# EBC Annex 79

## Occupant behaviour-centric building design and operation


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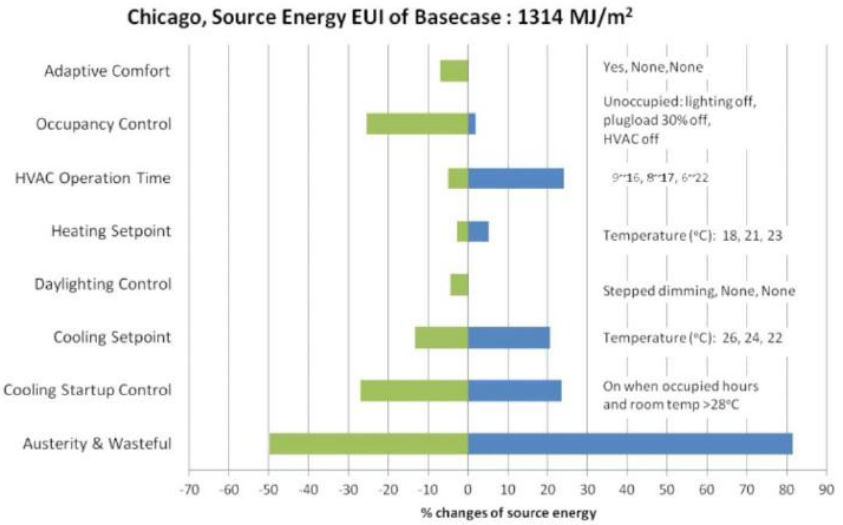
# Background

- Occupant behaviour has a strong influence on building performance

- Reasons for occupants' interventions:
  - dissatisfaction with building automation
  - interfaces are not designed/equipped for intended purpose
  - planners do not consider occupants' needs in building design (same is true for building operation)

→ **Occupants have to be included into overall building concept (by providing adaptive opportunities) and into control strategy (with appropriate interfaces)**




Hong and Lin, 2013

Gilani and O'Brien, 2018

# Open Questions

**Annex 66** provided sound framework for
- experimentally studying and modeling different (but single!) behavioral actions
- implementation of models into simulation platforms

**But**: discrepancy with design and building operation practice:
- What is impact of multiple and interdependent indoor environmental parameters on human perception and resulting behavioural reactions?
- How do building controls' interfaces and their underlying logic affect behaviour?
- How can building automation systems and other readily-available data sources be better leveraged for improving occupant-centric building concepts?
- What kind of information has to be provided to better inform designers and building managers on how to apply occupant behaviour knowledge and models in practice?

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# Objectives of Annex 79

- Improvement of knowledge about occupants' interactions with building technologies. Specific focus on
  - comfort-driven actions caused by multiple and interdependent environmental influences which are not yet covered by current models
  - building technologies' interfaces in terms of their suitability for taking advantage of adaptive opportunities, and their effect on building energy consumption
- Deployment of 'big data' (e.g. data mining and machine learning) for the building sector based on various sources of building and occupant data as well as sensing technologies
- Sustainable implementation of occupant behaviour models in building practice
  - guidelines / recommendations for standards for applying occupant behaviour models during building design and operation
  - focused case studies to implement and test the new models in different design and operation phases in order to get valuable feedback

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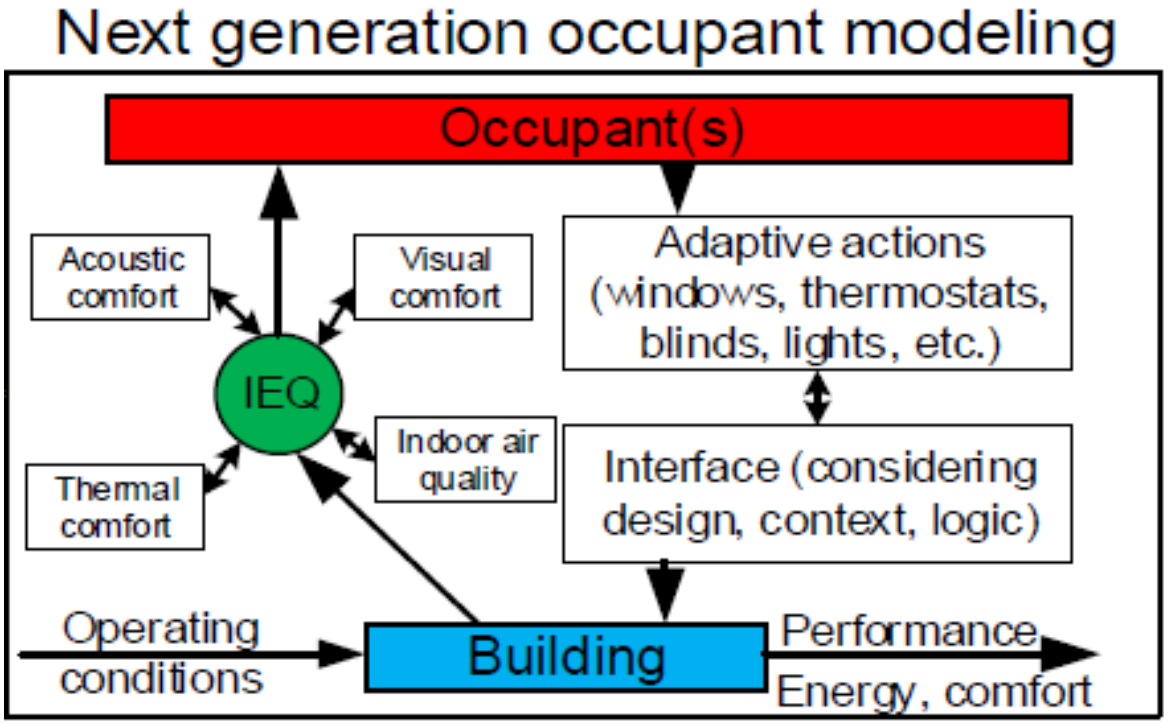
# Objectives (2): occupant-centric buildings



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# Scope of the work

- Building up a framework for identifying and describing the main influencing factors of occupancy and occupants' actions in buildings and their interrelations
- Examine exemplary use cases with primary focus on office and residential buildings (depending on available data and case study buildings focus may extend to other building types)
- All activities contribute to reduce operating energy of buildings, while improving comfort by offering applicable adaptive opportunities to occupants
- Focused case studies as a platform to implement, test and demonstrate new models, standards and guidelines emerging from Annex research in a real building context during different design and operation phases
- Research methods from various domains like engineering, architecture, information technology, psychology, social sciences, etc.

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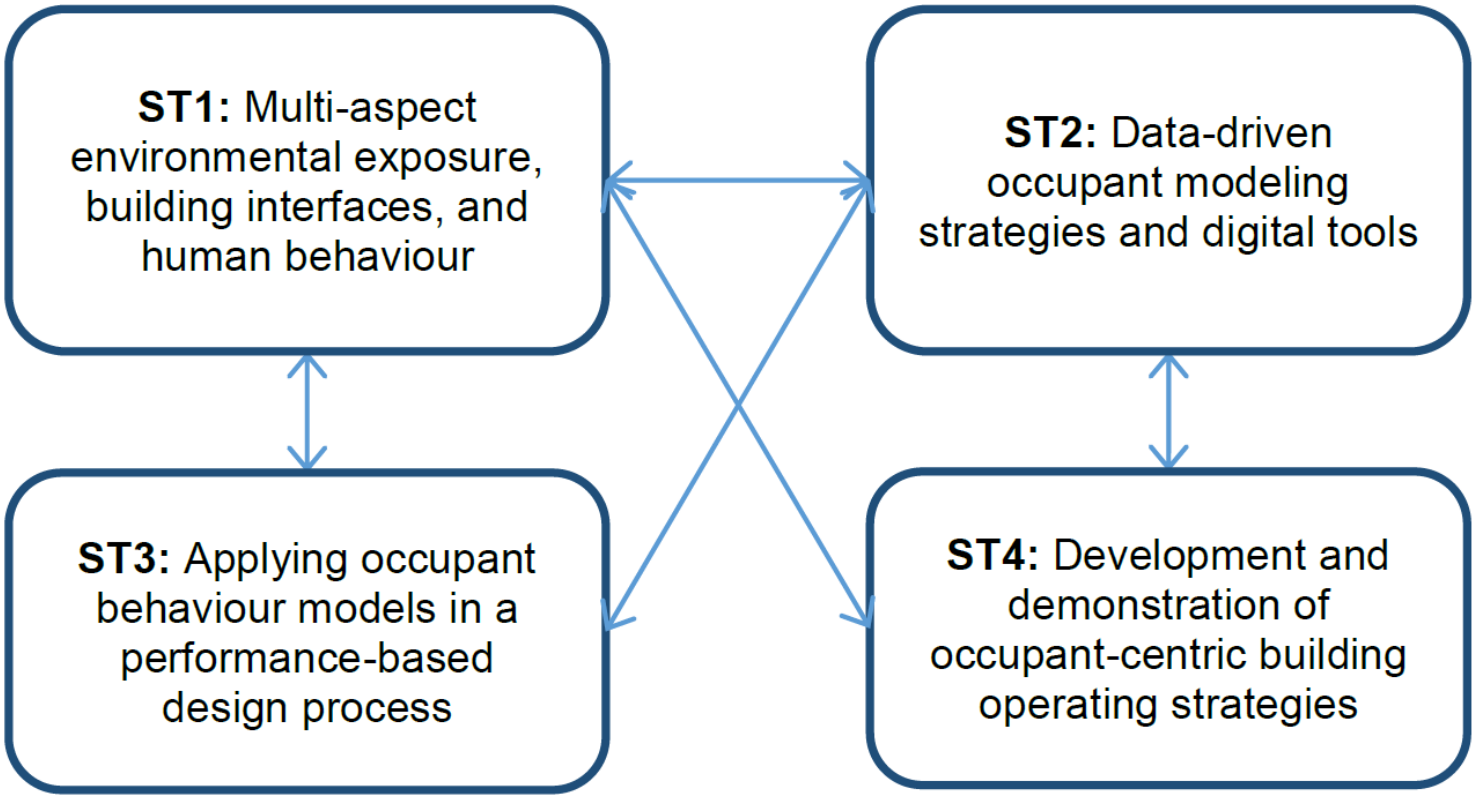
# Means

## Organisation in 4 Subtasks



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# Research approaches and topics

| | Occupant behaviour | Technologies, interfaces | "Big data" from BMS etc. | Advanced models |
|---|---|---|---|---|
| Experiments (lab / in situ) | ST1 | ST1 | | |
| Data mining, machine learning | | | ST2 | |
| Modeling and design guidelines, building policy (standard and code) recommendations | | | | ST3/4 |
| Field application - testing, monitoring and verification in case studies | | | ST3/4 | ST3/4 |

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# Expected outcomes

- Enhanced knowledge about coupled environmental influences on occupants and their interaction with building technologies (interfaces)
- New data-based occupant behavior models based on various large data sources/sensing technologies
- Open collaboration platform for data and software supporting the use of data-mining methods and tools
- Model repository for digital planning environments
- Proposals for standards and policy support / guidelines for designers and building operators in order to implement OB models in building practice

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# Deliverables and target audience

| Stakeholder | Deliverable (responsible subtask(s) in brackets) |
|---|---|
| **Scientists and academics** | Report on:<br>• Comprehensive literature review for the four Subtasks (1,2,3,4)<br>• Unified theoretical framework for perceptual and behavioural theory of building occupants;<br>• Guidelines for research methods related to: evaluating occupant comfort and building interfaces (1), occupant data collection (2), and applying data analytics to occupant data (2) |
| **Practitioners (architects, engineers, building managers)** | Report on:<br>• Best-practices for building interfaces (1), occupant-centric design workflows (3), and optimal control strategies (4)<br>• Focused case studies, including lessons learned (3 and 4) |
| **Industry (controls, HVAC, mechanical and electrical equipment, etc.)** | Report on:<br>• Best-practices for interface design and evaluation criteria of new products considering multi-aspect comfort (1) |
| **Policy-makers (e.g., government, building code officials)** | Report on:<br>• Recommendations on occupant modelling in building energy codes (1)<br>• Recommendations for standards on occupant metering/sensing infrastructure and controls (2) |

# Annex Management

**OAs:** Andreas Wagner (Germany), Liam O'Brien (Canada)

| ST | Subtask leaders |
|---|---|
| 1 | Ardeshir Mahdavi, TU Wien, Austria<br>Marcel Schweiker, Karlsruhe Institute for Technology, Germany<br>Julia Day, Washington State University, USA |
| 2 | Mikkel Kjaergaard, University of Southern Denmark, Denmark<br>Bing Dong, University of Texas San Antonio, USA<br>Salvatore Carlucci, Norwegian University of Science and Technology, Norway |
| 3 | Farhang Tahmasebi, TU Wien, Austria<br>Tianzhen Hong, Lawrence Berkeley National Laboratory, USA<br>Da Yan, Tsinghua University, China |
| 4 | Zoltan Nagy, University of Texas Austin, USA<br>Burak Gunay, Carleton University, Canada<br>Daniel Wölki, RWTH Aachen University, Germany |

# Expected Participants

**25** persons from **14** countries participated in the international workshop held in London on April 11/12 to prepare the draft Annex text

**60** persons from **16** countries expressed interest in participation with indication of subtask-related contribution

**14** countries completed the Technology Readiness Assessment

# Technology Readiness Assessment

| | Technology | | | | |
|---|---|---|---|---|---|
| | 1. Conceptual and mathematical modelling of - and research methods (laboratory, field studies) for - studying human comfort and behaviour with respect to multi-aspect environmental variables. | 2. Application of fields of human factors, occupant comfort, occupant behaviour, and building physics to inform the design and deployment of building interfaces. | 3. Application of data-driven occupant modelling strategies using centralized and common data sources and methods | 4. Integration of occupant models and sensed occupant data to: (A) the simulation-aided building design process and (B) building controls and automation systems. | Confidence in the accuracy of your assessment |
| **Average** | **2.3** | **3.0** | **2.5** | **2.9** | **3.9** |
| Min | 1 | 1 | 1 | 1 | 3 |
| Max | 4 | 5 | 4 | 5 | 4 |

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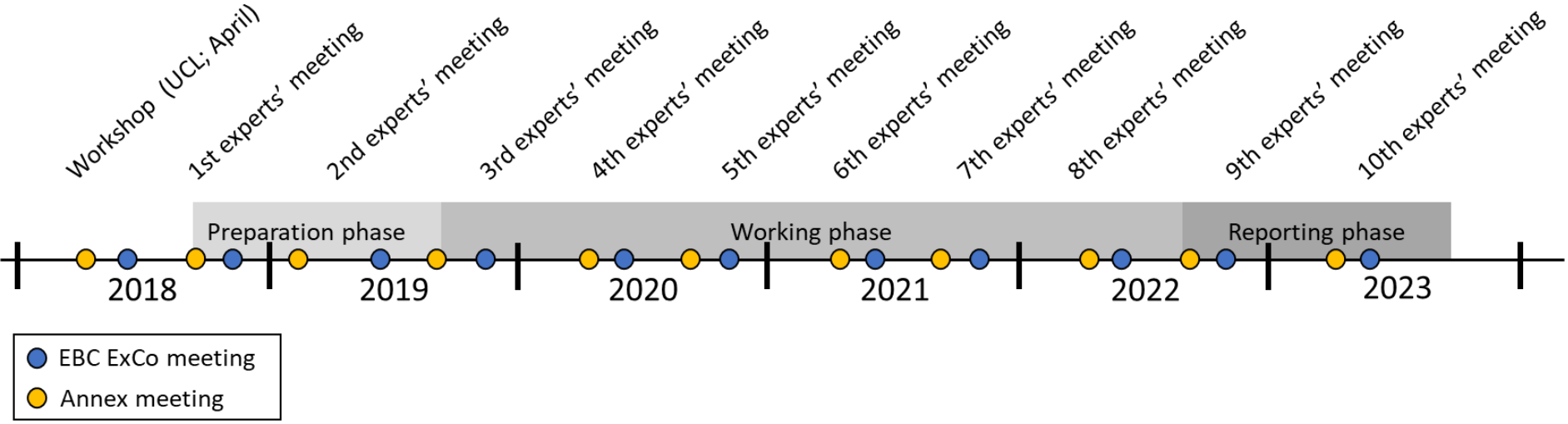
# Timeline

Planning workshop: April 2018 (London)
First meeting: October 2018
Preparation phase: October 2018 – September 2019
Working Phase: October 2019 – September 2022
Reporting Phase: October 2022 – September 2023



# Relations to EBC Strategic Plan and other EBC or IEA activities

EBC's five High-priority Research Themes: Integrated planning and building design, building energy systems, building envelope, real building energy use

Annex 66 Occupant Behavior
Annex 53 Total Energy Use in Buildings: Analysis & Evaluation Methods
Annex 69 Strategy & Practice of Adaptive Thermal Comfort in Low Energy Buildings
Annex 8 Inhabitant Behavior with Regard to Ventilation
Annex 68 Design and Operational Strategies for High IAQ in Low Energy Buildings
Annex 70 Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale

IEA DSM TCP Task 24 , activities of IEA Secretariat work on occupant behavior