

# On equity in a distributed electricity system

#### Fair voltage management in South Australia

#### Naomi Stringer<sup>1,2</sup>, Anna Bruce<sup>1,2,3</sup> and Iain MacGill<sup>1,4</sup>

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- $^{\rm 2}$  School of PV and Renewable Energy Engineering, UNSW
- <sup>3</sup> Australian Photovoltaic Institute
- <sup>4</sup> School of Electrical Engineering and Telecommunications, UNSW

IAEE International Conference Montreal, Canada

May 30<sup>th</sup>, 2019

- 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









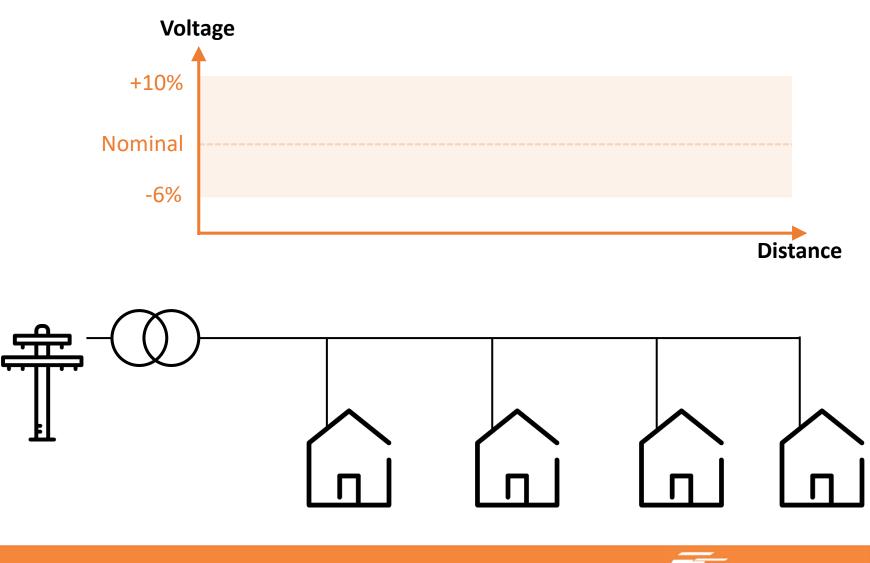
#### Overview

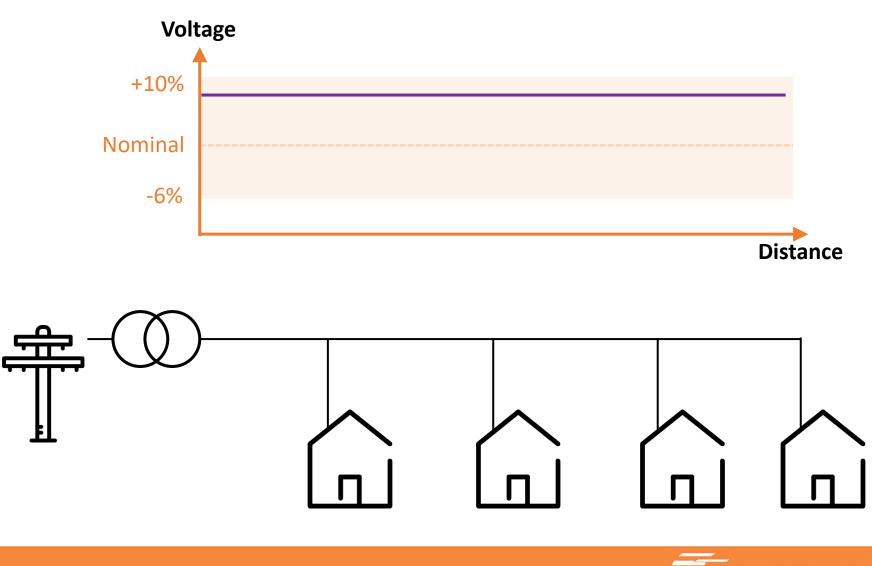
- Context voltage management and distributed solar PV
- **Specific issue** how much PV is being curtailed?
- Findings using 'in field' data as an evidence base
- Implications what are our objectives in a DER future?



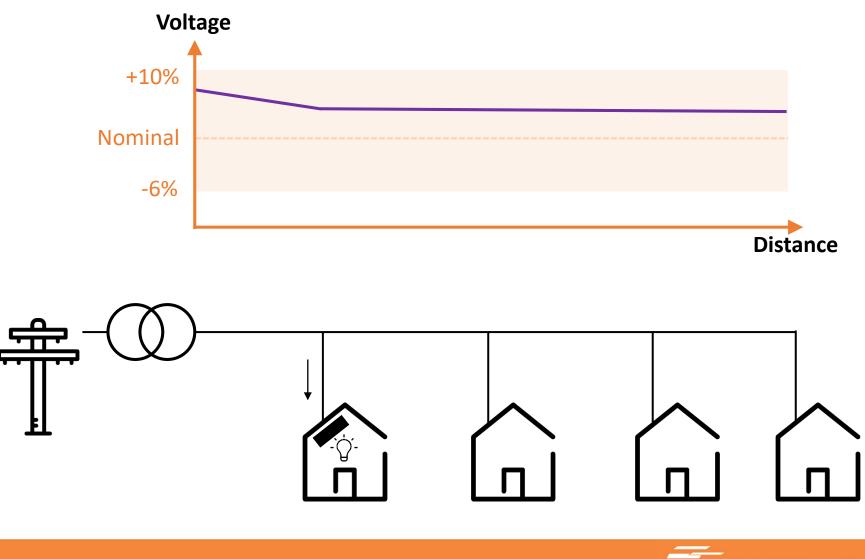


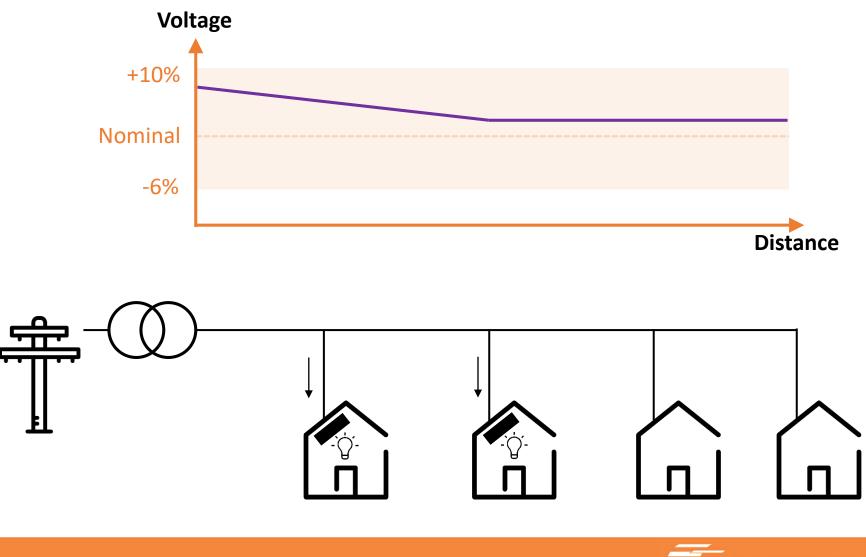


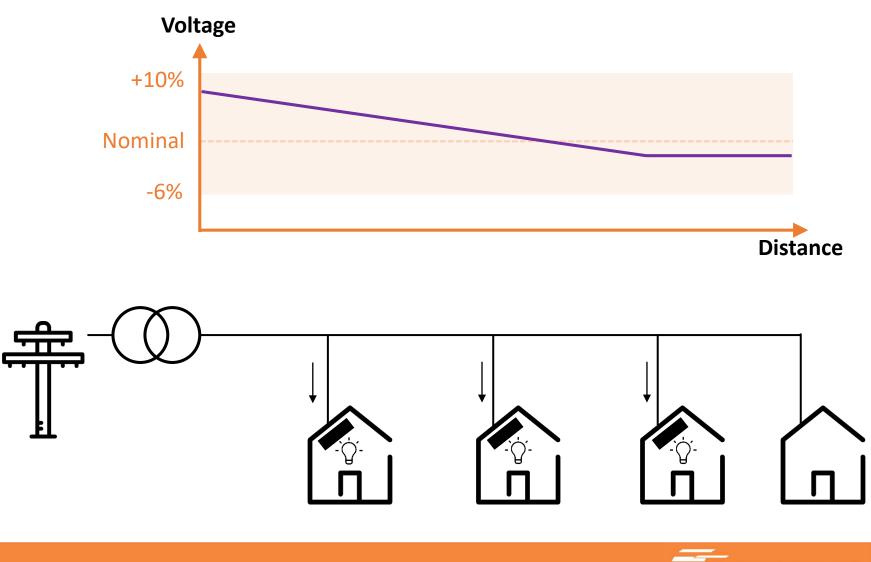


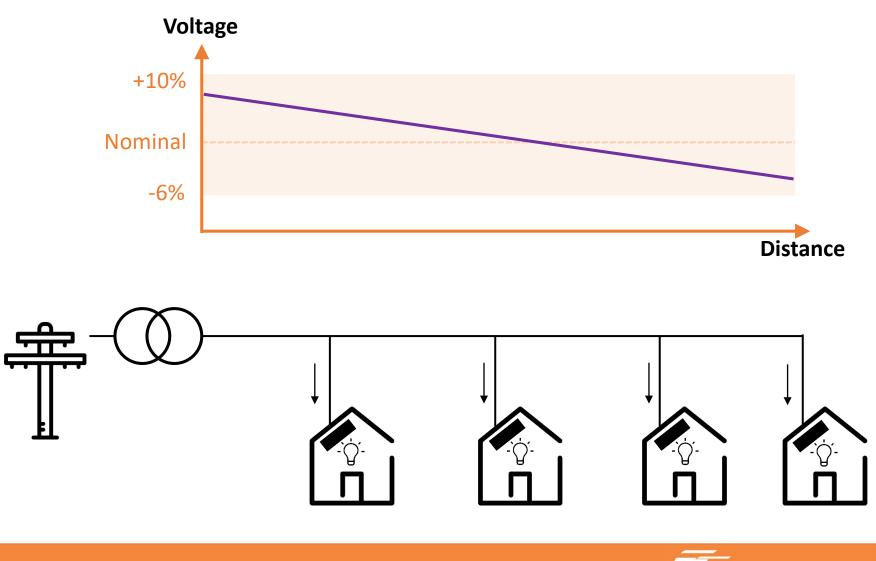


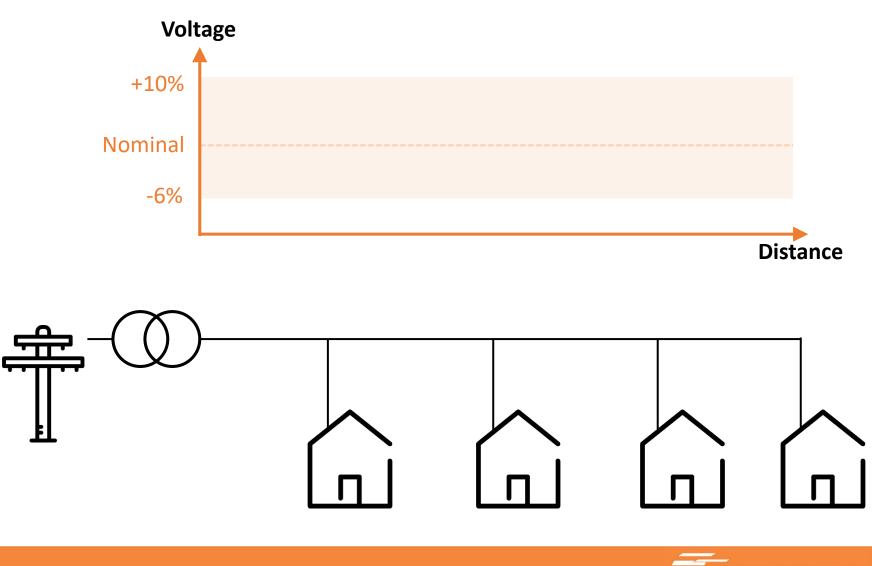


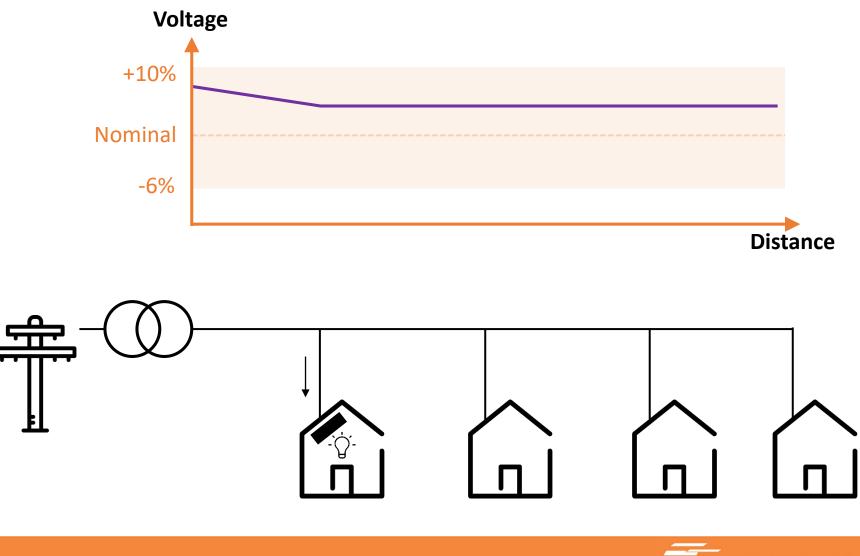


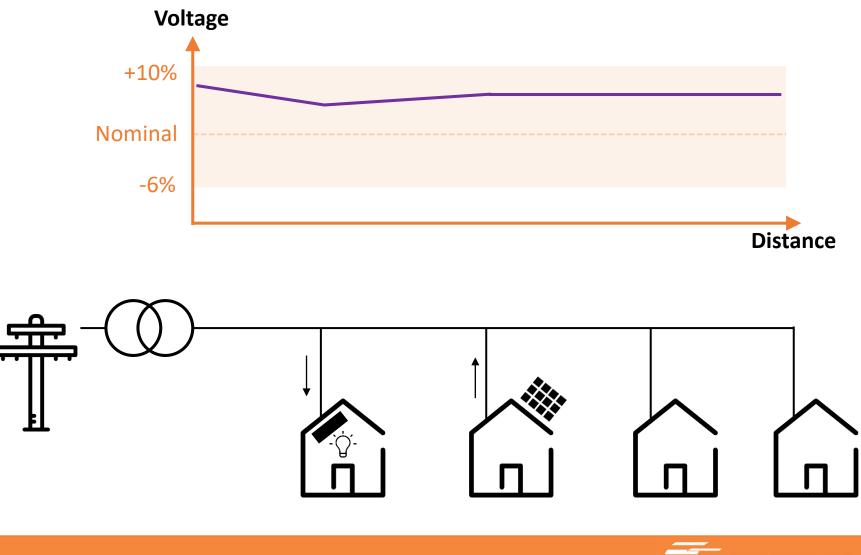


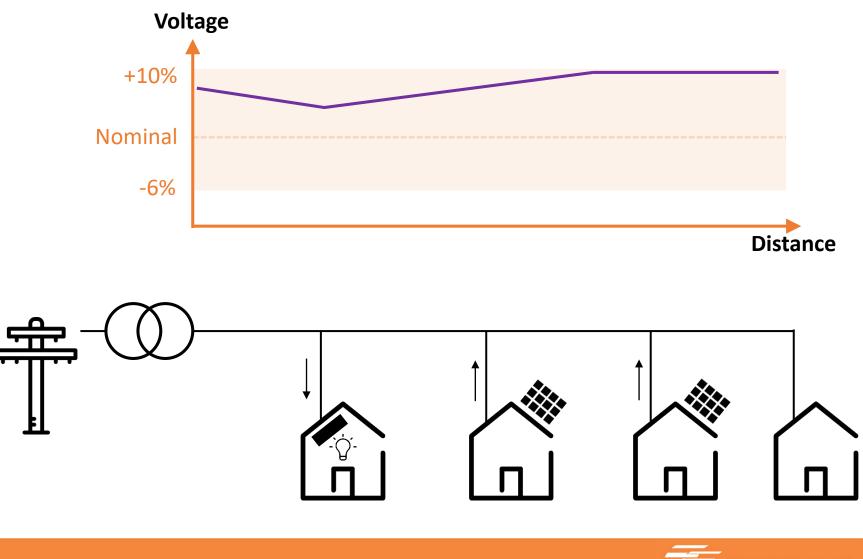


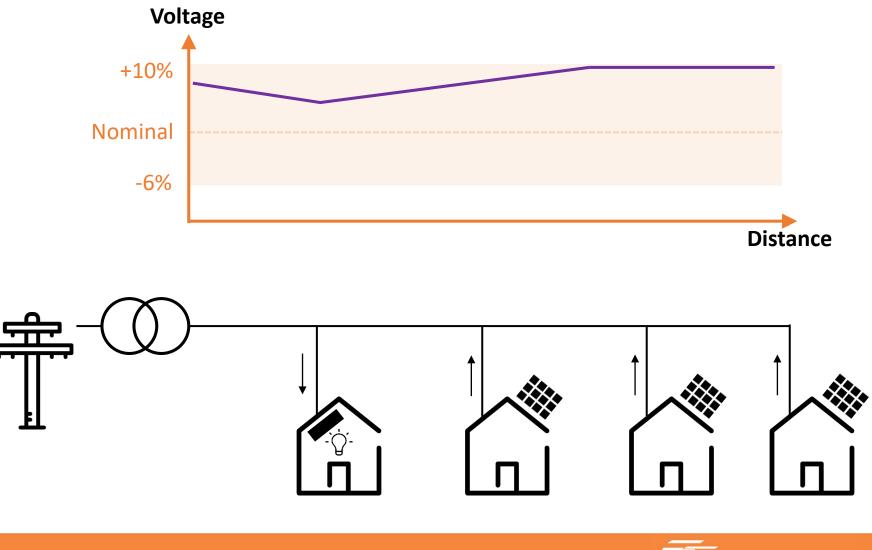


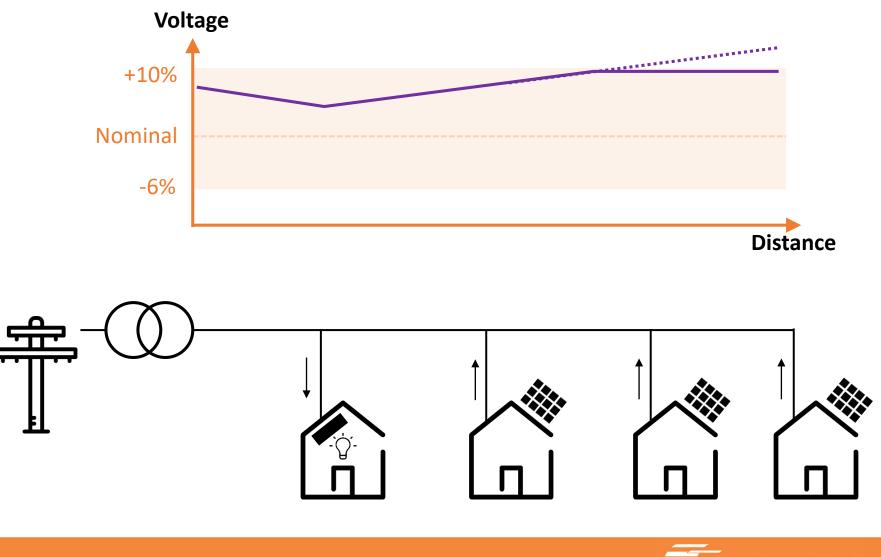


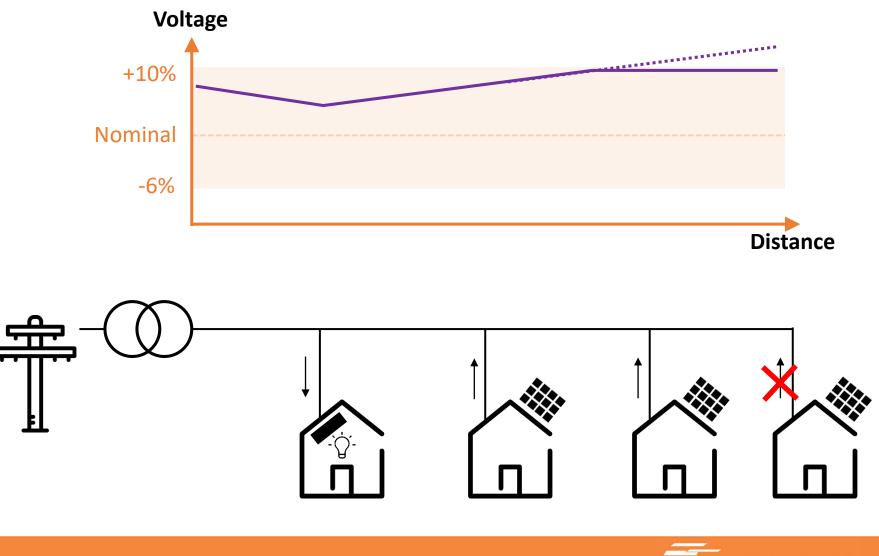




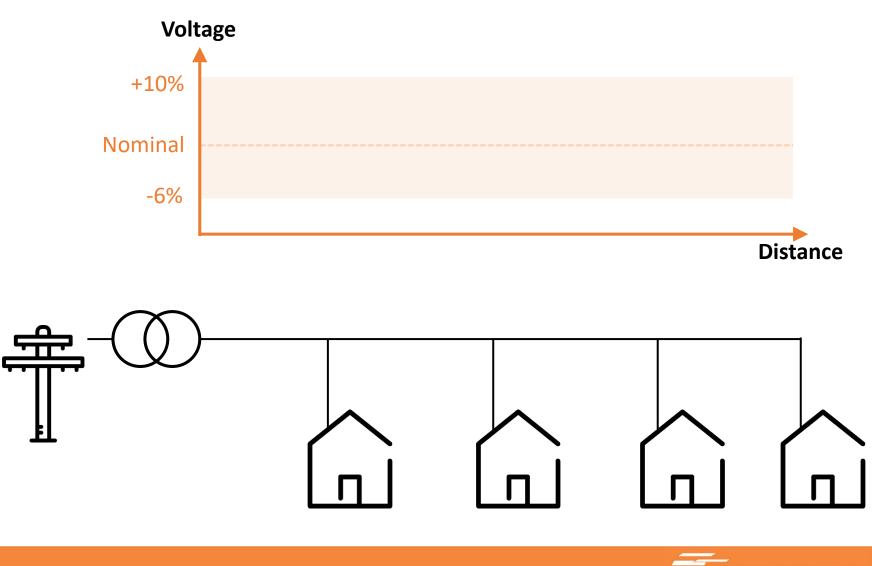


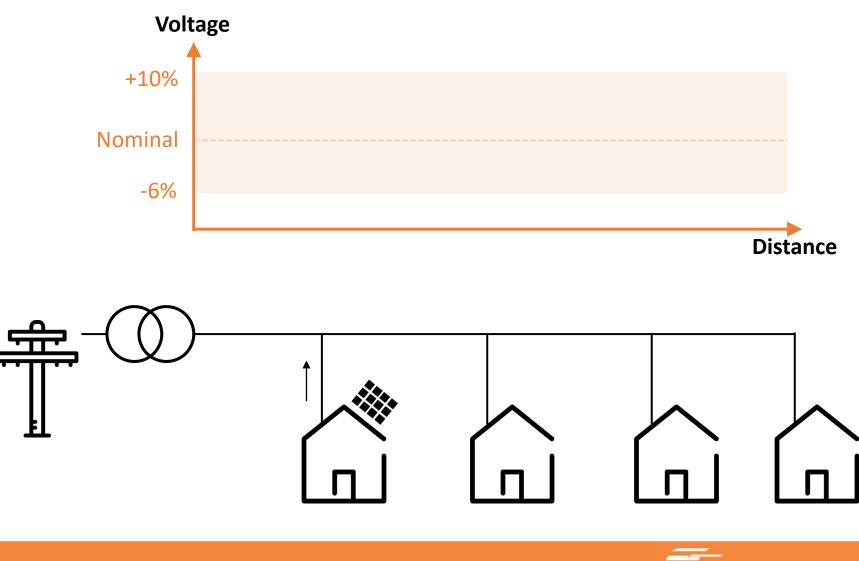


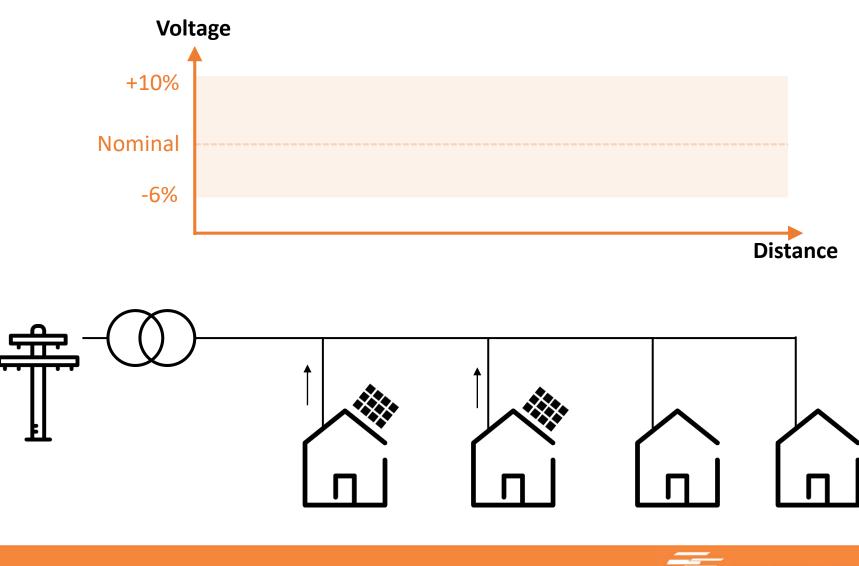


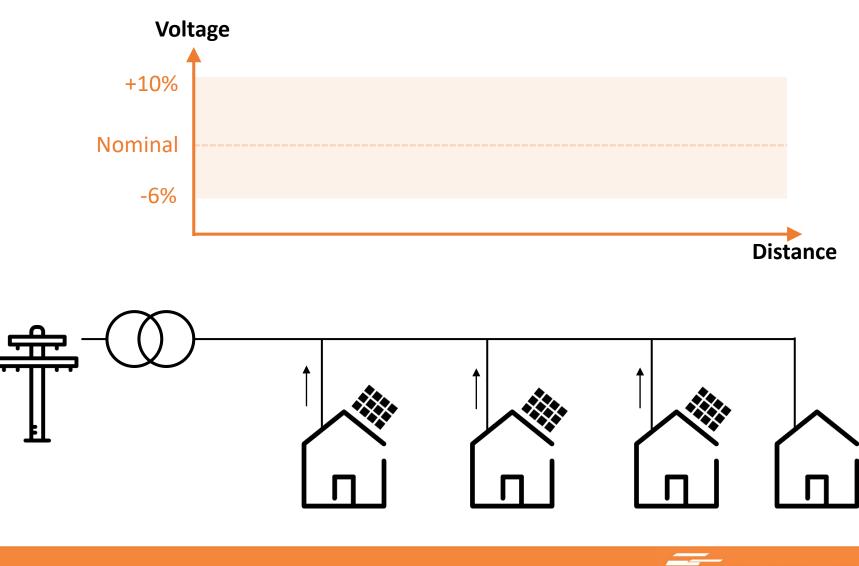


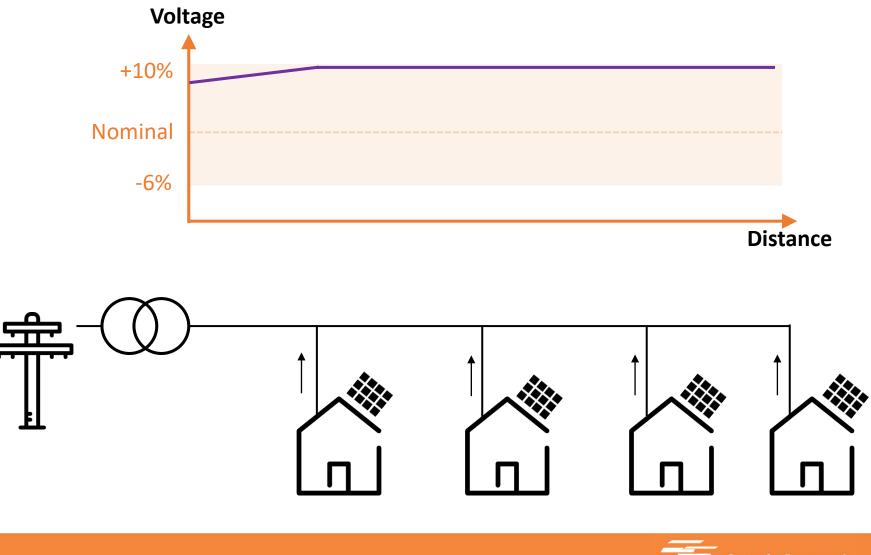


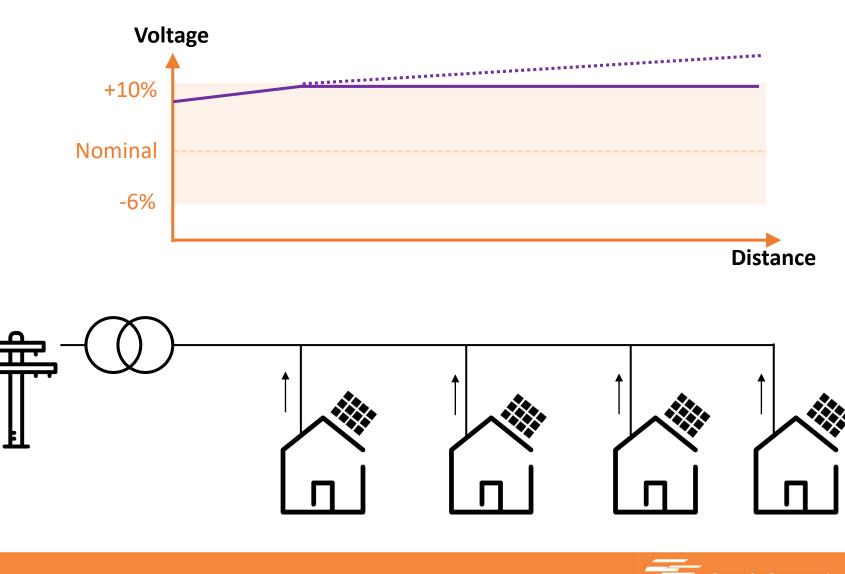


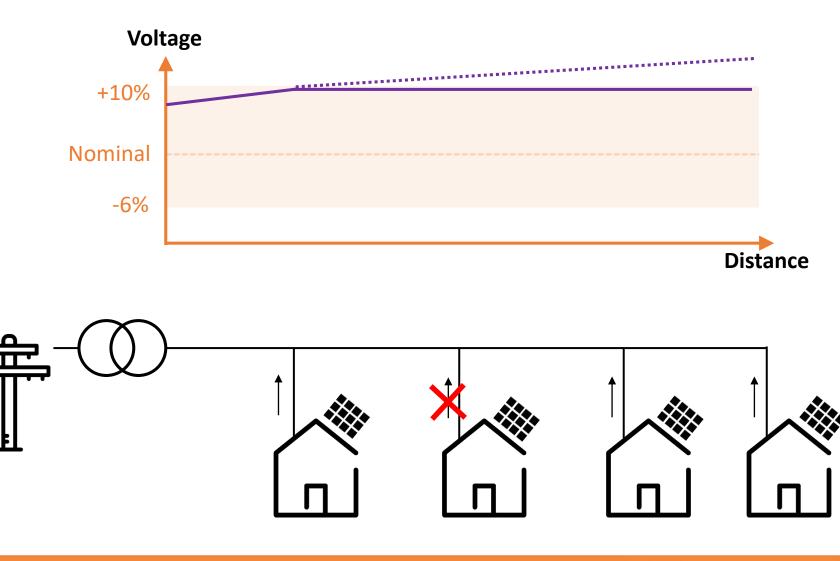




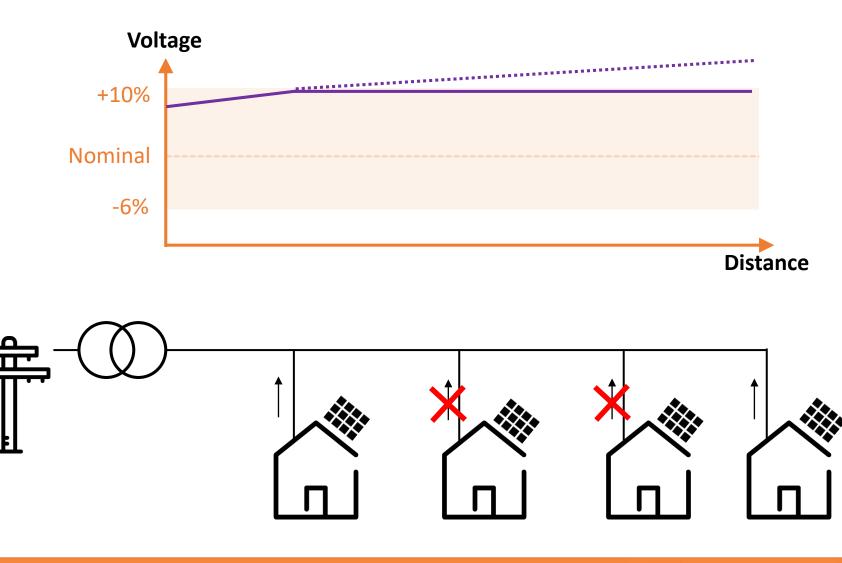




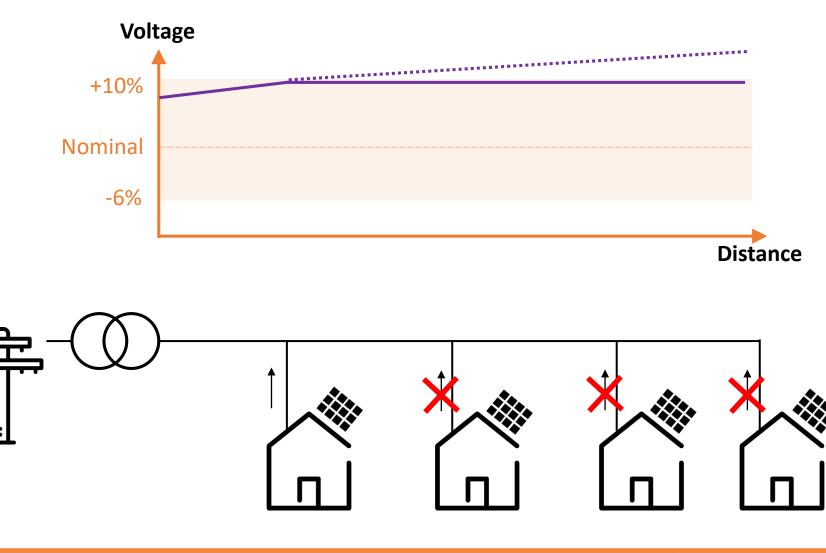




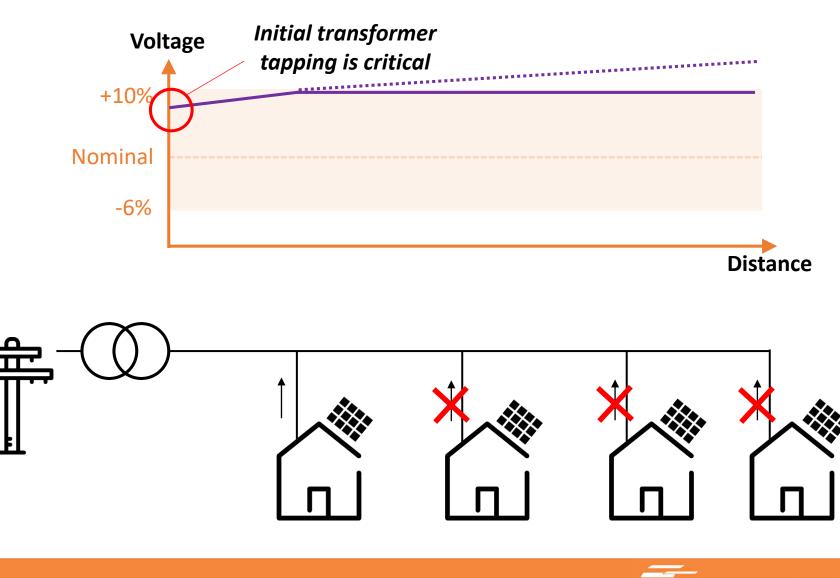


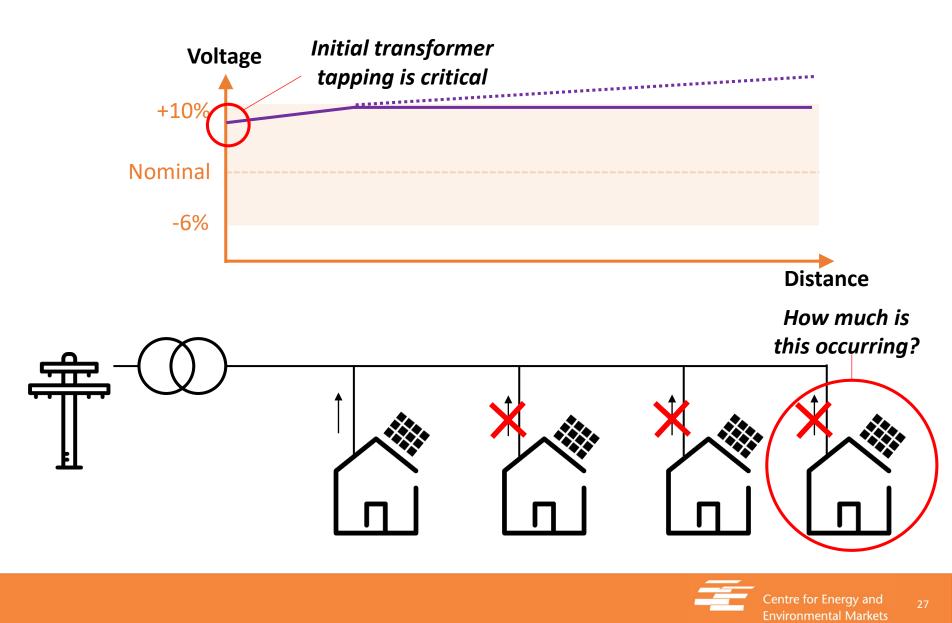












# Is PV curtailment an economically efficient outcome compared with 'network solutions'?

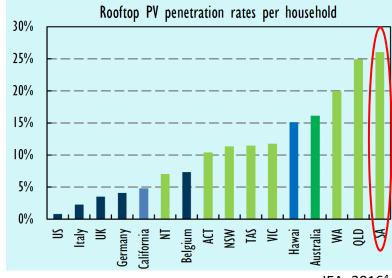
How are consumers with PV being impacted by this issue? (Is curtailment equitable?)



#### South Australian case study

- 33% dwellings have PV installed<sup>1</sup>
- ~60% have air conditioning<sup>2</sup>
- Maximum summer day 27 46°C (80 - 114 °F)<sup>3</sup>





IEA, 2016<sup>4</sup>



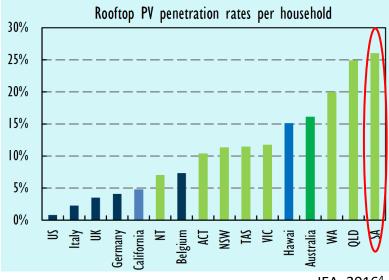
## <sup>1</sup> APVI maps: <u>http://nv-man.apvi.org.au/historical#4/-26.67/134.12</u> <sup>2</sup> Australian Bureau of Statistics: <u>http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4602.0.55.001Mar%202014?OpenDocument</u> <sup>3</sup> Bureau of Meteorology: <u>http://www.bom.gov.au/climate/data/</u> <sup>4</sup> IEA "Renewable Energy Medium-Term Market Report 2016, <u>"2016, http://www.iea.org/publications/publication/MTRMR2016.p</u>

<sup>5</sup> AEMC Distribution Market Model final report 2017, https://www.aemc.gov.au/markets-reviews-advice/distribution-market-model

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





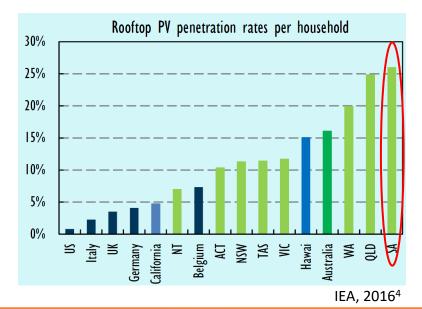


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- Australian Energy Market Commission, 'Distribution Market Model' key principal:
  - 'facilitating effective consumer choice'<sup>5</sup>



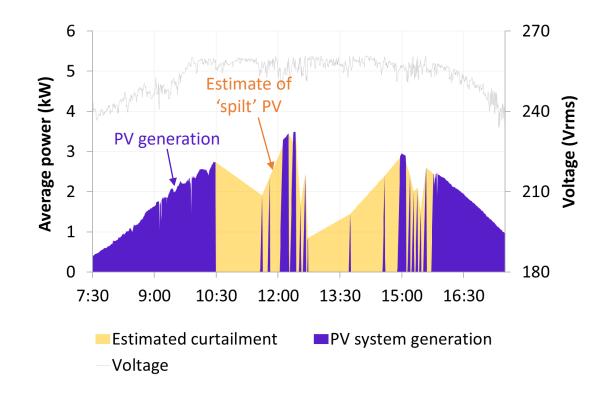




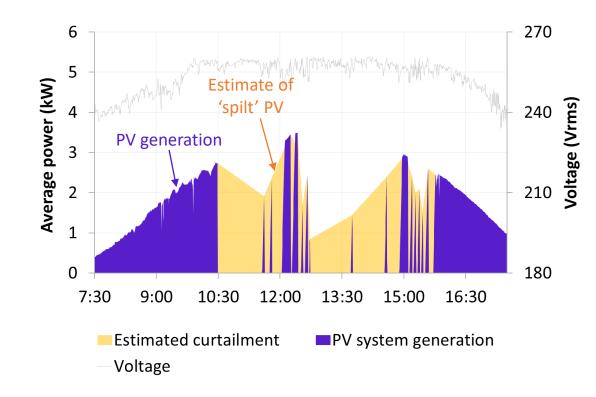
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#### <sup>2</sup> Australian Bureau of Statistics: <u>https://www.abs.gov.a</u>u

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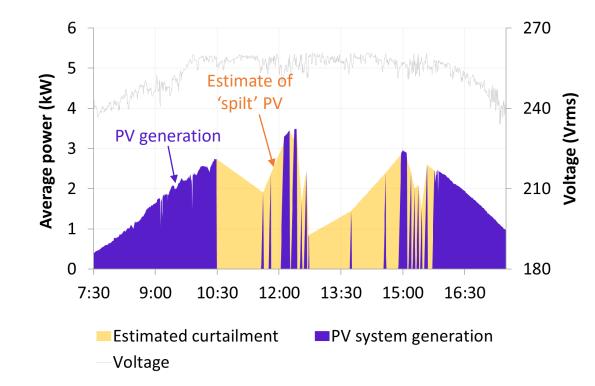
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#### Input data:

#### 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



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



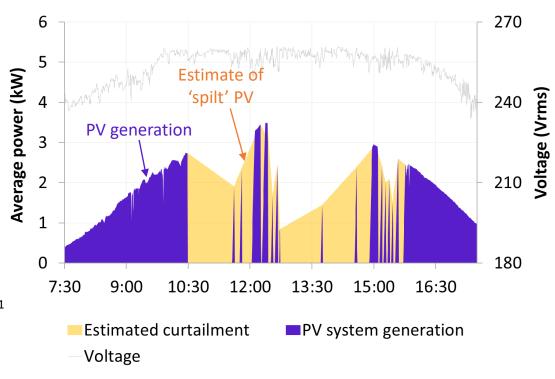
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- Network solution cost and ~asset lifetime<sup>1</sup>
- WACC<sup>1</sup>
- Battery system cost and ~lifetime<sup>2</sup>



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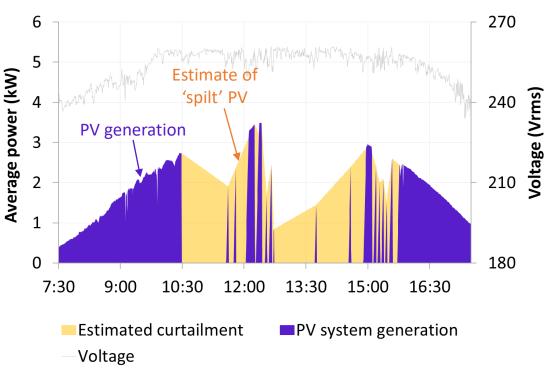
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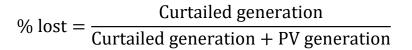
#### Financial

- Network solution cost and ~asset lifetime<sup>1</sup>
- WACC<sup>1</sup>
- Battery system cost and ~lifetime<sup>2</sup>

#### **Outputs:**

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







- 'Spilt PV'
  - 460 kWh in March 2017 for sample of distributed PV systems
  - Upscales to ~7.3 GWh p.a. across South Australia

 $\rightarrow$  ~\$0.6 – \$1.8m AUD p.a. lost value

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Chapter 13

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  - 460 kWh in March 2017 for sample of distributed PV systems
  - Upscales to ~7.3 GWh p.a. across South Australia

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- Indicative 'network solution' <sup>1</sup>
  - \$112m AUD capex
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  - $\rightarrow$  ~\$9.7m AUD p.a.

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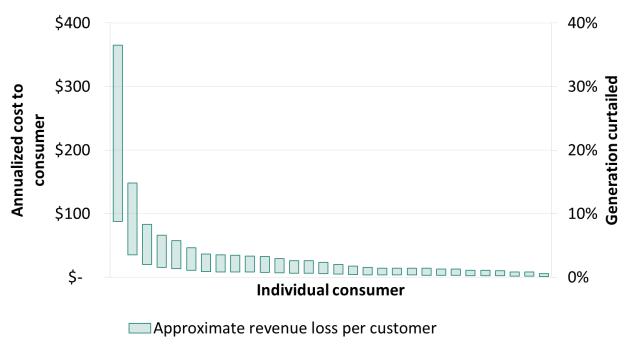
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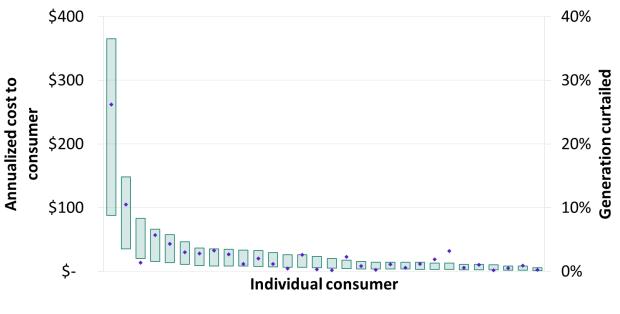


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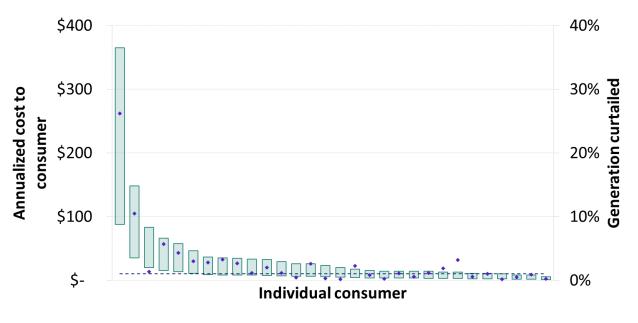
- ---- Approximate network solution cost per customer
- --- Approximate 3kWh battery cost
- Percentage generation curtailed





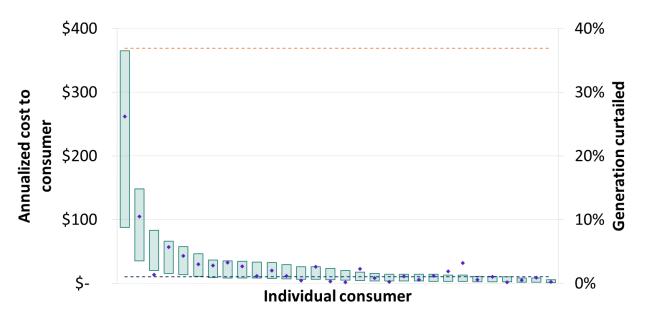
- Approximate revenue loss per customer
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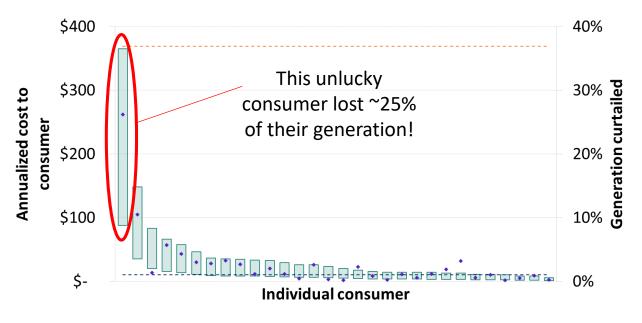
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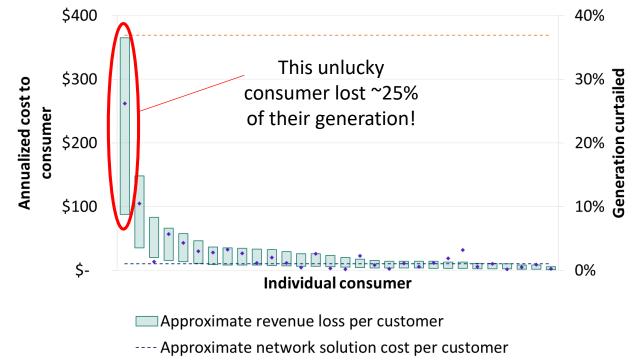
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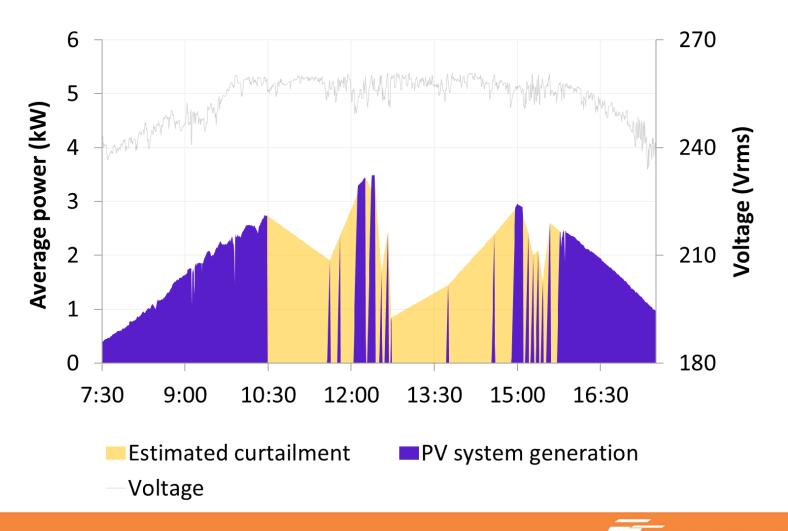
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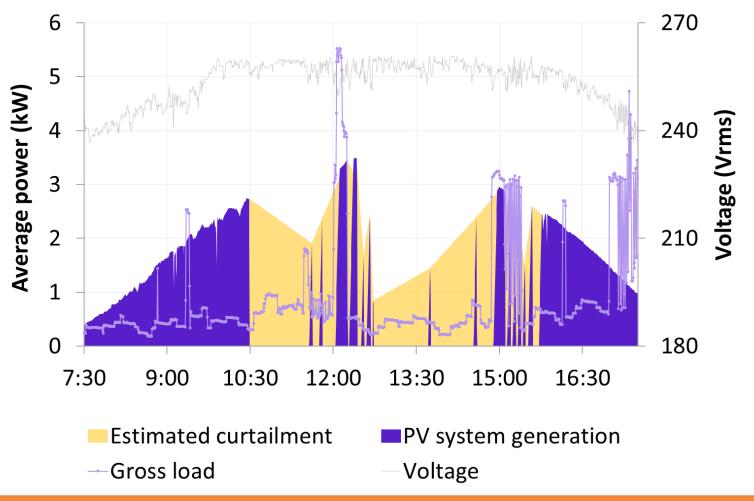


- --- Approximate 3kWh battery cost
- Percentage generation curtailed
- Network solution make sense for only 4 17% of PV customers studied (assuming a successful fix)
- Compensation? High PV penetrations in the future?

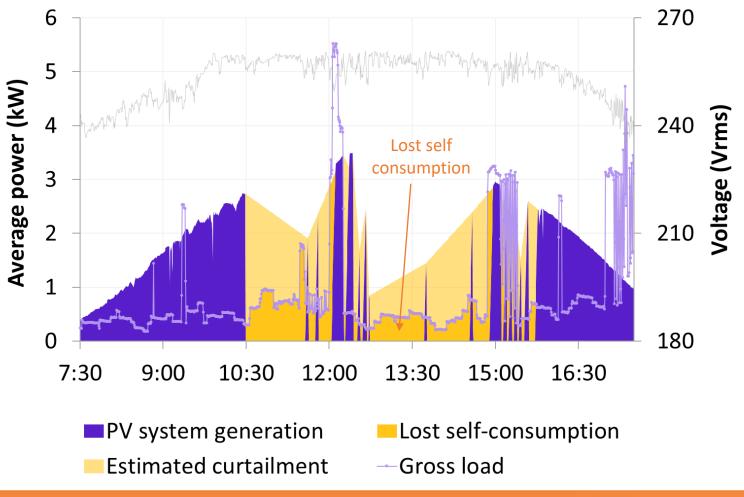


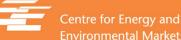




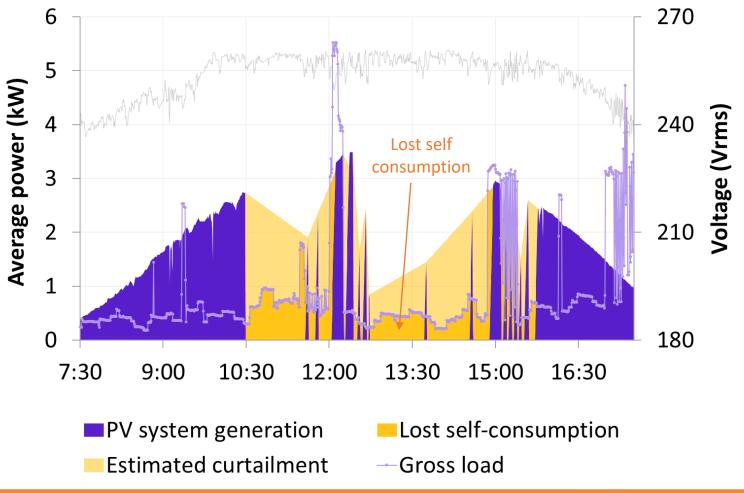






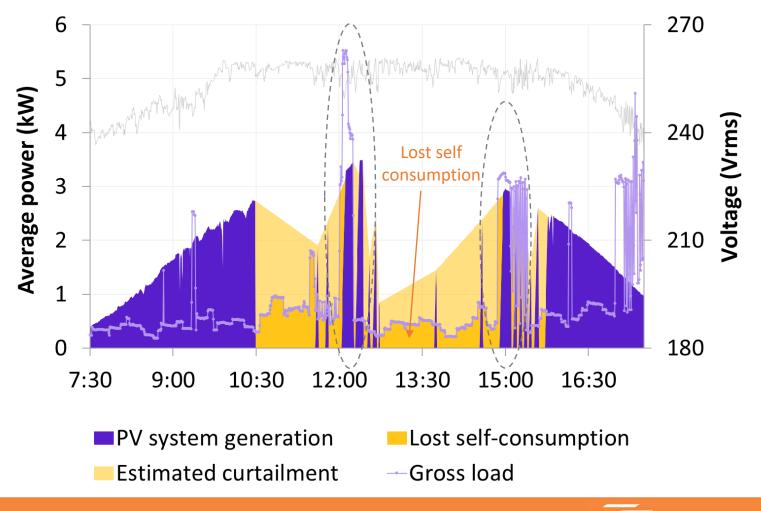


• This consumer is effectively being prevented from using their solar generation 'behind the meter'





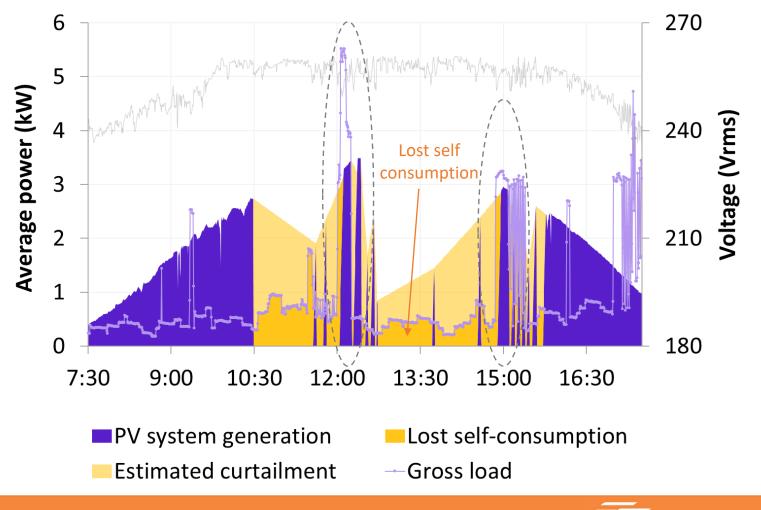
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- This consumer is effectively being prevented from using their solar generation 'behind the meter'
- Can self consume when load > generation, however in high penetration cases, even this may not be possible.

#### 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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