



## Integration of Passive and Active Functions in Additively Manufactured Construction Elements

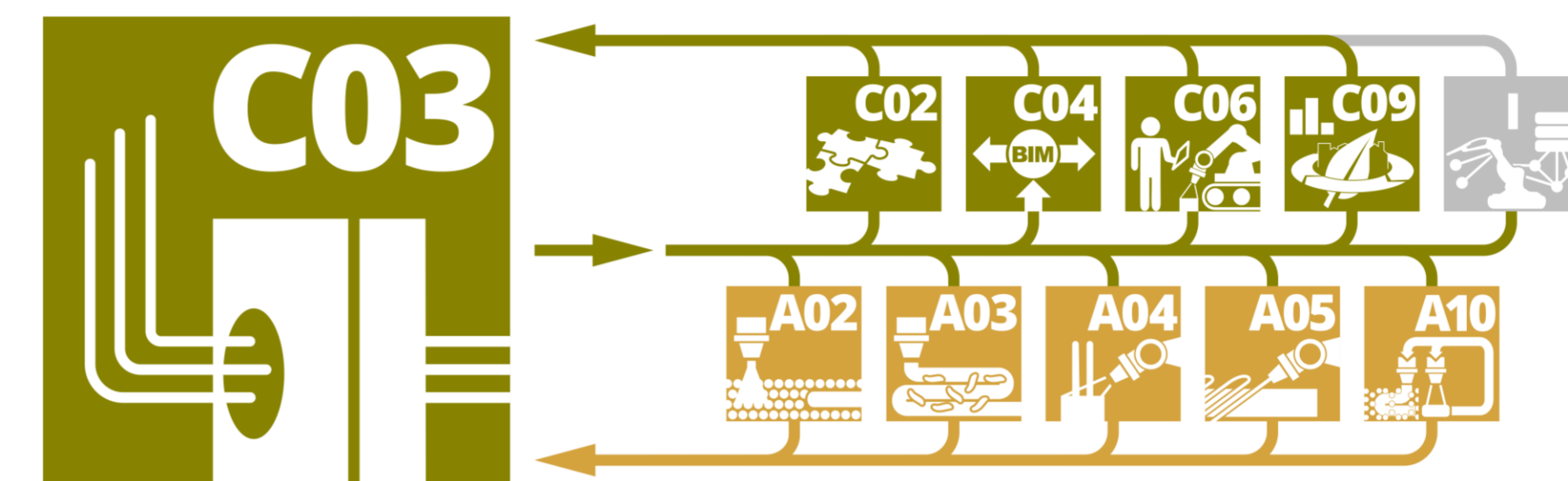
Prof. Dipl.-Ing. Thomas Auer  
M.Sc. David Briels  
M.Sc. Ahmad Saleem Nouman

Chair of Building Technology and Climate Responsive Design, TUM

### Project aims of 2<sup>nd</sup> funding period

- Achieving **climate-responsive** and **fabrication-aware** design for construction elements
- Decarbonizing buildings: **reducing embodied** and **operational carbon** emissions through advanced AM design
- Extend and merge simulation-based design of AM elements via **multi-objective design optimisation**
- Implementing AM elements with multiple integrated functions: **new design approaches** and impact assessment
- Demonstrating the potential of multi-functional AM elements through **1:1 demonstrators** and **performance evaluation**

### Key collaborations in 2<sup>nd</sup> funding period



**A02:** Lightweight aggregates for sustainable construction

**A03:** Graded lightweight concrete with phase change material (PCM) for improved thermal performance

**A04:** Acoustically enhanced surface design for optimal sound control in buildings

**A05:** Integration of electric wire heating for efficient temperature management

**A10:** Building physics of earth: exploring sustainable earth-based construction techniques

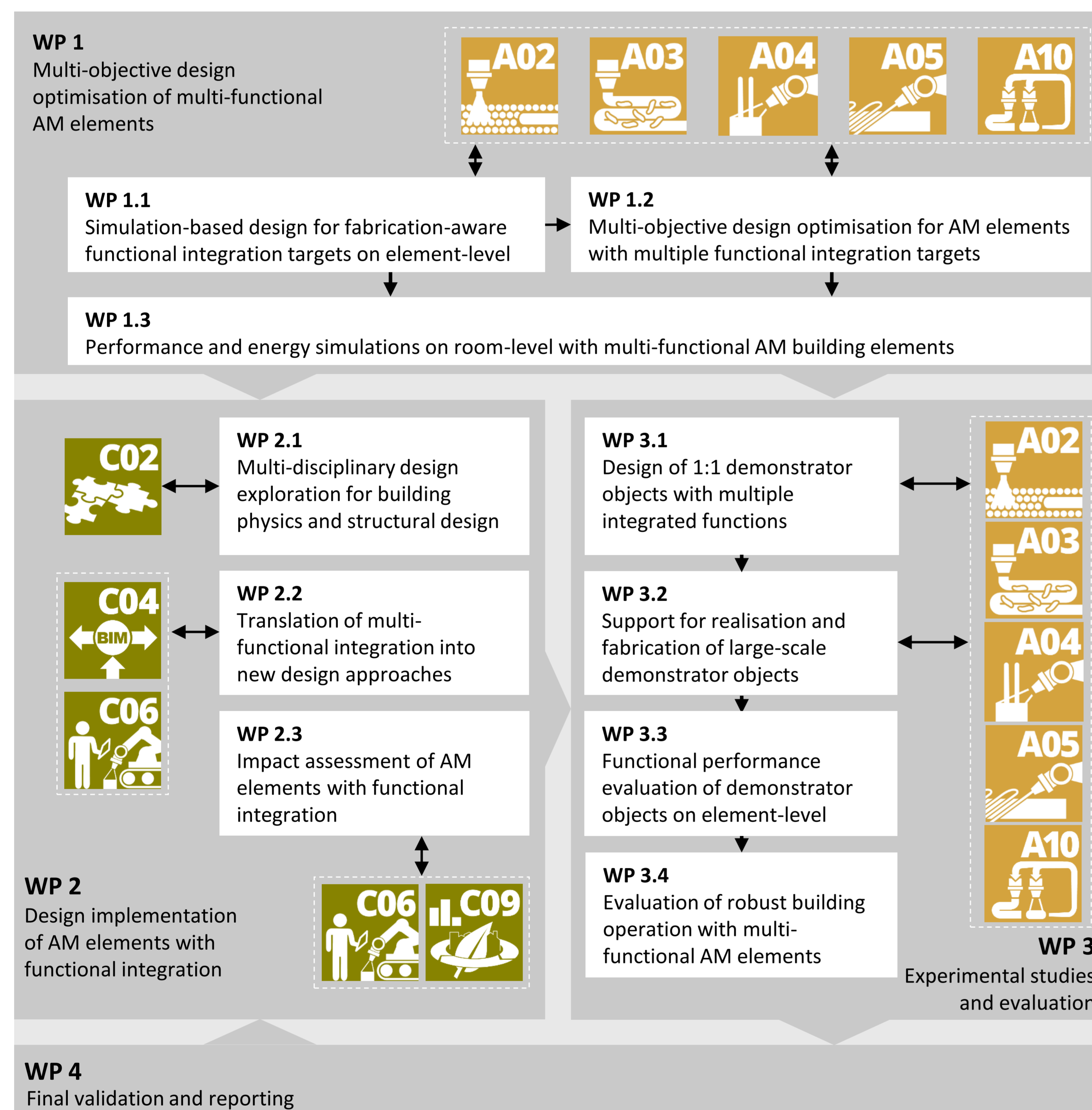
**C02:** Combining functional integration targets and structural behaviour for a multi-disciplinary design

**C04:** A simulation-based design approach for fabrication information modeling (FIM) for performance feedback

**C06:** The transformational effect of new AM design approaches and construction processes

**C09:** Assessing the impact of functional integration on embodied and operational carbon emissions in buildings

### Work Programme



### Methods

		1 <sup>st</sup> Funding Period	2 <sup>nd</sup> Funding Period	3 <sup>rd</sup> Funding Period
Passive	Heat Transfer	thermally enhanced cellular structures	- simulation-based optimisation - prototypes & demonstrators - measurements & validation	- multi-objective design optimisation - design implementation - multifunctional integration
	Heat Transfer	thermal load shifting (microcast)	- concept design - simulation workflow - prototype & measurements	- model validation - demonstrator & measurements
	Acoustics	AM room acoustics (shape, material, Helmholtz)	- simulation workflow - material parameters	- parameter studies - design implementation - prototypes & measurements
	Acoustics	enhanced wall joints for sound insulation	- concept design - modelling approach	- design implementation - design guidelines & tools
Active	MEP	vertical VS horizontal MEP distribution	- concept design - design parameters	- design implementation - design guidelines & tools
	Ventilation	ventilated hollow-core column	- concept design - design parameters	- proof of concept
	Heating	Electric Wire Heating	- concept design - proof of concept - prototype & measurements	- sensing & control - demonstrator
	Heating	thermally activated ribbed slab	- concept design - prototypical design implementation - simulation workflow	- multi-objective design optimisation - multifunctional integration
	MEP	integrated MEP services	- design parameters - demonstrator	- design implementation - design guidelines & tools

### Workflow

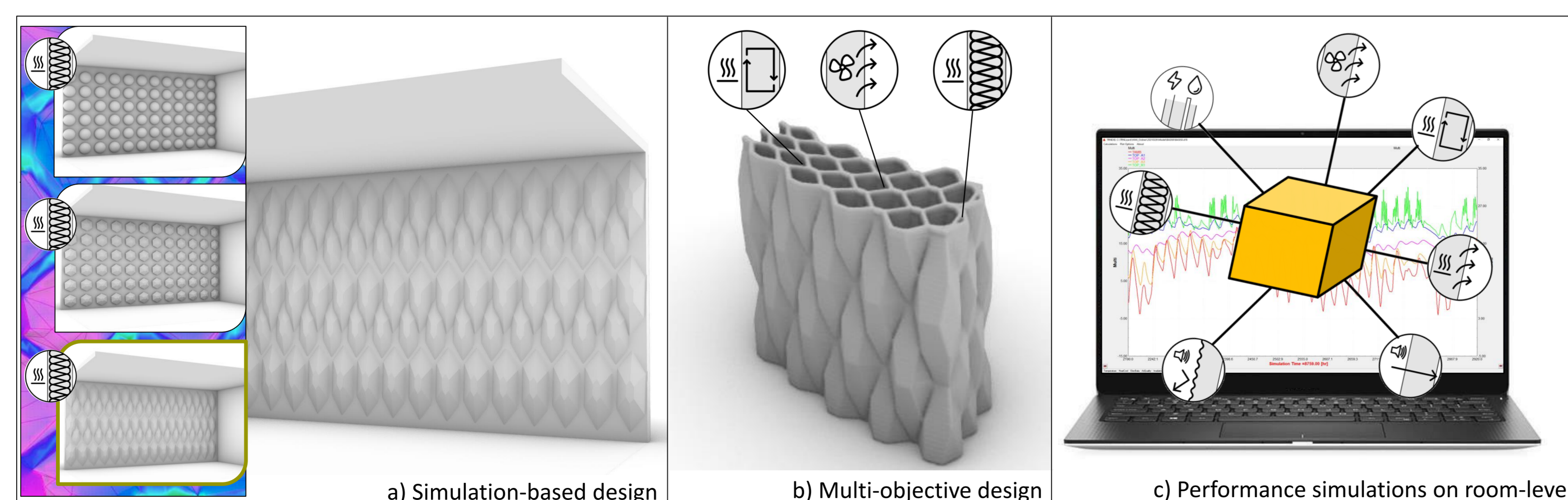


Fig 1: From a) simulation-based design with functional integration targets (e.g. insulation), to b) multi-objective design optimisation with multiple functional integration targets, to c) performance and energy simulations on room-level with multi-functional AM building elements

### Outlook 3<sup>rd</sup> funding period

- The impact of **functional integration on building-scale**: exploring interdisciplinary approaches
- Merging building physics and structural design into a joint, **multi-disciplinary design** optimization approach based on advanced multi-physics simulations
- Addressing **district-level** energy performance: demand-side management and interdependencies with the power grid