Constructing Low Voltage Network Models using Smart Meter Data

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1. Introduction

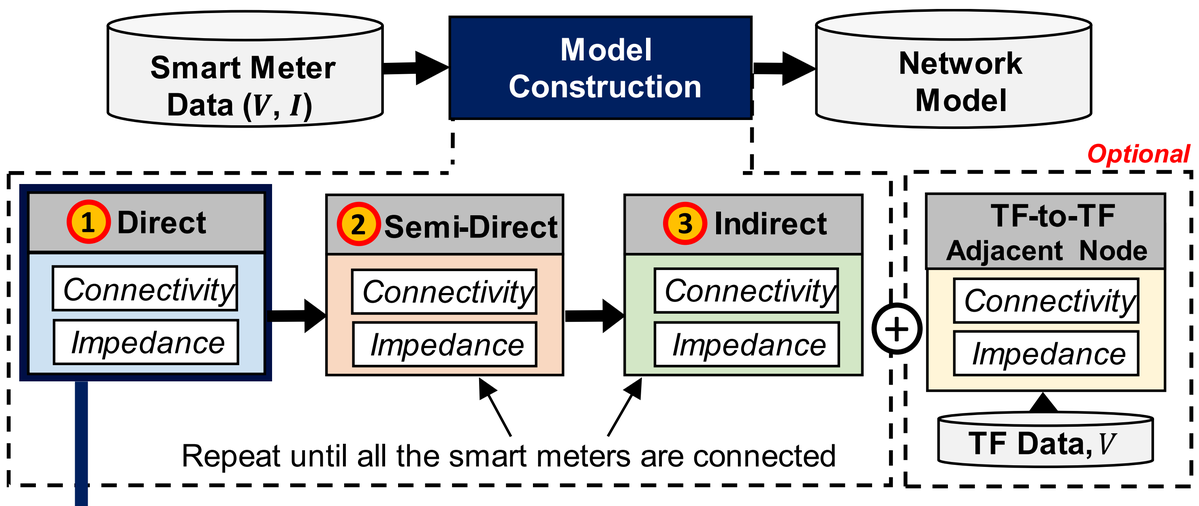
- **Adequate electrical models serve as the foundation** of common methods used for planning and operational techniques in distribution networks.
- However, in practice, **low-voltage (LV) network models** are often **incomplete/inaccurate or do not exist**.
- This work proposes an approach to construct **three-phase (3Φ) LV network models solely using real smart meter data** through regression analyses combined with machine learning approaches.

2. Methodology

- Three Types of nodes are defined to structure the network;

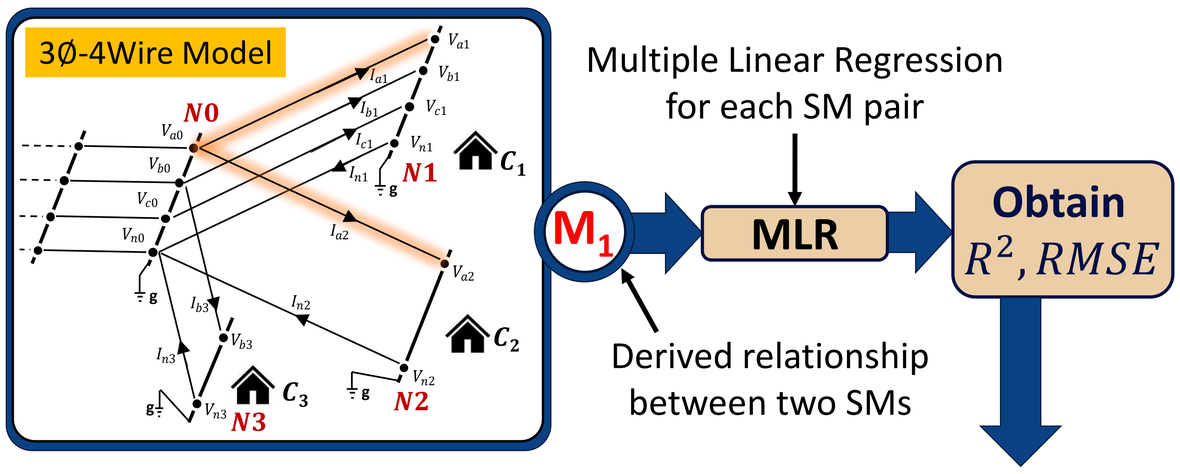
1. **Direct:** connect only smart meters (SMs)
2. **Semi-Direct:** connect one direct node and one or more SMs
3. **Indirect:** connect any combination of already identified nodes

- **Overview:**



- **Node Identification Process (7 Stages):**

Why 7? Real SM data and LV networks can bring challenges.



Stage 1: Clustering of R^2 and $RMSE$ Values (k-Means) for a possible set of nodes

Refinement of Nodes:

Stage 2: Spearman Correlation of voltages

Stage 3: Channel Check using GMM

Stage 4: Standard deviation of impedance from MLR

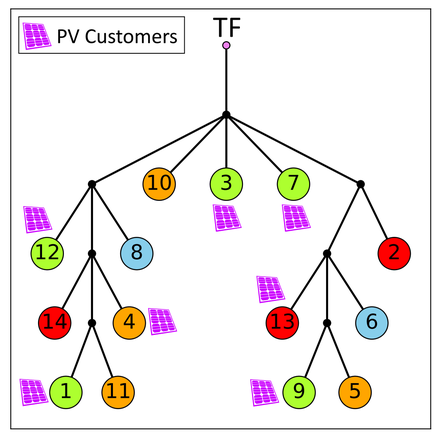
Stage 5: R/X Ratio

Stage 6: Merger of Nodes → *Connectivity*

Stage 7: Calculate V, I, and Z → *Line Impedance*

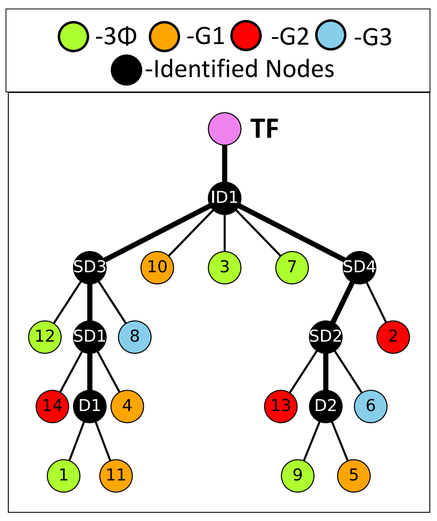
3. Real-World Case Study

- **Real LV feeder** in Victoria with **real SM data (V, I)** of **5min** resolution.
- 14 customers (9 are 1Φ and 5 are 3Φ)
- 7 customers installed with PVs
- This is the final model to be constructed from scratch.

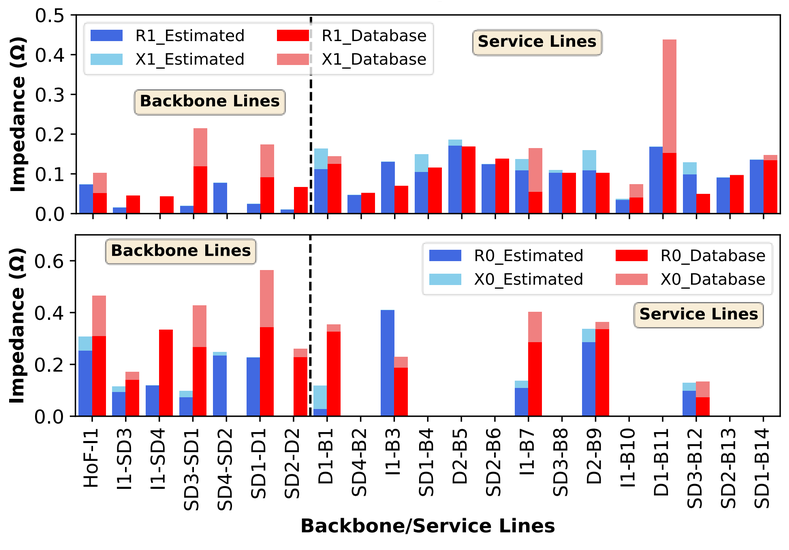


4. Results

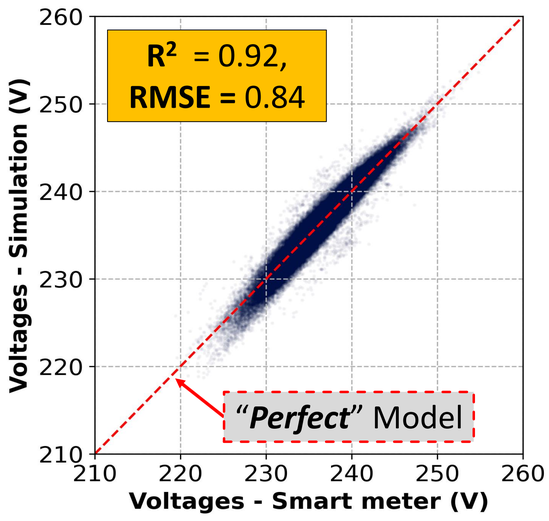
Constructed Model
(Topology & Phase Groups)



Estimated Impedances

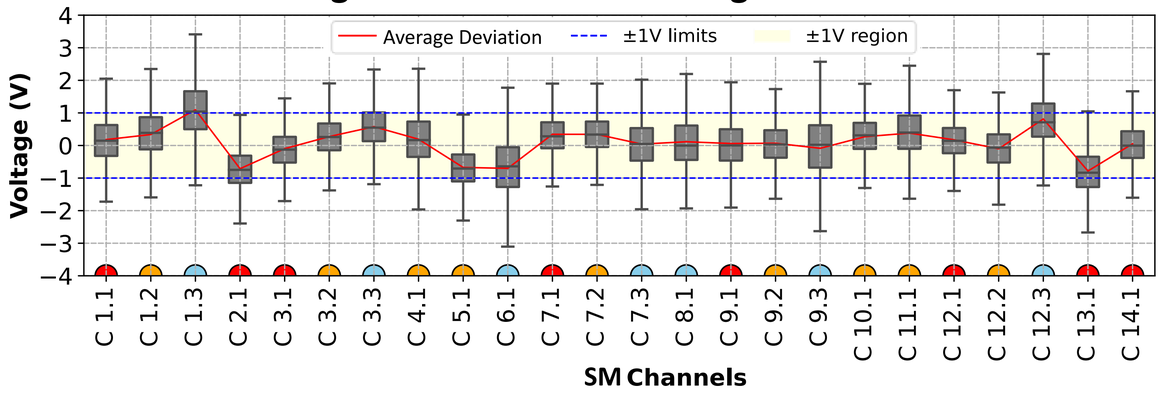


Performance Assessment



- Constructed topology and phase groups **match** the real LV feeder.
- Impedances **differ** from data--base values.
- Scatter plot **aligns** with perfect model line, but discrepancies are due to **imperfect SM data**.
- V deviation→$[-4, 4]V$
- Average V deviation→$[-1, 1]V$

Voltages: Deviation and Average Deviation



5. Conclusions

- The proposed smart meter data-driven methodology can construct **more accurate 3Φ LV network models**.
- **Only smart meter** data is used, and **no prior info** is needed.
- Can eliminate manual construction, **reducing time and cost**.
- Essential for Distribution Companies **to Effectively Manage** DER-Rich Networks.

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