



# 2025

## Electricity Five Year Planning Statement (2025 - 2030)

TAQA Distribution – Al Ain Region

October 2025

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## Table of Contents

<b>Summary</b>	<b>7</b>
<b>CHAPTER 1: Introduction &amp; General Overview</b>	<b>8</b>
1.1 Who We Are & What We Do	8
1.2 Commitment to System Performance	9
1.3 Purpose of the Statement	15
1.4 Company Purpose & Corporate Values	16
1.5 Strategic Network Development Plan & Strategy	16
1.6 Key Statistics Data	19
<b>CHAPTER 2: System Characteristics and Operational Philosophy</b>	<b>21</b>
2.1 Governing Standards	21
2.2 System Characteristics	30
2.3 Selection of Assets	47
2.4 System Configuration	48
2.5 Location of Electrical Assets	53
2.6 Key Asset Data	53
<b>CHAPTER 3: Power Demand Forecast</b>	<b>54</b>
3.1 Historical Peak Load Demand Data	54
3.2 Forecast Peak Load Demand Data	54
3.3 Historical Peak Demand Forecast Accuracy	56
3.4 Energy Forecast	56
3.5 Demand forecast coordination and alignment with TAQA Transmission and EWEC	59
<b>CHAPTER 4: System Capacity and Studies</b>	<b>73</b>
4.1 Load Flow Analysis	73
4.2 Short Circuit Analysis	76
4.3 Utilization of Assets	79
4.4 Demand Transfer Capability	79
4.5 Security of Supply Non-compliance	79
4.6 Reactive Power Compensation	79
<b>CHAPTER 5: Performance Measurement</b>	<b>81</b>
5.1 SAIFI and SAIDI Statistics	81

5.2 Distribution System Losses .....	92
5.3 Connections Timelines .....	96
5.4 Challenges and Proposed Solutions .....	96
<b>CHAPTER 6: Asset Management .....</b>	<b>97</b>
6.1 Asset Management Process .....	97
6.2 Asset Age Profiling & Condition Monitoring .....	97
6.3 Power Asset Replacement / Refurbishment Assessment Procedure .....	102
6.4 Asset Replacement Priority .....	102
6.5 Asset Replacement / Rehabilitation plan .....	102
6.6 Technical Due Diligence project No. D-110813.1 .....	103
<b>CHAPTER 7: Expansion Plans and Connection Opportunities .....</b>	<b>104</b>
7.1 Expansion Plans .....	104
7.2 Provision of Connection .....	106
7.3 Connection Constrains .....	107
7.4 Connection Interest .....	108
7.5 Assets Forecast .....	108
<b>CHAPTER 8: Expenditure (Financial Annex) .....</b>	<b>109</b>
8.1 Load - Related Cap-Ex .....	109
8.2 Non-Load - Related Cap-Ex .....	109
8.3 Business Case for Major Schemes .....	109
8.4 Capital Expenditure (CAPEX) forecast .....	110

## List of Appendices

Appendix	No.	Information	Title
Appendix 1	1.1	Table	Key Statistical Data
Appendix 2	2.1	Table	Standard Plant and Equipment Used
	2.2	Table	Asset Data -TAQA Transmission Grid Substations
	2.3	Table	Asset Data - TAQA Transmission Primary Substations
	2.4	Table	Asset Data - Primary Substations
	2.5	Table	Asset Data - Distribution Substations
	2.6	Table	Asset Data - Cables and Overhead Lines
	2.7	Table	Asset Data - Transformers
	2.8	Table	Automation Strategy
	2.8.1	Table	2025 Automatic Load Shedding Scheme in Al-Ain Area
	2.8.2	Table	2025 Manual Load Shedding Scheme in Al-Ain Area
Appendix 3	2.8.3	Table	AADC Initiated Contracts to meet Automation Strategy
	2.9	Table	Reactive Power Compensation
	2.10	GIS Map	Geographical Map
	3.1	Table/Figure	Peak Load Demand History and Forecast
	3.2	Table	Peak Demand Forecast Accuracy
	3.3	Table	Primary-wise Demand Forecast
	3.3.1	Table	Grid-wise Demand Forecast
	3.3.2	Table	Grid-wise Demand Forecast - Utilization
	3.4	Table	Embedded Generation and Renewables
	3.5	Table/Figure	Historical Energy Consumption and Forecast
Appendix 4	3.6	Table/Figure	Historical Energy Consumption by Category
	3.7	Table/Figure	Percentages of Annual Energy Consumption by Category
	3.8	Table	Historical Energy Demand Forecast Accuracy
	3.9	Table	Load Factor
	4.1	SLDs	Load Flow Analysis Output
	4.2	Table	Short Circuit Analysis Output
Appendix 5	4.3	Table	Asset Utilization
	4.3.1	Table	Asset Utilization - Summary
	4.4	Table	Security of Supply Non-Compliance
	4.5	Table	Demand Transfer Capability
	5.1	Table/Figure	Total System Historical SAIFI
Appendix 5	5.2	Table/Figure	Region-wise Historical SAIFI
	5.3	Table/Figure	Total System Historical SAIDI
	5.4	Table/Figure	Region-wise Historical SAIDI
	5.5	Table/Figure	Proposed Targets: SAIDI and SAIFI
	5.6	Table	Worst Performing Feeders
	5.7	Table	Asset Failure Rate
	5.8	Table	Supply Restoration
	5.9	Table/Figure	Historical Energy Losses
	5.10	Table	Proposed Targets: Energy Losses

Appendix 6	6.1	Figure	Asset Age Profile
Appendix 7	7.1	Table	Load/ Non-Load Related Schemes and other Strategic/Major
	7.2	Table	TAQA Transmission Shared Project
	7.3	Table	Planned Developments
	7.4	Table	Assets Forecast
Appendix 8	8.1	Table	Load/ Non-Load Related Schemes and other Strategic/Major
	8.1.1	Table	List of Projects in previous 5YPS and removed from current 5YPS
	8.2	Table	CAPEX Variance Cash flow Planned vs. Actual
	8.2.1	Table/Figure	Summary of CAPEX Variance Cash Flow Planned vs. Actual
	8.3	Table	Capital Program Overview
	8.4	PDF Document	Business Cases

## Summary

TAQA Distribution – Al Ain Region (formerly named as Al Ain Distribution Company - AADC) is a Public Joint Stock Company (PJSC) registered and incorporated in the United Arab Emirates on 01 January 1999 with its Head office in Al Ain. TAQA D – AA Region is a wholly owned subsidiary of Abu Dhabi National Energy Company (TAQA). TAQA D – AA Region is the sole distributor and supplier of water and electricity in the Eastern (Al Ain) Region of the Emirate of Abu Dhabi (Al Ain city and its surrounding rural areas). This includes the ownership, operation and maintenance of the water and electricity distribution network assets, meter reading, and services for the supply of water and electricity. The Company investment program is currently wholly financed by the Government of Abu Dhabi.

During every Calendar Year before the set date of 30th June, Electricity Five Years Planning Statement is required to be produced & submitted to Department of Energy (DoE). Submission of Electricity Five Years Planning Statement is defined in condition 28 of license issued by DoE to AADC, to run its supply & distribution businesses for water and electricity sectors within the defined jurisdiction of its work area, which is the Eastern Region of the Emirate of Abu Dhabi, comprising of Al-Ain Region Municipal limits.

In summary, this Electricity Five Years Planning Statement is aimed to provide an outline of the works execution program for the existing system improvement and extension; and develop of new power distribution networking system, consequent investment plans, and power demand growth etc. It also provides the information related to expected capacity utilization and future power demand allocations, to the persons and/or agencies (in addition to DoE), whom so ever may feel interested in knowing the planning and development of projects and make assessment of the opportunities available, when having the intention to connect to and make use of the AADC existing or future planned networking system. This statement provides further elaborations on the progress made on power network system security aspect, including the setting of planning criteria, undertaking risk analysis and making available the contingency planning etc. Along with the details of network modelling, loads flow, short circuit analysis for different operation scenarios. AADC has also assess the security of supply and risk analysis of existing distribution system as well as a number of future network systems proposed to be executed through forthcoming projects for year 2030.

# CHAPTER 1: Introduction & General Overview

## 1.1 Who We Are & What We Do

TAQA Distribution – Al Ain Region (formerly named as Al Ain Distribution Company - AADC) is a Public Joint Stock Company (PJSC) registered and incorporated in the United Arab Emirates on 01 January 1999 with its Head office in Al Ain. TAQA D – AA Region is a wholly owned subsidiary of Abu Dhabi National Energy Company (TAQA).

TAQA D – AA Region is the sole distributor and supplier of water and electricity in the Eastern (Al Ain) Region of the Emirate of Abu Dhabi (Al Ain city and its surrounding rural areas). This includes the ownership, operation and maintenance of the water and electricity distribution network assets, meter reading, and services for the supply of water and electricity. The Company investment program is currently wholly financed by the Government of Abu Dhabi

TAQA D – AA Region has progressed exceptionally since its inception and has made major strides towards its vision. Whilst there is still much to be done, TAQA D – AA Region has developed an enthusiastic, educated workforce, built upon an emerging base of world class information and communication technology systems and created an excellent working environment. The organization now exhibits many of the excellent characteristics visible in other organizations with a similar history. Staff have a professional outlook, are well trained and have a strong public service ethic.

TAQA D – AA Region is dedicated to ensuring excellence and has successfully achieved the following:

- SKEA - Shaikh Khalifa Excellence AWARD (2013, 2015).
- ADAEP (Abu Dhabi AWARD for Excellence in Government Performance) for the best Technical Project.
- Integrated Management System (ISO 9001:2008, ISO 14001:2004 & 18001:2007 combined standards).
- ISO/IEC 17025:2005 for Laboratory.
- Managements System Standard (ISO 10002:2004) for Handling Customer complaint in respect to water and electricity services.
- ADWEA NAJMA Excellence Award (2017).
- ISO (22301:2012) Certification “Business Continuity Management” (Jan 2017).
- ISO (55001:2014) Certification “Management of AADC’s Assets to Distribute and Supply Water and Electricity in Al Ain City and Its Rural Area” (Feb 2018).

- ISO 10002:2018 Handling Management System “CHMS”

TAQA D – AA Region had completed two tasks of international benchmarks. One which carried out by the IPA (2014) to improve and make further progress towards TAQA D – AA Region objectives, vision, mission statement and values toward the top quartile study. The other one by PMCI (2016) was the exercise to benchmark the TAQA D – AA Region against leaders in the utility distribution sectors in developed nations considering the Key Performance areas as well.

## 1.2 Commitment to System Performance

TAQA D – AA Region is committed to ensuring optimal system performance including the following areas:

- Safe operation
- Effective maintenance
- Repair or replacement of faulty equipment
- Health, Safety, Environment and Quality (HSEQ)

Below are brief descriptions of each of these areas:

### Safe operation:

TAQA D – AA Region is dedicated to ensuring the safe and efficient operation of its network, prioritizing the safety of customers, staff, and the environment, as well as the protection of network equipment. In this regard, we are committed to achieving the following:

- Have qualified staff to operate the network safely & efficiently.
- Executing the system safety rules in all works we performed, including procedures, tools, Personal Protection equipment (PPE).
- Monitoring the network and perform load management professionally by changing of the network’s NOPs between the summer and winter seasons which is done to maintain the load and voltage profile of the network in perfect status.
- Reporting the peak load status of network elements annually and on time. In the event of a load violation or abnormality, the concerned planning team in Asset Management analyzes the situation and takes appropriate measures to reinforce the network.
- Contingency plan is immediately prepared for the faults expected to be persisting for long time due to obstacles in the network or the faults’ nature itself.
- Contingency plans are prepared annually for 11 kV feeders expected to be overloaded if faults took place in the network before completing the reinforcement of that network.

- All operational activities are done in coordination with Al Ain Control center (for planned and unplanned)
- Updating the Single line diagram and the network status.
- All operations are recorded and logged in Maximo log sheet operation book (currently for DMS and in near future for the fieldwork to be in Maximo) where it is used as a reference for the network status for all staff in operations.
- Any planned work is done through shutdown request with the concerned signatures and a maneuvering form (switching plan) is created for that work.
- Involving high technology in the network such as monitoring all Grid and Primary stations as well as the downstream substations, using Earth Fault indicators for identifying the faults location, GPS, Auto- recloser and Sectionalizes for OHL network.
- Maintain the network in optimal condition through a variety of maintenance activities, including Condition-Based Maintenance, Preventive Maintenance, Corrective Maintenance, Reliability-Centered Maintenance, Inspections, and load readings.
- Wear proper PPE.
- Check all details mentioned in the safety document.
- Check the live network component using voltage detector (i.e busbar, cables,...etc.)
- Discharging the cable by earth stick.
- Issue the related safety document as per job requirement required (PTW-SFT-LAP).
- RISSP with other organizations is established.
- Ensure that all interactions with customers operating their equipment are formally documented through interface agreements.
- Prevent any kind of safety violation due to wrong asset identification.
- Digital Maintenance Management “DMM” puts a mandatory guide to comply with HSE safety rules as a specific Maximo Work Order raised for a particular equipment and recognized by scanning process.
- Conduct HSE and site visits by the management and senior level in order to ensure compliance with safety procedures.
- Identify potential issues proactively through predictive maintenance to prevent equipment failures. This includes utilizing thermal cameras for LV network, checking SF6 gas quality, performing electrical tests on CBs & PTRs, and implementing disposal

processes for used oil and SF6 gas. These measures have a broad range of positive impacts, as outlined below:

- Minimizing environmental impact
- Reducing exposure of operational staff to hazards
- Extending the lifespan of assets
- Ensuring public safety
- More precautions are taken where there is a probability of risk or unsafe operation such as working on equipment where earthing is stolen.

**Effective maintenance:**

- Cable preventive maintenance by applying Inspection & diagnosis (VLF test – Partial discharge test) to assess the cable reliability, Inspect the old terminations to avoid the flashovers cause interruption and remedy action for any abnormal cables (damage outer jacket-exposed cables).
- Corrective maintenance includes repair the cables due to Joint failure, end failure, manufacturer, and damage by making one or two joints with piece or new termination.
- Covering 98% of planned maintenance activities for Substation Maintenance Section.
- Fault Attendance, 24/7.
- Network Inspection.
- Substation Maintenance: PM, CM, CBM & RCM.
- New Substation Commissioning.
- Performance Analysis & Statistics in RCM technique.
- Cost reduction & feasibility studies.
- Review and Update of standard technical specifications.
- Raising New Innovative Projects. (RCM and EFI)
- Adopting RCM maintenance technique to optimize the maintenance techniques and provide accurate condition assessment of assets.
- Technical Training for the field employees.

### **Repair or replacement of faulty equipment**

- Cable replacement (depending on its condition); if the cable is in bad condition, we replace it via power-asset management depending on tests results and frequent faults. Otherwise, we repair it.
- Repairing of equipment's defects such as "Oil leakage, gas leakage, CB's Mechanism problem, ... "by SMS staff during corrective maintenance activities.
- Departmentally replacement of repetitive failure and aged equipment.
- Replacement of aged equipment's through outsource contracts.
- Raising list of aged assets along with condition grading to power-Asset Management for replacement, budget preparation.
- Replacing Stolen Earth conductors by new CCS.

### **Health, Safety, Environment and Quality (HSEQ)**

TAQA D – AA Region is committed to protect and conserve the environment, and to protect and promote human health and safety for all TAQA D – AA Region employees, contractors and public at large. TAQA D – AA Region complies with all HSEQ applicable legal and other requirements, including compliance to AD Emirate EHS policy, AD EHSMS R Table 2.9 regulatory Framework and Department of Energy (DoE). TAQA D – AA Region is committed to implement, maintain, and continually improve Quality, Occupational Health, Safety and Environment Management Systems Under the framework of Health Safety & Environment Management system (HSE-MS) and Integrated Management System (IMS), which include OSHAD SF v.3.1, ISO 45001:2018 & ISO 14001:2015.

### **TAQA D – AA Region Power Network:**

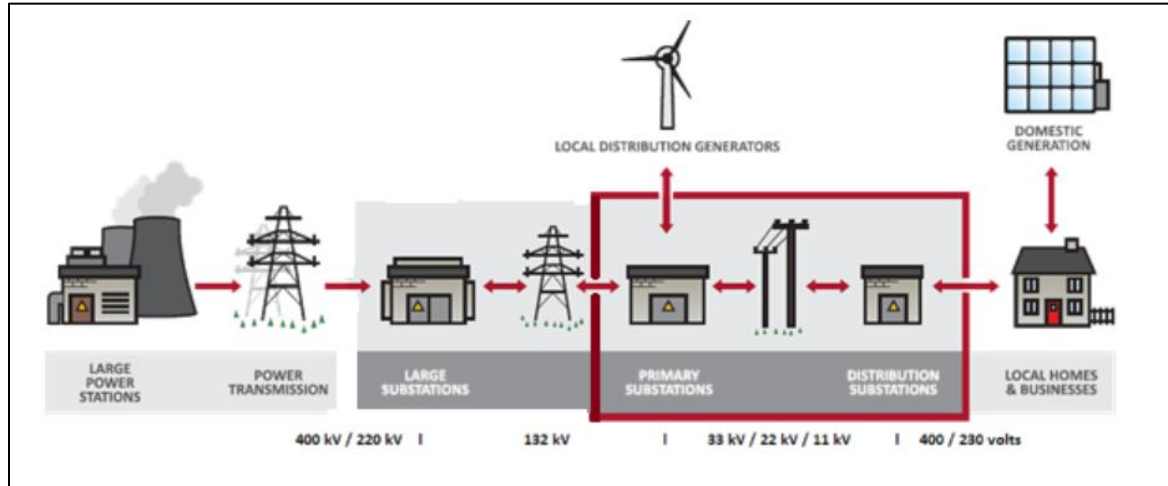
Based on TAQA D – AA Region license conditions, TAQA D – AA Region to run its supply & distribution part of electricity networks. TAQA D – AA Region part of overall electricity system represented in Fig. 1.1

TAQA D – AA Region has an extensive urban and rural network serving Central, Northern, Southern and Western regions. Faqa, Al Khazna and Um Al Zamool are the boundaries at North, West and South respectively. Each zone functions independently in operation and maintenance of network under umbrella of one Directorate named Electricity O&M Directorate (EOMD). Distribution of TAQA D – AA Region Power System per Region(s) as shown in Fig.1.2

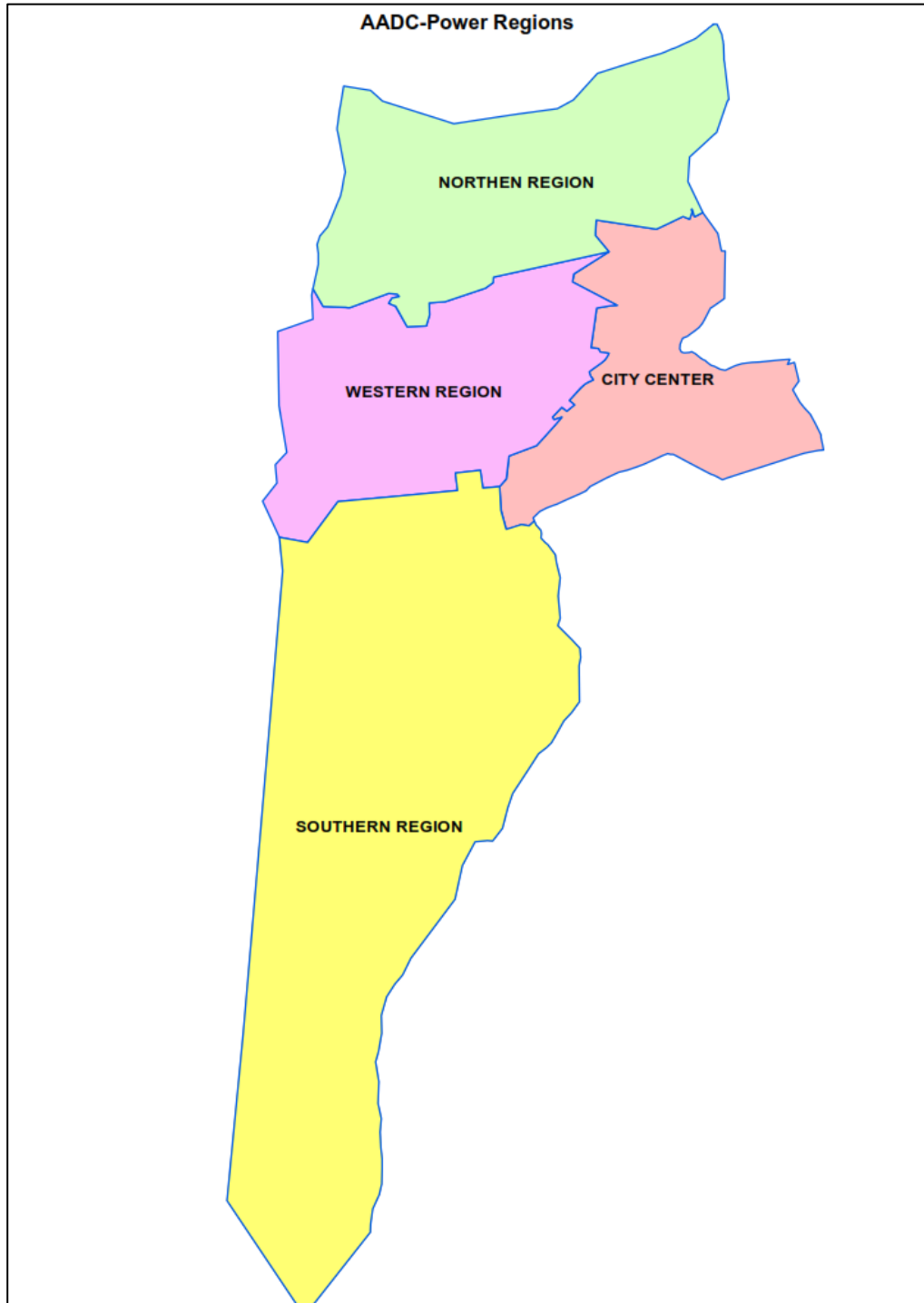
The zones are as follow:

1. City zone
2. Western zone,
3. North zone
4. South zone

**Fig.1.1: Representation of an Electricity Distribution System**



**Fig.1.2: Distribution of TAQA D – AA Region Power System per Region**



### 1.3 Purpose of the Statement

This Electricity Planning Statement details the existing Power Distribution Networks and Systems as well as its on-going and future developments plans and proposals, essentially placed in to effect to meet the anticipated growing demand of power over the next five years, until Year 2030.

During every Calendar Year before the set date of 30 June, Electricity Five Years Planning Statement is required to be produced & submitted to DOE. Submission of Five Years Planning Statement is defined in condition 28 of license issued by DOE to TAQA D – AA Region, to run its supply & distribution businesses for water and electricity sectors within the defined jurisdiction of its work area, which is the Eastern Region of the Emirate of Abu Dhabi, comprising of Al-Ain Region Municipal limits. Therefore, in the fulfilment of above-mentioned license condition compliance, this Electricity Five Years Planning Statement Year 2025-2030, has been prepared & is being submitted for DOE review and approval. This Planning Statement hereafter would include and not limited to, TAQA D – AA Region current power distribution networking system and its up-gradation, rehabilitation and phase replacement plans. Alongside it would also provide an insight of future power network expansion plans by TAQA D – AA Region and other Governmental/Private Agencies and their Developers, for the various on-going and future planned new developments of Al-Ain Region. The new power network development plans also necessitated the incorporation of the respective forecasted growth in the power demand for the power supply over the next five years. The power demand forecast details are also provided herein. In order to address the requirement of network planning for the rehabilitation and replacement of existing network; future network expansion plans for new developments and for power networking system up-gradation improvement and overhaul plans of current power supply system, many projects are being conceived and planned. Therefore, in order to implement the related execution projects in time, a comprehensive capital expenditure plan is also prepared and its cash flows projections are also presented.

In summary, this Electricity Five Years Planning Statement is aimed to provide an outline of the works execution program for the existing system improvement and extension; and creation of new power distribution networking system, consequent investment plans, and power demand growth etc. It also provides the information related to expected capacity utilization and future power demand allocations, to the persons and /or agencies (in addition to DOE), whom so ever may feel interested in knowing the planning and development of projects and make assessment of the opportunities available, when having the intention to connect to and make use of the TAQA D – AA Region existing or future planned networking system. This statement provides further, the elaborations on the progress made on power network system security aspect,

including the setting of planning criteria, undertaking the risk analysis and making available the contingency planning etc. along with the details of network modelling, loads flow, short circuit analysis for different operation scenarios. TAQA D – AA Region has also assessed the security of supply and risk analysis of existing distribution system as well as several future networking systems proposed for construction through upcoming projects.

Moreover, this Electricity Five Years Planning Statement provides the network performance indicators (SAIFI & SAIDI) profile for the last five years as well as the targeted values for the next five years along with various taken operational measures to meet the targeted values. At the same time, this document provides a list of worst performance OHL feeders with identified root causes and the set-up mitigation actions.

Furthermore, this document includes Asset Age Profiling, along with the identification of criteria for condition monitoring. Additionally, it outlines the Asset Replacement/Refurbishment plan, which is typically developed following Condition Assessment and Asset Replacement procedures.

## 1.4 Company Purpose & Corporate Values

### Company Purpose

As part of the TAQA group rebranding in 2025, our new purpose— powering communities— reflects our commitment to creating lasting, positive impact. This purpose is aligned with the overarching TAQA group purpose, reinforcing our shared vision and values across TAQA group.

### Core Values

We take pride in our values that are common across the TAQA Group of companies:

- 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.

## 1.5 Strategic Network Development Plan & Strategy

### 1.5.1 Strategy Statement

In 2024, Abu Dhabi Distribution Company (ADDC) and Al Ain Distribution Company (AADC) began restructuring their operations to form TAQA Distribution. Effective 1 January 2025, the unified entity will be responsible for delivering electricity and water services across the Emirate of Abu Dhabi.

The successful merger of ADDC and AADC into TAQA Distribution marks a momentous milestone in our journey toward operational excellence and enhanced service delivery. This integration strengthens our capabilities, embraces innovation, and reinforces our commitment to providing reliable utility solutions for our customers in the Emirate of Abu Dhabi.

By adopting cutting-edge technology and driving a customer-centric culture, we are enhancing efficiency, responsiveness, and service quality.

As we move forward under a shared vision, we remain dedicated to maximizing value for our stakeholders and ensuring a seamless and prosperous future for the communities we serve.

### **Strategies Priorities**

In alignment with our long-term vision, our strategic priorities define the critical focus areas that drive sustainable growth and operational excellence. These priorities guide our investment decisions, shape our organizational initiatives, and ensure that all business units are aligned toward delivering value to our stakeholders. We have identified five different strategic themes that will guide our efforts:

- Ensure safety and operational efficiency across the network
- Provide customer-centric services that exceed expectations
- Build a smart, sustainable, and digitally integrated network to meet future demands
- Enhance digital capabilities to empower our people and drive automation
- Support UAE's vision by advancing sustainable, technology-driven energy solutions

As we move forward as a joint company, we are shaping a new strategy that will further detail our priorities and direction for the years ahead. This strategic refresh is designed to align with our renewed purpose and the evolving needs of the communities we serve.

### **1.5.2 Summary of Strategic Direction and key Stakeholders**

Achieving the strategic direction requires solid execution of the 5-year strategic plan, which will enable TAQA Distribution to move towards the long-term goal of being a leading utility company.

This means that:

- Without jeopardizing the security of supply, HSE standards, and the health of the network, all business units should be financially steered towards increasing revenues and efficient operations.
- Each business unit must adopt the best practices to achieve excellence across all areas of the business.
- TAQA Distribution must engage in a productive manner with all stakeholders to support the sustainability of the business.

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

TAQA Distribution’s review and update the stakeholder requirements and preferences through an on-going process of formal and periodic communication and feedback.

**Table 1.1: TAQA Distribution’s Key Stakeholders**

Stakeholder	Stakeholder Needs from TAQA D – AA Region	Stakeholder Influence
TAQA Group	<ul style="list-style-type: none"> <li>Operating assets with a view of improving the financial performance.</li> <li>Ensure license compliance.</li> <li>Relationship with TAQA is driven by financial/ operational performance dashboards.</li> </ul>	<ul style="list-style-type: none"> <li>Active asset owner (oversees financial and operational performance of TAQA Distribution).</li> <li>No direct involvement in TQD operations.</li> </ul>
DoE	<ul style="list-style-type: none"> <li>Compliance with defined license requirements and conditions to safeguard consumer's interests.</li> </ul>	<ul style="list-style-type: none"> <li>Sector regulator (defines regulatory framework and policies)</li> <li>Relationship with TQD is defined by the regulatory framework and licensing processes.</li> </ul>
EWEC	Supply of Water/Electricity Demand/Energy Forecast	<ul style="list-style-type: none"> <li>Water/Electricity Producer.</li> </ul>
TAQA Transmission	<ul style="list-style-type: none"> <li>Enter into an agreement with TAQA Transmission for the provision of an uninterrupted supply for the distribution network.</li> <li>Compliance with Transmission code requirements.</li> </ul>	<ul style="list-style-type: none"> <li>Provides interface connection points to supply water/ electricity as required.</li> </ul>
DMT	<ul style="list-style-type: none"> <li>Future infrastructure expansion plans.</li> <li>TQD to Align its growth plans with Abu Dhabi’s envisioned growth and ensure the successful execution of all its growth capital projects.</li> </ul>	<ul style="list-style-type: none"> <li>Defines future development plans.</li> <li>Acquiring route approvals and permits related to</li> <li>TQD capital projects.</li> </ul>
Consultants & Contractors	<ul style="list-style-type: none"> <li>Grant fair terms and be transparent and reliable with our dealings with them.</li> </ul>	<ul style="list-style-type: none"> <li>Implementation of Asset Management Plan.</li> <li>Abide by the contract’s agreements.</li> </ul>
Mega Developers	<ul style="list-style-type: none"> <li>Water/Electricity to be connected/ supplied as requested.</li> </ul>	Demand forecasts to plan infrastructure expansion plans.
Customers	<ul style="list-style-type: none"> <li>Reliable and safe provision of water &amp; electricity and services.</li> </ul>	Customer’s satisfaction supports TQD’s road to excellence.

## 1.6 Key Statistics Data

Power distribution for Al Ain Region in Al-Ain Municipal limits is the sole responsibility of TAQA D – AA Region. Total population of Al-Ain including its suburban areas consists of approximately 1.039 million inhabitants. Power consumption for Al-Ain region consists mainly of domestic consumptions and bulk supplies to Palaces/Farms/VVIP's, with minimal industrial consumption as Al Ain currently is not a major business or Industrial Centre.

As a result of the sector's philosophy, a considerable amount of investments is annually allocated for electricity network infrastructure maintenance & expansion to ensure the reliable and secure service for all inhabitants in Al-Ain. TAQA D – AA Region has the capacity and the capability to meet the natural growth requirements as well as the economic growth requirements. TAQA D – AA Region has power supply network covering approx. 13,327.11 KM<sup>2</sup> providing power supply to 169,227 customers. The existing power supply system of Al-Ain main city has an interconnected zone-based power supply system with 23 numbers 220/33kV Grid Stations. Key statistical data for TAQA D – AA Region electrical network is provided in Table 1.2 below.

**Table 1.2: Key Statistical Data (up to 31<sup>st</sup>, Dec 2024)**

Item No.	Description		Unit	Quantity End of 2024
1	Power Transformers	33/11 KV	No.	451
	Distribution Transformers	11/0.4 KV	No.	20,229
	<b>Total Transformers</b>		<b>No.</b>	<b>20,680</b>
2	Power Transformer Capacity	33/11 KV	MVA	7,272.50
	Distribution Transformer Capacity	11/0.4 KV	MVA	12,279.84
	Tertiary winding at Grid stations	220/11 KV	MVA	50.00
	<b>Total Installed Capacity</b>		<b>MVA</b>	<b>19,602.34</b>
3	Length of OH Lines	33 KV	KM	1,420.31
		11 KV	KM	5,073.99
	<b>Total OHL's Networks Length</b>		<b>KM</b>	<b>6,494.30</b>
4	Length of UG Cables	33 KV	KM	3,050.77
		11 KV	KM	7,170.77
		Low Voltage	KM	14,283.47
	<b>Total Cables Networks Length</b>		<b>KM</b>	<b>24,505.01</b>
5	Grid Stations	220/33 KV	No.	23
	Primary Sub-stations	33/11 KV	No.	182
	Distribution Sub-stations	11/0.4 KV	No.	17,949
	<b>Total</b>		<b>No.</b>	<b>18,154</b>
6	Area covered by TAQA D – AA Region		KM <sup>2</sup>	13,327.11

# CHAPTER 2: System Characteristics and Operational Philosophy

TAQA D – AA Region has approved the Design Guidelines Version 04, issued on 05/10/2021. These guidelines provide design philosophies and practices applied to TAQA D – AA Region electrical distribution systems across various voltage levels. The approved Version 04 serves as the reference for all design-related purposes.

## 2.1 Governing Standards

### 2.1.1 Legal and Statutory Requirements:

AADC (TAQA D – AA Region) has Water and Electricity Distribution and Supply License dated 1/1/2018 and Law No (2) of 1998 & Law 11 of 2018 concerning the Regulation of the Water and Electricity Sector in the Emirate of Abu Dhabi.

### 2.1.2 Regulatory Requirements:

TAQA D – AA Region has the following Regulatory Requirements as below:

- AADC (TAQA D – AA Region) License Condition No. 28.
- The Electricity Supply Regulation (issued by the DoE and as amended from time to time).
- Electricity Wiring Regulation Edition (issued by the DoE and as amended from time to time).
- Electricity Transmission Code.
- Electricity Distribution Code.
- Engineering Recommendations of the Electricity Distribution Code:
  - No.1: Limits for Harmonics in the Electricity Supply System
  - No.3: Embedded Generating Plant up to and including 30 MW
  - No 4: Supply Security Standards for Classes of Group Demand
  - No.7: Limits for Voltage Fluctuations in the Electricity Supply System
  - No.8: Assessing the Rise of Earth Potential and Earthing of the Distribution System
  - No.10: Limits for Voltage Unbalance in the Electricity Supply System
  - No.11: Standard Connection Arrangements

### 2.1.3 National and International Standards Specifications:

All equipment, apparatus, and materials shall generally conform to the international standards listed below, ensuring compliance with the latest version of TAQA Distribution Standards & Technical Specifications (ASTS). Additionally, the equipment must be manufactured under a

quality assurance system that adheres to the latest ISO standards or equivalent national standards.

**Table 2.1: International Standards**

<b>ASTM</b>	American Society for Testing and Materials
<b>ANSI</b>	American National Standards Institute
<b>BS</b>	British Standards
<b>DIN</b>	German Industrial Standards
<b>EIA</b>	Electronic Industries Association
<b>EN</b>	European Standards
<b>ESI</b>	Electricity Supply Industry
<b>HD</b>	Harmonization Document (CENELEC – European Committee for Electromechanical Standardization)
<b>IEEE</b>	Institute of Electrical & Electronic Engineers
<b>IEC</b>	International Electro-technical Commission
<b>ISO</b>	International Standard Organization
<b>ITU-T</b>	International Telecommunication Union Telecommunication Standardization Sector of ITU
<b>ICEA</b>	Insulated Cable Engineers Association
<b>SS</b>	Swedish Standard
<b>VDE</b>	German Association of Electrical, Electronic & Information Technologies
<b>UL</b>	Underwriters' Laboratory

**Local Standards:**

We follow TAQA Distribution Standards & Technical Specifications (ASTS) issued in 2022, which reference the international standards mentioned above.

**2.1.4 The ability to meet the demands imposed by customers, supply performance and supply quality and regulations such as Incident Reporting Regulations, Security of Supply Standard:**

The incident Reporting Regulations (Second Edition) ED/R01/107 Codes, Engineering Recommendations, publications are available on DoE website:

<https://www.doe.gov.ae/en/Publications>

**Security of Supply Standards:**

The Supply Security Standards tabulated in next table {Supply Security Standards for Classes of Group Demand} in Engineering Recommendation No-4 /2019 of the Electricity Distribution Code.

The level of security provided is primarily a function of the magnitude of load lost as a consequence of a circuit outage.

This section defines the security criteria for the Main Distribution System, classified in a range of Group Demands, connection types and the maximum interruption times permissible.

**Class A1:**

Represents parts of networks supplied by 11/0.4 kV distribution substations (ground mounted or pole mounted) with one or more transformers of capacity up to 1500 kVA each, and where the group demand is up to 3000 kVA, as illustrated. In such cases, for a First Circuit Outage condition (transformer fault, switchgear fault, etc.), the supply must be restored after the time to repair the fault and there is no redundancy of supply.

**Note:** this arrangement assumes a maximum of 3000 kVA transformer capacity connected to a single HV unit (e.g., a ring main unit) or HV switchgear with a single bus bar and no bus section switch. Where a demand of greater than 3000 kVA is required, an arrangement must be made for two ring main units or switchgear with a bus section separating the transformers.

**Class B1:**

Represents a Group Demand of up to 6.5 MVA, which may be fed by an 11kV feeder (open ring configuration). Following outage of such circuit in urban or rural area, normally 50% of the demand shall be restored within 20 minutes (assuming the Circuit is equipped with remote/auto switching capability at the primary substation, halfway on the feeder, and at the normally open point) but without unit protection. Total demand shall be restored within 2 hours. If the outage is due to a fault at a distribution substation, the demand of that substation may be excluded from the Group Demand and for which the restoration criteria of Class A1 will apply.

**Class B2:**

Represents a Group Demand of up to 6.5 MVA, which may be fed by an 11kV feeder open ring Circuit in rural or urban areas. In this case the total demand shall be restored within 2 hours, assuming partial use of remote switching capability (i.e., at the primary substation and also at other strategic locations) and without unit protection. If the outage is due to a fault at a distribution substation, the demand of that substation may be excluded from the Group Demand and for which the restoration criteria of Class A1 will apply.

**Class B3:**

Represents a Group Demand up to 6.5 MVA, which may be fed by an 11kV feeder open ring Circuit in rural or urban areas. Total demand shall be restored within 3 hours assuming No DMS control (feeders connected in between two non-monitored 33/11kV PU's) and without unit protection. If the outage is due to a fault at a distribution substation, the demand of that substation may be excluded from the Group Demand and for which the restoration criteria of Class A1 will apply.

#### **Class B4:**

Represents a Group Demand of up to 5 MVA which may be fed by an 11kV overhead network with normally open main line ring circuits with monitored Auto-reclosers (with or without sectionalisers). The circuit is partial DMS control at Primary substations.

The overhead lines are divided into 3 sections with a maximum of 2MVA demand on a section and a group demand of 5 MVA on the feeder.

Following the first outage on a single section of an 11kV main line ring circuit and associated branch line radial circuits (with maximum 1.5MVA demand and not economical to complete a ring), the healthy OHL portions shall be restored within 2 Hours by switching operations on 11kV network, however, the remaining group demand shall be restored within the repair time. If the outage is due to a fault at a distribution substation, the demand of that substation may be excluded from the Group Demand and for which the restoration criteria of Class A1 will apply.

#### **Class B7:**

Represents 11kV BB with group demand up to 60 MVA supplied by a 33/11kV primary substation with two, three or four transformers 20 MVA each, normally operated in parallel (or parallel pairs for four transformers configuration) and with partial DMS control of substation and 11kV network. In this class, the demand lost as a result of the first 11kV busbar outage shall be restored within 3 hours. The demand lost as a result of the Second busbar outage shall be restored after repair time or the time to restore the planned first outage.

#### **Class C1:**

Represents the outage of up to 20 MVA Group Demand in rural areas where the demand is supplied by two or more 33/11 kV substations, which are interconnected through their 11 kV feeders. Remote switching capability may not be installed or may be partially installed. Following the First Circuit Outage (loss of one of the substation transformers or 33kV feeders), the Group Demand must be restored within 3 hours, by closing the open points on the 11 kV feeders. Following a Second Circuit Outage (at either substation), the power will be restored after the repair time or the time to restore the planned first outage.

#### **Class C2:**

Represents the outage of up to 20 MVA Group Demand in urban or rural areas where the demand is supplied by two 33/11 kV package unit substations, interconnected at the same site. Remote switching capability will be installed to enable Group Demand to be restored in 20 minutes following a First Circuit Outage. Following a Second Circuit Outage, the supply will be restored after the repair time or the time to restore the planned first outage.

### **Class D1:**

Represents group demand up to 20 MVA supplied by a 33/11kV primary substation with two transformers up to 20 MVA each, normally operated in parallel and with partial DMS control of substation and 11kV network. In this Class there must not be any supply interruption following a First Circuit Outage (33kV Circuit / BB or transformer outage). The demand lost as a result of the Second Circuit Outage shall be restored after repair time or the time to restore the planned first outage.

**Note:** For some primary substations, it may not be possible to run all transformers in parallel due to fault level limitations or due to incomers being from different buses of upstream grid station. In such cases, the transformers may be run independently and Class C1 or C 2 shall be applied as applicable (Note 4 – Security of supply standard for Classes of Group Demand Table below).

### **Class D2:**

Represents group demand up to 40 MVA supplied by a 33/11kV primary substation with three transformers up to 20 MVA normally operated in parallel, and with partial DMS control of substation and 11kV network, as shown. In this Class there must not be any supply interruption following a first 33kV circuit, BB or transformer outage for the parallel transformers. Following the Second circuit outage, 50% of the total demand must be restored in 1 hour. In such case, the third transformer may trip and should be restored by DMS, together with closure of the bus section and some or all of the 11kV feeders. The remainder of Group Demand must be restored in repair time.

**Note:** For some primary substations, it may not be possible to run all transformers in parallel due to fault level limitations or due to incomers being from different buses of upstream grid station. In such cases, the transformers may be run independently; the independent transformer may follow the same condition of class C1.

Paralleling of the 33/11kV transformers are subject to the following:

1. No violation of Firm capacity.
2. Similar Transformers characteristics
3. Feeding sources are from paralleled transformers.
4. Short circuit current levels shall not exceed the permitted levels at 33kV and 11kV sides.

### **Class D3:**

Represents Group demand up to 60 MVA supplied by a 33/11kV primary substation with four transformers up to 20 MVA each run in parallel pairs with availability of ATS, and with partial DMS control of substation and 11kV network. In this Class, there must be no supply interruption following a first 33kV circuit / BB or transformer outage. Following the Second circuit or transformer outage, 50% of the total demand must be restored within one hour. In such case, the third transformer may trip and should be restored by closure of the bus section and 11kV

switching operations. The remainder of Group Demand must be restored in repair time or restoration of the planned outage period.

Note: For some primary substations, it may not be possible to run all transformers in parallel due to fault level limitations or due to incomers being from different buses of upstream grid station. In such cases, the transformers may be run independently and transformers may follow the same condition of class C1.

Paralleling of the 33/11kV transformers are subject to the following:

1. No violation of Firm capacity.
2. Similar Transformers characteristics
3. Feeding source are from paralleled transformers.
4. Short circuit current levels shall not exceed the permitted levels at 33kV and 11kV sides.

**Class G1 –bb:**

Represents 33kV Busbar in grid primaries with group demand up to the limit of (N-1) MVA -firm capacity. The 33 kV BB's are fed from main TAQA Transmission grid power transformers; which are running in parallel pairs and with full DMS control of substation and 33kV network. In this Class, the demand lost as a result of first 33kV bus bar outage shall be restored within 30 minutes (assumption of having 33kV double Bus configuration). Following the Second Busbar outage, the full demand has to be restored within 1 hour if the two BB's are from different Sections. Otherwise, restoration to be upon restoring the planned outage or repair time.

**Table 2.2: Supply Security Standards for Classes of Group Demand**

Class	Network Description	Group Demand	Outage condition due to 1no. fault only	Restoration time after outage condition due to 1no. fault only	Outage condition due to 1no. fault after a planned outage. (See Note5)	Restoration time after outage condition due to 1no. fault after a planned outage (maintenance period demand)
A1	11/0.4kV secondary distribution substation fed via 11kV underground network with or without DMS control	up to 3 MVA	Outage on 11kV switchgear and/or associated 11/0.4kV transformers	(a) 100% of Group Demand in repair time	NA	NA
A2	22/0.4kV secondary distribution substation fed via 22kV underground network with or without DMS control	up to 3 MVA	Outage on 22kV switchgear and/or associated 22/0.4kV transformers	(a) 100% of Group Demand in repair time	NA	NA
B1	11kV underground network with normally open ring circuits and with full DMS control and without unit protection	up to 6.5 MVA	Outage on a single section of an 11kV ring circuit serving 11/0.4kV ring main substations	(a) 50% of Group Demand within 20 minutes (b) 100% of Group Demand within 2 hours (see Note1)	Outage on numerous sections of an 11kV ring circuit serving 11/0.4kV ring main substations	(a) 100% of Group Demand within time to restore planned outage or repair
B2	11kV underground network with normally open ring circuits and with partial DMS control and without unit protection	up to 6.5 MVA	Outage on a single section of an 11kV ring circuit serving 11/0.4kV ring main substations	(a) 100% of Group Demand within 2 hours (see Note 1)	Outage on numerous sections of an 11kV ring circuit serving 11/0.4kV ring main substations	(a) 100% of Group Demand within time to restore planned outage or repair
B3	11kV underground network with normally open ring circuits and with No DMS control and without unit protection	up to 6.5 MVA	Outage on a single section of an 11kV ring circuit serving 11/0.4kV ring main substations	(a) 100% of Group Demand within 3 hours (see Note 1)	Outage on numerous sections of an 11kV ring circuit serving 11/0.4kV ring main substations	(a) 100% of Group Demand within time to restore planned outage or repair
B4	11kV overhead network with normally open in main line ring circuits (monitored ARC with or without sectionalisers) and with partial DMS control at Primary substations.	up to 5 MVA	Outage on a single section of an 11kV main line ring circuit and associated branch line /radial circuits	(a) Healthy OHL portions within 2 Hours (b) 100% of Group Demand in repair time (see Note1)	Outage on numerous sections of an 11kV main line ring circuit and associated branch line radial circuits	(a) 100% of Group Demand within time to restore planned outage or repair
B5	22kV underground network with normally open ring circuits and with full DMS control and without unit protection.	up to 13 MVA	Outage on a single section of a 22kV ring circuit serving 22/0.4kV ring main substations	(a) 50% of Group Demand within 20 minutes (b) 100% of Group Demand within 2 hours (see Note 2)	Outage on numerous sections of a 22kV ring circuit serving 22/0.4kV ring main substations	(a) 100% of Group Demand within time to restore planned outage or repair
B6	22 kV underground network with normally open ring circuits and with Partial control and without unit protection	up to 13 MVA	Outage on a single section of an 22kV ring circuit serving 22/0.4kV ring main substations	(a) 100% of Group Demand within 2 hours (see Note 2)	Outage on numerous sections of an 22kV ring circuit serving 22/0.4kV ring main substations	(a) 100% of Group Demand within time to restore planned outage or repair
B7	11kV BB at 33/11kV substations with 2/3/ 4no. transformers up to 20 MVA each normally operated in parallel/parallel pairs and with partial DMS control of substation and 11kV network, Where BB protection is not available	up to 60 MVA	Outage on 1 no. 11kV busbar	(a) Group Demand lost is up to 20 MVA and is restored within 3 Hour. Restored by switching operations on 11kV network	Outage on 2no. 11kV busbars	(a) 100% of Group Demand within time to restore planned outage or repair
C1	33/11kV substation with 1no. Transformer and with partial DMS control of substation and 11kV network.	up to 20 MVA	Outage on 1 no. 33/11kV transformer or outage on 1 no. 11kV busbar or 1 no. 33kV Incomer	(a) 100% of Group Demand within 3 hours Restored by switching operations on 11kV network.	Outage on 11kV busbar and outage on the supporting 11kV network	(a) 100% of Group Demand within time to restore planned outage or repair
C2	Two 33/11kV package substation with DMS control of substation and 11kV network.	up to 20 MVA	Outage on 1 no. 33/11kV transformer or outage on 1 no. 11kV busbar or 1 no. 33kV Incomer	(a) Group Demand restored within 20 minutes Restored by switching operations on 11kV network.	Outage on 11kV busbar and outage on the supporting 11kV network	(a) 100% of Group Demand within time to restore planned outage or repair
D1	33/11kV substation with 2no. transformers up to 20 MVA normally operated in parallel and with partial DMS control of substation and 11kV network	up to 20 MVA	Outage on 1 no. 33/11kV transformer or 1 no. 33kV Incomer or 1no. 33kV busbar	(a) 100% of Group Demand is secure for a first outage (see Note 3)	Outage on 2nd 33/11kV transformer or 2nd 33kV Incomer or 2nd. 33kV busbar	(a) 100% of Group Demand within time to restore planned outage or repair.

Class	Network Description	Group Demand	Outage condition due to 1no. fault only	Restoration time after outage condition due to 1no. fault only	Outage condition due to 1no. fault after a planned outage. (See Note5)	Restoration time after outage condition due to 1no. fault after a planned outage (maintenance period demand)
D2	33/11kV substation with 3no. transformers up to 20 MVA normally operated in parallel and with partial DMS control of substation and 11kV network	up to 40 MVA	Outage on 1 no. 33/11kV transformer or 1 no. 33kV Incomer or 1no. 33kV busbar	(a) 100% of Group Demand is secure for a first outage (see Note 4)	Outage on 2nd 33/11kV transformer or 2nd 33kV Incomer or 2nd. 33kV busbar	Group Demand lost is up to 40 MVA as the 1no. remaining transformer could trip due to overload (a) 50% of Group Demand within 1-hour, restored by switching operations on bus couplers and 11kV network. (b) 100% of Group Demand within time to restore planned outage or repair
D3	33/11kV substation with 4no. transformers up to 20 MVA normally operated in parallel pairs with availability of ATS and with partial DMS control of substation and 11kV network	up to 60 MVA	Outage on 1 no. 33/11kV transformer or 1 no. 33kV Incomer or 1no. 33kV busbar	(a) 100% of Group Demand is secure for the paralleled ones for a first outage (see Note4)	Outage on 2nd 33/11kV transformer or 2nd 33kV Incomer or 2nd. 33kV busbar	Group Demand lost is up to 60 MVA as the 2no. remaining transformer could trip due to overload (a) 50% of Group Demand within 1 hour, (b) 100% of Group Demand within time to restore planned outage or repair
E1-bb	132/11kV substation with 4no. 40 MVA transformers normally operated in parallel pairs and with partial DMS control of substation and 11kV network	up to 120 MVA	Outage on 1 no. 11kV busbar	(a) Group Demand lost is up to 40 MVA and is restored within 2 Hour. Restored by switching operations on 11kV network	Outage on 2no. 11kV busbars	Group Demand lost is up to 120 MVA. a) 100% of Group Demand within 4 Hrs. Restored by switching operations on bus couplers and 11kV network
F1-bb	132/22kV substation with 4no. 60MVA, transformers normally operated in parallel pairs and with partial DMS control of substation and 22kV network	up to 180MVA	Outage on 1 no. 22kV busbar	(a) Group Demand lost is up to 60 MVA and is restored within 2 Hour. Restored by switching operations on 22kV network	Outage on 2no. 22kV busbars	Group Demand lost is up to 180 MVA. a) 100% of Group Demand within 4 Hrs. Restored by switching operations on bus couplers and 22kV network
G1-bb new	33kVBB in substation with double busbar 33kVconfiguration fed from TAQA Transmission Grid power transformer running in parallel pairs.	Up to (N-1) firm capacity	Outage on 1 no. 33kV busbar	(a) Group Demand lost is (subject to Grid power transformer Transformer's capacity) is restored within 30 minutes Restored by switching operations on 33kV network.	Outage on 2no. 33kV busbars.	Group Demand lost is subject to firm capacity in, MVA (a) 100% of Group Demand within 1 Hrs; if the two BB's are from different Sections otherwise restoration time of full demand to be upon restoring the planned outage or repair time. Restored by switching operations on bus couplers and 33kV network.

Note 1	If the outage is due to a fault at a distribution substation, the demand of that substation may be excluded from the Group Demand and for which the restoration criteria of Class A1 will apply.
Note 2	If the outage is due to a fault at a distribution substation, the demand of that substation may be excluded from the Group Demand and for which the restoration criteria of Class A2 will apply.
Note 3	For some primary substations, it may not be possible to run all transformers in parallel due to fault level limitations or due to incomers being from different busses of upstream grid station (s). In such cases, the transformers may be run independently.
Note 4	For some primary substations, it may not be possible to run all transformers in parallel due to fault level limitations or due to incomers being from different busses of upstream grid station. In such cases, the transformers may be run independently transformers and may follow the same condition of class C1. Paralleling of the 33/11kV transformers are subject to the following: <ol style="list-style-type: none"> <li>1. No violation of firm capacity.</li> <li>2. Similar Transformers characteristics</li> <li>3. Feeding source from paralleled transformers.</li> <li>4. Short circuit current levels shall not exceed the permitted levels at 33KV and 11KV sides.</li> </ol>
Note 5	Following the second outage circuit situation the Group demand shall be the maximum demand expected during the normal maintenance period.
Note 6	For any loss of supply exceeding the standard restoration, time may be acceptable if this leads to significant economies and has prior approval of DoE.

## 2.2 System Characteristics

The primary objective of the electrical power distribution system planning is to evolve a distribution system network, which satisfies the desired requirements of system performance and power supply security to meet the electrical load demand in an economic manner by ensuring maximum utilization of capital investment.

The planning, design and operation of electrical power distribution system requires continuous and comprehensive system analysis in order to evaluate system performance and to determine the effectiveness of the plans developed for the future system expansions, in line with established planning criteria as far as adequacy of quantity and quality of supply is concerned.

### 2.2.1 Plant and equipment sizes

The principal objective of distribution system planning includes the development of short term and long-term plans required: -

- To meet the increased future load growth by establishing new substations as appropriate.
- To strengthen sections of the existing distribution system, as appropriate, to meet the increased load in future.
- To load all system components in proportion to their rated capacities, to the extent practicable.
- To ensure, and if possible, improve the network operability and maintainability.
- To meet the power quality requirement according to The Electricity Distribution Code.

Various aspects play important parts in the planning requirements of the electrical distribution system, which includes aspects related to system supply security, voltage tolerance, fault levels, equipment loading limit and system power factor.

#### **Plant and equipment sizes based on the following:**

1. Meeting the Supply Security Standards.
2. Meeting Power Quality Standards:
  - Voltage Criteria.
  - Total Harmonic Distortion (THD).
  - Voltage Unbalance, Fluctuation, Dip, Over Voltages and Power Factor.
3. Loading Limits:
  - Underground Cable.
  - Overhead Line - OHL.
4. Circuit Loading Limits Based on Voltage Regulation Considerations.
5. Fault level.
6. TAQA Distribution's standard equipment and conductors' sizes.

### **Others:**

Network planning may be influenced by geography, such as falaj, mountains, valleys, and international borders. Political decisions and national approaches further shape planning by determining which sectors (residential, agricultural, industrial...etc.) are prioritized.

### **The details of plant and equipment sizes shall consider:**

- 1- Meeting the Security of Supply Standards described in the previous section.
- 2- Meeting Power Quality Standards:
  - Voltage Criteria:

In principle as per The Electricity Supply Regulations and The Electricity Distribution Code and Electricity Wiring Regulation 2020 for LV supply voltage operated under a restricted range. The distribution system planning should consider maintaining a voltage variation of – 6.0%: +10% at customer's service entrance terminals, allowing a 4% voltage drop in the consumer's wiring installation so that the minimum voltage at the terminals of the electrical equipment is limited to 90% of the nominal voltage.

The maximum voltage variation permitted at each of the 33kV & 11kV distribution voltage levels should be coordinated to achieve the required end result of voltage variation discussed above at customer's terminals, after accounting for the effects of on load tap changers at the primary substation transformers and the off-load tap changers at the distribution substation transformers, including the effects of the no load voltage regulation of the primary and distribution transformers. With respect to the above, the Voltage criteria applicable to TAQA D – AA Region system are as given below: -

- Typically, the 33kV voltage at the end of a 33kV circuit under normal loading should be maintained above the minimum acceptable value of 0.90 PU nominal. Under abnormal loading conditions, the HV terminal voltage at 33/11kV substation should be 0.85 PU or more.
- The ratio, impedance and tap-range of 33/11kV transformers should be sufficient to deliver rated load at 11kV, 0.85 P.F with 0.9 PU (29.7kV) applied to the HV terminals.
- Typically, the 11kV voltage at the end of an 11kV circuit should normally be maintained above the minimum acceptable value of 0.95 PU at the extreme end of the line, under normal loading conditions.
- The supply voltage provided to customer should be satisfied under all conditions by changing the tap changer of 33/11kV transformer and 11/0.4 kV distribution substations or by carrying out necessary 11kV network modification.

**Table 2.3: Total Harmonic Distortion (THD) Maximum Planning Limit**

Voltage Level KV	THD %
33	3
11	4
0.4	5

As per The Electricity Supply Regulations and the Electricity Distribution Code.

**Table 2.4: Voltage Unbalance, Fluctuation, Dip, Over Voltages and Power Factor**

Item	Permissible Value
Max. Voltage Unbalance	$\leq 2\%$ (at PCC), $\leq 1.3$ (at individual loads)
Max. Fluctuation	$\leq 3\%$ (depending on the rate of occurrence)
Max. Flickering	Pst $\leq 1.0$ and Plt $\leq 0.8$
Power Factor	0.9-1.0 at Customer end, $\geq 0.91$ at TAQA <b>Transmission</b> Interface
Max. Voltage Dip (Sag)	Amplitude $< 60\%$ V <sub>nom.</sub> , lasting $< 1$ Sec
Temp. Over Voltages	$\leq 1.7$ V <sub>nom.</sub>

As per The Electricity Supply Regulations and the Electricity Distribution Code.

### 3- Loading Limits of Distribution System Component:

One of the important objectives of the distribution system planning, apart from developing the system to meet increased load growths, is to fully exploit system component limits and thereby ensuring effective use of existing system components.

The distribution system should be planned to provide adequate system capacity for each of the different system components, i.e., overhead lines, cables, transformers and switchgear etc., without exceeding the limits related to thermal, voltage instability and voltage drop.

There are two principal limits to power transfer at a given power factor. These are:

- Current limit, which is set by the assigned current rating.
- Voltage limit, which is based on the minimum acceptable receiving end voltage.

The limiting loads for typical system elements are set by thermal considerations and such limits vary for different climatic conditions and the same with the limits of component temperature rise permitted.

The operating limits discussed above, for each of the different system components such as overhead lines, cables and transformers are covered in the guidelines.

▪ Overhead Line Conductor Loading Limits:

As far as thermal limit of overhead line circuits is concerned, the main factors determining the current carrying capacity limit of a conductor, apart from material and conductor cross sectional area, are the wind speed, ambient temperature, and the temperature at which the conductor is allowed to operate under fully loaded condition.

Aluminum conductors start to anneal above 80°C, resulting in loss of strength and an increased tendency to creep.

The continuous current rating limits, for each of the different types of overhead line conductors used in TAQA D – AA Region’s 33 kV distribution systems, to be considered for the design and planning considerations would be based on the following basic parameters:

- Ambient temperature: 50°C.
- Wind Velocity: 0.6 m/s.
- Intensity of solar radiation: 1000 W/m<sup>2</sup>.
- Solar radiation absorption coefficient: 0.8
- Emissivity coefficient: 0.8
- Final conductor temperature for continuous rating: -
  - Copper - 70°C., ACSR - 80°C., AAAC - 80°C.

For planning of the distribution system, the current carrying capacity, based on thermal limits, for each of the relevant overhead line conductors, as typically used in TAQA D – AA Region system, are summarized in Table 2.5. This table provides the current and the MVA rating of different conductors.

**Table 2.5: Recommended Ratings for 33kV Conductors**

Ref. Code	Conductor Description	Normal Conditions Amps	Normal Conditions MVA
OH1	150 mm <sup>2</sup> Wolf – ACSR	346	19.7
OH2	95 mm <sup>2</sup> CU	237	13.5
OH5	150 mm <sup>2</sup> CU	310	17.7
OH3	200 mm <sup>2</sup> CANTON – AAAC	381	21.8
OH4	240 mm <sup>2</sup> POPLAR – AAAC	429	24.5
OH6	300 mm <sup>2</sup> Sycamore – AAAC	508	29.0

▪ **Underground Cable Loading Limits:**

The MVA rating for normal conditions is based on cable operating at 90 degrees C and a load factor of 100%.

The MVA rating under Emergency conditions increases the normal rating by 20% based on a cable temperature of between 90 degrees C. and 130 degrees C. and a load factor of 75%.

The continuous current rating limits, for each of the different types of underground cables used in the distribution system in Al Ain, to be considered for the design and planning considerations would be based on the following basic parameters: -

- Ambient temperature: 50°C
- Maximum Soil Ambient temperature: 40°C
- Thermal soil resistivity: 1.2 K.m/W.
- Loading factor: 100%.
- Maximum conductor temperature for both the continuous and emergency rating:
  - Copper/XLPE - 90°C
- Final Conductor temperature for short time short circuit rating:
  - Copper/XLPE- 250°C

Typically, taking account of the cyclic nature of the load, the normal rating of underground cables can be increased to the extent of 5% on an average, when considering a load cycle

10 hours at 80% of rated capacity followed by 14 hours at 100%, rated capacity means load factor (0.92).

For planning of the distribution system, the current carrying capacity for underground cables is summarized in the following Table 2.6:

**Table 2.6: Recommended Ratings for 33kV Cables**

Cross-section Area mm <sup>2</sup> / Cable Type	Normal Conditions Amps	Normal Conditions MVA
3C x 240 mm <sup>2</sup> , Cu/ XLPE Cable	300	17.2
3C x 300 mm <sup>2</sup> , Cu/ XLPE Cable	335	19.1
3C x 400 mm <sup>2</sup> , Cu/ XLPE Cable	355	20.3
3C x 400 mm <sup>2</sup> , AL/ XLPE Cable	325	18.6

The rating shown in the above table is applicable to copper conductor and Aluminum cables spaced at 500 mm, from an adjacent fully loaded cable. The value of soil resistivity of 1.2 K.m/W is based on the trench being filled by selected backfill ( $\rho \leq 1.2$ ) when local soil resistivity is measured as greater than 1.2K.m/W during installation and allows for partial drying-out around the cable when fully loaded. Where groups of more than three cables are installed in close proximity, a stabilized cable surround, typically a 20:1 cement/sand mix should be employed to maintain the desired rating.

- Transformer Loading Limits:

The permissible loading of transformers is determined by the temperature reached at the hottest spot in the winding. Rapid deterioration and reduction of transformer lifetime results if temperatures are allowed to raise above the maximum hot spot temperature levels.

Transformers should not in practice be loaded above their assigned nominal name plate rating, although a higher emergency short time loading in excess of normal rating can be tolerated dependent on the extent of loading on the transformer prior to the application of emergency overloading.

The transformer-loading limit at the grid and the primary substations, in line with the Security Standards is as summarized below:

- The Grid transformers should normally be loaded to take their appropriate share of the total system load based on its firm capacity. These transformers

should not in practice be loaded in excess of 50% of its rating for substations with 2 transformers (or loaded below 67% for substations with 3 transformers) to account for “N-1” contingency outage criteria.

- The 33/11 kV primary substation transformers at each of the primary substations should normally be loaded up to 50% for substations with 2 transformers (loaded up to 67% for substations with 3 transformers, with the spare capacity enabling outage of one of the connected transformers for routine maintenance or breakdown. The maximum allowable transformer loading during contingencies is 100% of the nameplate.

#### 4- Circuit Loading Limits Based on Voltage Regulation Considerations:

Voltage regulation is concerned with the ability of the distribution circuits to maintain acceptable voltages at all points of the system under normal as well as contingency outage situations.

The loading limit at 33 kV, based on voltage drop are evaluated in this report as typical example, using following criteria: -

- The voltage at the sending end being 100% of rated nominal voltage.
- The maximum permissible voltage-drop along the 33 kV line being 6% normal loading conditions
- The load being concentrated at the receiving end of the line at typical load power factors.

Considering a more widely used 33kV cable or 33kV overhead line conductors in the TAQA D – AA Region system, the maximum loading and load length that can be served by these conductors using the planning criteria are as summarized in Table 2.7 shown below:

**Table 2.7: Load-Distance for Typical 33kV Feeders, based on 10% voltage regulation**

Feeder Type	Loading (MVA@11kV)	Feeding Distance (km)		
		0.85 p.f.	0.75 p.f.	0.95 p.f.
3c/ 240 mm <sup>2</sup> Cu/XLPE Cable	15	>40	>40	>40
“Wolf” 150 mm <sup>2</sup> ACSR Overhead Line	20	10	10	12
	15	20	18	23
	10	30	27	35
	7.5	40	40	47

Table 2.7 shows maximum feeding distances for an overhead line feeder utilizing “Wolf” 150 mm<sup>2</sup> ACSR Overhead Line. The model includes a transformer of the stated MVA rating, with an effective tapping of 0.85 p.u., e.g. a 33/11kV transformer with a -15% tap or a 33/11.55kV transformer with a -10% tap. Since the maximum load on the feeder is likely to be seen only under abnormal conditions (e.g. on outage of an

adjacent transformer or 33/11kV substation), the 11kV voltage was allowed to fall to 95% of nominal.

The “capacitor corrected” feeding distances presume that compensation is connected at 11 kV sufficient to correct load at 0.75 p.f. up to 0.95 p.f. at 11kV. The power factor seen at the Grid supply point is lower because of MVAR losses in the transformer and line, typically 0.9 p.f. net (as clarified in Item 2.2.1 Voltage Criteria)

Hence rural feeders utilizing 20 MVA transformers should be limited in length to around 10 km, with 15 MVA load maximum 18 km, unless the power factor can be improved. Should feeder lengths be greater than these values, loads must be reduced approximately pro-rata to the increase in feeding distance as shown in the above table.

5- Fault Level:

Fault level study is required for equipment sizing, protection settings and defining the appropriate operation modes.

6- TAQA D – AA Region standard equipment and conductors’ sizes:

Electrical equipment sized based on the above-mentioned requirements. Therefore, calculation of sizes and rating for equipment and conductors during the design stage are to be checked and matched with TAQA D – AA Region standards (almost same size or next higher size standards).

**2.2.2 Harmonics (design standards)**

Total Harmonic Distortion (THD) Maximum Planning Limit: -

**Table 2.8: Voltage & Harmonics Thresholds**

Voltage Level KV	THD %
33	3
11	4
0.4	5

As per The Electricity Supply Regulations and the Electricity Distribution Code.

### 2.2.3 Earthing:

#### - 33kV System Earthing

In general, neutral point of 220/33kV supply transformer of network 33 kV is in majority of the network directly connected to the earthing system through direct connection of the transformer neutral with earthing grid. There are few no. of 220/33 kV grid stations transformer earthing are with NGR at 33 kV side. Exposed metallic parts of elements of 33 kV network are connected to the 33kV protective earthing.

#### - 11kV System Earthing

Neutral point of 33/11kV supply transformer of network 11 kV is in majority of the network directly connected to the earthing through direct connection of the transformer neutral with earthing grid (there is no additional resistance or inductance - solidly grounded). Exposed metallic parts of elements of 11 kV network are connected to the 11kV protective earthing.

#### - LV System Earthing

LV network is directly earthed (solidly grounded).

In networks substations 220/33 kV and 33/11 kV, 33kV and 11kV protective earthing are connected to 33kV and 11kV operational earthing. The MV cable armours/interstitial conductors/screens and OHGW/OPGW - lightning conductor (if installed) and other lightning protection installations are connected to the protective earthing.

In distribution substations 11/0.4 kV, 11kV protective earthing is separated from 0.4kV operational earthing mostly in case of areas out of cities (poor soil conditions and enough space for effective separation) whilst mostly it is combined in city zones and where soil conditions allow the same.

### Criteria for Designing of Earthing Systems

The earthing system has to be designed based on TAQA Distribution Standard for Technical Specification and TRE (appendix to Specification) according to safety criteria, but also to withstand thermal overloads by ground fault currents.

### Maximum Allowable Touch and Step Voltage

The earthing system is sized according to touch and step voltage (IEEE std.80-2013 cl.8.4). The values of the touch voltage have to be under maximum allowable touch and step voltages for a body weight of 50 kg calculated as:

$$E_{touch} = (1000 + 1.5C_s \cdot \rho_s) \frac{0.157}{\sqrt{t_s}} \quad 2.1$$

Where

$$C_s = 1 - \frac{0.09(1 - \frac{\rho}{\rho_s})}{2h_s + 0.09} \quad 2.2$$

$$E_{step} = (1000 + 6C_s \cdot \rho_s) \frac{0.157}{\sqrt{t_s}} \quad 2.3$$

and

$E_{touch}$ : Maximum allowable touch voltage in [V] (for 50 kg person)

$E_{step}$ : Maximum allowable step voltage in [V] (for 50 kg person)

$\rho$ : Specific soil resistivity in [ $\Omega$ m]

$\rho_s$ : Specific resistivity of the surface material [ $\Omega$ m]

$h_s$ : Thickness of the surface material [m] and

$t_s$ : Fault duration time in [s]

The touch voltage has to be under allowed value determined using (2.1) at any ground fault, and at any fault location, but also overall in the network where touch voltage appears as a consequence of transferred potential.

## 2.2.4 Protection and Control Systems:

### Control-Protection-Supervision MV/LV Substation Protection Schemes

Table 2.9 summarizes generally the minimum requirements of the protection schemes in various types of feeders in 33kV and 11kV in TAQA D – AA Region network, which are in line with good engineering practices; For the protection system design and testing requirements, TAQA Distribution Standard Technical Specifications shall be met, which also cites compliance to international standards for protection systems such as IEC 60255.

**Table 2.9: Minimum Requirements of the Protection Schemes**

Feeder Type	Main Protection # 1	Main Protection # 2	Back-Up Protection	Remarks
1. 33kV Outgoing (Cable or OHL with OPGW)	Current Differential protection with Distance.	-	Over Current and Earth Fault Protection (OC/EF)	Distance function blocked only for cable circuits which are less than 5km.
2. 33kV Incomer (Cable)	Current Differential protection with Distance	Directional OC/EF protection	OC/EF	Distance Protection function blocked at LOAD ends
3. 33kV Outgoing (OHL without OPGW)	Distance protection	-	OC/EF	
4. 33kV Incomer (OHL without OPGW)	Distance protection	Directional OC/EF protection	OC/EF	Distance Protection function blocked at load ends
5. 33kV Bus Section (bus bars)	Bus differential protection	-	OC/EF protection, and OV/UV(2 stages)	The voltage relay configuration shall be for alarm in 2 stages.
6. 33kV Transformer	Transformer Differential protection	REF protection	OC/EF , SBEF protection, and OV/UV(Alarm)	The voltage relay configuration shall be for alarm in 2 stages.
7. 11kV Transformer incomer, 11kV Bus section and 11kV outgoing (Cable)	OC/EF			-
8. 11kV outgoing OHL	OC/EF + sensitive Earth Fault Protection + broken conductor protection			SEF/BCP shall be fed from CBCT, which shall be additionally provided.
9. 11 kV Incomer cable/OHL with OPGW (Switching station)	Current Differential protection	Directional OC/EF	OC/EF	-
10. 11 kV outgoing cable/OHL with OPGW (Switching station)	Current Differential protection	Directional OC/EF	OC/EF	-
11. 11 kV outgoing OHL without OPGW (to Switching station)	Distance	-	OC/EF	-

12. 11 kV incomers (OHL without OPGW at Switching Station)	-	Directional	OC/EF	-
13. 11kV Auxiliary Transformer	REF	SBEF	OC/EF	-
14. 11kV Distribution Transformer	OC/EF	-	SBEF	SBEF to be configured as an alarm/trip.
15. 11kV Capacitor Banks	OC/EF, Thermal Overload, Over Load, Neutral Unbalance, Over/Under Voltage			
16. Grid 33kV	Low Impedance Bus Bar Protection			
17. Grid 11kV, Primary 33kV, VIP Switching Station 11kV	High Impedance Bus Bar Protection			

### 2.2.5 Protection Setting Requirements:

Prior to field tests on protection relays/IEDs, the user/Bidder/Contractor shall provide protection setting study to TAQA Distribution for approval including settings and parameters with all necessary calculations using TAQA Distribution approved software/tool, single line diagrams, grading curves etc. to set the protection relays/systems to the substation conditions and power grid requirements.

Setting requirements for the distribution network shall adhere to standard specifications which covers various requirements, for example, operation time at grid station shall not exceed 0.8 sec in all cases

### 2.2.6 Transient stability:

- Replacing porcelain insulator with polymer insulator.
- TAQA D – AA Region power network is applying both automatically load shedding (UFLS), and manual load shedding, where both are updated annually as summarized below:
  - Auto Load shedding (UFLS) scheme 40% of Al Ain load will be automatically shed in five stages if the frequency is dropped below certain values starting at 49.3 HZ. Refer to Appendix 2.8.1.
  - Manual Load shedding list is prepared to cover 20 % Al Ain load that will be shed if requested. Refer to Appendix 2.8.2.

### 2.2.7 System Automation:

- Earth Fault Indicators (EFI) are installed in distribution substations to identify fault locations for proper isolation and service restoration.
- Auto-reclosers are used to clear transient faults, improving SAIDI & SAIFI.
- UFLS implemented in 33kV level at 220/33kV grid substations, with UFLS set based on TAQA Transmission 's requirement, which are updated annually.

TAQA D – AA Region plan related to system Automation is presented in Appendix 2.8, while TAQA D – AA Region initiated contracts to meet Automation Strategy is presented in Appendix 2.8.3.

#### **Additional Efforts/Initiatives:**

In addition to the above-mentioned contracts, TAQA D – AA Region works on the following internal efforts/initiatives to support the automation strategy:

##### **1. Activate the second communication links for (3G / 4G) based substations.**

This means that the substations that are connected to DMS through (3G / 4G) network which is provided from ETISALAT and the same substation have been provided with a connection of FOC to TAQA D – AA Region fiber network, accordingly, will be integrated to DMS with the 2nd fiber-based link by internal efforts. During the year of 2021, 5 substations have been completed with a 2nd fiber-based link fully by internal TAQA D – AA Region (in-house) efforts. Moreover, during 2022, four substations were added to the network followed by the addition of five substations in 2023. In 2024, six substations were backup by 3G/4G due to weather conditions.

##### **2. Interconnect grid stations to formulate DMS external network to be used for substations integration and to increase the stability of the network.**

This will be achieved by creating a fiber Optic based backbone for TAQA D – AA Region to be used for OT applications. Four grid stations have been interconnected for this purpose during 2023 (NZKHR-GD and DAHMA-GD). In 2024, AASW-GD is linked to NZKHR-GD

##### **3. In-house RTU configuration upgrade for the installation of new 3G/4G cellular gateways project.**

#### **2.2.8 Automatic load shedding scheme in Al Ain area**

For the existing network but not for the planned network, Auto & Manual Load shedding scheme, which is prepared and updated on a yearly basis. Where in the Auto Load shedding scheme 40% of Al Ain load will be automatically shed in five stages if the frequency is dropped below 49.3 HZ (Refer to in Annex A2 - 2.8.1 Auto Load Shedding scheme).

#### **2.2.9 Manual load shedding scheme in al Ain area**

While Manual Load shedding pre-prepared list of circuits, which represent 20% Al Ain load that will be shed if requested (Refer to in Annex A2 - 2.8.2 Manual Load Shedding scheme).

#### **2.2.10 Auto-recloser monitoring and indication.**

- TAQA D – AA Region 11 kV OHL Network is equipped with switching devices, which can identify the faulty portions along the OHL (sectionalizers) followed by automatic switching of specific devices called Auto-reclosers to restore supply to the customers fed from the healthy portions. These devices would help in reducing the number of affected customers who should not be affected by being fed from healthy portions. The availability of these equipment on the OHL plays a significant role in limiting the interrupted customers and would minimize the time required to inspect the suspected faulty portion following the activation of these devices. Such devices would help in areas having sand dunes where movement of vehicles might be hindered during patrolling.
- EFI and Auto-reclosers will be integrated with SCADA system, once the ADMS project completed (CR # A-16901). The majority of EFI in the 11 kV network will be integrated, however the ARC modeling is available in ADMS.

### **2.2.11 Operating voltages (target and bandwidth) for each voltage level of the distribution system**

- The voltage at grid stations is automated, where bandwidth is updated twice a year for summer and winter. Summer bandwidth is between 34 to 33 kV while winter bandwidth is between 33.7 and 32.4 kV. Also the 11 kV is almost set to auto mode in the primary stations and the bandwidth is between 11.3 to 10.8 kV. For the primary stations where the Auto tap changers are defected then the voltage for the 24 hour is monitored to ensure the voltage is between 11.6 to 10.5 kV.
- 33kV OHL feeders are provided with auto-recloser facilities.
- Auto reclose function is integrated into distance protection for 33 kV line feeders.
- The 3-phase time delays dead times shall cover between 0.1 and 3.0 seconds in steps of 0.05 seconds or less.
- There shall be a reclaim (blocking) time following the successful completion reclosure of about ten seconds (10 s). If during this period, a further fault takes place, a 3-phase trip and lockout shall be provided.
- Auto-reclose settings are activated for 33kV OHL feeders and 33kV composite feeders where cable circuit length is 20% or less of total circuit length.

### **2.2.12 Use of voltage drop compensation.**

- AVR, Capacitor bank for 11 KV OHL network.
- 33/11kV Power transformers- automatic on-load tap change control is employed and generally follow the requirements of standard technical specifications. 11/0.4 kV distribution transformer- off-load tap change control is employed.

### 2.2.13 Load management areas

Load management in the network is the responsibility of different sections in EOMD at TAQA D – AA Region, namely control center, Field operation in city and regions and it shall depend mainly on the studies performed by studies section to assure that the network is running under high level of security. Load management can be assured by the following:

- Load transfer between the grid stations and the primary substations to avoid load violation and to ensure that loading under criteria (N-1) is applicable to the utmost extent.
- Selection of optimum locations of the NOP's along the 11 kV feeder rings.
- Implementation of reinforcement schemes which shall be based on the network performance and loading during peak time.
- TAQA D – AA Region/EOMD is managing the load depending on provided power by 23 grid stations through M/s. TAQA Transmission.
- Relief of overloaded circuits.
- Increasing the number of integrated substations to SCADA system.

In general, studies are done for the power network. The first study is “Network Summer Preparation” where the study presents the following:

- The expected peak load for each grid, primary and 11kV feeders.
- The 11kV NOPs locations.
- Stations expected to violate firm capacity.
- Expected unsecured package unit.
- Expected Unsecured 11 kV rings.
- 11 kV Radial Feeders.

The second study is “Network Actual Peak Load study” where the study presents the following:

- The Actual peak load for each grid, primary and the 11 kV feeder.
- Stations with load violated the firm capacity.
- Unsecured package units.
- Unsecured 11 kV rings.
- 11 kV Radial Feeders.

These reports are considered as inputs for demand forecast, network expansion and reinforcement studies by TAQA D – AA Region planning team. Planning and Operation teams have internal discussions, meetings and clarifications to finalize required actions based on these reports.

However, there are some difficulties and challenges that could impact the load management as follows:

- Delay in commissioning of new grid stations and primary stations.
- The long process taken to award contracts.
- Critical status of some equipment in the network due to aging/non-availability of spares.
- Delay in execution and commissioning of 11 KV reinforcement schemes.

TAQA D – AA Region mitigation actions for the mentioned challenges and risks are as follow:

- Internal coordination with concerned departments and external coordination with TAQA Transmission to expedite required actions.
- Optimize load distribution within the neighborhood and nearby substations in collaboration with NOD

Moreover, the following are TAQA D – AA Region mitigation actions to address the critical status of certain equipment in the network due to aging and lack of spare parts:

- Work closely with internal departments to evaluate the condition of critical equipment.
- Ensure load is managed within the de-rated capacity with NOD.
- Collaborate with T&PS to adjust protection settings as necessary.
- Collaborate with internal departments to review/develop a replacement or rehabilitation plan based on their assessment.

These risks with Mitigation actions are identified in TAQA D – AA Region operating procedures and forms.

#### **2.2.14 Areas where constraints or other restrictions are used to maximize system utilization.**

- The 220/33 KV Grid station configuration are considered as main challenge that leading to operation constrains resulted in individual operation of 33/11kV primaries transformers without parallel operations due high short circuit currents from the source or to non-identical of the power transformers at the 220/33kV grid stations.
- The geographical location of AADC 33/11 KV primaries (the location of substation and how far they are from urban areas) considered as main constrain for better system. The substation locations are selected based on demand requirements and

locations, TAQA D – AA Region license obligations and according to Abu Dhabi Utility Plot Design Manual issued by DMT.

- The condition and age of the substation components may affect the substations utilization.
- External authorities' decisions or approaches affect the planning like supporting definite type of activities, agriculture, industrial or restricting system expansion in some areas.

### 2.2.15 Innovation

- Pilot implementation of online fixed partial discharge at Grid stations.
- Condition Monitoring Sensors / Web-portal (Cont. No. A20604.1), AI Powered Inspection platform for OHL Assets integrating GIS Assets in the platform and Maximo for workorder tracking.

### 2.2.16 Clean Energy Targets

TQD is enabling the sector to achieve the clean energy target, at various timelines, as set by the government and per TAQA strategy & directions. Meanwhile, we provide hereunder the status of our action plan:

- **Digitalization of Distributed Energy Resources (DER) Application Process:**

TQD has initiated steps to digitalize the DER application process to enhance efficiency and streamline approvals. This includes:

Current Status: All relevant internal stakeholders have agreed to the process flow chart, based on the earlier organization chart. However, due to changes within the organization, the process chart is being reviewed to incorporate the changes in designation and to establish a unified process for both AD and AA regions.

Projected Timeline: Expected test rollout by Q4-2025 and go-live by Q1-2026.

Benefits: Improved processing times, reduced paperwork, consistent records, and enhanced user experience and journey for applicants.

Alignment with DoE Policies: This initiative supports and enables DoE's objective of promoting renewable energy integration and operational efficiency.

- **Connection Agreement for Embedded Generation Projects:**

TQD is actively working on the DER application process and collaborating directly with customers to establish connection agreements. Specific details include:

Current Progress: Agreement template has been established and approved by TQD's internal stakeholders, and one agreement has been signed off. Currently connection agreements are under discussion with customers.

Eligibility Criteria and Process: Clear guidelines on the eligibility criteria and the step-by-step process for entering into these agreements have already been established.

Other Agreements: In addition to the connection agreements that are being signed between the applicant and TQD, we are also coordinating with EWEC for embedded generations, wherever Power Purchase Agreements are recommended per DoE's guidance.

Metering arrangement: TQD has also established a metering philosophy for all embedded generation and self-supply connections to facilitate any future policy implementation.

Future Reporting: TQD will provide the number of signed connection agreements to give a clear picture of progress, from the next submission.

- **Expected Outcomes of DER:**

Improvements: Reduced Power loss, lower peak demand, differed capacity investments for upstream infrastructure, clear TQD and user responsibility, enhanced grid stability, improved network utilization, increased renewable energy uptake and contributions to energy efficiency.

Support for DoE Policies: These efforts align with DoE's policies to support the integration of renewable energy sources and promote a flexible, reliable energy system.

TQD understands that a detailed policy from DoE may not be forthcoming at this stage. Therefore, TQDC remains committed to ongoing discussions and collaborative efforts to ensure these initiatives progress in alignment with DoE's overarching policies and objectives. This proactive approach will contribute significantly to the shared goals of energy efficiency and sustainability.

## 2.3 Selection of Assets

Selection of asset specifications based on operation condition (outdoor, indoor), geographical area, forecasted loading, and short circuit values at the planned location in the distribution network, voltage drop. The planned network is modelled by SINICAL software, this is to ensure that all technical aspects in all expected operation scenarios as loading limits, voltage drop, short circuit limit, etc...

## 2.4 System Configuration

TAQA D – AA Region power system configuration designed to meet and in line with Supply Security Standards, Voltage Criteria, Total Harmonic Distortion (THD), Voltage Unbalance, Fluctuation, Dip, Over Voltages and Power Factor, TAQA D – AA Region standard equipment's and conductors' sizes, TAQA D – AA Region Standards Technical Specifications ASTS, International standards and issued regulation. Brief description of various TAQA D – AA Region power network types are listed below:

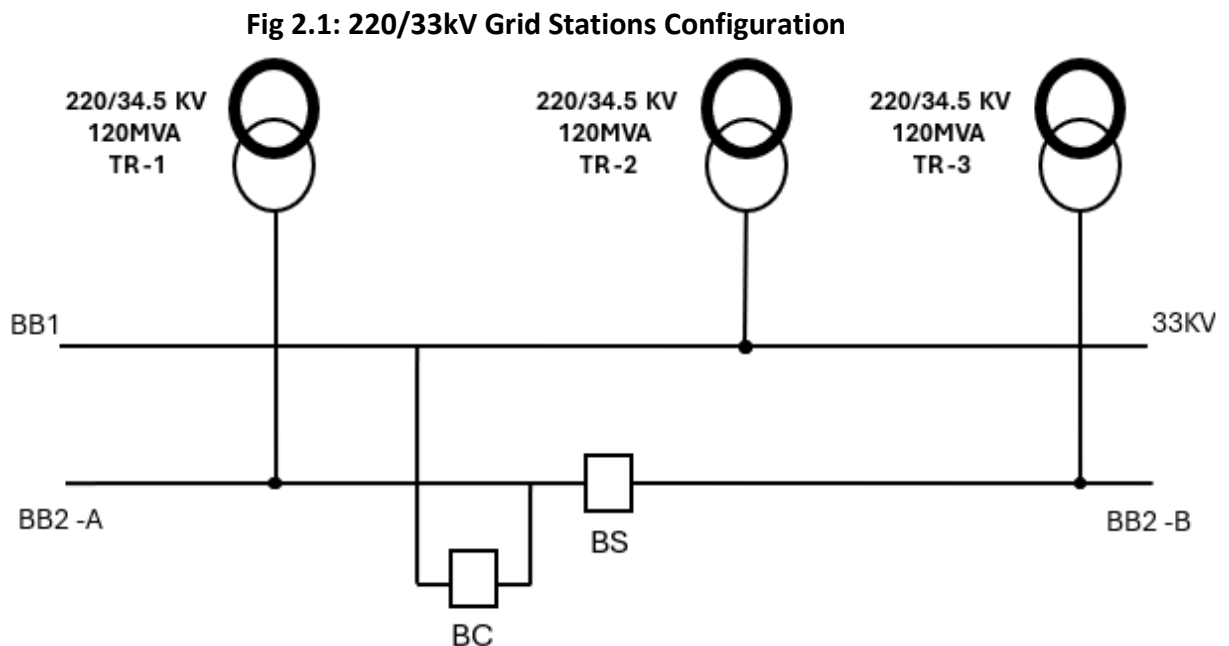
### 2.4.1 220/33kV Grid Stations configurations

M/s. TAQA Transmission consultant recommended the following configuration for the new Grid Stations:

For residential areas: 3x120 MVA Transformers with Z% = 25 to facilitate the parallel operation for three transformers and comply with security of supply standards.

For Industrial areas: 3x100 MVA Transformers with Z% = 25 to facilitate the parallel operation for three transformers and comply with security of supply standards.

For both types the recommended 33kV bus bar configuration is shown in the next drawing (one solid/continued bus bar and the second bus bar has two sections in addition one bus coupler).



## 2.4.2 33/11 KV Primary Substations Configuration

### A. Residential (Urban) Primary Substations:

The standard sizes of the residential area substations are supposed to be equipped with the following based on the load:

- 3x20 MVA transformers.
- 2x20 MVA transformers, with provision to add 3rd transformer in future according to load growth.
- 3x15 MVA transformers.
- 2x15 MVA transformers, with provision to add 3rd transformer in future according to load growth.

While 4 x 15 & 4x20 MVA transformers are not recommended due to:

- It will be more expensive than installing 3 x 20 MVA transformers, while little difference in the firm capacity.
- There are constraints for parallel operation of the four transformers from short circuit level point of view, accordingly the supply security standard can't be met in case of transformer or bus bar failed.
- Concentrating the capacity in one place.
  - Practical difficulties for cable corridors, de-rating for cables current carrying capacity due to the grouping condition especially in the primary substation vicinity.
  - Cost considerations.
- In some situations, Package Unit Substations are supposed to be installed to meet quick development with capacity of 2\*10 MVA or 2\*15 MVA Package Substations. Some of the temporary type of Package substations being/planned to be replaced with proper brick-built substations within the next years of development.
- Generally, Capacitor banks are connected at each section of the Primary Substation as shown on Drawing No DWG AA SWG 02 01 07 (Conceptual Design of 33/11KV Distribution Substation).

### Feeding Arrangement:

The standardized 33 kV cable size of 3\*300 mm<sup>2</sup> matches the 20 MVA transformer rating for the future development of the distribution system.

For substation installations with 3 Nos. 20 MVA transformers, 3 nos. cable feeders' size of 3\*300 mm<sup>2</sup> from the grid stations are required as normal supply feeding

arrangement (preferably all three feeders from the same grid station, but from three different bus-bars) to meet with the “N-1” security standard.

For substation installations with 2 Nos. 20 MVA transformers, 2 Nos. cable feeders’ size of 3\*300 mm<sup>2</sup> from the grid stations are required as normal supply feeding arrangement (preferably both the feeders from the same grid station, but from two different busbars) to meet with the “N-1” security standard.

For substation installations with 3 Nos. 15 MVA transformers, 3 nos. cable feeders’ size of 3\*240 mm<sup>2</sup> from the grid stations are required as normal supply feeding arrangement (preferably all three feeders from the same grid station, but from three different bus-bars) to meet with the “N-1” security standard.

For substation installations with 2 Nos. 15 MVA (or 2\*10 MVA) transformers, 2 Nos. cable feeders’ size of 3\*240 mm<sup>2</sup> from the grid stations are required as normal supply feeding arrangement (preferably both the feeders from the same grid station, but from two different busbars) to meet with the “N-1” security standard.

#### **B. Farm (Rural) Primary Substations:**

The substations in rural areas can be 10MVA or 15MVA installed singly, in pairs or with up to three units. The majority of substations feed farm loads. The 33kV circuits are predominately overhead, both looping and teed arrangements can be used to supply two or more primary substations after checking the protection difficulties by the specialists.

#### **Feeding Arrangement**

Where a rural area load is predominantly of farm type and the load is within 7.5 MVA, a single 33kV circuit feed arrangement with one/two transformers of appropriate size 10MVA or 15 MVA with interconnected 11kV network with other. When the load grows above 7.5 MVA, then one of the requirements stated below will apply and system upgrading will be affected then as appropriate to the nature and size of development.

#### **2.4.3 11kV Distribution Feeders:**

For planning of the 11kV distribution systems, the current carrying capacities for 11kV underground cables are summarized in the following Table:

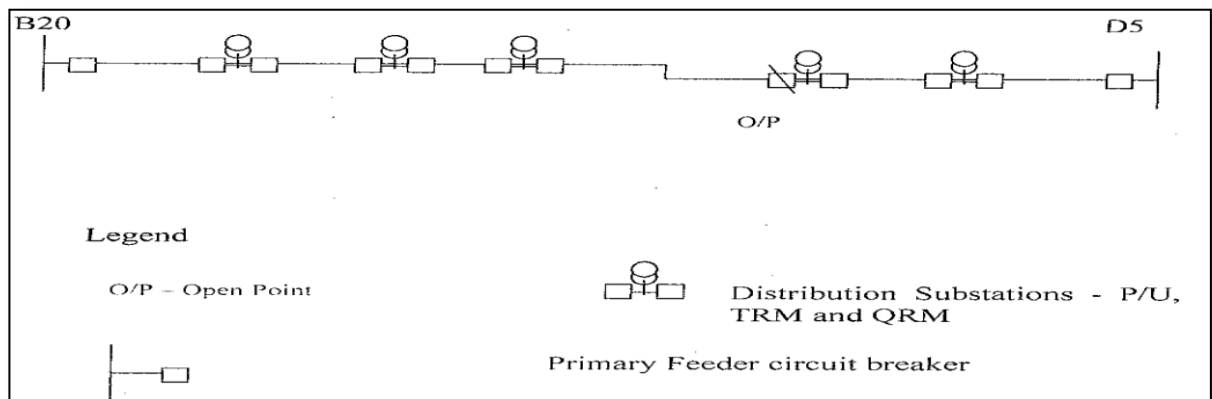
**Table 2.10: 11kV Underground Cable Ampacity (AMPS/MVA)**

Cross-section Area mm <sup>2</sup>	Normal Conditions	
	Amps	MVA
3C x 95 mm <sup>2</sup> Cu/ XLPE Cable	150	2.8
3C x 185 mm <sup>2</sup> Cu/ XLPE Cable	246	4.6
3C x 240 mm <sup>2</sup> Cu/ XLPE Cable	310	5.9
3C x 300 mm <sup>2</sup> Cu/ XLPE Cable	342	6.5
3C x 400 mm <sup>2</sup> Al/ XLPE Cable	325	6.2

**a) Open-Loop Ring Main Feeder Configuration:**

An open-loop ring main feeder configuration consists of two or more feeders that are interconnected through normally open switches or circuit breakers. The open loop has at least two sources. The open points are located in switchgear.

**Fig 2.2: Open-Loop Ring Main Feeder Configuration**



The number of distribution substations connected to each feeder is based on the peak demand of the substations and the type of feeder arrangement.

The following table can be used to provide a guide for the maximum number of distribution substations that can be installed on each 11kV underground feeder with 240 mm<sup>2</sup> copper cable. This is only an estimate based on average values. An annual review of actual feeder loading should be done to determine if additional substations could be installed on feeders without overloading the feeder.

**Table 2.11: Maximum Nos of distribution S/S to be installed on 11kV UG feeders**

Number of Feeders Interconnected	Load on Feeder as a % of Capacity	Maximum Quantity of Distribution Substations
2	50%	3
3 or more with an express feeder	100%	6
3 or more without an express feeder	50%	3

Recommended Open-Loop Feeder Arrangement with TRM/QRM Substations – Low to Medium Load Density

**b) Open-Loop Ring Main Feeder with Automatic Sectionalizing:**

The Open-Loop Ring Main Feeder with Automatic Sectionalizing configuration is a normal design practice that is used in TAQA D – AA Region Power Network planning for new loads in Rural Areas.

Automatic sectionalizing can be used to improve the reliability of an open-loop main feeder. One type of automatic sectionalizing uses three automatic switches installed between each of the two feeders. The three switches can be installed on either side of major loads or installed to split the two circuits into four sections if the load is uniformly distributed. This automatic sectionalizing scheme is called a switch and one-half scheme because the two feeders share three switches. A fault in any one of the four sections will be isolated so that power is automatically restored to the other three sections.

**c) 11kV OHL feeder's configuration:**

For planning of the 11kV distribution system, the current carrying capacity for 11kV OHL conductors are summarized in the following Table.

**Table 2.12: Current Carrying Capacity for 11kV OHL conductors**

Cross-section Area mm <sup>2</sup> / 11 KV OHL conductor Type	Normal Conditions Amps	Normal Conditions MVA
95 mm <sup>2</sup> /Cu	258	4.9
70 mm <sup>2</sup> /Cu	207	4
50 mm <sup>2</sup> /Cu	163	3.1

1. The OHL pole arm grounding/creepage length of insulators for different kind of areas.
2. The grounding of any metal part is done on H-Pole (Section & PMT), and it is executed as per the latest ASTS (i.e. by drilling and the criteria is based on the acceptable resistance value).

3. For the creepage distance related to insulators and since Al Ain area is considered as of similar weather condition, the creepage distance is depending on the material of the insulators, accordingly the accepted creepage distance should be as per the latest ASTS:
4. Porcelain: 50 mm/kV
5. Polymer: 40 mm/kV

#### **Auto reclosing scheme for 11kV OHLs:**

1. OHL Auto-reclosers are installed according to the number of customers, the load of the feeder and its topology.
2. OHL sectionalizers are installed mainly on branches in order to isolate only the faulty portion, and their locations are calculated according to the number of customers and the load to determine the number of needed sectionalizers.
3. More details are available in the Design Guidelines V03.

## **2.5 Location of Electrical Assets**

The locations of 220/33kV grids and 33/11kV primary substations on geographic plan(s) are shown in drawings region wise per Appendix 2, 2.10.

## **2.6 Key Asset Data**

Key assets currently owned and connected to electricity distribution system are described in Appendix-2 categorized by region, grid, primary, distribution, cables, overhead lines, underground cables, length, capacity etc. (Refer to table -1 in chapter-1, Annex A1 - 1.1 and Annex A2).

# CHAPTER 3: Power Demand Forecast

## 3.1 Historical Peak Load Demand Data

Al Ain area covers an area of about 13,327.11 KM<sup>2</sup>, the peak demand of Al Ain area increased from 1349 MW in year 2005 up to 2,821 MW in year 2024 with average rate of increase 4.0% since 2005. On 24 June 2024 TAQA D – AA Region peak Demand reached 2,821 MW. The rate of increase for peak demand of year 2024 compared with year 2023 is about 2.8%.

Moreover, TAQA D – AA Region evaluated the load behavior during the year with special attention on high demand season (from May 2024 - September 2024) and observed the following:

- TAQA D – AA Region Peak Demand forecast was prepared based on school timing, and leave season, special events and considering that, the temperature range / weather conditions will be the same during summertime (May-September) annually.
- June in the UAE is typically one of the hottest months, with temperatures frequently exceeding 45°C. This results in a significant increase in electricity demand, especially for cooling systems like air conditioning, which are essential in residential, commercial, and other sectors. The high temperature has a direct impact on peak demand.
- The peak demand for TAQA D – AA Region occurred on June 24, falls within the last week of the school year in the UAE.
- The total simultaneous load of three grid stations (SNYA-GD, MZYD-GD and FYDH-GD) was requested by EWEC to be limited to 590 MVA to avoid overloading at 220 kV lines connecting these substations, the actions taken by AADC in this regard impacted the forecast accuracy at the 220/33 KV interface points.

Appendix 3.1, Figure 3.1 and Table 3.1 show the historical data for the peak demand of Al Ain area from the year 2005 up to year 2024.

## 3.2 Forecast Peak Load Demand Data

### 3.2.1 Source of Data

To obtain precise forecast figures close to reality, all maximum possible efforts are made to collect information about the future major projects, industrial, commercial and residential, from different sources. Following are the key sources of this information:

### Outside TAQA D – AA Region:

- Department of Municipalities and Transport.
- Al Ain Municipality (Town Planning Department).
- Different consultants.
- Different Developers such as Qudra Holding, Mubadala and Al Dar.
- Customers' requests (applications).

### Inside TAQA D – AA Region:

- Customer Services Directorate.
- Asset Management Directorate (Power Network Performance Section).
- Electricity O&M Directorate (Operation & Maintenance Department).
- Electricity O&M Directorate (Network Management Division).

## 3.2.2 Demand Forecast Methodology.

### A. Primaries/ Grid Stations Forecast

The peak load for each primary/grid station is forecasted taking into consideration the following items:

- Addition of Bulk load and new Development projects. (Refer to chapter 7)
- Load transfer.
- Normal load growth.

Final yearly load forecast for each grid station and for Al Ain area whole system, up to the year 2030, is obtained by the summation of load for all primaries/ grids and applying appropriate coincidence factor of (0.96) (Average of the last years C.F).

Appendix 3, A3-3.3 shows the forecast of all the primary substations in Al Ain, in addition to the forecast of all grid stations up to year 2030.

The major impact to the forecast result from the new development projects expected completion date and the accuracy of projects calculated loads, in addition to the delay in execution of TAQA Transmission new projects in Al Ain, which is affecting all plans and forecast accuracy for grid stations.

### B. TAQA D – AA Region Global peak demand Forecast

TAQA D – AA Region peak load forecast is done by Regression Analysis (Extrapolation Technique) which is the study of the behavior of a time series or a process in the past and its mathematical modeling so that future behavior can be extrapolated from it. The general approach usually followed for the trend analysis is related mainly to fitting of mathematical functions through actual data to achieve the least overall error.

Referring to below Figure (3-1) / Table (3-1) the regression analysis of the historic information on the peak load (using trending tool in MS-EXCEL Program) indicates that the load can be represented by either of two equations which could be used for the development of high and low demands forecast scenarios:

**High demand forecast represented by the equation:**

$$P_h = 72.843 \times n + 1321.7$$

$$= 3,265 \text{ MW for the year 2030}$$

**Low demand forecast represented by the equation:**

$$P_l = -0.5915 \times n^2 + 85.265 \times n + 1276.2$$

$$= 3,179 \text{ MW for the year 2030}$$

Also, Figure (3-2)/Table (3-2) show the peak load forecast after adding the bulk load.

**High demand forecast will be:**

$$P_h = 3,413 \text{ MW for the year 2030}$$

**Low demand forecast will be:**

$$P_l = 3,242 \text{ MW for the year 2030}$$

### 3.2.3 TAQA D – AA Region Demand Forecast Conclusion

- Peak Demand Forecast has been developed for TAQA D – AA Region by two methods considering TAQA D – AA Region (System) Peak load and Grid Wise Demand Forecast, the detailed development for demand by each of these methodologies is discussed in the previous sections.
- Three scenarios for the peak demand forecast and a comparison between the results of the two methodologies are illustrated in Table (3-3) below.

### 3.3 Historical Peak Demand Forecast Accuracy

According to historical demand forecast accuracy monitoring, TAQA D – AA Region demand forecast showing exceptional demand forecast accuracy up to 99.1%. The calculation of the accuracy of the historical peak demand forecast for 5, 4, 3, 2, and 1 year ahead are included in Appendix 3, A3-3.2.

### 3.4 Energy Forecast

**Energy Forecast Methodology:**

TAQA D – AA Region Energy-forecast is done by Regression Analysis method, the energy consumption in the last years is plotted and a trend curve is fitted to this known data. These trend curves give the future energy requirements. Regression Analysis for getting energy consumption scenarios up to year 2030 is based on the following methods:

- Overall energy Forecast.
- Category-wise Energy Forecast.
- Customers Energy Forecast.

These methodologies are compared and three scenarios for the forecast are developed:

- Base case scenario.
- High forecast scenario.
- Low forecast scenario.

Bulk load above (5MW) customer energy consumption of mega projects, housing and industrial, is forecasted separately and added to the total energy forecast.

### 3.4.1 Overall Energy Forecast:

The total energy consumption is shown in Table (3-4) below by using two scenarios representing high forecast scenario and low forecast scenario.

High Energy forecast represented by the equation:

#### High energy forecast:

$$E_h = 16,430.466 \text{ GWh} \quad (\text{for the year 2030})$$

#### Low energy forecast:

$$E_l = 15,390.345 \text{ GWh} \quad (\text{for the year 2030})$$

### 3.4.2 Category-wise Energy Forecast:

This methodology is based on the energy forecast for each category supplied by TAQA D – AA Region and summation of these to come up with the total energy forecast. Two forecast scenarios are developed, high forecast scenario and low forecast scenario. The new bulk loads energy expected consumption is added to the corresponding consumption category.

The following categories are taken into consideration for the forecast: Residential, Commercial, Large Commercial, Agricultural, Industrial, Governmental, Non-Metered, Public Services and Losses.

The calculation of the accuracy of the historical energy consumption per category forecast for 5, 4, 3, 2, and 1 year ahead are included in appendix 3, A3-3.8.

### **Total Sum of Energy Forecast for All Categories:**

The energy forecast for TAQA D – AA Region is the summation of the forecast consumption of the different categories. Thus, the results of the total forecast for TAQA D – AA Region are presented in Table (3-5).

#### **High energy forecast:**

$$E_h = 16,349.466 \text{ GWh} \quad (\text{for the year 2030})$$

#### **Low energy forecast:**

$$E_l = 15,418.853 \text{ GWh} \quad (\text{for the year 2030})$$

Appendix 3, A3-3.6 shows the historical consumption per category from year 2007 up to year 2024. While Appendix 3.7 shows the percentage of each consumption category in the years 2023 and 2024, (reference is total sold energy during year 2023, 2024). While Figure (3-3) below shows the percentage of Energy Consumption per category up to year 2030 (reference is total received energy).

### **3.4.3 Customers Forecast**

An analysis has been carried out to develop the number of customers served by TAQA D – AA Region. The number of customers related to bulk load or mega projects is forecasted separately and added to the forecasted number of customers.

The average consumption per customer is an indicator of the social condition of the residential customers and an indicator of the economic conditions of the region, which affect the commercial and industrial sectors. The product of the forecasted number of customers by the forecasted consumption per customer gives the total energy forecast.

#### **Number of Customers forecast:**

Referring Table (3-6), the regression analysis of the historical information for the number of customers indicates that the development of the total number of customers can be represented by either of two scenarios, high and low forecast scenarios including bulk load customers:

The high forecast scenario:

$$C_h = 194,756 \quad (\text{By year of 2030})$$

And the low forecast scenario:

$$C_l = 188,373 \quad (\text{By year of 2030})$$

#### **Assumptions used for number of customers' estimation:**

- For load normal growth KW/customer is got from the historical data for the past years (about 15:16 KW/customer). This value is used to calculate the yearly-added no. of customers based on the added load (MW) due to normal growth.

- From the new projects load details, the yearly addition of demand due to bulk load is available.
- The yearly addition of number of customer due to bulk load is mainly equal to the addition of Residential and Commercial new projects load kW divided by kW/customer of such project, which is about 30 kW/ Customer.

#### Total Energy Forecast:

Referring to Table (3-7), total Energy forecast is the product of the forecasted number of customers by consumption per customer.

The forecast for the high scenario is **16,430.466 GWh** (By year of 2030) while, The forecast for the low scenario is **15,390.345 GWh** (By year of 2030).

#### 3.4.4 Conclusion

Energy forecast has been developed for TAQA D – AA Region by three Methodologies. These methodologies are discussed in the previous sections. The comparison between the results of these methodologies is illustrated in Table (3-8) and three scenarios for a high and low forecast are shown. The following is a comparison of the forecasts for the year 2030.

Methodology	Low Scenario (GWh)	High Scenario (GWh)
Overall Energy Forecast.	15,390.345	16,430.466
Category-wise Energy Forecast	15,418.853	16,349.466
Customers Energy Forecast	15,275.855	16,208.132

The average of the high and low energy forecast is calculated to get the base scenario to reduce the calculation errors. The base scenario of the energy forecast is the average of the all demand forecast scenarios, and the same is shown in appendix 3, A-3.5.

#### 3.4.5 Load Factor

The historical values of load factor “which shows the relation between the Energy (MWH) and load (MW)” is indicated in appendix 3, A3-3.9.

### 3.5 Demand forecast coordination and alignment with TAQA Transmission and EWEC

As per usual practice, TAQA D – AA Region coordinates with TAQA Transmission and EWEC to ensure alignment of sectors demand forecast and enable sector companies to proceed with further necessary actions related to their business. Once TAQA D – AA Region demand forecast submitted to EWEC and TAQA Transmission and

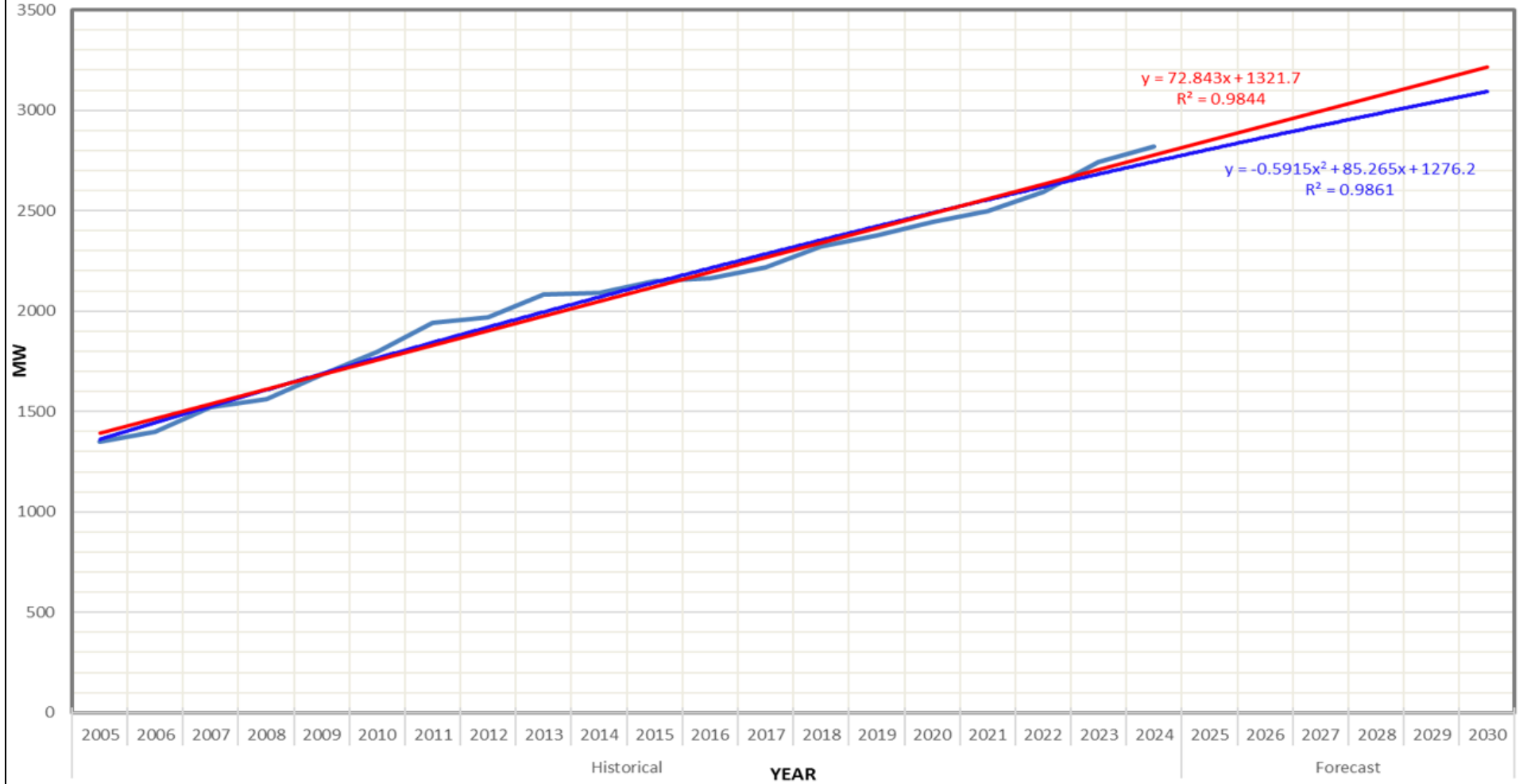
necessary coordination made, TAQA D – AA Region anticipate that each OPCO shall be responsible for own issued demand forecast accuracy. In case of updates accrued in Demand Forecast, TAQA D – AA Region share the updated forecast with TAQA Transmission and EWEC.

# DEMAND FORECAST TABLES & FIGURES

**Table (3-1): TAQA D – AA Region Demand Forecast Without Bulk Load**

Year	Historical Data (MW)	Forecasted (MW)	
		Low Scenario	High Scenario
2005	1,349		
2006	1,400		
2007	1,521		
2008	1,562		
2009	1,683		
2010	1,799		
2011	1,940		
2012	1,971		
2013	2,081		
2014	2,090		
2015	2,150		
2016	2,166		
2017	2,220		
2018	2,321		
2019	2,376		
2020	2,444		
2021	2,500		
2022	2,593		
2023	2,744		
2024	2,821		
2025		2,884	2,895
2026		2,945	2,969
2027		3,005	3,043
2028		3,065	3,117
2029		3,122	3,191
2030		3,179	3,265

**Fig (3-1)**  
**AADC Historical Peak Load**  
**With Best Fit Trend Equation**

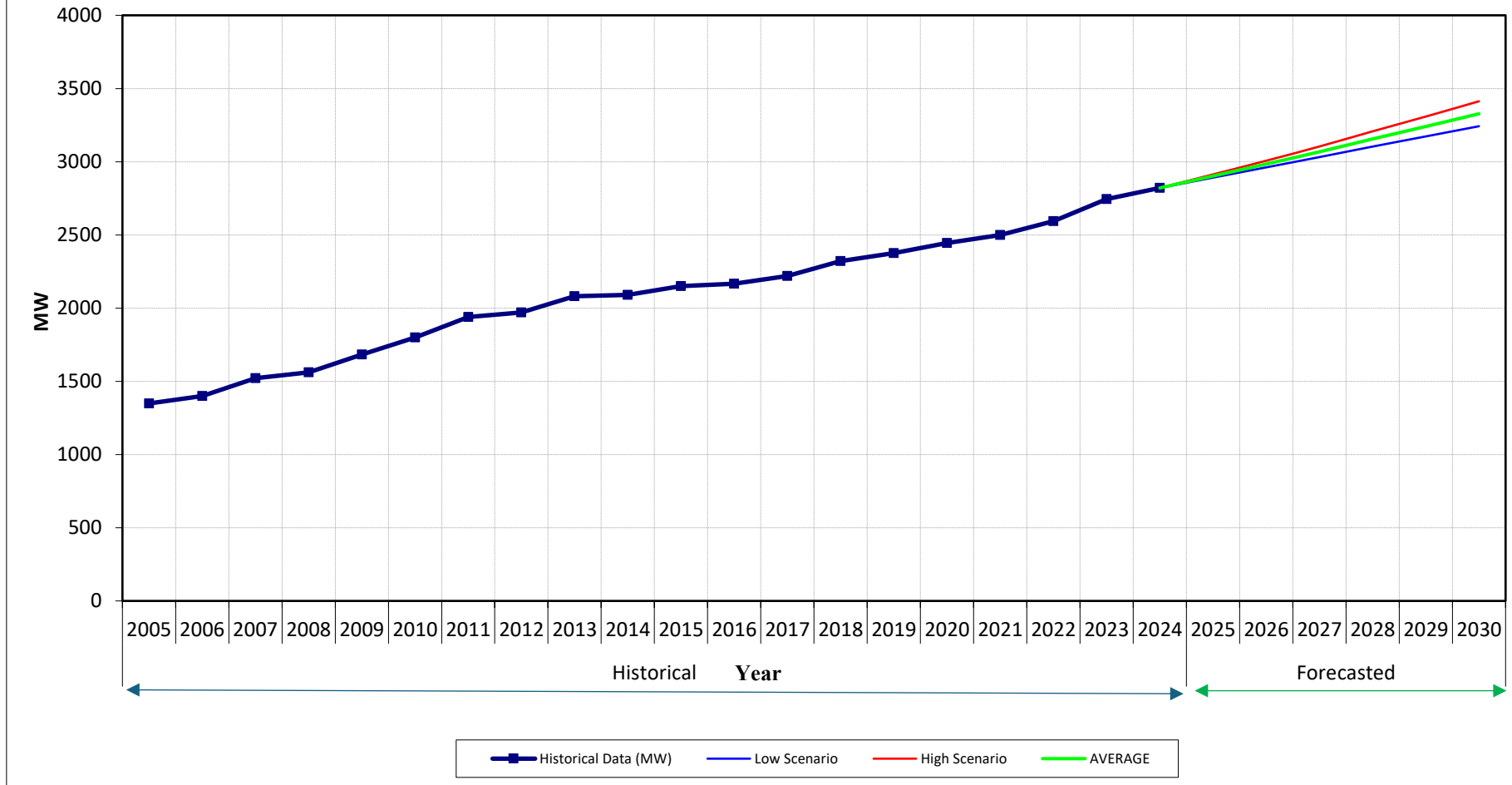


**Table (3-2): TAQA D – AA Region Demand Forecast Including Bulk Load**

Year	Historical Data (MW)	Forecasted (MW)	
		Low Scenario	High Scenario
2005	1,349		
2006	1,400		
2007	1,521		
2008	1,562		
2009	1,683		
2010	1,799		
2011	1,940		
2012	1,971		
2013	2,081		
2014	2,090		
2015	2,150		
2016	2,166		
2017	2,220		
2018	2,321		
2019	2,376		
2020	2,444		
2021	2,500		
2022	2,593		
2023	2,744		
2024	2,821		
2025		2,892	2,913
2026		2,961	3,007
2027		3,032	3,104
2028		3,103	3,208
2029		3,173	3,309
2030		3,242	3,413

\*These values are subjected to major changes as per the statues of Development Projects.

**Fig (3-2)**  
**AADC System Demand Forecast Up to Year 2030**  
**Including Bulk Load**



**Table 3-3: TAQA D – AA Region Demand Forecast - Average of The Two Methods**

Year	Historical Data (MW)	Method (1)			Method (2)	Average Forecast of the two methods	
		Total Demand Forecast (MW)			Grid Wise forecast (MW)	Base Scenario	Average growth rate %
		Low Scenario	Average	High Scenario			
2005	1,349						
2006	1,400						
2007	1,521						
2008	1,562						
2009	1,683						
2010	1,799						
2011	1,940						
2012	1,971						
2013	2,081						
2014	2,090						
2015	2,150						
2016	2,166						
2017	2,220						
2018	2,321						
2019	2,376						
2020	2,444						
2021	2,500						
2022	2,593						
2023	2,744						
2024	2,821						
2025		2,892	2,902	2,913	2,904	2,903	2.9%
2026		2,961	2,984	3,007	2,990	2,987	2.9%
2027		3,032	3,068	3,104	3,082	3,075	2.9%
2028		3,103	3,156	3,208	3,170	3,163	2.9%
2029		3,173	3,241	3,309	3,256	3,249	2.7%
2030		3,242	3,328	3,413	3,349	3,338	2.8%

\* These forecasted values are subjected to changes as per the statues of Development Projects.

**Table 3-4: Overall Energy Forecast Including Bulk Load Energy**

Year	Historical Data (GWH)	Forecasted Data (GWH)	
		Low Scenario	High Scenario
2005	6,693.150		
2006	6,984.000		
2007	7,370.000		
2008	7,485.069		
2009	8,328.192		
2010	8,751.593		
2011	9,071.286		
2012	9,280.432		
2013	9,438.516		
2014	10,041.799		
2015	10,629.658		
2016	10,517.018		
2017	10,946.255		
2018	11,045.039		
2019	11,031.014		
2020	11,294.198		
2021	12,105.575		
2022	12,382.504		
2023	13076.184		
2024	13,648.564		
2025		13,910.167	14,230.725
2026		14,310.530	14,800.084
2027		14,530.926	15,220.558
2028		14,830.534	15,580.271
2029		15,000.674	16,030.403
2030		15,390.345	16,430.466

\*These values are subjected to major changes as per the statuses of Development Projects.

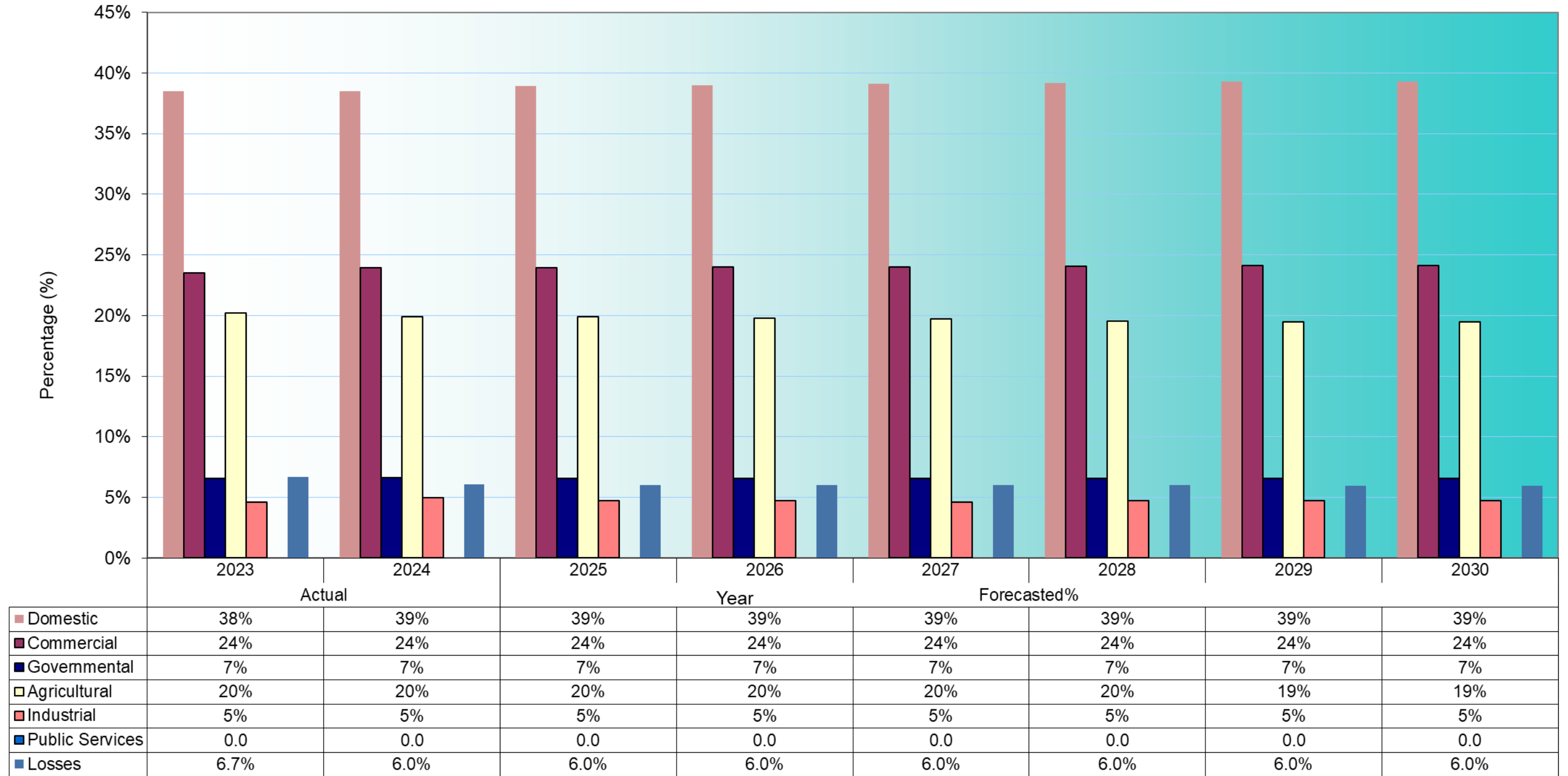
\* Energy figures includes AL Khazna Grid related metered values for ADDC.

**Table 3-5: Category-wise Energy Forecast Including Bulk Load Energy**

Year	Historical Data (GWH)	Forecasted Data (GWH)	
		Low Scenario	High Scenario
2005	6,693.150		
2006	6,984.000		
2007	7,370.000		
2008	7,485.069		
2009	8,328.192		
2010	8,751.593		
2011	9,071.286		
2012	9,280.432		
2013	9,438.516		
2014	10,041.799		
2015	10,629.658		
2016	10,517.018		
2017	10,946.255		
2018	11,045.039		
2019	11,031.014		
2020	11,294.198		
2021	12,105.575		
2022	12,382.504		
2023	13,076.184		
2024	13,648.564		
2025		13,909.964	14,210.745
2026		14,284.552	14,722.608
2027		14,595.823	15,175.542
2028		14,841.927	15,562.095
2029		15,020.406	16,032.327
2030		15,418.853	16,349.466

\*These values are subjected to major changes as per the statues of Development Projects

Fig (3-3)  
Percentage of Actual Energy Consumption / Forecasted Energy by Category (Average Scenario)



**Table 3-6: Total Number of Customers Forecast Including Bulk Load Customers**

Year	Historical Data (Customer)	Forecasted (Customer)	
		Low Scenario	High Scenario
2005	90,525		
2006	94,215		
2007	97,025		
2008	100,641		
2009	108,716		
2010	114,577		
2011	123,324		
2012	128,604		
2013	132,371		
2014	136,661		
2015	139,659		
2016	145,597		
2017	154,335		
2018	151,683		
2019	155,407		
2020	157,932		
2021	160,551		
2022	163,241		
2023	165,898		
2024	169,227		
2025		172,293	173,315
2026		175,421	177,486
2027		178,611	181,739
2028		181,865	186,078
2029		185,119	190,417
2030		188,373	194,756

The number of electricity customer accounts has fallen from 154,335 in 2017 to 151,683 in 2018. The cause of this reduction in total customer accounts is driven by the change in the SQL script that now identifies and removes cancelled SA's from PCR reporting

**Table 3-7: Energy Forecast (Per Customer Method)- Including Bulk load Energy**

Year	Historical Data (GWH)	Forecasted Data (GWH)	
		Low Scenario	High Scenario
2005	6,693.150		
2006	6,984.000		
2007	7,370.000		
2008	7,485.069		
2009	8,328.192		
2010	8,751.593		
2011	9,071.286		
2012	9,280.432		
2013	9,438.516		
2014	10,041.799		
2015	10,629.658		
2016	10,517.018		
2017	10,946.255		
2018	11,045.039		
2019	11,031.014		
2020	11,294.198		
2021	12,105.575		
2022	12,382.504		
2023	13,076.184		
2024	13,648.564		
2025		14,008.327	14,250.736
2026		14,318.541	14,816.846
2027		14,584.375	15,228.049
2028		14,858.732	15,599.683
2029		15,031.539	16,069.725
2030		15,275.855	16,208.132

**Table 3.8: Average of Energy Forecast Methods with Bulk Load Energy**

Year	Historical (GWH)	Method (1)		Method (2)		Method (3)		Average (GWH)		
		By Total Energy (GWH)		By Category (GWH)		By Customer (GWH)		Low	High	Base
		Low	High	Low	High	Low	High			
2006	6,984.000									
2007	7,370.000									
2008	7,485.069									
2009	8,328.192									
2010	8,751.593									
2011	9,071.286									
2012	9,280.432									
2013	9,438.516									
2014	10,041.799									
2015	10,629.658									
2016	10,517.018									
2017	10,946.255									
2018	11,045.039									
2019	11,031.014									
2020	11,294.198									
2021	12,105.575									
2022	12,382.504									
2023	13,076.184									
2024	13,648.564									
2025		13,910.167	14,230.725	13,909.964	14,210.745	14,008.327	14,250.736	13,942.819	14,230.735	14,086.777
2026		14,310.530	14,800.084	14,284.552	14,722.608	14,318.541	14,816.846	14,304.541	14,779.846	14,542.194
2027		14,530.926	15,220.558	14,595.823	15,175.542	14,584.375	15,228.049	14,570.375	15,208.050	14,889.212
2028		14,830.534	15,580.271	14,841.927	15,562.095	14,858.732	15,599.683	14,843.731	15,580.683	15,212.207
2029		15,000.674	16,030.403	15,020.406	16,032.327	15,031.539	16,069.725	15,017.540	16,044.152	15,530.846
2030		15,390.345	16,430.466	15,418.853	16,349.466	15,275.855	16,208.132	15,361.684	16,329.355	15,845.519

\*These values are subject to major changes as per the statuses of Development Projects. \* Energy figures includes AL Khazna Grid related metered values for ADDC

# CHAPTER 4: System Capacity and Studies

## 4.1 Load Flow Analysis

PSS/SINCAL software is used for power system analysis including load flow, short circuit analysis, power factor studies, and voltage drop analysis, the load flow calculation methods, and load flow output are included in Appendix- A4/ Appendix- A4.1 as described below:

- Appendix- A4 has Load-Flow calculation methods as described in the PSS/SINCAL program manual.
- Appendix- A4.1 has Load Flow Output introduces a brief for the Load Flow output.

### Circuits' Parameter per KM

Table below shows the 33kV OHL & UG cables electrical parameters.

**Table 4.1: 33 kV OHL & UG Cables Electrical Parameters**

Ref. Code	Conductor Description	Rating		Positive Sequence Impedance			Zero Sequence Impedance		
		Amps	MVA	R1	X1	B1	Ro	Xo	Bo
				$\Omega/\text{km}$	$\Omega/\text{km}$	$\mu\text{S}/\text{km}$	$\Omega/\text{km}$	$\Omega/\text{km}$	$\mu\text{S}/\text{km}$
OH1	Wolf – ACSR	346	19.7	0.2497	0.386	3.00	0.543	1.4620	3.00
OH2	95 mm <sup>2</sup> CU	237	13.5	0.2349	0.336	3.673	0.383	1.7560	3.673
OH3	CANTON – AAAC	381	21.8	0.2060	0.387	3.00	0.500	1.4630	3.00
OH4	POPLAR – AAAC	429	24.5	0.1707	0.380	3.00	0.464	1.4560	3.00
OH5	150 mm <sup>2</sup> CU	310	17.7	0.1492	0.320	3.60	0.297	1.7410	3.60
OH6	AAAC Sycamore	508	29.04	0.134	0.376	2.670	0.282	1.435	2.670
C1	CU-XLPE 3/C X 240 mm <sup>2</sup>	300	17.2	0.0984	0.107	65.0	0.440	0.0700	65.0
C2	CU-XLPE 3/C X 300 mm <sup>2</sup>	335	19.1	0.0795	0.102	72.0	0.410	0.0600	72.0
C3	Al-XLPE 3/C X 400 mm <sup>2</sup>	333	19.0	0.1019	0.1005	95.0	0.369	0.044	95.0

\* For UG cables (C1, C2 and & C3) the MVA rating is calculated based on:

1. Cables laid direct in ground.
2. Number of parallel cables in the trench: 3
3. Ground Temperature: 40°
4. Depth of Laying: 1.0m
5. Thermal Resistivity of Soil: 1.5 mK/W
6. Spacing between parallel cables: 0.5m

Table 4.2 shows 11kV OHL & UG cables electrical parameters.

**Table 4.2: 11 kV OHL & UG Cables Electrical Parameters**

Type	Conductor Description	Amps	MVA	R1 Ω/km	X1 Ω/km	B1 μΩ/km	R0 Ω/km	X0 Ω/km	B0 μΩ/km
OHL	CU-95	259	4.9	0.238	0.344	3.36	0.386	1.609	1.26
OHL	CU-70	214	4.1	0.339	0.355	3.25	0.487	1.620	1.25
OHL	CU-35	136	2.6	0.634	0.379	3.06	0.782	1.644	1.22
Cable	Al-XLPE 3/C X 400 mm <sup>2</sup>	330	6.3	0.102	0.083	158.3	0.282	0.0724	158.3
Cable	CU-XLPE 3/C X 300 mm <sup>2</sup>	342	6.5	0.079	0.090	109.90	0.560	0.065	109.900
Cable	CU-XLPE 3/C X 240 mm <sup>2</sup>	310	5.9	0.099	0.090	100.48	0.560	0.065	100.480
Cable	CU-XLPE 3/C X 185 mm <sup>2</sup>	273	5.2	0.127	0.101	91.06	0.635	0.505	91.060
Cable	CU-XLPE 3/C X 95 mm <sup>2</sup>	190	3.6	0.247	0.111	72.22	1.235	0.555	72.220

Table below shows the 33/11 KV Transformers Library electrical parameters.

**Table 4.3: 33/11 KV Transformers Electrical Parameters Library**

No.	Transformer			Vector Group	HV PRIMARY TRANSFORMER TAP DETAILS			
	MVA	Iz%	X/R		MINUS Range	PLUS Range	% Tap Steps	No. OF taps
1	20	15.00	20	DYn11	15%	10%	1.25	21
		12.00	20	DYn11	15%	10%	1.25	21
2	15	9.20	17.38	DYn11	10%	10%	1.25	17
		9.52	17.9		10%	6.25%	1.25	14
		9.60	18.1		12%	7.50%	1.50	14
		9.70	18.3		15%	5%	1.25	17
		10.00	19		15%	10%	1.25	21
		15.00	20		15%	10%	1.25	21
3	10	8.30	18	DYn11	15%	5%	1.25	17
		8.40	18		10%	10%	1.25	17
		8.50	18		10%	10%	1.25	17
		8.90	19		10%	10%	1.25	17
4	7.5	9.98	18	DYn11	10%	10%	1.25	17
		9.70	18		15%	5%	1.25	17
		9.63	18		15%	5%	1.25	17
5	5	6.80	18	DYn11	10%	10%	2.5	9
		6.60	18		10%	10%	2.5	9
		6.23	18		10%	10%	2.5	9

#### 4.1.1 Power Flow Study for Each Grid Station

The power flow for TAQA D – AA Region was done by modeling each grid station and its' connection to 33 KV network using PSS/SINCAL program. In this section, load flow analysis is carried out, for all the grid stations and primary substations in Al Ain, for the years 2025 up to year 2030.

Appendix A4-4.1 shows the results of the power flow analysis, which were performed to analyze the network weakness and strengths, and to identify the most effective mitigation actions when required. Also, the power system analysis is used to study future plans either for network growth or for existing network reinforcement.

#### 4.1.2 Finding, Actions and Plans

The results of the load flow studies for each grid station including related urban and rural areas are shown by the load flow output drawings.

Subsequent detailed analysis of the results, highlighting the distribution system inadequacies (related to each circuit elements) in meeting the requirements of the development plan.

Based on the substation (grids/primaries) loading demand analysis, load growth data and in the light of new grids/primaries planned commissioning dates.

Through the analysis, some important points were noticed as:

##### 4.1.2.1 Low P.F at some primaries

No low power factor at primary substations less than 0.8, however, in case of low power factor (less than 0.80) appears at 33/11 KV primaries, it will be rectified through the following actions:

- Managing existing capacitor banks at 33/11 KV primaries and on the 11kV overhead lines.
- To assure the customers have proper sizing of capacitor banks as per wiring regulation during the design stage and working properly after commissioning. However, due to absence of regulations or penalty mechanism still customers feel not accountable to meet these regulations.

##### 4.1.2.2 Loading of primaries and grid stations

It is noted that all primary substations and 33kV feeding arrangement are meeting electricity security of supply standards (SOS) and / or within the installed capacity except of the OHL feeding SHWEB-PY+ SHWBN2PU and SHWBN-PU that shall be resolved through TAQA D – AA

Region running contract A-20029 and NSASA-PU that shall be resolved through TAQA D – AA Region contract A-18644.

For non-complying 33/11 KV primary substation with SoS and future actions related to TAQA D – AA 33/11 KV primary substations and their 33 KV feeders are shown in Appendix 4.4.

There are some cases with low risk on TAQA D – AA Region power network. Some necessary temporary actions will be taken to mitigate the risk, such as:

- Issuance of 11kV schemes to shift some loads to nearby primaries.
- Installation of PUs as a temporary supply.
- Coordinate with different parties in order to expedite the construction of the new primaries.
- Operational techniques for load management to relief highly loaded assets.

#### **4.1.2.3 The plans for next summer 2025 are as the following:**

- TAQA D – AA Region arranged for emergency plans to secure the loads fed through primaries connected to AAPS due to severe weather conditions and floods occurred in Al Ain during February and April year 2024 by diverting part of the load through new installed 33 KV cables to other grid stations and through 11kV interconnected network.
- This action is temporary till the completion of replacing the AAPS grids with the new Grid station included in TAQA Transmission contract (N-17755) which is expected to be completed by year 2026.

## **4.2 Short Circuit Analysis**

TAQA D – AA Region uses PSS/SINCAL software for short circuit calculations. Appendix- 4 introduces a brief for the short circuit calculation methods as described in the PSS/SINCAL program manual.

The Short Circuit calculations were done by simulating each grid station and its connection to 33 KV network using PSS/SINCAL program. Three phases to ground and Single phase to ground short circuit calculations are carried out for all grid stations and primary substations in Al Ain, for the years 2025 up to year 2030.

Short circuit calculations were undertaken for maximum fault level conditions, for each grid station, to identify the highest fault currents. The calculation results of the three phases and single-phase Short Circuit are available in Appendix A4- 4.2.

**Table 4.4: Grid Stations Circuit Breakers Short Circuit Capacity**

S. No.	Grid S/S	Rated Voltage (kV)	Operating Voltage (kV)	Rated Short-Circuit Breaking Current (kA)	Rated Current (A)	Rated Peak Making Current (kA)
1	Al Arad	36	33	31.5	1250	80
2	Al Hayar	36	33	31.5	1250	80
3	Al Foah	36	33	31.5	1250	80
4	Al Wagan	36	33	31.5 *	1250 **	80 ***
5	Mezyad	36	33	31.5	1250	80
6	City Center	36	33	31.5	1250	80
7	Al Dahma	36	33	31.5	1250	80
8	AAPS - Calor Emag	36	33	26	1250	66.04
9	AAPS - Siemens	36	33	31.5	1250	80
10	AAPS - Toshiba	36	33	31.5	1250	80
11	Sweiha	36	33	31.5	1250	80
12	Al Sanaiya	36	33	31.5	1250	80
13	New Zakher	36	33	31.5	1250	80
14	Al Khazna	36	33	31.5	1250	80
15	Al Salamat	36	33	31.5	1250	80
16	Al Ain South West	36	33	31.5	1250	80
17	New Ramah	36	33	31.5	1250	80
18	Indu. City (AIAA- GD)	36	33	31.5	1250	80
19	Ain Al Fayda Grid	36	33	31.5	1250	80
20	UM-AL-OUSH	36	33	31.5	1250	80
21	New AAPH	36	33	31.5	1250	80
22	Zakher Grid****	36	33	26.2 *	1250 **	66.55 ***
23	Towaya Grid	36	33	31.5	1250	80

\*20KA is the short circuit interruption capacity value for 11kV switchgear (Transformer of tertiary winding)>

\*\*630 A is normal breaking current value for 11kV Switchgear (Transformer with Tertiary Winding).

\*\*\* 50.8KA is the making current capability value for 11kV Switchgear (Transformer with Tertiary Winding).

#### 4.2.1 Our findings

The existing configuration and characteristics of TAQA TRANSMISSION grid stations (3x140 MVA) at Al Ain city (City Centre, Sanaiya, and Al Salamat Grid Stations) has operational limitations that caused violation of security of supply standards as follow:

Operate the grid stations with 3x140 MVA transformers, with only two of them are operating in parallel with the third is operating independently at all times along with the provision of necessary interlocks to prevent long term paralleling of all the three 220/33kV grid

transformers on the 33kV side due to high short circuit current values which exceed switchgear short circuit rated current 31.5KA.

- Even with only two 220/33kV transformers running in parallel:  
Single phase to ground short circuit current values are high (29KA, which is 93% of switchgear short circuit rated current 31.5KA).

#### 4.2.2 Our Actions, Plans

TAQA D – AA Region highlighted some proposed solutions as follow:

- Consideration could be given to short time paralleling to enable live transfer of load from one transformer to the other two transformers when one of the respective is being taken out of service.
- Installation of Neutral Grounding Reactor (NGR) for TAQA Transmission/TAQA D – AA Region interface power transformers to limit the single-phase to ground short circuit values.
- Installation of current limiting series reactor with each 220/33kV power transformer to limit both the (3ph/LG) short circuit values and allow the operation of the grid stations with 3x 140 MVA transformers in parallel.
- Operate all 33kV grid bus sections closed at grids Al Dahma, Al Hayar, Sweihan, Al Wagan, and Al Araad (with 2x140 MVA or 2x80 MVA or with 3x 80 MVA transformers) to permit parallel operation of all the grid transformers at the respective grids.
- Operate the primary stations with 3 x 15 MVA, Z% = 10 with one of their three 11kV bus sections kept normally open (with one of the three transformers operated independently) based on transformers characteristics, available protections, interlocking systems and loads.
- Operate primary stations connected to grid stations where their 33kV bus bars are split; 33kV bus sections kept normally open at primary stations side in order to prevent paralleling of grid station transformers at the downstream primary end. This restriction could be avoided by re-arrangement of certain 33kV circuits in a few cases.

TAQA Transmission awarded two consultancy contracts to finalize the tender documents related to the output of consultancy services study N13848. The Implementation work shall be in stages:

- Stage 1: consultancy contract N16504 and contract N17722 which include (SWHG, SLMG and CTCG)
- Stage 2: consultancy contract N16169 and contract N17708 for the works in SNYG. The remaining shall be in later stages (which still not decided by TAQA TRANSMISSION).

### 4.3 Utilization of Assets

Appendix 4, Table 4.3 provides the utilization of existing grid, primary substations in 2024 and planned grid, primary substations from 2025-2030.

### 4.4 Demand Transfer Capability

Appendix A4-4.5, has table exploring the existing and planned load transfer capability based on existing and planned 33kV connections between grid and primary substations based on provided data in Appendix 3.3.

TAQA D – AA Region network configuration and interconnected substations through 33 KV and 11 KV networks enable high reliability of TAQA D – AA Region network and facilitate power restoration actions.

### 4.5 Security of Supply Non-compliance

There are two improvement notices for AA Network in the process be closed which are:

- ED L10 175 SHWEB-PY
- ED L10 212 NSASA-PU

where (SOS) is not met as described in Appendix A4 4.4.

TAQA D – AA Region is checking the network and any case that is not complied with SOS either primaries or feeders 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.

In addition, there are 7 Nos. of 220/33 kV grid stations belonging to TAQA Transmission where Electricity Transmission Security of Supply standard (SOS) are not met (with low risk for load restoration).

It is to note that AJBAN-GD project, currently under execution by TAQA Transmission, is expected to relieve the loading on SWHN-GD through planned load transfer. Furthermore, MASAKIN-GD project, which is currently under study and approval by TAQA Transmission, is anticipated to provide load relief to both AHYG-GD and FOHA-GD through similar load transfer arrangements, thereby facilitating the connection of new 33/11 kV primary substations to these grid substations.

### 4.6 Reactive Power Compensation

#### Primary Substations Capacitor bank

There are 11 kV capacitor banks in existing substations (BB /PU) in TAQA D – AA Region network, capacitor banks are switchable in different stages and set at 0.95 desired power factor, there are 24 loaded substitutions are set at 0.98 desired power factor.

New primary substations are equipped with 11 kV switchable capacitor banks, set at 0.95 desired power factor.

### **OHL Capacitor banks:**

Existing OHL Capacitor banks installed along TAQA D – AA Region network through contract A-5291 are set at 0.99 desired power factor to enhance the overall PF in different related subnetwork.

### **TAQA D – AA Region efforts:**

TAQA Distribution is continuously studying, reviewing and maintaining the existing capacitor banks and their associated controllers/relays, while analyzing its functionality through the real DMS/ADMS archived measurements comparing to the desired power factor. Overall, the capacitor banks are well functioning and achieve the desired reactive power compensation target.

However, currently there are limited numbers of capacitor banks at few primary substations which have some defects in the primary equipment side such as capacitor units and power factor controllers due to the equipment aging and obsolescence. TAQA Distribution is working to rectify these defects, through procurement of the required spare parts and replacement of the defective parts departmentally, associated with the related testing and commissioning activities to ensure the appropriate functioning towards achieving the desired reactive power compensation target.

### **Calculation of Integrated and Average Values:**

The calculation of the average values in the system is very precise building integrals based on the received analogs from the RTU's or SCMS's. The calculation of integrals is done via the following formula:

$$\text{Integral} = \text{Integral} + \text{old value} \times \text{time interval}$$

The time interval is the difference between two tele transmission cycles. During this period, the old value can be assumed as actual. The integration is performed at every transmission time as long as the predefined time interval has run out (half hour, one day). The division of the integral through the time interval results in the average value.

The average value is calculated for active and reactive power, but not for the power factor.

Refer to appendix 3.3 for actual and forecasted power factor at each primary substations and shows the actual and forecasted power factor for each grid station.

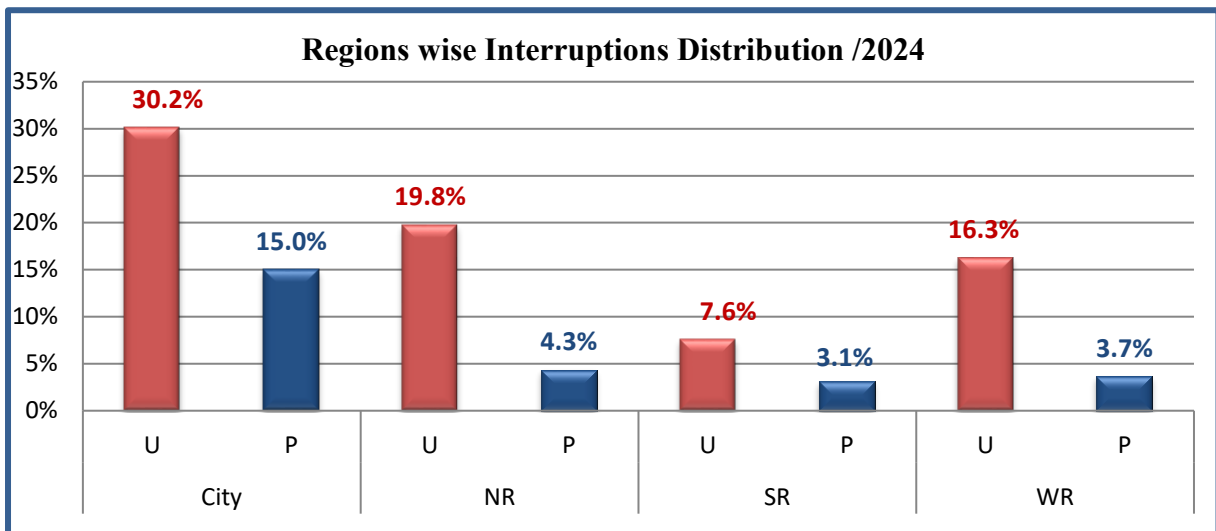
List of primary substations, which have existing capacitor banks & planned primary substations with capacitor banks already available in Appendix A2-2.9.

# CHAPTER 5: Performance Measurement

## 5.1 SAIFI and SAIDI Statistics

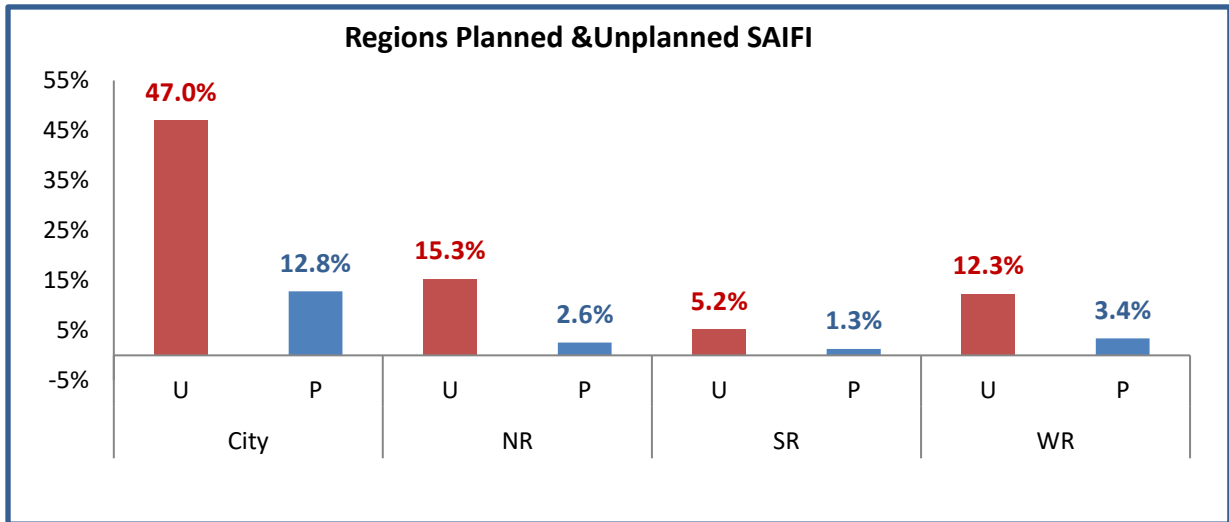
The results of the HV & LV customer’s interruptions records for the year 2024, define performance statistics, which accurately reflect the Licensee’s regional and cumulative clarification of System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) statistics. The data for the past 5 years with achieved figures and the performance targets for the next 2 years. The number of Unplanned and Planned outages in AL AIN networks are presented in the figure 5.1.

**Figure 5.1 Regions wise Interruptions Distribution /2024**

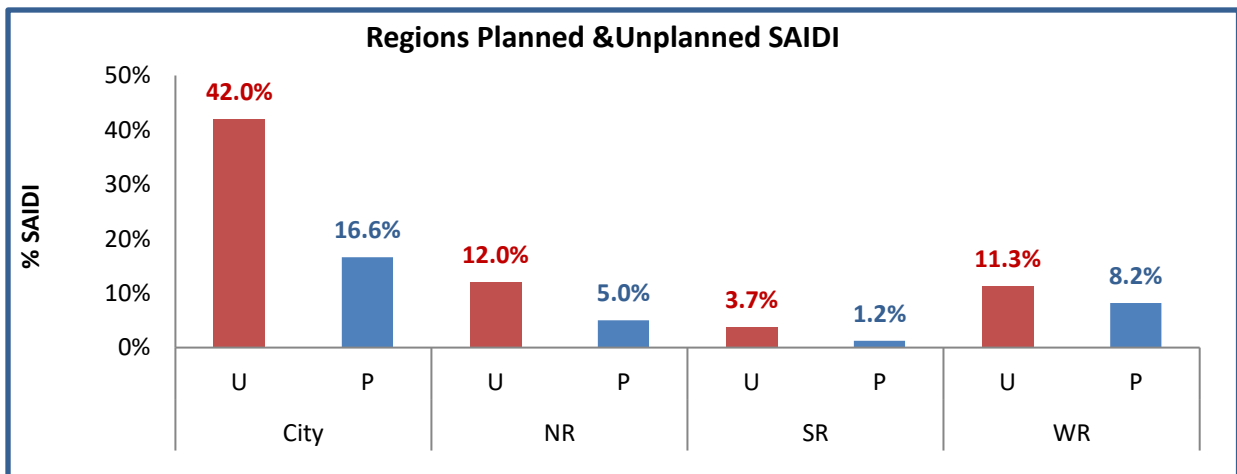


Unplanned and Planned interruptions in CR had the highest contribution, 30.2% & 15.0%, which is around 45.2% of total interruptions due to region length and region customers.

**Figure 5.2 Regions Planned & Unplanned SAIFI**

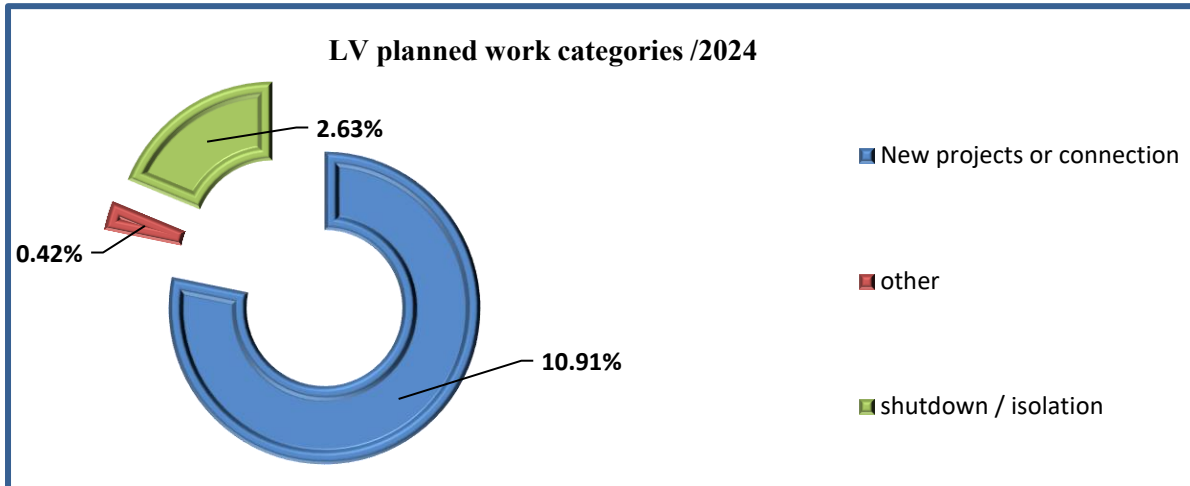


**Figure 5.3 Regions Planned & Unplanned SAIDI**

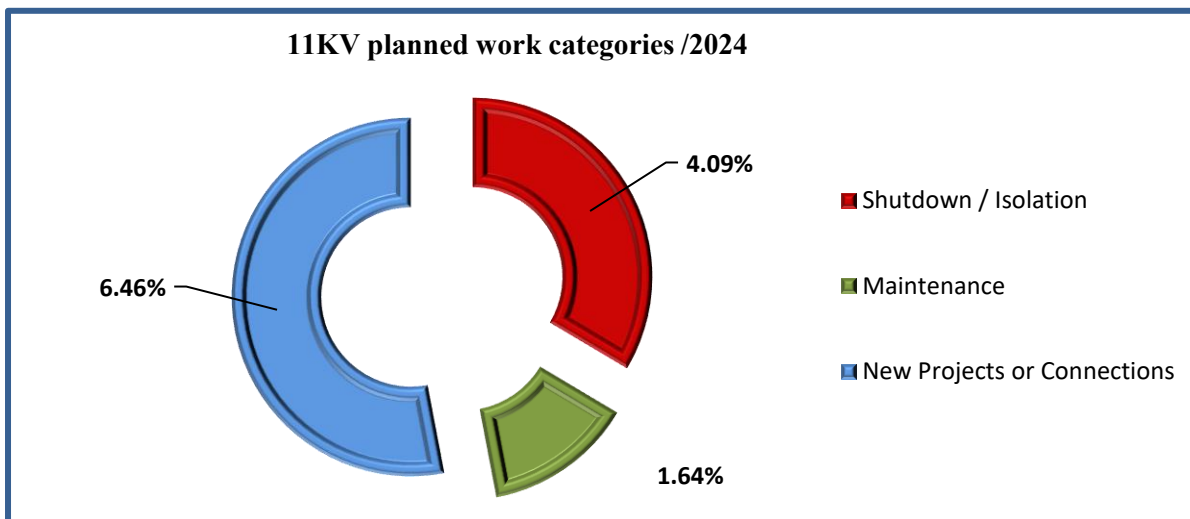


The average contribution of the number planned in 11KV & LV networks interruptions from the total interruptions in 2024 is around (26.15%), while the planned interruptions have impact on SAIFI (20.08%) and SAIDI (30.99%) in same year.

**Figure 5.4 LV planned work categories /2024**



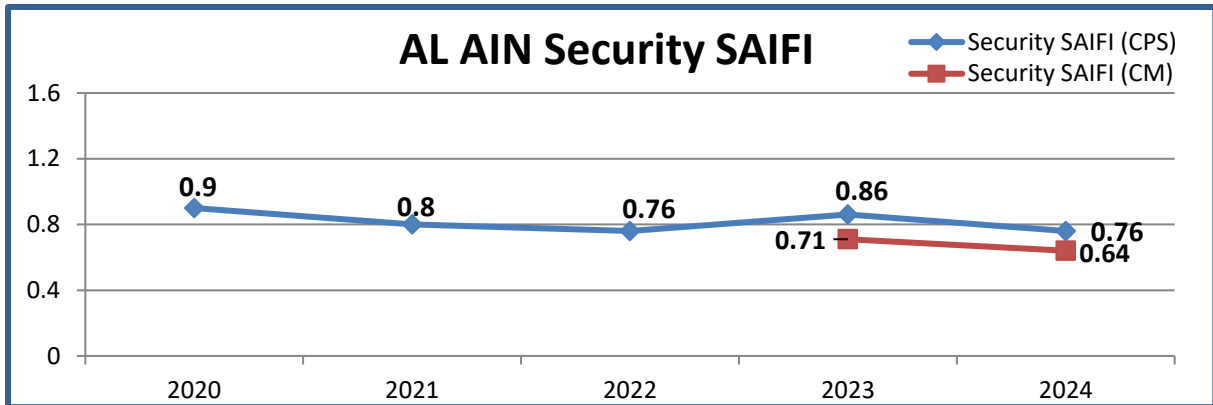
**Figure 5.5 11KV planned work categories /2024**



### 5.1.1 Total System Historical SAIFI

The following Figures 5.6 is presented from 2020 to 2024 the AL AIN System Average Interruption Frequency Index (SAIFI) for the last five years by using customer per substation methodology (CPS) while using Connectivity Model methodology (CM) during 2023 & 2024. The value of SAIFI from 2023 to 2024 has decreased from 0.71 to 0.64.

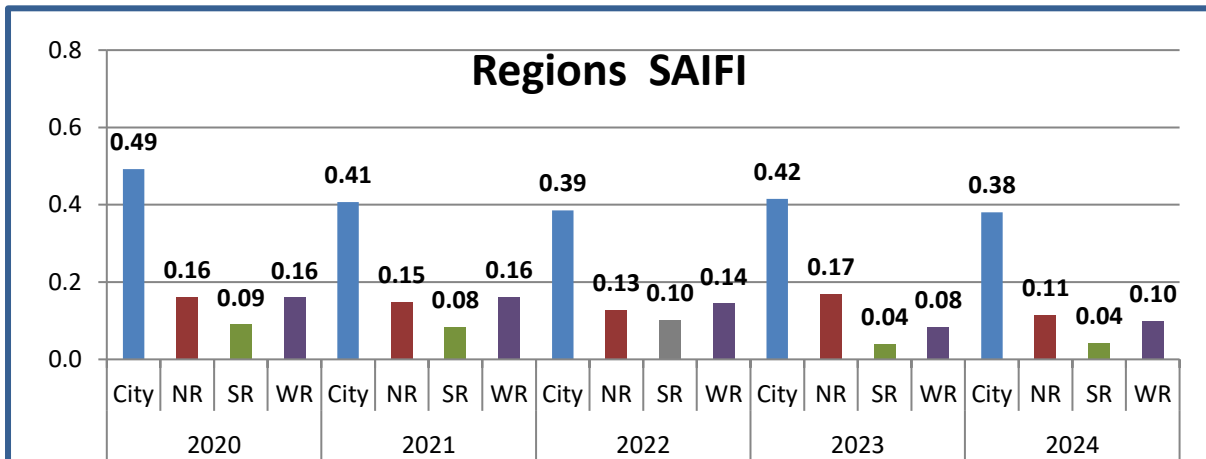
Figure 5.6 Total System Historical SAIFI



### 5.1.2 Region-wise Historical SAIFI

As shown in figure 5.7, city region has the largest contribution in AL AIN SAIFI by 59.8% (0.38).

Figure 5.7 Region-wise Historical SAIFI

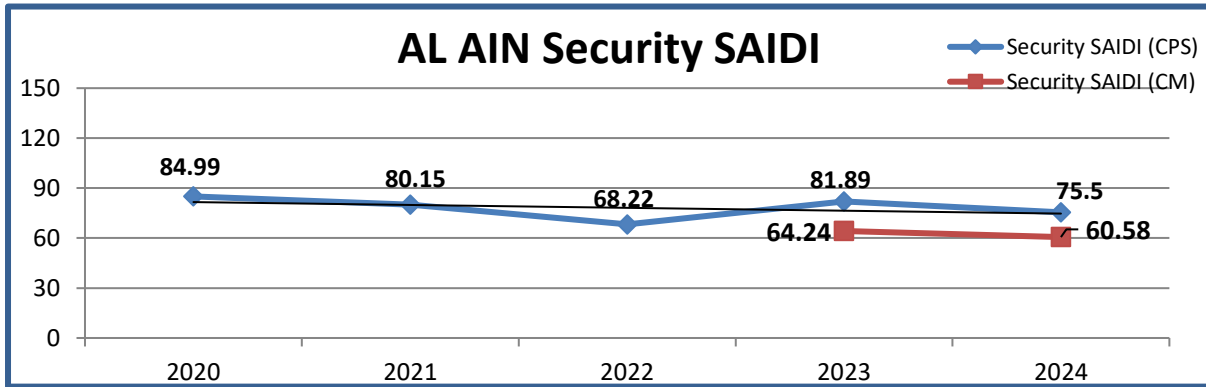


- The CR SAIFI had gradually decreased in 2021 & 2022, but slightly increased in 2023, while it decreased again in 2024.
- The NR SAIFI had decreased from 2020 to 2022 due to stable weather, while it had increased in 2023, but it had decreased in 2024.
- The SR SAIFI had decreased in 2021, but it has slightly increased in 2022 and has decreased again in 2023 & 2024.
- The WR SAIFI had decreased from 2022 to 2023, but it had increased in 2024.

### 5.1.3 Total System Historical SAIDI

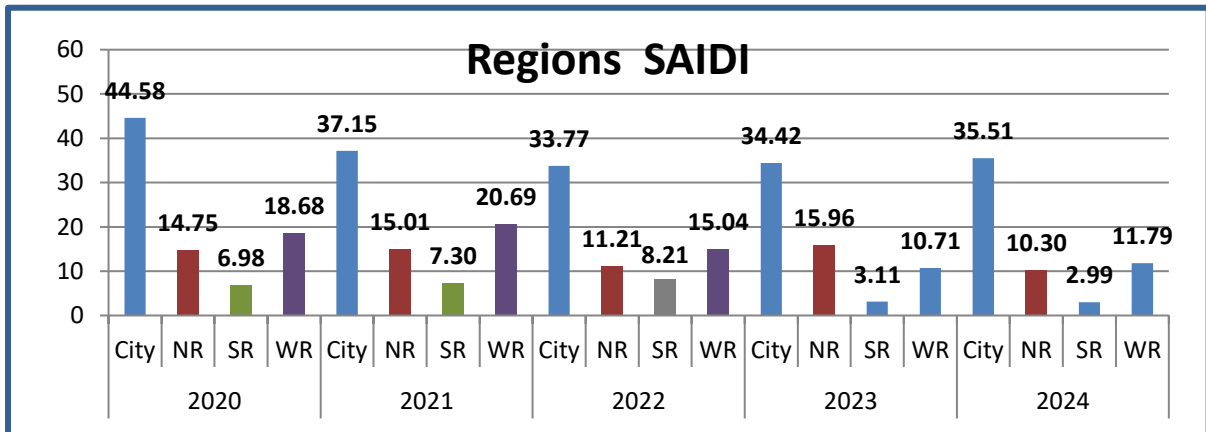
The AL AIN System Average Interruption Duration Index (SAIDI) in the last five years from 2020 to 2024 by using customer per substation methodology (CPS) while using Connectivity Model methodology (CM) during 2023 & 2024, the value of SAIDI from 2023 to 2024 got improvement which has decreased from 64.24 to 60.58.

Figure 5.8 Total System Historical SAIDI



AL AIN SAIDI per regions during the previous five years (2020-2024). The city region has the largest contribution in AL AIN SAIDI by 58.6% (35.51) while the South region has smallest contribution in AL AIN SAIDI by 4.9% (2.99).

5.9 Region-wise Historical SAIDI



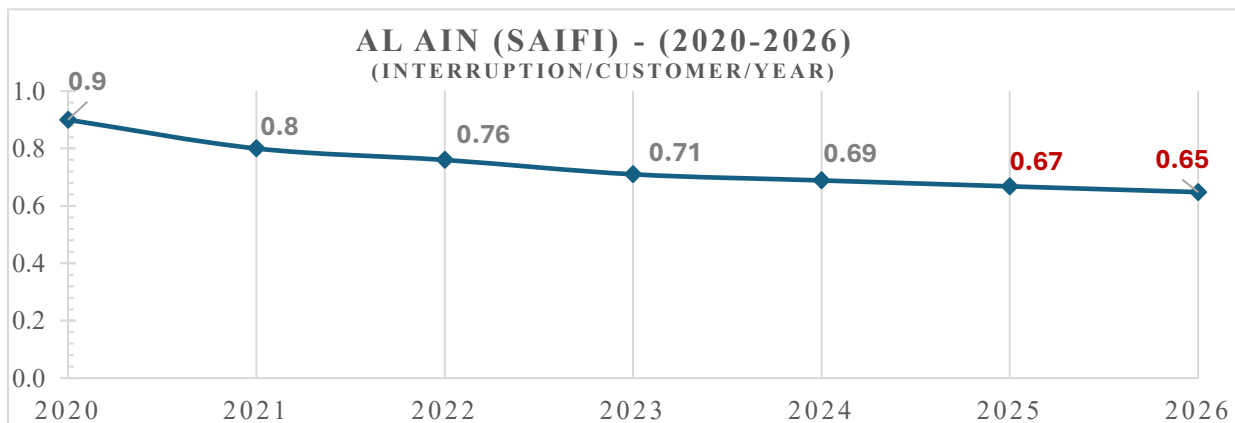
- The CR SAIDI had gradually decreased in 2021 & 2022, but in 2023 & 2024 it had increased again.
- The NR SAIDI was almost stable in 2020, then it had slightly increased in 2021, but it had decreased again in 2022 and had increased again in 2023.
- The SR SAIDI had slightly increased in 2021 & 2022, but in 2023 & 2024, it has decreased.
- The WR SAIDI had slightly increased in 2021, but it had decreased again in 2022 & 2023, while in 2024 got increased again.

### 5.1.5 Proposed Targets: SAIDI and SAIFI

The following tables (5.1 & 5.2) present the historical values for the last Five years (2020 -2024), in addition to the targeted values to next two years (2025 -2026). The targets for RC2 period, will be based on CM reported figures which to be set based on its historical performance.

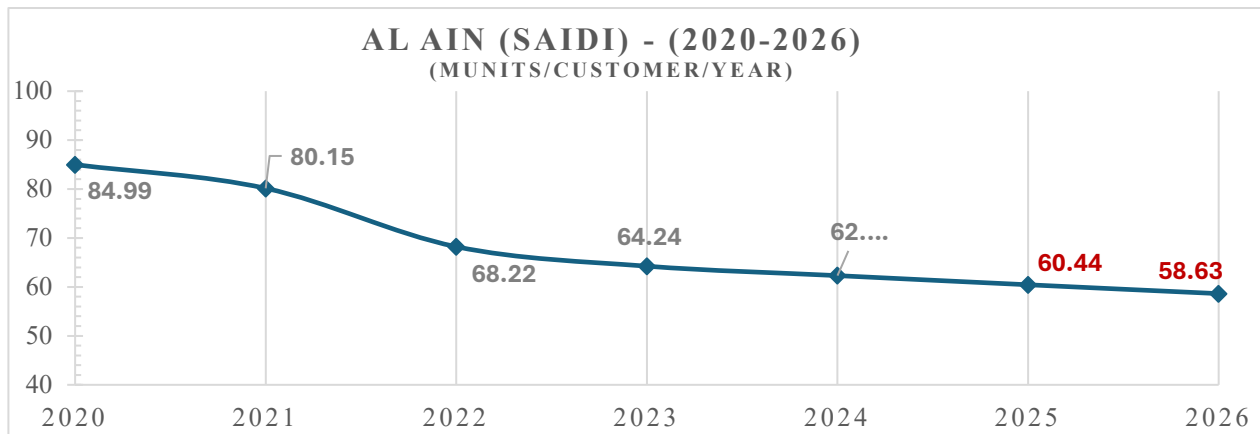
**Table 5.1: KPI (SAIFI) Historical & Target Values (2020-2029)**

Year	Historical Values					Target Values		Forecasted Targets*		
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
SAIFI	0.90	0.80	0.76	0.71(Actual) 0.75(Target)	0.64(Actual) 0.69(Target)	0.67	0.65	0.63	0.61	0.59
% Improvement	8.20%	11.10%	5.00%	6.60% 1.10%	9.86% 3.00%	3.00%	3.00%	3.00%	3.00%	3.00%



**Table 5.2: KPI (SAIDI) Historical & Target Values (2020-2029)**

Year	Historical Values					Target Values		Forecasted Targets*		
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
SAIDI	84.99	80.15	68.22	64.24(Actual)	60.6(Actual)	60.44	58.63	56.87	55.17	53.51
				75.34(Target)	62.31(Target)					
% Improvement	1.40%	5.70%	14.90%	5.80%	5.7%	3.00%	3.00%	3.00%	3.00%	3.00%
				-10.40%	3.00%					



### 5.1.6 Worst Performing Feeders

OHL outages have a significant influence on SAIFI & SAIDI Indexes; the top 20 OHL that negatively affect network performance are listed below in Table 5.6. City region has 70 % of the top worst performing feeders (14 Nos), followed by the North Region with 15% (3 Nos) feeders, and finally the Western Region with 3 Nos feeders representing 15%.

A comparison was done between the top 5 worst-performing feeders in 2023 and 2024; it was noticed that 3 out of 5 2023 top 5 worst-performing feeders were not in the 2024 top 5 worst-performing feeders. This gives indication that the taken short-term corrective actions were effective, the repeated feeders in the top 5 worst performance feeders are BBSD-SW-K07 & BBSD-SW-K06, taking into consideration the strategic corrective action is still in plan as described below. Although BBSD-SW K07 & BBSD-SW K06 are still in the top 5 worst performance feeders but there is clear improvement on the feeder performance within the list, five years noting that feeder CML were (146,023 & 251,067) in 2023 compared to (82,593 & 78,322) in 2024. Due to the feeder length "Very high", it's recommended to be divided into portions and shift some of the load to another feeder. Therefore, there is a plan to divide the feeder after adding a new package unit in the same area under the A-14947 contract.

**Table 5.3: Worst Performing Feeders**

Ref #	Region	Primary Name	Panel No	No. of Incidents					SAIFI					SAIDI				
				2020	2021	2022	2023	2024	2020	2021	2022	2023	2024	2020	2021	2022	2023	2024
1	CR	UMG-A-PY	K-11	27	6	7	7	13	0.0081	0.0004	0.0078	0.0018	0.0056	1.099	0.035	0.486	0.120	1.564
4	CR	BBSD-SW	K-07	14	7	13	11	15	0.0022	0.0006	0.0027	0.0067	0.0057	0.443	0.119	0.351	0.943	0.488
5	CR	BBSD-SW	K-06	20	21	26	23	18	0.0081	0.0135	0.0163	0.0118	0.0053	0.514	1.075	1.675	1.298	0.463
6	CR	KRR-A-PY	K-32	0	0	0	0	5	0.0000	0.0000	0.0000	0.0000	0.0057	0.000	0.000	0.000	0.000	0.406
7	CR	MNRWT-PU2	K-04	13	1	7	5	17	0.0010	0.0001	0.0044	0.0012	0.0046	0.058	0.004	0.181	0.083	0.388
8	CR	RMLTR-PY	K-07	16	3	7	10	11	0.0041	0.0011	0.0019	0.0041	0.0054	0.435	0.069	0.200	0.497	0.378
9	CR	KRR-A-PY	K-26	3	2	0	2	4	0.0026	0.0002	0.0000	0.0003	0.0018	0.165	0.044	0.000	0.042	0.338
11	CR	MSK-A-PY	K-06	0	0	2	10	12	0.0000	0.0000	0.0000	0.0017	0.0020	0.000	0.000	0.005	0.193	0.278
12	CR	GHRBH-PU2	K-04	0	8	11	5	12	0.0000	0.0002	0.0024	0.0014	0.0014	0.000	0.034	0.213	0.133	0.246
13	CR	BKRHF-PU2	K-01	5	6	9	12	6	0.0012	0.0007	0.0023	0.0035	0.0012	0.310	0.152	0.310	0.438	0.240
14	CR	MZYD1PY	K-20	7	2	4	4	10	0.0028	0.0013	0.0016	0.0026	0.0025	0.511	0.032	0.087	0.099	0.235
17	CR	ADD-A-PY	K-33	10	15	14	15	12	0.0026	0.0004	0.0026	0.0046	0.0015	0.228	0.093	0.105	0.448	0.211
19	CR	MSK-A-PY	K-38	0	0	0	4	7	0.0000	0.0000	0.0000	0.0003	0.0012	0.000	0.000	0.000	0.010	0.205
20	CR	RMLTR-PY	K-13	2	0	4	3	8	0.0002	0.0000	0.0004	0.0000	0.0033	0.016	0.000	0.081	0.004	0.203
2	NR	KHADR-PY	K-07	4	12	10	16	13	0.0003	0.0013	0.0021	0.0018	0.0037	0.019	0.239	0.180	0.272	0.689
15	NR	NSAS-PU	K-01	0	2	4	5	5	0.0000	0.0007	0.0007	0.0018	0.0020	0.000	0.067	0.128	0.223	0.225
18	NR	NAHIL-PY	K-03	8	9	7	6	10	0.0001	0.0010	0.0014	0.0002	0.0012	0.021	0.107	0.196	0.016	0.206
3	WR	KAZNA-GD	K-04	8	6	5	5	14	0.0055	0.0026	0.0013	0.0006	0.0045	1.170	0.268	0.358	0.080	0.551
10	WR	MRMTH-PU	K-03	16	7	14	5	10	0.0034	0.0045	0.0087	0.0011	0.0030	0.351	0.173	1.324	0.168	0.279
16	WR	SMEYA-PY	K-03	4	2	2	0	11	0.0005	0.0000	0.0005	0.0000	0.0023	0.053	0.004	0.126	0.000	0.216

The highest Five WPFs incidents are shown in the following tables:

- UMG-A-PY, K-011, this feeder had 13 incidents during 2024 due to No Fault - HV Fuse and No Fault - Transient Tripping (8 incidents) and while (5 incidents) due to other OHL components.

**Table: 5.3.1**

Grd/PYR name	Panel no.	Unplanned Incident Details	Unplanned Incident Root Cause	No. of Incidents	CI	CML
UMG-A-PY	K-11	Disc Insulator	Defective Equipment	1	136	195160
		No Fault - Transient Tripping	Weather	4	451	30102
			Unknown	1	261	26100
		MHS	Defective Equipment	2	64	6718
		No Fault - HV Fuse	Weather	2	17	5075
			Unknown	1	2	350
		Fuse Carrier	Age	1	4	1024
		Conductor	Bad Condition	1	15	150
<b>Grand Total</b>				<b>13</b>	<b>950</b>	<b>264,679</b>

- KHADR-PY, K-07, Conductor affected on this line due to damage by others, theft attempt and bad condition which caused by (49,191 CML). While single poles effected by (32,978 CML) and bad condition of Jumper/ Connection effected by (31,294 CML).

**Table: 5.3.2**

Grd/PYR name	Panel no.	Unplanned Incident Details	Unplanned Incident Root Cause	No. of Incidents	CI	CML
KHADR-PY	K-07	Conductor	Damage by others	1	42	27636
			Theft attempt	1	42	18480
			Bad Condition	1	41	3075
		Jumper / Connection	Bad Condition	2	238	31294
		No Fault - HV Fuse	Bad Condition	1	1	132
			Unknown	1	1	96
		No Fault - Transient Tripping	Unknown	1	53	2862
		Single Pole	Theft attempt	1	33	19074
			Fire	2	153	10147
			Bad Condition	2	28	3757
<b>Grand Total</b>				<b>13</b>	<b>632</b>	<b>116,553</b>

- KAZNA-GD, K-04, this feeder had 14 incidents due to OHL components (10 incident), No Fault - Transient Tripping (2 incidents), Aux DTR fault (1 incident), OD Termination flash Over (1 incident).

**Table: 5.3.3**

Grd/PYR name	Panel no.	Unplanned Incident Details	Unplanned Incident Root Cause	No. of Incidents	CI	CML
KAZNA-GD	K-04	Aux DTR	Weather	1	22	4,884
		Conductor	Bad Installation	2	93	19,645
		Fuse Carrier	Weather	1	4	1,460
		H-Pole	Bad Condition	1	22	4,136
		Jumper / Connection	Weather	1	94	24,158
			Bad Installation	1	18	540
		MHS	Fire	3	233	13,784
		No Fault - Transient Tripping	Weather	1	94	8,742
			Unknown	1	92	1874
		OD Termination	Flash Over	1	92	13,776
Single Pole	Bad Installation	1	1	316		
<b>Grand Total</b>				<b>14</b>	<b>765</b>	<b>93,315</b>

- BBSD-SW, K-07, the major root cause effect of this feeder is weather which caused by (50,989 CML), following by Bad Installation of Jumper / Connection (1 incident (24,145 CML)).

**Table: 5.3.4**

GRD/PYR name	Panel no.	Unplanned Incident Details	Unplanned Incident Root Cause	No. of Incidents	CI	CML
BBSD-SW	K-07	No Fault - Transient Tripping	Weather	1	300	47,100
		Jumper / Connection	Bad Installation	1	439	24,145
		No Fault - HV Fuse	Unknown	4	11	3,132
		Conductor	Theft attempt	1	16	2,960
		Sheath Bonding	Weather	1	137	1,781
		Disc Insulator	Weather	1	29	1,740
		VMS	Bad Condition	1	12	600
		Sectionalizer	Unknown	1	4	436
		No Fault - HV Fuse	Weather	1	2	368
		No Fault - HV Fuse	Birds / Animals	1	2	240
		No Fault - Other	Birds / Animals	1	7	77
		Jumper / Connection	Age	1	1	14
<b>Grand Total</b>				<b>15</b>	<b>960</b>	<b>82,593</b>

- BBSD-SW, K-06, this feeder had 18 incidents due to Autorecloser (2 incident (49,394 CML)), No Fault - Transient Tripping (3 incidents), No Fault - HV Fuse (5 incidents), OHL components (7 incident) and Cable Joint (1 incident).

**Table: 5.3.5**

Grd/PYR name	Panel no.	Unplanned Incident Details	Unplanned Incident Root Cause	No. of Incidents	CI	CML
BBSD-SW	K-06	Autorecloser	Age	2	360	49,394
		No Fault - Transient Tripping	Overload	1	171	9,576
		Jumper / Connection	Age	1	170	8,330
		No Fault - Transient Tripping	Unknown	1	148	6,068
		PMT Oil	Defective Equipment	1	15	2,430
		No Fault - HV Fuse	Age	2	5	965
			Unknown	3	11	890
		Jumper / Connection	Weather	2	9	243
			Bad Condition	2	6	210
		No Fault - Transient Tripping	Weather	1	2	196
		Conductor	Theft attempt	1	1	20
Joint	Fire	1	2	50		
<b>Grand Total</b>				<b>18</b>	<b>900</b>	<b>78,372</b>

### 5.1.7 Asset Reliability

The asset can be replaced when it becomes unreliable while this replacement will enhance the reliability and security of supply. The asset related reliability should be calculated from the failure rate data as shown in Appendix 5.7.

### 5.1.8 Supply Restoration Times

The interruption and restoration times for each incident are recorded in a variety of places. The restoration time categorized by voltage levels for the four regions during the last five years within 1 hour, between 1 hour & 3 hours, between 3 hours & 24 hours and more than 24 hours shown in Appendix 5.8. The city region in LV network has the largest contribution with 467 (between 1 and 3 hours) and 447 incidents (between 3 and 24 hours).

## 5.2 Distribution System Losses

### Electricity Energy Distribution Losses KPI (%)

KPI	Base line	Historical Values (%)*						Proposed Targets (%)					
		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Energy Losses	6.89	7.40	7.50	7.50	7.35	6.73	5.99	5.70	5.00	TBD	TBD	TBD	TBD

\*Reference: Electricity Losses Annual Report 2024

### TAQA D – AA Region Power Network Distribution Losses Description

TAQA D – AA Region power network energy losses have two components: Technical losses & non-technical losses.

#### 5.2.1 Technical Losses

Technical energy losses are the copper losses and are occurring when the feeder and/or the transformer are loaded. These losses are proportional to square of the current being supplied through the network equipment's ( $P_{loss} \propto I^2$ ), it is highly affected by system topology, peak demand level, and includes:

- Energy Losses because of power flow in feeders (i.e. 33kV & 11kV OHL's/Cables)
- Transformers no load losses (NLL), which is available when the transformer is energized even if the secondary is opened (no load), and it is caused by eddy and hysteresis currents
- Transformers load losses (LL), which is mainly affected by rating, demand and utilization factor.
- Portion of LV network energy losses, where most of the non-technical losses are allocated in LV network.
- Energy losses because of harmonic load currents of nonlinear electronic and motor loads.

No-Load Losses, this type of energy losses is allocated only in power and distribution transformers when the transformers are energized even when the transformer secondary is opened (non-loaded). This type of energy losses shall be valid for 8760 hours/year, and it shall be absent only during outages duration (planned/unplanned) shutdowns. No load losses are not depending on current, but it is depending on the square of the applied voltage ( $V^2$ ). No load losses are named "iron losses/core losses) and usually created because of:

- Hysteresis losses caused by the frictional movement of magnetic domains in the core laminations being magnetized and demagnetized by alternation of the magnetic field.
- Eddy current losses caused by varying magnetic fields inducing eddy currents in the laminations and thus generating heat.

- There are also less significant stray and dielectric losses that occur in the transformer core, accounting usually for no more than 1% of total no-load losses.

### 5.2.2 Non-Technical Energy Losses

Non-technical losses are the unmetered energy consumption, and utility meet difficulties to bill such customer's actual energy consumption. Non-technical losses are mainly located in LV network. These losses are associated with non-identified and uncollected revenue. Non-technical losses sources are but not limited to:

- Illegal electrification/connections.
- Meters tampering & fraud especially in absence of smart meters.
- Non-metered energy consumption for many reasons.
- Unbilled electricity adjustment.
- Electricity utilities premises & substations electrification (auxiliary losses).

### 5.2.3 Losses calculation methodology as per TAQA D – AA Region approved procedure

- Extract the total consumption reports from CC&B system (The quantities sold through the network Billed Units and Metered Customers) and (The quantities sold through the network Billed Units and Un-Metered Customers).
- EWEC report include Purchased quantities of TAQA Transmission and RASCO per unit KWh.
- Losses equal subtract total consumption sold per kWh from Purchased quantities per kwh.

TAQA D – AA Region focused on different Initiatives to reduce electricity losses, example of implemented actions affected in enhancing losses percentage is:

#### Actions Taken to Reduce Losses

- **Detection & Rectification:** Illegal connections and reverse wiring cases were identified, reported, and estimated, with damaged meters replaced promptly.
- **Routine Inspections:** 5% of total power meters underwent inspection and maintenance, including complaint resolution.
- **High-Load Customer Monitoring:** High-load customer meters were visited twice to ensure accurate readings and detect potential issues.

#### Supporting Measures

- **Monitoring & Awareness:** Meter readers played a crucial role in detecting on-site irregularities early.
- **Field Investigations:** Physical surveys were conducted to assess suspicious cases, with technical teams involved as needed.

- **Data Analysis:** The billing team used predictive analytics and site visit findings to refine reporting and justify discrepancies.
- **After-Hours Exploration:** Conducted to better understand unusual consumption patterns.

### Meter Maintenance Staff Training

- **Technical Training:** Hands-on training on meter reading, configuration, and troubleshooting.
- **Safety & Compliance:** Adherence to standard safety procedures, including Safe System Rules (SSR).
- **Field Engagement:** Technicians actively identified and reported meter damages, illegal connections, and other anomalies.

### Overview on Auxiliary Consumption Energy Meters Initiative Implemented in 2022:

The Auxiliary Loads Consumption in the electrical substation is not metered. This initiative aims to install energy meters at all primaries substation, which will help to capture and record all consumption of AADC auxiliary load and reduce commercial losses. The team started by focusing on one of each substation category from the size view in West Region as a pilot. Once samples of each substation type is fixed, the team will apply the same consumption pattern to the similar substation. In 2022, the team monitored the consumption for PRY BB Type and PU Type separately, and multiplied the average of each, by number of each type.

6 Meters were installed at Primary Substations BB and Primary Substations PU. Virtual read points added to billing system CC&B resulted in reduction by 27'642'000 kwh/year in power losses. The final initiative results will decrease the losses by 0.3% annually. Breakdown of the meters installed at AADC stations (PRY and PUs) as of the end of 2023 are below:

- **4 meters** installed in 2 substations (Primary Substations BB/ Virtual Read Point: VIRTPRYSBB01)
- **2 meters** installed in 2 substations (Primary Substations PU/ Virtual Read Point: VIRTPRYSPU01)

As a result of obtaining actual consumption at PRY and PUs. Virtual read point added in CC&B to record Primary Substations BB, based on the consumption avg of 4 meters installed in 2 substations, the consumption of 101 substation is calculated and entered in CC&B Virtual read point added in CC&B to record Primary Substations PU, based on the consumption avg of 2 meters installed in 2 substations, the consumption of 114 substation is calculated and entered in CC&B. The total result is a reduction by 27'642'000 kwh/year in power losses.

These virtual read points in CC&B calculate and record consumption averages based on the meters installed at each substation, enabling efficient monitoring and management of energy usage. Currently, there are no plans to proceed with installing additional meters in the remaining substations.

### Running contracts and actions:

Type of functional	Project No.	Description	Start Date	End Date	Duration	Status	Contribution on losses improvement	Remarks
Meter Reading Performance	• AD-110247.1	Outsourcing manpower (meter readers) for Metering Section <b>(Managed by the HR)</b>	01/09/2022	31/08/2025	36	Running	<ul style="list-style-type: none"> <li>Collect all Meter Reads in monthly basis for all customer class category (RES, COMRC, INDUS, GOV, AGRIC)</li> <li>Measure all unites distributed to customers.</li> <li>Handle all bills complain on time.</li> <li>Handle all close accounts request on time.</li> <li>Increase customer satisfaction.</li> <li>Achieve the GSS10 target.</li> </ul>	Contract # AD-110247.1 Managed by the HR
Accuracy of the Meter Read	• AD-110247.2	Outsourcing manpower (Electrician & Water Meter Maint.) for Metering Section <b>(Managed by the HR)</b>	01/09/2022	31/08/2025	36	Running	<ul style="list-style-type: none"> <li>Avoid reads error.</li> <li>Reducing the losses unites</li> <li>Discover illegal connection.</li> <li>6Replace / repair defected meters on time.</li> <li>Increase customer satisfaction.</li> </ul>	Contract # AD-110247.2 Managed by the HR

### 5.3 Connections Timelines

The break down for connection timeline Calendar Day (CD's) for electricity from submitting the Load Demand Notification LDN to Service Agreement (SA) is as listed in Appendix (5.11), the service connection implementation sequence is as listed below:

- Load Demand Notification: (LDN)
- Drawings Approval: (DA)
- Cable Termination: (CT)
- Inspection: (Insp.)
- Supply Activation: (SA)

### 5.4 Challenges and Proposed Solutions

- Limit No of Monitored Distribution Substation (increase No of Monitored Substation up to 30%)
- Damaged cables by third party.
- Updating GIS and Integration with Maximo.
- Old cables.
- Aged equipment which needs priority in replacement.
- Access to VIP S/S for operation and maintenance.
- Network expansion and staff reduction: applying the methods of RCM and effective Maintenance planning for effective utilization of the staff and manhour.
- Customer Expectation: In advance breakdown detection by perform electrical testing for condition assessment of 33/11 kV power transformers at primary substations and timing test for CB's.
- The rising incidents of OHL theft, causing operational disruptions and safety concerns, have prompted the installing aluminum conductors in place of copper to deter theft; however, most of the 11 kV network (about 5000 KM) is still copper, making it a prime target.

# CHAPTER 6: Asset Management

## 6.1 Asset Management Process

TAQA DISTRIBUTION power network portfolio is managed to ensure the most effective operation and maintenance practices to meet TAQA DISTRIBUTION demand requirements and to realize the TAQA DISTRIBUTION vision as well as stakeholder's requirements and expectations. Power network assets are maintained to operate properly along its life cycle to meet the future demand requirements. Moreover, TAQA DISTRIBUTION has the following approved regulation documents that are under continual revision to meet the integrated management system (IMS):

- Procedure for Power Asset Replacement / Refurbishment Assessment Procedure
- Procedure for Maintenance Activities for Power Distribution Network Components
- Procedure for Maintenance Assessment Report
- Procedure for Electricity Network Reliability Assessment Reporting
- Procedure for SAIDI & SAIFI Reporting Procedure

## 6.2 Asset Age Profiling & Condition Monitoring

### 6.2.1 Asset Age Profiling

The forthcoming age profiles within this report for different types of assets in Al Ain region have been developed based on the asset year of manufacturer extracted from the GIS in December 2024.

OHL and cables age profile was added as per DOE request, which had been retrieved from the extracted data from GIS as end of 2024, developed, based on the energization year, it is to be noted that any missing information with regards to the dates for the cables/OHL provided could be due to the following:

When the GIS was first introduced, the majority of the cable/OHL updates were based on various sources without available historical data (commissioning, installation) at that time.

It is to highlight that the historical data such as (commissioning dates, installation dates) for newly laid OHL/cables is being updated systematically in the GIS via the development of commissioning reports, which has been in effect since 2004/2005. The age profile charts for Transformers, Circuit Breakers, OHL & Cables shown in Appendix A6

### 6.2.2 Condition Monitoring

TAQA DISTRIBUTION in AA region built a new advanced maintenance program, which was adopted for the first time in power sector for the following objectives- :

- Detect equipment abnormalities at early stage by using:
  1. Pro-active technique "CBM tools ."
  2. Perform electrical testing for major assets such as power transformer and CBs at primary substations.

3. Check SF6 gas quality for GIS switchgear.
  4. Perform dissolved gas analysis (DGA) for PTR's.
- Using Reliability Centered Maintenance (RCM) for assets condition grading and optimal maintenance and replacement planning. Achieve high ROI "project cost covered in 1st year ."
  - Reduce planned outages.
  - Optimize yearly maintenance coverage of assets.
  - Improve yearly failure rate.
  - Strength asset database.
  - Optimize maintenance planning.
  - Create clear asset management plan/strategy.
  - Inspection & Diagnosis, Partial discharge and checking the old termination.

**Tables 6.1- Power assets life cycle**

Type	Equipment type	(Years)
<b>Substations</b>	Brick Built Substations (Primary-Distribution)	40
	Switchgear	40
	GMT –Package Unit	40
	QRM-TRM-RMU	35
	Primary LV Panels	30
	Distribution LV Panels	30
<b>OHL</b>	Wood Poles	40
	HV OHL (Pole-Tower- Conductors)	50
	VMS/MHS /Fuse switch/ Drop Out Fuse	30
	Pole Mounted Transformer (PMT)	40
<b>Cables</b>	HV Underground Cable	40
	LV Underground cable	40

**Tables 6.2: Power and Distribution Transformers Ages**

Equipment type	Life Cycle (Years)
Power Transformer	40
Distribution Transformer	40

**Tables 6.3 shows the agreed ages of DC systems & Digital relays**

<b>Equipment type</b>	<b>Life Cycle (Years)</b>
Substations Batteries/DC System	18
Numerical relays and IED's	25
Fault Indicator	20

\*\*Many important assets like DC systems, digital relays and electronic devices operating environment shall be air-conditioned.

\*\*\* It would be physically degraded because of direct expose to weather conditions.

Actual asset's performance would be affected by many factors as following:

- Environmental conditions.
- Manufacturing faults.
- TAQA DISTRIBUTION's Maintenance history.
- Failure history, failure rate.
- Asset's performance records and monitoring.

As asset's age is one of the factors of asset replacement decision but is not the only driver for the replacement, TAQA DISTRIBUTION closely monitored the aged assets from GIS and prepare asset profile for different assets categories (PTR, GMT, CB, etc.). TAQA DISTRIBUTION focuses in the aged asset that completed expected service lifetime and have high probability of failure to avoid major failure or major power supply interruption.

In addition to the asset age, the asset condition is captured from Maximo asset module following to maintenance.

**Table 6.4 Replacement plan of aged Assets**

Asset Category	Total number of aged Asset	Planned for replacement		Replacement Project/ Budget Code	Note
		Yes	No		
<b>33KV CB</b>	205	123	82	A-20655, A-P-022-0401-NA, A-P-022-0402-NA, A-P-023-0401-NA, A-P-023-0402-NA, A-P-024-0401-NA, A-P-024-0402-NA, A-P-024-0403-NA, A-P-025-0403-NA	The 33 kV CBs without replacement plan are: <ul style="list-style-type: none"> <li>- 22 CBs in the Zakher grid which are plans to be dismantled by TAQA Transmission.</li> <li>- The other 60 CBs are in fair to poor condition and will be included in future replacement plans based on the deterioration in condition.</li> </ul>
<b>11KV CB</b>	1080	720	360	A-18906, A-20300, A-20655, A-P-022-0401-NA, A-P-022-0402-NA, A-P-023-0401-NA, A-P-023-0402-NA, A-P-024-0401-NA, A-P-024-0402-NA, A-P-024-0403-NA, A-P-025-0403-NA, A-P-023-0403-NA, A-P-024-0405-NA, A-P-025-0404-NA, A-21102	Currently 384 under replacement with running contracts and project under planning with mentioned contract/budget and 336 no's of 11kV CBs are under A-21102 consultancy survey to design the replacement plan. Remaining breaker will be included in future plan based on the deterioration in condition and priority.
<b>11/0.4 DTR</b>	665	211	454	A-18906, A-20655, A-20300, A-21102, A-P-023-0403-NA, A-P-024-0405-NA, A-P-025-0404-NA	The DTRs without replacement plan are in fair condition that will be included in future replacement plans based on the deterioration in condition and priority.
<b>PTR</b>	46	39	7	A-20655, A-17672.1, A-P-022-0401-NA, A-P-022-0402-NA, A-P-023-0401-NA, A-P-023-0402-NA, A-P-024-0401-NA, A-P-024-0402-NA, A-P-024-0403-NA, A-P-025-0403-NA,	HTR without replacement are <ul style="list-style-type: none"> <li>- 2 HTR kept for TAQA TRANSMISSION Grid which is under their replacement</li> <li>- 2 HTR kept for emergencies</li> <li>- 3 HTR are in fair condition (1 of it is refurbished)</li> </ul>

**Table 6.5 Replacement of cables and OHL**

Asset Category	Replacement Project/ Budget Code	Note
<b>33KV &amp; 11 OHL</b>	Live line maintenance contracts phase 2 (A-18902)  A-P-022-0401-NA, A-P-022-0402-NA, A-P-024-0402-NA,	Usually OHL line grow gradually, where the same line may have aged assets and new assets. Therefore, live line maintenance contracts are raised periodically where one contract is closed (A-14992), one contract is in execution phase (A-18902). This live line maintenance contract is utilized to replace/ repair the 33&11 kV equipment that are aged/bad condition. Replacement/repair includes insulators, Jumpers , Pole, Switches, Autorecloser , Sectionalizer Lightning Arrestors,etc.  Taking in consideration that these replacement/ repairers are done live without interruption.  Replacement of OHL by cables for the primary which is going to be upgraded are considered during the primary replacement projects
<b>33 &amp; 11 kV cables</b>	TAQA DISTRIBUTION usually have two to three scheme based running contracts  33kV Cable projects and substation internal cables:  A-20655, A-P-022-0401-NA, A-P-022-0402-NA, A-P-023-0401-NA, A-P-023-0402-NA, A-P-023-0407-NA & A-P-024-0402-NA, A-P-025-0405-NA	Usually, 11 kV OHL & cable circuits grow gradually where the same circuit may have aged pieces and other new pieces. Therefore, the replacement need is identified periodically by end user teams.  33kV cable replacement included on the related primary stations replacement projects. The scope of these projects usually evaluates the need to replace or reinforce the existing 33 kV cable depending on the new transformer capacity.

### 6.2.3 Asset Condition Grading

- Asset condition grading is to have full awareness of the assets function, portfolio condition, performance and their cost drivers.
- Currently, Maximo is used as record for assets grading where grades usually updated by TAQA DISTRIBUTION maintenance team.

### 6.3 Power Asset Replacement / Refurbishment Assessment Procedure

TAQA DISTRIBUTION Power Asset Replacement / Refurbishment Assessment Procedure under approval following to merging with AD. TAQA DISTRIBUTION asset replacement policy had considered the asset replacement drivers as follows:

- Operational Safety feedback from field staff.
- Environmental hazards (Oil leakage to ground, Gas Emissions and Noise external to premises)
- Physical Condition (Condition monitoring results)
- Performance statistics such as failure frequency, outage duration and number of occurrences (frequency)
- Criticality of Assets (based on Nos. of customer served/load, type of customers, spare capacity, Mean Time To Repair Special criticality).
- Network criticality Depends on the criticality of other associated Assets in the network.
- Age of assets.
- Obsolescence (Spare parts availability)

Priority classification

- Personnel and public safety shall be given very high priority in determination of Asset Criticality.
- Feedback from field staff shall be carefully evaluated along with performance statistics to provide priority classification.

All other factors except condition monitoring results shall be carefully analysed on project by project basis to provide its own priority.

### 6.4 Asset Replacement Priority

Asset replacement would be partially for critical equipment or fully for substations as a whole. The priority of asset replacement decision shall depend on the analysis of critical factors like:

- Customer's importance/ substation location criticality (serving VIP premises, residential load) are considered rather than non-critical customers such as farms/etc.
- Lack of spare parts availability.

### 6.5 Asset Replacement / Rehabilitation plan

The assets physical condition and performance are considered as the major drivers for asset replacement/ rehabilitation. TAQA DISTRIBUTION is reviewing asset replacement/ rehabilitation plans yearly to update the requirements as well as for budgeting preparation.

Reliability of TAQA DISTRIBUTION power network is essential to guarantee the power service sustainability and business continuity.

## 6.6 Technical Due Diligence project No. D-110813.1

There is completed project “due diligence project” undertaken by the consultant CESI, the main scope of this project:

- Review existing systems, methodologies and processes/procedures adopted by the network operators. Moreover, to the records related to the asset maintenance management and maintenance management system, strategies, policies and procedures.
- Gap analysis and improvements, benchmark practices will be carried out an in-depth analysis to identify gaps and improvement opportunities, as well as risks that might jeopardize the performance of the network.
- Assessment of asset condition and cost of failure and accordingly Identify the critical asset.

During phase three of the project, which focuses on identifying critical assets requiring replacement or refurbishment, the CNAIM (Common Network Asset Indices Methodology), has been utilized by consultant as per approval by DOE. The critical assets across major asset categories that require replacement or corrective maintenance by 2028 have been identified by CESI in Table 6.3.1. Several projects, already underway or in the initial stages—as outlined in Table 6.4 are planned to address the required asset quantities, also through required maintenance intervals.

**Table 6.6 – The critical List Identified by CESI**

	<b>Identified Critical assets (quantity)</b>	<b>Prospective Asset Failing (quantity)</b>	<b>Recommendation by CESI</b>
<b>Power Transformers</b>	25	-	More Monitoring and Duly Replacement of Assets on further deterioration
<b>Distribution Transformer</b>	121	84	
<b>HV Panels</b>	11	637	
<b>Ring Main Unit</b>	10	41	
<b>Total</b>	<b>167</b>	<b>762</b>	

# CHAPTER 7: Expansion Plans and Connection Opportunities

## 7.1 Expansion Plans

TAQA D – AA Region is committed to the approved Development Budget capital expenditure. Additional Development Budget expenditure will be required during the period 2025 to 2030.

All new investments will be subject to a critical review of their cost and benefit before they are allowed to proceed.

### 7.1.1 Load - Related projects

TAQA D – AA Region propose new plans and projects based on major drivers listed below:

- Load forecast.
- Security of supply Standards.
- Current Network assets loading.
- Customers / developers Demands.
- Distribution Code requirements.
- Issued regulations.
- Stakeholder's requirements.
- Current running projects.

TAQA D – AA Region load related projects are segregated into different categories based on status of each as running, tendering, planning and proposed as shown in appendix A7-7.1.

### 7.1.2 Non-Load - Related projects

The assets physical condition and performance are considered as the major drivers for the non-load related projects. TAQA D – AA Region is reviewing Asset Replacement/Refurbishment plans yearly to update the requirements as well as budgeting concerns.

Innovation of TAQA D – AA Region power network is essential to guarantee the power service sustainability and business continuity. TAQA D – AA Region designed a replacement plan to replace all aging distribution substations based on service age, operational experience, performance...etc. as mentioned in the approved replacement policy.

TAQA D – AA Region non-load related projects are segregated into different categories based on status of each as running, tendering, planning and proposed as shown in appendix A7-7.1.

The submitted proposed projects for Year 2025 budget are not final and subjected to changes during approval process.

### 7.1.3 TAQA Transmission Shared projects

TAQA Transmission / TAQA D – AA Region shared projects mainly related to under construction / planned Grid Stations are shown in appendix A7-7.2.

### 7.1.4 Main Connection and Development in Al-Ain Region

It is worth mentioning that Mega projects and Developments are the major drivers behind the asset yearly addition. TAQA D – AA Region planned to meet some of Mega projects and Developments Demands from the existing power networks were applicable. The forecasted annual demand per project is distributed based on projects' completion date, forecasted utilization and historical data for similar projects in Al Ain. This approach is applicable for housing projects where government and developers are developing the infrastructure within the development. The government will distribute plots to tenants over the years to build their own houses, accordingly the demand utilization will expand beyond five years. The balance between the approved demand and annual expected utilization up to 2030 will appear in the upcoming 5 years planning statements based on actual utilization and development projects progress. The same data and approach communicated to TAQA Transmission and EWEC via TAQA D – AA Region Five Year Electricity Demand Forecast & Data Provision report (week 48). The Mega Projects details are shown in appendix A7-7.3.

#### Deleted Projects:

During TAQA D – AA Region update of Mega Project status, it was noticed that status of some of projects mentioned in the last TAQA D – AA Region 5 years load forecast 2024-2029 and in TAQA D – AA Region 5 years planning statement 2024-2029 either completed or no activities at the site since the initiation stage or no reply received from the developer/Customer. Based on TAQA D – AA Region Mega projects update procedure concept and to have the most accurate data to minimize the impact on overall TAQA D – AA Region load forecast, TAQA D – AA Region removed the below mentioned projects from Mega projects tables as per shown categories.

No.	Project	Developer Name	Conceptual Design Load details, MW		Actual Loading 2024	Developments Status
			Connected	demand		
1	Shuaiba (162 Shabias)	Musanada	17.8	5.8	2.4	The project to be considered a Normal Growth
2	Remah Residential Complex (1&2)	Musanada	6	4.5	0.7	The project to be considered a Normal Growth
3	Remah Army Airport	Army	39.6	16.5	0.8	The project to be considered a Normal Growth
4	Shaiba North Wadi	AAM	12.5	7.5	5.1	The project to be considered a Normal Growth
5	Livestock Market	BEN HARMAL	41	27	16.23	Completed
6	"Sheikh Hamdan Farm (Green House)	Private	10	7	3.12	Completed
7	Etisalat Data Center	Etisalat	9.807	9.277	0.3	Completed
8	Al Nasseem Development	Al Qudra	14	5.7	0	Hold
9	Jabel Hafeet (Green Mubazara)	Al Qudra	142	79	0	Hold

## 7.2 Provision of Connection

Currently TAQA D – AA Region have interconnected power network configuration specially at 11 KV network levels, while 33/11 KV primary substations are located at various Al Ain districts where there is no dedicated TAQA D – AA Region 33/11 KV primary substation with isolated loads except Umm Al Zmool and Al Aslab Primaries due to geographical location of demands.

TAQA D – AA Region existing and planned 33/11 KV primary substations are planned to meet the existing and forecasted loads.

To identify the connection opportunities in Al Ain region, TAQA D – AA Region planning engineers conducted detailed study based on the following:

- 1- TAQA D – AA Region load forecast report 2025-2030.
- 2- Requested New Demands.
- 3- Location of New Projects/demands.
- 4- TAQA D – AA Region in process / planned projects.
- 5- TAQA Transmission in process / planned projects timeline.
- 6- Existing and planned Grid substations and Pry substations individual capacities.
- 7- Available / planned 33 KV and 11 KV feeders.
- 8- Planned developments mentioned in Appendix 7.3.
- 9- Normal growth.

However, since the feeding arrangement and connection opportunity depends on project's time schedule, existing network capacity and along with other factors, TAQA D – AA Region shall review the possible feeding arrangement and system capacity for each project individually and upon customers' request.

### 7.3 Connection Constrains

The connection constraints were identified and analyzed, which need to be addressed. Constraints are as follows:

- Delay, changes/downsizing, and cancellation of Infrastructure Developments by third party.
- Lack of Planning Co-ordination between different government entities & their appointed planning consultants / representatives.
- Delay in Infrastructure Developments result subsequent delay in installing network & connections.
- Delay in TAQA Transmission Projects.
- Tremendously high increase in Demand, due to unplanned & unforeseen bulk connections.
- Lack of required Staff Resources & updating of their work skills to get apprehend with latest techniques.

To minimize the Risk that may occur TAQA D – AA Region apply various actions as listed below:

- TAQA D – AA Region closely monitor the Developers projects progress and TAQA D – AA Region planning Engineer to review the changes, coordinate with developers and customers, call for meeting and request clarifications.
- Scheduling the capital investments based on expected demand forecast and actual projects progress.
- Follow with TAQA Transmission Management to ensure completion of their projects on time.
- TAQA D – AA Region to gain necessary approvals to include the required works for unforeseen connections in TAQA D – AA Region plans and projects.
- Approach concerned Departments (internally and externally) to facilitate completion of TAQA D – AA Region works as planned.

## 7.4 Connection Interest

TAQA D – AA Region Manage the new connections for domestic consumptions customers through CC&B (Customer Care & Billing System) where customer submit supply arrangement request for the required power supply while for bulk supply customers based on the submitted data, information of the required demand and date required were recorded in Table (Bulk Load) and later customer will apply the request through CC&B.

## 7.5 Assets Forecast

The yearly addition of power network assets & percentage of annual growth is presented in Appendix 7.4.

### Methodology of forecasting Power Network Assets

The yearly addition of power network assets is calculated based on the following:

#### For 33 kV network:

- TAQA D – AA Region running and planned projects.
- Load forecast.
- Mega projects in Al Ain.

#### For 11 kV network:

- Historical data.
- TAQA D – AA Region running and planned projects.
- Mega projects in Al Ain.

# CHAPTER 8: Expenditure (Financial Annex)

## 8.1 Load - Related Cap-Ex

TAQA Distribution – AA Region load related projects are segregated into different categories based on status of each as execution, tendering, planning and newly added as shown in Appendix A8-8.1. Ex-anti Templates for 11 KV projects of Budget 2024 are available in Appendix 8.

## 8.2 Non-Load - Related Cap-Ex

TAQA Distribution – AA Region non-load related projects are segregated into different categories based on status of each as execution, tendering, planning and newly added as shown in appendix A8-8.1.

## 8.3 Business Case for Major Schemes

TAQA Distribution – AA Region proposing the load related new expenditure to meet the expansion plans as mentioned in chapter 7.

- TAQA Distribution – AA Region load related Capex are segregated to the various projects types as follows:
  - Supply and/or Installation 33/11 KV primary substation, 33 KV cables and related works projects, detailed summary as well as the options considered for the case study of this type of projects.
  - Supply and/or Installation of (11 & 0.4kV) Cables, 11kV pole line, (11 & 0.4kV) Equipment & Distribution Transformers and related items. These projects are scheme-based projects. The needs for project are based on previous years' statics and the needs of TAQA Distribution – AA Region business.
- Non- load - related projects where the assets physical condition and performance are considered as the major drivers for this type of projects. TAQA Distribution – AA Region is reviewing Asset Replacement/Refurbishment plans yearly to update the requirements as well as budgeting concerns.

TAQA Distribution – AA Region non load related Capex are segregated to the various projects types as follow:

- Replacement/Rehabilitation of 33/11 KV primary substation.
- Supply, Installation and Replacement of aging & unreliable Distribution Substations
- Supply, Installation and Replacement of aging & unreliable LV equipment's.
- DMS system replacement/upgradation and Substations' integration.
- Replacement and Reinforcement of main protection system.

#### 8.4 Capital Expenditure (CAPEX) forecast

TAQA Distribution – AA Region capital Expenditure forecast along with related schemes are shown in Appendix A8-8.1, during budget preparation, all tendering projects and plans were reviewed and accordingly some projects were cancelled/merged in order to make better resource optimization and enhancement without affecting the business continuity, ensure meeting customers' demand on time and complying with security of supply standards.