

IEA EBC Annex 94:

Validation and verification of in-situ building energy
performance measurement techniques

Report

Preparation Meeting

April 28-29, 2025

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Enschede, Netherlands



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1. Participants

11 countries were represented at this final preparation meeting, yielding 46 participants from 29 different institutes:

Country	Name	Organisation	In Person/Online
UK	Rich Fitton	University of Salford	In Person
UK	Jamie Corson	UCL	In Person
UK	Richard Jack	Build Test Solutions	In Person
FR	Sarah Juricic	CSTB	In Person
UK	Frances Hollick	UCL	In Person
UK	David Allinson	University of Loughborough	In Person
UK	Cliff Elwell	UCL	In Person
UK	Grant Henshaw	University of Salford	In Person
UK	Sam Stamp	UCL	In Person
NL	Arash Rasooli	EKO Instruments / TU Delft	In Person
BE	Timo De Mets	Buildwise	In Person
BE	Liesje Van Gelder	BCCA	In Person
AT	Yousef Al Aidy	TU Vienna	In Person
AT	Rene Kurzbauer	TU Vienna	In Person
FR	Hervé Illy	CSTB	In Person
BE	Cynthia Leveau	Buildwise	In Person
BE	Martin Prignon	Buildwise	In Person
UK	Vicente Orts	Vector Homes	In Person
US	Xiang (Jason) Zhang	Arizona State University	In Person
NL	Christian Struck	Saxion	In Person
NL	Twan Rovers	Saxion	In Person
DK	Matthias Van Hove	DTU	In Person
NL	Quint	Geerman	In Person
NL	Rob Meester	Saxion	In Person
NL	Jeroen Van 't Ende	Saxion	In Person
DE	Karsten Voss	Wuppertal	In Person
DE	Johannes Pernpeintner	DLR	In Person
BE	Hans Bloem	DYNASTEE	In Person
UK	Matthew Li	University of Loughborough	In Person
UK	Carlos Jimenez Bescos	University of Westminster	In Person
ES	Maria Jose Jiménez	CIEMAT	In Person
ES	Catalina Giraldo Soto	University of the Basque Country - UPV/EHU	In Person
FR	Baptiste Poirier	Cerema	Online
UK	Mark Collett	LBU	Online
NZ	Griffin Cherrill	BRANZ	Online
UK	Steven Heath	Knauf Insulation	Online
UK	David Johnston	LBU	Online
UK	Kami Rakhshanbabanari	University of Loughborough	Online

UK	Kate Crawford	KLH Sustainability	Online
BE	Katia Ritosa	KU Leuven	Online
FR	Myriam Humbert	Cerema	Online
SE	Per Kempe	RISE	Online
UK	Roger Hitchin		Online
BE	Staf Roles	KU Leuven	Online
NL	Zhengxuan Liu	TU Delft	Online
UK	Virginia Gori	UCL	Online

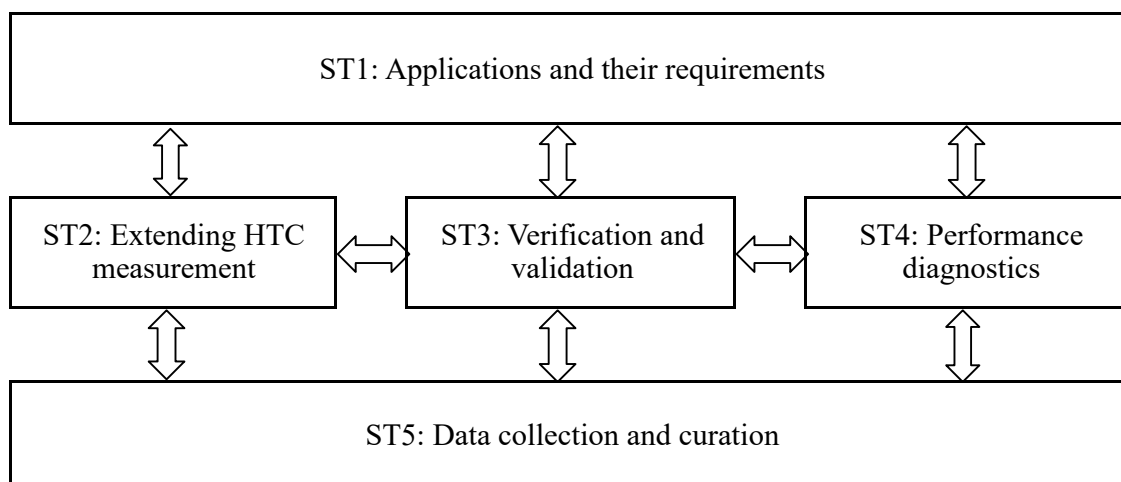
2. Agenda

Monday April 28, 2025

- 08.30 Arrival and coffee
- 09.00 Welcome and Keynote speaker
- 10.00 Mini-conference of presentations of work relevant to the annex
- 12.00 Networking lunch
- 13.00 Sub-task 2: progress update and planning
- 14.00 Group Photograph and break
- 15.00 Sub-task 3: progress update and planning
- 16.00 End of day 1 / Optional tour of test facilities

Tuesday April 29, 2025

- 08:30 Arrival and coffee
- 09.00 Sub-task 4: progress update and planning
- 10.00 Break
- 10:30 Sub-task 1: progress update and planning
- 11.30 Sub-task 5: progress update and planning
- 12.00 Networking lunch
- 13.00 Breakouts for finalising proposals (activities and outputs) and planning next steps (with deadlines)
- 14.30 Feedback from breakouts
- 15.30 Dynastee
- 15.40 Next meeting and closing remarks
- 16.00 Finish



Day 1 April 28, 2025**Welcome and keynote speaker**

Christian Struck welcomed us to Enschede and Saxion University.

Cliff, Richard and David welcomed everyone and thanked Saxion University for hosting the meeting. We are reaching the end of our preparation phase and need to finalise the proposal to submit this week. Agree the activities and deliverables for each sub-task. Any further letters of participation required this week.

Daniël van Rijn from the Netherlands Enterprise Agency introduced the IEA and the EBC, which is one of 38 technology collaboration programmes. There are 19 ongoing annexes and 78 completed annexes. The built environment in the Netherlands comprises 8.1 million homes with >90% heated with natural gas. Many homes were built in the 1970s and 1980s and are poorly insulated – need to be retrofitted. Also need to build 100,000 homes per year and this is many more than in recent years. The Nation Energy System Plan includes approaches to address these problems as part of the whole system. The National Climate Adaptation Implementation Programme has identified overheating as a key problem. Annex 94 is important to the Netherlands.

Arash Rasooli from TU Delft and EKO (thermal analysis instruments) introduced his research on in-situ determination of building's thermo-physical characteristics. He emphasized the importance of in-situ measurements due to large differences between measurement and prediction. His research focused on component level (thermal resistance and capacity) and building level (heat loss coefficient, thermal capacitance, and air change rate). At the component level, he introduced the new Excitation Pulse Method (EPM) for measuring thermal response factors. At the building level, on-board monitoring data were collected from 100 homes and inverse lumped capacitance models solved using genetic algorithms.

Mini-conference of presentations of work relevant to the annex

Participants presented past research work relevant to Annex 71. Details can be seen on the Annex 71 website.

Online presentations:

1. Roger Hitchen (Roger.Hitchin@hotmail.com) – Proposed procedure for sizing intermittently operated heating systems using in-situ measurements.
2. Maria Nuria Sanchez (CIEMAT) – Application of validity assessment of the dynamic integrated method to obtain the U and g values of walls.
3. Per Kempe (RISE Research Institute) – Swedish energy efficient multi-family houses with central AHU.
4. Jose Alberto Diaz Angulo (CIEMAT) - Test based on the coheating procedure, enhanced to the climate given in a semi-desert area, and its validity assessment.

In-person presentations:

5. Richard Jack (Build Test Solutions) –(quite) Large performance gap study.
6. Twan Rovers (Saxion University of Applied Sciences) - Diagnosing deficient HTC's: Experiences from seven years of applied research.
7. Catalina Giraldo Soto (University of the Basque Country) - Definition, estimation and decoupling of the overall measurement uncertainty of the indoor and outdoor air

temperature collected from a 3D monitoring and control system installed in a tertiary building.

8. Frances Hollick (UCL) – Year-round lumped thermal capacitance models.
9. Sarah Juricic (CSTB) – SEREINE measurement of apartments & housing blocks.
10. Jason Zhang (Arizona State University) - In-situ data-driven estimation of dynamic solar gains in buildings.
11. Karsten Voss (University Wuppertal) - Thermal in-situ characterisation of experimental housing.

Sub-task 2: progress update and planning

ST2 Extend HTC measurement, Maria Jose Jiminez and Katia Ritosa

- Review paper
 - Review of methods for assessing the measured heat transfer coefficient.
 - Based on 104 research items + supporting literature.
 - Paper to be finalized and sent for review soon.
- Current plan
 - WP2.1 Party wall heat transfer – how important and how can it be characterized?
 - WP2.2 Warm climates - does HTC depend on climate and how can it be measured in cooling climates?
 - WP2.3 Time as a variable – how do HTC measurements change with time and how do building dynamics influence this?
 - WP2.4 Well-performing buildings – linked with previous questions, how well do methods work in well-performing buildings with low measured heat/cooling input?
 - WP2.5 Innovation hub – to promote ideas that don't fit.
- Breakout
 - Ideas invited for ST2, and any data sources available, via questionnaire:
<https://forms.office.com/Pages/ResponsePage.aspx?id=m1hzOUCetU6ADrC2OD0WIWBbSo-vdbIBkgeS7O2ma2hUMzZFUVFXOTQ1SEINTk1LWjExNERNR0xLSi4u&origin=QRCode>
- Discussion
 - Requirements for data and use of synthetic data were discussed.
 - Party wall heat loss may matter for some applications, but not for others.
 - Volunteers: Jason Zhang, Dave Johnston, Kami, and Lubo.

Sub-task 3: progress update and planning

ST3 Verification and validation, Sarah Juricic and Frances Hollick

- Foundational concepts:
 - Robust uncertainty calculation.
 - Validation of methods.
 - Share a common language.
- All participants engaged in group discussions for ranking activities and deliverables by importance and urgency.
- The record of this will guide the final proposal.

3. Day 2 April 29, 2025

Sub-task 4: progress update and planning

ST4 Performance diagnostics, Grant Henshaw and Richard Jack.

- This is the tools and methods to understand why measured HTC does not match design.
 - The approach is to be problem-led.
 - Work has started with a stakeholder survey.
 - The idea is to design a standard diagnostic process.
 - Round Robin tests could be carried out to evaluate the process.
 - There will be a final state of the art review.
- A stakeholder map for the UK has been developed:
 - Does this work internationally?
 - Have we missed any stakeholders?
 - Anything else to add?
- The stakeholder map was described in detail
 - Examples were tenants have heating or cooling as part of the rent include students halls, flats in Dubai, some Swedish homes.
 - Participants worked in groups to chart stakeholders on a interest vs power map.
 - Having a problem was identified as a key driver for interest e.g. mould or high bills or cold home or overheating.
 - Funders are driven by risk.
 - Interest is driven by: problem or business risk or business opportunity or altruism.
- State of the art literature review
 - Discussed the methods identified and what missing.
- Consumer survey is being planned – target building users.
- Working with ST5 to look at data storage.
- Boundary of the sub-task discussed:
 - New methodologies based on on-board monitoring can be included.
 - Problems for predicted, tested and in-use HTC are in scope.
 - TBD: only HTC disaggregation or also wider problems such as distribution losses?

Sub-task 1: progress update and planning

ST1 Applications and their requirements, Liesje Van Gelder and Mark Collett.

- Main applications identified:
 - Verification, including mortgages and energy performance guarantee.
 - Retrofit, including targeting and performance checking.
 - Heating system sizing, especially for heat pumps.
 - EPC, to substitute or augment calculations.
- Planned activities and deliverables were discussed
 - Mapping of related projects during Y1.
 - Centralised terminology – technical and non-technical versions working with all other sub-tasks, already started and to be completed in Y1.
 - Stakeholder survey (with ST3 and ST4) work in progress for Y1.
 - Further in-depth interviews planned for Y2.
 - Impact report to be developed during Y2 – this will plan how the impact is created beyond the end of the annex, with pathways to impact published in Y3.
 - Form an advisory panel in Y2 to guide and ensure relevance.

- Stakeholder survey will be published in Y3.
- Stakeholder survey (with ST3 and ST4)
 - What has changed since the Annex 71 survey?
 - How are HTC measurements currently being used (ST1)?
 - How familiar are building professionals with building diagnostics (ST4)?
 - Perceptions of uncertainty (ST3)
- Requests for volunteers for the survey development, implementation, and analysis were identified.
- Volunteers for other activities deliverables were identified.
- Please contact lvj@bccca.be to be added to the mailing list for the ST1 activities.

Sub-task 5: progress update and planning

ST5 Data collection and curation, Matt Li and Josh Cooper.

- Activities and deliverables
 - Cataloguing existing data sets under way.
 - Review of data requirements under way with initial survey.
 - Review of methods for data best practice – management, sharing, reporting Y1.
 - Action plans for ST2-4 to gather new data in Y1.
 - Production of new data sets Y1-3.
 - Collation and curation and documentation of data in a repository Y1-3.
- Meetings planned for 6 times per year – with at least one representative from each sub-task.
- Request that sub-tasks include data as a regular agenda item on their meetings.
- Survey at last meeting identified preference for half hourly resolution with good metadata and a DOI for citing.
- A number of data sets have been identified but still issues around sharing to be resolved.
- Dataverse has been identified as a suitable tool to be centrally administered for Annex 94.
- Github has been identified for code and source controlled material.
- ST5 will provide guidelines for how to use these tools and license and control sharing.
- Plan to adhere to GDPR as this will be the highest general requirement.
- Work is ongoing to develop the configuration 1st June 2025.
- Tutorials planned to support data uploading and documentation.
- Josh Cooper has experience of accessing UK smart data and is happy to support smart meter data access in other countries.
- Work is needed to develop data requirements of different users e.g. temporal resolution, sensor accuracy, etc.
- Sub-task volunteers to liaise with ST5: ST1 Mark, ST2 Maria Jose, ST3 Catalina and Sarah, ST4 Grant.

Feedback from breakouts

ST2: Extend the methods

- Participants volunteered for different work packages.
- Available data sets were identified – and a lack of data for warm climates.
- Leaders of each work package will develop proposals for common exercises to discuss at the next meeting.

- The next month will focus on analysis of the survey outputs.
- There will be an online meeting in May.

ST3: Verifications and validation

- Volunteers identified to lead deliverables – which have been merged and simplified as a result of this meeting.
- Work has started on several of the deliverables for Y1, including looking at best practice and working with ST1 and ST2.
- Y2 work is planned around two groups – one on uncertainty and one on validation.
- Regular online meetings are being planned.
- Please get in touch if you wish to join in.

ST4: Performance diagnostics

- Good progress on the state of the art review.
- Prep work planned for developing further surveys.
- Pathology process identified for developing methods.

DYNASTEE

Hans Bloem presented the DYNASTEE Centre of Excellence. DYNASTEE is the Network for DYNamic Analysis Simulation and Testing of Energy and Environmental performance of buildings. Formed in 2005, DYNASTEE's roots go back to 1985 and PASSYS 1. DYNASTEE organise an annual summer school that is very relevant to Annex 94 – next one in 2026. A symposium in collaboration with CIEMAT is planned for Autumn 2026 in Madrid with a focus on in-situ HTC measurement and analysis – inviting industry and academics to come together with governmental organization. All Annex 94 ST leaders are invited to share work in progress through the newsletter in June

Next meeting and closing remarks

Next meeting may be in France – TBC. Please let us know if you can host one of the two meetings per year over the next three years.

David, Cliff and Richard thank:

- Sub-task leaders Liesje and Mark, Katia and Maria Jose, Sarah and Frances, Richard and Grant, Josh and Matt.
- All the volunteers doing the work between the meetings (please volunteer and help where you can).
- Everyone who travelled here.
- Everyone who joined online.
- The Dynastee network.

Extra special thanks to our brilliant hosts for the wonderful hospitality:

- Christian Struck and Twan Rovers and all the team at Saxion University in Enschede!