Application of CIM for Power System Analysis (PSA) Model Inter-Operability in DSO Flexibility Markets

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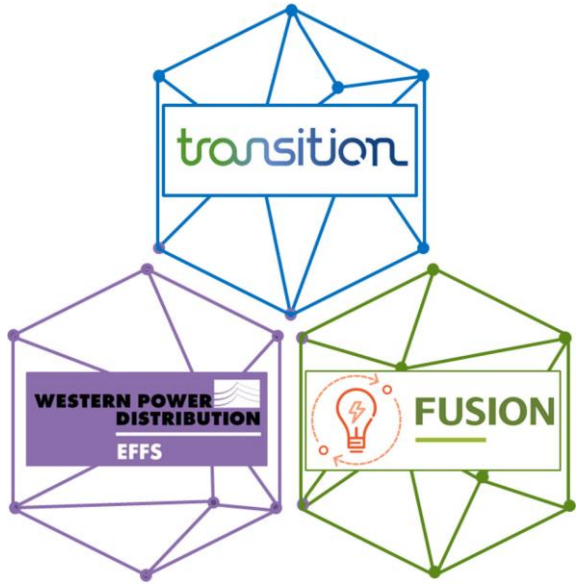

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PSA Model Use Case in TRANSITION/LEO

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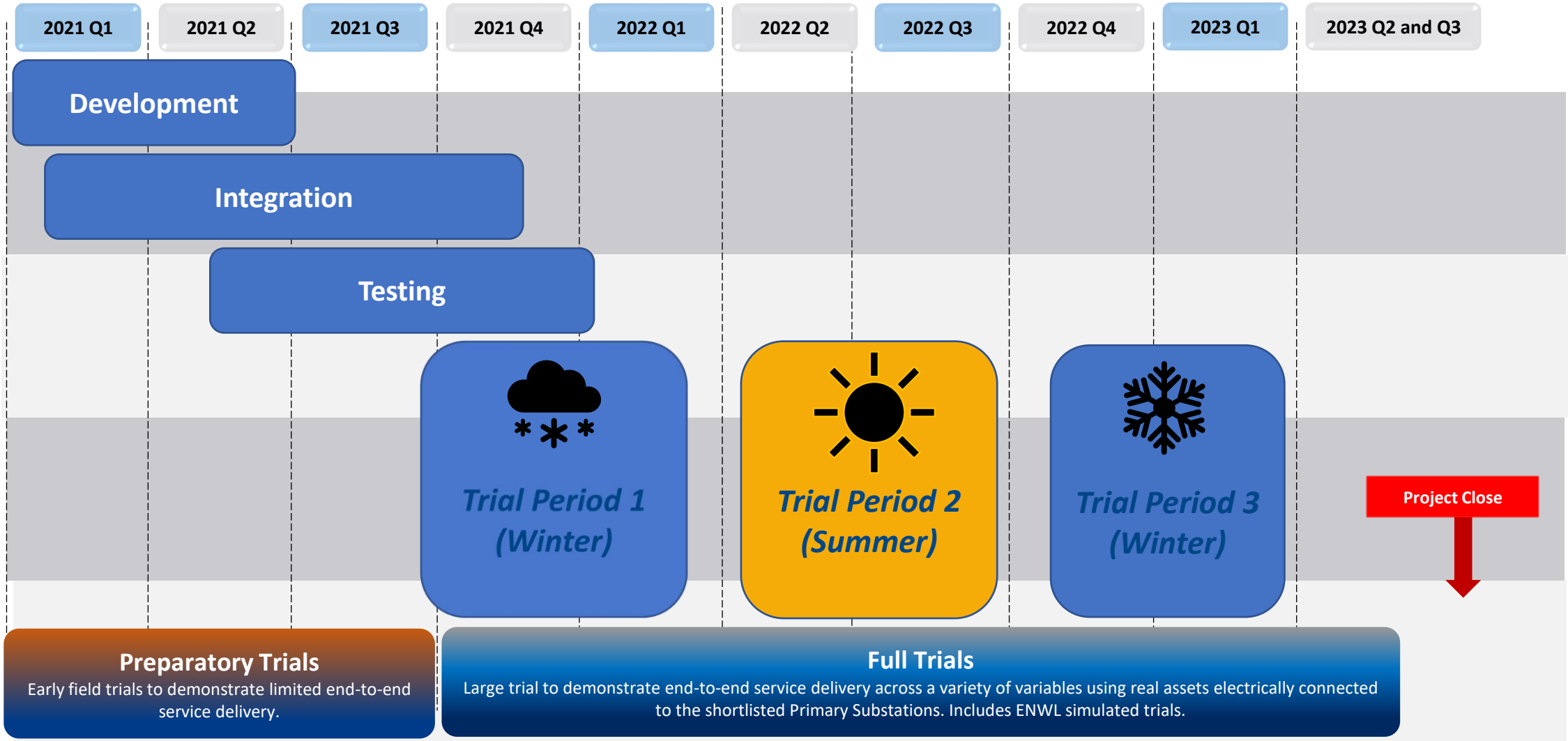
TRANSITION/LEO Timeline – 3 Trial Periods



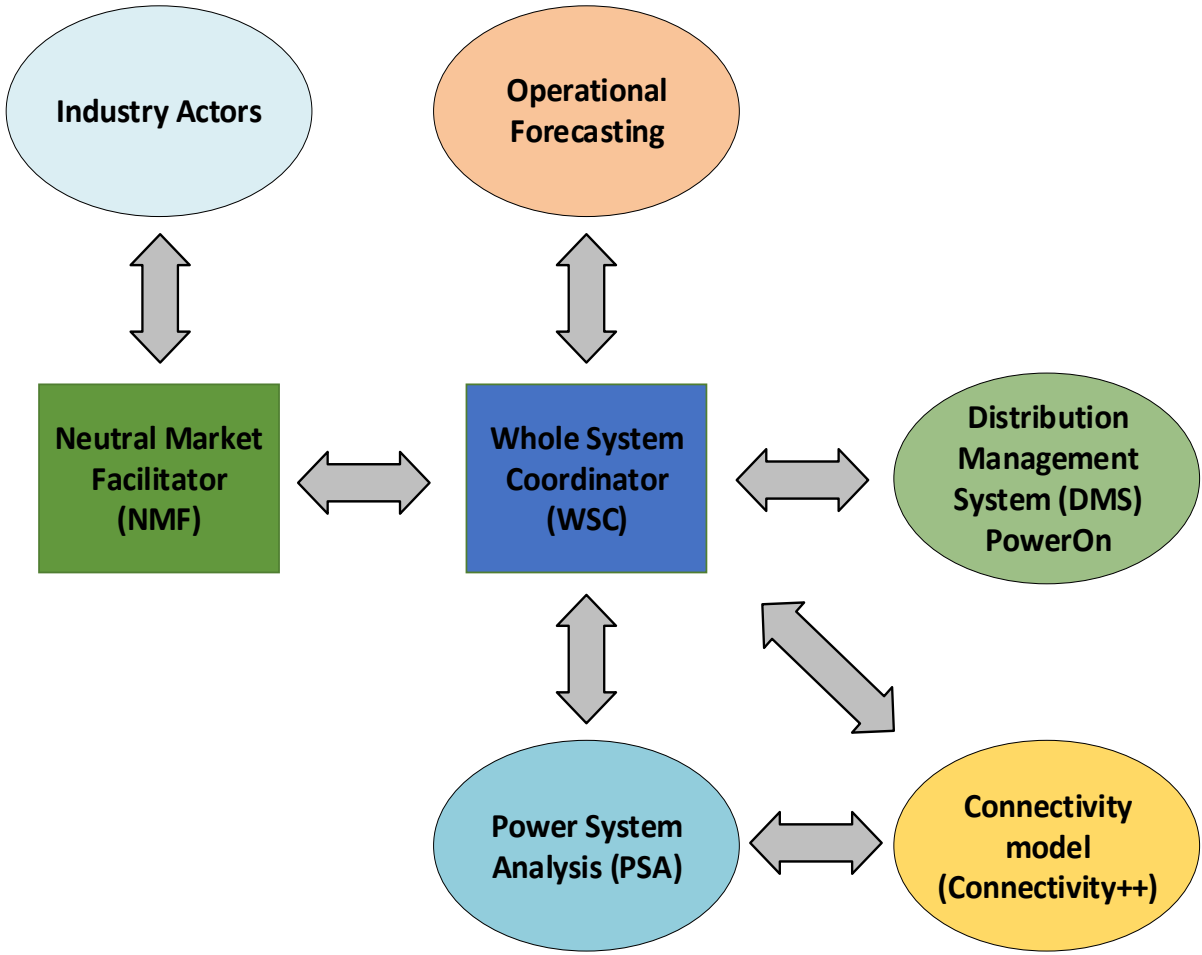
PSA network model use case in TRANSITION/LEO

The network model and PSA tool are used at several stages during the flexibility trials, with different functionalities required from the PSA tool depending on the timeframe and output required.

- Peer-Peer MEC capacity trade approval
- DSO flexibility requirements and contracting
- DSO flexibility dispatch

High Level Design of the TRANSITION Systems

- **Operational Forecasting:** provides a view of demand/generation profiles at granular nodal level for 0-10 days ahead of real-time
- **Distribution Management System (PowerOn):** Provides control room view of live/real-time network connectivity and power flows
- **Power System Analysis (PSA):** Computes anticipated power flows under different near-term topology change and forecast scenarios
- **Whole System Coordinator (WSC):** Provides the core intelligence for flex market decision making, allows an input interface for control room, and manages automated data flows between sub-component DSO systems
- **Neutral Market Facilitator (NMF):** Provides a user interface portal for DSO interaction with the Industry Actors to enter/accept their available flex service volumes/costs, and for them to request approval for peer-to-peer (P2P) capacity trades
- **Connectivity model (Connectivity++):** The master model that holds the network and how customers relate to it and master repository for key network parameters (e.g., impedance, ratings and normal running arrangement). It enables load to the designated and as well as being.



Network Model Development

- An accurate and functioning PSA model of the system network, operating in real time, is key to supporting the future of DSO Flexibility markets

- Integrated PSA network models that include various voltage levels (132/33/11kV) in the system are important to support DSO flexibility market analysis, considering the contribution from assets connected lower down in the network
  - A particular focus of LEO project is on the “small and many” flexibility sources, and these are mostly HV and LV connected in the system, areas where full PSA models are not well established
  - The work on the PSA network modelling to date has taken a simplified approach to LV modelling, (e.g. representing all LV feeders as one node, and ignoring technical issues like 3-phase modelling and phase imbalance etc)
  - The later Trial Periods will explore more detailed LV models

- Integrated model input data may come from various sources and models may be used in different applications – CIM interoperability is a key enabler

Network Model Development

Power System Analysis (PSA) tools

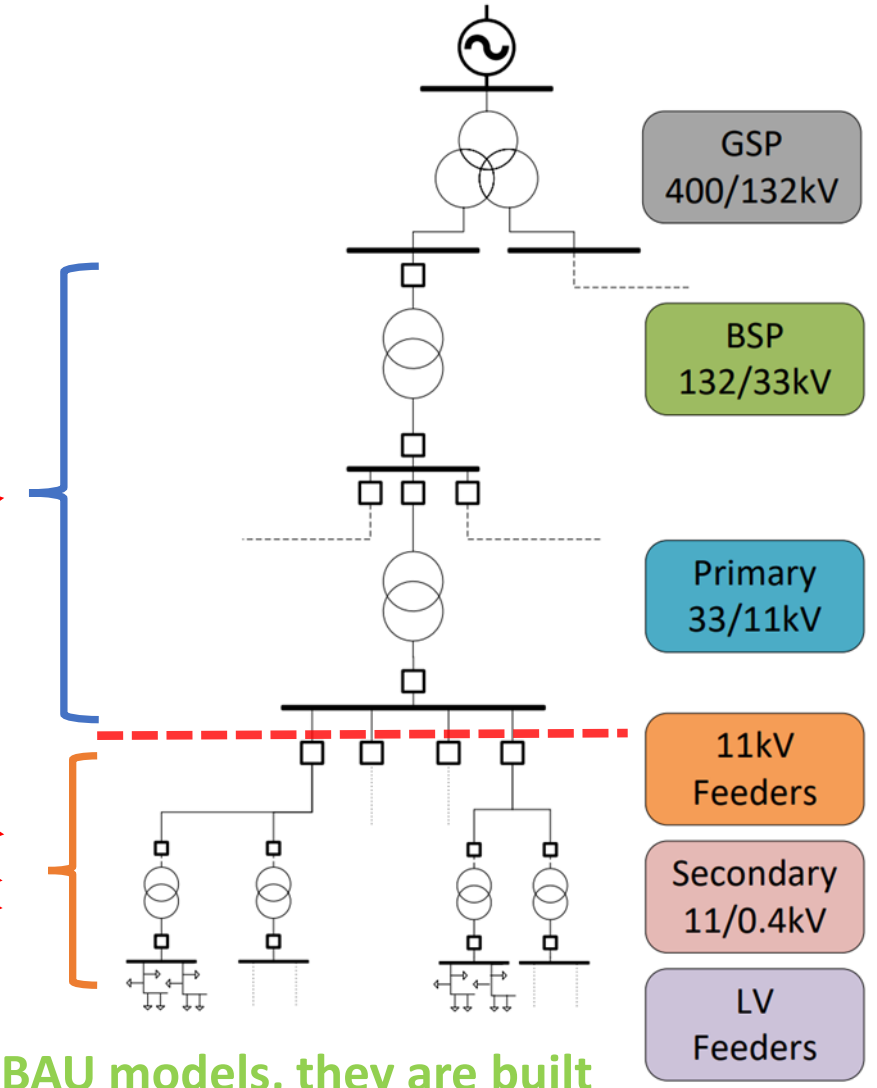
- PSSE and DIgSILENT PowerFactory
- OpusOne GridOS
- Common Information Model (CIM)

Input from multiple teams within SSEN:

- System planning PSSE (132/33kV)
- Outage planning
- New load/generation connections
- **Network planning (11kV)**
- **Connectivity+ project**
- **Cartographers (PowerOn)**

External support from:

- RINA consultants
- Open Grid Systems (OGS)



There are no 11kV or LV BAU models, they are built ad-hoc. GIS is the only source of 11kV/LV data

Network Model Development

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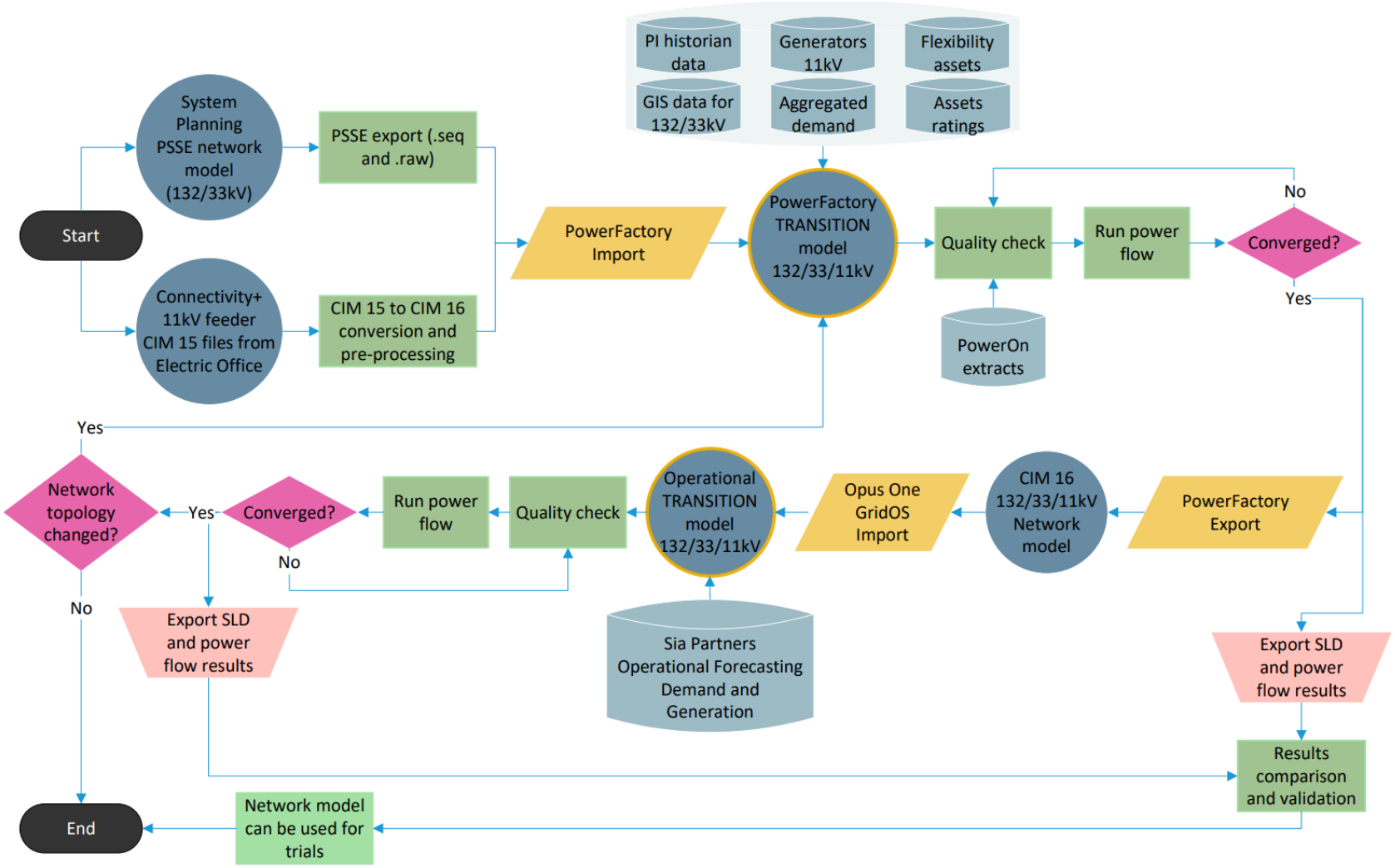
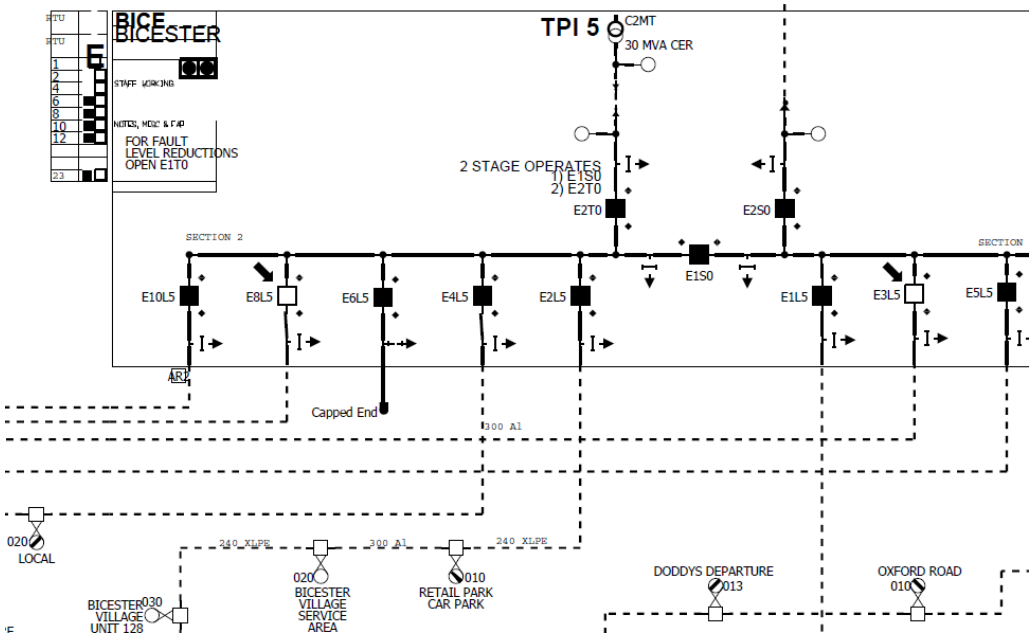
Network Model Development – Process Overview



Building 11kV Feeder Power Flow Models

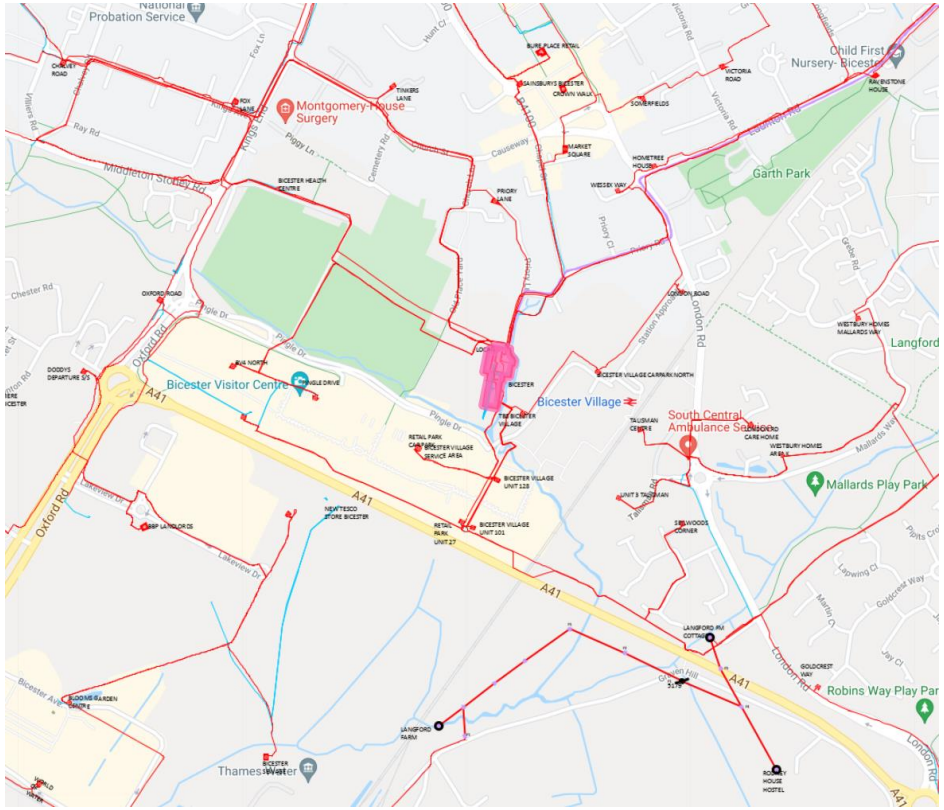
PowerON

Real-time connectivity
Schematic representation



Electric Office

Physical world



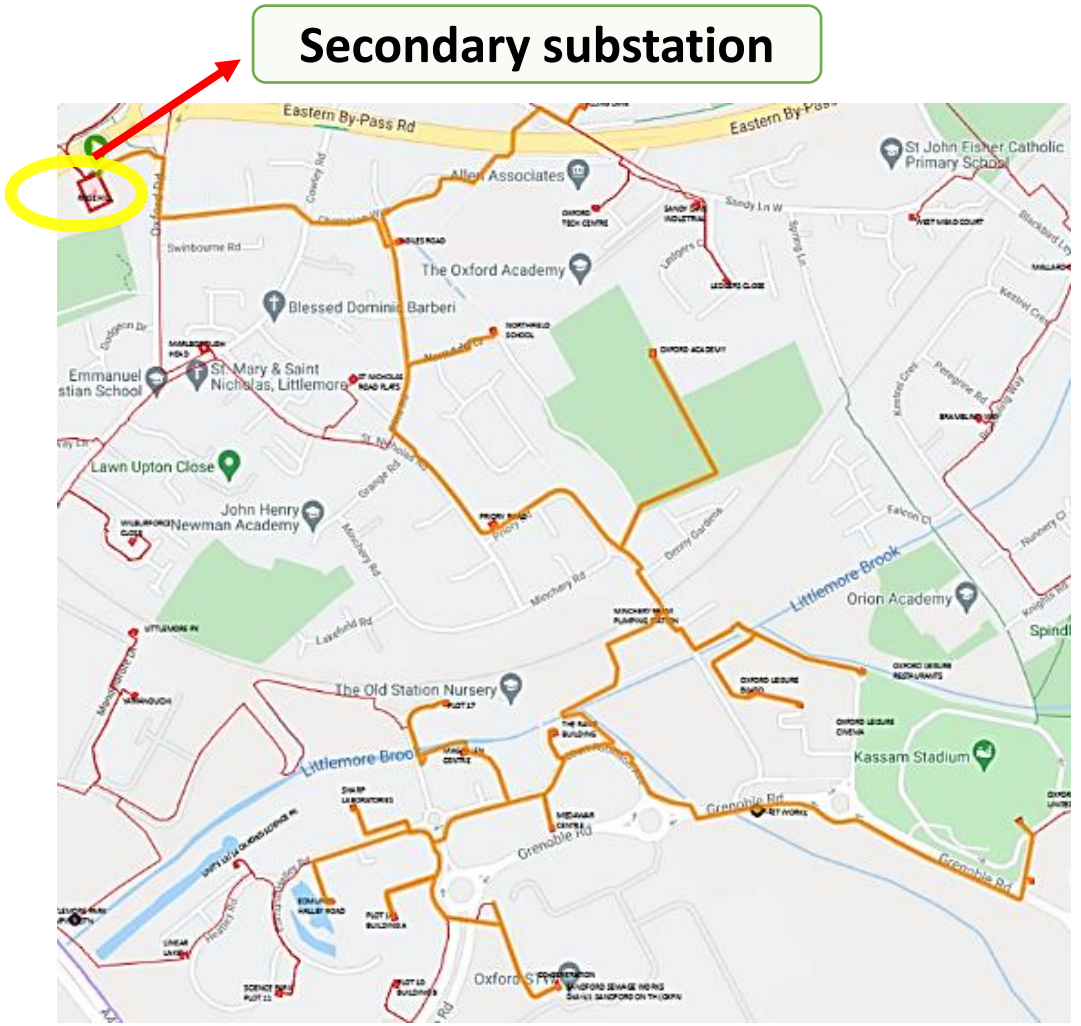
Common Information Model – TRANSITION use cases

- SSEN's **11kV network data** is stored and maintained within the Geographical Information System (GIS), **Electric Office (EO)**

- EO, is capable of **exporting connectivity data in CIM v15,** and so these exports were identified as a potential source to build the 11kV network models for use in TRANSITION.

- Several **pre-processing and conversion stages** were needed in order to convert the CIM exports from Electric Office into network models suitable for power flow analysis

- **Open Grid's Cimphony** suite was used to **pre-process and convert the CIM exports.** Cimphony is capable of directly importing a CIM network model into its Network Model Management (NMM) environment

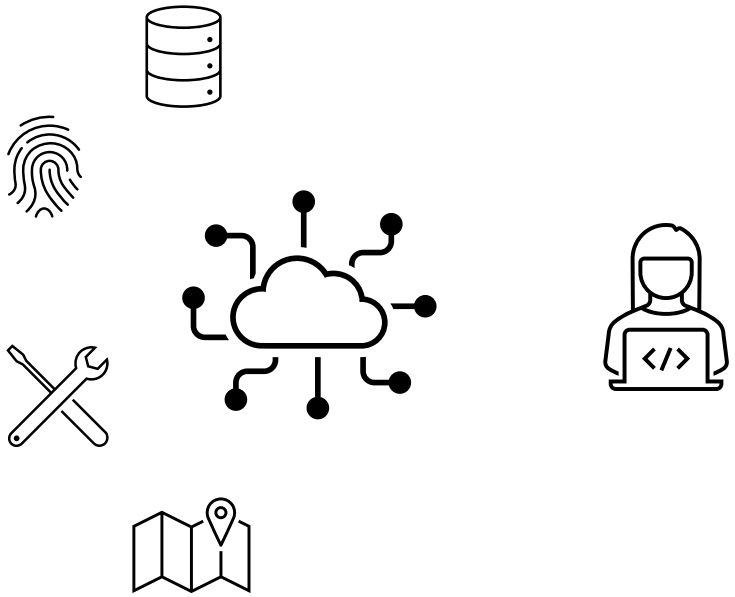


Use of Cimphony as a CIM Translation Tool

- **Open Grid's Cimphony** supports several versions of CIM (v10 to 16), including all extensions for ENTSO-E CGMES v2.4.15;

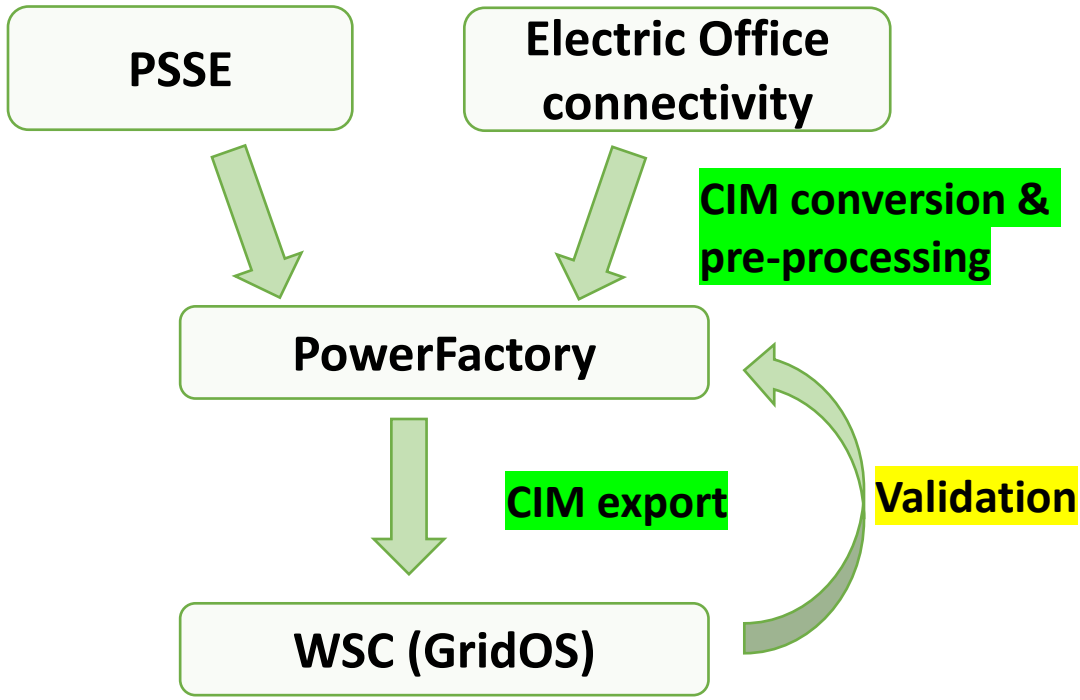
- It also supports the **import of data from a number of PSA tools** through its DGS format, including:
  - PSS/E
  - DigSILENT PowerFactory,

- In TRANSITION we used Open Grid's Cimphony for:
  - Importing and visualising CIM files in a GIS format
  - **Conversion from v15 into v16**
  - **Fixing connectivity problems**
  - Adding electrical parameters (impedance, ratings, etc.)
  - **Assigning UUIDs** compliant with the CIM standard
  - Packaging GML and XML



Common Information Model – TRANSITION Use Cases

- Electric Office exports individual 11kV feeder as **CIM v15 files with an accompanying GML file**
- The TRANSITION network model was developed in **DIgSILENT PowerFactory** and exported to the WSC
- Both PowerFactory and GridOS (PSA used in the WSC) can import and export network models in **CIM v16**
- The current target version of CIM for TRANSITION is **CIM v16**, as this aligns with the **CGMES v2.4.15** standard and currently has the **widest industry support.**
- It is expected that the CIM-based data used in TRANSITION will be able to move to **CGMES v3.0.0** with minimal changes



Challenges

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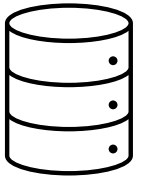
Problems and Issues – Invalid Classes, UUIDs and GML

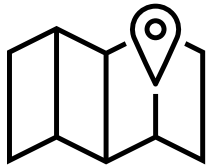
- Some classes and relationships in the data were **incorrectly marked as being IEC standard** and so produced errors, for example:
  - **EnergyServicePoint** – this class appears to represent a load, and should have been EnergyConsumer or one of its subclasses (ConformLoad or NonConformLoad).

- The CIM objects from Electric Office **do not have any impedance, susceptance, or ratings data on them.** A step was added to populate that information from a **separate database from SSEN** and calculate the total impedance.



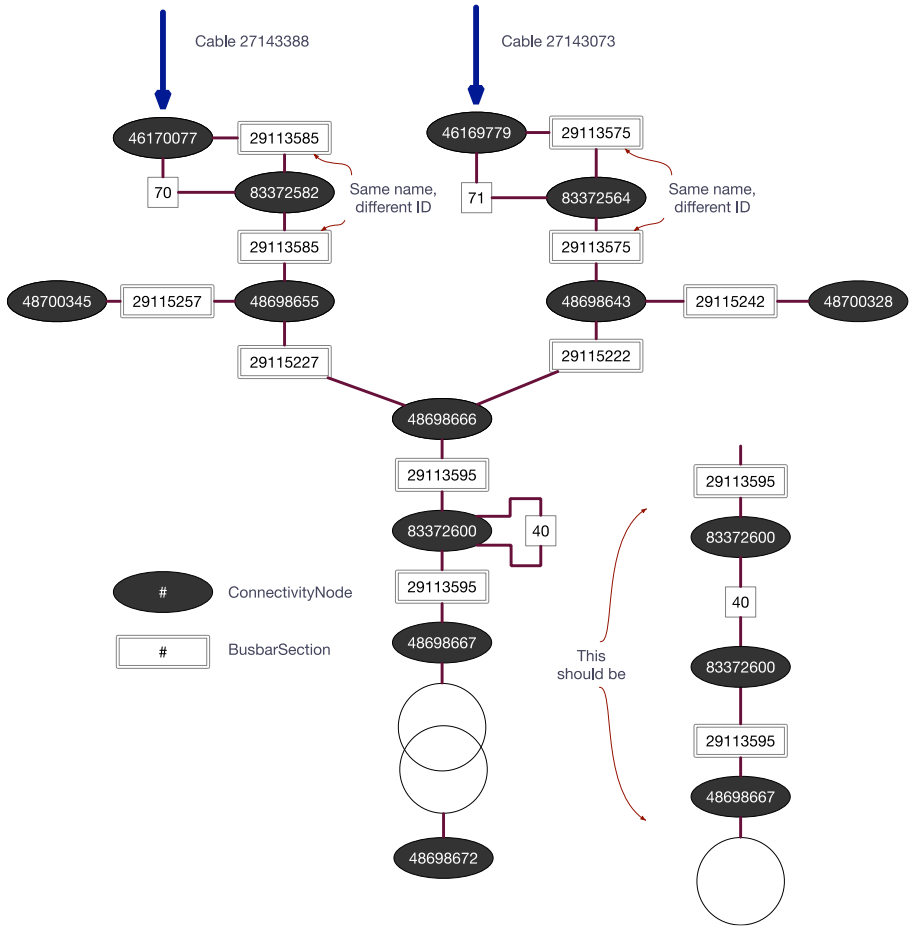
- The EO exports have **identifiers that are not compliant with the IEC CIM standard.** OGS created compliant UUIDs and used a persistent object registry when **converting CIM v15 to CIM v16** that **maps the EO identifier to the new UUIDs,** stores the mapping, and then allows this to be re-used during any subsequent conversions to ensure the same UUID is kept.

- EO exports all **geographical data** as a separate **Geographical Markup Language (GML) file.** This GML file was parsed, converted into CIM Location and PositionPoint instances and matched with the corresponding CIM data elements, to produce a CIM dataset that contained the network and geographical data.



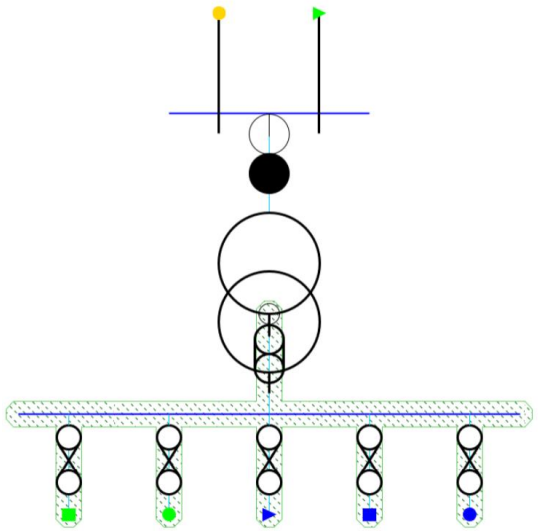
Problems and Issues – Substation Connectivity

- Fundamental issues with how Electric Office represents **internal substation connectivity** with its CIM export that needed to be corrected in order to make it **compliant with the IEC standards**
- In the CIM data exported by EO, the **busbar (represented by a CIM BusbarSection) essentially acts as a node**
- There were several occurrences of substation internals where multiple **ConnectivityNodes** and **BusbarSections** with the same identifier were present in the file. This then cause **issues with connectivity**
- There are **unnecessary objects, BusbarSections and ConnectivityNodes,** that represent elements in the drawing which **serve no electrical connectivity purposes.**
- **Topological analysis of the network was required to** identify where busbars and switches were in parallel, remove the buses, then merge together all ConnectivityNodes and BusbarSections

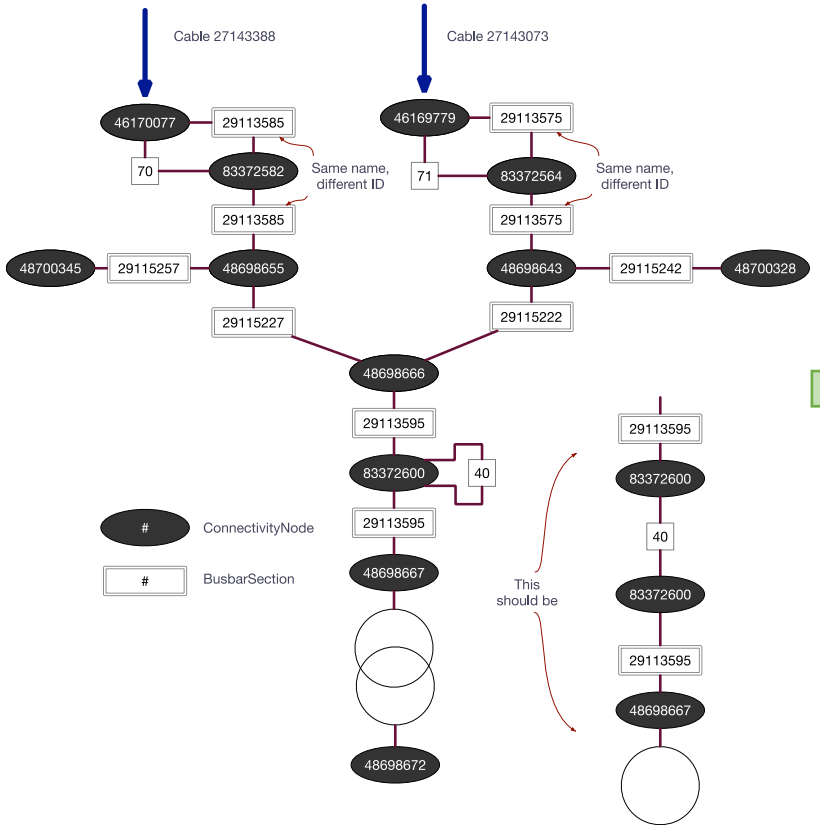


Problems and Issues – Substation Connectivity

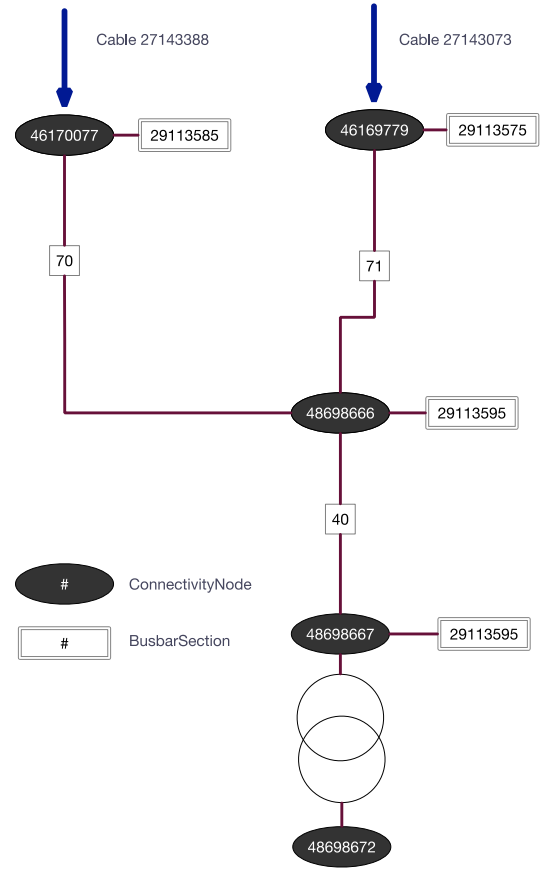
Electric Office Internal representation



Full CIM representation

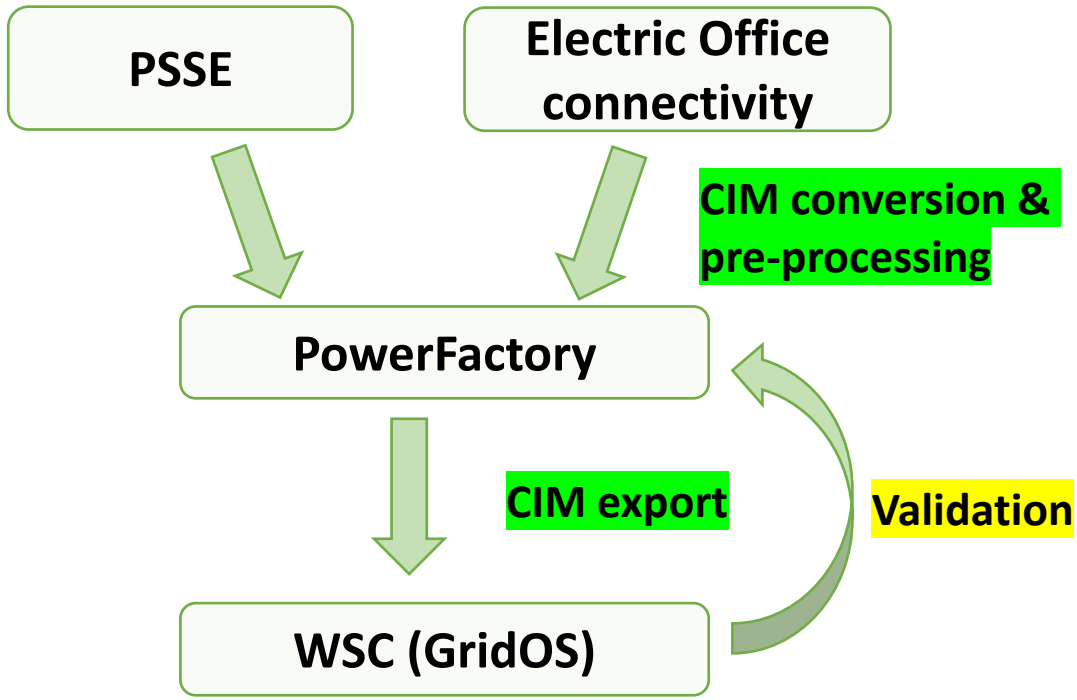


CIM representation after correction



Interoperability Results - Validation

- High risk of data been **“lost in translation”** when converting between **different versions of CIM** and when using **different profiles (e.g., CGMES v2.4.15).** This may be an ongoing concern, as there are several conversion stages. For example:
  - **PowerFactory only supports the ENTSO-E CGMES standard**, which was developed to support the exchange of balanced, **transmission network models.**
  - As such there are some aspects of the distribution data that are not compatible
  - **Imbalanced characteristics are lost** when importing/exporting from PowerFactory
  - The PSA used in the WSC (GridOS) has a different modelling philosophy than PowerFactory
- This translates into a requirement to **compare power flow results of the same network model in different PSA tools**



Key Learnings

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Key Learnings

- The CIM files exported from SSEN's GIS will be **constantly evolving,** as the physical network changes.
- The process of converting and pre-processing these CIM files into network models that are usable by a PSA software like PowerFactory needs to be as **automated as possible to allow for constant updates**
- **Data can be lost** when converting between different versions of CIM, depending on the profile being used (e.g., CGMES). This is an ongoing concern, as there are several **conversion stages**
- For instance, when converting from CIM 15 to CIM 16, the imbalance characteristic of certain parts of the network had to be changed to allow PowerFactory to recognise the data.
- The process required to validate and integrate the 11kV feeders (i.e., CIM 16 files) into PowerFactory is **time consuming**, especially because the CIM files are exported as individual feeders
- Exploring the option of automating the "bundling" process of 11kV feeders into Primaries as part of the CIM conversion process, to speed up the process.

Thank you for your attention

For more information on TRANSITION & LEO:

https://ssen-transition.com/

https://project-leo.co.uk/

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Appendix

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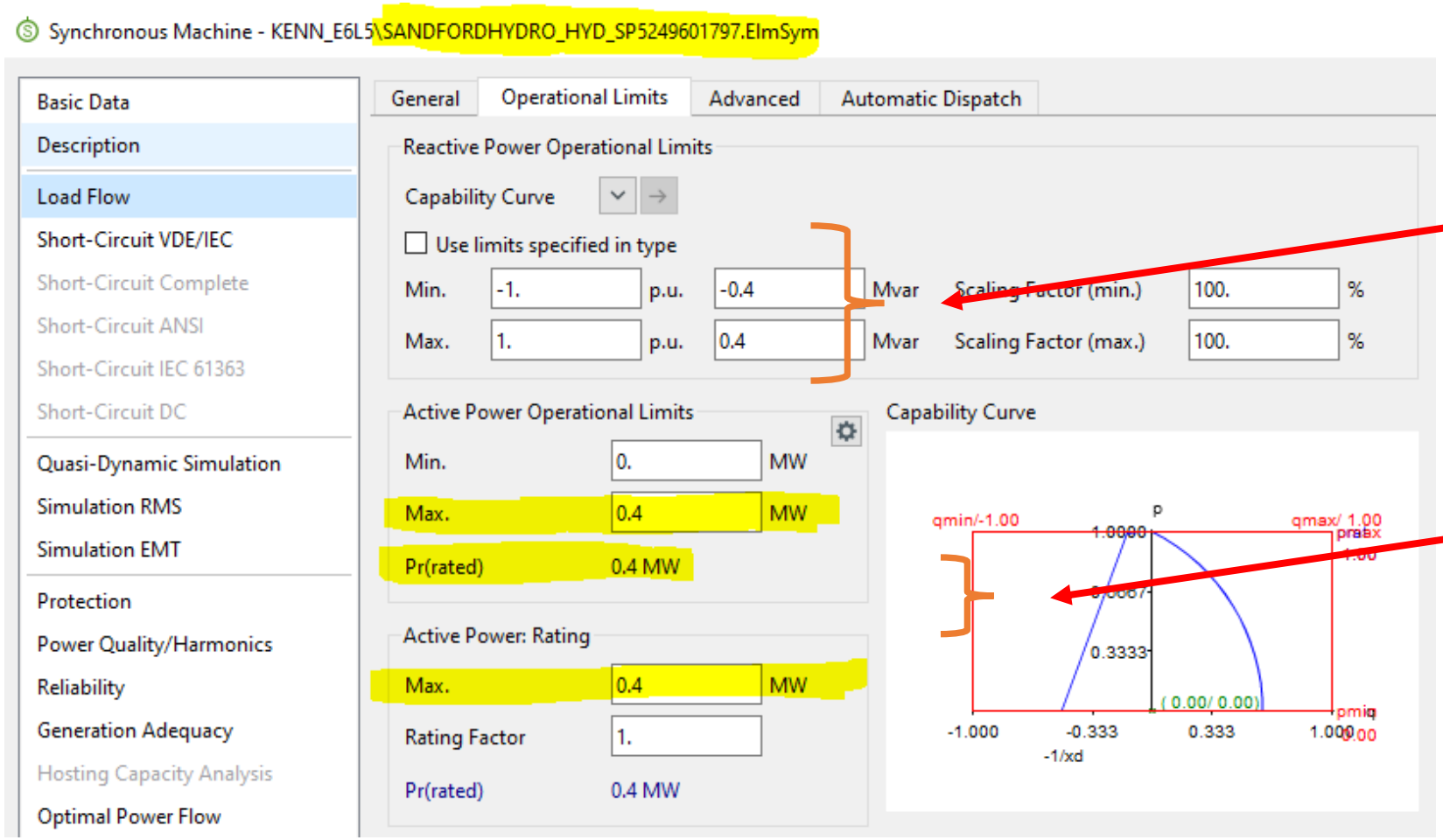
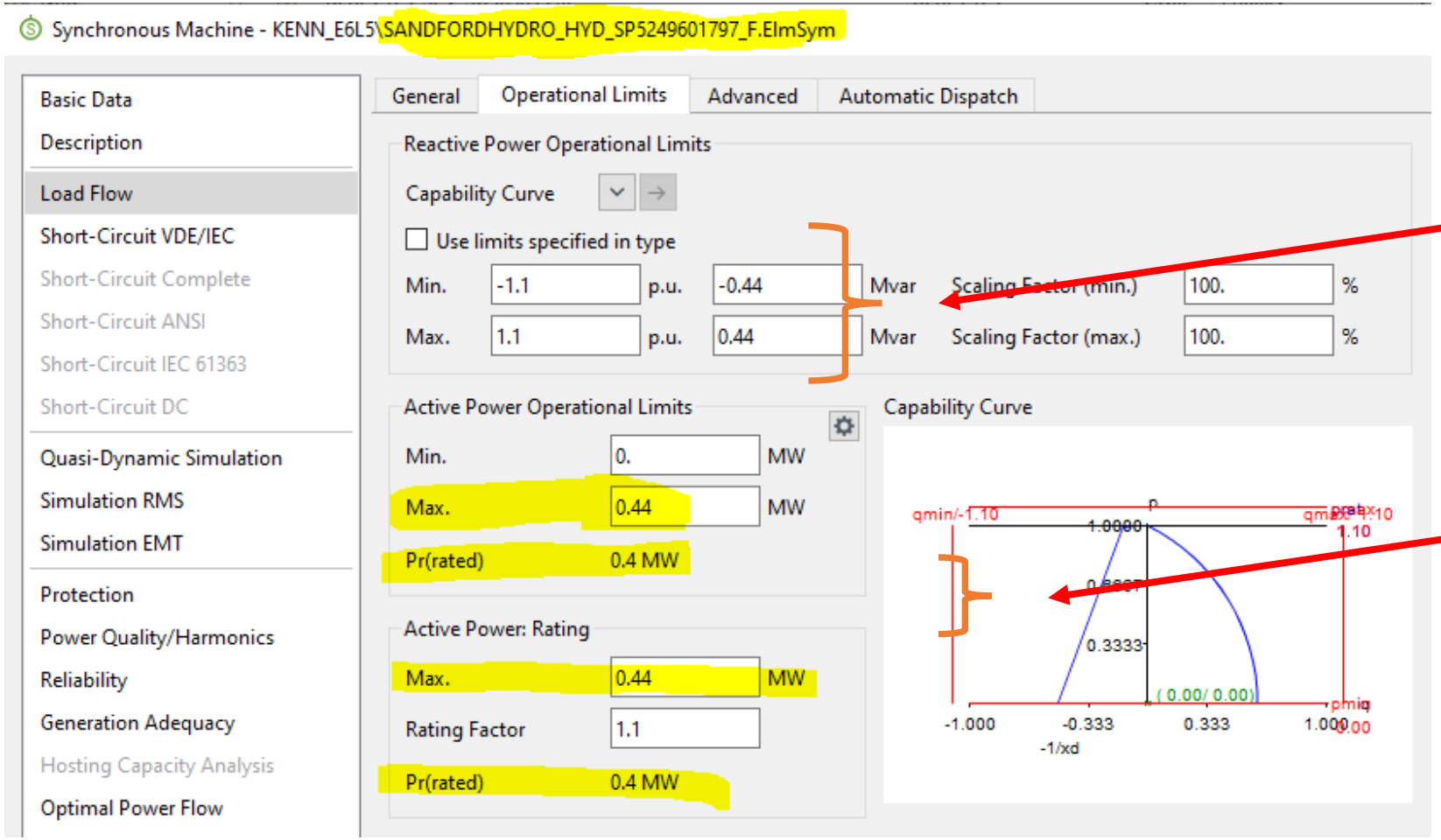
Generator in PowerFactory - Example



Generator in PowerFactory - Example



Prated (ratedS)

Pmax (maxOperatingP)

CIM export from PowerFactory - Example

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Relation

Prated (ratedS)

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```

Pmax (maxOperatingP)

CIM export from PowerFactory - Example

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```

Prated (ratedS)

Relation

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```

Pmax (maxOperatingP)

CIM export from GridOS - Example

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```

Pdispatch (p)

Prated (ratedS)

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```

Pdispatch (p)

Prated (ratedS)