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Assessment of Climate Change Robustness of a Deep Energy Retrofit Design of an Existing Day Care Centre

Amin Moazami, Salvatore Carlucci, Stig Geving

Faculty of Engineering Science and Technology
Department of Civil and Transport Engineering, NTNU

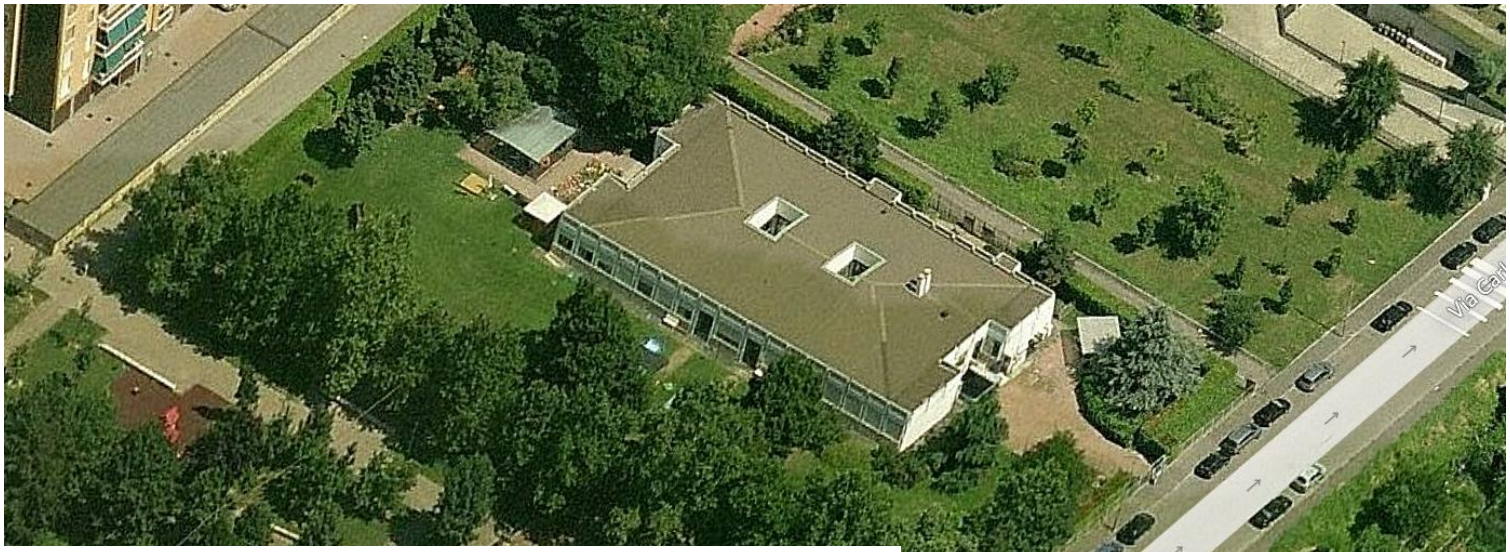
Lorenzo Pagliano, Francesco Causone

end-use Efficiency Research Group (eERG)
Department of Energy, POLIMI

Outline of presentation

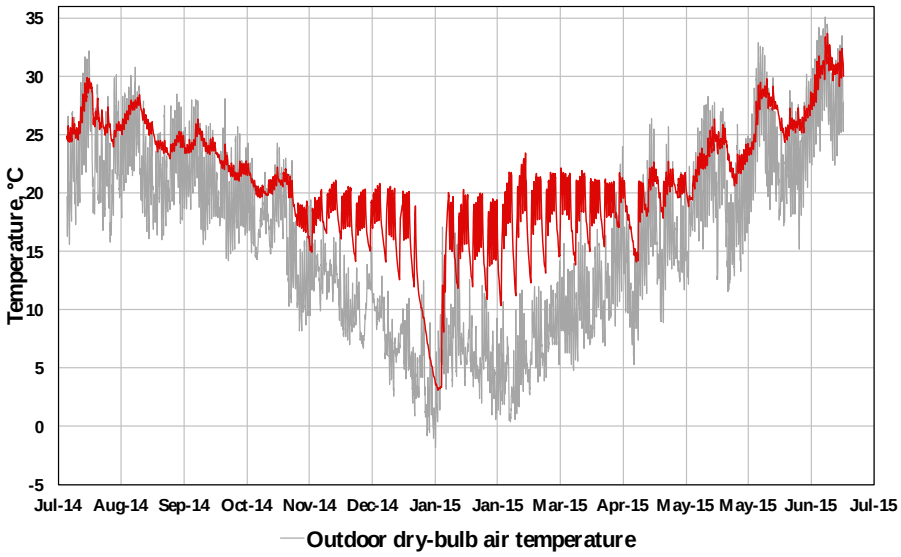
- Existing building, monitoring and modeling
- Energy retrofit design specification and target
- How to consider climate change in BPS tools
- Results and the impacts of climate change on the robustness of the design
- Q&A session

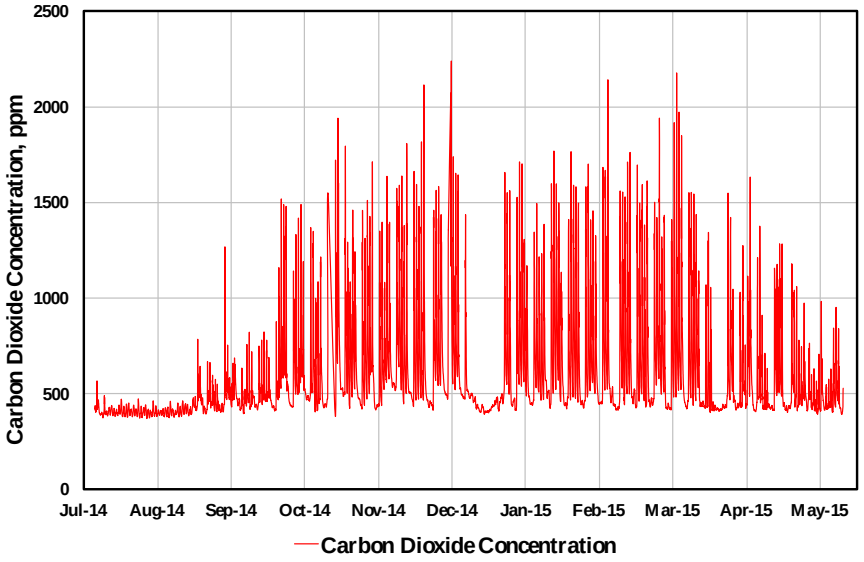
Building Description

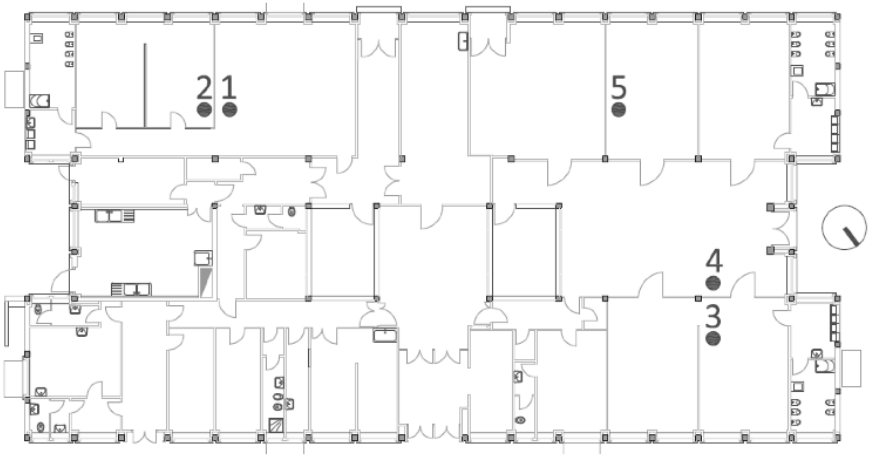


Component	PRE-retrofit U-value W/(m^{2}K)
Vertical opaque wall	1,20
Roof	1,30
Window	5,80

Indoor Environmental Monitoring

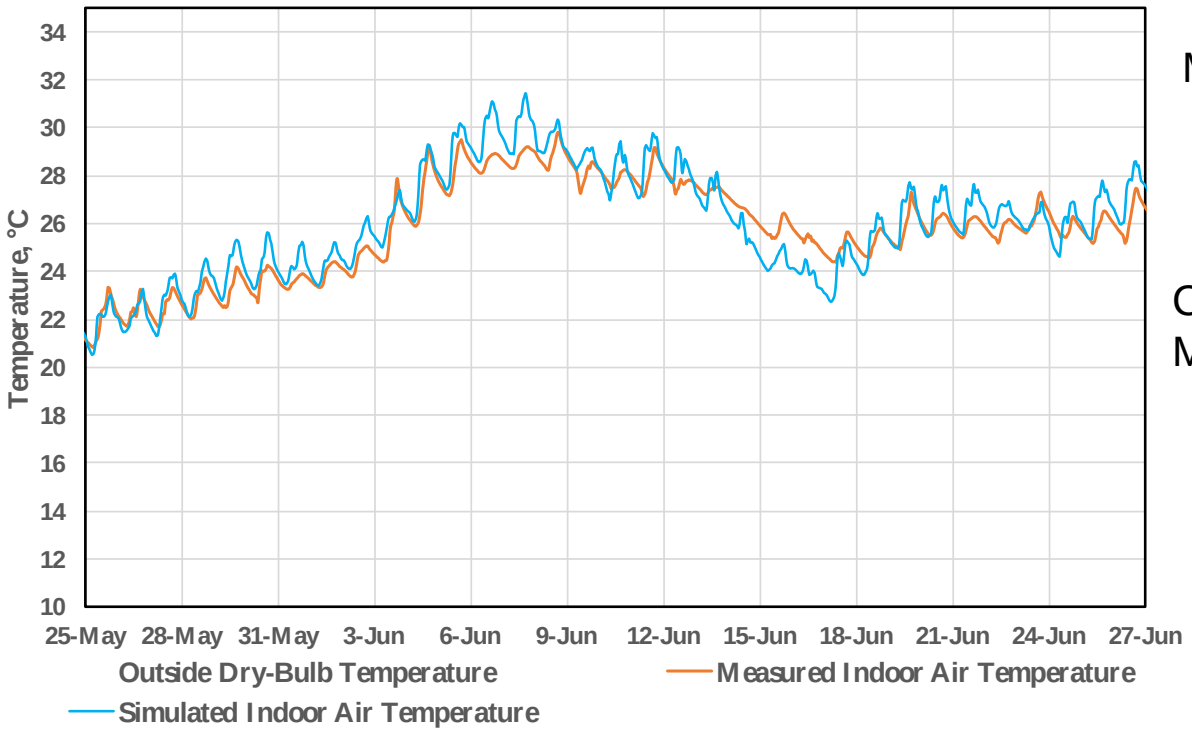






Ref: Moazami, Amin; Carlucci, Salvatore; Causone, Francesco; Pagliano, Lorenzo.(2016) Energy retrofit of a day care center for current and future weather scenarios. Procedia Engineering. vol. 145.

Numerical model calibration



Mean Bias Error (MBE) (%):

$$MBE = \frac{\sum_{i=1}^{N_p}(m_i - s_i)}{\sum_{i=1}^{N_p} m_i} \quad [\%]$$

Coefficient of Variation of Root Mean Square Error CV(RMSE) (%)

$$CV(RMSE) = \frac{\sqrt{\frac{\sum_{i=1}^{N_p}(m_i - s_i)^2}{N_p}}}{\bar{m}} \quad [\%]$$

Category	Goodness-of-fit index	Final Simulation (%)	ASHRAE Guideline 14 Criteria (%)
Monthly energy use	MBE	3,7	5,0
	CV (RMSE)	11,6	15,0
Hourly indoor air temperature	MBE	0,8	10
	CV RMSE	4,2	30

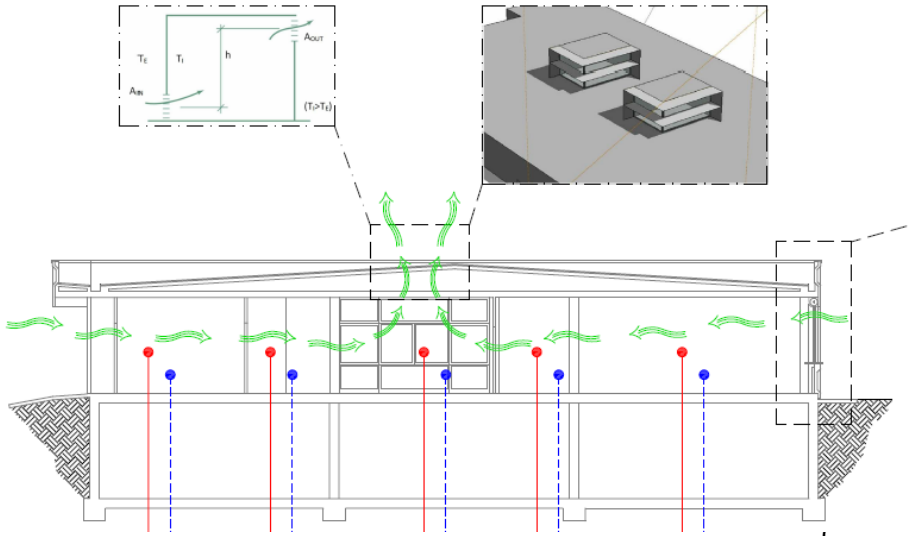
Energy Retrofit Targeting nZEB

- Reducing the energy need for space heating.
- Adopting passive strategies for cooling
- Improving IAQ by installing highly-efficient decentralised ventilation
- Installing new grid-connected renewable energy generation systems.
- Ensuring adequate thermal comfort conditions all-year long.
- Reducing construction time to limit the disturbance or interruption of the educational service.

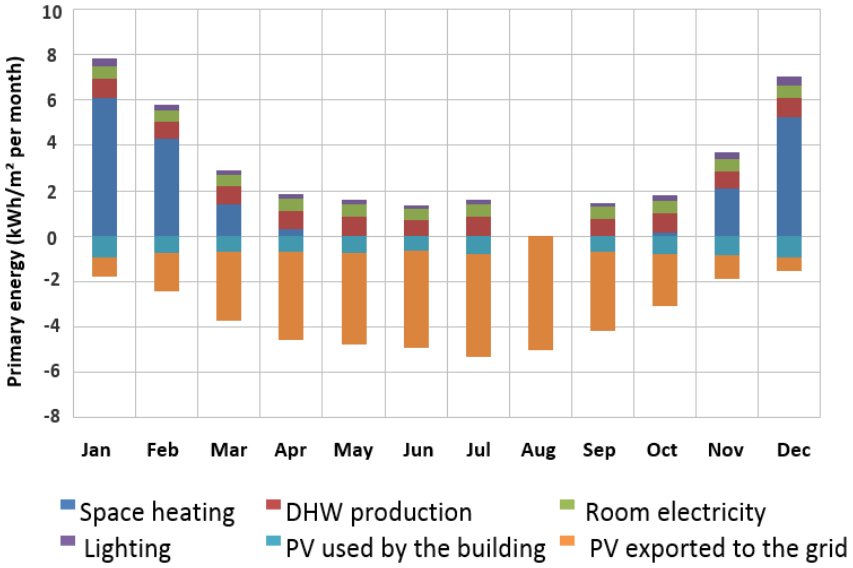
Energy Retrofit Design

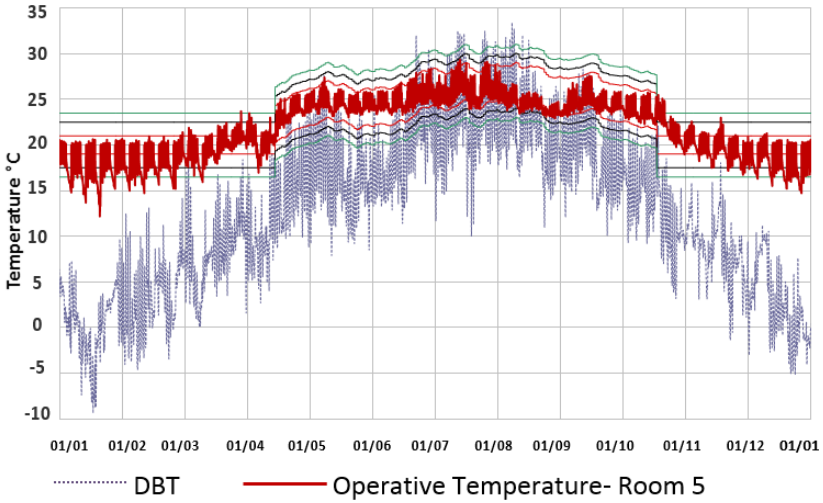
- Integrated wooden prefabricated façade
  - High Thermal insulation of opaque and transparent surfaces
  - Automated movable Solar shading
  - Automated openings for automatic natural ventilation
  - Mechanical ventilation with heat recovery
- Lighting controls
- Renewable energy generation system

Component	PRE-retrofit U-value, W/(m^{2}K)	POST-retrofit U-value, W/(m^{2}K)
Vertical opaque wall	1,00	0,10
Roof	0,90	0,10
Window	5,85	0,73



Preliminary results based on TMY





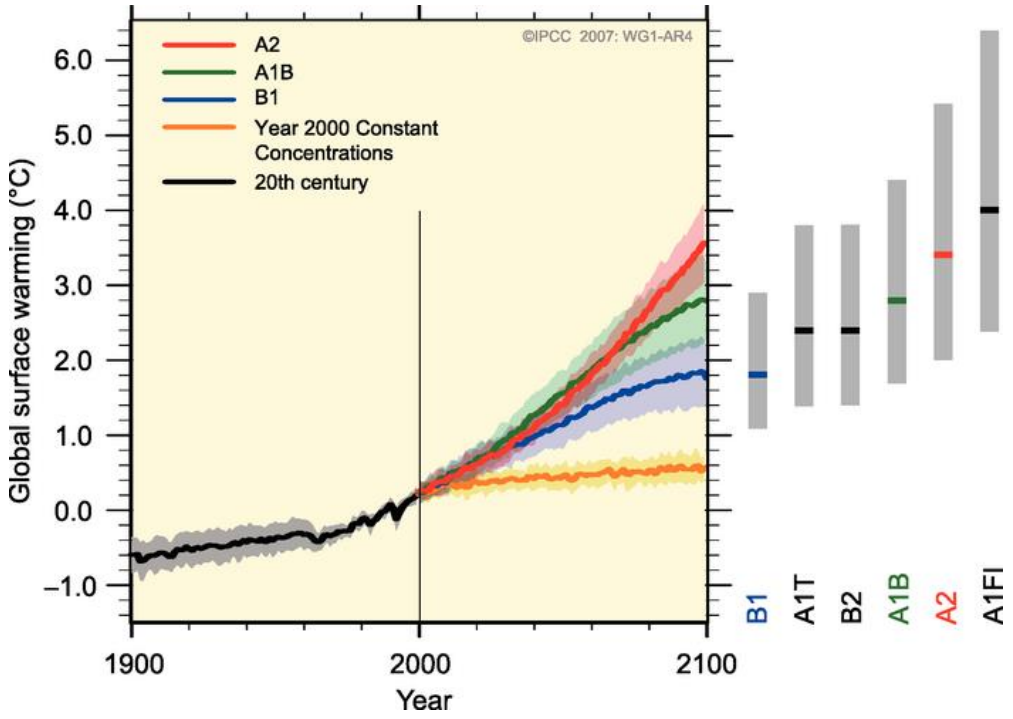
85% reduction of primary energy

- Can a TMY weather file (data from period of record 1951-1970) be representative of current and future weather conditions?
- **Will the retrofit design of today be robust against the climate change?**

Ref: Causone, Francesco; Moazami, Amin; Carlucci, Salvatore; Pagliano, Lorenzo; Pietrobon, Marco. (2015) Ventilation strategies for the deep energy retrofit of a kindergarten. *36th AIVC Conference*

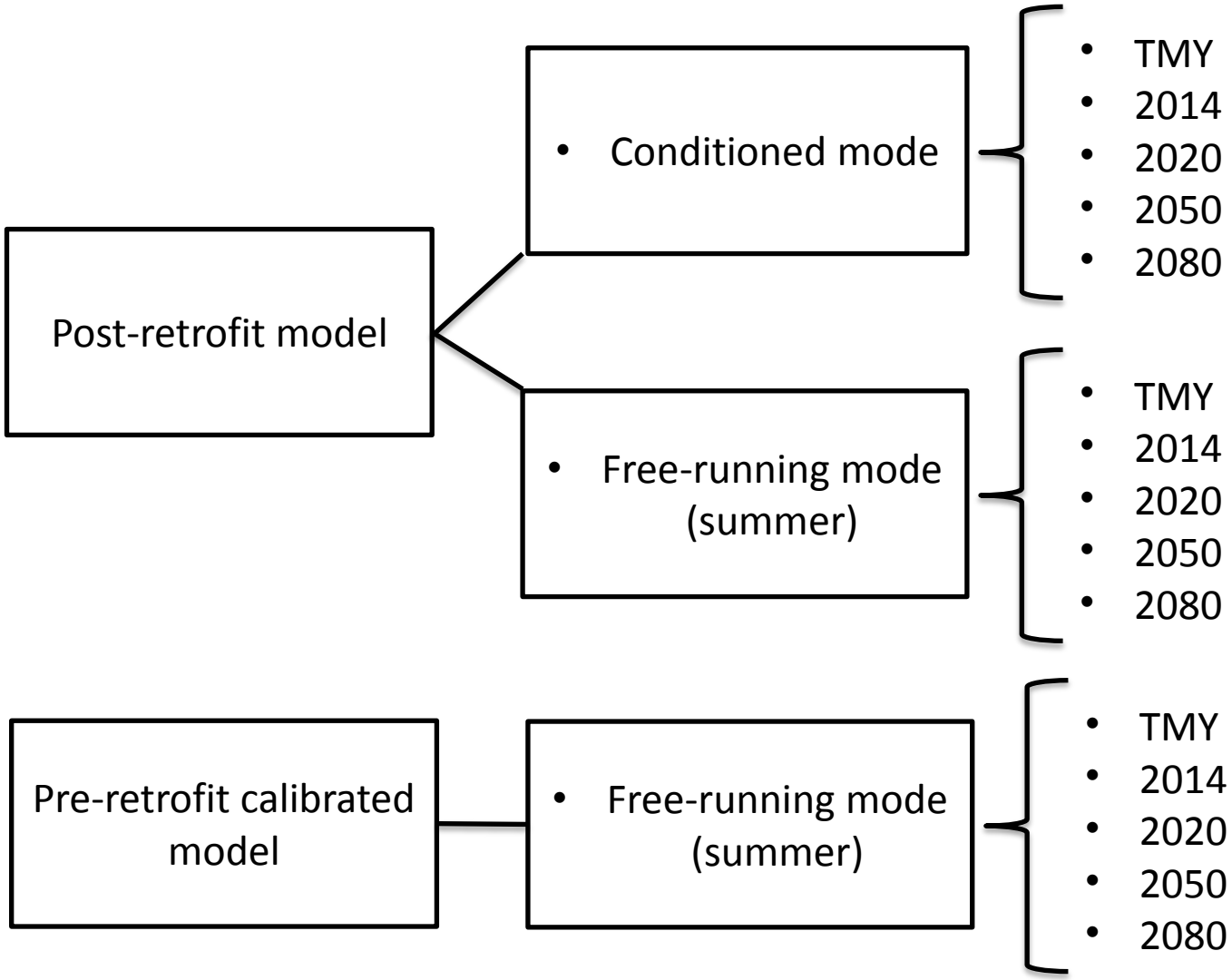
Climate Change

Figure SPM.5. Solid lines are multi-model global averages of surface warming (relative to 1980–1999). Shading denotes the ±1 standard deviation range of individual model annual averages.
(Ref: IPCC 2007,WG1-AR4)

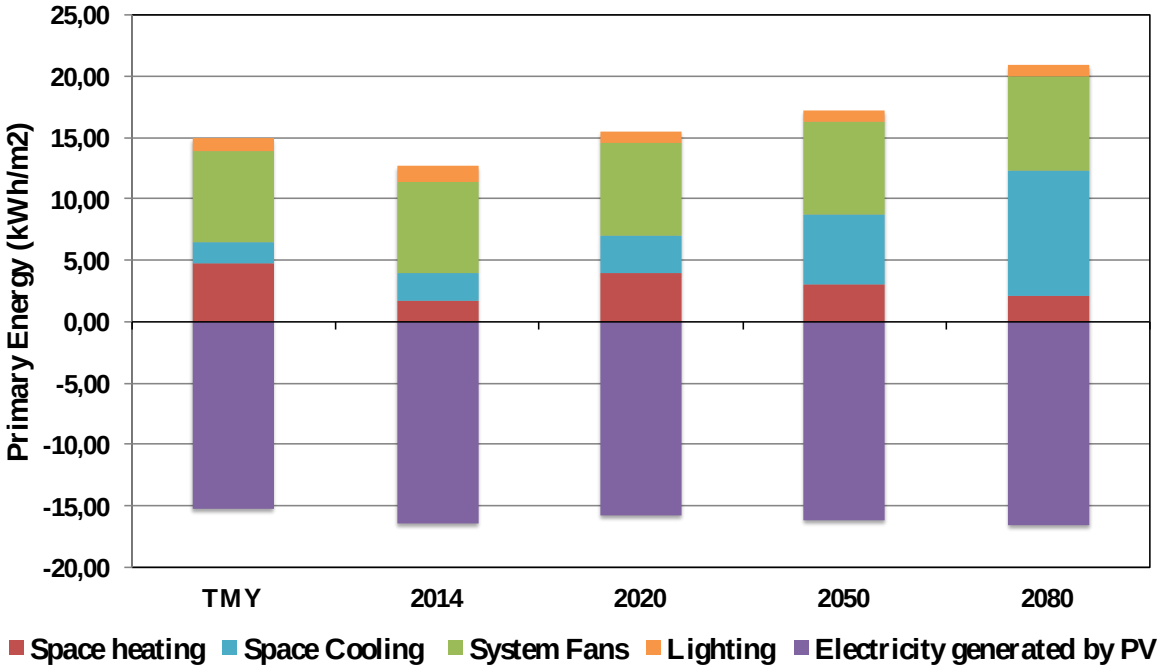


- To adjust current weather files to reflect climate change scenarios. A “morphing” technique is proposed by Belcher et al . (2005) and used by Jentsch et al . (2008) in the publicly available tool CCWorldWeatherGen (2009). The calculation principles of this tool are based on the A2 emission scenario and HadCM3 coupled model.

Current and future climate scenarios



Results - Conditioned Mode

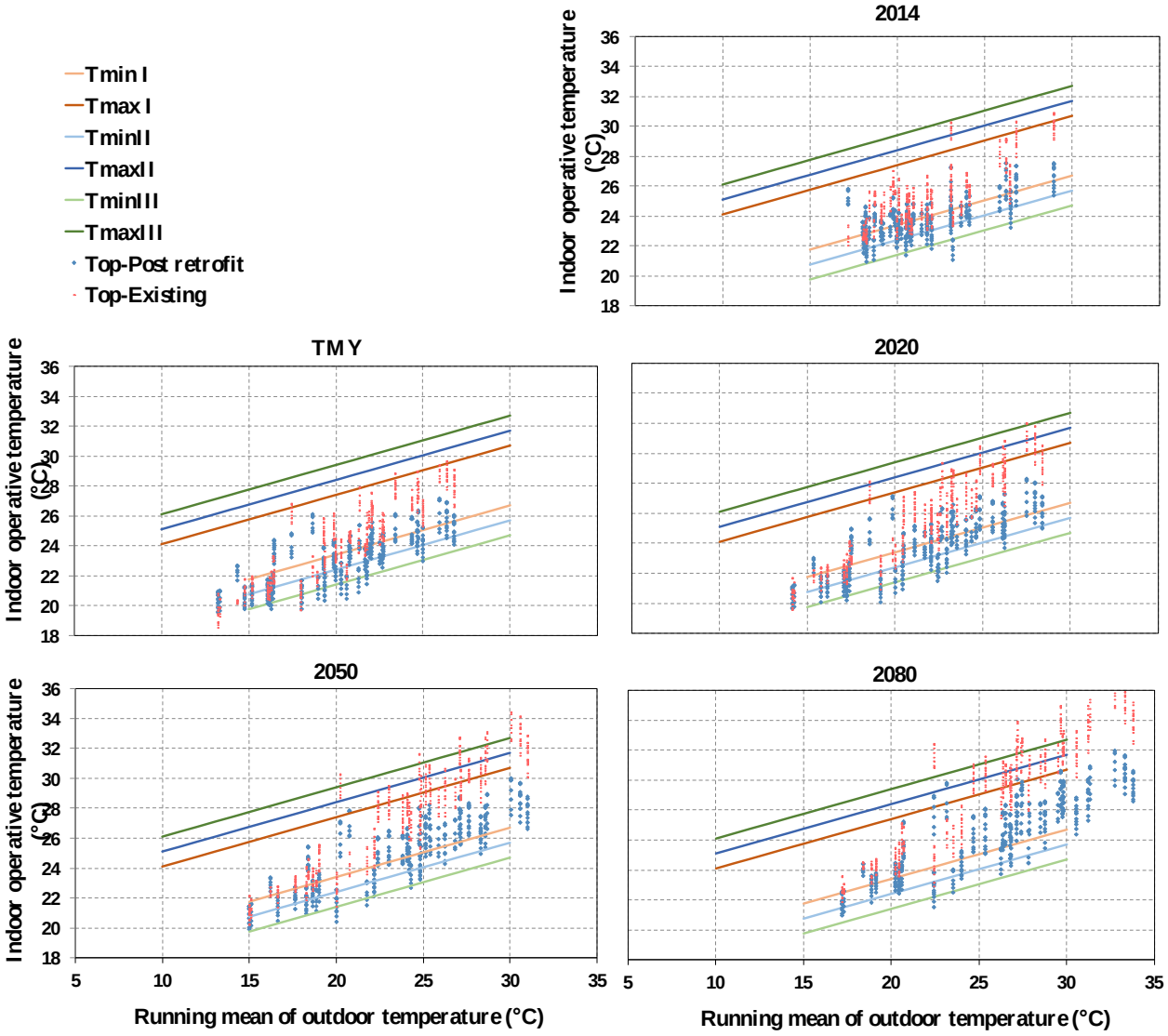


Parameter (unit of measure)	TMY	2014	2020	2050	2080
HDD (°C h)	3002	2274	2718	2384	1988
CDD (°C h)	3	45	26	116	289

Ref: Moazami, Amin; Carlucci, Salvatore; Causone, Francesco; Pagliano, Lorenzo.(2016) Energy retrofit of a day care center for current and future weather scenarios. Procedia Engineering. vol. 145.

Results – Free-running Mode (summer)

Comparison of the running mean of the outdoor temperature and the indoor operative temperature in the five weather scenarios.



Ref: Moazami, Amin; Carlucci, Salvatore; Causone, Francesco; Pagliano, Lorenzo.(2016) Energy retrofit of a day care center for current and future weather scenarios. Procedia Engineering. vol. 145.

Conclusion

- Designing a building for today, using only a **weather file based on historical data from 1960-1990 is not desirable** and even acceptable.
- In future weather conditions a substantial **shift from heating energy needs to cooling energy needs** can be expected in building operations for a climate such as Milan, Italy.
- A design shift from **‘static’ buildings into buildings that can respond and adapt** to climate change is therefore required.
- it should also be considered that the **applicability of the available comfort models** nowadays to child care centres and kindergartens presents several limitations.

Thank You!

Amin Moazami
amin.moazami@ntnu.no
+47 40476475