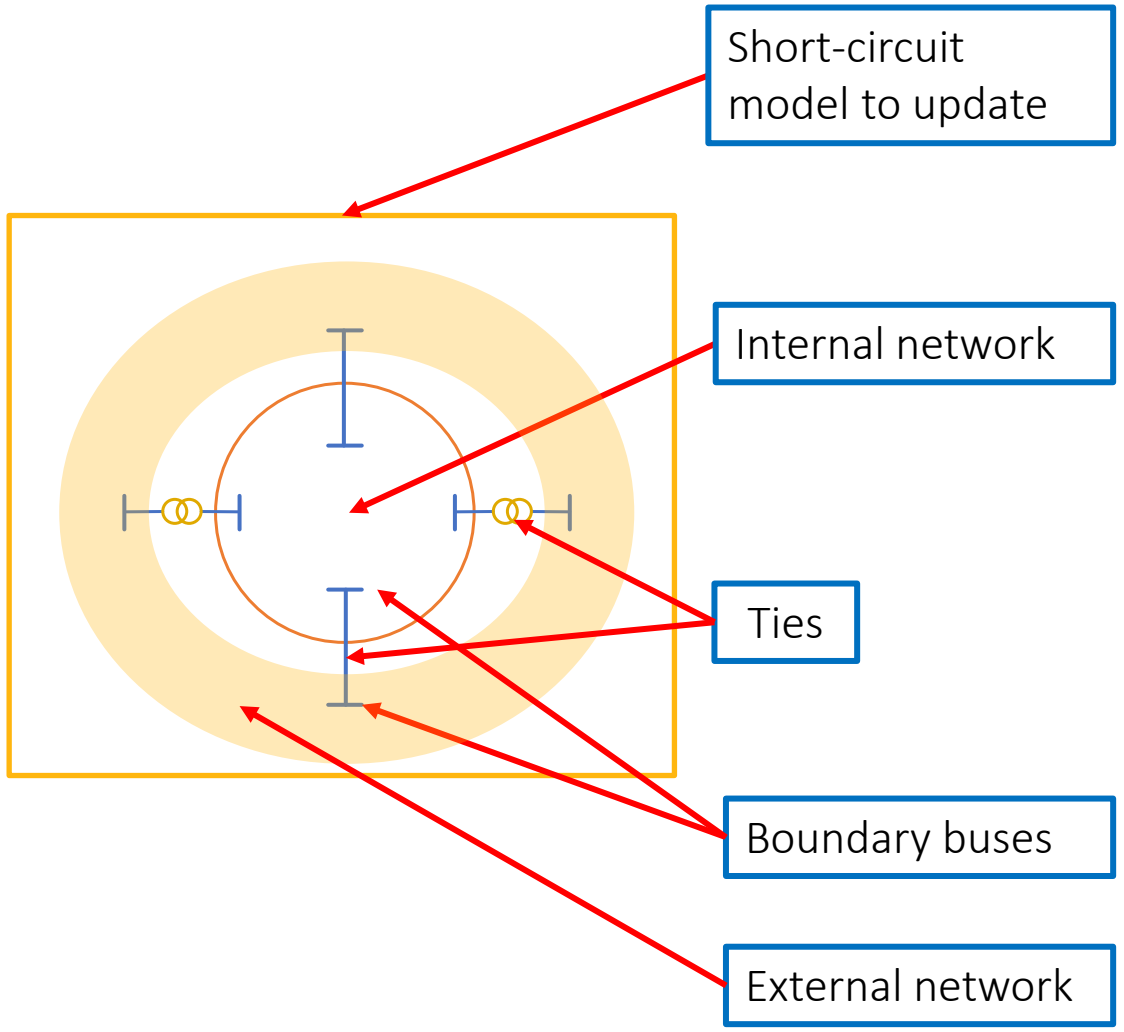
Short-Circuit Updates in ConEdison's Power System: Methodology, Challenges, and Lessons Learned

Hibourahima Camara, George Goddard – *Con Edison Company of NY, Inc*

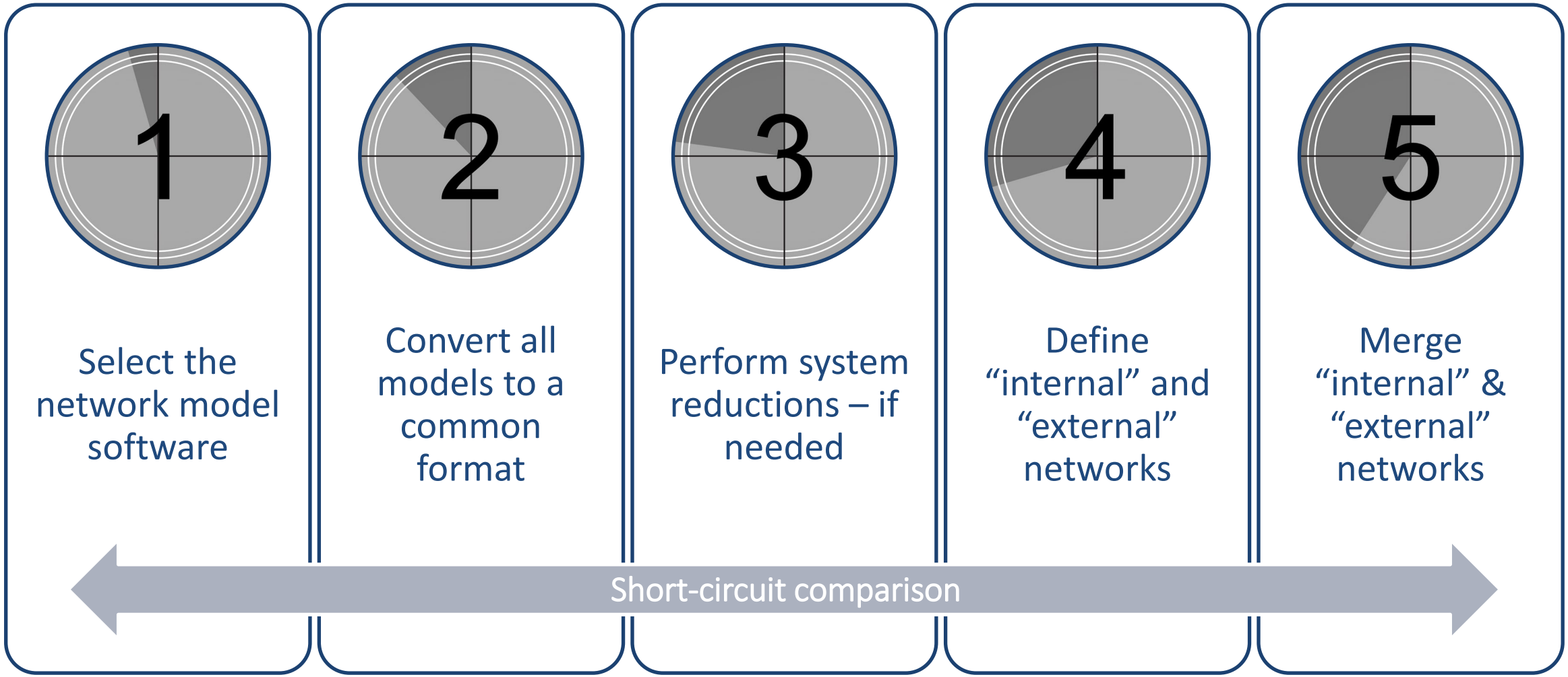
Majida Malki, Jinrong Li, Jorge Velez – *Quanta Technology, LLC*

Introduction

- **The project:** Update the network model used for protection studies to properly capture short-circuit contributions from "external" network
- **The challenge:**
  - The source to update the short-circuit model is kept by the Independent System Operator in a different software
  - The final network model does not require the whole network kept by the Independent System Operator but just a portion of it – two or three buses away from boundary buses, therefore system reduction is needed



Methodology

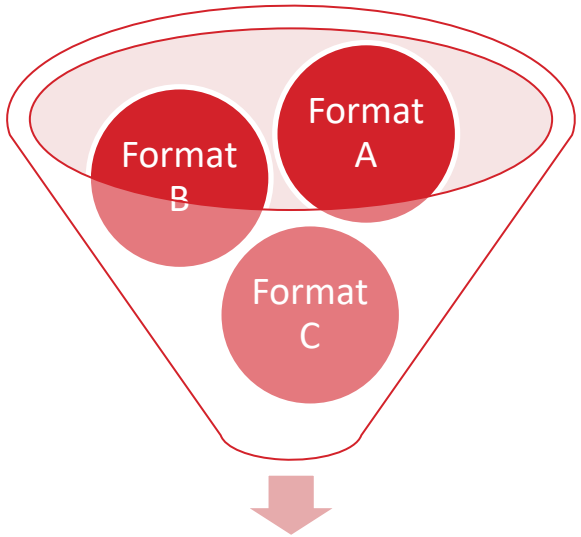


Network model software selection

- Most of the commercial short-circuit programs offer the option to convert models so that they can be read from other software
- The first step in this approach is to select the desired software to host the updated short-circuit model.
- In most of the cases, the software selected is the one that contains the network model for relay protection studies.
- Other considerations when making this software selection are:
  - Network reduction features. Some platforms can offer “enhanced” system reduction techniques.
  - Bus-tie and by-pass switch modeling styles.
  - Equipment modeling, e.g. Phase Angle Regulator (PAR) modeling styles.
  - Bus numbering and bus naming convention requirements.

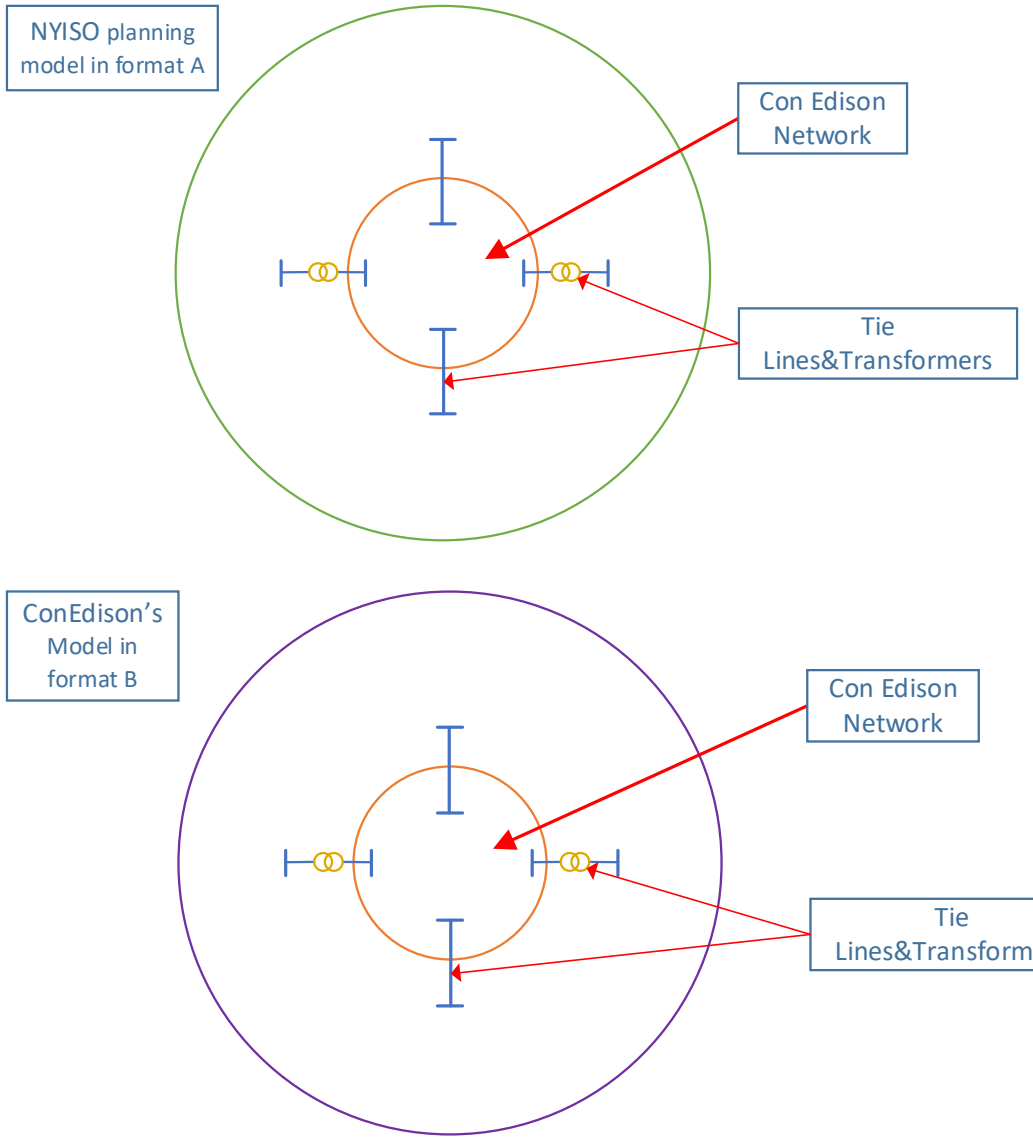
Network model conversion to a common format

- Although the conversion of format is a straightforward task, parameters such as impedance thresholds to model infinite or negligible impedances have to be carefully selected.
- After this network model conversion, a validation via short-circuit comparison is recommended.
- Typical issues at this step are:
  - Impedances not specified in the source model (blank fields) interpreted as infinite impedances in the converted model – this causes large differences when comparing single-line ground fault current between models
  - Three-winding transformers with one winding out-of-service converted with all the three windings in service
  - Zero-sequence impedance conversion for three-winding transformers in Y-Y-D connection



Challenges – Network model selection

- Most of the commercial short-circuit programs offer the option to convert models so that they can be read from other software
- The first step in this approach is to select the desired software to host the updated short-circuit model.
- In most of the cases, the software selected is the one that contains the network model for relay protection studies.
- Other consideration when making this selection is the capabilities of the software to perform network reductions if it is needed during the short-circuit update process.



Challenges – Network models conversion to a common format

- Next step is to convert all available network model into the selected format. Although the conversion of format is a straightforward task since most of short-circuit programs offer this feature via built-in executable tools, some parameters must be carefully set by the user when performing the network model conversion, especially the ones to indicate the impedance thresholds to model infinite or negligible impedances.
- After performing the network model conversion, a validation step is recommended to ensure the consistency of the results. This validation can be performed via comparison of short-circuit results in the converted model against the original model. Typical issues at this step are:
  - Impedances not specified in the source model (blank fields) interpreted as infinite impedances in the converted model – this causes large differences when comparing single-line ground fault current between models
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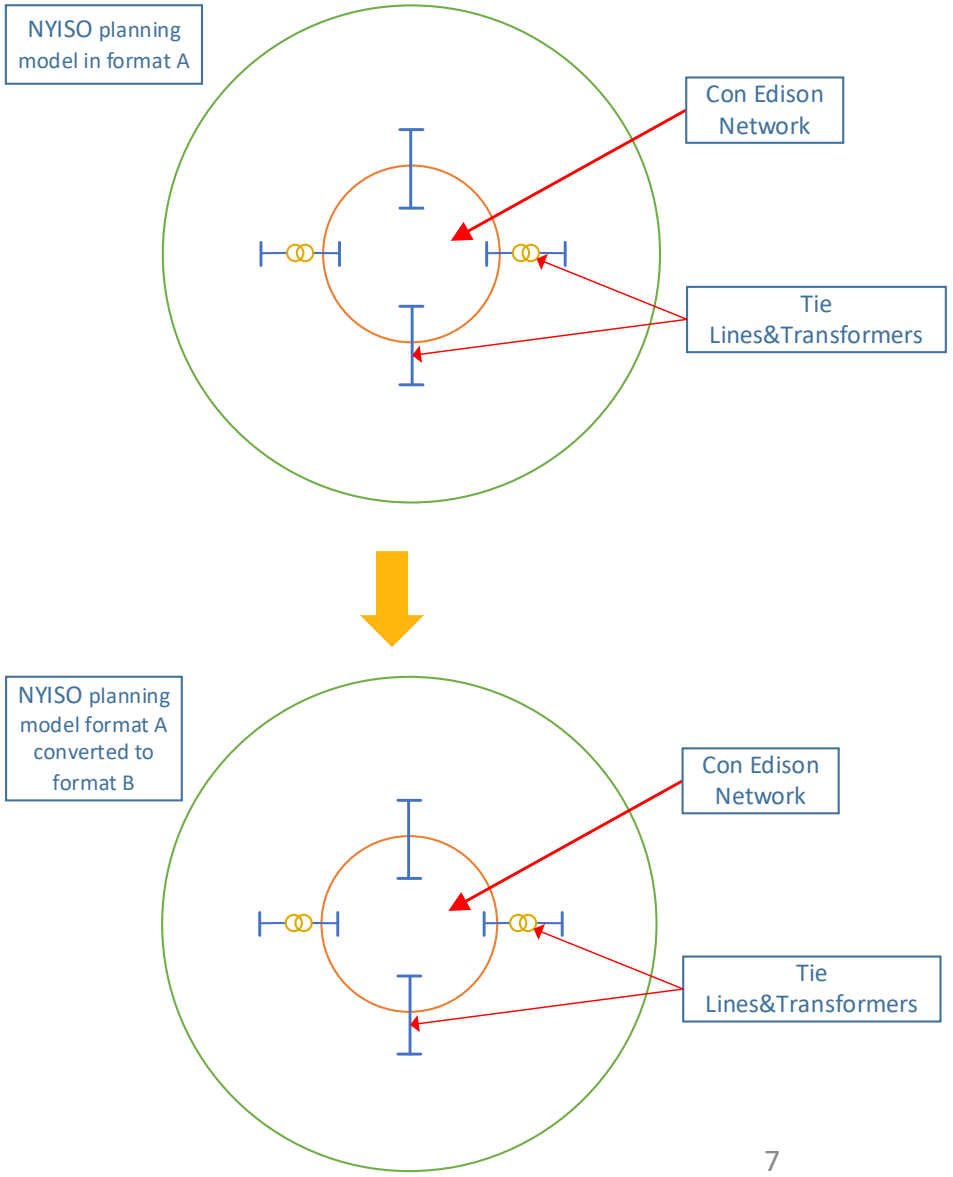
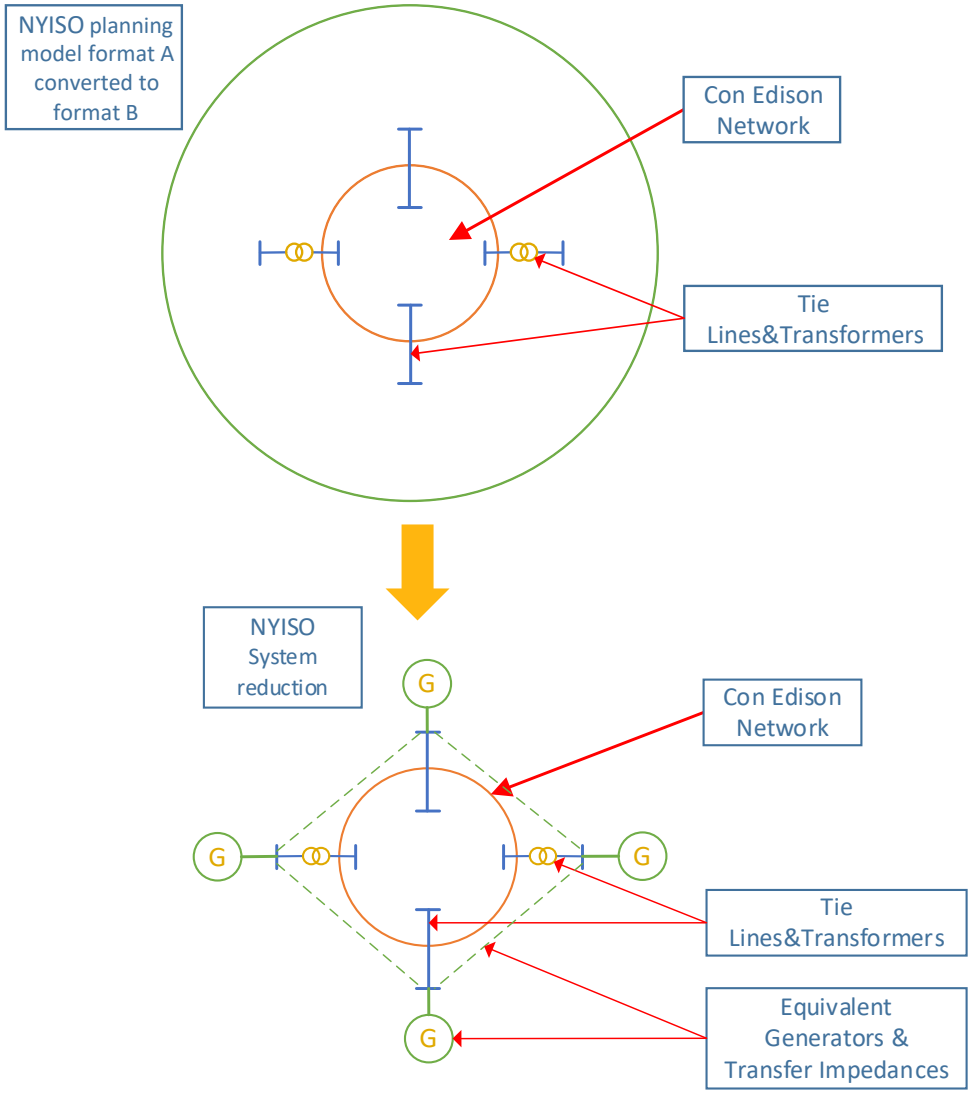


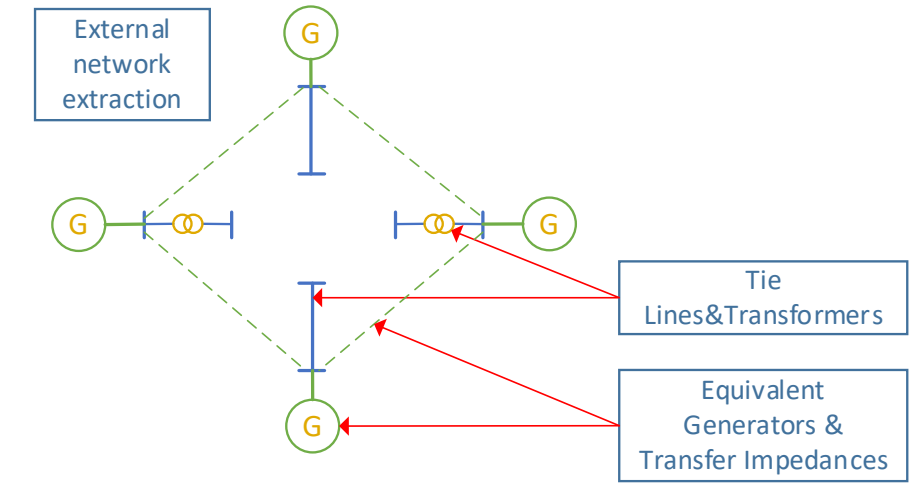
Challenges – System reductions

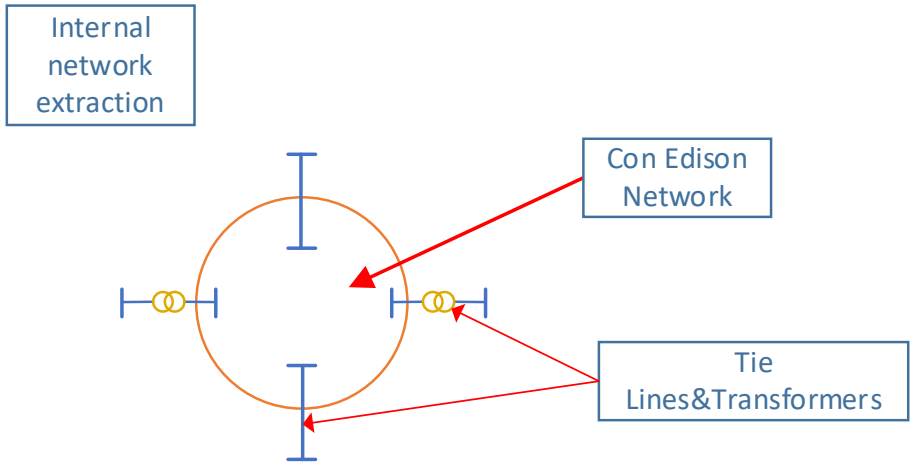
- When needed?
  - When the utility received new network model from Independent System Operator and need to update their short-circuit model to include the new external network information
- What's the target?
  - A system model reduction is done to create an equivalent circuits that can replace the extensive neighboring network with simpler circuit. The created equivalent circuits shall yield to the same voltage-current relationship as the original network
- How to perform?
  - Commercial short-circuit programs on the market offer built-in feature to achieve this reduction



Challenges – Defining “external” and “internal” networks

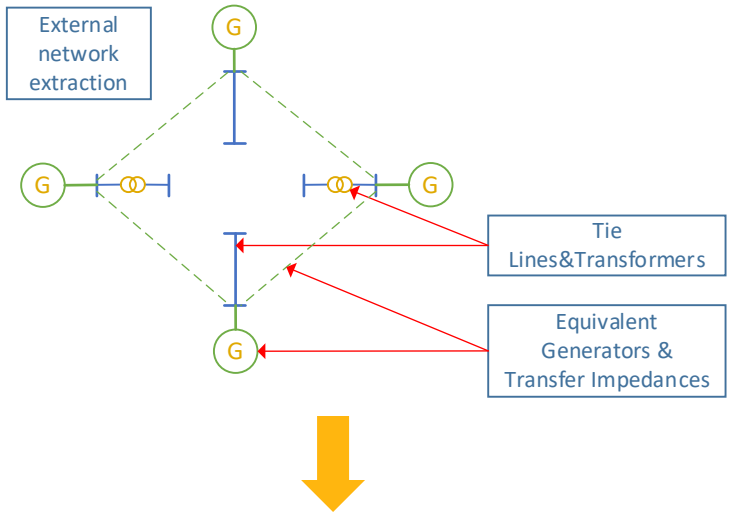
- The “internal” network is the portion of the system modeled and maintained by each utility containing utility-owned and third-party assets that operated by utility.
- The external network represents all equipment beyond the internal network not owned by a given utility. External networks are usually not maintained by a given utility but rather published and updated by reginal ISO or reliability council.
- In the real-world practice, it is not necessary to extract either external or internal network to form a new model. The word “extract” is used more conceptually to draw a clear line between the external or internal network versus the rest of the system in each model.
- This facilitates later efforts of merging the networks together into the new model in the way that it would be clear what is the desired data to be kept and what is the outdated data that can be overwritten.

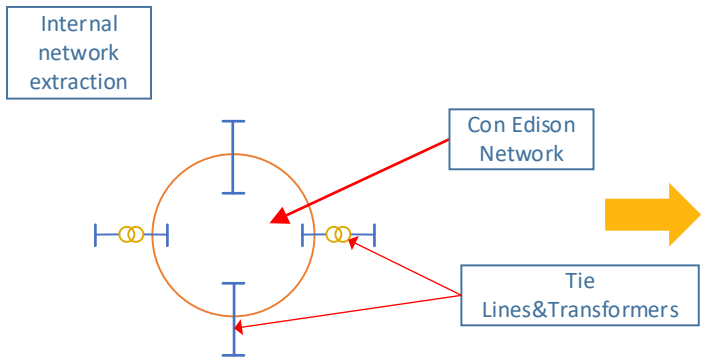


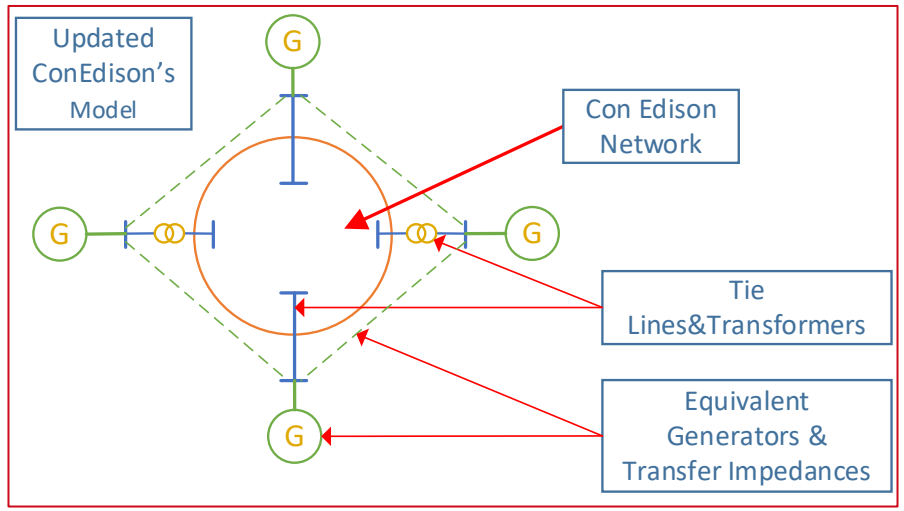


Challenges – Merging “external” and “internal” networks

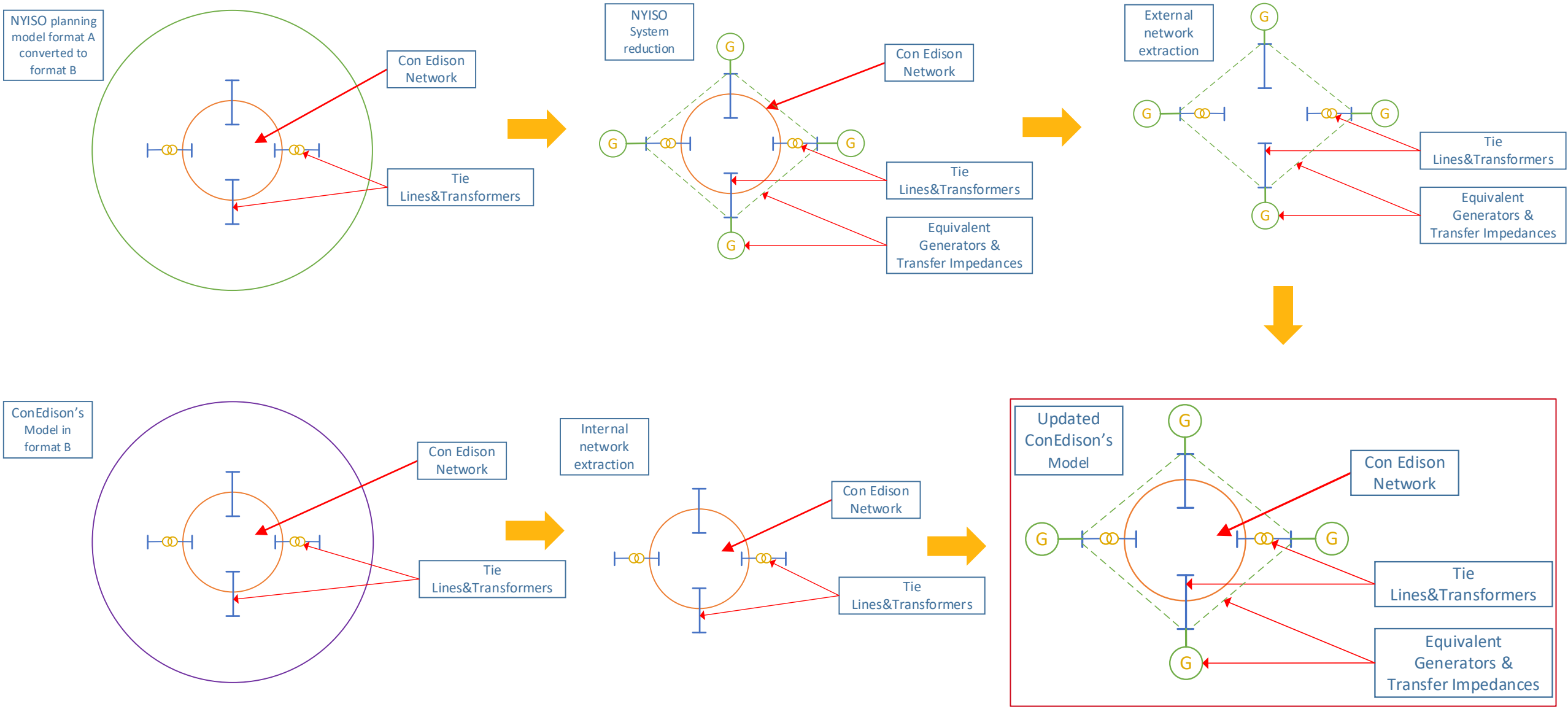
- This step essentially “glues” the two sets of network data together.
- Key steps are below:
  - Identify source and target databases
  - Create a bus map that corelating buses in each database. This map can be done by bus number, name and voltage level. Among them bus number prevails. Usually, boundary buses where equivalent generators and shunts are created on them are on the bus map list.
  - Control data transferring by specifying what type of data is to be merged, which data set dominated when there is common data field. Some short-circuit program might also display the comparison of each data point in the table format and let user to make selection for each point.



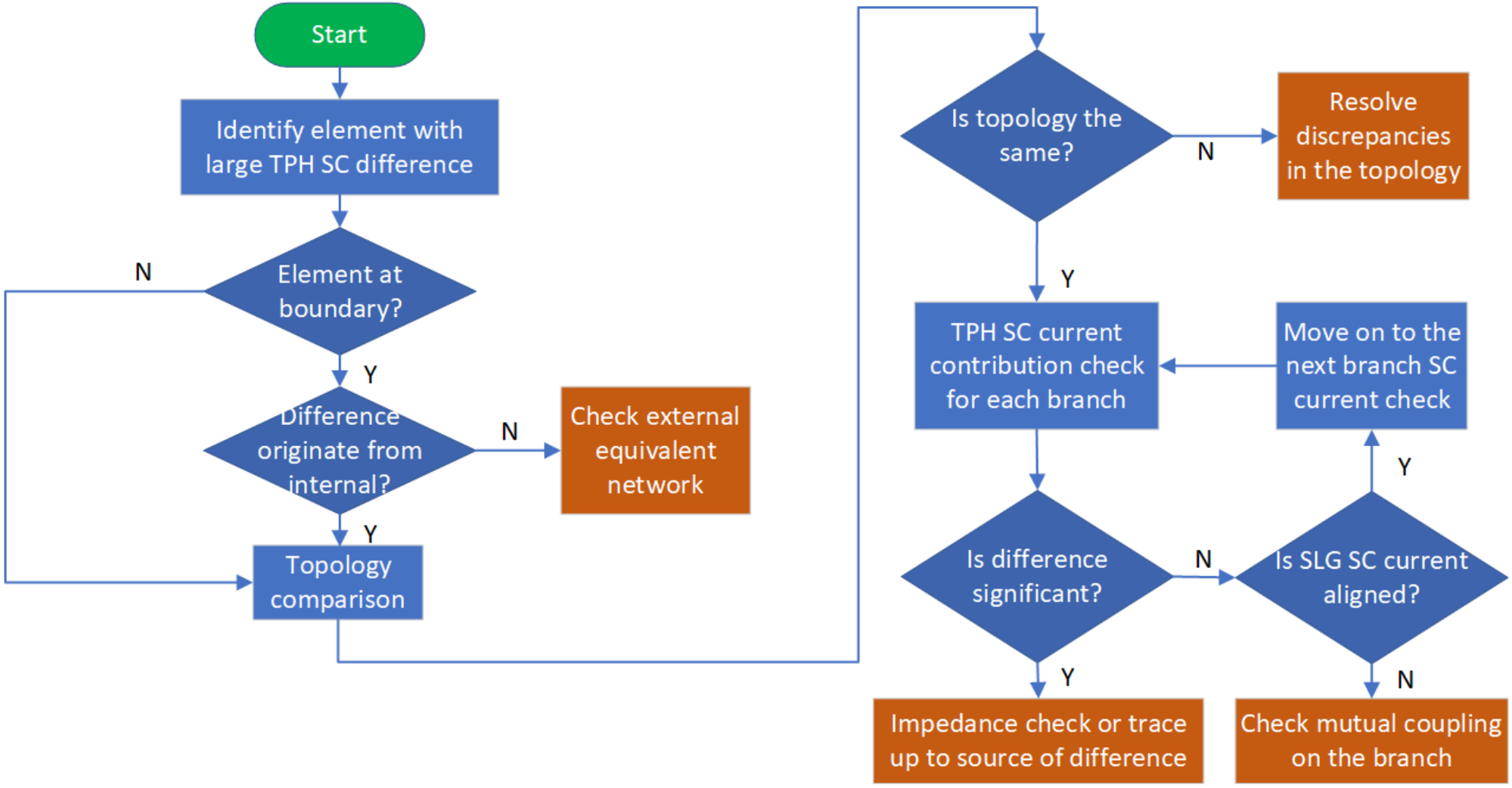




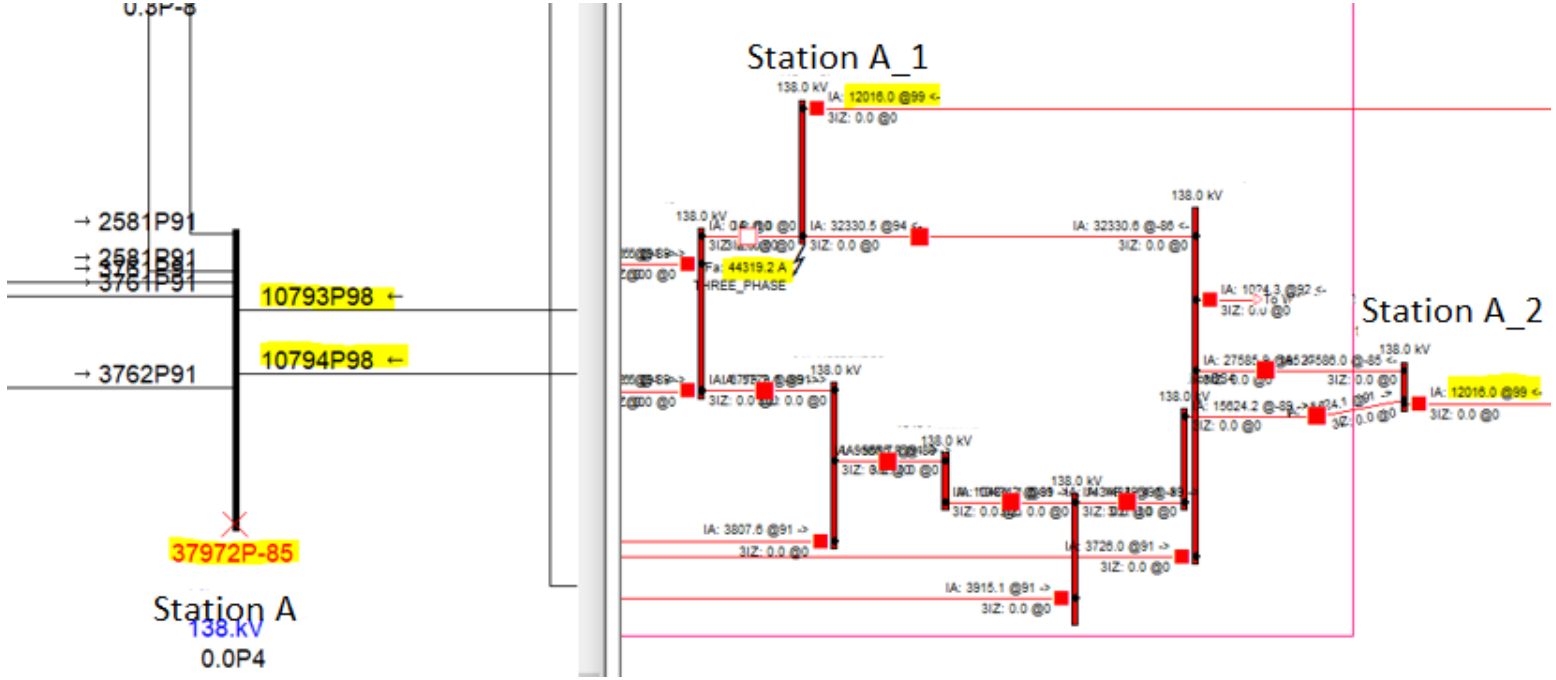
Network model manipulation process



Short-circuit model verification – General Approach



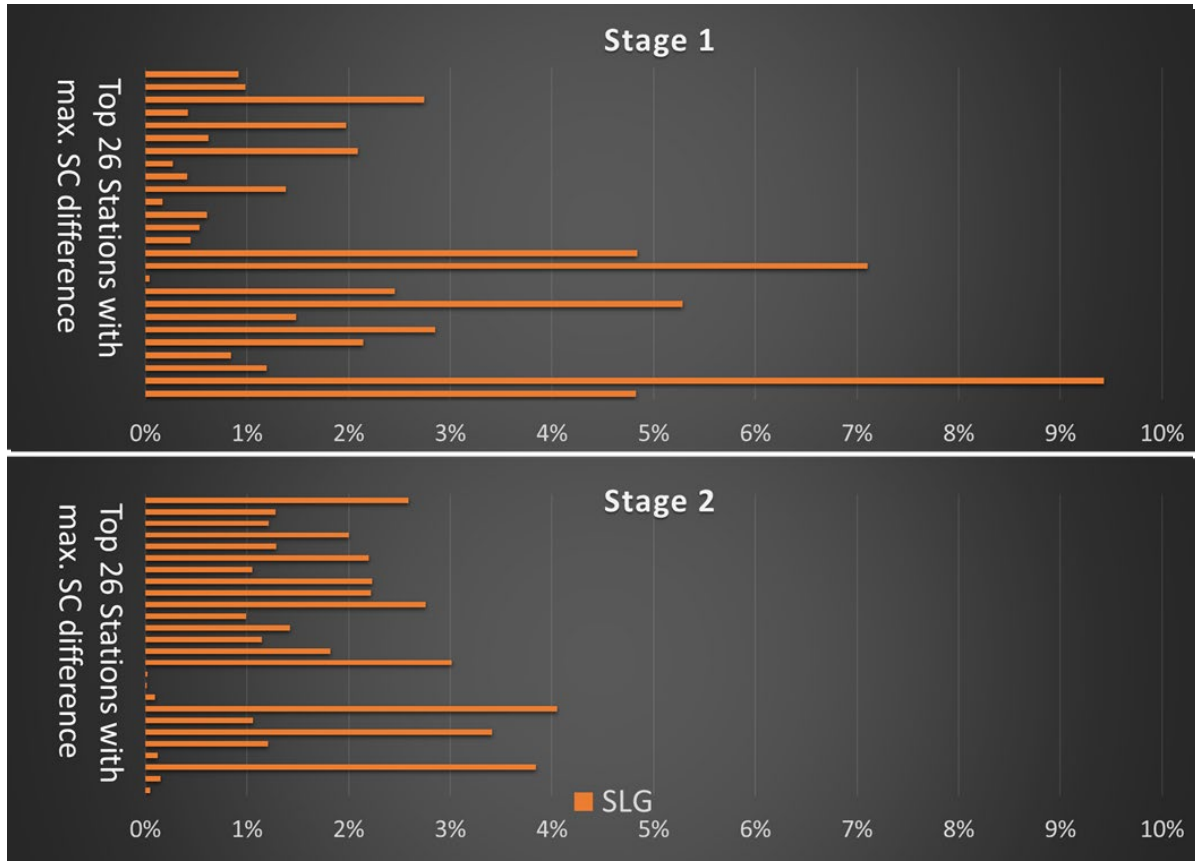
Short-circuit model verification - Example



Short-circuit model validation between different short-circuit platform

- In above example, Station A is identified due to SC current difference for TPH fault between two platforms. (37972A pri vs. 44319A pri)
- After topology comparison for station A, two branches highlighted in yellow are identified as the major contributors to the SC current difference at the station A.
- This leads to impedance check and mismatch were found on both feeders. Action to mitigate these mismatch was taken.

Example of Short-circuit model updates in ConEd's power system



Initial short-circuit comparison:
Some short-circuit discrepancies exceeding 10%

Stage 1: After external equivalent circuits alignment
Obvious positive changes can be observed after external equivalent circuits update

Stage 2: After internal topology alignment
Further fine-tuning of the internal network to bring the short-circuit difference between two databases even closer to target level

Conclusions

- Updating power system models for accurate short-circuit studies is a task that must be frequently performed specially under the significant changes that are happening nowadays due to the increasing availability of distributed energy resources (DERs).
- Having a proper representation of the short-circuit contributions from external networks can be a demanding task especially if the model resides in a different software.
- Establishing a methodology to conduct these short-circuit updates allows utilities to expedite this task and ensure accuracy of the results. It also provides a starting point to develop automation tools to streamline the process and integrate it to other Network Model Management (NMM) initiatives.
- Short-circuit comparisons along every step of the system model update process are fundamental to ensure accuracy of results. This helps to fine tune system models for both internal and external networks.
- The methodology presented in this work proves its efficiency when applied to Con Edison's power system. Initial short-circuit discrepancies between models that were greater than 10% were reduced to lees than 5% across the system.

Thank you!