# HTC accuracy and SMETERs

Cliff Elwell, Jez Wingfield, Frances Hollick
UCL Energy Institute,
Physical Characterisation of Buildings group

Department for Business, Energy & Industrial Strategy

Halton Housing

LEEDS BECKETT UNIVERSITY

UCL

Loughborough University

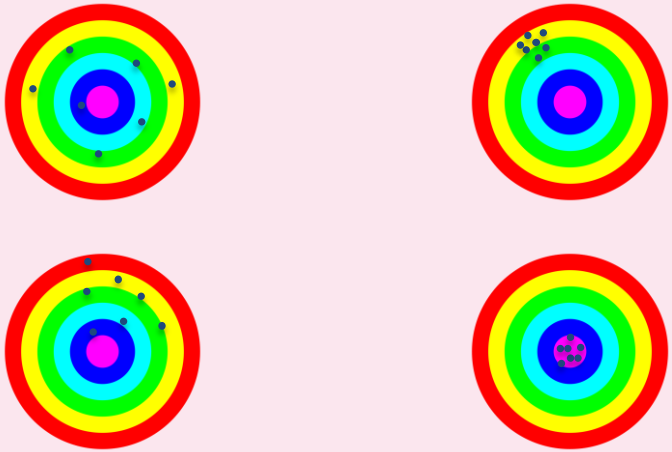
12th April, 2021

# HTC accuracy: requirements

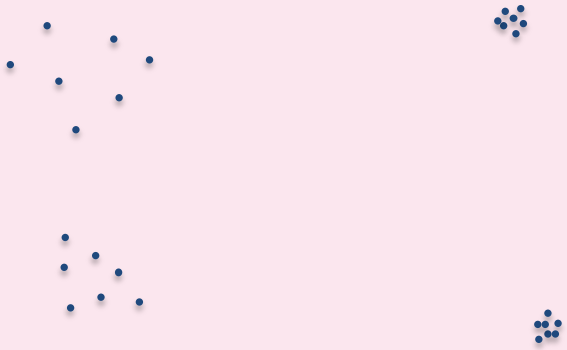
- What are the needs of SMETER estimated HTCs?
  - Guidance to homeowners
  - Assess performance of new build
  - Assess performance of retrofit
    - Link to metered energy savings
  - Policy evaluation and national strategy
- Performance of SMETERs to meet these needs?
  - Accuracy
  - Precision: repeatability and reproducibility
  - Error in an absolute HTC vs error in change of HTC

# Error on a measurement: hitting the target

- Accuracy: closeness between measurement and true value
- Precision: closeness of measurements to each other



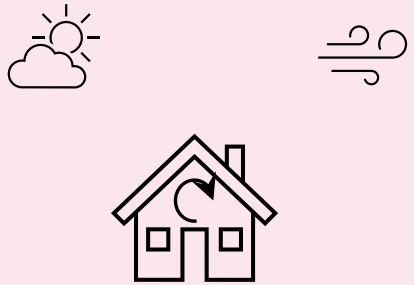
# Accuracy: the problem



What is the true value?

# Variation in HTC estimation

- HTC is defined variously… we use ISO 13789:2017.
  - Includes:
    - Transmission through the fabric.
    - Thermal bridging.
    - Infiltration and deliberate ventilation openings.
- Seasonal variation in estimated HTC:
  - Occupant practices.
  - Physical effects e.g. air flow in cavity, through leaks in the structure etc.
  - Inability to account for solar gains.
  - Ground temperature.

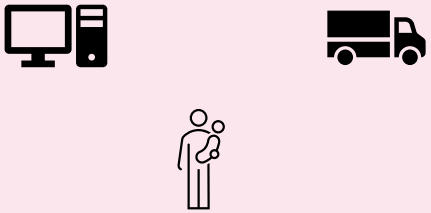


How much does HTC vary due to the weather/related effects?

How should this be mitigated?

# Variation in HTC

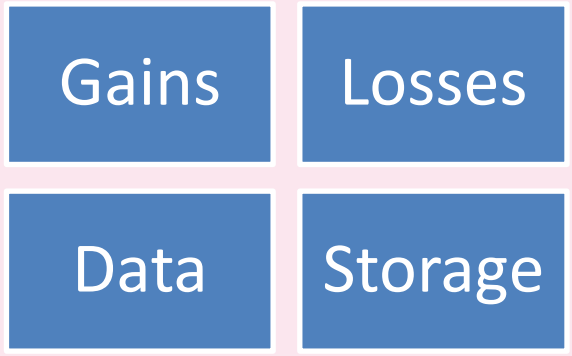
- Changes in circumstances/life events
  - Significant and potentially persistent changes to behaviour
  - E.g. heating more of the home to a high temperature
- Party element heat loss
  - Neighbours matter!



How much does estimated HTC vary due to such changes?

How should this be mitigated?

# Factors affecting SMETER accuracy




- Property efficiency and HTCs
  - High efficiency vs low efficiency property.
  - Importance of gains or DHW use.

Are SMETERs able to give acceptable estimates of HTC across the whole stock?

# SMETER accuracy: confounding gains

- Secondary non-metered heating sources
- Renewable generation consumed on-site e.g. PV
- Number of occupants
- Solar gains (including curtain and blind use)
- Gains from adjoining shared common spaces (e.g. hallways)

Limitations to SMETER application?

Additional information for additional accuracy?

# SMETER accuracy: confounding losses (?)

- Hot water use (drain losses)
- Losses from heating plant: inside or outside the envelope?
- Party elements: assumptions about neighbours' indoor temperatures
- Energy used outside the heated envelope e.g. garages, EV charging

Limitations to SMETER accuracy?

Additional information for additional accuracy?

# SMETER accuracy: data and measurement

- Dataset length vs seasonal (and other) effects
- For in-home monitored properties:
  - Where do we measure temperature? How many temps?
  - Part-heated homes… can you game the results?
- Remote-only SMETERs: accounting for any variation in internal temperature
- Heating and cooling plant performance
  - Heat metering for heat pumps
  - Efficiency of boilers
  - Air conditioning

Repeatability and reproducibility?

What are the limiters to robust HTC estimation?

Additional measurement/information?

# SMETER accuracy: storage

- Battery storage
- EVs and vehicle-to-grid (V2G)
- Thermal storage: fabric, tanks, stores

Is storage likely to significantly affect SMETER accuracy?

Additional measurement/information?

# Discussion questions

- What should be the accuracy requirements for thermal performance metrics, and how could these vary for different purposes?
- What is the likely variation in HTCs estimated by SMETERs over time, considering physical effects and occupant (or neighbours) behaviours? How can we mitigate this?
- What do you expect would be the other key sources of bias, and what needs to be done to address them?

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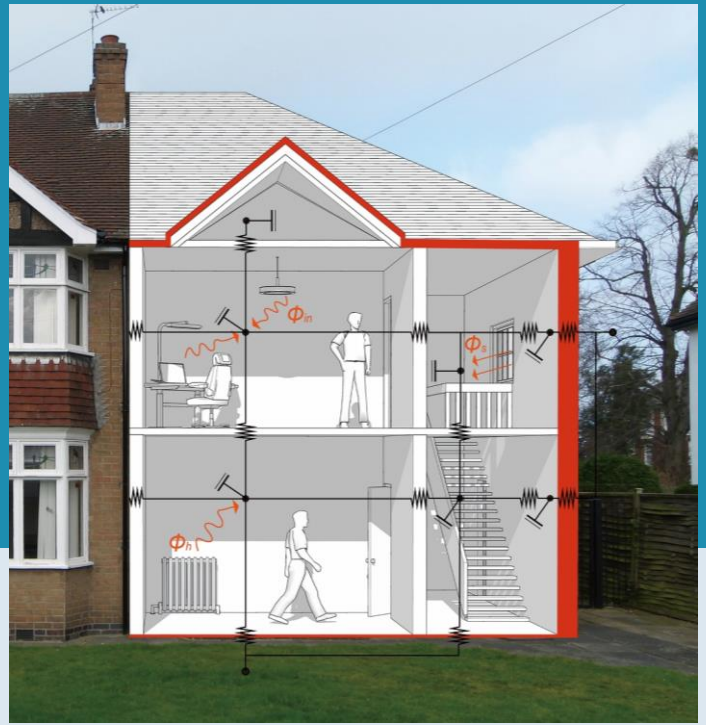
# On the accuracy of in-use HLC assessment

## SMETER workshop
12 April 2021

Prof. Staf Roels
Building Physics and Sustainable Design
KU Leuven, Belgium




*Drawing of Xiang Zhang (KU Leuven, Belgium) on a picture of the Loughborough test houses (Loughborough Univerisity).*

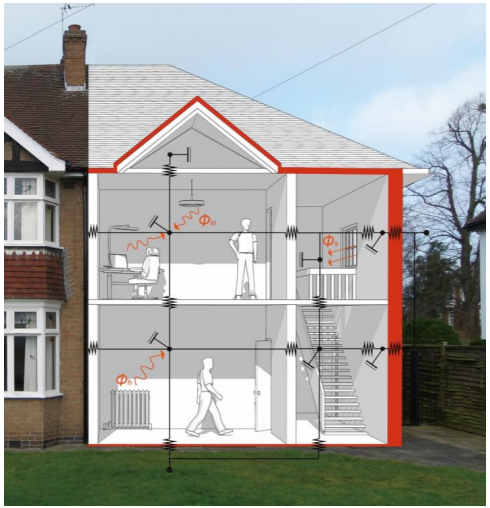
We are trying to determine a simple metric
from a complex dynamic heat balance equation

$$C_i \frac{\partial \theta_i}{\partial t} = \Phi_h + \Phi_{int} + \Phi_{sol} + \Phi_l + \Phi_{tr} + \Phi_v + \Phi_m$$

HTC

EBC Energy in Buildings and Communities Programme Annex 71

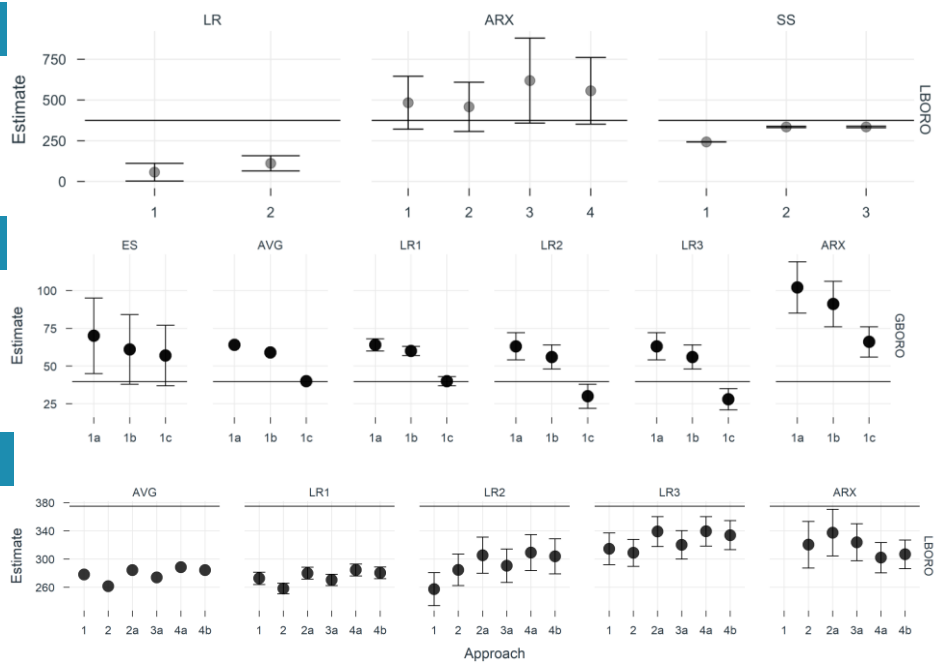
IEA EBC Annex 71, ST3: investigate impact of different input parameters



solar gains

heat input

temperature



# Requested accuracy will depend on the use case (e.g. quality assurance vs. estimate for renovation measures)

EBC Energy in Buildings and Communities Programme Annex 71

decision matrix

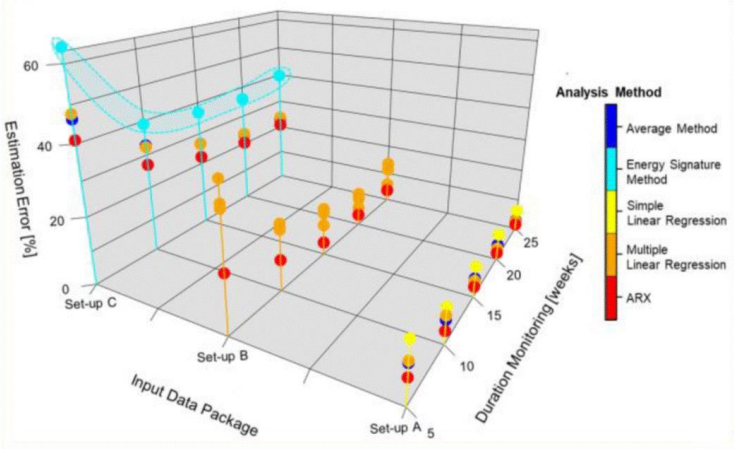
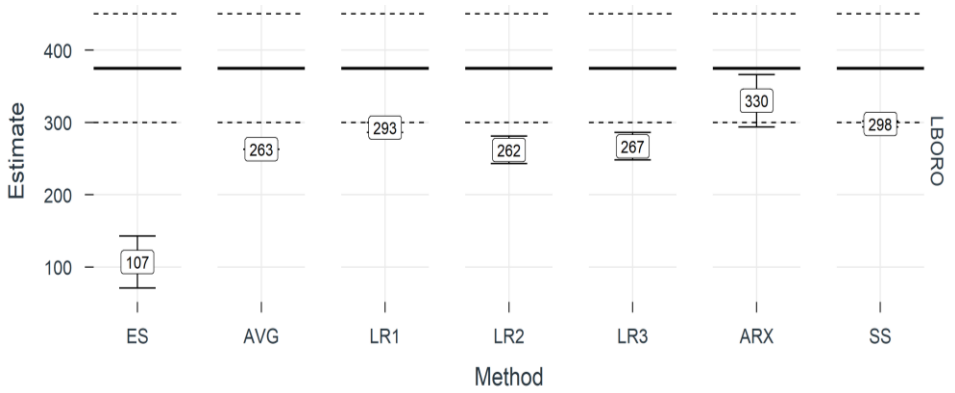



*Figure: Marieline Senave, KU Leuven*

estimation error versus statistical accuracy




no overlap of statistically predicted accuracy for different methods ?

SMARTHTC

# HTC Measurement and Repeatability

Dr Richard Jack

Build Test Solutions

BUILD TEST SOLUTIONS

SMARTHTC

# Cloud hosted HTC calculation algorithm

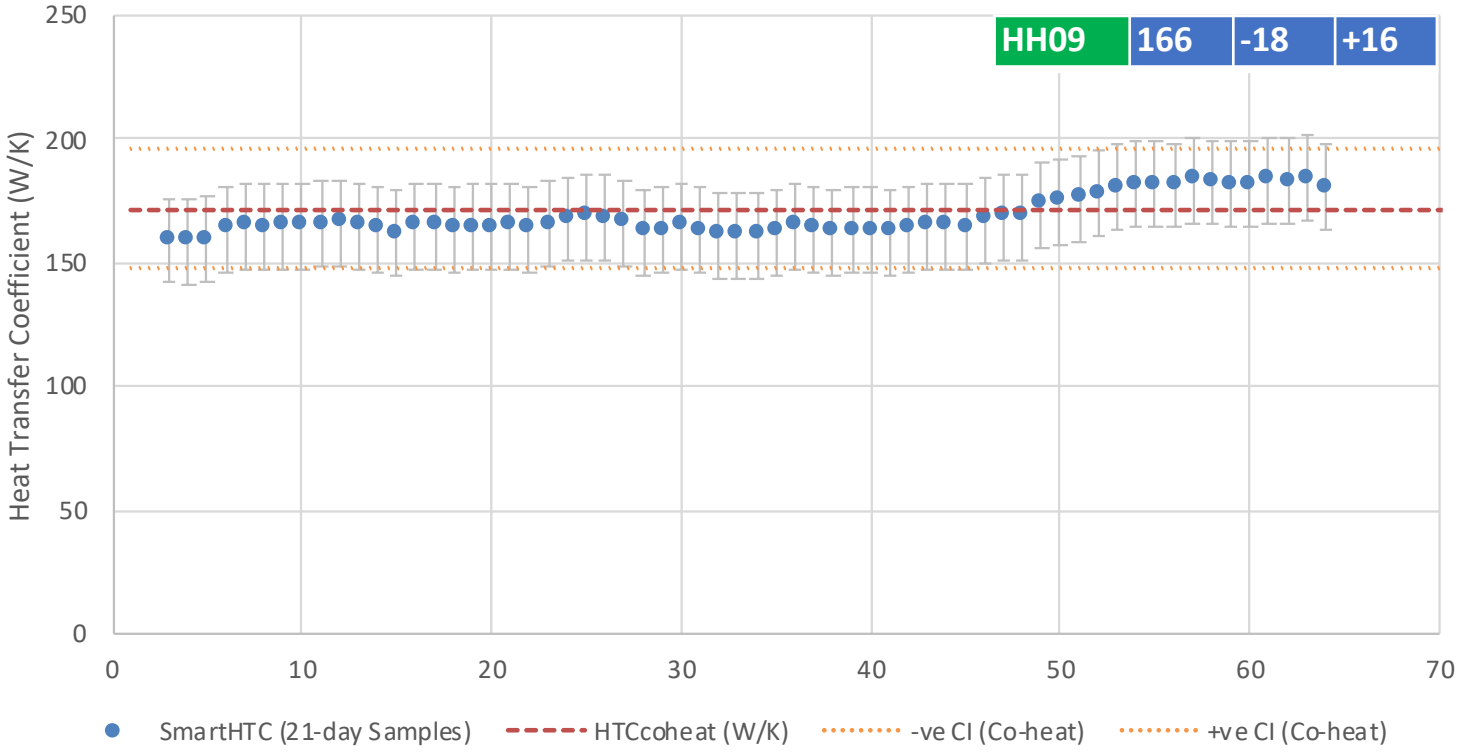
Required inputs:

- Floor area & location
- Minimum 21 days temperature monitoring
- Energy consumption for period – smart meter or dumb
- Optional extra info for more precise calculation.

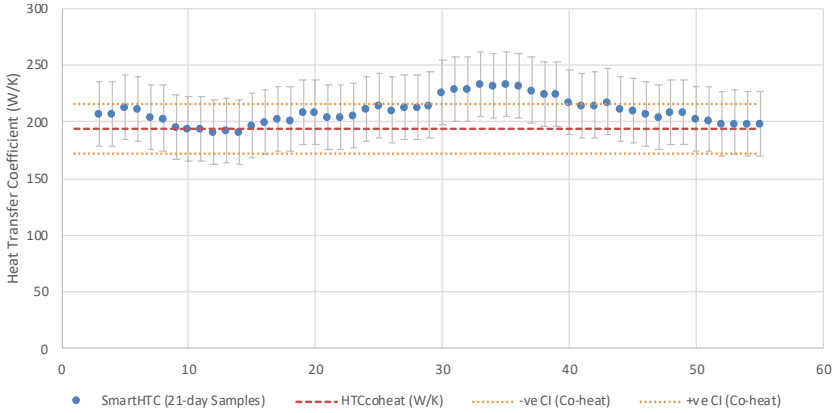
>500 HTC measurements so far

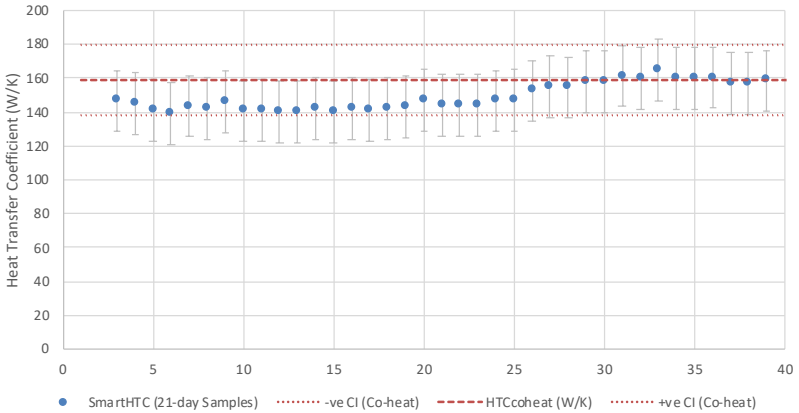
Additional mould & condensation risk indicator in validation

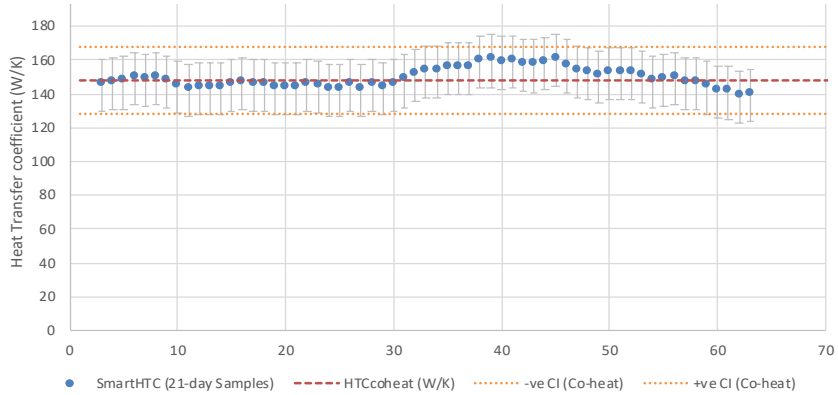
# Repeatability

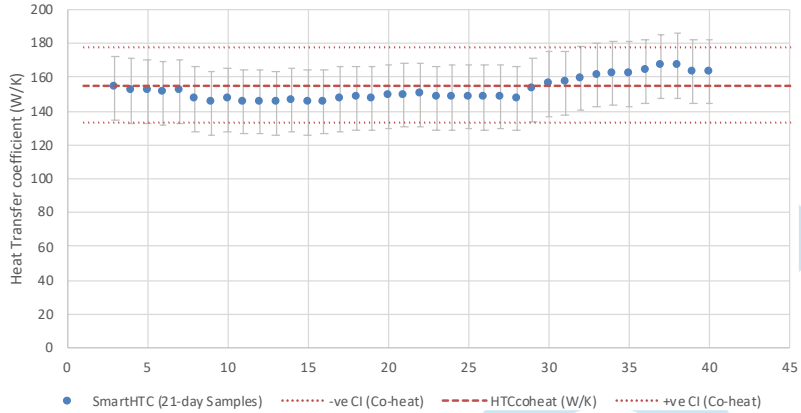


# Repeatability

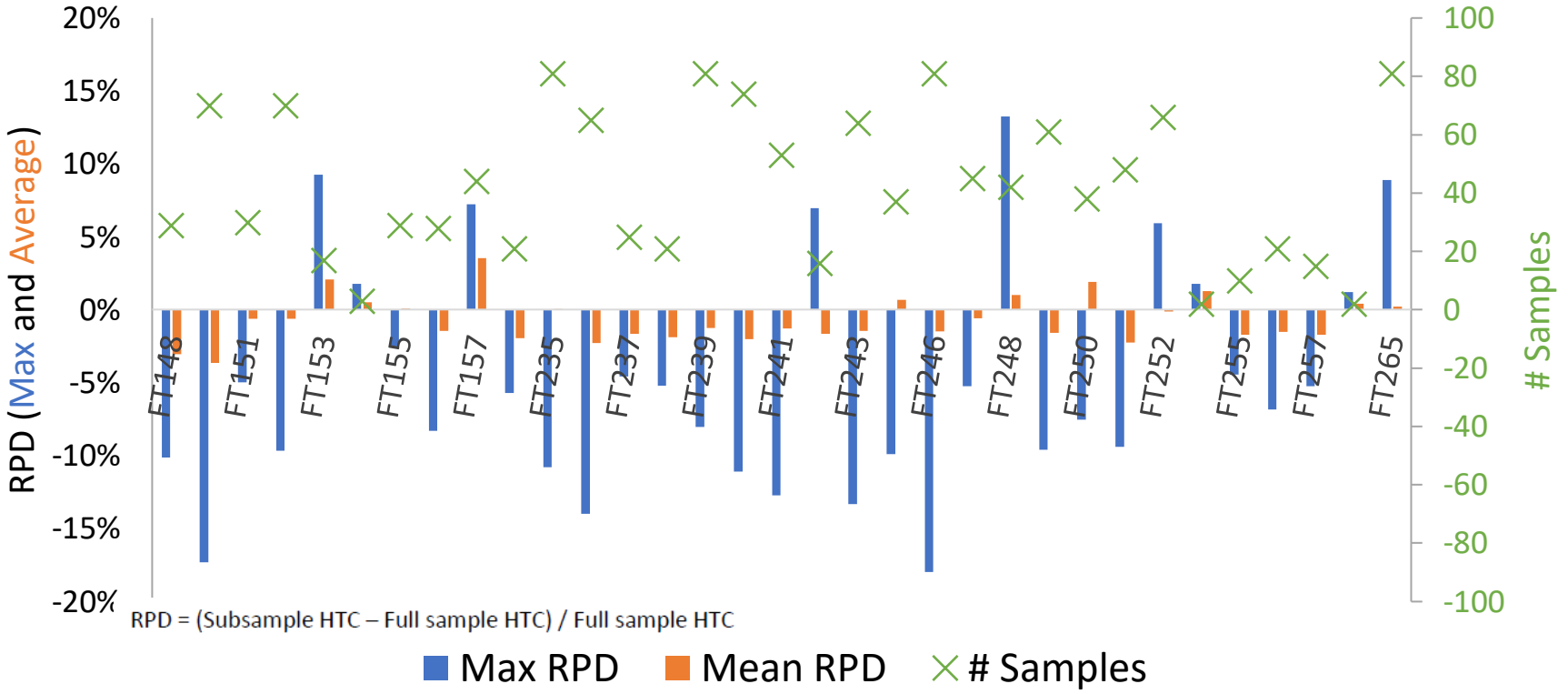


# Repeatability




- 1370 samples, all within CI of full sample SmartHTC
- 704 samples with coheat baseline, 99% within CI of coheat result

# Repeatability

- Measure of the success of HTC measurement
- Expect some variation
  - Real variation in HTC?
  - Imperfect accounting for weather, occupancy & systems
- Subsample measurements should be within confidence internal of full sample result

# HONEYWELL EVOHOME VS. AEOTEC ZIPATO SENSORS

## Honeywell Evohome TRVs

- Manage room temperatures by opening/closing the radiator valves, with a boiler interlock. Effectively zone control.

## Aeotec Multisensor (Zipato)

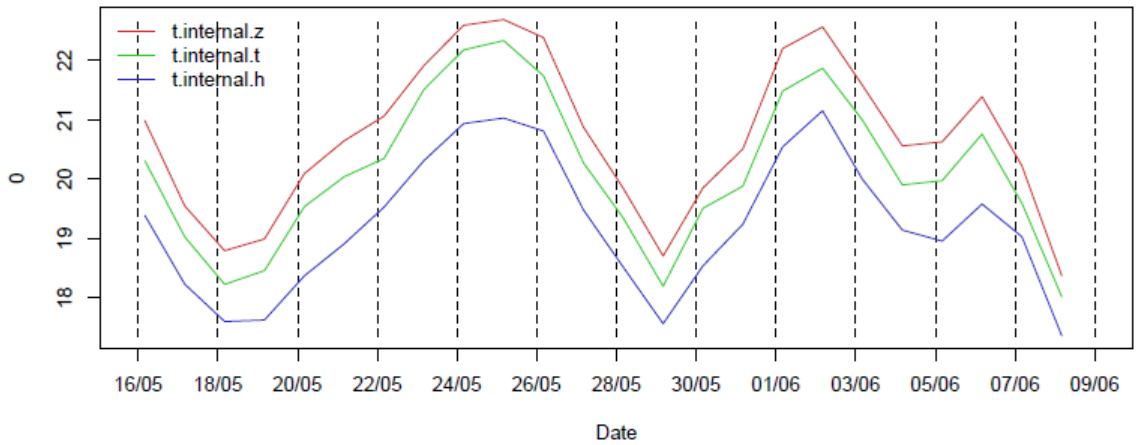
- Monitors temperature, humidity, light, motion, vibration and ultraviolet. Battery powered, linked to hub.

CAR Cambridge Architectural Research

Simble

# COMPARING TEMPERATURE READINGS (DAILY AVERAGE)

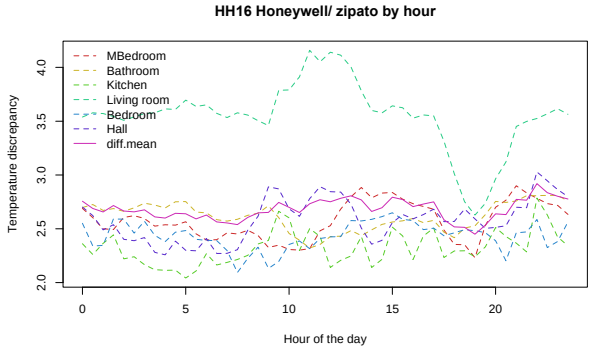
- Comparison of daily average temperatures reported by Tiny tags, Honeywell thermostats and Zipato multi-sensors
  - Honeywell sensors on radiators
  - Zipato sensors positioned following our instructions
- Zipato is consistently high, Honeywell low
- Over a sample of 10 homes, the difference between Zipato and Honeywell is 1.6°C

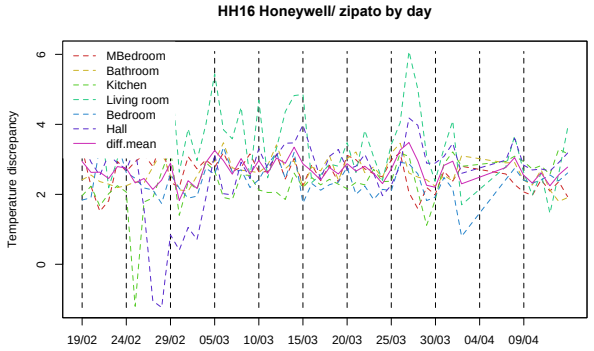


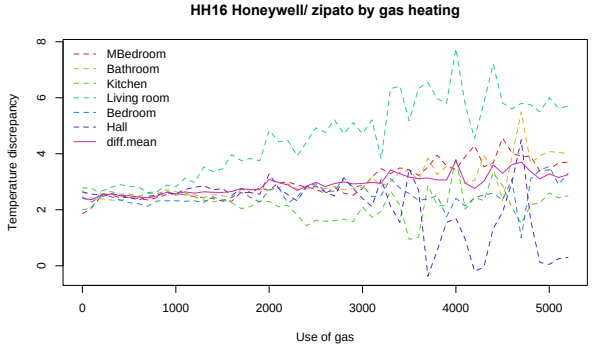
# COMPARING TEMPERATURE READINGS

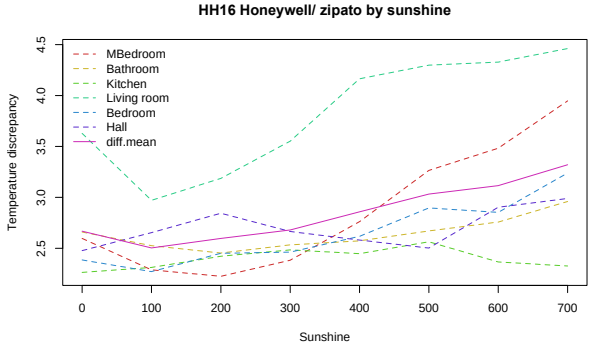
- Compared Honeywell and Zipato in 10 homes
  - Mean difference between 0.6 and 2.7°C
- Highly variable between rooms and over time – often influenced by sunshine or heating
- Averaging between rooms reduces variability

Gas and sunshine charts use lag with half life two hours



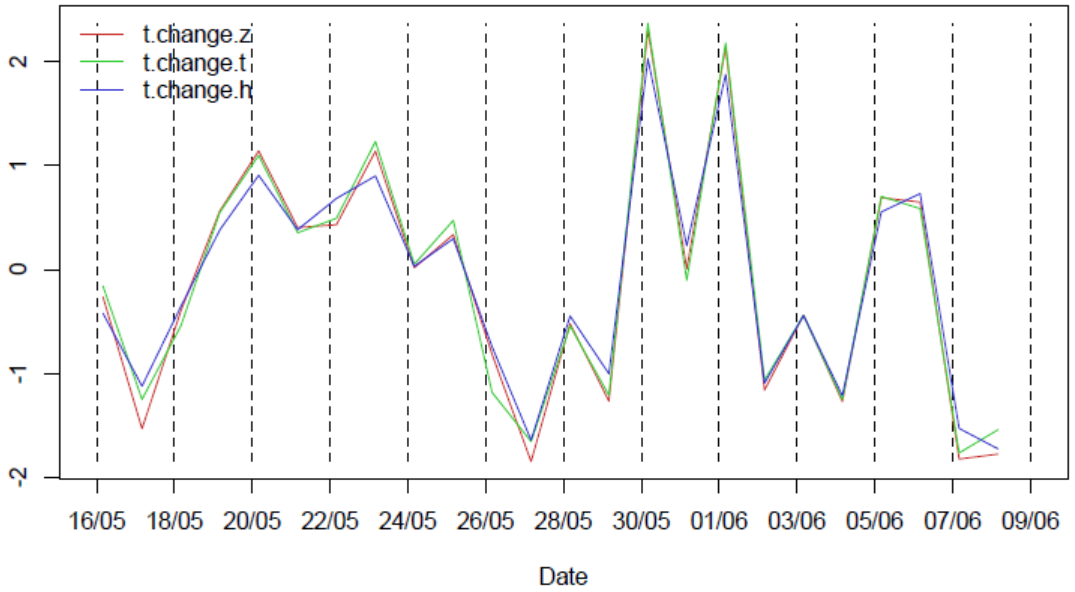



# ALGORITHMS – MINOR IMPACT

- The most sensitive parameter is the change in temperature between the start of one day to the next.
  - A proxy for thermal mass
- Changes are small and thermostat resolution is low (0.5°C)
  - Use average over a few readings to improve resolution
- No bias!

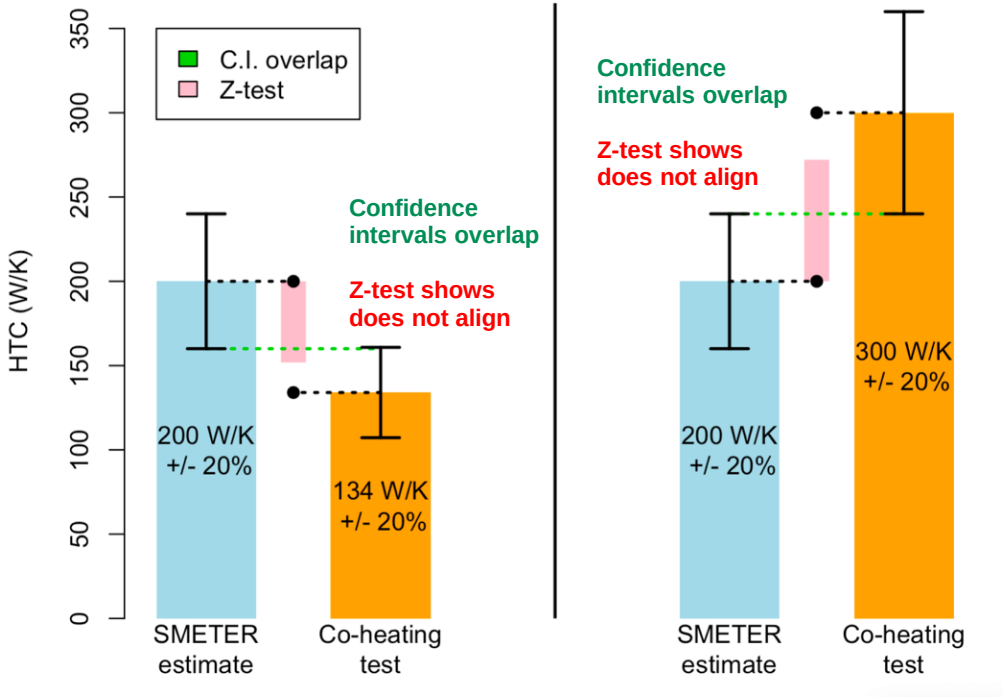


# SMETER Workshop

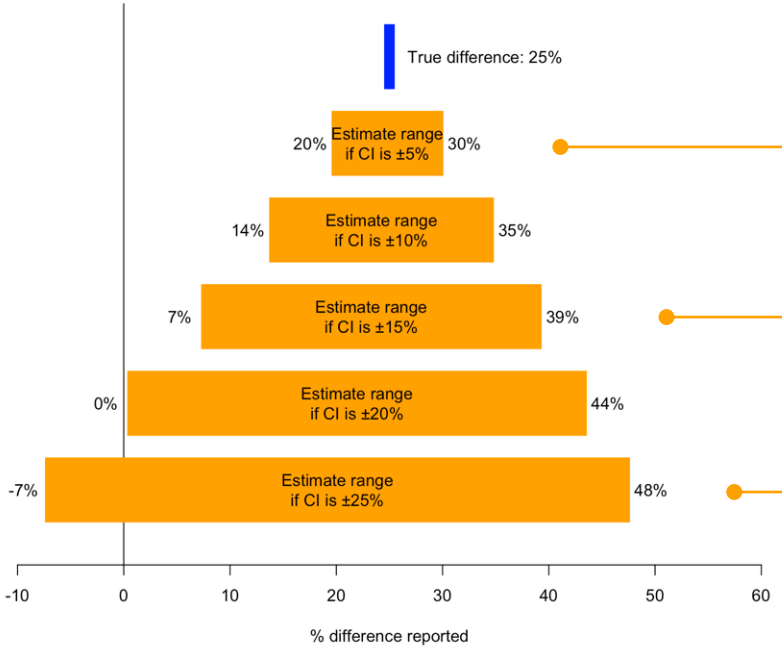
**Martin WARD, Head of Data Science**

# 1 Overlapping Confidence Intervals vs Z-test

- The most appropriate test for comparing two estimates with known confidence intervals is the standard statistical test known as the **"Z-test"**.
  - This is more statistically robust than testing whether the confidence intervals overlap.
- In this example – the Z-test is failed – showing that these estimates are not statistically aligned, even though the confidence intervals overlap.
  - The estimate of 200 W/K has overlapping confidence intervals with both a co-heating result of 134 W/K and a co-heating result of 300 W/K - or anywhere in between.
  - Even though 300 W/K is ~2.4x higher than 134 W/K - this result shows how wide the region of acceptance is for this test method



# 2 Accuracy requirements for a SMETER that can hold supply chains to account on fabric performance




**If a 25% improvement were made to a house, and a SMART HTC were taken before and after...**

A SMETER with a ±5% CI could report between 20%-30% improvement.
→ **Accurate enough to determine if the retrofit has been a success**

A SMETER with a ±15% CI could report anywhere between 7% and 39% improvement.
→ **Cannot distinguish between a very successful retrofit or a failure**

A SMETER with a ±25% CI could report anywhere between 7% worse and 48% improvement.
→ **Does not provide actionable insight**

**A SMART HTC with typical confidence intervals above 10% CANNOT:**

- **reliably distinguish between a successful retrofit and an unsuccessful retrofit**
- **hold supply chains to account on fabric performance**
- **detect poor workmanship on new-build houses.**

# SMETER Market Development: introduction

## Market development, data access and communications requirements

20 April, 2021

Department for Business, Energy & Industrial Strategy

# Scope of questions for this session

- **Commercial drivers and barriers** to the roll-out of SMETER measurements
- Potential **customer propositions** involving the installation of SMETER technology – e.g. links to new build, smart thermostats or smart metering equipment – and involvement of consumers and other stakeholders
- SMETER **data system design** – alternative configurations for connecting sensors (where required), accessing smart metering data, backhauling data and calculating HTC values
- Potential **additional sensor requirements** (e.g. heat metering of heat pumps, humidity)
- Risks and unintended consequences

# Summary of TEST stakeholder slides

| Activity | What other organisations should become involved? |
|---|---|
| Data supply | DCC, 3rd party data providers, energy suppliers, Ofgem, Public Interest Advisory Group |
| Testing (field) and tool use | Social housing providers, housing developers, Test Houses |
| Quality control | BRE or NPL |
| Policy | DCLG/policy makers, Local Authorities, inspectors, planners |
| Consumers / customers | Customer groups, marketing expertise, financiers |
| Manufacturers/products | SMETER product developers; makers of heat pumps, thermal-related building products |
| Further sources of funding | BEIS; IEA EBC Annex; Innovate UK; EPSRC; MHCLG |

# Smart Metering Implementation Programme update

Department for Business, Energy & Industrial Strategy

Official Statistics end Dec 2020

**23.6m** smart & advanced meters in GB homes and small businesses

**19.1m** were smart meters operating in smart mode or advanced meters

**15.7m** are SMETS1
**6.7m** are SMETS2
**1.3m** advanced

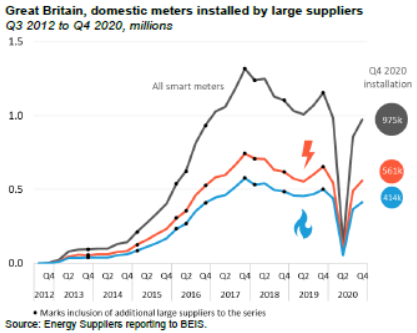
Data Communications Company

As at 18 March 2021

**10.8m** smart meters connected to the national secure network

**7m**
SMETS2 meters on the network

**3.8m**
SMETS1 meters migrated




Installations are recovering from the impact of COVID-19 pandemic.

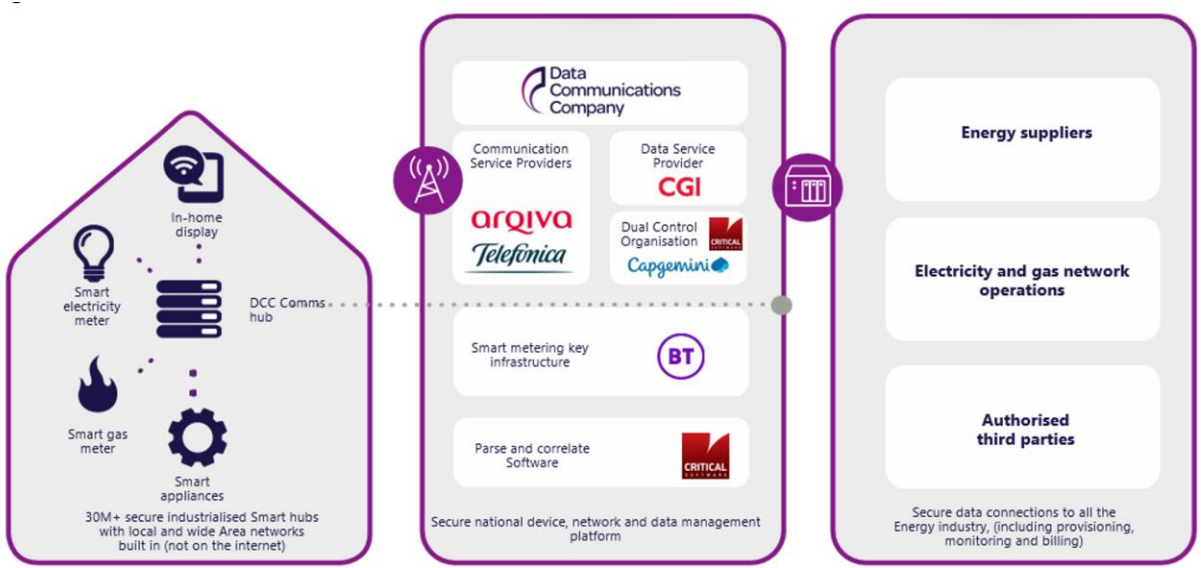
Policy framework is changing from 1 July 2021 from an All Reasonable Steps regime to a target regime to drive installation rates by energy suppliers.




Department for Business, Energy & Industrial Strategy

# Smart Metering System

- 99.3% of GB domestic and smaller non domestic premises covered



# Data access

- Via DCC
  - 13 months HH consumption and tariff information
  - Can be accessed by “Other User” with consumer consent
    - Some Other Users offer a proxy service to allow consumer and companies to access data
  - Response time can be ~minutes, depends on amount of data requested
  - This route not designed for frequent data requests (eg every few seconds etc)
- Via SMHAN
  - SMHAN (ZigBee) provides connectivity between devices
  - “Consumer Access Device” (CAD, aka Type 2) needs to be ZigBee Smart Energy Certified
    - No formal definition of CAD, most CADs tend to be internet gateways
    - SMETS and GBCS set out data available
  - CAD can be paired (with consumer content) by Energy Supplier and Other User
    - Various options exist, but in some cases a consumer may need to provide the “Install Code” that comes with the device
  - Same data available as DCC route, but in addition a consumption value for electricity can be requested every 10 seconds


Department for Business, Energy & Industrial Strategy

# Useful links

- Becoming a DCC User
  - https://www.smartdcc.co.uk/customer-hub/becoming-a-dcc-user/
  - https://smartenergycodecompany.co.uk/becoming-a-dcc-user/

- Becoming a SEC Party - https://smartenergycodecompany.co.uk/becoming-a-sec-party/

- SMETS and GBCS - https://smartenergycodecompany.co.uk/the-smart-energy-code-2/

- CAD guidance - https://smartenergycodecompany.co.uk/design-notes/

- Data access using smart meters - https://www.gov.uk/government/publications/smart-meters-smart-data-smart-growth




Department for Business, Energy & Industrial Strategy

# Questions:

- What specific aspects of implementing in use thermal performance metrics could build on the smart metering rollout?
- How more generally should market development be encouraged?
- How could consumers be involved in implementing in use thermal performance metrics, in order to achieve the greatest uptake and impact? How could other stakeholders (e.g. landlords) be best involved?
- What risks or unintended consequences should Government consider in seeking to develop the market in this area?

# Measured Energy Performance

Martyn Reed - Managing Director

elmhurst energy | EXCELLENCE IN ENERGY ASSESSMENT

# Measured Energy Performance

*Elmhurst use SmartHTC* to calculate the Heat Transfer Coefficient– a metric calculated in SAP;

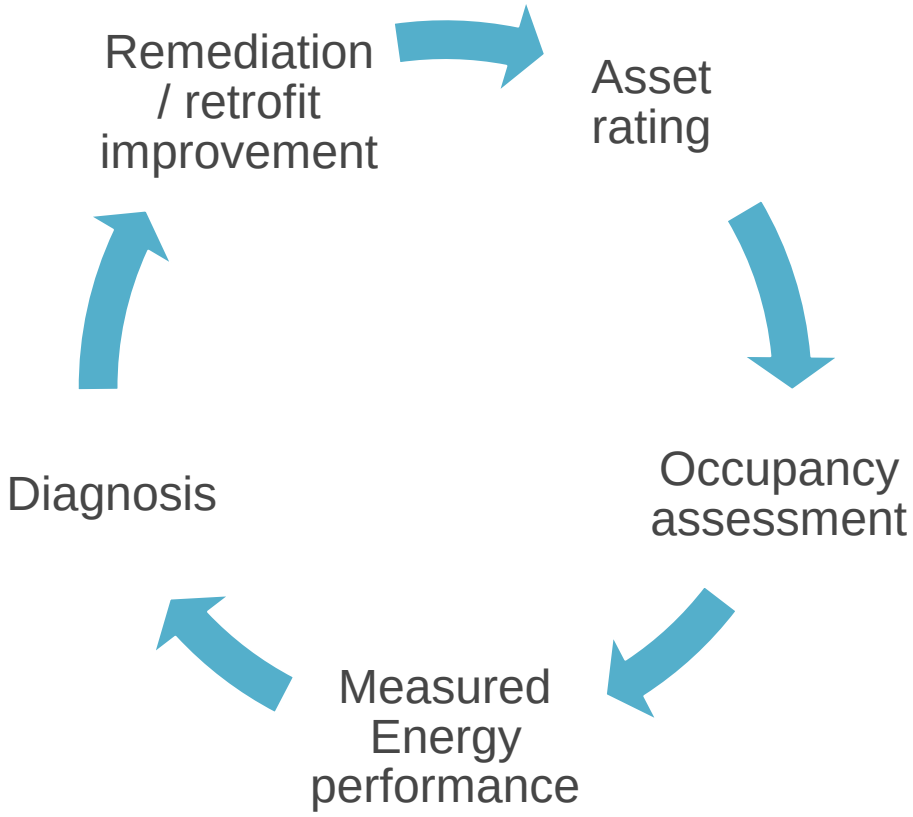
1. Using SAP data or our RdSAP to SAP convertor existing data can be used
2. A modified a version of DesignSAP is uses the measured HTC to overrule the calculated HTC and present it as a SAP Score / band rating
3. Presented as a *Measured Energy Report* in EPC style format

Delivered 70 assessments with over 250 in progress;

- Developers
- Product manufacturers
- Retrofit delivery
- Building owners

elmhurst energy | EXCELLENCE IN ENERGY ASSESSMENT

# Improvement loop



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# Issues and opportunities

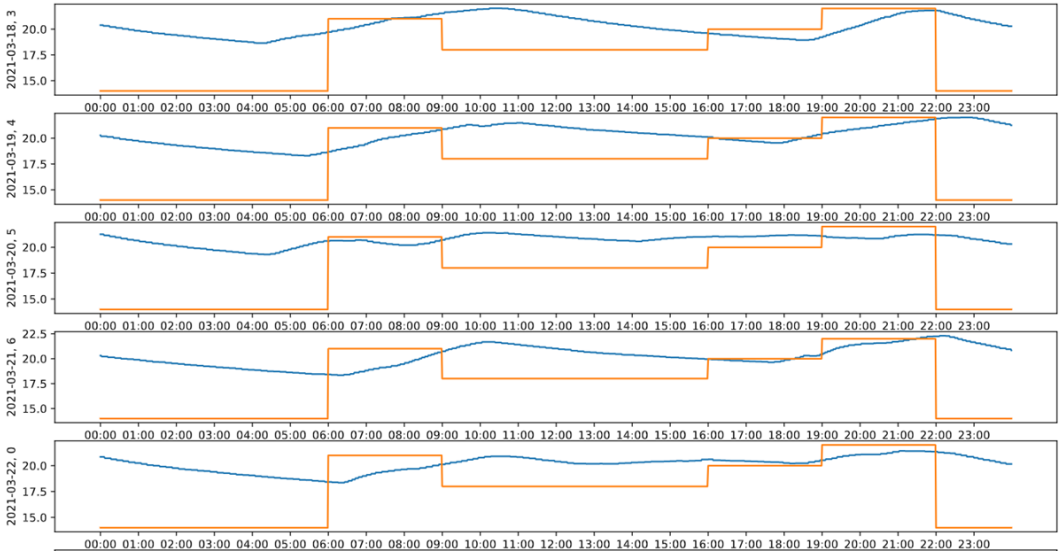
- Issues
  - Speed of roll out of smart meters
  - Access to Smart meter data
  - Awareness of  HTC
- Opportunities
  - Develop a real time feed to the EPC register to empower consumer with actual performance levels
  - Make actual performance levels available as Open Data
  - Make developers accountable with mandated monitoring
  - Consider warranty insurance products

## Data capture

- General data transfer from smart thermostats
- Incorporate temp sensing into cloud connected IHD/PPMID
- Add ZigBee based temp sensors to HAN – requires IHD/PPMID to be cloud connected

## Market evolution

- Around 15% homes fitted with some form of smart thermostat (85% not)
- Around 40% homes fitted with smart meters today – replacement of IHD/PPMID lower cost than adding standalone sensors
- Increased recognition of data value but low propensity by Retailers to pay for non-mandated features



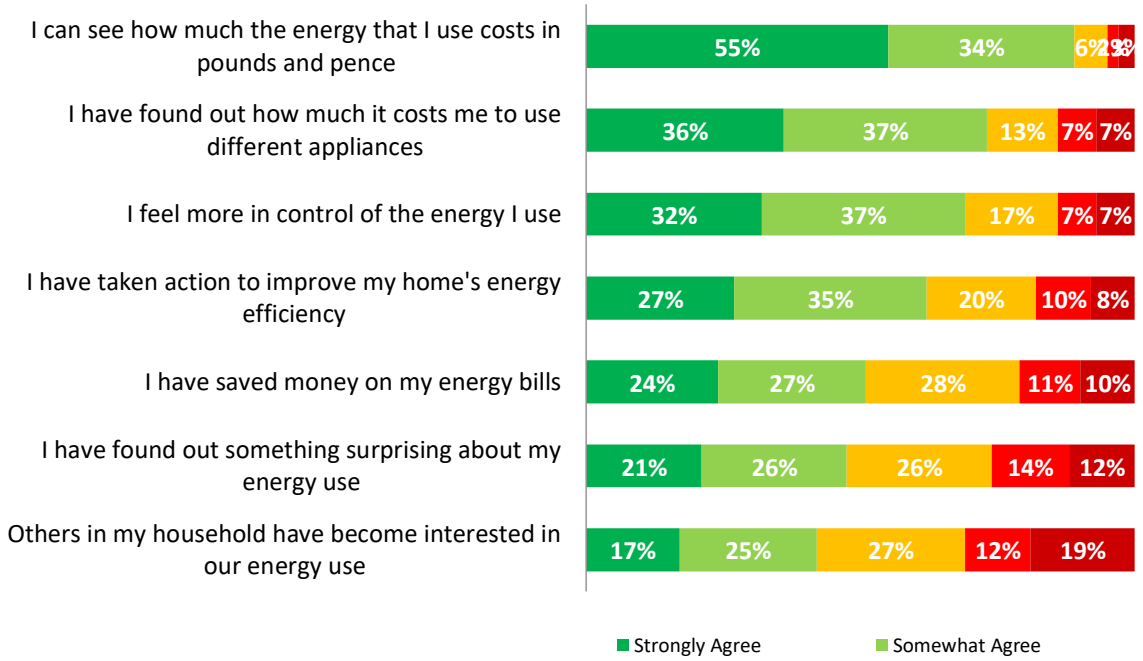
## Options for market uptake

- Change IHD/PPMID mandate
- Incorporate as ingredient to ECO obligations/GHG replacement
- Mandate as part of EPC compilation
- Incorporate into smart controls ratings

## Consumer engagement

- Presentation of deductions key
- Must offer actionable insight
- Potential home analysis report
- Insignificant as standalone metric

## Since having an IHD installed:



European Union
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# Zero Contact Monitoring for Efficient and Healthy Homes

Dr Richard Fitton
Reader in Energy Performance of Buildings

Applied Buildings and Energy Research Group

European Union
European Regional Development Fund

University of Salford MANCHESTER

# Zero Contact Monitoring for Efficient and Healthy Homes

## Background

- Smart meters installations are rising quickly and will be back on track following COVID
- COVID is present and will be an issue for a number of years
- People are not willing/able to allow access to add research or new innovations to be installed
- **However work in this area must continue**

European Union
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# Zero Contact Monitoring for Efficient and Healthy Homes


Smart energy data is great, but it is even greater with some additional sensors.


- We propose the connection of additional sensors that will operate on the existing smart meter infrastructure. (Estimated to cost over £13 billion gross over 20 years to 2034)
- We believe that to use this infrastructure will present value for money for government backed research and innovation of new products.
- Positive story for smart meters

European Union
European Regional Development Fund

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# Zero Contact Monitoring for Efficient and Healthy Homes

Let's see what we can do when we add sensors:

**First of all:**

We have already done some of this:

- Working with the DCC, we have got R and Temp sensors already talking to smart meters and backhauling data
- This was done at UoS smart meter lab with DCC.
- Currently running on GFI

European Union
European Regional Development Fund

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# Zero Contact Monitoring for Efficient and Healthy Homes

How do we do this????

**This is what we are aiming for:**

Hi, I would like to be in your trial

Just sign up online

We will pair your devices to your smart meter

Arrives through post

Stick on wall

All done !

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# Zero Contact Monitoring for Efficient and Healthy Homes

## How do we get there ?

- Provide a zero contact, zero setup solution to remote sensing of energy and internal environments.
- Works on **all** platforms
  - SMETS 1
  - SMETS 2
  - Alt HAN
  - Next gen
- This will be in the form of a “postable” box with pre-paired sensors which the occupant can simply place about their home, sign up to through an online portal with a mobile , with a long battery life.
- These sensors should be of a value that allows for them to be recycled or disposed of at the end of a project or their life (say 10 years)

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# Zero Contact Monitoring for Efficient and Healthy Homes

## Work Packages

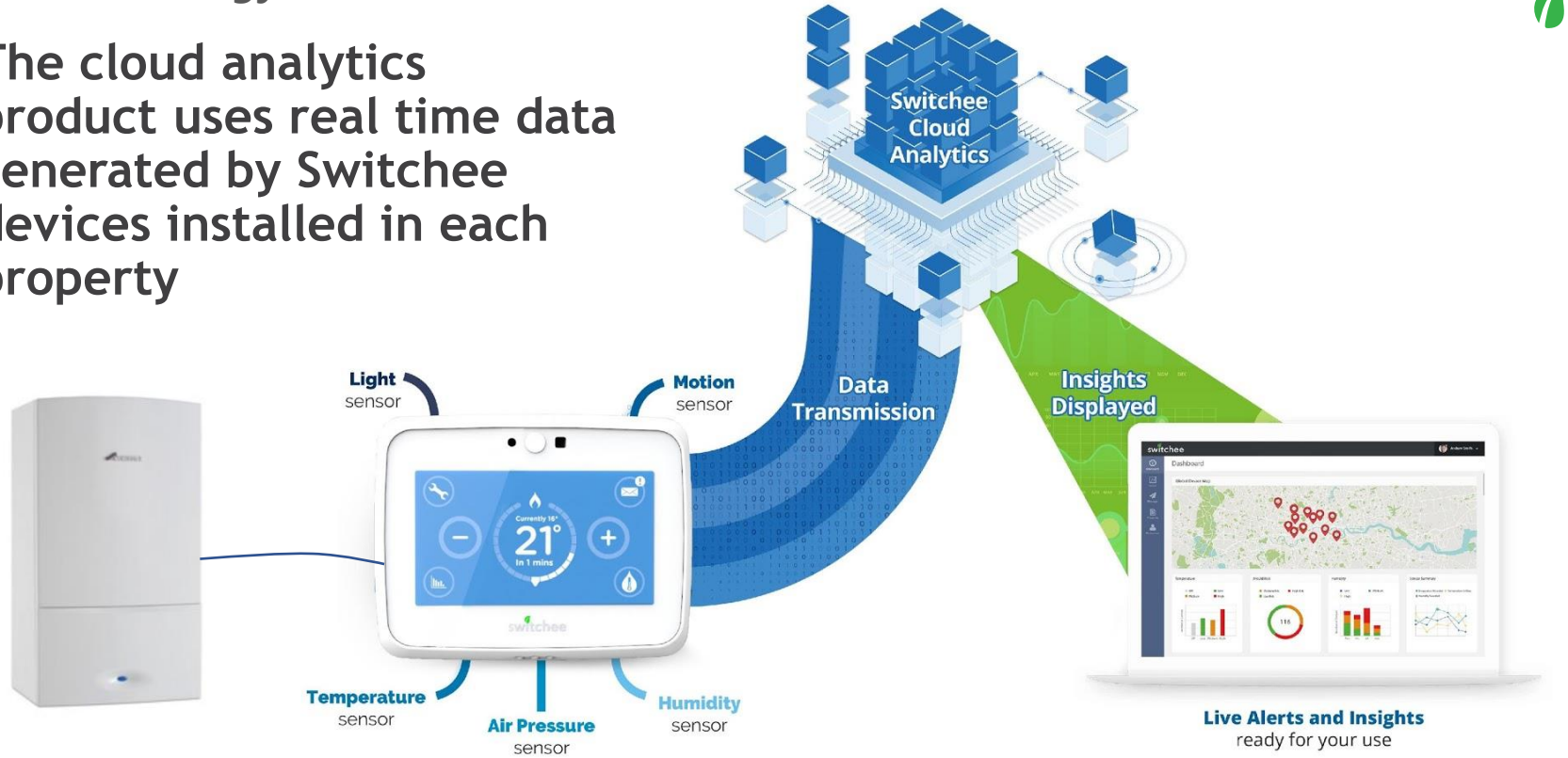
**Data Platform and API Development**

a. Review of technology – sensors etc and cost/benefit analysis
b. A field trial of 10-20 homes with GFI enabled equipment will be used to "soak test" the equipment to understand how robust the sensors are
c. The sensors will be developed including having security approvals etc to be pre-paired to live smart meters and to have data backhauled through the DCC architecture to a central data bucket, such as Amazon Web Services (AWS)
d. This trial will examine the performance of the sensor system and backhaul network across the UK using a large field trial sample of around 200 homes, data will be open sourced so researchers can use this or innovators.
e. API can be developed for developers, researchers and innovators,

- Want to be involved? R.fitton@Salford.ac.uk

## Our Technology

# The cloud analytics product uses real time data generated by Switchee devices installed in each property




Switchee smart thermostat control the heating, collects environmental data and displays on-screen messages & resident responses

# Validation

## SMETER Workshop

Professor Chris Gorse - Leeds Beckett University

Department for Business, Energy & Industrial Strategy

Halton Housing

LBU LEEDS BECKETT UNIVERSITY

UCL

Loughborough University

# Metrics Business Functions

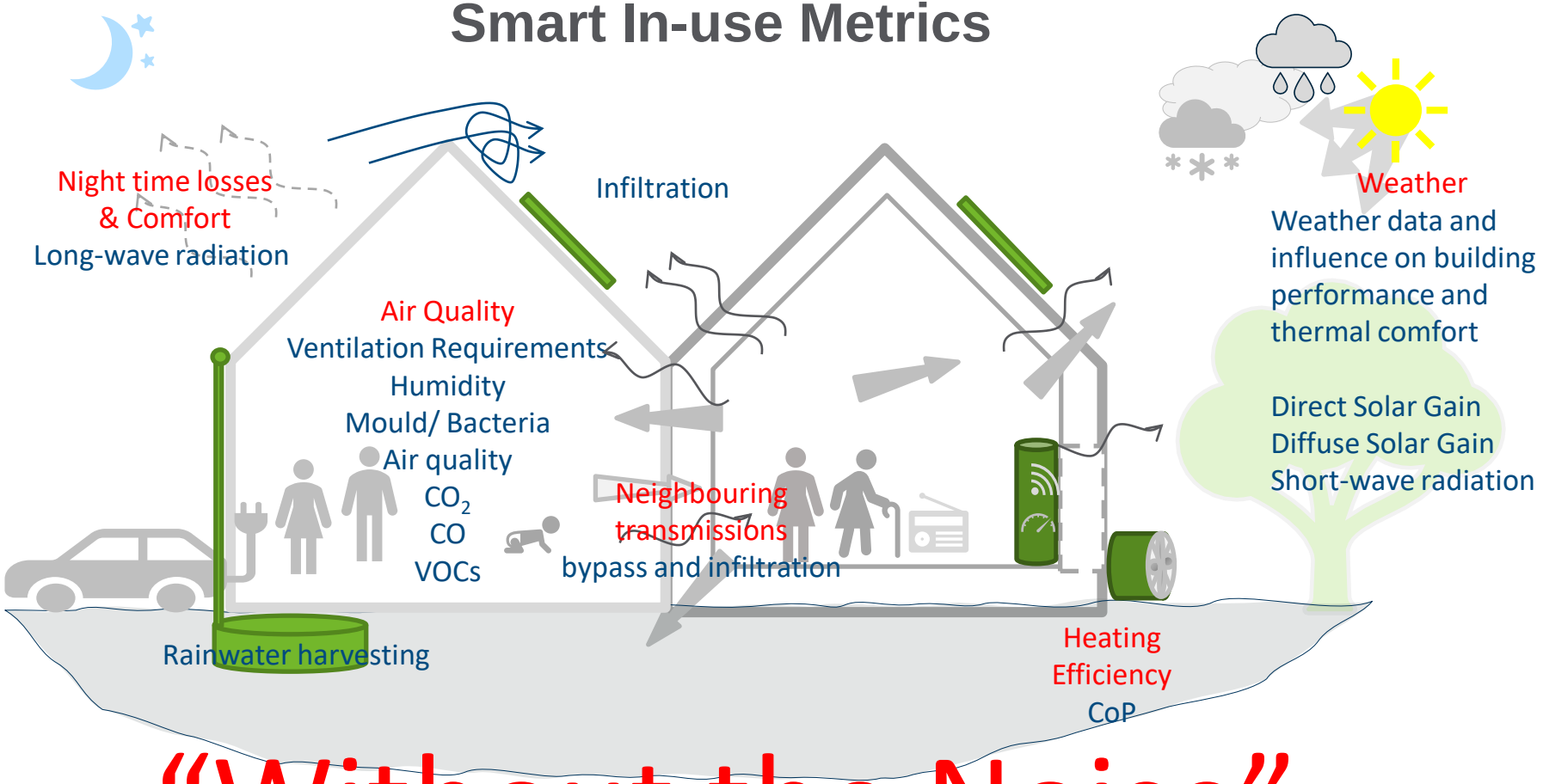
Quantitative assessment for comparing, and tracking performance or production

Distinct from data, which are inputs to such assessment.

Metrics for net zero buildings (and other aspects of net zero) can serve a number of functions:

- **Diagnostics**
- **Public and private information**
- **Performance – ROI and Penalties**

# Smart In-use Metrics

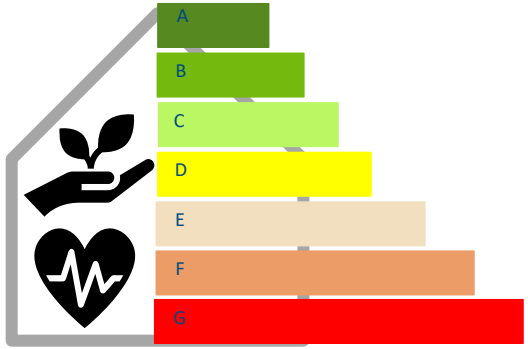



# "Without the Noise"

# Reliable

Building Performance Assessment

## Comfortable and energy efficient



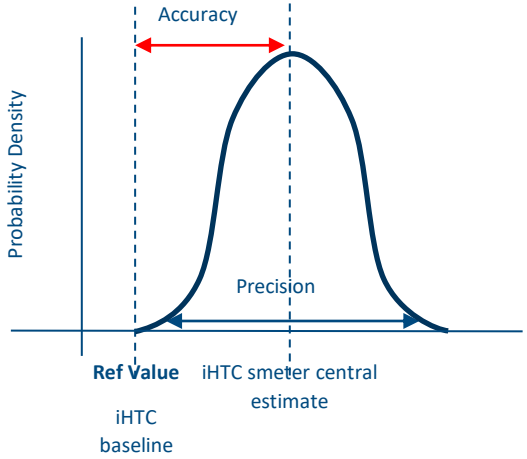

### Healthy Homes

- Safe & Secure
- No Damp, No Penalties
- No Consequences (emissions or otherwise)

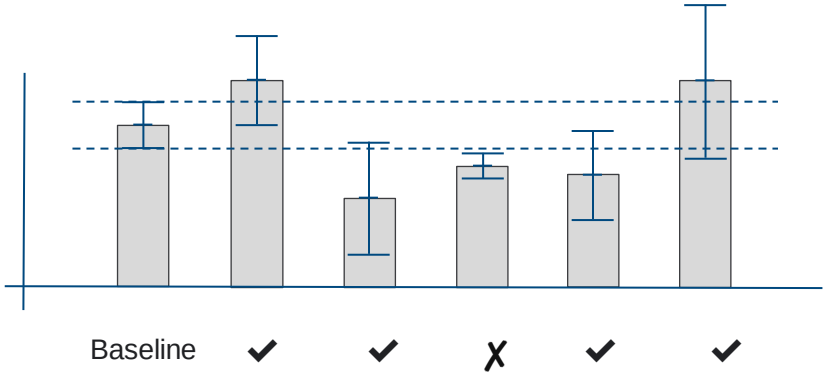
# Valid

Are measurements what they claim

- Validity
  - Self validation and control
  - Valid measurement and Certification
- Product – user and business requirements
  - **Fit for purpose,** Reliable and Acceptable
- Dimensions of validation
  - Accuracy - closeness to the underlying reference value
  - Consistency / repeatability over time and within different products

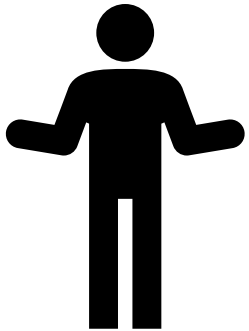


# Trusted EE Metrics
# iHTC

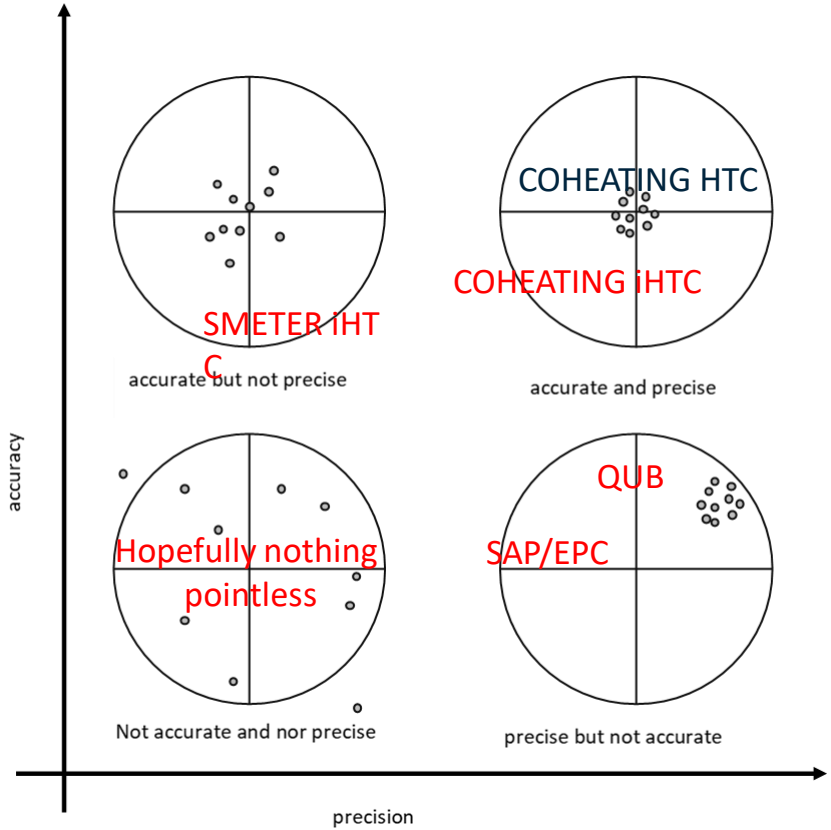


# Reliability Precision and Accuracy

Smeter direction of travel encouraging



So what?

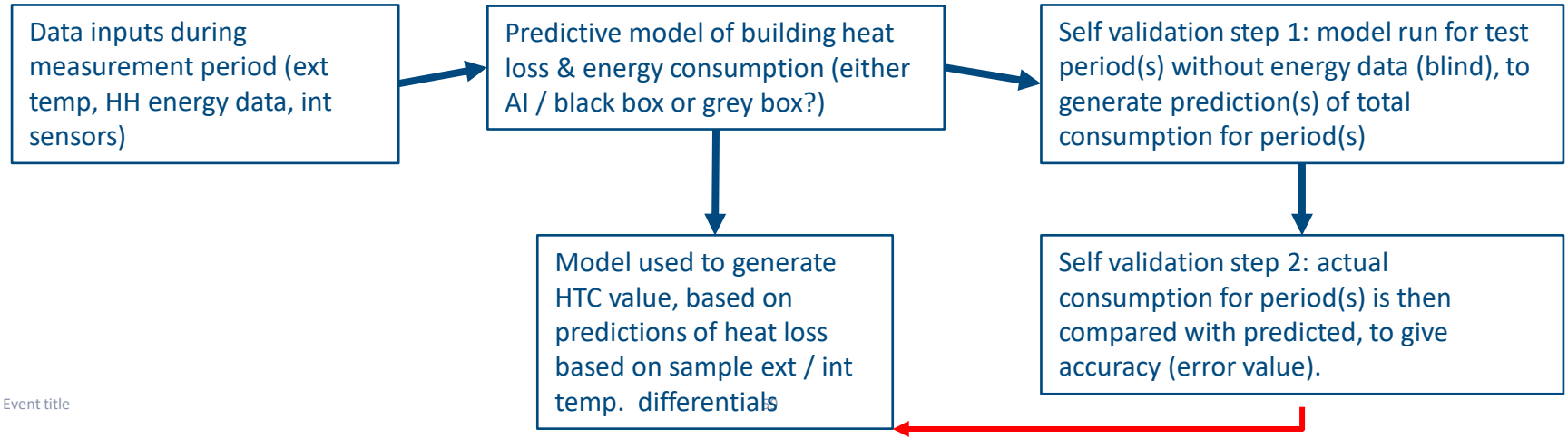


# Approaches to validation/1

- Smeter and iHTC: estimations of in-use HTC
- QUB and coheating: fabric orientated to derive HTC
- iHTC of a property varies with conditions and not consider a ‘true value’.
- Combination of approaches considered:
  - **Internal validation** consistency and repeatability
  - **External validation** systematic agreement against HTC for a range of conditions.

# Potential approaches to validation/2

- Comparisons of in-use HTC measurements with representative sample of **physical measurements** (CH test, QUB, Heatflux mix = iHTC)
- Assessment of repeatability - iHTC measurements over time
- Cross-validation between different measurement methods in-use and potential Self-validation



# Questions

- What requirements would a system of validation need to meet?
- What specific approaches do you think should be included?
- How could a validation system be delivered in practice?
- Do you agree that one objective of a central validation system, to approve / authorise in-use HTC measurement methods, for different purposes, should be to deliver increasing accuracy over time?

# Building Performance Evaluation – a new British Standard

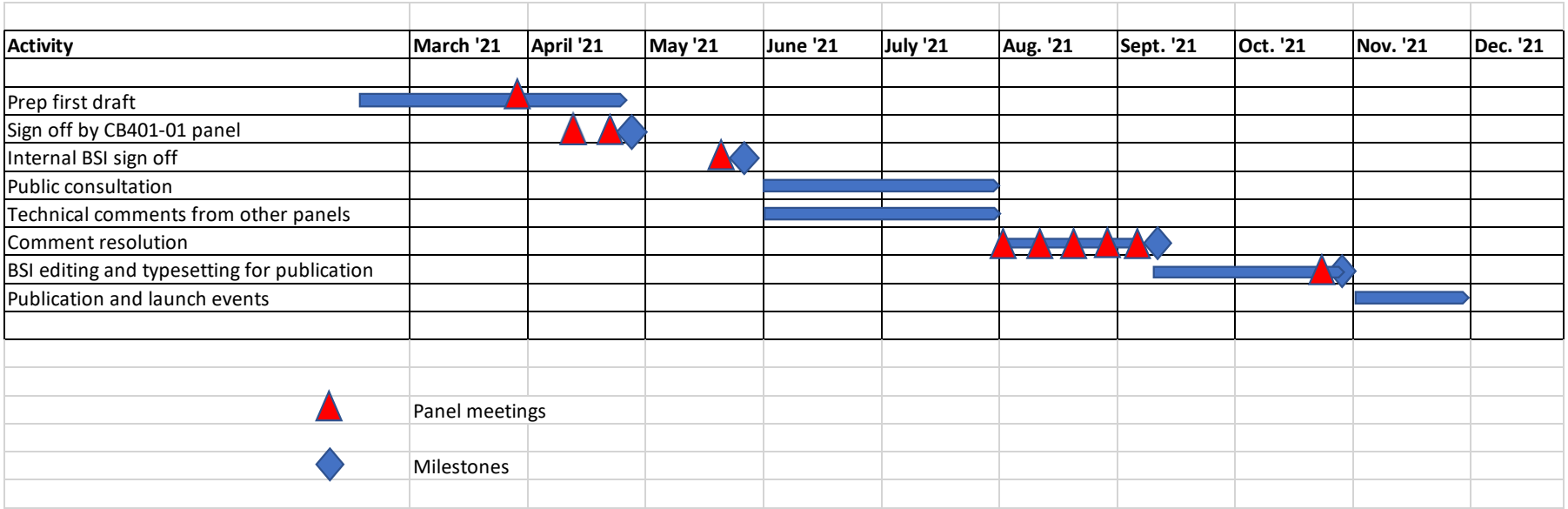
- Basis of case for development of the standard approved by BSI – Innovate UK BPE programme (2009 – 2013); ZCH; Assured Performance Process; Local plan policies; Each Home Counts; …climate emergency; fuel poverty; net zero
- Scope developed over several workshops arranged through Retrofit Standards Task Group
- BS commitment stimulated by PAS2035 (domestic retrofit) need to evaluate impact of retrofit works, also now PAS2038 (non-domestic retrofit)
- Work also supported by Building Performance Network (BPN) with funding from UKRI and the Industrial Strategy Challenge Fund, part of the Transforming Construction Challenge.

# What the standard will cover:

- Domestic and non-domestic, new build and existing (incl before and after retrofit)
- Post completion and in use
- Test, measurement and monitoring
- Comparison and basis for evaluation
- Recording and reporting

# BS401-01 Standard development plan

| Activity | March '21 | April '21 | May '21 | June '21 | July '21 | Aug. '21 | Sept. '21 | Oct. '21 | Nov. '21 | Dec. '21 |
|---|---|---|---|---|---|---|---|---|---|---|
| Prep first draft | | | | | | | | | | |
| Sign off by CB401-01 panel | | | | | | | | | | |
| Internal BSI sign off | | | | | | | | | | |
| Public consultation | | | | | | | | | | |
| Technical comments from other panels | | | | | | | | | | |
| Comment resolution | | | | | | | | | | |
| BSI editing and typesetting for publication | | | | | | | | | | |
| Publication and launch events | | | | | | | | | | |



# BEIS SMETER workshop on thermal performance measurements

EDF DIscussion Points

Nick DILLON
Digital Innovation Manager
EDF R&D UK Centre
nick.dillon@edfenergy.com

EDF R&D UK Centre

12 April 2021

# Validating SMETER against the full range of UK housing

Problem:

- We want to use our SMETER to generate HTC estimates for as many of our customers as possible
- However, to do this, we need to have confidence that our SMETER will perform well for **all** of our customers' dwellings
- The TEST dataset used in the SMETER competition is of limited range of house types and locations, which is not representative of the entire UK housing stock
- Therefore, how do we validate the accuracy of the HTC estimates across full range of UK housing stock?

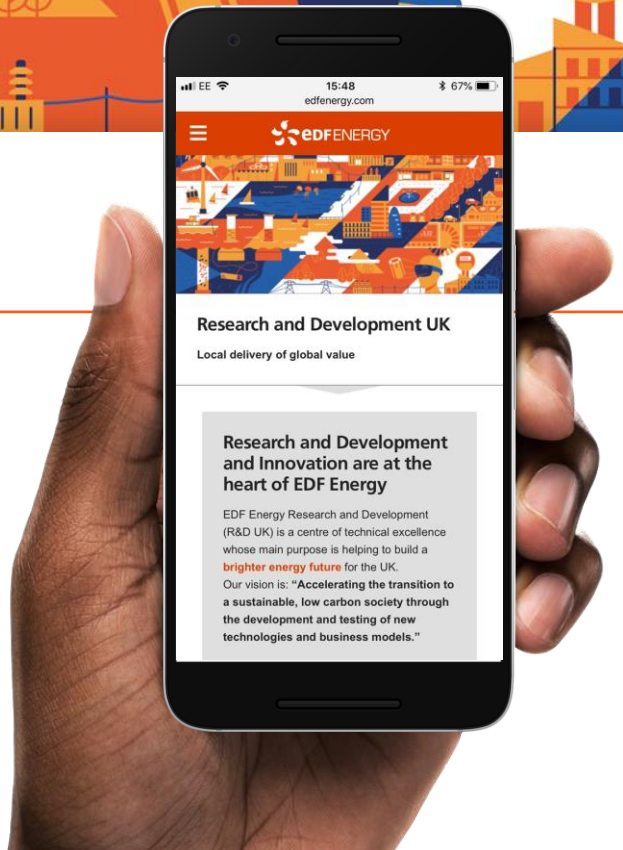
# Possible solutions

- To test our SMETER against a wide range of UK housing types, we need a larger and more representative test dataset of houses where the HTC and consumption data is known

- There are several options for creating this:
  - We create it ourselves
  - We partner with one or others to generate a dataset
  - An industry wide collaboration to create a shared data set

# THANK YOU

Visit us at :
https://www.edfenergy.com/about/research-development



# Future research and innovation priorities

Questions for this session

1. What do you see as the future research and innovation priorities?
2. What do you see as the risks or potential unintended consequences?
3. Following todays session, what are the key messages you would like to leave with us today?

HOARE LEA

# Next steps for SMETERs.

## From exposure to market.

- The concept of a Smart Meter enabled HTC calculator works.
- Current SMETERs only tested on a houses with a specific heating system.
- Development and testing is needed to ensure compatibility with apartments, and a more diverse range of heating systems.
  (e.g. electric, heat pumps, heat networks).
  - This will require disaggregating the energy data.
  - Additional metering makes cost unacceptable and would prevent rapid deployment at scale?

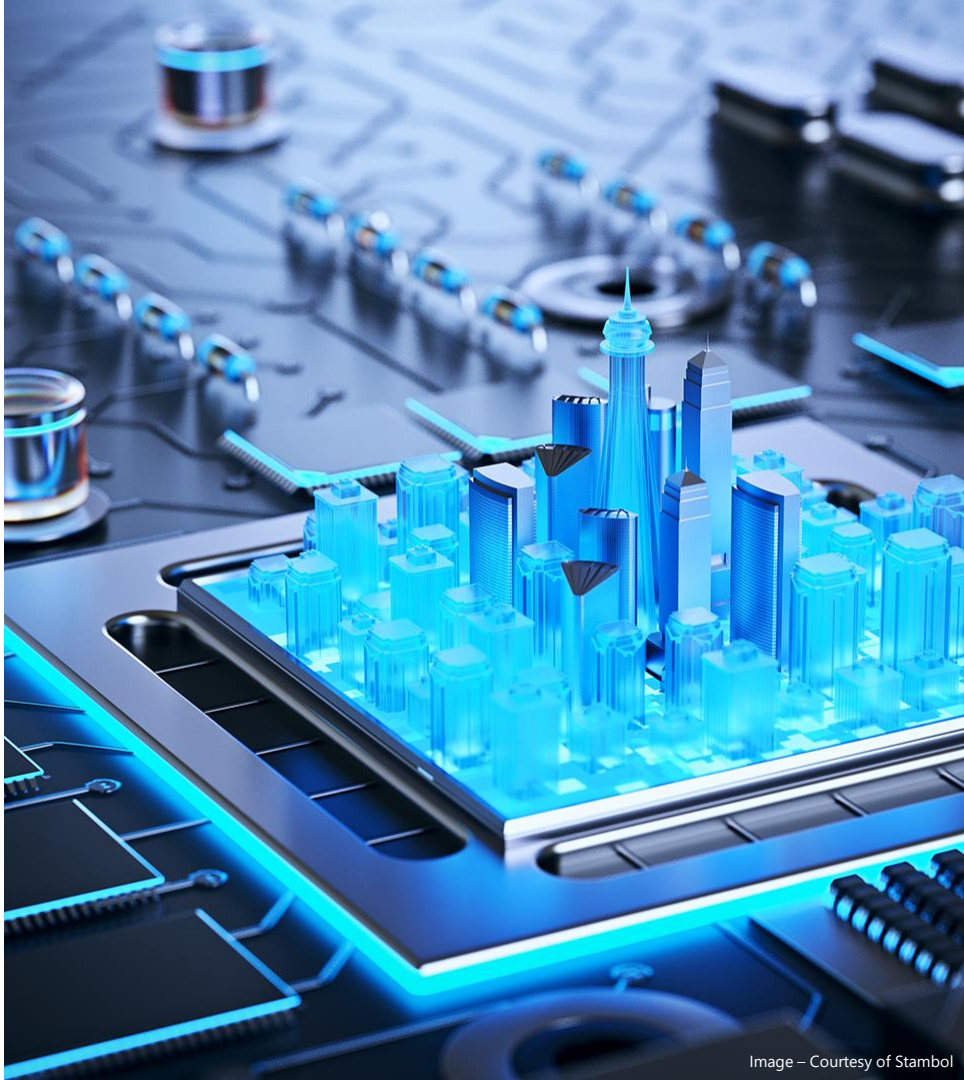


Image – Courtesy of Stambol

HOARE LEA

# What's the output?

## HTC is just the enabler.

- HTC is of limited use to the end user. They want more bespoke and specific retrofit advice.
- Social landlords are the current market.
  - They want to retrofit but approach it from a component standpoint (fabric, windows, vent, etc.)
- SMETERs need to output actionable advice. They need to tell people what to do. It should:
  - disaggregate the HTC and derive component based heat loss,
  - estimate the benefits of the retrofit proposals. SMETER can be a predictive tool.

HOARE LEA

# Innovation priorities.
## How can BEIS support?

- SMETER Programme a success – HTC calculators. But how does this fit into SAP / EPC landscape?
- Further innovation, testing and validation is needed to unlock the market:
  a) Broaden the range of compatible homes,
  b) Disaggregate energy data without restricting deployment at scale,
  c) Return actionable retrofit advice,
  d) Estimate the benefits of retrofit measures.
- Another competition focussing on these goals could allow SMETERs to unlock domestic decarbonisation.