حكـــومـــة أبـــوظـــبي
GOVERNMENT OF ABU DHABI

AADC ELECTRICITY NETWORK DESIGN GUIDELINES

EN-804

شركة أبوظبي للتوزيع
Abu Dhabi Distribution Co.

Abu Dhabi Distribution Company

2022
Electricity Five Year Planning Statement (2023 – 2027)

Issued by:
Asset Management Directorate, ADDC

Vol. 1 of 2

Rev.1
October 2022

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1 Introduction

1.1 Who We Are & What We Do

ADDC is one of the region's leading water and electricity distribution companies; it was established under law number (2) 1998 concerning the regulation of the water and electricity sector in the emirate of Abu Dhabi.

Our continued success is driven by the devotion of our people, who strive day and night to achieve excellence in everything they do.

ADDC operate under the umbrella of Abu Dhabi National Energy Company (TAQA) and within the license set by the Department of Energy (DoE), working side by side with other companies in the group to operate the water and electricity supply chain in Abu Dhabi.

Since ADDC were established, our dedicated team has strived to distribute the highest quality water and electricity to our growing number of customers, providing them with superior and sustainable services comparable with the best internationally.

Our family of employees works day and night to provide a continuous, reliable service to our customers. With strategically placed branches and a constantly expanding network, our operations cover most areas of the emirate of Abu Dhabi, except Al Ain which is serviced by Al Ain Distribution Company (AADC), our sister company.

On 13th December 1998, the RSB (currently DoE) issued Water and Electricity Distribution and Supply License ED/L01/008 Rev (0), on 1st January 2018 Rev.(6) of this license was issued, awarding ADDC sole rights to own and operate distribution and supply businesses within the area designated.

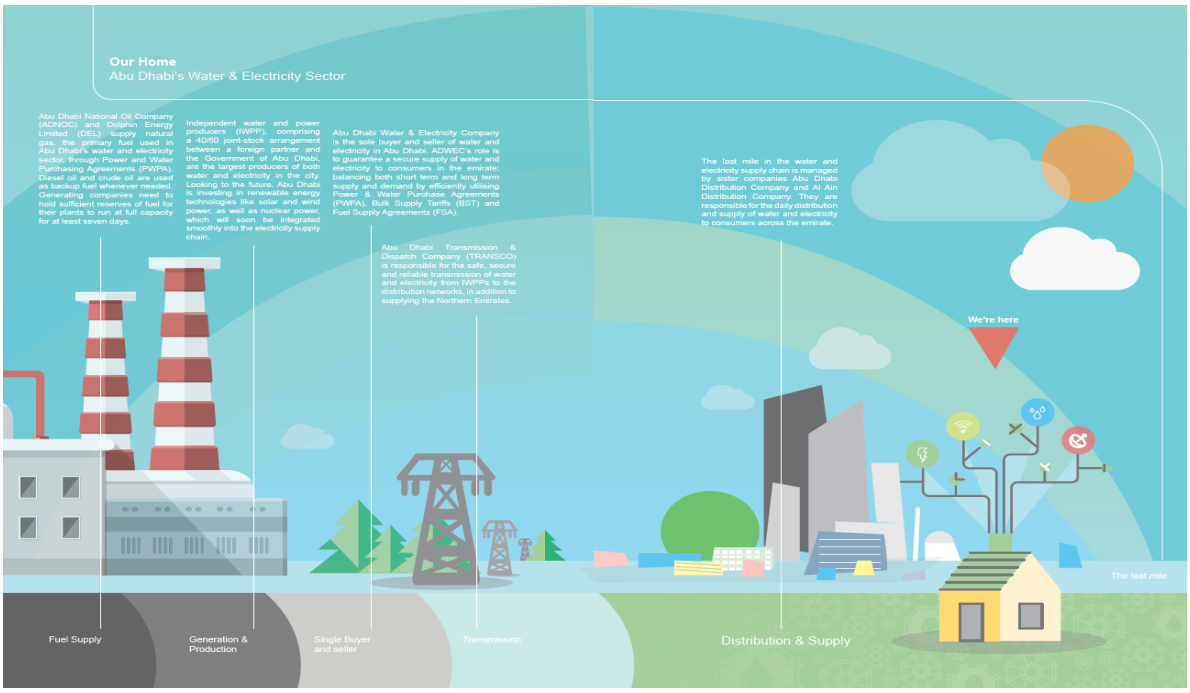
Generally, ADDC is licensed to:-

- Plan, develop, operate and maintain water and electricity distribution systems to the three geographical regions viz., Central Region, Eastern Region and Al Dhafra Region excluding Al Ain Municipal Jurisdiction.
- Purchase of water and electricity from the Emirates Water and Electricity Company (EWEC) through a transmission system owned by Transmission

and Dispatch Company (TRANSCO) and the resale of water and electricity to customers within the service area.

- Sell water and electricity to customers in Abu Dhabi Emirate with the exception of Al Ain,

The total service area of ADDC is approximately 47,705 sq. km. ADDC's core business is the planning, design, construction, and operation of the Abu Dhabi water and electricity distribution network.



Currently we are co-ordinating with our stakeholders on a long term strategic plan with following objectives:

- Ensuring the architecture of the electricity network is technically and economically efficient, meets customer requirements, and is safe, reliable and practical to operate.
- Ensuring the integrity of the existing asset base, through effective renewal, refurbishment and maintenance programmes;
- Keeping abreast with technological and consumption trends, assessing the potential impact thereof and devising strategies to effectively deal with this in the long-term. This would include Distributed Generation, Adoption of SMART grid technologies and DSM initiatives.
- Maintaining good strategic relationships with local government bodies (UPC, Municipality now merged as DPM) and major infrastructure providers to

support the long-term protection of ADDC's assets by ensuring that obligations (from all perspectives) are well understood and met.

1.2 Purpose of the Statement

As per the regulatory requirements (Condition 28), ADDC is required to submit its Five-Year Planning Statement to DoE every year enumerating its system expansion and reinforcement plans, to meet the growing demand adhering to all security and supply standards per DoE.

The objective of this 5-year planning statement is to produce a medium-term plan for the development of Abu Dhabi Electricity distribution system. This plan includes identification of the future Electricity demand of areas operated by ADDC.

The extent of the details of the plan includes future Electricity projects in line with ADDC strategy, budgeting, etc. which depends on the information of the existing system as well as the new developments in the region.

This document is also in line with the direction set in Asset Management Policy and objectives defined in the Asset Management Strategy.

The extract of Condition 28 of the License is stated below:

*"**Condition 28 – Five year planning statement***

1. The Licensee shall, by 30 June each year, prepare statements (separately in relation to the Licensee's electricity Distribution System and water Distribution System) in a form approved by the Bureau showing in respect of each of the succeeding five financial years:

a) Capacity, forecast flows and loading on each part of the Licensee's Relevant Distribution System;

b) The Licensee's plans for capital expenditure necessary to ensure the Licensee's Relevant Distribution System meets security standards, standards of performance and future demands; and

c) A quantification of the capital expenditure plans under (b) above with particular reference to the cost of major schemes or projects; together with:

d) A commentary explaining material differences between the capital expenditure undertaken in the previous year compared to capital expenditure envisaged for that year in such statement prepared in earlier years;

e) Such further information as shall be reasonably necessary to enable any person seeking use of system to identify and evaluate the opportunities available when connecting to and making use of such system;

f) A commentary prepared by the Licensee indicating the Licensee's views as to those parts of the Licensee's Relevant Distribution System most suited to new connections and transport of further quantities of water or electricity, as the case may be; and

g) Any other information as specified by the Bureau from time to time.

2. The Licensee shall include in every statement given or sent under paragraph 1 above the information required by that paragraph except that the Licensee may with the prior consent of the Bureau omit from any such statement any details as to the capacity, flows, loading or other information, disclosure of which would, in the view of the Bureau, seriously and prejudicially affect the commercial interests of the Licensee or any third party.

3. The Licensee shall send a copy of each statement prepared in accordance with paragraph 1 to the Bureau.

4. The Licensee shall give or send a copy of each statement prepared in accordance with paragraph 1 to any person who requests a copy of such statement or statements.

5. The Licensee may make a charge for each statement given or sent pursuant to paragraph 4 of an amount reflecting the Licensee's reasonable costs of providing such statement which shall not exceed the maximum amount specified in directions issued by the Bureau for the purposes of this Condition."

1.3 Vision, Mission & Corporate Values

1.3.1 Vision

A leading digital utility that delivers reliable and sustainable value to customers through empowering our people.

1.3.2 Mission

Plan, develop, maintain, and operate a reliable, secure, safe, and cost-effective distribution system in Abu Dhabi and deliver services that meet or exceed our customers' expectations.

1.3.3 Core Values

- Safe: We put safety above all else.
- Sustainable: We do what is right for our environment, community, and people.
- Collaborative: We are stronger together.
- Innovative: We seek creative ways to deliver results.
- Excellence: We strive for exceptional performance.

1.4 Strategy

1.4.1 Strategy Statement

ADDC has recently revised its strategic plan to continue actively contributing to the prosperity of Abu Dhabi in coordination with other sector stakeholders.

Our strategic direction is to achieve outstanding performance, delivering superior services and operations, and ensuring steady growth within and beyond the sector. All within an innovative and digital environment that delivers reliable and sustainable operations and services to our customers across all customer segments.

ADDC strategy map captures our direction, what we aspire to be, strategic pillars, and approach. It also describes the broad areas that we need to focus on to achieve goals.

Strategic Plan Map 2022 - 2026

Figure 1.1: Strategic Plan Map 2022 - 2026

The Strategic Plan map is the high-level summary of the five years strategic plan of the company, which by itself summarizes the strategic direction of the company in the next five years. It illustrates the logical cascade of goals across the different encompassing strategic themes and the logical link between them. The strategic plan map details the following:

Company's vision:

The vision is the final destination that the company aspires to reach after five years via successfully achieving all of its strategic objectives. Our vision is closely linked to the Abu Dhabi vision and TAQA, our parent company, goals. Furthermore, the vision represents the inspirations of the long-term decisions taken by the company.

Strategic themes:

Strategic themes are the contextual frames that foster all the company's aspirations and organizational goals that are deemed crucial to translate the strategic goals into reality. We have identified five different strategic themes that will guide our efforts.

Strategic aspirations:

Strategic aspirations are the priorities that sprouted from our strategic goals, which detail in a practical and logical manner the strategic objectives of the organization.

Strategic goals:

Strategic goals are the five years goals that were put by the company to translate its vision, mission, government direction, stakeholders' requirements especially employees and customers regardless of segmentation.

Organizational goals:

Organizational goals are the primary goals set by the company that when accomplished, the strategic aspirations and strategic goals are achieved and hence the ultimate vision of the company is fulfilled.

These goals are achieved via strategic initiatives, which within them encompasses several specialized projects spread across the organization and collectively contribute to the progress of the initiatives. The achievement of these goals is measured by strategic KPIs.

All the different directorates work collectively to achieve these strategic goals on daily basis via achieving the different elements of the strategic initiatives and enhancing the performance of the different KPIs.

Enablers:

Enablers are the elements that empower the company to achieve its strategic goals such as transforming the culture to an attractive culture that fosters innovation and creativity, attracting talented employees and retaining them, achieving performance excellence in all of the company's operations etc., in addition to any other aspect that will enable the company's directorates to successfully achieve the initiatives and improve the performance of the strategic and operational KPIs.

1.4.2 Strategic Pillars

Over the next five years, the following five strategic pillars will be on our focus:

- Financial Growth
    - We will achieve superior financial performance across all domains by enforcing strong financial governance across all levels.

- We will tactically grow our business exploring opportunities inside and outside the sector.
- We will streamline and integrate our strategic portfolio management effort ensuring cross-directorate accountability of deployment.

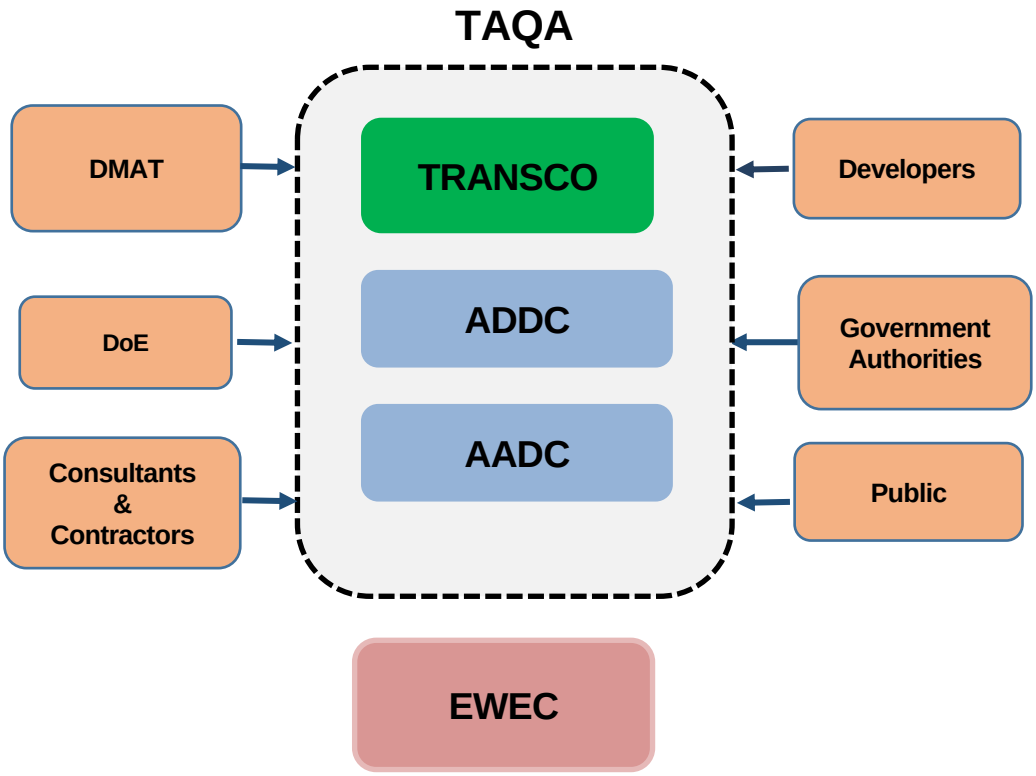
- Customer Delight
  - We will continue focusing on providing our customers with smart sustainable service across all service channels within one integrated experience.
  - Internally, we will achieve top quartile customer service operations across the customer journey within an optimum cost-to-serve model.
  - We will empower our customers with innovative tools, analytics and education to help them reduce their water and electricity consumption.
- Operational Excellence
  - Safety will remain our top priority, and we will achieve top quartile safety performance supported by a strong safety culture and enforcing accountability model across all levels.
  - Our operations will continue to be resilient ensuring security of supply and utmost reliability all while running highly efficient streamlined operations.
  - Our operations will be environmentally sustainable with reliance on green solutions across our buildings and processes to support the sector's net-zero emissions aspirations.
- Digital empowerment
  - We will integrate, digitize and automate key processes that impact our strategic direction.
  - We will empower sound decision-making with analytics and predictive business insights.
  - Our technological infrastructure will be fully protected by a robust cybersecurity model that is fully compliant with national security policies.
- People and Culture
  - We will effectively manage our talent, existing and new, working vigorously on retaining them via active engagement, providing them with clear career paths and rewarding schemes and recognize top performers.
  - We will ensure that our talent is future-ready by skilling and upskilling them through tailored learning and development programs.

- We will overhaul our corporate culture to be more nurturing of talent, empowering them to be strategy-focused, open and fluid in their communication and collaborative across all directorates.

The prioritized objectives listed under each theme represent the broad areas that we focus on to deliver our strategic intent.

The strategy plan map was created in alignment with the sector in the beginning of the year 2022. Since then, several strategic initiatives have been identified and many of which are currently in place to address the strategic priorities.

Key Stakeholders



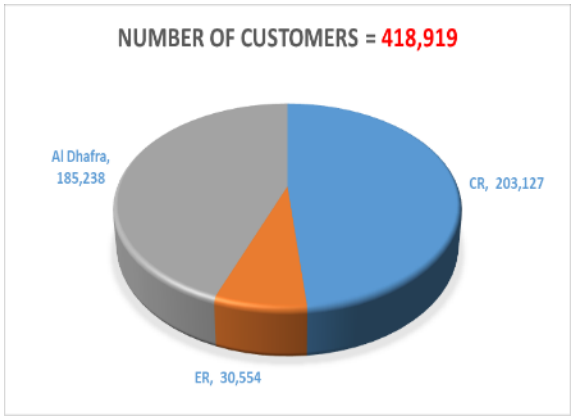
The following table identifies the key stakeholders in the ADDCs Strategic Asset Management Plan and their requirements, these stakeholder needs (many of which are mandatory) provide the basis for development of ADDCs asset management objectives and the KPIs that are used to manage our assets.

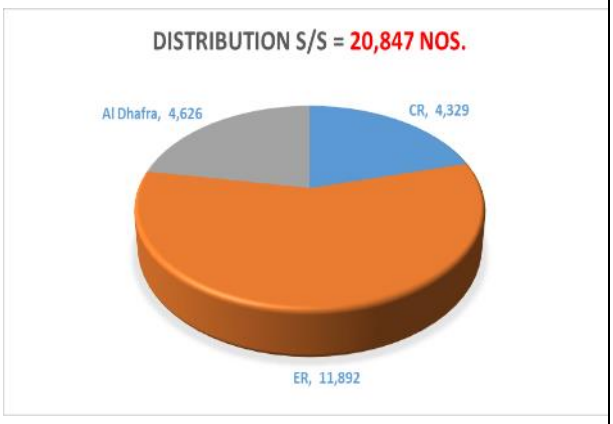
ADDC review and update the stakeholder requirements and preferences through an on-going process of formal and periodic communication and feedback.

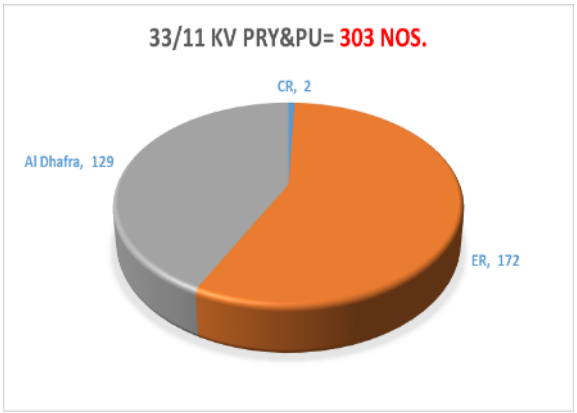
STAKEHOLDER	Stakeholder Needs from ADDC	Stakeholder Influence
TAQA	• Operating assets with a view of improving the financial performance • Ensure license compliance • Relationship with TAQA is driven by financial/ operational performance dashboards	• Active asset owner (oversees financial and operational performance of ADDC). • No direct involvement in ADDC's operations
DoE	• Compliance with defined license requirements and conditions in order to safeguard consumer's interests.	• Sector regulator (defines regulatory framework and policies) • Relationship with ADDC is defined by the regulatory framework and licensing processes.
EWEC	• Supply of Water/Electricity • Demand/Energy Forecast	• Water/Electricity Producer
TRANSCO	• Enter into agreement with TRANSCO for the provision of an uninterrupted supply for the distribution network. • Compliance with Transmission code requirements.	Provides interface connection points to supply water/ electricity as required
DMAT	• Future infrastructure expansion plans. • ADDC to Align its growth plans with Abu Dhabi's envisioned growth and ensure the successful execution of all its growth capital projects	• Defines future development plans. • Acquiring route approvals and permits related to ADDC capital projects.
Consultants & Contractors	• Grant fair terms and be transparent and reliable with our dealings with them	• Implementation of Asset Management Plan. • Abide by the contracts agreements
Mega Developers	• Water/Electricity to be connected/ supplied as requested	• Demand forecasts to plan infrastructure expansion plans
Customers	• Reliable and safe provision of water & electricity and services.	• Customer's satisfaction supports ADDC road to excellence.

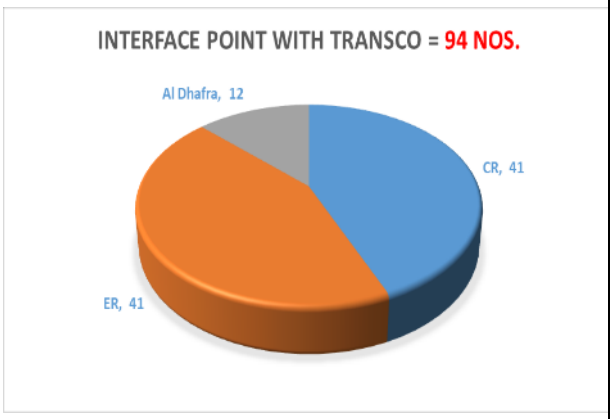
1.5 Key Statistics Data

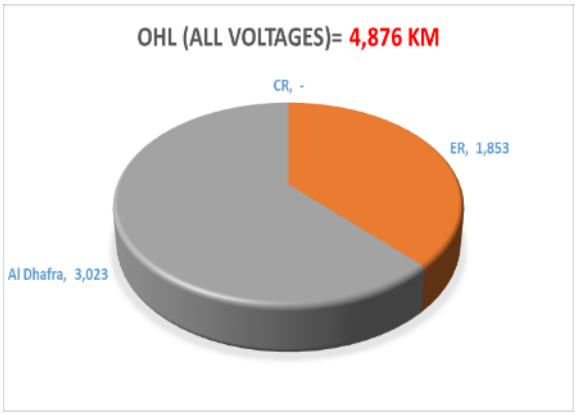
1.5.1 The key statistical figures with related to the existing electricity distribution network are enumerated in the Graphs below and detailed in Appendix 1.1:

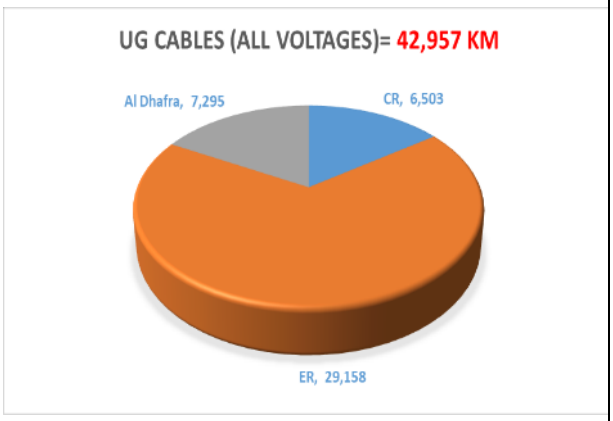




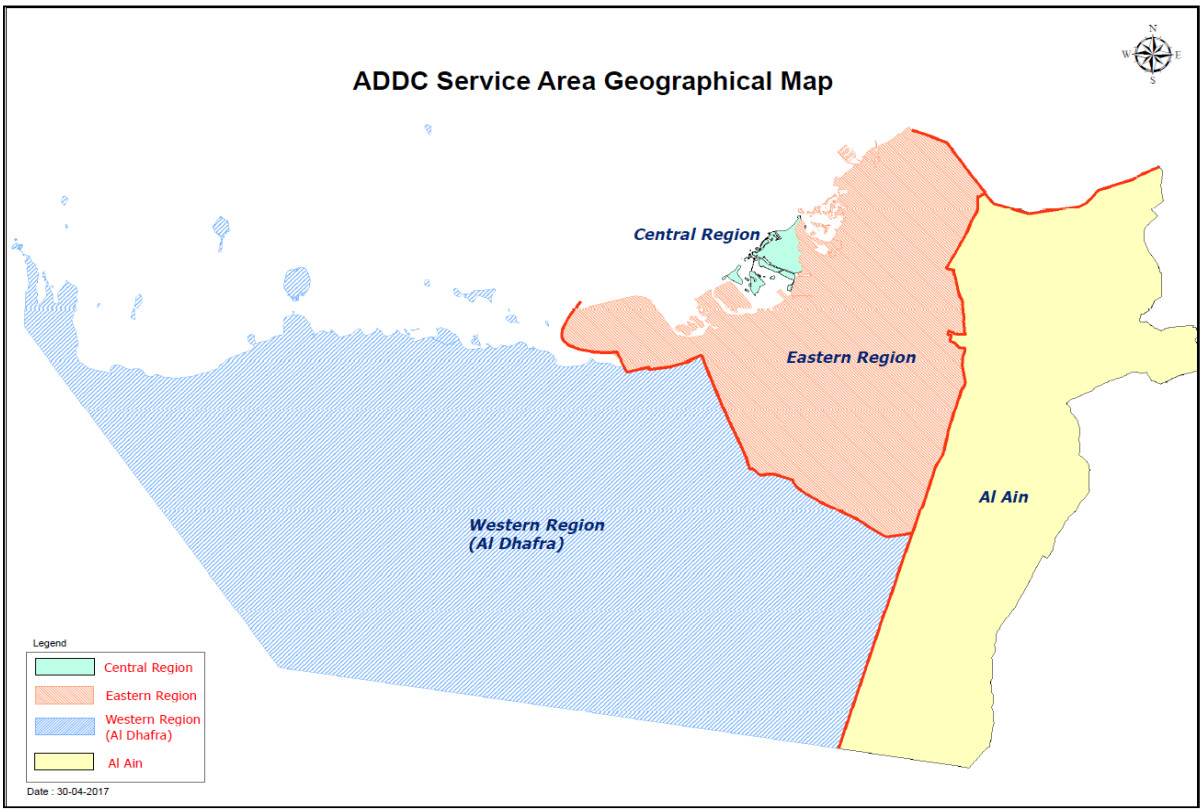








A geographical map presenting ADDC's service area is presented in the below figure



2 System Characteristics and Operational Philosophy

2.1 Governing Standards

ADDC's electricity distribution system and its associated assets are designed and operated under the governance of the following set of regulation and standards:-

2.1.1 As on 1st July, 2020, Abu Dhabi National Energy Company (TAQA) announced, the successful completion of its transaction with Abu Dhabi Power Corporation (ADPower), to transfer the majority of its power and water generation, transmission and distribution assets to TAQA

2.1.2 Law No. 3 / 2019 regarding all movable and non-movable assets, properties, shares and stocks in the companies owned by the Department of Energy will be transferred to ADPC (Abu Dhabi Power Corporation),

2.1.3 Law No. 11/2018 for establishment of DoE and replacing ADWEA and RSB.

2.1.4 Law No. 2/1998 issued by the Abu Dhabi Government to replace WED.

2.1.5 Water and Electricity Distribution and Supply License Rev 5 ED/ L01/008

2.1.6 Electricity Supply Regulation (second Edition 2018)

2.1.7 Electricity Wiring regulation (2020 Edition)

2.1.8 Distribution Code Version 3.0 (November 2005)

2.1.9 Electricity Network Planning and Design Guidelines (GL.AMD.03) June 2020

2.1.10 ADDC Standards and Specification (June 2015)

2.1.11 Security of Supply standards (version 3.0 – 2019)

2.1.12 Engineering Recommendations (Limit of harmonics, unbalance and voltage fluctuation) 2005

The Security of Supply Standards is issued based on "Condition 29" of the distribution License that License holders must develop, and keep under review, security standards for their distribution systems. It contains, criteria for the Main Distribution System, criteria for Grid stations at the interface points with TRANSCO and criteria for embedded generation connections, the classes are summarized in Appendix 2.1 A.

The Security of Supply Standards followed by ADDC, define the ability of the distribution system to provide electricity to end-users with a specified level of continuity and quality of supply. The distribution License allows the licensee to seek derogation from the Department of Energy (DoE) if security standards cannot be met on specific parts of its system, subject to consultation with affected customers.

2.2 Electricity Network Planning Process:

The planning process adopted by ADDC can be easily understood with the help of the chart depicted below (Figure-1). The process begins with the demand/load forecasting that determines the future demand. A reality check will be done with forecasted load/demand to evaluate the system capabilities.

The system should be capable of catering to the future demand without compromising the “Electricity Network Planning & Design Guidelines”, “Security of Supply Standards” and the quality of power supply or any other requirement that are defined by the regulator.

The system evaluation will be done with the help of simulation software by carrying out load flow, short circuit and stability studies and requirement of reinforcements for the existing system will be identified and finalized based on the system performance reports available.

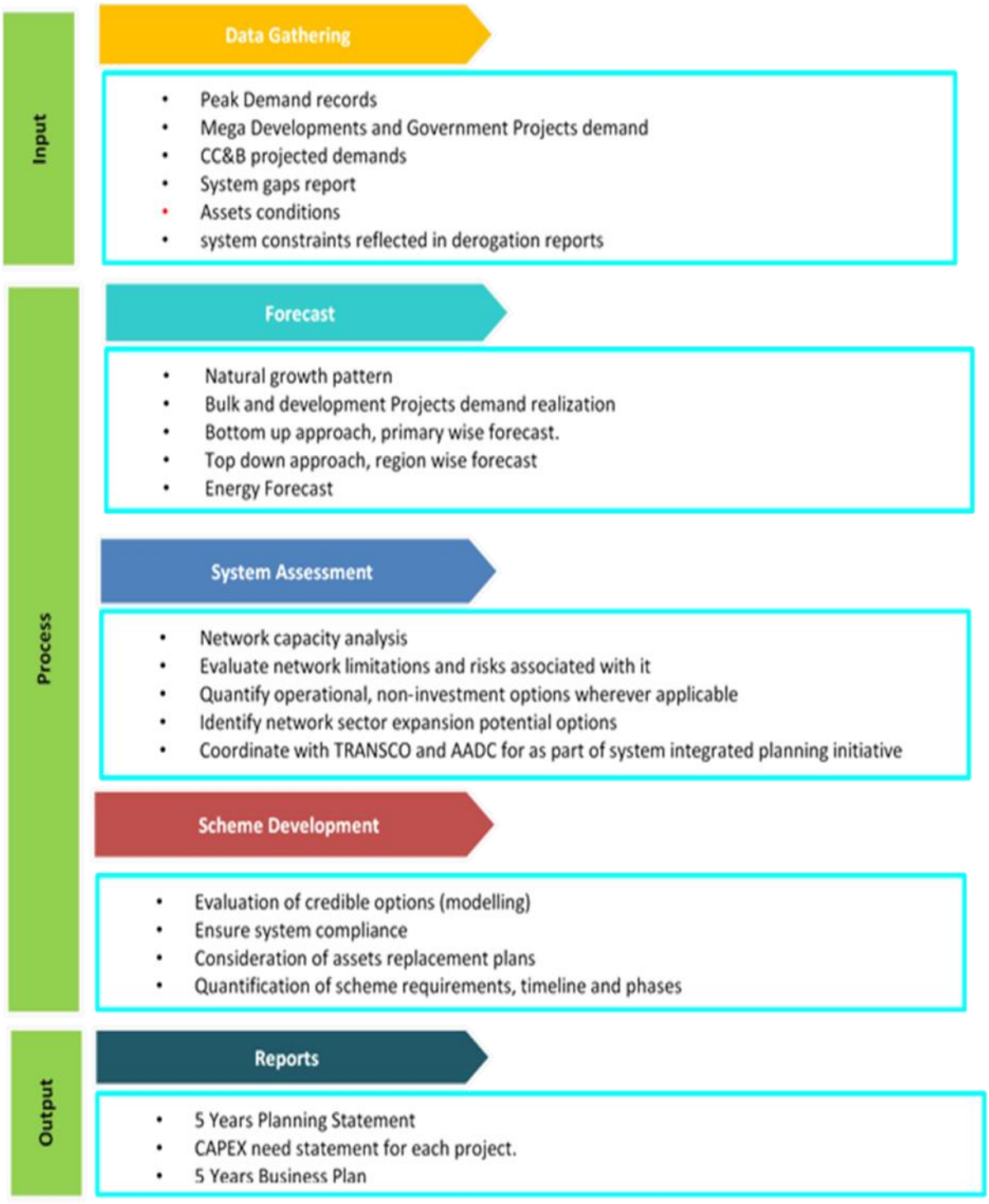
All the risks associated are clearly identified and if the risks cannot be managed with the existing system, new proposals are recommended for implementation.

Once the system design/plan meets the technical criteria, economic feasibility analysis will be carried out. The feasibility analysis process compares the investment and the economic benefit rising out of implementation of the expansion/augmentation proposals in the planning statement.

Feasibility for a proposal is determined with the help of standard cost evaluation methods. The feasibility studies are carried out to conclude whether the investment proposals are economically viable or not and would aid the management decision making process on the investment related issues.

This will enable ADDC to reach a decision with relatively lesser time involved and bring down the gestation period and helps to implement/realize the infrastructure as planned/scheduled within the planned time frame and without any cost overruns.

Electricity Network Planning Process:



2.3 Factors Affecting System Expansion Planning:

The planning process is affected/influenced by so many diverse factors. A sincere attempt is made to consider all the factors that affect the planning. The list of inputs/factors that is being considered for the planning in brief is presented below.

Figure below depicts the pictorial representation of the major inputs/factors that influence planning.

1. Load Forecast (the future demand to be catered by the system) and its level of confidence
2. Security of Supply Standards
3. Power Quality Standards/Guidelines
4. Operational concerns
5. Environment Health & Safety
6. Best practices
7. Economic feasibility
8. Urban Structure Frame Work Plan (Plan Abu Dhabi-2030)
9. System performance reports

e-

2.4 System Characteristics

ADDC designs its electricity distribution system based upon a number of technical characteristics so that it fulfils the requirements of the regulations and standards. system fundamental characteristics are described below:

2.4.1 System parameters are briefed in the following table and Appendix 2.1

sn	Parameter	Unit	Distribution System Voltages (kV)			
			LV	11	22	33
1	Design Voltage	kV rms	0.4	11	22	33
2	Power Frequency Withstand	kV rms	2	28	50	70
3	Lightning Impulse Withstand to Earth	kV rms		75	125	170
4	Rated Frequency	Hz	50	50	50	50
5	Short Circuit Levels	kA	46	31.5	31.5	31.5
6	Harmonic Level	%	5%	4%	3%	3%
7	Voltage Fluctuation Limits	%	3%	3%	3%	3%

2.4.2 Harmonics: the THD (Total Harmonic Distortion) at different voltage levels are as above tables and as per Engineering Recommendation No.1 of Electricity Distribution Code.

2.4.3 Method of Earthing: generally ADDC distribution networks are solidly earthed at different voltage levels except at secondary side of the interface point with TRANSCO as the earthing method and size are determined by TRANSCO.

2.4.4 Protection systems: 33 kV cables networks implements the cable line differential as the main protection and over current and earth fault as the backup protection, while 11 kV and 22 kV networks implements over current and earth fault as the main protection. 33 kV OHL implement distance function as the main protection

2.4.5 System Automation: ADDC established its DMS facility in 2006 providing automated operation and control systems such as supervisory control and data acquisition (SCADA) for major parts of ADDC network. Recently ADDC floated 2 Nos. of contracts to extend DMS integration to cover all primaries, switching stations and substations feeding VIP consumers and other important substations in the distribution system in all regions.

2.4.6 Operating voltage: Standard operation voltages are 33, 22, 11 kV with band width of ± 6% and LV (0.4 kV) with band width of +10% and 6%

2.4.7 Voltage drop mitigation: In order to maintain the voltage at any point of the network within the above mentioned band width, all power transformers are equipped with OLTC (on load tap changers) that works to maintain the voltage level at the low voltage side of the transformers within a range that allows the network operator achieves the permissible band width at any point of the system

2.4.8 Power factor: Consumer at the LV level are required to maintain a minimum of 0.9 lagging power factor, while ADDC is required to maintain a ≥0.91 at TRANSCO interface point (As per The Electricity Wiring Regulations, Section 4.1.9)

2.5 Selection of Assets

The choice of network assets suitable to connect a specific demand is subject to many factors including geographical location, size and nature of the demand, available network voltage level within the vicinity of the demand area and the spread of demand distribution (i.e. load density).

As an example, for connected load less than 500 kW it is usually connected on LV level, while a connected load up to 5000 kW are usually connected via HV connection through a dedicated substation in common loop on 11 kV or 22 kV voltage level.

On the other hand, connected load more than 5000 kW to be studied on case-by-case basis depending on the expected demand size as it may be connected via a dedicated 11 kV or 22 kV feeders or may require a dedicated primary substation.

Based on ADDC technical specification, standards and regulations, the size and rating of network assets have been determined and can be summarized as per the below table:-

Standard Substation Size and Rating

	Voltage ratio kV	Transformers	
		Nos.	Size (MVA)
ADDC Distribution S/S	11/0.4	1 or 2	0.5, 1.0, 1.5
ADDC Distribution S/S	22/0.4	1 or 2	0.5, 1.0, 1.5
ADDC P/U's	11/0.4 or 22/0.4	1	0.5, 1.0, 1.5
ADDC Primary	33/11	3 or 4	20
TRANSCO Primary	132/11	3 or 4	40
TRANSCO Primary	132/22	3 or 4	60

Also, ADDC uses a standard cable size in its networks as follows: -

- ADDC started the adoption of Low and Medium Voltage Aluminium cables of 3cx400 Sq. mm size in place of the presently used sizes of 3Cx240 Sq.mm and 3Cx300 Sq.mm Copper cables for 11/22/33kV.
- 4cx16 mm^2 up to 4cx240 mm^2 are commonly used for LV connections based on demand size.

2.6 System Configuration

2.6.1 Network Topology

Emirates Water and Electricity Company (EWEC) is the sole buyer and seller of water and electricity in Abu Dhabi. EWEC's role is to guarantee a secure supply of water and electricity to consumers in the emirate; balancing both short term and long term supply and demand by efficiently utilizing Power & Water Purchase Agreements (PWPA), Bulk Supply Tariffs (BST) and Fuel Supply Agreements (FSA).

Abu Dhabi Transmission & Dispatch Company (TRANSCO) is responsible for the safe, secure and reliable transmission of water and electricity from IWPPs to the distribution networks, the supply of electricity to non-embedded customers in addition to supplying the Northern Emirates.

Abu Dhabi Distribution Company (ADDC) and Al Ain Distribution Company (AADC) manage the last mile in the water and electricity supply chain. Both companies are responsible for the distribution and supply of water and electricity to consumers across the emirate.

ADDC's service area covers the entire Abu Dhabi Emirate except Al Ain, ADDC service area comprises of three regions i.e. Central, Eastern and Al Dhafra.

2.6.2 Connection to the Transmission System

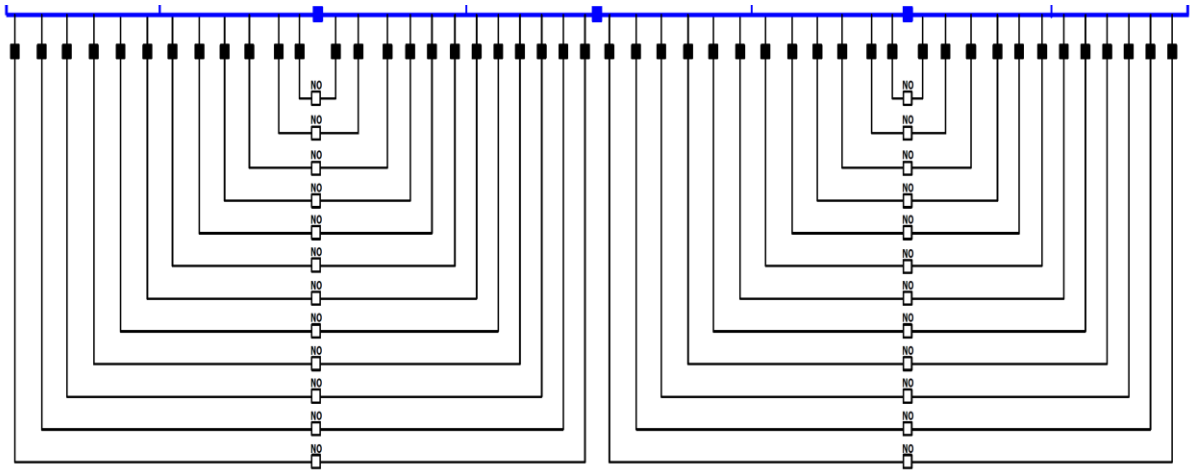
ADDC electricity network is interfaced with TRANSCO network at different voltage levels, namely 33kV, 22kV and 11kV; this applies to all regions except for WR where 33 kV and 11 kV are the only interface point voltages with TRANSCO.

Details of interface points with TRANSCO are presented in Appendix 2.2 (220/33 kV and 132/33kV) and Appendix 2.3 (132/22 kV and 132/11kV)

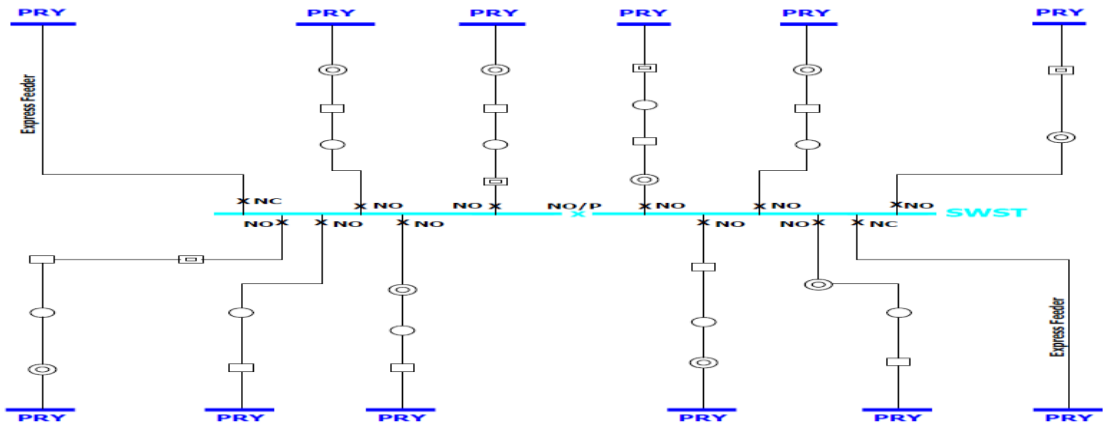
2.6.3 Configuration

The 11 kV network typically operated in two standard modes:-

1. Open loop configuration (either from same primary or as interconnection between different primaries) as shown in the below diagram



2. Switching station configuration as shown in the below diagram



On the other hand, the 22 kV network mainly operated in open loop configuration and the low voltage (LV) network is basically operated in a radial network mode..

Generally, ADDC adopt the (N-1) security of supply standards while planning and operating its distribution networks, this ensures that during emergency condition when a network element is out of service (planned or unplanned), the remaining network elements shall be operated without violating the stipulated operational measures and security criteria.

2.7 Detailed Asset Data

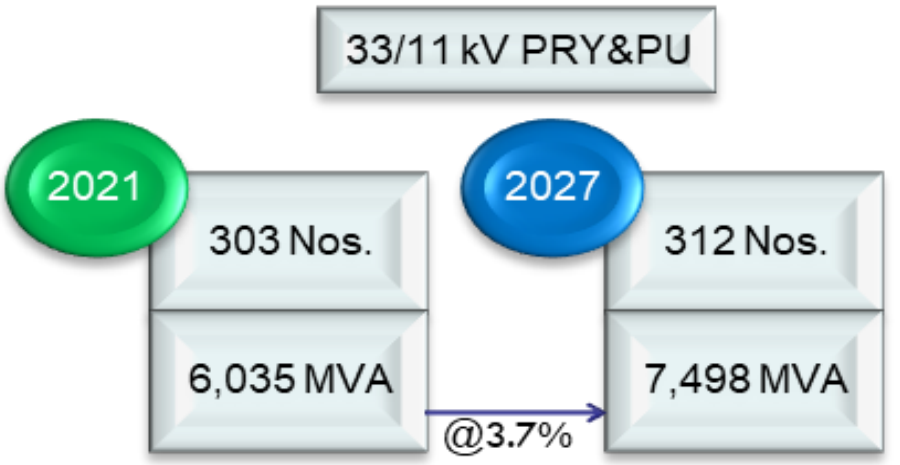
ADDC detailed assets list and evolution in the past five years is presented in Appendices 2.1 to 2.9 while Appendix 2.10 presents the geographical maps of the three regions under ADDC service area showing the locations of Interface point with TRANSCO as well as ADDC primary substation.

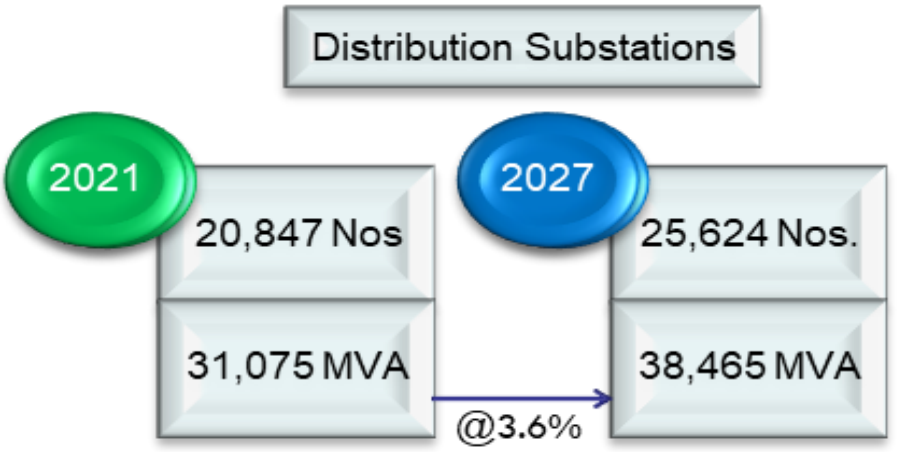
2.1	Table	Standard system parameters
2.2	Table	Asset Data - TRANSCO Grid Substations
2.3	Table	Asset Data - TRANSCO Primary Substations
2.4	Table	Asset Data – ADDC Primary Substations
2.5	Table	Asset Data - Distribution Substations
2.6	Table	Asset Data - Cables and Over-head Lines
2.7	Table	Transformation Capacity
2.8	Table	Automation
2.9	Table	Reactive Power Compensation
2.10	Geographical Map	Location of Electrical Assets

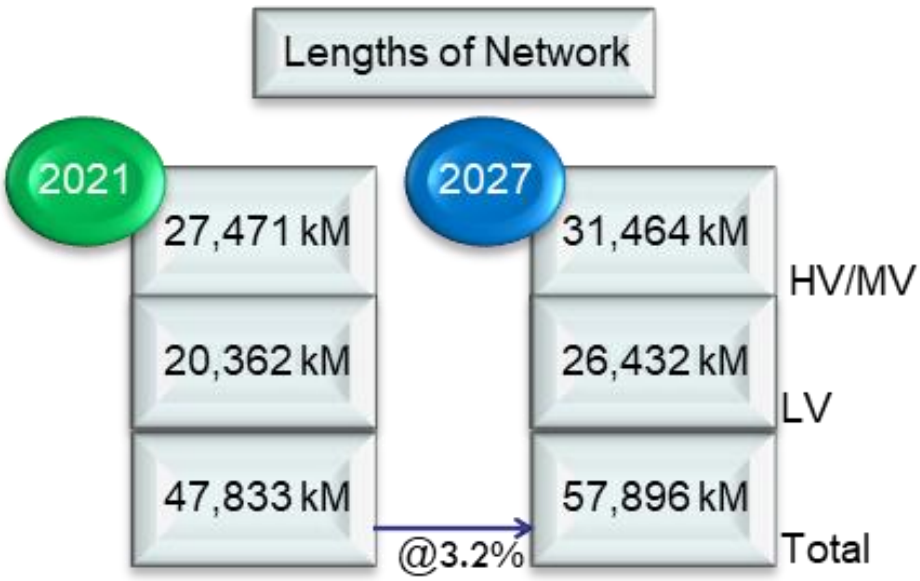
2.8 Asset Forecast

Asset forecast for the next 5 years is presented in the most right columns in tables 2.2 to 2.6. Asset forecast methodology is determined based on the type and voltage level of the assets as follows:-

- Forecasted 33/11 kV primaries Nos. and 33 kV cables length are calculated based on planned projects only.
- Forecasted 22/0.4 kV distribution substations and 22 kV cables length are calculated based on the expected assets to be handed over to ADDC as it is usually done by Mega developers only.
- Forecasted 11/0.4 kV distribution substations and 11 kV cables length are calculated using the smoothed exponential trending function available in EXCEL to predict the base, low and high scenario forecast with 0.95 confidence interval.
- Forecasted LV cables length are calculated using the smoothed exponential trending function available in EXCEL to predict the base, low and high scenario forecast with 0.95 confidence interval.
- The accuracy of 1 year ahead forecast for DSS (22/0.4+11/0.4kV) is 0.44%
- The accuracy of 1 years ahead forecast for UG Cables is 0.54%.


33/11 kV PRY&PU
2021
303 Nos.
6,035 MVA
2027
312 Nos.
7,498 MVA
@3.7%


Distribution Substations
2021
20,847 Nos
31,075 MVA
2027
25,624 Nos.
38,465 MVA
@3.6%


Lengths of Network
2021
27,471 kM
20,362 kM
47,833 kM
2027
31,464 kM
26,432 kM
57,896 kM
@3.2%
HV/MV
LV
Total

3 Demand and Energy Forecast

3.1 Introduction

Demand and Energy forecasting is a fundamental requirement of the development for a secure, reliable and economic electricity distribution network system. Forecast refers to projected requirements determined using a systematic process of defining future demand in sufficient quantitative detail to permit important system expansion decisions to be made. The demand forecast is used as a basis for the distribution system enhancement, reinstatement, development and expansion.

Accurate forecasts lead to substantial savings in operating and maintenance costs, increased reliability of power supply and delivery system, and correct decisions for future development. However, even with the best available information, basically, forecasting is an inexact science as it is open to the occurrences of various unpredictable events that may vary the future demand. Prediction of future demand may call for revising the estimate at regular intervals to take care of new policies and changes in socio-economic trends.

ADDC have adopted several assumptions in the peak demand forecast, such as:

1- The average natural growth rate in the past shall continue in the future.,

2- The Bulk and Mega Projects load is calculated as per the revised demand factors issued by ADDC on March 2019.,

3- Mega Development projects demand forecast and realization shall follow similar previous projects wherever applicable., and

4- Bulk Loads, Mega Projects and load transfer plans are reflected in the peak load records in the next year if expected to be realised in Q3/Q4 of the current year.

The above assumptions along with several revisions of actual demand realization cases versus the initially estimated forecasts, throughout the previous years, had led to improvement in the overall forecast accuracy and reduced the error in the ADDC total demand forecast for the 1-3 years ahead period to be within +/- 5% bandwidth and within +/-10% for 4-5 years ahead as shown in the subsequent sections

Moreover, A Consultancy Services contract for “Improvement to Electricity, Potable Water and Recycled Water Demand Forecasting for ADDC and AADC” is already

awarded, and shall include study of the impact of other factors such as GDP, population growth rate and tariff change on the new forecast model.

3.2 Peak Demand Forecast Approach

Peak demand and energy usage within an electric utility system grow for only two reasons, new customer's additions and growth in demand of the existing customers. The bulk of load growth on most power systems is due to addition of new customers. There are two widely used methods for load forecasting. First one is the Econometric Regression/Trending and the second is Simulation based.

The applicability and usefulness of each method depends upon the data availability, user segmentation, extent of details and accuracy required. The trending methods use historical load/energy data to determine future growth. The simulation methods are based on an engineering approach in which end use of energy is used to forecast the future growth.

The basic difference between the two approaches is that the trending involves extrapolation of past growth into the future, whereas in simulation method, the end use statistics & growth of appliance, land, floor area etc. are used to forecast the load.

Trending may be based on linear, polynomial or other functions, depending upon the past pattern of growth. As trending method is used only where historical information on load demand is available, the same therefore, can only be applied to the existing developments. For all new areas, simulation method is applied as the load demand can be forecasted based on the end-use statistics & growth of appliance, land, floor area etc.

Trending' is being used for each primary substations serving specific existing (already developed) and developing areas, for which past primary peak loads history is available. For new developing areas, having no past load record, 'Simulation Method' based on land use or floor area is used to validate load demand figures given by mega project's developers.

Trending technique is applied in order to forecast the peak demand for each individual Primary and summed up in order to reach peaks for each region and total system peak.

The methodology adopted is based on the assumption that the future trend of demand is similar to the historic trend of demand growth. This is generally the case, as long as there were/are no major changes in the past or in future in the economic and social conditions, which drastically affect the normal trend of peak demand.

Also, a top down approach where the total ADDC forecast is extrapolated to the horizon year is made to check for consistency with bottom up approach.

3.2.1 Trending

Various steps being followed by the Electricity Planning Engineers of respective areas in carrying out the 'Trending Method' to forecast the peak demand for each primary substation (bottom up) are detailed below:

i. Entire service territory (region wise) is divided into a number of groups, i.e. (a single 132 kV or 33 kV substations or group of substations usually geographically close and having similar consumption pattern and interconnected.

ii. Historical data is collected for individual primary substation peaks for the longest possible timeframe.

iii. Yearly natural growth load forecast is carried out by calculating the CAGR (Cumulative Average Growth Rate) for the past primary (group of primaries) load history as a guide line for trending pattern and then using a best fit curve to the past primary (group of primaries) load history by using trending functions available in EXCEL such as straight line, second order polynomial, exponential and power functions to estimate the next 5 years demands..

iv. Steps ii & iii are repeated for all the primaries in the entire service territory to forecast the demand expected on individual PRY's.

v. Forecast obtained in 'step iv' is modified to consider planned load transfers between PRYs and also to consider exceptional bulk load requirement as provided by the Customer Services Directorate, if any (short term only), which is not likely to be reflected in the trend.

vi. Region-wise forecast or total system forecast is carried out by calculating the sum of individual PRYs peak forecast from step v for each region and adding the region wise Mega Development loads that are not part of the Actual historical peak.

vii. Yearly load forecast reviews are carried out after receipt of the current year actual demands to check the accuracy of the demand forecast carried out in the previous year.

3.2.2 Simulation (land Use/Floor use):

For all major new developments, their maximum demand would be computed based on the area usage by applying appropriate specific load densities and diversity factors.

3.2.3 Improvement of Forecast Methodology Accuracy:

DoE's appointed consultant M/s Poyry, has prepared a list of recommendations for the improvement of the forecast process in all DoE companies, accordingly, a steering committee led by EWEC is in place to put a road map for the implementation of the recommendations. ADDC is already on the road of implementing these recommendations wherever applicable, as a start using Forecast sheet feature of EXCEL that uses an exponential smoothing trending function and confidence interval of 95% can be set to predict the base, low and high forecast scenarios. M/s NAVIGANT has been awarded the 1st phase of contract D-107980.1 on 14/4/2021.

The objective of this consultancy is to

- Review the existing Demand forecasting methodology adopted (Electricity, Potable Water & Recycled Water),
- Develop ADDC & AADC Electricity, Potable Water & Recycled Water Demand Forecast Model and methodology / approach. and
- Supervise successful implementation of the Demand Forecast Tool / Software (by others), that can simulate the recommended model. (Phase 2).

The SoW of the contract is attached in Annex A3A,

As of now the awarded consultant had completed the As-Is assessment stage and is in process of finalizing the framework for the To-Be recommendation stage

3.3 Evolution of Historical Peak Demand

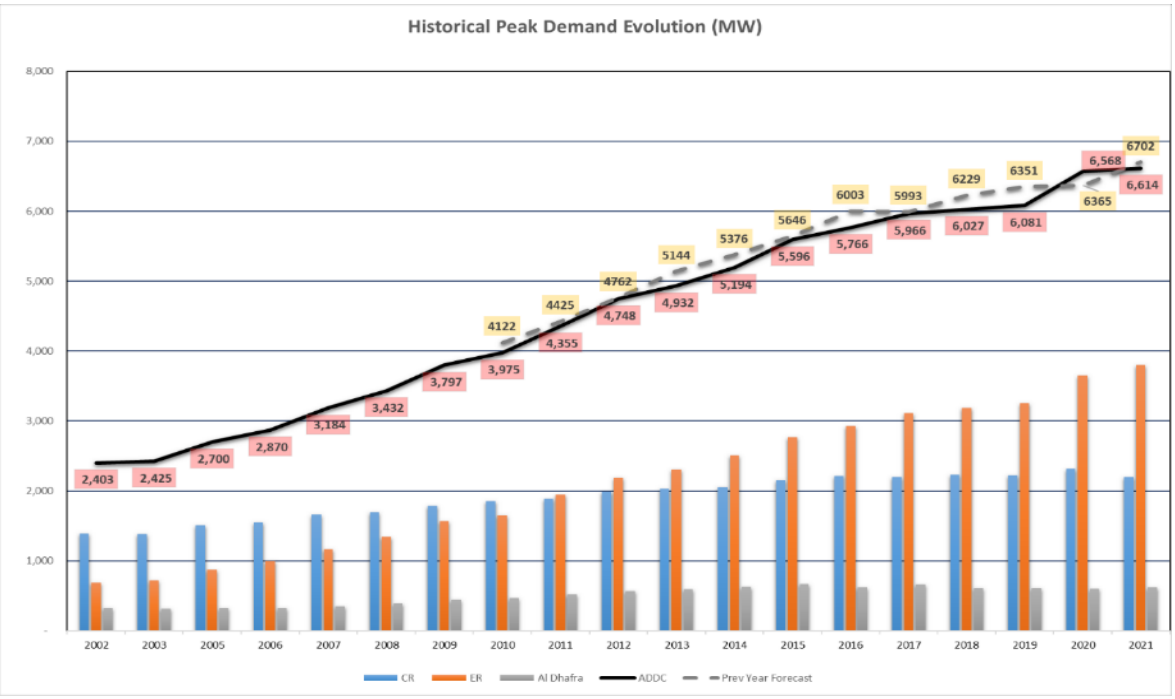
3.3.1 Historical Data

Peak demand considered in this report includes the demand of all customers fed from ADDC distribution network and excludes the demand of the customers fed directly from TRANSCO network (but currently billed by ADDC).

Distribution Network operated by ADDC is divided into three main regions, namely Central Region, Eastern Region and Al Dhafra Region. The electricity demand all over Abu Dhabi Distribution company coverage area has increased at a larger pace with an average annual growth rate of 5.47%. The detailed peak demand data in different regions for years 2002-2020 is provided in Appendix 3.1.

The historical peak demand in each region and ADDC total for the years from 2002 to 2021 in different regions; is shown in the below table and Figure:

Region	2002 (MW)	2021 (MW)	Average growth (%)
CR	1,392	2,196	2.43%
ER	686	3,802	9.43 %
Al Dhafrah	325	617	3.43%
Total	2,403	6,614	5.47%



Historical Peak Demand Evolution (2002 – 2021)

3.4 Historical Peak Demand Forecast Accuracy

The accuracy of peak demand forecast carried out by ADDC over the past 5 years are presented in Appendix 3.2. The peak load record for 2021 of individual regions and total of ADDC demand compared with the 2021 estimates in the previous planning statements back to 2018-2022 planning statement issued in June 2017 is presented in Appendix 3.2.

The accuracy of ADDC total demand forecast is summarized in the following table.

1 year ahead	2 year ahead	3 year ahead	4 year ahead	5 year ahead
-1.30%	-0.94%	-4.58%	-6.47%	-7.66%

It is noted that the forecast accuracy is within 5% band (ADDC KPI) for the first 3 years as the data for natural growth (LDN) and mega development projects realization are available and credible for this period, Beyond this period the uncertainty in future demand realization increases hence the accuracy start to fall between the 5% and 10% bandwidth, however, ADDC is continuously working with other stakeholder (internal and external) to minimize the errors.

3.5 Peak Demand Forecast

Based on the historical peak demand data and methodology described above, the peak demand on individual interface point with TRANSCO has been developed for the period of 2022 till 2027 reflecting the forecasted loading of primary substations (existing and proposed) considering forecasted load growth reflected on each primary, bulk loads, confirmed demand reported by AD Ports Company in KIZAD – A, and ICAD areas and considering the load transfer plans between primaries wherever applicable. This represents the Bottom-Up forecast methodology.

It is worthy to mention that there is a newly reported demand for Gemstone Project (Led by ADQ) summing to 660 MW and planned to be realized from 2023 onward.

ADDC demand forecast mentioned here does not include Transmission connected consumers such as ADNOC, ESI, Emirates CMS as well as Auxiliaries.

The individual regions and ADDC total forecast is presented in Appendix 3.1 and detailed peak demand forecast for individual primaries data is presented in Appendix3.3.

The Bottom-UP peak demand forecasted in 2027 is expected to reach 9,201 MW. While the demand forecast of ADDC including Gemstone Project in 2027 is expected to reach 9,861 MW

3.5.1 Top-down Forecast Comparison with Bottom-Up Forecast:

The Bottom-Up approach described above, is also compared with Top-Down approach, where the total ADDC historical trend is extrapolated to the horizon year 2027 using forecast feature of MS EXCEL which predicts the forecast to follow a similar trend of the historical growth rate.

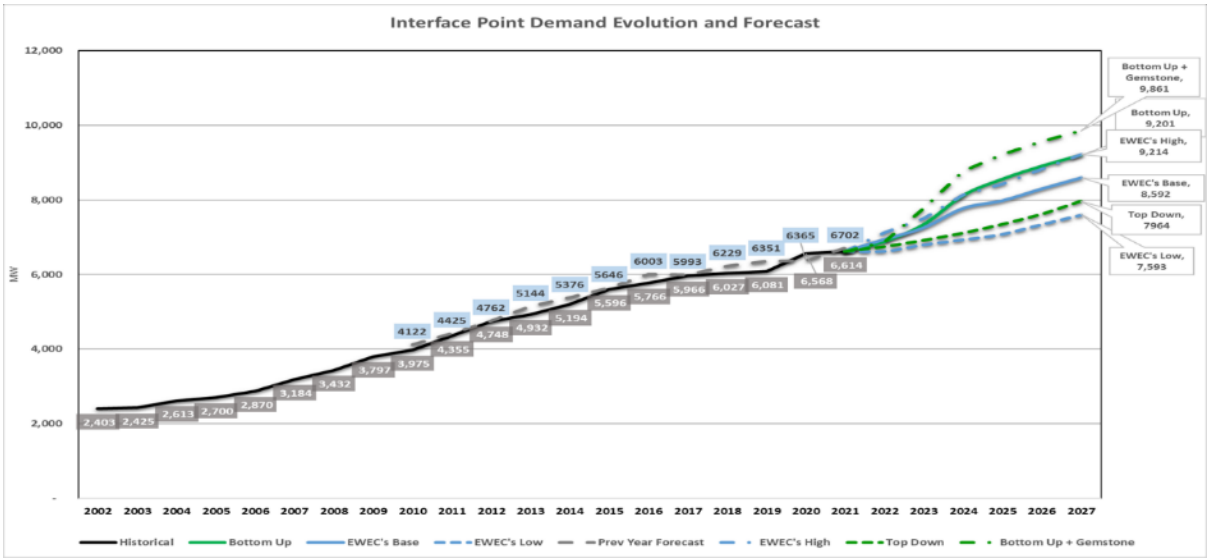
3.5.2 Forecast Comparison with EWEC's Week 7 Forecast:

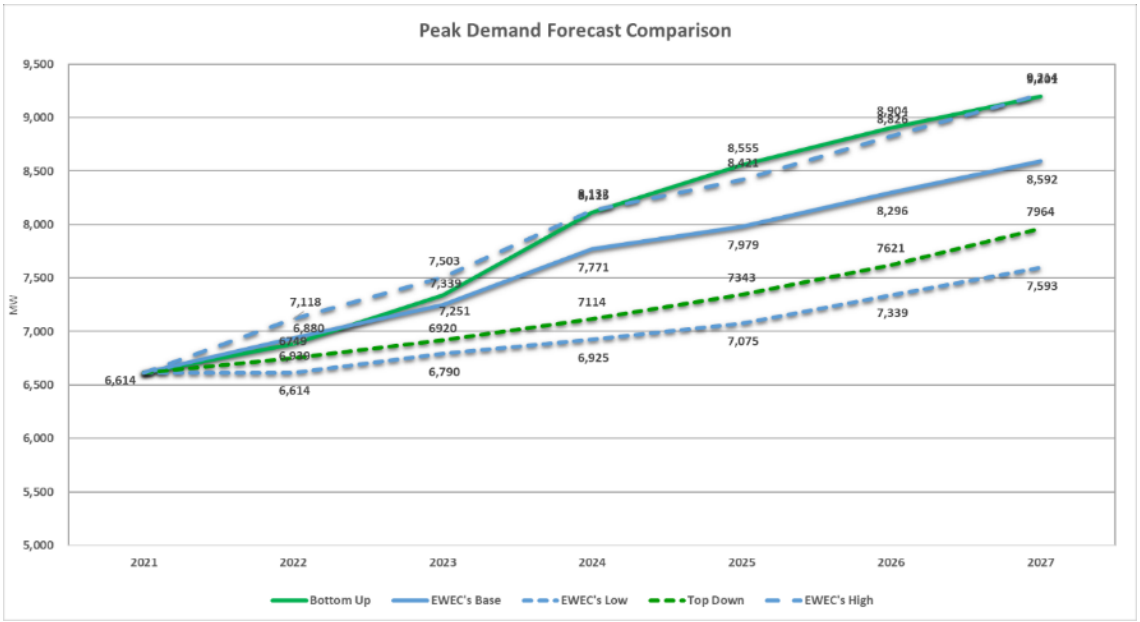
The Bottom-Up approach described above, is also compared with approach adopted by EWEC in the Week 7 forecast report, which is carried out for the individual regions as well as for overall peak demand of ADDC. Diversified loads of ADNOC, ESI and Auxiliaries has been excluded from EWEC's forecasted figures for ADDC in the Week 7 report

The 3 scenarios presented by EWEC in the Week 7 report (Low, Base and High) is also presented in the below table and chart.

Forecast carried out comparison is shown in the below table:-.

	Top-Down	Bottom-Up	Bottom-Up + Gemstone	EWEC's Low	EWEC's Base	EWEC's High
2021	6,614	6,614	6,614	6,614	6,614	6,614
2022	6,749	6,880	6,880	6,614	6,939	7,118
2023	6,920	7,339	7,779	6,790	7,251	7,503
2024	7,114	8,115	8,775	6,925	7,771	8,132
2025	7,343	8,555	9,215	7,075	7,979	8,421
2026	7,621	8,904	9,564	7,339	8,296	8,826
2027	7,964	9,201	9,861	7,593	8,592	9,214
CAGR% 2021-2027	3.14%	5.66%	6.88%	2.33%	4.46%	5.68%





Since the main purpose of peak demand forecast exercise carried out by ADDC is for the optimal planning of future required primaries and Grids capacities required to meet the demand while fulfilling the required licence conditions and other codes, the Bottom-Up approach shall be considered as the main forecast of ADDC

3.6 Embedded Generation

Currently, there are 21 Nos. embedded generation plants with sizes more than 50 kW and less than 5000 kW connected to ADDC network, the total size of these plans is 7780.7 kW, details of these plants are provided in Appendix 3 Table 3.4

3.7 Energy Forecast

3.7.1 Methodology

An econometric approach in calculating the forecast is used by ADDC's Customer Service Directorate, as described by the following methodology. This approach was developed in line with the recommendation of consultants Poyry in their 2016 Electricity Demand Forecasting Review project:

- Historical billing data is retrieved from the Customer Care & Billing system for all customer accounts
- This billing data is cleaned and transformed to provide information regarding historical consumption and active customer numbers by customer category, at monthly granularity, over the period from 2012 to 2021.
- For each customer class, stepwise, multivariate regression analysis is used to develop a predictive model for average daily consumption per account. A variety of independent variables including trend, weather variables and price are tested for statistical significance, and are incorporated within the final model if they appear to be significant with a confidence level of at least 95%.
- Predictive models are also developed for the number of active customer accounts in each category. These models use a double exponential smoothing process to predict numbers based on historical trends. The methodology is similar to a moving average, but with additional weight given to more recent data points compared to historical ones.
- The two sets of models for average consumption and number of accounts are then combined with numbers of days in each month to forecasts for total consumption per category over the next five years.
- The assumptions used in developing that forecast are:
    - that there will be no further tariff changes;
    - that the weather experienced during the years covered by the forecast will be seasonally normal, while incorporating an underlying annual increase in average temperatures that has been observed over the previous 18 years;
    - latest trends observed in the average consumption per account will continue; and

- customer account numbers will continue their recent trajectories.

An important methodology enhancement for 2021 was driven by the need to incorporate binary variables into the models to consider the impact of the COVID-19 pandemic on the consumption of various customer categories. Our updated analysis in 2022 has shown that the above approach did performed significantly well for many of our forecasting models. However, for some customers classes, evidence has shown that we are better off using covid adjustment factors that are based on our estimated impact of covid in 2020 and 2021 against baseline seasonal normal demand in 2019. Therefore, we have adjusted some of our forecast from Jan to August 2022 on this basis.

3.7.2 Forecast Model

The econometric approach discussed above is used to analyse and produce disaggregated forecasts for each of our customer classes that we subsequently add up to form our aggregated forecast.

Essentially, this approach allows us to have forecast models for customer groups with common characteristics, such that we have forecast for distributed connected customers and transmission connected customers separately.

The outputs from these models are then aggregated to develop the overall forecast.

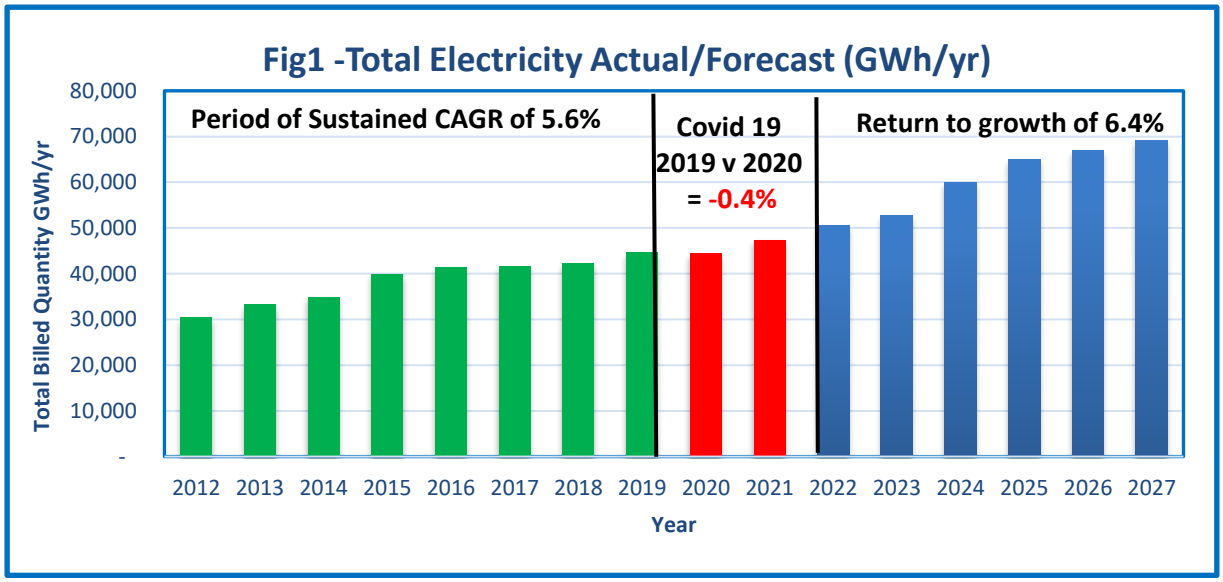
Model enhancements made for the 2022 forecast include:

- A significant change in this year's forecast is the addition of volumes for Emirates Steel following their confirmation of addition of new plants with requirements for power demand of 1230MW over this forecast horizon.
- Also, we have added a new forecast model for Emirates CMS to cater for their new reverse osmosis plants where our estimates has shown that we will see demand of 856GWh/yr in the current year 2022 and ramping up to 2,399GWh/yr by end of 2027.
- In addition, we have now included a new forecasting model and forecasts for Electric Vehicles (EV's) energy demand from Jan 2022 to 2027. This is based on our customers latest actual information that we have seen between August to December 2021 and an EV infrastructure strategy paper[1] published by Abu Dhabi Department for Municipalities and Transport (DMT) in June 2021. This has contributed an average of 5GWh/yr to our forecast over the current forecast horizon.

- We have done more splits of the previous Expat Residential and National Residential models into flats, villas and social card holders as analysis shows that long term trends for these sub-categories, the seasonality of consumption and overall level of their consumption are very different.
- We continue to uphold the split of Commercial electricity model to distinguish between the different trends in Large (mostly infrastructure development) which is driven by longer term economic trends and Medium/Small (i.e. individual commercial premises) which is more subject to short term economic fluctuations.

3.7.3 Forecast Results

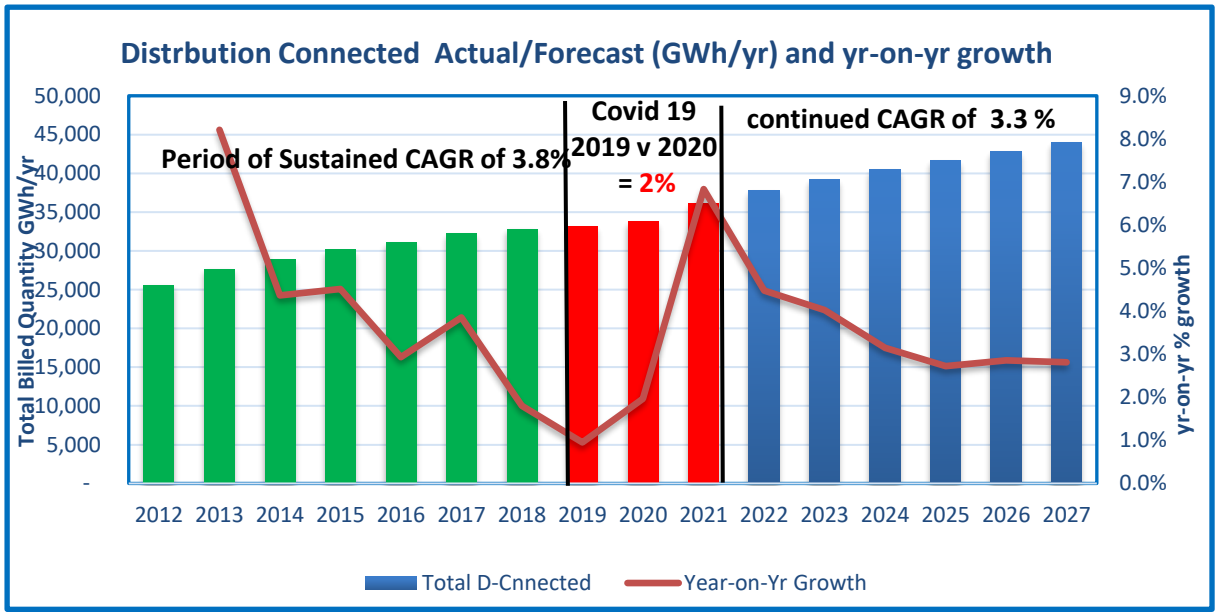
Total Historical actual and forecast of energy consumption (in TWh) is presented in Appendix 3 Table 3.6 and is shown in figure1



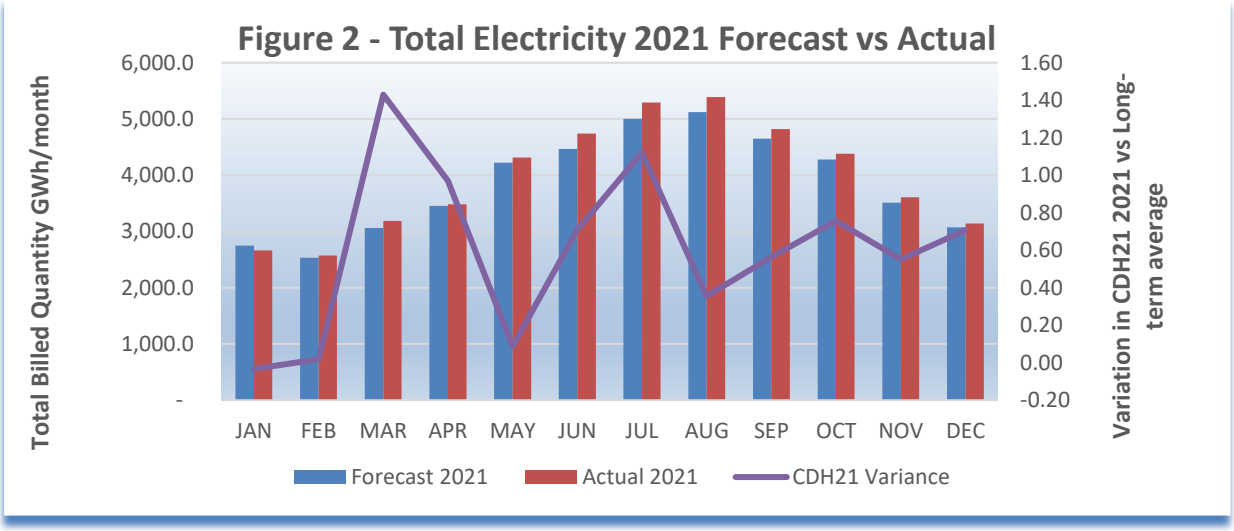
During the period 2012 to 2019, total electricity consumption grew steadily at a compound annual growth rate (CAGR) of 5.6%, driven largely by increased demand from Residential National, Commercial and industrial customers on our distribution network as well as increase in transmission connected customers demand; mainly by ADNOC and Emirates Steel.

Following the covid-19 pandemic, we observed that this broke the historical growth trend resulting to total consumption in 2020 to be marginally lower (-0.4%) when compared to 2019 level. However, latest evidence from 2021 actual data has shown that we now seeing return of consumption to levels above the pre-pandemic consumption.

For the purpose of clarity ***Figure1b*** shows the historical trajectory of actual consumption and future demand forecast on our electricity *distribution network* only. Here evidence shows a relatively smooth growth path, plus the fact that distribution network demand increased from 2019 to 2020 and 2021 despite the pandemic. The growth here was driven by increase in demand from the residential sectors, commercial landlords, agriculture, government large service points and interestingly in the industrial sector too.



In terms of latest actual for 2021, relative to 2019 and 2020 peak summer consumption of 5.1TWh and 5.2TWh respectively, 2021 peak volumes of 5.4TWh in August increased as a result of a combination of impact of very hot 2021 (that has been reported to be the hottest summer in Abu Dhabi since our records began in 2003) as well as resurgence of consumption by commercial, government, industrial on our distribution network and large consumers like transmission connected customers. Figure2 shows 2021 monthly forecast vs actual consumption and variations in actual cooling degree days compared to the long-term average where evidence shows that 2021 was generally hotter that seasonal normal temperature.



Looking forward, we have seen evidence that Industrial consumption that dropped during the early period of covid-19 lockdown in 2020, had already reverted to baseline by the end of the year and has continued to grow in 2021. As the recovery of the economy continues and the pandemic restrictions are removed, we expect that total volume over the period from 2022-27 will return to the sustained growth trend seen since 2012 as depicted in Figure1 and 1a respectively.

As mentioned earlier, most of the growth over the coming period is expected to come from the additional volumes connected to the transmission network, i.e. Emirates Steel, new forecast for Emirates CMS reverse osmosis plants and ADNOC. While the rest will be driven mainly by our Industrial customers and others on the distribution network as summarised below in table1.

DATE/Item	Total Forecast by Network (GWh/yr)		
	Total Distribution Network + Losses	Total Transmission Network	Total (GWh)
2021*	36,273	11,308	47,582
2022	37,782	12,824	50,606
2023	39,307	13,508	52,816
2024	40,539	19,342	59,881
2025	41,662	23,342	65,005
2026	42,858	24,122	66,979
2027	44,070	25,049	69,120
CAGR	3.3%	14.2%	6.4%

Table1- Summary of forecasts by Network types
****2021 includes actual from Jan to Oct and forecast afterwards***

In the previous year's statement, we noted the launch of the Electricity Tariff Incentive Programme (ETIP) by ADDC and AADC in partnership with the Industrial Development Bureau (IDB), an office of the Department of Economic Development. Under this scheme, the IDB provides incentive funding to key industrials in Abu Dhabi based on their economic value add to the local economy, productivity and other factors, with the funding being provided as a direct contribution to customers' electricity bills.

This scheme has continued to attract new participants and is expected to continue to help drive growth in distribution-connected industrial consumption at a cumulative annual growth rate of 8.1%.

For the residential sector, demand from the UAE residential National category is projected to grow at a CAGR of around 4.1%., driven by continued increase in customer numbers and increase in average demand per customer.

However, for the Expat residential customers, whilst we have seen increase in customer numbers, average consumption per account continues to drop following their historical pattern. Therefore, the core residential Expat consumption in flats and villa forecast has been projected at CAGR of -4% over this forecast horizon

For the EV's consumption, starting from very low base of just 1GWh/yr in 2021 we have projected growth of 9.9% through this forecast horizon. As mentioned earlier, our forecast here was based on very limited historical actual input data (just 5 months) and an EV infrastructure strategy paper published by Abu Dhabi Department for Municipalities and Transport (DMT) in 2021 where their compound annual growth rate for the adoption of EV's amount to 28.3% between 2021 and 2025. In the absence of access to EV registration data set that validates DMT's data; We have been cautious in growing ADDC current customer counts (379 at the end of Dec 2021) based on total DMT projected growth.

We have taken a third (9.4%) of DMT projection to grow our customer account. We have applied the derived customer number to the daily average usage per customer (25KWh/day) that we have seen in our actual data between August and Dec 2021.

For Commercial, Government and Agriculture consumption we continue to expect modest growth averaging around 2.0% over the next five years.

3.7.4 2021 Forecast Accuracy

Details of the accuracy of the previous year's forecast compared to actuals are summarised in the table 2 below and detailed up to 5 years ahead forecast accuracy is presented in Appendix A3 3.8 :

Item/Date	Actual/Forecast	Accuracy
Actuals (2020)	44,721 GWh	
Forecast (2021)	46,120 GWh	
Actuals (2021)	47,582 GWh	3.1%
Actuals (weather/covid adjusted)	46,607 GWh	1.1%

Table2- 2021 forecast performance

In summary, while actual consumption was 1462MWh (With 3.1% MAPE) higher than forecast, weather accounted for large part of this difference, and total demand after weather and covid normalisation is relatively closely aligned with forecast with MAPE estimated as 1.1%.

3.7.5 Alignment with EWEC

For the purpose of efficient planning and tariff setting across the sector, it important that the forecasts used by the different companies are in broad alignment. To this end, one of the KPIs recommended by Poyry for "Coordinated (Reporting Incentive)" is *"Explain difference between year-ahead consumption forecast and the equivalent ADWEC [now EWEC] forecast. Any difference should be below a target of 4%"*

Our latest forecasts have been discussed and compared with the 2022 Week 7 forecast for Abu Dhabi & Western Region developed by EWEC for generation planning and fuel purchasing, with the results shown in the table3. below:

Consumption Forecast				Growth Forecast (Yr-on-Yr)	
YEAR	ADDC GWh/Yr	EWEC GWh/Yr	Gap %	ADDC	EWEC
2021	47,582	47,590	0.02%		
2022	50,606	49,996	1.20%	6.36%	5.06%
2023	52,816	52,984	0.32%	4.37%	5.98%
2024	59,881	58,072	3.02%	13.38%	9.60%
2025	65,005	62,172	4.36%	8.56%	7.06%
2026	66,979	64,675	3.44%	3.04%	4.03%
2027	69,120	66,847	3.29%	3.20%	3.36%

Table3- ADDC and EWEC reconciled forecast

In this year's forecast, from current year 2022 to 2024, the discrepancy average is 1.5%, well within the Coordinated (Reporting Incentive) KPI.

However, from mid-2024 to 2027 the two forecasts diverge slightly, with EWEC anticipating different growth compared to ADDC. This divergence is driven partly by our respective forecasts for ADNOC but more significantly by the differences in forecasts for Emirates CMS reverse osmosis plants.

Specifically, EWEC has informed us that they have taken a more conservative view of addition of lower volumes to their forecast due to RO compared to ADDC approach where we have increased volumes based on addition of all the communicated information for RO sites and timeline.

Impact of COVID-19

Last year's Five-Year Planning Statement provided an indication of the impact of the COVID-19 pandemic on demand for the first three quarters of 2020. In this section we provide an update for 2021 to that analysis.

As noted in section 3.7.4 above, for the full year actual consumption was 47,582GWh 3.1% higher than forecast of 46,120GWh and 1.1% higher after weather correction. In total this suggest that our 2021 forecast was long (over forecast) by 1.1%. This performance is within the range of acceptable forecasting error, so the overall, annual performance is good.

However, when viewed at a customer category level, more significant variances emerge, as shown in the figure 3 below:

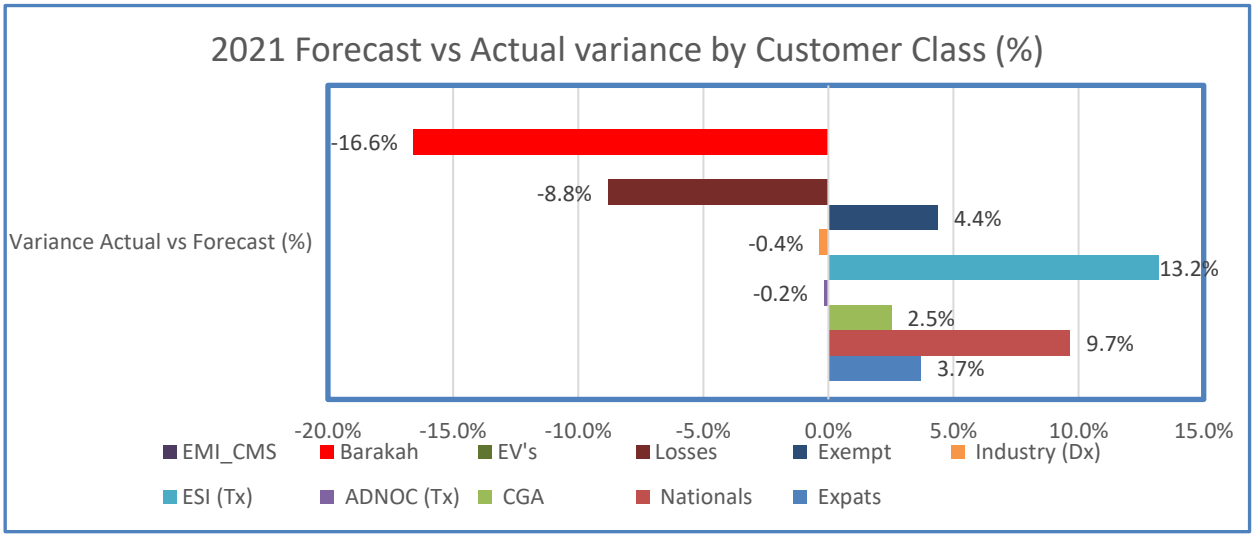


Fig3. + variances mean that actual is >forecast (we are short). -variances mean that actual is < forecast (we are long).

In particular:

- More time spent by residents in their homes due to working and schooling from home combined with less travel appears to have led to higher than expected Residential consumption both within Nationals and Expat communities. Therefore, suggesting that we our forecast here was short.
- Similarly, evidence from the above suggests that we also under forecast demand for Exempt customers and Emirates Steel by 4.4% and 13.2% respectively.
- The evidence with respect to commercials, government and agriculture is that we were short by 2.5%; whilst for industry, distribution losses, Barakah and ADNOC we were long in our forecasts by the margins shown in figure3

Looking forward, our 2022 forecast assumes that the impact of the pandemic for all customers classes be less than 2021 observations. Based on the above, for customer classes where we have seen convincing evidence of covid impact in 2021, we have applied 50% of such effect to our underlying forecast for 2022 from Jan to August only. We have assumed that unless if there is a major outbreak of pandemic infection and high rates of deaths as seen in 2020/2021, personal life and business activities should generally revert to pre pandemic levels; as such, we expect to see future growths in our customers electricity demand as projected in this year's forecast from 2022 to 2027.

3.8 Historical and Forecasted Load Factor

Load factor is the ratio of total energy (kWh) used in the billing period divided by the possible total energy used within the period, if used at the peak demand (kW) during the entire period. Additionally, the load factor is used to validate the energy and demand forecast, i,e, to ensure that the forecasted trend of both Energy and Peak demand having nearly similar patterns.

Annex 3 Table 3.9 shows the historical load factor from 2012 till 2021 based on ADDC interface point actuals and Energy consumption (excluding transmission connected customers). The historical load factor shows an average of 0.61 varying between 056 and 0.67. Based on the derived peak demand forecast and energy forecast, the calculated future load factor for 2022 till 2027 is presented in Annex 3 Table 3.9, the Load factor is ranging between 0.59 and 0.61.

3.9 Demand Side Management

ADDC has developed a Demand Side Management ("DSM") Programme to help its customers to reduce their consumption of water and power. The high level objectives of the programme are to:

- Raise awareness of the need for more sustainable use of resources and inculcate a sense of awareness and responsibility amongst key customer target groups;
- Provide the necessary incentives to all sectors of society to increase efficient use of resources;
- Provide the necessary technical and behavioural information to customers so that they understand how to save electricity and water;
- Achieve significant reductions in per capita consumption of electricity and water within Abu Dhabi;
- Reduce the gap between peak (summer daytime) electricity load and average load in order to make more efficient use of Abu Dhabi's generation and distribution assets.

In order to deliver these goals, the DSM programme for Electricity has developed initiatives that target specific issues as detailed in the following sections:

3.9.1 Awareness/Behavioural Change Initiative

3.9.1.1 Overview of Initiative

The Awareness/Behavioural Change Initiative is aligned with the Abu Dhabi DSM and Energy Rationalization Strategy 2030 theme "Rebates and Awareness". This initiative seeks to increase the awareness of our customers with respect to the importance of using energy and water efficiently, and to help them to understand the actions they need to take in order to reduce consumption. We have worked with stakeholders to open up new communications channels to address key user groups, aiming to promote efficiency through general publicity and communications. The ADDC initiative is closely aligned with similar work being carried out by AADC, and has been developed in collaboration with TAQA.

3.9.1.2 Key Activities Completed/Progressed This Year (2021)

A large number of activities were pursued during 2021 to assist in changing attitudes and behaviours amongst ADDC's customer base. These activities are listed below, with extracts, illustrations and links given in the Appendix:

- Providing online energy management training workshops for 17 government and commercial entities, and two (2) internal workshop for ADDC employees.
- Static and dynamic Tarsheed tips and information started to be sent in ADDC bills (see Appendix).
- Working with internal stakeholders, Tarsheed tips and services were integrated into the new ADDC mobile app, allowing users to directly access Tarsheed information from their devices.
- Ran the “Lose the Load” campaign and followed up with audience research.
- Published guides on energy efficiency for housemaids & labourers in 7 languages on the Tarsheed website.
- Provided virtual lectures during five local events on how to rationalize electricity and water consumption.
- Provided one to one energy management workshops to 20 industrial entities (See Industrial Efficiency Initiative for more details)
- The Green Corner Initiative MOU with Carrefour was agreed by both parties.
- Continued engagement with QCC and Department for Municipalities and Transport to improve competency of personnel working on HVAC and plumbing, (see later sections dedicated to this initiative).
- Continued use of social media and online videos to promote awareness of energy and water efficiency.

Analysis of web traffic showed that the “Lose the Load” campaign plan was successfully executed:

- The budget pacing was almost at 100%, indicating that the actual rate of expenditure on the project matched very closely to the planned spend rate.
- The total number of actual impressions exceeded the forecast volume of impressions by 131% (forecast was for 7,102,133 impressions while actual was 16,395,394)
- The total reach count exceeded forecasts on all activities (please refer to activity tables below)
- The overall number of views achieved was 67% above forecast (forecast was for 1,035,113 views, while actual was 1,728,278)

During the year the Awareness/Behavioural Change Initiative Team worked with the following stakeholders:

- DOE on review of strategy development.
- Large retailers on further development of the Green Corner Initiative.
- Government departments to assist in training their staff.
- QCC and DMT on the development of skills training schemes.

3.9.1.3 Key Activities Planned for the Following Year

A wide range of awareness and behavioural change activities are planned for 2022, as listed in the following table.

Table 1: Planned activities for the Awareness/Behaviour Change Initiative for 2022.

Topic Area	Activity	Planned Delivery Date/Notes
Media Production	• Tarsheed Academic Programme with Schools.	Q3 2022
	• Development of general behaviour change and awareness materials and flyers aimed at key areas: - AC maintenance - Irrigation	Q3 2022
Networking	• Target to provide a further twelve (12) DSM awareness seminars.	Ongoing throughout 2022
Capacity Building	• Estisharat re-launch with TAQA approval	Q1 2022
	• DSM training for mosque labourers and supervisors in coordination with AWQAF.	Q2 2022
	• Workshops for commercial and government sectors.	Ongoing throughout 2022 (Mainly Q2/Q3).
	• Workshops for manufacturing sites.	Ongoing throughout 2022
Mass Communications (Direct e-mail & SMS)	• Continuation of current SMS campaigns, with extension into more technical areas: - AC maintenance reminders - Irrigation efficiency awareness	Ongoing throughout 2022

This list of activities will be modified/augmented with appropriate activities from the Abu Dhabi Long Term Behavioural Change Programme.

3.9.1.4 Key Statistics and Performance Indicators

a) Savings from the Awareness/Behavioural Change Initiative

Savings are given in the table following:

Table 2: Savings from the Awareness/Behavioural Change Initiative

Progress	Penetration (Impressions + Views)	No. Installations (units)	Savings	Status (% implementation completion)
Realised for reported year (2021)	**16,395,394**[1] + **1,728,278**	N/A	N/A	N/A
Planned for next year (2022)	TBA[2]	N/A	N/A	N/A
Total targeted	TBA	N/A	N/A	N/A

A methodology for assessing market penetration has been investigated as part of the "Discovery" phase of ADDC's contract with Publicis Group in 2021, and was used to develop the results in the previous table(s).

In order to identify savings from awareness and behavioural change, DoE-Guidehouse have developed EM&V protocols that will guide the development of an EM&V plan from ADDC. The developed EM&V plan will be endorsed and submitted to DoE as per established procedures. Given the high variability in energy consumption under the influence of a range of factors that may be difficult to adjust for, ADDC will raise any concerns that it has regarding the likelihood of identifying savings based on the protocol, and whether these issues would lead to a difficulty in obtaining third party endorsement for the plan or in obtaining meaningful savings figures.

b) Costs of the Awareness/Behavioural Change Initiative

Costs are given in the table following:

Table 3: Costs for the Awareness/Behavioural Change Initiative

Cost Category	Realised in reported year (2021)	Planned for next year (2022)
Physical resources cost (equipment, etc.)	N/A	TBA
Human resources[3]	N/A	TBA

[1] See earlier footnotes on definitions of social media metrics.
[2] The penetration target must be expressed relative to the total number of unique residential account holders. However, there are significant duplications and mismatches when simple criteria are used to count up the total numbers of accounts. This issue will also be investigated and a solution will be proposed as part of the "Discovery" phase of work with Publicis Group.
[3] Human Resources costs are zero as they are already covered by Departmental OPEX and are formally reported to DoE through the Regulatory Compliance process.

Cost Category	Realised in reported year (2021)	Planned for next year (2022)
Outsourced resources cost	N/A[4]	TBA
Other cost (please specify)	N/A	TBA

3.9.1.5 Risks, Barriers and Issues for this Initiative

The following risks, barriers and issues were explored and mitigation measures were proposed:

Table 4: Risks, Barriers and Issues for the Awareness/Behavioural Change Initiative.

Risks, Barriers and Issues	Mitigation Measures
Residents are unresponsive to messages	• Developing awareness of efficiency that is linked to common-sense benefits to individuals. • Developing awareness of the long term societal, environmental and intergenerational equity benefits linked to improved energy and water efficiency. • Building linkages between ADDC DSM messaging and key influencers and stakeholders to change behavioural norms.
Difficulty in attributing savings to the initiative	• Follow DoE-Guidehouse EM&V protocols. • ADDC will exercise due diligence and raise any concerns that it has to DoE on this issue.

3.9.2 AC Rebate Initiative

3.9.2.1 Overview of Initiative

The AC Rebate Initiative is aligned with the Abu Dhabi DSM and Energy Rationalization Strategy 2030 theme “Rebates and Awareness”. This initiative focuses on improving the energy efficiency of split AC units in the homes of local tariff payers, who are a heavily subsidized customer segment. The initiative will fill the price gap between high efficiency and low efficiency AC units at the point of sale, removing the disincentive to invest in more efficient appliances. Savings will be achieved through the avoided marginal cost of fuel for generating electricity. Funding will be provided by ADDC initially, following which DoE will allow cost recovery via an Opex adjustment to MAR.

[4] DSM is fully integrated into all Media Department activities for CSD and not possible to separate.

3.9.2.2 Key Activities Completed/Progressed This Year.

- The web services system for performing checks on customer eligibility for the AC Rebate was commissioned with Lulu and went live in March 2021.
- The approved media plan was launched, targeting local tariff payers using SMS and emails.

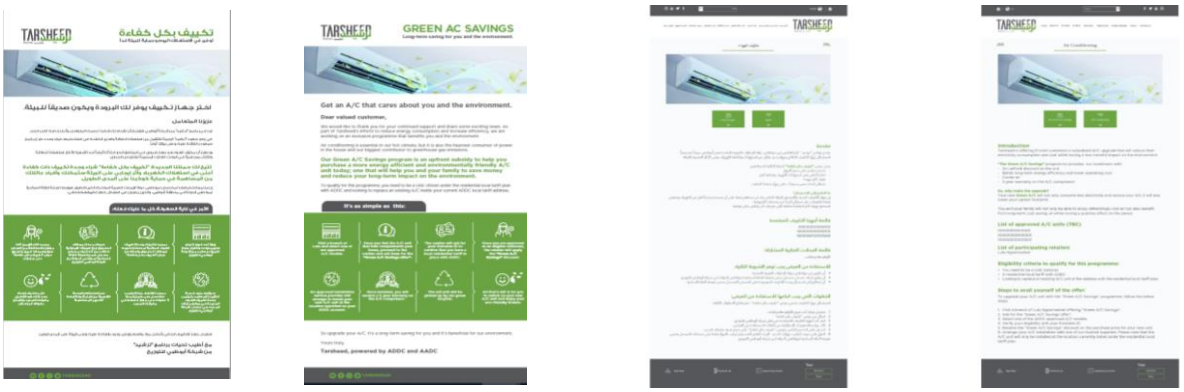


Figure 1: AC Rebate E-mailer and Landing Pages

- The first AC Rebate deal was registered on 29th March 2021, but only four deals in total were registered up to the end of June 2021.
- Owing to low uptake, customer feedback was gathered showing that a number of issues were combining to reduce the economic attractiveness of the rebate amount:
    - Homeowners have a perception that their old AC units have a residual value for spares or repairs, and surrendering the item to ADDC for disposal offset this sum against the rebate amount in their decision making process.
    - Homeowners perceive that small retailers who use low cost installers will offer the same quality of installation as the higher priced fully trained installers mandated by the AC Rebate deal, leading to an additional price disadvantage for the deal.
    - The pilot retailer, Lulu was pricing units according to the recommended retail price (RRP) agreed with the distributor, while small independent retailers were not, reducing the attractiveness of the rebate amount.
- In response the rebate amount was increased from AED 300 per unit to AED 500 per unit, with a media relaunch. In addition, Lulu agreed with the distributor that they could offer a discount on the targeted units so match the prices of smaller retailers. These measures increased the rate of deals until the cooling season began to fall away in mid-September:

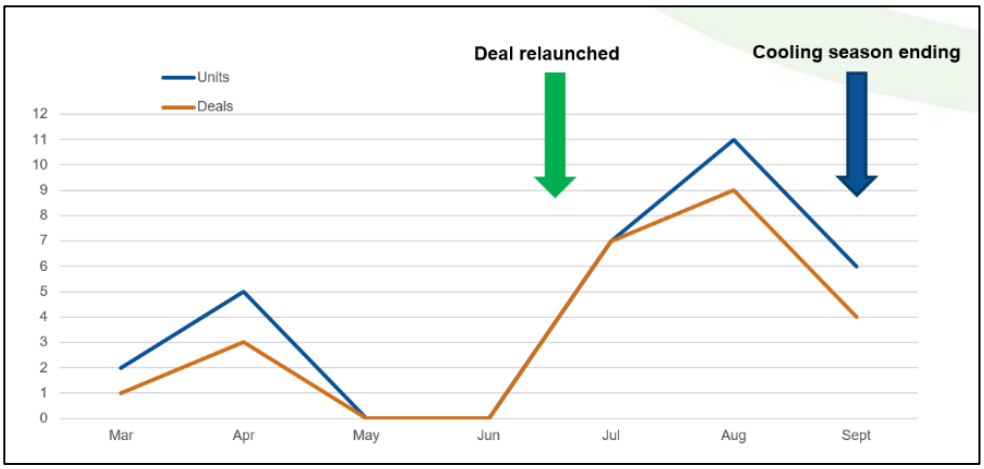


Figure 2: AC Rebate Deals and Number of Units per Month

- Further follow-up of rebate deal customers will be carried out in early 2022 to further understand attitude towards the deal and to identify any tactics that could improve uptake.
- Discussions took place with the distributor for O-General and Midea AC machinery to explore how a wider network of retailers could be brought into the deal.
- A new media plan was developed for launch in early 2022 to maintain awareness of the importance of AC selection and maintenance.
- Possibilities exist for extending the scope of the AC Rebate, and an initial study was conducted during 2021.

During the year the AC Rebate Initiative Team worked with the following stakeholders:

- DoE on updates to the business case.
- Lulu Hypermarkets on feedback from existing deals.
- Enviroserve on recycling of removed old AC units and an MoU was developed and signed.
- Taqeef on the possibility for extending the rebate scheme to include other retailers.
- QCC on the state of the market for efficient domestic appliances.

3.9.2.3 Key Activities Planned for the Following Year

- Depending on the findings of the pilot scheme review in early 2022, the scheme will be redesigned and/or relaunched.
- Discussions and planning with Media Department and Contact Centre on the viability of directly targeting Local Tariff payers with personalised messages or phone calls to increase uptake of the rebate.
- Any alterations to the rebate sums, conditions of the deal or process flow will be made based on the insights that arise from analysis of data of deals retrieved from the system.

3.9.2.4 Key Statistics and Performance Indicators

a) Savings from the AC Rebate Initiative

Savings from the AC Rebate initiative are given in the following table:

Table 5: Savings from the AC Rebate Initiative

Progress	**Penetration (No. Participants)**	**No. Installations (units)**	**Savings[5],[6]**	**Status (% implementation completion)**
Realised for reported year (2021)	24	31	Insufficient data	0.3%

[5] A 10% contingency has been built into the savings figures.

[6] Savings depend upon Local customers taking up the rebate offer, and this in turn depends upon the attractiveness of the offer relative to existing practices within the market. Practices that can diminish the net up-front perceived financial benefit of the rebate include the use of low cost and low skilled installers rather than the more-costly approved installers mandated by the rebate scheme.

Progress	Penetration (No. Participants)	No. Installations (units)	Savings[5],[6]	Status (% implementation completion)
Planned for next year (2022)	1,995	1,995	0.694 GWh	20%
Total targeted[7]	9,975	9,975	52.1 GWh[8]	100%

- IPMVP Option A, retrofit isolation, was chosen for developing the EM&V data for this initiative[9].
- The EM&V plan (endorsed by a third party in August 2019), will be run once a sufficient number of sample units has been installed and full year data is obtained.

b) Costs of the AC Rebate Initiative.
The costs of the AC Rebate Initiative are given in the table following:

Table 6: Costs of the AC Rebate Initiative

Cost Category	Realised in reported year (2021)	Planned for next year (2022)
Physical resources cost (equipment, etc.)	N/A	N/A
Human resources	N/A	N/A
Outsourced resources cost	N/A	N/A
Other cost (please specify)	AED 13,300 rebate repayment to retailers[10].	AED 997,500 rebate repayment to retailers.

3.9.2.5 Risks, Barriers and Issues for this Initiative

The following risks, barriers and issues were explored and mitigation measures were proposed:

[7] The savings were estimated based on engineering best practice, industry market data and results from other studies in the UAE (The Executive Affairs Authority Comprehensive Cooling Plan).
[8] The total targeted figures are for the full programme period and the latest assumptions based on continuing the present pilot scale on a rolling basis for 5 years. Savings are estimated over ten years. It is assumed that first year underperformance can be caught up in subsequent years.
[9] Third party endorsed EM&V Plan "ADDC EM&V Plan for Villa AC Rebate August 2019_Final V2", submitted to DoE in August 2019.
[10] The 2021 sum is being verified at present to ensure that only fully valid deals are counted.

Table 7: Risks, Barriers and Issues for the AC Rebate Initiative

Risks, Barriers and Issues	Mitigation Measures
Insufficient numbers of 4 and 5-Star units are available to meet increased demand	• The AC market is already moving to meet tightened standards under the new ESMA ratings (delayed due to COVID-19 but which came into force in 2021). As a result, there is a move to balance production in favour of more efficient models. The AC Rebate should ensure that demand harmonizes with the shift in supply capacity.
Level of expected savings fails to be realised	• Savings are a deterministic outcome based on the legally-required measurements of efficiency of new standard efficiency and high efficiency units. • Calculation methods conform to engineering best practices and proven in similar applications & environments. The project requires that only 4 & 5 Star rated AC units will be incentivised. • Savings assumed in the business case are set conservatively.
Untrained staff wrongly install AC units and adversely affect savings	• All units must be installed only by approved qualified suppliers and/or installers as per the scheme rules.
Homeowners alter settings adversely and reduce savings	• Homeowners will most probably control the new high efficiency units in the same way that they would for a normal unit, so savings against the baseline will be unaffected.
Scheme is not taken up	• It is not expected that anyone will refuse to accept a higher efficiency unit where the additional cost is fully covered by the rebate. However, a range of poor practices in the AC marketplace can erode the apparent financial benefit of the rebate, and the scheme will be closely monitored to identify whether this is happening and the nature of the required solutions.
Insufficient Data for EM&V	• Data suitable for M&V is part of the contractual obligation of the retailer, and if not supplied, then the rebate sum is not repayed by the initiative.
Equipment failure	• Equipment is covered by normal warranties and will not be treated any differently to a standard unit with respect to maintenance and repair.
Complaints about quality or performance	• The units concerned are higher efficiency units within the same model range as consumers would already have chosen anyway. Therefore, consumers will have already accepted the quality of the range before the high efficiency choice is incentivised. There will be no change in their expectations when the high efficiency unit is selected and no excess complaints are expected. • The units will differ only in their efficiency compared to standard units. The cooling capacity and overall function will be the same, so complaints on this issue will not arise.

3.9.3 Industrial Efficiency Initiative

3.9.3.1 Overview of Initiative

The Industrial Efficiency Initiative is a continuation of the ADDC Industrial Consultation process started in 2016, and is aligned with the Abu Dhabi DSM and Energy Rationalization Strategy 2030 theme “Rebates and Awareness”. This initiative is closely linked with the Department for Economic Development’s Electricity Tariff Incentive Programme (“ETIP”). ADDC has set a requirement that in order to join the ETIP scheme, industrial sites must adopt energy management systems aligned with the requirements of ISO50001. The focus in 2020 was to get basic systems in place, while in 2021 sites were required to also develop a basic site survey report to identify savings opportunities and to develop a basic savings implementation plan and energy reduction targets. The scheme forward plan highlights that these targets could become firm in future years if government and manufacturers are able to build capacity and agree on achievable targets.

3.9.3.2 Key Activities Completed/Progressed This Year

- ETIP eligibility requirements were tightened, requiring sites to develop a basic site survey and a basic energy efficiency implementation plan.
- Detailed templates were developed in order to assist sites in carrying out their site surveys and writing their reports and plans.
- Early in 2021, a number of government-owned sites were removed from ETIP at the request of the General Secretariat of the Executive Council (GSEC). These sites were later re-admitted to ETIP due to a relaxation of the ownership rules, necessitating significant admin work to reverse the earlier changes.
- The numbers of sites, the sectoral breakdown and the 2021 consumptions recruited to the scheme and mandated to develop energy management systems were as follows:

Table 8: Sectoral Consumption Breakdown Amongst ETIP Scheme Members.

ISIC Code Categories	Sites in ETIP During 2021	2021 kWh Covered by ETIP
2410 Manufacture of basic iron and steel	12	642,483,710
1701 Manufacture of pulp, paper and paperboard	7	476,980,604
2011 Manufacture of basic chemicals	4	234,058,149
2394 Manufacture of cement, lime and plaster	6	140,464,886
2393 Manufacture of other porcelain and ceramic products	1	53,414,000
1050 Manufacture of dairy products	3	48,756,326
1061 Manufacture of grain mill products	1	37,865,801
2220 Manufacture of plastics products	3	36,988,879

2310 Manufacture of glass and glass products	1	36,019,000
2420 Manufacture of basic precious and other non-ferrous metals	2	19,268,665
1393 Manufacture of carpets and rugs	1	18,040,668
1811 Printing	1	6,065,879
Grand Total	**42**	**1,750,406,567**

- A survey was conducted to ascertain the starting conditions of the energy management systems at the ETIP sites. An illustrative selection from these results is given in the Appendix.
- Analysis of submitted energy reports was used to identify which sites needed assistance in developing the more stringent submissions that would be required for the 2022-23 ETIP year.
  - Workshops took place on a one-to-one basis with sites if they had been identified as having lower quality submissions and being in need of further guidance.
  - The scores from the assessment are given in the following table:

Table 9: Scores for Quality of Key Elements of Energy Management Evidence.

Site	Energy Survey Score	EM Plan & Targets Score	ISO Certificate?
1	95	72	
2	100	55	ISO14001
3	50	90	ISO14001
4	87	20	ISO50001
5	73	80	
6	85	90	ISO14001
7	95	80	ISO14001
8	58	60	ISO14001
9	95	85	
10	93	40	ISO14001
11	83	65	ISO14001
12	83	65	ISO14001
13	83	70	
14	100	90	ISO14001
15	55	55	ISO14001
16	63	70	
17	88	80	
18	53	70	
19	83	85	ISO14001
20	60	85	
21	75	65	ISO14001
22	90	90	ISO14001
23	90	80	ISO14001
24	85	65	
25	75	70	ISO14001

26	30	75	ISO50001
27	80	75	ISO14001
28	80	95	ISO14001
29	71	85	ISO14001
30	55	50	
31	100	70	
32	Duplicate of other group site	Duplicate of other group site	
33	85	50	
34	No submission	No submission	ISO14001

Sites who scored 50 or below on any one item were offered training workshops to help them to improve their submissions ready for the 2022-2023 ETIP cycle.
The attendance statistics for the one-to-one training workshops were as follows:

Table 10: Attendee Statistics for Workshops to Improve Key Energy Management Submissions.

Initial Energy Management Workshop Statistic	Number
Number of one-to-one training workshops conducted	15
Number of people attending workshops	53
Number of different industrial sites represented	19

Overall, more than 106 individual focused training hours were delivered during 2021.
During the year the Industrial Efficiency Initiative Team worked with the following stakeholders:

- Industrial Development Bureau of DED on development of the scheme.
- DED on the impact of bringing new sectors into the scheme.
- Solution providers who may be able to bring new technologies to the industrial sector.

3.9.3.3 Key Activities Planned for the Following Year

- ADDC's energy management requirements to join the ETIP scheme will be expanded from the basic systems elements checked for 2020-2021 and 2021-2022, and will now additionally include submission of a detailed site energy efficiency survey and a detailed site energy management plan and targets. Materials will be scored against a structured set of requirements for each sub-sector of industry.
- A target of a further 25 workshops will be conducted during 2022, assisting sites in adding additional elements to their energy management systems, as per ADDC's requirements under the collaboration with Industrial Development Bureau.

3.9.3.4 Key Statistics and Performance Indicators

a) Savings from the Industrial Efficiency Initiative.
Savings from the initiative are given in the table below:

Table 11: Savings from the Industrial Efficiency Initiative

Progress	Penetration (No. Participants)	No. Installations (units)	Savings[11]	Status (% implementation completion)[12]
Realised for reported year (2021)	43	N/A	N/A (see footnote 19)	Influencing 78% of overall industrial consumption
Planned for next year (2022)	75	N/A	4.3GWh (see footnote 19)	influencing 80% of overall industrial consumption
Total targeted	250[13]	N/A	776GWh[14]	Influencing 90% of overall industrial consumption

b) Costs for the Industrial Efficiency Initiative.
Costs for the initiative are given in the table below:

Table 12: Costs for the Industrial Efficiency Initiative

Cost Category	Realised in reported year (2021)	Planned for next year (2022)
Physical resources cost (equipment, etc.)	N/A	N/A
Human resources	N/A	N/A
Outsourced resources cost	N/A	N/A
Other cost (please specify)	N/A	N/A

3.9.3.5 Risks, Barriers and Issues for this Initiative

The following risks, barriers and issues were explored and mitigation measures were proposed:

[11] A measurement methodology has not yet been agreed for industrial savings. The implementation of these savings is under the control of the individual organisations concerned, and ADDC can only encourage and educate sites. Guidance on developing an EM&V plan will be taken from the DoE-Guidehouse project. During the 2022-2023 ETIP year, ADDC will conduct research amongst ETIP members and workshop attendees to characterise the level of change that is attributable to the Industrial Efficiency initiative.
[12] The completion status gives the approximate percentage of overall industrial consumption that is within the ETIP scheme or with organisations formerly within ETIP and with whom ADDC now has strong relationships.
[13] Long term target for membership of the ETIP scheme, considering potential expansion beyond current large sites that constitute the majority of ETIP members.
[14] The estimated annual savings grow to 7.5% of the 2019 baseline consumption for the 10-year life of the programme, and are calculated based on engineering best practice, industry market data and results from similar work around the world. Current estimate does not take account of inability to estimate savings during 2021 and 2022, so will be subject to change when a proper methodology has been developed.

Table 13: Risks, Barriers and issues for the Industrial Efficiency Initiative.

Risks, Barriers and Issues	Mitigation Measures
Sites do not identify savings	• Ensure that sites submit monthly energy consumption reports so that management are aware of the scale, costs and trends in consumption, increasing their interest in making reductions. • Ensure that site survey reports are correctly developed as part of scheme qualifications.
Sites fail to plan effectively	• Ensure that site energy implementation plans are correctly developed and follow ADDC's template, which is structured to drive action and follow on to the development of business cases.
Sites fail to implement measures	• Ensure that savings measures are supported by ADDC advice that is based on global best practice and is proven to work. • Develop thinking within government and industry and consider firm targets as part of scheme criteria in future, once industry has built capacity for change.
Sites fail to provide information to identify impact of the initiative	• It is currently mandatory for sites within the ETIP scheme to submit information on their targets and opportunities, and in future years they will also have to describe their activities and achievements, allowing ADDC to calibrate its calculations of impact in the industrial sector.

3.9.4 Masjidi Electricity Initiative

3.9.4.1 Overview of Initiative

The Masjidi Electricity Initiative is aligned with the Abu Dhabi DSM and Energy Rationalization Strategy 2030 theme "Building Retrofits". This initiative focuses on reducing the electricity consumption in mosques, which is a 100% subsidized customer segment. The initiative will invest in the installation of smart thermostats that will improve the control efficiency of the mosque air-conditioning systems. The investment will be made upfront by ADDC, with subsequent cost recovery through Opex adjustments to the Maximum Allowed Revenue (MAR).

3.9.4.2 Key Activities Completed/Progressed This Year

DoE, in ref. letter DOE/US/2021/959 approved the business case. Subsequently, the ADDC DSM Dept. raised a contract request with the ADDC Supply Dept. to initiate the project tendering process.

A meeting with DoE representatives was conducted on 29th November, 2021 to discuss EM&V requirements in general and specifically those required for this initiative.

A line of communication was opened with AWQAF and Musanada to nominate representatives from their side to form a taskforce with ADDC representatives for the purpose of coordinating, optimizing the conservation measures and implementation methodology for this initiative, and to overcome any challenges.

During the year the Masjidi Electricity Initiative Team worked with the following stakeholders:

- AWQAF and Musanada on the existing air conditioning and lighting equipment schedule for the participating Mosques.
- Large suppliers of smart timing and control equipment.

3.9.4.3 Key Activities Planned for the Following Year

Key issues to be investigated and decisions to be taken in partnership with AWQAF and Musanada during 2022 include:

- The level of detailed information already available on the electrical systems in place within Mosques that in turn defines the extent to which an additional consulting survey is required to develop the BoQ for works.
- If necessary, writing the specifications and framing the BoQ for floating the tender.
- The contractual arrangements for initiating the contract for works.

3.9.4.4 Key Statistics and Performance Indicators

a) Savings from the Masjidi Electricity Initiative.
Savings from the initiative are given in the following table:

Table 14: Savings from the Masjidi Electricity Initiative

Progress	**Penetration (No. Participants)**	**No. Installations (units)**	**Savings[15]**	**Status (% implementation completion)**
Realised for reported year (2021)	N/A	N/A	N/A	DoE approved business case. Initiated contract request
Planned for next year (2022)	N/A	N/A	N/A	Complete tendering, awarding the contract & first phase of the project
Total targeted	850 mosques	13,800 thermostats	235.8 GWh[16]	

[15] The consumption savings were estimated as being 20%, based on engineering best practice and results from similar projects across the region.
[16] Savings are estimated over ten years.

- The proposed IPMVP Option for this initiative is Option C. The EM&V plan is under development.
- The final EM&V plan will be developed and shared with DoE for review, however, it does not need to be endorsed by a 3rd party. This is as per the stipulated criteria of DoE (i.e. the initiative contributes to less than 5% of the relevant DSM Program's targeted savings).

b) Costs for the Masjidi Electricity Initiative.
Costs for the initiative are given in the table below:

Table 15: Costs for the Masjidi Electricity Initiative

Cost Category	Realised in reported year (2021)	Planned for next year (2022)
Physical resources cost (equipment, etc.)	N/A	AED 4.60M
Human resources	N/A	N/A
Outsourced resources cost (survey of 850 mosques)	N/A	AED 0.51M
Other cost (installation)	N/A	AED 2.30M

Cost are distributed as follows:

1- AED 510,000 to survey 850 mosques to develop the BoQ,
2- AED 14,340,000 cost for equipment and installation, distributed over 2022 and 2023 (30% is allocated for installation).
3- AED 3,150,000 for EM&V, to be spent over the strategy period starting one year after completion of installation, testing and commissioning of control equipment.

The cost of equipment was based on market research into suitable equipment and central command control software for remote control of all participant mosques. Installation costs were estimated and a 10% contingency was added to all figures.

3.9.4.5 Risks, Barriers and Issues for this Initiative

The following risks, barriers and issues were explored and mitigation measures were proposed:

Table 16: Risks, Barriers and Issues for the Masjidi Electricity Initiative.

Risks, Barriers and Issues	Mitigation Measures
Saving potential fails to be realized	• The measure conforms to engineering best practices, already implemented and proven in a similar application & environment, and will be customized to Mosque A/C types. • Savings assumed in the Business Case are set conservatively (lower than theoretical and pilot results).
Not following the recommended AC programming profile (system & human error)	• Centralized real-time monitoring of retrofitted air-conditioning systems is considered. • Controllers will be password protected to avoid unauthorized tampering with programs and vandalism.

Unqualified / untrained O&M staff that may alter settings adversely	• Local control/intervention will not be required as the systems will be set to international best practice set points. • The Imam can call the control centre for updates, maintenance and control schedule changes. • Controllers and thermostats are solid-state electronics that do not require frequent maintenance; calibration & prayer time update might be required and maintenance personnel could be easily trained to execute this exercise.
Unwilling/un-cooperative facility management or caretakers	• Establish an MoU/formal agreement between ADDC & AWQAF with clear roles & responsibilities.
Equipment failure	• Free replacement under warranty period. Thereafter as part of O&M budget as cost is small, at less than AED1,000/unit.
Complaints about performance	• Establish a proper baseline during site surveys including current operation and equipment conditions. • Plan ahead of special events (e.g. Ramadan).

3.9.5 Social Card Holder Home Upgrades Initiative

3.9.5.1 Overview of Initiative

The Social Card Holder Home Upgrades Initiative is aligned with the Abu Dhabi DSM and Energy Rationalization Strategy 2030 theme “Building Retrofits”. This initiative focuses on reducing the electricity consumption of social card holders, who belong to a highly subsidized customer segment. The initiative will invest in improving energy efficiency for these customers, whose financial circumstances constrain their abilities to invest in efficient equipment.

The initiative focuses on energy efficiency, as water efficiency in this target group has already been addressed by previous initiatives delivered by other government stakeholders, including tap retrofit programmes offered to residents by DoE and the Abu Dhabi Department for Municipalities and Transportation (DMT). If minor water savings opportunities, such as flow aerators etc. are identified during the home energy visits, then these will be addressed if budget allows. Findings from the home visits will be evaluated to build a further business case focusing on water opportunities, if appropriate levels of savings are identified.

Energy conservation measures will mainly focus on replacing old and inefficient equipment for air-conditioning and lighting. This project is justified more on the corporate social responsibility and societal benefits than on the financial returns. Savings will be achieved through the avoided marginal cost of fuel for generating

electricity. Initial funding will be provided by ADDC, following which DoE will allow cost recovery via an Opex adjustment to MAR.

This initiative operates in the same technical space as the AC Rebate initiative, and covers a set of customers who also have access to the rebate. It is expected that Social Card holders will also take up the AC Rebate when purchasing new equipment to replace failed units. However, the Home Upgrades initiative targets the replacement of existing but inefficient fully functioning units. Units that have recently been replaced under the AC Rebate scheme will be efficient and therefore will not be replaced. As a result, there will not be any duplication or wasted overlap with the improvements delivered by the AC Rebate.

3.9.5.2 Key Activities Completed/Progressed This Year

DoE in ref. letter DOE/US/2021/959 rejected this business case on the grounds that it did not meet the minimum requirements for cost effectiveness tests required by DoE.

During the year the Social Card Holders Home Upgrade Initiative Team worked with the following stakeholders:

- DoE on the viability of the scheme.
- Abu Dhabi Social Support Authority on methods for targeting suitable recipients.

3.9.5.3 Key Activities Planned for the Following Year

Following the rejection of the business case by DoE, ADDC is continuing to look into ways to revive this initiative through discussion with various stakeholders including Abu Dhabi Department of Community Development (DCD).

3.9.5.4 Key Statistics and Performance Indicators

a) Savings from the Social Card Holder Home Upgrades Initiative.
Savings from the initiative are given in the table below:

Table 17: Projected Savings from the Social Card Holder Home Upgrades Initiative

Progress	Penetration (No. Participants)	No. Installations (units)	Savings[17]	Status (% implementation completion)
Realised for reported year (2021)	N/A	N/A	N/A	Business case rejected by DoE

[17] The savings were estimated based on engineering best practice and the results of other studies in the UAE (Executive Affairs Authority Comprehensive Cooling Plan).

Progress	Penetration (No. Participants)	No. Installations (units)	Savings[17]	Status (% implementation completion)
Planned for next year (2022)[18]	N/A	N/A	N/A	Depending on stakeholder discussions
Total targeted	60 Social Card Holders' homes	~600 AC split units in addition to light fixtures	12.8 GWh[19]	100%

- The IPMVP option for EM&V will be chosen when the EM&V plan for this initiative is developed.
- The final EM&V plan will be developed and shared with DoE for review, however, it does not need to be endorsed by a 3rd party. This is as per the stipulated criteria of DoE (i.e., the initiative contributes to less than 5% of the relevant DSM Program's targeted savings).

b) Costs for the Social Card Holder Home Upgrade Initiative.
Costs for the initiative are given in the table below:

Table 18: Projected Costs for the Social Card Holder Home Upgrades Initiative

Cost Category[20]	Realised in reported year (2021)	Planned for next year (2022)
Physical resources cost (equipment, etc.)	N/A	N/A
Human resources	N/A	N/A
Outsourced resources cost	N/A	N/A
Other cost (installation cost)	N/A	N/A

3.9.5.5 Risks, Barriers and Issues for this Initiative

The following risks, barriers and issues were explored and mitigation measures were proposed:

[18] Implementation may possibly start during 2022 if a revised business case can be developed that is acceptable to DoE and DCD.
[19] Savings are estimated over ten years.
[20] The cost of equipment was based on market research for suitable products and equipment, in addition to allowing for installation costs and further adding a 10% overall contingency.

Table 19: Risks, Barriers and Issues for the Social Card Holder Home Upgrades Initiative.

Risks, Barriers and Issues	Mitigation Measures
Saving potential fails to be realised	• The measure conforms to established engineering best practice that has been proven in similar applications and environments. The project requires that only 4 & 5 Star rated AC units be used. • Savings assumed in the business case are set conservatively (lower than results based on similar work).
Not following the recommended AC programming profile (system & human error)	• Provide all homeowners (~60) with an introduction and awareness session on the efficient use and best maintenance practice for their AC units.
Unqualified / untrained O&M staff alter settings adversely	• Homeowners will be advised to hire only QCC & DMAT accredited AC technicians to maintain their AC equipment. General tips on AC maintenance in leaflets and explanation during the awareness session will be delivered to empower the homeowner to control and supervise maintenance activities.
Unwilling / uncooperative homeowners	• It is not expected that anyone will refuse to replace old inefficient units with new high efficiency long life equipment that will be provided to them free of cost.
Equipment failure	• Free replacement during the warranty period. Thereafter the equipment will be the responsibility of the homeowners.
Complaints about performance	• Establish a proper baseline during site surveys including current operational patterns and the prior condition of existing equipment.

3.9.6 DED Industrial Sustainability Working Group

3.9.6.1 Introduction/background

This activity supports the DED in their attempts to improve industrial sustainability and efficiency, ensuring that water and energy efficiency are appropriately built into corporate plans.

3.9.6.2 Progress Brief

- Produced an updated electricity and water baseline for industry and provided a sub-sector breakdown.
- Provided input and advice during workshops on the development of industrial sustainability targets.

3.9.6.3 Challenges and Issues

- Difficulty of setting ambitious savings targets in a climate of economic pressure for manufacturing.

3.9.6.4 Mitigation Measures

- Building capacity for managing resource efficiency in industry to ensure that sites can properly consider the viability of firm reduction targets.
- Providing energy and water efficiency advice that offers measures that have short paybacks to support companies in working towards targets.

3.9.6.5 Next Steps

- Follow up with DED in developing their long-term industrial sustainability strategy.

3.9.7 Energy Performance Contracting/ESCO

3.9.7.1 Progress Brief

- Provided technical support and data to ADES.
- Provided 17 training workshops on energy efficiency and energy performance contracting to multiple Government entities, including Ministry of the Economy, Abu Dhabi Customs, ADAFSA, Department of Municipalities and Transport, Abu Dhabi Police, Telecommunications Regulation Authority, Abu Dhabi Fund for Development, etc.

3.9.7.2 Challenges and Issues

- Engaging with the commercial sector during challenging economic times.
- High profit mark-ups from ESCOs damaging the commercial attractiveness of efficiency propositions.

3.9.7.3 Mitigation Measures

- Present long term business strategy picture to ESCOs and customers.

3.9.7.4 Next Steps

- Continue supporting ADES and other stakeholders.

3.9.8 HVAC & Plumbing Personnel Conformity Scheme

3.9.8.1 Progress Brief

During 2020 ADDC supported QCC in the development of the plumbing and heating, ventilation and air-conditioning (HVAC) personnel conformity scheme. This scheme was intended to develop a clear framework of tests that Abu Dhabi HVAC and plumbing professionals should pass in order to be issued licenses by Abu Dhabi Municipality. The materials developed included the Occupational Terms (chiller mechanic, HVAC team leader, technical supervisor and plumber team leader), a questions bank, audit visits to test centres, identification of enforcement mechanisms, and trial exams with large FM providers.

During 2021 QCC indicated that the lead for the scheme should come from Abu Dhabi Department of Municipalities and Transport (DMT), as they would be responsible for enforcement. Accordingly, the scheme was presented to DMT, with the support of DoE. DMT indicated that they have a similar scheme in their plan for implementation in April 2021 but which covers engineers rather than technicians. DMT indicated that the ADDC concept of addressing technicians was of interest as a follow-on from their engineer's skills scheme. Follow-up emails were subsequently sent to DMT to request an update on progress and their response is awaited.

3.9.8.2 Challenges and Issues

- Prioritisation within DMT.
- Engaging with the commercial sector during challenging economic times.
- Enforcement of the tests to qualify various technicians.

3.9.8.3 Mitigation Measures

- Continue following up with DMT and ensure support of DoE to raise the priority of the scheme.
- Present long term business strategy picture to customers.

3.9.8.4 Next Steps

- Continue supporting QCC, DoE, DMT and other stakeholders.

3.9.9 Heat Map Application Development Initiative

3.9.9.1 Progress Brief

The Heat Map Application is aligned with the Abu Dhabi DSM and Energy Rationalization Strategy 2030 theme "Building Retrofits" and will assist the DoE's project "Energy and Water Consumption Benchmarking for Buildings in Abu Dhabi". The Heat Map Application will provide a graphical representation of the baseline energy and water consumption of all recorded facilities, and will provide clear depiction of participation in DSM initiatives and the impact of improved efficiency on consumption. This will help in overall targeting of areas for engagement in DSM initiatives and in identifying those specific buildings and facilities that can subsequently be addressed by other initiatives. The Business Requirement Standard (BRS) document for the project was developed by the DSM Department in collaboration with Injazat, along with the high level project implementation plan and associated cost estimates. The BRS document has been approved and the project has been awarded to Raqmiyat (the current ADDC IT service provider/contractor) after obtaining bids from other two (2) bidders. The Heat Map Application development has started.

3.9.9.2 Challenges and Issues

Data quality and harmonisation has been a major challenge. Some data is misaddressed due to GIS limitations. In addition, there is no direct link between the geographical information system (GIS) data and ADDC electricity and water accounts at a building level. In certain cases, plot demarcation in the GIS is intermingled, which leads to multiple counting of the same assets. In addition, the Heat Map application will tap into the current Tarsheed Buildings Survey application database, which has scalability and performance limitations.

3.9.9.3 Mitigation Measures

- Improve scalability of applications.
- Optimize performance for data storage and retrieval.
- Ensure geolocation accuracy.
- Improve selection criteria for premises.
- Improve computations for consumption data.
- Improve application architecture.
- Develop a very detailed BRS document to ensure good understanding of the application development requirements.
- Conduct data mapping and cleansing exercise where applicable.

3.9.9.4 Next Steps

Develop the Heat Map Application, conduct the necessary tests and then deploy the application to fulfil its intended functions.

4 System Capacity and Studies

4.1 Introduction:

Power system modelling is of a great importance to successful planning, operation and management of electricity networks. Long term planning can be optimized through the application of Power System Modelling software.

The software serves to provide a platform where simulations of different network scenarios can be performed and analysed in an offline environment such that the future operation of the networks can be optimised and planned appropriately. The application of PSS-SINCAL software is used in ADDC to exercise this engineering approach. Power system modelling is carried out to ensure that the optimization of long term planning is achieved accordingly.

In distribution network planning, power system studies and analysis through simulations are carried out to identify any weak points, deficiencies and reinforcements requirements in the existing networks.

This is as well applied to all proposed future expansions, reinforcements and modifications with considerations to the expected/forecasted new loads in the 33/11 kV Primary Substations. In this chapter, Electricity Network Modelling Section will carry out simulations using PSS SINCAL software and give summary of results for the 33 kV networks only.

4.2 Network Modelling Methodology

Network Modelling methodology shall follow the following steps:

4.2.1 Data Collection and Data Validation

- Receive network data during system peak load in 2021 from Operation Planning and Dispatch Division (OPDD) as Peak Load Records tables and Single Line Diagram (SLD).
- Collect equipment data from GIS such as cable length, cable size, transformer capacity… etc.
- Validate data, send discrepancies to OPDD for clarification and confirmation.
- Create tables for Peak Load Data for each primary and power transformers for 2021 records.

4.2.2 Missed Data and Assumptions

- Calculate load for each transformer from 11kV load data tables as Active Power (P) and Power Factor (Calculated from P & Q values).
- Calculate the peak load active power P (MW) using the current readings (in Amps) and assuming 0.91 Power factor for cases that P, Q & PF are not available.
- Calculate the peak load from 33kV side data if data is not available at 11kV side of the transformers
- Collect data for Breaking Capacity (KA) for each primary circuit breaker from Electricity Maintenance Department (EMD).

4.2.3 Load Forecast Data

- Send final data (Active Power and Power Factor) for each Primary in 2021 to Electricity Asset Strategy Section (EASS).
- EASS to prepare total load forecast for each primary for years from 2022 to 2027.
- Calculate annual growth rate for each primary from the ratio between Apparent Power of Consecutive years.
- Perform load forecast for each transformer using the calculated growth rate.

4.2.4 Network Modeling

- Perform network modelling using SLD received from OPDD and data from GIS.
- Model Future primaries as per future plans received from EASS as well as cables and transformers data
- Input load data as per final load forecast data tables.

4.3 Data considered for analysis:

Data considered in this study to model entire 33kV network is obtained from the following sources:

1. Operation Planning and Dispatch Division (OPDD)
   - Latest 33kV network connectivity Single Line Diagram
   - Annual peak load details
   - Capacitor Bank details
2. Asset Information Department (GIS)
   - Line (Cable & OHL) length and conductor size details
   - Transformer Capacity details

3. Abu Dhabi Transmission & Dispatch Company (TRANSCO)
   - Calculation of Infeeder input details from TRANSCO 7-Year planning statement
   - Power Transformers details from TRANSCO 7-Year planning statement
4. Electricity Asset Strategy Section (EASS)
   - Annual Load Forecast Report

PSS SINCAL-Power System Simulation SIEMENS Network Calculation is used to carry out all Power system studies and it has a broad range of calculation methods that can be used for planning purpose. The following Modules of the software are predominantly used and listed as follow:

- Load Flow calculation
- Short Circuit calculation

Resistance, reactance and other values considered for modeling different cable sizes in PSS SINCAL is presented in Appendix A4 -4.5

4.4 Load Flow Analysis:

The Load Flow calculation conducted for existing 33 kV network and its proposed future network expansion including new 33/11 kV primary substations and the suggested network modifications for existing network. The main objective of this study is to simulate and evaluate the future expansion in its steady state condition (normal operation) for planning purpose. The LF study is conducted for base year (2021) and for 2022 and following five years 2023, 2024, 2025, 2026 and 2027 while considering the operational conditions of 2021 (i.e. Transformers parallel operational mode, Capacitor Banks as on 2021, etc..). Load flow results shown in SLD format are presented in Appendix A4 – 4.1

4.4.1 Number of 33/11kV Primary Substations Exceeds 6% voltage drop

Load flow calculation was done using the simulation tool, below table is showing any voltage drop that is above 6% in the network.

Table 4-20: Number of 33/11kV Primary Substations Exceeds 6% voltage drop

Region	Area	2021	2022	2023	2024	2025	2026	2027
CR	**Abu Dhabi Island**	0	0	0	0	0	0	0
ER	**Mussafah**	0	0	0	0	0	0	0

Region	Area	2021	2022	2023	2024	2025	2026	2027
	Bani Yas	1	3	3	3	4	3	3
	Shahama	0	0	0	0	0	0	0
WR	**Liwa**	0	0	1	2	2	2	2
	Sila	3	3	0	0	0	0	0
	Madinat Zayed	7	7	7	7	8	8	8
	Habshan	0	0	0	0	0	0	0
	Ruwais	1	1	1	1	1	1	1
	Ghayathi	0	0	0	0	0	0	0
	Mirfa	3	0	0	0	0	1	1

4.4.2 Number of 33kV Feeders Exceeds 100% Loading

Load flow calculation was done using the simulation tool, below table is showing 33kV feeders with loading higher than 100% in normal operation conditions.

Table 0-21: Number of 33kV Feeders Exceeds 100% Loading

Region	Area	2021	2022	2023	2024	2025	2026	2027
CR	**Abu Dhabi Island**	0	0	0	0	0	0	0
ER	**Mussafah**	4	5	7	1	1	1	1
	Bani Yas	19	12	10	2	0	0	0
	Shahama	0	0	0	0	0	0	0
WR	**Liwa**	0	0	0	0	0	0	0
	Sila	0	0	0	0	0	0	0

Region	Area	2021	2022	2023	2024	2025	2026	2027
	Madinat Zayed	2	2	2	2	0	0	0
	Habshan	0	0	0	0	0	0	0
	Ruwais	0	0	0	0	0	0	0
	Ghayathi	0	0	0	0	0	0	0
	Mirfa	0	0	0	0	0	0	0

4.4.3 Number of Primaries without (N-1) for 33kV Incomer Feeders

Load flow calculation was done using the simulation tool, below table is showing 33kV feeders with loading higher than 100% in case of (N-1) condition.

Table 0-22: Number of 33/11kV Primaries without (N-1) for 33kV Incomer Feeders

Region	Area	2021	2022	2023	2024	2025	2026	2027
CR	**Abu Dhabi Island**	1*	1*	1*	1*	1*	1*	1*
ER	**Mussafah**	11	11	11	9	9	8	8
	Bani Yas	15	14	15	15	15	16	16
	Shahama	3	5	6	6	4	4	4
WR	**Liwa**	4	3	3	3	1	1	1
	Sila	1	2	2	2	2	2	2**
	Madinat Zayed	2	2	2	2	1	1	1*
	Habshan	1	0	0	0	0	0	0
	Ruwais	1	1	1	1	1	1	1**
	Ghayathi	2	2	0	0	0	0	0
	Mirfa	1	1	1	1	1	1	1**

* Can be managed operationally by changing the open points on 11kV network

** Radial Private Customer

4.4.4 Number of 33/11kV Primaries Exceed Firm Capacity

Load flow calculation was done using the simulation tool, below table is showing 33/11kV Primaries/Package Units with loading higher than 100% in case of (N-1) condition.

Table 0-23: Number of 33/11kV Primaries exceed Firm Capacity

Region	Area	2021	2022	2023	2024	2025	2026	2027
CR	Abu Dhabi Island	0	0	0	0	0	0	0
ER	Mussafah	5	5	4	2*	2*	2*	2*
	Bani Yas	17	10	9	7	6	1*	1*
	Shahama	0	1	1	1	1	1	2
WR	Liwa	0	0	0	0	0	0	0
	Sila	0	0	0	0	0	0	0
	Madinat Zayed	0	0	0	0	2	2	2**
	Habshan	0	0	0	0	0	0	0
	Ruwais	1	0	0	0	0	0	0
	Ghayathi	0	0	0	0	0	0	0
	Mirfa	1	0	0	0	0	0	0

*To be managed by changing open points on 11kV network
** to be monitored in the coming year to check requirement for reinforcement

Short Circuit Analysis:

Short Circuit (SC) calculation conducted to analyse three phase and single phase short-circuit fault current under the normal operating conditions of the entire 33 kV power distribution network and the 11 kV side of the 33/11 kV transformers in order to ensure that the network elements are not subject to a fault levels that exceeds its rated short circuit design values as per ADDC standards. Short circuit results shown in table format are presented in Appendix A4 – 4.2. The analysis of the short circuit results shows that none of existing or future networks shall be subject to a 3 phase and single phase fault levels that exceeds its rated capacity.

4.5 Asset Utilization

Asset utilization is reported as part of the Sector KPIs as per DoE method of calculation for the Distribution Assets Utilization KPI. The Distribution Asset Utilization is calculated for all ADDC regions and for 33/11 kV Primary Substations Level including 33kV private customers who might be operating at a secondary voltage level less than 11 kV (i.e 6.6, 3.3 kV such as industrial furnace, Tabreed, etc…). The Asset utilization KPI considers the firm capacity as the N-1 capacity of primary substation that have more than one 33/11kV transformer. In cases where there is only one transformer in the substation, the firm capacity shall be considered as the installed capacity.

The % utilization shall be calculated as follows:

$$Utilization = \frac{\Sigma Total\ Peak\ Load\ of\ the\ Primary\ Substation}{\Sigma Firm\ Capacity\ of\ the\ Primary\ Substation}\ X100$$

The utilization calculation as per the year 2021 based on system peak load conditions measured at 33 kV side is presented in Appendix A4 – 4.3 and summarized in the below table

Region	CR	ER	WR	ADDC
%Utilization	54	60	40	55

4.6 Demand Transfer Capability

ADDC Electricity Distribution Network is designed based on ADDC Planning Criteria & Design Philosophy. Available interconnectors between 33/11 kV primary substations are used wherever applicable to increase the security of power supply with minimum cost and avoid power supply interruption in case of primary substation outage.

The demand transfer capability between 33/11 kV primaries depends on relative location of 33/11 kV primaries to each other, actual load reading at the same time and is typically carried out on the 11 kV network level where switching stations are available. This is a case-by-case study and is carried out by operation planning team’s part of routine contingency planning studies.

No load transfer capability can be done in case of:

- Availability of spare panel, however non-availability of capacity in the primary
- Availability of capacity, however no spare panel in the primary due to dedicated feeders, non-realization of the load till date, Express Feeders….. etc.

4.7 Security of Supply Non-compliance

Currently, there are 15 nos. locations where Security of Supply standard (SOS) are not met, and derogation applications were submitted to DOE. This is for 33/11kV primaries and 11kV feeders.

Details of current measures in place and final resolution plans are presented in Appendix 4, Table 4.4.

ADDC is checking the network and any case that is not complied with SOS either primaries or feeders (if applicable) to be submitted as derogation application for DOE. In March and September, an update to be submitted to DOE with the status of the case and derogation.

It is worth to mention that not all overloaded primaries/feeders are applicable for derogation application. There are primaries that its loading exceeds the firm capacity however, through the backfeed for feeders, restoration of power supply is done within the specified restoration time in SOS documents.

Only cases that do not fulfil restoration time mentioned in SOS documents and energized after 2002 to be submitted as a derogation.

4.8 Reactive Power Compensation

Appendix A2 Table 2.9 provide details of capacitor banks in ADDC network ADDC total Reactive Power Compensation in 2021 is presented in the below table.

Capacitor Banks Count

	CR	ER	WR	Total
132/22 kV	4	24	-	28
132/11 kV	113	35	3	151
33/11 kV	-	195	50	245
Total	117	254	53	424

Capacitor Banks Installed Capacity

	CR	ER	WR	Total
132/22 kV	48	288	-	336
132/11 kV	1,322	420	36	1778
33/11 kV	-	993	263	1,256
Total	1,370	1,701	229	3,370

As per the Transmission code, ADDC is required to maintain a minimum power factor of 0.91 lagging at the secondary side of the interface substations. Individual PF at interface points with TRANSCO is showing in the following table:

SN	PRIMARY	PF
Central Region		
1.	ADPSNEW	NA
2.	CONFPRY	0.96
3.	E01PRY1	0.94
4.	E04PRY	0.90
5.	E08PRY	0.75
6.	E09PRY	0.95
7.	E11PRY	0.86
8.	E12PRY2	0.85
9.	E14PRY	0.96
10.	E15PRY	0.89
11.	E16PRY	0.96
12.	E18PRY	0.91
13.	E18PRY2	0.88
14.	E19PRY	0.87

SN	PRIMARY	PF
15.	E25PRY	0.88
16.	E25PRY2	0.92
17.	E40GPRY1	0.97
18.	E48PRY	0.87
19.	E48PRY2	0.96
20.	MRMLPRY	0.93
21.	REMGPRY1	0.96
22.	REMGPRY2	0.97
23.	REMGPRY3	1.00
24.	REMGPRY4	1.00
25.	SDTGPRY1	0.95
26.	SDTGPRY4	0.99
27.	SDTGPRY5	0.99
28.	SDTGPRY6	0.97
29.	SOWGPRY1	0.97
30.	W01PRY	0.89
31.	W02PRY2	0.95
32.	W09PRY	0.88
33.	W13PRY	0.89
34.	W17PRY	0.90
35.	W24PRY2	0.97

SN	PRIMARY	PF
36.	W39PRY	0.92
37.	W41GPRY1	0.95
38.	W42PRY1	0.99
39.	W47PRY	0.94
40.	W59PRY	0.93
41.	W59PRY2	0.96
Eastern Region		
1.	ARPPRY	0.92
2.	ARPPRY5	0.97
3.	BAHPRY	0.876*
4.	CDPRY3	0.86
5.	FLHPRY2	0.92
6.	MFQPRY2	NA*
7.	CNTGPRY	1
8.	GNTGPRY1	0.878
9.	GICGPRY	NA
10.	HFRPRY1	NA
11.	ICAGPRY1	0.97
12.	ICAGPRY2	0.94
13.	KHAPRY1	NA
14.	M12PRY1	0.94
15.	MBZPRY5	0.94

SN	PRIMARY	PF
16.	MBZPRY7	0.94
17.	KHAPRY3	0.94
18.	MOSGPRY	NA
19.	MOSPRY	NA*
20.	MHWGPRY	0.91
21.	MHWGPRY2	0.95
22.	NAHDPRY	0.97
23.	RAHGPRY1	0.99
24.	RAHGPRY2	0.99
25.	S18PRY	NA
26.	SE44PRY	0.98
27.	SHEPRY	NA
28.	SHSPRY1	0.99
29.	SMHGPRY	NA*
30.	SMKGPRY1	0.90
31.	SMKGPRY3	NA
32.	SMKGPRY4	0.95
33.	SNKPRY2	0.885
34.	TWLPRY	0.99*
35.	TWLGPRY2	0.99
36.	WTBGPRY3	0.94
37.	WTBPRY	0.94

SN	PRIMARY	PF
38.	YASPRY1	0.99
Al Dhafra Region		
1.	BABGPRY2	NA
2.	DLMGPRY1	0.95
3.	GHTGPRY	NA
4.	LWAGPRY1	NA
5.	LWAGPRY2	NA
6.	LWAGPRY3	NA
7.	LWAGPRY4	NA
8.	MDZGPRY1	NA
9.	MRPSGPRY	0.99
10.	RWSGPRY	NA
11.	SILGPRY	NA
12.	SBNPRY2	1

*Reading appeared to be not correct

Generally, ADDC is complied with this requirement. However, some interface points primaries had a PF less than 0.91 during the time period of the peak load record. An explanation and analysis of these cases is presented in Appendix 4.6., these cases are being investigated for the operative conditions of these capacitor banks and its control devices to make sure it would operate as appropriate in the upcoming years.

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5 Performance Measurement

5.1 Introduction

The ADDC network performance is assessed by SAIFI (System average interruption frequency index), and SAIDI (System average interruption duration index) SAIFI and number of faults represent the health of the system and effectiveness of the maintenance regime whereas SAIDI represent the promptness with which the customers are reconnected following an outage. These indices are calculate as per the interruption reporting guidelines issued by DoE (formerly RSB).

5.2 SAIFI and SAIDI Statistics

5.2.1 SAIFI

SAIFI is calculate using the following formula.

$$\text{SAIFI} = \frac{\text{Total number of customer interruptions in the year}}{\text{Total number of connected customers at the year-end}}$$

Wherein the Total number of customer interruption means the total numbers of customer affected by Planned or Unplanned Interruption in the relevant year.

Figure 5.1A presents the historical Total System Average Interruption Frequency Index (SAIFI) for the last five years based on Customer per Substation (CPS) and Connectivity Model (CM) method of calculation with 100% planned component consideration. Also presented in Figure 5.1B calculation on SAIFI based on CPS and CM method of calculation with 50% planned component consideration. As shown on below graph, with the exception of year 2019, SAIFI for both CPS and CM method has downward trend from year 2017 to 2021. The abrupt increase on SAIFI in year 2019 was caused by Planned SAIFI which was attribute from the execution of performance improvement projects.

The downward trend is attribute to the following;

- Performance improvements projects such as refurbishment of OHL, installation of auto-recloser and automation projects
- Pro-active maintenance such as condition monitoring, preventive and corrective maintenance activities
- Live line maintenance
- Optimize point of isolation to minimize the numbers of customer interrupted during rectification of faults and planned shut down

- Connecting DGs and Cable trolleys during emergencies
- Activation of the tripping coil of automated switching station and substation

In year 2021, the SAIFI value based on CPS has improved by 6.5% as compared to year that of year 2020, which is below by 4% of the year 2021 target. On the other hand, the SAIFI value based on CM Method has improved by 16.2% as compared to that of year 2020. The high improvement on the CM Method of Calculation as compared to CPS Methods indicates that the actual numbers of customer interrupted is less as compared to the assumed based on CPS Method. The Results of the Audit on the Connectivity Model carried out by the Technical Assessor (TA) shows 90.57% which is above the 90% RC1 requirement.

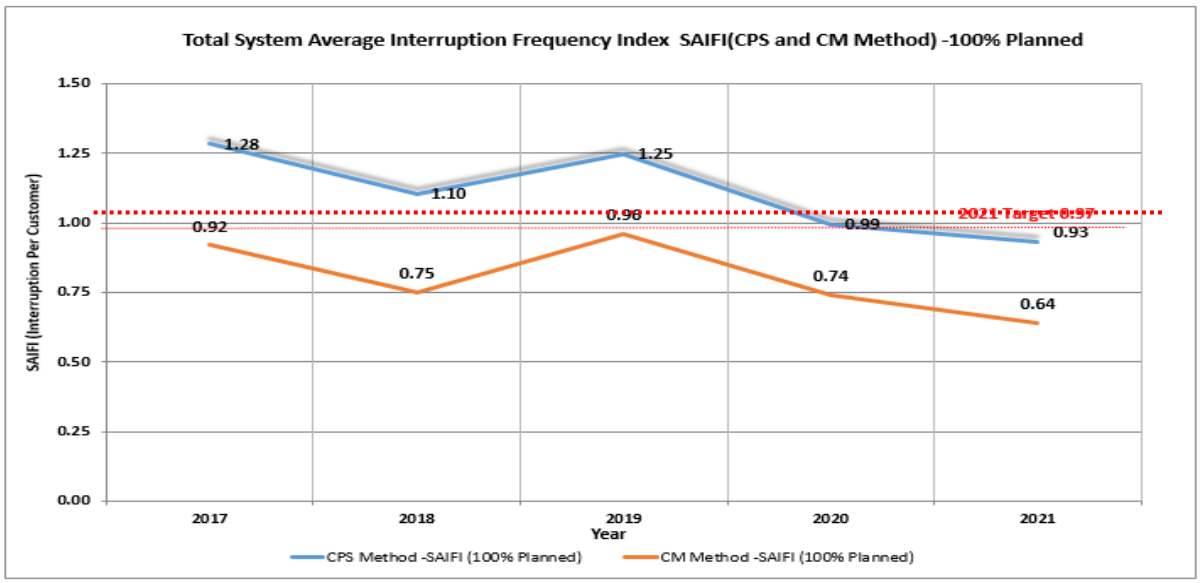

Figure 5.1A Historical Overall SAIFI (CPS&CM) -100% Planned

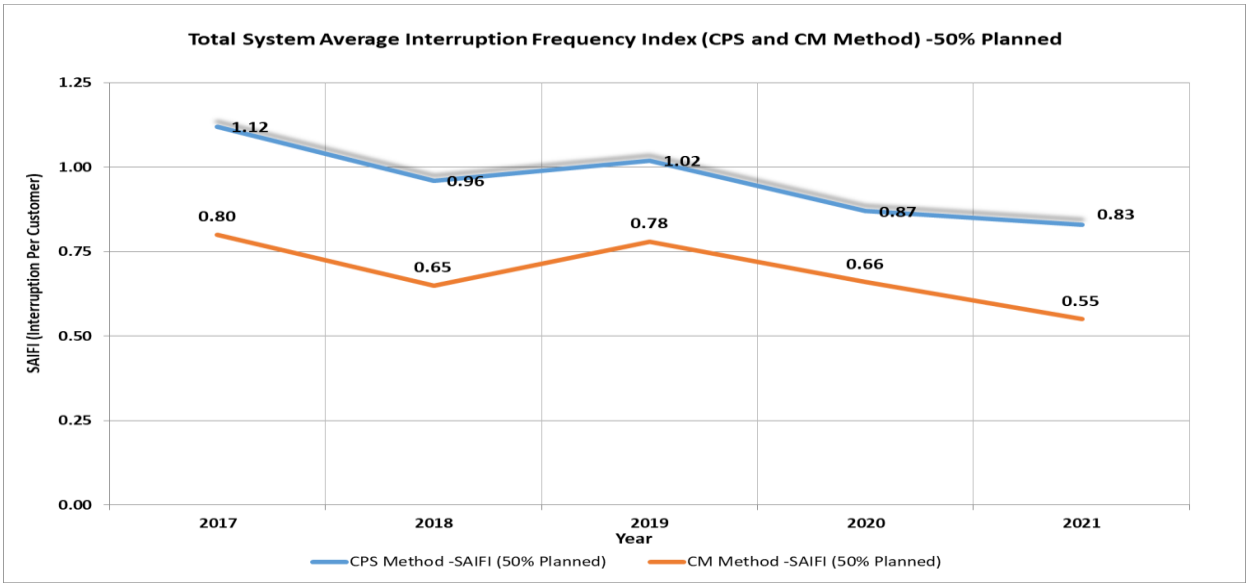

Figure 5.1B Historical Overall SAIFI (CPS&CM) - 50% Planned

Figure 5.1C presents the overall all unplanned SAIFI for the last five years based on CPS and CM method of calculation with 100% planned component consideration. As shown on below graph, the five year historical unplanned SAIFI as per CPS method of calculation has downward trend, on the other hand, the unplanned SAIFI as per CM method has downtrend from year 2017 to 2018 and slightly increased in year 2019, followed by downtrend until 2021.

In year 2021, the unplanned SAIFI value based on CPS has improved by 1.35%, while the unplanned SAIFI value based on CM Method has improved by 14.04% as compared to that of year 2020.

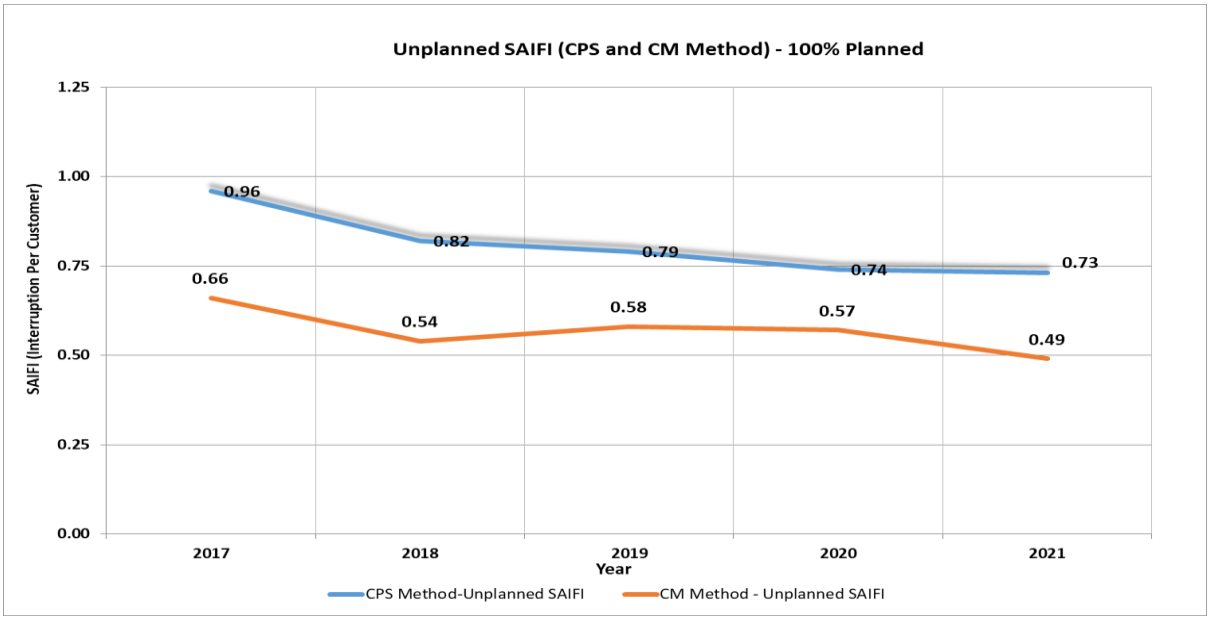

Figure 5.1C Historical Unplanned SAIFI (CPS&CM) -100% Planned

Figure 5.1D presents the overall all Planned SAIFI for the last five years based on CPS and CM method of calculation with 100% planned component consideration. As shown on below graph, the five year historical unplanned SAIFI as per CPS and CM method of calculation has downward trend, with the exception of year 2019. The increased on SAIFI in year 2019 is attribute to the planned outage from execution of performance improvement projects.

In year 2021, the Planned SAIFI value based on CPS has improved by 20%, while the Planned SAIFI value based on CM Method has improved by 17.6% as compared to that of year 2020. Planned SAIFI has reduced due to less planned outages due

to the following: completion of performance improvements project in Eastern and Al Dhafra region and Adopting strict measure to minimize planned outages.

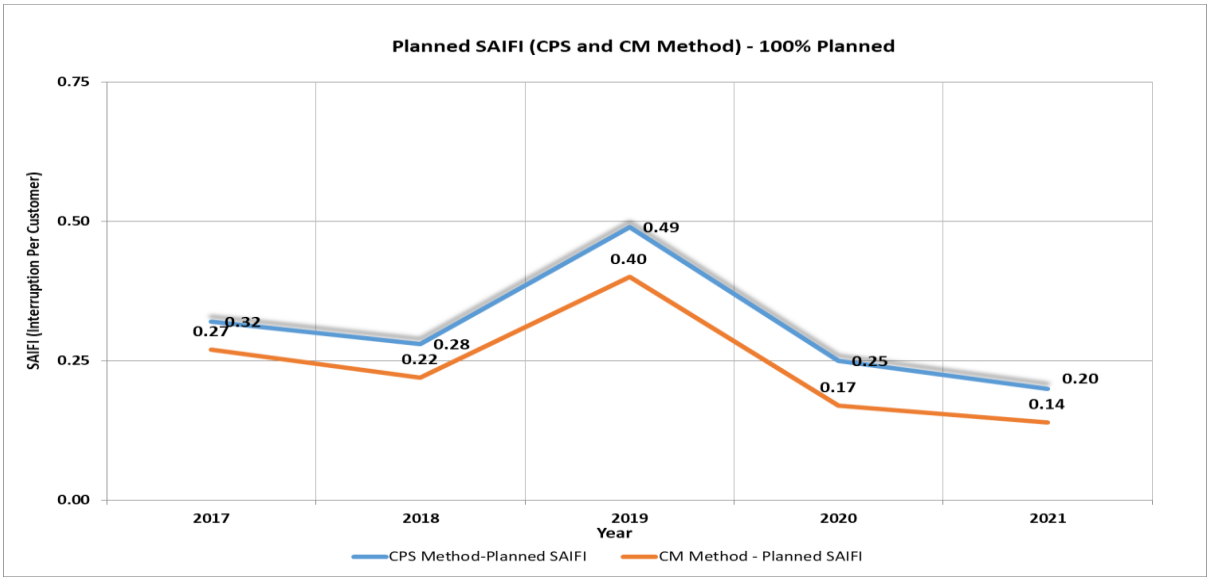

Figure 5.1D Historical Unplanned SAIFI (CPS&CM) -100% Planned

Figure 5.2 presents the five (5) Years historical region wise System Average Interruption Frequency Index (SAIFI) based on CPS Method of Calculation and 100% Planned Component Consideration. The Central Region SAIFI has reduced from 0.35 Interruption per customer to 0.30 interruption per customer in year 2017 to 2018. In year 2019, Central Region SAIFI slightly increased to 0.34 interruptions per customer and in year 2020, it has improved to 0.31 interruptions per customer. In year 2021, its value significantly improved to 0.24 interruptions per customer.

The Eastern Region SAIFI has shown a downward trend from year 2017 to year 2018, however in year 2019, it has worsened to 1.25 int/cust. The reason of this increase is due to planned outages from execution of performance improvement projects. In year 2020, Eastern Region SAIFI has improved to 1.37 int/cust. and further improved to 1.29 int/cust in year 2021.

The Al Dhafra Region SAIFI has shown downward trend from year 2017 to year 2018, however in year 2019, Al Dhafra Region SAIFI figure has slightly increased to 4.75 interruption per customer. The increase was cause by planned outages from execution of performance improvement projects. In year 2020, Al Dhafra Region SAIFI has significantly improved to 3.2 interruption per customer, however in year 2021, Its SAIFI value has increased to 3.43 interruption per customer.

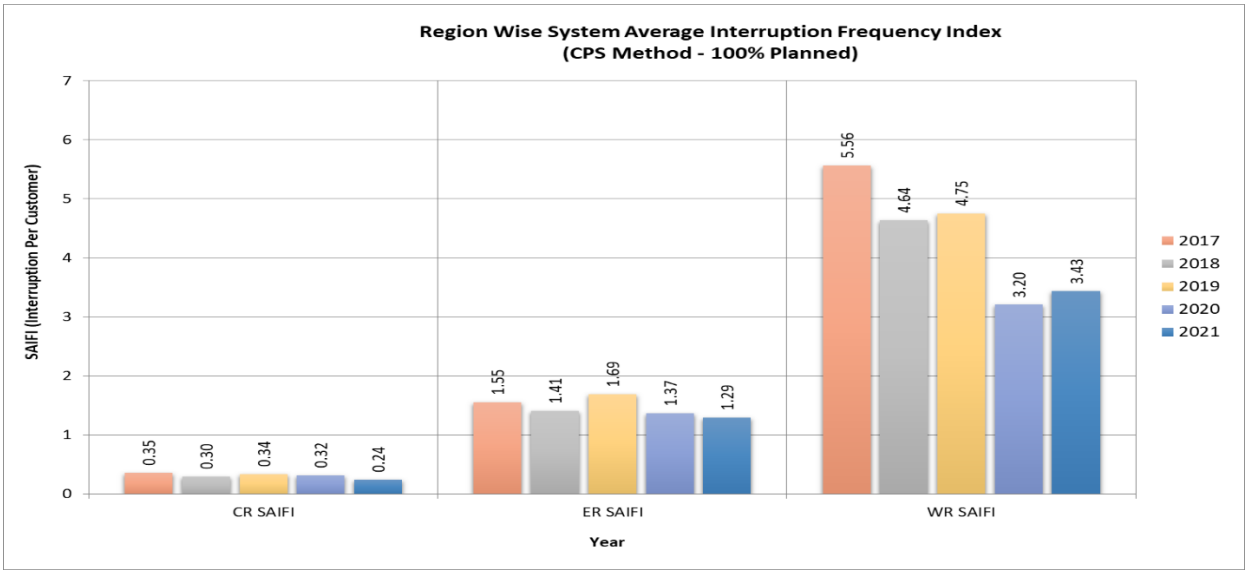

Figure 5.2 Historical (SAIFI) Region wise (CPS Method-100% Planned)

SAIDI is calculated with the following formula.

$$\text{SAIDI} = \frac{\text{Total customers' minutes lost in interruptions in the year}}{\text{Total number of connected customers at the year-end}}$$

Wherein the Total customers' minutes lost in interruptions is the products of duration of each interruption (in minutes) and numbers of customer affected by Planned or Unplanned Interruption in the relevant year.

Figure 5.3A presents the historical Total System Average Interruption Duration Index (SAIDI) for the last five years based on Customer per Substation (CPS) and Connectivity Model (CM) method of calculation with 100% planned component consideration. Also presented in Figure 5.3B calculation on SAIDI based on CPS and CM method of calculation with 50% planned component consideration. As shown on below graph, with the exception of year 2019, SAIDI for both CPS and CM method has downward trend from year 2017 to 2021. The increase on SAIDI in year 2019 was caused by Planned SAIDI component which was attribute from the execution of performance improvement projects.

The downward trend is attribute to the following;

- Performance improvements projects such as refurbishment of OHL, installation of auto-recloser and automation projects
- Pro-active maintenance such as condition monitoring, preventive and corrective maintenance activities
- Live line maintenance

- Optimize point of isolation to minimize the numbers of customer interrupted during rectification of faults and planned shut down
- Connecting DGs and Cable trolleys during emergencies
- Activation of the tripping coil of automated switching station and substation

In year 2021, the SAIDI value based on CPS has improved by 2.07% as compared to that of year 2020, which is below by 0.97% of the year 2021 target. On the other hand, the SAIDI value based on CM Method has improved by 14.4% as compared to that of year 2020. The high improvement on the CM Method of Calculation as compared to CPS Methods indicates that the actual numbers of customer interrupted is less as compared to the assumed based on CPS Method. The Results of the Audit on the Connectivity Model carried out by the Technical Assessor (TA) shows 90.57% which is above the 90% RC1 requirement.

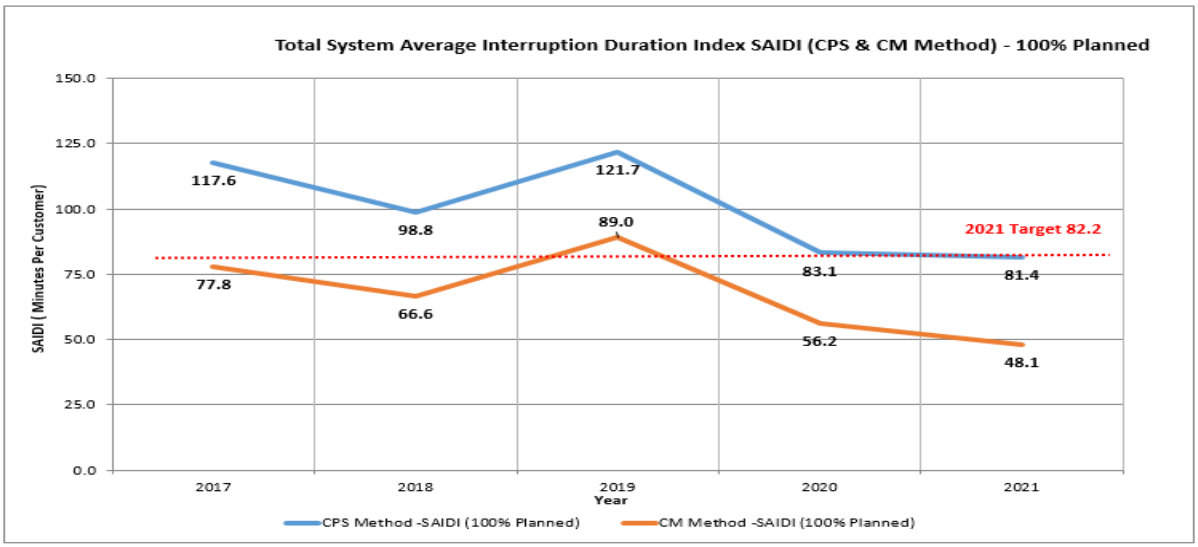

Figure 5.3A Historical Overall SAIDI (CPS&CM) -100% Planned

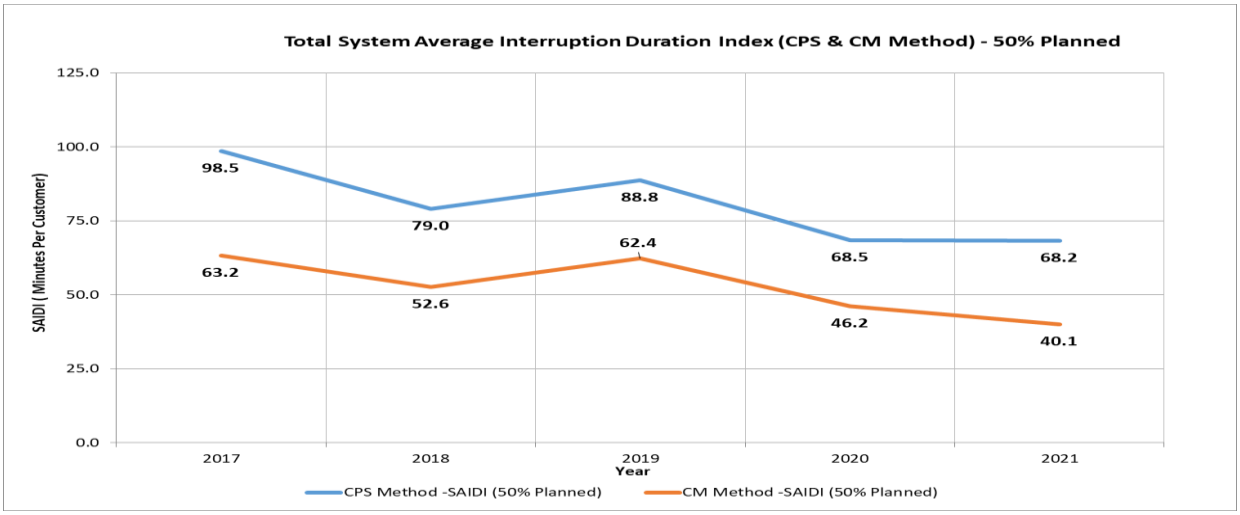

Figure 5.3B Historical Overall SAIDI (CPS&CM) -50% Planned

Figure 5.3C presents the overall all unplanned SAIDI for the last five years based on CPS and CM method of calculation with 100% planned component consideration. As shown on below graph, the five year historical unplanned SAIDI as per CPS method of calculation has downward trend from year 2017 to 2020, followed by slight increase in year 2021, on the other hand, the unplanned SAIFI based on CM method has downtrend from year 2017 to 2019 and slightly increased in year 2020, followed by downtrend until 2021.

In year 2021, the unplanned SAIDI value based on CPS has worsen by 2.04%, while the unplanned SAIDI value based on CM Method has improved by 11.3% as compared to that of year 2020.

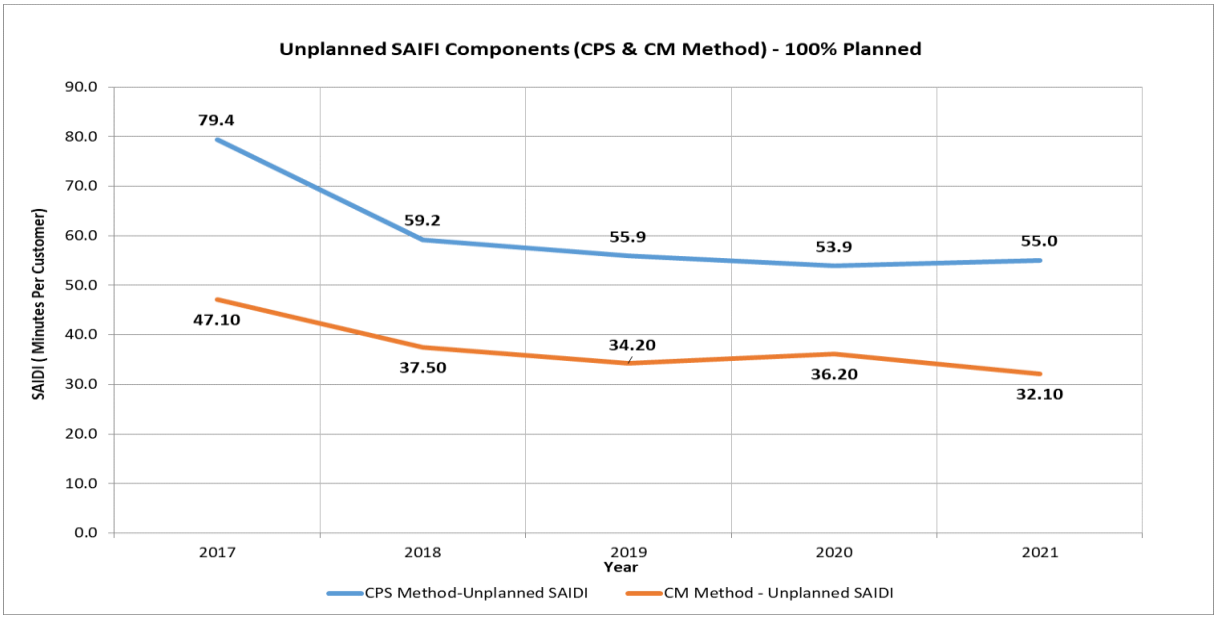

Figure 5.3C Historical Unplanned SAIFI (CPS&CM) -100% Planned

Figure 5.3D presents the overall Planned SAIDI for the last five years based on CPS and CM method of calculation with 100% planned component consideration. As shown on below graph, the five year historical unplanned SAIDI as per CPS and CM method of calculation has increasing from year 2017 and peak in year 2019, followed by significant reduction until year 2021. The increased on SAIDI in year 2019 was attribute to the planned outage from execution of performance improvement projects.

In year 2021, the Planned SAIDI value based on CPS has improved by 9.9%, while the Planned SAIDI value based on CM Method has improved by 20.4% as compared to that of year 2020. . Planned SAIDI has reduced due to less planned outages due to the following: completion of performance improvements project in Eastern and Al Dhafra region and Adopting strict measure to minimize planned outages

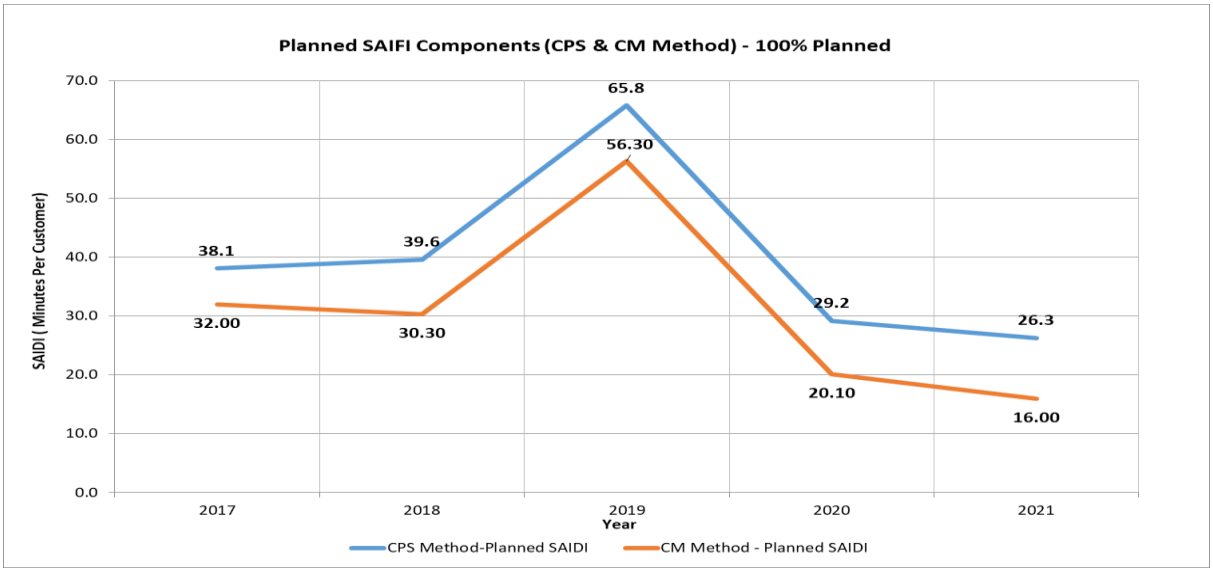

Figure 3 D Historical Unplanned SAIFI (CPS&CM) -100% Planned

Figure 5.4 presents the historical region wise System Average Interruption Duration Index (SAIDI). The Central Region SAIDI has shown a downward trend from year 2017 to year 2018. In year 2019, Central Region SAIDI slightly increased to 26 minutes per customer followed by downward trend until year 2021, on which its value has improved to 15 minutes per customer.

The Eastern Region SAIDI has shown a downward trend from year 2017 to year 2018, however in year 2019, it has increased to 159 minutes per customer. The increase was cause by planned outages from execution of performance improvement projects. In year 2021, Eastern Region SAIDI has improved to 112 minutes per customer, due to performance improvements initiatives that are complete in year 2020.

The Al Dhafra Region SAIDI has shown downward trend from year 2017 to year 2018. In year 2019, Al Dhafra Region SAIDI figure has increased to 543 minutes per customer. The increase was cause by planned outages from execution of performance improvement projects. In year 2020, Al Dhafra Region SAIDI has

improved to 289 minutes per customer followed by increased in year 2021 to 337 minutes per customer.

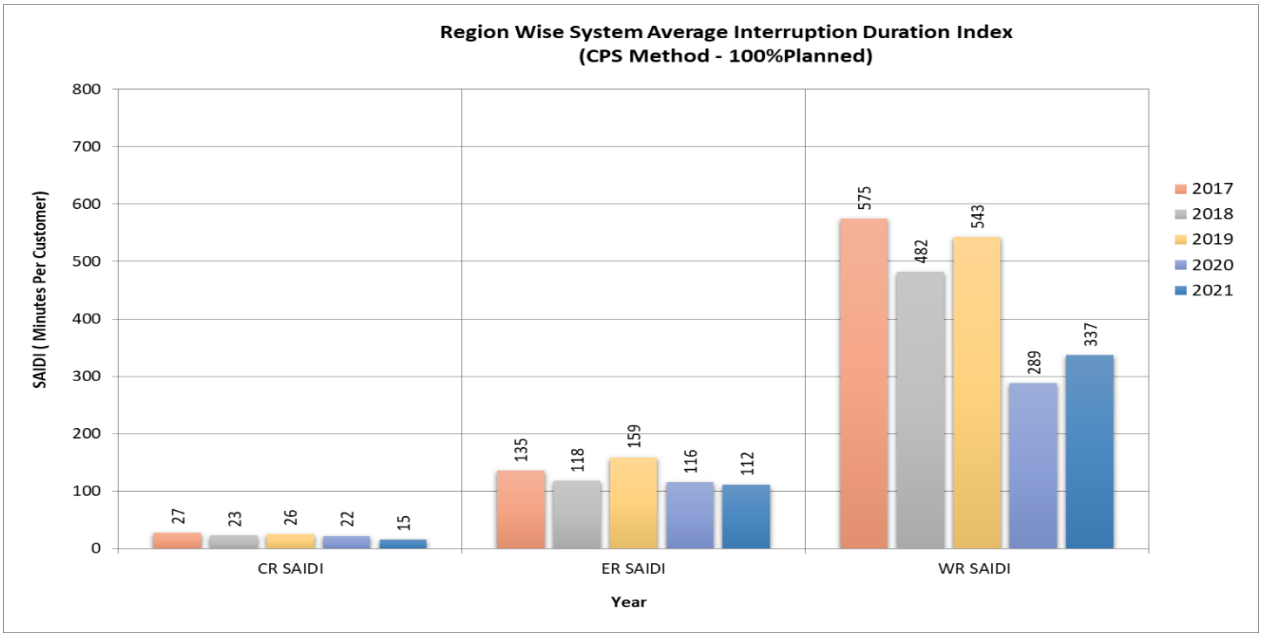

Figure 5.4 Historical (SAIDI) Region wise (CPS Method-100% Planned)

5.2.2 Proposed Performance Targets

The performance targets for every year are set, based on improvement obtained from the previous year and performance initiatives expected benefits to improve the SAIDI and SAIFI. Methods to improve performance are either reducing the fault rate or minimize its impact through preventive maintenance activities, automation or performance improvement initiatives, which are presented in Table 5.13.

Table 5.5: Proposed Targets: SAIDI and SAIFI based on 100% Planned (CPS Method)

KPI	2022	2023	2024	2025	2026
SAIFI	1.11	1.23	1.21	1.19	1.17
SAIDI	103	113	111.5	110.0	108.7

Note: These targets were given as tentative targets and ADDC team is currently working with DOE to finalize the targets mutually in RC2 revision.

5.3 Worst Performance Feeders

ADDC monitor the performance of individual OH lines and cables. Reporting on our worst performing feeders helps to identify and develop appropriate action plans to improve the poor performance and to address broader issues if any, with these

feeders. Table 5.6 in the annexure are the Top 50 worst performing feeders. The ranking shown in the table are based on highest on Customer Minutes loss, and Customer interruptions of the feeder.

These circuits contribute 49% to the unplanned Customer Minutes Loss and 36% unplanned Customer Interrupted of Overall ADDC. The worst performance circuit includes 35 Nos. from Eastern region and 15 Nos. from Al Dhafra region. Most of this circuit are predominantly OHL circuits. Also presented are the number of outage per major components. Most of the failures were due to failures of OHL components.

There are 42 Nos. of outages on failure due to OHL Conductor, 32 Nos. due to OHL Jumper failure, 18 Nos. OHL insulator, 16 Nos. due to Failure of Switch (VMSF/VMS), and 15 Nos. of outages due to Cable outdoor termination. In addition, there are 81 Nos. of outages due to HV fuse blown and 70 Nos. of outages due to OHL transient fault a significant reduction in year 2021 as compared to year 2020 top 50 worst performance circuit. Detailed information is presented in Table 5.6 Appendix A 5.6

ADDC prioritize the worst performance feeders in the condition monitoring and prioritize preventive maintenance activities of OHL as short-term solution. In addition, as long-term solution, ADDC has initiated project for overall refurbishment of OHL, installation of additional auto-reclosures and sectionalizer, installation of Fault Passage indicator with communication and automation of existing and new auto-recloser and sectionalizer. Detailed information is presented in Table 5.6 Appendix A 5.6

5.4 Asset Reliability

Asset Reliability can be measured by calculation of the failure rate of the asset portfolio. Asset failure (or fault) rate is a direct measure of the number of recordable events per system length/numbers, and provides a tool for understanding trends and anomalies in network performance, and is defined as: “The failure rate per 100 km of OHL and Cable network length associated with distribution network failure and failure rate per 1000 nos. for equipment for a period of time.

Table 5.7.1 Appendix A 5.7 presents the Cable and Overhead line (OHL) failure rate, it has shown an increased on the failure rate for 33kV by 36% during year 2021 as compared to that of year 2020. Most of the failure on 33kV Cable was due to

cable joint and cable outdoor termination failure. The failure rate of all the other cable component such as 11kV, 33kV and LV cable was reduced in year 2021 as compared to that of year 2020.

On the other hand, failure rate on 33kV OHL network has also increased by 40%, in year 2021 as compared to that of year 2020. Most of the failure on 33kV OHL was related to transient fault. Failure rate for 11kV has reduced during year 2021.

Table 5.7.2 presents the Transformer Failure rate per 1000 units, as found failure rate for transformer 22/0.415 kV ground mounted distribution transformer has increased from 0 to 0.37 f/1000 units. Failure rate for all the other transformer asset type has reduced during year 2021 Vs 2020.

Table 5.7.3 presents the Switchgear Failure rate per 1000 units, as found failure rate for 11KV Switchgear and 11 kV Ring Main Unit (RMU has increased by 39% and 18% respectively.

Failure rate of all other switchgear such as 33kV switchgear, 22kV switchgear and LV switchgear has reduced in year 2021 as compared to that of year 2020.

Supply restoration details based on time taken at operating voltage level is presented in the following ranges;

- Interruptions cleared and supply restored within an hour
- Interruptions cleared and supply restored more than an hour & less than 3 hours.
- Interruptions cleared and supply restored more than 3 hours & less than 24 hours
- Interruptions cleared and supply restored more than 24 hours

Figure 5.5 below presents the region wise comparative number of interruption per supply restoration ranges per voltage level for year 2021 and year 2020 for all outages (Planned & Unplanned).

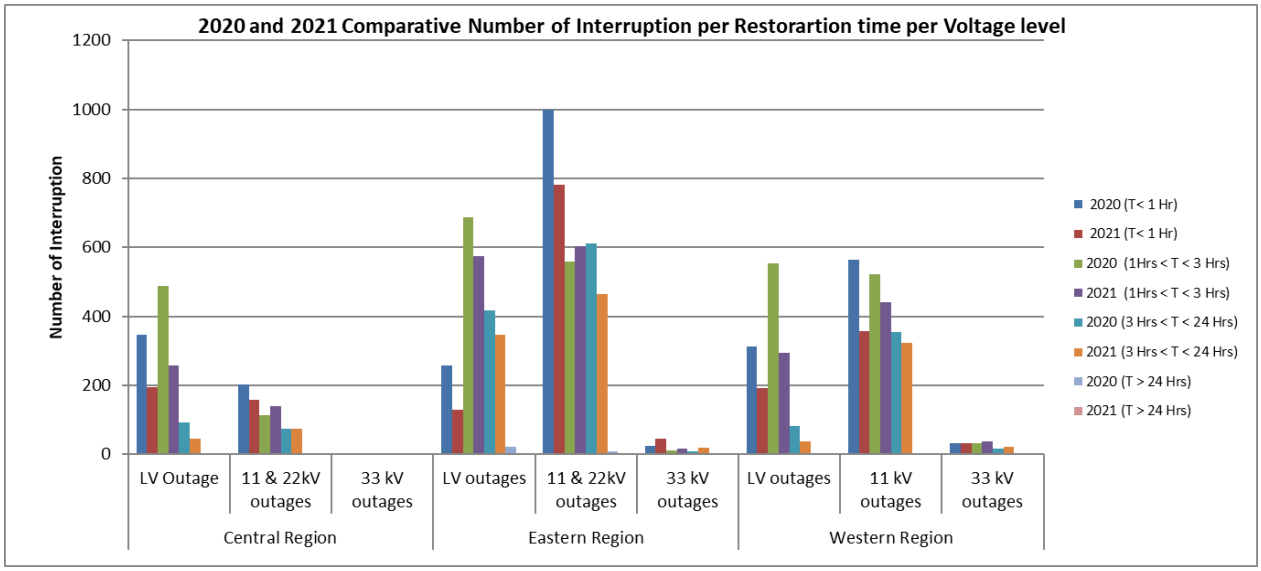

Figure 5.5 Comparative number of interruption

The number of outages for 11&22KV network in Central Region has reduced from 390 Nos. in 2020 to 370 Nos. of outages in 2021. The reduction was attribute to both planned and unplanned outages. The numbers of outages that was cleared and supply restored within an hour has reduced by 23%. On the other hand, Interruptions restored more than an hour & less than 3 hours has increased by 23%.

For LV network in central region, the numbers of outages were reduced from 927 nos. in year 2020 to 496 nos. in year 2021. Unplanned outages in LV network in central region significantly reduced from 839 nos. in 2020 to 396 nos. in year 2021.

The number of outages for 11&22KV network in Eastern Region has reduced from 2,179 nos. of outages in 2020 to 1,848 Nos. of outages in 2021. The numbers of both planned and unplanned outages has reduced by 24%and 1.3% respectively as compared to that in year 2020. Outages that was cleared and supply restored within an hour has reduced by 22%, on the other hand Interruptions restored more than an hour & less than 3 hours has increased by 8% and Interruptions restored more than 3 hours & less than 24 hours has reduced by 24% as compared to that of year 2020.

For 33kV network in Eastern Region, the numbers of outages were increased from 42 numbers in year 2020 to 79 numbers in year 2021. On the other hand, for LV network, the numbers of outages were reduced from 1,383 numbers in year 2020 to 1,049 numbers in year 2021. Unplanned outages in LV network in eastern region significantly increased from 667 nos. in 2019 to 1,077 nos. in year 2020

The number of outages for 11KV network in Al Dhafra Region has reduced from 1,442 nos. of outages in 2020 to 1,124 Nos. of outages in 2021. The reduction was caused by less numbers of planned and unplanned outages.

The numbers of outages that was cleared and supply restored within an hour has reduced by 36%, on the other hand the Interruptions restored more than an hour & less than 3 hours has reduced by 16% and Interruptions restored more than 3 hours & less than 24 hours has reduced by 9% as compared to that of year 2020.

For 33kV network in Al Dhafra Region, the numbers of outages were increased from 81 numbers in year 2020 to 87 numbers in year 2021. On the other hand, for LV network, the numbers of outages were reduced from 947 numbers in year 2020 to 522 numbers in year 2021. Supply restoration from 2010 to 2021 is shown in appendix A 5.8.

5.5 Distribution System Losses

Electricity system losses affect the operation of every network operator and in extreme cases can threaten financial sustainability of company and the entire energy sector. The network losses broadly classified into Technical losses and Non-technical losses.

Power network inherently consume and lose a portion of energy distributed in the network, which is termed as technical losses, and other losses due to unregistered customer meters, defected customer meters, thefts and illegal connections, unread meters, unbilled meters and unmetered connections imperfect commercial process etc. is termed as Non-technical (commercial) losses.

ADDC was following up this difference since 1999 to insure high performance in managing the network planning, operation, maintenance, metering and billing.

Data Collection and Methodology of Losses Calculation

Units Entering ADDC	Description of Source Data
Bulk/Grid Supply Points with TRANSCO including Embedded Generation entry.	The metering data downloaded & collected by TRANSCO LDC as per the MDEC instruction then validated and finalized by DCVS (data collection & validation system) the same data reflected in ADWEC monthly BST invoice.

RASCO entry	Reported by remote area team.
MASDER PV	Included in TRANSCO LDC data
Al Ain feeders	AADC installed MDEC complaint meters on the 7 feeders in Al Khazna grid S/S feeding ADDC customers, the data collected remotely to TRANSCO LDC

5.5.1 Loss Calculation

Direct Losses calculation is the difference between units entering and units exiting ADDC Network over the units entering ADDC network multiplied by 100.

Historical Losses as per TA report (Audited Data)

Year	2016	2017	2018	2019	2020	2021
Loss %	4.42	5.36	4.74	4.85	6.08%	6.35%

Target KPI for energy losses is presented in the below table and Appendix A 5.9

Year	2022	2023	2024	2025	2026
Loss %	6.30	6.22	6.08	5.96	5.84

Electricity Losses target is only draft and it will revisited in RC-2

The projection of Electricity Distribution loss for next five years are based on Network historical performance figures and expected loss reduction from ADDC Loss mitigation initiatives. Detailed of initiatives projects was submitted to DOE in the annual performance report.

5.6 Connections Timelines

The average connections time has been considerably reduced from 260 days in 2012 down to 22.9 days in 2021, ADDC target is to maintain the time as 30 days Appendix 5, Table 5.10 (shown below) presents the connection time distributed over the standard 5 steps.

Connection Time - 5 steps actual and target up to 2025

Stage	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022 Till Date	2023	2024	2025

LDN	8.0	4.0	3.0	2.0	2.0	2.0	2.0	2.0	3.1	0.0	0.0	0.0	0.0	0.0
Drawing	10.0	3.0	3.0	2.0	2.0	3.0	2.0	2.0	1.9	1.6	1.6	2.0	2.0	2.0
CTA	139.0	70.0	51.0	54.0	74.0	36.0	31.0	26.5	15.4	16.8	12.4	22.0	22.0	22.0
Inspection	38.0	9.0	6.0	6.0	9.0	6.0	5.0	4.0	2.8	3.0	2.5	4.0	4.0	4.0
SA	65.0	4.0	6.0	3.0	3.0	2.0	2.0	2.0	1.5	1.6	0.9	2.0	2.0	2.0
Total	**260.0**	**90.0**	**69.0**	**67.0**	**90.0**	**49.0**	**42.0**	**36.5**	**24.7**	**22.9**	**17.4**	**30.0**	**30.0**	**30.0**

5.7 Challenges and Proposed Solutions

SAIDI and SAIFI calculated both planned and unplanned outages on three areas that fall under ADDC's license, which are Central Region, Eastern Region and Al Dhafra Region. Table 5.11 and 5.12 presents the contribution of each region to the overall ADDC SAIFI and SAIDI. Six-year historical data on the percentage contribution on each region shows that Unplanned SAIFI and SAIDI in Eastern Region has the highest contribution to overall ADDC SAIFI and SAIDI, followed by Unplanned SAIFI and SAIDI in Al Dhafra Region. The reason is that both region has large and extensive OHL network, which is exposed disturbances such as weather, vegetation and failure of OHL components.

Table 5.11: Component SAIFI percentage contribution to the ADDC unplanned SAIFI

Component	Component Percentage Contribution to the Overall ADDC SAIFI						
	2016	2017	2018	2019	2020	2021	Average
Planned SAIFI AD	5.2%	3.3%	4.1%	3.6%	2.2%	1.9%	3.4%
Unplanned SAIFI AD	7.2%	10.8%	9.7%	9.9%	13.1%	10.4%	10.2%
Planned SAIFI ER	12.2%	11.7%	11.7%	22.0%	17.7%	11.8%	14.5%
Unplanned SAIFI ER	38.1%	37.9%	41.0%	35.4%	42.3%	48.3%	40.5%
Planned SAIFI ADF	7.9%	10.3%	9.9%	11.0%	5.4%	7.5%	8.7%
Unplanned SAIFI ADF	29.3%	26.1%	23.6%	18.1%	19.4%	20.1%	22.8%

Table 5.12: Component SAIDI percentage contribution to the ADDC unplanned SAIDI

Component	Component Percentage Contribution to the Overall ADDC SAIDI						
	2016	2017	2018	2019	2020	2021	Average
Planned SAIDI AD	8.3%	5.9%	6.7%	5.9%	3.7%	3.2%	5.6%
Unplanned SAIDI AD	4.6%	5.9%	5.2%	4.6%	8.5%	5.9%	5.8%
Planned SAIDI ER	11.3%	11.3%	15.5%	28.0%	21.2%	16.8%	17.4%
Unplanned SAIDI ER	36.0%	35.9%	33.8%	27.3%	39.9%	42.9%	35.9%
Planned SAIDI ADF	11.3%	15.3%	17.9%	20.1%	9.7%	12.0%	14.4%

Unplanned SAIDI ADF	28.5%	25.7%	20.9%	14.0%	17.2%	19.2%	20.9%

The reliability performance of ADDC network is mostly driven by the performance of overhead lines and cable components. Table 5.13 and 5.14 presents the SAIFI and SAIDI per components percentage contribution to the ADDC unplanned SAIFI and SAIDI.

Table 5.13: Component SAIFI percentage contribution to the ADDC unplanned SAIFI

Component	Component Percentage Contribution to the ADDC Unplanned SAIFI						
	2016	2017	2018	2019	2020	2021	Average
HV Cable	25%	27%	28%	29%	33%	37%	30%
OHL Permanent Fault	27%	28%	26%	24%	19%	20%	24%
OHL Transient Fault	17%	14%	18%	21%	19%	17%	18%
OHL HV Blown	12%	10%	7%	5%	2%	2%	6%
HV Equipment	8%	9%	8%	11%	8%	8%	9%
HV Transformer	1%	2%	2%	1%	1%	1%	1%
LV Component	2%	3%	3%	2%	2%	1%	2%
Other Component	7%	8%	9%	8%	15%	14%	10%

Table 5.14: Component SAIDI percentage contribution to the ADDC unplanned SAIDI

Component	Component Percentage Contribution to the ADDC Unplanned SAIDI						
	2016	2017	2018	2019	2020	2021	Average
HV Cable	21%	23%	24%	24%	27%	32%	25%
OHL Permanent Fault	35%	37%	32%	33%	25%	27%	31%
OHL Transient Fault	22%	16%	19%	23%	18%	17%	19%
OHL HV Blown	5%	6%	5%	3%	2%	2%	4%
HV Equipment	8%	8%	8%	10%	9%	8%	9%
HV Transformer	2%	3%	2%	1%	2%	1%	2%
LV Component	3%	3%	5%	2%	3%	2%	3%
Other Component	5%	4%	5%	5%	13%	11%	7%

In year 2021, the percentage contribution of OHL component to the unplanned SAIFI and SAIDI of overall ADDC is 39% and 46% respectively, in which 20% and 27% respectively was contribution due to OHL Permanent Fault, 17% was due to OHL Transient Fault and 2% respectively was due to OHL HV Fuse blown. Historical trend on percentage contribution of OHL is showing downward trend. The

prioritization for preventive maintenance on worst performance feeders and completion of performance improvement projects in OHL such as refurbishment of OHL and installation of auto recloser is the attribute for the improvement.

HV Cable component percentage contribution to the unplanned SAIFI and SAIDI of ADDC network has increased to 37% and 32% respectively. The failure related to Cable joint and Cable Damage by Third party has increased.

To be able to further improvement the SAIFI and SAIDI and able to achieved target, Initiation of performance improvement projects focusing on OHL and Cable components that has significant contribution to the SAIDI and SAIFI to improve the reliability performance is planned. This includes refurbishment of OHL, installation of auto recloser, automation of recloser / sectionalizer and installation of fault passage indicators in OHL. In addition, ADDC will continue to carry out the prioritization for preventive/ corrective maintenance on worst performance feeders, providing generator to reduce duration of outages and live line works to be able to improved SAIFI and SAIDI. Automation and other performance improvement methods are also consider as major initiatives for network performance improvement. Table 5.13 presents the performance improvement projects and timeline.

Table 5.13: Performance Improvement Projects

Phase	Budget Code/ CR Number	Project Name	Region	Planned/ Actual Start Date	Expected/ Actual Commissioning Date
Completed	D-103318	Replacement of insulator and Refurbishment of OHL in Coastal Areas of Al Dhafra Region	ADF	16-Jan	17-Apr
	D-103147	Replacement of insulator and fitting of 33 KV Abu Al Abyad OHL	ADF	15-Mar	17-Jun
	D-107054	Construction Works for Replacement of deteriorated OHL like VMS, LA, PMT, Jumper Etc. in Al Dhafra Region	ADF	18-Aug	20-Feb
	D-104559	Construction works for replacement of both 33kV and 11kV insulators and refurbishment of OHL in Eastern Region	ER	17-Dec	20-Dec
	D-106929	Construction Works to install Auto-Reclosure, Sectionalizer and Fault Passage Indicators in Al Dhafra Region – Phase I	ADF	18-Jul	20-Jul

Phase	Budget Code/ CR Number	Project Name	Region	Planned/ Actual Start Date	Expected/ Actual Commissioning Date
Running	D-105810	Integration of Abu Dhabi Eastern and Central Region (Abu Dhabi Island) Switching Stations and Package Units to be Controlled and Monitored from DMS	AD and ER	18-Jun	22-Oct
	D-105811	Integration of Abu Dhabi Al Dhafra Region Grid, Primary, Package Units and Switching Stations to be Controlled and Monitored from DMS	ADF	18-May	22-Jun
Planned	20EAPDD06	Replacement of porcelain insulator, defective OHL component and Refurbishment of OHL in Al Dhafra Region	ADF	22-Oct	24-sep
	20EAPDD07	Installation and automation of auto reclosures, fault passage indicators, electrical switchgear panels in Eastern Region-CAPEX Second stage	ER	22-Jul	24-Dec
	23EASIDDI02	Refurbishment and replacement of OH line components in Eastern Region	ER	23-Sep	25-Aug
	**	Strategic Substation Automation in All Regions	All	In planning	Will start implementing for new substations only if classified as strategic
Continuous Activity	*	Providing Mobile Generators	All	2018	Continuous Activity
	*	High Voltage Live Maintenance	All	Apr 2018	Continuous Activity

*These initiatives are already in place.

** This initiative is in planning stage to implement in new substations as per automation strategy.

ADDC has adopted a clear method to improve the performance by identifying the areas where network performances are deteriorating due to asset condition as well as severe climatic conditions. It is identified that maximum deterioration of network performance is happening in exposed OH lines of network. Hence optimized network performance improvement projects were selected in the network to obtain maximum improvement. As indicated in the above table OH line projects and automation projects are considered mainly for network performance improvement.

Asset replacement projects other than OH line components are also planned and executed regularly to make sure that current performance are not deteriorated further. However, asset replacement projects are not included in the above list since it is only assuring to keep up current performance level.

Other challenges are the increase on Planned SAIDI during the execution of the performance improvements projects particularly on OHL projects. Most of the works in the Overhead line requires shutdown/ isolation of the complete feeder or portion of feeders causing high numbers of customer interrupted. Strict measures shall be adopted to Minimize all planned outages which causes high numbers of customer interruptions.

6 Asset Management

6.1 Asset Management Strategy

This Strategy Framework provides a roadmap for the “line of sight” initiated by Asset Management Policy to achieve the Vision of ADDC as detailed in the Strategic Plan. This Document defines what ADDC intends to achieve from its Asset Management activities and cascaded across the organization to all involved in fulfilling Asset Management Strategy related obligations, including external stakeholders where appropriate.

The scope of the Strategy Framework comprises all assets related to the supply and distribution of Electricity and potable Water within the licensed area of ADDC.

6.1.1 References

This strategy supports a number of key ADDC Policies and in turn is supported by many Strategies. The list below details these but not intended to exhaustive

- Asset Management Policy (PL.AMD.01)
- Supply and Demand Policy (PL.AMD.03)
- Risk Management Policy (PL.AMD.04)
- Asset Creation Policy (PL.AMD.05)
- Asset Management Data & Information Policy (PL.AMD.06)
- Stakeholder Management Policy (PL.GN.02)
- Operations Policy (PL.OM.05)
- Asset Maintenance Policy (PL.OM.06)
- Network Service Policy (PL.OM.07)
- Asset Disposal Policy (PL.OM.08)
- Business Continuity Management Policy (PL.GN.03)
- Business Continuity Management Strategy (ST.GN.03)
- Business Continuity Management Framework and Methodology (MN.GN.02)
- Asset Management Strategy Frame work(ST.AMD.01)
- Supply and Demand Strategy (ST.AMD.02)
- Project Delivery Strategy (ST.AMD.03)
- Risk Management Strategy (ST.AMD.04)
- Asset Data & Information Strategy (ST.AMD.05)
- Asset Disposal Strategy (ST.AMD.01)

6.1.2 Strategic Objectives & Performance

The principal objective of the asset management is to guide the acquisition, use and disposal of distribution system assets to provide the level of service required by customers in a cost-effective manner, encompassing the strategic planning, utilization, operation and maintenance, and disposal of all physical assets throughout its life. The Asset Management Strategy Framework focuses on current and future capabilities of the organization, its processes, information systems, people, tools, resources etc. and how to organization intend to develop its future capabilities to deliver its organizational goals. This is achieved through the following objectives:

- Asset creation based on Supply and Demand Policy, shall be governed by 5-year planning statement. Investment prioritization and optimum of Capex expenditure shall be ensured during any Asset creation. A business case which clearly explains optioneering based on cost benefit analysis, Risks and constraints and reliability and sustainability shall be authorized by competent authorities for initiation of any new projects.
- The 5 –year planning statement shall be closely aligned with long term plans of Abu Dhabi, set out in Abu Dhabi 2030 economic vision. Close coordination between upstream companies and other stakeholders shall be managed to formulate a robust plan for the medium term (5 years)
- Timely delivery of strategic plan shall be accomplished by effective coordination with upstream Companies, Government entities, Developers, the supply chain, External consultants and Contractors.
- Efficient and cost effective Operation and Maintenance of all key assets shall be accomplished by adopting Reliability Centred Maintenance practice. The RCM module in Maximo shall be enabled and implementation to achieve this objective.
- Asset Lifecycle Costing, assessment and criticality of assets, shall be the decision making drivers for maintenance, refurbishment, replacement and disposal of assets.
- Simple and effective monitoring of Asset performance by establishing appropriate smart KPIs and other performance indicators. Projected targets of KPIs and other performance indicators shall be carefully monitored and achieved to match with regulatory requirements and benchmarked with relevant International standard and best practices.

- To prioritize appropriate initiatives (CAPEX & OPEX) interventions) in an optimum manner (SWOT analysis to close performance gaps identified through evaluation of targeted performance indicators.
- A systematic review and updating of existing Asset Data and Information in GIS and Maximo shall be carried out. Also procedures shall be strictly implemented to capture correct and reliable asset data during any network addition. Cancellation or modification
- Managing company risks by implementing a Risk Management Framework in all Asset Management functions to adopt adequate methods of monitoring and controlling risks. The Risk Management Framework consisting of the Risk Management Procedure, Roles and Responsibilities etc. will be formulated.
- All relevant Legal, Regulatory and statutory obligations shall be fully compiled by appropriate application of this strategy.
- This Asset Management Strategy should be fully supported by the company management, effectively communicated to all relevant stakeholders, and reviewed regularly to ensure that it is fit for purpose in meetings Asset Management Policy and Strategic Planning Statement.
- Company risks will be managed by implementing a Risk Management Framework in all Asset Management function to adopt adequate methods of monitoring and controlling risks. Feedback from all Internal and external stakeholders shall be considered during any development of investment plans.
- To establish a prudent and documented process for third party asset take overs.
- DSM strategy is intended to achieve significant reduction in water and Electricity consumption while ensuring the benefit of the programmes are distributed across a broad range of customer segment.
- To implement an effective Business Continuity Management (BCM) Program in order to continue performing essential functions and services that meet our customers' expectations in and after an emergency, crisis or disaster that could have resulted in a business disruption across our licensed area.

6.1.3 Deliverables

The Major Deliverables of these Strategy areas follows.

- 5-Year Planning Statements and week 48 submission (Load forecast).
- Annual CAPEX & OPEX
- Operational Contingency Plan
- Summer Reliability Assessment
- Annual Maintenance Plan

- Risk Register
- Capturing of all major Network KPIs and Internal functional KPIs for planned delivery on annual basis. Major network KPI includes SAIDI, SAIFI, equipment failure rate etc. Internal KPI includes efficiencies of internal departments based on projected Annual Goals.
- Realistic projection of network performance to meet regulatory requirements from external Stakeholders.
    - Need for the Projects.
    - Business case for all project initiative that Include:
    - Cost Benefit Analysis
    - Optioneering
    - Reliability and sustainability study
    - Risk Analysis
    - Evaluation to ensure compliance of Health Safety and Quality requirements.
    - Life Cycle Cost Analysis.
- Performance reporting and Gap Analysis.
- Prioritization of CAPEX projects based on performance Gap Analysis.
- SWOT analysis to prioritize initiatives.

6.2 Asset Age Profiling and condition monitoring

6.2.1 Asset Lifecycle Cost Plan

Asset Lifecycle cost plan is to implement the asset life costing procedure that was recently adopted. The main reason for adopting Asset life costing procedure is to compare maintaining a desired level of service at the lowest life cycle cost with the most appropriate cost for replacing an asset. It helps in making decisions in a timely matter which would result in delayed investments.

The process for computation of Life Cycle Cost is as follows:

Step 1: Determine useful life cycle of an asset based on estimated length of time during which the asset is able to deliver a given level of service.

Step 2: Estimate value of each cost element that will be incurred in every year.

Step 3: Calculate Net Present Value of each element, for every year (over its time period)

Step 4: Summation of Present Values (PV)

Step 5: Analysis

Asset Life cost analysis can be completed to help determine whether the asset should be maintained or replaced, taking into account specific energy and asset efficiency.

6.2.2 Condition Monitoring

The condition monitoring of all network elements are an ongoing process usually clubbed with Preventive Maintenance plan. However, some non-intrusive condition monitoring cannot be expedited such as power transformers as ongoing process. Such critical cases are outsourced to external agencies.

Once condition monitoring is carried out as ongoing process, asset condition code is applied on each individual equipment. This code helps to categorize asset conditions such as very good, good, moderate, poor and about to fail. This value is a major input for replacement policy described below. Major Asset such as Transformer, Switchgear and Ring Main Unit age profiling against condition is shown on Appendix A6 Table 6.1.1 to A6 Table 6.1.7.

Below table shown the detailed description of Asset condition monitoring codes.

Condition monitoring task are conducted based on various asset templates comprising of large number of technical parameters. Any one or two parameters shows signs of performance degradation such assets condition code will be changed to lower grade even though they are not critical to normal performance .This is to make sure that all such deterioration of asset condition is well recorded and necessary actions taken according to its criticality. Hence, it is natural that any assets newly installed can be under fair/moderate condition even after 2 or 3 years even though there is no failure happened to that asset. Any asset attains 4 or 5 asset condition grade, will undergo a planned corrective maintenance (predictive maintenance) to confirm that no failure happens.

Frequency of maintenance also will be decreased in case of any criticality arised after condition monitoring. Also please note that asset condition grades 4 and 5 shown in the profile are not permanent status. All such grades will be changed dynamically after carrying out necessary predictive maintenance as above.

Currently ADDC along with other OPCOS is planning to carry out a detailed due diligence study on current asset age profiling and condition grading methodology of ADDC critical assets. All necessary changes will be incorporated in the current methodology after this study if required.

Currently ADDC has employed external contractor also along with ADDC crew to carry out asset condition monitoring activities to cover all ADDC critical assets.

Condition Assessment - Electrical

Criteria to be used when assessing the asset condition of electrical equipment.

Grade	Description	General Meaning
1.	Very good	Sound modern electrical components in 'as new' condition all operable and well maintained. No major investment required.
2.	Good	As for Grade 1, but showing superficial wear and tear. Efficiency not significantly diminished. Minor oil leaks and wear may be evident. Protective coatings will generally be intact. Unlikely to require major overhauls or replacement within 10 years.
3.	Moderate	All components functioning acceptably but showing wear and tear with minor failures. Efficiency has started to diminish. Early signs of significant (rather than superficial) wear and tear. Corrosion becoming apparent. No major work likely to be required within five years.
4.	Poor	Function and/or running costs significantly affected by failures or maintenance needs. Still functioning as for Grade 3 but effective life exceeded. Requires major overhaul or replacement within three years.
5.	Fail	Electrically unsafe. Health and safety risk. Not working or out of commission because unsafe to use. Too unreliable or costly to run. Requires major overhaul or replacement within two years.

6.3 Asset Replacement Policy

Assets are replaced as per below mentioned points in the asset replacement procedure and also this methodology has been developed based on the Asset Disposal Policy:

- Personnel safety.
- Condition monitoring results.
- Performance statistics such as failure frequency, outage duration and number of occurrences.
- Criticality of Assets (based on type of customers).
- Network criticality (such as N-1 compliance)
- Life cycle cost
- Age of assets.
- Obsolescence.
- Feedback from field staff.
- Environmental hazard if any

Major replacement capital projects are planned based on Asset risk numbers(ARN) of network assets which is calculated based on asset condition code and criticality After performing the analysis based on procedure template the prioritization of replacement projects will be carried out as per below table.

ARN	0-15	16-40	41-60	61-80	81-100
Replacement Plan	No replacement plan	No replacement plan in 5 years	Include in the 5 year plan Lower priority	Include next year CAPEX	Urgent Execution required

6.4 Asset Replacement Priority

The priority of asset replacement is based on above table indicated above. However, for emergency cases where asset condition code shows a chance of immediate failure of assets shall be replaced on emergency ground. However, all major capital expenditure for refurbishment/replacement are planned based on above criteria of asset risk number calculated as per procedure.

6.5 Asset Replacement

Table 6.1.5 given below presents the replacements that are ongoing and proposed to be initiated in year 2022, based on condition assessment and other relevant factors as per asset replacement procedure.

S N	Proposed Actions	Justification/ Drivers	Planned/ Actual Start Date	Planned/ Actual Completion Date
1	D-107624 - Replacement of existing 33/11 kV, 2x15MVA, Primary Substation with 2 Nos., 5MVA PU at Medium wave substation and replacement of Power Transformer at Short Wave Substation in Eastern Region.	Asset condition is poor, old age, non-availability of spare parts , safety, design deficiencies, Environmental issues (using Oil circuit Breakers) etc.	19-Dec	22-May
2	D-108787-Contract for Refurbishment of Power Transformer (Critical) in Eastern Region	The purpose of the project is to prevent failure of the identified 6 Nos. of 33/11 KV Power Transformer in Eastern Region, which are in poor condition and have already reached the end of life.	20-Dec	22-Dec
3	Replacement/Refurbishment of Primary Substation Equipment'	Asset condition is poor, old age, non-availability of spare parts , high failure rate due to design and manufacturing defects, safety, etc.	21-Dec	23-Dec
4	D-109893- Refurbishment of old 33kV GIS swgr type ZV2 at. primaries Substation by OEM	Isolator faults frequently occurred in ZV2 type GIS breaker. Total refurbishment of these old breakers are required. These type of faults can only be fixed / repaired correctly and properly by manufacturer specialist	22-Jul	24-Jun
5	D-109780- Replacement of old and deteriorated HVAC Equipment in Primary Substation in All Region	Replacement of such very old HVAC system is required to present such damage of the auxiliary equipment such as relays, batteries, RTU, etc. which will affect the reliability and security of supply	21-Aug	23-Jul
6	D-110234 - Replacement/ Refurbishment of Primary Substation Equipment such as circuit breaker, protection relays and DC System	Asset condition is poor, old age, non-availability of spare parts , high failure rate due to design and manufacturing defects, safety, etc.	22-June	24-May
7	22EAPDD01- Replacement and Refurbishment of 33/11KV Power Transformers in All Region	The purpose of the project is to prevent failure of the identified 15 Nos. of 33/11 KV Power Transformer in All Region, which are in poor condition and have already reached the end of life.	23-Mar	25-Feb
8	22EAPDD02- Replacement of Existing DC System in Primaries and Package Units Substations in All Region	This project proposed to replace Battery Bank and Battery Charger of Primary and Package Units Substations in All Regions due to poor condition, old, obsolete and already reach the end of its service life.	23-May	25-Apr

S N	Proposed Actions	Justification/ Drivers	Planned/ Actual Start Date	Planned/ Actual Completion Date
9	22EASIDDI10- Replacement of deteriorated and not repairable electrical distribution equipment's (RMU, distribution transformers, switchgears, package units and LV Panels) in All Regions	Replacement is based on Asset condition, performance and criticality as stated in the asset replacement procedure.	22-Nov	25-Oct
10	22EASIDDI11- Replacement of old and obsolete battery system of RTU for 1,406 distribution substation in all region	This project proposed to replace the old and obsolete battery system of RTU is distribution substation due to poor condition, old, obsolete and already reach the end of its service life.	22-Oct	25-Sep
11	22EASIDDI12-Replacement of Old and obsolete SCMS in 9 Primaries in Central and Eastern Region	The condition of Legacy SCMS system in 9 Nos. of primaries are deteriorating and are at risk of complete failure.. If the current system fails, we will end up losing visibility of these stations in DMS	22-Dec	25-Nov
12	22EASIDDI16- Replacement of Electrical Distribution Equipment and Standby Generator at Al Asayel Horse Stables	Replacement is based on Asset condition, performance and criticality as stated in the asset replacement procedure.	22-Nov	23-Oct
13	21EAPDD02-Replacement of 11kV ABB SRU Switchgear at various Primary and Distribution Substations in Eastern Region	The Replacement are based on the following factors; Poor Asset Condition, Reliability of equipment, High Failure Rate, Deterioration in performance due to ageing and design deficiencies and end of life	22-Oct	24-Sep
14	23EAPDD01-Refurbishment and Retrofit of Gas Insulated Switchgear in Primary Substation in all Region	Isolator faults and breaker defects frequently occurred on the identified GIS switchgear. Total refurbishment of these old breakers are required. These type of faults can only be fixed / repaired correctly and properly by manufacturer specialist	22-Dec	24-Nov

6.6 Asset Disposal

ADDC developed Asset Disposal procedure to dispose or recover assets to realize value and minimize the cost and risks associated with non-operational assets. ADDC will undertake this in a manner which best meets the needs of the business, environment, statutory requirements, and stakeholders and will implemented in

2017. Asset Disposal is the process of evaluating every option available with its costs and risks for each asset to find the most optimum option.

Options	Description	Cost* (NPV)	Benefits		
			Risk Category	Equipment Life	Improvement in Asset Reliability (SAIDI and SAIFI)
Option No. 1	Replacement	To be estimated	Low Risk	Life = 30 years	High (CML, CI)
Option No. 2	Retrofitting	To be estimated	High Risk	Extended Life = 5 Years	Medium (CML, CI)
Option No. 3	Frequent Preventive Maintenance	To be estimated	Extra High Risk	Extended Life = 1 years	Low (CML, CI)
Option No. 4	Refurbishment	To be estimated	Extra High Risk	Extended Life = 2 Years	Low (CML, CI)
Option No. 5	Do Nothing	To be estimated	Extra High Risk	Extended Life = 0 Years	Low (CML, CI)

7 Expansion Plans and Connection Opportunities

7.1 Expansion Plans

One of the core objectives of ADDC is “To support the rapid development of Abu Dhabi Emirate as the utility service provider of choice”. ADDC is committed to supply electricity to the customers under its jurisdiction following the license regulations and in compliance with its commitments in terms of the readiness to handle the new requests for power supply whenever encountered.

In order to have a safe a reliable power supply system to all the existing and new customers, ADDC is planning the following main type of schemes for implementation:

- New Growth Projects
- Replacement/ Refurbishment/ Reinforcement Projects
- System Improvement Projects

To be in line with the increasing demand due to natural growth and due to mega developments, ADDC is initiating new projects to cater this demand in an effective and techno economically feasible manner. For the natural growth, ADDC is proposing new schemes in each CAPEX.

For Mega Developments, ADDC is reviewing the Development Master Plans, preliminary design and detailed design report and overviewing the construction activities through the developer’s appointed Consultant.

7.2 5 Year Investment Plan

The currently approved Business Plan 2022-2026 constitutes the following categories:

- Development CAPEX projects which are split into as load related and non-Load related projects,
- Non-Development CAPEX
- Staff Capitalisation
- Materials

7.2.1 Load Related Projects

The list of projects under this category covers the following:

1. New power source establishment such as new primaries and capacity upgrades of existing primaries.
2. Load transfer plans.
3. Reinforcement plans.
4. LTRA contracts for new connections
5. New customer meters projects

7.2.2 Non- Load Related Projects

The list of projects under this category covers the following:

1. Replacement of primary substations equipment,
2. Replacement of distribution substations equipment
3. Refurbishment of power transformers and switchgears,
4. Refurbishment and retrofitting of OHL components
5. Replacement of expired customer's meters

ADDC will identify the areas where enhancement or new networks are to be implemented. This will be proposed in the next year CAPEX with the budget estimate / 5 Year investment Plan.

These projects will be initiated once the CAPEX for the respective year is approved list of CPAEX projects is presented in Appendix A7 Tables 7.1 and 7.2 for Load related CAPEX and Non Load related CAPEX respectively.

7.2.3 TRANSCO related Projects

Appendix A7 Table 7.3 presents a list of ADDC load transfer projects that are linked to upstream interface point primaries that is either under execution or under initiation by TRANSCO.

The table presents ADDC project number, start and end date and related TRANSCO project information such as number, expected completion date as per TRANSCO interface point project quarterly status report as on Q1/2021.

7.2.4 Mega Development Projects

Mega Developments, both Government and private funded spread all over the Abu Dhabi Emirate in line with the Abu Dhabi 2030 Plan. Once the source of power for the mega development is approved by ADDC, the electricity distribution infrastructure works for Mega Development Projects were normally executed by the Developer by appointing his Consultant/Contractor. ADDC/ ADDC Consultant is overviewing the design and execution of the project to ensure that they are being constructed to ADDC Standards and Specifications. The assets are generally transferred to ADDC later in accordance with the standard handing-over procedure No. PR.AMD.10. The summary list of Mega Developments and drawings are provided under Appendix A7 7.4, meanwhile, ultimate and forecasted demands of Mega Developments are resented in appendix Table A7 7.4.

These drawings are prepared based on the requests received from Developers. At several instances, the Developers revised their master plan and subsequently the demand also has been changed. Our demand forecast is based on the latest demand details provided by the Developers.

In summary, ADDC requires that all electricity distribution works shall be constructed in accordance with ADDC's standard specifications, standards, and vendors list. Based on this, ADDC is phasing out the existing Overview Consultancies appointed by ADDC for the overview of design and construction of electricity distribution systems.

7.3 Provision of Connection

The drawings included in Appendix 2.10 illustrate the complete distribution network spread over Abu Dhabi Emirate. ADDC distribution network has adequate capacity (~54% Asset utilization) to accommodate growing demand. ADDC have taken its maximum efforts to supply the existing customers and trying its best to upgrade and augment its distribution system to cater to the identified prospective demand. The demand forecast and % utilisation of primaries given in Appendix 3 Table 4.3 provides an overview of areas where spare capacities are expected to be available in the upper stream sources (33/11 kV and 132/11 kV)

7.4 System Constraints

ADDC is committed to provide reliable power supply to all the customers as per the security of supply standards and in compliance with the license conditions, however,

some areas covered by ADDC have constrains due to various reasons such areas located away from nearest available networks, islands, farms and remotely located demands due its special nature. Due to the relatively small demand of such area or being spread over a large area with very load density, the power supply might be in the form of radial feeders, lateral from existing OHL or with single transformer feeding arrangements.

ADDC is continuously evaluating such areas with constraints from technical and economical point of view and mitigation actions are initiated accordingly.

7.5 Connection interest

Several mega development projects of which the master plans approved and the distribution systems are designed are being delayed or on hold or cancelled.

Similarly some other mega developments like Reem Island, Al Sowa Island, Yas Island, Raha Beach, Saadiyat Island, Danat Abu Dhabi, etc. did not reach the projected occupancy rate. In addition to that, areas designated for industrial use such as, Ghayathi and KPIZ are still underutilized.

For those underutilised distribution systems in such developments, ADDC has a potential opportunity in such developments to have more connections if the occupancy is increased. The 2021 utilization for 132/11 kV or 132/22 kV primaries have been provided in Annex A4 4.3 for each region. The forecast utilization of these primaries is also shown in Annex A3 3.3 for each region respectively.