بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering

Title

A Study and Analyses Beit-Aulla Power Station

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الاهداء

الى معلمنا الأول ومعلم الناس الخير نبينا محمد "صلى الله عليه وسلم"

الى من زرعوا في نفوسنا الطموح والمثابرة ....

الى من ترك صوته في اذني. الأقرب الى روحي، والأعمق في ذاكرتي

والدي العزيز رحمه الله.

الى ينابيع المحبة والعطاء.... امهاتنا الأحبه

الى معنى الحب والتفاني، الى بسمة الحياة وسر الوجود،

الى من كان دعائها سر نجاحي أغلى الحبايب والدتي العزيزة ادامها الله وجزاها عنا كل خير.

الى من يحملون في نفوسهم ذكريات الطفولة والشباب ... إخوتنا وأخواتنا

الى من مهدو لنا طريق العلم والمعرفة .... أساتذتنا الأفاضل

الى من هم احياء في قلوبنا رغم انهم غادرونا

الى من قدموا الغالي والنفيس لهذا الوطن.... اسرانا البواسل وشهدائنا الابرار

الى كافة الأصدقاء والأهل والأحبة

بعد رحلة بحث وجهد تكللت بإنجاز هذا البحث، نحمد الله عز وجل على نعمه التي من بها علينا فهو العلي القدير، كما لا يسعنا إلا أن نتقدم بأسمى عبارات الشكر والتقدير

للدكتور ماهر مغالسة

وله نقول بشراك قول رسولنا صلى الله عليه وسلم:

"ألا أخبرك عن الأجود الأجود؟ . الله الأجود الأجود، وأنا أجود ولد آدم، وأجودكم من بعدي رجل علم علما فنشر علمه؛ يبعث يوم القيامة أمة وحده ان كان هناك اهل للشكر ف أنت اهله"

فريق العمل

Abstract

This project shows a power distribution sub-station located in the Beit Ula area, north of Hebron, where this station converts voltage from 161/33 kilovolts, and works on distributing electricity to several areas.

In this project, you will learn about the main parts of the station and the capacity of this station at present and in the future.

The load of this station was studied over 30 years and some areas were proposed (Deir Samet, Beit Makdoom, Dura, Yatta, Beit Awa, Ethna, Beit Ula, Tarqumiya).

Where the increase in the load in these areas, and the increase in the population, was studied to find out the required quantity to be produced from the station to feed these loads.

The impact of renewable energy projects on these loads and how they help reduce the load on this station was studied.

The station was simulated by ETAP, and study the increase in loads and population growth by using the Excel program.

الملخص

هذا المشروع يوضح محطة فرعية لتوزيع الطاقة التي تقع في منطقة بيت أولا شمال الخليل حيث تقوم هذه المحطة بتحويل الجهد من 33/161كيلو فولت ,وتعمل على توزيع الكهرباء لعدة مناطق .

في هذا المشروع سوف تتعرف على أجزاء المحطة الرئيسية وقدرة هذه المحطة في الوقت الحالي والمستقبلي حيث تم دراسة الحمل لهذه المحطة خلال 30سنة وتم اقتراح بعض المناطق (دير سامت, بيت مقدوم, دورا, يطا, بيت عوا, أذنا, بيت أولا, ترقوميا).

حيث تم دراسة تزايد الحمل في هذه المناطق, وتزايد عدد السكان, لمعرفة الكمية الازمة انتاجها من المحطة لتغذية هذه الاحمال .

وتم دراسة تأثير مشاريع الطاقة المتجددة على هذه الاحمال وكيف تساعد في تقليل الحمل عن هذه المحطة.

تمت محاكاة المحطة عن طريق برنامج الأيتاب وتمت دراسة التزايد في الأحمال والتزايد السكاني عن طريق برنامج الأيكسل.

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Overview

A power station, also referred to as a power plant and sometimes generating station or generating plant, is an industrial facility for the generation of electric power. Power stations are generally connected to an electrical grid. An electrical substation is a subsidiary station of an electricity generation, transmission and distribution system, where voltage transformed from high to low or the reverse using transformers. Electric power may flow throw several substations between generating plant and consumer, and may be change in voltage in several steps. The station is located in the village of Beit Ula, north of Hebron city, with an area of 10 dunums. It works on converting electrical energy from high voltage (161 kV) to medium voltage (33 kV), with a capacity of (90 MW), which can be increased in the future to reach (180 MW). The station is expected to feed the surrounding areas.

The idea of the project is to study and analysis distribution substation and capacity and loads for (30years), with the future loads we suggestion it in this project.

Project Motivation

1 Increase our information about the distribution substation.
2 Find a solution for some villages has problem with electricity.

1.3 Project Important

- Study the capabilities of the substation.
- Explain the capacity of this substation.
- Suggestion loads for substation.
- Study the load for 30 years.

1.4 Project Objectives

- Study and analysis of the Beit-Aula station to ensure 30 years or more of generation with the best efficiency.
- Suggestion feeders in future.

- Study the increase in the demand for photovoltaic (PV) system.
- Study the capacity for 30 years.
- Study the effect of PV system on network.

1.5 Challenges

- Difficulties in data collection, because the required data (pregnancy prediction algorithm or load growth) is not effective for some time periods.
- The lack of a universal standard for the voltage level (33 kV).
- Lack of case studies about the voltage level (33 kV).
- limited knowledge of the forecasting and planning process due to lack of education courses.

1.6 Time Schedule

This table illustrate the tasks that we did and how long it takes weekly for each task.

Week Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Task 1																	
Task 2																	
Task 3																	
Task 4																	
Task 5																	

Week Tasks	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Task 6																			
Task 7																			
Task 8																			
Task 9																			
Task 10																			

Task 1: Selection project.

Task 2: Data collection.

Task 3: Study the load growth.

Task 4: Design the substation.

Task 5: Design the distribution line for the system.

Task 6: Finishing the introduction to graduation project book.

Task 7: Make the necessary adjustments to the content of introduction to the graduation project.

Task 8: Study the effect of pv system on distribution system.

Task 9: Simulate the distribution system by using ETAP and excel.

Task 10: Finishing the graduation project book and prepare the presentation

Chapter two SUBSTATION

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2.1 Introduction

An electrical subsidiary station of an electricity generation, transmission and distribution system, where voltage transformed from high to low or the reverse using transformers. Electrical power may flow through several substations between generating plant consumer, and may be change in voltage in several steps.

A substation that has a step-up transformer increases the voltage while decreasing the current, while a step-down transformer decreases the voltage while increasing the current for domestic and commercial distribution. Besides changing the voltage, the job of the distribution substation is to isolate faults in either the transmission or distribution systems.

Distribution substations may also be the point of voltage regulation, although on long distribution circuits (several km/miles), voltage regulation equipment may also be install along the line. Complicated distribution substations can be find in the downtown areas of large cities, with high- voltage switching, and switching and backup systems on the low-voltage side.

Figure2.1: Electrical Substation

2.2 Important Definitions

2.2.1 Electrical Power System:

Electrical energy is produced through an energy conversion process. The electric power system is a network of interconnected components which generate electricity by converting different from of energy, (Potential energy, Kinetic energy, or chemical energy) are the most common forms of energy converted to electrical energy; and transmit the electrical energy to load center to be used by the consumer. The production and transmission of electricity is relatively efficient and inexpensive, although unlike other forms of energy, electricity is not easily stored and thus must generally be used as it is being produced.

The electric power system consists of three main subsystems: the generation subsystem, the transmission subsystem, and the distribution subsystem. Electricity is generated at the generation station by converting a primary source of energy to electrical energy. The voltage output of the generators is then stepped-up to appropriate transmission levels using a step-up transformer. The transmission subsystem then transmits the power close to the load centers. The voltage is then stepped-down to appropriate levels. The distribution subsystem then transmit the power close to the consumer where the voltage is stepped-down to appropriate levels for use by a residential, industrial, or commercial customer.

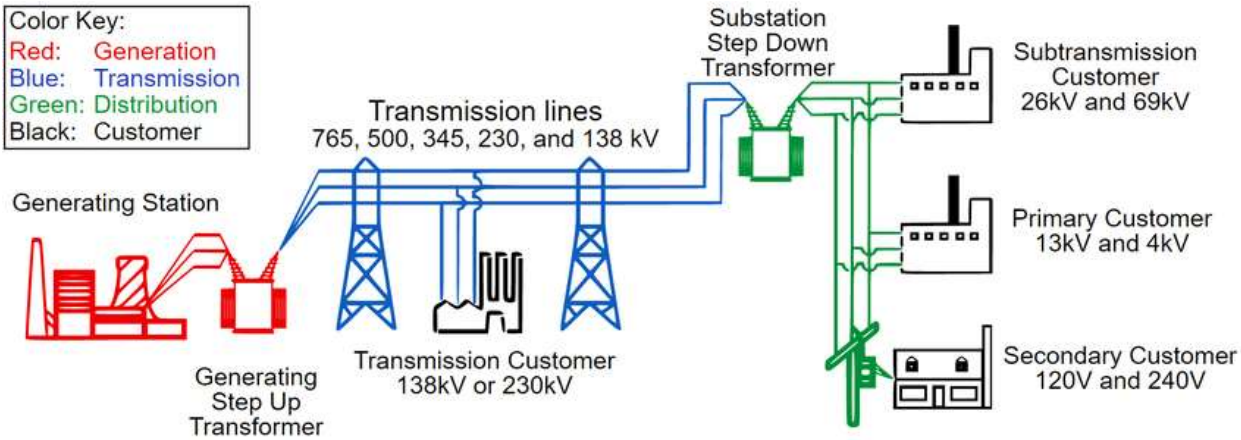

Figure2.2: structure of the electrical power system.

2.2.2 Power System Protection

Is a branch of electrical power engineering that deals with the protection of electrical power systems from faults[citation needed] through the disconnection of faulted parts from the rest of the electrical network. The objective of a protection scheme is to keep the power system stable by isolating only the components that are under fault, whilst leaving as much of the network as possible still in operation. The devices that are used to protect the power systems from faults are called protection devices.

2.2.3 Power-Flow Study

Power flow, or load flow, is widely used in power system operation and planning. The power flow model of a power system is built using the relevant network, load, and generation data. Outputs of the power flow model include voltages at different buses, line flows in the network, and system losses.

2.2.4 Load Profile

In a power system, a load curve or load profile is a chart illustrating the variation in demand/electrical load over a specific time. Generation companies use this information to plan how much power they will need to generate at any given time. A load duration curve is similar to a load curve.

2.2 Definition of Substation

A substation is a part of an electric generation, transmission, and distribution system, substation transform voltage from high to low, or the reverse, or perform any several other important functions, between the generating station and consumer, electric power may flow through several substations at different voltage levels.

2.3 Classification of Substation

1. Based on Service

- Transformer substation transform power from one voltage to another voltage.
- Switching substation switching of power lines without transforming voltage.
- Converting substation-conversion of AC-DC-AC(for HDVC transmission).

2. Based on Voltage

- High voltage substation 11kv-66kv.
- Extra high voltage substation 132kv-400kv.
- Ultra high voltage substation voltage above 400kv.

3. Based on Installation

- Outdoor substation.
- Indoor substation.
- Usually for<66KV.

- Heavily polluted areas.
- Adverse climatic conditions.
- Need for high reliability.
- Space constraints.

2.4 Function of a Substation

- The purpose of a substation is to “step down” high voltage electricity from the transmission system to lower voltage electricity so it can be easily supplied to homes and businesses through our distribution lines.
- Supply electric power to consumers continuously.
- Supply of electric power within specified voltage limits.
- Shortest possible fault duration.
- Optimum efficiency of electrical network.

Design of Substations

Substations generally have:

1. Switching equipment
2. Protection equipment
3. Control equipment
4. One or more transformers

The substation categorized as:

1. Distribution substations

   Distribution substation is a combination of switching, controlling and voltage step-down equipment.

2. Switching Substations

   A switching substation is a combination of switching and controlling equipment arranged to provide circuit protection and system switching flexibility.

3. Transmission Substations

   A transmission substation is a combination of switching, controlling, and voltage step-down equipment arranged to reduce transmission voltage to sub transmission voltage for distribution of electrical energy to distribution substations. Transmission substations frequently have two or more large transformers.

In a large substation, circuit breakers are using to interrupt any short-circuits or overload currents that may occur on the network. In smaller distribution stations, recloser circuit breakers should be using for protection of distribution circuits. Other devices such as capacitors and voltage regulators may also be located at a substation.

Substations may be on the surface in fenced enclosures, underground, or located in special-purpose buildings.

The design may include the following equipment:

1. The proper scheme
2. Power transformers
3. Circuit Breaker
4. Current transformers & Voltage transformers
5. Surge Arresters
6. Isolators
7. Wave trap
8. Insulator
9. Earth switch
10. Earthing system
11. Control panel

2.5.1 The proper scheme

The selection of a particular substation scheme is based upon

- ✓ Safety.
- ✓ Reliability.
- ✓ Economy.
- ✓ Simplicity.
- ✓ Other considerations.

The most commonly used substation bus schemes include

(1) Single bus scheme.

(2) Double bus–double breaker scheme.

(3) Main-and-transfer bus scheme.

(4) Double bus–single breaker scheme.

(5) Ring bus scheme.

(6) Breaker-and-a-half scheme.

Table 2.1: Comparison between the buses of layout system

Type of scheme	**Reliability**	**Cost**	**Available Area**
Single bus	Least reliable	Least cost	Least area
Sectionalized Bus	Highly reliable	High cost	Greater area
Main and transfer bus	Least reliable	Moderate cost	Low area
Ring Bus	High reliability	Moderate cost	Moderate area
Breaker-and-a-Half	Highly reliable	Moderate cost	Greater area
Double bus–double breaker	Moderately reliable	Moderate cost	Moderate area

To get main object of substation the ring bus scheme will selected; because it allows relatively faster service restoration when a fault occurs on one of the sub transmission circuits.

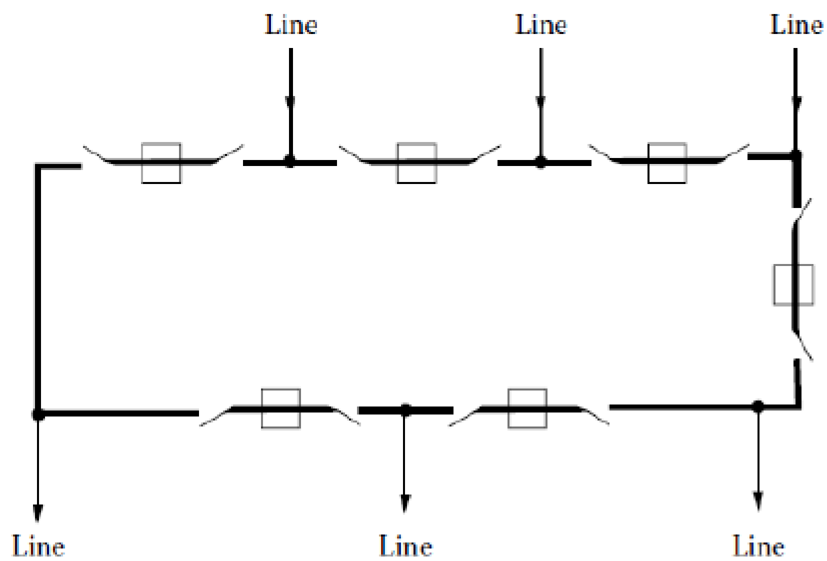

Figure 2.3 Ring bus scheme

25.2 Power Transformers

The transformer is the most important part of the transformer substation. The choice of transformer affects the design of the substation and is make on basis of several factors primarily:

- ✓ Characteristics of the User installation
- ✓ Level of continuity of service required
- ✓ Location of the electrical substation

Some important characteristics must consider and define according to the product standard:

- ✓ Type of transformer, for example with n separate windings or autotransformer, etc.
- ✓ Single-phase or three-phase.

- ✓ Frequency.
- ✓ Dry or in insulating liquid, and in the latter case what kind of liquid (oil, natural or synthetic liquid, etc.).
- ✓ For internal or external.
- ✓ Rated power for each winding.
- ✓ Nominal voltage for each winding (and therefore the transformation ratio).
- ✓ Type of cooling**.**
- ✓ Presence of load or no-load tap-changer.
- ✓ Earthing connections and method for each winding**.**

The transformers shall be double copper wound, three phase, oil immersed,161kV/33 kV ,50 Hz, with on –load Tap changer with Transformer only & off--load tap changer for other mounted in the high voltage End.

Selection of the location of a substation must consider many factors:

- ✓ Sufficient land area
- ✓ Necessary clearances for electrical safety
- ✓ Access to maintain large apparatus such as transformers.
- ✓ The site must have room for expansion; due to load growth or planned transmission additions.
- ✓ Environmental effects (drainage, noise and road traffic effects).
- ✓ Grounding must be taking into account to protect passers-by during a short-circuit in the transmission system
- ✓ The substation site must be reasonably central to the distribution area.

Note: Appendix G1 Transformer characteristic

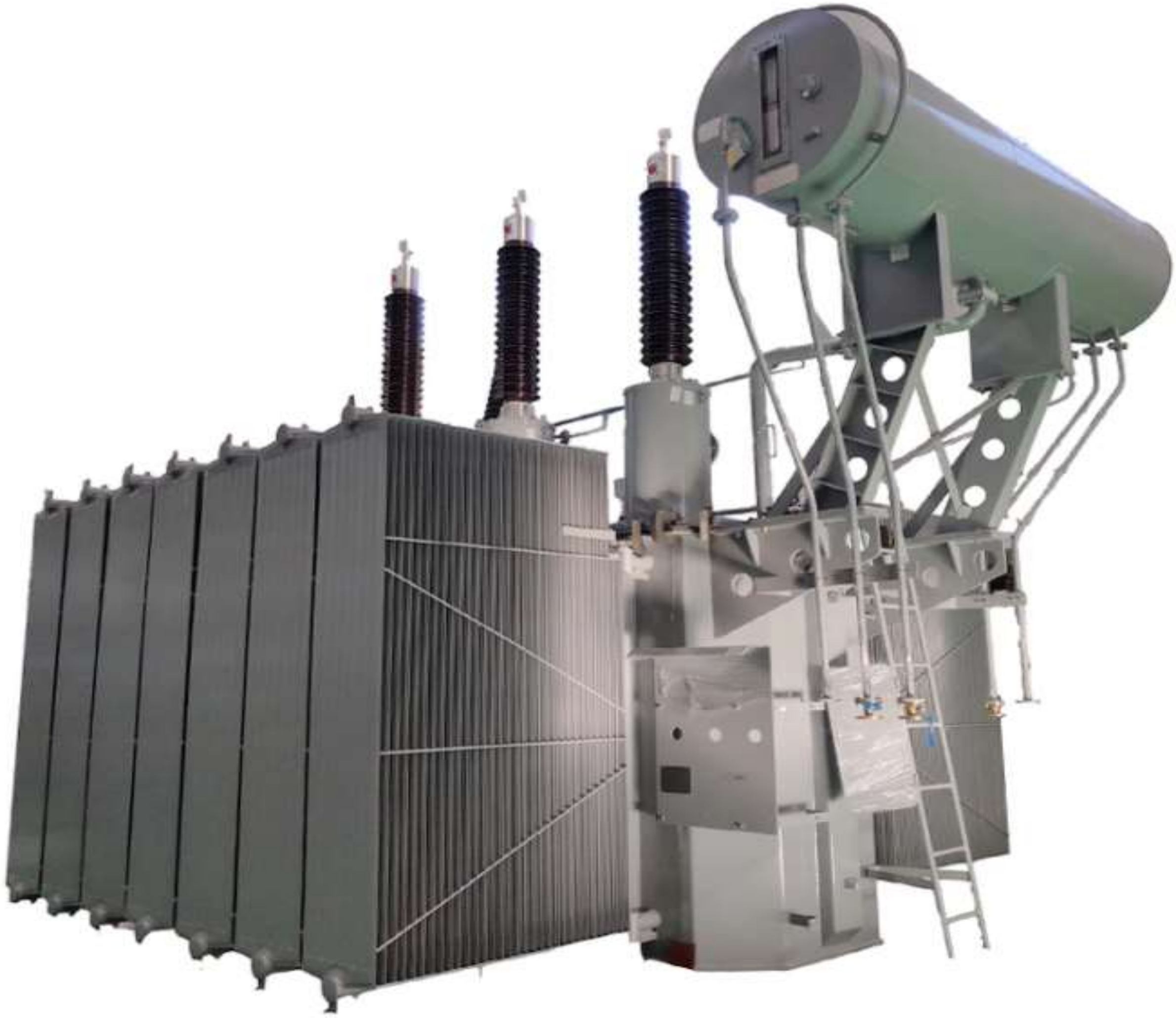

Figure 2.4: 161/36 KV 50 MVA power transformer

The design is typical single bus distribution substation that is feeding by single incoming 161 kV lines feeding two 161 kV/33 kV transformers.

There is one substation located at Beat-Aulla, step-down substation (161kV/33kV), and this substation has two transformer for each transformer 45 MVA but it still run with one transformer right now. The plan for this substation, it will run with 180 MVA with four transformers.

The final single line diagram for design will be like this.

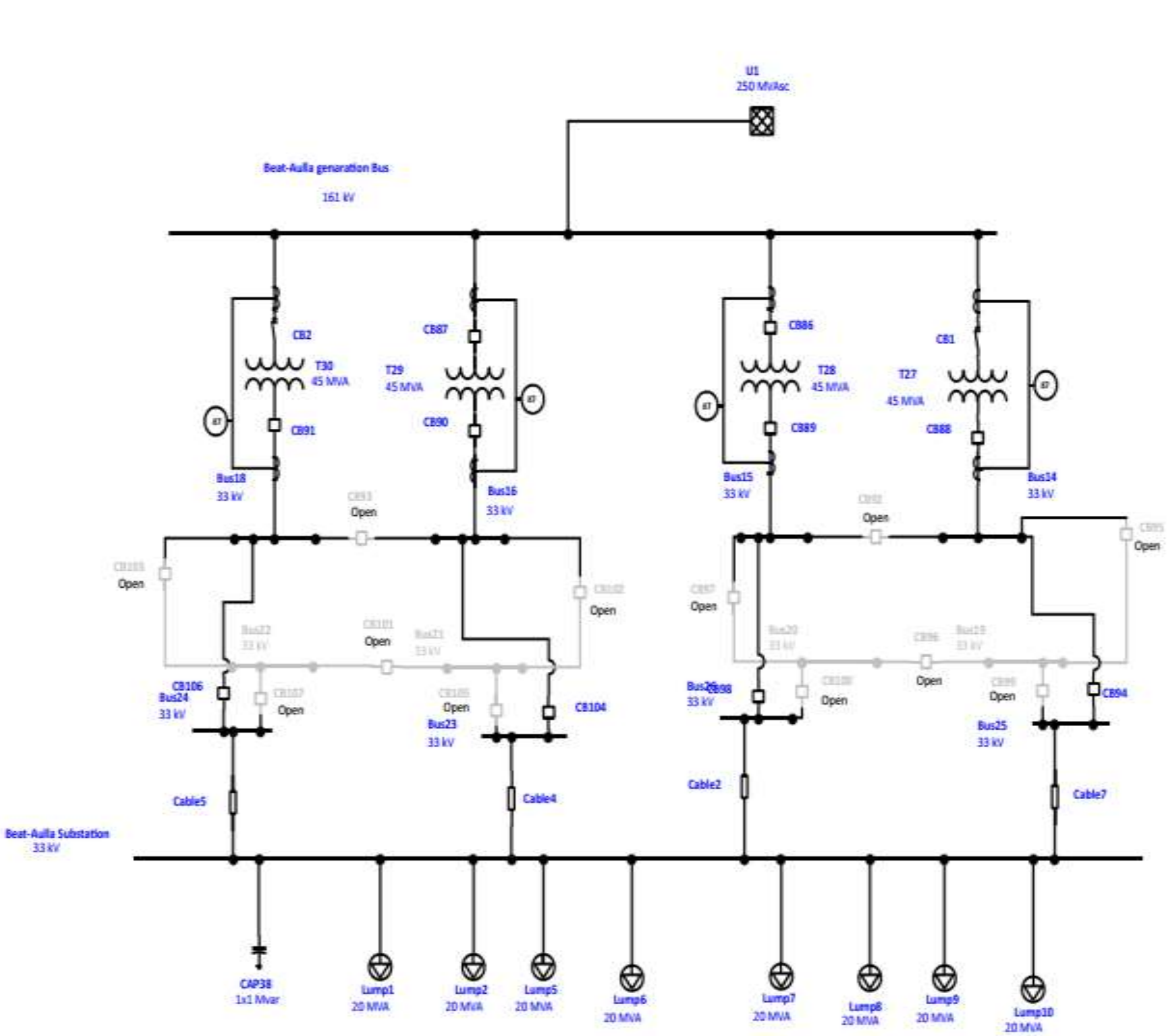

Figure 2.5: Single line diagram for substation.

Impedance:

Transformer impedance affects transformer voltage regulation, efficiency, and magnitude of through short-circuit currents. Both regulation and efficiency are generally improved with lower impedance.

For each transformer the impedance is 20%.

Protection:

Differential relay used to protect transformer, the current for each transformer will be at maximum power:

$$I = \frac{s}{\sqrt{3} * V} = \frac{45M}{\sqrt{3} * 33kV} = 787.29A \qquad (2.1)$$

$$I_1 - I_2 = m * \frac{I_1 + I_2}{2} \qquad (2.2)$$

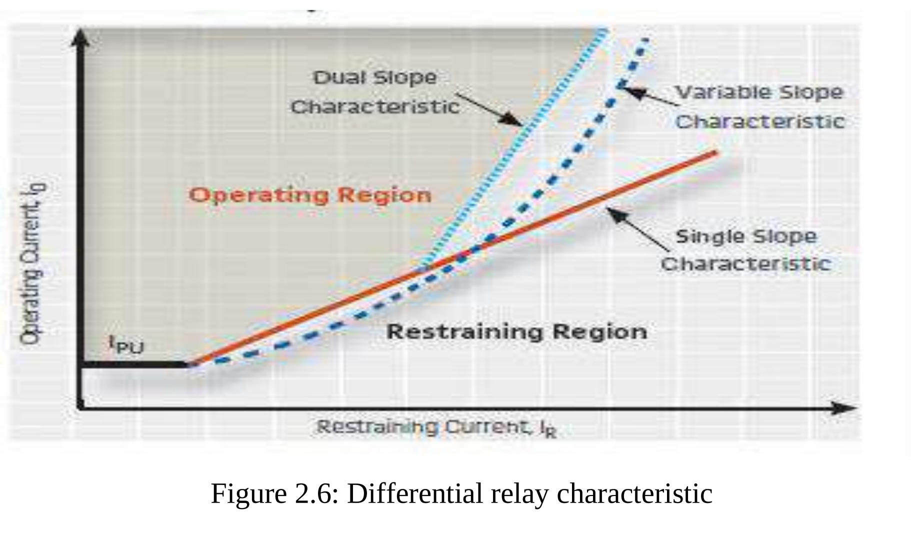

Figure 2.6: Differential relay characteristic

2.5.3 Circuit Breakers

circuit breaker is a device that closes and interrupts (opens) an electric circuit between separable contacts under both load and fault conditions, the power circuit breaker is limited to circuit breakers rated 1000 volts and above. A circuit breaker must be capable to make and break all the load and fault currents that it might be subject to at the specific installation.

Key factors with circuit breakers performance are; opening (break) and closing (make) time, rated continuous current-carrying capability, rated dynamic short circuit withstand capability, rated thermal short circuit withstand capability, maximum operation voltage and rated operation sequence.

Note: Circuit Breaker characteristic(Appendix G3).

Fig2.7: Alstom High Voltage Circuit Breaker

2.5.4 Instrument Transformers

Instrument Transformers are define as the instruments in which the secondary current or voltage is substantially proportional to the primary current or voltage and differs in phase from it by an angle, which is approximately zero for an appropriate direction of connection.

Direct measurement of current or voltage in high voltage system is not possible; because of high values and insulation problems of measuring instruments; because it is can't directly used for protection purposes.

Instrument transformers are of two types:

1. Current Transformers.
2. Voltage Transformers.

Current Transformer (CT)

It is use for measurement of alternating electric current. Current transformer is a current measuring device used to measure the currents in high voltage lines directly by stepping down the currents to measurable values by means of electromagnetic circuit. When current in a circuit is too high to apply directly to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments.

The most common CT secondary full-load current is 5 amps which matches the standard 5-amp full-scale current rating of switchboard indicating devices, power metering equipment, and protective relays. CTs with a (1) ampere full-load value and matching instruments with a (1) ampere full-range value are also available. Many new protective relays are programmable for either value.

Figure 2.8: Current Transformer

The basic principle induced in designing of current transformers is Primary ampere turns = Secondary ampere turns

$$\frac{I_p}{N_p} = \frac{I_s}{N_s} \quad (2.3)$$

Where,

Ip: Primary current

Np: Primary winding Turns

Is: Secondary current

Ns: Secondary Winding Turn

Voltage Transformers (VT)

Also called Potential Transformers (PT), parallel connect type of instrument transformer. They are design to present negligible load to the supply, being measure and have an accurate voltage ratio and phase relationship to enable accurate secondary connected metering.

It gives the reference voltage to the Relay for Over-voltage or Under-voltage Protection.

Figure 2.9: : Oil-paper insulated inductive voltage transformers type EOF.

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The basic principle involved in the designing of Voltage Transformer is

Voltage Ratio = Turns Ratio (2.4)

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

As heavy primary voltages will be reduce to low secondary voltages, it will have more turns in the primary and less turns in the secondary. It must always connected in parallel only.

Even if we connect it directly from high voltage to earth, it is not going to be a short circuit as its primary winding has very high resistance. Its core is a set of assembled laminations. It operates at constant flux density.

2.5.5 Surge Arresters

Surge arresters are used to protect high-voltage equipment in substations, such as transformers, circuit breakers, and bushings, against the effects of over voltages caused by incoming surges.

Note: High voltage isolator switch characteristic(Appendix G2).

Fig2.10: Surge arresters

2.5.6 Isolator and insulator

Isolator

Electrical isolators separate a part of the system from rest for safe maintenance works. So definition of isolator can be rewritten as Isolator is a manually operated mechanical switch which separates a part of the electrical power. Isolators use to open a circuit under no load. Its main purpose is to isolate one portion of the circuit from the other and not intended to be open, while current is flowing in the line. Isolators are generally used on both ends of the breaker in order that repair or replacement of circuit breaker can be done without and danger.

Types of Electrical Isolators:

There are different types of isolators available depending upon system requirement such as

1. Double Break Isolator.
2. Single Break Isolator.
3. Pantograph type Isolator.

Depending upon the position in power system, the isolators can be categorize as:

1. Bus side isolator – the isolator is directly connect with main bus.
2. Line side isolator – the isolator is situate at line side of any feeder.
3. Transfer bus side isolator – the isolator is directly connect with transfer bus.

Insulators

A very flexible coating of an insulator is often applied to electric wire and cable, this is called insulated wires commonly use just air, since a solid (e.g. plastic) coating is impractical. However, wires that touch each other produce cross connections, short circuits, and _re hazards. In coaxial cable the center conductor must be supported exactly in the middle of the hollow shield in order to prevent EM wave reflections. Finally, wires that expose voltages higher than 60 V can cause human shock and electrocution hazards. Insulating coatings help to prevent all of these problems.

Some wires have a mechanical covering with no voltage rating e.g.: service-drop, welding, doorbell, thermo-stat wire. An insulated wire or cable has a voltage rating and a maximum conductor temperature rating. It may not have an ampacity (current-carrying capacity) rating, since this is dependent upon the surrounding environment (e.g. ambient temperature).

Types of insulators

In terms of the type of material manufactured:

1. Glass insulators.

2. Rubber insulators.

3. Porcelain insulators.

In terms of design:

1. Cap & Pin type insulator.
2. Long rod type insulator.

In terms of type of tower mounted on two types:

1. Tension Insulators.
2. Suspension Insulators.

2.5.7 Wave trap

Wave trap is an instrument using for trapping of the wave. The function of this wave trap is that it traps the unwanted waves. Its shape is like a drum. It is connected to the main incoming feeder so that it can trap the waves, which may be dangerous to the instruments in the substation.

Generally, it is use to exclude unwanted frequency components, such as noise or other interference, of a wave.

Figure 2.11: Wave trap.

This is relevant in power line carrier communication (PLCC) systems, for communication among various substations without dependence on the telecom company network. The signals are primarily protection signals and in addition, voice and data communication signals. The Line trap offers high impedance to the high frequency communication signals thus obstructs the flow of these signals in to the substation bus bars. If these are not present in the substation, then signal loss is more and communication will be ineffective/probably impossible.

2.5.8 Earth switch

Earth switch is very important equipment as per safety of humans. While taking should down of any Equipment first we have to discharge the charge stored in it before doing any work on that. So in order to discharge the charge we have to connect earth switch (Out Door substation) or cable earthing trolley (In Door substation). We have to put the earth switch in close position; because of voltage will induce in dead equipment due to line running beside it.

Earthing switches are using for earthing and short-circuiting disconnected sections of substation or plant. Earthing switches type TEC and TEB are suitable for outdoor installations. They can be supply as the single column free-stand earthing switch or as earthing switch built-on the same base frame together with dis-connector type SGF, TFB or SDB. In earthing switch type TEB, in the end position, the earthing blade is inserting upwards into earthing contact where it is held in place.

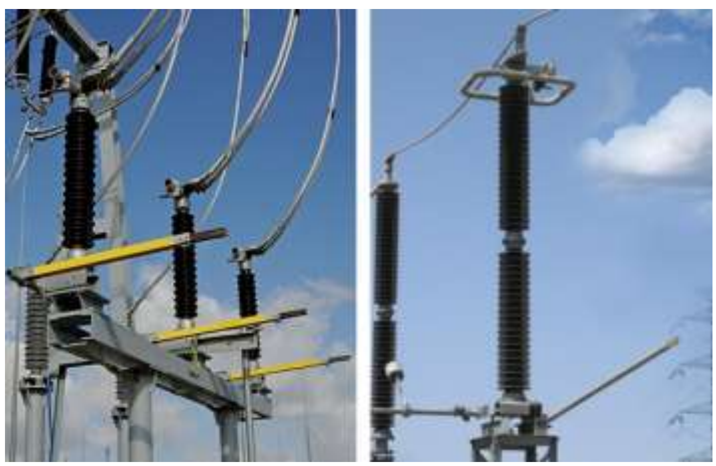


Figure 2.12: Earthing switches type TEC and TEB

2.5.9 Earthing system

The earthing of substation is one of the most important procedures that must be encouraged when designing any substation. The earthing system dose not only used to protecting workers in the substation or presence in one of its facilities only, but used to protect all components of the risk of faults and lightning. When designing a system, you should take reliability to consideration.

In principle of the safe earthing design has the following two objectives:

1. The purpose of the process is to provide a path for the current in certain circumstances without affecting the operation of the system.
2. Ensure that no person in the substation is exposing to electric shock due to faults or lightning.

The system is very important for a number of reasons, but all of them are relate to the protection of human and equipment located in the station, in addition to ensuring the optimal operation of the system. Among these reasons:

1. The earthing system provides a path for the current with low resistance for protecting both persons and equipment.
2. The earthing system provides low resistance path voltage transients such as lightning and surges or overvoltage's.
3. Equipotential bonding helps prevent electrostatic buildup and discharge, which can cause sparks with enough energy to ignite flammable atmospheres.
4. The earthing system provides a reference potential for electronic circuits and helps reduce electrical noise for electronic, instrumentation and communication systems.

Types of Earthing:

1. System Earthing. This system relates to the protection of equipment and devices located in the substation by stabilizing the voltage with respect to ground.

2. Equipment Earthing (Safety earthing). In this system, all the devices are connected with the ground in order to protect workers from the danger of electric shock.

In the earthing of the substations, the system earthing and safety earthing are interconnected to ensure the highest degree of protection and reliability.

Components of earthing system

1. Earth electrode.
2. Connecting cables.
3. Lightening arrester.
4. Earth mat.
5. Earth switch.

Types of earth electrode

1. Rod electrode.
2. Plate electrode.

2.5.10 Control Panel

The substation control panel is design to form automated control systems (SCADA) of the traction substations, using digital protection and programmable logic controllers.

Substation control panel provides:

- ✓ Telemechanical control of the substation (sending/receiving signals of telecommands, telemetry and tele signaling)
- ✓ Remote control of the substation (using integrated controls and indicating devices)
- ✓ Collection and transmission of the telemetry and diagnosing data via digital channels of the data transmission network (DTN)

Note: Switch Gear characteristic(Appendix G4).

Figure 2.13: Switch Gear.

With substation control panel, any traction substation may be reconstructed with gradual connection of the new smart controllers and bay terminals, while the unmodified equipment is still control with the existing telecommunications panel.

Substation control panel includes:

1. An operator station for remote equipment control.
2. A controller of the overall substation signaling.
3. A substation controller functioning as a concentrator of the substation information-control network.
4. An uninterruptible power system.
5. Interface convertors with galvanic separation.

Chapter three LITERATURE AND LOAD GROWTH

3.1 load growth

3.1.1 power consume

3.1.2 people growth

3.2 symmetrical components and fault analysis

3.2.1 faults

3.2.2 symmetrical components

3.3 reliability of transmission system

3.4 summary

3.1 Load growth

Load forecast study is a very important step to improving and designing the power system, where this study refer to the prediction of the load behavior in the future and it aims mainly to predict to the quantity of energy needed to meet the needs of customers, which is showing in appendix-B, the total demand is equal 181.2 MVA.

There are two types of forecast:

1. **Demand forecast**

   To predict the generation, transmission and distribution capacity required

2. **Energy forecast**

   To determine the type of generation facilities required.

3.1.1 Power Consumption

The figure below show the relation between the number of year and power consume, this data is the power growth from 2017-2050 for every town on the substation.

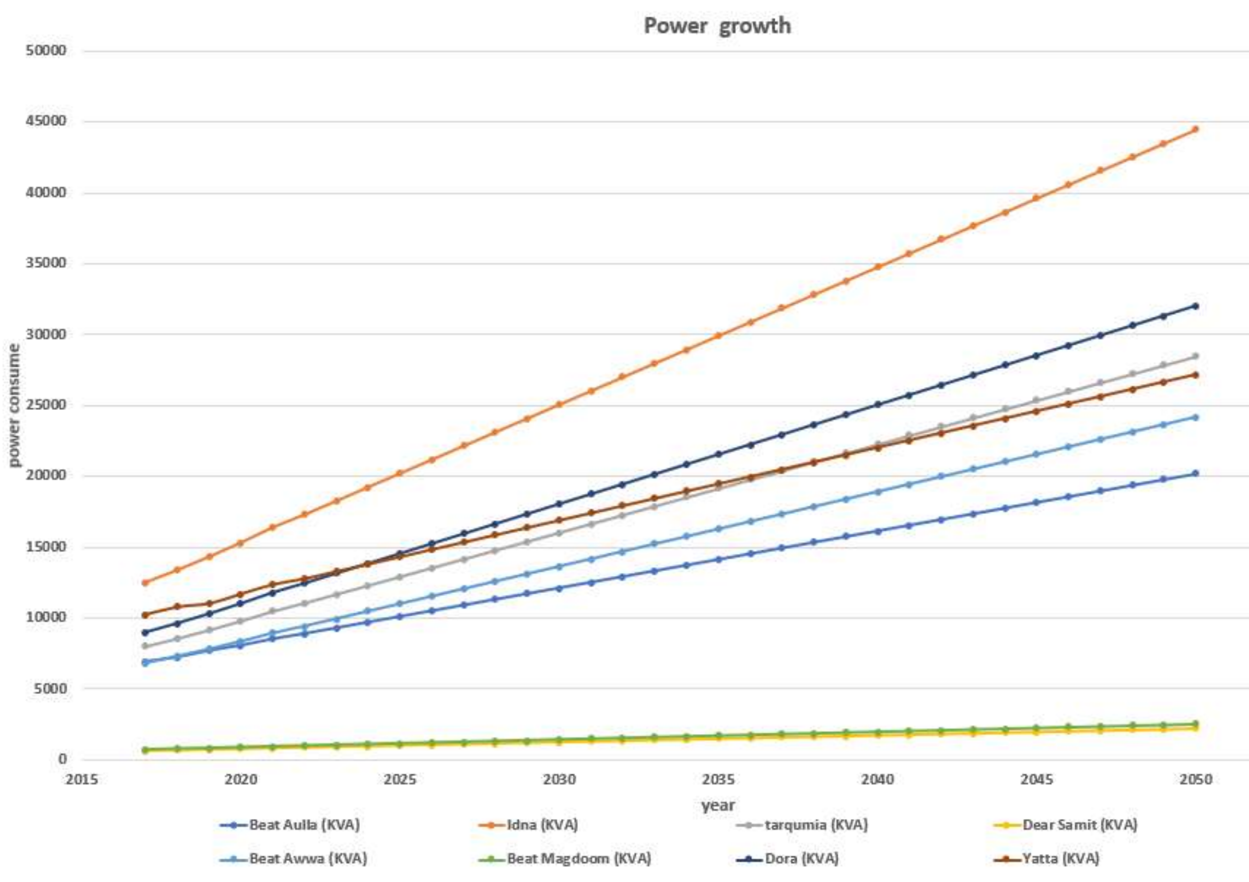


Figure 3.1: load growth for each town

Beat -Aulla load growth:

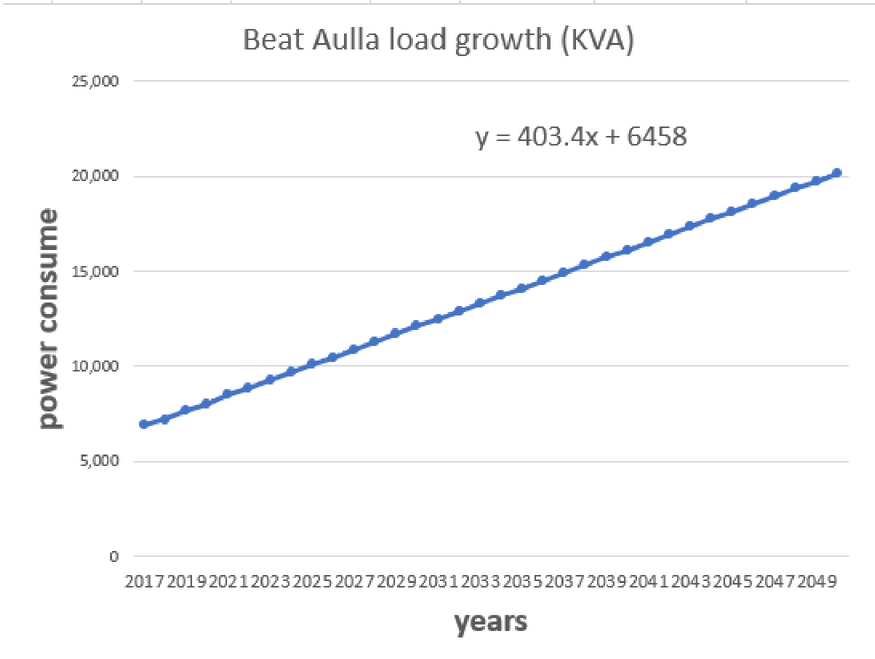


Figure 3.2: :Beat Aulla demand growth

To make this study more realistic, the large demand on photovoltaic system and the output power from photovoltaic also the result on the grid and, should be insert in design. According from Palestinian Energy and (Natural Resources Authority) PENRA at 2020, the renewable energy will cover 20% from total power. So if this percentage was for 2050 and still 20% for project towns and villages the result will be at 2050 like this:

Table 3.1: Expected demand from PV system

towns and villages	Demand in 2050 (MVA)	Expected demand from PV system (MVA)
Beat Aulla	20.1736	20.1736×20% = 4.034
Idna	44.471.6	44.4716×20% = 8.894
Tarqoumia	28.4582	28.4582×20% = 5.691
Dear Samit	2.2105	2.2105×20% = 0.442
Beat Awwa	24.1888	24.188×20% = 4.837

Beat Magdoom	2.528	2.528×20% = 0.505
Dora	32.017	32.017×20% = 6.403
Yatta	27.158	27.158×20% = 5.431

The selection for PV panel is→ watt/panel =630 W; Voc=42.7 V ;Isc=18.74 A.

The selected PV is YS630M-60 STC showing it specification in appendex

Table 3.2: Expected PV system designs

Towns and Villages	**Number of PV panel**	**Number of panel in string**	**Number of parallel panel**
Beat Aulla	6413	11	583
Idna	14113	11	1283
Tarqoumia	9042	11	822
Dear Samit	704	11	64
Beat Awwa	7689	11	699
Beat Magdoom	803	11	73
Dora	10164	11	924
Yatta	8624	11	784

3.1.2 People growth

Estimating the population is an important estimation for load growth. The figure below show the relation between population and years for 2050 for every town in the distribution line, while the numbers and estimation showing in appendix-A [4].

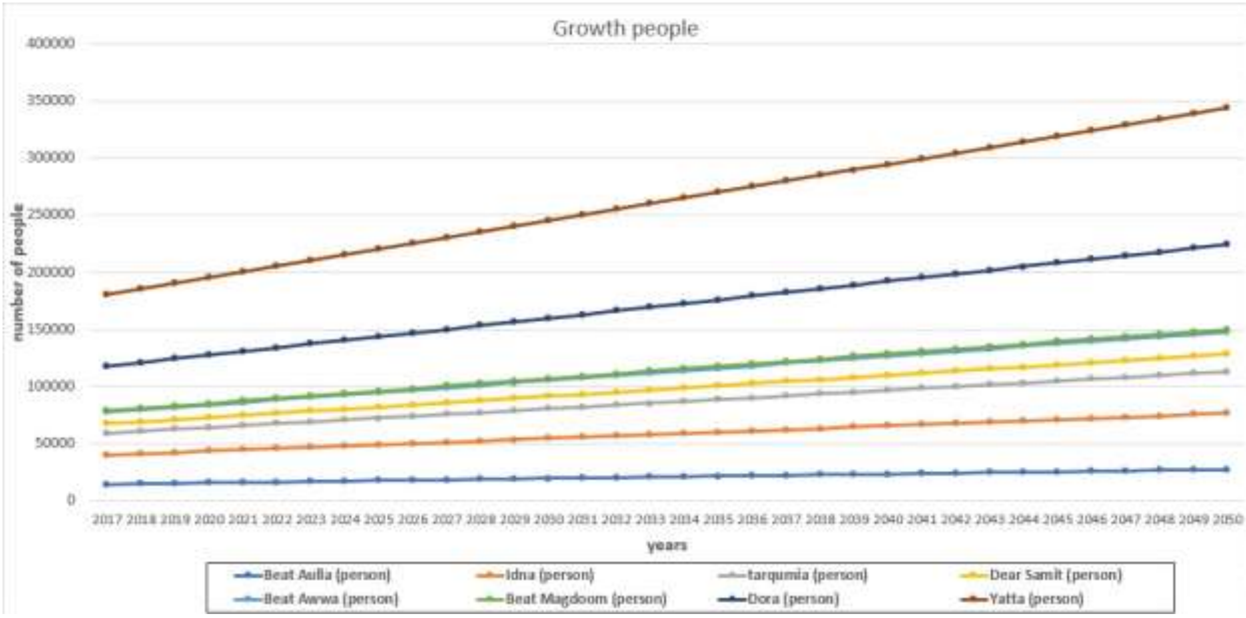


Figure 3.3: People growth

3.2 Symmetrical components and fault analysis

3.2.1 Faults

A fault in a circuit is any failure, which interferes which the normal flow of the current, or a physical change in the power system element; faults mainly caused by insulation failure, which effect on the distribution lines as short circuit, open circuit, or earth faults.

Faults Classification

Faults have two main types according to the symmetry of the system:

A. Symmetrical Faults.

In the balanced system the system impedance in each phase are identical and the three-phase voltages and currents through the system are completely balanced.

Faults under symmetrical conditions are causing in the system accidently through:

1. Insulation failure of equipment.
2. Flash over of lines initiated by lighting stroke.
3. Accidental faulty operation.

Symmetrical faults are rare and it is not exceeding 5% of the faults of the system.

B. Asymmetrical Faults.

Unbalanced system can result due to unsymmetrical faults, then the system operation, may also become unbalanced when load not balanced. Most faults in the system are unsymmetrical so it is very important to pay attention.

The asymmetrical faults can be classify as follow:

1. Single line to ground fault (L-G).
2. Line to line fault (L-L).
3. Double line to ground fault (L-L-G)

3.2.2 Symmetrical Components

In normal mode of operation, the three-phase system is symmetrical, so to analyze this system, we analyze one of the phases; the obtained results are the same for each phase but shifted by 120. In case of faults, we cannot apply the previous method to analyze the system due to the asymmetry, and we have to analyze each phase independently; but this method is long and hard to apply, so we use the symmetrical components and Fortescue's theorem.

3.3 Reliability of transmission system

Is a measure of the ability systems to transmit electrical power from the power generation points to all consumers, and it gives numerical indices to assess this process. The reliability of the system can be described by two basic functional features are security and adequacy.

Reliability refers to the ability of parts and components of the power system to complete the required functionality properly and in a specific time under certain conditions. Reliability is the probability of a component or system work reliably used as a characteristic reliable indicator. The reliability of electrical systems is the application of the theory of reliability and measure for the electrical systems, which provides consumers electrical energy with quantity and appropriate quality and according to the standards and from the lower number of interruption of electricity.

3.4 Summary

This chapter discussed several important and necessary issues for the distribution system design and important things for design. Always the first step in the design process is the planning, so it necessary to study the load growth in order to select the appropriate equipment for the system. This chapter also talked about the reliability and faults and there are very important things that must be consider when carrying out the transmission system design.

Chapter four DATA

4.1 capacity of substation

4.2 Place of substation

4.3 present load

4.4 Feeder lines

4.1 Capacity

A substation has capacity of (90MW), which can increase in future to reach (180MW).

4.2 Place of substation

The substation is located in the village of Beit Ula, north of Hebron city, with an area of 10 donums.

Note: Geographic information for Beit-Aulla substation (Appendix D)

4.3 present load

It has only 3 load and total apparent power 36,287 MVA.

Table 4.1:Present Load

present	Tarqumia	Dora	Yatta	total
year	(KVA)	(KVA)	(KVA)	(KVA)
2022	11,065	12447.9	12766	36278.5

4.4 Feeder lines

It has 4 feeder lines 3 on service and 1 out of service

feeder lines	places on feeder
feeder 1	tarqumia
feeder 2	yatta
feeder 3	dora

Table 4.2:feeder lines.

Chapter Five E-TAP and EXCEL

5.1 Introduction

5.2 ETAP Description

5.3 Filling data

5.3.1 Transformers

5.3.2 Distribution line

5.3.3 Load

5.3.4 Photovoltaic system

5.4 Load flow

5.5 ETAP Result

5.6 Excel and cases for P and Q

5.1 Introduction

ETAP Power Station is a graphical electrical transient analyzer program that can run under the Microsoft Windows 98. NT. 4.0. 2000. Me. and XP environments. The Windows NT, 4.0 and 2000 platforms provide the highest performance level for demanding applications, such as large network analysis requiring intensive computation and online monitoring and control applications. Windows NT. 4.0. And 2000 also provide the highest levels of reliability, protection. Moreover, security of critical applications. Large Power Station projects (approximately 500 buses and larger) should be built and maintained via Windows NT. 4.0. Or 2000. The Windows 98 and me platforms provide excellent performance for analysis of small and medium size systems (a few hundred buses) and support a variety of other popular applications.

5.2 ETAP Description

Modeling:

1. Virtual reality operation.
2. Total integration of data (electrical, logical, mechanical, and physical attributes).
3. Ring and radial systems.
4. Unlimited isolated subsystems.
5. Multiple loading conditions.
6. User access control and data validation.
7. Asynchronous calculations, allow multiple modules to calculate simultaneously.
8. 3-phase and single-phase modeling including panels and sub-panels.

5.3 Filling data

To run the program, we must to enter the data in filling spaces distribution line, transformers, and load, source, PV system.

5.3.1 Transformers

From the data for transformer Specifications and data, we can fill this parameter rating. In the E-TAP window below shows, voltage rating and power rating that needed for power flow calculation and short circuit analysis.

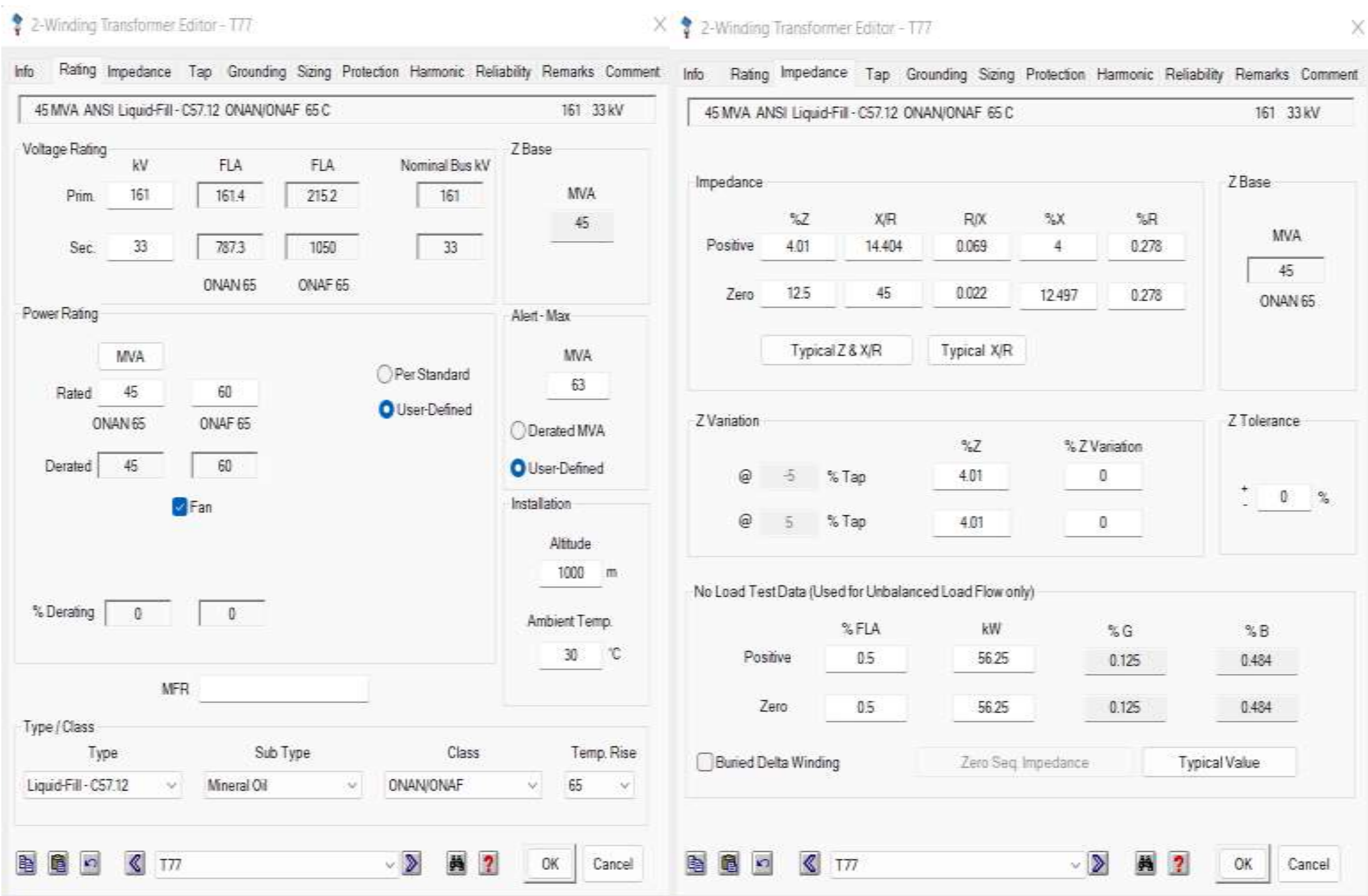


Figure 5.1: substation Transformers data in ETAP.

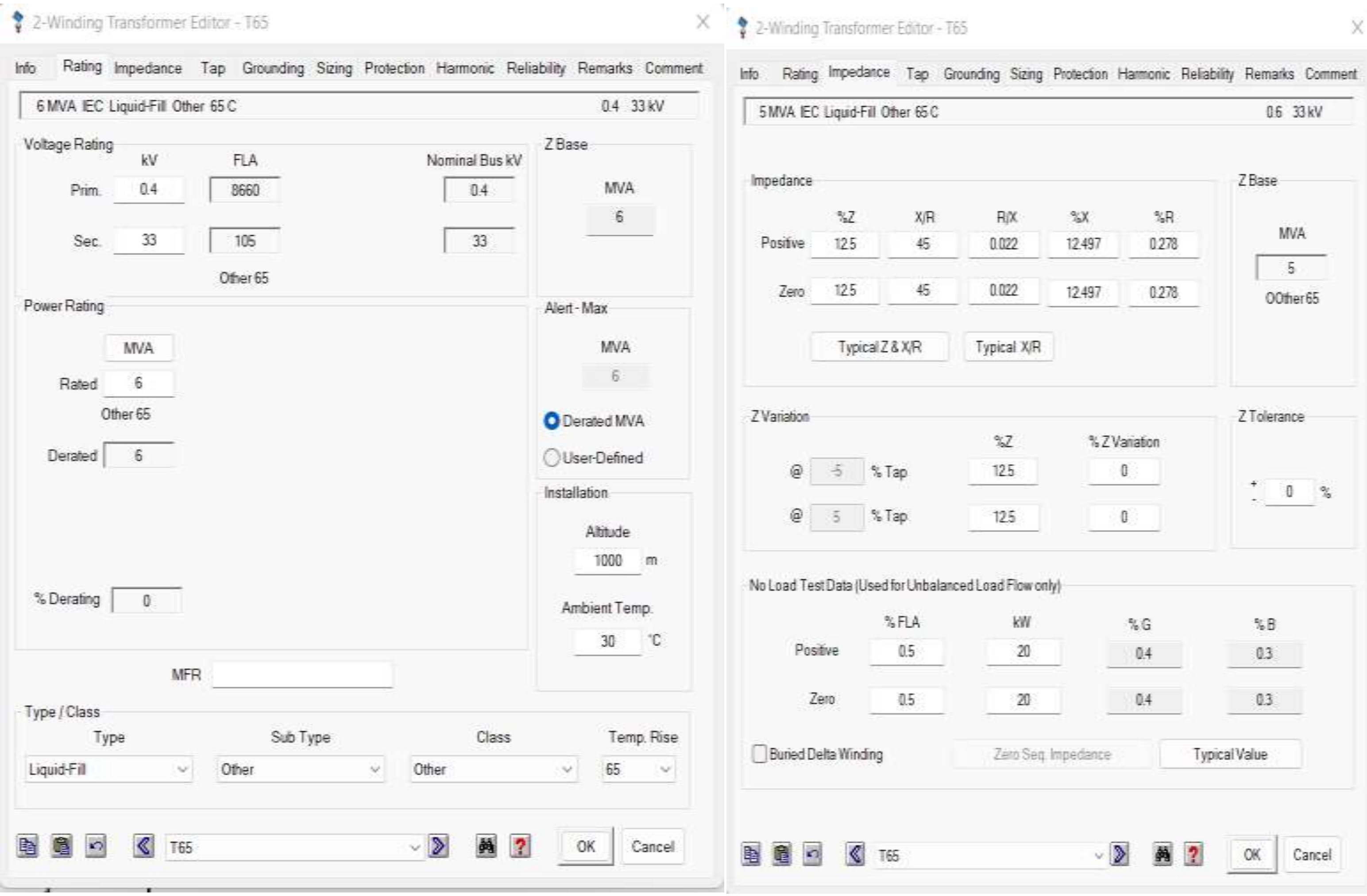


Figure 5.2: Tarqumia Transformer data for PV in ETAP.

Note: substation Transformers characteristic (Appendix G1)

5.3.2 Distribution line

In this part, we can put distribution line parameters and the information of impedance and we can insert a new distribution line and its parameter if we do not found the same distribution line.

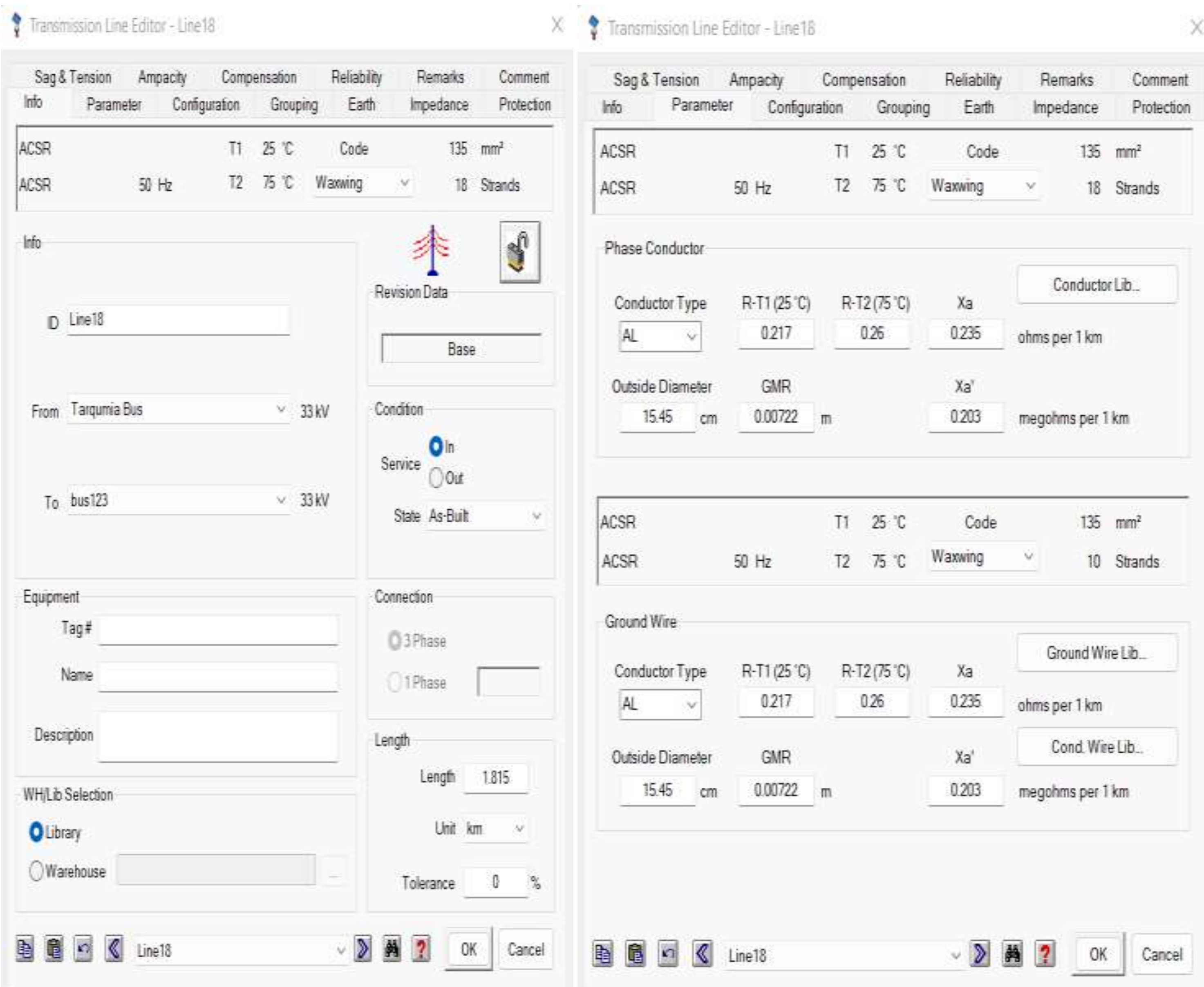


Figure 5.3: Distribution line data in ETAP.

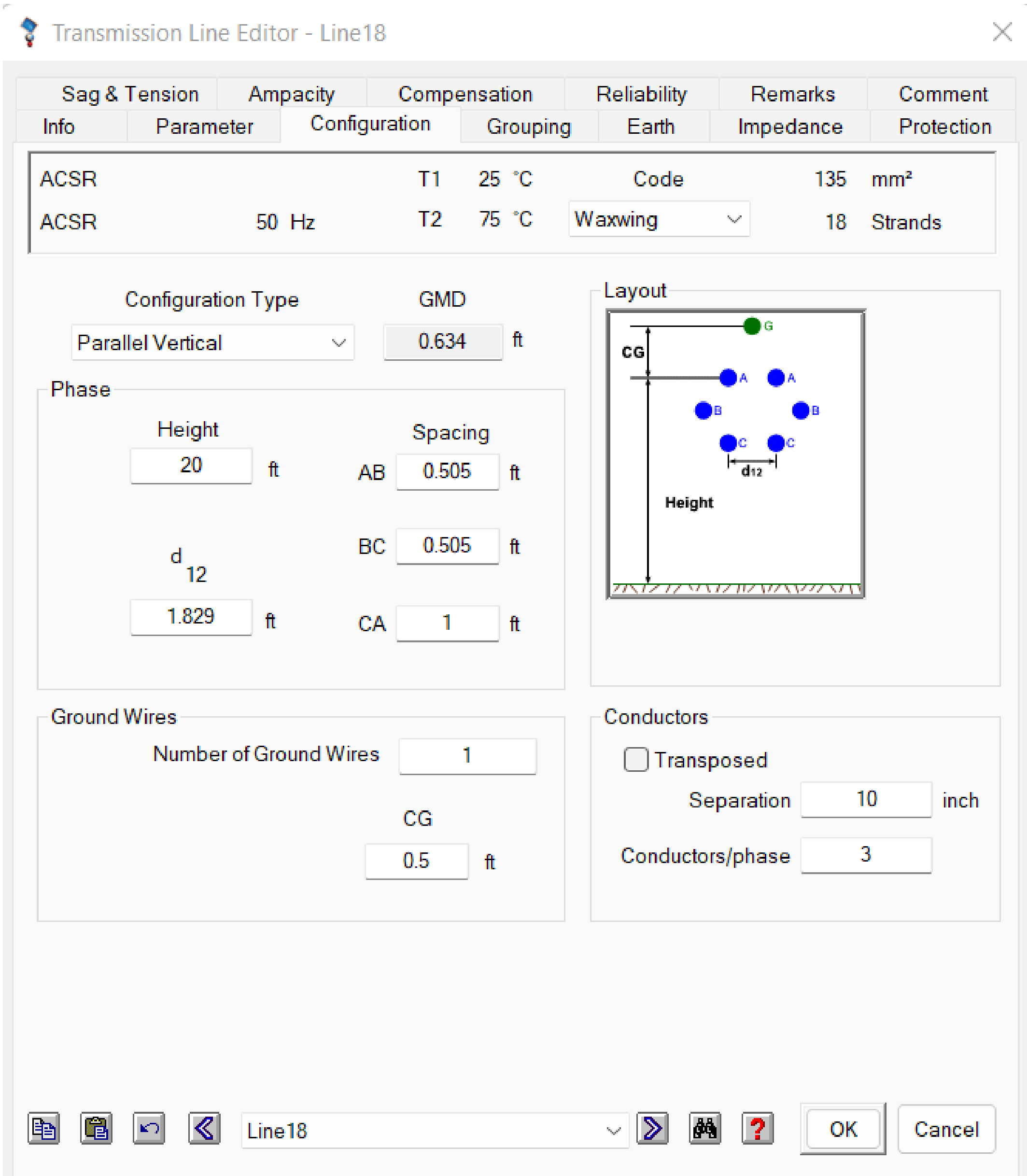


Figure 5.4: Distribution line data in ETAP.

Note: Distribution line characteristic (Appendix G5)

5.3.3 Load

In the following parameter, that concerning load.We put the power in MVA for lumped load rating and choose a value of resistive load between 15% and 20%, in domestic transformer and smaller or larger value of " Z " percentage in the industrial region because of induction and synchronous motors, the ETAP window show the parameter that filled for a Sponge factory.

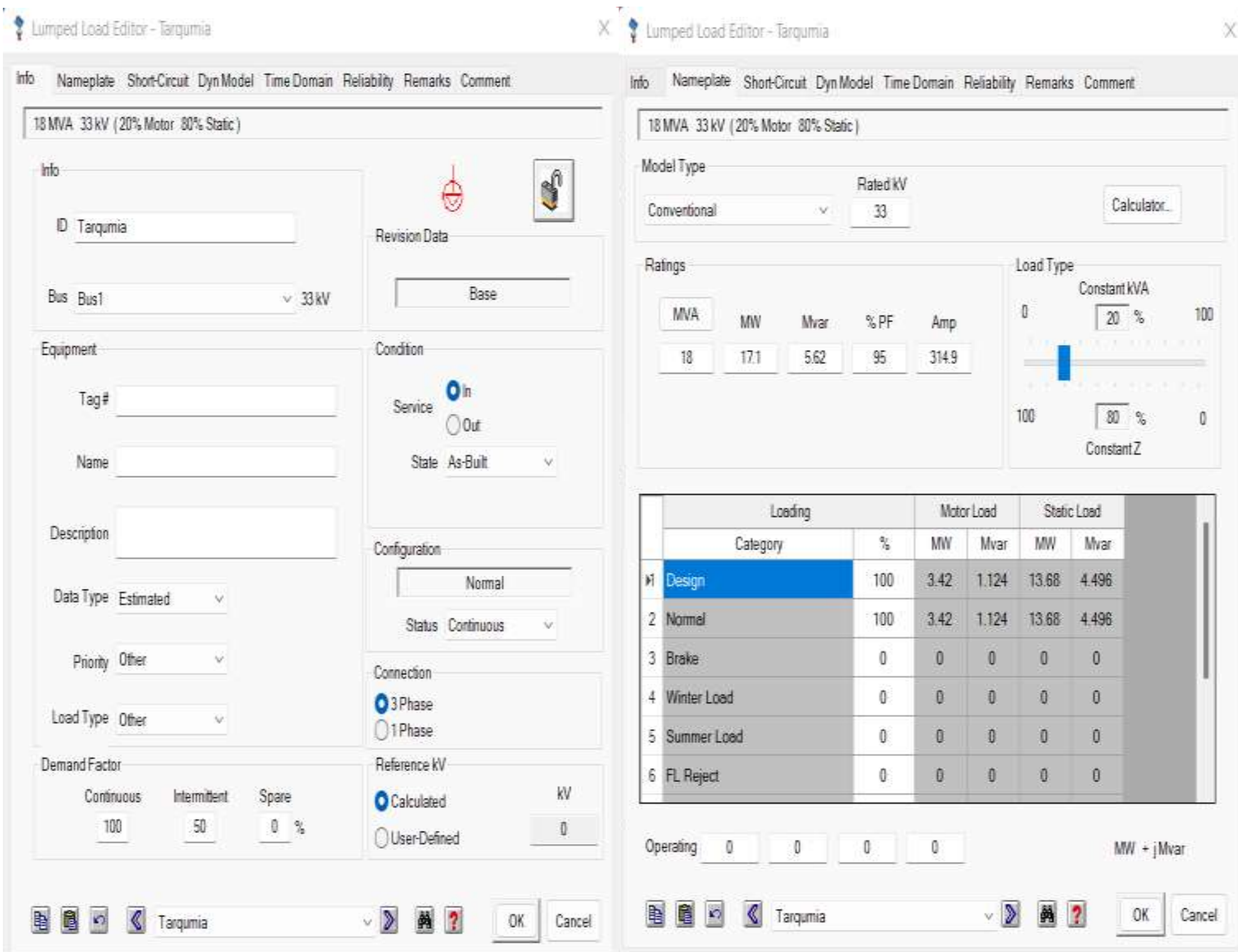


Figure 5.5: Tarqumia Load data in ETAP.

5.3.4 Photovoltaic system

Photovoltaic (PV) Array comprising of solar panels are the predominant power generation components of renewable distributed energy resources (DER), solar farms with grid-tied inverters, islanding micro grids, and smart grids. PV Array **converts solar radiation energy** into direct current using semiconductors and then to alternating current electric power through inverters.

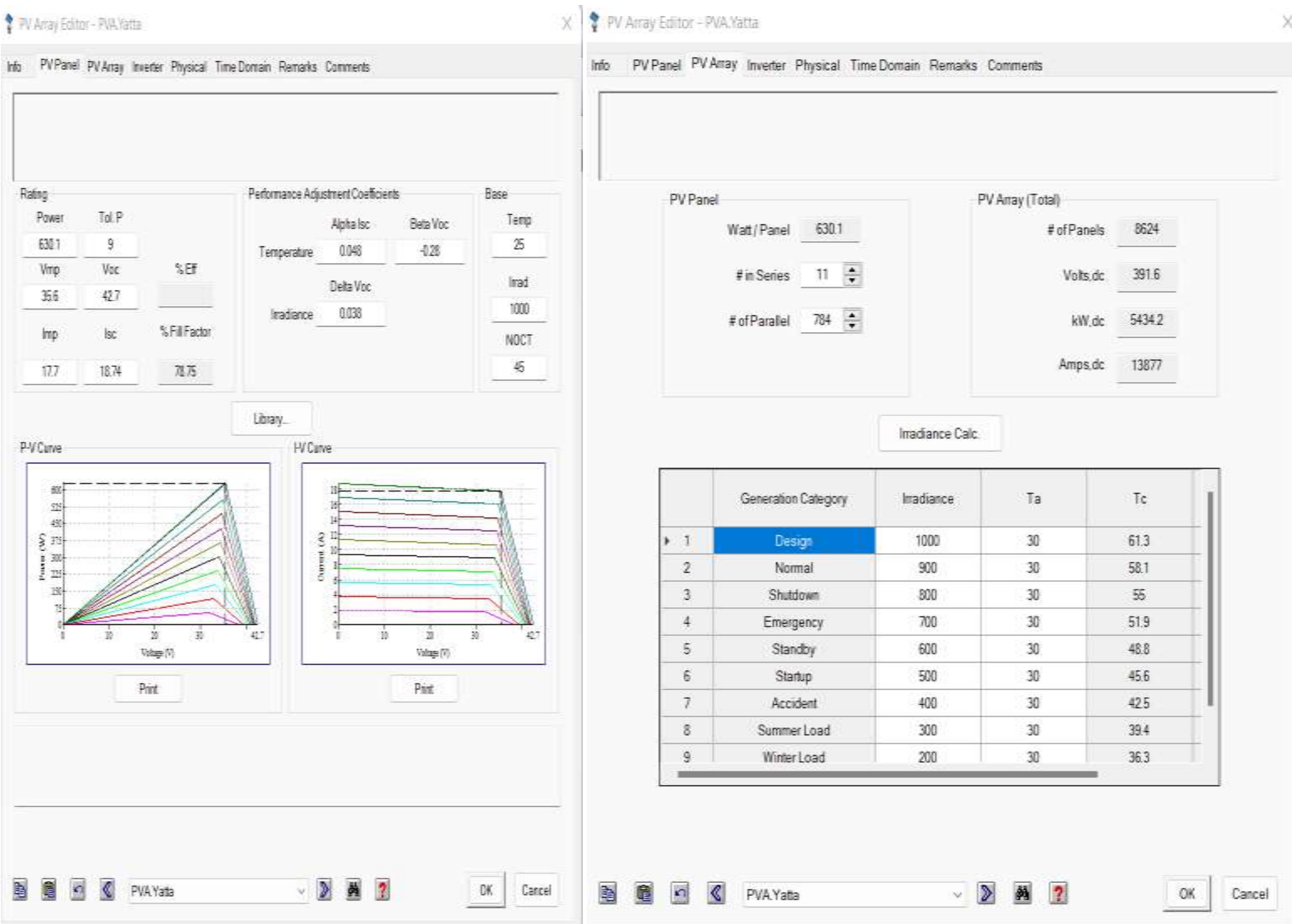


Figure 5.6: Yatta PV source sitting data in ETAP.

Note: pv panel selected (Appendix E9)

5.4 Load flow

In the following , the result from distribution line by using ETAP simulation

Note: load flow (Appendix E)

5.5 ETAP Result

Two part:

5.5.1 ETAP Report

Note: ETAP Report (Appendix E)

5.5.2 Result and comments on ETAP Simulation:

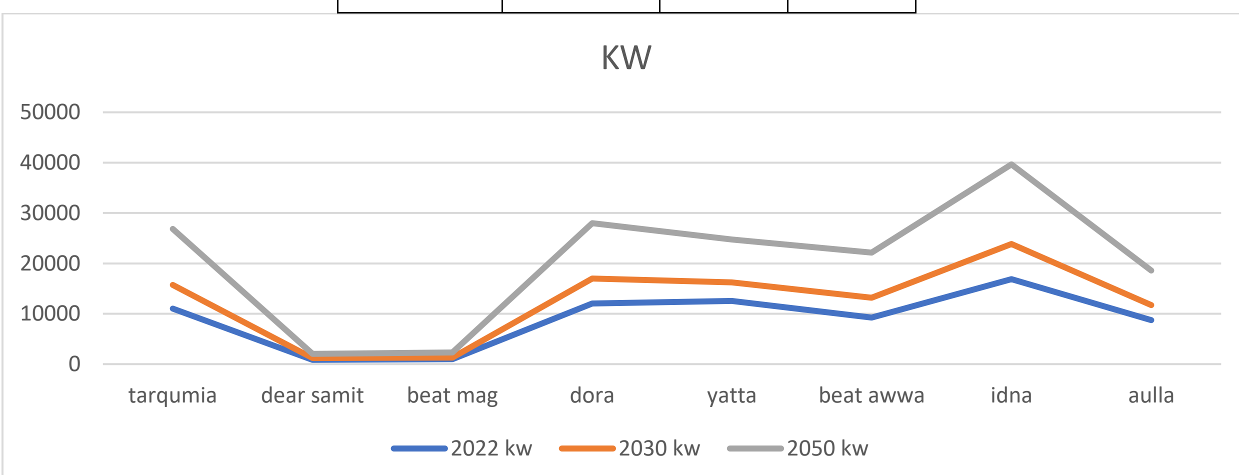
We improve the power factor by adding capacitor bank to the circuit.

- Increase the voltage drop after build the circuit by change the taps of transformer.
- We protect the distribution line by using overcurrent relay and differential relay to protect the transformer.

5.6 Excel and cases for P and Q

Case1: KW for (2022 ,2030,2050): Without PV system.

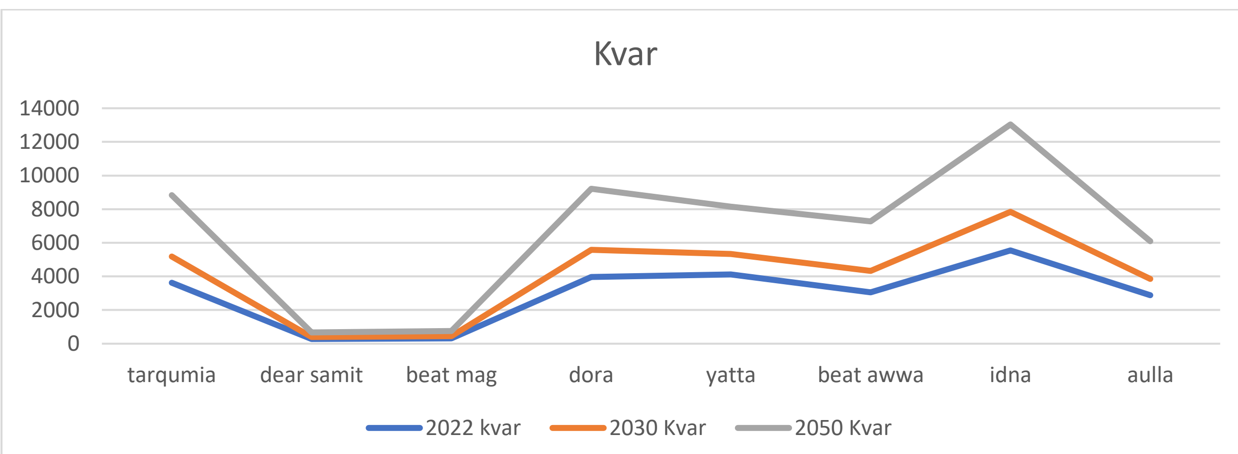
Year	2022	2030	2050
	kw	**kw**	**kw**
Tarqumia	11037	15754	26846
Dear samit	848.45	1208.1	2039.7
Beat mag	968.48	1276.2	2315
Dora	12060	16990	28009
Yatta	12534	16239	24773
Beat awwa	9270	13163	22126
Idna	16874	23854	39663
Aulla	8749.8	11716	18554



Case 2:

Kvar for (2022 ,2030,2050): Without PV system.

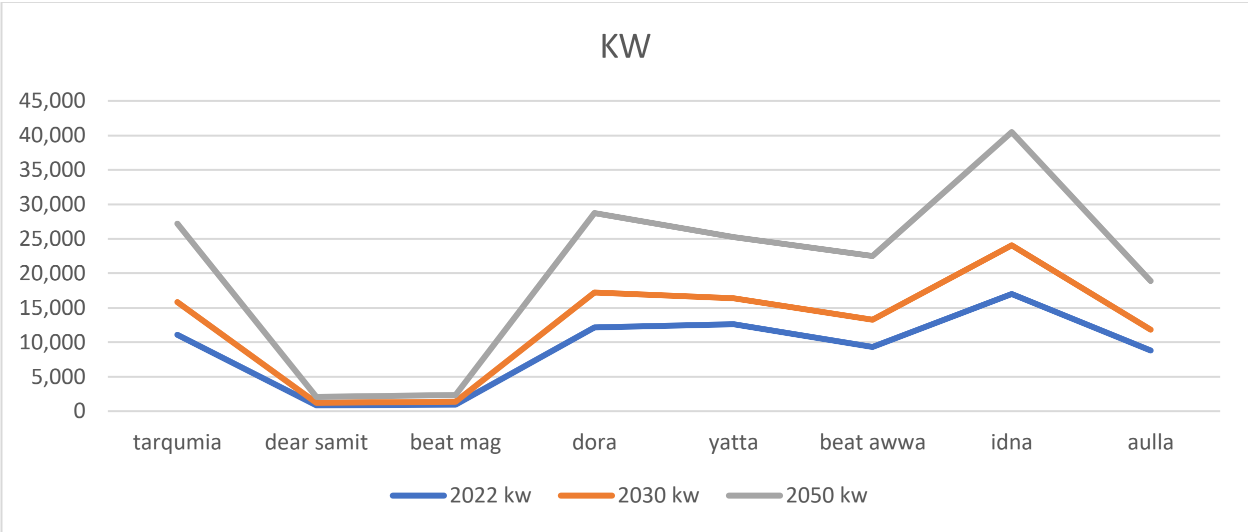
Year	2022	2030	2050
	kvar	Kvar	Kvar
Tarqumia	3627.6	5178.2	8823.8
Dear samit	278.9	397.09	670.42
Beat mag	318.32	452.35	761.02
Dora	3963.9	5584.4	9206
Yatta	4119.6	5337.6	8142.3
Beat awwa	3046.9	4326.3	7272.6
Idna	5546.3	7840.05	13037
Aulla	2875.9	3850.7	6098.4



Case3:

KW for (2022 ,2030,2050) with effect of PV system:

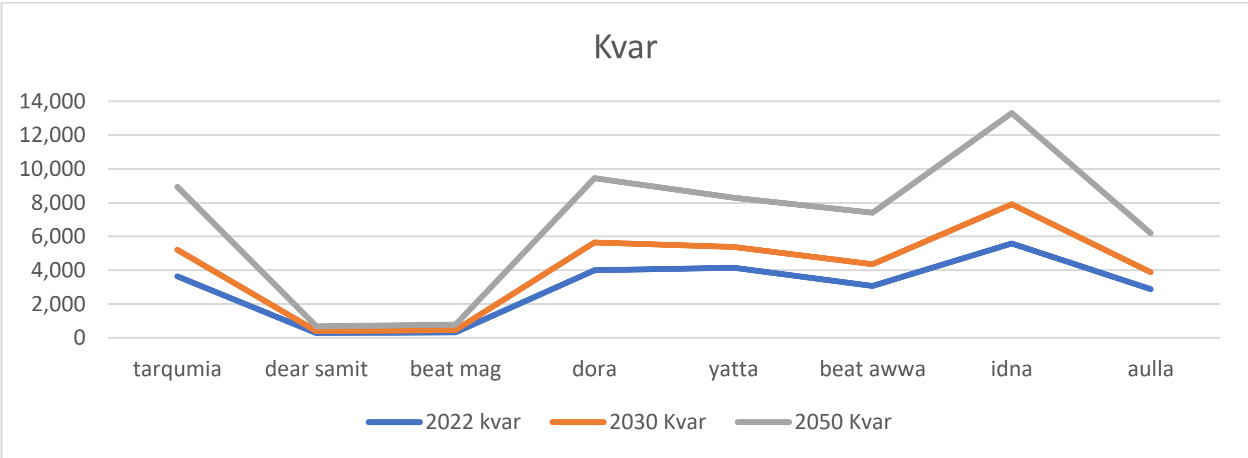
Year	2022	2030	2050
	kw	**kw**	**kw**
Tarqumia	11,075	15837	27183
Dear samit	852.66	1217	2073.4
Beat mag	973.62	1,387	2356.5
Dora	12,159	17,201	28738
Yatta	12,611	16384	25238
Beat awwa	9319.9	13270	22524
Idna	16,997	24060	40481
Aulla	8,795	11807	18870



Case 4:

Kvar for (2022 ,2030,2050) with effect of PV system:

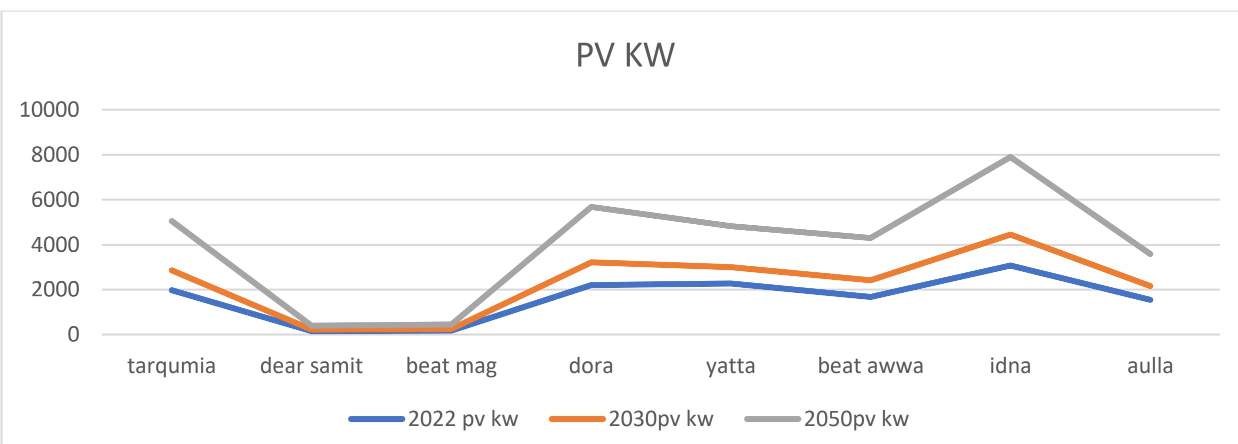
Year	2022	2030	2050
	kvar	Kvar	Kvar
Tarqumia	3,640	5205.3	8934.5
Dear samit	280.25	400.01	681.48
Beat mag	320.01	455.98	774.54
Dora	3,996.60	5653.7	9445.7
Yatta	4,145	5385.3	8295.2
Beat awwa	3063.3	4361.5	7403.4
Idna	5,587	7908.1	13306
Aulla	2890.9	3880.7	6202.1



Case 5:

PV KW for (2022,2030,2050):

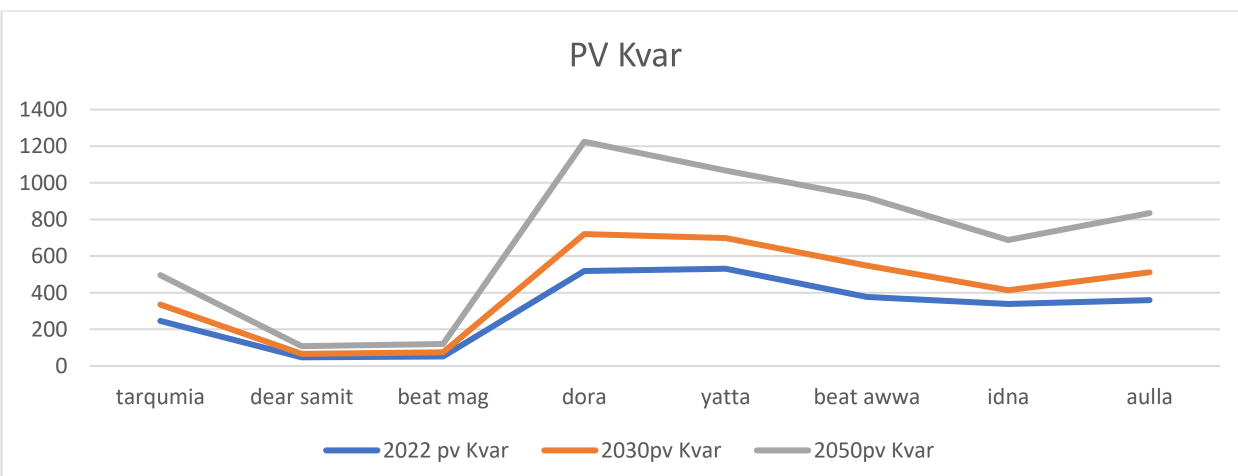
Year	2022 pv kw	2030 pv kw	2050 pv kw
Tarqumia	1969	2848.7	5055.3
Dear samit	154.07	221.82	394.13
Beat mag	172.55	252.6	449.47
Dora	2,202	3,204	5,682
Yatta	2264	2996.3	4822.2
Beat awwa	1672.9	2417.1	4297.9
Idna	3070	4446	7895
Aulla	1550.1	2153.2	3586.2



Case 6:

PV Kvar for(2022,2030,2050):

Year	2022 pv Kvar	2030 pv Kvar	2050 pv Kvar
Tarqumia	246.78	334.67	495.18
Dear samit	47.591	66.488	108.47
Beat mag	52.88	74.68	120.23
Dora	519.38	720.22	1224.4
Yatta	531.15	699.06	1066.5
Beat awwa	376.8	548.11	921.12
Idna	339.1	414.6	688.2
Aulla	360.54	511.69	835.69



Chapter six Conclusion and Recommendations

6.1 conclusion

6.2 Recommendations

6.1 Conclusion

In this project, we study a Beat-Aulla substation that and design distribution system from it to all prediction loads. The appropriate design for towers, conductors, insulators has been done as well as for protection system, considering future loads for the area of the project in the period of (2022-2050).

Using ETAP program, we noticed during design the substation on ETAP that the power factor needs to improves we add capacitor bank to improve it and to reach the desirable value.

6.2 Recommendations

FOR SELCO

- Upgrade the network to satisfy the expected load.
- Activate all feeder of substation .

For the future study

- Build the single line diagram of substation by using another method which are presenter in chapter five and compare the results to choose more accurate approach for the realist one.
- Make a projection for this project to another electrical distribution substation companies for west bank in general
- Start the design procedure for the construction of the power plants including all the dertails

For Palestinian Energy and Natural Resources Authority (PENRA)

- Working on organizing all the residents of the West Bank within the official distribution companies to ensure the availability of information which are necessary for any study and planning process.

For Palestine Polytechnic University

- Add new courses for teaching the students how to use ETAP.
- Add new courses for learning the mythology and process of planning the electrical network.

Reference

[1] Southern Electric Company (SELCO).

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Appendices

Appendix A: information collected from SELCO

Appendix B: information collected from Palestinian Central Bureau of Statistics

Appendix C: information collected using excel program by Regression Method (2017-2050)

Appendix D: Geographic information for Beit-Aulla substation

Appendix E: Electrical Transient Analyzer Program (ETAP) for Beit-Aulla substation

Appendix G: Data collection for power system

Appendix A:

information collected from SELCO

year	Beat Aulla (KVA)	Idna (KVA)	tarqumia (KVA)	Dear Samit (KVA)	Beat Awwa (KVA)
2017	6900	12500	8000	620	6800
2018	7215	13375	8560	663	7276
2019	7678	14311	9159	710	7785
2020	8047	15313	9800	760	8330
2021	8501	16385	10486	813	8913

year	Beat Magdoom (KVA)	Dora (KVA)	Yatta (KVA)	total (KVA)
2017	710	9000	10250	54780
2018	760	9630	10780	58259
2019	813	10304	11030	61790
2020	870	11025	11700	65845
2021	931	11797	12360	70186

Appendix B:

information collected from Palestinian Central Bureau of Statistics

year	Beat Aulla (person)	Idna (person)	tarqumia (person)	Dear Samit (person)	Beat Awwa (person)
2017	14,411	25,783	19,143	8,044	10,345
2018	14,797	26,475	19,657	8,259	10,623
2019	15,189	27,175	20,177	8,478	10,904
2020	15,586	27,886	20,704	8,699	11,189
2021	15,988	28,606	21,239	8,924	11,478

year	Beat Magdoom (person)	Dora (person)	Yatta (person)	total (person)
2017	1,099	38,995	62,960	180780
2018	1,129	40,040	64,648	185628
2019	1,159	41,100	66,359	190541
2020	1,189	42,174	68,094	195521
2021	1,220	43,263	69,852	200570

Appendix C:

information collected using excel program by Regression Method (2017-2050)

Appendix C1: People growth

Appendix C2: Power Consumption

Appendix C1:

People growth

year	Beat Aulla (person)	Idna (person)	tarqumia (person)	Dear Samit (person)	Beat Awwa (person)
2017	14,411	25,783	19,143	8,044	10,345
2018	14,797	26,475	19,657	8,259	10,623
2019	15,189	27,175	20,177	8,478	10,904
2020	15,586	27,886	20,704	8,699	11,189
2021	15,988	28,606	21,239	8,924	11,478
2022	16,377	29,302	21,756	9,141	11,757
2023	16,771	30,008	22,280	9,361	12,041
2024	17,166	30,714	22,804	9,581	12,324
2025	17,560	31,419	23,327	9,801	12,607
2026	17,954	32,125	23,851	10,021	12,890
2027	18,349	32,831	24,375	10,241	13,173
2028	18,743	33,536	24,899	10,461	13,457
2029	19,137	34,242	25,423	10,681	13,740
2030	19,532	34,948	25,947	10,901	14,023
2031	19,926	35,653	26,471	11,121	14,306
2032	20,320	36,359	26,995	11,341	14,589
2033	20,714	37,065	27,519	11,561	14,873
2034	21,109	37,771	28,043	11,781	15,156
2035	21,503	38,476	28,566	12,001	15,439
2036	21,897	39,182	29,090	12,221	15,722
2037	22,292	39,888	29,614	12,441	16,005
2038	22,686	40,593	30,138	12,661	16,289
2039	23,080	41,299	30,662	12,881	16,572
2040	23,475	42,005	31,186	13,101	16,855
2041	23,869	42,710	31,710	13,321	17,138
2042	24,263	43,416	32,234	13,541	17,421
2043	24,657	44,122	32,758	13,761	17,705
2044	25,052	44,828	33,282	13,981	17,988
2045	25,446	45,533	33,805	14,201	18,271
2046	25,840	46,239	34,329	14,421	18,554
2047	26,235	46,945	34,853	14,641	18,837
2048	26,629	47,650	35,377	14,861	19,121
2049	27,023	48,356	35,901	15,081	19,404
2050	27,418	49,062	36,425	15,301	19,687

	Beat Magdoom	Dora	Yatta	total
year	**(person)**	**(person)**	**(person)**	**(person)**
2017	1,099	38,995	62,960	180780
2018	1,129	40,040	64,648	185628
2019	1,159	41,100	66,359	190541
2020	1,189	42,174	68,094	195521
2021	1,220	43,263	69,852	200570
2022	1,250	44,315	71,552	205449.9
2023	1,280	45,382	73,275	210397.2
2024	1,310	46,449	74,998	215344.5
2025	1,340	47,516	76,721	220291.8
2026	1,371	48,583	78,444	225239.1
2027	1,401	49,650	80,167	230186.4
2028	1,431	50,717	81,890	235133.7
2029	1,461	51,784	83,613	240081
2030	1,491	52,851	85,336	245028.3
2031	1,522	53,918	87,059	249975.6
2032	1,552	54,985	88,782	254922.9
2033	1,582	56,052	90,505	259870.2
2034	1,612	57,119	92,228	264817.5
2035	1,642	58,186	93,951	269764.8
2036	1,673	59,253	95,674	274712.1
2037	1,703	60,320	97,397	279659.4
2038	1,733	61,387	99,120	284606.7
2039	1,763	62,454	100,843	289554
2040	1,793	63,521	102,566	294501.3
2041	1,824	64,588	104,289	299448.6
2042	1,854	65,655	106,012	304395.9
2043	1,884	66,722	107,735	309343.2
2044	1,914	67,789	109,458	314290.5
2045	1,944	68,856	111,181	319237.8
2046	1,975	69,923	112,904	324185.1
2047	2,005	70,990	114,627	329132.4
2048	2,035	72,057	116,350	334079.7
2049	2,065	73,124	118,073	339027
2050	2,095	74,191	119,796	343974.3

Appendix C2:

Power Consumption

	Beat Aulla	Idna	tarqumia	Dear Samit	Beat Awwa
year	**(KVA)**	**(KVA)**	**(KVA)**	**(KVA)**	**(KVA)**
2017	6900	12500	8000	620	6800
2018	7215	13375	8560	663	7276
2019	7678	14311	9159	710	7785
2020	8047	15313	9800	760	8330
2021	8501	16385	10486	813	8913
2022	8878.4	17289.2	11064.6	858.1	9404.8
2023	9281.8	18260	11685.8	906.4	9932.8
2024	9685.2	19230.8	12307	954.7	10460.8
2025	10088.6	20201.6	12928.2	1003	10988.8
2026	10492	21172.4	13549.4	1051.3	11516.8
2027	10895.4	22143.2	14170.6	1099.6	12044.8
2028	11298.8	23114	14791.8	1147.9	12572.8
2029	11702.2	24084.8	15413	1196.2	13100.8
2030	12105.6	25055.6	16034.2	1244.5	13628.8
2031	12509	26026.4	16655.4	1292.8	14156.8
2032	12912.4	26997.2	17276.6	1341.1	14684.8
2033	13315.8	27968	17897.8	1389.4	15212.8
2034	13719.2	28938.8	18519	1437.7	15740.8
2035	14122.6	29909.6	19140.2	1486	16268.8
2036	14526	30880.4	19761.4	1534.3	16796.8
2037	14929.4	31851.2	20382.6	1582.6	17324.8
2038	15332.8	32822	21003.8	1630.9	17852.8
2039	15736.2	33792.8	21625	1679.2	18380.8
2040	16139.6	34763.6	22246.2	1727.5	18908.8
2041	16543	35734.4	22867.4	1775.8	19436.8
2042	16946.4	36705.2	23488.6	1824.1	19964.8
2043	17349.8	37676	24109.8	1872.4	20492.8
2044	17753.2	38646.8	24731	1920.7	21020.8
2045	18156.6	39617.6	25352.2	1969	21548.8
2046	18560	40588.4	25973.4	2017.3	22076.8
2047	18963.4	41559.2	26594.6	2065.6	22604.8
2048	19366.8	42530	27215.8	2113.9	23132.8
2049	19770.2	43500.8	27837	2162.2	23660.8
2050	20173.6	44471.6	28458.2	2210.5	24188.8

	Beat Magdoom	Dora	Yatta	total
year	(KVA)	(KVA)	(KVA)	(KVA)
2017	710	9000	10250	54780
2018	760	9630	10780	58259
2019	813	10304	11030	61790
2020	870	11025	11700	65845
2021	931	11797	12360	70186
2022	982.4	12447.9	12766	73691.4
2023	1037.6	13146.8	13280	77531.2
2024	1092.8	13845.7	13794	81371
2025	1148	14544.6	14308	85210.8
2026	1203.2	15243.5	14822	89050.6
2027	1258.4	15942.4	15336	92890.4
2028	1313.6	16641.3	15850	96730.2
2029	1368.8	17340.2	16364	100570
2030	1424	18039.1	16878	104409.8
2031	1479.2	18738	17392	108249.6
2032	1534.4	19436.9	17906	112089.4
2033	1589.6	20135.8	18420	115929.2
2034	1644.8	20834.7	18934	119769
2035	1700	21533.6	19448	123608.8
2036	1755.2	22232.5	19962	127448.6
2037	1810.4	22931.4	20476	131288.4
2038	1865.6	23630.3	20990	135128.2
2039	1920.8	24329.2	21504	138968
2040	1976	25028.1	22018	142807.8
2041	2031.2	25727	22532	146647.6
2042	2086.4	26425.9	23046	150487.4
2043	2141.6	27124.8	23560	154327.2
2044	2196.8	27823.7	24074	158167
2045	2252	28522.6	24588	162006.8
2046	2307.2	29221.5	25102	165846.6
2047	2362.4	29920.4	25616	169686.4
2048	2417.6	30619.3	26130	173526.2
2049	2472.8	31318.2	26644	177366
2050	2528	32017.1	27158	181205.8

Appendix D: GIS Data for substation

Ministry of Local Government

Legend

- Communities Land Boundary
- Boundary
- Footprint
- Image
  - Red: Band_1
  - Green: Band_2
  - Blue: Band_3

101.6 | 0 | 50.80 | 101.6Meters

Scale: 1: 2,000

Palestine_1923_Palestine_Grid

Date: 21/5/2022 9:36 AM

Notes

Appendix E:

Electrical Transient Analyzer Program (ETAP) for Beit-Aulla substation

Appendix E1: present case

Appendix E2:2022 case without PV

Appendix E3: 2022 case with PV

Appendix E4: 2030 case without PV

Appendix E5: 2030 case with PV

Appendix E6:2050 case without PV

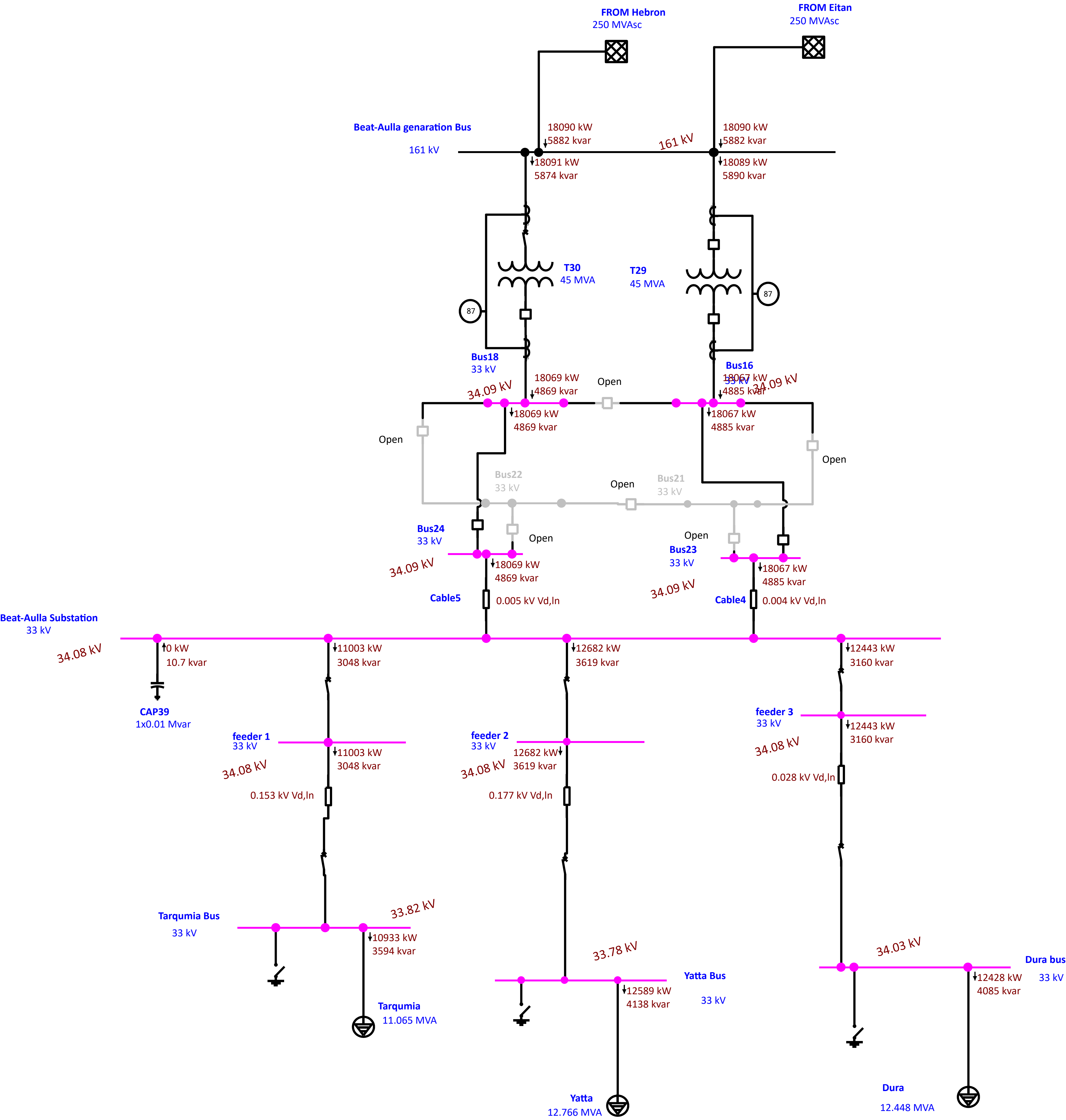
Appendix E7: 2050 case with PV

Appendix E8: future transformer single line diagram

Appendix E9: PV specification

Appendix E1: present case

One-Line Diagram - OLV1 (Load Flow Analysis)



LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
*Beat-Aulla genaration Bus	161.000	100.000	0.0	36.180	11.764	0.000	0.000	Bus16	18.089	5.890	68.2	95.1	
								Bus18	18.091	5.874	68.2	95.1	
Beat-Aulla Substation	33.000	103.278	-2.9	0.000	0.000	0.000	-0.011	Bus23	-18.064	-4.916	317.1	96.5	
								Bus24	-18.065	-4.900	317.1	96.5	
								feeder 3	12.443	3.160	217.5	96.9	
								feeder 1	11.003	3.048	193.4	96.4	
								feeder 2	12.682	3.619	223.4	96.2	
Bus16	33.000	103.298	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-18.067	-4.885	317.0	96.5	5.000
								Bus23	18.067	4.885	317.0	96.5	
Bus18	33.000	103.303	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-18.069	-4.869	316.9	96.6	5.000
								Bus24	18.069	4.869	316.9	96.6	
Bus23	33.000	103.298	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla Substation	18.067	4.885	317.0	96.5	
								Bus16	-18.067	-4.885	317.0	96.5	
Bus24	33.000	103.303	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla Substation	18.069	4.869	316.9	96.6	
								Bus18	-18.069	-4.869	316.9	96.6	
Dura bus	33.000	103.133	-2.9	0.000	0.000	12.428	4.085	feeder 3	-12.428	-4.085	221.9	95.0	
feeder 1	33.000	103.278	-2.9	0.000	0.000	0.000	0.000	Tarqumia Bus	11.003	3.048	193.4	96.4	
								Beat-Aulla Substation	-11.003	-3.048	193.4	96.4	
feeder 2	33.000	103.278	-2.9	0.000	0.000	0.000	0.000	Yatta Bus	12.682	3.619	223.4	96.2	
								Beat-Aulla Substation	-12.682	-3.619	223.4	96.2	
feeder 3	33.000	103.278	-2.9	0.000	0.000	0.000	0.000	Dura bus	12.443	3.160	217.5	96.9	
								Beat-Aulla Substation	-12.443	-3.160	217.5	96.9	
Tarqumia Bus	33.000	102.476	-3.2	0.000	0.000	10.933	3.594	feeder 1	-10.933	-3.594	196.5	95.0	
Yatta Bus	33.000	102.350	-3.2	0.000	0.000	12.589	4.138	feeder 2	-12.589	-4.138	226.5	95.0	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

Appendix E2:2022 case without PV

LOAD FLOW REPORT

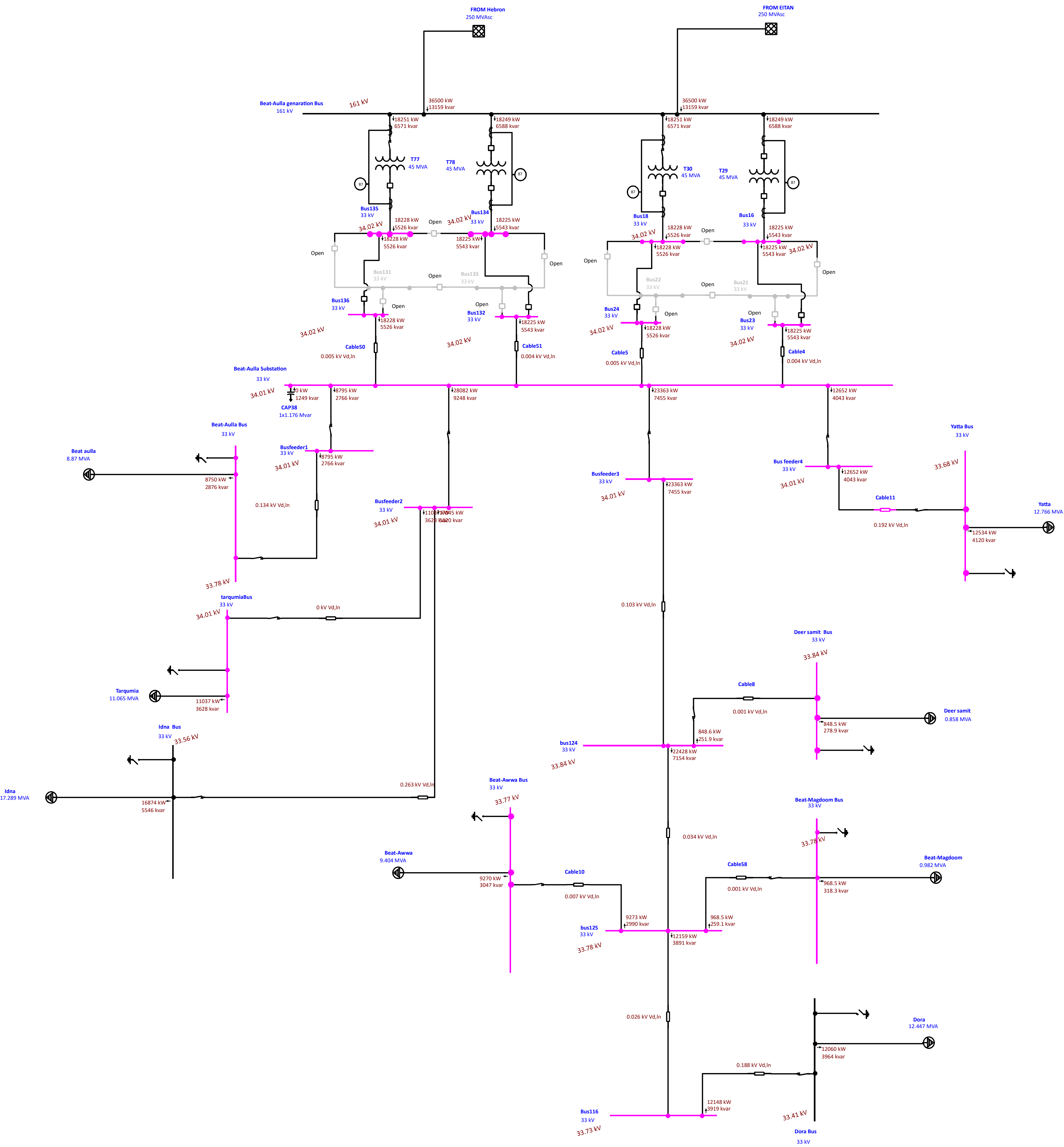
Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Beat-Aulla Bus	33.000	102.370	-3.2	0.000	0.000	8.750	2.876	Busfeeder1	-8.750	-2.876	157.4	95.0	
* Beat-Aulla genaration Bus	161.000	100.000	0.0	72.999	26.319	0.000	0.000	Bus16	18.249	6.588	69.6	94.1	
								Bus18	18.251	6.571	69.6	94.1	
								Bus135	18.251	6.571	69.6	94.1	
								Bus134	18.249	6.588	69.6	94.1	
Beat-Aulla Substation	33.000	103.075	-2.9	0.000	0.000	0.000	-1.249	Bus23	-18.222	-5.574	323.4	95.6	
								Bus24	-18.224	-5.557	323.4	95.7	
								Bus136	-18.224	-5.557	323.4	95.7	
								Bus132	-18.222	-5.574	323.4	95.6	
								Busfeeder3	23.363	7.455	416.3	95.3	
								Busfeeder2	28.082	9.248	501.8	95.0	
								Busfeeder1	8.795	2.766	156.5	95.4	
								Bus feeder4	12.652	4.043	225.4	95.3	
Beat-Awwa Bus	33.000	102.325	-3.3	0.000	0.000	9.270	3.047	bus125	-9.270	-3.047	166.8	95.0	
Beat-Magdoom Bus	33.000	102.356	-3.3	0.000	0.000	0.968	0.318	bus125	-0.968	-0.318	17.4	95.0	
Bus feeder4	33.000	103.075	-2.9	0.000	0.000	0.000	0.000	Yatta Bus	12.652	4.043	225.4	95.3	
								Beat-Aulla Substation	-12.652	-4.043	225.4	95.3	
Bus16	33.000	103.096	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-18.225	-5.543	323.3	95.7	5.000
								Bus23	18.225	5.543	323.3	95.7	
Bus18	33.000	103.101	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-18.228	-5.526	323.2	95.7	5.000
								Bus24	18.228	5.526	323.2	95.7	
Bus23	33.000	103.096	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla Substation	18.225	5.543	323.3	95.7	
								Bus16	-18.225	-5.543	323.3	95.7	
Bus24	33.000	103.101	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla Substation	18.228	5.526	323.2	95.7	
								Bus18	-18.228	-5.526	323.2	95.7	
Bus116	33.000	102.222	-3.4	0.000	0.000	0.000	0.000	bus125	-12.148	-3.919	218.5	95.2	
								Dora Bus	12.148	3.919	218.5	95.2	
bus124	33.000	102.537	-3.2	0.000	0.000	0.000	0.000	Deer samit Bus	0.849	0.252	15.1	95.9	
								Busfeeder3	-23.277	-7.406	416.8	95.3	
								bus125	22.428	7.154	401.7	95.3	
bus125	33.000	102.360	-3.3	0.000	0.000	0.000	0.000	Beat-Awwa Bus	9.273	2.990	166.5	95.2	

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Beat-Magdoom Bus	0.969	0.259	17.1	96.6	
								bus124	-22.401	-7.140	401.9	95.3	
								Bus116	12.159	3.891	218.2	95.2	
Bus132	33.000	103.096	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla Substation	18.225	5.543	323.3	95.7	
								Bus134	-18.225	-5.543	323.3	95.7	
Bus134	33.000	103.096	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-18.225	-5.543	323.3	95.7	5.000
								Bus132	18.225	5.543	323.3	95.7	
Bus135	33.000	103.101	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-18.228	-5.526	323.2	95.7	5.000
								Bus136	18.228	5.526	323.2	95.7	
Bus136	33.000	103.101	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla Substation	18.228	5.526	323.2	95.7	
								Bus135	-18.228	-5.526	323.2	95.7	
Busfeeder1	33.000	103.075	-2.9	0.000	0.000	0.000	0.000	Beat-Aulla Bus	8.795	2.766	156.5	95.4	
								Beat-Aulla Substation	-8.795	-2.766	156.5	95.4	
Busfeeder2	33.000	103.075	-2.9	0.000	0.000	0.000	0.000	tarqumiaBus	11.037	3.628	197.2	95.0	
								Idna Bus	17.045	5.620	304.6	95.0	
								Beat-Aulla Substation	-28.082	-9.248	501.8	95.0	
Busfeeder3	33.000	103.075	-2.9	0.000	0.000	0.000	0.000	bus124	23.363	7.455	416.3	95.3	
								Beat-Aulla Substation	-23.363	-7.455	416.3	95.3	
Deer samit Bus	33.000	102.532	-3.2	0.000	0.000	0.849	0.279	bus124	-0.849	-0.279	15.2	95.0	
Dora Bus	33.000	101.235	-3.8	0.000	0.000	12.060	3.964	Bus116	-12.060	-3.964	219.4	95.0	
Idna Bus	33.000	101.696	-3.5	0.000	0.000	16.874	5.546	Busfeeder2	-16.874	-5.546	305.6	95.0	
tarqumiaBus	33.000	103.075	-2.9	0.000	0.000	11.037	3.628	Busfeeder2	-11.037	-3.628	197.2	95.0	
Yatta Bus	33.000	102.070	-3.0	0.000	0.000	12.534	4.120	Bus feeder4	-12.534	-4.120	226.1	95.0	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

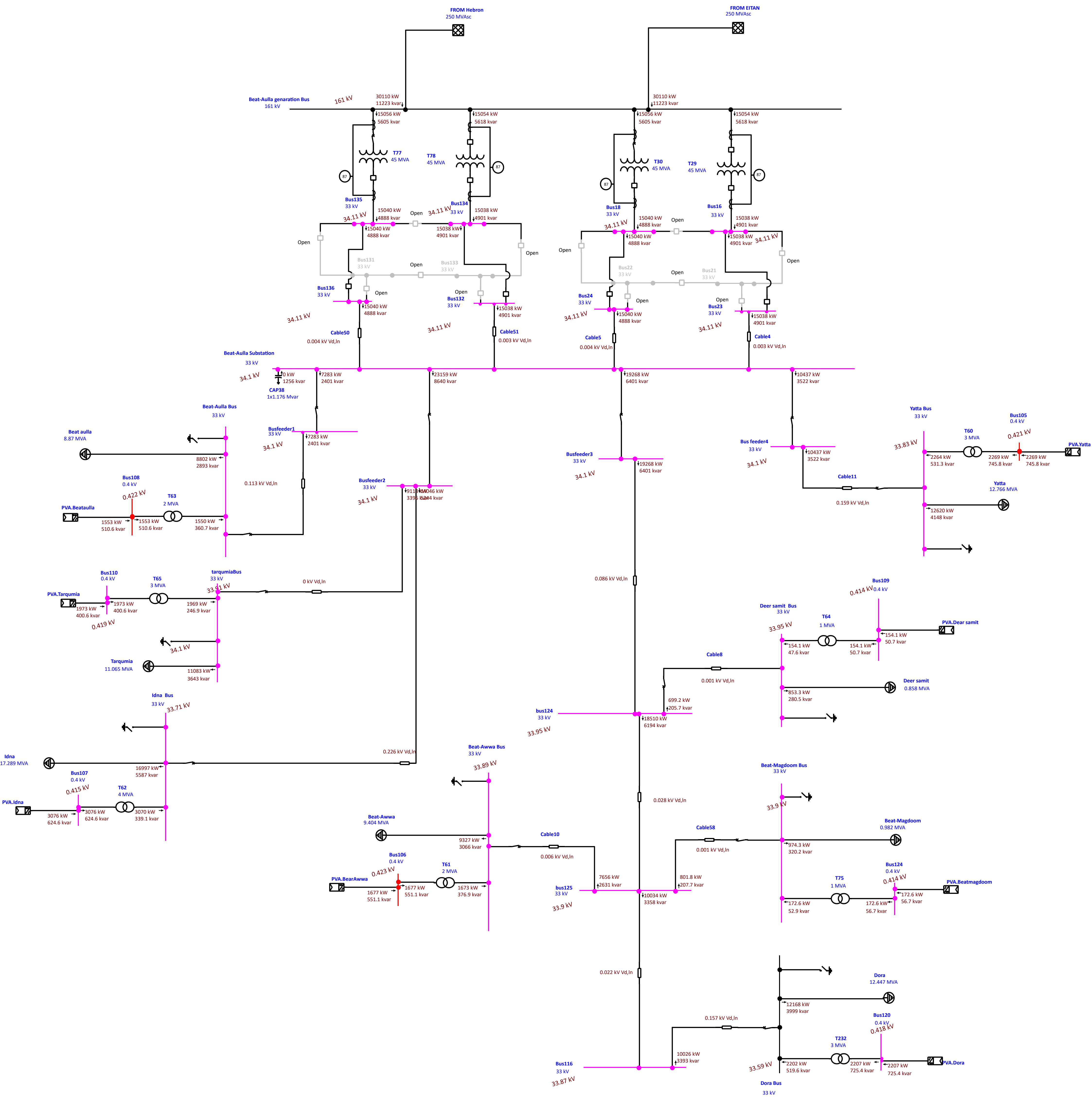
\# Indicates a bus with a load mismatch of more than 0.1 MVA

One-Line Diagram - OLV1 (Load Flow Analysis)



Appendix E3: 2022 case with PV

One-Line Diagram - OLV1 (Load Flow Analysis)



Project:		ETAP	Page:	1
Location:		19.0.1C	Date:	21-05-2022
Contract:			SN:	
Engineer:		Study Case: LF	Revision:	Base
Filename:	case 2022 with pv		Config.:	Normal

LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Beat-Aulla Bus	33.000	102.746	-2.7	0.000	0.000	8.802	2.893	Busfeeder1	-7.252	-2.532	130.8	94.4	
								Bus108	-1.550	-0.361	27.1	97.4	
* Beat-Aulla genaration Bus	161.000	100.000	0.0	60.221	22.446	0.000	0.000	Bus16	15.054	5.618	57.6	93.7	
								Bus18	15.056	5.605	57.6	93.7	
								Bus135	15.056	5.605	57.6	93.7	
								Bus134	15.054	5.618	57.6	93.7	
Beat-Aulla Substation	33.000	103.339	-2.4	0.000	0.000	0.000	-1.256	Bus23	-15.036	-4.934	267.9	95.0	
								Bus24	-15.038	-4.920	267.9	95.0	
								Bus136	-15.038	-4.920	267.9	95.0	
								Bus132	-15.036	-4.934	267.9	95.0	
								Busfeeder3	19.268	6.401	343.7	94.9	
								Busfeeder2	23.159	8.640	418.5	93.7	
								Busfeeder1	7.283	2.401	129.8	95.0	
								Bus feeder4	10.437	3.522	186.5	94.8	
Beat-Awwa Bus	33.000	102.711	-2.7	0.000	0.000	9.327	3.066	bus125	-7.654	-2.689	138.2	94.3	
								Bus106	-1.673	-0.377	29.2	97.6	
Beat-Magdoom Bus	33.000	102.737	-2.7	0.000	0.000	0.974	0.320	bus125	-0.802	-0.267	14.4	94.9	
								Bus124	-0.173	-0.053	3.1	95.6	
Bus feeder4	33.000	103.339	-2.4	0.000	0.000	0.000	0.000	Yatta Bus	10.437	3.522	186.5	94.8	
								Beat-Aulla Substation	-10.437	-3.522	186.5	94.8	
Bus16	33.000	103.356	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-15.038	-4.901	267.7	95.1	5.000
								Bus23	15.038	4.901	267.7	95.1	
Bus18	33.000	103.360	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-15.040	-4.888	267.7	95.1	5.000
								Bus24	15.040	4.888	267.7	95.1	
Bus23	33.000	103.356	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	15.038	4.901	267.7	95.1	
								Bus16	-15.038	-4.901	267.7	95.1	
Bus24	33.000	103.360	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	15.040	4.888	267.7	95.1	
								Bus18	-15.040	-4.888	267.7	95.1	
Bus105	0.400	105.268	2.5	2.269	0.746	0.000	0.000	Yatta Bus	2.269	0.746	3274.8	95.0	
Bus106	0.400	105.717	2.8	1.677	0.551	0.000	0.000	Beat-Awwa Bus	1.677	0.551	2409.8	95.0	
Bus107	0.400	103.823	2.3	3.076	0.625	0.000	0.000	Idna Bus	3.076	0.625	4363.7	98.0	

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus108	0.400	105.566	2.4	1.553	0.511	0.000	0.000	Beat-Aulla Bus	1.553	0.511	2235.8	95.0	
Bus109	0.400	103.521	-1.6	0.154	0.051	0.000	0.000	Deer samit Bus	0.154	0.051	226.2	95.0	
Bus110	0.400	104.809	1.9	1.973	0.401	0.000	0.000	tarqumiaBus	1.973	0.401	2772.0	98.0	
Bus116	33.000	102.626	-2.8	0.000	0.000	0.000	0.000	bus125	-10.026	-3.393	180.4	94.7	
								Dora Bus	10.026	3.393	180.4	94.7	
Bus120	0.400	104.511	1.8	2.207	0.725	0.000	0.000	Dora Bus	2.207	0.725	3208.3	95.0	
bus124	33.000	102.888	-2.6	0.000	0.000	0.000	0.000	Deer samit Bus	0.699	0.206	12.4	95.9	
								Busfeeder3	-19.209	-6.400	344.3	94.9	
								bus125	18.510	6.194	331.9	94.8	
Bus124	0.400	103.448	-1.6	0.173	0.057	0.000	0.000	Beat-Magdoom Bus	0.173	0.057	253.6	95.0	
bus125	33.000	102.740	-2.7	0.000	0.000	0.000	0.000	Beat-Awwa Bus	7.656	2.631	137.8	94.6	
								Beat-Magdoom Bus	0.802	0.208	14.1	96.8	
								bus124	-18.491	-6.196	332.1	94.8	
								Bus116	10.034	3.358	180.2	94.8	
Bus132	33.000	103.356	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	15.038	4.901	267.7	95.1	
								Bus134	-15.038	-4.901	267.7	95.1	
Bus134	33.000	103.356	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-15.038	-4.901	267.7	95.1	5.000
								Bus132	15.038	4.901	267.7	95.1	
Bus135	33.000	103.360	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-15.040	-4.888	267.7	95.1	5.000
								Bus136	15.040	4.888	267.7	95.1	
Bus136	33.000	103.360	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	15.040	4.888	267.7	95.1	
								Bus135	-15.040	-4.888	267.7	95.1	
Busfeeder1	33.000	103.339	-2.4	0.000	0.000	0.000	0.000	Beat-Aulla Bus	7.283	2.401	129.8	95.0	
								Beat-Aulla Substation	-7.283	-2.401	129.8	95.0	
Busfeeder2	33.000	103.339	-2.4	0.000	0.000	0.000	0.000	tarqumiaBus	9.113	3.396	164.7	93.7	
								Idna Bus	14.046	5.244	253.8	93.7	
								Beat-Aulla Substation	-23.159	-8.640	418.5	93.7	
Busfeeder3	33.000	103.339	-2.4	0.000	0.000	0.000	0.000	bus124	19.268	6.401	343.7	94.9	
								Beat-Aulla Substation	-19.268	-6.401	343.7	94.9	
Deer samit Bus	33.000	102.885	-2.6	0.000	0.000	0.853	0.280	bus124	-0.699	-0.233	12.5	94.9	
								Bus109	-0.154	-0.048	2.7	95.5	
Dora Bus	33.000	101.800	-3.1	0.000	0.000	12.168	3.999	Bus116	-9.966	-3.480	181.4	94.4	
								Bus120	-2.202	-0.520	38.9	97.3	

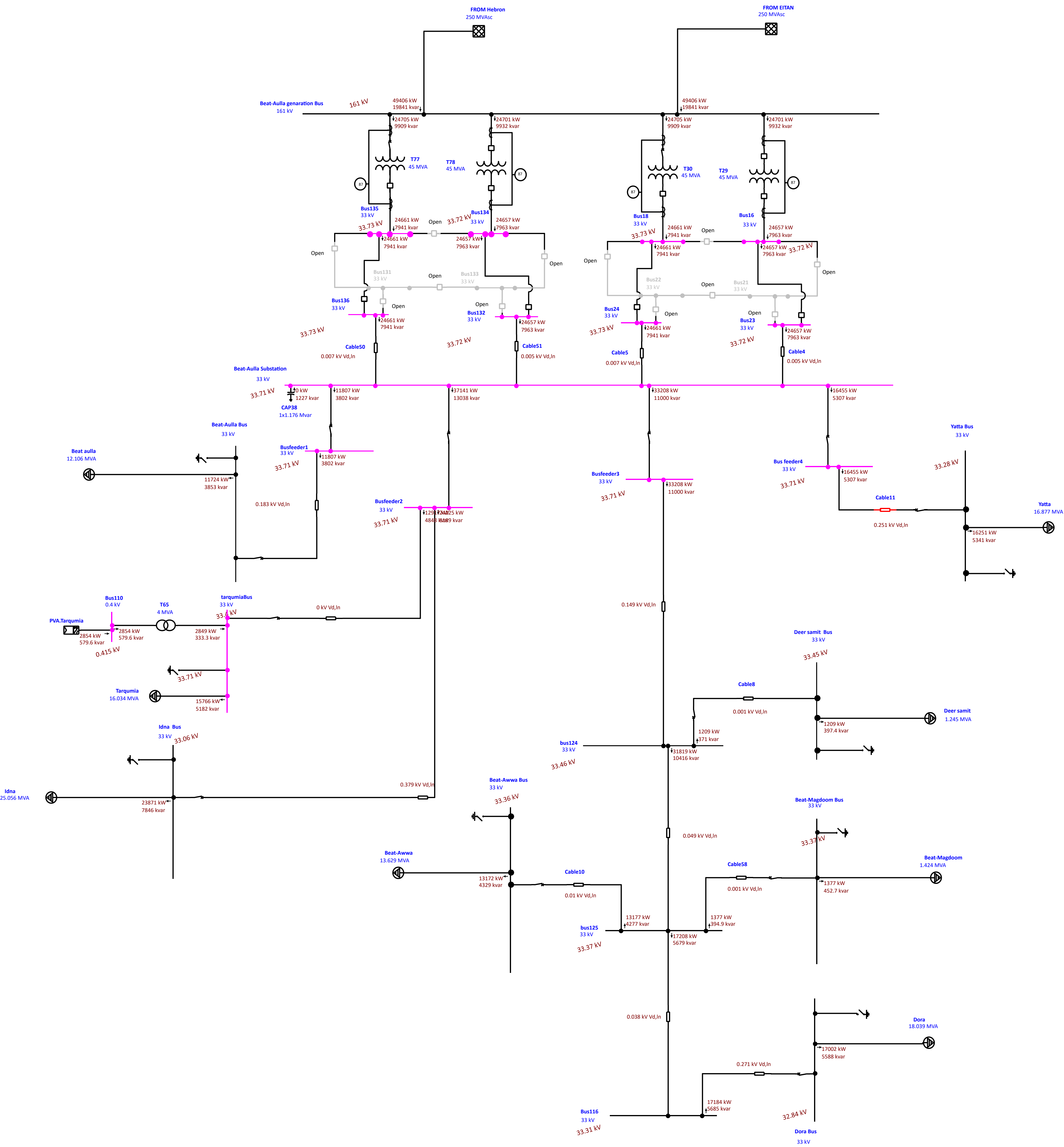
Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Idna Bus	33.000	102.154	-2.9	0.000	0.000	16.997	5.587	Busfeeder2	-13.927	-5.247	254.9	93.6	
								Bus107	-3.070	-0.339	52.9	99.4	
tarqumiaBus	33.000	103.338	-2.4	0.000	0.000	11.083	3.643	Busfeeder2	-9.113	-3.396	164.7	93.7	
								Bus110	-1.969	-0.247	33.6	99.2	
Yatta Bus	33.000	102.505	-2.5	0.000	0.000	12.620	4.148	Bus feeder4	-10.356	-3.617	187.2	94.4	
								Bus105	-2.264	-0.531	39.7	97.4	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

Appendix E4: 2030 case without PV

One-Line Diagram - OLV1 (Load Flow Analysis)



LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Beat-Aulla Bus	33.000	101.205	-4.4	0.000	0.000	11.724	3.853	Busfeeder1	-11.724	-3.853	213.3	95.0	
* Beat-Aulla genaration Bus	161.000	100.000	0.0	98.812	39.682	0.000	0.000	Bus16	24.701	9.932	95.5	92.8	
								Bus18	24.705	9.909	95.5	92.8	
								Bus135	24.705	9.909	95.5	92.8	
								Bus134	24.701	9.932	95.5	92.8	
Beat-Aulla Substation	33.000	102.165	-4.0	0.000	0.000	0.000	-1.227	Bus23	-24.652	-7.991	443.8	95.1	
								Bus24	-24.654	-7.969	443.7	95.2	
								Bus136	-24.654	-7.969	443.7	95.2	
								Bus132	-24.652	-7.991	443.8	95.1	
								Busfeeder3	33.208	11.000	599.1	94.9	
								Busfeeder2	37.141	13.038	674.1	94.4	
								Busfeeder1	11.807	3.802	212.4	95.2	
								Bus feeder4	16.455	5.307	296.1	95.2	
Beat-Awwa Bus	33.000	101.077	-4.6	0.000	0.000	13.172	4.329	bus125	-13.172	-4.329	240.0	95.0	
Beat-Magdoom Bus	33.000	101.122	-4.5	0.000	0.000	1.377	0.453	bus125	-1.377	-0.453	25.1	95.0	
Bus feeder4	33.000	102.165	-4.0	0.000	0.000	0.000	0.000	Yatta Bus	16.455	5.307	296.1	95.2	
								Beat-Aulla Substation	-16.455	-5.307	296.1	95.2	
Bus16	33.000	102.194	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-24.657	-7.963	443.6	95.2	5.000
								Bus23	24.657	7.963	443.6	95.2	
Bus18	33.000	102.200	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-24.661	-7.941	443.5	95.2	5.000
								Bus24	24.661	7.941	443.5	95.2	
Bus23	33.000	102.194	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	24.657	7.963	443.6	95.2	
								Bus16	-24.657	-7.963	443.6	95.2	
Bus24	33.000	102.200	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	24.661	7.941	443.5	95.2	
								Bus18	-24.661	-7.941	443.5	95.2	
Bus110	0.400	103.742	0.8	2.854	0.580	0.000	0.000	tarqumiaBus	2.854	0.580	4052.0	98.0	
Bus116	33.000	100.928	-4.6	0.000	0.000	0.000	0.000	bus125	-17.184	-5.685	313.8	94.9	
								Dora Bus	17.184	5.685	313.8	94.9	
bus124	33.000	101.383	-4.4	0.000	0.000	0.000	0.000	Deer samit Bus	1.209	0.371	21.8	95.6	
								Busfeeder3	-33.028	-10.787	599.6	95.1	
								bus125	31.819	10.416	577.8	95.0	

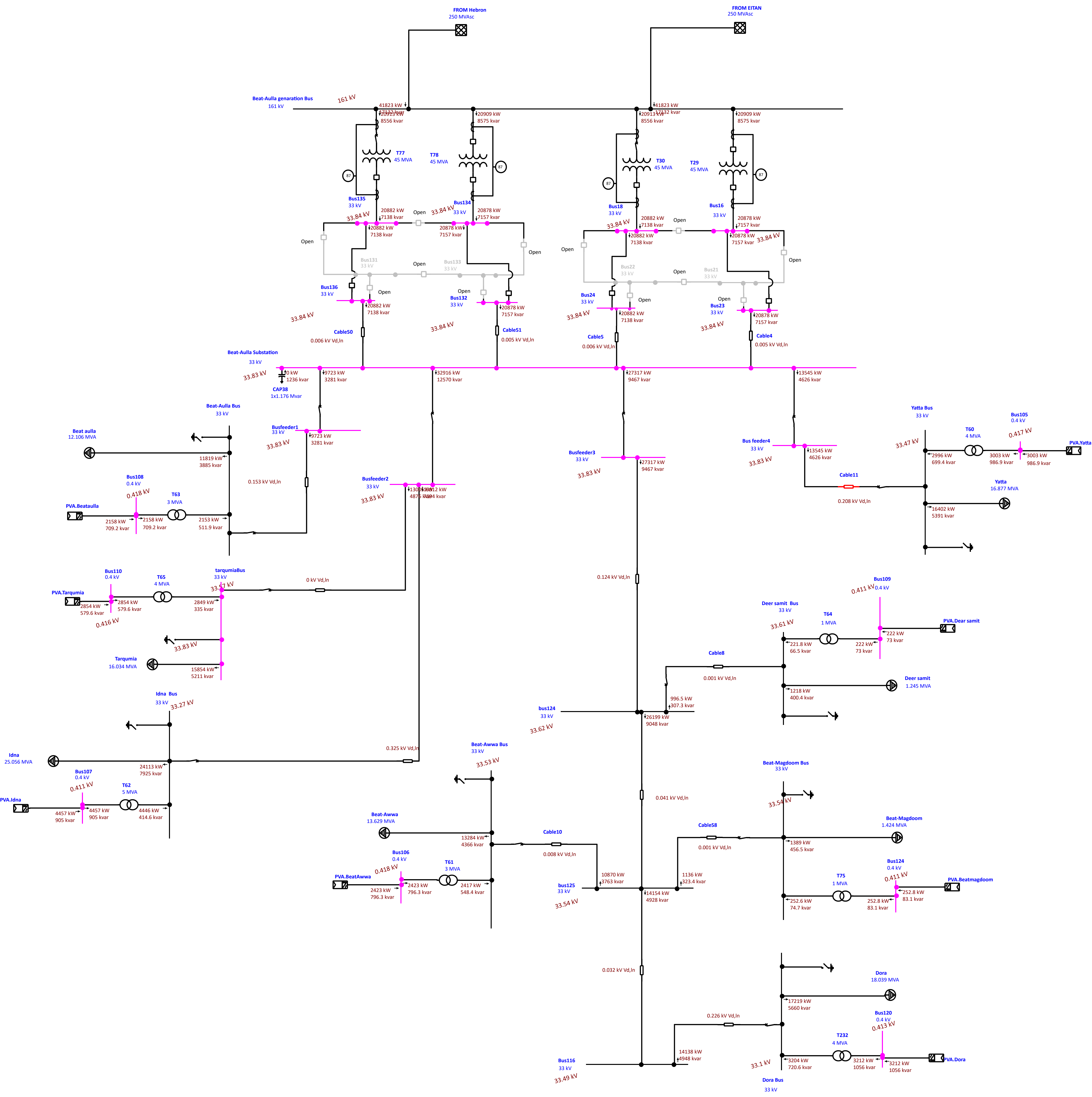
Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
bus125	33.000	101.127	-4.5	0.000	0.000	0.000	0.000	Beat-Awwa Bus	13.177	4.277	239.7	95.1	
								Beat-Magdoom Bus	1.377	0.395	24.8	96.1	
								bus124	-31.763	-10.350	577.9	95.1	
								Bus116	17.208	5.679	313.5	95.0	
Bus132	33.000	102.194	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	24.657	7.963	443.6	95.2	
								Bus134	-24.657	-7.963	443.6	95.2	
Bus134	33.000	102.194	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-24.657	-7.963	443.6	95.2	5.000
								Bus132	24.657	7.963	443.6	95.2	
Bus135	33.000	102.200	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-24.661	-7.941	443.5	95.2	5.000
								Bus136	24.661	7.941	443.5	95.2	
Bus136	33.000	102.200	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	24.661	7.941	443.5	95.2	
								Bus135	-24.661	-7.941	443.5	95.2	
Busfeeder1	33.000	102.165	-4.0	0.000	0.000	0.000	0.000	Beat-Aulla Bus	11.807	3.802	212.4	95.2	
								Beat-Aulla Substation	-11.807	-3.802	212.4	95.2	
Busfeeder2	33.000	102.165	-4.0	0.000	0.000	0.000	0.000	tarqumiaBus	12.917	4.848	236.3	93.6	
								Idna Bus	24.225	8.189	437.9	94.7	
								Beat-Aulla Substation	-37.141	-13.038	674.1	94.4	
Busfeeder3	33.000	102.165	-4.0	0.000	0.000	0.000	0.000	bus124	33.208	11.000	599.1	94.9	
								Beat-Aulla Substation	-33.208	-11.000	599.1	94.9	
Deer samit Bus	33.000	101.377	-4.4	0.000	0.000	1.209	0.397	bus124	-1.209	-0.397	22.0	95.0	
Dora Bus	33.000	99.507	-5.3	0.000	0.000	17.002	5.588	Bus116	-17.002	-5.588	314.7	95.0	
Idna Bus	33.000	100.178	-4.9	0.000	0.000	23.871	7.846	Busfeeder2	-23.871	-7.846	438.8	95.0	
tarqumiaBus	33.000	102.165	-4.0	0.000	0.000	15.766	5.182	Busfeeder2	-12.917	-4.849	236.3	93.6	
								Bus110	-2.849	-0.333	49.1	99.3	
Yatta Bus	33.000	100.845	-4.1	0.000	0.000	16.251	5.341	Bus feeder4	-16.251	-5.341	296.8	95.0	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

Appendix E5: 2030 case with PV

One-Line Diagram - OLV1 (Load Flow Analysis)



LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Beat-Aulla Bus	33.000	101.716	-3.7	0.000	0.000	11.819	3.885	Busfeeder1	-9.666	-3.373	176.1	94.4	
								Bus108	-2.153	-0.512	38.1	97.3	
*Beat-Aulla genaration Bus	161.000	100.000	0.0	83.645	34.263	0.000	0.000	Bus16	20.909	8.575	81.0	92.5	
								Bus18	20.913	8.556	81.0	92.6	
								Bus135	20.913	8.556	81.0	92.6	
								Bus134	20.909	8.575	81.0	92.5	
Beat-Aulla Substation	33.000	102.518	-3.4	0.000	0.000	0.000	-1.236	Bus23	-20.874	-7.186	376.8	94.6	
								Bus24	-20.877	-7.168	376.7	94.6	
								Bus136	-20.877	-7.168	376.7	94.6	
								Bus132	-20.874	-7.186	376.8	94.6	
								Busfeeder3	27.317	9.467	493.4	94.5	
								Busfeeder2	32.916	12.570	601.3	93.4	
								Busfeeder1	9.723	3.281	175.1	94.7	
								Bus feeder4	13.545	4.626	244.3	94.6	
Beat-Awwa Bus	33.000	101.610	-3.8	0.000	0.000	13.284	4.366	bus125	-10.867	-3.818	198.3	94.3	
								Bus106	-2.417	-0.548	42.7	97.5	
Beat-Magdoom Bus	33.000	101.647	-3.8	0.000	0.000	1.389	0.456	bus125	-1.136	-0.382	20.6	94.8	
								Bus124	-0.253	-0.075	4.5	95.9	
Bus feeder4	33.000	102.518	-3.4	0.000	0.000	0.000	0.000	Yatta Bus	13.545	4.626	244.3	94.6	
								Beat-Aulla Substation	-13.545	-4.626	244.3	94.6	
Bus16	33.000	102.542	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-20.878	-7.157	376.6	94.6	5.000
								Bus23	20.878	7.157	376.6	94.6	
Bus18	33.000	102.548	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-20.882	-7.138	376.5	94.6	5.000
								Bus24	20.882	7.138	376.5	94.6	
Bus23	33.000	102.542	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	20.878	7.157	376.6	94.6	
								Bus16	-20.878	-7.157	376.6	94.6	
Bus24	33.000	102.548	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	20.882	7.138	376.5	94.6	
								Bus18	-20.882	-7.138	376.5	94.6	
Bus105	0.400	104.191	1.6	3.003	0.987	0.000	0.000	Yatta Bus	3.003	0.987	4378.6	95.0	
Bus106	0.400	104.544	1.6	2.423	0.796	0.000	0.000	Beat-Awwa Bus	2.423	0.796	3520.8	95.0	
Bus107	0.400	102.673	2.1	4.457	0.905	0.000	0.000	Idna Bus	4.457	0.905	6393.3	98.0	

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus108	0.400	104.378	1.1	2.158	0.709	0.000	0.000	Beat-Aulla Bus	2.158	0.709	3140.6	95.0	
Bus109	0.400	102.772	-2.2	0.222	0.073	0.000	0.000	Deer samit Bus	0.222	0.073	328.1	95.0	
Bus110	0.400	104.092	1.4	2.854	0.580	0.000	0.000	tarqumiaBus	2.854	0.580	4038.4	98.0	
Bus116	33.000	101.485	-3.9	0.000	0.000	0.000	0.000	bus125	-14.138	-4.948	258.2	94.4	
								Dora Bus	14.138	4.948	258.2	94.4	
Bus120	0.400	103.244	1.1	3.212	1.056	0.000	0.000	Dora Bus	3.212	1.056	4726.3	95.0	
bus124	33.000	101.865	-3.7	0.000	0.000	0.000	0.000	Deer samit Bus	0.997	0.307	17.9	95.6	
								Busfeeder3	-27.196	-9.355	493.9	94.6	
								bus125	26.199	9.048	476.0	94.5	
Bus124	0.400	102.681	-2.1	0.253	0.083	0.000	0.000	Beat-Magdoom Bus	0.253	0.083	374.0	95.0	
bus125	33.000	101.651	-3.8	0.000	0.000	0.000	0.000	Beat-Awwa Bus	10.870	3.763	198.0	94.5	
								Beat-Magdoom Bus	1.136	0.323	20.3	96.2	
								bus124	-26.161	-9.014	476.2	94.5	
								Bus116	14.154	4.928	258.0	94.4	
Bus132	33.000	102.542	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	20.878	7.157	376.6	94.6	
								Bus134	-20.878	-7.157	376.6	94.6	
Bus134	33.000	102.542	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-20.878	-7.157	376.6	94.6	5.000
								Bus132	20.878	7.157	376.6	94.6	
Bus135	33.000	102.548	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-20.882	-7.138	376.5	94.6	5.000
								Bus136	20.882	7.138	376.5	94.6	
Bus136	33.000	102.548	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla Substation	20.882	7.138	376.5	94.6	
								Bus135	-20.882	-7.138	376.5	94.6	
Busfeeder1	33.000	102.518	-3.4	0.000	0.000	0.000	0.000	Beat-Aulla Bus	9.723	3.281	175.1	94.7	
								Beat-Aulla Substation	-9.723	-3.281	175.1	94.7	
Busfeeder2	33.000	102.518	-3.4	0.000	0.000	0.000	0.000	tarqumiaBus	13.005	4.876	237.0	93.6	
								Idna Bus	19.912	7.694	364.3	93.3	
								Beat-Aulla Substation	-32.916	-12.570	601.3	93.4	
Busfeeder3	33.000	102.518	-3.4	0.000	0.000	0.000	0.000	bus124	27.317	9.467	493.4	94.5	
								Beat-Aulla Substation	-27.317	-9.467	493.4	94.5	
Deer samit Bus	33.000	101.860	-3.7	0.000	0.000	1.218	0.400	bus124	-0.996	-0.334	18.1	94.8	
								Bus109	-0.222	-0.066	4.0	95.8	
Dora Bus	33.000	100.298	-4.4	0.000	0.000	17.219	5.660	Bus116	-14.015	-4.939	259.2	94.3	
								Bus120	-3.204	-0.721	57.3	97.6	

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Idna Bus	33.000	100.809	-4.0	0.000	0.000	24.113	7.925	Busfeeder2	-19.667	-7.511	365.4	93.4	
								Bus107	-4.446	-0.415	77.5	99.6	
tarqumiaBus	33.000	102.517	-3.4	0.000	0.000	15.854	5.211	Busfeeder2	-13.005	-4.876	237.0	93.6	
								Bus110	-2.849	-0.335	49.0	99.3	
Yatta Bus	33.000	101.426	-3.4	0.000	0.000	16.402	5.391	Bus feeder4	-13.405	-4.692	245.0	94.4	
								Bus105	-2.996	-0.699	53.1	97.4	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

\# Indicates a bus with a load mismatch of more than 0.1 MVA

Appendix E6:2050 case without PV

LOAD FLOW REPORT

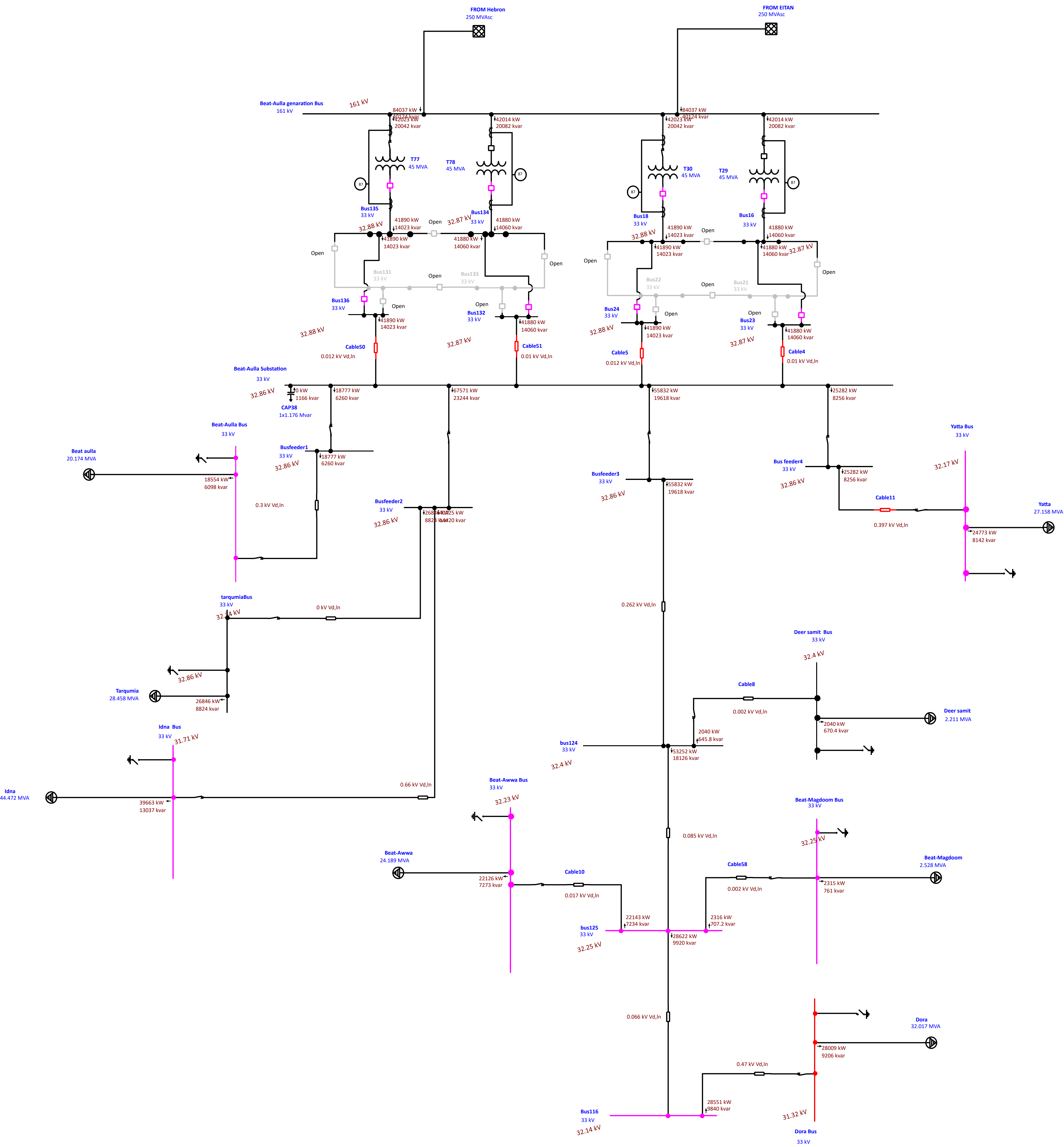
Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Beat-Aulla Bus	33.000	97.986	-7.7	0.000	0.000	18.554	6.098	Busfeeder1	-18.554	-6.098	348.7	95.0	
* Beat-Aulla genaration Bus	161.000	100.000	0.0	168.074	80.248	0.000	0.000	Bus16	42.014	20.082	167.0	90.2	
								Bus18	42.023	20.042	167.0	90.3	
								Bus135	42.023	20.042	167.0	90.3	
								Bus134	42.014	20.082	167.0	90.2	
Beat-Aulla Substation	33.000	99.562	-7.0	0.000	0.000	0.000	-1.166	Bus23	-41.863	-14.072	776.1	94.8	
								Bus24	-41.868	-14.034	775.9	94.8	
								Bus136	-41.868	-14.034	775.9	94.8	
								Bus132	-41.863	-14.072	776.1	94.8	
								Busfeeder3	55.832	19.618	1039.9	94.3	
								Busfeeder2	67.571	23.244	1255.7	94.6	
								Busfeeder1	18.777	6.260	347.8	94.9	
								Bus feeder4	25.282	8.256	467.3	95.1	
Beat-Awwa Bus	33.000	97.652	-8.0	0.000	0.000	22.126	7.273	bus125	-22.126	-7.273	417.3	95.0	
Beat-Magdoom Bus	33.000	97.730	-7.9	0.000	0.000	2.315	0.761	bus125	-2.315	-0.761	43.6	95.0	
Bus feeder4	33.000	99.562	-7.0	0.000	0.000	0.000	0.000	Yatta Bus	25.282	8.256	467.3	95.1	
								Beat-Aulla Substation	-25.282	-8.256	467.3	95.1	
Bus16	33.000	99.612	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-41.880	-14.060	775.9	94.8	5.000
								Bus23	41.880	14.060	775.9	94.8	
Bus18	33.000	99.624	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-41.890	-14.023	775.8	94.8	5.000
								Bus24	41.890	14.023	775.8	94.8	
Bus23	33.000	99.612	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	41.880	14.060	775.9	94.8	
								Bus16	-41.880	-14.060	775.9	94.8	
Bus24	33.000	99.624	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	41.890	14.023	775.8	94.8	
								Bus18	-41.890	-14.023	775.8	94.8	
Bus116	33.000	97.391	-8.1	0.000	0.000	0.000	0.000	bus125	-28.551	-9.840	542.5	94.5	
								Dora Bus	28.551	9.840	542.5	94.5	
bus124	33.000	98.187	-7.7	0.000	0.000	0.000	0.000	Deer samit Bus	2.040	0.646	38.1	95.3	
								Busfeeder3	-55.291	-18.772	1040.4	94.7	
								bus125	53.252	18.126	1002.3	94.7	
bus125	33.000	97.739	-7.9	0.000	0.000	0.000	0.000	Beat-Awwa Bus	22.143	7.234	417.0	95.1	

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								Beat-Magdoom Bus	2.316	0.707	43.3	95.6	
								bus124	-53.081	-17.861	1002.5	94.8	
								Bus116	28.622	9.920	542.2	94.5	
Bus132	33.000	99.612	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	41.880	14.060	775.9	94.8	
								Bus134	-41.880	-14.060	775.9	94.8	
Bus134	33.000	99.612	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-41.880	-14.060	775.9	94.8	5.000
								Bus132	41.880	14.060	775.9	94.8	
Bus135	33.000	99.624	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-41.890	-14.023	775.8	94.8	5.000
								Bus136	41.890	14.023	775.8	94.8	
Bus136	33.000	99.624	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla Substation	41.890	14.023	775.8	94.8	
								Bus135	-41.890	-14.023	775.8	94.8	
Busfeeder1	33.000	99.562	-7.0	0.000	0.000	0.000	0.000	Beat-Aulla Bus	18.777	6.260	347.8	94.9	
								Beat-Aulla Substation	-18.777	-6.260	347.8	94.9	
Busfeeder2	33.000	99.562	-7.0	0.000	0.000	0.000	0.000	tarqumiaBus	26.846	8.824	496.6	95.0	
								Idna Bus	40.725	14.420	759.2	94.3	
								Beat-Aulla Substation	-67.571	-23.244	1255.7	94.6	
Busfeeder3	33.000	99.562	-7.0	0.000	0.000	0.000	0.000	bus124	55.832	19.618	1039.9	94.3	
								Beat-Aulla Substation	-55.832	-19.618	1039.9	94.3	
Deer samit Bus	33.000	98.176	-7.7	0.000	0.000	2.040	0.670	bus124	-2.040	-0.670	38.3	95.0	
Dora Bus	33.000	94.924	-9.2	0.000	0.000	28.009	9.206	Bus116	-28.009	-9.206	543.4	95.0	
Idna Bus	33.000	96.100	-8.5	0.000	0.000	39.663	13.037	Busfeeder2	-39.663	-13.037	760.1	95.0	
tarqumiaBus	33.000	99.561	-7.0	0.000	0.000	26.846	8.824	Busfeeder2	-26.846	-8.824	496.6	95.0	
Yatta Bus	33.000	97.479	-7.1	0.000	0.000	24.773	8.142	Bus feeder4	-24.773	-8.142	468.0	95.0	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

One-Line Diagram - OLV1 (Load Flow Analysis)



Appendix E7: 2050 case with PV

LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Beat-Aulla Bus	33.000	99.058	-6.2	0.000	0.000	18.878	6.205	Busfeeder1	-15.292	-5.369	286.2	94.4	
								Bus108	-3.586	-0.836	65.0	97.4	
* Beat-Aulla genaration Bus	161.000	100.000	0.0	137.906	66.592	0.000	0.000	Bus16	34.472	16.664	137.3	90.0	
								Bus18	34.481	16.632	137.3	90.1	
								Bus135	34.481	16.632	137.3	90.1	
								Bus134	34.472	16.664	137.3	90.0	
Beat-Aulla Substation	33.000	100.369	-5.7	0.000	0.000	0.000	-1.185	Bus23	-34.370	-12.612	638.2	93.9	
								Bus24	-34.375	-12.581	638.1	93.9	
								Bus136	-34.375	-12.581	638.1	93.9	
								Bus132	-34.370	-12.612	638.2	93.9	
								Busfeeder3	45.791	16.919	850.9	93.8	
								Busfeeder2	55.489	21.964	1040.3	93.0	
								Busfeeder1	15.442	5.421	285.3	94.4	
								Bus feeder4	20.769	7.267	383.6	94.4	
Beat-Awwa Bus	33.000	98.782	-6.4	0.000	0.000	22.534	7.407	bus125	-18.236	-6.485	342.8	94.2	
								Bus106	-4.298	-0.921	77.9	97.8	
Beat-Magdoom Bus	33.000	98.846	-6.4	0.000	0.000	2.358	0.775	bus125	-1.908	-0.655	35.7	94.6	
								Bus124	-0.449	-0.120	8.2	96.6	
Bus feeder4	33.000	100.369	-5.7	0.000	0.000	0.000	0.000	Yatta Bus	20.769	7.267	383.6	94.4	
								Beat-Aulla Substation	-20.769	-7.267	383.6	94.4	
Bus16	33.000	100.411	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-34.382	-12.593	638.0	93.9	5.000
								Bus23	34.382	12.593	638.0	93.9	
Bus18	33.000	100.421	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-34.390	-12.562	637.9	93.9	5.000
								Bus24	34.390	12.562	637.9	93.9	
Bus23	33.000	100.411	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla Substation	34.382	12.593	638.0	93.9	
								Bus16	-34.382	-12.593	638.0	93.9	
Bus24	33.000	100.421	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla Substation	34.390	12.562	637.9	93.9	
								Bus18	-34.390	-12.562	637.9	93.9	
Bus105	0.400	101.640	-0.1	4.834	1.589	0.000	0.000	Yatta Bus	4.834	1.589	7225.8	95.0	
Bus106	0.400	101.931	-0.4	4.309	1.416	0.000	0.000	Beat-Awwa Bus	4.309	1.416	6422.7	95.0	
Bus107	0.400	99.277	-0.4	7.915	1.607	0.000	0.000	Idna Bus	7.915	1.607	11742.6	98.0	

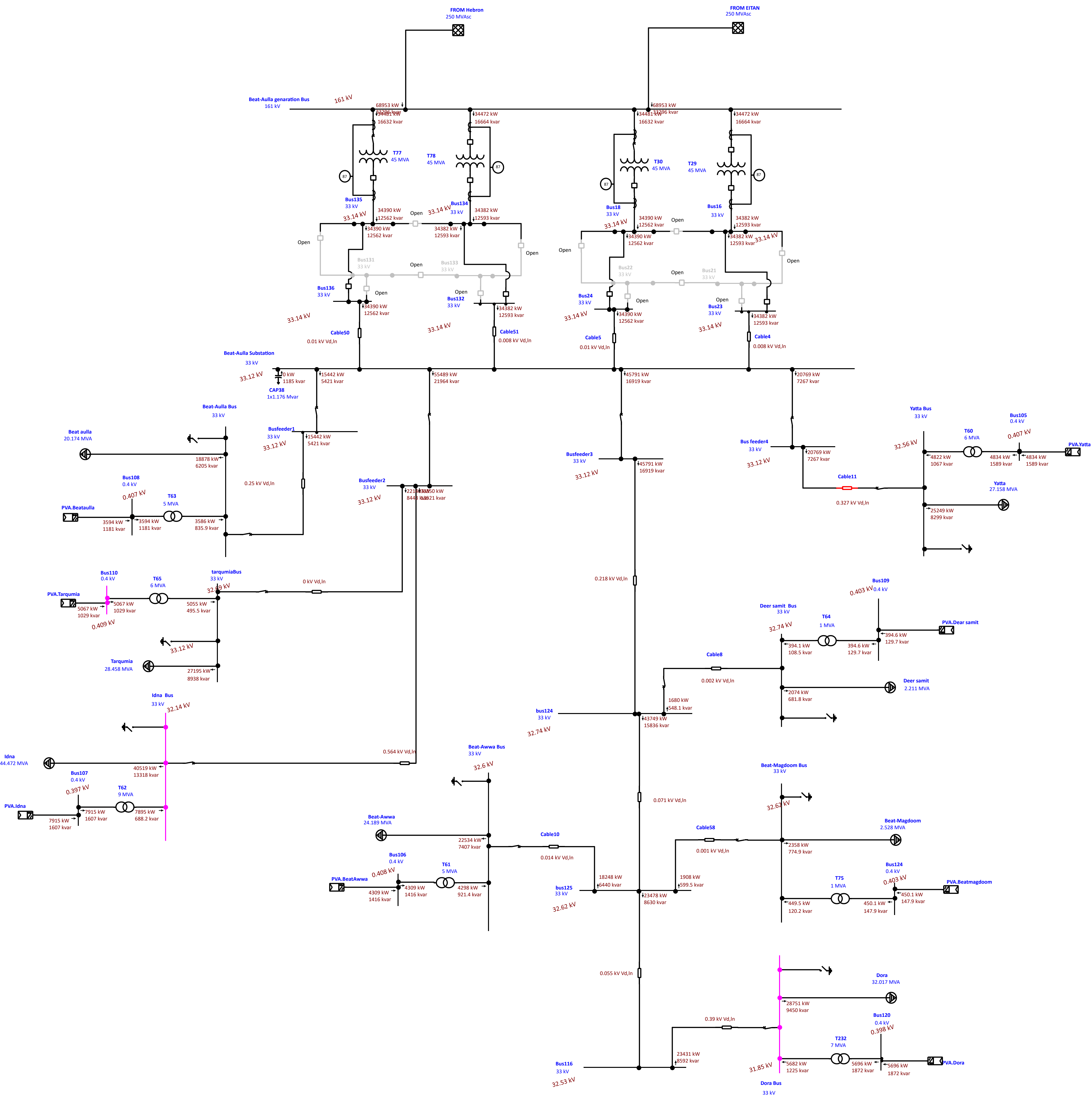
Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus108	0.400	101.768	-1.2	3.594	1.181	0.000	0.000	Beat-Aulla Bus	3.594	1.181	5365.5	95.0	
Bus109	0.400	100.816	-3.4	0.395	0.130	0.000	0.000	Deer samit Bus	0.395	0.130	594.7	95.0	
Bus110	0.400	102.167	0.2	5.067	1.029	0.000	0.000	tarqumiaBus	5.067	1.029	7304.8	98.0	
Bus116	33.000	98.565	-6.6	0.000	0.000	0.000	0.000	bus125	-23.431	-8.592	443.0	93.9	
								Dora Bus	23.431	8.592	443.0	93.9	
Bus120	0.400	99.567	-1.4	5.696	1.872	0.000	0.000	Dora Bus	5.696	1.872	8691.7	95.0	
bus124	33.000	99.227	-6.2	0.000	0.000	0.000	0.000	Deer samit Bus	1.680	0.548	31.2	95.1	
								Busfeeder3	-45.429	-16.385	851.5	94.1	
								bus125	43.749	15.836	820.3	94.0	
Bus124	0.400	100.652	-3.2	0.450	0.148	0.000	0.000	Beat-Magdoom Bus	0.450	0.148	679.4	95.0	
bus125	33.000	98.854	-6.4	0.000	0.000	0.000	0.000	Beat-Awwa Bus	18.248	6.440	342.5	94.3	
								Beat-Magdoom Bus	1.908	0.600	35.4	95.4	
								bus124	-43.634	-15.669	820.5	94.1	
								Bus116	23.478	8.630	442.7	93.9	
Bus132	33.000	100.411	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla Substation	34.382	12.593	638.0	93.9	
								Bus134	-34.382	-12.593	638.0	93.9	
Bus134	33.000	100.411	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-34.382	-12.593	638.0	93.9	5.000
								Bus132	34.382	12.593	638.0	93.9	
Bus135	33.000	100.421	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla genaration Bus	-34.390	-12.562	637.9	93.9	5.000
								Bus136	34.390	12.562	637.9	93.9	
Bus136	33.000	100.421	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla Substation	34.390	12.562	637.9	93.9	
								Bus135	-34.390	-12.562	637.9	93.9	
Busfeeder1	33.000	100.369	-5.7	0.000	0.000	0.000	0.000	Beat-Aulla Bus	15.442	5.421	285.3	94.4	
								Beat-Aulla Substation	-15.442	-5.421	285.3	94.4	
Busfeeder2	33.000	100.369	-5.7	0.000	0.000	0.000	0.000	tarqumiaBus	22.140	8.443	413.0	93.4	
								Idna Bus	33.350	13.521	627.3	92.7	
								Beat-Aulla Substation	-55.489	-21.964	1040.3	93.0	
Busfeeder3	33.000	100.369	-5.7	0.000	0.000	0.000	0.000	bus124	45.791	16.919	850.9	93.8	
								Beat-Aulla Substation	-45.791	-16.919	850.9	93.8	
Deer samit Bus	33.000	99.218	-6.3	0.000	0.000	2.074	0.682	bus124	-1.680	-0.573	31.3	94.6	
								Bus109	-0.394	-0.108	7.2	96.4	
Dora Bus	33.000	96.517	-7.4	0.000	0.000	28.751	9.450	Bus116	-23.069	-8.225	444.0	94.2	
								Bus120	-5.682	-1.225	105.4	97.8	

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Idna Bus	33.000	97.409	-6.8	0.000	0.000	40.519	13.318	Busfeeder2	-32.625	-12.630	628.3	93.3	
								Bus107	-7.895	-0.688	142.3	99.6	
tarqumiaBus	33.000	100.368	-5.7	0.000	0.000	27.195	8.938	Busfeeder2	-22.139	-8.443	413.0	93.4	
								Bus110	-5.055	-0.495	88.5	99.5	
Yatta Bus	33.000	98.655	-5.8	0.000	0.000	25.249	8.299	Bus feeder4	-20.426	-7.232	384.3	94.3	
								Bus105	-4.822	-1.067	87.6	97.6	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

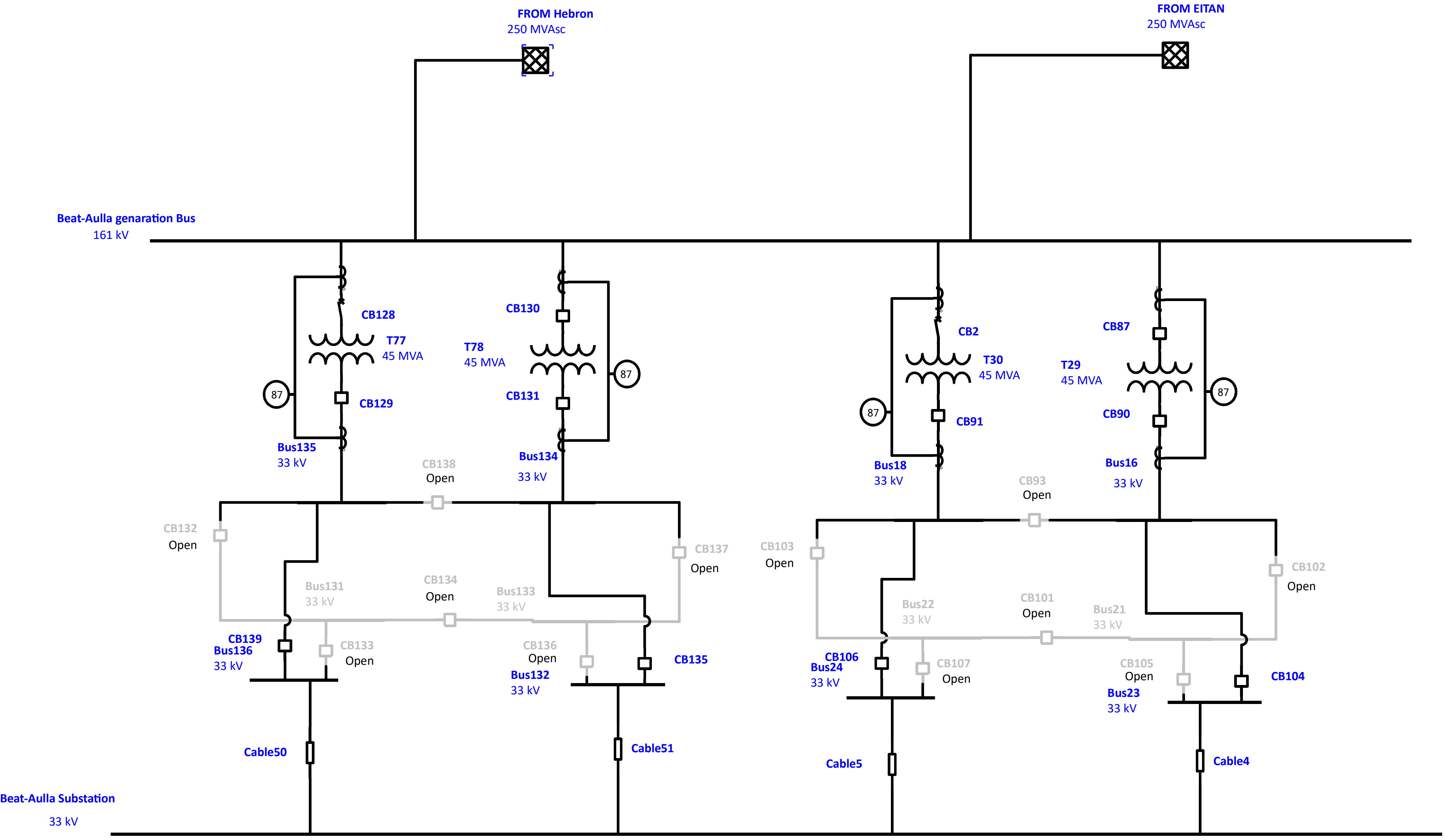
# Indicates a bus with a load mismatch of more than 0.1 MVA

One-Line Diagram - OLV1 (Load Flow Analysis)



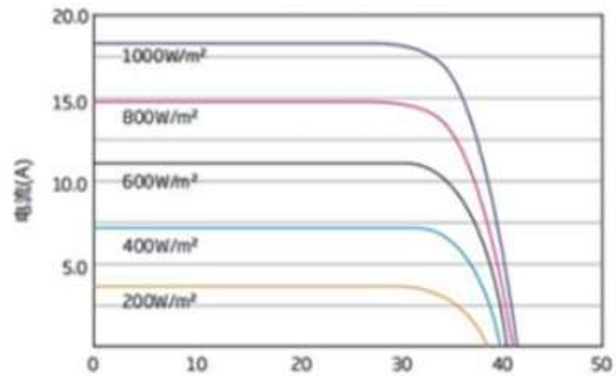
Appendix E8: future transformer single line diagram

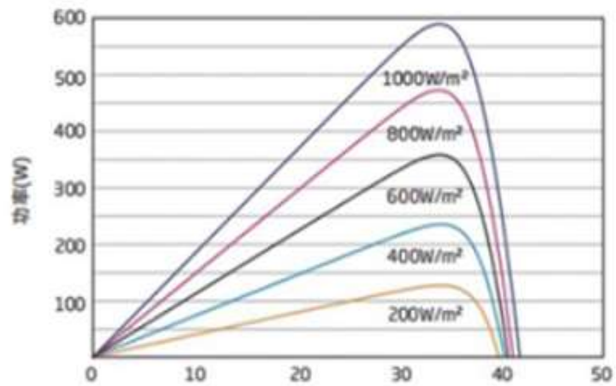
One-Line Diagram - OLV1 (Edit Mode)



Appendix E9: pv specification

Electrical Performance & Temperature Dependence





Mechanical Characteristics

Cell Type	210mm Mono-crystalline
No. of cells	120 (6×20)
Dimensions	2190×1303×35mm (86.22×51.3×1.38 inch)
Weight	28.9 kg (63.7 lbs)
Front Glass	3.2mm,Anti-Reflection Coating, High Transmission, Low Iron, Tempered Glass
Frame	Anodized Aluminium Alloy
Junction Box	IP68 Rated
Output Cables	TUV 1×4.0mm² (+): 400mm , (-): 200mm or Customized Length

SPECIFICATIONS

Module Type	YS600M-60		YS610M-60		YS620M-60		YS630M-60	
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax)	600W	454W	610W	461W	620W	468W	630W	475W
Maximum Power Voltage (Vmp)	34.4V	32.0V	34.8V	32.4V	35.2V	32.8V	35.6V	33.2V
Maximum Power Current (Imp)	17.44A	14.18A	17.53A	14.23A	17.62A	14.27A	17.70A	14.31A
Open-circuit Voltage (Voc)	41.5V	39.1V	41.9V	39.5V	42.3V	39.9V	42.7V	40.3V
Short-circuit Current (Isc)	18.52A	14.89A	18.58A	14.95A	18.67A	14.98A	18.74A	15.03A
Module Efficiency STC (%)	21.0%		21.3%		21.7%		22.0%	
Operating Temperature(℃)	-40℃~+85℃							
Maximum system voltage	1500VDC (IEC)							
Maximum series fuse rating	25A							
Power tolerance	0~+3%							
Temperature coefficients of Pmax	-0.35%/℃							
Temperature coefficients of Voc	-0.28%/℃							
Temperature coefficients of Isc	0.048%/℃							
Nominal operating cell temperature (NOCT)	45±2℃							

Appendix G: Data collection for power system

Appendix G1: Transformer characteristic

Appendix G2: High voltage isolator switch characteristic

Appendix G3: Circuit Breaker characteristic

Appendix G4: Switch Gear characteristic

Appendix G5: Transmission line characteristic

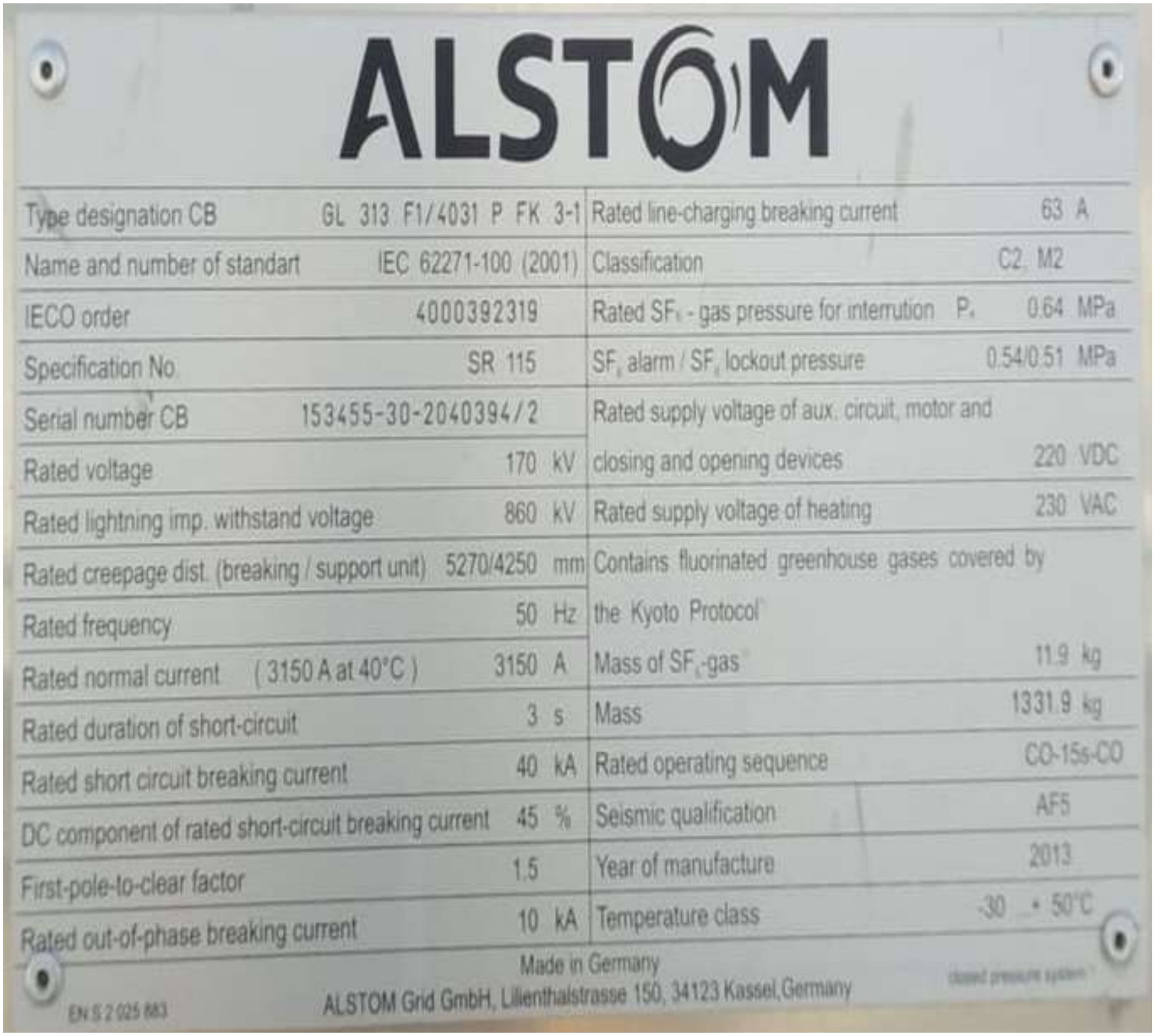
Appendix G1: Transformer characteristic

Model NO.	PEO-S-50, 000/161/36	Cooling Method	Oil-immersed Type Transformer
Winding Type	Two-winding Transformer	Certification	ISO9001-2000, ISO9001, CCC, Kema
Usage	Power Transformer, Power Supply	Frequency Characteristics	Power Frequency
Shape of Core	U	Brand	Pearl
Reference Standards	IEC60076	Type	Power Transformer
Rated Capacity	50 Mva	Rated H. V.	161 Kv
Rated L. V.	36kv	Cooling Way	Onan/Onaf
Core Material	Silicon Steel	Winding Material	Copper/Aluminum
Impedance	as Per IEC Standard	Temperature Rise (W)	60/65K
Vector Group	Dyn 11	Insulation Class	a-Class
Insulation Media	Mineral Oil as Per IEC 60296	AC Withstand Voltage	as Per IEC Standard
Lightning Impulse Withstand Voltage	as Per IEC Standard	Transport Package	Wooden Pallet
Specification	up to 63MVA	Trademark	PEARL EIECTRIC
Origin	China	HS Code	8504220000
Production Capacity	4000 Units/Year		

Appendix G2: High voltage isolator switch characteristic

Item		Technical parameter			
Rated Voltage kV		72.5	123	145	245
Rated Current A		1250 1600 2000 2500 3150 4000			
Rated Short Time withstand current and Time kA/s		25~50/4			
Rated Peak withstand current kA		63~125			
1min power frequency withstand voltage (effective value) kV	To earth	140	230	275	460
	To phase	140	230	275	460
	Across Isolating DS	180	300	315	605
Lightning Impulse wishstand voltage	To earth	325	550	650	1050
(peak value) kV	To phase	325	550	650	1050
	Across Isolating DS	405	650	750	1200
Rated mechanical terminal load N	Level of lateral load	750	1500	1500	2000
	Level of vertical load	500	1000	1000	1500
	Vertical	750	1000	1000	1250
Capacity and Inductive Ability (open and close)	Capacity Current A	1			
	Inductive Current A	0.5			
Max Man Operative Moment N. m		200			
Motor Drive operating mechanism control voltage V		AC220; DC110, 220			
Motor Drive operating mechanism motor voltage V		AC220, 380; DC110, 220			

Appendix G3: Circuit Breaker characteristic



Appendix G4: Switch Gear characteristic

Technical Specifications

Parameters	Unit	SIGP12	SIGP36
Rated Voltage	kV	12	36
Rated Frequency	Hz	50/60	50/60
Rated Normal Current	A	1250/2000	1250/2000/2500
Rated Insulation Level**	kV	12/28/75	36/70/170
VCB and DS Rated Short Time Current for 3 sec	kA	26.3/31.5	26.3/31.5
Rated Short-Circuit Breaking Current of the Circuit Breaker	kA	26.3/31.5	26.3/31.5
Rated Short-Circuit Making Current of the Circuit Breaker	kA	66/79	66/79
Rated Operating Sequence		O-0.3sec-CO-3min-CO	
Insulating Gas System			
Insulation Gas		SF_6	SF_6
Minimum Gas Pressure Level for Insulation	Bar	0.2 G	0.2 G
Rated Gas Filling Pressure Level for Insulation	Bar	0.4 G	0.4 G
Lock Out Pressure	Bar	0.2 G	0.2 G
Degree of Protection			
Gas Filled Compartment		IP 67	
Enclosure		IP 5X	
Panel Overall Dimensions			
Height (H)	mm	2200*	2200*
Width (W)	mm	500	600
Depth (D)	mm	1150	1150
Applied Standard		IEC 62271-200	

*Height Values would vary as per actual requirement of Instruments like Relays, Meters etc.
**Higher Values as per Request and Requirement.

Appendix G5: Transmission line characteristic

(6-36kV) Medium Voltage Underground Power Cables XLPE insulated cables [5]

Nominal cross-sectional area	mm²	3x70	3x95	3x120	3x150	3x185	3x240
Diameter over conductor	mm	9.8	11.5	12.8	14.3	15.9	18.4
Approximate diameter over insulation	mm	27	28.7	30	31.5	33.1	35.6
Approximate overall diameter	mm	75	79	83	86	89	95
Approximate weight of cable	kg/m	6400	7550	8550	9600	11000	13200
Minimum bending radius (static)	mm	1150	1200	1250	1300	1350	1450
Maximum pulling tension on cable	kg	1050	1425	1800	2250	2775	3600
Maximum DC resistance @20°C	Ω/km	0.2680	0.1930	0.1530	0.1240	0.0991	0.0754
Maximum AC resistance@ 90°C	Ω/km	0.3420	0.2470	0.1960	0.1590	0.1280	0.0978
Inductance	mH/km	0.427	0.405	0.387	0.375	0.365	0.348
Reactance@50Hz	Ω/km	0.134	0.127	0.122	0.118	0.115	0.109
Impedance @ 50Hz @ 90°C	Ω/km	0.367	0.277	0.23	0.198	0.172	0.147
Maximum capacitance (C)	μF/km	0.155	0.17	0.183	0.196	0.207	0.228
Maximum charging current	A/km	0.93	1.02	1.1	1.17	1.24	1.36
Short circuit ratings							
1 second short circuit-rating of conductor (90 to 250°C)	kA	9.7	13.5	17.1	21	26.3	34.6
1 second short circuit-rating of metallic screen (80 to 200°C)	kA	4.6	4.6	5	5	5.3	5.7

Nominal cross-sectional area	mm²	3x70	3x95	3x120	3x150	3x185	3x240
Continuous current carrying capacity (as per conditions detailed below)							
Direct buried	Amps	255	295	335	375	420	490
Single way ducts	Amps	230	260	305	335	380	435
In air	Amps	290	330	390	440	500	580