AARHUS UNIVERSITY

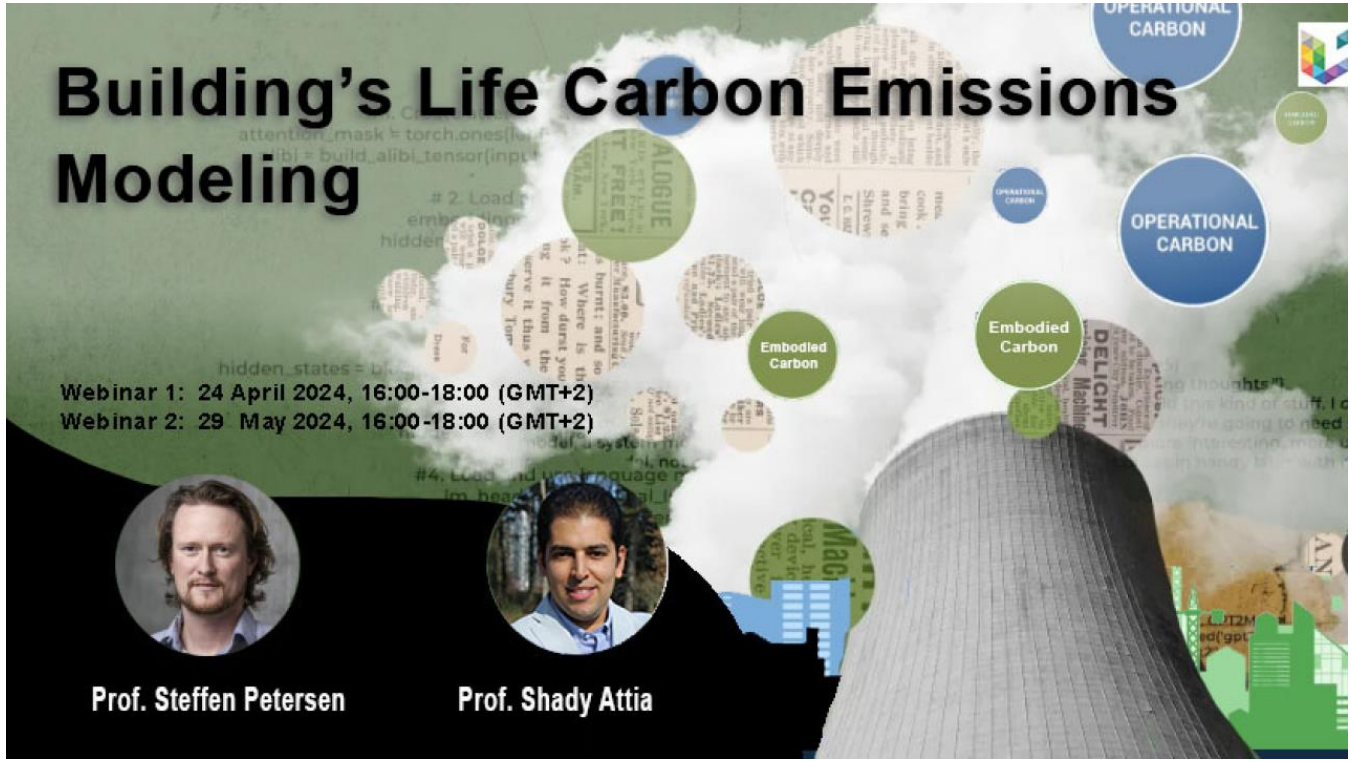
LIÈGE université

DynamicRenowave - Life Cycle Assessment and Energy Simulation of Building Renovation Strategies

Building Carbon Emissions Modeling Framework – Beta 1

Online Webinar 1 on 24 April 2024

Shady Attia (ULiege, BE)
Steffen Petersen (Aarhus Uni. DK)
André Stephan (Melbourne Uni. AU)
Émilie Gobbo (UCLouvain, BE)
Aurora Bertini (ULiege, UCLouvain BE)
Maxime Dasse (ULiege, UCLouvain BE)



LIÈGE université
AARHUS UNIVERSITY

Framework

Building Carbon Emissions Modeling Framework

Subtask 2: Paris-goal-compatible assessment methods

- evaluate the assessment methods proposed or required by current climate policies, aiming to check their compatibility with meeting the science-based carbon targets and budgets

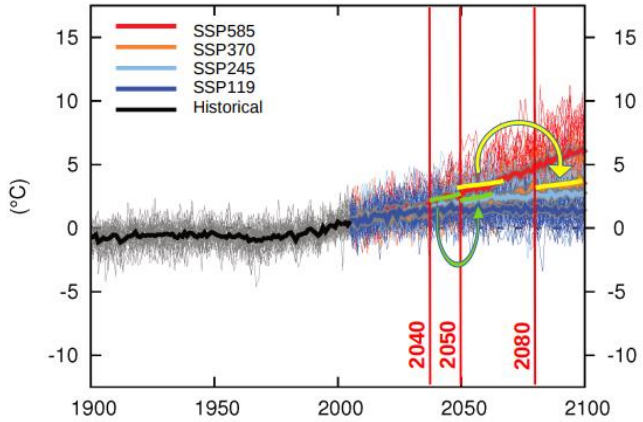
Objective 0: Coordination with all Groups and TF Weather Data

Objective 1: Define a common performance-based simulation framework for a multi-scale (from a single building to whole building stocks), multi-sectoral (i.e. lifecycle-based), and multi-stakeholder approach to decarbonizing the building and real estate sector.

Objective 2: Publish the (Liege-UCLouvain-Aarhus) framework by June 2024

Objective 3: Define a common benchmark

Carbon Emissions Modeling



Objective 0: Coordination with all Groups and TF Weather Data
Objective 1: Define common thermal conditions to assess different decarbonization pathways
Objective 2: Publish the (Liege-Aarhus) framework by June 2024
Objective 3: Define a common benchmark

Approach: Climate Change or GHG Budget

(1A) Climate Change Scenarios (Bottom Up)	(1B) Greenhouse Gas Emissions Budget (Top Down) [1]
-Baseline and Improved Design Approach -Benchmarking -Bias-adjusted TMY weather files based on the CORDEX project (SSP) for *2000-2020*, *2040-2060*, and *2080-2100*	-Planetary System Boundaries – GWP – IPCC Gas Potency -Paris-goal compatible GHG budget of about 500GT to limit global warming (annual of CO2-equiv.) -Safe Emissions Budget for Buildings

EPBD

DG ENERGY: Energy Efficiency Directive: EPBD (60% Carbon emissions reduction for buildings by 2030)
Introduction of zero-emission buildings as new standard for new buildings
Calculation of the whole life cycle of carbon
Phasing out incentives for fossil fuels

Carbon Emissions Modeling

Climate and location

(2) Weather data

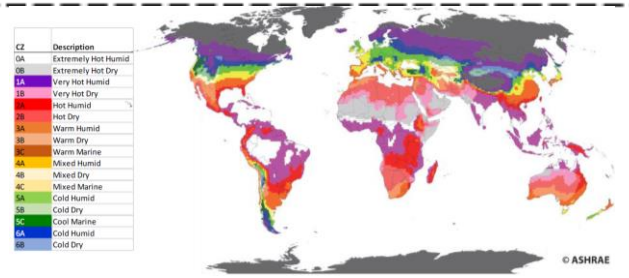
Urban heat island effect excluded

Urban heat island effect included

(2.2) Selected cities :

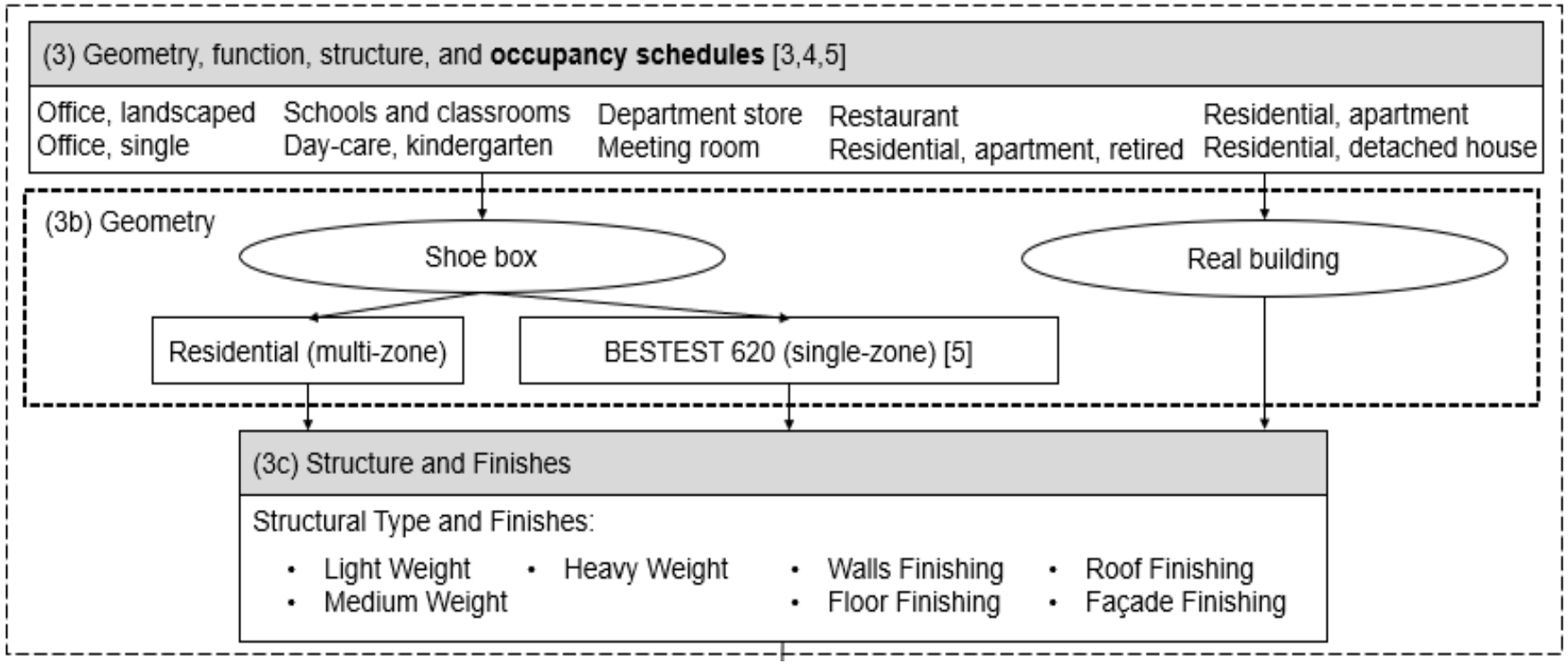
Singapore (0A)	Sao Paulo (2A)	Busan (3A)	London (4A)	Toronto (5A)
Abu Dhabi (0B)	Cairo (2B)	Tehran (3B)	Gent (4A)	Copenhagen (5A)
Lagos (1A)	Barcelona (3A)	Los Angeles (3B)	Brussels (4A)	Vienna (5A)
Guayaquil (1A)	Rome (3A)	Santiago (3C)	Xian (4B)	Montreal (6A)
New Delhi (1B)	Buenos Aires (3A)	Paris (4A)	Vancouver (4C)	Stockholm (6A)

IPCC scenarios: RCP 8.5 and RCP 4.5 –5th IPCC AR, 6TH IPCC published in 2021
DATA SOURCE: CORDEX Data need post-processing to create an epw file.
ASHRAE Handbook: Chapter 14: 15 cities (highest demographics + climate representative based on ASHRAE HDD Dominated, CDD Dominated, HDD and CDD Dominated (taking radiation into account !))
Time Scale: (2030/2050/2100)



Carbon Emissions Modeling

Building characterization



Benchmarking - Observatory
TABULA/EPISCOPE
ASHRAE
IBPSO - Irish Building Stock Observatory

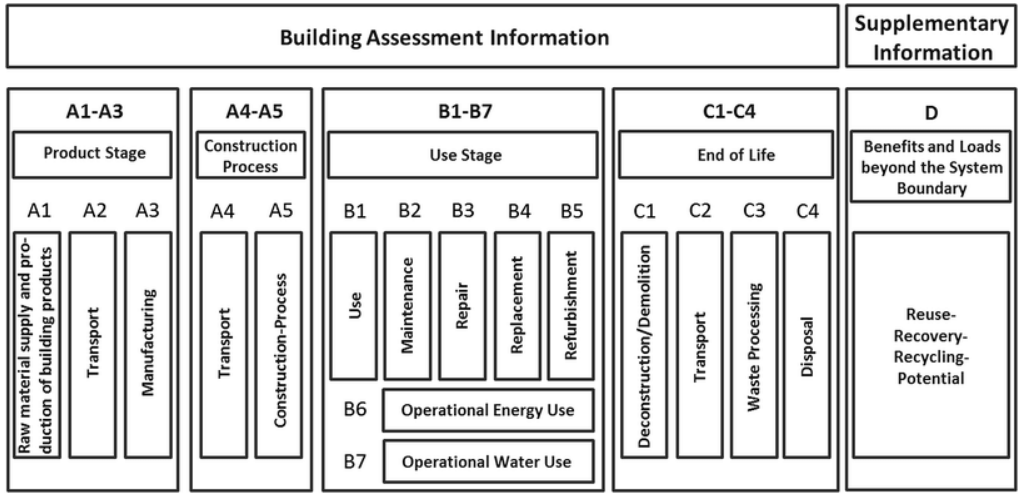
Carbon Emissions Modeling

LCA Database

Time: 50 Years EN 15804 + A2
Time: staged renovation, ownership change…
Life Stages: Stages A + B ~~- C - D~~

Database: Generic (example Econinvent….) or Construction
Localization, Transportation

EPDs…to be avoided !



Carbon Emissions Modeling

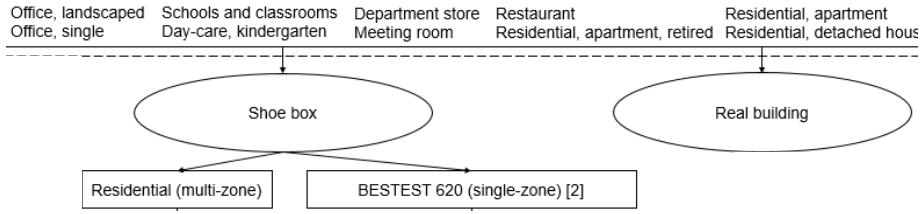
Benchmarking - Observatory
TABULA/EPISCOPE
ASHRAE
IBPSO - Irish Building Stock Observatory

Building characterization

- **Archetypes**….fixed cube while the dimensions are *function of the squared meter* (or occupant density). Thermal zoning : **theoretical building**, multiple zones (**simplicity** vs. detail, **single zone** vs. multizone) + **Neighborhood**

- **Zone adjacencies and orientations**…fixed (worst case e.g., in Europe: south oriented with to roof, the adjacent walls and floor have a standard heating and cooling setpoint)

- **Building Envelope** Zones 1 to 8 from ASHRAE 169. **8 Thermal proprieties**....*function of* the *climate zone* (low heating measures from regulations ‘’**National or ASHRAE 189.1-2017**’’, infiltration is wind-driven\fixed!!). (**new construction** (high efficient) and **existing building** (low efficient building)



Carbon Emissions Modeling

Building Envelope (Insulation based on EPC, EnergyStar or other)

(4)

Poor (E, F, G)

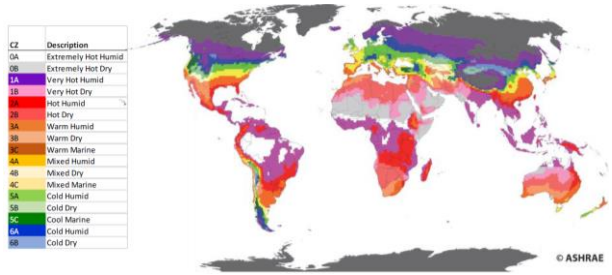
Low Energy (C, D)

Passive House (A, B)

(3b) Envelope characteristics [6]

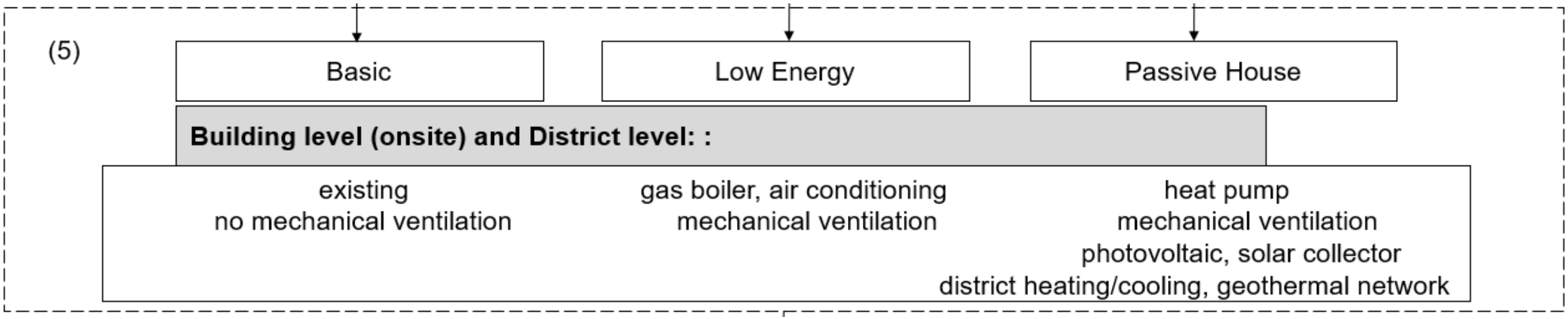
Climatic zones:

- Zone 1 (A,B)
- Zone 2 (A,B)
- Zone 3 (A,B,C)
- Zone 4 (A,B,C)
- Zone 5 (A,B,C)
- Zone 6 (A,B)
- Zone 7
- Zone 8



Carbon Emissions Modeling

HVAC Systems



Occupancy Schedule……*function of* the *building type* **ISO 17772.P1**, EN 16798.P1, **ISO 18523.P1-P2**, list of realistic, stochastic occupancy schedules? whole building or zonal schedule? **single space schedule**, **residential and offices**.

No shading, no natural ventilation YES/NO

HVAC system…(**ISO 17772.P1-p2** comfort category II) minimum ventilation depends on the IAQ requirements…...constant heating setpoint, ……..cooling setpoint… depending on the chosen comfort criteria but just using basic control.

Carbon Emissions Modeling

Storage

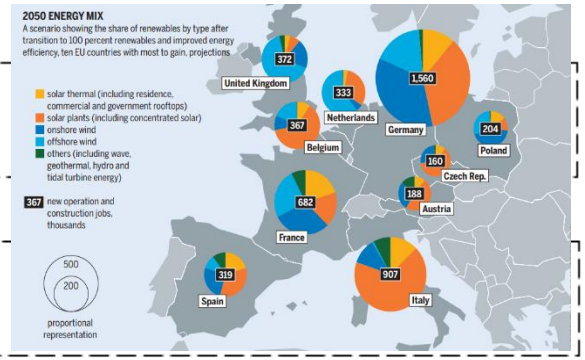
(6) Water Tanks | PCM | Batteries & Fuel Cells

Energy Mix

(7) Energy Mix Scenarios | Carbon Factors

ISO 52000-3:2023

ISO 52016-3:2023



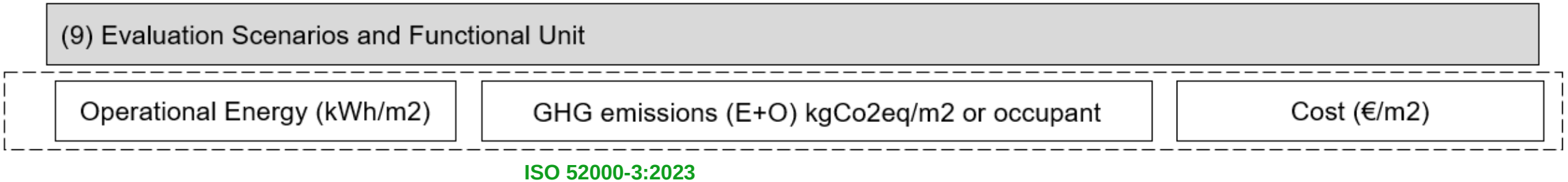
Additional Parameters

(8) Carbon Tax | Carbon Threshold (e.g. 2.5 kg/CO2eq/m2/year)

Level(s)
Renovation wave and Whole Life Carbon Roadmap

Potential technological changes…

Carbon Emissions Modeling



ISO 52000-3:2023

-Annual site energy use per floor area (indicate gas, electricity, or other energy) [kWh/m2.a]
-Annual primary energy use per floor area (indicate primary energy factor) [kWh/m2.a]
-Annual CO2 emission per floor area [gCO2/m2.a] (use national carbon emission factor, please indicate the carbon emission factor)

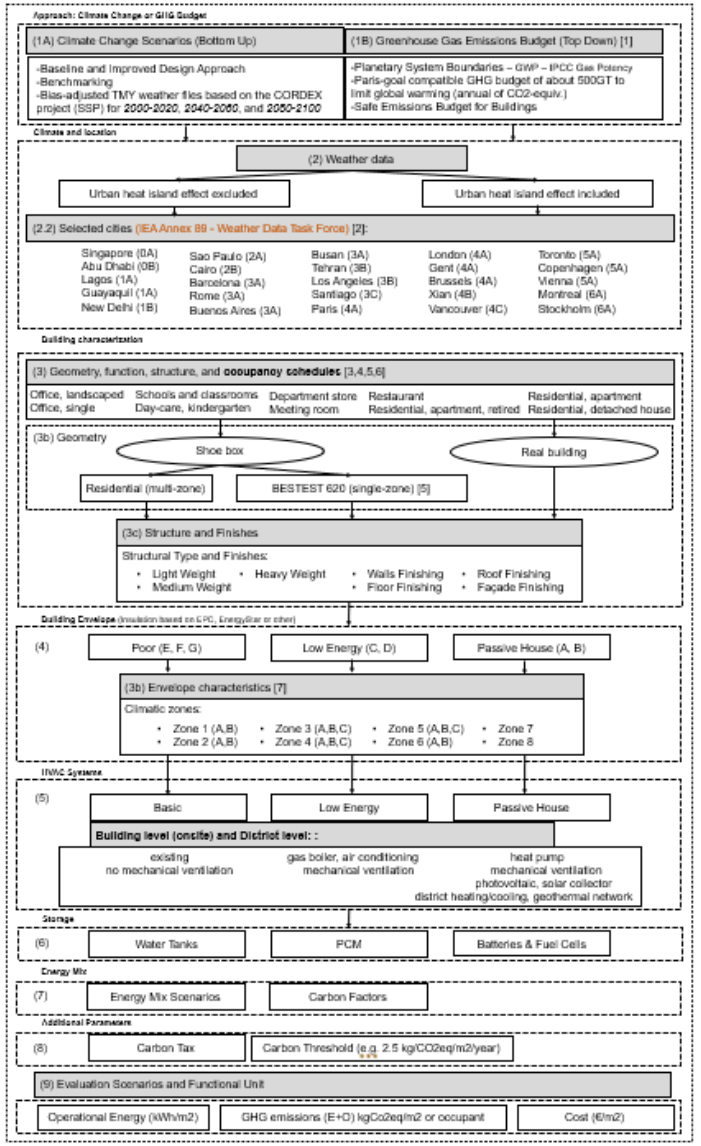
DynamicRenowave - Life Cycle Assessment and Energy Simulation of Building Renovation Strategies

Carbon Emissions Modeling

Objective 0: Coordination with all Groups and TF Weather Data
Objective 1: Define common thermal conditions to assess different decarbonization pathways
Objective 2: Publish the (Liege-UCLouvain-Aarhus) framework by June 2024
Objective 3: Define a common benchmark

Performance Evaluation

Step 1: Identify LCA ***database*** and potential inventory
Step 2: Identify GHG emissions for ***acceptable carbon targets*** under possible ***foreseeable decarbonization pathways***.
Step 3: Quantify the ***KPI margin violation*** and the ***severity of foreseeable emissions***
Step 4: Calculate the ***GHG emissions following the two approaches***



LIÈGE université
AARHUS UNIVERSITY

Q & A

Thanks for your attention

Shady Attia
Prof. in Sustainable Architecture & Building Technology
Université de Liège, Belgium
Email : Shady.Attia@uliege.be

DynamicRenowave - Building Carbon Emissions Modeling Framework \ References

[1] Brejnrod, K. N., Kalbar, P., Petersen, S., & Birkved, M. (2017). The absolute environmental performance of buildings. *Building and environment*, *119*, 87-98.
[2] ANSI/SHRAE Standard 169. (2013). Climatic Data for Building Design Standards. Atlanta, Georgia, United States.
[3] ISO 2017, DS/ISO 17772-1:2017 Energy performance of buildings – Indoor environmental quality – Part 1: Indoor environmental input parameters for the design and assessment of energy performance of buildings, ISO, 2017. Geneva, Switzerland.
[4] ISO 18523-2:2018, Energy performance of buildings: Schedule and condition of building, zone and space usage for energy calculation Part 1 and 2, Geneva, Switzerland.
[5] IWU. (2016). EPISCOPE and TABULA. Monitor Progress Towards Climate Targets in European Housing Stocks. https://episcope.eu/welcome/
[6] Judkoff, R., & Neymark, J. (1995). International Energy Agency building energy simulation test (BESTEST) and diagnostic method (No. NREL/TP--472-6231). National Renewable Energy Lab. Colorado, United States.
[7] ASHRAEANSI/ASHRAE/USGBC/IES standard 189.1-2014, standard for the design of high-performance green buildings, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, United States.