LIFE Project Number

**LIFE10 ENV/IT/000397**

# FINAL Report

## Covering the project activities from 01/01/2012 to 30/09/2014

Reporting Date

**29/12/2014**

LIFE+ PROJECT NAME or Acronym

# LIFE Integrated fumes depuration and heat recovery system in energy intensive industries – H-REII DEMO

Project Data

| | |
|---|---|
| **Project location** | Italy |
| **Project start date:** | 01/01/2012 |
| **Project end date:** | 31/12/2013 **Extension d** |
| **Total Project duration (in months)** | 33 months (i |
| **Total budget** | |
| **Total eligible budget** | |
| **EU contribution:** | |
| **(%) of total costs** | |
| **(%) of eligible costs** | |

**ABSTRACT FROM H-REII DEMO FINAL REPORT**

eficiary Data

| | |
|---|---|
| **Name Beneficiary** | RBODEN Srl |
| **Contact person** | Mr Marco Baresi |

| | |
|---|---|
| **Postal address** | Via Cernaia, 10, IT, 25124, Brescia |
| **Visit address** | Via Cernaia, 10, IT, 25124, Brescia |
| **Telephone** | +39-030-3552001 + direct n° +39-030-3552630 |
| **Fax:** | +39-030-3552011 |
| **E-mail** | marco.baresi@turboden.it |
| **Project Website** | www.hreii.eu/demo/it |

# 1. List of abbreviations

AL – Action leader
BAT – Best Available Technologies
BREF – Best available technologies (BAT) reference report
EAF – Electric Arc Furnace
ECEEE - European Council for an Energy Efficient Economy
EEIP - Energy Efficiency in Industrial Processes
EII – Energy Intensive Industry
ETS – Emission Trading Scheme
FAF – Financial Application Forms
FIRE – Federazione Italiana uso Razionale dell'Energia
Italcogen – Association of national co-generator manufacturers
M – project month
ORC – Organic Rankine Cycle
PA – Partnership Agreement
PL – project leader
PM assistant – project manager assistant
PMB – Project Management Board
PMS – project management structure
PPP – Public-Private Partnership
REP – Resource and Energy Efficiency Partnership
SC – Steering Committee
SPIRE – Sustainable Process Industry through Resource and Energy Efficiency
UNFCCC - United Nations Framework Convention on Climate Change
WHR – Waste Heat Recovery
WHSG – Waste Heat Steam Generator
WT – Working Table

# 2. **Executive Summary**

Project objectives:
The H-REII DEMO - Integrated fumes depuration and heat recovery system in energy intensive industries - project (LIFE10 ENV/IT/000397) was launched in 2012 in the wake of the previous H-REII - Heat Recovery in Energy Intensive Industries – project of which it represents the prosecution. The H-REII project (LIFE08 ENV/IT/000422 www.hreii.eu), launched in Brescia in 2010 and completed at the end of 2012, represented the first national pilot project about heat recovery and aimed at mapping the potential to recover waste heat in highly energy-intensive industries (cement, glass industries, steel, aluminium and nonferrous, heat treatments, chemical industry, refineries, oil & gas, agribusiness, textile, paper) using the ORC (Organic Rankine Cycle) technology with power generation sizes between 0.5 MWhel and 10 MWhel. The potential for energy recovery, at the outset, was estimated thanks to several energy audits carried out in Italy and other European countries and to an analysis of allocations quotes by National Allocation Plans (ETS). The prudential estimate on Italian cement, glass and steel, highlighted a potential saving of electricity ranging from 641 to 1025 GWhel/year, accounting for 5% of the total estimated energy savings for the Italian industry for 2016, and emission prevention of over 650.000 tons of $CO_2$/year. This remarkable estimated recovery potential led to undertake a second project co-financed by the LIFE+ program: the H-REII DEMO (www.hreii.eu/demo).

**The H-REII DEMO's main objectives can be summarised as follows:**

1. **Installation of a DEMO Plant involving an innovative integrated system of fumes depuration and heat recovery from process with ORC (Organic Rankine Cycle) technology in a leading steelmaking company – Elbe Stahlwerke Feralpi - Feralpi Group S.p.A, located in Germany;**
2. **Evaluation of the potential waste heat recovery for electricity valorisation of the different energy intensive sectors under analysis, by extending the potential estimated for one or more enterprises to an entire industrial sector;**
3. **Promotion of heat recovery policy and regulatory level, through monitoring existing legislation and producing a model for the environmental and energy authorization process for heat recovery plants, aimed at standardizing an uncertain and fragmented regulatory scenario at EU level;**
4. **Proposal of guidelines in order to amend the existing BREFs with the addition of heat recovery with ORC technology;**
5. **An intense dissemination activity at EU level.**

The H-REII DEMO project has been developed through different types of actions:

Action 1: Preparatory action
Action 2: Technological Action – Study development and realisation of innovative heat recovery application in energy intensive industries (EII)
Action 3: Technological Action – demonstration activities
Action 4: Policy and Governance Actions – barrier analysis and action to reduce

Action 5: networking activities for a new European Energy Technology Platform
Action 6: Dissemination
Action 7: Project Management
Action 8: Monitoring
Action 9: Audit
Action 10: After LIFE Communication Plan

Key deliverables:

Results have been twofold. First of all, **from a technical point of view**, **the H-REII DEMO project allowed the installation of the first worldwide prototype ever of heat recovery system with ORC technology in an Electric Arc Furnace (EAF) of iron and steel industry completely integrated into a fume extraction plant, by using water in a closed loop for cooling waste fumes and operating at a higher temperature and pressure than traditional methods**. The prototype has been realized in a European leader steel industry: the Feralpi group – ESF-Riesa plant in Germany.

The Feralpi group – not partner in the H-REII DEMO project – represents one of the largest and most successful steel producers at national and European level with plants in various countries. Since the project's preparation phase, Feralpi has been identified as the ideal subject in terms of availability of manufacturing processes for experimenting with the technical/technology solution and as an excellent driving force for the dissemination of results.

The heat recovery system integrated with the gas treatment, object of the development of the experimental project H-REII DEMO, consists of two macro-blocks:

1) partner COMECA: heat exchange system
2) partner TURBODEN: energy conversion ORC

1) The "heat exchange" system is designed to recover the thermal energy from the exhaust gas using a recovery boiler. The components are pipe system, pumps and valves, coils.
2) The innovative ORC turbogenerator prototype receives the waste heat from the heat exchanger COMECA so to generate and save electricity.

[…]

As a result, the prototype installation led to a significant reduction of the total power consumption. It also brought about a substantial improvement in the performance of the fume depuration plant applied to energy intensive industrial applications. More broadly, it proved that power generation from effluents, traditionally considered a waste, can drastically reduce (and in some applications even eliminate) the energy consumption of fume depuration, thus helping limit $CO_2$ emissions and other environmental damaging impacts. Furthermore, the adopted solution let increase know-how for applications in different Energy Intensive Industrial processes, so to consolidate the European leadership in integrated fume extraction plants with heat recovery, promoting the development of the market of environmental technologies. Taking into account the typical structure of the fumes treatment system in Iron&Steel industries (with EAF furnace), and the existing heat recovery ORC applications in other energy intensive industries (cement, glass), this demonstrator represents a cost-effective heat recovery solution and can be the leverage for improving the energy efficiency in the

Iron&Steel industry. In addition, thanks to the mapping and the energy audits already done in the previous H-REII project it was possible to target and contact potential stakeholders, giving a technological answer for different industrial and services actors.

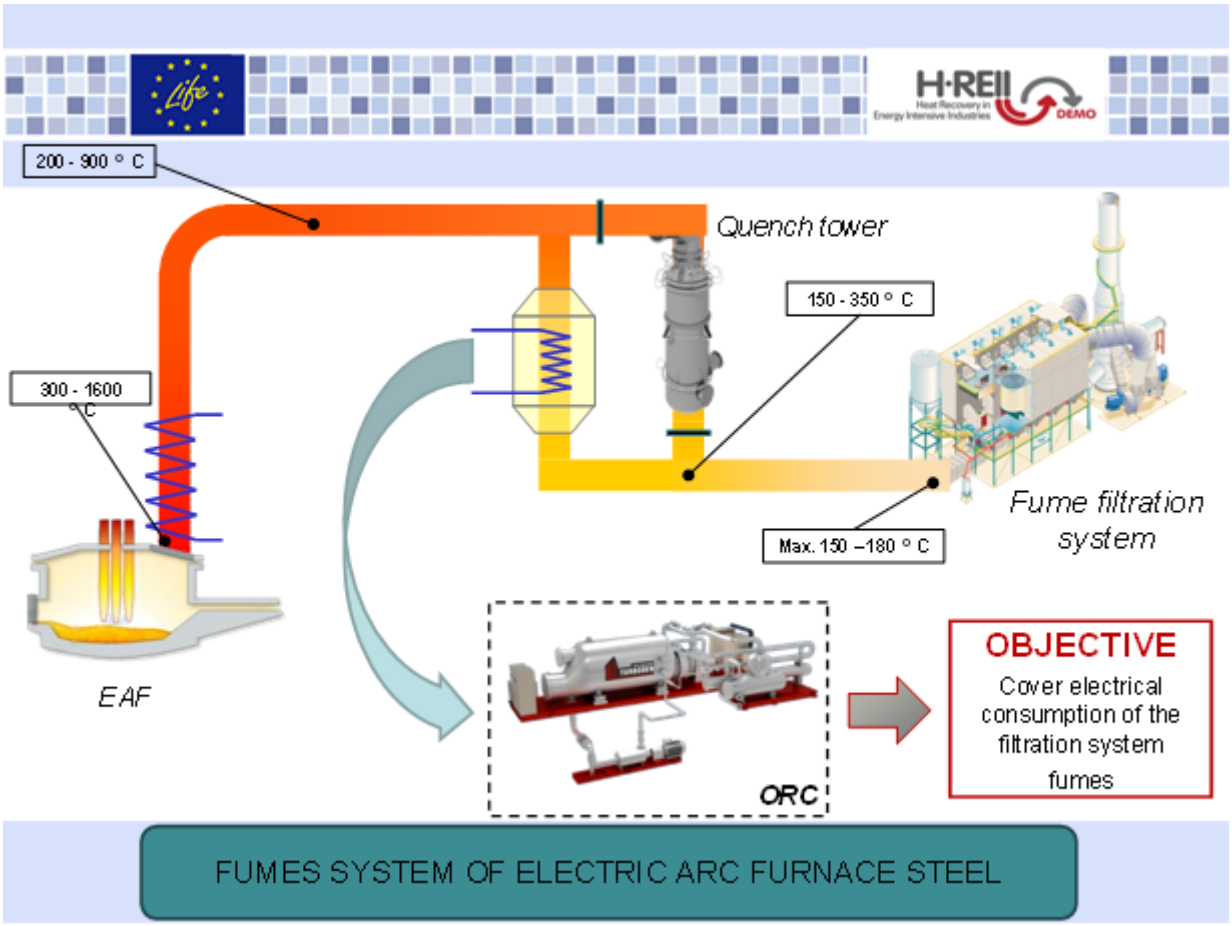



**Figure 1: H-REII DEMO general description**

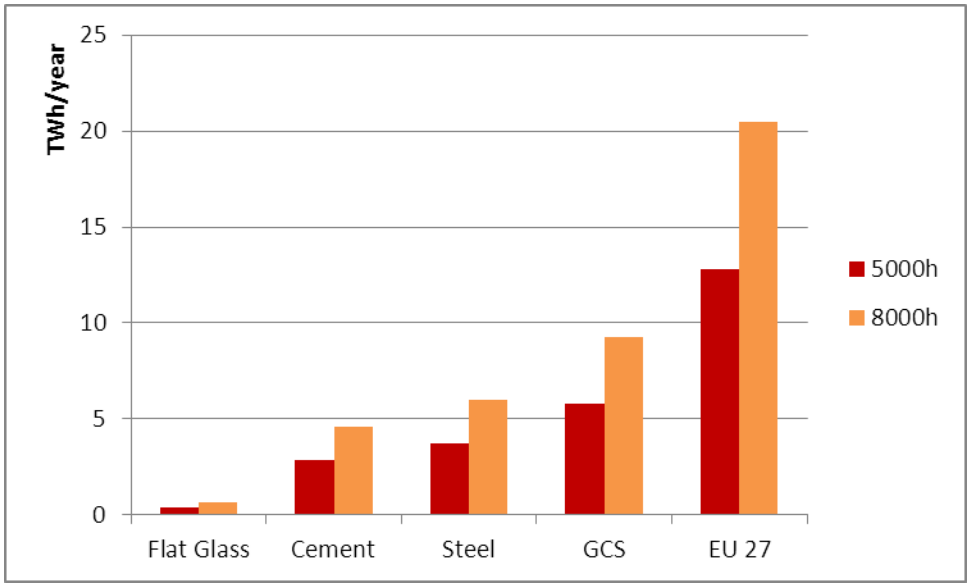
Secondly, **on the regulatory side** the H-REII DEMO policy activities started from the results achieved by the H-REII project. Thanks to the H-REII DEMO project it was possible to quantify the potential EU's contribution of E.I.I. in reaching greenhouses gas (GHG) reduction objectives by 2020 by using heat recovery. In particular, while one of the objectives of the previous H-REII project was a national estimation, the H-REII DEMO project extended the estimate at European level. **The calculated EU27 potential for the investigated sectors accounts for approximately 20 TWh of electric energy. This value represents 4.8% of total electricity consumption of EU industry in 2009 and implies avoided emissions of almost 7.5 million tonnes of $CO_2$.** In addition, the **new European Directive on Energy Efficiency (2012/27/EU) clearly refers to heat recovery as energy efficiency measure that proves a strong European commitment to the top**ic. Likewise, the Italian White Certificates increase the incentive from waste heat recovery from 17 €/MWh to 60 €/MWh, obtained also thanks to the former project H-REII. The H-REII DEMO carried on these policy activities in order to promote a more defined incentive framework for the heat recovery and

spread the Italian incentive model in different EU Member States, thanks to the institutional partner FIRE in particular. A number of action schedules and papers have been drafted to promote incentive mechanisms and the ORC as best practice for energy efficiency in the revision of the European Efficiency Directive ( EED) and its implementation at national level, EU ETS, EU Steel Action Plan, EU Industrial Plan, EU Green Paper "A 2030 framework for climate and energy policies". At national level, documents have been drafted to integrate BAT and BREF, like the White Certificate Scheme, in the Italian Energy Strategy (SEN), national Action Plan for Energy Efficiency (PAEE), Lombardia region's Environmental and Energy Programme (PEAR). Furthermore, the EU interest in the topic is demonstrated by its support to the energy efficiency platform start-up: the Energy Efficiency Industrial Processes (EEIP) – foreseen during the project drafting phase and currently started – is a platform for Business and Policy in Europe. The Sustainable Process Industry through Resource and Energy Efficiency (SPIRE), is a public private partnership with the objective to develop the enabling technologies and solutions along the value chain that are required to reach long term sustainability for Europe in terms of global competitiveness, ecology and employment. The H-REII DEMO project has actively followed the early activities of the platform.
The H-REII DEMO project will carry on promoting waste heat recovery at European and national level as waste heat recovery represents a double opportunity: a more environmental sustainable solution for energy intensive processes and an innovative development of new European industrial excellence in green economy technologies and services. Moreover, the Local Pilot Observatory, created on the occasion of the H-REII project to access $CO_2$ reduction from EII through heat recovery technical applications, has been further implemented by involving scientific organizations, institutional bodies as well as industrial organizations. The project was also useful to stress the importance of the involvement of financial actors in order to define standard instruments to support energy efficiency investments in EII. Finally, the H-REII DEMO project's main findings have been shared and supported by a number of academic studies and papers both at EU and international level. For instance, results have been shared by the National French Energy Agency (ADEME), the British consultancy in sustainable energy ECOFYS as well as by the IFC within the World Bank Group in the attempt to globally spread ORC as best practice within energy efficiency policies.

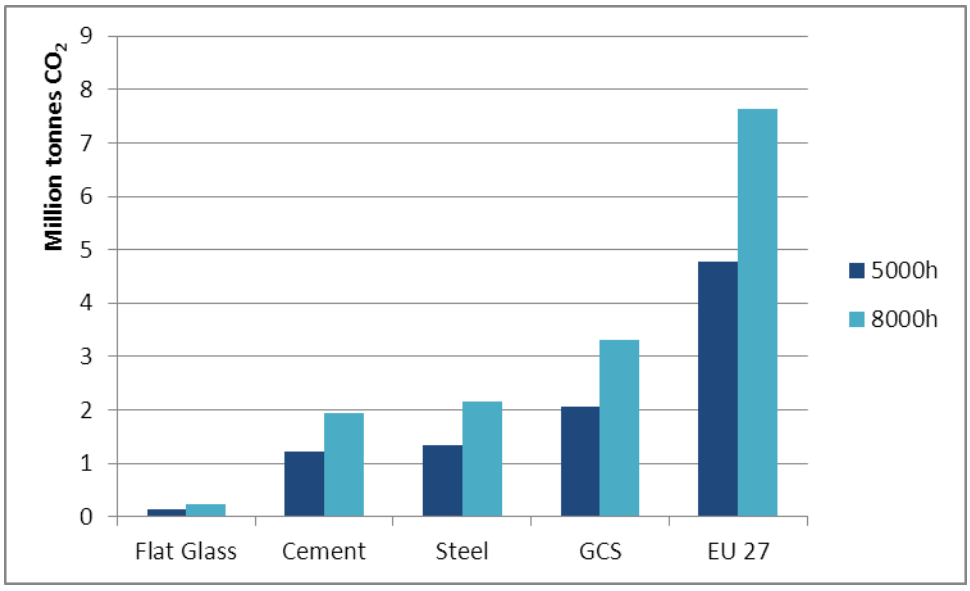
Project benefits:
The H-REII DEMO brought about positive results in a broad range of fields.

a) **Environmental benefits**: Some products, such as iron, steel, cement and glass, which are vital for the European economy, are produced through energy intensive industrial processes. These processes, using high temperatures, require massive quantities of fuel or electricity, playing therefore a key role in increasing global $CO_2$ emissions. In line with the EU 20-20-20 climate and energy targets and the Energy Efficiency Directive (2012/27/EU), H-REII DEMO made it possible to quantify the potential contribution of the energy intensive industries in meeting the - 20% greenhouses gas (GHG) emissions reduction objective by 2020 by using heat recovery. The calculated EU27 potential for the investigated sectors (flat glass, cement, steel and gas compression

stations) is about 2,5 GW of ORC gross power. The heat source is provided by the industrial process, whose operating hours depend on the market fluctuations. Considering 8 000 operating hours per year, it has been estimated that ORC plants can generate almost 20 TWh of electric energy. This value represents 4.8% of the overall electricity consumption of EU industry in 2009 and implies avoided emissions of almost 7.5 million tonnes of CO2.




**Estimated Energy Recovery in Europe (operating plants at 5000h/year – 8000h/year)**




**Estimated Emission $CO_2$ avoided in Europe (operating plants at 5000h/year – 8000h/year)**

Through fostering energy saving and the reduction of $CO_2$, heat recovery thus proves to be a valuable solution to shift energy intensive industrial processes towards more environmentally sustainable ones. While heat recovery systems were already installed in cement and glass plants, the H-REII DEMO's prototype helped steel industries not to dissipate thermal power

in the atmosphere. Thus, the demonstrator could be the right leverage to extend the good practice of heat recovery also in the iron&steel industries.
**In confirmation of the H-REII DEMO's high technological and environmental value, the installation of a second plant using the innovative integrated system of fumes depuration and heat recovery from process with ORC technology has been launched in 2014.** The plant will be realized in the steelmaking company Ori Martin in Brescia. As a further innovative improvement, this realization will allow to generate electricity during summer, while producing heat which will be distributed through the municipal district heating during winter. The recovered thermal power will be approximately 10 MW allowing savings on fossil fuels consumption with consequent emissions reduction of about 10,000 tons/year of $CO_2$. The plant is planned to be operational as from the 2015-2016 heating season. The H-REII DEMO plant has therefore proved to be an innovative solution in fostering environmental sustainability and energy efficiency in industrial applications.

**b) Economic benefits**: Thanks to the projects H-REII and H-REII DEMO heat recovery technology turned out to be an instrument for industrial policy, leadership and productivity as well as a strategic tool to boost competitiveness and investments in the manufacturing sectors. **It is possible to foresee potential investments up to 8 billion € for heat recovery across the EU**. However, it is worth underlying that important results could be reached through the introduction of innovation policies in order to increase and coordinate European R&D spending to support promising technologies in energy intensive industries.

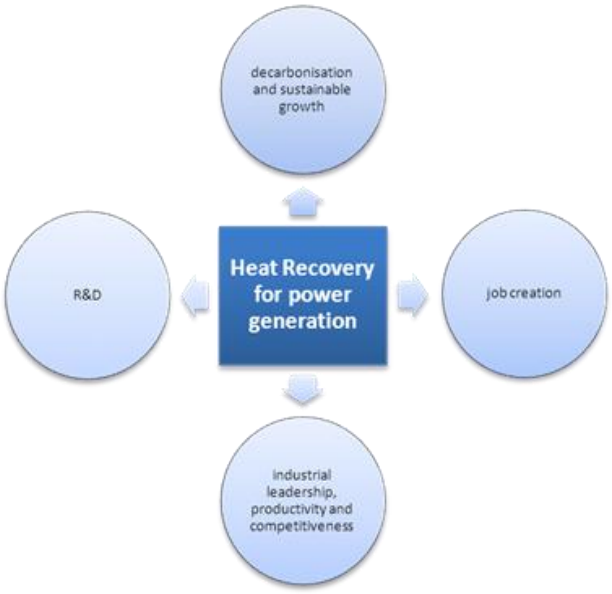
**c) Policy and regulatory side**: H-REII DEMO also carried on the policy and dissemination activity began with the H-REII. Firstly, by suggesting policy proposals and drafting BAT (Best Available Technologies) and BREFs (Best Available Technics Reference Documents), **H-REII DEMO helped fostering the EU commitment towards heat recovery as an energy efficiency measure as stated in the EU Energy Efficiency Directive (2012/27/EU).** In addition, it supported the waste heat to power generation technology at EU level by **disseminating the cutting-edge incentive scheme set by the Italian authorities across the EU countries** through the publication of position papers and participation to public consultations. Indeed, the White Certificates scheme increased the incentive from waste heat recovery from 17€/MWh to 60€/MWh proving to be a best practice in the energy efficiency field and replicable in other countries. The H-REII DEMO project's main findings have been shared and supported by a number of academic studies and papers both at EU and international level, such as those studies conducted by the National French Energy Agency (ADEME) and the British consultancy on sustainable energy ECOFYS.

**d) Social benefits:** Finally, the implementation of heat recovery technologies may significantly boost job creations and employment across the EU countries. Indeed, considering all the firms that are involved into the manufacturing process of heat recovery systems, job can be created alongside the entire value chain. The latter can be divided into four segments: materials, components, project elements and end user examples. Manufacturing components and plants require raw materials. There are many players among components manufacturers: producers of heat recovery steam generators, steam turbines and

ORC turbines, electric generators, condenser and cooling systems, steel pipes and electric components. In addition, all heat recovery projects require immaterial activities, such as finance experts and venture capitalists, engineering and energy consultants, plant designers and project managers.. There are four categories of new jobs that could be created: (i) jobs in the manufacture of waste energy recovery equipment. These employers range from large multinational corporations to small, specialized firms; (ii) jobs in creating on-site "energy islands" in host facilities including welders, pipefitters, design engineers and construction workers: installation services, including engineering, typically represent about 50% of project costs; (iii) jobs in operating on-site energy islands; (iv) jobs resulting from increased competitiveness.

In conclusion, all these positive results show that waste heat recovery for power generation (WHRPG) represents a concrete and valuable opportunity for the EU to achieve the 20-20-20 targets as well an example of best practice to be taken in due account during the implementation of the 2030 framework for climate and energy policies. Indeed, Waste Heat Recovery is a best practice of:

- **energy efficiency for a sustainable industry**: heat recovery can increase the environmental, economic feasibility and energy sustainability of the industrial processes. It also contributes to reduce GHG emissions since power is generated through the waste heat recovery without any fuel;
- **increasing industries competitiveness**: heat recovery is an instrument of industrial policy to boost competitiveness and investments in the manufacture sectors, able to involve different industrial actors.
- **promoting a new European supply chain to export**: in this respect it is possible to foresee a **potential investment of 8 billion €** in the new sector of heat recovery in the EU;
- **helping saving/creating new jobs**.




**Heat recovery comprehensive benefits**