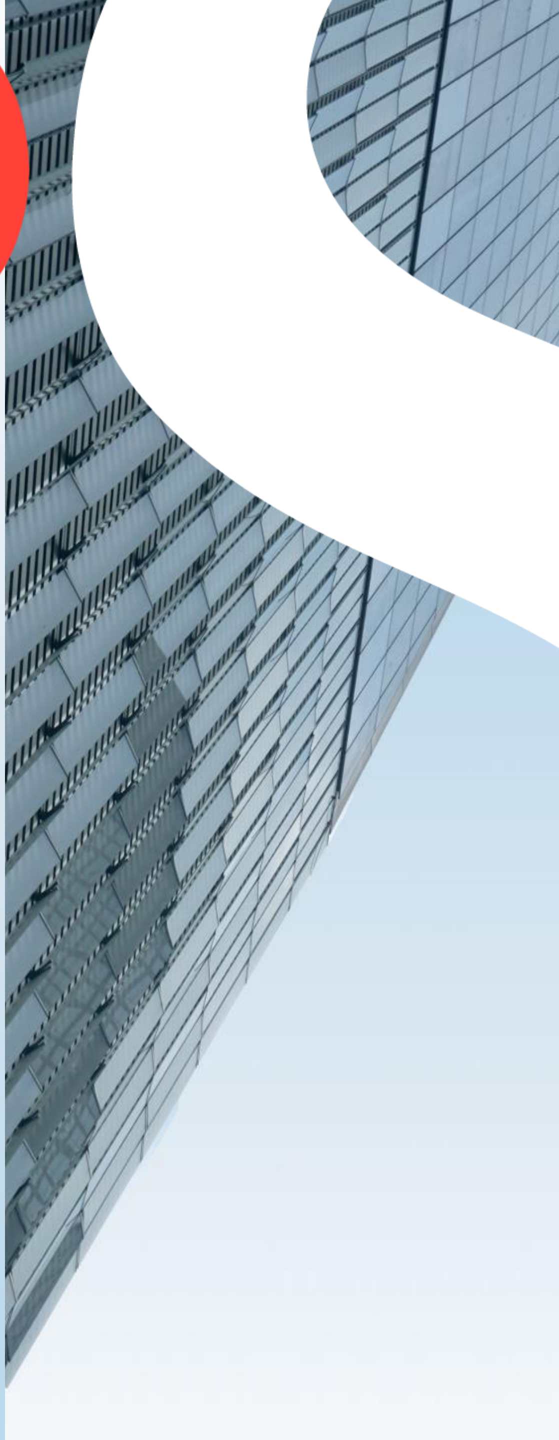
SWP1 Task 1.1

Deliverable D1.1: RaaS Sites Review and Technical Modelling Requirements

Author: Abdullah Emhemed



Quality Control

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Prepared by	Abdullah Emhemed (WSP)
Checked by	Manuel Castro (WSP)
Reviewed by (SSEN)	Maciej Fila (SSEN) and Sarah Rigby (SSEN)
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Glossary

Abbreviation	Meaning
BESS	Battery Energy Storage System
DG	Distributed Generation
DER	Distributed Energy Resource
DIgSILENT	Software package used for modelling electrical power systems
EHV	Extra High Voltage (i.e. 22kV ≤ EHV < 72kV)
HV	High Voltage (i.e. 1kV < HV < 22kV)
IIS	Interruptions Incentive Scheme
LV	Low Voltage (i.e. LV ≤ 1kV)
PSCAD	Power System Computer Aided Design (Software package used for modelling electrical power systems)
RaaS	Resilience as a Service
SSEN	Scottish and Southern Electricity Networks
SWP	SSEN Work Package

Content

1. Context

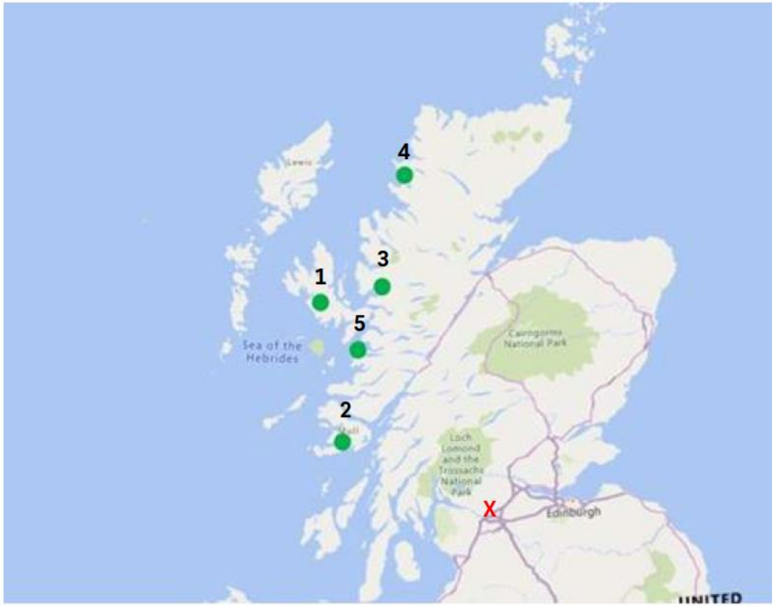
This slide deck is the Deliverable 1.1 (D1.1) which captures the outcomes of the initial review of the SSEN RaaS project, and presents key modelling requirements to be considered for SWP1 for simulating and analysis the performance of the RaaS scheme prior to installation and commissioning phases of the project.

The primary substations shortlisted as potential trial sites for the RaaS project will be modelled and analysed to study and develop conclusions and recommendations on the key technical challenges which may be encountered at the time of real implementation.

2. Selected RaaS Sites for modelling and studies

As advised by SSEN, the WSP team will initially consider the following sites for SWP1 modelling and simulation studies.

1. **Drynoch (shown as 1 on the map) -** good level of DG and space for BESS installation
2. **Kinloch (shown as 2 on the map) -** very high IIS
3. **Mallaig (shown as 5 on the map)** - high IIS, high number of faults & good level of hydro DG (perfect technology for supporting black start requirements)



3. Modelling and studies requirements

The WSP work will focus on the development of suitable models of the selected RaaS sites (initially Drynoch, Kinloch and Mallaig) to study the impact of implementing the RaaS scheme on the following:

- Load flow performance of each selected site
  - To ensure steady state parameters such as voltages and thermal capacity are within the statutory limits when RaaS scheme is implemented.
  - To identify the suitable MW capacity of the BESS to meet associated customers demand.
- Fault levels of the selected sites
  - To ensure no impact on the equipment ratings due to the implementation of RaaS scheme.
  - To ensure that adequate fault levels for fault detection, location, and protection operation are met.
- Transient and system stability performance of the selected sites
  - To ensure stable operation and seamless pick up of the customers loads under different operational conditions (e.g. during grid forming and islanding operation).
- Impact of transient inrush currents on the RaaS Hub (i.e. BESS performance) and the islanded networks voltage performance
  - To identify any risks that may be caused by inrush currents phenomenon & the required measure to minimise such risks.
- Earthing and protection/control performance of the selected sites
  - The selected RaaS trial networks to be safeguarded by suitable protection scheme that ensures safe and secure operation during faults (in particular sites with high number of faults).

4. RaaS Operational scenarios to be considered

The following operational scenarios as set out in the original SSEN Work Scope Document will be considered for the RaaS project modelling and simulation studies:

1. Transition from grid-connected mode to islanded operation mode
2. Black start and system restoration
3. Islanded operation with temporary diesel generation
4. Transferring from RaaS islanded mode back to grid-connected operation (synchronisation)

5. Modelling development approach

5.1 Models and data collection

Data to be collected:

- Test network layout and configuration (provided by the SSEN sites SINCAL models)
- Short circuit levels (to be used for the models validation).
- Cable lengths and positive and zero sequence parameters
  - Positive sequence values have been extracted from the SSEN sites SINCAL models, and typical zero sequence values will be used as required.
- Transformers capacity and parameters
  - 3-phase to 2-phase system split-phase transformers models couldn't be imported from the original sites SINCAL models when the models were converted to PowerFactory. New models based on data from the SINCAL models will be developed.
- LV load profiles of selected secondary substations
  - a number of secondary substations will be identified and considered for further detailed models to study the impact of RaaS scheme on LV stability protection performance. Assumptions based on number of customers and typical rural load profiles could be considered.
- Protection scheme, relay settings and fuse ratings (if implemented)
- Distributed generation connected to each site (e.g. type, size and location of each generator)

5.2. Models assumptions

1. **Each HV and LV load** will be modelled as a lumped demand, and only selected secondary substation(s) will be modelled in more detail (e.g. include LV feeder with distributed loads) to study LV protection performance if data is available and provided by SSEN.
2. **The load models** will be based on the current network(s) conditions and no inclusion of future scenarios will be considered.
3. **DGs** will be modelled as an aggregated source

5.3. Modelling and analysis tools

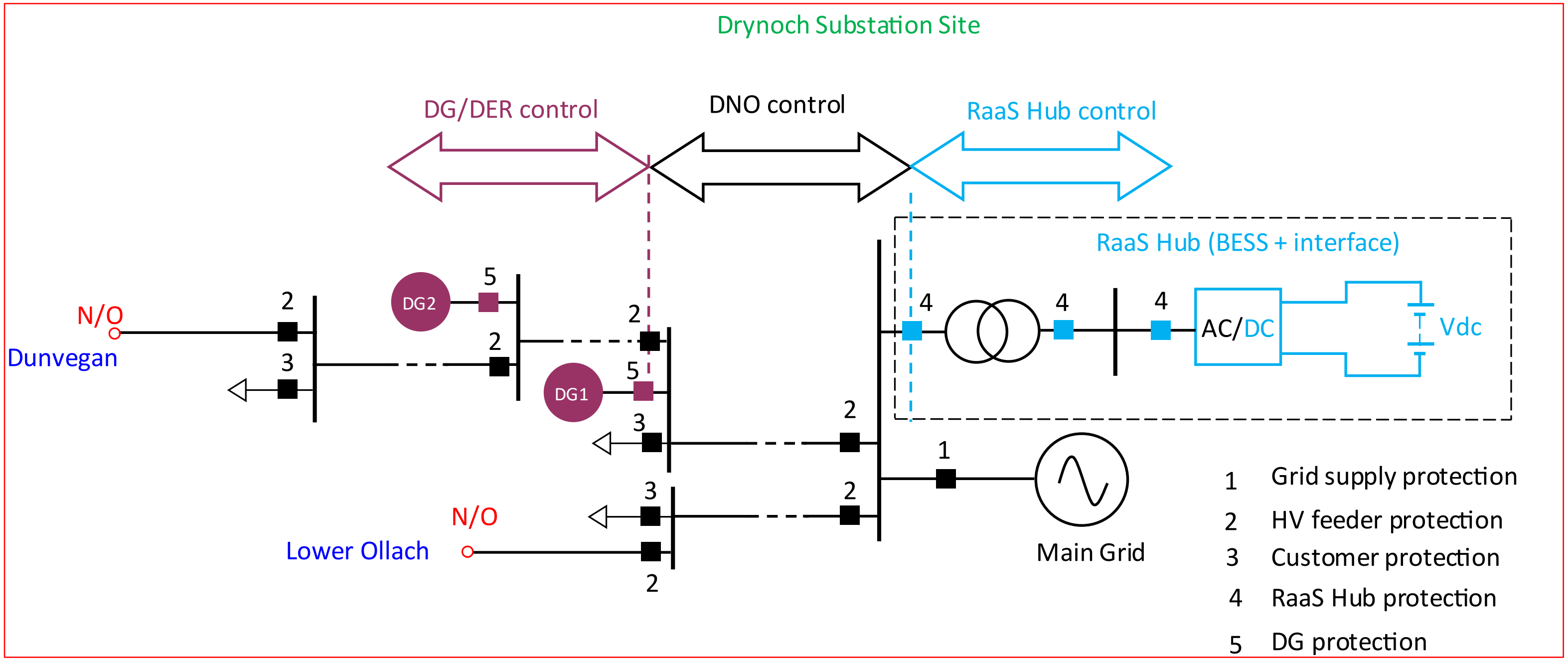
1. **DIgSILENT PowerFactory** power system software analysis has been used for the model development and simulation studies. DIgSILENT is a recognised tool for conducting balanced and unbalanced load flow studies, short circuit calculations, protection coordination and network management models.
2. **PSCAD/EMTDC –** if the PowerFactory models are not suitable for transient and inrush currents studies, PSCAD/EMTDC toll will be used. PSCAD/EMTDC is powerful tool to carry out more detailed transient switching studies and inrush currents modelling.

PowerFactory Feature Overview https://www.digsilent.de/en/features.html

https://www.pscad.com/

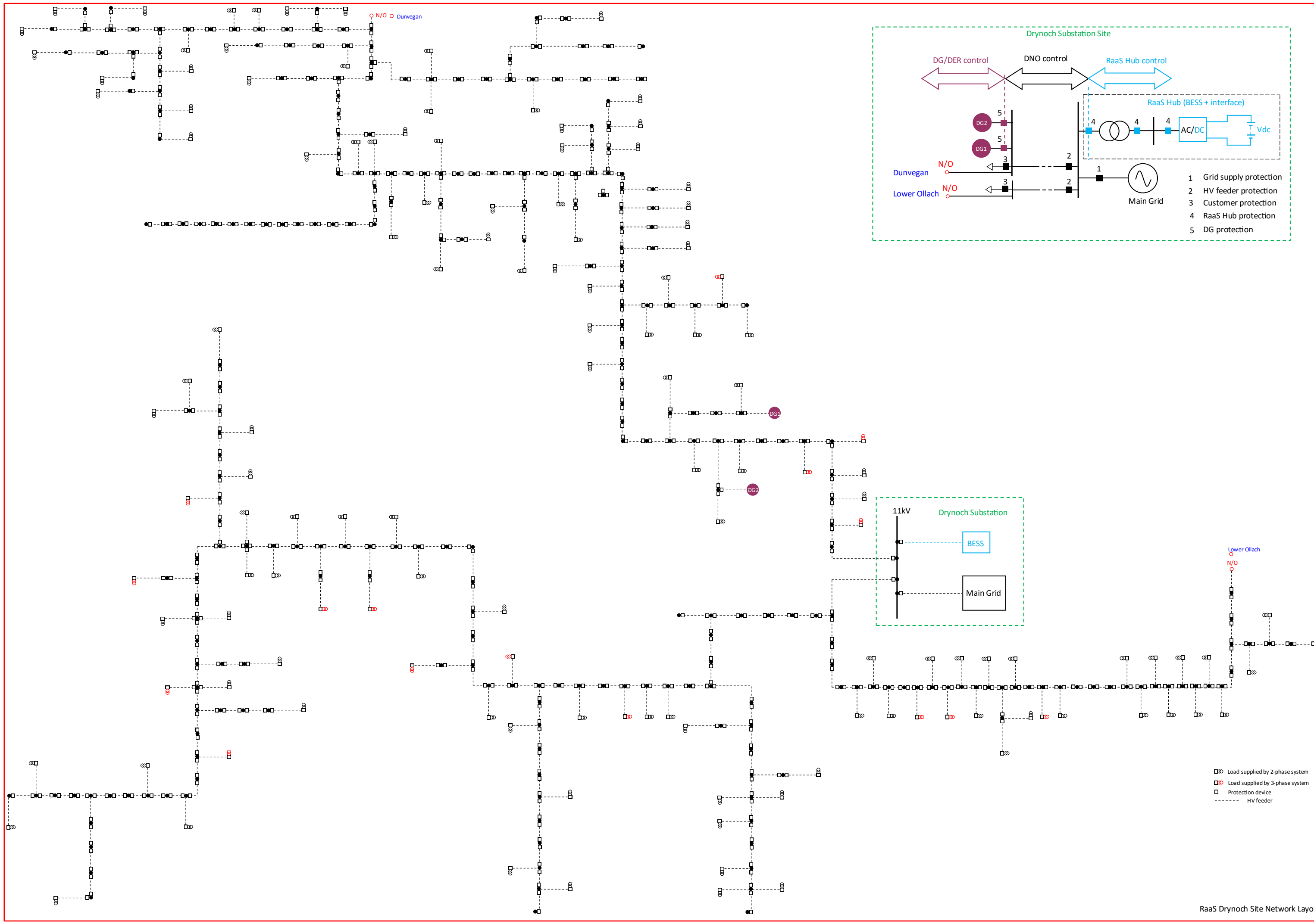
5.4. Schematic layout of the selected sites

I- SSEN Drynoch site



Simplified schematic layout of the SSEN Drynoch site

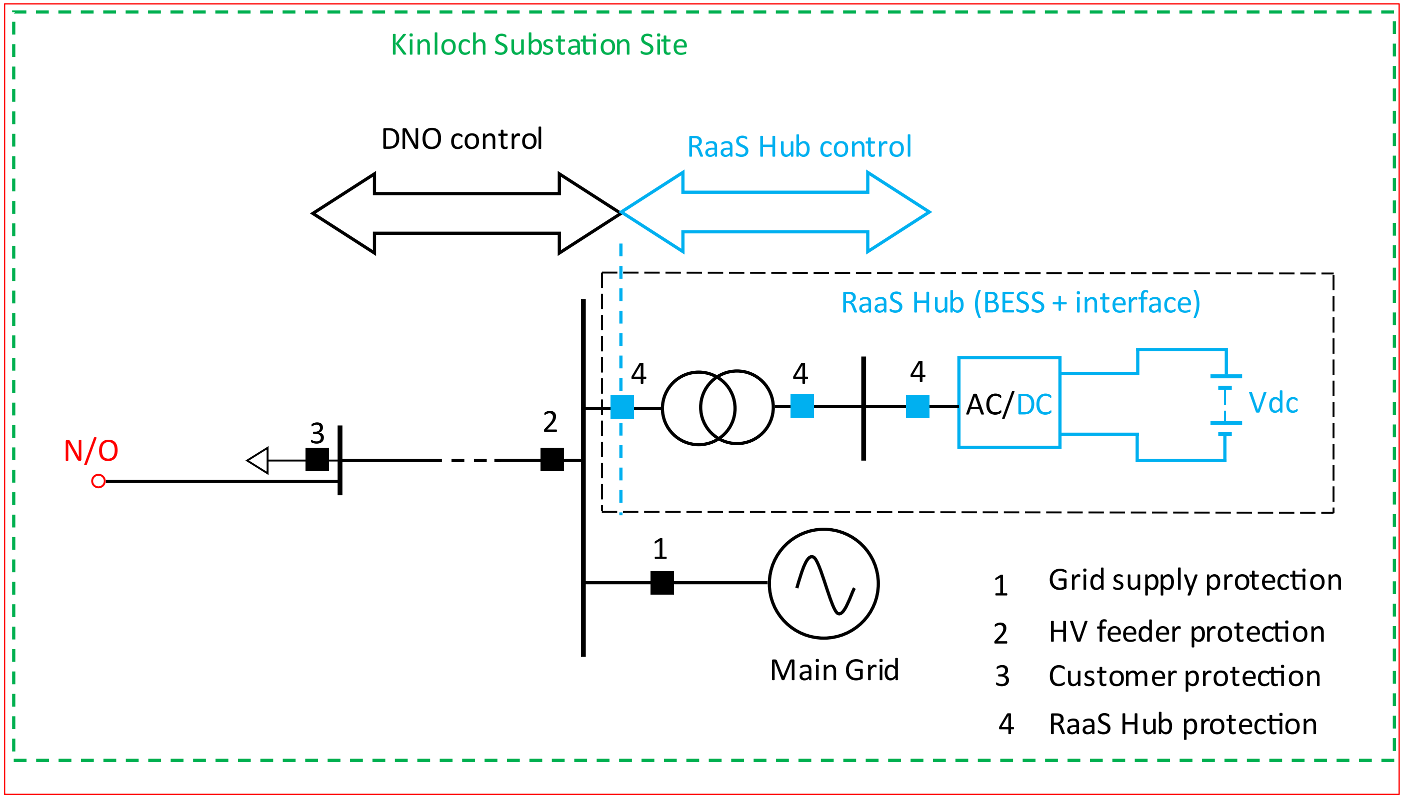
I- SSEN Drynoch site



Schematic layout of the SSEN Drynoch network site

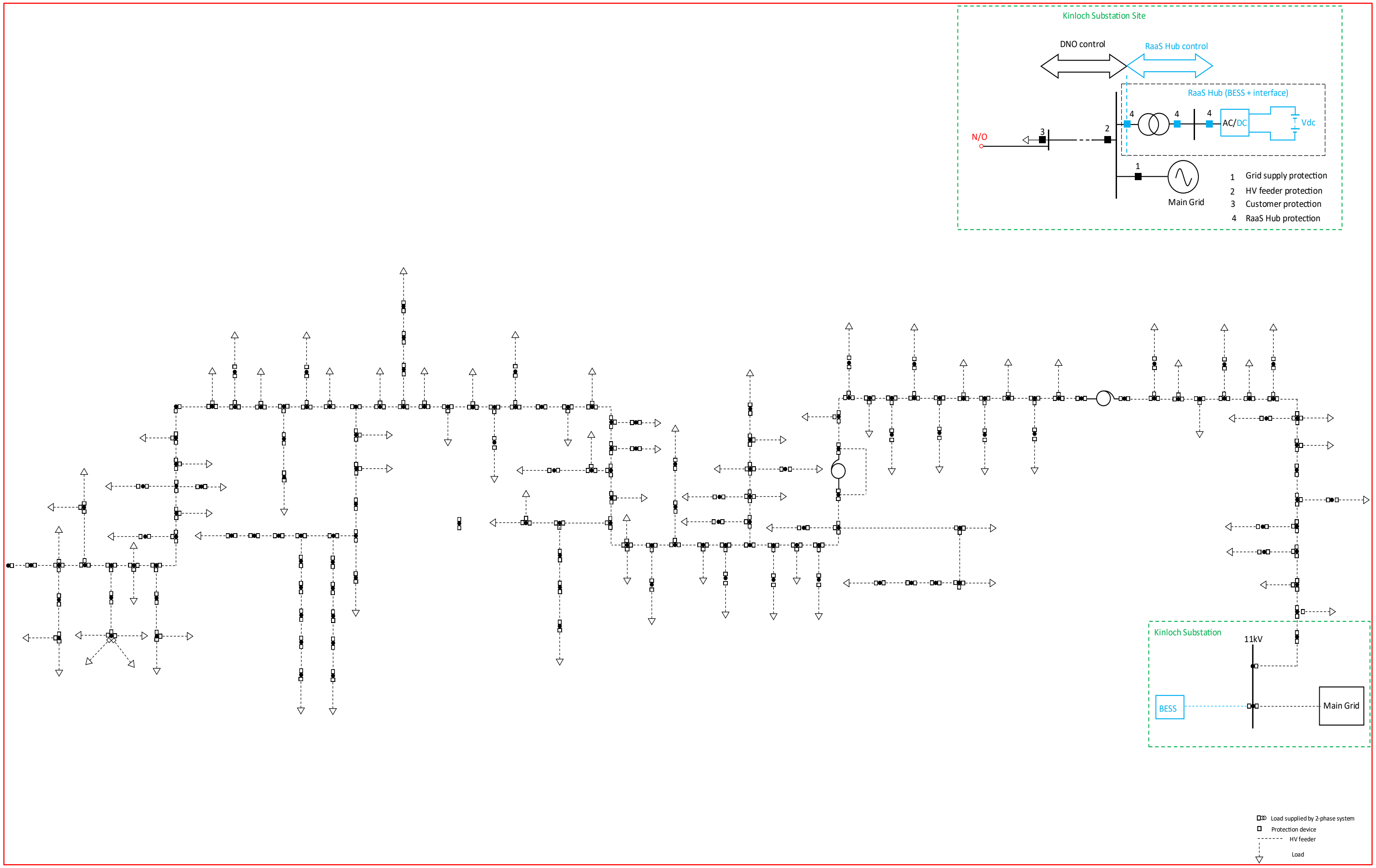
5.4. Schematic layout of the selected sites

II- SSEN Kinloch site



Simplified schematic layout of the SSEN Kinloch site

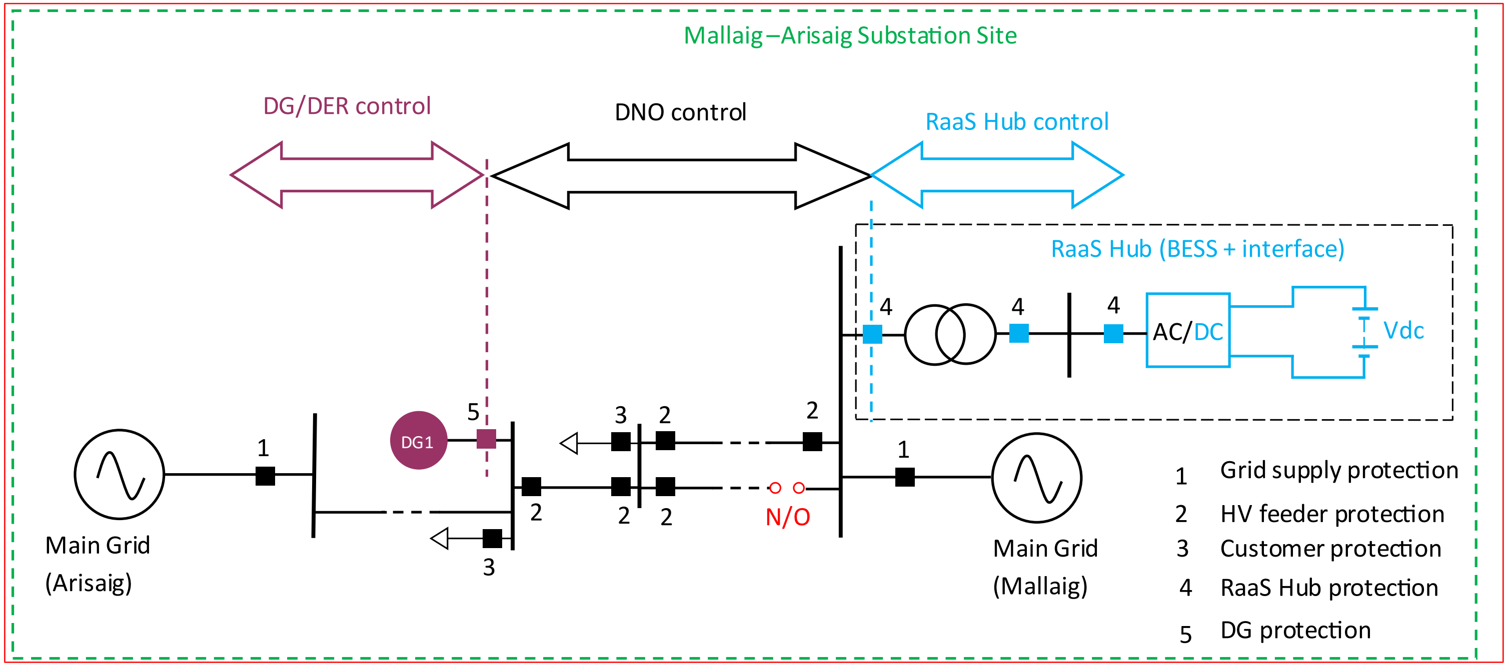
II- SSEN Kinloch site



Schematic layout of the SSEN Kinloch network site

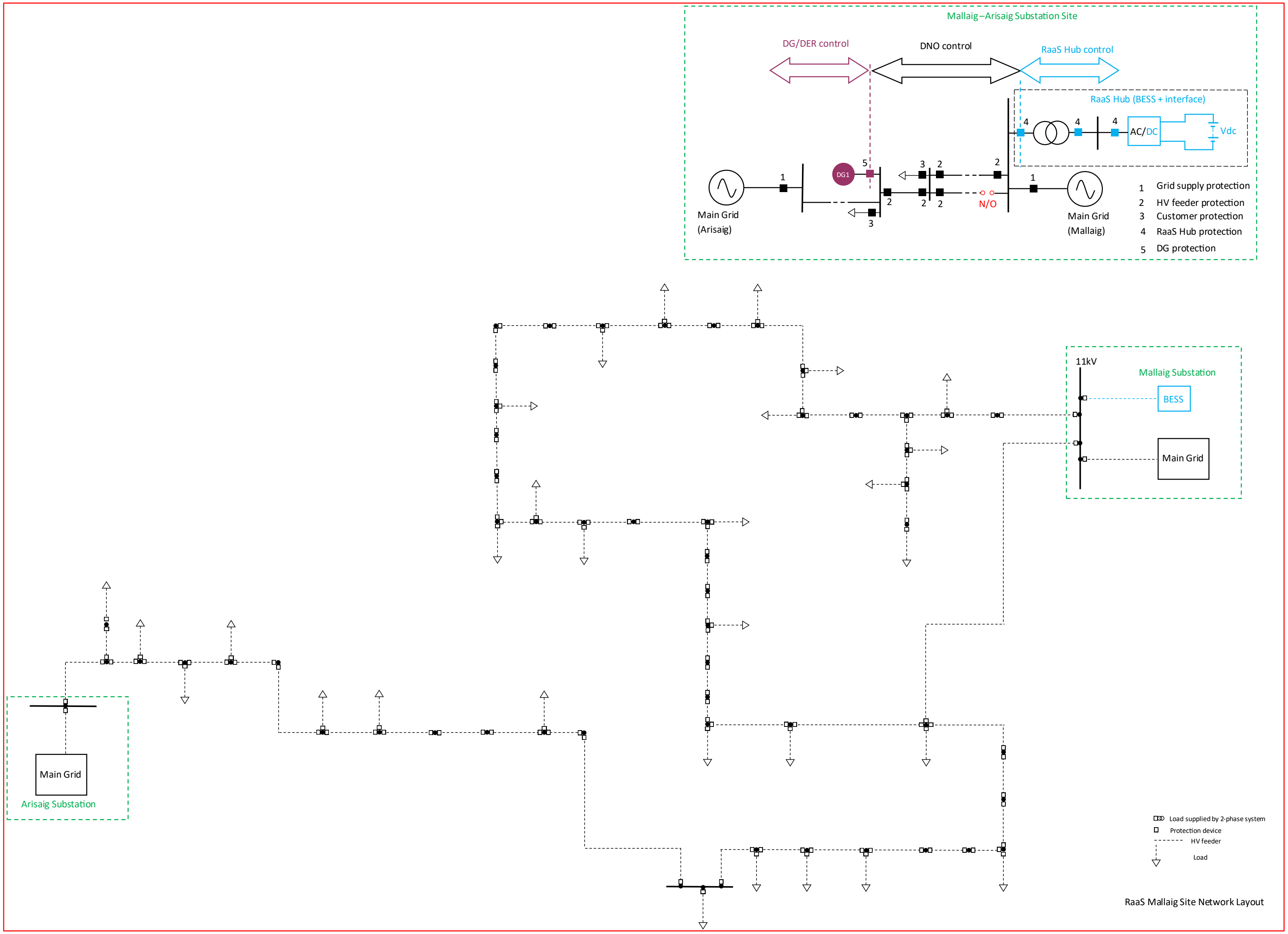
5.4. Schematic layout of the selected sites

III- SSEN Mallaig site



Simplified schematic layout of the SSEN Mallaig site

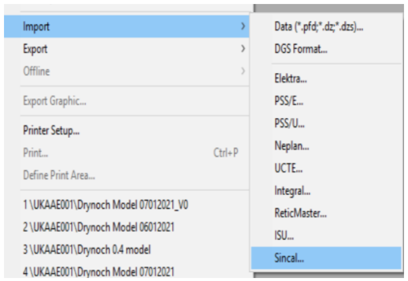
III- SSEN Mallaig site

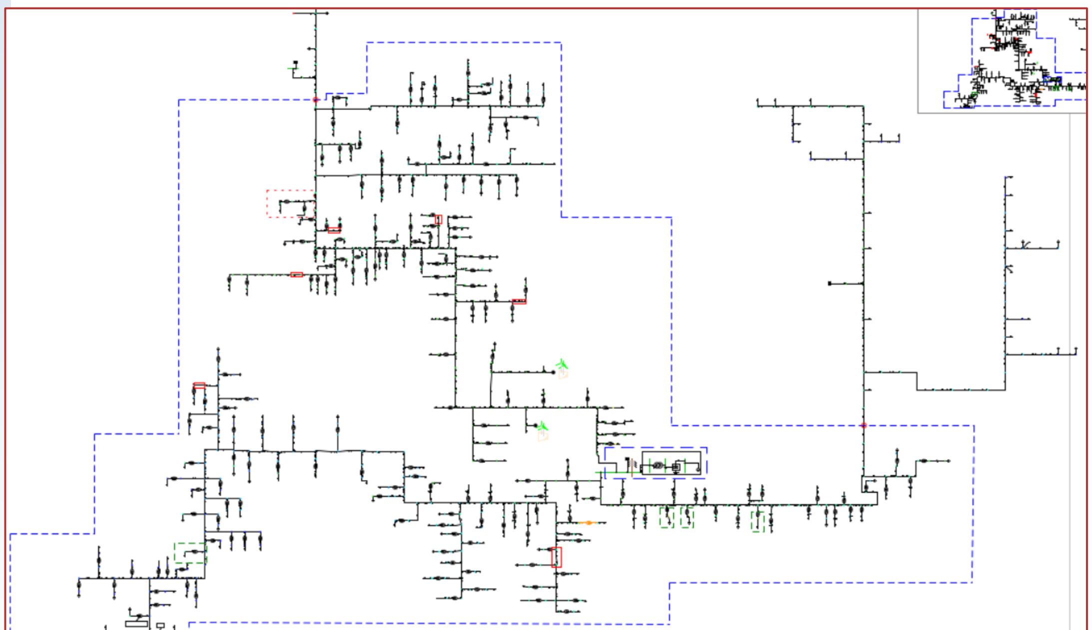


Schematic layout of the SSEN Mallaig network site

5.5. Models development and validation

1. **Conversion of the SSEN SINCAL models to PowerFactory**
2. **Refinement of the converted sites models & identification of any missing component/data.**





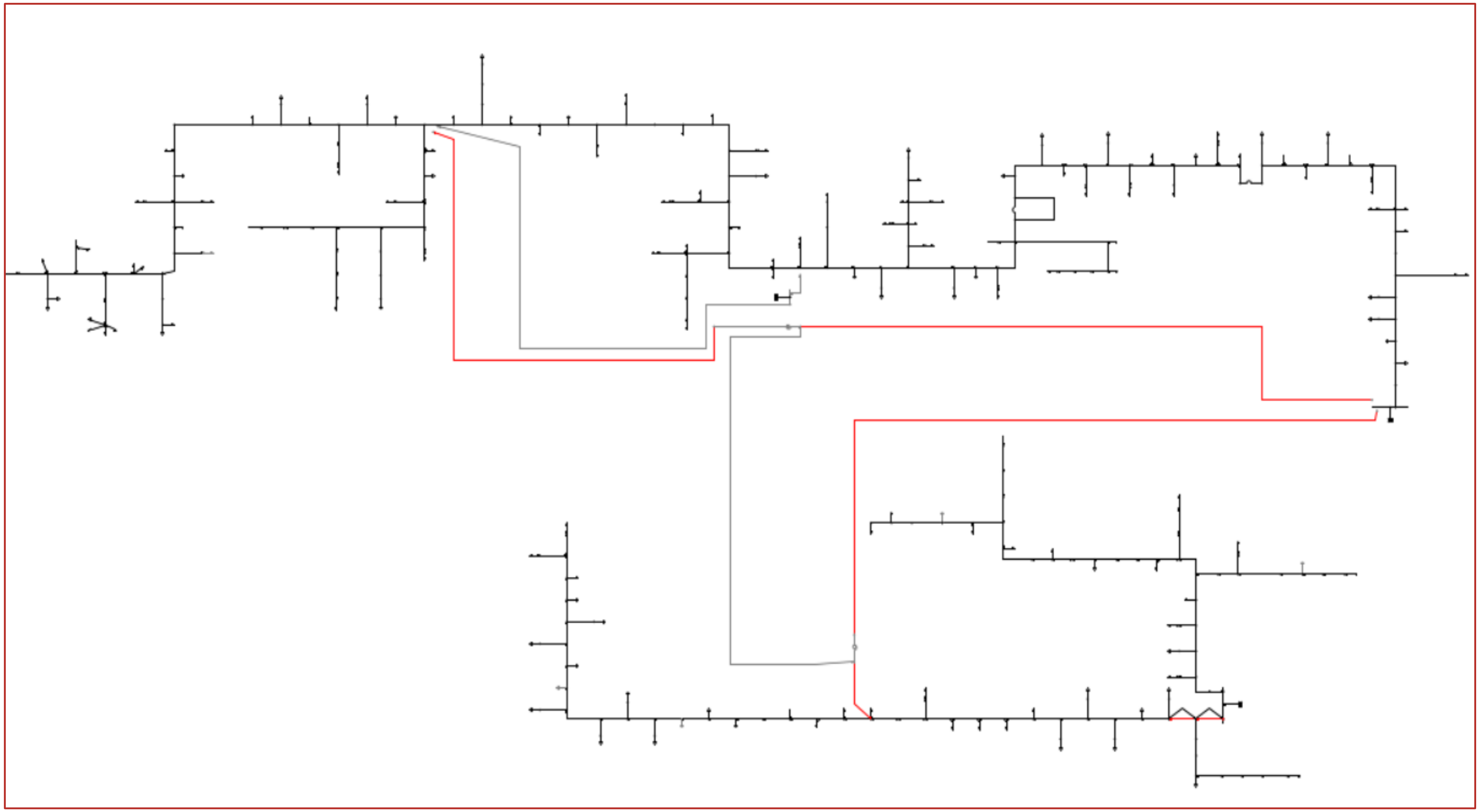
Example of Drynoch model converted from SINCAL to PowerFactory

Issues:

- HV-LV transformers (split-phase) cannot be imported (this issue is currently under investigation, and one option is to model the missing transformers and add them to the site model).
- Some phase-phase loads are disconnected from their associated HV nodes and hard to identify their locations in the models. One option to address this issue is for the SSEN to provide the list of the loads/transformers and name of nodes/buses connected to

5.5. Models development and validation

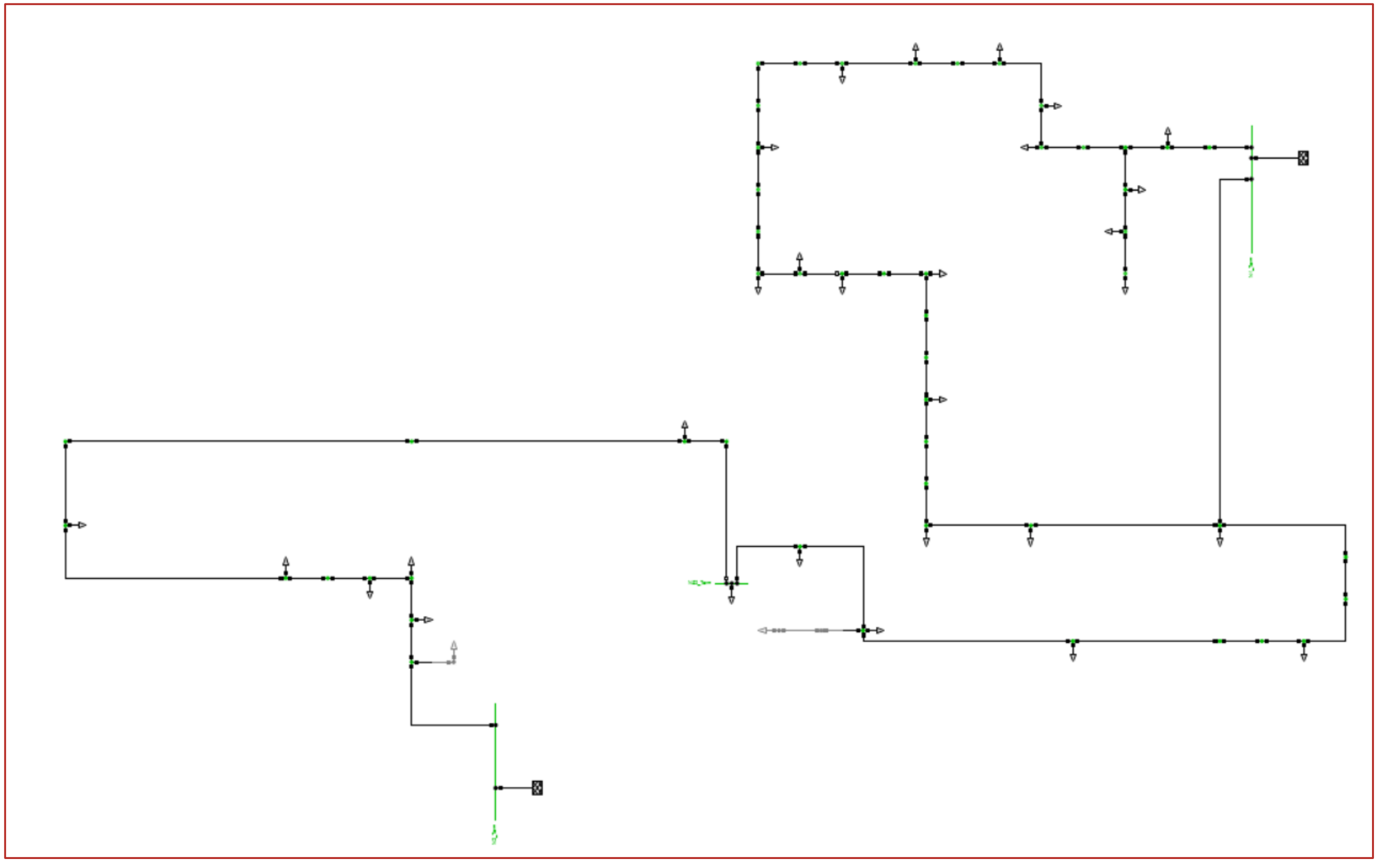
The SSEN SINCAL model of the Kinloch site was converted to DIgSILENT and some issues with autotransformers have been noticed.



Example of Kinloch model converted from SINCAL to PowerFactory

5.5. Models development and validation

The SSEN SINCAL model of the Mallaig site was successfully converted to DIgSILENT and no issues or missing data have been noticed.



Example of Mallaig model converted from SINCAL to PowerFactory

5.5. Models development and validation

3. Modelling of Distributed Generation connected to each site

- If DGs are not included within the SINCAL models or cannot be imported, they will be modelled and added to the converted models as an aggregated source as follows:
    - Voltage sources with constant real and reactive power outputs will be used for load flow studies.
    - Dynamic DGs aggregated models will be applied where DG dynamic response is required for assessing the RaaS Scheme (e.g. to contribute to frequency support during islanding operation).

- If **dynamic data for the DG/BESS** connected to each site is not available, typical parameters from the DIgSILENT library & literature will be used.

5.5. Models development and validation

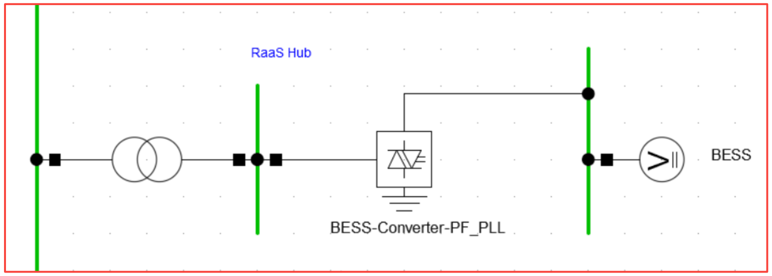
4. Models validation (without RaaS Hub)

The performance of the converted/developed sites models will be benchmarked against the SSEN SINCAL models. This will include:

1. Equivalent fault levels @ no load steady state condition and with <5% errors for each HV node/bus (SSEN to provide the fault level results of the SINCAL model of each site).
2. Equivalent voltages and line loading with <5% errors.

5. Modelling development of the BESS (RaaS Hub)

The battery will be developed as a DC voltage source, and the converter interface based on its type and topology will be modelled as an average/detailed model.



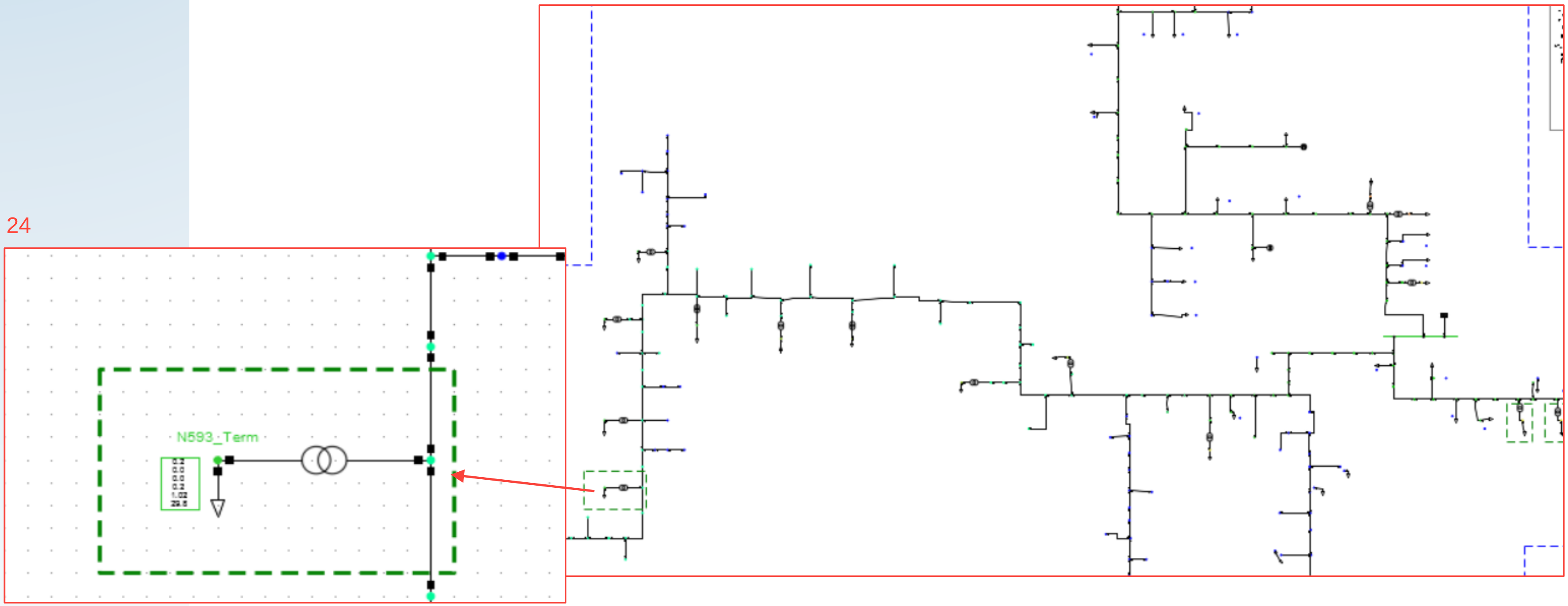
6. Models validation (with RaaS Hub)

The performance of the BESS converter interface model against changes in the references of outer controllers (e.g. real power reference, ramp up/down rate of the output power, AC voltage reference, etc.) will be benchmarked against any data provided by SSEN.

5.5. Models development and validation

7. Extension of LV network models

In consultation with SSEN team, secondary substation(s) will be identified and modelled in detail to enable the study of fault levels and LV protection performance when RaaS Hub is implemented.



6. Simulation studies and analysis SWP1

1. Load flow performance of each selected site
2. Fault levels of the selected sites
3. Transient and system stability performance of the selected sites

The modelling and simulation technical assessment work will identify the following:

- Technical requirements and challenges associated with enabling islanded operation from individual primary substations.
- The technical implications of transitioning from grid-connected to islanded operation (supply via RaaS).
- The requirements that ensure the BESS and RaaS Scheme to provide adequate frequency and voltage control in islanded operation mode.
- Requirements and actions necessary to operate the RaaS safely and maintain compliance with all relevant industrial codes and standards under each of the operational scenarios.

Next steps

1. Completion of the models conversion and validation (including DG models)
2. Completion of the BESS model (suitable for steady state and dynamic studies)
3. Conduction of load flow, fault levels, and transient dynamic studies.
4. Reporting the modelling and studies outcomes of SWP1 (D1.2 and D1.3)