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The performance gap of low-carbon building technologies and the role of public policy

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1) What is the performance gap?

2) Is there evidence for a performance gap and which factors can explain it?

3) How can policy address it?

The performance gap

Predicted impact by pre-installation modelling

Observed and measured energy performance

Causes of the performance gap

Design stage
Inaccurate modelling of expected performance

Construction stage
Poor workmanship and/or maintenance

Operational stage
User heterogeneity

Analysis of case studies

Method

- Grey literature evaluations of low-carbon technology field trials

Analysis of case studies

Method

- Grey literature evaluations of low-carbon technology field trials

  Criteria

  - Examine a technology still in use as of 2017
  - Comprise at least 12 months monitoring
  - Include a qualitative evaluation of trial stakeholders
  - Provide some level of replication

Analysis of case studies

Quantitative results

References	Subject	Metric	Performance gap
Orr et al. (2009)	In-situ efficiency of **condensing boilers**	Efficiency	**5.3% less efficient** than claimed: 75% had an annual electrical consumption of greater than an assumed 175kWh/year
EST (2009)	**Domestic wind turbine** performance	Load factor	**Fell short of a load factor of 10%** (commonly quoted), with no site achieving load factors of more than 3%.
EST (2011)	Performance of **solar thermal hot water systems**	Delivery temperature	**Much lower** than the assumed value of 60°C at 49.1°C
Dunbabin and Wickins (2012), EST (2013)	Seasonal performance factors of **air- and ground-source heat pumps**	System efficiency	**Performance varied**: air-source heat pump range = 1.2 - 2.2; ground-source heat pump range 1.55 - 3.47
TSB (2013)	**Retrofitting** of properties with renewable technologies and insulation	Opportunity scope/air infiltration rates	Most properties had lower air infiltration rates than suggested: 'prebound' effect; **smaller scope for performance**

Analysis of case studies

Qualitative factors

Contextual factors

The physical environment of the installation differs from what was expected/modelled

Installation factors

Low quality of installation

User factors

Ultimate use of technology

Contextual factors - examples

- **Solar thermal trial**
  - Level of insulation on storage cylinder
- **Retrofit trial**
  - Internal/external space issues
  - Local phenomena

Analysis of case studies

Qualitative factors

Contextual factors

The physical environment of the installation differs from what was expected/modelled

Installation factors

Low quality of installation

User factors

Ultimate use of technology

Installation factors - examples

- **Condensing boiler trail**
  - Oversized boilers, i.e. bigger than necessary for the space being serviced
- **Retrofit trial**
  - Lack of skills to install bespoke services

Analysis of case studies

Qualitative factors

Contextual factors

The physical environment of the installation differs from what was expected/modelled

Installation factors

Low quality of installation

User factors

Ultimate use of technology

User factors - examples

- **Condensing boiler/solar thermal**
  - Controls that can be manipulated by the user
- **In general**
  - Occupant characteristics
  - Knowledge and information provision

Analysis of case studies

Qualitative factors

Contextual factors

The physical environment of the installation differs from what was expected/modelled

Installation factors

Low quality of installation

User factors

Ultimate use of technology

Policy recommendations

Accounting for the performance gap in evaluation and policy

- High-level **principles for policy evaluation**
  - Key parameters to be analysed
  - Quality standards for monitoring and post-installation audits
  - Methods for EM&V

Policy recommendations

Installer standards and user training

- Industry **standards** and **quality assurance** schemes
- Installer **training**
- Minimum standards for **user engagement**

Policy recommendations

Experimentation with innovative policy measures

- **Pay-for-performance** programmes
  - Reward actual measured savings instead of specific technologies assuming a certain amount of savings
  - Feasible with increasing digitalization and energy data availability

Policy recommendations

- Accounting for the performance gap in evaluation and policy
- Installer standards and user training
- Experimentation with innovative policy measures

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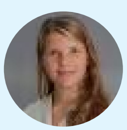

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References	Subject	Metric	Performance gap
EMC and EST (2008)	Amount of **hot water** used (an energy used to heat it)	Delivery temperature	Much lower than the widely assumed value of 60°C: 52.9°C ± 1.5°C for regular boilers; and 49.5 ± 2.0°C for combi boilers.
Orr et al. (2009)	In-situ efficiency of **condensing boilers**	Efficiency	5.3% less efficient than manufacturers' claimed performance; 75% of boilers had an annual electrical consumption of greater than an assumed 175kWh/year
EST (2009)	**Domestic wind turbine** performance	Load factor	Fell short of the commonly quoted load factor of 10%, with no site achieving load factors of more than 3%.
EST (2011)	Performance of **solar thermal hot water systems**	Solar fraction; Parasitic consumption	Variation ranging from 9 - 98% with a median of 39%; Variation ranging from 0 - 180 kWh p.a.
EST (2011)	Performance of **solar thermal hot water systems**	Delivery temperature	Much lower than the widely assumed value of 60°C: 49.1°C
Dunbabin and Wickins (2012), EST (2013)	Seasonal performance factors of **air- and ground-source heat pumps**	System efficiency	Performance varied: air-source heat pump range = 1.2 - 2.2; ground-source heat pump range 1.55 - 3.47
TSB (2013)	**Retrofitting** of properties with renewable technologies and insulation	Opportunity scope/air infiltration rates	Most properties had lower air infiltration rates than suggested (less than 10 $m^3/m^2/hr$ at 50Pa): 'prebound' effect, smaller scope for performance than anticipated.

References

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