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Building Performance Measurement CPD:
Introduction to Measurement

Build Test Solutions Open Day
21st September 2023

Agenda

- What is Building Performance Measurement?
- Why is it important?
- What has it told us about buildings?
- What are the available technologies and methods?

“You can’t manage what you don’t measure”

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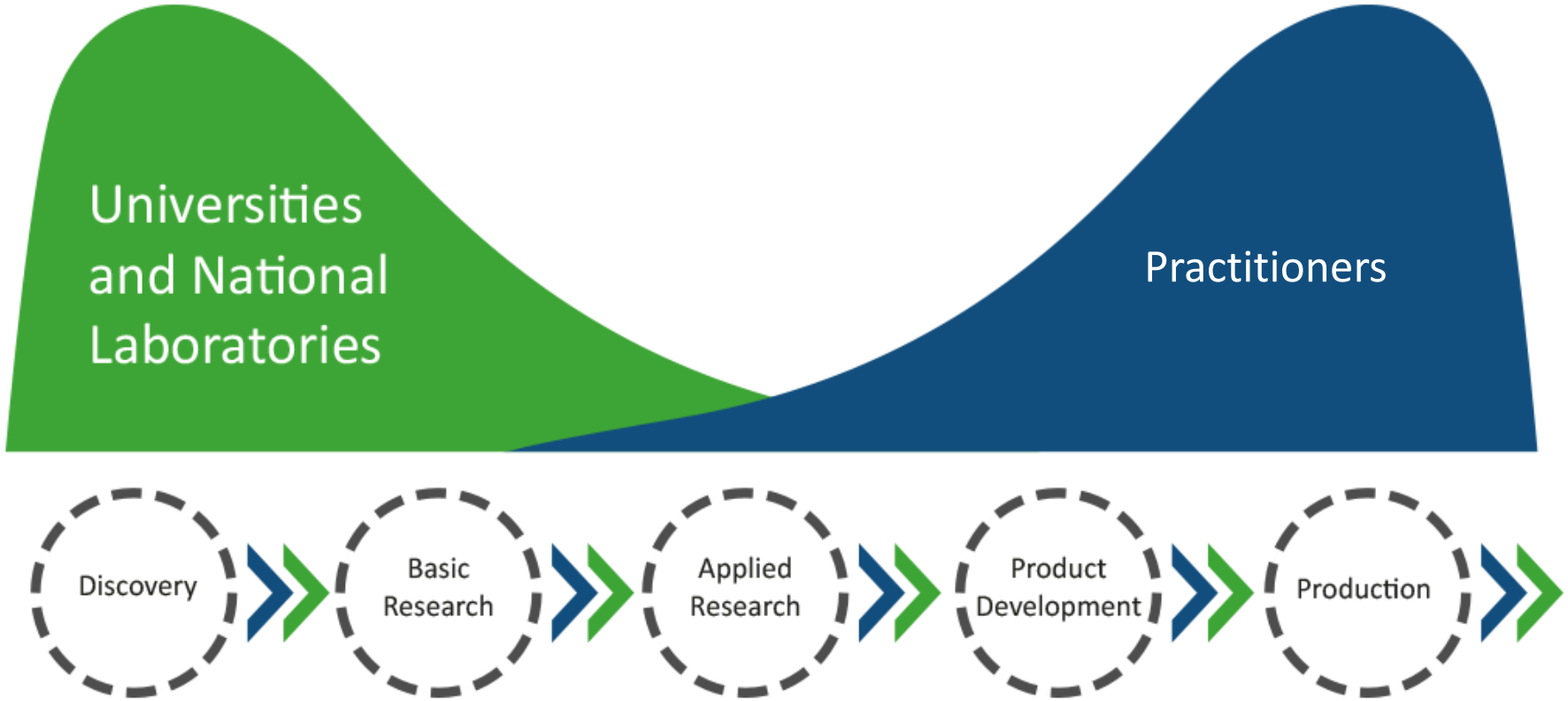
Making Measurement Mainstream



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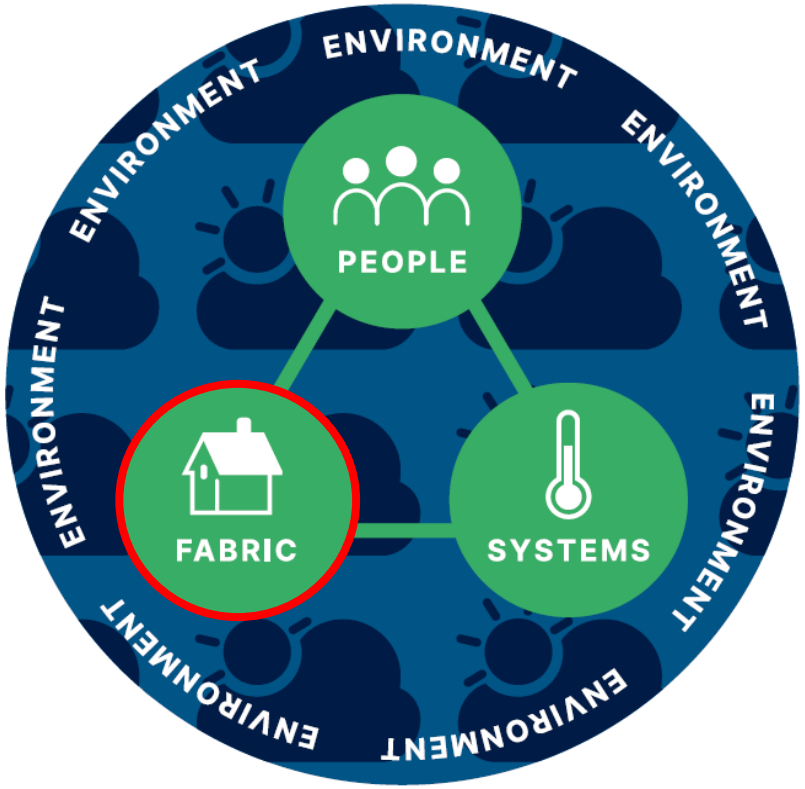
What is building performance measurement?

- On-site
- Physical measurements
- Typical metrics:
  - Heat loss rate
  - Airtightness
  - U-values
- AKA: BPE, POE, Monitoring & Verification

What affects building performance?



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What Makes up Thermal Performance

Excerpts from SAP:

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Window			31.70	x	1.33	=	42.31			(27)
Door			2.35	x	1.10	=	2.59			(26)
Door			1.97	x	1.50	=	2.96			(26)
Ground floor			81.25	x	0.15	=	12.03			(28a)
External wall			145.59	x	0.27	=	39.31			(29a)
Roof			2.13	x	0.17	=	0.36			(30)
Roof			79.12	x	0.11	=	8.70			(30)
Total area of external elements ∑A, m²			344.11							(31)

Fabric heat loss, W/K = ∑(A x U)	(26)...(30) + (32) =	108.25 (33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A (34)
Thermal mass parameter (TMP) in kJ/m²K		151.00 (35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		9.68 (36)
Total fabric heat loss	(33) + (36) =	117.93 (37)

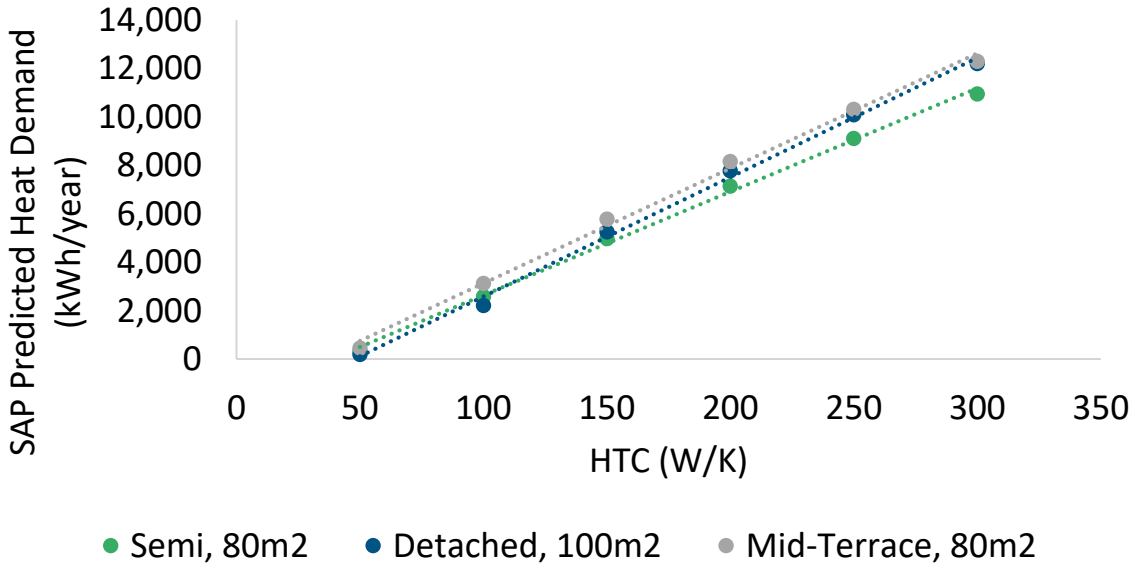
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)	74.11	73.81	73.51	72.10	71.83	70.60	70.60	70.38	71.08	71.83	72.37	72.92	(38)
Heat transfer coefficient, W/K (37)m + (38)m	192.04	191.73	191.43	190.02	189.76	188.53	188.53	188.30	189.00	189.76	190.29	190.85	

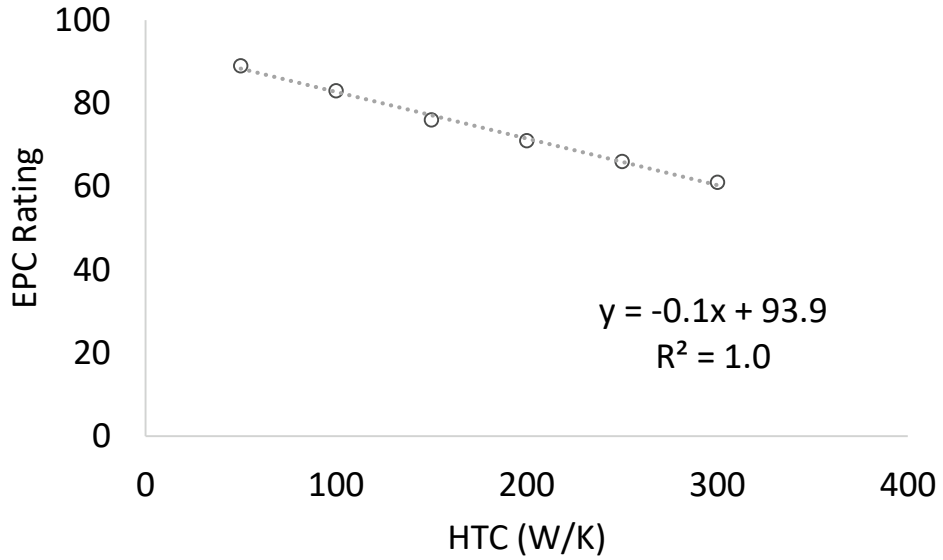
Average = ∑(39)1...12/12 = 190.02 (39)

Heat loss parameter (HLP), W/m²K (39)m ÷ (4)

Why is Thermal Performance Important?

- Determines heat loss… and therefore: kWhs, £s, CO_2e, EPC Rating





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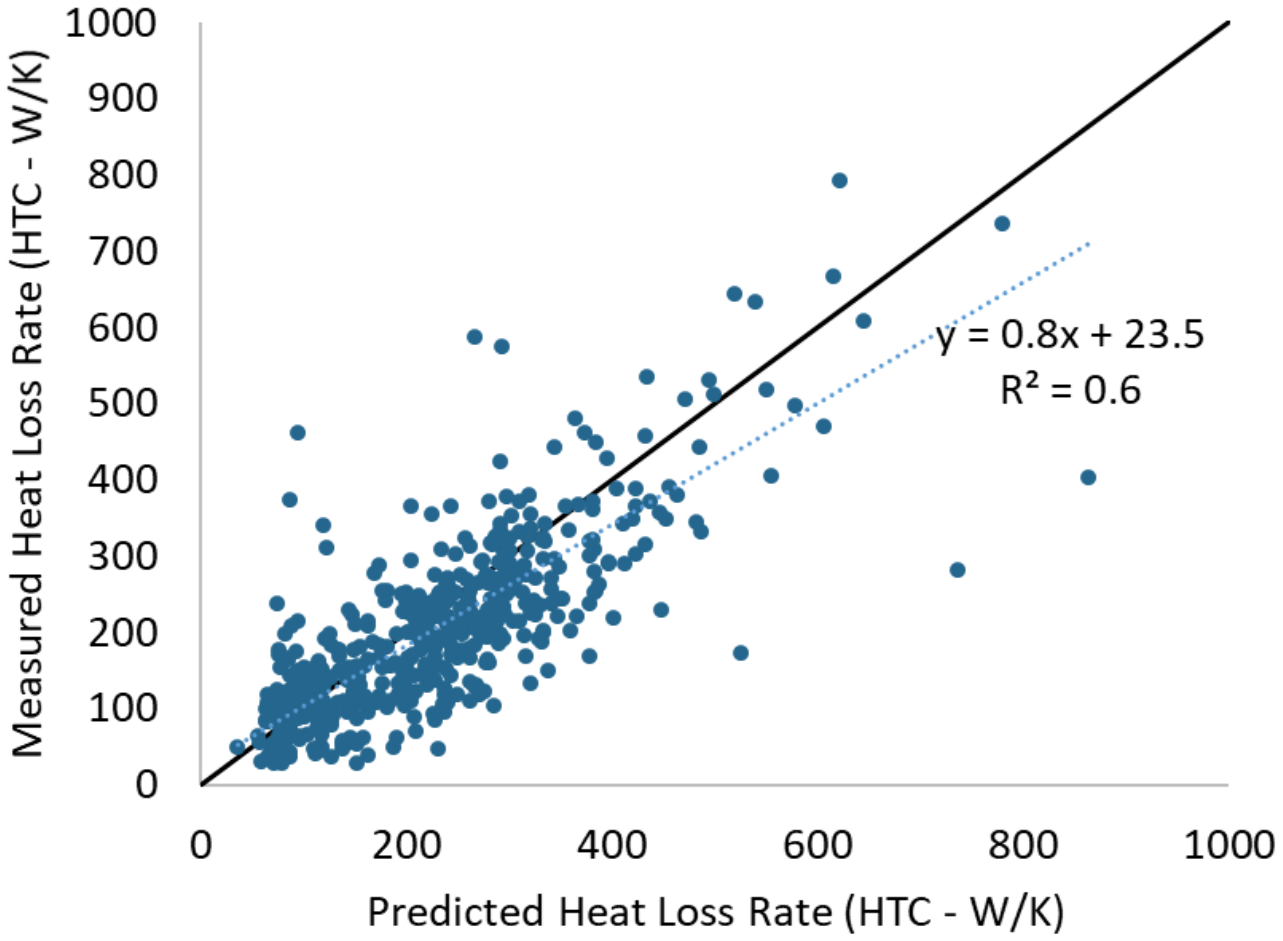
Why Measure Heat Loss?



Across 500+ homes:

- SAP heat loss predictions good… on average
- But only actually right for 42%!
- Differences of >50% are common

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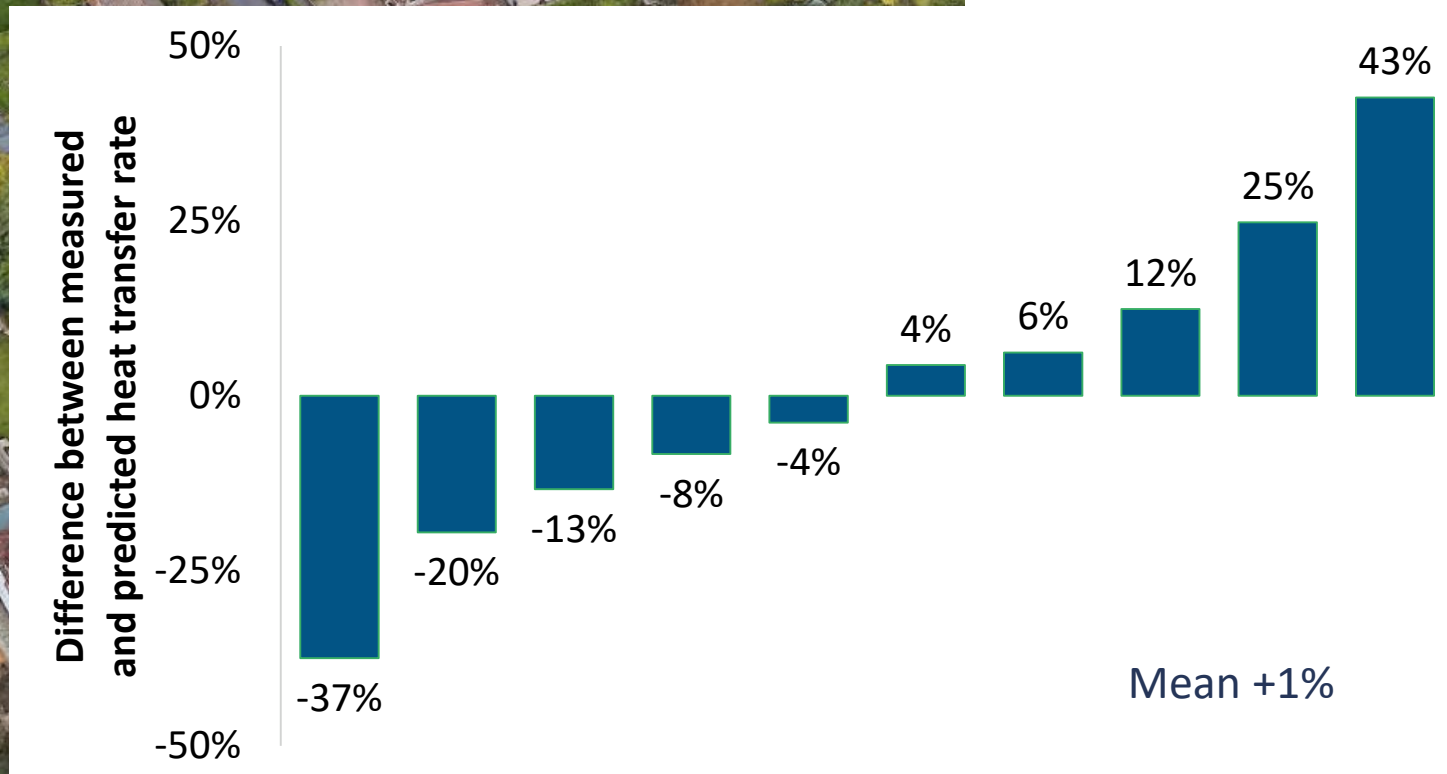
energy saving trust

Why measure?


Google Earth
© 2020 Google


Difference between measured and predicted heat transfer rate
50%
25%
0%
-25%
-50%
-37%
-20%
-13%
-8%
-4%
4%
6%
12%
25%
43%
Mean +1%

Why measure?

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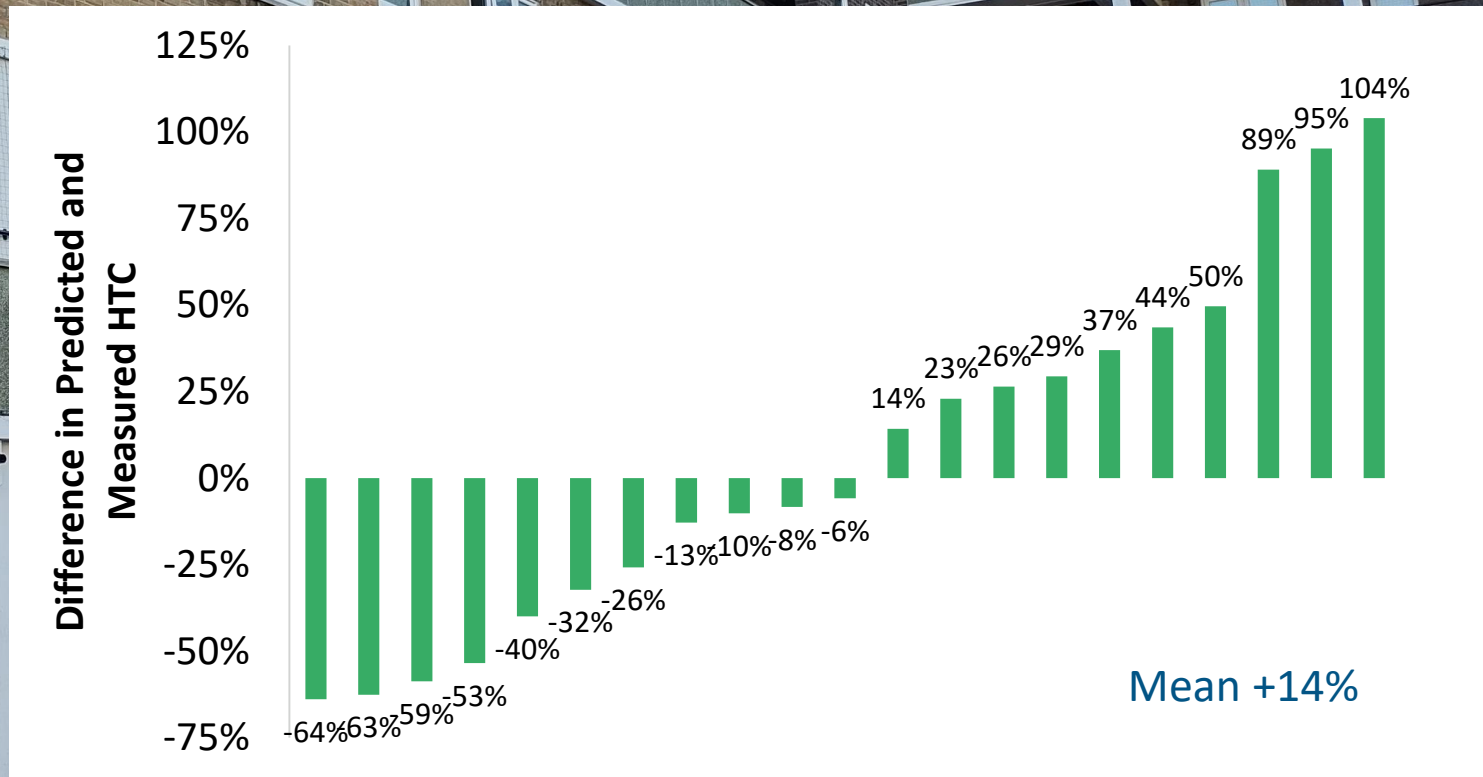
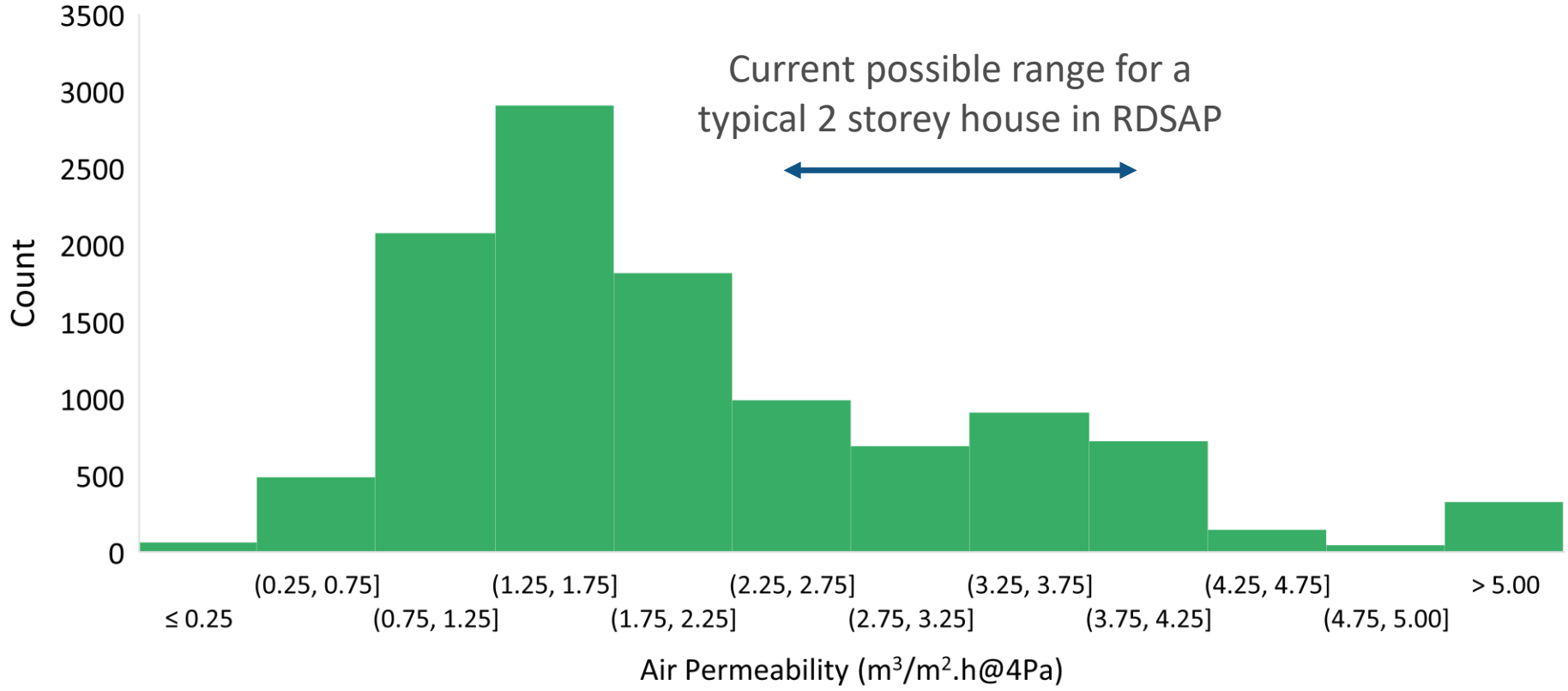


Why Measure Air Permeability?



Results from >10k Pulse tests

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Why Measure U-Values?

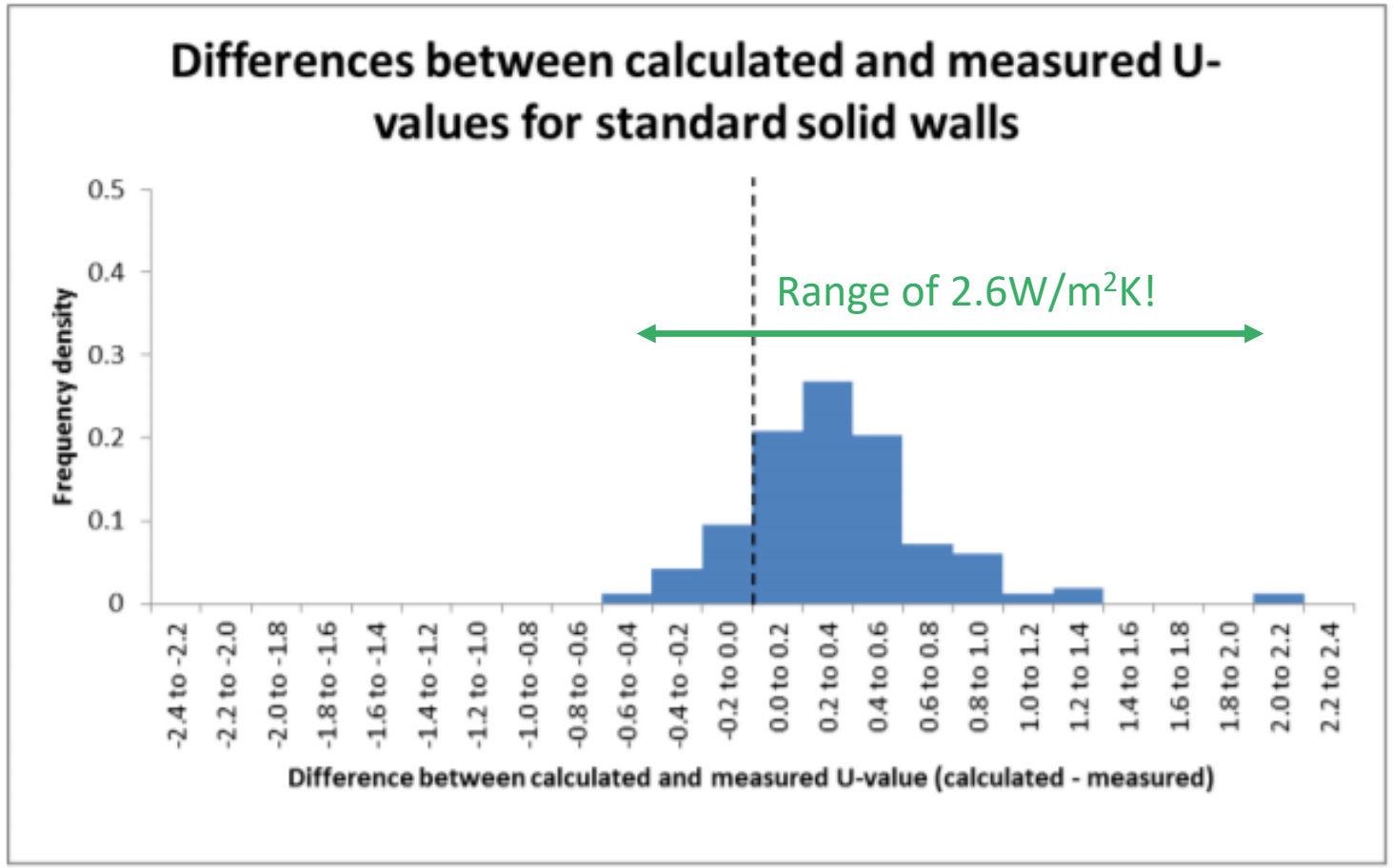

Figure from: BRE Report *In-situ measurements of wall U-values in English housing.* c.300 houses

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Improve Business as Usual by Replacing Assumptions with Measurements

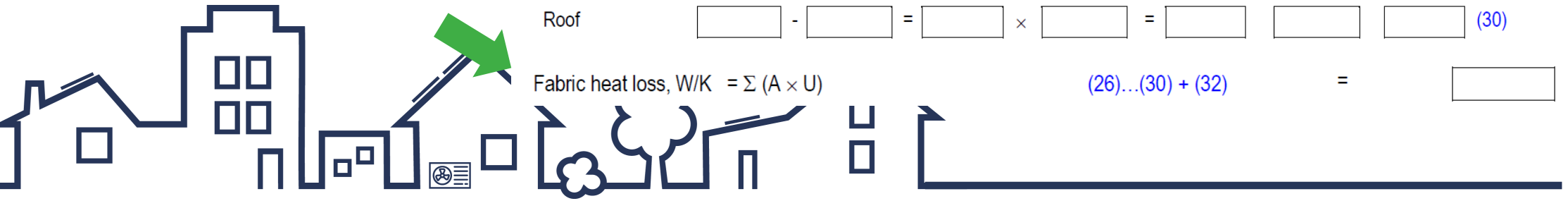
Excerpts from SAP 2012 9.92

3. Heat losses and heat loss parameter

Items in the table below are to be expanded as necessary to allow for different types of element e.g. 4 wall types.
The κ-value is the heat capacity per unit area, see Table 1e

Element	Gross area, m²		Openings m²		Net area A, m²		U-value W/m²K	=	A × U W/K	κ-value kJ/m²·K	A × κ kJ/K	
Solid door						×						(26)
Semi-glazed door						×						(26a)
Window						×	* below	=				(27)
Roof window						×	* below	=				(27a)
Basement floor						×		=				(28)
Ground floor						×		=				(28a)
Exposed floor						×		=				(28b)
Basement wall		-		=		×		=				(29)
External wall		-		=		×		=				(29a)
Roof		-		=		×		=				(30)

Fabric heat loss, W/K = Σ (A × U) (26)…(30) + (32) = (33)



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Unexpected performance = unintended consequences

- Energy
- Thermal comfort
- Ventilation
- Damp and mould
- Quality control
- Noise

You can't manage what you don't measure

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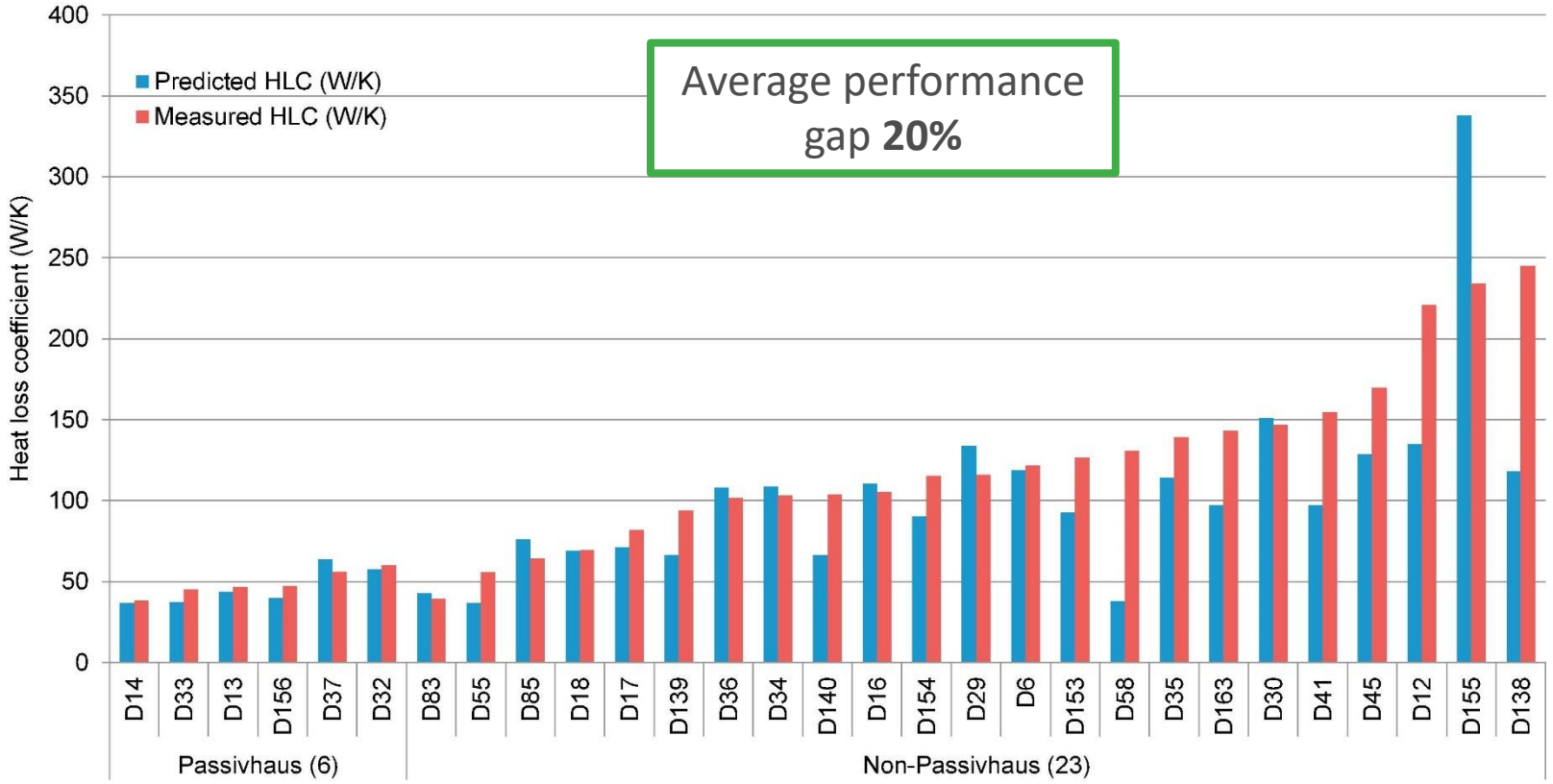
Why Measure? The Performance Gap?



Average performance gap **20%**

Figure from: Gupta, R., Kotopouleas, A., 2018. Magnitude and extent of building fabric thermal performance gap in UK low energy housing. Available at: https://www.sciencedirect.com/science/article/pii/S0306261918304343#b0240.

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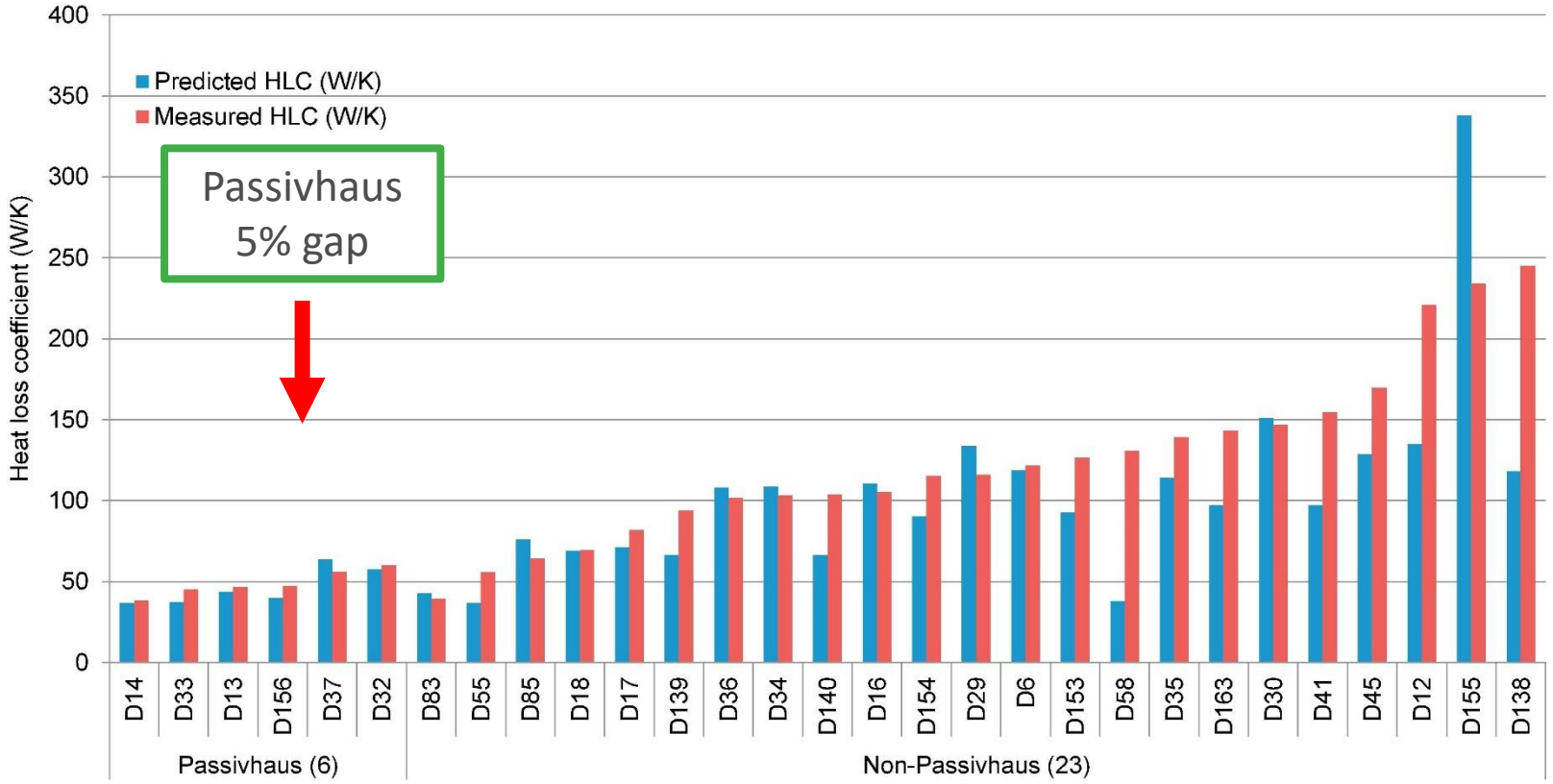

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Why Doesn't Everybody Measure??

- Pandora's box?
- Old methods prohibitively expensive and invasive
- Scalable new methods becoming available

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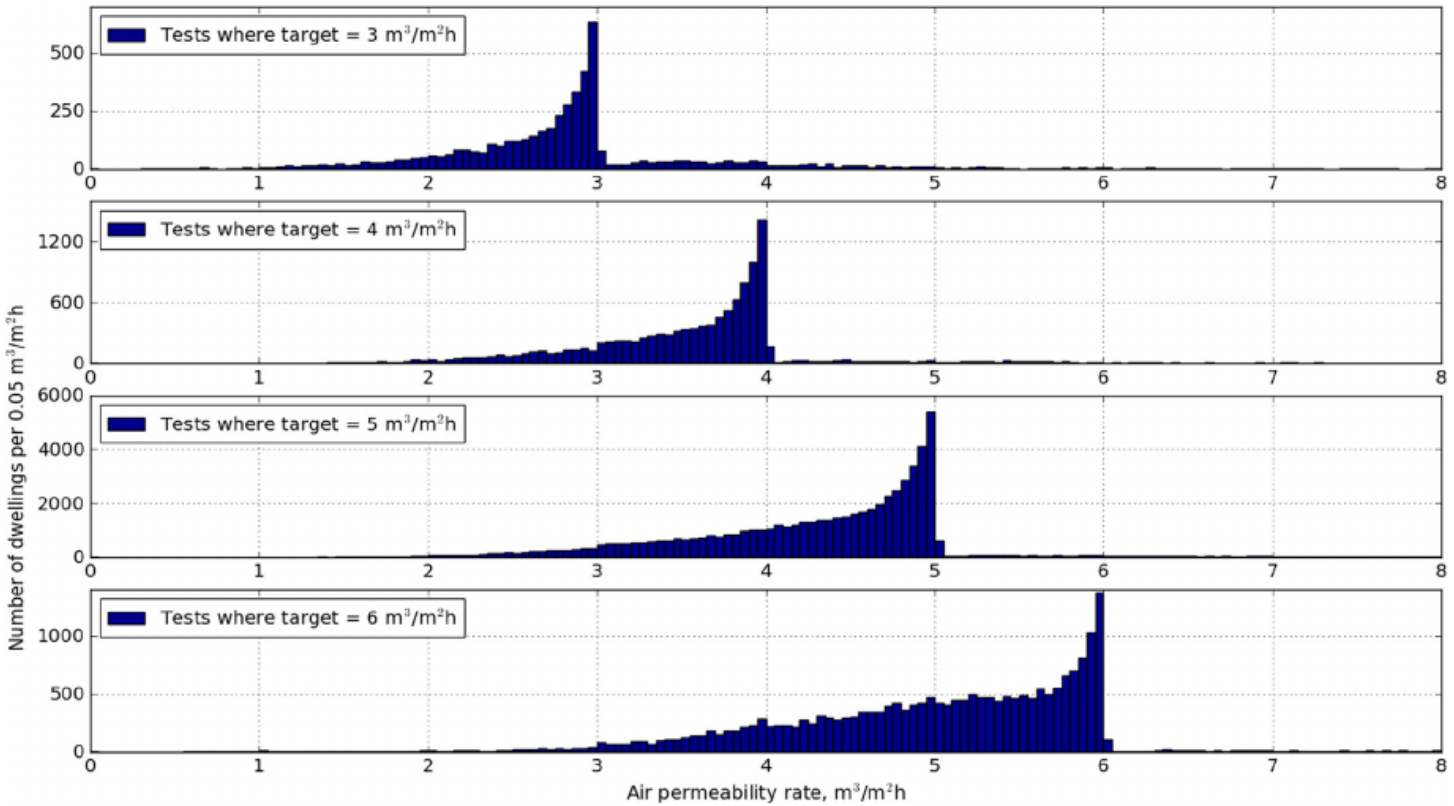
Measurement for the Right Reasons



Source: Jenny Love et al, UCL – Hitting the target and missing the point 140,000 tests

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Why Measure?

- Performance of houses is variable and impossible to assess visually
- Current energy models aren't wrong, but inputs should be improved
- Measurement & surveying/energy models aren't competitors, need both
- Measurement allows better understanding of individual buildings
- Better retrofit planning & design
- Quality assurance and feedback

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Setting Building Performance Targets

SMART

- Specific
- Measurable
- Achievable
- Relevant
- Time-bound

Metrics:

- ✓ Heat Transfer Coefficient
- ✓ Air permeability
- ✓ Ventilation rate
- ✓ U-values

- Energy Use
- CO_2e emissions
- Fuel costs

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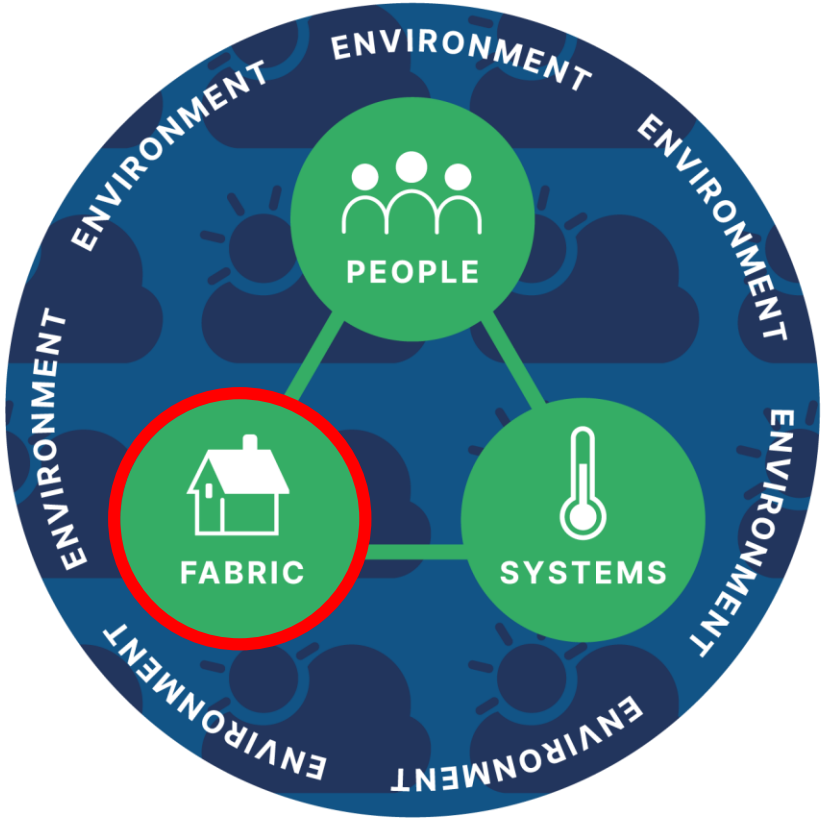
Available tools



- Whole Building Heat Loss (HTC)
- Airtightness (Pulse/Blower Door)
- U-values (Heat3D/Heat Flux)
- Ventilation flow rates
- Mould and overheating risk (temp/RH sensors)

- Occupant surveys (qualitative)
- Thermography (qualitative)

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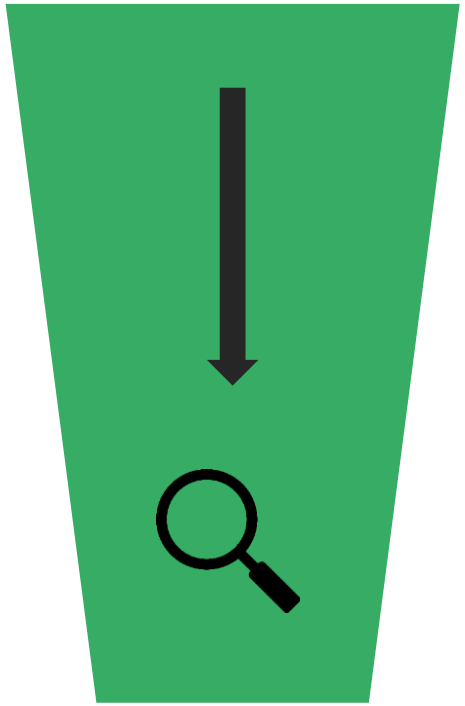
Our Core Technologies



SmartHTC – Measured total building heat loss

Pulse – Air leakage rate @ 4Pa

Heat3D – Rapid U-value measurement of walls, floors, roofs

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PULSE

LEAK CHECKER

SMARTHTC

HEAT3D

Whole building heat loss - SmartHTC

- Energy balance informed by measurements of energy consumption & internal temperature
- 3 weeks monitoring during winter
- Measures rate of heat loss per degree
- Directly comparable with design predictions
- Size heat pumps

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SMARTHTC

Additional metrics

- **Mould Risk Indicator**
  - Mould and condensation risk assessment
  - Live overall and individual room risk scores (0-100)
  - Assess portfolios of buildings and better target interventions e.g. fabric upgrade and/or ventilation

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Airtightness

Measurement	Test	Rough Cost	Test Length	Unit	Typical Uses
Airtightness	Pulse Blower door fan	£100-250	15 minutes 45 minutes	$m^3/m^2.h$ @4Pa or 50Pa Air movement (m^3) per surface area (m^2) per hour (h) @ a pressure difference (Pa)	- Building Regulations compliance - Check ventilation heat loss - Check ventilation provision

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U-values

Measurement	Test	Rough Cost	Test Length	Unit	Typical Uses
U-value (elemental performance)	Heat flux plates Heat3D	£1,000 £500	1 week 1-2 hours	$W/m^2.K$ Rate of heat transfer (W) per surface area (m^2) per degree temperature difference between inside and out (K or ^oC)	- Check walls/roofs/floors work as expected - Diagnose cause of performance gap

Summary

1. In-situ **measurement is really important** and yet often overlooked/deemed to complicated or expensive
2. **Tools and techniques exist** today that make measurement more accessible and affordable than ever before.
3. **What you don’t measure, you can’t manage!**
4. This in turn presents **lots of opportunities** for practicing surveyors, services engineers, architects, consultants and contractors!....

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Building Performance Measurement CPD:
Policy and Regulations

Build Test Solutions Open Day
21st September 2023

Agenda

- NOW
  - Current policy and regulations
  - Current voluntary standards
- SOON
  - Upcoming policy and regulations
- FUTURE?

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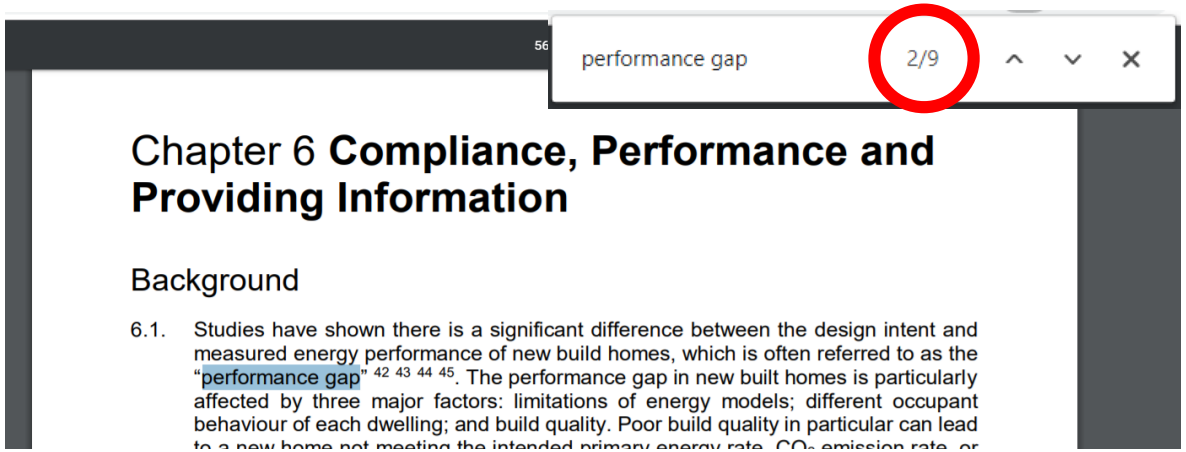
Performance Gap Research Spend



- PROBE – Government funded and CIBSE led – 1995 to 2002
- Retrofit for the Future + £8m InnovateUK BPE programme
- Zero Carbon Hub – Design vs. As-built
- £5m SMETER Programme – 2019-2021
- GHFA, IUK Net Zero Heat, Future Homes Hub, Smart Meter Roll Out…

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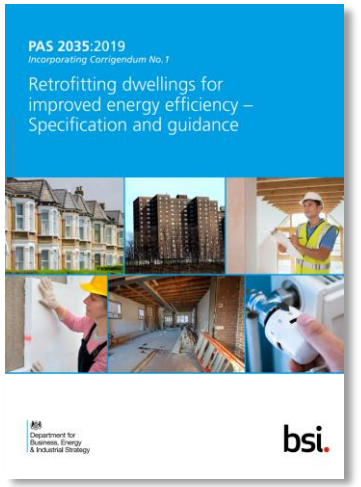
BPE in CURRENT policy, regulations and funding frameworks

- **AD Part L – New build airtightness testing**. 100% of all new build homes
- **PAS2035**
  - 9.3.3 – Pathway C pre and post retrofit airtightness test
  - Section 14 – Monitoring and Evaluation
  - Annex C – Background ventilation testing
- **Planning Policy –** Milton Keynes, GLA, EHDC
- **Social Housing Decarbonisation Fund** – Demonstrator (6 months monitoring), Wave 1 (SMETER), Wave 2 (Digitalisation)
- **Expert Witness** e.g. CPR 35 Reports
- **AD Part F – ventilation inspections and commissioning**
- **AD Part O – overheating – modelling and in-use verification**



BPE in CURRENT voluntary standards

- BS40101:2022 – Preliminary, Lite, Standard and Investigative
- Passivhaus and Enerphit
- Full SAP EPCs – U-values
- Energiesprong Performance Management Framework
- Soft Landings
- IPMVP - International Performance Measurement and Verification Protocol
- LETI Climate Emergency Retrofit Guide
- AECB Carbon Lite
- BRE Home Quality Mark

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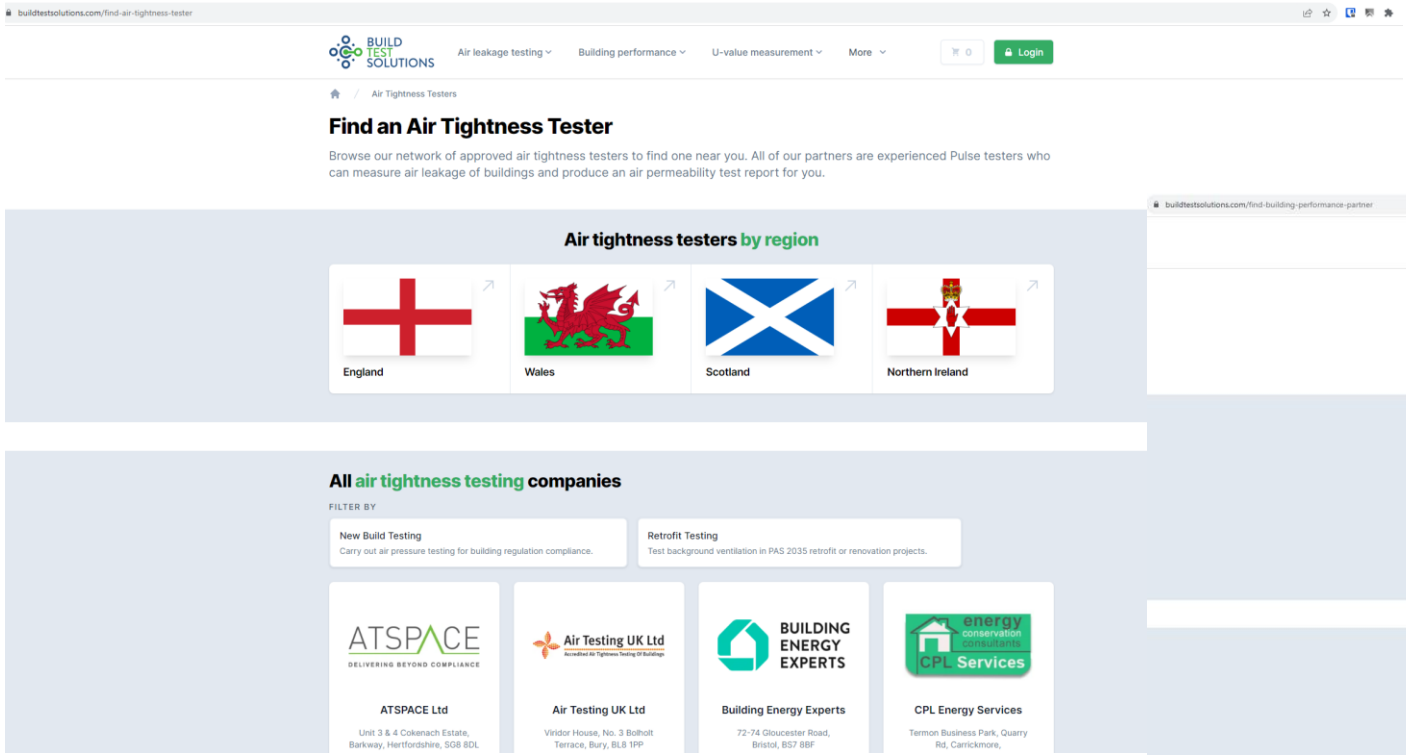
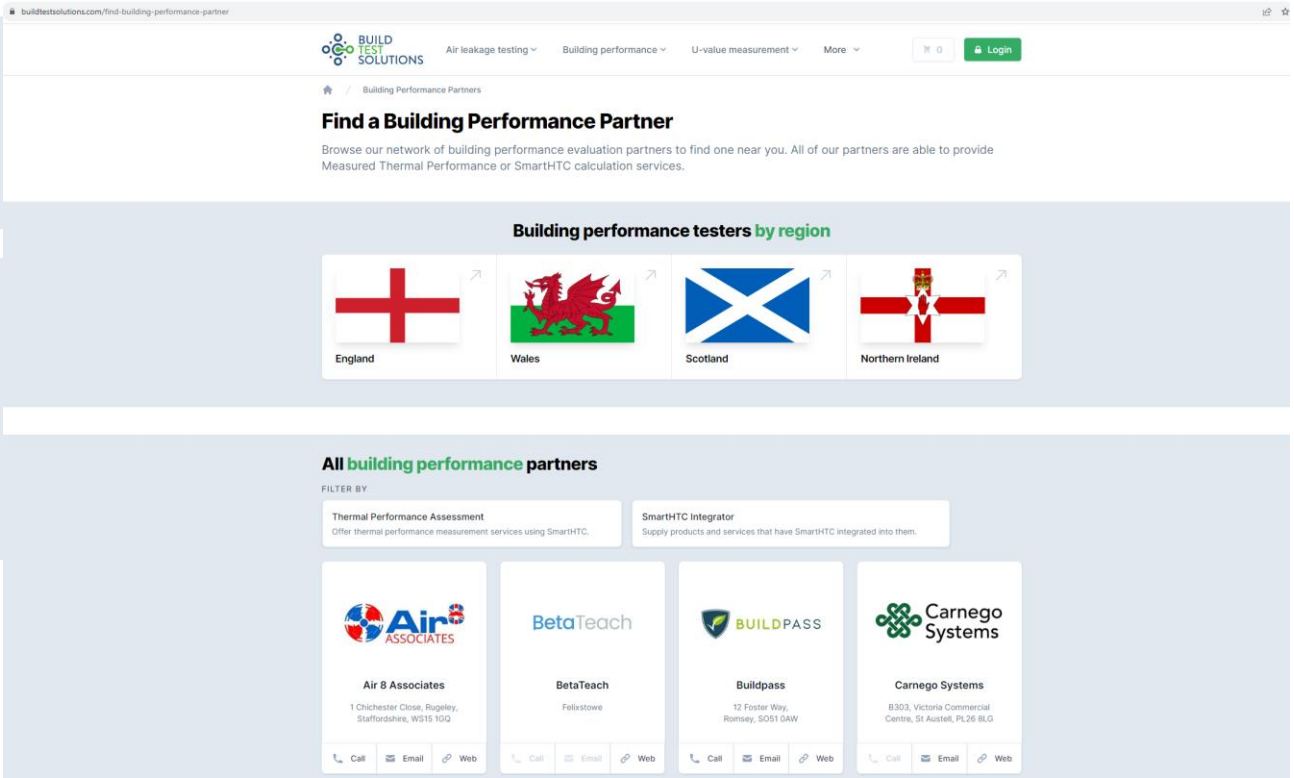
Join the revolution!





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BPE requirements on the near horizon…

- ECO4 – Pay 4 Performance – Expected 2024
- EPCs – 2024-26 onward
  - Airtightness measurements into rdSAP
  - U-value measurements into SAP and rdSAP
  - HTC's into SAP11?
- MCS heat loss assessment requirements linking in with measured HTCs
- Future Homes Standard – 2025/26 – sample based as-built testing?

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BPE in the future?

- Trustmark Data Warehouse / Property Passports populated with measured parameters
- Green Finance linked to measured impact
- Outcomes based building regulations
- Building Performance Insight algorithms more widely embedded in smart home technologies – IHD's, smart home hubs and thermostats etc.
    - Remote 'headline' assessment driving the market for further deeper dive diagnostics

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Summary

1. In-situ **measurement/BPE fast evolving** from what was once a cottage industry into something much bigger
2. **Regulation/policy direction is largely on our side** – we're pushing against an open door
3. We're not advocating measurement for the sake of measurement, there's **real value** in delivering buildings that do what they say on the tin!
4. This in turn presents **lots of opportunities** for practicing surveyors, services engineers, architects, consultants and contractors!....

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Building Performance Measurement CPD:
Market Opportunities

Build Test Solutions Open Day
21st September 2023

Agenda

- Market perspective – building owner/landlord
- Market perspective – contractor/developer
- Market perspective – professional advisors (surveyors, assessors, coordinators etc.)
- Case Studies

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Why Measure - Building owner or landlord

- **Better target and prioritise investment.** Going beyond EPCs - where is money best spent for maximum return on investment.
- **Deliver upon regulatory requirements.** Building regs, PAS2035 etc.
- **Unlock funding.** Funding pots dependent on measurement e.g. SHDF or better finance available where measurement can demonstrate impact delivered.
- **Right first time.** Check as built performance is in line with expectation. Quality assurance.
- **To provide a feedback loop into future projects.** What works well and not so well? Beyond customer satisfaction surveys!
- **Stay ahead of the curve!**

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Use Case: Lancaster West Estate

- £20m project, two SHDF rounds
- Shadow of Grenfell
- Pre and post retrofit testing across 00's of flats
- Pre results feeding into design teams and the RBKC asset management system
- Post retrofit results to check and validate delivered outcomes

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Why Measure – Contractor or Developer

- **Marketing/to differentiate from the competition.** “we measure and verify the performance of what we build and handover”
- **To instil customer trust, buy-in and confidence.**
- **Right first time.** Internal routine quality control and assurance.
- **Inform retrofit.** What’s the baseline you’re dealing with and what’s the best retrofit spec to deliver?
- **To meet other obligations or requirements within the contract.** BPE, POE, M&V etc.
- **Unlock finance?** ESG driven investing etc.
- **To provide a feedback loop into future projects.** What works well and not so well etc.

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Use Case: New Build Developers

- Is it a risk or an opportunity?
- Showcase quality vs. managing quality and risk
- Informing Future Homes Standard 2025/26
- Design vs. As-built and its possible implications for heat pumps and DNO infrastructure and connection costs

Why Measure – Professional Advisors

1. Offer **compliance orientated measurement services** in line with PAS2035, ADL and ADF, BS 40101:2021, RIBA Plan of Work POE etc.
2. **Access additional funding** on projects e.g. SHDF Digitalisation
3. Help EPC orientated landlords **override conservative/punitive assumptions**
4. Measure peak heat demand to determine **heat pump readiness**
5. **Validate performance of homes/products** e.g. post retrofit or as-built new builds under warranty. Expert witness services, research projects etc.
6. **Offer value add** measurement services to compliment your existing proposition e.g. Retrofit Assessment costs £X + heat loss + airtightness + U-value measurements. Single visit = efficiencies as well as a happier householder

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Use Case: Sizing Heat Demand

- HTC give heat loss per degree temperature difference
- Multiplying HTC by design internal & minimum external temperature gives peak space heat demand

Required Energy for Heat Generator

REQUIRED PEAK POWER	DESIGN INTERNAL TEMPERATURE	DESIGN MINIMUM EXTERNAL TEMPERATURE
20.2 kWp	34 °C	-5.1 °C

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Use Case: Ventilation Guidance

- Cavity wall insulation & draft stripping
- **32% reduction** in air permeability
- Building air permeability **>1ACH/h@4Pa**
- 1 room **<1.5ACH/h@4Pa**
- 1 door undercut required

PAS 2035 APPROVED

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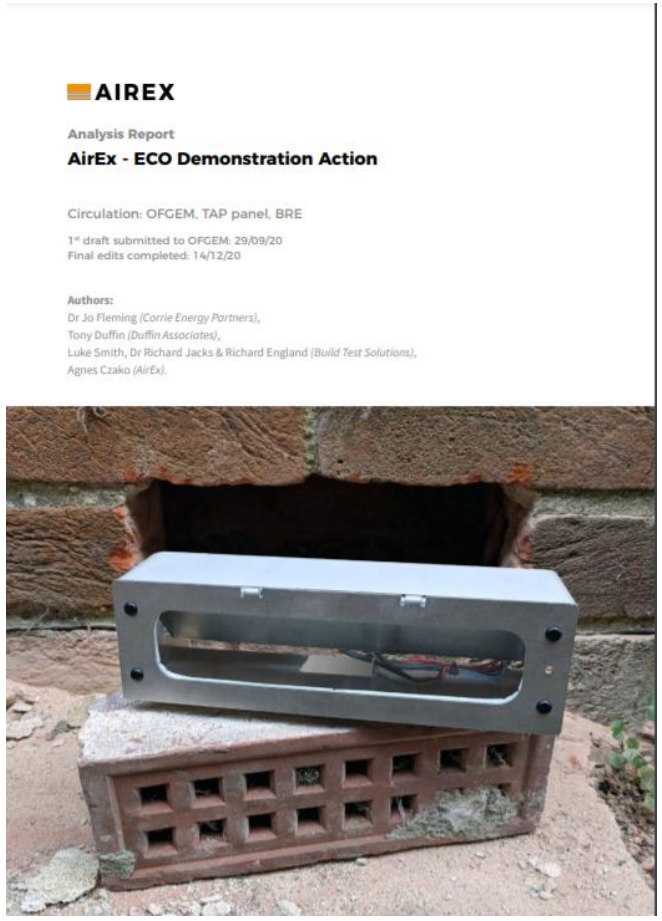
Use Case: Product Development & Validation

- Test and demonstrate new products in-situ
- Validate predicted savings



AIREX

Analysis Report

AirEx - ECO Demonstration Action

Circulation: OFGEM, TAP panel, BRE

1st draft submitted to OFGEM: 29/09/20
Final edits completed: 14/12/20

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