



UNIVERSIDAD PONTIFICA COMILLAS  
ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

OFFICIAL MASTER'S DEGREE IN THE  
ELECTRIC POWER INDUSTRY

MASTER'S THESIS

**JUBAIL ELECTRICAL TRANSMISSION AND  
DISTRIBUTION SYSTEM FEASIBILITY STUDY.**

**Author: Ricardo Cotarelo Hernández**

**Supervisor: Faustino Guillén Minguito**

**Madrid, July 2023**



**MASTER'S THESIS PRESENTATION AUTHORIZATION**

THE STUDENT:

RICARDO COTARELO HERNÁNDEZ

.....

THE SUPERVISOR

FAUSTINO GUILLÉN MINGUITO

Signed: .....

Date: 19/ 07/ 2023

THE CO-SUPERVISOR

Signed: .....

Date: ...../ ...../ .....

Authorization of the Master's Thesis Coordinator

Dr. Luis Olmos Camacho

Signed: .....

Date: ...../ ...../ .....





UNIVERSIDAD PONTIFICA COMILLAS  
ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

OFFICIAL MASTER'S DEGREE IN THE  
ELECTRIC POWER INDUSTRY

MASTER'S THESIS

**JUBAIL ELECTRICAL TRANSMISSION AND  
DISTRIBUTION SYSTEM FEASIBILITY STUDY.**

**Author: Ricardo Cotarelo Hernández**

**Supervisor: Faustino Guillén Minguito**

**Madrid, July 2023**



## **Abstract**

This Transmission and Distribution Network feasibility study intends to validate and verify that the proposed network is sufficient to support the expected future demand in the new area. Within this new area, a Green Industrial Park is going to be built, with some generation and demand. To this end, in addition to the planned future network, the capacity of the existing infrastructure (Jubail 1 and Jubail 2 industrial parks) and the adequacy of the corridors to support the proposed power grid will be evaluated.

To this purpose, a set of substations and 380 kV, 115 kV and 34,5 kV lines are proposed to feed the required demand through future generation in the Green Industrial Park (CCGTs and PV farms) or through the proposed interconnections with the elements described above. Minimum technical and safety requirements will be taken into account to ensure the correct operation of the proposed power grid. Mainly, two types of substations will be presented, the first 380 /115 kV substations will be connected in a ring to provide a level of security and redundancy, ensuring continuity of supply in the event of failure. Substations will be equipped on the 380 kV side with a configuration of breaker and a half, and on the 115 kV side with double busbar. Similarly, the 115/ 34,5 kV substation, the high voltage part will be equipped with double bus while the 34,5 kV part will be bus with coupling.

The viability of this whole system of substations, lines, interconnections, etc. has been tested through a simulation software, and following a good methodology, it has been possible to verify that under normal conditions the system fulfils 100% of its function since it has been designed with a great redundancy in mind.

A preliminary project development plan will be developed that will include phasing, cost estimates and timelines. A Class IV cost estimate will be performed to determine the feasibility of the project and ensure that it is within budgetary constraints.

The design of the transmission and distribution system for the JB2S4&3 Green Industrial Park is based on the connection to the external power grid and the incorporation of additional generation plants. The industrial park will be supplied internally with a capacity of approximately 2,052 MW, and at times of low demand, the energy generated by the generation plants can be evacuated to the external 380 kV grid.

The 380 kV substations will be integrated into the external grid and interconnected with the Jubail 1 and Jubail 2 substations at the 380/230 kV Jubail 2 substation.



## INDEX

Figure	Page
1	INTRODUCTION AND MOTIVATION ..... 12
1.1	Introduction..... 12
1.2	Motivation..... 12
2	OBJECTIVES OF THE MASTER THESIS ..... 13
3	T&D SYSTEMS ..... 15
3.1	Transmission Grid..... 15
3.2	Distribution Grid..... 19
4	BASIS OF DESIGN ..... 22
4.1	Project Scope. .... 22
4.2	Existing Network. System Analysis. .... 23
4.3	Future Demands. .... 25
4.4	Some Critical Assumptions..... 29
5	GENERATION PLANTS..... 30
5.1	Power Plant: CCGT ..... 30
5.2	Solar Farm..... 31
6	SUBSTATION DESCRIPTION..... 34
6.1	380 kV Substations Expansion. .... 35
6.2	380 / 115 kV Substations. .... 38
6.3	115 / 34,5 kV Substations. .... 49
6.4	34,5 / 0,4 kV Substations ..... 57
7	ELECTRICAL LINES DESCRIPTION..... 59
7.1	380 kV Overhead Lines. .... 59
7.2	115 kV Underground Lines..... 64
8	CALCULATION REPORTS ..... 66
8.1	Input Data, Assumptions and Methodology ..... 66
8.2	Load Flow Assessment ..... 68
8.3	Conclusions..... 89
9	COST ESTIMATION..... 94

---

9.1	Methodology .....	94
9.2	CAPEX Estimation .....	95
9.3	Exclusions .....	97
9.4	CAPEX Summary .....	98
10	CONCLUSION AND RECOMMENDATIONS .....	99
10.1	Summary of the main information .....	99
10.2	Conclusions .....	100
10.3	Recommendations .....	102
11	FUTURE PROSPECTS .....	104
12	BIBLIOGRAPHY .....	105

ANNEX I: FUTURE LOAD DEMANDS

ANNEX II: LOAD FLOW ANALYSIS

ANNEX III: GENERAL SINGLE LINE DIAGRAM

ANNEX IV: COST ESTIMATION

## INDEX OF FIGURES

Figure	Page
Figure 1: Electric Power System Diagram (Csanyi, 2023) .....	15
Figure 2: Evolution (per km) of the 400 and 220 kV grid in Spain until 2008 (Rivier, 2022)	17
Figure 3: Average maximum load (MW) of 400 kV lines on week days (Rivier, 2022) .....	17
Figure 4: Average maximum load (MW) of 220 kV lines on week days (Rivier, 2022) .....	17
Figure 5: REE Transmission Network Layout (Red Eléctrica de España, 2017) .....	19
Figure 6: Typical Distribution System (Cossent, 2022).....	20
Figure 7: Main DSOs in Spain (Energía, 2023) .....	21
Figure 8: Jubail 2 (stage 4) and Jubail 3 locations .....	23
Figure 9: Existing H.V Overhead Lines next to JB2S4&3 .....	23
Figure 10: Substation Locations next to JB2S4&3 .....	24
Figure 11: Diagram for Substations and Electrical Lines in JB2S4&3.....	27
Figure 12: Future Load Demands in JB2S4&3 .....	28
Figure 13: Typical CCGT Overall Diagram (Power, -) .....	30
Figure 14: Typical PV Plant Overall Diagram (Technology, -).....	32
Figure 15: Diagram for Substations and Electrical Lines in JB2S4&3.....	34
Figure 16: Diagram for 380 / 115 kV Substations. One breaker and a half.....	39
Figure 17: Diagram for 115 / 34,5 kV Substation. Doble Busbar.....	49
Figure 18: New 34,5 / 0,4 kV 1000 kVA Substation .....	58
Figure 19: New 34,5 kV VIS (RMU).....	58
Figure 20: Recommendation to solve the overload in the transformers .....	93
Figure 21: Workload Expectation per Phase.....	95

# 1 INTRODUCTION AND MOTIVATION

## 1.1 Introduction

An essential component for the functioning of contemporary society is the availability of electrical energy. Electric power is a key energy source involve in everything, from lighting and household appliances to industrial equipment and transportation systems. The construction and operation of an electric power transmission and distribution network is necessary to transport electric power from generators to consumers and ensure the supply of electric power to end-users. A variety of elements, including technical capacity, resource availability, economic profitability, environmental sustainability and social impacts, affect the viability of such a network. In this regard, feasibility studies are essential to assess the viability and impacts of grid construction and operation.

The Project mission is intended, based on engineering observation and engineering judgment, to validate the assessment that implies the Jubail Green Industrial Park, and check whether it is feasible and achievable.

The objective of T&D is the Design and Definition of the Power Transmission and Distribution Networks of the new Jubail Green Industrial Park, based mainly on an estimated industrial model, estimated generation model and another previous studies, and finally the cost estimation (Class IV).

The main points which will be developed in the submitted documentation are:

- T&D Basis of design: Analysis of input data, Load demand, Power Generation, Definition of the system voltage levels.
- Definition of main characteristics of the Substations and H.V Lines.
- Analysis of Interconnection with H.V Existing Network and with Jubail 2 Network.
- Cost estimation.

## 1.2 Motivation

The economic, social and technological progress of modern societies is driven by electricity, a key source of energy. Due to population growth, industrial development and the electrification of the economy, the demand for electricity has grown exponentially worldwide in recent decades and is expected to continue to do so in the future. To meet this demand effectively, safely and sustainably, an electricity transmission and distribution network must be built and operated. To ensure the success of the project, the significant technical, economic, social and environmental challenges associated with the implementation of such a grid need to be adequately addressed.

For this purpose, within the following section “2. Objectives of the Master Thesis” of this document, presents the requirements for a properly carried out grid.

## 2 OBJECTIVES OF THE MASTER THESIS

The main objective of T&D is the Design and Definition of the Power Transmission and Distribution Networks of Jubail 2 (stage 4) and Jubail 3, based mainly on an estimated industrial model, estimated generation model and another previous studies submitted by the Client, and finally the cost estimation Class IV.

As mentioned in the previous sections, the following are the proposed objectives for this Master's Thesis:

- **Definition of preliminary industrial model based on benchmark, previous studies, meetings and stakeholders:** The objective of this task is to establish a preliminary industrial model for the project, taking into consideration the benchmarking of similar projects, previous studies, and feedback from stakeholders. The model will identify key parameters such as the capacity of the power network, operational requirements, and potential future expansion needs.
- **Analyze the electricity demand in the study area and determine the capacity required for the proposed electricity network:** the purpose of this objective is to find out how much electricity is consumed in the area and to determine how much capacity will be required to meet the expected demand. This will consider factors such as the expected industrial activity, the distribution of demand and generation, etc.
- **Design the electricity grid with the substations and lines required considering the technical and safety requirements:** design an electricity network that meets the technical and safety requirements necessary to guarantee the correct operation of the electricity network and the protection of people. This design must consider the location and configuration of the substations and lines to meet the demand for electrical energy.
- **Assessment of infrastructure capacity and corridor adequacy, conceptual transportation plan and corridor schemes:** This objective involves assessing the capacity of the existing infrastructure and determining the adequacy of the corridors to support the proposed power network. A conceptual transportation plan will be developed to ensure the efficient movement of people and goods while minimizing the impact on the environment and the local community. Simulation software such as ETAP will be used to carry out studies to check the possible contingencies scenarios in the substations and lines.
- **Preliminary project phasing development plan with a CAPEX Class IV cost estimation:** This objective is to develop a preliminary project phasing development plan that outlines the project timeline, milestones, and deliverables. A Class IV cost estimation will be conducted to determine the estimated costs of the project, which will help to determine the project feasibility and ensure that it is within budget constraints.

- Finally, **to present conclusions and recommendations** based on the results obtained and the analyses carried out in the study, with the aim of making informed and sustainable decisions regarding the construction and operation of the electricity grid.

By achieving these objectives, the project will be well-planned and organized, ensuring that all stakeholders are aware of the project's requirements and limitations. This will lead to a successful implementation of the project, meeting the energy demands of the region while minimizing environmental impact and maximizing economic benefits.

## 3 T&D SYSTEMS

### 3.1 Transmission Grid.

Transmission grids are responsible for the transmission of electrical energy from the large generation points to the distribution electrical substations. By raising the voltage by means of transformers, electricity is transported over long distances with lower losses (ENDESA, 2023). This type of network is the backbone of the electric power systems. A diagram of an electrical system is shown below, in particular the transmission grid is shown in blue.

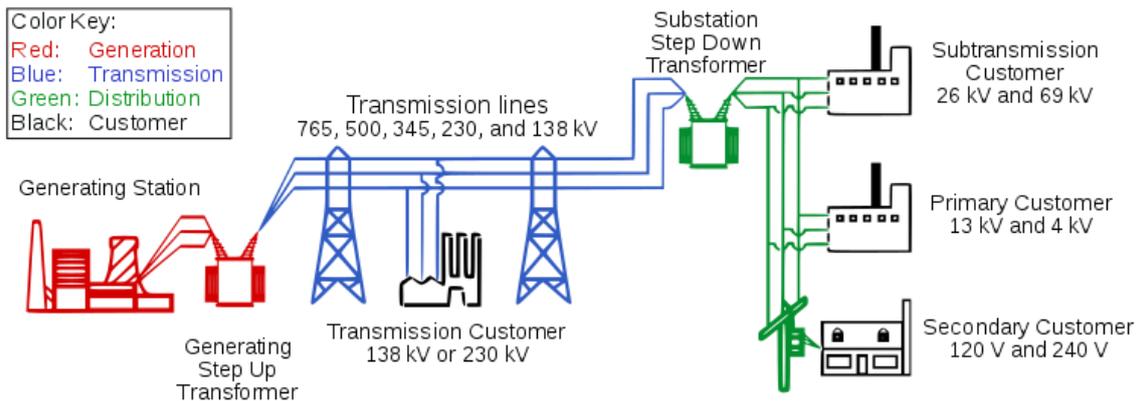


Figure 1: Electric Power System Diagram (Csanyi, 2023)

The transmission network is meshed, which means that all points (also called nodes) are interconnected with each other, i.e., that in the event of a power failure for any reason, the service is guaranteed. Therefore, thanks to these interconnections, we have a very reliable system which leads to a smaller reserve margin in case of an emergency.

However, with a meshed network, the short-circuit power increases because the more interconnected is the grid, the more feeding routes for electrical energy are. As a result, a short circuit at one point in the grid can create a current flow that can interact with other currents.

Despite this, as mentioned above, this network configuration also has the advantage of being more resilient to failures and providing greater reliability and flexibility in operation.

#### **Transmission Network facilities**

- **High-voltage power lines:** These are overhead or underground cables used to transport electricity over long distances. They operate at high voltages, to minimize power losses during transmission.
- **Substations:** Substations are essential facilities that connect power plants, transmission lines, and distribution networks. They serve as nodes for voltage conversion, switching, and control, allowing electricity to flow efficiently between different parts of the grid.
- **Transformers:** Transformers are used in substations to step up the voltage for long-distance transmission and step it down again for distribution to consumers. This voltage transformation reduces losses during power transmission.

- HVDC (High-Voltage Direct Current) transmission systems: HVDC systems are used to transmit power over extremely long distances, underwater or underground, with lower losses compared to traditional AC (Alternating Current) transmission.
- Transmission towers: These structures support overhead power lines and ensure they remain at a safe distance from the ground and other objects.
- Communication and control systems: Modern transmission networks rely on advanced communication and control systems to monitor and manage grid operations effectively. These systems enable real-time monitoring, fault detection, and grid optimization.
- Protection and safety devices: To ensure the safety and reliability of the transmission network, various protection devices are employed, such as circuit breakers, relays, and surge arrestors, which help prevent and mitigate potential faults and disturbances.

Building and maintaining transmission network facilities require significant investment, planning, and coordination between various stakeholders, including electricity generators, transmission companies, regulators, and governments. The continuous expansion and modernization of transmission infrastructure are vital for accommodating increasing power demand, integrating renewable energy sources, and enhancing the overall reliability of the electrical grid.

### **Voltage Level**

In Spain, throughout its evolution, the 400 kV transmission grid has experienced significant growth compared to the 220 kV grid (Rivier, 2022). The introduction of the 400 kV grid has made it possible to transmit greater energy capacities and reduce losses compared to 220 kV transmission. This has facilitated the interconnection of regions and countries, as well as the integration of large-scale renewable energy sources. In many cases, new 400 kV lines and substations have been built to improve transmission capacity and power system efficiency. Although the 220 kV grid remains important, the 400 kV grid has gained ground due to its technical and economic advantages in transmitting large volumes of power over long distances.

The following graph shows the evolution of the 400 kV network versus the 220 kV network from years 1969 until 2008.

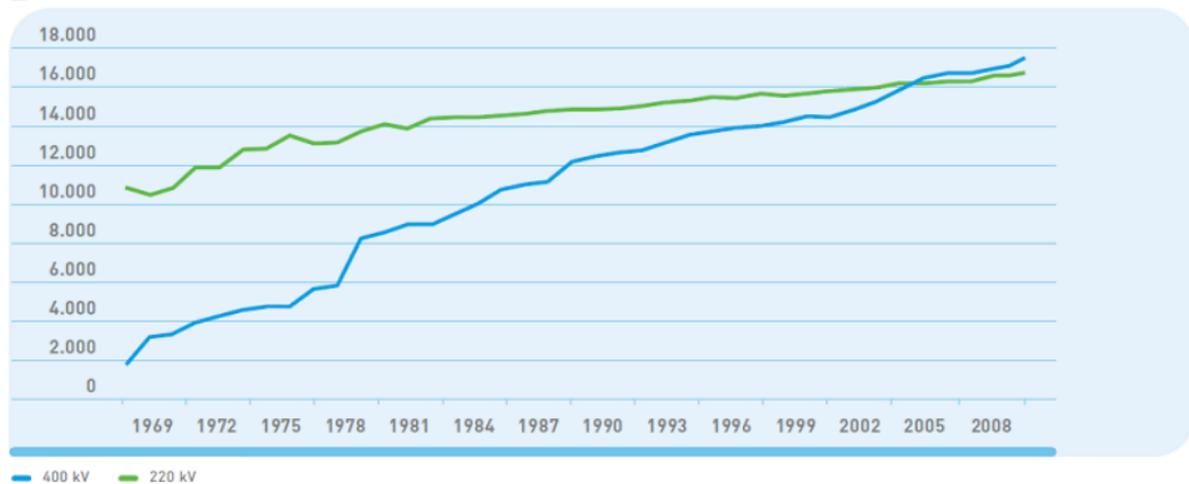


Figure 2: Evolution (per km) of the 400 and 220 kV grid in Spain until 2008 (Rivier, 2022)

### Overinvestment in Transmission Networks

As it can be seen in the figures below, there is a huge overinvestment in the Spanish Transmission Network.



Figure 3: Average maximum load (MW) of 400 kV lines on week days (Rivier, 2022)



Figure 4: Average maximum load (MW) of 220 kV lines on week days (Rivier, 2022)

The overinvestment can be justified based on several reasons:

- Grid reliability and resilience: Transmission networks are the backbone of the electricity grid, and overinvestment can enhance grid reliability and resilience. By building redundant or backup transmission lines, it becomes possible to minimize the impact of equipment failures, natural disasters, or other disruptions. This ensures a more stable and reliable electricity supply.

- **Renewable energy integration:** Renewable generation sites, such as wind farms or solar farms, are often located in remote areas with abundant renewable resources. Building additional transmission infrastructure enables the transport of renewable energy from these resource-rich areas to the load centers where electricity is consumed, ensuring a smooth integration of clean energy into the grid.
- **Strategic infrastructure planning:** Transmission networks are long-term assets with lifespans of several decades. Overinvesting in transmission infrastructure aligns with strategic planning, considering long-term benefits and anticipating future technological advancements, changes in energy generation, and shifts in electricity consumption patterns.

It is essential to strike a balance and avoid excessive or unnecessary overinvestment. Robust cost-benefit analysis, accurate demand forecasting, and consideration of alternative solutions should guide investment decisions to ensure that resources are allocated efficiently and cost-effectively while meeting the needs of the electricity system.

### **Interconnections**

The electricity transmission grid also plays a key role in the interconnection between countries, as it is the infrastructure that enables the exchange of electricity between different national electricity grids. One of the greatest advantages is the great stability and reliability they bring to the electricity system, as they allow energy to be shared at times of high demand or supply shortages (Rivier, 2022).

- **Cross-border electricity trade:** Interconnections allow for the import and export of electricity between neighbouring countries or regions. This facilitates the sharing of energy resources, promotes energy market integration, and enhances energy security by diversifying supply sources.
- **Balancing supply and demand:** Interconnections enable the balancing of supply and demand fluctuations across interconnected grids. When one grid experiences excess generation, it can export the surplus electricity to areas with higher demand or lower generation. This helps optimize the utilization of available resources and improves the overall efficiency of the electricity system.
- **Grid resilience and reliability:** Interconnections enhance the resilience and reliability of the transmission network. In the event of a grid outage or equipment failure, interconnections enable the flow of electricity from neighbouring grids, helping to maintain a stable power supply and minimize disruptions.
- **Cross-border system planning and coordination:** Interconnections require close coordination between grid operators and regulatory authorities across borders. This includes harmonizing technical standards, establishing common market rules, and ensuring effective system planning to support the efficient operation of interconnected grids.

In Spain, Red Eléctrica de España (REE, 2023) is responsible for supervising and managing the transmission system to always guarantee the continuity and security of the electricity supply. It is the only Transmission System Operator (TSO) of the Spanish electricity system.

As operator of the electricity system, through its control centers it always guarantees the operation of the electricity supply process, while as grid manager, it transports electricity from generation to the areas of consumption through the extensive transmission grid.

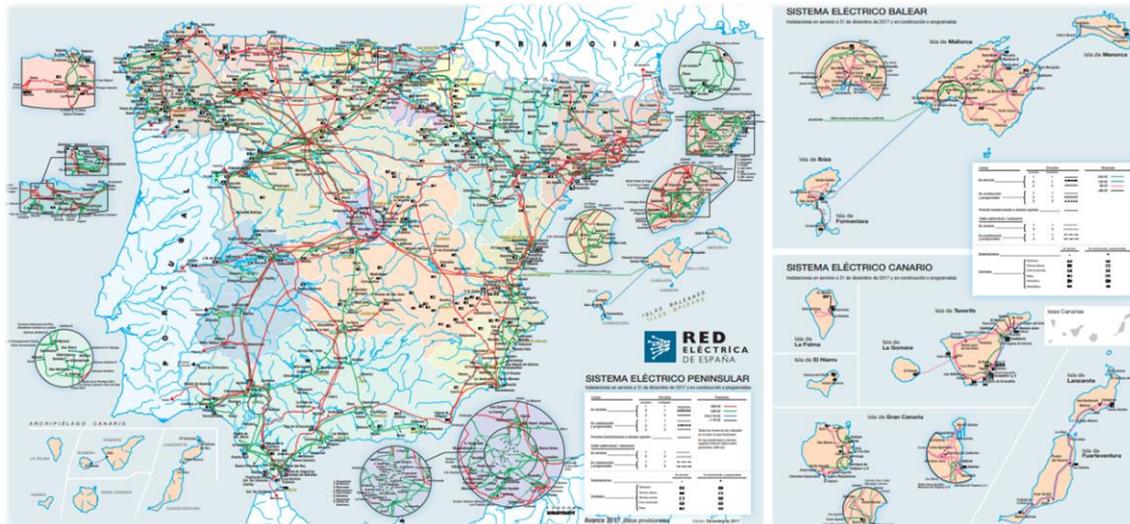


Figure 5: REE Transmission Network Layout (Red Eléctrica de España, 2017)

### 3.2 Distribution Grid.

Distribution grids are infrastructure systems designed to transport electricity from generating plants to end users. These networks are composed of an interconnected network of cables, conductors, transformers, and protection equipment. A diagram of an electrical system is shown in Figure 1, the distribution grid is shown in green.

The following are some of the most relevant points of the distribution networks (Cossent, 2022), which are shown in Figure 6.

- **Transmission Grid:** At the highest level, the transmission grid is responsible for the long-distance transport of electricity across countries or regions. It operates at high voltages, typically 220 kV and above, and connects major power generation facilities, large industrial consumers, and cross-border interconnections.
- **Transmission Substations:** connects power generation plants or other transmission substations to the distribution system. Its main function is to step down the high-voltage electricity received from the power plant or transmission lines to a lower voltage level, for efficient transmission over long distances. Transmission substations include various equipment such as transformers, circuit breakers, switches, and protective devices to regulate and control the flow of electricity

- Primary Distribution Network (Subtransmission Network): The primary distribution network receives electricity from the transmission grid and distributes it to regional or local areas. It operates at medium voltages, usually between 10 kV and 50 kV, and consists of substations, transformers, and mainly overhead, except in urban areas.
- Distribution Substation: receives electricity from the transmission system and further steps it down to lower voltage levels suitable for distribution to end-users. Distribution substations operate at medium voltage levels, typically ranging from 4 kV to 35 kV. Their primary function is to distribute electricity to residential, commercial, and industrial consumers through local distribution networks.
- Secondary Distribution Network (MV Feeders): The secondary distribution network is the next level down and delivers electricity from the primary distribution network to individual neighbourhoods or communities. It operates at low voltages, typically 400 V three-phase or 230 V single-phase, and consists of distribution transformers, overhead or underground cables, and switchgear.
- MV/LV Transformers: MV/LV transformers are typically located within distribution substations and are responsible for further reducing the voltage from medium voltage levels to low voltage levels suitable for consumer use. The transformers step down the voltage from around 4 kV to 35 kV on the MV side to commonly used voltages of 230 V or 400 V on the LV side. They ensure the safe and efficient delivery of electricity to homes, businesses, and other end-users.
- Low-Voltage Distribution Network (LV Lines): The low-voltage distribution network is the final stage of the distribution system, delivering electricity directly to end-users. It operates at the lowest voltages, usually 230 V single-phase or 400 V three-phase, and comprises local distribution substations, transformers, and the final service connections to homes, businesses, and other consumers.

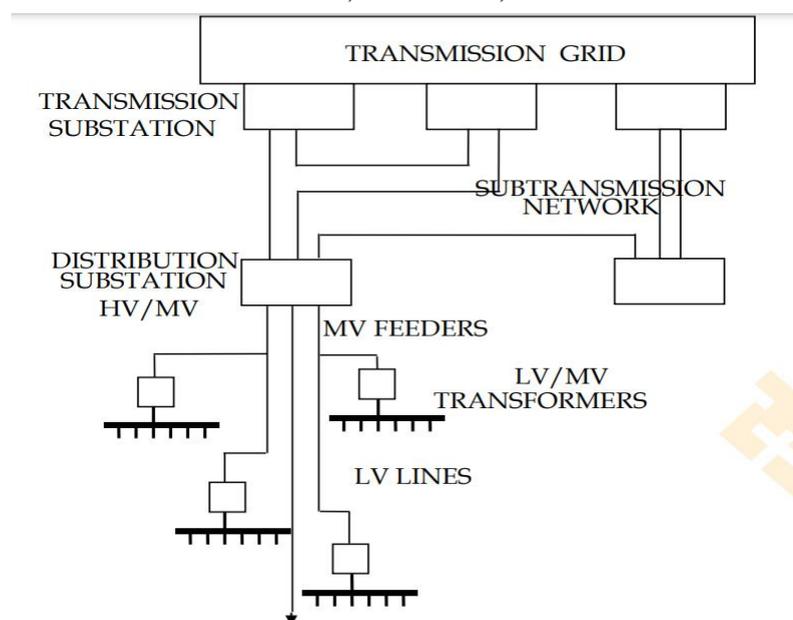


Figure 6: Typical Distribution System (Cossent, 2022)

Distribution network operators (DNOs), also known as distribution system operators (DSOs), are responsible for operating, maintaining, and developing the distribution network within their designated areas. They ensure the reliable delivery of electricity, manage grid connections, handle metering, and provide customer services.

In Spain, there are many (around 300) Distribution System Operators, which operate the grid. Although it is a big number of DSO, the main DSO are represented in the figure below.

Distribution network is regulated by the Spanish Energy Regulator (Comisión Nacional de Mercados y Competencias CNMC). The CNMC oversees the tariffs, quality of service and technical standards for distribution network operators to ensure fair and efficient operations.

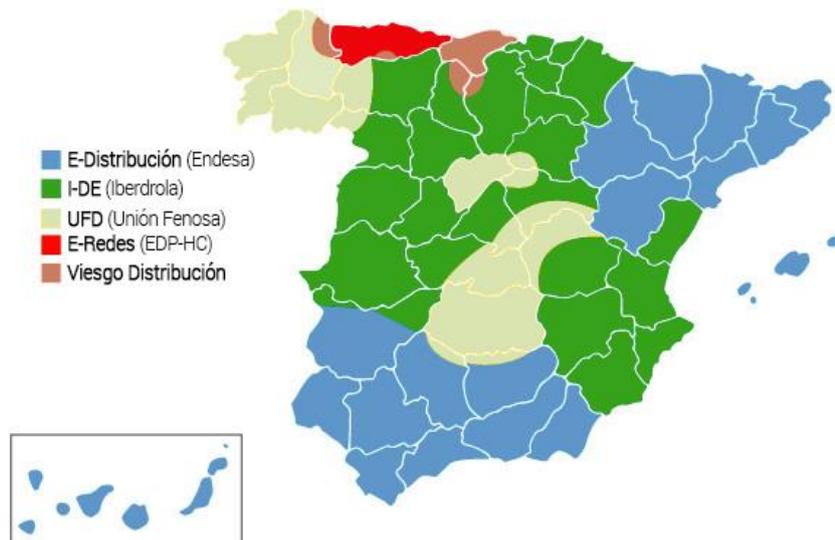


Figure 7: Main DSOs in Spain (Energía, 2023)

## 4 BASIS OF DESIGN

The aim of this section is to clearly establish the basis of design for the analysis relative to the Electrical T&D System feasibility study for the Jubail Green Industrial Park. For this task, it will be considering the existing network in Jubail 1 & 2, and the forecast relative to the Green Industrial Park called, Jubail 2 Stage 4 and Jubail 3 (hereinafter JB2S4&3).

Based on the above, this section collects the most important information and establishes the starting point concepts to be followed.

### 4.1 Project Scope.

The Project mission is intended, based on engineering observation and engineering judgment, to validate the assessment that implies the Jubail Green Industrial Park, and check whether it is technically feasible and achievable.

The Project will consist of two phases. The first phase which is the objective of this Master's Thesis is the feasibility study of Jubail 2-Stage 4 and Jubail 3 Phase 1 of 2. The 1<sup>st</sup> phase will develop the documentation to reach the following overall objectives that some of them have been previously described in section "2. Objectives of the Master's Thesis":

- Definition of preliminary industrial model based on benchmark, previous studies, meetings and stakeholders.
- Definition and assessment of Infrastructure and Utilities demands and conceptual layouts.
- Assessment of Infrastructure capacity and Corridor adequacy, conceptual Transportation plan and corridor schemes.
- Preliminary project phasing development plan with a Class IV cost estimation.

The project location is shown below, inside the purple area:

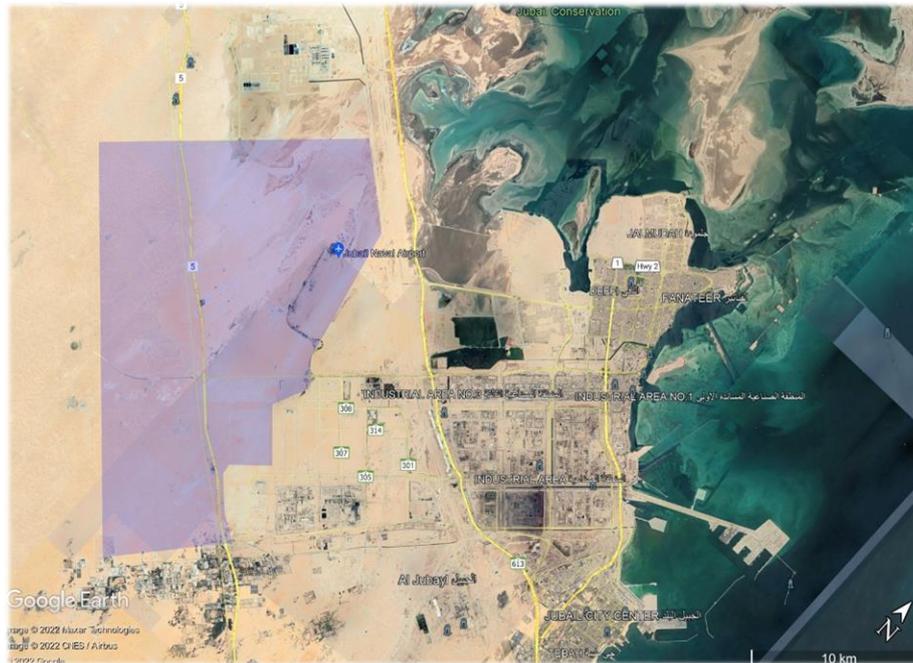


Figure 8: Jubail 2 (stage 4) and Jubail 3 locations

## 4.2 Existing Network. System Analysis.

The main purpose of this section is to analyse the existing network/system and the main concepts to consider in the basis of design.

The existing external H.V System consists of a series of 380 kV Overhead Lines and Substations as can be seen in the following figures extracted from Google Earth. Limits of JB2S4&3 have been marked in green and existing H.V. Overhead Lines in red.



Figure 9: Existing H.V Overhead Lines next to JB2S4&3

In order to obtain reliable and robust electrical system, is considered the interconnection of the new 380 kV System of JB2S4&3 with the External 380 kV System and also with the 230 kV Systems of Jubail 1 and 2.

The interconnection with the 380 kV System will be performed in at least two (2) points for better reliability and redundancy.

Here below is included a drawing with the Existing and Future Main Substations located in Jubail 1 and 2 area.

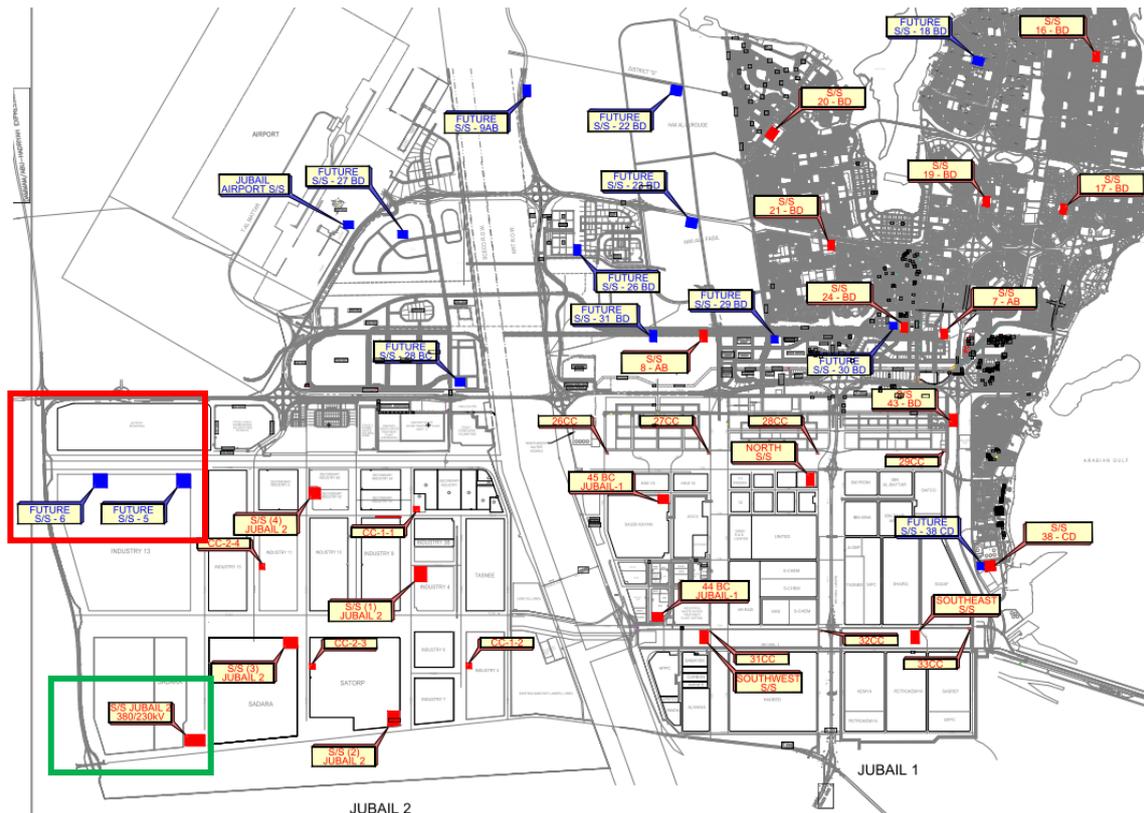


Figure 10: Substation Locations next to JB2S4&3

As shown in the above figure, in particular, inside the red box, there are two (2) Substations foreseen for JB2S4 (Future S/S-5 y Future S/S-6) that will be also taken into account in the design of this Jubail 1 and Jubail 2 area.

#### 4.2.1 Jubail 1.

According to the figure above, within Jubail 1, the Distribution System is fed from the following Substations: Southeast, Southwest, Jubail North and Secondary Industries Substations.

North, Southeast and Southwest Substations are fed through 230 kV Transmission Lines. Separate 230 kV Transmission Lines interconnect the Southeast Substation with other Secondary Industries Substations along different routes.

Thus, there is an internal 230 kV System within the industrial parks, which can supply power to any of the three main Substations from southeast Substation through two 115 kV Underground Lines.

## 4.2.2 Jubail 2.

The Distribution System within Jubail 2 is fed from four (4) main Substation which are Substation-1, Substation-2 and Substation-3 and Substation-4. The first three of these Substations are supplied with power at 230 kV from the Jubail 2 380 / 230 kV Substation. Separate 230 kV Transmission Lines interconnect Substation-1, Substation-2 and Substation-3 along different routes. Thus, there is an internal 230 kV System within Jubail 2, which can supply power to any of the three Substations from two directions. This internal 230 kV Network is tied to Jubail 1 internal Network and External Network.

Finally, the 4<sup>th</sup> Substation in Jubail 2 named Substation-4 is fed from Substation-1 at 115 kV Distribution Line.

All Substations in Jubail 2 are connected to the Jubail 2 internal Network that connects to the Jubail 1 internal Network and to the External Network. Interconnection of Substations to the External Network ensures availability of power supply from multiple resources that will guarantee stability and reliability of power supply.

As it can be seen from the previous descriptions, the H.V. System of Jubail 2 is at 230 kV and H.V. System of JB2S4&3 is at 380 kV. The interconnection between the 380 kV System of JB2S4&3 with the existing 230 kV System of Jubail 1 and 2 should be through the Jubail 2 380 / 230 kV Substation, as it can be checked in the Figure 5, in particular, inside the green box.

## 4.3 Future Demands.

The purpose of this section is to describe the conceptual design proposed for the Transmission and Distribution System of JB2S4&3 based in future demands.

The Green Industrial Park of JB2S4&3 will be supplied with electrical power from the External Network and with additional generation power plants (renewables, CCGTs, etc.) within the Green Industrial Park in order to supply a several portion of the projected power demand.

As it is indicated previously, in JB2S4&3 is planned to install approx. 2,000 MW in Generation Power Plant, and it means that can generate and evacuate electrical power to 380 kV Network and can be a reinforcement of the External 380 kV Network.

The electrical conceptual design for JB2S4&3 is based upon the supply and distribution of electrical power at 380 kV, 115 kV and 34,5 kV from several Substations, in order to satisfy the demand of the Green Industrial Park.

The electrical conceptual design for JB2S4&3 is based on the supply and distribution of electrical power at 380 kV, 115 kV and 34,5 kV from several substations to satisfy the demand of the Green Industrial Park.

In case of existing capacity in the External Network for the first stages, it would be utilised diverting the main 380 kV Overhead Lines. Once sufficient demand has been built up

in Green Industrial Park, the Generation Power Plants could be established in the site to provide required electric power.

The 380 kV Substations of JB2S4&3 will be fully integrated into the External Network, which means that 380 kV System will not be exclusively for Green Industrial Park of JB2S4&3 and an electric power will flow between substations.

All these requirements will result in a robust and reliable electrical system.

The proposal of the electrical system in JB2S4&3 and the substations, will be made based on the Industries Utilities Demand and Generation Power Plants.

The criteria for determining of the maximum allowable individual load that can be connected at each voltage level is according to the table below:

Category of Industrial User	Power Demand	Supply Voltage (kV)
Primary	> 100 MVA	380
Secondary	25 – 100 MVA	115
Tertiary	< 25 MVA	34,5

As it is indicated in above Table, the Primary Industrial of JB2S4&3 will be from the 380 / 115 kV Substation.

In addition, the Secondary Industries and Infrastructure Facilities of JB2S4&3 will be fed from the nearest 115 / 34,5 kV Substation. The 115 / 34,5 kV Substations will also provide supplies for 115 kV and 34,5 kV feeders.

The Support Industries and Infrastructure requiring an LV supply at 380 / 220 V will also be derived from the 34,5 / 0,4 kV Substations.

For the Generation Power Plants will be considered the same criteria than for Industrial consumers.

Below is included a Diagram with the final Substations and Electrical Lines in JB2S4&3. The overhead lines are represented in colour red and the underground lines are represented in blue.

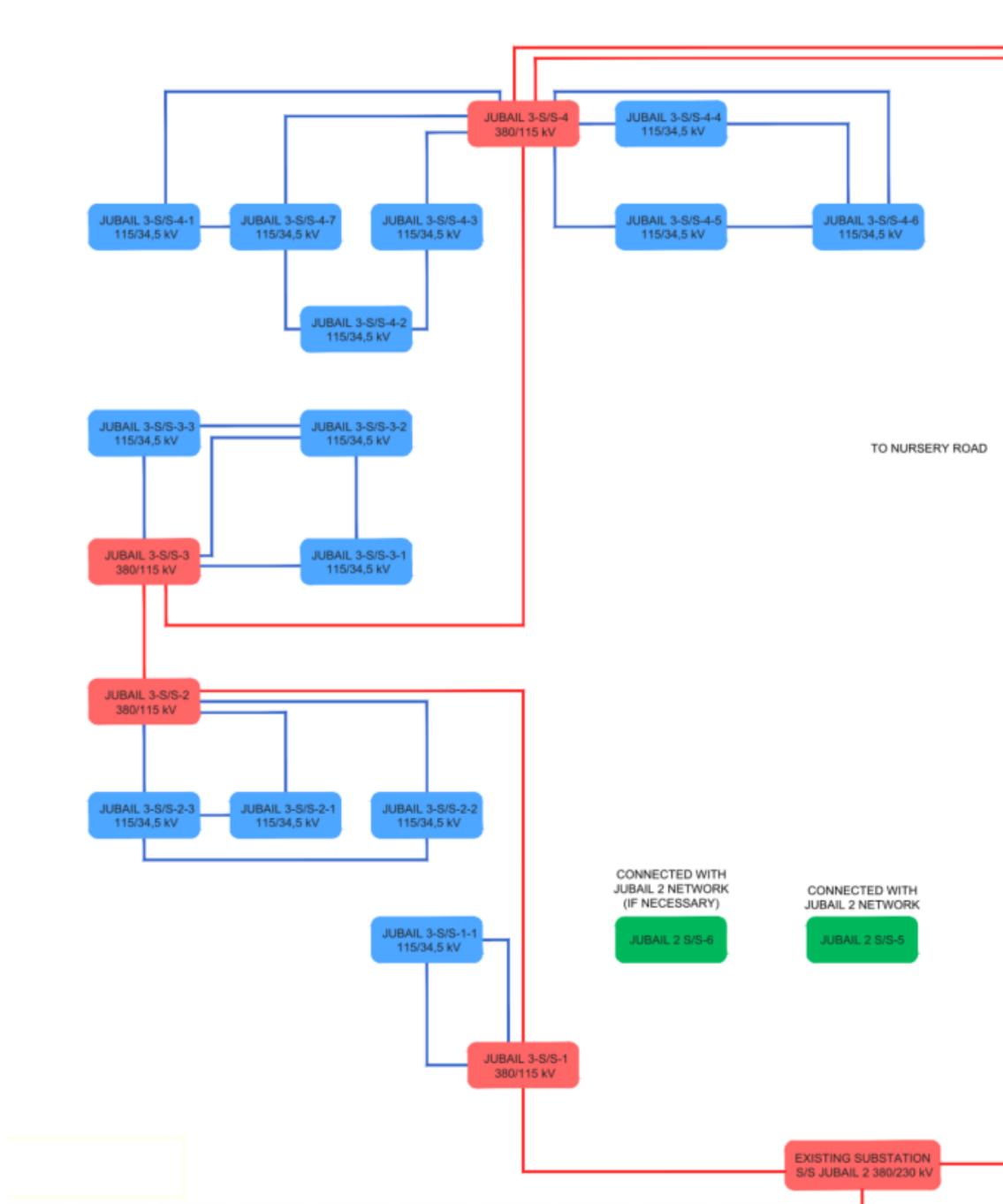


Figure 11: Diagram for Substations and Electrical Lines in JB2S4&3

As it is indicated above the two (2) Future Substations S/S-5 and S/S-6 will supply the Load Demand of JB2S4, but these Substations will be connected directly in 230 kV Network of JB2S4.

The proposed Future 380 KV Network in JB2S4&3 shall be coordinated and agreed with the External Network for concurrence as existing Substations.

### 4.3.1 Future Load Demand of the Green Industrial Park

Within Annex I is included a table with details the Future Load Demand. The resultant load per Substation can be summarised as follows:

Substation	MVA Load Demand At Utilisation Voltage					
	380 kV System (MVA)		115 kV System (MVA)		34.5 kV System (MVA)	
	Busbar 1	Busbar 2	Busbar 1	Busbar 2	Busbar 1	Busbar 2
JUBAIL 3-S/S-1 380/115 kV	1.400,0	---	---	---	---	---
JUBAIL 3-S/S-1-1 115/34.5 kV	---	---	72,8	45,0	31,1	33,3
JUBAIL 2 S/S-5 115/34.5 kV	---	---	---	---	---	---
JUBAIL 2 S/S-6 115/34.5 kV	---	---	---	---	---	---
JUBAIL 3-S/S-2 380/115 kV	1.140,0	1.140,0	---	---	---	---
JUBAIL 3-S/S-2-1 115/34.5 kV	---	---	---	---	43,3	44,4
JUBAIL 3-S/S-2-2 115/34.5 kV	---	---	---	---	55,6	38,9
JUBAIL 3-S/S-2-3 115/34.5 kV	---	---	---	---	33,3	44,4
JUBAIL 3-S/S-3 380/115 kV	701,9	714,8	---	---	---	---
JUBAIL 3-S/S-3-1 115/34.5 kV	---	---	55,6	---	44,4	48,9
JUBAIL 3-S/S-3-2 115/34.5 kV	---	---	---	---	55,6	38,9
JUBAIL 3-S/S-3-3 115/34.5 kV	---	---	---	---	38,9	50,0
JUBAIL 3-S/S-4 380/115 kV	---	---	---	---	---	---
JUBAIL 3-S/S-4-1 115/34.5 kV	---	---	66,7	100,0	28,9	28,9
JUBAIL 3-S/S-4-2 115/34.5 kV	---	---	---	55,6	55,6	22,2
JUBAIL 3-S/S-4-3 115/34.5 kV	---	---	---	---	11,1	11,1
JUBAIL 3-S/S-4-4 115/34.5 kV	---	---	---	---	16,7	16,7
JUBAIL 3-S/S-4-5 115/34.5 kV	---	---	---	---	33,3	38,9
JUBAIL 3-S/S-4-6 115/34.5 kV	---	---	---	---	55,6	44,4
JUBAIL 3-S/S-4-7 115/34.5 kV	---	---	---	---	43,3	43,3

Figure 12: Future Load Demands in JB2S4&3

### 4.3.2 Electrical Transmission and Distribution System

The basic philosophy in the design concept for the Electrical Transmission and Distribution System in the Green Industrial Park has been to provide central locations for power to minimise hook up costs, and, where necessary, to situate large power consumers adjacent to 380 / 115 kV Substations so that these industries can connect directly.

Underground cables will be used for the connection of 115 kV and 34,5 kV duplicate supplies from 380 / 115 kV Substations to each industry. The number of electrical towers within the Green Industrial Park is minimised and supply cables are to be put in underground if possible. For industries fed from the 380 and 115 kV supply, it is recommended that there will be two (2) feeds for each industry – one for normal supply the other for standby.

The Electrical Transmission and Distribution System to be developed for the Green Industrial Park JB2S4&3 will include the following:

- 380 kV Overhead Lines for connection of new electrical installation in JB2S4&3 with External 380 kV Network.
- 380 / 115 kV Substations.
- 115 kV Underground Lines for connection of the 380 / 115 kV Substations with 115 / 34,5 kV Substation.

- 115 / 34,5 kV Substation for secondary distribution.

The Electrical Transmission and Distribution System of JB2S4&3 will consist of four (4) 380 / 115 kV Substations, according with total power demand of JB2S4&3.

The 380 / 115 kV Substations will be connected in a ring, and they will be fed at least with a minimum of two (2) 380 kV Overhead Transmission Lines, connected with the External 380 kV Network, providing total 100% redundancy.

The connections to each 380 / 115 kV Substation shall be configured such that each circuit is looped in and out of the 380 / 115 kV Substation. Each pair of circuits will be connected onto separate busbars giving a total of four (4) connections to provide the level of security/redundancy required (minimum 100%) and the required current carrying capacity.

The proposed electrical design system for JB2S4&3 will be interconnected with Jubail 1 and Jubail 2 in the Jubail 2 380 / 230 kV Substation. With it Jubail 2 380 / 230 kV Substation will be reinforced with power at 380 kV Network from JB2S4&3.

The larger consumers will be located adjacent to 380 / 115 kV Substations with direct connections to the 380 kV Transmission network. In addition, from the 380 / 115 kV Substation will be fed the 115 / 34,5 kV Substation for secondary distribution.

The Secondary Industries and Infrastructure Facilities of JB2S4&3 will be fed from the nearest 115 / 34,5 kV Substation.

The 115 / 34,5 kV Substations will be located as near as possible to the consumers to be fed in order to minimise the connection lengths.

The 115 / 34,5 kV Substations will be connected in a ring, and they will be fed with two (2) 115 kV Underground Lines from the 380 / 115 kV Substations.

Finally, 34,5 / 0,4 kV Substation will be fed from the nearest 115 / 34,5 kV Substations through 34,5 kV underground cables. Each circuit will have a maximum load capacity of 25 MVA per circuit.

#### **4.4 Some Critical Assumptions.**

- Details of the demand for the Green Industrial Park are according to the Annex I.
- The 380 kV System of JB2S4&3 shall be connected with External 380 kV System by means of two (2) 380 kV Overhead Lines.
- The 380 kV System of JB2S4&3 shall be connected with existing 230 kV System of Jubail 1 and 2, through a 380 / 230 kV Substation located in Jubail 1 and Jubail 2.

## 5 GENERATION PLANTS

### 5.1 Power Plant: CCGT

#### 5.1.1 General Description

A Combined Cycle Gas Turbine (CCGT) plant is a highly efficient power generation facility that combines gas turbines and steam turbines to generate electricity. It operates on the principle of taking advantage of waste heat from the gas turbine to produce additional power using a steam turbine.

The heart of a CCGT plant is the gas turbine, where natural gas is burned in a combustion chamber. The burning fuel releases high-temperature gases, which expand through the turbine blades, driving the turbine rotor. The spinning rotor is connected to a generator, converting the mechanical energy into electrical energy.

One of the key advantages of a CCGT plant is its ability to recover the waste heat from the gas turbine exhaust. The exhaust gases, which still retain significant thermal energy, are directed into a Heat Recovery Steam Generator (HRSG). In the HRSG, the waste heat is used to generate high-pressure steam by heating water in a boiler section.

The high-pressure steam produced in the HRSG is then directed to a steam turbine. As the steam expands through the turbine blades, it drives the steam turbine rotor, which is also connected to a generator. This additional turbine-generator set produces electricity using the waste heat recovered from the gas turbine.

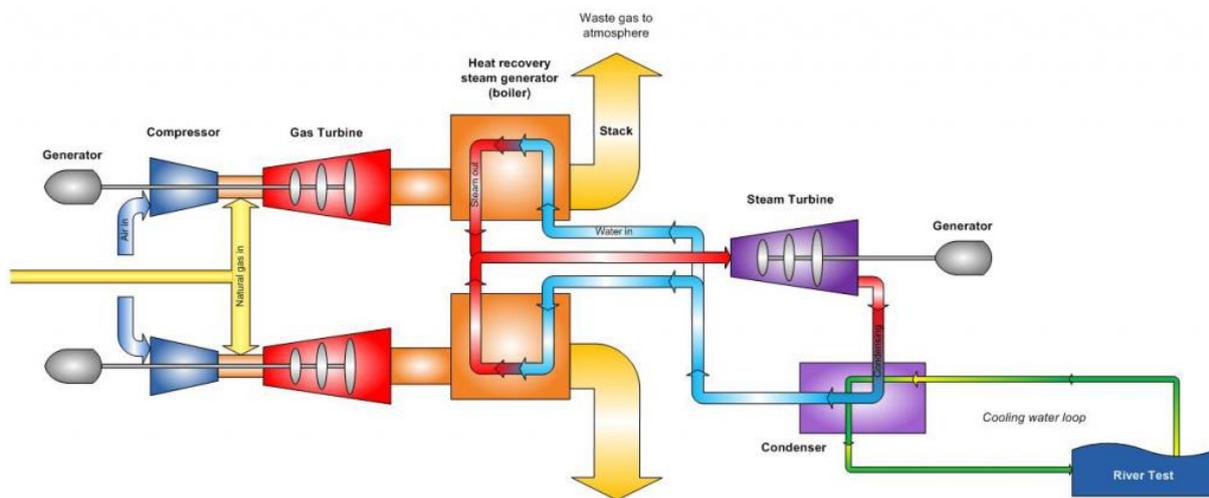


Figure 13: Typical CCGT Overall Diagram (Power, -)

By combining the power generated by both the gas turbine and the steam turbine, a CCGT plant maximizes its overall power output. This combined cycle configuration allows for a more efficient utilization of fuel, resulting in higher thermal efficiency and lower emissions compared to traditional power plants.

CCGT plants also require a cooling system to dissipate excess heat generated during the power generation process. Cooling can be achieved through methods such as evaporative cooling towers or air-cooled condensers, depending on the plant design and location.

The control and monitoring systems in a CCGT plant ensure efficient and reliable operation. These systems regulate the flow of fuel, monitor turbine and generator performance, and optimize plant operation based on electricity demand and grid requirements.

In summary, a CCGT plant utilizes gas turbines and steam turbines to maximize power generation efficiency. It leverages waste heat from the gas turbine to produce additional power using a steam turbine, resulting in a highly efficient and environmentally friendly power generation solution.

### 5.1.2 CCGT main characteristics

The power plant will be connected to the grid via substation JUBAIL 3-S/S-2 380/115 kV.

The basic performance data of the power plant is summarized in the next figure:

Parameter	Unit	Value
Design temperature	°C	42
Design humidity	%	50%
Gas turbine Power (1 unit)	MW	166
Steam turbine Power (1 unit)	MW	362
Gross plant power (2 trains)	MW	2052
Net plant power (2 trains)	MW	2000
Net plant thermal efficiency (HHV)	%	53.0%
Fuel type	--	Gas Natural
Fuel LHV (25°C)	kJ/kg	46280
Fuel consumption (1 unit)	kg/s	10.160
Stack Height	m	(tentative) 60
Stack internal diameter	mm	(tentative) 6100
Flue gas temperature	°C	125
Flue gas mass flow (1 GT unit)	kg/s	444
Water consumption	m <sup>3</sup> /d	613
Effluents	m <sup>3</sup> /d	484

## 5.2 Solar Farm

### 5.2.1 General Description

A photovoltaic (PV) solar plant, also known as a solar power plant or solar farm, is a facility that converts sunlight directly into electricity using solar panels. These plants take advantage of the power of solar radiation to generate clean and renewable energy.

A PV solar plant consists of arrays of solar panels or modules, typically mounted on racks or structures to capture sunlight. The solar panels are made up of photovoltaic cells,

usually composed of silicon or other semiconductor materials. When sunlight strikes these cells, it excites electrons, creating an electric current. It is known as photoelectric effect.

The solar panels are connected in series and parallel configurations to form strings and arrays. These configurations optimize the voltage and current levels to match the requirements of the power system. The electrical energy generated by the solar panels is in the form of direct current (DC).

To convert the DC power generated by the solar panels into alternating current (AC) electricity, an inverter is used. The inverter converts the DC power into AC power, which is the standard form of electricity used in homes, businesses, and the electrical grid. The AC electricity is then transmitted through transformers and power lines for distribution and use.

PV solar plants often include monitoring and control systems to track the performance of the solar panels and optimize power generation. These systems measure parameters such as solar irradiance, panel temperature, and electricity output. They help identify any issues or inefficiencies and enable operators to make adjustments to maximize energy production.

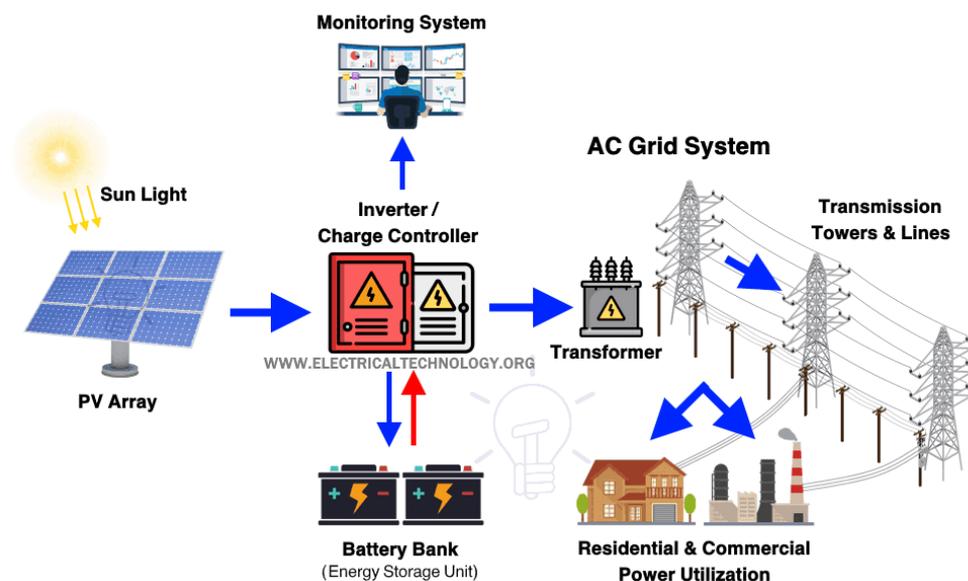


Figure 14: Typical PV Plant Overall Diagram (Technology, -)

The performance of a PV solar plant is influenced by various factors, including solar irradiance, panel orientation, shading, and temperature. Solar tracking systems may be employed to optimize panel orientation and maximize sunlight absorption throughout the day. Additionally, regular maintenance and cleaning of the solar panels are important to ensure their efficiency and longevity.

PV solar plants can be grid-connected, meaning they are connected to the electrical grid, or they can operate independently as standalone systems. In grid-connected solar plants, excess electricity generated during periods of high solar radiation can be fed back into the grid, while in standalone systems, the electricity is used locally or stored in batteries for later use.

Overall, PV solar plants provide a sustainable and environmentally friendly means of generating electricity. They help reduce greenhouse gas emissions, contribute to energy

independence, and play a vital role in the transition to a clean energy future. With ongoing technological advancements and decreasing costs, PV solar power is becoming an increasingly important part of the global energy mix.

## 5.2.2 PV plant main characteristics

The solar farm will cover 2545ha of land. The target energy production is 3.000 GWh/year of energy production to fulfil the production of 50 ktny of green hydrogen, which is the minimum required by the industrial model. Photovoltaics panels will suffer performance degradation (14% in 25 years)

The PV plant will be connected to substation JUBAIL 3-S/S-3 380/115 kV and it is intended that it sell its whole “green energy” production rights to the green Hydrogen plant.

There are two configurations of panels suggested:

- Baseline (1P): 1 Portrait (1P), N-S axis, 7 meters pitch, single axis tracker and bifacial.
- Optional (DO): 4 Portrait (4P), Dome, N-S axis, tracker less

The basic performance data of the solar farm (with the two options) is summarized in the next figure:

Description	Unit	1P	DO
Target H2 production (100%)	ktny	50	50
Target AEP (100%)	GWh/yr	3000	3000
Available plot land	ha	2545	2545
AEP from PV	GWh/y	3416	5908
AEP/ha from PV	MWh/(y·ha)	1342	2322
Solar Farm Peak power	GWp	1,351	3,146
H2 capacity yield	tpy/ha	22	39
H2 total capacity by Green Energy Farm	ktpy	57	98
Required area for minimum production (100%)	ha	2230	1290
Capacity coverage by Green Energy Farm	%	114%	197%

Rack Type	Pitch (m)	Modules (Qty)	Inverter (Qty)	Peak Power (MWp)	AEP (MWh/yr)	Yield (eq. hours/yr)
Tracker 1P	7.0	1237314	86	668	1689131	2528
Domes 4P	19.5	3508232	242	1894	3557715	1878

## 6 SUBSTATION DESCRIPTION

The aim of this section is to clearly establish the description of the elements that comprise the facilities of the future Network. This section collects the most important information and establishes the starting point concepts to be followed in the specialty. For this entire section, the following figure will be used as a reference:

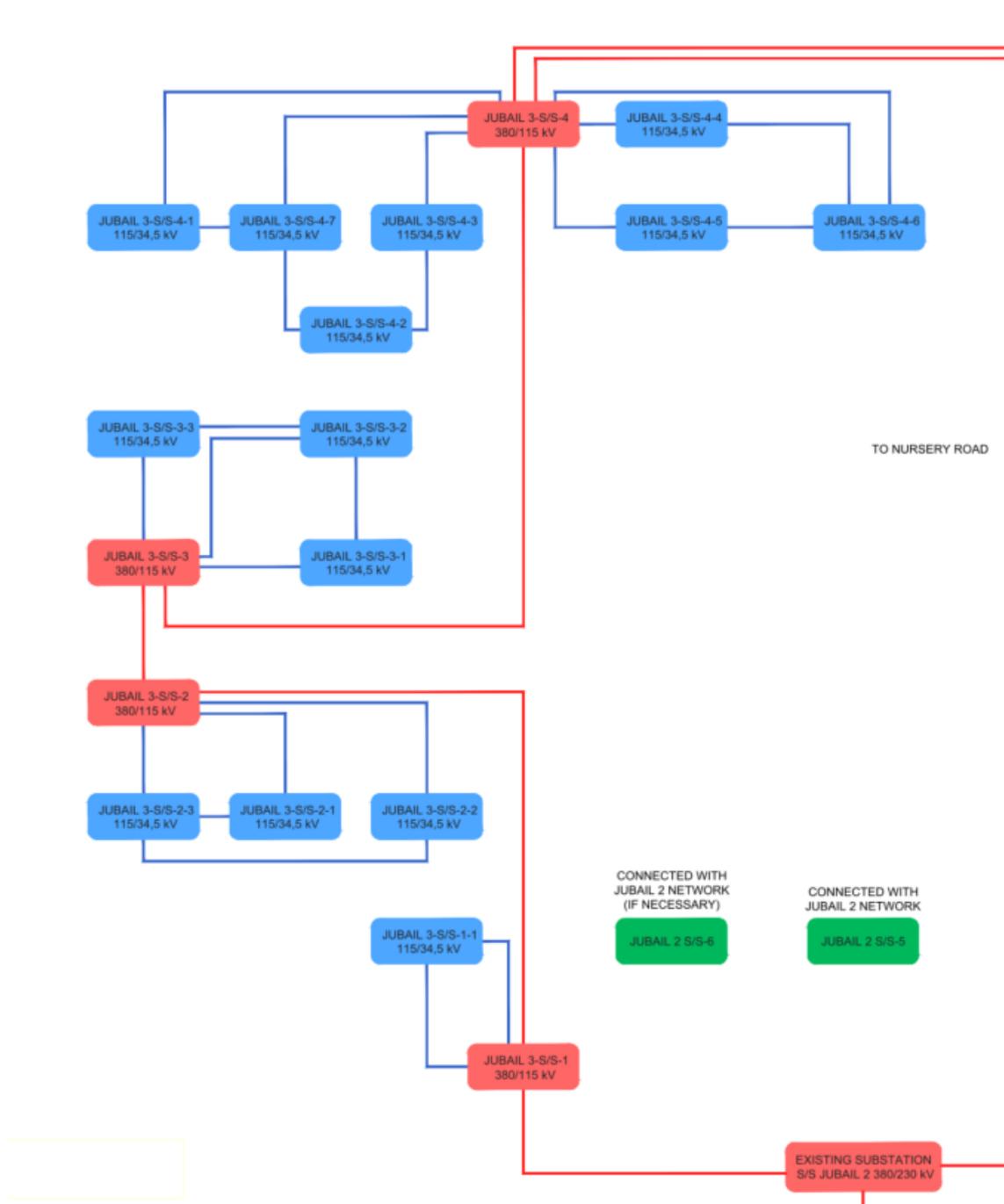


Figure 15: Diagram for Substations and Electrical Lines in JB2S4&3

## 6.1 380 kV Substations Expansion.

As stated in the previous section “4. Basic of Design”, in order to obtain a reliable and robust electrical system, is considered the interconnection of the new 380 kV System of J2S4&3 with the External 380 kV System and also with the 230 kV Systems of Jubail 1 and 2. The interconnection between the 380 kV System of J2S4&3 with the existing 230 kV System of Jubail 1 and 2 should be through the Jubail 2 380 / 230 kV Substation

With all this, the first interconnection will be in Jubail 2 380 / 230 kV Substation, where will interconnect the new 380 kV System of J2S4&3 with the External 380 kV System and also with the 230 kV systems of Jubail 1 and 2, as it can be seen in Figure 15.

This way, the future JUBAIL 3-S/S-1 380 / 115 kV Substation will interconnect with Jubail 2 380 / 230 kV Substation and the future JUBAIL 3-S/S-4 380 / 115 kV with the 380 kV Overhead Line "To Nursery Road", therefore the interconnecting the 380 / 115 kV Substations in ring form with the 380 kV Network.

The interconnections between the new 380 / 115 kV Substations of J2S4&3 and the External 380 kV System, will be made at JUBAIL 3-S/S-1 and JUBAIL 3-S/S-4 Substations, as it can be checked in Figure 15.

### 6.1.1 Interconnection in Jubail 2 380 / 230 kV Substation

For this purpose, the interconnection of the JUBAIL 3-S/S-1 Substation will be performed with the two (2) bays Not Utilized (Not Energized). The interconnection between both Substations will be done through a 380 kV Overhead Line, with double circuit.

If these bays are reserved for other uses and are not available, it is proposed, to extend the busbars of Jubail 2 380 / 230 kV Substation, and to build two (2) new bays.

The new bays for the interconnection of the JUBAIL 3-S/S-1 Substation will have the same configuration and switchgear as the existing bays.

The configuration planned is a double busbar configuration with one breaker a half with the following bays:

- Two (2) incoming / outgoing bays of 380 kV (one of them in each busbar) for interconnection between with JUBAIL 3-S/S-1 Substation.

Although the configuration of the new bays should be the same as the existing bays in Jubail 2 380 / 230 kV Substation, the switchgear planned with which each bay is equipped will be as follows:

- Incoming / outgoing bay of 380 kV:
  - One (1) three-phase line disconnector switch with earthing blades for line connection.
  - One (1) three-phase circuit breaker, in SF6.
  - Three (3) current transformers (1 per phase).

- Two (2) three-phase disconnecter switches (one at each side of the circuit breaker).
- Three (3) voltage transformers (1 per phase).
- Three (3) surge arresters (1 per phase).

In addition, in each interconnection between switchgear of the configuration of one breaker a half shall include the following (as 380 kV coupling bay):

- One (1) three-phase circuit breaker, in SF6.
- Three (3) current transformers (1 per phase).
- Two (2) three-phase disconnecter switches (one at each side of the circuit breaker).

The main technical characteristics of the switchgear considered for the interconnection in the expansion of existing JUBAIL 2 380 kV / 230 kV Substation shall be as follows:

### **Circuit breaker and Disconnecter**

- Rated voltage: .....380 kV
- Highest voltage for the material (Um):.....420 kV
- Frequency: .....60 Hz
- Rated continuous current: ..... 3.150 or 4.000 A
- Short circuit current (rms): .....50 or 63 kA
- Maximum time of faulting clearing: ..... 1 s
- Withstand voltage at lightning impulse (peak):.....1.425 kV
- Withstand voltage at switching impulse: .....1.050 kV

### **Current Transformers**

Three (3) current transformers (1 per phase) will be installed, that will supply the protection and measurement circuits.

- Rated voltage: .....380 kV
- Highest voltage for the material (Um):.....420 kV
- Frequency: .....60 Hz
- Transformer ratio: ..... 3.000-4.000 / 5 or 1 A (several cores)
- Withstand voltage at lightning impulse (peak):.....1.425 kV
- Withstand voltage at switching impulse: .....1.050 kV

### **Voltage Transformers**

- Rated voltage: .....380 kV
- Highest voltage for the material (Um):.....420 kV

- Frequency: .....60 Hz
- Transformer ratio:
  - Primary winding: .....380: $\sqrt{3}$  / 0,110/ $\sqrt{3}$  kV
  - Secondary winding: .....380: $\sqrt{3}$  / 0,110/ $\sqrt{3}$  kV
  - Tertiary winding: .....380: $\sqrt{3}$  / 0,110/ $\sqrt{3}$  kV
- Withstand voltage at lightning impulse (peak): .....1.425 kV
- Withstand voltage at switching impulse: .....1.050 kV

### **Surge Arresters**

To protect the installation against atmospheric origin overvoltages, or those that could occur for any other reason, a set of three (3) surge arresters (1 per phase) shall be installed in each line bay.

- Rated voltage: .....380 kV
- Highest voltage for the material ( $U_m$ ): .....420 kV
- Rated voltage of surge arrester ( $U_r$ ): .....336 kV
- Maximum continuous operating voltage of surge arrester ( $U_c$ ) .....267 kV
- Arrester class.....3

### **Busbars**

The main and auxiliary busbars will be chosen in such a way that the maximum expected temperatures do not cause overheating of more than 40 °C above the ambient temperature. The busbars will also need to withstand the electrodynamic and thermal stresses of the expected short-circuit currents without permanent deformation.

The 380 kV main busbars will be made of aluminium alloy tube, 200/184 mm in diameter, equivalent to 4.825 mm<sup>2</sup> of nominal section, which admits a permanent current flow of 4.154 A (65 °C) and short circuit of 50 kA, or 250/230 mm in diameter, equivalent to 7.540 mm<sup>2</sup> of nominal section, which admits a permanent current flow of 5.700 A (65 °C) and short circuit of 63 kA.

### **Line Description**

The configuration planned for the 380 kV Overhead line shall be double circuit configuration and the main characteristics shall be as follows:

- Rated Voltage: .....380 kV
- Frequency: .....60 Hz
- Rated thermal rating: .....Aprox. 1.600 MVA per circuit
- Number of circuits: .....2
- Number of conductors per phase: .....2

- Conductor: ..... ACSR CURLEW

For more details refer to the section “7.1 380 kV Overhead Lines”.

### 6.1.2 Interconnection in 380 kV Overhead Line “To Nursery Road”

For this interconnection, it is proposed a brunch of the 380 kV Overhead Line, to make an incoming / outgoing of the 380 kV Overhead Line "To Nursery Road" in JUBAIL 3-S/S-4 Substation.

A quadruple circuit will be formed by the incoming and outgoing double circuits between the 380 kV Overhead Line "To Nursery Road" and the JUBAIL 3-S/S-4 Substation is the line known as 380 kV Overhead Lines.

The configuration planned for the 380 kV Overhead line shall be quadruple circuit configuration and the main characteristics shall be as follows:

- Rated Voltage: ..... 380 kV
- Frequency: ..... 60 Hz
- Rated thermal rating: ..... Aprox. 1.600 MVA per circuit
- Number of circuits: ..... 2
- Number of conductors per phase: ..... 2
- Conductor: ..... ACSR CURLEW

For more details refer to the section “6.1 380 kV Overhead Lines”.

## 6.2 380 / 115 kV Substations.

In order to have a high reliability and a robust grid in the new 380 / 115 kV Substations, a configuration with one breaker and a half has been considered in 380 kV and double busbars in 115 kV System. In the case of a failure of one of the busbars systems, the 380 kV and 115 kV Systems can continue to operate with the other busbars system.

The double bar configuration will also allow a better balance of the connected consumers and generation plants, being able to transfer consumers and generation between both busbar systems.

Above, in Figure 15, it is shown the layout and interconnection of all the new 380 / 115 kV Substations, marked in red box while in Figure 16 there is a General Single Line Diagram for these Substations.

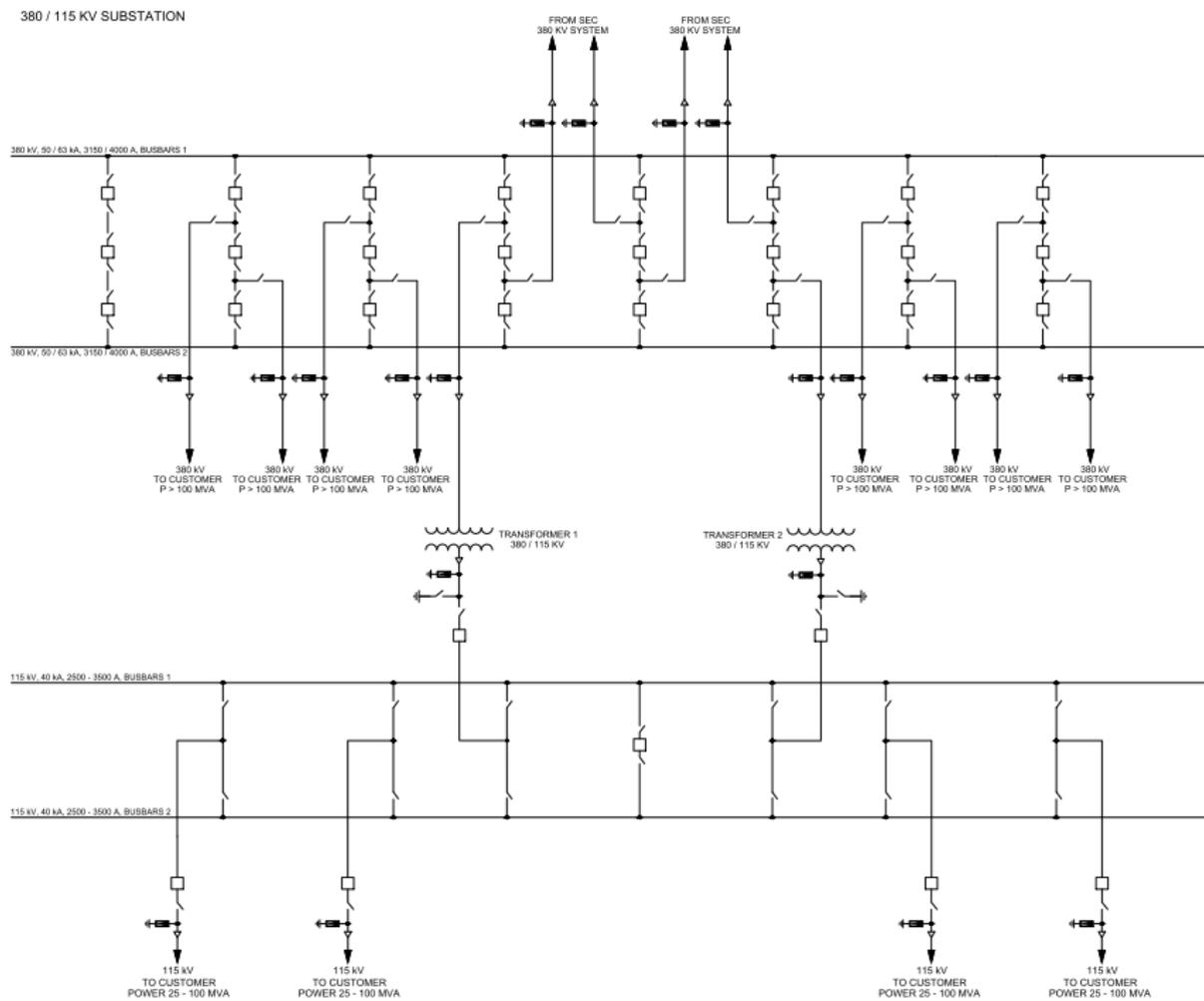


Figure 16: General Diagram for 380 / 115 kV Substations. One breaker and a half

## 6.2.1 380 kV System

The configuration established is a double busbar configuration with one breaker and a half with the following bays:

- Two (2) incoming bays and two (2) outgoing bays of 380 kV (one of them in each busbar) for interconnection between 380 / 115 kV Substations. In main proposal for the interconnection between Jubail 3-S/S-4 with 380 kV External Network, the Substation could have three (3) incoming / outgoing bays of 380 kV.
- Two (2) transformer bays of 380 kV.
- Several outgoing bays of 380 kV for large consumers of 100 MVA.

The switchgear with which each bay is equipped will be as follows:

- Incoming or outgoing bay of 380 kV:
  - One (1) three-phase line disconnector switch with earthing blades for line connection.
  - One (1) three-phase circuit breaker, in SF<sub>6</sub>.

- Three (3) current transformers (1 per phase).
- Two (2) three-phase disconnecter switches (one at each side of the circuit breaker).
- Three (3) voltage transformers (1 per phase).
- Three (3) surge arresters (1 per phase).

In addition, in each interconnection between switchgear of the configuration of one breaker a half shall include the following (as 380 kV coupling bay):

- One (1) three-phase circuit breaker, in SF6.
- Three (3) current transformers (1 per phase).
- Two (2) three-phase disconnecter switches (one at each side of the circuit breaker).
- Transformer bay of 380 kV:
  - One (1) three-phase disconnecter switch with earthing blades.
  - One (1) three-phase circuit breaker, in SF6.
  - Three (3) current transformers (1 per phase).
  - Two (2) three-phase disconnecter switches (one at each side of the circuit breaker).
  - Three (3) voltage transformers (1 per phase).
  - Three (3) surge arresters (1 per phase).
  - One (1) three-phase power transformer 380 / 115 kV.

In addition, in each interconnection between switchgear of the configuration of one breaker a half shall include the following (as 380 kV coupling bay):

- One (1) three-phase circuit breaker, in SF6.
- Three (3) current transformers (1 per phase).
- Two (2) three-phase disconnecter switches (one at each side of the circuit breaker).
- Busbar bay of 380 kV:
  - One (1) three-phase busbars disconnecter switch.
  - Three (3) voltage transformers (1 per phase).

### **380 kV Circuit Breaker**

For the opening and closing operations the circuits under load and short circuit, it is expected to instal three-phase circuit breakers. A circuit breaker will be installed at each line and transformer bays.

The main technical characteristics of the circuit breakers shall be as follows:

- Rated voltage: ..... 380 kV
- Highest voltage for the material ( $U_m$ ): ..... 420 kV
- Frequency: ..... 60 Hz
- Rated continuous current: ..... 3.150 or 4.000 A (recommended)
- Short circuit current (rms): ..... 50 or 63 kA
- Maximum time of fault clearing: ..... 1 s
- Withstand voltage at lightning impulse (peak): ..... 1.425 kV
- Withstand voltage at switching impulse: ..... 1.050 kV

The extinguishing chamber of the circuit breakers is made of SF<sub>6</sub> gas.

The three poles of each circuit breaker are mounted on a common chassis and are driven by the same spring-loaded motorized control, which is coupled to them by means of mechanical transmissions.

The phase-earth insulation consists of a porcelain or polymeric insulator support and the insulating bar inside it.

### **380 kV Disconnecter Switches**

The disconnecter switches shall be of the type with three-columns, double side-opening, electrically operated.

The disconnecter switches shall be a three-phase weatherproof disconnecter and consist of three independent poles, mounted on a common structure.

Each phase consists of three columns of insulators. The two lateral columns are fixed and carry the fixed contact at their upper end and current tap, while the central column is rotating, and on it is mounted the blade performing two breaks per phase.

The drive of the three rotating columns is simultaneously operated with a single control, by means of an articulated system of adjusted tube tie rods, which allows for the closing and opening manoeuvre in the three phases to be synchronized.

The disconnecter switches installed at the line output and provided with earthing blades, with independent control and has a mechanical interlock that prevents any manoeuvre when the main blades are closed.

The main technical characteristics of the disconnecter switches shall be as follows:

- Rated voltage: ..... 380 kV
- Highest voltage for the material ( $U_m$ ): ..... 420 kV
- Frequency: ..... 60 Hz
- Rated continuous current: ..... 3.150 or 4.000 A (recommended)

- Short circuit current (rms): .....50 or 63 kA
- Maximum time of fault clearing: ..... 1 s
- Withstand voltage at lightning impulse (peak): ..... 1.425 kV
- Withstand voltage at switching impulse: ..... 1.050 kV

### **380 kV Current Transformers**

The current transformers shall be mounted next to the 380 kV circuit breaker. Three (3) current transformers (1 per phase) will be installed, that will supply the protection and measurement circuits.

The main technical characteristics of the current transformers shall be as follows:

- Rated voltage: .....380 kV
- Highest voltage for the material ( $U_m$ ): .....420 kV
- Transformers ratio:
  - Line bays: ..... 3.000-4.000 / 5 or 1 A (several cores)
  - Transformer Type 1 bays: .....600-1.200 / 5 or 1 A (several cores)
  - Transformer Type 2 bays: .....600-1.200 / 5 or 1 A (several cores)
  - Transformer Type 3 bays: .....600-1.200 / 5 or 1 A (several cores)
  - Transformer Type 4 bays: .....300-600 / 5 or 1 A (several cores)
- Withstand voltage at lightning impulse: ..... 1.425 kV
- Withstand voltage at switching impulse: ..... 1.050 kV

### **380 kV Voltage Transformers**

In order to supply the various 380 kV protection and metering devices, voltage transformers have been installed at each of the line bays, and busbars bays (at each end of the busbars).

The main technical characteristics of the voltage transformers shall be as follows:

- Rated voltage: .....380 kV
- Highest voltage for the material ( $U_m$ ): .....420 kV
- Frequency: ..... 60 Hz
- Transformer ratio:
  - Primary winding: .....  $380:\sqrt{3} / 0,110/\sqrt{3}$  kV
  - Secondary winding: .....  $380:\sqrt{3} / 0,110/\sqrt{3}$  kV
  - Tertiary winding: .....  $380:\sqrt{3} / 0,110/\sqrt{3}$  kV
- Lightning impulse withstand voltage: ..... 1.425 kV

- Withstand voltage at switching impulse: ..... 1.050 kV

### **380 kV Surge Arresters**

To protect the installation against overvoltages of atmospheric origin, or those that could occur for any other reason, a set of three (3) surge arresters (1 for each phase) shall be installed in each line and transformer bay.

The surge arresters to be used will be made of metallic oxides without explosives and with a polymeric envelope.

The main technical characteristics of the surge arresters shall be as follows:

- Rated voltage: ..... 380 kV
- Highest voltage for the material ( $U_m$ ): ..... 420 kV
- Rated voltage of surge arrester ( $U_r$ ): ..... 336 kV
- Maximum continuous operating voltage of surge arrester ( $U_c$ ): ..... 267 kV
- Arrester class: ..... 3

### **6.2.2 115 kV System**

The configuration established is a double busbar configuration with the following bays:

- Two (2) incoming bays of 115 kV from the power transformers 380 / 115 kV.
- One (1) coupling bay of 115 kV.
- Several outgoing bays of 115 kV for consumers between 25 MVA up to 100 MVA.

The switchgear with which each bay is equipped will be as follows:

- Incoming bay of 115 kV from the power transformer 380 / 115 kV:
  - Two (2) busbars disconnector switches.
  - One (1) three-phase circuit breaker, in SF<sub>6</sub>.
  - Three (3) current transformers (1 per phase).
  - One (1) three-phase line disconnector switch with earthing blades for line connection.
  - Three (3) surge arresters (1 per phase).
- Coupling bay of 380 kV:
  - Two (2) three-phase busbar disconnector switches (one at each side of the circuit breaker).
  - One (1) three-phase circuit breaker, in SF<sub>6</sub>.
  - Three (3) current transformers (1 per phase).
- Outgoing bay of 115 kV:

- Two (2) busbars disconnecter switches.
- One (1) three-phase circuit breaker, in SF<sub>6</sub>.
- Three (3) current transformers (1 per phase).
- Three (3) voltage transformers (1 per phase).
- One (1) three-phase line disconnecter switch with earthing blades for line connection.
- Three (3) surge arresters (1 per phase).
- Busbar bay of 115 kV:
  - Two (2) three-phase busbars disconnecter switch.
  - Three (3) voltage transformers (1 per phase).

### **115 kV Circuit Breaker**

For the opening and closing operations the circuits under load and short circuit, it is expected to instal three-phase circuit breakers. A circuit breaker will be installed at each line and transformer bays.

The main technical characteristics of the circuit breakers shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material (Um):..... 145 kV
- Frequency: ..... 60 Hz
- Rated continuous current: ..... 3.150 A
- Short circuit current (rms): ..... 40 kA
- Maximum time of fault clearing: ..... 1 s
- Withstand voltage at lightning impulse (peak):..... 650 kV
- Withstand voltage at industrial frequency: ..... 275 kV

The extinguishing chamber of the circuit breakers is made of SF<sub>6</sub> gas.

The three poles of each circuit breaker are mounted on a common chassis and are driven by the same spring-loaded motorized control, which is coupled to them by means of mechanical transmissions.

The phase-earth insulation consists of a porcelain or polymeric insulator support and an insulating bar inside it.

### **115 kV Disconnecter Switches**

The disconnecter switches shall be of the type with three-columns, double side-opening, electrically operated.

The disconnecter switches shall be a three-phase weatherproof disconnecter and consist of three independent poles, mounted on a common structure.

Each phase consists of three columns of insulators. The two lateral columns are fixed and carry the fixed contact at their upper end and current tap, while the central column is rotating, and on it is mounted the blade performing two breaks per phase.

The drive of the three rotating columns is simultaneously operated with a single control, by means of an articulated system of adjusted tube tie rods, which allows for the closing and opening manoeuvre in the three phases to be synchronized.

The disconnecter switches installed at the line output and provided with earthing blades, with independent control and has a mechanical interlock that prevents any manoeuvre when the main blades are closed.

The main technical characteristics of the disconnecter switches shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material (Um): ..... 145 kV
- Frequency: ..... 60 Hz
- Rated continuous current: ..... 3.150 A
- Short circuit current (rms): ..... 40 kA
- Maximum time of fault clearing: ..... 1 s
- Withstand voltage at lightning impulse (peak): ..... 650 kV
- Withstand voltage at industrial frequency: ..... 275 kV

### **115 kV Current Transformers**

The current transformers shall be mounted next to the 115 kV circuit breaker. Three (3) current transformers (1 per phase) will be installed, that will supply the protection and measurement circuits.

The main technical characteristics of the current transformers shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material (Um): ..... 145 kV
- Transformers ratio:
  - Line bays: ..... 2.500-3.000 / 5 or 1 A (several cores)
  - Transformer Type 1 bays: ..... 2.000-3.000 / 5 or 1 A (several cores)
  - Transformer Type 2 bays: ..... 2.000-3.000 / 5 or 1 A (several cores)
  - Transformer Type 3 bays: ..... 2.000-3.000 / 5 or 1 A (several cores)
  - Transformer Type 4 bays: ..... 1.000-2.000 / 5 or 1 A (several cores)
- Withstand voltage at lightning impulse (peak): ..... 650 kV

- Withstand voltage at industrial frequency: .....275 kV

### **115 kV Voltage Transformers**

In order to supply the various 115 kV protection and metering devices, voltage transformers have been installed at each of the line bays, and busbars bays (at each end of the busbars).

The main technical characteristics of the voltage transformers shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material ( $U_m$ ): ..... 145 kV
- Frequency: ..... 60 Hz
- Transformer ratio:
  - Primary winding: .....  $115:\sqrt{3} / 0,110:\sqrt{3}$  kV
  - Secondary winding: .....  $115:\sqrt{3} / 0,110/\sqrt{3}$  kV
  - Tertiary winding: .....  $115:\sqrt{3} / 0,110/\sqrt{3}$  kV
- Withstand voltage at lightning impulse (peak): ..... 650 kV
- Withstand voltage at industrial frequency: ..... 275 kV

### **115 kV Surge Arrester**

To protect the installation against overvoltages of atmospheric origin, or those that could occur for any other reason, a set of three (3) surge arresters (1 for each phase) shall be installed in each line and transformer bay.

The surge arresters to be used will be made of metallic oxides without explosives and with a polymeric envelope.

The main technical characteristics of the surge arresters shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material ( $U_m$ ): ..... 145 kV
- Rated voltage of surge arrester ( $U_r$ ): ..... 138 kV
- Maximum continuous operating voltage of surge arrester ( $U_c$ ): ..... 92 kV
- Arrester class: ..... 3

### **6.2.3 Busbars**

The main and auxiliary busbars will be chosen in such a way that the maximum expected temperatures do not cause overheating of more than 40 °C above the ambient temperature. The busbars will also need to withstand the electrodynamic and thermal stresses of the expected short-circuit currents without permanent deformation.

The designs have been made based on:

- Supported aluminium tubular busbars for the main busbars in the 380 kV System.
- Cable busbars for the connection of the disconnector switches to the main busbars and lines, as well as for the rest of the connections between switchgear, which avoids the bending and shaping of tubes, as well as the use of elastic connections for these cases.

The main technical characteristics of the busbars shall be as follows:

### **380 kV System**

- Rated design current: 3.150 or 4.000 A (recommended) considering the power connected to the 380 kV busbars.
- Design short circuit current (I<sub>cc</sub>): 50 or 63 kA.

The 380 kV main busbars will be made of aluminium alloy tube, 200/184 mm in diameter, equivalent to 4.825 mm<sup>2</sup> of rated section, which admits a permanent current flow of 4.154 A (65 °C) and short circuit of 50 kA, or 250/230 mm in diameter, equivalent to 7,540 mm<sup>2</sup> of rated section, which admits a permanent current flow of 5.700 A (65 °C) and short circuit of 63 kA.

### **115 kV System**

- Rated design current: 3.150 A considering the power connected to the 115 kV busbars.
- Design short circuit current (I<sub>cc</sub>): 50 kA.

The 115 kV main busbars will be made of aluminium alloy tube, 200/184 mm in diameter, equivalent to 4.825 mm<sup>2</sup> of rated section, which admits a permanent current flow of 4.154 A (65 °C) and short circuit of 50 kA.

These tubular busbars will be supported by a set of three rigid insulators at both ends of each bar supported by a single structure. Damping cable will be installed inside the tube.

## **6.2.4 Power Transformers**

The power transformers can be, depending on the required power, of the following types:

- Type Power Transformer 1: rated power 300 / 400 / 500 MVA (ONAN / ONAF1 / ONAF2), outdoor installation, mineral oil immersed, vector group YNyn, YNd or YN, with On-Load Tap Changer.
- Type Power Transformer 2: rated power 210 / 280 / 350 MVA (ONAN / ONAF1 / ONAF2), outdoor installation, mineral oil immersed, vector group YNyn, YNd or YN, with On-Load Tap Changer.
- Type Power Transformer 3: rated power 175 / 350 MVA (ONAN / ONAF) outdoor installation, mineral oil immersed, vector group YNyn, YNd or YN, with On-Load Tap Changer.

- Type Power Transformer 4: rated power 100 / 125 MVA (ONAN / ONAF), outdoor installation, mineral oil immersed, vector group YNyn, YNd or YN, with On-Load Tap Changer.

### **6.2.5 Buildings and other facilities**

The facility will have a single-story building, of prefabricated concrete for control and communications.

In addition to the circuits and main elements described in the previous paragraphs, the installation of the corresponding measurement, control, monitoring, protection and communications equipment necessary for the proper operation of the installation.

In addition, the distribution systems for auxiliary services in alternating current and direct current from the respective rectifier-battery equipment, must also be foreseen.

Due to their characteristics, these devices will be installed indoors, and for their control and easy manoeuvrability, they will be in panels and cabinets located in the control and communications rooms. This rooms will be enabled in the building where all the installed components, due to their function, centralize in some way the control of the Substation.

### **6.2.6 Control Panels and Protection Cabinets**

The Integrated Protection and Control System will be of digital type and of distributed configuration, being formed by the following elements:

- One (1) Substation Control Unit (SCU).
- One (1) Bay Control Unit (BCU) per each line and transformer bay.
- One (1) General Services Control Unit (BCU).

From each BCU it will be possible to control and act locally on the associated position, and from the SCU it will be possible to control any of the bays, as well as to have information related to measurements, alarms and system status in general.

### **6.2.7 Auxiliary Services**

The auxiliary services of the Substation will necessarily be served by the two voltage systems of alternating current (AC) and direct current (DC).

#### **AC Auxiliary Services**

Three (3) voltage transformers  $380:\sqrt{3} / 0,42:\sqrt{3}$  kV - 250 kVA will be installed.

The auxiliary services transformer supplies low voltage power to the AC auxiliary services distribution cabinet located in control room of the building.

An emergency diesel generator set will be installed to guarantee power supply in the event of a system failure or a power failure, to the Substation's Auxiliary Services plant generation stoppage, by means of a relay switching system.

## DC Auxiliary Services

Two (2) compact rectifier-battery chargers units will be installed for the DC auxiliary services. Under normal conditions, both units will operate separately, each one feeding a part of the control, power and protection services according to the established load distribution.

The busbars of the DC auxiliary services distribution panel located in the building's control room, where the circuit breakers of the various outlets for DC auxiliary services to the substation are housed, will be fed from this equipment.

## 6.3 115 / 34,5 kV Substations.

In order to have high reliability and availability in the 115 / 34,5 kV Substations, a configuration with double busbar has been considered in 115 kV and half-busbar coupled in 34,5 Systems. In the case of a failure of one of the double busbar and half-busbar systems, the 115 kV and 34,5 Systems can continue operating with the other double busbar and half-busbar system.

In the case of a failure of one of the busbars systems, the 115 kV System can continue operating with the other busbars system.

Below is included a typical arrangement of double busbars Substation:

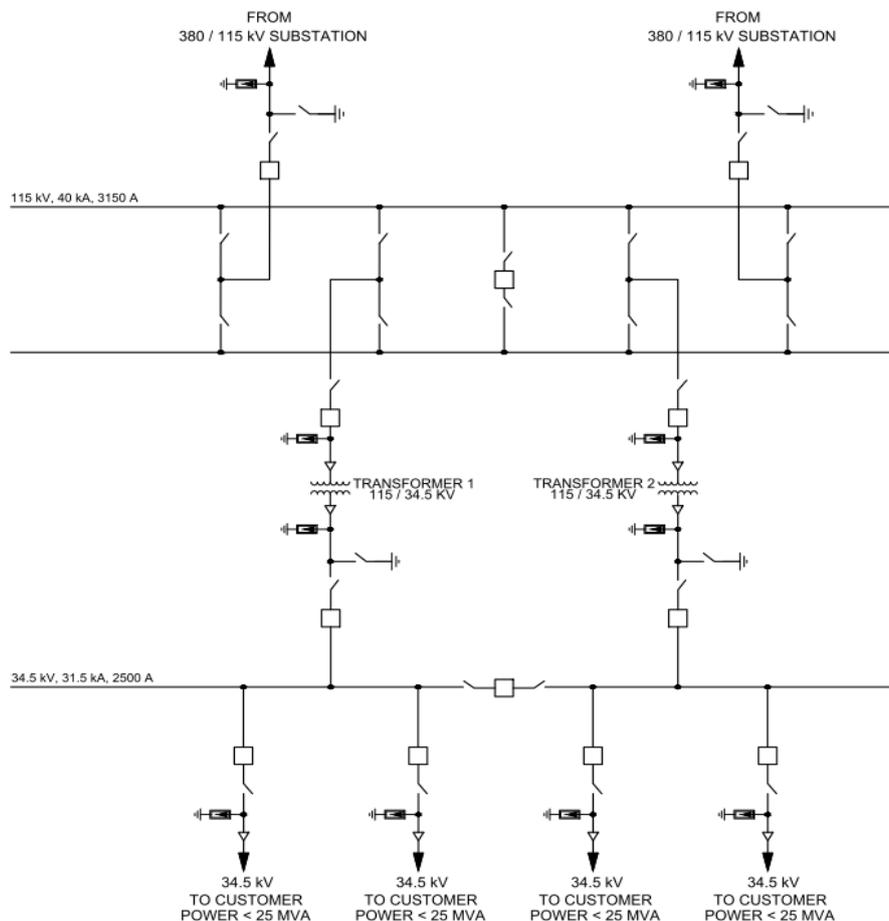


Figure 17: Diagram for 115 / 34,5 kV Substation. Doble Busbar.

### 6.3.1 115 kV System

The configuration established double busbar configuration with the following bays:

- Two (2) incoming bays of 115 kV from 380 / 115 kV Substation.
- One (1) coupling bay of 115 kV.
- Two (2) transformer bays of 115 kV.
- Two (2) reserve transformer bays of 115 kV.

The switchgear with which each bay is equipped will be as follows:

- Incoming bay of 115 kV:
  - Two (2) three-phase busbars disconnecter switches.
  - One (1) three-phase circuit breaker, in SF<sub>6</sub>.
  - Three (3) current transformers (1 per phase).
  - Three (3) voltage transformers (1 per phase).
  - One (1) three-phase line disconnecter switch with earthing blades for line connection.
  - Three (3) surge arresters (1 per phase).
- Coupling bay of 115 kV:
  - Two (2) three-phase busbars disconnecter switches (one at each side of the circuit breaker).
  - One (1) three-phase circuit breaker, in SF<sub>6</sub>.
  - Three (3) current transformers (1 per phase).
- Transformer bay of 115 kV:
  - Two (2) three-phase busbars disconnecter switch.
  - One (1) three-phase circuit breaker, in SF<sub>6</sub>.
  - Three (3) current transformers (1 per phase).
  - One (1) three-phase transformer disconnecter switch with earthing blades for transformer connection.
  - Three (3) surge arresters (1 per phase).
  - One (1) three-phase power transformer 115 / 34,5 kV.
- Busbar bay of 115 kV:
  - One (1) three-phase busbars disconnecter switch.
  - Three (3) voltage transformers (1 per phase).

### **115 kV Circuit Breaker**

For opening and closing operations the circuits under load and short circuit, it is expected to instal three-phase circuit breakers. A circuit breaker will be installed in each line and transformer bays.

The main technical characteristics of the circuit breakers shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material ( $U_m$ ): ..... 145 kV
- Frequency: ..... 60 Hz
- Rated continuous current: ..... 3.150 A
- Short circuit current (rms): ..... 40 kA
- Maximum time of fault clearing: ..... 1 s
- Withstand voltage at lightning impulse (peak): ..... 650 kV
- Withstand voltage at industrial frequency: ..... 275 kV

The extinguishing chamber of the circuit breakers is made of SF<sub>6</sub> gas.

The three poles of each circuit breaker are mounted on a common chassis and are driven by the same spring-loaded motorized control, which is coupled to them by means of mechanical transmissions. The phase-earth insulation consists of a porcelain or polymeric insulator support and an insulating bar inside it.

### **115 kV Disconnecter Switches**

The disconnecter switches shall be of the type with three-columns, double side-opening, electrically operated.

The disconnecter switches shall be a three-phase weatherproof disconnecter and consist of three independent poles, mounted on a common structure.

Each phase consists of three columns of insulators. The two lateral columns are fixed and carry the fixed contact at their upper end and current tap, while the central column is rotating, and on it is mounted the blade performing two breaks per phase.

The drive of the three rotating columns is simultaneously operated with a single control, by means of an articulated system of adjusted tube tie rods, which allows for the closing and opening manoeuvre in the three phases to be synchronized.

The disconnecter switches installed at the line output and provided with earthing blades, with independent control and has a mechanical interlock that prevents any manoeuvre when the main blades are closed.

The main technical characteristics of the disconnecter switches shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material ( $U_m$ ): ..... 145 kV

- Frequency: .....60 Hz
- Rated continuous current: .....3.150 A
- Short circuit current (rms): .....40 kA
- Maximum time of fault clearing: .....1 s
- Withstand voltage at lightning impulse (peak): .....650 kV
- Withstand voltage at industrial frequency: .....275 kV

### **115 kV Current Transformers**

The current transformers shall be mounted next to the 115 kV circuit breaker. Three (3) current transformers (1 per phase) will be installed, that will supply the protection and measurement circuits.

The main technical characteristics of the current transformers shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material ( $U_m$ ): ..... 145 kV
- Transformers ratio:
  - Line bays: ..... 2.500-3.000 / 5 or 1 A (several cores)
  - Transformer Type 1 bays: .....500-1.000 / 5 or 1 A (several cores)
  - Transformer Type 2 bays: .....500-1.000 / 5 or 1 A (several cores)
  - Transformer Type 3 bays: .....500-1.000 / 5 or 1 A (several cores)
- Withstand voltage at lightning impulse (peak): .....650 kV
- Withstand voltage at industrial frequency: .....275 kV

### **115 kV Voltage Transformers**

In order to supply the various 115 kV protection and metering devices, voltage transformers have been installed at each of the line bays, and busbars bays (at each end of the busbars).

The main technical characteristics of the voltage transformers shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material ( $U_m$ ): ..... 145 kV
- Frequency: .....60 Hz
- Transformer ratio:
  - Primary winding: .....  $115:\sqrt{3} / 0,110:\sqrt{3}$  kV
  - Secondary winding: .....  $115:\sqrt{3} / 0,110/\sqrt{3}$  kV
  - Tertiary winding: .....  $115:\sqrt{3} / 0,110/\sqrt{3}$  kV

- Withstand voltage at lightning impulse (peak): .....650 kV
- Withstand voltage at industrial frequency: .....275 kV

### **115 kV Surge Arrester**

To protect the installation against overvoltages of atmospheric origin, or those that could occur for any other reason, a set of three (3) surge arresters (1 for each phase) shall be installed in each line and transformer bay.

The surge arresters to be used will be made of metallic oxides without explosives and with a polymeric envelope.

The main technical characteristics of the surge arresters shall be as follows:

- Rated voltage: ..... 115 kV
- Highest voltage for the material ( $U_m$ ): ..... 145 kV
- Rated voltage of surge arrester ( $U_r$ ): ..... 138 kV
- Maximum continuous operating voltage of surge arrester ( $U_c$ ): .....92 kV
- Arrester class: .....3

### **6.3.2 34,5 kV System**

The configuration established is two (2) half-busbars coupled configuration with the following cabinets:

- Two (2) incoming cabinets of 34,5 kV from the power transformer 115 / 34,5 kV.
- One (1) coupling cabinet of 34,5 kV.
- Several outgoing cabinets of 34,5 kV for consumers up to 25 MVA.
- Several outgoing cabinets of 34,5 kV for Distribution Feeders for infrastructure and smaller consumers.
- Two (2) outgoing cabinets of 34,5 kV for auxiliary services of the 115 / 34,5 kV Substation.

The switchgear with which each cabinet is equipped will be as follows:

- Incoming cabinet of 34,5 kV from power transformer 115 / 34,5 kV:
  - One (1) three-phase withdrawable circuit breaker.
  - Three (3) current transformers (1 per phase).
  - Three (3) voltage transformers (1 per phase).
  - One (1) three-phase earthing disconnector switch.
- Coupling cabinet of 34,5 kV:
  - One (1) three-phase withdrawable circuit breaker.
  - Three (3) current transformers (1 per phase).

- One (1) three-phase disconnector switch.
- Outgoing cabinet of 34,5 kV:
  - One (1) three-phase withdrawable circuit breaker.
  - Three (3) current transformers (1 per phase).
  - Three (3) voltage transformers (1 per phase).
  - One (1) three-phase earthing disconnector switch.

### **34,5 kV Circuit Breaker**

For opening and closing operations the circuits under load and short circuit, it is expected to instal three-phase circuit breakers, located in the 34,5 kV Cabinets. A circuit breaker will be installed in each 34,5 kV Cabinet.

The main technical characteristics of the circuit breakers shall be as follows:

- Rated voltage: ..... 34,5 kV
- Highest voltage for the material ( $U_m$ ): ..... 38 kV
- Frequency: ..... 60 Hz
- Rated continuous current: ..... 1.250 or 2.500 A
- Short circuit current (rms): ..... 31.5 kA
- Maximum time of fault clearing: ..... 1 s
- Withstand voltage at lightning impulse (peak): ..... 170 kV
- Withstand voltage at industrial frequency: ..... 70 kV

### **34,5 kV Current Transformers**

The current transformers shall be located in 34,5 kV Cabinets. Three (3) current transformers (1 per phase) will be installed, that will supply the protection and measurement circuits.

The main technical characteristics of the current transformers shall be as follows:

- Rated voltage: ..... 34,5 kV
- Highest voltage for the material ( $U_m$ ): ..... 38 kV
- Transformers ratio:
  - Incoming Transformer Type 1 bays: ..... 1.250-2.500 / 5 or 1 A (several cores)
  - Incoming Transformer Type 2 bays: ..... 1.250-2.500 / 5 or 1 A (several cores)
  - Incoming Transformer Type 3 bays: ..... 1.250-2.500 / 5 or 1 A (several cores)
  - Outgoing bays: ..... 1.250 / 5 or 1 A (several cores)
- Withstand voltage at lightning impulse (peak): ..... 170 kV

- Withstand voltage at industrial frequency: .....70 kV

### **34,5 kV Voltage Transformers**

In order to supply the various 34,5 kV protection and metering devices, voltage transformers have been installed at each of the 34,5 kV Cabinets, and busbars of 34,5 kV Cabinets (at each end of the busbars).

The main technical characteristics of the voltage transformers shall be as follows:

- Rated voltage: .....34,5 kV
- Highest voltage for the material ( $U_m$ ):.....38 kV
- Frequency: .....60 Hz
- Transformer ratio:
  - Primary winding: .....  $34,5:\sqrt{3} / 0,110:\sqrt{3}$  kV
  - Secondary winding:.....  $34,5:\sqrt{3} / 0,110/\sqrt{3}$  kV
  - Tertiary winding (only in busbar cabinets): .....  $34,5:\sqrt{3} / 0,110/\sqrt{3}$  kV
- Withstand voltage at lightning impulse (peak):.....170 kV
- Withstand voltage at industrial frequency: .....70 kV

### **6.3.3 Busbars**

The main and auxiliary busbars will be chosen in such a way that the maximum expected temperatures do not cause overheating of more than 40 °C above the ambient temperature. They will also need to withstand the electrodynamic and thermal stresses of the expected short-circuit currents without permanent deformation.

The designs have been made based on:

- Supported aluminum tubular busbars for the main busbars in the 115 kV System.
- Cable busbars for the connection of the isolation switches to the main busbars and lines, as well as for the rest of the connections between switchgear, which avoids the bending and shaping of tubes, as well as the use of elastic connections for these cases.

The main technical characteristics of the busbars shall be as follows:

#### **115 kV System**

- Rated design current: 3.150 A considering the power connected to the 115 kV busbars.
- Design short circuit current ( $I_{cc}$ ): 40 kA

The 115 kV main busbars will be made of aluminium alloy tube, 200/184 mm in diameter, equivalent to 4.825 mm<sup>2</sup> of rated section, which admits a permanent current flow of 4.154 A (65 °C) and short circuit of 40 kA.

These tubular busbars will be supported by a set of three rigid insulators at both ends of each bar supported by a single structure. Damping cable will be installed inside the tube.

### **6.3.4 Buildings and other facilities**

The facility will have a single-story building, of prefabricated concrete for control and communications, and 34,5 kV Cabinets.

In addition to the circuits and main elements described in the previous paragraphs, the installation of the corresponding measurement, control, monitoring, protection, and communications equipment necessary for the proper operation of the installation.

In addition, the distribution systems for auxiliary services in alternating current and direct current from the respective rectifier-battery equipment, must also be foreseen.

Due to their characteristics, these devices will be installed indoors, and for their control and easy manoeuvrability, they will be located in panels and cabinets located in the control and communications rooms. This rooms will be enabled in the building where all the installed components, due to their function, centralize in some way the control of the Substation.

### **6.3.5 Power Transformers**

The power transformers can be, depending on the required power, of the following types:

- Type Power Transformer 1: rated power 80 / 100 MVA (ONAN / ONAF), outdoor installation, mineral oil immersed, vector group YNyn or Dyn, with On-Load Tap Changer.
- Type Power Transformer 2: rated power 50 / 67 MVA (ONAN / ONAF), outdoor installation, mineral oil immersed, vector group YNyn or Dyn, with On-Load Tap Changer.
- Type Power Transformer 3: rated power 30 / 40 MVA (ONAN / ONAF), outdoor installation, mineral oil immersed, vector group YNyn or Dyn, with On-Load Tap Changer.

### **6.3.6 Control Panels and Protection Cabinets**

The Integrated Protection and Control System will be of digital type and of distributed configuration, being formed by the following elements:

- One (1) Substation Control Unit (SCU).
- One (1) Bay Control Unit (BCU) per each line and transformer bay (115 kV System).
- One (1) General Services Control Unit (BCU).

From each BCU it will be possible to control and act locally on the associated position, and from the SCU it will be possible to control any of the bays, as well as to have information related to measurements, alarms, and system status in general.

### **6.3.7 Auxiliary Services**

The auxiliary services of the Substation will necessarily be served by the two voltage systems of alternating current (AC) and direct current (DC).

#### **AC Auxiliary Services**

From the 34,5 kV System will be fed two (2) three-phase transformers (one from each busbar), with transformation ratio 34,5 kV / 0,420-0,242 kV - 250 kVA.

The auxiliary services transformer supplies low voltage power to the AC auxiliary services distribution cabinet located in control room of the building.

An emergency diesel generator set will be installed to guarantee power supply in the event of a system failure or a power failure, to the Substation's Auxiliary Services plant generation stoppage, by means of a relay switching system.

#### **DC Auxiliary Services**

Two (2) compact rectifier-battery chargers' units will be installed for the DC auxiliary services. Under normal conditions, both units will operate separately, each one feeding a part of the control, power and protection services according to the established load distribution.

The busbars of the DC auxiliary services distribution panel located in the building's control room, where the circuit breakers of the various outlets for DC auxiliary services to the substation are housed, will be fed from this equipment.

## **6.4 34,5 / 0,4 kV Substations**

A brief description of the 34,5 / 0,4 kV substations is proposed below, as they are not within the scope of this feasibility study.

In order to have high reliability and availability of power for infrastructure loads like Road Lightings, Pump Station, Lift Stations, etc. will be provided with a configuration of RMU consisting of 2 legs of load break switches with Tee off VI Circuit breaker, Distribution Transformer 36 kV and Low Voltage Distribution Panel in 34,5 / 0,4 kV Substation, and similarly to have high reliability and availability of power for industrial lots power supply is provided through power tie in source utilizing 34, 5 kV VIS .

A Ring Main Unit (RMU) system is a type of equipment which consists of a combination of circuit breakers, disconnectors, current transformers and other components necessary for the operation of the system.

The primary purpose of an RMU system is to enable the efficient control and distribution of electrical power in a ring distribution network. It is designed to facilitate the switching and

routing of power in different directions, allowing for greater operational flexibility and the ability to isolate sections of the network in the event of faults or maintenance.

The RMU system is typically installed in compact metal enclosures that contain the necessary switchgear and other components. These units are usually small in size and can be mounted outdoors or indoors, depending on system requirements and environmental conditions.

See below a Figure 18 indicating typical 1000KVA Substation and Figure 19 is an interconnection and Schematic Diagram of 34,5 VIS(RMU).

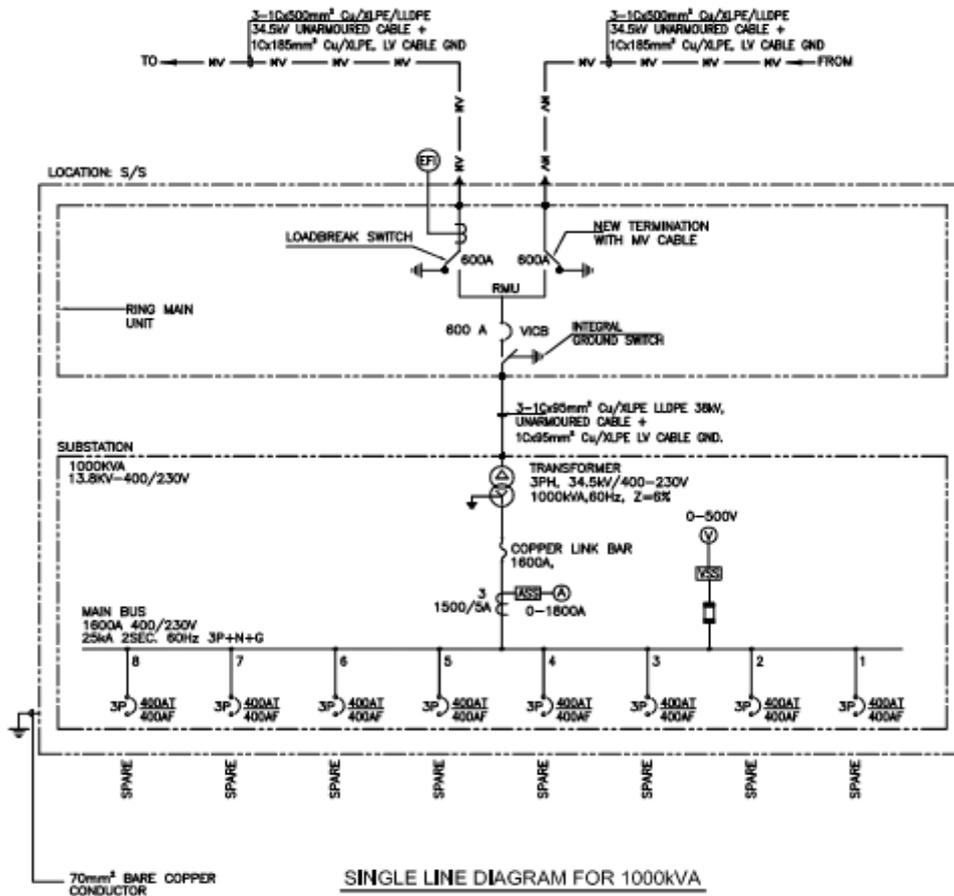


Figure 18: New 34,5 / 0,4 kV 1000 kVA Substation

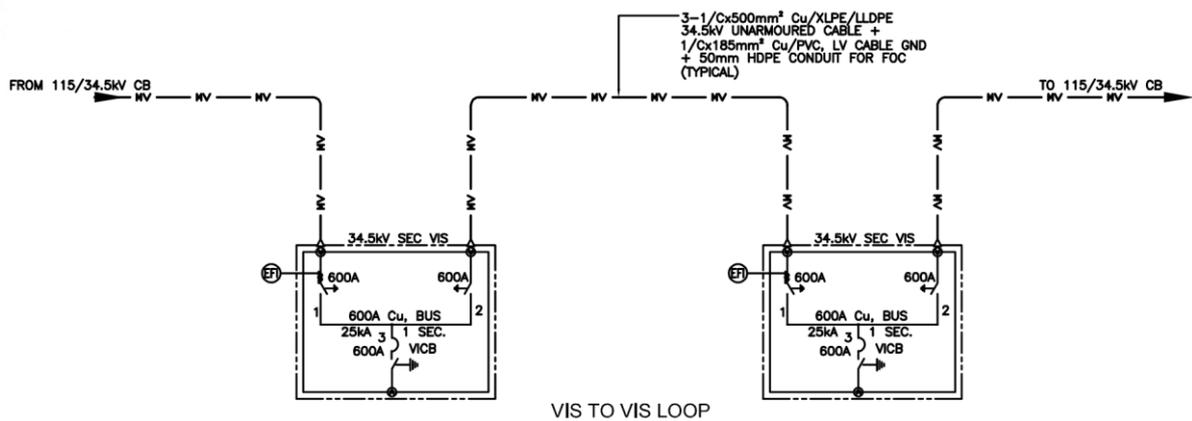


Figure 19: New 34,5 kV VIS (RMU)

## 7 ELECTRICAL LINES DESCRIPTION

The aim of this section is to clearly establish the description of the elements that comprise the facilities of the future Network 380 kV Overhead Lines.

### 7.1 380 kV Overhead Lines.

#### 7.1.1 General Characteristics of the OHL

The 380 / 115 kV Substations will be connected in a ring, and they will be fed at least with a minimum of two (2) 380 kV Overhead Transmission Lines, connected with External Electrical System.

The number and capacity of the proposed 380 kV Overhead Transmission Lines will be sufficient to supply the total power demand for JB2S4&3 from the 380 kV Network.

The 380 kV Overhead Lines shall be double circuit configuration and the main characteristics shall be as follows:

- Rated voltage: .....380 kV
- Frequency: .....60 Hz
- Rated thermal rating: .....Aprox. 1,600 MVA per circuit.
- Number of circuits: .....2
- Number of conductors per phase: .....2

According with the Table 2 of the Standard 10-TMSS-01-R1, the preferred conductor types and ampacity shall be the following:

- Curlew:.....760 A
- Drake:.....640 A
- Condor: .....640 A
- Grosbeak: .....560 A

#### 7.1.2 Characteristics of the conductor

According with the Table 2 of the Standard 10-TMSS-01-R1 and based on the conductor type selected, the cable shall have the follow characteristics:

CURLEW:

- Type of conductor:..... ACSR CURLEW
- Rated overall diameter. ....31,59 mm
- Rated aluminium area: .....522,5 mm<sup>2</sup>
- Current cross-section: .....590,2 mm<sup>2</sup>
- Rated strength: .....162,65 kN

- Calculated DC resistance at 20 °C: .....0,05531  $\Omega$
- Stranding Al+Stl: .....54+7
- Rated conductor mass: .....1.977 kg/km

## DRAKE:

- Type of conductor:..... ACSR DRAKE
- Rated overall diameter: .....28,11 mm
- Rated aluminium area: .....402,3 mm<sup>2</sup>
- Current cross-section: .....468,0 mm<sup>2</sup>
- Rated strength: .....139,91 kN
- Calculated DC resistance at 20 °C: .....0,07192  $\Omega$
- Stranding Al+Stl: .....26+7
- Rated conductor mass: .....1.626 kg/km

## CONDOR:

- Type of conductor:..... ACSR CONDOR
- Rated overall diameter: .....27,72 mm
- Rated aluminium area: .....402,3 mm<sup>2</sup>
- Current cross-section: .....454,5 mm<sup>2</sup>
- Rated strength: .....125,24 kN
- Calculated DC resistance at 20 °C: .....0,07192  $\Omega$
- Stranding Al+Stl: .....54+7
- Rated conductor mass: .....1.522 kg/km

## GROSBEAK:

- Type of conductor:..... ACSR GROSBEAK
- Rated overall diameter: .....25,15 mm
- Rated aluminium area: .....312,8 mm<sup>2</sup>
- Current cross-section: .....374,3 mm<sup>2</sup>
- Rated strength: .....111,8 kN
- Calculated DC resistance at 20 °C: .....0,08989  $\Omega$
- Stranding Al+Stl: .....26+7
- Rated conductor mass: .....1.302 kg/km

### 7.1.3 Insulation

The insulation levels of the 380 kV Overhead Lines projected are as follows:

- Rated voltage: .....380 kV
- Highest voltage for the material ( $U_m$ ): .....420 kV
- Withstand voltage at switching impulse. ....1.050 kV
- Withstand voltage at lightning impulse (peak): .....1.425kV

The insulation shall consist of the following elements:

- Suspension chains, by 1 composite element capable of withstanding the assigned tension and with dust protection characteristics.
- Strain chains, by 2 composite elements capable of withstanding the assigned tension and with dust protection characteristics.

The ranged of insulators used would be in accordance with the main National and International Standards.

### 7.1.4 Electrical Calculations

The electrical calculations of the 380 kV Overhead Lines have been made for the conductor type CURLEW, which is the one that offers the highest power carrying capacity, being able to carry the indicated nominal thermal rating of 1.600 MVA per circuit.

#### Conductor Resistance

The impedance is a quantity that establishes the relationship between voltage and current. The impedance is described by the following equation:

$$Z_k = R_k + jX_k \text{ } \Omega/\text{km}$$

Where:

- $R_k$  is the resistance per km, which in this case will be:

$$R_k = 0,0277 \text{ } \Omega/\text{km}$$

#### Conductor Reactance

The impedance is a quantity that establishes the relationship between voltage and current. The impedance is described by the following equation:

$$Z_k = R_k + jX_k \text{ } \Omega/\text{km}$$

Where:

- $X_k$  is the inductive reactance per km, defined by the following equation

$$X_k = L_k \cdot \omega = 0,3253 \text{ } \Omega/\text{km}$$

Where:

- $\omega$  is the current pulse  $2 \pi f$ .

- Lk is the coefficient of self-inductance measured in H/km, obtained by means of the equation:

$$Lk = \left[ \frac{1}{2n} + 4,6 \log \frac{DMG}{GMR} \right] 10^{-4}$$

Where:

- GMR (Geometric Means Radius) is determined by  $\sqrt[n]{nrR^{n-1}}$ , where n is the number of subconductors making up the bundle, r is the radius of the conductor and R is the radius of the circumference passing through the centers of the subconductors.
- GMD (Geometric Mean Distance) is determined for a simple three-phase circuit as follows:

$$GMD = \sqrt[3]{D_1 D_2}$$

Where:

$$D_1 = \frac{\sqrt{d_{12}d_{12'}d_{13}d_{13'}}}{d_{11'}} \quad D_2 = \frac{\sqrt{d_{21}d_{21'}d_{23}d_{23'}}}{d_{22'}}$$

Where dij is the distance between the two phases of the same circuit, and dij' is the distance between two phases of different circuits.

In this case GMD will be:

$$GMD = 12,436 \text{ m}$$

### Conductor Susceptance

Susceptance is defined as the imaginary part of the admittance. The susceptance of the line per unit length and per phase is calculated according to the expression:

$$B = 2 \cdot \pi \cdot f \cdot \frac{0,0556 \cdot 10^{-6}}{\ln \left( \frac{GMD}{GMR} \right)}$$

$$B = 3,46 \text{ } \mu\text{S}$$

### Average Line Capacity

The maximum steady-state AC current density at a frequency of 60 Hz for aluminium conductors ( $\delta_L$ ) and the reduction coefficient "k" for aluminium-steel (Al-Stl) conductors, such that the maximum current density for an Al-Stl conductor ( $\delta_{LA}$ ) will be given by the equation:

$$\delta_{LA} = \delta_L \cdot k \text{ (A / mm}^2\text{)}$$

For the conductor used, the current density and capacity per conductor will be:

- Type of conductor:.....CURLEW
- Maximum current density ( $\delta_{LA}$ ):.....1,62 A/mm<sup>2</sup>
- Rated capacity:.....955 A

The apparent power for each three-phase circuit at 380 kV will be as follows:

$$S = \sqrt{3} \cdot U \cdot I = 628,8 \text{ MVA}$$

In this case, because the Electrical Line have two (2) conductor per phase, the total apparent power for the 380 kV Overhead Line will be 1.257,2 MVA.

### **Maximum Admissible Capacity**

Considering an ambient temperature of 40 °C, a wind speed of 0.6 m/s perpendicular to the conductor, the effect of solar radiation null and a conductor temperature of 85 °C, the maximum admissible capacity of the 380 kV Overhead Line will be 1.398,3 MVA per circuit in summer and 1.630,4 MVA per circuit in winter, with average temperatures of 38 °C and 24 °C respectively, with a solar radiation of 650 W/m<sup>2</sup> in summer and 560 W/m<sup>2</sup> in winter.

### **Voltage Drop**

For the voltage drop calculation, it will be taken into consideration a simplified modelling of the Overhead Line where only the impedance will be considered. As a result, current on both the generation and reception sides will be the same.

For the current, the I<sub>max</sub> current obtained previously will be taken:

$$I_{\max} = 955 \text{ A}$$

Considering a  $\cos \varphi = 0.90$ , the voltage drop can be calculated as:

$$\Delta U\% = \frac{Rk + Xk \cdot \tan \varphi}{U^2} \cdot P \cdot L \cdot 100 = 0,15 \frac{\%}{\text{km}}$$

Where P is the active power considered for a given current or load (the maximum currents obtained previously or for the usual service conditions):

$$P = \sqrt{3} \cdot U \cdot I \cdot \cos \varphi = 1.131,76 \text{ MW}$$

### **Power Loss**

For power loss, the following expression is used:

$$\Delta P\% = \frac{P \cdot Rk}{U^2 \cdot \cos^2 \varphi} \cdot 100 = 0,03 \%/km$$

### **Summary Table of Electrical Characteristics of the OHL**

The following is a summary of the electrical characteristics of the 380 kV Overhead Line:

- Type of conductor:..... ACSR CURLEW
- Rated overall diameter:..... 31,59 mm
- Rated aluminum area: ..... 522,5 mm<sup>2</sup>
- Section A<sub>c</sub>:..... 67,7 mm<sup>2</sup>
- Section Total:..... 590,2 mm<sup>2</sup>
- Stranding:..... 54+7

- Maximum current density ( $\delta LA$ ): ..... 1,62 A/mm<sup>2</sup>
- Rated capacity: ..... 955 A

### **Towers**

The towers will be made of steel L-laminated profiles, forming a double lattice structure with bolted joints.

The bars will be connected to each other by means of plates and bolts.

For the overhead lines, towers with a symmetrical double-circuit geometry have been used.

## **7.2 115 kV Underground Lines.**

The 115 / 34,5 kV Substations will be connected in a ring and will be fed by at least with a minimum of two circuits (2), in the event of failure of one cable, the redundant cable must feed 2 substations. 115 kV / 34,5 kV substations cables will be fed from 380 kV / 115 kV substation and 115 kV / 34,5 kV.

The number and capacity of the proposed 115 kV Underground Lines will be sufficient to supply the total power demand for J2S4&3 from the 115 kV Network.

The 115 kV underground Lines shall be single circuit configuration connected in a ring, and the interconnection with the 115 kV System in at least two (2) points for redundancy and the main characteristics shall be as follows:

- Rated voltage: ..... 115 kV
- Frequency: ..... 60 Hz
- Number of Normal power circuit: ..... 1
- Number of Redundant power circuit: ..... 1

The minimum technical requirements for 115 KV shall be in accordance to 11-TMSS-02, TES-P-104.1, TES-P-104.2 Rev.01.

### **7.2.1 Characteristics of the conductor**

Accordance to the standard 11-TMSS-02 and TES-P-104 cable conductor shall have the minimum characteristics and following below provides the details:

- Type of conductor: ..... Copper
- Section: ..... 2.000 mm<sup>2</sup>
- Number of conductors per phase: ..... 3
- Nominal System Voltage (Table 01-1) ..... 115 kV
- Voltage Range (Normal Operating +/-5%): ..... 109,3-121 kV
- Rated Continuous Current (trefoil formation, direct buried): ..... 1.066 A

- Short-circuit Capacity per second: .....40 kA
- Short-circuit Duration: ..... 1 s
- Insulation: .....XLPE
- Jacket: .....LLDPE
- Normal Operation Temperature:.....90 °C
- Emergency Overload Temperature:..... 105 °C
- Short-Circuit Temperature:.....250 °C
- Conductor DC Resistance at 20°C: .....0,0090  $\Omega$ /km
- Conductor AC Resistance at 20°C: .....0,0141  $\Omega$ /km

## 8 CALCULATION REPORTS

The aim of this section is to study the Load Flow Assessment of the facilities of the future Network 380 kV of Jubail 2S4&3. Electrical Calculations have been performed with ETAP PowerStation software

### 8.1 Input Data, Assumptions and Methodology

#### 8.1.1 Input Data

##### External Network

Data obtained from the Client.

##### Expansion of the existing 380 kV Network

The Expansion of the Existing Network 380 kV Substations in Jubail 2S4&3 will consist of the installations described in section above “5. Substation Description”.

As a summary, the first interconnection will be in Jubail 2 380 / 230 kV Substation, where will interconnect the new 380 kV System of Jubail 2S4&3 with the external 380 kV Network. In addition, the 380 kV System of Jubail 2S4&3 will be interconnected in a second interconnection with the 380 kV System External Network. For this purpose, the 380 kV System of J2S4&3 will be connected to the 380 kV Overhead Line "To Nursery Road" that runs close to Jubail 2S4&3.

##### 380 kV System

The model of the 380 kV System is defined by the following main characteristics:

- Rated voltage: ..... 380 kV
- Voltage variation range (normal conditions): ..... ±5%
- Voltage variation range (emergency conditions - 30 mins): ..... ±10%
- Rated frequency: ..... 60 Hz
- Frequency variation range: ..... 59,9-60,1 Hz
- Frequency variation range (transient): ..... 58,5-61,5 Hz
- Maximum short circuit current (3Ph): ..... 50 or 63 kA
- Maximum X/R: ..... 10 (Estimated)

##### 380 / 115 kV Transformer

The 380 / 115 kV Transformers will be the followings:

- JUBAIL 3-S/S-1 380 / 115 kV Transformer 1 and 2: ..... 300/400/500 MVA
- JUBAIL 3-S/S-2 380 / 115 kV Transformer 1 and 2: ..... 175/350 MVA
- JUBAIL 3-S/S-3 380 / 115 kV Transformer 1 and 2: ..... 300/400/500 MVA
- JUBAIL 3-S/S-4 380 / 115 kV Transformer 1 and 2: ..... 300/400/500 MVA

The 380 / 115 kV Transformers will have the following main characteristics:

- Rated power 1 (ONAN/ONAF1/ONAF2):.....300/400/500 MVA
- Rated power 2 (ONAN/ONAF):.....175/350 MVA
- Transformation ratio: .....380 / 115 kV

### **115 / 34,5 kV Transformer**

The 115 / 34,5 kV Transformers will be the followings:

- JUBAIL 3-S/S-1-1 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-2-1 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-2-2 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-2-3 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-3-1 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-3-2 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-3-3 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-4-1 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-4-2 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-4-3 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-4-4 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-4-5 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-4-6 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA
- JUBAIL 3-S/S-4-7 115 / 34,5 kV Transformer 1 and 2: .....80/100 MVA

The 115 / 34,5 kV Transformers will have the following main characteristics:

- Rated power 1 (ONAN/ONAF):.....80/100 MVA
- Transformation ratio: .....115 / 34,5 kV

## **8.1.2 Assumptions**

### **Generator**

All the Generator data are provided, and reference values have been considered.

### **Transformers**

Based on the apparent power rating (MVA) of the transformers, the following Transformer data were used as preliminary values in the Load Flow Assessment:

The 380 / 115 kV Transformers:

- Voltage regulation: ..... On-load,  $\pm 10 \times 1,25\%$

- Short circuit impedance: ..... 12% (ONAF)
- Tolerance short circuit impedance: .....  $\pm 7,5\%$
- X/R: ..... 50 (Estimated)

The 115 / 34,5 kV Transformers:

- Voltage regulation: ..... On-load,  $\pm 10 \times 1,25\%$
- Short circuit impedance: ..... 12% (ONAF)
- Tolerance short circuit impedance: .....  $\pm 7,5\%$
- X/R: ..... 45 (Estimated)

### **Load Demand**

The Load Demand are provided according with the section “4.3.1 Future Load Demand of JB2S4&3 “

A Table with the Load Demand considered in the Load Flow Assessment is included in Annex I.

### **8.1.3 Methodology**

The Load Flow Assessment of the Future 380 kV and 115 kV Networks of Jubail 2S4&3 are performed to ensure that all new 380 kV and 115 kV Substations and 380 kV Overhead Lines remains within acceptable limits for all network contingent scenarios considered.

The Load Flow Assessment will show load-generation balance at each 380 kV and 115 kV Busbars of the Substations.

All load flow scenarios will be carried out to confirm that the proposed interconnection points and 380 kV and 115 kV Busbars of the Substations are suitable.

## **8.2 Load Flow Assessment**

### **8.2.1 Considerations**

The present study has been performed with ETAP Powerstation Software, version 20.5.0. All the parameters of the electrical equipment not specified in this document have been assumed by the default values of the calculation Software.

According to IEC Standard 60076, a tolerance of  $\pm 10\%$  for transformers with  $Z_{cc} \leq 10\%$  and  $\pm 7.5\%$  for transformers with  $Z_{cc} \geq 10\%$  is considered in the calculations.

It must be assured that the voltage limits on the 380 / 115 kV Substations and 115 kV / 34,5 kV Substations are within the 95% and the 105% of the rated voltage of the busbars in normal conditions and within the 90% and the 110% in emergency conditions (30 mins), in any of the operation modes. Therefore, it is performed the calculation of the maximum and minimum voltage in the different operation modes.

## 8.2.2 Operation Modes

The Load Flow studies are performed to assess the steady state operation (voltage conditions and thermal ratings) of the Future 380 kV Network of Jubail 2S4&3. These studies are carried out to ensure that all elements in the Future 380 kV Network of Jubail 2S4&3 (mainly busbars and transformers) remain within their voltage and thermal limits for all network contingent scenarios considered.

Two different conditions with respect to the status of interconnection with the External Network are considered:

- Future 380 kV Network of Jubail 2S4&3 connected to External Network and all Power Plant are connected (Generation 100%). As it is indicated in next Section, the Load Flow Assessment will include different scenarios for intact network conditions and for the disconnection of single network element (N-1 contingency).
- Future 380 kV Network of Jubail 2S4&3 connected to External Network and all Power Plants are disconnected (Generation 0%), except the PV Plants which will provide the necessary power for the Electrolytic Hydrogen Production, and the electrical demanded power of the Industrial Park is supplied completely from the External Network.

## 8.2.3 Scenarios Analysed

The steady state analysis included Load Flow Assessment for the following scenarios:

- Scenario 0: Normal conditions in all the 380 kV Busbars, 380 kV Overhead Lines, 115 kV Busbars, 115 kV Underground Lines, etc.
- Scenario 1: The 380 kV Busbars 2 disconnected in all 380 / 115 kV Substations, the 380 kV Overhead Line Circuit 2 disconnected between two (2) 380 / 115 kV Substations, the 380 / 115 kV Transformer 2 disconnected in all 380 / 115 kV Substations, and the 115 kV Busbars 2 disconnected in all 380 / 115 kV Substations.
- Scenario 2: The 115 kV Underground Line Circuit 2 disconnected of the 115 / 34,5 kV Substations, the 115 kV Busbars 2 disconnected in all 115 / 34,5 kV Substations, the 115 / 34,5 kV Transformer 2 disconnected in all 115 / 34,5 kV Substations.
- Scenario 3: Tripping in Future Generation Power Plants and all Power Plants are disconnected (Generation 0%), except the PV Plants which will provide the necessary power for the Electrolytic Hydrogen Production, and the electrical demanded power of the Industrial Park is supplied completely from External Network.

### **Scenario 0: Normal Condition**

In this scenario, all Substations and Electrical Lines are connected in normal conditions, and the Load Demand of Jubail 2S4&3 are supplied from the Future Generation Power Plants, and Future 380 kV Network of Jubail 2S4&3 is connected with External 380 kV Network. In the Annex 2 are included the results corresponding to the following conditions:

- Voltage in the 380 kV Network: 100% (380 kV)
- Future Generation Power Plants connected.
- Future 380 kV Network of Jubail 2S4&3 connected with External 380 kV Network.
- All 380 kV Busbars connected of all 380 / 115 kV Substations.
- All 380 kV Overhead Line connected.
- All 380 / 115 kV Transformer connected in all 380 / 115 kV Substations.
- All 115 kV Busbars connected in all 380 / 115 kV Substations.
- All 115 kV Underground Line connected in all 115 / 34,5 kV Substations.
- All 115 kV Busbars connected in all 115 / 34,5 kV Substations.
- All 115 / 34,5 kV Transformer connected in all 115 / 34,5 kV Substations.
- All the loads demand connected in normal operation.

The following results have been obtained:

#### Substation / Busbars

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-1 380 kV BUSBAR 1	380	3.150	100,0	380,0	1.506,0	991,0
JUBAIL 3-S/S-1 380 kV BUSBAR 2	380	3.150	100,0	380,0	1.922,0	1.265,0
JUBAIL 3-S/S-1 115 kV BUSBAR 1	115	3.150	100,2	115,2	921,2	184,0
JUBAIL 3-S/S-1 115 kV BUSBAR 2	115	3.150	100,2	115,2	0,0	0,0
JUBAIL 3-S/S-2 380 kV BUSBAR 1	380	3.150	100,0	380,0	2.173,1	1.430,1
JUBAIL 3-S/S-2 380 kV BUSBAR 2	380	3.150	100,0	380,0	2.234,9	1.470,8
JUBAIL 3-S/S-2 115 kV BUSBAR 1	115	3.150	100,3	115,3	850,0	169,9
JUBAIL 3-S/S-2 115 kV BUSBAR 2	115	3.150	101,3	116,5	485,4	97,9
JUBAIL 3-S/S-3 380 kV BUSBAR 1	380	3.150	100,0	380,0	971,7	639,6
JUBAIL 3-S/S-3 380 kV BUSBAR 2	380	3.150	100,0	380,0	989,1	651,0
JUBAIL 3-S/S-3 115 kV BUSBAR 1	115	3.150	100,7	115,8	1.226,0	245,8
JUBAIL 3-S/S-3 115 kV BUSBAR 2	115	3.150	100,0	115,0	489,4	97,5
JUBAIL 3-S/S-4 380 kV BUSBAR 1	380	3.150	100,0	380,0	576,0	379,1
JUBAIL 3-S/S-4 380 kV BUSBAR 2	380	3.150	100,0	380,0	511,4	336,6
JUBAIL 3-S/S-4 115 kV BUSBAR 1	115	3.150	100,4	115,5	1.808,0	361,1
JUBAIL 3-S/S-4 115 kV BUSBAR 2	115	3.150	101,1	116,3	1.605,0	323,4
JUBAIL 3-S/S-1-1 115 kV BUSBAR 1	115	3.150	100,3	115,3	921,2	184,0
JUBAIL 3-S/S-1-1 115 kV BUSBAR 2	115	3.150	100,3	115,3	396,6	79,2
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 1	34,5	2.500	101,0	34,8	519,2	31,3
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 2	34,5	2.500	100,8	34,8	556,2	33,5
JUBAIL 3-S/S-2-1 115 kV BUSBAR 1	115	3.150	100,3	115,3	451,0	90,1
JUBAIL 3-S/S-2-1 115 kV BUSBAR 2	115	3.150	100,3	115,3	228,4	45,6

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 1	34,5	2.500	100,2	34,6	723,6	43,3
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	742,3	44,4
JUBAIL 3-S/S-2-2 115 kV BUSBAR 1	115	3.150	101,3	116,5	485,4	97,9
JUBAIL 3-S/S-2-2 115 kV BUSBAR 2	115	3.150	101,3	116,5	198,5	40,0
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 1	34,5	2.500	101,8	35,1	920,6	56,0
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 2	34,5	2.500	101,5	35,0	645,1	39,1
JUBAIL 3-S/S-2-3 115 kV BUSBAR 1	115	3.150	100,3	115,3	398,9	79,7
JUBAIL 3-S/S-2-3 115 kV BUSBAR 2	115	3.150	100,3	115,3	228,4	45,6
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 1	34,5	2.500	100,9	34,8	554,3	33,4
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 2	34,5	2.500	100,9	34,8	742,3	44,4
JUBAIL 3-S/S-3-1 115 kV BUSBAR 1	115	3.150	100,7	115,8	769,2	154,2
JUBAIL 3-S/S-3-1 115 kV BUSBAR 2	115	3.150	100,7	115,8	251,5	50,4
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 1	34,5	2.500	100,4	34,6	779,8	46,8
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	817,2	48,9
JUBAIL 3-S/S-3-2 115 kV BUSBAR 1	115	3.150	100,0	115,0	489,4	97,5
JUBAIL 3-S/S-3-2 115 kV BUSBAR 2	115	3.150	100,0	115,0	200,1	39,9
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 1	34,5	2.500	100,4	34,6	928,1	55,7
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	650,4	38,9
JUBAIL 3-S/S-3-3 115 kV BUSBAR 1	115	3.150	100,7	115,8	456,5	91,5
JUBAIL 3-S/S-3-3 115 kV BUSBAR 2	115	3.150	100,7	115,8	257,4	51,6
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 1	34,5	2.500	100,9	34,8	647,6	39,0
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	836,0	50,0
JUBAIL 3-S/S-4-1 115 kV BUSBAR 1	115	3.150	101,1	116,3	1.125,0	226,7
JUBAIL 3-S/S-4-1 115 kV BUSBAR 2	115	3.150	101,1	116,3	645,7	130,1
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 1	34,5	2.500	102,0	35,2	478,0	29,1
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 2	34,5	2.500	102,0	35,2	478,0	29,1
JUBAIL 3-S/S-4-2 115 kV BUSBAR 1	115	3.150	100,4	115,5	678,6	135,7
JUBAIL 3-S/S-4-2 115 kV BUSBAR 2	115	3.150	100,4	115,5	391,7	78,3
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 1	34,5	2.500	99,5	34,3	933,3	55,5
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 2	34,5	2.500	101,6	35,1	367,9	22,3
JUBAIL 3-S/S-4-3 115 kV BUSBAR 1	115	3.150	101,1	116,3	111,7	22,5
JUBAIL 3-S/S-4-3 115 kV BUSBAR 2	115	3.150	101,1	116,3	55,8	11,3
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 1	34,5	2.500	101,8	35,1	183,8	11,2
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 2	34,5	2.500	101,8	35,1	183,8	11,2
JUBAIL 3-S/S-4-4 115 kV BUSBAR 1	115	3.150	100,4	115,5	169,1	33,8
JUBAIL 3-S/S-4-4 115 kV BUSBAR 2	115	3.150	100,4	115,5	84,6	16,9
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 1	34,5	2.500	100,7	34,7	278,4	16,7
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 2	34,5	2.500	100,7	34,7	278,4	16,7
JUBAIL 3-S/S-4-5 115 kV BUSBAR 1	115	3.150	101,1	116,3	368,4	74,2
JUBAIL 3-S/S-4-5 115 kV BUSBAR 2	115	3.150	101,1	116,3	198,7	40,0
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 1	34,5	2.500	101,7	35,1	551,6	33,5
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 2	34,5	2.500	101,4	35,0	645,7	39,1

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-4-6 115 kV BUSBAR 1	115	3.150	100,4	115,5	515,5	103,1
JUBAIL 3-S/S-4-6 115 kV BUSBAR 2	115	3.150	100,4	115,5	228,3	45,7
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 1	34,5	2.500	99,5	34,3	933,3	55,5
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	742,0	44,4
JUBAIL 3-S/S-4-7 115 kV BUSBAR 1	115	3.150	100,4	115,5	1,124,0	224,7
JUBAIL 3-S/S-4-7 115 kV BUSBAR 2	115	3.150	100,4	115,5	901,1	180,2
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 1	34,5	2.500	100,3	34,6	723,3	43,4
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 2	34,5	2.500	100,3	34,6	723,3	43,4

### Transformers

Transformers	Rated Power (MVA)	Demanded Power (MVA)	Load Factor (%)
JUBAIL 3-S/S-1 380/115 kV Transformer 1	500	184,0	36,8%
JUBAIL 3-S/S-1 380/115 kV Transformer 2	500	0,0	0,0%
JUBAIL 3-S/S-2 380/115 kV Transformer 1	350	169,9	48,5%
JUBAIL 3-S/S-2 380/115 kV Transformer 2	350	97,9	28,0%
JUBAIL 3-S/S-3 380/115 kV Transformer 1	500	253,6	50,7%
JUBAIL 3-S/S-3 380/115 kV Transformer 2	500	98,7	19,7%
JUBAIL 3-S/S-4 380/115 kV Transformer 1	500	379,1	75,8%
JUBAIL 3-S/S-4 380/115 kV Transformer 2	500	336,6	67,3%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 1	100	31,9	31,9%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 2	100	34,2	34,2%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 1	100	44,5	44,5%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 2	100	45,6	45,6%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 1	100	57,9	57,9%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 2	100	40,0	40,0%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 1	100	34,1	34,1%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 2	100	45,6	45,6%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 1	100	48,1	48,1%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 2	100	50,4	50,4%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1	100	57,6	57,6%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 2	100	39,9	39,9%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 1	100	40,0	40,0%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 2	100	51,6	51,6%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 1	100	29,6	29,6%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 2	100	29,6	29,6%
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 1	100	57,4	57,4%
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 2	100	22,6	22,6%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 1	100	11,3	11,3%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 2	100	11,3	11,3%

<b>Transformers</b>	<b>Rated Power (MVA)</b>	<b>Demanded Power (MVA)</b>	<b>Load Factor (%)</b>
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 1	100	16,9	16,9%
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 2	100	16,9	16,9%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 1	100	34,2	34,2%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 2	100	40,0	40,0%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 1	100	57,4	57,4%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 2	100	45,7	45,7%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 1	100	44,5	44,5%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 2	100	44,5	44,5%

### Electrical Lines

<b>Electrical Lines</b>	<b>Rated Power (MVA) (Summer)</b>	<b>Demanded Power (MVA)</b>	<b>Load Factor (%)</b>
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 1	1.398,3	397,9	28,5%
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 2	1.398,3	397,9	28,5%
380 OHL J3-S/S-1 - J3-S/S-2 Circuit 1	1.398,3	991,0	70,9%
380 OHL J3-S/S-1 - J3-S/S-2 Circuit 2	1.398,3	1.265,0	90,5%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 1	1.398,3	254,1	18,2%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 2	1.398,3	294,8	21,1%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 1	1.398,3	379,1	27,1%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 2	1.398,3	336,6	24,1%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 1	1.398,3	0,0	0,0%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 2	1.398,3	0,0	0,0%
115 UDL J3-S/S-1 - J3-S/S-1-1 Circuit 1	---	184,0	---
115 UDL J3-S/S-1 - J3-S/S-1-1 Circuit 2	---	0,0	---
115 UDL J3-S/S-2 - J3-S/S-2-1 Circuit 1	---	90,1	---
115 UDL J3-S/S-2 - J3-S/S-2-2 Circuit 1	---	97,9	---
115 UDL J3-S/S-2 - J3-S/S-2-3 Circuit 1	---	79,7	---
115 UDL J3-S/S-2-1 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-2-2 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3 - J3-S/S-3-1 Circuit 1	---	154,2	---
115 UDL J3-S/S-3 - J3-S/S-3-2 Circuit 1	---	97,5	---
115 UDL J3-S/S-3 - J3-S/S-3-3 Circuit 1	---	91,5	---
115 UDL J3-S/S-3-1 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3-2 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4 - J3-S/S-4-1 Circuit 1	---	226,7	---
115 UDL J3-S/S-4 - J3-S/S-4-3 Circuit 1	---	22,5	---
115 UDL J3-S/S-4 - J3-S/S-4-4 Circuit 1	---	33,8	---
115 UDL J3-S/S-4 - J3-S/S-4-5 Circuit 1	---	74,2	---
115 UDL J3-S/S-4 - J3-S/S-4-6 Circuit 1	---	103,1	---
115 UDL J3-S/S-4 - J3-S/S-4-7 Circuit 1	---	224,7	---
115 UDL J3-S/S-4-1 - J3-S/S-4-7 Circuit 1	---	0,0	---

Electrical Lines	Rated Power (MVA) (Summer)	Demanded Power (MVA)	Load Factor (%)
115 UDL J3-S/S-4-2 - J3-S/S-4-7 Circuit 1	---	135,7	---
115 UDL J3-S/S-4-2 - J3-S/S-4-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-4 - J3-S/S-4-6 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-5 - J3-S/S-4-6 Circuit 1	---	0,0	---

The values marked in red colour indicate values of currents or powers where the rated values of the equipment are exceeded.

As it can be checked in the Tables included previously, there are not values marked in red colour, therefore there are no values of Currents of Powers where the rated values of equipment are exceeded.

All parameters are corrected according to normal operation.

It is due to that the general criteria considered, as it is indicated in the section "4. Basis of Design" is that all the equipment is dimensioned redundantly, so that in case of disconnection of single network element (N-1 contingency), the Network can be operated properly.

### **Scenario 1:**

In this scenario, all Substations and Electrical Lines are connected considering a disconnection of single network element (N-1 contingency) in all elements of the 380 kV System (380 kV Busbars, 380 kV Overhead Lines, 380 / 115 kV Transformers, and 115 kV Busbars). The Load Demand of Jubail 2S4&3 are supplied from the Future Generation Power Plant, and Future 380 kV Network of Jubail 2S4&3 is connected with External 380 kV Network. In the Annex 3 are included the results corresponding to the following conditions:

- Voltage in the 380 kV Network: 100% (380 kV)
- Future Generation Power Plants connected.
- Future 380 kV Network of Jubail 2S4&3 connected with External 380 kV Network.
- All 380 kV Busbars 1 connected, and 380 kV Busbars 2 disconnected of all 380 / 115 kV Substations.
- All 380 kV Overhead Line Circuit 1 connected, and Circuit 2 disconnected.
- All 380 / 115 kV Transformer 1 connected, and 380 / 115 kV Transformer 2 disconnected in all 380 / 115 kV Substations.
- All 115 kV Busbars 1 connected, and 115 Busbars 2 disconnected in all 380 / 115 kV Substations.
- All 115 kV Underground Line connected in all 115 / 34,5 kV Substations.
- All 115 kV Busbars connected in all 115 / 34,5 kV Substations.
- All 115 / 34,5 kV Transformer connected in all 115 / 34,5 kV Substations.

- All the loads demand connected in normal operation.

The following results have been obtained:

### Substations / Busbars

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-1 380 kV BUSBAR 1	380	3.150	100,0	380,0	<b>3.387,0</b>	2.229,0
JUBAIL 3-S/S-1 380 kV BUSBAR 2	380	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-1 115 kV BUSBAR 1	115	3.150	100,3	115,3	921,0	184,0
JUBAIL 3-S/S-1 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-2 380 kV BUSBAR 1	380	3.150	100,0	380,0	<b>4.429,8</b>	2.915,6
JUBAIL 3-S/S-2 380 kV BUSBAR 2	380	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-2 115 kV BUSBAR 1	115	3.150	100,3	115,3	1.338,0	267,4
JUBAIL 3-S/S-2 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-3 380 kV BUSBAR 1	380	3.150	100,0	380,0	1.961,0	1.291,0
JUBAIL 3-S/S-3 380 kV BUSBAR 2	380	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-3 115 kV BUSBAR 1	115	3.150	100,6	115,7	1.713,0	343,4
JUBAIL 3-S/S-3 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4 380 kV BUSBAR 1	380	3.150	100,0	380,0	1.138,0	748,9
JUBAIL 3-S/S-4 380 kV BUSBAR 2	380	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4 115 kV BUSBAR 1	115	3.150	100,0	115,0	<b>3.431,0</b>	683,6
JUBAIL 3-S/S-4 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-1-1 115 kV BUSBAR 1	115	3.150	100,3	115,3	921,2	184,0
JUBAIL 3-S/S-1-1 115 kV BUSBAR 2	115	3.150	100,3	115,3	396,6	79,2
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 1	34,5	2.500	101,0	34,8	519,2	31,3
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 2	34,5	2.500	100,8	34,8	556,2	33,5
JUBAIL 3-S/S-2-1 115 kV BUSBAR 1	115	3.150	100,3	115,3	451,1	90,1
JUBAIL 3-S/S-2-1 115 kV BUSBAR 2	115	3.150	100,3	115,3	228,4	45,6
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 1	34,5	2.500	100,2	34,6	723,7	43,3
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 2	34,5	2.500	100,1	34,5	742,4	44,4
JUBAIL 3-S/S-2-2 115 kV BUSBAR 1	115	3.150	100,3	115,3	488,4	97,6
JUBAIL 3-S/S-2-2 115 kV BUSBAR 2	115	3.150	100,3	115,3	199,7	39,9
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 1	34,5	2.500	100,8	34,8	926,2	55,8
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 2	34,5	2.500	100,5	34,7	649,0	39,0
JUBAIL 3-S/S-2-3 115 kV BUSBAR 1	115	3.150	100,3	115,3	399,0	79,7
JUBAIL 3-S/S-2-3 115 kV BUSBAR 2	115	3.150	100,3	115,3	228,4	45,6
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 1	34,5	2.500	100,9	34,8	554,4	33,4
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 2	34,5	2.500	100,1	34,5	742,4	44,4
JUBAIL 3-S/S-3-1 115 kV BUSBAR 1	115	3.150	100,6	115,7	769,3	154,2
JUBAIL 3-S/S-3-1 115 kV BUSBAR 2	115	3.150	100,6	115,7	251,5	50,4
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 1	34,5	2.500	100,4	34,6	779,9	46,8
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	817,3	48,9
JUBAIL 3-S/S-3-2 115 kV BUSBAR 1	115	3.150	100,6	115,7	487,3	97,7

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-3-2 115 kV BUSBAR 2	115	3.150	100,6	115,7	199,3	40,0
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 1	34,5	2.500	101,1	34,9	924,2	55,9
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 2	34,5	2.500	100,9	34,8	647,7	39,0
JUBAIL 3-S/S-3-3 115 kV BUSBAR 1	115	3.150	100,6	115,7	456,5	91,5
JUBAIL 3-S/S-3-3 115 kV BUSBAR 2	115	3.150	100,6	115,7	257,4	51,6
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 1	34,5	2.500	100,9	34,8	647,7	39,0
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 2	34,5	2.500	100,1	34,5	836,1	50,0
JUBAIL 3-S/S-4-1 115 kV BUSBAR 1	115	3.150	100,0	115,0	1.133,0	225,7
JUBAIL 3-S/S-4-1 115 kV BUSBAR 2	115	3.150	100,0	115,0	649,9	129,5
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 1	34,5	2.500	100,9	34,8	481,2	29,0
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 2	34,5	2.500	100,9	34,8	481,2	29,0
JUBAIL 3-S/S-4-2 115 kV BUSBAR 1	115	3.150	100,0	115,0	680,1	135,5
JUBAIL 3-S/S-4-2 115 kV BUSBAR 2	115	3.150	100,0	115,0	392,5	78,2
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 1	34,5	2.500	99,1	34,2	935,5	55,4
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 2	34,5	2.500	101,3	34,9	368,7	22,3
JUBAIL 3-S/S-4-3 115 kV BUSBAR 1	115	3.150	100,0	115,0	112,4	22,4
JUBAIL 3-S/S-4-3 115 kV BUSBAR 2	115	3.150	100,0	115,0	56,2	11,2
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 1	34,5	2.500	100,6	34,7	185,0	11,1
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 2	34,5	2.500	100,6	34,7	185,0	11,1
JUBAIL 3-S/S-4-4 115 kV BUSBAR 1	115	3.150	100,0	115,0	169,5	33,8
JUBAIL 3-S/S-4-4 115 kV BUSBAR 2	115	3.150	100,0	115,0	84,7	16,9
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 1	34,5	2.500	100,3	34,6	279,0	16,7
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 2	34,5	2.500	100,3	34,6	279,0	16,7
JUBAIL 3-S/S-4-5 115 kV BUSBAR 1	115	3.150	100,0	115,0	370,9	73,9
JUBAIL 3-S/S-4-5 115 kV BUSBAR 2	115	3.150	100,0	115,0	200,0	39,9
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 1	34,5	2.500	100,6	34,7	555,4	33,4
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	650,1	38,9
JUBAIL 3-S/S-4-6 115 kV BUSBAR 1	115	3.150	100,0	115,0	519,4	103,5
JUBAIL 3-S/S-4-6 115 kV BUSBAR 2	115	3.150	100,0	115,0	228,8	45,6
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 1	34,5	2.500	101,9	35,2	920,2	56,0
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 2	34,5	2.500	99,9	34,5	743,6	44,4
JUBAIL 3-S/S-4-7 115 kV BUSBAR 1	115	3.150	100,0	115,0	1.126,0	224,4
JUBAIL 3-S/S-4-7 115 kV BUSBAR 2	115	3.150	100,0	115,0	903,1	179,9
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 1	34,5	2.500	99,9	34,5	724,9	43,3
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 2	34,5	2.500	99,9	34,5	724,9	43,3

### Transformers

Transformers	Rated Power (MVA)	Demanded Power (MVA)	Load Factor (%)
JUBAIL 3-S/S-1 380/115 kV Transformer 1	500	188,2	37,6%

Transformers	Rated Power (MVA)	Demanded Power (MVA)	Load Factor (%)
JUBAIL 3-S/S-1 380/115 kV Transformer 2	500	0,0	0,0%
JUBAIL 3-S/S-2 380/115 kV Transformer 1	350	277,0	79,1%
JUBAIL 3-S/S-2 380/115 kV Transformer 2	350	0,0	0,0%
JUBAIL 3-S/S-3 380/115 kV Transformer 1	500	359,2	71,8%
JUBAIL 3-S/S-3 380/115 kV Transformer 2	500	0,0	0,0%
JUBAIL 3-S/S-4 380/115 kV Transformer 1	500	748,9	149,8%
JUBAIL 3-S/S-4 380/115 kV Transformer 2	500	0,0	0,0%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 1	100	31,9	31,9%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 2	100	34,2	34,2%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 1	100	44,5	44,5%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 2	100	45,6	45,6%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 1	100	57,7	57,7%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 2	100	39,9	39,9%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 1	100	34,1	34,1%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 2	100	45,6	45,6%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 1	100	48,1	48,1%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 2	100	50,4	50,4%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1	100	57,8	57,8%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 2	100	40,0	40,0%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 1	100	40,0	40,0%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 2	100	51,6	51,6%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 1	100	29,5	29,5%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 2	100	29,5	29,5%
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 1	100	57,4	57,4%
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 2	100	22,6	22,6%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 1	100	11,2	11,2%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 2	100	11,2	11,2%
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 1	100	16,9	16,9%
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 2	100	16,9	16,9%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 1	100	34,0	34,0%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 2	100	39,9	39,9%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 1	100	57,9	57,9%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 2	100	45,6	45,6%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 1	100	44,4	44,4%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 2	100	44,4	44,4%

### Electrical Lines

Electrical Lines	Rated Power (MVA) (Summer)	Demanded Power (MVA)	Load Factor (%)
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 1	1.398,3	379,4	27,1%
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 2	1.398,3	379,4	27,1%

380 OHL J3-S/S-1 - J3-S/S-2 Circuit 1	1.398,3	<b>2.229,0</b>	159,4%
380 OHL J3-S/S-1 - J3-S/S-2 Circuit 2	1.398,3	0,0	0,0%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 1	1.398,3	562,6	40,2%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 2	1.398,3	0,0	0,0%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 1	1.398,3	748,9	53,6%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 2	1.398,3	0,0	0,0%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 1	1.398,3	0,0	0,0%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 2	1.398,3	0,0	0,0%
115 UDL J3-S/S-1 - J3-S/S-1-1 Circuit 1	---	183,0	---
115 UDL J3-S/S-1 - J3-S/S-1-1 Circuit 2	---	0,0	---
115 UDL J3-S/S-2 - J3-S/S-2-1 Circuit 1	---	90,1	---
115 UDL J3-S/S-2 - J3-S/S-2-2 Circuit 1	---	97,6	---
115 UDL J3-S/S-2 - J3-S/S-2-3 Circuit 1	---	79,7	---
115 UDL J3-S/S-2-1 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-2-2 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3 - J3-S/S-3-1 Circuit 1	---	154,2	---
115 UDL J3-S/S-3 - J3-S/S-3-2 Circuit 1	---	97,7	---
115 UDL J3-S/S-3 - J3-S/S-3-3 Circuit 1	---	91,5	---
115 UDL J3-S/S-3-1 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3-2 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4 - J3-S/S-4-1 Circuit 1	---	225,7	---
115 UDL J3-S/S-4 - J3-S/S-4-3 Circuit 1	---	22,4	---
115 UDL J3-S/S-4 - J3-S/S-4-4 Circuit 1	---	33,8	---
115 UDL J3-S/S-4 - J3-S/S-4-5 Circuit 1	---	73,9	---
115 UDL J3-S/S-4 - J3-S/S-4-6 Circuit 1	---	103,5	---
115 UDL J3-S/S-4 - J3-S/S-4-7 Circuit 1	---	224,4	---
115 UDL J3-S/S-4-1 - J3-S/S-4-7 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-2 - J3-S/S-4-7 Circuit 1	---	135,5	---
115 UDL J3-S/S-4-2 - J3-S/S-4-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-4 - J3-S/S-4-6 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-5 - J3-S/S-4-6 Circuit 1	---	0,0	---

The values marked in red colour indicate values of currents or powers where the rated values of the equipment are exceeded.

As it can be checked in the Tables included previously, in Scenario 1 with contingencies in 380 kV System, the following values of the equipment are exceeded:

- JUBAIL 3-S/S-1 380 kV BUSBAR 1: .....3.387,00 A
- JUBAIL 3-S/S-2 380 kV BUSBAR 1: .....4.429,8 A
- JUBAIL 3-S/S-4 115 kV BUSBAR 1: .....3.431,0 A
- JUBAIL 3-S/S-4 380/115 kV Transformer 1: .....748,9 MVA (149,8%)
- 380 OHL J3-S/S-1 - J3-S/S-2 Circuit 1: .....2.229,0 MVA

In the case of JUBAIL 3-S/S-1 380 kV BUSBAR 1 (3.387,00 A), is operated with only one Busbar, in addition to supplying the large load of the Electrolytic Hydrogen Production, the current necessary to supply all the loads of the 115 kV System, as well as all the power being evacuated to the External 380 kV Network, must circulate through this Busbar.

In this case, given that the section "4. Basis of Design" considered 380 kV Busbars standard of 3.150 and 4.000 A, it is finally recommended to consider 380 kV Busbars of 4.000 A. Therefore, for this 380 / 115 kV Substation is proposed to consider 380 kV Busbars of 4.000 A and all switchgears (circuit breakers, disconnecter switches, etc.) of 3.150 A. This is also recommended for the rest of the 380 / 115 kV Substations.

In the specific case of JUBAIL 3-S/S-2 380 kV BUSBAR 1 (4.429,8 A), even considering 380 kV Busbars of 4.000 A, it would not be sufficient to circulate the expected maximum current. This is mainly since in case of failure in one 380 kV Busbar, it is necessary to evacuate all the power of the Generation Power Plants through only one 380 kV Busbar. In this case, the recommendation would be to reduce the power generated by the Power Plants, so that the 380 kV Network is not unnecessarily oversized.

In relation to JUBAIL 3-S/S-4 115 kV BUSBAR 1 (3.431,0 A), and associated JUBAIL 3-S/S-4 380/115 kV Transformer 1 (748,9 MVA (149,8%)), in case of these contingencies occur because in JUBAIL 3-S/S-4 Substation quite a lot of loads are connected in the 115 and 34,5 kV Systems, so that the values considered in the case of these contingencies are exceeded. In this case, given that the transformers exceed the 130% overload, according to IEC 60076-7 Standard, as in the previous case, it is recommended to consider 380 / 115 kV transformers with a power of 625 MVA, which with the 130% overload could achieve a power even higher than the power demand of 748,9 MVA. Another alternative would be to install two (2) sets of 500 MVA power transformers, and in this way, by having two (2) sets of 115 kV Busbars, the rated current of 3.150 A would not be exceeded.

Finally, in the case of 380 OHL J3-S/S-1 – JUBAIL 3-S/S-2 Circuit 1 (2.229,0 MVA), as in the case of JUBAIL 3-S/S-2 380 kV BUSBAR 1 (4.429,8 A), there is an excess in the power to be transported by the 380 kV Overhead Line, mainly because the evacuation power of all the Generation Power Plants will have to be evacuated by a only one circuit. Similarly, in this case, the power generated in the Generation Power Plants will have to be reduced.

### **Scenario 2: Contingencies in 115 kV System**

In this scenario, all Substations and Electrical Lines are connected considering a disconnection of single network element (N-1 contingency) in all elements of the 115 kV System (115 kV Busbars, 115 kV Underground Lines, and 115 / 34,5 kV Transformers). The Load Demand of Jubail 2S4&3 are supplied from the Future Generation Power Plant, and Future 380 kV Network of Jubail 2S4&3 is connected with External 380 kV Network. In the Annex 4 are included the results corresponding to the following conditions:

- Voltage in the 380 kV Network: 100% (380 kV)
- Future Generation Power Plants connected.

- Future 380 kV Network of Jubail 2S4&3 connected with External 380 kV Network.
- All 380 kV Busbars connected of all 380 / 115 kV Substations.
- All 380 kV Overhead Line connected.
- All 380 / 115 kV Transformer connected in all 380 / 115 kV Substations.
- All 115 kV Busbars connected in all 380 / 115 kV Substations.
- All 115 kV Underground Line Circuit 1 connected, and Circuit 2 disconnected in all 115 / 34,5 kV Substations.
- All 115 kV Busbars 1 connected, and 115 Busbars 2 disconnected in all 115 / 34,5 kV Substations.
- All 115 / 34,5 kV Transformer 1 connected, and 115 / 34,5 kV Transformer 2 disconnected in all 115 / 34,5 kV Substations.
- All 34,5 kV Busbars 1 connected, and 34,5 Busbars 2 connected in all 115 / 34,5 kV Substations.
- All the loads demand connected in normal operation.

The following results have been obtained:

#### Substation / Busbar

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-1 380 kV BUSBAR 1	380	3.150	100,0	380,0	1.665,0	1.096,0
JUBAIL 3-S/S-1 380 kV BUSBAR 2	380	3.150	100,0	380,0	1.828,0	1.203,0
JUBAIL 3-S/S-1 115 kV BUSBAR 1	115	3.150	101,6	116,8	919,4	186,0
JUBAIL 3-S/S-1 115 kV BUSBAR 2	115	3.150	101,3	116,5	0,0	0,0
JUBAIL 3-S/S-2 380 kV BUSBAR 1	380	3.150	100,0	380,0	2.210,7	1.454,9
JUBAIL 3-S/S-2 380 kV BUSBAR 2	380	3.150	100,0	380,0	2.201,1	1.448,6
JUBAIL 3-S/S-2 115 kV BUSBAR 1	115	3.150	100,1	115,1	873,8	174,2
JUBAIL 3-S/S-2 115 kV BUSBAR 2	115	3.150	101,1	116,3	498,3	100,4
JUBAIL 3-S/S-3 380 kV BUSBAR 1	380	3.150	100,0	380,0	971,7	639,6
JUBAIL 3-S/S-3 380 kV BUSBAR 2	380	3.150	100,0	380,0	989,1	651,0
JUBAIL 3-S/S-3 115 kV BUSBAR 1	115	3.150	99,8	114,7	979,1	194,6
JUBAIL 3-S/S-3 115 kV BUSBAR 2	115	3.150	101,8	117,1	775,3	157,2
JUBAIL 3-S/S-4 380 kV BUSBAR 1	380	3.150	100,0	380,0	497,8	327,6
JUBAIL 3-S/S-4 380 kV BUSBAR 2	380	3.150	100,0	380,0	513,2	337,8
JUBAIL 3-S/S-4 115 kV BUSBAR 1	115	3.150	100,8	115,9	1.563,0	313,6
JUBAIL 3-S/S-4 115 kV BUSBAR 2	115	3.150	99,6	114,5	1.632,0	323,7
JUBAIL 3-S/S-1-1 115 kV BUSBAR 1	115	3.150	101,6	116,8	919,4	186,0
JUBAIL 3-S/S-1-1 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 1	34,5	2.500	101,5	35,0	1.072,0	65,0

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 2	34,5	2.500	101,5	35,0	554,0	33,6
JUBAIL 3-S/S-2-1 115 kV BUSBAR 1	115	3.150	100,1	115,1	464,2	92,6
JUBAIL 3-S/S-2-1 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 1	34,5	2.500	99,7	34,4	1.470,0	87,6
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 2	34,5	2.500	99,7	34,4	744,3	44,4
JUBAIL 3-S/S-2-2 115 kV BUSBAR 1	115	3.150	101,1	116,3	498,3	100,4
JUBAIL 3-S/S-2-2 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 1	34,5	2.500	100,4	34,6	1.578,0	94,6
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 2	34,5	2.500	100,4	34,6	649,5	39,0
JUBAIL 3-S/S-2-3 115 kV BUSBAR 1	115	3.150	100,1	115,1	409,5	81,7
JUBAIL 3-S/S-2-3 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 1	34,5	2.500	100,4	34,6	1.297,0	77,8
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 2	34,5	2.500	100,4	34,6	741,1	44,5
JUBAIL 3-S/S-3-1 115 kV BUSBAR 1	115	3.150	101,8	117,1	775,3	157,2
JUBAIL 3-S/S-3-1 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 1	34,5	2.500	99,6	34,3	1.604,0	95,4
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 2	34,5	2.500	99,6	34,3	820,6	48,8
JUBAIL 3-S/S-3-2 115 kV BUSBAR 1	115	3.150	99,8	114,7	505,1	100,4
JUBAIL 3-S/S-3-2 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 1	34,5	2.500	100,3	34,6	1.578,0	94,6
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 2	34,5	2.500	100,3	34,6	649,8	38,9
JUBAIL 3-S/S-3-3 115 kV BUSBAR 1	115	3.150	99,8	114,7	474,0	94,2
JUBAIL 3-S/S-3-3 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 1	34,5	2.500	100,7	34,7	1.481,0	89,2
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 2	34,5	2.500	100,7	34,7	833,2	50,1
JUBAIL 3-S/S-4-1 115 kV BUSBAR 1	115	3.150	99,6	114,5	1.140,0	226,2
JUBAIL 3-S/S-4-1 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 1	34,5	2.500	99,8	34,4	968,2	57,8
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 2	34,5	2.500	99,8	34,4	484,1	28,9
JUBAIL 3-S/S-4-2 115 kV BUSBAR 1	115	3.150	100,8	115,9	404,7	81,2
JUBAIL 3-S/S-4-2 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 1	34,5	2.500	98,3	33,9	1.315,0	77,3
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 2	34,5	2.500	98,3	33,9	375,3	22,1
JUBAIL 3-S/S-4-3 115 kV BUSBAR 1	115	3.150	99,6	114,5	113,2	22,5
JUBAIL 3-S/S-4-3 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 1	34,5	2.500	99,5	34,3	372,7	22,2
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 2	34,5	2.500	99,5	34,3	186,3	11,1
JUBAIL 3-S/S-4-4 115 kV BUSBAR 1	115	3.150	100,8	115,9	169,8	34,1
JUBAIL 3-S/S-4-4 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 1	34,5	2.500	100,0	34,5	558,9	33,4
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 2	34,5	2.500	100,0	34,5	279,5	16,7
JUBAIL 3-S/S-4-5 115 kV BUSBAR 1	115	3.150	99,6	114,5	379,3	75,2

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-4-5 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 1	34,5	2.500	98,8	34,1	1.217,0	71,9
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 2	34,5	2.500	98,8	34,1	655,6	38,7
JUBAIL 3-S/S-4-6 115 kV BUSBAR 1	115	3.150	100,8	115,9	532,2	106,8
JUBAIL 3-S/S-4-6 115 kV BUSBAR 2	115	3.150	0,0	0,0	0,0	0,0
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 1	34,5	2.500	101,0	34,8	1.663,0	100,4
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 2	34,5	2.500	101,0	34,8	738,5	44,6
JUBAIL 3-S/S-4-7 115 kV BUSBAR 1	115	3.150	100,8	115,9	860,9	172,8
JUBAIL 3-S/S-4-7 115 kV BUSBAR 2	115	3.150	100,8	115,9	0,0	0,0
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 1	34,5	2.500	100,5	34,7	1.445,0	86,8
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 2	34,5	2.500	100,5	34,7	722,3	43,4

### Transformers

Transformers	Rated Power (MVA)	Demanded Power (MVA)	Load Factor (%)
JUBAIL 3-S/S-1 380/115 kV Transformer 1	500	190,3	38,1%
JUBAIL 3-S/S-1 380/115 kV Transformer 2	500	0,0	0,0%
JUBAIL 3-S/S-2 380/115 kV Transformer 1	350	178,5	51,0%
JUBAIL 3-S/S-2 380/115 kV Transformer 2	350	101,8	29,1%
JUBAIL 3-S/S-3 380/115 kV Transformer 1	500	200,0	40,0%
JUBAIL 3-S/S-3 380/115 kV Transformer 2	500	160,4	32,1%
JUBAIL 3-S/S-4 380/115 kV Transformer 1	500	327,6	65,5%
JUBAIL 3-S/S-4 380/115 kV Transformer 2	500	337,8	67,6%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 1	100	67,6	67,6%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 1	100	92,6	92,6%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 1	100	<b>100,4</b>	100,4%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 1	100	81,7	81,7%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 1	100	<b>101,4</b>	101,4%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1	100	<b>100,4</b>	100,4%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 1	100	94,2	94,2%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 1	100	59,9	59,9%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 1	100	81,2	81,2%

Transformers	Rated Power (MVA)	Demanded Power (MVA)	Load Factor (%)
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 1	100	22,5	22,5%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 1	100	34,1	34,1%
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 1	100	75,2	75,2%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 1	100	<b>106,8</b>	106,8%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 2	100	0,0	0,0%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 1	100	91,6	91,6%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 2	100	0,0	0,0%

### Electrical Lines

Electrical Lines	Rated Power (MVA) (Summer)	Demanded Power (MVA)	Load Factor (%)
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 1	1.398,3	164,4	11,8%
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 2	1.398,3	164,4	11,8%
380 OHL J3-S/S-1 - J3-S/S-2 Circuit 1	1.398,3	1.096,0	78,4%
380 OHL J3-S/S-1 - J3-S/S-2 Circuit 2	1.398,3	1.088,0	77,8%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 1	1.398,3	278,9	19,9%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 2	1.398,3	252,2	18,0%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 1	1.398,3	327,6	23,4%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 2	1.398,3	337,8	24,2%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 1	1.398,3	0,0	0,0%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 2	1.398,3	0,0	0,0%
115 UDL J3-S/S-1 - J3-S/S-1-1 Circuit 1	---	184,4	---
115 UDL J3-S/S-1 - J3-S/S-1-2 Circuit 1	---	237,9	---
115 UDL J3-S/S-1 - J3-S/S-1-3 Circuit 1	---	143,3	---
115 UDL J3-S/S-1-1 - J3-S/S-1-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-1-2 - J3-S/S-1-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-2 - J3-S/S-2-1 Circuit 1	---	92,6	---
115 UDL J3-S/S-2 - J3-S/S-2-2 Circuit 1	---	100,4	---
115 UDL J3-S/S-2 - J3-S/S-2-3 Circuit 1	---	81,7	---
115 UDL J3-S/S-2-1 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-2-2 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3 - J3-S/S-3-1 Circuit 1	---	268,4	---
115 UDL J3-S/S-3 - J3-S/S-3-2 Circuit 1	---	100,4	---
115 UDL J3-S/S-3 - J3-S/S-3-3 Circuit 1	---	94,2	---
115 UDL J3-S/S-3-1 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3-2 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4 - J3-S/S-4-1 Circuit 1	---	226,2	---

Electrical Lines	Rated Power (MVA) (Summer)	Demanded Power (MVA)	Load Factor (%)
115 UDL J3-S/S-4 - J3-S/S-4-3 Circuit 1	---	22,5	---
115 UDL J3-S/S-4 - J3-S/S-4-4 Circuit 1	---	34,1	---
115 UDL J3-S/S-4 - J3-S/S-4-5 Circuit 1	---	75,2	---
115 UDL J3-S/S-4 - J3-S/S-4-6 Circuit 1	---	106,8	---
115 UDL J3-S/S-4 - J3-S/S-4-7 Circuit 1	---	172,8	---
115 UDL J3-S/S-4-1 - J3-S/S-4-7 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-2 - J3-S/S-4-7 Circuit 1	---	81,2	---
115 UDL J3-S/S-4-2 - J3-S/S-4-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-4 - J3-S/S-4-6 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-5 - J3-S/S-4-6 Circuit 1	---	0,0	---

The values marked in red colour indicate values of currents or powers where the rated values of the equipment are exceeded.

As it can be checked in the Tables included previously, in Scenario 2 with contingencies in 115 kV System, in general except the values of the equipment indicated below, there are no values of Currents or Powers where the rated values of equipment are exceeded significantly:

- JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 1: ..... 100,4 MVA (100,4%)
- JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 1: ..... 101,8 MVA (101,8%)
- JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1: ..... 100,4 MVA (100,4%)
- JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 1: ..... 106,8 MVA (106,8%)

For JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 1 (100,4 MVA (100,4%)), JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 1 (101,8 MVA (101,8%)), JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1 (100,4 MVA (100,4%)), JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1 (100,4 MVA (100,4%)), in case of unavailability in one of the 115 / 34,5 kV Transformers, an overload occurs in the other transformer. In this case, the overload is very small (6,8% in the worst case), and as indicated in Table 4 of IEC 60076-7, for large power Transformers a Normal cyclic loading of 130% is allowed, which would be below the maximum demanded load. An alternative in the event that the 115 / 34,5 kV Transformer does not work under overload, would be the possibility of considering transformers with a slightly higher power of around 110 MVA, but due to the standardisation of the installation, and that the power of the transformers is not very exceeded, this is not considered necessary.

### **Scenario 3: Tripping in Generation Power Plants**

In this scenario, all Substations and Electrical Lines are connected in normal conditions (equal than Scenario 0), all Generation Power Plants are disconnected (Generation 0%), except the PV Plants which will provide the necessary power for the Electrolytic Hydrogen Production, and the Load Demand of Jubail 2S4&3 are supplied completely from External 380 kV Network. In the Annex 5 are included the results corresponding to the Scenario 3.

The following results have been obtained:

### Substations / Busbars

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-1 380 kV BUSBAR 1	380	3.150	100,0	380,0	1.184,0	779,4
JUBAIL 3-S/S-1 380 kV BUSBAR 2	380	3.150	100,0	380,0	1.184,0	779,4
JUBAIL 3-S/S-1 115 kV BUSBAR 1	115	3.150	101,6	116,8	912,2	184,7
JUBAIL 3-S/S-1 115 kV BUSBAR 2	115	3.150	101,3	116,5	0,0	0,0
JUBAIL 3-S/S-2 380 kV BUSBAR 1	380	3.150	100,0	380,0	885,3	582,6
JUBAIL 3-S/S-2 380 kV BUSBAR 2	380	3.150	100,0	380,0	447,3	294,4
JUBAIL 3-S/S-2 115 kV BUSBAR 1	115	3.150	100,3	115,3	850,0	169,9
JUBAIL 3-S/S-2 115 kV BUSBAR 2	115	3.150	101,3	116,5	485,4	97,9
JUBAIL 3-S/S-3 380 kV BUSBAR 1	380	3.150	100,0	380,0	971,7	639,6
JUBAIL 3-S/S-3 380 kV BUSBAR 2	380	3.150	100,0	380,0	989,1	651,0
JUBAIL 3-S/S-3 115 kV BUSBAR 1	115	3.150	100,7	115,8	1.226,0	245,8
JUBAIL 3-S/S-3 115 kV BUSBAR 2	115	3.150	101,3	116,5	485,4	97,9
JUBAIL 3-S/S-4 380 kV BUSBAR 1	380	3.150	100,0	380,0	576,0	379,1
JUBAIL 3-S/S-4 380 kV BUSBAR 2	380	3.150	100,0	380,0	511,4	336,6
JUBAIL 3-S/S-4 115 kV BUSBAR 1	115	3.150	100,8	115,9	1.808,0	361,6
JUBAIL 3-S/S-4 115 kV BUSBAR 2	115	3.150	100,8	115,9	1.605,0	323,4
JUBAIL 3-S/S-1-1 115 kV BUSBAR 1	115	3.150	101,6	116,8	912,2	184,7
JUBAIL 3-S/S-1-1 115 kV BUSBAR 2	115	3.150	101,6	116,8	392,6	79,5
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 1	34,5	2.500	101,0	34,8	518,9	31,3
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 2	34,5	2.500	100,9	34,8	556,0	33,5
JUBAIL 3-S/S-2-1 115 kV BUSBAR 1	115	3.150	100,3	115,3	451,0	90,1
JUBAIL 3-S/S-2-1 115 kV BUSBAR 2	115	3.150	100,3	115,3	228,4	45,6
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 1	34,5	2.500	100,2	34,6	723,6	43,3
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	742,3	44,4
JUBAIL 3-S/S-2-2 115 kV BUSBAR 1	115	3.150	101,3	116,5	485,4	97,9
JUBAIL 3-S/S-2-2 115 kV BUSBAR 2	115	3.150	101,3	116,5	198,5	40,0
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 1	34,5	2.500	101,8	35,1	920,6	56,0
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 2	34,5	2.500	101,5	35,0	645,1	39,1
JUBAIL 3-S/S-2-3 115 kV BUSBAR 1	115	3.150	100,3	115,3	398,9	79,7
JUBAIL 3-S/S-2-3 115 kV BUSBAR 2	115	3.150	100,3	115,3	228,4	45,6
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 1	34,5	2.500	100,9	34,8	554,3	33,4
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	742,3	44,4
JUBAIL 3-S/S-3-1 115 kV BUSBAR 1	115	3.150	100,7	115,8	769,2	154,2
JUBAIL 3-S/S-3-1 115 kV BUSBAR 2	115	3.150	100,7	115,8	251,5	50,4
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 1	34,5	2.500	100,4	34,6	779,8	46,8
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	817,2	48,9
JUBAIL 3-S/S-3-2 115 kV BUSBAR 1	115	3.150	101,3	116,5	485,4	97,9
JUBAIL 3-S/S-3-2 115 kV BUSBAR 2	115	3.150	101,3	116,5	198,5	40,0

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Voltage (%)	Voltage (kV)	Current (A)	Apparent Power (MVA)
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 1	34,5	2.500	101,8	35,1	920,6	56,0
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 2	34,5	2.500	101,5	35,0	645,1	39,1
JUBAIL 3-S/S-3-3 115 kV BUSBAR 1	115	3.150	100,6	115,7	456,7	91,5
JUBAIL 3-S/S-3-3 115 kV BUSBAR 2	115	3.150	100,6	115,7	257,2	51,6
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 1	34,5	2.500	100,8	34,8	647,6	39,0
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 2	34,5	2.500	100,1	34,5	836,5	50,0
JUBAIL 3-S/S-4-1 115 kV BUSBAR 1	115	3.150	101,1	116,3	1.125,0	226,7
JUBAIL 3-S/S-4-1 115 kV BUSBAR 2	115	3.150	101,1	116,3	645,7	130,1
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 1	34,5	2.500	102,0	35,2	478,0	29,1
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 2	34,5	2.500	102,0	35,2	478,0	29,1
JUBAIL 3-S/S-4-2 115 kV BUSBAR 1	115	3.150	100,4	115,5	678,6	1.357,7
JUBAIL 3-S/S-4-2 115 kV BUSBAR 2	115	3.150	100,4	115,5	391,7	78,3
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 1	34,5	2.500	99,5	34,3	933,3	55,5
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 2	34,5	2.500	101,6	35,1	367,9	22,3
JUBAIL 3-S/S-4-3 115 kV BUSBAR 1	115	3.150	101,1	116,3	111,7	22,5
JUBAIL 3-S/S-4-3 115 kV BUSBAR 2	115	3.150	101,1	116,3	55,8	11,3
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 1	34,5	2.500	101,8	35,1	183,8	11,2
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 2	34,5	2.500	101,8	35,1	183,8	11,2
JUBAIL 3-S/S-4-4 115 kV BUSBAR 1	115	3.150	100,4	115,5	169,1	33,8
JUBAIL 3-S/S-4-4 115 kV BUSBAR 2	115	3.150	100,4	115,5	84,6	16,9
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 1	34,5	2.500	100,7	34,7	278,4	16,7
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 2	34,5	2.500	100,7	34,7	278,4	16,7
JUBAIL 3-S/S-4-5 115 kV BUSBAR 1	115	3.150	101,1	116,3	368,4	74,2
JUBAIL 3-S/S-4-5 115 kV BUSBAR 2	115	3.150	101,1	116,3	198,7	40,0
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 1	34,5	2.500	101,7	35,1	551,6	33,5
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 2	34,5	2.500	101,4	35,0	645,7	39,1
JUBAIL 3-S/S-4-6 115 kV BUSBAR 1	115	3.150	100,4	115,5	515,5	103,1
JUBAIL 3-S/S-4-6 115 kV BUSBAR 2	115	3.150	100,4	115,5	228,3	45,7
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 1	34,5	2.500	99,5	34,3	933,3	55,5
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 2	34,5	2.500	100,2	34,6	742,0	44,4
JUBAIL 3-S/S-4-7 115 kV BUSBAR 1	115	3.150	100,4	115,5	1.124,0	224,7
JUBAIL 3-S/S-4-7 115 kV BUSBAR 2	115	3.150	100,4	115,5	901,1	180,2
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 1	34,5	2.500	100,3	34,6	723,3	43,4
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 2	34,5	2.500	100,3	34,6	723,3	43,4

### Transformers

Transformers	Rated Power (MVA)	Demanded Power (MVA)	Load Factor (%)
JUBAIL 3-S/S-1 380/115 kV Transformer 1	500	188,8	37,8%
JUBAIL 3-S/S-1 380/115 kV Transformer 2	500	0,0	0,0%

<b>Transformers</b>	<b>Rated Power (MVA)</b>	<b>Demanded Power (MVA)</b>	<b>Load Factor (%)</b>
JUBAIL 3-S/S-2 380/115 kV Transformer 1	350	173,6	49,6%
JUBAIL 3-S/S-2 380/115 kV Transformer 2	350	99,2	28,3%
JUBAIL 3-S/S-3 380/115 kV Transformer 1	500	253,6	50,7%
JUBAIL 3-S/S-3 380/115 kV Transformer 2	500	99,2	19,8%
JUBAIL 3-S/S-4 380/115 kV Transformer 1	500	379,1	75,8%
JUBAIL 3-S/S-4 380/115 kV Transformer 2	500	336,6	67,3%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 1	100	31,9	31,9%
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 2	100	34,2	34,2%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 1	100	44,5	44,5%
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 2	100	45,6	45,6%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 1	100	57,9	57,9%
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 2	100	40,0	40,0%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 1	100	34,1	34,1%
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 2	100	45,6	45,6%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 1	100	48,1	48,1%
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 2	100	50,4	50,4%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1	100	57,9	57,9%
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 2	100	40,0	40,0%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 1	100	40,0	40,0%
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 2	100	51,6	51,6%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 1	100	29,6	29,6%
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 2	100	29,6	29,6%
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 1	100	57,4	57,4%
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 2	100	22,6	22,6%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 1	100	11,3	11,3%
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 2	100	11,3	11,3%
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 1	100	16,9	16,9%
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 2	100	16,9	16,9%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 1	100	34,2	34,2%
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 2	100	40,0	40,0%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 1	100	57,4	57,4%
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 2	100	45,7	45,7%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 1	100	44,5	44,5%
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 2	100	44,5	44,5%

### Electrical Lines

<b>Electrical Lines</b>	<b>Rated Power (MVA) (Summer)</b>	<b>Demanded Power (MVA)</b>	<b>Load Factor (%)</b>
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 1	1.398,3	1.033,0	73,9%
380 OHL J2 380/230 kV - J3-S/S-1 Circuit 2	1.398,3	1.033,0	73,9%

Electrical Lines	Rated Power (MVA) (Summer)	Demanded Power (MVA)	Load Factor (%)
380 OHL J3-S/S-1 - J3-S/S-2 Circuit 1	1.398,3	419,2	30,0%
380 OHL J3-S/S-1 - J3-S/S-2 Circuit 2	1.398,3	250,2	17,9%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 1	1.398,3	301,2	21,5%
380 OHL J3-S/S-2 - J3-S/S-3 Circuit 2	1.398,3	294,4	21,1%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 1	1.398,3	379,1	27,1%
380 OHL J3-S/S-3 - J3-S/S-4 Circuit 2	1.398,3	336,6	24,1%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 1	1.398,3	0,0	0,0%
J3-S/S-4 - 380 OHL J2 380/230 kV Circuit 2	1.398,3	0,0	0,0%
115 UDL J3-S/S-1 - J3-S/S-1-1 Circuit 1	---	183,5	---
115 UDL J3-S/S-1 - J3-S/S-1-2 Circuit 1	---	230,3	---
115 UDL J3-S/S-1 - J3-S/S-1-3 Circuit 1	---	140,0	---
115 UDL J3-S/S-1-1 - J3-S/S-1-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-1-2 - J3-S/S-1-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-2 - J3-S/S-2-1 Circuit 1	---	90,1	---
115 UDL J3-S/S-2 - J3-S/S-2-2 Circuit 1	---	97,9	---
115 UDL J3-S/S-2 - J3-S/S-2-3 Circuit 1	---	79,7	---
115 UDL J3-S/S-2-1 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-2-2 - J3-S/S-2-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3 - J3-S/S-3-1 Circuit 1	---	265,5	---
115 UDL J3-S/S-3 - J3-S/S-3-2 Circuit 1	---	97,9	---
115 UDL J3-S/S-3 - J3-S/S-3-3 Circuit 1	---	91,5	---
115 UDL J3-S/S-3-1 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-3-2 - J3-S/S-3-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4 - J3-S/S-4-1 Circuit 1	---	226,7	---
115 UDL J3-S/S-4 - J3-S/S-4-3 Circuit 1	---	22,5	---
115 UDL J3-S/S-4 - J3-S/S-4-4 Circuit 1	---	33,8	---
115 UDL J3-S/S-4 - J3-S/S-4-5 Circuit 1	---	74,2	---
115 UDL J3-S/S-4 - J3-S/S-4-6 Circuit 1	---	103,1	---
115 UDL J3-S/S-4 - J3-S/S-4-7 Circuit 1	---	224,7	---
115 UDL J3-S/S-4-1 - J3-S/S-4-7 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-2 - J3-S/S-4-7 Circuit 1	---	135,7	---
115 UDL J3-S/S-4-2 - J3-S/S-4-3 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-4 - J3-S/S-4-6 Circuit 1	---	0,0	---
115 UDL J3-S/S-4-5 - J3-S/S-4-6 Circuit 1	---	0,0	---

The values marked in red colour indicate values of currents or powers where the rated values of the equipment are exceeded.

As it can be checked in the Tables included previously, and very similar than in Scenario 0, there are not values marked in red colour, therefore there are no values of Currents or Powers where the rated values of equipment are exceeded.

All parameters are corrected according to normal operation.

In this case, due that Future Generation Power Plants are disconnected (Generation 0%), except the PV Plants which will provide the necessary power for the Electrolytic Hydrogen Production, the electrical demanded power of the Industrial Park of Jubail 2S4&3 from External 380 kV Network will be 2.066 MVA (3.138 A).

### 8.3 Conclusions

The maximum currents and powers obtained from the studies included above and that shall be taken into account for the T&D Basis Design are the following:

#### Substations / Busbars

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Rating Current Recommended (A)	Maximum Current (A)	Maximum Power (MVA)	Worst Scenario
JUBAIL 3-S/S-1 380 kV BUSBAR 1	380	3.150	4.000	<b>3.387,0</b>	2.229,0	Scenario 1
JUBAIL 3-S/S-1 380 kV BUSBAR 2	380	3.150	4.000	1.922,0	1.265,0	Scenario 0
JUBAIL 3-S/S-1 115 kV BUSBAR 1	115	3.150	3.150	921,2	186,0	Scenario 0
JUBAIL 3-S/S-1 115 kV BUSBAR 2	115	3.150	3.150	0,0	0,0	Scenario 0
JUBAIL 3-S/S-2 380 kV BUSBAR 1	380	3.150	4.000 (1)	<b>4.429,8</b>	2.915,6	Scenario 1
JUBAIL 3-S/S-2 380 kV BUSBAR 2	380	3.150	4.000	2.234,9	1.470,8	Scenario 0
JUBAIL 3-S/S-2 115 kV BUSBAR 1	115	3.150	3.150,0	1.338,0	267,4	Scenario 1
JUBAIL 3-S/S-2 115 kV BUSBAR 2	115	3.150	3.150,0	498,3	100,4	Scenario 2
JUBAIL 3-S/S-3 380 kV BUSBAR 1	380	3.150	4.000	1.961,0	1.291,0	Scenario 1
JUBAIL 3-S/S-3 380 kV BUSBAR 2	380	3.150	4.000	989,1	651,0	Scenario 0
JUBAIL 3-S/S-3 115 kV BUSBAR 1	115	3.150	3.150,0	1.713,0	343,4	Scenario 1
JUBAIL 3-S/S-3 115 kV BUSBAR 2	115	3.150	3.150,0	775,3	157,2	Scenario 2
JUBAIL 3-S/S-4 380 kV BUSBAR 1	380	3.150	4.000	1.138,0	748,9	Scenario 1
JUBAIL 3-S/S-4 380 kV BUSBAR 2	380	3.150	4.000	513,2	337,8	Scenario 2
JUBAIL 3-S/S-4 115 kV BUSBAR 1	115	3.150	4.000	<b>3.431,0</b>	683,6	Scenario 1
JUBAIL 3-S/S-4 115 kV BUSBAR 2	115	3.150	3.150,0	1.632,0	323,7	Scenario 2
JUBAIL 3-S/S-1-1 115 kV BUSBAR 1	115	3.150	3.150,0	921,2	186,0	Scenario 0
JUBAIL 3-S/S-1-1 115 kV BUSBAR 2	115	3.150	3.150,0	396,6	79,5	Scenario 0
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.072,0	65,0	Scenario 2
JUBAIL 3-S/S-1-1 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	556,2	33,6	Scenario 0
JUBAIL 3-S/S-2-1 115 kV BUSBAR 1	115	3.150	3.150,0	464,2	92,6	Scenario 2
JUBAIL 3-S/S-2-1 115 kV BUSBAR 2	115	3.150	3.150,0	228,4	45,6	Scenario 0
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.470,0	87,6	Scenario 2
JUBAIL 3-S/S-2-1 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	744,3	44,4	Scenario 2
JUBAIL 3-S/S-2-2 115 kV BUSBAR 1	115	3.150	3.150,0	498,3	100,4	Scenario 2
JUBAIL 3-S/S-2-2 115 kV BUSBAR 2	115	3.150	3.150,0	199,7	40,0	Scenario 1
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.578,0	94,6	Scenario 2
JUBAIL 3-S/S-2-2 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	649,5	39,1	Scenario 2
JUBAIL 3-S/S-2-3 115 kV BUSBAR 1	115	3.150	3.150,0	409,5	81,7	Scenario 2
JUBAIL 3-S/S-2-3 115 kV BUSBAR 2	115	3.150	3.150,0	228,4	45,6	Scenario 0
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.297,0	77,8	Scenario 2

Substation / Busbars	Rated Voltage (kV)	Rating Current (A)	Rating Current Recommended (A)	Maximum Current (A)	Maximum Power (MVA)	Worst Scenario
JUBAIL 3-S/S-2-3 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	742,4	44,5	Scenario 1
JUBAIL 3-S/S-3-1 115 kV BUSBAR 1	115	3.150	3.150,0	775,3	157,2	Scenario 2
JUBAIL 3-S/S-3-1 115 kV BUSBAR 2	115	3.150	3.150,0	251,5	50,4	Scenario 0
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.604,0	95,4	Scenario 2
JUBAIL 3-S/S-3-1 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	820,6	48,9	Scenario 2
JUBAIL 3-S/S-3-2 115 kV BUSBAR 1	115	3.150	3.150,0	505,1	100,4	Scenario 2
JUBAIL 3-S/S-3-2 115 kV BUSBAR 2	115	3.150	3.150,0	200,1	40,0	Scenario 0
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.578,0	94,6	Scenario 2
JUBAIL 3-S/S-3-2 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	650,4	39,1	Scenario 0
JUBAIL 3-S/S-3-3 115 kV BUSBAR 1	115	3.150	3.150,0	474,0	94,2	Scenario 2
JUBAIL 3-S/S-3-3 115 kV BUSBAR 2	115	3.150	3.150,0	257,4	51,6	Scenario 0
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.481,0	89,2	Scenario 2
JUBAIL 3-S/S-3-3 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	836,5	50,1	Scenario 3
JUBAIL 3-S/S-4-1 115 kV BUSBAR 1	115	3.150	3.150,0	1.140,0	226,7	Scenario 2
JUBAIL 3-S/S-4-1 115 kV BUSBAR 2	115	3.150	3.150,0	649,9	130,1	Scenario 1
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	968,2	57,8	Scenario 2
JUBAIL 3-S/S-4-1 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	484,1	29,1	Scenario 2
JUBAIL 3-S/S-4-2 115 kV BUSBAR 1	115	3.150	3.150,0	680,1	1.357,7	Scenario 1
JUBAIL 3-S/S-4-2 115 kV BUSBAR 2	115	3.150	3.150,0	392,5	78,3	Scenario 1
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.315,0	77,3	Scenario 2
JUBAIL 3-S/S-4-2 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	375,3	22,3	Scenario 2
JUBAIL 3-S/S-4-3 115 kV BUSBAR 1	115	3.150	3.150,0	113,2	22,5	Scenario 2
JUBAIL 3-S/S-4-3 115 kV BUSBAR 2	115	3.150	3.150,0	56,2	11,3	Scenario 1
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	372,7	22,2	Scenario 2
JUBAIL 3-S/S-4-3 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	186,3	11,2	Scenario 2
JUBAIL 3-S/S-4-4 115 kV BUSBAR 1	115	3.150	3.150,0	169,8	34,1	Scenario 2
JUBAIL 3-S/S-4-4 115 kV BUSBAR 2	115	3.150	3.150,0	84,7	16,9	Scenario 1
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	558,9	33,4	Scenario 2
JUBAIL 3-S/S-4-4 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	279,5	16,7	Scenario 2
JUBAIL 3-S/S-4-5 115 kV BUSBAR 1	115	3.150	3.150,0	379,3	75,2	Scenario 2
JUBAIL 3-S/S-4-5 115 kV BUSBAR 2	115	3.150	3.150,0	200,0	40,0	Scenario 1
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.217,0	71,9	Scenario 2
JUBAIL 3-S/S-4-5 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	655,6	39,1	Scenario 2
JUBAIL 3-S/S-4-6 115 kV BUSBAR 1	115	3.150	3.150,0	532,2	106,8	Scenario 2
JUBAIL 3-S/S-4-6 115 kV BUSBAR 2	115	3.150	3.150,0	228,8	45,7	Scenario 1
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.663,0	100,4	Scenario 2
JUBAIL 3-S/S-4-6 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	743,6	44,6	Scenario 1
JUBAIL 3-S/S-4-7 115 kV BUSBAR 1	115	3.150	3.150,0	1.126,0	224,7	Scenario 1
JUBAIL 3-S/S-4-7 115 kV BUSBAR 2	115	3.150	3.150,0	903,1	180,2	Scenario 1
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 1	34,5	2.500	2.500,0	1.445,0	86,8	Scenario 2
JUBAIL 3-S/S-4-7 34,5 kV BUSBAR 2	34,5	2.500	2.500,0	724,9	43,4	Scenario 1

Transformers

Transformers	Rated Power (MVA)	Rated Power Recommended (MVA)	Maximum Power (MVA)	Worst Scenario
JUBAIL 3-S/S-1 380/115 kV Transformer 1	500	625	190,3	Scenario 2
JUBAIL 3-S/S-1 380/115 kV Transformer 2	500	500	0,0	Scenario 0
JUBAIL 3-S/S-2 380/115 kV Transformer 1	350	350	277,0	Scenario 1
JUBAIL 3-S/S-2 380/115 kV Transformer 2	350	350	101,8	Scenario 2
JUBAIL 3-S/S-3 380/115 kV Transformer 1	500	500	359,2	Scenario 1
JUBAIL 3-S/S-3 380/115 kV Transformer 2	500	500	160,4	Scenario 2
JUBAIL 3-S/S-4 380/115 kV Transformer 1	500	625 (2)	748,9	Scenario 1
JUBAIL 3-S/S-4 380/115 kV Transformer 2	500	625 (2)	337,8	Scenario 2
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 1	100	100	67,6	Scenario 2
JUBAIL 3-S/S-1-1 115/34,5 kV Transformer 2	100	100	34,2	Scenario 0
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 1	100	100	92,6	Scenario 2
JUBAIL 3-S/S-2-1 115/34,5 kV Transformer 2	100	100	45,6	Scenario 0
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 1	100	100 (3)	100,4	Scenario 2
JUBAIL 3-S/S-2-2 115/34,5 kV Transformer 2	100	100 (3)	40,0	Scenario 0
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 1	100	100	81,7	Scenario 2
JUBAIL 3-S/S-2-3 115/34,5 kV Transformer 2	100	100	45,6	Scenario 0
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 1	100	100 (3)	101,4	Scenario 2
JUBAIL 3-S/S-3-1 115/34,5 kV Transformer 2	100	100 (3)	50,4	Scenario 0
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 1	100	100 (3)	100,4	Scenario 2
JUBAIL 3-S/S-3-2 115/34,5 kV Transformer 2	100	100 (3)	40,0	Scenario 1
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 1	100	100	94,2	Scenario 2
JUBAIL 3-S/S-3-3 115/34,5 kV Transformer 2	100	100	51,6	Scenario 0
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 1	100	100	59,9	Scenario 2
JUBAIL 3-S/S-4-1 115/34,5 kV Transformer 2	100	100	29,6	Scenario 0
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 1	100	100	81,2	Scenario 2
JUBAIL 3-S/S-4-2 115/34,5 kV Transformer 2	100	100	22,6	Scenario 0
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 1	100	100	22,5	Scenario 2
JUBAIL 3-S/S-4-3 115/34,5 kV Transformer 2	100	100	11,3	Scenario 0
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 1	100	100	34,1	Scenario 2
JUBAIL 3-S/S-4-4 115/34,5 kV Transformer 2	100	100	16,9	Scenario 0
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 1	100	100	75,2	Scenario 2
JUBAIL 3-S/S-4-5 115/34,5 kV Transformer 2	100	100	40,0	Scenario 0
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 1	100	100 (3)	106,8	Scenario 2
JUBAIL 3-S/S-4-6 115/34,5 kV Transformer 2	100	100 (3)	45,7	Scenario 0
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 1	100	100	91,6	Scenario 2
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 2	100	100	44,5	Scenario 0
JUBAIL 3-S/S-4-7 115/34,5 kV Transformer 2	100	100	44,5	Scenario 0

The following conclusions are pointed out:

(1) - In this specific case, even considering 380 kV Busbars of 4.000 A, it would not be sufficient to circulate the expected maximum current. This is mainly due to the fact that in case of failure in one 380 kV Busbar, it is necessary to evacuate all the power of the Generation Power Plants through only one 380 kV Busbar. In this case, the recommendation would be to reduce the power generated by the Power Plants, so that the 380 kV Network is not unnecessarily oversized.

(2) - Given that the transformers exceed the 130% overload, according to IEC 60076-7 Standard, it is recommended to consider 380 / 115 kV transformers with a power of 625 MVA, which with the 130% overload could achieve a power even higher than the power demand of 748,9 MVA. Another alternative would be to install two (2) sets of 500 MVA power transformers, and in this way, by having two (2) sets of 115 kV Busbars, the rated current of 3.150 A would not be exceeded.

Below a diagram is included showing the recommendation with the installation of two (2) set of power transformers.

(3) - The overload is very small (6,8% in the worst case), and as it is indicated in Table 4 of IEC 60076-7, for large power Transformers a Normal cyclic loading of 130% is allowed, which would be below the maximum demanded load.

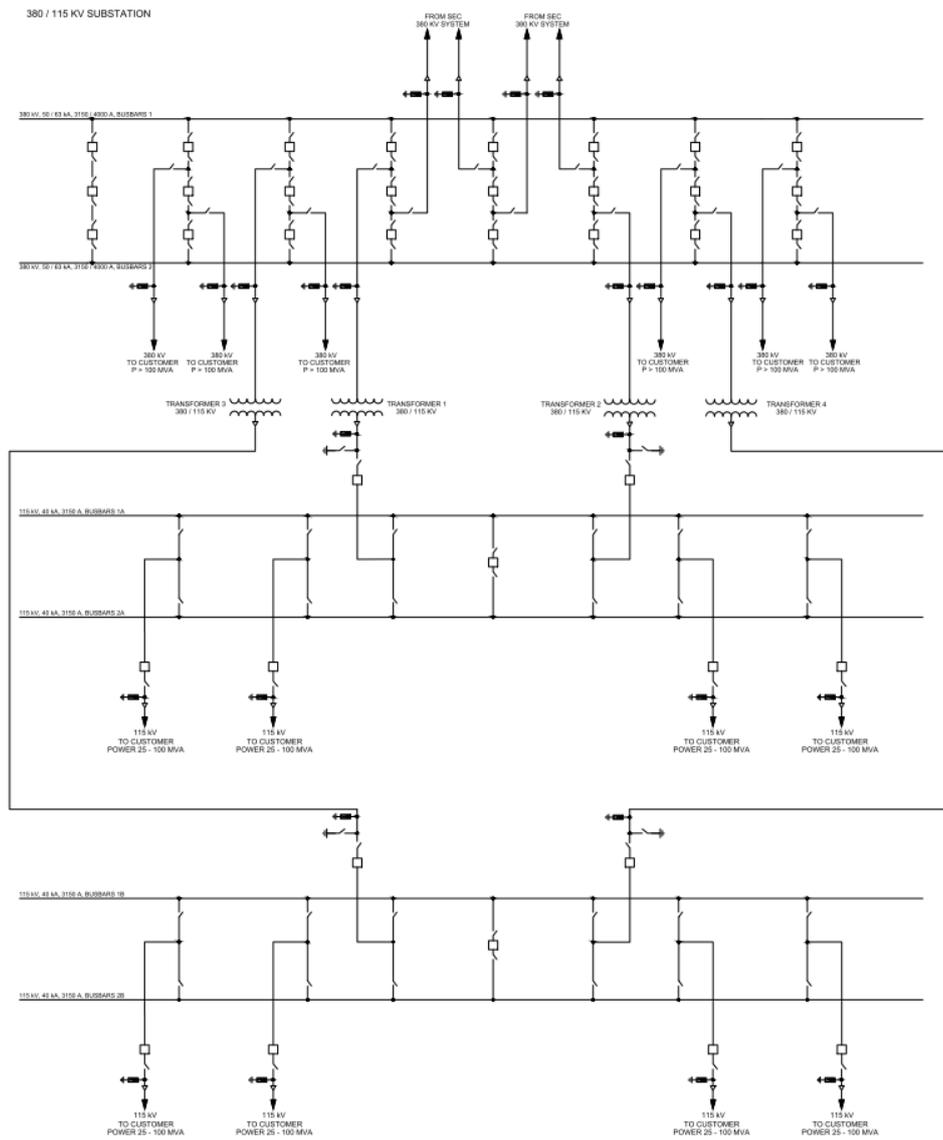


Figure 20: Recommendation to solve the overload in the transformers

## 9 COST ESTIMATION

The aim of this section is to present the Class IV Cost Estimation for the main concepts and activities related to Transmission and Distribution Electrical System (T&D) to be located in the development of the Green Industrial Park.

The CAPEX accuracy will be according to Class IV estimation according AACE (American Association of Cost Engineering).

For this type of technical/budget analysis, project team strongly recommends developing a FEED study as previous EPC stage in order to have a clear picture once finished the Feasibility Study. This FEED study is usually the decision gate for the project.

The methodology used consists of identifying cost drivers on defined elements by applying global ratios, relationships, and composite ratios to them.

The starting information for this estimation is the Feasibility Study package that Project Team has developed. In this case main documents consists mainly of:

- 380 / 115 kV Substations.
- 115 / 34,5 kV Substations.
- 34,5 / 0,4 kV Substations.
- 380 kV Overhead Lines.
- 115 kV Underground Lines.
- 380 kV Expansion of Existing Substations.

The present section will include only the direct costs and indirect construction costs for the current project area.

### 9.1 Methodology

The methodology applied for Class IV CAPEX cost estimation related to Transmission and Distribution System (T&D) considered the following aspects:

- The methodology consists of identifying cost drivers on defined elements by applying global ratios, relationships, and composite ratios to them.
- The Future Load Demand included in the section “4.3.1 Future Load Demand of the Green Industrial Park”.
- All criteria and considerations of the T&D System included in the section “4. Basis of Design”.
- The characteristics and amount of equipment of the 380 / 115 kV Substations, 115 / 34,5 kV Substations, 380 kV Overhead Lines, etc. included in all sections included in the section 5 and 6, especially the information included in Annex III: General Single Line Diagrams, in order to obtain the quantities.

- Cost of equipment, civil work, etc. obtained from market prices, in order to obtain the Cost Estimation. For the buildings of the Substations, the cost estimation has been performed through ratios, measurement, etc., including a % for engineering, construction, etc.
- All cost estimates were undertaken in Q1 2023 \$ and converted to Saudi Riyals at the rate of 1 U\$ = 3,75 SAR.

## 9.2 CAPEX Estimation

To better understand how the budget is structured, it is necessary to understand that 4 phases (7 years each) are foreseen for the construction of the Green Industrial Park. Within each phase, the first years are dedicated to infrastructure and as the phase progresses, industrial construction takes centre stage. Below is a general diagram of the evolution of each phase.

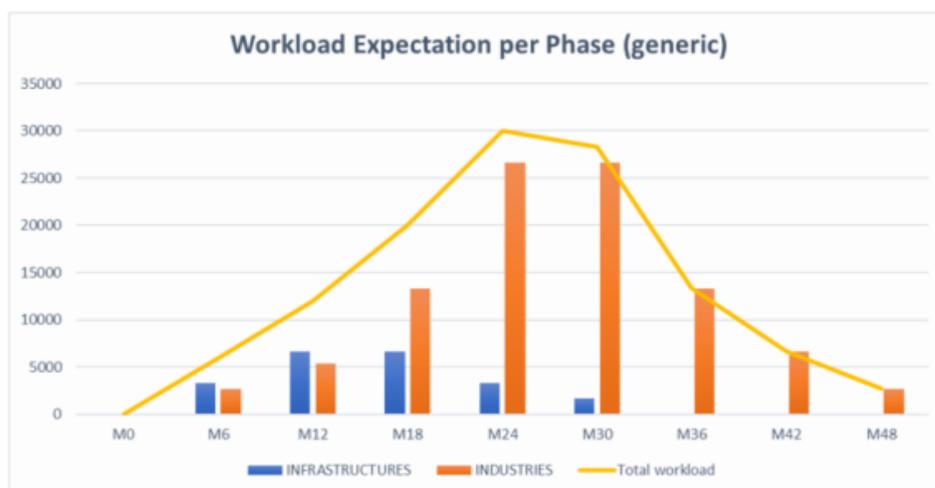


Figure 21: Workload Expectation per Phase

For this reason, the CAPEX estimation has been planned according to the phases of the project, depending on the need for construction and start-up.

It can be seen in the sections below how the 380 kV System is predominant in Phase 1 while the 115 kV and 34,5 kV systems are predominant in Phases 2 and 3.

## 9.2.1 380 / 115 kV Substations

CHAPTER 1: 380/115 KV SUBSTATIONS		COST			
		PHASE 1	PHASE 2	PHASE 3	PHASE 4
1.1	JUBAIL 3-S/S-1 380/115 kV	63,781,980.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
1.2	JUBAIL 3-S/S-2 380/115 kV	76,578,880.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
1.3	JUBAIL 3-S/S-3 380/115 kV	74,259,660.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
1.4	JUBAIL 3-S/S-4 380/115 kV	71,617,260.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
SUBTOTAL CHAPTER 1:		286,237,780.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR

## 9.2.2 115 / 34,5 kV Substations

CHAPTER 2: 115/34.5 KV SUBSTATIONS		COST			
		PHASE 1	PHASE 2	PHASE 3	PHASE 4
2.1	JUBAIL 3-S/S-1-1 115/34.5 kV	39,586,100.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
2.2	JUBAIL 3-S/S-2-1 115/34.5 kV	0.00 SAR	37,289,900.00 SAR	0.00 SAR	0.00 SAR
2.3	JUBAIL 3-S/S-2-2 115/34.5 kV	0.00 SAR	37,049,900.00 SAR	0.00 SAR	0.00 SAR
2.4	JUBAIL 3-S/S-2-3 115/34.5 kV	0.00 SAR	37,975,300.00 SAR	0.00 SAR	0.00 SAR
2.5	JUBAIL 3-S/S-3-1 115/34.5 kV	40,494,500.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
2.6	JUBAIL 3-S/S-3-2 115/34.5 kV	0.00 SAR	38,455,300.00 SAR	0.00 SAR	0.00 SAR
2.7	JUBAIL 3-S/S-3-3 115/34.5 kV	0.00 SAR	0.00 SAR	38,455,300.00 SAR	0.00 SAR
2.8	JUBAIL 3-S/S-4-1 115/34.5 kV	0.00 SAR	0.00 SAR	39,346,100.00 SAR	0.00 SAR
2.9	JUBAIL 3-S/S-4-2 115/34.5 kV	0.00 SAR	0.00 SAR	0.00 SAR	37,940,700.00 SAR
2.1	JUBAIL 3-S/S-4-3 115/34.5 kV	0.00 SAR	0.00 SAR	0.00 SAR	35,369,900.00 SAR
2.11	JUBAIL 3-S/S-4-4 115/34.5 kV	0.00 SAR	0.00 SAR	0.00 SAR	35,849,900.00 SAR
2.12	JUBAIL 3-S/S-4-5 115/34.5 kV	0.00 SAR	36,569,900.00 SAR	0.00 SAR	0.00 SAR
2.13	JUBAIL 3-S/S-4-6 115/34.5 kV	0.00 SAR	37,735,300.00 SAR	0.00 SAR	0.00 SAR
2.14	JUBAIL 3-S/S-4-7 115/34.5 kV	0.00 SAR	0.00 SAR	37,015,300.00 SAR	0.00 SAR
SUBTOTAL CHAPTER 2:		80,080,600.00 SAR	225,075,600.00 SAR	114,816,700.00 SAR	109,160,500.00 SAR

### 9.2.3 34,5 / 0,4 kV Substations

CHAPTER 3: 34.5/0.4 KV SUBSTATIONS		COST			
		PHASE 1	PHASE 2	PHASE 3	PHASE 4
3.1	34.5/0.4 kV, 300 kVA, 3Ph, 60 Hz, RMU-TRF-LVDP	0.00 SAR	0.00 SAR	364,000.00 SAR	0.00 SAR
3.2	34.5/0.4 kV, 500 kVA, 3Ph, 60 Hz, RMU-TRF-LVDP	3,640,000.00 SAR	1,092,000.00 SAR	2,548,000.00 SAR	728,000.00 SAR
3.3	34.5/0.4 kV, 1000 kVA, 3Ph, 60 Hz, RMU-TRF-LVDP	4,732,000.00 SAR	1,456,000.00 SAR	2,912,000.00 SAR	182,000.00 SAR
3.4	34.5 kV VIS INSET with 2 VIS of LBS (600 A) + 1 VICB (600 A)	1,404,000.00 SAR	3,432,000.00 SAR	3,900,000.00 SAR	1,092,000.00 SAR
SUBTOTAL CHAPTER 3:		9,776,000.00 SAR	5,980,000.00 SAR	9,724,000.00 SAR	2,002,000.00 SAR

### 9.2.4 380 kV Overhead Lines

CHAPTER 4: 380 KV OVERHEAD LINE S		COST			
		PHASE 1	PHASE 2	PHASE 3	PHASE 4
4.1	380 KV OHL JUBAIL 2 380/230 KV - JUBAIL 3-S/S-1	14,429,368.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
4.2	380 KV OHL JUBAIL 3-S/S-1 - JUBAIL 3-S/S-2	54,480,742.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
4.3	380 KV OHL JUBAIL 3-S/S-2 - JUBAIL 3-S/S-3	22,947,446.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
4.4	380 KV OHL JUBAIL 3-S/S-3 - JUBAIL 3-S/S-4	77,825,594.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
4.5	380 KV OHL JUBAIL 3-S/S-4 - EXISTING 380 KV OHL	91,197,111.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR
SUBTOTAL CHAPTER 4:		260,880,261.00 SAR	0.00 SAR	0.00 SAR	0.00 SAR

Note 1: This estimate does not take into account the earthworks of the RoW but does take into account the earthworks in the area associated with the towers.

### 9.2.5 115 kV Underground Lines

CHAPTER 5: 115 KV UNDERGROUND LINES		COST			
		PHASE 1	PHASE 2	PHASE 3	PHASE 4
5.1	Cable 3-1/Cx2000 mm2 Cu, XLPE, LLDPE, 115 kV	313,090,859.52 SAR	856,586,884.32 SAR	392,581,779.84 SAR	401,062,479.84 SAR
SUBTOTAL CHAPTER 5:		313,090,859.52 SAR	856,586,884.32 SAR	392,581,779.84 SAR	401,062,479.84 SAR

### 9.2.6 380 kV Expansion of Existing Substations

CHAPTER 7: 380 KV EXPANSION OF EXISTING SUBSTATIONS		COST				
		PHASE 1	PHASE 2	PHASE 3	PHASE 4	COST
7.1	INTERCONNECTION IN JUBAIL 2 380/230 KV SUBSTATION					
7.1.1	Expansion Jubail 2 380/230 kV with two (2) existing non-energized bays	1.995.000,00 SAR	0,00 SAR	0,00 SAR	0,00 SAR	1.995.000,00 SAR
7.1.2	Expansion Jubail 2 380/230 kV with building of two (2) new bays (Optional)	3.685.900,00 SAR	0,00 SAR	0,00 SAR	0,00 SAR	3.685.900,00 SAR
7.2	INTERCONNECTION IN 380 KV OVERHEAD LINE "TO NURSERY ROAD"					
7.2.1	Incoming/outgoing of the 380 kV OHL (Quadruple circuit)	91.197.111,00 SAR	0,00 SAR	0,00 SAR	0,00 SAR	91.197.111,00 SAR
SUBTOTAL CHAPTER 7:		93.192.111,00 SAR	0,00 SAR	0,00 SAR	0,00 SAR	93.192.111,00 SAR

## 9.3 Exclusions

The following equipment or facilities have not been considered for Class IV CAPEX cost estimation related to Transmission and Distribution Electrical System (T&D):

- RoW Lighting.
- Contingencies, insurance, transportation, etc.
- In Chapter 9.2.4 "380 kV Overhead Lines" of the CAPEX ESTIMATION does not take into account the earthworks of the RoW.

## 9.4 CAPEX Summary

The aggregate cost of development for Power Transmission and Distribution System supplying for Green Industrial Park of JB2S4&3 will be the following:

	PHASE 1	PHASE 2	PHASE 3	PHASE 4	TOTAL
<b>1. 380/115 KV SUBSTATIONS</b>	286.237.780,00 SAR	0,00 SAR	0,00 SAR	0,00 SAR	<b>286.237.780,00 SAR</b>
<b>2. 115/34.5 KV SUBSTATIONS</b>	80.080.600,00 SAR	225.075.600,00 SAR	114.816.700,00 SAR	109.160.500,00 SAR	<b>529.133.400,00 SAR</b>
<b>3. 34.5/0.4 KV SUBSTATIONS</b>	9.776.000,00 SAR	5.980.000,00 SAR	9.724.000,00 SAR	2.002.000,00 SAR	<b>27.482.000,00 SAR</b>
<b>4. 380 KV OVERHEAD LINES</b>	260.880.261,00 SAR	0,00 SAR	0,00 SAR	0,00 SAR	<b>260.880.261,00 SAR</b>
<b>5. 115 KV UNDERGROUND LINES</b>	313.090.859,52 SAR	856.586.884,32 SAR	392.581.779,84 SAR	401.062.479,84 SAR	<b>1.963.322.003,52 SAR</b>
<b>6. 380 KV EXPANSION OF EXISTING SUBSTATIONS</b>	280.000,00 SAR	0,00 SAR	0,00 SAR	0,00 SAR	<b>280.000,00 SAR</b>
<b>TOTAL T&amp;D NETWORKS</b>	<b>950.345.500,52 SAR</b>	<b>1.087.642.484,32 SAR</b>	<b>517.122.479,84 SAR</b>	<b>512.224.979,84 SAR</b>	<b>3.067.335.444,52 SAR</b>

## 10 CONCLUSION AND RECOMMENDATIONS

The aim of this section is to collect and summarize the analysis of the Transmission and Distribution System in the JB2S4&3 Green Industrial Park, and the most important conclusions included in all previous sections developed during the T&D System Design, and finally indicate the recommendations to be considered in this stage and specially in next stages.

### 10.1 Summary of the main information

The main information considered in the design of The Transmission and Distribution System (T&D) of JB2S4&3 is included below:

- The Transmission and Distribution System of JB2S4&3 has been designed according with the Future Load Demands. The Future Load Demand is according with the section “4.3.1 Future Demand Load of the Green Industrial Park”.
- The T&D System will be a robust and reliable electrical system.
- The Green Industrial Park of JB2S4&3 will be supplied with electrical power from the External Network and with additional Generation Power Plants (Combined Cycle Power Plant and PV Power Plant) within the Green Industrial Park, in order to supply a substantial portion of the projected load demand.
- As it is indicated previously, in JB2S4&3 is planned to install approx. 2,000 MW in Generation Power Plant (Combined Cycle Power Plant), and it means that can generate and evacuate electrical power to 380 kV Network and can be a reinforcement of the External 380 kV Network.
- In addition, in JB2S4&3 is planned to install approx. 1,250 MW in PV Plants which will provide the necessary power for the Electrolytic Hydrogen Production and these PV Plants will be connected in Transmission System of JB2S4&3 and therefore in the External 380 kV Network.
- The T&D System for JB2S4&3 is based in the supply and distribution of electrical power at 380 kV, 115 kV and 34,5 kV from several Substations, in order to satisfy the load demand of the Green Industrial Park.
- The 380 kV Substations of JB2S4&3 will be fully integrated into the External Network.
- The proposal T&D System in JB2S4&3 and the location for Substations, has been made based on the Industries Utilities Demand and Generation Power Plants.
- The criteria for determining of the maximum allowable individual load that can be connected at each voltage level is included below in a Table with the voltage connection philosophy.

Category of Industrial User	Power Demand	Supply Voltage (kV)
Primary	> 100 MVA	380

Category of Industrial User	Power Demand	Supply Voltage (kV)
Secondary	25 – 100 MVA	115
Tertiary	< 25 MVA	34,5

- As it is indicated in above Table, the Primary Industrial will be fed from the 380 / 115 kV Substation. The Secondary Industries and Infrastructure Facilities will be fed from the nearest 115 / 34,5 kV Substation. Support Industries and Infrastructure requiring an LV supply at 380 / 220 V will also be derived from the 34,5 / 0.4 kV Substations.
- The Electrical Transmission and Distribution System to be developed for the Industrial Area JB2S4&3 will include the following systems:
  - 380 kV Overhead Lines for connection of new electrical installation in JB2S4&3 with External 380 kV Network.
  - 380 / 115 kV Substations.
  - 115 kV Underground Lines for connection of the 380 / 115 kV Substations with 115 / 34,5 kV Substation.
  - 115 / 34,5 kV Substation for secondary distribution.
  - 34,5 / 0.4 kV Substation for final distribution to auxiliary demands.

## 10.2 Conclusions

The conclusions obtained during the T&D System design are included below:

- The Transmission and Distribution System of JB2S4&3 has been designed according with the Future Load Demands “4.3.1 Future Demand Load of the Green Industrial Park”. This Estimated Load Demands must be reviewed during the next stage (FEED) according with the Final Load Demands.
- The Green Industrial Park of JB2S4&3 shall be connected with electrical power from the External Network and supplied with additional Generation Power Plants (Combined Cycle Power Plant), approx. 2,052 MW. This will allow that the Green Industrial Park of JB2S4&3 to be supplied internally, and in some times of low demand, the energy generated for the Generation Power Plants can be evacuated to the External 380 kV Network.
- The 380 kV Substations of JB2S4&3 will be fully integrated into the External 380 kV Network and interconnected with Jubail 1 and Jubail 2 in the Jubail 2 380 / 230 kV Substation.
- In addition, the 380 / 115 kV Substations will be connected in a ring, and they shall be fed at least with a minimum of two (2) circuits of the 380 kV Overhead Transmission Lines. Each circuit shall be connected in separate busbars in the

Substations, in order to provide the level of security/redundancy required. Therefore, if one section of the ring is lost, then the power will be supplied from other section thus providing total 100% redundancy.

- The voltage level of the Transmission Network must be 380 kV to be able to transport more rated power between the Transmission Substations. As can be checked in the section "7.2 Load Flow Assessment", in order to transport a capacity of 2,000 MW (Estimated Load Demands) is necessary to have a voltage level of 380 kV. A voltage level of 230 kV would be insufficient for the design of Substations and Overhead Lines.
- The 380 kV Overhead Transmission Lines will all be double circuit configuration and shall design with a nominal thermal rating of 1,600 MVA per circuit, in order to evacuate all electrical power obtained in the Generation Power Plant.
- In addition, the 115 / 34,5 kV Substations will be connected in a ring, and they will be fed with two (2) 115 kV Underground Lines from the 380 / 115 kV Substations. Therefore, the 115 kV Distribution Network of JB2S4&3 will be a robust and reliable electrical system.
- In order to have high reliability and availability, is recommended that the 115 / 34,5 kV Substations will have a configuration with double busbar configuration in 115 kV and two (2) half-busbars configuration in 34,5 kV Systems. In the case of a failure of one of the busbars systems, the 115 kV System can continue operating with the other half-busbars system.
- The 115 / 34,5 kV Substations will be located as near as possible to the consumers to be fed in order to minimise the connection lengths.
- The T&D System for JB2S4&3 is based in the supply and distribution of electrical power at 380 kV, 115 kV and 34,5 kV from several Substations.
- As it is indicated in the Table of "Category of Industrial User" included in seccion 2, the Primary Industrial will be fed from the 380 / 115 kV Substation. The Secondary Industries and Infrastructure Facilities will be fed from the nearest 115 / 34,5 kV Substation. Support Industries and Infrastructure requiring an LV supply at 380 / 220 V will also be derived from the 34,5 / 0,4 kV Substations.
- The general characteristics of the Transmission and Distribution Systems will be according to 01-TMSS-01 with the main characteristics indicated in the sections developed in T&D System.
- Finally, 34,5 / 0.4 kV Substation will be fed from the nearest 115 / 34,5 kV Substations through 34,5 kV underground cables.
- The design of 34,5 / 0.4 kV Substations shall be strictly in accordance with External Standards.
- Underground cables will be used for the connection of 115 kV and 34,5 kV, in order to minimize the 380 kV Overhead Lines inside if JB2S4&3.

## 10.3 Recommendations

In this section, are included all the recommendations indicated in the design of The Transmission and Distribution System of JB2S4&3:

- The proposed Future 380 kV Network in JB2S4&3 and interconnection with External 380 kV Network shall be coordinated and agreed with the owner of the External Network for concurrence as existing Substations. All considerations from the owner must be considered during the next stage (FEED).
- In addition, to the interconnection in Jubail 2 380 / 230 kV Substation, was recommended that the 380 kV System of JB2S4&3 will be interconnected in a second interconnection with the External 380 kV System to obtain a reliable and robust electrical system. For this purpose, the 380 kV System of J2S4&3 will be connected to the 380 kV Overhead Line "To Nursery Road" that runs close to JB2S4&3.
- The Generation Power Plants shall be located as near as possible of the 380 / 115 kV Substations. For this reason, the 380 / 115 kV Substations Jubail 3-S/S-2 and Jubail 3-S/S-3 have been located in the same plot than Generation Power Plants.
- All 380 / 115 kV Substations and 115 / 34,5 kV have similar configurations, and equipment and component with the similar rating in order to standardization. In addition, all equipment, busbars, transformers are redundant. The 380 / 115 kV Substations will have a configuration with one breaker a half in 380 kV System and double busbars in 115 kV System. Therefore, the T&D System of JB2S4&3 will be a robust and reliable electrical system.
- In order to have high reliability and availability, is recommended that the 380 / 115 kV Substations will have a configuration with one breaker a half in 380 kV System and double busbars in 115 kV System. In the case of a failure of one of the busbars systems, the 380 kV System can continue to operate with the other busbars system.
- Also is recommended that as far as possible, all 380 / 115 kV Substations and 115 / 34,5 kV have the similar configurations, and equipment and component with the similar rating in order to standardization.

In addition, according with the conclusions obtained from the section "8.2 Load Flow Assessment", if during the Engineering Stage the Load Demand of the Green Industrial Park of JB2S4&3 are equal or higher than Estimated Load Demand could be necessary the reinforcement of some equipment, as the followings:

- 380 kV Busbars of the 380 / 115 kV Substations of 4,000 A. This is mainly due to the fact that in case of failure in one 380 kV Busbar, it is necessary to evacuate all the power of the Generation Power Plants through only one 380 kV Busbar.
- In case of unavailability of one of the redundant transformers, in such cases where the rated power of the transformers exceeds 130% overload, it is recommended to

consider transformers with a rated power higher than the standard rated power or to install two (2) sets of power transformers.

## 11 FUTURE PROSPECTS

The transition towards a more sustainable energy matrix and the need to improve the efficiency and reliability of the power system within the Green Industrial Park are key challenges in the current and future scenario. In this context, it is proposed the implementation of microgrids, demand response and energy storage systems as innovative solutions that can improve the existing infrastructure of a 380 kV and 115 kV power grid.

The integration of energy storage systems is an exciting and promising future field of work in the electric transmission and distribution sector. With the increase in power generation from intermittent renewable sources, such as solar and wind power, greater operational flexibility is required to balance supply and demand. Energy storage systems, such as large-scale batteries, play a crucial role by storing excess power generated during periods of low demand and supplying it when demand is high. This not only helps improve power system stability, but also reduces congestion on transmission lines, minimizes energy losses, and enables greater penetration of renewables into the grid by optimizing their location and capacity to maximize benefits to the power system.

Demand response and optimization is another important area. Electricity demand varies throughout the day and at different times of the year. Demand response involves adjusting the energy consumption of end users to balance the load and avoid demand peaks that could overload the system. By implementing real-time monitoring technologies, building automation systems, and two-way communication with consumers, it is possible to manage and optimize electricity demand more efficiently. This involves strategies such as flexible tariffs that encourage consumers to reduce their consumption during peak demand periods or demand response programs that allow consumers to adjust their consumption based on price signals or system stability indicators. In addition, the implementation of advanced building energy management systems and distributed control systems can help optimize energy use in real time. It is important to coordinate and regulate energy demand from end consumers, which could help reduce energy costs, improve efficiency and minimize environmental impact.

The implementation of smart grids is another important future field of work. Smart grids use information and communications technologies to optimize the operation and performance of the electricity system. This involves the deployment of smart meters that collect detailed data on energy consumption, advanced monitoring and control systems that enable real-time management, data analysis for demand forecasting, and the integration of distributed energy sources, such as small-scale solar and wind generation. Smart grids enable greater interaction between the different players in the electricity system, such as generators, distribution networks and end consumers, facilitating more efficient energy management and greater reliability of supply. Advanced communication infrastructures and systems, data management algorithms and analysis tools will be needed to optimize energy efficiency, improve supply reliability and facilitate the integration of distributed energy resources into the power grid.

## 12 BIBLIOGRAPHY

- Arriaga, I. J. P., 2013. *Regulation of the Power Sector*. s.l.:s.n.
- Cossent, R., 2022. *Distribution Networks: structure, roles and fundamentals of the regulation*, Madrid: s.n.
- Csanyi, E., 2023. *Electrical Engineering Portal*. [En línea]  
Available at: <https://electrical-engineering-portal.com/electric-power-systems>
- ENDESA, 2023. *ENDESA Fundación*. [En línea]  
Available at: <https://www.fundacionendesa.org/es/educacion/endesa-educa/recursos/transporte-de-electricidad>
- Power, M. W., -. *March Wood Power*. [En línea]  
Available at: <https://www.marchwoodpower.com/ccgt/>
- Red Eléctrica de España, R., 2017. *Avance del mapa de la red de transporte: datos provisionales*. [En línea]  
Available at: [https://www.ree.es/sites/default/files/downloadable/mapa\\_lineas\\_2017\\_v1.pdf](https://www.ree.es/sites/default/files/downloadable/mapa_lineas_2017_v1.pdf)
- REE, 2023. *Negocio Eléctrico en España*. [En línea]  
Available at: <https://www.ree.es/es/conocenos/actividades-de-negocio/negocio-electrico-en-espana>
- Rivier, M., 2022. *The Transmission Activity*, Madrid: s.n.
- Saudi Electricity Company, S., 2012. *TES-P-104.01 GEneral Engineering Requirements for all U/G Cables*, s.l.: s.n.
- Saudi Electricity Company, S., 2018. *11-TMSS-02 Power Cable XLPE Insulated Copper Conductor Single Core*, s.l.: s.n.
- Saudi Electricity Company, S., 2006. *01-TMSS-01 General Requirements for All Equipment / Materials*, s.l.: s.n.
- Saudi Electricity Company, S., 2009. *10-TMSS-01 Bare Conductors*, s.l.: s.n.
- Saudi Electricity Company, S., 2013. *10-TMSS-06 Conductor, Bare, Overhead Line (Heat-Resistant, Alluminum Alloy)*, s.l.: s.n.
- Saudi Electricity Company, S., 2013. *TES-P-119.02 Basic Design Aspects*, s.l.: s.n.
- Technology, E., -. *Electrical Technology*. [En línea]  
Available at: <https://www.electricaltechnology.org/2021/07/solar-power-plant.html>

## **ANNEX I: FUTURE LOAD DEMANDS**

Item No	Parcel	Parcel Area (Ha)	Industry type (Functional Groups)	Industrial type (Description)	Total Electricity / Functional group (MW)	Power (MVA)			Substation Feed	Rated Voltage (kV)	Current (A)	Ratio (kVA/ha)				
						380 kV (>100 MVA)	115 kV (100-25 MVA)	34.5 kV (<25 MVA)								
1	13	340	Basic Petchem	Ethylene cracking (based on Liquid feedstocks)	81.0	45.0	22.2	JUBAIL 3-S/S-1-1 115/34.5 kV	115	225.92	132.35					
	14	295		Ethylene Oxide Unit				JUBAIL 3-S/S-1-1 115/34.5 kV	115	225.92	152.54					
2	18	240	Secondary Petrochemical	Acrylo Nitrile Butadiene Styrene Rubber	100.0	45.0	22.2	JUBAIL 3-S/S-2-3 115/34.5 kV	34.5	371.88	92.59					
				Adhesives				JUBAIL 3-S/S-2-3 115/34.5 kV	34.5	185.94	46.30					
				Alkyl Chloride				JUBAIL 3-S/S-2-3 115/34.5 kV	34.5	92.97	23.15					
				Bi axially Oriented Poly Propylene (BOPP)				JUBAIL 3-S/S-2-3 115/34.5 kV	34.5	92.97	23.15					
				Butadiene				JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	92.97	24.69					
				Butyl Acrylate				JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	92.97	24.69					
	Butyl Glcol Ether (MGBE)	JUBAIL 3-S/S-2-1 115/34.5 kV		34.5				92.97	24.69							
	Carbon Black	JUBAIL 3-S/S-2-1 115/34.5 kV		34.5				92.97	24.69							
	Epichlorohydrin (ECH)	JUBAIL 3-S/S-2-1 115/34.5 kV		34.5				92.97	24.69							
	Epoxy Resin (Liquid)	JUBAIL 3-S/S-2-1 115/34.5 kV		34.5				92.97	24.69							
	Ethanol Amine	JUBAIL 3-S/S-2-3 115/34.5 kV		34.5				92.97	28.49							
	Ethoxylates 3EO	JUBAIL 3-S/S-2-3 115/34.5 kV		34.5				92.97	28.49							
	Expanded PolyStyrene	JUBAIL 3-S/S-2-3 115/34.5 kV		34.5				92.97	28.49							
	Flexible Film Packaging (food grade film)	JUBAIL 3-S/S-2-3 115/34.5 kV		34.5				92.97	28.49							
	Gamma Butiro Lactone (GBL) / Normal Methyl Pyrrolidone (NMP)	JUBAIL 3-S/S-2-3 115/34.5 kV		34.5				92.97	28.49							
	Propylene Oxidation for Acrylic Acid	JUBAIL 3-S/S-2-3 115/34.5 kV		34.5				92.97	28.49							
	Polymerization Units Group	JUBAIL 3-S/S-2-2 115/34.5 kV		34.5				371.88	130.72							
	3	15		170				Derivate Petrochemical	HDPE/LDPE	94.0	45.0	22.2	JUBAIL 3-S/S-2-2 115/34.5 kV	34.5	278.91	98.04
Poly Butadiene Rubber (PBR)			JUBAIL 3-S/S-2-2 115/34.5 kV		34.5	185.94	65.36									
Poly Butylene Terephthalate (PBT)			JUBAIL 3-S/S-2-2 115/34.5 kV		34.5	92.97	32.68									
Poly Methyl Metha crylate (PMMA)			JUBAIL 3-S/S-2-2 115/34.5 kV		34.5	92.97	32.68									
Poly Oxymethylene (POM)			JUBAIL 3-S/S-2-2 115/34.5 kV		34.5	92.97	32.68									
Polyamide 6,6 (Nylon 6,6)			JUBAIL 3-S/S-2-2 115/34.5 kV		34.5	92.97	21.79									
Polyurethane (UPR)		JUBAIL 3-S/S-2-2 115/34.5 kV	34.5	92.97	21.79											
Styrene Butadiene Rubber Emulsion (SBR Emulsion)		JUBAIL 3-S/S-2-2 115/34.5 kV	34.5	92.97	21.79											
Super Absorbent Polymer (SAP)		JUBAIL 3-S/S-2-2 115/34.5 kV	34.5	92.97	21.79											
Thermoplastic Vulcanizate (TPV)		JUBAIL 3-S/S-2-2 115/34.5 kV	34.5	92.97	21.79											
Special High resistance Plastics(HRP) Unit		JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	92.97	21.79											
Propionic Acid		JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	74.38	17.43											
4		17	100	Factories	Factory 1	40.0	45.0		11.1				JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	185.94	111.11
					Factory 2								JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	185.94	111.11
					Factory 3								JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	185.94	111.11
					Factory 4								JUBAIL 3-S/S-2-1 115/34.5 kV	34.5	185.94	111.11
5		11	370	Green Fuels N° 2	Electrolytic Hydrogen Production (1)	1,270.0	1,400.0		11.1				JUBAIL 3-S/S-1 380/115 kV	380	2,127.08	3,783.78
					Green Ammonia								JUBAIL 3-S/S-1-1 115/34.5 kV	34.5	185.94	30.03
	HVO: EcoDiesel & Bio - kerosene (SAF) Unit				JUBAIL 3-S/S-1-1 115/34.5 kV			115		139.46	81.70					
	Biodiesel Unit				JUBAIL 3-S/S-1-1 115/34.5 kV			34.5		278.91	49.02					
	Pyrolysis Oil from Waste Unit				JUBAIL 3-S/S-1-1 115/34.5 kV			34.5		185.94	32.68					
	EcoMethanol from Green Hydrogen and CO2				JUBAIL 3-S/S-1-1 115/34.5 kV			34.5		148.75	26.14					
	12	340	Green Fuels N° 1	Carbon Capture Units	63.0	45.0	5.6	JUBAIL 3-S/S-1-1 115/34.5 kV	34.5	92.97	16.34					
				Inorganic Chemical Industrial 1				JUBAIL 2 S/S-5	115	167.35	61.73					
				Inorganic Chemical Industrial 2				JUBAIL 2 S/S-5	115	167.35	61.73					
				Inorganic Chemical Industrial 3				JUBAIL 2 S/S-6	34.5	278.91	30.86					
				Inorganic Chemical Industrial 4				JUBAIL 2 S/S-5	34.5	278.91	30.86					
				Inorganic Chemical Industrial 5				JUBAIL 2 S/S-5	34.5	185.94	20.58					
6	4	540	Inorganic Chemicals	Inorganic Chemical Industrial 6	288.0	45.0	11.1	JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 7				JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 8				JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 9				JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 10				JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 11				JUBAIL 2 S/S-5	34.5	223.13	24.69					
				Inorganic Chemical Industrial 12				JUBAIL 2 S/S-5	34.5	334.70	37.04					
				Inorganic Chemical Industrial 13				JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 14				JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 15				JUBAIL 2 S/S-5	34.5	185.94	20.58					
				Inorganic Chemical Industrial 16				JUBAIL 2 S/S-6	34.5	185.94	20.58					
				Inorganic Chemical Industrial 17				JUBAIL 2 S/S-6	34.5	185.94	20.58					
				Inorganic Chemical Industrial 18				JUBAIL 2 S/S-6	34.5	185.94	20.58					
				Inorganic Chemical Industrial 19				JUBAIL 2 S/S-6	34.5	185.94	20.58					
				Inorganic Chemical Industrial 20				JUBAIL 2 S/S-6	34.5	185.94	20.58					
				Inorganic Chemical Industrial 21				JUBAIL 2 S/S-6	34.5	148.75	16.46					
				Inorganic Chemical Industrial 22				JUBAIL 2 S/S-6	34.5	92.97	10.29					
				Inorganic Chemical Industrial 23				JUBAIL 2 S/S-6	34.5	92.97	10.29					
				Inorganic Chemical Industrial 24				JUBAIL 2 S/S-6	34.5	92.97	10.29					
				Inorganic Chemical Industrial 25				JUBAIL 2 S/S-6	34.5	92.97	10.29					
7	5	230	Utilities Area	Storage Park	35.0	33.3	5.6	JUBAIL 2 S/S-6	34.5	92.97	24.15					
	6	170		Utilities Park				JUBAIL 2 S/S-6	115	167.35	196.08					
8	7	165	Waste Management	Waste Management 1	10.0	5.6	5.6	JUBAIL 3-S/S-1-1 115/34.5 kV	34.5	92.97	33.67					
	8	135		Waste Management 2				JUBAIL 3-S/S-1-1 115/34.5 kV	34.5	92.97	41.15					
	1	140		Storm Water Holding Ponds (existing)				JUBAIL 2 S/S-5	34.5	37.19	15.87					
9	46	375	Storm Water Holding Ponds	Storm Water Holding Ponds	6.0	2.2	2.2	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	37.19	5.93					
	23	245		Storm Water Holding Ponds				JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	37.19	9.07					
10	2	215	Other Tertiary Industries	Vehicle Factory 1	1,000.0	55.6	55.6	JUBAIL 2 S/S-5	115	278.91	258.40					
	3	150		Vehicle Factory 2				JUBAIL 2 S/S-6	115	278.91	370.37					
	28	430		Dynamic/Innovation Industrial 1-1				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-2				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-3				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-4				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-5				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-6				JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-7				JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-8				JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-9				JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	185.94	25.84					
				Dynamic/Innovation Industrial 1-10				JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	185.94	25.84					
	30	350		Dynamic/Innovation Industrial 2-1				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	185.94	31.75					
				Dynamic/Innovation Industrial 2-2				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	185.94	31.75					
				Dynamic/Innovation Industrial 2-3				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	92.97	15.87					
				Dynamic/Innovation Industrial 2-4				JUBAIL 3-S/S-3-3 115/34.5 kV	34.5	92.97	15.87					
				Regional Park 1				JUBAIL 3-S/S-4-7 115/34.5 kV	34.5	241.72	-					
				Regional Park 2				JUBAIL 3-S/S-4-7 115/34.5 kV	34.5	241.72	-					
				Regional Park 3				JUBAIL 3-S/S-4-7 115/34.5 kV	34.5	241.72	-					
				Regional Park 4				JUBAIL 3-S/S-4-7 115/34.5 kV	34.5	241.72	-					
				Regional Park 5				JUBAIL 3-S/S-4-7 115/34.5 kV	34.5	241.72	-					
				Regional Park 6				JUBAIL 3-S/S-4-7 115/34.5 kV	34.5	241.72	-					
	36	770		Regional Park 7				JUBAIL 3-S/S-4-1 115/34.5 kV	34.5	241.72	-					
				Regional Park 8				JUBAIL 3-S/S-4-1 115/34.5 kV	34.5	241.72	-					
				Regional Park 9				JUBAIL 3-S/S-4-1 115/34.5 kV	34.5	241.72	-					
				Regional Park 10				JUBAIL 3-S/S-4-1 115/34.5 kV	34.5	241.72	-					
				Bio-Life Industrial 1				JUBAIL 3-S/S-4-1 115/34.5 kV	115	167.35	144.93					
				Bio-Life Industrial 2				JUBAIL 3-S/S-4-1 115/34.5 kV	115	167.35	81.30					
				Bio-Life Industrial 3				JUBAIL 3-S/S-4-1 115/34.5 kV	115	167.35	49.38					
				Bio-Life Industrial 4				JUBAIL 3-S/S-4-1 115/34.5 kV	115	167.35	303.03					
Bio-Life Industrial 5			JUBAIL 3-S/S-4-1 115/34.5 kV	115	167.35	303.03										
Connectivity 1-1			JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
38	425	Connectivity 1-2	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-3	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-4	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-5	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-6	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-7	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-8	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-9	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-10	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-11	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-12	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-13	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-14	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 1-15	JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	7.22										
		Connectivity 2-1	JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	92.97	13.07										
Connectivity 2-2	JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	92.97	13.07												
Connectivity 2-3	JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	92.97	13.07												
Connectivity 2-4	JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	92.97	13.07												
Connectivity 2-5	JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	92.97	13.07												

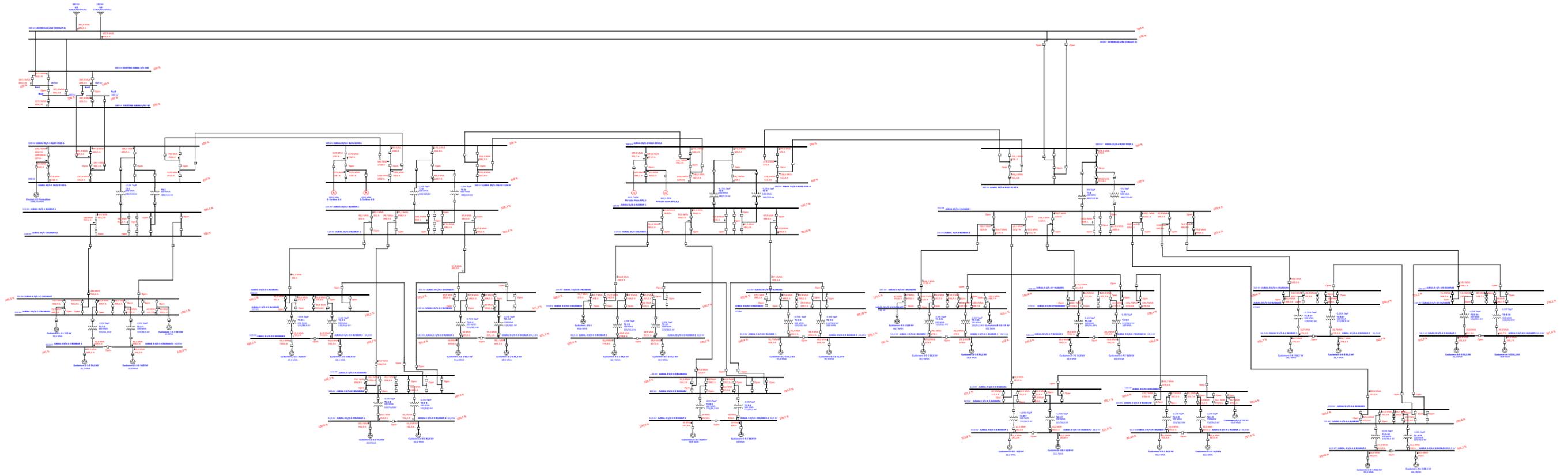
Item No	Parcel	Parcel Area (Ha)	Industry type (Functional Groups)	Industrial type (Description)	Total Electricity / Functional group (MW)	Power (MVA)			Substation Feed	Rated Voltage (kV)	Current (A)	Ratio (KVA/ha)
						380 kV (>100 MVA)	115 kV (100-25 MVA)	34.5 kV (<25 MVA)				
37	495	735	Other Tertiary Industries	Connectivity 2-6	1,000.0	5.6		JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	92.97	13.07	
				Connectivity 2-7		5.6		JUBAIL 3-S/S-3-2 115/34.5 kV	34.5	92.97	13.07	
				Connectivity 2-8		5.6		JUBAIL 3-S/S-3-1 115/34.5 kV	34.5	92.97	13.07	
				Defense 1		55.6		JUBAIL 3-S/S-3-1 115/34.5 kV	115	278.91	112.23	
				Defense 2-1		11.1		JUBAIL 3-S/S-4-2 115/34.5 kV	34.5	185.94	15.12	
				Defense 2-2		11.1		JUBAIL 3-S/S-4-2 115/34.5 kV	34.5	185.94	15.12	
				Defense 2-3		11.1		JUBAIL 3-S/S-4-2 115/34.5 kV	34.5	185.94	15.12	
				Defense 2-4		11.1		JUBAIL 3-S/S-4-2 115/34.5 kV	34.5	185.94	15.12	
				Defense 2-5		11.1		JUBAIL 3-S/S-4-2 115/34.5 kV	34.5	185.94	15.12	
				Assembly		22.2		JUBAIL 3-S/S-4-2 115/34.5 kV	34.5	371.88	43.57	
				Defense 3		55.6		JUBAIL 3-S/S-4-2 115/34.5 kV	115	278.91	106.84	
				Movement & Travel 1-1		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	13.63	
				Movement & Travel 1-2		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	13.63	
				Movement & Travel 1-3		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	13.63	
				Movement & Travel 1-4		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	13.63	
				Movement & Travel 1-5		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	13.63	
				Movement & Travel 2		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	55.56	
				Movement & Travel 3-1		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	28.13	
				Movement & Travel 3-2		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	28.13	
				Movement & Travel 3-3		11.1		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	185.94	28.13	
				Movement & Travel 4-1		11.1		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	185.94	19.32	
				Movement & Travel 4-2		11.1		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	185.94	19.32	
				Movement & Travel 4-3		11.1		JUBAIL 3-S/S-4-6 115/34.5 kV	34.5	185.94	19.32	
				Movement & Travel 4-4		11.1		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	185.94	19.32	
				Future Specialities 1-1		5.6		JUBAIL 3-S/S-4-3 115/34.5 kV	34.5	92.97	9.66	
				Future Specialities 1-2		5.6		JUBAIL 3-S/S-4-3 115/34.5 kV	34.5	92.97	9.66	
				Future Specialities 1-3		5.6		JUBAIL 3-S/S-4-3 115/34.5 kV	34.5	92.97	9.66	
				Future Specialities 1-4		5.6		JUBAIL 3-S/S-4-3 115/34.5 kV	34.5	92.97	9.66	
				Future Specialities 2-1		5.6		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	92.97	9.03	
				Future Specialities 2-2		5.6		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	92.97	9.03	
				Future Specialities 2-3		5.6		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	92.97	9.03	
				Future Specialities 2-4		5.6		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	92.97	9.03	
				Future Specialities 2-5		5.6		JUBAIL 3-S/S-4-5 115/34.5 kV	34.5	92.97	9.03	
				Future Specialities 3-1		5.6		JUBAIL 3-S/S-4-4 115/34.5 kV	34.5	92.97	7.88	
				Future Specialities 3-2		5.6		JUBAIL 3-S/S-4-4 115/34.5 kV	34.5	92.97	7.88	
				Future Specialities 3-3		5.6		JUBAIL 3-S/S-4-4 115/34.5 kV	34.5	92.97	7.88	
				Future Specialities 3-4		5.6		JUBAIL 3-S/S-4-4 115/34.5 kV	34.5	92.97	7.88	
Future Specialities 3-5	5.6		JUBAIL 3-S/S-4-4 115/34.5 kV	34.5	92.97	7.88						
Future Specialities 3-6	5.6		JUBAIL 3-S/S-4-4 115/34.5 kV	34.5	92.97	7.88						
11	21	50	Power Generation (CCPP)	GT Turbine 1	2,052	184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				GT Turbine 2		184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				GT Turbine 3		184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				GT Turbine 4		184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				GT Turbine 5		184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				GT Turbine 6		184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				GT Turbine 7		184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				GT Turbine 8		184.4		JUBAIL 3-S/S-2 380/115 kV	380	280.23	---	
				ST Turbine 1		402.2		JUBAIL 3-S/S-2 380/115 kV	380	611.11	---	
12	1115	155	Green Energy	ST Turbine 2	1,275	402.2		JUBAIL 3-S/S-2 380/115 kV	380	611.11	---	
				PV Solar Farm N° 1		80.3		JUBAIL 3-S/S-3 380/115 kV	380	121.98	---	
				PV Solar Farm N° 2		124.3		JUBAIL 3-S/S-3 380/115 kV	380	188.88	---	
				PV Solar Farm N° 3		349.6		JUBAIL 3-S/S-3 380/115 kV	380	531.21	---	
				PV Solar Farm N° 4		284.9		JUBAIL 3-S/S-3 380/115 kV	380	432.84	---	
				PV Solar Farm N° 5		577.5		JUBAIL 3-S/S-3 380/115 kV	380	877.49	---	

Substation	MVA Load Demand At Utilisation Voltage					
	380 kV System (MVA)		115 kV System (MVA)		34.5 kV System (MVA)	
	Busbar 1	Busbar 2	Busbar 1	Busbar 2	Busbar 1	Busbar 2
JUBAIL 3-S/S-1 380/115 kV	1,400.0	---	---	---	---	---
JUBAIL 3-S/S-1-1 115/34.5 kV	---	---	72.8	45.0	31.1	33.3
JUBAIL 2 S/S-5 115/34.5 kV	---	---	---	---	---	---
JUBAIL 2 S/S-6 115/34.5 kV	---	---	---	---	---	---
JUBAIL 3-S/S-2 380/115 kV	1,140.0	1,140.0	---	---	---	---
JUBAIL 3-S/S-2-1 115/34.5 kV	---	---	---	---	43.3	44.4
JUBAIL 3-S/S-2-2 115/34.5 kV	---	---	---	---	55.6	38.9
JUBAIL 3-S/S-2-3 115/34.5 kV	---	---	---	---	33.3	44.4
JUBAIL 3-S/S-3 380/115 kV	701.9	714.8	---	---	---	---
JUBAIL 3-S/S-3-1 115/34.5 kV	---	---	55.6	---	44.4	48.9
JUBAIL 3-S/S-3-2 115/34.5 kV	---	---	---	---	55.6	38.9
JUBAIL 3-S/S-3-3 115/34.5 kV	---	---	---	---	38.9	50.0
JUBAIL 3-S/S-4 380/115 kV	---	---	---	---	---	---
JUBAIL 3-S/S-4-1 115/34.5 kV	---	---	66.7	100.0	28.9	28.9
JUBAIL 3-S/S-4-2 115/34.5 kV	---	---	---	55.6	55.6	22.2
JUBAIL 3-S/S-4-3 115/34.5 kV	---	---	---	---	11.1	11.1
JUBAIL 3-S/S-4-4 115/34.5 kV	---	---	---	---	16.7	16.7
JUBAIL 3-S/S-4-5 115/34.5 kV	---	---	---	---	33.3	38.9
JUBAIL 3-S/S-4-6 115/34.5 kV	---	---	---	---	55.6	44.4
JUBAIL 3-S/S-4-7 115/34.5 kV	---	---	---	---	43.3	43.3

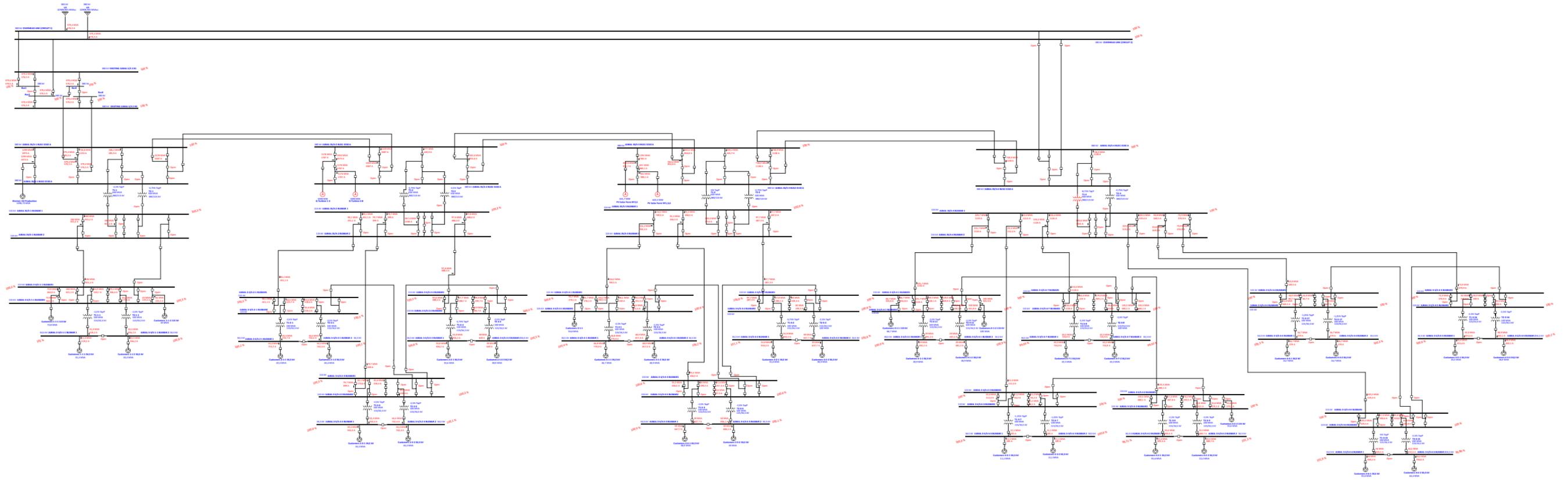
The loads of JUBAIL 2 S/S-5 115/34.5 kV and JUBAIL 2 S/S-6 115/34.5 kV have not been considered in the load flow study.

## **ANNEX II: LOAD FLOW SCENARIOS**

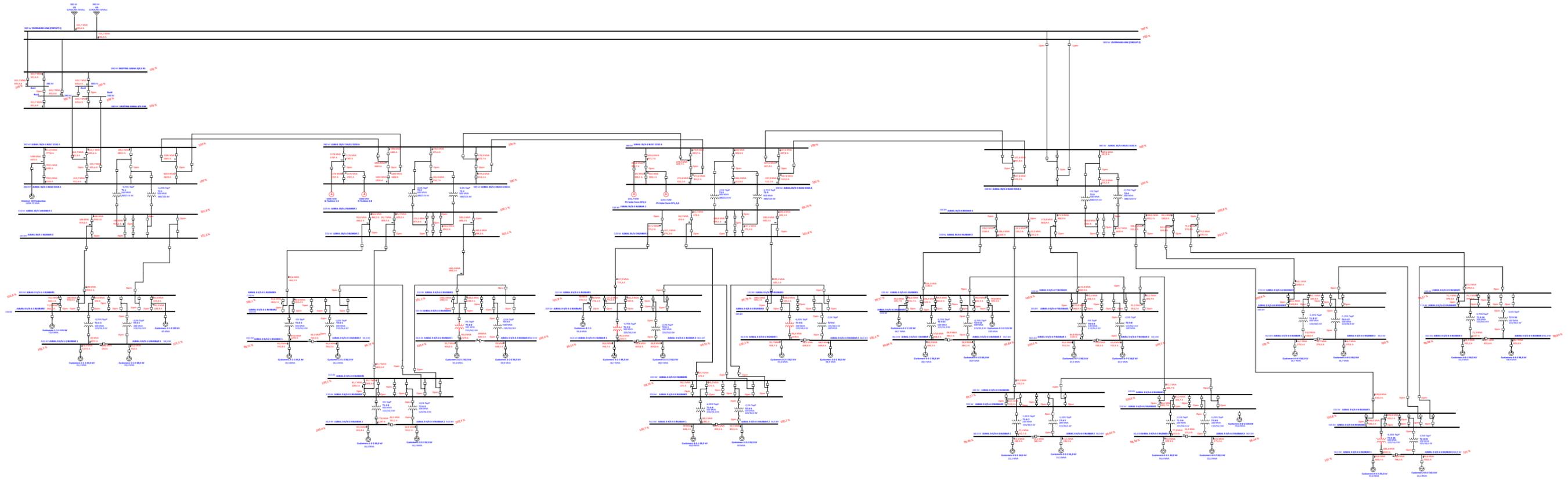
# SCENARIO 0



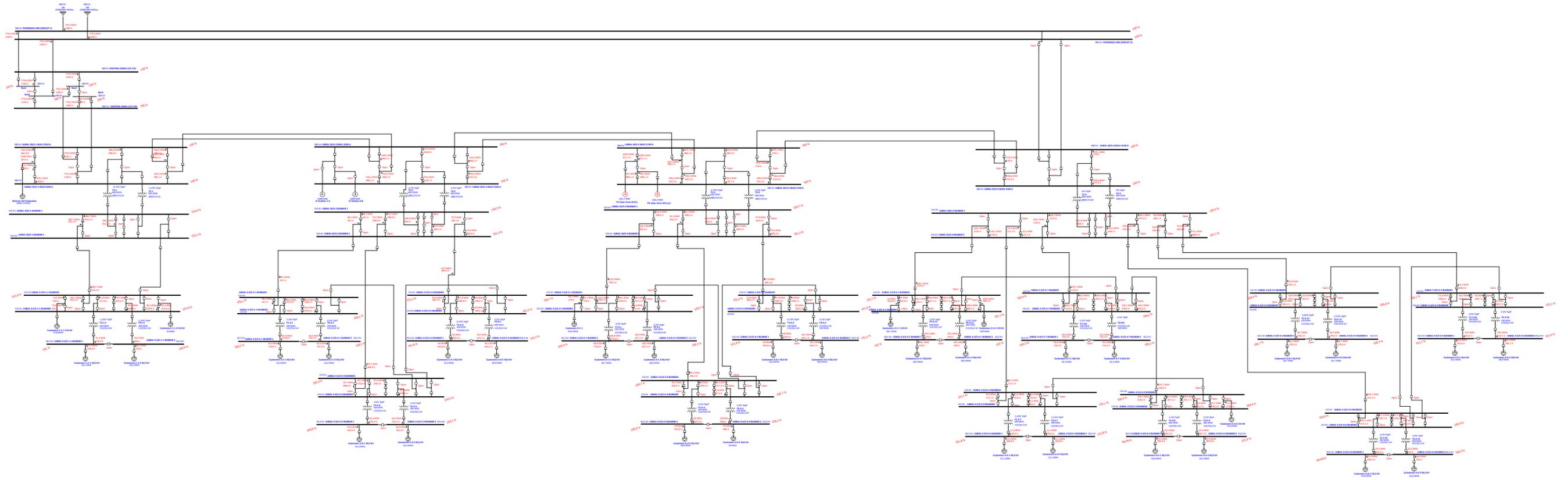
# SCENARIO 1



### SCENARIO 2

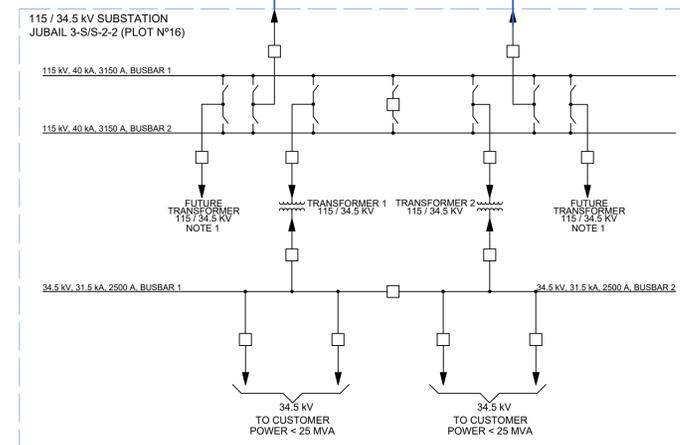
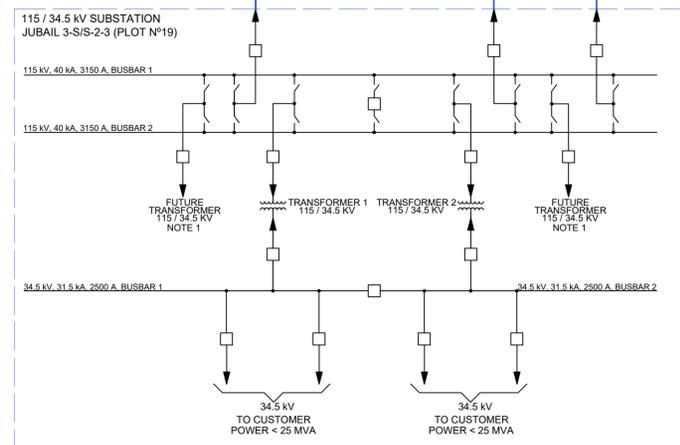
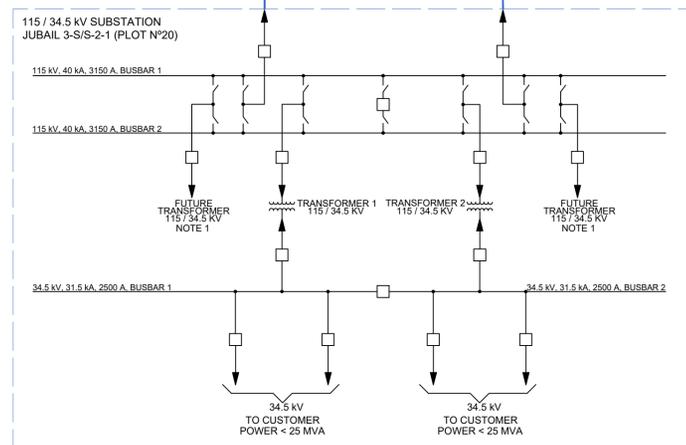
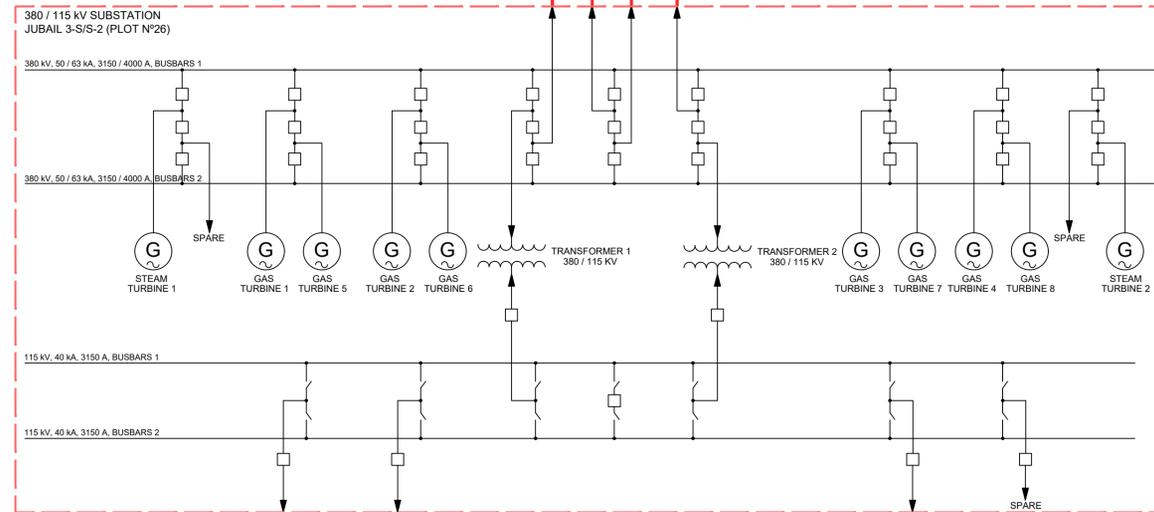
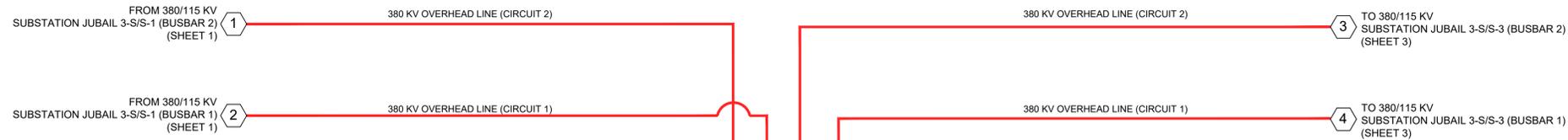


### SCENARIO 3

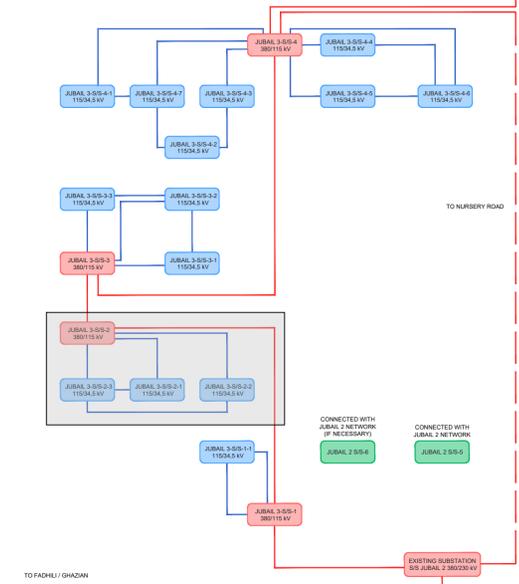


## **ANNEX III: GENERAL SINGLE LINE DIAGRAM**

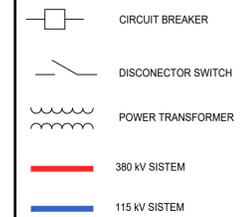




### GENERAL BLOCK DIAGRAM



### LEGEND



### NOTES

NOTE 1: IN CASE THAT FUTURE 115/34.5 KV TRANSFORMERS WILL BE INSTALLED, THESE TRANSFORMERS MUST BE CONNECTED IN A SET OF 34.5 KV CABINETS (E.G. BUSBARS 3 AND 4) EQUAL THAN 34.5 KV CABINETS (BUSBARS 1 AND 2).

### FEASIBILITY STUDY OF JUBAIL 2 (STAGE 4) AND JUBAIL 3 (PHASE 1 OF 2)

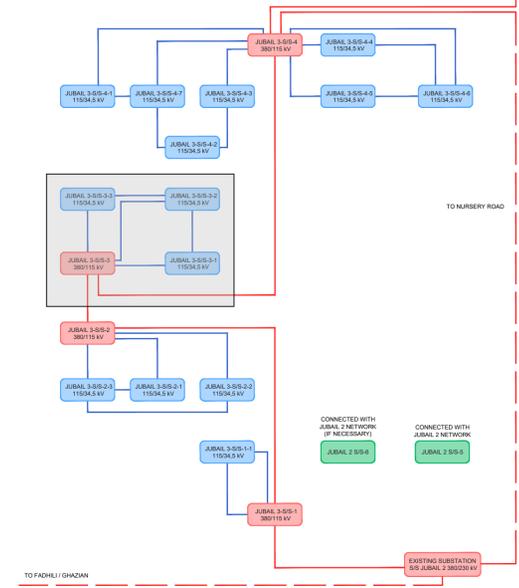
NAME: RICARDO COTARELO HERNÁNDEZ

DATE: 21/07/2023

SCALE:  
NO SCALE

DRAWING NAME:  
GENERAL SINGLE LINE DIAGRAM

### GENERAL BLOCK DIAGRAM



### LEGEND

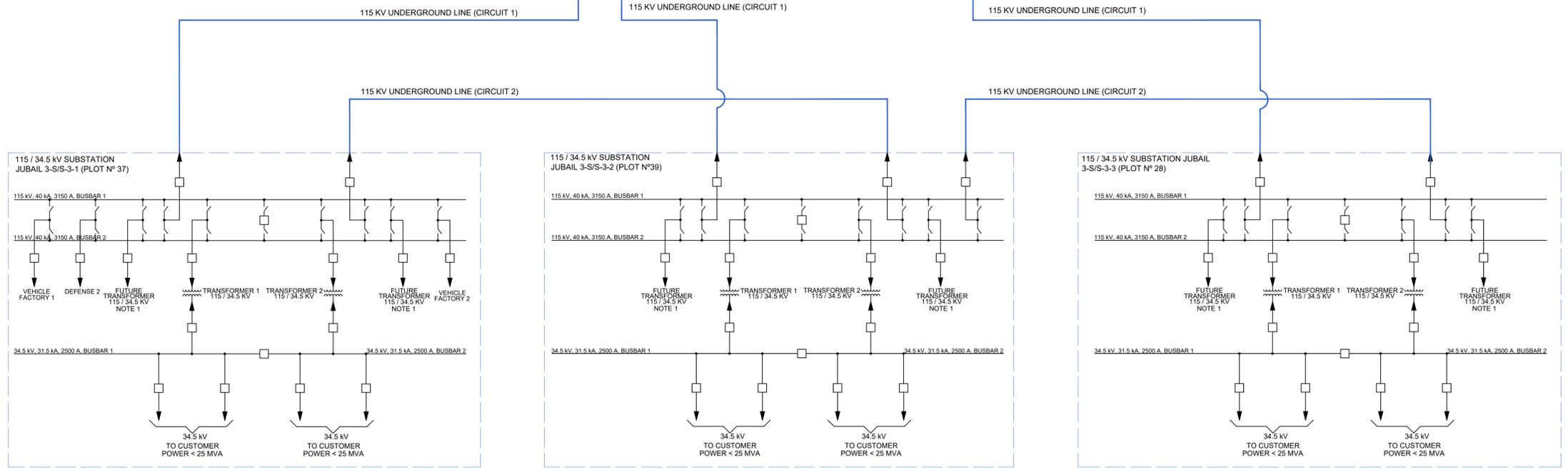
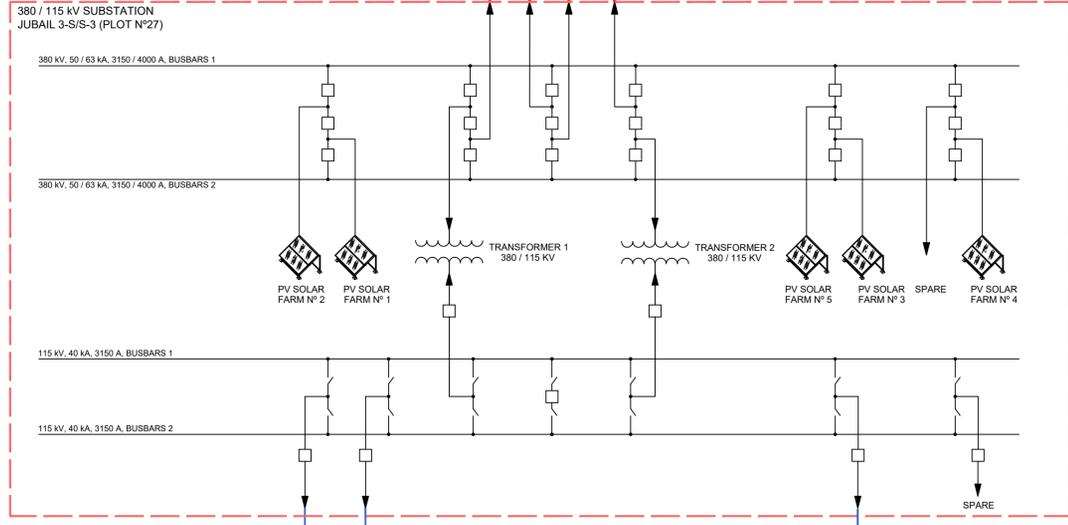
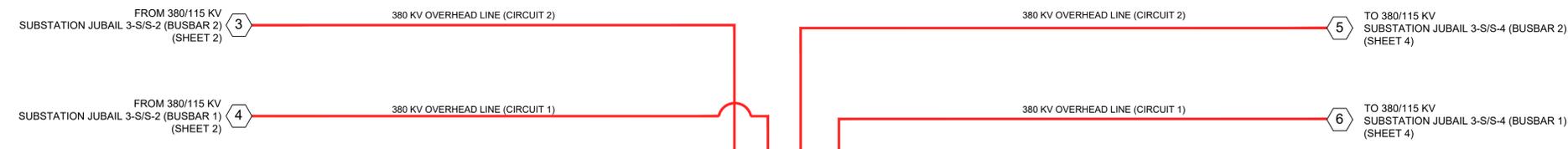
- CIRCUIT BREAKER
- DISCONNECTOR SWITCH
- POWER TRANSFORMER
- 380 kV SYSTEM
- 115 kV SYSTEM

### NOTES

NOTE 1: IN CASE THAT FUTURE 115/34.5 kV TRANSFORMERS WILL BE INSTALLED, THESE TRANSFORMERS MUST BE CONNECTED IN A SET OF 34.5 kV CABINETS (E.G. BUSBARS 3 AND 4) EQUAL THAN 34.5 kV CABINETS (BUSBARS 1 AND 2).

### FEASIBILITY STUDY OF JUBAIL 2 (STAGE 4) AND JUBAIL 3 (PHASE 1 OF 2)

NAME: RICARDO COTARELO HERNÁNDEZ	
DATE: 21/07/2023	
SCALE:	DRAWING NAME:
NO SCALE	GENERAL SINGLE LINE DIAGRAM



FROM 380/115 KV SUBSTATION JUBAIL 3-S/S-3 (BUSBAR 2) (SHEET 3) 5

FROM 380/115 KV SUBSTATION JUBAIL 3-S/S-3 (BUSBAR 1) (SHEET 3) 6

380 KV OVERHEAD LINE (CIRCUIT 2)

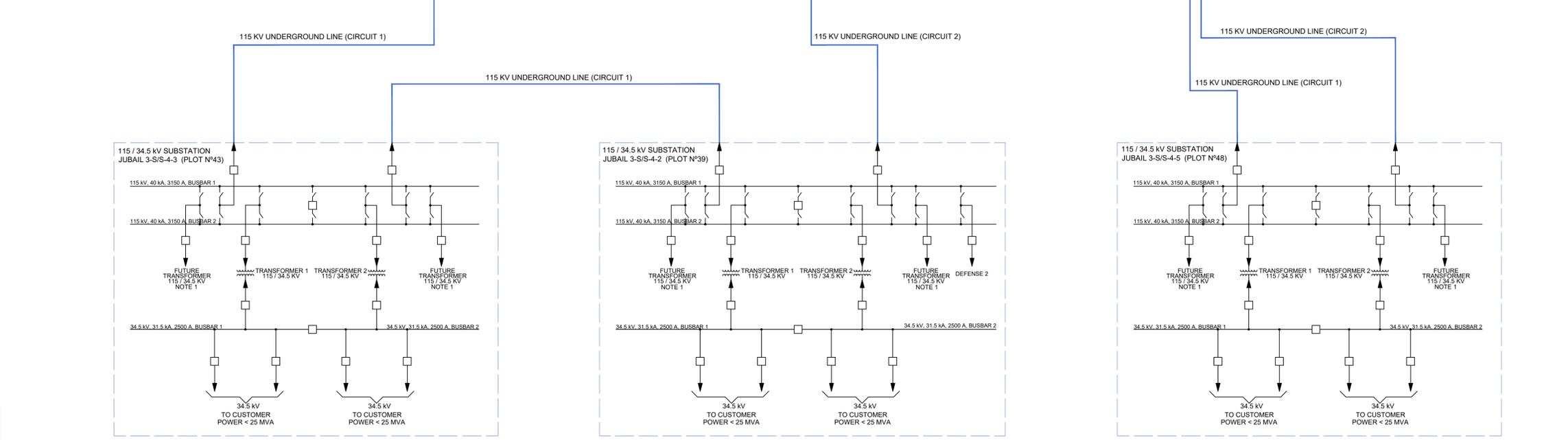
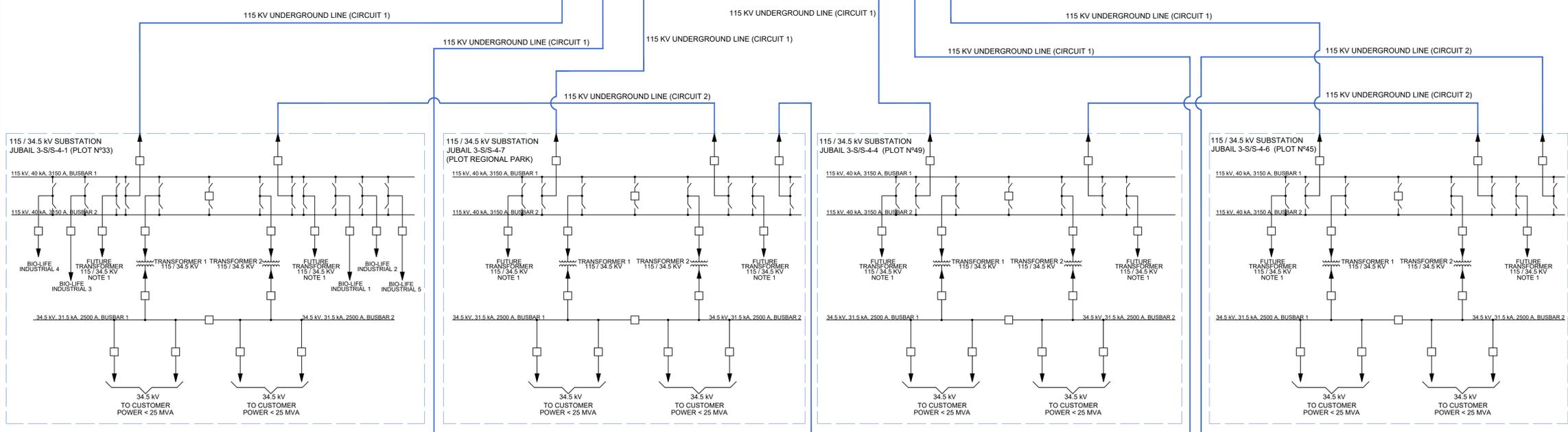
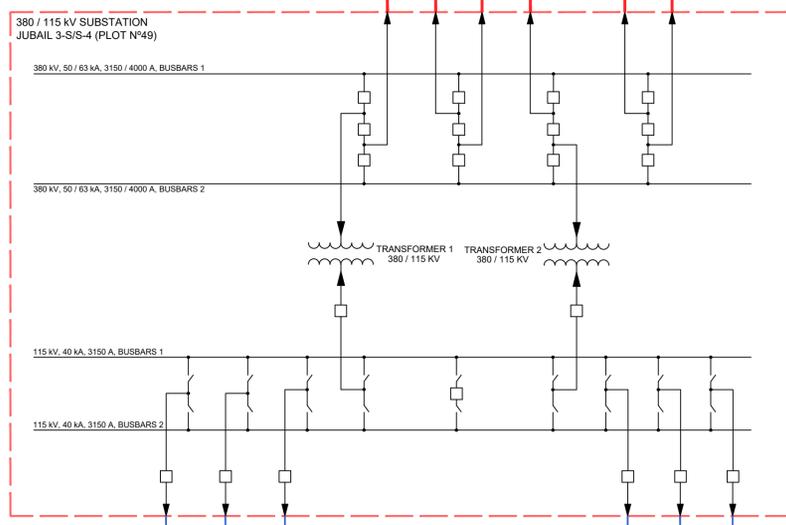
380 KV OVERHEAD LINE (CIRCUIT 1)

TO EXISTING 380 KV OVERHEAD LINE (CIRCUIT 2)

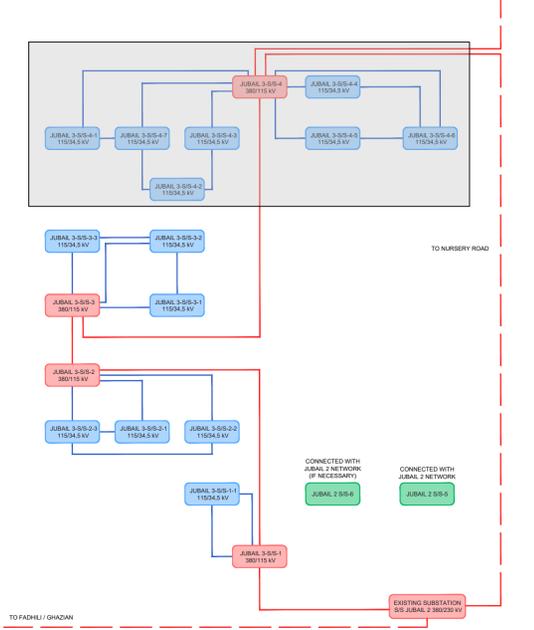
TO NURSERY ROAD ( CIRCUIT 2)

TO EXISTING 380 KV OVERHEAD LINE (CIRCUIT 1)

TO NURSERY ROAD ( CIRCUIT 1)



### GENERAL BLOCK DIAGRAM



### LEGEND

- CIRCUIT BREAKER
- DISCONNECTOR SWITCH
- POWER TRANSFORMER
- 380 KV SYSTEM
- 115 KV SYSTEM

### NOTES

NOTE 1: IN CASE THAT FUTURE 115/34.5 KV TRANSFORMERS WILL BE INSTALLED, THESE TRANSFORMERS MUST BE CONNECTED IN A SET OF 34.5 KV CABINETS (E.G. BUSBARS 3 AND 4) EQUAL THAN 34.5 KV CABINETS (BUSBARS 1 AND 2).

### FEASIBILITY STUDY OF JUBAIL 2 (STAGE 4) AND JUBAIL 3 (PHASE 1 OF 2)

NAME: RICARDO COTARELO HERNÁNDEZ	
DATE: 21/07/2023	
SCALE:	DRAWING NAME:
NO SCALE	GENERAL SINGLE LINE DIAGRAM

## **ANNEX IV: COST ESTIMATION**

ITEM.	DESCRIPTION	QTY	UNIT COST (€)	TOTAL COST (€)	UNIT COST (SAR)	UNIT COST (SAR)	TOTAL COST (SAR)
<b>1</b>	<b>380/115 KV SUBSTATIONS</b>						<b>286,237,780.00</b>
<b>1.1</b>	<b>JUBAIL 3-S/S-1 380/115 KV</b>						<b>63,781,980.00</b>
<b>1.1.1</b>	<b>380 KV System</b>						<b>11,564,920.00</b>
1.1.1.1	Three-phase circuit breaker, SF6, 420 kV, 3,150 A	12	64,000.00	768,000.00	255,360.00	255,500.00	3,066,000.00
1.1.1.2	Three-phase line disconnector switch with earthing blades, 420 kV, 3,150 A	8	45,000.00	360,000.00	179,550.00	180,000.00	1,440,000.00
1.1.1.3	Three-phase busbar disconnector switch, 420 kV, 3,150 A	27	45,000.00	1,215,000.00	179,550.00	180,000.00	4,860,000.00
1.1.1.4	One-phase current transformers	36	5,000.00	180,000.00	19,950.00	20,000.00	720,000.00
1.1.1.5	One-phase voltage transformers, transformer ratio 380√3 : 0.110√3 - 0.110√3 - 0.110 kV	30	5,300.00	159,000.00	21,147.00	21,500.00	645,000.00
1.1.1.6	One-phase voltage transformer for Auxiliary Services, transformer ratio 380√3 / 0.42√3 kV	3	8,500.00	25,500.00	33,915.00	34,000.00	102,000.00
1.1.1.7	One-phase surge arrester 420 kV	24	1,800.00	43,200.00	7,182.00	7,200.00	172,800.00
1.1.1.8	One-phase terminal cables 420 kV	6	1,500.00	9,000.00	5,985.00	6,000.00	36,000.00
1.1.1.9	Lightning Rods	12	1,200.00	14,400.00	4,788.00	4,800.00	57,600.00
1.1.1.10	Metal structure with hardware and screws (kg)	51100	1.80	91,980.00	7.18	7.20	367,920.00
1.1.1.11	Aluminium tube 200/184 (mm) or 250/230 (mm)	400	50.00	20,000.00	199.50	200.00	80,000.00
1.1.1.12	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00	17,600.00
<b>1.1.2</b>	<b>115 KV System</b>						<b>5,451,560.00</b>
1.1.2.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	6	60,000.00	360,000.00	239,400.00	240,000.00	1,440,000.00
1.1.2.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	5	40,000.00	200,000.00	159,600.00	160,000.00	800,000.00
1.1.2.3	Three-phase busbar disconnector, 145 kV, 3,150 A	14	40,000.00	560,000.00	159,600.00	160,000.00	2,240,000.00
1.1.2.4	One-phase current transformers	18	5,000.00	90,000.00	19,950.00	20,000.00	360,000.00
1.1.2.5	One-phase voltage transformers, transformer ratio 115√3 : 0.110√3 - 0.110√3 - 0.110 kV	15	4,000.00	60,000.00	15,960.00	16,000.00	240,000.00
1.1.2.6	One phase surge Arrester 115 kV	15	1,500.00	22,500.00	5,985.00	6,000.00	90,000.00
1.1.2.7	Metal structure with hardware and screws (kg)	25550	1.80	45,990.00	7.18	7.20	183,960.00
1.1.2.8	Aluminium tube 200/184 (mm)	400	50.00	20,000.00	199.50	200.00	80,000.00
1.1.2.9	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00	17,600.00
<b>1.1.3</b>	<b>Transformer</b>						<b>32,000,000.00</b>
1.1.3.1	Rated power 300/400/500 MVA (ONAN/ONAF1/ONAF2), outdoor, mineral oil immersed, OLTC	2	4,000,000.00	8,000,000.00	15,960,000.00	16,000,000.00	32,000,000.00
<b>1.1.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>5,798,000.00</b>
1.1.4.1	AC & DC Main Distribution Board	1	60,000.00	60,000.00	239,400.00	160,000.00	160,000.00
1.1.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,200,000.00	1,200,000.00
1.1.4.3	Bay Control Unit (BCU)	12	67,500.00	810,000.00	269,325.00	270,000.00	3,240,000.00
1.1.4.4	Telecommunications system	1	300,000.00	300,000.00	1,197,000.00	1,198,000.00	1,198,000.00
<b>1.1.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
1.1.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>1.1.6</b>	<b>Foundations and Bedplates</b>						<b>958,000.00</b>
1.1.6.1	Excavation and concreting of foundations (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
1.1.6.2	Power transformer base including rails, traxem, bushings and termination (ud)	2	70,000.00	140,000.00	279,300.00	279,500.00	559,000.00
<b>1.1.7</b>	<b>Electrical Conduits and Drains</b>						<b>1,038,000.00</b>
1.1.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	260,000.00	260,000.00	1,037,400.00	1,038,000.00	1,038,000.00
<b>1.1.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>1,995,000.00</b>
1.1.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	500,000.00	500,000.00	1,995,000.00	1,995,000.00	1,995,000.00
<b>1.1.9</b>	<b>Buildings</b>						<b>1,795,500.00</b>
1.1.9.1	Prefabricated Control and Communications Building	1	450,000.00	450,000.00	1,795,500.00	1,795,500.00	1,795,500.00
<b>1.1.10</b>	<b>Electromechanical assembly</b>						<b>2,360,000.00</b>
1.1.10.1	Assembly, Transport and Miscellaneous (pa)	1	590,000.00	590,000.00	2,354,100.00	2,360,000.00	2,360,000.00
<b>1.1.11</b>	<b>Complementary Installations</b>						<b>422,000.00</b>
1.1.11.1	Lighting and power system (pa)	1	75,000.00	75,000.00	299,250.00	300,000.00	300,000.00
1.1.11.2	Ventilation and air-conditioning system (pa)	1	12,500.00	12,500.00	49,875.00	50,000.00	50,000.00
1.1.11.3	Fire protection system (pa)	1	18,000.00	18,000.00	71,820.00	72,000.00	72,000.00
<b>1.2</b>	<b>JUBAIL 3-S/S-2 380/115 KV</b>						<b>76,578,880.00</b>
<b>1.2.1</b>	<b>380 KV System</b>						<b>19,534,060.00</b>
1.2.1.1	Three-phase circuit breaker, SF6, 420 kV, 3,150 A	21	64,000.00	1,344,000.00	255,360.00	255,500.00	5,365,500.00
1.2.1.2	Three-phase line disconnector switch with earthing blades, 420 kV, 3,150 A	14	45,000.00	630,000.00	179,550.00	180,000.00	2,520,000.00
1.2.1.3	Three-phase busbar disconnector switch, 420 kV, 3,150 A	45	45,000.00	2,025,000.00	179,550.00	180,000.00	8,100,000.00
1.2.1.4	One-phase current transformers	63	5,000.00	315,000.00	19,950.00	20,000.00	1,260,000.00
1.2.1.5	One-phase voltage transformers, transformer ratio 380√3 : 0.110√3 - 0.110√3 - 0.110 kV	48	5,300.00	254,400.00	21,147.00	21,500.00	1,032,000.00
1.2.1.6	One-phase voltage transformer for Auxiliary Services, transformer ratio 380√3 / 0.42√3 kV	3	8,500.00	25,500.00	33,915.00	34,000.00	102,000.00
1.2.1.7	One-phase surge arrester 420 kV	42	1,800.00	75,600.00	7,182.00	7,200.00	302,400.00
1.2.1.8	One-phase terminal cables 420 kV	12	1,500.00	18,000.00	5,985.00	6,000.00	72,000.00
1.2.1.9	Lightning Rods	12	1,200.00	14,400.00	4,788.00	4,800.00	57,600.00
1.2.1.10	Metal structure with hardware and screws (kg)	86800	1.80	156,240.00	7.18	7.20	624,960.00
1.2.1.11	Aluminium tube 200/184 (mm) or 250/230 (mm)	400	50.00	20,000.00	199.50	200.00	80,000.00
1.2.1.12	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00	17,600.00
<b>1.2.2</b>	<b>115 KV System</b>						<b>5,080,320.00</b>
1.2.2.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	6	60,000.00	360,000.00	239,400.00	240,000.00	1,440,000.00
1.2.2.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	5	40,000.00	200,000.00	159,600.00	160,000.00	800,000.00
1.2.2.3	Three-phase busbar disconnector, 145 kV, 3,150 A	12	40,000.00	480,000.00	159,600.00	160,000.00	1,920,000.00
1.2.2.4	One-phase current transformers	12	5,000.00	60,000.00	19,950.00	20,000.00	240,000.00
1.2.2.5	One-phase voltage transformers, transformer ratio 115√3 : 0.110√3 - 0.110√3 - 0.110 kV	6	4,000.00	24,000.00	15,960.00	16,000.00	96,000.00
1.2.2.6	One phase surge Arrester 115 kV	45	1,500.00	67,500.00	5,985.00	6,000.00	270,000.00
1.2.2.7	Metal structure with hardware and screws (kg)	30100	1.80	54,180.00	7.18	7.20	216,720.00
1.2.2.8	Aluminium tube 200/184 (mm)	400	50.00	20,000.00	199.50	200.00	80,000.00
1.2.2.9	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00	17,600.00
<b>1.2.3</b>	<b>Transformer</b>						<b>32,000,000.00</b>
1.2.3.1	Rated power 300/400/500 MVA (ONAN/ONAF1/ONAF2), outdoor, mineral oil immersed, OLTC	2	4,000,000.00	8,000,000.00	15,960,000.00	16,000,000.00	32,000,000.00
<b>1.2.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>6,608,000.00</b>
1.2.4.1	AC & DC Main Distribution Board	1	60,000.00	60,000.00	239,400.00	160,000.00	160,000.00
1.2.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,200,000.00	1,200,000.00
1.2.4.3	Bay Control Unit (BCU)	15	67,500.00	1,012,500.00	269,325.00	270,000.00	4,050,000.00
1.2.4.4	Telecommunications system	1	300,000.00	300,000.00	1,197,000.00	1,198,000.00	1,198,000.00
<b>1.2.5</b>	<b>Earthworks and earth mesh</b>						<b>4,788,000.00</b>
1.2.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	12	100,000.00	1,200,000.00	399,000.00	399,000.00	4,788,000.00
<b>1.2.6</b>	<b>Foundations and Bedplates</b>						<b>958,000.00</b>
1.2.6.1	Excavation and concreting of foundations (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
1.2.6.2	Power transformer base including rails, traxem, bushings and termination (ud)	2	70,000.00	140,000.00	279,300.00	279,500.00	559,000.00
<b>1.2.7</b>	<b>Electrical Conduits and Drains</b>						<b>1,038,000.00</b>
1.2.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	260,000.00	260,000.00	1,037,400.00	1,038,000.00	1,038,000.00
<b>1.2.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>1,995,000.00</b>
1.2.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	500,000.00	500,000.00	1,995,000.00	1,995,000.00	1,995,000.00
<b>1.2.9</b>	<b>Buildings</b>						<b>1,795,500.00</b>
1.2.9.1	Prefabricated Control and Communications Building	1	450,000.00	450,000.00	1,795,500.00	1,795,500.00	1,795,500.00
<b>1.2.10</b>	<b>Electromechanical assembly</b>						<b>2,360,000.00</b>
1.2.10.1	Assembly, Transport and Miscellaneous (pa)	1	590,000.00	590,000.00	2,354,100.00	2,360,000.00	2,360,000.00
<b>1.2.11</b>	<b>Complementary Installations</b>						<b>422,000.00</b>
1.2.11.1	Lighting and power system (pa)	1	75,000.00	75,000.00	299,250.00	300,000.00	300,000.00
1.2.11.2	Ventilation and air-conditioning system (pa)	1	12,500.00	12,500.00	49,875.00	50,000.00	50,000.00
1.2.11.3	Fire protection system (pa)	1	18,000.00	18,000.00	71,820.00	72,000.00	72,000.00

<b>1.3</b>	<b>JUBAIL 3-S/S-3 380/115 kV</b>								<b>74,259,660.00</b>
<b>1.3.1</b>	<b>380 kV System</b>								<b>16,843,600.00</b>
1.3.1.1	Three-phase circuit breaker, SF6, 420 kV, 3,150 A	18	64,000.00	1,152,000.00	255,360.00	255,500.00			4,599,000.00
1.3.1.2	Three-phase line disconnector switch with earthing blades, 420 kV, 3,150 A	12	45,000.00	540,000.00	179,550.00	180,000.00			2,160,000.00
1.3.1.3	Three-phase busbar disconnector switch, 420 kV, 3,150 A	39	45,000.00	1,755,000.00	179,550.00	180,000.00			7,020,000.00
1.3.1.4	One-phase current transformers	54	5,000.00	270,000.00	19,950.00	20,000.00			1,080,000.00
1.3.1.5	One-phase voltage transformers, transformer ratio 380√3 : 0.110√3 - 0.110√3 - 0.110 kV	42	5,300.00	222,600.00	21,147.00	21,500.00			903,000.00
1.3.1.6	One-phase voltage transformer for Auxiliary Services, transformer ratio 380√3 / 0.42√3 kV	3	8,500.00	25,500.00	33,915.00	34,000.00			102,000.00
1.3.1.7	One-phase surge arrester 420 kV	36	1,800.00	64,800.00	7,182.00	7,200.00			259,200.00
1.3.1.8	One-phase terminal cables 420 kV	6	1,500.00	9,000.00	5,985.00	6,000.00			36,000.00
1.3.1.9	Lightning Rods	12	1,200.00	14,400.00	4,788.00	4,800.00			57,600.00
1.3.1.10	Metal structure with hardware and screws (kg)	73500	1.80	132,300.00	7.18	7.20			529,200.00
1.3.1.11	Aluminium tube 200/184 (mm) or 250/230 (mm)	400	50.00	20,000.00	199.50	200.00			80,000.00
1.3.1.12	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00			17,600.00
<b>1.3.2</b>	<b>115 kV System</b>								<b>5,451,560.00</b>
1.3.2.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	6	60,000.00	360,000.00	239,400.00	240,000.00			1,440,000.00
1.3.2.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	5	40,000.00	200,000.00	159,600.00	160,000.00			800,000.00
1.3.2.3	Three-phase busbar disconnector, 145 kV, 3,150 A	14	40,000.00	560,000.00	159,600.00	160,000.00			2,240,000.00
1.3.2.4	One-phase current transformers	18	5,000.00	90,000.00	19,950.00	20,000.00			360,000.00
1.3.2.5	One-phase voltage transformers, transformer ratio 115√3 : 0.110√3 - 0.110√3 - 0.110 kV	15	4,000.00	60,000.00	15,960.00	16,000.00			240,000.00
1.3.2.6	One phase surge Arrester 115 kV	15	1,500.00	22,500.00	5,985.00	6,000.00			90,000.00
1.3.2.7	Metal structure with hardware and screws (kg)	25550	1.80	45,990.00	7.18	7.20			183,960.00
1.3.2.8	Aluminium tube 200/184 (mm)	400	50.00	20,000.00	199.50	200.00			80,000.00
1.3.2.9	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00			17,600.00
<b>1.3.3</b>	<b>Transformer</b>								<b>32,000,000.00</b>
1.3.3.1	Rated power 300/400/500 MVA (ONAN/ONAF1/ONAF2), outdoor, mineral oil immersed, OLTC.	2	2,000,000.00	4,000,000.00	7,980,000.00	16,000,000.00			32,000,000.00
<b>1.3.4</b>	<b>Control, Protection and Auxiliary Services</b>								<b>6,608,000.00</b>
1.3.4.1	AC & DC Main Distribution Board	1	60,000.00	60,000.00	239,400.00	160,000.00			160,000.00
1.3.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,200,000.00			1,200,000.00
1.3.4.3	Bay Control Unit (BCU)	15	67,500.00	1,012,500.00	269,325.00	270,000.00			4,050,000.00
1.3.4.4	Telecommunications system	1	300,000.00	300,000.00	1,197,000.00	1,198,000.00			1,198,000.00
<b>1.3.5</b>	<b>Earthworks and earth mesh</b>								<b>4,788,000.00</b>
1.3.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	12	100,000.00	1,200,000.00	399,000.00	399,000.00			4,788,000.00
<b>1.3.6</b>	<b>Foundations and Bedplates</b>								<b>958,000.00</b>
1.3.6.1	Excavation and concreting of foundations (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00			399,000.00
1.3.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	70,000.00	140,000.00	279,300.00	279,500.00			559,000.00
<b>1.3.7</b>	<b>Electrical Conduits and Drains</b>								<b>1,038,000.00</b>
1.3.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	260,000.00	260,000.00	1,037,400.00	1,038,000.00			1,038,000.00
<b>1.3.8</b>	<b>Perimeter Fencing and Accesses</b>								<b>1,995,000.00</b>
1.3.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	500,000.00	500,000.00	1,995,000.00	1,995,000.00			1,995,000.00
<b>1.3.9</b>	<b>Buildings</b>								<b>1,795,500.00</b>
1.3.9.1	Prefabricated Control and Communications Building	1	450,000.00	450,000.00	1,795,500.00	1,795,500.00			1,795,500.00
<b>1.3.10</b>	<b>Electromechanical assembly</b>								<b>2,360,000.00</b>
1.3.10.1	Assembly, Transport and Miscellaneous (pa)	1	590,000.00	590,000.00	2,354,100.00	2,360,000.00			2,360,000.00
<b>1.3.11</b>	<b>Complementary Installations</b>								<b>422,000.00</b>
1.3.11.1	Lighting and power system (pa)	1	75,000.00	75,000.00	299,250.00	300,000.00			300,000.00
1.3.11.2	Ventilation and air-conditioning system (pa)	1	12,500.00	12,500.00	49,875.00	50,000.00			50,000.00
1.3.11.3	Fire protection system (pa)	1	18,000.00	18,000.00	71,820.00	72,000.00			72,000.00
<b>1.4</b>	<b>JUBAIL 3-S/S-4 380/115 kV</b>								<b>71,617,260.00</b>
<b>1.4.1</b>	<b>380 kV System</b>								<b>11,564,920.00</b>
1.4.1.1	Three-phase circuit breaker, SF6, 420 kV, 3,150 A	12	64,000.00	768,000.00	255,360.00	255,500.00			3,066,000.00
1.4.1.2	Three-phase line disconnector switch with earthing blades, 420 kV, 3,150 A	8	45,000.00	360,000.00	179,550.00	180,000.00			1,440,000.00
1.4.1.3	Three-phase busbar disconnector switch, 420 kV, 3,150 A	27	45,000.00	1,215,000.00	179,550.00	180,000.00			4,860,000.00
1.4.1.4	One-phase current transformers	36	5,000.00	180,000.00	19,950.00	20,000.00			720,000.00
1.4.1.5	One-phase voltage transformers, transformer ratio 380√3 : 0.110√3 - 0.110√3 - 0.110 kV	30	5,300.00	159,000.00	21,147.00	21,500.00			645,000.00
1.4.1.6	One-phase voltage transformer for Auxiliary Services, transformer ratio 380√3 / 0.42√3 kV	3	8,500.00	25,500.00	33,915.00	34,000.00			102,000.00
1.4.1.7	One-phase surge arrester 420 kV	24	1,800.00	43,200.00	7,182.00	7,200.00			172,800.00
1.4.1.8	One-phase terminal cables 420 kV	6	1,500.00	9,000.00	5,985.00	6,000.00			36,000.00
1.4.1.9	Lightning Rods	12	1,200.00	14,400.00	4,788.00	4,800.00			57,600.00
1.4.1.10	Metal structure with hardware and screws (kg)	51100	1.80	91,980.00	7.18	7.20			367,920.00
1.4.1.11	Aluminium tube 200/184 (mm) or 250/230 (mm)	400	50.00	20,000.00	199.50	200.00			80,000.00
1.4.1.12	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00			17,600.00
<b>1.4.2</b>	<b>115 kV System</b>								<b>8,087,840.00</b>
1.4.2.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	9	60,000.00	540,000.00	239,400.00	240,000.00			2,160,000.00
1.4.2.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	8	40,000.00	320,000.00	159,600.00	160,000.00			1,280,000.00
1.4.2.3	Three-phase busbar disconnector, 145 kV, 3,150 A	20	40,000.00	800,000.00	159,600.00	160,000.00			3,200,000.00
1.4.2.4	One-phase current transformers	27	5,000.00	135,000.00	19,950.00	20,000.00			540,000.00
1.4.2.5	One-phase voltage transformers, transformer ratio 115√3 : 0.110√3 - 0.110√3 - 0.110 kV	24	4,000.00	96,000.00	15,960.00	16,000.00			384,000.00
1.4.2.6	One phase surge Arrester 115 kV	24	1,500.00	36,000.00	5,985.00	6,000.00			144,000.00
1.4.2.7	Metal structure with hardware and screws (kg)	39200	1.80	70,560.00	7.18	7.20			282,240.00
1.4.2.8	Aluminium tube 200/184 (mm)	400	50.00	20,000.00	199.50	200.00			80,000.00
1.4.2.9	Bare copper wire (kg)	400	11.00	4,400.00	43.89	44.00			17,600.00
<b>1.4.3</b>	<b>Transformer</b>								<b>32,000,000.00</b>
1.4.3.1	Rated power 300/400/500 MVA (ONAN/ONAF1/ONAF2), outdoor, mineral oil immersed, OLTC.	2	2,000,000.00	4,000,000.00	7,980,000.00	16,000,000.00			32,000,000.00
<b>1.4.4</b>	<b>Control, Protection and Auxiliary Services</b>								<b>6,608,000.00</b>
1.4.4.1	AC & DC Main Distribution Board	1	60,000.00	60,000.00	239,400.00	160,000.00			160,000.00
1.4.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,200,000.00			1,200,000.00
1.4.4.3	Bay Control Unit (BCU)	15	67,500.00	1,012,500.00	269,325.00	270,000.00			4,050,000.00
1.4.4.4	Telecommunications system	1	300,000.00	300,000.00	1,197,000.00	1,198,000.00			1,198,000.00
<b>1.4.5</b>	<b>Earthworks and earth mesh</b>								<b>4,788,000.00</b>
1.4.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	12	100,000.00	1,200,000.00	399,000.00	399,000.00			4,788,000.00
<b>1.4.6</b>	<b>Foundations and Bedplates</b>								<b>958,000.00</b>
1.4.6.1	Excavation and concreting of foundations (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00			399,000.00
1.4.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	70,000.00	140,000.00	279,300.00	279,500.00			559,000.00
<b>1.4.7</b>	<b>Electrical Conduits and Drains</b>								<b>1,038,000.00</b>
1.4.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	260,000.00	260,000.00	1,037,400.00	1,038,000.00			1,038,000.00
<b>1.4.8</b>	<b>Perimeter Fencing and Accesses</b>								<b>1,995,000.00</b>
1.4.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	500,000.00	500,000.00	1,995,000.00	1,995,000.00			1,995,000.00
<b>1.4.9</b>	<b>Buildings</b>								<b>1,795,500.00</b>
1.4.9.1	Prefabricated Control and Communications Building	1	450,000.00	450,000.00	1,795,500.00	1,795,500.00			1,795,500.00
<b>1.4.10</b>	<b>Electromechanical assembly</b>								<b>2,360,000.00</b>
1.4.10.1	Assembly, Transport and Miscellaneous (pa)	1	590,000.00	590,000.00	2,354,100.00	2,360,000.00			2,360,000.00
<b>1.4.11</b>	<b>Complementary Installations</b>								<b>422,000.00</b>
1.4.11.1	Lighting and power system (pa)	1	75,000.00	75,000.00	299,250.00	300,000.00			300,000.00
1.4.11.2	Ventilation and air-conditioning system (pa)	1	12,500.00	12,500.00	49,875.00	50,000.00			50,000.00
1.4.11.3	Fire protection system (pa)	1	18,000.00	18,000.00	71,820.00	72,000.00			72,000.00

ITEM.	DESCRIPTION	QTY	UNIT COST (€)	TOTAL COST (€)	UNIT COST (SAR)	UNIT COST (SAR)	TOTAL COST (SAR)
<b>2</b>	<b>115/34.5 KV SUBSTATIONS</b>						<b>#JREF1</b>
<b>2.1</b>	<b>JUBAIL 3-S/S-1-1 115/34.5 KV</b>						<b>39,586,100.00</b>
<b>2.1.1</b>	<b>115 kV System</b>						<b>9,794,600.00</b>
2.1.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	10	64,000.00	640,000.00	255,360.00	255,000.00	2,550,000.00
2.1.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	9	45,000.00	405,000.00	179,550.00	179,600.00	1,616,400.00
2.1.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	20	45,000.00	900,000.00	179,550.00	179,600.00	3,592,000.00
2.1.1.4	One-phase current transformers	30	5,000.00	150,000.00	19,950.00	20,000.00	600,000.00
2.1.1.5	One-phase voltage transformers, transformer ratio 115v3 : 0,110v3 - 0,110v3 - 0,110 kV	33	5,300.00	174,900.00	21,147.00	21,200.00	699,600.00
2.1.1.6	Surge Arrester 145 kV	27	1,800.00	48,600.00	7,182.00	7,200.00	194,400.00
2.1.1.7	Terminal Cables 145 kV	27	1,500.00	40,500.00	5,985.00	6,000.00	162,000.00
2.1.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.1.1.9	Metal structure with hardware and screws (kg)	39,000	1.80	70,200.00	7.18	7.20	280,800.00
2.1.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.1.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.1.2</b>	<b>34.5 kV System</b>						<b>6,240,000.00</b>
2.1.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	26	60,000.00	1,560,000.00	239,400.00	240,000.00	6,240,000.00
<b>2.1.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.1.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.1.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.1.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,771,500.00</b>
2.1.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.1.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.1.4.3	Bay Control Unit (BCU)	10	45,000.00	450,000.00	179,550.00	179,600.00	1,796,000.00
2.1.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.1.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.1.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.1.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.1.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.1.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.1.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.1.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.1.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.1.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.1.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.1.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.1.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.1.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.1.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.1.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.1.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.1.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.2</b>	<b>JUBAIL 3-S/S-2-1 115/34.5 KV</b>						<b>37,289,900.00</b>
<b>2.2.1</b>	<b>115 kV System</b>						<b>6,837,200.00</b>
2.2.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	7	64,000.00	448,000.00	255,360.00	255,000.00	1,785,000.00
2.2.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	6	45,000.00	270,000.00	179,550.00	179,600.00	1,077,600.00
2.2.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	14	45,000.00	630,000.00	179,550.00	179,600.00	2,514,400.00
2.2.1.4	One-phase current transformers	21	5,000.00	105,000.00	19,950.00	20,000.00	420,000.00
2.2.1.5	One-phase voltage transformers, transformer ratio 115v3 : 0,110v3 - 0,110v3 - 0,110 kV	24	5,300.00	127,200.00	21,147.00	21,200.00	508,800.00
2.2.1.6	Surge Arrester 145 kV	18	1,800.00	32,400.00	7,182.00	7,200.00	129,600.00
2.2.1.7	Terminal Cables 145 kV	18	1,500.00	27,000.00	5,985.00	6,000.00	108,000.00
2.2.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.2.1.9	Metal structure with hardware and screws (kg)	27,000	1.80	48,600.00	7.18	7.20	194,400.00
2.2.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.2.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.2.2</b>	<b>34.5 kV System</b>						<b>7,440,000.00</b>
2.2.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	31	60,000.00	1,860,000.00	239,400.00	240,000.00	7,440,000.00
<b>2.2.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.2.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.2.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.2.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,232,700.00</b>
2.2.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.2.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.2.4.3	Bay Control Unit (BCU)	7	45,000.00	315,000.00	179,550.00	179,600.00	1,257,200.00
2.2.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.2.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.2.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.2.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.2.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.2.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.2.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.2.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.2.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.2.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.2.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.2.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.2.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.2.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.2.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.2.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.2.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.2.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.3</b>	<b>JUBAIL 3-S/S-2-2 115/34.5 KV</b>						<b>37,049,900.00</b>
<b>2.3.1</b>	<b>115 kV System</b>						<b>6,837,200.00</b>
2.3.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	7	64,000.00	448,000.00	255,360.00	255,000.00	1,785,000.00
2.3.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	6	45,000.00	270,000.00	179,550.00	179,600.00	1,077,600.00
2.3.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	14	45,000.00	630,000.00	179,550.00	179,600.00	2,514,400.00
2.3.1.4	One-phase current transformers	21	5,000.00	105,000.00	19,950.00	20,000.00	420,000.00
2.3.1.5	One-phase voltage transformers, transformer ratio 115v3 : 0,110v3 - 0,110v3 - 0,110 kV	24	5,300.00	127,200.00	21,147.00	21,200.00	508,800.00
2.3.1.6	Surge Arrester 145 kV	18	1,800.00	32,400.00	7,182.00	7,200.00	129,600.00
2.3.1.7	Terminal Cables 145 kV	18	1,500.00	27,000.00	5,985.00	6,000.00	108,000.00
2.3.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.3.1.9	Metal structure with hardware and screws (kg)	27,000	1.80	48,600.00	7.18	7.20	194,400.00
2.3.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.3.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.3.2</b>	<b>34.5 kV System</b>						<b>7,200,000.00</b>
2.3.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	30	60,000.00	1,800,000.00	239,400.00	240,000.00	7,200,000.00
<b>2.3.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.3.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.3.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.3.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,232,700.00</b>
2.3.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.3.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.3.4.3	Bay Control Unit (BCU)	7	45,000.00	315,000.00	179,550.00	179,600.00	1,257,200.00
2.3.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.3.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.3.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.3.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.3.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.3.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<							

<b>2.4</b>	<b>JUBAIL 3-S/S-2-3 115/34.5 kV</b>									<b>37,975,300.00</b>
<b>2.4.1</b>	<b>115 kV System</b>									<b>7,823,000.00</b>
2.4.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	8	64,000.00	512,000.00	255,360.00	255,000.00				2,040,000.00
2.4.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	7	45,000.00	315,000.00	179,550.00	179,600.00				1,257,200.00
2.4.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	16	45,000.00	720,000.00	179,550.00	179,600.00				2,873,600.00
2.4.1.4	One-phase current transformers	24	5,000.00	120,000.00	19,950.00	20,000.00				480,000.00
2.4.1.5	One-phase voltage transformers, transformer ratio 115v:3 : 0,110v:3 - 0,110v:3 - 0,110 kV	27	5,300.00	143,100.00	21,147.00	21,200.00				572,400.00
2.4.1.6	Surge Arrester 145 kV	21	1,800.00	37,800.00	7,182.00	7,200.00				151,200.00
2.4.1.7	Terminal Cables 145 kV	21	1,500.00	31,500.00	5,985.00	6,000.00				126,000.00
2.4.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00				38,400.00
2.4.1.9	Metal structure with hardware and screws (kg)	31,000	1.80	55,800.00	7.18	7.20				223,200.00
2.4.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00				50,000.00
2.4.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00				11,000.00
<b>2.4.2</b>	<b>34.5 kV System</b>									<b>6,960,000.00</b>
2.4.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	29	60,000.00	1,740,000.00	239,400.00	240,000.00				6,960,000.00
<b>2.4.3</b>	<b>Transformer</b>									<b>16,068,000.00</b>
2.4.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00				16,000,000.00
2.4.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00				68,000.00
<b>2.4.4</b>	<b>Control, Protection and Auxiliary Services</b>									<b>3,412,300.00</b>
2.4.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00				160,000.00
2.4.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00				1,197,000.00
2.4.4.3	Bay Control Unit (BCU)	8	45,000.00	360,000.00	179,550.00	179,600.00				1,436,800.00
2.4.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00				618,500.00
<b>2.4.5</b>	<b>Earthworks and earth mesh</b>									<b>399,000.00</b>
2.4.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00				399,000.00
<b>2.4.6</b>	<b>Foundations and Bedplates</b>									<b>1,318,000.00</b>
2.4.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00				120,000.00
2.4.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00				1,198,000.00
<b>2.4.7</b>	<b>Electrical Conduits and Drains</b>									<b>247,380.00</b>
2.4.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00				247,380.00
<b>2.4.8</b>	<b>Perimeter Fencing and Accesses</b>									<b>339,150.00</b>
2.4.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00				339,150.00
<b>2.4.9</b>	<b>Buildings</b>									<b>466,830.00</b>
2.4.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00				466,830.00
<b>2.4.10</b>	<b>Electromechanical assembly</b>									<b>798,000.00</b>
2.4.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00				798,000.00
<b>2.4.11</b>	<b>Complementary Installations</b>									<b>143,640.00</b>
2.4.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00				99,750.00
2.4.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00				19,950.00
2.4.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00				23,940.00
<b>2.5</b>	<b>JUBAIL 3-S/S-3-1 115/34.5 kV</b>									<b>40,494,500.00</b>
<b>2.5.1</b>	<b>115 kV System</b>									<b>7,823,000.00</b>
2.5.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	8	64,000.00	512,000.00	255,360.00	255,000.00				2,040,000.00
2.5.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	7	45,000.00	315,000.00	179,550.00	179,600.00				1,257,200.00
2.5.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	16	45,000.00	720,000.00	179,550.00	179,600.00				2,873,600.00
2.5.1.4	One-phase current transformers	24	5,000.00	120,000.00	19,950.00	20,000.00				480,000.00
2.5.1.5	One-phase voltage transformers, transformer ratio 115v:3 : 0,110v:3 - 0,110v:3 - 0,110 kV	27	5,300.00	143,100.00	21,147.00	21,200.00				572,400.00
2.5.1.6	Surge Arrester 145 kV	21	1,800.00	37,800.00	7,182.00	7,200.00				151,200.00
2.5.1.7	Terminal Cables 145 kV	21	1,500.00	31,500.00	5,985.00	6,000.00				126,000.00
2.5.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00				38,400.00
2.5.1.9	Metal structure with hardware and screws (kg)	31,000	1.80	55,800.00	7.18	7.20				223,200.00
2.5.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00				50,000.00
2.5.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00				11,000.00
<b>2.5.2</b>	<b>34.5 kV System</b>									<b>9,120,000.00</b>
2.5.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	38	60,000.00	2,280,000.00	239,400.00	240,000.00				9,120,000.00
<b>2.5.3</b>	<b>Transformer</b>									<b>16,068,000.00</b>
2.5.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00				16,000,000.00
2.5.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00				68,000.00
<b>2.5.4</b>	<b>Control, Protection and Auxiliary Services</b>									<b>3,771,500.00</b>
2.5.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00				160,000.00
2.5.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00				1,197,000.00
2.5.4.3	Bay Control Unit (BCU)	10	45,000.00	450,000.00	179,550.00	179,600.00				1,796,000.00
2.5.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00				618,500.00
<b>2.5.5</b>	<b>Earthworks and earth mesh</b>									<b>399,000.00</b>
2.5.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00				399,000.00
<b>2.5.6</b>	<b>Foundations and Bedplates</b>									<b>1,318,000.00</b>
2.5.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00				120,000.00
2.5.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00				1,198,000.00
<b>2.5.7</b>	<b>Electrical Conduits and Drains</b>									<b>247,380.00</b>
2.5.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00				247,380.00
<b>2.5.8</b>	<b>Perimeter Fencing and Accesses</b>									<b>339,150.00</b>
2.5.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00				339,150.00
<b>2.5.9</b>	<b>Buildings</b>									<b>466,830.00</b>
2.5.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00				466,830.00
<b>2.5.10</b>	<b>Electromechanical assembly</b>									<b>798,000.00</b>
2.5.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00				798,000.00
<b>2.5.11</b>	<b>Complementary Installations</b>									<b>143,640.00</b>
2.5.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00				99,750.00
2.5.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00				19,950.00
2.5.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00				23,940.00
<b>2.6</b>	<b>JUBAIL 3-S/S-3-2 115/34.5 kV</b>									<b>38,455,300.00</b>
<b>2.6.1</b>	<b>115 kV System</b>									<b>7,823,000.00</b>
2.6.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	8	64,000.00	512,000.00	255,360.00	255,000.00				2,040,000.00
2.6.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	7	45,000.00	315,000.00	179,550.00	179,600.00				1,257,200.00
2.6.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	16	45,000.00	720,000.00	179,550.00	179,600.00				2,873,600.00
2.6.1.4	One-phase current transformers	24	5,000.00	120,000.00	19,950.00	20,000.00				480,000.00
2.6.1.5	One-phase voltage transformers, transformer ratio 115v:3 : 0,110v:3 - 0,110v:3 - 0,110 kV	27	5,300.00	143,100.00	21,147.00	21,200.00				572,400.00
2.6.1.6	Surge Arrester 145 kV	21	1,800.00	37,800.00	7,182.00	7,200.00				151,200.00
2.6.1.7	Terminal Cables 145 kV	21	1,500.00	31,500.00	5,985.00	6,000.00				126,000.00
2.6.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00				38,400.00
2.6.1.9	Metal structure with hardware and screws (kg)	31,000	1.80	55,800.00	7.18	7.20				223,200.00
2.6.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00				50,000.00
2.6.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00				11,000.00
<b>2.6.2</b>	<b>34.5 kV System</b>									<b>7,440,000.00</b>
2.6.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	31	60,000.00	1,860,000.00	239,400.00	240,000.00				7,440,000.00
<b>2.6.3</b>	<b>Transformer</b>									<b>16,068,000.00</b>
2.6.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,				

2.7.1.6	Surge Arrester 145 kV	21	1,800.00	37,800.00	7,182.00	7,200.00	151,200.00
2.7.1.7	Terminal Cables 145 kV	21	1,500.00	31,500.00	5,985.00	6,000.00	126,000.00
2.7.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.7.1.9	Metal structure with hardware and screws (kg)	31,000	1.80	55,800.00	7.18	7.20	223,200.00
2.7.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.7.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.7.2</b>	<b>34.5 kV System</b>						<b>7,440,000.00</b>
2.7.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	31	60,000.00	1,860,000.00	239,400.00	240,000.00	7,440,000.00
<b>2.7.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.7.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.7.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.7.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,412,300.00</b>
2.7.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.7.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.7.4.3	Bay Control Unit (BCU)	8	45,000.00	360,000.00	179,550.00	179,600.00	1,436,800.00
2.7.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.7.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.7.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.7.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.7.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.7.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.7.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.7.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.7.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.7.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.7.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.7.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.7.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.7.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.7.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.7.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.7.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.7.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.8</b>	<b>JUBAIL 3-S/S-4-1 115/34.5 kV</b>						<b>39,345,100.00</b>
<b>2.8.1</b>	<b>115 kV System</b>						<b>2,974,600.00</b>
2.8.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	10	64,000.00	640,000.00	255,360.00	255,000.00	2,550,000.00
2.8.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	9	45,000.00	405,000.00	179,550.00	179,600.00	1,616,400.00
2.8.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	20	45,000.00	900,000.00	179,550.00	179,600.00	3,592,000.00
2.8.1.4	One-phase current transformers	30	5,000.00	150,000.00	19,950.00	20,000.00	600,000.00
2.8.1.5	One-phase voltage transformers, transformer ratio 115/√3 : 0,110/√3 - 0,110/√3 - 0,110 kV	33	5,300.00	174,900.00	21,147.00	21,200.00	699,600.00
2.8.1.6	Surge Arrester 145 kV	27	1,800.00	48,600.00	7,182.00	7,200.00	194,400.00
2.8.1.7	Terminal Cables 145 kV	27	1,500.00	40,500.00	5,985.00	6,000.00	162,000.00
2.8.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.8.1.9	Metal structure with hardware and screws (kg)	39,000	1.80	70,200.00	7.18	7.20	280,800.00
2.8.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.8.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.8.2</b>	<b>34.5 kV System</b>						<b>6,000,000.00</b>
2.8.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	25	60,000.00	1,500,000.00	239,400.00	240,000.00	6,000,000.00
<b>2.8.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.8.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.8.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.8.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,771,500.00</b>
2.8.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.8.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.8.4.3	Bay Control Unit (BCU)	10	45,000.00	450,000.00	179,550.00	179,600.00	1,796,000.00
2.8.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.8.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.8.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.8.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.8.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.8.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.8.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.8.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.8.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.8.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.8.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.8.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.8.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.8.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.8.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.8.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.8.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.8.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.9</b>	<b>JUBAIL 3-S/S-4-2 115/34.5 kV</b>						<b>37,940,700.00</b>
<b>2.9.1</b>	<b>115 kV System</b>						<b>8,808,800.00</b>
2.9.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	9	64,000.00	576,000.00	255,360.00	255,000.00	2,295,000.00
2.9.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	8	45,000.00	360,000.00	179,550.00	179,600.00	1,436,800.00
2.9.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	18	45,000.00	810,000.00	179,550.00	179,600.00	3,232,800.00
2.9.1.4	One-phase current transformers	27	5,000.00	135,000.00	19,950.00	20,000.00	540,000.00
2.9.1.5	One-phase voltage transformers, transformer ratio 115/√3 : 0,110/√3 - 0,110/√3 - 0,110 kV	30	5,300.00	159,000.00	21,147.00	21,200.00	636,000.00
2.9.1.6	Surge Arrester 145 kV	24	1,800.00	43,200.00	7,182.00	7,200.00	172,800.00
2.9.1.7	Terminal Cables 145 kV	24	1,500.00	36,000.00	5,985.00	6,000.00	144,000.00
2.9.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.9.1.9	Metal structure with hardware and screws (kg)	35,000	1.80	63,000.00	7.18	7.20	252,000.00
2.9.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.9.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.9.2</b>	<b>34.5 kV System</b>						<b>5,760,000.00</b>
2.9.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	24	60,000.00	1,440,000.00	239,400.00	240,000.00	5,760,000.00
<b>2.9.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.9.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.9.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.9.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,591,900.00</b>
2.9.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.9.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.9.4.3	Bay Control Unit (BCU)	9	45,000.00	405,000.00	179,550.00	179,600.00	1,616,400.00
2.9.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.9.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.9.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.9.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.9.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.9.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.9.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.9.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.9.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.9.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.9.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.9.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.9.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.9.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.9.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.9.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.9.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.9.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.1</b>	<b>JUBAIL 3-S/S-4-3 115/34.5 kV</b>						<b>35,369,900.00</b>
<b>2.10.1</b>	<b>115 kV System</b>						<b>6,837,200.00</b>
2.10.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	7	64,000.00	448,000.00	255,360.00	255,000.00	1,785,000.00
2.10.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	6	45,000.00	270,000.00	179,550.00	179,600.00	1,077,600.00
2.10.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	14	45,000.00	630,000.00	179,550.00	179,600.00	2,514,400.00
2.10.1.4	One-phase current transformers	21	5,000.00	105,000.00	19,950.00	20,000.00	420,000.00
2.10.1.5	One-phase voltage transformers, transformer ratio 115/√3 : 0,110/√3 - 0,110/√3 - 0,110 kV	24	5,300.00	127,200.00	21,147.00	21,200.00	508,800.00
2.10.1.6	Surge Arrester 145 kV	18	1,800.00	32,400.00	7,182.00	7,200.00	129,600.00

2.10.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	23	60,000.00	1,380,000.00	239,400.00	240,000.00	5,520,000.00
<b>2.10.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.10.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.10.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.10.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,232,700.00</b>
2.10.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.10.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.10.4.3	Bay Control Unit (BCU)	7	45,000.00	315,000.00	179,550.00	179,600.00	1,257,200.00
2.10.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.10.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.10.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.10.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.10.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.10.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.10.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.10.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.10.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.10.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.10.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.10.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.10.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.10.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.10.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.10.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.10.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.10.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.11</b>	<b>JUBAIL, 3-S/S-4-4 115/34.5 kV</b>						<b>38,849,900.00</b>
<b>2.11.1</b>	<b>115 kV System</b>						<b>6,837,200.00</b>
2.11.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	7	64,000.00	448,000.00	255,360.00	255,000.00	1,785,000.00
2.11.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	6	45,000.00	270,000.00	179,550.00	179,600.00	1,077,600.00
2.11.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	14	45,000.00	630,000.00	179,550.00	179,600.00	2,514,400.00
2.11.1.4	One-phase current transformers	21	5,000.00	105,000.00	19,950.00	20,000.00	420,000.00
2.11.1.5	One-phase voltage transformers, transformer ratio 115v3 : 0,110v3 - 0,110v3 - 0,110 kV	24	5,300.00	127,200.00	21,147.00	21,200.00	508,800.00
2.11.1.6	Surge Arrester 145 kV	18	1,800.00	32,400.00	7,182.00	7,200.00	129,600.00
2.11.1.7	Terminal Cables 145 kV	18	1,500.00	27,000.00	5,985.00	6,000.00	108,000.00
2.11.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.11.1.9	Metal structure with hardware and screws (kg)	27,000	1.80	48,600.00	7.18	7.20	194,400.00
2.11.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.11.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.11.2</b>	<b>34.5 kV System</b>						<b>6,000,000.00</b>
2.11.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	25	60,000.00	1,500,000.00	239,400.00	240,000.00	6,000,000.00
<b>2.11.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.11.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.11.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.11.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,232,700.00</b>
2.11.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.11.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.11.4.3	Bay Control Unit (BCU)	7	45,000.00	315,000.00	179,550.00	179,600.00	1,257,200.00
2.11.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.11.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.11.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.11.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.11.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.11.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.11.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.11.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.11.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.11.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.11.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.11.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.11.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.11.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.11.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.11.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.11.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.11.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.12</b>	<b>JUBAIL, 3-S/S-4-5 115/34.5 kV</b>						<b>38,849,900.00</b>
<b>2.12.1</b>	<b>115 kV System</b>						<b>6,837,200.00</b>
2.12.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	7	64,000.00	448,000.00	255,360.00	255,000.00	1,785,000.00
2.12.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	6	45,000.00	270,000.00	179,550.00	179,600.00	1,077,600.00
2.12.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	14	45,000.00	630,000.00	179,550.00	179,600.00	2,514,400.00
2.12.1.4	One-phase current transformers	21	5,000.00	105,000.00	19,950.00	20,000.00	420,000.00
2.12.1.5	One-phase voltage transformers, transformer ratio 115v3 : 0,110v3 - 0,110v3 - 0,110 kV	24	5,300.00	127,200.00	21,147.00	21,200.00	508,800.00
2.12.1.6	Surge Arrester 145 kV	18	1,800.00	32,400.00	7,182.00	7,200.00	129,600.00
2.12.1.7	Terminal Cables 145 kV	18	1,500.00	27,000.00	5,985.00	6,000.00	108,000.00
2.12.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.12.1.9	Metal structure with hardware and screws (kg)	27,000	1.80	48,600.00	7.18	7.20	194,400.00
2.12.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.12.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.12.2</b>	<b>34.5 kV System</b>						<b>6,720,000.00</b>
2.12.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	28	60,000.00	1,680,000.00	239,400.00	240,000.00	6,720,000.00
<b>2.12.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.12.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.12.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.12.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,232,700.00</b>
2.12.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.12.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.12.4.3	Bay Control Unit (BCU)	7	45,000.00	315,000.00	179,550.00	179,600.00	1,257,200.00
2.12.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.12.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.12.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.12.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.12.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.12.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.12.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.12.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.12.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.12.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.12.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.12.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.12.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.12.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.12.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.12.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.12.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.12.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.13</b>	<b>JUBAIL, 3-S/S-4-6 115/34.5 kV</b>						<b>37,735,300.00</b>
<b>2.13.1</b>	<b>115 kV System</b>						<b>7,823,000.00</b>
2.13.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	8	64,000.00	512,000.00	255,360.00	255,000.00	2,040,000.00
2.13.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	7	45,000.00	315,000.00	179,550.00		

2.13.4.3	Bay Control Unit (BCU)	8	45,000.00	360,000.00	179,550.00	179,600.00	1,436,800.00
2.13.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.13.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.13.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.13.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.13.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.13.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.13.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.13.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.13.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.13.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.13.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.13.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.13.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.13.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.13.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.13.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.13.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.13.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00
<b>2.14</b>	<b>JUBAIL, 3-S/S-4-7-11S/34.5 kV</b>						<b>66,207,600.00</b>
<b>2.14.1</b>	<b>115 kV System</b>						<b>7,823,000.00</b>
2.14.1.1	Three-phase circuit breaker, SF6, 145 kV, 3,150 A	8	64,000.00	512,000.00	255,360.00	255,000.00	2,040,000.00
2.14.1.2	Three-phase line disconnector switch with earthing blades, 145 kV, 3,150 A	7	45,000.00	315,000.00	179,550.00	179,600.00	1,257,200.00
2.14.1.3	Three-phase busbar disconnector switch, 145 kV, 3,150 A	16	45,000.00	720,000.00	179,550.00	179,600.00	2,873,600.00
2.14.1.4	One-phase current transformers	24	5,000.00	120,000.00	19,950.00	20,000.00	480,000.00
2.14.1.5	One-phase voltage transformers, transformer ratio 115√3 : 0,110√3 - 0,110√3 - 0,110 kV	27	5,300.00	143,100.00	21,147.00	21,200.00	572,400.00
2.14.1.6	Surge Arrester 145 kV	21	1,800.00	37,800.00	7,182.00	7,200.00	151,200.00
2.14.1.7	Terminal Cables 145 kV	21	1,500.00	31,500.00	5,985.00	6,000.00	126,000.00
2.14.1.8	Lightning Rods	8	1,200.00	9,600.00	4,788.00	4,800.00	38,400.00
2.14.1.9	Metal structure with hardware and screws (kg)	31,000	1.80	55,800.00	7.18	7.20	223,200.00
2.14.1.10	Aluminium tube 200/184 (mm)	250	50.00	12,500.00	199.50	200.00	50,000.00
2.14.1.11	Bare copper wire (kg)	250	11.00	2,750.00	43.89	44.00	11,000.00
<b>2.14.2</b>	<b>34.5 kV System</b>						<b>6,000,000.00</b>
2.14.2.1	34.5 kV Cabinets with earthing blades, 38 kV, 2,500 A	25	60,000.00	1,500,000.00	239,400.00	240,000.00	6,000,000.00
<b>2.14.3</b>	<b>Transformer</b>						<b>16,068,000.00</b>
2.14.3.1	Rated power 80/100 MVA (ONAN/ONAF), outdoor, mineral oil immersed, OLTC	2	1,200,000.00	2,400,000.00	4,788,000.00	8,000,000.00	16,000,000.00
2.14.3.2	Auxiliary Transformer, transformer ratio 34.5/0.42 kV - 250 kVA	2	8,500.00	17,000.00	33,915.00	34,000.00	68,000.00
<b>2.14.4</b>	<b>Control, Protection and Auxiliary Services</b>						<b>3,412,300.00</b>
2.14.4.1	AC & DC Main Distribution Board	1	40,000.00	40,000.00	159,600.00	160,000.00	160,000.00
2.14.4.2	Control, protection and measurement cabinets	1	300,000.00	300,000.00	1,197,000.00	1,197,000.00	1,197,000.00
2.14.4.3	Bay Control Unit (BCU)	8	45,000.00	360,000.00	179,550.00	179,600.00	1,436,800.00
2.14.4.4	Telecommunications system	1	155,000.00	155,000.00	618,450.00	618,500.00	618,500.00
<b>2.14.5</b>	<b>Earthworks and earth mesh</b>						<b>399,000.00</b>
2.14.5.1	Land transport to landfill, clearing, excavation and backfilling (pa)	1	100,000.00	100,000.00	399,000.00	399,000.00	399,000.00
<b>2.14.6</b>	<b>Foundations and Bedplates</b>						<b>1,318,000.00</b>
2.14.6.1	Excavation and concreting of foundations (pa)	1	30,000.00	30,000.00	119,700.00	120,000.00	120,000.00
2.14.6.2	Power transformer base including rails, tramex, bushings and termination (ud)	2	150,000.00	300,000.00	598,500.00	599,000.00	1,198,000.00
<b>2.14.7</b>	<b>Electrical Conduits and Drains</b>						<b>247,380.00</b>
2.14.7.1	Construction of cable ducts, drainage system for the entire substation (pa)	1	62,000.00	62,000.00	247,380.00	248,000.00	247,380.00
<b>2.14.8</b>	<b>Perimeter Fencing and Accesses</b>						<b>339,150.00</b>
2.14.8.1	Perimeter enclosure including metal door and inner roads (pa)	1	85,000.00	85,000.00	339,150.00	339,500.00	339,150.00
<b>2.14.9</b>	<b>Buildings</b>						<b>466,830.00</b>
2.14.9.1	Prefabricated Control and Communications Building	1	117,000.00	117,000.00	466,830.00	467,000.00	466,830.00
<b>2.14.10</b>	<b>Electromechanical assembly</b>						<b>798,000.00</b>
2.14.10.1	Assembly, Transport and Miscellaneous (pa)	1	200,000.00	200,000.00	798,000.00	798,000.00	798,000.00
<b>2.14.11</b>	<b>Complementary Installations</b>						<b>143,640.00</b>
2.14.11.1	Lighting and power system (pa)	1	25,000.00	25,000.00	99,750.00	100,000.00	99,750.00
2.14.11.2	Ventilation and air-conditioning system (pa)	1	5,000.00	5,000.00	19,950.00	20,000.00	19,950.00
2.14.11.3	Fire protection system (pa)	1	6,000.00	6,000.00	23,940.00	24,000.00	23,940.00

ITEM.	DESCRIPTION		QTY	UNIT COST (€)	TOTAL COST (€)	UNIT COST (SAR)	UNIT COST (SAR)	TOTAL COST (SAR)
<b>4</b>	<b>380 KV OVERHEAD LINES</b>							<b>260.880.261.00</b>
<b>4.1</b>	<b>380 KV OHL JUBAIL 2 380/230 KV - JUBAIL 3-S/S-1</b>							<b>14.429.368.00</b>
4.1.1	Towers	Ton	400	2.850,00	1.140.000,00	11.371,50	11.400,00	4.560.000,00
4.1.2	Cable conductor ACSR CURLEW (590.2 mm2)	km	49,01	44.000,00	2.156.440,00	175.560,00	175.600,00	8.606.156,00
4.1.3	Cable ground-communication	km	8,17	7.150,00	58.415,50	28.528,50	28.600,00	233.662,00
4.1.4	Insulators strings for cable conductor	ud	240	170,00	40.800,00	678,30	680,00	163.200,00
4.1.5	Insulators strings for cable ground-communications	ud	40	170,00	6.800,00	678,30	680,00	27.200,00
4.1.6	Accessories (signaling plate, bird savers, junction boxes, etc)	km	3	3.500,00	11.900,00	13.965,00	14.000,00	47.600,00
4.1.7	Foundations	m3	330	510,00	168.300,00	2.034,90	2.035,00	671.550,00
4.1.8	Grounding of tower	ud	10	3.000,00	30.000,00	11.970,00	12.000,00	120.000,00
<b>4.2</b>	<b>380 KV OHL JUBAIL 3-S/S-1 - JUBAIL 3-S/S-2</b>							<b>54.480.742.00</b>
4.2.1	Towers	Ton	1.280	2.850,00	3.648.000,00	11.371,50	11.400,00	14.592.000,00
4.2.2	Cable conductor ACSR CURLEW (590.2 mm2)	km	170,20	44.000,00	7.488.800,00	175.560,00	175.600,00	29.887.120,00
4.2.3	Cable ground-communication	km	28,37	7.150,00	202.845,50	28.528,50	28.600,00	811.382,00
4.2.4	Insulators strings for cable conductor	ud	768	170,00	130.560,00	678,30	680,00	522.240,00
4.2.5	Insulators strings for cable ground-communications	ud	128	170,00	21.760,00	678,30	680,00	87.040,00
4.2.6	Accessories (signaling plate, bird savers, junction boxes, etc)	km	432	3.500,00	1.512.000,00	13.965,00	14.000,00	6.048.000,00
4.2.7	Foundations	m3	1.056	510,00	538.560,00	2.034,90	2.035,00	2.148.960,00
4.2.8	Grounding of tower	ud	32	3.000,00	96.000,00	11.970,00	12.000,00	384.000,00
<b>4.3</b>	<b>380 KV OHL JUBAIL 3-S/S-1 - JUBAIL 3-S/S-3</b>							<b>22.947.446.00</b>
4.3.1	Towers	Ton	560	2.850,00	1.596.000,00	11.371,50	11.400,00	6.384.000,00
4.3.2	Cable conductor ACSR CURLEW (590.2 mm2)	km	70,16	44.000,00	3.087.040,00	175.560,00	175.600,00	12.320.096,00
4.3.3	Cable ground-communication	km	11,70	7.150,00	83.655,00	28.528,50	28.600,00	334.620,00
4.3.4	Insulators strings for cable conductor	ud	336	170,00	57.120,00	678,30	680,00	228.480,00
4.3.5	Insulators strings for cable ground-communications	ud	56	170,00	9.520,00	678,30	680,00	38.080,00
4.3.6	Accessories (signaling plate, bird savers, junction boxes, etc)	km	181	3.500,00	633.500,00	13.965,00	14.000,00	2.534.000,00
4.3.7	Foundations	m3	462	510,00	235.620,00	2.034,90	2.035,00	940.170,00
4.3.8	Grounding of tower	ud	14	3.000,00	42.000,00	11.970,00	12.000,00	168.000,00
<b>4.4</b>	<b>380 KV OHL JUBAIL 3-S/S-3 - JUBAIL 3-S/S-4</b>							<b>77.825.594.00</b>
4.4.1	Towers	Ton	1.760	2.850,00	5.016.000,00	11.371,50	11.400,00	20.064.000,00
4.4.2	Cable conductor ACSR CURLEW (590.2 mm2)	km	247,70	44.000,00	10.898.800,00	175.560,00	175.600,00	43.496.120,00
4.4.3	Cable ground-communication	km	41,29	7.150,00	295.223,50	28.528,50	28.600,00	1.180.894,00
4.4.4	Insulators strings for cable conductor	ud	1.056	170,00	179.520,00	678,30	680,00	718.080,00
4.4.5	Insulators strings for cable ground-communications	ud	176	170,00	29.920,00	678,30	680,00	119.680,00
4.4.6	Accessories (signaling plate, bird savers, junction boxes, etc)	km	626	3.500,00	2.191.000,00	13.965,00	14.000,00	8.764.000,00
4.4.7	Foundations	m3	1.452	510,00	740.520,00	2.034,90	2.035,00	2.954.820,00
4.4.8	Grounding of tower	ud	44	3.000,00	132.000,00	11.970,00	12.000,00	528.000,00
<b>4.5</b>	<b>380 KV OHL JUBAIL 3-S/S-4 - EXISTING 380 KV OHL</b>							<b>91.197.111.00</b>
4.5.1	Towers	Ton	2.060	2.850,00	5.871.000,00	11.371,50	11.400,00	23.484.000,00
4.5.2	Cable conductor ACSR CURLEW (590.2 mm2)	km	314,79	44.000,00	13.850.760,00	175.560,00	175.600,00	55.277.124,00
4.5.3	Cable ground-communication	km	52,47	7.150,00	375.160,50	28.528,50	28.600,00	1.500.642,00
4.5.4	Insulators strings for cable conductor	ud	1.392	170,00	236.640,00	678,30	680,00	946.560,00
4.5.5	Insulators strings for cable ground-communications	ud	232	170,00	39.440,00	678,30	680,00	157.760,00
4.5.6	Accessories (signaling plate, bird savers, junction boxes, etc)	km	399	3.500,00	1.396.500,00	13.965,00	14.000,00	5.586.000,00
4.5.7	Foundations	m3	1.915	510,00	976.650,00	2.034,90	2.035,00	3.897.025,00
4.5.8	Grounding of tower	ud	29	3.000,00	87.000,00	11.970,00	12.000,00	348.000,00

ITEM.	DESCRIPTION		QTY	UNIT COST (€)	TOTAL COST (€)	UNIT COST (SAR)	UNIT COST (SAR)	TOTAL COST (SAR)
<b>7</b>	<b>380 KV EXPANSION OF EXISTING SUBSTATIONS</b>							<b>93.192.111,00</b>
<b>7.1</b>	<b>INTERCONNECTION IN JUBAIL 2 380/230 KV SUBSTATION</b>							<b>1.995.000,00</b>
<b>7.1.1</b>	<b>Expansion Jubail 2 380/230 kV with two (2) existing non-energized bays</b>							<b>1.995.000,00</b>
7.1.1.1	Necessary equipment and accessories for the expansion Jubail 2 380/230 kV (protection relays, measurement equipments, wires, cable trays, etc)		2	250.000,00	500.000,00	997.500,00	997.500,00	1.995.000,00
<b>7.1.2</b>	<b>Expansion Jubail 2 380/230 kV with building of two (2) new bays (Optional)</b>							<b>3.685.900,00</b>
7.1.2.1	380 kV System							<b>2.746.900,00</b>
7.1.2.1.1	Three-phase circuit breaker, SF6, 420 kV, 3.150 A		3	64.000,00	192.000,00	255.360,00	255.500,00	766.500,00
7.1.2.1.2	Three-phase line disconnector switch with earthing blades, 420 kV, 3.150 A		2	45.000,00	90.000,00	179.550,00	180.000,00	360.000,00
7.1.2.1.3	Three-phase busbar disconnector switch, 420 kV, 3.150 A		6	45.000,00	270.000,00	179.550,00	180.000,00	1.080.000,00
7.1.2.1.4	One-phase current transformers		9	5.000,00	45.000,00	19.950,00	20.000,00	180.000,00
7.1.2.1.5	One-phase voltage transformers, transformer ratio 380√3 : 0.110√3 - 0.110√3 - 0.110 kV		6	5.300,00	31.800,00	21.147,00	21.500,00	129.000,00
7.1.2.1.6	One-phase surge arrester 420 kV		6	1.800,00	10.800,00	7.182,00	7.200,00	43.200,00
7.1.2.1.7	One-phase terminal cables 420 kV		3	1.500,00	4.500,00	5.985,00	6.000,00	18.000,00
7.1.2.1.8	Lightning Rods		12	1.200,00	14.400,00	4.788,00	4.800,00	57.600,00
7.1.2.1.9	Metal structure with hardware and screws (kg)		12250	1,80	22.050,00	7,18	7,20	88.200,00
7.1.2.1.10	Aluminium tube 200/184 (mm) or 250/230 (mm)		100	50,00	5.000,00	199,50	200,00	20.000,00
7.1.2.1.11	Bare copper wire (kg)		100	11,00	1.100,00	43,89	44,00	4.400,00
7.1.2.2	Control, Protection and Auxiliary Services							<b>939.000,00</b>
7.1.2.2.1	Control, protection and measurement cabinets		1	100.000,00	100.000,00	399.000,00	399.000,00	399.000,00
7.1.2.2.2	Bay Control Unit (BCU)		2	67.500,00	135.000,00	269.325,00	270.000,00	540.000,00
<b>7.2</b>	<b>INTERCONNECTION IN 380 KV OVERHEAD LINE "TO NURSERY ROAD"</b>							<b>91.197.111,00</b>
<b>7.2.1</b>	<b>Incoming/outgoing of the 380 KV OHL (Quadruple circuit)</b>							<b>91.197.111,00</b>
7.2.1.1	Towers	Ton	2.060	2.850,00	5.871.000,00	11.371,50	11.400,00	23.484.000,00
7.2.1.2	Cable conductor ACSR CURLEW (590.2 mm2)	km	314,79	44.000,00	13.850.760,00	175.560,00	175.600,00	55.277.124,00
7.2.1.3	Cable ground-communication	km	52,47	7.150,00	375.160,50	28.528,50	28.600,00	1.500.642,00
7.2.1.4	Insulators strings for cable conductor	ud	1.392	170,00	236.640,00	678,30	680,00	946.560,00
7.2.1.5	Insulators strings for cable ground-communications	ud	232	170,00	39.440,00	678,30	680,00	157.760,00
7.2.1.6	Accessories (signaling plate, signaling devices, junction boxes, etc)	ud	399	3.500,00	1.396.500,00	13.965,00	14.000,00	5.586.000,00
7.2.1.7	Foundations	m3	1.915	510,00	976.650,00	2.034,90	2.035,00	3.897.025,00
7.2.1.8	Grounding of tower	ud	29	3.000,00	87.000,00	11.970,00	12.000,00	348.000,00