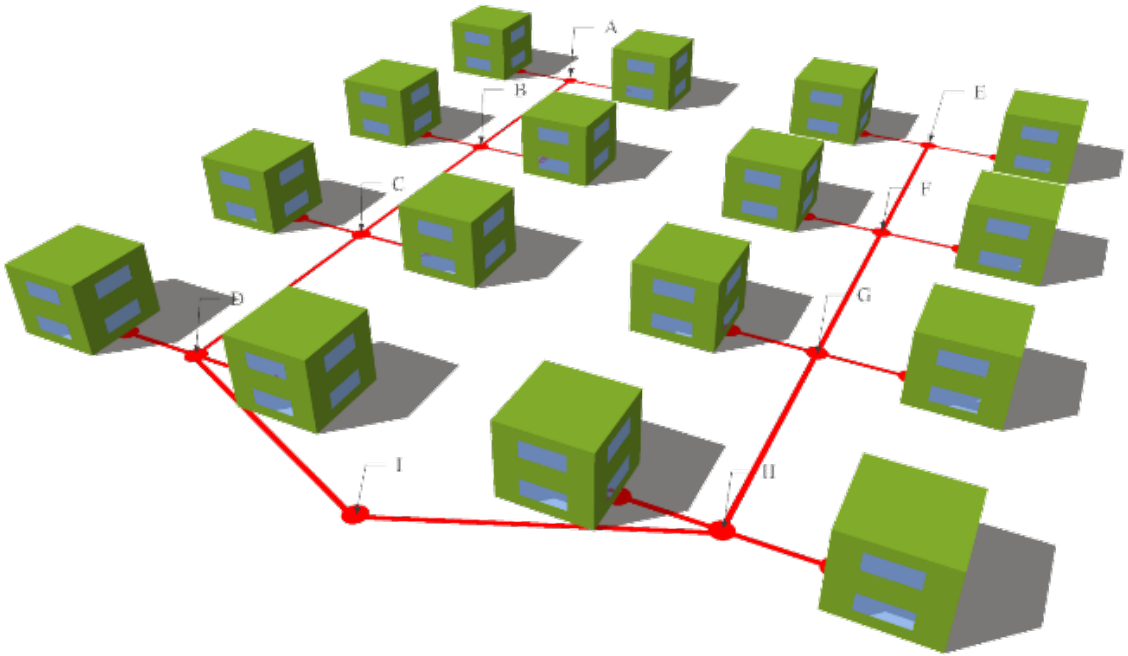
Creating common exercises for modelling building and district energy systems: lessons learnt from the IBPSA Project 1 - DESTEST



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Authors

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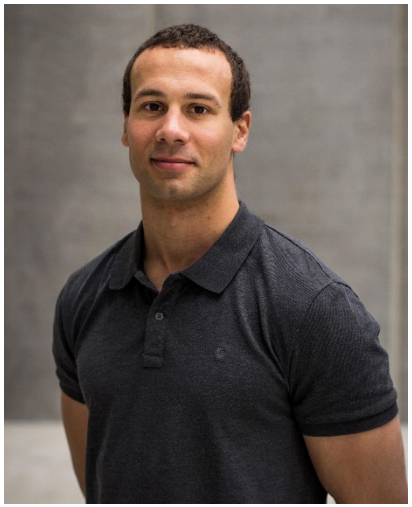

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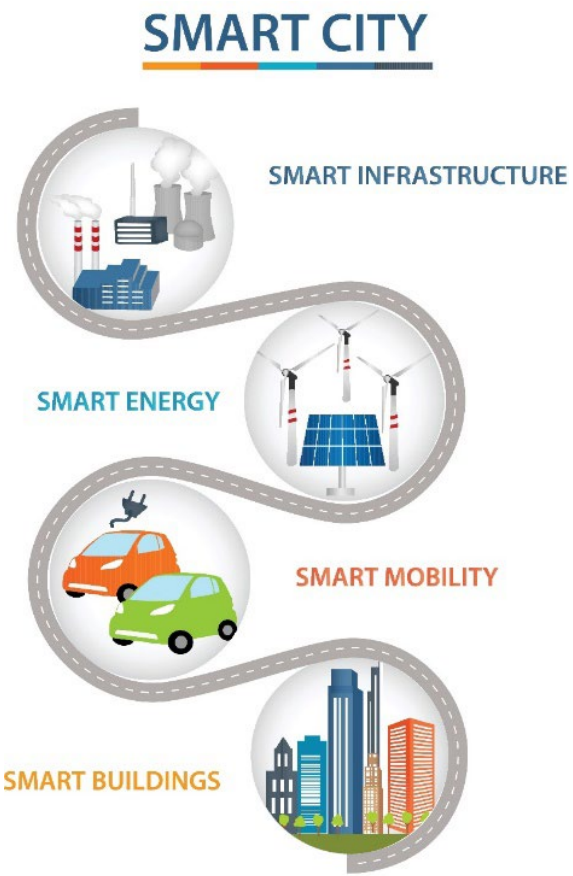
Motivations

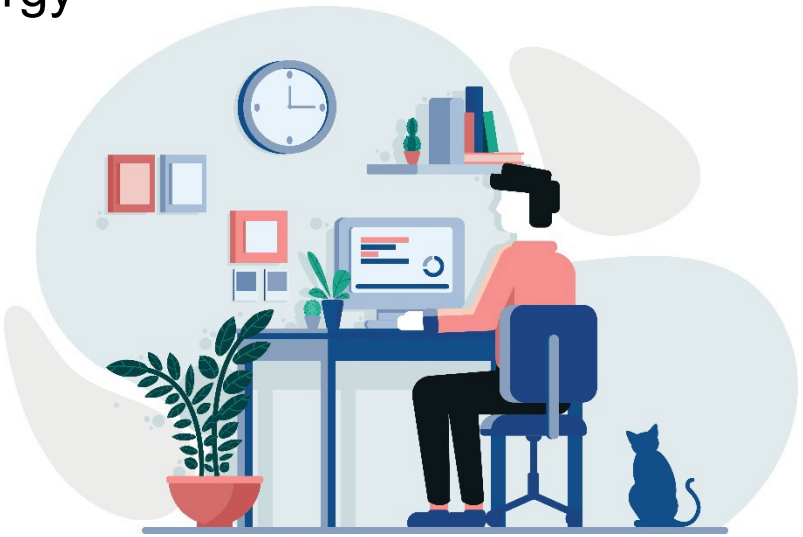
Ever-increasing need for accurate numerical models of buildings and energy grids:

- Building design optimization
- Urban-scale modelling and planning
- Model predictive control
- Automated fault detection
- Smart grids with demand response



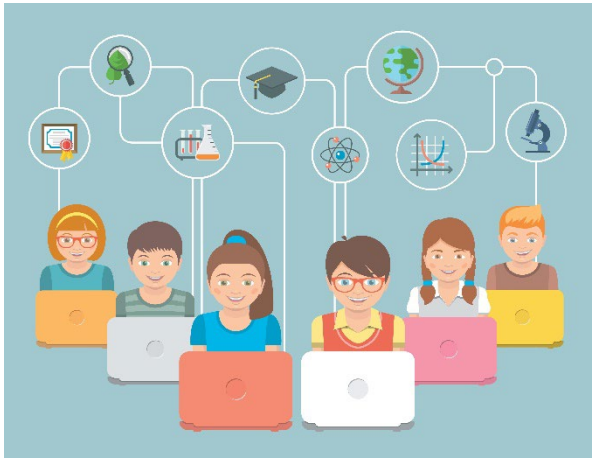
Motivations

- Need to benchmark and validate numerical models
- Provide guidelines to improve good practices among modelers/engineers
- Provide training tools for new modelers simulating buildings and district energy systems



Common Modelling Exercises

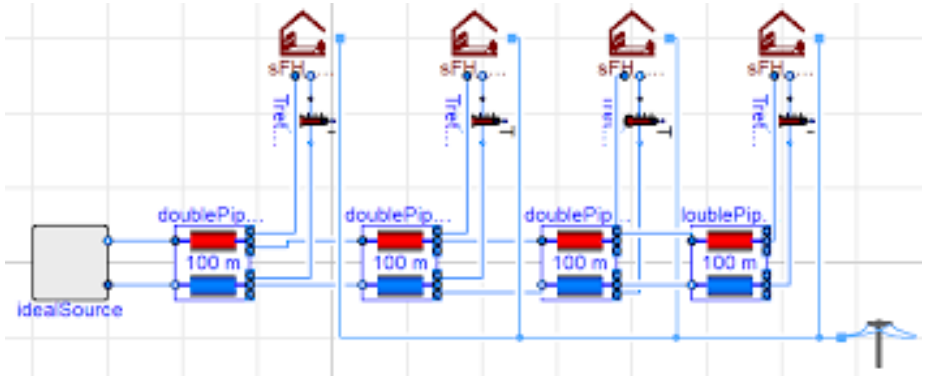
- Common modelling exercises (CME) are a good way to address these 3 points
- A series of well-defined cases modelled by different people with different tools
- Comparison and analysis of the different simulation outputs
- BESTEST (ASHRAE 140-2017): most-known common exercise for modelling building systems



DESTEST

District Energy Simulation Test (DESTEST): Series of common modelling exercises:

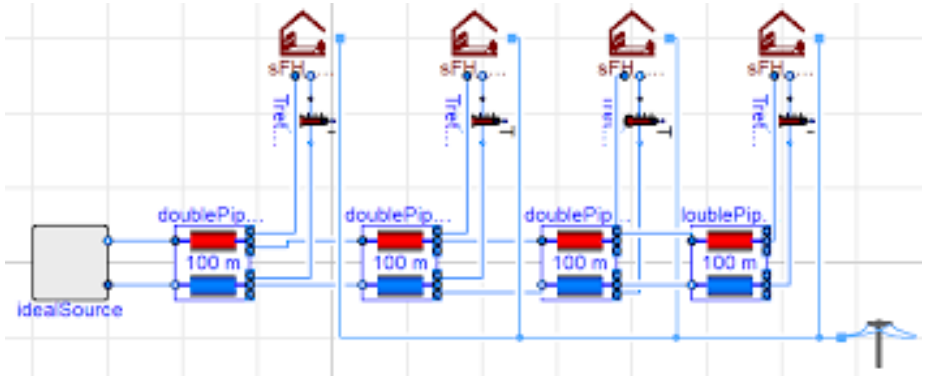
- Building clusters, district heating network alone, building clusters connected to a district heating network
- Benchmarking and verifying urban-scale energy system simulation tools



DESTEST

DESTEST - District Energy Simulation Test: Series of common modelling exercises:

- A forum for participants to discuss common mistakes and pitfalls
- Experience and feedback gathered into guidelines for good modelling practices
- Self-training material to teach dynamic simulations of urban-scale energy systems



Lessons Learnt from DESTEST

- Creating common modelling exercises is much more difficult and time-consuming than one might think
- Here are some lessons learnt while creating the DESTEST
- Some key points to keep in mind when designing common modelling exercises
- Valid for energy network and building applications

Goals and Ambitions

- Clearly set goals and structure for the whole series and specific focus at beginning of each exercise:
  - Make sure that people creating the exercise are on the same page: exercise coherence
  - Motivate participants when they start reading the exercise: *why am I doing that work?*
- Keep moderate workload (participants are often unpaid volunteers):
  - 1 month to complete a single exercise in a series
  - Not more than 1 year for the entire execution of the series of exercises

Goals and Ambitions

- Collecting exploitable results from 10 participants is already a great achievement
- Late participants can join in after and add their results to the first ones
- Balance between modifications of exercises to include many numerical tools and the necessity to exclude certain tools to preserve the goals and focus
- Not more than 5-10 different exercises/variations per series

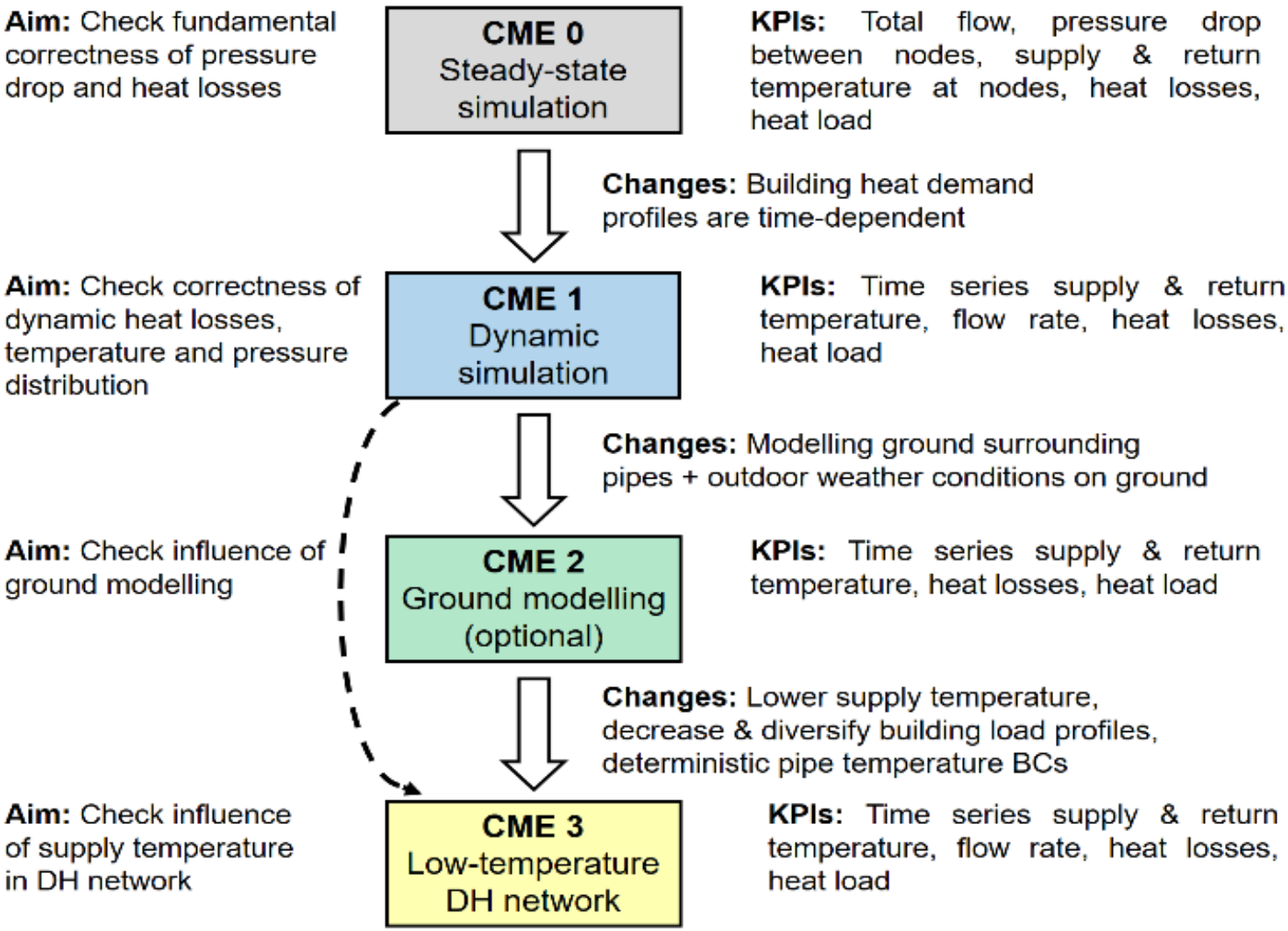
Structure of the Series of Exercises

- Consecutive exercises should be built upon the previous ones
- 1st exercise: generation of building geometries and network topology
- Very time-consuming: keep geometries and topology as simple and stable as possible throughout the series
- Maximize reusability of the models created in the previous exercises

Structure of the Series of Exercises

- Logical progression in the series with incremental complexity and variations of boundary conditions
- Allows rapid completion of each exercise and ensures good testing power
- If too many parameters are changed at once, difficult to assess which one of these modifications has a significant impact on the simulation results and could cause discrepancies between the numerical tools or modelers
- On the other hand, if exercises are too similar, participants will get bored and the series will not explore much

Structure of the Series of Exercises



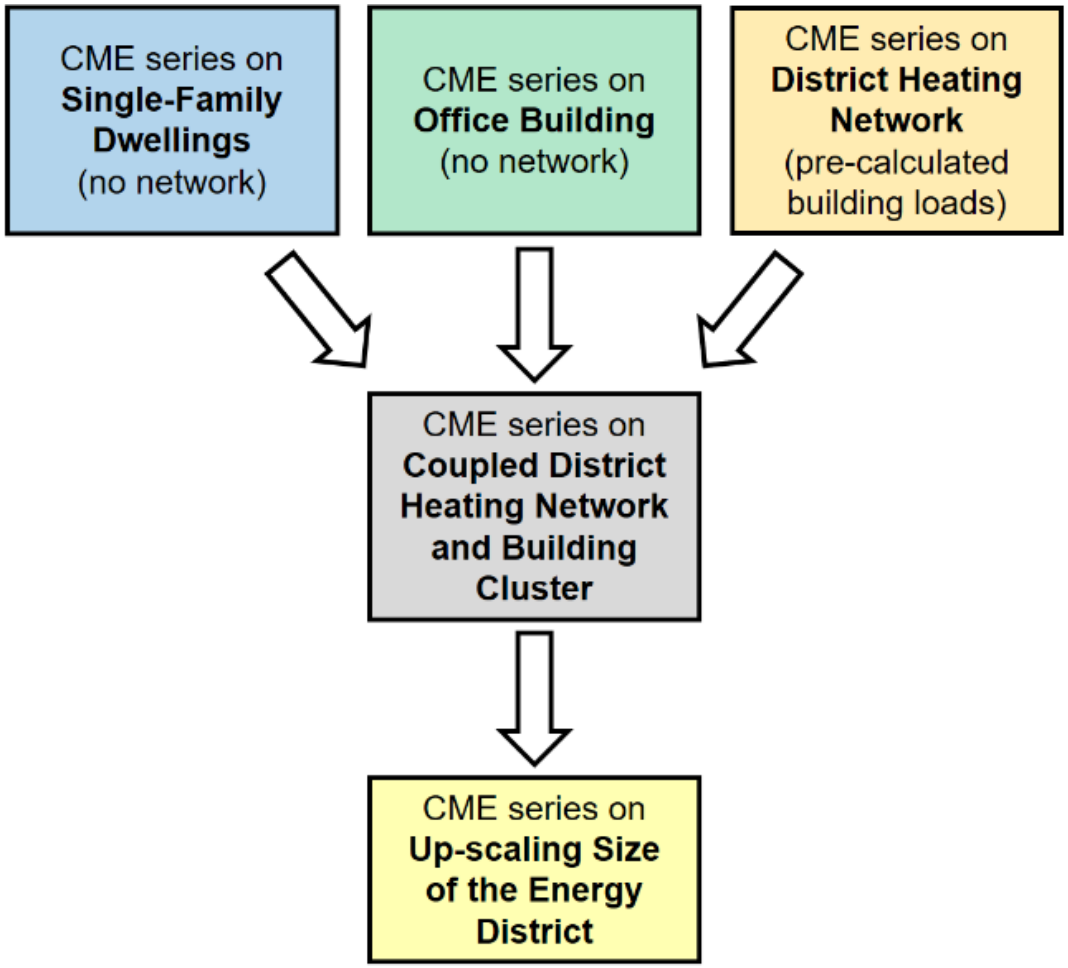
Structure of the Series of Exercises

Keep the same consistent document structure in the description of each exercise, e.g.:

- Introduction and goals of the current exercise
- General description
- General assumptions and simplifications: *state what aspects or physics phenomena are not included*
- Specific description
- How to compare and report results
- Results of participants
- Analysis and discussions: important points of interest and common modelling mistakes

Structure of the Series of Exercises

Meta-collection of exercises: a collection of collections of exercises

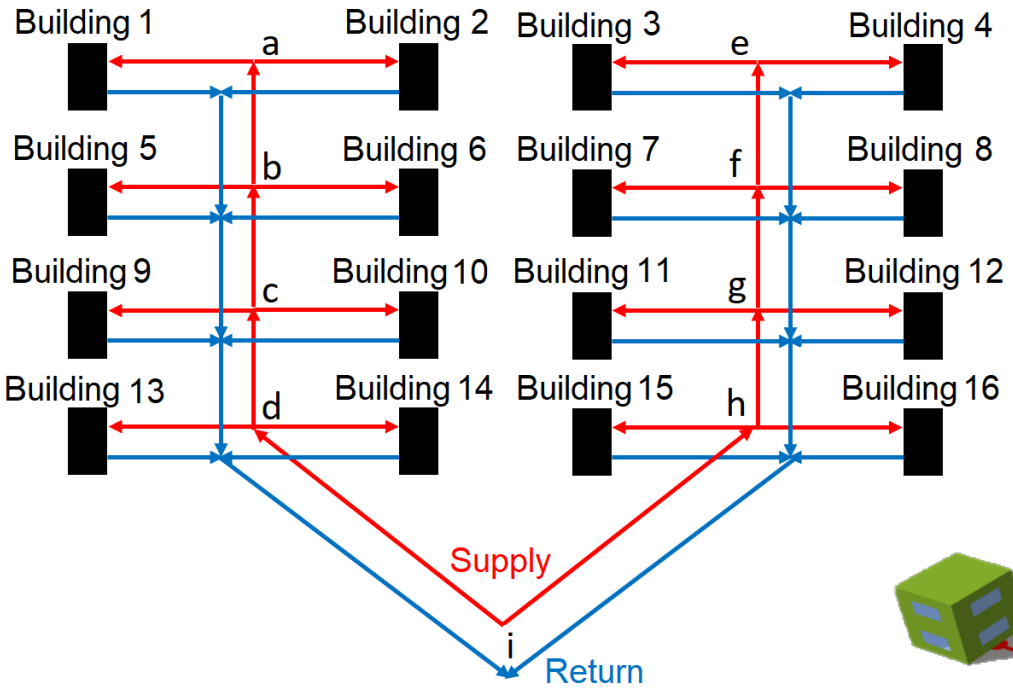


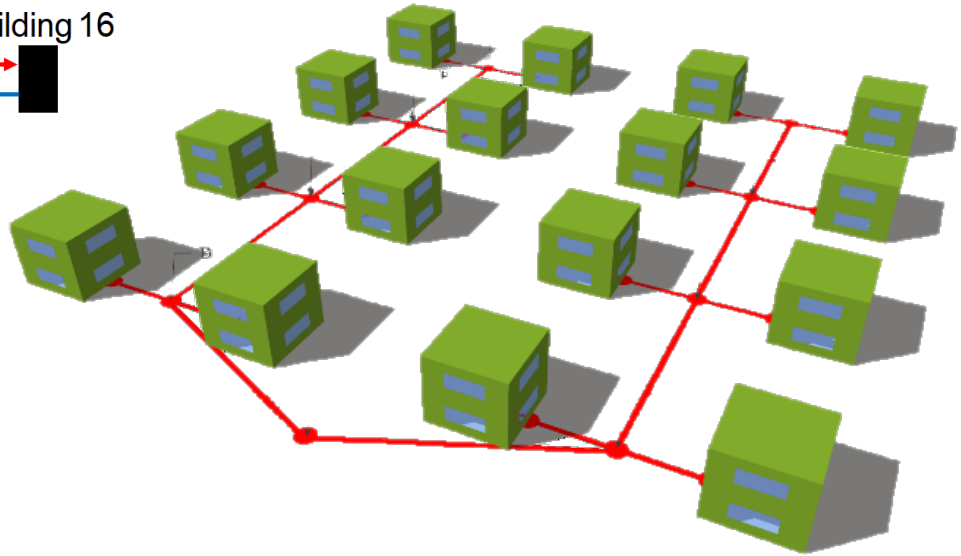
Creation of the Exercises

- Collaborative and iterative creation process
- Test each exercise and refine if needed
- Limit exercise complexity to keep participants motivated
- Balance the different expectations, visions, expertise levels and personal interests of the design team creating the exercises
- Ideally, make realistic study cases, not just academic cases
- Include professionals and practitioners in the creation team
- Clear case modelling instructions for all types of modelers with different backgrounds and modelling conventions or paradigms

Creation of the Exercises

Multiple overview and detail schematics





Collecting, Analysing, Reporting Results

- Comparison of simulation results to an empirical reference (rare)
- Comparison of simulation results to a reference model: high-accuracy reference model or analytical solutions (rare or limited)
- Comparison of simulation results to an “average” reference formed with all collected results (*see IBPSA Building Simulation – Johra et al., 2021 for further discussion*)

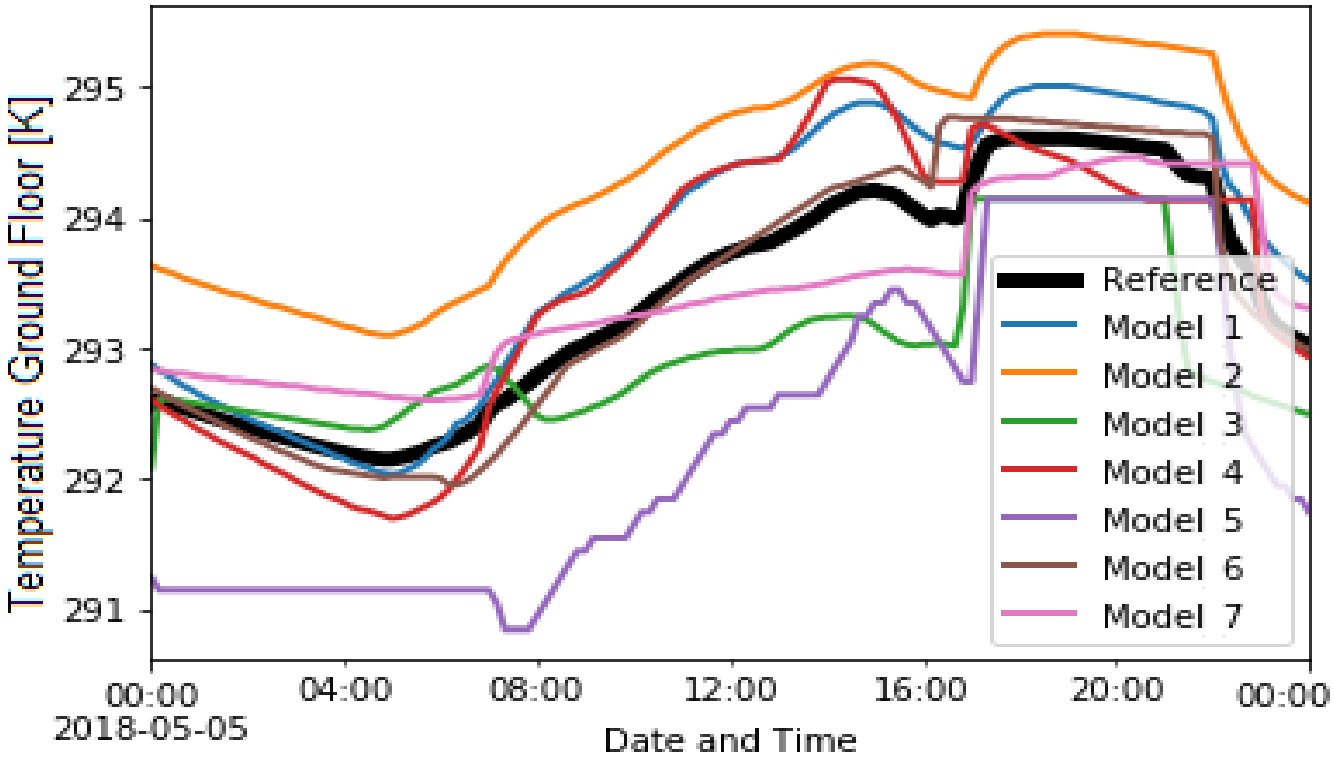
Collecting, Analysing, Reporting Results

- Comparing results with a limited number of metrics and KPIs (less than 10-20 per exercise)
- Selected KPIs should support aims and focus of the exercise
- For direct comparison of variable time series: recommended to use common point-to-point normalized comparison metrics:
  - NMBE (Normalized Mean Bias Error)
  - CVRMSE (Coefficient of Variation of Root Mean Square Error)
  - Other time series comparison metrics could be of interest, such as the CVRMSE of the daily amplitude

See IBPSA Building Simulation – Johra et al., 2021 for further discussion

Collecting, Analysing, Reporting Results

- Online (web-app) or open-source code (Python, R) for direct self-comparison of participants results
- Include graphical qualitative comparison for specific periods of time
- Include guidelines for the interpretation of results comparison



Dissemination and Execution

- Try to include common exercises in large international projects such as IEA EBC Annex projects
- Provide in-depth analysis, discussions and publish results in peer-reviewed articles including all participants as co-authors is a good incentive for the latter
- Regular online meetings to keep participants motivated and address questions
- Some in-person analysis and discussion workshops (e.g., during international conferences) with all participants are very appreciated and boost engagement

Thank you for your attention !
Any questions ?

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