INGRID PARTNERSHIP:
AN INTRODUCTION TO STUDIO TECNICO BFP

Studio Tecnico BFP is an engineering company with multiple years of experience in both the energy sector for the production, transmission and supply of electrical energy, in particular from renewable sources (sun and wind) and also in the oil sector (roadside fuel service stations). The company's professional skills ensure the integrated management of all design and implementation processes carried out by specialized engineers working for the company. BFP electrical, civil, mechanical and environmental engineers capable of dealing with and solving all types of problems related to the development and the implementation of large and complex projects involving Italian and foreign companies.

The Engineering Services for Renewable Energy Sources are:
- design and authorization of electricity production plants from renewable sources and network electrical systems (MV-HV);
- provision of all technical services required for their implementation;
- administrative compliance checks, analysis and validation of final working designs for private companies;
- technical and administrative consulting for the authorization of electricity production; t
- echnical and administrative due diligence reports;
- environmental impact studies;
- preparation and follow up of requests for connection to the electrical grid and notice of commencement for new electrical workshops;
- operation and maintenance management.

BFP involvement to the INGRID projects was related to the preparation of the final design for authorisation purposes, the follow-up of authorisation processes, final working designs (electrical-civil) for construction purposes and engineering activities necessary for the development and the set-up of the INGRID Demonstrator plant.

Join INGRID community on LinkedIn

INGRID project is now also on LinkedIn.
Join our community on LinkedIn project page at https://www.linkedin.com/company/ingrid-project

Consortium

Engineering Ingegneria Informatica (coordinator)	www.eng.it	Italy
McPhy Energy S.A.	www.mcphy.com	France
Hydrogenics	www.hydrogenics.com	Belgium
Tecnalia	www.tecnalia.com	Spain
RSE	www.rse-web.it	Italy
Enel Distribuzione	www.enel.it/it-IT/reti/enel_distribuzione/	Italy
ARTI	www.arti.puglia.it	Italy
Studio Tecnico BFP	www.studiobfp.com	Italy

Imprint

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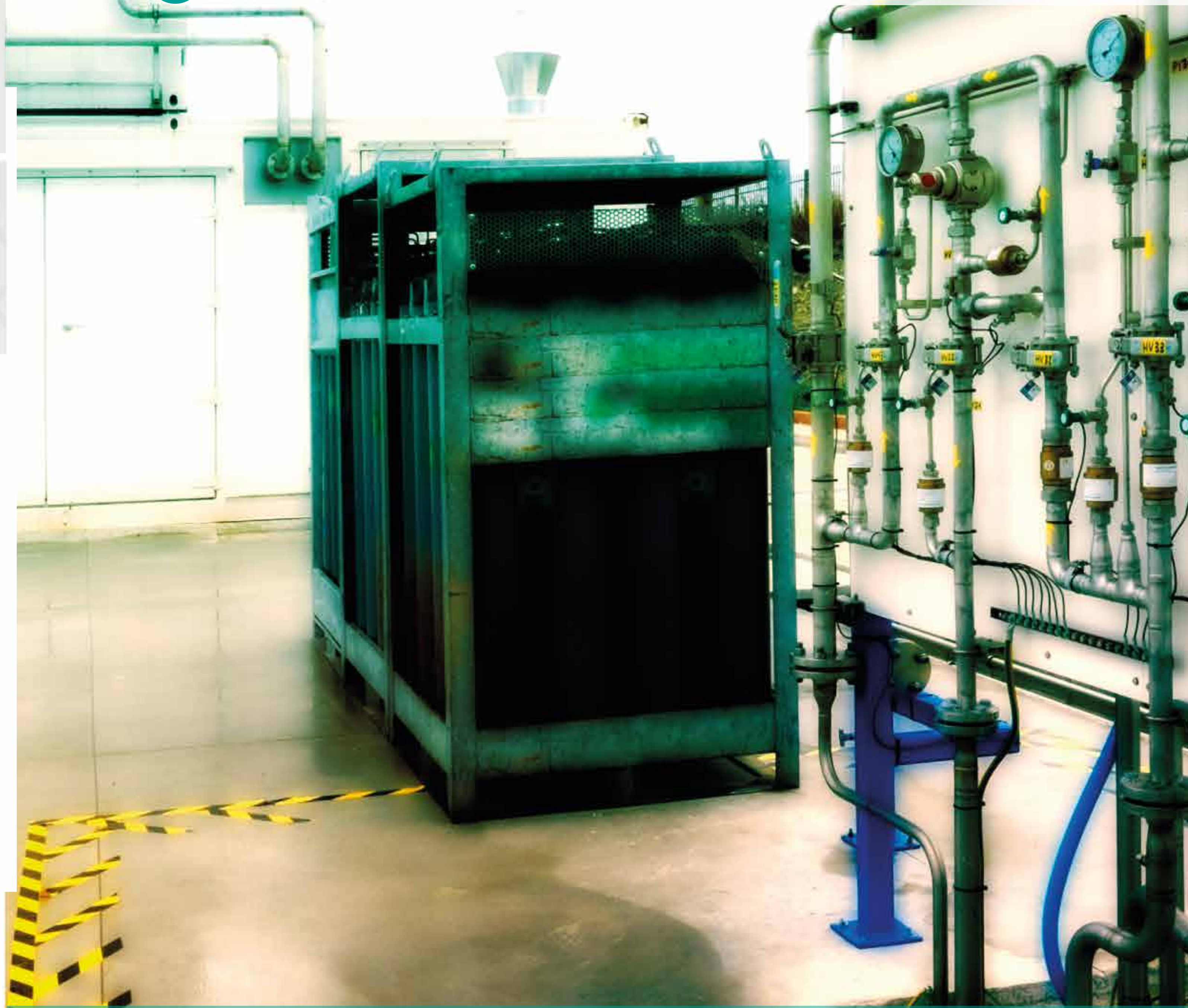


Editorial
by ARTI

Welcome to the last issue of the newsletter of INGRID, the 7FP strategic project dealing with high-capacity hydrogen-based green-energy storage solutions for grid balancing.
The newsletter will introduce you to the recent developments and first results of the INGRID project, its consortium and some of the technologies used.

RECENT DEVELOPMENTS
TOWARDS THE INTERNATIONAL FINAL EVENT
BY ARTI

After 5 years, INGRID project is coming to an end. The test phase of the demonstrator pilot plant built in Troia is underway and the first results will be illustrated to the general public in the **INGRID final event**, that will take place on **March 28th at Camera di Commercio di Bari** (Puglia, Italy).

During the international conference, all the project partners and those who shared the INGRID experience will talk about the **results of the demonstrator testings and the possible replicability of the INGRID model. The idea is to demonstrate what is the impact in terms of environmental and economic sustainability**. Moreover, thanks to the involvement of eminent international and national speakers, the event will also give the chance to discuss on **smart grids and the opportunities from energy storage** to achieve a smarter electricity grid and a more efficient energy distribution system.

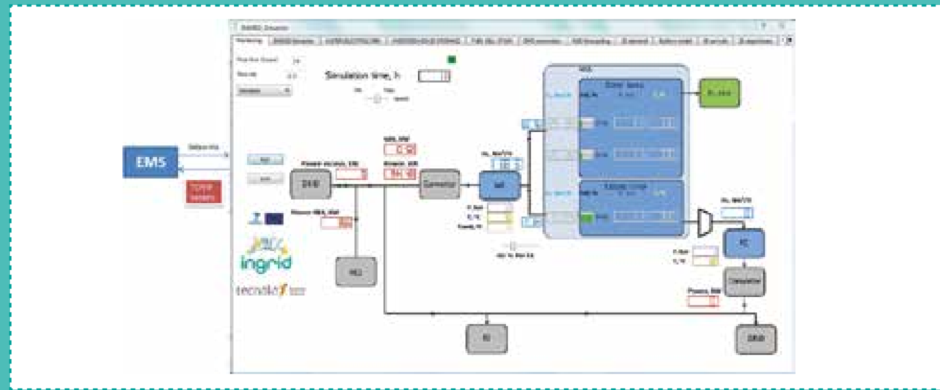
Thanks to the INGRID project, the combination of the most advanced ICT technologies for real-time monitoring of smart distribution networks and storage of solid hydrogen solutions will enable the integration of renewable sources in the balance of energy supply and demand, with benefits from both environmental and economic point of view.
The pilot plant is the first icon of the INGRID's legacy to Troia community and it will contribute to consolidate the image of the Puglia region as a leader in energy production from renewable sources and constantly committed to the protection of the environment and its territory.

A FOCUS ON TECHNOLOGIES
THE INTERACTION BETWEEN THE INGRID SIMULATOR AND THE ENERGY MANAGEMENT SYSTEM
BY TECNALIA

The INGRID project aims to exploit, on a large industrial real scale, a solid state hydrogen based energy storage technology, storing the excess of electricity in the form of hydrogen. The hydrogen, generated by electrolysis of water, is stored by absorption in Magnesium hydride disks, to be used for industrial purposed (open loop) or to generate electricity (close loop) when required.

The INGRID Energy Management System (EMS) decides when the hydrogen is generated, absorbed and desorbed to generate electricity according to different objective functions. However, before connecting the EMS to a real INGRID plant, a validation and tuning process has to be followed by the use of the INGRID Simulator. It simulates a real plant generating providing the state evolution of the plant components according on initial and boundary conditions. The former establish the initial state of the INGRID plant in time cero. The latter represents the external conditions that affect the proper operation to the plant such as the energy price, RES generation foreseen, 24 hydrogen and electric vehicle (EV) recharging demand, or the DSO energy absorption capacity.

The architecture of the INGRID simulator and its communication with the EMS is depicted in the following figure.



The main components of the INDGRID simulator are the water electrolyzer (WE), the hydrogen solid storage system (HSS) and the fuel cell module that generates the electricity (FC). They generate the evolution of the main process variables: the hydrogen level and the fuel cell hydrogen demand. Besides, other components of the simulators generate the boundary conditions:
• The RES Simulator generates the excess of electricity considering wind turbines, solar panels and other energy sources;
• The Intelligent Dispatcher (ID) generates the energy demand for Electric Vehicle recharging according to different vehicle arrival and departure models;
• The Hydrogen module (H2 sale) generates the hydrogen demand and price profile and the 24 hour energy price.
Both data, process variables and boundary conditions are sent periodically to the EMS that, through a TCP/IP real time bidirectional communication between the EMS and the INGRID Simulator. With this information and with the energy absorption capacity of the Distribution Operator provided by the DSO, the EMS can control the whole process sending the appropriate set points back to the INGRID Simulator.

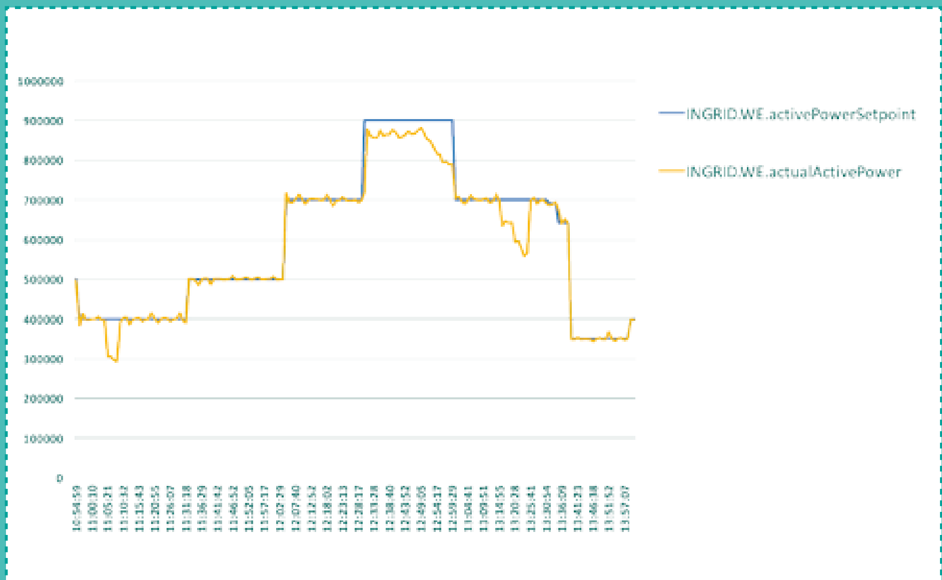
INGRID LEGACY
THE DEMONSTRATION PHASE: TESTS DESIGNED AND FIRST RESULTS
BY ENGINEERING

The INGRID Demonstration phase has started in February and will last till the end of the Project. During this period several tests have been designed to be performed. The tests span from single unit tests, aimed at proving the integration of each component, to complex business tests, which execute and simulates operational scenarios of the whole plant. As for the second kind of tests, which are meaningful to understand how the INGRID system works, eight group of tests have been identified:
• Test 1 – Fill up all the HDSs;
• Test 2 – Empty out all the HDSs;
• Test 3 – Fill up all the HDSs following a MV consumption profile;
• Test 4 – Fill and empty the HDSs following a MV consumption profile;
• Test 5 – Respond to real time LV generation request;
• Test 6 – Provide full flexibility services at MV and LV to the DSO;
• Test 7 – Fulfill H2 requests as soon as possible;
• Test 8 – Fulfill H2 requests following a MV consumption profile.

The first two groups aim at defining how the plant react in stress conditions, and define its boundaries (max production time, ramp-up and ramp-down rates, etc.). The third, the forth and the fifth groups test how the plant can manage the storages to provide flexibility services either at MV or LV level. The sixth group will test how to provide flexibility services simultaneously at MV and LV level. The last two groups will test how to fulfill requests coming from the H2 market using the FC to simulate customer consumption.

All these tests are designed to be run in series or in parallel, and results will be interpreted as possibile scenarios for a fully operative plant running the INGRID system. The results are expected to match the mathematical model used by the EMS to perform its planning, and the first output demonstrated its reliability.

In the following figure, the results of 4 hours of tests during the 3rd day are reported, running Test 3. The blue line represents the set points sent by the EMS to the WE, the orange one represents the actual process value of the WE power consumption.



RECENT DEVELOPMENTS
MAIN RESULTS OF THE LIFE CYCLE ASSESSMENT OF INGRID PROJECT
BY P&R PROJECT and Commodity Science Research Group - DEMDI - University of Bari

The study of life cycle assessment (LCA) is a methodology which allows to provide the assessment of the global environmental impacts throughout the life cycle of a product/service from "cradle to grave", considering raw material, materials processing, manufacture, distribution, use, repair and/or maintenance and waste or recycling of the finished product. In the INGRID project, the role of the LCA study is to calculate the environmental impacts of the pilot plant and to calculate environmental and economic impacts associated with different scenarios system use.

The specific study will be integrated with the Input-Output (IOA) analysis for the detection and quantification of the flows within the process production and LCA analysis and the life cycle cost (LCC) analysis, in order to quantify both the impact environmental and the economic impact to define further development of the demonstrator plant.

The study will be performed using the model of thinkstep GABI v.6 and the relative database Ecoinvent v3.3. If necessary other data from scientific literature will be adopted. Furthermore, the functional unit (FU), which is a measure of the performance of the functional outputs of the product system, will be calculated. According to the PCR, the FU is 1 kWh of net energy produced/accumulated and distributed. The time span of the study goal is 20 years.

The LCA analysis will be carried out in 3 phases (summarized in the picture besides):
• Phase of the "Upstream". This phase encompasses environmental information "cradle to gate" in relation to the production and transport of energy carriers and auxiliary substances. The IOA analysis will applied, drawing up a matrix for defining and assessing the quality of data to be used to carry an LCA report out;
• Phase of the "Core". According to the PCR, the process flow also includes the end of the plant life (20 years, parametrically based on the process variables). This parameter will allow to evaluate and reduce processing time scenarios resulting from different assumptions. Data will be collected using collection sheets through personal contacts with project partners and visits on sites and surveys;
• Step of "Downstream". This phase encompasses processes post installation plant and the study of all subsequent processes to the phase of production with the relative scenario assumptions. Primary data will be used and, where not available, the Ecoinvent database will be used.

The results will be stated according to parameters listed in CPC 171 and 173 which are outlined in the following way:
• GWP. 100 years (Global Warming potential) – Emission of greenhousegases in carbon dioxide equivalents;
• Acidification potentials - Emission of acidifying gases in sulphur dioxide (SO2) equivalents;
• Ozone Creating potential – emissions of gases that contribute to the creation of ground level ozone in C2H4 (Ethylene) equivalents;
• Eutrophication potential EP – emission of substances to water contributing to oxygen depletion in phosfate equivalents.

The results of the study will be useful for stakeholders and policy makers to validate INGRID project in order to support decisions for future projects development.