EBC

Energy in Buildings and Communities Programme

IEA EBC Annex 71

Building energy performance assessment based on in-situ measurements

9th expert meeting

IEA EBC Annex 71 – Webex-meeting
October 19-21, 2020

agenda

Monday 19th October

9 am – 1 pm Intro + break out session on ST3

9 am – 10 am: Plenary session with overview and status of different subtasks

10 am – 1 pm: Breakout session on subtask 3

2 – 5 pm Break out session on ST2

Tuesday 20th October

9 – 12 Joint break out session on ST1 and ST4

2 – 3 pm Break out session on BES-validation exercise

3 – 5 pm core group meeting

Wednesday 21st October

9 – 10 am plenary wrap-up session:

feedback of the breakout session, follow up actions

Feedback from IEA EBC ExCo

EBC
Energy in Buildings and Communities Programme

IEA Energy in Buildings and Communities

87th Executive Committee Meeting Minutes

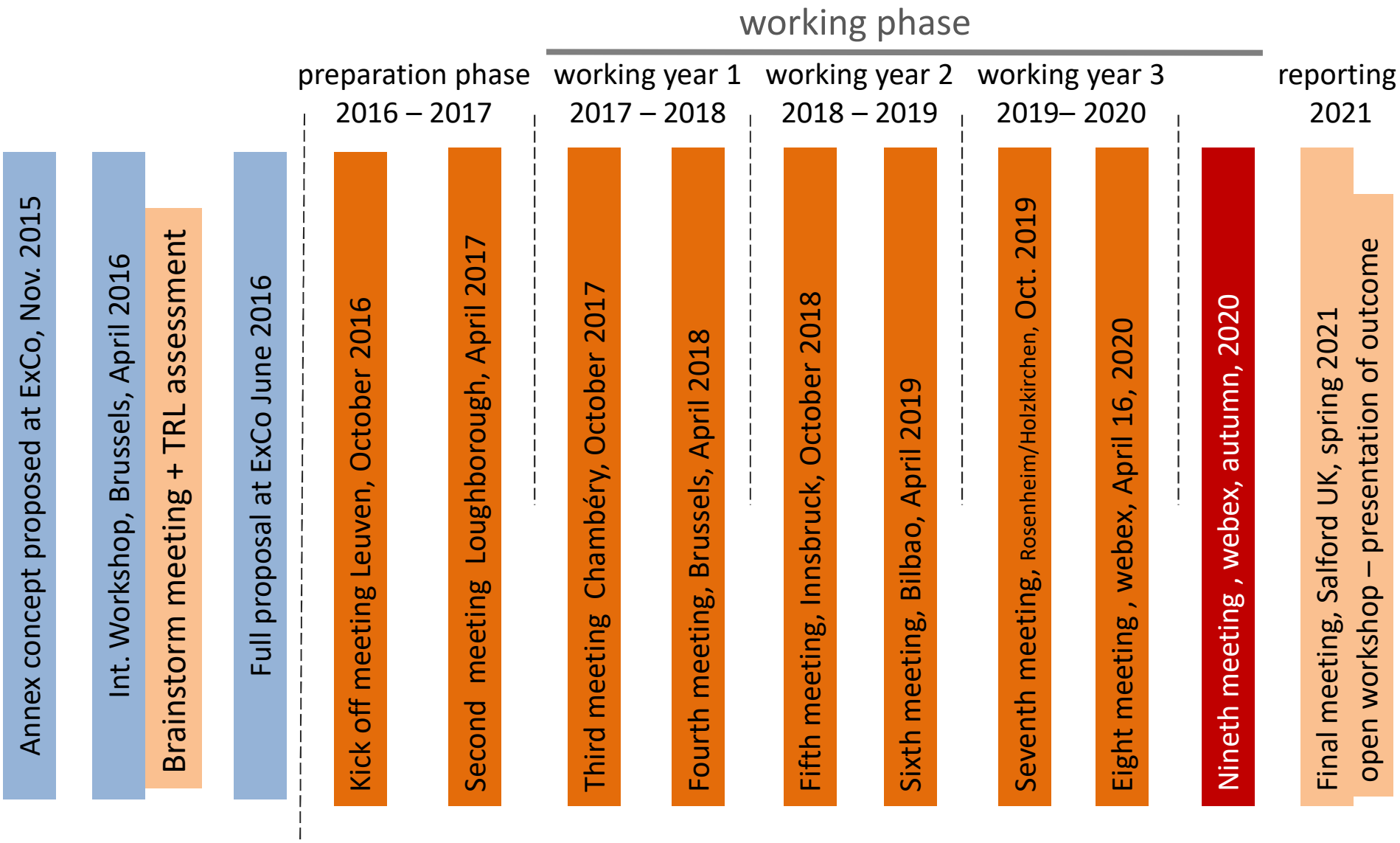
25th - 26th June 2020, Internet Meeting

4.17 Annex 71: Building Energy Performance Assessment Based on In-situ Measurements

SR provided a short update on the Annex 71 working phase. They will be requesting reviewers to be assigned at the November 2020 meeting. Under Item 1.5, it was agreed to extend Annex 71 by six months.

4.18 Annex 70: Building Energy Epidemiology: Analysis of Real Building Energy Use at

New time schedule



Reporting time schedule

Outline and first onset of reports	At next Expert Meeting in Trondheim October 2020 instead of April 2020
Draft reports ready for internal review	~~Begin September 2020~~ January 2021
Internal review due by	Last Expert Meeting ~~October 2020~~ April 2021
Draft reports ready for ExCo-review	~~Mid November 2020~~ May 2021
Final reports	~~Spring 2021~~ Autumn 2021

Reporting time schedule

Status of IEA EBC A71 project

ST1: Gathering input data (Richard Fitton)

ST2: Building behavior identification (Dirk Saelens, Glenn Reynders)

ST3: Physical parameter identification (Chris Gorse, Geert Bauwens)

BES Validation exercise (Paul Strachan, Matthias Kersken)

ST4: Towards quality assessment (Liesje van Gelder)

ST5: Network of excellence (Hans Bloem, Luk Vandaele, Maria José Jimenez)

Subtask 1.
Gathering input data

Richard Fitton (USal, UK)

Sub Task 1 Update

Progress Update

- All work has focused on preparation of the final report.
- We have worked with ST4 to provide a common report
- Easier to read, and flows as such:
  1. Background to work Performance gap- modelling etc.
  2. Quality Guarantee
  3. Stakeholder Survey
  4. State of the art survey
  5. HTC
  6. Current methods of gathering HTC in situ (very in depth!)
  7. Smart meters and on board controls
  8. Use Cases for HTC
  9. Conclusions

Sub Task 1 Update

Progress Update

- PDF Draft has been passed around for comments, structure, missing items etc, not formatted or proofread yet
- We welcome all comments and feedback for ST1 areas to r.fitton@Salford.ac.uk
- Or to Richard Jack for ST4 areas Richard Jack richard.jack@buildtestsolutions.com

Sub Task 1 Update

Special Edition Journal:

Prof David Johnston at Leeds Beckett and I are editing:

- Special Issue of *Sustainability* on *"*Understanding and measuring the Building Fabric Performance of Low Carbon Dwellings*",*
- We invite original papers or state-of-the-art reviews dealing with the issues surrounding the thermal performance of the building fabric in new build dwellings and new, novel or existing techniques that can be used to assess, measure and quantify the fabric performance of new dwellings in-use.
- **We would encourage the submission of papers that develop the area of cost effective and rapid solutions of building performance measurement**
- **Deadline 31/Dec 2021**
- **I will circulate link after meeting.**

Subtask 2.
Building behaviour identification

Dirk Saelens (KUL, Belgium), Glenn Reynders (EV, Belgium)

ST2: Building behavior identification

Dirk Saelens (KUL, BE), Glenn Reynders (EV, BE)

Two main applications were defined

- Fault Detection and Diagnostic (FDD)
- Model Prediction Control (MPC)

Work centered around common exercises on the Twin Houses case

Fault Detection & Diagnostics (FDD)

Theoretical background

- FDD framework (Tianyun)
- Statistical framework (Michael)
- Model versus fault (Tuule will initiate)

Wikipage (consolidation in final report):

https://docs.google.com/document/d/1MfeJeU3iE6SWumz4yqu1y6Pdx0LNlDTLg3Ywnoh0xC0/edit?usp=sharing

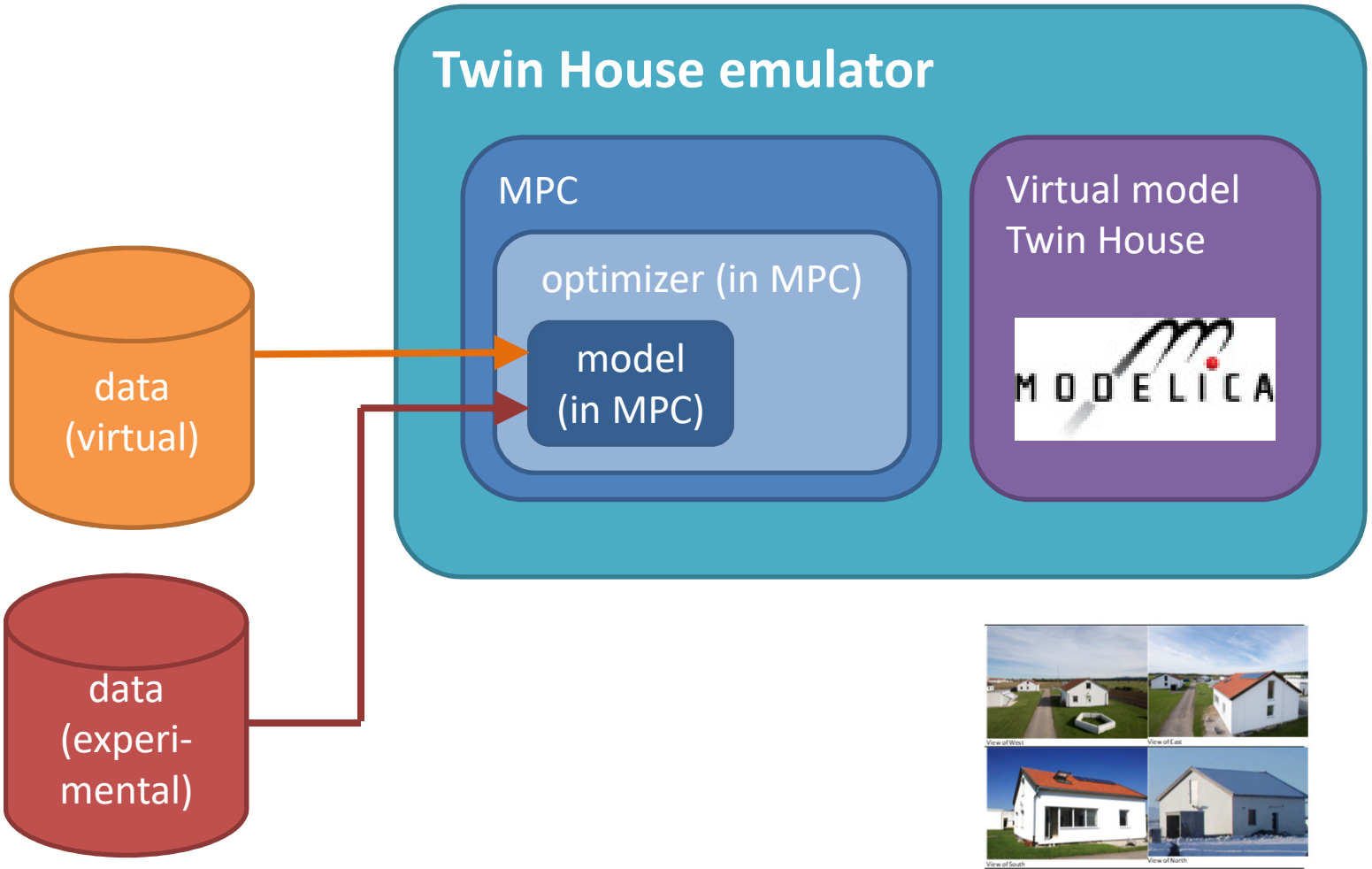
Common Exercise 2

Application related: the Twin Houses case

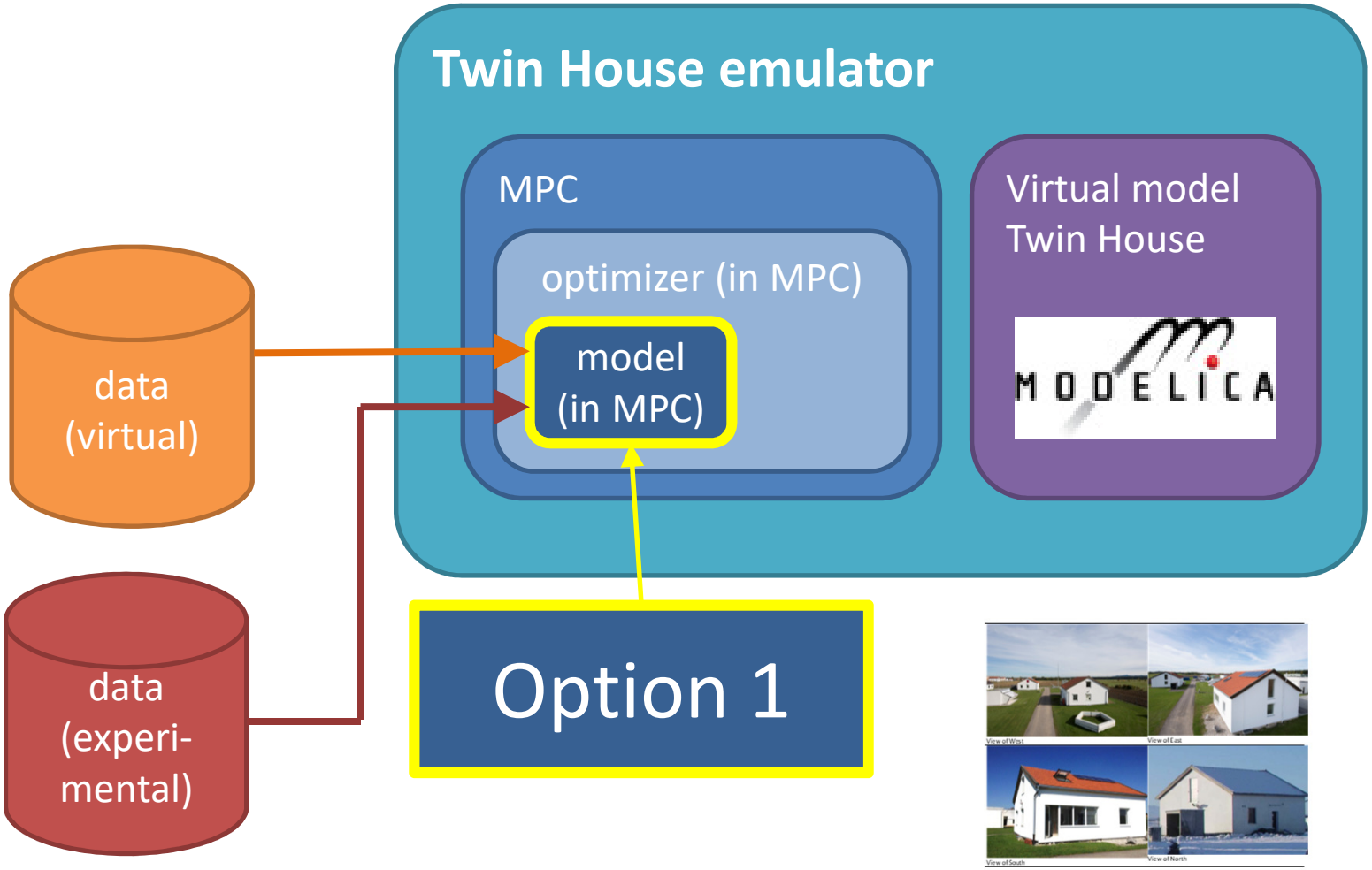
Fault Detection and Diagnostic (FDD)

- CE2 FDD Bilbao case
  - model based on virtual data
  - virtual data set with fault
- CE2 FDD Rosenheim case (closed)
  - model based on virtual data
  - second virtual data set with fault
- CE3 FDD Holzkirchen case (preliminary results)
  - model based on virtual data
  - model based on experimental data
  - experimental data set with fault

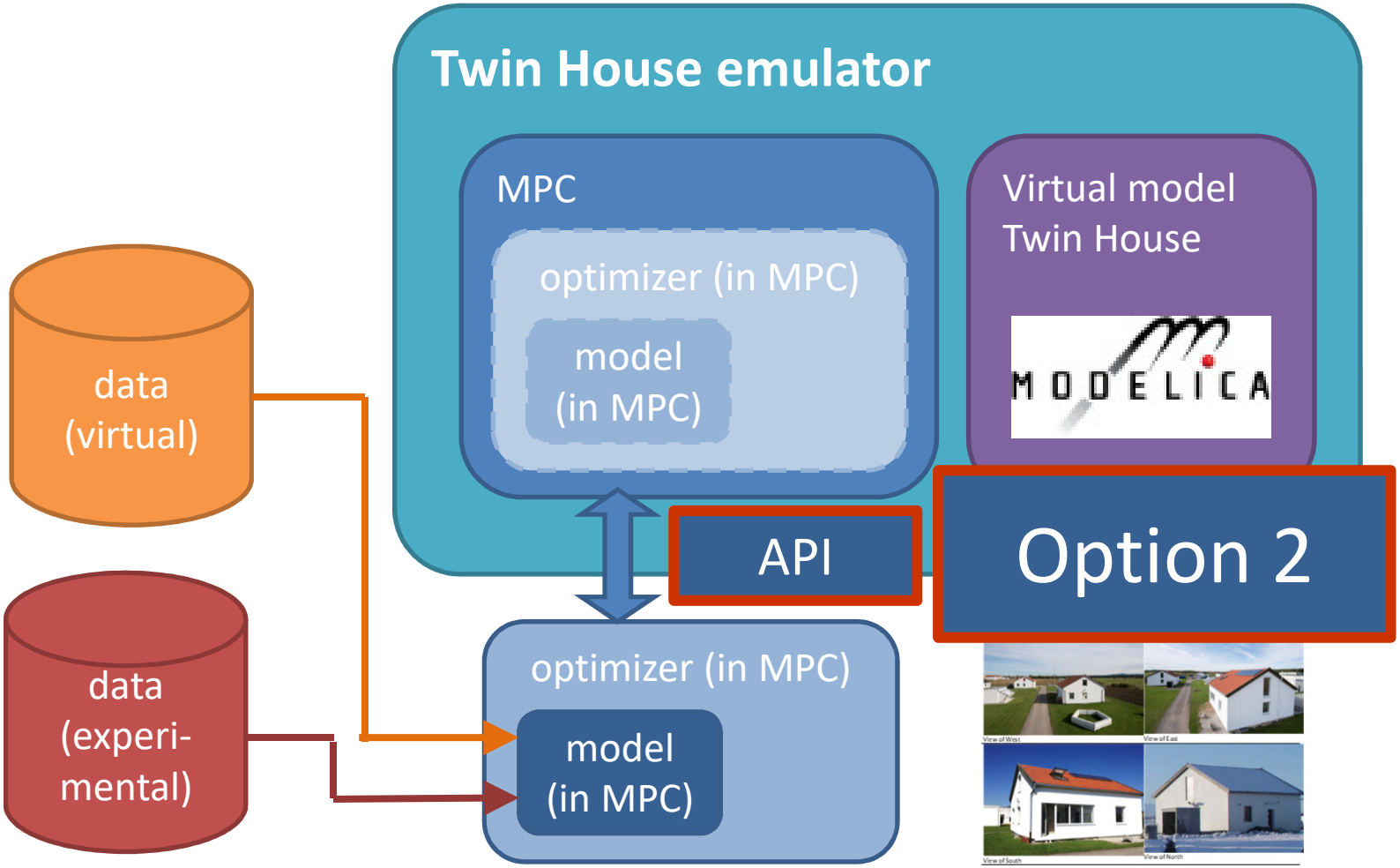
Common Exercise: MPC framework



Common Exercise: MPC framework



Common Exercise: MPC framework



Common Exercise MPC: Lessons learned

They don't really correspond !

Model description		Model's KPIs	Controller's KPIs		
Type of model	Number of states/ neurons	R^2 (%) One-step ahead	Discomfort Level (Kh)	Electricity Consumption (kWh)	Electricity cost (€)
Reference case	-------	-------	9.1	210	11.9
ARX (Tuule)	3	97.8	10.8	174	9.1
ANN - NARX	7	99.21	10.3	173	9.05
Black-box	1	97.4	10.9	169.6	8.83
Grey-box Peder	2	97.82	9.9	175.8	8.82
Black-box state space	7	98.31	10.3	161	8.54

Common Exercise MPC: Lessons learned

Model description		Model's KPIs			Controller's KPIs		
Type of model	Number of states/ neurons	R^2 (%) One-step ahead	R^2 (%) Multi-step-ahead (Mean)	R^2 (%) Multi-step-ahead (Min)	Discomfort Level (Kh)	Electricity Consumption (kWh)	Electricity cost (€)
Reference case	-------	-------	-------	-------	9.1	210	11.9
Black-box (ARX)	3	97.8	-------	86.7	10.8	174	9.1
ANN - NARX	7	99.21	91.97	85.03	10.3	173	9.05
Black-box	1	97.4	92.95	90.4	10.9	169.6	8.83
Grey-box Peder	2	97.82	94.38	90.72	9.9	175.8	8.82
Black-box state space	7	98.31	97.62	96.42	10.3	161	8.54

MSPE (Multi-step ahead prediction error) is a better indicator than the one step-ahead error

ST2: Building behavior identification

Dirk Saelens (KUL, BE), Glenn Reynders (EV, BE)

Towards final report

1) Introduction
2) Test-cases
3) Fault-detection and diagnostics
    1) Problem statement
    2) Theoretic background
        1) Statistical tests to determine faulty behavior
        2) Linking types of faults to modelling and detection approaches
        3) Components of building energy systems and the classification of faults
    3) Description of modelling techniques
    4) Application to simulated data
    5) Application to real data
    6) Lessons learned
4) Model predictive control
    1) Problem statement
    2) Description of modelling techniques
    3) Application to simulated data
    4) Application to real data
    5) Lessons learned
5) Lessons learned

Agenda meeting

1) Consolidation of TOC final report & assigning roles
2) Discussion major lessons learned & remaining gaps
    1) MPC
    2) FDD

Subtask 3.
Physical parameter identification

Chris Gorse (LBU, UK), Geert Bauwens (KUL, Belgium)

Status

Aim of Subtask 3

Assess H in a **precise**, **reproducible** and **repeatable** way

Status

- Since last virtual Trondheim meeting, Subtask 3 participants met May 18, June 22, September 7 and October 5
- Since 1 year focus on **individual heat balance terms**:

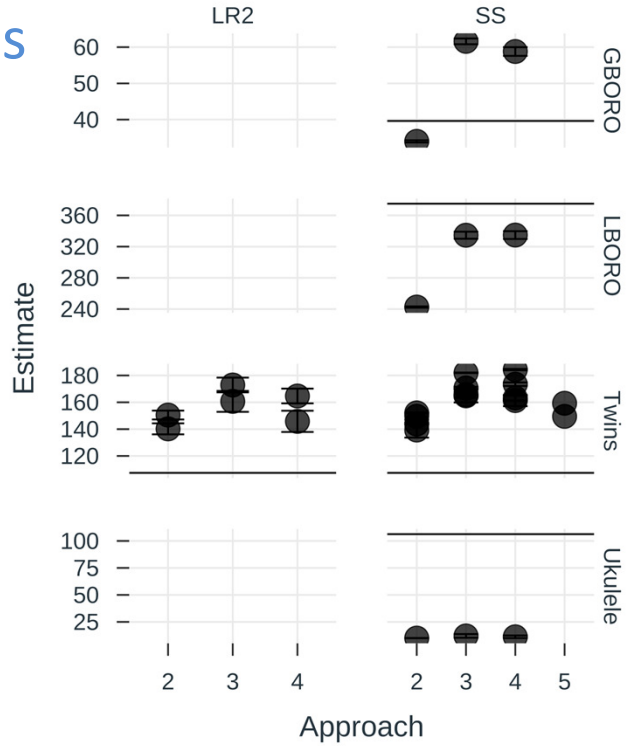
Working groups

- **Solar gains**
  Christoffer, Kristian, Jason, Simon, Frances
- **Heat input**
  Geert, Matthew, Jade, Katia, Frances
- **Infiltration heat loss and ventilation heat loss**
  Simon, Kristian, Twan
- **Occupant and appliance heat gain**
  Jade, Maria, Twan, Jason
- **Weather data**
  Kristian, Geert, Christoffer
- **Indoor temperature**
  Jason, Lorena, Gabrielle

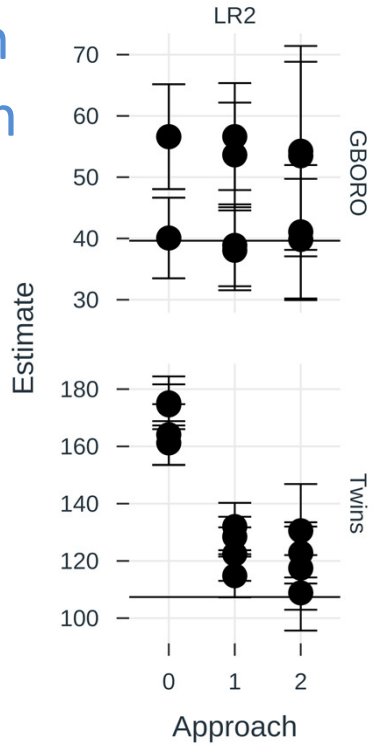
Status

- Working groups have: (1) generated additional input data, and (2) refined modelling approaches

Solar gains



Infiltration
Ventilation

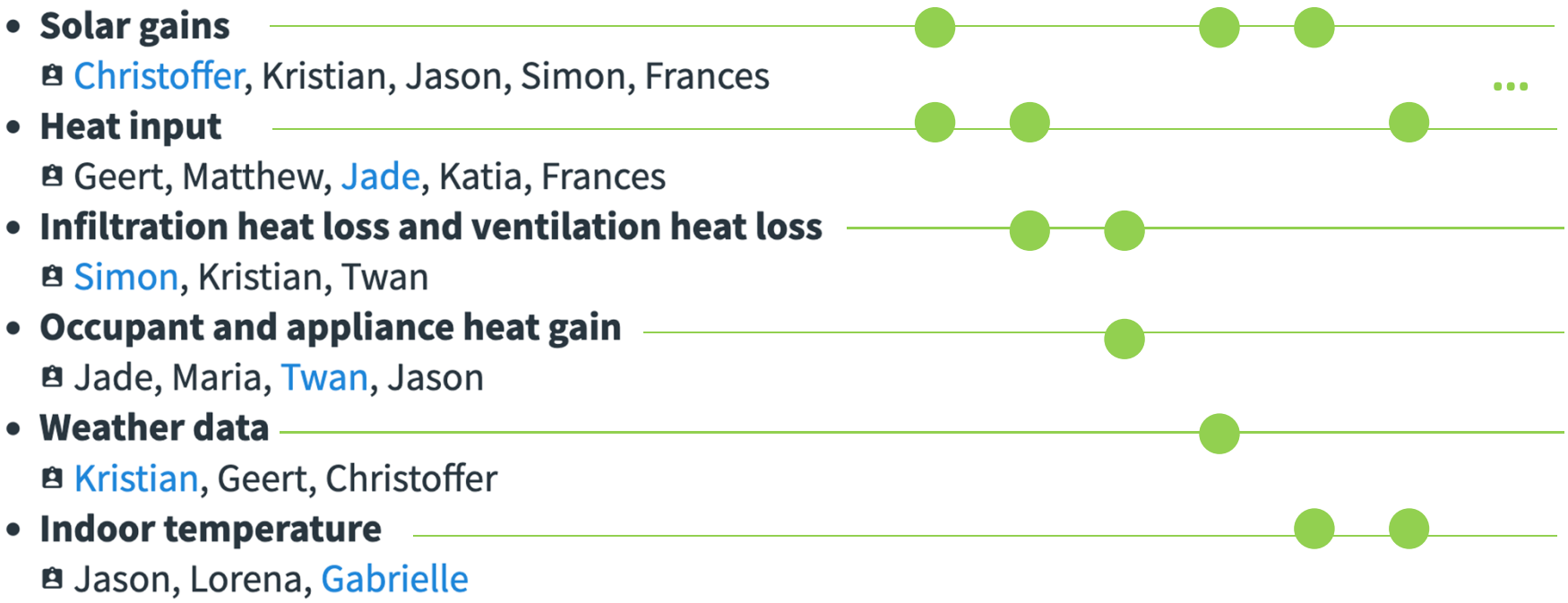


ST3: Physical parameter identification

Chris Gorse (LBU, UK), Geert Bauwens (KUL, BE)

Status

- Towards combined optimal approaches



Status

- Towards optimal approach for case studies

Twin Test Houses (Twins)		HLC	107.38 W/K	Co-heating
		gA	10.21 m2	Co-heating
Uccle test house (Ukulele)		HLC	106.3 +- 15.3 W/K	PRBS
		gA	5.92 m2	SAP
LBORO		HLC	375 +- 88 W/K	
		gA	5.3 m2	LBORO
GBORO		HLC	39.63 +- 10.32 W/K	
		gA	3.6 m2	GBORO

Status

- Towards optimal approach for case studies

BEIS TEST project case studies?

BEIS TEST project

The Technical Evaluation of SMETER Technologies (TEST) Project

Funded by the UK Department for Business, Energy and Industrial Strategy (BEIS)

- Loughborough University: David Allinson, Ben Roberts, Kevin Lomas, and Dennis Loveday.
- Leeds Beckett University: Chris Gorse, Adam Hardy, Felix Thomas, Dominic Miles-Shenton, David Johnston, David Glew, Fiona Fylan, and David Farmer.
- UCL: Cliff Elwell, Jenny Crawley, Frances Hollick, and Jez Wingfield.
- Halton Housing: Gavin Roberts, and Lee Reevell.

Department for Business, Energy & Industrial Strategy
Halton Housing
LBU LEEDS BECKETT UNIVERSITY
UCL
Loughborough University

BEIS TEST project

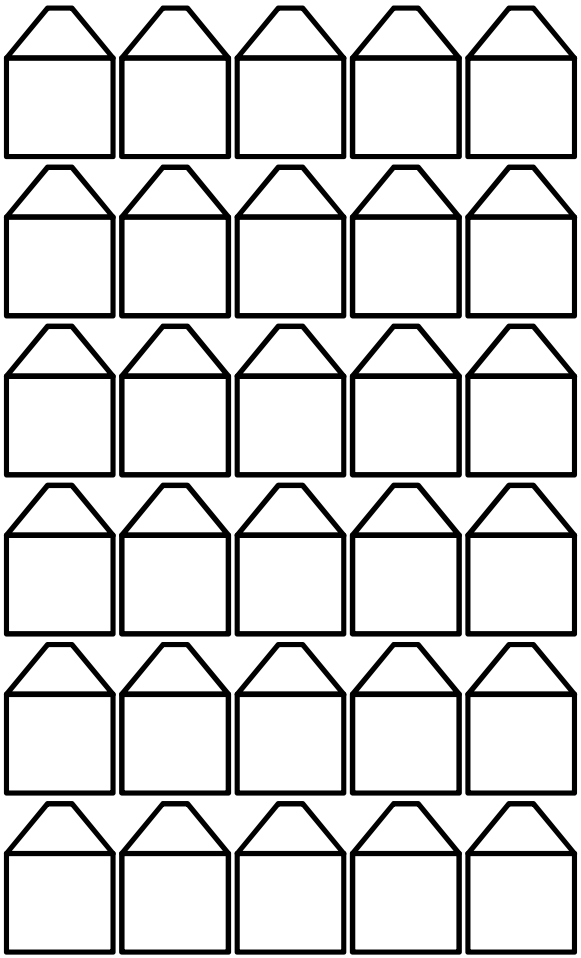
SMETER = **S**mart **M**eter **E**nabled **T**hermal **E**fficiency **R**atings.

SMETERs use smart meter data to measure the HTC of a home, while it is occupied.

Nine innovators have been funded by the Department of BEIS to develop SMETERs.

The TEST Project is funded to support the development of SMETERs and evaluate their performance in a field trial.

BEIS TEST project



Field trial

30 void single family homes in NW England

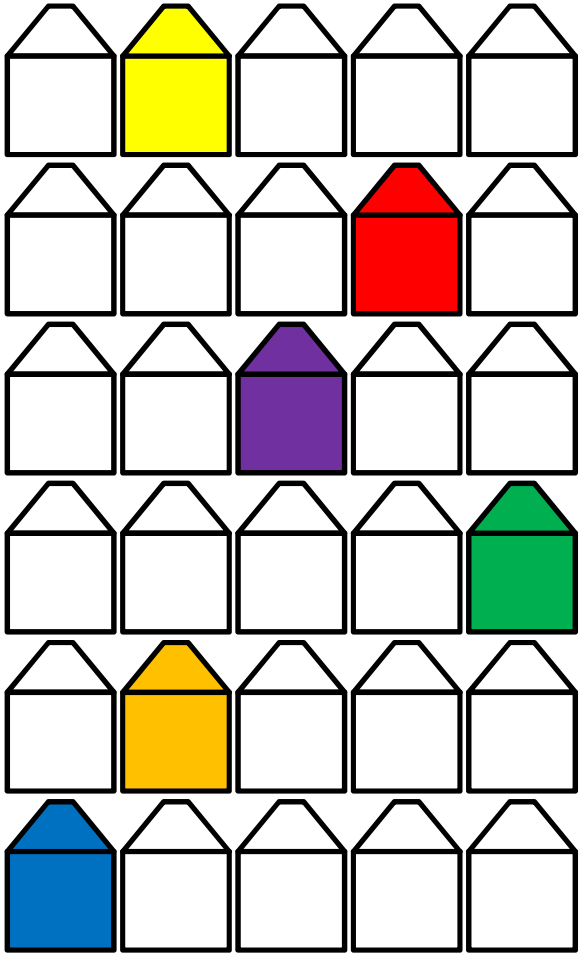
Full survey

Co-heating test (and QUB)

Airtightness tests

Household moved into to every home

BEIS TEST project



Opportunity

BEIS have agreed to release data from six homes for Annex 71

In-situ monitored data winter 2019 - summer 2020

- Half hourly gas and electricity
- Air temperature in multiple rooms
- Weather station data
- Associated survey information

Blind test of algorithms ?

Draft report

1. Introduction
2. Building Physical Framework
3. Statistical modelling approaches
4. Determining the input variables
5. Case studies
6. Exploration of inputs
7. Discussion of results
8. Conclusion
9. Annex 1: CEs
10. Annex 2: Implementation of modelling approaches in R and Python
11. References

Planning

2020 2021

Nov Dec Jan Feb Mar Apr Salford May

Dec 24: Draft report out for internal review

April: Internal review due

Dec 18: Draft report reworked

May: Draft report ExCo

Oct 29: Action plan for draft report rework + final division of work

April: Rework draft report

4 case studies combined modeling approaches

BEIS Test data prep

Launch of BEIS Test case

ST 3 break-out session

Session 1 10:00 – 11:15

- **Your feedback**
ST 3 process, observations, remarks on global structure
- Draft report
Major lessons learned?
Remaining knowledge gaps?
What are we still missing in report?
- Discuss Ch 6 & Ch 7

Session 2 11:30 – 13:00

- BEIS Test case
- Annex 1 & Annex 2:
How best to provide access to resources for report readers

- Steps to consolidate report
- Assigning roles & planning

Action points

Volunteers

- Review draft report
- Ch 4 Determining the input variables
  Geert provides **heat input** part as example by end of October
  WG leaders rewrite part by November 25
  Still some gaps and lacks consistency
  Review your part
  Provide context and binding text
  Some parts -> Ch 6
  Indoor temperature: now only for Twin Test Houses; also refer to Senave et al. (2020)
- Ch 5 Case studies:
  Twin Test Houses and LBORO as example
  Add **Uccle** & **GBORO**
- Ch 6 Evaluation of impact

Action points

Volunteers

- Ch 5 Case studies:
  Twin Test Houses and LBORO as example
  Add **Uccle** & **GBORO**

By **November 25**

Uccle: Jade

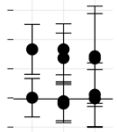
GBORO: 1-2 pager based on paper; Twan?

- Ch 6 Exploration of inputs

Action points

Volunteers

- Ch 6 Exploration of inputs:
  Quantify impact of approaches
  Consistency



Geert provides by November 11

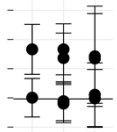
R-script to generate charts and csv format on Trello-board!

WG leaders provide part by December 16

Action points

Volunteers

- Ch 6 Exploration of inputs:
  Quantify impact of approaches
  Consistency
- Ch 7 Discussion of results:
  Combine approaches for case studies



By mid November collect approaches, report by **December 16**

Twin Test House O5	**Katia** (ARX, LR), Jason (GB), Gabrielle
Twin Test House N2	**Katia** (ARX, LR), Jason (GB), Gabrielle
Uccle Test House	**Jade** (GB), Kristian (ARX, LR)
Loughborough	**Frances** (GB, LR), Christoffer (ARX)
Gainsborough	**Kristian** (ARX, LR), Jason (GB)

Action points

Volunteers

- Ch 8 Blind test
  BEIS TEST case (include?)
- Annex 1: CEs
- Annex 2: implementations

Annex 71 website

Host it on Dynastee website as well; contact Hans/Luk

Host it on IEA EBC

Action points

Volunteers

- October 29: action plan ch 4 and 6
- November 18: Ch 7 data & approaches collected (@Katia)
- November 25: Ch 4 rewritten
- **Wednesday December 9, 9am**: **WebEx** to discuss results (ch 7)
- December 16: Ch 6 rewritten
- December 23: Draft report ready for internal review A71

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GE)

Agenda of the BESmodVAL break out session an Tuesday (14:00 - 15:00)

- Status of this Annex71-part
- Analysis
  - Metrics used
  - 2-step validation method
  - Data decomposition
  - Questionnaire
- Results of
  - Main Experiment
  - Extended Experiment
- First Conclusions of the BES Model Validation
- Next steps

BES-validation exercise

Matthias Kersken (IBP, GER), Paul Strachan (ESRU, UK)

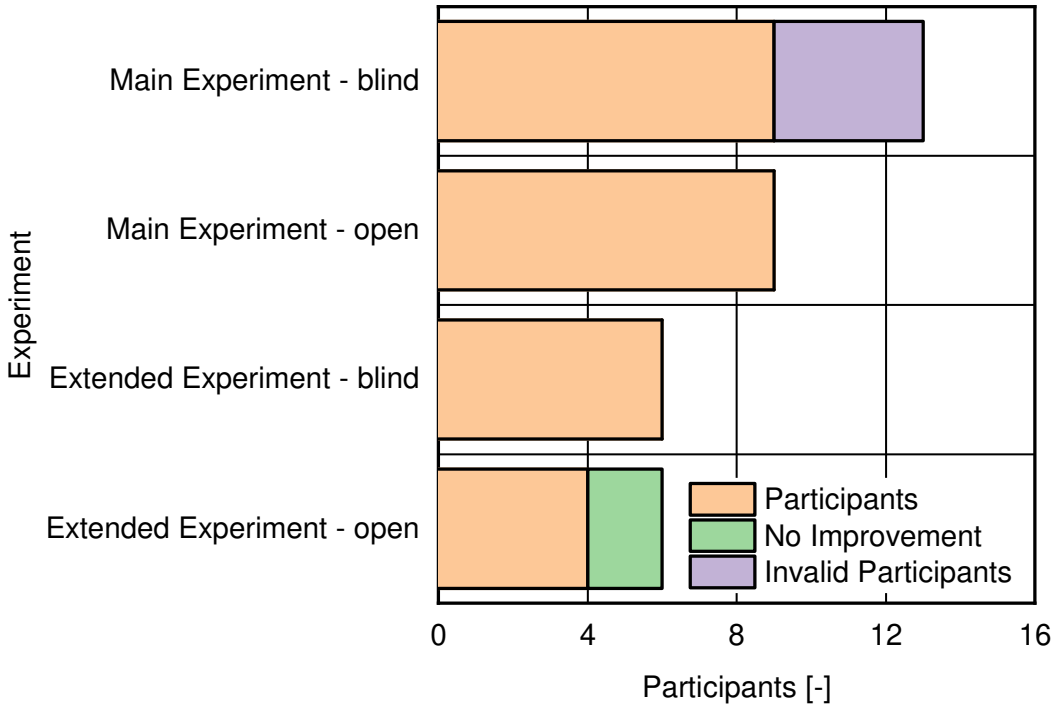
Status

- Experiment ✓
  - Experimental design ✓
  - Experimental setup ✓
  - Conduction of Experiment ✓
  - Experimental specifications ✓
- Validation ✓
  - Dissemination ✓
  - Results from ✓
    - ME – blind & open phase ✓
    - EE – blind & open phase ✓
  - Project reports and questionnaire ✓
- Analysis ✓
  - Trend line graphs ✓
  - Metrics' tables ✓
  - Questionnaire ✓
- Documentation
  - QnA -> Experimental specs ✓
  - Data & specs with DOI ✓
  - IEA report *(near completion)*
- Publications *(so far)*
  - Experimental design (BS2019)✓
  - Experiment (NSB2020) ✓
  - Results: Blind (BS2021);Open (?)

BES-validation exercise

Matthias Kersken (IBP, GER), Paul Strachan (ESRU, UK)

Submission overview

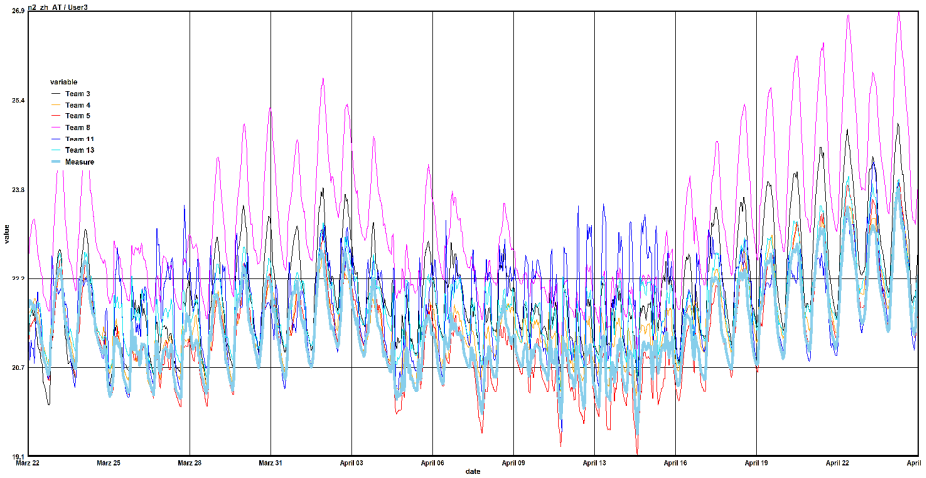


BES-validation exercise

Matthias Kersken (IBP, GER), Paul Strachan (ESRU, UK)

Extended experiment: results' preview

metric	mean					
Summe von Value	**Spaltenbeschriftungen**					
Zeilenbeschriftungen	**team_03**	**team_04**	**team_05**	**team_08**	**team_11**	**team_13**
n2_zh_AT						
User3	0,7	0,2	-0,1	1,9	0,5	0,5
PRBS	1,2	1,0	0,7	2,9	2,5	0,8
FreeF	0,9	2,4	0,4	2,7	2,7	1,0
o5_zh_AT						
User3	0,5	-0,7	-0,2	1,5	0,1	0,0
PRBS	0,8	-0,1	0,1	2,8	2,1	0,5
FreeF	0,4	1,3	-0,4	2,5	2,0	0,6
n2_gf_AT						
User3	0,9	0,8	0,0	2,5	1,1	0,5
PRBS	2,1	1,6	1,7	4,0	4,7	1,2
FreeF	1,6	2,7	0,9	3,3	4,3	1,1
o5_gf_AT						
User3	0,6	-0,3	-0,1	2,0	0,4	0,0
PRBS	1,5	0,2	1,1	3,8	4,0	0,8
FreeF	0,9	1,4	0,1	3,0	3,3	0,6
n2_att_AT						
User3	0,4	-0,6	-0,1	1,0	-0,3	0,5
PRBS	0,0	0,1	-0,8	1,3	-0,6	0,1
FreeF	0,0	1,9	-0,4	1,7	0,4	0,8
o5_att_AT						
User3	0,2	-1,2	-0,2	0,8	-0,4	0,0
PRBS	-0,2	-0,5	-1,2	1,2	-0,6	0,1
FreeF	-0,4	1,2	-1,0	1,7	0,3	0,6
n2_aroom_living_110_AT						
User3	0,7	0,4	0,0	2,5	1,3	0,6
PRBS	1,3	0,9	1,4	3,5	4,4	1,0
FreeF	1,4	2,6	0,9	3,3	4,6	1,3
o5_aroom_living_110_AT						
User3	0,6	-0,9	-0,2	1,9	0,7	0,1
PRBS	0,8	-0,7	0,7	3,2	3,5	0,4
FreeF	0,8	1,2	0,1	2,8	3,5	0,7



Subtask 4.
Towards quality assessment

Liesje van Gelder (BCCA, Belgium)

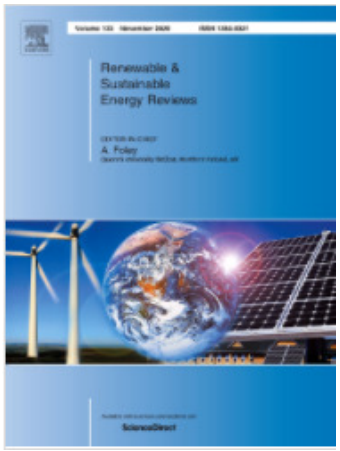
EBC Annex 71

ST4: Towards quality assessment

Liesje van Gelder (BCCA, BE)

Original brief:

- Understand how HTC measurement can be used (in regulations, guidelines, commercially)
- Define required operating conditions for performance measurement (reliability, accuracy, cost, length)



Activities:

- Survey of annex members
- Survey of stakeholders (243 stakeholders, 14 countries)

Outputs:

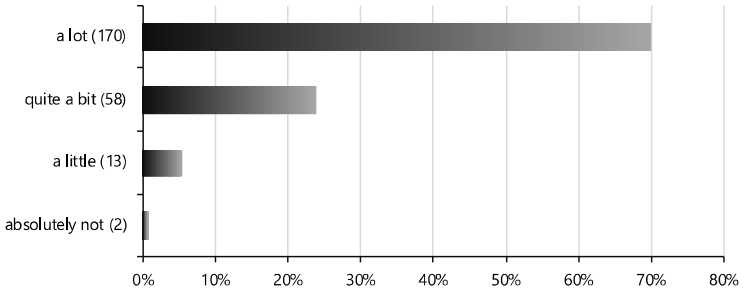
- Annex report ☺, draft complete combined with ST1
- Journal paper ☺, submitted to Renewable and Sustainable Energy Reviews journal, under review

Thanks to the work of Chirag Deb, Liesje van Gelder, Marleen Speekman, Gillaume Pandraud, Richard Jack & Richard Fitton

ST 4 Findings: How to use HTC measurements?

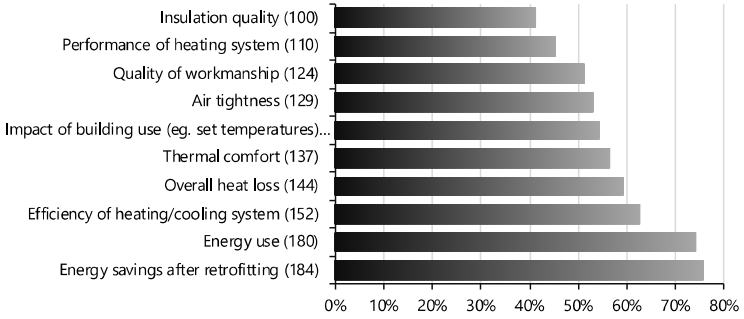
People want measurement ☺

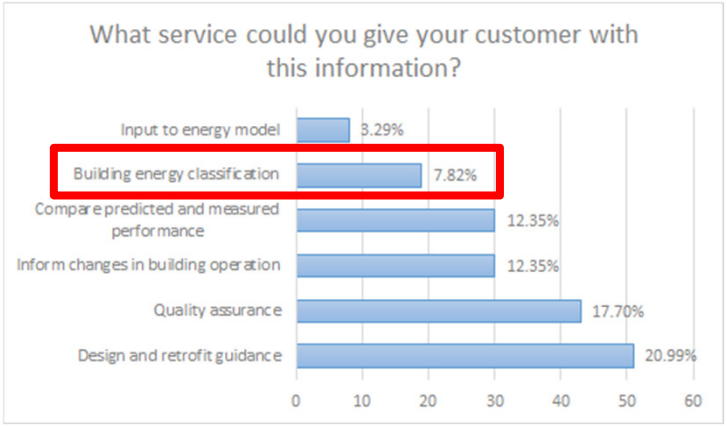
Q: How interested are you in a method that is able to measure the actual energy performance of a building after delivery?



Most interested in energy use

Q: If yes, in which aspects of this energy performance?





Services leading from measurement less clear…

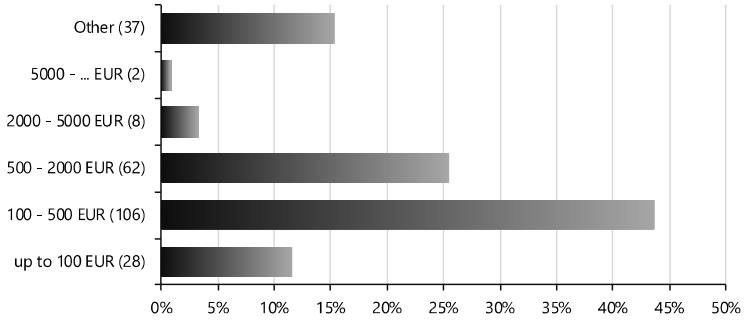
Focussed on advice and quality assurance

Not so much on classification… demand for legislated HTC performance not YET there?

ST 4 Findings: Required operating conditions

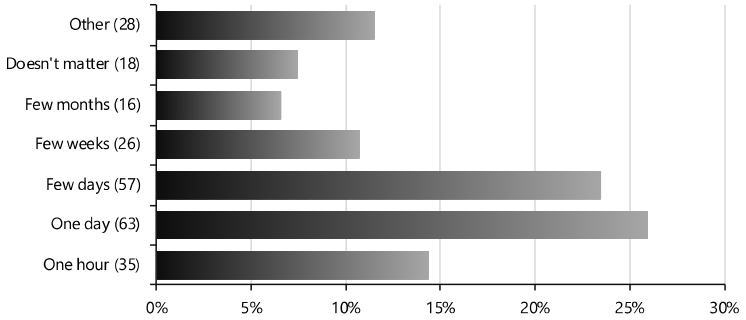
Must be cheap, <500EUR

Q: What should be for you the acceptable cost?



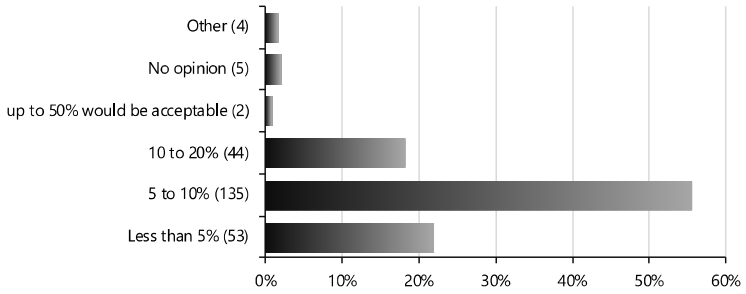
Should be quick

Q: What is an acceptable duration of the test in your opinion?



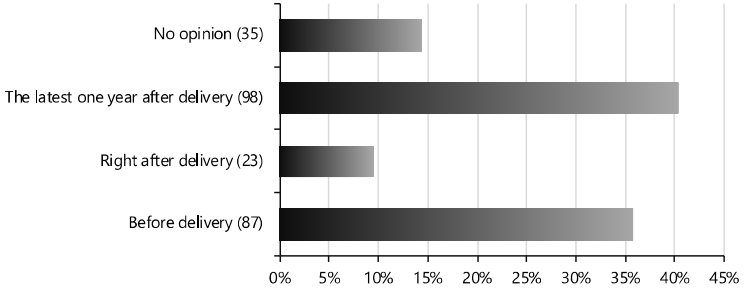
Must be accurate, CI<10%!

Q: What should be for you the acceptable error (confidence interval associated to the measured value of the HTC)?



Best before or just after delivery

Q: When should the determination be done to be most beneficial?



ST 4 Conclusions

- Lots of interest
- Not yet thought of as a legislative tool/metric
- Must be fast, cheap & accurate!
  - Accuracy demand of <10% particularly challenging
  - Qualitative answers show test needs to be short as is assumed to be invasive, if non-invasive can be longer
  - Acceptable cost often linked to cost of energy use (hence relatively cheap)
- Little agreement in how to use an HTC measurement – e.g. require builder to repair? Fines for builder or designer? Use to adjust future or retrofit designs?

Two attractive specifications:

- Quick, carried out before occupancy, more useful for new-build
- Non-invasive, carried out during occupancy, more useful for existing buildings

What next?

- Original brief largely met, but outstanding question is once you have a reliable HTC measurement, what do you do with it?!

Subtask 5.
Network of excellence

Hans Bloem, Luk Vandaele, Maria José Jimenez, Richard Fitton

Input to final report Annex 71 project 2016 – 2021
Dissemination by means of:

Web-site; www.**DYNASTEE.info**

Newsletters; 10 issues published. Foreseen another 2 until June 2021.

Events; Webinar, Workshops and Summer Schools

Training on *Dynamic Calculation Methods for Building Energy Performance Assessment.* Summer Schools have been organised in 2016, 2017, 2018 and 2019. The **Summer School** organisers have scheduled a weeklong physical Summer School in Almeria, June 2021. **On-line** training; 5 webinars in September 2020.

Scientific and technical exchange events: **Symposium** in Bilbao, Spain 2019. The Building as the Cornerstone of our Future Energy Infrastructure – The importance of dynamic and real data for reliable assessment. 52 participants.
Workshop on Building energy performance assessment and quality assurance based on in-situ measurements that took place in Brussels, 2018. 80 participants
Workshop: "Building energy performance assessment based on optimised in-situ measurements", was successfully held in Brussels, 2016. 100 participants attended this event

DYNASTEE On-line training
Dynamic Calculation Methods for Building Energy Performance Assessment

Five webinars, replacing the weeklong physical Summer School, have taken place in **September, every Wednesday 10:00-12:00**

Each webinar has been composed of two lectures and the introduction of an exercise using benchmark data that has been made available to the participants for training. Lecturers came from 5 different countries. Participants were mostly from Europe but several from other parts of the world (Brazil, Australia, etc.)

The **Summer School** organisers have scheduled a weeklong physical Summer School in Almeria, in **June 2021**.
Feel free to contact mjose.jimenez@psa.es or hans.bloem@inive.org to be placed on the Summer School mailing-list

Initial evaluation of the DYNASTEE training webinars, September 2020

110 different true participants over 5 webinars (each Wednesday 10:00 – 12:00);

Webinar 1 (72 p) Presenting DYNASTEE and its history; training at Summer School
Webinar 2 (76 p) Introduction to dynamic methods and software tool LORD.

Webinar 3 (43 p) Presenting the experimental set-up and measurement equipment

Webinar 4 (45 p) Introduction to CTSM-R and application with PSA data

Webinar 5 (33 p) Conclusions and Questions & Answer

51 persons attended 3 or more webinars of which 27 attended 4 or all 5 webinars.

A survey has been prepared and mailed to all 110 participants. Results will be published in the DYNASTEE Newsletter 17, November 2020

agenda

Monday 19th October

9 am – 1 pm Intro + break out session on ST3

9 am – 10 am: Plenary session with overview and status of different subtasks

10 am – 1 pm: Breakout session on subtask 3

2 – 5 pm Break out session on ST2

Tuesday 20th October

9 – 12 Joint break out session on ST1 and ST4

2 – 3 pm Break out session on BES-validation exercise

3 – 5 pm core group meeting

Wednesday 21st October

9 – 10 am plenary wrap-up session:

feedback of the breakout session, follow up actions


COFFE
BREAK
TIME

Subtask 2.
Building behaviour identification

Glenn Reynders (EV, Belgium), Arash Erfani (KUL, Belgium)

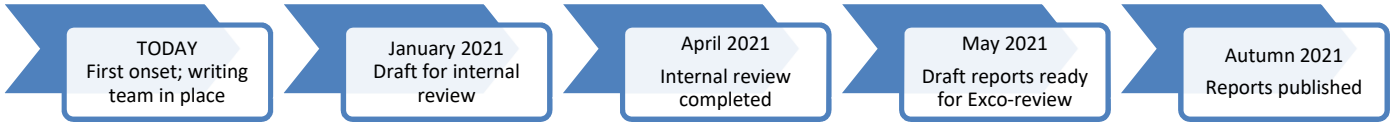
Agenda

- **Final report**
  - Planning
  - TOC
  - Setting up writing team
- **MPC common exercise**
  - Results of last iterations of CE
  - Discussion on lessons learned
  - Steps to finalize
- **FDD common exercise**
  - Discussion of lessons learned
  - Steps to finalize

ST2: Building behavior identification

Glenn Reynders (EV, BE), Arash Erfani (KUL, BE)

Final report



Practical

Google doc has been started and shared amongst CE participants

Next steps

What?	When?
Finalize TOC and contributions	Today
Install writing team	Today
Finalize modelling	November 20th
Finalize first draft	December 1st
Editors review	December 15th

ST2: Building behavior identification

Glenn Reynders (EV, BE), Arash Erfani (KUL, BE)

Final report

1. Introduction
2. Modelling techniques for building behavior identification
3. Test-cases
    - Semi-detached house (Gainsborough, UK)
    - Twin Houses (Holzkichen, Germany)
4. Fault-detection and diagnostics
    - Problem statement
    - Theoretic background
    - Application to simulated data
    - Application to real data
    - Lessons learned
5. Model predictive control
    - Problem statement
    - Description of modelling framework
    - Application to simulated data
    - Application to real data
    - Lessons learned
6. Lessons learned

Final report

(editors : Dirk, Glenn Arash)

1. Introduction -> Editors

context; intro applications; structure report

intro applications will be based mostly upon free papers

- Jaume Palmer et al. (CIMNE)
- Gerard Mor et al. (CIMNE)
- Tianyun Gao (CSTB)
- Rune Junker et al. (DTU)

Final report

(editors : Dirk, Glenn Arash)

2. Modelling techniques for building behavior identification -> all participants

2.1. Overview of modelling techniques

Model	Inputs	Outputs	Ti prediction	FDD	MPC
ARX	T_out, wind speed…	T_i	x	x	
Greybox	…	…	x		x

2.2. Description of modelling techniques

x. Model structure

x. Preprocessing steps

x. Validation steps

Final report

(editors : Dirk, Glenn Arash)

3. Case studies -> Editors

introduction to central case studies (Gainsborough & Twinhouse)
with reference to papers and reports

Final report

(editors : Dirk, Glenn Arash)

4. Fault-detection and diagnostics

- Problem statement -> Editors + Gerard, Peder, Kim?
  - Literature review on FDD
- Theoretic background ->
  - Based upon wiki
  - Statistical tests -> Michael , Peder, Simon, Jordan?
  - type of faults -> Tuule (lead) & Tianyun? + Ulrich Spindler + Gerard + Peder
- Application to simulated data
  - Results of CE2 -> all contributors: any final updates?
- Application to real data
  - Results of CE3 -> all contributors : updates pending
  - *Last call:*
    - *apply models of trained on CE2 on CE3*
    - *apply models of MPC on CE2 and CE3*
- Lessons learned
  - ase discussion

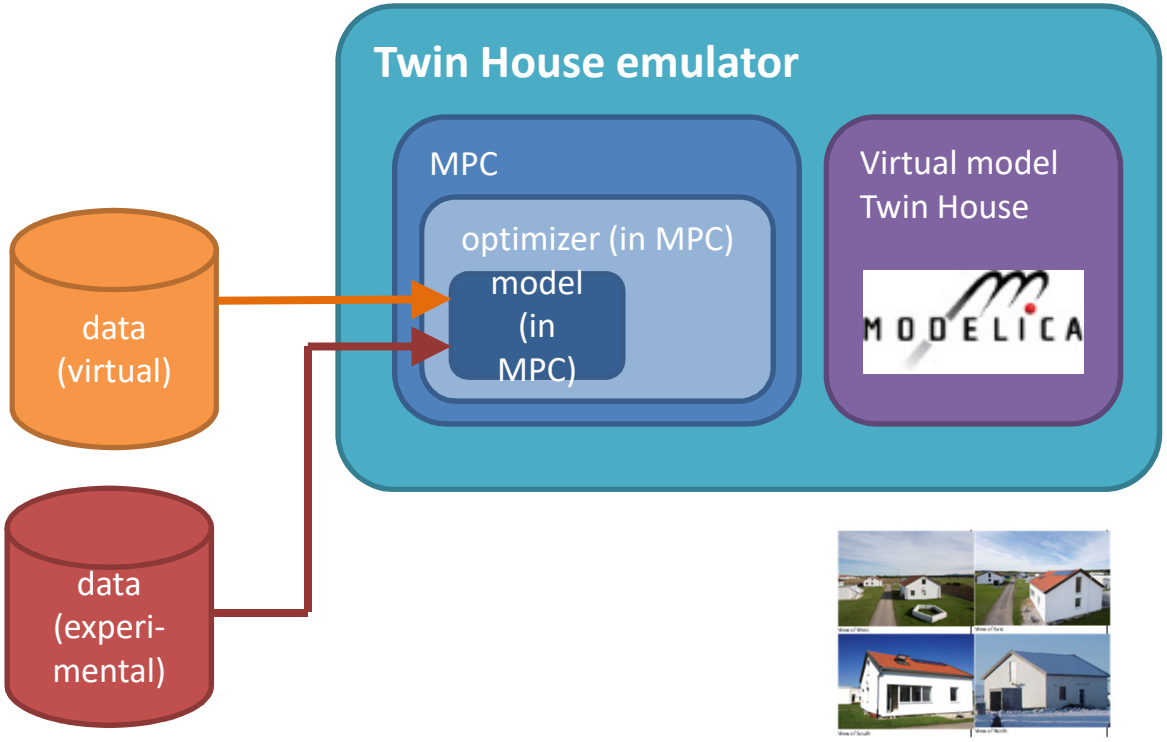
Final report

(editors : Dirk, Glenn Arash)

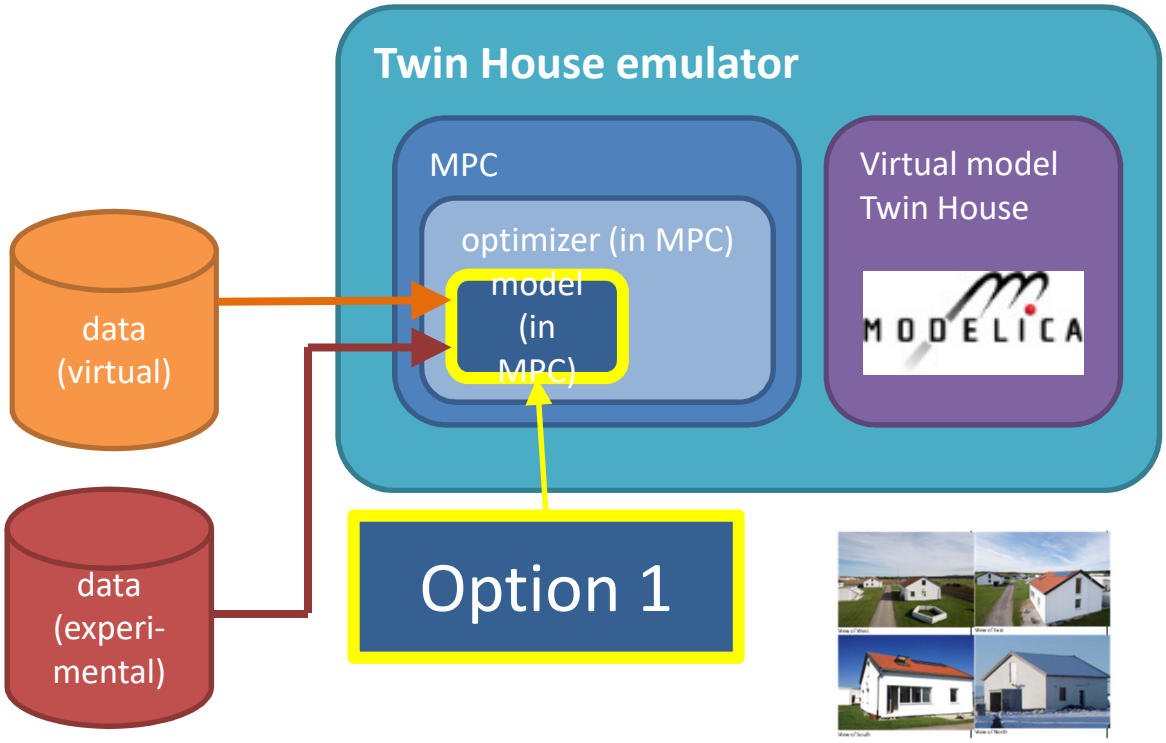
5. MPC

- Problem statement -> Editors?
  - Literature review on MPC
- Description of the modelling framework -> Editors
- Results -> Editors + ?
- Lessons learned
  - see discussion

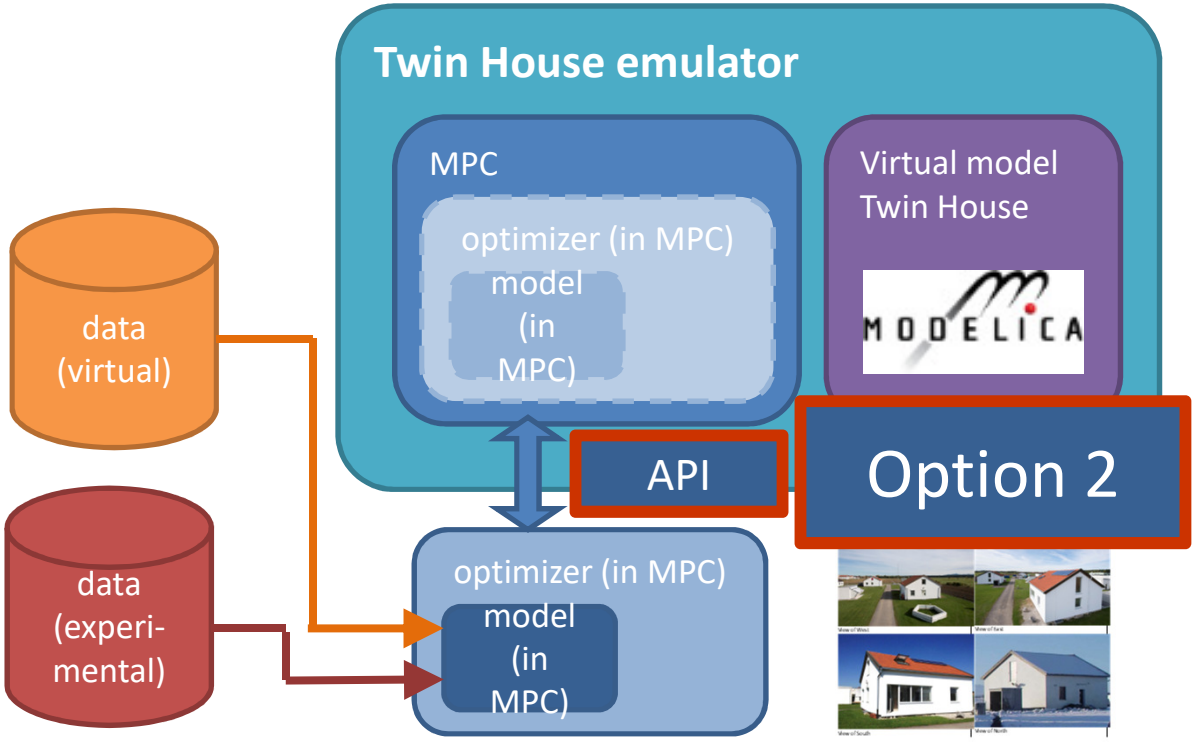
Common Exercise: MPC framework



Common Exercise: MPC framework



Common Exercise: MPC framework



Common Exercise MPC: Lessons learned

They don't really correspond !

Model description		Model's KPIs	Controller's KPIs		
Type of model	Number of states/ neurons	R^2 (%) One-step ahead	Discomfort Level (Kh)	Electricity Consumption (kWh)	Electricity cost (€)
Reference case	-------	-------	9.1	210	11.9
ARX (Tuule)	3	97.8	10.8	174	9.1
ANN - NARX	7	99.21	10.3	173	9.05
Black-box	1	97.4	10.9	169.6	8.83
Grey-box Peder	2	97.82	9.9	175.8	8.82
Black-box state space	7	98.31	10.3	161	8.54

Common Exercise MPC: Lessons learned

Model description		Model's KPIs			Controller's KPIs		
Type of model	Number of states/ neurons	R^2 (%) One-step ahead	R^2 (%) Multi-step-ahead (Mean)	R^2 (%) Multi-step- ahead (Min)	Discomfort Level (Kh)	Electricity Consumption (kWh)	Electricity cost (€)
Reference case	-------	-------	-------	-------	9.1	210	11.9
Black-box (ARX)	3	97.8	-------	86.7	10.8	174	9.1
ANN - NARX	7	99.21	91.97	85.03	10.3	173	9.05
Black-box	1	97.4	92.95	90.4	10.9	169.6	8.83
Grey-box Peder	2	97.82	94.38	90.72	9.9	175.8	8.82
Black-box state space	7	98.31	97.62	96.42	10.3	161	8.54

MSPE (Multi-step ahead prediction error) is a better indicator than the one step-ahead error

Two main applications were defined

- Fault Detection and Diagnostic (FDD)
- Model Prediction Control (MPC)

Work centered around common exercises on the Twin Houses case

Fault Detection & Diagnostics (FDD)

Theoretical background

- FDD framework (Tianyun)
- Statistical framework (Michael)
- Model versus fault (Tuule will initiate)

Wikipage (consolidation in final report):

https://docs.google.com/document/d/1MfeJeU3iE6SWumz4yqu1y6Pdx0LNlDTLg3Ywnoh0xC0/edit?usp=sharing

Common Exercise 2

Application related: the Twin Houses case

Fault Detection and Diagnostic (FDD)

- CE2 FDD Bilbao case
  - model based on virtual data
  - virtual data set with fault
- CE2 FDD Rosenheim case (closed)
  - model based on virtual data
  - second virtual data set with fault
- CE3 FDD Holzkirchen case (preliminary results)
  - model based on virtual data
  - model based on experimental data
  - experimental data set with fault

FDD – lessons learned

- Event errors can be accurately identified in contrast to drifts
- ‘input’ faults cannot be detected with ‘traditional’ modelling approaches
- No significant discrepancy (so far) between performance on simulated and real data
- Not only model but also detection criteria are important

FDD – Open items

- Final contributions on CE3
- Cross-application test
  - Virtual data & real data?
  - MPC > FDD?

Action points

- Closing meeting CE's : 9-13 November 2020
- Editorial one-on-ones: 26-30 October
- Content submission model descriptions: 13 November
- Final CE submissions: 20 November
- First draft: 1 December
- Revised results and lesson learned: 15 December

Sub Task 1 Update

Progress Update

- All work has focused on preparation of the final report.
- We have worked with ST4 to provide a common report
- Easier to read, and flows as such:

1. Background to work Performance gap- modelling etc.
2. Quality Guarantee
3. Stakeholder Survey
4. State of the art survey
5. HTC
6. Current methods of gathering HTC in situ (very in depth!)
7. Smart meters and on board controls
8. Use Cases for HTC
9. Conclusions

Sub Task 1 Update

Progress Update

- PDF Draft has been passed around for comments, structure, missing items etc, not formatted or proofread yet
- We welcome all comments and feedback for ST1 areas to r.fitton@Salford.ac.uk
- Or to Richard Jack for ST4 areas Richard Jack richard.jack@buildtestsolutions.com

ST4 Update: Towards quality assessment

Original brief:

- Understand how HTC measurement can be used (in regulations, guidelines, commercially)
- Define required operating conditions for performance measurement (reliability, accuracy, cost, length)

Activities:

- Survey of annex members
- Survey of stakeholders (243 stakeholders, 14 countries)

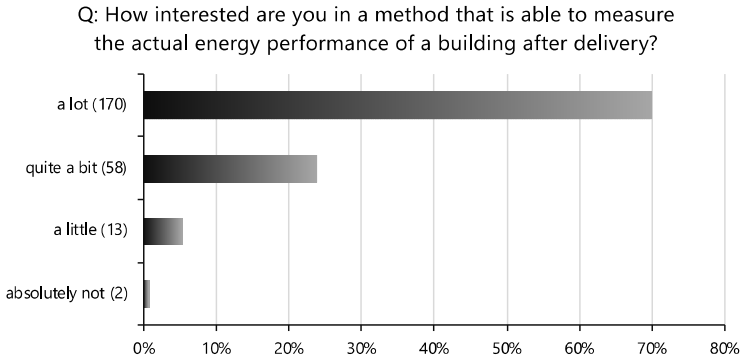
Outputs:

- Annex report ☺, draft complete combined with ST1
- Journal paper ☺, submitted to Renewable and Sustainable Energy Reviews journal, under

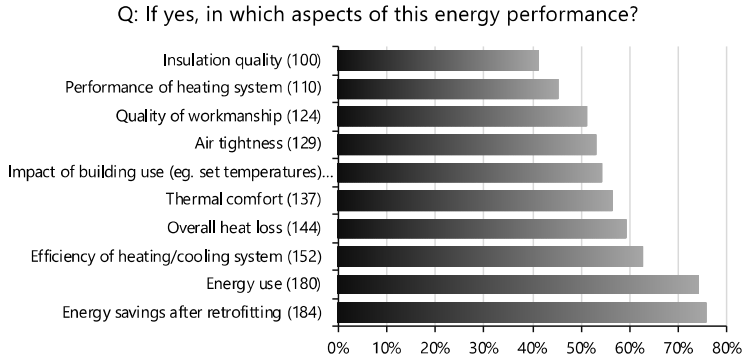
Thanks to the work of Chirag Deb, Liesje van Gelder, Marleen Speekman, Gillaume Pandraud, Richard Jack & Richard Fitton

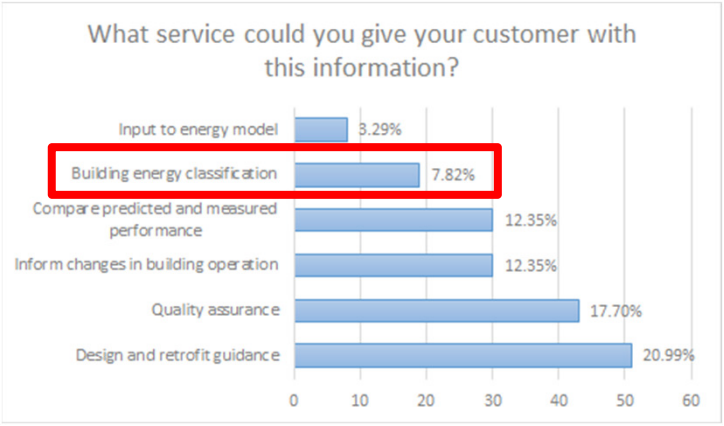
ST4 Findings: How to use HTC measurements?

People want measurement ☺



Most interested in energy use





Services leading from measurement less clear…

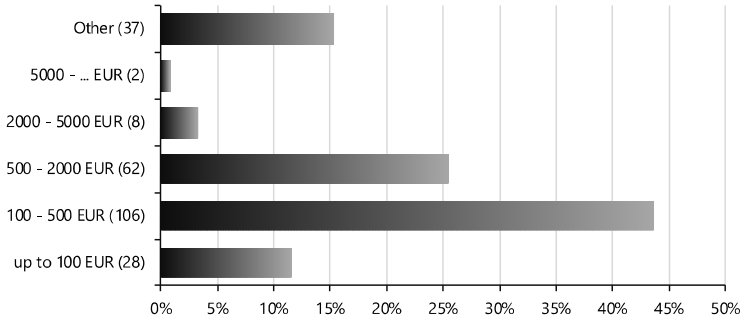
Focussed on advice and quality assurance

Not so much on classification… demand for legislated HTC performance not YET there?

ST4 Findings: Required operating conditions

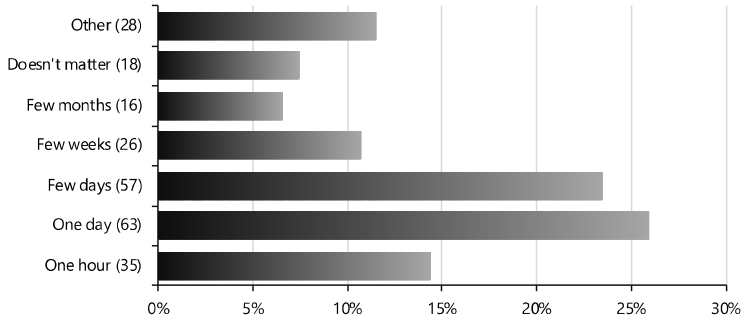
Must be cheap, <500EUR

Q: What should be for you the acceptable cost?



Should be quick

Q: What is an acceptable duration of the test in your opinion?



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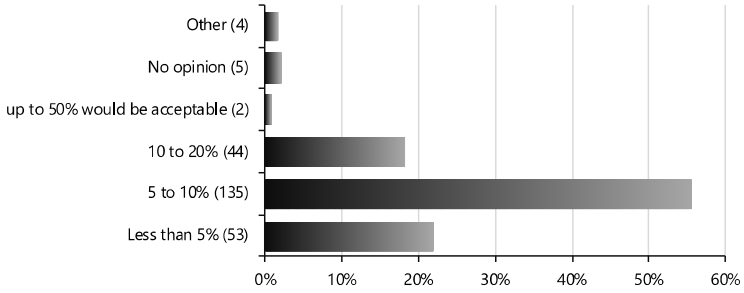
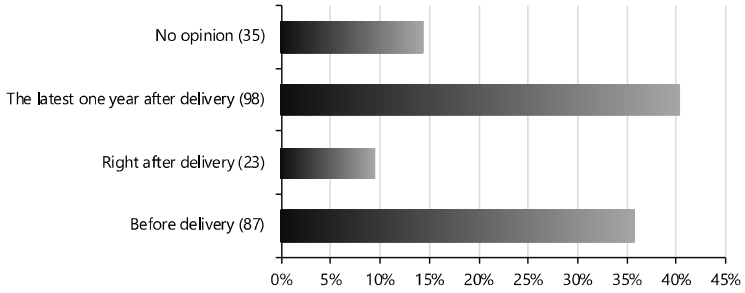
Q: What should be for you the acceptable error (confidence interval associated to the measured value of the HTC)?



Best before or just after delivery

Q: When should the determination be done to be most beneficial?



ST4 Conclusions

- Lots of interest
- Not yet thought of as a legislative tool/metric
- Must be fast, cheap & accurate!
  - Accuracy demand of <10% particularly challenging
  - Qualitative answers show test needs to be short as is assumed to be invasive, if non-invasive can be longer
  - Acceptable cost often linked to cost of energy use (hence relatively cheap)
- Little agreement in how to use an HTC measurement – e.g. require builder to repair? Fines for builder or designer? Use to adjust future or retrofit designs?

Two attractive specifications:

- Quick, carried out before occupancy, more useful for new-build
- Non-invasive, carried out during occupancy, more useful for existing buildings

What next?

- Original brief largely met, but outstanding question is once you have a reliable HTC measurement, what do you do with it?!

Sub Task 1 Update

Special Edition Journal:

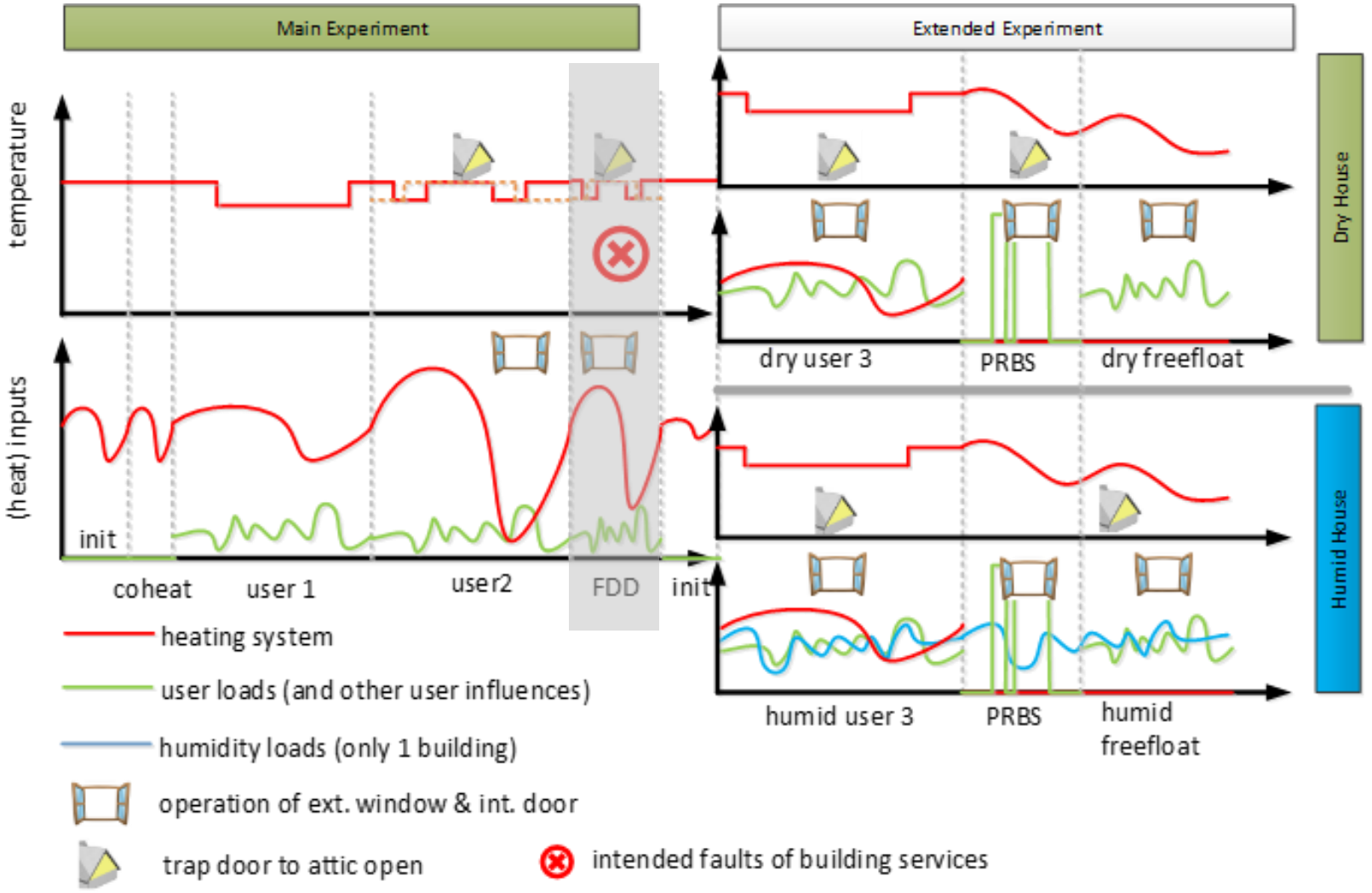
Prof David Johnston at Leeds Beckett and I are editing:

- Special Issue of *Sustainability* on *"*Understanding and measuring the Building Fabric Performance of Low Carbon Dwellings*",*
- We invite original papers or state-of-the-art reviews dealing with the issues surrounding the thermal performance of the building fabric in new build dwellings and new, novel or existing techniques that can be used to assess, measure and quantify the fabric performance of new dwellings in-use.
- **We would encourage the submission of papers that develop the area of cost effective and rapid solutions of building performance measurement**

- **Deadline 31/Dec 2021**
- **I will circulate link after meeting.**

BES-validation exercise
review

Experimental schedule - *review*



2-step validation procedure - *review*

	Blind phase	Open phase
Purpose	Setup of simulation models	- Separate user from program errors
Data for modelling teams	Experimental specification QnA by teams Measured weather Measured boundaries	x x x x Measured validation goals
Limitations	Measured validation goals unknown	Only changes with physical background No generic optimizations

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Agenda

- Status of this Annex71-part
- Analysis
  - Metrics used
  - 2-step validation method
  - Data decomposition
- Results of
  - Main Experiment
  - Extended Experiment
- Questionnaire
- First Conclusions of the BES Model Validation
- Report Draft
- Next steps

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

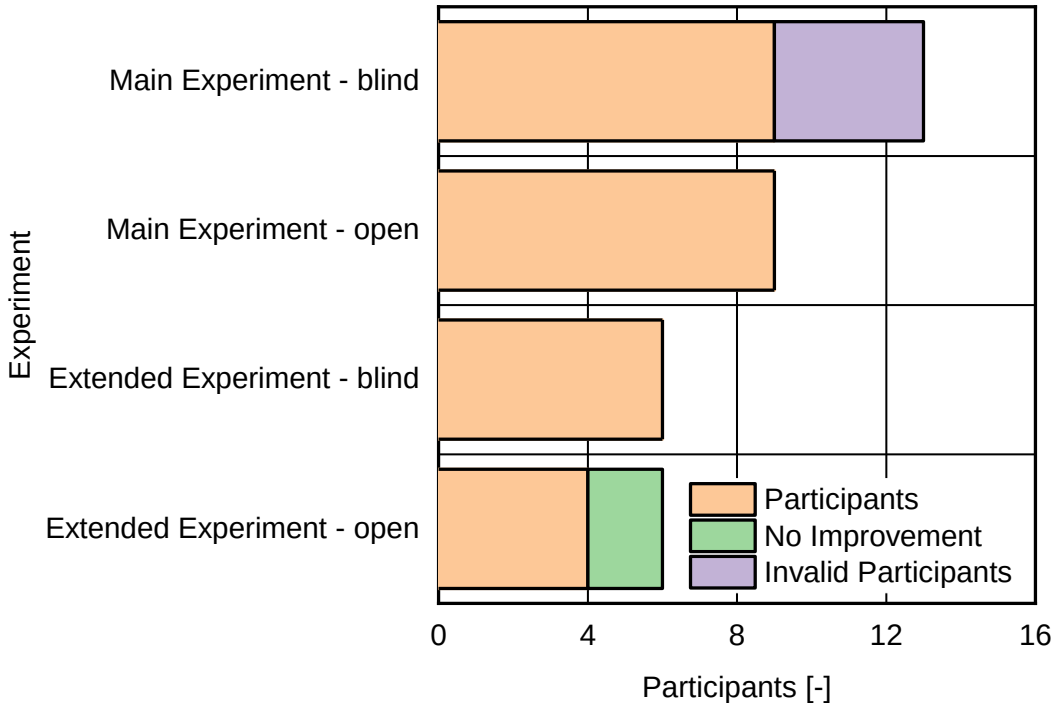
Status

- Experiment ✓
  - Experimental design ✓
  - Experimental setup ✓
  - Conduction of Experiment ✓
  - Experimental specifications ✓
- Validation ✓
  - Dissemination ✓
  - Results from ✓
    - ME – blind & open phase ✓
    - EE – blind & open phase ✓
  - Questionnaire ✓
- Analysis ✓
  - Trend line graphs ✓
  - metrics' tables ✓
  - Questionnaire ✓
- Documentation
  - QnA -> Experimental specs ✓
  - **Data & specs with DOI ✓**
  - **IEA report** *(near completion)*
- Publications *(so far)*
  - Experimental design (BS2019)✓
  - Experiment (NSB2020) ✓
  - Results: Blind (BS2021);Open (?)

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Submission overview



Focus of the analysis

Changes from Annex 58 Experiment

- Underfloor Heating -> return temperatures (living & child1)
- ~~Heatpump~~ (not modelled in detail)
- Synthetic users
  - operated door -> kitchen air temperature
  - operated window -> child1 air temperature
- Attic - Trap door (-> No good indicator)
- ~~Stratification~~ (modelled by 2 teams only)

metrics

- Bias
  - **Mean Deviation** *(Annex 58)*
  - NMBE *(Normalized Mean Bias Error)*
- Dynamics
  - **Spearman's rank correlation** *(Annex 58)*
  - R^2
  - CV(RMSE) *(Coefficient of the Root Mean Squared Error)*
- *Absolute mean value (plausibility check only)*

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

2-step validation approach – mean deviation

Summe von Value	Spaltenbeschriftunge								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	-0,6	0,3	-1,2	-2,1	-0,1	-0,3	1,8	5,5	1,5
User2	-0,9	2,5	-1,4	-2,6	-0,3	1,2	4,2	8,6	-0,1
o5_zh_AT									
User1	-0,4	-0,7	0,4	-1,7	-0,4	-1,5	0,7	-6,4	-6,1
User2	-0,9	0,8	0,0	-2,3	-1,0	-0,5	2,2	-6,2	-7,8
n2_gf_AT									
User1	-0,7	1,0	-0,8	-1,8	-0,2	-0,4	1,5	5,1	2,8
User2	-1,0	2,3	-1,1	-2,2	-0,5	0,1	4,5	8,3	2,1
o5_gf_AT									
User1	-0,6	-0,4	0,6	-0,8	-0,4	-2,0	1,3	-6,7	-4,5
User2	-1,0	1,1	0,2	-1,5	-1,1	-1,3	3,0	-6,5	-5,2
n2_att_AT									
User1	-0,6	-0,5	-1,9	-2,5	-0,1	-0,1	2,2	6,0	-0,2
User2	-0,9	2,7	-1,9	-3,1	-0,1	2,8	3,7	8,9	-3,2
o5_att_AT									
User1	-0,2	-1,0	0,1	-3,0	-0,3	-0,7	0,0	-5,9	-8,4
User2	-0,8	0,3	-0,4	-3,5	-0,9	0,5	1,2	-5,8	-11,4

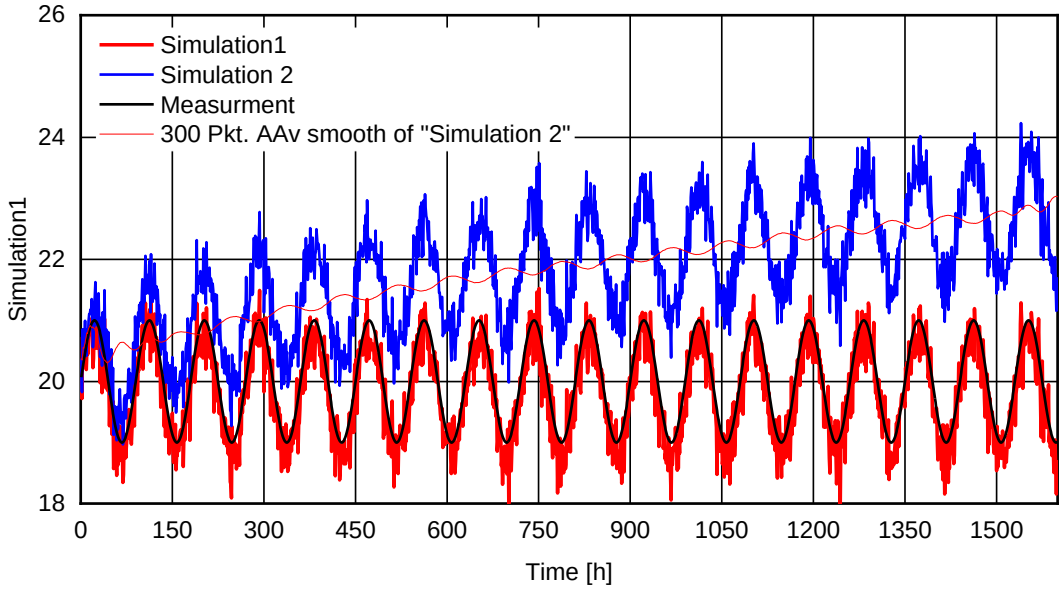
Summe von Value	Spaltenbeschriftunge								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	-0,1	0,8	0,9	0,2	-0,1	1,1	3,2	-0,1	0,2
User2	-0,4	1,9	1,5	-2,6	-0,3	1,1	4,5	-0,3	0,5
o5_zh_AT									
User1	-0,8	-0,5	0,6	-0,5	0,1	-0,4	1,8	-0,3	-0,1
User2	-1,0	0,4	0,9	-2,3	-0,5	0,1	2,6	-1,1	-0,1
n2_gf_AT									
User1	-0,2	1,1	1,4	0,1	-0,2	2,0	2,5	-0,1	0,2
User2	-0,5	1,4	1,9	-2,2	-0,5	2,0	4,6	-0,2	0,6
o5_gf_AT									
User1	-0,9	-0,5	0,6	-0,7	-0,1	-0,2	1,9	0,0	-0,6
User2	-1,3	0,4	1,1	-1,5	-0,7	0,8	3,1	-0,7	0,1
n2_att_AT									
User1	0,1	0,4	0,0	0,2	-0,1	-0,1	4,1	0,0	0,3
User2	-0,2	2,7	0,9	-3,1	-0,1	-0,2	4,3	-0,4	0,4
o5_att_AT									
User1	-0,7	-0,6	0,6	-0,3	0,4	-0,7	1,6	-0,7	0,5
User2	-0,7	0,4	0,6	-3,5	-0,1	-0,8	1,9	-1,5	-0,3

Summe von Value	Spaltenbeschriftunge								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	72%	39%	63%	49%	66%	76%	41%	32%	67%
User2	83%	53%	64%	61%	87%	64%	58%	35%	72%
o5_zh_AT									
User1	84%	70%	85%	75%	70%	88%	68%	8%	17%
User2	87%	81%	84%	77%	85%	80%	65%	48%	68%
n2_gf_AT									
User1	77%	33%	66%	37%	65%	69%	26%	29%	56%
User2	94%	63%	92%	71%	90%	82%	60%	39%	77%
o5_gf_AT									
User1	82%	56%	76%	66%	72%	72%	48%	8%	20%
User2	97%	85%	89%	83%	89%	79%	62%	46%	70%
n2_att_AT									
User1	62%	45%	60%	57%	58%	71%	51%	35%	76%
User2	75%	31%	36%	55%	73%	23%	38%	17%	73%
o5_att_AT									
User1	78%	84%	84%	76%	64%	91%	71%	6%	20%
User2	40%	43%	46%	63%	68%	41%	46%	20%	47%

Summe von Value	Spaltenb								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	73%	57%	70%	73%	71%	80%	36%	55%	76%
User2	86%	54%	88%	61%	90%	78%	62%	65%	76%
o5_zh_AT									
User1	79%	86%	93%	78%	70%	96%	84%	70%	76%
User2	77%	84%	95%	77%	89%	84%	70%	79%	79%
n2_gf_AT									
User1	79%	51%	62%	68%	76%	63%	20%	60%	72%
User2	95%	68%	94%	71%	92%	84%	69%	73%	87%
o5_gf_AT									
User1	77%	77%	85%	45%	76%	86%	60%	68%	80%
User2	97%	91%	97%	83%	90%	76%	69%	84%	92%
n2_att_AT									
User1	60%	55%	71%	74%	59%	72%	46%	35%	71%
User2	73%	31%	53%	55%	88%	49%	36%	57%	68%
o5_att_AT									
User1	80%	90%	94%	90%	59%	95%	88%	59%	63%
User2	28%	41%	73%	63%	79%	75%	49%	71%	47%

Data decomposition - problem

- For the user (1,2 & 3) -periods the heat inputs are given
- When the set point temperature is not used
  even (small) inaccuracy in the building's energy balance leads to an accumulation of temperature deviation
  - Because there is no control loop for heating power <-> temperature
- This deviation compensates the inaccuracy when reaching a certain dT
  - Saturation ->
    the trend flattens out

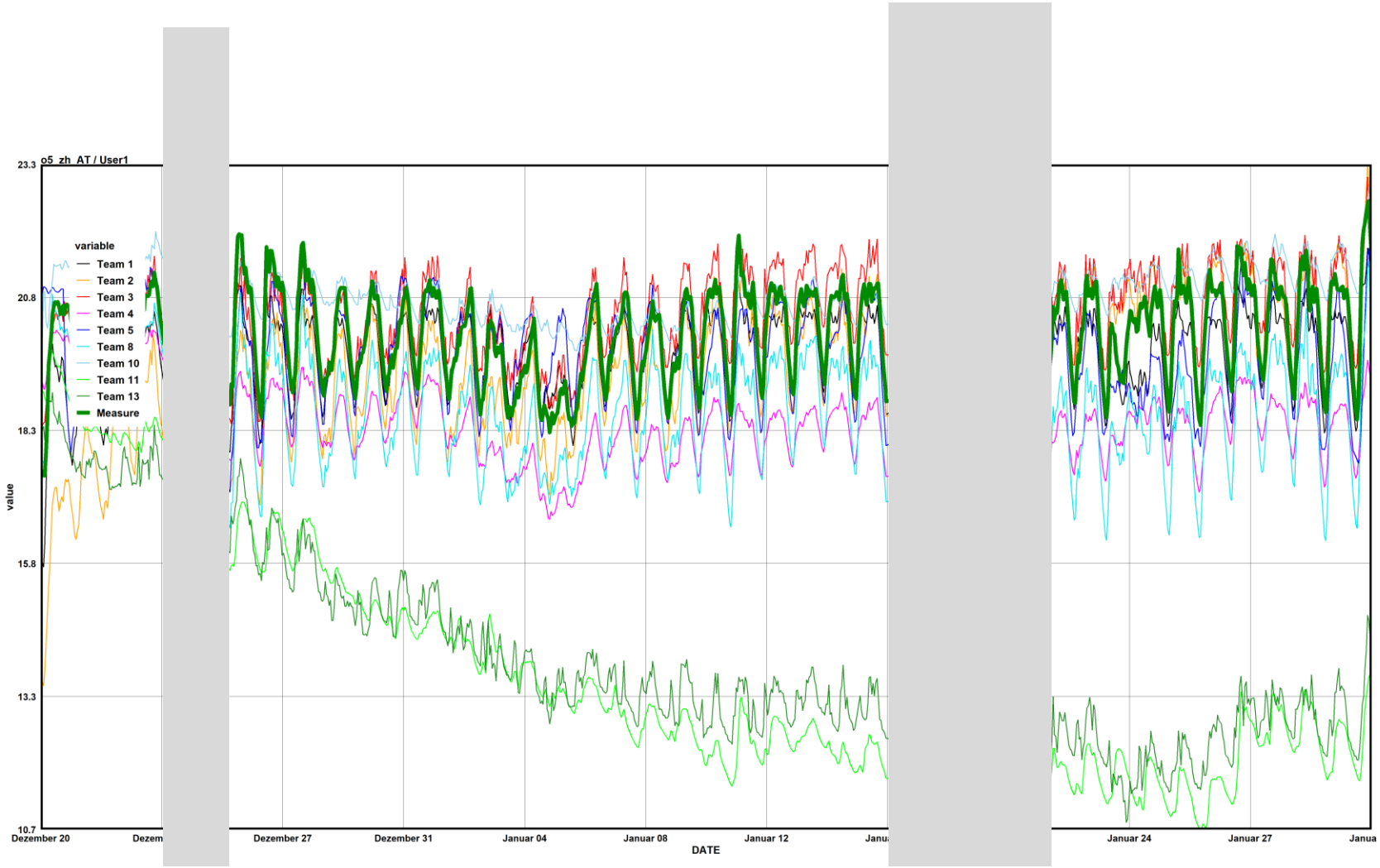


generic example

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Data decomposition

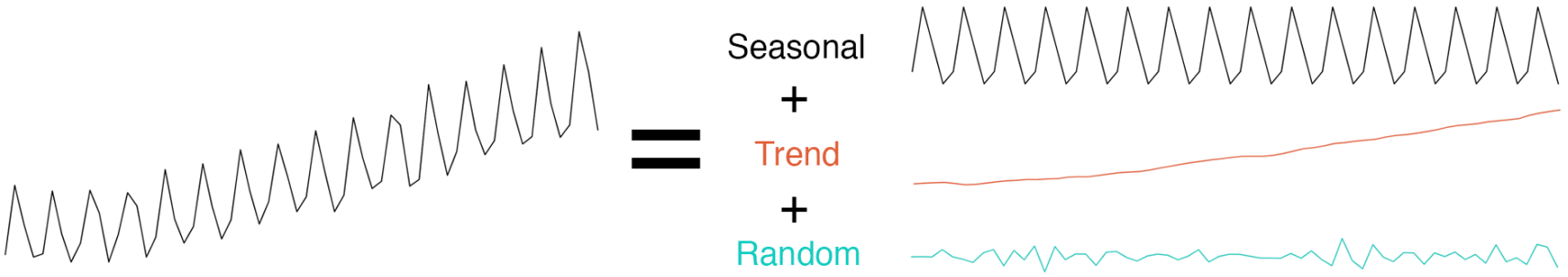


BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

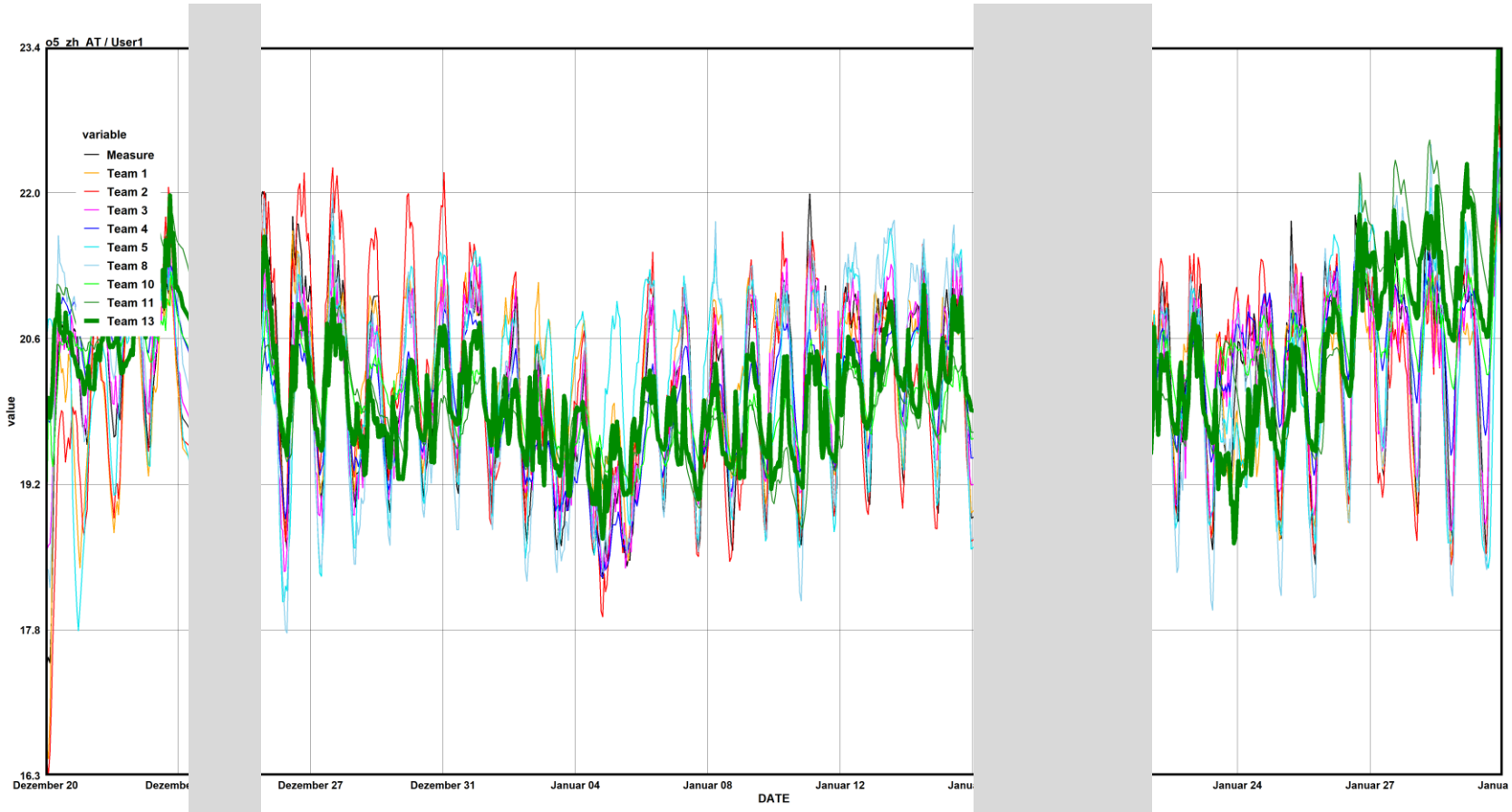
Data decomposition

- What is decomposition



- We just extract the trend
  - Document it
  - Seasonal + Random are analyzed as a normal simulation's deviation
- De-trending for user 1-3 & PRBS not for coheating & free float
- Trend function not (moving average) $\Theta_{room} = a * \sqrt{timestep} + b$
- Should the decomposition applied for the metrics or for plots only

Data decomposition



Data decomposition – Effect on metric – blind phase results mean deviation / Spearman's ranked correlation

Summe von Value	Spaltenbeschriftunge								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	-0,6	0,3	-1,2	-2,1	-0,1	-0,3	1,8	5,5	1,5
User2	-0,9	2,5	-1,4	-2,6	-0,3	1,2	4,2	8,6	-0,1
o5_zh_AT									
User1	-0,41	-0,69	0,40	-1,70	-0,36	-1,46	0,74	-6,37	-6,12
User2	-0,9	0,8	0,0	-2,3	-1,0	-0,5	2,2	-6,2	-7,8
n2_gf_AT									
User1	-0,7	1,0	-0,8	-1,8	-0,2	-0,4	1,5	5,1	2,8
User2	-1,00	2,30	-1,09	-2,23	-0,51	0,09	4,45	8,30	2,09
o5_gf_AT									
User1	-0,6	-0,4	0,6	-0,8	-0,4	-2,0	1,3	-6,7	-4,5
User2	-1,0	1,1	0,2	-1,5	-1,1	-1,3	3,0	-6,5	-5,2
n2_att_AT									
User1	-0,6	-0,5	-1,9	-2,5	-0,1	-0,1	2,2	6,0	-0,2
User2	-0,9	2,7	-1,9	-3,1	-0,1	2,8	3,7	8,9	-3,2
o5_att_AT									
User1	-0,16	-1,03	0,11	-2,96	-0,25	-0,74	-0,01	-5,88	-8,44
User2	-0,8	0,3	-0,4	-3,5	-0,9	0,5	1,2	-5,8	-11,4

Summe von Value	Spaltenbeschriftungen								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
User2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
o5_zh_AT									
User1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
User2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
n2_gf_AT									
User1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
User2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
o5_gf_AT									
User1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
User2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
n2_att_AT									
User1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
User2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
o5_att_AT									
User1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
User2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Absolute deviation	< 1 K	1 - 2 K	2 - 4 K	4 - 8 K	> 8 K

Summe von Value	Spaltenbeschriftunge								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	72%	39%	63%	49%	66%	76%	41%	32%	67%
User2	83%	53%	64%	61%	87%	64%	58%	35%	72%
o5_zh_AT									
User1	84%	70%	85%	75%	70%	88%	68%	8%	17%
User2	87%	81%	84%	77%	85%	80%	65%	48%	68%
n2_gf_AT									
User1	77%	33%	66%	37%	65%	69%	26%	29%	56%
User2	94%	63%	92%	71%	90%	82%	60%	39%	77%
o5_gf_AT									
User1	82%	56%	76%	66%	72%	72%	48%	8%	20%
User2	97%	85%	89%	83%	89%	79%	62%	46%	70%
n2_att_AT									
User1	62%	45%	60%	57%	58%	71%	51%	35%	76%
User2	75%	31%	36%	55%	73%	23%	38%	17%	73%
o5_att_AT									
User1	78%	84%	84%	76%	64%	91%	71%	6%	20%
User2	40%	43%	46%	63%	68%	41%	46%	20%	47%

Summe von Value	Spaltenbeschriftungen								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	75%	59%	64%	70%	70%	77%	61%	72%	73%
User2	84%	49%	78%	67%	87%	61%	63%	39%	79%
o5_zh_AT									
User1	85%	87%	89%	80%	74%	92%	67%	54%	63%
User2	87%	83%	84%	80%	85%	83%	71%	44%	66%
n2_gf_AT									
User1	78%	49%	66%	61%	65%	74%	48%	72%	66%
User2	95%	65%	92%	81%	90%	88%	75%	40%	81%
o5_gf_AT									
User1	83%	78%	88%	73%	73%	83%	49%	49%	63%
User2	97%	91%	91%	87%	90%	90%	76%	55%	82%
n2_att_AT									
User1	67%	58%	63%	63%	68%	71%	61%	69%	76%
User2	76%	30%	44%	58%	75%	23%	37%	19%	75%
o5_att_AT									
User1	78%	89%	84%	80%	71%	93%	73%	52%	49%
User2	46%	38%	45%	63%	67%	34%	44%	1%	42%

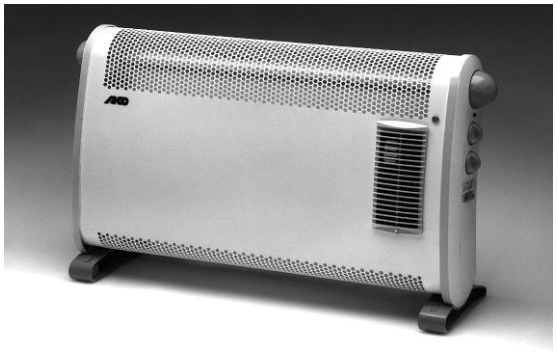
100 % - 80 %	80 % - 70 %	70 % - 60 %	60 % - 35 %	< 35 %

Data decomposition

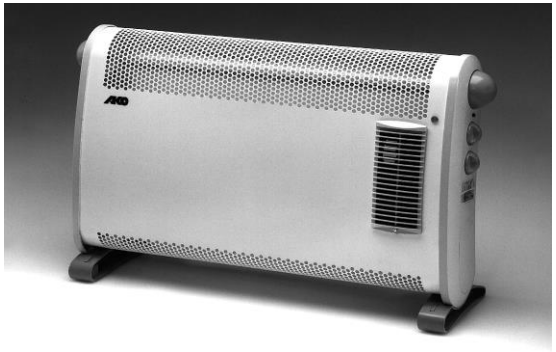
- The use of detrending results is not planned for future analysis
  - Detrending effects also the dynamic metrics
  - A metric for the detrending magnitude would need to be introduced

Validation results- side by side experimental design

Main experiment - dry



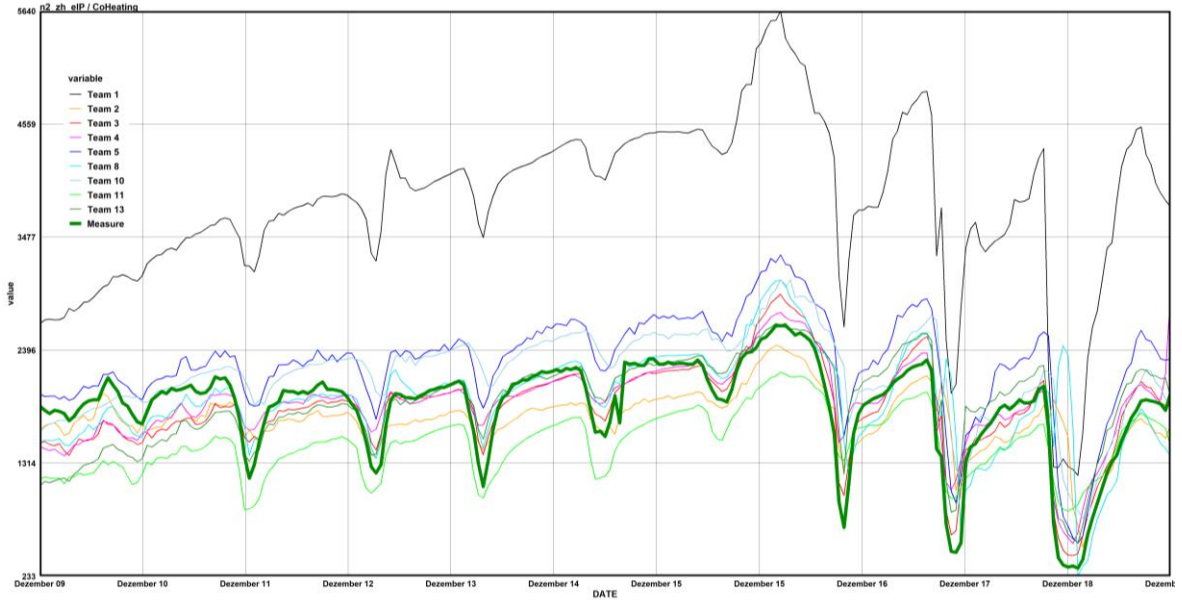
Extended Experiment
internal moisture source

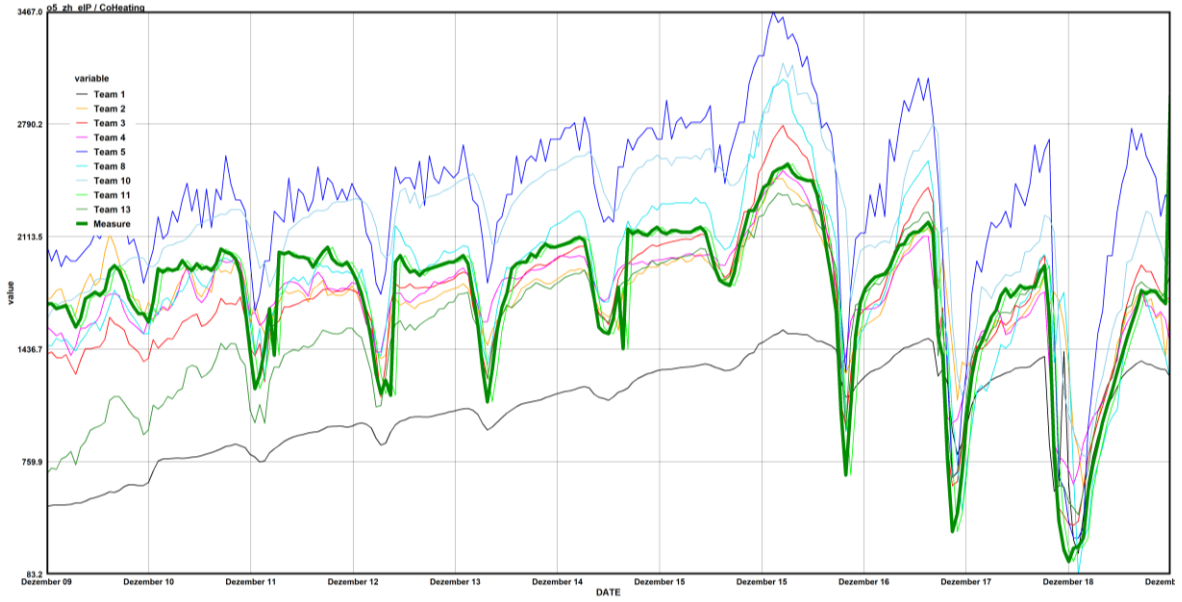


BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Main Experiment (open phase) Coheating

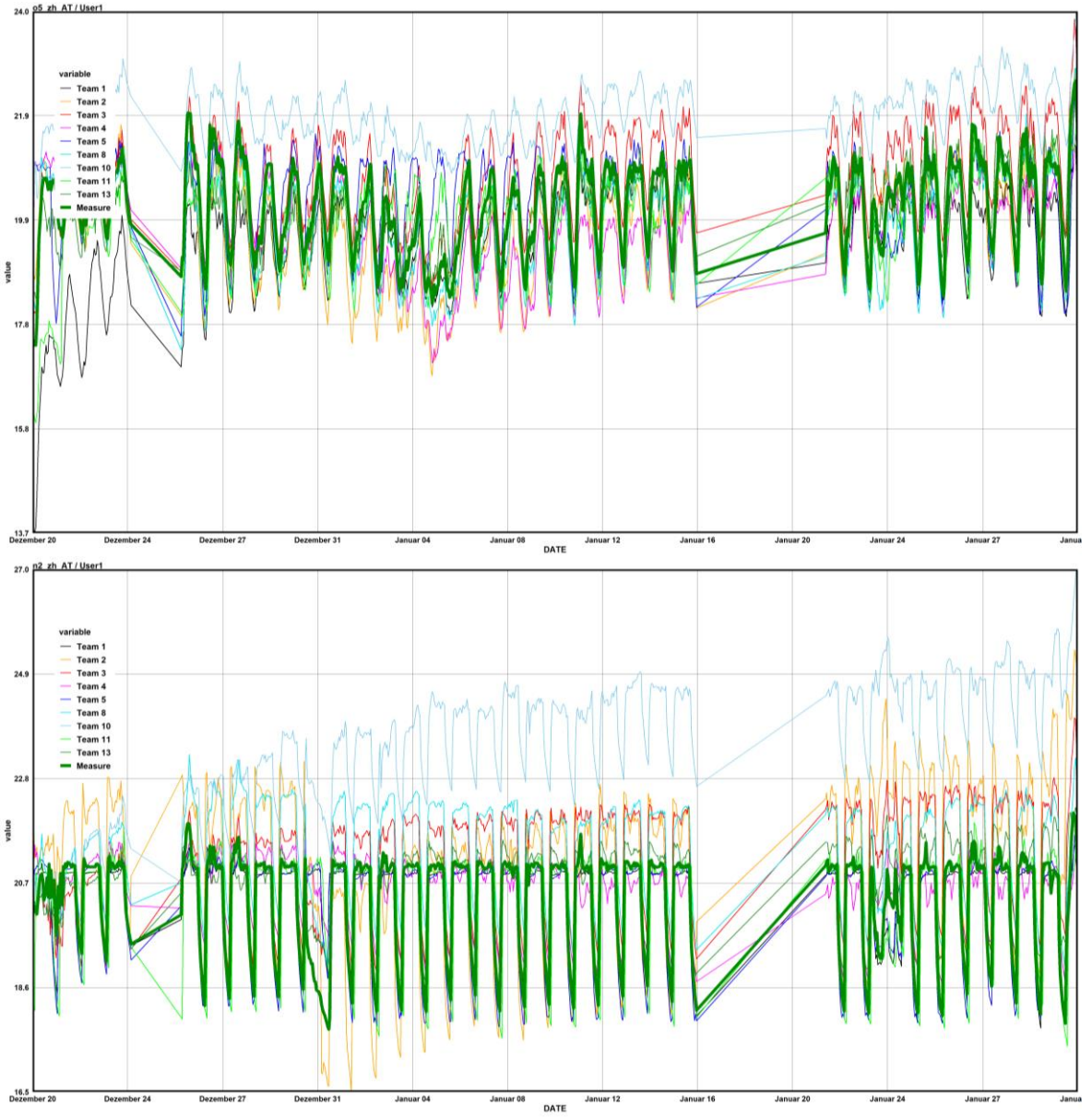




BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Main Experiment
(open phase)
User 1



Main Experiment (open phase) Coheating

Phase	CoHeati
metric	mean

Summe von Value	Spalten								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT	-0,1	0,0	-0,1	0,0	0,0	0,0	0,0	-0,1	0,0
o5_zh_AT	-5,7	0,0	0,0	0,0	0,0	0,0	0,0	-1,5	0,0
n2_zh_elP	1950,1	-116,7	-19,5	34,1	423,3	58,8	307,9	-353,3	29,9
o5_zh_elP	-700,6	-13,6	-54,4	-23,5	559,6	59,4	419,1	-5,6	-210,6
n2_gf_elP	1484,4	-118,2	-58,8	-31,6	174,1	-53,1	47,1	-446,0	52,7
o5_gf_elP	-259,4	-14,2	-66,4	-52,7	307,7	-20,3	161,0	-3,3	-184,6
n2_att_elP	465,7	1,5	39,2	65,6	249,2	111,9	260,7	92,7	-22,8
o5_att_elP	-441,2	0,7	12,0	29,2	251,9	79,6	258,0	-2,3	-26,1
n2_aroom_bath_heat_elP	165,6	-13,5	8,7	-1,2	-86,0	-6,5	19,3	-14,0	5,0
o5_aroom_bath_heat_elP	-75,3	-6,4	-5,0	-5,0	23,1	-2,9	24,3	0,0	-46,1
n2_aroom_bed_heat_elP	235,0	-35,1	-3,5	-1,5	58,6	0,1	17,6	-27,6	12,2
o5_aroom_bed_heat_elP	-167,2	-43,3	-27,5	5,1	37,2	-18,1	14,1	-0,5	-73,2
n2_aroom_child1_heat_elP	148,1	-36,9	-17,8	-32,5	152,6	2,7	76,3	35,4	-59,0
o5_aroom_child1_heat_elP	-248,1	-25,9	-30,1	-1,0	131,8	-19,5	62,4	-0,4	-77,2
n2_aroom_child2_heat_elP	253,4	-3,6	1,6	39,8	124,2	69,3	119,2	84,9	-2,6
o5_aroom_child2_heat_elP	-185,7	-23,9	-28,3	37,7	104,9	33,5	110,5	-1,3	-15,2
n2_aroom_dining_heat_elP	191,4	-47,3	-27,5	-16,7	-85,1	-16,6	-25,6	-73,3	-13,4
o5_aroom_dining_heat_elP	-103,3	2,4	25,9	6,9	80,4	30,5	43,7	-0,1	-38,2
n2_aroom_kitchen_heat_elP	144,9	-61,9	-55,4	-47,7	-34,5	-64,5	-50,6	-125,9	9,2
o5_aroom_kitchen_heat_elP	-224,2	-83,0	-96,8	-84,1	-24,2	-104,5	-67,8	-1,4	-15,6
n2_aroom_living_heat_elP	475,5	25,7	30,8	47,7	193,6	79,4	61,0	-122,4	45,3
o5_aroom_living_heat_elP	411,8	95,0	64,0	51,6	203,8	117,1	145,4	-0,8	14,5

Phase	CoHeat
metric	sd

Summe von Value	Spalte								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT	49%	97%	80%	96%	60%	83%	97%	68%	97%
o5_zh_AT	16%	86%	35%	87%	9%	74%	86%	37%	86%
n2_zh_elP	75%	84%	86%	83%	87%	78%	76%	80%	73%
o5_zh_elP	48%	82%	86%	87%	84%	87%	76%	90%	73%
n2_gf_elP	83%	66%	91%	89%	91%	67%	83%	85%	86%
o5_gf_elP	60%	61%	92%	87%	89%	81%	84%	92%	85%
n2_att_elP	46%	70%	70%	61%	61%	78%	45%	39%	42%
o5_att_elP	5%	66%	57%	78%	50%	73%	35%	88%	35%
n2_aroom_bath_heat_elP	74%	64%	81%	74%	18%	77%	76%	61%	41%
o5_aroom_bath_heat_elP		62%	69%	67%	58%	79%	67%	89%	27%
n2_aroom_bed_heat_elP	79%	85%	90%	77%	87%	79%	67%	72%	82%
o5_aroom_bed_heat_elP		85%	91%	63%	77%	78%	69%	91%	76%
n2_aroom_child1_heat_elP	38%	73%	78%	67%	63%	77%	38%	34%	36%
o5_aroom_child1_heat_elP	19%	81%	70%	81%	47%	84%	15%	90%	11%
n2_aroom_child2_heat_elP	84%	84%	85%	81%	84%	83%	71%	72%	82%
o5_aroom_child2_heat_elP	47%	76%	76%	63%	74%	82%	65%	87%	70%
n2_aroom_dining_heat_elP	74%	65%	74%	67%	76%	65%	69%	71%	60%
o5_aroom_dining_heat_elP		88%	90%	89%	79%	94%	86%	94%	79%
n2_aroom_kitchen_heat_elP	79%	1%	89%	15%	19%	69%	63%	53%	51%
o5_aroom_kitchen_heat_elP		33%	58%	27%	15%	53%	61%	89%	21%
n2_aroom_living_heat_elP	72%	66%	81%	83%	78%	62%	75%	82%	72%
o5_aroom_living_heat_elP	52%	58%	93%	90%	82%	78%	85%	94%	86%

100 % - 80 %	80 % - 70 %	70 % - 60 %	60 % - 35 %	< 35 %

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Main Experiment (open phase) User 1 & 2

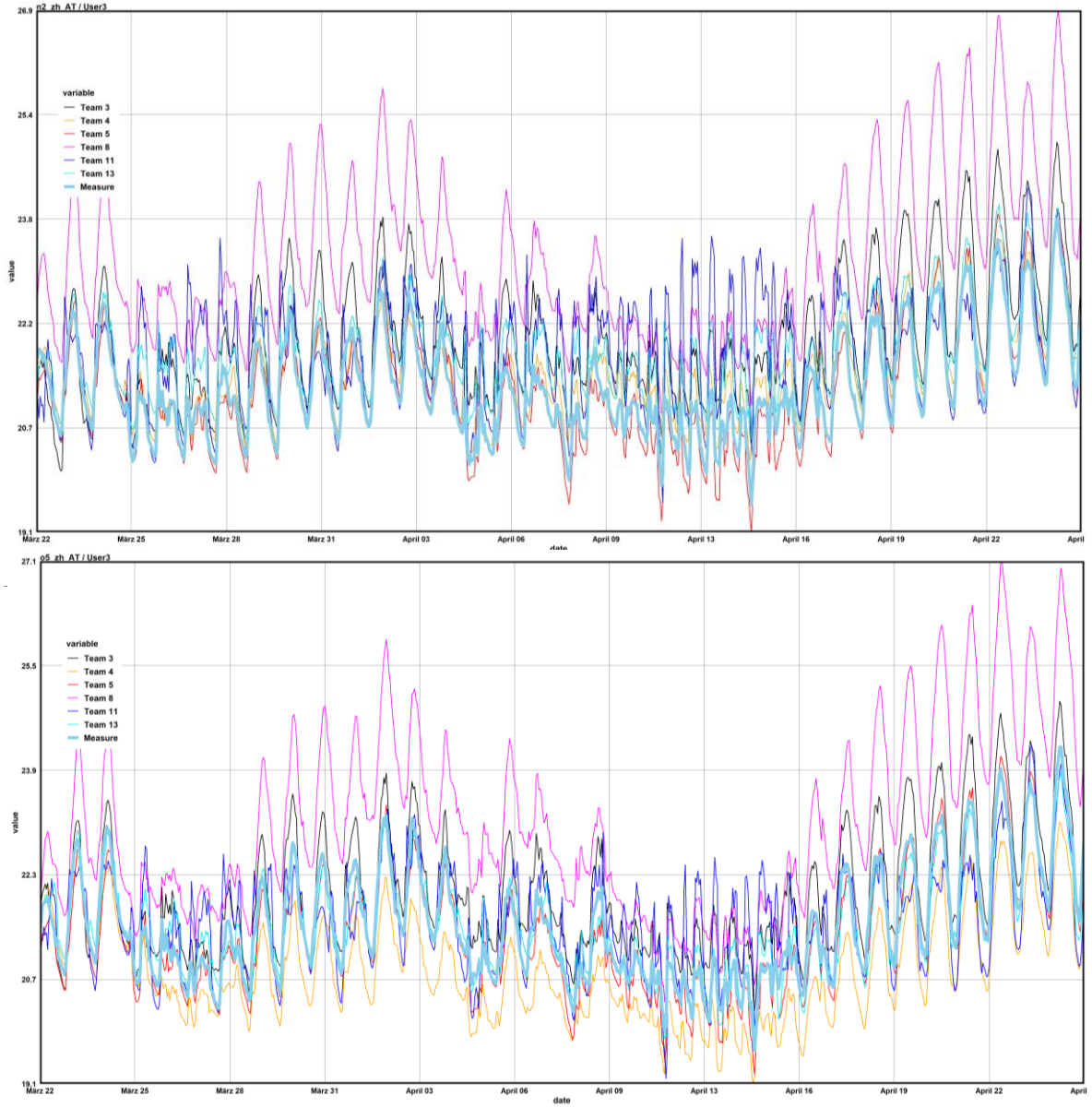
Summe von Value	Spaltenbeschriftung								
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	-0,1	0,8	0,9	0,2	-0,1	1,1	3,2	-0,1	0,2
User2	-0,4	1,9	1,5	-2,6	-0,3	1,1	4,5	-0,3	0,5
o5_zh_AT									
User1	-0,8	-0,5	0,6	-0,5	0,1	-0,4	1,8	-0,3	-0,1
User2	-1,0	0,4	0,9	-2,3	-0,5	0,1	2,6	-1,1	-0,1
n2_gf_AT									
User1	-0,2	1,1	1,4	0,1	-0,2	2,0	2,5	-0,1	0,2
User2	-0,5	1,4	1,9	-2,2	-0,5	2,0	4,6	-0,2	0,6
o5_gf_AT									
User1	-0,9	-0,5	0,6	-0,7	-0,1	-0,2	1,9	0,0	-0,6
User2	-1,3	0,4	1,1	-1,5	-0,7	0,8	3,1	-0,7	0,1
n2_att_AT									
User1	0,1	0,4	0,0	0,2	-0,1	-0,1	4,1	0,0	0,3
User2	-0,2	2,7	0,9	-3,1	-0,1	-0,2	4,3	-0,4	0,4
o5_att_AT									
User1	-0,7	-0,6	0,6	-0,3	0,4	-0,7	1,6	-0,7	0,5
User2	-0,7	0,4	0,6	-3,5	-0,1	-0,8	1,9	-1,5	-0,3
n2_aroom_living_110_AT									
User1	0,0	0,7	1,1	-0,2	-0,3	1,7	0,4	-0,2	0,0
User2	-0,3	1,1	1,6	-2,5	-0,6	1,8	2,3	-0,2	0,4
o5_aroom_living_110_AT									
User1	0,0	-0,9	0,3	-1,7	-0,3	-0,5	0,5	-0,4	-0,6
User2	0,1	0,0	0,9	-2,0	-1,1	0,6	1,6	-0,8	0,0

metric	sd							
Summe von Value	Spaltenb							
Zeilenbeschriftungen	team_01	team_02	team_03	team_04	team_05	team_08	team_10	team_11	team_13
n2_zh_AT									
User1	73%	57%	70%	73%	71%	80%	36%	55%	76%
User2	86%	54%	88%	61%	90%	78%	62%	65%	76%
o5_zh_AT									
User1	79%	86%	93%	78%	70%	96%	84%	70%	76%
User2	77%	84%	95%	77%	89%	84%	70%	79%	79%
n2_gf_AT									
User1	79%	51%	62%	68%	76%	63%	20%	60%	72%
User2	95%	68%	94%	71%	92%	84%	69%	73%	87%
o5_gf_AT									
User1	77%	77%	85%	45%	76%	86%	60%	68%	80%
User2	97%	91%	97%	83%	90%	76%	69%	84%	92%
n2_att_AT									
User1	60%	55%	71%	74%	59%	72%	46%	35%	71%
User2	73%	31%	53%	55%	88%	49%	36%	57%	68%
o5_att_AT									
User1	80%	90%	94%	90%	59%	95%	88%	59%	63%
User2	28%	41%	73%	63%	79%	75%	49%	71%	47%
n2_aroom_living_110_AT									
User1	88%	53%	72%	74%	79%	76%	48%	66%	80%
User2	96%	71%	96%	78%	92%	90%	69%	80%	90%
o5_aroom_living_110_AT									
User1	86%	81%	91%	55%	79%	91%	63%	70%	83%
User2	97%	92%	98%	88%	90%	82%	73%	85%	94%

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

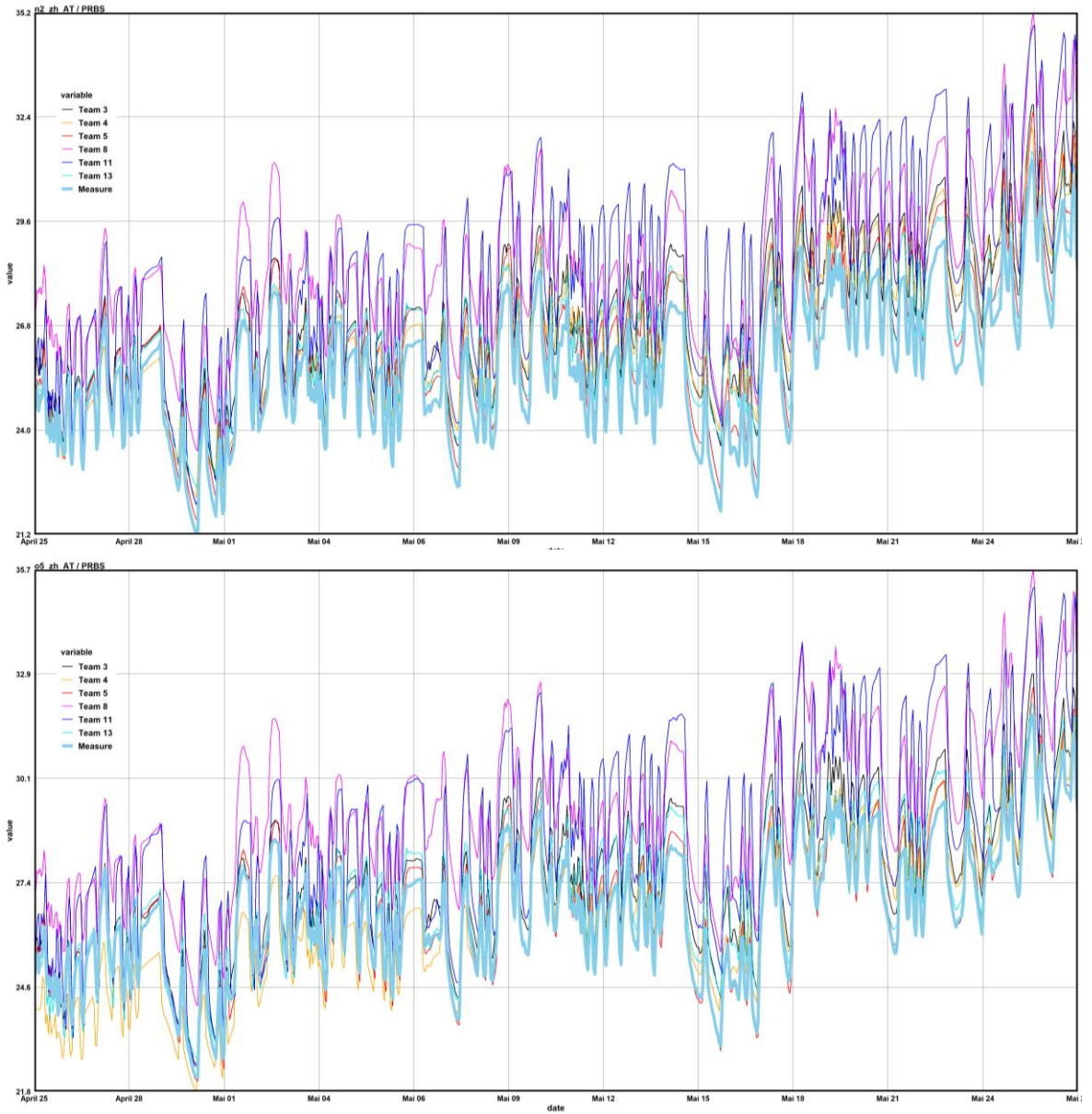
Extended Experiment (open phase) User 3



BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

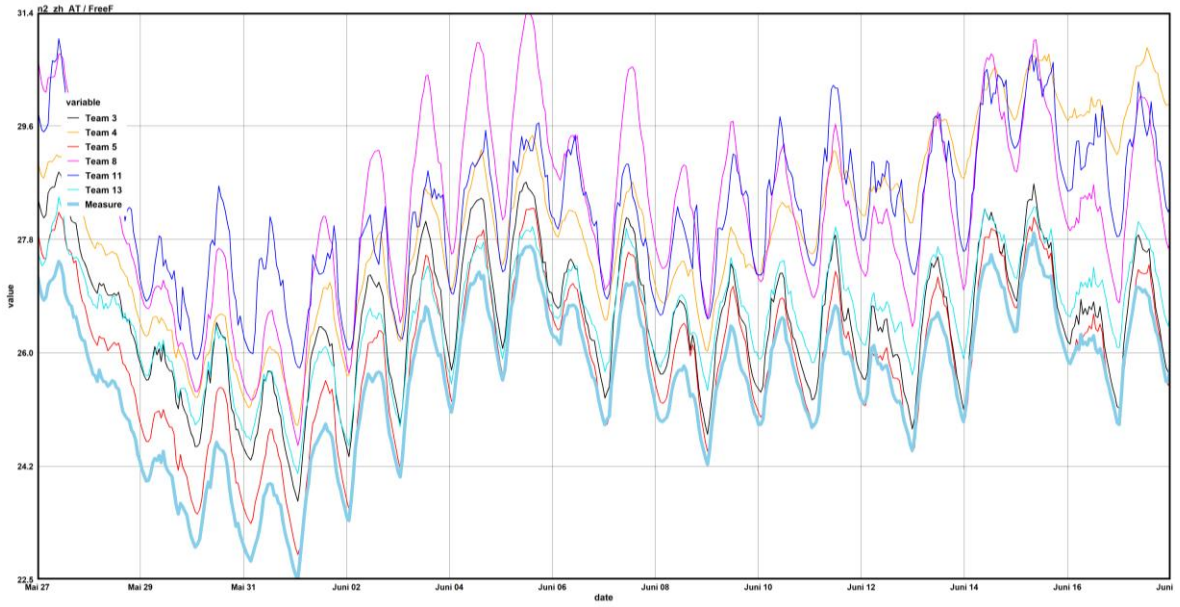
Extended Experiment (open phase) PRBS

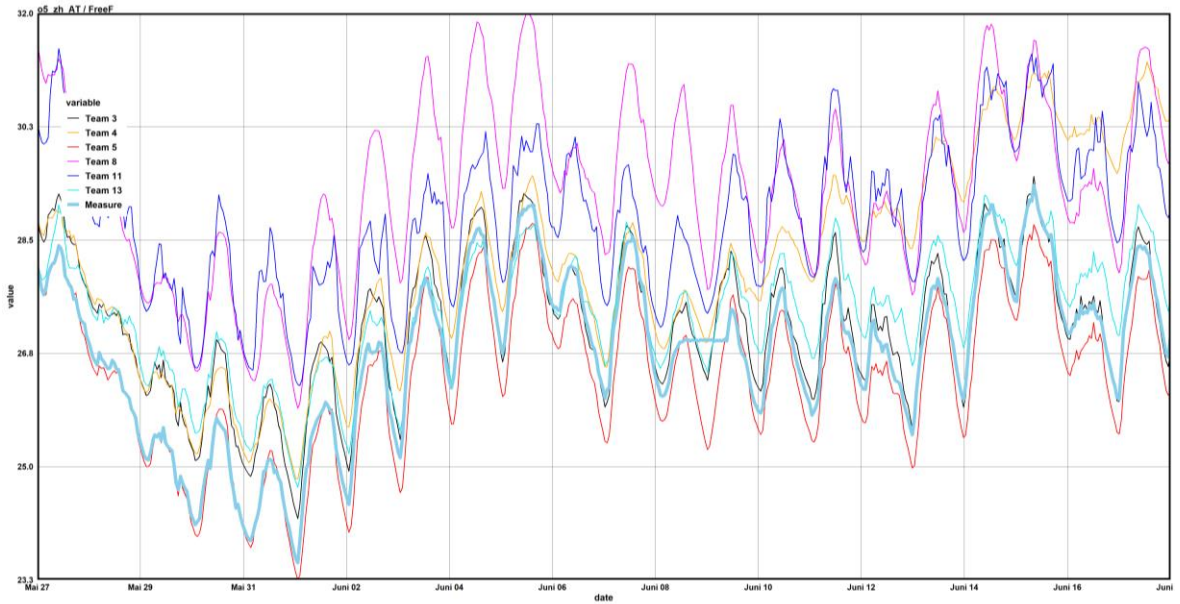


BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Extended Experiment (open phase) Free Float





Extended Experiment – mean deviation

Summe von Value	Spalten					
Zeilenbeschriftungen	team_03	team_04	team_05	team_08	team_11	team_13
n2_zh_AT						
User3	0,7	0,2	-0,1	1,9	0,5	0,5
PRBS	1,2	1,0	0,7	2,9	2,5	0,8
FreeF	0,9	2,4	0,4	2,7	2,7	1,0
o5_zh_AT						
User3	0,5	-0,7	-0,2	1,5	0,1	0,0
PRBS	0,8	-0,1	0,1	2,8	2,1	0,5
FreeF	0,4	1,3	-0,4	2,5	2,0	0,6
n2_gf_AT						
User3	0,9	0,8	0,0	2,5	1,1	0,5
PRBS	2,1	1,6	1,7	4,0	4,7	1,2
FreeF	1,6	2,7	0,9	3,3	4,3	1,1
o5_gf_AT						
User3	0,6	-0,3	-0,1	2,0	0,4	0,0
PRBS	1,5	0,2	1,1	3,8	4,0	0,8
FreeF	0,9	1,4	0,1	3,0	3,3	0,6
n2_att_AT						
User3	0,4	-0,6	-0,1	1,0	-0,3	0,5
PRBS	0,0	0,1	-0,8	1,3	-0,6	0,1
FreeF	0,0	1,9	-0,4	1,7	0,4	0,8
o5_att_AT						
User3	0,2	-1,2	-0,2	0,8	-0,4	0,0
PRBS	-0,2	-0,5	-1,2	1,2	-0,6	0,1
FreeF	-0,4	1,2	-1,0	1,7	0,3	0,6
n2_aroom_living_110_AT						
User3	0,7	0,4	0,0	2,5	1,3	0,6
PRBS	1,3	0,9	1,4	3,5	4,4	1,0
FreeF	1,4	2,6	0,9	3,3	4,6	1,3
o5_aroom_living_110_AT						
User3	0,6	-0,9	-0,2	1,9	0,7	0,1
PRBS	0,8	-0,7	0,7	3,2	3,5	0,4
FreeF	0,8	1,2	0,1	2,8	3,5	0,7
Absolute deviation	< 1 K	1 - 2 K	2 - 4 K	4 - 8 K	> 8 K	

Summe von Value	Spalten					
Zeilenbeschriftungen	team_03	team_04	team_05	team_08	team_11	team_13
n2_zh_rH						
User3	3,0		2,7	-0,4	2,0	3,6
PRBS	2,0		1,2	-1,9	-1,0	2,8
FreeF	4,9		3,8	-1,3	-1,2	4,4
o5_zh_rH						
User3	3,4		3,6	0,2	3,1	4,0
PRBS	1,6		1,6	-2,6	-0,3	2,7
FreeF	3,1		3,9	-3,1	-1,0	3,3
n2_gf_rH						
User3	2,3		2,5	-1,6	0,8	3,4
PRBS	0,3		-0,6	-3,4	-4,2	1,6
FreeF	3,1		2,6	-2,4	-4,4	3,8
o5_gf_rH						
User3	2,7		6,5	-0,6	1,6	5,6
PRBS	-0,4		1,0	-4,5	-3,7	1,8
FreeF	-0,3		5,1	-5,1	-5,7	3,6
n2_att_rH						
User3	3,9		3,0	1,3	3,7	3,8
PRBS	4,4		3,8	0,3	3,5	4,5
FreeF	7,4		5,4	0,2	3,3	5,3
o5_att_rH						
User3	4,4		-0,5	1,4	5,3	1,8
PRBS	4,4		2,3	0,1	4,6	3,9
FreeF	8,0		2,1	-0,3	5,6	2,9
n2_aroom_living_110_rH						
User3	3,5		3,1	-0,9	1,0	4,2
PRBS	2,2		0,4	-2,5	-3,4	3,2
FreeF	3,5		2,4	-2,7	-5,3	4,4
o5_aroom_living_110_rH						
User3	4,0		8,5	0,6	1,4	5,7
PRBS	1,4		3,2	-3,1	-3,1	3,1
FreeF	0,8		7,0	-4,0	-6,3	4,2
Absolute deviation	< 5 %	5 - 10 %	10 - 20 %	20 - 30 %	> 30 %	

Extended Experiment – Spearman's Ranked Correlation

100 % - 80 % | 80 % - 70 % | 70 % - 60 % | 60 % - 35 % | < 35 %

Summe von Value	Spaltenbeschriftungen					
Zeilenbeschriftungen	team_03	team_04	team_05	team_08	team_11	team_13
n2_zh_AT						
User3	91%	92%	97%	93%	64%	90%
PRBS	98%	91%	99%	98%	87%	97%
FreeF	93%	84%	98%	96%	88%	96%
o5_zh_AT						
User3	94%	93%	97%	92%	75%	93%
PRBS	98%	90%	99%	97%	88%	96%
FreeF	94%	79%	97%	92%	85%	94%
n2_gf_AT						
User3	94%	88%	96%	88%	63%	92%
PRBS	97%	90%	98%	95%	86%	97%
FreeF	82%	86%	91%	91%	82%	95%
o5_gf_AT						
User3	98%	93%	97%	90%	73%	95%
PRBS	98%	92%	99%	95%	88%	96%
FreeF	83%	82%	89%	88%	77%	92%
n2_att_AT						
User3	72%	76%	86%	79%	42%	61%
PRBS	98%	92%	98%	96%	92%	89%
FreeF	98%	81%	97%	95%	82%	90%
o5_att_AT						
User3	75%	77%	85%	82%	44%	61%
PRBS	97%	87%	97%	96%	90%	83%
FreeF	97%	77%	96%	91%	80%	88%
n2_aroom_living_110_AT						
User3	97%	92%	97%	92%	73%	94%
PRBS	97%	91%	97%	94%	86%	98%
FreeF	92%	81%	94%	94%	86%	96%
o5_aroom_living_110_AT						
User3	98%	94%	98%	90%	79%	95%
PRBS	98%	92%	98%	92%	88%	96%
FreeF	91%	76%	91%	89%	81%	92%

Summe von Value	Spaltenbeschriftungen					
Zeilenbeschriftungen	team_03	team_04	team_05	team_08	team_11	team_13
n2_zh_rH						
User3	93%		91%	92%	81%	90%
PRBS	97%		95%	95%	84%	96%
FreeF	96%		95%	96%	82%	93%
o5_zh_rH						
User3	88%		86%	60%	81%	87%
PRBS	95%		95%	64%	84%	95%
FreeF	91%		95%	45%	94%	96%
n2_gf_rH						
User3	94%		91%	89%	81%	91%
PRBS	98%		96%	96%	79%	96%
FreeF	96%		95%	96%	88%	96%
o5_gf_rH						
User3	83%		81%	43%	76%	83%
PRBS	91%		90%	50%	77%	86%
FreeF	94%		96%	49%	94%	95%
n2_att_rH						
User3	91%		89%	89%	81%	88%
PRBS	96%		91%	91%	88%	89%
FreeF	91%		80%	77%	67%	82%
o5_att_rH						
User3	90%		82%	79%	81%	84%
PRBS	94%		79%	78%	86%	85%
FreeF	82%		68%	51%	70%	80%
n2_aroom_living_110_rH						
User3	94%		93%	88%	83%	92%
PRBS	97%		96%	94%	80%	97%
FreeF	95%		96%	95%	87%	95%
o5_aroom_living_110_rH						
User3	87%		87%	44%	79%	83%
PRBS	90%		89%	41%	78%	87%
FreeF	93%		97%	45%	93%	95%

Questionnaire

Focus:

- Detailed Information on
  - Modelling difficult air flow aspects
  - The underfloor heating (groundfloor / attic)
  - Inside thermal bridges
  - Albedo modelling
  - Glazing modelling

Questionnaire

EBC

Questionair for Modelling details

Main Experiment

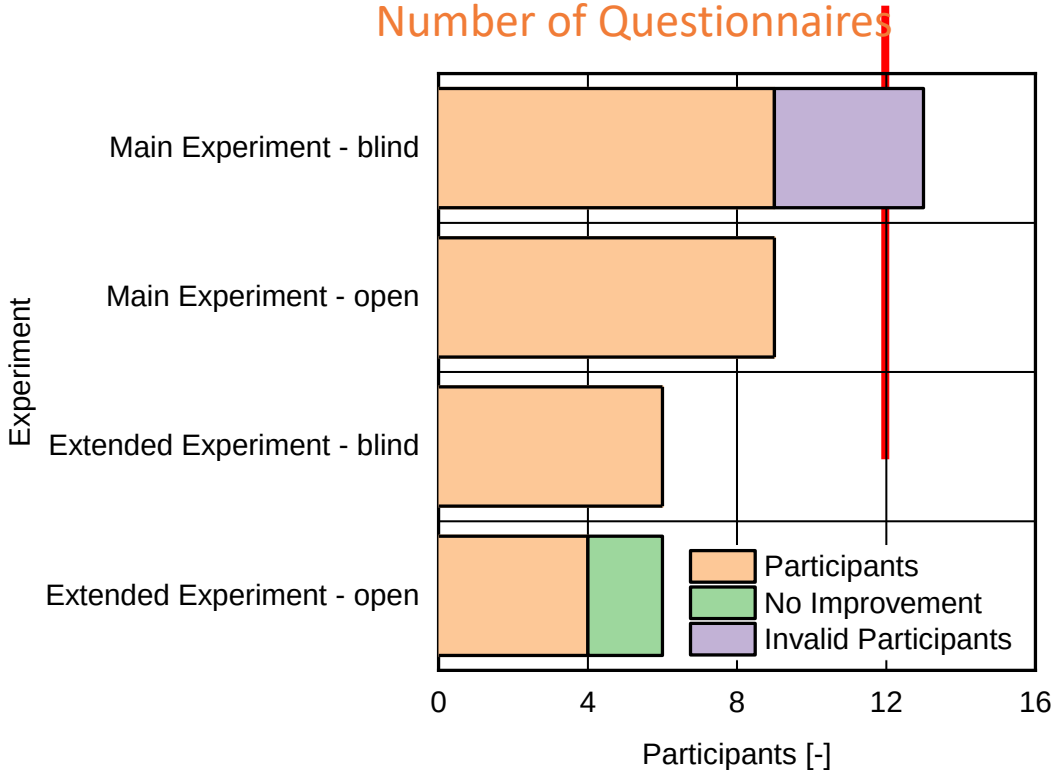
Open Phase

Explanation:	x	-> yes
		-> no / not applicable
		underlined -> text / value input

Please use only columns "C" and "D" for answers

User 1+2 phase	
Were the heating's heat inputs used	
Were the set temperatures used	
Albedo	
Were the provided Albedo measurement data (downward solar radiation) used?	
As a mean value	
As transient value	
If yes for "mean" or "transient" please describe pre processing	
To estimate the presence of a snow cover	
If yes please provide albedo values for	
dry ground	
snow cover	
Fixed albedo / if yes please provide value	
Was the measured vertical solar radiation used instead of albedo	
Additional Comment	

Questionnaire – return rate



Questionnaire – findings

Different modelling approaches to potentially important determinants of performance

- Use of temperatures to predict heat inputs and vice versa (see later slide).
- Thermal bridge modelling: some teams did not include these, others include only external thermal bridges, others modelled some of the bridges and not others.
- Stratification: 2 teams included this using upper and lower zones in rooms.
- Snow cover: some teams used measured vertical solar on each facade, others used time-varying measured albedo; others used a single fixed value, others used banded values.
- UFH modelling: some used measured supply flow rates and temperatures with details of all loops to predict return temperatures and heat injection; others combined some loops; others assumed a fixed return temperature (in blind phase) to calculate heat injection. Some had different models for wet and dry systems (ground floor and attic).
- Airflow modelling: most programs used a network flow model; some used empirical correlations for window and door openings superimposed on the mechanical ventilation flow rate.

Other differences in modelling approach (probably less important)

- External longwave radiation; some models used measured net longwave radiation, others used internal algorithms.
- Shading: some included shading from surrounding buildings (minimal); some included window reveal shading; some did not model shading.
- Mechanical ventilation: some used fixed values, others used measured values (these were stable except for rare experimental problems).
- Window modelling: similar modelling with angular dependent optical properties; some teams used g-values for thermal transmission, others used detailed modelling of convective/radiant transfer.
- Open trapdoor modelling: different opening algorithms used.

Some preliminary conclusions

- Due to large number of combinations of modelling approaches, impossible to conclude that one approach is better than another. Not possible to say that teams who included, for example, thermal bridges, got better results than those who didn't.
- Datasets are comprehensive and valuable for model developers to test their programs through sensitivity studies, use of additional sensor information (heat flux, surface temperatures etc).
- Perhaps surprisingly, predictions for O5 house with UFH better than for N2 house with electric heating. Possibly because less stratification, but models including stratification also had better results with O5 house.
- Some programs had significantly better predictions for the attic than the ground floor, and vice versa, including periods with the trap door shut, and for both houses.
- Observed stratification was significant, particularly in electrically heated house, but difficult to model – limitation of most commonly used programs. Research needed.
- Modelling for validation required many inputs of measured data - this data would not normally be available, so modellers would use assumptions (e.g. albedo, flow rates). Some programs don't have the capability of using extensive time-varying input data; it can also increase the likelihood of user error.

Modelling with temperature or heat inputs

Co-heating period

Teams using setpoints as control were better than those using measured temperatures which sometimes had cooling spikes as the temp rapidly increased with solar high solar radiation, even though they don't follow the actual temperatures on sunny days.
(Possibly using a PI controller or using smoothed measured data would be best solution.)

User 1 and User 2 periods

Some teams used measured setpoints to predict heat inputs; others used measured heat inputs to predict temperatures (although modelling guidelines asked teams to predict the temperatures). As expected, this results in two sets of results - one with good temperature and poorer heat predictions, and vice versa.
Qu: why did some teams use setpoints when heating inputs were provided?

Sensitivity studies

Several (most?) teams carried out sensitivity studies – try to collate these (inputs in breakout session and follow-up email). Examples:

- Stratification: impact of using two air temperatures/room? Could also compare results for co-heating phase (minimal stratification) with user-1 and user-2 phases.
- Snow cover: Simulations done using measured albedo in fixed discrete bands (0.85/0.65/0.35/0.26) with measured global and diffuse horizontal, and using measured Gv. Only small differences observed. However, assuming a fixed typical reflectivity (0.2) resulted in significant differences.
- Thermal bridges: One modeller reported little impact of modelling thermal bridges. Another reported significant differences between modelling external only bridges and external+internal bridges.
- External longwave: Minor difference between using measured horizontal longwave radiation and the common Berdahl and Martin algorithm
- Airflow: Impact of airflow from the cellar in pressurization tests?

Conclusions

- The results of the Extended Experiment are MUCH better:
  - Why?
- We exceeded a complexity level feasible for model validation for two reasons:
  - The modelling becomes complicated, even for experienced modelers, and running into the limits of some softwares.
  - The number of potential and possibly in parallel appearing errors makes it hard to determine if a change was an improvement.

Conclusions

- Dataset available for training and educational purposes
  - Especially for applications focusing on complex simulations
- Modeling underfloor heating is not less accurate than electrical heater
  - stratification
- Problems discovered -> future research required (detail models)
  - Internal heat exchange:
    - Thermal bridges
    - air flow
  - stratification

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GER)

Draft Report

Next steps

- Finalize report
  - Text
  - Internal Review
  - IEA Exco Review
- Further publications
  - Journal on Building Performance Simulation (IP: *3.020*)
  - Energy and Bulding (IP: 4.867)
- Next Meeting
  - Call for contributions

Call for contributions for the last meeting

- Sensitivity analysis performed by modelling teams
- Findings of their work
  - Critical issues
  - Research needed
  - Lessons Learnd
  - In-detail analysis of certain aspects
- ~ 5-15 Min Each

BES-validation exercise

Thank you for all contributions !!!

Matthias.kersken@ibp.fraunhofer.de

http://dx.doi.org/10.24406/fordatis/76

EBC

Energy in Buildings and Communities Programme

IEA EBC Annex 71

Building energy performance assessment based on in-situ measurements

9th expert meeting – wrap up

IEA EBC Annex 71 – Webex-meeting
October 19-21, 2020

agenda

Monday 19th October

9 am – 1 pm Intro + break out session on ST3

9 am – 10 am: Plenary session with overview and status of different subtasks

10 am – 1 pm: Breakout session on subtask 3

2 – 5 pm Break out session on ST2

Tuesday 20th October

9 – 12 Joint break out session on ST1 and ST4

2 – 3 pm Break out session on BES-validation exercise

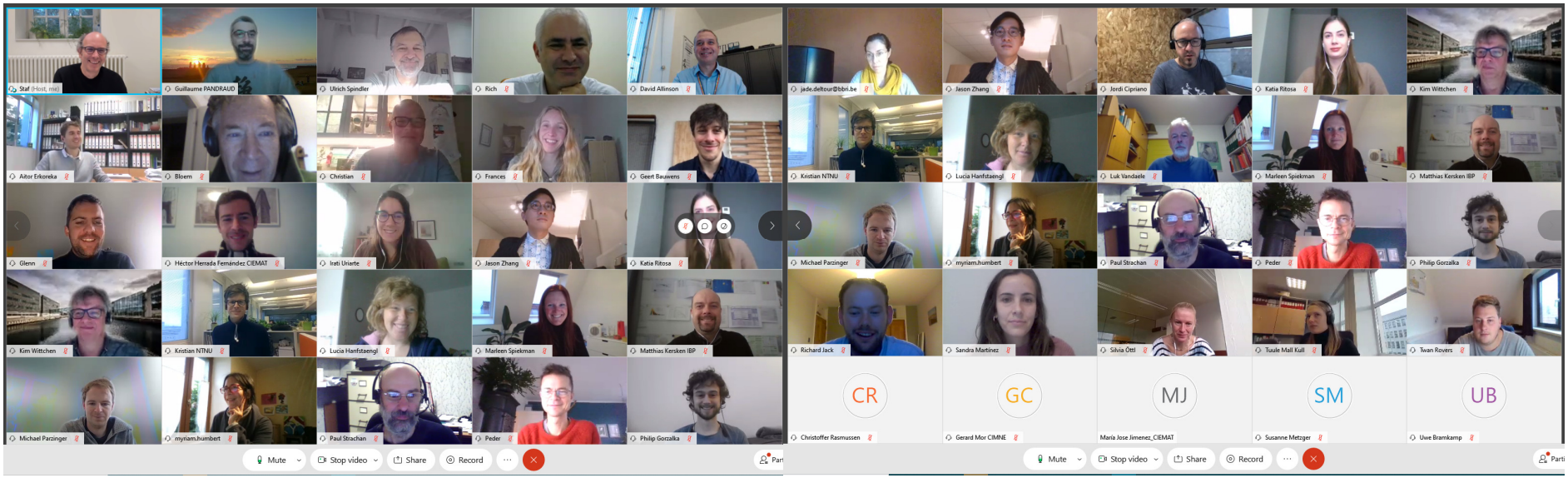
3 – 5 pm core group meeting

Wednesday 21st October

9 – 10 am plenary wrap-up session:

feedback of the breakout session, follow up actions

Group picture



Feedback break out sessions

ST1 – ST4: Gathering input data (Richard Fitton)

Towards quality assessment (Richard Jack, Liesje van Gelder)

ST2: Building behavior identification (Dirk Saelens, Glenn Reynders)

ST3: Physical parameter identification (Chris Gorse, Geert Bauwens)

BES Validation exercise (Paul Strachan, Matthias Kersken)

ST5: Network of excellence (Hans Bloem, Luk Vandaele, Maria José Jimenez)

Subtask 1. Gathering input data

Richard Fitton

Subtask 4. Towards quality assessment

Richard Jack, Liesje van Gelder

Sub Task 1 Update

Actions from break out session

- Main actions are as follows (individual task are to be sent out over email in the coming week)
- Some missing evidence required for PG studies in Belgium and France, any ideas?
- Amongst the group, how many coheating measurements have been carried out?
- Some overlap in description of coheating, to be amalgamated and edited down
- Overview of onboard technologies, any access to data on number of installed smart devices?
- Describe the evolution of on board/consumer data sources

Sub Task 1 Update

- Normalization, no agreement between members so options will be presented with strengths and weaknesses
- The stakeholder survey did give some guidance and thoughts around this which will be used
- Future work:
  - It was felt that we are a world away from where we started in terms of data, alexa's with temp sensors, nest/ tado etc and also leaps in the knowledge with projects like SMETERS etc
  - How would we do it differently, what would we do next
  - What is next for decision makers and policy makers.

Sub Task 4 Update

- Main activities complete – reported in paper & ST1/4 report
- Support paper submission led by Chirag
- Support workshop at Salford at the end of the Annex
- Seek feedback on inclusion of HTC measurement in policy with policy makers
  - UK through SMETER w/help from David Allinson
  - Any volunteers with contacts in other countries/EU?

Sub Task 1 – 4 Actions

- 4 reviewers needed
- Document in draft 1st week in January for internal review
- Reviewers to be from inside and outside ST1/4.

Sub Task 1 – 4

- We welcome all comments and feedback for ST1 areas to r.fitton@Salford.ac.uk
- Or to Richard Jack for ST4 areas Richard Jack richard.jack@buildtestsolutions.com

Subtask 2.
Building behaviour identification

Dirk Saelens (KUL, Belgium), Glenn Reynders (EV, Belgium)

Subtask 2.
Building behaviour identification

Glenn Reynders (EV, Belgium), Arash Erfani (KUL, Belgium)

ST2: Building behavior identification

Glenn Reynders (EV, BE), Arash Erfani (KUL, BE)

Final report

1. Introduction
2. Modelling techniques for building behavior identification
3. Test-cases
    - Semi-detached house (Gainsborough, UK)
    - Twin Houses (Holzkichen, Germany)
4. Fault-detection and diagnostics
    - Problem statement
    - Theoretic background
    - Application to simulated data
    - Application to real data
    - Lessons learned
5. Model predictive control
    - Problem statement
    - Description of modelling framework
    - Application to simulated data
    - Application to real data
    - Lessons learned
6. Lessons learned

Fault-detection and diagnostics

Application to simulated data

Results of CE2 -> all contributors: any final updates?

Application to real data

Results of CE3 -> all contributors : updates pending

Last call:

- apply models of trained on CE2 on CE3

- apply models of MPC on CE2 and CE3

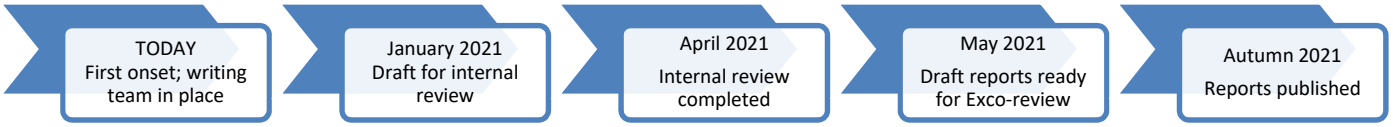
MPC

- Main conclusions were discussed
  - Multi-step ahead predictions
  - Successful framework
- Final iterations are being conducted (option 2)
- In-depth analysis of time series plots suggested to support summary tables

ST2: Building behavior identification

Glenn Reynders (EV, BE), Arash Erfani (KUL, BE)

Final report



Practical

Google doc has been started and shared amongst CE participants

Next steps

What?	When?
Finalize TOC and contributions	OK
Install writing team	OK
Finalize modelling	November 20th
Finalize first draft	December

Action points

Teams/Sharepoint for writing team: 22 October

One-on-ones writing teams: 26-30 October

Closing meeting CE's : 9-13 November

Content submission model descriptions: 13 November

Final CE submissions: 20 November

First draft: 1 December

Revised results and lesson learned: 15 December

Subtask 3.
Physical parameter identification

Chris Gorse (LBU, UK), Geert Bauwens (KUL, Belgium)

Report outline

1. Introduction
2. Building Physical Framework
3. Statistical modelling approaches
4. Determining the input variables
5. Case studies
6. Exploration of inputs
7. Discussion of results
8. Conclusion
9. Annex 1: CEs
10. Annex 2: Implementation of modelling approaches in R and Python
11. References

ST3: Physical parameter identification

Chris Gorse (LBU, UK), Geert Bauwens (KUL, BE)

Timeline

2020 2021

Nov Dec Jan Feb Mar Apr Salford May

Dec 24: Draft report out for internal review

April: Internal review due

Dec 18: Draft report reworked

May: Draft report ExCo

Oct 29: Action plan for draft report rework + final division of work

April: Rework draft report

4 case studies combined modeling approaches

BEIS Test data prep

Launch of BEIS Test case

Action points

Volunteers

- Ch 4 Determining the input variables
  Geert provides heat input part as example by end Oct
  WG leaders rewrite part by Nov 25
- Ch 5 Case studies
  Jade adds Uccle and Twan adds Gainsborough by Nov 25
- Ch 6 Exploration of inputs
  Geert provides R-script to generate charts by Nov 11
  WG leaders provide part by Dec 16

Action points

Volunteers

- Ch 7 Discussion of results:
  By mid Nov collect approaches, report by **Dec 16**
  - Twin Test House O5 **Katia** (ARX, LR), Jason (GB), Gabrielle
  - Twin Test House N2 **Katia** (ARX, LR), Jason (GB), Gabrielle
  - Uccle Test House **Jade** (GB), Kristian (ARX, LR)
  - Loughborough **Frances** (GB, LR), Christoffer (ARX)
  - Gainsborough **Kristian** (ARX, LR), Jason (GB)
- Ch 8 Blind test on BEIS TEST case study
  David and Chris prepare common exercise by Dec 21

Deadlines

- Oct 29: action plan Ch 4 and Ch 6
- Nov 18: Ch 7 data & approaches collected (@Katia)
- Nov 25: Ch 4 rewritten
- Dec 9, 9am: **WebEx** to discuss results (Ch 7)
- Dec 16: Ch 6 rewritten
- Dec 23: Draft report ready for internal review A71

Internal reviewers wanted!

- *Your name here*

BES-validation exercise

Paul Strachan (ESRU, UK), Matthias Kersken (IBP, GE)

BES-validation exercise

Matthias Kersken (IBP, GER), Paul Strachan (ESRU, UK)

Status

- Experiment ✓
  - Experimental design ✓
  - Experimental setup ✓
  - Conduction of Experiment ✓
  - Experimental specifications ✓
- Validation ✓
  - Dissemination ✓
  - Results from ✓
    - ME – blind & open phase ✓
    - EE – blind & open phase ✓
  - Project reports and questionnaire ✓
- Analysis ✓
  - Trend line graphs ✓
  - Metrics' tables ✓
  - Questionnaire ✓
    - Sensitivity analysis
- Documentation
  - QnA -> Experimental specs ✓
  - Data & specs with DOI ✓
  - IEA report *(near completion)*
- Publications *(so far)*
  - Experimental design (BS2019)✓
  - Experiment (NSB2020) ✓
  - Results: Blind (BS2021);Open (?)

BES-validation exercise

Matthias Kersken (IBP, GER), Paul Strachan (ESRU, UK)

Status

- No big difference between electrical and UFH (unexpected)
- Results with moisture relatively good (different boundaries?)
- Hard to correlate between metrics and approaches
  - disaggregate by sensitivity
- Additional sensitivity study required
- Report
  - Conclusions + discussion

next steps

- Finish report text
- Call out for existing sensitivity analysis
- Ask modelling teams to estimate specified sensitivities

Item	Variance value	Influence
Stratification modelled	bool	+30 %
Albedo	Mesaurement Fixed @ 0.5	-3 %

- Analyse sensitivities
- Inquire why in User 1 & 2 set points were used

BES-validation exercise

Matthias Kersken (IBP, GER), Paul Strachan (ESRU, UK)

time line

- Finish report text – ready for internal review — end Dec. 2020
- Call out for existing sensitivity analysis — mid Oct. 2020
- Ask modelling teams to estimate specified sensitivities — end Nov 2020

Internal Reviewers for BESmodVAL report

Nr	Name
1	
2	
3	
4	

Subtask 5.
Network of excellence

Hans Bloem, Luk Vandaele, Maria José Jimenez, Richard Fitton

The Network of Excellence

Network for

- DYNamic
- Analysis
- Simulation and
- Testing of
- Energy and
- Environmental performance of buildings

The Network of Excellence

- DYNASTEE is an informal network
- No admission fee
- Functions under the umbrella of INIVE EEIG
- Platform for exchange of information, dissemination, training and expertise
- For researchers, industry, product developers, designers, …
- **Towards a Network of Excellence**

The Network of Excellence

- The expertise developed in the Annex 58 project remains available to the community of builders, designers, industrial developers, scientists and public authorities.
- The DYNASTEE platform will continue to act as the information exchange medium
  - Training Exercises, software and data
  - Summer School: Dynamic Methods For Whole Building Energy Assessment
  - Collaboration with other IEA Annexes

Subtask 5. Network of excellence

In January 2020, DYNASTEE has strengthen its management team. Maria-Jose Jimenez and Richard Fitton have agreed to join Peter Wouters, Luk Vandaele and Hans Bloem.

After participating to 2 EBC Annexes, DYNASTEE is expected to act again on its own feet and investigate new directions:
- Training, e.g. Summer School on Dynamic Analysis for Energy Performance Assessment of Buildings. Investigate on-line training.
- Dynamic analysis of (smart-)metering data, which is a new area based on existing analysis methods and will include acquisition of data and basic analysis

The planned Workshop, in collaboration with University of Salford will move from October to the Spring 2021 meeting in Manchester.

Subtask 5. Network of excellence

Hans Bloem (INIVE), Luk Vandaele (INIVE)
Maria José Jimenez, Richard Fitton

Input to final report Annex 71 project 2016 – 2021

Dissemination by means of:

- Web-site; www.DYNASTEE.info
- Newsletters; 10 issues. Foreseen another 2 until June 2021.
- Events; Webinar, Workshops and Summer Schools

Training on *Dynamic Calculation Methods for Building Energy Performance Assessment.*
Summer Schools have been organised in 2016, 2017, 2018 and 2019.

On-line training; 5 webinars in September 2020.

The **Summer School** organisers have scheduled a weeklong physical Summer School in Almeria, June 2021.

Subtask 5. Network of excellence

Hans Bloem (INIVE), Luk Vandaele (INIVE)
Maria José Jimenez, Richard Fitton

Input to final report Annex 71 project 2016 – 2021

Summary reports of scientific and technical exchange events:

Symposium in Bilbao, Spain 2019. The Building as the Cornerstone of our Future Energy Infrastructure – The importance of dynamic and real data for reliable assessment. 52 participants.

Workshop on Building energy performance assessment and quality assurance based on in-situ measurements that took place in Brussels, 2018. About 80 participants

Workshop: “Building energy performance assessment based on optimised in-situ measurements”, was successfully held in Brussels, 2016. About 100 participants attended this event

Subtask 5. Network of excellence

Hans Bloem (INIVE), Luk Vandaele (INIVE)
Maria José Jimenez, Richard Fitton

DYNASTEE On-line training
Dynamic Calculation Methods for Building Energy Performance Assessment

Five webinars, replacing the weeklong physical Summer School, have taken place in **September, every Wednesday 10:00-12:00**

Each webinar has been composed of two lectures and the introduction of an exercise using benchmark data that has been made available to the participants for training. Lecturers came from 5 different countries. Participants were mostly from Europe but several from other parts of the world (Brazil, Australia, etc.)

The **Summer School** organisers have scheduled a weeklong physical Summer School in Almeria, in **June 2021**.
Feel free to contact mjose.jimenez@psa.es or hans.bloem@inive.org to be placed on the Summer School mailing-list

Subtask 5. Network of excellence

Hans Bloem (INIVE), Luk Vandaele (INIVE)
Maria José Jimenez, Richard Fitton

Evaluation of the DYNASTEE training webinars, September 2020

110 different participants over 5 webinars (each Wednesday 10:00 – 12:00);

Webinar 1 (72 p) Presenting DYNASTEE and its history; training at Summer School
Webinar 2 (76 p) Introduction to dynamic methods and software tool LORD.

Webinar 3 (43 p) Presenting the experimental set-up and measurement equipment

Webinar 4 (45 p) Introduction to CTSM-R and application with PSA data

Webinar 5 (33 p) Conclusions and Questions & Answer

51 persons attended 3 or more webinars of which 27 attended 4 or all 5 webinars.

A survey has been prepared and mailed to all 110 participants. Results will be published in the DYNASTEE Newsletter 17, November 2020

Newsletter 16 has been published in May

Editors:
Twan Rovers,
Luk Vandaele and
Hans Bloem

Newsletter 17
is due by November.

Input from Annex 71 is welcome until 26 October

DYNASTEE
NEWSLETTER ISSUE 2020/16

Foreword

I hope this Newsletter reaches you in good health. The current COVID-19 pandemic has drastically changed the ways in which we learn and work, collaborate and socialize.

As a result of the measures that are being taken to prevent the further spreading of the virus, both the DYNASTEE Summer School on Dynamic Calculation Methods for Building Energy Performance Assessment and the DTU Summer School on Time Series Analysis with a focus on modelling and forecasting in energy systems, will take place digitally.

Just days before all travel and meetings would be restricted, the 2nd European SimStadt Workshop took place at Saxion UAS in the Netherlands. You'll find an article on the workshop and the ELISE project in this issue. This 16th DYNASTEE Newsletter also contains an article on Model Predictive Control applied to thermostatic controlled systems.

Finally, the NSB 2020 conference in Tallinn (Estonia) has been rescheduled to 6 – 9 September 2020. I hope we will be able to physically meet again by then. Take care.

Twan Rovers, Saxion University of Applied Sciences

individual shading and/or cooling of apartments

CONTENTS

DYNASTEE Management Board

Since January 2020, the DYNASTEE board has strengthened its management team and is hence been extended to five persons. Maria Jose Jimenez and Richard Fitton have agreed to join Peter Wouters, Luk Vandaele and Hans Bloem.

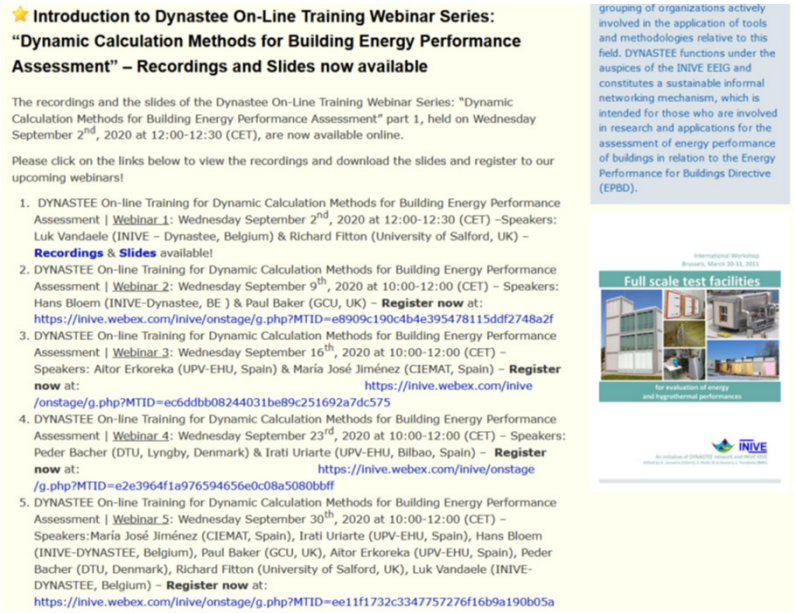
María José Jiménez holds a PhD in Physics and has been working for the CIEMAT (Public National Research Institution dedicated to Energy and Environment) since 1992. She is Head of CIEMAT group for Experimental Energy Analysis in Buildings and member of several International Committees related to Building Energy Performance Assessment. Her expertise is in the areas of Building Physics, Measurements in the built environment, System identification applied to energy performance assessment of buildings - Bridging physics and statistics, and tests and analysis in warm and sunny weather.

Richard Fitton (University of Salford, Manchester, UK) holds a PhD in Building Physics and is also a chartered building surveyor. He leads a task group for the development of international standards around energy performance. He is also active in the International Energy Agency studying the use of smart meter data to provide energy efficiency data for dwellings. He holds a place on the SAP Scientific Integrity Group at the Building Research Establishment (BRE) which oversees the domestic energy model used in the UK. Richard is also the technical lead for the new Energy House 2 project, a building physics test lab.

COMMUNICATION

Dissemination by means of

- Web-site **www.dynastee.info**
- Newsletters
  - 10 published so far
  - Number 17 in November
- Events organised
  - Webinar (5)
  - Workshops (3)
  - Summer Schools (4)



Introduction to Dynastee On-Line Training Webinar Series: "Dynamic Calculation Methods for Building Energy Performance Assessment" – Recordings and Slides now available

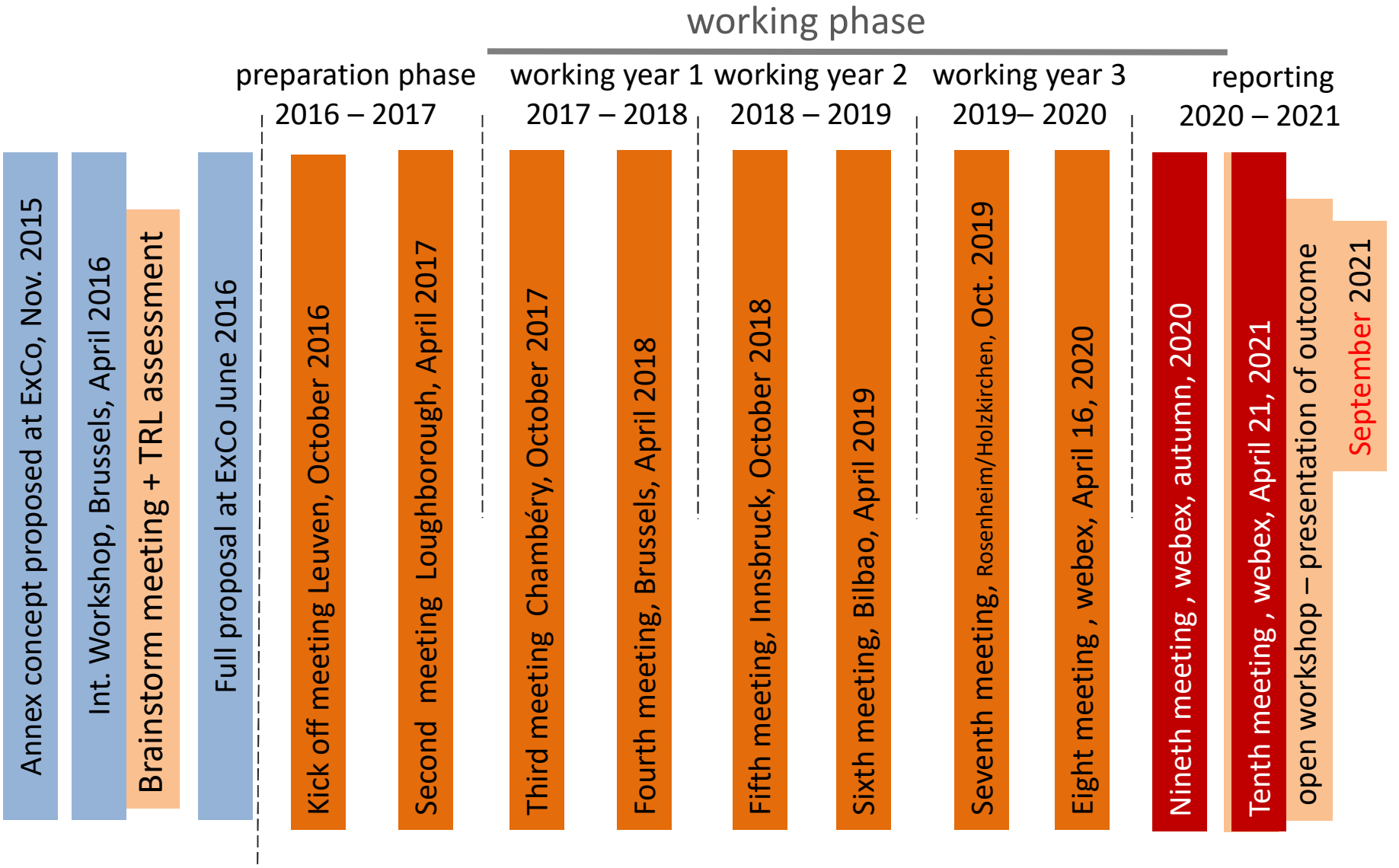
The recordings and the slides of the Dynastee On-Line Training Webinar Series: "Dynamic Calculation Methods for Building Energy Performance Assessment" part 1, held on Wednesday September 2nd, 2020 at 12:00-12:30 (CET), are now available online.

Please click on the links below to view the recordings and download the slides and register to our upcoming webinars!

1. DYNASTEE On-line Training for Dynamic Calculation Methods for Building Energy Performance Assessment | Webinar 1: Wednesday September 2nd, 2020 at 12:00-12:30 (CET) –Speakers: Luk Vandaele (INIVE – Dynastee, Belgium) & Richard Fitton (University of Salford, UK) – **Recordings** & **Slides** available!
2. DYNASTEE On-line Training for Dynamic Calculation Methods for Building Energy Performance Assessment | Webinar 2: Wednesday September 9th, 2020 at 10:00-12:00 (CET) – Speakers: Hans Bloem (INIVE-Dynastee, BE) & Paul Baker (GCU, UK) – **Register now** at: https://inive.webex.com/inive/onstage/g.php?MTID=e8909c190c4b4e395478115ddf2748a2f
3. DYNASTEE On-line Training for Dynamic Calculation Methods for Building Energy Performance Assessment | Webinar 3: Wednesday September 16th, 2020 at 10:00-12:00 (CET) – Speakers: Aitor Erkoreka (UPV-EHU, Spain) & María José Jiménez (CIEMAT, Spain) – **Register now** at: https://inive.webex.com/inive/onstage/g.php?MTID=ec6ddbb08244031be89c251692a7dc575
4. DYNASTEE On-line Training for Dynamic Calculation Methods for Building Energy Performance Assessment | Webinar 4: Wednesday September 23rd, 2020 at 10:00-12:00 (CET) – Speakers: Peder Bacher (DTU, Lyngby, Denmark) & Irati Uriarte (UPV-EHU, Bilbao, Spain) – **Register now** at: https://inive.webex.com/inive/onstage/g.php?MTID=e2e3964f1a976594656e0c08a5080bbff
5. DYNASTEE On-line Training for Dynamic Calculation Methods for Building Energy Performance Assessment | Webinar 5: Wednesday September 30th, 2020 at 10:00-12:00 (CET) – Speakers:María José Jiménez (CIEMAT, Spain), Irati Uriarte (UPV-EHU, Spain), Hans Bloem (INIVE-DYNASTEE, Belgium), Paul Baker (GCU, UK), Aitor Erkoreka (UPV-EHU, Spain), Peder Bacher (DTU, Denmark), Richard Fitton (University of Salford, UK), Luk Vandaele (INIVE-DYNASTEE, Belgium) – **Register now** at: https://inive.webex.com/inive/onstage/g.php?MTID=ee11f1732c3347757276f16b9a190b05a

grouping of organizations actively involved in the application of tools and methodologies relative to this field. DYNASTEE functions under the auspices of the INIVE EEIG and constitutes a sustainable informal networking mechanism, which is intended for those who are involved in research and applications for the assessment of energy performance of buildings in relation to the Energy Performance for Buildings Directive (EPBD).

New time schedule

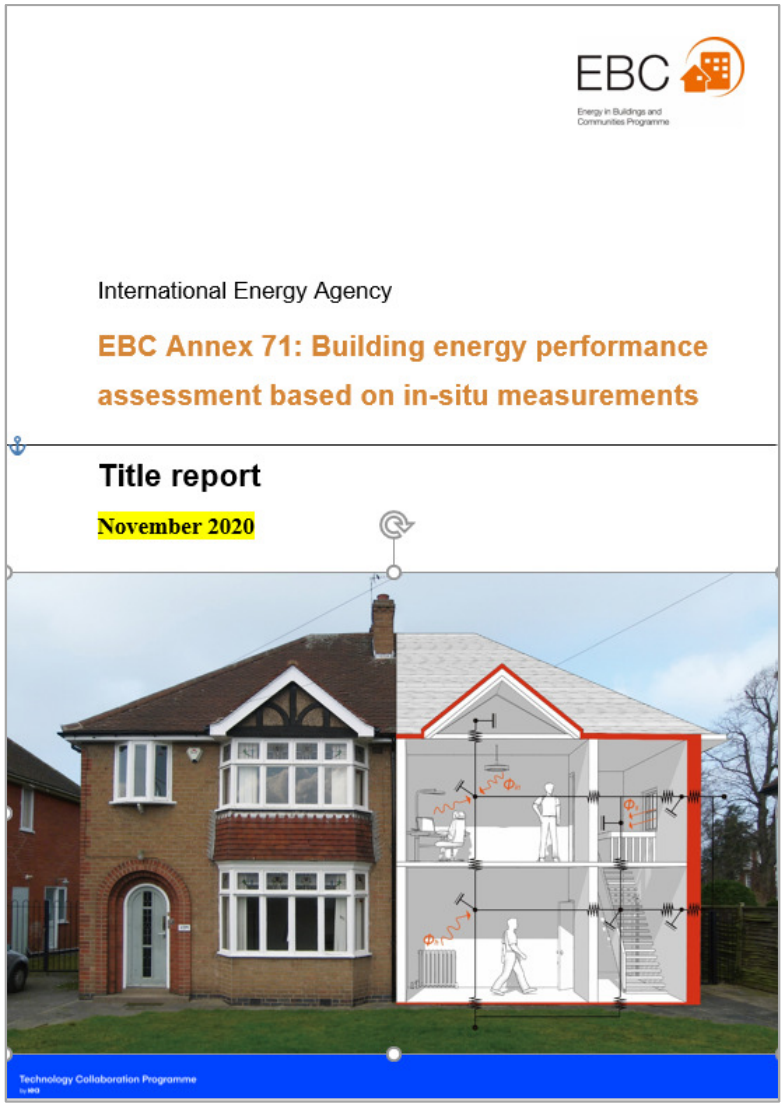


Reporting time schedule

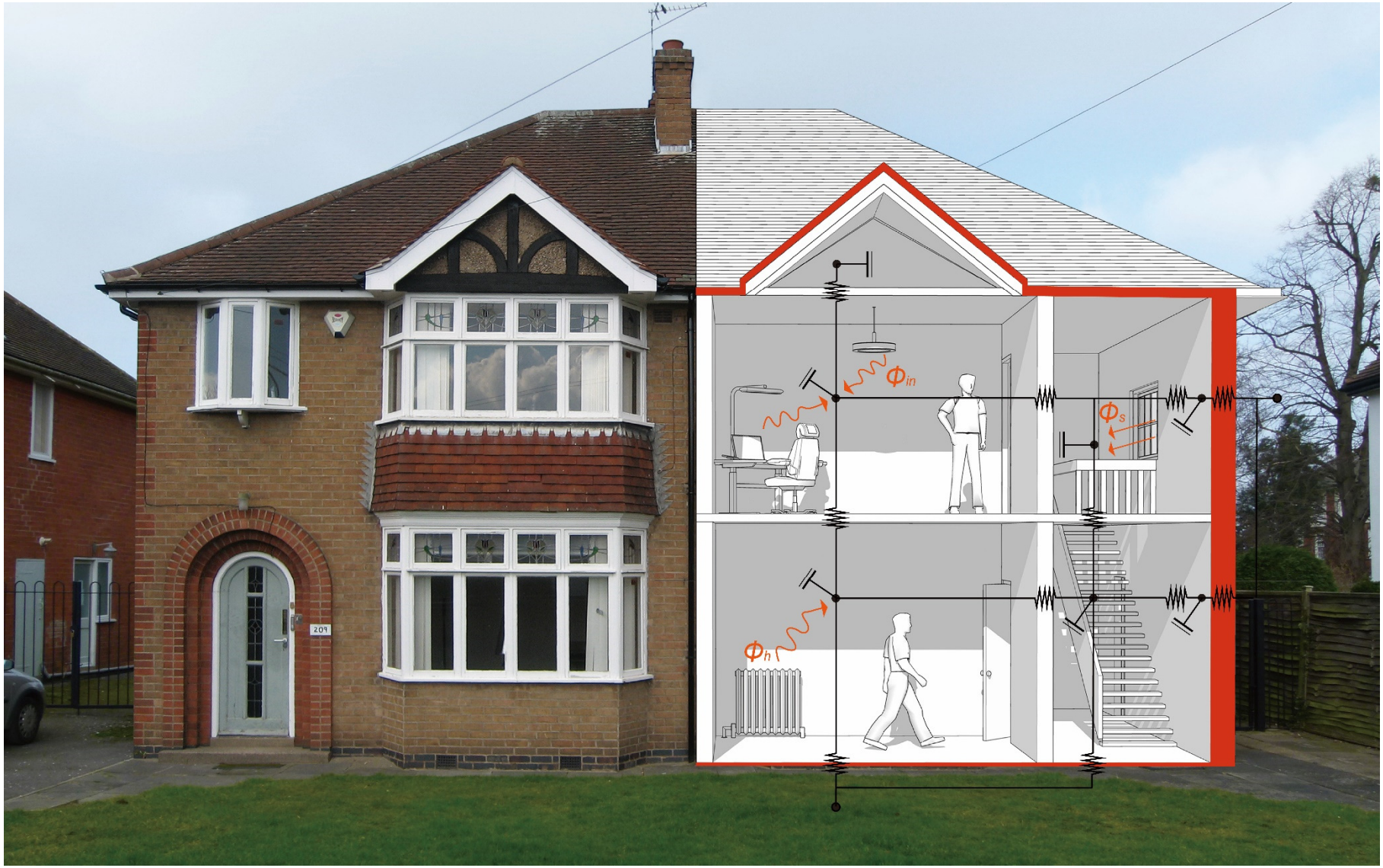
Outline and first onset of reports	At next Expert Meeting in Trondheim October 2020 instead of April 2020
Draft reports ready for internal review	~~Begin September 2020~~ January 2021
Internal review due by	Last Expert Meeting ~~October 2020~~ April 2021
Draft reports ready for ExCo-review	~~Mid November 2020~~ May 2021
Final reports	~~Spring 2021~~ Autumn 2021

Reporting time schedule

Proposal cover picture



Proposal cover picture



What after Annex 71 ?

There have been some suggestions / requests for a follow-up Annex

We welcome all ideas to:
staf.roels@kuleuven.be or katia.ritosa@kuleuven.be

Discussion on the next expert meeting

EBC

Energy in Buildings and Communities Programme

IEA EBC Annex 71

Building energy performance assessment based on in-situ measurements

Tenth expert meeting
April 21, 2021

Webex-meeting

Closure of 9th expert meeting

Thank you all for your input!

Looking forward to meet you again April 21