Modelling Electric Hot Water Cylinders for Demand Management

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Peak Demand

$P=IV$, $V=IR$, $P=I^2R$

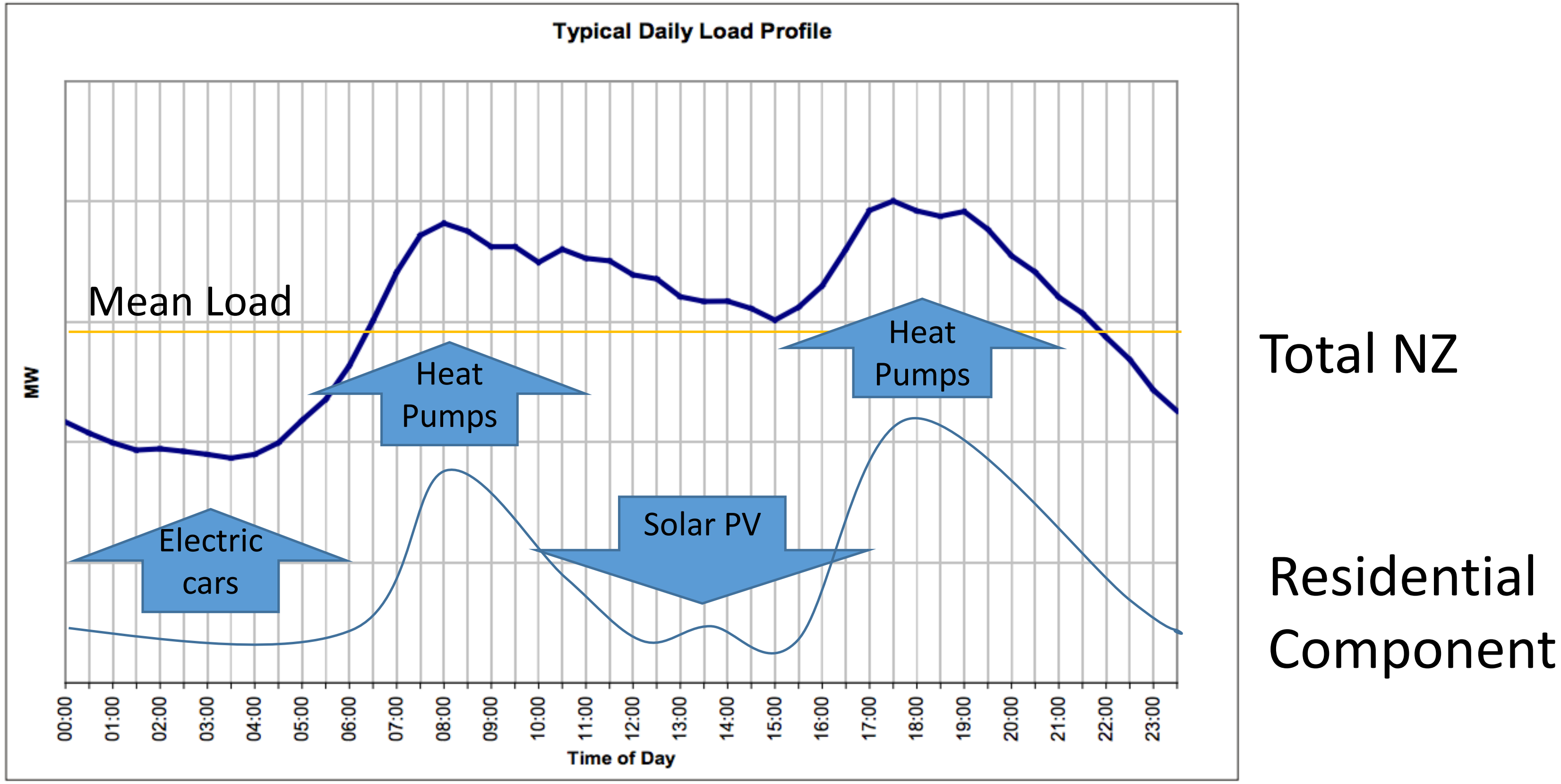


Figure Source: Transpower

A more flexible load allows more renewables

- Solar PV- Daytime, Summer, No Clouds
- Wind Turbines- Windy Weather
- Hydroelectric- rainfall/snowmelt conditions
- Geothermal- Constant

- Coal - On demand, Longer running times
- Natural gas – On demand, Fast startup

Demand Management

- Large User Demand Response/AUVLS
- Dynamic pricing incentives
- Embedded generation/storage capacity
- Residential Hot Water Ripple control

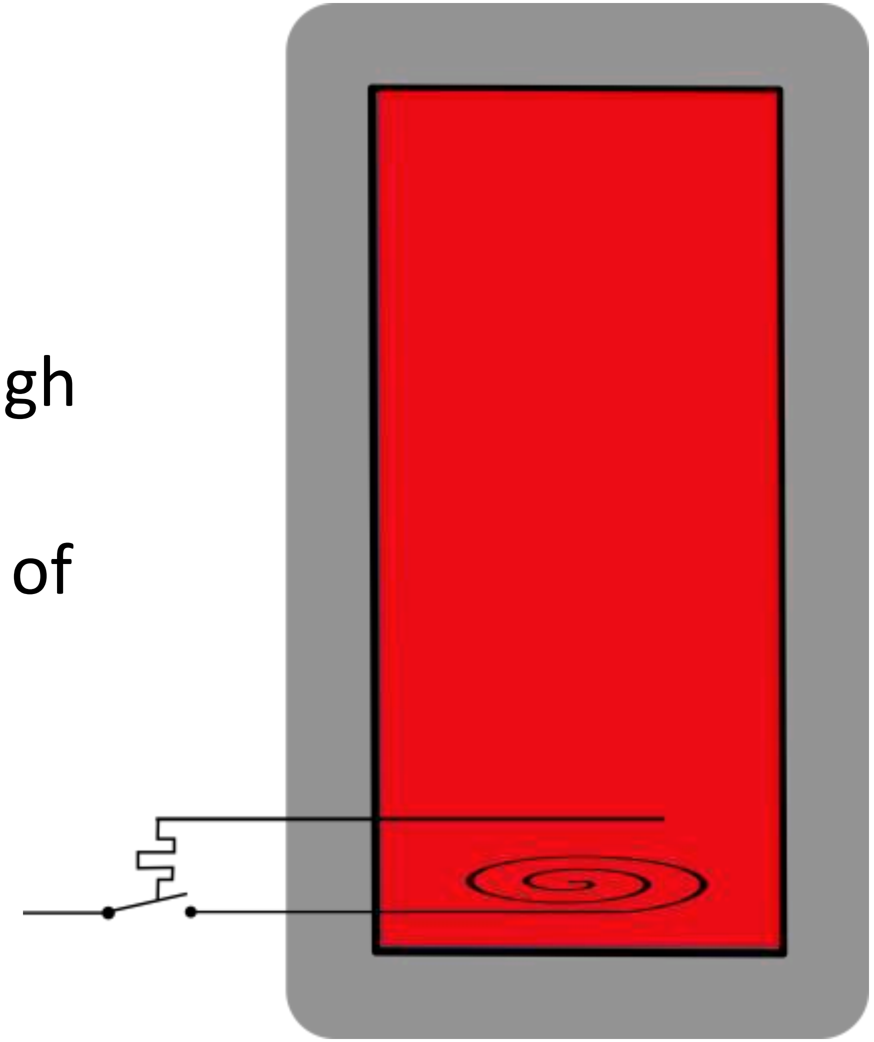
- Increase flexibility
- Allows greater renewable energy utilisation
- Reduce network stress
- Flexibility from all sectors

Which appliances to choose?

- ~30% of household energy usage
- Up to 50% of household demand during peaks
- Storage capability (>10 kWh)
- Widespread ownership nationwide (>90%)
- Autonomous thermostat operation
- Ripple outdated and varied use across networks

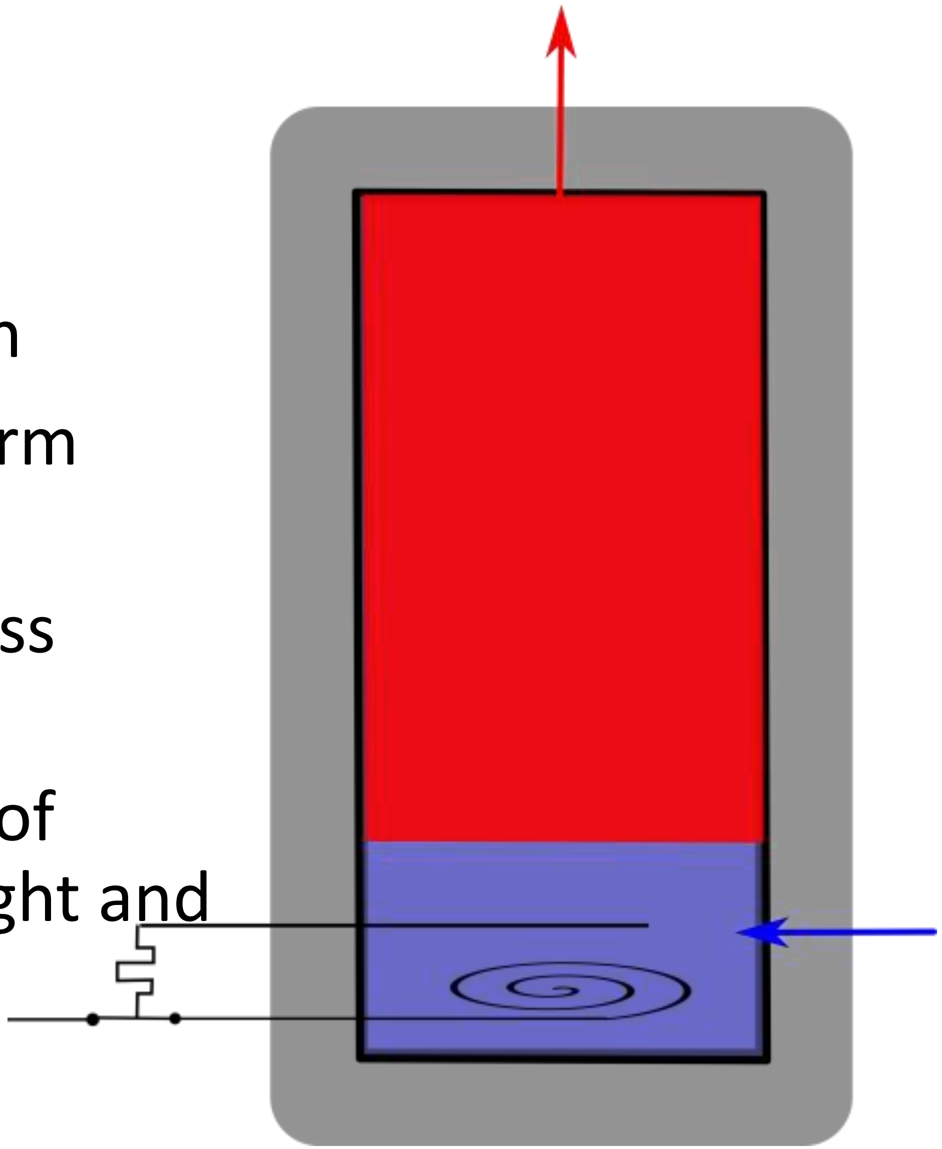
Physical Model

- Hot Uniform Temperature
- Lose Heat through walls
- Dynamic model of temperature

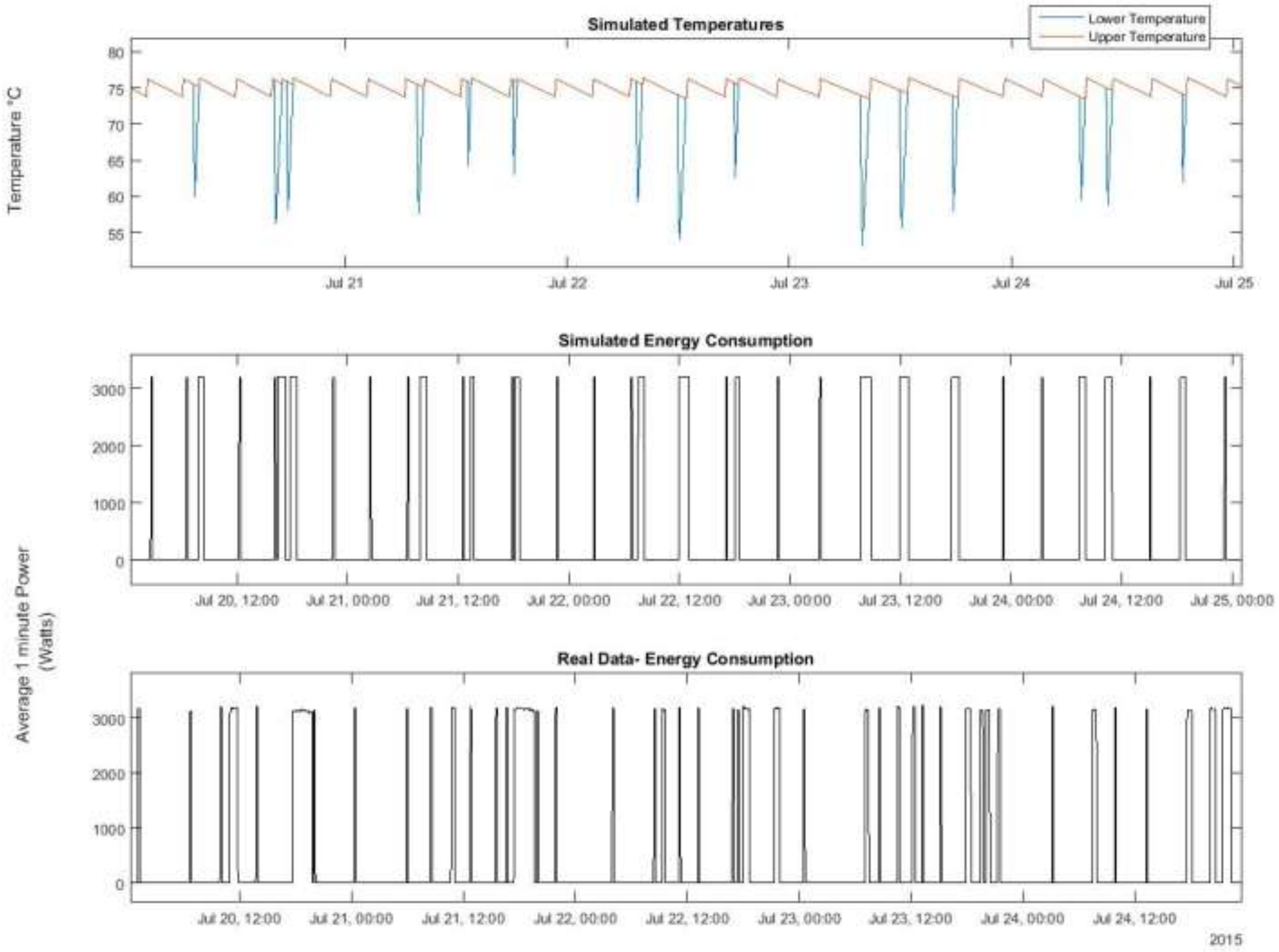


Physical Model

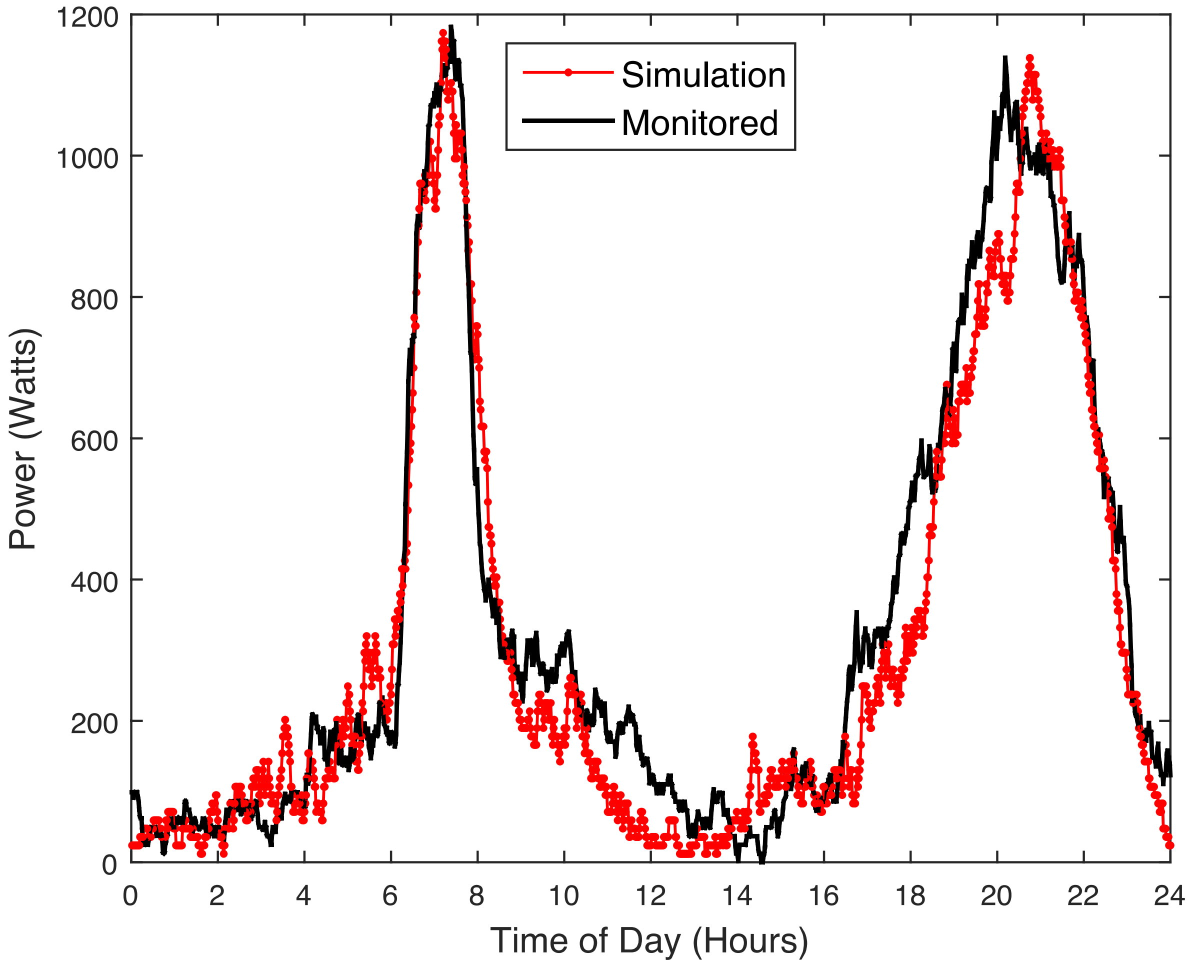
- Flow out=Flow in
- 2 separate uniform temperatures
- Separate heat loss terms
- Dynamic model of thermocline height and temperatures



Validating- Raw Signal



Average Load Profiles

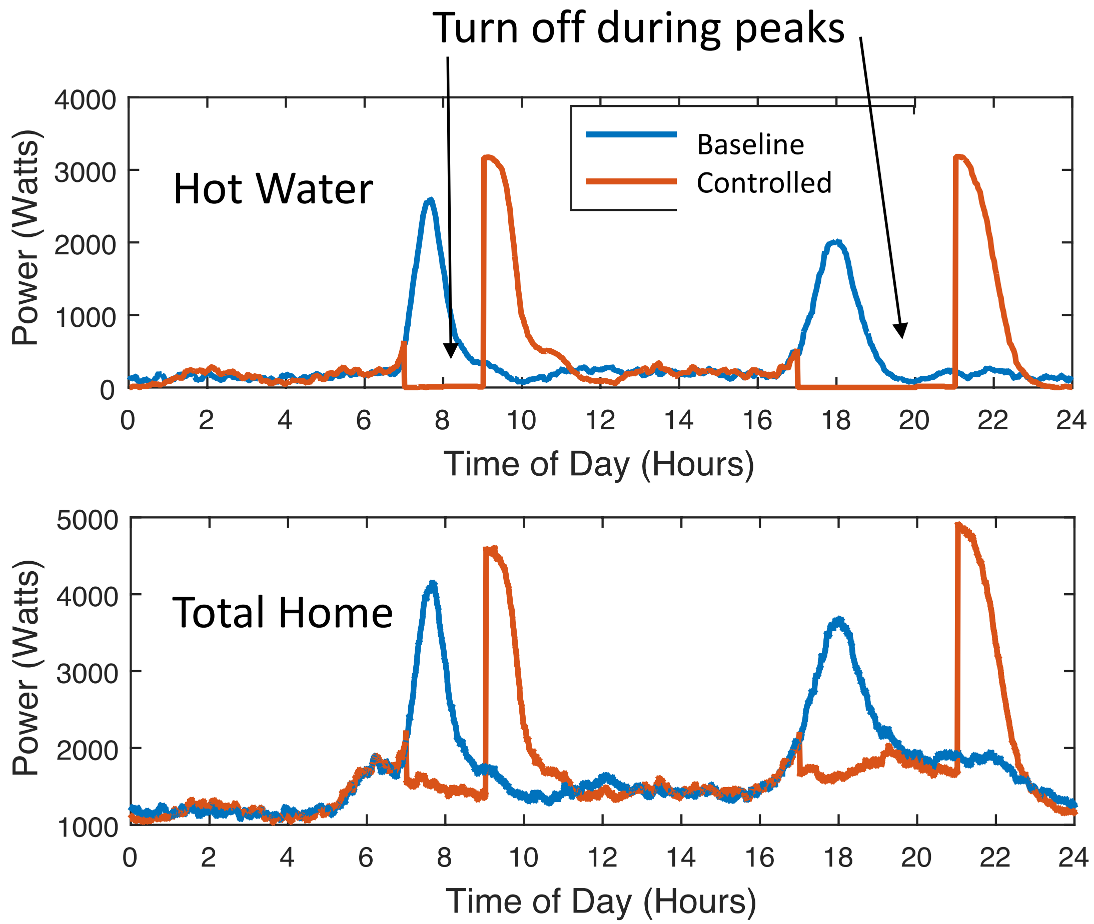


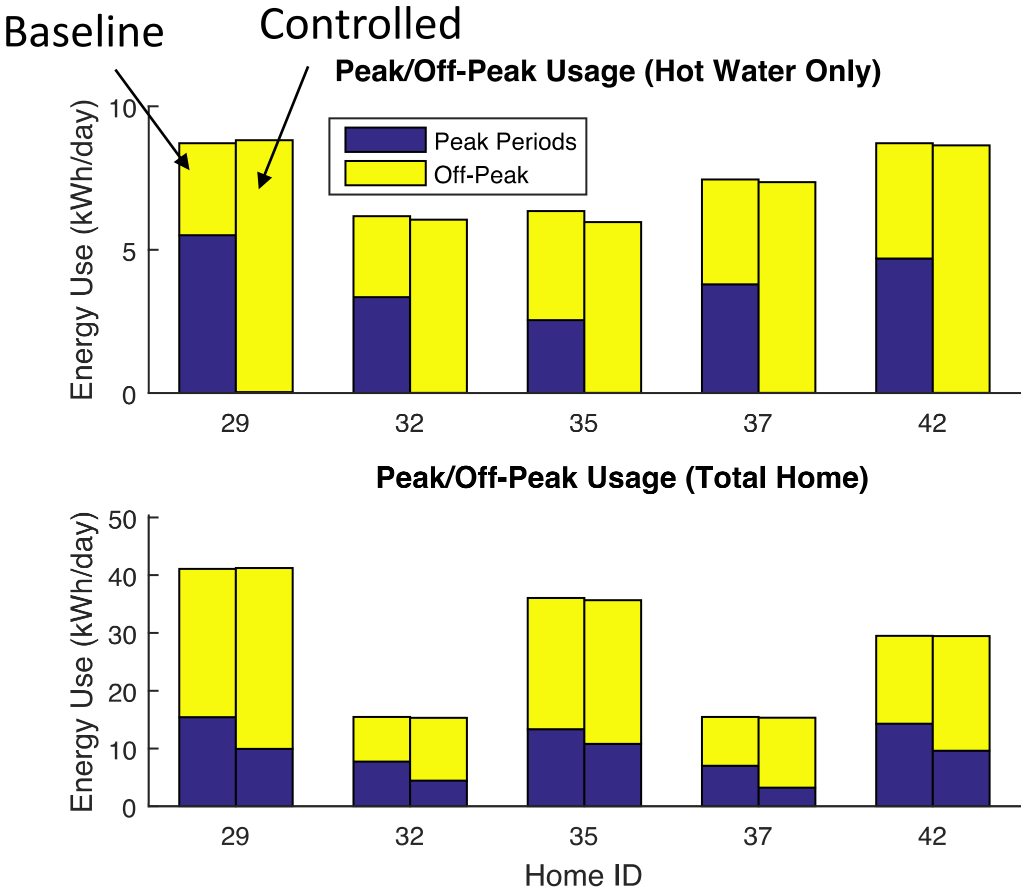
Demand Management Experiments

- Time Scheduling
  - Avoid peak periods (7am-9am, 5pm-9pm)
  - Maximise Solar PV Utilisation (10am-4pm, Midnight boost)

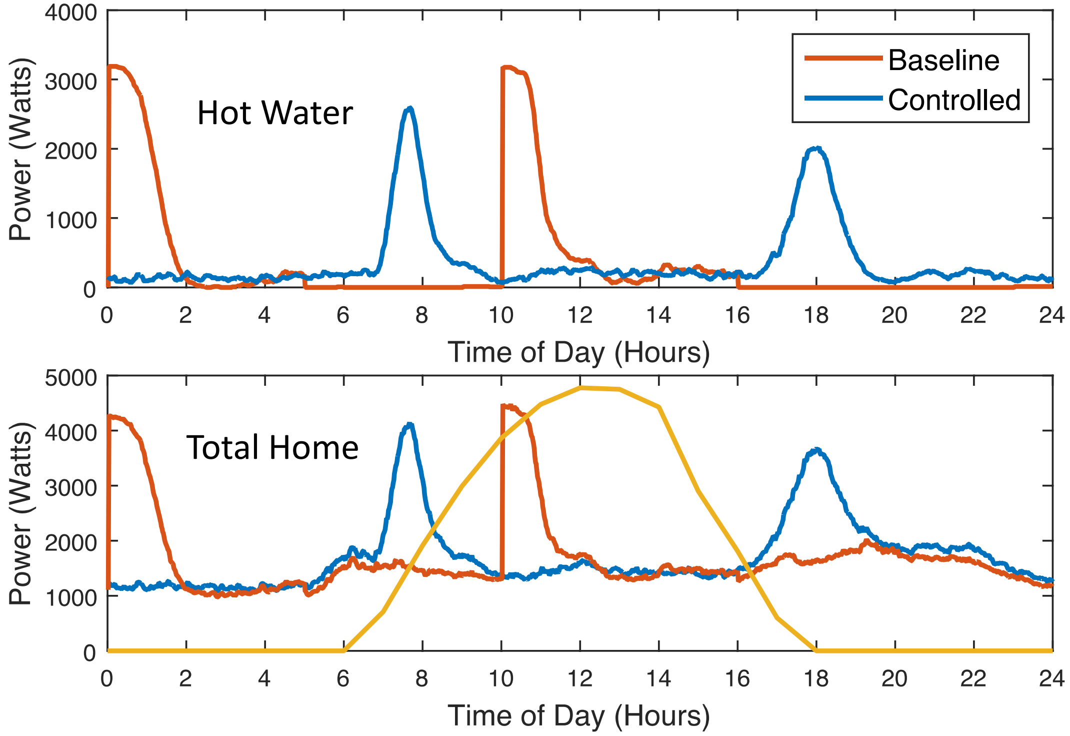
- Variable Element Power
  - Set household threshold for heating element to operate below.

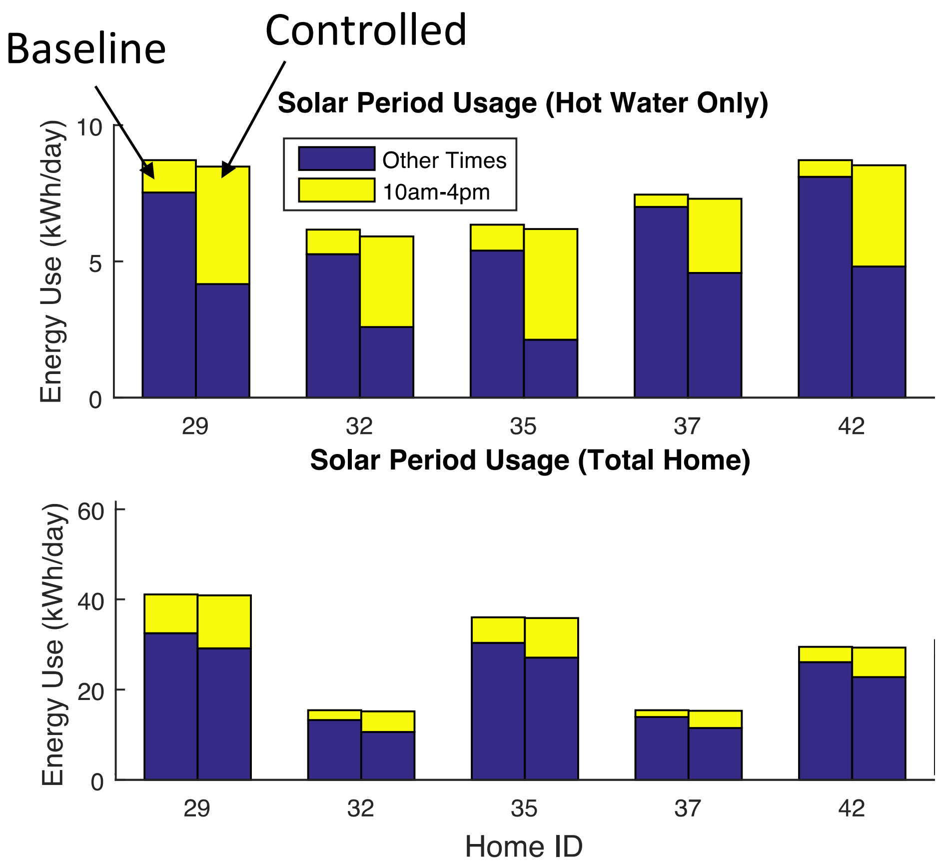
Control scenarios: minimise peaks



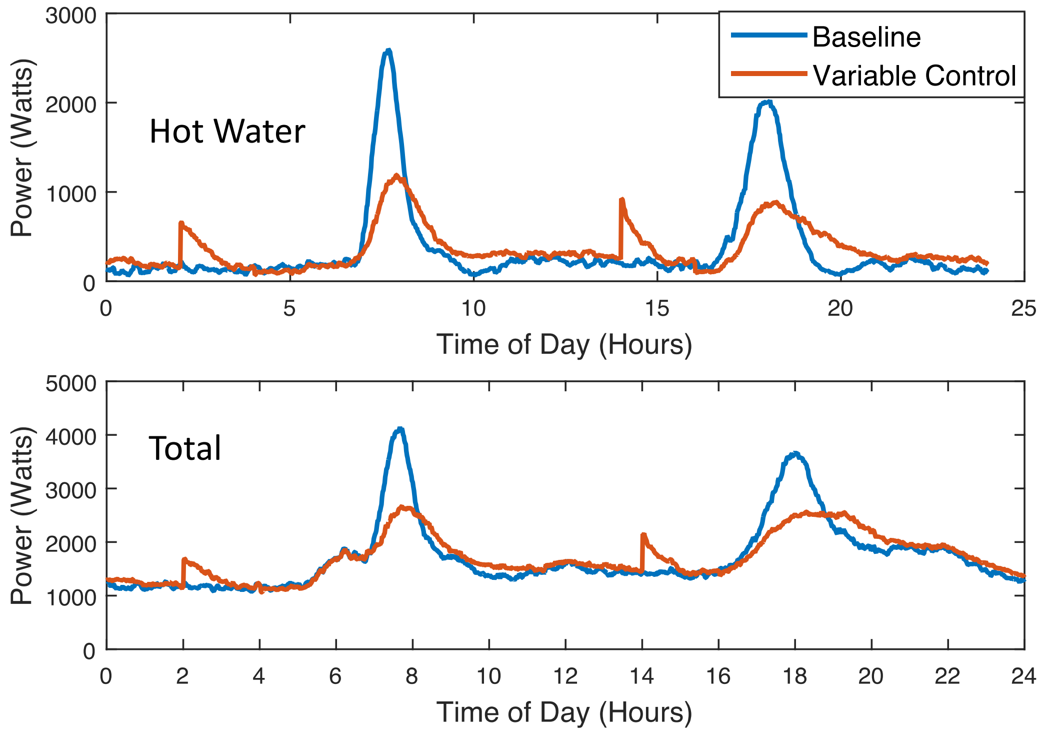


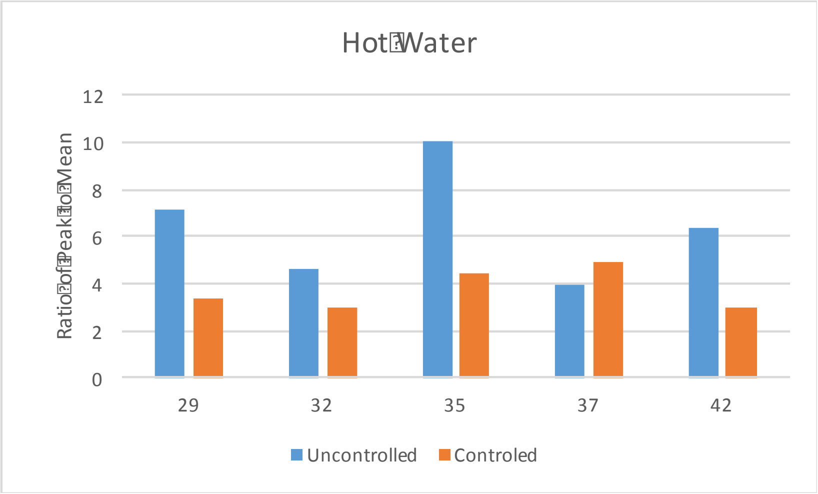
Control scenarios: maximize solar

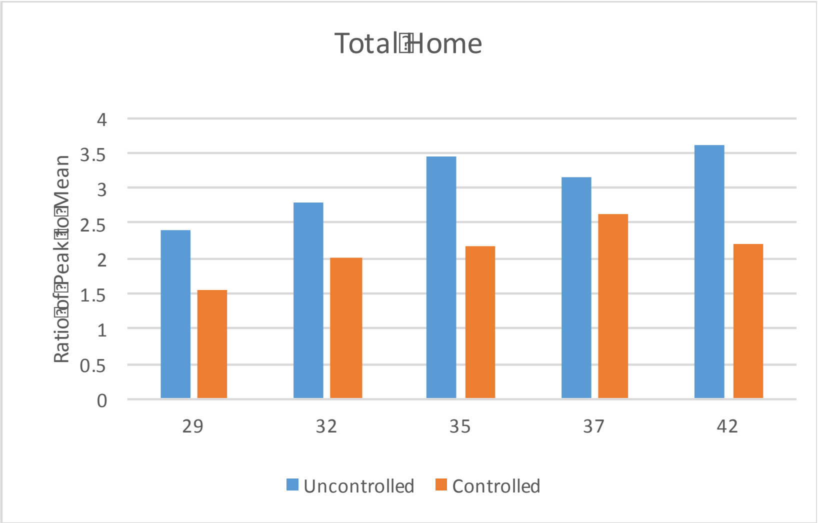




Control scenarios: Load smoothing







How do control scenarios impact service?

Average minutes per month with less than 0L or 15L remaining.

ID	Baseline		Min Peaks		Max Solar		Smooth	
	0L	15L	0L	15L	0L	15L	0L	15L
29	0	0	0	16	0	18	0	1
32	16	247	39	459	128	584	31	815
35	0	71	12	608	312	590	16	218
37	0	0	0	0	0	0	0	0
42	0	0	8	80	8	48	2	39

Legionella also considered, All control regimes forced to comply with building code

Summary/Discussion

- Demonstrated simulation of hot water electricity demand
  - Explored some simple control scenarios/many more possibilities
  - Impact on service can be evaluated
  - Can also use model to explore different cylinder parameters (size etc..)

- Possible to compare peak reduction potential with other technology:
  - Heat Pump Water Cylinders
  - Batteries

- Other appliances can be modelled to build full household simulation.

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