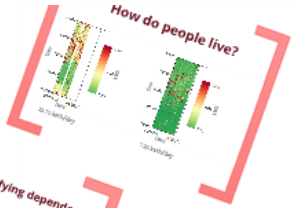
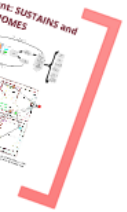
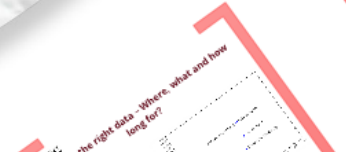
Occupied buildings - Performance assessment & the rise of sensor technologies: Why? How? and...The benefits?

Elena Gaura &
Ross Wilkins

COGENT computing







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What everyone wants:
Low carbon buildings- more, quicker, and with a low defect rate, whilst reducing costs

"What can be measured can be evaluated, improved, directed – in short managed."
(Lord Kelvin)

Not everything that can be counted counts, not everything that counts can be counted."
(Albert Einstein)

Cogent's Perspective on Buildings and Carbon Cuts: the facts and the standpoints

• The facts:

– Specified and Occupied: the performance gap is a reality - causes are anecdotal though...
– Buildings don't consume energy, people do! and...
– People are different - we all wear different carbon shoes (mostly by choice but sometimes by force...)
– Believing in "green" doesn't make us "green"
– New technologies don't always do what is said on the tin

• The Standpoints:

– You can not cut what you have not measured (and understood...)
– Homes are a complex systems problem: fabric, systems, people and multiple interactions
– Data is power ... IF it has statistical validity
– The sensing technology is here - USE IT

Carbon Cuts: the standpo

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- The Star

– You car

e...)

d on the

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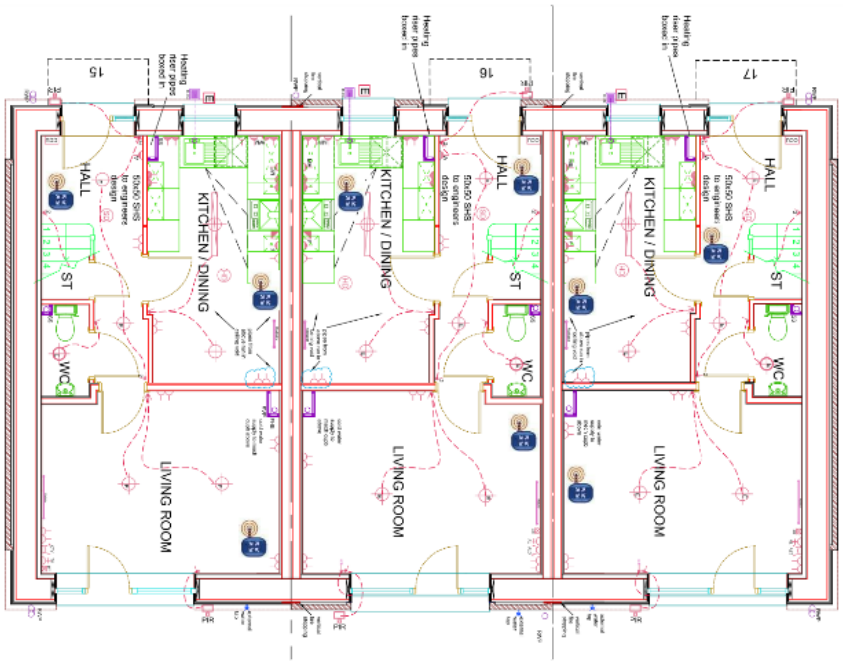
Passiv Homes or Passiv Living?



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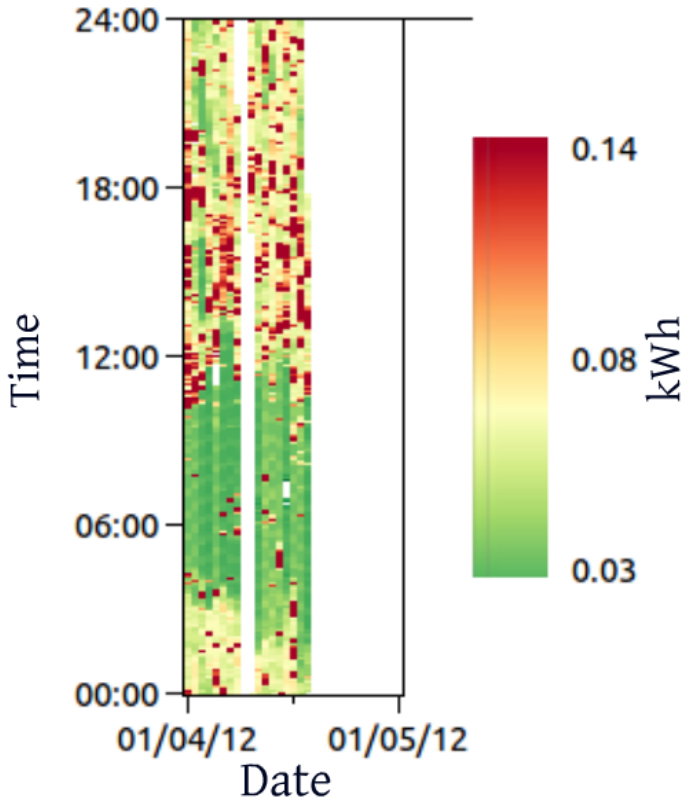
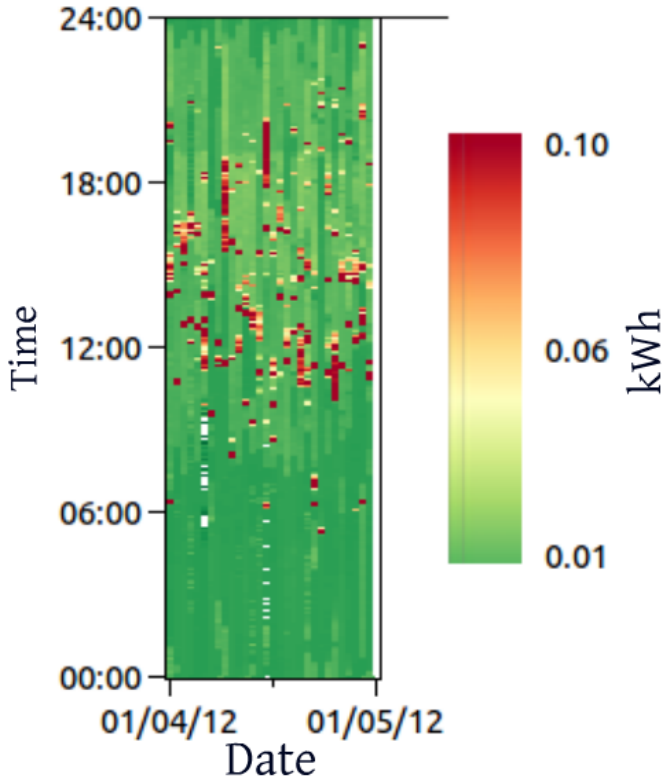
How do people live?



21.75 kWh/day



7.23 kWh/day

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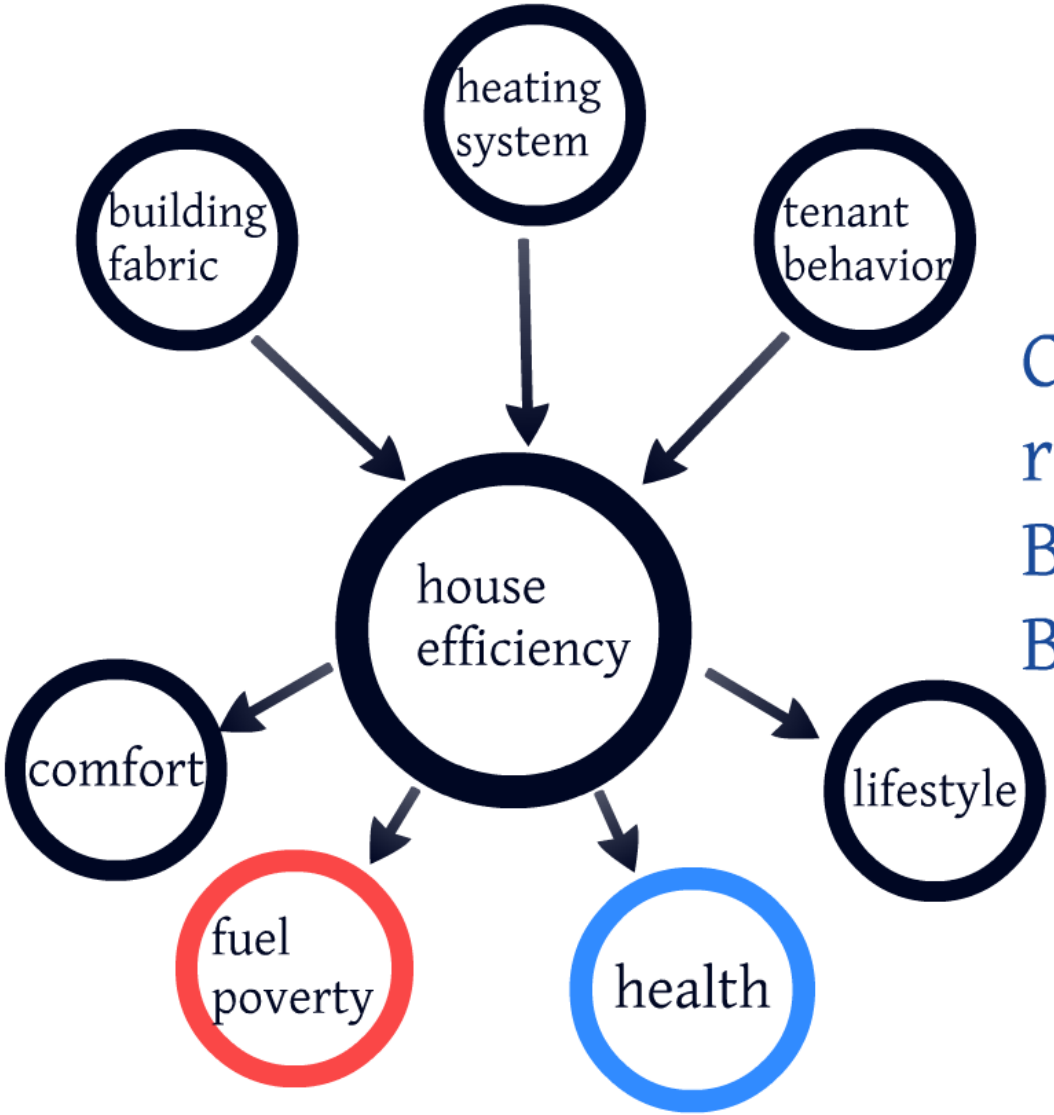
The holy grail – quantifying dependencies



Carbon footprint reduction is not about BUILDINGS, but OCCUPIED BUILDINGS

The tools - Wireless networked sensors

Cheap
Easy to use
Infrastructure free
Flexible, evolving

Portable
Drop and go
Unobtrusive
Knowledge generators

Occupied Buildings:
Simple DATA vs Complex KNOWLEDGE Space

Buildings assessment: SUSTAINS and DECENT HOMES

Challenges

- unclear informational needs
- lack of holistic metrics
- complex phenomena: energy, building fabric, heating/cooling systems and PEOPLE
- unattended operation/limited access post deployment
- long-lived robust systems
- large scale networks (over 200 nodes)
- mix of wireless protocols
- evolving needs for additional sensing modalities
- dealing with the client - knowledge transfer and requirements negotiation

Innovations

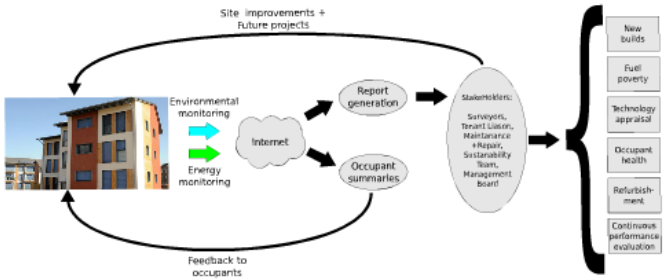
- designing with patterns
- transmission suppression - SIP
- knowledge driven design - BN
- failure monitoring tools (Heartbeat)
- occupant-focused sustainability assessment methods - MAKE
- holistic metrics for building fabric performance assessment (heating/cooling curves; time exposure)
- end-user archiving and analysis tools

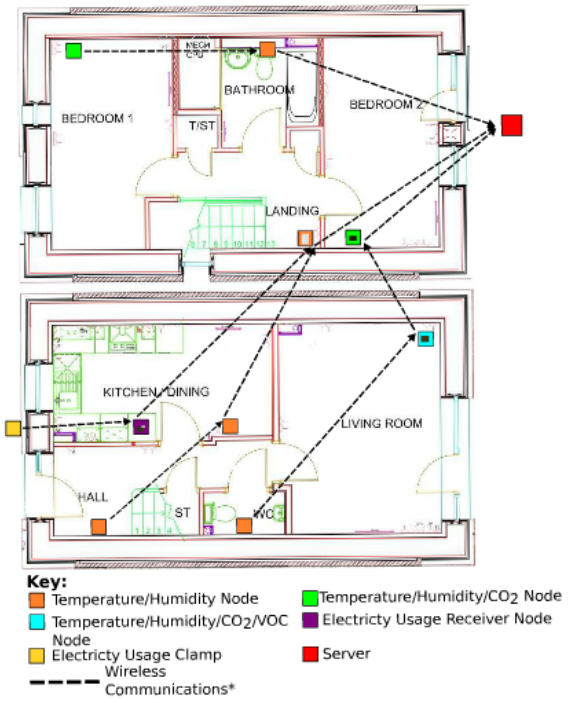
Results

productised end-to-end monitoring system
250 node on-site network (23 co-located homes) for over 15 months
63.1% yield - 22.5% loss from occupant intervention, 11.3% loss from vandalism, 2.7% loss from maintenance issues. Only 0.4% loss due to network or sensor issues.

Impact

Industry - adoption and change of current practice





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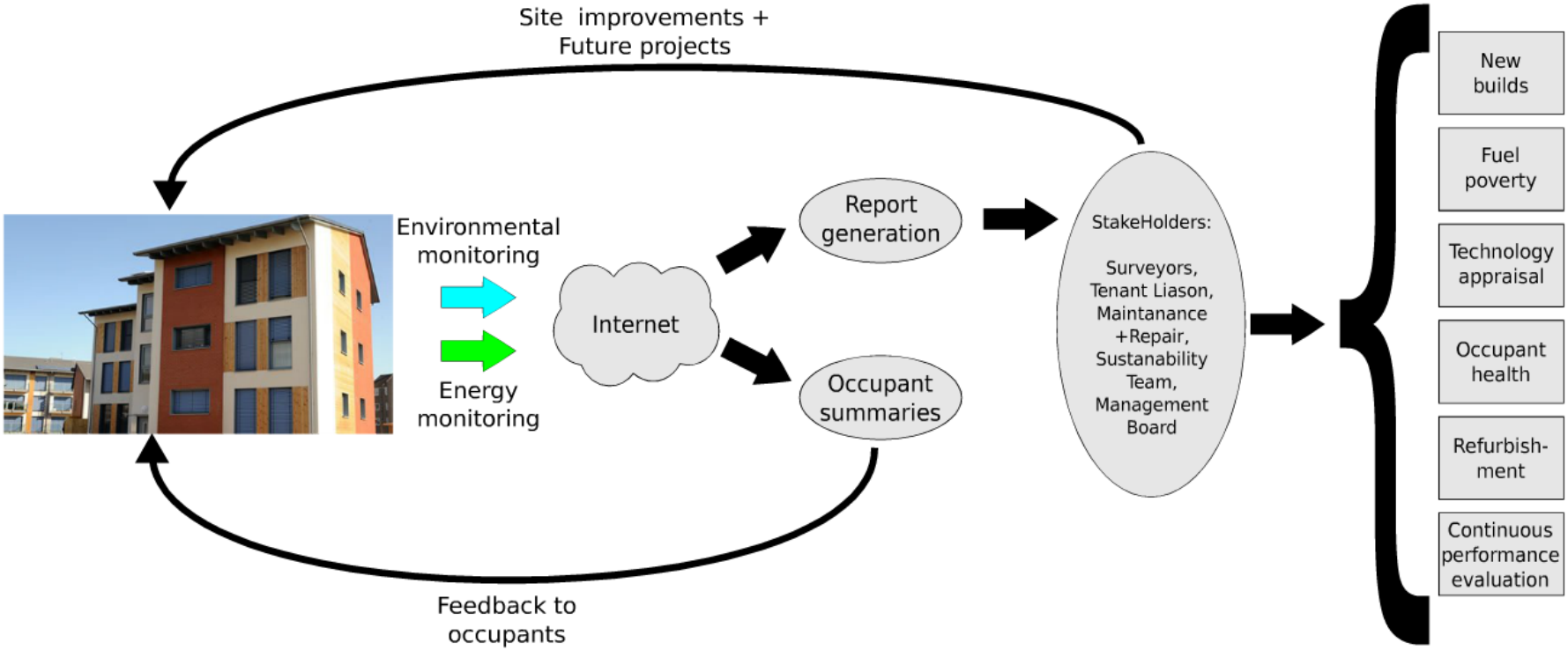
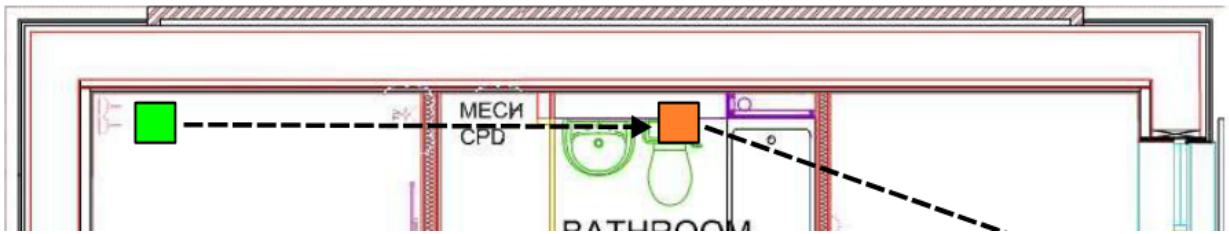
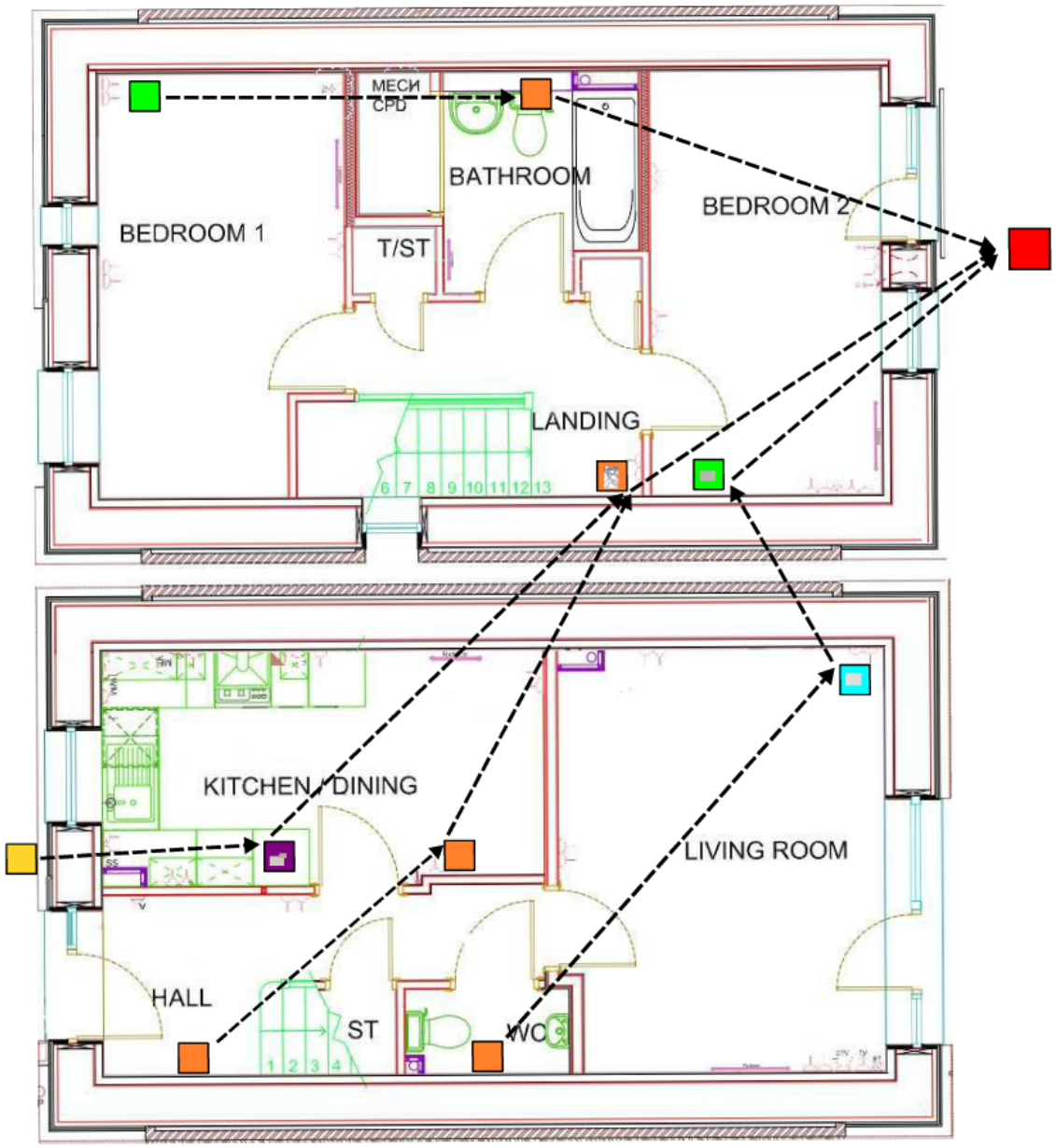

Site improvements +
Future projects
Environmental monitoring
Energy monitoring
Internet
Report generation
Occupant summaries
StakeHolders:
Surveyors, Tenant Liason, Maintanance +Repair, Sustanability Team, Management Board
New builds
Fuel poverty
Technology appraisal
Occupant health
Refurbish-ment
Continuous performance evaluation
Feedback to occupants

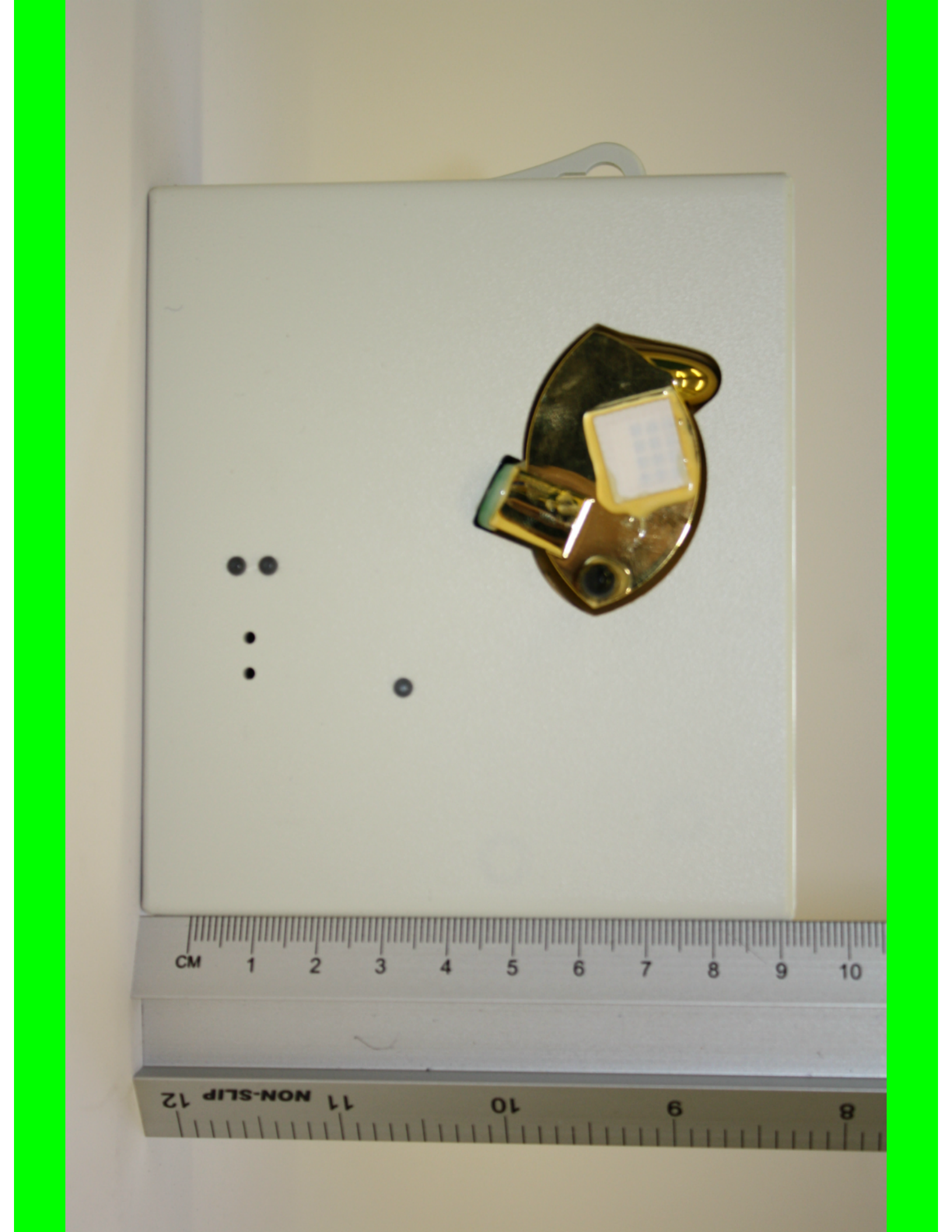

MECH
CPD



Key:

- Temperature/Humidity Node
- Temperature/Humidity/CO_2 Node
- Temperature/Humidity/CO_2/VOC Node
- Electricty Usage Receiver Node
- Electricty Usage Clamp
- Server
- Wireless Communications*

8
7
6
5
4
3
2
1
CM


CM
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NON-SLIP
12
11
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8

CM
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8
9

OK
2-4-1-4164
CURRENT
cost

NON-SLIP

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Towards…

Assessment & evaluation

Choices

Diagnosis

Focused action

Education

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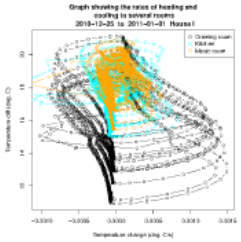
Deployments experiences – beyond pilots

Period: mostly heating period with some summer samples.
Environmental quality monitoring and energy auditing.
Deployment duration- variable (24 months).
20 million+ data points; yield 95%.

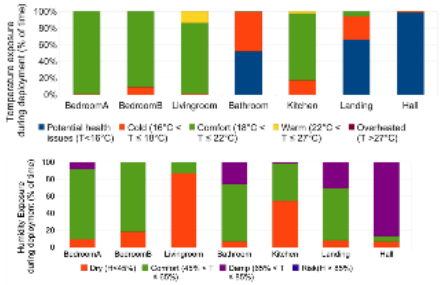
50+ Social/owned/privately rented
Victorian to PassivHaus; bungalows, terraced, detached, apartments.
Heating systems: ground source, air source, gas central, mixed, district heating schemes.
Occupants: age groups – from 1 to 70; family sizes – from 2 to 7.

Inferring meaning from data

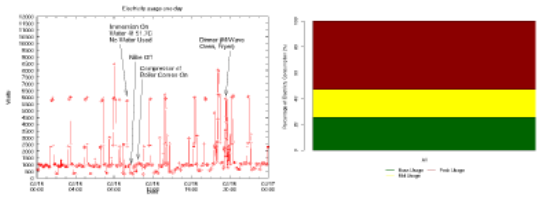
Inferring meaning from data - the building envelope



Inferring meaning from data- Decent Home/ Decent Living?



Inferring meaning from data - system diagnosis



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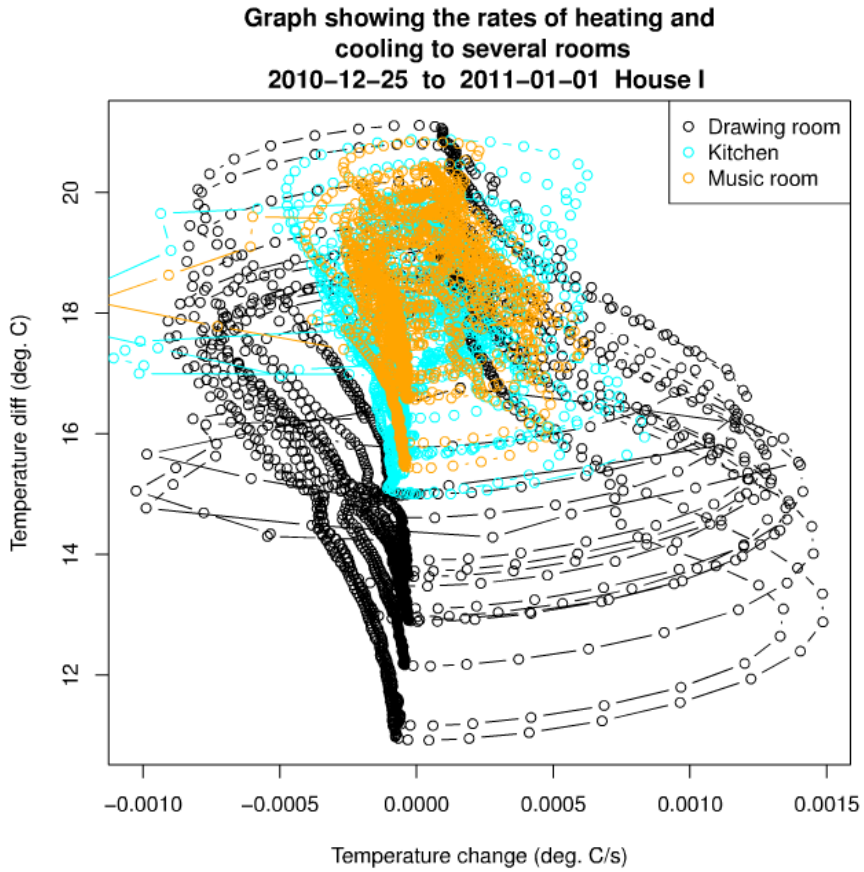

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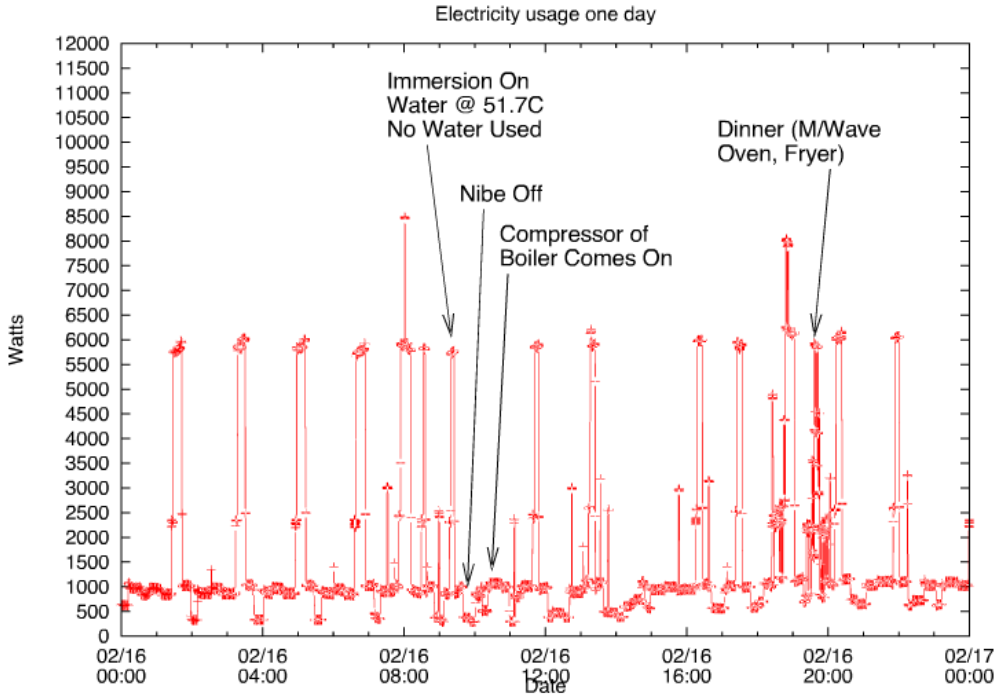

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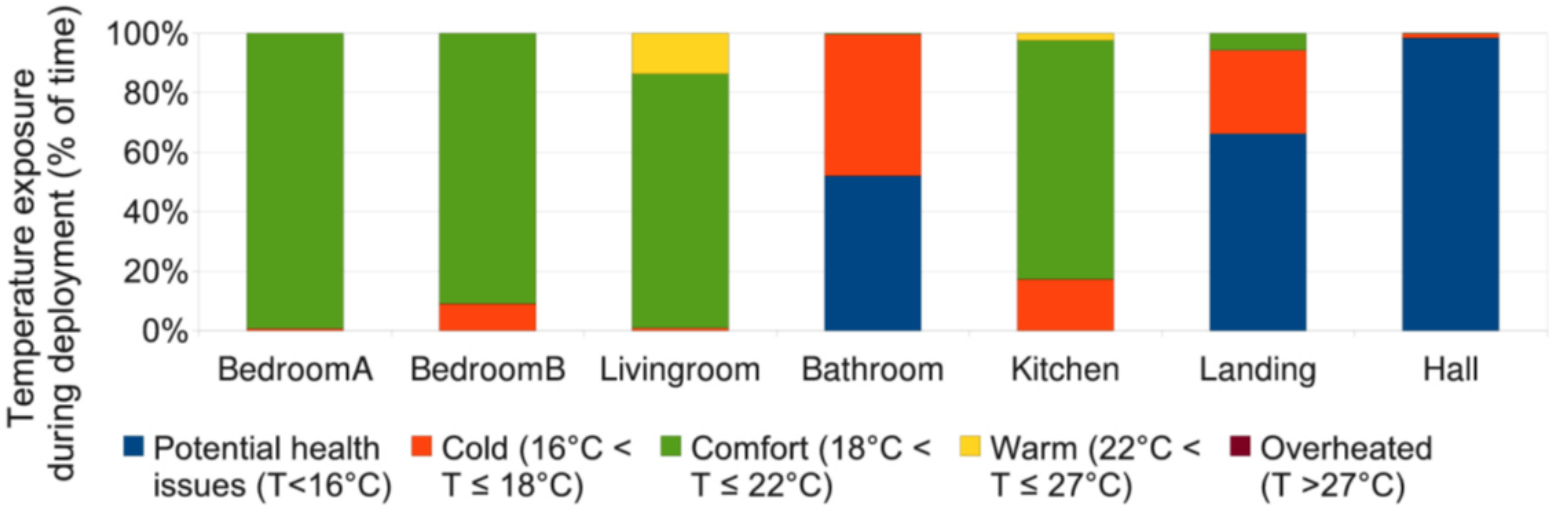
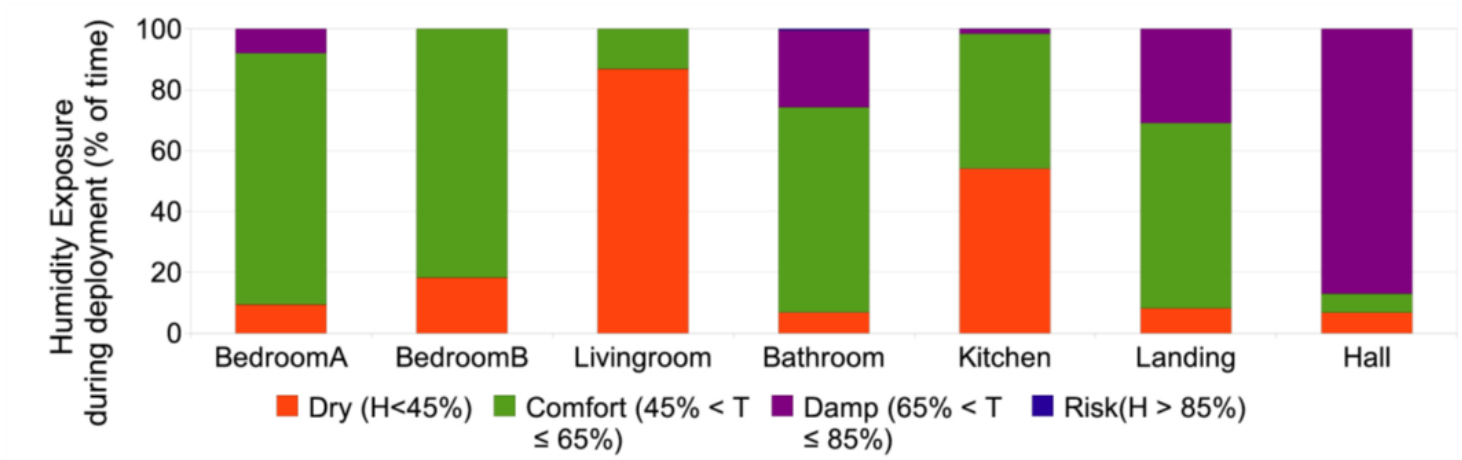
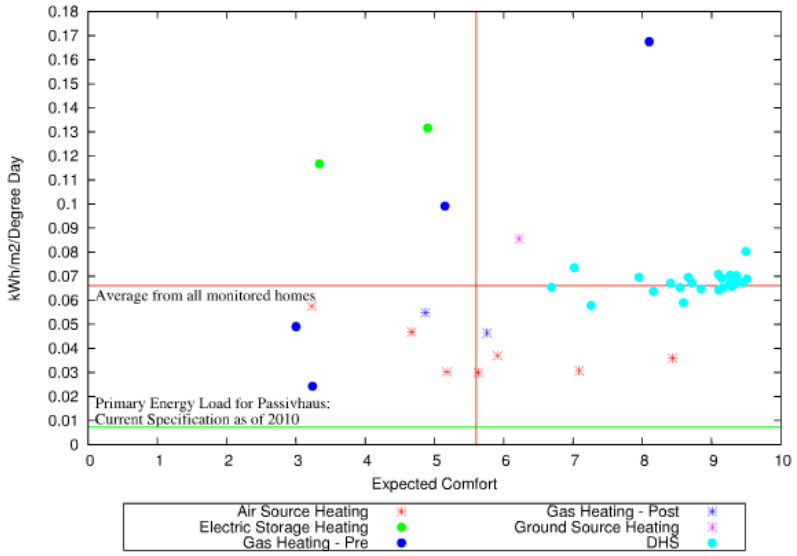
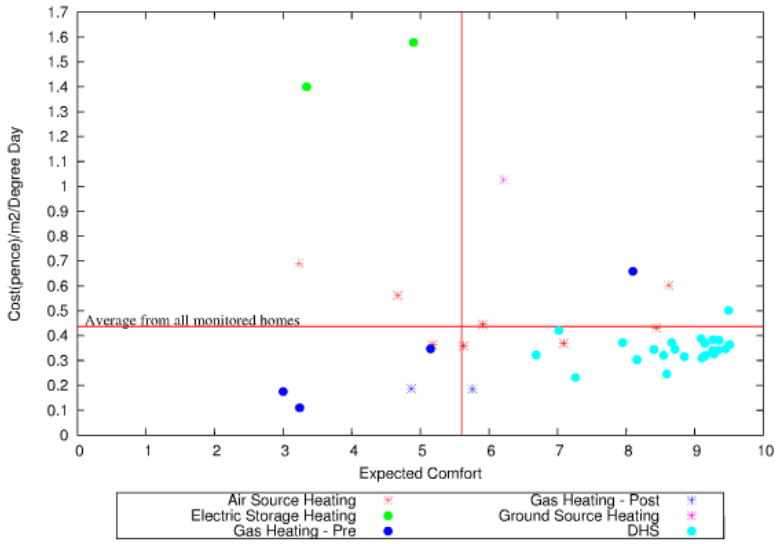
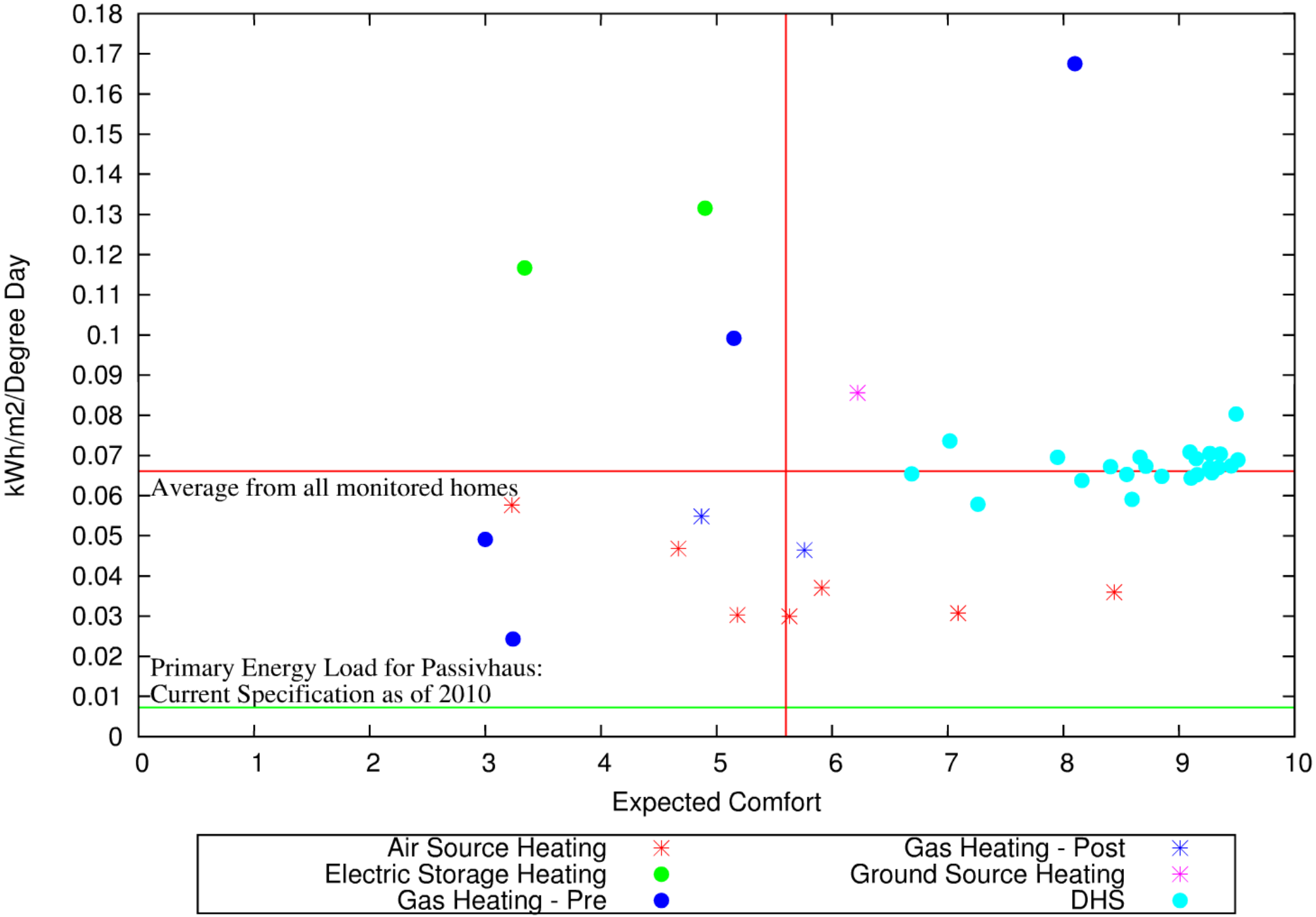




Inferring Knowledge from Information – cost of comfort






kWh/m2/Degree Day
0.18
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0.16
0.15
0.14
0.13
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0.1
0.09
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0.05
0.04
0.03
0.02
0.01
0
0
1
2
3
4
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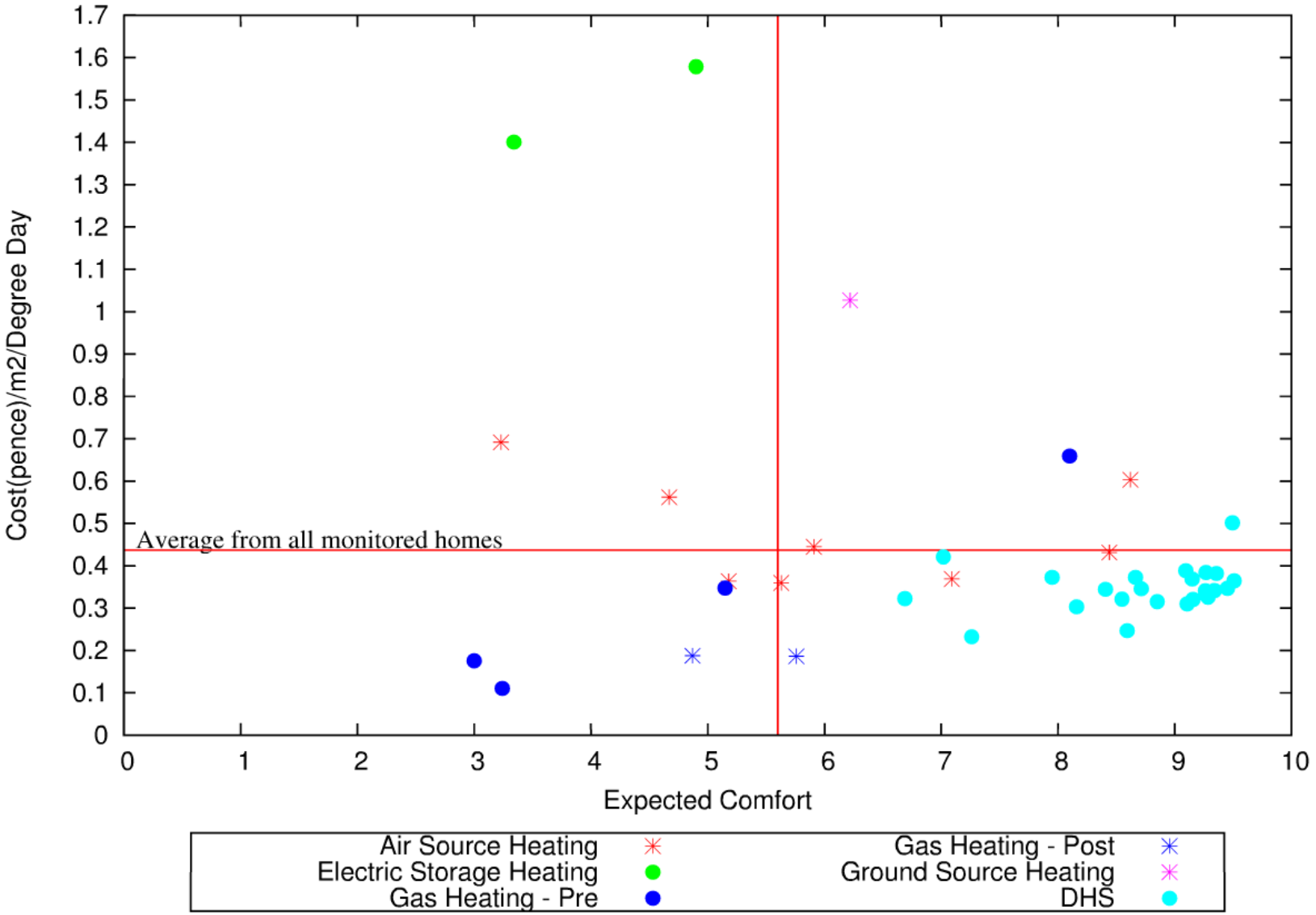
7
8
9
10
Expected Comfort
Average from all monitored homes
Primary Energy Load for Passivhaus:
Current Specification as of 2010
Air Source Heating
Electric Storage Heating
Gas Heating - Pre
Gas Heating - Post
Ground Source Heating
DHS


Cost(pence)/m2/Degree Day
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Average from all monitored homes
0
1
2
3
4
5
6
7
8
9
10
Expected Comfort
Air Source Heating
Electric Storage Heating
Gas Heating - Pre
Gas Heating - Post
Ground Source Heating
DHS

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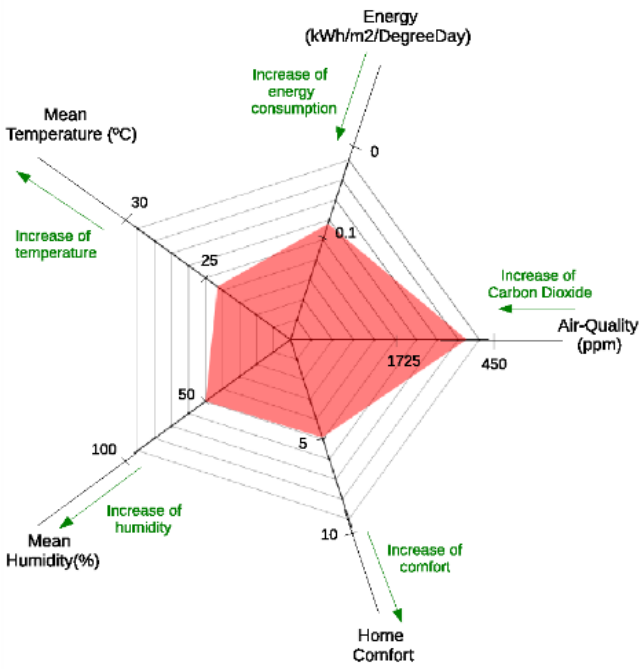
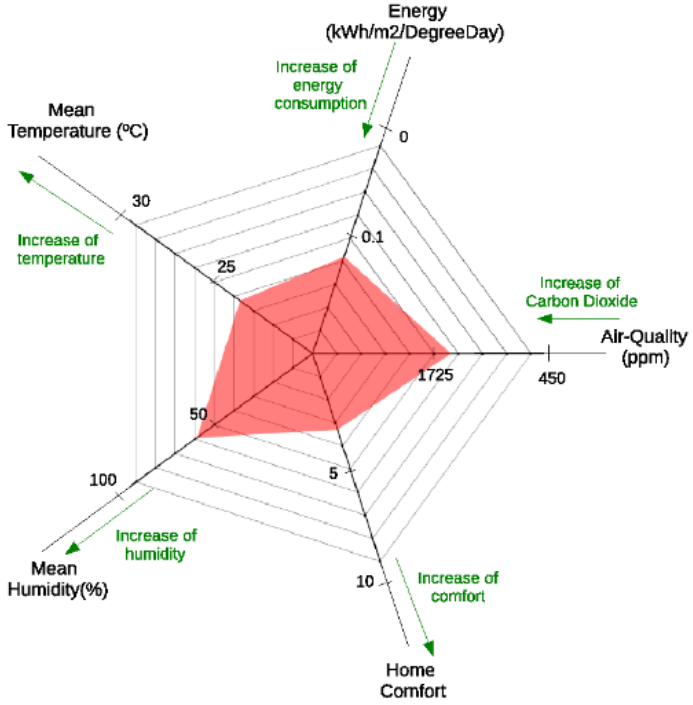
Reasoning about energy and environment

Using More Energy
Higher level of comfort



Using Less Energy
Lower level of comfort



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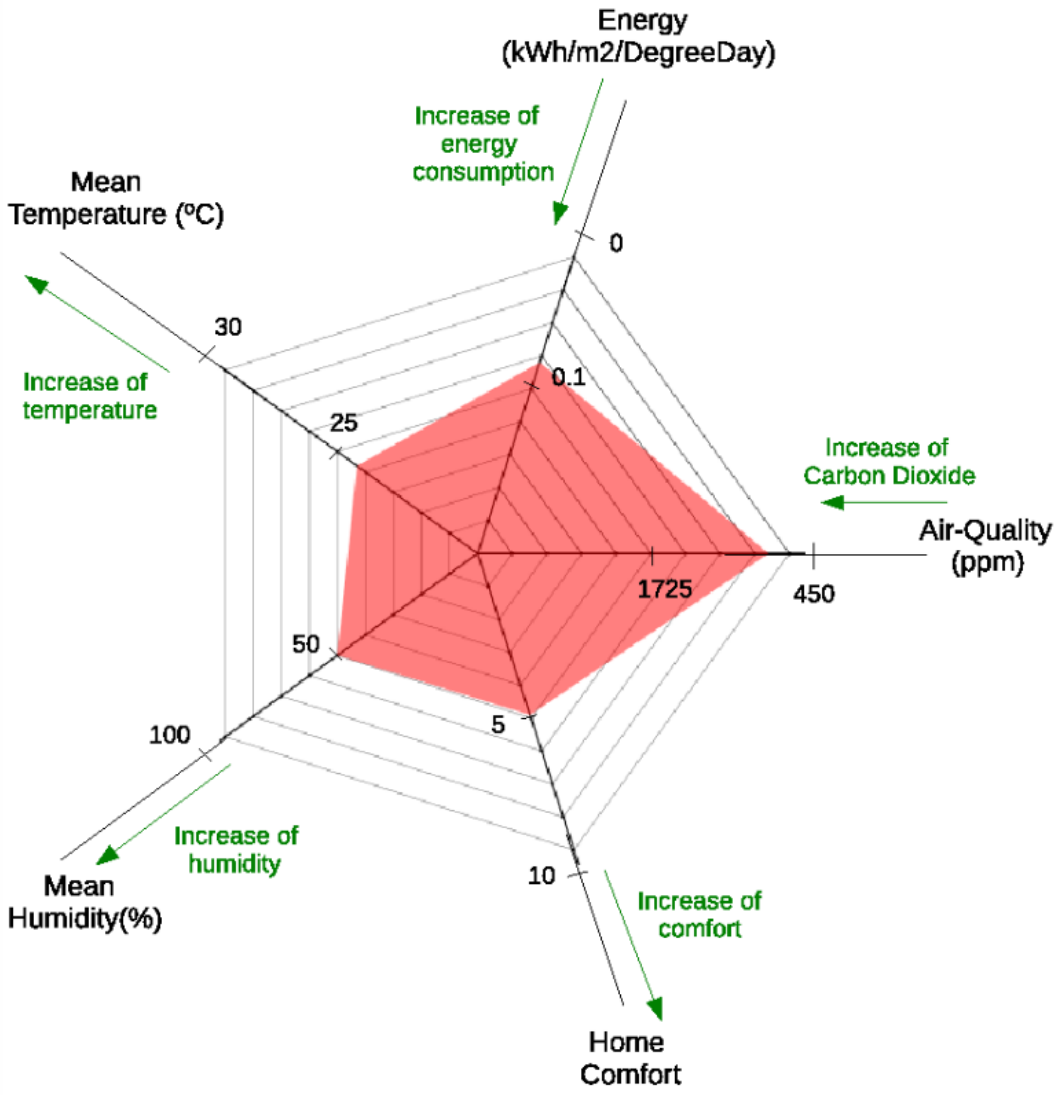
Higher level of comfort



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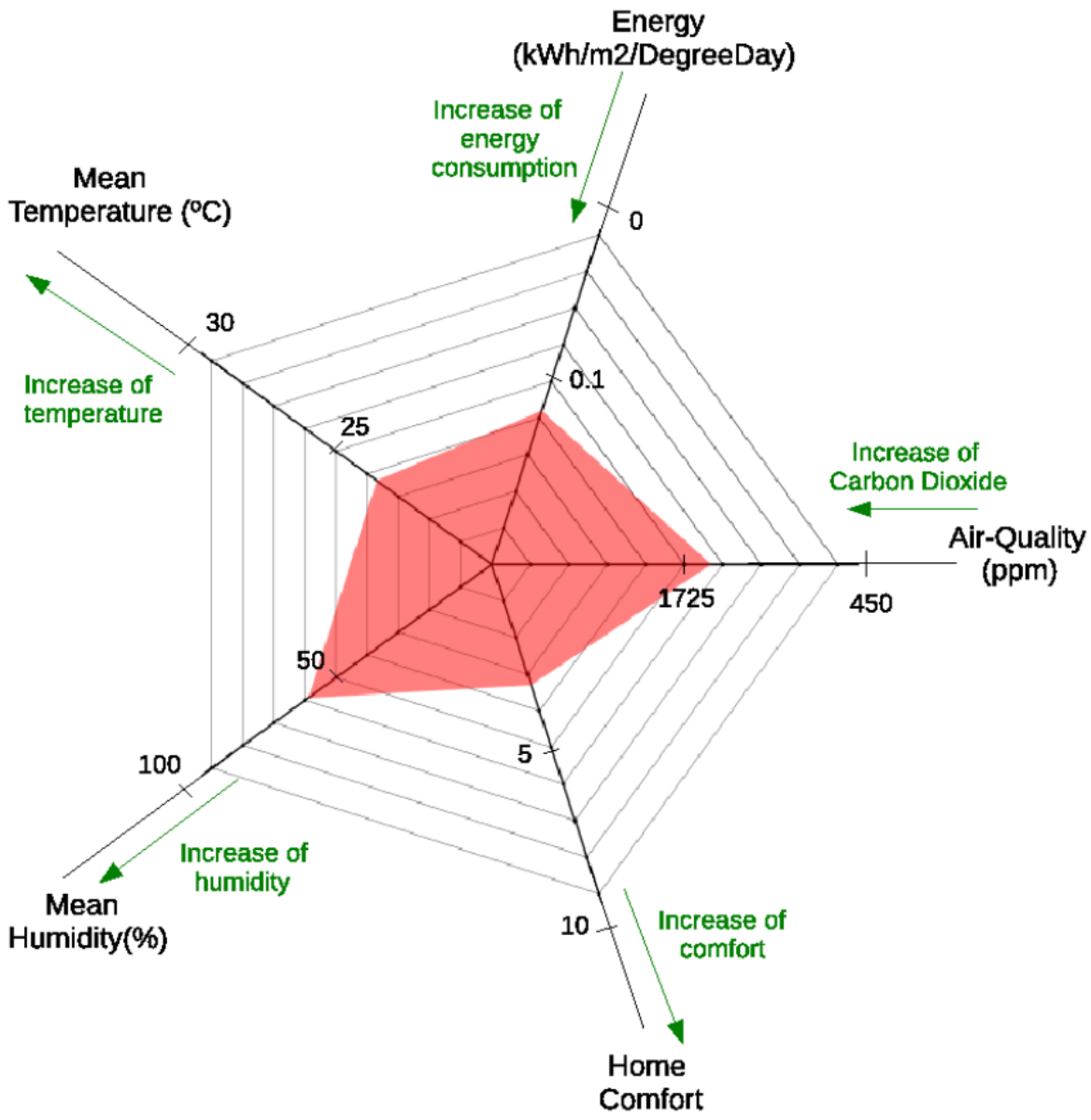
Lower level of comfort



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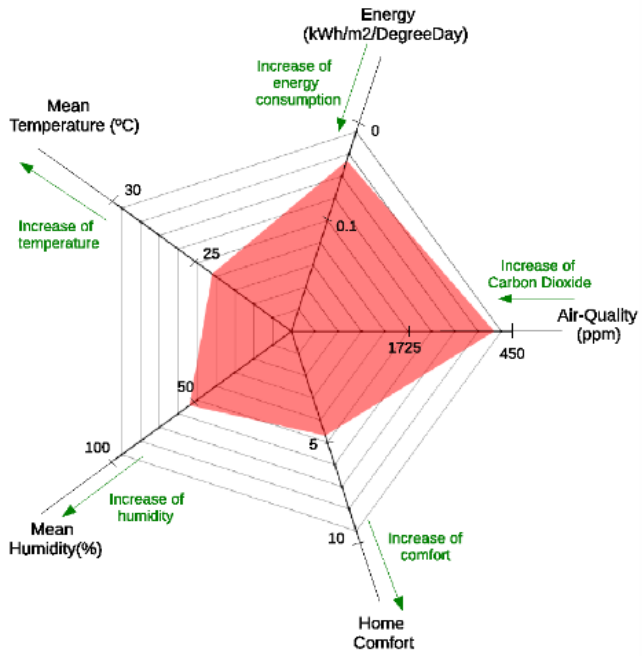
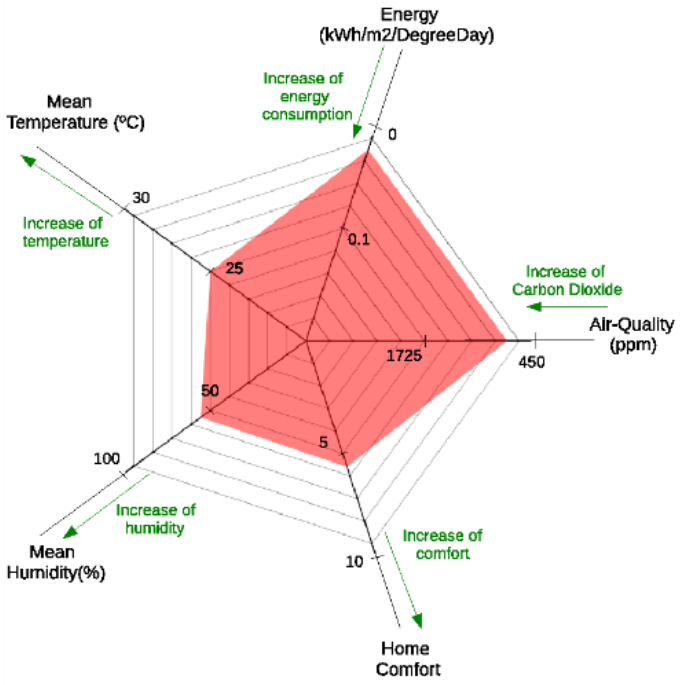
Understanding homes in terms of quantified information

Identical House – Always Occupied
Lower Energy Used, Lower Comfort



Identical House – Always Occupied
More energy Used, Higher Comfort



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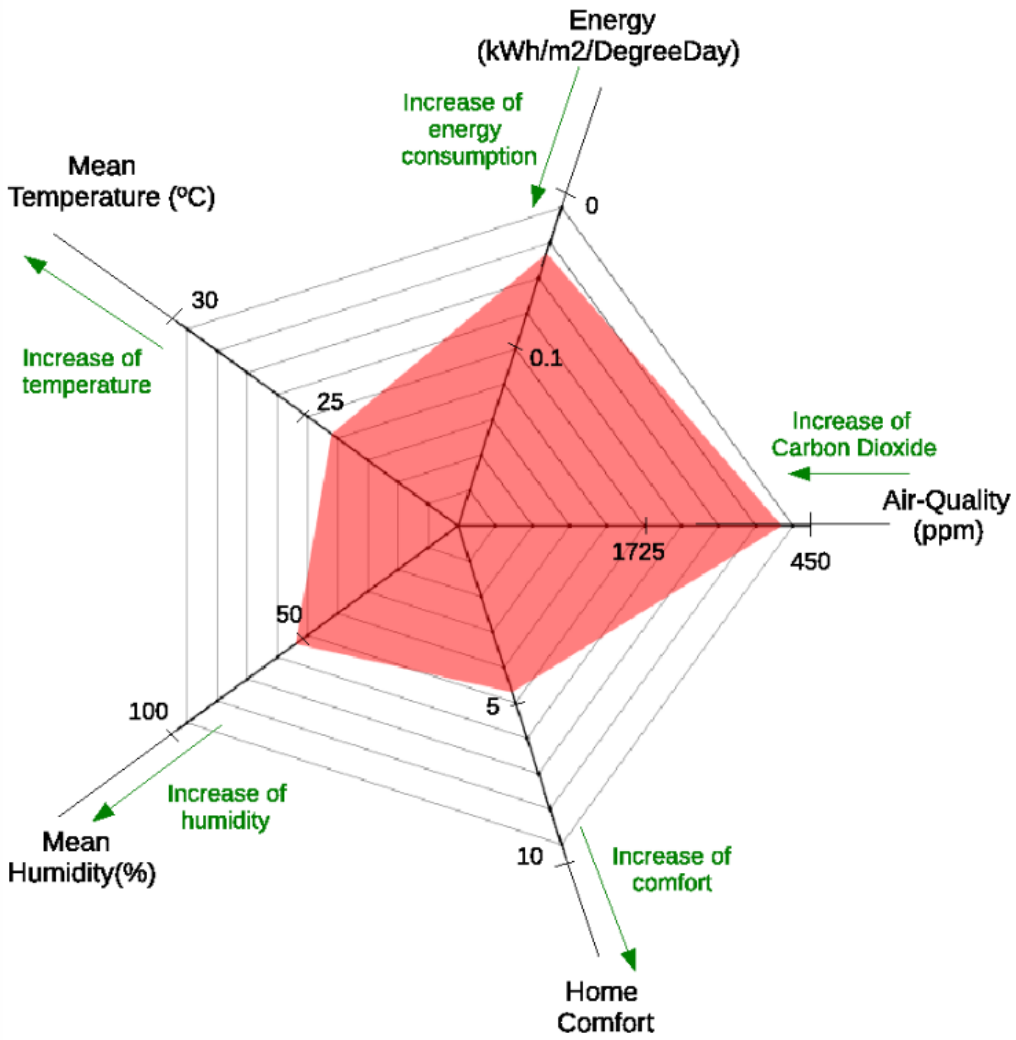

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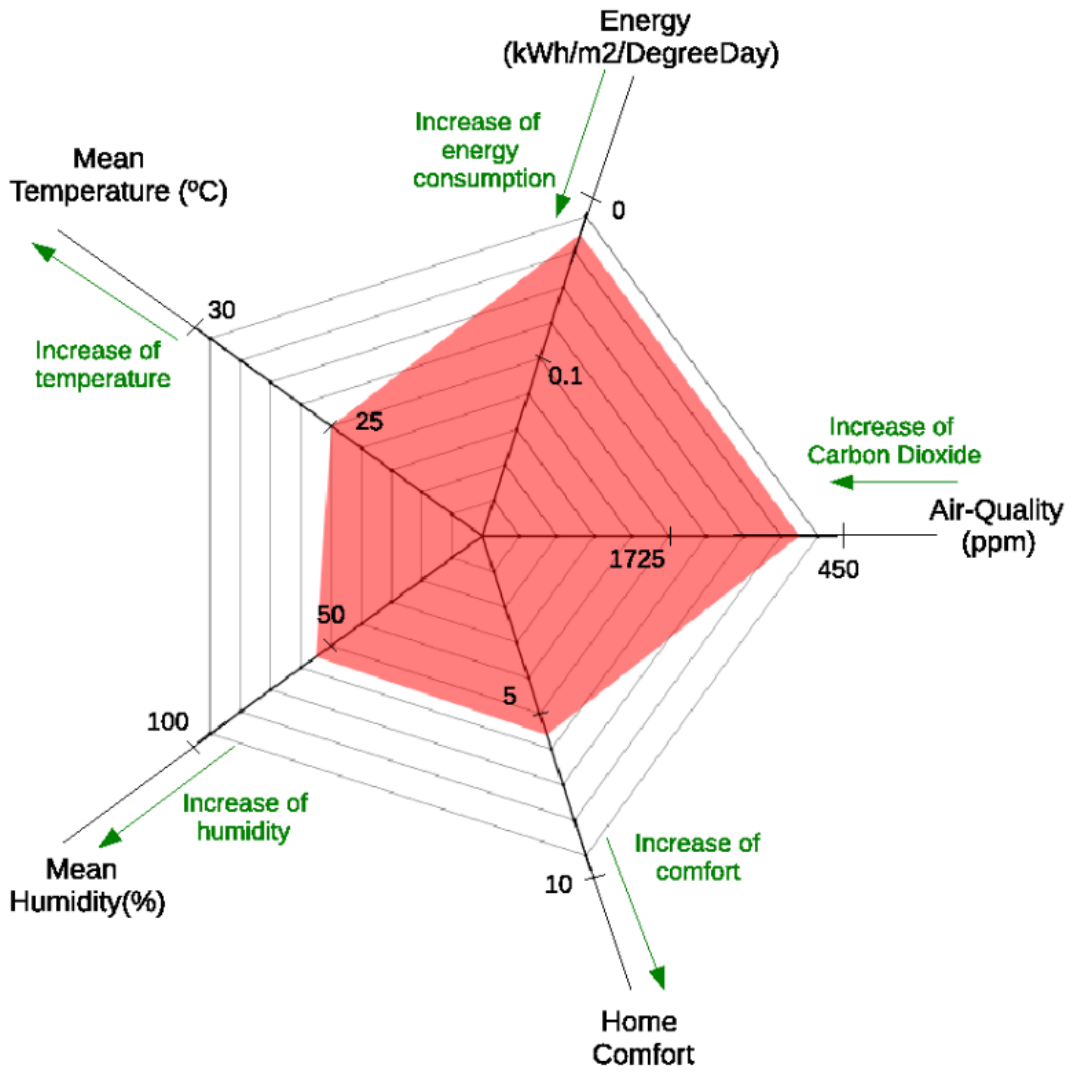
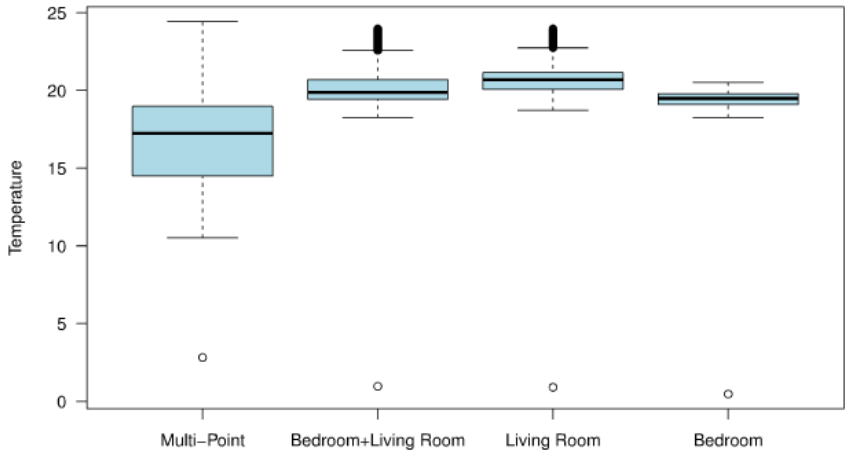
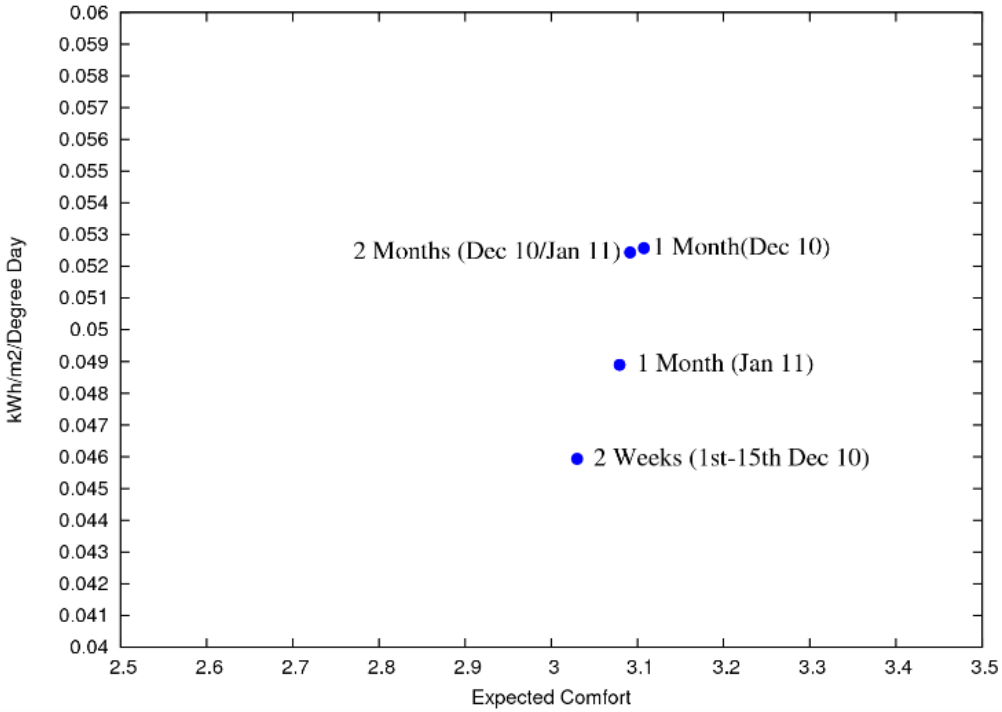
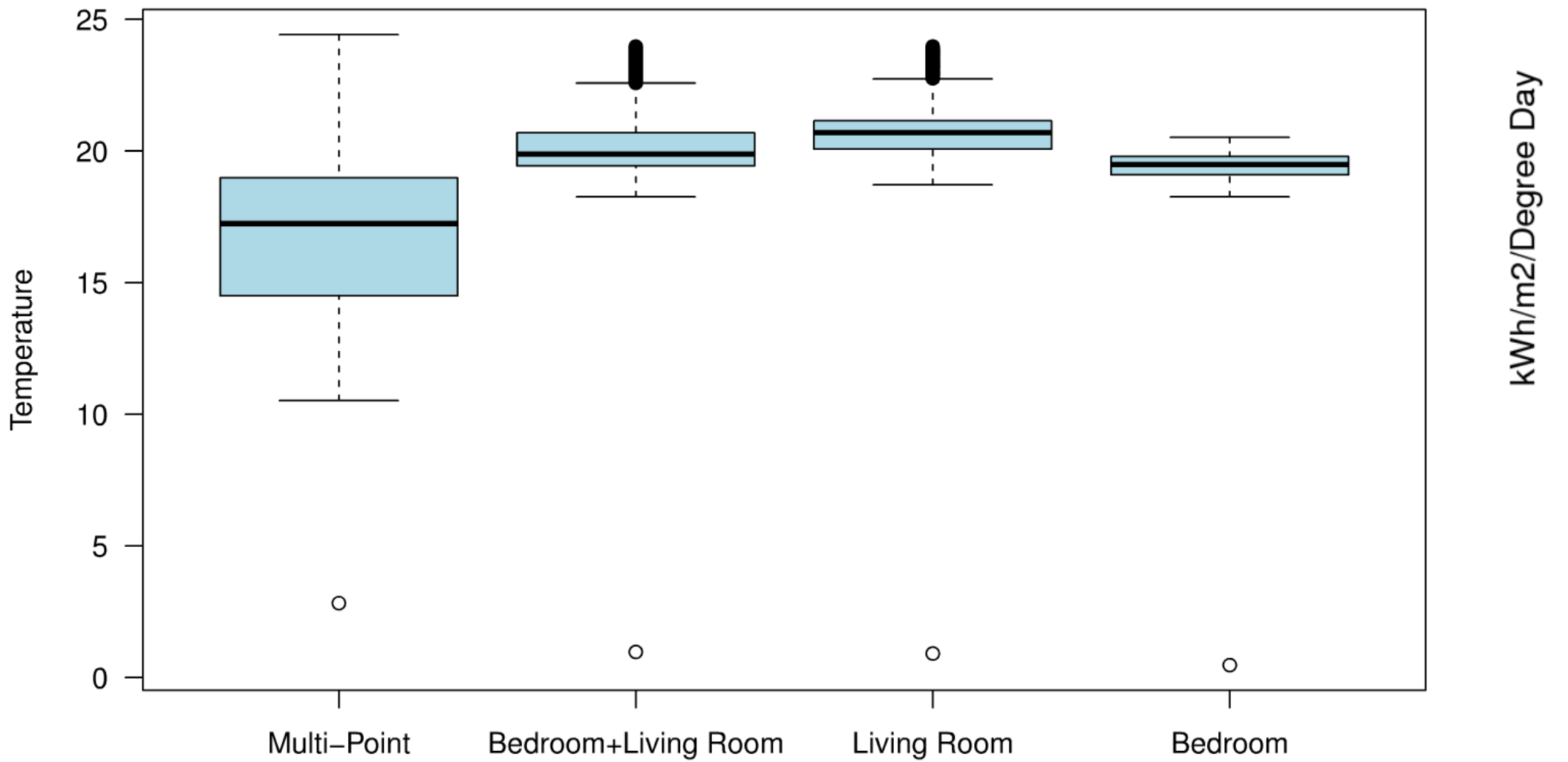


Getting the right data – Where, what and how long for?






Temperature
25
20
15
10
5
0
Multi−Point
Bedroom+Living Room
Living Room
Bedroom
kWh/m2/Degree Day

COGENT computing

Using the data right

Privacy: My home is my castle

Habits

Living choices

Duty of care

COGENT computing

Open research question: Defining Holistic approaches to assessment

Integrative of sub-systems interactions: climate, fabric, mechanical systems and PEOPLE - new science, tools and data are key.

Stages:

- Understand interactions, effects, drivers, attitudes.
    - Build and roll out appropriate instrumentation – heavily constrained by application (privacy, ethics, opportunity, cost, utility, portability, long shelf life, robustness, re-use, end-user adoption).
    - Build large data banks - archetypes (buildings, systems and people).
- Develop new informational metrics (assessment and diagnosis, comparative assessment).
- Develop solution sets – generate knowledge from information (education, measures costs efficiency, contextualized strategies).
- Roll out solutions and loop and refine.

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Opportunity, tools and data

Opportunity:

Large stock owners, community driven associations.

Tools:

Strong WSN devices market; mostly DIY, research instruments; expensive services for data collection and return.
Need for detailed instrumentation systems specification, integrative of drivers for energy consumption in residential buildings.

Data:

Shift from “observational” approaches to fully fledged statistical approaches based on new metrics.

Remarks

Apportioning consumption (thus making judgments) to fabric, systems and behaviour/lifestyle/preferences needs accurate well specified measurement.

Environmental Data can be obtained, Knowledge is hard to be inferred.

Pioneers stand to gain – insight - early understanding – market leadership.

Thank you !

Any questions?