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Explaining spatial variation in small-scale solar uptake across Australia

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ENERGY TRANSITION HUB an Australian-German innovation partnership

The solar revolution

Globally, solar additions exceeded total net additions of coal + natural gas + nuclear in 2017

Australia is a world-leader in small-scale rooftop PV installations

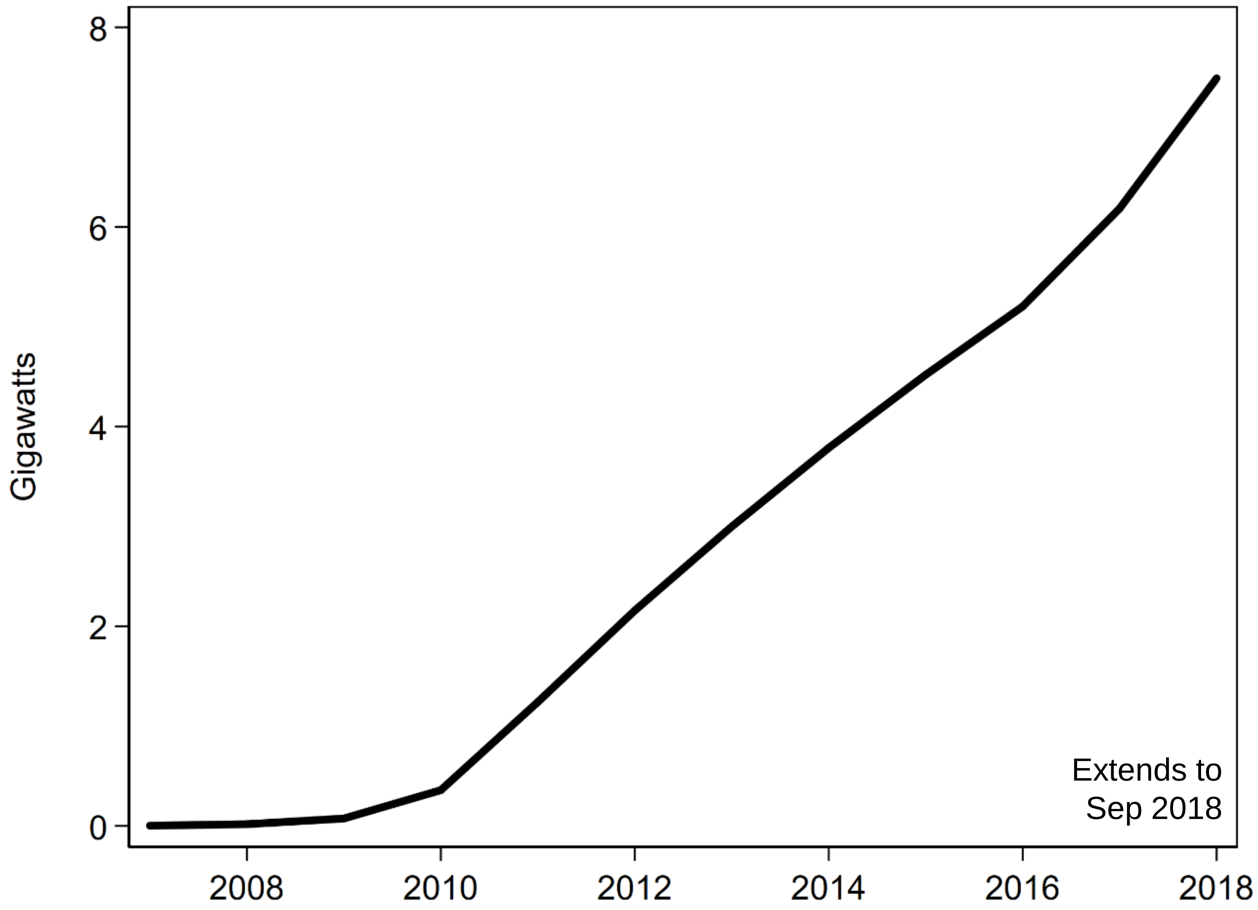
- > 20% of households have rooftop solar PV
- This is > 2 million households
- > 8 GW of small-scale solar capacity (systems of <100 kW)
- Total number of small-scale installations is similar to the US

Rooftop solar:

- Helps households reduce their electricity bills
- Helps to reduce emissions

Picture: https://www.solarchoice.net.au/residential-solar-panels-and-batteries

Total capacity of solar PV systems (100 kW and below), 2007–2018



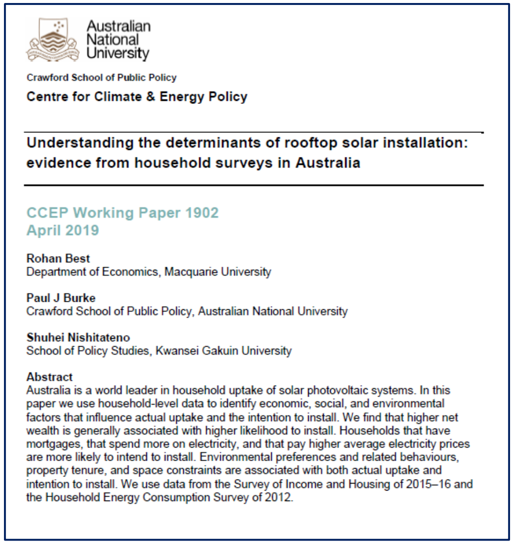
= 74% of Australia's total solar PV

Questions

What are the reasons for differences in uptake of small-scale solar PV across Australian postcodes?

What effect has the Small-scale Renewable Energy Scheme (SRES) had?

Which household-level factors explain differences in solar installation rates?



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Understanding the determinants of rooftop solar installation: evidence from household surveys in Australia

CCEP Working Paper 1902
April 2019

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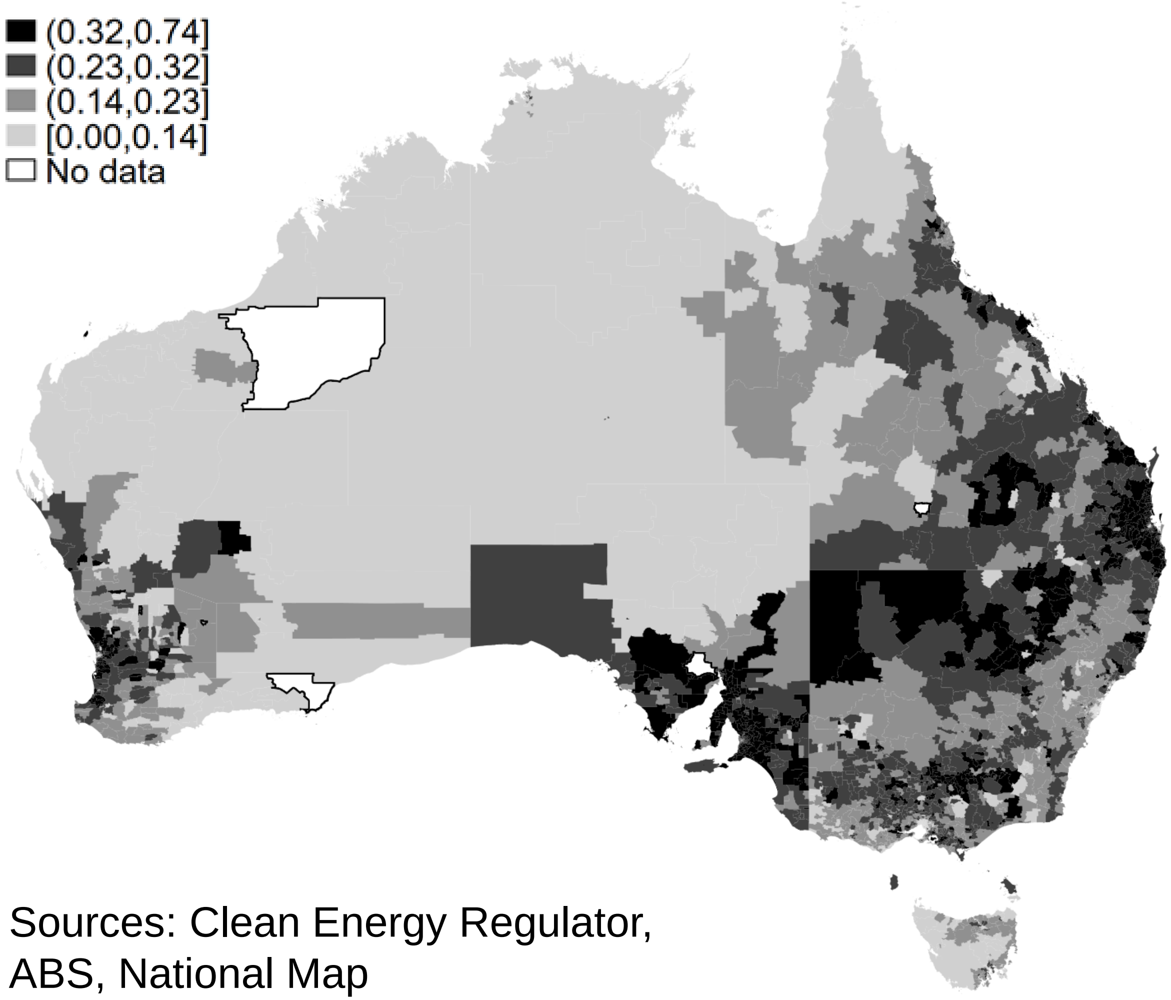
Abstract
Australia is a world leader in household uptake of solar photovoltaic systems. In this paper we use household-level data to identify economic, social, and environmental factors that influence actual uptake and the intention to install. We find that higher net wealth is generally associated with higher likelihood to install. Households that have mortgages, that spend more on electricity, and that pay higher average electricity prices are more likely to intend to install. Environmental preferences and related behaviours, property tenure, and space constraints are associated with both actual uptake and intention to install. We use data from the Survey of Income and Housing of 2015–16 and the Household Energy Consumption Survey of 2012.

See: https://ccep.crawford.anu.edu.au/panel/3309/publications

Solar PV uptake across Australian postcodes



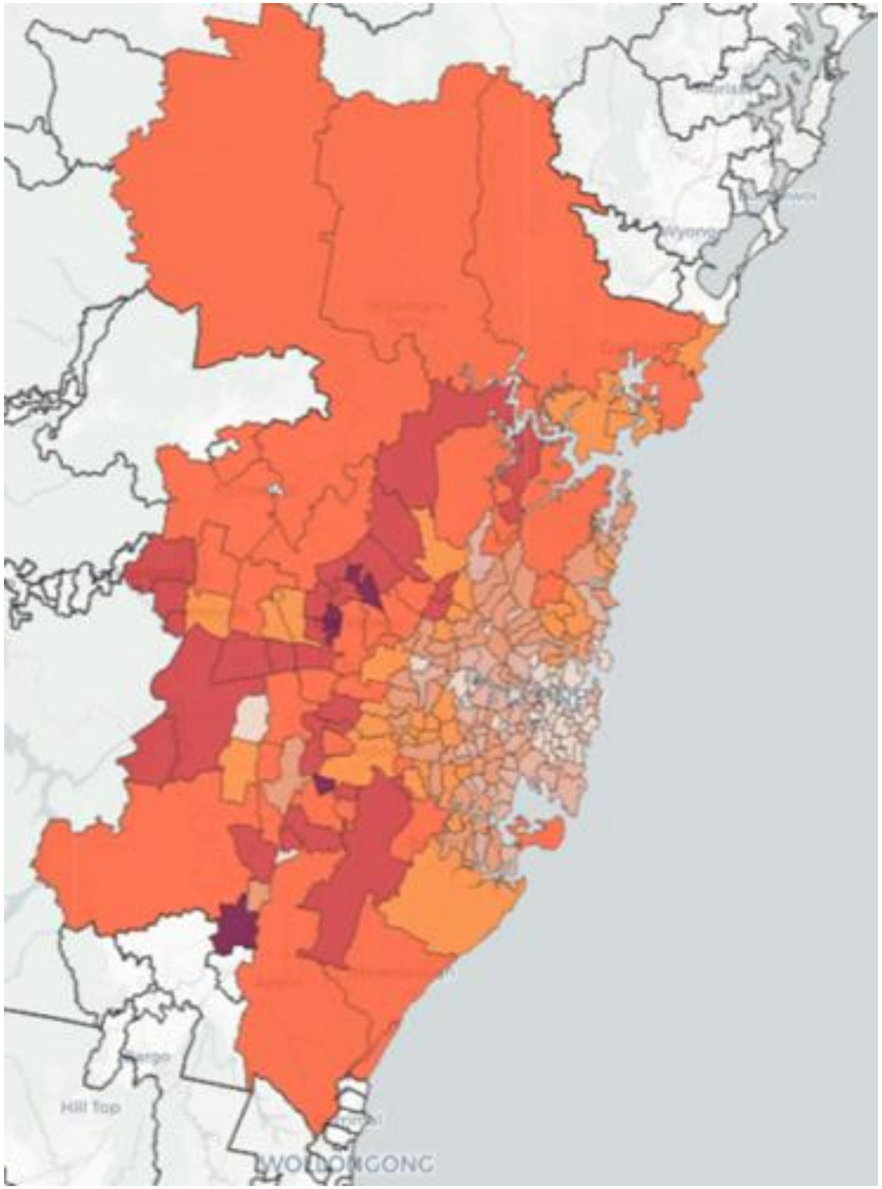
Data for December 2018

Only shows systems <100 kW

Darker shading = greater uptake per household

Sources: Clean Energy Regulator, ABS, National Map

Sydney

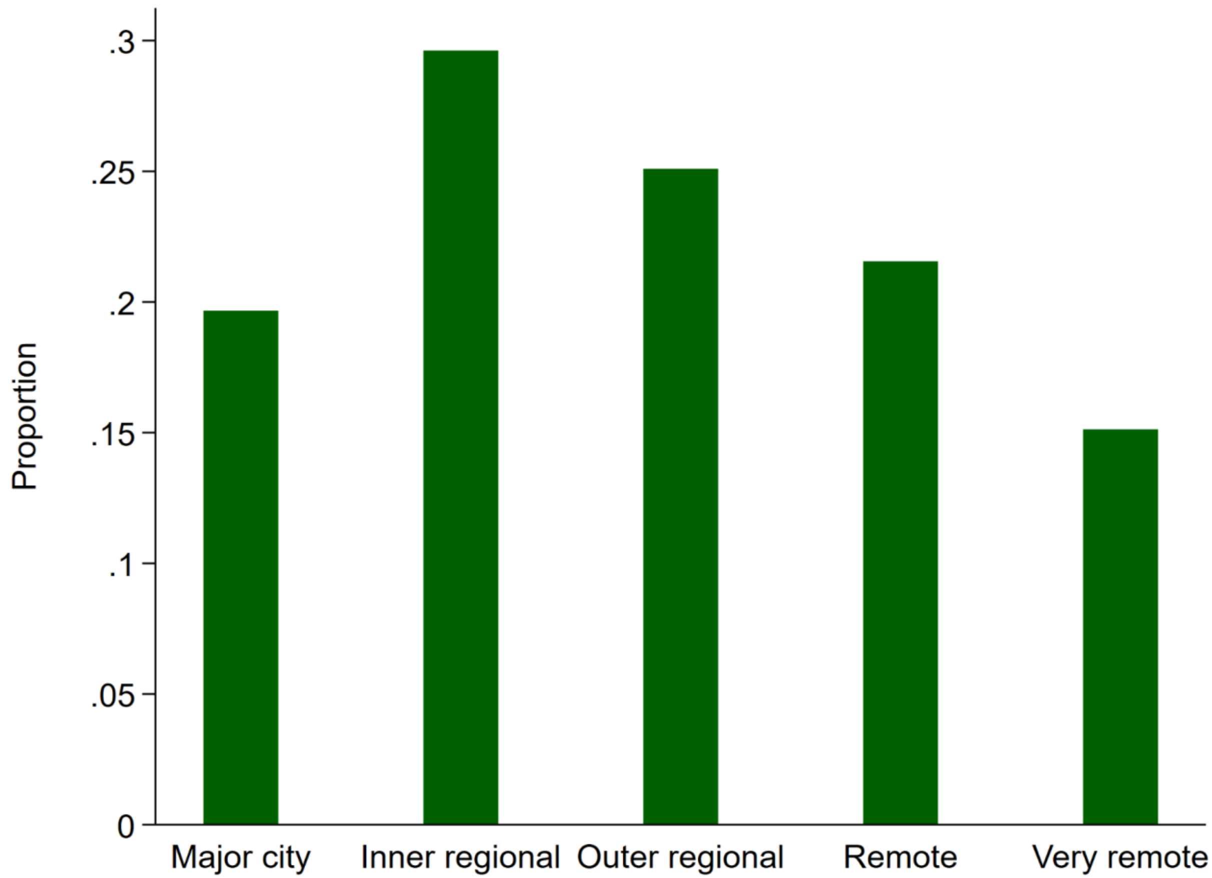


Sources: Clean Energy Regulator, ABS, National Map

Top postcode in each state/territory

	Solar penetration (% of households, 2018)
Elimbah (QLD)	68
Willunga (SA)	52
Narrabri (NSW)	46
Gidgegannup (WA)	43
Wangaratta South (VIC)	35
Grindelwald (TAS)	24
Alice Springs (NT)	21
Gowrie (ACT)	20

Proportion of Australian households with solar PV



Small-scale Renewable Energy Scheme (SRES)

A green certificate scheme – the key national instrument for increasing uptake of small-scale solar PV

Certificates are provided up-front to installers for future power generation

Electricity retailers and other large consumers of wholesale electricity are required to buy certificates

Effective up-front subsidy ($) =
Certificate price ($/certificate)
* Size of system (kW)
* Deeming period (years)
* Subsidy factor

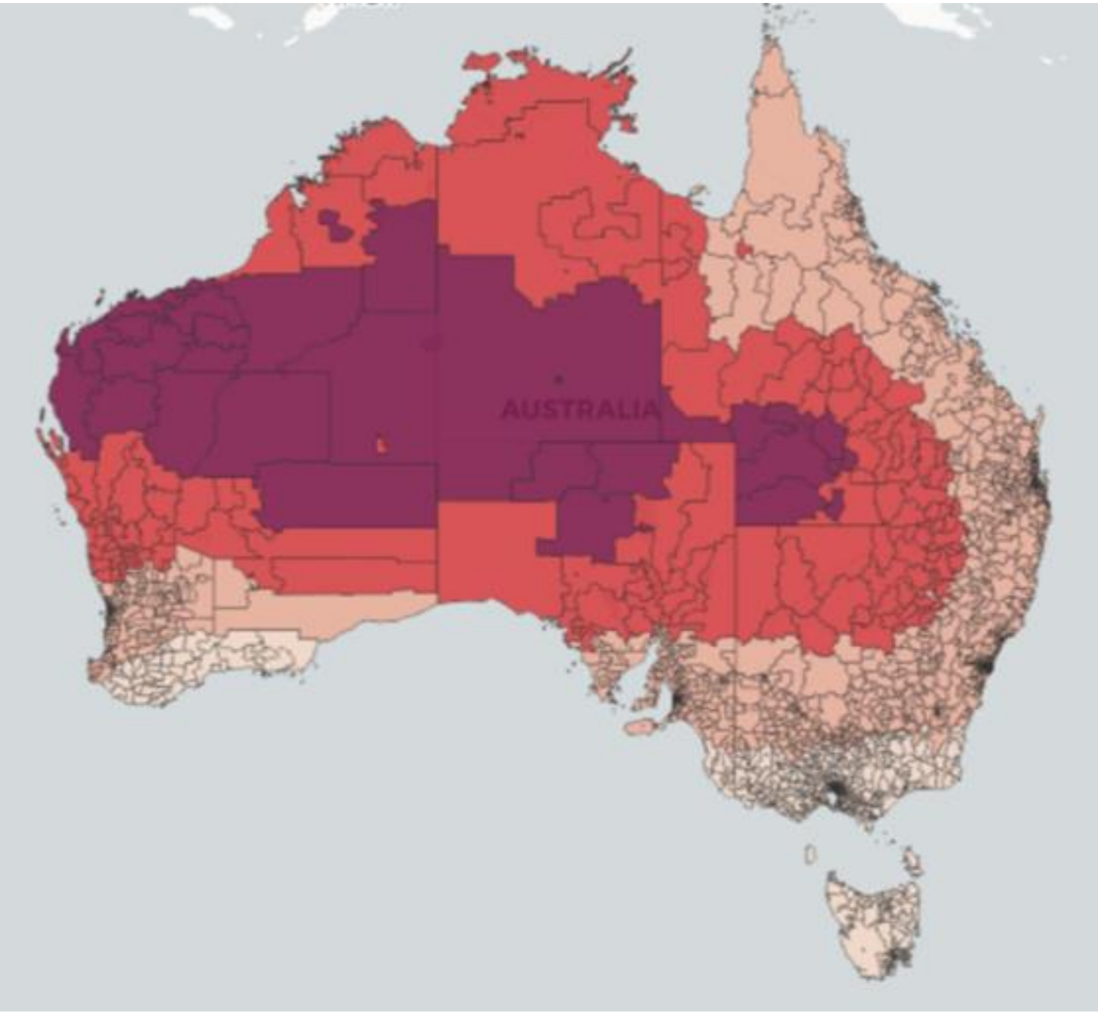
Subsidy factor varies by postcode

There are 4 zones

Has been no change in subsidy factor over time

A household installing a 3-kW system in zone 3 in 2018 would have received a subsidy of around A$2,000

Subsidy factors



Zone 1 (darkest)
- 1.622
- e.g. Alice Springs

Zone 2
- 1.536
- e.g. Darwin

Zone 3
- 1.382
- e.g. Sydney

Zone 4 (lightest)
- 1.185
- e.g. Melbourne

Method:
Cross-sectional estimations

$$S_p = \theta \ln Z_p + \text{many controls} + \epsilon_p$$

S_p= solar dependent variable for postcode *p*

Z = subsidy factor

- Solar PV installations per household
- Log capacity of solar PV installations (kW)

For systems of < 100 kW

Measured as at December 2018

Controls include:

- Economic variables
- Geographic variables
- Household characteristics
- Spatial auto-regressive term

Explanatory variables

Economic

- Log median income per capita
- Log median superannuation balance
- Households with a mortgage (%/100)
- Log number of employing businesses per capita
- Number of households in income bands (proportions)

Geographic

- Log solar exposure (MJ/m^2)
- Electricity distribution area binary variables
- Enhanced vegetation index
- Remoteness-area binary variables
- Log land area
- 69 climate zones

Household characteristics
(all measured as %/100)

- Rental properties
- Units/flats/apartments
- One-bedroom or less
- < 1 year at current address
- Green party votes
- Aged over 60
- Living at a different address one year prior

R^2 values of 0.8 to 0.9 and above

Identification strategy

We use sharp geographical discontinuities in the SRES subsidy factor

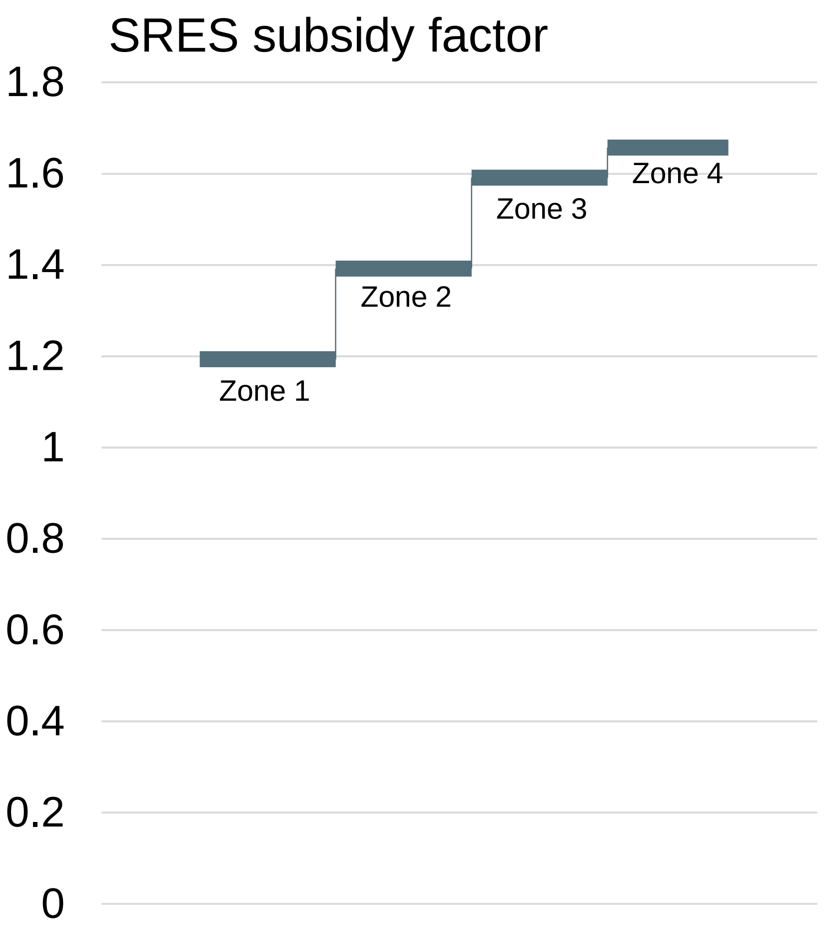
… while controlling for solar exposure conditions and other variables

… to evaluate:

- Effectiveness of the scheme
- Cost effectiveness of the scheme

Expect higher installation rates in areas with higher subsidy factors

⇨ Due to both a demand response and a supply response



Data sources

- Clean Energy Regulator
- Australian Bureau of Statistics
- Australian Electoral Commission
- ++

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Results

Higher rooftop solar PV installation rates in:

- Middle-income areas
- Mortgage-belt areas
- Sunnier areas
- Areas with fewer renters
- Areas with fewer apartment dwellers
- Areas with more older people (>60 years)
- Areas with more tree cover
- Outside major cities
- Areas neighbouring postcodes with high installation rates

Picture: solarbay.com.au

Magnitudes of effects

10 pp ↑ in proportion of renting households

⇨ 1 pp fewer households with solar installations

10 pp ↑ in proportion of households in apartments

⇨ 0.5 pp fewer households with solar installations

Results for SRES subsidy factor

1% higher SRES subsidy ⇨ 0.2 percentage points in additional rooftop solar uptake

Subsidy elasticity of the flow of small-scale solar PV installations in 2018 = 1.2

Results

Dependent variable: Log solar PV capacity

	Coefficient	(Standard error)
SRES subsidy factor, log	0.631***	(0.230)
Enhanced vegetation index	0.538***	(0.137)
Solar exposure, log	2.316***	(0.220)
Rented households, %/100	-0.649***	(0.183)
Apartments, %/100	-1.161***	(0.095)
Proportion aged over 60 years	0.791***	(0.193)
Mortgage, %/100	2.093***	(0.143)
Spatial auto-regressive term	0.015***	(0.004)

(Selected explanatory variables only)

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Results for recent installations

	Log solar capacity additions during:	
	2017	**2018**
SRES subsidy factor, log	1.627***	1.150**
Additional controls	Yes	Yes
R^2	0.81	0.84

Subsidy cost of emissions reductions under the SRES

We ask:

If a higher subsidy factor were applied across the board, how many additional panels would be installed – and how many tonnes of CO_2 emissions avoided?

We use the subsidy elasticity of the flow of small-scale installations of 1.2 estimated for 2018

Answer: Subsidy per t CO_2 reduced = A$51 = **US$36**

This calculation is subject to assumptions:

- Emissions intensity of displaced electricity (0.001 t CO_2/kWh)
- Life of panels (13 years)
- Capacity factor of panels (0.2)

We carry out a sensitivity analysis also

Comparing our cost estimate to estimates from the US

US$36 per t CO_2 reduced is lower than found for some schemes in the US

Likely to be due to reasons such as:

- More favourable solar conditions in Australia
- Higher carbon intensity of electricity in Australia
- Smaller subsidies in Australia than US
- Lower panel costs in recent years

Similar to the estimated **social cost of carbon** of the US Government

Results from household surveys

Households more likely to **install** if:

- Higher household net wealth (except at very high levels)
- Not renting
- Not in an apartment
- In a larger house (measured by # bedrooms)
- In a newer house
- Self-funded retiree
- Participate in a green power scheme
- Outside the capital city (applies to NSW, VIC, SA)

Households more likely to **intend to** install if:

- Have higher electricity bills
- Face higher electricity prices
- Have a mortgage

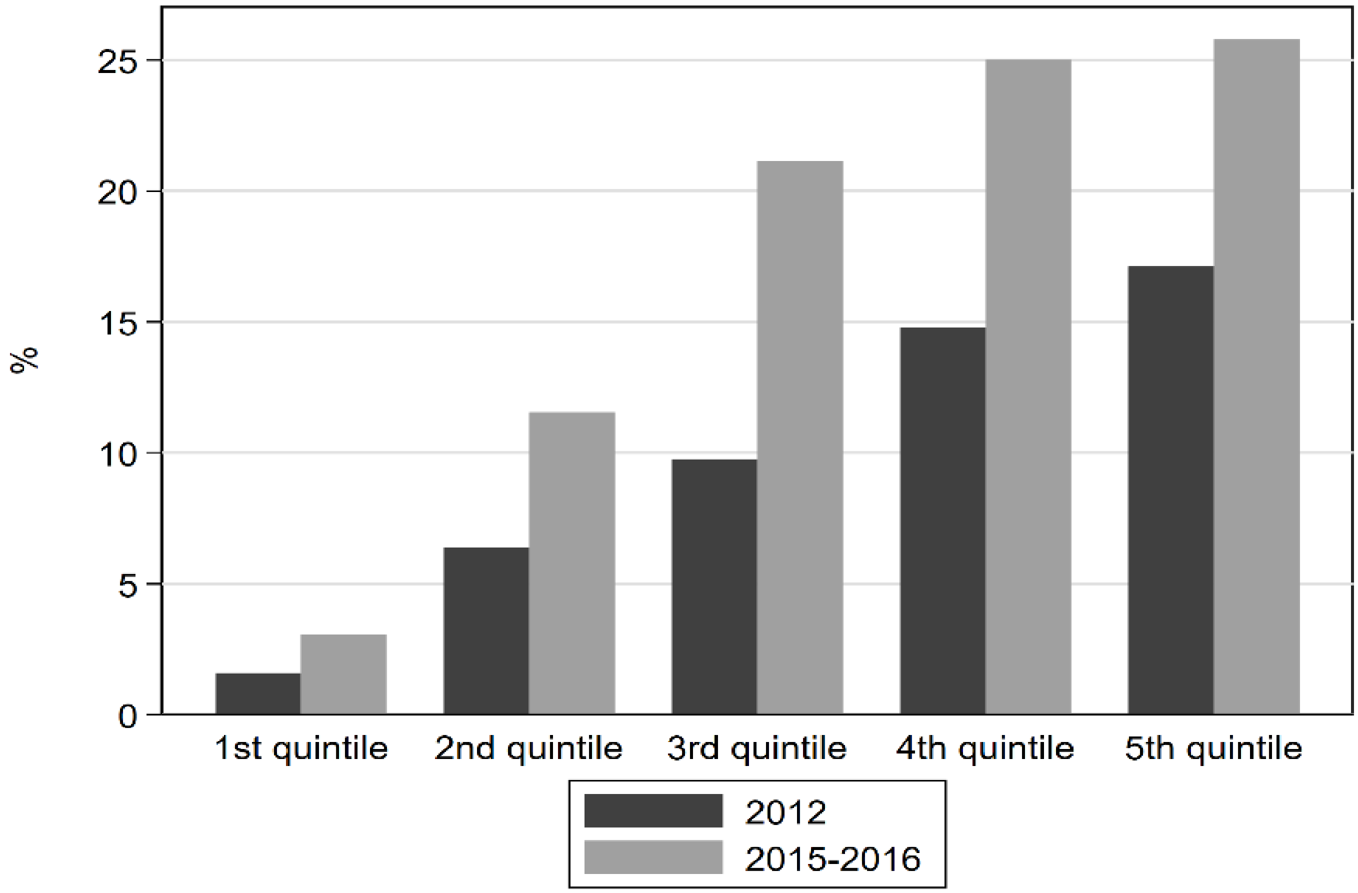
Income not found to play a significant role

ABS surveys:

- Survey of Income and Housing of 2015–16
- Household Energy Consumption Survey of 2012

Can use samples of > 11,000 households

Proportion of households with solar panels by net wealth quintile (survey results)



Policy implications

Scope to reduce barriers to uptake by:

- Renters
- Apartments

In future schemes, there is the potential for subsidies to be better targeted based on criteria such as:

- Solar exposure
- Transmission/distribution capacity
- Remoteness
- Net wealth

Consider carbon pricing if interested in achieving the cheapest emissions reductions

Picture: https://solarbay.com.au/september-record-month-rooftop-solar-australia/

Questions welcome

Australia's utility-scale solar PV sector is now starting to boom

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Picture: https://en.wikipedia.org/wiki/Solar_power_in_Australia