SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

PV Hot Water Technologies

Task 69: Solar Hot Water for 2030

Subtask C

Prof Tony Day

PV Hot Water – an emerging technology

There is a growing use of PV electricity to heat hot water through direct resistance heaters or indirectly using heat pumps.

In the past this was seen as a poor (thermodynamic) use of high value energy to heat a low value application. This new shift has been driven by the following:

- Solar PV hardware has seen dramatic cost reductions in the last decade
- Highly flexible technology with multiple applications
- Smart control systems enable optimisation of PV generated electricity
- Electrification of heat strategies and the value of thermal storage, e.g. load management and/or cost reductions
- Time of Use tariffs and policy measures encouraging uptake

Publications from the Task

- The Emergence of PV Hot Water Systems

  https://task69.iea-shc.org/publications

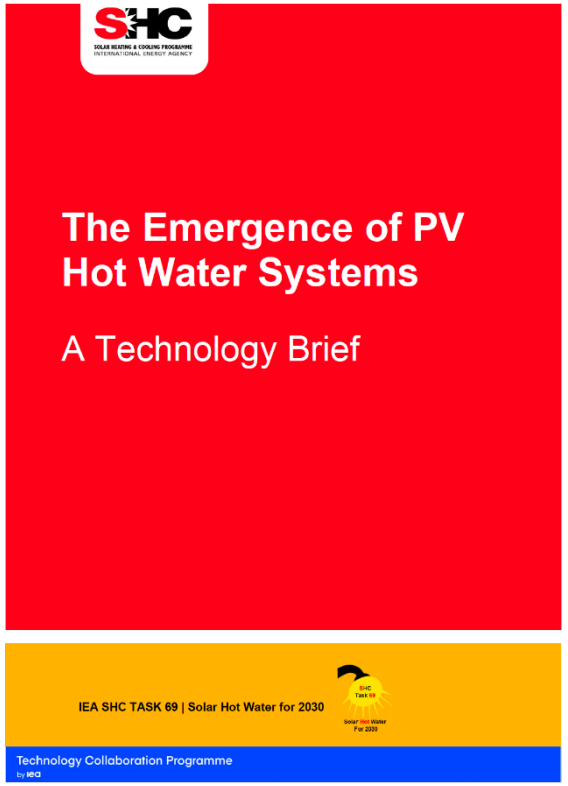
- Three journal publications on state-of-the-art research:

  https://doi.org/10.1016/j.energy.2022.126577

  https://doi.org/10.1016/j.solener.2023.112049

  https://doi.org/10.1016/j.apenergy.2023.122182

- In progress: Policy Initiatives for PV Hot Water



Applications

- PV2Heat:

  Dedicated PV to hot water immersion heater for use in off-grid or unstable grid applications. Direct competition with solar thermal systems

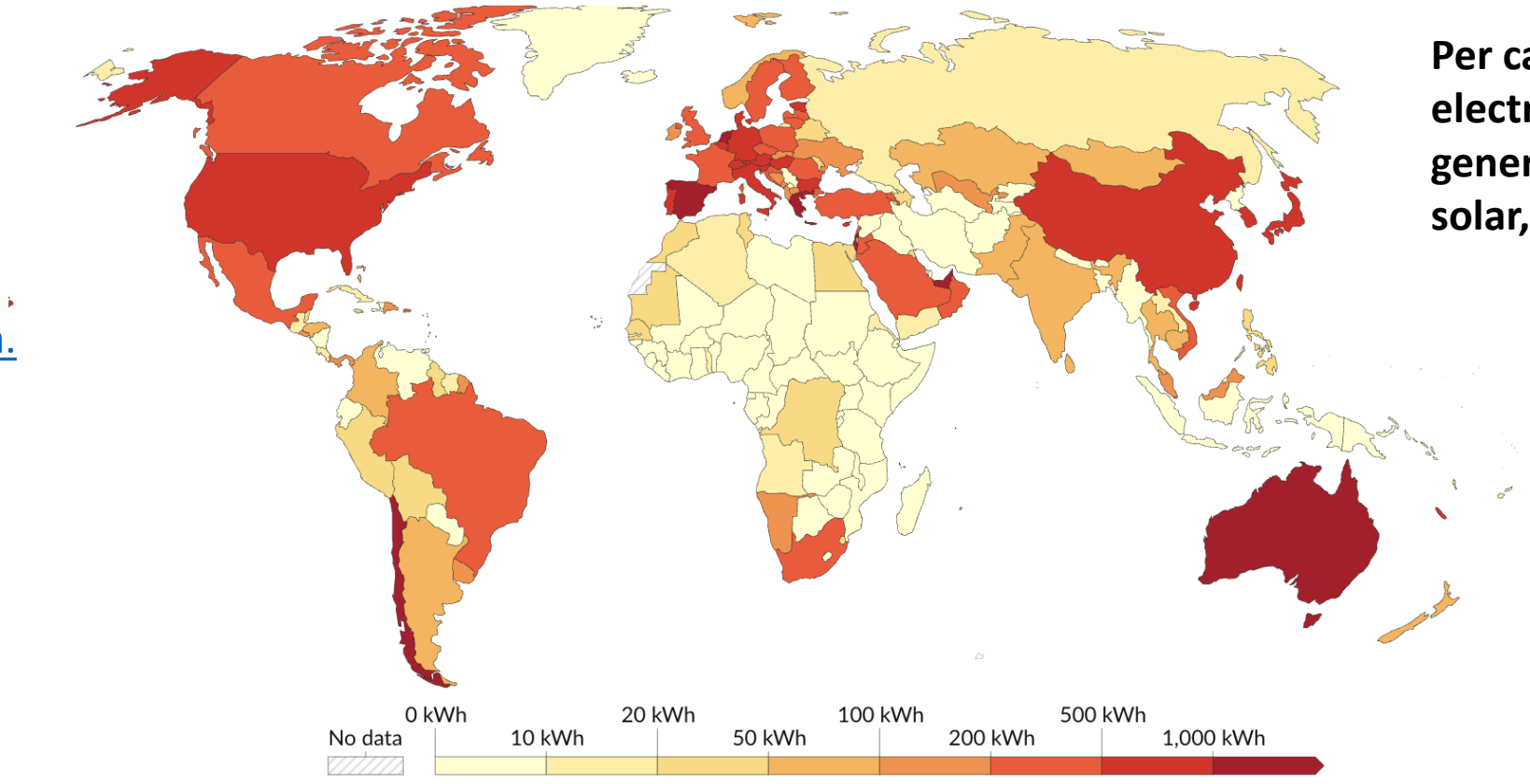
- PV self-consumption for hot water:

  PV diverters or integrated smart systems; excess generated PV maybe exported or used for hot water. Used for electricity value optimisation or network load management

- Hot water from grid PV:

  Centralised switching of residential hot water heaters at times of high insolation where grid connected PV is significant

Areas with high solar uptake

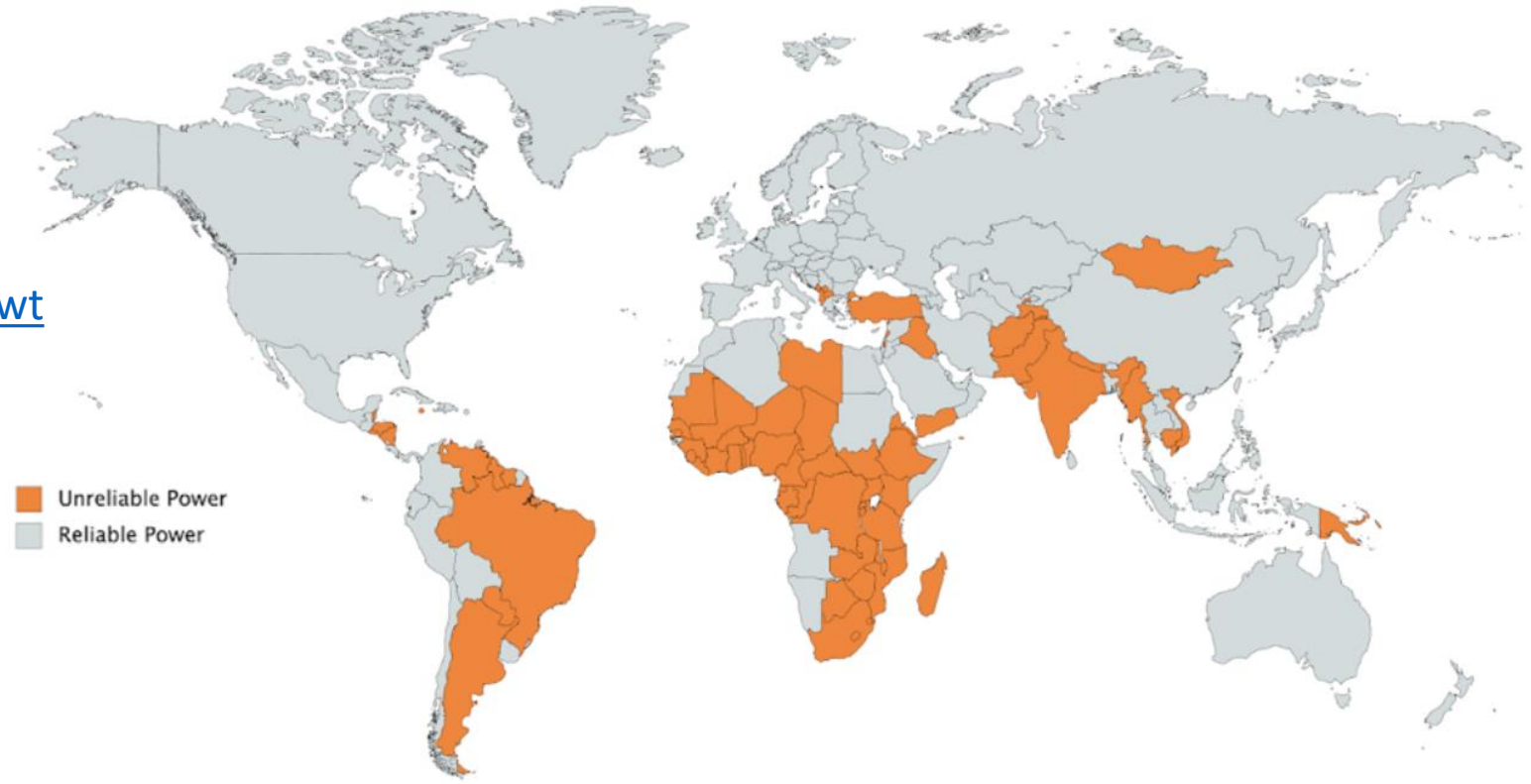


Per capita electricity generation from solar, 2024

https://ourworldindata.org/grapher/solar-electricity-per-capita?time=2024

Countries with unreliable power services

https://energyforgrowth.org/article/3-5-billion-people-lack-reliable-power/

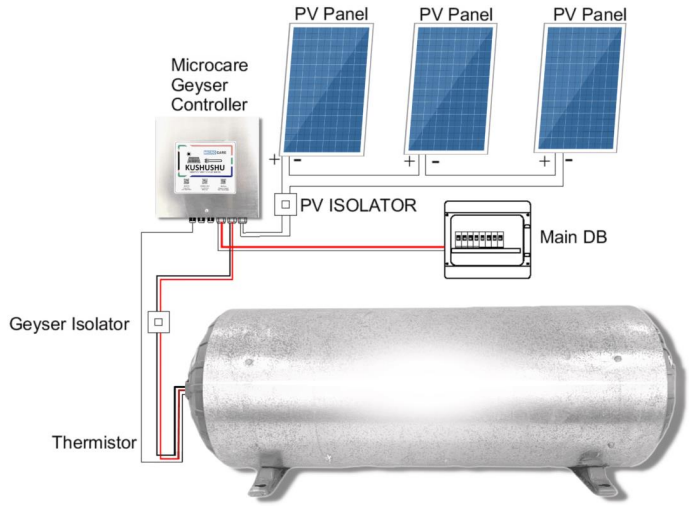


PV2Heat

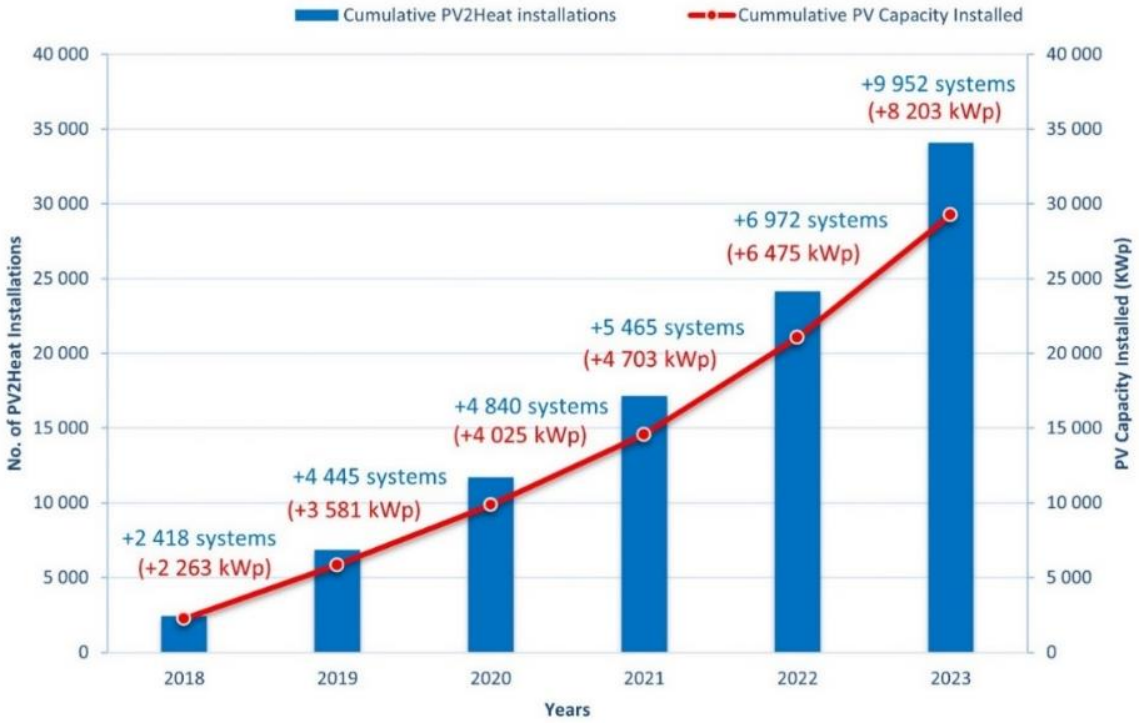
Growth markets include areas of high-cost grid connections

Photo source: Lavhe Maluleke, Stellenbosch University, South Africa;

Maximum power-point tracking necessary to match PV output with heater elements



PV2Heat schematic (Microcare)



Market development in South Africa between 2018 and 2023
Source: Lavhe Maluleke, Stellenbosch University, South Africa;

Self-consumption

PV diverters

- Low cost, simple to install and retrofit

Optimised heat storage control

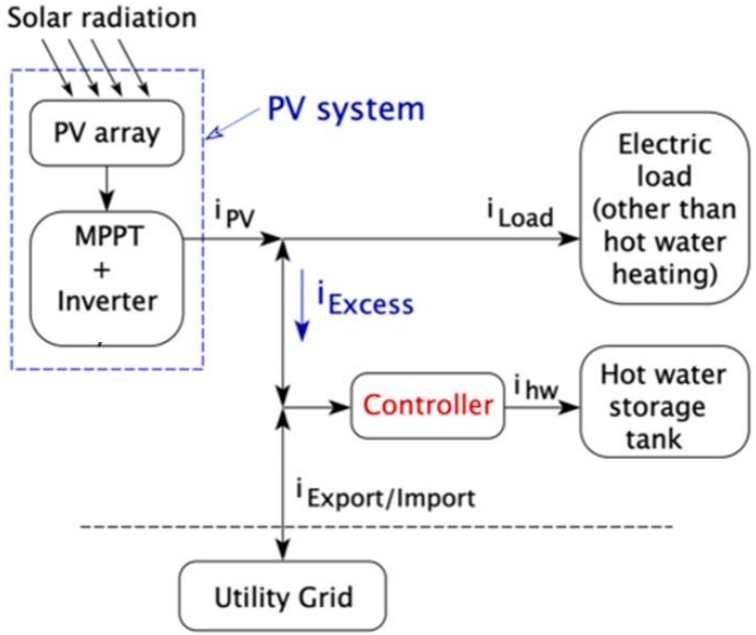
- Modulating heater elements to vary power flows

Smart hot water tanks

- Integrated control using stratification and machine learning for optimised thermal battery operation

PV driven heat pumps

- Small but growing market share



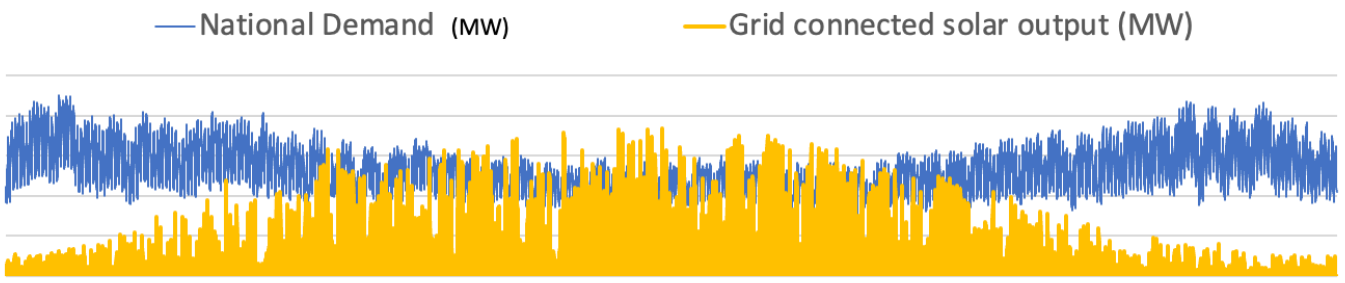
Clift, D.H. and H. Suehrcke, Solar Energy 2021

Mixergy smart hot water tank, UK

Grid PV to heat

For regions with high grid connected PV

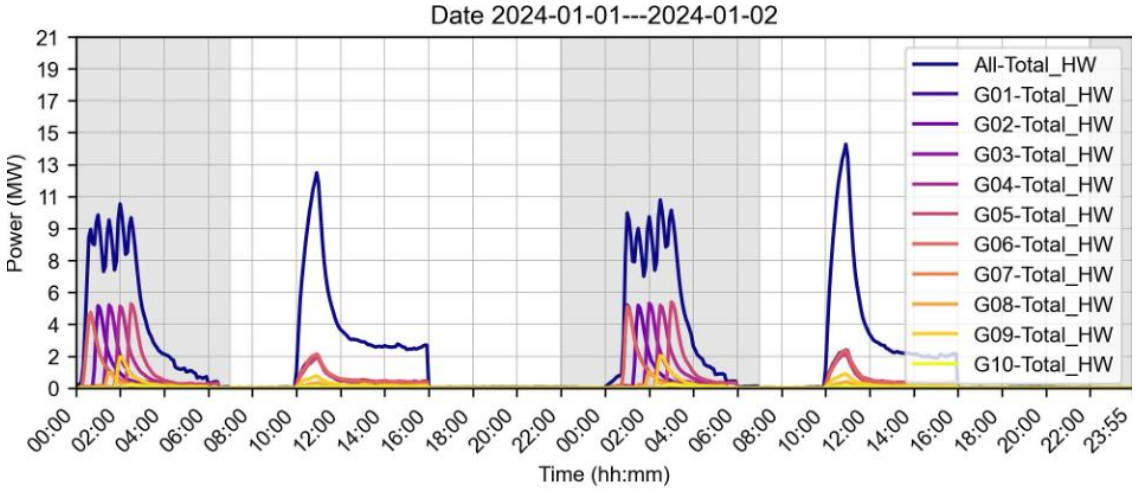
- Avoid curtailment
- Pricing mechanisms; on-off timers
- Centralised smart switching



Modelling annual GB electricity demand and potential solar output for 2030, Tony Day 2025

Particularly relevant in regions with high penetration of rooftop PV:

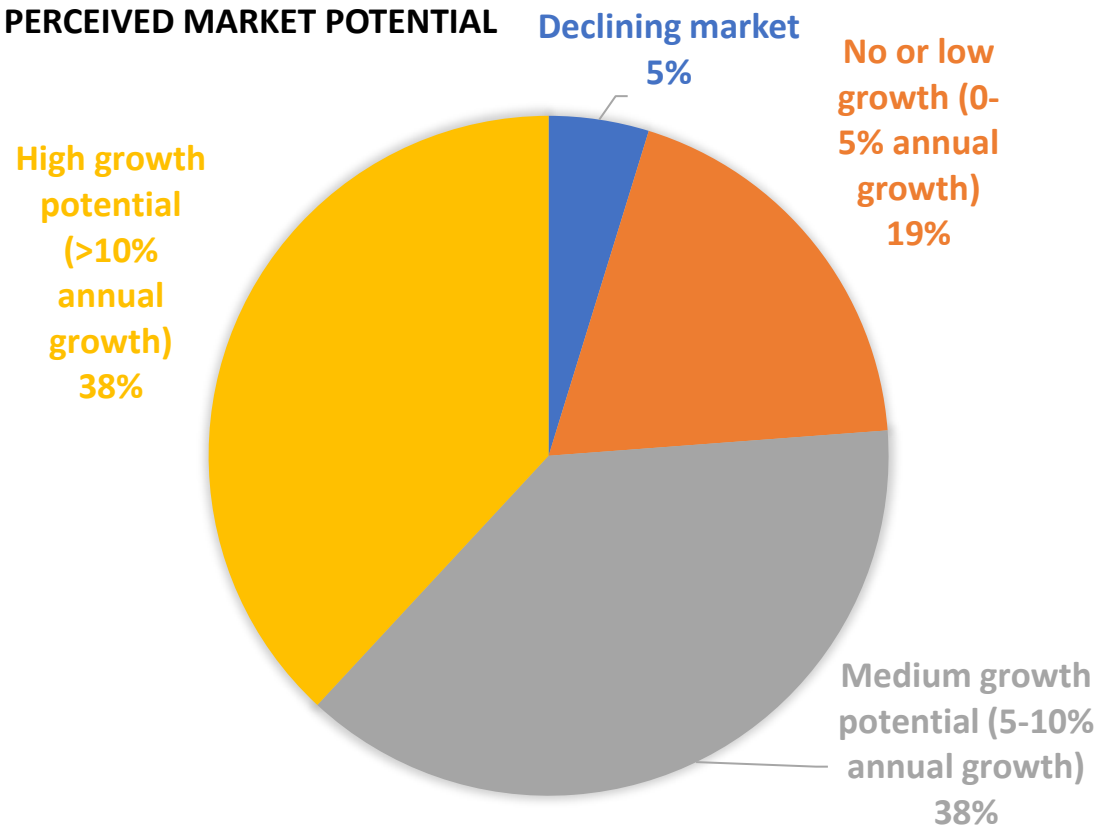
- Distributed generation exports compete with grid level generators
- Using regional hot water storage as a large thermal battery avoids centralised rooftop curtailment



Daily water scheduling operations for around 20,000 households in South Australia on the 1st and 2nd of January 2024

Market potential

- A survey of international experts looked at market potential, barriers and indicators (42 respondents)
- The outlook is positive
- Perceived barriers include:
  - system cost
  - lack of skills and knowledge
  - technology competition
  - lack of regulation



Market drivers

- Operational savings
  - PV diverters allow residential owners to reduce their energy bills and optimise the value of self-generated electricity
  - Grid scale control of thermal batteries can shift load to avoid curtailment and reduce peak-time demand
- System balancing and quality control
  - High numbers of distributed (rooftop) PV systems can cause system security and quality issues at high penetration rates
  - Some regions use kill switches to curtail residential rooftop output which can be avoided using thermal batteries

Perceptions

- PV not traditionally seen as a prime technology for hot water generation
- Competition with higher efficiency solar thermal in sunbelt regions often rule it out
- Direct electricity is higher cost than fossil fuel heating in temperate regions
- Engineering resistance to using electricity for heat
- Cost reductions and rapid PV deployment are changing the market dynamics

Policy and regulation

- Policy and regulation has not been widely developed
- Subtask C is now undertaking a piece of work to understand the international policy landscape
- Aims to:
  - Identify any policy or regulatory measures in place
  - Present case studies where these are being developed
  - Identify gaps in policy design and identify best practice
- Currently the evidence is limited and often measures are buried within broader regulatory instruments (e.g. renewable energy mandates)

Conclusions

- PV hot water systems are seeing significant growth
- Application and uptake vary depending on climate, electricity system maturity and PV market penetration rates
- PV hot water can be lower cost than solar thermal
- Advantages for reducing operational costs for residential PV owners
- May have a significant role in grid balancing, security and operating costs
- Clearer regulation may be required to fully unlock the market potential

Thank you for listening

Any Questions?

Contact: Tony Day tony@tonyday.co.uk
Robert Taylor robert.taylor@unsw.edu.au

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