# I-PCM: IoT-monitored PCM-based façade for low-energy buildings

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# Project Summary

**I-PCM · IoT-monitored PCM-based Facade for Low-energy Buildings**

- **T1 Customization of microturbines and IoT system** for a residential building.
- **T2 Modelling and simulation of a residential building** equipped with PCM technology and an IoT sensor system powered by microturbines.
- **T3 Engage commercial partners** to ensure a successful market launch.

# Microturbine Prototype

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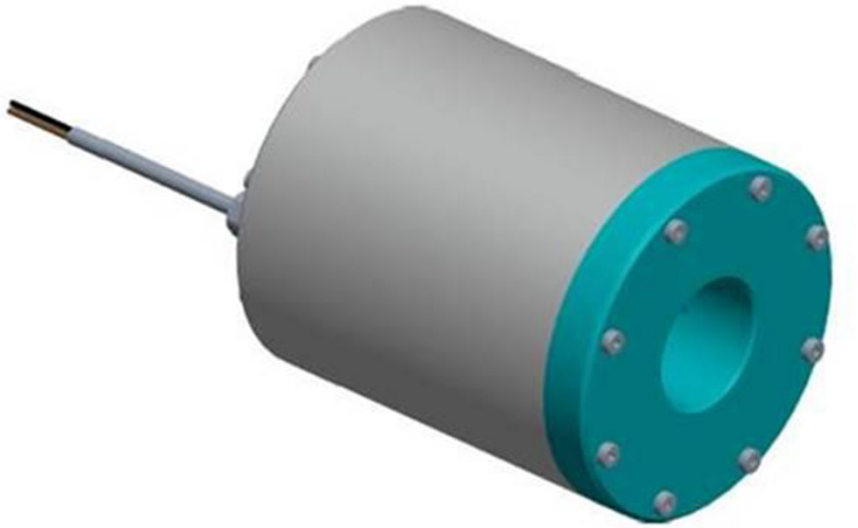

**CAD Design**

**Microturbine prototype made in POM-C plastic**

# How It Works

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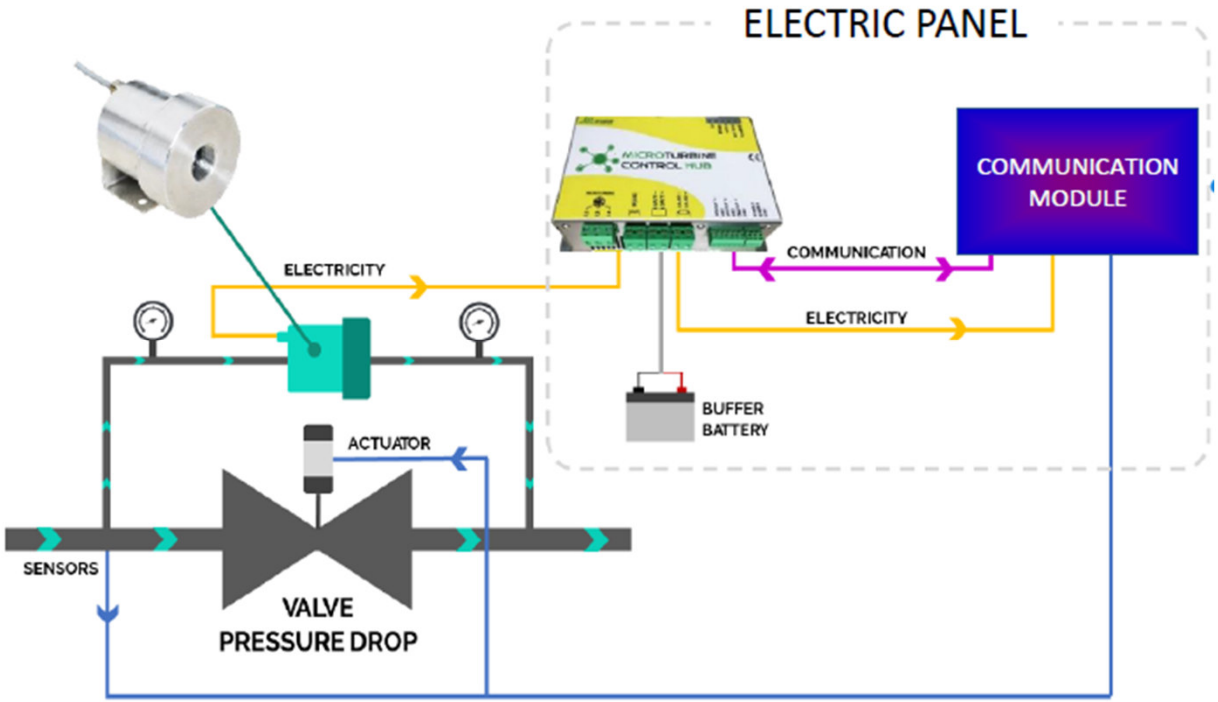
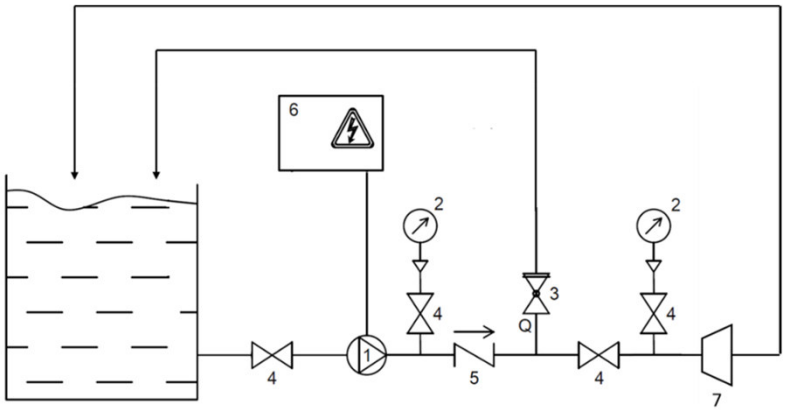
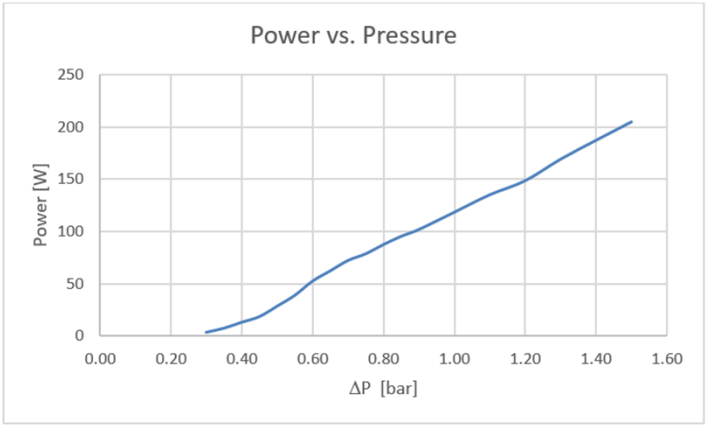


# Microturbine Lab Testing






**Bench test schematic**

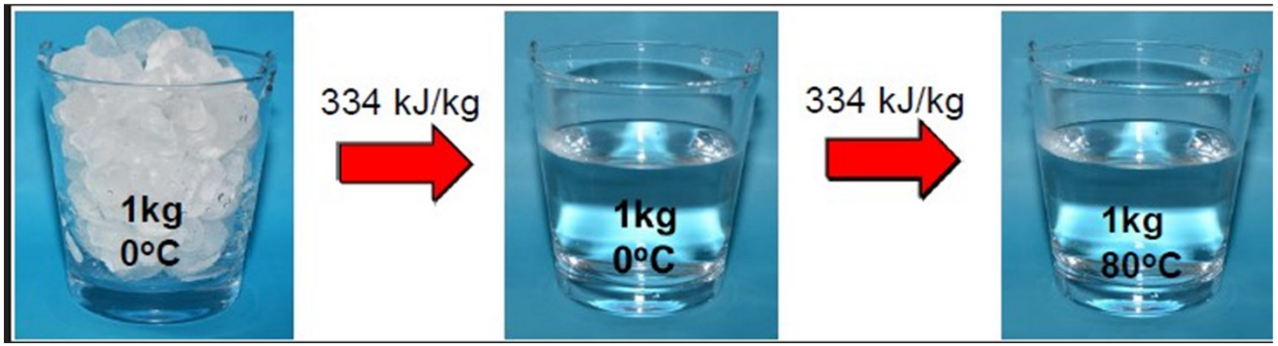


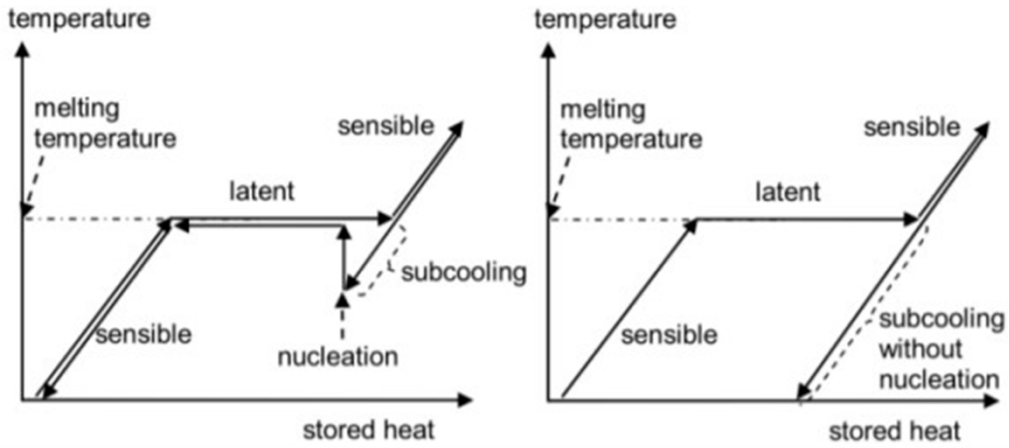

**Power vs. pressure**

# PCM Analysis and Building Simulation

# PCM – Phase Change Materials





# PCM – Phase Change Materials

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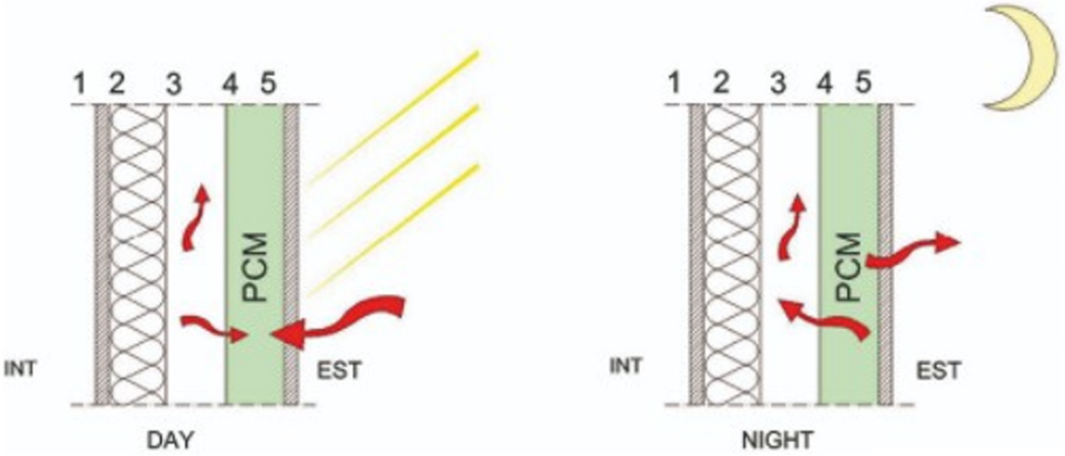


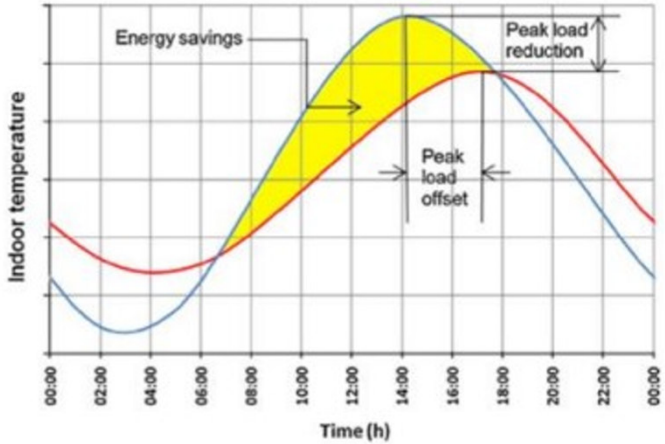

# PCM vs. Insulators



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## *PCMs*

- ✓ Store heat during their phase change
- ✓ In winter conditions, PCMs prevent heat to be transferred outside
- ✓ In summer PCMs prevent the heat to be transferred inside by storing it in
- ✓ PCMs can be chemical customized for its purpose
- × Problems if wall is not fully irradiated
- × New technology

## *Insulators*

- × Store heat during their phase change
- ✓ In winter conditions, insulators prevent heat to be transferred outside
- × In summer insulators store heat inside
- × Insulators cannot be chemical customized for its purpose
- ✓ No problems if wall is not fully irradiated
- ✓ Known technology

# Materials: PCM & Insulator Assembly Methods



**PCMs capsule**

Micro, macro incapsulation; avoid contact with outside

Thermal and acoustic insulation; cheap and moderately effective

**Insufflated Insulators**

**PCMs layer**


Simple solution; it can be integrated in specific brick

Lightweight, long lasting; non-fireproof

**Insulators layer**

# Building simulation

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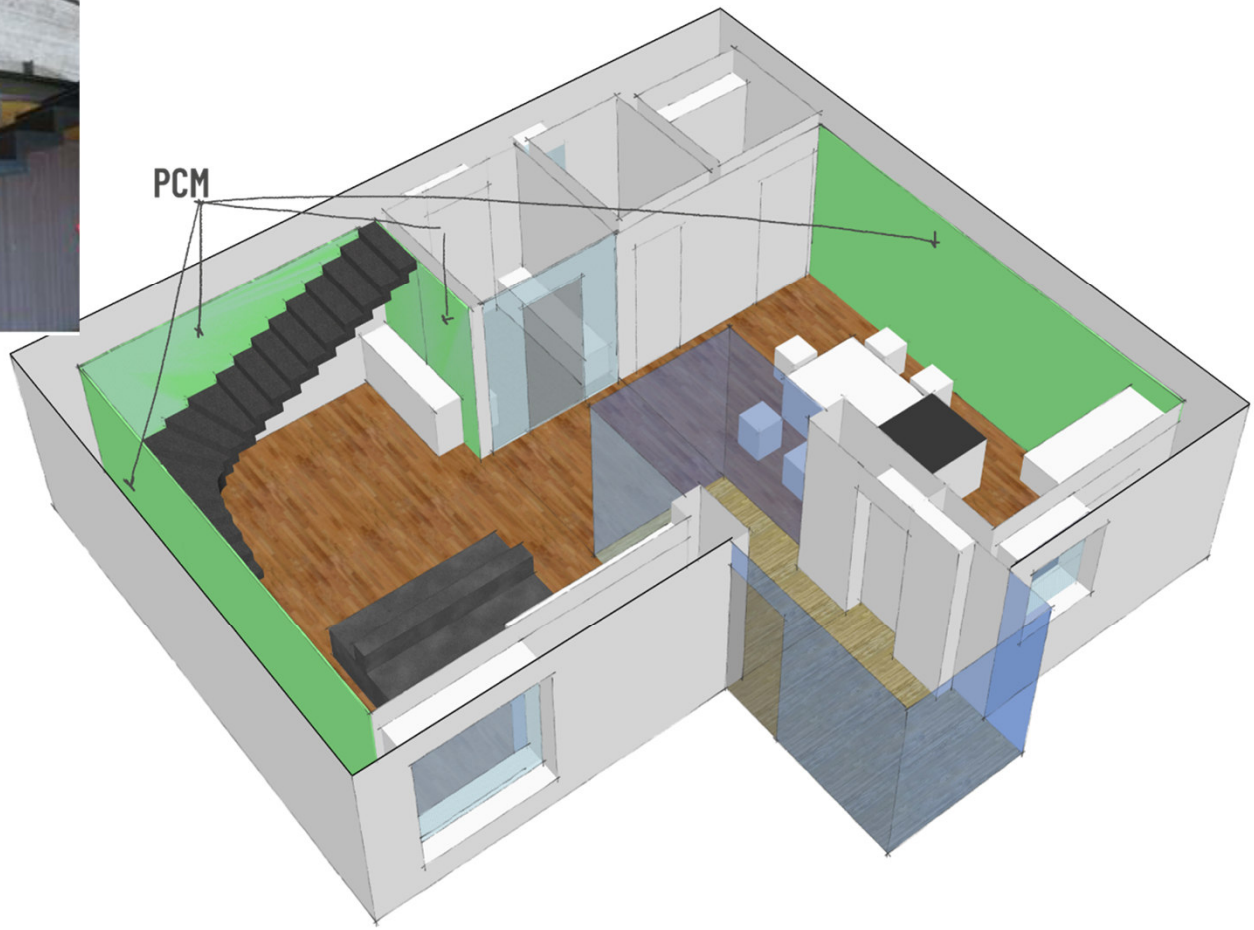
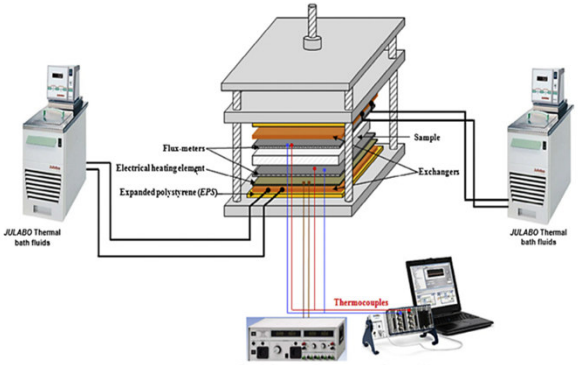


# PCM Model for 3D Simulation

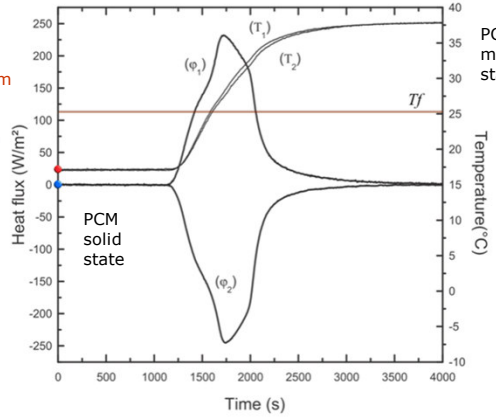


Karkri et al., Thermal properties of smart microencapsulated paraffin/plaster composites for the thermal regulations of buildings. Energy and Buildings 88 (2015): 183-192.




Imposed T: top and bottom of the sample

Heat flux from simulation




Plaster/Micronal (70/30)

Tf melting temperature
T1 temperature on surface 1 (top)
T2 temperature on surface 2 (bottom)
φ1 heat flux on surface 1 (top)
φ2 heat flux on surface 2 (bottom)

## PCM computational model

**Momentum equation**

*buoyancy source term*

$$\rho_0 \frac{\partial \boldsymbol{v}}{\partial t} + \rho_0 \nabla \cdot (\boldsymbol{v}\boldsymbol{v}) = -\nabla p + \mu_0 \nabla^2 \boldsymbol{v} + \boldsymbol{S}_b + \boldsymbol{S}_d$$

*Source term to force **v**=0 in the solid region*

**Energy equation**

$$\rho c_p \frac{\partial T}{\partial t} + \rho c_p \nabla \cdot (\boldsymbol{v} T) = \nabla \cdot (k \nabla T) - S_h$$

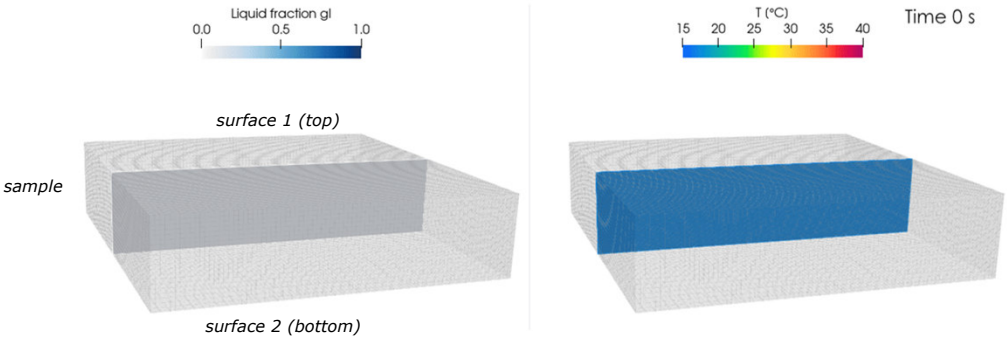
where

*Latent heat*

*Liquid fraction (0 all solid, 1 all liquid), depending on the melting temperature Tf*

$$S_h = \rho_0 L_f \left[ \frac{\partial g_l}{\partial t} + \nabla \cdot (\boldsymbol{v} g_l) \right]$$

Source term to release latent heat during solidification



# CFD Simulation of Indoor Environment

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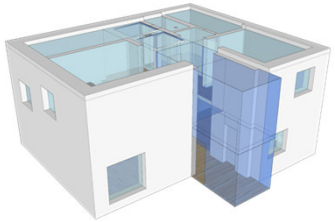
*Bejan et al., The implementation of phase changing materials in energy-efficient buildings. Case study: EFdeN project. Energy Procedia 85 (2016): 52-59.*

*Bejan et al., Indoor environmental quality experimental studies in an energy-efficient building. Case study: EFdeN project. Energy Procedia 112 (2017): 269-276.*

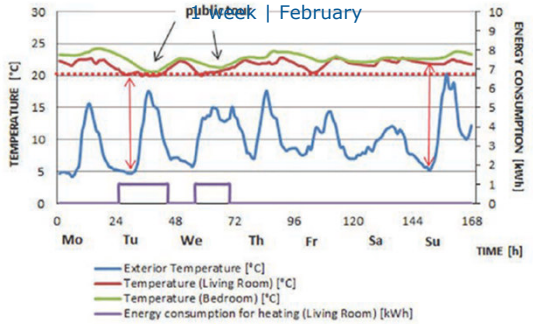


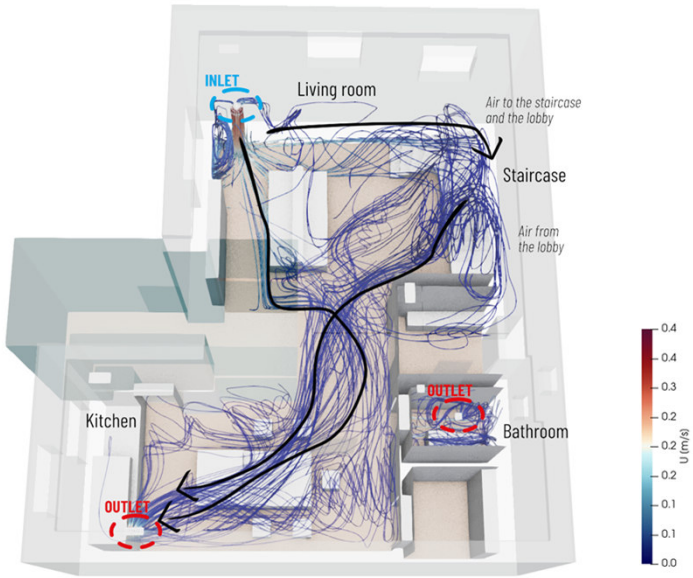
Building size 130 m2

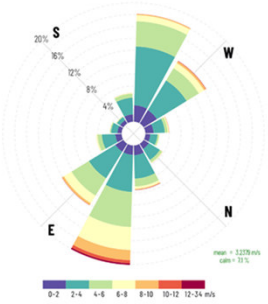
**Passive** strategies

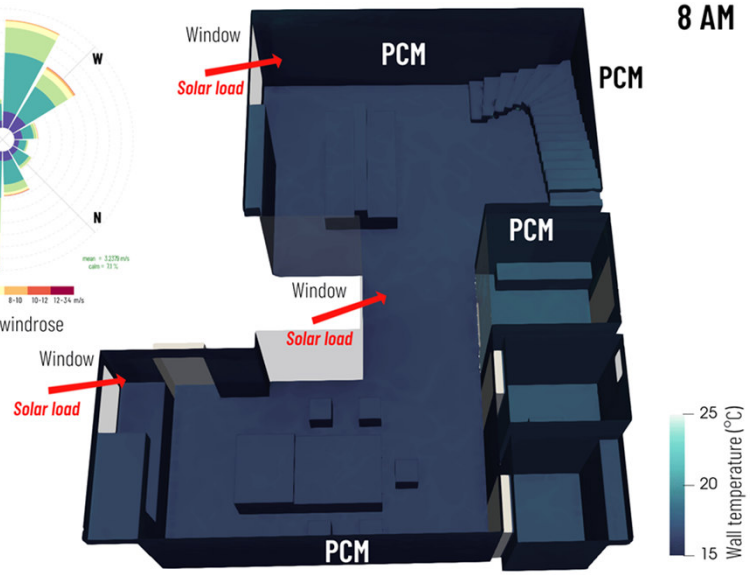
| |
|---|
| PCM |
| Ventilated facade |
| Natural ventilation |
| Greenhouse |
| House orientation |
| Materials |

Typical **measured** **T**



# COMMERCIAL ANALYSIS

# Market Analysis

**I-PCM · IoT-monitored PCM-based Facade for Low-energy Buildings**

**1.04 billion m²/year** to be refurbished in EU

EU construction output to increase by **2.1% in 2020**

| | EUROPE | ITALY |
|---|---|---|
| BUILDING RETROFITTING | € Bn 41.5 | € Bn 7.3 |
| NEW BUILDING CONSTRUCTION | € Bn 6.3 | € Bn 2.7 |
| TOTAL | € Bn 47.8 | € Bn 10.0 |

**FISCAL BONUS** FOR RETROFITTING COSTS IN ITALY

RISKS AND MITIGANTS

| | |
|---|---|
| WELL-REPUTED COMPETITORS | These companies do **not address** the market of **small-to-medium-sized residential buildings**. **Tax incentives** schemes and the growing awareness **create momentum.** |
| CUSTOMER PROXIMITY | We build our network through **partnership, licensing and certification** of local agents. |
| SPENDING ADVERSE INDUSTRY | Tax incentive program for the **existing buildings.**<br>Enforcement of building codes for **new buildings.** |

# Business Model

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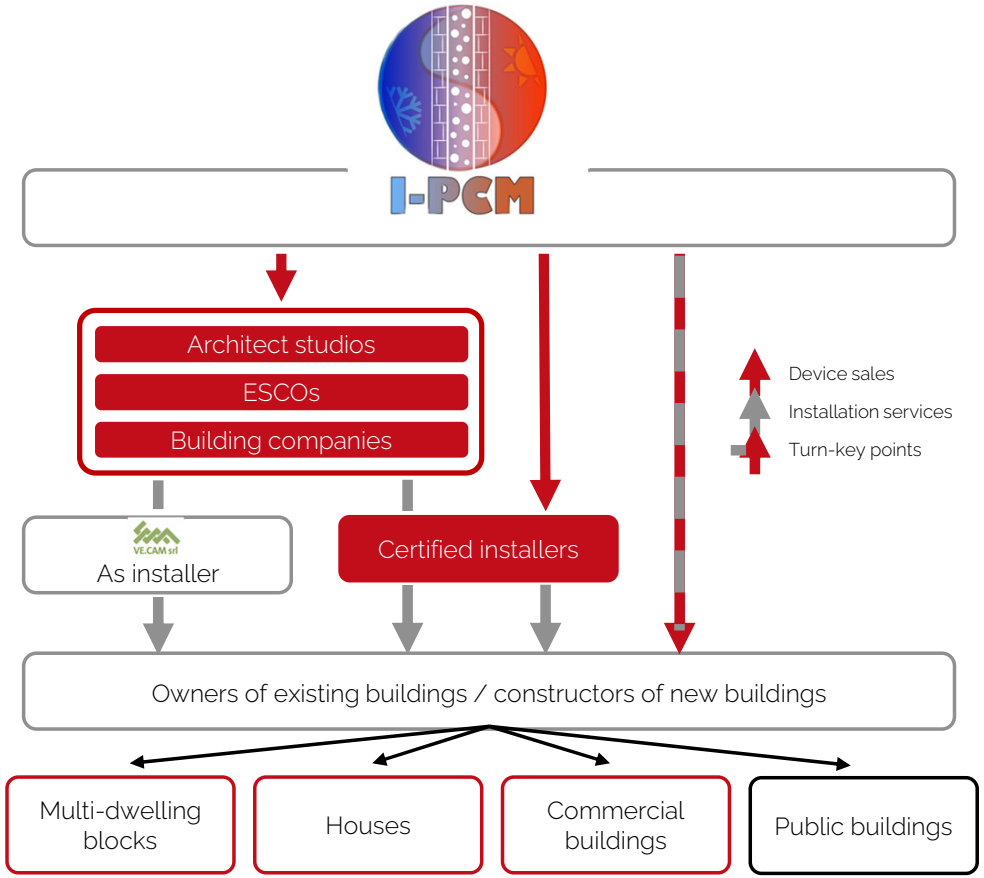

# Consortium

**I-PCM · IoT-monitored PCM-based Facade for Low-energy Buildings**

**Advanced Microturbines** (AMT), an italian company focused on IoT and energy harvesting microturbines.

Role: **Development of ioT system and water microturbine.**

**BuildWind,** a Belgian company specialized in building modeling and simulation.

Role: **Simulation of the PCM-coated building.**

**Ve.Cam,** an italian company, focused on building construction.

Role: **Testing and market analysis.**

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# Thank you for your kind attention

Project :
www.metabuilding-project.eu

Platform :
www.metabuilding.com

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