Using smart energy storage to increase self-consumption of solar-generated electricity and reduce peak grid load at household and community level

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Outline of presentation

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- Context
- Overview of Project ERIC
- Dwelling and household survey
- Baseline electricity consumption and PV electricity generation
- Contribution of smart electricity storage
- Key findings

Need for energy flexibility in the energy system

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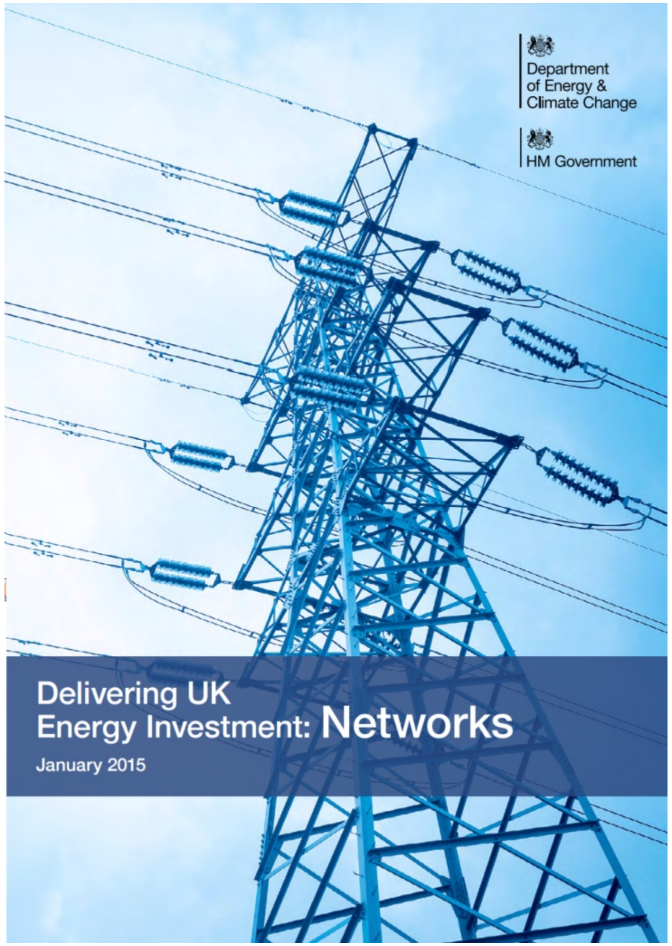
- Solar PV electricity generation increased by 87% in 2015, however on their own they provide little resilience given the mismatch between PV electricity generation and consumption

- Energy storage capabilities: physical means to achieve resilience, since:
  - Able to balance energy demand and supply
  - Respond to sudden changes in conventional energy supply

- Domestic battery storage technologies have smaller storage capacity and very low discharge time (milliseconds). Deployment is limited: mostly theoretical studies



Overview of Project ERIC

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- £1.2million (€1.2m) project part-funded by Innovate UK under the *Localised Energy generation* competition, 2015-2017
- New initiative bringing Solar PV and smart electricity storage to 75-100 households in a community
- Demonstrate how management of distributed storage in a community can increase self consumption of PV electricity and reduce average peak grid load
- Give householders more control over their energy use
- Real life, research project and a collaboration between industry, local government and academia

PROJECT ERIC
re-energising communities

moixa TECHNOLOGY | Innovate UK | Bioregional | OXFORD BROOKES UNIVERSITY | OXFORD CITY COUNCIL | British Gas | Scottish and Southern Energy Power Distribution | reenergise GROUP

Project ERIC winner of Energy Awards 2016

- Winner
  - Residential energy project of the year

- Highly commended:
  - Innovation energy project of the year

ERIC community

■ ERIC households

- South-east region in England
  - Socially deprived community with mainly local council rented households
- **82 ERIC households**
  - 74 social rented
  - 8 owner-occupied
- All households have solar PV systems
- All households have a 2kWh electricity storage unit

Evaluating Project ERIC: methods

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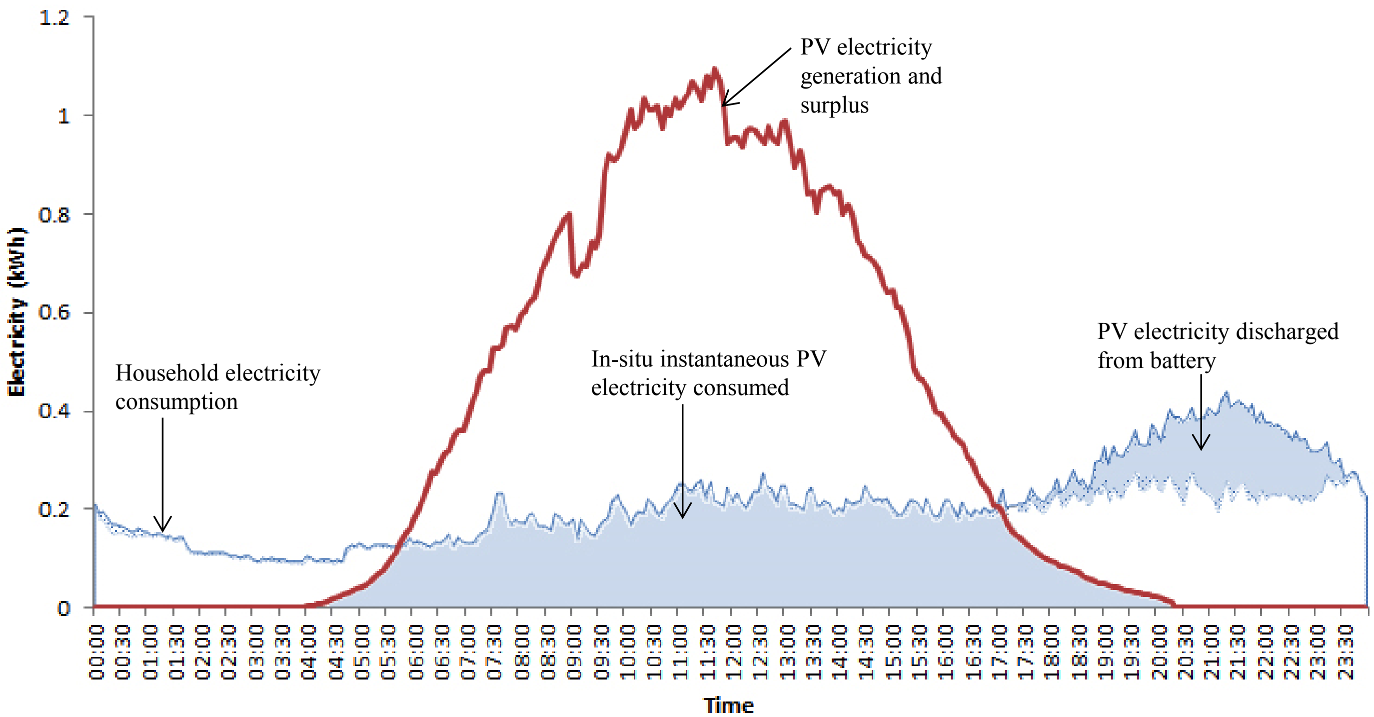
Monitoring method		Purpose
1	**Dwelling surveys**	Assess the physical characteristics of the dwellings
2	**Household surveys and interviews**	Assess socio-economic characteristics and energy attitudes of households
3	**Baseline electricity use and solar PV electricity generation**	Assess the potential to increase self-consumption
4	**Contribution of electricity storage**	Assess the actual increase in self-consumption of PV electricity and reduction in peak grid demand

- Varying sample sizes due to the availability of complete and reliable data

Evaluating storage performance



- Batteries charge only when there is excess PV electricity – PV generation exceeding household consumption
- Batteries discharge only when there is little or no PV generation

Dwelling and household characteristics

- Houses (terraced, semi-detached, detached) and flats
- Energy efficiency rating B to D
- Variety of household sizes: 1 to 8 householders
- Variety of household types: e.g. families with dependent children, single person over 65
- Variety of occupancy patterns: e.g. always occupied, evenings and weekends only

Householders' energy attitudes

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- Households' attitudes towards energy and climate change were recorded to provide a context for ERIC
  - **75%** of ERIC householders were **concerned** about **rising energy prices**
  - 80% frequently think about their household energy use
  - **72%** were **concerned** about **climate change**
  - **60%** were **concerned** about **energy supplies**

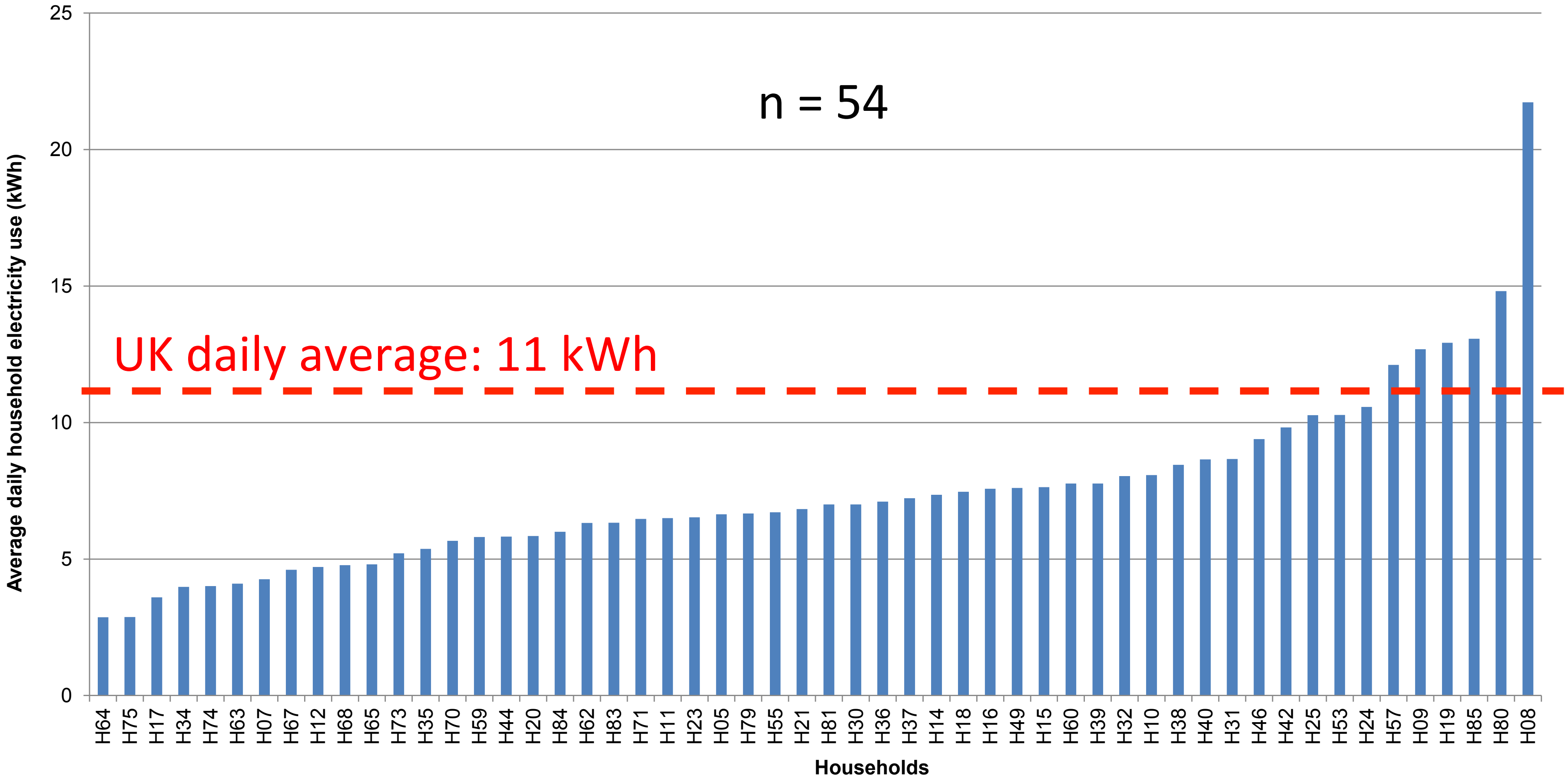
'Yes, they [energy prices] are too high. You don't have no control over that'
(social rented householder)

'I do believe we are running out, …, so we've got to do something. We must all try and save what we can'
(social rented householder)

- This was presented at the 2016 European Conference on Behaviour and Energy Efficiency (Behave)

Baseline electricity consumption and PV generation

Baseline electricity consumption



Daily average consumption	kWh	Daily average consumption	kWh
Minimum	2.9	Median	6.9
Maximum	21.7	**Mean**	**7.3**

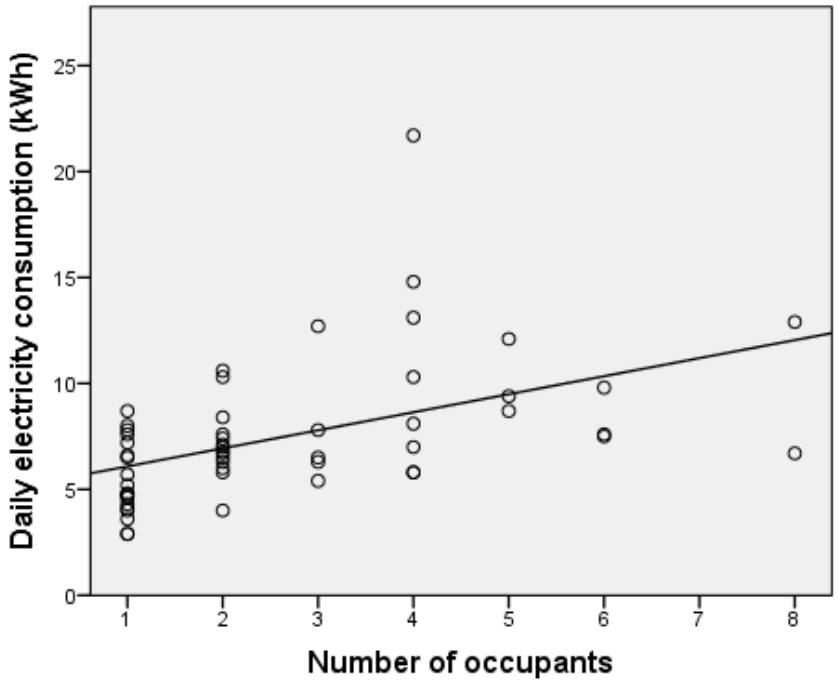
Factors affecting electricity use

Factors found to influence household electricity use

- Dwelling type – daily average is highest in detached houses and lowest in the flats
- Occupancy pattern – households that are ‘always occupied’ have higher daily average consumption than those occupied for part of the time in the day
- Household size – as number of occupants in the household increases, daily average consumption increases

Number of occupants in the household

n=54, r = 0.48 (moderate)



PV generated electricity

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- Solar PV systems were installed in the social rented households
- PV system sizes range from 1.5kWp to 3.5kWp
- Approximately 91MWh of electricity generated from 47 households in one year (Apr-15 to Mar-16)
- Average daily generation matches daily consumption in some households in the summer

PV Size (kWp)	Average daily generation (kWh)				
	1.5	2.0	2.5	3.0	3.5
Summer	4.1	6.6	8.2	8.7	12.0
Winter	1.6	3.7	4.1	4.8	5.3

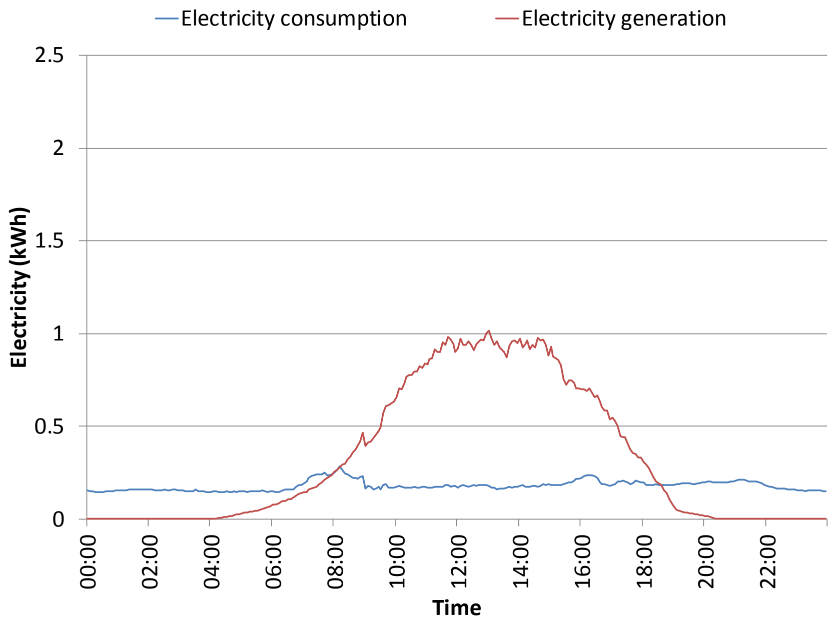
- Without export meters it is assumed 50% of generated PV electricity is consumed on-site and 50% is exported to the grid
- Savings of £6,825 can be achieved by the ERIC households

Electricity consumption and generation

- In most households peaks in generation and consumption are mismatched and profiles show surplus PV generated electricity

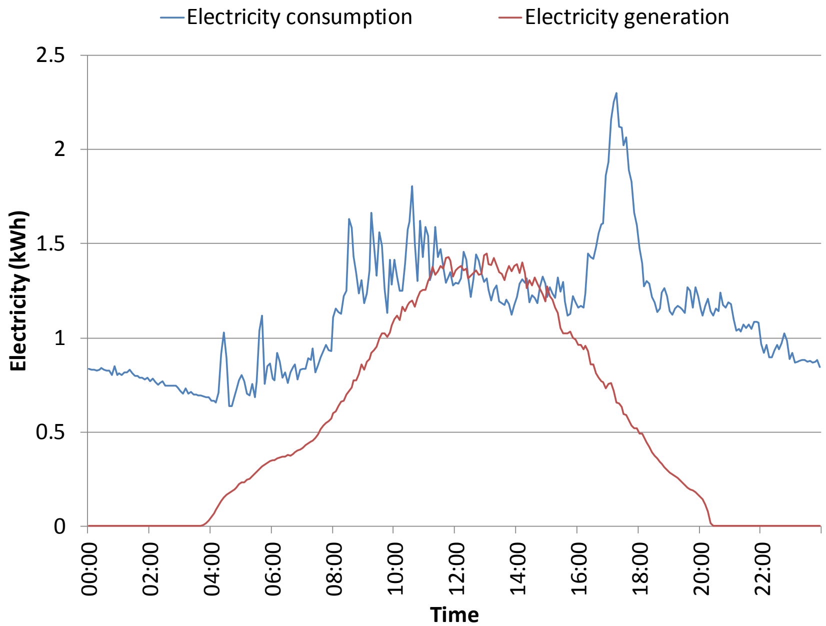
Low electricity consumer

Daily average consumption: 4.3kWh
2 occupants, always occupied
PV system size: 2.5kWp



High electricity consumer

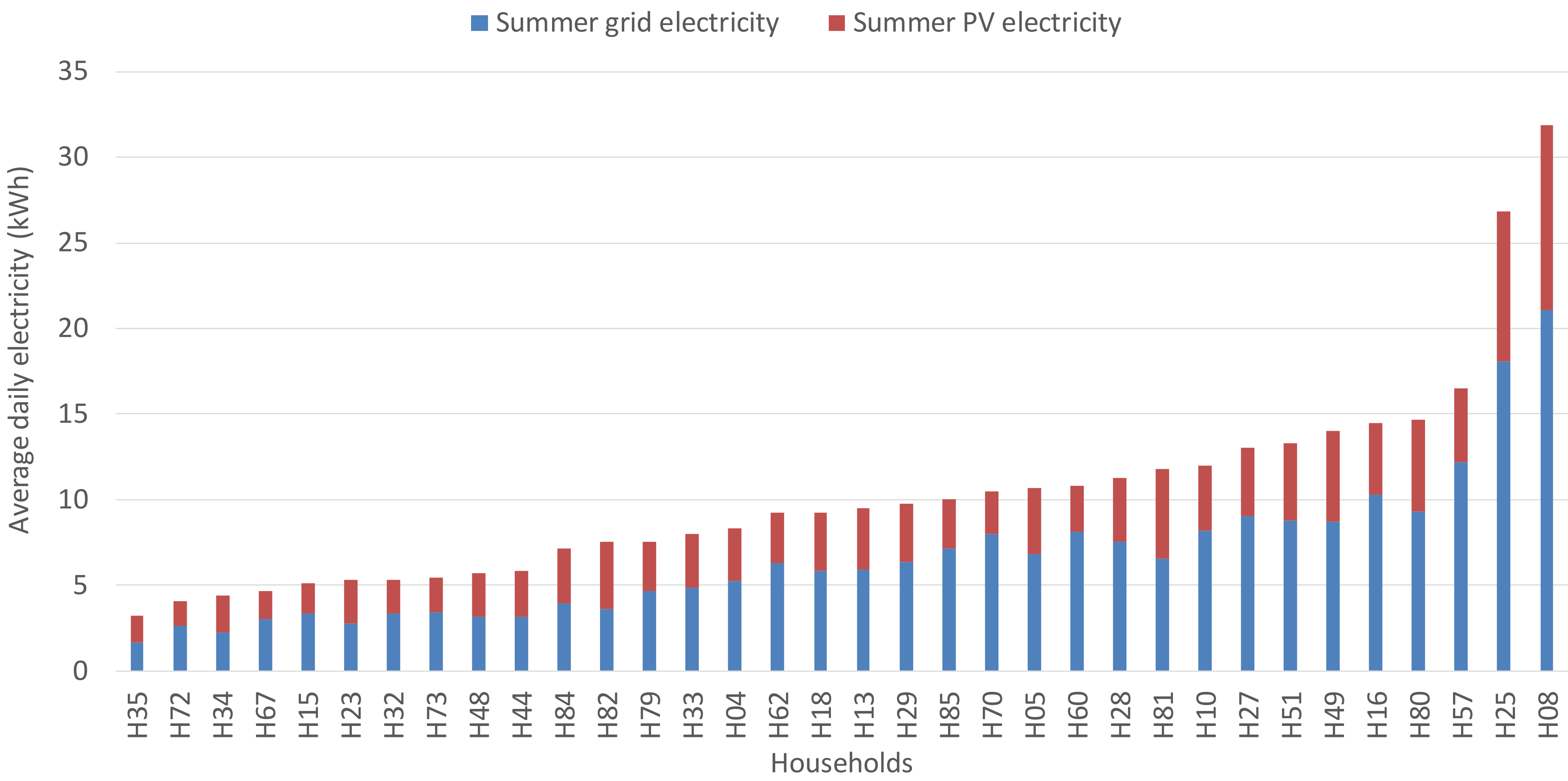
Daily average consumption: 21.7kWh
4 occupants, always occupied
PV system size: 2.75kWp



- There is a potential for meeting a substantial proportion of household electricity demand through instant consumption and storage of PV generated electricity

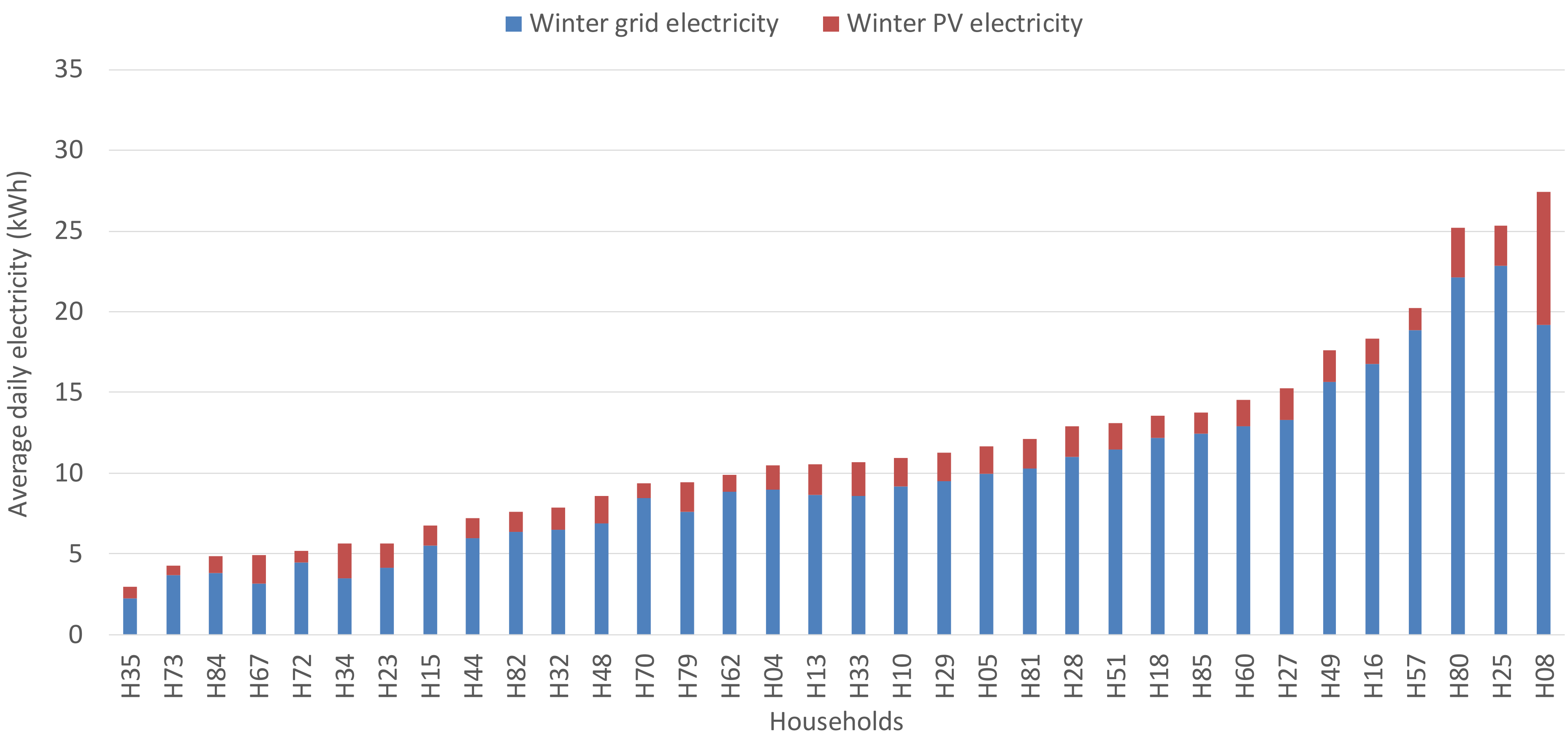
Household electricity demand: summer

- In the summer months (June to September 2016), average percentage of PV electricity consumed was **43%** (19% to 70%) of total generated
- On average 37% of household electricity demand was provided by instant consumption of PV electricity



Household electricity demand: winter

- In the winter months (October to December 2016), average percentage of PV electricity consumed was **40%** (17% to 87%) of the total generated
- On average, 17% of household electricity demand was provided by instant consumption of PV electricity



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Contribution of smart electricity storage

(n=34)

Household electricity demand

Proportion of household electricity demand		Summer	Winter
Instant consumption of PV electricity	Range	24% - 53%	7% - 38%
	Average	37%	17%
Battery: discharged PV electricity (increase in self-consumption)	Range	0% - 13%	0.4% - 25%
	Average	6%	12%
Grid	Range	39% - 75%	49% - 93%
	Average	57%	71%

- Proportion of PV consumed is affected by PV size and household characteristics: low/medium/high consumer, occupancy pattern, electricity use behaviour

Household electricity demand

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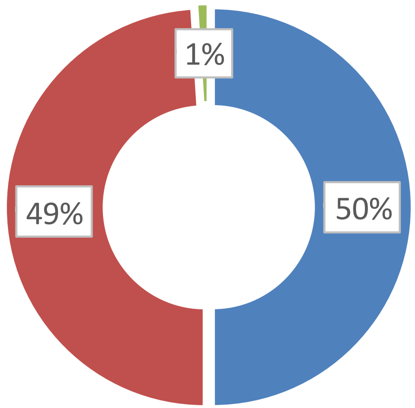
Household characteristics	Summer	Winter

Low consumer

- 2 occupants
- Always occupied
- 2.5kWp PV

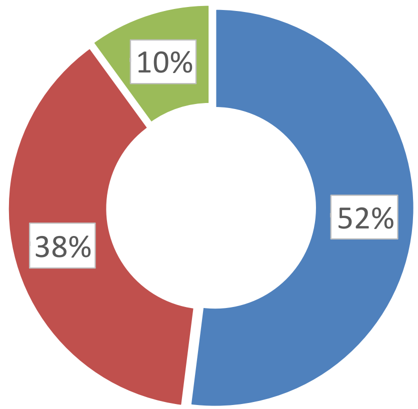
■ Grid electricity
■ PV electricity
■ Battery electricity

Summer



Daily average consumption: 4.4kWh
Instant consumption of PV elec.: 26%
% increase in self-consumption: 10%

Winter



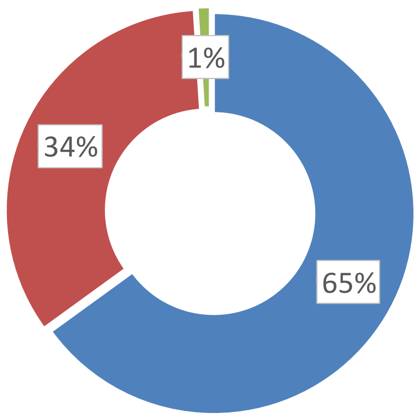
Daily average consumption: 5.6kWh
Instant consumption of PV elec.: 45%
% increase in self-consumption.: 12%

High consumer

- 4 occupants
- Always occupied
- 2.75kWp PV

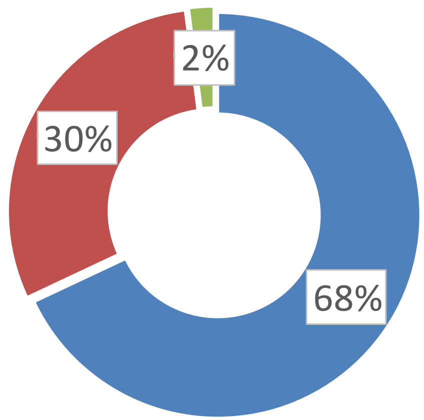
■ Grid electricity
■ PV electricity
■ Battery electricity

Summer



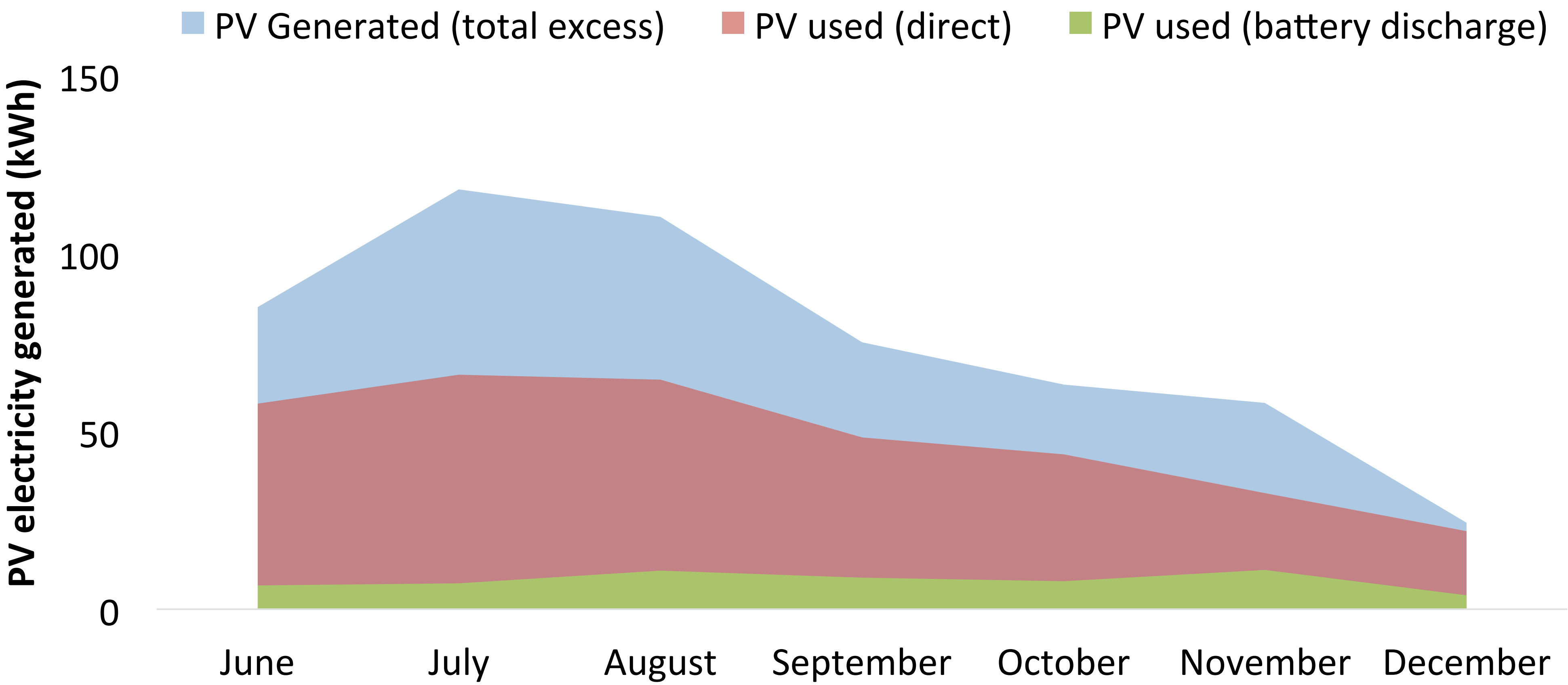
Daily average consumption: 31.9kWh
Instant consumption of PV elec.: 70%
% increase in self-consumption: 3%

Winter



Daily average consumption: 27.5kWh
Instant consumption of PV elec.: 52%
% increase in self-consumption: 3%

Self-consumption of PV electricity

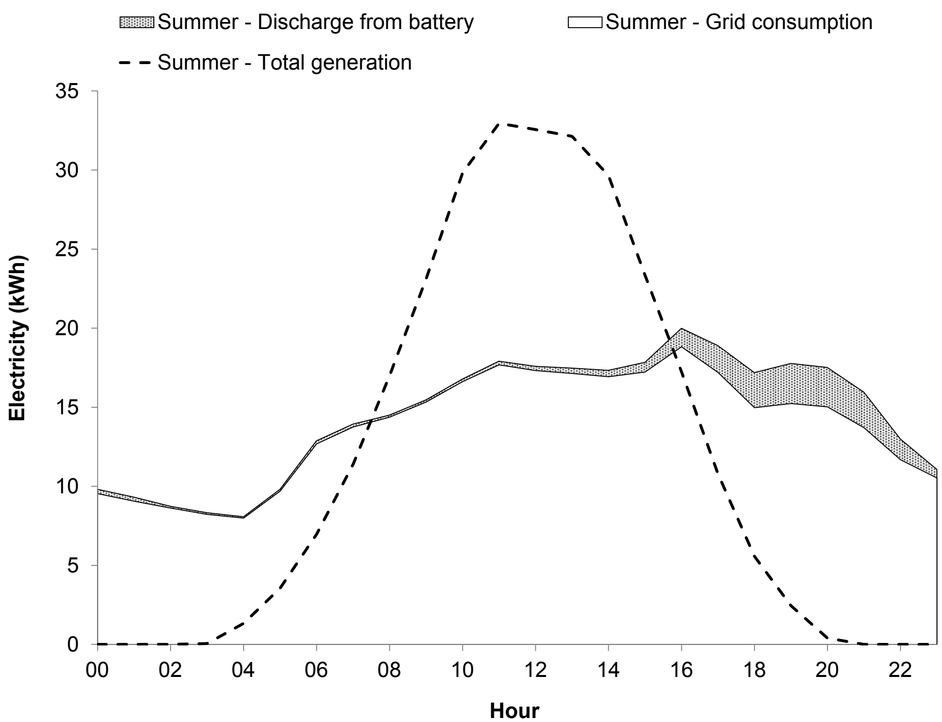


- There is still significant surplus PV electricity when aggregated on community level in the summer
- Minimal amount of PV Electricity stored could also be due to the limited capacity of the battery

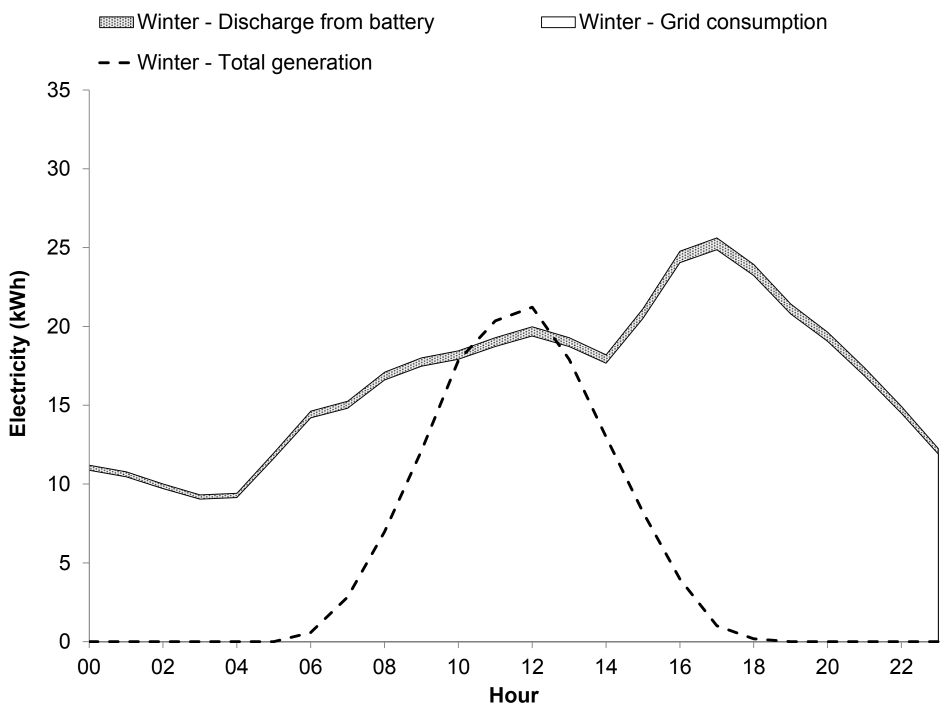
Community electricity demand

- Aggregation on community level smoothens out the peaks from individual household consumption profiles
- Peak demand was reduced by 6% in the summer and 3% in the winter through discharge of stored electricity

Summer



Winter



Key findings

- Even in a socially deprived community, there are high levels of concern about climate change and the future of energy supplies in addition to rising energy prices
- Wide range of household electricity use makes a strong case for community scale energy management
- Installed PV solar units are making significant contribution towards reducing household electricity costs
- Installed storage units are making some contribution by increasing self-consumption of PV electricity and reducing grid electricity demand. However, this is dependent on household characteristics:
    - In low energy consuming households, most of the electricity demand during the day is met by instant consumption of PV generated electricity and there is still significant excess. Household baseload is too low for storage to have an impact
    - In high energy consuming households, most of the generated PV electricity is consumed instantly and there is little surplus for storage
- There will be network benefits of aggregating household storage as there is still significant surplus PV electricity after storage at household level

Thank you!

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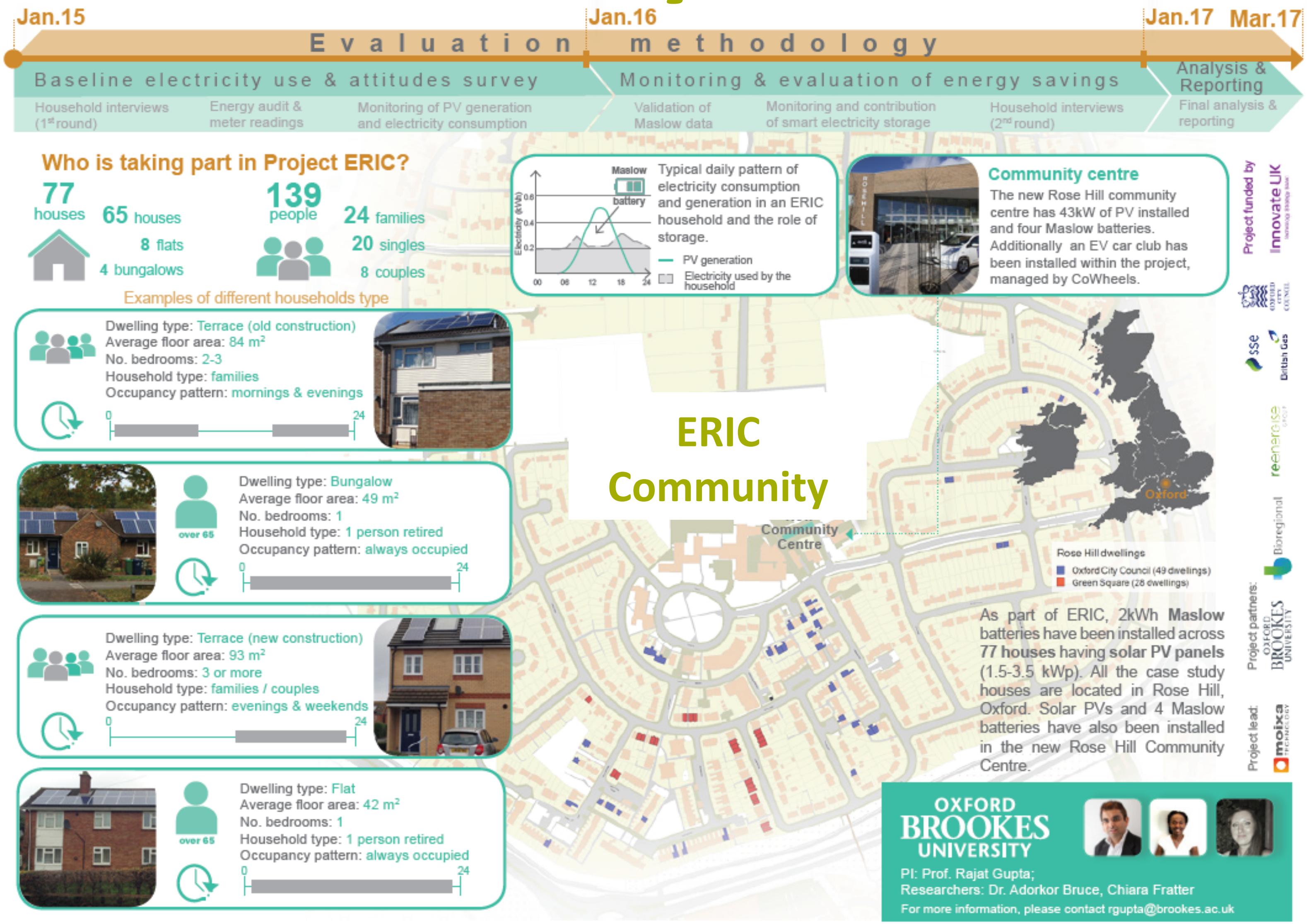

https://www.brookes.ac.uk/about-brookes/news/energy-saving-community-project-wins-prestigious-energy-awards/