BIM/GIS and Modelica Framework for building and community energy system design and operation

TASK 3: Application and Dissemination
ST 3.1 District Energy DESTEST

Last update: 07/05/2020

Change log

- 21/04/2020: creation of the presentation - Ina
- 05/05/2020: changes plots for new simulation results for Trnsys, AixLib and DIMOSIM - Ina
- 06/05/2020: changes plots for new simulation results for Trnsys (CE2) - Ina
- 07/05/2020: changes structure + improve general information + add agenda points for virtual break-out session - Ina

General information

- Make sure you are subscribed to our WP3 Google Group
  - That way, you do not miss anything
  - Meeting invites and minutes are sent here
- All information is on the Project 1 GitHub page or is referenced in the e-mails sent in the Google Group
- Also, make sure you are subscribed to the IBPSA Project 1 Google Group
  - Expert meeting invites are sent here
  - On the general website, you find general info on the project and all work packages

General information

- ➔ General objective: development of a DESTEST to
  - develop typical or representative DES cases that can be used for testing different DES simulation environments (intermodel comparison, …)
  - develop a test framework for testing models in a predefined DES environment
- ➔ Approach:
  - Two tracks are working in parallel
    - Focus on building models: Ina De Jaeger (KUL)
    - Focus on network and energy system models: Michael Mans (RWTH)
  - Discussion is organized in online coordination meetings and subgroup meetings (minutes are available on GitHub)
  - Common Exercises
    - Start with description of (very) simple neighborhood of buildings
    - Use this information to design thermal network(s)
    - Gradually increase the complexity

General information

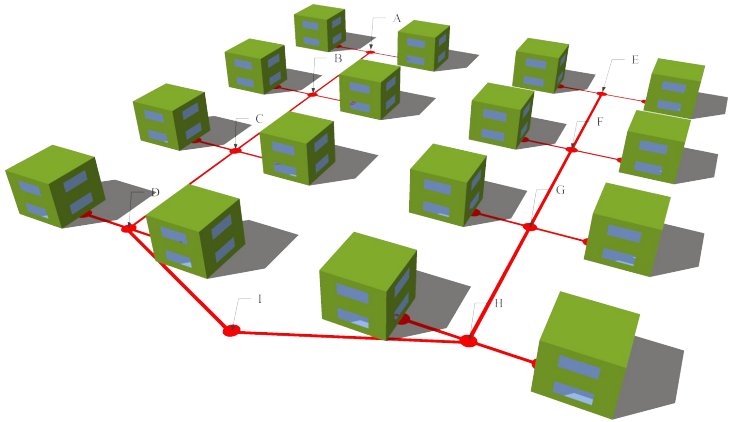
- ➔ This document provides an overview of
  - Past activities
  - Current activities
  - Future activities
  - Further recommendations for contributors

Past activities

➔ 1st common exercise (CE)

Past activities

- 1st common exercise (CE)
  - 16 identical single-family dwellings
  - Single-family dwelling of 1980
    - Thermal performance based on TABULA project for Belgium
    - Two-zone model (day zone and night zone)
    - Only heat demand for space heating
    - Standard occupant (ISO 13790)
  - Connected by a district heating network



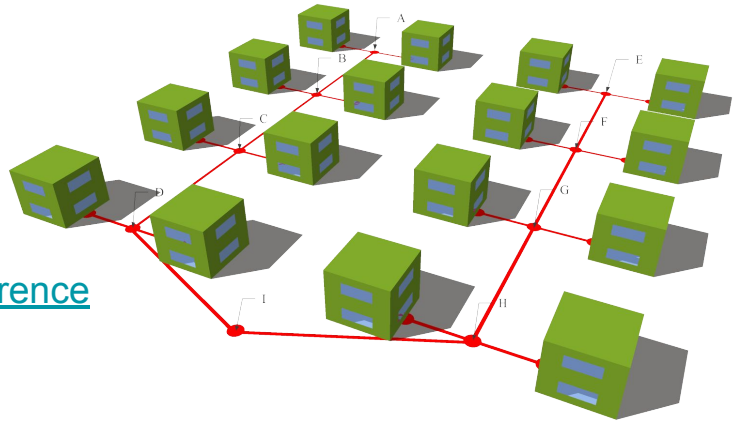
TO DISCUSS:
- Enora thinks the EPW file is not the exact format of EPW. I don't remember who made this file → who will check? → Enora to ask what the problem is :)

Past activities

➔ 1st common exercise - resources

TO DO:
- Ina: small updates on teaserXML file (caught by Enora)

- Buildings
  - First description can be found here
    - There, you find a README-file that explains the followed workflow and the provided documents as much as possible
    - All of your questions are remarks are collected here
  - Final documentation is available
    - In text format
    - In CityGML format
- Network
  - First description can be found here
  - Final documentation is available
    - In text format
- Described in a paper presented at the BS2019 conference



Past activities

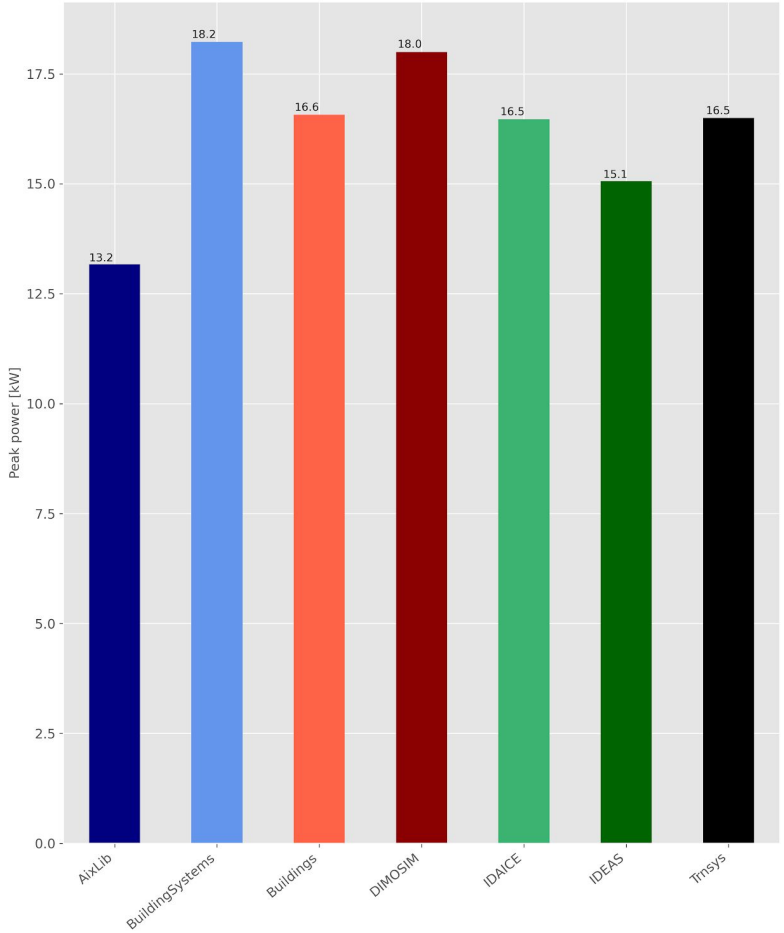
➔ 1st common exercise - results

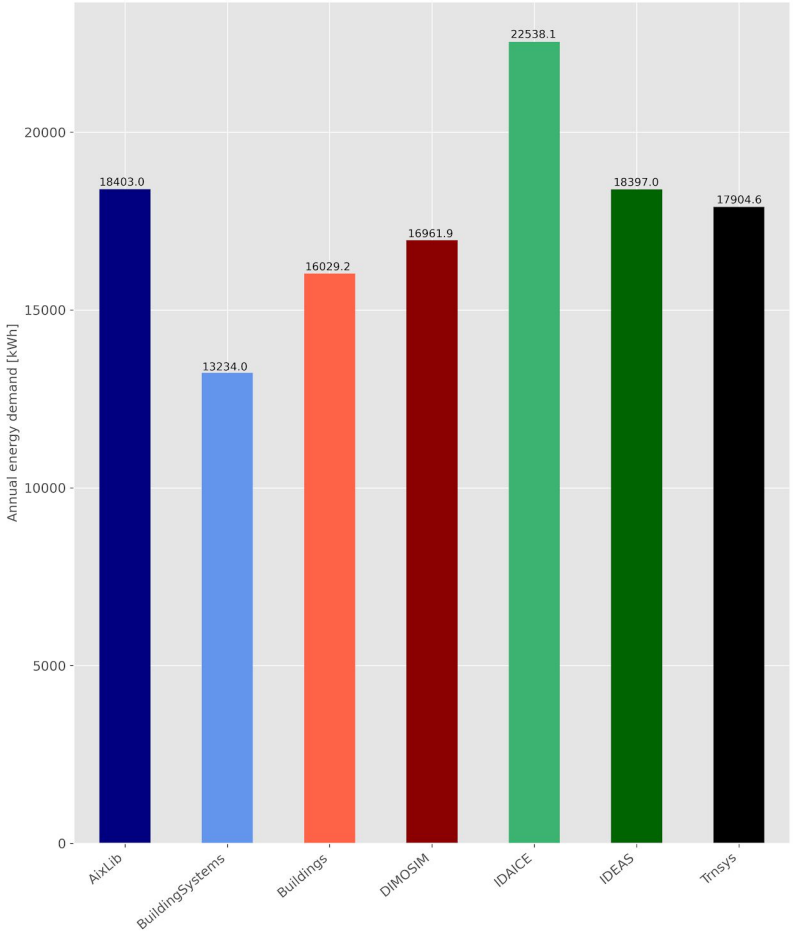
Modelling environment	Modeler	Affiliation of participant
Modelica IDEAS	Ina De Jaeger	KU Leuven / VITO / EnergyVille
Modelica Buildings	Alessandro Maccarini	Aalborg University
Modelica AixLib	Michael Mans	RWTH Aachen
Modelica BuildingSystems	Haris Shamsi	UCD Dublin
IDA ICE	Øystein Rønneseth, Igor Sartori	Sintef Norway
DIMOSIM	Enora Garreau	CSTB
Trnsys	Lien De Backer	UGent

TO DO:

- Ina: increase font size of all plots

CE 1 - RESULTS

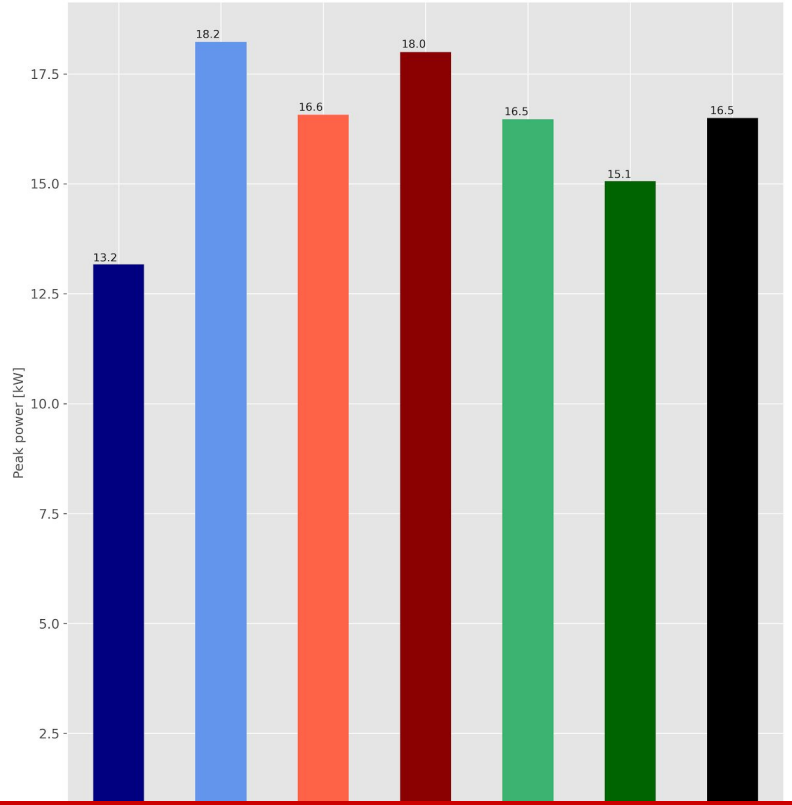


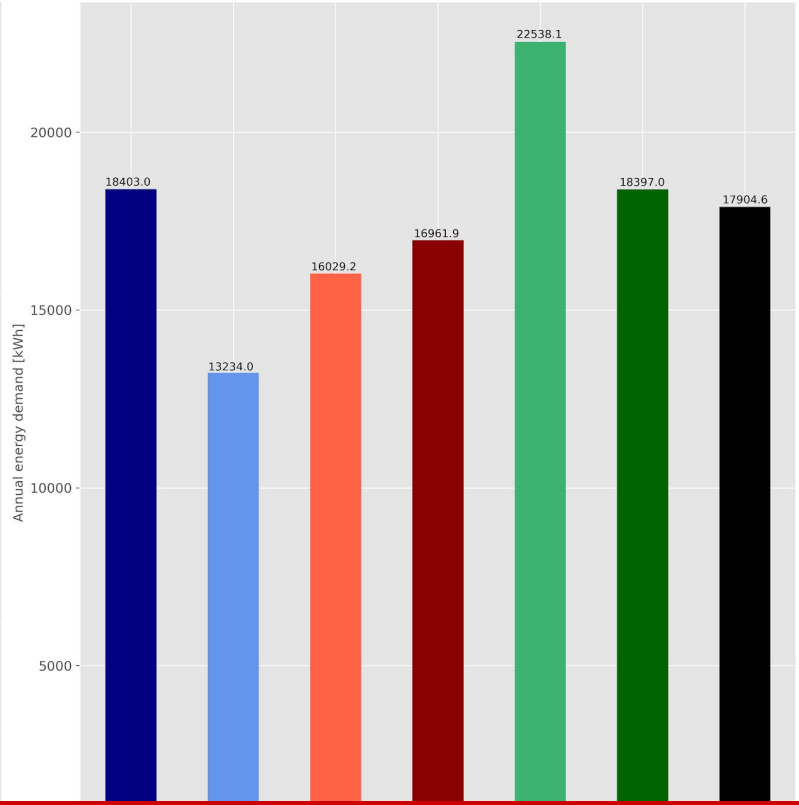


TO DO:

- Ina: increase font size of all plots

CE 1 - RESULTS

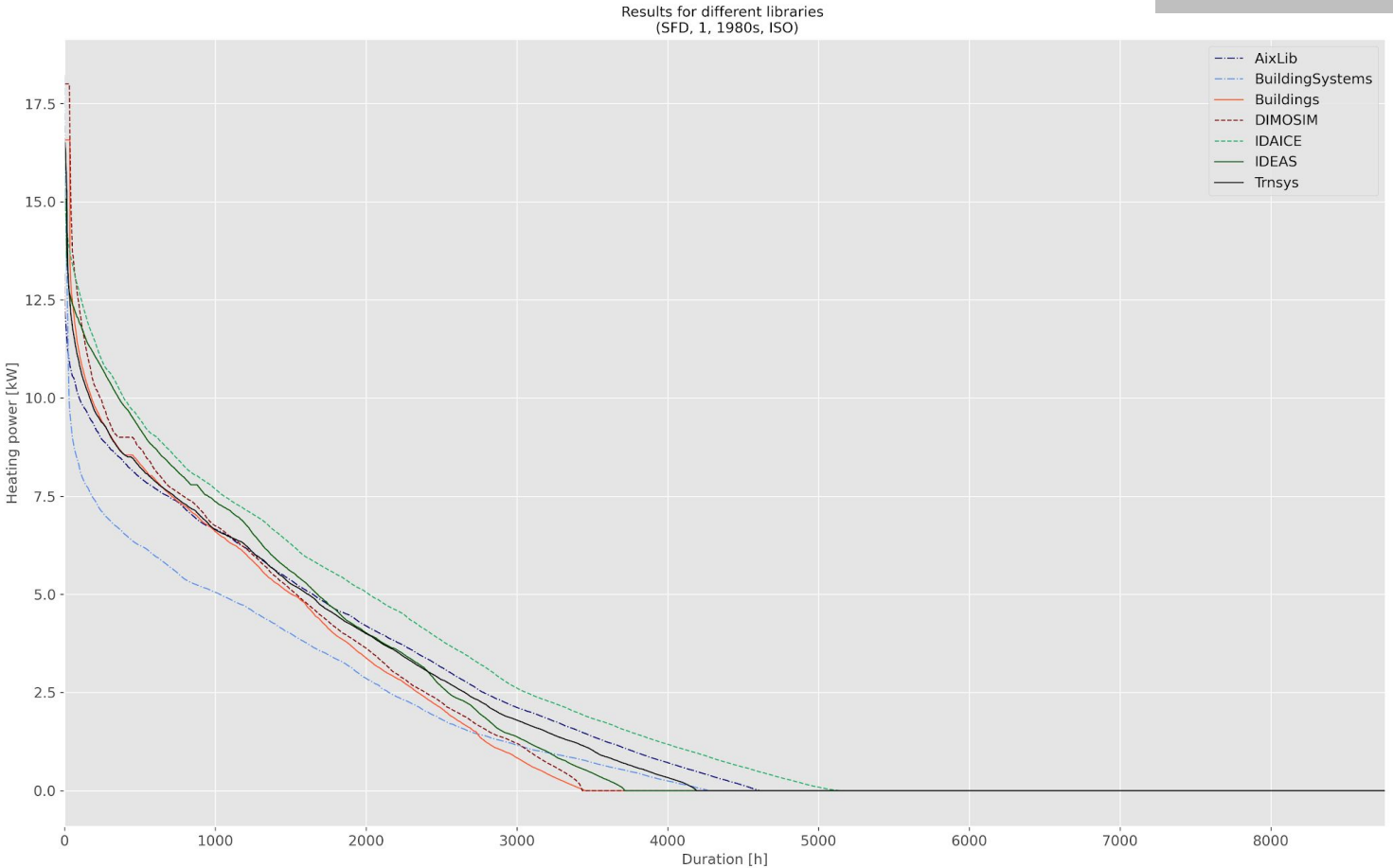




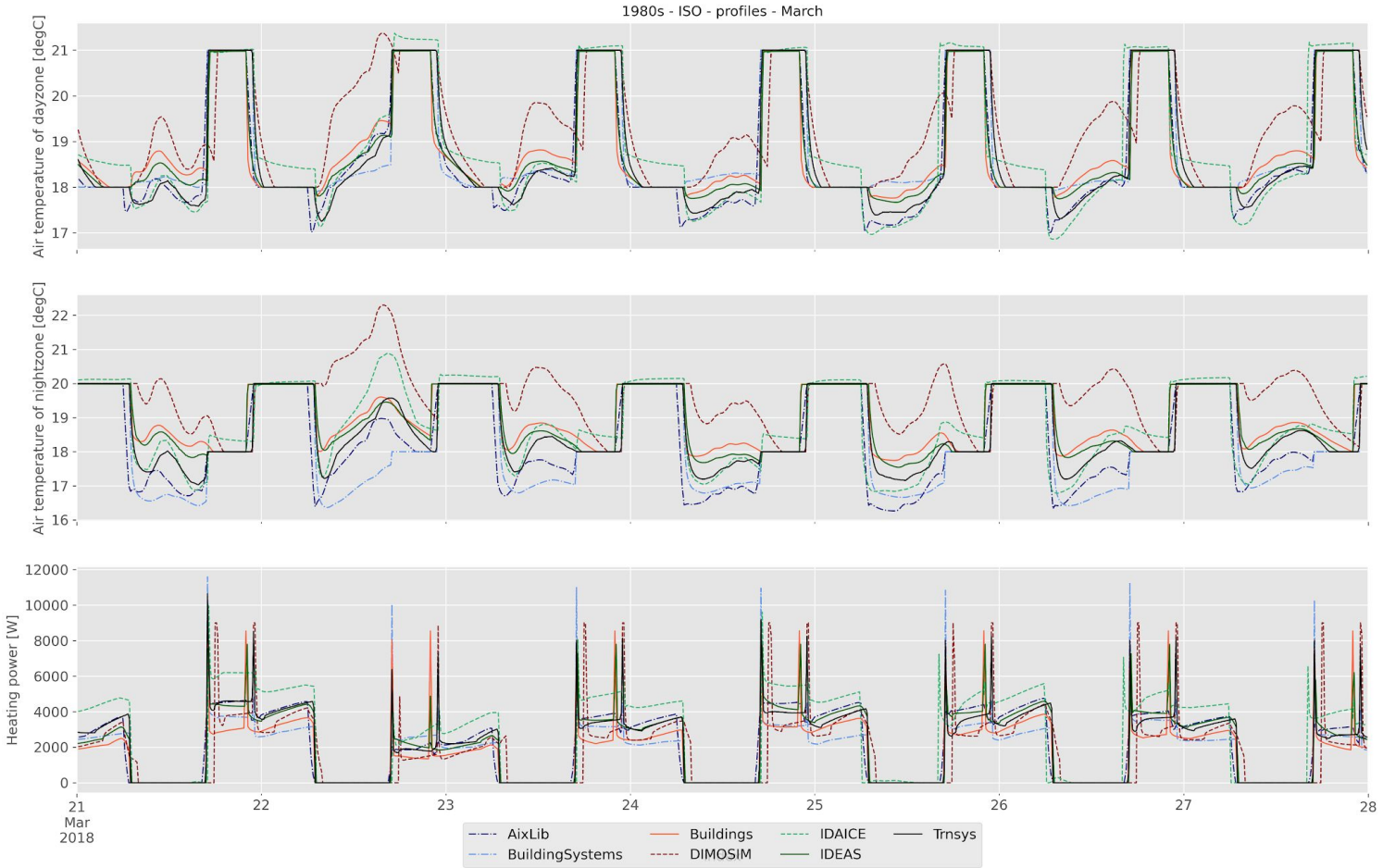
TO DISCUSS:

- We started looking into the solar radiation to explain differences: continue?
  - Who? Arash (look into the solar radiation processes in IDEAS) → contact Ina + Jason

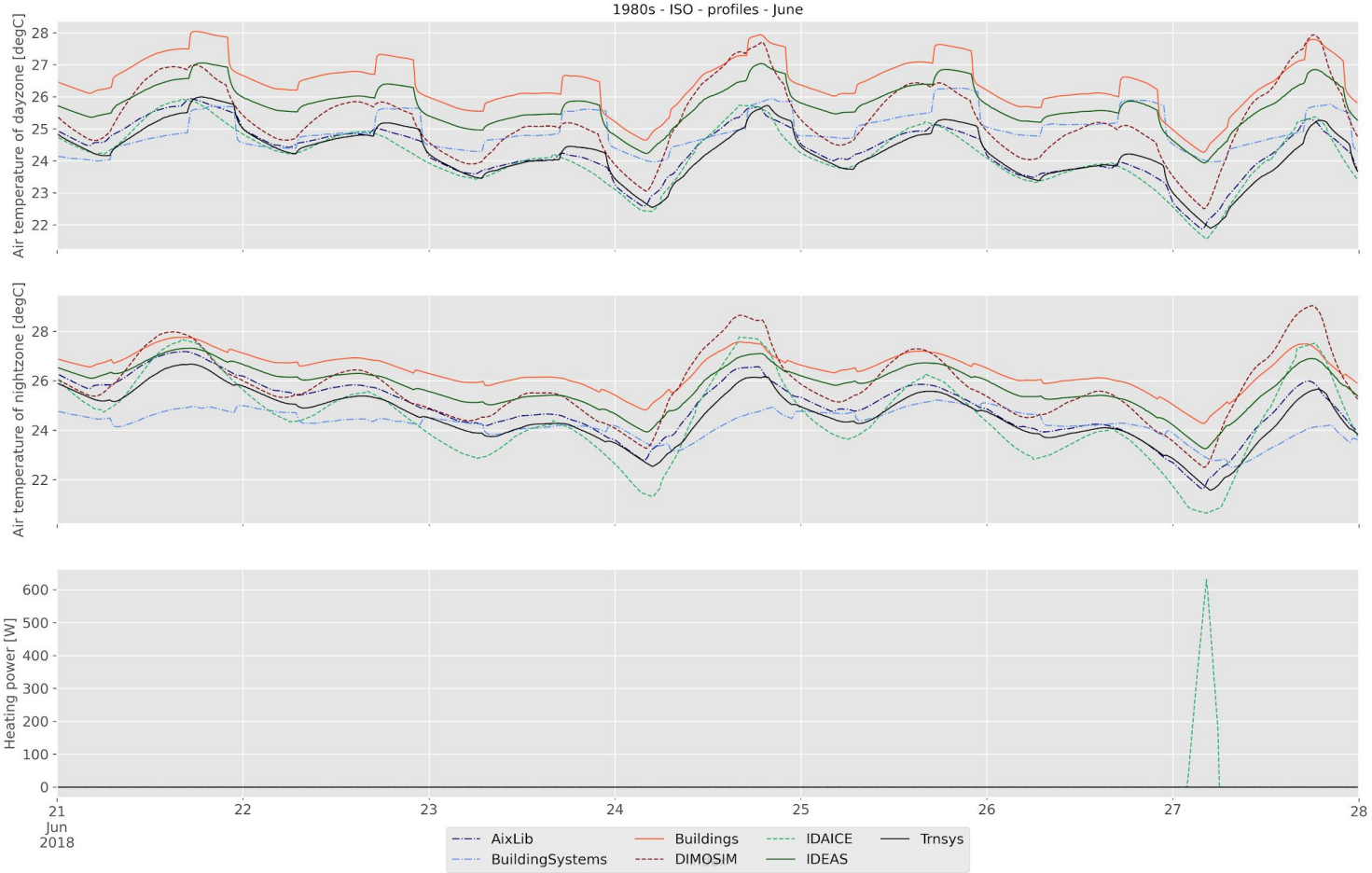
CE 1 - RESULTS


Results for different libraries
(SFD, 1, 1980s, ISO)
AixLib
BuildingSystems
Buildings
DIMOSIM
IDAICE
IDEAS
Trnsys
Heating power [kW]
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
Duration [h]

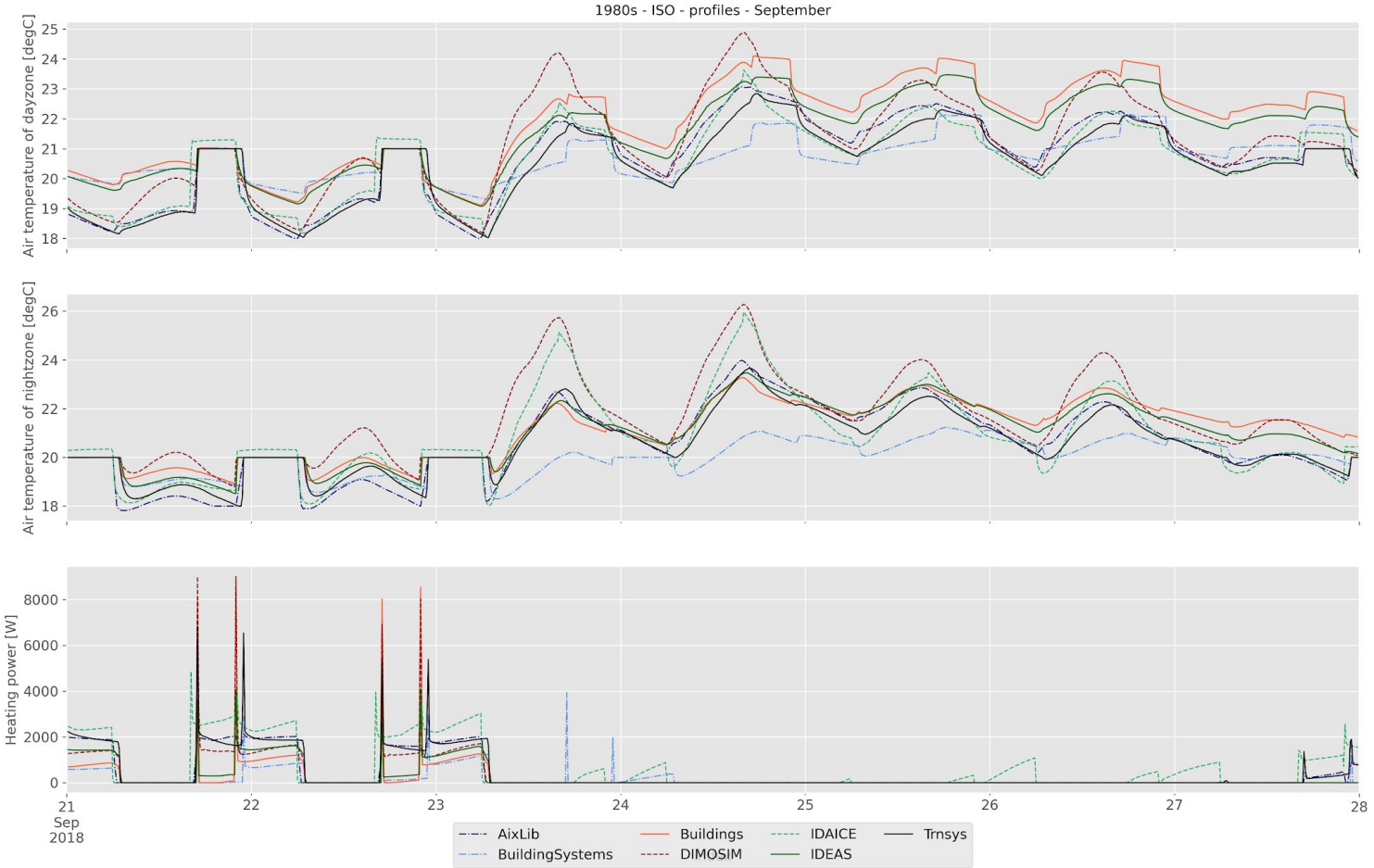
CE 1 - RESULTS


1980s - ISO - profiles - March
Air temperature of dayzone [degC]
Air temperature of nightzone [degC]
Heating power [W]
21
Mar
2018
22
23
24
25
26
27
28
AixLib
BuildingSystems
Buildings
DIMOSIM
IDAICE
IDEAS
Trnsys

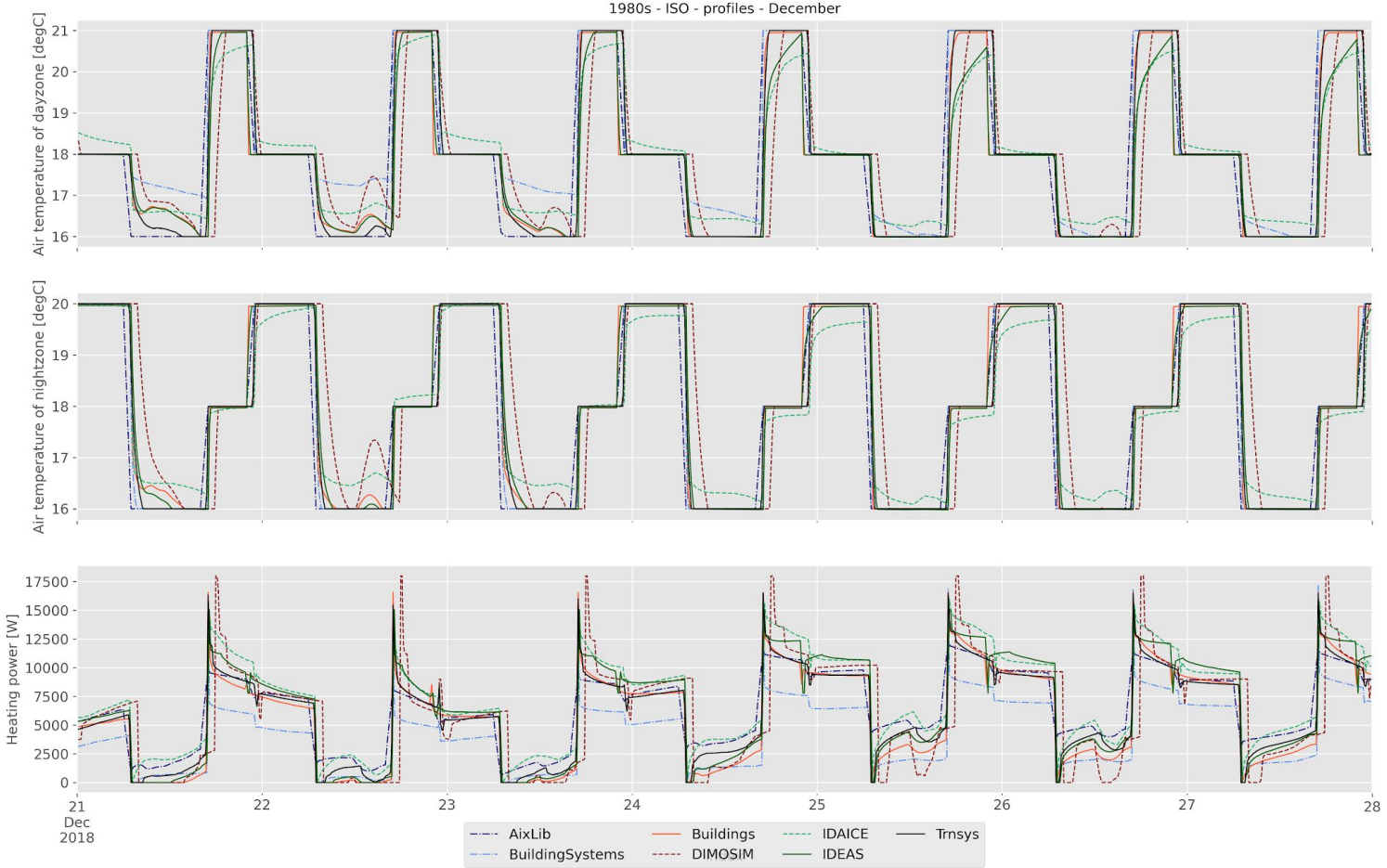
CE 1 - RESULTS


1980s - ISO - profiles - June
Air temperature of dayzone [degC]
Air temperature of nightzone [degC]
Heating power [W]
21
Jun
2018
22
23
24
25
26
27
28
AixLib
BuildingSystems
Buildings
DIMOSIM
IDAICE
IDEAS
Trnsys

CE 1 - RESULTS


1980s - ISO - profiles - September
Air temperature of dayzone [degC]
Air temperature of nightzone [degC]
Heating power [W]
21
Sep
2018
22
23
24
25
26
27
28
AixLib
BuildingSystems
Buildings
DIMOSIM
IDAICE
IDEAS
Trnsys

CE 1 - RESULTS


1980s - ISO - profiles - December
Air temperature of dayzone [degC]
Air temperature of nightzone [degC]
Heating power [W]
21
Dec
2018
22
23
24
25
26
27
28
AixLib
BuildingSystems
Buildings
DIMOSIM
IDAICE
IDEAS
Trnsys

Current activities

➔ Gradually defining next common exercises based on the 1st common exercise

- Single-family dwelling of 1980
  - Thermal performance based on TABULA project for Belgium
    → Also include renovations (light and heavy) — CE 3
  - Two-zone model (day zone and night zone)
  - Only heat demand for space heating
  - Standard occupant (ISO 13790)
    → Also include stochastic occupants (16 different profiles) — CE 2
- Office building — CE 4
- Connected by a district heating network
    → Also include different network layouts (8 and 32 buildings) — CE X

Current activities

- ➔ 2nd common exercise
  - Single-family dwelling of 1980
    - Thermal performance based on TABULA project for Belgium
    - Two-zone model (day zone and night zone)
    - Only heat demand for space heating
    - Standard occupant (ISO 13790)

      → Also include stochastic occupants (16 different profiles) generated by StROBe
      - Different household sizes: 1 – 5
      - Different types of employment
      - Heated night zone or not
  - Connected by a district heating network
  -

Current activities

- ➔ 2nd common exercise
  - ◆ Single-family dwelling of 1980
    - Thermal performance based on TABULA project for Belgium

TO DISCUSS:

- Include network in CE 2 or create separate CEs? CE on building energy demand, CE on networks, CE on coupling of buildings and network
  - What about CE 1 then? Split in Building and Network
- The temperatures and gains for the variation of occupants are still with 15 min time step, it would be better to have them in 10 min. I kept my resampling of the 15 min but if we want to have really the same profiles for simulating with 10min, it would be better to have the file already in the good format. → Take 10 min for all, output and input, to avoid confusion;
- The convective and radiative gains are not linked. I mean, in the first case we suppose that the internal gains are divided 40% for convective and 60% for radiative. But when I tried to do so with the Qrad and Qconv of the profiles, I don't go back on my feet. There are no ratio between the two. So that can explain the differences (in average it is still ok, there is only a difference of 15W, but there are peaks quite importants of more than 1000W of difference) when I simulated first by adding the Qconv and Qrad. Normally I can't in DIMOSIM apply directly the convective and radiative gains, only the total internal gains that are multiplied by 0.4 and 0.6. So maybe write somewhere clear that it's not like in the first version ? I add an option to take your inputs as they are into account in the new version 🙂 Here if I add the Qcon + Qrad, Qrad is not 60% of the total. Here the ratio Qcond/Qrad, not constant at all. → other libraries are separated…

Current activities

- 2nd common exercise - resources
  - Buildings
    - First description can be found here
    - Final documentation is not yet available
  - Network
    - ?

TO DO:
- Should we start on the report for CE2 and CE3, but how to approach? Really copy paste and just change relevant parts? Who will do it? → only mention relevant changes, for the other parts, refer to other reports

Current activities

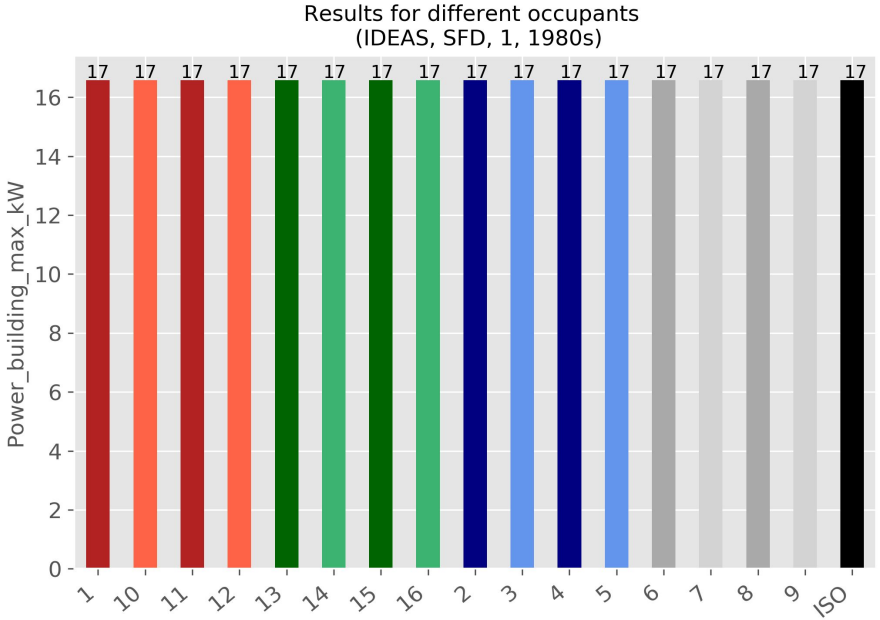
➔ 2nd common exercise - results

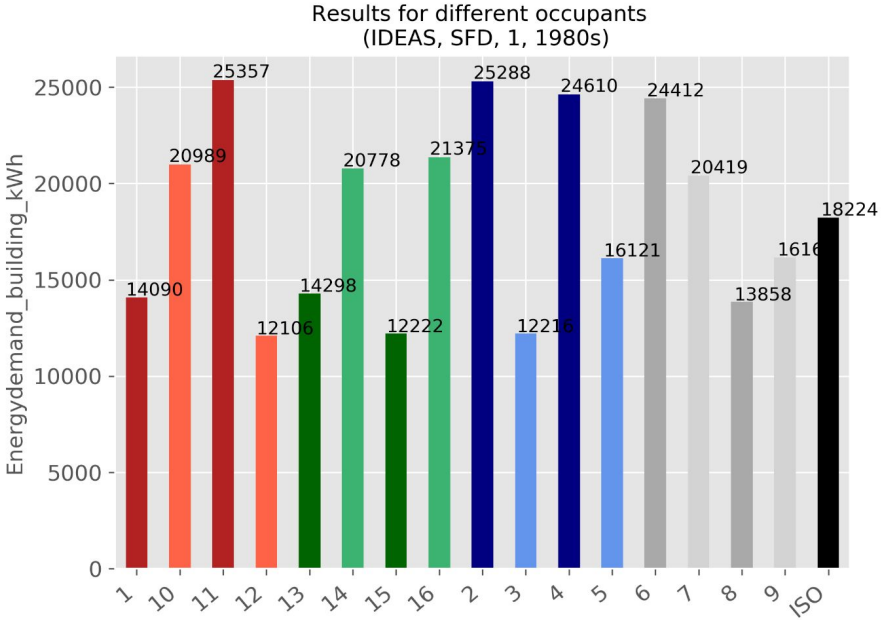
Modelling environment	Modeler	Affiliation of participant
Modelica IDEAS	Ina De Jaeger	KU Leuven / VITO / EnergyVille
Modelica Buildings	Alessandro Maccarini	Aalborg University
DIMOSIM	Enora Garreau	CSTB
Modelica AixLib	Michael Mans, Peter Remmen	RWTH Aachen
Trnsys	Lien De Backer	UGent

TO DO:
- Ina: re-simulate and re-make plots

Current activities

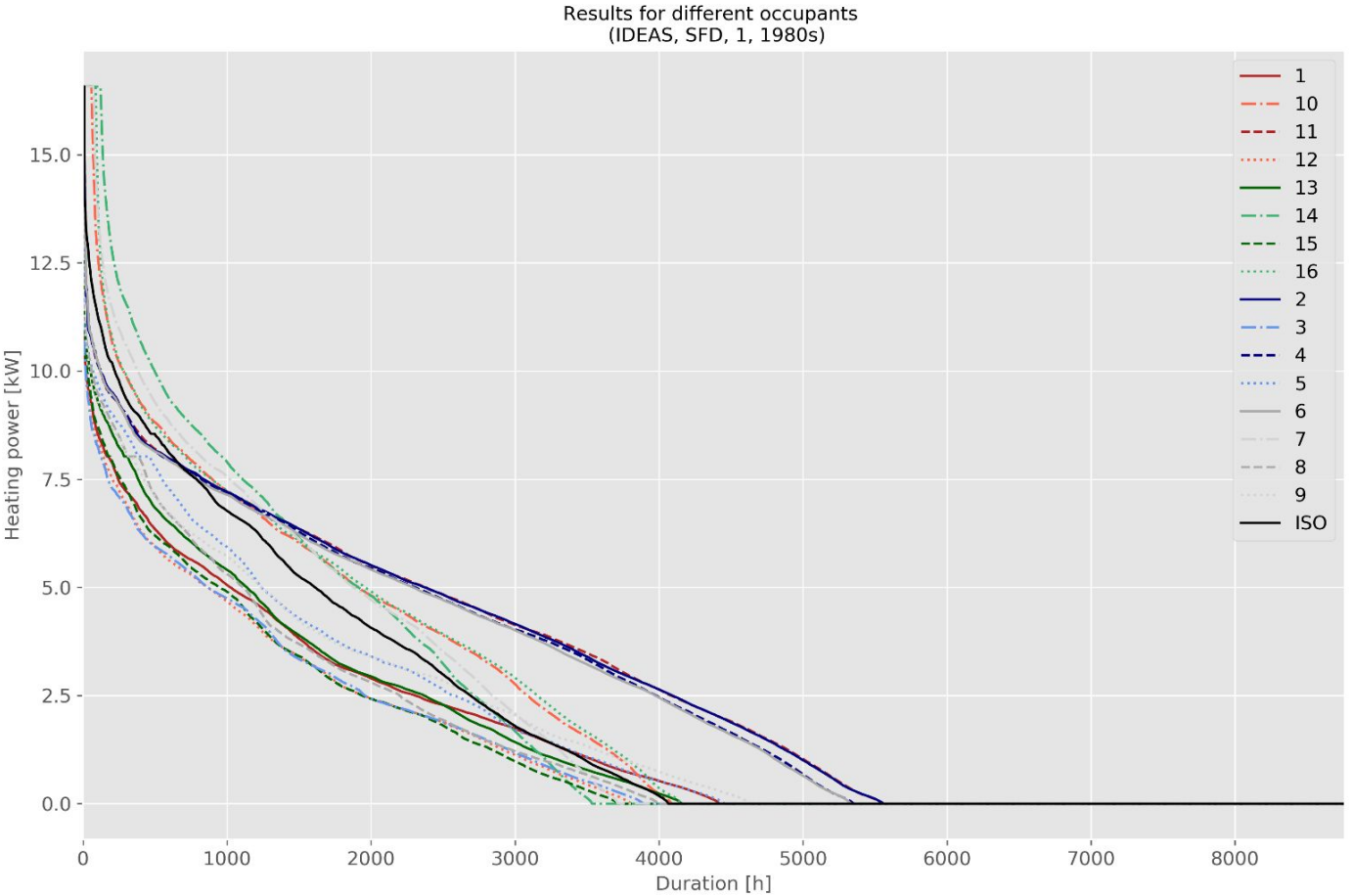
➔ 2nd common exercise - results





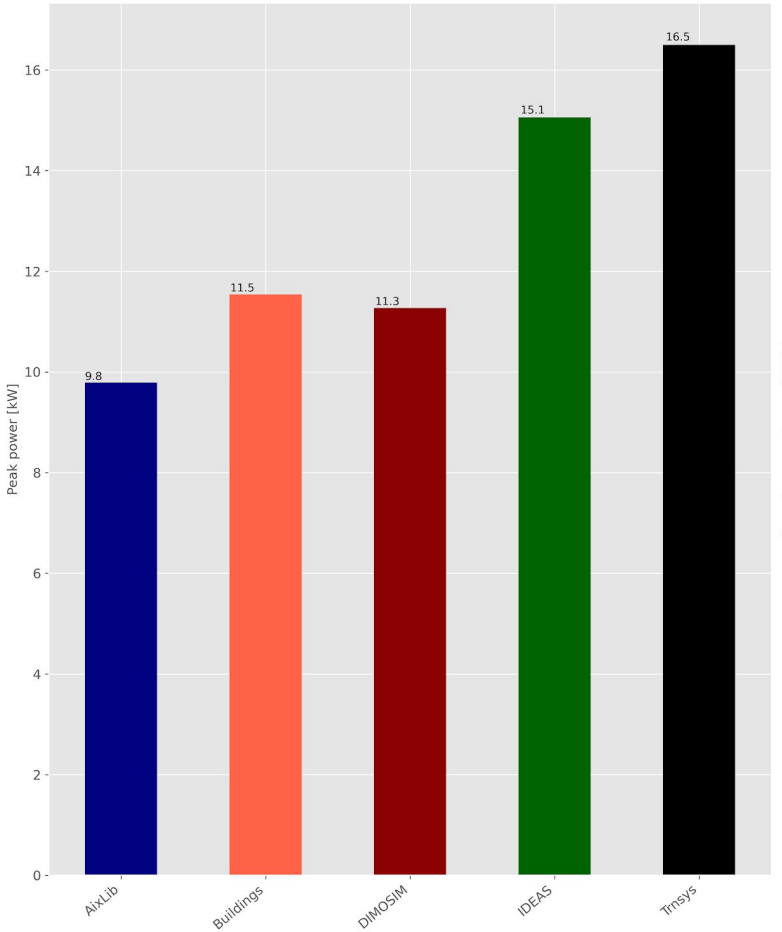
CE 2 - RESULTS

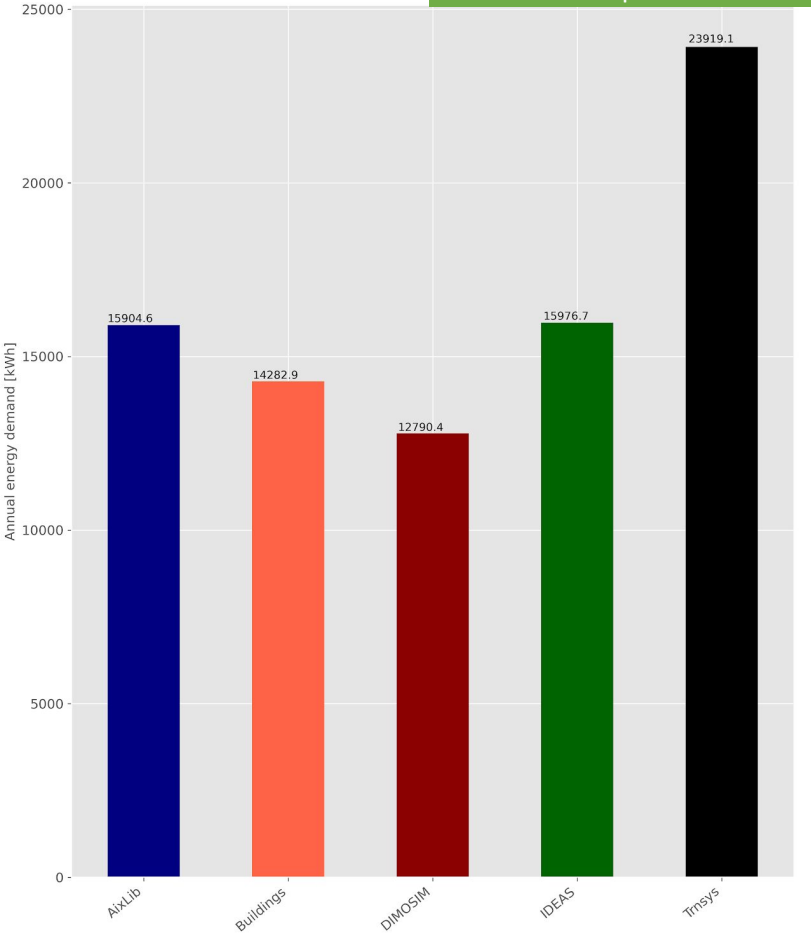
Results from IDEAS library



CE 2 - RESULTS

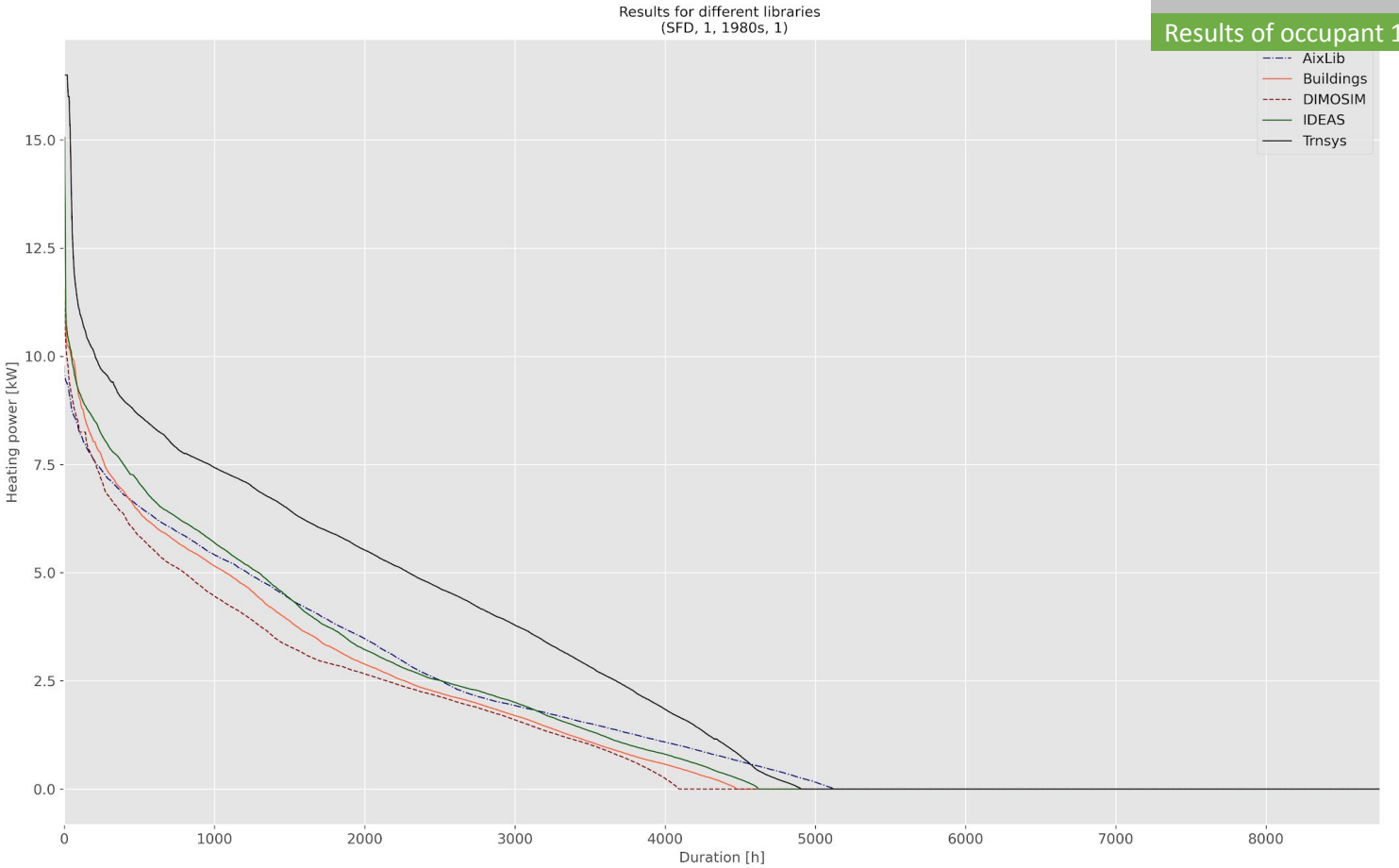
Results of occupant 1





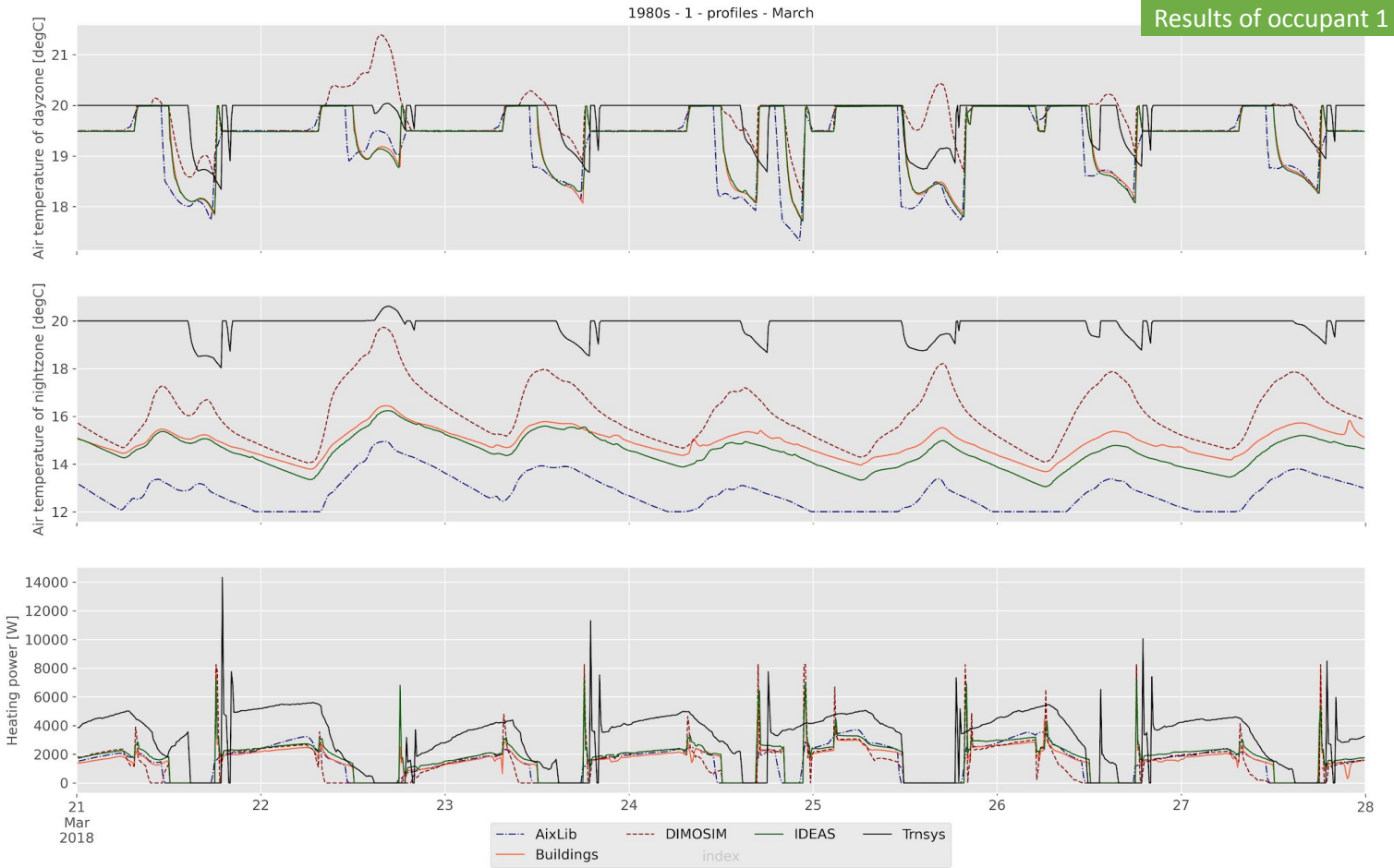
CE 2 - RESULTS

Results of occupant 1



CE 2 - RESULTS

Results of occupant 1

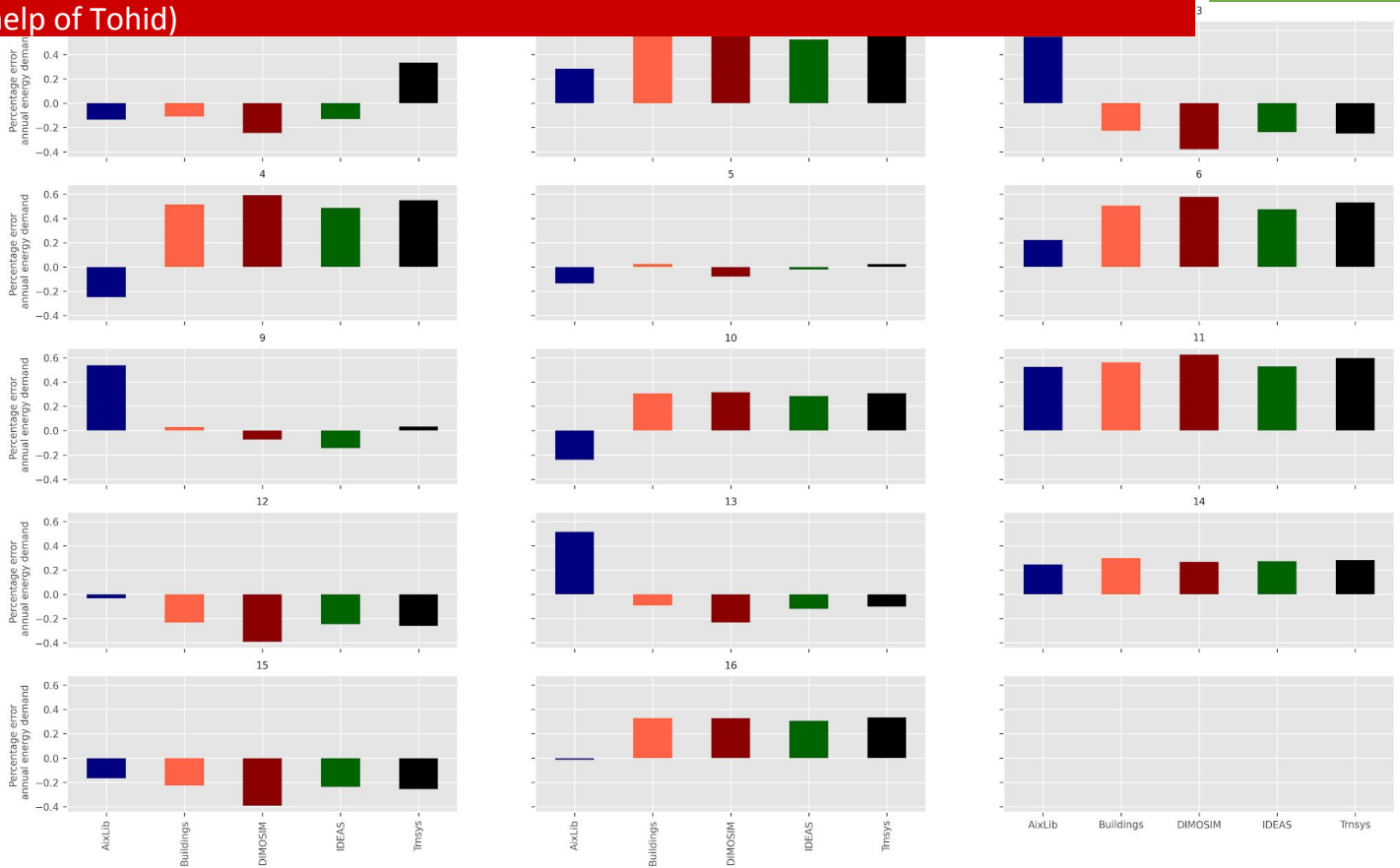


TO DO:

- How to better compare? Provide occupancy profiles as an output as well? Setpoints for day zone and nightzone, internal gains (conv, rad). + Plot for indoor temperature (help of Tohid)

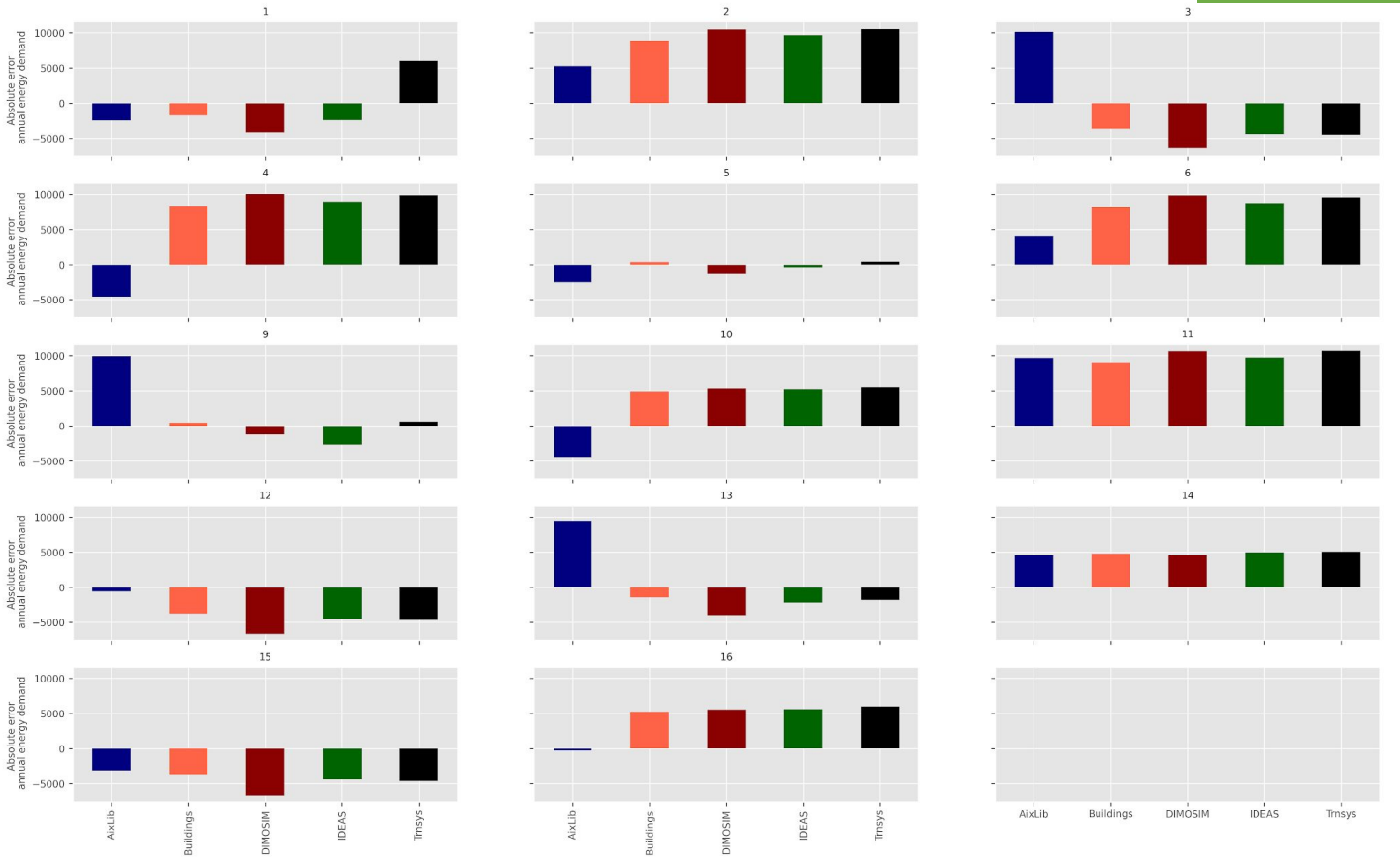
CE 2 - RESULTS

Results of all occupants



CE 2 - RESULTS

Results of all occupants



Current activities

- ➔ 3rd common exercise
  - Single-family dwelling of 1980
    - Thermal performance based on TABULA project for Belgium
      → Also include renovations (light and heavy)
        - Light renovation is referred to as 2000s
        - Heavy renovation is referred to as 2010s
        - Both based on original dwelling, but improved insulation and air tightness
    - Two-zone model (day zone and night zone)
    - Only heat demand for space heating
    - Standard occupant (ISO 13790)
      → Also include stochastic occupants (16 different profiles)
  - Connected by a district heating network

Current activities

- ➔ 3rd common exercise - resources
  - ◆ Buildings
    - First description can be found here
      - Models can be found here
    - Final documentation is not yet available
  - ◆ Network
    - ?

TO DO:
- Final documentation should stress that CE 3 contains 2 new envelope definitions that should be combined with all previous occupants

Current activities

➔ 3rd common exercise - results

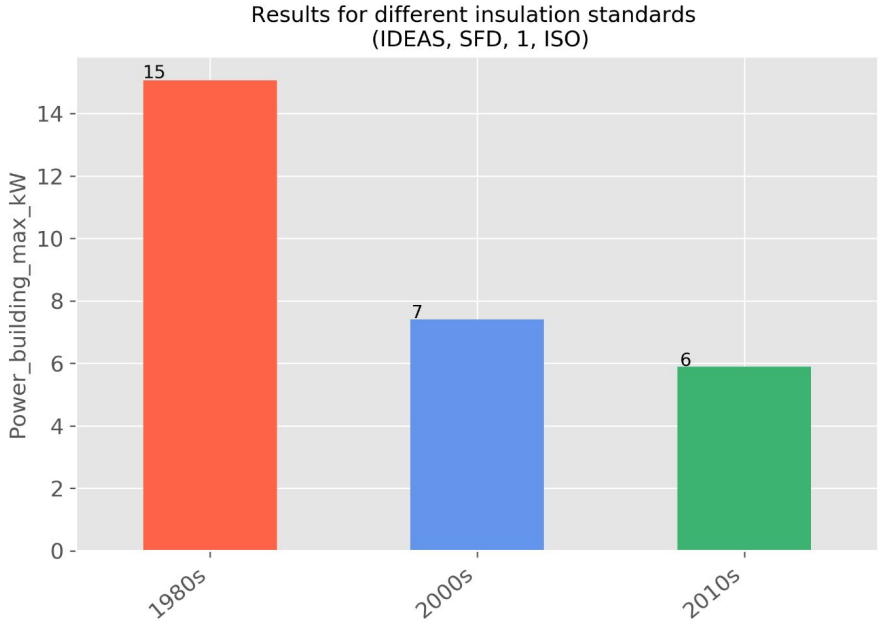
Modelling environment	Modeler	Affiliation of participant
Modelica IDEAS	Ina De Jaeger	KU Leuven / VITO / EnergyVille
Modelica Buildings	Alessandro Maccarini	Aalborg University
DIMOSIM	Enora Garreau	CSTB
Modelica AixLib	Michael Mans, Peter Remmen	RWTH Aachen

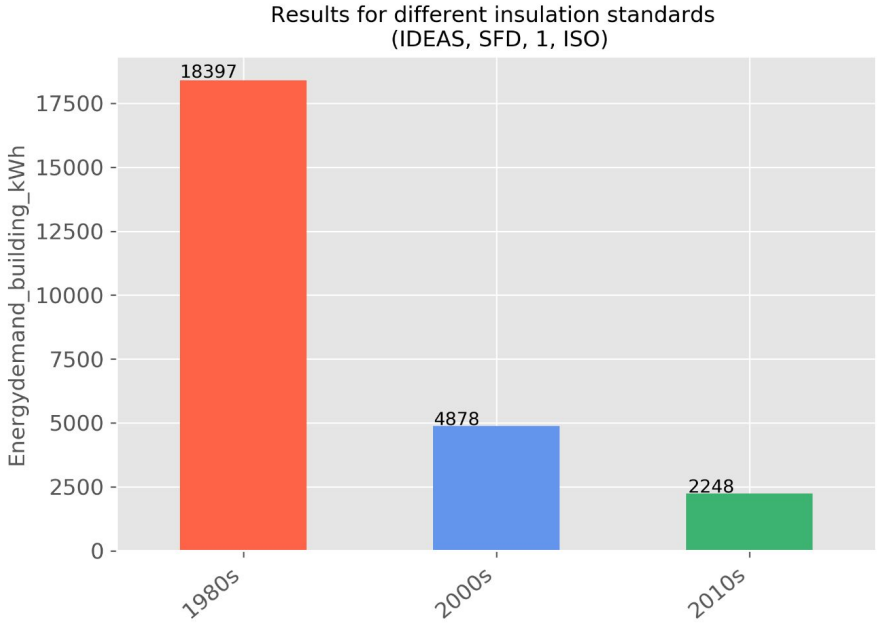
TO DO:

- Ina: re-simulate and re-make plots

CE 3 - RESULTS

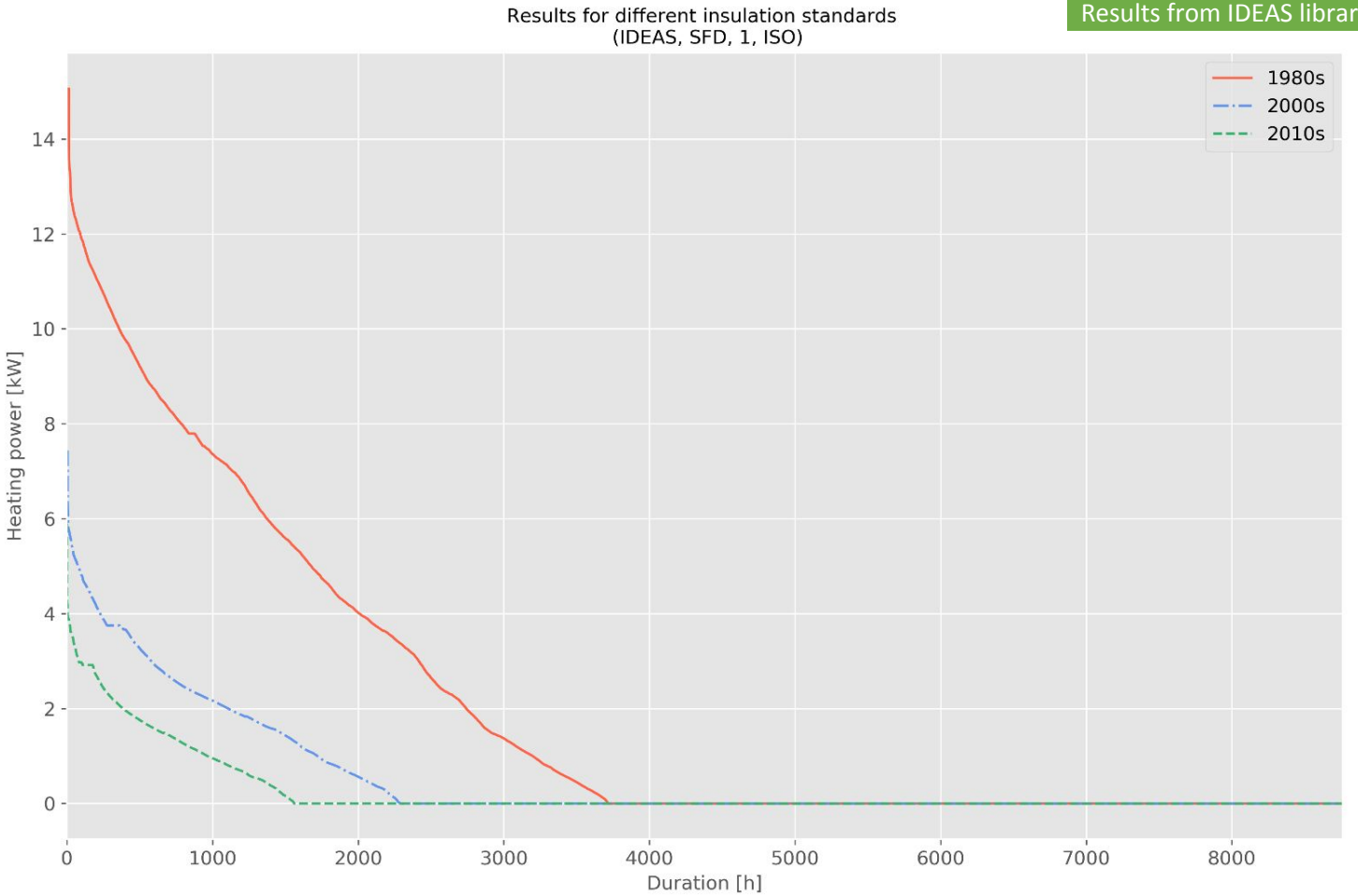
Results from IDEAS library





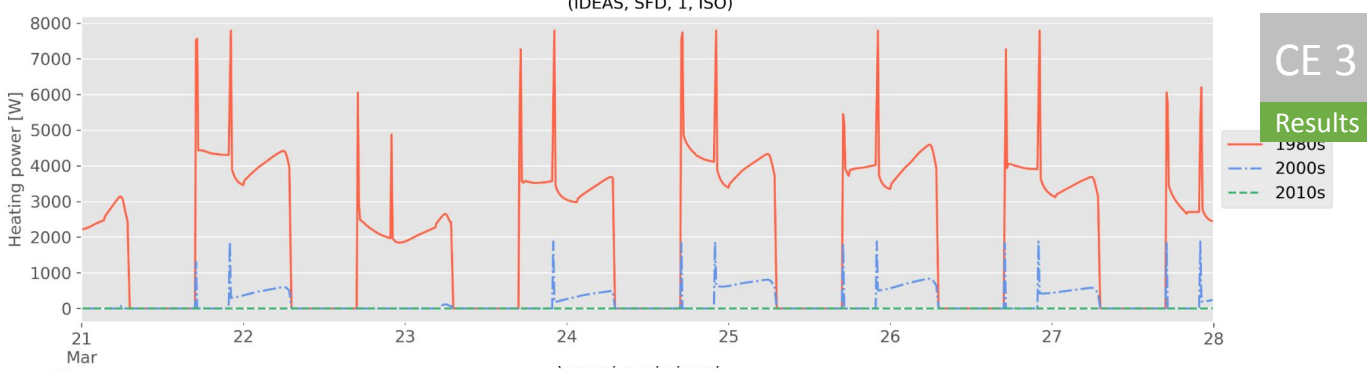
CE 3 - RESULTS

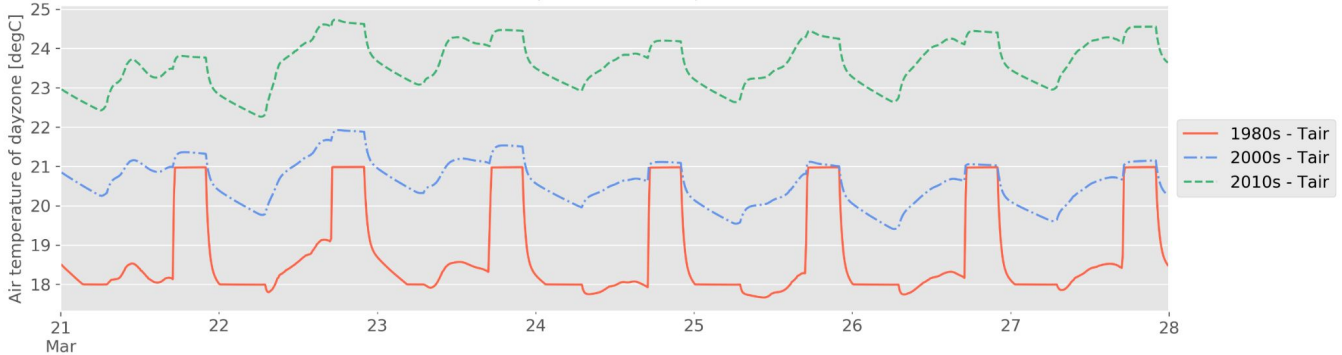
Results from IDEAS library

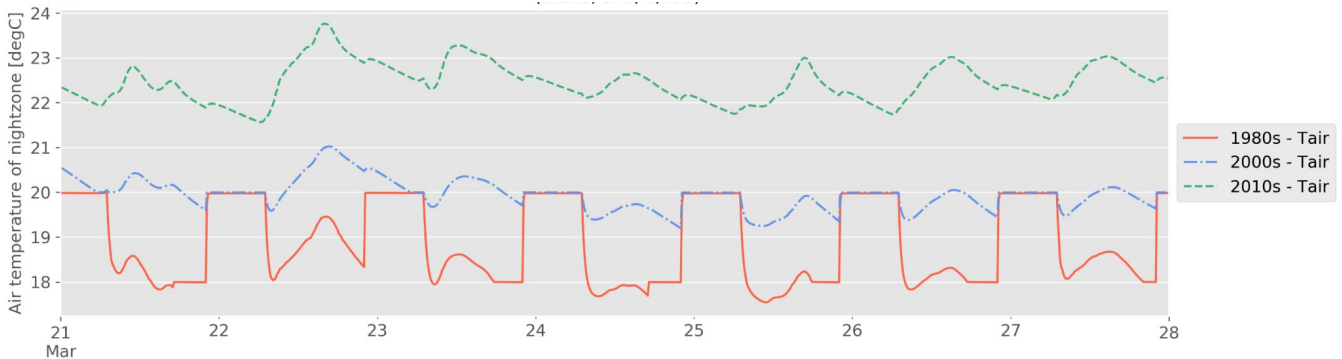


CE 3 - RESULTS

Results from IDEAS library

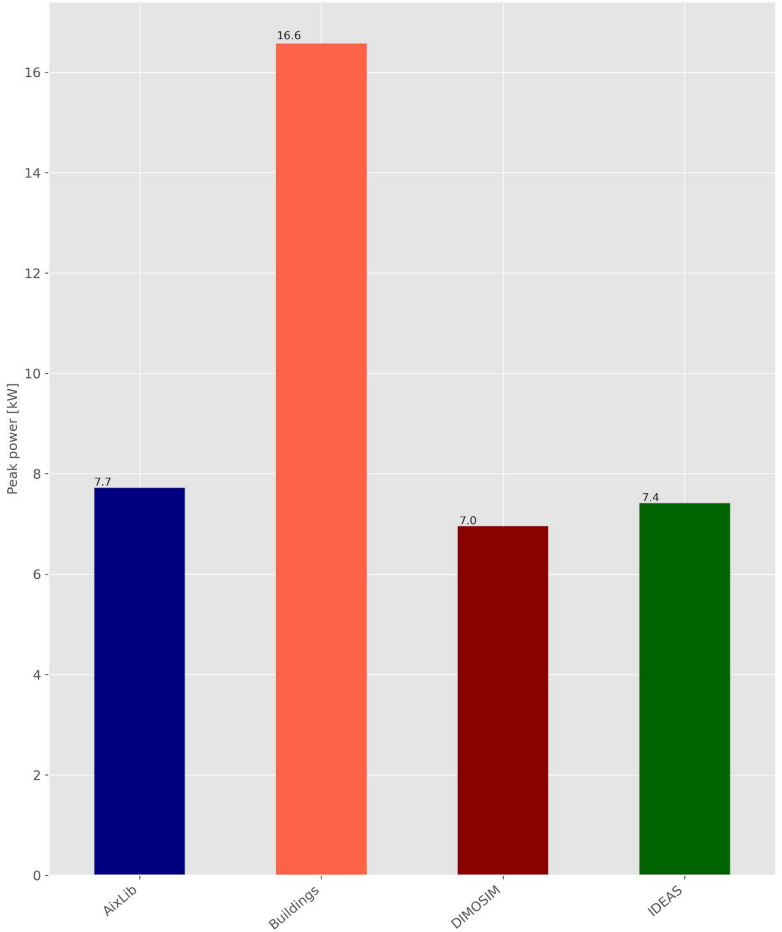


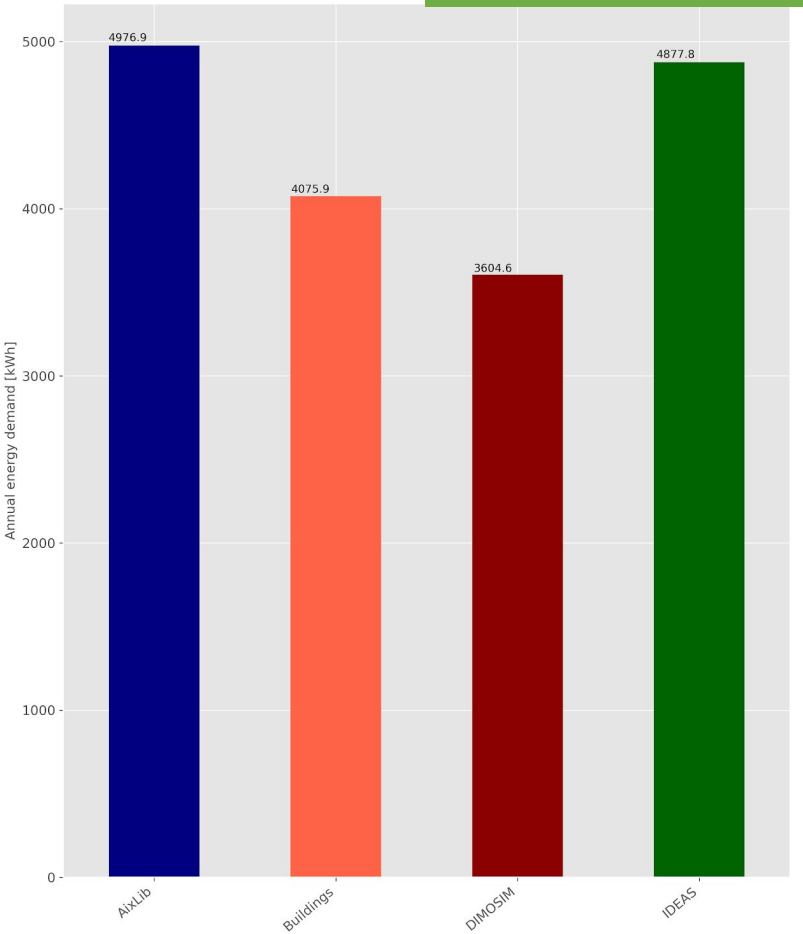




CE 3 - RESULTS

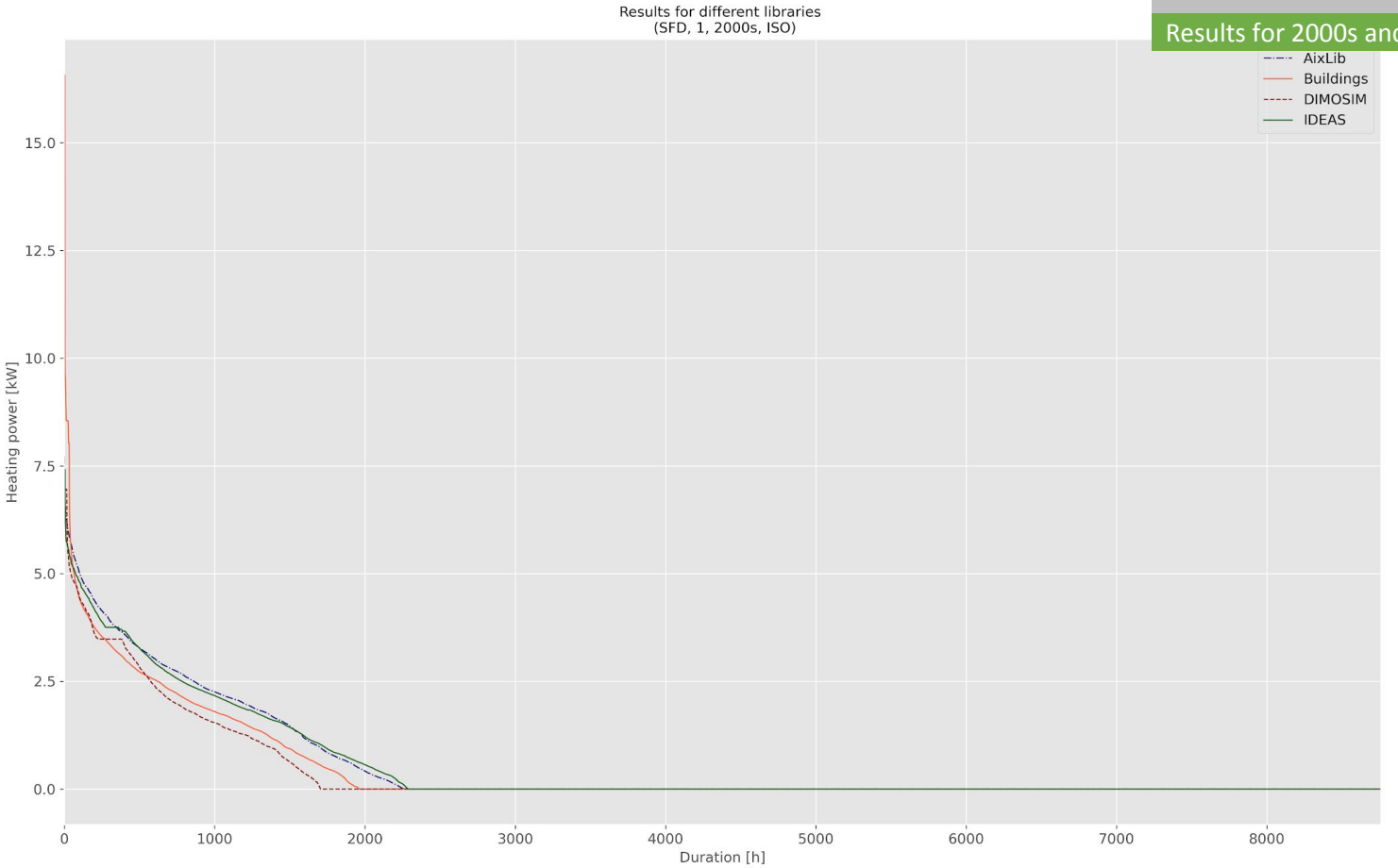
Results for 2000s and ISO occupant





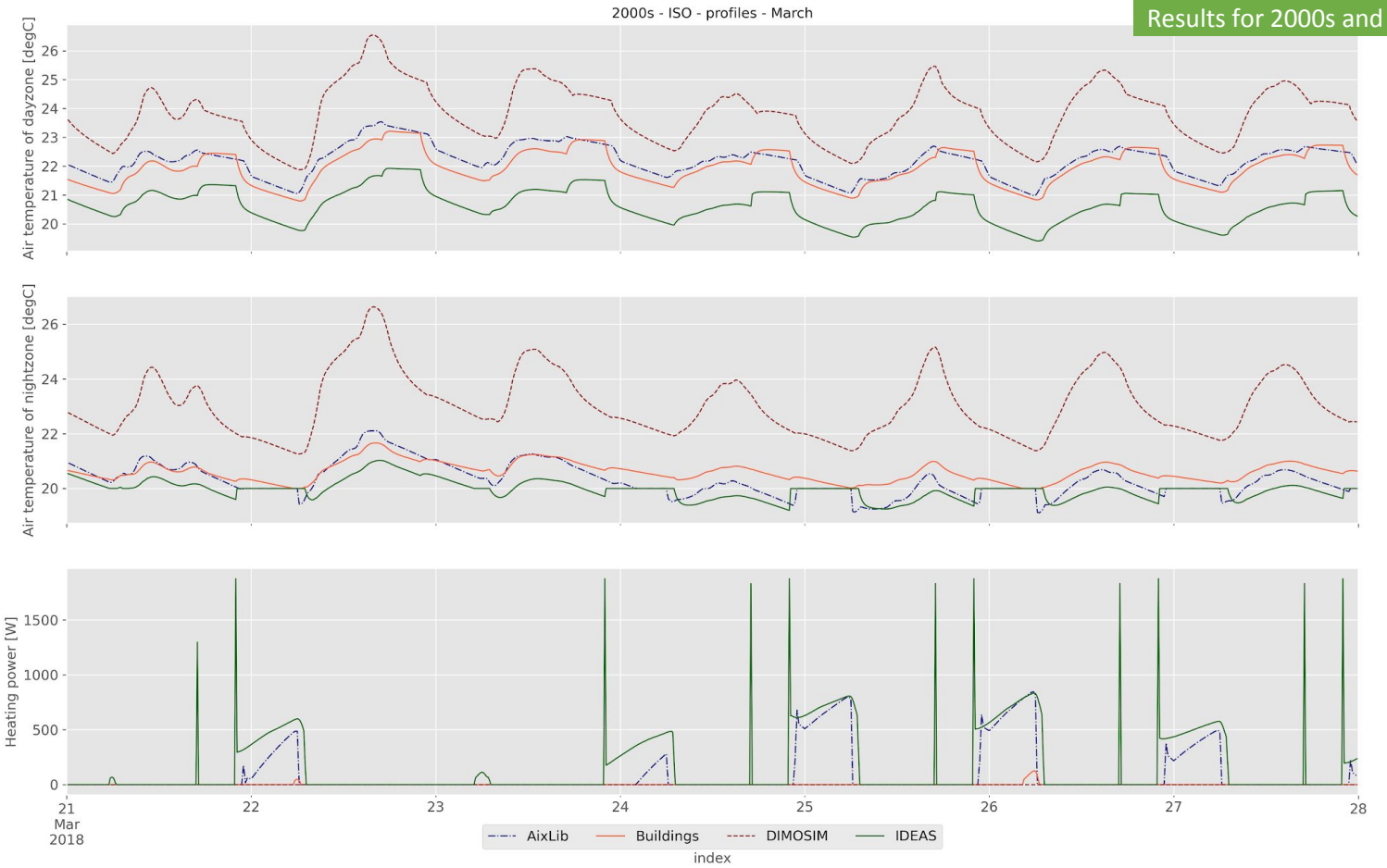
CE 3 - RESULTS

Results for 2000s and ISO occupant



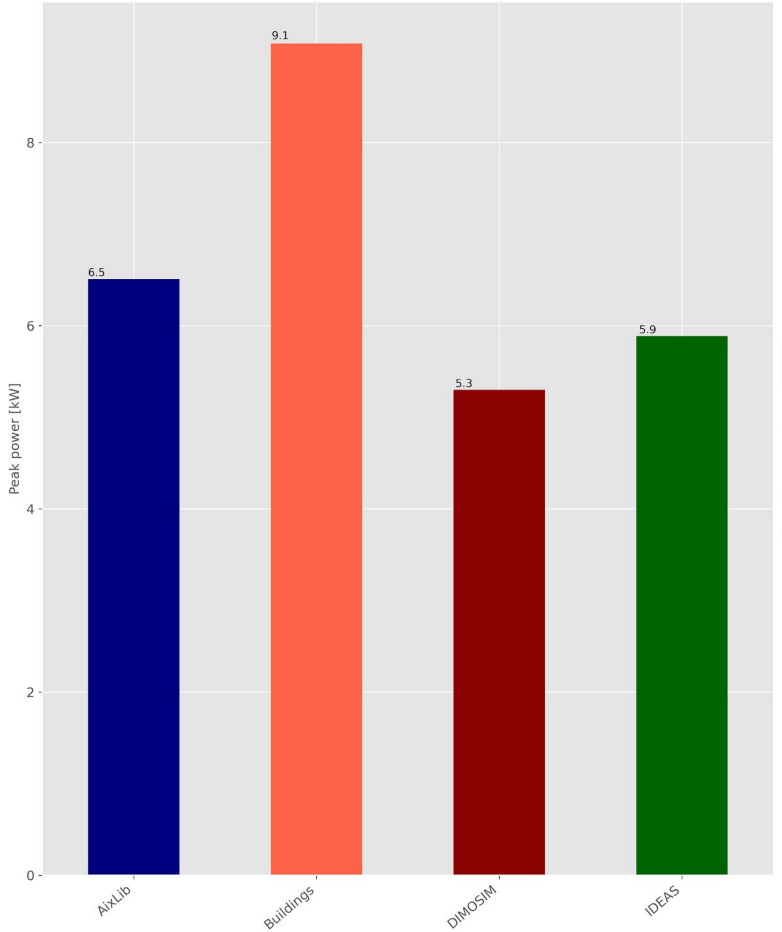
CE 3 - RESULTS

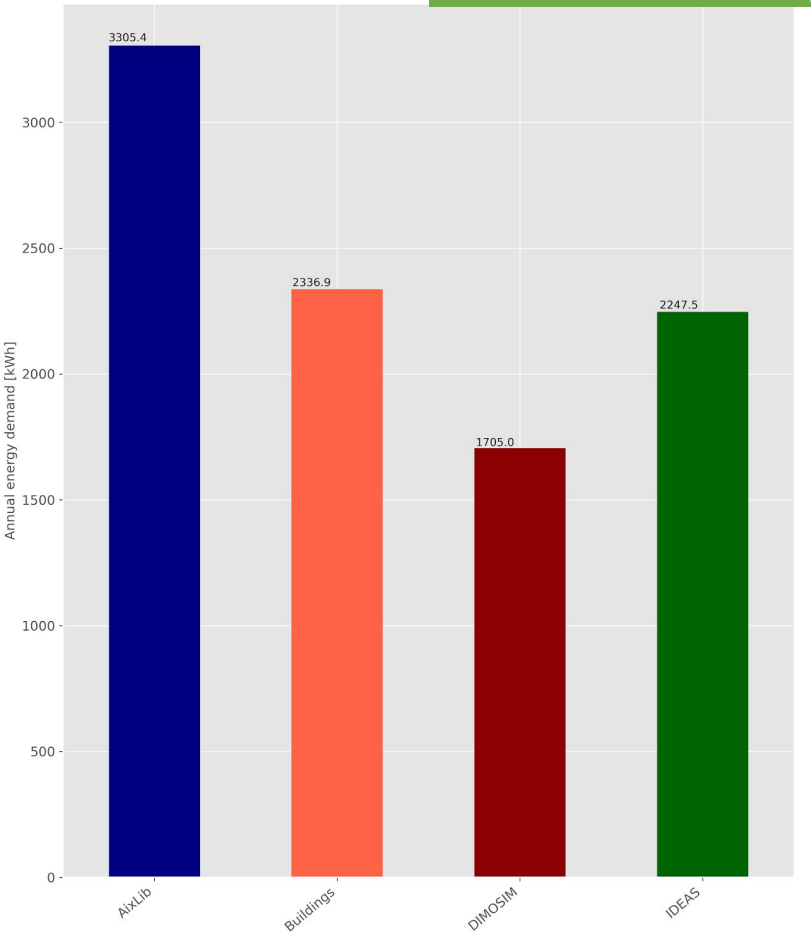
Results for 2000s and ISO occupant



CE 3 - RESULTS

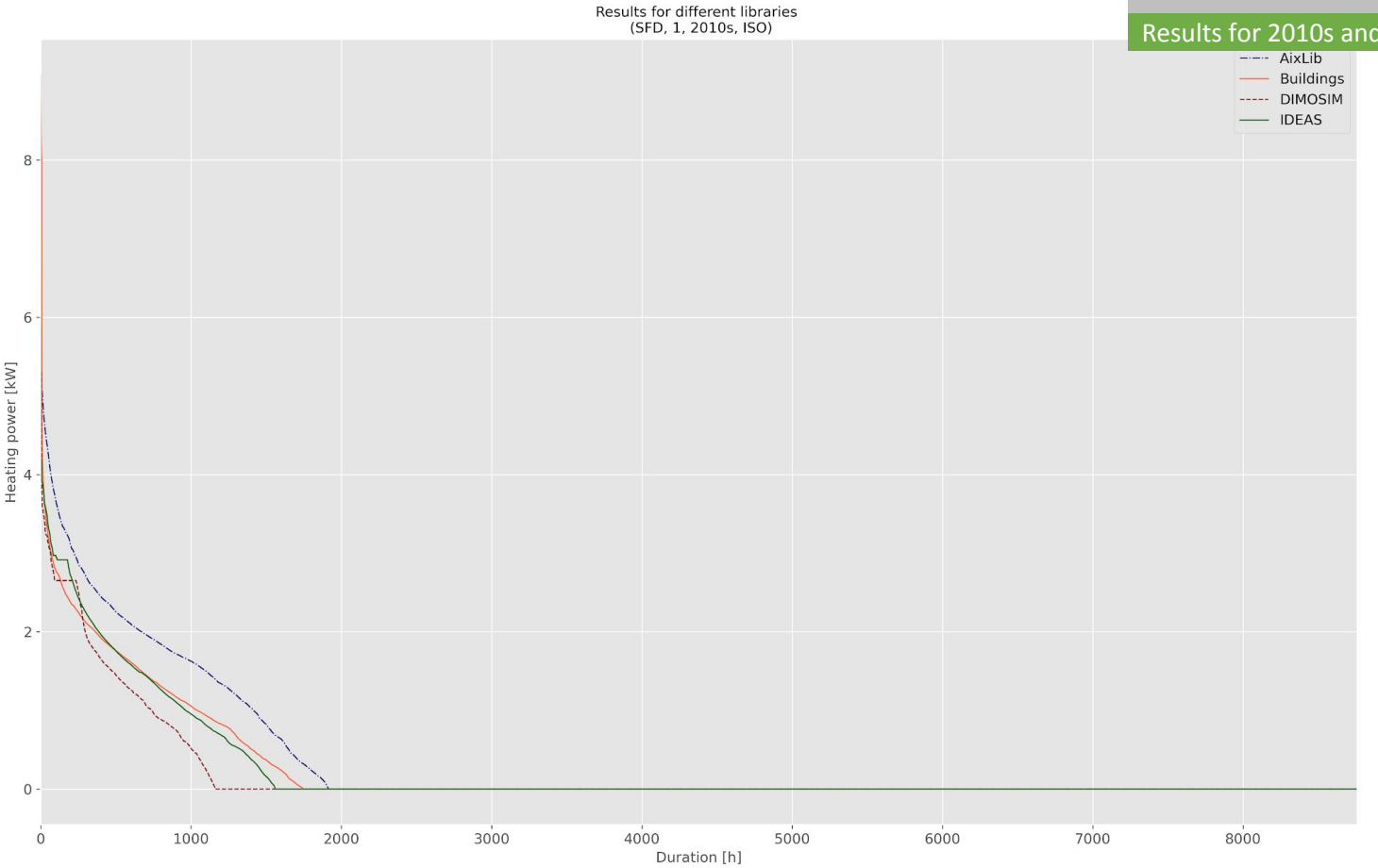
Results for 2010s and ISO occupant





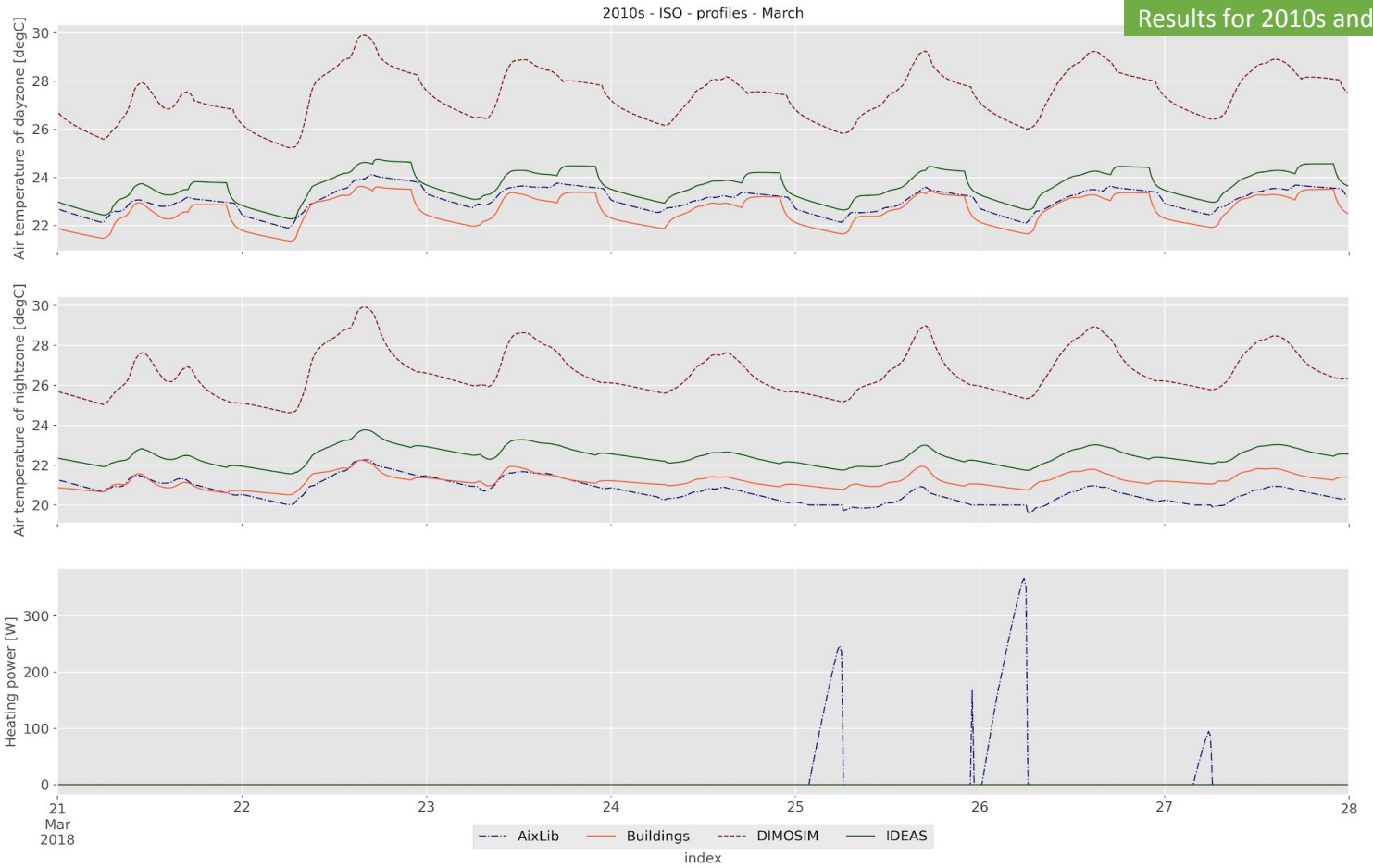
CE 3 - RESULTS

Results for 2010s and ISO occupant



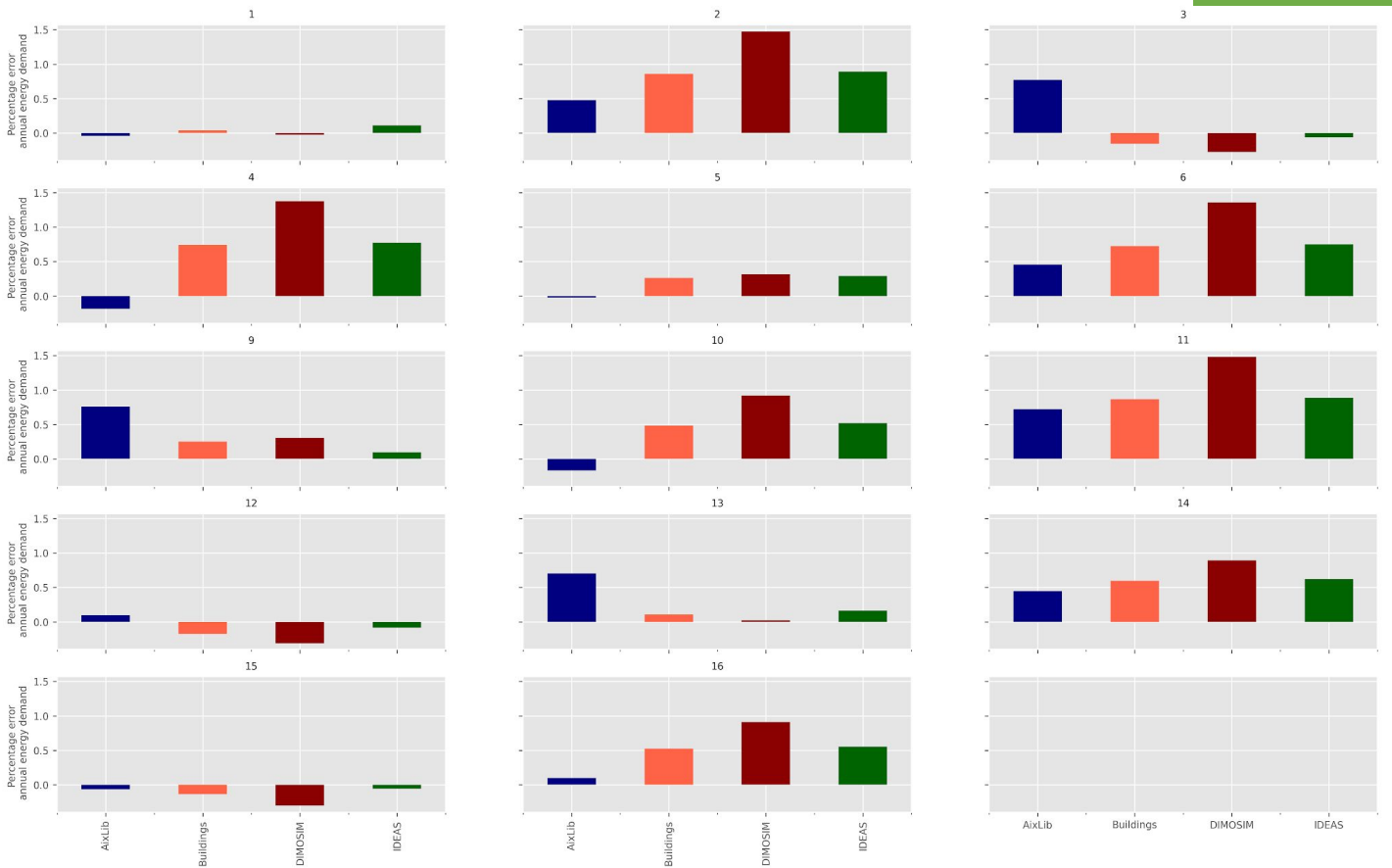
CE 3 - RESULTS

Results for 2010s and ISO occupant



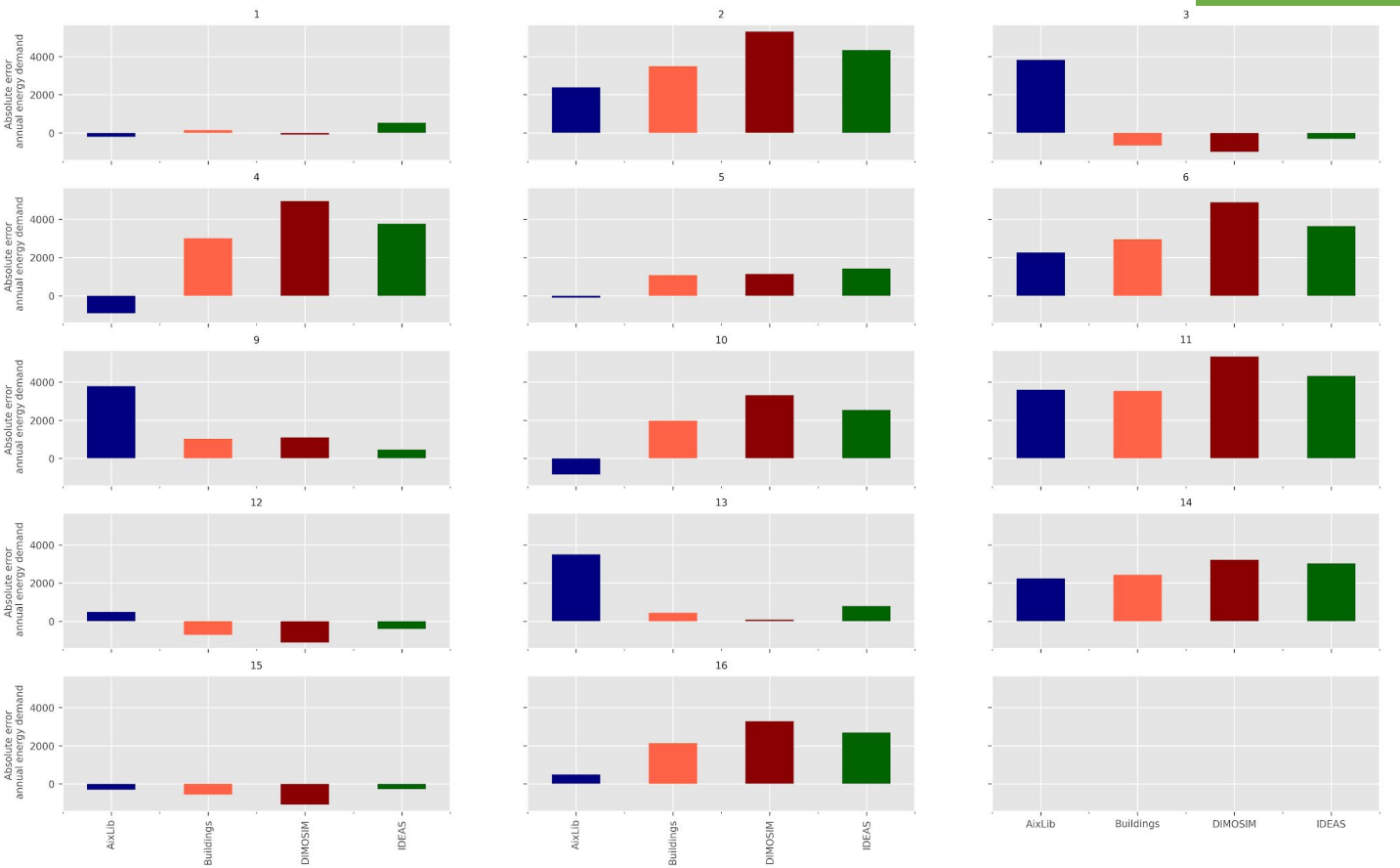
CE 3 - RESULTS

Results for 2000s and all occupants



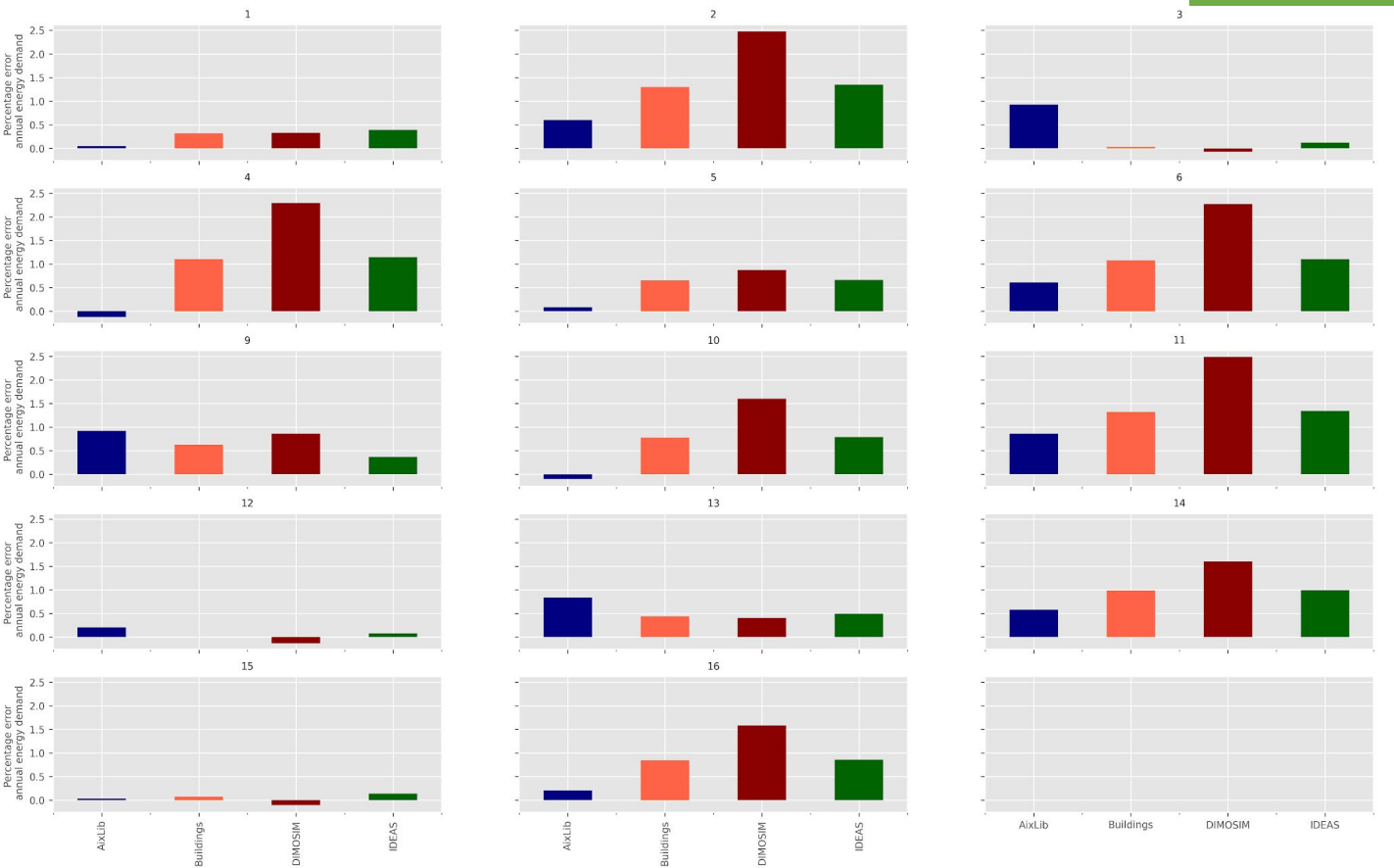
CE 3 - RESULTS

Results for 2000s and all occupants



CE 3 - RESULTS

Results for 2010s and all occupants



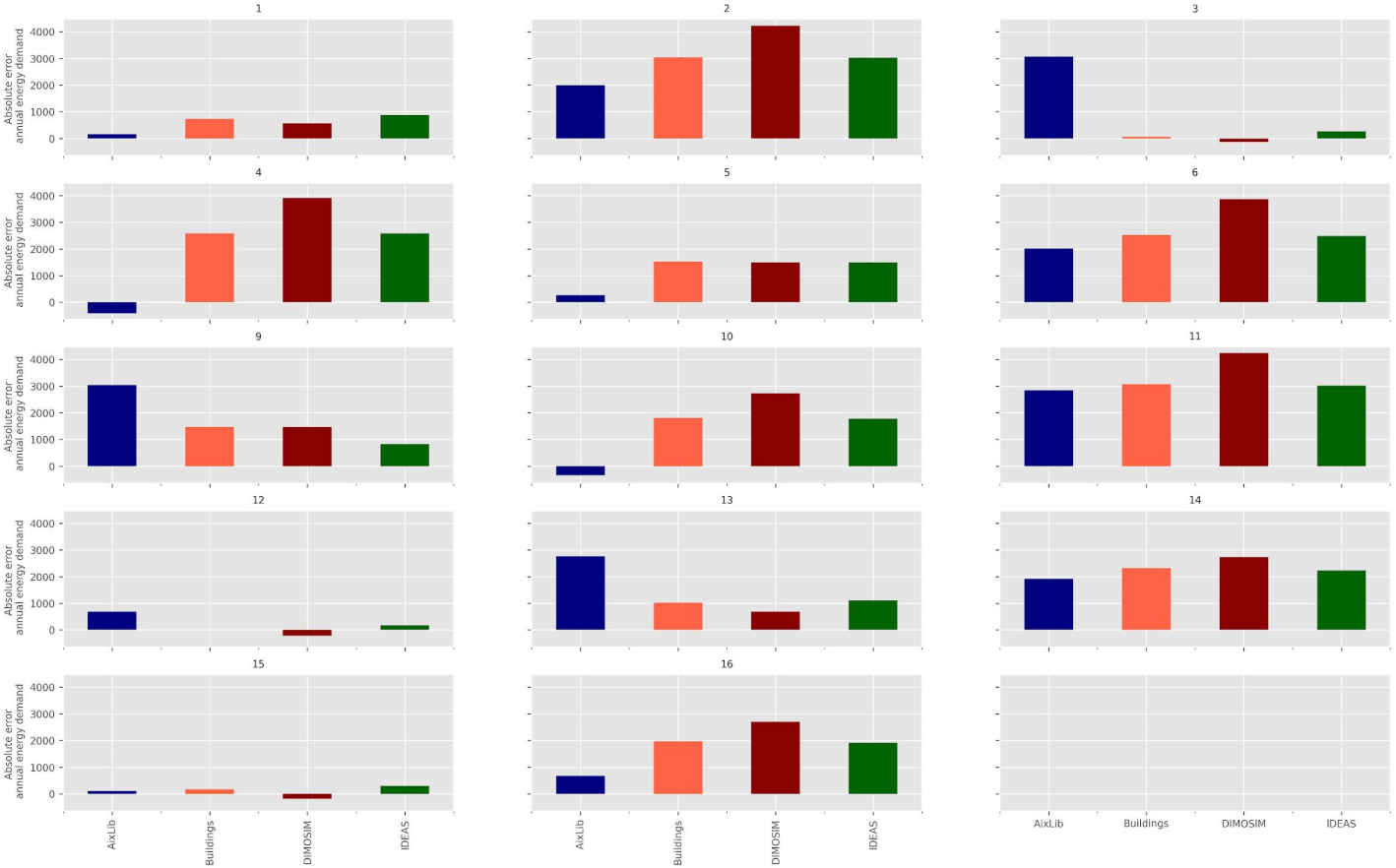
TO DISCUSS:

- Who else wants to contribute? Lien :D + Hicham :D

ve to ISO occupant

CE 3 - RESULTS

Results for 2010s and all occupants

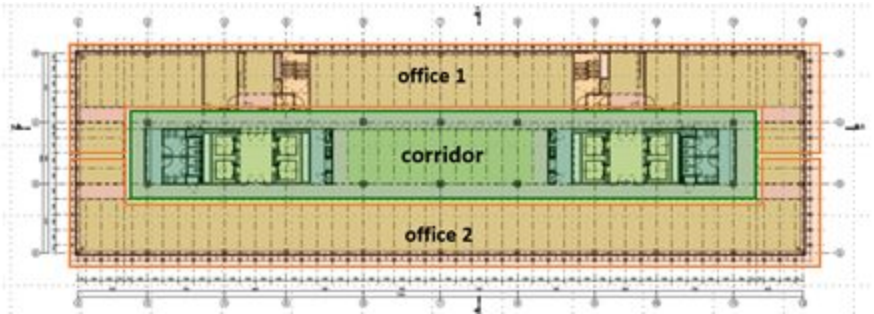


Current activities

- ➔ 4th common exercise
  - Single-family dwelling of 1980
    - Thermal performance based on TABULA project for Belgium
      → Also include renovations (light and heavy)
    - Two-zone model (day zone and night zone)
    - Only heat demand for space heating
    - Standard occupant (ISO 13790)
      → Also include stochastic occupants (16 different profiles)
  - Office building
  - Connected by a district heating network

Current activities

- ➔ Buildings: 4th common exercise - resources
  - ◆ Buildings
    - First description of office building can be found here
      - Models are not yet available
    - Final documentation is not yet available



CE 4 - RESULTS

TO DISCUSS:

- Who else wants to contribute? → Deadline: beginning of July
  - Arash
  - Alessandro
  - Enora ? (ask)
  - Hicham

➔ 4th common exercise - results

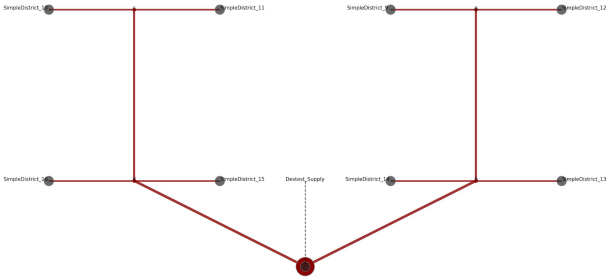
- Not yet available

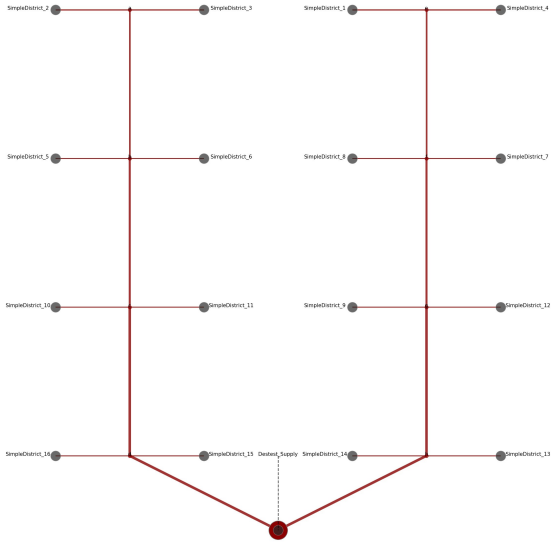
TO DISCUSS:
- Who else wants to contribute?

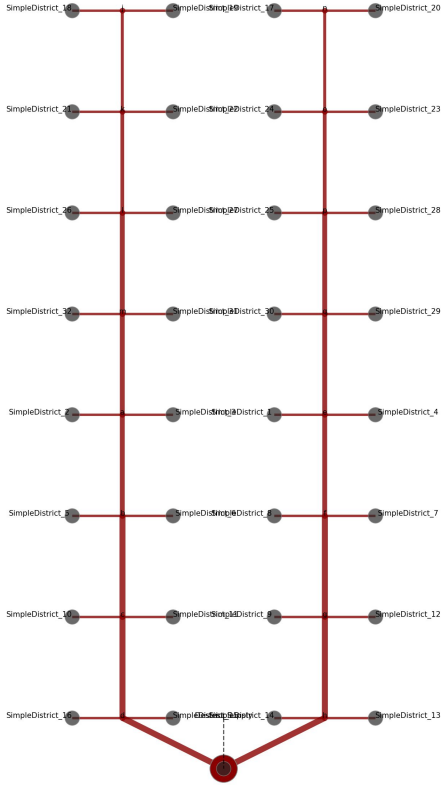
Current activities

➔ New CE for networks:

- We split up the network layout to have a 8 and a 32 buildings layout in addition







Future activities

➔ Scale up to …

TO DISCUSS:
- Brainstorm !

Future activities

- ➔ Next Steps:
  - ◆ Next exercise:
    - Change building demand profiles
      - ○ Upscaling and Downscaling the network
      - ○ Does this influence the differences in terms of results between different modellers?
        - ◆ Does it scale linear?
        - ◆ Does upscaling and downscaling with different heat loads change the simulation results and complexity?

You want to contribute?

- ➔ Great! What do you want to do?
  - ◆ You want to model
    - A single-family dwelling
      - We suggest to start with common exercise (CE) 1, as CE 2 and CE 3 build further on this
    - An office building
      - We suggest to start with CE 4
    - A district heating network
      - We suggest to start with CE 1
  - ◆ All required data, you can find in the resources of the CE you want to do
- ➔ Once you are ready, please provide your simulation results in the specified format
  - ◆ See next slide

How to provide simulation results?

- Thank you for providing your results in the correct format (makes plotting easier)
- Buildings
  - Results should be reported in a standardized format (1 csv per building)
    - The filename: LIBRARY_BUILDINGTYPE_BUILDINGID_INSULATIONSTANDARD_OCCUPANT.csv
      - Where LIBRARY is the library you are working with. Choose from: IDEAS, Buildings, AixLib, BuildingSystems, IDAICE, DIMOSIM, Trnsys (case-sensitive!)
      - Where BUILDINGID is an ID for the specific building and always equals 1 in the current simulations. This is just a placeholder (e.g. Enora can include the shading from the surrounding buildings, then this ID can be used).
      - Where BUILDINGTYPE currently always equals SFD (single-family dwelling). This is just a placeholder for the offices (OFF) in the nearby future.
      - Where INSULATIONSTANDARD is the insulation standard that you are using. Choose from: 1980s, 2000s, 2010s
      - Where OCCUPANT is the occupant profile that is used. Choose from: ISO, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
    - The file itself is a comma separated csv, which contains 4 columns:
      - Datetime - in seconds. Time step is **600 seconds** or 10 minutes
      - Qheating_building_W in Watt. Heating power for the whole building
      - Tair_dayzone_K in Kelvin. Air temperature of the day zone
      - Tair_nightzone_K in Kelvin. Air temperature of the night zone
    - You can find an example here (attachment at the bottom of the message).

- Network
  - ...

How to access the simulation results of the others?

- Results of other models can be found here
  - Should be transferred to another platform because it is too
  - While awaiting a better solution, you can send the results to Ina by wetransfer/e-mail (in the proper format)

→ a new repository: https://github.com/ibpsa/project1-destest

which naming is preferred? → Michael M ask Michael W to create

- Better way of sharing data + plotting is under construction:
  - A joint effort of Michael, Enora and me has resulted in this nice feature: a notebook.ai: https://notebooks.ai/MichaMans/project-1-plots-e59f9de8
    - This notebook allows you to download some of the simulated power profiles and temperatures of the others' models and upload your own. Subsequently, you can compare your results and see if they are reasonable. You can fork this code from Michael's account
    - Feel free to add interesting plots

→ could be added to the repo, together with the error calculation script of Hicham?

Michael W also suggests to upload our models online, include the solver specification in the models, refer to the models in the case report (eg in the figure: simulation results for 1 week, for different models and different solvers) → could be on new repository!

→ couldn't it be a website for the destest? Where people can find all descriptions + results + scripts to compare their own results? (Inspired by Alessandro's nice-looking webpage?)

TO DISCUSS:
- Additional topics

Break-out session 07/05/2020

Discussion:

- ➔ Current presentation: good idea? Suggestions? → Good idea, clear for newcomers
  - ◆ Current version can always be downloaded to have a snapshot (suggestion to do it every meeting)
- ➔ Someone active in Annex 82?
  - ◆ Lieve: can these district models be used to test controllers for DR on? IEA-EBC Annex 82 is looking for district models (not necessarily with DH). If not, then Ina will contact Lieve for more information. → no one is active there, Ina contacts Lieve
- ➔ Michael W: automated result comparison in ASHRAE 140 (?)
  - ◆ Who can look into it? → Hicham already looked into it
- ➔ Michael W: dissemination? Include DESTEST in standard? → First work on central platform, then look from there
- ➔ Michael W/ Gerald S: Focus on uncertainty propagation → is someone interested in contributing? Not immediately it seems, maybe first specify better what we want to do, then come back to group