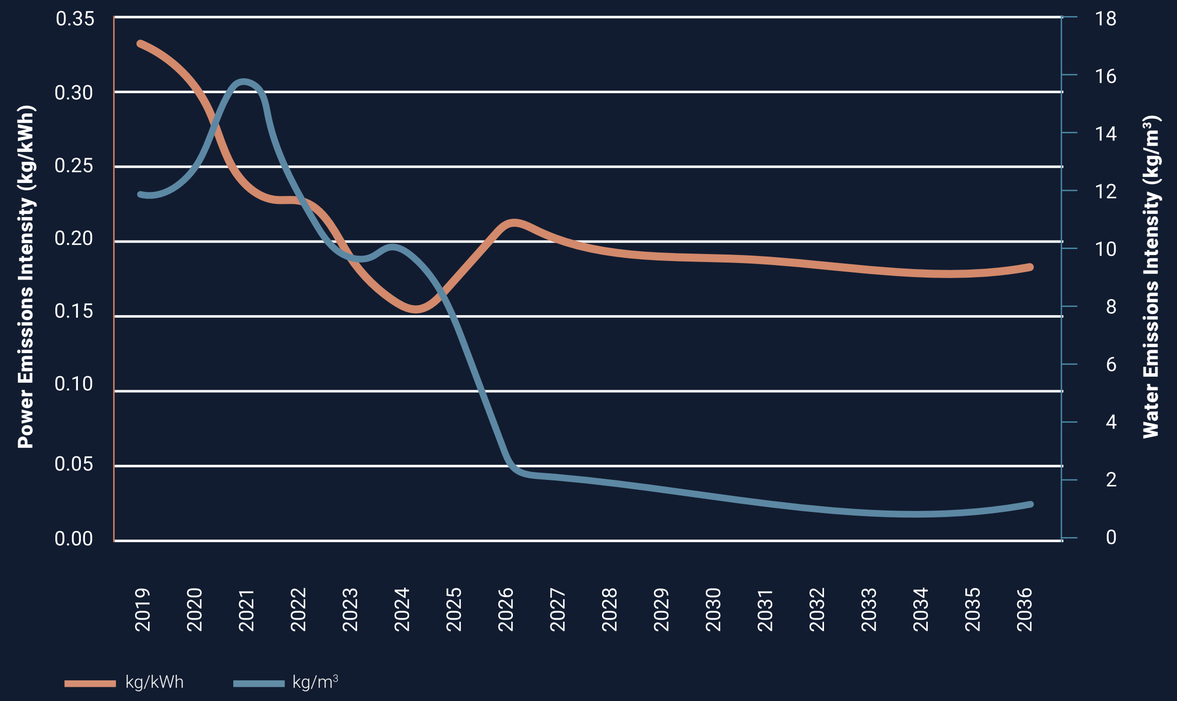
CARBON

We are required by law and our licence to recommend new asset development to achieve security of supply at the least cost. However, we also have an important role to play in translating the government's 2050 net zero goal into a viable strategy for the power and water sector that supports minimising carbon emissions whilst complying with our least-cost planning mandate. Since the 2022 SFCR was developed, the Abu Dhabi Government has approved the 2035 Clean Energy Target of producing 60% of all energy from clean energy sources (i.e., renewable and nuclear energy). In future iterations of the Statement and in coordination with the Department of Energy, the Clean Energy Targets will form the Base Case.

Projected total CO_2 emissions decrease around 35 per cent from 40 million tonnes per annum (MTPA) in 2021 to 26MTPA in 2025. Total emissions for most sensitivities are within 5% of the total emissions from the Base Case.

Power emissions intensity falls overall from 2019 to 2029, largely due to the commissioning of additional nuclear units, whilst emissions associated with water production also drop markedly over the forecast horizon.

Figure 5.1: EWEC emissions intensity of power and water production: Base Case, 2019-2036



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GLOSSARY

Glossary

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.

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

Learning Rates: The potential for the tariff associated with the provision of a particular service to fall as a result of technology or supply cost declines leading to a change in the mix and uptake of new-generation technologies.

Peaking Gas Generation Power Plants are those that operate during peak periods or when the system is constrained and requires generating assets that can rapidly ramp up (or down) production.

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.