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Estimating the Economic Value of Distributed PV Systems in Australia

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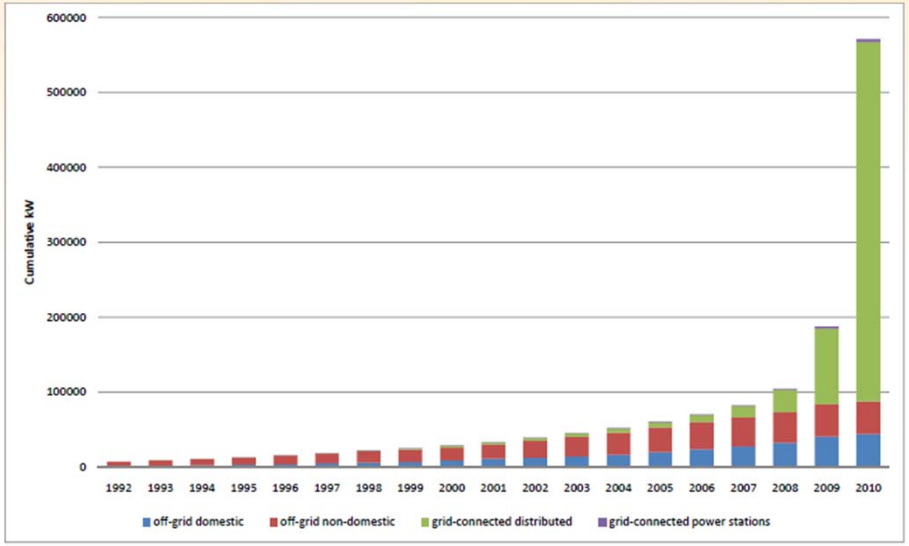
IEEE PES Conference on Innovative Smart Grid Technology 2011
Perth, Australia
13-16 November 2011

Presentation Outline

- Australian context for PV systems
- Economic valuation of PV_{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.

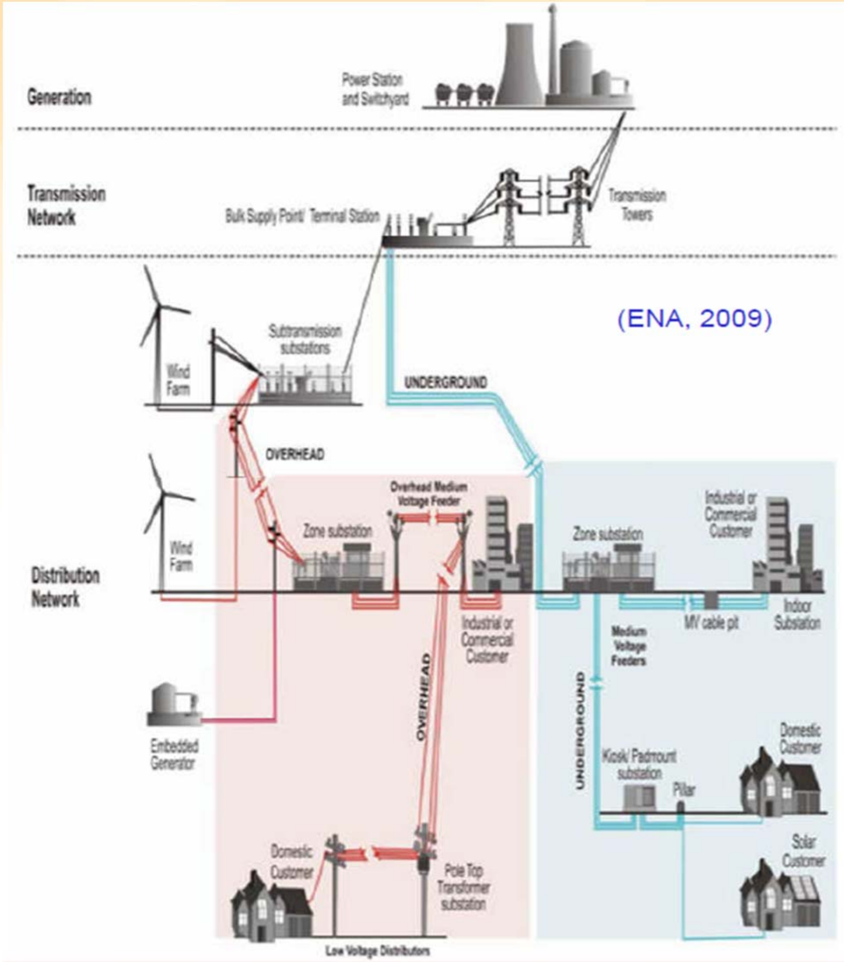


Cumulative PV Installations in Australia 1992 – 2010.

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

Economic valuation of PV_{elec}: costs and benefits

- Possible benefits:
  - **Energy**
  - **Avoided Losses**
  - **Avoided CO_2 Emissions**
  - **Deferring Network Augmentation**
  - Impact on Power Quality
  - Security of Supply
  - Available firm Capacity
  - Reduction Stress in the System and Wholesale Prices



Approach to estimate PV value in Australia

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

$$\boxed{PV_{elec} \times w_t}$$

PV_{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.

Avoided losses value

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

Overall system losses L_t

$$\boxed{L_t = a \times G_t^2}$$

$\boxed{a}$

$$\boxed{7\% \times \sum_{t=1}^{T} G_t = \sum_{t=1}^{T} a\, G_t^2}$$

'a' can be derived by combining system production data with the average losses in the system

Change in systemwide losses

$$\boxed{\frac{dL_t}{dG_t} = 2aG_t}$$

$$\boxed{PV_{elec} \times w_t \times 2aG_t}$$

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

Avoided CO_2 emissions value

- PV system avoids the equivalent emissions of the generating plant who's output is displaced:

$$\boxed{I_t \times C}$$

  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.)

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: $A = \dfrac{\text{reduction of demand}}{\text{maximum solar output}}$
  - Performance of the panels: $P = \dfrac{\text{maximum solar output}}{\text{PV capacity}}$
- Value of deferral investments per kW of PV installed:

$$\boxed{D = S \times A \times P}$$

- Limitation: Deferral only at the substation level.

Monthly PV_{elec} energy and environmental value during 2010

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

$$PV_{elec} \times \left(w_t + w_t \cdot 2aG_t + I_t \times C \right)$$

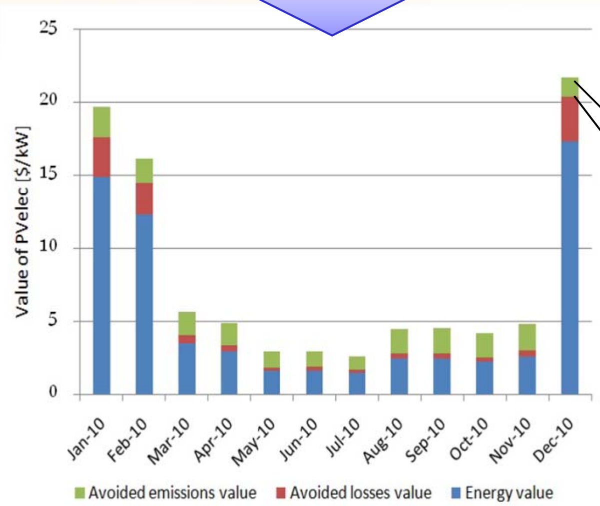
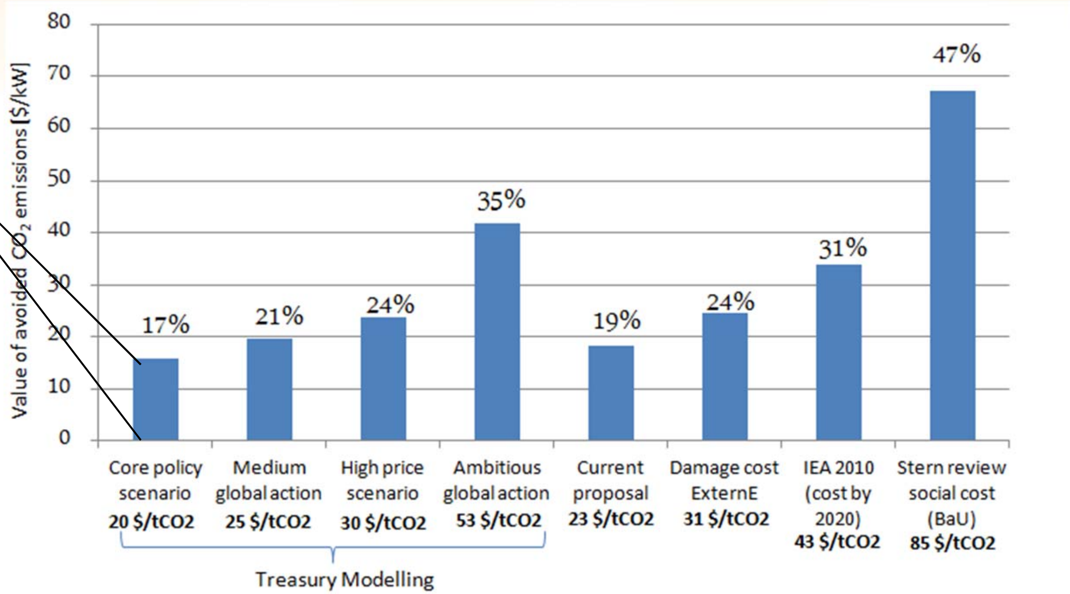
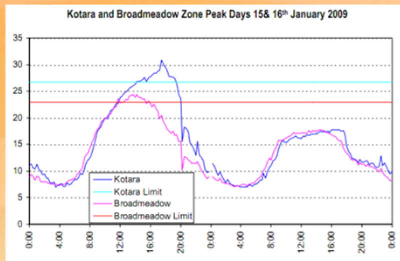
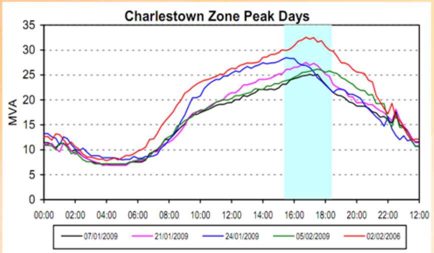


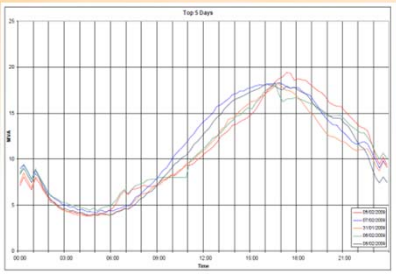
Fig. 1. Monthly PVelec energy value during 2010.



Deferring network augmentation value







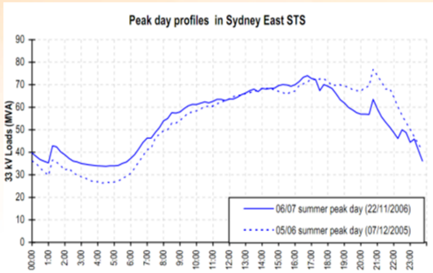
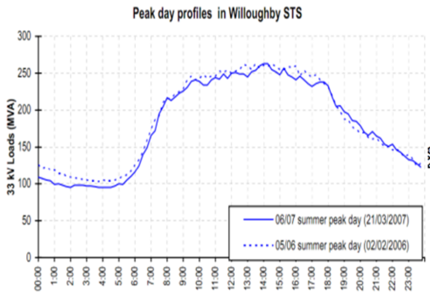
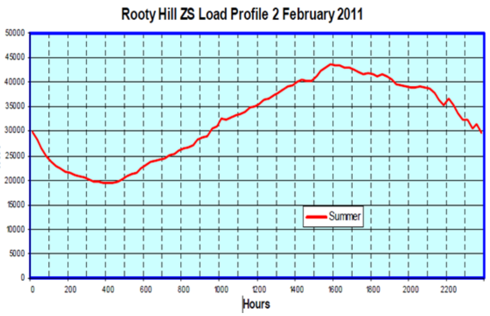


TABLE I
PARTICULAR CASES OF DEFERRAL NETWORK INVESTMENT IN SYDNEY

Area/Zone Substation	A	P	S [$/kW]	D [$/kW]	Reason
Broadmeadow	94%	52%	103	51	Cheaper Investment
Charlestown	52%	47%	799	194	Deferral by 2 years
North Western Pennant Hills	72%	52%	608	229	Deferral by 2 years
Sydney East	37%	48%	161	28	Deferral by 2 years
Willoughby	91%	44%	550	220	Deferral by 1 year
Rooty Hill	68%	47%	204	65	Deferral by 1 year





- Use of average PV_{elec} of the peak month for:

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

$$P = \frac{\text{maximum solar output}}{\text{PV capacity}}$$

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

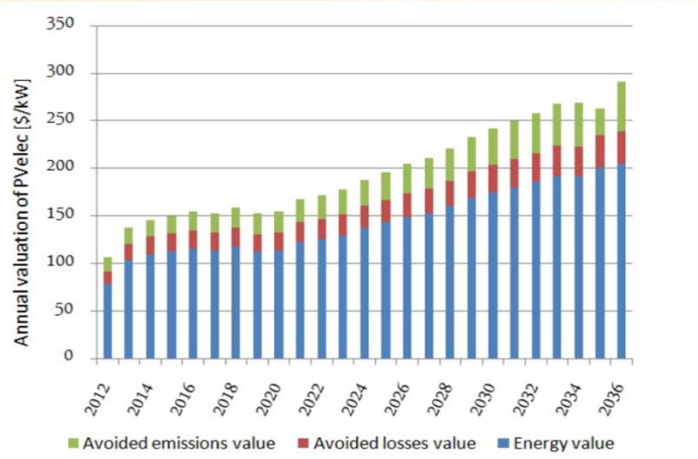


Fig. 3. Future annual value of a 1.1 kW residential PV system located in Sydney.

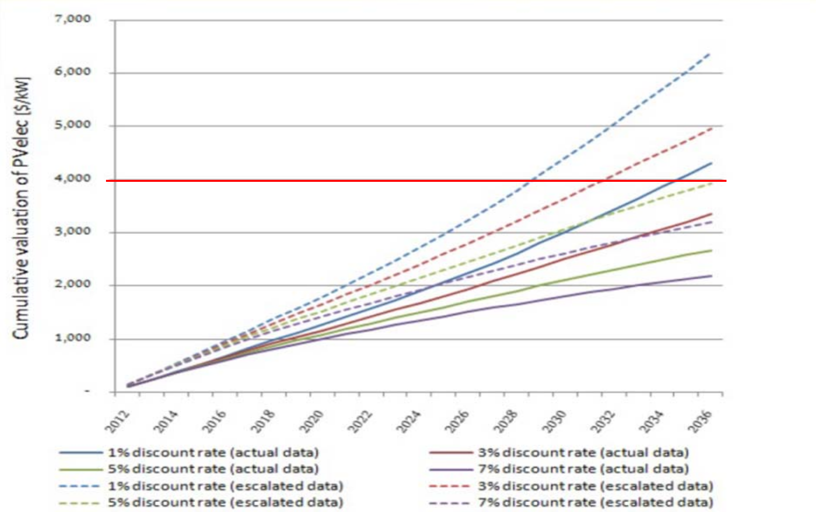


Fig. 4. Cumulative PVelec of a residential PV system.

High correlation between PV_{elec} and w_t

Benefits > Cost => Beneficial Investment

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

The authors would like to thank Simon Lewis for providing the PV output data and the funding support by Australian Solar Institute (ASI).

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Thank you,

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Questions?

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