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Indice

1 Overview

1.1 The European framework

Some industrial processes are characterized by significant amounts of waste heat released in the environment as hot gases, if not recovered.

The recovery for thermal purposes is often not feasible (the thermal loads are not able to absorb the waste heat), while the conversion into electrical energy can now represent the best way to enhance this kind of waste heat.

Technological and legislative barriers are often obstacles for the energy-intensive industrial companies in developing systems for recovering heat from electricity production process.

Thanks to ORC (Organic Rankine Cycle), the above-mentioned technological barriers have been overcome.

The heat recovery from fumes, even at medium-low temperatures (below 300 ° C), with little sources constant in time and in amounts even modest (on the order of a few megawatts thermal) is a target is technically and economically achievable.

Generally, the ORC technology allows the recovery of heat from any industrial process with an available waste heat output over 3/5 MWt, corresponding to an annual consumption of some 20 MSm3 natural gas (or alternatively 15 Mt coal).

The development of technological solutions for overcoming the above mentioned barriers, and the evolution of the energy market are the economic foundation for reusing waste heat to produce electricity.

The increasing attention to the environment, which is sometimes a barrier to the energy intensive industries activities, can now become a driving force allowing the industrial processes efficiency through the reduction of CO_2 released into the environment.

The implementation of solutions for heat recovery and power generation could also represent, in terms of "system", a significant help to achieve the ambitious goals set by the EU climate and energy package 20-20-20 (reduction 20% of greenhouse gas emissions, increase energy efficiency by 20% and reached 20% share of renewable energy alternatives).

The energy intensive industries (glass, cement and steel) can obtain an important environmental goal with a limited number of installations.

Public companies have found little incentive to make these technologies viable in times valued as acceptable for the industry.

2 Goals

The main goal of this action 4d) is to provide drafts of policy documents "Policy Addendum" to integrate and / or update the existing rules in the CO2 field (ETS - Energy Efficiency - IPPC and harmonized technical standards). These drafts will promote some actions for heat recovery in intensive industrial processes through the waste heat conversion into electric power.
This method allows a reduction at the source (which generates energy from the utility) of CO2 emissions in the environment and an economic advantage for the company that can sell the electricity produced or used to feed internal loads.
These drafts are a technical - legislative basis to define a new policy approach for the reduction of CO2 and to define a set of policies to encourage industries in emphasizing the waste effluents.

The work was developed by analyzing technical aspects and normative aspects through:

- Technical analysis: analysis of intensive industrial processes and related emissions of CO2 (and database audit)
- Legislative Analysis: analysis of the regulations on CO2 emission and how these self-influence (policy addendum).

3 Achieved Results

The technical analysis has shown how the industrial sectors with the greatest potential in waste heat recovery for the electrical enhancement (using ORC technology) are:

- Cement,
- Glass,
- Steel.

For all other areas, the solution must be evaluated case by case in relation with technical or economic issues (return on investment too long).
We have mapped the major companies available and subject to the ETS normative, by on-site audits and by public data analysis.
The technical analysis has produced two databases on the three investigated areas (glass cement and steel containing) for the CO2 shares allocated in Europe.

Based on all collected data, an "ad hoc" calculation model was created to calculate the heat recovery potential and the resulting CO2 avoided both at Italian and at European level.

In the analysis of current legislation, the main European regulations with impact on the shares of CO2 released into the environment (ETS - Energy Efficiency - harmonized technical standards and IPPC) were taken into consideration.

For each of these standards, some limits were detected. Therefore, we have defined some documents of integration (Policy Addendum), in order to insert the heat recovery in the existing legislative framework.

3.1 Estimation of producible energy estimate and avoided CO2

The development of action 4d) in the three investigated areas (cement, glass and steel) was organized in five main activities:

1. Analysis of technical regulations,
2. Collection of data of CO2 allocations for industries in the energy intensive sectors (cement, glass and iron and steel for the classification of ETS),
3. Organization of the DATABASE about allocated CO2 shares in the investigated areas,
4. Evaluation of potential ORC heat recovery systems and calculation of indirect savings achievable CO2,
5. Analysis of the ETS system Energy Efficiency – IPPC and Technical standard, evaluation of links between the CO2 savings and the heat recovery systems.
6. "Policy Addendum" implementation for the public companies proposed to enhance the carbon emissions avoided through the heat recovery projects.

General considerations and implications have emerged:

- Applications of Recovery with ORC technology is technically feasible,
- The potential for dissemination of these distributed energy generation systems are very high and replicable in Europe,
- Italy is currently the European leader in ORC technology with enormous potential for consolidation of the production chain.

The barriers for the projects development in the field of heat recovery have been identified:

- Pay-back time is often considered too long by the investor (6-8 years (average) without incentives, while the expectations are on a 4-5 years basis),
- The current incentives (Energy Efficiency Credits) for these applications have a low economic value.

The solution of the electric power generation with ORC technology has the advantage of being able to operate in synergy with the heat recovery designed to process uses or air-conditioned building. The amount of energy recovered in these areas is combined with the power generation on site, and can be used in industrial applications where such heat recovery are not feasible

The prudential estimate (see database I-CM-100801 REV_00-10-05-2012.xls-and I-CM-100701-REV_00 FI-10-05-2012.xls) on cement, glass industries, iron and steel industries-limited to the reheating furnaces detects a potential of at least 640 Italian GWhel / year of electricity (Figure 1) (about 120,000 toe / year), accounting for 9% of total energy savings estimated for Italian industrial sector expected in 2010, and over 407,000 tons of CO2 / year avoided (Figure 2).

If the iron and steel industry would be treated as a whole (steel production plants, coke ovens, sintering plants), the potential could be much higher.

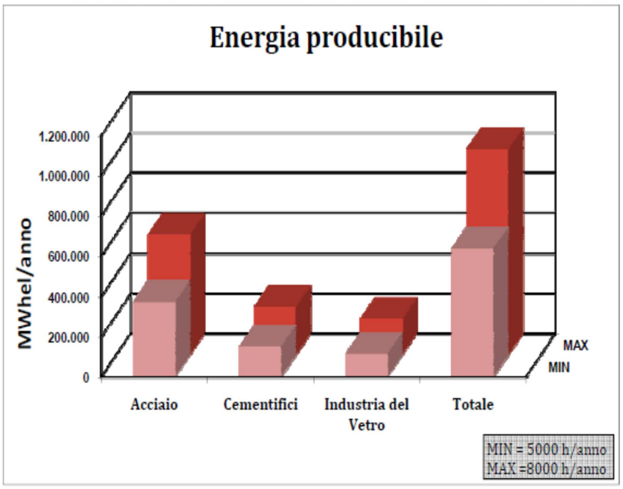

Fig. 1

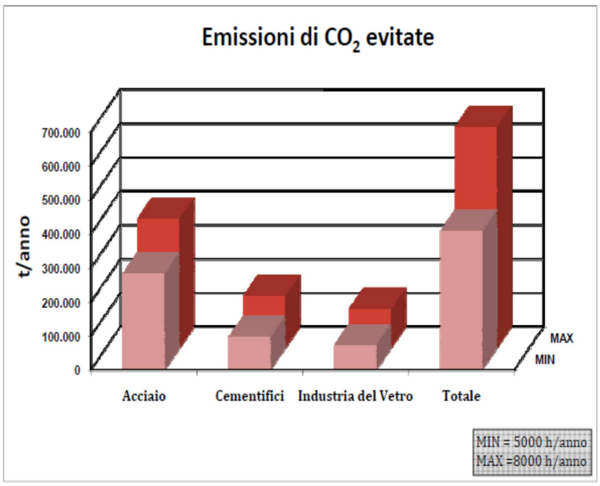

Fig. 2

These data mean a potential of about 130 MWe installed with sizes between 0.8 MW and 5 MW and about 80 heat recover plants from the process by ORC technology in the sectors of cement, glass and steel.

The estimate at the European level (based on I-FI-CM-100801-REV_00-10-05-2012.xls-and I-CM-100701-REV_00 FI-10-05-2012.xls) on cement plants, glass industries, iron and steel industries and limited to the reheating furnaces detects a potential between 2 and 3.2Mton CO2 / year avoided.

3.2 Policy action (Policy Addendum) and energy efficiency incentive

Due to the multiplicity and complexity of industrial processes, energy efficiency through heat recovery from process to enhance supply (eg by recombinant ORC) is not mentioned: in Europe and in Italy there are no adequate policy instruments to encourage acts on such applications.

The current incentives (Energy Efficiency Credits) do not trigger investments because they have low economic value, and these incentives are not standardized.

During the HREII project, the policy actions have achieved four important results:

- heat recovery in industry is now mentioned in the Decree No. 28 of March 3 in the DCO43 AEEG (Italian energy authority). (I-FI-CM-100501-2010.pdf-REV_01). The proposed text is a multiplicative factor of 2.4 of TEE for the "Drive Systems or generation of electricity from recoveries in industry" that takes the value from 17 € / MWh to 57 € / MWh incentive contribution.
- heat recovery in industry is now included in "proposals for the special plan of Confindustria Energy Efficiency 2010".
- the guideline containing the HREII proposal to encourage the ORC plants in industrial applications by means of government grants has been implemented.
- a supplement to the draft standard prEN16247 Energy Audits Part 3 Processes under discussion at the Italian tables Uni. (I-CM-100901-FI-REV_01-23-04-2012.pdf) has been deveolped.

The documents analyzed and the related Policy Addendum (attached) are:

cap.	Settore/ Documento Esaminato	Policy Addendum	Ente competente
6.1	Direttiva efficienza energetica 2006/32/CE e Decreto Legislativo n.115/08	“Piano straordinario task force efficienza energetica Recuperi termici per generazione elettrica nelle industrie”.	Ministero dello sviluppo economico PAE 2011 DCO 43 (AEEG)
6.2	Direttiva 2003/87/CE (EU-ETS Emission Trading Scheme) Direttiva ETS	“Convenienza dell’investimento in tecnologie ambientalmente sostenibili mediante recupero calore di scarto/ cogenerazione”.	EU-ETS
6.3	Progetto di norma prEN16247 Energy Audits part 3 Processes.	“Indicatori di efficienza energetica finalizzati a stimare le potenzialità di recupero di calore da processi industriali per generazione elettrica mediante tecnologia ORC (Organic Rankin Cycle) Addendum al Progetto di Norma Europea prEN16247 Energy Audits part 3”.	CTI – UNI

Tab. 1

4. Conclusions

A system of heat recovery is similar to a plant for renewable energy, because it does not have a direct consumption of fossil fuels (the installation of the system of heat recovery does not require additional consumption of fossil fuel). The heat recovery systems to industrial process for power generation (via ORC systems) are technically feasible and economically profitable in the long term for both the beneficiaries of the interventions, and for the industry.

The implementation of systems for heat recovery and power generation could also represent, in terms of "system", a significant help to achieve the ambitious goals set by the EU climate and energy package 20-20-20 (reduction 20% of greenhouse gas emissions, increase energy efficiency by 20% and reached 20% share of renewable energy alternatives).

As shown for heat recovery in industry, it will be possible to bring out what and how many opportunities remain unexplored even today in the three areas examined Cement, glass and steel.

The heat recovery systems are less profitable investments if linked to the productivity of the industrial process, but this should be alongside to the environmental aspect as these systems are an appropriate response to the need for reducing energy waste and CO_2 emissions..

Thanks to an amount of quite 100 energy audits around Italy and Europe and thanks to an analysis of allocations developed by the National Allocation Plans (ETS), a potential for energy recovery in the 3 energy-intensive industries preventing 407ktonCO2 / year in Italy and 2 to 3MtonCO2 / year in Europe has been estimated.

Our general considerations are:

- Heat Recovery effluents with ORC technology is technically feasible.
- The potential for dissemination of these systems is very high and replicable in Europe and worldwide.
- The existing regulations do not enhance the recovery of heat through incentives. Before the project HREII, the regulations did not foresee this possibility.
- Pay-back time is often considered too long by the investor (6-8 years (average) without incentives, while the expectations are on a 4-5 years basis),
- heat recovery in industry is now mentioned in the Decree No. 28 of March 3 in the DCO43 AEEG (Italian energy authority). (I-FI-CM-100501-2010.pdf-REV_01). The proposed text is a multiplicative factor of 2.4 of TEE for the "Drive Systems or generation of electricity from recoveries in industry" that takes the value from 17 € / MWh to 57 € / MWh incentive contribution.

The successes in terms of innovation achieved by the project HREII in energy efficiency through the use of ORC systems in industrial environments are highlighted by the European Union approval of the second project HREII named "HERII-DEMO", which implies the construction of the first European ORC pilot plant linked to a steel plant in Europe.

The currently available normative analysis (conducted by ETS - dir. Energy efficiency - IPPC-harmonized standards) has revealed a number of incongruities.

The existence of white certificates for energy efficiency incentives (also known as energy efficiency certificates) has some significant implications to ETS: the reduction in electricity demand would affect plants fueled by fossil fuels and improve a de-carbonisation of the electricity sector, subject to ETS mechanism.

The ETS limit is fixed and the reduction promoted by use of the emitted white certificates has a depressing impact on prices of CO2. Therefore, ETS results weakened by the introduction of such national mechanisms to promote the energy efficiency. As a consequence the uncoordinated use of these mechanisms may cause distortions that imply limits on the effectiveness of the entire system of environmental regulation and energy.

However, white certificates may have a short and long term significant impact on reducing emissions in those areas not included in the ETS, as they encourage investment in areas going beyond the market for emission allowances. These areas are not currently subject to any specific climate policy.

In conclusion, this mechanism to encourage energy efficiency has actually a negative effect on the efficient functioning of the ETS, due to the significant impact on prices of emission permits (especially in the short term), but the same mechanism has a positive impact in the not ETS areas.

Further to the savings in electric energy, the realization of a system of self-production determines (regardless of the technology) other benefits with additional indirect economic returns.

A concrete example is given by the reduction of peak power in the public power supply network, knowing how this parameter is important in defining the price of energy purchased on the market (transport component).

Furthermore, it is important to consider how any action at national level on energy efficiency is promoted through the mechanism of TEE (energy efficiency certificates, also known as White Certificates).

The TEE impact is often not decisive in the investment choice, but can surely help in increasing the project operative margin for approximately 5% -10% and the pay-back times are consequently reduced.

Finally, the return in terms of image and the possibility of underlining the impacts of the energy saved and the emissions of CO2 on in the environmental balance should be relevant for all those industrial entities with a business social responsibility to be taken into account.

At a Macro-level, it should be also emphasized as the distributed generation from heat recovery (leading to an auto-consumption, so as an electrical energy input to a network), provides the following advantages:

- Economics: the reduction of the dependence on fossil fuels and the reduction of production costs at the park thermoelectric.
- Electrical Network: reduction of losses and reduction of power commitment.
- Environmental: absence of pollutants emissions.

5. Methodology

The methodology is based on the analysis of regulations / directives that have an impact in reducing and / or monitor CO2 emissions in the environment and on the elaboration of technical information collected during companies audit and on the search data freely available .

Main national and European regulations and directives were analyzed and the links between energy efficiency (as discussed in the documents) and heat recovery from energy-intensive industrial processes for electric generation were evaluated.

Furthermore, the gaps and / or technical limitations of the Technical - Legislative framework were also highlighted.

The technical standards (UNI-EN-ISO), which are assumed as state of the art of available technology, were also examined.

Finally, the "Policy Addendum" (Table 1) was proposed to integrate these regulations / directives with the reduction of CO2 emission by using the waste heat and generating electricity.

The documents analyzed and the related Policy Addendum (attached) are:

cap.	Settore/ Documento Esaminato	Policy Addendum	Ente competente
6.1	Direttiva efficienza energetica 2006/32/CE e Decreto Legislativo n.115/08	“Piano straordinario task force efficienza energetica Recuperi termici per generazione elettrica nelle industrie”.	Ministero dello sviluppo economico PAE 2011 DCO 43 (AEEG)
6.2	Direttiva 2003/87/CE (EU-ETS Emission Trading Scheme) Direttiva ETS	“Convenienza dell’investimento in tecnologie ambientalmente sostenibili mediante recupero calore di scarto/ cogenerazione”.	EU-ETS
6.3	Progetto di norma prEN16247 Energy Audits part 3 Processes.	“Indicatori di efficienza energetica finalizzati a stimare le potenzialità di recupero di calore da processi industriali per generazione elettrica mediante tecnologia ORC (Organic Rankin Cycle) Addendum al Progetto di Norma Europea prEN16247 Energy Audits part 3”.	CTI – UNI

Tab. 1

Documents produced in sections 4 and 5 will be sent in draft to the relevant Institutions in order to inform them about the potential in CO2 emissions reduction allowed by the heat recovery systems with ORC technology.

The reference documents in sections 3 have been sent and adopted at national level by competent Institutions.

5.1 Directive 2006/32/CE “Energy Efficiency”

The European Directive 2006/32/EC and its implementation in Italy with Legislative Decree n.115/08 represent the basic legislation for the energy efficiency of machines and plants. They contain the measures and actions to achieve the overall objectives of efficiency and energy savings. They are also the basis for the set of standards published later.
The legislation introduces two important aspects: energy management as a tool for improving efficiency (including the technology, but also the structure and organization) and a methodological approach to energy management.
The "Directive 2006/32/EC" granted the functions of National Agency for Energy Efficiency to ENEA, providing a support role to the Italian Ministry of Economic Development.
Furthermore, the legislation defines the ways to reinforce the market mechanism based on the Energy Efficiency Certificates (TEE).
In Italy, the decrees of the Ministry of Productive Activities (dm July 20, 2004 Electricity, gas dm July 20, 2004) and their modifies integrated in the dm 21 December 2007 on energy saving introduced an innovative system based on the exchange of TEE, with security factors evidencing energy savings achieved through specific actions increasing the energy efficiency of the final consumption.
This system requires that the national distributors of electricity and natural gas realize actions by the end users in order to achieve a mandatory annual energy savings.
The decree, particularly, determine the quantitative national targets to increase energy efficiency to be achieved by the distributors of electricity and natural gas with more than 50,000 end customers through projects that provide for measures and actions on end-use energy.
These projects give the right to issue and TEE can be made directly from distributors, from companies controlled, from Energy Service Companies (ESCOs), or other companies operating in the energy services sector, as well as subjects in art. 19, paragraph 1 of the Law 9 January 1991, n. 10, which effectively appointed the manager for the conservation and rational use of energy.

The system for the promotion of energy efficiency outlined by the Ministerial Decrees of 2004, wants to limit the total cost related to the achievement of energy savings imposed on electricity distributors and gas.
These subjects, indeed, may adopt a strategy of “make” or “buy” and decided to make direct investments in the implementation of energy saving projects, or, if the choice of “make” should lead to higher marginal costs, may decide to buy the TEE from subjects achieving energy savings golas through projects with lower marginal costs.

The GME emits the TEE on the basis of the certification of the savings made by the Authority for Electricity and Gas (AEEG), which assesses the projects and certifies the savings achieved. The GME emits the corresponding Energy Efficiency Certificates (particularly, TEE is issued for each toe of energy savings achieved) in favor of the person who carried out the project.

The TEE is divided into three categories:
- Type I: TEE for the achievement of primary energy savings through measures to reduce consumption of electricity;
- Type II: TEE for the achievement of primary energy savings through measures to reduce consumption of natural gas;
- Type III: TEE demonstratingfor the achievement of primary energy savings through different actions.

The analysis of the Directive and Decree Law has shown two possibilities:

1) In Article 5 of legislative decree 115/2008 Section 2 is required to submit a second National Action Plan for Energy Efficiency (PAEE) within June 30, 2011. This point has allowed the creation of a document produced by the Confindustria Task Force with the contribution of the H-REII partners, where the potential for recovering heat from industrial processes are identified and analyzed. This chapter has been accepted by the national commission and included in the PAEE 2011.
   The contents of the EEAP are related to the 2011 European Action Plan for Energy Efficiency 2011. Inside the EEAP 2011, there is a chapter on how to recover waste heat for electricity generation using ORC technology.

   This submitted document is the hereby attached I-CM-FI-100501-rev_01-2010 (as later integrated in the document "Proposte di Confindustria per il Piano Straordinario di EFFICIENZA ENERGETICA 2010 .pdf")

2) The Article 12 of the "DIRECTIVE 2006/32/EC indicates the need to execute energy audits at industrial level even in SMEs. This point has led the H-REII partners to analyze the European harmonized standards relating to energy audits, the PrEN 16247 Energy audits, where requirements, methodology and reporting for energy audits are illustrated and to be applied to all energy systems. The publication is expected in 2012.

The harmonized standard prEN 16247 Part 3 – process (under discussion at the European tables) harmonizes the energy audits in industry environment and represents a good way to introduce the concepts of energy efficiency by recovering the waste heat into electricity generation.

The waste heat recovery in industrial processes for electricity production is not considered in standard pr EN 16247-3.

The H-REII partners realized then the document "Energy efficiency indicators" designed to estimate the potential for heat recovery from industrial processes for electricity generation by the ORC technology. This document is a supplementary part of the standard.

A harmonized standard has the advantage of being transversal across all the industrial sectors and it is related to large, medium and small industries. It could introduce a general energy audit model, allowing also to investigate all industrial sectors where the H-REII Project has already shown no potential for heat recovery and that are not covered by the ETS and could also show an unknown potential (know-how of process / product).

These aspects are then implemented in chapter 5.5 "Progetto di norma prEN16247 Energy Audits part 3 Processes" of this document.

5.2 Directive 2003/87/EC " EU-ETS Emission Trading Scheme "

The European Union with its EU Directive 2003/87/EC has established and fixed the trading of greenhouse gas emissions in the EU, with effectiveness from the 1st January 2005.
This system regulates the international trade of emission allowances between companies located in member countries, in order to reduce these emissions (Emission Trading).
In this context, the term "quota" means the right to emit one ton of carbon dioxide (CO2) or other greenhouse gases equivalent effect for a specified period (European unit allowances EUAs).
Starting from the 1st January 2005, all installations carrying out any activity listed in Annex I of the Directive (see Table 3) must have an authorization issued by the National Authority where it is defined the maximum level of greenhouse gases (CAP) emissions. This permit is subject to the national and international trade of emission allowances as an alternative mechanism for the direct reduction of the same.

	Activity	**Greenhouse gases**
1	Production transmission and distribution of electricity	carbon dioxide
2	Steel industries	carbon dioxide
3	Extraction of minerals from quarries and mines	carbon dioxide
4	Paper Industries	carbon dioxide

Tab. 3

This trading system has created a market for emissions, called Emissions Trading System (EU-ETS). The overall environmental outcome is the same, with the important difference that both the transferee and the transferor could benefit from the flexibility of the exchange system, without harming to the environment.

The European Commission has explained these criteria listed in Annex III of the Directive for the preparation of National Allocation Plan (NAP). The commission determines the amount of units to be allocated to the individual sectors and then identifies the amount per each individual plant.

The methodology used is based on two factors:

- the weight of emissions must remain constant in the period 2005-2012.
- two macro-areas must have the same potential for reduction.

It is also set up a monitoring system to ensure the reliability of monitoring systems, data and information submitted.

Market participation is expected for any operator holding a deposit account at one of the European registries.

It is expected a dual requirement for facilities regulated by the ETS:

- the need to operate with the possess of an authorization for releasing greenhouse gases into the atmosphere. This corresponds to a certain number of allowances;
- the obligation to return at the end of the year a number of allowances (permits) emission equivalent to the emissions of greenhouse gases released during the year.

Not to yield this share issue provides for a penalty.

The strict limits for emissions allowances would favor an increase in demand with a consequent increase in market price of shares. In this way, compared with a high share price, companies should invest in clean technologies as more convenient.
The aim of the European emission trading is to get companies to consider investing in better technologies environmentally rather than buying shares on the market and payment of fines.

On April 23, 2009, it was adopted the Directive 2009/29/EC amending Directive 2003/87/EC and related to the scheme for trading greenhouse gas emissions.
The amendments to Directive 2009/29/EC concern with the adaptation of legislation to implement a more rigorous engagement of communities in the area of reductions, the rules governing the modification of plants, and support measures in favor of intensive energy industries.

5.2.1 Directive 2004/101/CE Linking

To complete the ETS Directive, was approved by the European Parliament and the Council of 27 October 2004, Directive 2004/101/EC, aka "Linking Directive" in order to integrate the system with the flexible mechanisms provided by the Emissions Trading Directive 2003 / 87/CE and to provide a wide choice for the industries.
The Linking Directive has recognized the flexible mechanisms of Kyoto Protocol - CDM and JI - within the EU system, establishing the validity of emission credits resulting from implementation of these projects to answer their obligations to reduce emissions.
Therefore, it will be specified in the PNA national the percentage of the obligation allowing operators to use CERs and ERUs for the expected performance.

Conclusions.
A company that provides a level of emissions exceeding the fixed quota may use different strategies (i.e.: internal and/ or external Strategy).
The company may choose for an internal abatement of emissions by innovating the production process, by increasing energy efficiency or by choosing outsourcing.
Alternatively, the organization may choose external strategies by sponsoring and promoting CDM / JI, or resorting to trading by buying EUAs, ERUs and CERs
Vice versa, if during the year the company could reduce emissions below the quota, the company could sell excess permits, or store them for subsequent years.
The EU ETS has often caused speculative actions, not corresponding to its original good purposes.

The European Union aims to extend and consolidate its Emission Trading Scheme (ETS Phase III), although a series of structural problems and implementation have resulted in the first phase of this scheme, with insufficient reductions in regulated emissions.

The policy of creating global emissions markets carries to underestimation of a series of further opportunities including heat recovery from industrial processes for electricity generation.

The industrial activities subject to the ETS Directive are in most cases energy intensive activities.

It is evident that the three areas identified in the technical analysis (Section 1): Cement, Glass and Steel also fully included in the ETS Directive.

Therefore, there is a point of contact between the ETS and the possibility of reducing the CO2 emitted by the recovery of waste heat from industrial process for electrical generation, even if in phase III (2013-2020) are eligible for assignment only the production (defined as a benchmark) of heat and the process emissions. The production of electricity will not be entitled to free allocation.
However, some areas during phase II (2008-2012) may benefit of free allocation for electricity production.

Once these limits have been analyzed, the HREII project has implemented the document I-CM-100601-REV_00-FI-10-05-2012 with the analysis of some potential heat recovery / cogeneration of waste heat for electricity generation.

5.3 Normative prEN16247 “Energy Audits part 3 Processes”

Generally, a technical standard is a technical document of voluntary adoption that represents the state of the art of a product, system or process.

If the topic covered by the technical standard has a significant influence (generally in terms of safety, but not only), the legislator refers to it in legislative documents and, as a consequence, the technical document becomes mandatory (not voluntary).

The set of technical standards prEN 16247-1 is particularly interesting because their analysis on the issue of energy audits and it is composed of:

1. prEN 16247-1 Energy audits – Part 1: General requirements
2. prEN 16247-2 Energy audits – Part 2: Buildings
3. **prEN 16247-3 Energy audits – Part 3: Processes**
4. prEN 16247-4 Energy audits – Part 4: Trasportation.

The Technical standard (under construction) "prEN 16247-3 Energy audits - part3: Processes," is particularly appropriate for the project HREII, because applicable to all energy systems and in all industries. The three energy-intensive sectors "Cement, glass steel" are subject to this standard that analyzes the problem of energy audits in industry to improve energy efficiency and greenhouse gases emissions (CO2) in the environment.

It defines:

- the requirements, methodology and reporting for energy audits,
- the requirements of data collection, audit on site and meetings with the client.

It aims to provide tools to the Energy Auditor for an energy audit on site to know the profile of energy consumption of an industrial site and to identify and quantify opportunities for energy savings (cost-benefit analysis).

In Section 5.5.3 "Identify energy efficiency improvement opportunities" this standard requires that the energy auditor identifies opportunities for improving energy efficiency by analyzing the site of production, including the ability to reduce or recover energy losses through the recovery of waste heat (letter a).

Being a general document, the Directive cannot investigate in detail all the existing industrial processes to address the energy auditors in choosing the best available technology. However, it does not also define a general methodology that could be a support to the auditor in evaluating the potential of waste heat in the process.

The HREII partners have developed a document that defines the general methodology. The document shows that as the first approach is always advisable to assess the recovery of waste heat for thermal purposes and only if these are not possible to assess the possibility of converting waste into electricity using ORC technology.

6 Annex “Policy Addendum”

6.1 Directive 2006/32/CE “Energy Efficiency”

Title

"Extraordinary Plan Task Force efficiency. Heat recovery for power generation in energy intensive industrie".

Introduction

This paper considers the industrial heat recovery and it is the document produced in order to be integrated in the proposals of Confindustria for the ENERGY EFFICIENCY 2010 Extraordinary Plan Task Force. This document was then inserted in the EEAP 2011 (national energy .plan 2011).

Heat recovery

The preliminary output of the report highlights how to encourage action to heat recovery in energy intensive industries by usefully defining:

- A feed-in tariff or a multiplier mechanism in kWhel Energy Efficiency for the electricity generated by recovery: currently under study and not yet in a consolidated position is the idea of a value not higher than 0.05 _ / kWhel (compared to the current 0.016 _ / kWhel) about the TEE type III (source: GSE));
- A guaranteed value of TEE withdrawal from heat recovery with a minimum guaranteed withdrawal;
- a fixed duration of the incentive period (10 -12 years).
- The positive economic impact on the national energy system can be quantified in the following aspects:
- CO2 savings in terms of minors quantities to buy on the market;
    - lower cost of electricity generation from renewable sources to attain the objectives of the climate-energy package;
    - Sales and VAT on the construction of plant and cost of maintenance and service;
    - potential for dissemination of these systems for distributed generation of very small size are replicable in Europe and worldwide.

6.2 Directive 2003/87/CE "EU-ETS Emission Trading Scheme"

Title

"Convenience of investment in environmentally sustainable technologies using waste heat recovery / cogeneration".

Overview

The EU-ETS Directive 2003/87/EC and subsequent amendments and additions, does not identify any opportunity for implementing energy efficiency measures for the use the waste heat in the process to reduce CO2 emissions.

Considerations

We deepened the subject on the production of electrical energy from waste heat recovery. In accordance with the legislation that regulates the mechanism of phase III of the Emission Trading (2013 - 2020), the allocation of shares is in accordance with a general formula (simplified):

Allocation = Activity Level * Benchmark

For a cogeneration plant, this implies that the shares will be allocated on the basis of the thermal energy (activity level), multiplied by a benchmark. The benchmark for the production of heat is equal to 62.3 tCO2/TJ, which corresponds to the emission factor of natural gas (56.1 tCO2/TJ) divided by a hypothetical yield of 0.9 (the shares are allocated as a "boiler with a thermal equivalent production").

In order to overcome this penalty, there are support mechanisms for cogeneration, such as white certificates, which cover what the Emission Trading off.

There is an exception to the above case and it is the possibility to allocate CO2 allowances for the "process emissions" defined according to European Decision n.278/2011: as emissions from the combustion of carbon is completely oxidized in activities as per Table 1 for the production of measurable heat, no measurable heat or electricity less emissions result from burning a quantity of natural gas with an energy content equal to the one of these gases; (see. guidance Document no. 8 on the gas discharge and under installations with process emissions for more information on the exhaust gas, on the distinction between emissions of type b and c the respective assignment).

Annulla modifiche

The chemical or electrolytic reduction of metal compounds in minerals, concentrates and secondary materials;
The removal of impurities from metals and metal compounds;
The thermal decomposition of carbonates, except those used for the cleaning of chimneys;
Chemical syntheses where the carbon-containing material participates in the reaction for a purpose different from the main production of heat;
The use of carbon containing additives or raw materials for a purpose different from the primary heat generation;
The chemical or electrolytic reduction of oxides metalloids or non-metallic, such as oxides of silicon and phosphates.

Tab. 1

We emphasize that, in the third period, the production of electrical energy by thermal recovery would be advantageous if compared to the technologies of direct production of energy. For these technologies will not be allocated CO2 shares and therefore the emissions from fuel used to produce electricity will be covered by creating the cost of the shares purchase.

6.3 Draft of standard "prEN16247 Energy Audits part 3 Processes"

Title

"Energy efficiency indicators designed to estimate the potential for heat recovery from industrial processes for electricity generation by ORC (Organic Rankin Cycle) Technology. Addendum to the Draft European Standard prEN16247 Energy Audits Part 3".

Overview

Thanks to the ORC (Organic Rankine Cycle) technology, the heat recovery is technically and economically achievable, even at medium-low temperatures (below 300 °C), with no constant sources and in an even modest amount (in the order of some thermal megawatts).

Generally, the ORC technology enables the heat recovery from any industrial process with an available heat waste output greater than 3/5 MWt, equivalent to a 20 MSm3 annual consumption of natural gas (or 15 Mtoe of coal).

Goal

The aim of this paper is to integrate the Draft: "European Standard prEN16247 Energy Audits - Part 3 Processes" by indicating the methodology and by supporting the 'Energy Auditor in evaluating the potential for heat recovery from industrial waste.

This intervention is integrated with the other ones in the field of energy efficiency as required by Standard.

Methodology

The energy auditor in cooperation with the company must identify all the heat waste in the production site. For each type, he will define the parameters characterizing these wastes. Generally, the following parameters are sufficient:

- ΔT (°C) = (T1-T2) (°C) temperature Delta
- M (kg/s) = Mass of heat waste
- Cp = specific heat of the heat waste (generally between 1.02 and 1.2)
- hy = Number of operating hours per year.

The energy auditor will evaluate if measurements in critical points are necessary in case of not enough available data.

This paper proposes an methodological approach based on the principle that energy efficiency is maximized by using the thermal recovery of heat waste, but if not possible or in absence of end-users within or nearby the process, then the heat recovery is analyzed for purposes of electricity generation.

methodology:

1. heat recovery within the production process (eg, the first material preheating, preheating combustion air, etc. ..)

2. heat recovery to power facilities,

3. heat recovery for heating offices, workshops, warehouses, industrial heating, etc..

4. heat recovery for power generation.

The heat recovery inside a production process (to supply power to the facilities and/or to warm up outdoor or indoor spaces are generally not standardized as they are linked to the layout of the production site, to the presence of civil or industrial thermal loads at economically interesting distances, to the age and type of the installed equipment and to the peculiarities of production processes.

It is in charge to the energy auditors to map the peculiar characteristics of the production site in cooperation with the company and to evaluate the effectiveness (also the economic one) of an intervention aimed at recovering the waste heat to generate electricity.

As the exploitation of waste heat has no direct impact on production processes but downstream effects (with exclusion of some special cases), the heat recovery from an industrial process for electric power generation is defined by standardized performance indicators.

Technological indicators of performance

We have defined two types of indicators:

- the indicator of compatibility $\mathbf{C_{HREII}}$ is a qualitative indicator that is closely linked to the type of economic activity in the manufacturing site.
- the indicator of energy efficiency $\mathbf{P_{HREI}}$ is a quantitative indicator that defines the electrical power recoverable from a heat flow of waste.

Compatibility Indicator

Thanks to the information extracted from the analysis of industrial processes and from previous studies on interventions for heat recovery, it could be possible to associate a compatibility indicator CHREII for interventions in heat recovery by using ORC technology in the various different sectors.

The evaluation of the indicator CHREII is a preliminary assessment preceeding the evaluation of the electrical efficiency indicator $\mathbf{P_{HREI}}$ and it is useful as a first orientation element for the Energy auditor.

This characteristic has been expressed by a number from 1 to 3, where 1 indicates maximum compatibility,
and 3 indicates little or no compatibility. In this last case, the Energy auditors may decide with the Company to stop and not to calculate the 'indicator of energy efficiency $\mathbf{P_{HREI}}$.

$\mathbf{C_{HREII} = 1}$ maximum compatibility of economic activity for the purposes of the enhancement of electrical waste heat,
$\mathbf{C_{HREII} = 2}$ intermediate compatibility of economic activity for the purposes of the enhancement of electrical waste heat,
$\mathbf{C_{HREII} = 3}$ low or no compatibility of economic activity for the purposes of the enhancement of electrical waste heat.

Activity Sectors	**Compatibility Indicators C_{HREII}**
Extraction of minerals from quarries and mines	3
Extraction of crude oil and natural gas	3
Food Manufacture	3
Wood and wood products	2
Beverage Industry	3
Manufacture of chemicals	2
Manufacture of glass and other glass products	1
Manufacture of coke and other products derived from oil refining	2
Manufacture of other non-metallic mineral processing	1
Production of cement lime and plaster	1
Manufacture of refractory	1
Manufacture of concrete products, cement and plaster	1
Iron and Steel	1
Production of precious metals	3
Production of aluminum	1
Production of cooper	1
Production of lead-zinc and tin	3
Production of other non-ferrous metals	3
Casting of iron	1
Manufacture of furniture	3
Production of electricity transmission and distribution	1
Treatment and disposal of waste	3
Gas Compressors networks	1

Extract from the list available on the site www.HREII.eu

Energy efficiency indicator

The electrical efficiency PHREII indicator is an estimate of potentially recoverable energy from heat waste in the production site and not fully exploited in other ways (eg raw material preheating, preheating combustion air, facilities etc. ..).

For the application of ORC technology, the indicator PHREII is calculated by using either the data of some internal reports or the on-site measurements:

- ΔT (°C) = (T1-T2) (°C) temperature Delta
- M (kg/s) = Mass of waste heat
- Cp = specific heat of the heat waste (generally between 1.02 and 1.2).

It is necessary to calculate the lost thermal power:

$$\mathbf{P_t}\ (Kw) = \Delta T * M * Cp$$

The indicator of electric efficiency PHREII can be calculated using as a first approximation an electrical efficiency of 0.2:

$$\mathbf{P_{HREII}}\ (Kw) = \mathbf{P_t}\ (Kw) * 0.2$$

But it is also necessary to evaluate the performance shown in the datasheet of the ORC machines that are different from manufacturer to manufacturer.

- If 250 Kw_{el} < $\mathbf{P_{HREII}}$ < 5 Mw_{el} , then the ORC technology is applicable.
- If $\mathbf{P_{HREII}}$ < 250 Kw_{el} , then the ORC technology is applicable, but the performances are lower.
- If $\mathbf{P_{HREII}}$ > 5 Mw_{el} , then it is suggested the steam technology.

Economic indicators of performance

An econometric estimation of investment parameters of an ORC plant is possible

An econometric estimation of parameters for an ORC plant investment is possible if are known size and technical characteristics of the system, so as its components:

hy = Number of operating hours per year.

Plant costs:

- ORC Turbine
- Heat exchenger
- Facilities
- civil engineering

maintenance costs:
- Ordinary
- exceptional

Operating Costs

Selling price of electricity.

It is possible to calculate the parameters econometric of the investment by using these data with a calculation method chosen by the Energy auditor.

Estimation of CO2 avoided

In the different processes for generating electricity from fossil fuels, the carbon in the fuel is completely converted into carbon dioxide by the reaction with the oxygen in the air.

Therefore, there are several "CO2 factor" linked to fuels, which represent how much CO2 is formed from the complete conversion of one unit of fuel.

The energy produced by a plant to recover heat from industrial processes (e.g.: ORC plant) replaces an amount of electricity that the company should buy from the grid. In many countries, the in plant-produced electricity has various sources such as coal, oil, natural gas, hydroelectric, wind and photovoltaic power, geothermal power plants.

1kWh corresponds to the production of the combustion of 2.56kWh in the form of fossil fuel, and consequently they are emitted into the air about 0.545grammi CO2/kWh of carbon dioxide.

Each kWh of energy produced by recovering waste heat waste from industrial processes, avoids the emission of 0,545 grams of carbon dioxide CO2 (source Terna budget).

The energy auditor may, in agreement with the Company, perform the analysis of the environmental benefits that are obtained as a result of recovery of waste heat for electricity generation.

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