



# Project Area 15: Sustainable Construction



ISTITUTO PER LE TECNOLOGIE DELLA COSTRUZIONE  
CONSIGLIO NAZIONALE DELLE RICERCHE

Main research activities of ITC-CNR related to PA are aimed at the development of sustainable buildings and cities through the development, analysis and evaluation of building materials, components and systems and through the energy and environmental retrofitting of urban areas.

## BUILDING



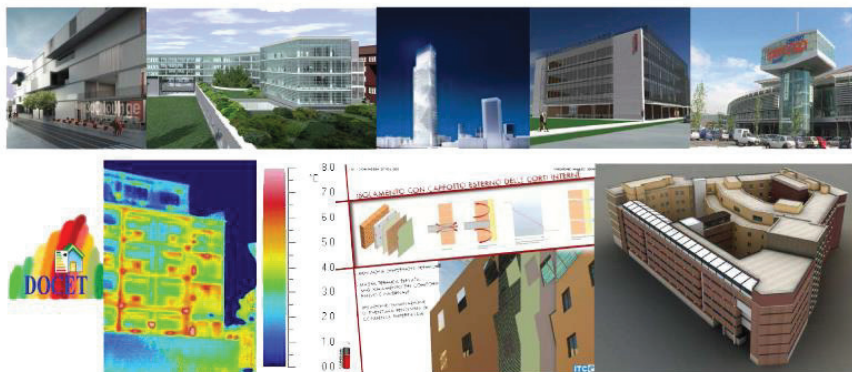
### BUILDING MATERIALS

- **Traditional**  
Analysis of thermal and acoustic performances through experimental methods in certified laboratories (e.g heat flow meter, guarded hot-box , reverberation test room,...) and during building construction referred to national and international technical standards.
- **Innovative**  
Evaluation of energy and comfort performances in real working conditions through outdoor test cells (e.g. Phase-change Material, heat-reflecting membrane, ...)   
Analysis of performances of thin insulating panels, coating products and photocatalytic cementitious materials



### BUILDING COMPONENTS AND PLANTS

- **Opaque and transparent envelope**
- Evaluation of energy and comfort performance in real working conditions through outdoor test cells (e.g. micro-ventilated roof, green roof, electrochromic glass, ventilated glass,...).
- **Plants**
- Analysis and monitoring in real working conditions of energy production, management and distribution systems (e.g co- and polygeneration);
- Analysis and experimentation of solar renewable energy components integrated into the building (e.g. thin film photovoltaic technologies,...);



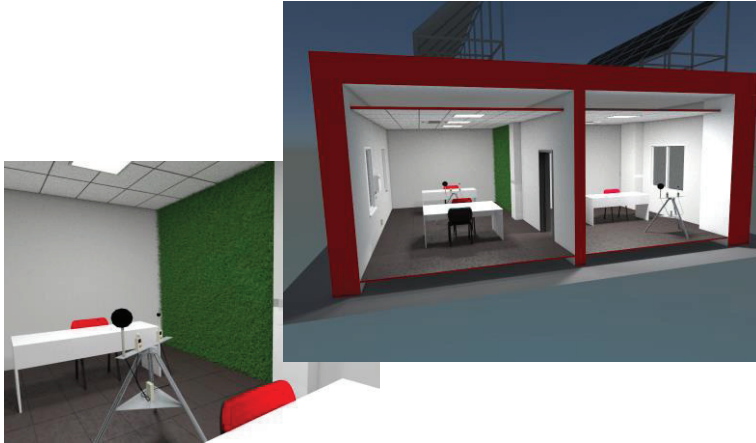
### BUILDING ANALYSIS AND ASSESSMENT SYSTEMS

- Energy audit through Finite Element Analysis and simulations models;
- On-site audit and monitoring of IEQ (Indoor Environmental Quality) performances;
- Technological design solutions with an approach based on Life Cycle Assessment and Life Cycle Costing analysis;
- Energy audit and calculation tools for all intended uses;
- Building environmental sustainability assessment tools for all intended uses.

## CITY



## ACTIVE PROJECTS AND RESEARCH TOPICS



- **Towards Intelligent Zero Energy Buildings for a smart city growth: I-ZEB.**  
Ref. ITC with ICMATE, IFN, IFP, IMATI, IMM, IRCRES, IRSA, ISMAC, ISTM, ITIA

Innovative infrastructure for verifying the functional-seismic resistance of facades



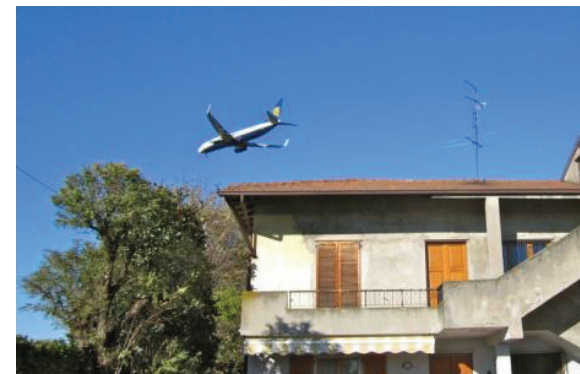
- **RIGERS City regeneration: smart building and grid.** Ref. ICIE with ITC, CPL, Sacmi, Sata, Alma Mater Studiorum



GIS Maps for consumptions, comfort, SRI and heat island effects.



- **SACBO Planning support and verification of interventions of sound insulation improvement**  
Ref. ITC with SACBO

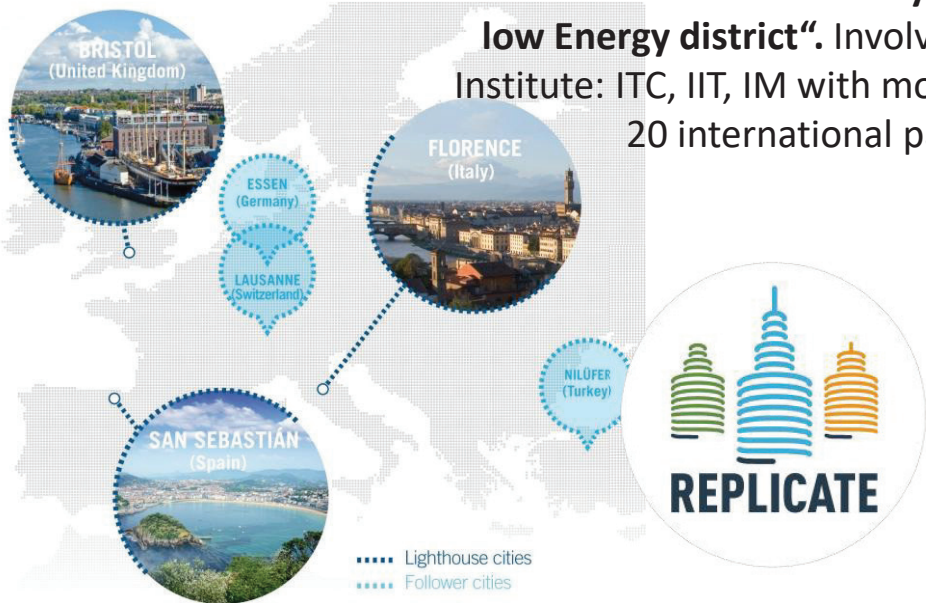


Acoustic renovation of building facades against aircraft traffic noise



## ACTIVE PROJECTS AND RESEARCH TOPICS

- **H2020 REPLICATE "Nearly zero or low Energy district"**. Involved CNR Institute: ITC, IIT, IM with more than 20 international partners.



- **Program Agreement MIUR-CNR - Rational use of energy in buildings. Energy and environmental retrofitting of court in Vibo Valentia (VB).** Ref. ITC with ICIE, ITAE

Thermal and energy performance evaluation of green roofs— ITC with IRSA



- **Future Home for Future Communities (FHfFC)** Ref. ITIA with ITC, IMATI, IREA, IBBA, IFN, IPCB, IBFM, INO, ICMATE

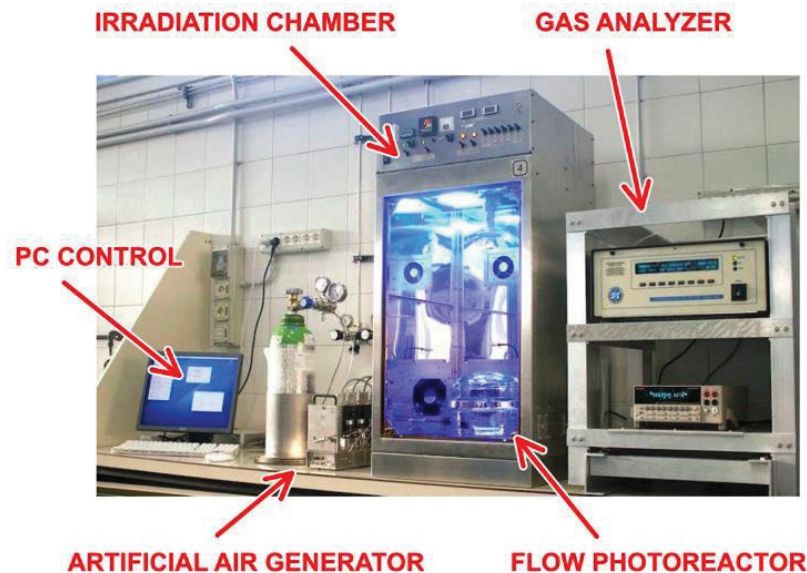
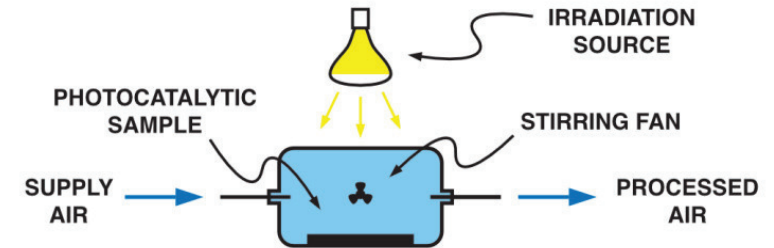


## ACTIVE PROJECTS AND RESEARCH TOPICS

### HETEROGENEOUS PHOTOCATALYSIS

CHEMICAL REACTIONS CATALYZED BY LIGHT AND SOLID PHOTOCATALYSTS

- Sustainable technology for air and water depollution and for green chemistry processes
- Needs of specific instruments for the study of photocatalytic materials performance



### MAIN ACTIVITIES

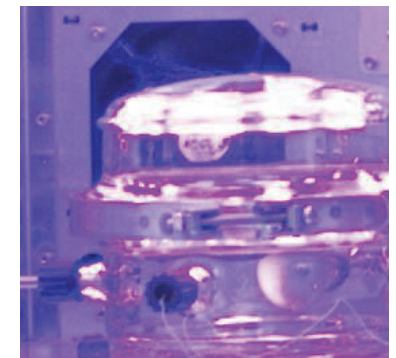
DEVELOPMENT OF SPECIALIZED ANALYTICAL SYSTEMS FOR PHOTOCATALYTIC ACTIVITY MEASUREMENTS

- Advanced measurement of photocatalytic air depollution with a state-of-the-art, specifically developed analytical system
- Activity studies of nanostructured photocatalysts in air and water for special photocatalytic materials development
- Study of water-based photocatalytic oxidation processes of natural products

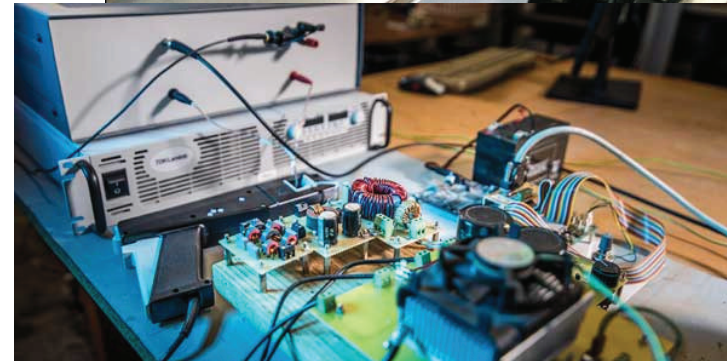
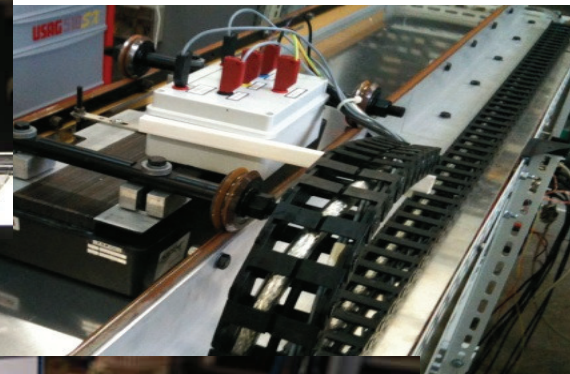
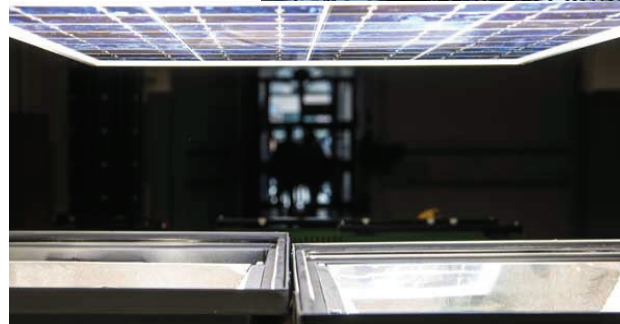
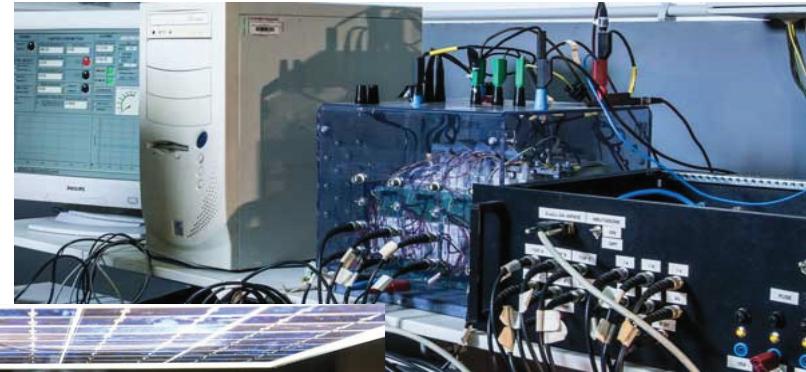
### POSSIBLE APPLICATIONS

DEVELOPMENT OF HIGH EFFICIENCY PHOTOCATALYSTS OPERATING IN UV AND VISIBLE LIGHT

- Special photocatalysts for sustainable construction materials for outdoor and indoor applications
- Air and water depollution by special photocatalytic technologies
- Photocatalysis-based advanced oxidation processes (AOP) for waste water treatments







**PA-related activities of the Institute:**

Development of methodologies, technologies and energy conversion systems supporting the implementation of novel paradigms for generation, distribution and efficient use of electrical energy, i.e., *Smart Grid*, **Smart Building**, *Smart Vehicle*, *Smart Factory*.

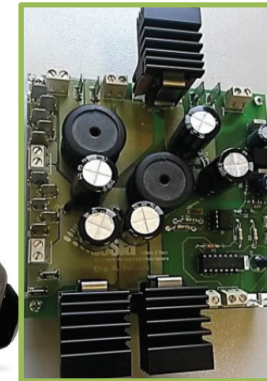
## POWER ELECTRONIC CONVERTERS FOR BUILDING APPLICATIONS

APPLICATIONS: battery integration, renewables integration, vehicle integration, ...

Design and experimental prototyping of several typologies/topologies of power electronic converters with high dynamic performance, high efficiency, high power density and reliability for interfacing the building electric power plant with the main power network, renewables and storage systems.



Half-bridge interleaved bidirectional converter for storage systems integration in building electrical power plants.



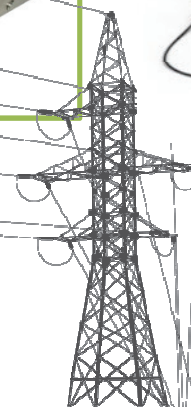
DC/DC power converter for photovoltaic generator integration



3-level neutral point clamped (NPC) Voltage Source Inverter (20 kW)



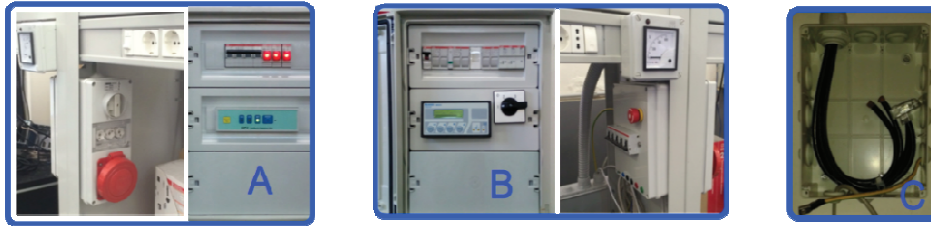
Dual half-bridge converter



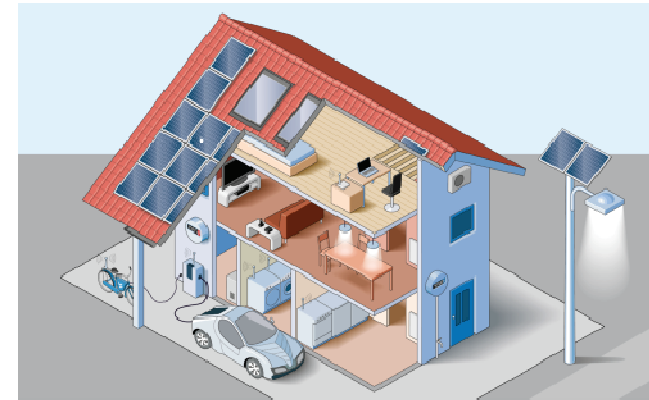
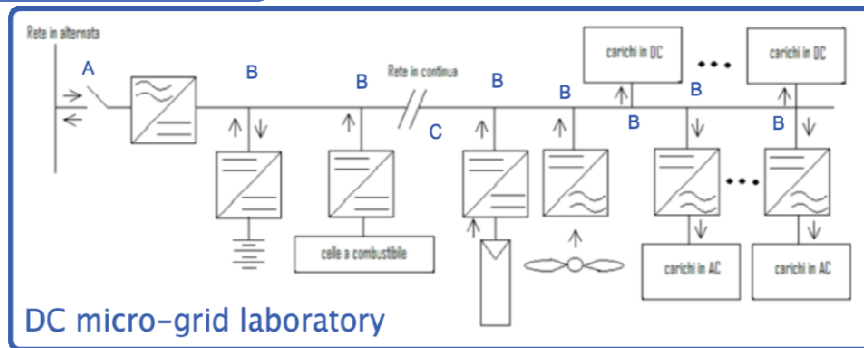


## DC NANOGRIDS/MICROGRIDS FOR BUILDING APPLICATIONS

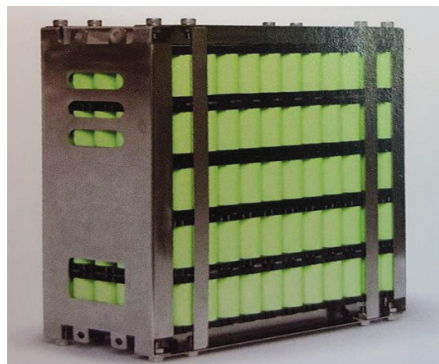
Definition of novel architectures for the electric energy distribution in buildings (both commercial and residential): DC and hybrid AC/DC distribution systems.



*A 3kW lab prototype of a DC distribution nanogrid for building application connected to the national power grid is available for research and testing.*



Battery



DC power source



Bidirectional DC/DC battery converter

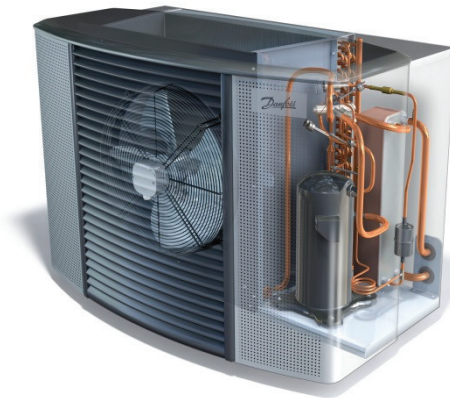


Programmable electronic load

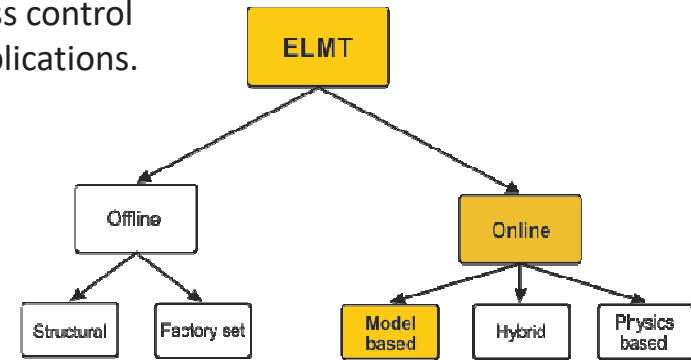


## ENERGY EFFICIENCY OF ELECTRICAL DRIVES FOR BUILDING APPLICATIONS

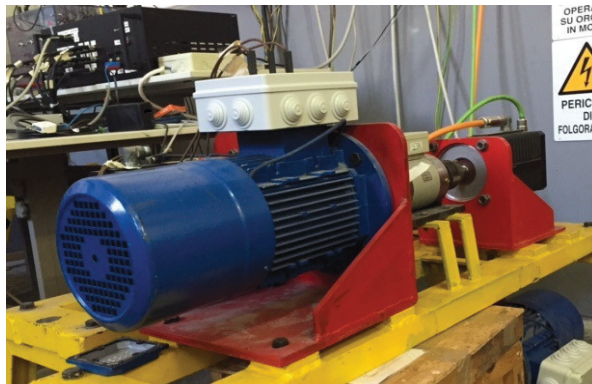
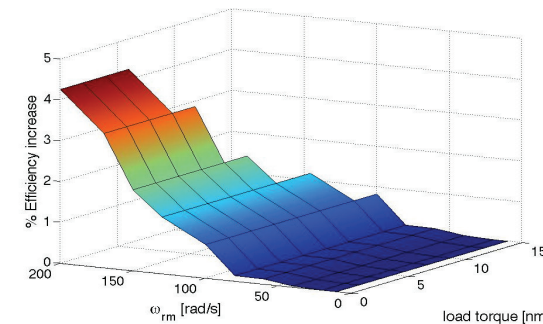
Development and implementation of appropriate online minimum loss control techniques to optimize operation of motor drives used in building applications.



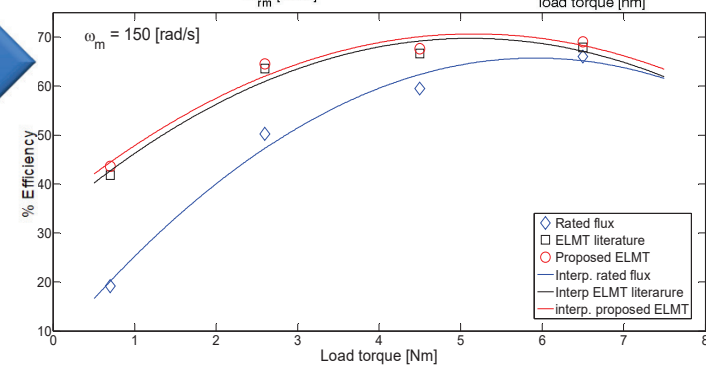
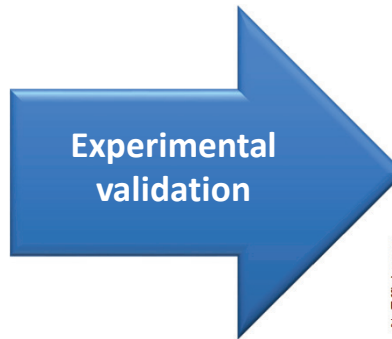
Potential applications: elevators, heat pumps, ...



Electric loss minimization techniques



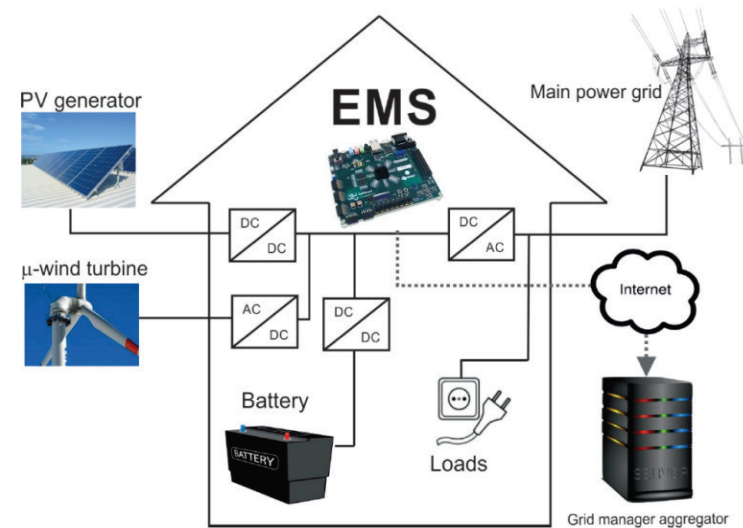
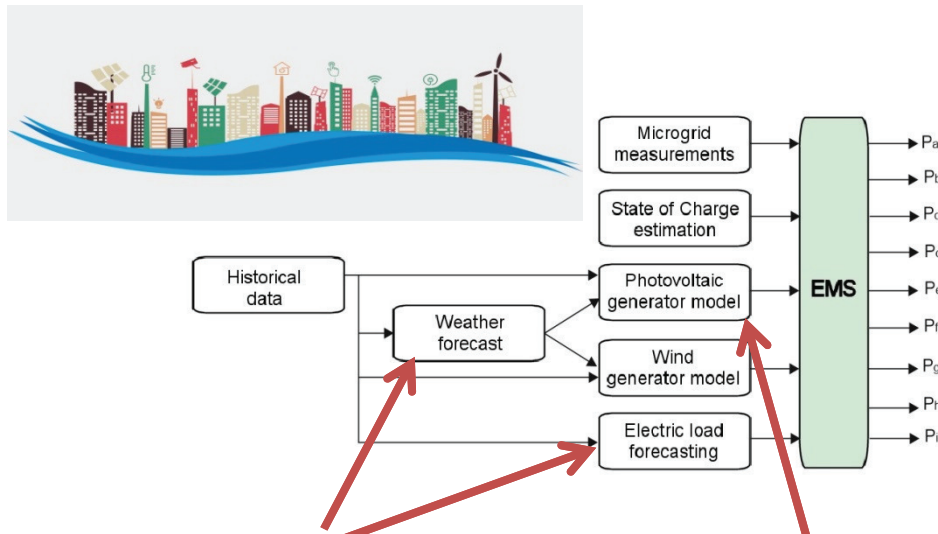
Laboratory test bench



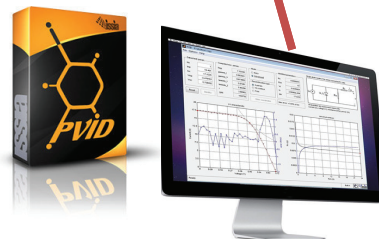


## INTELLIGENT MANAGEMENT OF ELECTRICAL ENERGY IN BUILDINGS: ENERGY MANAGEMENT SYSTEM (EMS)

Development of methodologies and systems for the optimal and coordinated management of building electrical power plants' components, including: renewable generators, storage systems, loads, main power grid connection. Implementation of the energy management algorithms on embedded platforms (FPGA, micro-controllers).



Power production and load demand forecasting: algorithms for embedded implementation and online operation.

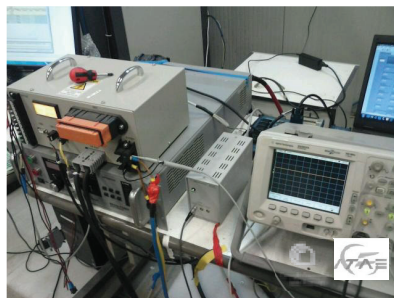


Online parameter identification of PV models on low cost embedded platforms

### EMS capabilities

- Minimum user's cash-flow
- Demand response
- Peak shaving
- Maximum electrical self-sufficiency
- Support to the grid manager policy
- etc.

# THE INSTITUTE



FUEL CELLS AND HYDROGEN  
JOINT UNDERTAKING



## FUEL CELL SYSTEMS

### SOFC 2.5 kW CHP system

Results: performance test and long run test (1,000 hours)  
Life Cycle Assessment



Pel [W]	Pth [W]	Eff.el. [%]	Eff.th . [%]	Eff.tot. (CHP) [%]
2,000	2,700	38%	38%	83%
2,500	3,000	45%	38%	83%
2,800	3,400	83%	40%	88%

### SOFC 1.5 kW new generation CHP system

Results: performance test and long run test (3,000 hours)  
Availability: 100%  
Life Cycle Assessment



Pel [W]	Pth [W]	Max el. ff. [%]	Avg. el. ff. [%]
1,500	530	62%	53%

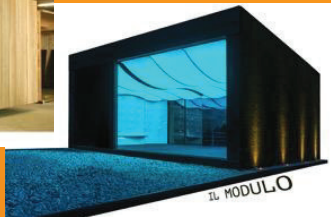
## SMART BUILDING

Innovative, multifunctional buildings and Advanced prefabrication systems  
 Expected outcomes: energy efficient buildings integrating RES, storage and domotics  
 Results: prototypes of innovative smart buildings developed with SMEs



WOOD  
 T-Domus concept  
 (TIME-TEMPORARY-TRANSPORTABILITY)

PULTRUDED GLASS  
 REINFORCED PLASTIC



IL MODULO

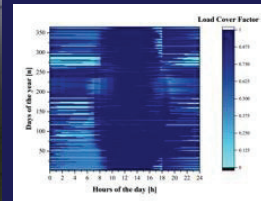
Thermophysical modeling and LCA studies

## SMART BUILDING

Net Zero Energy Building - Grid Interaction  
 Expected outcomes: optimization of interaction between the power grid and Smart Buildings  
 Results: prototypes of innovative smart active buildings supporting smart (micro) grids



Batts + Fuel Cell



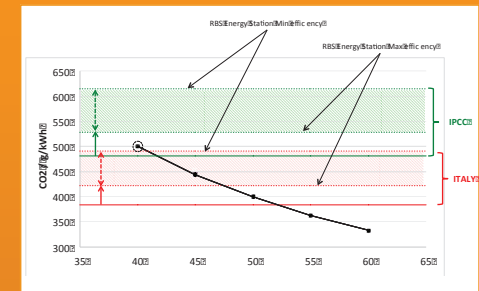
Modelling and experimental analysis of the building/grid interaction and set-up of algorithms for the energy efficiency and optimal integration (IEA Task 40 - Annex 52)

## HYBRID SYSTEMS

10 kW SOFC/SNC hybrid system for telecom/datacenter  
 Results: Life Cycle Assessment



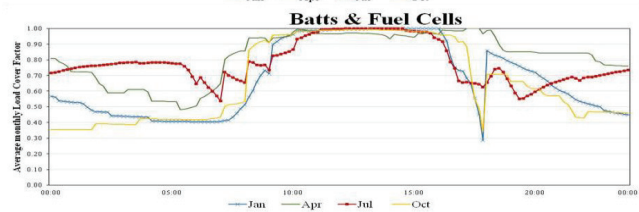
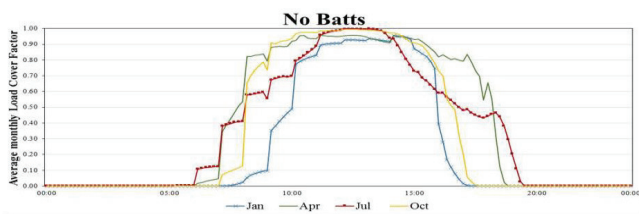
Evaluation of economical and environmental aspects





# Targets Development and advanced prefabrication of innovative, multifunctional building

- LOW COST
- EASY TO INSTALL
- ENVIRONMENTAL FOOTPRINT
- NZEB
- MICRO GRID FOR RURAL AREAS
- SMART GRID FOR URBAN AREAS

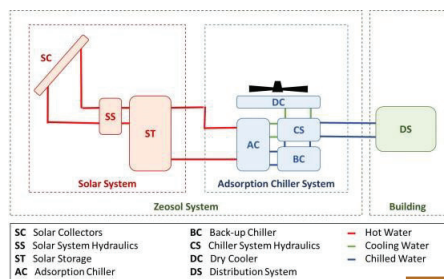


## H202 project ZeoSol (GRANT AGREEMENT N:760210)



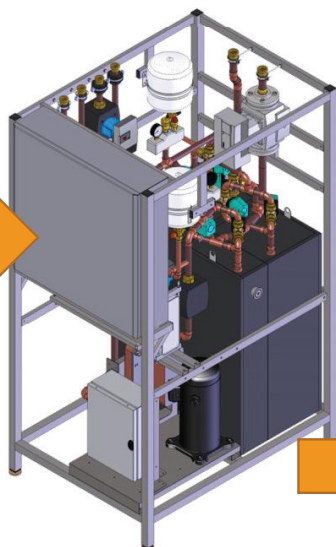
Horizon 2020  
European Union funding  
for Research & Innovation

Integrated solar heating and cooling unit based on a novel zeolite chiller and heat pump

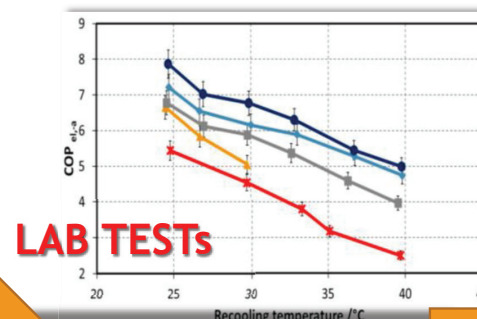
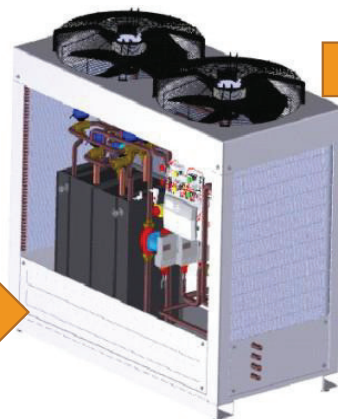


CONCEPT

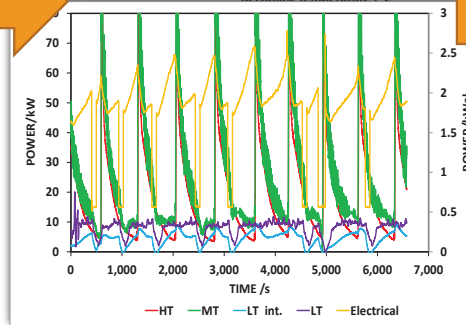
PROTOTYPE



INTEGRATED UNIT



LAB TESTS



DEMO-SITE

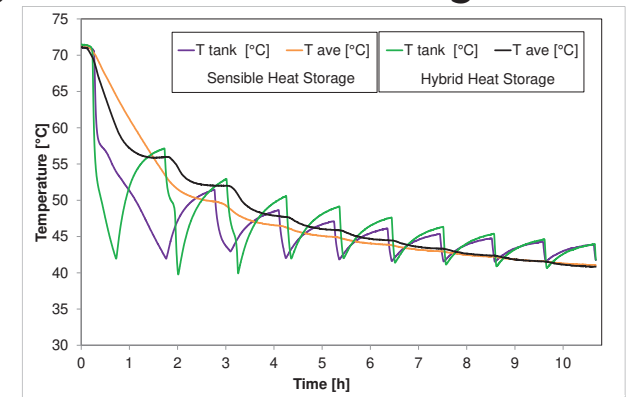
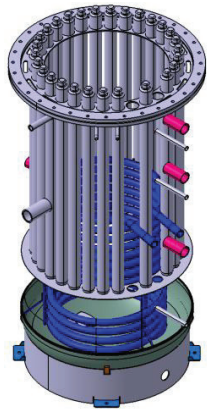


National Technical University of Athens

Athens

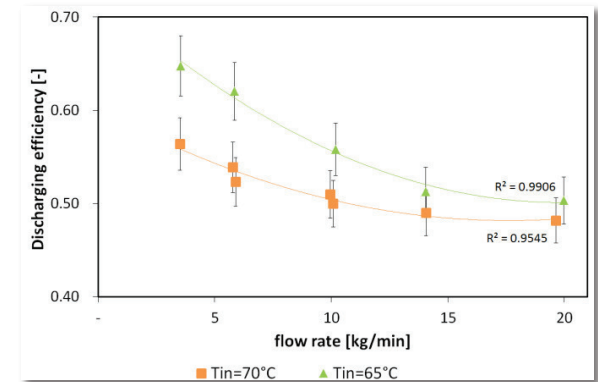
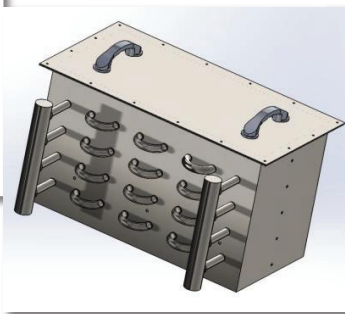
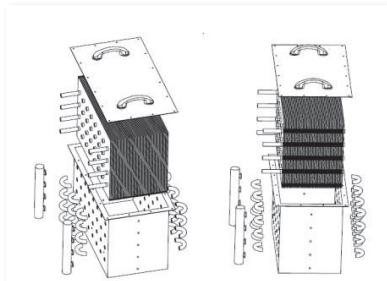


## Development of innovative solutions for thermal energy storage in buildings based on latent storage technology



### PERFORMANCE EVALUATION

### DESIGN/ REALIZATION



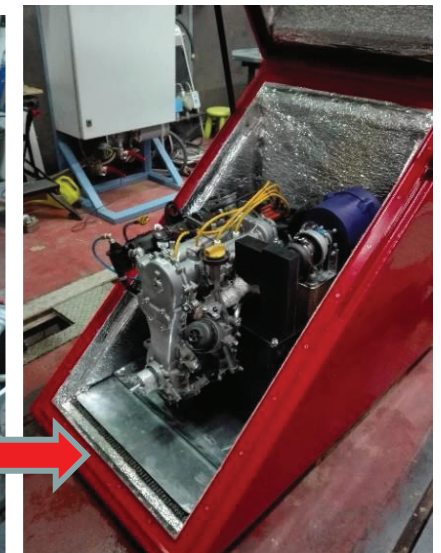
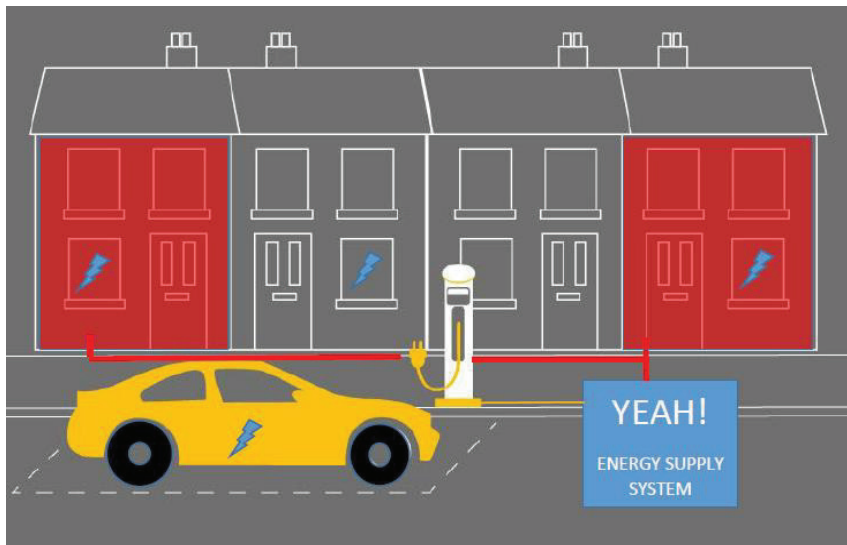
# THE INSTITUTE





# DESIGN AND CONSTRUCTION OF NEW SMALL MICROCOGENERATION POWERPLANTS

Development of small high efficiency cogeneration, low-cost units, based on internal combustion engine and Organic Rankine Cycle for building electricity and heat supply and efficient charging of electric vehicles





- Development of new design heat exchangers and recovery systems (for high efficiency, low noise, low corrosion)
- Multistage catalyst with special structure
- Design of induction generators and traction motors with innovative cooling systems
- Innovative ignition systems for extra low turbulence engines
- Development of dedicated solid/liquid nanostructured lubricants tested on innovative self made tribometers

