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SUSTAINABLE PLACES 2024

Accelerating deep renovation through prefabricated solutions in the European Building Sector: an approach for matching effective modular retrofit technologies for different ecosystems

G. Paoletti, A. Sanchis, A. Vera, M.S. Di Maggio, S. Avesani, R. Pinotti

24.09.2024

BuildUPspeed

The BuildUPspeed project has received funding from the LIFE programme of the European Unition under Grant Agreement no. 101075843.

in view of…

EU Climate neutrality goals

Green Deal initiative for supporting the transition to a more competitive, modern and resource-efficient continent

Need to reduce the net greenhouse gas emissions by at least 55% by 2030.

And considering,

Impacts of the building and construction sector, in terms of
resources need (using about 50% of extracted materials)
waste generation (producing over 35% of EU's total waste)
greenhouse gas emissions (generating about 5.12% of total GHG emissions)
fatal workplace accidents (first position in 2021, and third for non-fatal workplace accidents)

the challange ...

to **accelerate** the deep renovation of EU building stock by **prefabricated solutions** developed by a **circularity approach,** and through the support of **digital technologies** and more **industrialized processes**...

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by **a matching process** used to identify the more **suitable** solutions for different contexts

matching approach

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Matchmaking is the process of matching two or more people together, usually for the purpose of marriage *(https://en.wikipedia.org/wiki/Matchmaking)*

In this case, the **matching** is between a **product** and a **context**

A **collaborative dialogue** among building experts and local stakeholders is essential for matching the prefabricated solutions with the unique features of each ecosystem.

method used

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The matching approach is based on **capitalizing** existing results,

methods and products already developed and tested in EU project on:

1.Ecosystems mapping

Energy retrofitting of building stock

Lacks and barriers

2. Identify the innovative and industrialized best practices (solutions, products...)

Technical requirements

1. Ecosystem mapping

Identifications of morphological characteristics, climate rigidity, policies, cultural, economic, and technical aspects, know-how and local capacities

Austrian ecosystem

French ecosystem

Italian ecosystem

Dutch ecosystem

Spanish ecosystem

Identification of:

- Building codes

(energy performance requirements, seismic, circularity and construction waste laws, recovery-oriented demolition...)

- Reference building and deep renovation strategies
- Innovated prefabricated solutions, circularity schemes/criteria and local players

1. Ecosystem mapping

Building stock

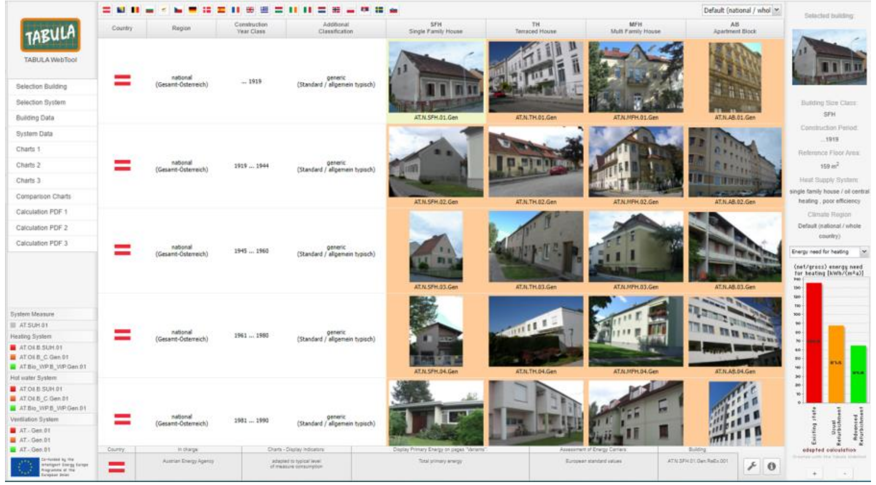
Identification of retrofit needs for specific reference buildings in specific context

Reference buildings

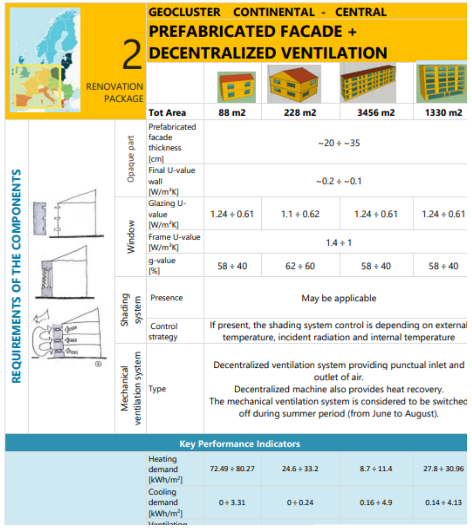
Deep retrofit

Energy Conservation Measures

EU Building Stock Observatory
https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/eu-building-stock-observatory_en



TABULA/EPISCOPE Web-tool
https://webtool.building-typology.eu/#bm



4RinEU
http://www.4rineu.e

6 geo-clusters
Building archetypes
Renovation packages

2. Best practice collection

Collection of positive results of **in-house experiences**

and results of **previous EU projects**

Target solutions:

- to improve the energy performance of buildings
- to improve the indoor comfort
- to increase the workers safety,
- to reduce the construction timing
- to improve the circularity of the solutions (reduce, reuse, recycling…)
- to add a significant economic and ecological value

Prefabricated solutions

source: 4RinEU

Circularity approach

Re-Use-Box concept by BauKarussell

Some example of design and technical Innovation solutions

Austrian	❖ *Prefabricated modular multifunctional solutions for façades and roofs* ❖ *ESSBAR - Edible balcony gardens for retrofit* ❖ *Digital innovations (BIM)* ❖ *Circularity and environmentally friendly solutions*
French	❖ *Circular deconstructing and rebuilding the building - DomoFrance approach* ❖ *"Re fair" approach - La Fab*
Italian	❖ *Energiesprong model – Edera*
Dutch	❖ *Prefabricated modular multifunctional solutions for façades, biomaterials, photovoltaics & heat pump*
Spanish	❖ *Disassembly and adaptability (DfD/A) analysis tool - RE10* ❖ *Tool for construction waste estimation and costs* ❖ *BIM catalogue*

2. Best practice collection

Catalogue of best practices, innovative industrialized and modular solutions, guidelines, processes, products and digital technologies (tools, 3Dscanning, 3Dprinting, drones, robotics, BIM, AI..)

RESULTS

Topics:	Prefabricated solutions	Circularity principles: reduce, reuse, recycle	Digital technologies	Energy performances, IEQ improvements	Cost-optimality and LCC evaluation	Saving potential solutions	Platform
Number of projects analyzed for such topic:	13	10	7	12	7	8	5

Matching best practices in specific Ecosystems

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Identification of the **suitability level** and **interesting solutions**

RESULTS

Workshop

made in presence

4-6 local players for ecosystem

WORKSHOP 1. Ecosystems market profiling and market readiness for industrialized solution

Bordeaux - 1st May 2030

BuildUPspeed - 2nd Consortium Meeting

BuildUPspeed

		ECOSYSTEM:	Austria		FRENCH ECOSYSTEM		SPAIN		DUTCH ECOSYSTEM		ITALY	
CATEGORY	MAIN TOPIC	NAME OF THE SOLUTION	Interest for each solution	SUITABILITY LEVEL Very suitable/ Applicable / Careful design needed	Interest for each solution	SUITABILITY LEVEL Very suitable/ Applicable / Careful design needed	Interest for each solution	SUITABILITY LEVEL Very suitable/ Applicable / Careful design needed	Interest for each solution	SUITABILITY LEVEL Very suitable/ Applicable / Careful design needed	Interest for each solution	SUITABILITY LEVEL Very suitable/ Applicable / Careful design needed
Methodology/ Guidelines	End of Life	Manual deconstruction and dismantling activities	X	Very suitable	X	Very suitable	X	Careful design needed	X	Applicable	X	Very suitable
	Energy and IEQ Performance Evaluation	Repository of results for performance evaluation			X	Very suitable	X	Very suitable	X	Very suitable	X	Very suitable
		Building energy performance simulation (BEPS) tools into the BIM platform	X	Very suitable	X	Very suitable	X	Careful design needed	X	Very suitable	X	Applicable
Technical component	Advanced window	Solar Window Block	X	Careful design needed	X	Very suitable	X	Very suitable	X	Applicable	X	Very suitable
		Active Window System	X	Careful design needed	X	Very suitable	X	Very suitable	X	Applicable		
		BGTEC smart windows			0	Careful design needed	X	Very suitable	X	Applicable		
		Bloomframe® folding balcony			0	Careful design needed	X	Applicable	0	Careful design needed	X	Careful design needed
	HVAC component	PnPprefabHVACsystems			0	Applicable	X	Applicable	X	Applicable		
		Energy storage	X	Very suitable	X	Very suitable			X	Applicable	X	Applicable
		Microheatpumps facade integrated	X	Very suitable	X	Very suitable	X	Applicable	0	Careful design needed	X	Careful design needed
	Monitoring system	Monitoring system	X	Applicable	X	Very suitable			X	Very suitable	X	Applicable
	New envelope component	PAN rooftopretrofitting/ extensionmodule			X	Very suitable	X	Applicable	0	Careful design needed		
	Balcony	Edible Balcony gardens for Retrofit - Vertical Greening technology for the city	0	Applicable	0	Applicable	0	Applicable	0	Applicable		

List of technical requirements for industrial solutions

The objective is to **facilitate the replicability process identifying the technical, regulatory, context barriers for industrial solutions.**

List of **technical requirements** has been done with the knowledge, know-how and experiences of "players"

Technical Requirements categories:

- Homeowners
- Building data

  (general info, building features, façade, windows, roof, systems)
- Surrounding
- Regulations
- Process management

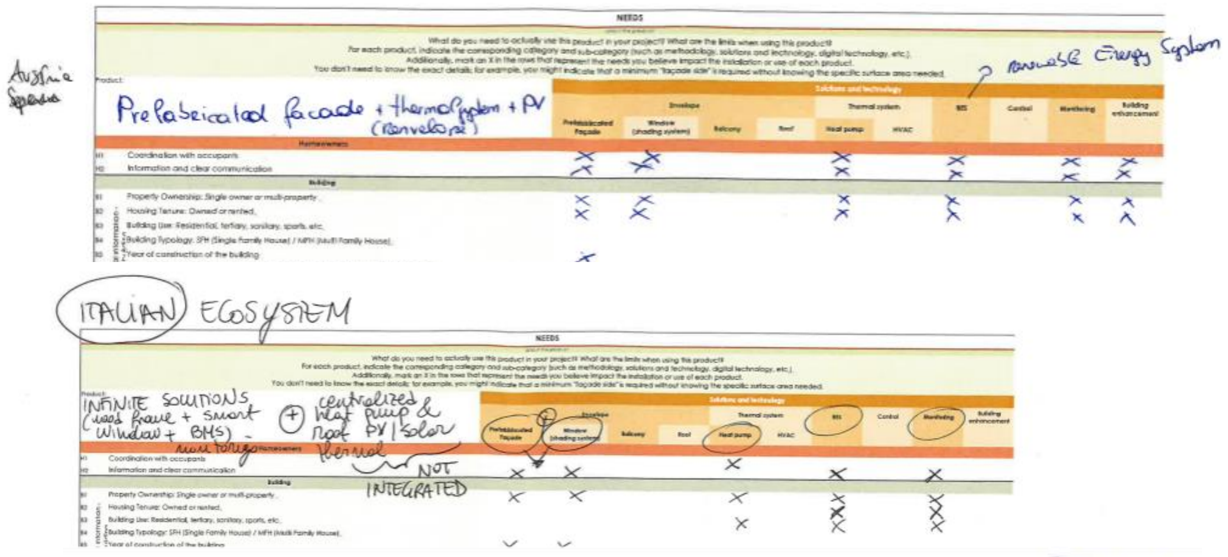
	Homeowners
	Coordination with occupants
	Information and clear communication
	Building
General information - building	Property Ownership: Single owner or multi-property.
	Housing Tenure: Owned or rented.
	Building Use: Residential, tertiary, sanitary, sports, etc.
	Building Typology: SFH (Single Family House) / MFH (Multi Family House).
	Year of construction of the building
	NO monumental protection: Whether the building is not under heritage protection.
	NO colour restrictions in architectonic elements as facades, roof..
	Expansion Potential: Possibility to build more floors or increase the useful surface.
Building features	Number of Floors
	Number of underground floors
	Dwelling Surface (m2)
	Building height: e.g. free height from street level
	Indoor Height: free height between pavement and ceiling
	Renovation Size: number of m2 renovated (facedes, roof...) or n.of elments (e.g. windows...)
	Structural Type: Material and structure (wall, pillars).
	Structural Capacities of the existing building.
	Technical Room: Existence and size
Façade feature	Perimetral Wall Length
	Dimension of the façade
	Façade height: e.g. free height from street level
	Co-planar façade geometry (e.g. simple façade geometry)
	Façade Construction System: type of construction/material
	Presence of insulation
	Presence of balconies, terraces or other elements
	Façade Finish: type of external finish.
Windows features	Number of windows to renovate (there is a minimum number of windows to renovate?)
	Openings Layout: Distribution and variety/regular size of openings.
	Openings Size: Window sizes.
Roof features	Roof Type: Flat or sloping.
	Roof Size: Dimensions (x or m2)
	Roof Construction System: Type of construction.
	Shading and obstacles (chimney, antennas...)
Systems	Electrical Network: Status of the home's electrical network, circuit separation.
	HVAC System: Type of heating, ventilation, and air conditioning system.
	Heating/DHW System: Individual or centralized.
	DHW System: Type of domestic hot water system.
	Existence of thermal or electrical storage systems.
	Existing Renewable Energy Systems

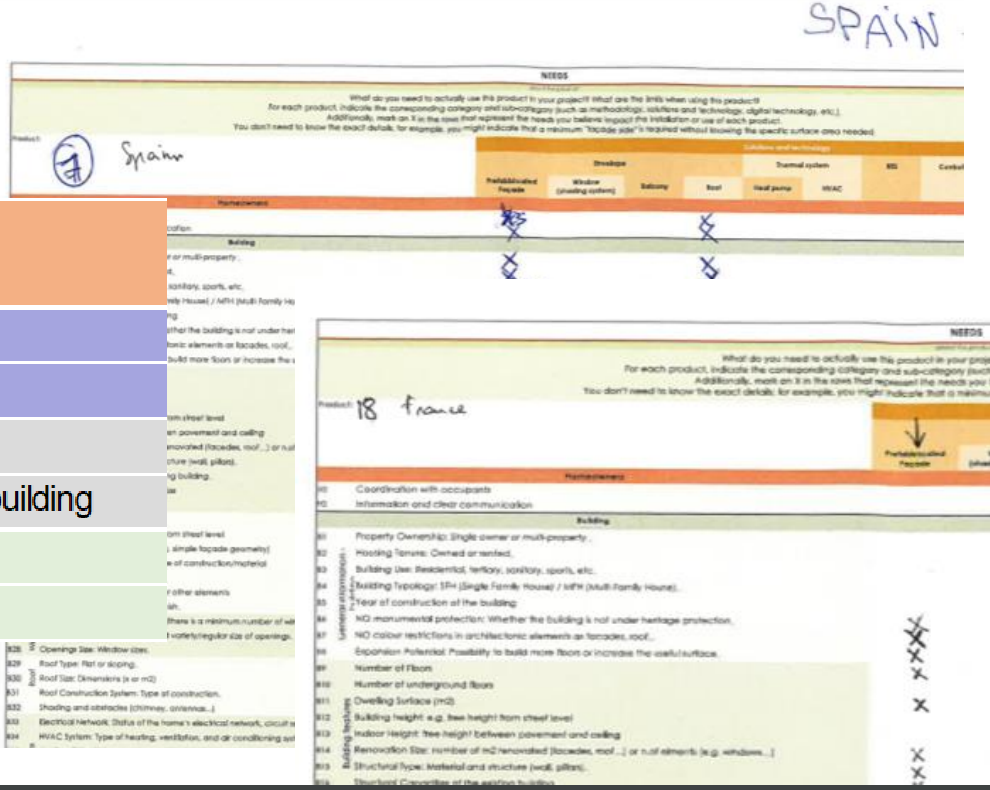
Surroundings
Façade orientation
Shadows (on the façade/roof/windows)
Possibility of crane access from the street
Free space between the façade and the façade of the opposite building
Possibility of soil connection ne1t to the façade
Possibility to install scaffolding

Regulations (national, local)
Fire
Seismic
Energy efficiency and RES use
Waste redaction
Circularity
Water use restrictions
Energy sharing / energy community's legislation
Labour

Process management
Training and expertise, knowledge
Data monitoring
Coordination between different actors (constructor, designer...)

Identification of technical requirements for each solution/product





RESULTS

by level of importance

	Prefabbircated Façade	
Very important	Building_Façade feature	Dimension of the façade
	Building_Façade feature	Co-planar façade geometry (e.g. simple façade geometry)
	Surroundings	Possibility of crane access from the street
	Surroundings	Free space betw een the façade and the façade of the opposite building
	Regulations (national, local)	Fire
	Regulations (national, local)	Seismic

Identification of lacks

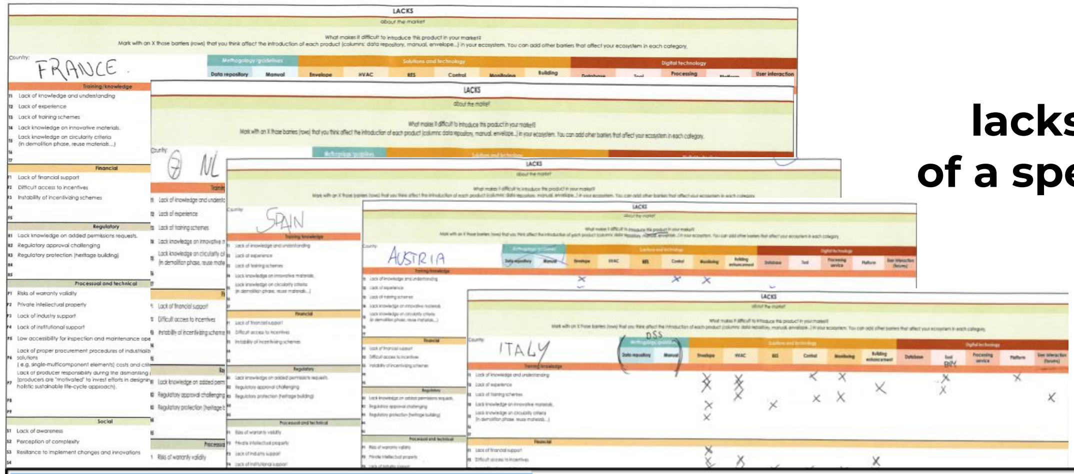
Industrialized solutions to be easy replicated in different contexts needs to be used by different actors, applied in different buildings with different degrees of applicability.

Identified different type of lacks:

- Cultural (training/knowledge): 5
- Economic: 4
- Regulatory: 3
- Processual and technical: 7
- Social: 3

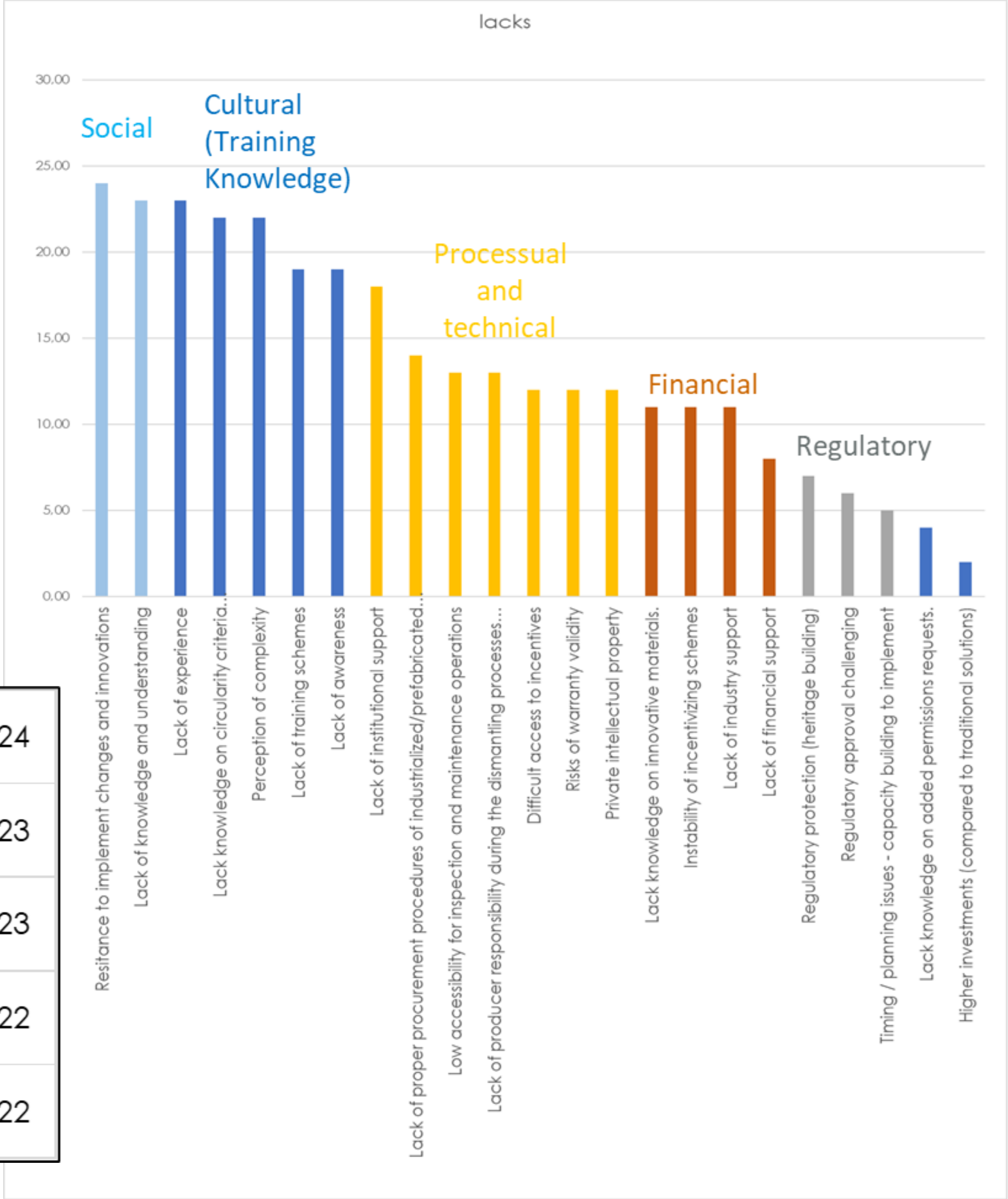
	Training/knowledge
T1	Lack of knowledge and understanding
T2	Lack of experience
T3	Lack of training schemes
T4	Lack knowledge on innovative materials
T5	Lack knowledge on circularity criteria (in demolition phase, reuse materials...)
	Financial
F1	Lack of financial support
F2	Difficult access to incentives
F3	Instability of incentivizing schemes
F4	Higher investments (compared to traditional solutions)
	Regulatory
R1	Lack knowledge on added permissions requests.
R2	Regulatory approval challenging
R3	Regulatory protection (heritage building)
	Processual and technical
P1	Risks of warranty validity
P2	Private intellectual property
P3	Lack of industry support
P4	Lack of institutional support
P5	Low accessibility for inspection and maintenance operations
P6	Lack of proper procurement procedures of industrialized/prefabricated solutions (e.g. single-multicomponent elements) costs and criteria.
P7	Lack of producer responsibility during the dismantling processes (producers are "motivated" to invest efforts in designing it with a more holistic sustainable life-cycle approach).
	Social
S1	Lack of awareness
S2	Perception of complexity
S3	Resistance to implement changes and innovations

Matching lacks in specific Ecosystems



RESULTS
lacks and barriers
of a specific context

S3	**Social**	Resitance to implement changes and innovations	24
T1	**Cultural (Training/knowledge)**	Lack of knowledge and understanding	23
T2	**Cultural (Training/knowledge)**	Lack of experience	23
T5	**Cultural (Training/knowledge)**	Lack knowledge on circularity criteria (in demolition phase, reuse materials...)	22
S2	**Social**	Perception of complexity	22



Conclusion

- **Catalogue of the most interesting solutions, to drive and accelerate the energy retrofit of the building stock**
- **Technical requirements identification of each product/solution**
- **Lacks and barrier of each ecosystem in relation of a specific technical solution**

Solutions for target users:

- Homeowners
- Local players

(building manufacturers, experts, workers…)

- Investors
- Public authorities

(One Stop-Shop, policies, incentives)

Thanks for the attention

giulia.paoletti@eurac.edu

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The Pilot Cases of FORTESIE project:

Establishing innovative renovation packages towards the Renovation Wave acceleration

Christos Kontzinos – National Technical University of Athens, NTUA

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Content

1. The FORTESIE project
2. FORTESIE Pilots & Methodology
3. FORTESIE Digital Services
4. Pilot Cases
5. Next steps

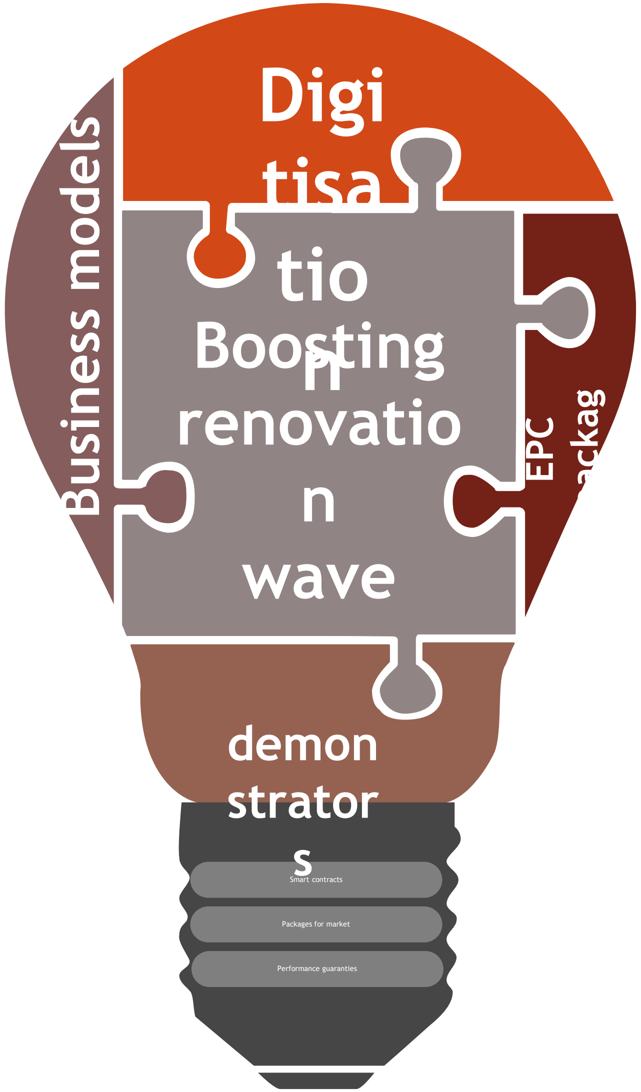
The FORTESIE Project

Main Challenges:

- Renovation wave: Deep energy renovation rate should reach 3% per year, by 2030
- Climate Change puts at stake life on earth
- Lack of trust and uncertainty about energy performance improvements
- Monetary incentives to mobilise mass initiatives and construct a collective narrative are not largely explored
- Lack of large public awareness eradicates sceptisism and understanding of added value
- Large investments require novel financing schemes

The FORTESIE Project

FORTESIE



Digitisation and automation enablers

1. Architecture for deep renovation and ESIE with performance guarantees
2. 6 tailored digital services (Technological Exploitable Results)
3. Automated Measurement and Verification (M&V) and EG rewards
4. EPC smart contracts

Integrated EPC packages to raise overall EPC value proposition

1. Exploitation of at least 7 SOTA renovation technologies
2. 7 renovation packages with at least 5 guarantees (energy, CO2, comfort, costs, deployment duration)

Real demonstrators targeting several different stakeholders

1. SSH Engagement and inclusive methods
2. 3 target groups, 8 real life demonstrations in 6 countries
3. At least 10 ESIE and behavioural KPIs evaluated and improved

New business models for original and replicated packages serving, immediate market take up

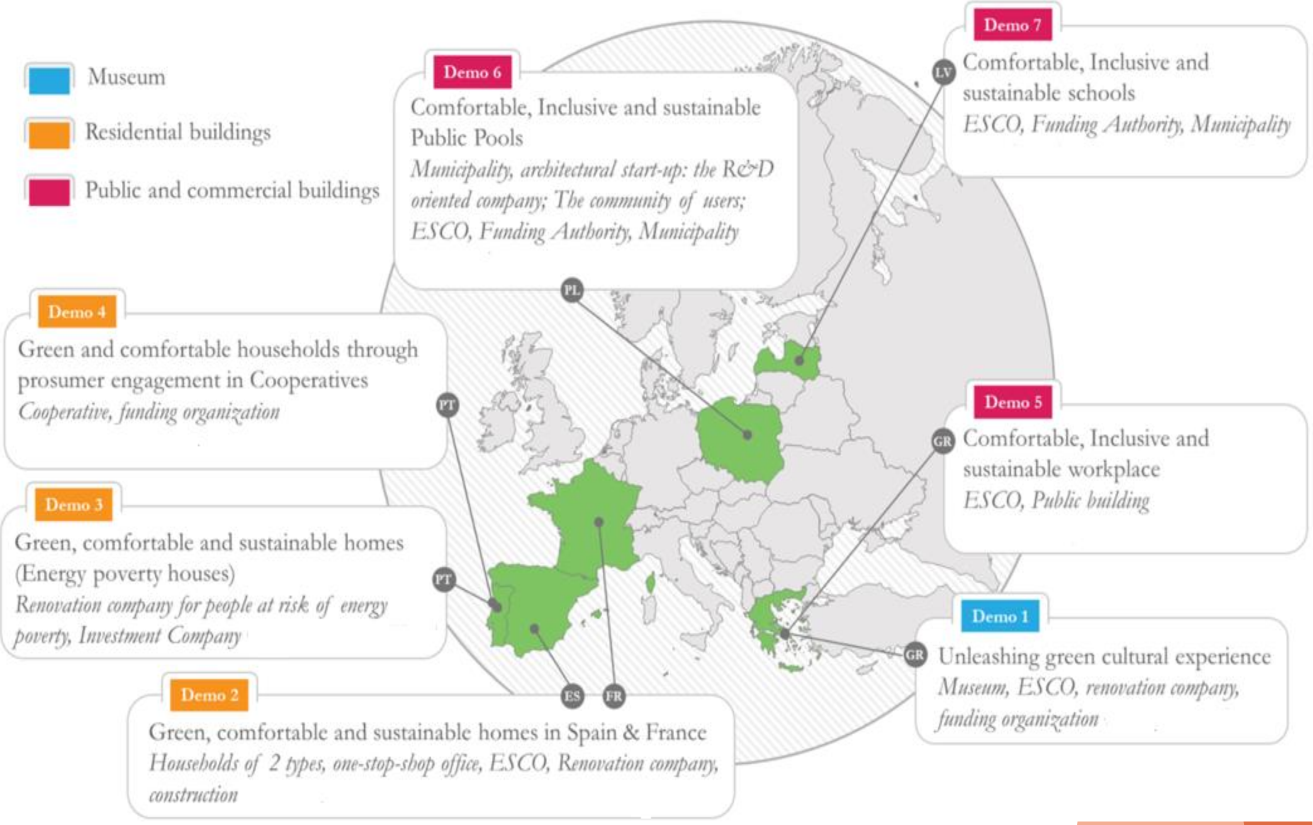
1. At least 15 alternative business models (at least 2 for most target groups+25 replicated (at least 5 in each country)

Boosting renovation wave with performance guaranties

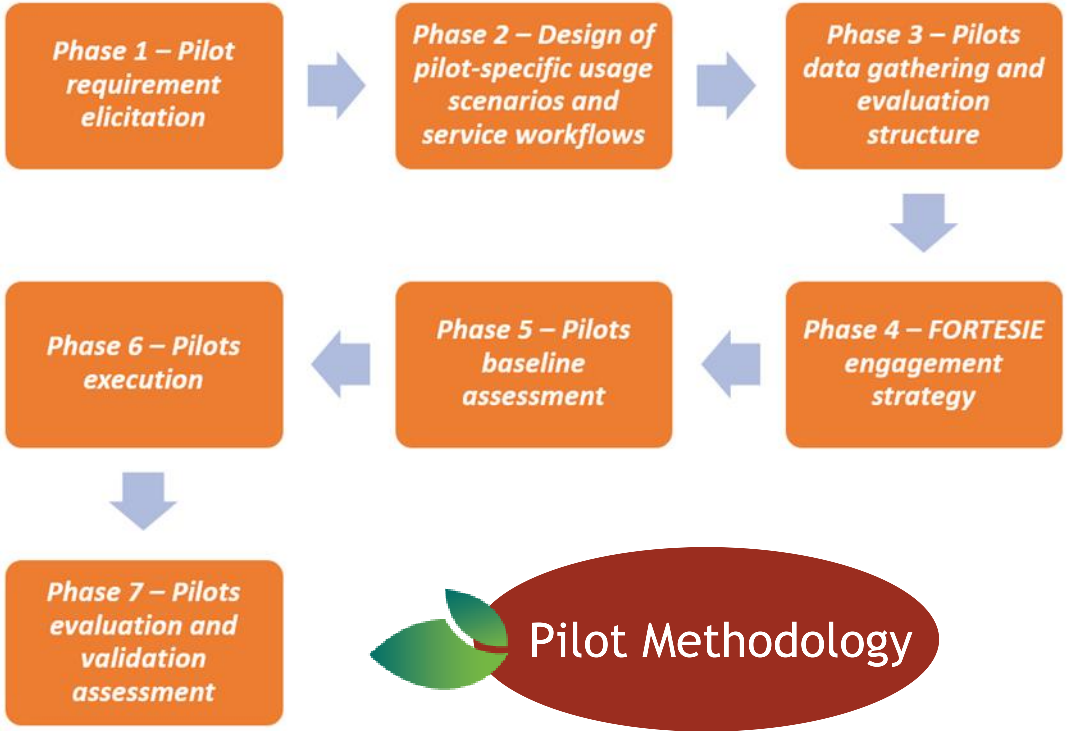
1. Establishment of online network of OSSs
2. Variety of Dissemination channels

FORTESIE Pilots & Methodology

- 10 Pilot cases, 7 scenarios.
- Renovation packages: SotA construction materials & technological components.
- Adoption of methodologies from Social Sciences and Humanities (SSH):
  - ✓ Creation of collaborative business models,
  - ✓ Novel incentivisation and behavioural change models,
  - ✓ Incorporation of a digital currency, green-euro, (€G),
  - ✓ Collection of feedback for recommendations,
  - ✓ Mapping and understanding the complex interplay between the different stakeholders.



FORTESIE Pilots & Methodology



Pilot Methodology

Pilot	Selected the building?	Stage of renovations	Available Baseline Data
Pilot 1	Yes	Almost complete	Yes (equipment, consumption, frequency)
Pilot 2 (GAR)	Yes	Expected to initiate in June 2024	Indicative data
Pilot 2 (VEO)	Yes	Completed (prior to FORTESIE)	Yes (equipment, consumption, frequency)
Pilot 2 (ENE)	N/A	N/A	N/A
Pilot 2 (OKT)	No	Large scale monitoring will take place instead of renovations	Not yet (will have access to energy bills and energy audits data, when the houses will be selected)
Pilot 3	Yes	The first house will be renovated in April – May 2024 and be used as a prototype for the rest houses	Not yet (Collection of 6 months of energy bills will take place)
Pilot 4	Yes	The first house will be renovated in April – May 2024 and be used as a prototype or the rest houses	Not yet (Will have access to either client data or consented data)
Pilot 5	Yes	Installation of energy meters has been complete, while deployment of the renovations depends on the arrival of the ordered materials	Yes (equipment, consumption, frequency)
Pilot 6	Yes	Selected but not yet initiated	Yes (consumption, frequency, costs)
Pilot 7	Yes	Renovations are expected to finish in May 2024	Yes (equipment, consumption, frequency)

Pilot Status

FORTESIE Digital Services

- **Data Sovereignty Service:** supports the creation of the ESIE data space
- **Data Analysis Service:** detects patterns from real energy consumption data in a tailored way,
- **Behaviour and Recommendation Service:** captures the user behaviour and current performance progress and supports the consumers in the direction of optimising long-term behaviour
- **User Engagement Service & User Profile Service:** refer to the FORTESIE mobile application, which is responsible for generating easy-to-understand visualisations, charts, and reports
- **Improvements Achieved Calculation and Green Euro Service:** Bank account with a payment card, will allow to send and receive money by tapping a button, calculating CO2 reduction and accordingly rewarding green-euros for achieved savings and behaviour
- **OSS Marketplace:**
  - ✓ Promotes the services offered in FORTESIE as packages or service components for building new packages,
  - ✓ Networks consumers and building owners (target groups) with renovation and other value chain suppliers, (financing, consulting, digitisation etc.),
  - ✓ Informs about best practice, benefits, and opportunities to support further investments.

FORTESIE

FORTESIE Digital Services

	Data sovereignty service	Data analysis service	Behaviour and recommendation service	User engagement service	User profile service	Improvements achieved calculation and green euro service	OSS Marketplace
Pilot 1	✓	✓	✓	✓	✓	✓	✓
Pilot 2 (GAR)	✓	✓	✓	✓	✓	✓	✓
Pilot 2 (VEO)	✓	✓	✓	✓	✓	✓	✓
Pilot 2 (ENE)							✓
Pilot 2 (OKT)	✓	✓	✓	✓	✓	✓	✓
Pilot 3	✓	✓					
Pilot 4	✓	✓	✓	✓	✓	✓	✓
Pilot 5	✓	✓	✓	✓	✓	✓	✓
Pilot 6	✓	✓	✓	✓	✓	✓	✓
Pilot 7	✓	✓	✓	✓	✓	✓	✓

FORTESIE Pilot Cases

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Museum

- **Concept:**
  - ✓ Building built in 1990, renovated in 2021.
  - ✓ 4 floors, 532m^2 & an unexploited roof.
  - ✓ Renovation included space unification, covering of ceiling and windows with gypsum boards, new climate control unit, new laminated floor.

- **Necessity:**
  - ✓ Increasingly considered internal conditions.
  - ✓ Recognised value of maintaining comfort at high standards

  - ✓ Upgrade of the Hybrid Renewable Converter -HRC system,
  - ✓ Insulation of the external wall of the north façade,
  - ✓ Installation of a photovoltaic system (covering approximately 70m2),
  - ✓ Installation of Smart windows with integrated PV panels for the front windows (covering 60m2),
  - ✓ Building of a green roof

- **Issues & Challenges:**
  - ✓ Delays in the procurement of the renovation material
  - ✓ Long delivery time for the smart windows (procured by Australia)

SUSTAINABLE PLACES 2024

FORTESIE Pilot Cases

Residential Buildings

- <u>Concept</u>:

Pilot 2: 4 sub-pilots

- ✓ Single family homes & apartment blocks in Spain (Garcia Rama) & France (Oktave),
- ✓ Application of the FORTESIE digital tools in a residential area in Spain (Veolia).

Pilot 3:

- ✓ Renovations in houses of people suffering from energy poverty and house deprivation, Portugal (Just a Change).

Pilot 4:

- ✓ Renovations in houses of prosumers, Portugal (Coopernico).

- <u>Necessity</u>:

Pilot 2 – Garcia Rama (El Entrego, Asturias, Spain):

- ✓ 36 housing units, constructed in 1958,
- ✓ Inadequate thermal insulation and thermal bridges,
- ✓ Pathologies in the envelopes.

- ✓ Insulation of the building facades and under-roof space,
- ✓ Replacement of windows in staircases and entrance doors of the buildings,
- ✓ Installation of PV panels with an annual production of 33,000 kWh/year in each building

Pilot 2 - Oktave (France):

- ✓ Monitor of 50-100 renovation projects (with sensors).

Pilot 2 - Veolia (South-East of Valladolid, Spain):

- ✓ 20 buildings, called FASA,
- ✓ Constructions during 1950's-1960's, renovations in 2019 (19/20),
- ✓ Leverage the FORTESIE digital services to measure improvements.

FORTESIE Pilot Cases

Residential Buildings

- <u>Necessity</u>:

Pilot 3 – Just a Change (Portugal):

- ✓ 10 energy poverty – old houses,
- ✓ Several deficiencies (e.g. leaky roofs, rotten floors, inadequately insulated walls, etc).

- ✓ Provision of basic structures (e.g. roofs, flooring, façades, insulation, doors, and windows, and photovoltaic panels installations)
- ✓ Provision of basic needs (e.g. piped water, electricity)

Pilot 4 – Coopernico (Portugal):

- ✓ 10 prosumer houses, 15 years old or more,
- ✓ Insufficient renovations implemented in 2 houses (2007 & 2019),

- ✓ Innovations focus on passive measures, such as placing thermal insulation in the external envelope or replacing windows and doors.

- <u>Issues & Challenges</u>:

- ✓ Unforeseen delays in the pilot of Garcia Rama, due to administrative public processes,
- ✓ Pending selection of buildings in the pilot of Oktave, might cause a series of other delays (selection, procurements etc.),
- ✓ Challenges in the engagement of of elderly occupants in the pilot of Garcia Rama,
- ✓ Delays in the collection of data on the energy consumption and internal comfort in the pilot of Just a Change,
- ✓ Possible minor delays in the implementation of the renovations in the pilot of Coopernico.

FORTESIE Pilot Cases

Public Buildings: G.S.I.S.P.A

- **Concept:**
  - ✓ General Secretariat of Information Systems for Public Administration (G.S.I.S.P.A.), of the Ministry of Digital Governance in Athens, Greece,
  - ✓ Building reconstructed in 1995-1999: 2 basements, 5 floors and 930 employees.

- **Necessity:**
  - ✓ Several efforts from the EU to impose energy efficiency practices have not seemed to work (lack of expertise, of time and will, hesitation to introduce smart metering devices)
  - ✓ Installation of sensors (temperature, humidity, CO2), energy consumption meters and controlled switches or controllers on existing devices in building facilities (e.g. HVAC).
  - ✓ Installation of PV panels will be on the roof
  - ✓ Installation of variable speed drivers to the HVAC system to control the speed of fan motors.

- **Issues & Challenges:**
  - ✓ Delays in administrative public processes ,
  - ✓ Delays in the installation of inverters,
  - ✓ Not timely arrival of the material orders,
  - ✓ Advanced age of most building employees might cause difficulties in the use of the FORTESIE application.

FORTESIE Pilot Cases

Public Buildings: Swimming Pool

- **Concept:**
  - ✓ Swimming pool located in Góra Kalwaria, Poland,
  - ✓ 20 employees, 110 000 tickets monthly,
  - ✓ Need for a constant temperature, two degrees lower than the air temperature (29-31 °C),
  - ✓ Air humidity: Air humidity between 55-60%.

- **Necessity:**
  - ✓ Obsolete technological solutions,
  - ✓ Wear of existing building elements,
  - ✓ High energy consumption.

  - ✓ Replacement of ducts, insulation, and installing of new equipment for air handling units and heating substation,
  - ✓ Update of the electrical board,
  - ✓ Installation of access control and user satisfaction measurement systems,
  - ✓ Installation of a PV plant the pool's roof.

- **Issues & Challenges:**
  - ✓ Delays in the public procurement,
  - ✓ Potential delays in the delivery of materials and appliances.

FORTESIE Pilot Cas

FORTESIE

Public Buildings: School

- **Concept:**
  - ✓ Secondary School, located in Riga, Latvia,
  - ✓ Constructed in 1972,
  - ✓ Renovation of the façade and roof thermal insulation in 2022,
  - ✓ 4 floors, 37 classrooms,
  - ✓ 38 teachers, 23 members of technical staff and 315 pupils.

- **Necessity:**
  - ✓ Reconstruction of engineering networks was not included in the 2022 renovation,
  - ✓ Operation of the old heating system (1972),
  - ✓ Inoperative natural ventilation system
  - ✓ Installation of a heating adjustment system
  - ✓ Installation of new equipment for ventilation and sensors and controllers for the micloclimate management,

- **Issues & Challenges:**
  - ✓ Discrepancy in public documents regarding the conditions,
  - ✓ Possible delays in the building renovation.

Next steps

- Finalisation of the baseline data collection,
- Provision of data on patterns of energy behaviour and respective analysis,
- Completion of all the renovations,
- Application of the FORTESIE digital services.

THANK YOU!

Christos Kontzinos,

email: ckontzinos@epu.ntua.gr

FORTESIE

Home Energy Optimization using Vehicle-to-Home (V2H)

Shuo Zhang*, Liam Fennelly ,Sean Byrne, Terence O'Donnell

University College Dublin, Ireland.
*[*shuo.zhang1@ucd.ie](mailto:shuo.zhang1@ucd.ie)*

University College Dublin
Ireland's Global University

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FORTESIE

Content

1. Introduction
2. Methodology - Model configuration
3. Data acquisition
4. Results and discussions
5. Conclusions

Introduction

- Vehicle to Home (V2H)
- Flexible charging
- Uncontrolled charging
- Irish household (electricity demand, heating demand)
- PV generation
- EV usage
- Spine model
- Home energy optimisation

Methodology – Model configuration

- Home energy management system (HEMS)
- Grid electricity tariffs
- Micro-generation prices
- Energy consumers
    - Household electricity demand
    - EV driving profile (usage)
    - Heat pump (HP) demand
    - EV charging
    - Standby losses (charger)
- Energy suppliers
    - PV generations
    - Grid import capacity
    - EV discharging
- Minimize electricity bills p.a.:

$$min\left(\sum_{t=1}^{T}\left[p_{elec}(t)\cdot P_{grid}(t)-p_{micro}\cdot P_{micro}(t)\right]\right)$$

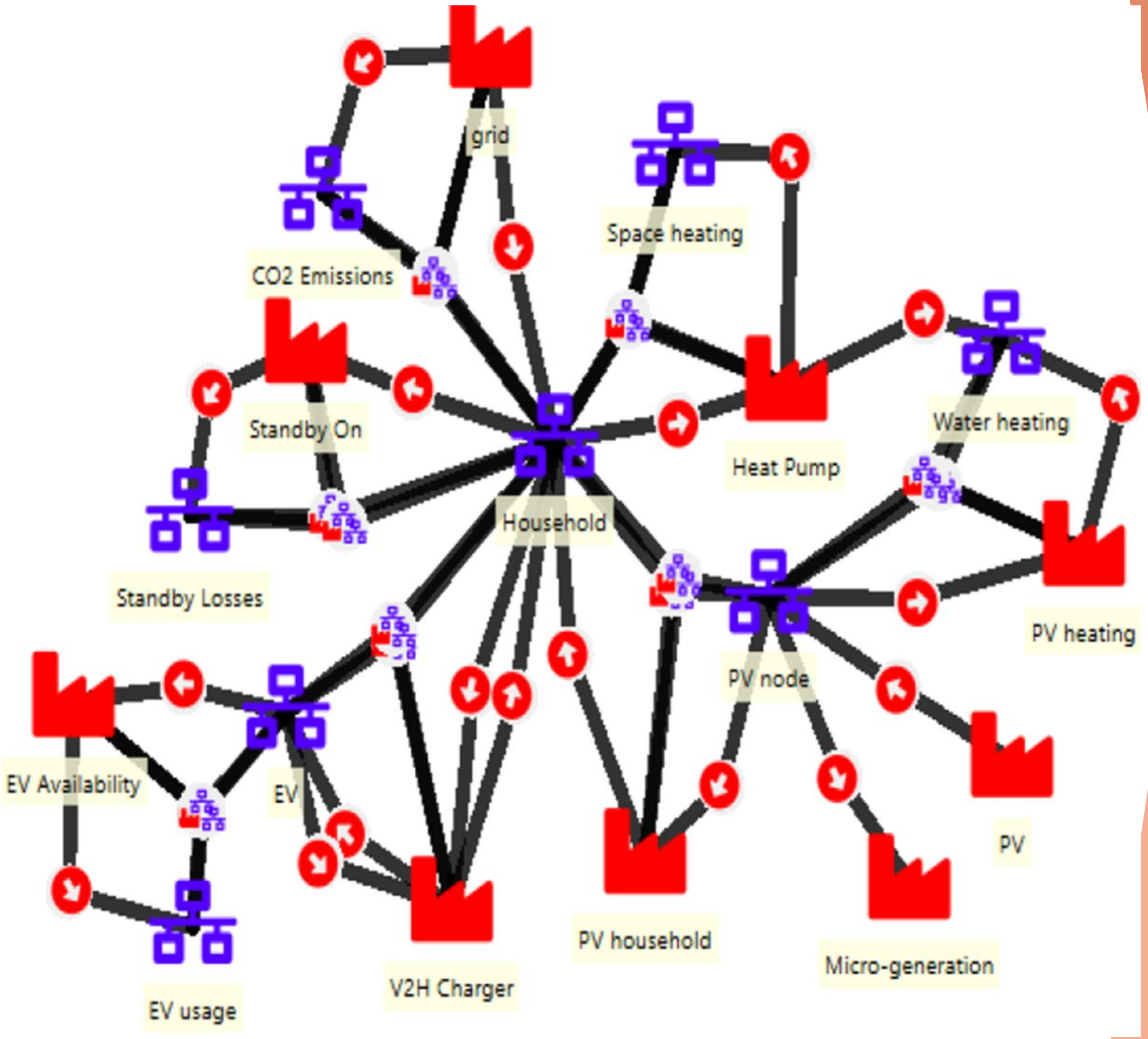

Fig. 1 Configuration of V2H model

Data Acquisition

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Table 1 V2H model inputs

Household	
Household demand p.a.	4200 kWh
Heat pump demand p.a.	3620 kWh
Grid electricity tariff	
Day rate (08:00-17:00, 19:00-00:00)	44.51 c/kWh (off peak)
Night rate (00:00-08:00)	23.39 c/kWh
Peak rate (17:00-19:00)	47.46 c/kWh
PV system	
PV capacity	3 kW
PV generation p.a.	3129 kWh
Micro-generation price	20 c/kWh
EV	
Max EV charging/discharging rate	7.2 kW (90% efficiency)
EV charger standby losses	0.05 kW
EV battery capacity	57.5 kWh
Travelling distance	16,867 km
EV usage per km	0.15 kWh
Max SOC	46 kWh (80%)
Min SOC (08:00 - 07:00)	17.25 kWh (30%)
Min SOC (07:00 - 08:00)	40.25 kWh (70%)

- Non-commuter (German dataset)
- 3-tier tariff
- Irish household (heat pump)
- Net present Value (NPV)

Table 2 Investment costs

Components	Cost range
Bidirectional charger	€1500 - €7500
Grant	€0 - €600
HEMS	€28 - €560
Installation	€500 - €3000
Uncontrolled charger	€0 - €1500

Results and discussions

Table 3 Result comparison based on charging strategies

Output parameter	Uncontrolled	Flexible	V2H	Units
Household demand	4179	4179	4179	kWh
HP demand	3620	3620	3620	kWh
Standby losses	0	381	381	kWh
EV depletion	2529	2529	2529	kWh
EV charging	2529	2529	6240	kWh
EV discharging	0	0	3801	kWh
Annual throughput	5058	5058	12570	kWh
PV self-consumption	1533 (48%)	2427 (76%)	2842 (89%)	kWh
Microgeneration	1646	769	357	kWh
Grid electricity import	8782	8576	8911	kWh
Electricity costs	3174	2818	2235	€

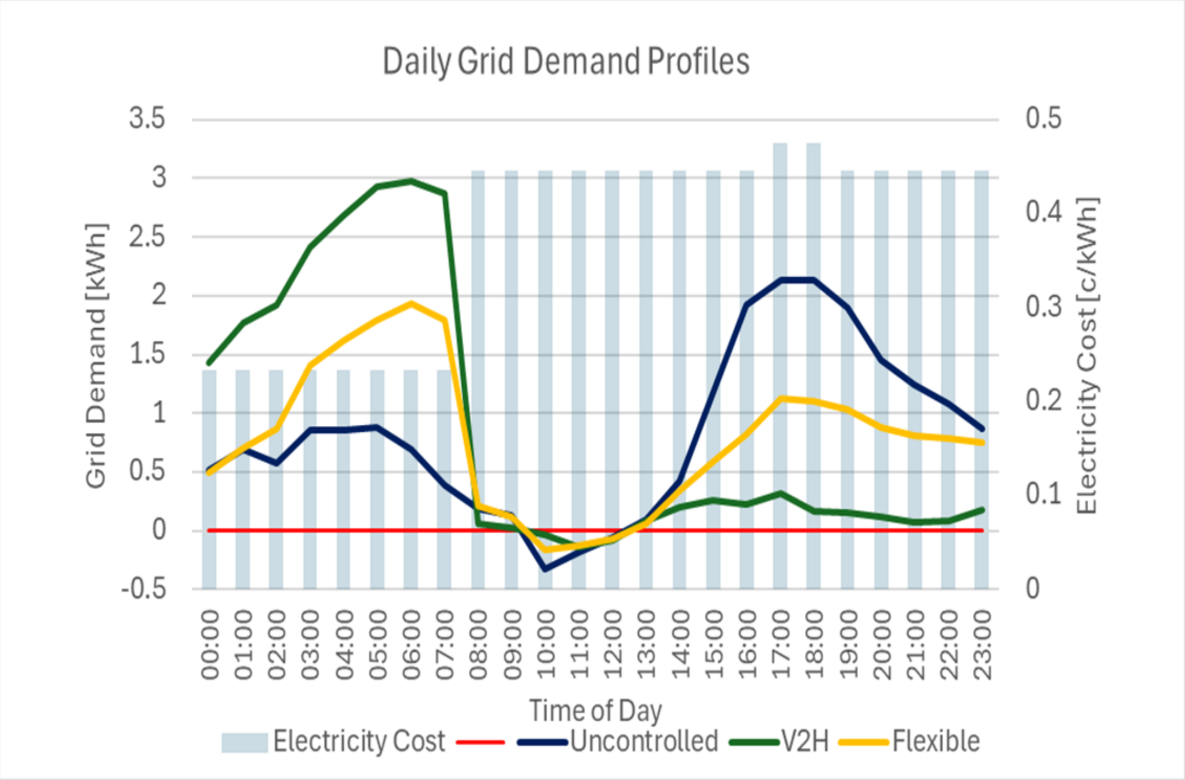

Fig. 2 Averaged grid demand each day

Results and discussions

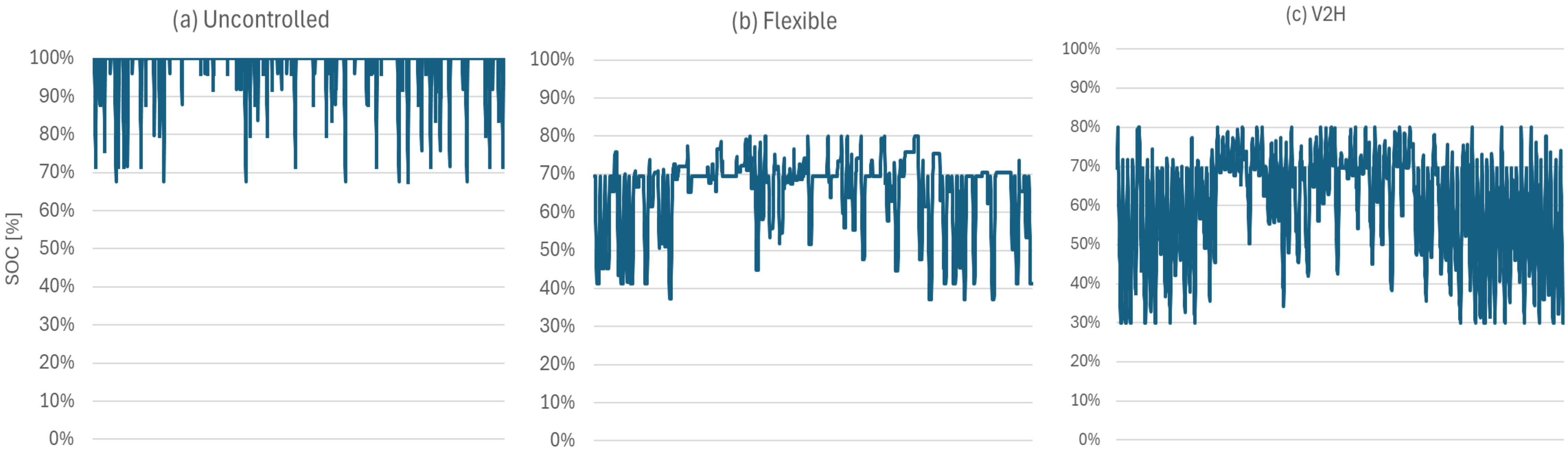

Fig. 3 SOC under (a) uncontrolled, (b) flexible, and (c) V2H charging strategy

Results and discussions

- Sensitivity analysis
  - Tariff
  - Household demand
  - EV availability
  - EV usage

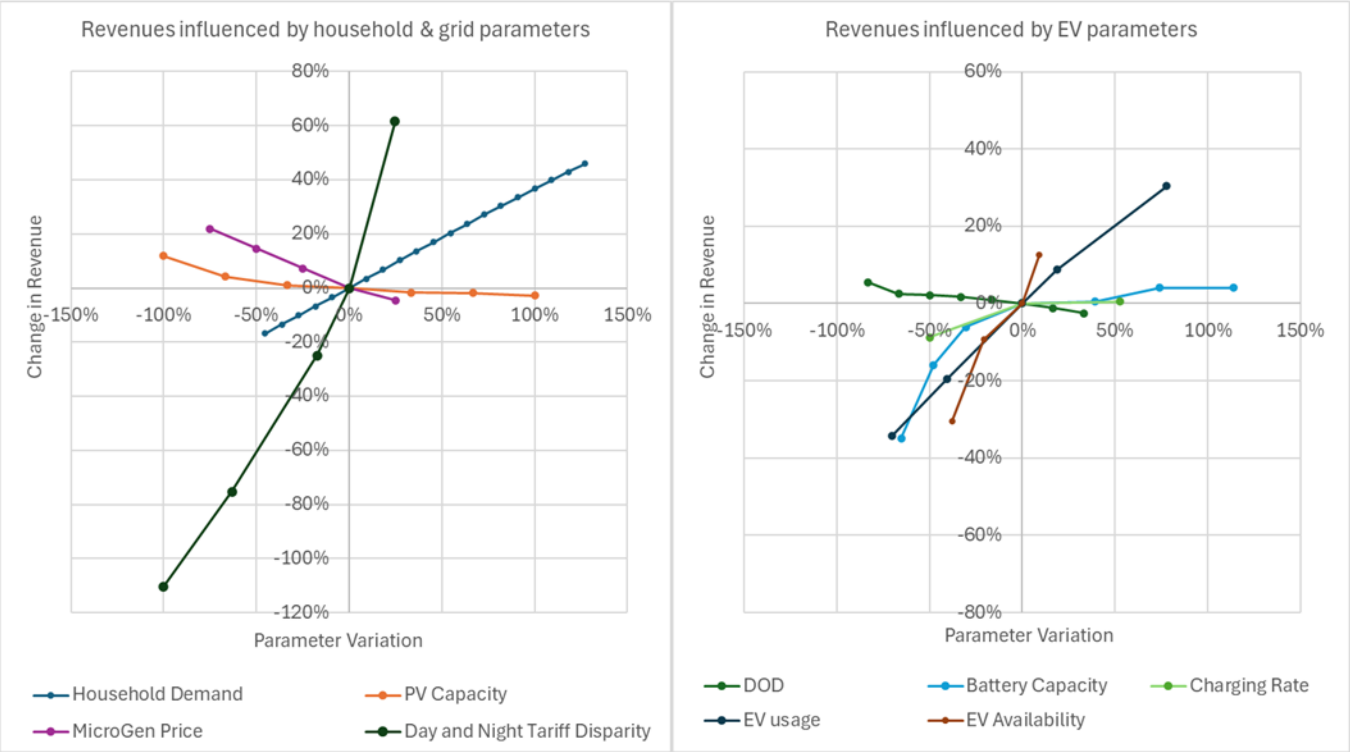

Fig. 4 Impacts of various parameters on V2H revenues

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Results and discussions

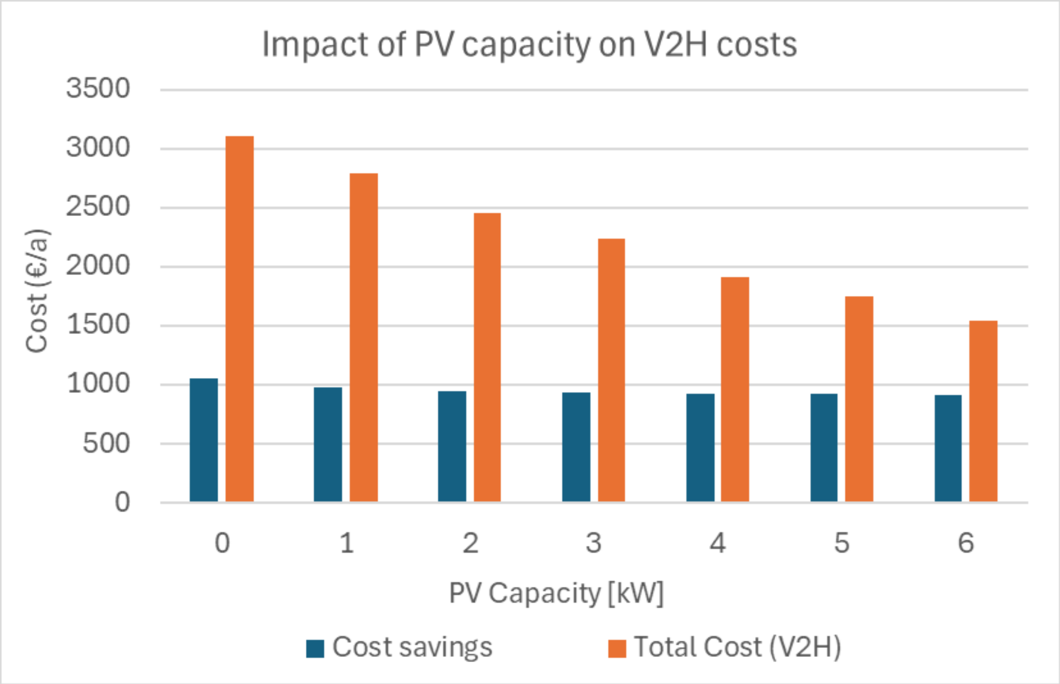

Fig. 5 Impacts of PV capacity on V2H costs

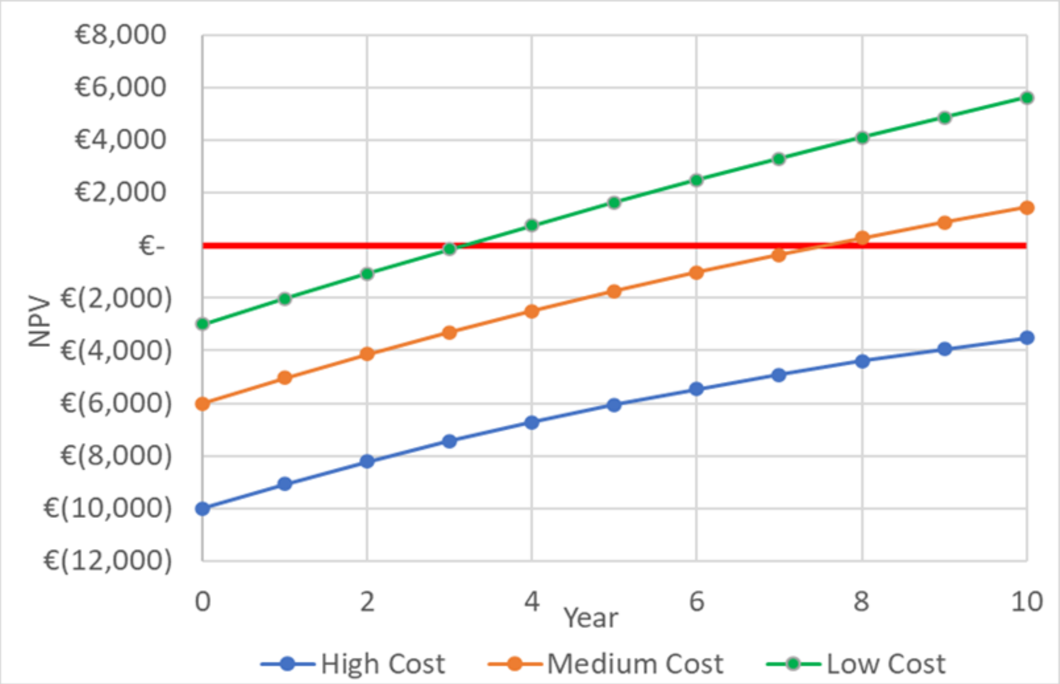

Fig. 6 NPV of V2H investment over 10 years

Conclusions

- V2H reduced the energy costs by 30% for an average Irish household, with optimal savings of €939 per year.
- V2H was able to significantly increase the self-consumption rate of PV to 89% from 48% (uncontrolled charging) and 78% (flexible charging), respectively.
- V2H managed to shift large portions of residential electricity demand to off-peak hours
- Electricity tariff, household demand, EV usage and EV availability have significant impact on V2H revenue
- If the investment on a bidirectional charger is below €6000, the Discounted Payback Period (DPP) for an average Irish V2H user will be 8 years (< one decade)

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THANK YOU!

SUSTAINABLE PLACES 2024

The emerging role for cities in coordinating secure, green and locally powered energy systems.

25th September 2024

Interreg North Sea

Co-funded by the European Union

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SUSTAINABLE PLACES 2024

E.DSO

ghent:

Session Speakers

Bram Roeland
Project Lead, COPPER

Laia Guitart
Projects Officer, E.DSO

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Session Agenda

1. The role for cities in local energy planning – Perspective from Ghent
2. DSO-city collaborations – Perspective from E.DSO
3. Conclusions

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02

Local Energy Action Planning by cities – Ghent's perspective

ghent:

Local Energy Action Plan

How are we working in Ghent?

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provincie Oost-Vlaanderen

A LEAP?

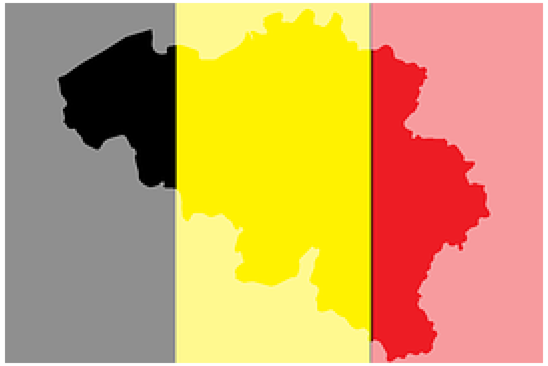
In 60 seconds


STAKEHOLDERS
DISTRIBUTION SYSTEM OPERATOR
PUBLIC TRANSPORT OPERATOR
HOUSING ASSOCIATIONS
LOCAL BUSINESSES
CITY-LEVEL
LOCAL ENERGY ACTION PLAN (LEAP)
DEPARTMENTS
MOBILITY
ENERGY
ECONOMY
CLIMATE
HOUSING
PLANNING

The problem

Discrepencies between policy and targets

Jurisdiction: Belgium – Flanders – DSO and city of Ghent



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Discrepencies between policylevels

+- 20% solar energy in 2025

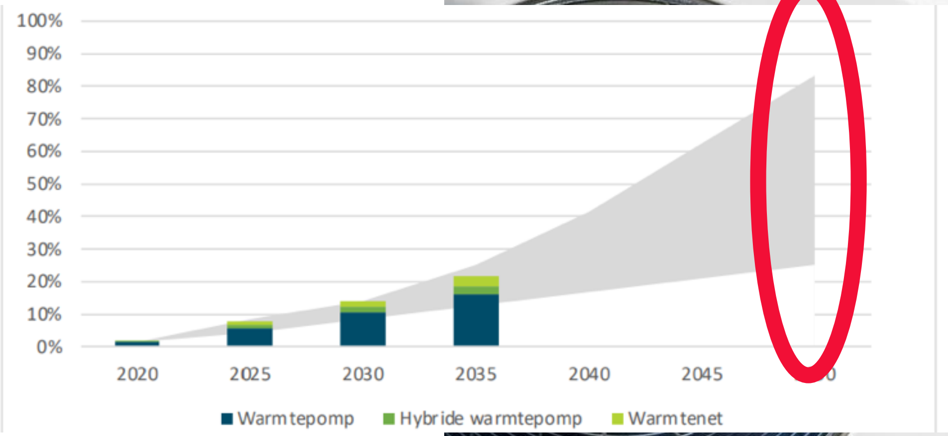
+- 33% more solar energy in 2025

+-100% more solar energy in 2025

➔ 3 widely different goals, 1 low voltage network!

Discrepancies between policylevels

Officially fossil free by 2050
But today no plan of action to quit fossil he



25 – 80% fossil free* heating by 2050

*This is including hybrid systems

100% fossil free heating by 2050

➔ 3 widely different goals, 1 low voltage network!

Why LEAP's will solve the problem

The solution

Coordination by the local government

Energy System

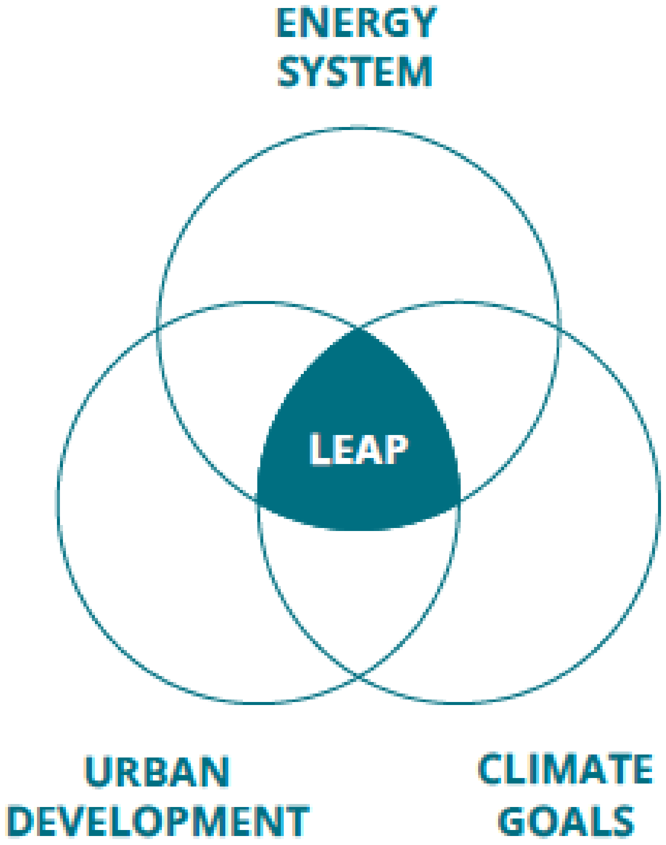
- Authority of our DSO Fluvius
  - Wants to know what the goals are off the city.

Climate Goals

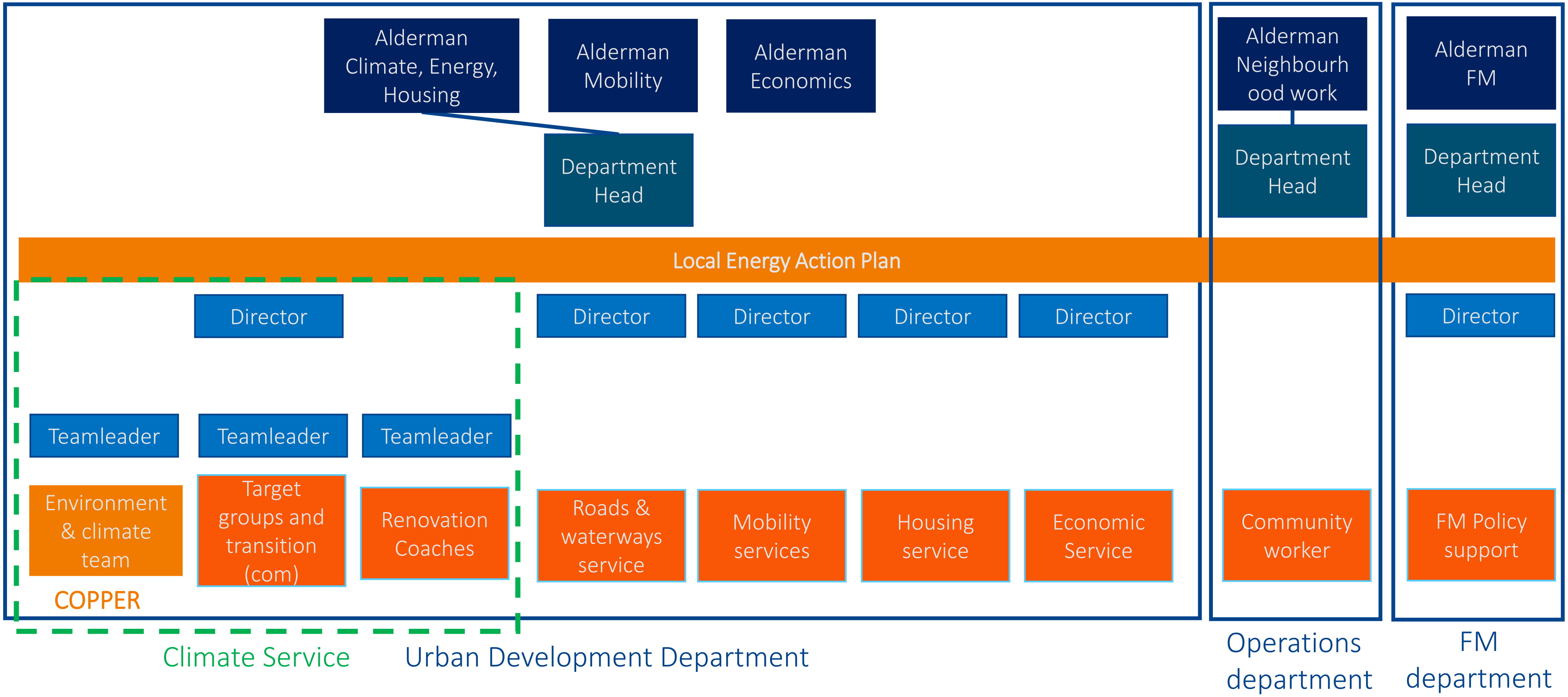
- City’s translation of European, Belgian, and Flemish goals and regulation.
  - Most of the time more ambitious than the national goals.

Urban Development

- Energy becomes a relevant factor to take into account.



Ghent: Internal LEAP stakeholders



Working together

1. First motivate the different city-services, convince them of the relevance of the LEAP. (2024)
2. With the DSO around the table, what do we need to learn from each-other. (2025-2026)
3. Reaching out to different external stakeholders. (2026)

The goal:

- Starting in the neighbourhood Mariakerke within the COPPER-project.
- Deliver by 2027 a LEAP-methodology which can be implemented in all 25 neighbourhoods of Ghent and other municipalities.
- Collaborating on a low voltage network that’s ready for the future, so development delays can be avoided.

COPPER

03

The increasing need for DSO-city collaborations – Perspective from E.DSO

E.DSO

Securing the Grid: The Importance of DSO- City Cooperation

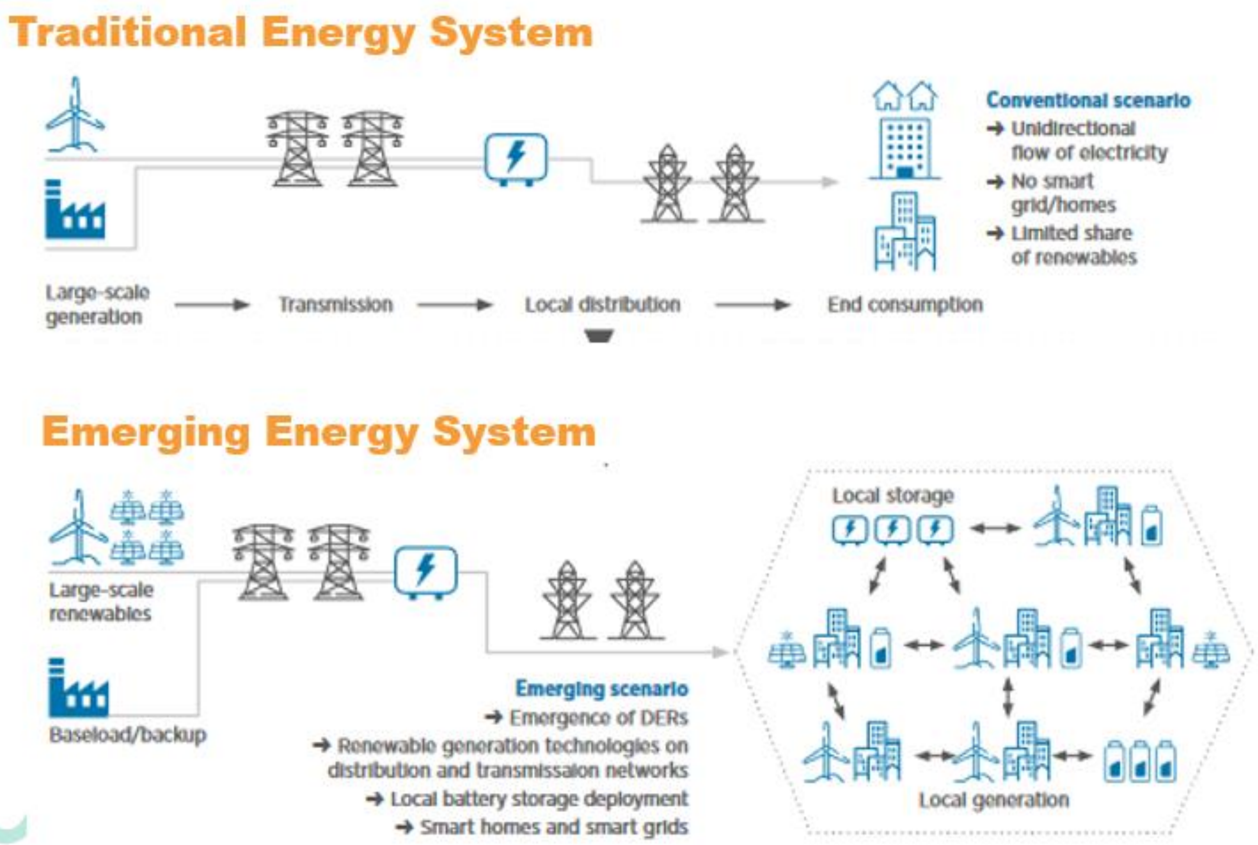
The growing need for cooperation

The energy transition is reshaping our power system

- Shift from centralized to local generation.
- Unprecedented stress to the distribution system.

Increased population in urban areas

- With more than 75% of the EU population living in cities, urban areas are the largest energy consumers.
- Cities are also the most affected by local grid constraints.



To prevent further disruption of city activities, city-DSO is essential. In particular, to ensure that the status and needs of the grid are considered in urban planning and local decision-making.

Challenges in DSO-city cooperation

- **Misaligned priorities + Reactive approach = Increased risk of disrupted city activities**
  - Ex: A city wants to install EV chargers but if the grid is congested will not be feasible.
- **Local decision-making cannot overlook the status of the grid** because its capacity and stability dictates the feasibility of these decisions.

Effective communication is essential. However, practice shows that effective communication between DSOs and cities is hindered by:

- The **multitude of stakeholders** that need to be involved
- The **complexity of technical grid issues** for external stakeholders;
- The existence of **practices that limit information sharing.**

To address these challenges, COPPER is developing the concept of Local Energy Action Plans (LEAPs) to enable seamless DSO-city collaboration.

LEAPs aim to streamline communication, reduce the knowledge gap and foster a culture of transparency and open communication for consistent information sharing.

Filling the gaps: The concept of LEAP

A LEAP is an action plan jointly developed by the city and the DSO in consultation with other relevant stakeholders.

LEAPs combine urban + energy planning in a way that addresses the 3 challenges hindering DSO-City cooperation:

Challenge	Solution
The **multitude of stakeholders** that need to be involved	LEAPs provide a single plan, streamlining communication. LEAPs reconcile interests and enable coordinated action.
The **complexity of technical grid issues** for external stakeholders;	LEAPs are designed to simplify and clarify technical grid issues for non-expert stakeholders, facilitating the translation of complex technical jargon into understandable concepts.
The **existence of practices that limit information sharing**.	The LEAP process enables the identification of practices that hinder information sharing and allows for the exploration of solutions to overcome these obstacles

EU wide replication & future prospects

The content of a city LEAP will depend on the local priorities. However, the LEAP framework developed in COPPER will remain consistent so it can be replicated across the EU. This is essential **to ensure that LEAPs respond to the local needs but can be replicated in multiple scenarios facing similar issues.**

<u>In line with the project UCs, A LEAP can cover:</u>

- Implementation of smart city technologies.
- Resilience planning.
- Funding models.

In the NSR, 6 pilots **tailoring the framework LEAP to their specific needs** to foster sustainable development.

Do you want to contribute to the development of LEAPs?

So far, we have identified several challenges & solutions to the cooperation between cities and DSOs.

However, your input as a stakeholder in city-DSO collaboration is crucial to map the challenges and shape effective collaboration strategies.

Please take a minute to share your experience with this short survey and help us drive positive change.

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04 Conclusions

Learn more about local energy planning

Read our Introduction to Local Energy Action Planning

bit.ly/leapintroduction

Fill in our survey on City-DSO cooperation

bit.ly/copperleapsurvey

Learn about Ghent's role in the COPPER project

bit.ly/coppergent

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PLURAL

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Development of a Grey-box model for a Multi-Residential Passive Building incorporating Radiant Wall and Radiant Floor Heating Systems

Jordi Macià Cid, Thibault Q. Péan, Jordi Pascual, Angelos Mylonas

24.09.2024

CONTENTS

Shaping Energy for a Sustainable Future

1. CONTEXT

PLURAL

- **H2020 PROJECT (2021-2024)**
- **Total cost € 9.663.495,03 funded by EU Commission**
- **Coordinated by NTUA (ATHENS)**

PLURAL

WP3 – OBJECTIVES

- **To develop energy efficiency control system, based on MPC and reduced models.**
- **Demonstrate it in a virtual demo-building multi-family block in Bern, Switzerland.**

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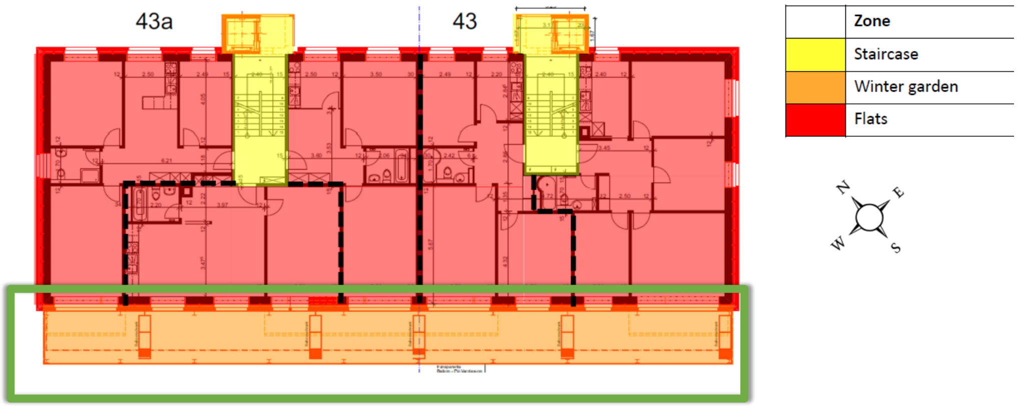
1. CONTEXT

Demonstrator building

Bern building exterior views after PLURAL renovation in 2019.

- **BERN, SWITZERLAND**
- **GF + 4 Levels + Cellar. 5 dwellings/level = 20 dw.**
- **Highly insulated, low infiltration**
  - **Uwall = 0.13 W/m²·K**
  - **Uwin = 2.17**
  - **Inf = 0.15 m³/h·m²**
- **Winter Garden (glassed room) in W-S façade.**
- **Centralized HVAC system with Heat Pump.**

Winter Garden (glassed room)



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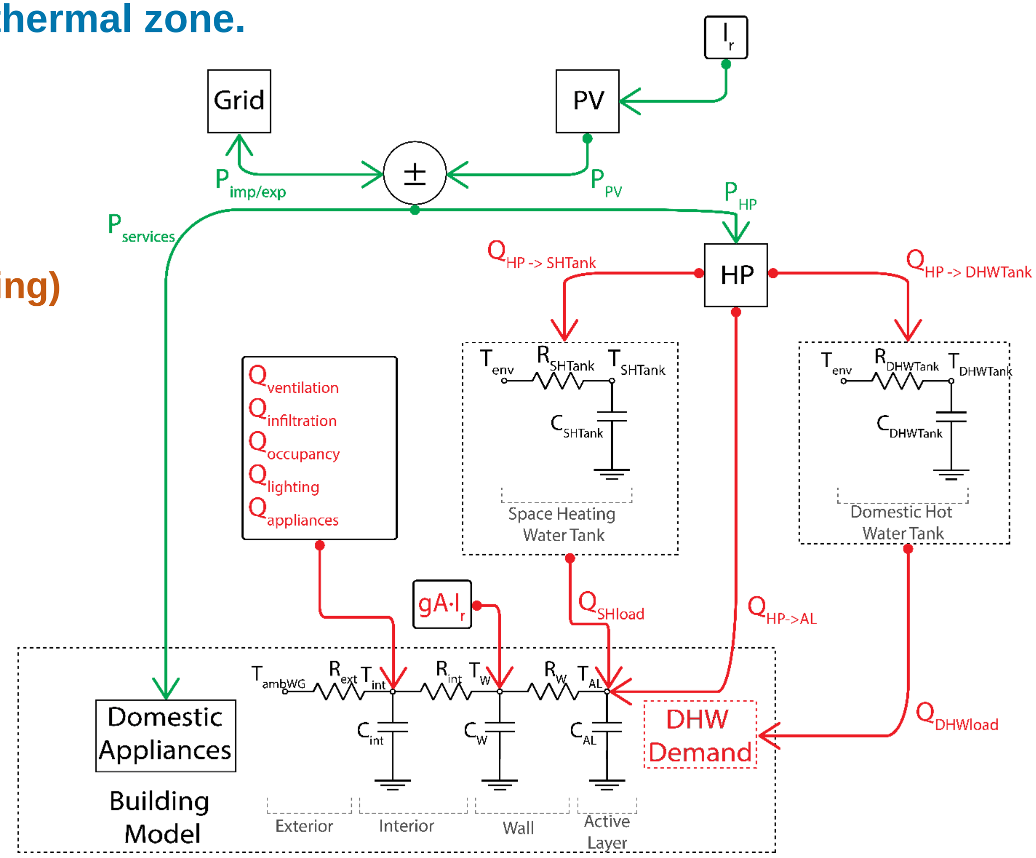
2. OBJECTIVES & CHALLENGES

- **To develop an RC model, simple to implement and computationally fast, to be integrated in MPC optimizer.**
- **Centralized MPC regulates HP and tanks.**
- **Model the building as one single thermal zone.**
- **Assure comfort.**
- **Two variations for:**
  - **a) Radiant Wall (Heating)**
  - **b) Radiant Floor (Heating + Cooling)**

HVAC system consists of:

- 1xHP 55 kW
- 2 storage tanks (DHW, Space Heating)
- BIPV in facades
- Centralized AHU + HR



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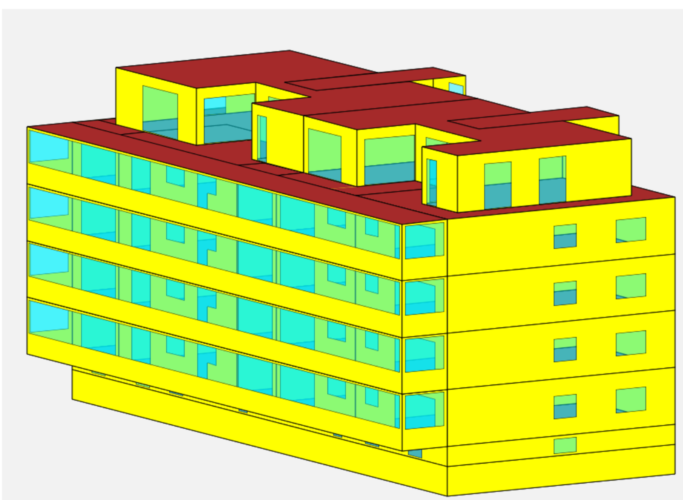
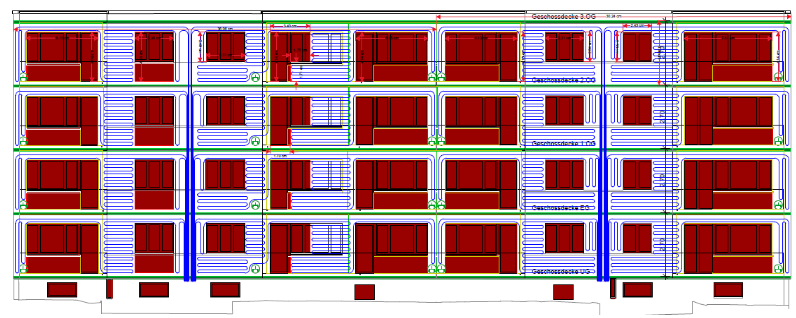
3. METHODOLOGY

Generation of calibration data

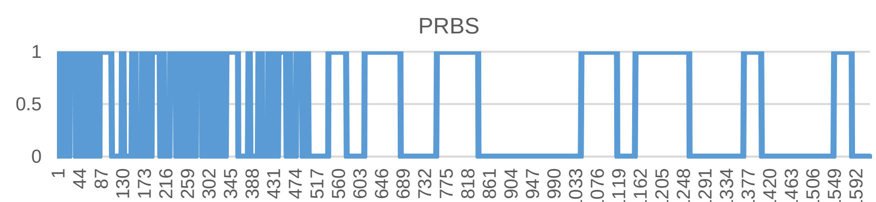
- **White model** in TRNSYS to generate calibration data.
- **TRNSYS** includes a feature to simulate **Active Layers (AL)** in buildings surface, thus, simulating the heating loops of the radiant wall or the radiant floor.
- Simulation data is generated for a 250h hours period (**10 days**), when is the highest heating demand, with **time-step of 15 min**.
- Use of **Pseudo-Random Binary Signal (PRBS)** to stimulate the building at different frequencies.



TRNSYS model of the building



Distribution of the heating loops on the South-West facade of the building



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3. METHODOLOGY

Winter Garden temperature

The presence of a glass chamber in the west-south facade causes the greenhouse effect, making Tamb for this façade to be higher than the other three. Therefore, the ambient temperature is calculated as weighed average between the winter garden temperature and outdoor temperature.

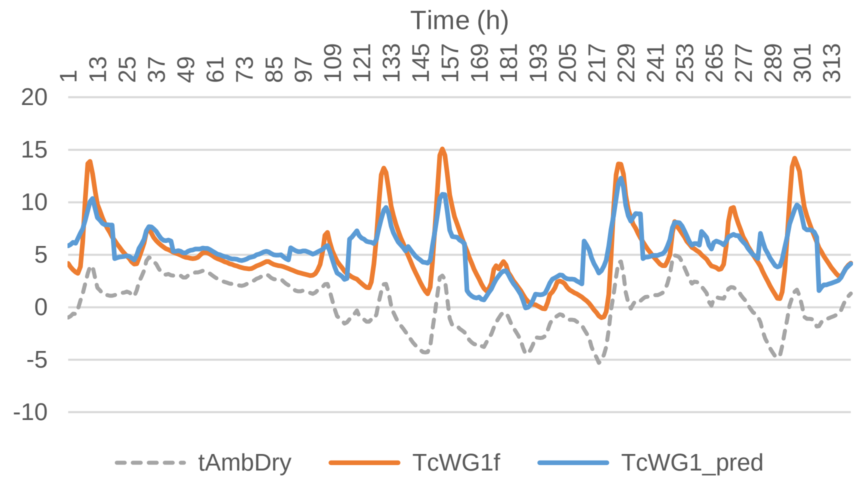
$$T_{amb\,WG} = \frac{A_{amb} \cdot T_{amb} + A_{WG} \cdot \hat{T}_{WG}}{A_{amb} + A_{WG}}$$

Where:

- $\hat{T}_{WG} = \beta_0 + \beta_1 T_{amb} + \beta_2 \overline{Ir} + \beta_3 T_{amb}^2 + \beta_4 \overline{Ir}^2 + \beta_5 T_{amb} \overline{Ir}$
- $\overline{Ir}$ is the daily accumulated solar radiation.
- A_{amb} facade surface in touch with outdoor
- A_{WG} facade surface covered by winter garden

ONLY – Heating Season

- Coeff: 8.965e-01, 8.356e-02, -1.929e-03, 4.924e-04, -1.784e-04.
- Intercept: 2.194 ºC
- R^2 = 87.41%
- RMSE = 2.27° C.



Predicted WG temperature compared to TRNSYS result and ambient temperature.

3. METHODOLOGY

Parameters identification

- To identify the parameters, an optimization algorithm (Nelder–Mead method in Python) is used to find the solution that minimizes the following objective function.
- In this case was considered as the sum of mean square errors of Ti, Tw and Tal without weighing.
- Some of the parameters can be set constant by the user and let the algorithm identify the remaining ones.

$$V(\theta) = \frac{1}{N} \sum_{\theta=1}^{M} \sum_{t=1}^{N} (m_{\theta.t} - s_{\theta.t})^2$$

Where:

- $V(\theta)$: objective function
- θ: Variables (in this case T_i, T_w and T_{al}).
- t: Number of observations.
- $m_{\theta.t}$: Measured variable.
- $s_{\theta.t}$: Simulated variable.

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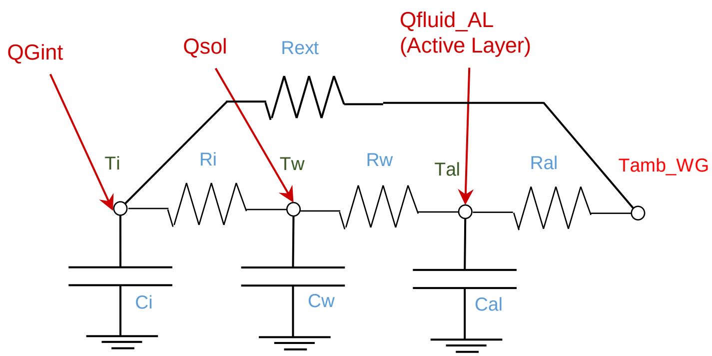
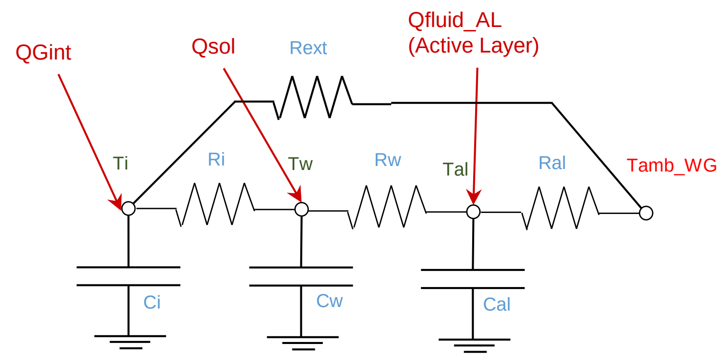
3. METHODOLOGY – a) Radiant Wall

RC topologies proposed

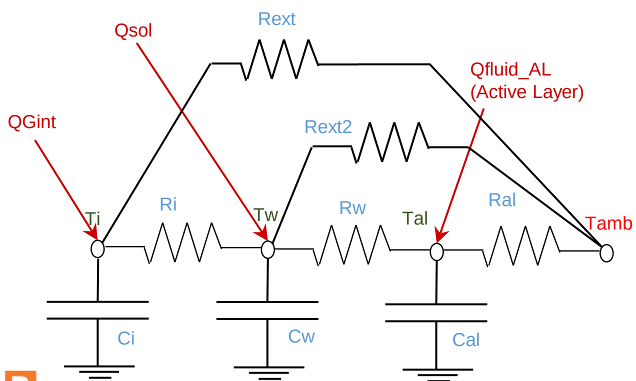
R4C3-a



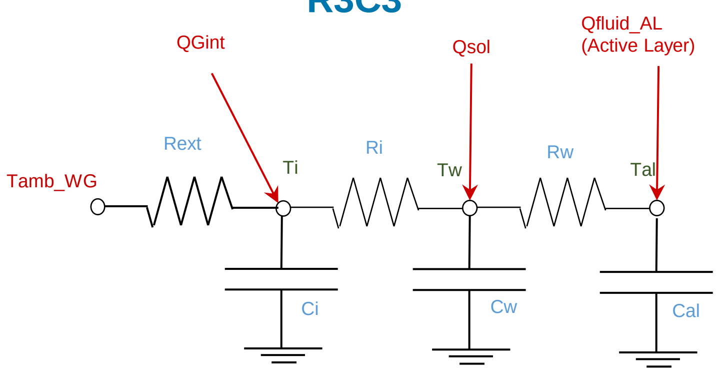
R4C3-b



R5C3



R3C3



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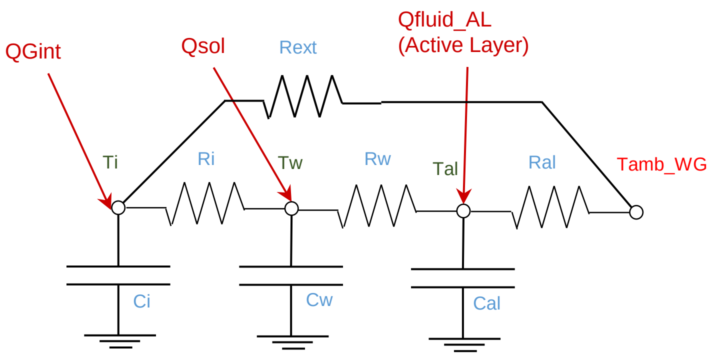
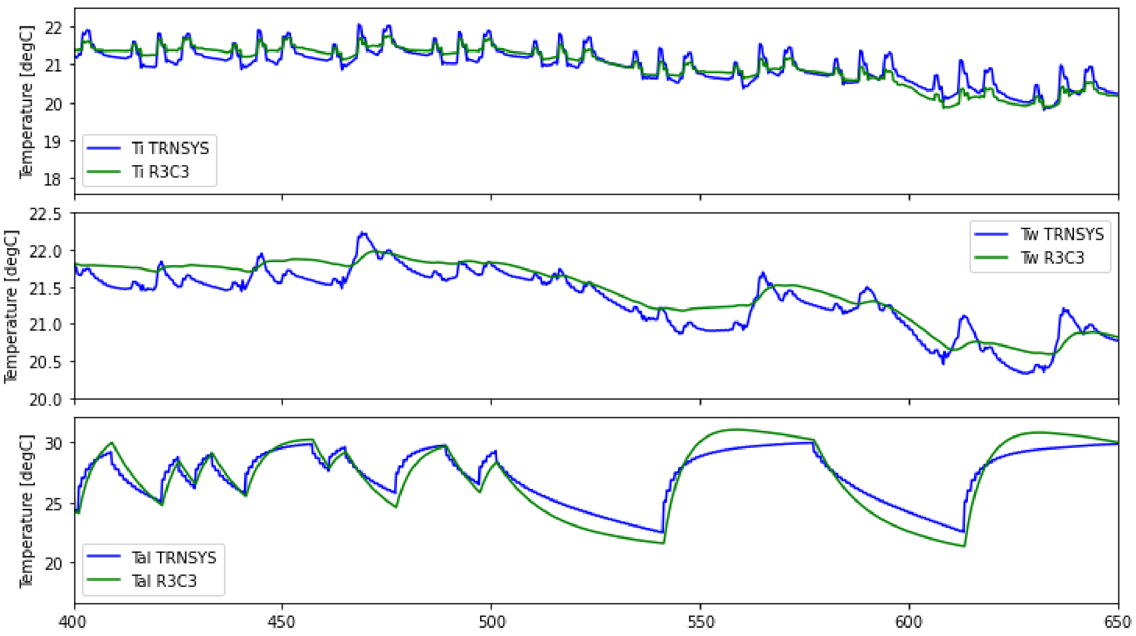
3. METHODOLOGY – a) Radiant Wall

R4C3-a





Cint	0.21102
Cwall	440.6
Cal	17.022
gA	66.48
Rint	0.0355
Rwall	0.7038
Ral	8.4487E+10
Rext	1.5400

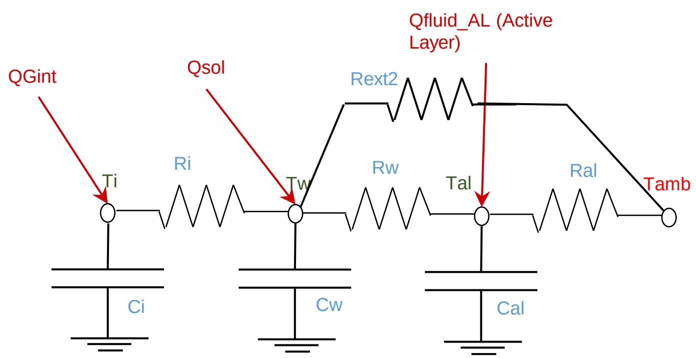
RMSE Ti : 0.3943 ºC
NRMSE Ti : **1.91%**
RMSE Tw : 0.377 ºC
NRMSE Tw : **1.8%**
RMSE Tal : 2.1347 ºC
NRMSE Tal : **8.17%**

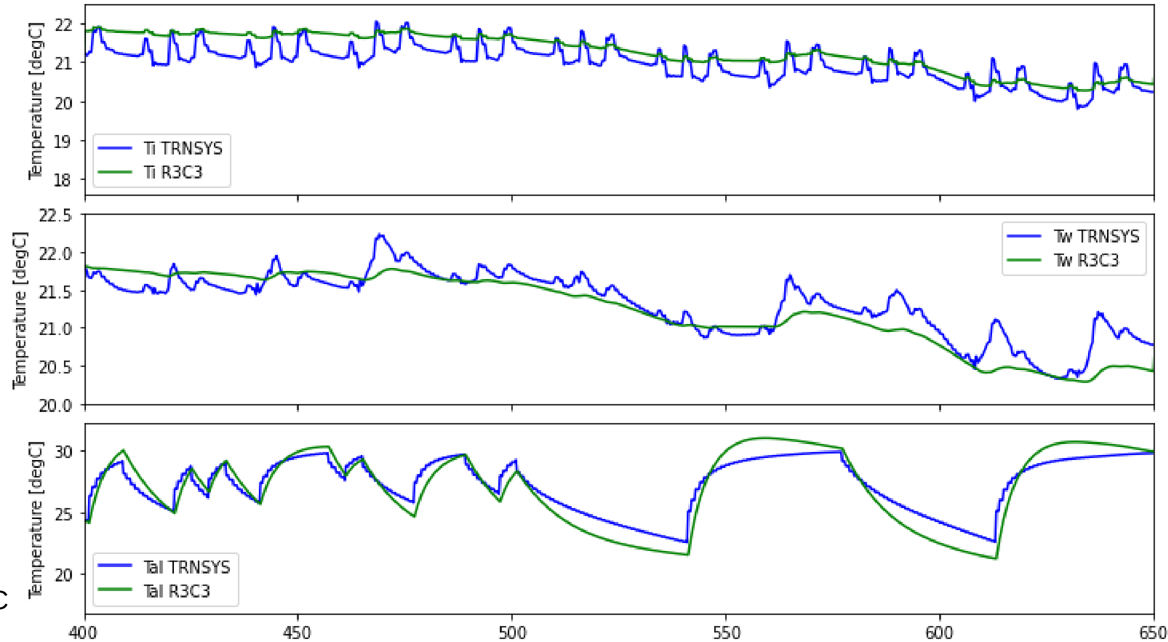
Shaping Energy for a Sustainable Future

Parameter fixed by user
Parameter identified by algorithm

3. METHODOLOGY – a) Radiant Wall

R4C3-b





Cint	0.21102
Cwall	566.90
Cal	17.022
gA	66.48
Rint	0.01276
Rwall	0.72919
Ral	108557917995.4
Rext	1.4274

RMSE Ti : 0.7681 ºC
NRMSE Ti : **3.71 %**
RMSE Tw : 0.4464 ºC
NRMSE Tw : **2.13 %**
RMSE Tal : 2.2384 ºC
NRMSE Tal : **8.57 %**

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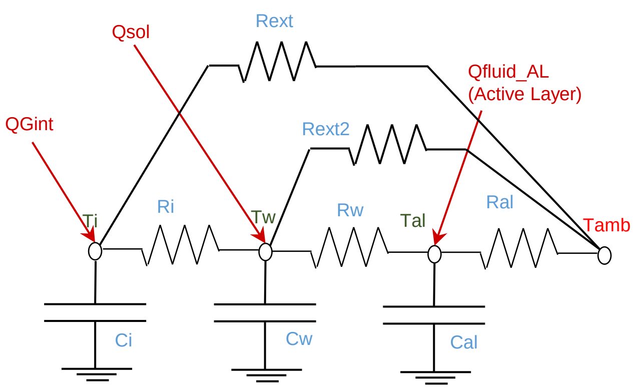
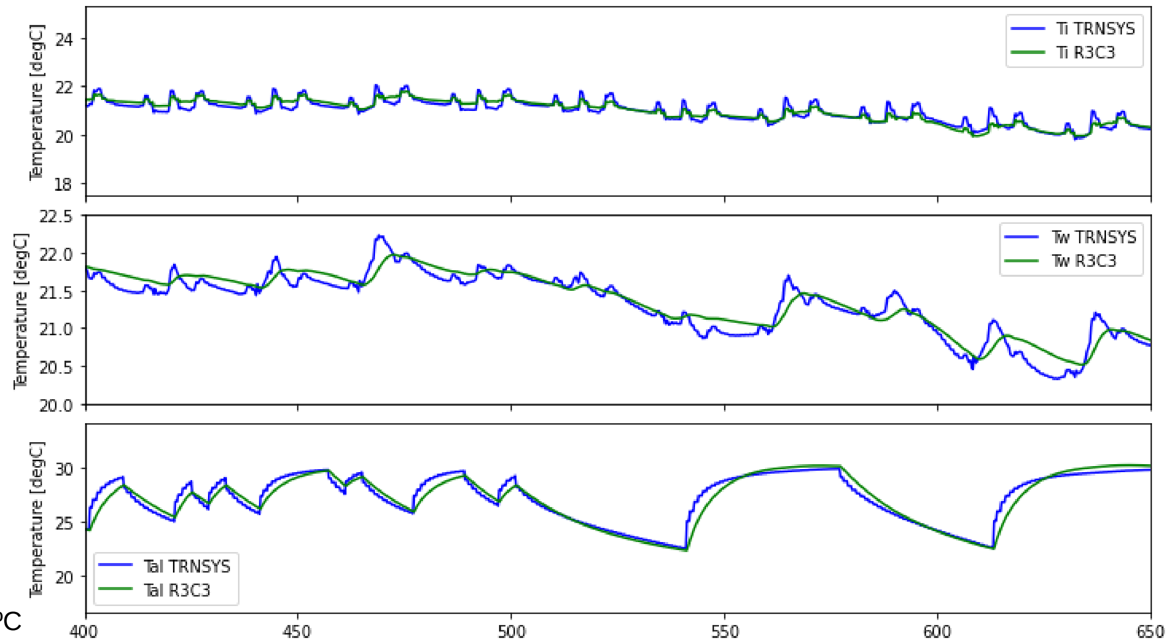
Parameter fixed by user
Parameter identified by algorithm

3. METHODOLOGY – a) Radiant Wall

R5C3





Cint	0.21102
Cwall	469.3053
Cal	27.32609
gA	125.79
Rint	0.0312539
Rwall	0.75447
Ral	671.12801
Rext	1.5700
Rext2	5.6505

RMSE Ti : 0.3519 ºC
NRMSE Ti : **1.7 %**
RMSE Tw : 0.2866 ºC
NRMSE Tw : **1.36 %**
RMSE Tal : 1.3931 ºC
NRMSE Tal : **5.33 %**

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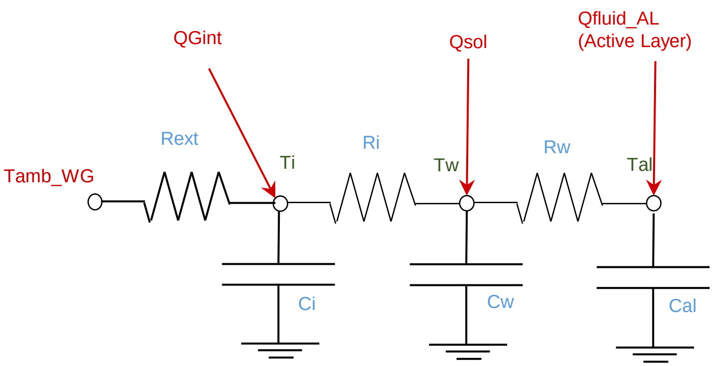
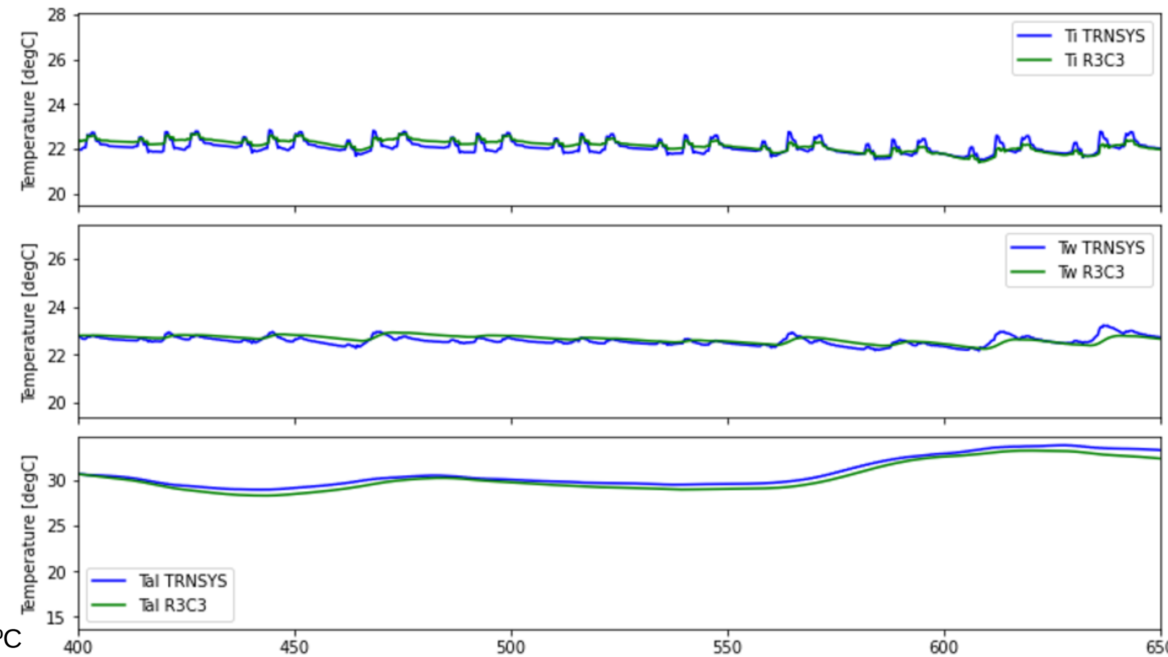
Parameter fixed by user
Parameter identified by algorithm

3. METHODOLOGY – a) Radiant Wall

R3C3





Cint	0.21102
Cwall	469.3053
Cal	27.32609
gA	98.69
Rint	0.0312539
Rwall	0.75447
Rext	1.3434

RMSE Ti : 0.4095 ºC

NRMSE Ti : **1.7 %**

RMSE Tw : 0.3447 ºC

NRMSE Tw : **1.36 %**

RMSE Tal : 1.0171 ºC

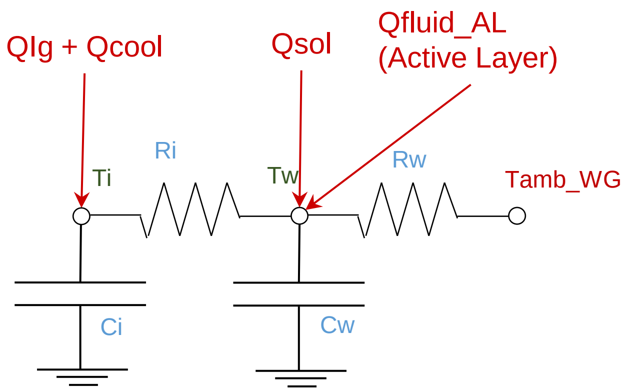
NRMSE Tal : **5.33 %**

Shaping Energy for a Sustainable Future

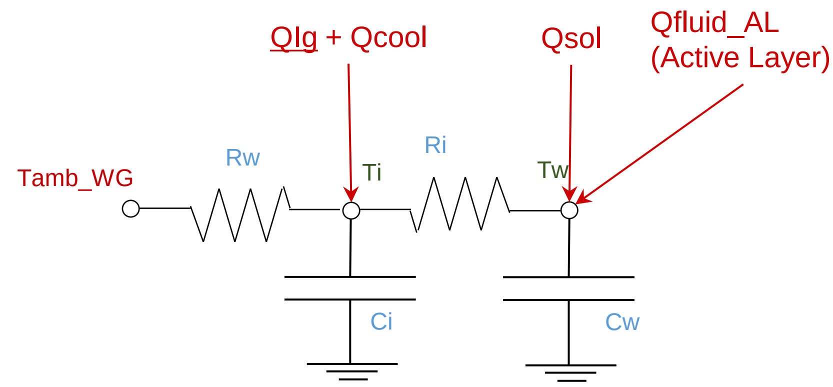
Parameter fixed by user
Parameter identified by algorithm

3. METHODOLOGY – b) Radiant Floor

RC topologies proposed

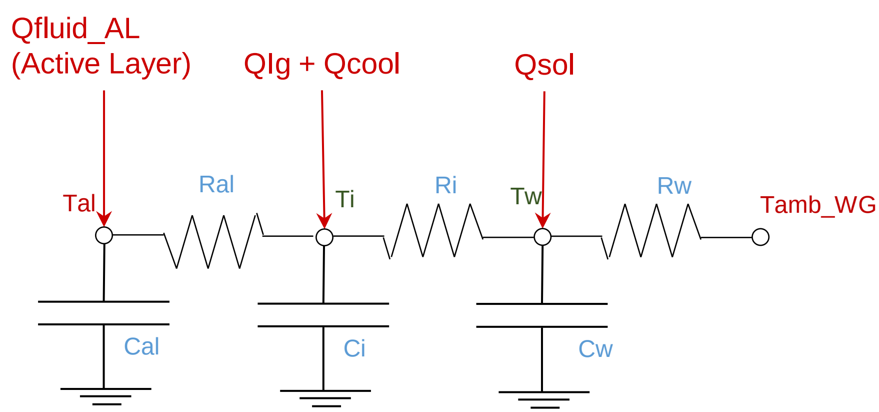


R2C2-a



R2C2-b

R3C3



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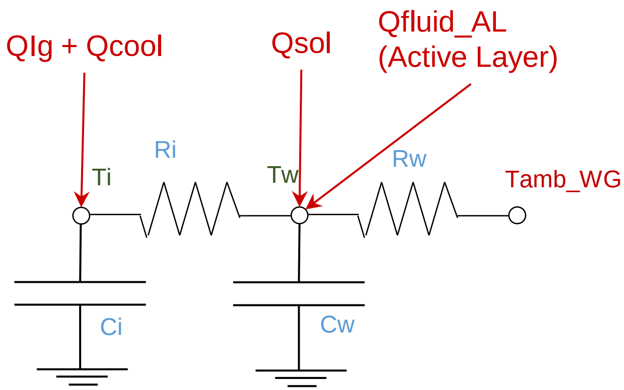
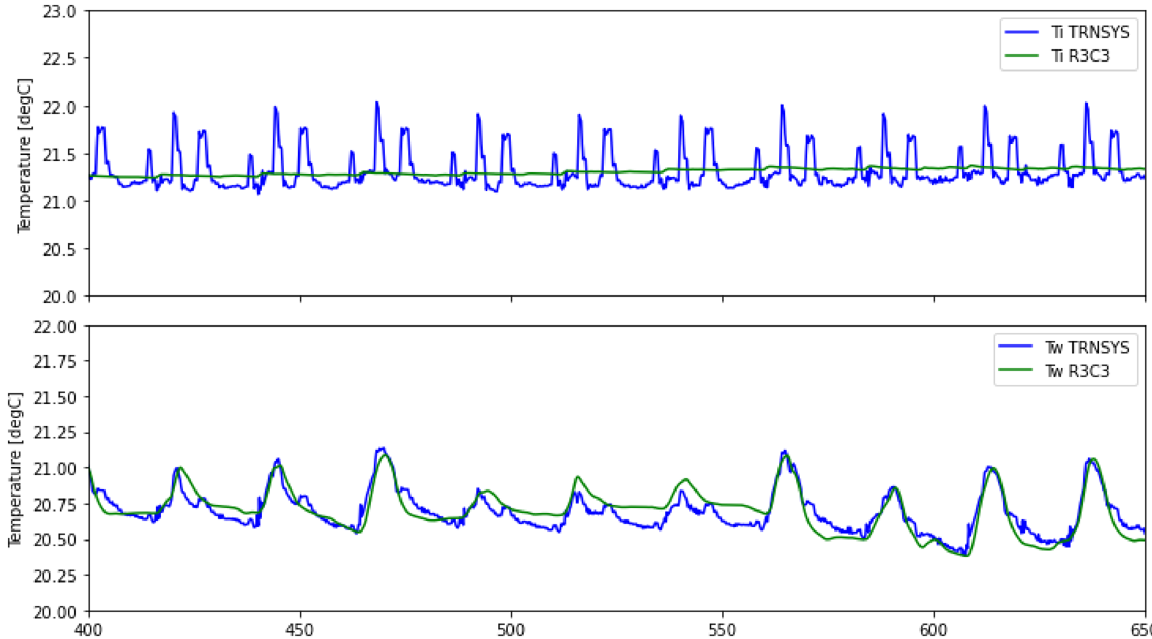
3. METHODOLOGY – b) Radiant Floor

R2C2-a





Cint	**2373.76423**
Cwall	**21.89249**
gA	**22.80**
Rint	**0.04955**
Rwall	**1.64605**

RMSE Ti : 0.3997 ºC

NRMSE Ti : **1.73 %**

RMSE Tw : 0.1574 ºC

NRMSE Tw : **0.69 %**

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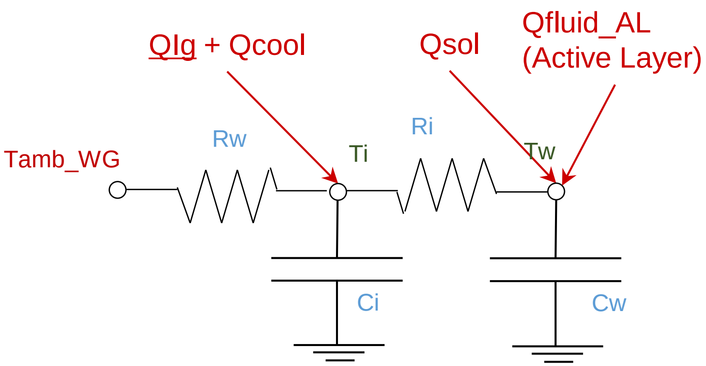
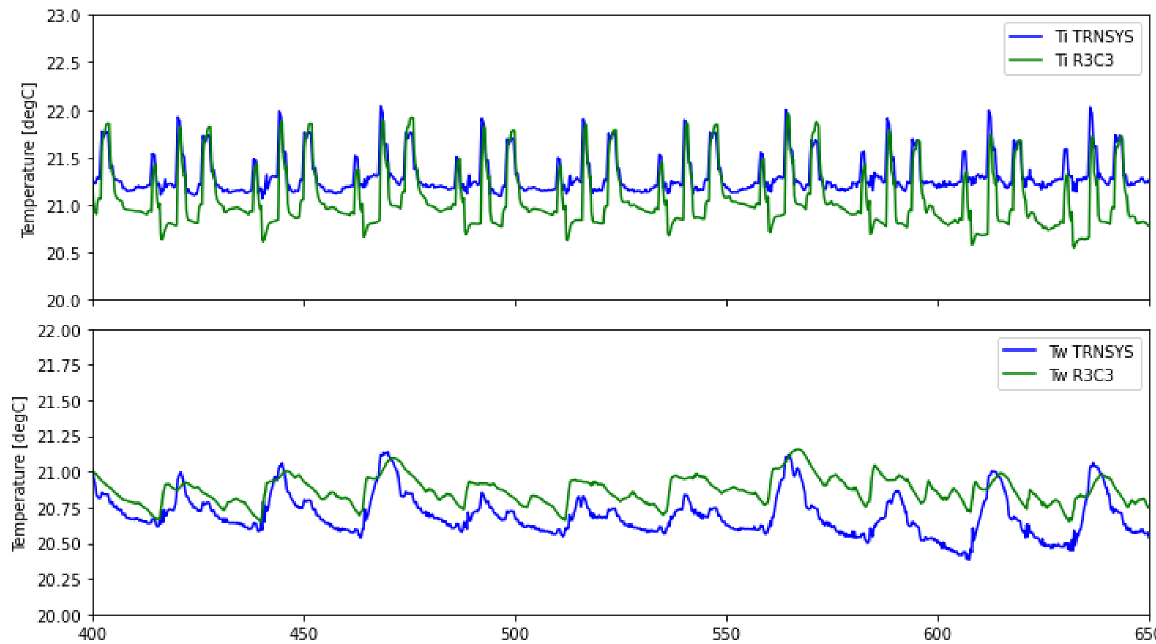
3. METHODOLOGY – b) Radiant Floor

R2C2-b





Cint	**2.26470**
Cwall	**318.97494**
gA	**71.28168**
Rint	**0.10944**
Rwall	**1.30560**

RMSE Ti : 0.632 ºC

NRMSE Ti : **2.74 %**

RMSE Tw : 0.4096 ºC

NRMSE Tw : **1.8 %**

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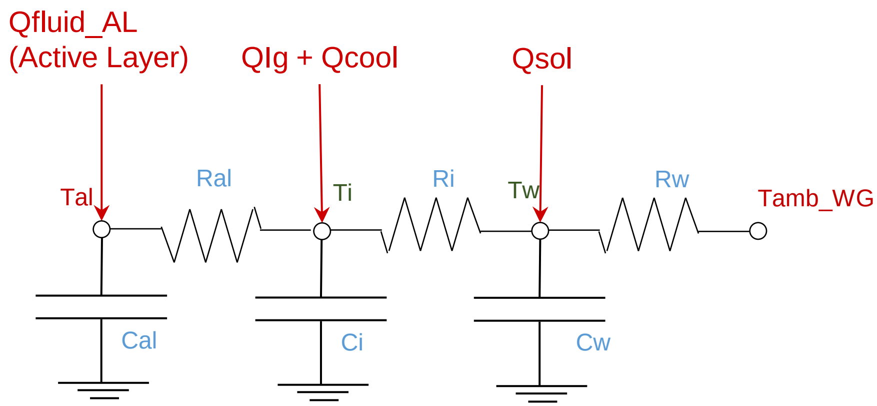
3. METHODOLOGY – b) Radiant Floor

R3C3



Coeff.	Winter	Shoulder	Summer
C_{int} [kW/K]	0.068	0.148	0.175
C_W[kW/K]	560.473	609.582	569.089
C_{AL} [kW/K]	52.898	60.496	15.531
gA [m^2]	136.040	16.900	7.778
R_{int} [m^2K/kW]	0.039	0.044	0.042
R_W[m^2K/kW]	1.077	1.488	1.591
R_{AL}[m^2K/kW]	0.068	0.062	0.049
NRMSE T_{in} [%]	1.19	1.26	1.21
NRMSE T_w [%]	1.47	1.27	0.75
NRMSE T_{al} [%]	1.64	1.10	0.67

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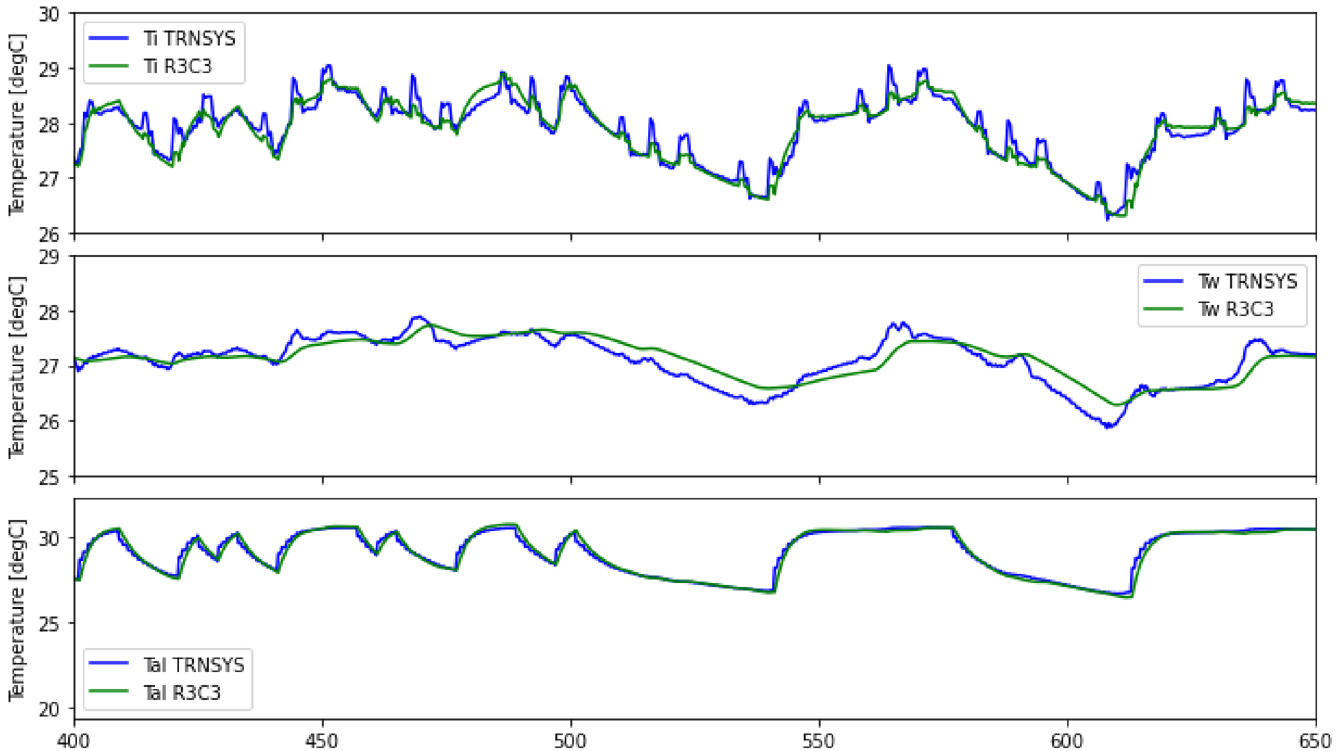
3. METHODOLOGY – b) Radiant Floor

R3C3

Coeff.	Winter
C_{int} [kW/K]	0.068
C_W[kW/K]	560.473
C_{AL} [kW/K]	52.898
gA $[m^2]$	136.040
R_{int} $[m^2K/kW]$	0.039
$R_W[m^2K/kW]$	1.077
$R_{AL}[m^2K/kW]$	0.068
NRMSE T_{in} [%]	1.19
NRMSE T_w [%]	1.47
NRMSE T_{al} [%]	1.64

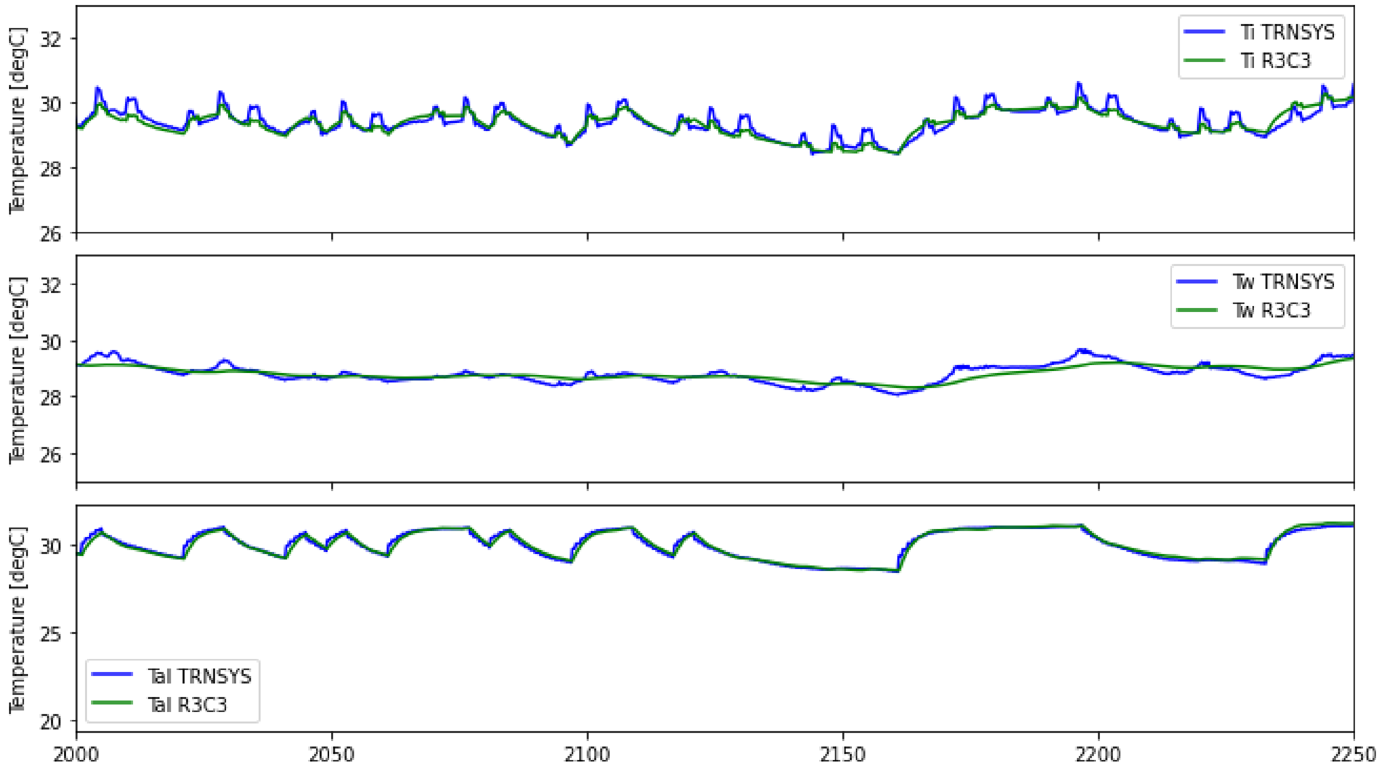


January

3. METHODOLOGY – b) Radiant Floor

R3C3

Coeff.	Shoulder
C_{int} [kW/K]	0.148
C_W[kW/K]	609.582
C_{AL} [kW/K]	60.496
gA [m^2]	16.900
R_{int} [m^2K/kW]	0.044
R_W[m^2K/kW]	1.488
R_{AL}[m^2K/kW]	0.062
NRMSE T_{in} [%]	1.26
NRMSE T_w [%]	1.27
NRMSE T_{al} [%]	1.10

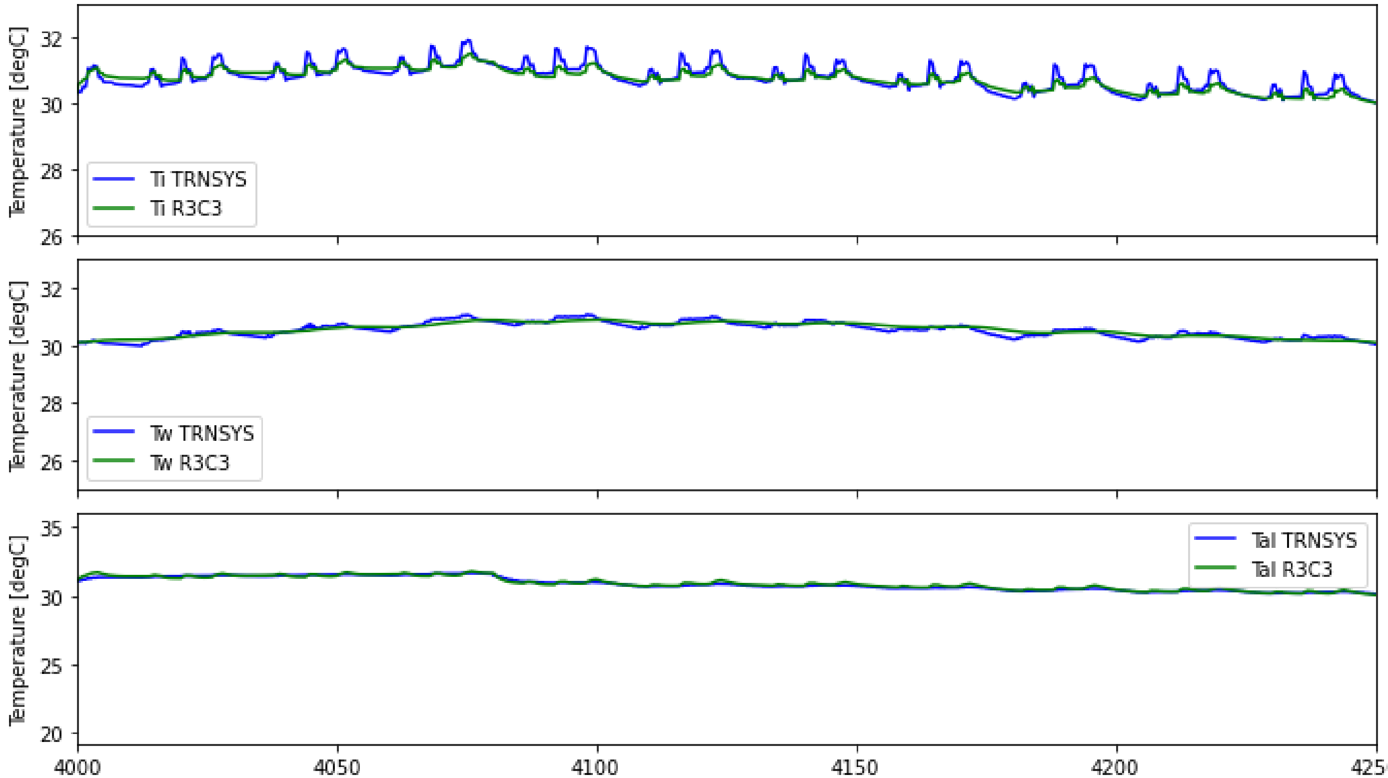


March-April

3. METHODOLOGY – b) Radiant Floor

R3C3

Coeff.	Summer
C_{int} [kW/K]	0.175
C_W[kW/K]	569.089
C_{AL} [kW/K]	15.531
gA [m^2]	7.778
R_{int} [m^2K/kW]	0.042
R_W[m^2K/kW]	1.591
R_{AL}[m^2K/kW]	0.049
NRMSE T_{in} [%]	1.21
NRMSE T_w [%]	0.75
NRMSE T_{al} [%]	0.67



June

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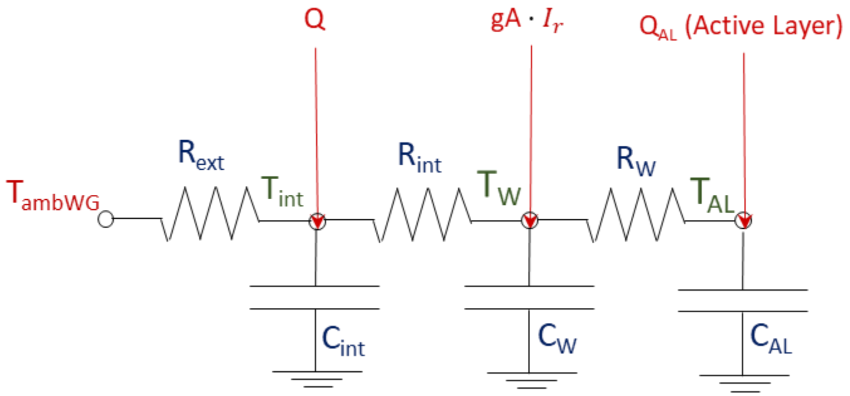
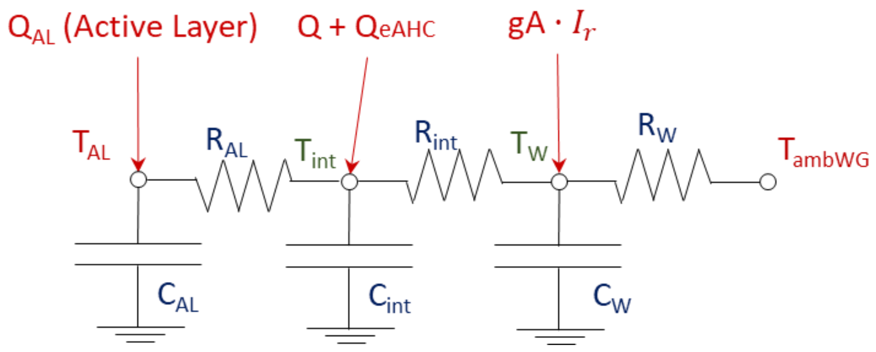
4. RESULTS – RADIANT WALL

Radiant Wall – R3C3



Coeff.	Winter
C_{int} [kW/K]	0.21102
C_W[kW/K]	0.03125
C_{AL} [kW/K]	421.4972
gA [m^2]	98.69
R_{int} [m^2K/kW]	0.7451
R_{ext}[m^2K/kW]	27.2333
R_{AL}[m^2K/kW]	1.34329
NRMSE T_{in} [%]	1.7
NRMSE T_w [%]	1.43
NRMSE T_{al} [%]	3.8

Radiant Floor – R3C3



Coeff.	Winter	Shoulder	Summer
C_{int} [kW/K]	0.068	0.148	0.175
C_W[kW/K]	560.473	609.582	569.089
C_{AL} [kW/K]	52.898	60.496	15.531
gA [m^2]	136.040	16.900	7.778
R_{int} [m^2K/kW]	0.039	0.044	0.042
R_W[m^2K/kW]	1.077	1.488	1.591
R_{AL}[m^2K/kW]	0.068	0.062	0.049
NRMSE T_{in} [%]	1.19	1.26	1.21
NRMSE T_w [%]	1.47	1.27	0.75
NRMSE T_{al} [%]	1.64	1.10	0.67

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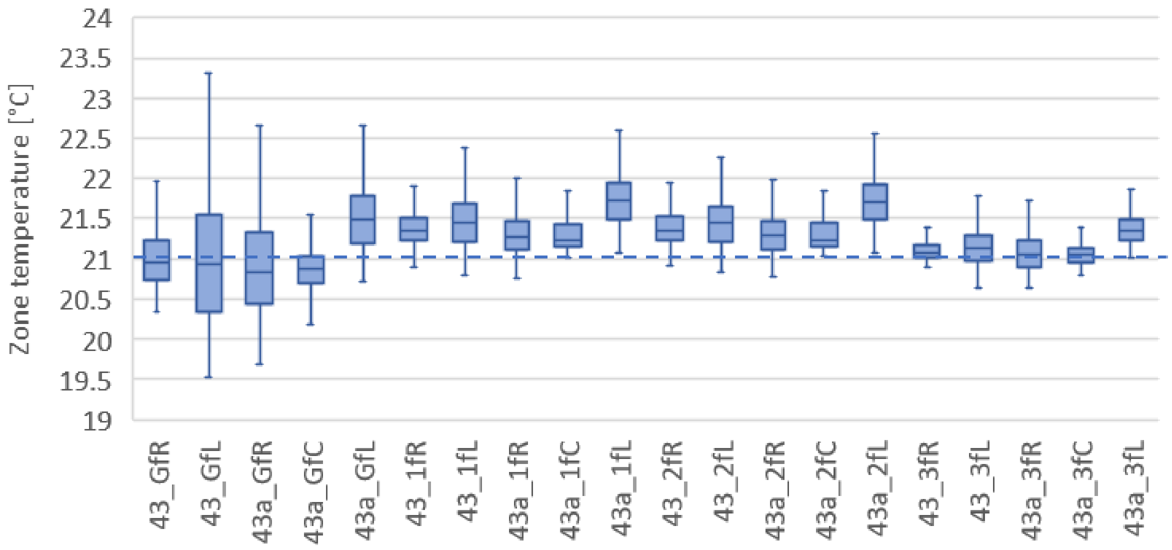
4. RESULTS – RADIANT WALL

Comfort compliance

- Tin setpoint was 21ºC in winter.
- Result of applying MPC control for 15 days in January using the R3C3 model. Indoor temperature (Tin) is mostly >75% over the setpoint, except for zones in Ground Floor which are above an unconditioned zone (cellar).



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6. CONCLUSIONS

- **A multi-zone / multi-dwelling building can be modelled as one single thermal zone, and it can reflect the transients in it.**
- **Active (radiant) layers must be treated as a separate state (Tal), instead as a heat gain of other common states (Tin or Twall).**
- **High insulation values of external walls (façade), can be modelled as adiabatic walls because transmittance through windows and infiltration is much higher.**
- **Despite using a single thermal zone model, comfort can be assured with a single zone model in an MPC for a multi-family building.**

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THANK YOU FOR YOUR ATTENTION!

Development of a Grey-box model for a Multi-Residential Passive Building incorporating Radiant Wall and Radiant Floor Heating Systems

Jordi Macià Cid, Thibault Q. Péan, Jordi Pascual, Angelos Mylonas

24.09.2024