

SPOKE 6 - Tecnologie per l'incremento delle fonti rinnovabili in rete

Spoke 6 Team

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DOTTORATO TRANSIZIONE ECOLOGICA



GRINS FOUNDATION



Funded by the European Union NextGenerationEU



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Introduzione

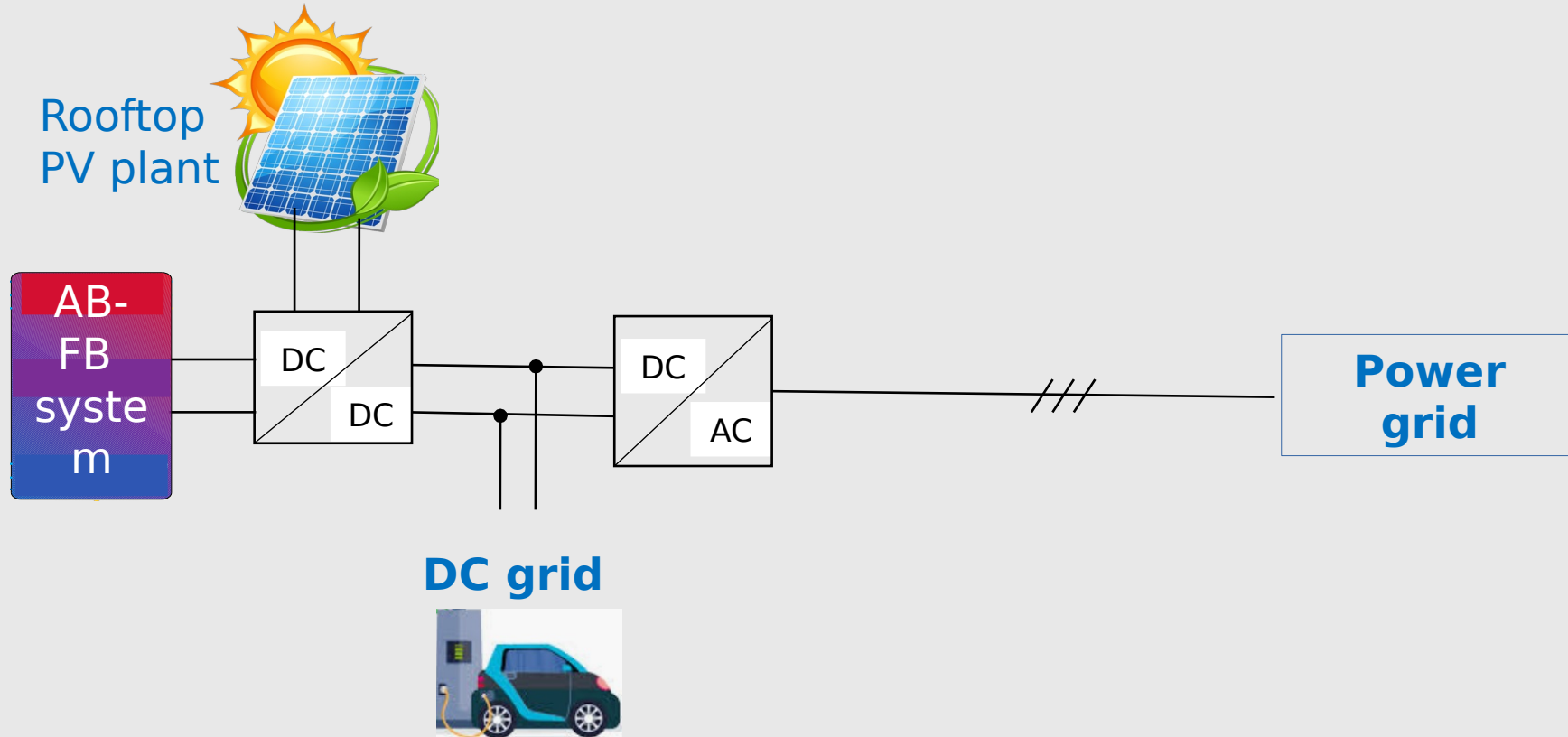
La transizione energetica necessita di un sempre maggiore impiego delle fonti rinnovabili per produrre energia elettrica a zero emissioni.



Tuttavia, numerose sfide emergono in tale contesto, soprattutto relative alla gestione di una rete elettrica in continua evoluzione. Per affrontare tali sfide è necessario sviluppare tecnologie hardware e software innovative. In tale ambito, dunque, l'attività di ricerca è fondamentale per conseguire l'obiettivo di decarbonizzazione del sistema elettrico.

Attività di ricerca

A system (see fig.) for Light-Commercial applications, integrating an AB-FB based energy storage system with a rooftop PV plant could be designed and built, in order to test the behavior of the AB-FB in a real grid scenario.



Attività di ricerca

In particolare, nel nostro laboratorio ci occupiamo del controllo di inverter, ovvero dispositivi che vengono utilizzati per interfacciare gli impianti di produzione da pannelli fotovoltaici alla rete.

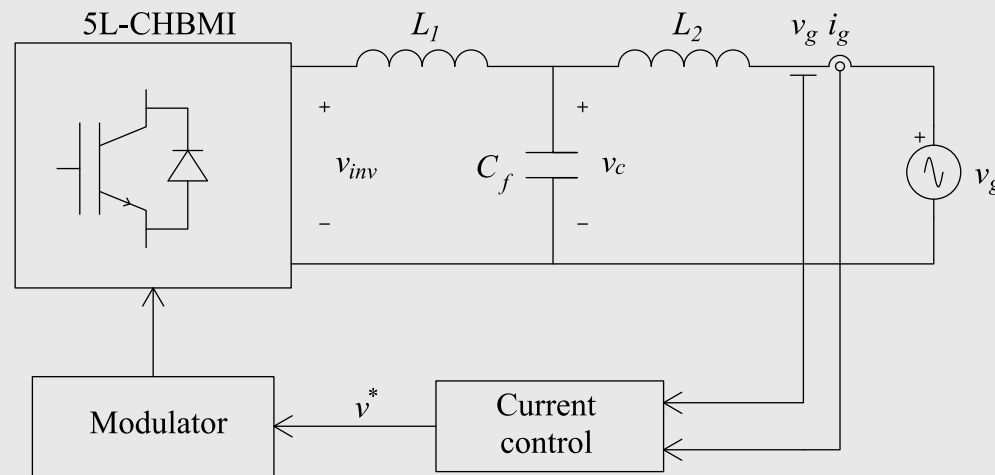
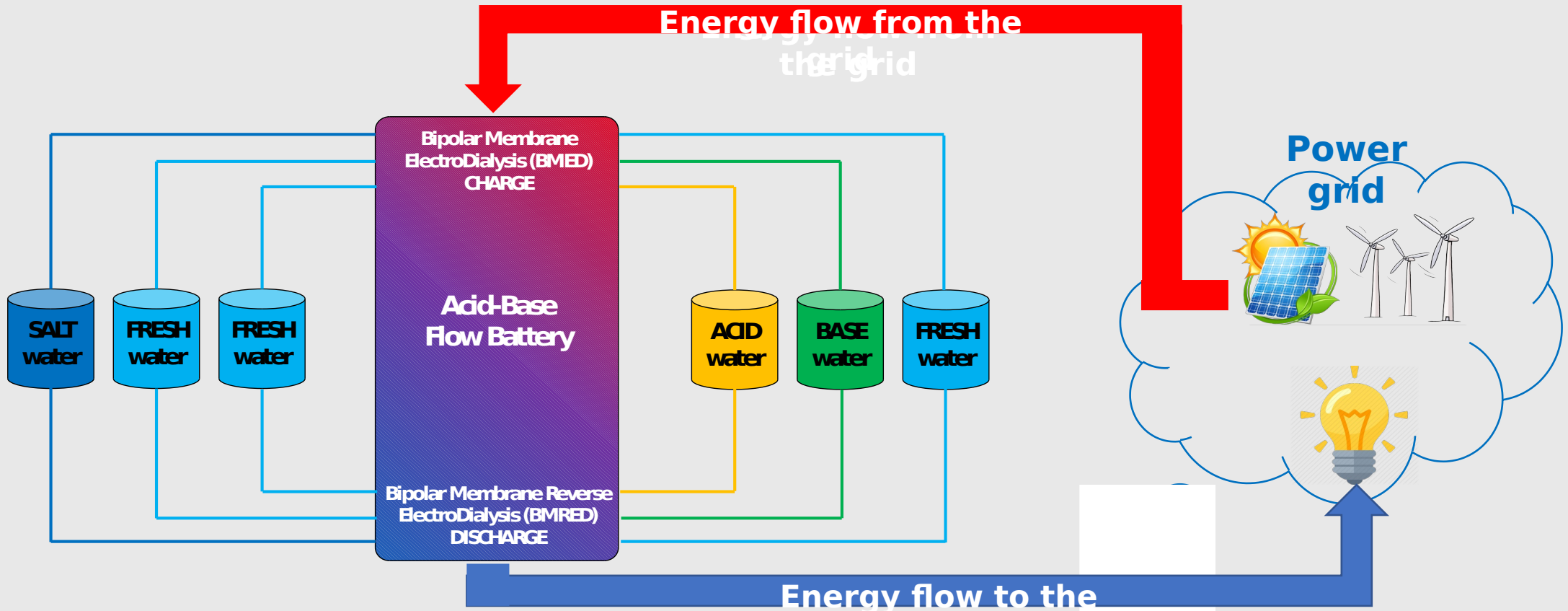


Fig. 1. Schema di un inverter connesso alla rete.

Attività di ricerca

THE ACID/BASE FLOW BATTERY (AB-FB) NEW TECHNOLOGY



Operation principle of the AB-FB tech.

Attività di ricerca



- It is an **environmentally friendly tech., without issues regarding operation safety** ^[1] (since it does not use dangerous storage mediums and pollutants for its operation)
- **Wide availability of raw materials for mass production of this tech.** (since only water solutions and membranes are needed)
- **Extremely flexible and modular design** of an AB-FB system
- **Desirable durability** (since no storage medium degradation should occur)
- **Economically promising tech.**, with a good trade-off in terms of energy density and cost, **in competition with the leading technology for large-scale energy storage** ^[1]
- **Very low self-discharge rate;** this aspect makes the technology **suitable also for a long-term energy storage** (such as an inter-seasonal storage, for instance useful in the case of integration with PV systems).

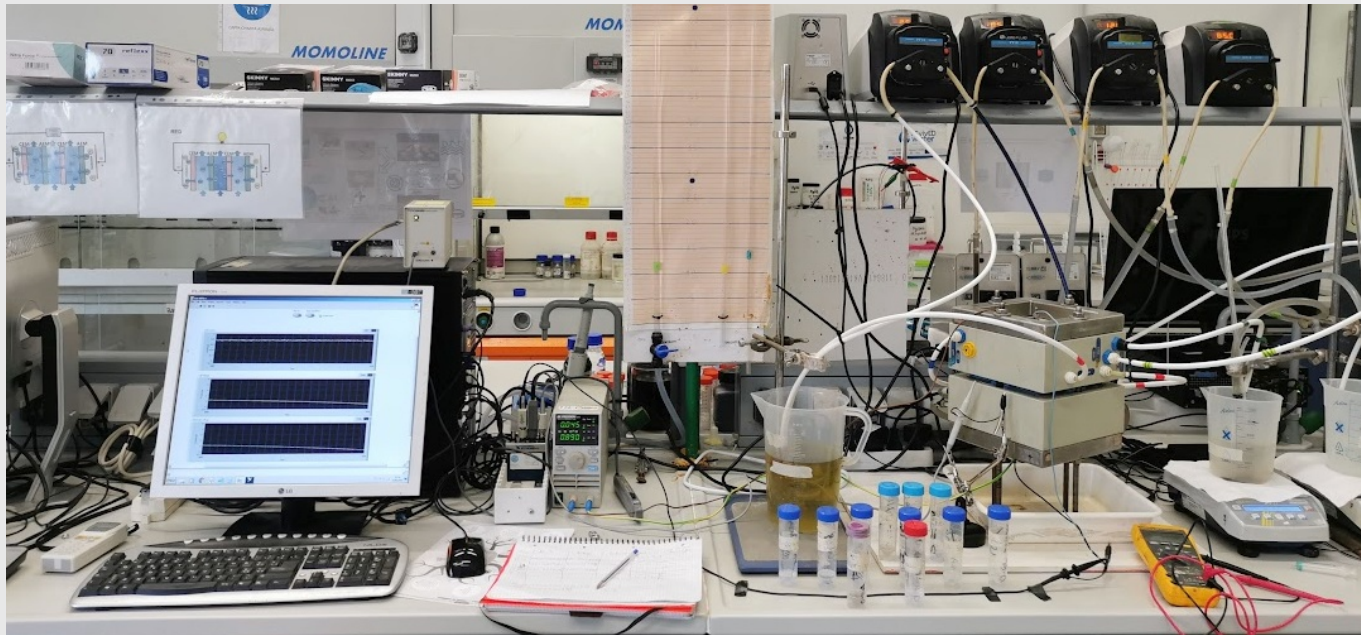
Attività di ricerca



The UNIPA researchers, involved in the NEST project, in the fields of electrical and chemical engineering are working in close collaboration to carry on the research activities in the context of the SPOKE 6 of the project.

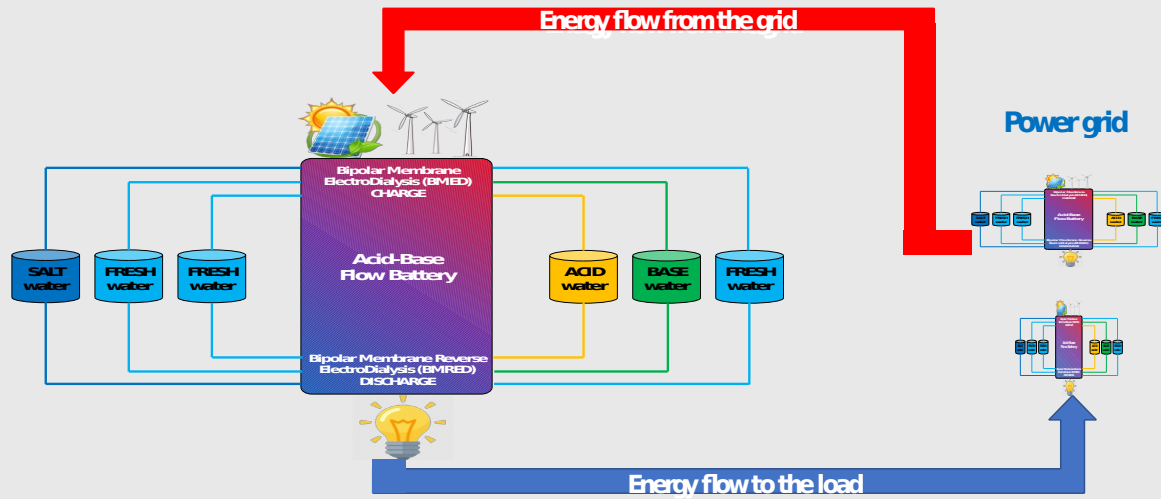
Currently, the following main activities are in progress:

- modeling and testing of an AB-FB lab-scale unit, aimed at the electrical characterization of such an innovative electrochemical ESS;
- semi-experimental activities regarding innovative control strategies for controlling three-phase grid connected inverter.



Overview of the experimental set-up for testing the AB-FB lab-scale unit (mounted at "Laboratorio di teoria dello Sviluppo dei Processi Chimici", Viale delle Scienze Ed. 6)

THE ACID/BASE FLOW BATTERY



AB-FB as innovative and sustainable Energy Storage System

Energy stored as pH and salinity gradient

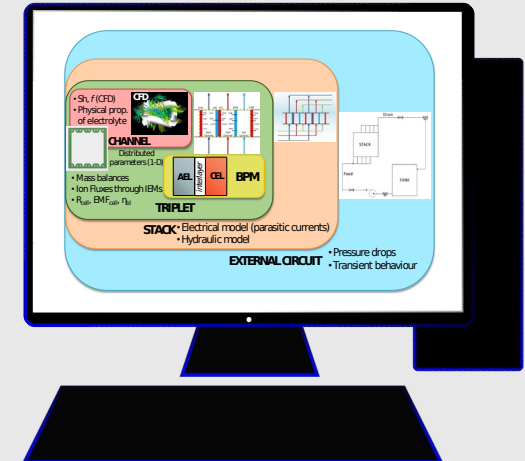
METHODOLOGY

Experimental testing



An original experimental campaign was carried out using an AB-FB unit provided by Fumatech®

Process modelling

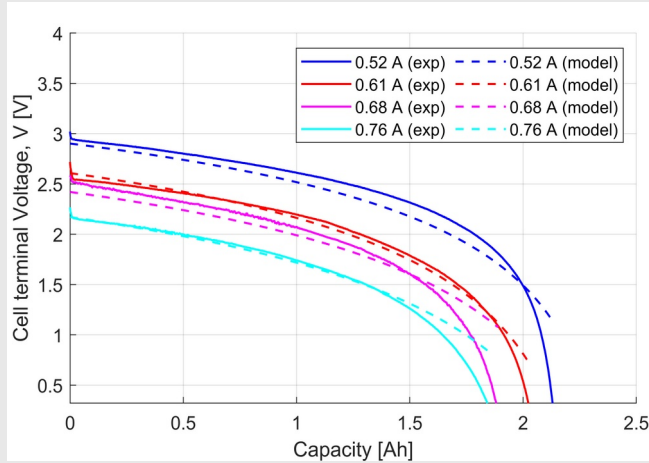


A multi-scale model was used to predict the behavior of the AB-FB

AIMS

- Comparison between the use of the electrochemical model and the Rint model for the prediction of the electrical variables;
- Experimental investigation of the AB-FB for enhancing the energy density.

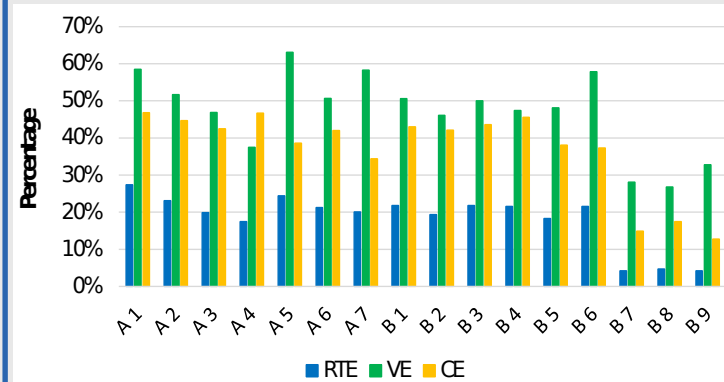
RESULTS Experimental results VS model prediction



- The model was validated across a range of currents from 52 to 76 A/m²;
- Data were recently published in IEEE Access.

RESEARCH ARTICLE
Electrical Characterization and Modeling of an Innovative Acid/Base Flow Battery
 FABIO RICCO GALLUZZO, NICOLA CAMPAGNA (Member, IEEE), ANDREA CULCASI, ALESSANDRO TAMBURINI, ANTONINO OSCAR DI TOMMASO, GIORGIO MICALE, AND ROSARIO MICELI (Member, IEEE)
 Department of Engineering, University of Palermo, 90128 Palermo, Italy

Lab-scale investigation to enhance AB-FB performance



- Tests were carried out under various operating conditions;
- Two different types of ion exchange membranes were used.

REMARKS

- A simulation tool was validated across different electric currents;
- A best set of process conditions were identified to improve the battery Round Trip Efficiency, Energy density and Power density.

...AND WORK IN PROGRESS

- Testing at higher acid/base concentrations to further improve the energy density;
- Investigation using multi-ionic feeds.

The following future activities and perspectives are foreseen hopefully:

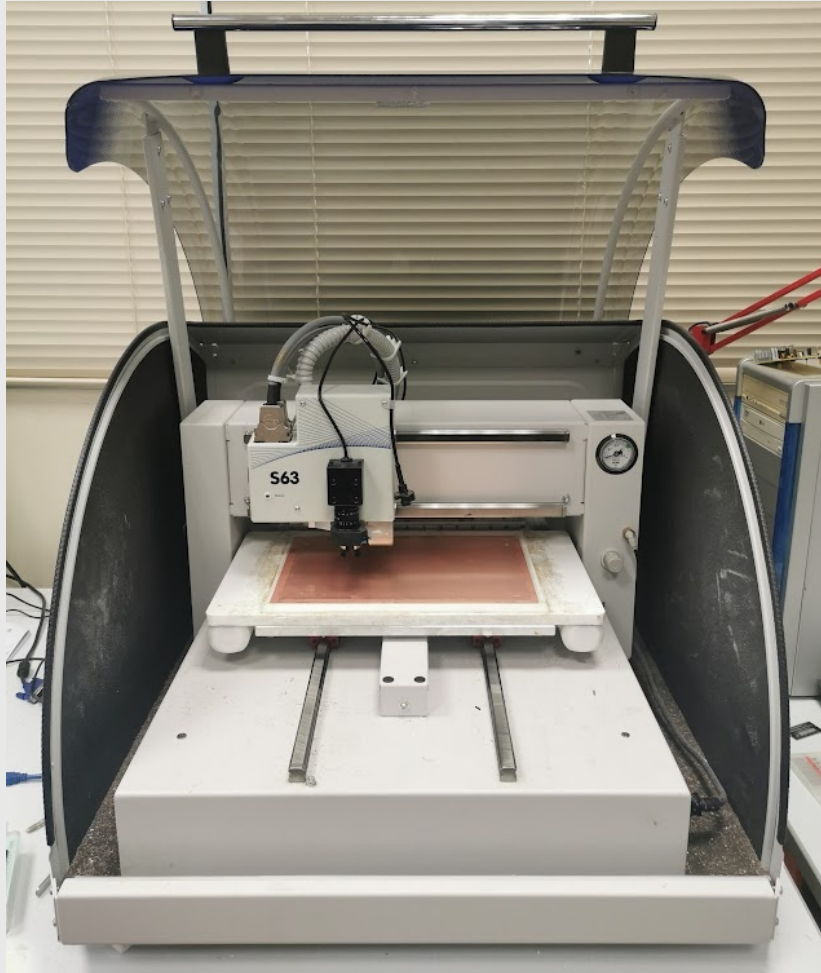
- realization at UNIPA of an AB-FB pilot-scale prototype (with rated power of the order of some hundreds of Watt in discharge phase) (similar to the one shown in fig.),
- integration and testing of such pilot-scale prototype in a real micro-grid scenario.

EDBM pilot-scale system available at "Laboratorio Grandi Esperienze" - UNIPA (Viale delle Scienze, Ed. 6)





AVAILABLE EQUIPMENT AT THE RPLAB-RAPID PROTOTYPING LABORATORY OF UNIPA (Viale delle Scienze, Ed. 9)



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Ulteriori temi di ricerca:

1. **Materiali per applicazioni termoelettriche**
2. **Materiali per l'economia a idrogeno**
3. **Materiali per la catalisi eterogenea**

13 Member States

- 27.5% France
- 24% Germany
- 13.2% Italy
- 10.5% United Kingdom
- 6% Russia
- 5.8% Benesync (Belgium, The Netherlands)
- 5% Nordsync (Denmark, Finland, Norway, Sweden)
- 4% Spain
- 4% Switzerland

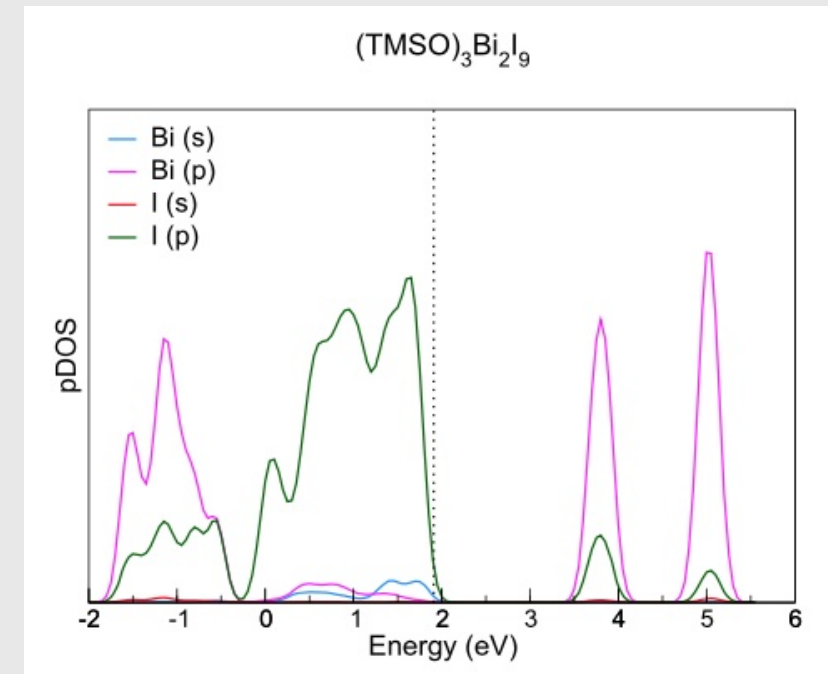
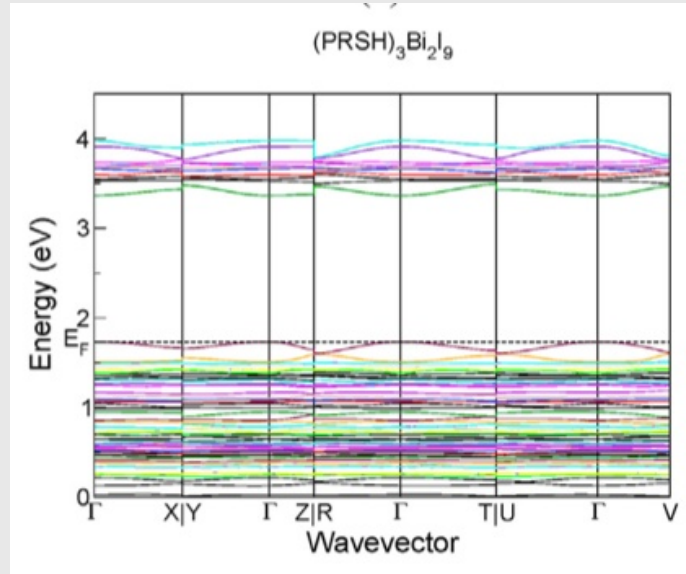
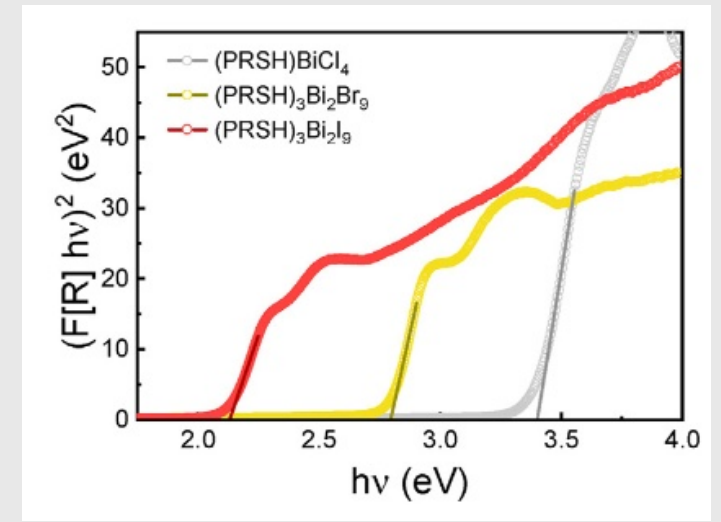
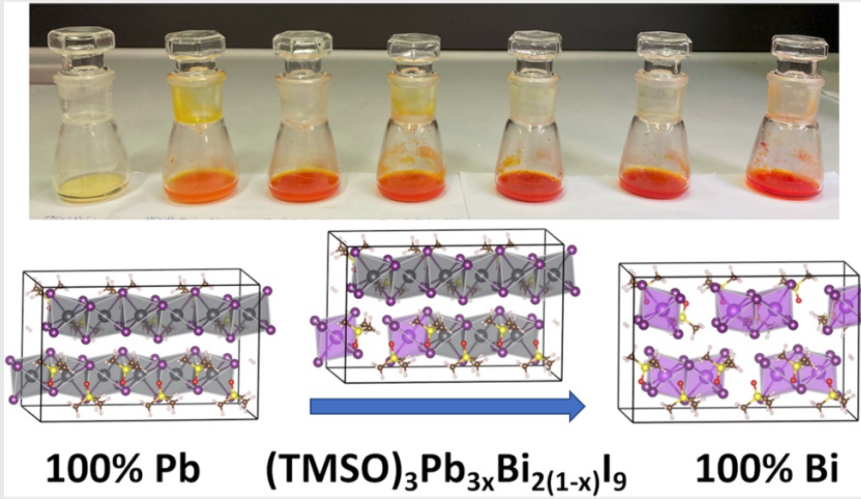


Linee di luce
 (beamlines)

European Synchrotron Radiation Facility (ESRF) – Grenoble, Francia

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Materiali per applicazioni termoelettriche



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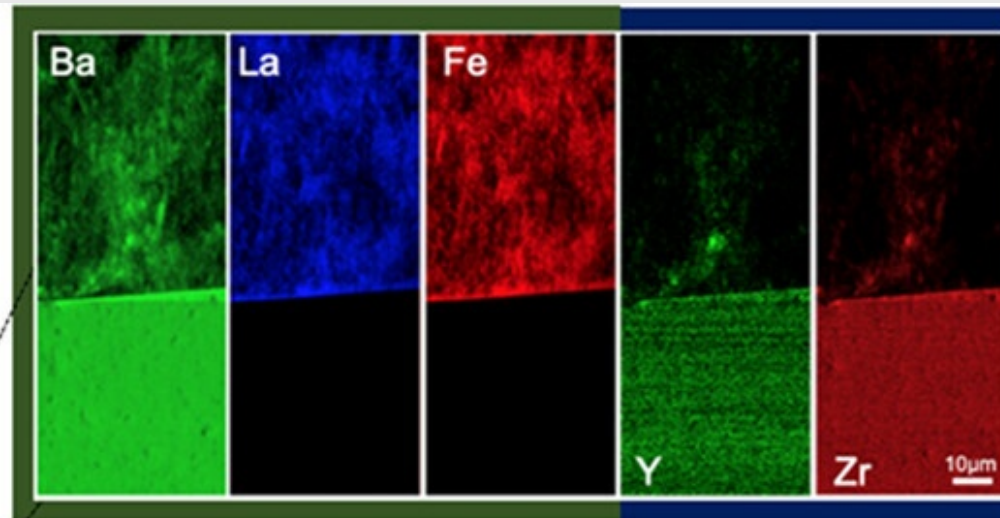
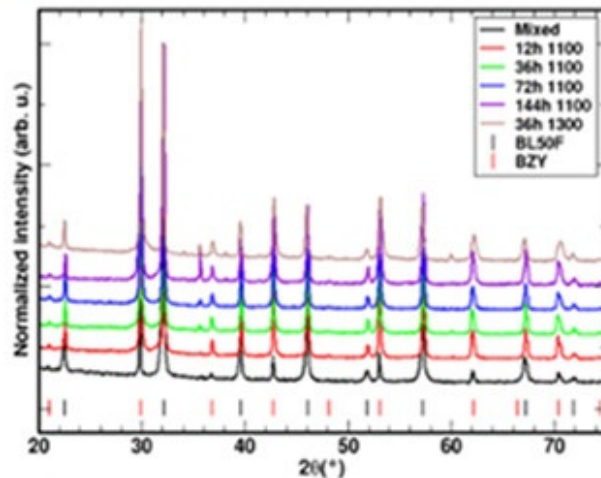
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Materiali per l'economia a idrogeno

Average information - XRD

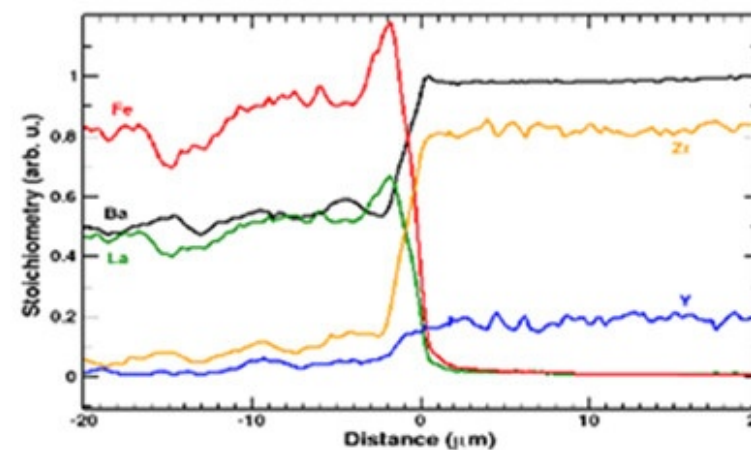
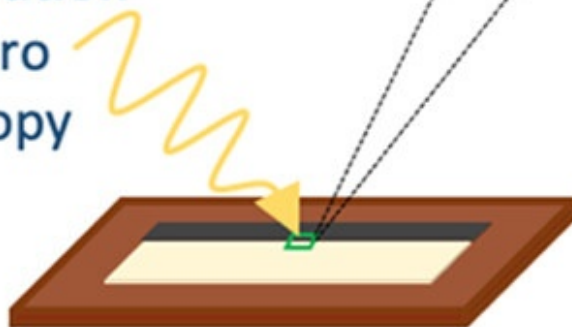


$(\text{Ba}, \text{La})\text{FeO}_{3-\delta}$

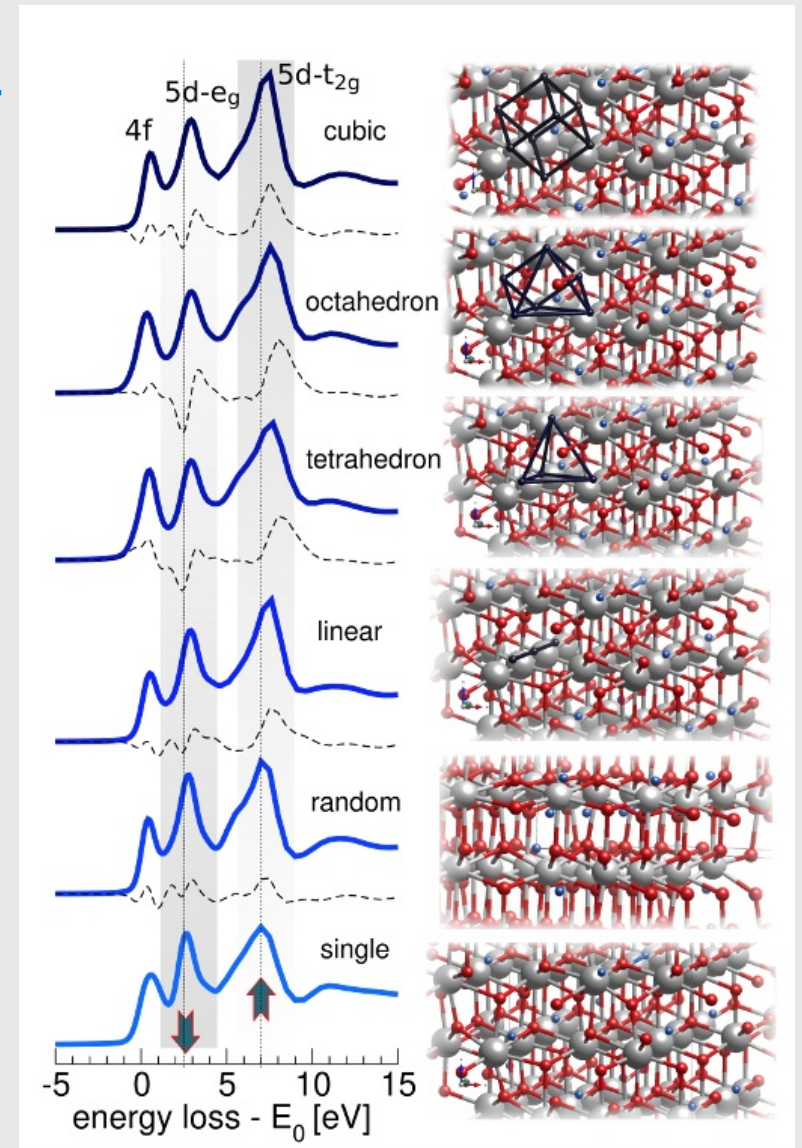
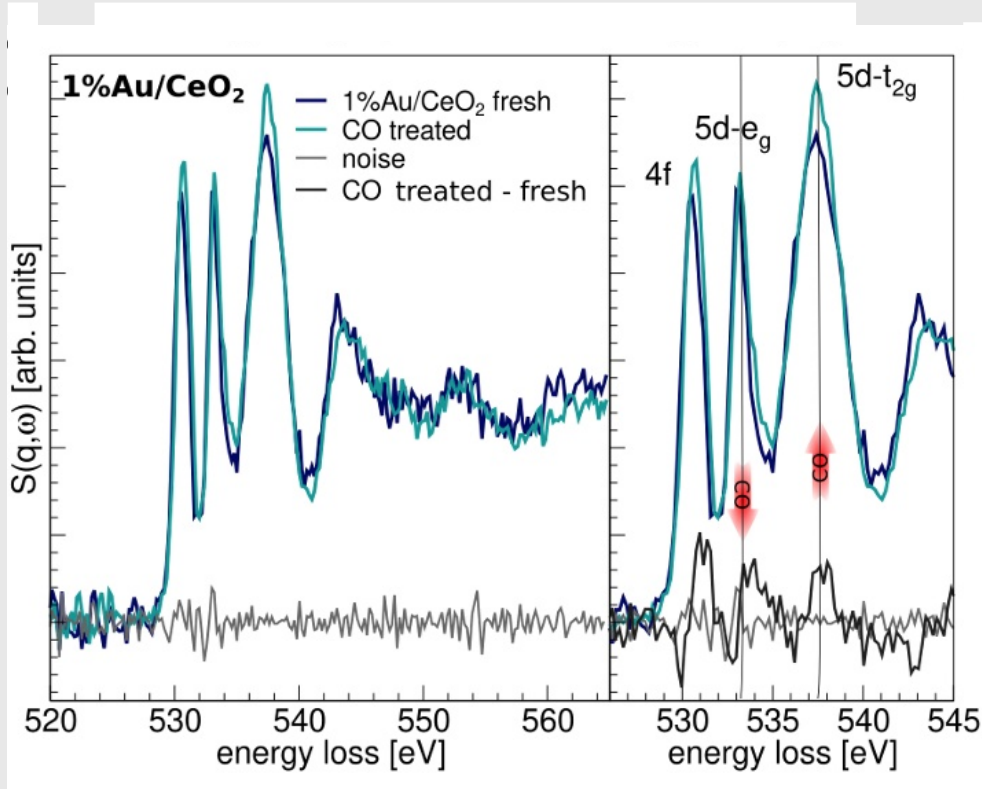
$\text{Ba}(\text{Zr}, \text{Y})\text{O}_{3-\gamma}$

Local information

X-ray micro spectroscopy



Organizzazione delle vacanze di ossigeno nel bulk





ACKNOWLEDGEMENTS

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Conclusioni

Grazie per la cortese attenzione

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any question?