



UNSW
SYDNEY



On equity in a distributed electricity system

Fair voltage management in South Australia

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² School of PV and Renewable Energy Engineering, UNSW

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Centre for Energy and Environmental Markets, UNSW

- Electricity tariffs (rates)
- Community energy
- Electricity market design
- Renewable energy in developing countries
- Energy data
- PV on apartment buildings

- Open source modelling tools
 - Tariff tool
 - Capacity Expansion Model
 - Nemlite
 - NEMOSIS
 - Local electricity sharing



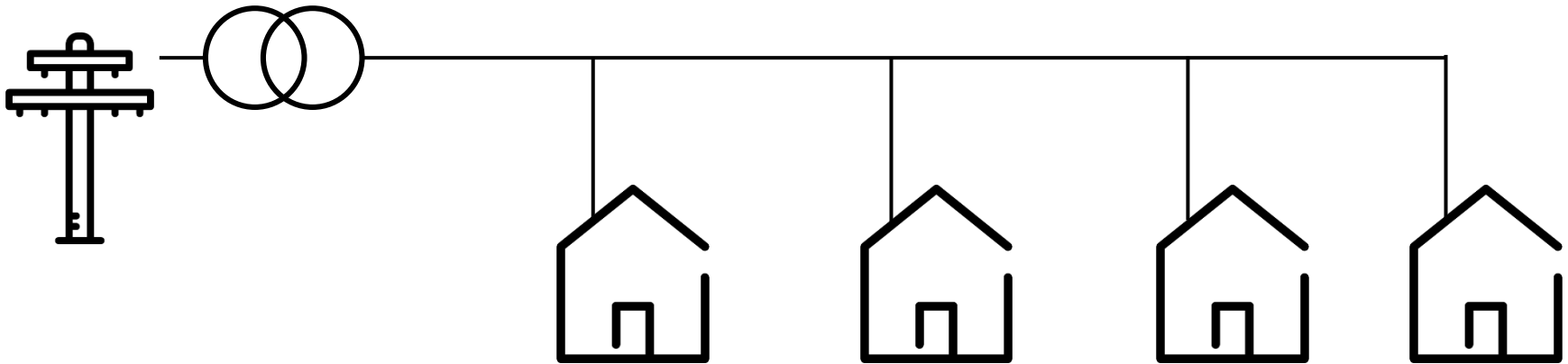
Overview

- **Context** – voltage management and distributed solar PV
- **Specific issue** – how much PV is being curtailed?
- **Findings** – using ‘in field’ data as an evidence base
- **Implications** – what are our objectives in a DER future?

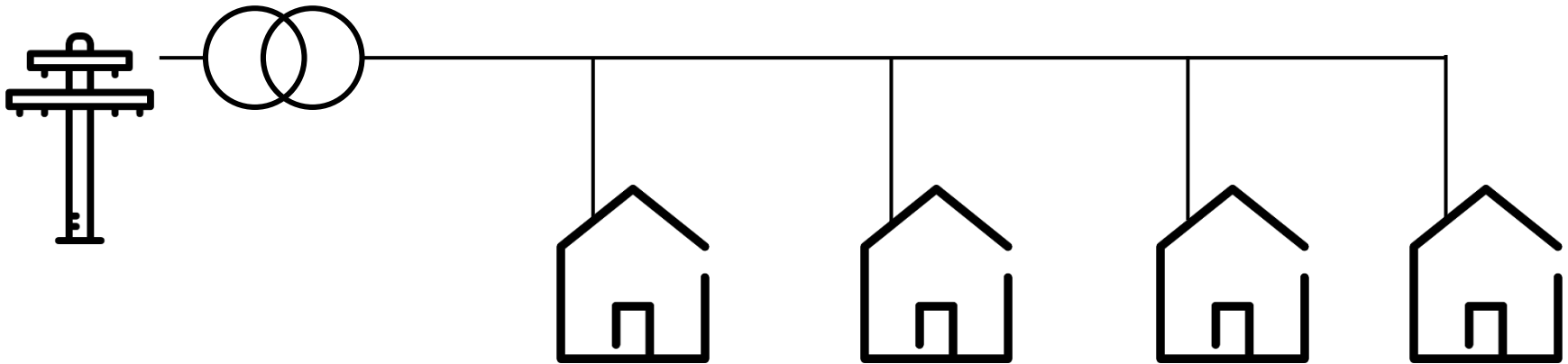
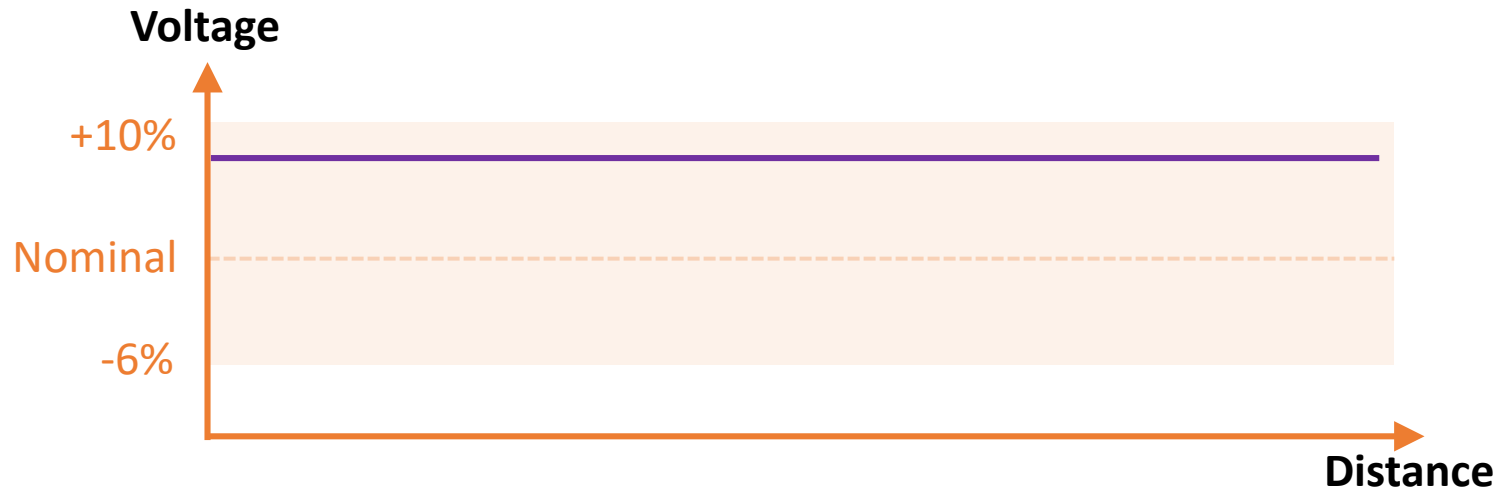


solar  analytics

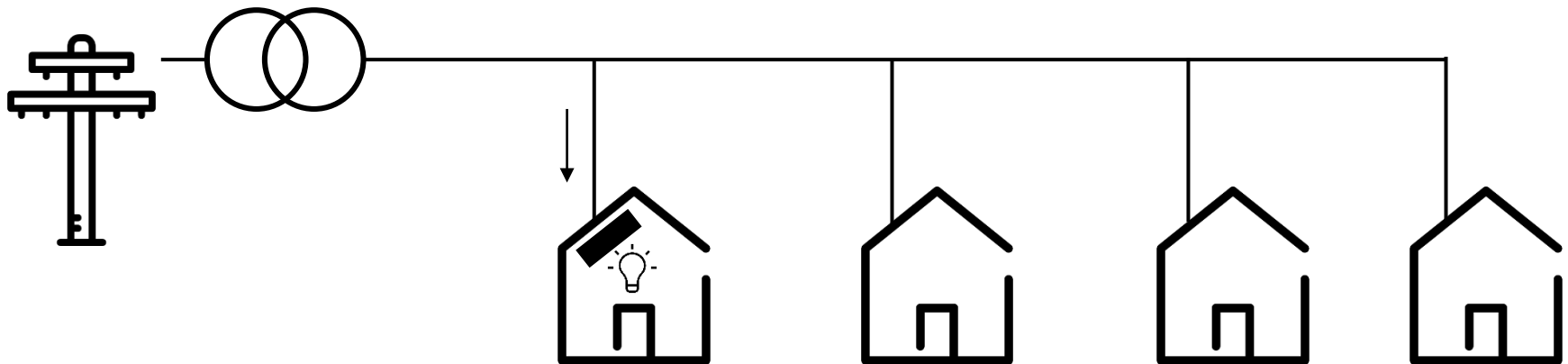
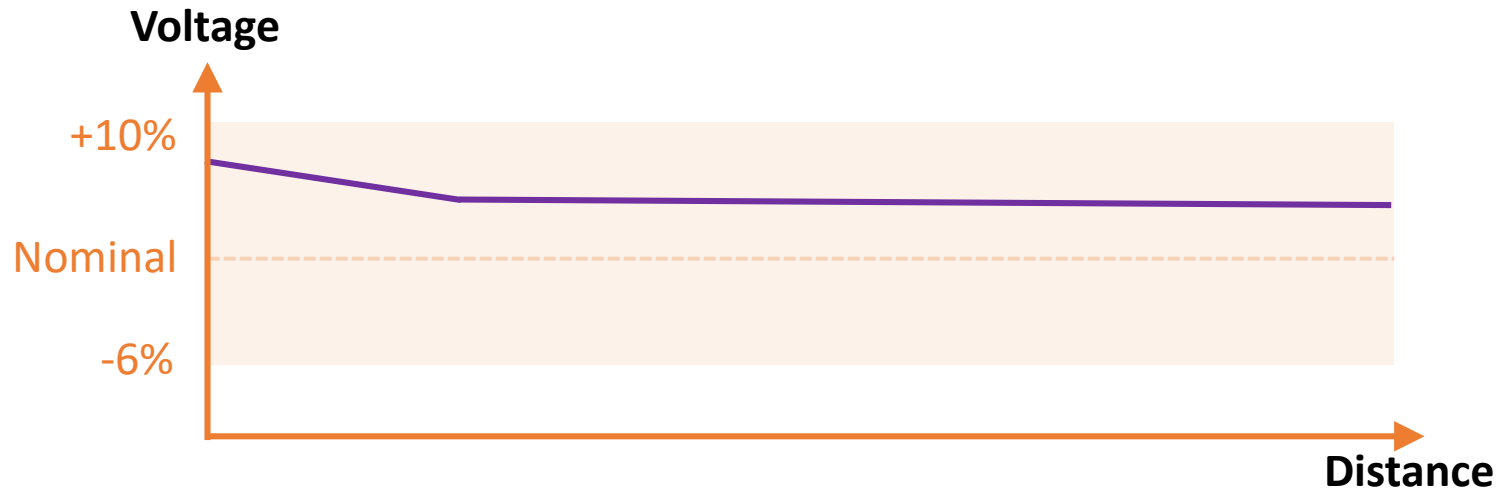
Network voltage management and distributed PV



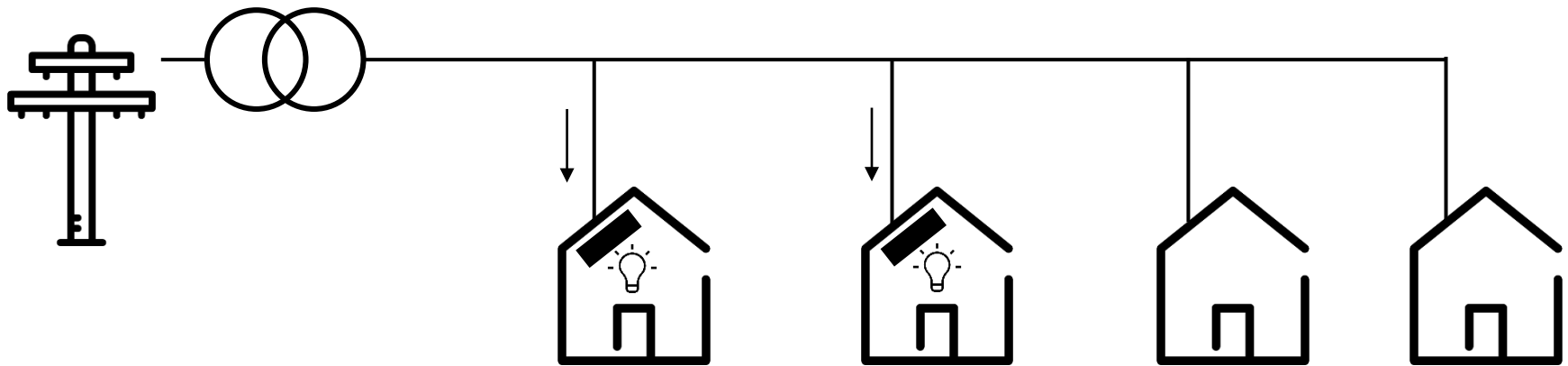
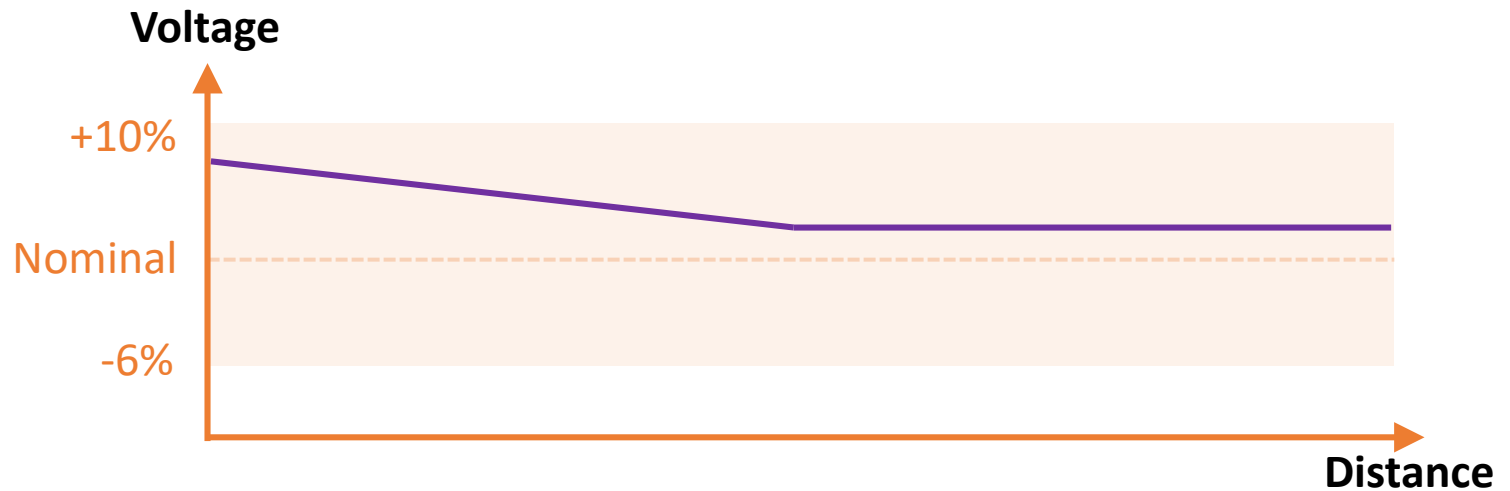
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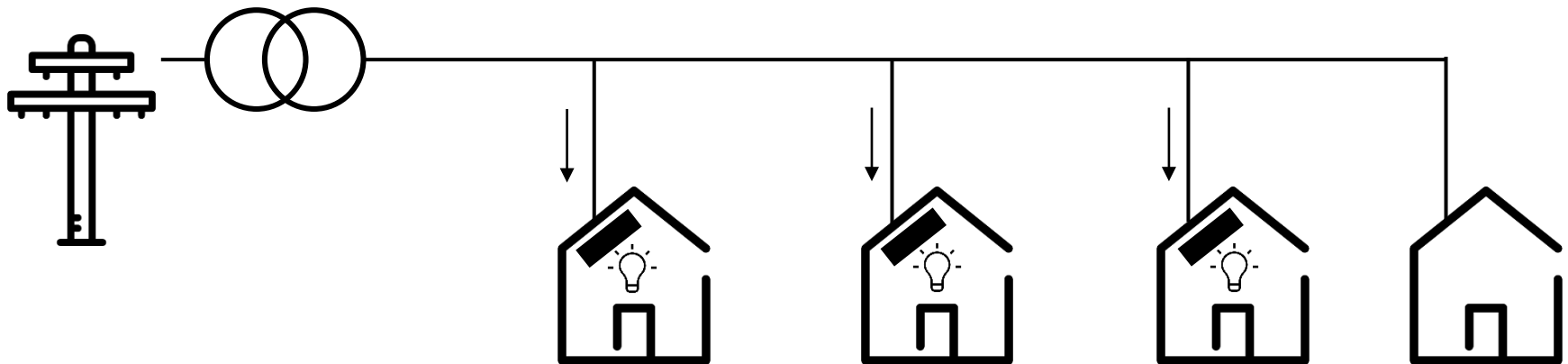
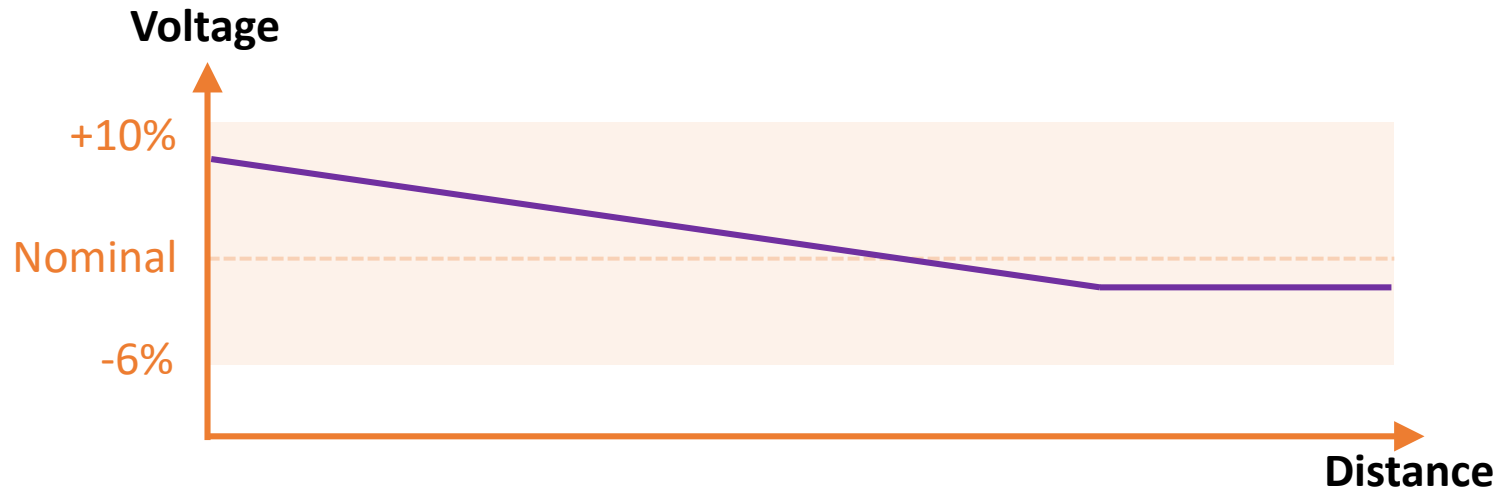
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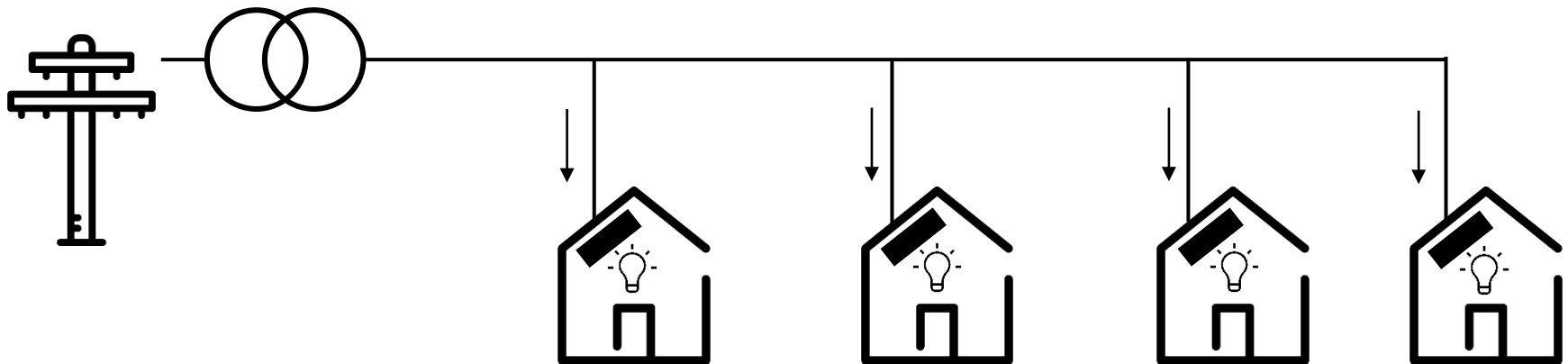
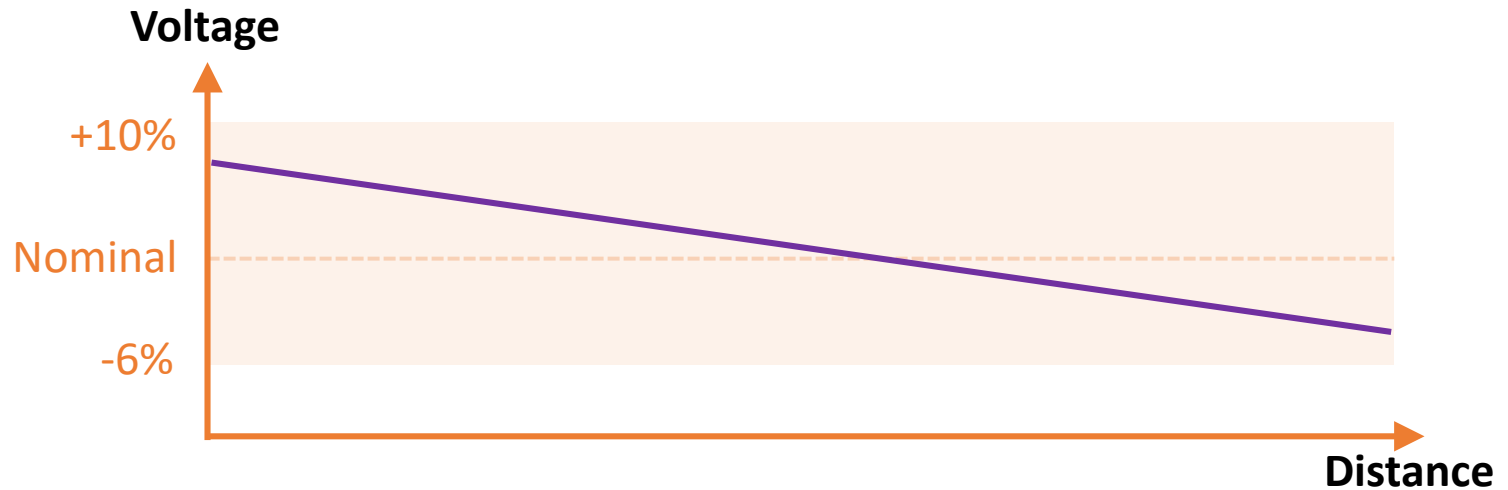
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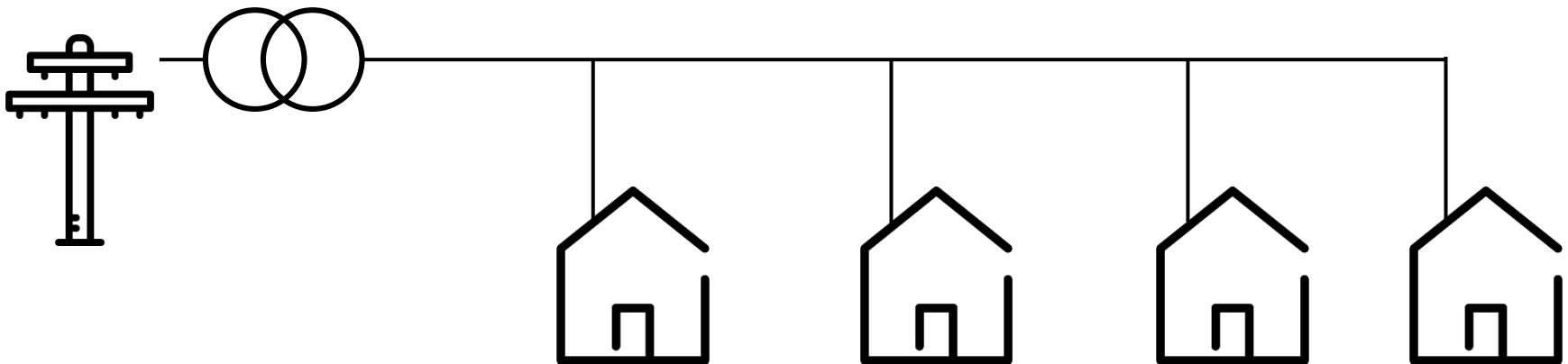
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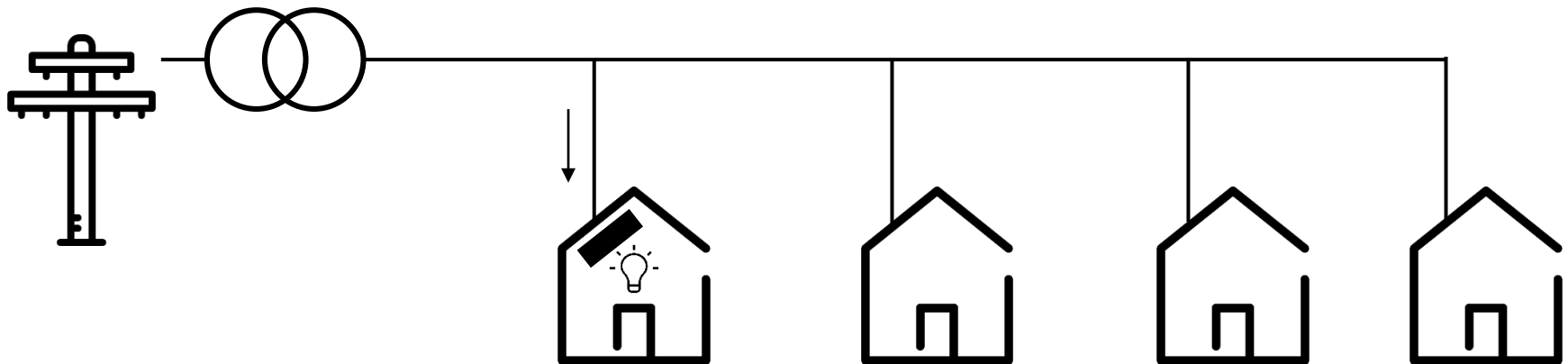
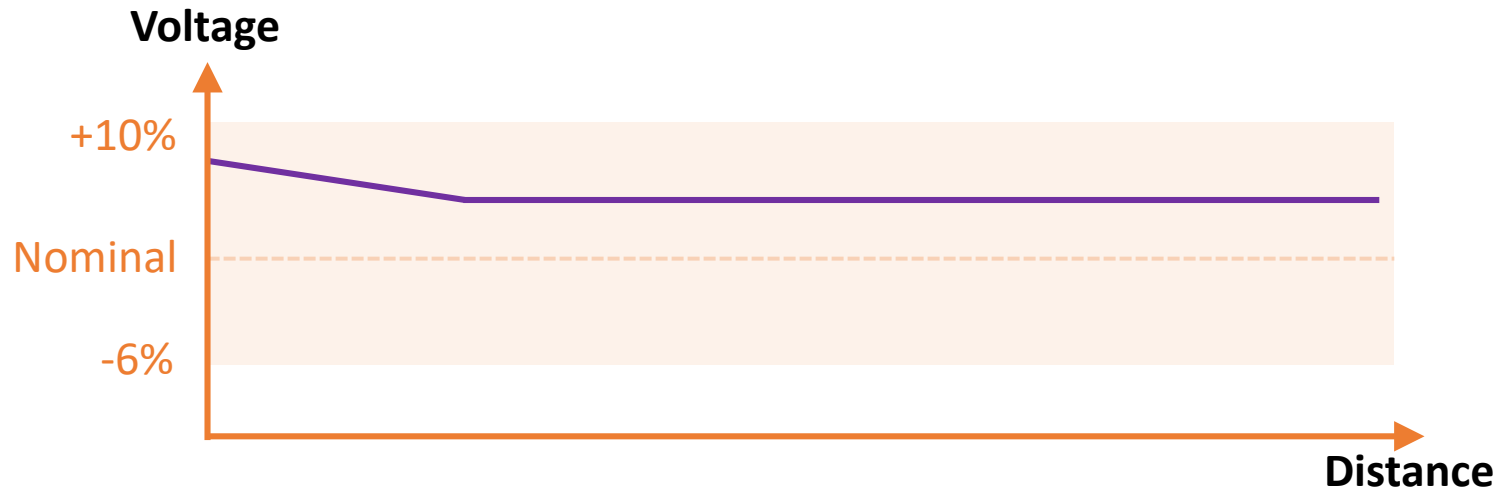
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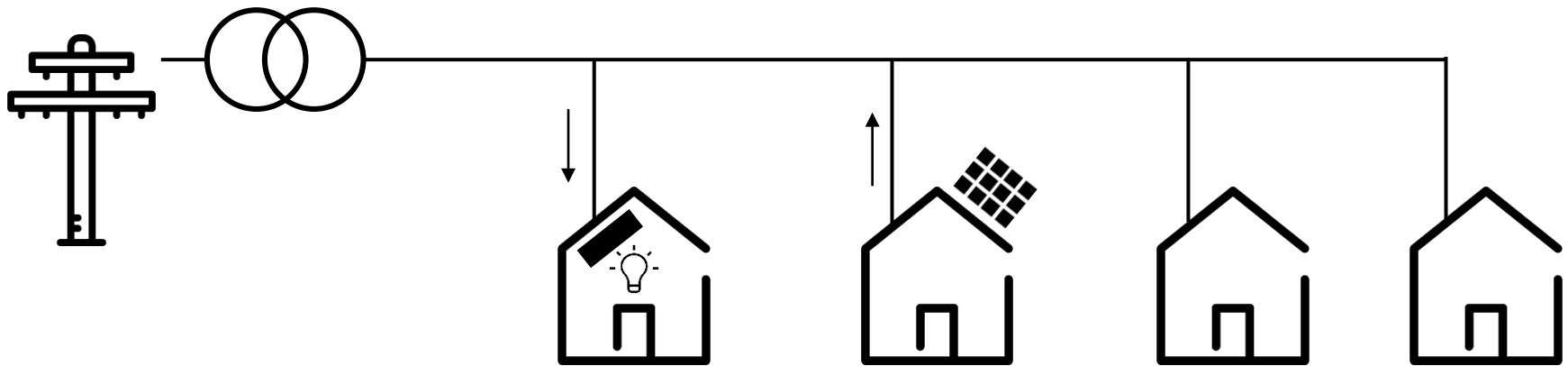
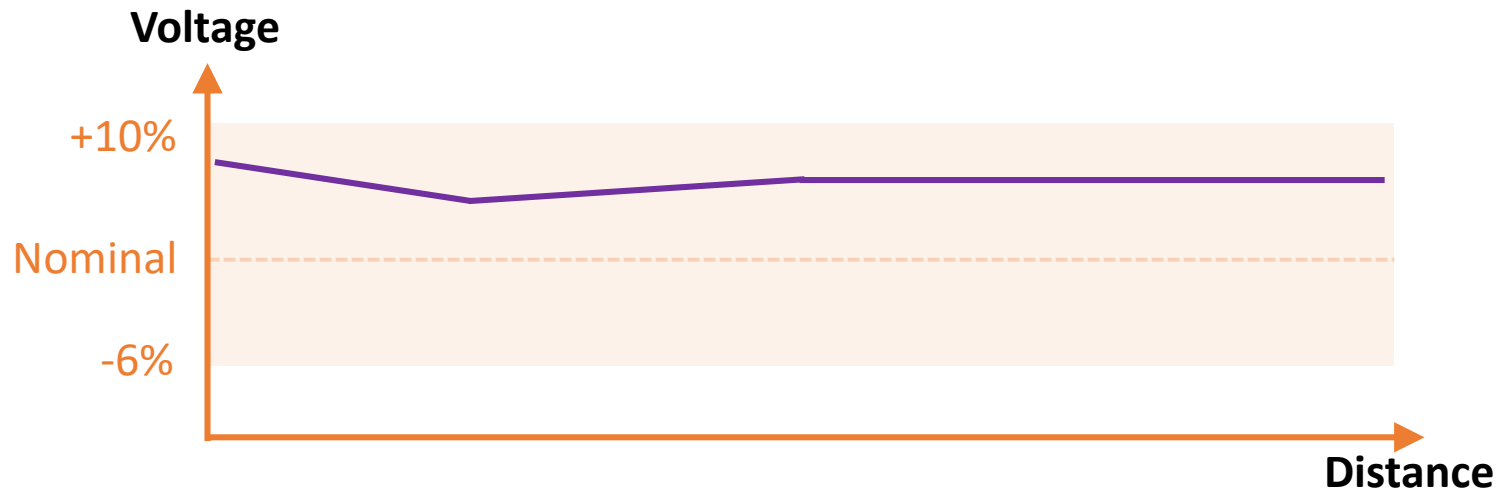
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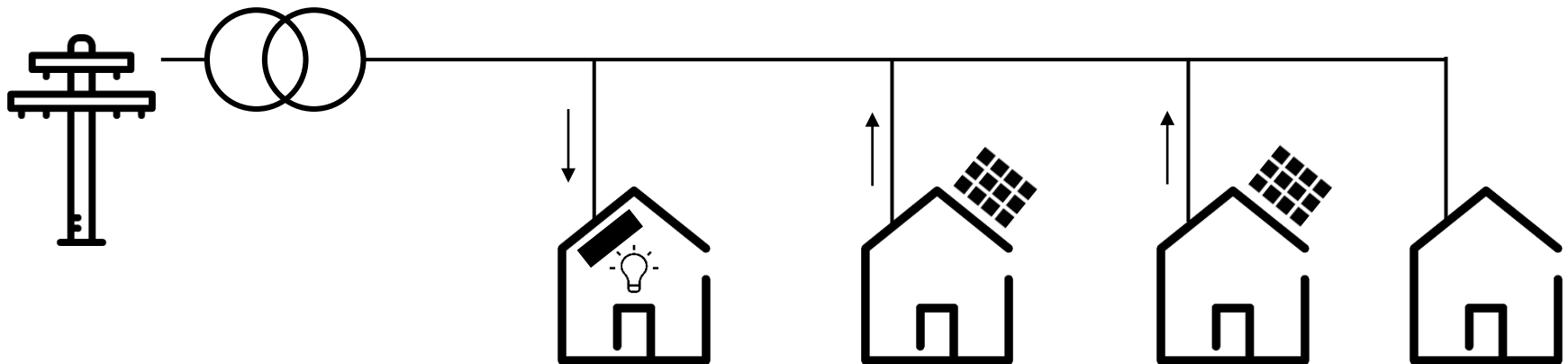
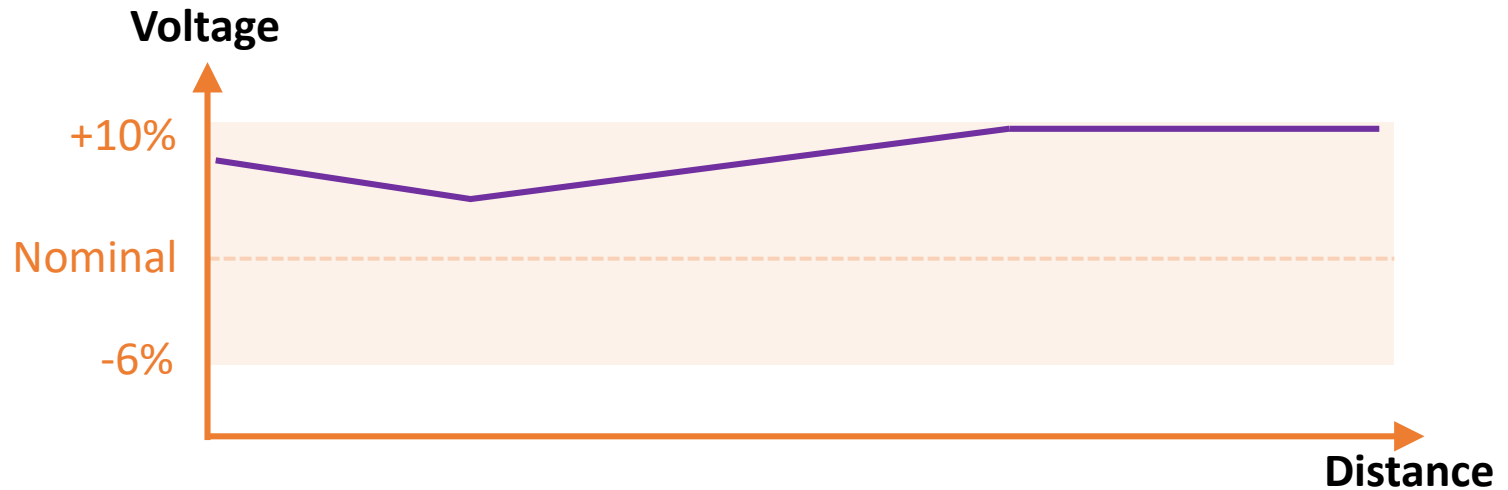
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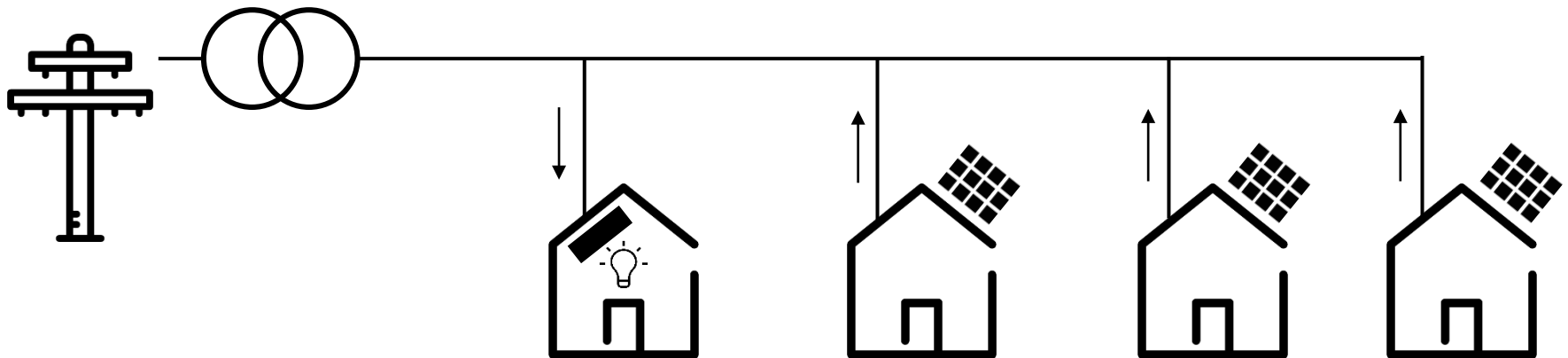
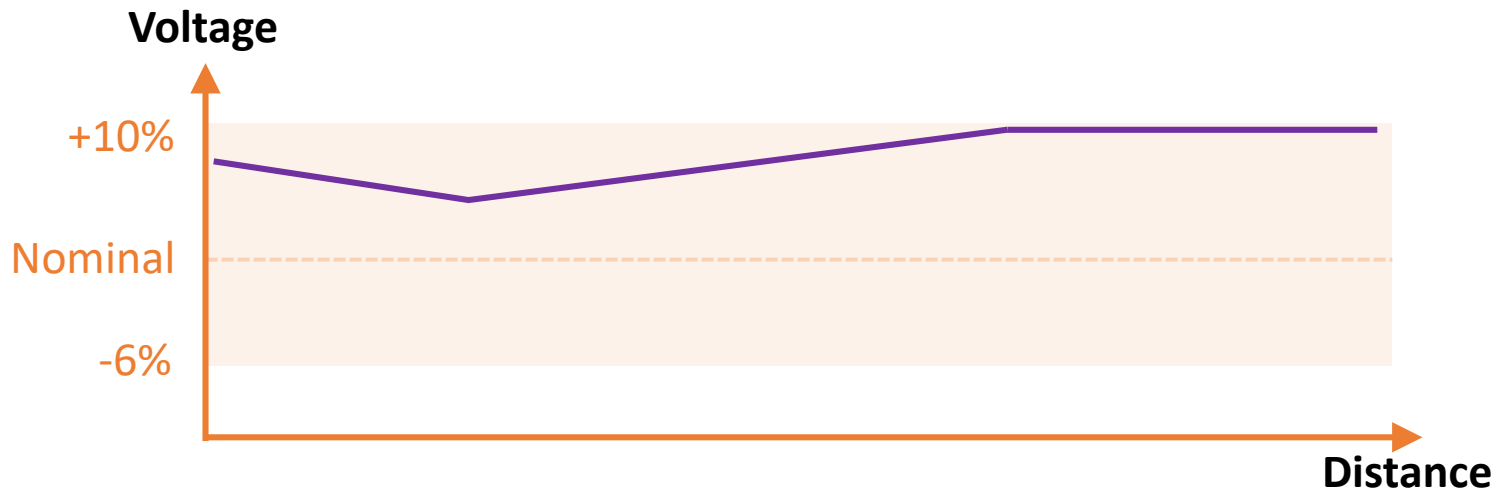
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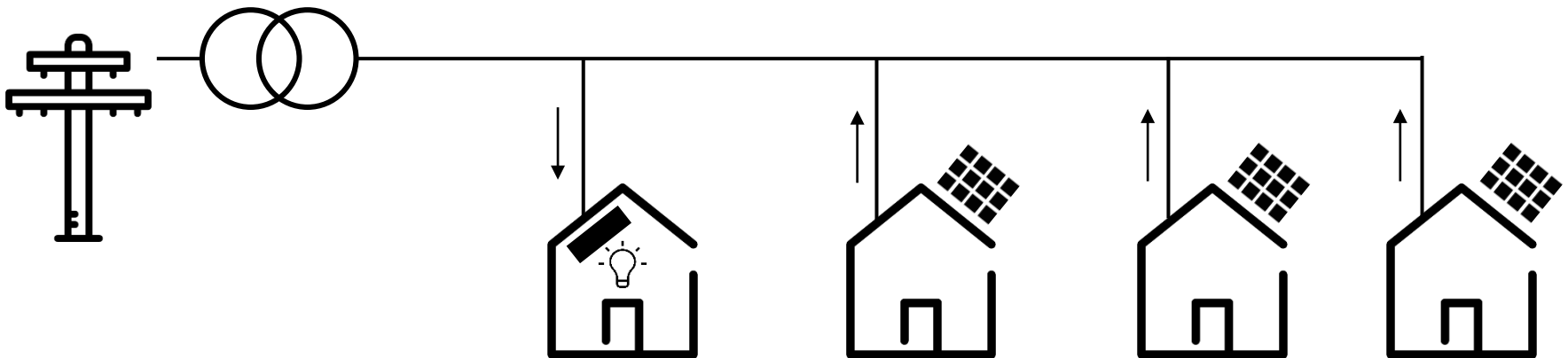
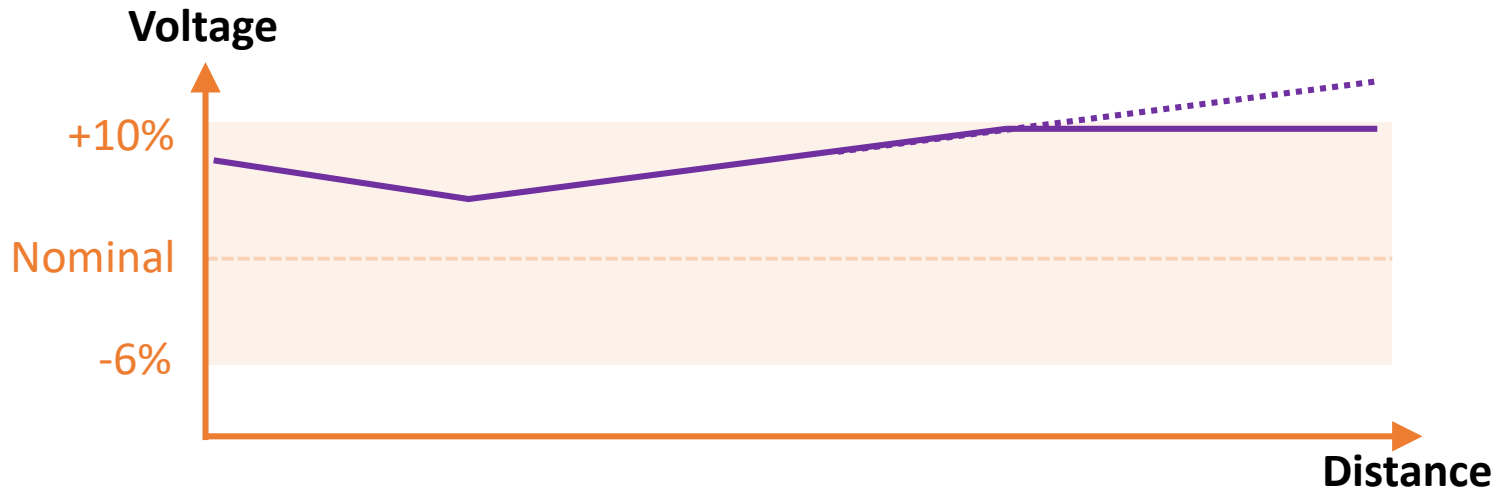
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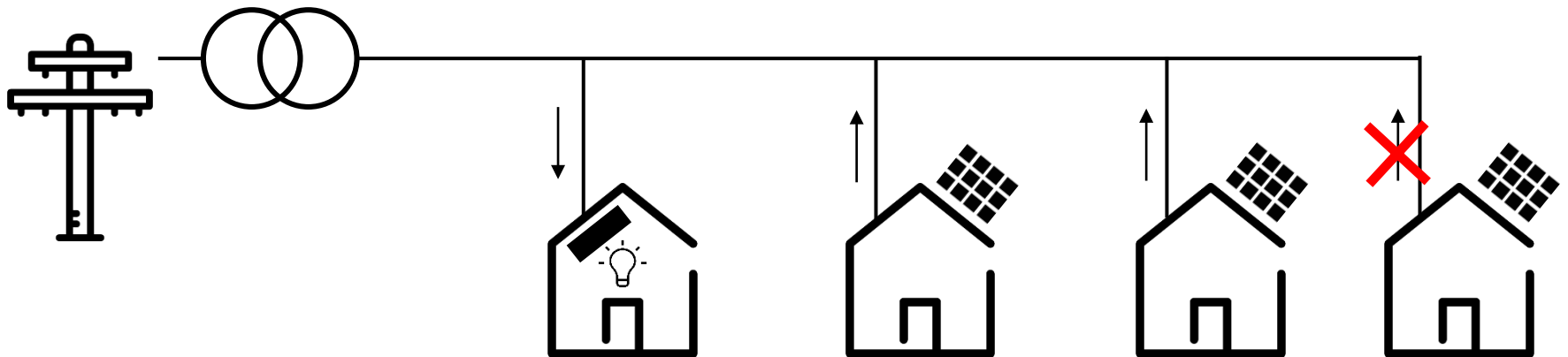
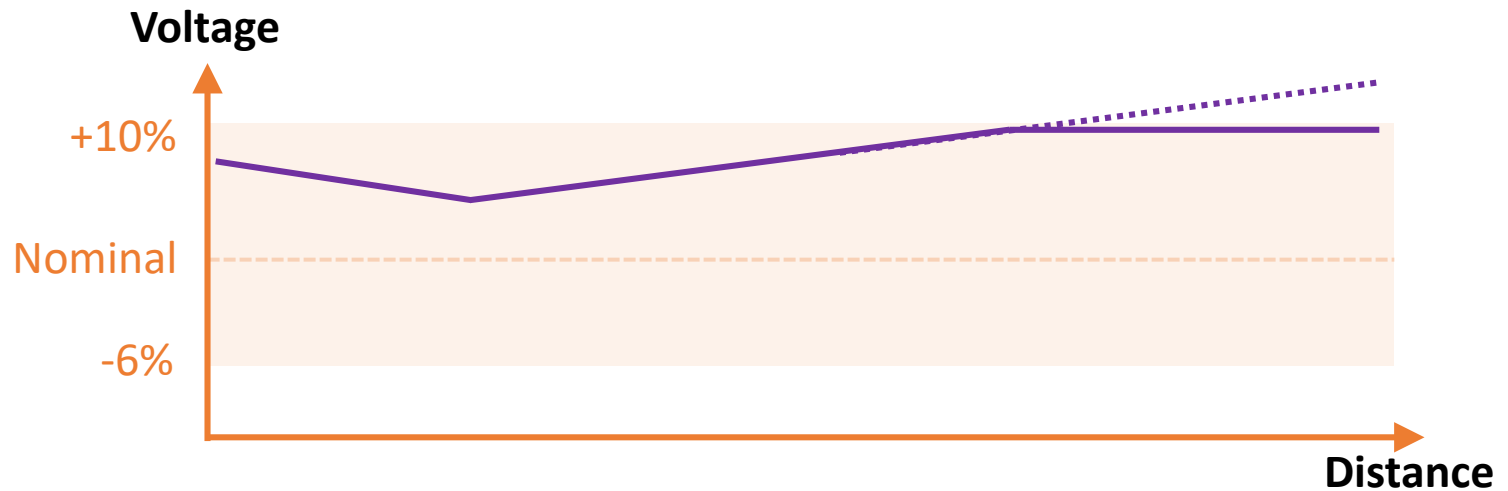
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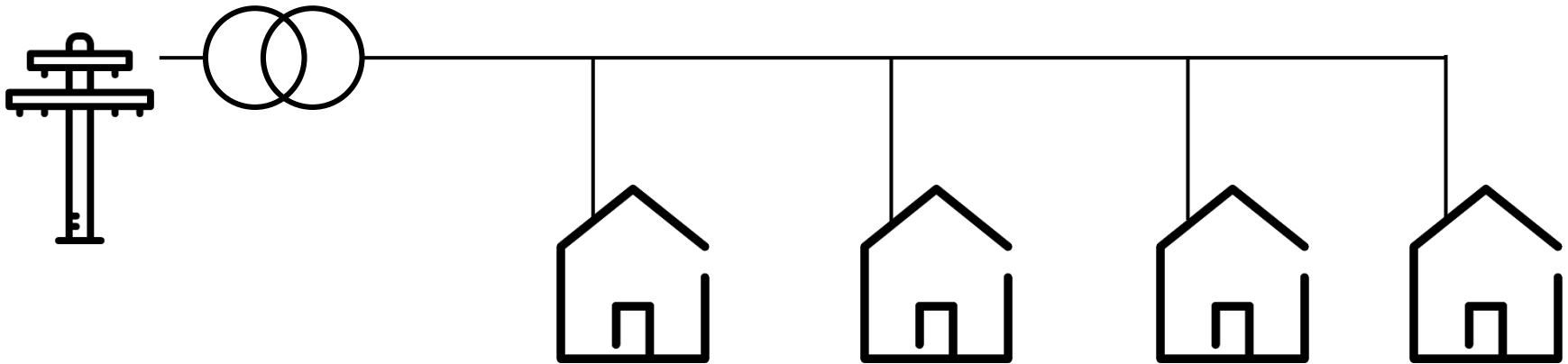
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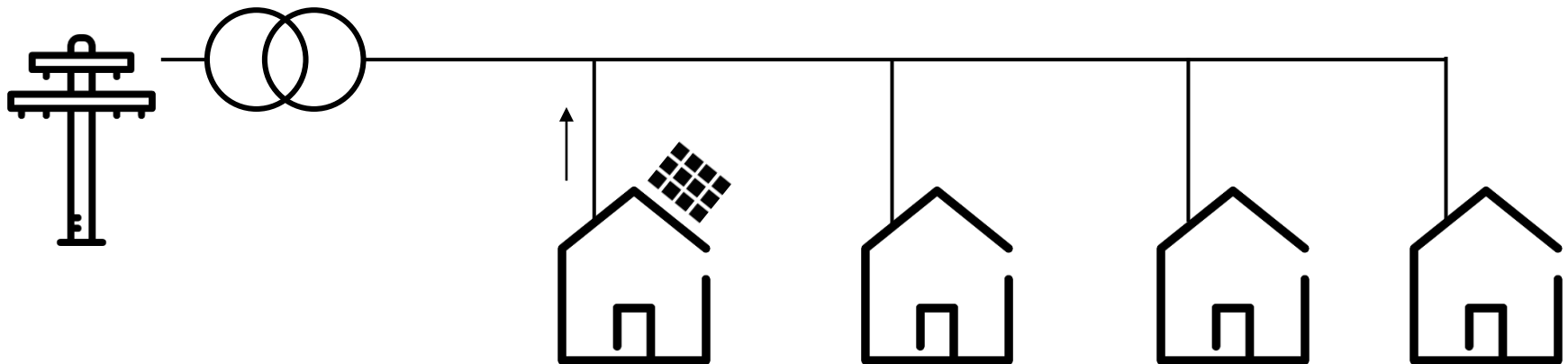
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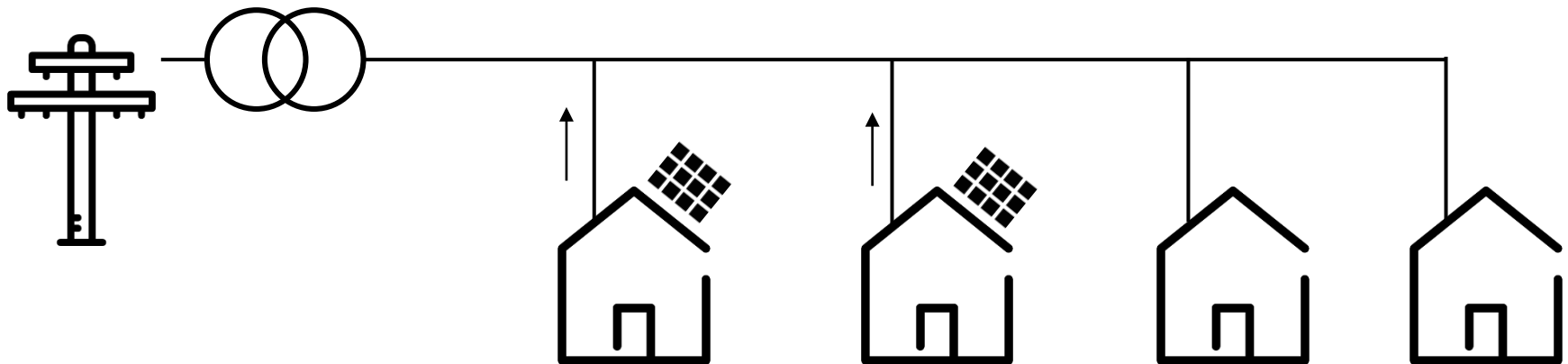
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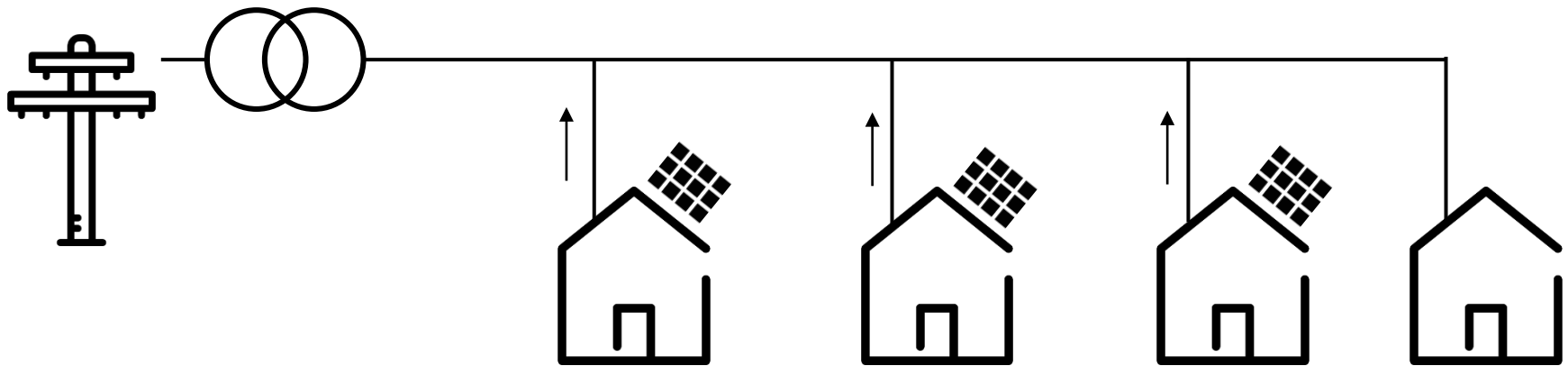
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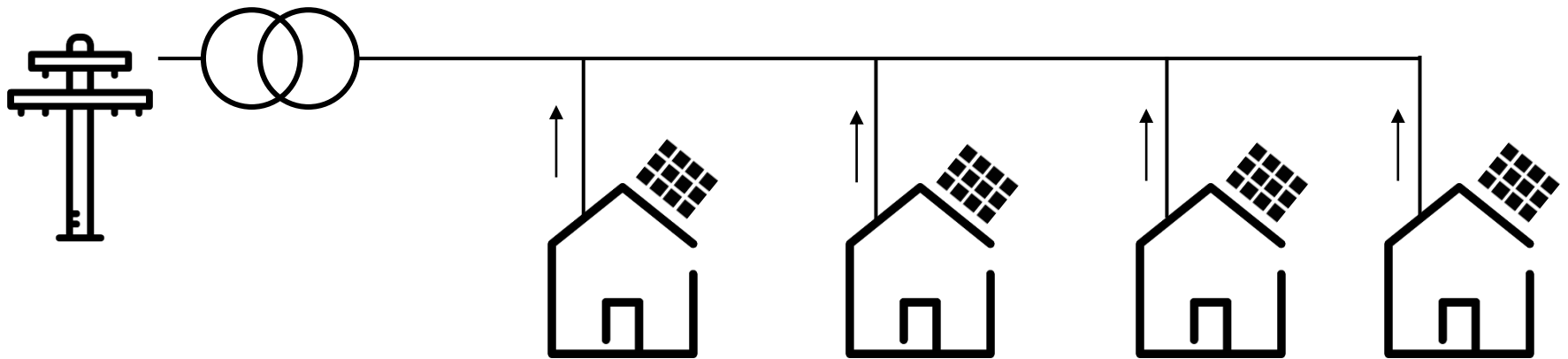
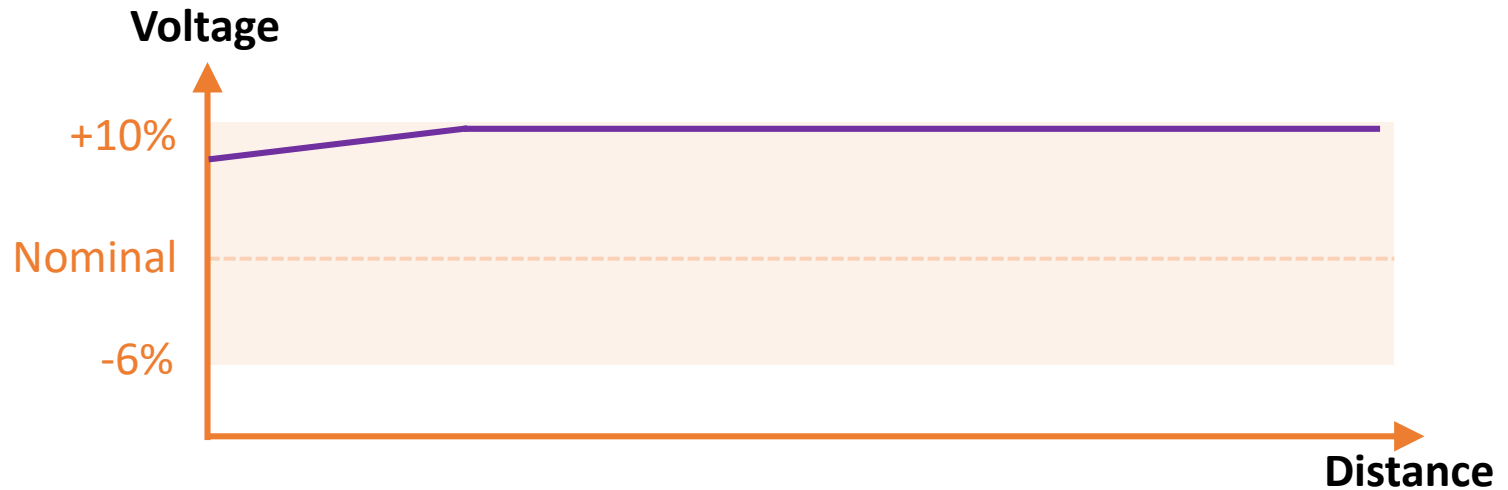
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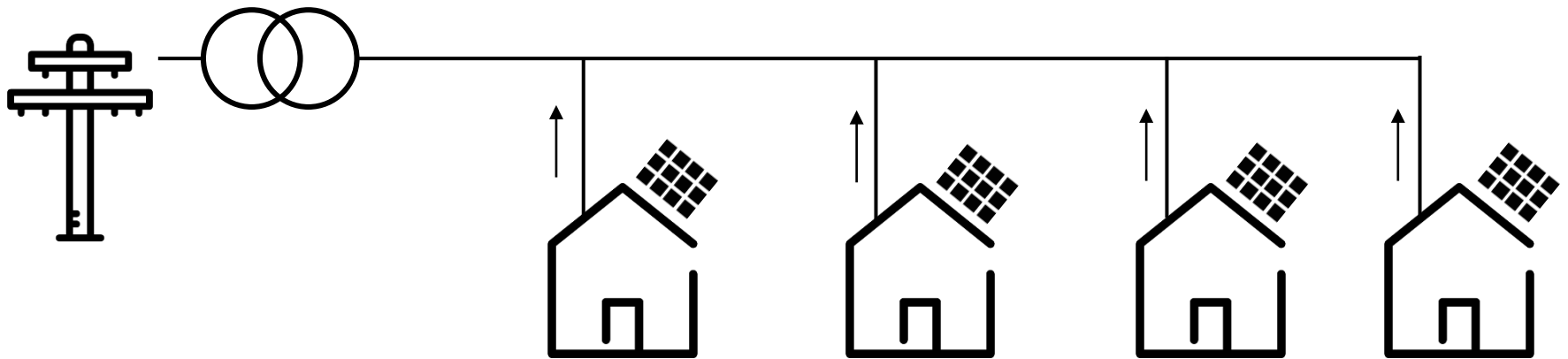
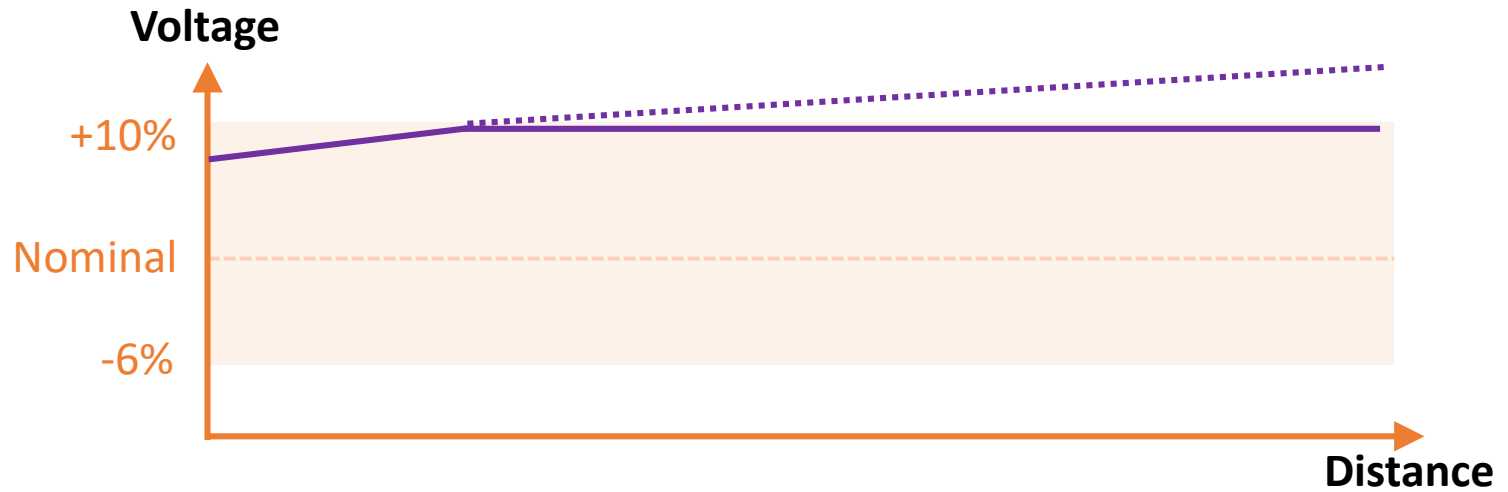
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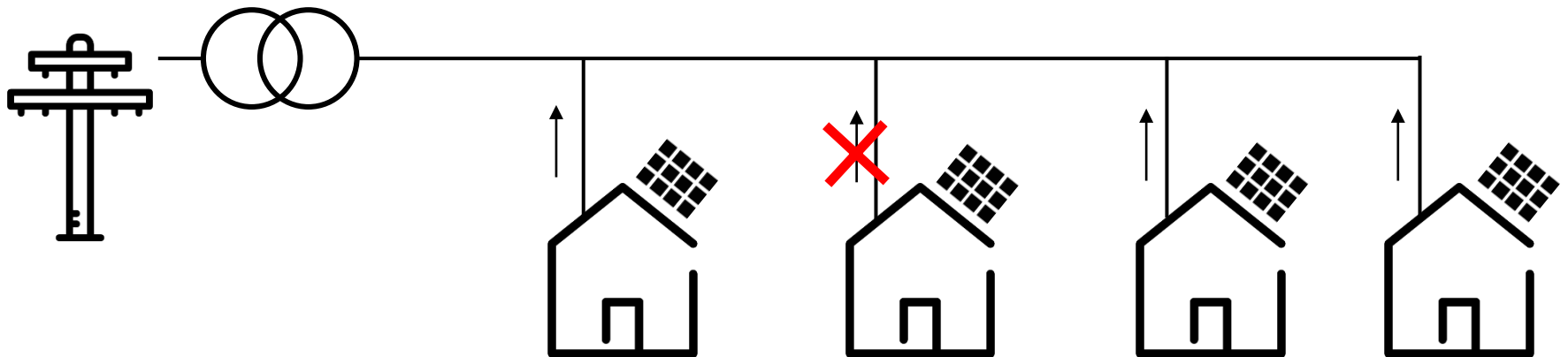
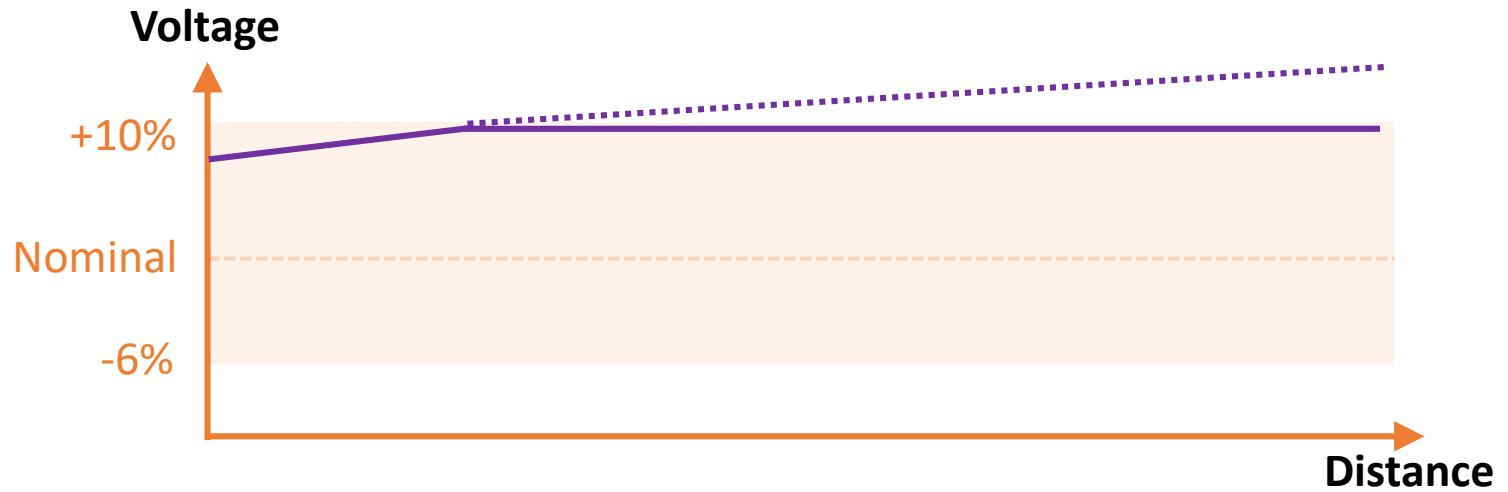
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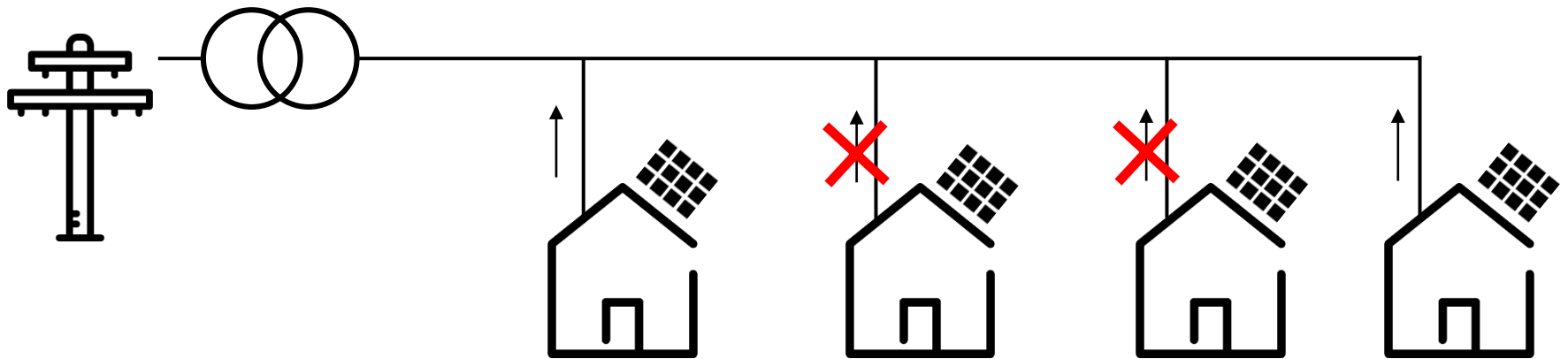
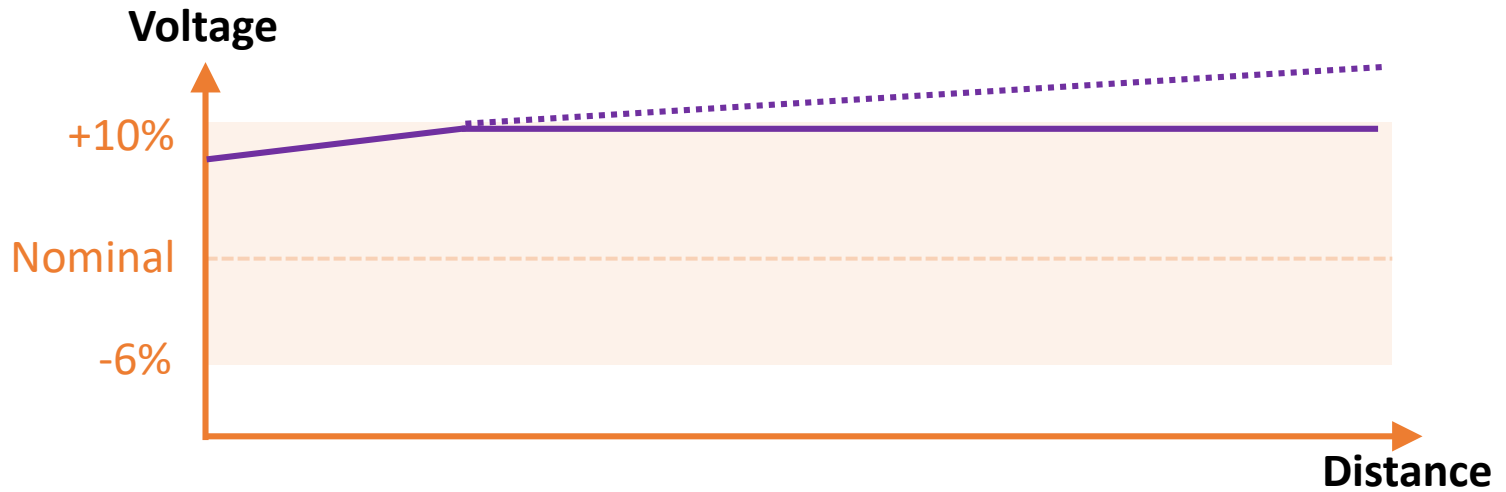
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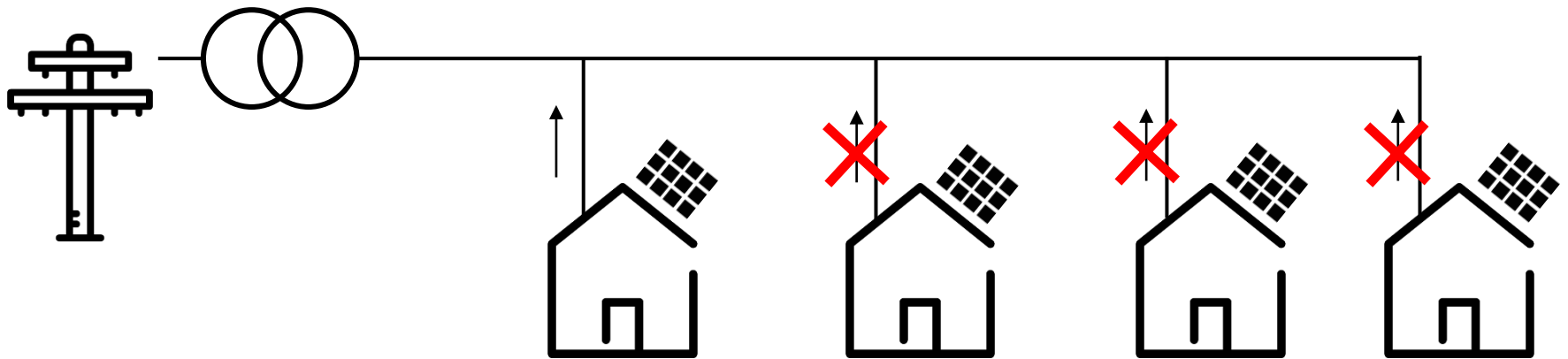
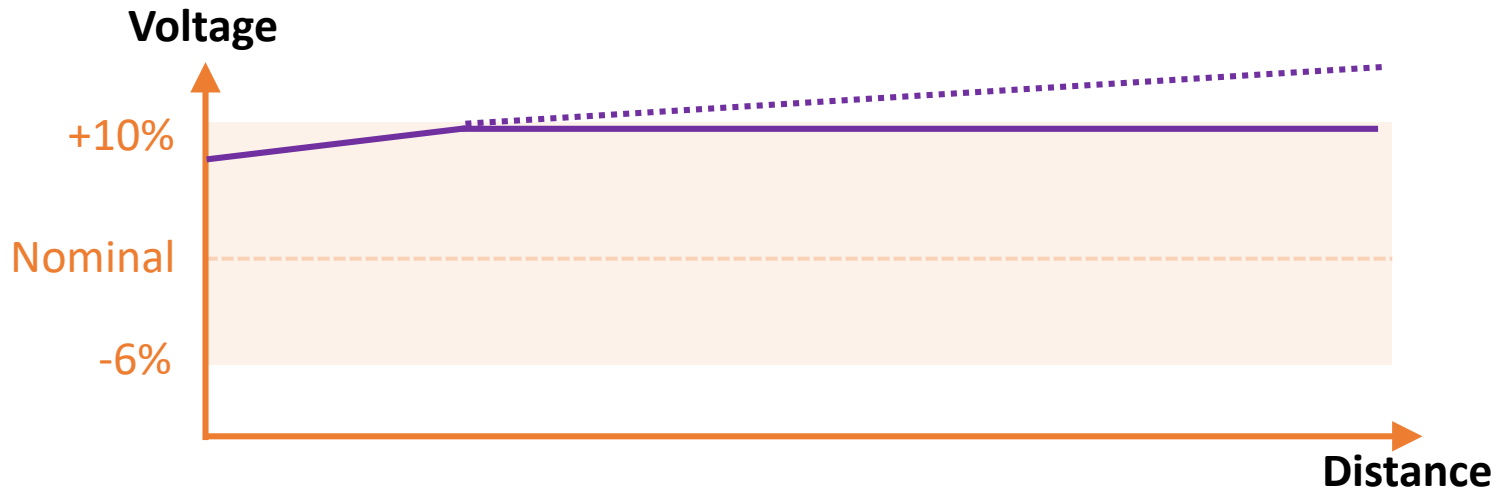
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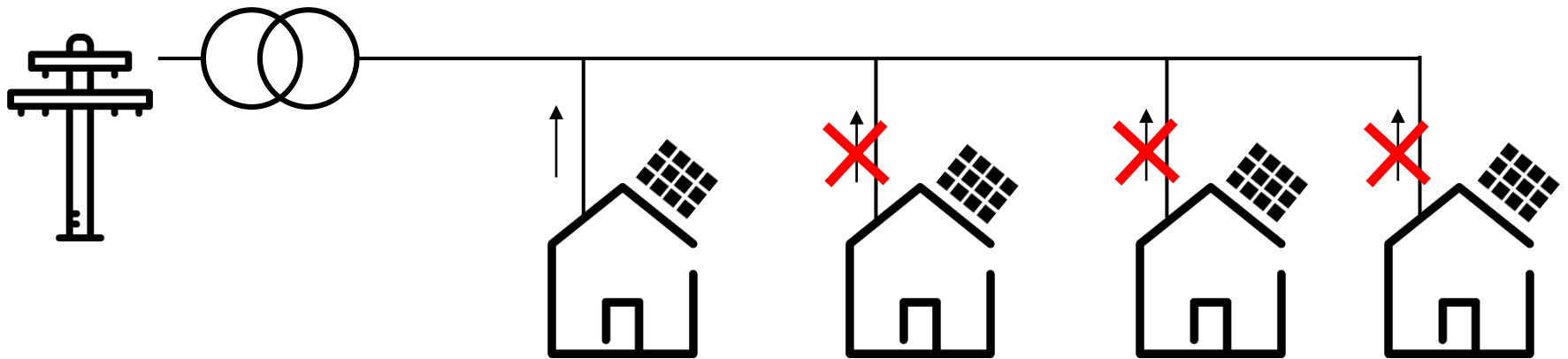
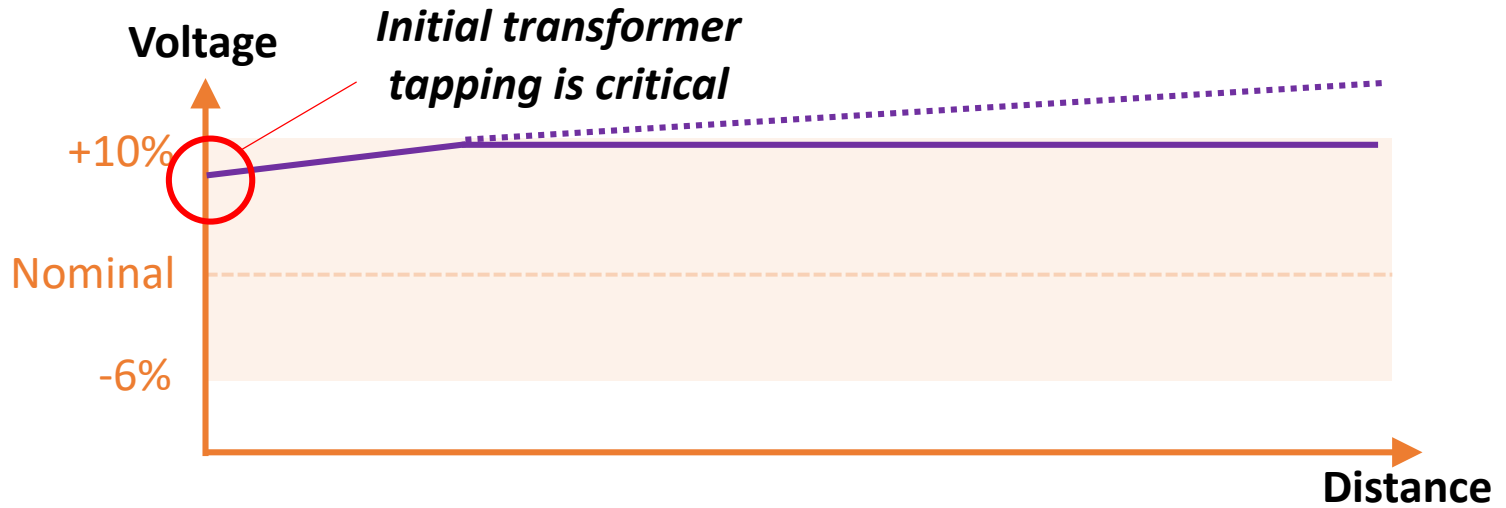
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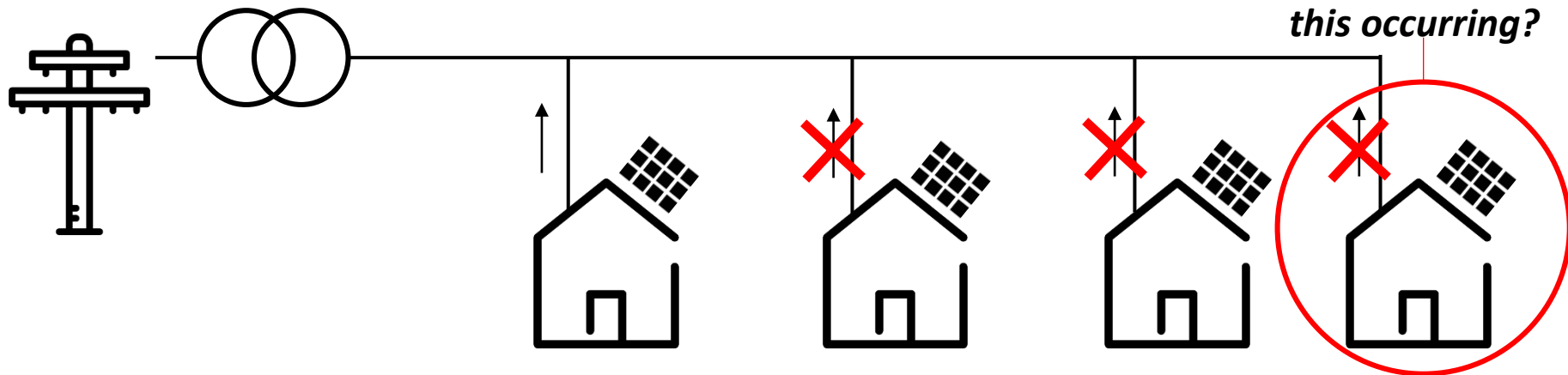
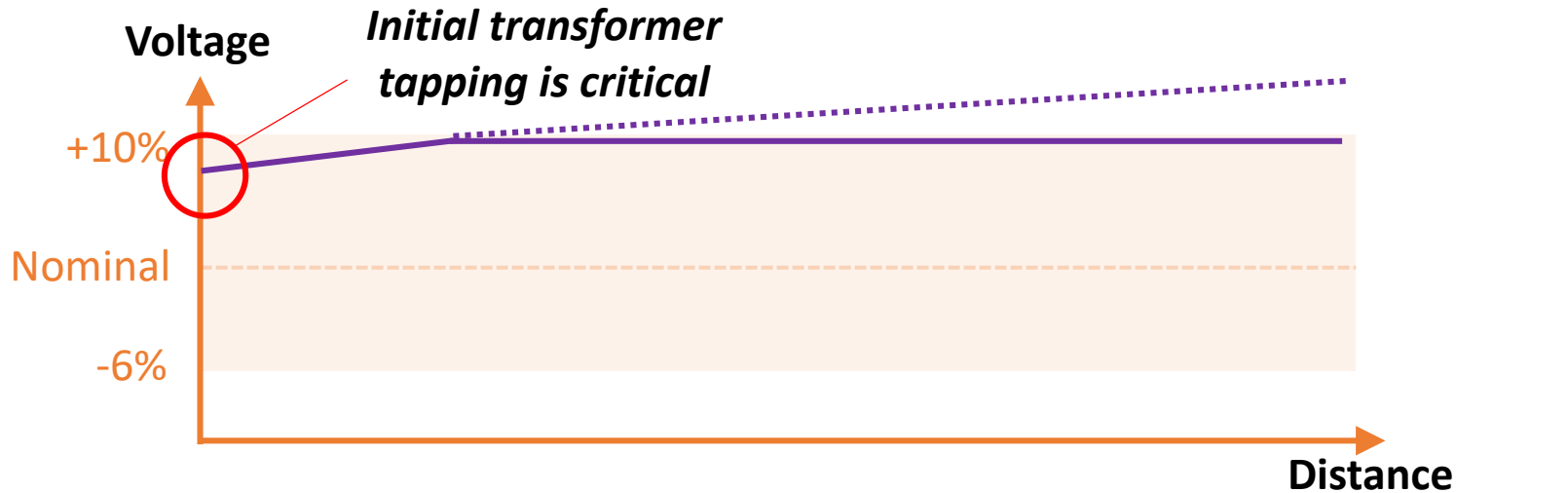
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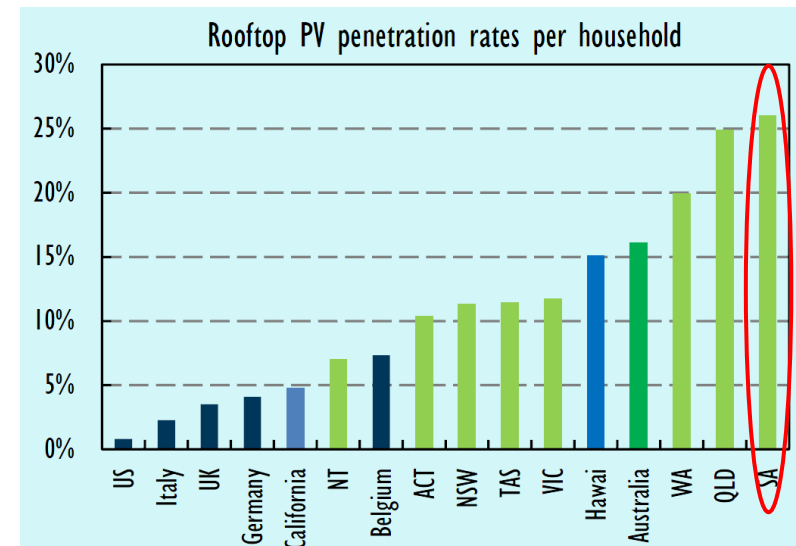
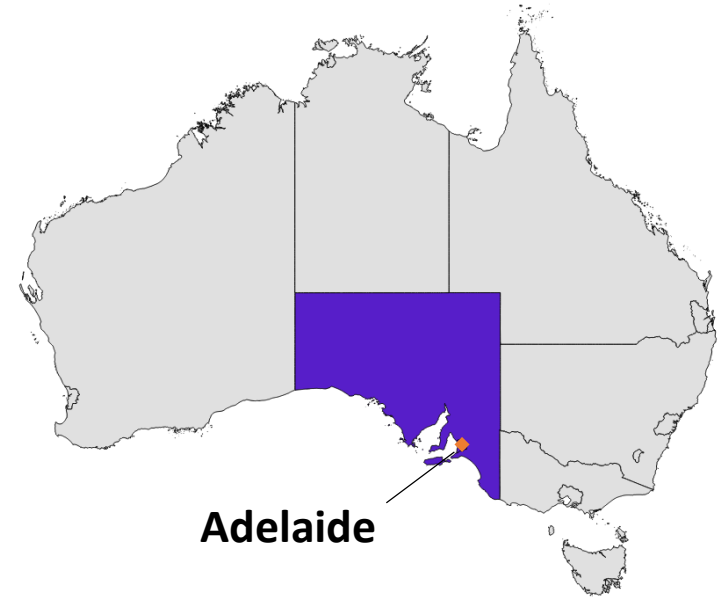


Is PV curtailment an economically efficient outcome compared with 'network solutions'?

How are consumers with PV being impacted by this issue?
(Is curtailment equitable?)

South Australian case study

- 33% dwellings have PV installed¹
- ~60% have air conditioning²
- Maximum summer day 27 - 46°C (80 - 114 °F)³



IEA, 2016⁴

¹ APVI maps: <http://pv-map.apvi.org.au/historical#4/-26.67/134.12>

² Australian Bureau of Statistics: <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4602.0.55.001Mar%202014?OpenDocument>

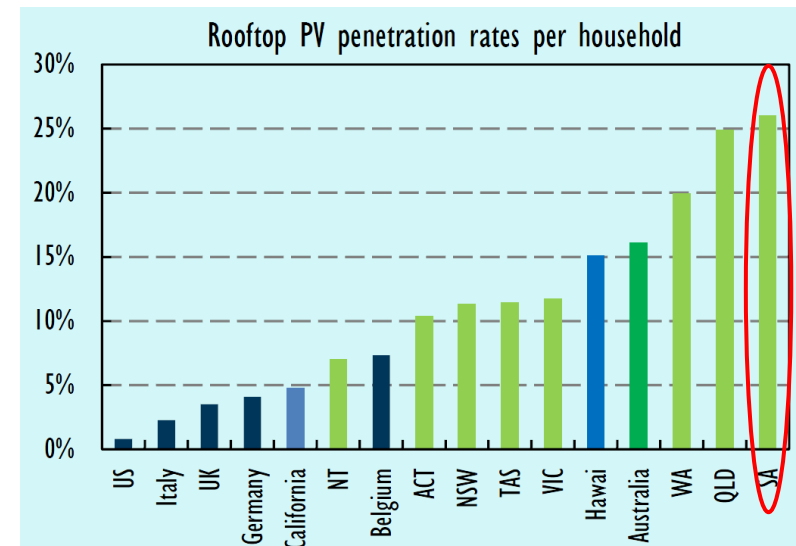
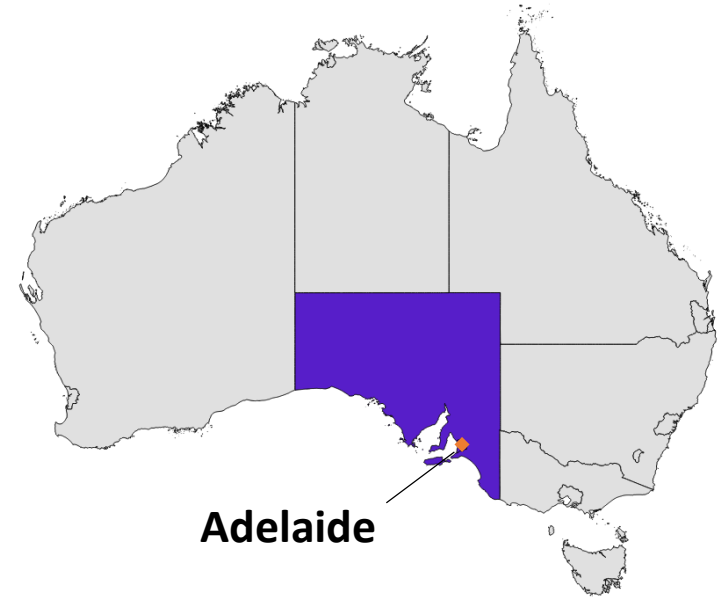
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- Network regulation
 - Five year regulatory periods
 - Building block framework
 - Performance based incentive schemes



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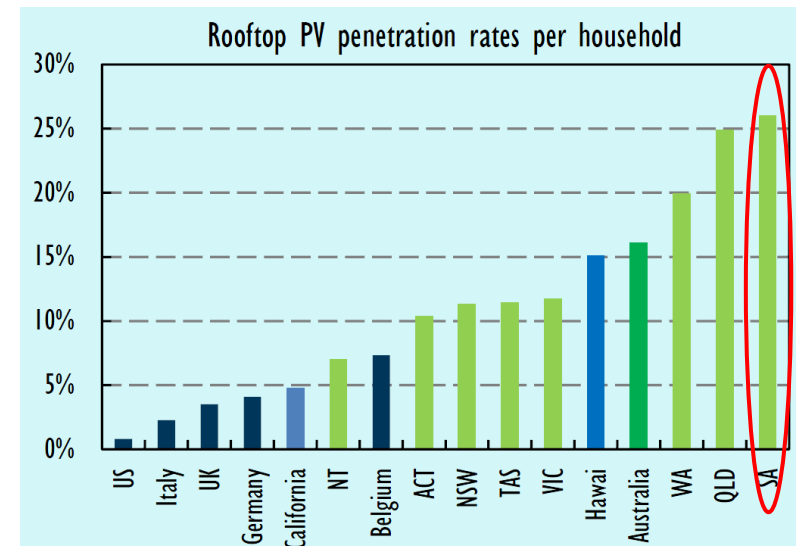
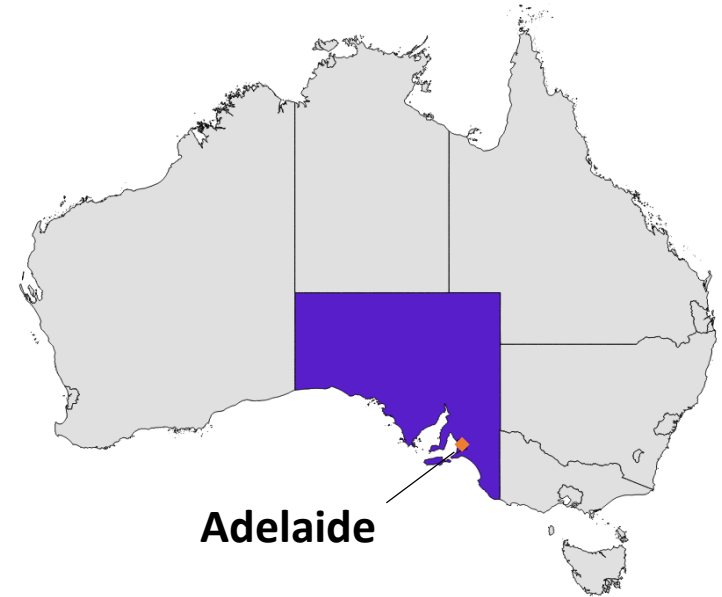
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 - Performance based incentive schemes
- Australian Energy Market Commission, 'Distribution Market Model' key principal:
 - 'facilitating effective consumer choice'⁵



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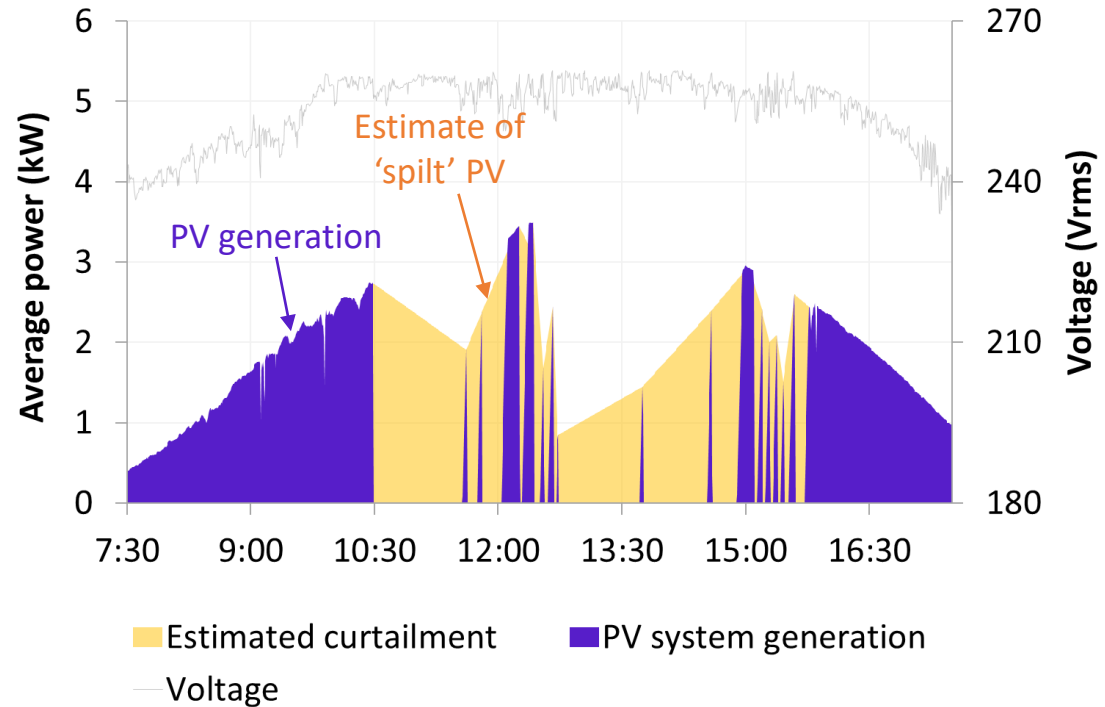
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Method overview and data

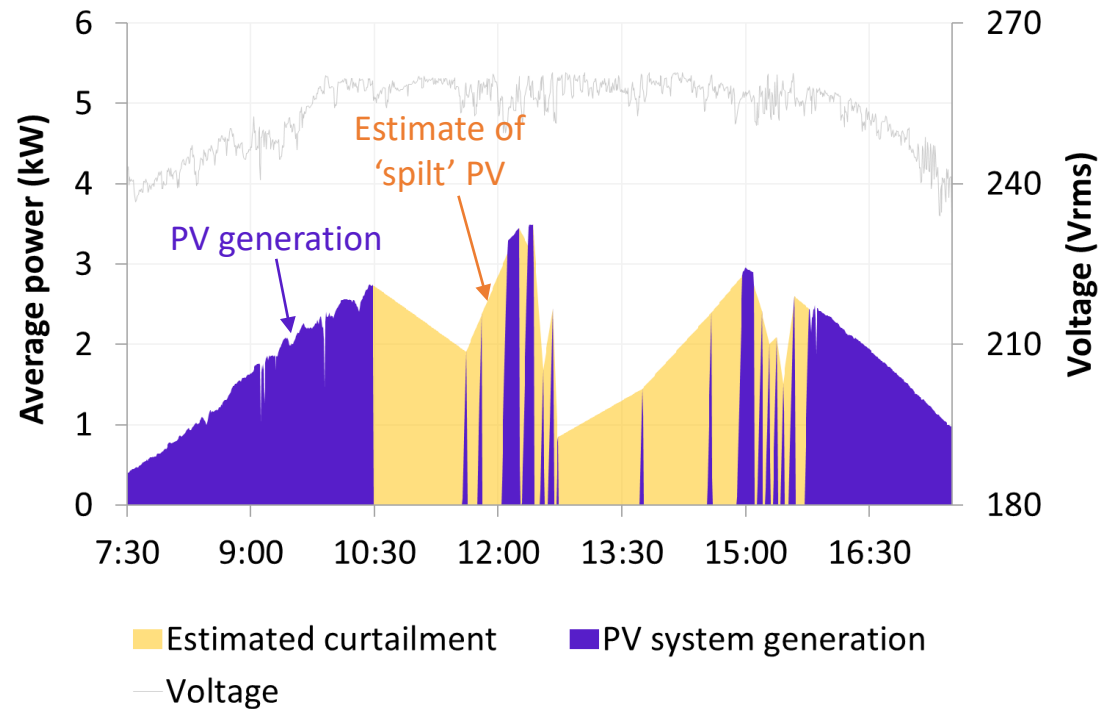


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$$\% \text{ lost} = \frac{\text{Curtailed generation}}{\text{Curtailed generation} + \text{PV generation}}$$

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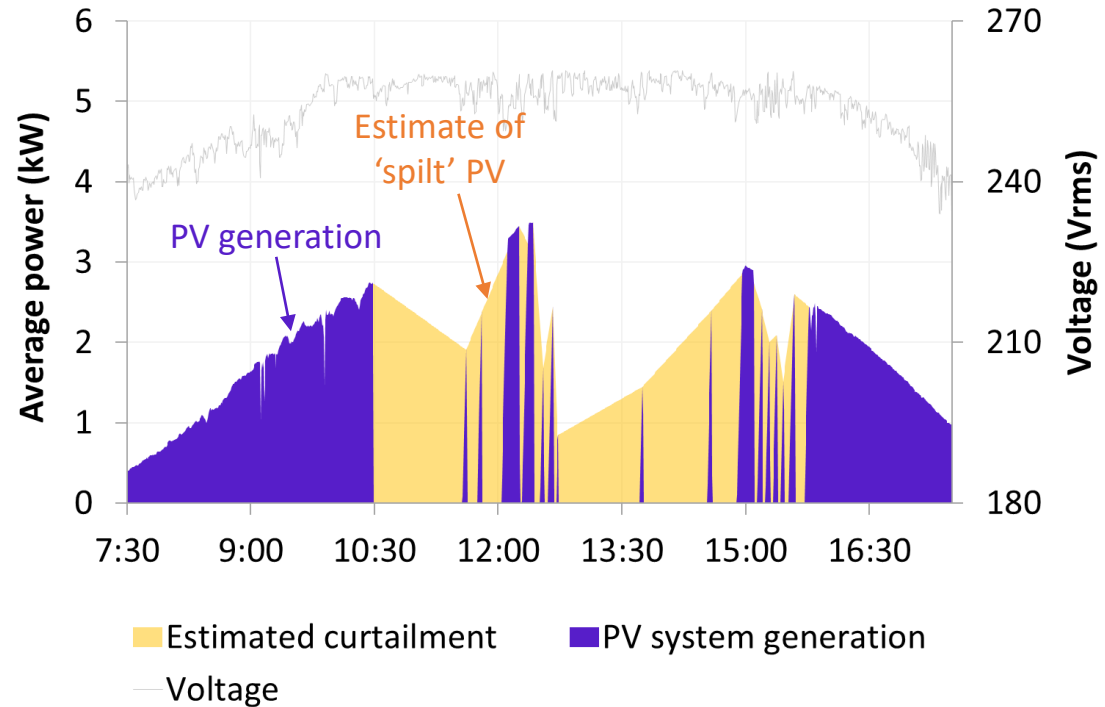
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Method overview and data

Input data:

Solar PV generation

- 170 distributed PV systems
- Located in Adelaide (SA capital)
- 1 month of data, March 2017 (Autumn, 8-35 °C)
- 30sec measurement intervals



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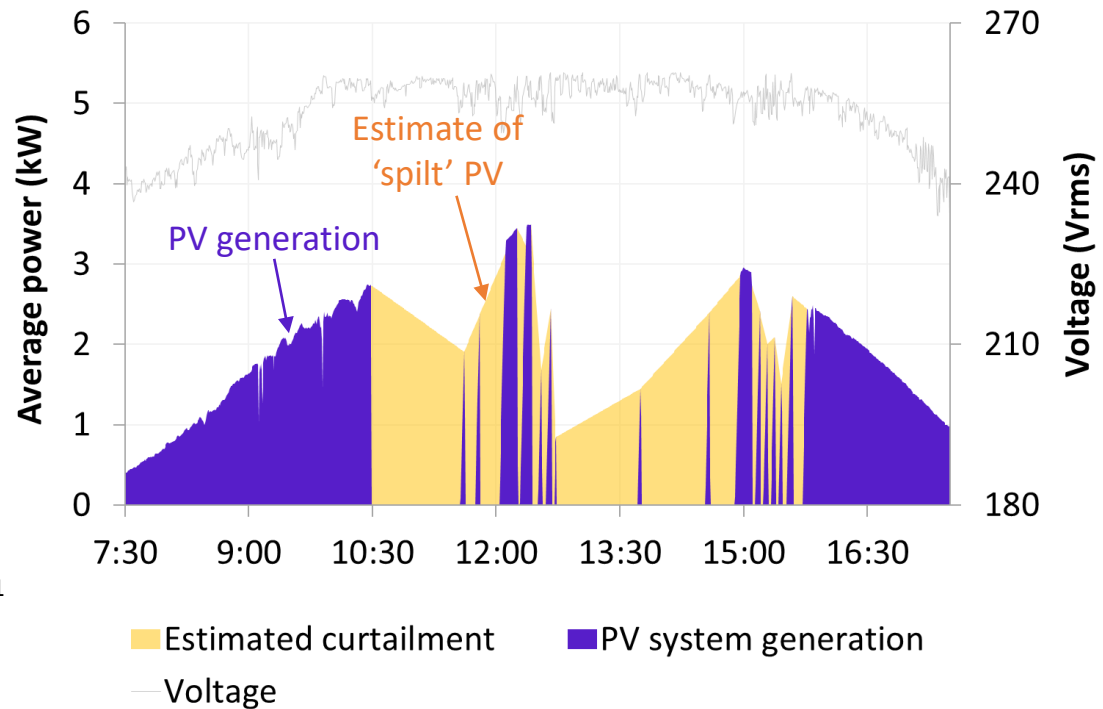
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- Network solution cost and ~asset lifetime¹
- WACC¹
- Battery system cost and ~lifetime²



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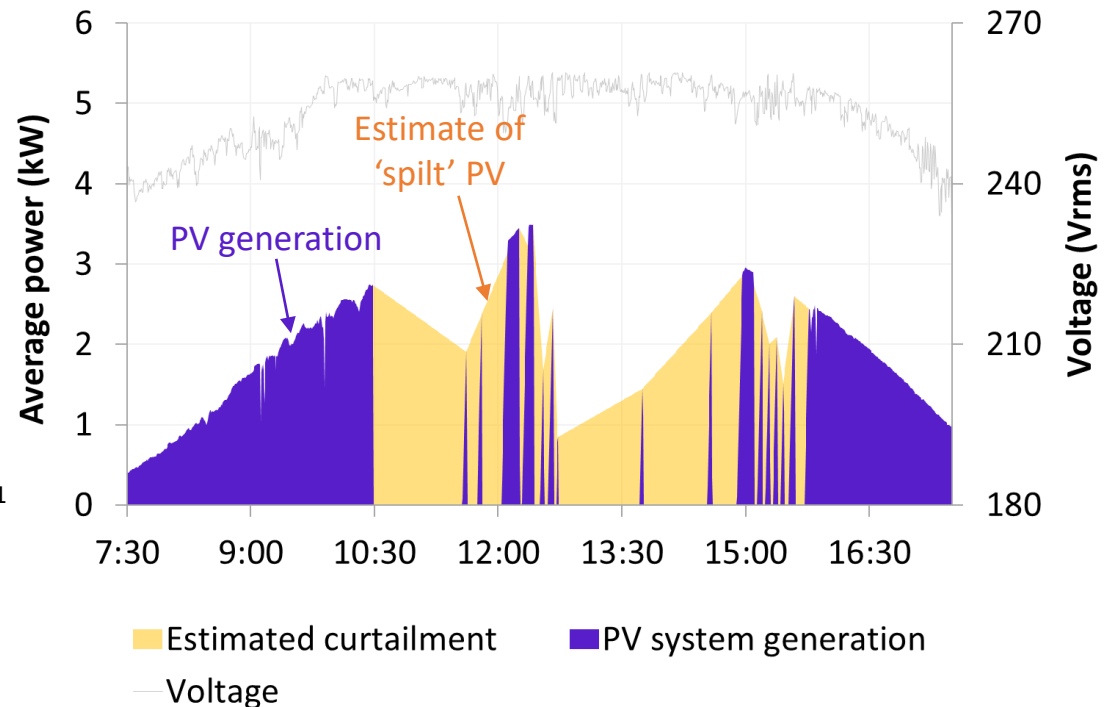
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Outputs:

- Amount of PV generation curtailed (kWh)
- Financial value of PV generation curtailed
- Financial comparison of network solutions and PV curtailment
- Distribution of impacts



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Findings

- ‘Spilt PV’
 - 460 kWh in March 2017 for sample of distributed PV systems
 - Upscales to ~7.3 GWh p.a. across South Australia
- ~\$0.6 – \$1.8m AUD p.a. lost value



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- \$112m AUD capex
- \$1m AUD opex

→ ~\$9.7m AUD p.a.



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• Distribution of impacts?

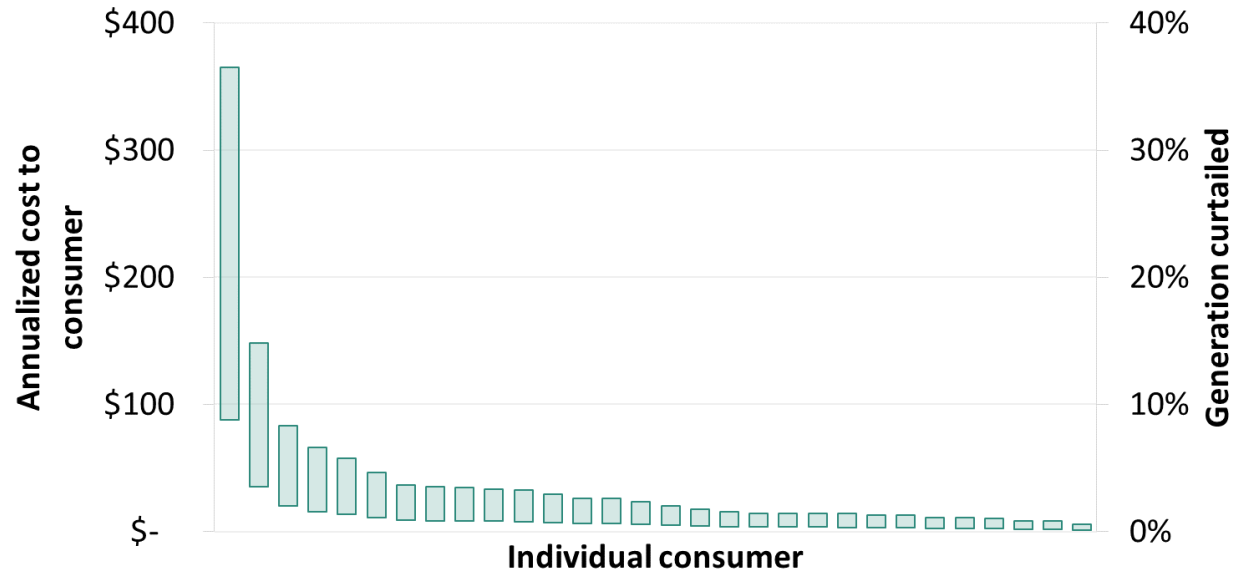
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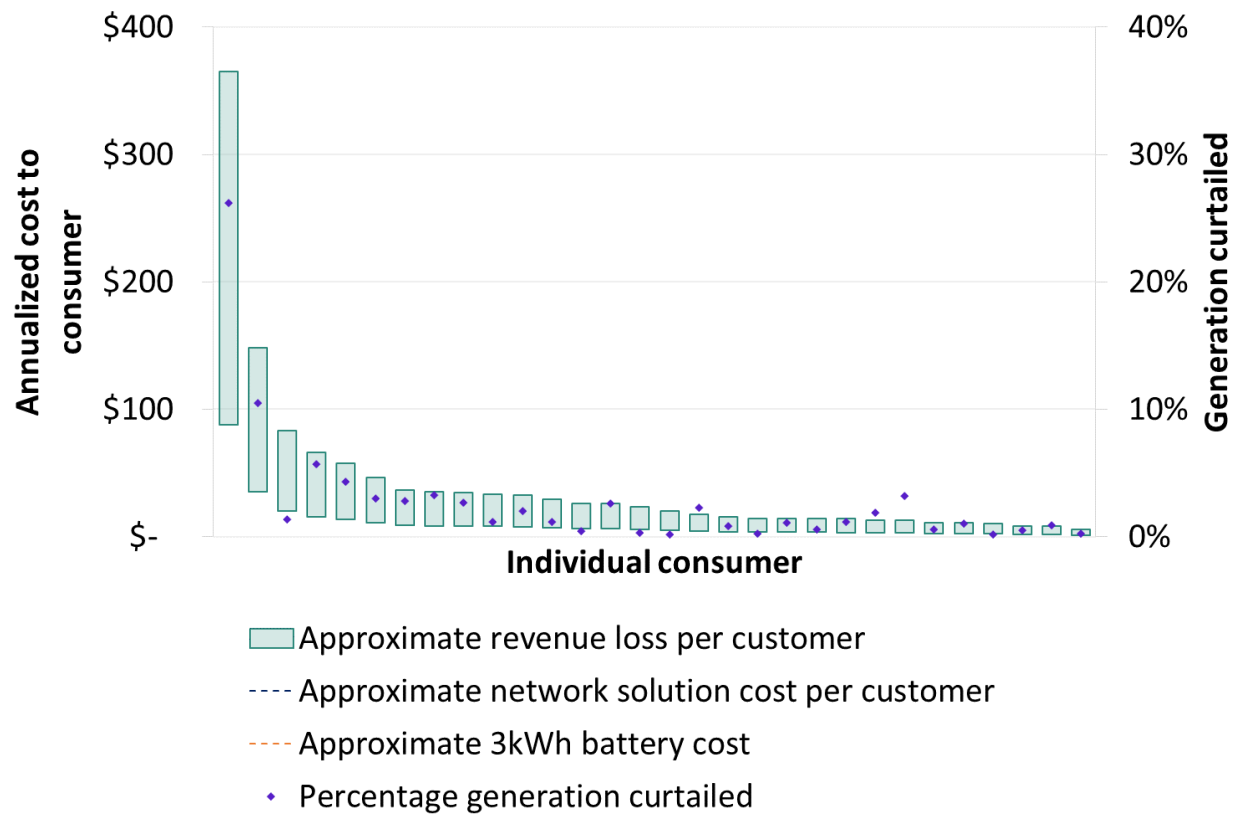
Cost comparison for 30 most impacted consumers



- Approximate revenue loss per customer
- Approximate network solution cost per customer
- Approximate 3kWh battery cost
- ◆ Percentage generation curtailed

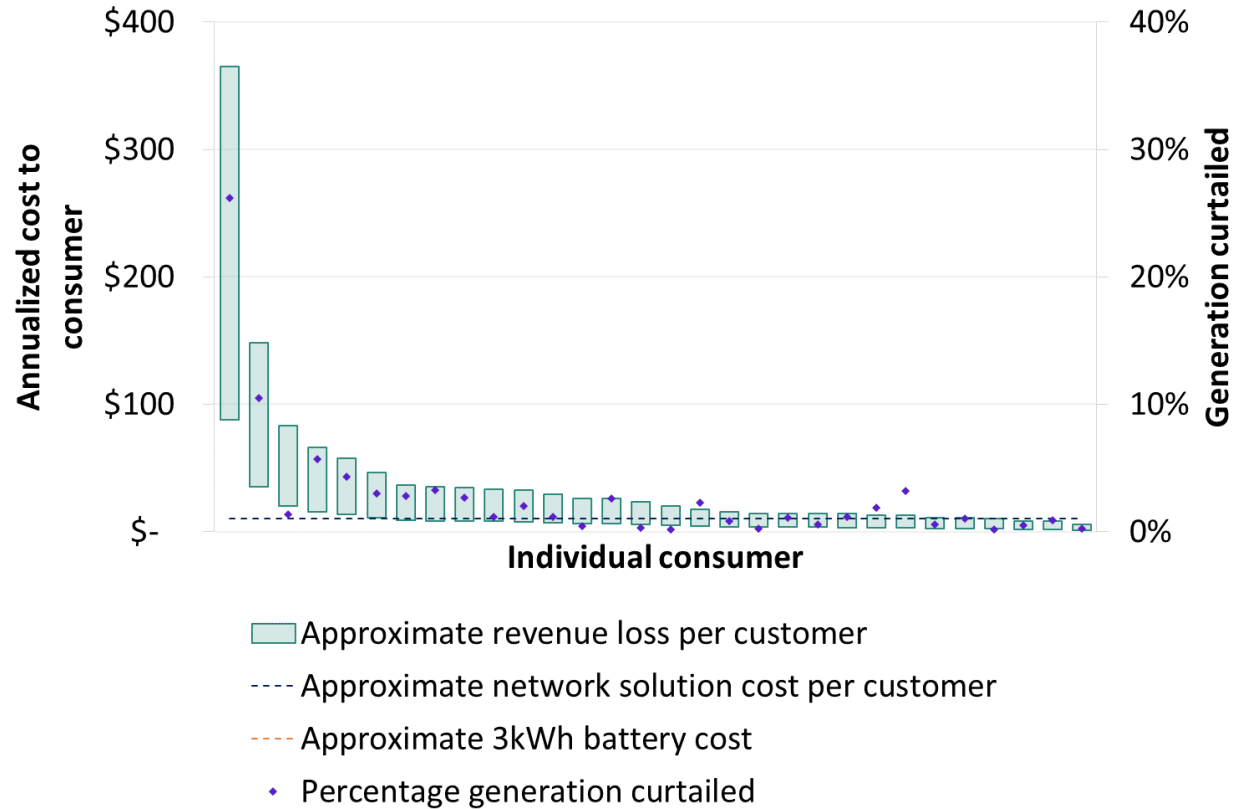
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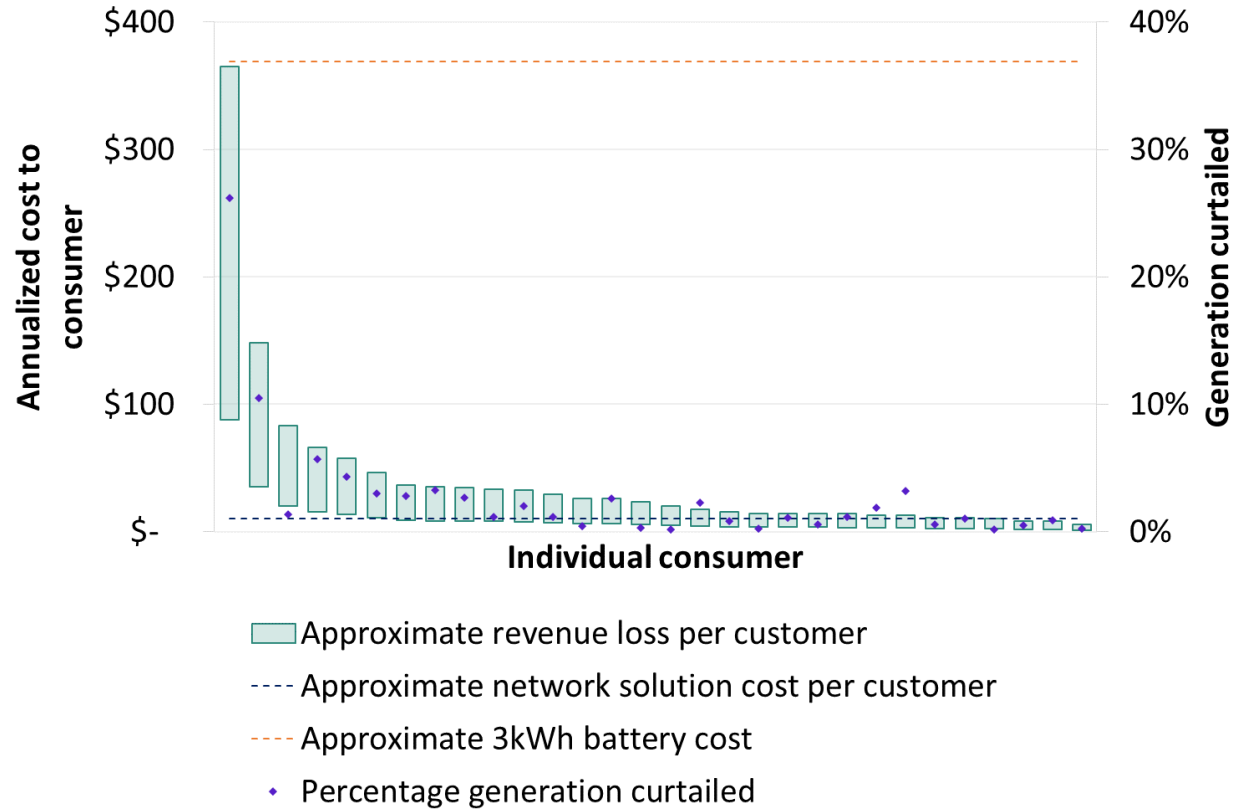
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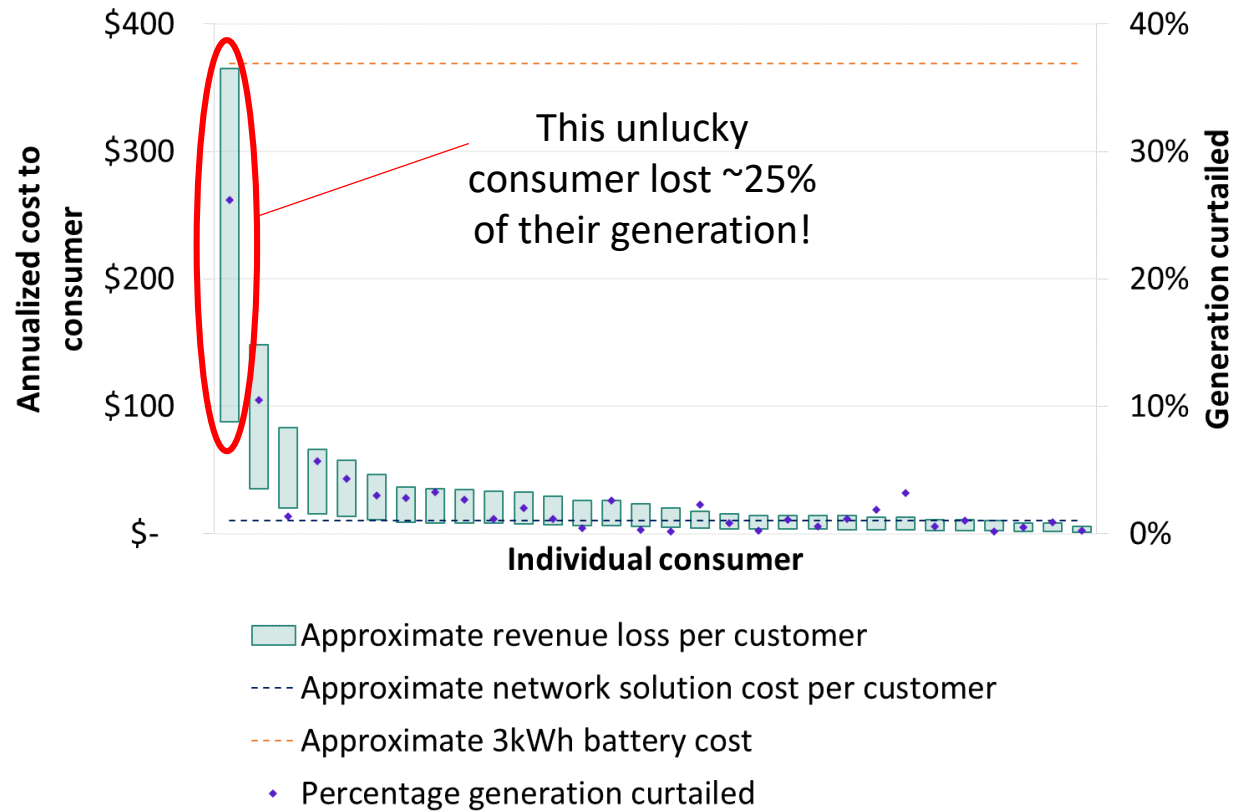
Findings

Cost comparison for 30 most impacted consumers



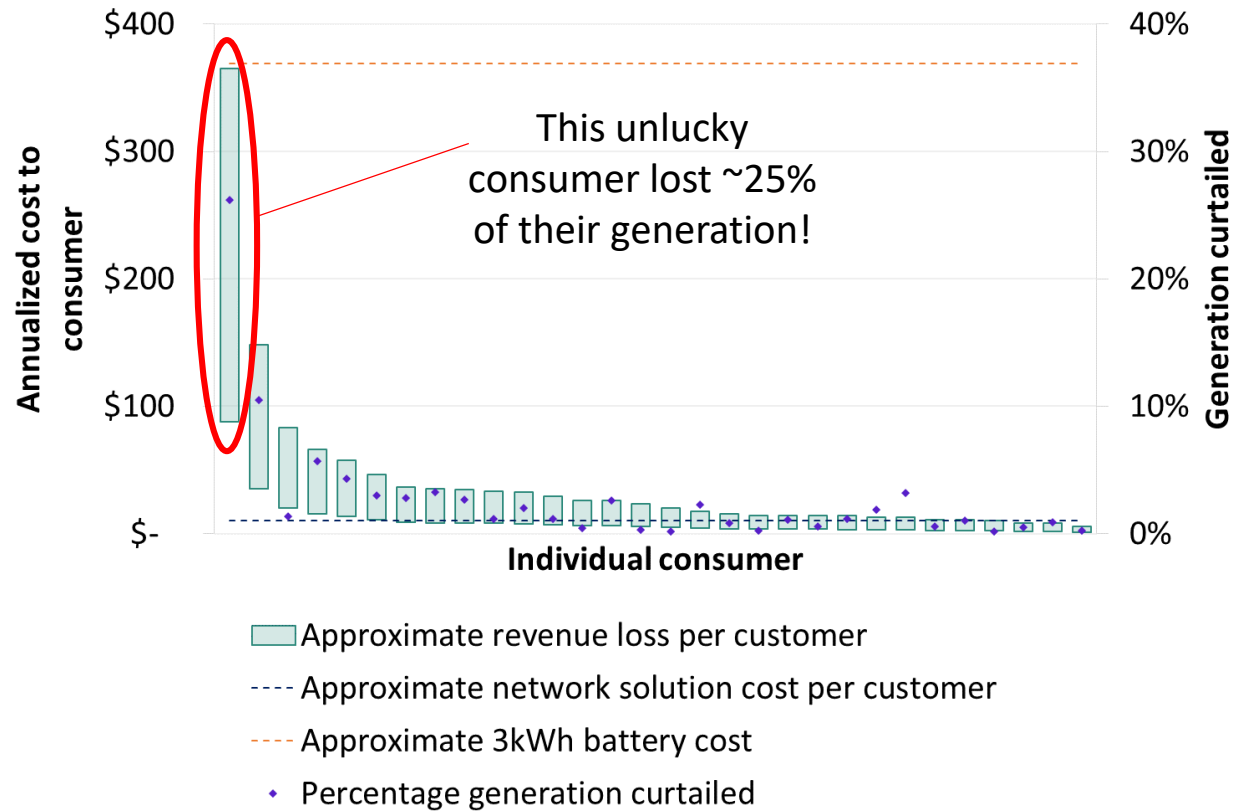
Findings

Cost comparison for 30 most impacted consumers



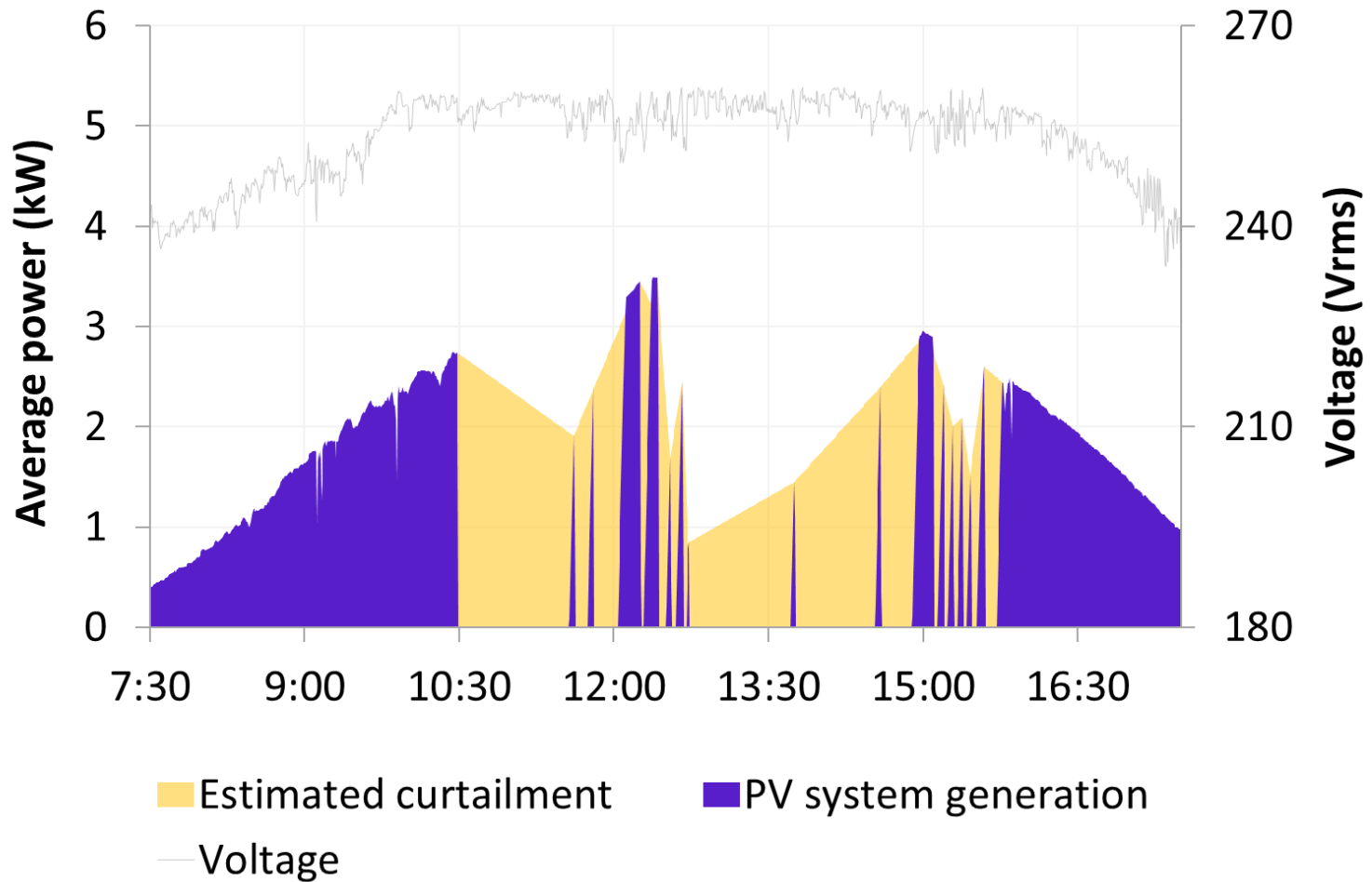
Findings

Cost comparison for 30 most impacted consumers

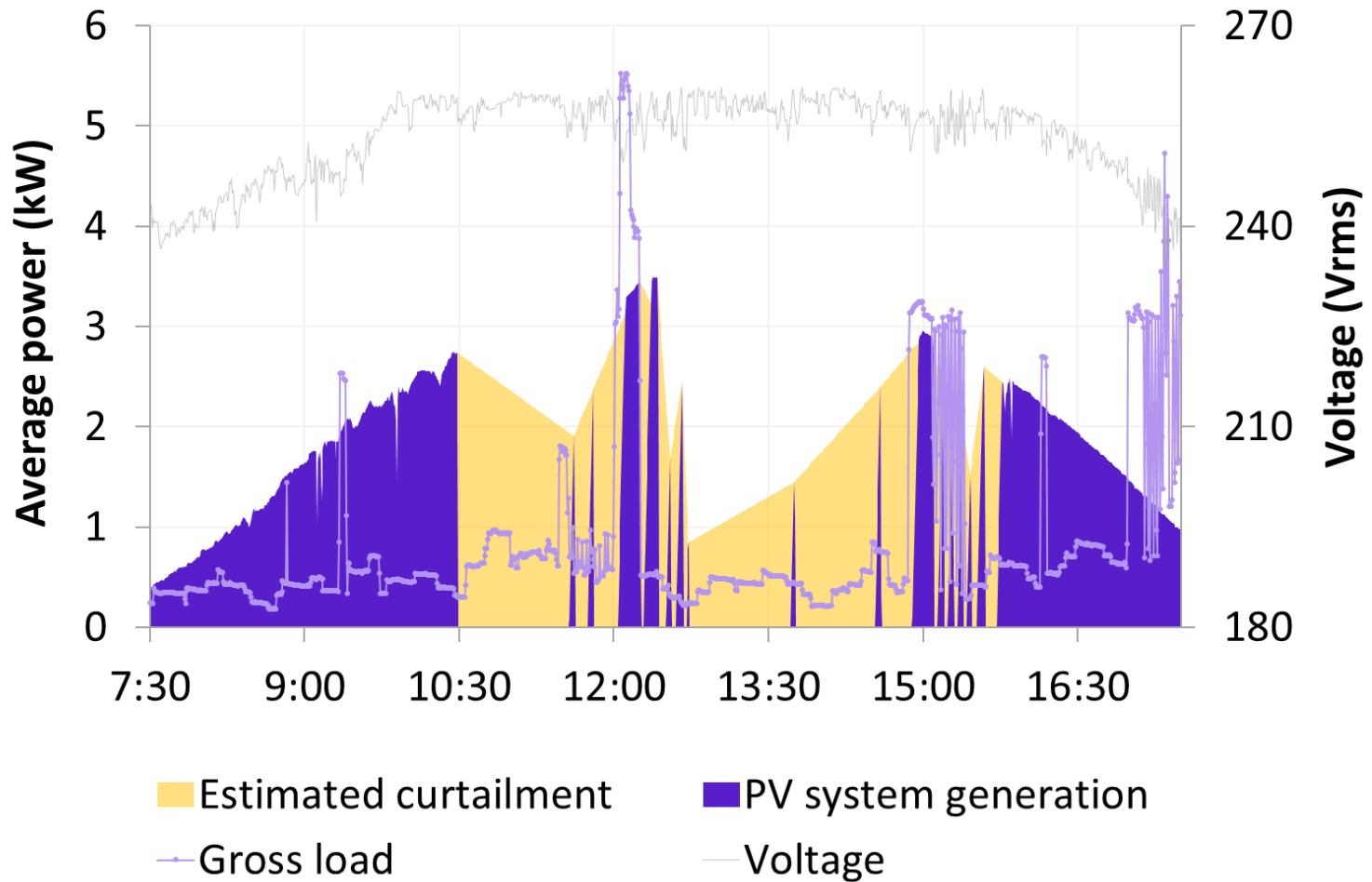


- Network solution make sense for only 4 - 17% of PV customers studied (assuming a successful fix)
- Compensation? High PV penetrations in the future?

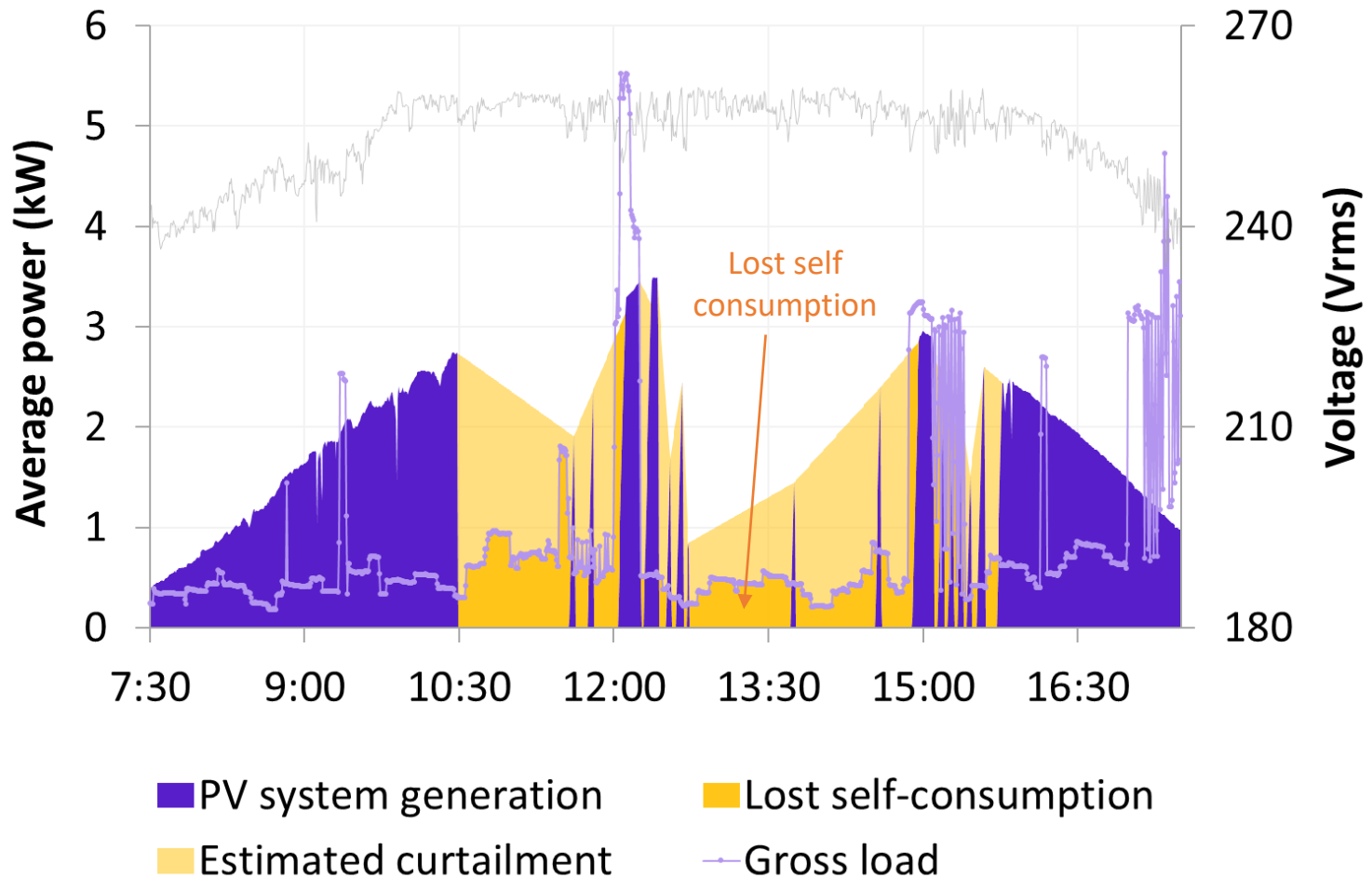
Choice



Choice

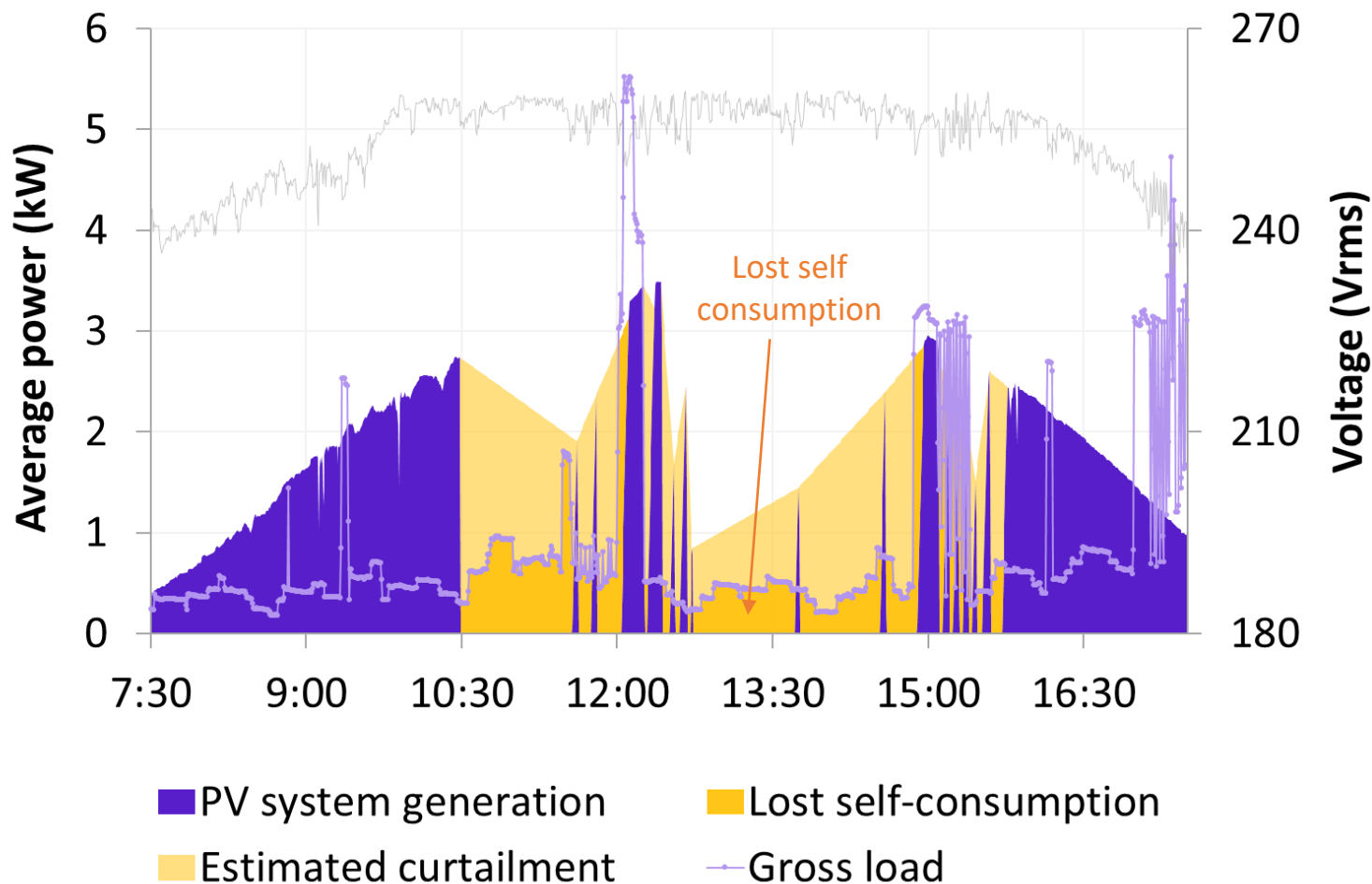


Choice



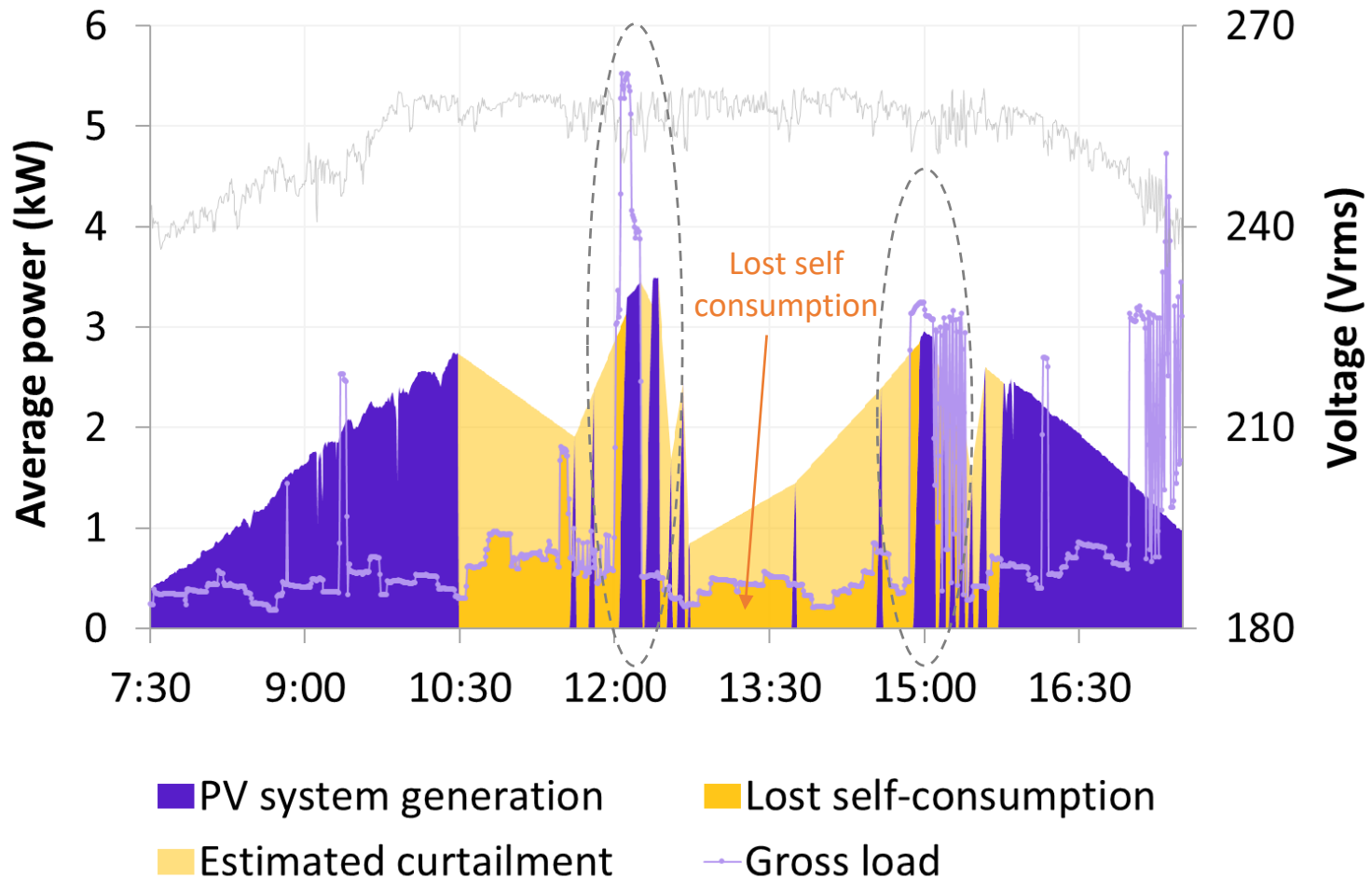
Choice

- This consumer is effectively being prevented from using their solar generation 'behind the meter'



Choice

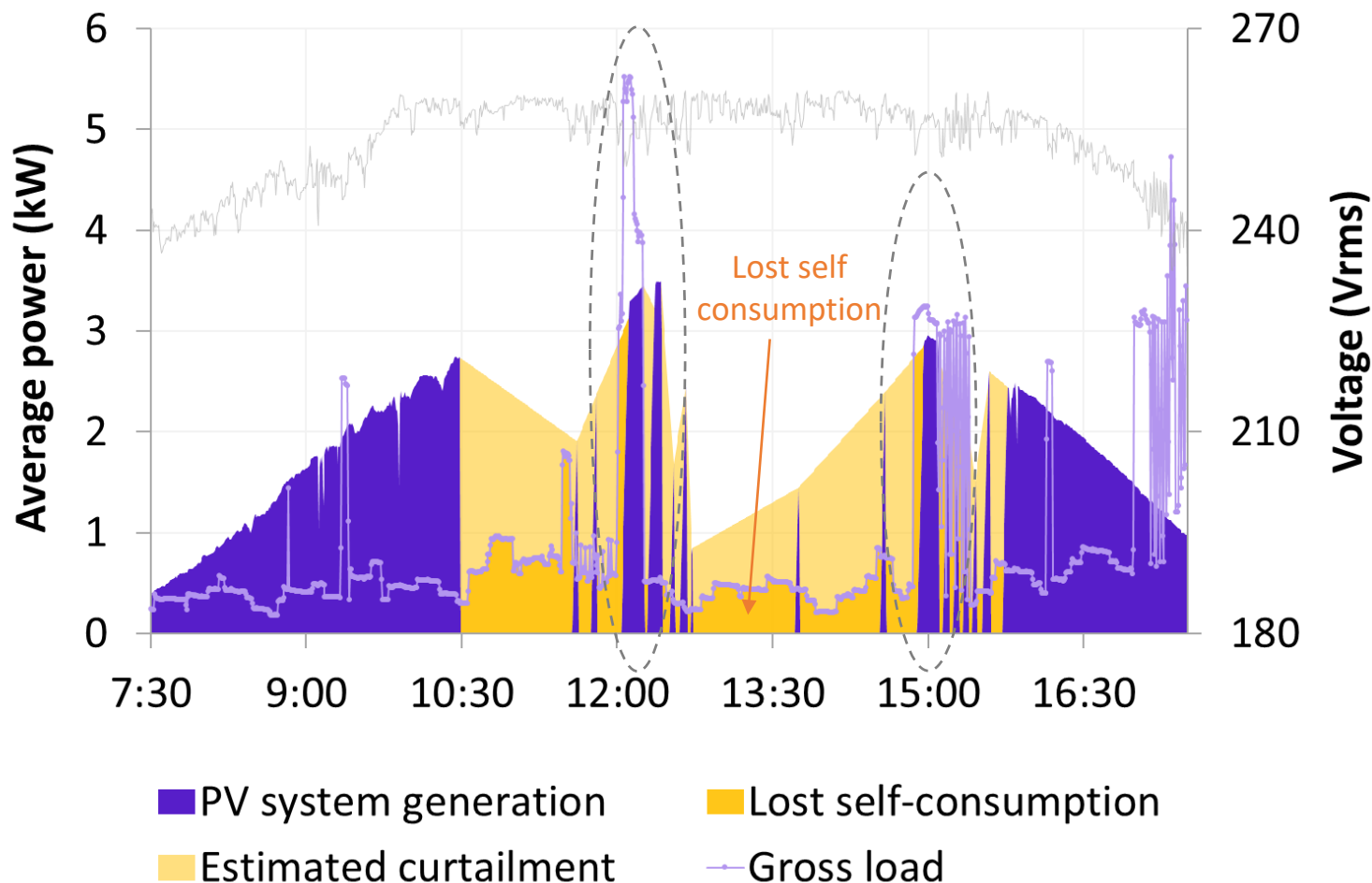
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Choice

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Should consumers be able to influence their 'behind the meter' load profile using their own generation?



Implications and thoughts

'To what extent should efficiency be compromised in the pursuit of equity?'

- Y. Varoufakis, *Foundations of Economics*

- Network solutions, cross subsidisation and equity concerns – ongoing!
 - Curtailment cost to consumers with PV
 - Network solutions paid for collectively
 - Translate 'open access' arrangements from transmission system ?
- May prevent DER participation in the broader power system ?
 - Limits on VPP, distribution market model etc.
 - Challenge of managing legacy systems
- ***What do we expect from our electricity system?***
 - 'Right to export'? Asymmetry in treatment of load and generation
 - Rights and responsibilities of consumers, utilities and aggregators?
- An evidence base is required to inform policy making

Thank you!

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