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Lessons Learned from H-REII DEMO

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Introduction

The H-REII DEMO - Integrated fumes depuration and heat recovery system in energy intensive industries - project (LIFE10 ENV/IT/000397) was launched in 2012 following the successful H-REII - Heat Recovery in Energy Intensive Industries – project. The H-REII, launched in Brescia in 2010 and completed at the end of 2012, represented the first national pilot project on heat recovery whose aim was to map the potential to recover waste heat in highly energy intensive sectors (cement, glass, steel, aluminium and nonferrous, heat treatments, chemical industry, refineries, oil & gas, agribusiness, textile, paper) using the Organic Rankine Cycle (ORC) technology with power generation sizes between 0.5 MWhel and 10 MWhel. The potential for energy recovery, was estimated at the outset, thanks to several energy audits carried out in Italy and to an analysis of allocations assigned by National Allocation Plans (ETS). The prudential assessment on Italian cement, glass and steel industries highlighted a potential saving of electricity ranging from 641 to 1025 GWhel/year, accounting for 5% of the total energy savings estimated for the Italian industry for 2016 and emissions prevention of over 650.000 tons of CO_2/year. This remarkable recovery potential led to undertake a second project co-financed by the LIFE+ program: the H-REII DEMO. The H-REII DEMO allowed the installation of the first prototype ever of heat recovery system 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. It also carried on the policy activity implemented by the H-REII, by extending it at EU level in order to evaluate the potential waste heat recovery in highly intensive energy companies across the EU Member states, in strong connection with the implementation of the Energy Efficiency Directive (EED).

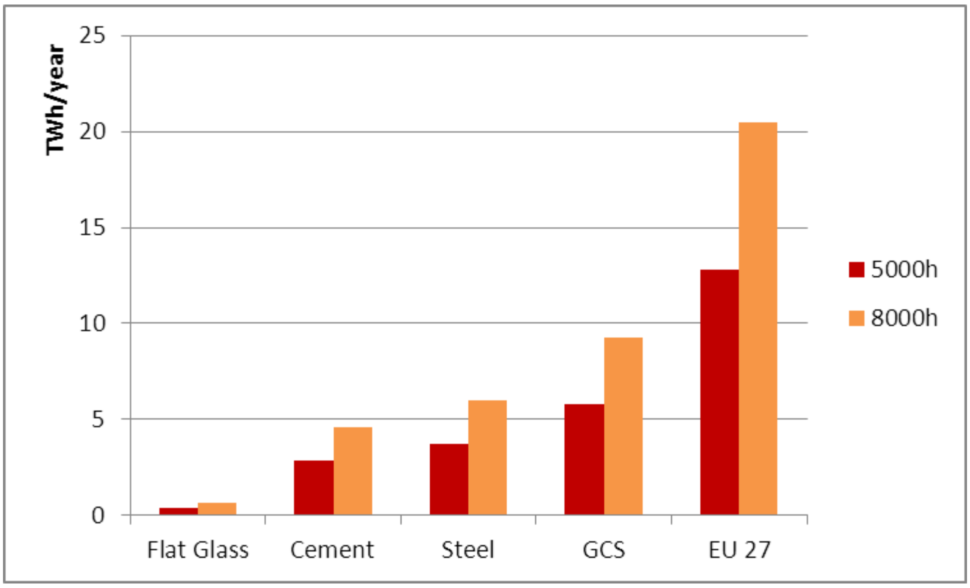
H-REII DEMO achievements and steps forward

a) Environmental benefits

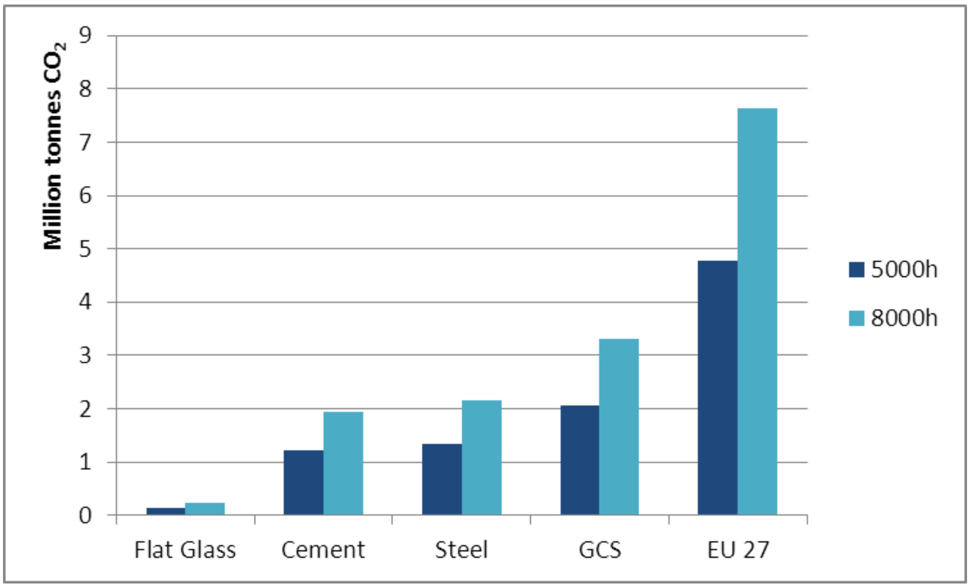
Some products, such as iron, steel, cement and glass, which are vital for the European economy, are produced through energy intensive industrial processes. These processes, using high temperatures, require massive quantities of fuel or electricity, playing therefore *a key role in increasing global CO_2 emissions*. For example, it is possible to estimate that the glass manufacturing process produces about 1,8 ton/CO_2

for each ton of final product. Likewise, similar values apply to the steel sector, while each ton of cement produces about 0,8 ton/CO_2. Cement industry is responsible by itself for about 5% of global CO_2 emissions from human activities. Fume extraction plants are necessary to ensure environmental sustainability and to rule energy intensive products. However, these systems unfortunately produce waste energy by cooling system of fumes and require energy to operate, generating additional power consumption and CO_2 emissions. *In several Energy Intensive Industries (EII) processes waste heat with high energy content can be recovered*. 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 EII in meeting the - 20% greenhouses gas (GHG) emissions reduction objective by 2020 by using heat recovery. Building upon the national estimation carried out in the framework of the H-REII, the H-REII DEMO evaluated the potential electricity generation through ORC (Organic Rankine Cycle) technology at European level. 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 CO_2.



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 results achieved by 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.

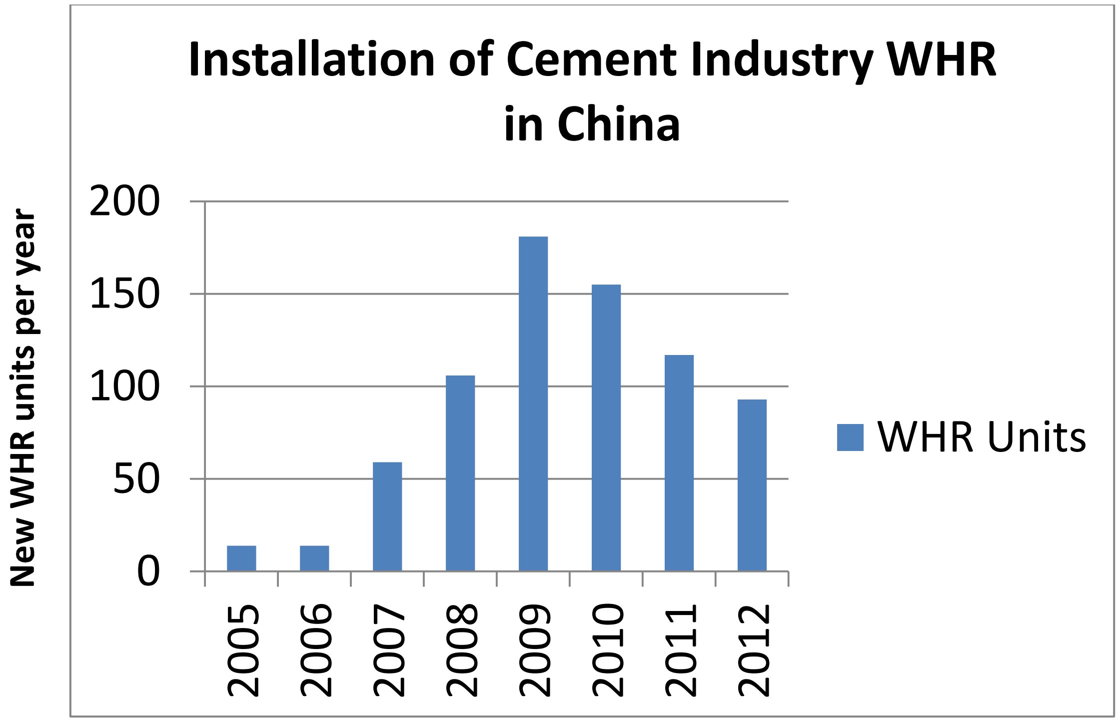
The H-REII DEMO project's main findings have been shared and supported by a number of academic studies and papers both at EU and international level, such as the those studies conducted by the National French Energy Agency (ADEME) and the British consultancy on sustainable energy ECOFYS. Moreover, the importance of waste heat recovery has been also dealt with in the report published by the World Bank's International Finance Corporation, in collaboration with the Institute for Industrial Productivity, on "*Waste Heat Recovery for the Cement Sector: Market and Supplier Analysis*"[1] which broaden the analysis on heat recovery at international level. Through comparing different experiences in several countries, the report allows to draw valuable information and interesting insights for further developing industrial energy efficiency policies in Europe. Indeed, starting from the positive example of

[1] IFC, "*Waste Heat Recovery for the Cement Sector: Market and Supplier Analysis*", June 2014, http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/publications/report_waste_heat_recovery_for_the_cement_sector_market_and_supplier_analysis

China in the field of Waste Heat Recovery (WHR), the report emphasizes some key points useful to allow a brainstorming on the way forward in the EU market as well.

- To date, there are over 850 Waste Heat Recovery power installations in the world. China leads in the number of WHR installations (739), followed by a large margin by India (26) and Japan (24);
- WHR can reduce the operating costs and improve earnings before interest, tax, depreciation and amortization (EBITDA) margins of cement factories by about 10 to 15 %. On average, electric power expenses account for up to 25 % of total operating costs of a cement factory. WHR technology utilizes residual heat in the exhaust gases generated in the cement manufacturing process and can provide low-temperature heating or generate up to 30 % of overall plant electricity needs;
- Regulatory measures and lower capital costs have been key factors behind China's success in mainstreaming WHR technology. Initially, WHR development in China was driven by incentives such as tax breaks and Clean Development Mechanism (CDM) revenues for emissions reductions from clean energy projects. In 2011, a national energy efficiency regulation mandated WHR on all new clinker lines constructed after January 2011. These drivers were reinforced when multiple Chinese WHR suppliers entered the market, lowering WHR capital and installation costs by adopting domestic components and design capability, which developed the technology for the Chinese market;
- Domestic components and design capability revealed fundamental and have been a key factor for developing the technology for the Chinese market;
- The study also revealed a business opportunity in terms of investment of ~US$5 billion to introduce ~2GWe of WHR power capacity in eleven developing and emerging countries;
- Finally, structured financing is the key to realize the untapped WHR potential. A number of commercially-viable WHR opportunities are not implemented due to financing issues.

The IFC report effectively shows how **policy, regulation and finance** in the waste heat recovery in the energy intensive industries field **together can be the three key elements** to achieve energy efficiency and industrial competitiveness of manufacturers issues as well as a driver to develop innovative and sustainable technologies both for domestic and foreign markets. Such successful mixture of policy regulation and financial incentives led China to become leader in "big size" heat to power recovery plants in the cement industry with more than 700 units developed in the past years for the domestic field. Moreover, they are now ready to export their technology in foreign markets and other industrial sectors.



Source: OneStone Research, "Latest Waste Heat Utilisation Trends in Cement Plants", 2nd Global CemPower, 2013

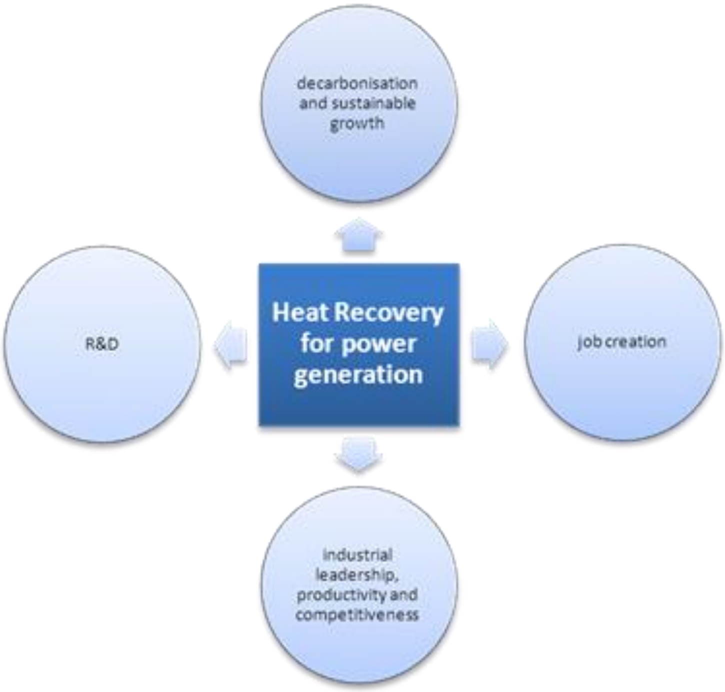
On the contrary, **"small size" heat-to-power recovery plants addressed to refurbishing the old existing manufacturers plants represent a peculiarity of the European industrial market as shown in the H-REII and H-REII DEMO projects**. **However, they are still at an early stage with less than 10 existing WHR plants** as mapped in the report. **The untapped potential is thus significant. In this respect, the Energy Efficiency Directive (2012/27/EU), currently being implemented by Member states and under revision at EU level, could be a "driver" in setting a certain and standardized EU regulatory framework against the current fragmented one, therefore contributing in further exploiting the heat recovery potential in Europe.**

Building upon the Chinese positive experience, the European Union is urged to take further actions to promote and incentivize heat recovery within the energy efficiency framework. In particular:

- ✓ at **policy** level: by issuing **documents and guidelines dedicated to Waste Heat Recovery to Power Generation (WHRPG)** in energy intensive industrial sectors;
- ✓ at **regulatory** level: by **making heat recovery** measures **compulsory** in refurbishing the old existing manufacturers plants;
- ✓ at **financial** level: by creating **targeted financial instruments** to overcome economic barriers and support the development of WHR technology towards the transition to a EU low carbon economy.

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. End users that would benefit from this new sector are not only related to industry; funding for R&D, greenhouse gases emissions reduction and job opportunities are clear examples of social improvements. 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.



Heat recovery comprehensive benefits

Concluding remarks

In conclusion, 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** such as: (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; (iii) jobs in operating on-site energy islands; (iv) jobs resulting from increased competitiveness.