UCL Energy Institute

Analysis of international residential solar PV self-consumption

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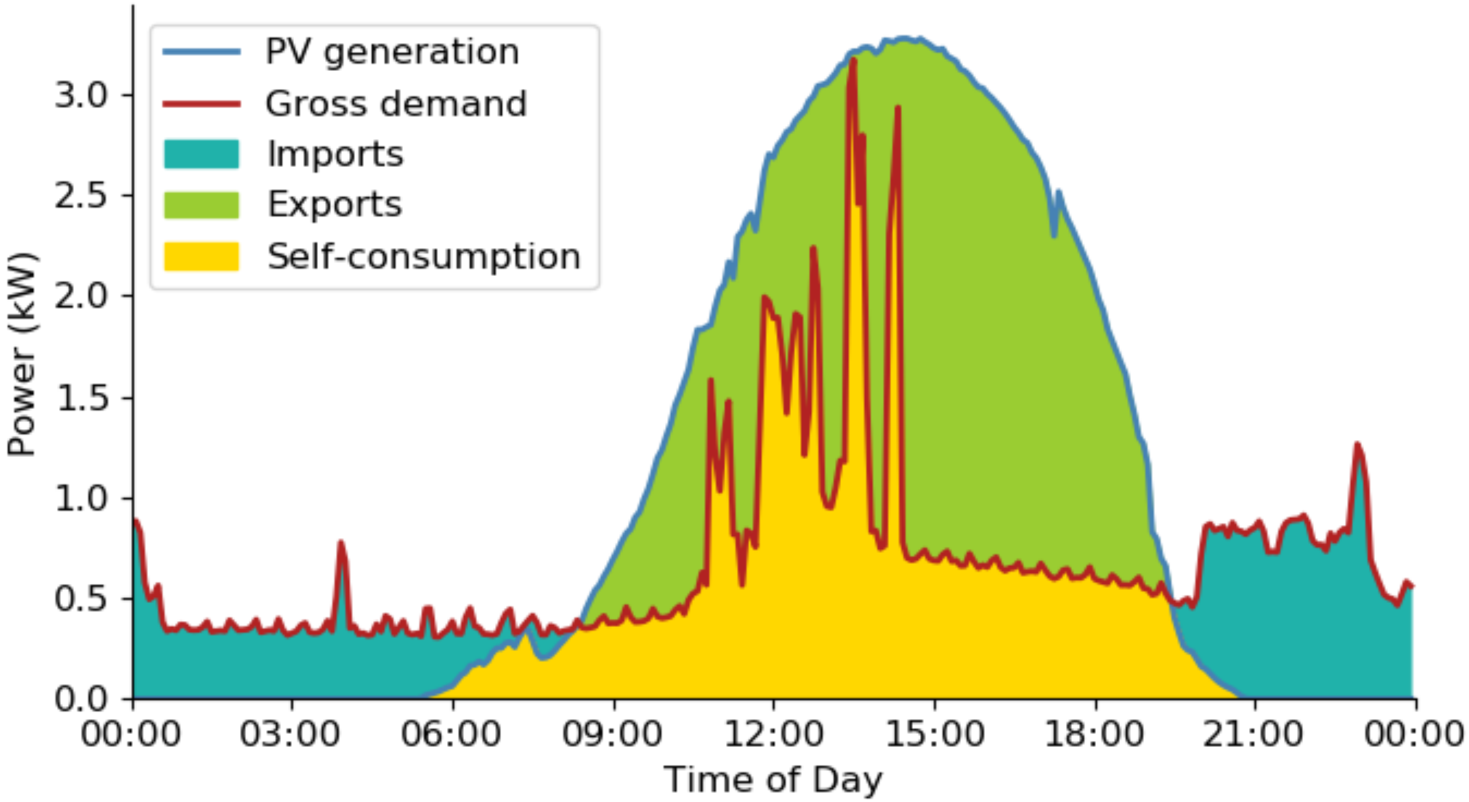
What is solar self-consumption?

Self-consumption is PV generation that reduces household imports from the grid



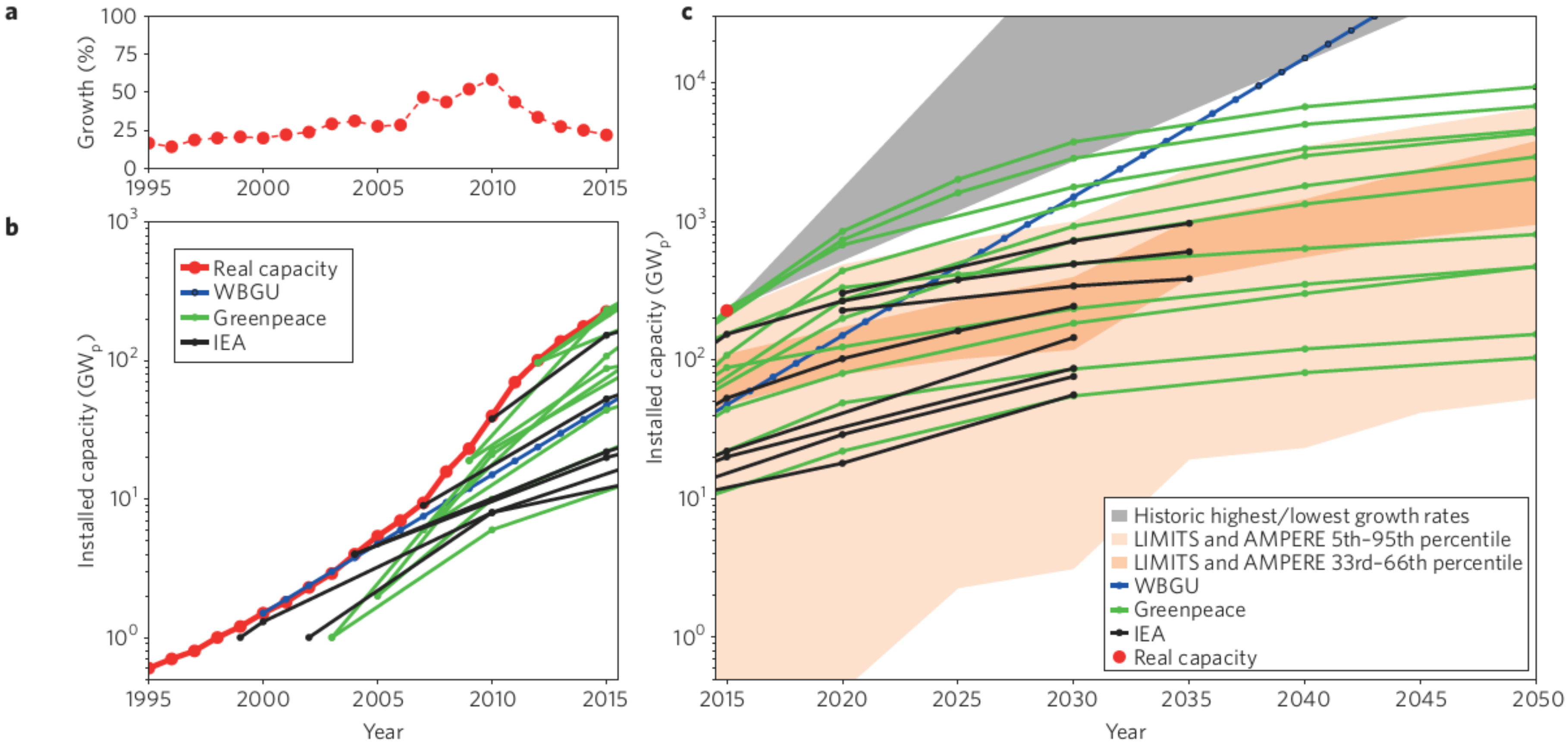
Electrical power flows for a summer day for an example residential household with PV in the UK.

WHY IS SOLAR SELF-CONSUMPTION IMPORTANT?

Self-consumption is a legal requirement in EU

- The revised EU Renewable Energy Directive makes it a legal requirement that all member states allow ‘self-consumers to generate, store, consume, and sell electricity without facing disproportionate burdens’ (European Parliament, 2018)

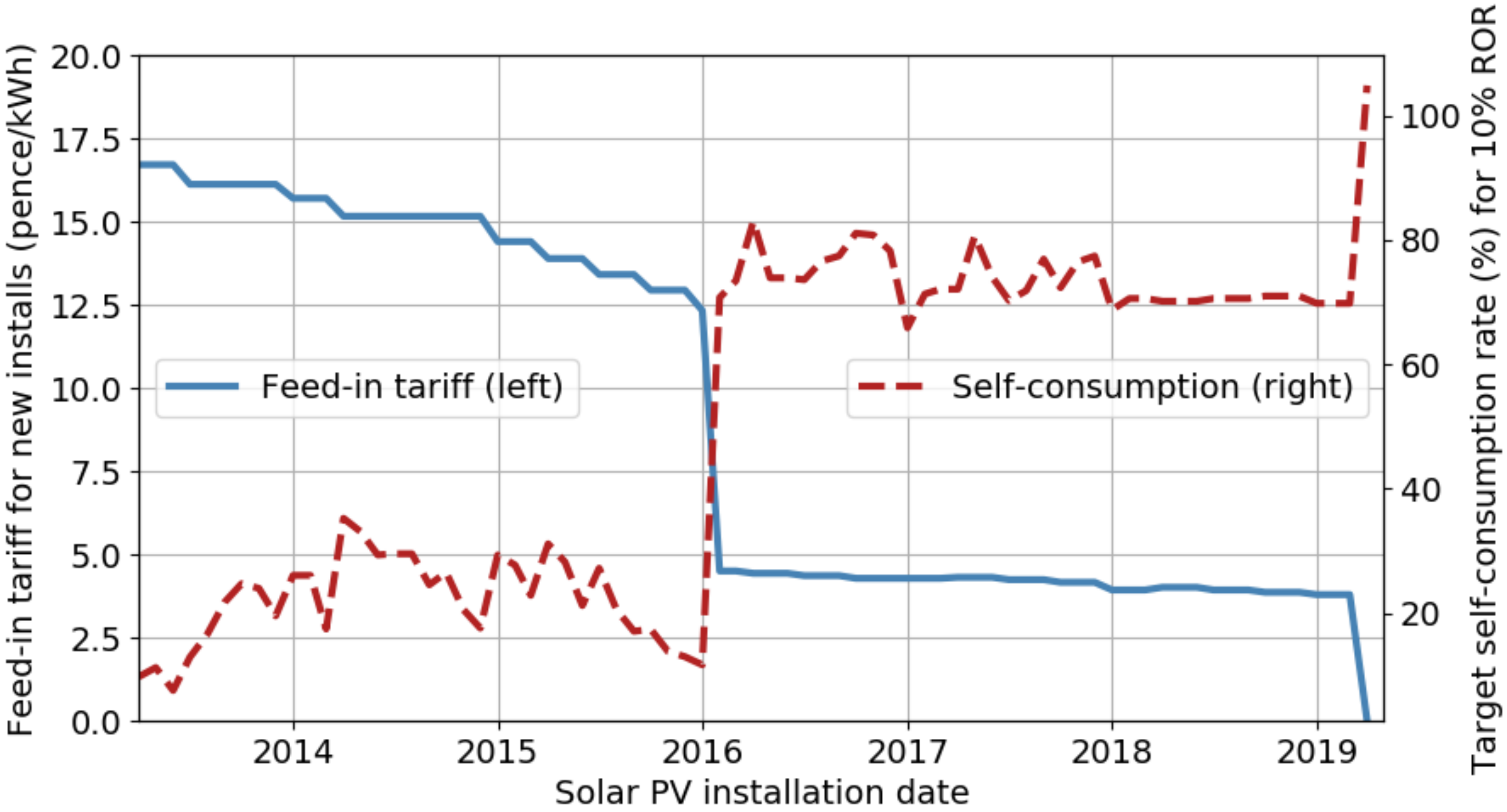
A future with much more self-consumption?



Growth in PV capacity and scenario projects

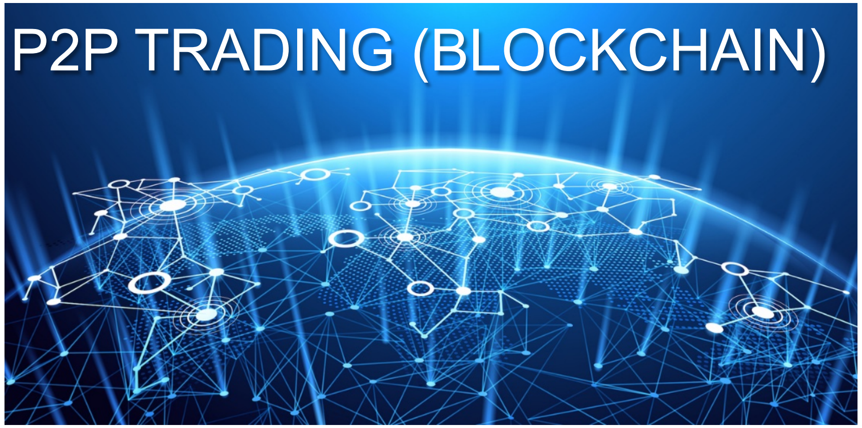
Creutzig, F., Agoston, P., Goldschmidt, J. C., Luderer, G., Nemet, G., & Pietzcker, R. C. (2017). The underestimated potential of solar energy to mitigate climate change. *Nature Energy*, *2*(9), nenergy2017140.

Post-subsidy PV: self-consumption is the primary economic driver for adoption of residential PV



Timeline showing the progressive reduction of the feed-in tariff (generation) rate in the UK and the corresponding target self-consumption rate to achieve a rate of return of 10% of the installation cost.

Self-consumption can drive adoption of technologies

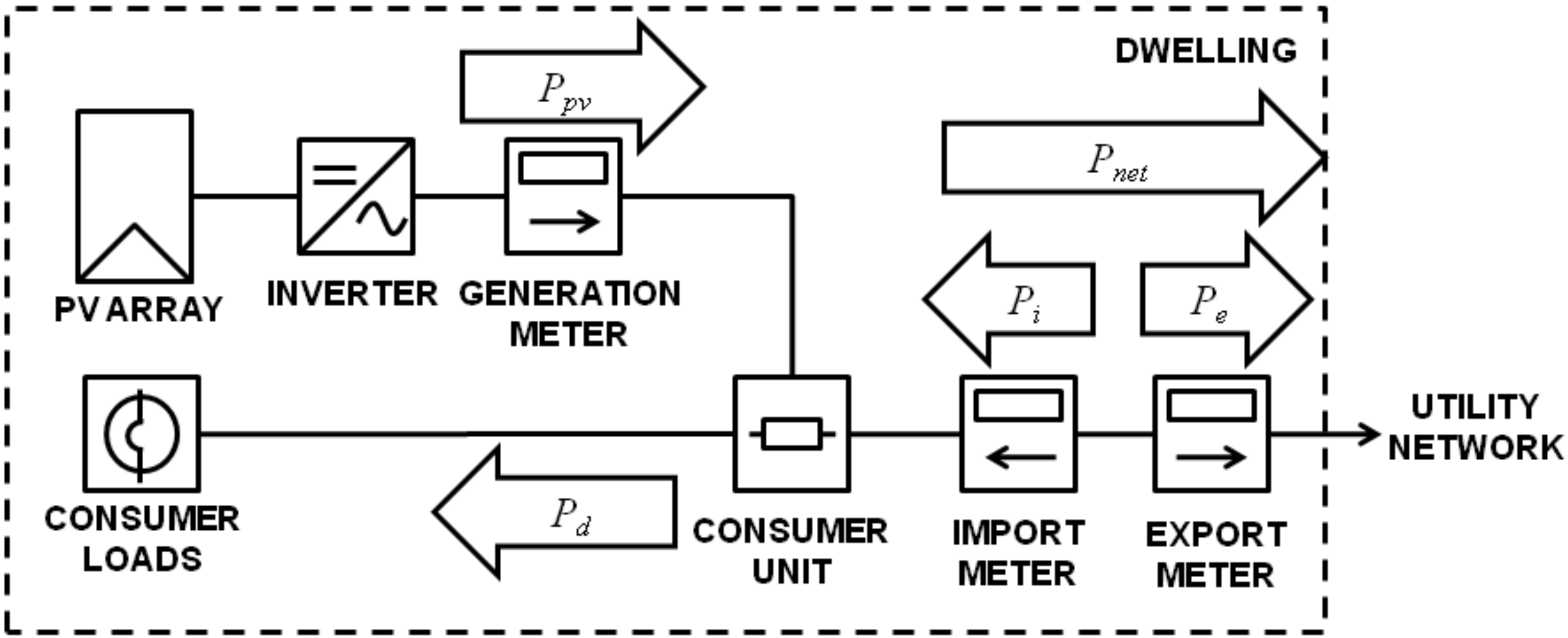


Problem:

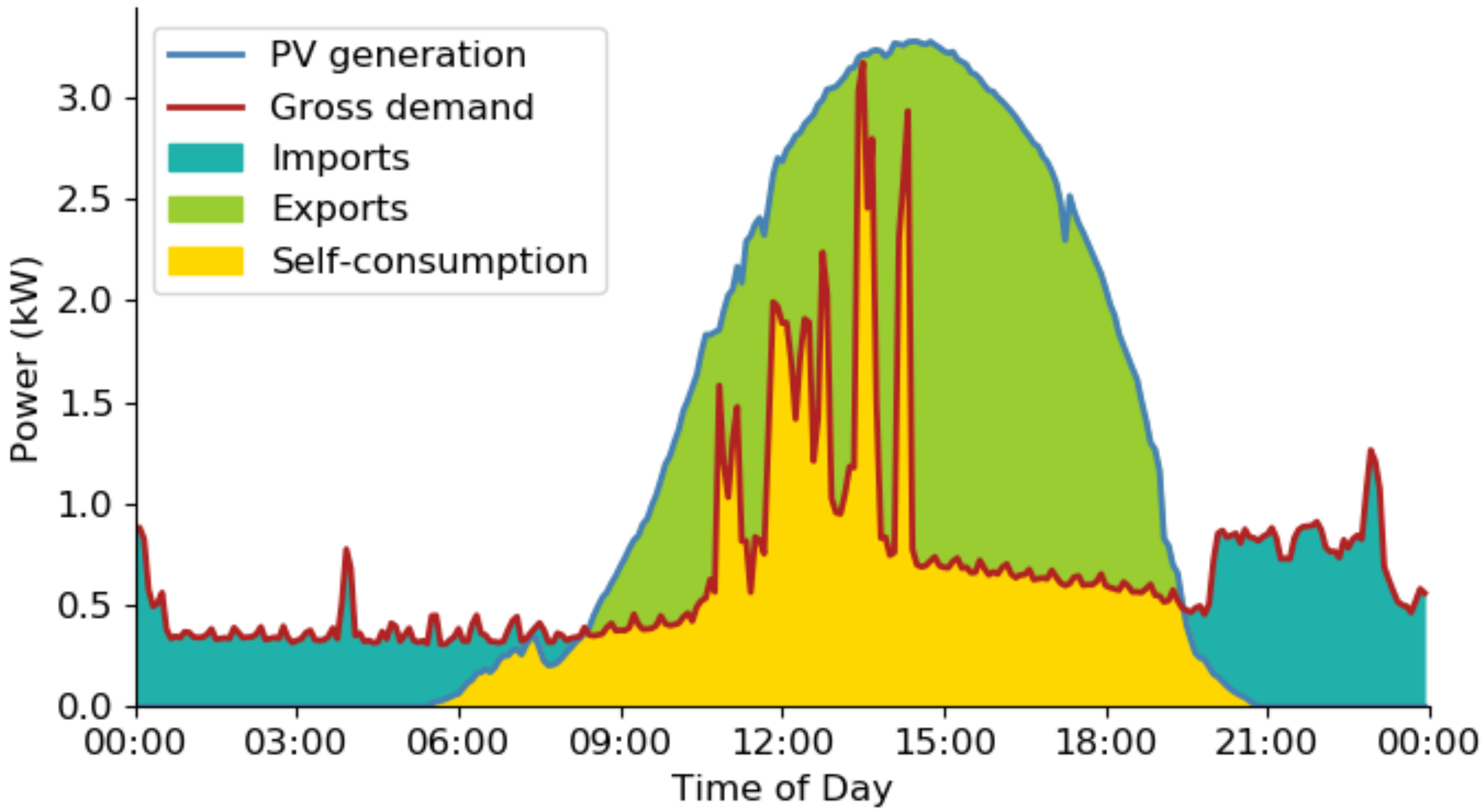
THERE IS A LACK OF EVIDENCE ON SELF-CONSUMPTION

Households with PV are not 'fully smart metered' by regulation: generation data is not available

A 'fully metered' household with PV



Without ‘full metering’ cannot measure generation, self-consumption or gross demand



Governments and solar industry make simplistic assumptions about self-consumption in the absence of reliable evidence. Some examples:

- UK
  - DECC (2015): '*little usable evidence*' on self-consumption.[1]
  - BEIS (2017): '*Our FiTs work doesn't cover self-consumption as the data is [not available].*'[2]
- Australia
  - Clean Energy Regulator (2017): '*We do not have data on household PV self-consumption*.'[3]
  - Clean Energy Council (2017): *'… there is no measured data available for electricity consumption behind the meter [and self-consumption] in Victoria*.'[4]

1. DECC, 2015a. Impact Assessment: Government response to consultation on a review of the Feed-in Tariff scheme.
2. Nick Jesson, BEIS. Personal communication.
3. Michael Whitelaw, Manager, Clean Energy Regulator, Australia. Personal communication.
4. Darren Gladman, Director, Clean Energy Council, Australia. Personal communication.

Lack of visibility of distribution generation is a problem for integrating solar into networks

System balancing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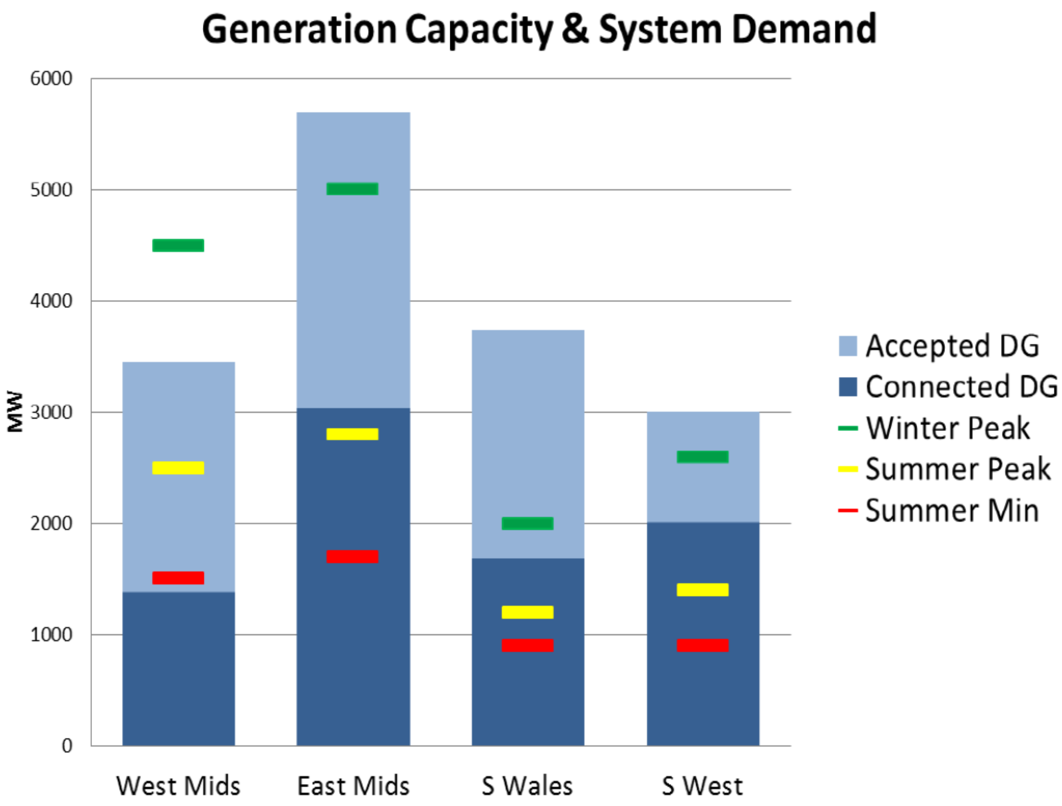
LV networks



Source: Western Power Distribution, Distributed Generation Stakeholder Workshop, November 2016

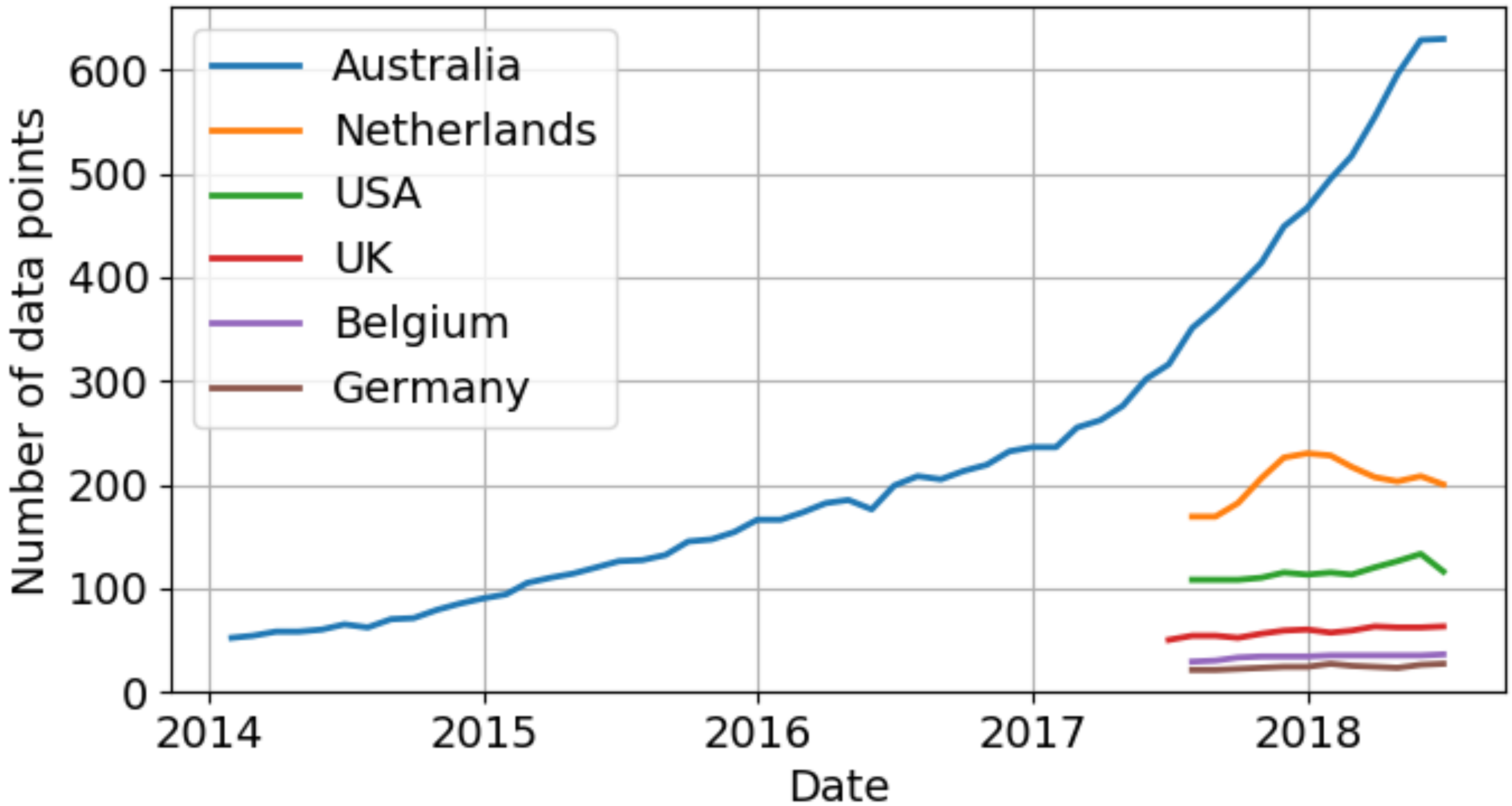
Requirement:

BETTER DATA AND ANALYSIS OF SELF-CONSUMPTION IN SOLAR HOUSEHOLDS

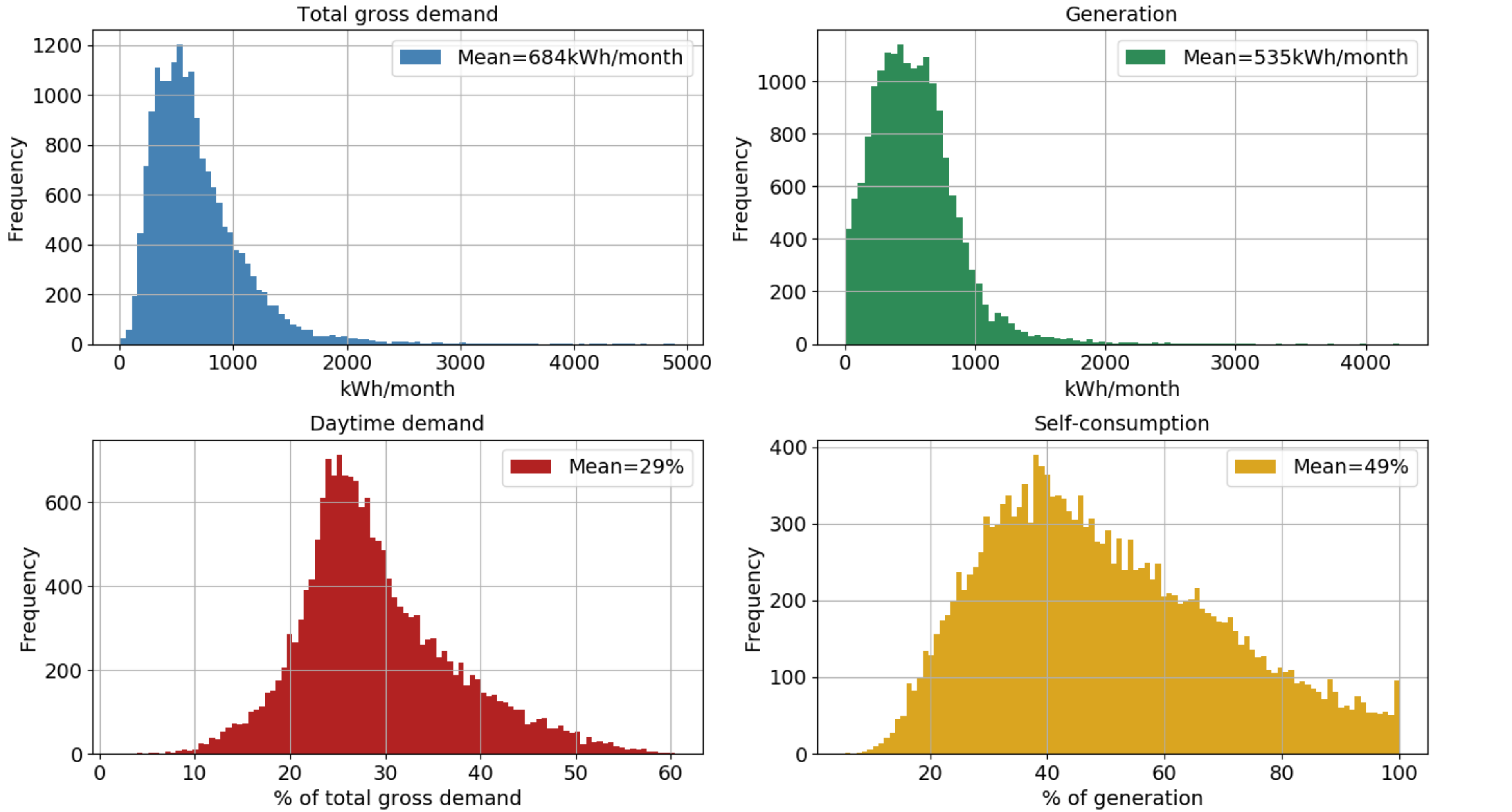
Data requirements (ideal vs. best available)

Ideal data requirements	Data analysed in this paper
Cross-sectional	1300 households, 6 countries
Longitudinal	Multi-year
Empirical observations (not simulated)	Yes
Fully metered (not net metered)	Yes
High-resolution, real-time	5 minute real-time
Accurate	'Clip-on' current sensors (probably)
No missing data	Some
Contextual data such as: • Socio-demographics • Tariff • Presence of techs (e.g. battery)	None
Representative	No

Data for 1315 systems, six countries and multiple years



Considerable variation in self-consumption



Histograms of total demand, PV generation, daytime demand fraction and self-consumption (as a percentage of PV generation) for each household each month. The legend indicates the mean values of each distribution.

Predicting self-consumption: a simple regression model based on monthly data (r squared 0.915)

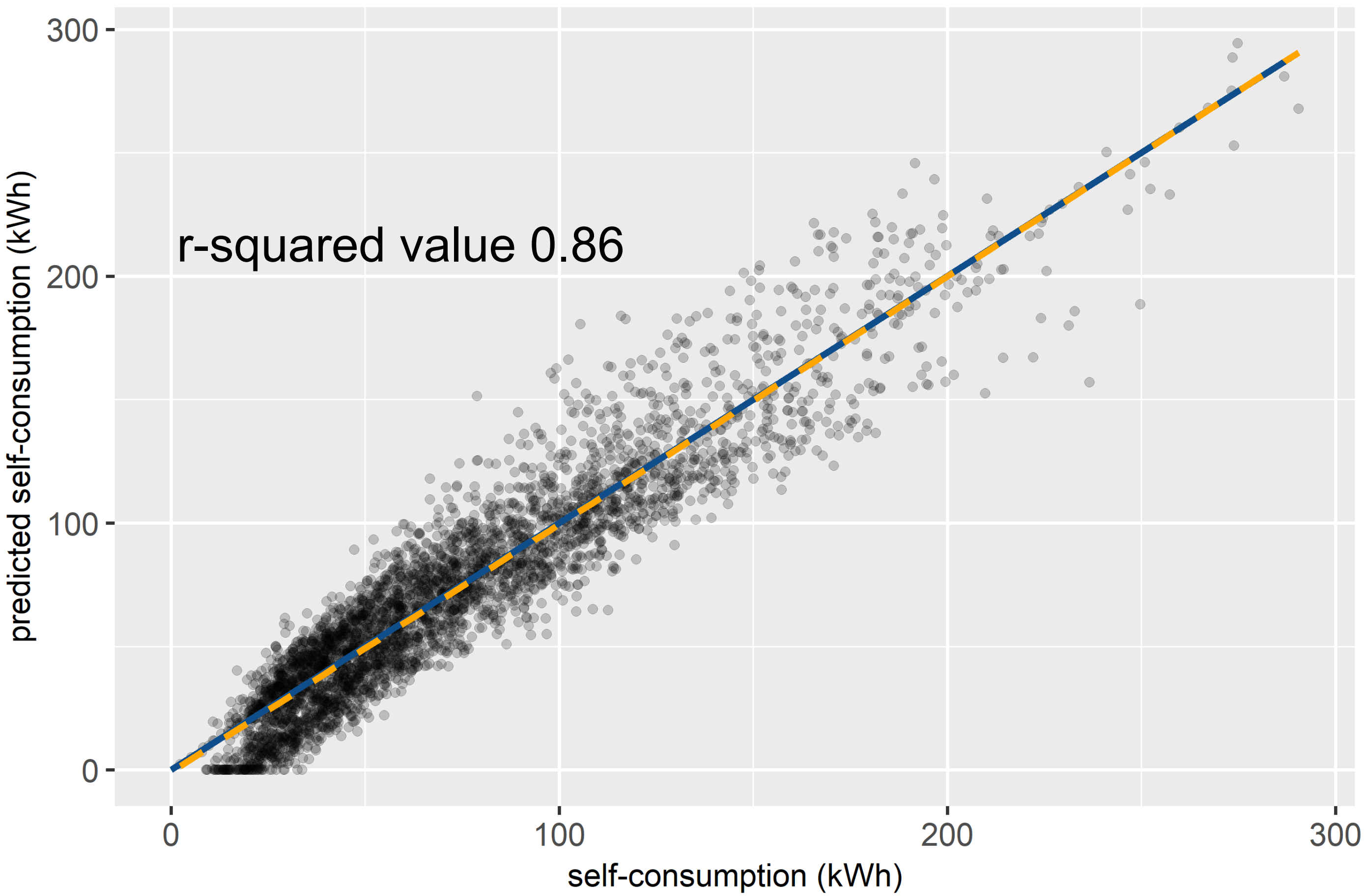
$$E_i^{self} = \beta_0 + \beta_1 E_i^{pv} + \beta_2 E_i^{gross} f_i^{day} + u_i$$

Regression coefficients by country. The highest (lowest) values out of all countries are shown in blue and yellow shading). The 5th row (Generation/daytime demand) is the calculated ratio of the coefficients.

	AU	BE	DE	NL	GB	US	All
Number of observations	12225	405	287	2446	751	1385	**17529**
PV Generation	0.221 (0.001)***	0.276 (0.009)***	0.183 (0.006)***	0.282 (0.003)***	0.390 (0.007)***	0.238 (0.004)***	**0.230 (0.001)*** **
Daytime demand	0.836 (0.003)***	0.679 (0.031)***	0.753 (0.032)***	0.419 (0.010)***	0.626 (0.019)***	0.835 (0.012)***	**0.805 (0.003)*** **
Intercept	-36.357 (1.012)***	-47.686 (6.298)***	-19.438 (3.852)***	-11.792 (1.404)***	-47.501 (3.521)***	-76.857 (4.032)***	**-38.187 (0.769)*** **
R-Squared	0.914	0.852	0.934	0.842	0.877	0.922	**0.915**

Checking the results: predicting self-consumption for an independent set of households with PV using UK data

$$E_i^{self} = -47.5 + 0.39 E_i^{pv} + 0.84 E_i^{gross} f_i^{day} + u_i$$



Conclusions

- Understanding self-consumption important for uptake of PV (and other techs)
- Considerable variation in household self-consumption
- Well-explained by solar generation and day-time electricity demand (r-squared 0.915)
- Good accuracy in predicting self-consumption for independent group (r-squared 0.864)
- A simple model to predict self-consumption internationally
- Empirical self-consumption data (and analysis) is still rare
- Requirement for better data: large representative samples of households with PV
- Lack of integrated generation metering a concern

THANK YOU

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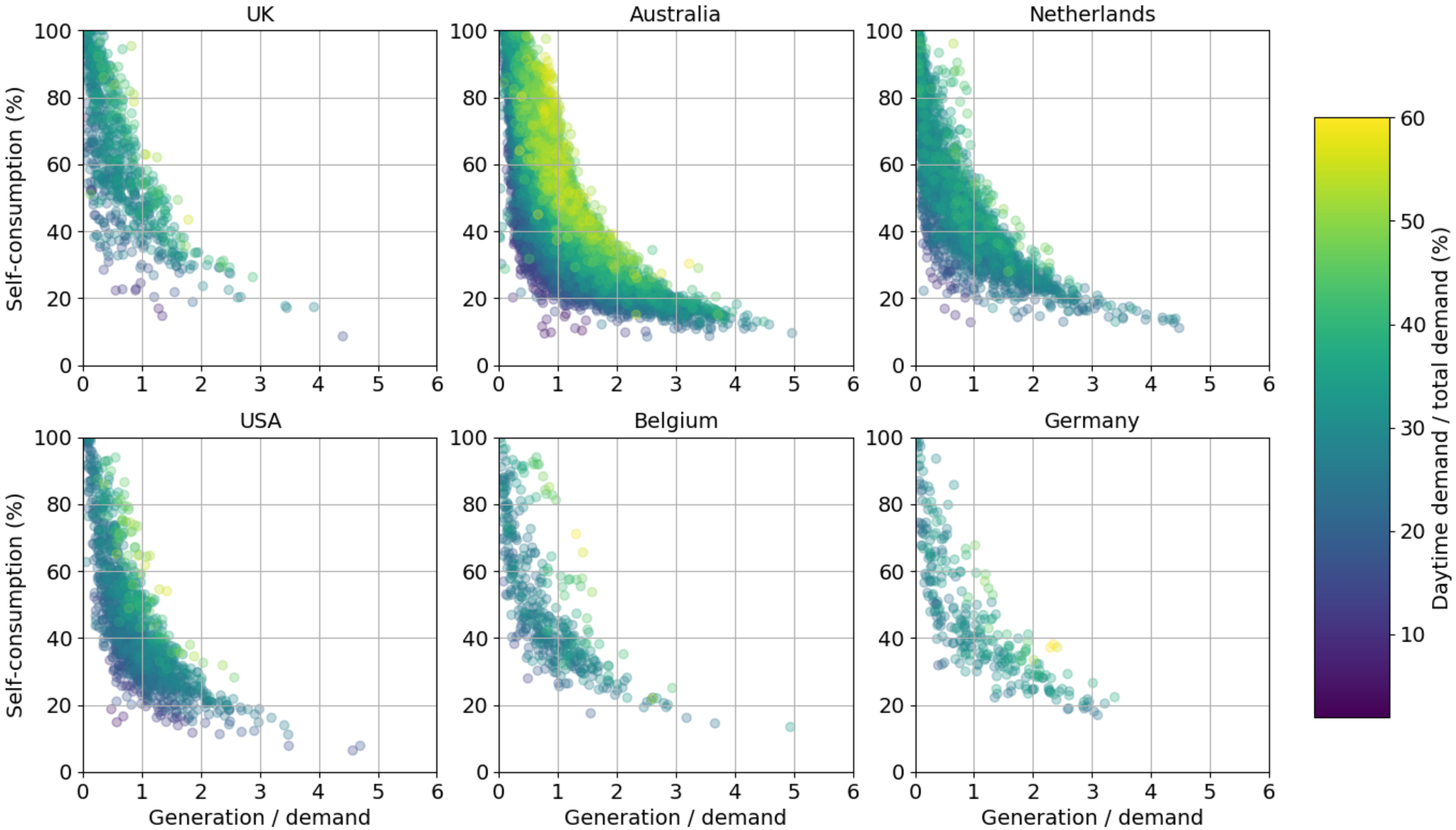
Come along to my informal session!

FURTHER SLIDES

Factors affect self-consumption are similar between countries



Self-consumption (as a percentage of generation) against monthly generation divided by monthly demand for each country. Each circle represents one month's totals for one PV system. Circle colour indicates the proportion of demand consumed during the daytime (10:00 – 16:00)