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LCBE Seminar: The Future is electric heating, but is it sustainable?

HOME SPACE AND WATER HEATING ASPECTS OF THE SSE SHETLAND NINES PROJECT

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Home space and water heating aspects of the SSE Shetland NINES project

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1. NINES controllable domestic space and water heating
2. UoS ESRU – Customer demand forecast model
3. NINES trial house monitoring - early outcomes
4. Simulations and forecasting – work in progress

SSE's challenges in Shetland

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- Old, diesel fired power station
- High potential for renewables
- Isolated, constrained grid, network stability issues

Actively manage the network

http://www.smartgrid.epri.com/Demo.aspx

Control demand via (heat) storage

http://www.dimplex.co.uk/products/water_heating/literature_pdfs_-_Water_Heating.htm

http://www.quantumheating.co.uk/gallery.php

http://www.sheap-ltd.co.uk/images/Boiler.jpg

- Less need for imported diesel
- More reliable, better quality supply

NINES controllable domestic space and water heating

A collaborative project

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Hjaltland Housing Association

a registered scottish charity (no. SC031954)

Shetland Islands Council

Scottish and Southern Energy Power Distribution

Glen Dimplex

University of Strathclyde Glasgow

smarter grid solutions

NINES controllable domestic space and water heating

Rollout scope: 750 houses

Timber kit, low insulation: 58%

Traditional stone built: 12%

Block & render, heavy build 11%

Lightweight, well insulated: 10%

Stone conversion, well insulated: 2%

Timber kit, well insulated: 7%

NINES controllable domestic space and water heating
Trial houses and heaters

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Type	Number Monitored
Light timber built, sealed and insulated	5 houses 4 house types 2/3 occupancy patterns
Conversion of 1900s stone building	1 house 2 occupancy patterns

Controllable space heaters in living areas & hall:
Input: 4.3-6.3 kW per house total
Output: 2.2-3.2 kW + 3-4.5kW manual boost

Old panel heaters elsewhere: 2-5 kW total

Controllable water heater: 2.6kW + 3kW manual boost

UoS ESRU – Customer demand forecast model

ESRU work objectives

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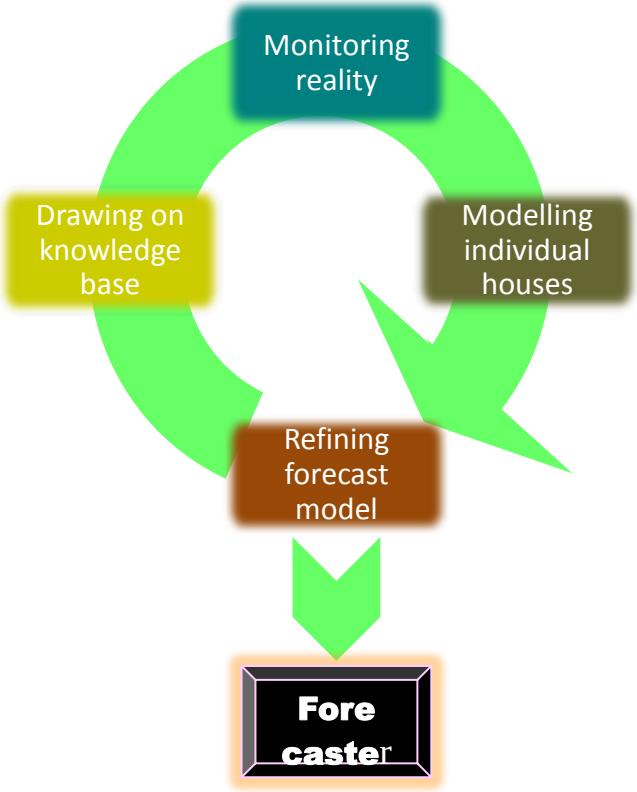
- How effectively will domestic hot water tanks and electric space heaters store energy?
- What is the impact of different charging schedules?
- Where might there be a risk to customer amenity?
- Forecast domestic demand for space and water heating
  - input to Active Network Management System
  - groups of 100-150 houses
  - varying with time and season



UoS ESRU – Customer demand forecast model

Conditions of trial

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- Normal tariff daily schedules retained
- Central instructions for charging at 15 minute intervals

PLC Data Point	Description	Home 1	Home 2	Home 3	Home 4	Home 5	Home 6
N26:0	IH Day Ahead Schedule 1	2900	0	0	0	0	0
N26:1	IH Day Ahead Schedule 2	2900	0	0	0	0	0
N26:2	IH Day Ahead Schedule 3	2900	5000	6000	5000	5000	4000
N26:3	IH Day Ahead Schedule 4	2900	5000	6000	5000	5000	4000
N26:4	IH Day Ahead Schedule 5	2900	5000	6000	5000	5000	4000
N26:5	IH Day Ahead Schedule 6	2900	5000	6000	5000	5000	4000
N26:6	IH Day Ahead Schedule 7	2900	0	0	0	0	0
N26:7	IH Day Ahead Schedule 8	2900	0	0	0	0	0
N26:8	IH Day Ahead Schedule 9	2900	0	0	0	0	0
N26:9	IH Day Ahead Schedule 10	2900	0	0	0	0	0

- Safety and comfort overrides set centrally
- Space heater controller sets upper temperature for core
  - adaptive control

User controls on space heaters only
- timer and thermostat

UoS ESRU – Customer demand forecast model

Space heater monitoring

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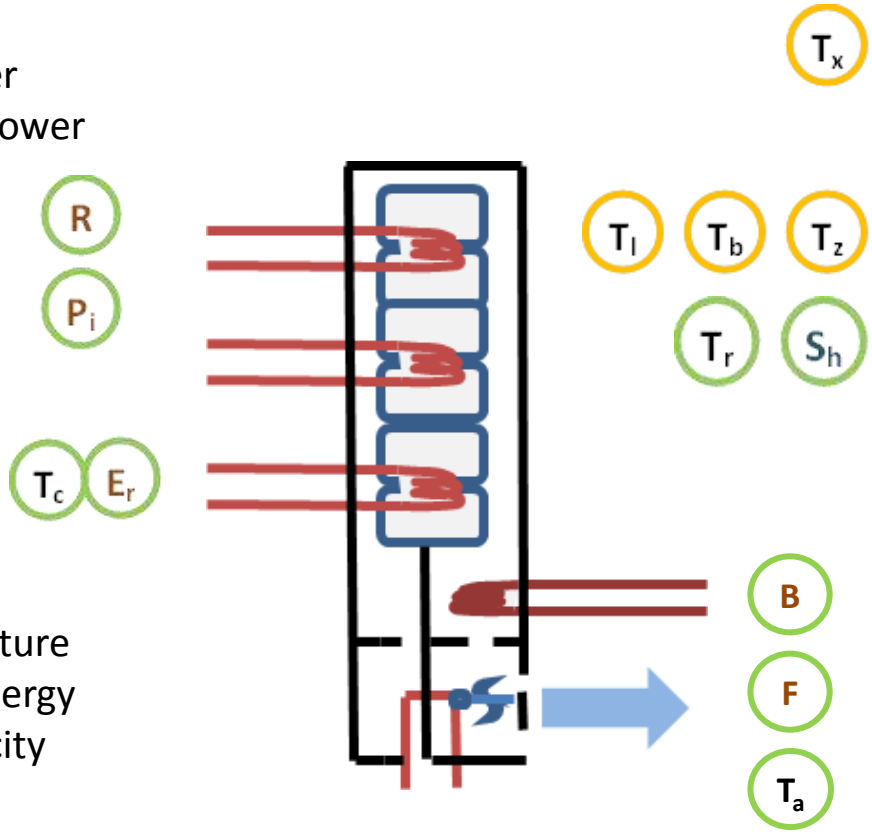
Energy in:
- scheduled power
- instantaneous power



Amenity:
- outside air temperature
- room temperature
- thermostat setting
- air intake temperature

Energy stored:
- core temperature
- Remaining energy storage capacity

Energy out:
- boost status
- fan status
- fan duct temperature (7 heaters only)

UoS ESRU – Customer demand forecast model

Water heater monitoring

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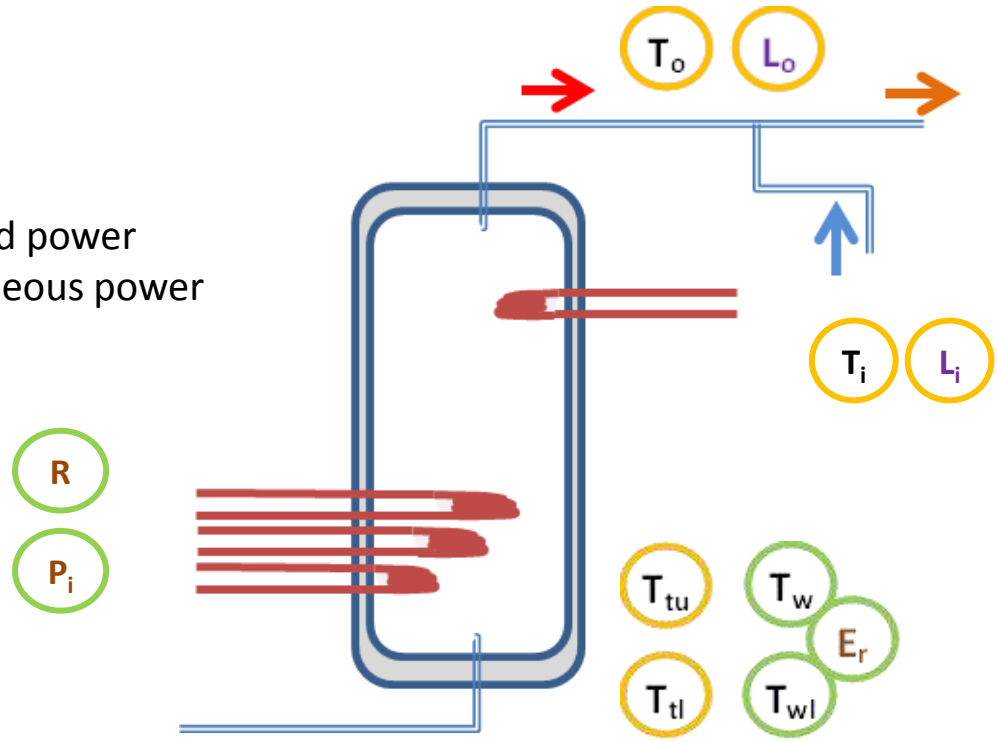
Energy in:
- scheduled power
- instantaneous power



Amenity :
- hot water volume
- hot water temperature
- cold mixer volume

Energy out:
- hot water volume
- hot water temperature
- cold water temperature

Energy stored:
- Water temperature top & bottom of tank
- Remaining energy storage capacity

NINES trial house monitoring - early outcomes

Data, data everywhere

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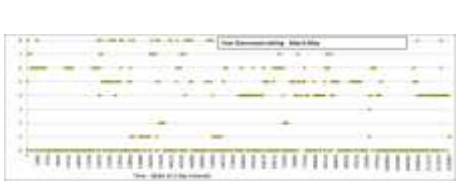
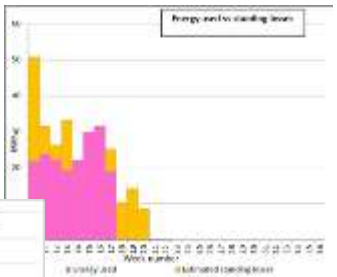

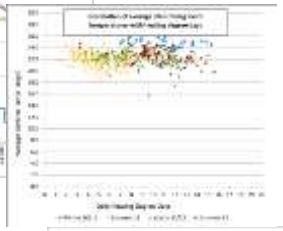
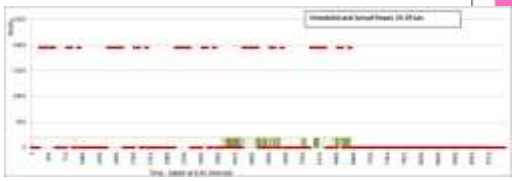

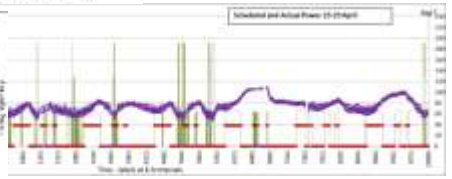


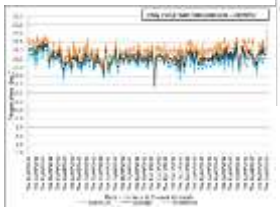
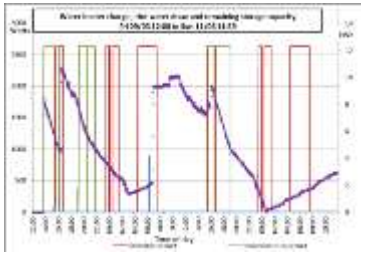
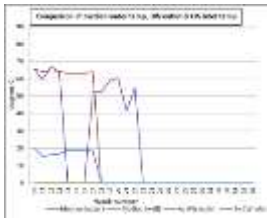
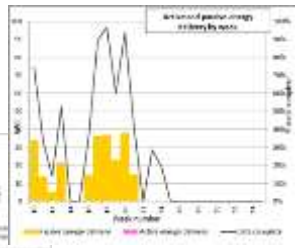
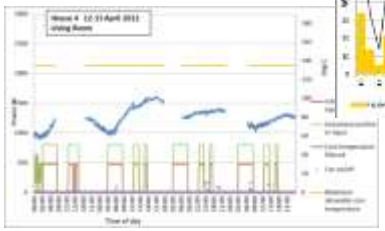
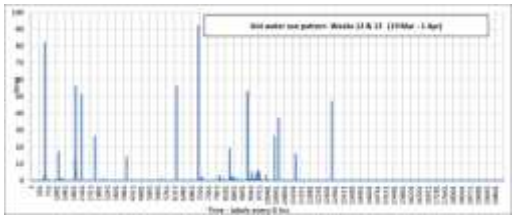

19 devices

12-14 data channels per device

1-5 minute frequency

House 2					
		Water	Heater 1 (KI)	Heater 2 (LR)	Heater 3 (HA)
March	2012	47%	30%	12%	47%
April	2012	42%	42%	42%	40%
May	2012	62%	48%	62%	44%
June	2012	0%	0%	0%	0%

NINES trial house monitoring - early outcomes

Utilisation of storage capacity – space heaters

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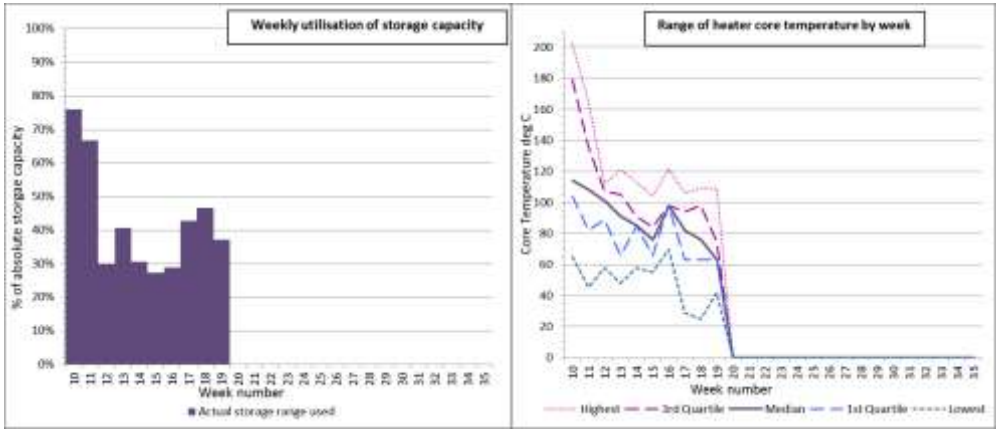
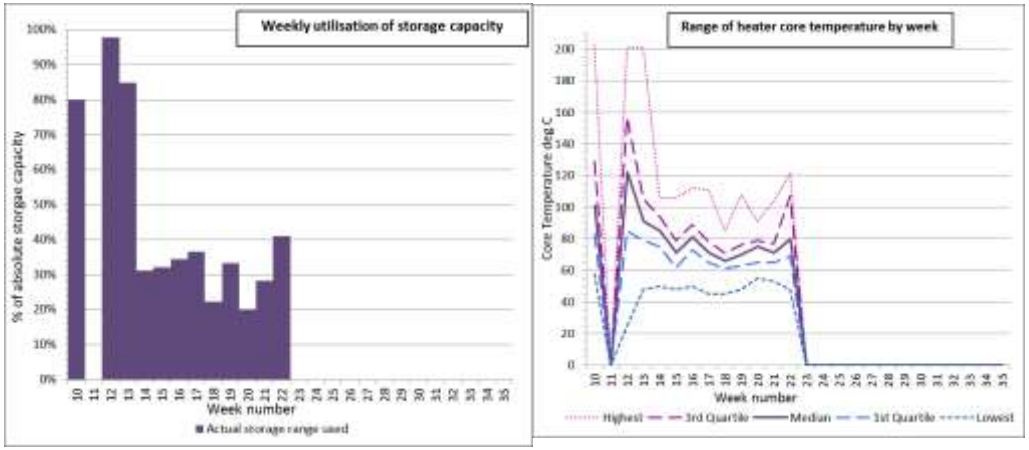


Single person, house unoccupied during day

Family, house occupied during day



- 35-40% of capacity used typically
- practical range even smaller
  - narrow 1-3Q temperature band
- spare storage capacity exists
- caveats
  - user comfort (overheating)
  - test houses vs rollout

LH: weekly storage capacity utilisation as % of max
RH: range of measured core temperature

NINES trial house monitoring - early outcomes

Utilisation of storage capacity – water heaters

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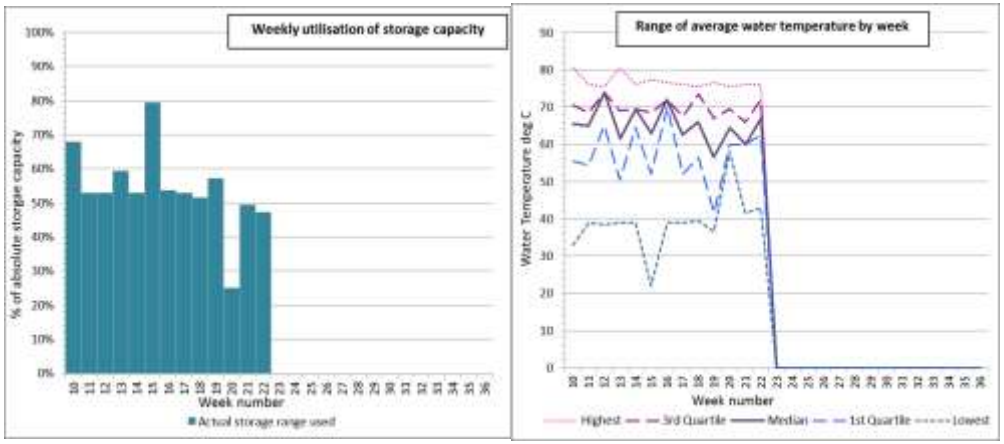
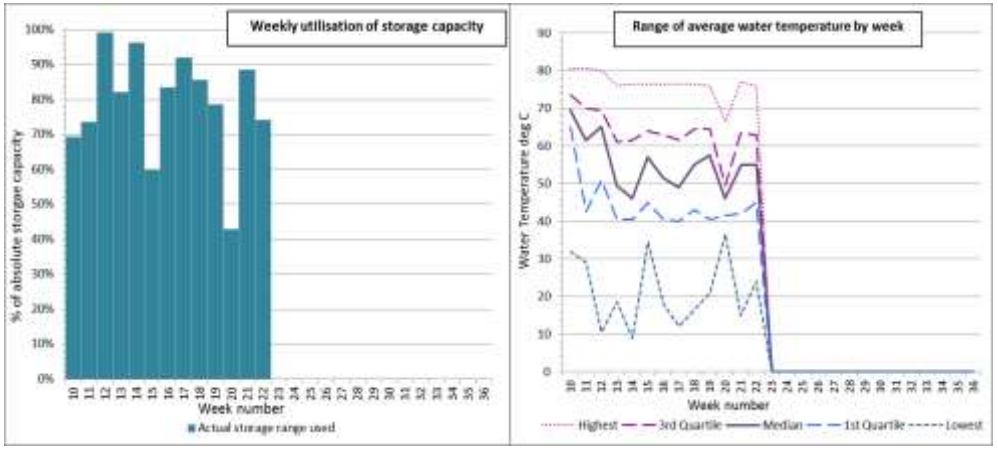


Single person
Out at work during day
Regular use of hot water

Family
House occupied during day
Irregular use of hot water



- 50-70% utilisation typical
- wider variation between houses
- practical range even smaller
  - narrow 1-3Q temperature band
- spare storage capacity in principle
- caveat
  - variation in hot water use

RH: weekly storage capacity utilisation as % of max realistic
LH: range of measured core temperature

NINES trial house monitoring - early outcomes

Monitoring outcomes – heater output

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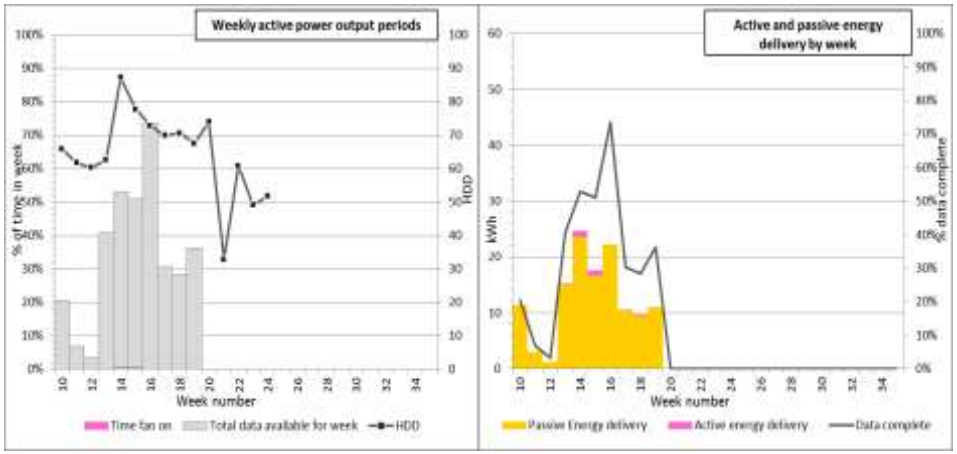
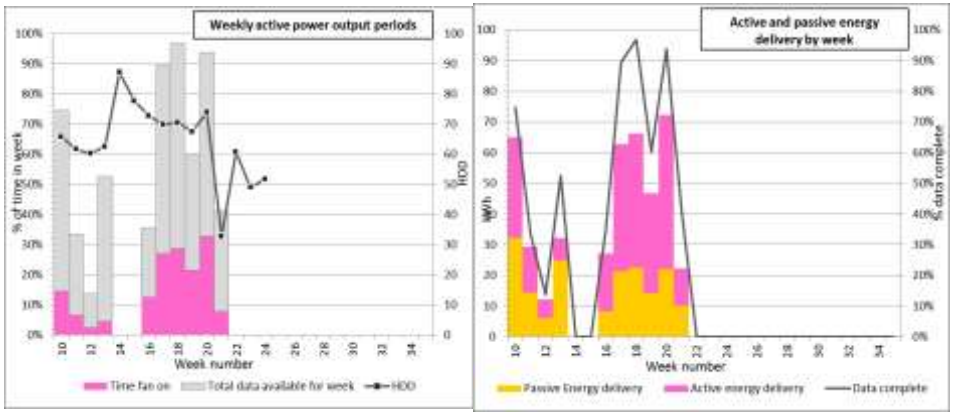
Single person
Out at work all day
Lightweight timber building



Single person
Out at work all day
Converted stone building



- significant % of heat supply is passive in all cases
- highest use of fan is in the smallest (stone) house
- lightweight insulated houses may not need such big heaters

LH: time fan is on in week, relative to total data available and to Heating Degree Days
RH: energy output in passive and active (fan assisted) mode

NINES trial house monitoring - early outcomes

Monitoring outcomes – controllability

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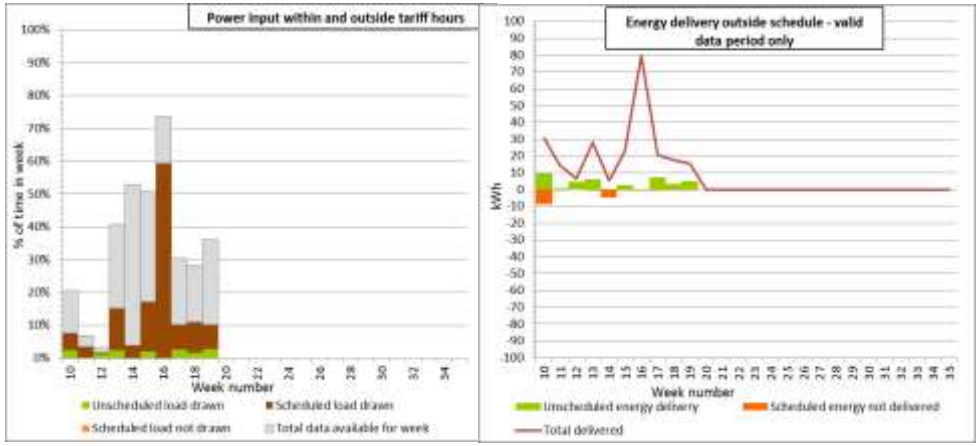
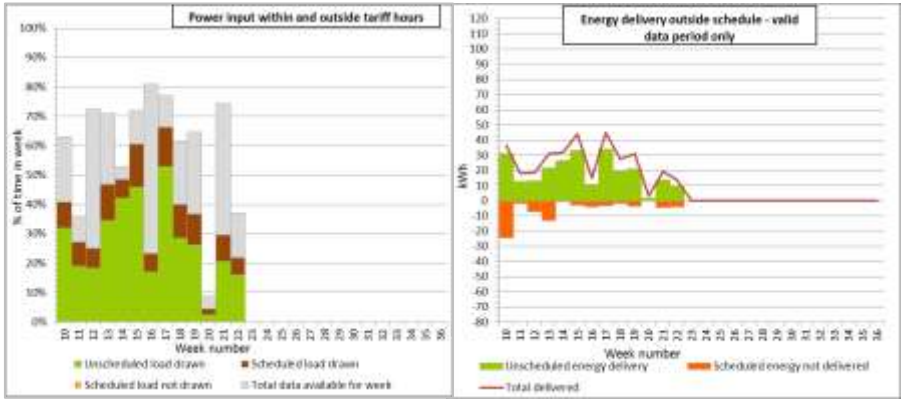


Living room heater
Single person,
House unoccupied during day

Water heater
Single person,
House unoccupied during day

- power drawn outside scheduled hours
  - 20% of time for space heaters
  - up to 70% of time for water heaters
- complex interaction of central, heater and occupant controls
- more investigation needed



LH: amount of time charging within (brown) and outside (green) schedule
RH: energy delivered outside schedule (green), scheduled not drawn (orange)

NINES trial house monitoring - early outcomes

Impact on occupant amenity

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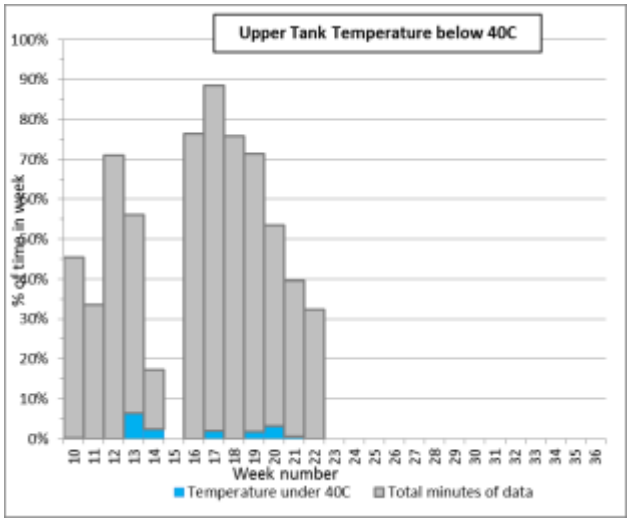
House	Average temperature Feb-Mar 2011 (^{0}C)	Average temperature Oct 11-Mar 2012 (^{0}C)
1	21.6	19.4
2	24.2	22.2
3	19.7	21.7
4	17.2	18.9
5	17.1	18.9
6	21.2	20.3

Indoor temperature

- average winter living room temperatures converge after installation
- heaters appear more controllable

Hot water

- top of tank is >40^{o}C almost all the time
- better hot water availability
- but higher standing losses



Simulations and forecasting – work in progress

Modelling - calibrating trial houses

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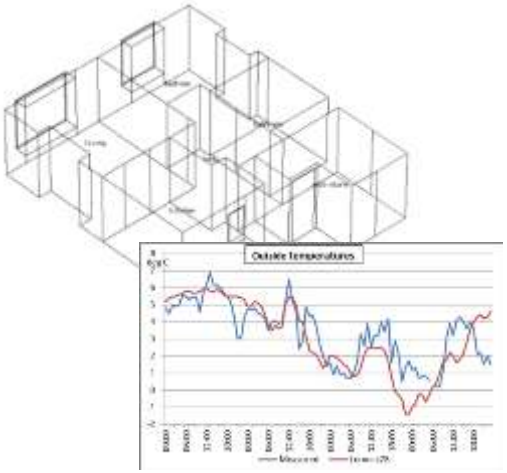


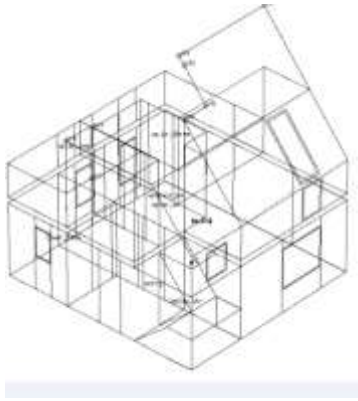
Detailed models of each trial house built in ESP-r

- actual dimensions, construction details
- best guess occupancy & casual gains
- ideal heating assumed

Compare periods where outdoor temperature pattern close to TY

Storage heater models built separately using performance test data

Ultimately: library of typical houses and occupancy profiles



Simulations and forecasting – work in progress

Next steps: modelling and forecasting

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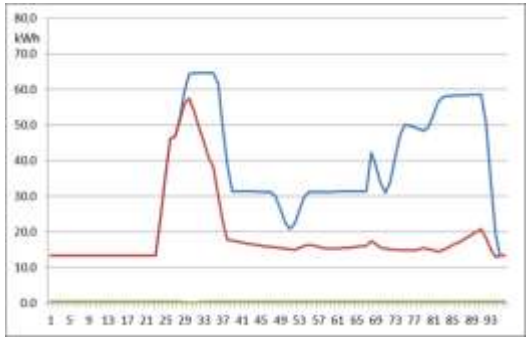
Individual house & heater models will allow us to

- investigate wider range of conditions than actually encountered
  - house types
  - weather conditions
  - occupant behaviour
- explore possible improvements in control regime
- extrapolate to other regions



Build forecaster from individual profiles:

- synthesise 15-minute demand profiles for groups
- generate real time forecasts from weather outlook
- tool is adaptable to other situations