Estimating the Economic Value of Distributed PV Systems in Australia

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Presentation Outline

- Australian context for PV systems
- Economic valuation of $\text{PV}_{\text{elec}}$ costs and benefits
- Approach to estimate PV value in Australia
- Value of a typical residential PV system in Sydney
- Conclusions and future work
Australian context for PV systems

- Challenge of electricity industry transformation to a low-carbon future.
- PV policy support basis => current energy markets do not price the adverse environmental impacts of conventional fossil-fuel generation or appropriately capture other market benefits.
- Policy support => PV deployment increases 10 times in the last 2 years.
- Assessment of PV economic value can play an important role to tailor policies that maximise the value to the society.

Emerging challenges
- Strict cost/benefits analysis of PV support
- How best to design policies to maximise PV value

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Economic valuation of $\text{PV}_{\text{elec}}$: costs and benefits

- Possible benefits:
  - Energy
  - Avoided Losses
  - Avoided $\text{CO}_2$ Emissions
  - Deferring Network Augmentation
  - Impact on Power Quality
  - Security of Supply
  - Available firm Capacity
  - Reduction Stress in the System and Wholesale Prices

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Approach to estimate PV value in Australia

- Retail tariffs are not an appropriate basis for energy value.
- Energy valuation:

\[
PV_{\text{elec}} \times w_t
\]

- \(PV_{\text{elec}}\): Photovoltaic electricity [MWh]
- \(w_t\): Wholesale spot price [$/MWh]

- Actual data capture correlation between solar output and wholesale prices.
- Limitation: Backward looking historical wholesale price data, but future prices is what matters.

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Avoided losses value

- Methodology that considers the non-linear relationship between losses and power flow in network elements:

\[ L_t = a \times G_t^2 \]

Overall system losses \( L_t \)

\[ \frac{dL_t}{dG_t} = 2aG_t \]

Change in systemwide losses

\[ PV_{elec} \times W_t \times 2aG_t \]

- ‘a’ can be derived by combining system production data with the average losses in the system.

- Limitations: Actual losses highly context-specific and difficult to estimate accurate.

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Avoided CO$_2$ emissions value

- PV system avoids the equivalent emissions of the generating plant whose output is displaced:
  \[ I_t \times C \]

  where $I_t$ is the emission intensity of the marginal plant in tCO$_2$/MWh and $C$ is the social costs of CO$_2$ emissions in $$/tCO_2$.

- In the NEM $I_t$ corresponds to OCGT power plants 0.76 [tCO$_2$/MWh]

- Valuing $C$ is highly abstracted and hence controversial
  - Control cost: materialized in a carbon price imposed on the electricity industry (Treasury estimates, IEA, etc.)
  - Damage cost: estimate arising from unchecked greenhouse emissions (Stern Review, ExternE, etc.)

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Deferring Network Augmentation Value

- Estimated savings from the deferral of particular planned network investments.
- Process undertaking by NSW DNSPs as part of their demand management obligations
- $S$ is the financial savings per each kW of reduced peak load
- PV contribution to reduce peak load:
  - Coincidence peak factor: $A = \frac{\text{reduction of demand}}{\text{maximum solar output}}$
  - Performance of the panels: $P = \frac{\text{maximum solar output}}{\text{PV capacity}}$
- Value of deferral investments per kW of PV installed:

$$D = S \times A \times P$$

- Limitation: Deferral only at the substation level.

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Monthly $P_{\text{elec}}$ energy and environmental value during 2010

- Data
  - Actual solar output ($P_{\text{elec}}$) data from 1.1 kW residential PV system for 2010.
  - Actual wholesale price ($w_t$) data from AEMO.

\[
P_{\text{elec}} \times \left( w_t + w_t \cdot 2aG_t + I_t \times C \right)
\]

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Deferring network augmentation value

- Use of average $P_{\text{elec}}$ of the peak month for:

$$A = \frac{\text{Reduction of peak}}{\text{max imum solar output}}$$

$$P = \frac{\text{max imum solar output}}{\text{PV capacity}}$$
PV Systems in Sydney: Economically Beneficial?

- Compare total benefits against total costs
- Future C and scaled up $w_t$ values obtained from the Treasury modelling
- Key assumptions:
  - OGCT plants keep being the peaking marginal plants
  - Annual degradation factor of the panels is 0.5%
  - Percentage of NEM average losses doesn’t change in the future

High correlation between $\text{PV}_{\text{elec}}$ and $w_t$  

Benefits > Cost => Beneficial Investment

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Conclusions and Future Work

- Estimating the societal economic costs and benefits of PV has significant potential value to policy makers.
- Value highly dependent on PV system performance, carbon price and also location.
- Need of approaches to estimate security benefits, network costs, etc.
- Further investigation is required at a more commercial level:
  - Estimate the impact of PV deployment on key stakeholder revenues and costs based on the PV value
  - Estimate the contribution that industry stakeholder should give to afford PV deployment
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Thank you,

and

Questions?

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