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Renewable Energy Grid Study Project

Prepared for

American Samoa Power Authority

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Date	Rev.	Description
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December 09, 2014	3	Revised with ASPA comments
December 27, 2014	4	Final

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Executive Summary

American Samoa Power Authority (ASPA) requested a comprehensive study of their system, with the intent to add more renewable generation resources in the future. Siemens PTI partnered with HOMER Energy to identify and address the issues for which ASPA would need to prepare. The study period spanned the period from 2013 to 2022, with future demand forecast levels developed in 2013.

The broad goals for the study were as follows:

1. Identify an optimal dispatch pattern for expected demand patterns, served by an expected future resource portfolio.

2. Determine if the optimal dispatch scenario must be modified because of possible system inadequacies.

3. Identify options to mitigate system inadequacies, if necessary.

4. Provide ASPA with a system model to perform studies in the future, in ETAP format.

An optimized economic generation dispatch was developed for current conditions and for anticipated future system conditions in which more renewables were included in the ASPA resource portfolio. Of the dispatchable generation on the island, the following key factors influenced our study results:

1. Satala had better economic parameters and had more generation available. In the system analysis cases, Satala had seven units modeled, with five of them available to provide base output, and two as peaking units, totaling 25 MW.

2. Tafuna had worse economic parameters than Satala. In the system analysis case, Tafuna had four units modeled, with a total capacity of nearly 15 MW output.

The optimized generation dispatch resulted in Satala being dispatched before Tafuna in meeting the various demand scenarios evaluated. As future years were appraised, with the anticipated trend of greater renewables into the future, less and less Tafuna generation was dispatched.

When the ASPA system integrated more than 1.9 MW of renewable generation voltages above ANSI's 105% limit were observed. However frequency became a concern when renewable generation reached 6.4 MW (24% of 2022 peak demand). Recommendations from our study include the following:

- Change the voltage setpoints at Satala and Tafuna from 100% to 104%. This change helps to mitigate some low voltages identified in the Tafuna area with the optimal dispatch through the ten-year study period.

- Add measures to reduce high voltages on feeders served from Satala. When expected future wind generation on feeders one and six exceed 1.9 MW, high voltages result. Possible mitigation measures are discussed within.

- UFLS relays are key devices to the further penetration of renewables on the ASPA system. The trip points for these relays need to be reevaluated and possibly recalibrated as more renewable are added. Without UFLS, the ASPA system will only be able to accommodate approximately a 24% renewable penetration level.

- Dynamic model refinement through generator testing is recommended. In this study, all generators (wind, solar PV and diesel unit) were represented by typical parameters and generic models, primarily due to the lack of accurate dynamic model information. The model provided to ASPA will also have typical parameters.. As all types of generation is added to the ASPA system, better models will be a critical tool for system studies.

- As the ASPA system adds renewable resources, and as these additions vary from the expansion studied herein, updated dynamic studies should be carried out. Variations may exist in terms of locations, technologies, output levels, or other pertinent ways.

Other actions recommended to ASPA, but not necessarily determined from this study effort, are as follows:

- As renewable resources are added in the future, perform protection coordination studies to assure that there are no islanding scenarios possible during fault clearing events.

- Automated demand side management (DSM), linked to UFLS relays and ASPA's water pumps to regulate frequency should be considered. This would be an automated implementation of the load shedding evaluated in this study.

- Consider the implementation of a Virtual Power Plant (VPP), where plant output can be forecast, based on predicted system demand and renewable output. Such a system can help to bridge the optimal generation pattern identified earlier with the spinning reserve requirement also discussed.

Section

1

Homer - Production Cost Modeling for the Electric Grid on Tutuila

Production Cost Modeling for the Electric Grid on Tutuila[1]

prepared for

American Samoa Power Authority

Authors: John Glassmire and Peter Lilienthal

October 7, 2014

[1] Note: this final report has been updated with Addendum A, "Revised cost estimates based on new data inputs". The overarching outcomes and conclusions of this primary report still apply, however the LCOE estimates and benefits of expanded transmission capability between Tafuna/Satala have been updated with revised cost data.

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<u>NOTE: All Tables have been revised based new data inputs. New Tables are presented in Addendum A</u>

Acronyms and abbreviations

Acronym or abbreviation	Definition
ASPA	American Samoa Power Authority
DM	Demand Management
DR	Demand Response
EE	Energy Efficiency
EOI	Expression of Interest
Ft	Feet
GDP	Gross Domestic Product
IPP	Independent Power Producer
IRP	Integrated Resource Plan
kV	Kilovolt (a unit of voltage, commonly used with T&D systems)
kW	Kilowatt (a unit of power)
kWh	kilowatt-hours (a unit of energy)
kWh/m^2/day	A measure of incident solar radiation (equal to Peak Solar Hours)
LCOE	Levelized cost of energy, a measurement of the cost of energy including lifetime and investment costs ($/kWh)
MW	Megawatt (a unit of power = 1000 kW)
NREL	National Renewable Energy Laboratory, and laboratory within the US Department of Energy
PPA	Power Purchase Agreement
PV	Photovoltaic [Solar]
PSH	Peak Sun Hours (equal to kWh/m^2/day), also known as full sun hours
RFP	Request for Proposal
T&D	Transmission and Distribution
Yr	Year

1 Background

HOMER Energy, LLC, in collaboration with Siemens PTI was selected as the successful tenderer for the Request for Proposal RFP No. FY13.1127.ESD.RENEWABLE ENERGY issued on June 17, 2013 by the American Samoa Power Authority (ASPA). This report represents the culmination of work for the second Milestone of this project, "Projection Cost Modeling".

The work presented is a combination of HOMER Energy's industry knowledge, site-specific data provided by ASPA, and analysis using the HOMER software.

American Samoa is a group of five electrically non-interconnected islands in the South Pacific. This study focuses on the electrical grid on the largest of the American Samoa islands, Tutuila. The American Samoa Power Authority (ASPA) is the only electric utility on Tutuila and serves over 12,000 customers.

American Samoa, like many island nations worldwide, is largely reliant on expensive imported diesel fuel for meeting its electric power needs. Diesel fuel, in addition to having high cost and substantial negative environmental impacts, has a highly volatile price on the international markets. This perfect storm of high costs, high volatility, and high pollution emissions has created both an economic, political, social, and environmental impetus to transition the islands from 100% reliance on diesel fuel for their electrical needs. ASPA has already introduced 1.8 MW of solar photovoltaic generation to displace some electrical generation that would otherwise be produced from the combustion of diesel, and has plans for increasing the amount of wind and solar on the island.

This study explores the economic business case and costs of increasing the share of electricity produced from renewable (non-diesel) energy sources.

1.1 Background on the HOMER Software

The HOMER energy modeling software is a powerful tool for designing and analyzing hybrid power systems, which contain a mix of conventional generators, cogeneration, wind turbines, solar photovoltaics, hydropower, batteries, fuel cells, hydropower, biomass and other inputs. It is currently used by over 100,000 people in over 193 countries in the world.

For either grid-tied or off-grid environments, HOMER helps determine how variable resources such as wind and solar can be optimally integrated into hybrid systems. It is particularly well suited for electrical island applications such as American Samoa.

The chronological annual simulation that underpins the software, combined with cost optimization and sensitivity analysis, provide a framework for evaluating any system that can be modeled as a microgrid. In the case of Tutuila, the software will provide a techno-economic basis for shifting the electrical systems from near 100% reliance on diesel to lower cost, and frequently more environmentally sustainable, electrical supplies.

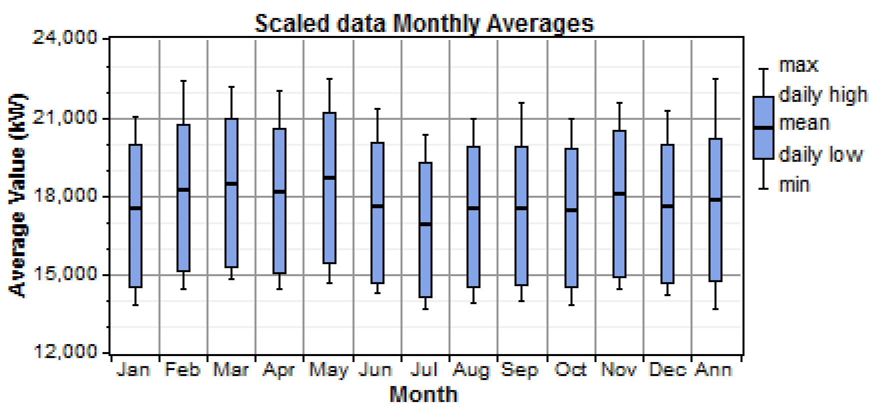
2 Options for meeting electrical demand on Tutuila

American Samoa, like many island nations, has a bountiful wind and solar resource that can be harnessed to provide electricity. However, these resources are variable/intermittent and must be balanced with other technologies to ensure reliable electrical power. Diesel gensets are a good option for balancing renewable resources, not only because they are the incumbent electrical generation technology, but also because they can be readily dispatched and are, relatively, flexible for integrating these variations into the island grid supply. The challenge is to choose the mix of these technologies that captures the best value for the islands while maintaining a reliable electrical supply.

This section will discuss the electrical demand, the various generation options, and the important considerations for the island.

2.1 Tutuila combined electrical load and load forecast

For the study, the load on Tutuila was developed by analyzing the hourly generation data for January 2014 for the Satala, Tafuna, and PV plants[2]. The hourly load data was cleaned up, combined, split into weekend and weekday loads, and analyzed for typical daily and hourly variations. The typical January profile was then scaled up and down by the expected amount for each month of the year. Several graphics of the extensive combined load resulted in the electrical demand profile shown below in Figure 1.



[2] Data provided by ASPA, March 19, 2014 & April 11, 2014.

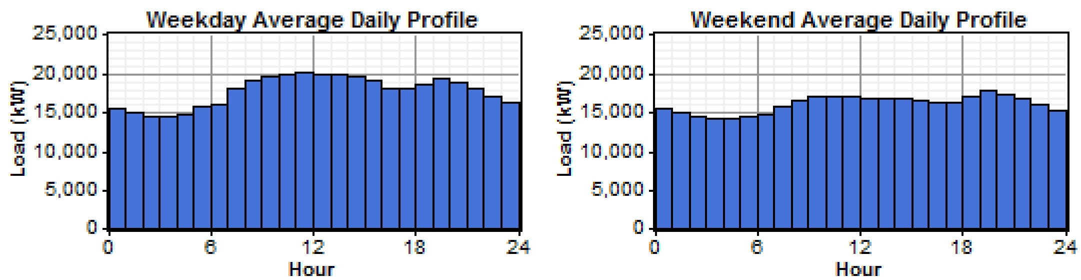


Figure 1: Average and peak load data for the baseline year (2013). "Daily high/low refers to the highest/lowest power draw in the average day for that month. Max/min refers to the absolute highest/lowest, respectively, average power draw for an hour.

There are a number of interesting observations about the load data. The weekday and weekend daily profiles are similar in the early morning (from midnight to ~5AM), but then the weekday load increases substantially during daytime hours (5AM-6PM). Both loads have a slightly increased evening peak as well (6PM-midnight), although the weekday evening peak is higher. System peak loads occur February to May and November, with lowest average loads in July.

The average load (excluding PV production) currently is served in a split manner, about 50%-50% between the Tafuna and Satala plants. Excluding unusual or outage events, the portion of the entire island load met by the Satala plant is between ~40 % and ~60%. However, the preliminary direction from ASPA indicates that the load could be aggregated for the purpose of this production cost modeling study.

2.2 Diesel gensets

The modeling included consideration for 11 gensets, 4 existing gensets at the Tafuna power plant and 7 gensets to be acquired and installed at the Satala plant soon. The existing Satala gensets will be retired shortly, so were excluded from the modeling. Table 1 lists the gensets on Tutuila and shows how their efficiency varies with their power output.

Table 1: Diesel generators included in the production cost modeling

REVISED TABLE AVAILABLE IN ADDENDUM A

The Tafuna gensets are 4.7 MW nameplate rated, but due to their age are only capable of 3.8 MW of continuous output. The Satala gensets are new, and will have a continuous output capability of 2.8 MW. Each of the gensets is assumed to have a lifetime of 50,000 operating hours, before a $2000/kW replacement/overhaul fee is incurred. In addition, each genset incurs an operation and maintenance cost equal to $0.0175 times their continuous output capability for every hour of operation. For the Tafuna gensets, this corresponds to an average cost of $66.50 for each hour of operation, and includes costs of filter changes, ring replacements, oil changes, and general maintenance – all costs except for major overhauls/replacements and fuel costs. The fuel costs make up the remaining (and majority) cost of operating the gensets, accounting for around 70-80% of the total cost of operating the gensets. Since fuel costs provide the largest proportion of generation costs, strategies to reduce fuel usage provide the greatest opportunity for cost savings.

2.3 Wind turbine generators and wind resource

2.3.1 Wind resource

American Samoa is currently undertaking an in-depth study of the wind resource available on the island. As part of this there have been a number of anemometer towers installed to measure the wind at strategic points across Tutuila. The wind measurement sites are shown below in Figure 2.

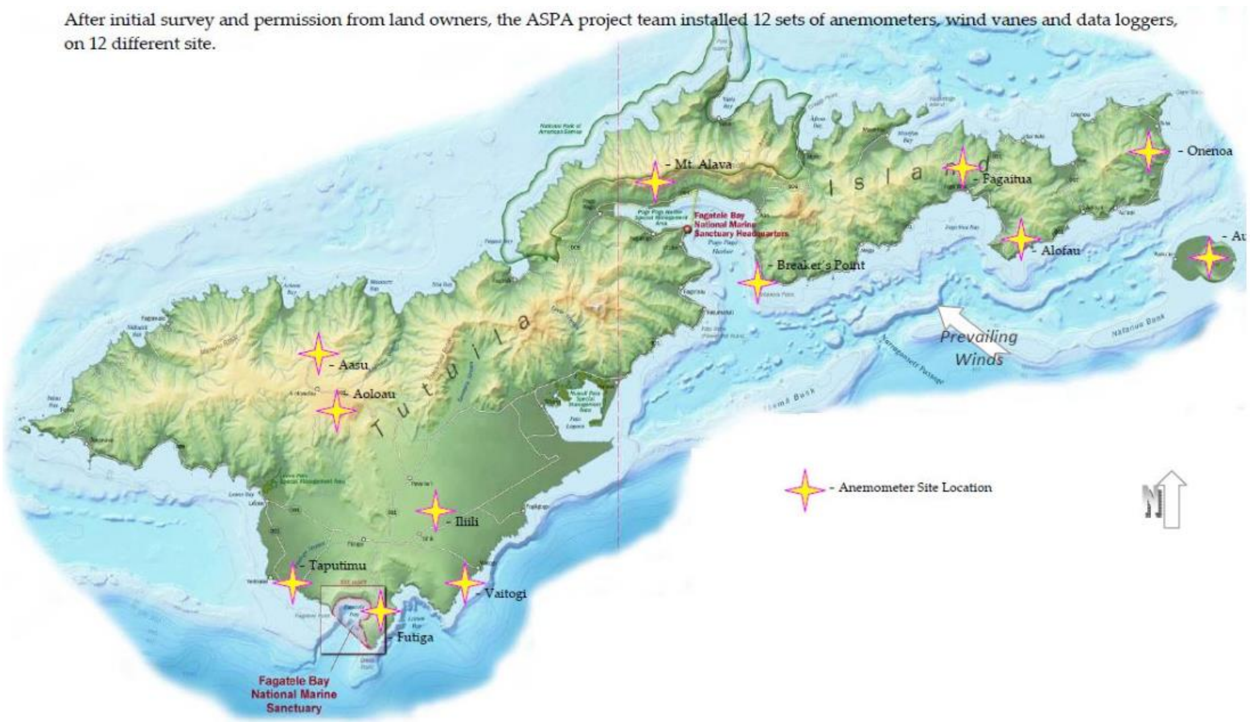


Figure 2: Wind measurement sites on Tutuila

The data from the wind measurement sites is incomplete in many of the sites, but the overall data is complete enough to provide a preliminary understanding of the likely wind resource if wind turbines are installed in the appropriate locations. A more detailed study will site the individual wind turbine generators, including consideration of site factors such as the prevailing winds from the south east. For this study, we are predicting the production from wind turbines are properly sited and installed.

A summary of the average annual wind speed at each anemometer is plotted against the height of the measurements above ground in Figure 3. This figure is not intended to illustrate the effect of wind shear (variations in wind speed with height above ground at a particular site) because each data point is from a completely different site. Rather it is meant to present summary data about the different sites. The average of all wind speeds is much different than the wind speed at the most and least promising sites. This indicates a large deviation in the wind resource at available sites, and demonstrates the need to thoroughly screen potential sites.

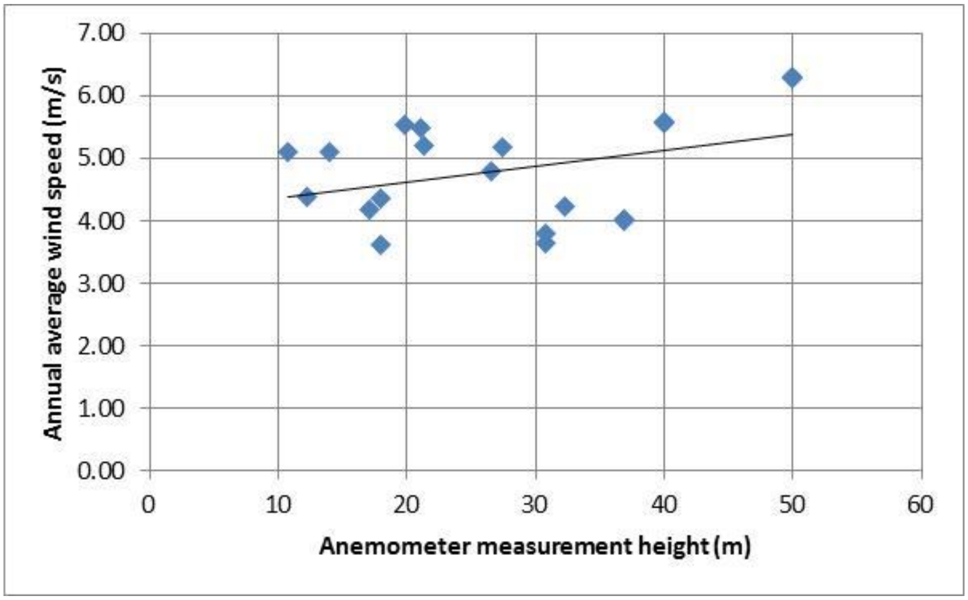


Figure 3: Plot of annual average wind speed vs height of the anemometer at the wind measurement sites on Tutuila

Thorough site selection is beyond the scope of the wind resource analysis included in this study, but the collected data was used to provide indicative wind resources assuming careful site selection. Based on the above data, we assumed that the wind speed at 25 m height above ground (the height of the wind turbines used in this study, see below) is expected to range between 5.5 m/s and 6.2 m/s. Therefore these wind speeds were selected as the poor wind resource and good wind resource, respectively. These values are used in this study to perform a sensitivity analysis on the wind available.[3]

When considering wind resource it is important to consider the fluctuations in the wind with time. The average wind speeds are one important set of information; however, measured chronological wind speed data is important to fully characterize the wind resource. For example, in American Samoa occasional tropical cyclones occur during the otherwise weak winds of the monsoon season. Because of these seasonal variations, a full year's worth of data is generally accepted as the minimum amount of wind data necessary for a study to assess the potential for wind. Therefore, the wind resource at all of the sites was reviewed for completeness. The measurement at Asifoa's Land (Site #7803, Channel 1, 19.8 height) was used because it contained a complete set of 10-minute wind data for the year 2013. A histogram of this measured wind data is in Figure 4.

[3] Data was provided from NRG meters and collected by AWS Truepower

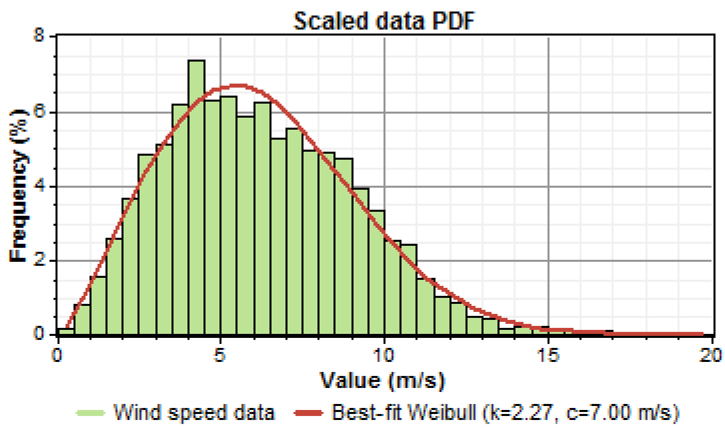


Figure 4: Histogram plot of measure 2013 wind speed data at Asifoa's Land (Site #7803, Channel 1)

A plot of the seasonal average, minimum and maximum wind data at the same site is in Figure 5. In general, the months from May to October have higher average wind speeds than the other months.

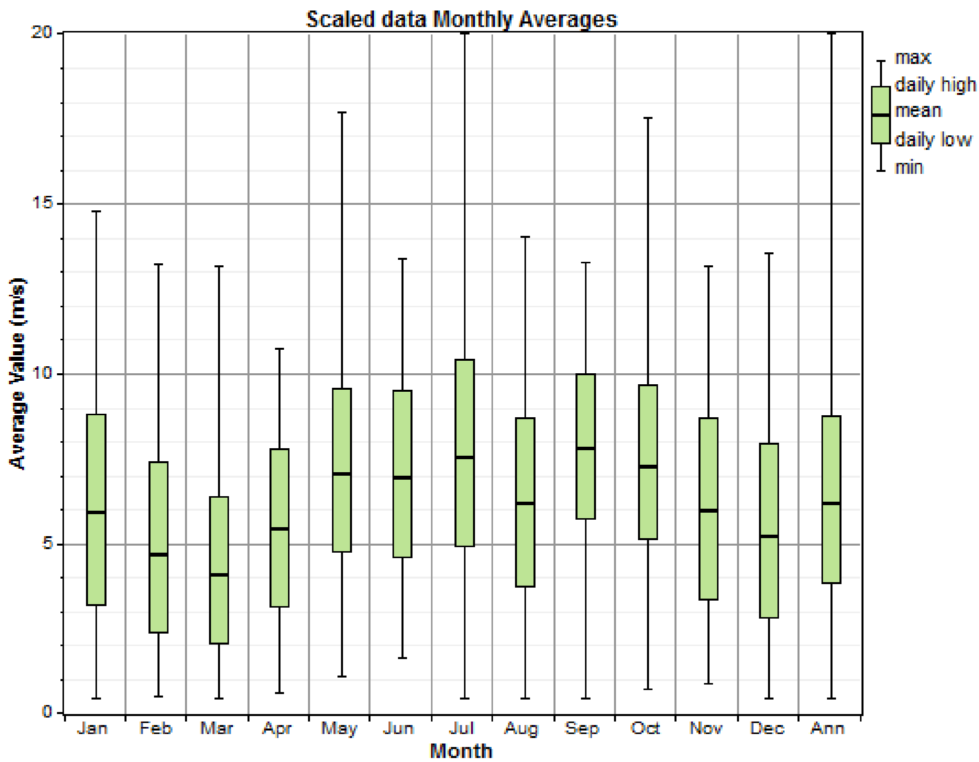


Figure 5: Monthly average, maximum, and minimum wind speeds at Asifoa's Land (Site #7803, Channel 1)

The measured annual data was used in the HOMER software as the wind resource used to predict the wind turbine generator production. It was then scaled to different average annual wind speeds to account for uncertainty in the wind resource because the actual site may be different from this particular site.

A preliminary map of wind speeds at 100 m elevation was provided and is shown in Figure 6 below. It shows promising wind speeds along the mountain ridges. Surprisingly, the map shows only moderately promising wind speeds along the wind-ward southeast-facing coastline.

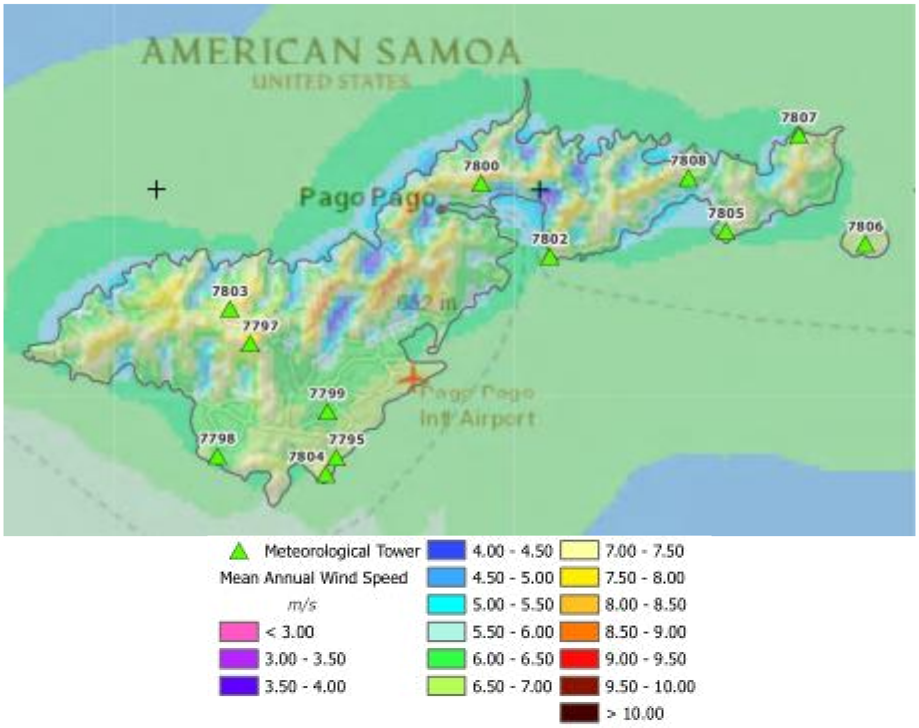


Figure 6: Preliminary wind map of expected wind speeds at 100m from AWS Truepower, May 28, 2014

This map provides a good spatial mapping at high elevations, although additional scoping is necessary to confirm whether this elevation is appropriate given site logistics constraints (notably, port size and road sizes for large turbine deliveries) and prevalence of high wind events during seasonal typhoons. It is worthwhile evaluating the wind speed at lower elevations for wind turbines that are smaller and designed specifically for major wind events.

2.3.2 Wind turbine generator modeling

Based on conversations with ASPA staff, HOMER Energy selected Vergnet Wind Turbine's 275 kW rated wind turbine MP-C, with 25 m hub height as the basis for the wind turbine generator modeling on the island. The Vergnet is specifically designed for island and remote systems and features a tilt-up guy wired mast so that it can lay flat in tempests, hurricanes, and storms. It requires five (5) 40' shipping containers + blades and a 20ton crane for erection, all of which are deemed feasible logistical installation constraints in American Samoa. There are likely other turbines that may be appropriate as well, but further study is recommended for final turbine selection.

The turbine cost was assumed to be $4,000/kW, or $1.1 M/turbine, with 1.5% of the capital cost paid annually to cover maintenance costs, $16,500/yr/turbine.

The recommended number of wind turbines varies with the wind resource available, the cost of diesel fuel, and the electrical demand. These are explored later in this study, in Section 4.

2.4 Solar photovoltaics (PV) and solar resource

2.4.1 Solar resource

The solar resource in Tutuila is expected to average about 4.7 kWh/m^2/day (equivalent to 4.7 PSH, peak sun hours or full sun hours). On average, this means that 1 kW of PV array capacity will be expected to produce an average of 4.7 kWh per day under ideal conditions. However, the solar resource is seasonal, with peak solar resource October to December and again from February to April. The seasonal impacts and peak solar resource hours can be seen in Figure 7.

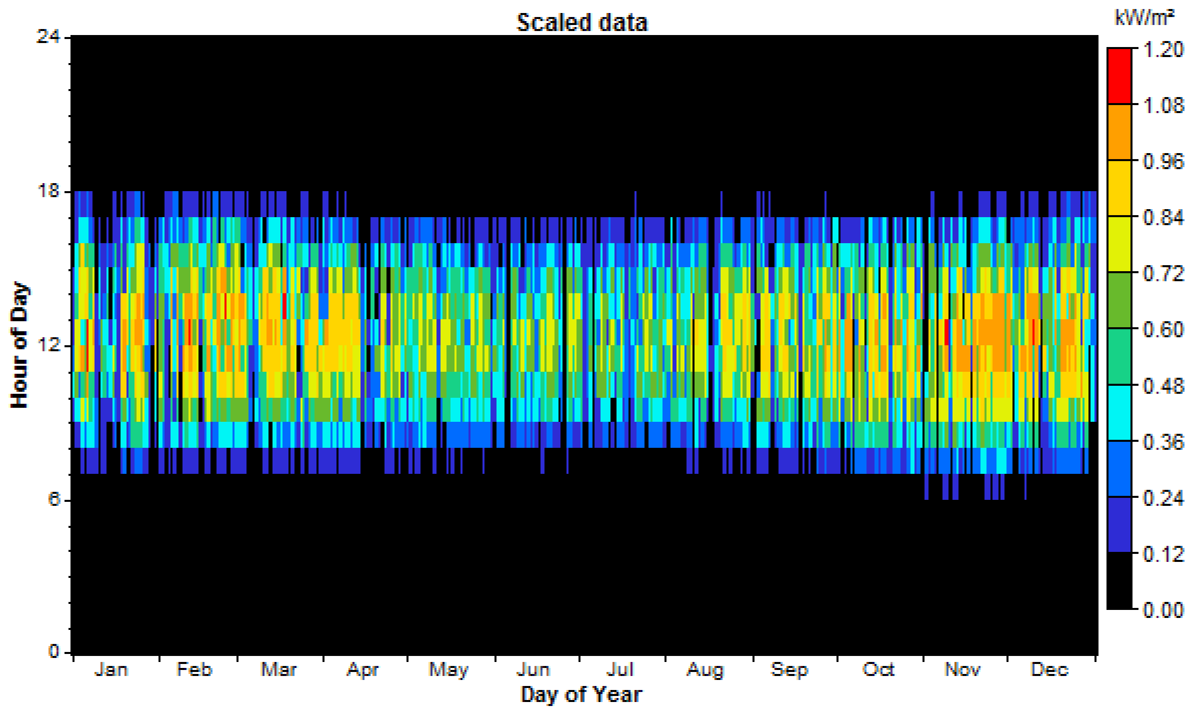


Figure 7: A three-dimensional plot of the typical solar resource expected in Tutuila.

2.4.2 Solar PV panels

The existing 1,754 kW_{DC} PV farms together cost ~$9,200,000, or ~$5,410/kWDC. ASPA currently owns 1,800 kW_{DC} of panels that cost ~$1560/kWDC for panels only. 1000 kW_{DC} of these uninstalled panels are currently being installed and will cost ~$1,800/$kW_{DC}$ for install and BOP. Adding in the cost of the panels and the installation cost yields a total average cost of ~$3,360/$kW_{DC}$. Another new 218 kW_{DC} of PV farm capacity will cost ~$2290/$kW_{DC}$ to install. Adding in the cost of the panels yields a total installed cost of ~$3,850/$kW_{DC}$.[4]

Averaging the total cost of the two new plants yields an average cost of ~$3,600/$kW_{DC}$. This cost was used in the model for all new PV installations in Tutuila.

[4] Data provided by conversations with ASPA staff May 1, 2014

The expected production from 1 kW of solar array capacity is shown in Figure 8.

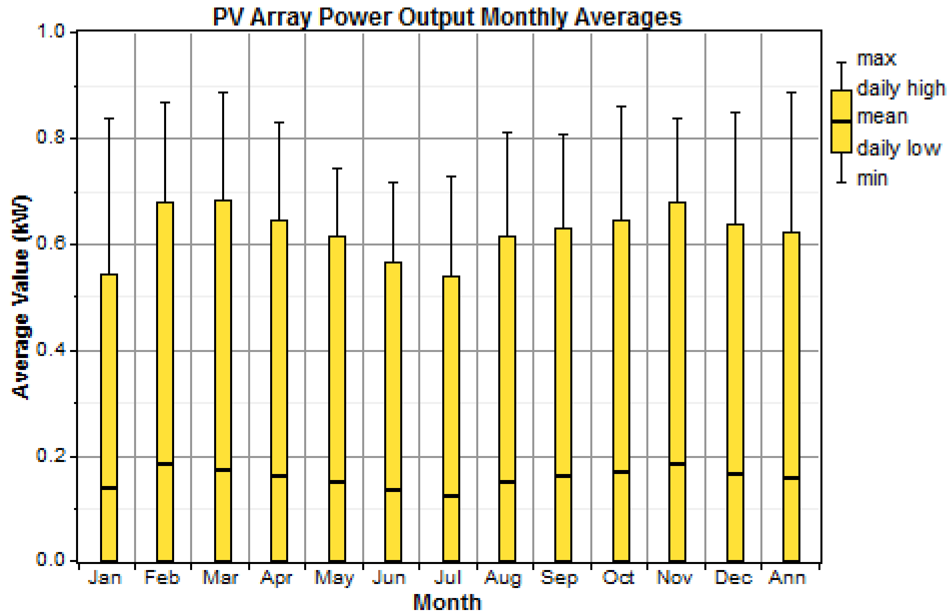


Figure 8: Expected average, minimum, and maximum power production from each 1kW of installed PV array capacity

This report is agnostic about the selection of PV array technology, which is dependent on a wide array of factors. The panel technology, whether thin-film, mono-, poly-crystalline, or other array type, will be influenced by shipping considerations, experience of the installers/contractors, space available for installation, and prior PV experience on the island. This report does not provide detailed guidance about these factors, but assumes that ASPA will build upon their prior experience with PV on the island and that the costs will remain consistent with those already received.

2.5 Geothermal

Geothermal uses heat from underground to produce useful energy. If the resource is of sufficient quality, the heat may be used to make steam to turn a Rankine-cycle steam turbine to produce electricity. There are various methods of heat extraction, of varying complexity depending on the geology, water available, depth of heat resource, and quantity of heat resource.

Geothermal is a promising technology in locations where there is a resource available. However, the cost of determining the resource is typically very high with no guarantee of locating a geothermal resource.

A 2011 study of geothermal potential in American Samoa presented at a 2011 workshop found that geothermal potential was possible, but the development potential was low.[5] However, additional

[5] McCoy-West, et al, "Geothermal Resources in the Pacific Islands: The Potential of Power Generation to Benefit Indigenous Communities", Thirty-Sixth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 31 - February 2, 2011
https://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2011/mccoy.pdf

exploration is necessary to determine conclusively if geothermal is a viable option on Tutuila. Geothermal electrical generation should be revisited once the ongoing geothermal analysis concludes with more detailed resource information.

2.6 Liquefied natural gas (LNG)

A detailed study of converting the diesel gensets to LNG is beyond the scope of this study. However, HOMER Energy recently completed a study evaluating LNG for the island of Saipan in the Commonwealth of the Northern Marianas[6] found that converting to LNG required substantial investment in gasification, port, and natural gas storage facilities, in addition to the logistical challenge of coordinating the deliveries for LNG. These challenges are exacerbated by the relatively small LNG demand necessary for meeting Saipan's average 27 MW electrical load. Tutuila has a smaller average demand – closer to 18MW – further exacerbating issues related to economics of scale.

The study found that LNG could be considered if the market price for LNG stays sufficiently low relative to the cost of diesel. The delivered cost of LNG on Saipan had to be less than about $30/mmBTU at current diesel prices of $1/L ($3.78/gal). However, the necessary infrastructure investment to convert to LNG effectively prevented investment in other technologies, because the demand for LNG must remain sufficiently high to amortize the cost of the infrastructure. LNG does not store for extended periods, and deliveries with proven LNG distribution technologies are much larger than the LNG for a small island nation. Research into smaller gasification plants, and smaller delivery tankers could change this, but LNG infrastructure at this scale has limited deployment and would be considered still under research.

2.7 Energy efficiency (EE) and Levelized Cost of Energy (LCOE)

The results presented here show all systems in terms of LCOE – they are presented per unit of kWh energy delivered. This is an appropriate measure for supply side generation upgrades, but can be misleading when considering energy efficiency programs to reduce demand for electricity. Examples of EE programs include programs that encourage customers to use more efficient appliances, switch from incandescent light bulbs to more efficient light emitting diode (LED) bulbs, or programs that encourage customers to turn off appliances when not in use. The goal of an EE program is not to reduce the LCOE, but rather to reduce the entire cost of having electricity while not diminishing the usefulness of the electricity provided (i.e. maintain the *energy services* even if the overall energy consumption goes down).

The typical equation for LCOE is:

$$LCOE = \frac{Cost\ of\ providing\ electricity\ services}{Units\ of\ electricity\ delivered}$$

The fundamental challenge is that while an EE measure should reduce the cost of providing electricity services, it will also reduce the units of electricity delivered. This inverse relationship can actually cause the overall costs to decrease, but the LCOE still increase. One technique that is used to manage this

[6] Lilienthal & Glassmire, "Energy Investment Opportunities in Saipan and Tinian", prepared for 4iS-CNMI, http://www.4is-cnmi.com/feasability/Final-r-Saipan-Energy-InvestmentOpp-2013-02-08.pdf

problem is to include the hours that would have been required in absence of the EE program in the LCOE calculation (i.e. include the *negawatt-hours* that did not have to be generated).[7] Another approach is to provide customers with a calculation that shows how their overall bill cost decreased. This nuanced issue, if improperly communicated or managed, causes problems for implementing common sense measures to reduce overall costs to customers.

EE programs provide a substantial opportunity for ASPA to help customers to reduce their monthly bills. These programs include behavior outreach programs, cost-share energy audits, and incentive programs for efficient appliances and audits. This study assumes that ASPA is already pursuing these opportunities as part of its integrated resource planning (IRP).

3 Production Cost Modeling Results for ASPA

The production cost modeling results presented here are the costs of generating electricity to meet the projected load demands and operating reserve requirements of the island of Tutuila. The costs do not include the additional costs of distributing the electricity (including transmission and distribution upgrades and maintenance), nor the cost of administration and billing.

The results presented here are based on a techno-economic feasibility analysis that includes an annual hourly chronological dispatch to ensure that supply meets demand within each hour. The simulated results are used to determine the expected costs of operating the described system for 25 years.

The modeling results presented here do not consider individual feeder limitations and constraints, which will be explored in subsequent modeling currently being undertaken by Siemens PTI. The findings from that research should be used to refine the results presented here. It does, however, include the need to switch on generators to meet load and reserve requirements, as well as assuming that solar and wind generation only contribute 75% and 50% "reliable" electricity –that is, uncurtailed solar generation must be backed up with reserves equal to 25% of solar power output, and wind 50%.[8]

All cost results are presented in 2014 US dollars – they do not include inflation.

3.1 Scenario results (Sub-task 2.a)

ASPA requested several simulations based on their current plans for installed wind and solar capacity on Tutuila. The expected solar and wind capacities by year are summarized below in Table 2, along with the expected levelized cost of energy (LCOE) and total payback for investing in renewables as compared to diesel only operation.

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[7] The term negawatt-hours originated in 1989 as a way to distinguish the benefits of electricity (energy services) from the sale of electricity (kWh).

[8] These reserve requirements for solar and wind were selected because they are the default values used in the HOMER software.

Table 2: Summary of economic results, fuel savings, and emissions from baseline scenarios requested by ASPA. All comparisons are relative to a system with no renewables

<u>REVISED TABLE AVAILABLE IN ADDENDUM A</u>

The cost of diesel in the table increases 5% in real terms annually, based on the recommendations of ASPA. In general, the total cost of generation decreases when renewable energy is added to the system. The cost savings increases (and payback on the capital outlay for renewables) as the cost of diesel fuel increases. In the subsequent sections, we will explore the potential savings if the amount of renewable energy increases beyond those requested by ASPA.

3.2 Optimal results without storage (Sub-task 2.c and Sub-task 2.e)

HOMER Energy performed annual simulations of tens of thousands of different system designs at a range of different fuel prices, two wind speeds, and 6 different electrical load levels. Each of the different electrical load levels corresponds to the 6 years of analysis: 2013, 2014, 2016, 2018, 2020, and 2022. The two wind speeds corresponds to the high and low wind annual average speeds at 55 meter elevation expected from preliminary analysis of the wind data. The fuel prices range across various levels of annual escalation: 0%/yr, 5%/yr, 7.5%/yr, and 10%/yr. Each annual simulation includes days with peak and light loads, as well as days when the renewable resource production is low and days when the renewable resource is high. The cost impacts from these days are included. The optimal systems at each of these were analyzed, and a range of useful results are presented below.

The results presented below show a comparison if the available wind resource is high or low, and if the fuel price rises quickly or slowly.

3.2.1 Analysis of critical sensitivity factors

HOMER performed an analysis of the various sensitivity factors and identified those with the greatest impact on the optimal design. As described above, the key factors considered are: load, average annual wind speed available at the wind sites, and fuel price.

The range of load growth considered has a limited impact on the recommended capacity of PV and number of wind turbines in the optimal system design as compared to other sensitivity variables. Figure 9 is a plot of the wind turbine and solar photovoltaic capacities in the system with the lowest net present cost across the range of loads expected between 2013 and 2022. Figure 9 shows that the recommended installed PV capacity increases approximately 3MW (about 33%) across the 9 year range of this study. However, in the absence of other changes in the data, the recommended installed wind capacity does not vary with the load. In other words, within the expected demands for the next 9 years, the load demand does not impact the economic decision to install wind, but impacts the decision on PV capacity by about 3MW. There are potential transmission, distribution, and feeder constraints not considered here that may limit the ability of the system to handle this amount of renewables, however this provides a clear indication of the value that renewables can play in reducing diesel fuel usage to reduce system operating costs.

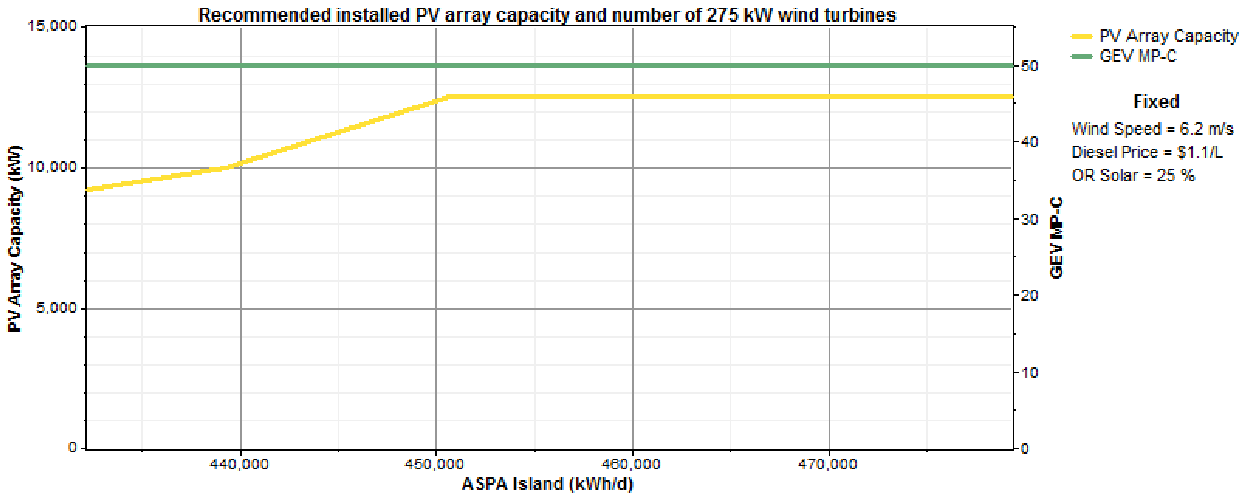

Figure 9: Chart showing how the recommended PV array capacity and number of 275 kW wind turbine varies with ASPA Tutuila island load projected across 2013 to 2022.

In contrast to load, the price of diesel fuel has a much larger impact on the optimal system design across the range of expected values, as does the available average annual wind speed. Figure 10 and Figure 11 and figure provide a sensitivity analysis on the wind speed available and price of diesel. The three-dimensional plots in Figure 10 and Figure 11 (below) show how the recommended installed number of wind turbines and recommended capacity of solar PV, respectively, varies with the wind speed and the diesel price.

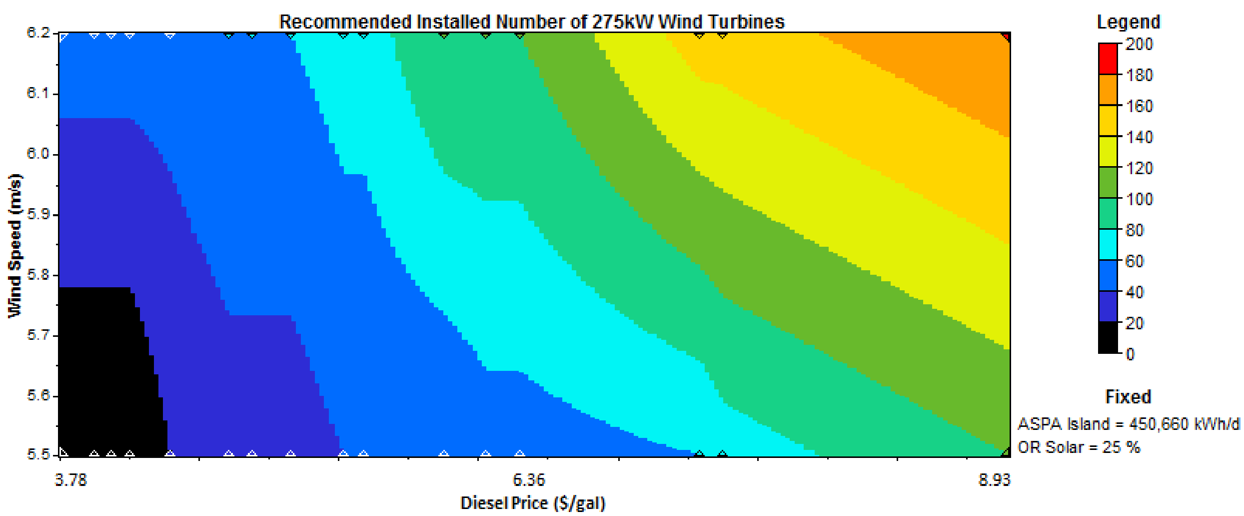

Figure 10: Recommended number of 275 kW wind turbines across the range of expected values for diesel price and average annual wind speed based on the load profile predicted for 2018. The recommended numbers of wind turbine are in addition to the PV array capacities in Figure 11.

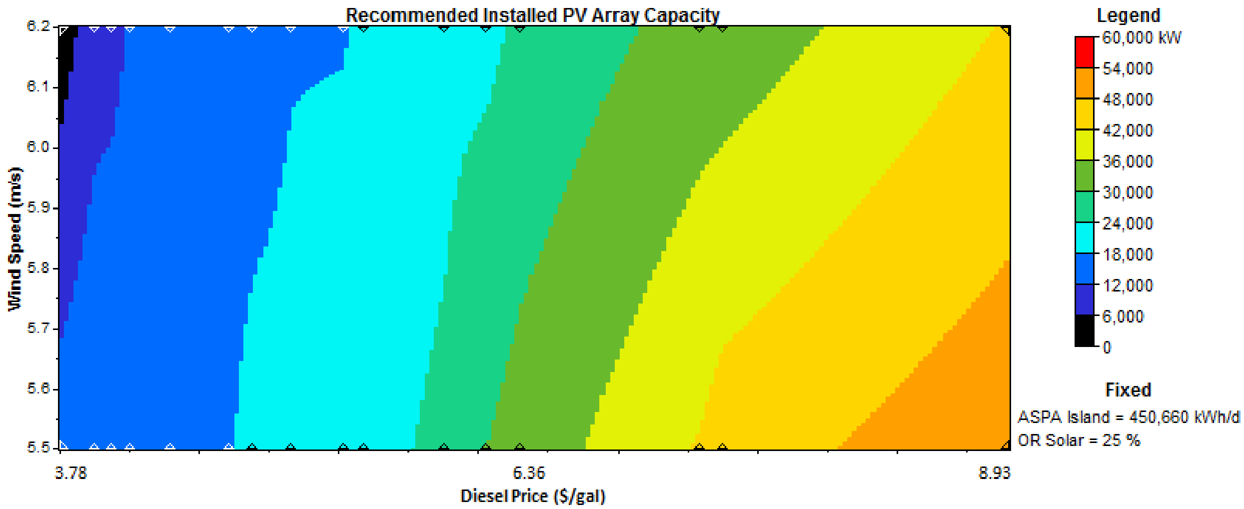

Figure 11: Recommended PV array capacity across the range of expected values for diesel price and average annual wind speed based on the load profile predicted for 2018. The recommended PV array capacities are in addition to the numbers of wind turbine capacities in Figure 10.

If the price of diesel and the average annual wind speed are both low, wind turbines are not part of the lowest cost option. However between 12 and 18MW of PV is recommended in this same range. As the available wind resource improves to 6.2 m/s, the recommended PV decreases while the recommended number of wind turbines increases—the installation of wind crowds out the need for PV. At higher fuel prices, both solar and wind are increasingly recommended. Across the range of expected diesel prices and average wind speed, the recommended PV array capacity varies from 0MW to almost 60MW, while the recommended number of installed 275 kW wind turbines ranges from 0 to 200 (0MW to 55MW).

Figure 10 and Figure 11 demonstrate the importance of good fuel price projections and the importance of accurately characterizing the wind resource to make good economic investments in wind and solar technologies. Higher fuel prices increase the importance of investment in both wind and solar, whereas the available wind resource impacts to what extent those investments should be in wind and/or solar.

In the following sections, these values are projected out into the future under various scenarios.

3.2.2 High fuel cost escalation, high wind resource

Under a scenario with high fuel cost escalation (10% annual escalation), and moderately high wind speeds (6.2 m/s at 55m), our analysis recommends installing substantial wind and solar into the ASPA grid. The results presented in Table 3 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

Table 3: Summary of economic results, fuel savings, and emissions for the system with the lowest total cost if fuel price escalates 10% annually and the available average annual wind speed is 6.2 m/s at 55m. All comparisons are relative to a system with no renewables.

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As the real cost of diesel rises, both more solar PV and wind turbines are recommended, if distribution constraints and siting issues do not limit the installation of the variable renewable generation.

3.2.3 High fuel cost escalation, low wind resource

Under a scenario with high fuel cost escalation (10% annual escalation), and low available wind speeds (5.5 m/s at 55m), our analysis recommends installing substantial solar into the ASPA grid. As the fuel price rises, increasing amounts of wind are recommended. The results presented in Table 4 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

Table 4: Summary of economic results, fuel savings, and emissions the system with the lowest total cost if fuel price escalates 10% annually and the available average annual wind speed is 5.5 m/s at 55m. All comparisons are relative to a system with no renewables.

REVISED TABLE AVAILABLE IN ADDENDUM A

3.2.4 Low fuel cost escalation, high wind resource

Under a scenario with limited fuel cost escalation (equal to general inflation), and moderately high wind speeds (6.2 m/s at 55m), our analysis recommends installing substantial wind into the ASPA grid. As the fuel price rises, increasing amounts of wind are recommended. However, the role of solar plays a limited role until 2022. The results presented in Table 5 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

Table 5: Summary of economic results, fuel savings, and emissions the system with the lowest total cost if fuel price escalates at the same rate as general inflation and the available average annual wind speed is 6.2 m/s at 55m. All comparisons are relative to a system with no renewables.

REVISED TABLE AVAILABLE IN ADDENDUM A

3.2.5 Low fuel cost escalation, low wind resource

Under a scenario with limited fuel cost escalation (equal to general inflation), and low available wind speeds (5.5 m/s at 55m), our analysis recommends installing substantial wind into the ASPA grid. As the fuel price rises, increasing amounts of wind are recommended. However, the role of solar plays a limited role until 2022. The results presented in Table 6 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

Table 6: Summary of economic results, fuel savings, and emissions the system with the lowest total cost if fuel price escalates at the same rate as general inflation and the available average annual wind speed is 5.5 m/s at 55m. All comparisons are relative to a system with no renewables.

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3.3 The benefits of load aggregation

Updated Section 3.3 available in Addendum A.

3.4 Storage (Subtask 2.b)

A recent paper from the Electric Power Research Institute (EPRI), the US Department of Energy, and Sandia National Laboratories[9] found a number of values that storage can offer to grid operators:

- Electric Energy Time-shift (Arbitrage)
- Electric Supply Capacity upgrade deferral
- Power flow Regulation
- Reserve, including Operational (spinning), non-synchronized (non-spinning), and supplemental
- Voltage support
- Black start capability
- Load Following/Ramping Support for Renewables
- Frequency Response
- Transmission Upgrade Deferral and Congestion Relief
- Transmission Stability Damping and Resonance Damping
- Distribution Upgrade Deferral and Voltage Support

From a broad grid perspective, the key attributes of importance for American Samoa in the near term is reserve support to improve the dispatch of the generators and reduce the diesel fuel use. This reserve support will become more important as the amount of variable renewables on the system increases. This is the focus of the analysis presented here.

Each type of storage provides different values. For this study, HOMER Energy has analyzed two technologies in detail: lithium-ion batteries and flywheels.

3.4.1 Lithium-ion (Li-ion) batteries

Li-ion is a general term for a range of battery chemistries in which lithium ions in the electrolyte carry charge between the positive and negative electrodes during battery charging and discharging. The battery class includes a large number of specific chemistries. The classes of most interest for American Samoa are large format batteries, where energy density is not as important as in portable applications. These include lithium iron phosphate ($LiFePO_4$) and lithium titanate, but advances in the manufacturing as well as the underlying component technologies make the economics of particular Li-ion chemistries change rapidly in favor of other Li-ion chemistries.

Li-ion batteries provide strong power output throughout its state of charge range. Unlike lead acid batteries, the power output capability is similar at high states of charge as at low states of charge.

The cost of Li-ion batteries is currently estimated to be ~$1500/kWh in American Samoa, including associated charge controllers and inverter/chargers. However, Lithium-ion technologies are steadily decreasing in cost. The small format Li-ion batteries common in portable consumer electronics have fallen in cost substantially over the past decade. It is expected that this trend for small-format will continue, and that a similar trend will happen for the large format Li-ion battery most useful for

[9] Akhil et al, “Electricity Storage Handbook in Collaboration with NRECA”, July 2013, White paper, http://www.sandia.gov/ess/publications/SAND2013-5131.pdf

stationary applications like the ASPA grid.[10] There is growing consensus from industry analysts that the cost of large-format Li-ion batteries will reduce by more than half within the next decade.[11] Due to the expected rapid decline in cost, HOMER Energy recommends re-evaluating this technology again in the next five to ten years.

3.4.2 Flywheels

Flywheels use a heavy rotating mass to store energy that can be quickly released in high bursts of power. Typically, they are sized for power discharge durations of a few minutes – enough time to bring on additional reserves during contingency events and sudden shifts in load or changes in power output from variable/intermittent renewable energy technologies. One of the primary values that flywheels add to island systems is operating reserve (i.e. spinning reserve). This additional system reserve can be used to turn off gensets that would otherwise be required to be spinning to provide operating reserve. This contribution is particularly valuable as the contribution from intermittent/variable energy sources increases—variable generation on the grid can increase the need for reserve.

The estimated cost of installing a flywheel in American Samoa is ~$1600/kW.

3.4.2.1 Impact of flywheels in high fuel escalation, high wind resource scenario

Under a scenario with high fuel cost escalation (10% annual escalation), and moderately high available wind speeds (6.2 m/s at 55m), our analysis recommends 10-15 MW of flywheel capacity. The flywheels allow for increased wind and solar in the early years, but make the need for more renewable generation less critical in later years. The results presented in Table 7 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

Table 7: Summary of the change in recommended wind and solar capacity, change in LCOE, fuel savings improvement, and increased emissions reduction when system design is optimized with flywheels for fuel price escalation at 10% real inflation and the available average annual wind speed is 5.5 m/s at 55m

REVISED TABLE AVAILABLE IN ADDENDUM A

3.4.2.2 Impact of flywheels in high fuel escalation, low wind resource scenario

Under a scenario with high fuel cost escalation (10% annual escalation), and low available wind speeds (5.5 m/s at 55m), our analysis recommends 10 MW of flywheel capacity. The flywheels allow for increased solar in the early years, but make the need for more renewable generation less critical in later years. The results presented in Table 8 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

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[10] Navigant, "The Lithium Ion Inflection Point", Webinar, Nov 2013, http://www.navigantresearch.com/webinarvideos/webinar-replay-the-lithium-ion-inflection-point

[11] HOMER Energy, Rocky Mountain Institute, Cohn-Reznick Think Energy, "The Economics of Grid Defection", February 2014, http://www.rmi.org/electricity_grid_defection

Table 8: Summary of the change in recommended wind and solar capacity, change in LCOE, fuel savings improvement, and increased emissions reduction when system design is optimized with flywheels for fuel price escalation at 10% real inflation and the available average annual wind speed is 5.5 m/s at 55m

REVISED TABLE AVAILABLE IN ADDENDUM A

3.4.2.3 Impact of flywheels in low fuel escalation, high wind resource scenario

Under a scenario with limited fuel cost escalation (equal to general inflation), and moderately high available wind speeds (6.2 m/s at 55m), our analysis recommends installing 10MW of flywheel capacity into the ASPA grid. The results presented in Table 9 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

Table 9: Summary of the change in recommended wind and solar capacity, change in LCOE, fuel savings improvement, and increased emissions reduction when system design is optimized with flywheels for fuel price escalation at the same rate as general inflation and the available average annual wind speed is 6.2 m/s at 55m

REVISED TABLE AVAILABLE IN ADDENDUM A

3.4.2.4 Impact of flywheels in low fuel escalation, low wind resource scenario

Under a scenario with limited fuel cost escalation (equal to general inflation), and low available wind speeds (5.5 m/s at 55m), our analysis recommends installing 5-10MW of flywheel capacity into the ASPA grid. The use of flywheels allows the cost-effective integration of more solar and wind. The results presented in Table 10 provide the economic benefits for installing renewables to reduce the risk of rising fuel prices, as well as the associated environmental benefits under this future scenario.

Table 10: Summary of the change in recommended wind and solar capacity, change in LCOE, fuel savings improvement, and increased emissions reduction when system design is optimized with flywheels for fuel price escalation at the same rate as general inflation and the available average annual wind speed is 5.5 m/s at 55m

REVISED TABLE AVAILABLE IN ADDENDUM A

3.4.3 Considering additional storage values and next steps in the analysis

HOMER Energy has determined that flywheels, with their ability to supplement operating reserve, will improve the dispatch of the gensets, lowering fuel requirements, and ultimately lowering operational costs. Our findings also indicate that Li-ion battery storage, with its ability to perform bulk transfer of energy to enable, for example, energy from solar panels to meet night time loads is not currently cost-competitive, however this may change in the near future.

Further exploration is recommended based on the findings of the subsequent steady state analysis, dynamic stability analysis, and feeder analysis being undertaken by Siemens PTI. This analysis will establish whether there are cost-effective applications for firming up individual feeders and voltage/frequency support. It may also consider the additional value that storage can offer with ramping support for renewables. These values for storage will impact whether storage is important for these more localized (rather than system-wide) effects.

3.5 Impacts of forecasting (Sub-task 2.f)

Forecasting will help ASPA to reduce the need for additional operating reserves to back-up the power production from variable/intermittent solar and wind production. **In the analysis presented above, HOMER has assumed that forecasting has allowed the solar to only require a 25% reserve backup, and wind a 50% wind backup.** If the forecasting is worse, the necessary reserve backup will increase. This section describes the economic impact requiring 100% reserve backup for all output from wind and solar.

If additional reserve is required for solar and wind generation (whether or not due to poorer forecasting capability), there are three typical impacts on the recommendations presented: 1) the recommended solar and wind decrease, 2) the use of flywheels and other sources of reserve becomes more critical for keeping costs low, and 3) the cost of electricity increases.

3.5.1 Impact on Baseline scenarios

Poorer forecasting leads to increased reserve requirements for solar and wind generation, which impacts the dispatch of the system and worsens the economic and environmental performance of the ASPA grid. **If the solar and wind require 100% reserve backup, baseline scenarios all increase in cost between \$0.002/kWh and \$0.024/kWh, increase diesel fuel usage between 96 and 1477 gal/day, and increase CO2 emissions between 351 and 5274 tonnes/yr**, as summarized below in Table 11.

Table 11: Summary of increased LCOE, increased fuel usage, and increased emissions when reserves are increased to account for poorer forecasting in the baseline scenarios requested by ASPA. All comparisons are relative to the same system with better forecasting.

REVISED TABLE AVAILABLE IN ADDENDUM A

3.6 Generator dispatch (Sub-task 2.d)

In all scenarios provided, the generators are dispatched to meet both the load and reserve requirements. If necessary, **generators are brought automatically online to fulfill both the actual energy requirements and the reserve to ensure reliability**. It is implicit that the generators themselves are automated to handle the variability of both the load and the increasing production expected from variable output wind and solar generation.

A sample day from the analysis is shown below in Figure 12. One of the conclusions from the analysis is that it is less expensive to operate the Satala diesel gensets (Units S1-S7) than the Tafuna gensets (Units T2-T4). This can be seen in the diagram, where units S1 through S5 are on at full output. There are times when it is cheaper to operate the gensets in the Tafuna plant (for example, from 2AM to 7AM in the sample figure) due to their better matching to the load power and reserve capacity requirements. There are other times when the remaining Satala units are switched on (for example, from 7AM to 6PM).

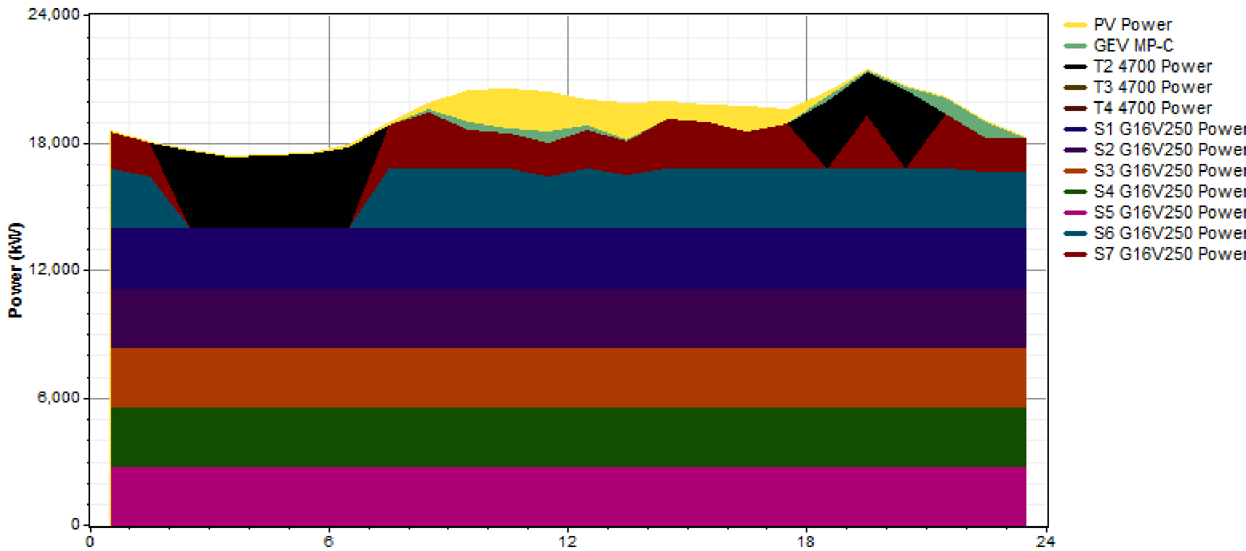


Figure 12: Generator dispatch from a sample day in 2014

This automated dispatch compares the cost of operating the gensets, factoring in fuel cost, replacement cost, and O&M cost. It also factors in the contribution of solar and wind generation to both the reserve requirement and the load demand (as seen during the day for solar and periodically throughout the day for the wind—wind output is highest from 8AM to 1PM and ~7PM to 11PM).

4 Conclusions

American Samoa can stabilize current energy costs and reduce energy cost escalation by adding solar and wind energy into their generation mix. However, the lowest cost mix of energy sources will vary based on the cost of diesel fuel and the available wind resource.

Flywheels and other storage technologies that can provide reserve to the grid can both improve the dispatch of the existing gensets, but also improve the integration of future solar and wind.

The results presented here provide a strong economic case for increasing the use of solar PV and wind turbines beyond what is currently planned. However, there may be additional technical and economic challenges related to the distribution system that will be explored in a subsequent phase of this study. It is also recognized that there may be siting issues that limit the possibility of pursuing the aggressive targets described in this paper.

4.1 Recommendations and next steps

Quantifying and improving the understanding of the wind resource on Tutuila should be high priority. The uncertainty of the available wind creates challenges in planning the installation of wind turbines relative to solar. Wind speed maps at lower heights (50 or 55 m) are recommended to evaluate wind turbines that may be more appropriate for an island in a typhoon area. Likely tentative wind farm locations from the wind map findings should be validated with actual site measurements as soon as possible. A study on wind turbine generator technologies that considers these logistical challenges is also recommended.

Any technology that can reduce the reserve margins required for reliable power on the ASPA grid should be explored. This may include more responsive (i.e. faster ramping) gensets, improved genset switching and controls, as well as flywheels or other high-power storage technology.

A study to determine the feasibility of increasing the power flow capability between the Tafuna and Satala plants may be recommended. These results and related recommendations are presented in Addendum A.[12]

ASPA has a number of supply-side options for stabilizing the rising cost of electricity—wind, solar, and storage can all play a role. However, there are limited options for substantially reducing the cost of energy. For this reason, it is highly recommended that ASPA aggressively pursue EE measures. While this will not reduce the levelized cost of energy, it will help customers to reduce their overall bills. There are a range of EE and behavior change programs that could be applied, but recommendations for individual EE programs are beyond the scope of this study. An additional study looking at programs well-suited for American Samoa will help ASPA to continue to provide reliable power at an overall lower cost.

[12] The savings and values of load aggregation are revised in Addendum A. Readers are referred there for more information.

Section

2

Steady State Analysis

2.1 Introduction

Siemens PTI conducted a 10 year feasibility study to determine the potential impact of renewable generation to the ASPA (American Samoa Power Authority) electrical power system, for the years 2013 - 2022. The island of American Samoa is located in the Pacific Ocean and has an electrical power system that consists of a 34.5 kV and 13.2 kV distribution system.

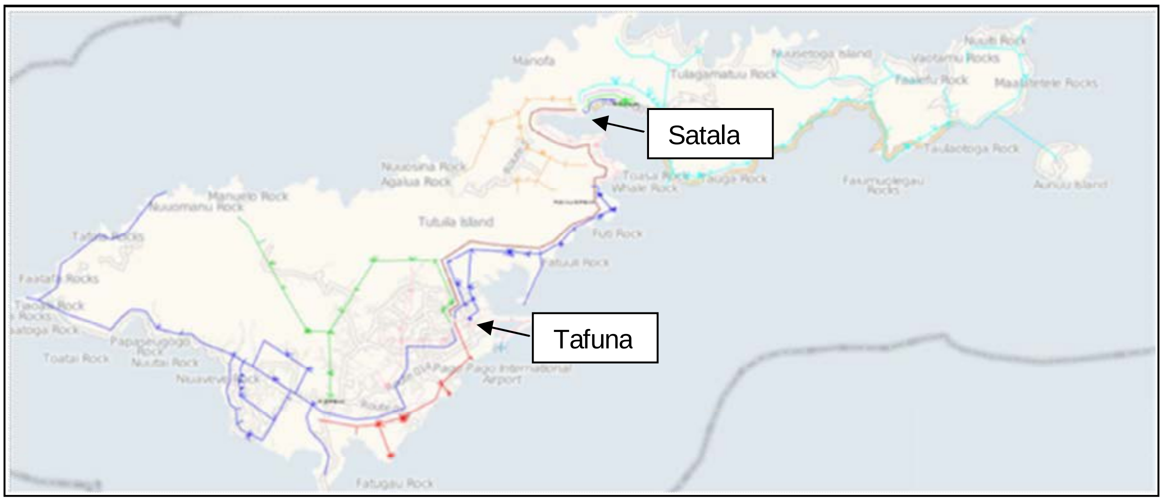


Figure 2-1. ASPA Power Flow Network Model in PSS®SINCAL

There are two 34.5/13.2 kV substations in ASPA, Tafuna in the southwest part of the island and Satala in the northeast that are interconnected by a single 34.5 kV tie line, as shown in Figure 2-1 above. The Satala – Tafuna 34.5 kV tie line is an underground circuit.

From each substation, a total of ten 13.2 kV distribution feeders serve the island's commercial, residential and industrial loads in a radial fashion. The highest loading is generally in the southwest part of the island, however there are also several medium sized industrial facilities fed from the Satala substation.

The results documented in this section are steady state power flow results that were obtained by analyzing the generation dispatch and load conditions defined by the HOMER economic dispatch simulation. The results from HOMER's analysis formulated the input to Siemens PTI's analysis, performed in PSS®SINCAL simulation software. Upon completion of this study, Siemens PTI provided ASPA with this system model in the ETAP data format.

- The selected study period for this study was the high demand week and the minimum demand week. Each week was studied through hourly demand cycles and expected renewable output cycles. Each study year, listed in Table 2-1, was evaluated for those two study weeks.

The data were obtained from the HOMER results for each year and inserted into PSS®SINCAL. A single steady state power flow solution was obtained for every hour of simulation for seven days per week (Monday –Sunday), therefore: 7 x 24 x 2 = 336 steady state power flow solutions per study year.

This study assessed the following levels of renewable generation over the 10 years, as shown in Table 2-1 below.

Table 2-1 ASPA Renewable Generation Penetration Levels

Scenario	Wind Capacity (MW)	Solar PV (MW_{AC})	Penetration (% of peak load)
Baseline (Year 2013)	0	2.6	10.4
Scenario 1 (Year 2014)	0.3	3.9	17
Scenario 2 (Year 2016)	2.3	5.4	31
Scenario 3 (Year 2018)	5.3	7.3	49
Scenario 4 (Year 2020)	8.3	9.2	66
Scenario 5 (Year 2022)	11.3	10.8	80

To conduct the study several major steps were performed as follows:

1. Created a new power system steady state model of ASPA in PSS®SINCAL.

2. Performed base case (2013 & 2014) steady state system assessment and made any suggested improvements.

3. Performed 10 year (2013-2022) steady state assessment and made any suggested improvements.

This report describes each major step in detail and documents the key findings and recommendations.

2.2 PSS®SINCAL ASPA Model Development

A major part of this project was to develop a new power flow model of the ASPA system in PSS®SINCAL. This task was performed using multiple sources of data provided by ASPA that included: one line diagrams, geographical diagrams, customer billing data etc.

In order to develop the model in the most accurate and efficient manner, several steps were performed as described below.

1. Based on geographical maps and one-line diagrams we created a base network that included the Satala – Tafuna 34.5 kV tie line, ten 13.2 kV feeders and the Satala and Tafuna generating plants.

2. Using customer billing data we grouped customer loads by geographical location and by class i.e. all commercial loads for "FOGAGOGO" on feeder 9.

3. We summed up the kWh energy consumption values from the billing data for each load class and location, and then applied typical load factors to obtain peak equivalent loads.

4. In PSS®SINCAL we modeled a single equivalent balanced (3 ph) load for each load class per geographic location.

5. Performed load allocation (an automatic function in SINCAL) to fine tune all the loads to match each peak feeder loading values recorded by ASPA for 2013.

6. Added the existing solar PV generation according to data provided by ASPA.

Figure 2-2 below shows the power flow model developed in PSS®SINCAL.

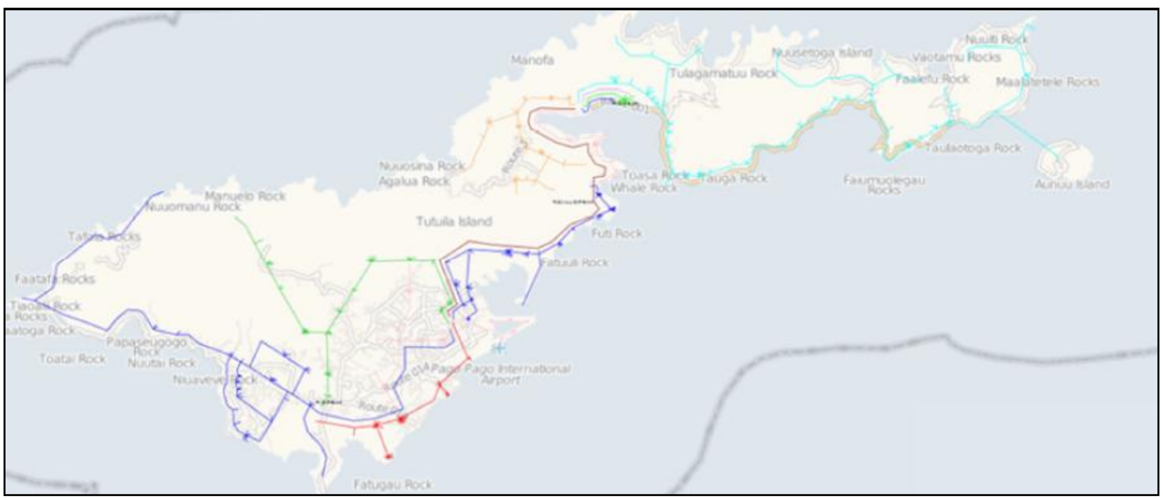


Figure 2-2. ASPA Power Flow Network Model in PSS®SINCAL

2.3 Analysis Assumptions and Limitations

The following items describe the assumptions and limitations of this study:

- All the ASPA loads reach light and peak loads simultaneously.

- The solar irradiance and wind speed are the same at each generation site at any given point in time.

- All loads have the same power factor of 0.92.

- The analysis, results and mitigations specified in this report covers only two weeks per year, that is, one peak load and one light load week.

- Typical load factors were used to capture commercial, residential and industrial peak values.
- All residential loads are single phase loads and all commercial and industrial loads are three phase loads.
- All residential loads are converted to three phase balanced equivalents.
- All commercial and industrial loads are balanced, thus the ASPA system is only a positive sequence representation.
- The load power factor remains constant for all load variations.
- Used estimated Satala and Tafuna PQ curves.

2.4 Base Case (2013 & 2014) System Assessment

This section of the report highlights the results for the 2013 and 2014 steady state analysis of the ASPA electrical power system. The purpose of the base case assessment is to ensure the network model is an accurate representation of today's ASPA system. The Base case system assessment also aims to identify any issues that need to be rectified before conducting the ten year assessment. Table 2-2 below shows the renewable generation levels considered in this base case analysis.

Table 2-2 ASPA 2013 & 2014
Renewable Generation Penetration Levels

Scenario	Wind Capacity (MW)	Solar PV (MW_{AC})	Penetration (% of Peak)
Baseline (Year 2013)	0	2.6	10.4
Scenario 1 (Year 2014)	0.3	3.9	17.0

2.4.1 Load and Generation Profiles

The plots provided below show the generation and load profiles simulated for 2013 and 2014 peak and light load conditions.

Figure 2-3 below illustrates 2013 and 2014 demand profiles. The 2013 peak load week (2013 PK) is shown first on the left starting with Monday and ending with Sunday, followed by the 2013 light load week (2013 LL) condition. To the right of the 2013 load profile is the 2014 load profile, which follows the same pattern, displaying the peak load week's profile first and then the light load week's profile.

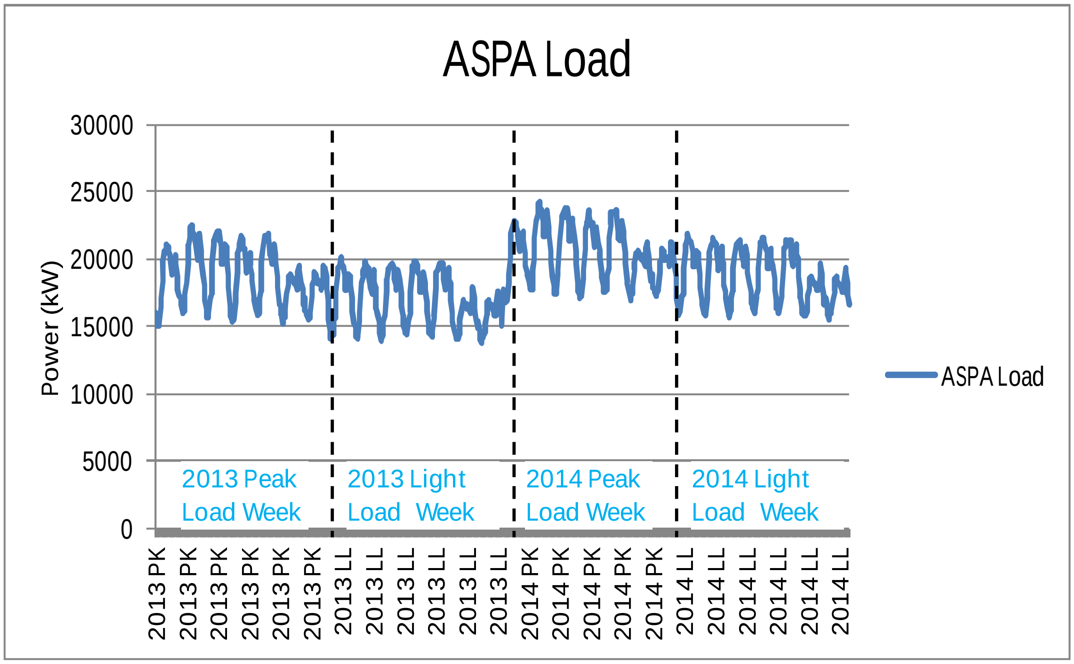


Figure 2-3. ASPA Load Profile

Figure 2-4 below shows the Solar PV and Wind non-controllable generation for 2013 and 2014, in the same x-axis pattern as the demand profile above. The solar PV generation is modeled at the three existing major sites on feeder 7 and feeder 9. Each spike represents one day of solar PV power output. Please note wind generation does not come online until 2014, hence the initial flat line at zero power output during the 2013 period.

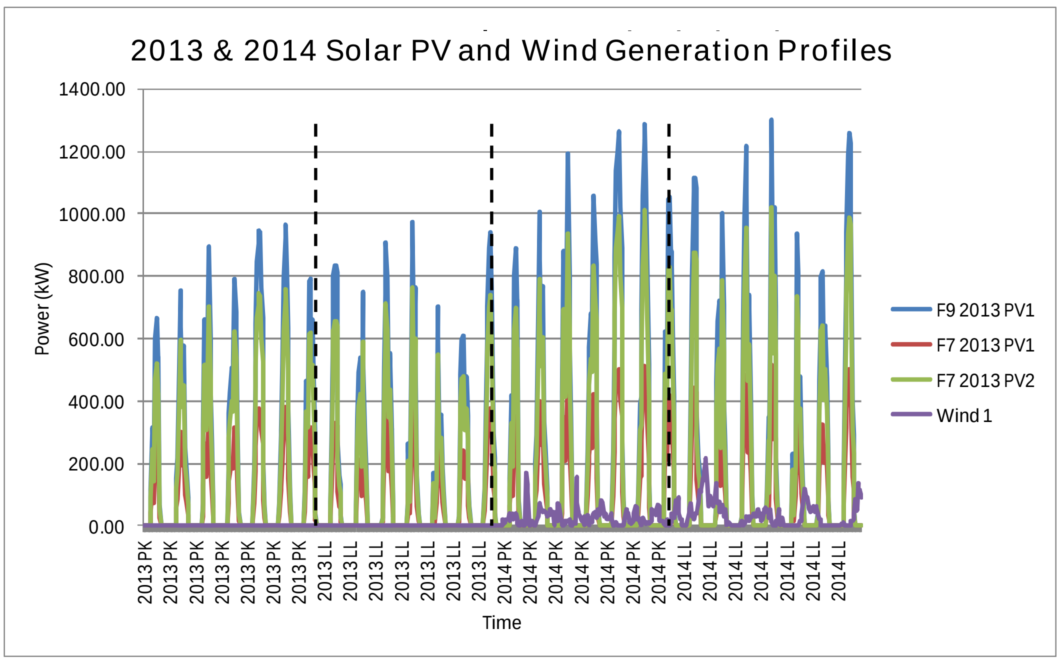


Figure 2-4. Solar and Wind Generation Dispatch

Figure 2-5 below shows the aggregated total hourly ASPA generation dispatch to meet varying daily load cycles. Satala Generating Units are designated by *S*, and Tafuna Generating Units are designated with *T.* Therefore, *S1* indicates Satala Unit 1, the unit dispatched first in each of the generation profiles shown below. Renewable generation is also shown on the chart below, indicated with *PV* or *Wind*.

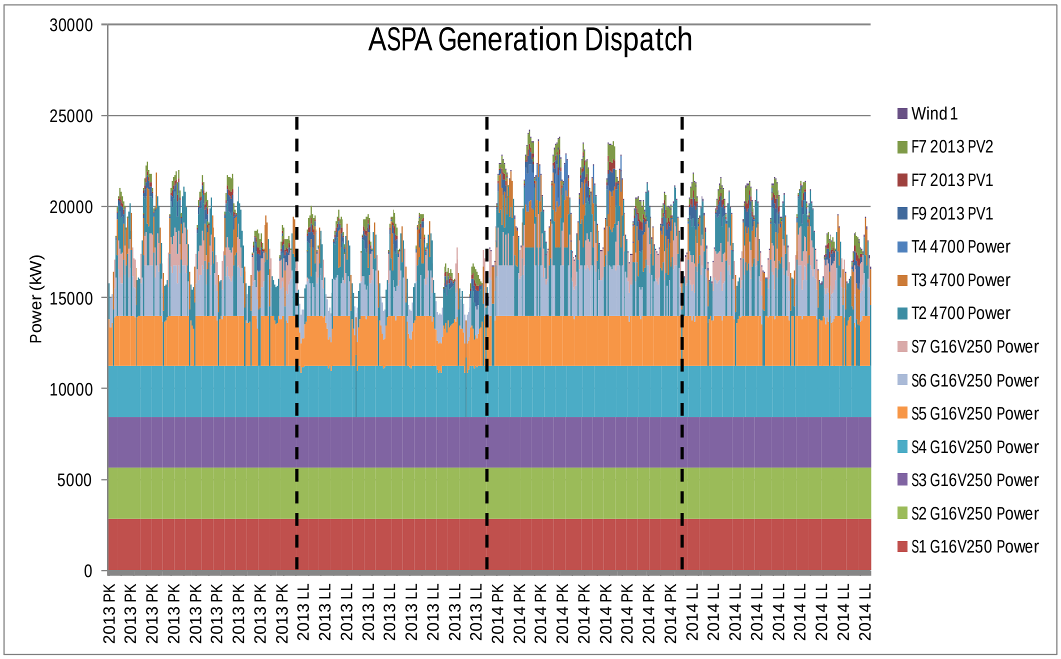


Figure 2-5. ASPA Generation Profile

Of the dispatchable generation shown on the chart, it can be observed that the Satala generation is dispatched to meet base load (base generation), whereas the Tafuna units are dispatched to meet the varying portion of the load i.e. dispatched as peaking generation. This is because the Satala generation is more fuel efficient than the Tafuna generation and thus they are dispatched to meet the lowest operating costs by the HOMER analysis. According to ASPA this method of generation dispatch is somewhat different to today's operation of the ASPA system that in general balances the loading equally across all Satala and Tafuna generation. However, the ASPA team determined (from an intermediate meeting) the economic generation dispatch analyzed in this study should be maintained for the ten years assessment due to the expected reduction in operating fuel costs.

As agreed with the ASPA team, the Satala and Tafuna generating units were modeled to hold scheduled voltage at 104% of nominal, and shared the reactive power load among all online units (according to each unit's active power output). Siemens PTI used an estimated generator PQ curve for each generating unit as shown below in Figure 2-6. The sharp decrease in reactive capability at ~0.1 MW – 0 MW is to ensure the power flow simulation does not allow the generation unit to provide reactive power when the unit is not dispatched i.e. at 0MW.

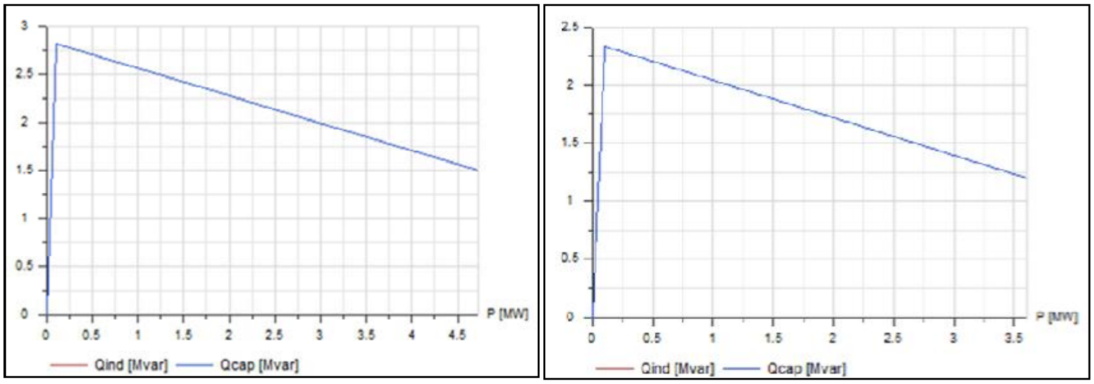


Figure 2-6. Tafuna (left) and Satala (right) Generator Reactive Capability Curves

Figure 2-7 below illustrates the power flow model of the Tafuna and Satala substations in PSS®SINCAL.

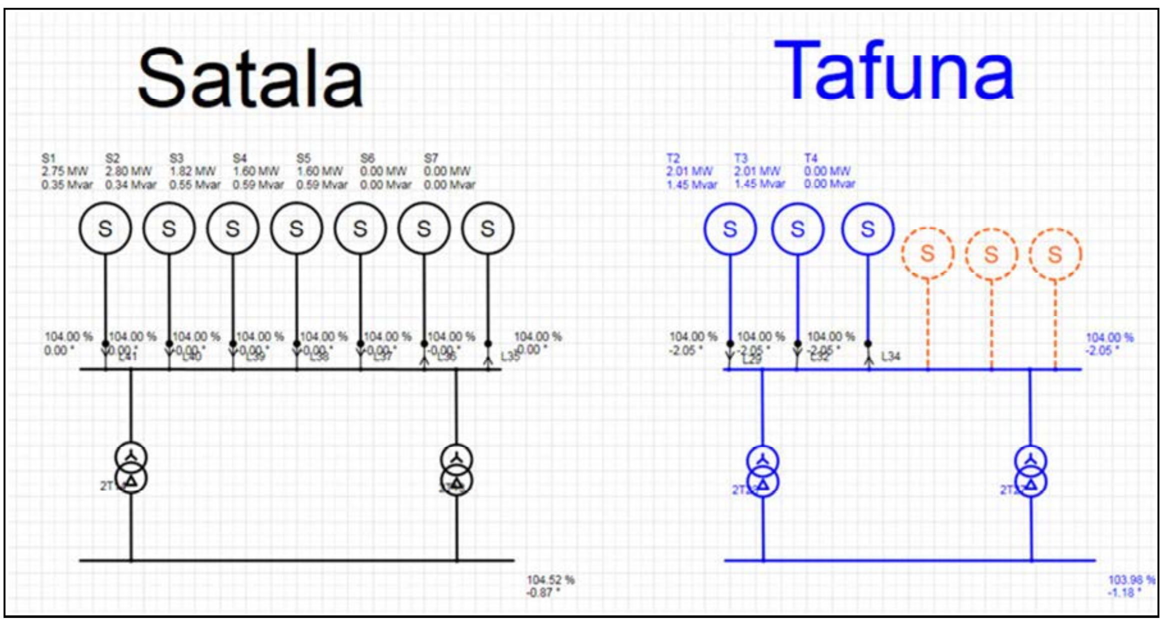


Figure 2-7. PSS®SINCAL Model of Satala and Tafuna Generation Units

2.4.2 Steady State Power Flow Result

Power flows and voltages on the ASPA system on 2013 and 2014 were acceptable. No Thermal overloads were identified. Voltages were within technical ANSI limits. Table 2-3 shows limits in 120 V base and Table 2-4 below shows those limits in percentages

Table 2-3. ANSI C84.1 Standard in absolute values

ANSI C84.1

Classification	Range A	Range B
Service Voltage	114 to 126 volts	110 to 127 volts
Utilization Voltage	110 to 125 volts	106 to 127 volts

Key
Range A – Normal Conditions.
Range B – Emergency conditions.
Service Voltage – Utility supply point
Utilization Voltage – Equipment supply point

Table 2-4. ANSI C84.1 Standard in percentages

ANSI C84.1, represented in %

Classification	Range B			Range B		
Service Voltage	95%	to	105%	92%	to	106%
Utilization Voltage	92%	to	104%	88%	to	106%

From Figure 2-8 below it can be seen that the thermal loading on the Satala – Tafuna 34.5 kV tie line was approaching its 10 MVA limit, with a maximum loading of just over 90%. This condition was observed in study simulations for 2013 and 2014. Minimum loading was around 20%, while average loading was situated around 60% for both peak and light demand conditions.

Figure 2-9 below displays the MVA loading on the 34.5 kV line in 2013 and 2014. The maximum load reaches 9 MVA while the average is situated around 6 MVA.

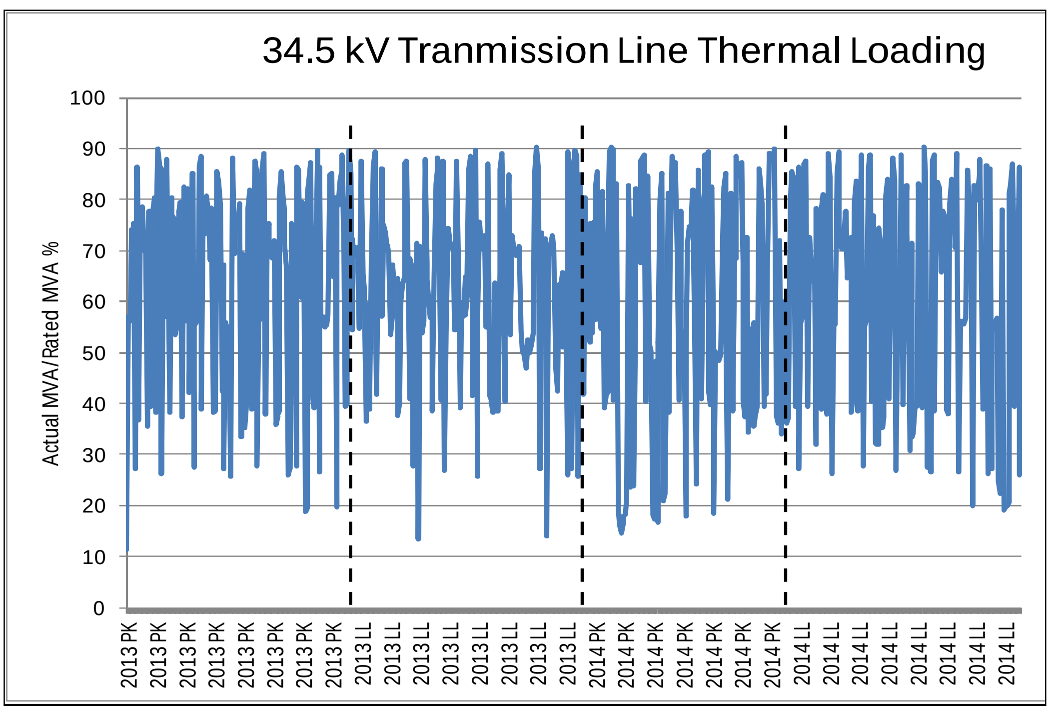


Figure 2-8. 34.5 kV Transmission Line Thermal Loading

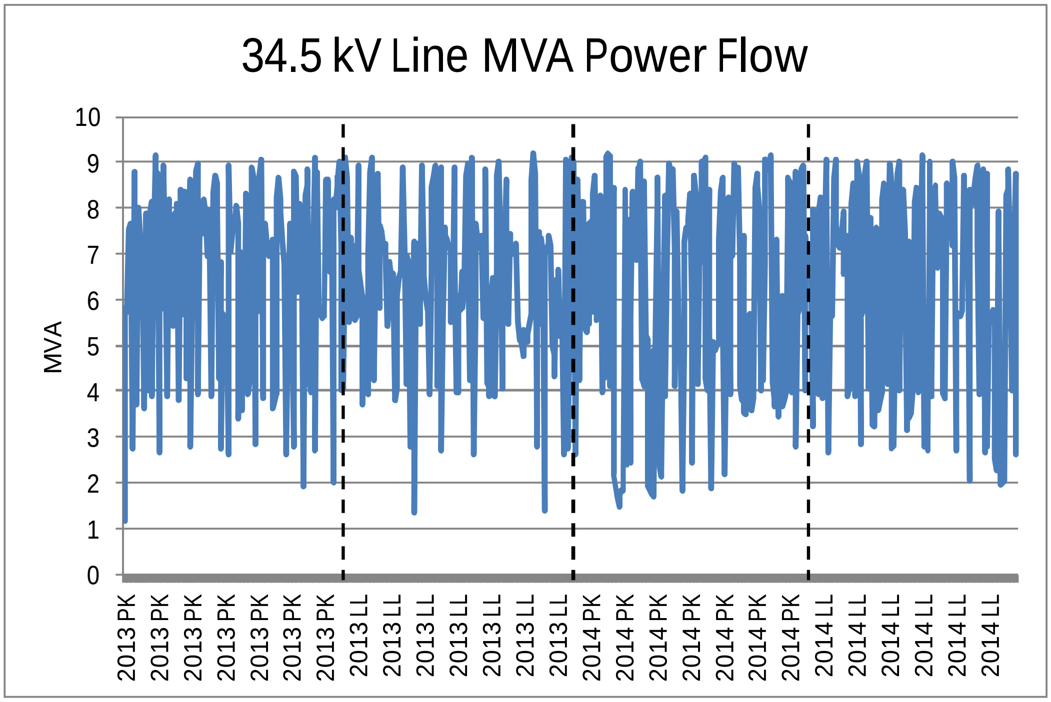


Figure 2-9. 34.5 kV Transmission Line MVA Loading

High flows on Satala – Tafuna 34.5 kV is caused by the dispatch order previously described. Table 2-5 captures unit generation levels for one occurrence of high 34.5 kV tie line flows to demonstrate the cause-and-effect relationship.

Table 2-5 ASPA Generation Dispatch During High 34.5 kV Loading

Unit Name	S1	S2	S3	S4	S5	S6	S7	T2	T3	T4	Wind	F913PV1	F713PV1	F713PV2
MW Dispatch	3.3	2.8	2.8	2.8	2.8	2.8	1.81	2	0	0	0.041	0.9	0.353	0.7

Of all the ASPA circuit modeled, the Satala – Tafuna 34.5 line had the highest thermal loading. The highest thermal loading on the 13.2 kV system was at 56% (3.1 MVA) of the 244 Ampere cable capacity on feeder 5.

Figure 2-10 below presents the voltage heat map representing the 2014 peak load condition The lowest recorded voltage in the system was 94.1% (113.4 V) on feeder 10, upstream from the voltage regulator. Feeders 6 and 7 also recorded low voltages although less severe (around 95%), while the voltage levels on feeders 5 and 9 were around 100% (due to lower impedance conductor on feeder 5 and shorter feeder length, plus solar PV on feeder 9). The low voltages in this area are attributable to Satala units being dispatched sooner than the Tafuna units, in turn leading to the Tafuna units not being on line to support local voltages.

Satala's feeders on the other hand, experienced voltage levels above 100%. This is explained by the fact that the Satala voltage schedule was set to 104%, and the highest loaded feeder connected to Satala only had a maximum demand of 4 MW.

The 104% voltage set point at Satala and Tafuna provided acceptable voltage performance through near term study years of 2013 and 2014.

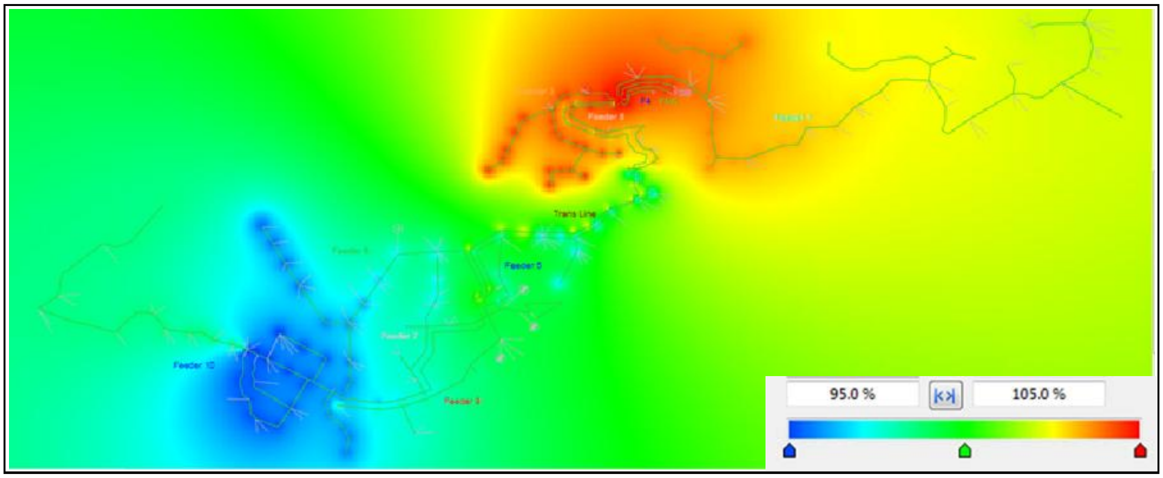


Figure 2-10. Voltage Results for 2014 Peak Load Conditions.

2.4.3 Voltage Setpoint Sensitivity Analysis

Siemens PTI investigated changing the 104% voltage setpoint at both Satala and Tafuna, to 100%. The results were that the system's low voltage buses went even lower, to unacceptable levels. Also, flow levels on the Satala – Tafuna 34.5 kV line increase. Therefore, Siemens PTI recommends retaining the 104% setpoint at Satala and Tafuna.

During 2013 peak demand, the lowest recorded voltage was **89%** compared to **94%,** with voltage set point at 100% and 104% respectively. The system's low voltages occurred on feeder 10 in each simulation.

Evolution of the voltage profile from Satala to the end node of feeder 10 is described below:

- In the first 13 km, Voltage drops to 96% across the Satala – Tafuna tie line, it then lessens to 93% on the 34.5/13.2 KV transformer. Please note, the 13.2 kV transformer LTC was modeled at fixed at nominal tap position, due to limited data.

- Between 13 km and 23 km, voltage drops with increased distance on the feeder 10 13.2 kV circuit to 89%.

- At 23 km, the sharp increase in voltage to 98% is due to the feeder 10 voltage regulator.

The lowest voltage of 89% on the 13.2 kV feeder could be problematic to customers, especially considering a typical 3% additional voltage drop across a 13.2/0.12 kV distribution transformer. However further investigation is not in the scope of this study.

Figure 2-11 below depicts the voltage profile from Satala 34.5 kV bus down to the last feeder 10 13.2 kV node, for four loading conditions i.e. 2013 PK (peak), 2013 LL (light load), 2014 PK and 2014 LL. As orientation, the x-axis from 1 to 13 represents the Satala – Tafuna 34.5 kV transmission line, which is 13 km in length.

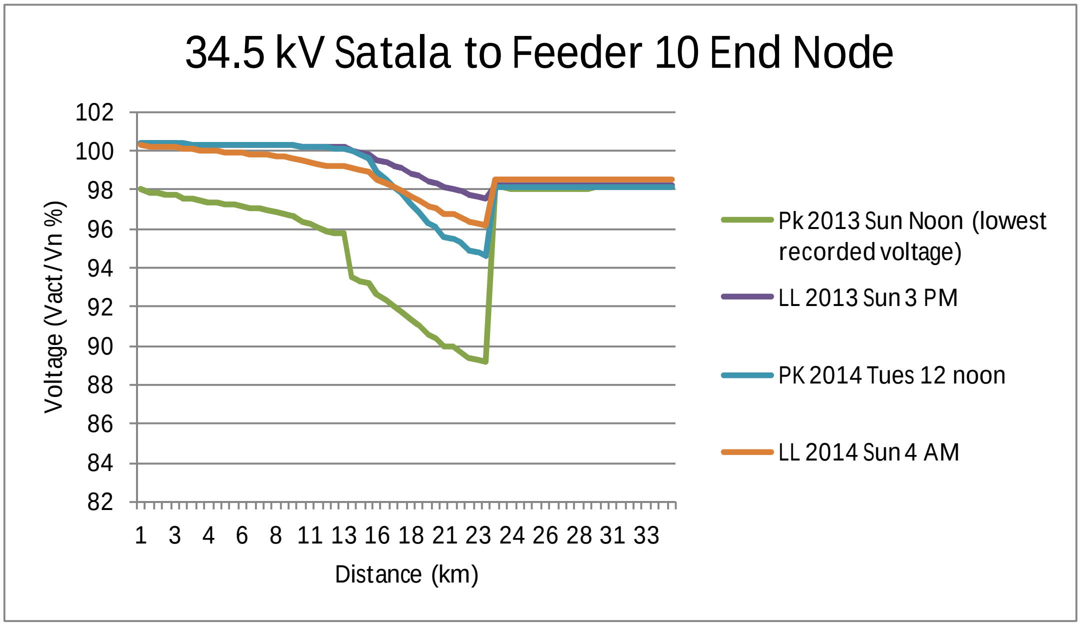


Figure 2-11. Voltage Profile

Flows on the Satala – Tafuna 34.5 kV line were also impacted by the change in the set point. The maximum power flows increased from 90% to 95% when the Satala and Tafuna set point was changed from 104% to 100%.

2.4.4 Economic generation dispatch versus today's dispatch approach

The HOMER economic dispatch study, which did not include transmission impacts, resulted in a $3.25M annual savings to ASPA. However, transmission losses increased because of larger flows on Satala – Tafuna 34.5 kV, resulting in a $200k annual cost (based on peak and light load week results, extrapolated over one year). The net result was a $3 Million annual savings, after considering transmission impacts.

ASPA current dispatching philosophy employs a balanced approach. This causes Satala and Tafuna units to be loaded roughly equally on a percentage of capacity basis. HOMER's economic dispatch emphasized unit economics, leading to Satala units generally being dispatched before Tafuna units.

One major trade-off in implementing HOMER's economic dispatch is increased reliance on the Satala – Tafuna 34.5 kV line. This, in turn, increases the risk that a Satala – Tafuna 34.5 kV forced outage could lead to low frequency or voltage in the vicinity of Tafuna. An optimization of generation dispatch and tie line risks was not in scope for this study, but is noted here.

As quantification for the above, the following is helpful. When Satala and Tafuna generation were economically dispatched, at a 100% voltage set point, the following impacts were observed on Satala – Tafuna 34.5 kV:

- Maximum 2013 line loading was 95%.

- Annual 2013 line losses at peak loading, was 860 MWh; with an annual cost of $223,000 (based on $0.26/kWh).

- Annual 2014 line losses (based on peak loading) was 829 MWh; with an annual cost of $215,000.

The reduction in losses between 2013 and 2014 can be attributed to the increased 2014 solar PV and wind projects in the Tafuna region. This Tafuna area renewable generation offsets power flowing through the system from Satala, compared to the 2013 dispatch.

2.5 2015-2022 Years System Assessment

The 2013-2014 analysis that preceded this section provided valuable information with which to move forward into an analysis of future scenarios. Moving forward, this study applied the HOMER economic dispatch and the 104% voltage set point. In addition to the 2015 and forward paradigm, the following studies will also identify potential risks in system operation and possible mitigation measures to be considered by ASPA in integrating more renewable generation.

2.5.1 Load and Generation Profiles and Locations

The following sub-sections describe how the future was captured in this study, including demand levels and how the demands were served. The HOMER study provided both the demand and resource levels. This system study provided locational modeling on the system, to evaluate the adequacy of the ASPA system to support future system needs.

Figure 2-12 below shows the weekly peak load and light load profiles, over the ten year study period, on which our study is based. Note that the projected demand increase is approximately 1.9% / yr. over the 2013 to 2022 period.

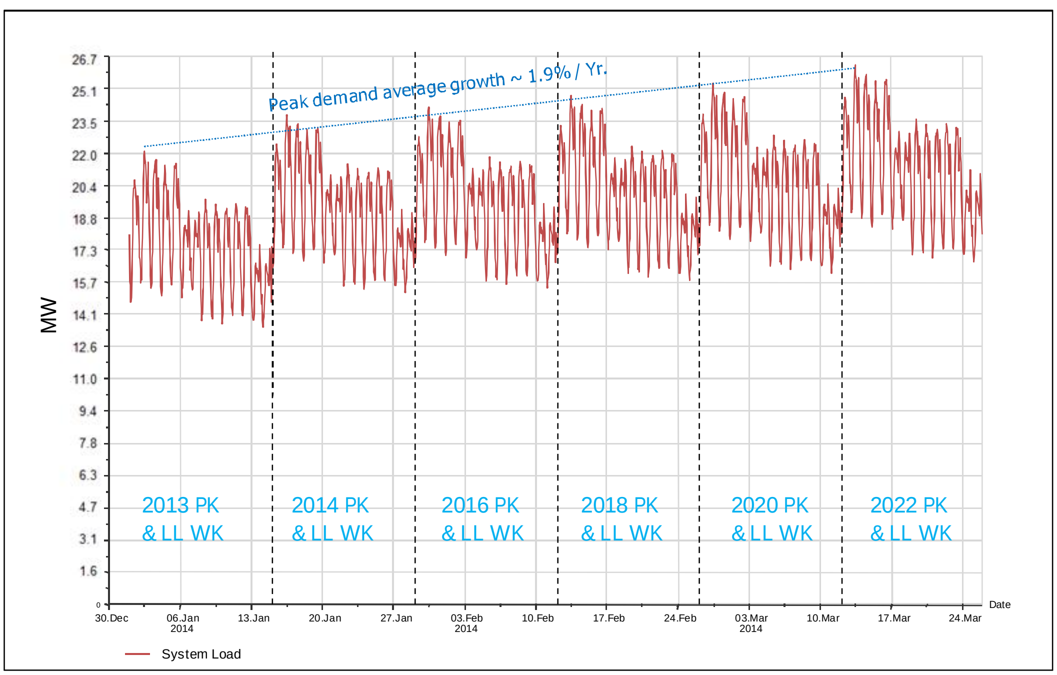


Figure 2-12. Ten Year Load Profile

2.5.1.1 Wind

Although ASPA may be considering several locations to add wind generation, for this study three locations were selected to identify potential system impacts through the 10 year study period. ASPA selected the three locations based on recorded historic wind speeds across the island as well as locations at which wind facilities could physically be added. Figure 2-13 below shows the three geographic locations selected and thus modeled and simulated in the steady state analysis.

Figure 2-14 below shows the three sites based on the electrical network interconnections.

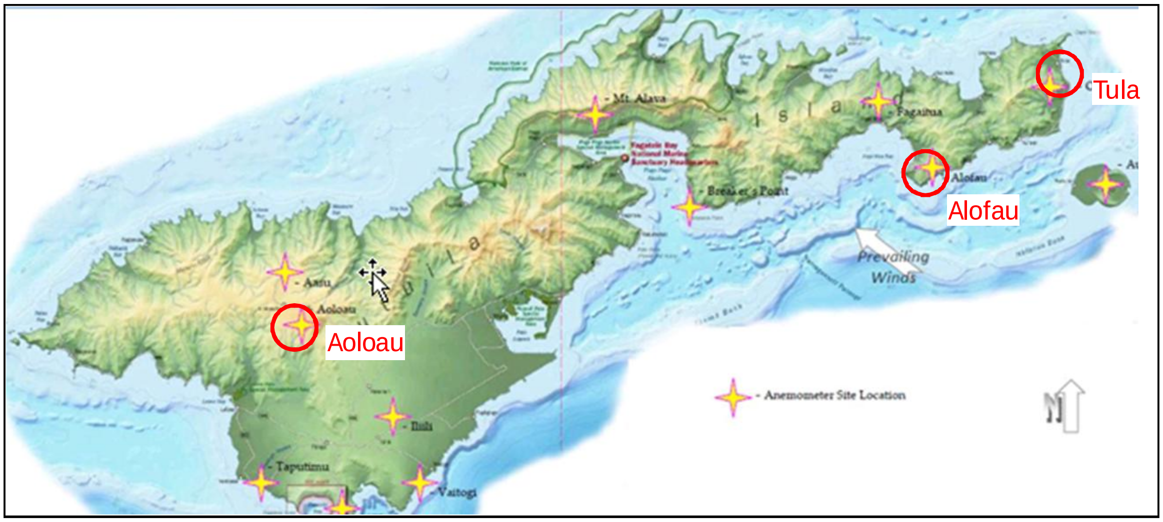


Figure 2-13. Selected Wind Generation Sites

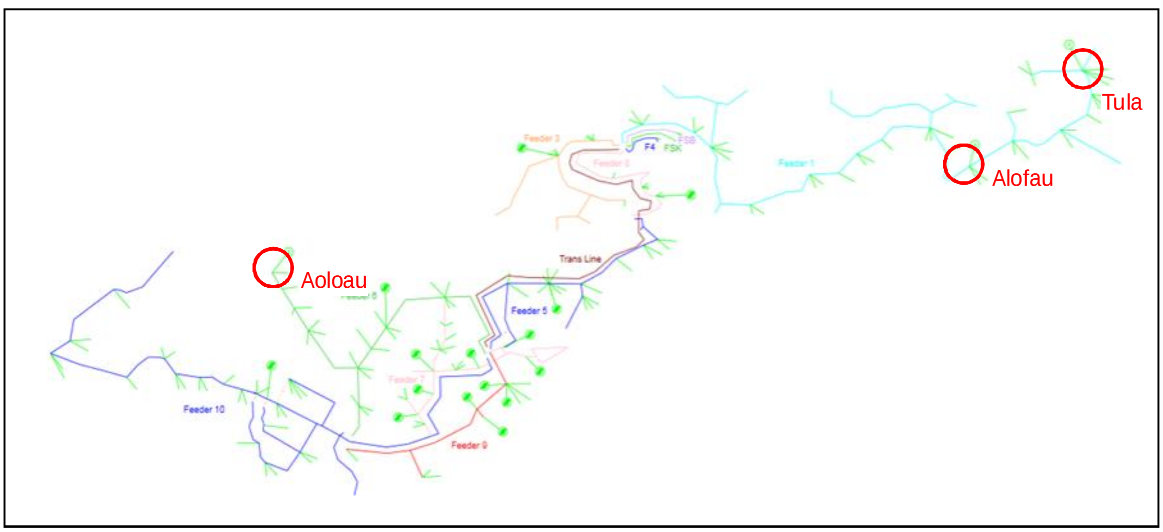


Figure 2-14. Selected Wind Generation Sites to Electrical Feeders

Table 2-6 below details the resultant wind allocation to each of the three sites in this study. . The wind generation allocation was based on wind speed and ASPA's input.

Figure 2-15 depicts the 10-year output profile for each of the three wind sites

Table 2-6. Wind Capacity Per Selected Sites

Scenario	Wind Totals (MW)	Aoloau (MW)	Tula (MW)	Alofau (MW)
2013	0	0	0	0
2014	0.3	0.3	0	0
2016	2.3	2.3	0	0
2018	5.3	2.3	3	0
2020	8.3	2.3	3	3
2022	11.3	5.3	3	3

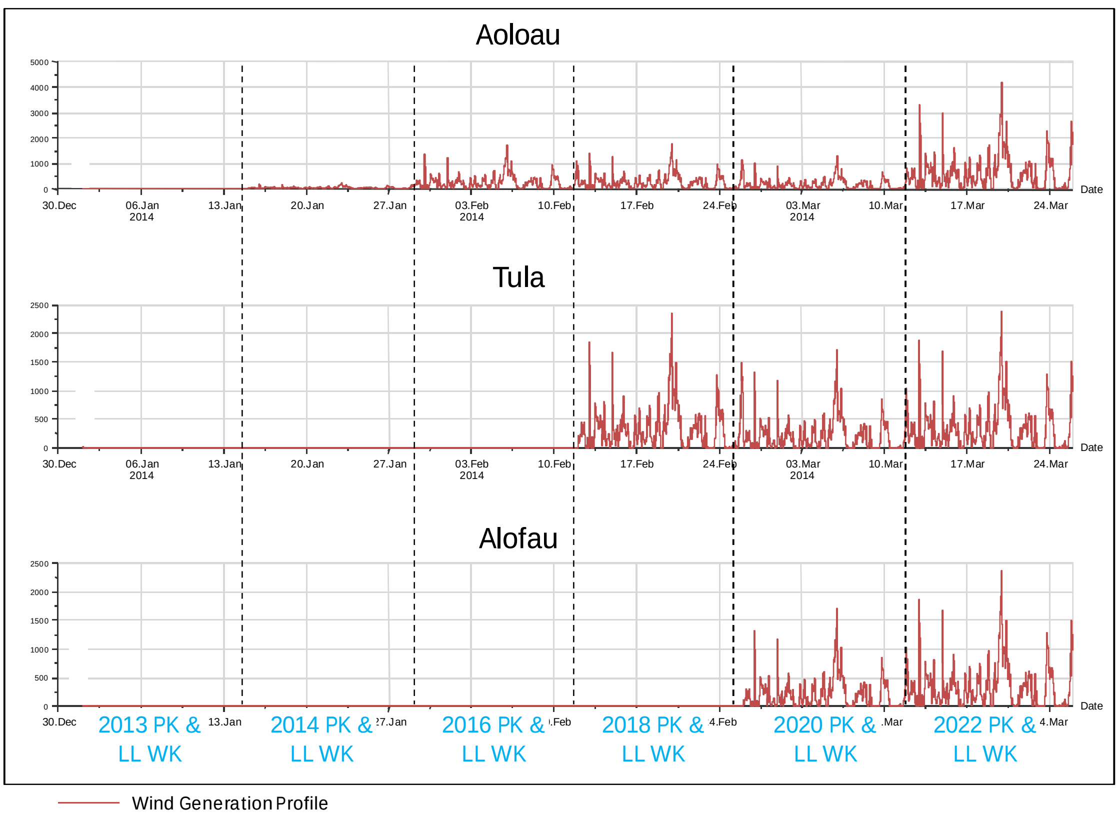


Figure 2-15. Wind Profile Per Site

The wind turbines modeled were based on the 275 kW Vergnet wind turbines (see Appendix A). ASPA selected these turbines for the study, citing ease of installation compared to larger units, plus their hurricane proof design.

These wind turbines are considered fixed speed, although they can have small speed variability. They are also asynchronous, squirrel cage induction generators known as "**Wind Turbine Type 1**". Type 1 turbines operate at fixed real power and no direct voltage control capability. They are fairly basic in functionality compared to much larger wind turbines.

According to manufacturer's specifications, these turbines are often accompanied by external reactive power compensation provided via capacitor banks. Therefore, for this analysis we assumed sufficient capacitor banks would be installed to correct for the typical lagging power factor of induction machines, resulting in each machine being modeled at unity power factor.

The wind turbines were modeled as single aggregated units connected directly to the 13.2 kV system (i.e. no step up transformer was modeled) as shown in Figure 2-16 below.

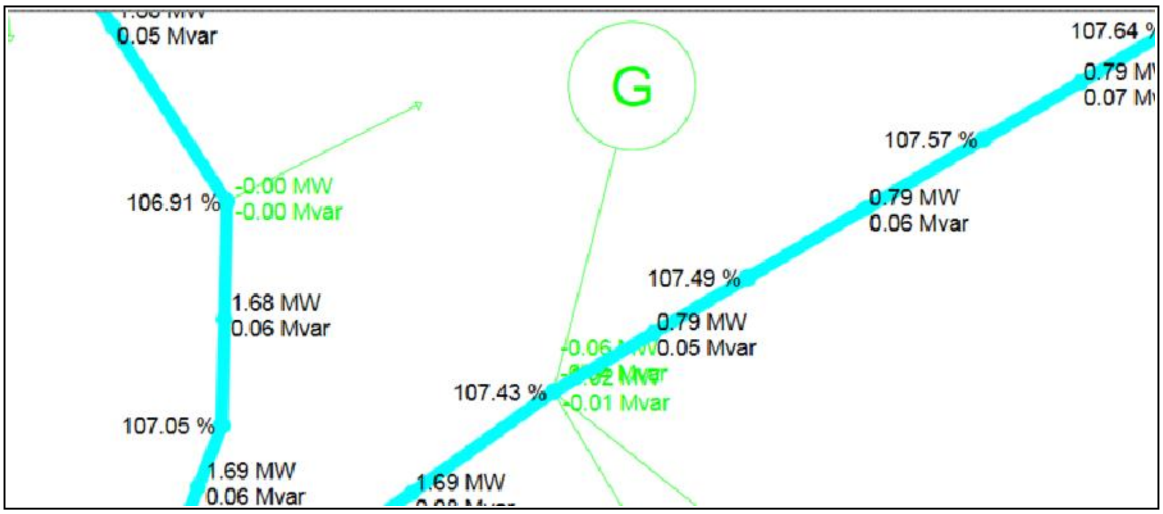


Figure 2-16. Aggregated Wind Farm Model for Alofau on Feeder 1

2.5.1.2 Solar PV

As a practical matter, modeling some of the existing and anticipated dispersed solar PV systems required consolidation. The solar PV locations in this study were determined in collaboration with ASPA, in three deployment categories:

1. Category 1: Existing ASPA owned solar PV generation and anticipated expansions over the 10 years shown in Figure 2-17 below.

2. Category 2: Expected roof top solar PV in residential areas around the Tafuna region. All roof top solar PV's were aggregated into five individual sites as shown in Figure 2-18 below.

3. Category 3: Existing privately owned solar PV sites and their anticipated expansions over the 10 years. Shown in Figure 2-19 below, the seven sites shown are also aggregations of multiple smaller solar PV projects.

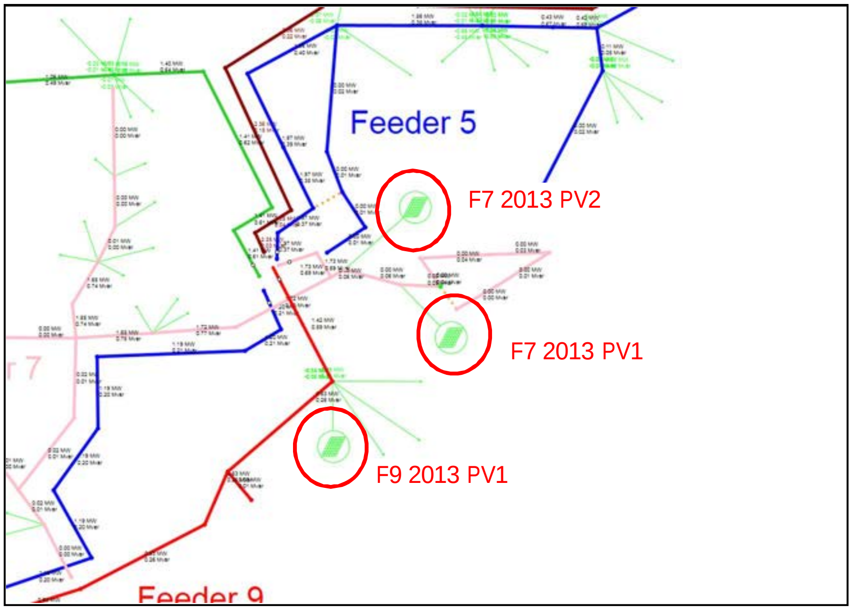


Figure 2-17. Category 1: Three Large Existing Solar PV Sites Near Tafuna Substation

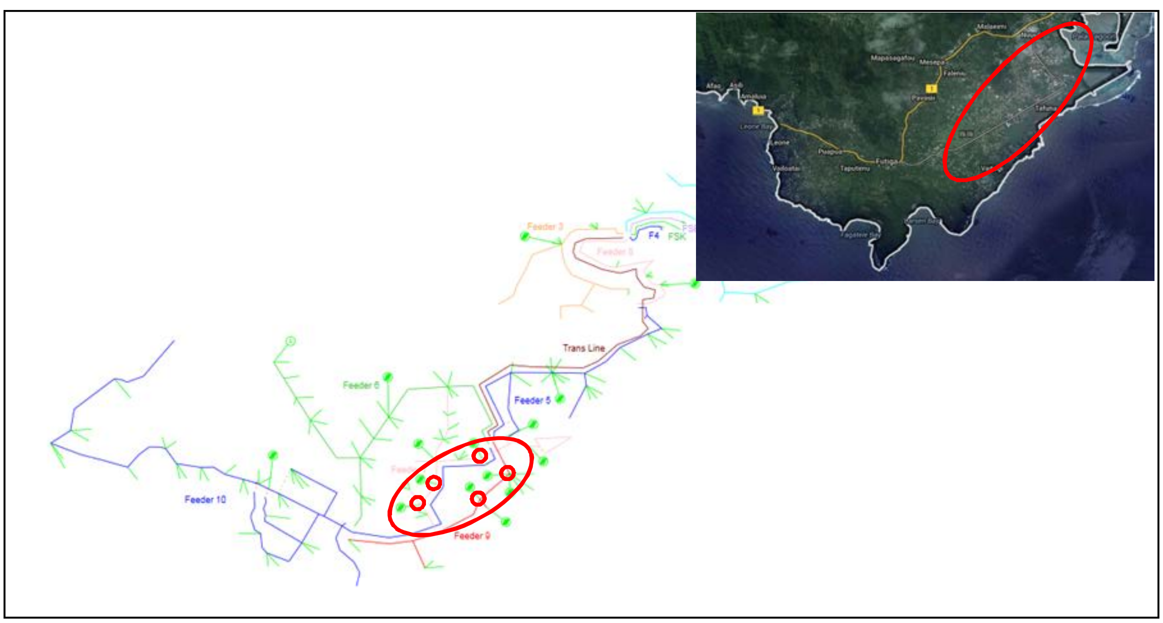


Figure 2-18. Category 2: Location of 30% Residential Roof Top Solar 2016 Onwards

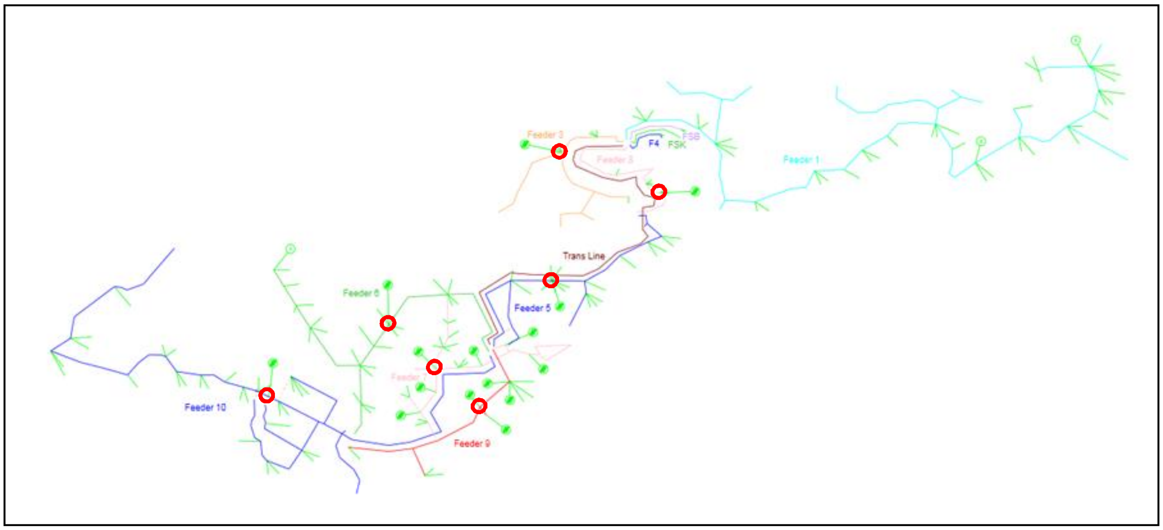


Figure 2-19. Category 3: Private Solar Locations Based on Current Distribution

For categories 2 and 3 above, the aggregated models were placed at the actual solar PV site that was furthest away from the substation. This was to be conservative since typically more electrical network issues occur when Distributed Generation (DG) is placed towards the end of a feeder.

Table 2-7 below shows how the total solar PV penetration per year was allocated among the above three categories.

Table 2-7. Solar PV Capacity to Locations

Year	PV Totals (MW AC)	Category 1			Category 2	Category 3
		Feeder 9 PV1 (MW AC)	Feeder 7 PV1 (MW AC)	Feeder 7 PV2 (MW AC)	Roof Top (30% of 2016's) (MW AC)	Private Solar PV (MW AC)
2013	2.60	1.00	0.43	0.75	0.00	0.42
2014	3.90	1.50	0.65	1.13	0.00	0.62
2016	5.40	1.46	0.63	1.09	1.62	0.60
2018	7.30	1.97	0.85	1.48	2.19	0.82
2020	9.20	2.48	1.07	1.86	2.76	1.03
2022	10.80	2.92	1.25	2.19	3.24	1.21

Each PV source was modeled as maintaining unity power factor. In reality many smart inverters do have the capability to provide VAR support. **Figure 2-20** depicts one aggregated solar installation modeled on feeder 5.

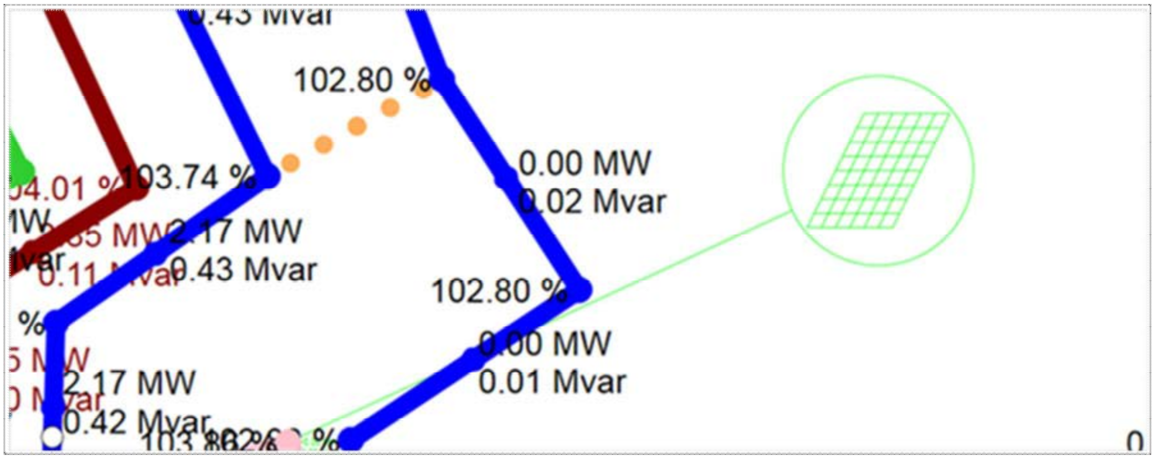


Figure 2-20. Solar PV Model on Feeder 5

2.5.2 Steady State Power Flow Results

Even though some preliminary 2013 and 2014 results were presented earlier in this report, it is advantageous to describe the trends from those years into the future. Therefore, those prior results may also be discussed in this future-oriented section. Our focus in this section is steady state power flow results obtained over the 10 year study period. The results highlight thermal and high or low voltages that may arise in the study period at any given node or section of the ASPA system.

2.5.2.1 Thermal Results

All expected flows on the ASPA system through 2022 were acceptable. No thermal overloads were identified although, as previously discussed, flows on Satala – Tafuna 34.5 kV tend to increase in association with the economic dispatch pattern developed and discussed earlier.

The following two figures are related. Figure 2-21 depicts maximum loading on the ASPA system through the ten-year study period, regardless of where the maximum loading occurred. Figure 2-22 shows loading specifically on the Satala – Tafuna 34.5 kV line. Visual inspection tells us that the Satala – Tafuna 34.5 kV line is where ASPA's maximum loading arose.

The noticeable drop in loading from 2014 to 2016 is due to several renewable additions anticipated to be added between those years on feeders served from Tafuna. These expected power sources counteracted flow patterns from 2013 and 2014, which were primarily from Satala to Tafuna.

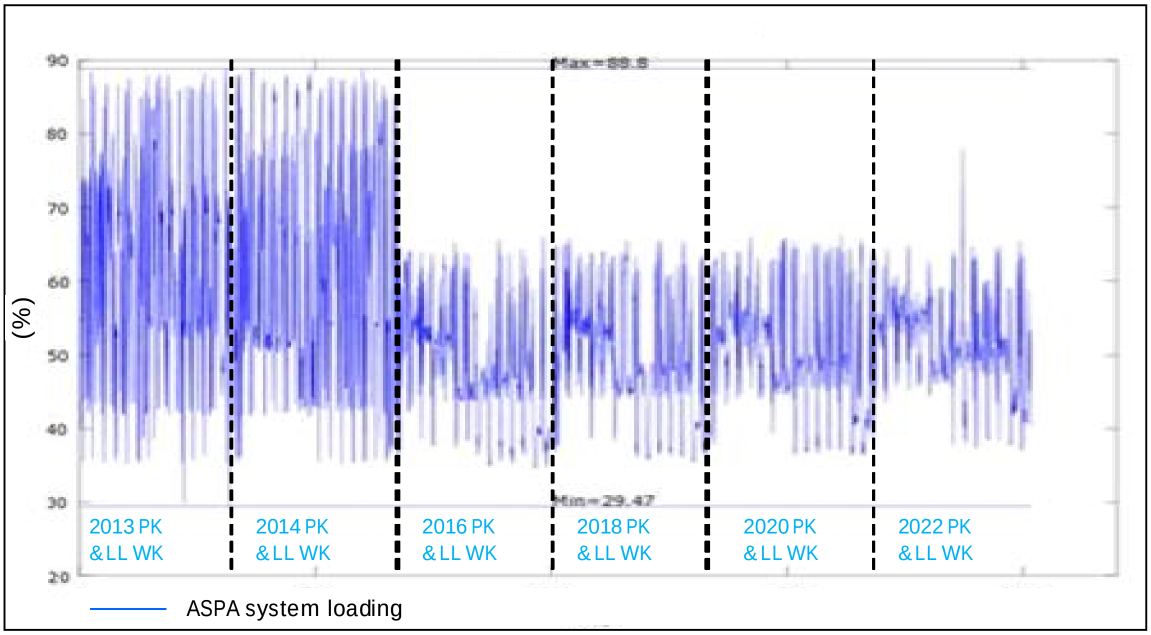


Figure 2-21. 2013 – 2022 Max % Thermal Loading for all ASPA branches

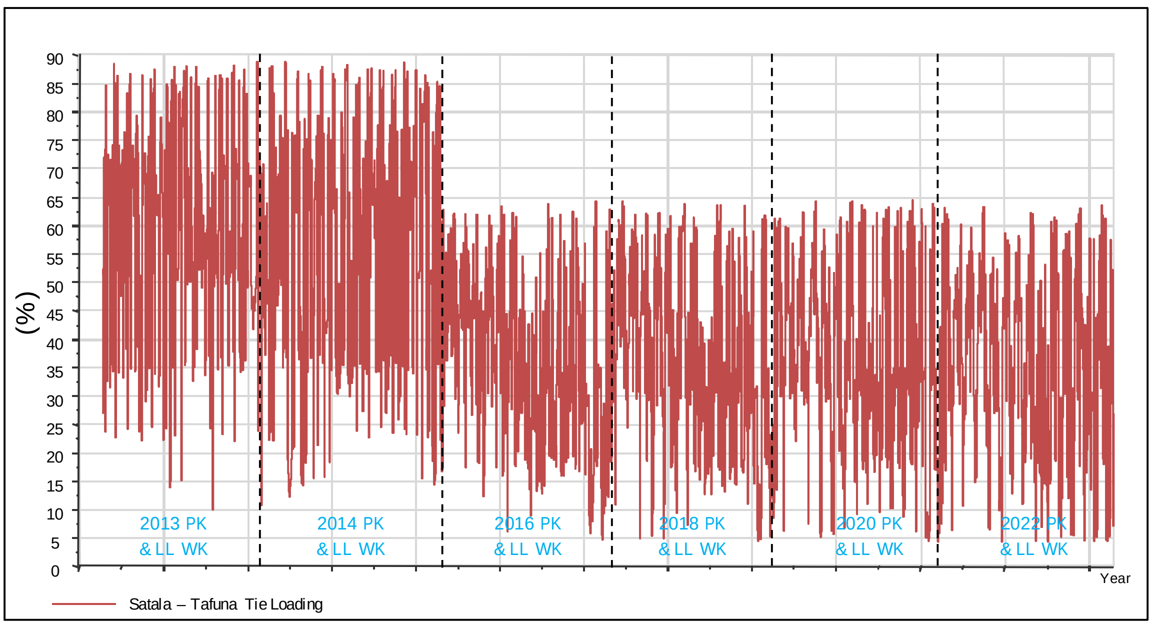


Figure 2-22. 2013 - 2022 34.5 kV Tie Line Loading in MVA

2.5.2.2 Voltage Results

In the near term, in 2013 and 2014, low voltages near Tafuna were a concern, although still acceptable. These concerns lessened into the future in association with anticipated new renewable additions there.

In the future, from 2016 onward, high voltages near Satala were a concern. These concerns increased into the future as new renewable additions occurred on feeders served from Satala.

Figure 2-23 denotes the lowest and highest ASPA voltages through the ten-year study period. The lowest identified voltage was 94%. The highest voltage was 116%, which exceeds applicable standards.

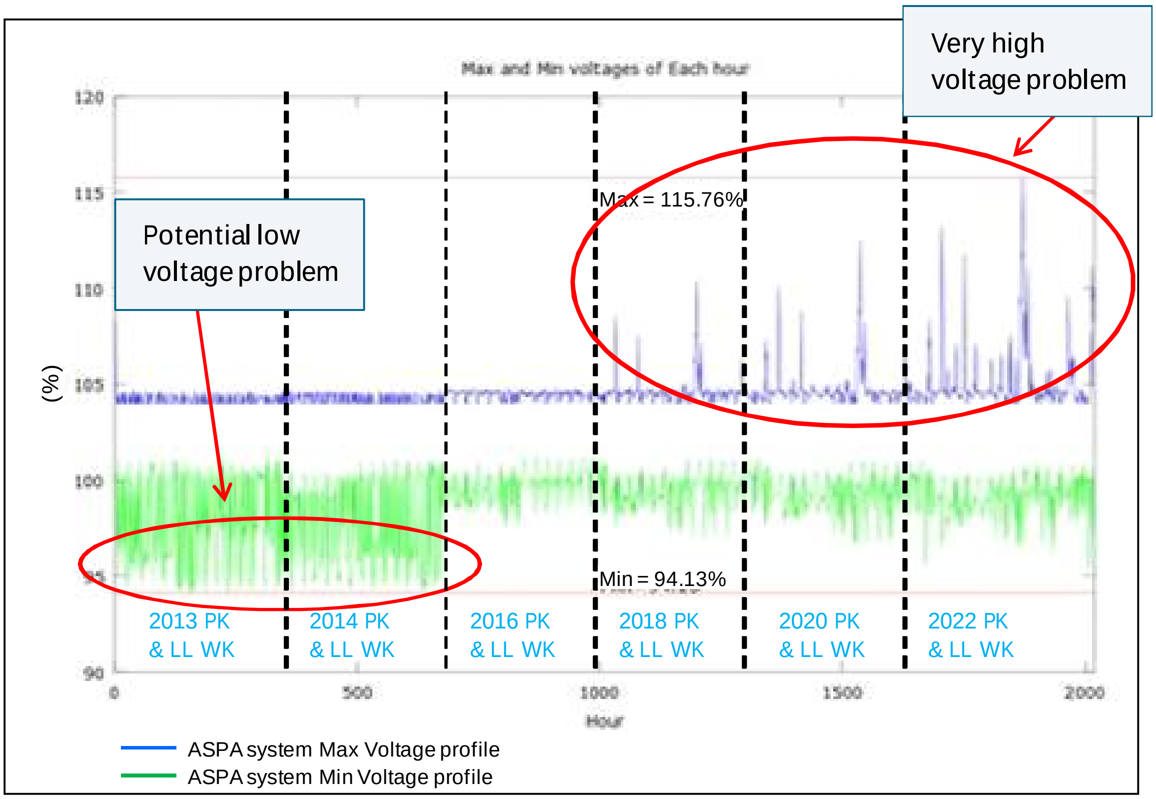


Figure 2-23. 2013 – 2022 Voltage Min & Max

System minimum voltages tended to improve post-2016 to levels around 100%.

From 2016 onwards high voltages were identified, reaching levels above 110%. The highest recorded voltages documented in this study through the 10-year study period occurred on feeders 6 and 1. Figure 2-24 below indentifies geographical locations/areas where high voltages (shown in red) are recorded.

It is a well-known phenomenon that high voltages may occur near distributed generation. Note in Figure 2-24. High Voltages - 2022 Light Load Condition (night time) the highest voltages occur in the areas near the future wind generation sites added to the system.

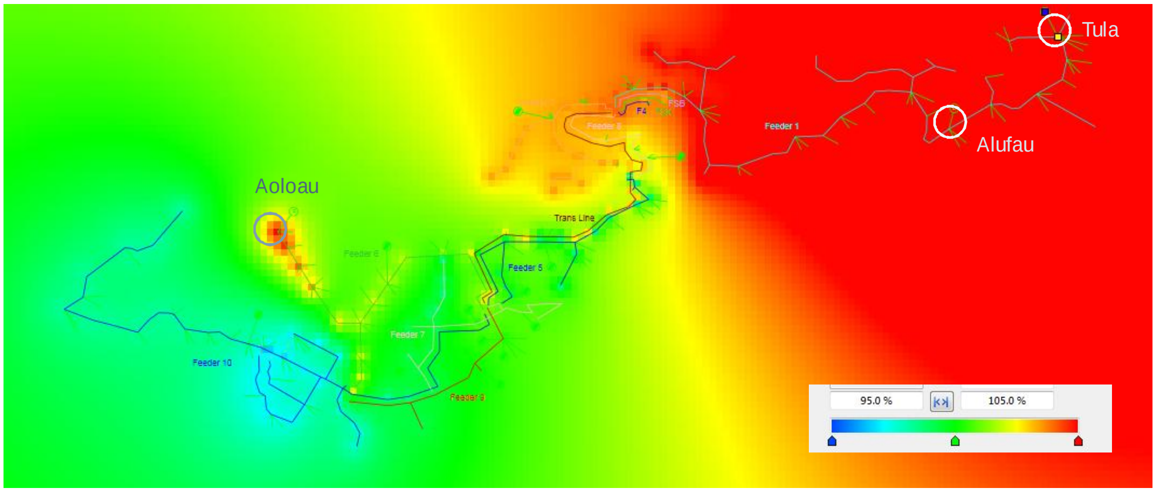


Figure 2-24. High Voltages - 2022 Light Load Condition (night time)

The future high voltages in our study are caused by new wind generation on Satala feeders. The graphics below demonstrate the association between high voltages and wind output.

Figure 2-25 below, shows two curves, the upper curve is the maximum voltage in percentage and the lower curve is the total ASPA wind power output in kW. We can deduce the following facts:

- The highest voltage was 116%, it occurred at the end of feeder 1, adjacent to Tula wind generation in the year 2022.
- A high voltage of 106% was recorded at the end of feeder 6, adjacent to Aoloau wind generation in the year 2022.
- Anytime the total wind output was greater than ~1500 kW, voltages above 105% were possible.
- High voltage concerns were first possible in 2018, and got progressively worse to 2022.
- High voltage problems occurred during both peak load and light load conditions, but were worse during light loads.

By reviewing the full 8760 hourly data from HOMER for 2018 onwards, to quantify the amount of time total wind power was above 1500 kW, the following was determined:

- In 2018: 2803 hrs (31% of the year) the power output was above 1500KW.
- 2020: 2834 hrs (32% of the year).

- 2022: 4258 hrs (48% of the year).

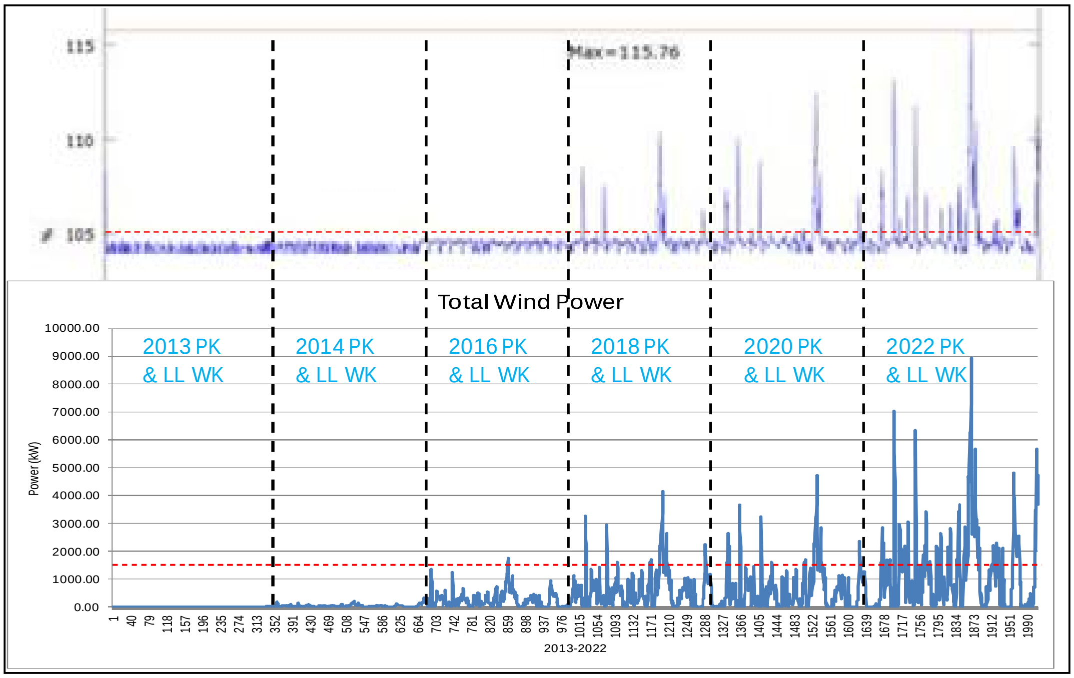


Figure 2-25. High Voltage to Wind Association

Figure 2-26 shows high voltage and wind generation profiles for 2022 system conditions

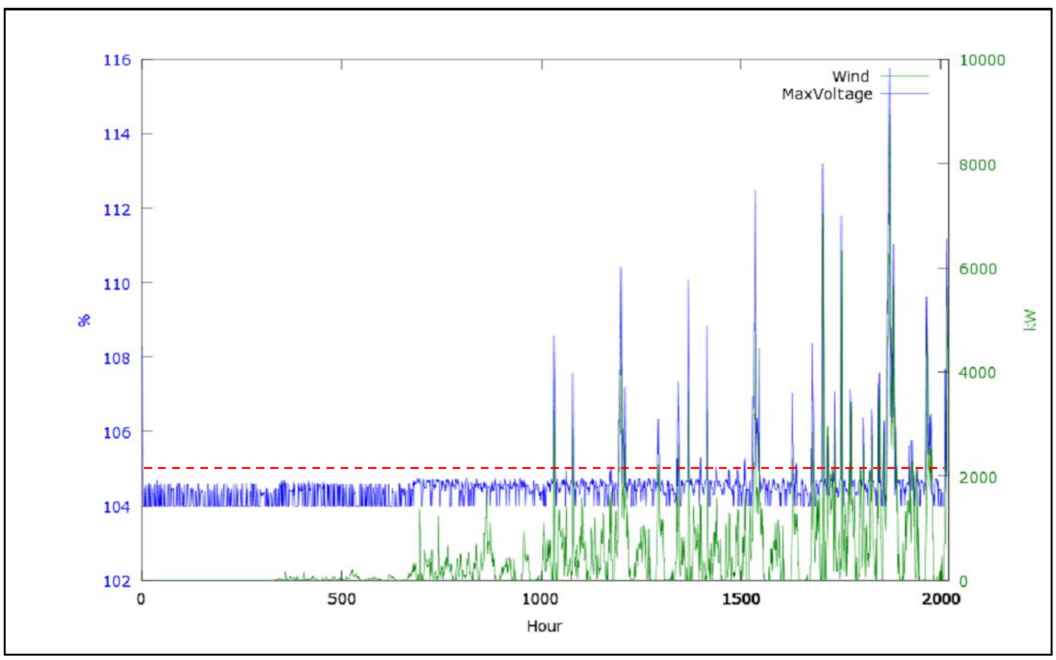


Figure 2-26. High Voltage to Wind association, 2022 conditions

The cause for this high voltage is graphically described in Figure 2-27 below, demonstrating that the voltage at the end of the feeder "Vend" is greater than the source (substation) voltage "Vsource".

This situation is a common issue for DG interconnections, especially when they are connected towards the end of long distribution feeders. The issue is due to the voltage drop along the feeder looking backwards from the wind generation towards the substation that has a scheduled voltage of 104%. This voltage drop is a result of the wind generation current being injected through the impedance (resistance and inductive reactance) of the feeder conductor. By adding the voltage drop we see a voltage rise at the end of the feeder. This is quite contrary to the common convention that voltage drops as you move away from the substation towards the end of a heavily loaded feeder (zero DG), however in the conventional case, the feeder current is downstream, compared to the high voltage case were we have DG> feeder load, thus the current flows upstream towards the substation.

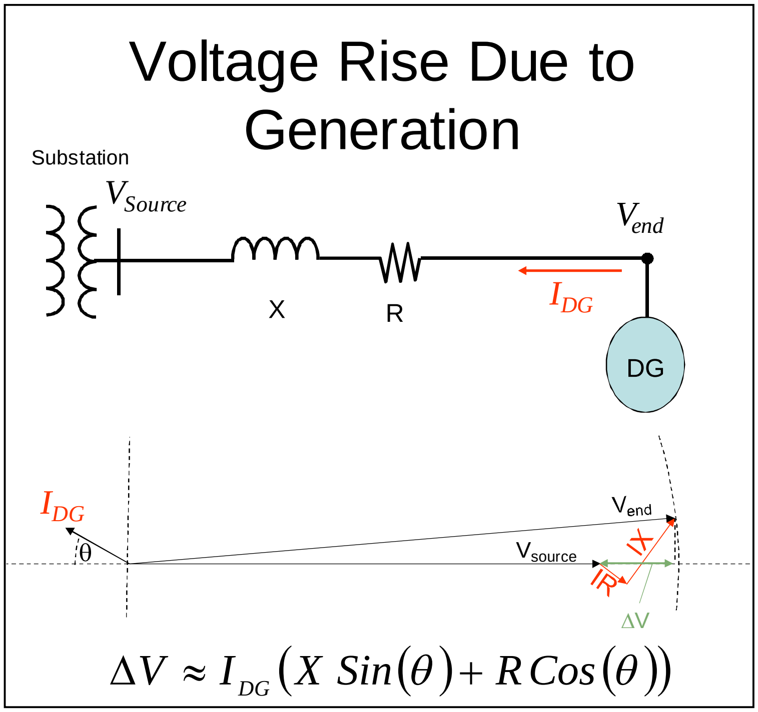


Figure 2-27. Cause of Problem - High V at Wind Sites

2.5.3 Mitigation

From Figure 2-27 above we can deduce there are three major contributors to the high voltage problem:

1. Feeder 1 current phase angle (Ø).

2. Feeder conductor Impedance (R & X).

3. Injected current magnitude.

With the above causes, the following potential mitigation measures come into focus:

1. Shunt reactors.
2. Energy storage.
3. Wind turbine reactive power support.
4. Redistributing wind from Alofau and Tula to Aoloau.
5. Adjusting Satala and Tafuna generation voltage setpoints.
6. Upgrading or adding new conductors.
7. Wind curtailment.

Each mitigation option is determined by its ability to bring the voltages along feeder 1 to less than 108% for the period of the highest recorded voltage in each year. Please note these values are only estimates and only cover the two weeks (peak load week and light load week) analyzed per year.

2.5.3.1 Shunt Reactor (Assuming Wind PF = 1.0)

Shunt reactors are known and effective devices for reducing system voltages. Shunt reactors applied at Tula and Alofau brought voltages down to below 108%. The employed shunt sizes are shown in Table 2-8 below.

For the year 2022 the capacities required were quite significant. A loading level of 95% on feeder 1 resulted, and higher system losses were also created, rising from 0.7 MW to 1.4 MW (for the hour of concern). These higher losses were caused by higher reactive power flow from Satala to each shunt reactor.

An additional concern is that shunt reactors would need to be variable, and controlled to increase as wind power output increased.

Table 2-8 Quantity of Shunt Reactors

Study Year	Alofau		Tula	
	KVAr (3PH)	Wind (kW)	KVAr (3PH)	Wind (kW)
2018	0	0	300	2346
2020	800	1711	1000	1711
2022	1400	2375	1600	2375

2.5.3.2 Energy Storage

Tula and Alofau were able to inject up to 1.9 MW of wind power on feeder 1 before the 13.2 kV voltage rose above 108%. Since these two wind sites produced power at levels above 1.9 MW, energy storage was evaluated to see what energy and power capacities would be required to absorb all of the wind energy, to keep net injection levels at 1.9 MW or below.

For the year 2022, a total of between 450-1000 MWh of energy capacity, and 6 MW of charge/discharge capability was required. These capacity requirements occurred during several periods of the year, notably September through October, in which the wind consistently and substantially exceeded 1.9 MW.

2.5.3.3 Wind Turbine PF Control

Some wind turbines have typical lagging power factors of 0.84. Employing that power factor in the study's wind models, improved voltages were observed, although at levels above 107% for the year 2020 and above 108% for the year 2022 (See Table 2-9). Additionally, feeder 1 loading increased to 90%.

Table 2-9. Recorded Voltages for High Wind Periods with PF=0.84

Study Year	Alofau			Tula		
	Voltage (%)	Wind (kW)	Wind (kVAr)	Voltage (%)	Wind (kW)	Wind (kVAr)
2018	105.41	0	0	106.02	2346	1515
2020	107.09	1711	1098	107.49	1711	1098
2022	108.51	2375	1534	109.10	2375	1534

From Figure 2-28 below, the rated generating output has a relatively high power factor which helps to mitigate the high voltage problem, (as shown in the previous table), however, for low wind speeds, we can get a significant decrease in power factor (moving along the power factor curve towards synchronous speed). This could potentially lead to low voltage problems at the end of feeder 1. Therefore, we recommend the wind turbines should have smart power factor correction capabilities that vary in line with the generated active power/wind speeds. That is, capacitive support at low wind speeds and rely the natural lagging power factor of the induction generator, plus some additional inductive support, during high wind speeds. Without more detailed information of the actual wind turbine operation it difficult to gauge the exact +/- reactive power range required.

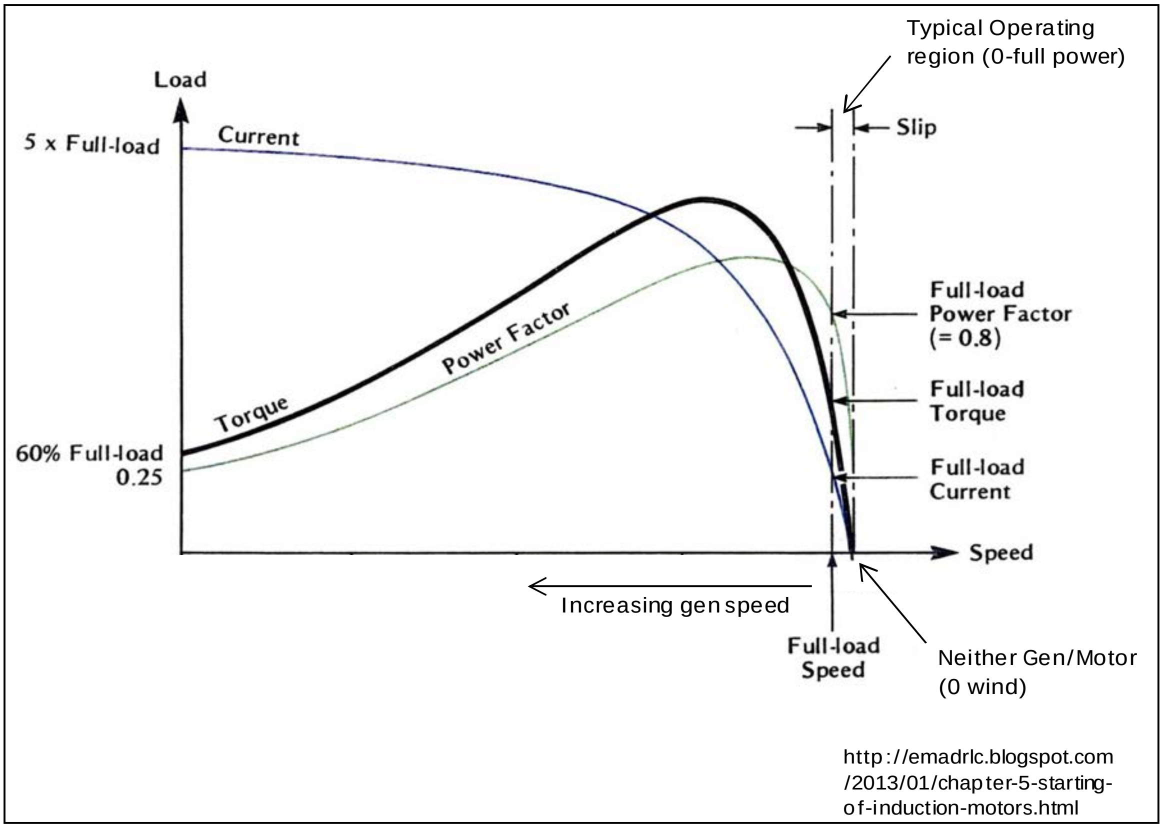


Figure 2-28. Wind Squirrel Cage Induction Generator Curves vs Speed

2.5.3.4 Redistributing Wind From Alofau and Tula to Aoloau

Aoloau is the most favorable site among the three modeled for reducing prospective high voltages. The high voltages caused by the wind generation were not as high at Aoloau as at Alofau and Tula. By presuming more of the total anticipated wind generation to be developed at Aoloau, more favorable voltages emerged, but still not acceptable in 2022. From Table 2-10 below, the extreme voltages are reduced to 113% from a previous value of 116%.

Table 2-10. Recorded Voltages for High Wind Conditions with Relocated Wind

Study Year	Alofau				Tula				Aoloau			
	Voltage (%)	Wind (kW)	New Wind Capacity (kW)	Orig Wind Capacity (kW)	Voltage (%)	Wind (kW)	New Wind Capacity (kW)	Orig Wind Capacity (kW)	Voltage (%)	Wind (kW)	New Wind Capacity (kW)	Orig Wind Capacity (kW)
2018	105.12	0	0	0	106.2	1173	1.5	3	107.28	2971	3.8	2.3
2020	106.57	855	1.5	3	107.27	855	1.5	3	105.25	3021	5.3	2.3
2022	109.66	1471	1.85	3	111.0	1471	1.85	3	112.68	6000	7.6	5.3

2.5.3.5 Impact of Adjusting Satala and Tafuna Vsched to 102.5%

From Figure 2-29 below (also shown earlier in this section) it was possible to decrease the scheduled voltage at Satala and Tafuna from 2016 onwards to a value that a) avoided low voltage problems and b) helped to reduce the high voltage problem.

Figure 2-29 below shows the results of adjusting the scheduled voltage from 104% to 102.5% from 2016 onwards. The voltages marginally improved, with the highest voltage at 115%, still above 108% from 2018 onwards.

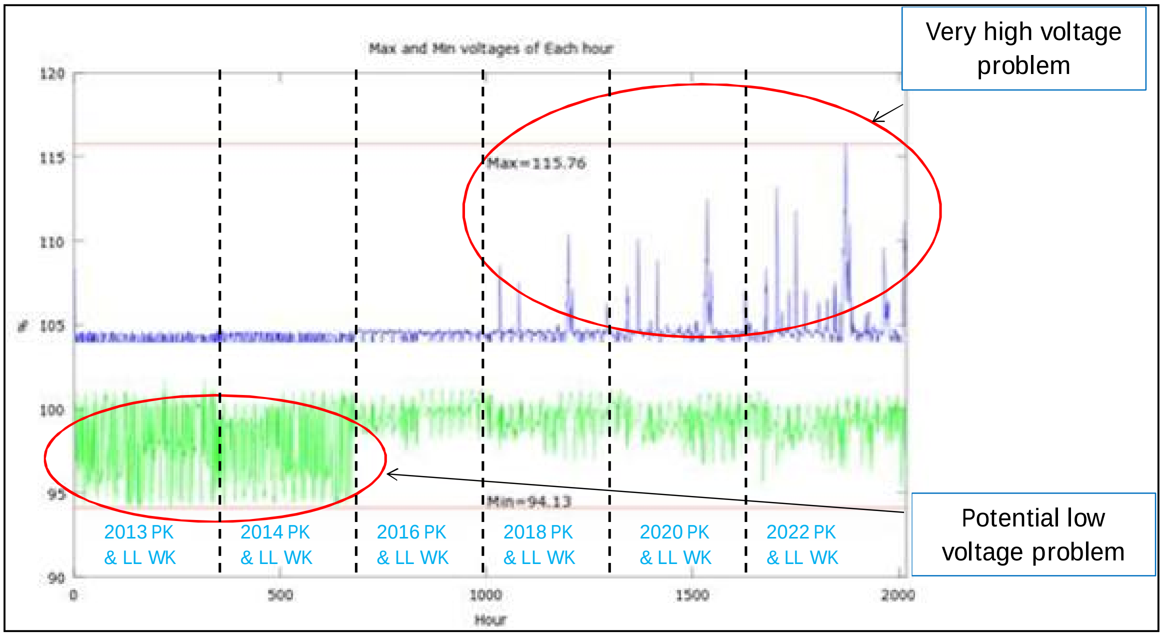


Figure 2-29. 2013 – 2022 Voltage Min & Max

Table 2-11. Recorded Voltages with Adjusted Voltage Schedule at Satala & Tafuna

Study Year	Alofau			Tula		
	Voltage (%)	Original Voltage (%)	Wind (kW)	Voltage (%)	Original Voltage (%)	Wind (kW)
2018	106.67	108.17	0	108.99	110.49	2346
2020	109.49	110.99	1711	111.09	112.59	1711
2022	112.54	114.04	2375	114.76	116.26%	2375

2.5.3.6 Conductor Upgrade/Dedicated

As stated previously one major contributor to the high voltage problem is feeder impedance, as such we analyzed two different options:

1. Building a new express/dedicated feeder to the wind generation.
2. Upgrading existing feeder 1 conductors.

There are pros and cons for each option. A new dedicated feeder would cause less customer impact because the new feeder could be constructed without removing the existing circuit from service. However, upgrading the existing circuit has the advantage of serving some demand, which offsets the influence of the renewable generation to increase feeder voltage levels. Voltage on a dedicated feeder would need to accommodate voltages as high as 108%, but without demand customers, this may be acceptable.

Table 2-1 below shows the conductors required for each of the two options to ensure voltages are below 108%.

Table 2-1. Conductor Upgrades/Dedicated Options

Study Year	Alofau			Tula		
	Dedicated OH Feeder Conductor	Upgraded Feeder Conductor	Wind (kW)	Dedicated OH Feeder Conductor	Upgraded Feeder Conductor	Wind (kW)
2018	477 ACSR (15 miles)	350 AL Cable (replace existing #4/0) & 4/0 ACSR OH (replace existing 2/0)	0	477 ACSR (15 miles)	350 AL Cable (replace existing #4/0) & 4/0 ACSR OH (replace existing 2/0)	2346
2020	556 ACSR (15 miles)	350 AL Cable (replace existing #4/0)	1711	556 ACSR (15 miles)	350 AL Cable (replace existing #4/0)	1711
2022	636 ACSR (15 miles)	1000 AL Cable (replace existing #4/0) & 4/0 ACSR OH (replace existing 2/0)	2375	636 ACSR (15 miles)	1000 AL Cable (replace existing #4/0) & 4/0 ACSR OH (replace existing 2/0)	2375

2.5.3.7 Wind Curtailment

Another possible mitigation, to maintain voltage levels below 106%, was to curtail the wind power injection to a combined (Tula and Alofau) maximum of 1.9 MW. This question boils down to how much wind energy would be wasted or unused. Table 2-12 below provides insight as to the amount of potential wasted energy through curtailment.

Table 2-12. Energy Lost for Curtailing Wind

Study Year	Energy Curtailed (kWh)	Time Over 1.9 MW (% of 2 Wks)
2018	446 (Tula)	0.6
2020	4764 (Tula & Alofau)	3.0
2022	19922 (Tula & Alofau)	7.5

2.6 Feeder Level Assessment

This section of the report provides a graphical overview of the feeder level performance over the 10 year period of study.

2.6.1 Feeder Voltage Results

Lower voltages on Tafuna's feeders were a concern reaching levels below 95%, however within acceptable levels. Voltages at all feeders stayed within standard levels until 2022 when feeder 6 registered voltages above 109%. The overvoltage occurred after wind generation penetration on this feeder, increased from 2.3MW in 2020 to 5.3 MW in 2022.

Voltage on Satala's feeders on the contrary, stayed at reasonable minimum and maximum ranges throughout the study period except on feeder 1. Voltages on Feeder 1, was above 110% levels in 2018, 2020 and 2022. In 2018, 3 MW wind generation was integrated to feeder 1 and it increased to 6 MW in 2020.

Overall the distribution system experienced overvoltages after 5.3 MW of wind generation and 7.3 MW solar PV are integrated to the ASPA system. See Figure 2-30 and Figure 2-31for voltage details.

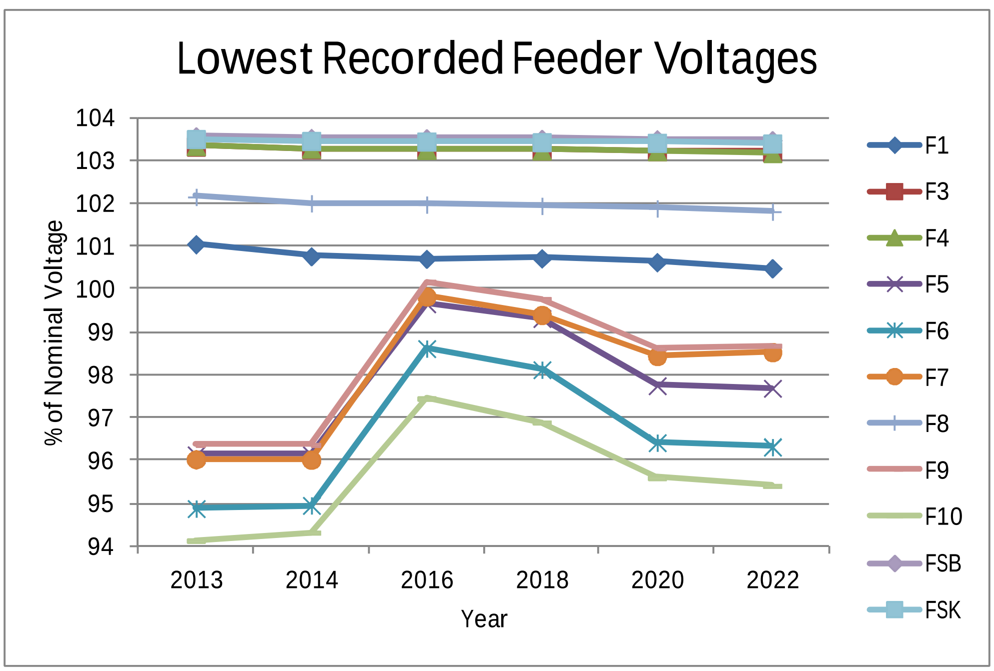


Figure 2-30. Lowest Voltages

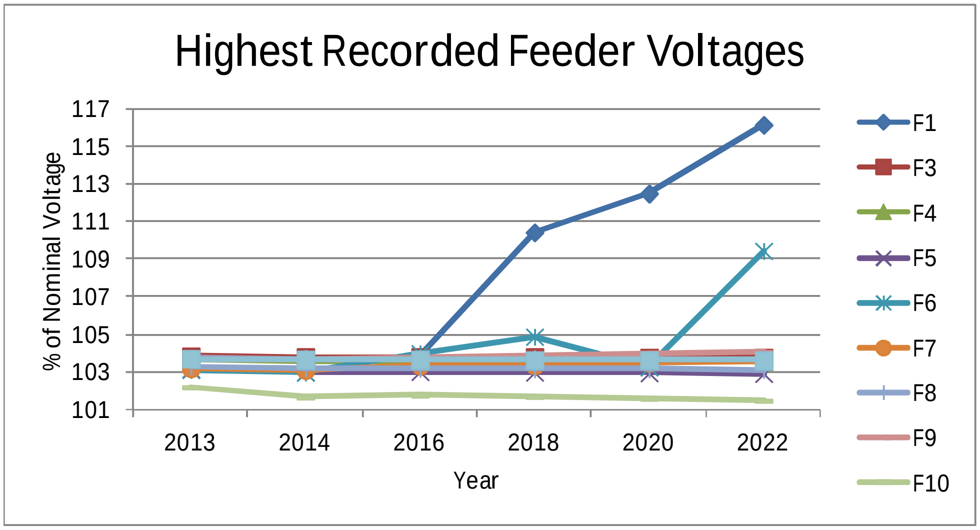


Figure 2-31. Highest Voltages

2.6.2 Feeder Thermal Results

No thermal capacity concerns were identified. The maximum loading condition were observed on feeder 1, it reached 80% loading factor in 2022 when 6 MW wind generation were added toward the end of this feeder. See Figure 2-32, below. It is due to increased renewable generation on feeder 1 which reached 4,750 kW of effective wind generation. See Figure 2-33 for details of renewable integration per feeder.

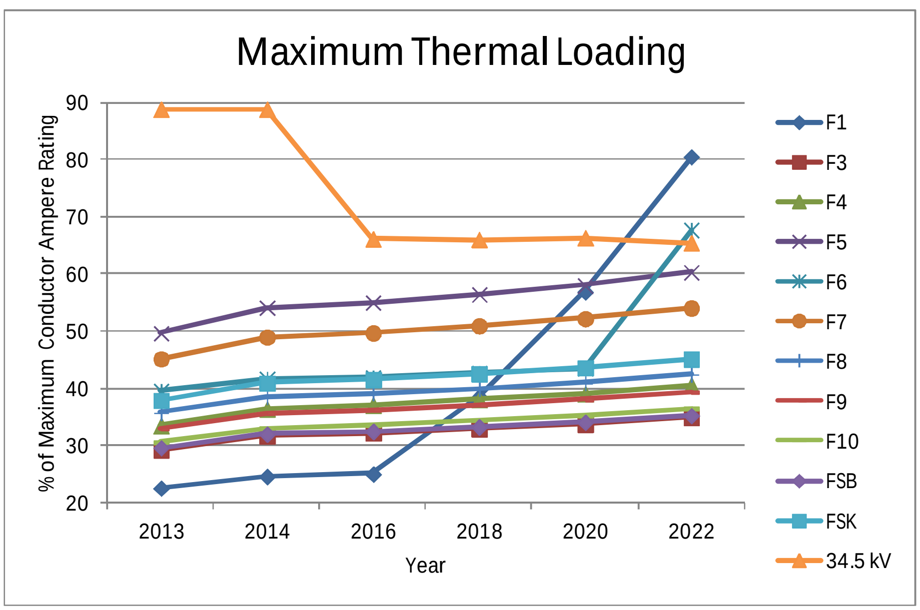


Figure 2-32. Thermal Loading

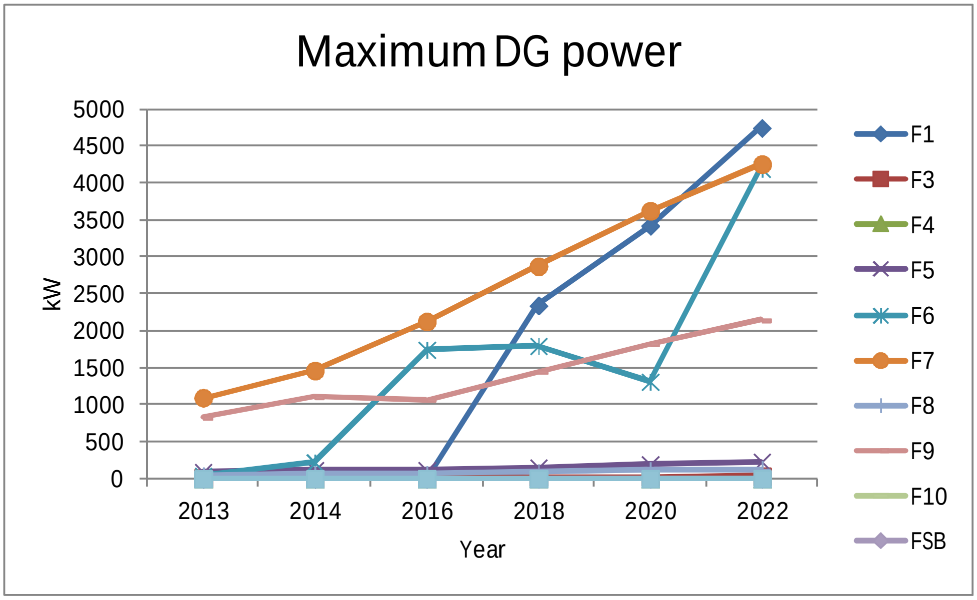


Figure 2-33. Maximum Distributed Generation Power Output

2.7 Conclusions and Recommendations

Our analyses indicated that there were no thermal overloads through the 10-year period studied, out to 2022. However, low and high voltage problems were indentified, some in the near term and some in future years.

The low voltage problems were confined to the Tafuna region, on feeders 10 and 6, in the 2013 – 2014 period. Fortunately, these low voltages can be resolved by a 104% scheduled voltage at the Tafuna and Satala units.

For the 2016-2022 period, voltages above 106% on the 13.2 kV system were observed, and worsen further into the future as more renewables are added to the system. The expected future wind generation at the remote end of feeder 1 was the primary cause for these future high voltages.

Suggested mitigation options include the following:

1. Reduce scheduled voltage at Satala and Tafuna beginning in 2016.

2. Add smart power factor correction capabilities, such as controllable capacitor banks or , dynamic VAR devices, that vary reactive power support as necessary.

3. Install most of the wind capacity at Aoloau, rather than at Tula or Alofau.

4. Curtail or store excess wind that causes high voltages. Storage requires an energy storage mechanism, such as a battery or a flywheel.

5. Implement a smart control system capable of monitoring, controlling and managing in real time: demand (load shedding), network (system availability) and generation (excess management).

Please note that this study did not include mitigation evaluation. Such a follow-up study would include CapEx, OpEx and quantification of overall system benefits.

2.8 Recommendations for Future System Impact Study

As this study is considered a feasibility study, we recommend once more details are known of generator specifications, geographical locations and capacities a System Impact Study (SIS) should be performed to find the optimal solutions and system configurations. The SIS should consider at a minimum the following items:

- Determine definite geographical locations of wind and solar PV and the manufacturer's selection along with accurate machine specifications.

- Determine optimal the solution for the high voltage problem based on techno-economical evaluation that considers Capex, Opex and system benefits.

Run 8760 hours steady state analysis for each year of study to cover all potential impacts.

Section

3

Dynamic Stability Analysis

3.1 Introduction

The intermittent nature of wind and solar irradiance often leads to abrupt changes in renewable generation output. This is in contrast to traditional generation sources, which are dispatchable and more easily controlled.

As a result, power systems experience real power variations, which often fluctuate in the opposite direction from what is necessary to serve system demands at a given moment. Diesel generators, the dispatchable generation available at ASPA, are then challenged to correct the load and resource mismatch, to regulate system voltages and frequency.

The simulation tools used to evaluate system reliability include two powerful types, both used in this study. The first is power flow simulation, which focuses on steady-state system conditions. In steady-state, there are only small system adjustments occurring, so time elements can be eliminated from the evaluation. The section 2 of this report was Siemens PTI's steady-state evaluation of ASPA's system.

The second study type is dynamic stability analysis, sometimes referred to as *dynamic analysis* or *stability analysis*, and is the topic of this section. Dynamic analyses have a time element in each simulation, so impacts through a transition from one steady-state condition to another steady-state condition can be evaluated.

Dynamic stability covers transient voltages and transient frequency analysis.

3.2 Analysis Assumptions and Limitations

The following items describe the dynamic study assumptions and limitations:

- All seven Satala generators and all three Tafuna generators had identical generator models. There was some variation in MW rating among the Satala units, but the generator model primarily provides the software with generator inertia and internal impedance as inputs, which are both scalable parameters, based on each unit's MW rating. Therefore this assumption at Satala and Tafuna should have introduced negligible inaccuracies.

- Each diesel unit's excitation model, either at Satala or Tafuna, was the same.

- Each diesel unit's governor model, either at Satala or Tafuna, was the same.

- The excitation system model used for each diesel unit is known as *ESAC5A*, with a template in the PSS®E model library utilized by PSS®SINCAL. The parameters for each unit were generic, typical values for diesel applications.

- The governor model used for each diesel unit is identified as *TGOV1*, also in our software library. All model parameters represented typical diesel applications.
- All photovoltaic models included typical parameters with no reactive power capability and no onsite VAR compensation.
- All wind models are presumed to be Type 1[1], with no reactive power capability and no onsite VAR compensation.
- All renewable power generation output is presumed to remain constant through a simulated transition period.
- With ASPA's system, spinning reserves are provided via excess on-line generation at Satala and Tafuna. For example, if a Tafuna unit with a 2 MW capacity was only generating 1 MW, the other available MW would be considered spinning reserve. Spinning reserve levels had to be estimated in this dynamic study, with our estimate being that we modeled less spinning reserve than ASPA allocates in real-time operation. This creates conservative dynamic results.

3.3 Scenarios Definition

The following scenarios simulated extreme system events and contingencies, and were the basis to evaluate the ability of the ASPA system to withstand prospective system transitions. Each scenario was applied to a 2014 case and a 2022 case.

Table 3-1 summarizes simulated pre-contingency conditions, and the contingency event for the four scenarios studied.

Figure 3-1, shows system locations where voltage were tested after applying contingencies scenarios.

[1] Wind Turbine Type 1: Induction generator with fixed rotor resistance. It operates at fixed real power with the unit supplying real power and consuming reactive power. It has no direct voltage control

Table 3-1 Scenario Definition – System Status

Scenario	System conditions before contingency	2014	2022
Scenario 1	Load (peak) (MW)	24.22	26.69
	PV(MW)	1.86	5.15
	Wind(MW)	0.07	2.75
	Renewable Generation	8.0%	29.6%
	Contingency	Loss of renewable generation (Ramping down) to 0%	
Scenario 2	Load (peak) (MW)	24.22	26.69
	PV(MW)	3.9	4.86
	Wind(MW)	0.3	5.09
	Renewable Generation	17.3%	37.3%
	Contingency	Loss of load (3-Ph fault at feeder 5)	
Scenario 3	Load (peak) (MW)	15.43	16.94
	PV(MW)	1.86	5.15
	Wind(MW)	0.07	2.75
	Renewable Generation	12.5%	46.6%
	Contingency	Renewable generation increase (Ramping up) to 27.2%	
Scenario 4	Load (peak) (MW)	15.43	16.94
	PV(MW)	3.9	4.86
	Wind(MW)	0.3	5.09
	Renewable Generation	27.2%	58.7%
	Contingency	Loss of load (3-Ph fault at feeder 5)	

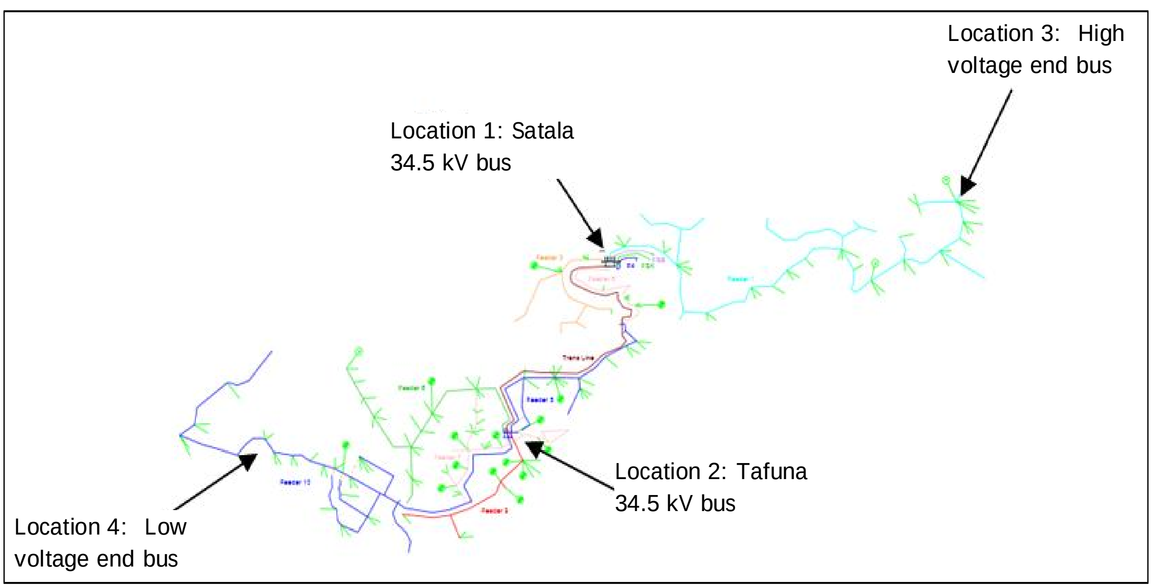


Figure 3-1. Transient Voltage Testing Locations

3.4 Scenario Results

Discussed below are the results of these simulations, first for near-term conditions and second for long-term future conditions. A key performance indicator in these simulations is the level of spinning reserves at Satala and Tafuna. Therefore, those levels are summarized below in Table 3-2 and Table 3-3.

Table 3-2. 2014 Real and Reactive Power Reserve at Satala and Tafuna.

Scenario	2014	
	MW	MVAR
Scenario 1	13	3
Scenario 2	19	4
Scenario 3	7	3
Scenario 4	15	5

Table 3-3. 2022 Combined Satala and Tafuna Reserves

Scenario	2022	
	MW	MVAR
Scenario 1	16	1
Scenario 2	18	1
Scenario 3	12	5
Scenario 4	25	6

3.4.1 System Response: 2014

The ASPA system was stable, for both transient voltage and transient frequency for 2014 scenarios.

Table 3-4 summarizes post event system status. 2014 transient voltage and frequency are all within IEEE 1547[2] guidelines.

Table 3-4. Transient system conditions

	2014	2022
Scen-1	Stable	Stable, UFLS
Scen-2	Stable	Stable, TOV
Scen-3	Stable	Stable, TOF
Scen-4	Stable	Stable, TOV

3.4.2 System Response: 2022 Scenario 1

Our Scenario 1 results for 2022 were twofold. First, without mitigation measures, Scenario 1 settled at a frequency unacceptably below 60 Hz. See Table 3-5

[2] ASPA uses a less stringent voltage and frequency guidelines than those in IEEE 1547.

Table 3-5. Scenario 1 definition

Scenario	System conditions before contingency	2014	2022
Scenario 1	Load (peak) (MW)	24.22	26.69
	PV(MW)	1.86	5.15
	Wind(MW)	0.07	2.75
	Renewable Generation	8.0%	29.6%
	Contingency	Loss of renewable generation (Ramping down) to 0%	

Figure 3-2 captures our system frequency compared to the applicable IEEE 1547 frequency criterion. The blue trace was system frequency, and the red trace represented minimum IEEE 1547 frequency. The blue trace needed to settle above the red trace to be acceptable.

So, the overall conclusion related to Scenario 1, in 2022, is that mitigation was required. Below two acceptable options were simulated. All voltages in Scenario 1 were within criteria.

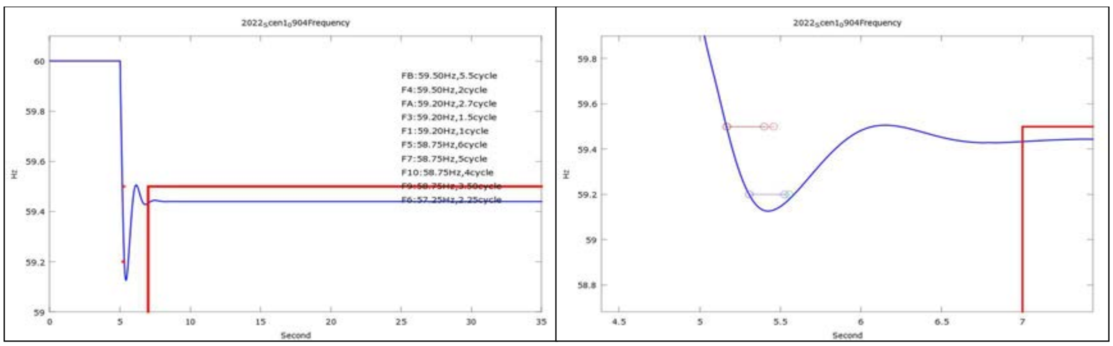


Figure 3-2. 2022 Scenario 1, System Frequency

ASPA does have UFLS deployed throughout its system, and intends to continue to rely on UFLS into the future. By modeling the actions of the UFLS deployed on feeder 4, our Scenario 1 results were acceptable, since frequency settled within IEEE 1547 frequency limits. Figure 3-3 demonstrates the resultant frequency by shedding feeder 4 via a UFLS trip action. ASPA's UFLS settings are detailed in Table 3-6.

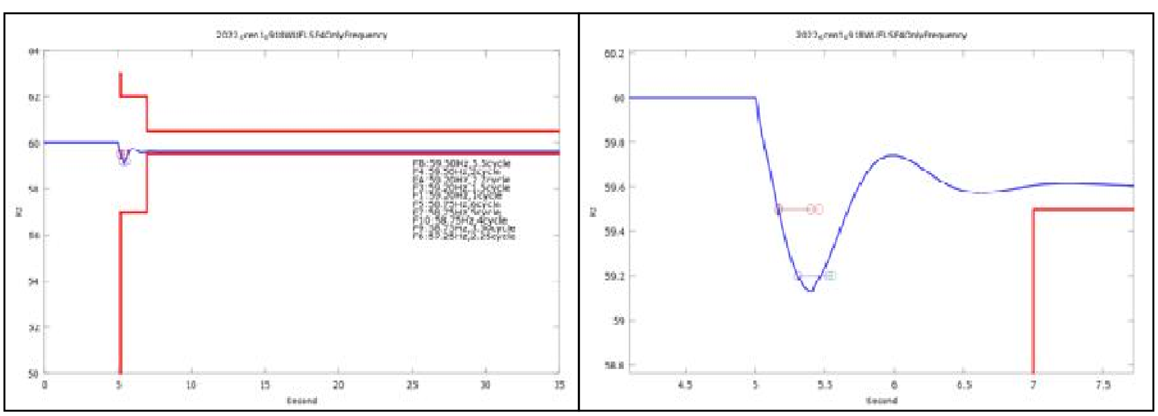


Figure 3-3. 2022 Scenario 1, Shedding Feeder 4

Table 3-6. ASPA Under Frequency Settings

Satala	U/F Setting	
	Hz	Cycles
F1	59.2	1
F3	59.2	1.5
F4	59.2	2
F8	Disabled	
FA	59.2	2.7
FB	59.2	5.5

Tafuna	U/F Setting	
	Hz	Cycles
F5	58.75	6
F6	57.25	2.25
F7	58.75	5
F9	58.75	3.5
F10	58.75	4
F11	58.75	7

The above trip points will need to be reevaluated as new renewable resources are added to the ASPA system.

The second acceptable mitigation measure included a higher level of spinning reserves. An assessment was completed wherein all Satala and Tafuna units were on-line. There will be an economic impact for this strategy; however, the results were successful, as shown in

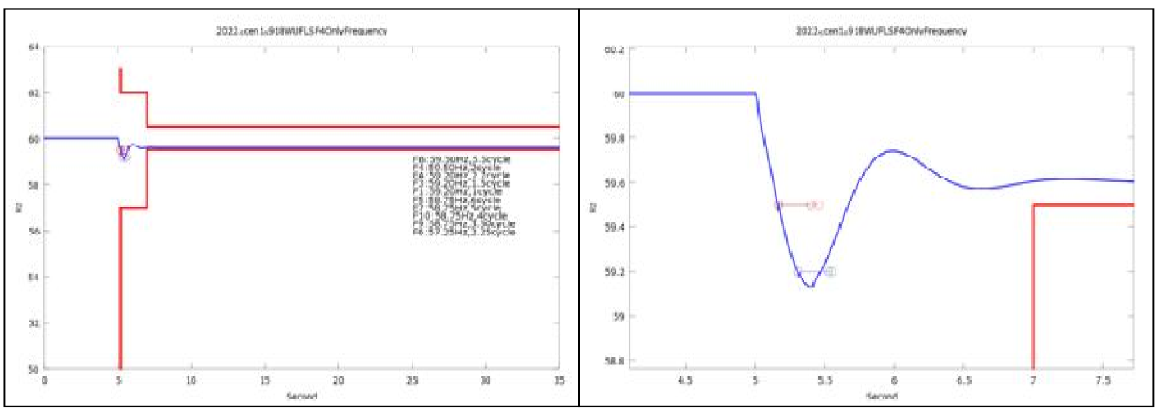


Figure 3-4. 2022 Scenario1, Increasing spinning reserve (all 10 units are on)

3.4.3 System Response: 2022 Scenario 2

In Scenario 2, all frequency results were acceptable. However, there were high voltages encountered on feeder 1. The findings for Scenario 2 (see Table 3-7. Scenario 2 definition) , confirm the findings in the Steady-state evaluation, discussed previously, without any addition voltage constraints.

Figure 3-5, below, shows system voltages through this simulation. The red indicates IEEE 1547 voltage limits. Each of the other traces should remain between the two red traces.

Table 3-7. Scenario 2 definition

Scenario	System conditions before contingency	2014	2022
Scenario 2	Load (peak) (MW)	24.22	26.69
	PV(MW)	3.9	4.86
	Wind(MW)	0.3	5.09
	Renewable Generation	17.3%	37.3%
	Contingency	Loss of load (3-Ph fault at feeder 5)	

The green trace was the system's high voltage measured at location 3, denoted in Figure 3-1. The dark blue trace was the system's low voltage measured at location 4. Except for the momentary occurrence of the system's high voltage exceeding IEEE limits at the six-second point, monitored voltages returned to pre-disturbance levels after roughly seven seconds, or two seconds after the disturbance was applied.

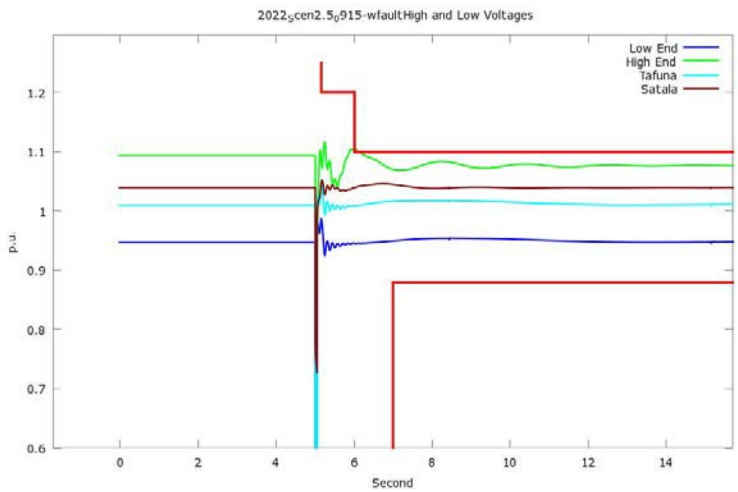


Figure 3-5. 2022 System Voltage Spectrum

3.4.4 System Response: 2022 Scenario 3

An over generation condition was created in this scenario by suddenly increasing renewable generation output. Although there were no voltage problems identified in Scenario 3 (see Table 3-8. Scenario 3 definition), Figure 3-6 depicts the frequency concern that was identified. The recovered frequency stabilized at around 60.65 Hz, which is within 2% ASPA's over-frequency limit.

This simulation behaved as it did because of the generic governor control modeled at Satala and Tafuna, including the governor droop. This simulation could be improved if a more precise model were available.

Table 3-8. Scenario 3 definition

Scenario	System conditions before contingency	2014	2022
Scenario 3	Load (peak) (MW)	15.43	16.94
	PV(MW)	1.86	5.15
	Wind(MW)	0.07	2.75
	Renewable Generation	12.5%	46.6%
	Contingency	Renewable generation increase (Ramping up) to 27.2%	

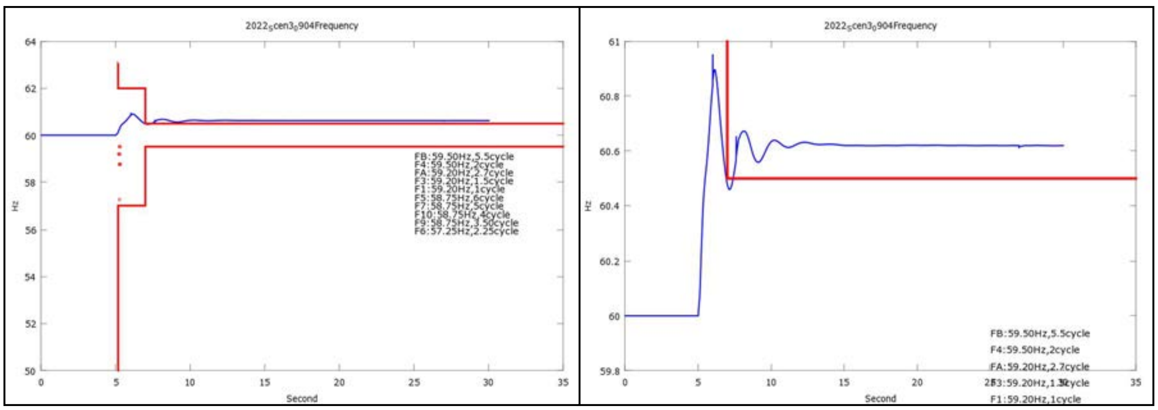


Figure 3-6. System Frequency in Year 2022

3.4.5 System Response: 2022 Scenario 4

Scenario 4 (see Table 3-9) resulted in acceptable frequency behavior, but voltages were a concern. As with Scenario 2, location 3, as denoted by the green trace below, was momentarily above the limits of IEEE 1547. Scenario 4 also confirmed this study's steady-state results.

Starting from a 59% renewable generation integration level, a sudden loss of load on feeder 5 was simulated. Voltages above 116 % were observed. Recall that this study's steady state outcome was that high voltages were associated with wind generation above 1900 kW.

Table 3-9. Scenario 4 definition

Scenario	System conditions before contingency	2014	2022
Scenario 4	Load (peak) (MW)	15.43	16.94
	PV(MW)	3.9	4.86
	Wind(MW)	0.3	5.09
	Renewable Generation	27.2%	58.7%
	Contingency	Loss of load (3-Ph fault at feeder 5)	

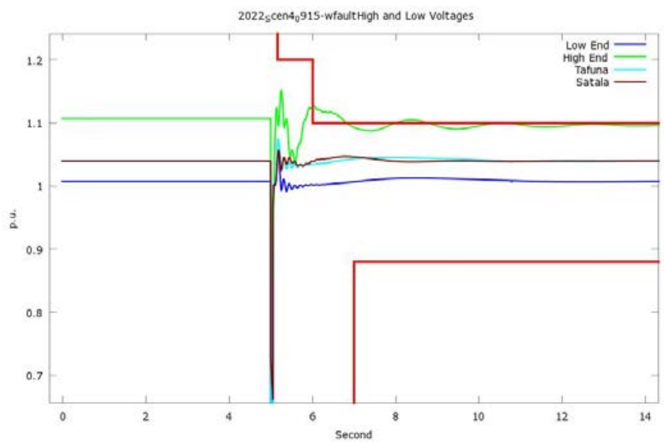


Figure 3-7. 2022 System Voltage Spectrum

3.5 Transient Over Voltages During Feeder Island Condition

Transient over-voltages (TOV) are short duration, rapid rises in voltage along electric lines. TOV is a concern because without appropriate mitigation, TOVs can damage utility or customer equipment. One possible source of TOV results when two conditions simultaneously apply: (a) the generation on a distribution circuit exceeds the load on that circuit and (b) the utility's protective equipment or procedures (such as switching to a backup circuit) isolates that circuit. Under these circumstances, more power is being generated than can be absorbed by loads on that circuit, causing voltage to rise rapidly.

In order to prevent TOV during feeder island condition it is important the distributed generation is equipped with a protection scheme often called "anti-islanding" that can detect the feeder has islanded from the rest of the network and trip the associated distributed generation feeding the island within a short time.

According to the IEEE Std 1547a™-2014, the latest version of the standard, implementing the following distributed generation trip times provided in Table 3-10 and Table 3-11 below, should mitigate the risk of TOV caused by feeder island conditions.

Table 3-10. IEEE Std 1547a™-2014 - Interconnection system default response to abnormal voltages

Default settings[a]		
Voltage range (% of base voltage[b])	Clearing time (s)	Clearing time: adjustable up to and including (s)
$V < 45$	0.16	0.16
$45 \leq V < 60$	1	11
$60 \leq V < 88$	2	21
$110 < V < 120$	1	13
$V \geq 120$	0.16	0.16

[a] Under mutual agreement between the EPS and DR operators, other static or dynamic voltage and clearing time trip settings shall be permitted
[b] Base voltages are the nominal system voltages stated in ANSI C84.1-2011, Table 1.

Table 3-11. IEEE Std 1547a™-2014 - Interconnection system default response to abnormal frequencies

	Default settings		Ranges of adjustability	
Function	Frequency (Hz)	Clearing time (s)	Frequency (Hz)	Clearing time (s) adjustable up to and including
UF1	< 57	0.16	56 – 60	10
UF2	< 59.5	2	56 – 60	300
OF1	> 60.5	2	60 – 64	300
OF2	> 62	0.16	60 – 64	10

3.6 Dynamic Recommendations

The dynamic analysis presented in this section disclosed potential operation challenges that ASPA system may encounter under certain levels of renewable integrations. To further qualify the impacts of intermittent solar PV and wind energy, the following technical evaluations are recommended to ASPA engineering team.

- UFLS relays are key devices to the further penetration of renewables on the ASPA system. The trip points for these relays need to be reevaluated and possibly recalibrated as more renewable are added. Without UFLS, the ASPA system will only be able to accommodate approximately a 24% renewable penetration level.

- Dynamic model refinement through generator testing is recommended. In this study, all generators (wind, solar PV and diesel unit) were represented by typical parameters and generic models, primarily due to the lack of accurate dynamic model information. The model provided to ASPA will also have typical parameters.. As all types of generation is added to the ASPA system, better models will be a critical tool for system studies.

- As the ASPA system adds renewable resources, and as these additions vary from the expansion studied herein, updated dynamic studies should be carried out. Variations may exist in terms of locations, technologies, output levels, or other pertinent ways.

- As renewable resources are added in the future, perform protection coordination studies to assure that there are no islanding scenarios possible during fault clearing events.

- Automated demand side management (DSM), linked to UFLS relays and ASPA's water pumps to regulate frequency should be considered. A further analysis is suggested as course of load shedding actions.

  – Should load shed is required, stopping water pump motor should be considered first,

  – If water pump motor is not in service, then apply feeder load shedding as set in the UFLS schedule defined by ASPA.

This would be an automated implementation of the load shedding scheme.

- Consider the implementation of a Virtual Power Plant (VPP), where plant output can be forecast, based on predicted system demand and renewable output. Such a system can help to bridge the optimal generation pattern identified earlier with the spinning reserve requirement also discussed.

- Ensure all distributed generation is has anti-islanding protection and the IEEE Std 1547a™-2014 trip settings.

Section

4

Short Circuit Analysis

The short circuit study was performed to determine the adequacy of the ASPA system circuit breakers by tabulating and comparing the short-circuit ratings of these devices with the available fault currents.

The short circuit calculation of the ASPA network captured a worst case scenario with all Satala and Tafuna generation units, solar PV and wind turbines online at their year 2023 capacities, as shown in Table 4-1 below.

Table 4-1. 2023 Generation Capacities for Short Circuit Study

Generator Name	Generation Capacity (MVA)	Energy Source
Tafuna	4.342	Diesel
Tafuna	4.342	Diesel
Tafuna	4.342	Diesel
Tafuna	4.342	Diesel
Tafuna	4.342	Diesel
Tafuna	4.342	Diesel
Tafuna	4.342	Diesel
Satala	2.5	Diesel
Satala	2.5	Diesel
Satala	6.5	Diesel
Satala	6.5	Diesel
Satala	6.5	Diesel
Satala	6.5	Diesel
Wind Aoloau	5.3	Wind
Wind Alofau	3	Wind
Wind Tula	3	Wind
F9 2013 PV1	2.12	Sun
F7 2013 PV2	1.59	Sun
F7 2013 PV1	0.911	Sun
Roof Top 1	0.471	Sun
Roof Top 2	0.471	Sun
Roof Top 3	0.471	Sun
Roof Top 4	0.471	Sun
Roof Top 5	0.471	Sun
Private PV F3	0.034	Sun
Private PV F10	0.003	Sun
Private PV F5	0.23	Sun
Private PV F6	0.11	Sun
Private PV F7	0.34	Sun
Private PV F8	0.134	Sun
Private PV F9	0.023	Sun

Three phase and single phase to ground short circuit values were calculated and compared against the circuit breaker ratings provided by ASPA.

In order to perform the short circuit study several assumptions based on common industry practice were made:

- Wind turbines are squirrel cage inductions generators therefore the short circuit contribution is typically five-six times the nominal current. As such, the sub transient reactance xd" equals the locked rotor reactance at 0.166 per unit (on machine MVA base).

- Solar PV inverters typically inject currents equal to nominal current during a short circuit event. Therefore the sub transient reactance xd" is set to 1.0 per unit.

- Tafuna and Satala generating units maintain a scheduled voltage of 104%.

- Short circuit contributions from induction machines were not included.

- All generators are modeled as connected directly to 13.2 kV system i.e. generator step up (GSU) transformers were not modeled. This is considered a conservative approach as modeling the GSU's would increase the system impedance and therefore lower the short circuit levels.

- For faults inside the high or low side windings of the 13.2/34.5 kV transformer the circuit breakers on either side of transformer do not open at the exactly the same instant.

- The circuit breaker ratings provided by ASPA are their interrupting ratings.

- All generators have fixed grounding with a Z0/Z1 ratio of 0.5 per unit and a R0/X0 ratio of 0.1 per unit.

- The 13.2/34.5 kV transformers have fixed grounds on the low side with a Z0/Z1 ratio of 1.0 per unit and a R0/X0 ratio of 0.1 per unit.

A summary of the results is provided below in Table 4-2. The results show that none of the circuit breakers modeled exceed their interrupting rating. The full version of the short circuit results are provided in Appendix B.

Table 4-2. Three 3 Phase and Single Phase to Ground Short Circuit Results on the ASPA System

		3 Phase Fault to Ground				1 Phase Fault to Ground			
Circuit Breaker	**Fault Location**	**Momentary Current Rms at Point of Fault ImomRms (kA)**	**Circuit Breaker Interrupting Rating Ir (kA)**	**Interrupting Current Ic (kA)**	**Ic/Ir %**	**Momentary Current Rms at Point of Fault ImomRms (kA)**	**Circuit Breaker Interrupting Rating Ir (kA)**	**Interrupting Current Ic (kA)**	**Ic/Ir %**
Satala Area									
F1	Down Stream	14.41	40	10.79	26.98%	9.04	40	7.05	17.63%
F3	Down Stream	14.41	40	11.5	28.75%	9.04	40	7.04	17.60%
F4	Down Stream	14.41	40	11.5	28.75%	9.04	40	7.04	17.60%
FSK	Down Stream	14.41	40	11.5	28.75%	9.04	40	7.04	17.60%
FSB	Down Stream	14.41	40	11.5	28.75%	9.04	40	7.04	17.60%
F8	Down Stream	14.41	18	11.5	63.89%	9.04	18	7.04	39.11%
Satala New Generators (S1-S7)	Satala 13.2 kV bus	14.41	40	1.266	3.17%	9.04	40	0.63	1.58%
	Gen HV Windings	14.41	40	10.24	25.60%	9.04	40	2.86	7.15%
35 kV Tie Line Satala	34.5 kV bus	3.561	18	0.82	4.56%	0.07	18	0.08	0.44%
	HV winding of 13.2/34.5 kV XMFR	3.561	18	2.15	11.94%	0.07	18	0.08	0.44%
13.2 kV Tie Line Satala	13.2 kV bus	14.41	18	1.23	6.83%	9.04	18	0.54	3.00%
	LV winding of 13.2/34.5 kV XMFR	14.41	18	10.29	57.17%	9.04	18	4.25	23.61%
Tafuna Area									
F5	Down Stream	13.81	18	11.41	63.39%	13.25	18	10.88	60.44%
F6	Down Stream	13.81	18	10.75	59.72%	13.25	18	10.492	58.29%
F7	Down Stream	13.81	18	11.06	61.44%	13.25	18	10.38	57.67%
F9	Down Stream	13.81	25	11.16	44.64%	13.25	25	10.53	42.12%
F10	Down Stream	13.81	25	11.41	45.64%	13.25	25	10.88	43.52%
Tafuna Generation (T2-T6)	Tafuna 13.2 kV bus	13.81	25	1.78	7.12%	13.25	25	1.17	4.68%
	Gen HV Windings	13.81	25	9.63	38.52%	13.25	25	3.51	14.04%
35 kV Tie Line Tafuna	34.5 kV bus	3.56	18	0.79	4.39%	0.07	18	0.09	0.50%
	HV winding of 13.2/34.5 kV XMFR	3.56	18	2.17	12.06%	0.07	18	0.08	0.44%
13.2 kV Tie Line Tafuna	13.2 kV bus	13.81	18	1.26	7.00%	13.25	18	0.83	4.61%
	LV winding of 13.2/34.5 kV XMFR	13.81	18	10.15	56.39%	13.25	18	4.14	23.00%

Appendix

A

Homer – Annexes of Production Cost Modeling for the Electric Grid on Tutuila

Annex A: Production Cost Modeling Cases Summary (no Storage)

Annex B: Baseline Scenario System Summary reports

Annex A: Production Cost Modeling Cases Summary (no storage)

No.	Sensitivity case name	Year	Fuel price annual escalation	Fuel price ($/L)	Fuel price ($/gal)	Wind speed case	Average wind speed (m/s)	Tuna Load?	Average Island load (kWh/day)	Combined average load (kWh/day)	Combined average load (MW)	Storage ?	Improved forecasting ?	Installed wind (# turbines)	Wind turbine capacity (MW)	Installed solar (MW_{AC})
1	Baseline 1	2013	N/A	$1.00	$3.79	N/A	N/A	No	428604	428604	17.86	No	No	0	0.0	1.8
2	Baseline 2	2013	N/A	$1.00	$3.79	N/A	N/A	No	428604	428604	17.86	No	No	0	0.0	2.92
3	2014 Base	2014	Mid	$1.05	$3.97	High	6.2	Yes	432184	470584	19.61	No	No	1	0.3	3.9
4	2014 high fuel, high wind	2014	High	$1.10	$4.16	High	6.2	Yes	432184	470584	19.61	No	No	50	13.8	7.5
5	2014 high fuel, low wind	2014	High	$1.10	$4.16	Low	5.5	Yes	432184	470584	19.61	No	No	0	0.0	17.5
6	2014 low fuel, high wind	2014	Low	$1.00	$3.79	High	6.2	Yes	432184	470584	19.61	No	No	50	13.8	2.92
7	2014 low fuel, low wind	2014	Low	$1.00	$3.79	Low	5.5	Yes	432184	470584	19.61	No	No	0	0.0	15
8	2016 Base	2016	Mid	$1.16	$4.38	High	6.2	Yes	439277	477677	19.90	No	No	8	2.2	5.4
9	2016 high fuel, high wind	2016	High	$1.33	$5.04	High	6.2	Yes	439277	477677	19.90	No	No	60	16.5	17.5
10	2016 high fuel, low wind	2016	High	$1.33	$5.04	Low	5.5	Yes	439277	477677	19.90	No	No	30	8.3	20
11	2016 low fuel, high wind	2016	Low	$1.00	$3.79	High	6.2	Yes	439277	477677	19.90	No	No	50	13.8	2.92
12	2016 low fuel, low wind	2016	Low	$1.00	$3.79	Low	5.5	Yes	439277	477677	19.90	No	No	0	0.0	15
13	2018 Base	2018	Mid	$1.28	$4.83	High	6.2	Yes	450659	489059	20.38	No	No	19	5.2	7.3
14	2018 high fuel, high wind	2018	High	$1.61	$6.10	High	6.2	Yes	450659	489059	20.38	No	No	110	30.3	22.5
15	2018 high fuel, low wind	2018	High	$1.61	$6.10	Low	5.5	Yes	450659	489059	20.38	No	No	50	13.8	30
16	2018 low fuel, high wind	2018	Low	$1.00	$3.79	High	6.2	Yes	450659	489059	20.38	No	No	50	13.8	2.92
17	2018 low fuel, low wind	2018	Low	$1.00	$3.79	Low	5.5	Yes	450659	489059	20.38	No	No	0	0.0	15
18	2020 Base	2020	Mid	$1.41	$5.33	High	6.2	Yes	462175	500575	20.86	No	No	30	8.3	9.2
19	2020 high fuel, high wind	2020	High	$1.95	$7.38	High	6.2	Yes	462175	500575	20.86	No	No	150	41.3	32.5
20	2020 high fuel, low wind	2020	High	$1.95	$7.38	Low	5.5	Yes	462175	500575	20.86	No	No	70	19.3	45
21	2020 low fuel, high wind	2020	Low	$1.00	$3.79	High	6.2	Yes	462175	500575	20.86	No	No	50	13.8	2.92
22	2020 low fuel, low wind	2020	Low	$1.00	$3.79	Low	5.5	Yes	462175	500575	20.86	No	No	0	0.0	15
23	2022 Base	2022	Mid	$1.55	$5.87	High	6.2	Yes	479309	517709	21.57	No	No	41	11.3	10.8
24	2022 high fuel, high wind	2022	High	$2.36	$8.93	High	6.2	Yes	479309	517709	21.57	No	No	180	49.5	42.5
25	2022 high fuel, low wind	2022	High	$2.36	$8.93	Low	5.5	Yes	479309	517709	21.57	No	No	100	27.5	52.5
26	2022 low fuel, high wind	2022	Low	$1.00	$3.79	High	6.2	Yes	479309	517709	21.57	No	No	50	13.8	5
27	2022 low fuel, low wind	2022	Low	$1.00	$3.79	Low	5.5	Yes	479309	517709	21.57	No	No	0	0.0	17.5

Cases 1 and 2 are Baseline cases used to calibrate the models and confirm high-level agreement with the model and real-world operation. The remaining cases are split into Base cases that represent ASPA's goals for renewable integration (Cases 3, 8, 13, 18, and 23) and the cases with installed wind and solar capacities that yield the lowest overall total cost of ownership each year (Cases 4-7, 9-12, 14, 17, and 19-22) for the various input extrinsic sensitivity variables (diesel cost, system load by year, and wind speed). In the lowest total cost of ownership cases, the solar array and wind turbine capacities are selected such that the system is the lowest cost (that is, these capacities are outputs of the analysis). The lowest total cost of ownership systems, however, typically include substantial variable renewable capacity (solar and/or wind) with varying curtailment necessary to achieve stable system operation. However, the effects that cause stability issues typically occur on a short time horizon, much shorter than the one-hour modeling used to guide the conceptual modeling at this stage. Therefore, additional stability and power modeling is currently being undertaken in the subsequent phases of this study led by Siemens PTI to determine the ability of the grid to stabilize the variability of these resources. The one year annual operational and dispatch data for each of the listed sensitivity cases was output for more detailed power flow and stability modeling in the PSS® SINCAL software.

Annex B: Baseline scenario system summary reports

The HOMER software system reports for each of the 6 baseline cases are attached (Cases 2, 3, 8, 13, 18, and 23).

HOMER models developed for the production cost modeling are also available for ASPA to extend the analysis using the HOMER software.

NOTE: These reports are based on the inputs provided and do not reflect data updates provided in Addendum A.

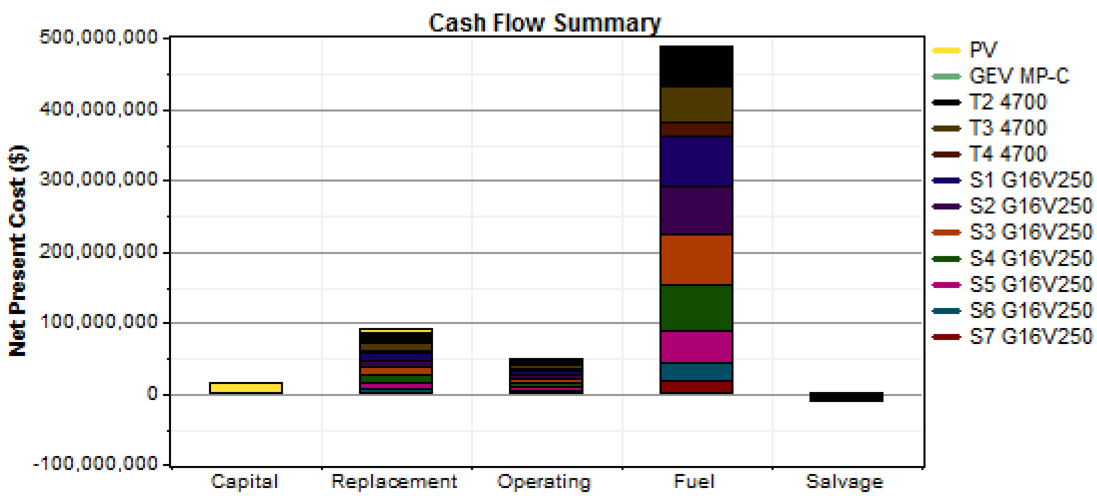
System Report - 03-2014 Base.hmr

System architecture

PV Array	3,900 kW
Wind turbine	1 GEV MP-C
T2 4700	3,800 kW
T3 4700	3,800 kW
T4 4700	3,800 kW
S1 G16V250	2,800 kW
S2 G16V250	2,800 kW
S3 G16V250	2,800 kW
S4 G16V250	2,800 kW
S5 G16V250	2,800 kW
S6 G16V250	2,800 kW
S7 G16V250	2,800 kW

Cost summary

Total net present cost	$ 635,936,000
Levelized cost of energy	$ 0.290/kWh
Operating cost	$ 48,562,832/yr



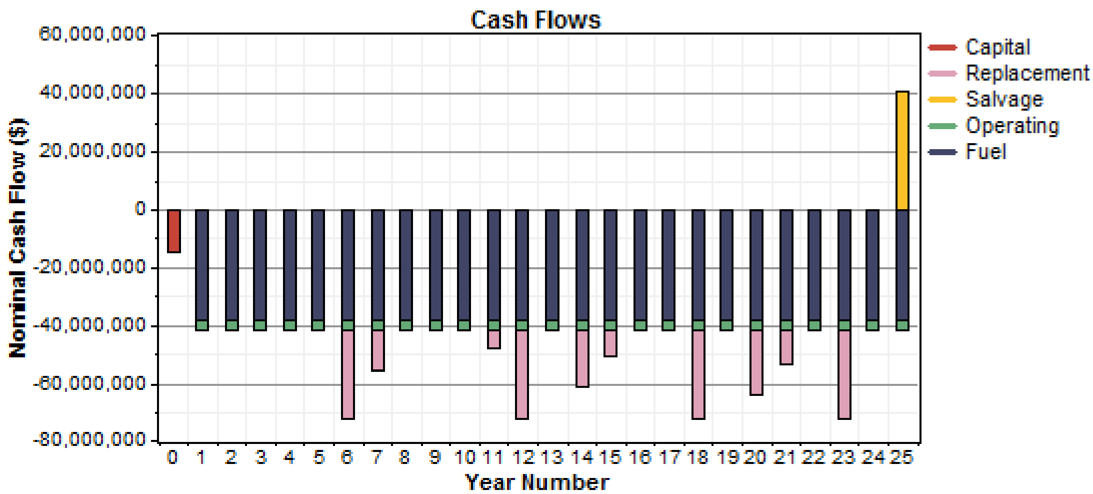
Net Present Costs

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($)	($)	($)	($)	($)	($)
PV	14,040,000	4,377,743	498,551	0	-2,453,479	16,462,812
GEV MP-C	1,100,000	367,194	210,925	0	-68,346	1,609,773
T2 4700	0	14,169,047	7,446,820	57,731,884	-1,097,891	78,249,848
T3 4700	0	11,031,870	6,387,603	49,216,472	-430,302	66,205,636
T4 4700	0	3,229,284	2,893,718	22,295,166	-527,696	27,890,482
S1 G16V250	0	10,664,818	5,487,130	68,604,208	-826,365	83,929,808
S2 G16V250	0	10,664,818	5,487,130	68,604,208	-826,365	83,929,808
S3 G16V250	0	10,664,818	5,487,130	68,595,320	-826,365	83,920,904
S4 G16V250	0	10,664,818	5,487,130	65,824,480	-826,365	81,150,072
S5 G16V250	0	8,033,992	4,487,421	45,138,788	-557,130	57,103,076
S6 G16V250	0	4,868,278	3,046,109	25,630,808	-757,724	32,787,472

S7 G16V250	0	2,534,511	2,241,832	18,200,870	-280,564	22,696,648
System	15,140,000	91,271,192	49,161,496	489,842,112	-9,478,595	635,936,192

Annualized Costs

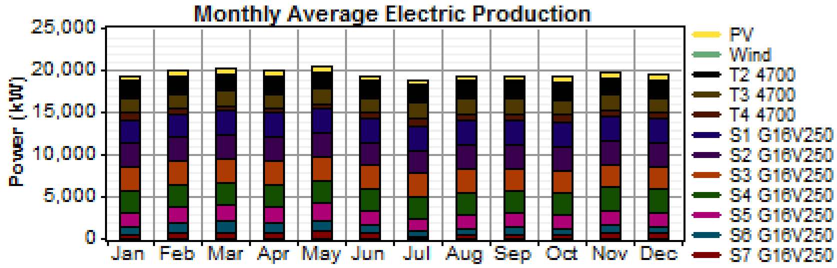
Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)
PV	1,098,303	342,456	39,000	0	-191,928	1,287,832
GEV MP-C	86,049	28,724	16,500	0	-5,347	125,927
T2 4700	0	1,108,398	582,540	4,516,176	-85,884	6,121,229
T3 4700	0	862,987	499,681	3,850,043	-33,661	5,179,050
T4 4700	0	252,616	226,366	1,744,078	-41,280	2,181,781
S1 G16V250	0	834,274	429,240	5,366,682	-64,644	6,565,553
S2 G16V250	0	834,274	429,240	5,366,682	-64,644	6,565,553
S3 G16V250	0	834,274	429,240	5,365,987	-64,644	6,564,857
S4 G16V250	0	834,274	429,240	5,149,233	-64,644	6,348,104
S5 G16V250	0	628,473	351,036	3,531,059	-43,582	4,466,986
S6 G16V250	0	380,829	238,287	2,005,014	-59,274	2,564,856
S7 G16V250	0	198,266	175,371	1,423,794	-21,948	1,775,484
System	1,184,353	7,139,846	3,845,742	38,318,740	-741,479	49,747,200



Electrical

Component	Production	Fraction
	(kWh/yr)	
PV array	5,424,170	3%
Wind turbine	581,621	0%
T2 4700	17,759,390	10%
T3 4700	15,133,195	9%
T4 4700	6,855,656	4%
S1 G16V250	24,528,000	14%
S2 G16V250	24,528,000	14%
S3 G16V250	24,524,110	14%
S4 G16V250	23,309,710	14%
S5 G16V250	15,250,988	9%

S6 G16V250	8,156,080	5%
S7 G16V250	5,712,084	3%
Total	171,763,008	100%



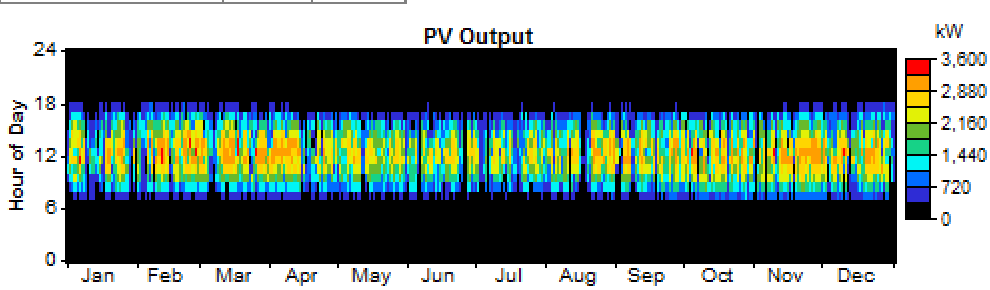
Load	Consumption	Fraction
	(kWh/yr)	
AC primary load	171,763,328	100%
Total	171,763,328	100%

Quantity	Value	Units
Excess electricity	1.57	kWh/yr
Unmet load	1.60	kWh/yr
Capacity shortage	0.00	kWh/yr
Renewable fraction	0.035	

PV

Quantity	Value	Units
Rated capacity	3,900	kW
Mean output	619	kW
Mean output	14,861	kWh/d
Capacity factor	15.9	%
Total production	5,424,170	kWh/yr

Quantity	Value	Units
Minimum output	0.00	kW
Maximum output	3,461	kW
PV penetration	3.16	%
Hours of operation	4,334	hr/yr
Levelized cost	0.237	$/kWh

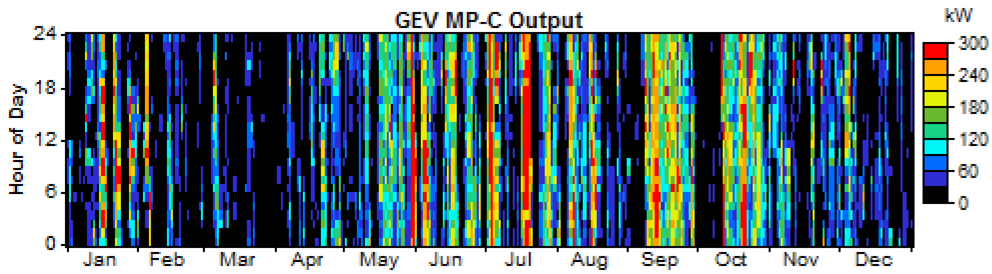


AC Wind Turbine: GEV MP-C

Variable	Value	Units
Total rated capacity	275	kW

Mean output	66.4	kW
Capacity factor	24.1	%
Total production	581,621	kWh/yr

Variable	Value	Units
Minimum output	0.00	kW
Maximum output	275	kW
Wind penetration	0.339	%
Hours of operation	7,120	hr/yr
Levelized cost	0.217	$/kWh

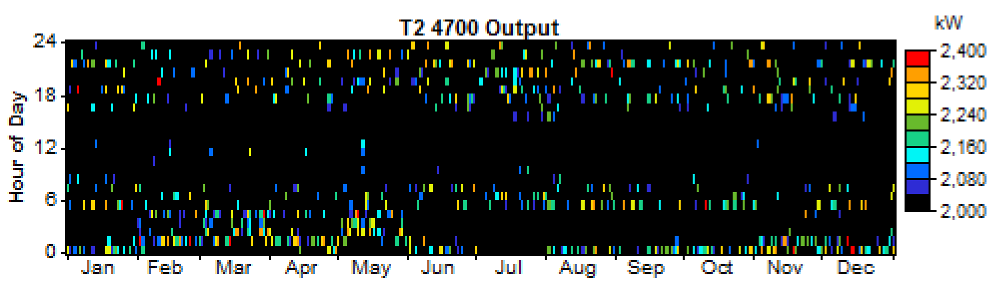


T2 4700

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	53.4	%
Fixed generation cost	253	$/hr
Marginal generation cost	0.237	$/kWhyr

Quantity	Value	Units
Electrical production	17,759,390	kWh/yr
Mean electrical output	2,027	kW
Min. electrical output	2,014	kW
Max. electrical output	2,381	kW

Quantity	Value	Units
Fuel consumption	4,301,118	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	42,323,000	kWh/yr
Mean electrical efficiency	42.0	%

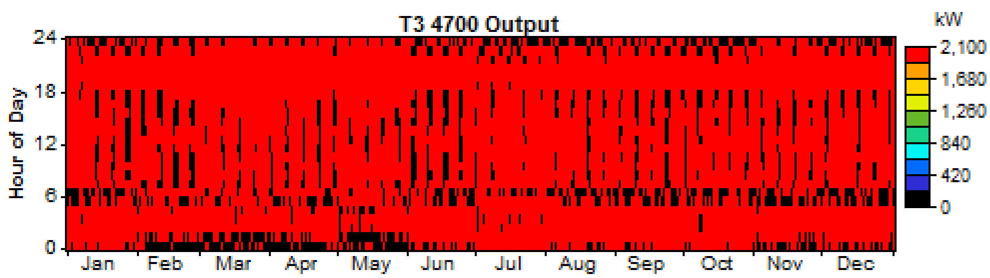


T3 4700

Quantity	Value	Units
Hours of operation	7,514	hr/yr
Number of starts	758	starts/yr
Operational life	6.65	yr
Capacity factor	45.5	%
Fixed generation cost	253	$/hr
Marginal generation cost	0.237	$/kWhyr

Quantity	Value	Units
Electrical production	15,133,195	kWh/yr
Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	3,666,706	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	36,080,388	kWh/yr
Mean electrical efficiency	41.9	%

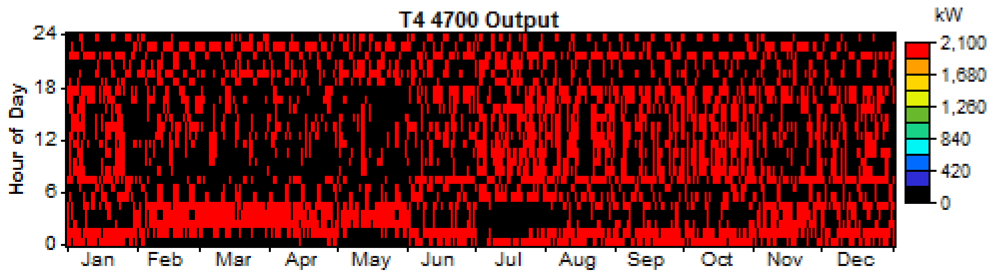


T4 4700

Quantity	Value	Units
Hours of operation	3,404	hr/yr
Number of starts	1,688	starts/yr
Operational life	14.7	yr
Capacity factor	20.6	%
Fixed generation cost	253	$/hr
Marginal generation cost	0.237	$/kWhyr

Quantity	Value	Units
Electrical production	6,855,656	kWh/yr
Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	1,661,026	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	16,344,495	kWh/yr
Mean electrical efficiency	41.9	%

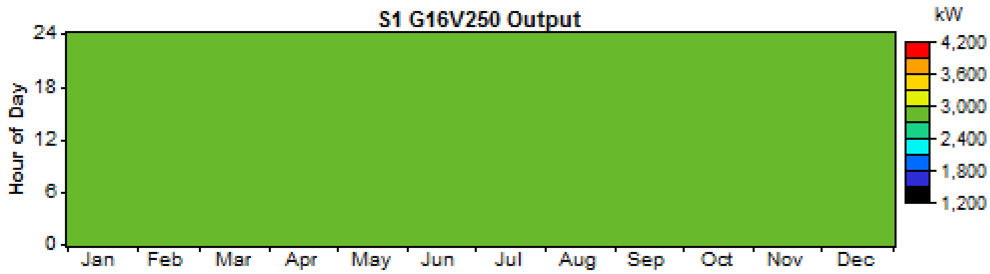


S1 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	100	%
Fixed generation cost	277	$/hr
Marginal generation cost	0.178	$/kWhyr

Quantity	Value	Units
Electrical production	24,528,000	kWh/yr
Mean electrical output	2,800	kW
Min. electrical output	2,800	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,111,123	L/yr
Specific fuel consumption	0.208	L/kWh
Fuel energy input	50,293,456	kWh/yr
Mean electrical efficiency	48.8	%



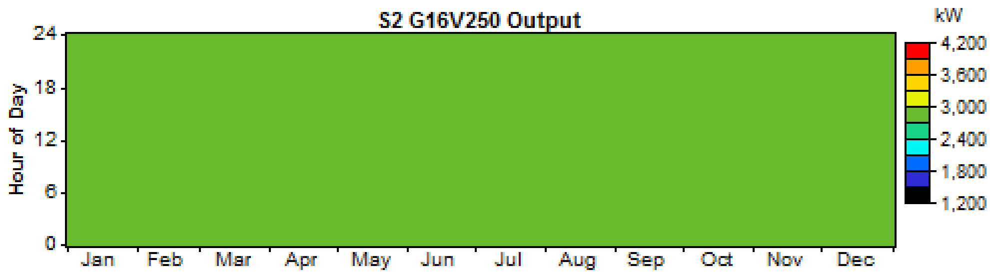
S2 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	100	%
Fixed generation cost	277	$/hr
Marginal generation cost	0.178	$/kWhyr

Quantity	Value	Units
Electrical production	24,528,000	kWh/yr

Mean electrical output	2,800	kW
Min. electrical output	2,800	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,111,123	L/yr
Specific fuel consumption	0.208	L/kWh
Fuel energy input	50,293,456	kWh/yr
Mean electrical efficiency	48.8	%

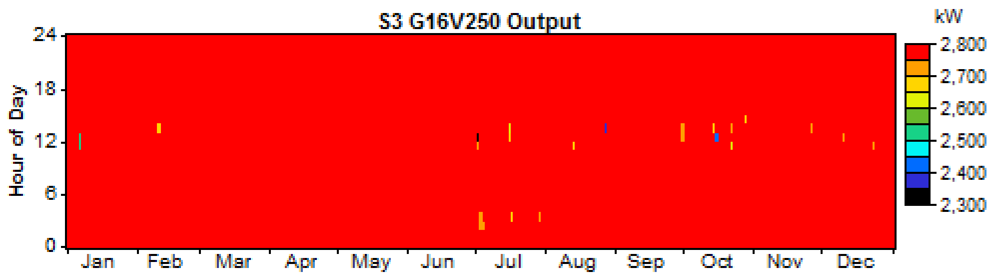


S3 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	100.0	%
Fixed generation cost	277	$/hr
Marginal generation cost	0.178	$/kWhyr

Quantity	Value	Units
Electrical production	24,524,110	kWh/yr
Mean electrical output	2,800	kW
Min. electrical output	2,317	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,110,461	L/yr
Specific fuel consumption	0.208	L/kWh
Fuel energy input	50,286,940	kWh/yr
Mean electrical efficiency	48.8	%



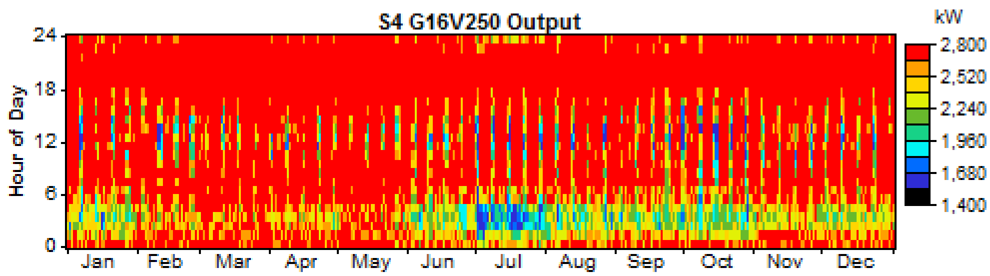
S4 G16V250

Quantity	Value	Units

Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	95.0	%
Fixed generation cost	277	$/hr
Marginal generation cost	0.178	$/kWhyr

Quantity	Value	Units
Electrical production	23,309,710	kWh/yr
Mean electrical output	2,661	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,904,029	L/yr
Specific fuel consumption	0.210	L/kWh
Fuel energy input	48,255,652	kWh/yr
Mean electrical efficiency	48.3	%

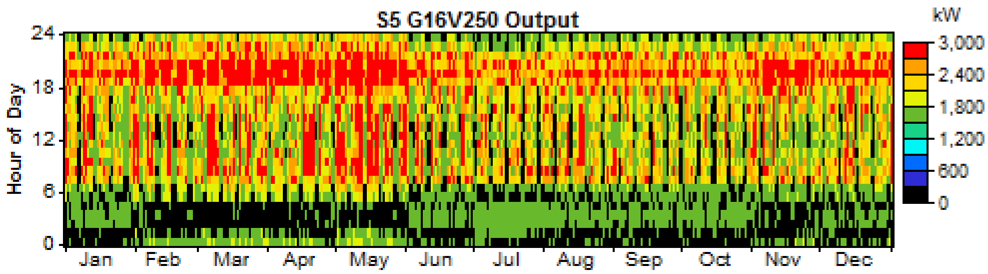


S5 G16V250

Quantity	Value	Units
Hours of operation	7,164	hr/yr
Number of starts	684	starts/yr
Operational life	6.98	yr
Capacity factor	62.2	%
Fixed generation cost	277	$/hr
Marginal generation cost	0.178	$/kWhyr

Quantity	Value	Units
Electrical production	15,250,988	kWh/yr
Mean electrical output	2,129	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	3,362,913	L/yr
Specific fuel consumption	0.221	L/kWh
Fuel energy input	33,091,062	kWh/yr
Mean electrical efficiency	46.1	%

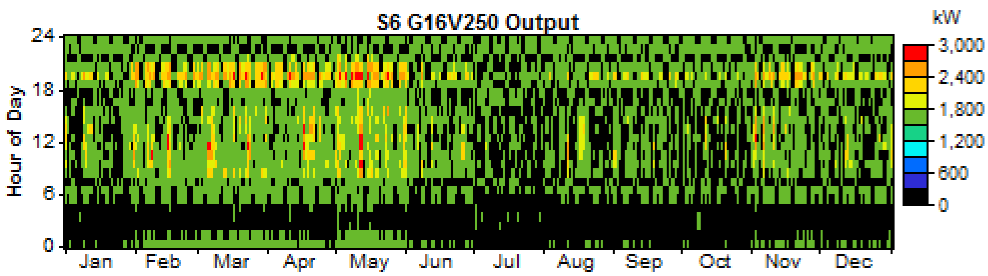


S6 G16V250

Quantity	Value	Units
Hours of operation	4,863	hr/yr
Number of starts	1,354	starts/yr
Operational life	10.3	yr
Capacity factor	33.3	%
Fixed generation cost	277	$/hr
Marginal generation cost	0.178	$/kWhyr

Quantity	Value	Units
Electrical production	8,156,080	kWh/yr
Mean electrical output	1,677	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	1,909,536	L/yr
Specific fuel consumption	0.234	L/kWh
Fuel energy input	18,789,838	kWh/yr
Mean electrical efficiency	43.4	%



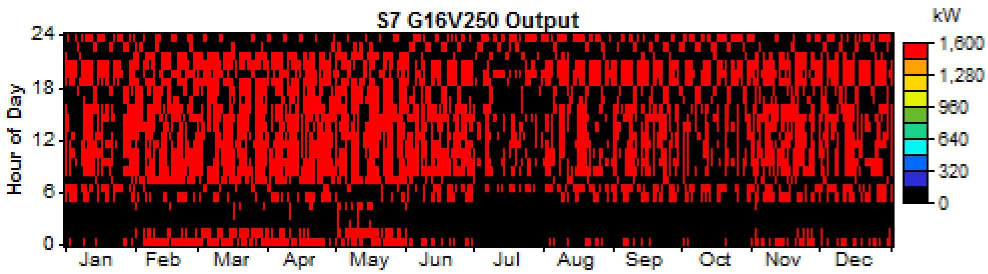
S7 G16V250

Quantity	Value	Units
Hours of operation	3,579	hr/yr
Number of starts	1,421	starts/yr
Operational life	14.0	yr
Capacity factor	23.3	%
Fixed generation cost	277	$/hr
Marginal generation cost	0.178	$/kWhyr

Quantity	Value	Units
Electrical production	5,712,084	kWh/yr

Mean electrical output	1,596	kW
Min. electrical output	1,596	kW
Max. electrical output	1,596	kW

Quantity	Value	Units
Fuel consumption	1,355,994	L/yr
Specific fuel consumption	0.237	L/kWh
Fuel energy input	13,342,981	kWh/yr
Mean electrical efficiency	42.8	%



Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	96,100,784
Carbon monoxide	237,211
Unburned hydocarbons	26,276
Particulate matter	17,882
Sulfur dioxide	192,987
Nitrogen oxides	2,116,654

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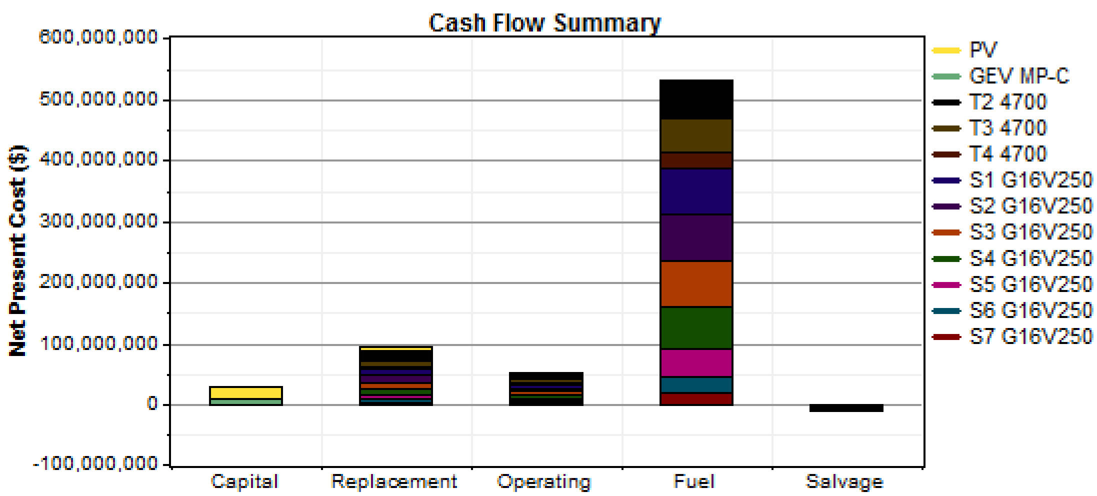
System architecture

PV Array	5,400 kW
Wind turbine	8 GEV MP-C
T2 4700	3,800 kW
T3 4700	3,800 kW
T4 4700	3,800 kW
S1 G16V250	2,800 kW
S2 G16V250	2,800 kW
S3 G16V250	2,800 kW
S4 G16V250	2,800 kW
S5 G16V250	2,800 kW
S6 G16V250	2,800 kW
S7 G16V250	2,800 kW

Cost summary

Total net present cost	$ 690,703,744
Levelized cost of energy	$ 0.310/kWh
Operating cost	$ 51,942,832/yr



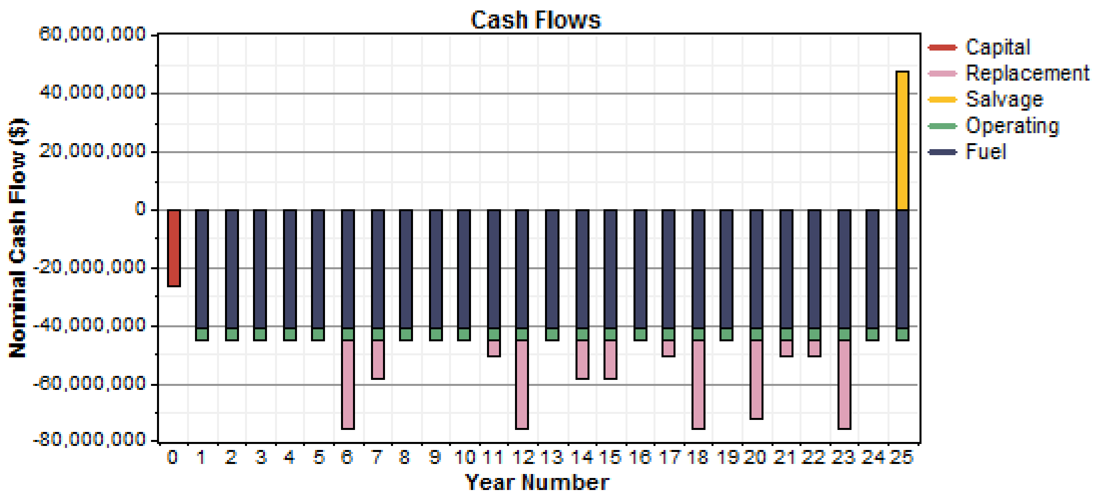
Net Present Costs

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($)	($)	($)	($)	($)	($)
PV	19,440,000	6,061,491	690,302	0	-3,397,125	22,794,670
GEV MP-C	7,260,000	2,423,477	949,165	0	-451,086	10,181,556
T2 4700	0	14,169,047	7,446,820	63,468,504	-1,097,891	83,986,472
T3 4700	0	11,081,423	6,430,107	54,639,924	-386,032	71,765,432
T4 4700	0	3,308,348	2,977,878	25,303,560	-440,042	31,149,742
S1 G16V250	0	10,664,818	5,487,130	75,660,648	-826,365	90,986,224
S2 G16V250	0	10,664,818	5,487,130	75,644,056	-826,365	90,969,640
S3 G16V250	0	10,664,818	5,487,130	74,904,688	-826,365	90,230,280
S4 G16V250	0	10,662,271	5,485,252	69,207,840	-828,364	84,527,000
S5 G16V250	0	8,051,380	4,501,201	47,119,792	-542,469	59,129,912
S6 G16V250	0	4,754,416	2,959,668	27,322,112	-849,690	34,186,512

S7 G16V250	0	2,219,987	1,928,012	17,263,080	-614,443	20,796,636
System	26,700,000	94,726,280	49,829,800	530,534,240	-11,086,238	690,703,936

Annualized Costs

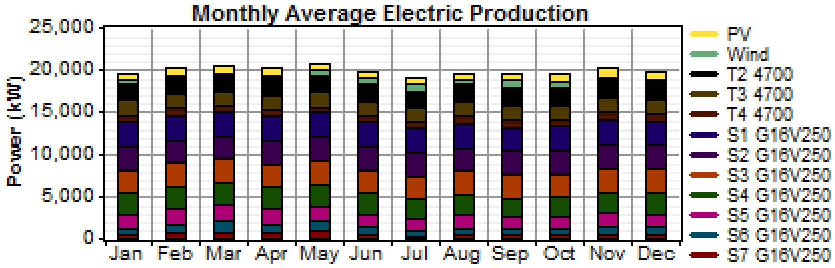
Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)
PV	1,520,727	474,171	54,000	0	-265,746	1,783,152
GEV MP-C	567,926	189,581	74,250	0	-35,287	796,470
T2 4700	0	1,108,398	582,540	4,964,933	-85,884	6,569,986
T3 4700	0	866,863	503,006	4,274,302	-30,198	5,613,974
T4 4700	0	258,801	232,950	1,979,414	-34,423	2,436,742
S1 G16V250	0	834,274	429,240	5,918,684	-64,644	7,117,554
S2 G16V250	0	834,274	429,240	5,917,386	-64,644	7,116,256
S3 G16V250	0	834,274	429,240	5,859,548	-64,644	7,058,419
S4 G16V250	0	834,074	429,093	5,413,902	-64,800	6,612,270
S5 G16V250	0	629,833	352,114	3,686,027	-42,436	4,625,539
S6 G16V250	0	371,922	231,525	2,137,319	-66,468	2,674,299
S7 G16V250	0	173,662	150,822	1,350,434	-48,066	1,626,853
System	2,088,653	7,410,126	3,898,022	41,501,952	-867,240	54,031,500



Electrical

Component	Production	Fraction
	(kWh/yr)	
PV array	7,510,388	4%
Wind turbines	4,652,969	3%
T2 4700	17,699,098	10%
T3 4700	15,233,895	9%
T4 4700	7,055,042	4%
S1 G16V250	24,528,000	14%
S2 G16V250	24,521,416	14%
S3 G16V250	24,227,616	14%
S4 G16V250	21,964,834	13%
S5 G16V250	14,178,315	8%

S6 G16V250	7,867,840	5%
S7 G16V250	4,912,488	3%
Total	174,351,904	100%



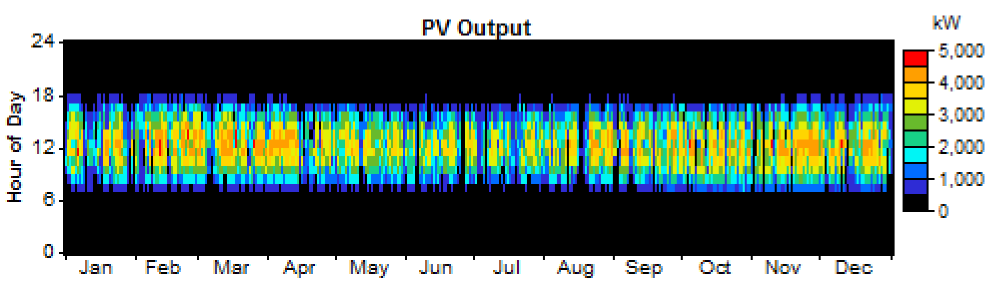
Load	Consumption	Fraction
	(kWh/yr)	
AC primary load	174,351,440	100%
Total	174,351,440	100%

Quantity	Value	Units
Excess electricity	1.40	kWh/yr
Unmet load	1.41	kWh/yr
Capacity shortage	0.00	kWh/yr
Renewable fraction	0.070	

PV

Quantity	Value	Units
Rated capacity	5,400	kW
Mean output	857	kW
Mean output	20,576	kWh/d
Capacity factor	15.9	%
Total production	7,510,388	kWh/yr

Quantity	Value	Units
Minimum output	0.00	kW
Maximum output	4,793	kW
PV penetration	4.31	%
Hours of operation	4,334	hr/yr
Levelized cost	0.237	$/kWh

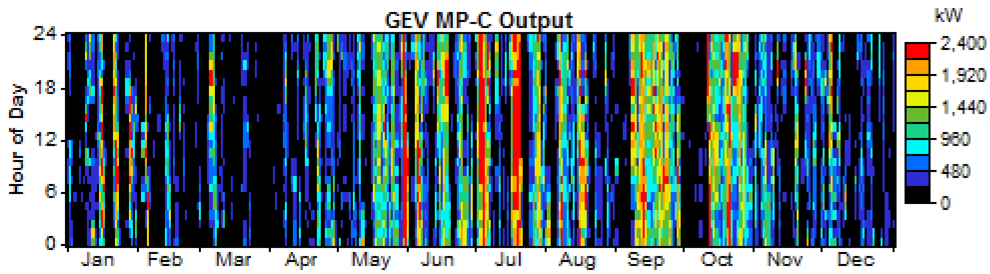


AC Wind Turbine: GEV MP-C

Variable	Value	Units
Total rated capacity	2,200	kW

Mean output	531	kW
Capacity factor	24.1	%
Total production	4,652,969	kWh/yr

Variable	Value	Units
Minimum output	0.00	kW
Maximum output	2,200	kW
Wind penetration	2.67	%
Hours of operation	7,120	hr/yr
Levelized cost	0.171	$/kWh

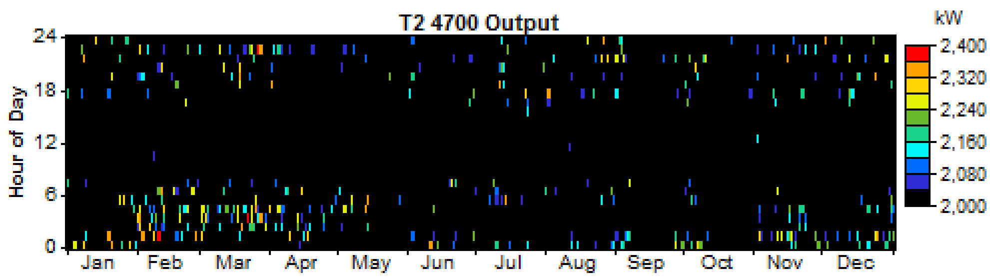


T2 4700

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	53.2	%
Fixed generation cost	256	$/hr
Marginal generation cost	0.262	$/kWhyr

Quantity	Value	Units
Electrical production	17,699,098	kWh/yr
Mean electrical output	2,020	kW
Min. electrical output	2,014	kW
Max. electrical output	2,376	kW

Quantity	Value	Units
Fuel consumption	4,287,505	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	42,189,048	kWh/yr
Mean electrical efficiency	42.0	%

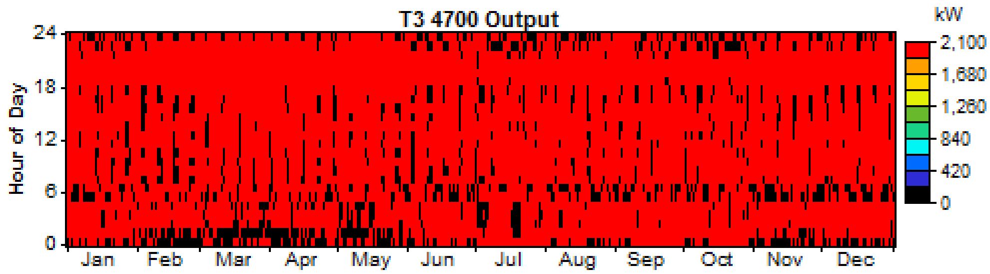


T3 4700

Quantity	Value	Units
Hours of operation	7,564	hr/yr
Number of starts	786	starts/yr
Operational life	6.61	yr
Capacity factor	45.8	%
Fixed generation cost	256	$/hr
Marginal generation cost	0.262	$/kWhyr

Quantity	Value	Units
Electrical production	15,233,895	kWh/yr
Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	3,691,106	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	36,320,484	kWh/yr
Mean electrical efficiency	41.9	%

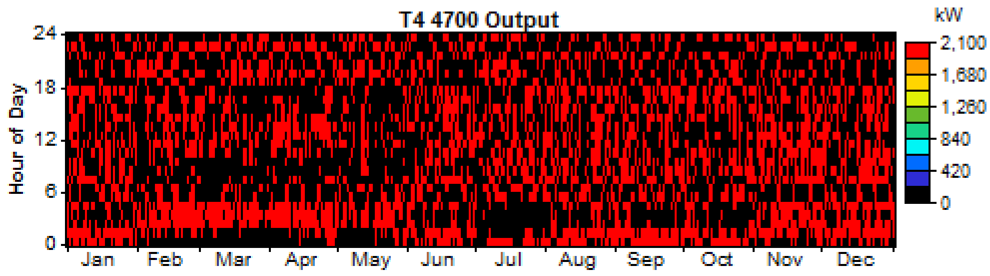


T4 4700

Quantity	Value	Units
Hours of operation	3,503	hr/yr
Number of starts	1,796	starts/yr
Operational life	14.3	yr
Capacity factor	21.2	%
Fixed generation cost	256	$/hr
Marginal generation cost	0.262	$/kWhyr

Quantity	Value	Units
Electrical production	7,055,042	kWh/yr
Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	1,709,338	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	16,819,886	kWh/yr
Mean electrical efficiency	41.9	%

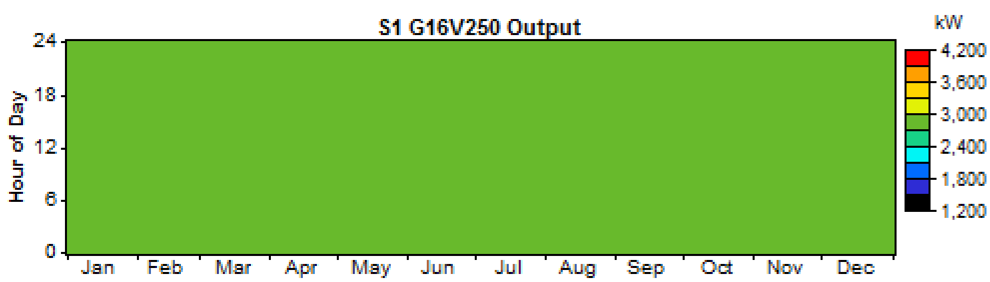


S1 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	100	%
Fixed generation cost	288	$/hr
Marginal generation cost	0.197	$/kWhyr

Quantity	Value	Units
Electrical production	24,528,000	kWh/yr
Mean electrical output	2,800	kW
Min. electrical output	2,800	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,111,123	L/yr
Specific fuel consumption	0.208	L/kWh
Fuel energy input	50,293,456	kWh/yr
Mean electrical efficiency	48.8	%



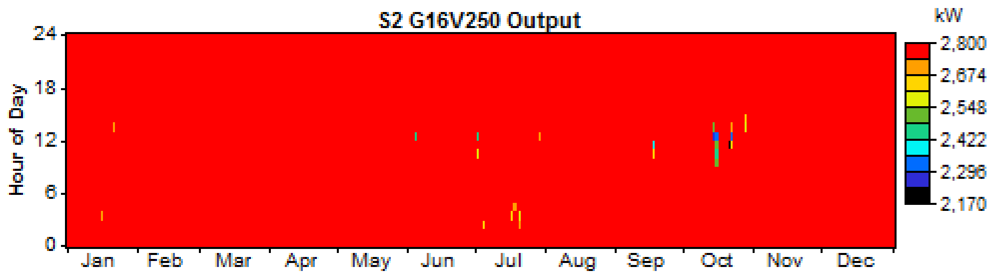
S2 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	100.0	%
Fixed generation cost	288	$/hr
Marginal generation cost	0.197	$/kWhyr

Quantity	Value	Units
Electrical production	24,521,416	kWh/yr

Mean electrical output	2,799	kW
Min. electrical output	2,193	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,110,003	L/yr
Specific fuel consumption	0.208	L/kWh
Fuel energy input	50,282,432	kWh/yr
Mean electrical efficiency	48.8	%

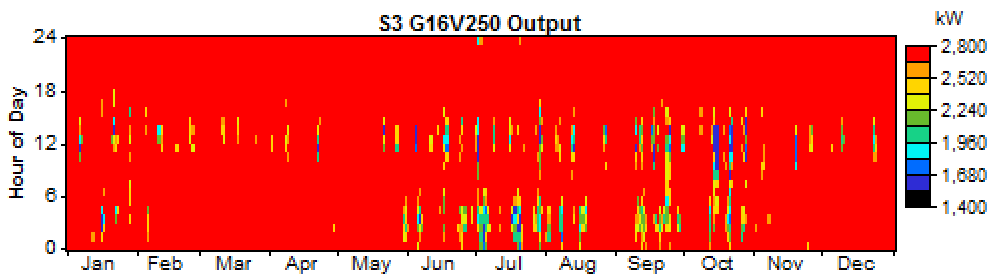


S3 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	98.8	%
Fixed generation cost	288	$/hr
Marginal generation cost	0.197	$/kWhyr

Quantity	Value	Units
Electrical production	24,227,616	kWh/yr
Mean electrical output	2,766	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,060,057	L/yr
Specific fuel consumption	0.209	L/kWh
Fuel energy input	49,790,960	kWh/yr
Mean electrical efficiency	48.7	%



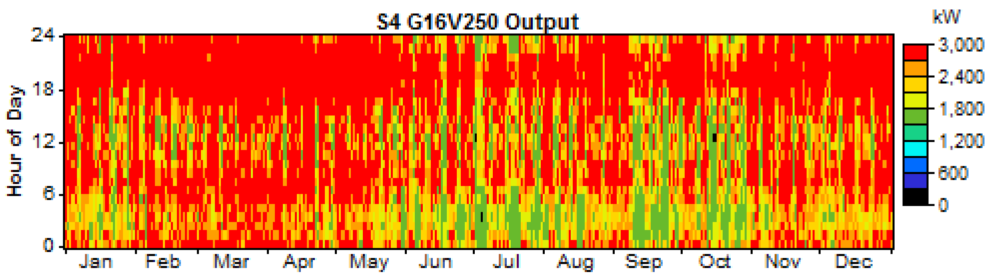
S4 G16V250

Quantity	Value	Units

Hours of operation	8,757	hr/yr
Number of starts	4	starts/yr
Operational life	5.71	yr
Capacity factor	89.6	%
Fixed generation cost	288	$/hr
Marginal generation cost	0.197	$/kWhyr

Quantity	Value	Units
Electrical production	21,964,834	kWh/yr
Mean electrical output	2,508	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,675,216	L/yr
Specific fuel consumption	0.213	L/kWh
Fuel energy input	46,004,132	kWh/yr
Mean electrical efficiency	47.7	%

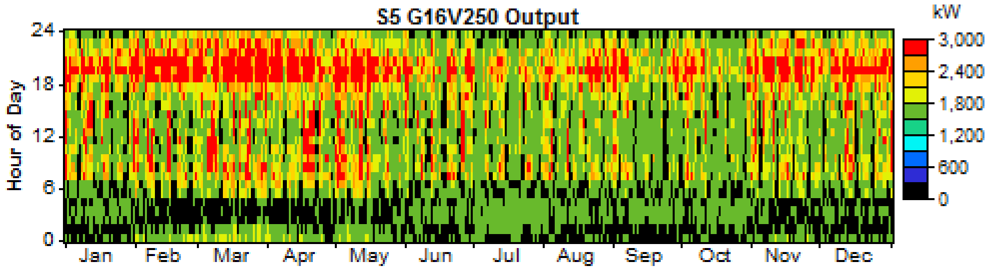


S5 G16V250

Quantity	Value	Units
Hours of operation	7,186	hr/yr
Number of starts	721	starts/yr
Operational life	6.96	yr
Capacity factor	57.8	%
Fixed generation cost	288	$/hr
Marginal generation cost	0.197	$/kWhyr

Quantity	Value	Units
Electrical production	14,178,315	kWh/yr
Mean electrical output	1,973	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	3,183,096	L/yr
Specific fuel consumption	0.225	L/kWh
Fuel energy input	31,321,664	kWh/yr
Mean electrical efficiency	45.3	%

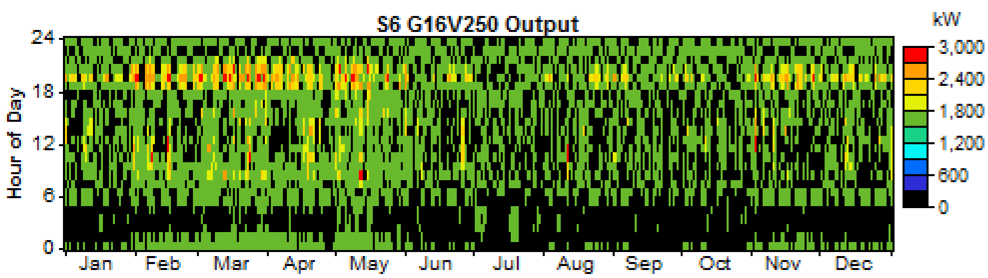


S6 G16V250

Quantity	Value	Units
Hours of operation	4,725	hr/yr
Number of starts	1,457	starts/yr
Operational life	10.6	yr
Capacity factor	32.1	%
Fixed generation cost	288	$/hr
Marginal generation cost	0.197	$/kWhyr

Quantity	Value	Units
Electrical production	7,867,840	kWh/yr
Mean electrical output	1,665	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	1,845,698	L/yr
Specific fuel consumption	0.235	L/kWh
Fuel energy input	18,161,672	kWh/yr
Mean electrical efficiency	43.3	%



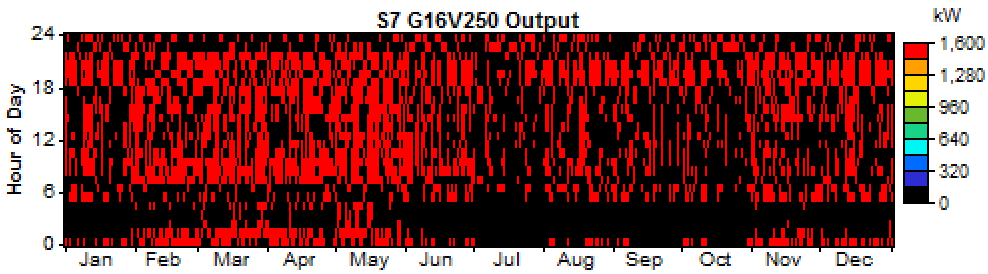
S7 G16V250

Quantity	Value	Units
Hours of operation	3,078	hr/yr
Number of starts	1,424	starts/yr
Operational life	16.2	yr
Capacity factor	20.0	%
Fixed generation cost	288	$/hr
Marginal generation cost	0.197	$/kWhyr

Quantity	Value	Units
Electrical production	4,912,488	kWh/yr

Mean electrical output	1,596	kW
Min. electrical output	1,596	kW
Max. electrical output	1,596	kW

Quantity	Value	Units
Fuel consumption	1,166,178	L/yr
Specific fuel consumption	0.237	L/kWh
Fuel energy input	11,475,188	kWh/yr
Mean electrical efficiency	42.8	%



Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	94,376,712
Carbon monoxide	232,956
Unburned hydocarbons	25,804
Particulate matter	17,561
Sulfur dioxide	189,525
Nitrogen oxides	2,078,680

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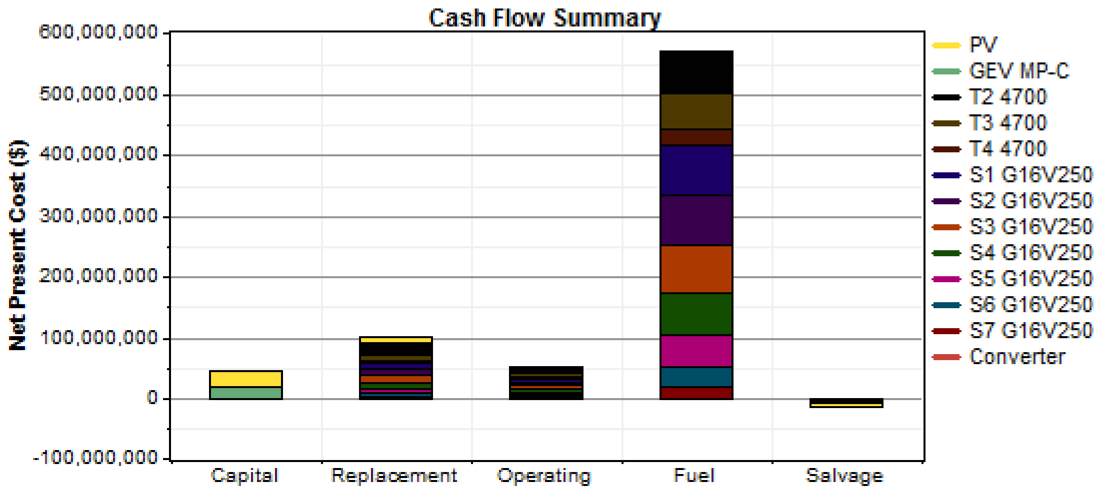
System architecture

PV Array	7,300 kW
Wind turbine	19 GEV MP-C
T2 4700	3,800 kW
T3 4700	3,800 kW
T4 4700	3,800 kW
S1 G16V250	2,800 kW
S2 G16V250	2,800 kW
S3 G16V250	2,800 kW
S4 G16V250	2,800 kW
S5 G16V250	2,800 kW
S6 G16V250	2,800 kW
S7 G16V250	2,800 kW
Inverter	100,000,000 kW
Rectifier	100,000,000 kW

Cost summary

Total net present cost	$ 751,182,720
Levelized cost of energy	$ 0.329/kWh
Operating cost	$ 55,381,596/yr



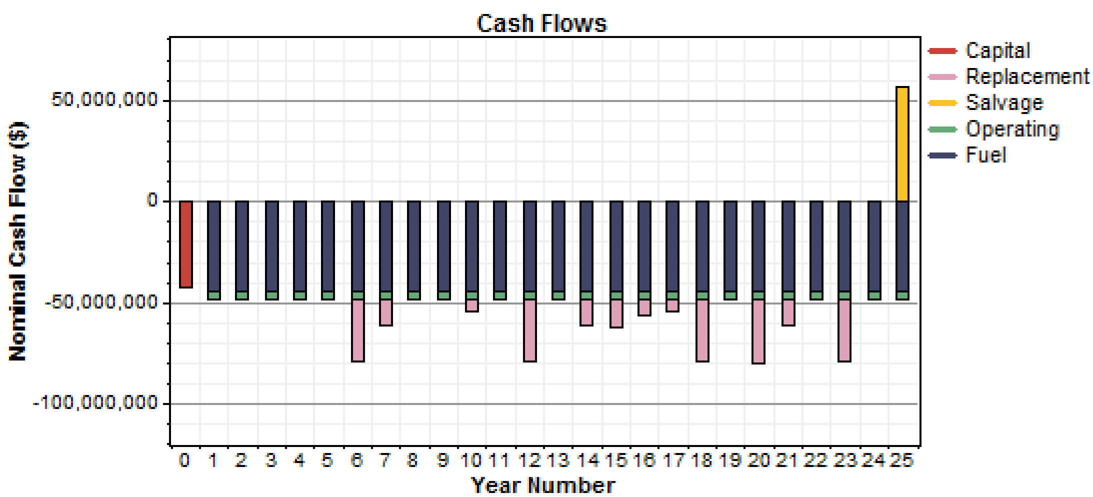
Net Present Costs

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($)	($)	($)	($)	($)	($)
PV	26,280,000	8,194,237	933,185	0	-4,592,410	30,815,012
GEV MP-C	16,940,000	5,654,781	2,109,255	0	-1,052,534	23,651,504
T2 4700	0	14,097,699	7,393,264	69,409,656	-1,153,671	89,746,936
T3 4700	0	10,714,686	6,123,225	57,334,156	-705,661	73,466,400
T4 4700	0	3,123,078	2,784,907	26,075,054	-641,027	31,342,014
S1 G16V250	0	10,664,818	5,487,130	83,107,976	-826,365	98,433,560
S2 G16V250	0	10,664,818	5,487,130	81,777,440	-826,365	97,103,024
S3 G16V250	0	10,664,818	5,487,130	78,482,536	-826,365	93,808,112
S4 G16V250	0	10,632,478	5,463,327	71,237,736	-851,690	86,481,848
S5 G16V250	0	8,151,343	4,581,379	51,376,904	-457,167	63,652,456

S6 G16V250	0	5,081,166	3,215,233	32,758,718	-577,789	40,477,328
S7 G16V250	0	2,190,414	1,901,078	18,756,448	-643,099	22,204,836
Converter	0	0	0	0	0	0
System	43,220,000	99,834,336	50,966,240	570,316,544	-13,154,141	751,183,104

Annualized Costs

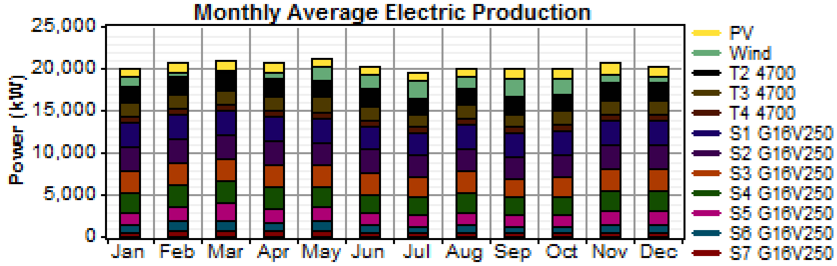
Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)
PV	2,055,798	641,008	73,000	0	-359,249	2,410,557
GEV MP-C	1,325,161	442,355	165,000	0	-82,336	1,850,180
T2 4700	0	1,102,817	578,351	5,429,690	-90,248	7,020,608
T3 4700	0	838,175	479,000	4,485,063	-55,202	5,747,035
T4 4700	0	244,308	217,854	2,039,766	-50,145	2,451,783
S1 G16V250	0	834,274	429,240	6,501,264	-64,644	7,700,134
S2 G16V250	0	834,274	429,240	6,397,181	-64,644	7,596,051
S3 G16V250	0	834,274	429,240	6,139,431	-64,644	7,338,301
S4 G16V250	0	831,744	427,378	5,572,694	-66,625	6,765,191
S5 G16V250	0	637,653	358,386	4,019,047	-35,763	4,979,323
S6 G16V250	0	397,483	251,517	2,562,607	-45,199	3,166,409
S7 G16V250	0	171,349	148,715	1,467,255	-50,308	1,737,011
Converter	0	0	0	0	0	0
System	3,380,959	7,809,712	3,986,922	44,613,988	-1,029,005	58,762,588



Electrical

Component	Production	Fraction
	(kWh/yr)	
PV array	10,152,925	6%
Wind turbines	11,050,739	6%
T2 4700	17,565,484	10%
T3 4700	14,506,841	8%
T4 4700	6,597,864	4%
S1 G16V250	24,433,354	14%
S2 G16V250	23,953,326	13%

S3 G16V250	22,764,346	13%
S4 G16V250	20,174,138	11%
S5 G16V250	13,900,503	8%
S6 G16V250	8,566,288	5%
S7 G16V250	4,843,860	3%
Total	178,509,664	100%



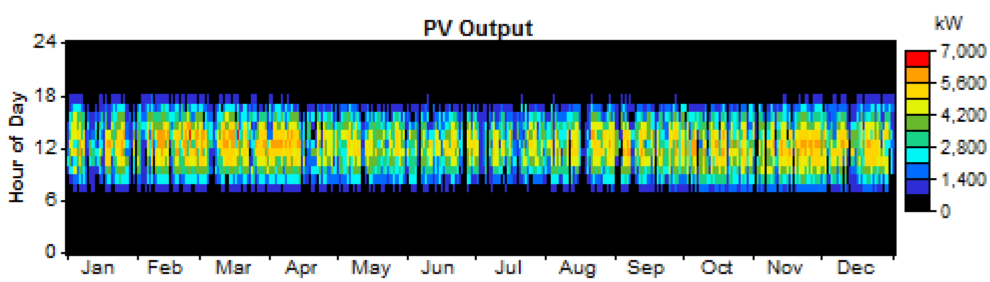
Load	Consumption (kWh/yr)	Fraction
AC primary load	178,506,784	100%
Total	178,506,784	100%

Quantity	Value	Units
Excess electricity	3,154	kWh/yr
Unmet load	1.18	kWh/yr
Capacity shortage	0.00	kWh/yr
Renewable fraction	0.119	

PV

Quantity	Value	Units
Rated capacity	7,300	kW
Mean output	1,159	kW
Mean output	27,816	kWh/d
Capacity factor	15.9	%
Total production	10,152,925	kWh/yr

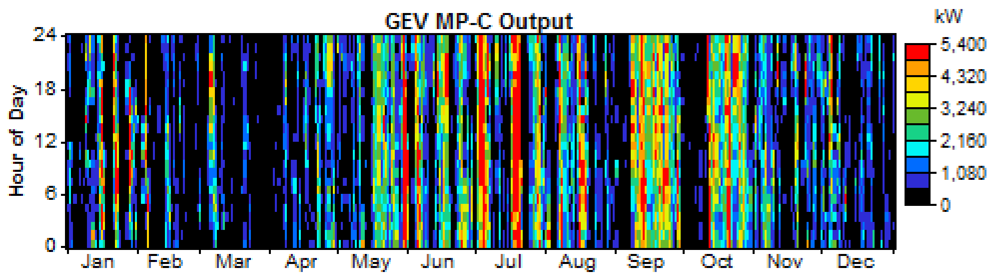
Quantity	Value	Units
Minimum output	0.00	kW
Maximum output	6,479	kW
PV penetration	5.69	%
Hours of operation	4,334	hr/yr
Levelized cost	0.237	$/kWh



AC Wind Turbine: GEV MP-C

Variable	Value	Units
Total rated capacity	5,225	kW
Mean output	1,261	kW
Capacity factor	24.1	%
Total production	11,050,739	kWh/yr

Variable	Value	Units
Minimum output	0.00	kW
Maximum output	5,225	kW
Wind penetration	6.19	%
Hours of operation	7,120	hr/yr
Levelized cost	0.167	$/kWh

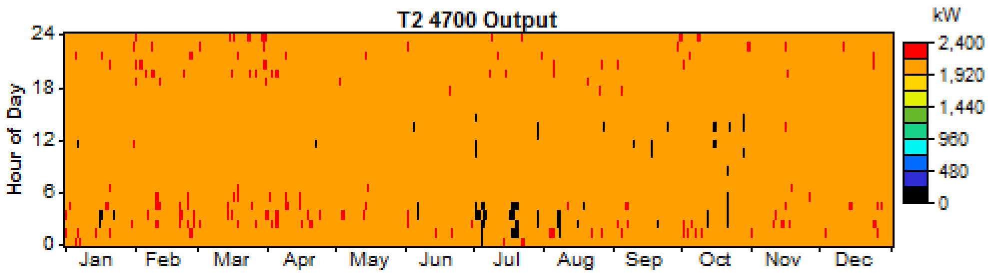


T2 4700

Quantity	Value	Units
Hours of operation	8,697	hr/yr
Number of starts	42	starts/yr
Operational life	5.75	yr
Capacity factor	52.8	%
Fixed generation cost	260	$/hr
Marginal generation cost	0.288	$/kWhyr

Quantity	Value	Units
Electrical production	17,565,484	kWh/yr
Mean electrical output	2,020	kW
Min. electrical output	2,014	kW
Max. electrical output	2,380	kW

Quantity	Value	Units
Fuel consumption	4,255,240	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	41,871,568	kWh/yr
Mean electrical efficiency	42.0	%

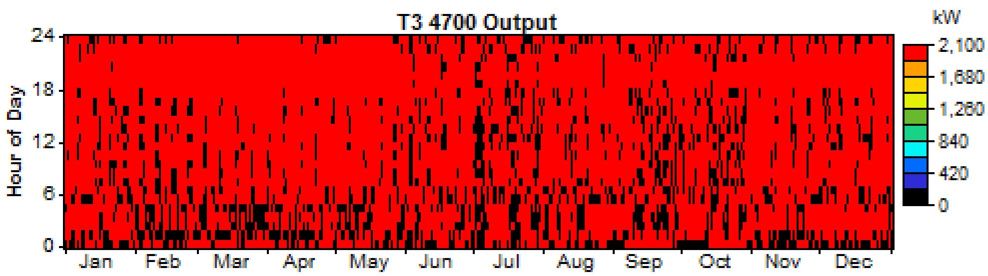


T3 4700

Quantity	Value	Units
Hours of operation	7,203	hr/yr
Number of starts	947	starts/yr
Operational life	6.94	yr
Capacity factor	43.6	%
Fixed generation cost	260	$/hr
Marginal generation cost	0.288	$/kWhyr

Quantity	Value	Units
Electrical production	14,506,841	kWh/yr
Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	3,514,938	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	34,586,992	kWh/yr
Mean electrical efficiency	41.9	%



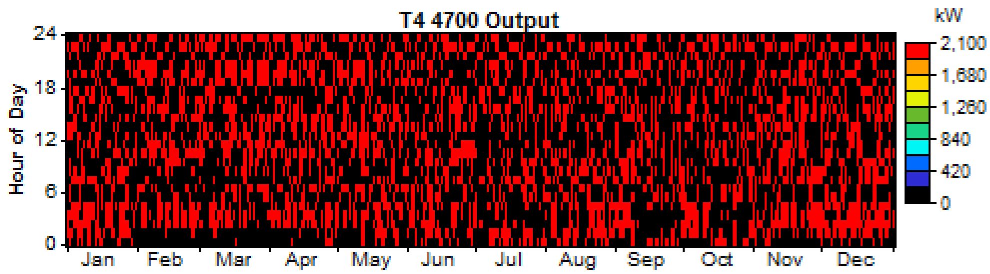
T4 4700

Quantity	Value	Units
Hours of operation	3,276	hr/yr
Number of starts	1,830	starts/yr
Operational life	15.3	yr
Capacity factor	19.8	%
Fixed generation cost	260	$/hr
Marginal generation cost	0.288	$/kWhyr

Quantity	Value	Units
Electrical production	6,597,864	kWh/yr

Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	1,598,562	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	15,729,849	kWh/yr
Mean electrical efficiency	41.9	%

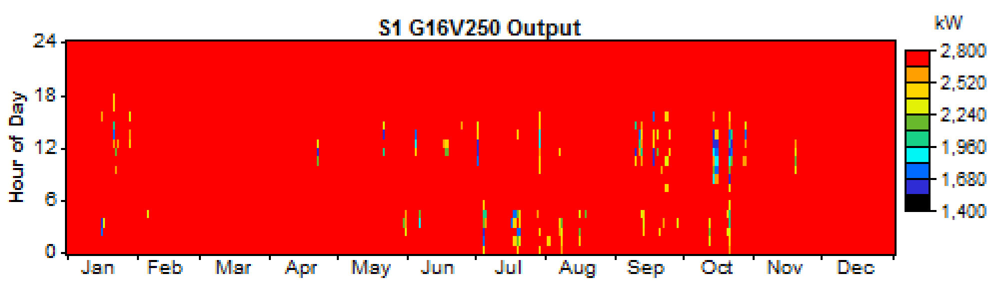


S1 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	99.6	%
Fixed generation cost	301	$/hr
Marginal generation cost	0.217	$/kWhyr

Quantity	Value	Units
Electrical production	24,433,354	kWh/yr
Mean electrical output	2,789	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,095,032	L/yr
Specific fuel consumption	0.209	L/kWh
Fuel energy input	50,135,120	kWh/yr
Mean electrical efficiency	48.7	%



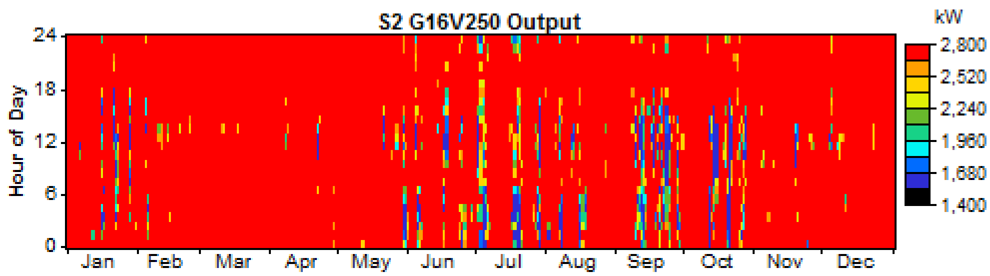
S2 G16V250

Quantity	Value	Units

Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	97.7	%
Fixed generation cost	301	$/hr
Marginal generation cost	0.217	$/kWhyr

Quantity	Value	Units
Electrical production	23,953,326	kWh/yr
Mean electrical output	2,734	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,013,461	L/yr
Specific fuel consumption	0.209	L/kWh
Fuel energy input	49,332,460	kWh/yr
Mean electrical efficiency	48.6	%

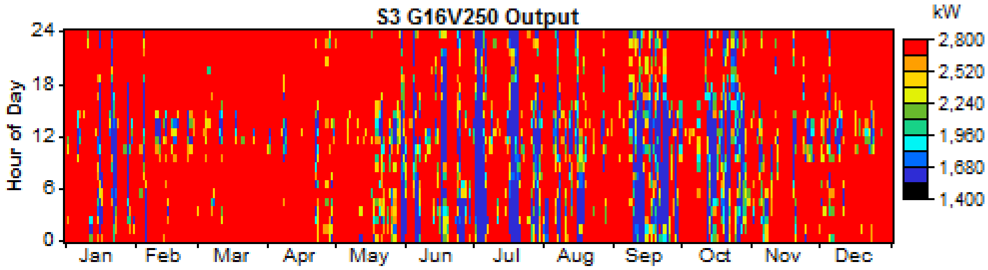


S3 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	92.8	%
Fixed generation cost	301	$/hr
Marginal generation cost	0.217	$/kWhyr

Quantity	Value	Units
Electrical production	22,764,346	kWh/yr
Mean electrical output	2,599	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,811,464	L/yr
Specific fuel consumption	0.211	L/kWh
Fuel energy input	47,344,808	kWh/yr
Mean electrical efficiency	48.1	%

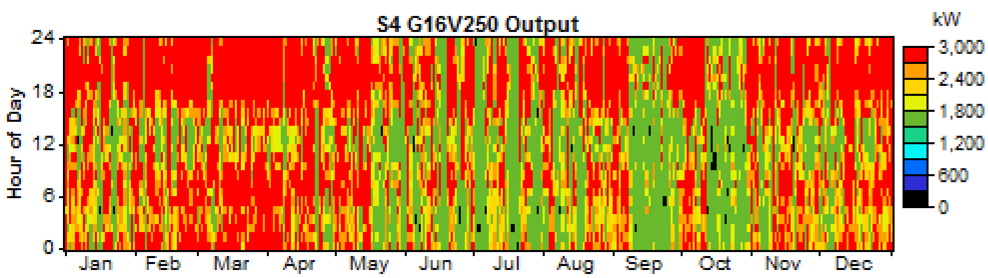


S4 G16V250

Quantity	Value	Units
Hours of operation	8,722	hr/yr
Number of starts	33	starts/yr
Operational life	5.73	yr
Capacity factor	82.2	%
Fixed generation cost	301	$/hr
Marginal generation cost	0.217	$/kWhyr

Quantity	Value	Units
Electrical production	20,174,138	kWh/yr
Mean electrical output	2,313	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,367,313	L/yr
Specific fuel consumption	0.216	L/kWh
Fuel energy input	42,974,364	kWh/yr
Mean electrical efficiency	46.9	%



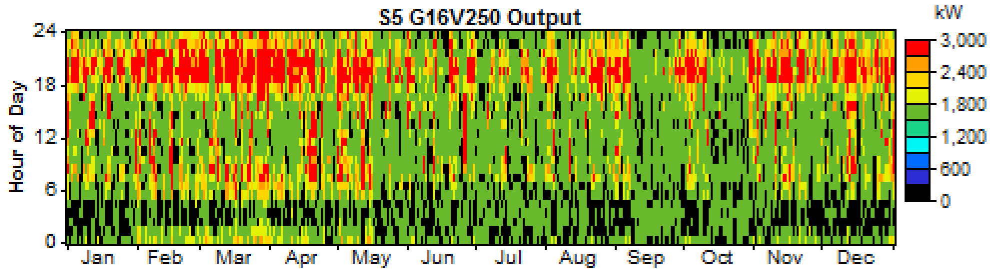
S5 G16V250

Quantity	Value	Units
Hours of operation	7,314	hr/yr
Number of starts	726	starts/yr
Operational life	6.84	yr
Capacity factor	56.7	%
Fixed generation cost	301	$/hr
Marginal generation cost	0.217	$/kWhyr

Quantity	Value	Units
Electrical production	13,900,503	kWh/yr

Mean electrical output	1,901	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	3,149,721	L/yr
Specific fuel consumption	0.227	L/kWh
Fuel energy input	30,993,258	kWh/yr
Mean electrical efficiency	44.9	%

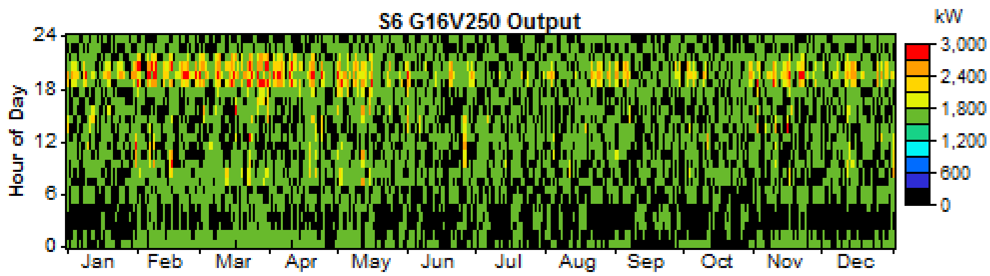


S6 G16V250

Quantity	Value	Units
Hours of operation	5,133	hr/yr
Number of starts	1,562	starts/yr
Operational life	9.74	yr
Capacity factor	34.9	%
Fixed generation cost	301	$/hr
Marginal generation cost	0.217	$/kWhyr

Quantity	Value	Units
Electrical production	8,566,288	kWh/yr
Mean electrical output	1,669	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	2,008,312	L/yr
Specific fuel consumption	0.234	L/kWh
Fuel energy input	19,761,788	kWh/yr
Mean electrical efficiency	43.3	%



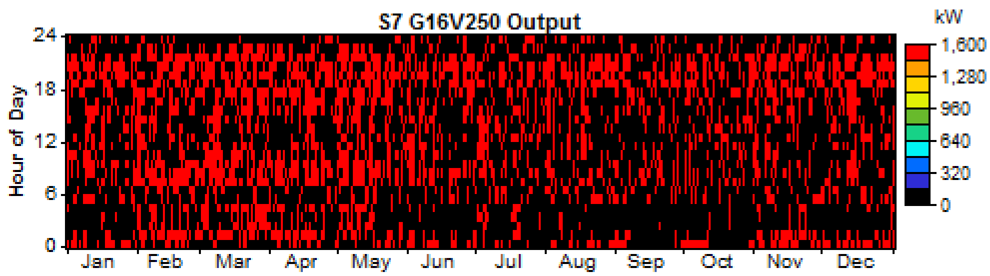
S7 G16V250

Quantity	Value	Units

Hours of operation	3,035	hr/yr
Number of starts	1,557	starts/yr
Operational life	16.5	yr
Capacity factor	19.7	%
Fixed generation cost	301	$/hr
Marginal generation cost	0.217	$/kWhyr

Quantity	Value	Units
Electrical production	4,843,860	kWh/yr
Mean electrical output	1,596	kW
Min. electrical output	1,596	kW
Max. electrical output	1,596	kW

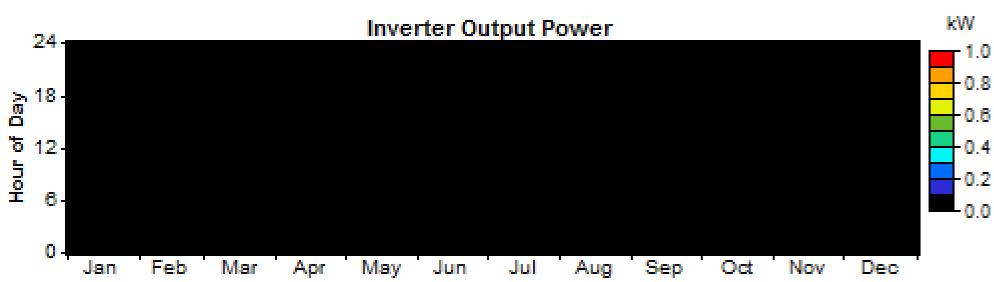
Quantity	Value	Units
Fuel consumption	1,149,886	L/yr
Specific fuel consumption	0.237	L/kWh
Fuel energy input	11,314,878	kWh/yr
Mean electrical efficiency	42.8	%

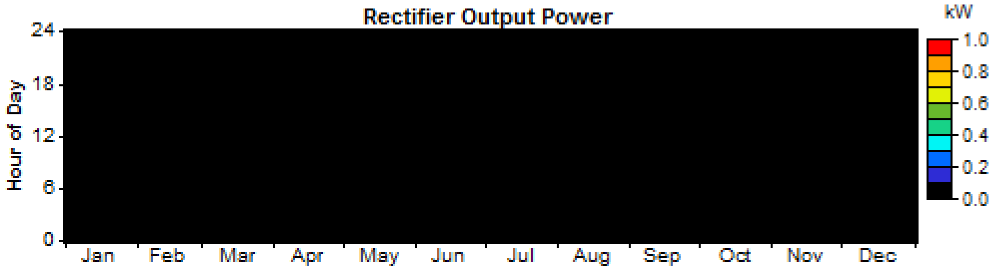


Converter

Quantity	Inverter	Rectifier	Units
Capacity	100,000,000	100,000,000	kW
Mean output	0	0	kW
Minimum output	0	0	kW
Maximum output	0	0	kW
Capacity factor	0.0	0.0	%

Quantity	Inverter	Rectifier	Units
Hours of operation	0	0	hrs/yr
Energy in	0	0	kWh/yr
Energy out	0	0	kWh/yr
Losses	0	0	kWh/yr





Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	92,071,536
Carbon monoxide	227,266
Unburned hydocarbons	25,174
Particulate matter	17,132
Sulfur dioxide	184,896
Nitrogen oxides	2,027,908

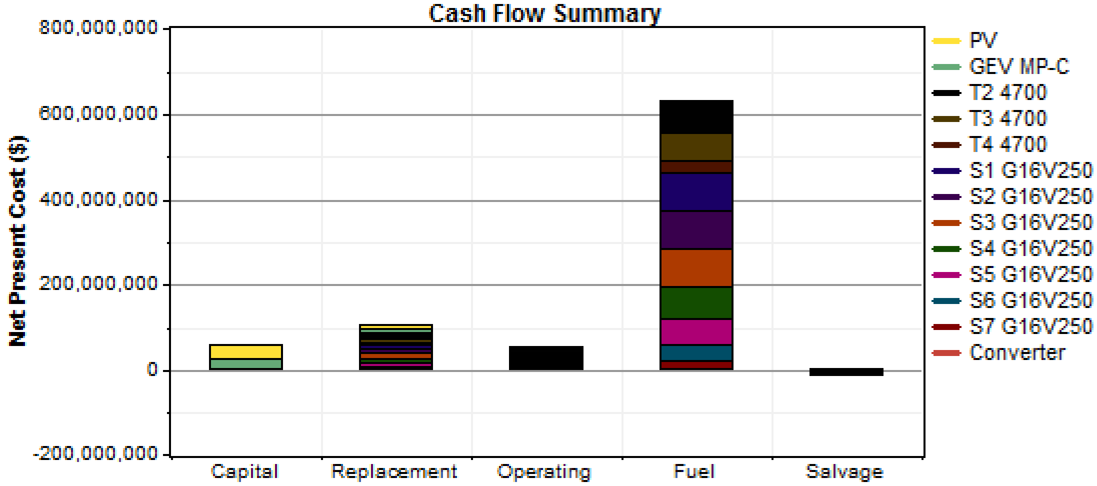
System Report - 18-2020 Base.hmr

System architecture

PV Array	9,200 kW
Wind turbine	30 GEV MP-C
T2 4700	3,800 kW
T3 4700	3,800 kW
T4 4700	3,800 kW
S1 G16V250	2,800 kW
S2 G16V250	2,800 kW
S3 G16V250	2,800 kW
S4 G16V250	2,800 kW
S5 G16V250	2,800 kW
S6 G16V250	2,800 kW
S7 G16V250	2,800 kW
Inverter	100,000,000 kW
Rectifier	100,000,000 kW

Cost summary

Total net present cost	$ 834,579,328
Levelized cost of energy	$ 0.357/kWh
Operating cost	$ 60,613,136/yr



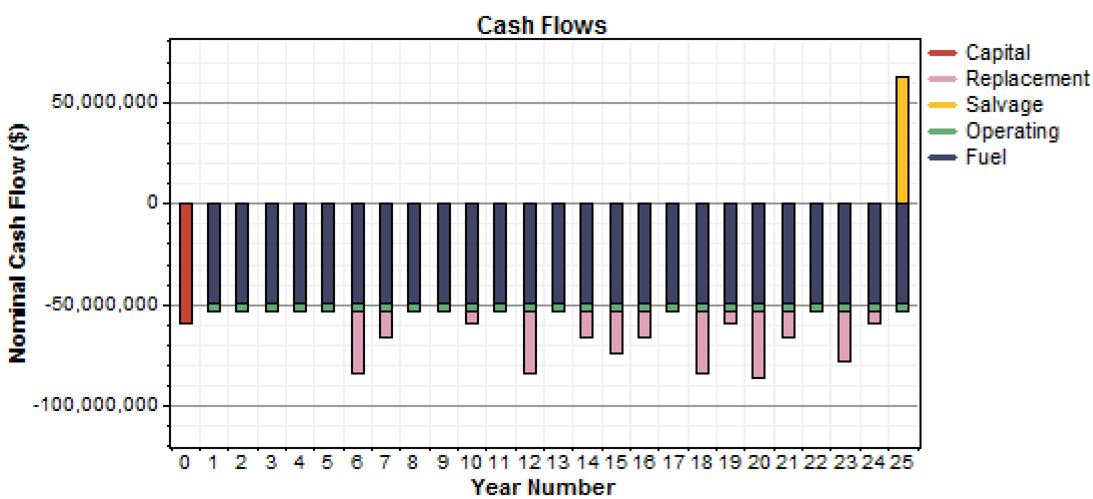
Net Present Costs

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($)	($)	($)	($)	($)	($)
PV	33,120,000	10,326,984	1,176,070	0	-5,787,694	38,835,352
GEV MP-C	26,620,000	8,886,084	3,269,345	0	-1,653,982	37,121,448
T2 4700	0	14,127,213	7,415,367	76,734,392	-1,130,651	97,146,328
T3 4700	0	10,708,410	6,118,124	63,167,668	-710,973	79,283,240
T4 4700	0	3,162,610	2,824,861	29,164,568	-599,413	34,552,624
S1 G16V250	0	10,664,818	5,487,130	90,725,504	-826,365	106,051,112
S2 G16V250	0	10,664,818	5,487,130	88,946,256	-826,365	104,271,848
S3 G16V250	0	10,663,969	5,486,504	85,586,696	-827,032	100,910,160
S4 G16V250	0	10,578,512	5,423,866	77,739,848	-893,674	92,848,536
S5 G16V250	0	8,259,881	4,670,325	58,496,252	-362,534	71,063,928

S6 G16V250	0	5,333,291	3,429,457	38,843,400	-349,873	47,256,268
S7 G16V250	0	2,275,853	1,980,002	21,542,218	-559,129	25,238,946
Converter	0	0	0	0	0	0
System	59,740,000	105,652,448	52,768,176	630,946,752	-14,527,685	834,579,776

Annualized Costs

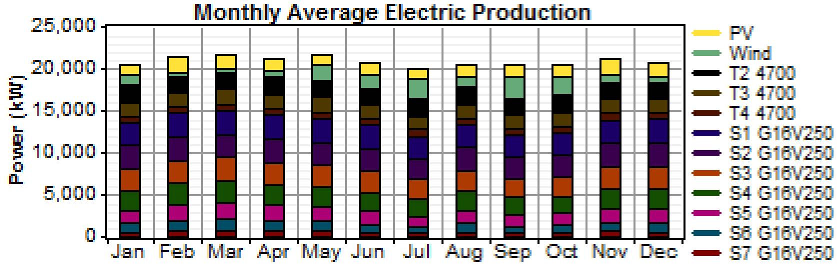
Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)
PV	2,590,869	807,846	92,000	0	-452,752	3,037,962
GEV MP-C	2,082,395	695,129	255,750	0	-129,386	2,903,889
T2 4700	0	1,105,126	580,080	6,002,680	-88,447	7,599,438
T3 4700	0	837,684	478,601	4,941,399	-55,617	6,202,068
T4 4700	0	247,401	220,980	2,281,448	-46,890	2,702,938
S1 G16V250	0	834,274	429,240	7,097,158	-64,644	8,296,030
S2 G16V250	0	834,274	429,240	6,957,974	-64,644	8,156,844
S3 G16V250	0	834,207	429,191	6,695,166	-64,696	7,893,871
S4 G16V250	0	827,522	424,291	6,081,333	-69,909	7,263,236
S5 G16V250	0	646,143	365,344	4,575,970	-28,360	5,559,098
S6 G16V250	0	417,206	268,275	3,038,592	-27,369	3,696,703
S7 G16V250	0	178,032	154,889	1,685,177	-43,739	1,974,360
Converter	0	0	0	0	0	0
System	4,673,264	8,264,844	4,127,881	49,356,892	-1,136,453	65,286,436



Electrical

Component	Production	Fraction
	(kWh/yr)	
PV array	12,795,469	7%
Wind turbines	12,431,771	7%
T2 4700	17,610,628	10%
T3 4700	14,494,757	8%
T4 4700	6,692,522	4%
S1 G16V250	24,134,048	13%
S2 G16V250	23,551,782	13%

S3 G16V250	22,452,980	12%
S4 G16V250	19,948,460	11%
S5 G16V250	14,414,101	8%
S6 G16V250	9,239,960	5%
S7 G16V250	5,045,454	3%
Total	182,811,920	100%



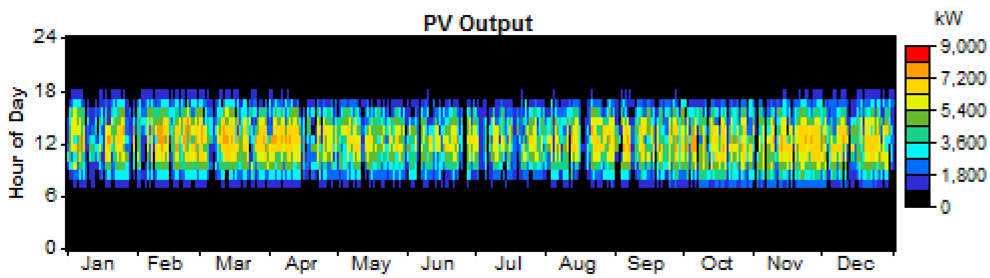
Load	Consumption (kWh/yr)	Fraction
AC primary load	182,709,648	100%
Total	182,709,648	100%

Quantity	Value	Units
Excess electricity	102,006	kWh/yr
Unmet load	1.22	kWh/yr
Capacity shortage	0.00	kWh/yr
Renewable fraction	0.138	

PV

Quantity	Value	Units
Rated capacity	9,200	kW
Mean output	1,461	kW
Mean output	35,056	kWh/d
Capacity factor	15.9	%
Total production	12,795,469	kWh/yr

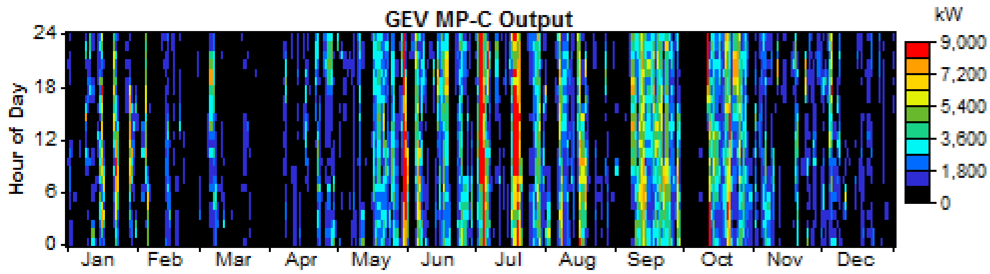
Quantity	Value	Units
Minimum output	0.00	kW
Maximum output	8,165	kW
PV penetration	7.00	%
Hours of operation	4,334	hr/yr
Levelized cost	0.237	$/kWh



AC Wind Turbine: GEV MP-C

Variable	Value	Units
Total rated capacity	8,250	kW
Mean output	1,419	kW
Capacity factor	17.2	%
Total production	12,431,771	kWh/yr

Variable	Value	Units
Minimum output	0.00	kW
Maximum output	8,250	kW
Wind penetration	6.80	%
Hours of operation	6,635	hr/yr
Levelized cost	0.234	$/kWh

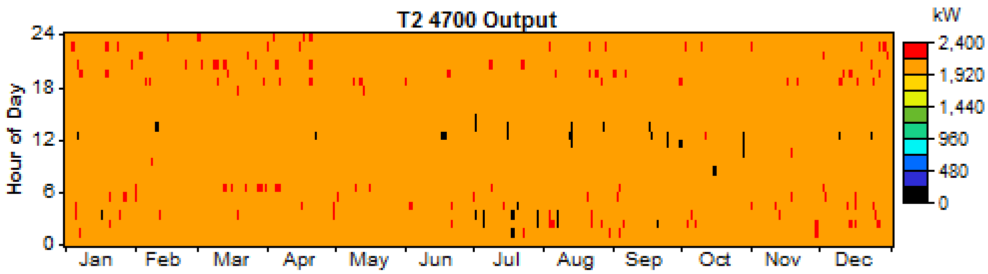


T2 4700

Quantity	Value	Units
Hours of operation	8,723	hr/yr
Number of starts	28	starts/yr
Operational life	5.73	yr
Capacity factor	52.9	%
Fixed generation cost	265	$/hr
Marginal generation cost	0.318	$/kWhyr

Quantity	Value	Units
Electrical production	17,610,628	kWh/yr
Mean electrical output	2,019	kW
Min. electrical output	2,014	kW
Max. electrical output	2,366	kW

Quantity	Value	Units
Fuel consumption	4,266,295	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	41,980,348	kWh/yr
Mean electrical efficiency	41.9	%

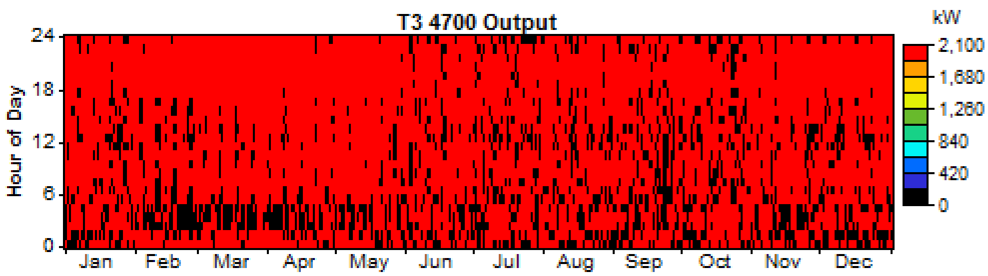


T3 4700

Quantity	Value	Units
Hours of operation	7,197	hr/yr
Number of starts	957	starts/yr
Operational life	6.95	yr
Capacity factor	43.5	%
Fixed generation cost	265	$/hr
Marginal generation cost	0.318	$/kWhyr

Quantity	Value	Units
Electrical production	14,494,757	kWh/yr
Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	3,512,010	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	34,558,180	kWh/yr
Mean electrical efficiency	41.9	%



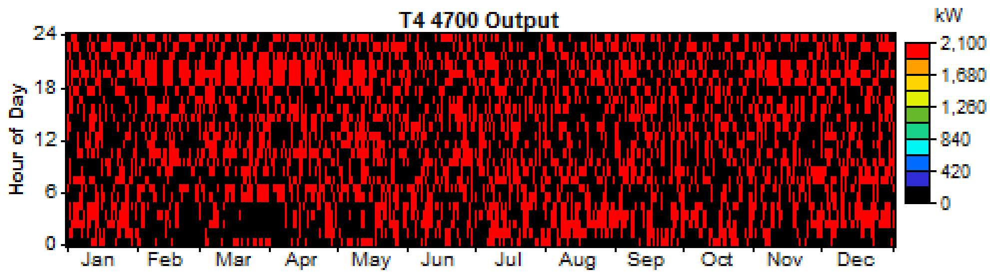
T4 4700

Quantity	Value	Units
Hours of operation	3,323	hr/yr
Number of starts	1,844	starts/yr
Operational life	15.0	yr
Capacity factor	20.1	%
Fixed generation cost	265	$/hr
Marginal generation cost	0.318	$/kWhyr

Quantity	Value	Units
Electrical production	6,692,522	kWh/yr

Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	1,621,498	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	15,955,540	kWh/yr
Mean electrical efficiency	41.9	%

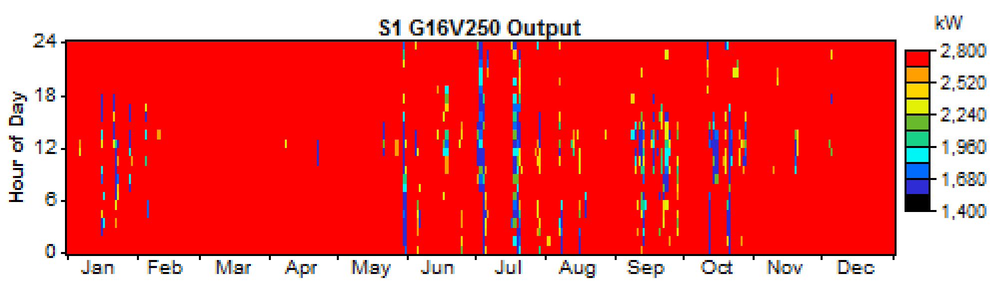


S1 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	98.4	%
Fixed generation cost	315	$/hr
Marginal generation cost	0.239	$/kWhyr

Quantity	Value	Units
Electrical production	24,134,048	kWh/yr
Mean electrical output	2,755	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	5,044,176	L/yr
Specific fuel consumption	0.209	L/kWh
Fuel energy input	49,634,696	kWh/yr
Mean electrical efficiency	48.6	%



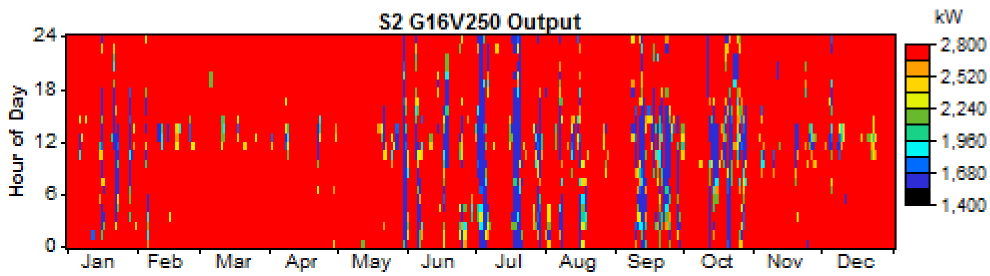
S2 G16V250

Quantity	Value	Units

Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	96.0	%
Fixed generation cost	315	$/hr
Marginal generation cost	0.239	$/kWhyr

Quantity	Value	Units
Electrical production	23,551,782	kWh/yr
Mean electrical output	2,689	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,945,253	L/yr
Specific fuel consumption	0.210	L/kWh
Fuel energy input	48,661,296	kWh/yr
Mean electrical efficiency	48.4	%

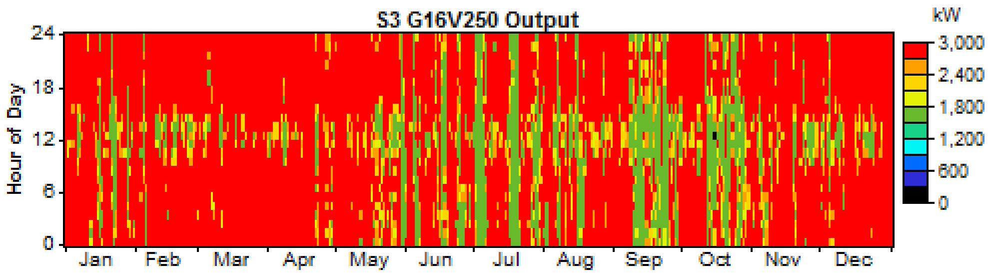


S3 G16V250

Quantity	Value	Units
Hours of operation	8,759	hr/yr
Number of starts	2	starts/yr
Operational life	5.71	yr
Capacity factor	91.5	%
Fixed generation cost	315	$/hr
Marginal generation cost	0.239	$/kWhyr

Quantity	Value	Units
Electrical production	22,452,980	kWh/yr
Mean electrical output	2,563	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,758,467	L/yr
Specific fuel consumption	0.212	L/kWh
Fuel energy input	46,823,320	kWh/yr
Mean electrical efficiency	48.0	%

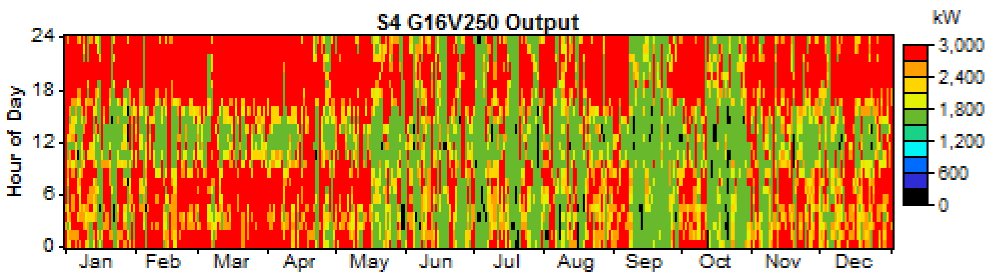


S4 G16V250

Quantity	Value	Units
Hours of operation	8,659	hr/yr
Number of starts	68	starts/yr
Operational life	5.77	yr
Capacity factor	81.3	%
Fixed generation cost	315	$/hr
Marginal generation cost	0.239	$/kWhyr

Quantity	Value	Units
Electrical production	19,948,460	kWh/yr
Mean electrical output	2,304	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,322,196	L/yr
Specific fuel consumption	0.217	L/kWh
Fuel energy input	42,530,408	kWh/yr
Mean electrical efficiency	46.9	%



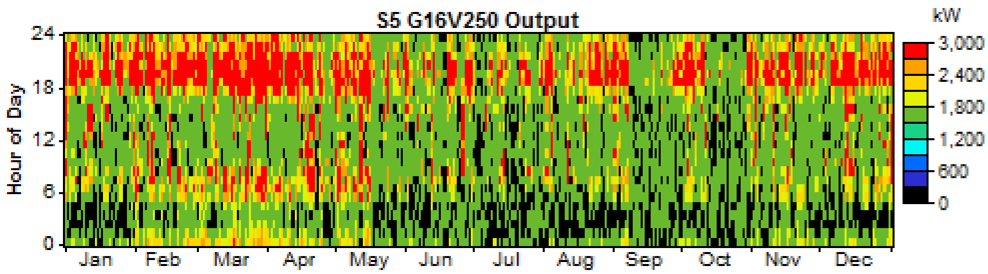
S5 G16V250

Quantity	Value	Units
Hours of operation	7,456	hr/yr
Number of starts	669	starts/yr
Operational life	6.71	yr
Capacity factor	58.8	%
Fixed generation cost	315	$/hr
Marginal generation cost	0.239	$/kWhyr

Quantity	Value	Units
Electrical production	14,414,101	kWh/yr

Mean electrical output	1,933	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	3,252,287	L/yr
Specific fuel consumption	0.226	L/kWh
Fuel energy input	32,002,508	kWh/yr
Mean electrical efficiency	45.0	%

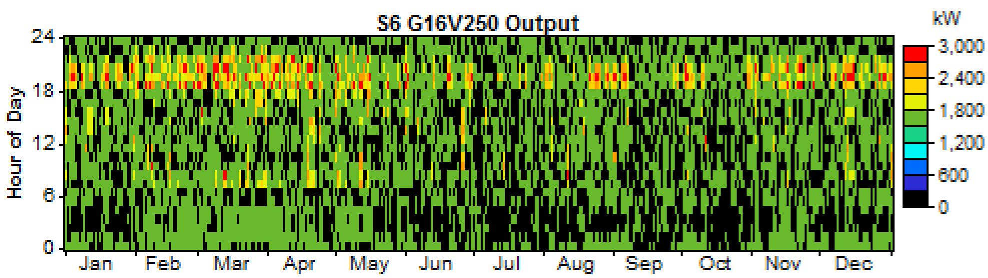


S6 G16V250

Quantity	Value	Units
Hours of operation	5,475	hr/yr
Number of starts	1,520	starts/yr
Operational life	9.13	yr
Capacity factor	37.7	%
Fixed generation cost	315	$/hr
Marginal generation cost	0.239	$/kWhyr

Quantity	Value	Units
Electrical production	9,239,960	kWh/yr
Mean electrical output	1,688	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	2,159,623	L/yr
Specific fuel consumption	0.234	L/kWh
Fuel energy input	21,250,696	kWh/yr
Mean electrical efficiency	43.5	%



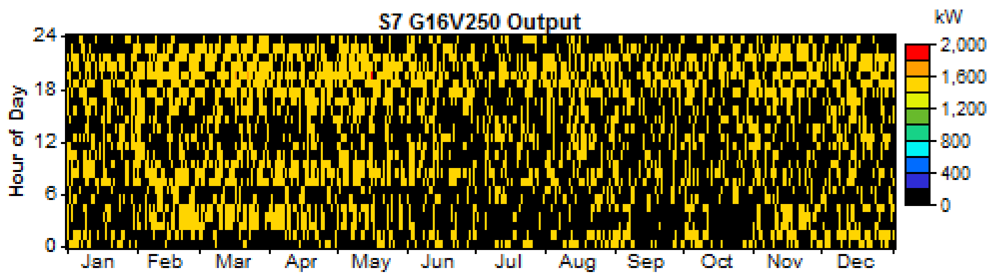
S7 G16V250

Quantity	Value	Units

Hours of operation	3,161	hr/yr
Number of starts	1,673	starts/yr
Operational life	15.8	yr
Capacity factor	20.6	%
Fixed generation cost	315	$/hr
Marginal generation cost	0.239	$/kWhyr

Quantity	Value	Units
Electrical production	5,045,454	kWh/yr
Mean electrical output	1,596	kW
Min. electrical output	1,596	kW
Max. electrical output	1,918	kW

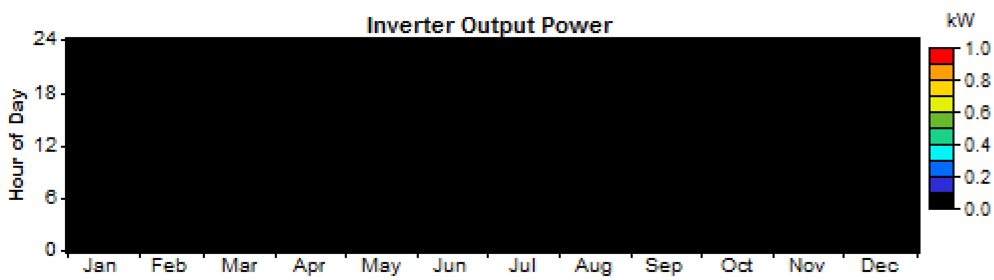
Quantity	Value	Units
Fuel consumption	1,197,709	L/yr
Specific fuel consumption	0.237	L/kWh
Fuel energy input	11,785,454	kWh/yr
Mean electrical efficiency	42.8	%

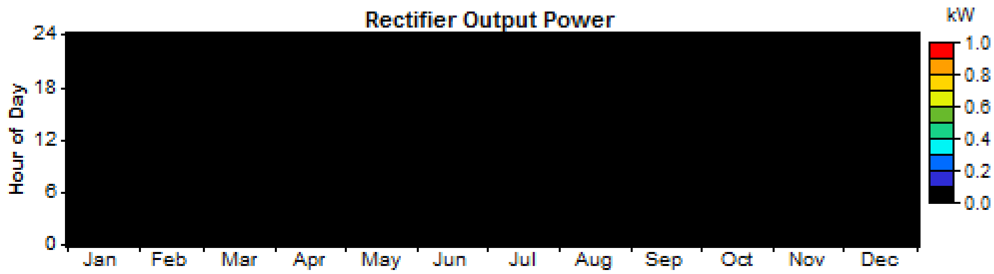


Converter

Quantity	Inverter	Rectifier	Units
Capacity	100,000,000	100,000,000	kW
Mean output	0	0	kW
Minimum output	0	0	kW
Maximum output	0	0	kW
Capacity factor	0.0	0.0	%

Quantity	Inverter	Rectifier	Units
Hours of operation	0	0	hrs/yr
Energy in	0	0	kWh/yr
Energy out	0	0	kWh/yr
Losses	0	0	kWh/yr





Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	92,375,904
Carbon monoxide	228,017
Unburned hydocarbons	25,257
Particulate matter	17,189
Sulfur dioxide	185,507
Nitrogen oxides	2,034,612

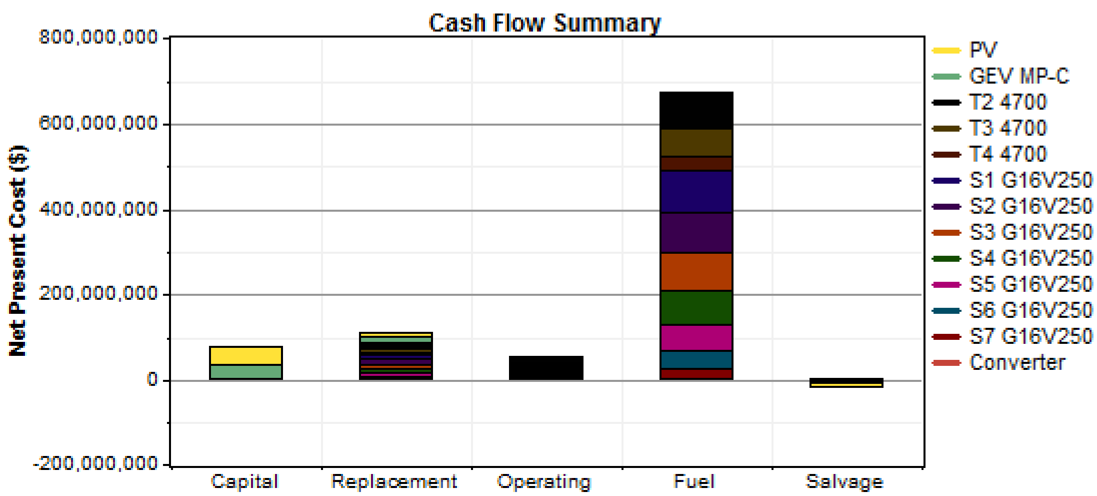
System Report - 23-2022 Base.hmr

System architecture

PV Array	10,800 kW
Wind turbine	41 GEV MP-C
T2 4700	3,800 kW
T3 4700	3,800 kW
T4 4700	3,800 kW
S1 G16V250	2,800 kW
S2 G16V250	2,800 kW
S3 G16V250	2,800 kW
S4 G16V250	2,800 kW
S5 G16V250	2,800 kW
S6 G16V250	2,800 kW
S7 G16V250	2,800 kW
Inverter	100,000,000 kW
Rectifier	100,000,000 kW

Cost summary

Total net present cost	$ 898,147,584
Levelized cost of energy	$ 0.372/kWh
Operating cost	$ 64,378,052/yr



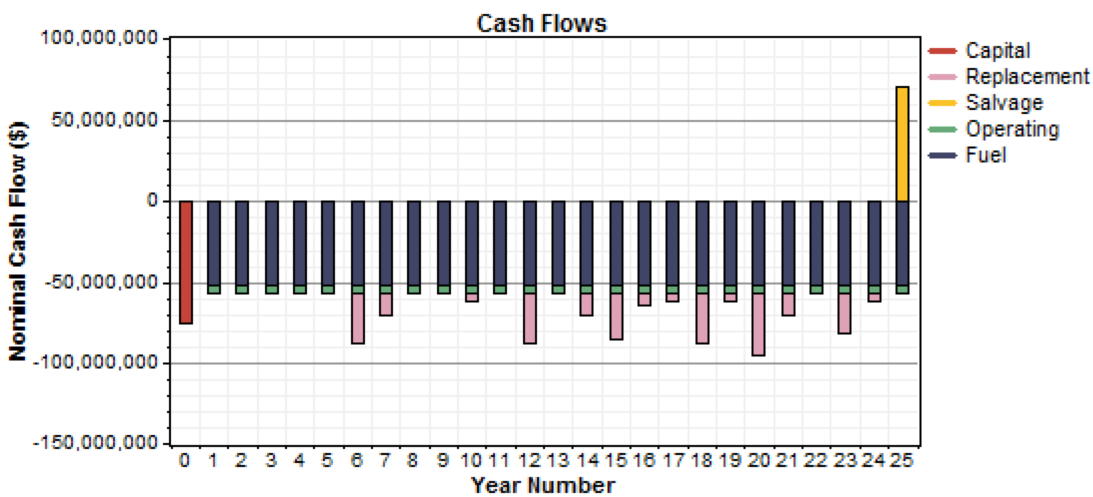
Net Present Costs

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($)	($)	($)	($)	($)	($)
PV	38,880,000	12,122,981	1,380,603	0	-6,794,250	45,589,340
GEV MP-C	36,300,000	12,117,387	4,429,436	0	-2,255,430	50,591,392
T2 4700	0	14,130,614	7,417,917	84,543,696	-1,127,995	104,964,232
T3 4700	0	10,715,730	6,124,073	69,700,336	-704,775	85,835,368
T4 4700	0	3,135,763	2,797,658	31,839,810	-627,746	37,145,484
S1 G16V250	0	10,664,818	5,487,130	96,223,600	-826,365	111,549,192
S2 G16V250	0	10,664,818	5,487,130	93,362,064	-826,365	108,687,664
S3 G16V250	0	10,636,742	5,466,459	88,824,416	-848,357	104,079,240
S4 G16V250	0	10,413,083	5,304,853	80,473,912	-1,020,295	95,171,552
S5 G16V250	0	8,226,510	4,642,764	63,792,324	-391,857	76,269,752

S6 G16V250	0	5,343,927	3,438,853	43,019,120	-339,876	51,462,024
S7 G16V250	0	2,228,162	1,935,529	23,245,570	-606,446	26,802,816
Converter	0	0	0	0	0	0
System	75,180,000	110,400,544	53,912,404	675,024,896	-16,369,757	898,148,224

Annualized Costs

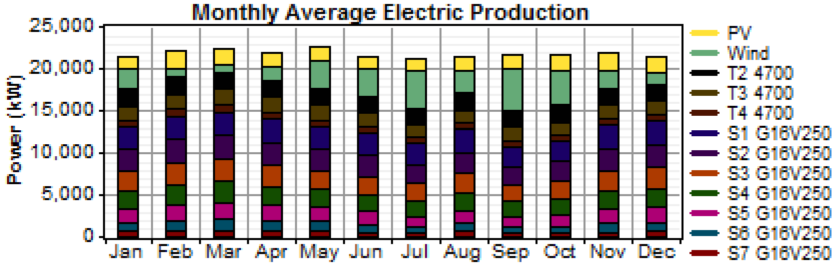
Component	Capital	Replacement	O&M	Fuel	Salvage	Total
	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)
PV	3,041,455	948,341	108,000	0	-531,492	3,566,304
GEV MP-C	2,839,630	947,903	346,500	0	-176,435	3,957,599
T2 4700	0	1,105,392	580,279	6,613,576	-88,239	8,211,007
T3 4700	0	838,256	479,066	5,452,429	-55,132	6,714,619
T4 4700	0	245,300	218,852	2,490,724	-49,106	2,905,769
S1 G16V250	0	834,274	429,240	7,527,256	-64,644	8,726,127
S2 G16V250	0	834,274	429,240	7,303,408	-64,644	8,502,279
S3 G16V250	0	832,077	427,623	6,948,443	-66,364	8,141,777
S4 G16V250	0	814,581	414,981	6,295,210	-79,814	7,444,958
S5 G16V250	0	643,533	363,188	4,990,264	-30,654	5,966,332
S6 G16V250	0	418,038	269,010	3,365,245	-26,587	4,025,705
S7 G16V250	0	174,302	151,410	1,818,425	-47,440	2,096,696
Converter	0	0	0	0	0	0
System	5,881,085	8,636,272	4,217,391	52,804,980	-1,280,552	70,259,184



Electrical

Component	Production	Fraction
	(kWh/yr)	
PV array	15,020,776	8%
Wind turbines	23,846,410	13%
T2 4700	17,600,316	9%
T3 4700	14,508,855	8%
T4 4700	6,628,074	3%
S1 G16V250	23,009,560	12%
S2 G16V250	22,159,968	12%

S3 G16V250	20,833,736	11%
S4 G16V250	18,518,396	10%
S5 G16V250	14,236,913	7%
S6 G16V250	9,289,893	5%
S7 G16V250	4,941,623	3%
Total	190,594,496	100%



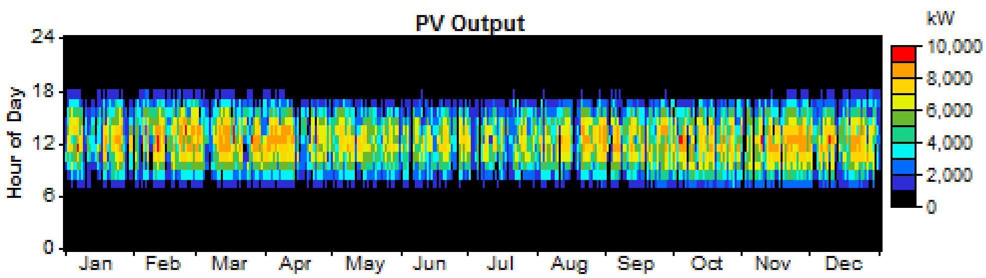
Load	Consumption (kWh/yr)	Fraction
AC primary load	188,963,872	100%
Total	188,963,872	100%

Quantity	Value	Units
Excess electricity	1,630,696	kWh/yr
Unmet load	1.01	kWh/yr
Capacity shortage	0.00	kWh/yr
Renewable fraction	0.197	

PV

Quantity	Value	Units
Rated capacity	10,800	kW
Mean output	1,715	kW
Mean output	41,153	kWh/d
Capacity factor	15.9	%
Total production	15,020,776	kWh/yr

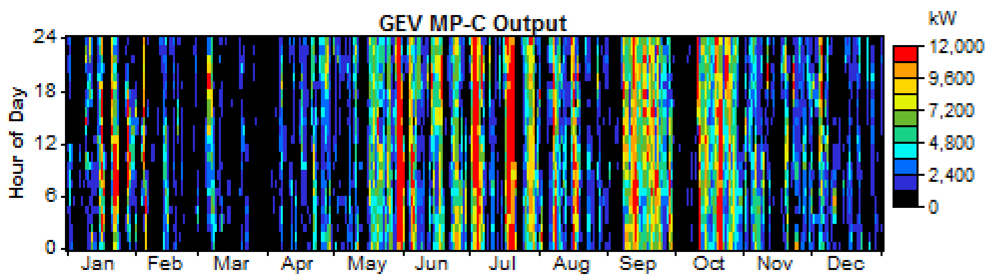
Quantity	Value	Units
Minimum output	0.00	kW
Maximum output	9,585	kW
PV penetration	7.95	%
Hours of operation	4,334	hr/yr
Levelized cost	0.237	$/kWh



AC Wind Turbine: GEV MP-C

Variable	Value	Units
Total rated capacity	11,275	kW
Mean output	2,722	kW
Capacity factor	24.1	%
Total production	23,846,410	kWh/yr

Variable	Value	Units
Minimum output	0.00	kW
Maximum output	11,275	kW
Wind penetration	12.6	%
Hours of operation	7,120	hr/yr
Levelized cost	0.166	$/kWh

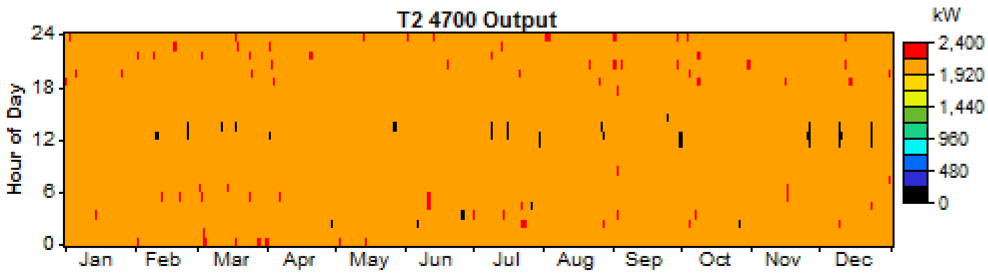


T2 4700

Quantity	Value	Units
Hours of operation	8,726	hr/yr
Number of starts	24	starts/yr
Operational life	5.73	yr
Capacity factor	52.9	%
Fixed generation cost	269	$/hr
Marginal generation cost	0.351	$/kWhyr

Quantity	Value	Units
Electrical production	17,600,316	kWh/yr
Mean electrical output	2,017	kW
Min. electrical output	2,014	kW
Max. electrical output	2,379	kW

Quantity	Value	Units
Fuel consumption	4,264,070	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	41,958,452	kWh/yr
Mean electrical efficiency	41.9	%

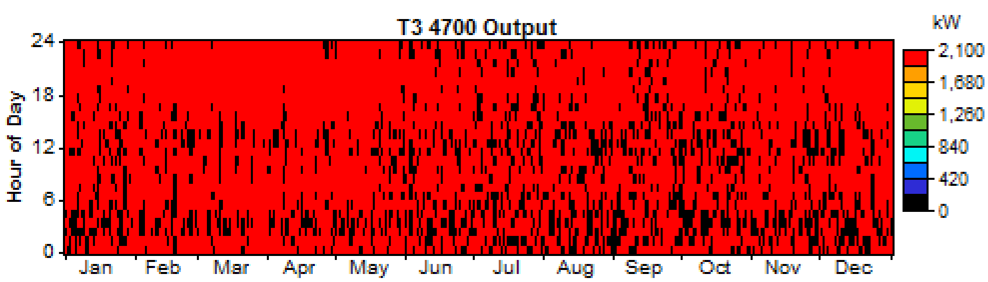


T3 4700

Quantity	Value	Units
Hours of operation	7,204	hr/yr
Number of starts	1,001	starts/yr
Operational life	6.94	yr
Capacity factor	43.6	%
Fixed generation cost	269	$/hr
Marginal generation cost	0.351	$/kWhyr

Quantity	Value	Units
Electrical production	14,508,855	kWh/yr
Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	3,515,426	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	34,591,792	kWh/yr
Mean electrical efficiency	41.9	%



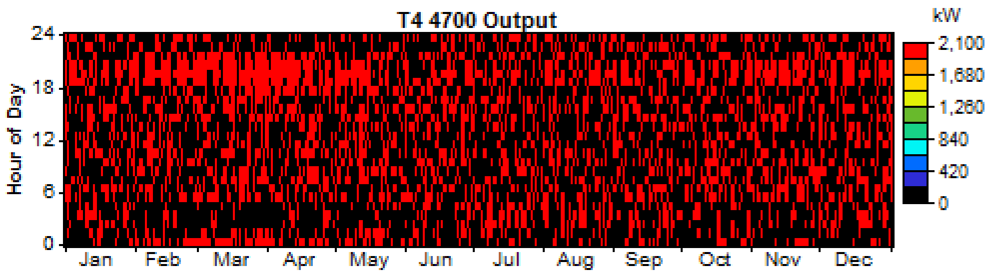
T4 4700

Quantity	Value	Units
Hours of operation	3,291	hr/yr
Number of starts	1,843	starts/yr
Operational life	15.2	yr
Capacity factor	19.9	%
Fixed generation cost	269	$/hr
Marginal generation cost	0.351	$/kWhyr

Quantity	Value	Units
Electrical production	6,628,074	kWh/yr

Mean electrical output	2,014	kW
Min. electrical output	2,014	kW
Max. electrical output	2,014	kW

Quantity	Value	Units
Fuel consumption	1,605,882	L/yr
Specific fuel consumption	0.242	L/kWh
Fuel energy input	15,801,878	kWh/yr
Mean electrical efficiency	41.9	%

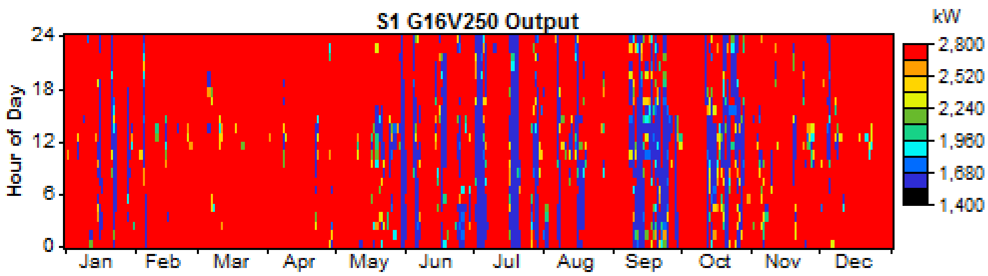


S1 G16V250

Quantity	Value	Units
Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	93.8	%
Fixed generation cost	330	$/hr
Marginal generation cost	0.264	$/kWhyr

Quantity	Value	Units
Electrical production	23,009,560	kWh/yr
Mean electrical output	2,627	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,853,161	L/yr
Specific fuel consumption	0.211	L/kWh
Fuel energy input	47,755,104	kWh/yr
Mean electrical efficiency	48.2	%



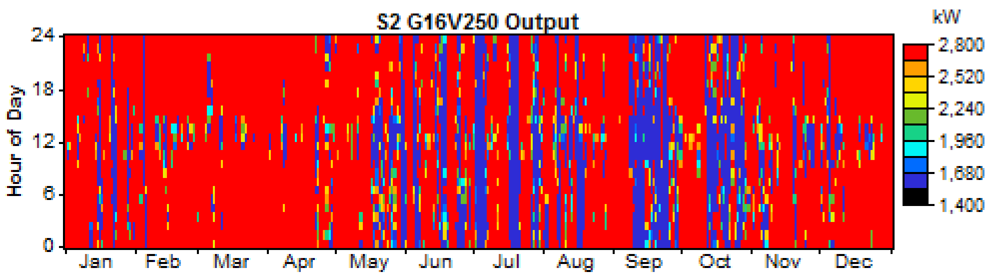
S2 G16V250

Quantity	Value	Units

Hours of operation	8,760	hr/yr
Number of starts	1	starts/yr
Operational life	5.71	yr
Capacity factor	90.3	%
Fixed generation cost	330	$/hr
Marginal generation cost	0.264	$/kWhyr

Quantity	Value	Units
Electrical production	22,159,968	kWh/yr
Mean electrical output	2,530	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,708,836	L/yr
Specific fuel consumption	0.212	L/kWh
Fuel energy input	46,334,952	kWh/yr
Mean electrical efficiency	47.8	%

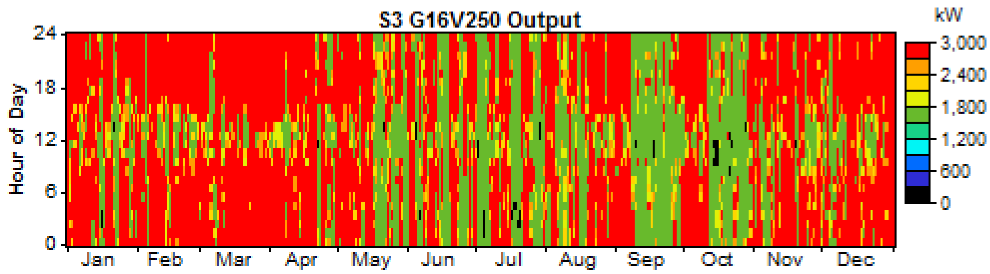


S3 G16V250

Quantity	Value	Units
Hours of operation	8,727	hr/yr
Number of starts	24	starts/yr
Operational life	5.73	yr
Capacity factor	84.9	%
Fixed generation cost	330	$/hr
Marginal generation cost	0.264	$/kWhyr

Quantity	Value	Units
Electrical production	20,833,736	kWh/yr
Mean electrical output	2,387	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,479,973	L/yr
Specific fuel consumption	0.215	L/kWh
Fuel energy input	44,082,940	kWh/yr
Mean electrical efficiency	47.3	%

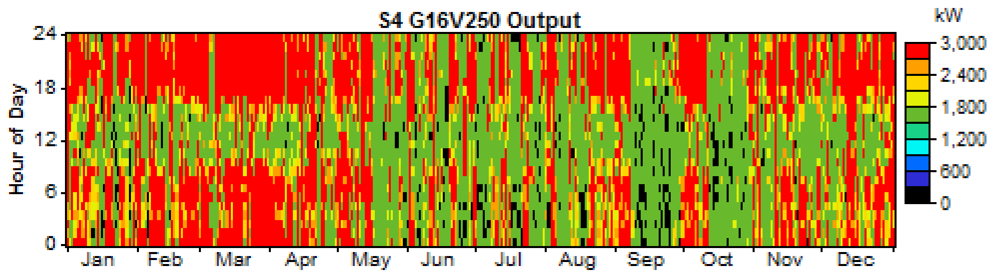


S4 G16V250

Quantity	Value	Units
Hours of operation	8,469	hr/yr
Number of starts	208	starts/yr
Operational life	5.90	yr
Capacity factor	75.5	%
Fixed generation cost	330	$/hr
Marginal generation cost	0.264	$/kWhyr

Quantity	Value	Units
Electrical production	18,518,396	kWh/yr
Mean electrical output	2,187	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	4,058,805	L/yr
Specific fuel consumption	0.219	L/kWh
Fuel energy input	39,938,648	kWh/yr
Mean electrical efficiency	46.4	%



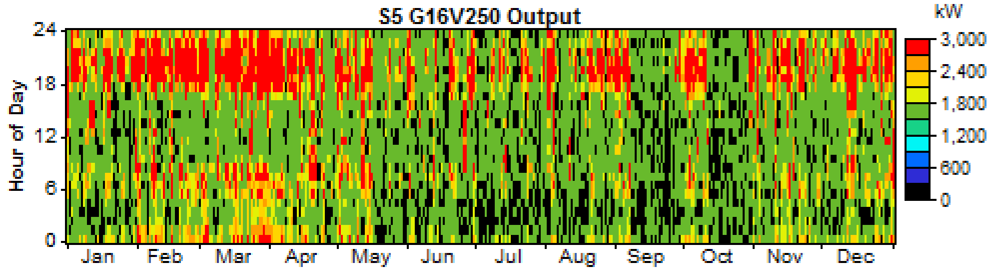
S5 G16V250

Quantity	Value	Units
Hours of operation	7,412	hr/yr
Number of starts	761	starts/yr
Operational life	6.75	yr
Capacity factor	58.0	%
Fixed generation cost	330	$/hr
Marginal generation cost	0.264	$/kWhyr

Quantity	Value	Units
Electrical production	14,236,913	kWh/yr

Mean electrical output	1,921	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	3,217,448	L/yr
Specific fuel consumption	0.226	L/kWh
Fuel energy input	31,659,694	kWh/yr
Mean electrical efficiency	45.0	%

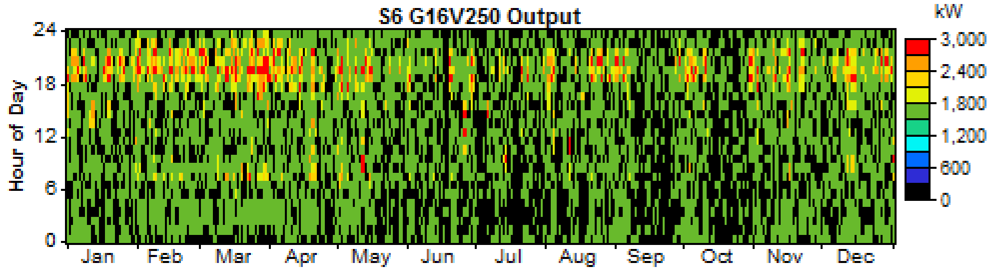


S6 G16V250

Quantity	Value	Units
Hours of operation	5,490	hr/yr
Number of starts	1,473	starts/yr
Operational life	9.11	yr
Capacity factor	37.9	%
Fixed generation cost	330	$/hr
Marginal generation cost	0.264	$/kWhyr

Quantity	Value	Units
Electrical production	9,289,893	kWh/yr
Mean electrical output	1,692	kW
Min. electrical output	1,596	kW
Max. electrical output	2,800	kW

Quantity	Value	Units
Fuel consumption	2,169,725	L/yr
Specific fuel consumption	0.234	L/kWh
Fuel energy input	21,350,094	kWh/yr
Mean electrical efficiency	43.5	%



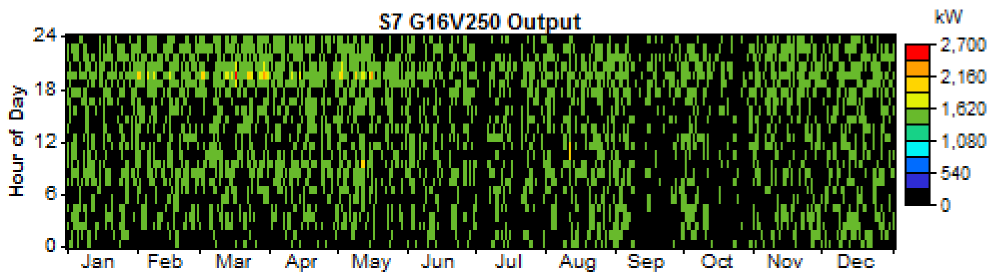
S7 G16V250

Quantity	Value	Units

Hours of operation	3,090	hr/yr
Number of starts	1,584	starts/yr
Operational life	16.2	yr
Capacity factor	20.1	%
Fixed generation cost	330	$/hr
Marginal generation cost	0.264	$/kWhyr

Quantity	Value	Units
Electrical production	4,941,623	kWh/yr
Mean electrical output	1,599	kW
Min. electrical output	1,596	kW
Max. electrical output	2,614	kW

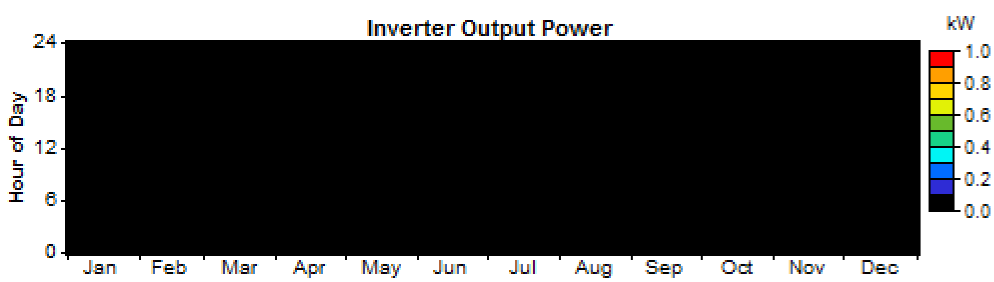
Quantity	Value	Units
Fuel consumption	1,172,420	L/yr
Specific fuel consumption	0.237	L/kWh
Fuel energy input	11,536,617	kWh/yr
Mean electrical efficiency	42.8	%

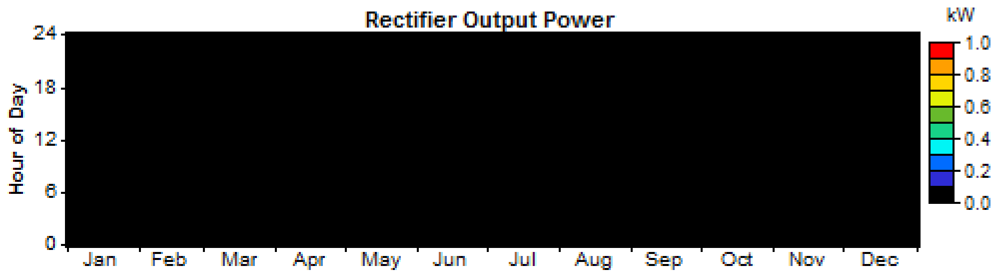


Converter

Quantity	Inverter	Rectifier	Units
Capacity	100,000,000	100,000,000	kW
Mean output	0	0	kW
Minimum output	0	0	kW
Maximum output	0	0	kW
Capacity factor	0.0	0.0	%

Quantity	Inverter	Rectifier	Units
Hours of operation	0	0	hrs/yr
Energy in	0	0	kWh/yr
Energy out	0	0	kWh/yr
Losses	0	0	kWh/yr





Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	89,653,656
Carbon monoxide	221,297
Unburned hydocarbons	24,513
Particulate matter	16,682
Sulfur dioxide	180,040
Nitrogen oxides	1,974,653

Appendix

B

275 kW Vergnet Wind Turbines

GEV MP C
275 kW

Wind with a vision

VERGNET
WIND TURBINES

GEV MP C
275 kW

32-m rotor
55/60-m height

Energy throughout the world

In remote locations, it is very difficult to install wind turbines. However, such sites often have the strongest need for a dependable, cost-effective and self-reliant source of energy – like wind energy.

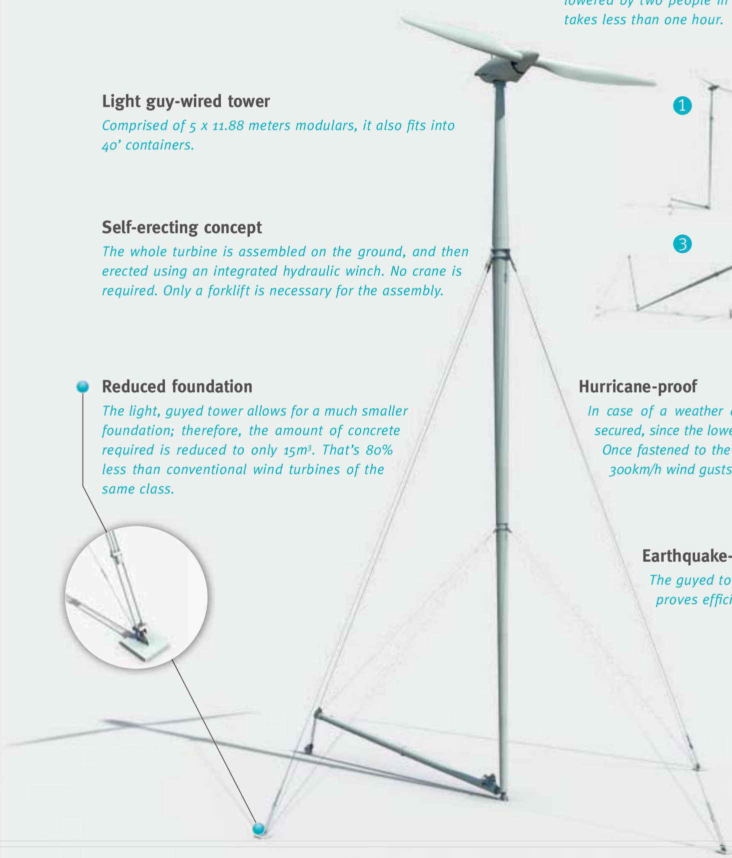
We at Vergnet took up this challenge. For more than 20 years we have been developing innovative, practical solutions to the specific concerns of all complex sites, either difficult to reach or subject to harsh conditions, such as hurricane-prone areas or salty environments.

Like all our Farwind® turbines, the GEV MP C is both robust and light. Thanks to its guy-wired tilting mast, it is very easy to transport and install anywhere in the world, and can sustain hurricane winds when secured to the ground.

The GEV MP C meets all the specific requirements of small grids and outperforms any turbine of its class. All these assets have transformed a technological breakthrough into a commercial success, with more than 350 GEV MP-type wind turbines running worldwide.

- Easy to transport
- Easy to install
- Ground-level maintenance
- Hurricane-proof
- Suited for the harshest conditions
- Robust and long-lasting
- High performance
- Remote supervision

A light, compact and versatile design



Lightweight structure

Despite being 55m tall, the GEV MP only weights 20 tons. It is twice as light as a conventional wind turbine for the same rated power.

Compact nacelle

Two nacelles can fit in a standard 20' container.

Light guy-wired tower

Comprised of 5 x 11.88 meters modulars, it also fits into 40' containers.

Self-erecting concept

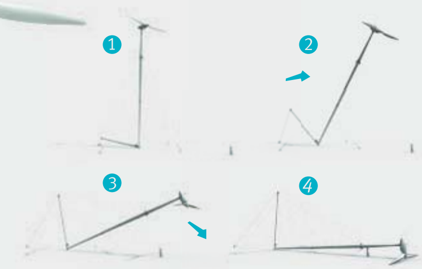
The whole turbine is assembled on the ground, and then erected using an integrated hydraulic winch. No crane is required. Only a forklift is necessary for the assembly.

Reduced foundation

The light, guyed tower allows for a much smaller foundation; therefore, the amount of concrete required is reduced to only 15m³. That's 80% less than conventional wind turbines of the same class.

2-blade rotor - Exclusive lowering system

Thanks to its 2-blade design, the GEV MP can be lowered to the ground for maintenance operations and blade cleaning. Using an integrated winch, the whole machine can be lowered by two people in an easy and safe operation that takes less than one hour.



Hurricane-proof

In case of a weather alert, any wind farm can be rapidly secured, since the lowering operation takes less than 1 hour. Once fastened to the ground, a GEV MP can sustain up to 300km/h wind gusts (a Category 5 hurricane).

Earthquake-proof

The guyed tower's adaptable architecture also proves efficient in areas prone to seismic activity.

Easy to tranport

Designed to fit in five 40' standard containers (blades excluded), the GEV MP can be shipped easily and cost-effectively. Standard trucks, unpaved roads, islands, hilly countries... We can reach any destination.

Easy to install

Thanks to its exclusive self-erecting concept, the GEV MP is astonishingly simple to install, and requires no crane.

Ground-level maintenance

All maintenance operations can be performed at ground level thanks to the lowering system, which drastically reduces maintenance costs, as well as downtime.

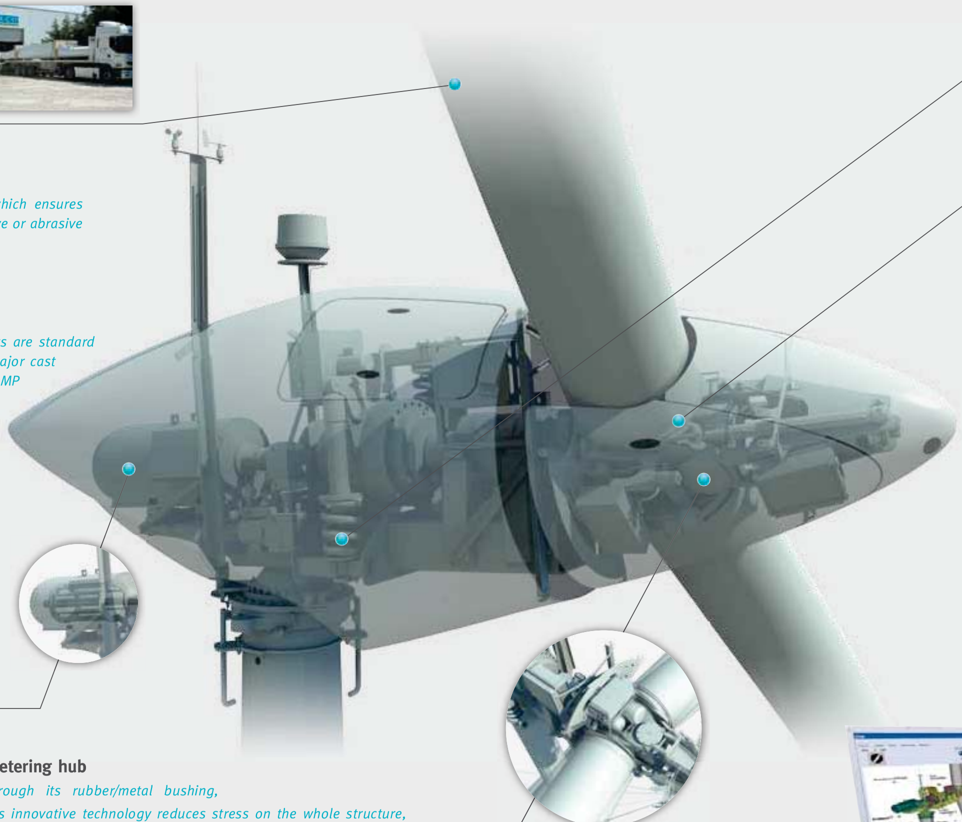
Hurricane-proof

The GEV MP can sustain up to Category 5 hurricane winds. This protection is recognized by our insurers.

An all-terrain wind turbine

Highly resistant blades

Our rotor blades feature an optimized design. They are manufactured in our own facilities using state-of-the-art methods: a vacuum infusion process, appropriate finish processes including gel coat, filler and edge protection, and disposable anti-abrasion strips.



Anti-corrosion treatment

The mast and all exposed parts are protected by a special coating, which ensures effective protection during the entire usage time even in wet, salty, corrosive or abrasive conditions.

Robust design

All parts of GEV MP are made from superior quality materials. Most parts are standard and widely used in many industries, which guarantees their reliability. Major cast components including rotor hubs are made of spheroidal cast iron. The GEV MP is designed to bear 365 grid outages per year, compared with 20 per year for conventional turbines.

All-terrain generator

The GEV MP features a robust and reliable squirrel-cage generator, supplied by a first-class specialist. It is designed to operate even in extreme weather conditions:

- *from -20°C to +50°C*
- *100% relative humidity*
- *marine environments (less than 100m from the seashore)*
- *IP 55 sealing protection*
- *specific tropical corrosion treatment of the stator and rotor, including stainless steel greasers, screws and fan cover*

Protected sensors

- *varnish coat on electronic components to withstand possible condensation*
- *High protection grade sealed connectors (up to IP 67)*
- *EMC immunity*

Teetering hub

Through its rubber/metal bushing, this innovative technology reduces stress on the whole structure, including the drive train and mast, by 35%. It thereby reduces maintenance costs and provides a longer turbine life.

Controlled power

Higher energy production even in hurricane-prone areas

Thanks to its unique lowering system, GEV MP can be installed in places where only reinforced class-1 conventional wind turbines previously could be installed. With a 32-meter rotor and a height of 55-meters, the 804m² rotor swept area maximizes wind potential.

Shock absorber

A mechanical shock absorber evenly adjusts the torque variations. This device reduces the stress on the drive train and helps produce a pure sine-wave signal.

Electrical pitch regulation

The pitch regulation, with hydraulic actuators, allows direct coupling to the grid and accurate setting of the power output. It also cancels any risk from excessive speed.

Safety systems

All the safety systems comply with international standards:

- *aerodynamic braking system through pitch regulation, including individual backup power units in case of supply failure*
- *safety rotor lock system to ensure safe service operations*
- *lightning protection*

INDUSTRIAL PLC

The PLC (Programmable Logical Controller) is sheltered in the electrical building. It constantly monitors all the necessary parameters:

- *Wind data (direction and speed)*
- *Wind turbine parameters (rotor speed, blade angle, yaw position, generator power output...)*

V-SCADA™

- *real-time production monitoring, either remote or on-site*
- *allows recovery from system failures directly from a remote computer or from Vergnet headquarters: no need to send a technician.*
- *records data and establishes statistics in graphical, user-friendly forms*
- *adapted to digital or analog telecommunications system (public phone wire)*
- *backup protection in case of a grid outage by a battery located in the electrical building*

Suited for the harshest conditions

Our 20 years of worldwide experience helped us design GEV MP as a real world traveler.
Perfectly protected from aggressive elements, including the most extreme weather conditions, it will provide trustworthy power production during its entire service life.

Robustness and reliability

A wind turbine must withstand unequalled loads and stresses, and endure even more hardships in hurricane-prone areas. Equipped with heavy-duty parts and efficient dampering technologies, GEV MP is astonishingly reliable, even in the windiest areas.

High performance

The whole GEV MP is designed to make the most of wind potential. At 55 meters high, the 32-meter rotor harnesses maximum wind energy. The pitch control, together with the regulation of torque variations, ensures high quality power production.

Remote supervision

As it is designed to be installed anywhere in the world, a GEV MP can be monitored and controlled remotely, using any telecommunications system available locally, even the lightest ones.

Eritrea

Trip to the end of the Earth at Assab

Sand storms, scorching heat, corrosive air, undeveloped logistics, unstable grids… In Eritrea, extreme conditions make it far from easy to install a wind farm. However, this country had a strong need for a cheap, self-reliant source of energy. Vergnet Eolien took up this challenge and installed a wind farm in Assab in 2007. Being easy to transport, to install and to operate, the GEV MP has turned out to be particularly reliable and high performing.

Guadeloupe

August 2007
GEV MP gets a jump on Hurricane Dean

In the Caribbean, Vergnet wind turbines rapidly turned out to be the market benchmark, as the only effective answer to hurricane hazards.

On August 16, 2007, while Hurricane Dean was approaching, local crews lowered the 216 wind turbines located in the Caribbean in record time: 14 hours. Among them, the 27 turbines of Guadeloupe, which were securely fastened to the ground, sustained more than 250 km/h wind gusts. Once Dean passed over the island, the wind farms quickly resumed production, maintaining availability rates above 95%.

Australia

Successfully combining wind and diesel energy

The Coral Bay wind farm perfectly demonstrates Vergnet's know-how regarding wind/diesel coupling and high penetration rate. Installed in a very isolated, cyclone-prone site, the farm includes three GEV MPs, which are coupled with seven low load diesel generators, with energy storage through flywheel. The complete wind farm supplies 95% of the local grid production, and offers up to a 90% penetration rate.

TURBINE CONCEPT

- 2-blade down wind rotor, two-speed generator
- Teetering hub with rubber/metal dampening
- Hydraulic pitch control

• Cut in wind speed	3.5 m/s
• Cut out wind speed	25 m/s
• Output Voltage & Frequency (3-phase)	400 V - 50 Hz or 460 V - 60 Hz
• **Class (as per IEC 61400-1): 1999**	**From class II to class IV**
• Hub height	55/60 m (180/197')
• Rotor diameter	32 m (105')
• Rotation speed *(50 & 60 Hz)*	31 to 46 rpm
• Max. wind speed - *m/s (average 10 mn)*	
Operating position	30 - 42,5 m/s
Lowered position	85 m/s

EXTREME CONDITION PROTECTION

• Corrosion	Marine anti-corrosion protection (C5)
• Generator tightness/insulation	IP55 / Class F
• Hurricane resistance	Lowering system
• Earthquake resistance	Flexible architecture (guyed tower) Multi-pole, shock-absorbent anchors
• Lightning protection	Fully-integrated lightning protection (IEC-61400-24) Lightning arrester on nacelle (IEC 62305/61643-12)
• Operating limits	From -10°C to +50°C (14°F to 122°F) • Cold weather package available (- 20°C/- 4° F)

PERFORMANCE DETAILS

• Gearbox	2-stage planetary gearbox
• Generator	2-speed, asynchronous, squirrel cage generator - rated power : 275 kW
• Grid connection	Power factor compensation Electrical cabinet including transformer at tower base
• Emergency and parking brake	Aerodynamic and disc on high speed shaft
• Yaw	Hydraulic active yaw, automatic cable untwisting

MAST

• Type	Guyed : Tubular or Lattice
• Sections	5 x 11,88m (5x39')
• Material	Galvanized steel
• Installation	Self-erection via hydraulic winch
• Anchors	Boreholes with steel rods cast in concrete

BLADES

• Material	Twisted vinylester reinforced with fiber glass

CONTROL COMMAND SYSTEM

• Automation control	Industrial automation Siemens through Profibus
• UPS (voltage outage)	56 Ah
• Remote supervision	V-SCADA™ / through RTC, radio, internet…

WEIGHT - DIMENSIONS (CLASS III)

• Nacelle with rotor	7 800 kg (17196 lb)
• Wind turbine mast	12 000 kg (26455 lb)
• Total packed volume	5x40' containers + blades (1 load)

MANUFACTURERS

• Blades	ACO (VERGNET)
• Blade design	AERODYN
• Gearbox	BONFIGLIOLI
• Generator	ABB

POWER CURVE

Wind speed (m/s) d=1.225kg/m³	Power curve (kW) 32m blades
2,5	0
3,0	0
3,5	0
4,0	3
4,5	10
5,0	18
5,5	27
6,0	36
6,5	47
7,0	58
7,5	78
8,0	98
8,5	119
9,0	141
9,5	164
10,0	189
10,5	215
11,0	243
11,5	262
12	275
Up to 25	275

PRODUCTION ESTIMATES

Hub height wind speed (m/s)	Annual gross production (MWh/year)
4	164
4,5	246
5	342
5,5	449
6	560
6,5	674
7	785
7,5	893
8	996
8,5	1092
9	1182

www.**vergnet**.com

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Appendix

C

Virtual Power Plant - DEMS

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Virtual Power Plants by Siemens

DEMS® – Decentralized Energy Management System

Key Challenges Drive Implementation of Demand Response & Virtual Power Plants

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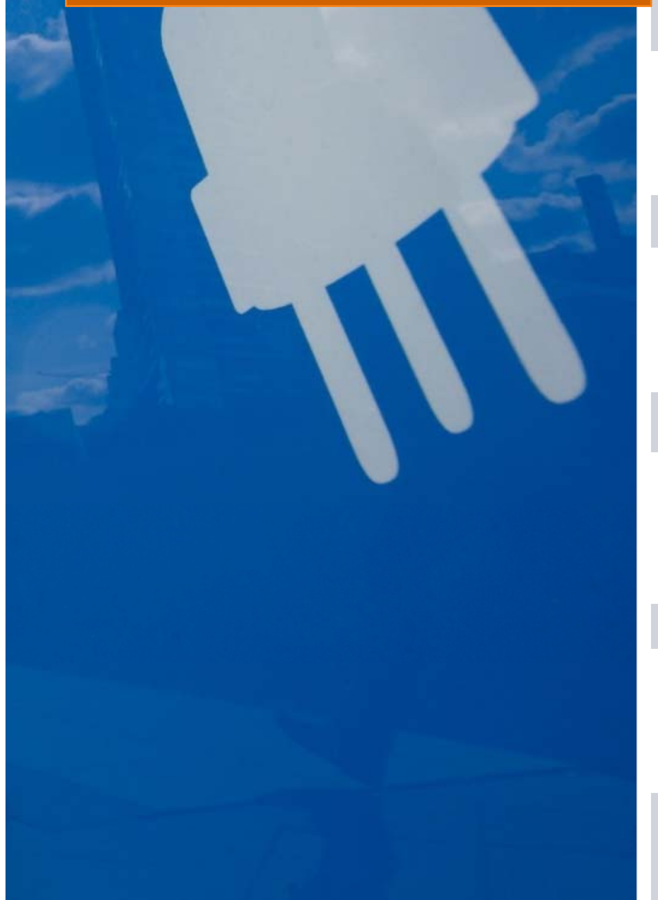

Trends

Generation & network bottlenecks

Increasing peak load prices

Increasing distributed & renewable generation

Rising consumption

Customer challenges

Generation & network capacity bottlenecks:
E.g. California, US

Increasing peak load prices:
E.g. Germany 6% in 2009

Dispatch load as most economic power supply:
Avoidance of generation & network bottlenecks and high peak load prices

Increased grid stability through emergency load shed & selective load dispatch

New market opportunities for distributed energy resources

Demand Response & Virtual Power Plant – Current Portfolio of Siemens Smart Grid

SIEMENS

Virtual Power Plant

Grid-specific Enterprise IT	Business analytics, IT integration
Operational IT	Demand response management system (DRMS) , decentralized energy management system (DEMS)
Information & Communication	Support of standard communication protocols like IEC 104 and OPC, etc. over public/private TCP/IP networks
Automation	Distributed energy resources (DER) controller
Field Equipment	DER controller, load controller
Smart Grid Services	Consulting, system installation & maintenance site enrollment & enablement

Integrated Solutions

Business consulting for identification & analysis of customer business models

Energy management system for monitoring, planning and optimized operation of DER, loads & storage

Fully automated demand response management system: DRMS platform for load aggregation and enablement

Forecasting system for consumption and renewable generation

Linking together a number of individual plants to be combined to form a large-scale virtual power plant

Optimized operation of decentralized energy resources, load & storage, enabling trading of energy flexibility at minimized risk.

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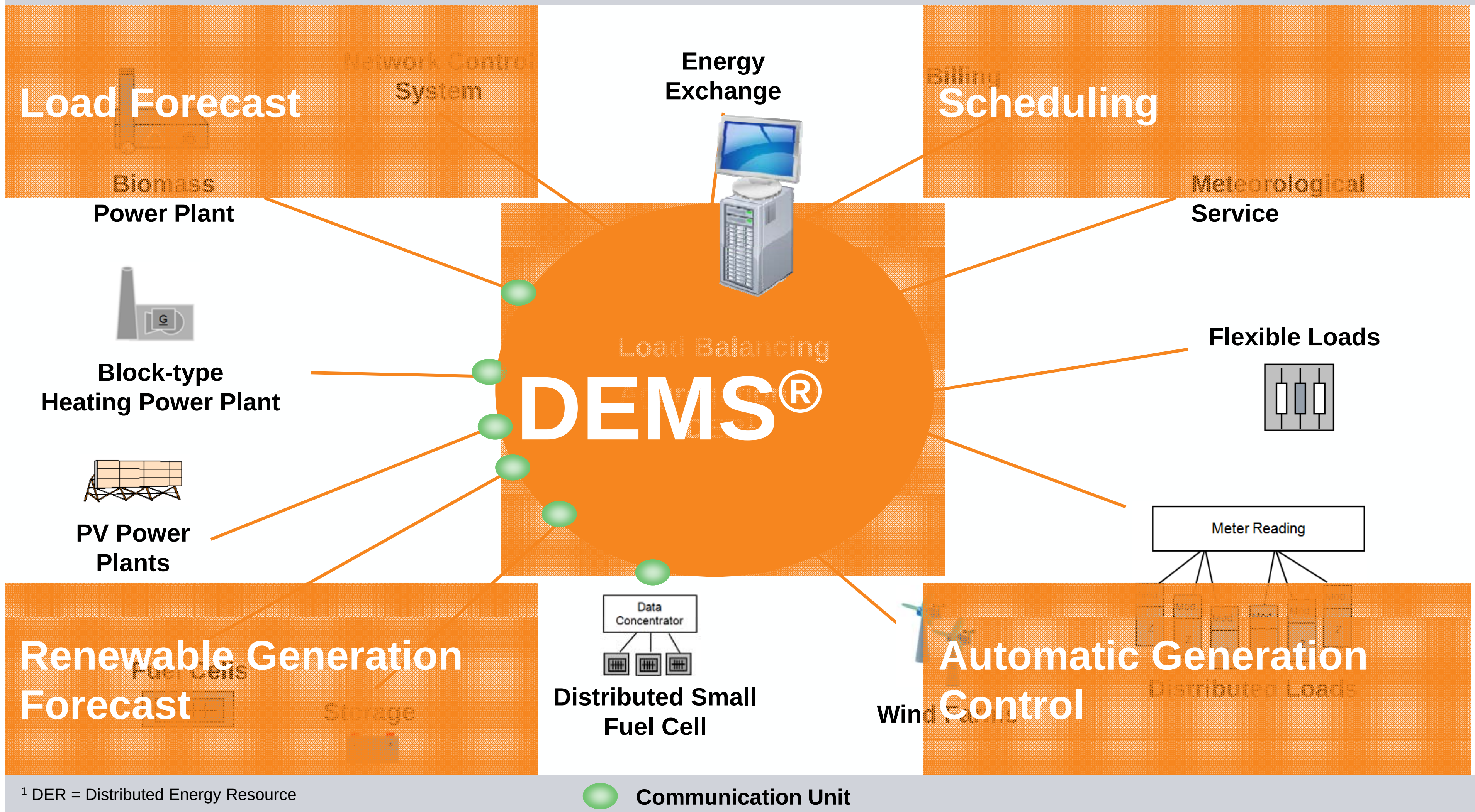
Virtual Power Plants

A Virtual Power Plant (VPP) is a cluster of distributed energy resources (generation, controllable loads and storages such as microCHP, wind-turbines, small hydro, back-up gensets, flexible loads, batteries etc.) which are collectively run by a central control entity.

Virtual Power Plants:
Technical Structure and Use Cases

SIEMENS



¹ DER = Distributed Energy Resource

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Three Main Target Groups for Customers for Virtual Power Plants

Use Case	Target Customers
Facilitate participation in energy trading/participate in markets for reserve capacity (day ahead and reserve markets)	Aggregators and utilities
To optimize of fleet management and ensure compliance with fleet schedule	Operators with larger generation units with - More than one generation source[1]/converter[2] and/or - Different modalities of energy (e.g. electricity, heat)
Economic optimization of energy costs	Industries and municipalities with their own - Generation source and/or - Load control - Storage[3]

[1]Including Boilers, turbines, CHP, fuel cells, renewables [2]Including compressors, chillers, electrolysis
[3]Including heat/cold storage, accumulators, e-cars

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DEMS® for Load Balancing

- Energy contracts
- Production plan
- Operator inputs
- Process control
- Quality information
- Field information
- Energy counter

DEMS®

Energy Data
- Acquisition
- Archiving
- Reporting
- Monitoring

Supply Monitoring
- Natural Gas
- Electricity

Load Forecast
- Electricity
- Steam
- Natural Gas

Optimization
- Unit Commitment
- Fuels
- Contracts

optimize resource utilization

optimize short-term purchasing on the market

optimize supply contracts

energy cost savings

$

DEMS® – Decentralized Energy Management System

DEMS® – Decentralized Energy Management System

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Forecast of Renewable Generation

Load Forecast

SCADA
(Supervisory Control and Data Acquisition)

User Interface

Archive

Automatic Generation Control

Scheduling

Communication

Reports

Market Interfaces

DEMS®

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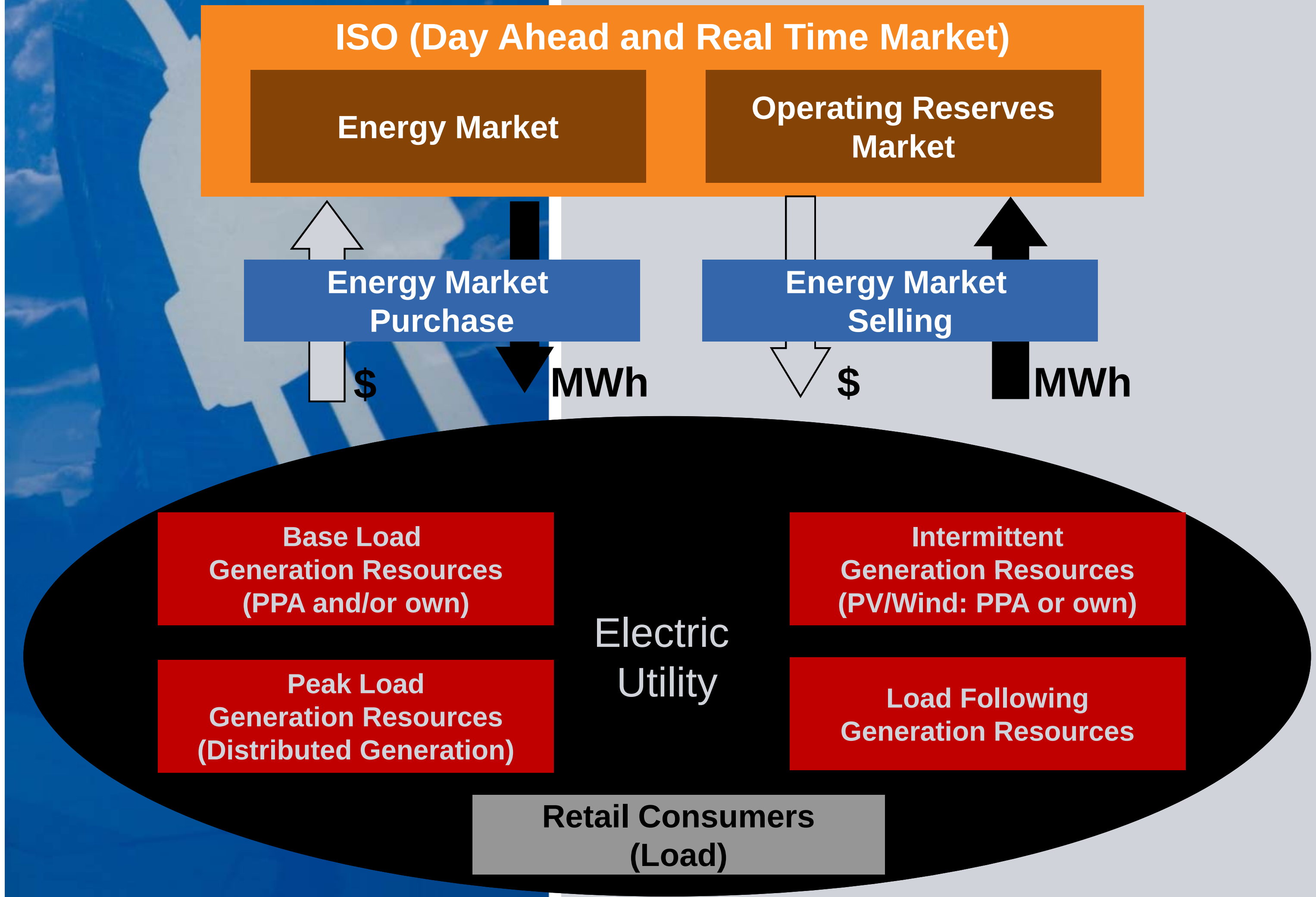
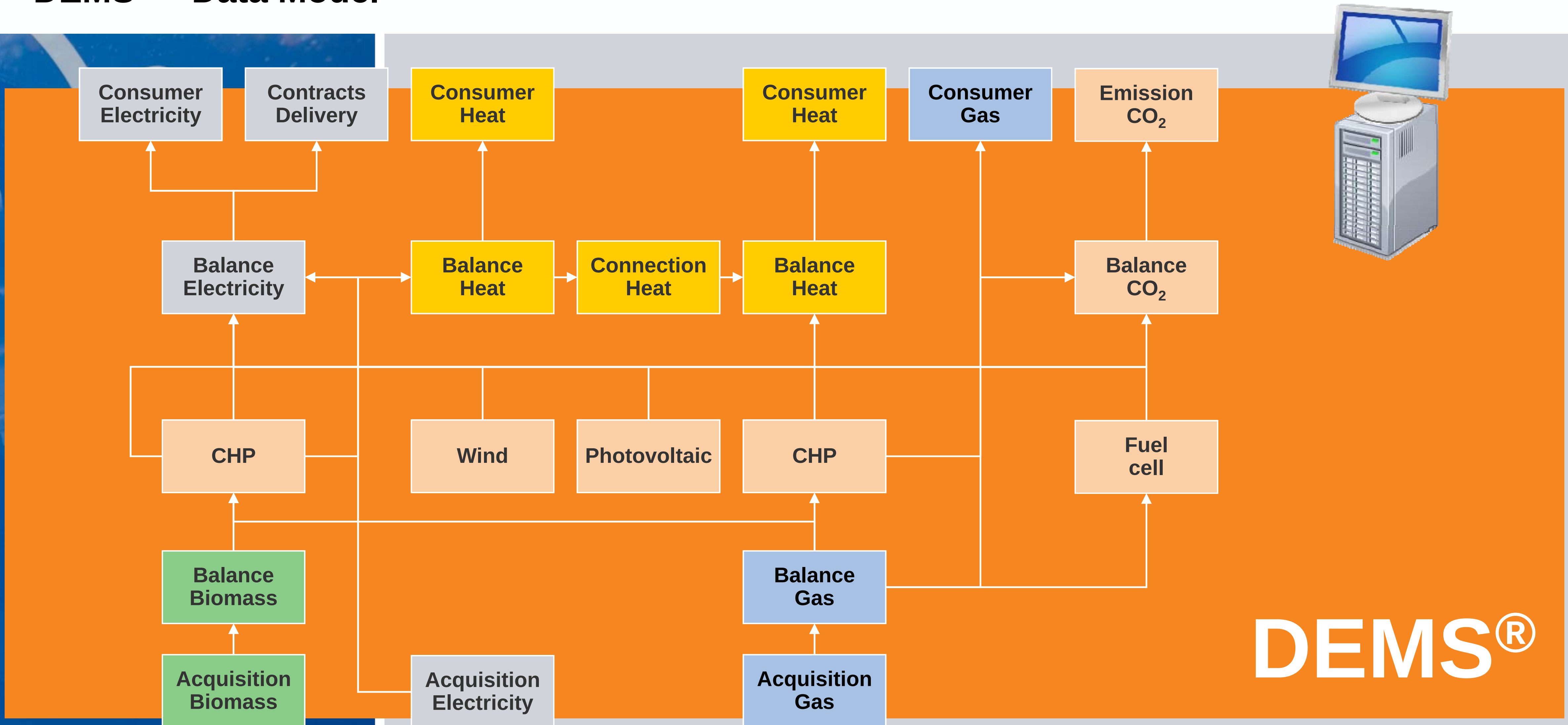
Virtual Power Plant Application for Electric Utilities



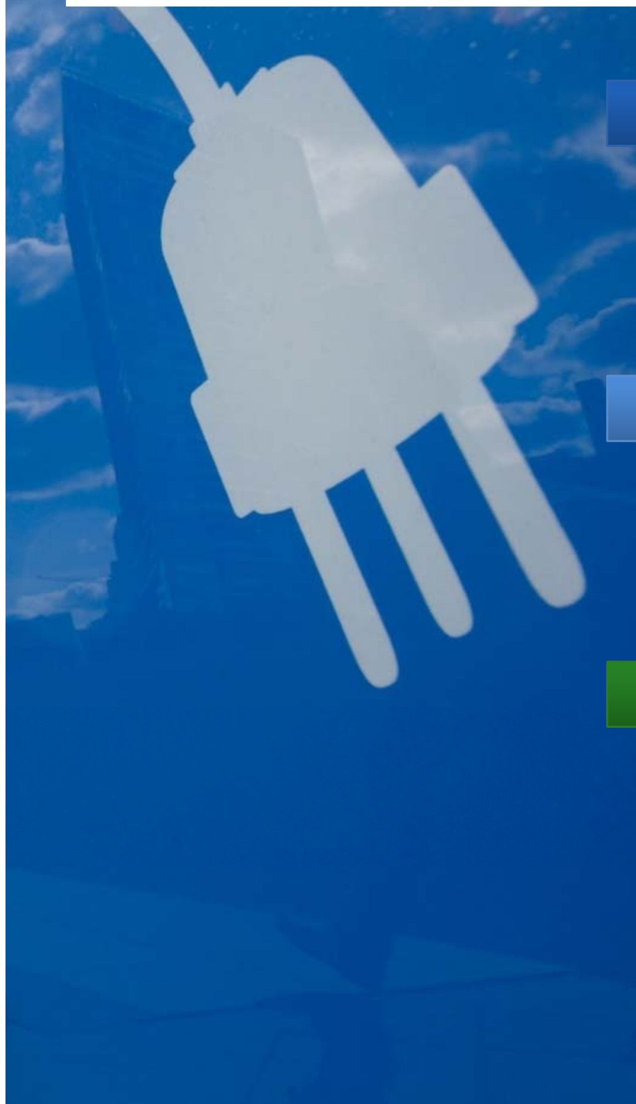
Optimization of Generation and Demand Portfolio

- Offer the delta generation (Gen – Load) to the Energy and Operating Reserves market (when load < PPA + DG). Aggregate and optimize the schedules of available generation during the bidding phase.
- Coordinate between participation in energy market and/or operating reserve market
- Maximize the benefit (Revenue – Cost): Cost of operating own generation (vs.) purchasing from energy market
- Curtailment of interruptible load as per the available load reduction programs

DEMS® – Data Model



DEMS® – Data Model



Energy / Media Purchase / Sales Contracts

- Primary energy consumption
- Bilateral electricity purchase / sales
- Energy markets (day ahead and reserve markets)

Energy / Media Demands

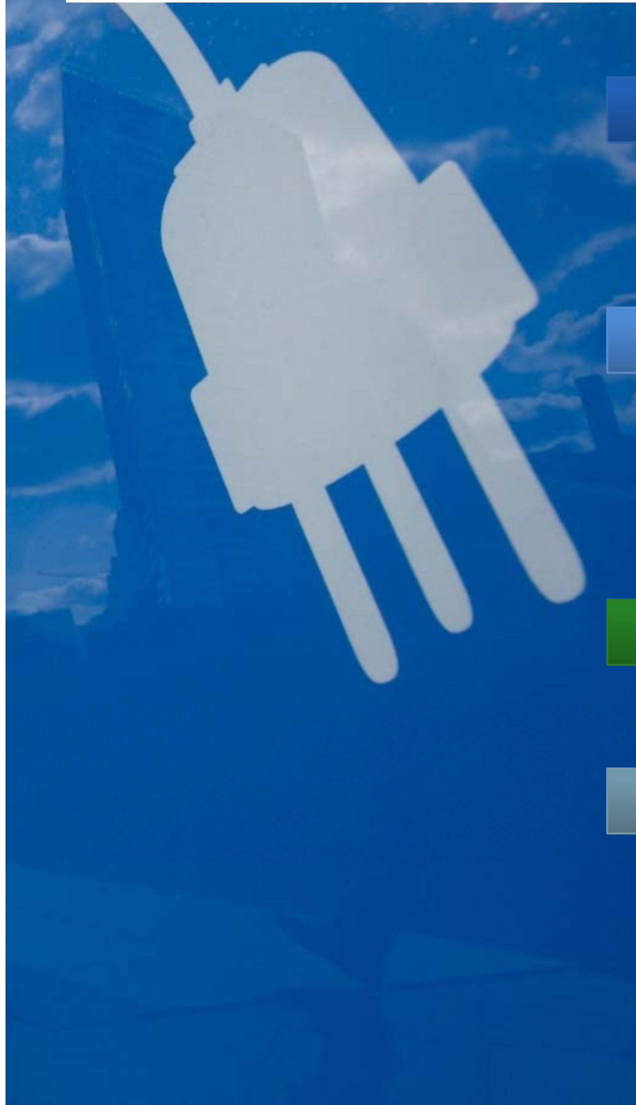
- Non-flexible loads
- Switchable loads
- Time controllable loads

Renewables

- Wind power
- Photovoltaic
- Small hydro power
- Solar thermal
- Geothermal

DEMS® – Data Model

SIEMENS



Energy / Media Converters

- Boilers, Turbines, CHP, Fuel Cells
- Compressors, Chillers, Electrolysis

Energy / Media Storages

- Heat / Cold Storage
- Accumulators, E-Cars
- Media Storage

Emissions

- CO_2, SOX, NOX, …

Electric system reserve consideration

- Forecast uncertainties
- Own reserve capacity
- Sellable reserve or imbalance risk

SIEMENS

DEMS® – Forecast Function

Multi Area Weather Forecast

- Import from meteorological service
- Refine imported forecasts with local online measurements

Load Forecast

- Forecast model: Day types, calendar, weather data, production schedules, trends
- Continuous self adapting model coefficient training
- Kalman filter allows dynamic, partly static or fully static forecast models
- Forecast uncertainty (bandwidth) calculation

Renewable Generation

- Plant characteristic (power as function of weather) is analyzed in offline step
- Forecast uncertainty (bandwidth) calculation

Time Grid:
15/30/60 Min.

Horizon: Up to
7 days ahead

DEMS® – Scheduling Functions

SIEMENS

Scheduling

- Cost / revenue optimized scheduling of all flexible resources
- Consideration of energy / media flow topology
- Consideration of:
  - Reserve / risk strategy
  - Technical constraints of all modeled elements
  - Environmental constraint of all modeled elements
  - Contractual constraints of all modeled elements
  - Fuel prices, contract prices and market options
  - Actual process status and operating point
- Includes DSM concepts already in the operations planning phase
- Problem solution algorithm MILP is used
- Calculation of
  - Power and commitment schedules
  - Regulation costs around the scheduled power base points

Time Grid:
15/30/60 Min.

Horizon: Up to
7 days ahead

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DEMS® – Online Functions

General

- Cycle Time: typically 1 Minute or lower

Multi Area Exchange Monitoring

- Supervision of electrical “interchange” of area
- Comparison with scheduled commitment for area
- Energy (15/30/60 Minutes interval) or flat power area regulation mode
- Minute reserve monitoring
- Reaction on market reserve call
- Calculation of required area power correction term

Online Optimization

- Distribution of required area power correction term to all objects in regulating mode
- Usage of storage, flexible demands and flexible generating units
- Preference for elements with lowest regulation costs calculated by the scheduling

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DEMS® – Online Functions

Generation Management

- Unit operation modes: Independent, Manual, Scheduled, Regulating
- Considering technical constraints of units
- Considering actual unit states (disturbed, on/off, local/remote control)
- Start / Stop command and set point control
- Supervision of unit command and set point following behavior
- Applicable to storages and generating units
- Including active and reactive power set points

Load Management

- Load operation modes: Independent, Scheduled, Regulating
- Prioritization of load classes via their regulating costs
- One load class (continuous model) has several load groups (discrete model)
- Rotational load switching of load groups of one load class for continuous regulation
- Consideration of
  - Actual load state (on/off, local remote, dead time)
  - Actual power when switching off
  - Nominal power & switching risk factor when switching on

Virtual Power Plant – RWE ProVipp
Aggregation of Generation + Minute Reserve Market

SIEMENS

Project partner: RWE
Country: Germany

Challenge

- Integration of multiple renewable energy resources
- Defining of various operation strategies
- Implementation of an optimal operation strategy for distributed generation

Solution

- Build up a virtual power plant integrating small hydro power plants, combined heat and power units, and emergency generators based on DEMS®
- DER*-Controller for innovative communication with DEMS®

Benefits

- Allows market access for distributed energy resources
- Increases the economical benefit of distributed energy resources
- Provides regulating energy to reserve markets

*DER = Distributed Energy Resource

Case Study ProViPP – Virtual Power Plant for RWE in Operation Since 31-Oct-2008

SIEMENS

Project partner: RWE
Country: Germany

DEMS – Decentralized Energy Management System

9 Small hydro units (8,6 MVA). Additional units will be connected in the next weeks

Project Focus: Development of a marketable Virtual Power Plant

Definition of business models in different energy markets

Definition and implementation of optimal operation strategies for distributed generation

Implementation of innovative communication concepts between distributed generation and DEMS

Stadtwerke München (SWM) – Start up Virtual Power Plant

SIEMENS

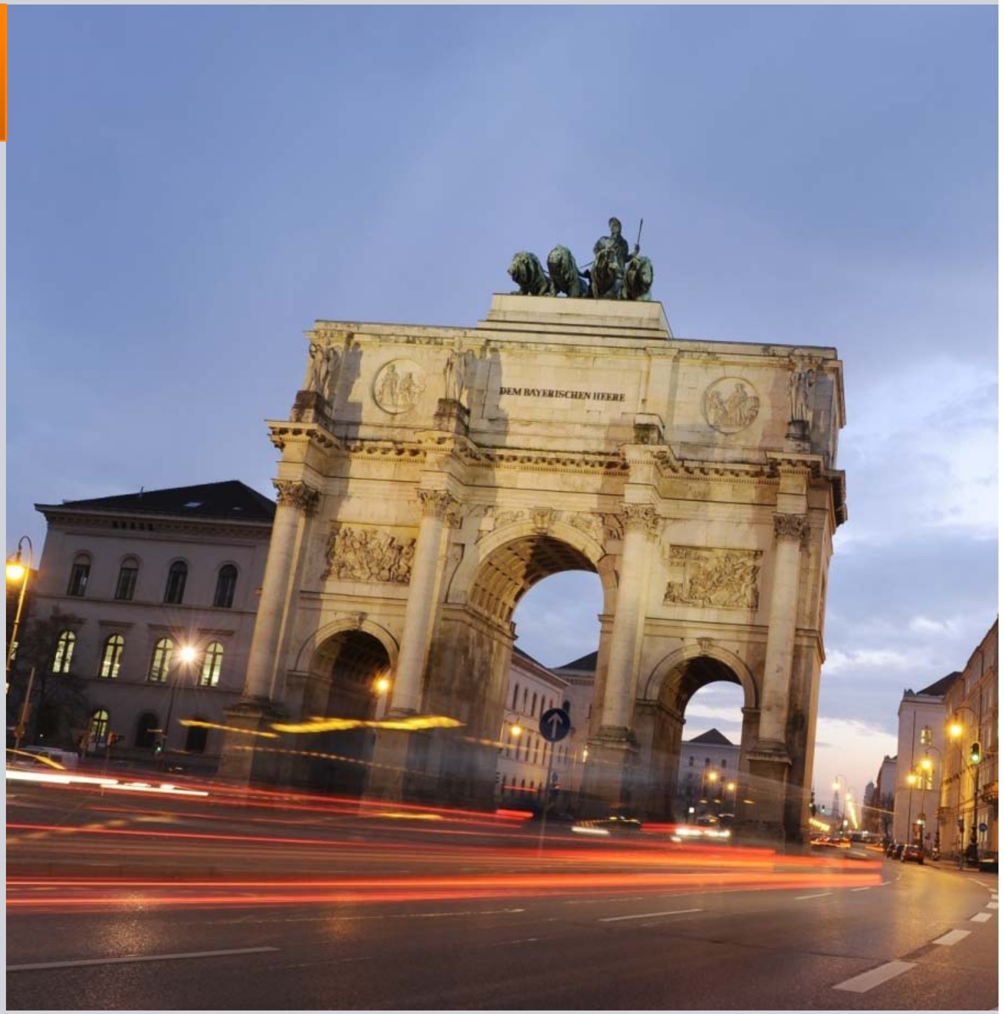
Stadtwerke München (SWM)

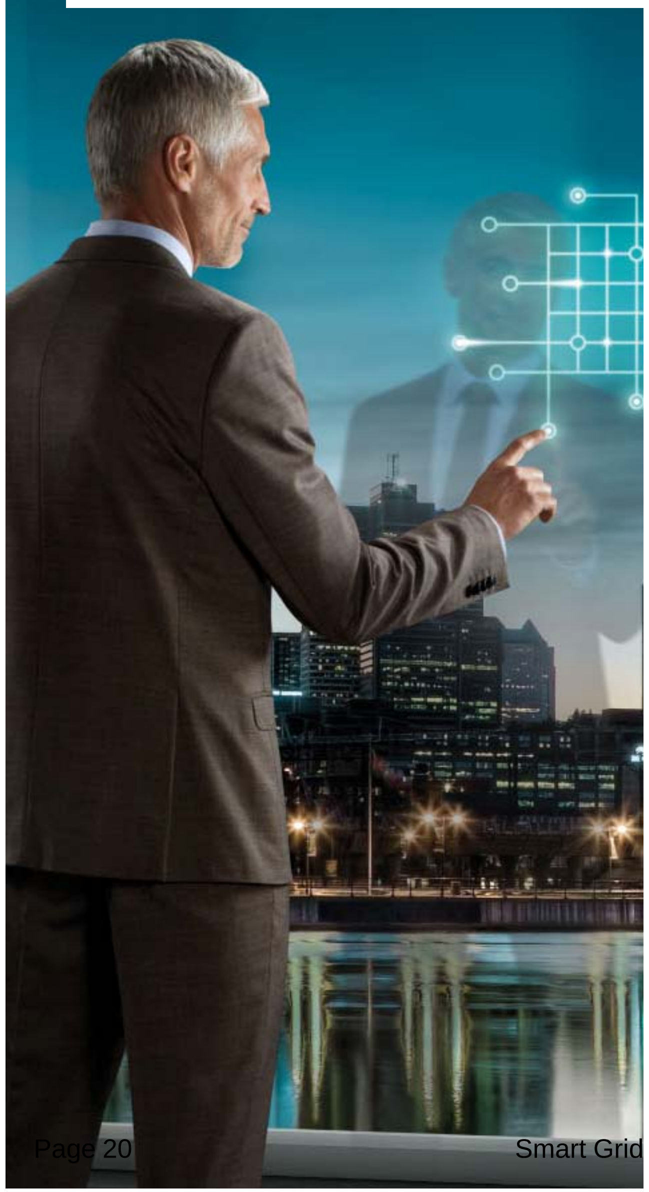
Key Features

- Integration of 6 unit-type cogeneration modules, 5 hydropower plants and 1 wind farm to form a virtual power plant
- Scope is the distributed energy management system DEMS
- Automated deployment and trading schedule based on exact usage and generation forecasts

Customer Benefits

- Opens up further marketing alternatives for distributed energy sources
- Minimization of generation and operational costs





Our Technology – Your Future

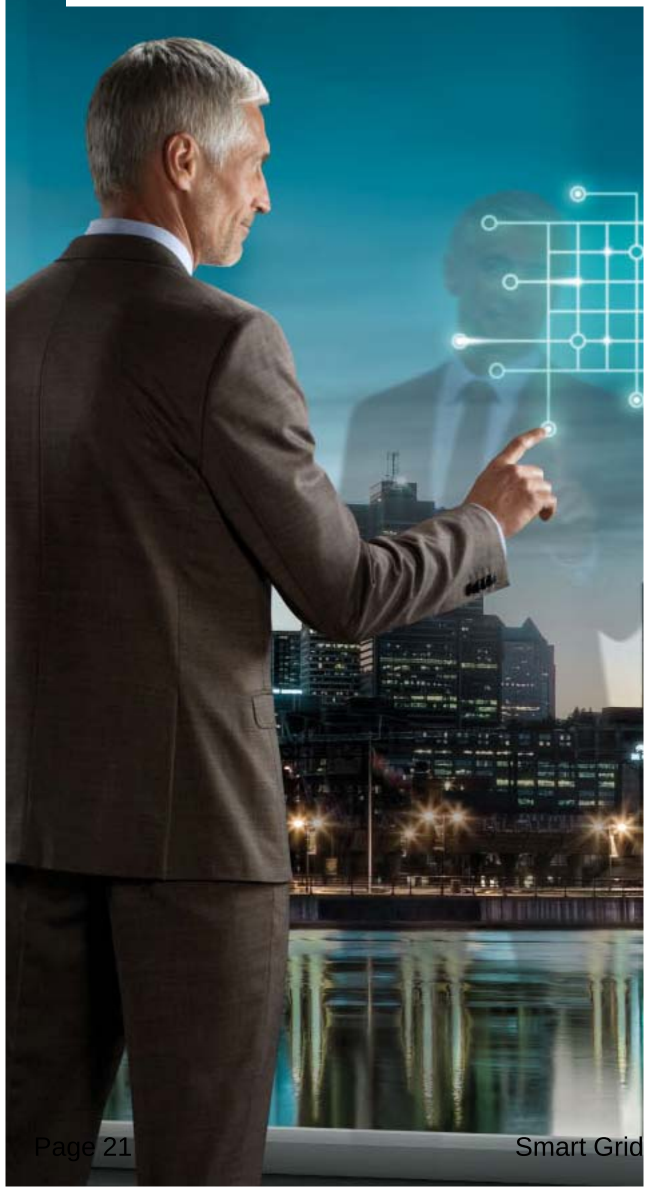
Already today, Siemens **DEMS®** and Siemens **DER-Controller** offer the technical basis for managing distributed energy systems.

Your Benefits:

- Use of synergies by aggregating distributed generation
- Achievement of remarkable economical and ecological benefits
- Obtaining new market opportunities for distributed generation
- Support of new operation concepts like virtual power plants

Create your future energy system with DEMS® !

10 Good Reasons for DEMS®



1 Comprehensive Modeling of power system elements

2 Intelligent forecasting and planning using advanced mathematical techniques

3 Integral consideration of all resources

4 Open interfaces for a seamless integration into the IT-environment

5 Workflow support to reduce operators’ workload

6 Preparation of a solid background for energy trading decisions

6 Simple real-time operation

8 Clear, straightforward operation

9 Scalable system

10 Decentralized power generation with the character of a power plant

Ten reasons for a smart grid with DEMS

DEMS offers intelligent solutions for central control of decentralized systems for power supply companies, industrial companies, operators of functional buildings, energy self-sustaining municipalities and regions, as well as energy service providers in deregulated markets.

1 **Everything under control with three components**
Energy optimization with DEMS makes use of three tools which are interlinked in a smart network. This helps you save money directly in two respects: through energy efficiency, and through reduced costs for energy optimization.

2 **Intelligent forecasting and planning**
With the planning component, DEMS automatically delivers forecasts for renewable power generation and consumption. On the basis of these forecasts, you can draw up the time schedules for the decentralized generation plants. In this way, you can optimize dispatch for the following day or following week

3 **Simple real-time optimization**
You can use the system operation component via a process coupling to monitor adherence to the time schedule you have drawn up for your decentralized energy park. DEMS compensates optimally for any unforeseen deviations in, for example, renewable power generation or loads.

4 **Integral consideration of all resources**
DEMS takes into account the interconnections between electricity, thermal and cooling energy, gas, and other energy sources, as well as DSM concepts. Decentralized power generation is used with minimized operating costs and at the same time helps to significantly reduce environmental pollution and the depletion of resources; for instance, you can achieve a significant reduction in CO_2 emissions.

5 **Decentralized power generation with the character of a power plant**
Intelligent control of your assets allows you to react flexibly to changes in demand. That offers an approach for the fluctuating supply of electricity from renewable sources, such as wind and sun, for example using combined heat/cold and power plant with heat storage.

6 **Modular range of functions**
You have a uniform product family with modular structures to choose from – from forecast and planning to real-time optimization. We can configure the range of functions incorporated in DEMS in accordance with your needs.

7 **Scalable system**
Combining several DEMS systems permits large-scale utilization of decentralized power supply concepts. In the case of small-scale distributed generating units – for example, small domestic cogeneration systems – a concentrator allows grouping in accordance to similarity of equipment/ application and network topology factors.

8 **Windows-based software**
The software is based on Windows standards. The operator control and visualization functions are based on the Windows-oriented Siemens product, WinCC. With DEMS, you willthus be using proven software technology that is known all over the world.

9 **Comprehensive mapping of units**
The Decentralized Energy Management System handles
- Contracts for power import and export (electricity, primary energy, reserves).
- Controllable, switchable, and noncontrollable loads (electric, thermal, gas).
- Power plants – for example, biomass cogeneration plants, wind turbines, and photovoltaic systems.
- Electric and thermal storage.

10 **Clear, straightforward operation**
Standardized Excel files facilitate the importing of equipment data into the system.

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Decentralized Energy Management System DEMS

The intelligent way to manage decentralized generation and virtual power plants

Answers for energy.

SIEMENS

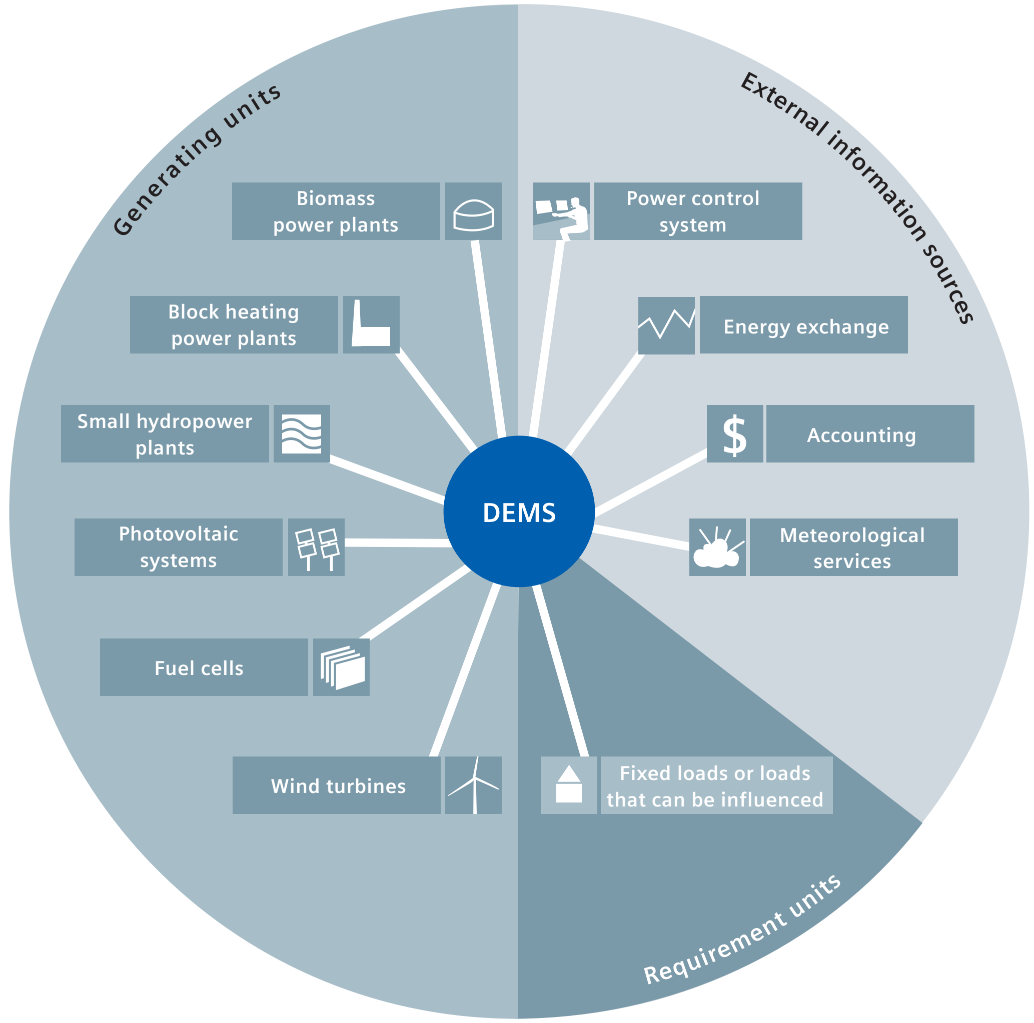
Intelligent integration of decentralized energy supply structures

Prepared for change in the power supply
Over the next few years the number of decentralized generating units – such as wind, photovoltaic, fuel-cell, biomass, and block heating power plants – will increase sharply. The reasons for this include the efforts to reduce environmental pollution and the depletion of resources, and to increase energy efficiency; as well as deregulation and liberalization of the market. With DEMS you can network these decentralized generating units in a smart grid, control them centrally, and optimize their use both economically and ecologically.

Fully exploiting the potential of virtual power plants
Linking together a number of individual plants requires state-of-the-art information and communication technology. With DEMS® from Siemens, distributed power generating units can be combined to form a large-scale virtual power plant. The system uses all important information, such as weather forecasts, current electricity prices, and the energy demands. This data forms the basis for drawing up and monitoring a generally optimized dispatch plan.

DEMS as the "brain" of a decentralized generator park

Interfaces to possible components and participating systems for optimizing energy import, contract management, and online optimization:



Up-to-date forecasts for optimum scheduling

Forecasting
Electrical and thermal loads are typically forecast as a function of the type of day (work day or weekend, for example) and time of day. The forecast of renewable energy generation is also important, and is based on the weather forecast and the characteristics of the power plants. With parameterizable forecast bandwidth, you can determine the reserve and risk strategies for plant operation in advance. Depending on the confidence intervals selected, the width of the forecasting band varies, and, accordingly, so does the amount of reserve power to be kept aside.

Planning
Short-term scheduling for all the configured units is carried out in order to minimize the costs of power generation and operation in accordance with the general technical conditions and terms of the contracts. This is done in a 15-minute time grid for a maximum of a week in advance. The calculated dispatch plan minimizes generation and operating costs. Naturally, DEMS takes both economic and ecological factors into consideration.

The optimized dispatch plan for thermal power plants takes into account power-up costs, maximum output ramps, minimum operating and shutdown times, fuel quantity limits, and energy limits, as well as time-dependent fuel prices.

With regard to energy demands, equipment dispatch planning differentiates between three types of loads: independent loads, switchable loads, and controllable loads. Storage systems are managed according to specific requirements.

Also taken into account are complex energy-supply and energy-purchase contracts with power-zoned energy prices, time-dependent tariff structures, power bands, and energy limits.

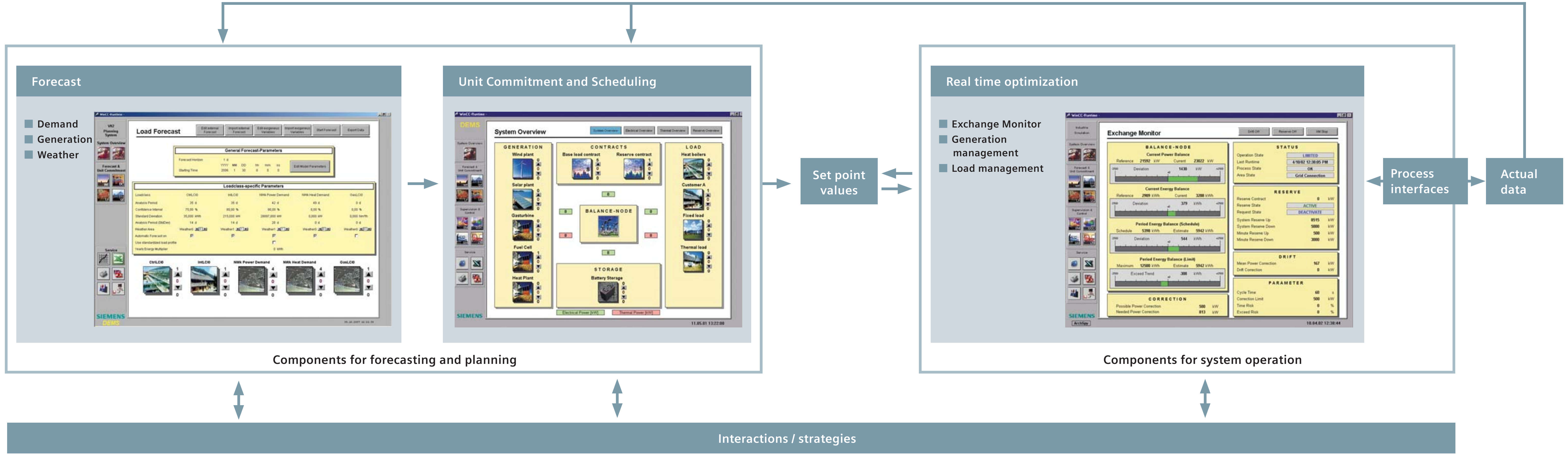
Annual dispatch planning is based on the daily and weekly dispatch planning of model days, thus enabling analysis of economic efficiency and potential. This is helpful when considering the construction, expansion, or modernization of equipment, or even new long-term contracts.

Powerful communication for real-time optimization

Real-time optimization
Based on the dispatch plan, any deviations that occur during operation are distributed cyclically at minimum cost among generators, storage systems, and loads, which can be influenced so that the planned value can be met. In this way, any external stipulations relating to import, supply, or corresponding contracts are fulfilled.

Process connection
DEMS is connected to the processes using the Siemens automation system WinCC, and is thus compatible with the SIMATIC world. The functions of operator control and visualization, as well as customer-specific additions, can thus be implemented without difficulty. Real-time data is exchanged with secondary automation systems via the SIMATIC communications world, OPC, and XML. Relevant data are saved manually or automatically while DEMS is being run.

Communication
Standardized data interfaces based on TCP/IP, such as Web-based XML, are used for the exchange of individual values and sequences of values between DEMS and the components involved. Since communication takes place via LAN or WAN, GPRS, bus systems, or ISDN lines, you can continue to use your existing communications infrastructure.



Appendix

D

Short Circuit Results

3-Ph Fault

Node	Network Level	Vk [kV]	idc [kA]	Zr [Ohm]	Zi [Ohm]	Za [Ohm]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	I PF15 [kA]	I PF20 [kA]	I PF30 [kA]	I PF50 [kA]	I sym 2 [kA]	I sym 3 [kA]	I sym 5 [kA]	I sym 8 [kA]	I tot 2 [kA]	I tot 3 [kA]	I tot 5 [kA]	I tot 8 [kA]
N5	13 kV	13.2	16.28071	0.130195	0.649066	0.661995	11.5122	-78.6577	4.985344	263.2043	11.49966	-79.1453	5.215115	262.9175	14.41151	24.95025	10.82643	11.5577	12.73445	14.06657	11.79308	11.79308	11.79308	11.79308	12.74098	11.79308	11.79308	11.79308
Satala 35 k	35 kV	34.5	4.190864	1.56497	6.536834	6.721557	2.963389	-76.5363	4.17697	177.0795	2.958412	-77.5322	4.52272	176.7821	3.561458	6.166291	2.675491	2.856207	3.147012	3.476214	3.007556	3.007556	3.007556	3.007556	3.197236	3.007556	3.007556	3.007556
N7	13 kV	13.2	16.23788	0.153931	0.645645	0.663742	11.48192	-76.5902	4.194373	262.5118	11.40874	-78.2176	4.794083	260.8388	13.81247	23.91577	10.37641	11.07728	12.20512	13.48187	12.01434	12.01434	12.01434	12.01434	12.85357	12.01434	12.01434	12.01434
N8	35 kV	34.5	4.214532	1.600808	6.489279	6.683811	2.980124	-76.1427	4.053753	178.0795	2.964186	-77.2684	4.425957	177.1271	3.556862	6.156214	2.672039	2.852521	3.142951	3.471728	2.964381	2.964381	2.964381	2.964381	3.144167	2.964381	2.964381	2.964381
N9	13 kV	13.2	16.22972	0.154023	0.645967	0.664075	11.47615	-76.589	4.193973	262.3799	11.40302	-78.2162	4.7935	260.708	13.80523	23.90321	10.37097	11.07147	12.19872	13.4748	11.25051	11.25051	11.25051	11.25051	12.03622	11.25051	11.25051	11.25051
N10	13 kV	13.2	16.22972	0.154023	0.645967	0.664075	11.47615	-76.589	4.193973	262.3799	11.40302	-78.2162	4.7935	260.708	13.80523	23.90321	10.37097	11.07147	12.19872	13.4748	11.25051	11.25051	11.25051	11.25051	12.03622	11.25051	11.25051	11.25051
N17	13 kV	13.2	16.22972	0.154023	0.645967	0.664075	11.47615	-76.589	4.193973	262.3799	11.40302	-78.2162	4.7935	260.708	13.80523	23.90321	10.37097	11.07147	12.19872	13.4748	11.25051	11.25051	11.25051	11.25051	12.03622	11.25051	11.25051	11.25051
N19	13 kV	13.2	16.2714	0.130281	0.649435	0.662374	11.50562	-78.6567	4.984881	263.0538	11.49308	-79.1442	5.214594	262.7672	14.40297	24.93548	10.82001	11.55084	12.7269	14.05823	11.51478	11.51478	11.51478	11.51478	12.44017	11.51478	11.51478	11.51478
N20	13 kV	13.2	16.2714	0.130281	0.649435	0.662374	11.50562	-78.6567	4.984881	263.0538	11.49308	-79.1442	5.214594	262.7672	14.40297	24.93548	10.82001	11.55084	12.7269	14.05823	11.51478	11.51478	11.51478	11.51478	12.44017	11.51478	11.51478	11.51478
N21	13 kV	13.2	16.27149	0.130286	0.649431	0.66237	11.50568	-78.6562	4.98467	263.0552	11.49315	-79.1437	5.214362	262.7686	14.40291	24.93538	10.81996	11.5508	12.72684	14.05817	11.35959	11.35959	11.35959	11.35959	12.27244	11.35959	11.35959	11.35959
N22	13 kV	13.2	16.27149	0.130286	0.649431	0.66237	11.50568	-78.6562	4.98467	263.0552	11.49315	-79.1437	5.214362	262.7686	14.40291	24.93538	10.81996	11.5508	12.72684	14.05817	11.35959	11.35959	11.35959	11.35959	12.27244	11.35959	11.35959	11.35959
N23	13 kV	13.2	16.27149	0.130286	0.649431	0.66237	11.50568	-78.6562	4.98467	263.0552	11.49315	-79.1437	5.214362	262.7686	14.40291	24.93538	10.81996	11.5508	12.72684	14.05817	11.35959	11.35959	11.35959	11.35959	12.27244	11.35959	11.35959	11.35959
N24	13 kV	13.2	16.27149	0.130286	0.649431	0.66237	11.50568	-78.6562	4.98467	263.0552	11.49315	-79.1437	5.214362	262.7686	14.40291	24.93538	10.81996	11.5508	12.72684	14.05817	11.35959	11.35959	11.35959	11.35959	12.27244	11.35959	11.35959	11.35959
N25	13 kV	13.2	16.27152	0.130271	0.649433	0.662369	11.5057	-78.6574	4.985229	263.0556	11.49317	-79.145	5.214973	262.7691	14.4033	24.93603	10.82026	11.55111	12.72719	14.05855	11.27406	11.27406	11.27406	11.27406	12.1802	11.27406	11.27406	11.27406
N2	13 kV	13.2	16.23788	0.153931	0.645645	0.663742	11.48192	-76.5902	4.194373	262.5118	11.40874	-78.2176	4.794083	260.8388	13.81247	23.91577	10.37641	11.07728	12.20512	13.48187	12.01434	12.01434	12.01434	12.01434	12.85357	12.01434	12.01434	12.01434
N4	13 kV	13.2	8.863709	0.629283	1.040441	1.215942	6.267589	-58.8335	1.653374	143.2963	6.17527	-60.8493	1.792909	141.1856	6.406235	10.1893	4.812587	5.137652	5.660743	6.2529	6.105544	6.105544	6.105544	6.105544	6.186229	6.105544	6.105544	6.105544
N5	13 kV	13.2	5.790995	1.130986	1.478056	1.861123	4.094852	-52.5773	1.306874	93.62089	4.028702	-54.6526	1.409878	92.1085	4.128155	6.314299	3.101213	3.310684	3.647762	4.029346	4.008343	4.008343	4.008343	4.008343	4.035725	4.008343	4.008343	4.008343
N6	13 kV	13.2	5.529939	1.23663	1.506413	1.948983	3.910257	-50.6171	1.218161	89.40049	3.847035	-52.6926	1.312334	87.95504	3.932691	5.949398	2.954374	3.153927	3.475044	3.838561	3.845936	3.845936	3.845936	3.845936	3.865957	3.845936	3.845936	3.845936
N7	13 kV	13.2	5.050728	1.339356	1.661223	2.133901	3.571404	-51.1226	1.240315	81.65326	3.51373	-53.1932	1.336398	80.33465	3.593865	5.451899	2.699836	2.882196	3.175648	3.507845	3.51373	3.51373	3.51373	3.51373	3.53343	3.51373	3.51373	3.51373
N8	13 kV	13.2	3.859845	1.840632	2.099734	2.792277	2.729322	-48.7621	1.140768	62.40069	2.695649	-49.8854	1.186926	61.63082	2.740367	4.105629	2.058659	2.197711	2.421471	2.674776	2.695649	2.695649	2.695649	2.695649	2.704048	2.695649	2.695649	2.695649
N11	13 kV	13.2	2.477079	3.005266	3.146349	4.350993	1.75156	-46.3138	1.046945	40.04603	1.729984	-47.432	1.088713	39.55275	1.75589	2.600317	1.319085	1.408183	1.551557	1.713862	1.729984	1.729984	1.729984	1.729984	1.732542	1.729984	1.729984	1.729984
N16	13 kV	13.2	2.964381	2.474828	2.663441	3.635752	2.096134	-47.1022	1.076213	47.92406	2.070313	-48.2206	1.119247	47.33372	2.102233	3.124402	1.579271	1.685942	1.857597	2.051916	2.070313	2.070313	2.070313	2.070313	2.074428	2.070313	2.070313	2.070313
N17	13 kV	13.2	3.332687	2.176549	2.39188	3.233953	2.356566	-47.6986	1.098932	53.87833	2.327537	-48.817	1.142974	53.21464	2.364301	3.523781	1.776145	1.896114	2.089168	2.307711	2.327537	2.327537	2.327537	2.327537	2.333083	2.327537	2.327537	2.327537
N18	13 kV	13.2	2.893274	2.550126	2.715379	3.725107	2.045853	-46.7976	1.064802	46.77449	2.020689	-47.9111	1.107154	46.19916	2.051446	3.044646	1.541117	1.645212	1.812719	2.002344	2.020689	2.020689	2.020689	2.020689	2.024298	2.020689	2.020689	2.020689
N19	13 kV	13.2	14.90781	0.267791	0.671535	0.722961	10.54141	-68.2592	2.507683	241.009	10.44528	-69.9233	2.736078	238.8111	11.36938	19.16708	8.541071	9.117976	10.04632	11.09725	10.56396	10.56396	10.56396	10.56396	10.86962	10.56396	10.56396	10.56396
N20	13 kV	13.2	13.94514	0.34722	0.690481	0.772868	9.860701	-63.3037	1.988597	225.4459	9.759293	-64.9729	2.141864	223.1274	10.27069	16.81805	7.7157	8.236855	9.075492	10.02486	9.896938	9.896938	9.896938	9.896938	10.08529	9.896938	9.896938	9.896938
N21	13 kV	13.2	13.39584	0.391725	0.702758	0.80456	9.472286	-60.8642	1.794008	216.5655	9.372683	-62.5368	1.924001	214.2883	9.753488	15.72099	7.32716	7.822071	8.618477	9.520036	9.416707	9.416707	9.416707	9.416707	9.561725	9.416707	9.416707	9.416707
N22	13 kV	13.2	11.55327	0.557117	0.748249	0.932875	8.169396	-53.3301	1.343073	186.7775	8.076475	-55.0152	1.428954	184.653	8.244986	12.66116	6.19392	6.612288	7.285519	8.047641	8.03613	8.03613	8.03613	8.03613	8.093582	8.03613	8.03613	8.03613
N23	13 kV	13.2	6.096333	1.456044	1.002714	1.767908	4.310759	-34.5535	0.688656	98.55718	4.272569	-35.5718	0.715186	97.68404	4.311229	6.159991	3.238745	3.457505	3.809532	4.208038	4.272569	4.272569	4.272569	4.272569	4.272569	4.272569	4.272569	4.272569
N24	13 kV	13.2	10.77315	0.646219	0.763712	1.000427	7.61777	-49.7636	1.181815	174.1656	7.517165	-51.4659	1.255639	171.8655	7.655079	11.52802	5.750762	6.139195	6.764259	7.471853	7.538236	7.538236	7.538236	7.538236	7.570353	7.538236	7.538236	7.538236
N25	13 kV	13.2	7.764003	0.942596	1.019082	1.38817	5.489979	-47.2328	1.081143	125.5178	5.405439	-49.0307	1.151616	123.5849	5.506384	8.18873	4.136587	4.415992	4.865607	5.374587	5.446577	5.446577	5.446577	5.446577	5.46034	5.446577	5.446577	5.446577
N26	13 kV	13.2	6.208905	1.210654	1.243988	1.735854	4.390359	-45.778	1.027534	100.3771	4.313991	-47.6626	1.097546	98.63108	4.400051	6.500782	3.305471	3.528738	3.888018	4.294734	4.325089	4.325089	4.325089	4.325089	4.332121	4.325089	4.325089	4.325089
N27	13 kV	13.2	5.082231	1.494046	1.505019	2.120674	3.59368	-45.2096	1.007345	82.16256	3.540308	-46.4464	1.051807	80.94231	3.600699	5.306943	2.70497	2.887677	3.181686	3.514515	3.540308	3.540308	3.540308	3.540308	3.543365	3.540308	3.540308	3.540308
N28	13 kV	13.2	5.69595	1.329427	1.346464	1.892179	4.027645	-45.3648	1.012815	92.08433	3.957784	-47.2246	1.080831	90.4871	4.03578	5.952076	3.031819	3.236602	3.566137	3.939183	3.957784	3.957784	3.957784	3.957784	3.963116	3.957784	3.957784	3.957784
N29	13 kV	13.2	5.092016	1.500271	1.493043	2.116599	3.600599	-44.8616	0.995182	82.32075	3.547324	-46.0868	1.038676	81.10273	3.607116	5.30874	2.709791	2.892823	3.187356	3.520778	3.547324	3.547324	3.547324	3.547324	3.549611	3.547324	3.547324	3.547324
N30	13 kV	13.2	4.670462	1.640748	1.622701	2.307642	3.302515	-44.6832	0.989001	75.50564	3.254258	-45.8629	1.030582	74.40232	3.308261	4.865361	2.485281	2.653149	2.92328	3.229077	3.254258	3.254258	3.254258	3.254258	3.255916	3.254258	3.254258	3.254258
N31	13 kV	13.2	4.214489	1.824301	1.792139	2.55731	2.980094	-44.4905	0.98237	68.13409	2.94349	-45.3303	1.011597	67.29722	2.985061	4.386629	2.242482	2.39395	2.63769	2.913613	2.94349	2.94349	2.94349	2.94349	2.944059	2.94349	2.94349	2.94349
N32	13 kV	13.2	3.612384	2.137615	2.081398	2.983558	2.554341	-44.2366	0.973701	58.40008	2.527451	-44.8757	0.99567	57.78529	2.558363	3.75579	1.921932	2.051748	2.260647	2.497128	2.527451	2.527451	2.527451	2.527451	2.527451	2.527451	2.527451	2.527451
N33	13 kV	13.2	5.077913	1.500169	1.501466	2.122477	3.590627	-45.0248	1.000864	82.09276	3.531724	-46.3405	1.047922	80.74604	3.597362	5.297946	2.702464	2.885001	3.178738	3.511259	3.519628	3.519628	3.519628	3.519628	3.522439	3.519628	3.519628	3.519628
N34	13 kV	13.2	4.20829	1.827193	1.79457	2.561077	2.97571	-44.4839	0.982145	68.03388	2.931784	-45.4566	1.016065	67.02959	2.980663	4.380052	2.239178	2.390423	2.633804	2.90932	2.905223	2.905223	2.905223	2.905223	2.906001	2.905223	2.905223	2.905223
N35	13 kV	13.2	3.742363	2.062894	2.009597	2.879933	2.646251	-44.2502	0.974164	60.50141	2.611845	-45.021	1.000734	59.7148	2.65043	3.891157	1.991096	2.125584	2.342	2.586992	2.611845	2.611845	2.611845	2.611845	2.611877	2.611845	2.611845	2.611845
N36	13 kV	13.2	3.888183	1.983093	1.936728	2.771926	2.749361	-44.3223	0.97662	62.85883	2.708777	-45.2949	1.010347	61.93096	2.753775	4.044034	2.068731	2.208463	2.433318	2.687862	2.708777	2.708777	2.708777	2.708777	2.709244	2.708777	2.708777	2.708777
N37	13 kV	13.2	3.520665	2.196937	2.131883	3.061284	2.489486	-44.139	0.970389	56.9173	2.457119	-44.9098	0.996857	56.17729	2.493321	3.658899	1.87307	1.999586	2.203174	2.433643	2.457119	2.457119	2.457119	2.457119	2.457119	2.457119	2.457119	2.457119
N38	13 kV	13.2	16.23788	0.153931	0.645645	0.663742	11.48192	-76.5902	4.194373	262.5118	11.40874	-78.2176	4.794083	260.8388	13.81247	23.91577	10.37641	11.07728	12.20512	13.48187	12.01434	12.01434	12.01434	12.01434	12.85357	12.01434	12.01434	12.01434
N39	13 kV	13.2	16.23788	0.153931	0.645645	0.663742	11.48192	-76.5902	4.194373	262.5118	11.40874	-78.2176	4.794083	260.8388	13.81247	23.91577	10.37641	11.07728	12.20512	13.48187	12.01434	12.01434	12.01434	12.01434	12.85357	12.01434	12.01434	12.01434
N40	13 kV	13.2	15.32685	0.228857	0.664911	0.703194	10.83772	-71.007	2.905357	247.7836	10.76779	-72.633	3.197456	246.1848	12.01984	20.52497	9.029724	9.639635	10.6211	11.73214	10.78207	10.78207	10.78207	10.78207	11.17696	10.78207	10.78207	10.78207
N41	13 kV	13.2	13.81309	0.351625	0.696534	0.780256	9.767333	-63.2144	1.980901	223.3112	9.703289	-64.8284	2.127843	221.847	10.16858	16.64139	7.638993	8.154967	8.985267	9.925195	9.715149	9.715149	9.715149	9.715149	9.897768	9.715149	9.715149	9.715149
N42	13 kV	13.2	5.826058	1.543385	1.01989	1.849922	4.119645	-33.4573	0.660814	94.18774	4.113977	-33.5237	0.662481	94.05815	4.119951	5.876256	3.09505	3.304105	3.640513	4.021339	4.113977	4.113977	4.113977	4.113977	4.113977	4.113977	4.113977	4.113977
N43	13 kV	13.2	5.467136	1.665309	1.055012	1.971371	3.865849	-32.3552	0.633523	88.38518	3.86053	-32.4217	0.63515	88.26358	3.86604	5.505518	2.904304	3.100474	3.416149	3.773505	3.86053	3.86053	3.86053	3.86053	3.86053	3.86053	3.86053	3.86053
N44	13 kV	13.2	5.122332	1.79779	1.093193	2.104072	3.622036	-31.3028	0.608076	82.81086	3.617063	-31.3687	0.609652	82.69716	3.622154	5.151554	2.721088	2.904883	3.200645	3.535457	3.617063	3.617063	3.617063	3.617063	3.617063	3.617063	3.617063	3.617063
N45	13 kV	13.2	6.243454	1.418405	0.983901	1.726249	4.414789	-34.7478	0.693667	100.9356	4.408715	-34.8142	0.695386	100.7968	4.415303	6.310833	3.316929	3.540971	3.901495	4.309622	4.408715	4.408715	4.408715	4.408715	4.408715	4.408715	4.408715	4.408715
N46	13 kV	13.2	9.660544	0.772019	0.805391	1.115647	6.831036	-46.212	1.043227	156.1785	6.783156	-47.8183	1.103554	155.0838	6.847566	10.13605	5.14413	5.491589	6.050716	6.683668	6.790246	6.790246	6.790246	6.790246	6.801965	6.790246	6.790246	6.790246
N47	13 kV	13.2	7.866969	1.051436	0.878285	1.370001	5.562787	-39.8726	0.835319	127.1824	5.522098	-41.4738	0.883909	126.2521	5.565796	8.049968	4.18122	4.46364	4.918106	5.432578	5.527654	5.527654	5.527654	5.527654	5.527654	5.527654	5.527654	5.527654
N48	13 kV	13.2	6.171751	1.444082	0.98194	1.746304	4.364087	-34.2147	0.679976	99.77642	4.35576	-34.2897	0.681891	99.58604	4.36451	6.23255	3.278772	3.500236	3.856613	4.260045	4.339727	4.339727	4.339727	4.339727	4.339727	4.339727	4.339727	4.339727
N49	13 kV	13.2	5.202517	1.773453	1.070779	2.071642	3.678735	-31.1228	0.603782	84.10718	3.671729	-31.197	0.60555	83.947	3.678846	5.231126	2.763677	2.950349	3.25074	3.590792	3.671729	3.671729	3.671729	3.671729	3.671729	3.671729	3.671729	3.671729
N50	13 kV	13.2	4.906329	1.897579	1.106664	2.196704	3.469299	-30.2506	0.583198	79.31882	3.462693	-30.3248	0.584934	79.16779	3.469371	4.928782	2.606312	2.782355	3.065641	3.386331	3.462693	3.462693	3.462693	3.462693	3.462693	3.462693	3.462693	3.462693
N51	13 kV	13.2	4.183539	2.271812	1.214837	2.576229	2.958209	-28.1354	0.534744	67.63373	2.952576	-28.2095	0.536409	67.50495	2.958232	4.19529	2.222327	2.372433	2.613983	2.887426	2.952576	2.952576	2.952576	2.952576	2.952576	2.952576	2.952576	2.952576
N52	13 kV	13.2	4.646563	2.021607	1.137205	2.319511	3.285617	-29.3589	0.562525	75.11928	3.279355	-29.4329	0.564228	74.97612	3.285663	4.664009	2.468304	2.635025	2.903311	3.20702	3.279355	3.279355	3.279355	3.279355	3.279355	3.279355	3.279355	3.279355
N53	13 kV	13.2	4.268753	2.225971	1.191503	2.524802	3.018464	-28.159	0.535273	69.01135	3.012708	-28.2329	0.536935	68.87976	3.018488	4.280813	2.267593	2.420757	2.667227	2.94624	3.012708	3.012708	3.012708	3.012708	3.012708	3.012708	3.012708	3.012708
N54	13 kV	13.2	3.789205	2.5426	1.274915	2.844332	2.679372	-26.6302	0.501422	61.25868	2.674258	-26.7039	0.503034	61.14176	2.679382	3.796408	2.012845	2.148802	2.367583	2.61525	2.674258	2.674258	2.674258	2.674258	2.674258	2.674258	2.674258	2.674258
N55	13 kV	13.2	3.5872	2.700885	1.316153	3.004503	2.536534	-25.9802	0.487304	57.99295	2.531689	-26.0539	0.488897	57.88218	2.53654	3.592888	1.905537	2.034246	2.241363	2.475827	2.531689	2.531689	2.531689	2.531689	2.531689	2.531689	2.531689	2.531689
N56	13 kV	13.2	3.356238	2.904868	1.368918	3.21126	2.373219	-25.2321	0.47125	54.25907	2.368681	-25.3057	0.472821	54.15533	2.373223	3.36051	1.782847	1.903269	2.097051	2.316419	2.368681	2.368681	2.368681	2.368681	2.368681	2.368681	2.368681	2.368681
N57	13 kV	13.2	3.193684	3.063778	1.414394	3.374709	2.258276	-24.7881	0.461813	51.63111	2.253958	-24.8617	0.463373	51.5324	2.258278	3.197231	1.696497	1.811087	1.995483	2.204226	2.253958	2.253958	2.253958	2.253958	2.253958	2.253958	2.253958	2.253958
N58	13 kV	13.2	16.23788	0.153931	0.645645	0.663742	11.48192	-76.5902	4.194373	262.5118	11.40874	-78.2176	4.794083	260.8388	13.81247	23.91577	10.37641	11.07728	12.20512	13.48187	12.01434	12.01434	12.01434	12.01434	12.85357	12.01434	12.01434	12.01434
N59	13 kV	13.2	12.75373	0.309176	0.786478	0.845067	9.018247	-68.5395	2.543786	206.1848	8.960879	-70.1523	2.770368	204.8732	9.751254	16.46293	7.325482	7.82028	8.616503	9.517856	8.96104	8.96104	8.96104	8.96104	9.225445	8.96104	8.96104	8.96104
N60	13 kV	13.2	10.42876	0.461932	0.924483	1.033465	7.374245	-63.4503	2.001338	168.5979	7.327233	-65.0584	2.150231	167.523	7.686955	12.59896	5.774708	6.164759	6.792426	7.502966	7.327374	7.327374	7.327374	7.327374	7.467843	7.327374	7.327374	7.327374
N61	13 kV	13.2	6.258377	0.997553	1.403791	1.722133	4.425341	-54.6019	1.407235	101.1769	4.396909	-56.1936	1.493423	100.5268	4.475968	6.929679	3.362503	3.589622	3.9551	4.368835	4.39702	4.39702	4.39702	4.39702	4.433179	4.39702	4.39702	4.39702
N62	13 kV	13.2	5.237704	1.254483	1.631105	2.057725	3.703616	-52.4361	1.300221	84.67604	3.679732	-54.0199	1.377387	84.12996	3.733008	5.705223	2.804365	2.993786	3.298599	3.643657	3.679836	3.679836	3.679836	3.679836	3.702981	3.679836	3.679836	3.679836
N63	13 kV	13.2	4.466365	1.525932	1.869371	2.413093	3.158197	-50.7759	1.225068	72.20608	3.15749	-50.8236	1.227154	72.18992	3.176849	4.810113	2.38656	2.547759	2.80716	3.100811	3.157585	3.157585	3.157585	3.157585	3.169539	3.157585	3.157585	3.157585
N64	13 kV	13.2	3.887172	1.800588	2.108424	2.772647	2.748646	-49.5028	1.170965	62.84248	2.748562	-49.5047	1.171046	62.84058	2.761462	4.152915	2.074506	2.214629	2.440111	2.695366	2.748654	2.748654	2.748654	2.748654	2.756489	2.748654	2.748654	2.748654
N65	13 kV	13.2	3.266014	2.204179	2.455893	3.299972	2.309421	-48.0918	1.114199	52.80044	2.309334	-48.0941	1.114289	52.79848	2.317618	3.460766	1.741075	1.858676	2.047917	2.26214	2.309423	2.309423	2.309423	2.309423	2.313822	2.309423	2.309423	2.309423

3-Ph Fault

Node	Network Level	Vk [kV]	idc [kA]	Zr [Ohm]	Zi [Ohm]	Za [Ohm]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	I PF15 [kA]	I PF20 [kA]	I PF30 [kA]	I PF50 [kA]	I sym 2 [kA]	I sym 3 [kA]	I sym 5 [kA]	I sym 8 [kA]	I tot 2 [kA]	I tot 3 [kA]	I tot 5 [kA]	I tot 8 [kA]
N66	13 kV	13.2	2.95362	2.472116	2.683996	3.648998	2.088525	-47.3531	1.085708	47.75009	2.088437	-47.3557	1.085805	47.74809	2.09492	3.117183	1.573777	1.680077	1.851134	2.044777	2.088525	2.088525	2.088525	2.088525	2.091512	2.088525	2.088525	2.088525
N67	13 kV	13.2	2.544445	2.924442	3.064248	4.235798	1.799194	-46.3373	1.047806	41.13511	1.799105	-46.3403	1.047914	41.13307	1.803664	2.671347	1.354975	1.446497	1.593772	1.760493	1.799192	1.799192	1.799192	1.799192	1.800628	1.799192	1.799192	1.799192
N69	13 kV	13.2	2.31473	3.238132	3.345793	4.65616	1.636761	-45.9368	1.033248	37.42139	1.636676	-45.9399	1.033359	37.41944	1.640499	2.425399	1.2324	1.315642	1.449594	1.601233	1.636676	1.636676	1.636676	1.636676	1.637586	1.636676	1.636676	1.636676
N70	13 kV	13.2	2.207941	3.401397	3.501168	4.88136	1.56125	-45.8281	1.029333	35.69497	1.561168	-45.8312	1.029443	35.69311	1.564733	2.312291	1.175482	1.25488	1.382646	1.527281	1.561168	1.561168	1.561168	1.561168	1.561935	1.561168	1.561168	1.561168
N71	13 kV	13.2	2.071144	3.635113	3.723596	5.203769	1.46452	-45.6889	1.024341	33.48342	1.464443	-45.692	1.024451	33.48167	1.467692	2.167583	1.102581	1.177055	1.296897	1.432562	1.464443	1.464443	1.464443	1.464443	1.46504	1.464443	1.464443	1.464443
N72	13 kV	13.2	1.98779	3.793282	3.874129	5.42198	1.40558	-45.6041	1.021313	32.13586	1.405506	-45.6072	1.021423	32.13419	1.408569	2.07951	1.058166	1.12964	1.244654	1.374855	1.405506	1.405506	1.405506	1.405506	1.406008	1.405506	1.405506	1.405506
N73	13 kV	13.2	1.900555	3.973659	4.045802	5.670845	1.343896	-45.5154	1.018155	30.72558	1.343826	-45.5185	1.018264	30.72398	1.3467	1.987418	1.011688	1.080022	1.189985	1.314466	1.343826	1.343826	1.343826	1.343826	1.344235	1.343826	1.343826	1.343826
N74	13 kV	13.2	2.43916	3.065915	3.181901	4.418634	1.724746	-46.0635	1.037831	39.433	1.724656	-46.0666	1.037942	39.43094	1.728792	2.557354	1.298728	1.386451	1.527612	1.687413	1.724743	1.724743	1.724743	1.724743	1.725834	1.724743	1.724743	1.724743
N75	13 kV	13.2	2.281397	3.29799	3.382492	4.724192	1.613191	-45.7247	1.025622	36.8825	1.6131	-45.728	1.02574	36.88042	1.616712	2.388034	1.21453	1.296565	1.428575	1.578015	1.613187	1.613187	1.613187	1.613187	1.613879	1.613187	1.613187	1.613187
N76	13 kV	13.2	2.08217	3.628993	3.691015	5.176213	1.472316	-45.4855	1.017091	33.66167	1.472234	-45.4887	1.017207	33.65978	1.475369	2.177026	1.108348	1.183212	1.30368	1.440056	1.472234	1.472234	1.472234	1.472234	1.472656	1.472234	1.472234	1.472234
N77	13 kV	13.2	2.238842	3.36538	3.442191	4.813986	1.5831	-45.6465	1.022824	36.19454	1.583009	-45.6498	1.022944	36.19246	1.586498	2.342617	1.191833	1.272335	1.401878	1.548525	1.583096	1.583096	1.583096	1.583096	1.583701	1.583096	1.583096	1.583096
N78	13 kV	13.2	1.927408	3.933491	3.974457	5.591839	1.362883	-45.2968	1.010415	31.1597	1.362807	-45.3001	1.01053	31.15795	1.365596	2.01344	1.025883	1.095176	1.206682	1.33291	1.362807	1.362807	1.362807	1.362807	1.363046	1.362807	1.362807	1.362807
N79	13 kV	13.2	1.780416	4.271897	4.289035	6.053505	1.258944	-45.1147	1.004012	28.78333	1.258873	-45.118	1.004126	28.78171	1.261352	1.858326	0.947572	1.011575	1.114569	1.231162	1.258873	1.258873	1.258873	1.258873	1.25896	1.258873	1.258873	1.258873
N80	13 kV	13.2	1.9508	3.89666	3.916541	5.524786	1.379424	-45.1458	1.005102	31.53787	1.379332	-45.1496	1.005237	31.53576	1.382081	2.036457	1.038267	1.108397	1.221249	1.349001	1.379418	1.379418	1.379418	1.379418	1.379539	1.379418	1.379418	1.379418
N81	13 kV	13.2	1.999299	3.785137	3.838373	5.390767	1.413718	-45.4001	1.014064	32.32193	1.413637	-45.4034	1.014183	32.32007	1.416595	2.089544	1.064196	1.136077	1.251746	1.382689	1.413637	1.413637	1.413637	1.413637	1.413971	1.413637	1.413637	1.413637
N82	13 kV	13.2	1.752279	4.335361	4.363009	6.150707	1.239048	-45.1821	1.006377	28.32845	1.238977	-45.1855	1.006495	28.32682	1.241454	1.829524	0.932623	0.995617	1.096986	1.211739	1.238977	1.238977	1.238977	1.238977	1.239111	1.238977	1.238977	1.238977
N83	13 kV	13.2	1.689011	4.502161	4.522061	6.381104	1.194311	-45.1263	1.00442	27.30562	1.194242	-45.1297	1.004537	27.30405	1.196602	1.763016	0.898929	0.959647	1.057353	1.167961	1.194242	1.194242	1.194242	1.194242	1.194333	1.194242	1.194242	1.194242
N84	13 kV	13.2	1.657021	4.591346	4.607105	6.504297	1.171691	-45.0982	1.003432	26.78844	1.171623	-45.1015	1.00355	26.7869	1.173924	1.729401	0.881893	0.94146	1.037315	1.145826	1.171623	1.171623	1.171623	1.171623	1.171693	1.171623	1.171623	1.171623
N85	13 kV	13.2	1.635253	4.654025	4.666874	6.590877	1.156299	-45.079	1.002761	26.43654	1.156232	-45.0823	1.002878	26.43502	1.158494	1.706533	0.870301	0.929085	1.02368	1.130765	1.156232	1.156232	1.156232	1.156232	1.156288	1.156232	1.156232	1.156232
N86	13 kV	13.2	1.720365	4.417967	4.441778	6.264808	1.216482	-45.154	1.005389	27.8125	1.216412	-45.1573	1.005507	27.8109	1.218829	1.795971	0.915627	0.977472	1.076994	1.189656	1.216412	1.216412	1.216412	1.216412	1.216523	1.216412	1.216412	1.216412
N87	13 kV	13.2	1.862107	4.073501	4.111784	5.787934	1.316709	-45.268	1.009398	30.10401	1.316633	-45.2713	1.009516	30.10228	1.319313	1.944965	0.991114	1.058059	1.165785	1.287735	1.316633	1.316633	1.316633	1.316633	1.316842	1.316633	1.316633	1.316633
N88	13 kV	13.2	1.783147	4.259593	4.288193	6.044231	1.260876	-45.1917	1.006714	28.82749	1.260803	-45.195	1.006832	28.82583	1.263329	1.861836	0.949056	1.01316	1.116315	1.233091	1.260803	1.260803	1.260803	1.260803	1.260947	1.260803	1.260803	1.260803
N89	13 kV	13.2	1.737615	4.374595	4.397197	6.202614	1.228679	-45.1476	1.005167	28.09138	1.228609	-45.151	1.005284	28.08977	1.231047	1.813927	0.924805	0.987271	1.08779	1.201581	1.228609	1.228609	1.228609	1.228609	1.228717	1.228609	1.228609	1.228609
N90	13 kV	13.2	1.7022	4.468026	4.486279	6.331663	1.203637	-45.1168	1.004085	27.51884	1.203568	-45.1201	1.004202	27.51726	1.205941	1.776705	0.905945	0.967136	1.065606	1.177076	1.203568	1.203568	1.203568	1.203568	1.203652	1.203568	1.203568	1.203568
N91	13 kV	13.2	1.639554	4.643177	4.653277	6.57359	1.15934	-45.0623	1.002175	26.50607	1.159273	-45.0656	1.002292	26.50454	1.161532	1.71089	0.872584	0.931522	1.026365	1.133731	1.159273	1.159273	1.159273	1.159273	1.159317	1.159273	1.159273	1.159273
N92	13 kV	13.2	1.60921	4.732907	4.73885	6.697545	1.137883	-45.0359	1.001256	26.0155	1.137818	-45.0393	1.001372	26.01401	1.140023	1.679024	0.856425	0.914272	1.007359	1.112736	1.137818	1.137818	1.137818	1.137818	1.137844	1.137818	1.137818	1.137818
N93	13 kV	13.2	1.558976	4.889127	4.887834	6.913356	1.102362	-44.9924	0.999736	25.20339	1.102299	-44.9958	0.999852	25.20194	1.104416	1.626289	0.829675	0.885716	0.975895	1.077981	1.102299	1.102299	1.102299	1.102299	1.102299	1.102299	1.102299	1.102299
N94	13 kV	13.2	1.540009	4.950761	4.946614	6.998501	1.088951	-44.976	0.999162	24.89676	1.088888	-44.9793	0.999279	24.89533	1.090972	1.606384	0.819576	0.874934	0.964016	1.064859	1.088888	1.088888	1.088888	1.088888	1.088888	1.088888	1.088888	1.088888
N95	13 kV	13.2	1.514914	5.034677	5.026646	7.114432	1.071206	-44.9543	0.998405	24.49106	1.071145	-44.9576	0.998522	24.48965	1.073185	1.580052	0.806214	0.860669	0.948298	1.047498	1.071145	1.071145	1.071145	1.071145	1.071145	1.071145	1.071145	1.071145
N96	13 kV	13.2	1.456522	5.241126	5.223546	7.399651	1.029917	-44.9037	0.996646	23.54706	1.029857	-44.9071	0.996762	23.5457	1.031798	1.518802	0.775123	0.827478	0.911728	1.007102	1.029857	1.029857	1.029857	1.029857	1.029857	1.029857	1.029857	1.029857
N97	13 kV	13.2	1.836597	4.15326	4.145806	5.868328	1.29867	-44.9485	0.998205	29.69159	1.298581	-44.9525	0.998343	29.68954	1.301066	1.915517	0.977406	1.043425	1.149661	1.269925	1.299399	1.299399	1.299399	1.299399	1.299399	1.299399	1.299399	1.299399
N98	13 kV	13.2	1.694524	4.492713	4.502168	6.360345	1.198209	-45.0602	1.002104	27.39474	1.198124	-45.0643	1.002246	27.3928	1.200474	1.768235	0.901838	0.962753	1.060775	1.171741	1.198124	1.198124	1.198124	1.198124	1.198169	1.198124	1.198124	1.198124
N99	13 kV	13.2	1.608767	4.738698	4.735665	6.699387	1.13757	-44.9817	0.99936	26.00835	1.13749	-44.9857	0.999501	26.00651	1.139684	1.678149	0.85617	0.914	1.007059	1.112406	1.13749	1.13749	1.13749	1.13749	1.13749	1.13749	1.13749	1.13749
N100	13 kV	13.2	1.553227	4.912498	4.900646	6.938946	1.098297	-44.9308	0.997588	25.11044	1.098219	-44.9348	0.997728	25.10866	1.100315	1.61984	0.826595	0.882427	0.972272	1.073979	1.098219	1.098219	1.098219	1.098219	1.098219	1.098219	1.098219	1.098219
N101	13 kV	13.2	1.507162	5.06636	5.046698	7.151026	1.065725	-44.8886	0.996119	24.36574	1.065649	-44.8927	0.99626	24.36401	1.067665	1.5715	0.802067	0.856242	0.943421	1.04211	1.065649	1.065649	1.065649	1.065649	1.065649	1.065649	1.065649	1.065649
N102	13 kV	13.2	1.419968	5.384908	5.349109	7.590138	1.004069	-44.8089	0.993352	22.9561	1.003998	-44.813	0.993492	22.95448	1.005865	1.480054	0.755641	0.806681	0.888813	0.98179	1.003998	1.003998	1.003998	1.003998	1.003998	1.003998	1.003998	1.003998
N103	13 kV	13.2	1.360871	5.623951	5.57616	7.919747	0.962281	-44.7555	0.991502	22.0007	0.962213	-44.7596	0.991642	21.99914	0.963983	1.418117	0.724177	0.773092	0.851804	0.940909	0.962213	0.962213	0.962213	0.962213	0.962213	0.962213	0.962213	0.962213
N104	13 kV	13.2	1.345398	5.69	5.638908	8.010829	0.95134	-44.7416	0.991021	21.75056	0.951273	-44.7457	0.991161	21.74902	0.953017	1.401907	0.71594	0.764297	0.842115	0.930206	0.951273	0.951273	0.951273	0.951273	0.951273	0.951273	0.951273	0.951273
N105	13 kV	13.2	1.312604	5.835132	5.776788	8.210971	0.928151	-44.7121	0.990001	21.22039	0.928085	-44.7162	0.990141	21.21888	0.929777	1.367555	0.698481	0.745659	0.821579	0.907522	0.928085	0.928085	0.928085	0.928085	0.928085	0.928085	0.928085	0.928085
N106	13 kV	13.2	1.276494	6.003564	5.936804	8.443247	0.902618	-44.6797	0.98888	20.63661	0.902554	-44.6837	0.98902	20.63515	0.904187	1.329742	0.679257	0.725137	0.798967	0.882545	0.902554	0.902554	0.902554	0.902554	0.902554	0.902554	0.902554	0.902554
N107	13 kV	13.2	1.23358	6.216551	6.13915	8.736971	0.872273	-44.6411	0.987549	19.94284	0.872211	-44.6451	0.987689	19.94142	0.873777	1.284818	0.656411	0.700748	0.772095	0.852862	0.872211	0.872211	0.872211	0.872211	0.872211	0.872211	0.872211	0.872211
N108	13 kV	13.2	1.169797	6.561976	6.467332	9.213355	0.827171	-44.5838	0.985577	18.91168	0.827113	-44.5879	0.985716	18.91034	0.828579	1.218077	0.622457	0.664501	0.732158	0.808747	0.827113	0.827113	0.827113	0.827113	0.827113	0.827113	0.827113	0.827113
N109	13 kV	13.2	1.124257	6.832577	6.724434	9.586559	0.79497	-44.543	0.984172	18.17545	0.794913	-44.547	0.984311	18.17416	0.79631	1.170447	0.598216	0.638622	0.703644	0.777251	0.794913	0.794913	0.794913	0.794913	0.794913	0.794913	0.794913	0.794913
N110	13 kV	13.2	1.060914	7.247576	7.118747	10.15893	0.75018	-44.4862	0.982225	17.15141	0.750126	-44.4903	0.982363	17.15019	0.751429	1.104227	0.5645	0.602629	0.663985	0.733443	0.750126	0.750126	0.750126	0.750126	0.750126	0.750126	0.750126	0.750126
N111	13 kV	13.2	1.01934	7.547956	7.404212	10.57327	0.720782	-44.4492	0.980956	16.4793	0.720731	-44.4532	0.981094	16.47813	0.721973	1.060783	0.542371	0.579005	0.637957	0.704692	0.720731	0.720731	0.720731	0.720731	0.720731	0.720731	0.720731	0.720731
N112	13 kV	13.2	0.983735	7.825363	7.667892	10.95595	0.695606	-44.4177	0.979877	15.90368	0.695556	-44.4217	0.980015	15.90256	0.696747	1.02359	0.52342	0.558775	0.615666	0.68007	0.695556	0.695556	0.695556	0.695556	0.695556	0.695556	0.695556	0.695556
N113	13 kV	13.2	0.910192	8.467026	8.277872	11.84119	0.643603	-44.3528	0.97766	14.71474	0.643557	-44.3568	0.977798	14.7137	0.644643	0.946801	0.484279	0.516989	0.569626	0.629214	0.643557	0.643557	0.643557	0.643557	0.643557	0.643557	0.643557	0.643557
N114	13 kV	13.2	0.900817	8.556347	8.362801	11.96443	0.636974	-44.3446	0.97738	14.56317	0.636928	-44.3486	0.977518	14.56214	0.638001	0.937014	0.479289	0.511662	0.563757	0.622731	0.636928	0.636928	0.636928	0.636928	0.636928	0.636928	0.636928	0.636928
N115	13 kV	13.2	0.892581	8.636358	8.438879	12.07482	0.63115	-44.3374	0.977134	14.43002	0.631105	-44.3414	0.977272	14.429	0.632167	0.928419	0.474906	0.506983	0.558601	0.617036	0.631105	0.631105	0.631105	0.631105	0.631105	0.631105	0.631105	0.631105
N116	13 kV	13.2	0.870313	8.860259	8.651785	12.38376	0.615405	-44.3179	0.976471	14.07004	0.615361	-44.322	0.976609	14.06904	0.616392	0.905181	0.463055	0.494332	0.544662	0.601638	0.615361	0.615361	0.615361	0.615361	0.615361	0.615361	0.615361	0.615361
N117	13 kV	13.2	0.856602	9.003918	8.788396	12.58199	0.605709	-44.306	0.976064	13.84837	0.605666	-44.31	0.976201	13.84739	0.606678	0.890874	0.455757	0.486542	0.536079	0.592157	0.605666	0.605666	0.605666	0.605666	0.605666	0.605666	0.605666	0.605666
N118	13 kV	13.2	0.815463	9.463902	9.225864	13.21673	0.576619	-44.2703	0.974848	13.18329	0.576578	-44.2743	0.974985	13.18235	0.577534	0.847959	0.433864	0.463169	0.510327	0.563711	0.576578	0.576578	0.576578	0.576578	0.576578	0.576578	0.576578	0.576578
N121	13 kV	13.2	1.894752	4.018696	4.025652	5.688215	1.339792	-45.0495	1.001731	30.63175	1.339699	-45.0535	1.00187	30.62963	1.342319	1.977077	1.008396	1.076508	1.186113	1.31019	1.339508	1.339508	1.339508	1.339508	1.33955	1.339508	1.339508	1.339508
N124	13 kV	13.2	3.269348	2.987871	1.392926	3.296606	2.311778	-24.9946	0.466194	52.85435	2.307358	-25.0682	0.467758	52.7533	2.311782	3.27322	1.736691	1.853995	2.04276	2.256449	2.307358	2.307358	2.307358	2.307358	2.307358	2.307358	2.307358	2.307358
N125	13 kV	13.2	16.23788	0.153931	0.645645	0.663742	11.48192	-76.5902	4.194373	262.5118	11.40874	-78.2176	4.794083	260.8388	13.81247	23.91577	10.37641	11.07728	12.20512	13.48187	12.01434	12.01434	12.01434	12.01434	12.85357	12.01434	12.01434	12.01434
N126	13 kV	13.2	14.64217	0.285666	0.678383	0.736076	10.35358	-67.1641	2.374737	236.7146	10.29088	-68.7774	2.575135	235.2811	11.06376	18.5422	8.311482	8.872879	9.776273	10.79895	10.29094	10.29094	10.29094	10.29094	10.5611	10.29094	10.29094	10.29094
N128	13 kV	13.2	13.29338	0.394798	0.708144	0.810761	9.399842	-60.8599	1.793689	214.9093	9.34559	-62.4551	1.917312	213.6689	9.678722	15.60003	7.270993	7.762111	8.552411	9.44706	9.351963	9.351963	9.351963	9.351963	9.494941	9.351963	9.351963	9.351963
N131	13 kV	13.2	9.696814	0.746788	0.823214	1.111474	6.856683	-47.7869	1.10234	156.7648	6.823378	-49.3465	1.164517	156.0034	6.87959	10.25776	5.168187	5.517271	6.079014	6.714925	6.883706	6.883706	6.883706	6.883706	6.902581	6.883706	6.883706	6.883706
N132	13 kV	13.2	7.472114	0.963869	1.073064	1.442397	5.283582	-48.0686	1.113288	120.7989	5.260645	-49.5731	1.17388	120.2745	5.30225	7.916649	3.983235	4.252281	4.685228	5.175339	5.329249	5.329249	5.329249	5.329249	5.344694	5.329249	5.329249	5.329249
N133	13 kV	13.2	5.672688	1.237326	1.4418	1.899938	4.011196	-49.3644	1.165255	91.70826	4.008358	-49.4146	1.167323	91.64336	4.029415	6.05543	3.027037	3.231498	3.560513	3.93297	4.09836	4.09836	4.09836	4.09836	4.109789	4.09836	4.09836	4.09836
N134	13 kV	13.2	4.852795	1.401623	1.722794	2.220938	3.431444	-50.869	1.229142	78.45335	3.42841	-50.9314	1.231879	78.38398	3.452057	5.229471	2.593305	2.768469	3.050341	3.369431	3.527775	3.527775	3.527775	3.527775	3.541409	3.527775	3.527775	3.527775
N135	13 kV	13.2	4.433448	1.486845	1.923304	2.431009	3.134921	-52.2935	1.293547	71.67393	3.132383	-52.3539	1.296369	71.6159	3.15919	4.824276	2.373293	2.533597	2.791555	3.083574	3.248795	3.248795	3.248795	3.248795	3.264842	3.248795	3.248795	3.248795
N136	13 kV	13.2	4.160729	1.531807	2.088898	2.590353	2.94208	-53.7471	1.363682	67.26498	2.939895	-53.8057	1.36661	67.21503	2.971287	4.576314	2.232134	2.382903	2.625519	2.900168	3.066687	3.066687	3.066687	3.066687	3.085425	3.066687	3.066687	3.066687
N137	13 kV	13.2	3.302318	2.020579	2.562999	3.263694	2.335091	-51.749	1.268448	53.38736	2.33336	-51.8074	1.27111	53.34776	2.351517	3.579772	1.766541	1.885862	2.077871	2.295233	2.33336	2.33336	2.33336	2.33336	2.343903	2.33336	2.33336	2.33336
N138	13 kV	13.2	2.969855	2.281011	2.822587	3.62905	2.100005	-51.0574	1.237428	48.01256	2.098447	-51.1157	1.24001	47.97695	2.113057	3.204356	1.587402	1.694623	1.867161	2.062481	2.098447	2.098447	2.098447	2.098447	2.106842	2.098447	2.098447	2.098447
N139	13 kV	13.2	2.800115	2.437669	2.978739	3.849041	1.97998	-50.7046	1.221962	45.26842	1.978512	-50.763	1.224506	45.23485	1.991523	3.014221	1.496101	1.597155	1.75977	1.943855	1.978512	1.978512	1.978512	1.978512	1.985915	1.978512	1.978512	1.978512
N140	13 kV	13.2	3.933657	1.550358	2.259058	2.739882	2.781515	-55.5388	1.45712	63.59398	2.779634	-55.5958	1.460231	63.55097	2.818557	4.389111	2.117398	2.260418	2.490563	2.751095	2.917596	2.917596	2.917596	2.917596	2.939976	2.917596	2.917596	2.917596
N141	13 kV	13.2	3.645115	1.498009	2.549204	2.956767	2.577485	-59.5599	1.701729	58.92923	2.576077	-59.6137	1.705391	58.89703	2.640926	4.220491	1.983955	2.117961	2.333602	2.577715	2.741173	2.741173	2.741173	2.741173	2.773399	2.741173	2.741173	2.741173
N142	13 kV	13.2	3.53388	1.41464	2.701906	3.049836	2.49883	-62.3647	1.90996	57.13093	2.497653	-62.4167	1.914182	57.10401	2.590276	4.216067	1.945906	2.077342	2.288847	2.528278	2.682164	2.682164	2.682164	2.682164	2.72303	2.682164	2.682164	2.682164
N143	13 kV	13.2	3.46791	1.310872	2.817865	3.107853	2.452183	-65.0521	2.149611	56.06443	2.451186	-65.1025	2.154559	56.04165	2.580683	4.272101	1.938699	2.069648	2.280369	2.518914	2.655393	2.655393	2.655393	2.655393	2.70649	2.655393	2.655393	2.655393
N144	13 kV	13.2	3.430452	1.202051	2.902741	3.141789	2.425696	-67.5051	2.414823	55.45886	2.424841	-67.5541	2.420675	55.43932	2.599302	4.36446	1.952686	2.08458	2.296822	2.537087	2.647921	2.647921	2.647921	2.647921	2.710618	2.647921	2.647921	2.647921

3-Ph Fault

Node	Network Level	Vk [kV]	idc [kA]	Zr [Ohm]	Zi [Ohm]	Za [Ohm]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	I PF15 [kA]	I PF20 [kA]	I PF30 [kA]	I PF50 [kA]	I sym 2 [kA]	I sym 3 [kA]	I sym 5 [kA]	I sym 8 [kA]	I tot 2 [kA]	I tot 3 [kA]	I tot 5 [kA]	I tot 8 [kA]
N145	35 kV	34.5	4.214532	1.600808	6.489279	6.683811	2.980124	-76.1427	4.053753	178.0795	2.964186	-77.2684	4.425957	177.1271	3.556862	6.156214	2.672039	2.852521	3.142951	3.471728	2.964381	2.964381	2.964381	2.964381	3.144167	2.964381	2.964381	2.964381
N146	35 kV	34.5	4.214263	1.605216	6.488629	6.684237	2.979934	-76.1046	4.042216	178.0682	2.964138	-77.2287	4.411743	177.1243	3.554296	6.151532	2.670111	2.850463	3.140683	3.469223	2.964417	2.964417	2.964417	2.964417	3.143152	2.964417	2.964417	2.964417
N149	35 kV	34.5	4.213712	1.613697	6.487425	6.68511	2.979545	-76.0316	4.020225	178.0449	2.964035	-77.1523	4.384623	177.1182	3.549359	6.142511	2.666402	2.846503	3.136321	3.464404	2.964527	2.964527	2.964527	2.964527	3.141259	2.964527	2.964527	2.964527
N150	35 kV	34.5	4.211582	1.640514	6.484183	6.688491	2.978038	-75.802	3.952531	177.9549	2.963588	-76.9103	4.300753	177.0914	3.533702	6.113776	2.65464	2.833947	3.122486	3.449123	2.965383	2.965383	2.965383	2.965383	3.135948	2.965383	2.965383	2.965383
N154	35 kV	34.5	4.209733	1.657399	6.482921	6.69143	2.976731	-75.6592	3.911503	177.8768	2.963159	-76.7572	4.249249	177.0658	3.523678	6.095305	2.64711	2.825908	3.113629	3.439338	2.966648	2.966648	2.966648	2.966648	3.133466	2.966648	2.966648	2.966648
N155	35 kV	34.5	4.208537	1.665577	6.482787	6.693331	2.975885	-75.591	3.892216	177.8263	2.96287	-76.6826	4.22456	177.0486	3.518677	6.086087	2.643352	2.821897	3.109209	3.434456	2.96772	2.96772	2.96772	2.96772	3.132766	2.96772	2.96772	2.96772
N156	35 kV	34.5	4.205987	1.676407	6.484188	6.69739	2.974082	-75.5043	3.867909	177.7185	2.962242	-76.582	4.191721	177.011	3.511488	6.072905	2.637952	2.816132	3.102856	3.427439	2.970685	2.970685	2.970685	2.970685	3.133458	2.970685	2.970685	2.970685
N157	35 kV	34.5	4.20513	1.678083	6.485163	6.698754	2.973476	-75.4925	3.864625	177.6823	2.962029	-76.5656	4.186399	176.9983	3.510088	6.07038	2.6369	2.815009	3.10162	3.426073	2.971895	2.971895	2.971895	2.971895	3.134339	2.971895	2.971895	2.971895
N158	35 kV	34.5	4.20381	1.678753	6.487162	6.700857	2.972543	-75.4912	3.864274	177.6265	2.961702	-76.5571	4.183677	176.9788	3.508913	6.068337	2.636018	2.814067	3.100582	3.424927	2.973976	2.973976	2.973976	2.973976	3.136331	2.973976	2.973976	2.973976
N159	35 kV	34.5	4.202544	1.677204	6.489649	6.702877	2.971647	-75.5094	3.869326	177.573	2.96139	-76.5684	4.18731	176.9601	3.508908	6.068489	2.636014	2.814063	3.100577	3.424922	2.976226	2.976226	2.976226	2.976226	3.138974	2.976226	2.976226	2.976226
N160	35 kV	34.5	4.201991	1.675851	6.490908	6.703758	2.971257	-75.5233	3.873201	177.5497	2.961254	-76.5792	4.190827	176.952	3.509254	6.069207	2.636273	2.81434	3.100883	3.425259	2.977286	2.977286	2.977286	2.977286	3.140354	2.977286	2.977286	2.977286
N161	35 kV	34.5	4.20153	1.674402	6.492043	6.704495	2.97093	-75.5377	3.87723	177.5302	2.961141	-76.5911	4.19468	176.9452	3.509706	6.070115	2.636613	2.814703	3.101282	3.4257	2.978209	2.978209	2.978209	2.978209	3.141615	2.978209	2.978209	2.978209
N162	35 kV	34.5	4.200401	1.669643	6.495128	6.706295	2.970132	-75.5836	3.890129	177.4825	2.960865	-76.6309	4.207618	176.9287	3.511442	6.07351	2.637917	2.816095	3.102816	3.427395	2.980606	2.980606	2.980606	2.980606	3.145107	2.980606	2.980606	2.980606
N163	35 kV	34.5	4.199828	1.666561	6.496864	6.70721	2.969727	-75.6128	3.898365	177.4583	2.960725	-76.6569	4.216133	176.9204	3.51267	6.07588	2.63884	2.817079	3.103901	3.428593	2.981899	2.981899	2.981899	2.981899	3.147107	2.981899	2.981899	2.981899
N164	35 kV	34.5	4.199405	1.663999	6.498219	6.707886	2.969428	-75.6369	3.905182	177.4404	2.960622	-76.6787	4.223269	176.9142	3.513727	6.077908	2.639634	2.817927	3.104835	3.429625	2.982887	2.982887	2.982887	2.982887	3.148681	2.982887	2.982887	2.982887
N165	35 kV	34.5	4.198811	1.659988	6.500225	6.708836	2.969007	-75.6743	3.915826	177.4153	2.960477	-76.7128	4.234525	176.9055	3.515429	6.081159	2.640913	2.819293	3.106339	3.431287	2.984321	2.984321	2.984321	2.984321	3.151034	2.984321	2.984321	2.984321
N166	35 kV	34.5	4.198167	1.655107	6.502531	6.709865	2.968552	-75.7196	3.928769	177.3881	2.960319	-76.7545	4.248347	176.8961	3.51756	6.085208	2.642513	2.821001	3.108222	3.433366	2.985933	2.985933	2.985933	2.985933	3.153768	2.985933	2.985933	2.985933
N167	35 kV	34.5	4.197748	1.651633	6.504105	6.710535	2.968256	-75.7517	3.937986	177.3704	2.960217	-76.7843	4.25826	176.89	3.519106	6.088135	2.643675	2.822241	3.109588	3.434875	2.987014	2.987014	2.987014	2.987014	3.15565	2.987014	2.987014	2.987014
N168	35 kV	34.5	4.196892	1.64382	6.507496	6.711903	2.967651	-75.8234	3.958764	177.3342	2.960006	-76.8513	4.280761	176.8774	3.522655	6.094824	2.646341	2.825088	3.112724	3.438339	2.989298	2.989298	2.989298	2.989298	3.159745	2.989298	2.989298	2.989298
N169	35 kV	34.5	4.195937	1.634	6.511542	6.71343	2.966976	-75.9131	3.985031	177.2939	2.959768	-76.9358	4.309434	176.8632	3.527225	6.10339	2.649774	2.828753	3.116763	3.4428	2.991959	2.991959	2.991959	2.991959	3.164702	2.991959	2.991959	2.991959
N170	35 kV	34.5	4.194413	1.616031	6.518539	6.71587	2.965898	-76.0764	4.033672	177.2295	2.95938	-77.0907	4.362985	176.84	3.535826	6.119385	2.656236	2.835651	3.124363	3.451196	2.996427	2.996427	2.996427	2.996427	3.17344	2.996427	2.996427	2.996427
N173	35 kV	34.5	4.194037	1.611196	6.520356	6.716472	2.965632	-76.1201	4.046903	177.2136	2.959283	-77.1325	4.377627	176.8342	3.538184	6.123744	2.658007	2.837541	3.126446	3.453496	2.997564	2.997564	2.997564	2.997564	3.175741	2.997564	2.997564	2.997564
N174	35 kV	34.5	4.193559	1.604832	6.522713	6.717237	2.965294	-76.1776	4.064421	177.1934	2.959157	-77.1874	4.397054	176.8266	3.541311	6.129513	2.660356	2.84005	3.12921	3.456549	2.999028	2.999028	2.999028	2.999028	3.178749	2.999028	2.999028	2.999028
N175	35 kV	34.5	4.192947	1.59635	6.525803	6.718217	2.964862	-76.2542	4.087953	177.1675	2.958994	-77.2607	4.423216	176.8169	3.545521	6.137251	2.663519	2.843426	3.13293	3.460658	3.000927	3.000927	3.000927	3.000927	3.182725	3.000927	3.000927	3.000927
N178	35 kV	34.5	4.190864	1.56497	6.536834	6.721557	2.963389	-76.5363	4.17697	177.0795	2.958412	-77.5322	4.52272	176.7821	3.561458	6.166291	2.675491	2.856207	3.147012	3.476214	3.007556	3.007556	3.007556	3.007556	3.197236	3.007556	3.007556	3.007556
N179	13 kV	13.2	16.28071	0.130195	0.649066	0.661995	11.5122	-78.6577	4.985344	263.2043	11.49966	-79.1453	5.215115	262.9175	14.41151	24.95025	10.82643	11.5577	12.73445	14.06657	11.79308	11.79308	11.79308	11.79308	12.74098	11.79308	11.79308	11.79308
N180	13 kV	13.2	15.84055	0.164412	0.660227	0.68039	11.20096	-76.0164	4.015674	256.0884	11.18848	-76.5042	4.166649	255.803	13.33957	23.08504	10.02115	10.69803	11.78725	13.02028	11.19697	11.19697	11.19697	11.19697	11.80347	11.19697	11.19697	11.19697
N181	13 kV	13.2	12.73647	0.409868	0.740326	0.846212	9.006044	-61.0297	1.806254	205.9058	9.003041	-61.069	1.80918	205.8372	9.279735	14.97358	6.97126	7.442132	8.199854	9.057623	9.0088	9.0088	9.0088	9.0088	9.130296	9.0088	9.0088	9.0088
N182	13 kV	13.2	10.93852	0.580577	0.796086	0.985303	7.7347	-53.8971	1.371198	176.839	7.731121	-53.9387	1.373292	176.7572	7.813439	12.04497	5.869727	6.266196	6.90419	7.626422	7.735732	7.735732	7.735732	7.735732	7.78386	7.735732	7.735732	7.735732
N183	13 kV	13.2	10.0298	0.683021	0.829572	1.074573	7.092139	-50.534	1.214564	162.1481	7.088303	-50.5771	1.216428	162.0604	7.132213	10.7848	5.357966	5.719869	6.302239	6.961502	7.092406	7.092406	7.092406	7.092406	7.117989	7.092406	7.092406	7.092406
N185	13 kV	13.2	8.080779	0.964152	0.921577	1.333752	5.713974	-43.7066	0.955842	130.639	5.709648	-43.7539	0.957422	130.5401	5.721951	8.382806	4.298528	4.588872	5.056088	5.584994	5.712794	5.712794	5.712794	5.712794	5.712794	5.712794	5.712794	5.712794
N186	13 kV	13.2	7.502409	1.071588	0.956787	1.436573	5.305004	-41.7607	0.892868	121.2887	5.300547	-41.8095	0.894402	121.1868	5.309663	7.7248	3.988804	4.258227	4.691779	5.182575	5.30344	5.30344	5.30344	5.30344	5.30344	5.30344	5.30344	5.30344
N187	13 kV	13.2	6.518944	1.293502	1.029682	1.653298	4.609589	-38.5213	0.796042	105.3894	4.60492	-38.5735	0.797532	105.2826	4.61131	6.644902	3.464176	3.698163	4.074693	4.500937	4.607413	4.607413	4.607413	4.607413	4.607413	4.607413	4.607413	4.607413
N188	13 kV	13.2	6.029187	1.428838	1.074209	1.787597	4.263279	-36.9361	0.751806	97.47165	4.258612	-36.9833	0.753097	97.36494	4.264279	6.121542	3.203475	3.419853	3.768046	4.162213	4.260919	4.260919	4.260919	4.260919	4.260919	4.260919	4.260919	4.260919
N191	13 kV	13.2	5.659905	1.545383	1.112601	1.904229	4.002157	-35.7521	0.719951	91.5016	3.997408	-35.8011	0.721251	91.39301	4.002806	5.731968	3.007047	3.210157	3.537	3.906998	3.999581	3.999581	3.999581	3.999581	3.999581	3.999581	3.999581	3.999581
N192	13 kV	13.2	5.470386	1.610968	1.134226	1.9702	3.868147	-35.148	0.704065	88.43772	3.863356	-35.1981	0.705372	88.32819	3.868662	5.533506	2.906274	3.102577	3.418467	3.776065	3.865463	3.865463	3.865463	3.865463	3.865463	3.865463	3.865463	3.865463
N193	13 kV	13.2	5.199821	1.711639	1.168951	2.072717	3.676828	-34.3308	0.682942	84.06359	3.67199	-34.3824	0.684263	83.95296	3.6772	5.252084	2.76244	2.949029	3.249285	3.589185	3.674004	3.674004	3.674004	3.674004	3.674004	3.674004	3.674004	3.674004
N194	13 kV	13.2	5.004252	1.790918	1.196294	2.153719	3.538541	-33.7421	0.667978	80.90191	3.533669	-33.7949	0.669312	80.79051	3.538832	5.049625	2.658493	2.838061	3.127019	3.454129	3.524143	3.524143	3.524143	3.524143	3.524143	3.524143	3.524143	3.524143
N195	13 kV	13.2	4.783131	1.887974	1.229977	2.253284	3.382185	-33.0834	0.65148	77.32712	3.377528	-33.1362	0.652793	77.22065	3.382404	4.821629	2.540979	2.712609	2.988794	3.301445	3.377528	3.377528	3.377528	3.377528	3.377528	3.377528	3.377528	3.377528
N198	13 kV	13.2	4.686986	1.932937	1.245585	2.299506	3.3142	-32.7977	0.6444	75.77278	3.309636	-32.8505	0.645705	75.66845	3.314393	4.722764	2.489887	2.658066	2.928698	3.235062	3.309636	3.309636	3.309636	3.309636	3.309636	3.309636	3.309636	3.309636
N199	13 kV	13.2	4.658559	1.946573	1.250324	2.313538	3.294099	-32.7135	0.642321	75.31322	3.289563	-32.7663	0.643623	75.20952	3.294285	4.693563	2.474781	2.64194	2.91093	3.215435	3.289563	3.289563	3.289563	3.289563	3.289563	3.289563	3.289563	3.289563
N200	13 kV	13.2	4.404278	2.07617	1.295325	2.44711	3.114295	-31.9601	0.623901	71.20234	3.110007	-32.0129	0.625182	71.1043	3.114427	4.432922	2.339666	2.497698	2.752001	3.039882	3.110007	3.110007	3.110007	3.110007	3.110007	3.110007	3.110007	3.110007
N201	13 kV	13.2	4.169212	2.209636	1.341699	2.585082	2.948078	-31.2663	0.607203	67.40212	2.944019	-31.3191	0.608465	67.30931	2.948173	4.192821	2.21477	2.364366	2.605095	2.877608	2.944019	2.944019	2.944019	2.944019	2.944019	2.944019	2.944019	2.944019
N202	13 kV	13.2	16.28071	0.130195	0.649066	0.661995	11.5122	-78.6577	4.985344	263.2043	11.49966	-79.1453	5.215115	262.9175	14.41151	24.95025	10.82643	11.5577	12.73445	14.06657	11.79308	11.79308	11.79308	11.79308	12.74098	11.79308	11.79308	11.79308
N203	13 kV	13.2	15.8809	0.149446	0.662003	0.678662	11.22949	-77.2788	4.429721	256.7406	11.21725	-77.7662	4.612027	256.4608	13.68061	23.69484	10.27735	10.97153	12.0886	13.35316	11.21725	11.21725	11.21725	11.21725	11.94975	11.21725	11.21725	11.21725
N204	13 kV	13.2	14.49002	0.202692	0.715655	0.743805	10.24599	-74.1865	3.530754	234.2549	10.24234	-74.3347	3.565894	234.1712	11.84919	20.44175	8.901526	9.502778	10.47031	11.56558	10.24234	10.24234	10.24234	10.24234	10.68035	10.24234	10.24234	10.24234
N205	13 kV	13.2	12.3657	0.303572	0.81701	0.871585	8.743867	-69.6167	2.691322	199.9117	8.74279	-69.6518	2.696378	199.887	9.553237	16.21396	7.176724	7.661474	8.441529	9.324578	8.74279	8.74279	8.74279	8.74279	8.989975	8.74279	8.74279	8.74279
N206	13 kV	13.2	10.29433	0.437638	0.951103	1.04696	7.279194	-65.2911	2.173265	166.4247	7.278298	-65.3259	2.176746	166.4042	7.672654	12.71982	5.763965	6.153291	6.779789	7.489008	7.278298	7.278298	7.278298	7.278298	7.421043	7.278298	7.278298	7.278298
N207	13 kV	13.2	8.75335	0.575652	1.088419	1.231272	6.189553	-62.1262	1.89076	141.5122	6.188789	-62.1609	1.893533	141.4947	6.408749	10.41513	4.814475	5.139668	5.662964	6.255354	6.188789	6.188789	6.188789	6.188789	6.280954	6.188789	6.188789	6.188789
N208	13 kV	13.2	16.28071	0.130195	0.649066	0.661995	11.5122	-78.6577	4.985344	263.2043	11.49966	-79.1453	5.215115	262.9175	14.41151	24.95025	10.82643	11.5577	12.73445	14.06657	11.79308	11.79308	11.79308	11.79308	12.74098	11.79308	11.79308	11.79308
N209	13 kV	13.2	15.85288	0.151117	0.662853	0.679861	11.20968	-77.1572	4.386345	256.2877	11.19746	-77.6445	4.565159	256.0083	13.62541	23.59852	10.23589	10.92727	12.03983	13.29929	11.19746	11.19746	11.19746	11.19746	11.91554	11.19746	11.19746	11.19746
N210	13 kV	13.2	15.17506	0.185589	0.685551	0.710228	10.73039	-74.8522	3.693917	245.3297	10.71932	-75.3116	3.81493	245.0766	12.53674	21.65802	9.418039	10.05418	11.07785	12.23668	10.71932	10.71932	10.71932	10.71932	11.22223	10.71932	10.71932	10.71932
N211	13 kV	13.2	14.0503	0.247295	0.726128	0.767084	9.935062	-71.1928	2.936279	227.146	9.933557	-71.2412	2.944418	227.1116	11.04244	18.87004	8.295462	8.855777	9.757429	10.77813	9.933558	9.933558	9.933558	9.933558	10.25547	9.933558	9.933558	9.933558
N212	13 kV	13.2	13.0565	0.307884	0.765904	0.82547	9.232341	-68.1005	2.487642	211.0797	9.231208	-68.1355	2.492044	211.0538	9.943514	16.74938	7.469914	7.974468	8.78639	9.705514	9.231208	9.231208	9.231208	9.231208	9.460764	9.231208	9.231208	9.231208
N213	13 kV	13.2	12.25077	0.362413	0.801647	0.879762	8.6626	-65.673	2.211971	198.0536	8.661537	-65.7079	2.215573	198.0293	9.154481	15.21115	6.877165	7.341681	8.089176	8.935367	8.661537	8.661537	8.661537	8.661537	8.837016	8.661537	8.661537	8.661537
N214	13 kV	13.2	16.28071	0.130195	0.649066	0.661995	11.5122	-78.6577	4.985344	263.2043	11.49966	-79.1453	5.215115	262.9175	14.41151	24.95025	10.82643	11.5577	12.73445	14.06657	11.79308	11.79308	11.79308	11.79308	12.74098	11.79308	11.79308	11.79308
N215	13 kV	13.2	15.97533	0.144919	0.658901	0.67465	11.29626	-77.5958	4.546681	258.2673	11.28395	-78.0833	4.738475	257.9858	13.84513	23.98045	10.40094	11.10347	12.23397	13.51374	11.28395	11.28395	11.28395	11.28395	12.05647	11.28395	11.28395	11.28395
N216	13 kV	13.2	15.54189	0.166357	0.673215	0.693465	10.98978	-76.1198	4.046809	251.26	10.97779	-76.607	4.199833	250.9861	13.11142	22.6927	9.849751	10.51505	11.58564	12.79759	10.97779	10.97779	10.97779	10.97779	11.58153	10.97779	10.97779	10.97779
N217	13 kV	13.2	14.02226	0.24784	0.727564	0.768618	9.915234	-71.1889	2.935623	226.6927	9.913732	-71.2373	2.943765	226.6584	11.0199	18.83123	8.278529	8.8377	9.737512	10.75613	9.913732	9.913732	9.913732	9.913732	10.2349	9.913732	9.913732	9.913732
N218	13 kV	13.2	12.68751	0.330447	0.782571	0.849478	8.971423	-67.1077	2.36822	205.1143	8.970322	-67.1428	2.37227	205.0891	9.582477	16.05462	7.19869	7.684924	8.467366	9.353118	8.970322	8.970322	8.970322	8.970322	9.175484	8.970322	8.970322	8.970322
N219	13 kV	13.2	11.89272	0.38637	0.819759	0.906248	8.409423	-64.7645	2.121696	192.2652	8.408391	-64.7995	2.125062	192.2416	8.83387	14.59806	6.636311	7.084559	7.805874	8.622429	8.408391	8.408391	8.408391	8.408391	8.566057	8.408391	8.408391	8.408391
N220	13 kV	13.2	16.28071	0.130195	0.649066	0.661995	11.5122	-78.6577	4.985344	263.2043	11.49966	-79.1453	5.215115	262.9175	14.41151	24.95025	10.82643	11.5577	12.73445	14.06657	11.79308	11.79308	11.79308	11.79308	12.74098	11.79308	11.79308	11.79308
N221	13 kV	13.2	13.55418	0.247245	0.755745	0.795161	9.584252	-71.8843	3.056672	219.1254	9.582848	-71.932	3.065292	219.0933	10.74138	18.40386	8.0693	8.614339	9.49141	10.48429	9.608452	9.608452	9.608452	9.608452	9.939189	9.608452	9.608452	9.608452
N222	13 kV	13.2	10.05209	0.471768	0.962822	1.07219	7.107903	-63.8958	2.04088	162.5085	7.107116	-63.9289	2.043866	162.4905	7.427814	12.20851	5.580032	5.956934	6.563441	7.250027	7.112763	7.112763	7.112763	7.112763	7.23651	7.112763	7.112763	7.112763
N224	13 kV	13.2	8.225649	0.654734	1.134949	1.310262	5.816412	-60.012	1.73345	132.981	5.815808	-60.0519	1.735682	132.9672	5.969452	9.568669	4.48446	4.787362	5.274788	5.826571	5.816787	5.816787	5.816787	5.816787	5.888109	5.816787	5.816787	5.816787
N225	13 kV	13.2	7.272857	0.783367	1.257938	1.481915	5.142687	-58.0878	1.605808	117.5776	5.14218	-58.1188	1.607745	117.566	5.244455	8.301001	3.939817	4.205931	4.634159	5.118928	5.142241	5.142241	5.142241	5.142241	5.194327	5.142241	5.142241	5.142241
N226	13 kV	13.2	6.341345	0.94332	1.413786	1.699601	4.484008	-56.2876	1.498734	102.5182	4.483599	-56.3173	1.500419	102.5088	4.551262	7.120868	3.419066	3.650006	4.021632	4.442326	4.483861	4.483861	4.483861	4.483861	4.521258	4.483861	4.483861	4.483861
N227	13 kV	13.2	5.963812	1.069292	1.4569	1.807192	4.217052	-53.7232	1.362491	96.41475	4.216712	-53.7523	1.363943	96.40698	4.258748	6.558295	3.19932	3.415417	3.763159	4.156814	4.220584	4.220584	4.220584	4.220584	4.246185	4.220584	4.220584	4.220584
N228	13 kV	13.2	5.759422	1.139262	1.484568	1.871326	4.072526	-52.4973	1.303096	93.11045	4.072285	-52.5201	1.304173	93.10495	4.10519	6.276257	3.083962	3.292267	3.62747	4.006932	4.079851	4.079851	4.079851	4.079851	4.100534	4.079851	4.079851	4.079851
N229	13 kV	13.2	5.65084	1.177193	1.500649	1.907284	3.995747	-51.8874	1.274769	91.35505	3.995747	-51.8874	1.274769	91.35505	4.024551	6.13148	3.023383	3.227597	3.556215	3.928223	4.005853	4.005853	4.005853	4.005853	4.024198	4.005853	4.005853	4.005853
N230	13 kV	13.2	5.463708	1.243842	1.531025	1.972608	3.863425	-50.9087	1.230884	88.32976	3.863425	-50.9087	1.230884	88.32976	3.8868	5.889341	2.9199	3.117124	3.434494	3.793769	3.878726	3.878726	3.878726	3.878726	3.893652	3.878726	3.878726	3.878726

3-Ph Fault

Node	Network Level	Vk [kV]	idc [kA]	Zr [Ohm]	Zi [Ohm]	Za [Ohm]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	I PF15 [kA]	I PF20 [kA]	I PF30 [kA]	I PF50 [kA]	I sym 2 [kA]	I sym 3 [kA]	I sym 5 [kA]	I sym 8 [kA]	I tot 2 [kA]	I tot 3 [kA]	I tot 5 [kA]	I tot 8 [kA]
N231	13 kV	13.2	5.151524	1.358533	1.591061	2.092149	3.642677	-49.5075	1.171161	83.28279	3.642677	-49.5075	1.171161	83.28279	3.659678	5.50386	2.749277	2.934976	3.233802	3.572082	3.669509	3.669509	3.669509	3.669509	3.679977	3.669509	3.669509	3.669509
N232	13 kV	13.2	4.839379	1.476575	1.667236	2.227094	3.421958	-48.4706	1.129124	78.23647	3.421958	-48.4706	1.129124	78.23647	3.435042	5.13891	2.580523	2.754824	3.035307	3.352824	3.464736	3.464736	3.464736	3.464736	3.472192	3.464736	3.464736	3.464736
N233	13 kV	13.2	4.507192	1.602244	1.775054	2.391235	3.187066	-47.9292	1.107855	72.86612	3.187066	-47.9292	1.107855	72.86612	3.19802	4.771651	2.402464	2.564738	2.825867	3.121474	3.253143	3.253143	3.253143	3.253143	3.258991	3.253143	3.253143	3.253143
N234	13 kV	13.2	4.398813	1.641802	1.818715	2.450151	3.110431	-47.9266	1.107755	71.11399	3.110431	-47.9266	1.107755	71.11399	3.121115	4.656847	2.34469	2.503062	2.757912	3.046411	3.18615	3.18615	3.18615	3.18615	3.191872	3.18615	3.18615	3.18615
N235	13 kV	13.2	4.275135	1.684757	1.87542	2.521032	3.022977	-48.0655	1.113169	69.11454	3.022977	-48.0655	1.113169	69.11454	3.033651	4.529398	2.278984	2.432918	2.680626	2.96104	3.11136	3.11136	3.11136	3.11136	3.117229	3.11136	3.11136	3.11136
N236	13 kV	13.2	4.103753	1.737473	1.969448	2.626317	2.901791	-48.5808	1.133513	66.34386	2.901791	-48.5808	1.133513	66.34386	2.913128	4.360503	2.188443	2.336261	2.574128	2.843402	3.011487	3.011487	3.011487	3.011487	3.018188	3.011487	3.011487	3.011487
N237	13 kV	13.2	3.968506	1.76929	2.060412	2.715821	2.806158	-49.3471	1.164542	64.15738	2.806158	-49.3471	1.164542	64.15738	2.818862	4.235824	2.117627	2.260662	2.490831	2.751391	2.93689	2.93689	2.93689	2.93689	2.944944	2.93689	2.93689	2.93689
N238	13 kV	13.2	3.842521	1.786244	2.162546	2.804865	2.717073	-50.4436	1.210667	62.12063	2.717073	-50.4436	1.210667	62.12063	2.732173	4.12937	2.052503	2.191139	2.41423	2.666778	2.871813	2.871813	2.871813	2.871813	2.881897	2.871813	2.871813	2.871813
N239	13 kV	13.2	3.777881	1.787769	2.223213	2.852857	2.671365	-51.1959	1.243569	61.07561	2.671365	-51.1959	1.243569	61.07561	2.688389	4.079947	2.019611	2.156025	2.375542	2.624042	2.840662	2.840662	2.840662	2.840662	2.852194	2.840662	2.840662	2.840662
N240	13 kV	13.2	3.724718	1.784146	2.27807	2.893576	2.633774	-51.9326	1.276841	60.21615	2.633774	-51.9326	1.276841	60.21615	2.652911	4.042799	1.992959	2.127573	2.344193	2.589413	2.816439	2.816439	2.816439	2.816439	2.829435	2.816439	2.816439	2.816439
N241	13 kV	13.2	3.644785	1.768233	2.370107	2.957035	2.577252	-53.275	1.340381	58.92389	2.577252	-53.275	1.340381	58.92389	2.600877	3.994545	1.953869	2.085843	2.298213	2.538624	2.782809	2.782809	2.782809	2.782809	2.798596	2.782809	2.782809	2.782809
N242	13 kV	13.2	3.325569	1.961117	2.580173	3.240875	2.351533	-52.7626	1.315665	53.76326	2.351533	-52.7626	1.315665	53.76326	2.371279	3.63095	1.781387	1.901711	2.095334	2.314522	2.351533	2.351533	2.351533	2.351533	2.363904	2.351533	2.351533	2.351533
N243	13 kV	13.2	2.91044	2.274922	2.921977	3.703136	2.057992	-52.0973	1.28443	47.05201	2.057992	-52.0973	1.28443	47.05201	2.073385	3.162623	1.557599	1.662807	1.832106	2.023758	2.057992	2.057992	2.057992	2.057992	2.067748	2.057992	2.057992	2.057992
N244	13 kV	13.2	2.62036	2.552982	3.22486	4.113081	1.852874	-51.6329	1.263173	42.3624	1.852874	-51.6329	1.263173	42.3624	1.865642	2.838253	1.401535	1.496202	1.648538	1.820988	1.852874	1.852874	1.852874	1.852874	1.861002	1.852874	1.852874	1.852874
N245	13 kV	13.2	2.751016	2.420503	3.080555	3.917736	1.945262	-51.842	1.272692	44.47467	1.945262	-51.842	1.272692	44.47467	1.959173	2.984069	1.471799	1.571211	1.731185	1.91228	1.945262	1.945262	1.945262	1.945262	1.954103	1.945262	1.945262	1.945262
N246	13 kV	13.2	3.0755	2.14005	2.775058	3.504392	2.174707	-52.3616	1.296726	49.72047	2.174707	-52.3616	1.296726	49.72047	2.191742	3.348237	1.646513	1.757727	1.93669	2.139283	2.174707	2.174707	2.174707	2.174707	2.185461	2.174707	2.174707	2.174707
N247	13 kV	13.2	2.922312	2.264726	2.910849	3.688092	2.066386	-52.116	1.285298	47.24394	2.066386	-52.116	1.285298	47.24394	2.081894	3.175942	1.563991	1.66963	1.839624	2.032063	2.066386	2.066386	2.066386	2.066386	2.076212	2.066386	2.066386	2.066386
N248	13 kV	13.2	2.7212	2.449641	3.112251	3.960663	1.924179	-51.7939	1.270493	43.99264	1.924179	-51.7939	1.270493	43.99264	1.937822	2.950743	1.455759	1.554088	1.712318	1.89144	1.924179	1.924179	1.924179	1.924179	1.932854	1.924179	1.924179	1.924179
N249	13 kV	13.2	2.582234	2.59419	3.26969	4.173811	1.825915	-51.5713	1.260389	41.74602	1.825915	-51.5713	1.260389	41.74602	1.83836	2.79578	1.38104	1.474322	1.62443	1.794358	1.825915	1.825915	1.825915	1.825915	1.833839	1.825915	1.825915	1.825915
N250	13 kV	13.2	2.413419	2.792118	3.48527	4.465761	1.706545	-51.3011	1.248253	39.01686	1.706545	-51.3011	1.248253	39.01686	1.717628	2.608226	1.290342	1.377498	1.517748	1.676516	1.706545	1.706545	1.706545	1.706545	1.713606	1.706545	1.706545	1.706545
N251	13 kV	13.2	2.25721	3.001573	3.713409	4.774814	1.596088	-51.0512	1.237154	36.49148	1.596088	-51.0512	1.237154	36.49148	1.605997	2.43534	1.206481	1.287973	1.419108	1.567558	1.596088	1.596088	1.596088	1.596088	1.602397	1.596088	1.596088	1.596088
N252	13 kV	13.2	2.053874	3.321838	4.062253	5.247524	1.452308	-50.726	1.222893	33.20423	1.452308	-50.726	1.222893	33.20423	1.460808	2.211229	1.09741	1.171534	1.290814	1.425843	1.452308	1.452308	1.452308	1.452308	1.457704	1.452308	1.452308	1.452308
N253	13 kV	13.2	1.967347	3.478165	4.232535	5.47832	1.391124	-50.5877	1.216888	31.80537	1.391124	-50.5877	1.216888	31.80537	1.399063	2.116173	1.051025	1.122016	1.236254	1.365576	1.391124	1.391124	1.391124	1.391124	1.396153	1.391124	1.391124	1.391124
N254	13 kV	13.2	3.545723	1.73321	2.497089	3.03965	2.507205	-55.2358	1.440731	57.32239	2.507205	-55.2358	1.440731	57.32239	2.539005	3.946314	1.907389	2.036223	2.243542	2.478234	2.743969	2.743969	2.743969	2.743969	2.764125	2.743969	2.743969	2.743969
N255	13 kV	13.2	3.497607	1.70668	2.565672	3.081465	2.473182	-56.3682	1.503311	56.54453	2.473182	-56.3682	1.503311	56.54453	2.510749	3.930311	1.886162	2.013562	2.218574	2.450654	2.727175	2.727175	2.727175	2.727175	2.750052	2.727175	2.727175	2.727175
N256	13 kV	13.2	3.471648	1.689421	2.604577	3.104507	2.454826	-57.0311	1.541698	56.12485	2.454826	-57.0311	1.541698	56.12485	2.49617	3.924079	1.87521	2.00187	2.205691	2.436423	2.718709	2.718709	2.718709	2.718709	2.743254	2.718709	2.718709	2.718709
N257	13 kV	13.2	3.45061	1.673831	2.637069	3.123434	2.43995	-57.5954	1.575468	55.78475	2.43995	-57.5954	1.575468	55.78475	2.484761	3.920378	1.866639	1.992721	2.19561	2.425288	2.712155	2.712155	2.712155	2.712155	2.738168	2.712155	2.712155	2.712155
N258	13 kV	13.2	3.379716	1.610191	2.752582	3.188953	2.38982	-59.6734	1.709476	54.63862	2.38982	-59.6734	1.709476	54.63862	2.449622	3.917681	1.840241	1.96454	2.16456	2.390989	2.697274	2.697274	2.697274	2.697274	2.729168	2.697274	2.697274	2.697274
N259	13 kV	13.2	3.115436	1.815621	2.944732	3.459469	2.202946	-58.3434	1.621887	50.3661	2.202946	-58.3434	1.621887	50.3661	2.248247	3.564482	1.688961	1.803042	1.986619	2.194434	2.281189	2.281189	2.281189	2.281189	2.304833	2.281189	2.281189	2.281189
N260	13 kV	13.2	2.906015	1.98634	3.132006	3.708775	2.054863	-57.6168	1.576772	46.98047	2.054863	-57.6168	1.576772	46.98047	2.092725	3.302294	1.572128	1.678317	1.849195	2.042635	2.054863	2.054863	2.054863	2.054863	2.074616	2.054863	2.054863	2.054863
N261	13 kV	13.2	2.684514	2.195411	3.361352	4.014787	1.898238	-56.8501	1.531081	43.39956	1.898238	-56.8501	1.531081	43.39956	1.929325	3.029456	1.449376	1.547274	1.70481	1.883146	1.898238	1.898238	1.898238	1.898238	1.91504	1.898238	1.898238	1.898238
N262	13 kV	13.2	3.026964	1.842083	3.047044	3.560582	2.140387	-58.845	1.654129	48.93582	2.140387	-58.845	1.654129	48.93582	2.187816	3.480046	1.643564	1.754578	1.93322	2.13545	2.221664	2.221664	2.221664	2.221664	2.245884	2.221664	2.221664	2.221664
N263	13 kV	13.2	2.944997	1.863622	3.149634	3.659683	2.082427	-59.3874	1.69006	47.61068	2.082427	-59.3874	1.69006	47.61068	2.132408	3.403973	1.601939	1.710141	1.88426	2.081368	2.166916	2.166916	2.166916	2.166916	2.191838	2.166916	2.166916	2.166916
N264	13 kV	13.2	2.896749	1.874418	3.213985	3.720638	2.048311	-59.749	1.714658	46.83068	2.048311	-59.749	1.714658	46.83068	2.100133	3.360407	1.577693	1.684258	1.855741	2.049866	2.134914	2.134914	2.134914	2.134914	2.160343	2.134914	2.134914	2.134914
N265	13 kV	13.2	2.770586	1.892721	3.398558	3.890064	1.9591	-60.8857	1.795594	44.79104	1.9591	-60.8857	1.795594	44.79104	2.017437	3.252228	1.515569	1.617938	1.782668	1.969149	2.052252	2.052252	2.052252	2.052252	2.079465	2.052252	2.052252	2.052252
N267	13 kV	13.2	2.632569	1.884232	3.634633	4.094006	1.861508	-62.5973	1.928972	42.55978	1.861508	-62.5973	1.928972	42.55978	1.931835	3.149072	1.451262	1.549287	1.707028	1.885596	1.964326	1.964326	1.964326	1.964326	1.994739	1.964326	1.964326	1.964326
N268	13 kV	13.2	2.555114	1.856715	3.787488	4.218111	1.806739	-63.8848	2.039887	41.30759	1.806739	-63.8848	2.039887	41.30759	1.887937	3.102837	1.418284	1.514081	1.668238	1.842748	1.916827	1.916827	1.916827	1.916827	1.950048	1.916827	1.916827	1.916827
N269	13 kV	13.2	2.494746	1.816684	3.919647	4.320182	1.764052	-65.1331	2.157583	40.33164	1.764052	-65.1331	2.157583	40.33164	1.857471	3.076397	1.395396	1.489648	1.641317	1.813012	1.881203	1.881203	1.881203	1.881203	1.917497	1.881203	1.881203	1.881203
N270	13 kV	13.2	2.473683	1.79734	3.96897	4.356967	1.749158	-65.6367	2.208246	39.99113	1.749158	-65.6367	2.208246	39.99113	1.848017	3.070016	1.388295	1.482067	1.632964	1.803784	1.869176	1.869176	1.869176	1.869176	1.906816	1.869176	1.869176	1.869176
N271	13 kV	13.2	2.04594	2.431096	4.673359	5.267876	1.446698	-62.5164	1.922326	33.07595	1.446698	-62.5164	1.922326	33.07595	1.500752	2.445093	1.127417	1.203569	1.32611	1.464832	1.446698	1.446698	1.446698	1.446698	1.468937	1.446698	1.446698	1.446698
N272	13 kV	13.2	2.241849	2.111848	4.318845	4.807528	1.585227	-63.9421	2.045055	36.24316	1.585227	-63.9421	2.045055	36.24316	1.657015	2.724294	1.244807	1.328887	1.464188	1.617354	1.585227	1.585227	1.585227	1.585227	1.612838	1.585227	1.585227	1.585227
N273	13 kV	13.2	16.28071	0.130195	0.649066	0.661995	11.5122	-78.6577	4.985344	263.2043	11.49966	-79.1453	5.215115	262.9175	14.41151	24.95025	10.82643	11.5577	12.73445	14.06657	11.79308	11.79308	11.79308	11.79308	12.74098	11.79308	11.79308	11.79308
N274	13 kV	13.2	15.40272	0.19743	0.6713	0.699733	10.89137	-73.6114	3.400201	249.0102	10.87938	-74.0988	3.510246	248.7359	12.49017	21.51684	9.383053	10.01683	11.03669	12.19122	10.88142	10.88142	10.88142	10.88142	11.33667	10.88142	10.88142	10.88142
N275	13 kV	13.2	14.74685	0.247217	0.68777	0.730852	10.42759	-70.2291	2.782045	238.4068	10.42184	-70.4597	2.817609	238.2752	11.4657	19.5142	8.613435	9.195228	10.13144	11.19127	10.42371	10.42371	10.42371	10.42371	10.73948	10.42371	10.42371	10.42371
N276	13 kV	13.2	12.47907	0.430816	0.748543	0.863666	8.824036	-60.0779	1.737502	201.7446	8.822442	-60.1141	1.740047	201.7081	9.058157	14.52519	6.804802	7.264431	8.004061	8.841348	8.823859	8.823859	8.823859	8.823859	8.932693	8.823859	8.823859	8.823859
N277	13 kV	13.2	10.40342	0.636807	0.81715	1.035982	7.356331	-52.0706	1.283198	168.1883	7.354712	-52.1074	1.2849	168.1513	7.411099	11.30274	5.567475	5.943529	6.548671	7.233713	7.355805	7.355805	7.355805	7.355805	7.390733	7.355805	7.355805	7.355805
N278	13 kV	13.2	9.833497	0.704415	0.839685	1.096025	6.953332	-50.0066	1.192032	158.9745	6.95171	-50.0436	1.193598	158.9374	6.988971	10.5384	5.250358	5.604993	6.175666	6.821688	6.952725	6.952725	6.952725	6.952725	6.975159	6.952725	6.952725	6.952725
N279	13 kV	13.2	8.786678	0.846976	0.887234	1.226602	6.21312	-46.3298	1.047531	142.051	6.211497	-46.3674	1.048907	142.0139	6.228531	9.22456	4.679089	4.995137	5.503718	6.07945	6.209535	6.209535	6.209535	6.209535	6.214597	6.209535	6.209535	6.209535
N280	13 kV	13.2	7.050724	1.159814	0.995719	1.528603	4.985615	-40.6466	0.858516	113.9865	4.984312	-40.6842	0.859655	113.9567	4.988919	7.232279	3.74785	4.000997	4.40836	4.869508	4.984312	4.984312	4.984312	4.984312	4.984312	4.984312	4.984312	4.984312
N281	13 kV	13.2	6.425093	1.309946	1.047793	1.677447	4.543227	-38.6554	0.799875	103.8721	4.54204	-38.693	0.80095	103.845	4.544988	6.551608	3.414353	3.644975	4.016089	4.436203	4.54204	4.54204	4.54204	4.54204	4.54204	4.54204	4.54204	4.54204
N282	13 kV	13.2	5.733947	1.511264	1.117643	1.87964	4.054513	-36.4845	0.739542	92.69861	4.053842	-36.4944	0.73981	92.68329	4.055341	5.815899	3.046513	3.252289	3.583422	3.958275	4.053842	4.053842	4.053842	4.053842	4.053842	4.053842	4.053842	4.053842
N283	13 kV	13.2	5.442171	1.610755	1.152176	1.980415	3.848196	-35.5762	0.715302	87.98157	3.84756	-35.5861	0.715564	87.96703	3.848785	5.509524	2.891341	3.086636	3.400903	3.756664	3.84756	3.84756	3.84756	3.84756	3.84756	3.84756	3.84756	3.84756
N284	13 kV	13.2	4.992268	1.785902	1.212995	2.158889	3.530067	-34.1846	0.679206	80.70816	3.529483	-34.1945	0.679459	80.69482	3.530406	5.041191	2.652164	2.831303	3.119573	3.445905	3.529483	3.529483	3.529483	3.529483	3.529483	3.529483	3.529483	3.529483
N285	13 kV	13.2	7.99776	0.974065	0.931243	1.347597	5.655271	-43.7125	0.956083	129.2969	5.653793	-43.75	0.957293	129.2631	5.663176	8.296886	4.254375	4.541736	5.004153	5.527627	5.653793	5.653793	5.653793	5.653793	5.653793	5.653793	5.653793	5.653793
N286	13 kV	13.2	7.427042	1.080906	0.968236	1.45115	5.251711	-41.8528	0.896763	120.0702	5.250339	-41.8904	0.896945	120.0389	5.25643	7.649717	3.948813	4.215535	4.64474	5.130616	5.250339	5.250339	5.250339	5.250339	5.250339	5.250339	5.250339	5.250339
N287	13 kV	13.2	6.963638	1.179326	1.00231	1.547719	4.924035	-40.3612	0.849901	112.5786	4.922749	-40.3988	0.85103	112.5492	4.927066	7.13642	3.701383	3.951393	4.353704	4.809136	4.922749	4.922749	4.922749	4.922749	4.922749	4.922749	4.922749	4.922749
N288	13 kV	13.2	6.370908	1.324409	1.052538	1.691714	4.504913	-38.475	0.794723	102.9961	4.503735	-38.5125	0.795792	102.9692	4.506572	6.493202	3.385494	3.614166	3.982143	4.398706	4.503735	4.503735	4.503735	4.503735	4.503735	4.503735	4.503735	4.503735
N289	13 kV	13.2	6.024327	1.421576	1.086178	1.789039	4.259842	-37.3822	0.764066	97.39308	4.258729	-37.4198	0.765104	97.36762	4.260985	6.123007	3.201	3.417211	3.765135	4.158997	4.258729	4.258729	4.258729	4.258729	4.258729	4.258729	4.258729	4.258729
N290	13 kV	13.2	5.506569	1.588128	1.143981	1.957254	3.893733	-35.7664	0.720333	89.02268	3.893089	-35.7764	0.720596	89.00797	3.894367	5.576843	2.925584	3.123192	3.44118	3.801154	3.893089	3.893089	3.893089	3.893089	3.893089	3.893089	3.893089	3.893089
N291	13 kV	13.2	5.026822	1.77157	1.207679	2.14405	3.5545	-34.2822	0.6817	81.26678	3.553912	-34.2922	0.681953	81.25334	3.554853	5.076924	2.670529	2.85091	3.141175	3.469767	3.553912	3.553912	3.553912	3.553912	3.553912	3.553912	3.553912	3.553912
N292	13 kV	13.2	5.265658	1.676301	1.174483	2.046801	3.723383	-35.0166	0.70064	85.12796	3.722767	-35.0265	0.700898	85.11388	3.723857	5.325104	2.797491	2.986447	3.290513	3.634726	3.722767	3.722767	3.722767	3.722767	3.722767	3.722767	3.722767	3.722767
N293	13 kV	13.2	5.025203	1.772322	1.207802	2.14474	3.553355	-34.2736	0.68148	81.24061	3.552768	-34.2836	0.681733	81.22718	3.553707	5.075215	2.669668	2.849991	3.140163	3.468648	3.552768	3.552768	3.552768	3.552768	3.552768	3.552768	3.552768	3.552768
N294	13 kV	13.2	4.769321	1.884723	1.246818	2.259809	3.372419	-33.4862	0.661539	77.10386	3.371861	-33.4961	0.661788	77.09111	3.372672	4.810628	2.533669	2.704805	2.980195	3.291946	3.371861	3.371861	3.371861	3.371861	3.371861	3.371861	3.371861	3.371861
N295	13 kV	13.2	4.516138	2.008035	1.28964	2.386498	3.193392	-32.7102	0.64224	73.01074	3.192864	-32.7201	0.642485	72.99867	3.193572	4.55005	2.399122	2.56117	2.821936	3.117133	3.192864	3.192864	3.192864	3.192864	3.192864	3.192864	3.192864	3.192864
N296	13 kV	13.2	4.90369	1.824269	1.225866	2.197886	3.467433	-33.9002	0.671977	79.27616	3.46686	-33.9101	0.672228	79.26305	3.467734	4.949413	2.605083	2.781042	3.064195	3.384733	3.46686	3.46686	3.46686	3.46686	3.46686	3.46686	3.46686	3.46686
N297	13 kV	13.2	4.849626	1.522633	1.618827	2.222389	3.429203	-46.7539	1.063175	78.40212	3.429203	-46.7539	1.063175	78.40212	3.438493	5.10221	2.583116	2.757592	3.038356	3.356192	3.429203	3.429203	3.429203	3.429203	3.432814	3.429203	3.429203	3.429203
N298	13 kV	13.2	4.475751	1.717002	1.68835	2.408033	3.164834	-44.518	0.983313	72.35782	3.164834	-44.518	0.983313	72.35782	3.170142	4.659124	2.381521	2.54238	2.801233	3.094264	3.164834	3.164834	3.164834	3.164834	3.164834	3.164834	3.164834	3.164834
N299	13 kV	13.2	4.097325	1.945669	1.770189	2.630437	2.897246	-42.2962	0.90981	66.23995	2.897246	-42.2962	0.90981	66.23995	2.900147	4.227005	2.178691	2.325851	2.562658	2.830731	2.897246	2.897246	2.897246	2.897246	2.897246	2.897246	2.897246	2.897246
N300	13 kV	13.2	3.832389	2.130065	1.836232	2.812281	2.709908	-40.7631	0.862054	61.95683	2.709908	-40.7631	0.862054	61.95683	2.711759	3.932566	2.037168	2.174768	2.396192	2.646853	2.709908	2.709908	2.709908	2.709908	2.709908	2.709908	2.709908	2.709908
N301	13 kV	13.2	4.617304	1.640123	1.660882	2.33421	3.264927	-45.3603	1.012657	74.64626	3.264927	-45.3603	1.012657	74.64626	3.271515	4.824827	2.457676	2.623679	2.89081	3.193211	3.264927	3.264927	3.264927	3.264927	3.265616	3.264927	3.264927	3.264927
N302	13 kV	13.2	4.207441	1.875221	1.745081	2.561594	2.97511	-42.9413	0.9306	68.02015	2.97511	-42.9413	0.9306	68.02015	2.978585	4.351285	2.237617	2.388756	2.631968	2.907292	2.97511	2.97511	2.97511	2.97511	2.97511	2.97511	2.97511	2.97511

3-Ph Fault

Node	Network Level	Vk [kV]	idc [kA]	Zr [Ohm]	Zi [Ohm]	Za [Ohm]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	I PF15 [kA]	I PF20 [kA]	I PF30 [kA]	I PF50 [kA]	I sym 2 [kA]	I sym 3 [kA]	I sym 5 [kA]	I sym 8 [kA]	I tot 2 [kA]	I tot 3 [kA]	I tot 5 [kA]	I tot 8 [kA]
N305	13 kV	13.2	2.391623	2.615233	3.669978	4.50646	1.691133	-54.5263	1.403308	38.66449	1.691133	-54.5263	1.403308	38.66449	1.710241	2.646562	1.284793	1.371574	1.511221	1.669306	1.691133	1.691133	1.691133	1.691133	1.702501	1.691133	1.691133	1.691133
N307	13 kV	13.2	6.214228	0.985173	1.427398	1.734368	4.394123	-55.387	1.448881	100.4631	4.393737	-55.4166	1.450479	100.4543	4.451232	6.924969	3.34392	3.569785	3.933243	4.344691	4.39474	4.39474	4.39474	4.39474	4.427736	4.39474	4.39474	4.39474
N308	13 kV	13.2	6.117832	1.017277	1.438303	1.761695	4.32596	-54.7291	1.413875	98.90473	4.325592	-54.7585	1.415413	98.89631	4.376493	6.780974	3.287774	3.509846	3.867201	4.27174	4.327478	4.327478	4.327478	4.327478	4.357439	4.327478	4.327478	4.327478
N309	13 kV	13.2	6.054896	1.038421	1.445719	1.780007	4.281458	-54.3113	1.392228	97.88728	4.281101	-54.3406	1.39373	97.87912	4.32815	6.688929	3.251457	3.471076	3.824484	4.224555	4.283713	4.283713	4.283713	4.283713	4.311823	4.283713	4.283713	4.283713
N310	13 kV	13.2	5.786872	1.131689	1.479188	1.862449	4.091936	-52.5813	1.307063	93.55423	4.091606	-52.6104	1.30844	93.54669	4.125238	6.309984	3.099022	3.308345	3.645185	4.0265	4.091606	4.091606	4.091606	4.091606	4.11264	4.091606	4.091606	4.091606
N312	13 kV	13.2	5.278288	1.311461	1.565068	2.041903	3.732313	-50.0384	1.193377	85.33215	3.732313	-50.0384	1.193377	85.33215	3.751557	5.657781	2.8183	3.008661	3.314989	3.661762	3.753996	3.753996	3.753996	3.753996	3.766094	3.753996	3.753996	3.753996
N317	13 kV	13.2	4.911521	1.468424	1.630658	2.194382	3.47297	-47.9966	1.110482	79.40276	3.47297	-47.9966	1.110482	79.40276	3.485067	5.201644	2.618104	2.794943	3.07951	3.401651	3.47297	3.47297	3.47297	3.47297	3.479365	3.47297	3.47297	3.47297
N318	13 kV	13.2	4.964784	1.428885	1.63427	2.17084	3.510633	-48.8359	1.143738	80.26384	3.510633	-48.8359	1.143738	80.26384	3.525043	5.283197	2.648135	2.827003	3.114835	3.44067	3.546387	3.546387	3.546387	3.546387	3.554883	3.546387	3.546387	3.546387
N319	13 kV	13.2	4.726338	1.519635	1.700222	2.28036	3.342026	-48.2101	1.118836	76.40897	3.342026	-48.2101	1.118836	76.40897	3.354168	5.011482	2.519768	2.689965	2.963844	3.273885	3.391835	3.391835	3.391835	3.391835	3.398553	3.391835	3.391835	3.391835
N321	13 kV	13.2	3.495487	1.854081	2.463602	3.083334	2.471683	-53.0353	1.328746	56.51026	2.471683	-53.0353	1.328746	56.51026	2.493433	3.824106	1.873153	1.999675	2.203272	2.433752	2.471683	2.471683	2.471683	2.471683	2.485225	2.471683	2.471683	2.471683
N325	13 kV	13.2	3.292083	1.678489	2.810819	3.27384	2.327854	-59.1563	1.674613	53.2219	2.327854	-59.1563	1.674613	53.2219	2.381863	3.79643	1.789338	1.910199	2.104686	2.324853	2.388915	2.388915	2.388915	2.388915	2.415775	2.388915	2.388915	2.388915
N326	13 kV	13.2	3.190971	1.757154	2.884519	3.377579	2.256357	-58.6516	1.641586	51.58725	2.256357	-58.6516	1.641586	51.58725	2.304941	3.66172	1.731552	1.848509	2.036715	2.249772	2.32695	2.32695	2.32695	2.32695	2.351832	2.32695	2.32695	2.32695
N333	13 kV	13.2	11.67669	0.543427	0.746086	0.923015	8.256664	-53.9315	1.372927	188.7727	8.20083	-55.542	1.457295	187.4962	8.3412	12.86122	6.2662	6.689449	7.370536	8.141551	8.209982	8.209982	8.209982	8.209982	8.272555	8.209982	8.209982	8.209982
N335	13 kV	13.2	5.538339	1.64688	1.036728	1.946027	3.916197	-32.1908	0.62951	89.53629	3.908737	-32.2651	0.631322	89.36574	3.916378	5.576011	2.94212	3.140844	3.46063	3.822639	3.908737	3.908737	3.908737	3.908737	3.908737	3.908737	3.908737	3.908737
N336	13 kV	13.2	7.358492	1.144177	0.914392	1.464669	5.20324	-38.6308	0.79917	118.962	5.144037	-40.3159	0.848539	117.6085	5.205243	7.502885	3.91036	4.174484	4.59951	5.080654	5.144037	5.144037	5.144037	5.144037	5.144037	5.144037	5.144037	5.144037
N339	13 kV	13.2	9.629149	0.773117	0.809375	1.119284	6.808836	-46.3125	1.046898	155.6709	6.731379	-47.9976	1.110519	153.9	6.825664	10.10814	5.127676	5.474024	6.031363	6.66229	6.731379	6.731379	6.731379	6.731379	6.743778	6.731379	6.731379	6.731379
N342	13 kV	13.2	6.592442	1.320235	0.964243	1.634865	4.661561	-36.1428	0.730357	106.5776	4.608654	-37.8094	0.775942	105.368	4.662416	6.681763	3.502569	3.73915	4.119852	4.55082	4.608654	4.608654	4.608654	4.608654	4.608654	4.608654	4.608654	4.608654
N343	13 kV	13.2	8.293397	0.969823	0.865041	1.299559	5.864317	-41.7316	0.891958	134.0763	5.797597	-43.4167	0.946206	132.5509	5.869431	8.538354	4.409321	4.707148	5.186407	5.728945	5.797597	5.797597	5.797597	5.797597	5.797597	5.797597	5.797597	5.797597
N345	13 kV	13.2	2.185192	3.451389	3.523393	4.932178	1.545164	-45.5915	1.020862	35.32719	1.545075	-45.5948	1.020982	35.32516	1.548441	2.285884	1.163243	1.241814	1.368249	1.511379	1.545075	1.545075	1.545075	1.545075	1.545615	1.545075	1.545075	1.545075
N346	13 kV	13.2	2.100928	3.601392	3.653336	5.129998	1.48558	-45.4102	1.014423	33.96492	1.485488	-45.4138	1.01455	33.96283	1.488611	2.195864	1.118296	1.193831	1.315381	1.45298	1.485575	1.485575	1.485575	1.485575	1.485935	1.485575	1.485575	1.485575
N347	13 kV	13.2	1.738563	4.375812	4.391212	6.199231	1.22935	-45.1006	1.003519	28.10671	1.229263	-45.1047	1.003661	28.10472	1.231694	1.814526	0.925292	0.98779	1.088362	1.202214	0.073683	0.073683	0.073683	0.073683	0.073687	0.073683	0.073683	0.073683
N356	13 kV	13.2	10.45343	0.673031	0.781052	1.031025	7.391694	-49.2486	1.160499	168.9968	7.307611	-50.9337	1.231979	167.0744	7.424535	11.15099	5.577569	5.954305	6.560544	7.246827	7.307611	7.307611	7.307611	7.307611	7.335865	7.307611	7.307611	7.307611

1-Ph Fault

Node	Network Level	idc [kA]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	IL1a [kA]	IL1r [kA]	IL1i [kA]	3I0a [kA]	3I0r [kA]	3I0i [kA]	VL1a [kV]	VL1r [kV]	VL1i [kV]	VL2a [kV]	VL2r [kV]	VL2i [kV]	VL3a [kV]	VL3r [kV]	VL3i [kV]	V0a [kV]	V0r [kV]	V0i [kV]	Z0/Z1a [pu]	Z0/Z1r [pu]	Z0/Z1i [pu]	Z1a [Ohm]	Z1r [Ohm]	Z1i [Ohm]	Z0a [Ohm]	Z0r [Ohm]	Z0i [Ohm]
N5	13 kV	14.17939	10.02634	-79.4786	5.384292	76.41098	10.02511	-79.5137	5.402703	76.40163	12.77181	22.09087	10.02634	1.830838	-9.85777	10.02634	-1.83084	9.857765	3.34E-06	6.10E-07	-3.29E-06	8.610304	-4.55796	-7.30495	8.449434	-5.43583	6.468743	3.342905	3.331264	0.278738	2.007161	2.006613	0.046923	0.569095	0.110464	0.558272	1.142266	0.195462	1.125418
Satala 35 k	35 kV	0.067353	0.047626	94.63171	12.34338	0.948638	0.047553	93.69997	15.46394	0.947186	0.070675	0.119571	0.047626	-0.00385	0.04747	0.047626	0.003846	-0.04747	1.59E-08	-1.28E-09	1.58E-08	36.10808	-29.7082	-20.5236	36.15875	-32.8134	15.19002	20.91622	20.84052	1.777864	202.2103	-199.838	-30.8853	6.26614	1.46331	6.092884	1267.078	-104.244	-1262.78
N7	13 kV	17.27264	12.2136	-76.8498	4.280236	93.08013	12.13608	-78.4673	4.900831	92.48933	14.76176	25.56344	12.2136	2.77866	-11.8933	12.2136	-2.77866	11.89332	4.07E-06	9.26E-07	-3.96E-06	7.724496	-2.61857	-7.26711	7.656249	-4.24375	6.372496	2.306796	2.287439	0.298208	1.2802	1.280147	0.01171	0.570683	0.131817	0.555251	0.730588	0.162242	0.712346
N8	35 kV	0.067842	0.047971	95.15209	11.09088	0.955519	0.047834	94.57475	12.49772	0.952778	0.070094	0.118948	0.047971	-0.00431	0.047777	0.047971	0.004308	-0.04778	1.60E-08	-1.44E-09	1.59E-08	36.37017	-29.7351	-20.9431	36.42056	-33.1886	14.99906	21.06795	20.97458	1.981346	201.9431	-199.63	-30.4744	6.22934	1.498363	6.046453	1257.972	-114.857	-1252.72
N9	13 kV	9.026486	6.382689	-77.1588	4.386903	48.64262	6.342184	-78.7761	5.039356	48.33394	7.758414	13.43718	6.382689	1.418553	-6.22306	6.382689	-1.41855	6.223056	2.13E-06	4.73E-07	-2.07E-06	10.18843	-6.61493	-7.74898	10.12912	-8.24012	5.890623	4.990281	4.951685	0.619454	4.27301	4.272637	0.056431	0.571035	0.131916	0.555589	2.44004	0.532277	2.381277
N10	13 kV	9.026486	6.382689	-77.1588	4.386903	48.64262	6.342184	-78.7761	5.039356	48.33394	7.758414	13.43718	6.382689	1.418553	-6.22306	6.382689	-1.41855	6.223056	2.13E-06	4.73E-07	-2.07E-06	10.18843	-6.61493	-7.74898	10.12912	-8.24012	5.890623	4.990281	4.951685	0.619454	4.27301	4.272637	0.056431	0.571035	0.131916	0.555589	2.44004	0.532277	2.381277
N17	13 kV	9.026486	6.382689	-77.1588	4.386903	48.64262	6.342184	-78.7761	5.039356	48.33394	7.758414	13.43718	6.382689	1.418553	-6.22306	6.382689	-1.41855	6.223056	2.13E-06	4.73E-07	-2.07E-06	10.18843	-6.61493	-7.74898	10.12912	-8.24012	5.890623	4.990281	4.951685	0.619454	4.27301	4.272637	0.056431	0.571035	0.131916	0.555589	2.44004	0.532277	2.381277
N19	13 kV	6.962324	4.923107	-80.0763	5.715794	37.51911	4.922505	-80.1114	5.736467	37.51453	6.354871	10.98071	4.923107	0.84843	-4.84945	4.923107	-0.84843	4.849448	1.64E-06	2.83E-07	-1.62E-06	11.03604	-8.08244	-7.51455	10.92989	-8.96026	6.259098	5.696291	5.680898	0.418484	6.155425	6.152769	0.180787	0.569486	0.110555	0.558652	3.505431	0.579224	3.457245
N20	13 kV	6.962324	4.923107	-80.0763	5.715794	37.51911	4.922505	-80.1114	5.736467	37.51453	6.354871	10.98071	4.923107	0.84843	-4.84945	4.923107	-0.84843	4.849448	1.64E-06	2.83E-07	-1.62E-06	11.03604	-8.08244	-7.51455	10.92989	-8.96026	6.259098	5.696291	5.680898	0.418484	6.155425	6.152769	0.180787	0.569486	0.110555	0.558652	3.505431	0.579224	3.457245
N21	13 kV	6.962362	4.923134	-80.0759	5.715519	37.51932	4.922532	-80.1109	5.73619	37.51473	6.354839	10.98066	4.923134	0.848474	-4.84947	4.923134	-0.84847	4.849468	1.64E-06	2.83E-07	-1.62E-06	11.0361	-8.08242	-7.51465	10.92995	-8.96036	6.259059	5.696322	5.680925	0.418532	6.155425	6.152769	0.180787	0.569483	0.110559	0.558648	3.505412	0.579249	3.457222
N22	13 kV	6.962362	4.923134	-80.0759	5.715519	37.51932	4.922532	-80.1109	5.73619	37.51473	6.354839	10.98066	4.923134	0.848474	-4.84947	4.923134	-0.84847	4.849468	1.64E-06	2.83E-07	-1.62E-06	11.0361	-8.08242	-7.51465	10.92995	-8.96036	6.259059	5.696322	5.680925	0.418532	6.155425	6.152769	0.180787	0.569483	0.110559	0.558648	3.505412	0.579249	3.457222
N23	13 kV	6.962362	4.923134	-80.0759	5.715519	37.51932	4.922532	-80.1109	5.73619	37.51473	6.354839	10.98066	4.923134	0.848474	-4.84947	4.923134	-0.84847	4.849468	1.64E-06	2.83E-07	-1.62E-06	11.0361	-8.08242	-7.51465	10.92995	-8.96036	6.259059	5.696322	5.680925	0.418532	6.155425	6.152769	0.180787	0.569483	0.110559	0.558648	3.505412	0.579249	3.457222
N24	13 kV	6.962362	4.923134	-80.0759	5.715519	37.51932	4.922532	-80.1109	5.73619	37.51473	6.354839	10.98066	4.923134	0.848474	-4.84947	4.923134	-0.84847	4.849468	1.64E-06	2.83E-07	-1.62E-06	11.0361	-8.08242	-7.51465	10.92995	-8.96036	6.259059	5.696322	5.680925	0.418532	6.155425	6.152769	0.180787	0.569483	0.110559	0.558648	3.505412	0.579249	3.457222
N25	13 kV	6.962373	4.923141	-80.0771	5.716248	37.51938	4.92254	-80.1121	5.736924	37.51479	6.355027	10.98096	4.923141	0.84837	-4.84949	4.923141	-0.84837	4.849494	1.64E-06	2.83E-07	-1.62E-06	11.03612	-8.08259	-7.51449	10.92997	-8.96024	6.259263	5.696331	5.680943	0.41841	6.155425	6.152769	0.180787	0.569482	0.110547	0.55865	3.505406	0.579174	3.457229
N2	13 kV	17.27264	12.2136	-76.8498	4.280236	93.08013	12.13608	-78.4673	4.900831	92.48933	14.76176	25.56344	12.2136	2.77866	-11.8933	12.2136	-2.77866	11.89332	4.07E-06	9.26E-07	-3.96E-06	7.724496	-2.61857	-7.26711	7.656249	-4.24375	6.372496	2.306796	2.287439	0.298208	1.2802	1.280147	0.01171	0.570683	0.131817	0.555251	0.730588	0.162242	0.712346
N4	13 kV	6.928245	4.899009	-59.6808	1.70998	37.33547	4.826849	-61.6967	1.856942	36.78553	5.021731	8.031645	4.899009	2.473102	-4.22895	4.899009	-2.4731	4.228955	1.63E-06	8.24E-07	-1.41E-06	9.136672	-4.80013	-7.77416	8.993339	-6.6486	6.056091	3.858974	3.816243	0.57269	2.133254	2.127839	0.151903	1.129821	0.605833	0.953657	2.410196	1.144252	2.121257
N5	13 kV	4.14897	2.933765	-55.5451	1.457463	22.35829	2.896904	-56.7238	1.523735	22.07737	2.972874	4.629598	2.933765	1.659801	-2.4191	2.933765	-1.6598	2.419099	9.78E-07	5.53E-07	-8.06E-07	9.663171	-5.29905	-8.08065	9.219152	-7.17948	5.783408	4.22941	4.159511	0.765748	2.389675	2.369705	0.308295	1.779012	1.107233	1.392451	4.251262	2.194531	3.641052
N6	13 kV	4.001195	2.829272	-53.4493	1.348924	21.56195	2.794229	-54.582	1.4062	21.29488	2.855985	4.390899	2.829272	1.684927	-2.27284	2.829272	-1.68493	2.27284	9.43E-07	5.62E-07	-7.58E-07	9.617308	-5.24314	-8.06239	9.187561	-7.12374	5.802034	4.190584	4.122293	0.753451	2.334503	2.315551	0.29686	1.868093	1.212877	1.42081	4.361069	2.386697	3.650013
N7	13 kV	3.550276	2.510424	-54.6981	1.412254	19.132	2.47939	-55.8279	1.473	18.89549	2.5396	3.934127	2.510424	1.450734	-2.0488	2.510424	-1.45073	2.048804	8.37E-07	4.84E-07	-6.83E-07	9.778234	-5.40578	-8.14809	9.257719	-7.28194	5.716532	4.306207	4.229241	0.810519	2.447745	2.422297	0.352041	2.0529	1.315549	1.575985	5.024976	2.631839	4.280632
N8	13 kV	2.633218	1.861966	-53.4033	1.346665	14.19009	1.838999	-54.5261	1.403299	14.01506	1.87941	2.888685	1.861966	1.110063	-1.49488	1.861966	-1.11006	1.494884	6.21E-07	3.70E-07	-4.98E-07	9.962453	-5.57239	-8.25827	9.315222	-7.43821	5.607712	4.425947	4.336865	0.883518	2.541497	2.505087	0.428656	2.713329	1.816696	2.015384	6.895918	3.687075	5.82745
N11	13 kV	1.643859	1.162384	-52.0956	1.284352	8.858557	1.158687	-52.3335	1.295411	8.830379	1.171076	1.786275	1.162384	0.714106	-0.91716	1.162384	-0.71411	0.917164	3.87E-07	2.38E-07	-3.06E-07	10.13881	-5.72202	-8.36982	9.364008	-7.58067	5.497102	4.536445	4.434229	0.957574	2.623442	2.574	0.506927	4.274032	2.981234	3.062612	11.21268	6.121176	9.394431
N16	13 kV	1.983275	1.402387	-52.5248	1.304393	10.68763	1.385113	-53.6431	1.358505	10.55598	1.413689	2.161676	1.402387	0.853238	-1.11296	1.402387	-0.85324	1.112958	4.67E-07	2.84E-07	-3.71E-07	10.08574	-5.67949	-8.3346	9.350498	-7.53827	5.532302	4.503848	4.405917	0.9341	2.601457	2.55614	0.483457	3.558264	2.450801	2.579693	9.256673	5.017419	7.778914
N17	13 kV	2.243698	1.586534	-52.8543	1.320047	12.09102	1.566991	-53.9727	1.375002	11.94207	1.600069	2.451372	1.586534	0.958019	-1.26463	1.586534	-0.95802	1.26463	5.29E-07	3.19E-07	-4.22E-07	10.04522	-5.64654	-8.30801	9.339808	-7.50539	5.558879	4.478726	4.383975	0.916377	2.584526	2.542186	0.465902	3.156076	2.152527	2.308126	8.156962	4.396763	6.870553
N18	13 kV	1.926162	1.362002	-52.408	1.298902	10.37985	1.34525	-53.5216	1.352486	10.25218	1.372758	2.097671	1.362002	0.830868	-1.07922	1.362002	-0.83087	1.079217	4.54E-07	2.77E-07	-3.60E-07	10.11575	-5.71002	-8.35009	9.360416	-7.56118	5.517787	4.523353	4.423731	0.944103	2.622016	2.574066	0.499152	3.648242	2.526018	2.632282	9.565749	5.188226	8.036533
N19	13 kV	15.59795	11.02942	-65.3893	2.183111	84.05544	10.92912	-67.0436	2.360849	83.29109	11.63321	19.29707	11.02942	4.593209	-10.0275	11.02942	-4.59321	10.02749	3.68E-06	1.53E-06	-3.34E-06	7.432305	-2.82432	-6.87476	8.171535	-4.47887	6.83474	2.434424	2.434397	0.013342	1.283087	1.279301	-0.09849	0.631837	0.245766	0.58208	0.810701	0.371737	0.72045
N20	13 kV	14.32883	10.13201	-58.7968	1.65099	77.21629	10.02781	-60.4661	1.765055	76.4222	10.35493	16.46586	10.13201	5.249134	-8.66627	10.13201	-5.24913	8.666269	3.38E-06	1.75E-06	-2.89E-06	7.336509	-3.0178	-6.68709	8.466646	-4.68419	7.052832	2.570224	2.567331	-0.12191	1.30577	1.295768	-0.16131	0.683853	0.325269	0.601544	0.892955	0.518506	0.726994
N21	13 kV	13.62415	9.633728	-55.6465	1.463009	73.41887	9.532427	-57.3191	1.558803	72.64685	9.764254	15.21536	9.633728	5.436286	-7.95333	9.633728	-5.43629	7.953333	3.21E-06	1.81E-06	-2.65E-06	7.308247	-3.12083	-6.60842	8.595821	-4.79002	7.137494	2.64284	2.636949	-0.17636	1.319959	1.306202	-0.19008	0.716629	0.369768	0.613864	0.945921	0.599672	0.731546
N22	13 kV	11.31859	8.003452	-46.3576	1.04855	60.9945	7.912418	-48.0427	1.11228	60.30073	8.02342	11.88429	8.003452	5.523621	-5.79179	8.003452	-5.52362	5.791792	2.67E-06	1.84E-06	-1.93E-06	7.324039	-3.4691	-6.45034	8.947662	-5.14875	7.317856	2.887136	2.872618	-0.28917	1.379192	1.352717	-0.26894	0.849313	0.535137	0.659515	1.171365	0.901257	0.748219
N23	13 kV	5.358088	3.78874	-26.3153	0.494564	28.87408	3.755872	-27.2859	0.515827	28.62359	3.788752	5.367426	3.78874	3.396105	-1.67959	3.78874	-3.3961	1.679591	1.26E-06	1.13E-06	-5.60E-07	7.784158	-4.29162	-6.49423	9.411187	-5.97129	7.274212	3.430835	3.42097	-0.25999	1.575118	1.527847	-0.38299	1.700536	1.430439	0.913977	2.678544	2.541035	0.847196
N24	13 kV	10.30587	7.287354	-42.1801	0.906112	55.5371	7.191113	-43.8824	0.961732	54.80364	7.294448	10.62749	7.287354	5.400206	-4.89319	7.287354	-5.40021	4.893189	2.43E-06	1.80E-06	-1.63E-06	7.415769	-3.6779	-6.43946	9.123165	-5.37009	7.375248	3.032083	3.015995	-0.31193	1.426619	1.39407	-0.303	0.920704	0.624602	0.676439	1.313494	1.075701	0.753746
N25	13 kV	6.452665	4.562723	-45.0276	1.000964	34.77262	4.492462	-46.8255	1.065843	34.23716	4.571287	6.732355	4.562723	3.224777	-3.22789	4.562723	-3.22478	3.227887	1.52E-06	1.07E-06	-1.08E-06	8.630052	-4.52138	-7.35084	9.038295	-6.2634	6.516181	3.605677	3.594927	0.278221	1.821733	1.821555	-0.02543	1.311175	0.920501	0.933734	2.388611	1.700489	1.677438
N26	13 kV	4.821845	3.409559	-46.1133	1.039638	25.98433	3.358921	-47.3501	1.085592	25.59842	3.41764	5.05673	3.409559	2.363622	-2.45731	3.409559	-2.36362	2.457312	1.14E-06	7.88E-07	-8.19E-07	9.168203	-4.91309	-7.74064	9.111702	-6.70093	6.174195	3.906392	3.871339	0.522148	2.039602	2.036693	0.126209	1.660756	1.188144	1.160356	3.387282	2.272248	2.512083
N27	13 kV	3.799217	2.686452	-47.0101	1.072746	20.47351	2.653315	-47.8576	1.105076	20.22098	2.694123	4.002378	2.686452	1.831811	-1.96507	2.686452	-1.83181	1.965068	8.95E-07	6.11E-07	-6.55E-07	9.438825	-5.1298	-7.92317	9.151705	-6.91763	5.991666	4.067093	4.015809	0.643835	2.165045	2.154049	0.217935	2.045913	1.471535	1.421387	4.429494	2.859988	3.382437
N28	13 kV	4.329196	3.061204	-46.5036	1.053912	23.3295	3.01687	-47.6899	1.098597	22.98783	3.069077	4.548893	3.061204	2.107055	-2.22065	3.061204	-2.10705	2.22065	1.02E-06	7.02E-07	-7.40E-07	9.320283	-5.03982	-7.84012	9.134251	-6.82106	6.075167	3.997161	3.953628	0.588318	2.112474	2.105028	0.177212	1.817699	1.306845	1.263403	3.839842	2.527054	2.891087
N29	13 kV	3.773301	2.668126	-46.9443	1.070282	20.33385	2.640038	-47.5834	1.094505	20.11979	2.675643	3.97372	2.668126	1.821553	-1.94958	2.668126	-1.82155	1.949575	8.89E-07	6.07E-07	-6.50E-07	9.494276	-5.18844	-7.95118	9.166343	-6.96014	5.964755	4.103304	4.049527	0.662143	2.200623	2.187588	0.239168	2.042947	1.477586	1.410805	4.495756	2.89493	3.439651
N30	13 kV	3.41606	2.415519	-47.2718	1.082622	18.40873	2.390091	-47.9109	1.107147	18.21494	2.422795	3.603678	2.415519	1.63898	-1.7744	2.415519	-1.63898	1.774395	8.05E-07	5.46E-07	-5.91E-07	9.583733	-5.26145	-8.01031	9.183747	-7.03312	5.90563	4.157803	4.098187	0.701561	2.244453	2.227927	0.271865	2.234089	1.618062	1.540464	5.014308	3.186125	3.871937
N31	13 kV	3.039889	2.149526	-47.6167	1.095781	16.38159	2.126897	-48.2558	1.120634	16.20913	2.156467	3.212767	2.149526	1.448968	-1.58775	2.149526	-1.44897	1.587751	7.17E-07	4.83E-07	-5.29E-07	9.677592	-5.33897	-8.07163	9.204189	-7.11063	5.844319	4.215756	4.149866	0.742437	2.291815	2.271144	0.307115	2.483864	1.801614	1.709903	5.692557	3.566587	4.43674
N32	13 kV	2.558772	1.809325	-48.0578	1.112869	13.78891	1.793363	-48.5816	1.133542	13.66726	1.815704	2.710838	1.809325	1.209317	-1.34581	1.809325	-1.20932	1.345811	6.03E-07	4.03E-07	-4.49E-07	9.797127	-5.43909	-8.14862	9.233465	-7.21074	5.767325	4.290672	4.21661	0.793766	2.354251	2.327564	0.353479	2.910252	2.114927	1.999163	6.851466	4.215964	5.400762
N33	13 kV	3.793114	2.682137	-46.8534	1.066885	20.44063	2.644896	-47.7808	1.102104	20.15682	2.689553	3.992711	2.682137	1.834224	-1.95691	2.682137	-1.83422	1.956905	8.94E-07	6.11E-07	-6.52E-07	9.472114	-5.12579	-7.96537	9.179939	-6.96026	5.985493	4.08238	4.028682	0.659961	2.167663	2.156492	0.21978	2.047955	1.477472	1.418166	4.439276	2.874473	3.382983
N34	13 kV	3.054369	2.159765	-47.4065	1.087738	16.45962	2.131684	-48.1773	1.117547	16.24561	2.166449	3.224426	2.159765	1.461714	-1.58996	2.159765	-1.46171	1.589961	7.20E-07	4.87E-07	-5.30E-07	9.684382	-5.28246	-8.11683	9.235725	-7.14315	5.854402	4.209965	4.141868	0.754143	2.265387	2.246616	0.291024	2.486954	1.804389	1.711467	5.633913	3.555691	4.37013
N35	13 kV	2.676015	1.892228	-47.7365	1.100395	14.42071	1.867626	-48.5073	1.130586	14.23322	1.898486	2.83004	1.892228	1.2726	-1.40036	1.892228	-1.2726	1.400363	6.31E-07	4.24E-07	-4.67E-07	9.783363	-5.3652	-8.181	9.259569	-7.22584	5.790232	4.272004	4.197015	0.796924	2.316936	2.293512	0.328624	2.80595	2.040089	1.926498	6.501206	4.045874	5.088869
N36	13 kV	2.793152	1.975057	-47.6341	1.096449	15.05195	1.949378	-48.4049	1.12652	14.85626	1.981456	2.952276	1.975057	1.330917	-1.45928	1.975057	-1.33092	1.459283	6.58E-07	4.44E-07	-4.86E-07	9.752887	-5.33966	-8.1613	9.251985	-7.20027	5.809934	4.252825	4.179975	0.78379	2.300918	2.278986	0.316928	2.697902	1.960287	1.853631	6.20765	3.879999	4.84567
N37	13 kV	2.499877	1.76768	-47.8902	1.106341	13.47153	1.74772	-48.545	1.132085	13.31942	1.773709	2.645989	1.76768	1.185324	-1.31137	1.76768	-1.18532	1.311373	5.89E-07	3.95E-07	-4.37E-07	9.829339	-5.40397	-8.21054	9.271448	-7.26458	5.760694	4.301084	4.22285	0.816617	2.341436	2.315656	0.346497	2.987368	2.174131	2.048786	6.994731	4.32464	5.497613
N38	13 kV	17.27264	12.2136	-76.8498	4.280236	93.08013	12.13608	-78.4673	4.900831	92.48933	14.76176	25.56344	12.2136	2.77866	-11.8933	12.2136	-2.77866	11.89332	4.07E-06	9.26E-07	-3.96E-06	7.724496	-2.61857	-7.26711	7.656249	-4.24375	6.372496	2.306796	2.287439	0.298208	1.2802	1.280147	0.01171	0.570683	0.131817	0.555251	0.730588	0.162242	0.712346
N39	13 kV	17.27264	12.2136	-76.8498	4.280236	93.08013	12.13608	-78.4673	4.900831	92.48933	14.76176	25.56344	12.2136	2.77866	-11.8933	12.2136	-2.77866	11.89332	4.07E-06	9.26E-07	-3.96E-06	7.724496	-2.61857	-7.26711	7.656249	-4.24375	6.372496	2.306796	2.287439	0.298208	1.2802	1.280147	0.01171	0.570683	0.131817	0.555251	0.730588	0.162242	0.712346
N40	13 kV	16.15379	11.42246	-69.1208	2.621601	87.05082	11.34905	-70.737	2.861477	86.49138	12.41866	21.02726	11.42246	4.070945	-10.6724	11.42246	-4.07094	10.67239	3.81E-06	1.36E-06	-3.56E-06	7.484879	-2.73828	-6.96601	7.973883	-4.36166	6.67523	2.368631	2.366647	0.096927	1.277198	1.275678	-0.06228	0.610935	0.206845	0.574854	0.780285	0.299672	0.720445
N41	13 kV	14.17784	10.02525	-58.6811	1.643493	76.40263	9.95951	-60.2951	1.75284	75.90166	10.24206	16.27408	10.02525	5.211125	-8.56445	10.02525	-5.21112	8.564446	3.34E-06	1.74E-06	-2.85E-06	7.285165	-3.02164	-6.62898	8.411773	-4.64205	7.014931	2.5578	2.554563	-0.12865	1.307242	1.297222	-0.16154	0.690829	0.329784	0.607032	0.903081	0.525863	0.734182
N42	13 kV	5.048888	3.570103	-25.428	0.475433	27.20784	3.565201	-25.4938	0.476843	27.17048	3.570109	5.055702	3.570103	3.224252	-1.53292	3.570103	-3.22425	1.532916	1.19E-06	1.07E-06	-5.11E-07	7.808371	-4.37264	-6.46921	9.349271	-5.97572	7.190247	3.457814	3.449451	-0.24034	1.61106	1.565532	-0.38029	1.785966	1.522526	0.93359	2.877298	2.7386	0.88256
N43	13 kV	4.711366	3.331439	-24.3944	0.453503	25.38898	3.326865	-24.4603	0.45489	25.35411	3.331442	4.715986	3.331439	3.034021	-1.37594	3.331439	-3.03402	1.375938	1.11E-06	1.01E-06	-4.59E-07	7.842726	-4.40776	-6.48691	9.358198	-6.01084	7.172562	3.480379	3.472867	-0.22855	1.621179	1.575399	-0.38255	1.908563	1.644448	0.968712	3.094122	2.961237	0.897032
N44	13 kV	4.390975	3.104888	-23.4184	0.43312	23.66242	3.100625	-23.4843	0.434486	23.62993	3.10489	4.394082	3.104888	2.849129	-1.23401	3.104888	-2.84913	1.234014	1.03E-06	9.50E-07	-4.11E-07	7.875864	-4.44034	-6.50481	9.365483	-6.04343	7.154666	3.501298	3.49459	-0.21662	1.630787	1.584847	-0.38435	2.042378	1.776928	1.006893	3.330682	3.203158	0.912812
N45	13 kV	5.446711	3.851406	-26.6533	0.501927	29.35166	3.846118	-26.7192	0.503368	29.31135	3.85142	5.457131	3.851406	3.442144	-1.72771	3.851406	-3.44214	1.727707	1.28E-06	1.15E-06	-5.76E-07	7.768672	-4.33022	-6.44992	9.337091	-5.9333	7.20952	3.430532	3.421175	-0.2532	1.599146	1.554027	-0.37718	1.660972	1.397548	0.897601	2.656137	2.510387	0.867766
N46	13 kV	9.023033	6.380248	-38.311	0.790065	48.62402	6.335528	-39.9173	0.836644	48.28321	6.382491	9.192247	6.380248	5.006306	-3.95531	6.380248	-5.00631	3.955309	2.13E-06	1.67E-06	-1.32E-06	7.422792	-3.8457	-6.34889	9.116879	-5.45579	7.304238	3.116807	3.100496	-0.31845	1.470889	1.43457	-0.32484	1.038701	0.750771	0.717805	1.527815	1.310208	0.785858
N47	13 kV	7.051928	4.986466	-31.6877	0.617317	38.00198	4.979607	-31.7542	0.61892	37.9497	4.986656	7.095393	4.986466	4.243102	-2.61934	4.986466	-4.2431	2.619338	1.66E-06	1.41E-06	-8.73E-07	7.618947	-4.14873	-6.39033	9.269375	-5.7518	7.268984	3.313148	3.300177	-0.29288	1.551504	1.509213	-0.35978	1.299755	1.030592	0.791986	2.016574	1.840322	0.824492
N48	13 kV	5.329647	3.768629	-26.2214	0.492524	28.72081	3.761449	-26.2958	0.494139	28.66609	3.76864	5.338694	3.768629	3.380813	-1.66513	3.768629	-3.38081	1.665133	1.26E-06	1.13E-06	-5.55E-07	7.833862	-4.40226	-6.47993	9.360936	-5.99611	7.188452	3.474159	3.466122	-0.23617	1.62914	1.584952	-0.37686	1.682989	1.423782	0.897383	2.741825	2.594816	0.88574
N49	13 kV	4.428035	3.131093	-23.511	0.43504	23.86214	3.12513	-23.5852	0.436581	23.81669	3.131095	4.431271	3.131093	2.871161	-1.24909	3.131093	-2.87116	1.249071	1.04E-06	9.57E-07	-4.16E-07	7.938762	-4.48827	-6.54823	9.363818	-6.07953	7.121829	3.527784	3.522599	-0.1912	1.653202	1.611156	-0.37047	2.011494	1.752983	0.986488	3.325405	3.189798	0.939952
N50	13 kV	4.15904	2.940885	-22.6966	0.418239	22.41256	2.935286	-22.7707	0.41976	22.36988	2.940886	4.161314	2.940885	2.713147	-1.13474	2.940885	-2.71315	1.134743	9.80E-07	9.04E-07	-3.78E-07	7.963718	-4.5132	-6.56139	9.369754	-6.10418	7.108538	3.543821	3.539125	-0.18238	1.660269	1.617935	-0.37253	2.137497	1.877123	1.022401	3.548821	3.417942	0.954884
N51	13 kV	3.513948	2.484737	-20.7572	0.379009	18.93624	2.480006	-20.8313	0.38049	18.90018	2.484737	3.514831	2.484737	2.323455	-0.88061	2.484737	-2.32345	0.880611	8.28E-07	7.74E-07	-2.94E-07	8.023549	-4.56786	-6.59636	9.379084	-6.15884	7.073605	3.579103	3.575566	-0.15908	1.675705	1.632996	-0.37591	2.519282	2.251352	1.130573	4.221573	4.101447	0.999906
N52	13 kV	3.926986	2.776798	-22.0347	0.40473	21.16205	2.771506	-22.1087	0.406235	21.12171	2.776799	3.928657	2.776798	2.573973	-1.04177	2.776798	-2.57397	1.041765	9.26E-07	8.58E-07	-3.47E-07	7.997983	-4.5272	-6.59334	9.356152	-6.11796	7.078709	3.552074	3.548388	-0.16179	1.6634	1.623318	-0.36295	2.261078	2.000935	1.052966	3.761077	3.630332	0.983053
N53	13 kV	3.591092	2.539285	-21.0591	0.384973	19.35195	2.534443	-21.1293	0.386455	19.31505	2.539286	3.592118	2.539285	2.369747	-0.91229	2.539285	-2.36975	0.912289	8.46E-07	7.90E-07	-3.04E-07	8.039113	-4.55181	-6.62634	9.348319	-6.14217	7.047329	3.567422	3.564661	-0.14033	1.669927	1.631412	-0.35658	2.467538	2.205133	1.107307	4.120608	3.992329	1.020159
N54	13 kV	3.169937	2.241484	-19.8418	0.360847	17.0824	2.237205	-19.9156	0.362303	17.04979	2.241484	3.170461	2.241484	2.108414	-0.76081	2.241484	-2.10841	0.760815	7.47E-07	7.03E-07	-2.54E-07	8.092711	-4.58058	-6.6716	9.334711	-6.17035	7.004544	3.585359	3.583641	-0.11098	1.677552	1.641357	-0.34659	2.788543	2.52151	1.190781	4.677924	4.551414	1.080559
N55	13 kV	2.994837	2.117669	-19.342	0.351018	16.13881	2.113624	-19.4157	0.352463	16.10798	2.117669	2.995225	2.117669	1.998145	-0.70138	2.117669	-1.99815	0.701384	7.06E-07	6.66E-07	-2.34E-07	8.115274	-4.59025	-6.69233	9.326694	-6.1801	6.985244	3.591442	3.590115	-0.09764	1.679735	1.644699	-0.34128	2.949301	2.679649	1.232014	4.954042	4.827679	1.111781
N56	13 kV	2.795895	1.976996	-18.7785	0.340009	15.06674	1.973216	-18.8521	0.341442	15.03793	1.976996	2.796166	1.976996	1.871761	-0.63642	1.976996	-1.87176	0.636415	6.59E-07	6.24E-07	-2.12E-07	8.14149	-4.60013	-6.71734	9.316076	-6.19018	6.96211	3.597695	3.59677	-0.08159	1.681769	1.648182	-0.33443	3.156713	2.88344	1.284761	5.30886	5.182091	1.153224
N57	13 kV	2.65541	1.877658	-18.3526	0.331738	14.30968	1.874068	-18.4262	0.333165	14.28232	1.877658	2.655614	1.877658	1.782154	-0.59121	1.877658	-1.78215	0.591208	6.26E-07	5.94E-07	-1.97E-07	8.152221	-4.61196	-6.72224	9.32028	-6.202	6.957212	3.605504	3.604653	-0.07832	1.68537	1.651347	-0.33693	3.320655	3.04235	1.330736	5.596531	5.472344	1.172439
N58	13 kV	17.27264	12.2136	-76.8498	4.280236	93.08013	12.13608	-78.4673	4.900831	92.48933	14.76176	25.56344	12.2136	2.77866	-11.8933	12.2136	-2.77866	11.89332	4.07E-06	9.26E-07	-3.96E-06	7.724496	-2.61857	-7.26711	7.656249	-4.24375	6.372496	2.306796	2.287439	0.298208	1.2802	1.280147	0.01171	0.570683	0.131817	0.555251	0.730588	0.162242	0.712346
N59	13 kV	11.58391	8.19106	-67.8271	2.453745	62.42426	8.138955	-69.4399	2.666099	62.02716	8.801136	14.80362	8.19106	3.091327	-7.58533	8.19106	-3.09133	7.585326	2.73E-06	1.03E-06	-2.53E-06	8.244947	-3.8611	-7.28499	8.392836	-5.48132	6.355692	3.129507	3.114139	0.309767	1.704764	1.704707	0.013941	0.753421	0.286966	0.69663	1.284404	0.479482	1.19155
N60	13 kV	8.671139	6.131421	-63.3956	1.996568	46.72771	6.092332	-65.0037	2.144872	46.42981	6.389525	10.46883	6.131421	2.745824	-5.48222	6.131421	-2.74582	5.482224	2.04E-06	9.15E-07	-1.83E-06	8.672	-4.45851	-7.43809	8.681975	-6.07383	6.203645	3.534814	3.510782	0.411483	1.951647	1.950015	0.079808	0.943813	0.439627	0.835172	1.84199	0.790625	1.663683
N61	13 kV	4.568045	3.230096	-57.3056	1.557994	24.61663	3.22928	-57.3715	1.561947	24.61042	3.286845	5.176186	3.230096	1.744763	-2.71833	3.230096	-1.74476	2.71833	1.08E-06	5.82E-07	-9.06E-07	9.402458	-5.24259	-7.80522	8.994556	-6.84057	5.840254	4.080631	4.027722	0.654989	2.329333	2.31139	0.28856	1.638066	0.974898	1.316371	3.8156	1.873519	3.323963
N62	13 kV	3.719781	2.630282	-56.0712	1.48654	20.04544	2.630227	-56.0727	1.486624	20.04502	2.668409	4.169247	2.630282	1.468126	-2.18243	2.630282	-1.46813	2.182428	8.77E-07	4.89E-07	-7.27E-07	9.572004	-5.39824	-7.90457	9.044799	-6.98782	5.742708	4.191104	4.128688	0.720622	2.41193	2.385524	0.355925	1.975537	1.231655	1.544595	4.764856	2.388382	4.123043
N63	13 kV	3.109838	2.198988	-55.1927	1.438422	16.75854	2.198931	-55.1945	1.438515	16.75811	2.226686	3.459956	2.198988	1.255221	-1.80554	2.198988	-1.25522	1.805538	7.33E-07	4.18E-07	-6.02E-07	9.699887	-5.51065	-7.98251	9.077329	-7.0913	5.666686	4.270991	4.200651	0.771943	2.472901	2.438283	0.412327	2.332548	1.502915	1.783824	5.768161	2.929013	4.969161
N64	13 kV	2.667742	1.886378	-54.5636	1.405243	14.37613	1.886321	-54.5655	1.405345	14.3757	1.907823	2.952991	1.886378	1.093721	-1.53694	1.886378	-1.09372	1.536944	6.29E-07	3.65E-07	-5.12E-07	9.797222	-5.59361	-8.04345	9.098671	-7.16516	5.607702	4.329729	4.252921	0.811917	2.518425	2.47626	0.458911	2.693519	1.777374	2.023854	6.783426	3.472472	5.827247
N65	13 kV	2.207551	1.560974	-53.9195	1.372324	11.89622	1.560916	-53.9218	1.37244	11.89578	1.576925	2.43127	1.560974	0.919291	-1.26156	1.560974	-0.91929	1.261565	5.20E-07	3.06E-07	-4.21E-07	9.905096	-5.68316	-8.11249	9.118343	-7.24123	5.541554	4.392539	4.30813	0.85698	2.567831	2.515697	0.514807	3.222627	2.18067	2.372762	8.27516	4.264391	7.091773
N66	13 kV	1.981221	1.400935	-53.6091	1.356816	10.67656	1.400876	-53.6116	1.356943	10.67611	1.414523	2.176817	1.400935	0.831163	-1.12774	1.400935	-0.83116	1.127735	4.67E-07	2.77E-07	-3.76E-07	9.961938	-5.72944	-8.14946	9.126768	-7.27847	5.506522	4.424563	4.335969	0.88098	2.593351	2.535152	0.546329	3.572698	2.448405	2.601822	9.26526	4.78563	7.933649
N67	13 kV	1.68965	1.194763	-53.2188	1.337642	9.105315	1.194703	-53.2217	1.337785	9.104862	1.205611	1.851015	1.194763	0.715377	-0.95692	1.194763	-0.71538	0.956919	3.98E-07	2.38E-07	-3.19E-07	10.04103	-5.79289	-8.20151	9.135922	-7.32652	5.457766	4.467748	4.373135	0.914583	2.628184	2.560431	0.592911	4.161091	2.900384	2.983697	10.93611	5.657167	9.359219
N69	13 kV	1.530199	1.082014	-53.0241	1.328206	8.246054	1.081958	-53.0272	1.328354	8.245624	1.091517	1.673918	1.082014	0.650809	-0.86441	1.082014	-0.65081	0.864409	3.61E-07	2.17E-07	-2.88E-07	10.0704	-5.81992	-8.21836	9.1443	-7.3487	5.441955	4.486039	4.389539	0.92547	2.642123	2.571403	0.607206	4.581993	3.213959	3.26575	12.10619	6.281401	10.3491
N70	13 kV	1.457259	1.030438	-52.9405	1.324179	7.85299	1.030384	-52.9435	1.324327	7.852581	1.039359	1.593147	1.030438	0.620988	-0.8223	1.030438	-0.62099	0.822299	3.43E-07	2.07E-07	-2.74E-07	10.07708	-5.82837	-8.22056	9.149796	-7.35715	5.439766	4.491856	4.395176	0.92693	2.646049	2.575235	0.608065	4.807257	3.377221	3.421125	12.72024	6.616873	10.86377
N71	13 kV	1.364168	0.964613	-52.8338	1.319065	7.351335	0.964562	-52.8368	1.319211	7.350952	0.972812	1.49021	0.964613	0.582751	-0.76869	0.964613	-0.58275	0.768686	3.22E-07	1.94E-07	-2.56E-07	10.08563	-5.83916	-8.22339	9.156788	-7.36794	5.436936	4.499279	4.402364	0.928817	2.651069	2.580129	0.609179	5.129749	3.610935	3.643552	13.59932	7.097102	11.60054
N72	13 kV	1.307634	0.924637	-52.769	1.315972	7.04668	0.924589	-52.7721	1.316114	7.046312	0.93241	1.427779	0.924637	0.559215	-0.7362	0.924637	-0.55922	0.736198	3.08E-07	1.86E-07	-2.45E-07	10.09083	-5.8457	-8.22513	9.161022	-7.37448	5.435199	4.503785	4.406725	0.929976	2.654122	2.583104	0.609866	5.34801	3.769102	3.794085	14.19427	7.422096	12.09916
N73	13 kV	1.248621	0.882908	-52.7014	1.312755	6.728664	0.882862	-52.7045	1.312901	6.728313	0.890244	1.362674	0.882908	0.535015	-0.70234	0.882908	-0.53501	0.702343	2.94E-07	1.78E-07	-2.34E-07	10.09628	-5.85252	-8.22696	9.165431	-7.3813	5.43337	4.508488	4.411274	0.931195	2.657311	2.58621	0.610593	5.596929	3.949479	3.965758	14.87278	7.792717	12.6678
N74	13 kV	1.615488	1.142322	-53.1219	1.332936	8.705665	1.142263	-53.125	1.333085	8.705211	1.152524	1.768496	1.142322	0.685524	-0.91376	1.142322	-0.68552	0.91376	3.81E-07	2.29E-07	-3.05E-07	10.06262	-5.81002	-8.21583	9.137854	-7.3388	5.444484	4.479235	4.382941	0.923783	2.637539	2.566926	0.606219	4.342994	3.041746	3.101859	11.4585	5.927531	9.806208
N75	13 kV	1.497552	1.058929	-52.9683	1.325517	8.070125	1.05887	-52.9716	1.325675	8.06967	1.068141	1.637532	1.058929	0.637748	-0.84535	1.058929	-0.63775	0.845346	3.53E-07	2.13E-07	-2.82E-07	10.10237	-5.86228	-8.22749	9.16533	-7.38152	5.432899	4.511811	4.414599	0.93153	2.673888	2.600338	0.622831	4.650864	3.273816	3.303432	12.43589	6.455548	10.62907
N76	13 kV	1.360658	0.96213	-52.8121	1.318028	7.332417	0.962076	-52.8154	1.318185	7.332004	0.970279	1.48614	0.96213	0.581542	-0.76649	0.96213	-0.58154	0.766488	3.21E-07	1.94E-07	-2.55E-07	10.12515	-5.88743	-8.23308	9.179743	-7.40353	5.427284	4.527963	4.430319	0.935267	2.688279	2.613858	0.628164	5.103267	3.604832	3.612274	13.719	7.153417	11.7064
N77	13 kV	1.466765	1.037159	-52.93	1.323677	7.904216	1.0371	-52.9334	1.323838	7.903761	1.046123	1.603416	1.037159	0.62519	-0.82755	1.037159	-0.62519	0.827549	3.46E-07	2.08E-07	-2.76E-07	10.11095	-5.87357	-8.22998	9.171338	-7.39079	5.430435	4.518858	4.421453	0.933181	2.681572	2.607411	0.626288	4.740853	3.341201	3.36334	12.71294	6.605465	10.86217
N78	13 kV	1.254958	0.887389	-52.6924	1.312329	6.762816	0.88734	-52.6957	1.312484	6.762436	0.894751	1.369501	0.887389	0.537841	-0.70582	0.887389	-0.53784	0.705824	2.96E-07	1.79E-07	-2.35E-07	10.13708	-5.90791	-8.23754	9.19129	-7.42112	5.422807	4.540894	4.443009	0.938244	2.700222	2.625037	0.632756	5.519227	3.909345	3.896009	14.90314	7.796949	12.70083
N79	13 kV	1.155078	0.816763	-52.5804	1.30702	6.224572	0.816717	-52.5837	1.307175	6.224223	0.823409	1.259484	0.816763	0.496304	-0.64868	0.816763	-0.4963	0.648679	2.72E-07	1.65E-07	-2.16E-07	10.15255	-5.92384	-8.24354	9.202647	-7.43836	5.418448	4.553893	4.45558	0.941141	2.712373	2.636372	0.637583	5.98125	4.24777	4.210915	16.22338	8.513892	13.80984
N80	13 kV	1.262416	0.892663	-52.6852	1.311985	6.803006	0.892603	-52.6891	1.312168	6.80255	0.90006	1.377568	0.892663	0.541127	-0.70995	0.892663	-0.54113	0.70995	2.98E-07	1.80E-07	-2.37E-07	10.16506	-5.94515	-8.24522	9.209274	-7.44879	5.415366	4.563209	4.464648	0.943285	2.730076	2.651992	0.648269	5.452952	3.872475	3.839091	14.88697	7.781007	12.69165
N81	13 kV	1.304809	0.922639	-52.7489	1.315015	7.031453	0.922586	-52.7523	1.315175	7.031049	0.930368	1.424485	0.922639	0.558482	-0.73441	0.922639	-0.55848	0.734412	3.08E-07	1.86E-07	-2.45E-07	10.127	-5.89452	-8.23472	9.184073	-7.41006	5.4257	4.532629	4.434811	0.93634	2.691643	2.617105	0.629051	5.317569	3.760308	3.759692	14.31386	7.477731	12.20533
N82	13 kV	1.140572	0.806506	-52.5696	1.30651	6.146405	0.80646	-52.573	1.306668	6.146052	0.813057	1.243571	0.806506	0.490192	-0.64044	0.806506	-0.49019	0.640441	2.69E-07	1.63E-07	-2.13E-07	10.13765	-5.90828	-8.23797	9.193261	-7.42381	5.422457	4.542047	4.44403	0.938505	2.695899	2.621533	0.628835	6.07795	4.311151	4.284326	16.38554	8.607693	13.94251
N83	13 kV	1.098648	0.776861	-52.5239	1.304352	5.92048	0.776817	-52.5273	1.30451	5.920139	0.783121	1.197467	0.776861	0.472666	-0.61652	0.776861	-0.47267	0.616523	2.59E-07	1.58E-07	-2.06E-07	10.14037	-5.91178	-8.23881	9.195596	-7.42732	5.421636	4.54445	4.446367	0.939066	2.696986	2.622663	0.628783	6.308379	4.47795	4.443378	17.01361	8.950232	14.46915
N84	13 kV	1.077472	0.761887	-52.5008	1.303265	5.806362	0.761844	-52.5042	1.303422	5.806028	0.768002	1.174191	0.761887	0.463799	-0.60445	0.761887	-0.4638	0.604453	2.54E-07	1.55E-07	-2.01E-07	10.14175	-5.91355	-8.23924	9.196774	-7.42909	5.421189	4.545663	4.447547	0.93935	2.697534	2.623234	0.628758	6.431589	4.567135	4.528423	17.34943	9.133379	14.75073
N85	13 kV	1.063071	0.751705	-52.4851	1.302526	5.728758	0.751661	-52.4885	1.302683	5.728428	0.757721	1.158367	0.751705	0.457763	-0.59625	0.751705	-0.45776	0.596249	2.51E-07	1.53E-07	-1.99E-07	10.14269	-5.91475	-8.23953	9.197575	-7.43029	5.420898	4.546488	4.448349	0.939545	2.697908	2.623625	0.628741	6.51818	4.629813	4.588191	17.58545	9.262092	14.94863
N86	13 kV	1.119417	0.791548	-52.5466	1.30542	6.032403	0.791502	-52.5499	1.305578	6.032056	0.797951	1.220303	0.791548	0.481353	-0.62837	0.791548	-0.48135	0.628368	2.64E-07	1.60E-07	-2.09E-07	10.13902	-5.91004	-8.2384	9.19444	-7.42558	5.422033	4.543259	4.445209	0.938787	2.696447	2.622104	0.628809	6.192067	4.393757	4.363095	16.69658	8.777333	14.20332
N87	13 kV	1.212986	0.85771	-52.6477	1.310203	6.536631	0.857661	-52.651	1.310361	6.536255	0.864771	1.323269	0.85771	0.520386	-0.68181	0.85771	-0.52039	0.681811	2.86E-07	1.73E-07	-2.27E-07	10.13477	-5.90466	-8.23703	9.190394	-7.41958	5.423392	4.539357	4.441412	0.93788	2.695956	2.621331	0.629921	5.715172	4.049294	4.033164	15.40785	8.073965	13.12299
N88	13 kV	1.160278	0.82044	-52.5896	1.307455	6.252594	0.820393	-52.593	1.307614	6.252234	0.827127	1.265238	0.82044	0.498433	-0.65168	0.82044	-0.49843	0.651679	2.73E-07	1.66E-07	-2.17E-07	10.13931	-5.91057	-8.23838	9.194056	-7.4251	5.422047	4.54327	4.445222	0.938777	2.698506	2.623824	0.630464	5.97154	4.235381	4.209612	16.11424	8.458885	13.71554
N89	13 kV	1.12993	0.798981	-52.5563	1.305879	6.089053	0.798935	-52.5596	1.306037	6.088703	0.805455	1.231849	0.798981	0.485766	-0.63435	0.798981	-0.48577	0.634352	2.66E-07	1.62E-07	-2.11E-07	10.14196	-5.91401	-8.23916	9.196177	-7.42829	5.421265	4.545542	4.447453	0.939299	2.700003	2.625284	0.630793	6.129965	4.350381	4.318641	16.55093	8.696818	14.08185
N90	13 kV	1.106495	0.78241	-52.5308	1.304677	5.962768	0.782365	-52.5341	1.304835	5.962425	0.788722	1.20608	0.78241	0.475968	-0.62098	0.78241	-0.47597	0.620984	2.61E-07	1.59E-07	-2.07E-07	10.14343	-5.91591	-8.23961	9.197444	-7.43019	5.42082	4.546841	4.448699	0.939596	2.700554	2.625864	0.630576	6.259031	4.44381	4.407723	16.90285	8.888733	14.37695
N91	13 kV	1.065085	0.753129	-52.4858	1.302557	5.73961	0.753085	-52.4892	1.302715	5.73928	0.759157	1.160567	0.753129	0.458624	-0.59738	0.753129	-0.45862	0.597383	2.51E-07	1.53E-07	-1.99E-07	10.14603	-5.91925	-8.2404	9.199682	-7.43353	5.42003	4.549135	4.450932	0.940123	2.701528	2.62689	0.630636	6.500987	4.618956	4.574722	17.5626	9.248504	14.93017
N92	13 kV	1.04505	0.738962	-52.4641	1.301534	5.631644	0.738919	-52.4674	1.301692	5.631321	0.744855	1.138559	0.738962	0.450219	-0.58598	0.738962	-0.45022	0.585975	2.46E-07	1.50E-07	-1.95E-07	10.14727	-5.92086	-8.24078	9.200751	-7.43513	5.419651	4.550231	4.451999	0.940376	2.701981	2.627369	0.630579	6.624957	4.708685	4.660295	17.90051	9.432769	15.21351
N93	13 kV	1.01191	0.715528	-52.4281	1.299845	5.453058	0.715487	-52.4315	1.300002	5.452745	0.721199	1.10217	0.715528	0.436298	-0.56712	0.715528	-0.4363	0.56712	2.39E-07	1.45E-07	-1.89E-07	10.14932	-5.92351	-8.24141	9.202518	-7.43778	5.419022	4.552043	4.453762	0.940796	2.702729	2.628161	0.630485	6.840792	4.864902	4.809279	18.48881	9.753569	15.70681
N94	13 kV	0.999406	0.706687	-52.4145	1.299209	5.385676	0.706646	-52.4179	1.299366	5.385367	0.712274	1.088445	0.706687	0.431039	-0.56001	0.706687	-0.43104	0.56001	2.36E-07	1.44E-07	-1.87E-07	10.1501	-5.9245	-8.24165	9.203185	-7.43878	5.418783	4.552726	4.454427	0.940955	2.703011	2.62846	0.630451	6.925946	4.926534	4.868058	18.72091	9.880133	15.90143
N95	13 kV	0.98287	0.694994	-52.3966	1.298368	5.296566	0.694954	-52.4	1.298525	5.296261	0.700472	1.070299	0.694994	0.42408	-0.55061	0.694994	-0.42408	0.550612	2.32E-07	1.42E-07	-1.84E-07	10.15113	-5.92582	-8.24196	9.204065	-7.4401	5.418468	4.55363	4.455306	0.941166	2.703385	2.628855	0.630403	7.04189	5.01045	4.948091	19.03694	10.05245	16.16642
N96	13 kV	0.944426	0.66781	-52.355	1.296417	5.089394	0.667771	-52.3583	1.296574	5.089102	0.673035	1.02813	0.66781	0.407877	-0.52878	0.66781	-0.40788	0.528778	2.23E-07	1.36E-07	-1.76E-07	10.15351	-5.92889	-8.2427	9.206109	-7.44316	5.41773	4.555731	4.457349	0.941657	2.704252	2.629773	0.630296	7.327138	5.216898	5.14499	19.81443	10.47639	16.81835

1-Ph Fault

Node	Network Level	idc [kA]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	IL1a [kA]	IL1r [kA]	IL1i [kA]	3I0a [kA]	3I0r [kA]	3I0i [kA]	VL1a [kV]	VL1r [kV]	VL1i [kV]	VL2a [kV]	VL2r [kV]	VL2i [kV]	VL3a [kV]	VL3r [kV]	VL3i [kV]	V0a [kV]	V0r [kV]	V0i [kV]	Z0/Z1a [pu]	Z0/Z1r [pu]	Z0/Z1i [pu]	Z1a [Ohm]	Z1r [Ohm]	Z1i [Ohm]	Z0a [Ohm]	Z0r [Ohm]	Z0i [Ohm]
N97	13 kV	1.182645	0.836256	-52.5931	1.30762	6.373129	0.836193	-52.5989	1.307895	6.372647	0.843076	1.289661	0.836256	0.508002	-0.66427	0.836256	-0.508	0.664273	2.79E-07	1.69E-07	-2.21E-07	10.1867	-5.9741	-8.25099	9.224351	-7.47159	5.409624	4.580878	4.481897	0.947122	2.749852	2.670108	0.657427	5.79705	4.129068	4.068979	15.94103	8.349998	13.57917
N98	13 kV	1.092979	0.772853	-52.5689	1.306476	5.889928	0.772798	-52.573	1.306667	5.889511	0.779129	1.191673	0.772853	0.469745	-0.61371	0.772853	-0.46975	0.613711	2.58E-07	1.57E-07	-2.05E-07	10.18342	-5.95052	-8.26398	9.2347	-7.48541	5.408175	4.578691	4.478641	0.951935	2.739117	2.66238	0.643814	6.285338	4.467087	4.421607	17.21628	9.046391	14.64797
N99	13 kV	1.037126	0.733359	-52.5002	1.303235	5.588944	0.733307	-52.5043	1.303426	5.588547	0.739244	1.130219	0.733359	0.446438	-0.58181	0.733359	-0.44644	0.581814	2.44E-07	1.49E-07	-1.94E-07	10.18568	-5.95324	-8.2648	9.236404	-7.48808	5.407381	4.580563	4.48044	0.952475	2.738651	2.662063	0.643138	6.624397	4.713027	4.655106	18.14191	9.552502	15.42331
N100	13 kV	1.000984	0.707803	-52.4558	1.301144	5.39418	0.707752	-52.4598	1.301334	5.393798	0.713439	1.090485	0.707803	0.431316	-0.5612	0.707803	-0.43132	0.561205	2.36E-07	1.44E-07	-1.87E-07	10.18714	-5.95499	-8.26534	9.237504	-7.48981	5.406867	4.581771	4.481602	0.952824	2.738347	2.661857	0.642698	6.863965	4.886794	4.820089	18.79592	9.910086	15.97112
N101	13 kV	0.971027	0.686619	-52.4189	1.299414	5.232743	0.686571	-52.423	1.299604	5.232372	0.692052	1.057571	0.686619	0.418758	-0.54414	0.686619	-0.41876	0.54414	2.29E-07	1.40E-07	-1.81E-07	10.18836	-5.95646	-8.26579	9.238416	-7.49125	5.406438	4.582776	4.482567	0.953116	2.738099	2.66169	0.642336	7.076051	5.040628	4.966142	19.37493	10.22666	16.4561
N102	13 kV	0.914371	0.646558	-52.3493	1.296152	4.927431	0.646512	-52.3533	1.296342	4.927081	0.651612	0.995371	0.646558	0.394947	-0.51191	0.646558	-0.39495	0.511912	2.16E-07	1.32E-07	-1.71E-07	10.19064	-5.9592	-8.26663	9.240128	-7.49394	5.405631	4.584662	4.484378	0.953666	2.737613	2.661358	0.641638	7.515172	5.359118	5.268554	20.57364	10.88203	17.46012
N103	13 kV	0.876018	0.619438	-52.3023	1.293956	4.720752	0.619394	-52.3063	1.294145	4.720418	0.624241	0.953302	0.619438	0.378783	-0.49013	0.619438	-0.37878	0.490129	2.06E-07	1.26E-07	-1.63E-07	10.19211	-5.96096	-8.26717	9.241248	-7.4957	5.405109	4.585888	4.485553	0.954021	2.737214	2.661073	0.641119	7.844782	5.598119	5.495604	21.47285	11.37367	18.21326
N104	13 kV	0.865982	0.612342	-52.29	1.293383	4.66667	0.612298	-52.2941	1.293572	4.666339	0.617079	0.942298	0.612342	0.374548	-0.48443	0.612342	-0.37455	0.484434	2.04E-07	1.25E-07	-1.61E-07	10.19249	-5.96142	-8.26731	9.241536	-7.49615	5.404975	4.586199	4.485855	0.954112	2.737103	2.660992	0.640978	7.935864	5.664156	5.558351	21.72127	11.50949	18.42133
N105	13 kV	0.844717	0.597305	-52.264	1.29217	4.552075	0.597263	-52.268	1.292358	4.551753	0.601905	0.91899	0.597305	0.365565	-0.47237	0.597305	-0.36557	0.472372	1.99E-07	1.22E-07	-1.57E-07	10.19329	-5.96238	-8.26761	9.242148	-7.49711	5.404691	4.586865	4.486494	0.954306	2.736866	2.660821	0.640681	8.136005	5.809264	5.696229	22.26716	11.80795	18.87853
N106	13 kV	0.821311	0.580754	-52.2354	1.290837	4.425943	0.580713	-52.2394	1.291025	4.425629	0.585205	0.893345	0.580754	0.355665	-0.45911	0.580754	-0.35567	0.459106	1.94E-07	1.19E-07	-1.53E-07	10.19418	-5.96343	-8.26793	9.242821	-7.49816	5.404377	4.587599	4.487199	0.954519	2.736607	2.660633	0.640353	8.368279	5.977667	5.856243	22.90069	12.15431	19.40913
N107	13 kV	0.793507	0.561094	-52.2014	1.289256	4.276112	0.561054	-52.2054	1.289444	4.275808	0.565368	0.862895	0.561094	0.343888	-0.44336	0.561094	-0.34389	0.44336	1.87E-07	1.15E-07	-1.48E-07	10.19523	-5.96469	-8.26832	9.24362	-7.49942	5.404002	4.588471	4.488036	0.954774	2.7363	2.66041	0.639965	8.662	6.190618	6.058588	23.70183	12.5923	20.0801
N108	13 kV	0.752207	0.531891	-52.1509	1.286914	4.053551	0.531853	-52.155	1.287102	4.053264	0.535907	0.817693	0.531891	0.326359	-0.42	0.531891	-0.32636	0.419997	1.77E-07	1.09E-07	-1.40E-07	10.19679	-5.96656	-8.26891	9.244804	-7.50128	5.403445	4.589765	4.489279	0.955153	2.735842	2.660078	0.639386	9.138378	6.535989	6.386768	25.00116	13.30263	21.16832
N109	13 kV	0.722738	0.511053	-52.115	1.285249	3.894746	0.511017	-52.119	1.285436	3.894469	0.514887	0.785459	0.511053	0.313827	-0.40335	0.511053	-0.31383	0.403346	1.70E-07	1.05E-07	-1.34E-07	10.19791	-5.96789	-8.26932	9.245648	-7.50261	5.403045	4.590689	4.490166	0.955425	2.735516	2.659842	0.638975	9.511576	6.806549	6.643867	26.01907	13.85908	22.02085
N110	13 kV	0.681774	0.482087	-52.0651	1.282942	3.673994	0.482053	-52.0691	1.283128	3.673733	0.485672	0.74068	0.482087	0.296371	-0.38023	0.482087	-0.29637	0.380226	1.61E-07	9.88E-08	-1.27E-07	10.19947	-5.96974	-8.2699	9.24682	-7.50445	5.402488	4.591974	4.491399	0.955805	2.735064	2.659514	0.638405	10.08394	7.221491	7.038177	27.58022	14.71245	23.32836
N111	13 kV	0.654906	0.463088	-52.0324	1.281436	3.529207	0.463055	-52.0365	1.281622	3.528956	0.466513	0.711328	0.463088	0.284899	-0.36508	0.463088	-0.2849	0.36508	1.54E-07	9.50E-08	-1.22E-07	10.20047	-5.97094	-8.27028	9.247577	-7.50564	5.402128	4.592802	4.492194	0.956049	2.734747	2.659281	0.638019	10.49827	7.521834	7.32364	28.71012	15.33005	24.27469
N112	13 kV	0.631908	0.446826	-52.0046	1.280152	3.405272	0.446794	-52.0086	1.280338	3.405031	0.450114	0.686215	0.446826	0.275066	-0.35213	0.446826	-0.27507	0.352126	1.49E-07	9.17E-08	-1.17E-07	10.20131	-5.97194	-8.27059	9.248215	-7.50665	5.401825	4.593499	4.492862	0.956254	2.73446	2.659067	0.637679	10.88095	7.799211	7.587319	29.75353	15.90035	25.14858
N113	13 kV	0.584433	0.413256	-51.9473	1.277517	3.149437	0.413227	-51.9513	1.277703	3.149214	0.416267	0.634407	0.413256	0.254726	-0.32542	0.413256	-0.25473	0.325416	1.38E-07	8.49E-08	-1.08E-07	10.20304	-5.974	-8.27123	9.249526	-7.50871	5.401199	4.594933	4.494238	0.956678	2.733861	2.658619	0.636978	11.76618	8.440818	8.197295	32.1671	17.21942	27.1701
N114	13 kV	0.578384	0.408979	-51.94	1.277183	3.11684	0.40895	-51.9441	1.277369	3.116619	0.411955	0.627809	0.408979	0.25213	-0.32202	0.408979	-0.25213	0.322016	1.36E-07	8.40E-08	-1.07E-07	10.20325	-5.97426	-8.27131	9.24969	-7.50897	5.401121	4.595112	4.49441	0.95673	2.73378	2.658557	0.636886	11.88942	8.530134	8.282223	32.50307	17.40302	27.45149
N115	13 kV	0.573071	0.405222	-51.9336	1.276891	3.088208	0.405193	-51.9377	1.277076	3.087989	0.408167	0.622014	0.405222	0.249849	-0.31903	0.405222	-0.24985	0.31903	1.35E-07	8.33E-08	-1.06E-07	10.20344	-5.97449	-8.27138	9.249834	-7.5092	5.401052	4.59527	4.494561	0.956777	2.733708	2.658503	0.636805	11.99982	8.61014	8.358301	32.80401	17.56747	27.70355
N116	13 kV	0.558708	0.395066	-51.9164	1.276101	3.010808	0.395038	-51.9205	1.276286	3.010595	0.397929	0.606352	0.395066	0.243681	-0.31096	0.395066	-0.24368	0.310961	1.32E-07	8.12E-08	-1.04E-07	10.20395	-5.9751	-8.27157	9.250222	-7.50981	5.400866	4.595694	4.494969	0.956902	2.733513	2.658355	0.636587	12.30876	8.83403	8.571206	33.64617	18.02767	28.40894
N117	13 kV	0.549865	0.388814	-51.9059	1.275616	2.963157	0.388786	-51.9099	1.275801	2.962947	0.391626	0.596712	0.388814	0.239881	-0.306	0.388814	-0.23988	0.305996	1.30E-07	8.00E-08	-1.02E-07	10.20427	-5.97547	-8.27169	9.250461	-7.51019	5.400752	4.595955	4.495219	0.956978	2.733393	2.658263	0.636453	12.50699	8.977683	8.707817	34.18652	18.32293	28.86154
N118	13 kV	0.523343	0.37006	-51.8743	1.274169	2.820234	0.370033	-51.8783	1.274354	2.820034	0.372721	0.567806	0.37006	0.228471	-0.29111	0.37006	-0.22847	0.29111	1.23E-07	7.62E-08	-9.70E-08	10.2052	-5.97659	-8.27203	9.251172	-7.51131	5.400409	4.596734	4.495967	0.957208	2.733026	2.657983	0.63605	13.14175	9.43766	9.145284	35.91675	19.26828	30.31082
N121	13 kV	1.223214	0.864943	-52.6396	1.309822	6.591749	0.864877	-52.6454	1.310098	6.591249	0.872053	1.334349	0.864943	0.52487	-0.68749	0.864943	-0.52487	0.687486	2.88E-07	1.75E-07	-2.29E-07	10.17555	-5.95913	-8.24807	9.216601	-7.45989	5.412561	4.571776	4.473007	0.945169	2.739598	2.660721	0.652658	5.616647	3.994508	3.948498	15.38736	8.051254	13.1129
N124	13 kV	2.720733	1.923849	-18.5504	0.335575	14.6617	1.92017	-18.624	0.337004	14.63366	1.923849	2.720967	1.923849	1.823893	-0.61205	1.923849	-1.82389	0.612052	6.41E-07	6.08E-07	-2.04E-07	8.147216	-4.60647	-6.71994	9.318351	-6.19651	6.959517	3.60188	3.600995	-0.07986	1.683691	1.64987	-0.33578	3.242322	2.966442	1.308769	5.459069	5.333695	1.163241
N125	13 kV	17.27264	12.2136	-76.8498	4.280236	93.08013	12.13608	-78.4673	4.900831	92.48933	14.76176	25.56344	12.2136	2.77866	-11.8933	12.2136	-2.77866	11.89332	4.07E-06	9.26E-07	-3.96E-06	7.724496	-2.61857	-7.26711	7.656249	-4.24375	6.372496	2.306796	2.287439	0.298208	1.2802	1.280147	0.01171	0.570683	0.131817	0.555251	0.730588	0.162242	0.712346
N126	13 kV	15.12631	10.69591	-63.1481	1.975215	81.51381	10.63134	-64.7536	2.120648	81.02173	11.13139	18.20938	10.69591	4.831196	-9.54265	10.69591	-4.8312	9.542648	3.57E-06	1.61E-06	-3.18E-06	7.301273	-2.95346	-6.67725	8.307904	-4.56406	6.941946	2.507393	2.50584	-0.08823	1.309685	1.301267	-0.14825	0.646842	0.265986	0.589624	0.84716	0.43353	0.727827
N128	13 kV	13.25755	9.374506	-54.3983	1.396696	71.44333	9.320401	-55.9935	1.482197	71.03099	9.478219	14.65586	9.374506	5.457347	-7.62225	9.374506	-5.45735	7.622252	3.12E-06	1.82E-06	-2.54E-06	7.191963	-3.3019	-6.3892	8.719636	-4.90006	7.21259	2.747727	2.733985	-0.27446	1.371536	1.348004	-0.25298	0.72638	0.377159	0.620789	0.996257	0.665456	0.741414
N131	13 kV	8.706126	6.156161	-37.7248	0.77358	46.91625	6.126259	-39.2844	0.818036	46.68836	6.157988	8.856132	6.156161	4.869267	-3.76677	6.156161	-4.86927	3.76677	2.05E-06	1.62E-06	-1.26E-06	7.392412	-4.17912	-6.09776	9.396986	-5.73465	7.444271	3.334932	3.30459	-0.44884	1.595034	1.526674	-0.46195	1.044155	0.73591	0.74074	1.665463	1.465682	0.790913
N132	13 kV	5.81455	4.111507	-43.3209	0.943042	31.3339	4.108972	-43.4	0.945653	31.31457	4.116757	6.022392	4.111507	2.991213	-2.82084	4.111507	-2.99121	2.82084	1.37E-06	9.97E-07	-9.40E-07	8.478679	-4.96032	-6.87628	9.253428	-6.45219	6.632882	3.805035	3.80417	0.081133	2.028704	2.018531	-0.20292	1.382016	0.956351	0.997679	2.803703	2.132869	1.819786
N133	13 kV	3.852092	2.72384	-47.7669	1.101568	20.75845	2.721916	-47.8166	1.10349	20.74379	2.732904	4.074484	2.72384	1.830823	-2.01678	2.72384	-1.83082	2.016777	9.08E-07	6.10E-07	-6.72E-07	9.215176	-5.69716	-7.24305	9.429753	-7.0933	6.213319	4.277282	4.263487	0.343245	2.539142	2.538993	-0.02745	1.849207	1.234638	1.376676	4.695398	3.172527	3.461479
N134	13 kV	3.02542	2.139295	-50.1523	1.198208	16.30362	2.137403	-50.2147	1.200863	16.2892	2.150561	3.245259	2.139295	1.37075	-1.64244	2.139295	-1.37075	1.642445	7.13E-07	4.57E-07	-5.47E-07	9.54488	-6.13615	-7.31111	9.630165	-7.45134	6.100621	4.547103	4.529166	0.403497	2.907707	2.907632	0.020999	2.17765	1.402467	1.665906	6.331968	4.042876	4.873292
N135	13 kV	2.606222	1.842877	-51.681	1.265358	14.04461	1.841385	-51.7414	1.268103	14.03324	1.855685	2.823871	1.842877	1.142656	-1.44587	1.842877	-1.14266	1.445868	6.14E-07	3.81E-07	-4.82E-07	9.719294	-6.42365	-7.29392	9.786393	-7.67007	6.078112	4.715358	4.69791	0.405271	3.1843	3.184251	0.017547	2.393038	1.490123	1.872476	7.620151	4.71207	5.98858
N136	13 kV	2.325735	1.644543	-52.9154	1.322975	12.5331	1.643322	-52.974	1.325791	12.52379	1.65872	2.542139	1.644543	0.991649	-1.31193	1.644543	-0.99165	1.311927	5.48E-07	3.31E-07	-4.37E-07	9.843743	-6.65924	-7.2494	9.928684	-7.84402	6.086879	4.849927	4.834422	0.387506	3.437318	3.437295	-0.01264	2.556851	1.537021	2.043295	8.788708	5.309014	7.003981
N137	13 kV	1.886925	1.334257	-52.814	1.318119	10.16841	1.333268	-52.8724	1.320912	10.16087	1.345561	2.06097	1.334257	0.806432	-1.06297	1.334257	-0.80643	1.062973	4.45E-07	2.69E-07	-3.54E-07	9.872749	-6.55344	-7.38401	9.760768	-7.73489	5.953494	4.786586	4.762776	0.476839	3.304156	3.300695	0.151178	3.231361	2.025648	2.517627	10.67692	6.305438	8.616152
N138	13 kV	1.714229	1.212143	-52.7939	1.317161	9.237772	1.211244	-52.8523	1.319952	9.230921	1.222377	1.872071	1.212143	0.732963	-0.96543	1.212143	-0.73296	0.965431	4.04E-07	2.44E-07	-3.22E-07	9.877695	-6.50525	-7.43307	9.692662	-7.6867	5.904432	4.758014	4.730651	0.509547	3.246092	3.239537	0.206193	3.597093	2.28608	2.777215	11.6765	6.833196	9.468263
N139	13 kV	1.624779	1.148893	-52.7836	1.316667	8.755737	1.148041	-52.842	1.319456	8.749244	1.158575	1.774251	1.148893	0.694882	-0.91493	1.148893	-0.69488	0.914928	3.83E-07	2.32E-07	-3.05E-07	9.880425	-6.48028	-7.45847	9.657386	-7.66173	5.879033	4.74331	4.714001	0.52648	3.216425	3.207925	0.233679	3.817277	2.442737	2.933367	12.27798	7.150651	9.980837
N140	13 kV	2.101195	1.485769	-54.1182	1.382372	11.32308	1.484764	-54.1752	1.385272	11.31542	1.501462	2.317708	1.485769	0.870831	-1.20381	1.485769	-0.87083	1.203812	4.95E-07	2.90E-07	-4.01E-07	9.929285	-6.8621	-7.17651	10.06551	-7.9894	6.122414	4.962952	4.950499	0.351367	3.677787	3.676915	-0.0801	2.710364	1.557443	2.218208	9.968143	5.904267	8.031408
N141	13 kV	1.781179	1.259484	-56.3099	1.499998	9.598557	1.258796	-56.3637	1.503053	9.593312	1.278441	2.000522	1.259484	0.698637	-1.04795	1.259484	-0.69864	1.047954	4.20E-07	2.33E-07	-3.49E-07	10.06509	-7.2374	-6.99471	10.34092	-8.25258	6.231347	5.169593	5.163327	0.254456	4.189804	4.17917	-0.29832	2.934312	1.508039	2.517142	12.29419	7.053252	10.06969
N142	13 kV	1.641733	1.160881	-57.5574	1.573162	8.8471	1.160334	-57.6094	1.576317	8.842931	1.182078	1.864587	1.160881	0.622759	-0.9797	1.160881	-0.62276	0.979702	3.87E-07	2.08E-07	-3.27E-07	10.12251	-7.43879	-6.8651	10.50329	-8.39065	6.317917	5.279631	5.27648	0.182394	4.506195	4.478829	-0.49587	3.030973	1.426032	2.674553	13.65816	7.713181	11.27174
N143	13 kV	1.541588	1.090067	-58.6173	1.639379	8.307429	1.089624	-58.6677	1.642624	8.304054	1.113419	1.768426	1.090067	0.567654	-0.9306	1.090067	-0.56765	0.9306	3.63E-07	1.89E-07	-3.10E-07	10.16713	-7.60916	-6.74324	10.64699	-8.50667	6.40273	5.373142	5.371943	0.113504	4.799425	4.745971	-0.71431	3.09183	1.323186	2.794386	14.83901	8.275862	12.31691
N144	13 kV	1.469449	1.039057	-59.4943	1.697274	7.918678	1.038691	-59.5432	1.700597	7.915888	1.064388	1.700278	1.039057	0.527451	-0.89523	1.039057	-0.52745	0.895229	3.46E-07	1.76E-07	-2.98E-07	10.20181	-7.7494	-6.63505	10.76958	-8.60182	6.480161	5.45065	5.450405	0.051629	5.059337	4.971926	-0.9364	3.127953	1.214955	2.882355	15.82537	8.739697	13.19318
N145	35 kV	0.067842	0.047971	95.15209	11.09088	0.955519	0.047834	94.57475	12.49772	0.952778	0.070094	0.118948	0.047971	-0.00431	0.047777	0.047971	0.004308	-0.04778	1.60E-08	-1.44E-09	1.59E-08	36.37017	-29.7351	-20.9431	36.42056	-33.1886	14.99906	21.06795	20.97458	1.981346	201.9431	-199.63	-30.4744	6.22934	1.498363	6.046453	1257.972	-114.857	-1252.72
N146	35 kV	0.067828	0.047962	95.15447	11.08575	0.955328	0.047825	94.57799	12.48883	0.952611	0.070075	0.118918	0.047962	-0.00431	0.047768	0.047962	0.004309	-0.04777	1.60E-08	-1.44E-09	1.59E-08	36.36664	-29.7347	-20.9375	36.41722	-33.1837	15.00176	21.06595	20.97283	1.978568	201.9695	-199.634	-30.6242	6.22976	1.503171	6.045691	1258.221	-114.94	-1252.96
N149	35 kV	0.067801	0.047943	95.15853	11.07697	0.954951	0.047809	94.58381	12.47291	0.952284	0.070039	0.118859	0.047943	-0.00431	0.047749	0.047943	0.004311	-0.04775	1.60E-08	-1.44E-09	1.59E-08	36.35954	-29.734	-20.9262	36.41049	-33.1739	15.00719	21.06192	20.96931	1.972989	202.0204	-199.641	-30.9138	6.230622	1.512426	6.044271	1258.713	-115.091	-1253.44
N150	35 kV	0.067709	0.047878	95.16502	11.06297	0.953654	0.047753	94.59678	12.43756	0.951173	0.06993	0.11868	0.047878	-0.00431	0.047683	0.047878	0.00431	-0.04768	1.60E-08	-1.44E-09	1.59E-08	36.33344	-29.7314	-20.8846	36.3856	-33.1376	15.027	21.04709	20.95632	1.952519	202.1832	-199.659	-31.8492	6.233977	1.54174	6.040324	1260.405	-115.443	-1255.11
N154	35 kV	0.067641	0.047829	95.16028	11.07319	0.952691	0.047687	94.46831	12.7967	0.949857	0.06987	0.118573	0.047829	-0.0043	0.047635	0.047829	0.004302	-0.04764	1.59E-08	-1.43E-09	1.59E-08	36.31193	-29.7292	-20.8502	36.36487	-33.1075	15.0432	21.03481	20.94556	1.935681	202.2905	-199.668	-32.4655	6.236902	1.560268	6.038585	1261.666	-115.49	-1256.37
N155	35 kV	0.067601	0.047801	95.15251	11.08998	0.952134	0.047653	94.39884	12.99959	0.949172	0.069845	0.118526	0.047801	-0.00429	0.047608	0.047801	0.004293	-0.04761	1.59E-08	-1.43E-09	1.59E-08	36.29836	-29.7278	-20.8286	36.3517	-33.0884	15.05334	21.02704	20.93873	1.925079	202.3464	-199.673	-32.7812	6.238791	1.569285	6.0382	1262.397	-115.405	-1257.11
N156	35 kV	0.067527	0.047749	95.12401	11.15199	0.951095	0.047606	94.33398	13.19492	0.948242	0.069827	0.118477	0.047749	-0.00426	0.047558	0.047749	0.004265	-0.04756	1.59E-08	-1.42E-09	1.59E-08	36.26991	-29.7249	-20.7831	36.32384	-33.0482	15.07445	21.0107	20.92435	1.902888	202.4356	-199.685	-33.2568	6.242809	1.581372	6.039199	1263.767	-114.932	-1258.53
N157	35 kV	0.067506	0.047734	95.11084	11.1809	0.950787	0.047595	94.32427	13.22464	0.948032	0.069831	0.118475	0.047734	-0.00425	0.047544	0.047734	0.004252	-0.04754	1.59E-08	-1.42E-09	1.58E-08	36.26043	-29.7239	-20.768	36.31448	-33.0347	15.08143	21.00524	20.91954	1.895512	202.4571	-199.69	-33.3583	6.244152	1.583314	6.040079	1264.173	-114.685	-1258.96
N158	35 kV	0.067475	0.047712	95.08691	11.23377	0.950354	0.047581	94.30583	13.28149	0.947747	0.069849	0.118489	0.047712	-0.00423	0.047524	0.047712	0.00423	-0.04752	1.59E-08	-1.41E-09	1.58E-08	36.24588	-29.7224	-20.7447	36.30004	-33.014	15.0921	20.99683	20.91212	1.884194	202.4823	-199.699	-33.4582	6.246214	1.584239	6.041968	1264.748	-114.217	-1259.58
N159	35 kV	0.067448	0.047693	95.05983	11.29421	0.949982	0.04757	94.28392	13.34968	0.947519	0.069877	0.118519	0.047693	-0.00421	0.047507	0.047693	0.004206	-0.04751	1.59E-08	-1.40E-09	1.58E-08	36.23193	-29.721	-20.7224	36.28612	-32.994	15.10227	20.98876	20.90499	1.873365	202.4974	-199.709	-33.4895	6.248184	1.582759	6.044392	1265.241	-113.668	-1260.12
N160	35 kV	0.067438	0.047686	95.04671	11.32372	0.949833	0.047565	94.27314	13.38349	0.947433	0.069893	0.118537	0.047686	-0.00419	0.047501	0.047686	0.004195	-0.0475	1.59E-08	-1.40E-09	1.58E-08	36.22585	-29.7203	-20.7126	36.28002	-32.9853	15.10668	20.98524	20.90187	1.86865	202.5013	-199.714	-33.4833	6.24904	1.581383	6.045637	1265.439	-113.397	-1260.35
N161	35 kV	0.06743	0.04768	95.03516	11.34983	0.949716	0.047562	94.26348	13.41392	0.947368	0.069909	0.118555	0.04768	-0.00418	0.047496	0.04768	0.004185	-0.0475	1.59E-08	-1.39E-09	1.58E-08	36.22077	-29.7198	-20.7045	36.27492	-32.978	15.11036	20.98229	20.89926	1.864712	202.5033	-199.718	-33.4687	6.249754	1.57989	6.046766	1265.596	-113.156	-1260.53
N162	35 kV	0.067411	0.047667	95.00462	11.41946	0.949453	0.047526	94.02258	14.22012	0.946659	0.069952	0.118609	0.047667	-0.00416	0.047485	0.047667	0.004158	-0.04748	1.59E-08	-1.39E-09	1.58E-08	36.20837	-29.7185	-20.6846	36.26242	-32.9601	15.11931	20.97508	20.89289	1.85511	202.503	-199.73	-33.3974	6.251495	1.574924	6.04986	1265.947	-112.51	-1260.94
N163	35 kV	0.067402	0.047661	94.98784	11.45805	0.949333	0.047525	94.00888	14.26887	0.946622	0.069978	0.118641	0.047661	-0.00414	0.04748	0.047661	0.004144	-0.04748	1.59E-08	-1.38E-09	1.58E-08	36.20208	-29.7179	-20.6746	36.25605	-32.951	15.12383	20.97142	20.88964	1.850244	202.5002	-199.736	-33.3416	6.252377	1.571684	6.051614	1266.108	-112.152	-1261.13
N164	35 kV	0.067396	0.047657	94.97494	11.48792	0.94925	0.047523	93.99826	14.3069	0.946601	0.069999	0.118667	0.047657	-0.00413	0.047477	0.047657	0.004133	-0.04748	1.59E-08	-1.38E-09	1.58E-08	36.19745	-29.7174	-20.6671	36.25134	-32.9443	15.12716	20.96872	20.88725	1.846659	202.4969	-199.741	-33.292	6.253027	1.568982	6.052987	1266.219	-111.875	-1261.27
N165	35 kV	0.067389	0.047651	94.95603	11.53196	0.949143	0.047522	93.98256	14.3635	0.946579	0.07003	0.118708	0.047651	-0.00412	0.047473	0.047651	0.004117	-0.04747	1.59E-08	-1.37E-09	1.58E-08	36.19095	-29.7167	-20.6567	36.24473	-32.9349	15.13181	20.96493	20.88388	1.841633	202.4905	-199.749	-33.2102	6.25394	1.564742	6.055026	1266.363	-111.466	-1261.45
N166	35 kV	0.067381	0.047646	94.93457	11.58239	0.949037	0.047522	93.96459	14.42882	0.946567	0.070067	0.118755	0.047646	-0.0041	0.047469	0.047646	0.004098	-0.04747	1.59E-08	-1.37E-09	1.58E-08	36.18392	-29.716	-20.6455	36.23756	-32.9247	15.13683	20.96083	20.88025	1.836209	202.4813	-199.757	-33.1058	6.254926	1.559569	6.057379	1266.506	-111	-1261.63
N167	35 kV	0.067377	0.047643	94.92004	11.61674	0.948975	0.047522	93.95233	14.47373	0.946565	0.070093	0.118789	0.047643	-0.00409	0.047467	0.047643	0.004086	-0.04747	1.59E-08	-1.36E-09	1.58E-08	36.17937	-29.7155	-20.6381	36.2329	-32.9181	15.14007	20.95817	20.87788	1.832692	202.4741	-199.762	-33.0291	6.255568	1.555882	6.05899	1266.59	-110.683	-1261.74
N168	35 kV	0.067369	0.047637	94.88915	11.69051	0.948863	0.047522	93.92603	14.57098	0.946577	0.070149	0.118862	0.047637	-0.00406	0.047464	0.047637	0.00406	-0.04746	1.59E-08	-1.35E-09	1.58E-08	36.17011	-29.7146	-20.6233	36.2234	-32.9046	15.14665	20.95275	20.87307	1.825547	202.456	-199.773	-32.8511	6.256877	1.547576	6.062468	1266.742	-110.005	-1261.96
N169	35 kV	0.067362	0.047632	94.85268	11.77879	0.948763	0.047524	93.89467	14.68865	0.946613	0.070218	0.118954	0.047632	-0.00403	0.047461	0.047632	0.004029	-0.04746	1.59E-08	-1.34E-09	1.58E-08	36.15986	-29.7135	-20.6068	36.21284	-32.8897	15.15389	20.94674	20.86773	1.817652	202.4308	-199.785	-32.62	6.258336	1.537117	6.066633	1266.88	-109.2	-1262.17
N170	35 kV	0.067354	0.047627	94.79058	11.9322	0.948655	0.04753	93.8407	14.89571	0.946722	0.07034	0.119117	0.047627	-0.00398	0.04746	0.047627	0.003977	-0.04746	1.59E-08	-1.33E-09	1.58E-08	36.14376	-29.7119	-20.581	36.19615	-32.8661	15.16521	20.93728	20.85931	1.805257	202.3796	-199.804	-32.1826	6.260669	1.517941	6.073864	1267.032	-107.819	-1262.44
N173	35 kV	0.067353	0.047626	94.77465	11.9722	0.948638	0.047531	93.82674	14.95022	0.946757	0.070372	0.119161	0.047626	-0.00396	0.047461	0.047626	0.003964	-0.04746	1.59E-08	-1.32E-09	1.58E-08	36.13985	-29.7115	-20.5747	36.19208	-32.8603	15.16795	20.93498	20.85726	1.802251	202.3649	-199.809	-32.0625	6.261244	1.512775	6.075746	1267.056	-107.462	-1262.49
N174	35 kV	0.067352	0.047625	94.75399	12.02448	0.948622	0.047534	93.80856	15.02177	0.946808	0.070415	0.119218	0.047625	-0.00395	0.047461	0.047625	0.003947	-0.04746	1.59E-08	-1.32E-09	1.58E-08	36.13492	-29.7109	-20.5668	36.18694	-32.8531	15.17139	20.93207	20.85467	1.798459	202.3451	-199.814	-31.9034	6.261978	1.505973	6.078191	1267.08	-107	-1262.55
N175	35 kV	0.067351	0.047624	94.72703	12.09338	0.94861	0.047538	93.78478	15.11646	0.94688	0.070471	0.119294	0.047624	-0.00392	0.047462	0.047624	0.003925	-0.04746	1.59E-08	-1.31E-09	1.58E-08	36.12867	-29.7103	-20.5567	36.18041	-32.8439	15.17575	20.92839	20.85138	1.793662	202.3179	-199.821	-31.6897	6.262918	1.496902	6.0814	1267.1	-106.394	-1262.63
N178	35 kV	0.067353	0.047626	94.63171	12.34338	0.948638	0.047553	93.69997	15.46394	0.947186	0.070675	0.119571	0.047626	-0.00385	0.04747	0.047626	0.003846	-0.04747	1.59E-08	-1.28E-09	1.58E-08	36.10808	-29.7082	-20.5236	36.15875	-32.8134	15.19002	20.91622	20.84052	1.777864	202.2103	-199.838	-30.8853	6.26614	1.46331	6.092884	1267.078	-104.244	-1262.78
N179	13 kV	14.17939	10.02634	-79.4786	5.384292	76.41098	10.02511	-79.5137	5.402703	76.40163	12.77181	22.09087	10.02634	1.830838	-9.85777	10.02634	-1.83084	9.857765	3.34E-06	6.10E-07	-3.29E-06	8.610304	-4.55796	-7.30495	8.449434	-5.43583	6.468743	3.342905	3.331264	0.278738	2.007161	2.006613	0.046923	0.569095	0.110464	0.558272	1.142266	0.195462	1.125418
N180	13 kV	13.83477	9.782661	-76.4269	4.142009	74.55389	9.781214	-76.4624	4.153303	74.54286	11.73415	20.31473	9.782661	2.295853	-9.50944	9.782661	-2.29585	9.509444	3.26E-06	7.65E-07	-3.17E-06	8.558566	-4.54137	-7.25431	8.477786	-5.41903	6.519739	3.329149	3.320132	0.244858	1.977415	1.976847	0.047393	0.587635	0.144707	0.569539	1.161999	0.259071	1.13275
N181	13 kV	11.13826	7.875941	-58.926	1.659424	60.02273	7.873318	-58.9651	1.661989	60.00274	8.05257	12.81559	7.875941	4.06512	-6.74576	7.875941	-4.06512	6.745757	2.63E-06	1.36E-06	-2.25E-06	8.310954	-4.55792	-6.94963	8.725575	-5.43401	6.82695	3.330892	3.330641	0.040894	1.826886	1.826873	-0.00692	0.758556	0.390349	0.650411	1.385794	0.717616	1.185518
N182	13 kV	9.48569	6.707395	-50.6498	1.219579	51.11722	6.704292	-50.6914	1.221387	51.09356	6.746108	10.20736	6.707395	4.252883	-5.18673	6.707395	-4.25288	5.186728	2.24E-06	1.42E-06	-1.73E-06	8.243489	-4.63242	-6.81878	8.875073	-5.50741	6.959552	3.380267	3.379941	-0.04692	1.777712	1.776727	-0.05916	0.902426	0.56119	0.70671	1.604254	1.038895	1.222428
N183	13 kV	8.646513	6.114008	-46.7948	1.064699	46.595	6.1107	-46.8379	1.066306	46.56979	6.130711	9.098759	6.114008	4.185729	-4.45654	6.114008	-4.18573	4.456542	2.04E-06	1.40E-06	-1.49E-06	8.226794	-4.68079	-6.76538	8.947391	-5.55512	7.014015	3.412978	3.411972	-0.08288	1.761568	1.759385	-0.08767	0.994429	0.663715	0.740521	1.751754	1.23265	1.244674
N185	13 kV	6.859023	4.850062	-39.1	0.812679	36.96243	4.84639	-39.1473	0.81405	36.93445	4.852189	7.002704	4.850062	3.763871	-3.05882	4.850062	-3.76387	3.058819	1.62E-06	1.25E-06	-1.02E-06	8.225104	-4.80158	-6.67811	9.092013	-5.67409	7.10418	3.494779	3.491892	-0.14202	1.744554	1.738038	-0.15064	1.26006	0.945072	0.83342	2.198242	1.768117	1.306151
N186	13 kV	6.334626	4.479257	-36.9437	0.752014	34.13652	4.475493	-36.9925	0.75335	34.10784	4.48031	6.431771	4.479257	3.579942	-2.69217	4.479257	-3.57994	2.692165	1.49E-06	1.19E-06	-8.97E-07	8.232766	-4.84112	-6.65898	9.132073	-5.71292	7.124413	3.521432	3.518013	-0.15514	1.743914	1.735658	-0.16949	1.364944	1.052596	0.868973	2.380346	1.974231	1.329834
N187	13 kV	5.451768	3.854982	-33.3936	0.659219	29.37891	3.851171	-33.4388	0.660351	29.34987	3.855262	5.498204	3.854982	3.218559	-2.12174	3.854982	-3.21856	2.121737	1.28E-06	1.07E-06	-7.07E-07	8.253622	-4.91154	-6.63318	9.197277	-5.78196	7.152545	3.568699	3.564497	-0.17312	1.747267	1.73561	-0.20149	1.58533	1.274691	0.942568	2.769995	2.402283	1.379097
N188	13 kV	5.01645	3.547166	-31.6745	0.616997	27.03303	3.543282	-31.7217	0.618136	27.00344	3.5473	5.047287	3.547166	3.018799	-1.86259	3.547166	-3.0188	1.862589	1.18E-06	1.01E-06	-6.21E-07	8.267784	-4.9485	-6.62334	9.228763	-5.81807	7.16381	3.593375	3.588856	-0.18016	1.751236	1.737686	-0.21742	1.721538	1.410139	0.987523	3.014819	2.66509	1.409408
N191	13 kV	4.690238	3.316499	-30.398	0.586651	25.27512	3.312564	-30.4471	0.587801	25.24513	3.316573	4.712394	3.316499	2.860583	-1.67816	3.316499	-2.86058	1.678163	1.11E-06	9.54E-07	-5.59E-07	8.280183	-4.97736	-6.6172	9.252226	-5.84619	7.171174	3.612573	3.607851	-0.18466	1.755332	1.74027	-0.22945	1.839653	1.526782	1.026285	3.229202	2.892497	1.435689
N192	13 kV	4.523517	3.198609	-29.7494	0.571532	24.37668	3.194648	-29.7994	0.572692	24.34649	3.198663	4.542063	3.198609	2.777046	-1.58717	3.198609	-2.77705	1.587172	1.07E-06	9.26E-07	-5.29E-07	8.287145	-4.99255	-6.61447	9.264217	-5.86097	7.174593	3.622654	3.61784	-0.18671	1.75783	1.741965	-0.23564	1.906401	1.592423	1.04812	3.351129	3.020919	1.450556
N193	13 kV	4.29377	3.036154	-28.8891	0.551781	23.1386	3.032159	-28.9407	0.552956	23.10815	3.036189	4.30823	3.036154	2.658325	-1.46681	3.036154	-2.65832	1.466814	1.01E-06	8.86E-07	-4.89E-07	8.291642	-5.00287	-6.61231	9.274583	-5.87215	7.178843	3.629919	3.625004	-0.18884	1.755834	1.738989	-0.24264	2.009759	1.693089	1.082859	3.528804	3.207003	1.472275
N194	13 kV	4.128064	2.918982	-28.2709	0.537789	22.24563	2.914963	-28.3237	0.538977	22.215	2.919007	4.140052	2.918982	2.570801	-1.38255	2.918982	-2.5708	1.382548	9.73E-07	8.57E-07	-4.61E-07	8.29516	-5.01037	-6.61104	9.282024	-5.88033	7.18176	3.635215	3.630234	-0.19024	1.75454	1.736967	-0.2477	2.091375	1.772364	1.110214	3.669401	3.353541	1.489383
N195	13 kV	3.94111	2.786785	-27.5808	0.52236	21.23816	2.782948	-27.6335	0.523533	21.20891	2.786802	3.950741	2.786785	2.470093	-1.29028	2.786785	-2.47009	1.290277	9.29E-07	8.23E-07	-4.30E-07	8.298156	-5.01844	-6.60868	9.288976	-5.8884	7.184137	3.640671	3.635614	-0.19182	1.75321	1.734799	-0.25341	2.191626	1.869418	1.143897	3.84238	3.532944	1.510693
N198	13 kV	3.859943	2.729392	-27.2819	0.515739	20.80076	2.725634	-27.3347	0.516906	20.77212	2.729406	3.868675	2.729392	2.425779	-1.25107	2.729392	-2.42578	1.25107	9.10E-07	8.09E-07	-4.17E-07	8.299518	-5.02196	-6.60772	9.291949	-5.89191	7.185101	3.643043	3.637956	-0.19246	1.75268	1.733898	-0.2559	2.238147	1.91438	1.159505	3.922756	3.616056	1.520576
N199	13 kV	3.835959	2.712432	-27.1939	0.513796	20.67151	2.708698	-27.2467	0.514961	20.64305	2.712446	3.844438	2.712432	2.412613	-1.23959	2.712432	-2.41261	1.239591	9.04E-07	8.04E-07	-4.13E-07	8.299932	-5.023	-6.60745	9.292816	-5.89295	7.185371	3.643745	3.638649	-0.19264	1.752529	1.733638	-0.25663	2.252268	1.928016	1.164244	3.947165	3.64126	1.523592
N200	13 kV	3.621715	2.560939	-26.4077	0.496572	19.51698	2.557413	-26.4605	0.497721	19.4901	2.560947	3.628191	2.560939	2.293709	-1.13899	2.560939	-2.29371	1.138993	8.54E-07	7.65E-07	-3.80E-07	8.30373	-5.0323	-6.60514	9.300506	-5.90225	7.187688	3.650018	3.644849	-0.19418	1.751286	1.731396	-0.2632	2.386637	2.057611	1.209244	4.179684	3.880809	1.552122
N201	13 kV	3.424135	2.421229	-25.6858	0.480963	18.45224	2.417895	-25.7386	0.482098	18.42683	2.421234	3.429121	2.421229	2.181973	-1.04945	2.421229	-2.18197	1.049449	8.07E-07	7.27E-07	-3.50E-07	8.307465	-5.0409	-6.60328	9.307409	-5.91085	7.189555	3.655811	3.650584	-0.19542	1.750314	1.729479	-0.26926	2.52535	2.191077	1.255618	4.420155	4.127507	1.5816
N202	13 kV	14.17939	10.02634	-79.4786	5.384292	76.41098	10.02511	-79.5137	5.402703	76.40163	12.77181	22.09087	10.02634	1.830838	-9.85777	10.02634	-1.83084	9.857765	3.34E-06	6.10E-07	-3.29E-06	8.610304	-4.55796	-7.30495	8.449434	-5.43583	6.468743	3.342905	3.331264	0.278738	2.007161	2.006613	0.046923	0.569095	0.110464	0.558272	1.142266	0.195462	1.125418
N203	13 kV	13.61505	9.627296	-76.0758	4.033515	73.36985	9.626119	-76.1109	4.044103	73.36088	11.47718	19.86332	9.627296	2.316689	-9.3444	9.627296	-2.31669	9.344398	3.21E-06	7.72E-07	-3.11E-06	8.479494	-4.68257	-7.06933	8.709819	-5.56004	6.704241	3.416371	3.414203	0.121697	2.054596	2.053036	-0.08007	0.585821	0.129713	0.57128	1.203626	0.312045	1.162473
N204	13 kV	11.93807	8.441491	-73.1869	3.309419	64.3328	8.440457	-73.2219	3.316735	64.32492	9.623164	16.5583	8.441491	2.441711	-8.08064	8.441491	-2.44171	8.080644	2.81E-06	8.14E-07	-2.69E-06	8.665218	-4.94675	-7.11447	8.845762	-5.82288	6.658947	3.593087	3.589877	0.151841	2.158178	2.157867	-0.03664	0.65137	0.182908	0.625162	1.405773	0.417597	1.342315
N205	13 kV	9.640046	6.816542	-69.3061	2.647269	51.94903	6.815706	-69.341	2.652157	51.94265	7.42445	12.58236	6.816542	2.408803	-6.37675	6.816542	-2.4088	6.376748	2.27E-06	8.03E-07	-2.13E-06	8.950032	-5.29416	-7.21629	9.001822	-6.16773	6.556825	3.826948	3.820629	0.219824	2.298388	2.297911	0.046819	0.780346	0.283691	0.726952	1.793538	0.617861	1.683753
N206	13 kV	7.647721	5.407755	-65.9965	2.245671	41.21263	5.40709	-66.0313	2.249347	41.20756	5.727818	9.535598	5.407755	2.199831	-4.9401	5.407755	-2.19983	4.940097	1.80E-06	7.33E-07	-1.65E-06	9.220352	-5.58096	-7.33947	9.110628	-6.4511	6.433258	4.022046	4.010687	0.302071	2.417391	2.413158	0.143005	0.957503	0.417629	0.861625	2.31466	0.884589	2.13896
N207	13 kV	6.293553	4.450214	-63.7671	2.029328	33.91518	4.449664	-63.8018	2.032432	33.911	4.647102	7.631894	4.450214	1.967086	-3.99186	4.450214	-1.96709	3.991864	1.48E-06	6.56E-07	-1.33E-06	9.415188	-5.76892	-7.44079	9.171619	-6.63553	6.331532	4.151316	4.134817	0.369753	2.49707	2.487191	0.221899	1.143533	0.555512	0.999537	2.855482	1.159867	2.609308
N208	13 kV	14.17939	10.02634	-79.4786	5.384292	76.41098	10.02511	-79.5137	5.402703	76.40163	12.77181	22.09087	10.02634	1.830838	-9.85777	10.02634	-1.83084	9.857765	3.34E-06	6.10E-07	-3.29E-06	8.610304	-4.55796	-7.30495	8.449434	-5.43583	6.468743	3.342905	3.331264	0.278738	2.007161	2.006613	0.046923	0.569095	0.110464	0.558272	1.142266	0.195462	1.125418
N209	13 kV	13.56902	9.594744	-75.7902	3.949123	73.12177	9.593571	-75.8252	3.959296	73.11283	11.38274	19.69337	9.594744	2.355251	-9.30118	9.594744	-2.35525	9.301178	3.20E-06	7.85E-07	-3.10E-06	8.471048	-4.69536	-7.05069	8.732122	-5.5726	6.722803	3.424397	3.422653	0.109297	2.059947	2.057958	-0.0905	0.587064	0.131383	0.572174	1.209321	0.322165	1.165619
N210	13 kV	12.57514	8.891965	-70.3906	2.806876	67.76587	8.890878	-70.4256	2.812309	67.75759	9.794236	16.68123	8.891965	2.984191	-8.37625	8.891965	-2.98419	8.376254	2.96E-06	9.95E-07	-2.79E-06	8.343852	-4.95285	-6.71485	9.1541	-5.82904	7.058315	3.595787	3.593963	-0.11449	2.17179	2.151945	-0.29293	0.617742	0.16585	0.595062	1.341606	0.53121	1.231959
N211	13 kV	10.94086	7.736359	-62.5696	1.926696	58.95897	7.735413	-62.6046	1.929573	58.95176	8.027534	13.0833	7.736359	3.56391	-6.86657	7.736359	-3.56391	6.866571	2.58E-06	1.19E-06	-2.29E-06	8.335445	-5.42731	-6.32644	9.754749	-6.30163	7.446112	3.927422	3.909648	-0.37322	2.40855	2.335294	-0.58951	0.675462	0.227549	0.63598	1.626885	0.906309	1.351058
N212	13 kV	9.582202	6.77564	-56.7118	1.523039	51.63731	6.774811	-56.7467	1.525061	51.631	6.884241	10.80018	6.77564	3.718813	-5.6639	6.77564	-3.71881	5.663897	2.26E-06	1.24E-06	-1.89E-06	8.466414	-5.84309	-6.12686	10.17576	-6.71556	7.645094	4.216696	4.186216	-0.50608	2.646817	2.518695	-0.81352	0.734928	0.288131	0.676091	1.945219	1.275727	1.468468
N213	13 kV	8.563023	6.054971	-52.5799	1.306996	46.14508	6.054231	-52.6147	1.308643	46.13944	6.104237	9.336993	6.054971	3.679329	-4.80887	6.054971	-3.67933	4.808868	2.02E-06	1.23E-06	-1.60E-06	8.624384	-6.15755	-6.03859	10.4496	-7.02835	7.73282	4.431432	4.395299	-0.56474	2.848786	2.678222	-0.97093	0.790286	0.342655	0.712137	2.251354	1.609142	1.574566
N214	13 kV	14.17939	10.02634	-79.4786	5.384292	76.41098	10.02511	-79.5137	5.402703	76.40163	12.77181	22.09087	10.02634	1.830838	-9.85777	10.02634	-1.83084	9.857765	3.34E-06	6.10E-07	-3.29E-06	8.610304	-4.55796	-7.30495	8.449434	-5.43583	6.468743	3.342905	3.331264	0.278738	2.007161	2.006613	0.046923	0.569095	0.110464	0.558272	1.142266	0.195462	1.125418
N215	13 kV	13.74858	9.721711	-76.85	4.280321	74.08939	9.720522	-76.8851	4.29217	74.08033	11.75003	20.34794	9.721711	2.2117	-9.46679	9.721711	-2.2117	9.466787	3.24E-06	7.37E-07	-3.16E-06	8.506444	-4.65202	-7.12168	8.650069	-5.52954	6.651905	3.397464	3.393853	0.156593	2.042535	2.041895	-0.05111	0.581798	0.125186	0.56817	1.188342	0.284654	1.153746
N216	13 kV	13.12208	9.278712	-73.3052	3.334283	70.71328	9.277578	-73.3403	3.341706	70.70464	10.59495	18.23662	9.278712	2.665522	-8.8876	9.278712	-2.66552	8.887603	3.09E-06	8.89E-07	-2.96E-06	8.399489	-4.80474	-6.88955	8.925807	-5.68176	6.883871	3.495498	3.495497	0.001895	2.105557	2.097522	-0.18378	0.600744	0.146622	0.582576	1.2649	0.414606	1.195021
N217	13 kV	10.92105	7.722349	-62.5292	1.923373	58.8522	7.721405	-62.5641	1.926244	58.84501	8.011393	13.0536	7.722349	3.562295	-6.85162	7.722349	-3.56229	6.851623	2.57E-06	1.19E-06	-2.28E-06	8.332317	-5.4268	-6.32276	9.757913	-6.30189	7.450036	3.927579	3.909563	-0.37576	2.40769	2.333801	-0.5919	0.676866	0.228097	0.637275	1.629685	0.909538	1.352262
N218	13 kV	9.132627	6.457743	-54.9289	1.424382	49.21461	6.456953	-54.9638	1.426228	49.20859	6.535676	10.13892	6.457743	3.710572	-5.28527	6.457743	-3.71057	5.285271	2.15E-06	1.24E-06	-1.76E-06	8.5227	-5.97235	-6.08008	10.29701	-6.84548	7.69207	4.306264	4.272609	-0.53733	2.726326	2.579438	-0.88281	0.759133	0.310699	0.69264	2.069645	1.412898	1.512333

1-Ph Fault

Node	Network Level	idc [kA]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]	IL1a [kA]	IL1r [kA]	IL1i [kA]	3I0a [kA]	3I0r [kA]	3I0i [kA]	VL1a [kV]	VL1r [kV]	VL1i [kV]	VL2a [kV]	VL2r [kV]	VL2i [kV]	VL3a [kV]	VL3r [kV]	VL3i [kV]	V0a [kV]	V0r [kV]	V0i [kV]	Z0/Z1a [pu]	Z0/Z1r [pu]	Z0/Z1i [pu]	Z1a [Ohm]	Z1r [Ohm]	Z1i [Ohm]	Z0a [Ohm]	Z0r [Ohm]	Z0i [Ohm]
N219	13 kV	8.164527	5.773192	-51.0828	1.238553	43.99763	5.772486	-51.1177	1.240095	43.99225	5.80924	8.810689	5.773192	3.6267	-4.49186	5.773192	-3.6267	4.491859	1.92E-06	1.21E-06	-1.50E-06	8.687147	-6.26883	-6.01401	10.54374	-7.14062	7.757702	4.507448	4.469816	-0.58123	2.924073	2.737121	-1.02877	0.816952	0.366619	0.73007	2.388829	1.754555	1.621122
N220	13 kV	14.17939	10.02634	-79.4786	5.384292	76.41098	10.02511	-79.5137	5.402703	76.40163	12.77181	22.09087	10.02634	1.830838	-9.85777	10.02634	-1.83084	9.857765	3.34E-06	6.10E-07	-3.29E-06	8.610304	-4.55796	-7.30495	8.449434	-5.43583	6.468743	3.342905	3.331264	0.278738	2.007161	2.006613	0.046923	0.569095	0.110464	0.558272	1.142266	0.195462	1.125418
N221	13 kV	10.66904	7.544147	-72.6288	3.196632	57.49412	7.543254	-72.6632	3.203384	57.48731	8.535741	14.66212	7.544147	2.25239	-7.20006	7.544147	-2.25239	7.200062	2.51E-06	7.51E-07	-2.40E-06	8.992572	-5.22849	-7.31637	8.866869	-6.08979	6.444827	3.783928	3.772759	0.290516	2.291725	2.288928	0.113194	0.706357	0.228603	0.668342	1.618777	0.447604	1.555663
N222	13 kV	7.009398	4.956393	-65.9615	2.241981	37.77279	4.955844	-65.9946	2.245466	37.76861	5.248431	8.735723	4.956393	2.018989	-4.52653	4.956393	-2.01899	4.526535	1.65E-06	6.73E-07	-1.51E-06	9.530829	-5.94349	-7.45062	9.238044	-6.77068	6.28485	4.255833	4.238056	0.388589	2.65215	2.638971	0.264068	0.992761	0.455275	0.882212	2.632951	0.968494	2.448357
N224	13 kV	5.364961	3.7936	-63.186	1.978462	28.91111	3.793206	-63.2179	1.981201	28.90811	3.948848	6.461317	3.7936	1.711277	-3.3857	3.7936	-1.71128	3.385695	1.26E-06	5.70E-07	-1.13E-06	9.822292	-6.30463	-7.53187	9.414359	-7.10147	6.180561	4.491344	4.4687	0.450435	2.876085	2.852772	0.365458	1.238412	0.640065	1.060179	3.561778	1.438509	3.258367
N225	13 kV	4.555605	3.221299	-61.9142	1.873952	24.5496	3.220982	-61.9452	1.876394	24.54718	3.332083	5.407668	3.221299	1.516565	-2.84197	3.221299	-1.51657	2.841971	1.07E-06	5.06E-07	-9.47E-07	9.985135	-6.513	-7.5686	9.519551	-7.28648	6.126102	4.624889	4.599826	0.480834	3.026724	2.996572	0.426166	1.415329	0.770032	1.187521	4.283811	1.801376	3.886654
N226	13 kV	3.784792	2.676252	-60.8092	1.789968	20.39578	2.676252	-60.8092	1.789968	20.39578	2.755085	4.439137	2.676252	1.305258	-2.33637	2.676252	-1.30526	2.33637	8.92E-07	4.35E-07	-7.79E-07	10.16154	-6.75208	-7.59384	9.647477	-7.49337	6.076446	4.775345	4.748483	0.505798	3.224884	3.186861	0.49376	1.639623	0.931723	1.349168	5.287595	2.303107	4.75966
N227	13 kV	3.586793	2.536246	-57.5173	1.570731	19.32879	2.536246	-57.5173	1.570731	19.32879	2.582273	4.072172	2.536246	1.362079	-2.13946	2.536246	-1.36208	2.139459	8.45E-07	4.54E-07	-7.13E-07	10.0746	-6.70839	-7.51633	9.639244	-7.43855	6.130494	4.738218	4.715646	0.461946	3.155865	3.12693	0.426373	1.752222	1.060286	1.395019	5.529777	2.720641	4.814202
N228	13 kV	3.475243	2.457368	-55.8026	1.471597	18.72766	2.457368	-55.8026	1.471597	18.72766	2.491502	3.886247	2.457368	1.381155	-2.0325	2.457368	-1.38115	2.032503	8.19E-07	4.60E-07	-6.78E-07	10.0236	-6.68866	-7.46555	9.642874	-7.41252	6.167621	4.720262	4.700393	0.432641	3.123552	3.100213	0.381124	1.819143	1.131724	1.424248	5.682187	2.965768	4.8468
N229	13 kV	3.414337	2.414301	-54.8992	1.422812	18.39944	2.414301	-54.8992	1.422812	18.39944	2.443296	3.789635	2.414301	1.388264	-1.97524	2.414301	-1.38826	1.975239	8.05E-07	4.63E-07	-6.58E-07	9.995349	-6.68003	-7.43534	9.647923	-7.40033	6.190115	4.711771	4.693453	0.415074	3.108486	3.088253	0.354085	1.856631	1.170468	1.441208	5.77131	3.104391	4.865262
N230	13 kV	3.306591	2.338113	-53.3544	1.344264	17.81881	2.338113	-53.3544	1.344264	17.81881	2.359836	3.626053	2.338113	1.395535	-1.87597	2.338113	-1.39553	1.875968	7.79E-07	4.65E-07	-6.25E-07	9.944806	-6.66864	-7.37756	9.662268	-7.38241	6.233732	4.699177	4.683684	0.381276	3.086387	3.07156	0.302164	1.924678	1.238581	1.473195	5.9403	3.359228	4.899261
N231	13 kV	3.118625	2.205201	-50.8134	1.226707	16.80589	2.205201	-50.8134	1.226707	16.80589	2.218314	3.35947	2.205201	1.393352	-1.70923	2.205201	-1.39335	1.709235	7.35E-07	4.64E-07	-5.70E-07	9.855259	-6.66151	-7.26296	9.704563	-7.36303	6.321738	4.685363	4.674847	0.31374	3.062387	3.055961	0.198271	2.049033	1.355916	1.536238	6.274931	3.839037	4.963522
N232	13 kV	2.91956	2.064441	-48.3286	1.123505	15.73315	2.064441	-48.3286	1.123505	15.73315	2.072118	3.097767	2.064441	1.372559	-1.54208	2.064441	-1.37256	1.542076	6.88E-07	4.58E-07	-5.14E-07	9.75919	-6.67378	-7.12056	9.775459	-7.36078	6.43261	4.683805	4.678188	0.229318	3.059091	3.058365	0.066633	2.189194	1.476914	1.61595	6.696943	4.409268	5.040576
N233	13 kV	2.696316	1.906583	-45.805	1.028503	14.53011	1.906583	-45.805	1.028503	14.53011	1.910816	2.823433	1.906583	1.329084	-1.36697	1.906583	-1.32908	1.366966	6.36E-07	4.43E-07	-4.56E-07	9.649353	-6.71274	-6.93174	9.889215	-7.38144	6.581099	4.699516	4.698063	0.116882	3.083548	3.081416	-0.11465	2.359302	1.6061	1.728222	7.275022	5.147206	5.141227
N234	13 kV	2.620151	1.852727	-45.01	1.000349	14.11967	1.852727	-45.01	1.000349	14.11967	1.856191	2.733502	1.852727	1.309847	-1.3103	1.852727	-1.30985	1.310304	6.18E-07	4.37E-07	-4.37E-07	9.611687	-6.7341	-6.85831	9.938591	-7.3958	6.639102	4.710536	4.709969	0.073069	3.100843	3.095153	-0.18778	2.420311	1.646919	1.773574	7.505007	5.4305	5.180232
N235	13 kV	2.531025	1.789705	-44.1268	0.969976	13.63938	1.789705	-44.1268	0.969976	13.63938	1.792454	2.630265	1.789705	1.284651	-1.24608	1.789705	-1.28465	1.24608	5.97E-07	4.28E-07	-4.15E-07	9.567505	-6.76513	-6.76536	10.00437	-7.41805	6.712666	4.727759	4.727727	0.017566	3.127846	3.115034	-0.28281	2.493686	1.691391	1.832393	7.799865	5.786953	5.229633
N236	13 kV	2.403433	1.699484	-42.9615	0.931258	12.9518	1.699484	-42.9615	0.931258	12.9518	1.701478	2.485798	1.699484	1.243703	-1.15821	1.699484	-1.2437	1.158209	5.66E-07	4.15E-07	-3.86E-07	9.503972	-6.82224	-6.61684	10.11569	-7.46129	6.830554	4.761707	4.761174	-0.07124	3.180866	3.150144	-0.44102	2.602626	1.746356	1.929741	8.278602	6.352323	5.308789
N237	13 kV	2.299081	1.625696	-42.1086	0.903842	12.38947	1.625696	-42.1086	0.903842	12.38947	1.627251	2.370206	1.625696	1.206063	-1.09009	1.625696	-1.20606	1.090091	5.42E-07	4.02E-07	-3.63E-07	9.451725	-6.88199	-6.47868	10.2248	-7.50832	6.94058	4.799239	4.796769	-0.15397	3.239132	3.183864	-0.59581	2.695206	1.780073	2.023728	8.730127	6.87326	5.382695
N238	13 kV	2.199541	1.55531	-41.3972	0.881533	11.85306	1.55531	-41.3972	0.881533	11.85306	1.556558	2.261857	1.55531	1.166705	-1.02849	1.55531	-1.16671	1.028489	5.18E-07	3.89E-07	-3.43E-07	9.401104	-6.95096	-6.32968	10.34657	-7.56386	7.059707	4.844391	4.838276	-0.24334	3.308459	3.217339	-0.77113	2.78725	1.798877	2.129039	9.221504	7.429352	5.462679
N239	13 kV	2.147448	1.518475	-41.0713	0.871474	11.57233	1.518475	-41.0713	0.871474	11.57233	1.519597	2.205836	1.518475	1.144767	-0.99763	1.518475	-1.14477	0.997634	5.06E-07	3.82E-07	-3.33E-07	9.374368	-6.99286	-6.24329	10.4189	-7.59808	7.129005	4.872598	4.863646	-0.29524	3.351323	3.234584	-0.87683	2.836846	1.80138	2.191512	9.507188	7.7483	5.509126
N240	13 kV	2.104159	1.487865	-40.8283	0.86404	11.33906	1.487865	-40.8283	0.86404	11.33906	1.488899	2.159624	1.487865	1.125826	-0.97276	1.487865	-1.12583	0.972759	4.96E-07	3.75E-07	-3.24E-07	9.351985	-7.03109	-6.16631	10.48424	-7.62954	7.190917	4.898799	4.886879	-0.34154	3.390772	3.248025	-0.97348	2.878916	1.798571	2.247955	9.761748	8.030147	5.550537
N241	13 kV	2.03855	1.441473	-40.5152	0.854539	10.9855	1.441473	-40.5152	0.854539	10.9855	1.442396	2.090156	1.441473	1.095856	-0.93645	1.441473	-1.09586	0.936452	4.80E-07	3.65E-07	-3.12E-07	9.317681	-7.09561	-6.03916	10.5936	-7.68303	7.29351	4.943928	4.926216	-0.41812	3.457743	3.265146	-1.1379	2.944457	1.783885	2.342558	10.18117	8.490234	5.618917
N242	13 kV	1.884245	1.332362	-41.643	0.889184	10.15396	1.332362	-41.643	0.889184	10.15396	1.333499	1.93929	1.332362	0.995674	-0.88534	1.332362	-0.99567	0.885337	4.44E-07	3.32E-07	-2.95E-07	9.322506	-7.01024	-6.14538	10.45857	-7.59766	7.187298	4.881672	4.869301	-0.34731	3.369339	3.224291	-0.97795	3.228539	1.97676	2.552622	10.87804	8.869997	6.297217
N243	13 kV	1.676623	1.185552	-43.1529	0.937516	9.035116	1.185552	-43.1529	0.937516	9.035116	1.187007	1.735389	1.185552	0.864897	-0.81085	1.185552	-0.8649	0.810855	3.95E-07	2.88E-07	-2.70E-07	9.340424	-6.90264	-6.29263	10.27927	-7.49006	7.040051	4.804031	4.797566	-0.24914	3.259952	3.16738	-0.77136	3.69112	2.290561	2.894426	12.03287	9.487709	7.400908
N244	13 kV	1.526828	1.07963	-44.2371	0.973719	8.227887	1.07963	-44.2371	0.973719	8.227887	1.081331	1.587444	1.07963	0.77351	-0.75318	1.07963	-0.77351	0.753182	3.60E-07	2.58E-07	-2.51E-07	9.361327	-6.83023	-6.40174	10.15182	-7.41766	6.930932	4.752573	4.749298	-0.1764	3.187577	3.125109	-0.62797	4.101292	2.568621	3.197308	13.07318	10.03503	8.37892
N245	13 kV	1.59478	1.12768	-43.7458	0.957152	8.594075	1.12768	-43.7458	0.957152	8.594075	1.129268	1.654655	1.12768	0.814652	-0.77975	1.12768	-0.81465	0.779746	3.76E-07	2.72E-07	-2.60E-07	9.351027	-6.86253	-6.35196	10.20942	-7.44996	6.980719	4.775431	4.77083	-0.20959	3.219743	3.144401	-0.69245	3.905844	2.436142	3.053003	12.57581	9.774261	7.912957
N246	13 kV	1.760122	1.244594	-42.5465	0.917826	9.485081	1.244594	-42.5465	0.917826	9.485081	1.245918	1.817535	1.244594	0.916928	-0.84158	1.244594	-0.91693	0.84158	4.15E-07	3.06E-07	-2.81E-07	9.331662	-6.94491	-6.23283	10.35103	-7.53233	7.099848	4.834394	4.825748	-0.28901	3.302663	3.190523	-0.85331	3.492246	2.155688	2.747506	11.53371	9.222257	6.926503
N247	13 kV	1.682668	1.189826	-43.1087	0.936069	9.06769	1.189826	-43.1087	0.936069	9.06769	1.191271	1.741341	1.189826	0.868642	-0.81311	1.189826	-0.86864	0.813109	3.97E-07	2.90E-07	-2.71E-07	9.339725	-6.90566	-6.28827	10.28446	-7.49309	7.044411	4.806197	4.799583	-0.25205	3.263003	3.16908	-0.77725	3.676063	2.280361	2.883296	11.99501	9.467698	7.364975
N248	13 kV	1.579338	1.11676	-43.857	0.960876	8.510857	1.11676	-43.857	0.960876	8.510857	1.118374	1.639392	1.11676	0.805264	-0.77376	1.11676	-0.80526	0.773759	3.72E-07	2.68E-07	-2.58E-07	9.353258	-6.85513	-6.36322	10.19632	-7.44256	6.969457	4.770179	4.765897	-0.20208	3.212366	3.140058	-0.67774	3.948787	2.465271	3.084697	12.68495	9.831724	8.01531
N249	13 kV	1.506844	1.065499	-44.3808	0.978615	8.120196	1.065499	-44.3808	0.978615	8.120196	1.067233	1.56764	1.065499	0.76152	-0.74524	1.065499	-0.76152	0.745235	3.55E-07	2.54E-07	-2.48E-07	9.364622	-6.82093	-6.41647	10.13498	-7.40836	6.916214	4.746022	4.743097	-0.16658	3.17836	3.119429	-0.60921	4.162041	2.609817	3.242135	13.22847	10.11628	8.523686
N250	13 kV	1.417574	1.002376	-45.0246	1.000859	7.639132	1.002376	-45.0246	1.000859	7.639132	1.004256	1.478998	1.002376	0.708483	-0.70909	1.002376	-0.70848	0.709091	3.34E-07	2.36E-07	-2.36E-07	9.380708	-6.78024	-6.48275	10.06003	-7.36767	6.849933	4.717558	4.71597	-0.1224	3.138172	3.09374	-0.52621	4.454121	2.80774	3.457714	13.9778	10.50591	9.219802
N251	13 kV	1.333791	0.943133	-45.6277	1.022155	7.187637	0.943133	-45.6277	1.022155	7.187637	0.945149	1.395491	0.943133	0.659549	-0.67416	0.943133	-0.65955	0.674162	3.14E-07	2.20E-07	-2.25E-07	9.397877	-6.74348	-6.54565	9.990299	-7.33091	6.787032	4.692155	4.691465	-0.08046	3.102117	3.069354	-0.44966	4.763293	3.017192	3.685853	14.77629	10.91822	9.956474
N252	13 kV	1.223037	0.864818	-46.4235	1.050965	6.590797	0.864818	-46.4235	1.050965	6.590797	0.867005	1.284587	0.864818	0.596139	-0.62652	0.864818	-0.59614	0.626521	2.88E-07	1.99E-07	-2.09E-07	9.423606	-6.69703	-6.62979	9.899095	-7.28446	6.702889	4.660559	4.660496	-0.02437	3.056877	3.03673	-0.35038	5.236161	3.337454	4.034697	16.0063	11.54863	11.0829
N253	13 kV	1.175326	0.831081	-46.7658	1.063618	6.333687	0.831081	-46.7658	1.063618	6.333687	0.833338	1.236616	0.831081	0.569276	-0.60549	0.831081	-0.56928	0.605492	2.77E-07	1.90E-07	-2.02E-07	9.435739	-6.67777	-6.66638	9.860161	-7.2652	6.666307	4.647656	4.647656	2.32E-05	3.038224	3.022545	-0.30826	5.467024	3.49378	4.204979	16.61004	11.85043	11.63275
N254	13 kV	1.960897	1.386564	-40.2505	0.846577	10.56703	1.386564	-40.2505	0.846577	10.56703	1.387393	2.00885	1.386564	1.058263	-0.8959	1.386564	-1.05826	0.895901	4.62E-07	3.53E-07	-2.99E-07	9.273436	-7.17717	-5.87238	10.73613	-7.75089	7.428881	5.002995	4.97602	-0.51883	3.541467	3.270396	-1.35886	3.029535	1.75029	2.472766	10.729	9.084281	5.708525
N255	13 kV	1.923628	1.36021	-40.1689	0.844135	10.36619	1.36021	-40.1689	0.844135	10.36619	1.361006	1.970167	1.36021	1.0394	-0.87739	1.36021	-1.0394	0.877394	4.53E-07	3.46E-07	-2.92E-07	9.251594	-7.22103	-5.78349	10.81283	-7.7876	7.501374	5.035541	5.002877	-0.57263	3.586062	3.266686	-1.47939	3.072557	1.724426	2.543022	11.01838	9.395288	5.756148
N256	13 kV	1.903749	1.346154	-40.1392	0.843247	10.25907	1.346154	-40.1392	0.843247	10.25907	1.346935	1.949627	1.346154	1.029109	-0.86779	1.346154	-1.02911	0.867793	4.49E-07	3.43E-07	-2.89E-07	9.239749	-7.2458	-5.73335	10.85626	-7.80839	7.542369	5.054165	5.018064	-0.60301	3.611026	3.262376	-1.54804	3.096249	1.707515	2.582857	11.18064	9.568912	5.782955
N257	13 kV	1.887794	1.334872	-40.1228	0.842759	10.17309	1.334872	-40.1228	0.842759	10.17309	1.335644	1.93319	1.334872	1.02073	-0.86023	1.334872	-1.02073	0.860229	4.45E-07	3.40E-07	-2.87E-07	9.23013	-7.26642	-5.69162	10.89247	-7.82571	7.576552	5.069794	5.030709	-0.62831	3.631645	3.257504	-1.60546	3.115702	1.6922	2.616115	11.31512	9.712427	5.805236
N258	13 kV	1.835377	1.297807	-40.1212	0.84271	9.890621	1.297807	-40.1212	0.84271	9.890621	1.298557	1.879503	1.297807	0.992412	-0.83632	1.297807	-0.99241	0.836315	4.33E-07	3.31E-07	-2.79E-07	9.197714	-7.33901	-5.54408	11.02086	-7.88687	7.697836	5.125817	5.075293	-0.71792	3.702838	3.230386	-1.80987	3.182971	1.629422	2.73428	11.78603	10.21235	5.883743
N259	13 kV	1.698437	1.200976	-38.6431	0.799523	9.15267	1.200976	-38.6431	0.799523	9.15267	1.20144	1.731823	1.200976	0.938023	-0.74997	1.200976	-0.93802	0.749971	4.00E-07	3.13E-07	-2.50E-07	9.163391	-7.32024	-5.51197	11.0051	-7.85541	7.70745	5.111214	5.058551	-0.73183	3.679851	3.198791	-1.81908	3.456349	1.835254	2.928854	12.71885	11.1984	6.030327
N260	13 kV	1.602278	1.132982	-39.6136	0.827671	8.63448	1.132982	-39.6136	0.827671	8.63448	1.133553	1.638277	1.132982	0.872806	-0.7224	1.132982	-0.87281	0.722396	3.78E-07	2.91E-07	-2.41E-07	9.152593	-7.2313	-5.61054	10.87259	-7.76648	7.60888	5.043442	4.999261	-0.66611	3.590323	3.189827	-1.64785	3.705965	2.005972	3.116128	13.30561	11.53363	6.634361
N261	13 kV	1.497904	1.059178	-40.6618	0.858975	8.072022	1.059178	-40.6618	0.858975	8.072022	1.059883	1.53655	1.059178	0.80346	-0.69015	1.059178	-0.80346	0.690152	3.53E-07	2.68E-07	-2.30E-07	9.14813	-7.13906	-5.72033	10.72988	-7.67423	7.499099	4.973234	4.937763	-0.59292	3.49851	3.175844	-1.46751	4.012307	2.215043	3.345474	14.0371	11.94414	7.374108
N262	13 kV	1.636179	1.156954	-39.6703	0.829341	8.81717	1.156954	-39.6703	0.829341	8.81717	1.157546	1.673222	1.156954	0.890542	-0.73856	1.156954	-0.89054	0.738564	3.86E-07	2.97E-07	-2.46E-07	9.203509	-7.33915	-5.5535	10.97983	-7.86606	7.660411	5.116829	5.068403	-0.7023	3.717076	3.258545	-1.78845	3.55783	1.861414	3.032044	13.22472	11.48815	6.551009
N263	13 kV	1.577263	1.115293	-40.6613	0.858962	8.499675	1.115293	-40.6613	0.858962	8.499675	1.116035	1.617954	1.115293	0.846033	-0.72671	1.115293	-0.84603	0.72671	3.72E-07	2.82E-07	-2.42E-07	9.244581	-7.36297	-5.59007	10.96143	-7.88138	7.618188	5.126225	5.081452	-0.67604	3.760039	3.319898	-1.76527	3.657294	1.882639	3.135517	13.75157	11.7852	7.086235
N264	13 kV	1.541963	1.090333	-41.2654	0.877451	8.309451	1.090333	-41.2654	0.877451	8.309451	1.091179	1.584931	1.090333	0.819563	-0.71913	1.090333	-0.81956	0.719126	3.63E-07	2.73E-07	-2.40E-07	9.270671	-7.38023	-5.61048	10.95327	-7.89321	7.594161	5.133907	5.091147	-0.66123	3.789823	3.359212	-1.75455	3.718473	1.893231	3.200425	14.09236	11.97508	7.429135
N265	13 kV	1.447112	1.023263	-42.9347	0.930388	7.798309	1.023263	-42.9347	0.930388	7.798309	1.024456	1.496548	1.023263	0.749161	-0.69701	1.023263	-0.74916	0.697011	3.41E-07	2.50E-07	-2.32E-07	9.346489	-7.43897	-5.65849	10.94354	-7.93588	7.535448	5.162998	5.12495	-0.62565	3.887384	3.476043	-1.74037	3.888532	1.91092	3.386601	15.11622	12.53637	8.446273
N267	13 kV	1.338539	0.94649	-44.9819	0.99937	7.213225	0.94649	-44.9819	0.99937	7.213225	0.948249	1.396268	0.94649	0.669481	-0.66906	0.94649	-0.66948	0.669059	3.15E-07	2.23E-07	-2.23E-07	9.443229	-7.53085	-5.69744	10.95793	-8.00602	7.481966	5.213007	5.178958	-0.59484	4.036408	3.633238	-1.75846	4.093261	1.901576	3.624747	16.52207	13.28284	9.825731
N268	13 kV	1.27424	0.901024	-46.2676	1.045257	6.866725	0.901817	-46.3509	1.048302	6.87277	0.90323	1.337329	0.901024	0.622869	-0.65106	0.901024	-0.62287	0.651059	3.00E-07	2.08E-07	-2.17E-07	9.506475	-7.60106	-5.70938	10.98348	-8.0613	7.460042	5.253299	5.220787	-0.58356	4.150231	3.741873	-1.79522	4.217863	1.873454	3.77896	17.5051	13.79428	10.77713
N269	13 kV	1.222038	0.864111	-47.3635	1.086604	6.585411	0.864879	-47.4434	1.089146	6.591267	0.866763	1.289782	0.864111	0.585301	-0.6357	0.864111	-0.5853	0.635697	2.88E-07	1.95E-07	-2.12E-07	9.561024	-7.66805	-5.71089	11.01568	-8.11482	7.449484	5.29278	5.260956	-0.57953	4.259895	3.839608	-1.84502	4.320356	1.832865	3.912299	18.40426	14.25577	11.64001
N270	13 kV	1.20323	0.850812	-47.7717	1.101752	6.484062	0.851572	-47.8502	1.104791	6.489848	0.853646	1.27273	0.850812	0.57182	-0.63	0.850812	-0.57182	0.630003	2.84E-07	1.91E-07	-2.10E-07	9.581529	-7.69475	-5.70933	11.03022	-8.13632	7.447543	5.308739	5.277026	-0.5794	4.304007	3.877273	-1.86848	4.357297	1.813304	3.962066	18.75384	14.43373	11.97388
N271	13 kV	1.033497	0.730793	-48.8996	1.146305	5.569387	0.73153	-48.9884	1.149898	5.575006	0.733829	1.100188	0.730793	0.480409	-0.5507	0.730793	-0.48041	0.550695	2.44E-07	1.60E-07	-1.84E-07	9.542519	-7.47445	-5.9323	10.71716	-7.91599	7.224585	5.1482	5.130148	-0.43076	4.019064	3.775138	-1.37884	5.26914	2.447051	4.666453	21.17701	15.67225	14.24241
N272	13 kV	1.1126	0.786727	-48.375	1.125336	5.995668	0.787521	-48.4638	1.128855	6.001717	0.78968	1.180822	0.786727	0.522586	-0.58808	0.786727	-0.52259	0.588085	2.62E-07	1.74E-07	-1.96E-07	9.557697	-7.57579	-5.82726	10.86284	-8.01736	7.329615	5.221787	5.197718	-0.50078	4.149234	3.827949	-1.60092	4.808369	2.127811	4.311941	19.95105	15.04823	13.09943
N273	13 kV	14.17939	10.02634	-79.4786	5.384292	76.41098	10.02511	-79.5137	5.402703	76.40163	12.77181	22.09087	10.02634	1.830838	-9.85777	10.02634	-1.83084	9.857765	3.34E-06	6.10E-07	-3.29E-06	8.610304	-4.55796	-7.30495	8.449434	-5.43583	6.468743	3.342905	3.331264	0.278738	2.007161	2.006613	0.046923	0.569095	0.110464	0.558272	1.142266	0.195462	1.125418
N274	13 kV	13.48041	9.532093	-73.6304	3.404379	72.6443	9.530804	-73.6657	3.412149	72.63448	10.93433	18.83755	9.532093	2.686451	-9.1457	9.532093	-2.68645	9.145697	3.18E-06	8.95E-07	-3.05E-06	8.51105	-4.52977	-7.2055	8.507302	-5.40698	6.56801	3.319059	3.31225	0.212496	1.949995	1.949481	0.04477	0.607265	0.17774	0.580672	1.184164	0.320504	1.139965
N275	13 kV	12.92879	9.142034	-69.6821	2.700757	69.67166	9.140711	-69.715	2.705898	69.66157	9.994894	16.96873	9.142034	3.174377	-8.57322	9.142034	-3.17438	8.573221	3.05E-06	1.06E-06	-2.86E-06	8.448131	-4.52259	-7.13562	8.556407	-5.39931	6.637739	3.31146	3.307299	0.165962	1.913018	1.912664	0.036813	0.639146	0.227559	0.597264	1.222697	0.413257	1.150742
N276	13 kV	10.9114	7.715522	-57.8008	1.588021	58.80018	7.714132	-57.8369	1.590241	58.78958	7.861718	12.42048	7.715522	4.11133	-6.52888	7.715522	-4.11133	6.528878	2.57E-06	1.37E-06	-2.18E-06	8.293002	-4.5604	-6.92652	8.741526	-5.43529	6.846304	3.332003	3.331896	0.026738	1.816815	1.81676	-0.01409	0.776375	0.411274	0.658492	1.410529	0.756466	1.190526
N277	13 kV	9.005145	6.367399	-48.5292	1.131455	48.52762	6.366197	-48.566	1.132921	48.51694	6.392226	9.565716	6.367399	4.216869	-4.7712	6.367399	-4.21687	4.771198	2.12E-06	1.41E-06	-1.59E-06	8.221643	-4.64802	-6.78169	8.908046	-5.52114	6.990727	3.390436	3.38972	-0.06968	1.763757	1.762129	-0.07577	0.954195	0.61738	0.727551	1.682968	1.14303	1.235259
N278	13 kV	8.480423	5.996565	-46.1692	1.04167	45.69996	5.995166	-46.2063	1.043018	45.6893	6.010946	8.89597	5.996565	4.152806	-4.32585	5.996565	-4.15281	4.325852	2.00E-06	1.38E-06	-1.44E-06	8.212058	-4.678	-6.74938	8.951512	-5.55054	7.022896	3.410732	3.409514	-0.09117	1.754254	1.751744	-0.0938	1.015928	0.685025	0.750234	1.782196	1.270359	1.249964
N279	13 kV	7.520174	5.317566	-42.0047	0.900554	40.52529	5.316177	-42.0423	0.901741	40.51471	5.322525	7.749887	5.317566	3.951427	-3.55847	5.317566	-3.95143	3.558473	1.77E-06	1.32E-06	-1.19E-06	8.204361	-4.73792	-6.69804	9.027965	-5.60922	7.073949	3.451322	3.449046	-0.1253	1.74194	1.73727	-0.12746	1.14978	0.827667	0.798099	2.002847	1.539606	1.281019
N280	13 kV	5.967923	4.219959	-35.7156	0.718986	32.1604	4.218856	-35.7531	0.71998	32.152	4.220635	6.043464	4.219959	3.426288	-2.46345	4.219959	-3.42629	2.463453	1.41E-06	1.14E-06	-8.21E-07	8.204829	-4.82263	-6.63788	9.127841	-5.69392	7.134195	3.509417	3.505516	-0.16544	1.723737	1.714371	-0.17944	1.456917	1.14049	0.906582	2.511341	2.1179	1.349569
N281	13 kV	5.414834	3.828866	-33.5467	0.663059	29.17987	3.828233	-33.5566	0.663308	29.17505	3.829159	5.462245	3.828866	3.191113	-2.11589	3.828866	-3.19111	2.115895	1.28E-06	1.06E-06	-7.05E-07	8.210582	-4.85463	-6.62164	9.160529	-5.72592	7.150463	3.531254	3.526851	-0.17627	1.720301	1.708854	-0.19813	1.607703	1.290617	0.958655	2.765734	2.39541	1.382496
N282	13 kV	4.808499	3.400123	-31.2041	0.605719	25.91241	3.399561	-31.214	0.605956	25.90813	3.400229	4.835385	3.400123	2.908217	-1.76156	3.400123	-2.90822	1.761563	1.13E-06	9.69E-07	-5.87E-07	8.21998	-4.89048	-6.60691	9.194479	-5.76177	7.165228	3.555624	3.55075	-0.18611	1.718253	1.704289	-0.21861	1.812091	1.49193	1.028504	3.113631	2.767523	1.426715
N283	13 kV	4.554097	3.220233	-30.2311	0.582741	24.54147	3.2197	-30.241	0.582973	24.53741	3.220299	4.57485	3.220233	2.782286	-1.62135	3.220233	-2.78229	1.621352	1.07E-06	9.27E-07	-5.40E-07	8.224847	-4.90572	-6.60167	9.208113	-5.777	7.170473	3.565947	3.560903	-0.1896	1.717912	1.702823	-0.22719	1.913808	1.591419	1.063037	3.287754	2.951417	1.448608
N284	13 kV	4.163728	2.9442	-28.7486	0.548588	22.43782	2.943713	-28.7585	0.548813	22.43411	2.944231	4.177292	2.9442	2.581293	-1.41607	2.9442	-2.58129	1.416065	9.81E-07	8.60E-07	-4.72E-07	8.233341	-4.92925	-6.59472	9.228306	-5.80053	7.177427	3.581865	3.576595	-0.19423	1.717968	1.701077	-0.24032	2.093754	1.766566	1.123855	3.597002	3.275146	1.487226
N285	13 kV	6.811949	4.816775	-39.0901	0.812392	36.70876	4.815517	-39.1277	0.81348	36.69917	4.818883	6.954449	4.816775	3.738565	-3.03718	4.816775	-3.73857	3.037179	1.61E-06	1.25E-06	-1.01E-06	8.201476	-4.77549	-6.66775	9.075093	-5.64678	7.104307	3.477135	3.474089	-0.14552	1.732004	1.725399	-0.15112	1.273059	0.954744	0.842106	2.204943	1.774574	1.308687
N286	13 kV	6.302422	4.456486	-37.0369	0.754563	33.96298	4.455321	-37.0744	0.755592	33.95411	4.457564	6.400448	4.456486	3.557381	-2.68427	4.456486	-3.55738	2.68427	1.49E-06	1.19E-06	-8.95E-07	8.202547	-4.8037	-6.64878	9.107543	-5.67498	7.123339	3.496472	3.492892	-0.15819	1.726563	1.718341	-0.1683	1.378315	1.061574	0.879097	2.379748	1.972097	1.331928
N287	13 kV	5.890752	4.165391	-35.4013	0.710696	31.74454	4.164303	-35.4388	0.711683	31.73625	4.165994	5.961612	4.165391	3.395273	-2.41301	4.165391	-3.39527	2.413008	1.39E-06	1.13E-06	-8.04E-07	8.205234	-4.82709	-6.63514	9.132828	-5.69836	7.13703	3.512471	3.508485	-0.1673	1.723163	1.7135	-0.18223	1.476295	1.159986	0.91317	2.543896	2.154046	1.353327
N288	13 kV	5.367169	3.795162	-33.3478	0.658071	28.92302	3.794534	-33.3577	0.658319	28.91823	3.795432	5.412506	3.795162	3.170286	-2.08627	3.795162	-3.17029	2.086274	1.27E-06	1.06E-06	-6.95E-07	8.210896	-4.8575	-6.61994	9.163734	-5.72875	7.1523	3.533209	3.52875	-0.17745	1.720077	1.70841	-0.2	1.622131	1.305058	0.963397	2.79019	2.422253	1.384864
N289	13 kV	5.062679	3.579855	-32.166	0.628906	27.28216	3.579263	-32.1759	0.629147	27.27765	3.580019	5.096951	3.579855	3.03038	-1.90582	3.579855	-3.03038	1.905823	1.19E-06	1.01E-06	-6.35E-07	8.215298	-4.87546	-6.61219	9.181043	-5.74671	7.160088	3.54543	3.540723	-0.18263	1.718901	1.705983	-0.21034	1.72055	1.402217	0.997036	2.957455	2.601873	1.405986
N290	13 kV	4.610194	3.259899	-30.4309	0.587422	24.84377	3.25936	-30.4408	0.587655	24.83966	3.259973	4.632125	3.259899	2.810817	-1.65114	3.259899	-2.81082	1.651136	1.09E-06	9.37E-07	-5.50E-07	8.223433	-4.90246	-6.60233	9.205653	-5.77371	7.169962	3.563748	3.558721	-0.18921	1.717981	1.703107	-0.22558	1.890427	1.568767	1.054838	3.247718	2.90973	1.442618
N291	13 kV	4.193635	2.965348	-28.849	0.550869	22.59899	2.964858	-28.8589	0.551095	22.59525	2.965381	4.207625	2.965348	2.597331	-1.43079	2.965348	-2.59733	1.43079	9.88E-07	8.66E-07	-4.77E-07	8.232409	-4.92757	-6.59482	9.22727	-5.79882	7.177481	3.580734	3.575463	-0.19422	1.717973	1.701187	-0.23957	2.078787	1.752208	1.118536	3.5713	3.2488	1.483065
N292	13 kV	4.400713	3.111774	-29.6292	0.568752	23.7149	3.111259	-29.6391	0.568982	23.71098	3.111823	4.418277	3.111774	2.704889	-1.53841	3.111774	-2.70489	1.538412	1.04E-06	9.02E-07	-5.13E-07	8.227655	-4.91506	-6.59822	9.216785	-5.7863	7.174112	3.572279	3.567118	-0.19196	1.717863	1.702028	-0.2327	1.980754	1.656932	1.085339	3.402663	3.07271	1.461702
N293	13 kV	4.19227	2.964383	-28.8386	0.550631	22.59163	2.963893	-28.8485	0.550857	22.5879	2.964416	4.206221	2.964383	2.596747	-1.42985	2.964383	-2.59675	1.42985	9.88E-07	8.66E-07	-4.77E-07	8.232303	-4.92765	-6.59462	9.2275	-5.79889	7.177719	3.580791	3.575513	-0.19436	1.717956	1.70115	-0.23971	2.079479	1.752952	1.118658	3.572454	3.25019	1.482801
N294	13 kV	3.971201	2.808063	-28.0038	0.531795	21.40031	2.807599	-28.0137	0.532017	21.39678	2.808084	3.981998	2.808063	2.479285	-1.31847	2.808063	-2.47928	1.318471	9.36E-07	8.26E-07	-4.39E-07	8.237609	-4.94105	-6.59122	9.238581	-5.81229	7.181131	3.589838	3.584449	-0.19664	1.718269	1.700405	-0.24713	2.195392	1.865352	1.157674	3.772275	3.457945	1.507539
N295	13 kV	3.753232	2.653936	-27.1845	0.513589	20.22571	2.653497	-27.1945	0.513808	20.22236	2.653949	3.761509	2.653936	2.360782	-1.21247	2.653936	-2.36078	1.212471	8.85E-07	7.87E-07	-4.04E-07	8.243216	-4.95431	-6.58828	9.249215	-5.82555	7.184076	3.598771	3.593287	-0.1986	1.718791	1.699859	-0.25441	2.322922	1.988662	1.200496	3.992619	3.685863	1.534737
N296	13 kV	4.087186	2.890077	-28.4426	0.541659	22.02535	2.889599	-28.4525	0.541883	22.02171	2.890104	4.099561	2.890077	2.54123	-1.37648	2.890077	-2.54123	1.37648	9.63E-07	8.47E-07	-4.59E-07	8.234809	-4.93401	-6.593	9.232764	-5.80525	7.179342	3.585087	3.579756	-0.19545	1.718081	1.700778	-0.24321	2.133026	1.8049	1.136722	3.664711	3.346202	1.494335
N297	13 kV	3.111453	2.20013	-50.6434	1.219303	16.76724	2.20013	-50.6434	1.219303	16.76724	2.212813	3.348036	2.20013	1.3952	-1.70117	2.20013	-1.3952	1.701172	7.33E-07	4.65E-07	-5.67E-07	9.87616	-6.39175	-7.52888	9.388957	-7.12189	6.118103	4.529026	4.504546	0.47026	2.79787	2.768642	0.403355	2.171418	1.513604	1.55694	6.075345	3.562627	4.921129
N298	13 kV	2.934137	2.074748	-48.2416	1.120074	15.81171	2.074748	-48.2416	1.120074	15.81171	2.082333	3.111706	2.074748	1.381765	-1.54768	2.074748	-1.38176	1.547678	6.92E-07	4.61E-07	-5.16E-07	9.794774	-6.2813	-7.51551	9.31427	-7.01144	6.131507	4.454864	4.430912	0.461334	2.683767	2.656998	0.378113	2.358502	1.707968	1.626462	6.329671	3.923079	4.967312
N299	13 kV	2.74466	1.940768	-45.7504	1.026544	14.79064	1.940768	-45.7504	1.026544	14.79064	1.945027	2.873305	1.940768	1.354239	-1.39019	1.940768	-1.35424	1.390186	6.47E-07	4.51E-07	-4.63E-07	9.704466	-6.16823	-7.49197	9.245125	-6.89837	6.15507	4.378271	4.355533	0.445633	2.571965	2.548747	0.344813	2.582409	1.936632	1.708301	6.641866	4.34694	5.021802
N300	13 kV	2.605764	1.842553	-43.968	0.96461	14.04214	1.842553	-43.968	0.96461	14.04214	1.845284	2.70611	1.842553	1.326136	-1.2792	1.842553	-1.32614	1.279205	6.14E-07	4.42E-07	-4.26E-07	9.636433	-6.08871	-7.46917	9.201234	-6.81884	6.177873	4.323993	4.302516	0.430432	2.49613	2.475892	0.317215	2.76533	2.121028	1.774343	6.902624	4.688587	5.065903
N301	13 kV	3.002405	2.123021	-49.159	1.156838	16.17959	2.123021	-49.159	1.156838	16.17959	2.132294	3.201046	2.123021	1.388374	-1.60612	2.123021	-1.38837	1.606124	7.08E-07	4.63E-07	-5.35E-07	9.826521	-6.32328	-7.52174	9.341817	-7.05342	6.125256	4.483135	4.458903	0.465495	2.726555	2.698714	0.388646	2.284129	1.631092	1.598995	6.227804	3.780407	4.949148
N302	13 kV	2.800879	1.98052	-46.4859	1.053263	15.09359	1.98052	-46.4859	1.053263	15.09359	1.985596	2.942756	1.98052	1.363653	-1.43628	1.98052	-1.36365	1.436284	6.60E-07	4.55E-07	-4.79E-07	9.731648	-6.20118	-7.50002	9.264368	-6.93132	6.146981	4.400671	4.377498	0.451015	2.604067	2.579702	0.355391	2.513126	1.866189	1.683193	6.544349	4.21602	5.005365
N305	13 kV	1.29729	0.917323	-39.8	0.833169	6.990937	0.917999	-39.8796	0.835526	6.996095	0.917809	1.327176	0.917323	0.704764	-0.58719	0.917323	-0.70476	0.587187	3.06E-07	2.35E-07	-1.96E-07	9.278626	-7.22116	-5.82647	10.67	-7.71808	7.36751	5.006171	4.979747	-0.51368	3.627349	3.354674	-1.37979	4.507332	2.633431	3.658017	16.34967	13.8816	8.637872
N307	13 kV	3.719598	2.630153	-59.692	1.710743	20.04446	2.630153	-59.692	1.710743	20.04446	2.696146	4.312471	2.630153	1.327304	-2.27068	2.630153	-1.3273	2.270676	8.77E-07	4.42E-07	-7.57E-07	10.13338	-6.73603	-7.57042	9.642227	-7.47373	6.092282	4.762145	4.736587	0.492714	3.200032	3.16478	0.473679	1.676034	0.974425	1.363667	5.363363	2.4379	4.777269
N308	13 kV	3.669172	2.594496	-58.8509	1.654511	19.77272	2.594496	-58.8509	1.654511	19.77272	2.652038	4.218622	2.594496	1.342047	-2.22043	2.594496	-1.34205	2.220433	8.65E-07	4.47E-07	-7.40E-07	10.11127	-6.72473	-7.55088	9.63988	-7.4596	6.105868	4.752581	4.72811	0.481671	3.182242	3.1493	0.4567	1.704637	1.007188	1.375267	5.424567	2.543854	4.79111
N309	13 kV	3.635782	2.570886	-58.3045	1.619422	19.59278	2.570886	-58.3045	1.619422	19.59278	2.623445	4.158286	2.570886	1.350757	-2.18744	2.570886	-1.35076	2.187444	8.57E-07	4.50E-07	-7.29E-07	10.09648	-6.71778	-7.53727	9.639144	-7.45076	6.11549	4.746568	4.722849	0.473926	3.171149	3.139801	0.444788	1.723794	1.02877	1.383148	5.466407	2.614924	4.800393
N310	13 kV	3.516234	2.486353	-56.4503	1.507993	18.94856	2.486353	-56.4503	1.507993	18.94856	2.52461	3.954074	2.486353	1.374107	-2.07214	2.486353	-1.37411	2.072144	8.29E-07	4.58E-07	-6.91E-07	10.04735	-6.6596	-7.52323	9.597252	-7.38976	6.123616	4.706302	4.68312	0.46654	3.097434	3.067644	0.428556	1.808082	1.122678	1.417306	5.600417	2.836583	4.828919
N312	13 kV	3.19623	2.260076	-51.8394	1.272574	17.22409	2.260076	-51.8394	1.272574	17.22409	2.276231	3.466937	2.260076	1.396428	-1.77706	2.260076	-1.39643	1.777057	7.53E-07	4.65E-07	-5.92E-07	9.892413	-6.6624	-7.31247	9.684354	-7.36912	6.283528	4.689733	4.677175	0.342981	3.069977	3.060319	0.24333	1.996789	1.307737	1.50897	6.130096	3.634913	4.93614
N317	13 kV	3.015989	2.132626	-49.4167	1.16741	16.25279	2.132626	-49.4167	1.16741	16.25279	2.142409	3.220496	2.132626	1.387385	-1.61965	2.132626	-1.38739	1.619647	7.11E-07	4.62E-07	-5.40E-07	9.814796	-6.59307	-7.2706	9.647732	-7.29458	6.314095	4.640184	4.629217	0.318836	2.984099	2.977131	0.203818	2.152172	1.465806	1.575835	6.422295	4.042713	4.990225
N318	13 kV	3.000948	2.121991	-49.3192	1.163397	16.17174	2.121991	-49.3192	1.163397	16.17174	2.131546	3.202555	2.121991	1.383207	-1.60922	2.121991	-1.38321	1.609218	7.07E-07	4.61E-07	-5.36E-07	9.798591	-6.6661	-7.18161	9.743001	-7.35926	6.384935	4.682656	4.67512	0.265557	3.05749	3.054995	0.123496	2.130791	1.427994	1.581487	6.514871	4.167207	5.007787
N319	13 kV	2.845227	2.011879	-47.4578	1.089695	15.33258	2.011879	-47.4578	1.089695	15.33258	2.018171	3.004464	2.011879	1.360299	-1.48231	2.011879	-1.3603	1.482311	6.71E-07	4.53E-07	-4.94E-07	9.722726	-6.68314	-7.06166	9.808622	-7.36438	6.478812	4.686536	4.682507	0.194282	3.063244	3.063224	0.010996	2.244422	1.521117	1.650343	6.875211	4.641374	5.072098
N321	13 kV	1.966956	1.390848	-41.0391	0.870487	10.59969	1.390848	-41.0391	0.870487	10.59969	1.391868	2.020219	1.390848	1.049063	-0.9132	1.390848	-1.04906	0.913195	4.64E-07	3.50E-07	-3.04E-07	9.319008	-7.05543	-6.08809	10.53077	-7.64285	7.244584	4.91457	4.899428	-0.3855	3.41595	3.246352	-1.06297	3.070869	1.869729	2.436052	10.48993	8.659257	5.92081
N325	13 kV	1.789867	1.265627	-39.6044	0.827403	9.645374	1.265627	-39.6044	0.827403	9.645374	1.266264	1.830031	1.265627	0.97512	-0.80682	1.265627	-0.97512	0.806817	4.22E-07	3.25E-07	-2.69E-07	9.188042	-7.33206	-5.53724	11.01288	-7.87593	7.697608	5.120223	5.06933	-0.72012	3.694918	3.222029	-1.80858	3.268816	1.697858	2.793284	12.07801	10.52242	5.929335
N326	13 kV	1.737493	1.228593	-39.0405	0.810956	9.363137	1.228593	-39.0405	0.810956	9.363137	1.229123	1.773592	1.228593	0.954249	-0.77385	1.228593	-0.95425	0.773854	4.10E-07	3.18E-07	-2.58E-07	9.174798	-7.32489	-5.52475	11.00698	-7.8639	7.701471	5.114656	5.062929	-0.72557	3.686106	3.209806	-1.81233	3.373648	1.776677	2.867912	12.43562	10.90038	5.985523
N333	13 kV	11.43172	8.083449	-47.0953	1.075949	61.60416	8.028787	-48.7057	1.138506	61.18758	8.106937	12.04838	8.083449	5.503063	-5.92102	8.083449	-5.50306	5.921018	2.69E-06	1.83E-06	-1.97E-06	7.274299	-3.46087	-6.39827	8.850534	-5.0766	7.249833	2.859943	2.845821	-0.28385	1.384406	1.359339	-0.26226	0.839392	0.521855	0.657454	1.162059	0.8818	0.756842
N335	13 kV	4.73717	3.349685	-24.4342	0.454339	25.52803	3.343304	-24.5084	0.455904	25.4794	3.349688	4.741874	3.349685	3.049678	-1.38559	3.349685	-3.04968	1.385588	1.12E-06	1.02E-06	-4.62E-07	7.902031	-4.45944	-6.52346	9.364179	-6.05169	7.145968	3.509851	3.503711	-0.2075	1.644979	1.602078	-0.37323	1.884771	1.626475	0.952334	3.100409	2.961184	0.918656
N336	13 kV	6.620682	4.681529	-30.3015	0.584388	35.67804	4.640056	-31.3198	0.608484	35.36198	4.681629	6.651315	4.681529	4.041949	-2.36207	4.681529	-4.04195	2.362067	1.56E-06	1.35E-06	-7.87E-07	7.652024	-4.13365	-6.43944	9.354592	-5.81331	7.328973	3.328883	3.315651	-0.29651	1.531042	1.485906	-0.36902	1.393193	1.122175	0.825656	2.133037	1.972128	0.812747
N339	13 kV	9.064184	6.409346	-38.349	0.791141	48.84578	6.336433	-40.0341	0.840114	48.2901	6.411624	9.235091	6.409346	5.026506	-3.97668	6.409346	-5.02651	3.976676	2.14E-06	1.68E-06	-1.33E-06	7.441316	-3.79977	-6.39804	9.183939	-5.47942	7.370257	3.109992	3.093061	-0.32407	1.448581	1.411345	-0.32633	1.040919	0.751127	0.72064	1.507856	1.295267	0.771954
N342	13 kV	5.846733	4.134265	-27.8468	0.528285	31.50733	4.098389	-28.818	0.550163	31.23392	4.134293	5.862018	4.134265	3.655515	-1.93115	4.134265	-3.65552	1.931153	1.38E-06	1.22E-06	-6.44E-07	7.73153	-4.23183	-6.47057	9.391736	-5.91149	7.297876	3.392332	3.381105	-0.27577	1.557998	1.511384	-0.37825	1.565859	1.298231	0.875507	2.439605	2.293289	0.832166
N343	13 kV	7.598862	5.373207	-33.4625	0.660945	40.94934	5.312075	-35.1476	0.704054	40.48345	5.373607	7.664396	5.373207	4.482581	-2.96274	5.373207	-4.48258	2.962739	1.79E-06	1.49E-06	-9.88E-07	7.559457	-4.00398	-6.41198	9.29625	-5.68364	7.35639	3.244516	3.229208	-0.3148	1.497428	1.454894	-0.35437	1.225163	0.947825	0.776306	1.834593	1.654081	0.793566
N345	13 kV	1.430399	1.011445	-52.8893	1.321723	7.708245	1.011387	-52.8926	1.321883	7.707802	1.020125	1.563195	1.011445	0.610263	-0.8066	1.011445	-0.61026	0.806598	3.37E-07	2.03E-07	-2.69E-07	10.1145	-5.8782	-8.23103	9.174171	-7.39508	5.429386	4.52191	4.424425	0.933881	2.683775	2.609536	0.626875	4.8591	3.427206	3.444577	13.04073	6.784098	11.13717

1-Ph Fault

Node	Network Level	idc [kA]	I sym 1c [kA]	Phi I sym 1c [°]	X/R 1c	S 1c [MVA]	I sym int [kA]	Phi I sym int [°]	X/R int	S int [MVA]	I mom rms [kA]	I mom peak [kA]
N346	13 kV	1.368557	0.967716	-52.8114	1.317994	7.374985	0.967656	-52.8149	1.318165	7.37453	0.97591	1.49476
N347	13 kV	1.121686	0.793152	-52.6043	1.308147	6.044629	0.793096	-52.6083	1.308338	6.0442	0.799632	1.223285
N356	13 kV	10.00939	7.07771	-41.6218	0.888522	53.93939	6.997199	-43.3069	0.94258	53.32581	7.083716	10.30104

Node	IL1a [kA]	IL1r [kA]	IL1i [kA]	3I0a [kA]	3I0r [kA]	3I0i [kA]	VL1a [kV]	VL1r [kV]	VL1i [kV]	VL2a [kV]	VL2r [kV]	VL2i [kV]
N346	0.967716	0.584927	-0.77093	0.967716	-0.58493	0.770931	3.23E-07	1.95E-07	-2.57E-07	10.13611	-5.90675	-8.23718
N347	0.793152	0.481695	-0.63013	0.793152	-0.48169	0.630127	2.64E-07	1.61E-07	-2.10E-07	10.18225	-5.94911	-8.26356
N356	7.07771	5.290909	-4.70109	7.07771	-5.29091	4.701091	2.36E-06	1.76E-06	-1.57E-06	7.38123	-3.66296	-6.40822

Node	VL3a [kV]	VL3r [kV]	VL3i [kV]	V0a [kV]	V0r [kV]	V0i [kV]	Z0/Z1a [pu]	Z0/Z1r [pu]	Z0/Z1i [pu]	Z1a [Ohm]	Z1r [Ohm]	Z1i [Ohm]	Z0a [Ohm]	Z0r [Ohm]	Z0i [Ohm]
N346	9.189046	-7.41797	5.423316	4.539528	4.441571	0.937953	2.703881	2.627951	0.636273	5.057451	3.577211	3.575106	13.67475	7.125992	11.67129
N347	9.233819	-7.48402	5.408584	4.577723	4.477711	0.951657	2.739349	2.662536	0.644156	6.124215	4.350207	4.31065	16.77636	8.805855	14.27947
N356	9.094706	-5.34261	7.360037	3.018579	3.001859	-0.31727	1.418447	1.3854	-0.3044	0.950349	0.651045	0.692318	1.34802	1.112699	0.760959

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