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Regulatory framework on policy to support electricity generation from waste heat recovery

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Index of abbreviations used in the report:

CCGT - Combined Cycle Gas Turbine
CHP - Combined Heat and Power
ESCO - Energy Service Company
NPV - Net Present Value
ORC - Organic Rankine Cycle
RES - Renewable Energy Sources
TEE - white certificates under the Italian mechanism
TOE - ton of oil equivalent
WHR - Waste Heat Recovery
WHRPG - Waste Heat Recovery Power Generation

BE - Belgium (Walloon Region)
FR - France
DE - Germany
IT - Italy
NL - Netherlands
NO - Norway
PL - Poland
ES - Spain
SE - Sweden
UK - United Kingdom

Countries involved in the HREII DEMO study on policies support to waste heat recovery for electricity generation in Europe are those ones which could have an interesting potential for the diffusion of the this technology: Belgium, France, Germany, Italy, Netherlands Norway, Poland, Spain, Sweden and UK.
The study focuses on electricity generation from waste heat recovery in general and does not consider the case where the recovered heat is from renewable source, since it is a limited subset and it is usually supported with *ad hoc* incentives.

Acknowledgement

The authors would like to thank for their kind contribution to the HREII DEMO study on policies support to waste heat recovery for electricity generation in Europe: Jens Acker - Bundesministerium für Wirtschaft und Technologie, Thomas Björkman - Energimyndigheten, Cyrielle Borde - ADEME, Samantha Eisenhauer - ENEA, Charo Julián Rodríguez - IDAE, Ryszard Wnuk - KAPE and all the other people who helped in the drafting of this document, Hans-Paul Siderius - RVO.

Summary

1. European Union

At European level the heat recovery form energy intensive industries falls in various directives.
The Directive 2010/75/EU on industrial emissions and the 2012/27/EU on energy efficiency can have meaningful influences on the national regulations and decision processes fostering the diffusion of waste heat recovery for electricity generation.

Directive 2010/75/EU
Provides the general framework for the control of the main industrial activities, giving priority to intervention at source, ensuring prudent management of natural resources.
The heat is listed in the definitions of emission and pollution, but limit values are not assigned for heat emissions. The Directive establishes an integrated approach to prevention and control of emissions, passing through the definition of the sectorial Best Available Techniques (BAT) - to be revised at least every 8 years - and the integrated authorisation of the plants.

Directive 2012/27/EU
Requires the Member States to set energy efficiency obligations schemes (e.g. White Certificate) or alternative measures, periodical high quality energy audit or energy management systems for large enterprises and a cost benefit analysis of utilising the waste heat for new and substantially refurbished installations with a total thermal input exceeding 20 MW.

2. Member States

Hereafter are presented summaries of national regulatory frameworks supporting in various ways the heat recovery for electricity generation. A separate section is dedicated to some of the heat mapping tools developed around Europe and at other projects in the field of heat recovery for electricity generation at national and European level.

2.1 Belgium – Walloon region[1]

The Walloon Commission for Energy is in charge of the management of the green certificates mechanism for the support of electricity production from renewable energy sources and CHP. As defined by the Décret 12 avril 2001, art. 2, 11°[2], it is considered electricity produced from renewable energy or high efficiency cogeneration:

"L'électricité produite à partir de sources d'énergie renouvelables ou de cogénération de qualité dont la filière de production génère un taux minimum de 10 % d'économie de dioxyde de carbone par rapport aux émissions de dioxyde de carbone, définies et publiées annuellement par la CwaPE (Commission wallonne pour l'Énergie)."	"the electricity produced from renewable energy sources and cogeneration whose quality production chain generates a minimum rate of 10% less carbon dioxide compared to emissions of carbon dioxide, defined and published annually by the CwaPE (Commission wallonne pour l'Énergie)."

The carbon dioxide emissions are those produced by the whole cycle of production of green electricity, encompassing fuel production, emissions during the eventual combustion and, where appropriate, the treatment of waste. The green certificates mechanism in Walloon region gives indeed support for CO_2 avoided. The electrical production or CHP is compared to standard combined cycle gas turbines plants (CCGT) with emission factor of 456[3] kg/MWh and standard boiler with 279[4] kg/MWh. When the CO_2 saving is more than 10%, the installation can receive green certificates.

The green certificates mechanism thus foresees a specific support also for the recovered heat: in fact, the heat that can apply to the mechanism in order to obtain some support (and certificates) is the one coming from renewable biomasses, a boiler or an engine/reactor used in high efficiency cogeneration up to the threshold of environmental performance (measured in CO_2 economy rate) or from a gas turbine combined with a steam turbine which is high efficiency cogeneration. Limited to this definition, it possible to be considered eligible for incentives in case of heat recovery. For the power generation from waste heat recovery (WHRPG) the calculation of the CO_2 during the electricity production takes into account the fuel used for the process, in this case no CO_2 saving compared to a CCGT, then no support. What it is still under evaluation is that this CO_2 is produced for the process and then there is no extra CO_2 for electricity production itself. For a new and broader support scheme to be created in the region in the next future for waste heat recovery there are some open questions, such as the definition of what is heat recovery, what kind of support and which kind of recovery (energy recovery or heat recovery?) can apply to the new supposed mechanism.

The potential power generation from the recovery of wasted heat in the energy intensive industries of the Walloon Region has been evaluated in around 400 MWh/year (Table 1).

[1] "La récupération de chaleur fatale: réflexions du régulateur", Pierre-Yves CORNÉLIS, Commission wallonne pour l'Énergie, Promotion des énergies renouvelables - Namur, le 13 décembre 2011.

[2] 12 avril 2001 – Décret relatif à l'organisation du marché régional de l'électricité, Available at wallex.wallonie.be/index.php?doc=9075

[3] The reference electric efficiency of CCGT is 55% efficiency, the emission factor of NG is not the one of combustion (201 kg/MWh), but is calculated considering the life cycle: 251kg/MWh. 251/0.55 = 456 kg/MWh.

[4] The reference efficiency of a boiler is 90%. With the assumption of note 3, 251/90% = 279 kg/MWh.

Technology	Waste heat	Producible power	Plants in Walloon Region	Total GWh
Glassworks	10 MW/float	2 MW/float	6	100
Cement industry (dry line)	20 MW/kiln	4 MW/kiln	2	60
Lime (rotative furnace)	10 MW/kiln	2 MW/kiln	4	60
Steel industry BOF	0,07 MWh/t	0,014 MWh/t	-	-
Steel industry EAF	0,18 MWh/t	0,036 MWh/t	5	90*
Others (estimation)				90
Total potential				400
*Based on 2008 production				

Table 1 - Potential waste heat recovery in Walloon Region, Daniel Marenne - December 2011

2.2 France

In France the white certificates scheme promotes energy efficiency in the industrial sector, but only a few measures are rewarded and power generation from WHR (Waste Heat Recovery) is not considered.[5] In the French White Certificate scheme the only waste heat recovery operations eligible to receive white certificates are those ones concerning heat in residential, tertiary or agricultural buildings. The scheme recognizes white certificates for the kWh of renewable heat production (or waste heat) but do not recognize certificates for the kWh of electricity produced. The electricity production cannot receive white certificates according to the present rules of the French mechanism.
France at the moment is considering the implementation of a specific measure to support heat recovery for electricity generation, taking in to account the existing European and international policies in this field as it is considered an effective measure to reduce CO_2 emissions.
French energy agency, ADEME, commissioned to a consultancy company a Worldwide study on the dispersed heat (chaleur fatale) for electricity generation. The study was delivered at the beginning of 2013.
At the end of 2013 ADEME completed a study for the Ministry of environment and energy, with an estimation of a realistic potential in France of 1,5 TWhe electricity generation from waste heat.

2.3 Germany[6]

In Germany the first CHP support policy and regulation was reviewed in August 2012. The relevant article concerning waste heat recovery is article 3, paragraph 2:

"KWK-Anlagen im Sinne dieses Gesetzes sind Feuerungsanlagen mit Dampfturbinen-Anlagen (Gegendruckanlagen, Entnahme- und Anzapfkondensationsanlagen) oder Dampfmotoren, Gasturbinen-Anlagen (mit Abhitzekessel oder mit Abhitzekessel und Dampfturbinen-Anlage), Verbrennungsmotoren-Anlagen, Stirling-Motoren, ORC (Organic Rankine Cycle)-Anlagen sowie Brennstoffzellen-Anlagen, in denen Strom und Nutzwärme erzeugt werden. Bei KWKK-Anlagenwerden die KWK-Anlagen durch eine thermisch angetriebene Kältemaschine ergänzt."	"CHP in the meaning of this law are combustion turbines (pressure equipment, removal and release condensation units) or steam engines, gas turbine plants (waste heat boilers or heat recovery boiler and steam turbine plant), systems of internal combustion engines, Stirling engines, ORC (Organic Rankine cycle) systems and fuel cell systems in which to generate electricity and heat. In trigeneration plant are complemented by a thermally driven chiller the CHP".

To be clearer, ORC - as said in the article above[7] - can be considered as CHP and then eligible for incentives only if the heat that is used to produced electricity is going to be re-used for heating after this process. In this case it can receive incentives under the current CHP regulation.

The first CHP law for existing big plants was initially proposed in 2001 and became law in 2002. This law applied for CHP plants which could not receive support from RES law (because

[5] "Driving a Resource Efficiency Power Generation Sector in Europe", Delta Final Report 19 May 2011.
[6] "German policy and market update", COGEN Europe Webinar, Adi Golbach, 20/09/2012.
[7] Those information was clarified by officials from the German Federal Ministry of Economics and Technology.

fed by fossil fuels) mainly for modernization of big plants or for new installations up to 2 MW_{el} with a bonus support for electricity fed into the public grid and depending on size category: up to 50 kW_{el}, up to 2 MW_{el} and over 2 MW_{el}. Some adjustment have been proposed since then, and in 2009 the 2nd CHP law was published, setting new goals: 25% CHP share in total electricity production (without a deadline) from modernization and new installations without size limit, with bonus payments for the complete produced electricity (also for use in site). It was foreseen also a support for heat grids (up to 20% of investment cost) with a yearly cost limit equal to 750 million €[8]. The monitoring of effects will be done after 2 years, and the CHP share will include also bio-CHP for 15% of the total.

A reviewed ("amended") CHP law was launched in August 2012 and should run until 2020. With this new legislative framework the goal of 25% CHP share is finally set up to 2020 as in the old legislative framework the time horizon was not clearly defined. CHP will receive priority of connection and dispatch as set for RES and the overall budget allocated will be confirmed (up to 750 million €/year). All categories will get a 0,3 €cent more and from 2013 also an additional 0,3 €cents for ETS as "compensation cost".
A new category is introduced for plants from >50 to 250 kW_{el} with options for Mini CHP (≤ 50 kW_{el}) and Micro CHP up to 2 kW_{el}[9]. The bonuses for all the categories are summarized in Table 2. Moreover, the industrial waste heat is counted as CHP heat and the support of heat storage infrastructure will be equal to 250 €/m3 up to 30% of investment costs (up to 5 million euro). Incentive for flexible CHP operation with regards to the growing supply of fluctuating wind and solar electricity is also set in the new framework.

Bonus payments for new high efficient installations and modernisations		
Elect. Power (proportional*)	Bonus per kWh produced	Support
≤ 50	5,41 cent Optional for ≤ 2 kW: one time payment for 30.000 foh**	10 years or optional 30.000 foh**
≤ 250 kW	4 cent	
≤ 2.000 kW	2,41 cent	30.000****
> 2.000 kW	1,8 cent	Foh**
From 2013 for ETS plants	2,1 cent	
*** proportional means: for the first 50 kW 5,41 cent; for the next 200 kW 4 cent; for the next 1.750 kW 2,41 cent; for the exceeding power capacity 1,8 cent or – in case of ETS plant – 2,1 cent. ** foh = full operating hours *** if modernisation costs are ≥ 50% of the cost of a new installation. Otherwise, (if ≥ 25%) 15.000 foh.**		

Table 2 - Bonus payments for new high efficiency installations and modernizations, from COGEN Europe

The German ORC association[10] stated in August 2012 that heat recovery is an energy source that can replace four large nuclear power plants in performance and load profile on environmentally neutral and network-friendly manner, but unfortunately this energy source is not used, because a legal basis does not exist at the moment in Germany.

[8] The support is not paid by the Federal budget but by the electricity consumers as an allocation of the grid operators.
[9] Other news coming from the new CHP law concern the support for heating and cooling networks if 60% of the heat or cold comes from CHP or waste heat. What is particularly interesting is the inclusion of cooling into the network support and the support for heat (and cold) networks that rises to 100 €/m and max. 40% of investment (<= 100 mm diameter) or 30% (> 100 mm diameter).
[10] www.orc-fachverband.de/

An interesting chance for demonstration projects is represented by the "Environmental Innovation Program" (Umweltinnovationsprogramm) from the Ministry of Environment[11] in the form of subsidized loans to long-term effective interest rate of 1.86%/year that can reach a period of 30 years. This program applies to projects demonstrating the first time the manner in which advanced techniques to avoid or reduce environmental impacts can be realized, thus also to projects where electricity is generated from waste heat.
The eligibility criteria are in the funding guidelines of 4/2/1997. The KfW Banking Group is in charge of the administrative and financial management, while the technical examination of projects is due to the Federal Environment Agency[12].

2.4 Italy

2.4.1. The Italian white certificate scheme

In Italy, projects related to waste heat recovery to electricity generation can be eligible for white certificates under the Italian mechanism (TEE). The mechanism is applicable in the case of energy efficiency actions in the end uses and recognizes one white certificate for each saved toe (ton of oil equivalent).

The Italian scheme foresees three kind of method to present different energy efficiency actions:

1) through special "files" already defined and approved by the authority managing the mechanism (standardized procedure method),

2) deemed savings (where savings are calculated on the basis of an algorithm - already defined and approved - based on at least one measurement),

3) proposing an energy monitoring plan (the so called "metodo a consuntivo").

It is not possible to present projects related to heat recovery to electricity generation in the industrial sector through the first two options, so only the energy monitoring plan shall be eligible. ORC feed by recovered heat can receive TEE for the electricity production of the first 5 years. 5,35 MWh of electricity are 1 toe (the equivalence is stated by the authority managing the mechanism, considering the average efficiency of the Italian thermoelectric plants) and there is a multiplication factor (called "tau", based on the durability exceeding the five years, so it can be different for other efficiency measures) of 3,36 to obtain the number of TEE.

In case of renewable sources it is possible to obtain TEE only if the produced electricity does not already receive other incentives.

In the NEEAP 2011 at Appendix A – "preliminary analysis for the provisions of new standardised technical data sheets for awarding white certificates" it is written that: "heat recovery does not relate to a single technology, since it is not linked to a specific plant or device; rather it is a procedure within the structure of a manufacturing process determined by the need to optimise flows of energy". This is the reason why waste heat recovery technologies could only apply to the energy monitoring plan.

[11] More information ca be found at: www.bmu.de/en/topics/government-funding/assistance-programmes/general information/?cHash=708635c8a9f766bc5d0c165b53867c44 (in English) and www.bmu.de/themen/forschung-foerderung/foerderprogramme/umweltinnovationsprogramm-inland/
[12] www.umweltbundesamt.de

The Italian White Certificate scheme is a baseline and trade incentive scheme and it is one of the first started in Europe. The first draft was defined in July 2004 by two Ministerial Decrees with the aim of promoting energy efficiency measures on final energy uses. After that, there were several changes, the last of them with the Ministerial Decree of 28/12/2012.
The system is based on the obligation, imposed on electricity and natural gas distribution system operators (DSOs) with more than 50,000 customers, to reach yearly energy saving targets, measured in tons of oil equivalent (toe). These target savings have to be fulfilled with the presentation of a corresponding number of white certificates, (WhCs) with unitary value of 1 toe each, also known as energy efficiency certificates (TEEs).
The DSOs can reach their targets either by acting directly on final consumers or by buying WhCs from voluntary subjects:

- Energy Service Companies, ESCOs
- companies that have an appointed energy manager as provided by Italian law 10/1991;
- companies with energy management system certified in accordance with ISO 50.001 ;
- distributors without obligation (with less than 50.000 customers);

The Ministerial Decree of 28/12/2012 hands over the managing role in the WhC mechanism from the Italian Electricity and Gas Authority (AEEG) to the Manager of Energy Services or "Gestore dei Servizi Energetici" (GSE), with the support of the Italian Energy Agency (ENEA) and Research of Energy System (RSE) for the technical evaluation and approval of projects.
Figure 1 shows how the scheme currently works.

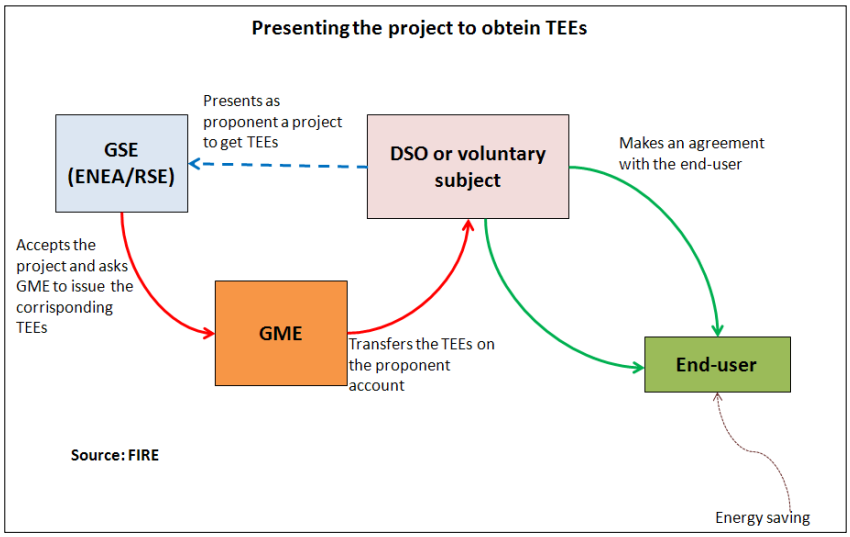

Figure 1: Italian WhC scheme. Presenting the project to obtain TEEs

A DSO or a voluntary subject may apply for WhC by presenting an energy efficiency project. If the project satisfies the rules set by GSE and is approved by ENEA or RSE - whose tasks are to check that the projects, forwarded to one of them by GSE, are technically and administratively correct - the subject receives from GME (Gestore dei Mercati Energetici, which manages the Italian Power Exchange and the Emission Trading) on its dedicated WhCs' electronic account a number of WhC corresponding to the recognized savings. DSO or voluntary subject can then trade the certificates (**Figure 2**) either on the real time GME electronic market or through bilateral contracts registered on the GME's platform.

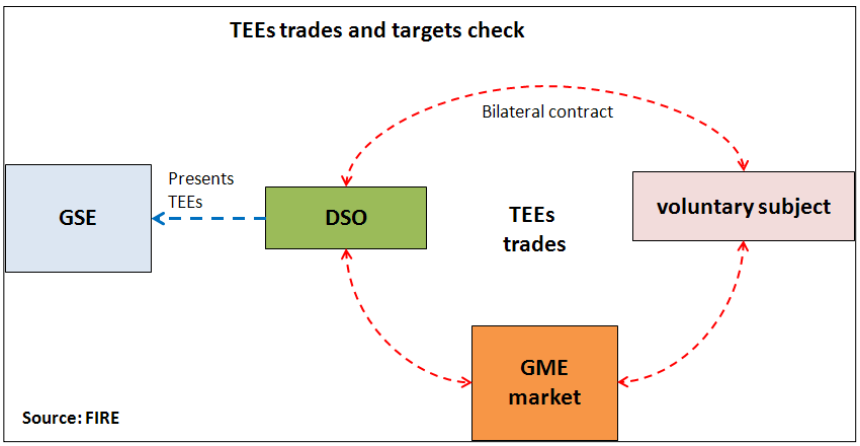

Figure 2: Italian WhCs scheme. TEEs trades and targets check

Operators that cannot present WhC projects may join the market too as traders. The end-user can benefit from part of the economic value of the WhC or, less frequently, from a discount on the capital cost of the solution or on the energy service annual fee, where applicable.

The scope of WhC trading is to allow obliged DSOs to obtain an amount of WhC sufficient to reach their targets. The certificates should be presented to GSE within May 31st of the year that follows the obligation and in the case of an insufficient number of certificates the DSO is subjected to penalties.

End users pay the cost of WhCs' mechanism via a tariff component on electricity and natural gas distribution fees. To recover costs for the DSOs, the GSE recognize an amount, established year by year, for each WhC presented to fulfill the obligation.

Figure 3 shows Italian WhC targets and results obtained until 31/03/2013.

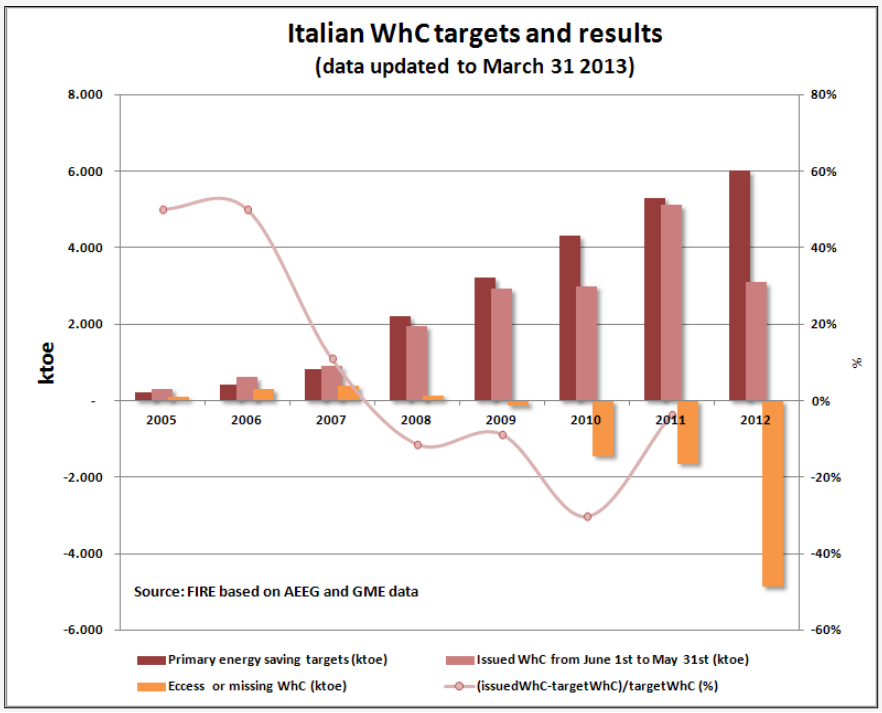

Figure 3: Italian WhC targets and results

The aim of the mechanism is to give the incentive only to the savings promoted by the scheme – and not to the ones that would be obtained in any case because of technological improvement, mandatory standards or market developments, thus theoretically ensuring that the incentive is both cost-effective and able to promote an increase in energy efficiency. The mechanism subsidizes those measures which are evaluated to be innovative and go beyond the market average and regulatory requirements for that product / sector (i.e. that they are "additional"). "Additional" savings are evaluated with respect to a standard market baseline, depending on the considered solution and/or sector, that represents the average energy performance of the typical action. In case the system already installed in the client premises is more efficient of the market baseline, the client's system is considered as baseline.
There are three ways of saving reporting:

1. Standard files;
2. Analytical files;
3. Monitoring plan.

The first two types belong to the group of simplified files approved by the Ministry (in the past by AEEG) including a series of standardized and cross-cutting measures, applicable on large scale. Currently there are about 40 files. The savings are recognized by an algorithm indicated on the files, in relation to the number of units installed or substituted, (for example by reason of square meters installed in the case of solar thermal energy, with a saving variable in function of the type of panel, the boiler replaced and the geographic region).
If the measure of interest is not included in the files, and / or in the case of heterogeneous measures within a single customer, a monitoring plan has to be implemented. This method is mainly used in industrial sector, where there are complex processes difficult to standardize. This requires the proponent (an obliged or voluntary subject) to submit a preliminary "Proposal for a plan and program of measures" (PPPM), indicating the description of the

project, the measurement chain, the algorithm for calculating the savings, identification of baseline and additionality, and finally the durability coefficient.
These durability coefficients, introduced in November 2011 by AEEG, increase the WhCs issued considering the useful life of the measure and not only the period during which the WhCs are issued (five years or eight years for measures on the building envelope). To calculate the "tau" coefficients, the savings after the first five years (or eight years for building envelope) till the usual life span are considered (**Figure 4**), with a conventional reduction factor of 2% each year. The tau coefficients are associated with the categories of the measures. For a monitoring plan is the proposer in charge of defining the baseline and the algorithm for the determination of savings through statistics, field studies, surveys and references from the major players in the sector considered.

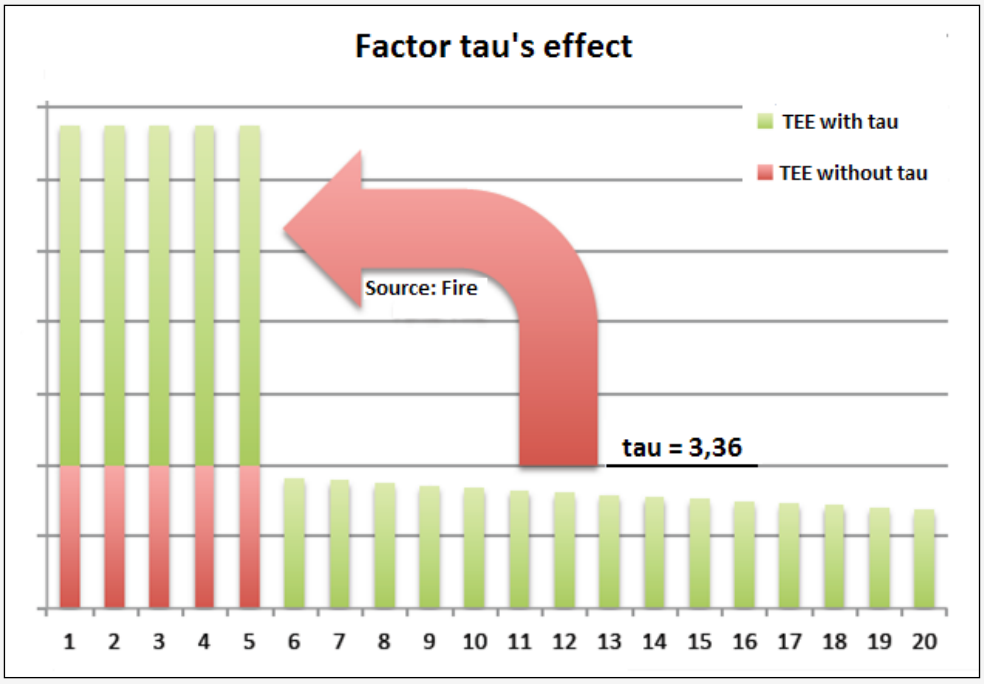

Figure 4: The tau factor, recognizing the savings during the useful life, after the first five years

The category of interest (see **Table 3**) for the thermal recovery for electricity generation in the industrial sector is the "IND-GEN Processes industrial generation of electricity from or recoveries from renewable sources or cogeneration", which among the examples of measures lists the use of waste heat for the generation of energy electricity. The coefficient of durability associated with this type of measure is equal to 3.36.**EE Measure**	**tau**
IND-T Industrial processes: generation or heat recovery for cooling, drying, burning, melting	3,36
IND-GEN Industrial processes: electricity generation from renewable sources, heat recovery, or cogeneration	3,36
IND-FF Industrial processes: interventions other than the above, for the energy optimization of production processes and plant layout designed to achieve a lasting energy consumption reduction normalized by quantity and quality of production	3,36
IND-E Industrial processes: efficient drive systems (motors, etc.), automation and power factor measures	2,65

Table 3: EE Measure and tau for industrial processes

In the case of heat recovery for power generation or cogeneration in industry there are no simplified files, so it is necessary to proceed through a monitoring plan. Applications regarding Organic Rankine Cycle (ORC) projects can benefit from TEE for the electricity produced from recovered energy or from renewables. In case of renewable energy sources TEE are alternative to other incentives for the renewables (i.e. feed in tariff and green certificates).

There are different types of WhCs but only three have a real market:
- Type I: electricity savings;
- Type II: natural gas savings;
- Type III: savings of other fuels (LPG, diesel oil, etc.) for other purposes than transportation;

TEE are negotiable on an electronic market managed by the GME or through agreements between the parties (bilateral contracts) and each certificate has an economic value estimated to be between 50 and 115 € (**Figure 5**,**Figure 6** and **Figure 7**).

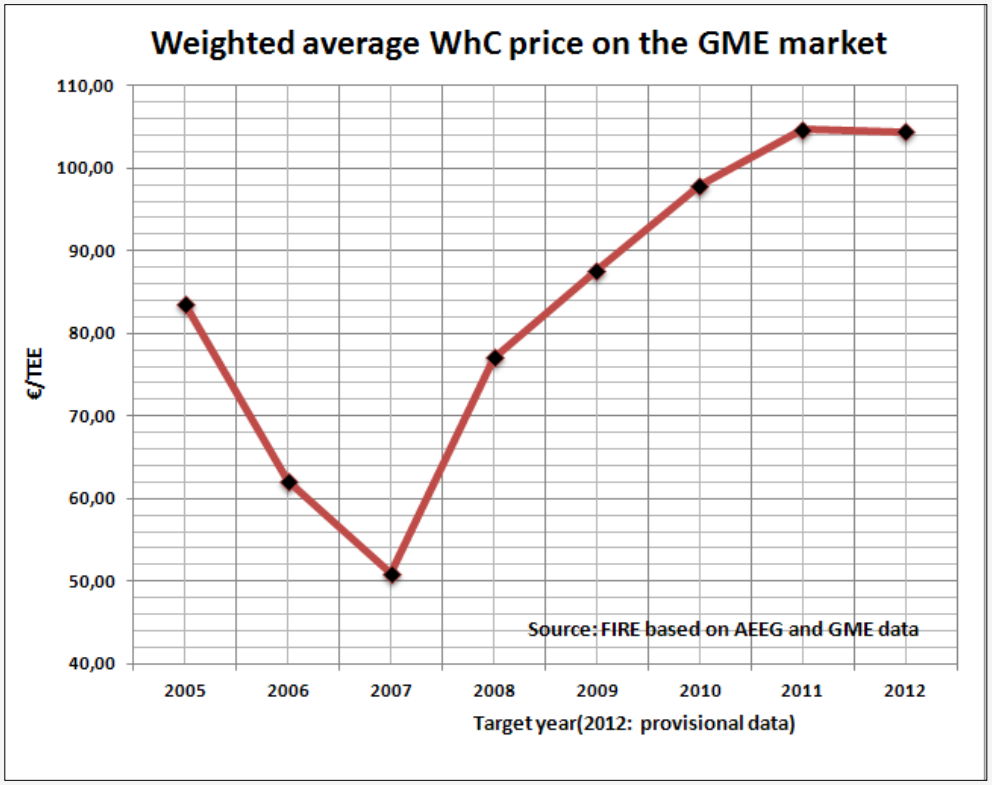

Figure 5: Weighted average WhC price on the GME market

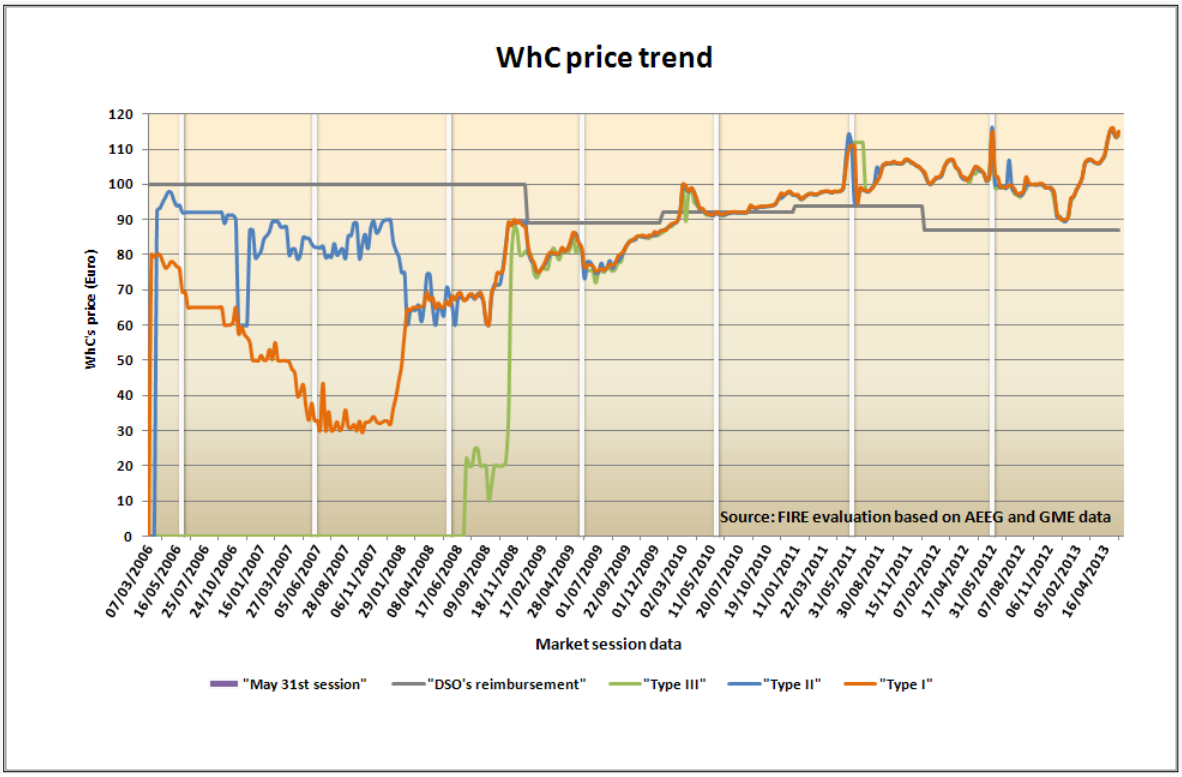

Figure 6: WhC prices trend

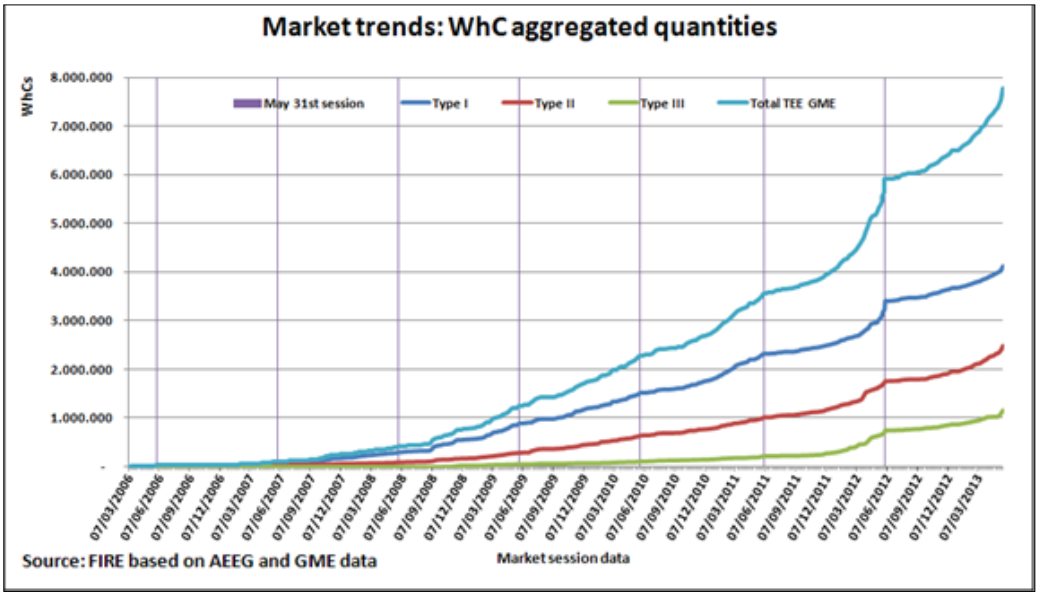

Figure 7: Market trends and WhC aggregated quantities

The scheme provides a minimum saving threshold for presenting projects, which varies from 20 to 60 toe, depending of the evaluation method (Table 2). The threshold can be a problem for small projects, especially in the civil sector, but it is possible to combine different projects to achieve the required threshold (for a company with the energy manager reaching a 60 toe savings is not a hard task).

Threshold	Toe (with tau)
Deemed savings	**20**
Engineering estimates	**40**
Monitoring plan	**60**

Table 4: minimum threshold for presenting projects

Different actions benefiting different clients (**Table 5**) can be presented together specifying that they apply for the same evaluation method how showed in table 4:

Possibility to aggregate different measures	Homogenous savings evaluation methods			Non homogeneous evaluation methods
One client	Deemed savings	Engineering estimates	Monitoring plan	Monitoring plan
Many clients	Deemed savings	Engineering estimates	Monitoring plan	Not permitted

Table 5: Possibility to aggregate different actions in a project to reach the minimum threshold

2.4.2. Italian "Big projects" (Grandi progetti)

The Ministerial Decree 28/12/2012 introduces the provision regarding "big projects". Big projects concern measures in the infrastructures, transports and industrial processes with an annual electricity and fuel savings higher than 35,000 toe and a technical life of more than twenty years.

The proponent presents the project to the Ministry of Economic Development starting the the evaluation procedure dedicated to these specific kind of big projects in order to access to the WhC scheme,.

Then, the Ministry of Economic Development, in coordination with the Ministry of Environment and consulting the interested Region(s) sends the project to GSE (supported by ENEA and RSE) for technical and economic examination and the project must be approved within 120 days. There are also some possible awards for these projects, depending on the level of technological innovation and the impact on reducing emissions, in terms of a multiplier coefficients for the WhCs, up to 1.3. This can be increased, until 1,4, if the project is carried out in metropolitan areas.

The proponent can also choose for arrangements which ensure a constant value of WhC for all five years, equal to the value at the date of approval of the project. Every big project is subject to ex-post controls to verify the correct technical and administrative execution.

Table 6 shows how a plant generating electricity from the recovered industrial heat of around 8 MWe can reach in 7,000 hours/year a number of WhCs equal to 35,000, approximately equal to $3{,}9*10^6$ €/year (considering 1 TEE = 110 €).

In Italy plants around 1-3 MWe already exist and it's also possible to add, in the same context other efficiency measures.

Threshold value [tep/year]	Load factor [Hour/year]	Conversion factor [tep/MWhe]	Coefficients of durability tau	Elettrical power [MWe]
35.000	6,000	0,187	3,36	9,3
	7,000			7,9
	8,000			6,9

Table 6: Example about "Big Project"

2.5 Netherlands

The EIA13 Energie Investeringsaftrek, Energy Investment Allowance, is a support program started in 1997 for investment in energy efficiency and renewable energies in the enterprises, via tax deduction up to 41,5% for 2014. The budget for 2014 is 111M€.
The mechanism works lowering the income tax or corporation tax, thus decreasing the payback time and the need of financing, with the addition benefit of the lower expenses in energy due the implementation energy efficiency/renewable energy measure.
It is possible to apply for the around 160 measures present in a list published by the ministry and updated every year, taking into account the energy saving potential, the market penetration, etc. of the energy saving/renewable energy measures. The measures on the list are mature and efficient, so "the list itself is also likely to have an attention value that may contribute to reduce information failures in the market for technology adoption"14.
It is also possible to request the addition of other technologies to the list, if certain criteria are meet.

In the list of technologies for 2014 (Energielijst 201415) the ORC for waste heat recovery are already present, in:
Part B
Energy re use
221102 Organic Rankine Cycle or Kalina cycles
intended for: converting heat to mechanical or electrical energy using waste heat16,
consisting of: condenser, evaporator, pump, turbine, separator (if any), (possibly) heat exchanger, (possibly) generator, (possibly) connection to the mains supply.

ORC are also present in other two points of the list:
Part D
Sustainable heat
250102 Geothermal heat extraction
and
Part D
Sustainable power generation
251110 Organic Rankine Cycle or Kalina cycle using sustainable heat17
Regarding the latter one, ORC feed by sustainable heat (e.g. from biomass) also receive SDE (Subsidies Duurzame Energie), but from 2014 it is not possible anymore to benefit of both.

There were some ORC installations within the EIA18:
2012 2 ORC feed by sustainable energy
2011 2 ORC feed by waste heat recovery
2010 5 ORC feed by waste heat recovery
2009 No ORC

[13] www.rvo.nl/eia
[14] A. Ruijs, H. R.J. Vollebergh, Lessons from 15 Years of Experience with the Dutch Tax Allowance for Energy Investments for Firms,
[15] www.rvo.nl/sites/default/files/2013/12/EIA%20Energielijst%202014.pdf
[16] Waste heat is heat that is not useful in the existing situation.
[17] Sustainable heat is here means: heat submitted by investment defined in Chapter 3, category D. sustainable energy.
[18] EIA annual report (Jaarverslag Energie-Investeringsaftrek) 2012, 2011, 2010 and 2009.

2.6 Norway[19]

In Norway the Norwegian Energy Fund aid scheme is a financing mechanism with the aim of encouraging energy saving measures and the production of environmentally sound energy.

"Energifondets formål er å fremme en miljøvennlig omlegging av energibruk og energiproduksjon ... Energifonden hører under Olje- og energidepartementet. Enova SF skal forvalte midlene fra Energifondet ... Fondets inntekter består av overføringer fra statsbudsjettet og inntekter fra et påslag på nettariffen. Nærmere bestemmelser om påslagets grunnlag, størrelse og innkreving fastsettes av Olje- og energidepartementet i forskrift.[20]"	"Energy Fund's purpose is to promote environmentally friendly restructuring of energy consumption and production ... Energy Fund under the Petroleum and Energy Department. Enova SF to manage funds from the Energy Foundation ... Fund's income consists of transfers from the state budget and revenue from a levy on the electricity distribution tariff. Further provisions for mark-up basis, size and collection is determined by the Ministry of Petroleum and Energy in regulation. "

The fund is managed by Enova SF[21] ("Enova"), a state owned administrative body[22], and the funds are allocated under specific programmes. Enova supports various forms of environmental measures under this Fund, such as energy recovery and cogeneration. Every year Enova organized call for project proposals for interested parties. Projects are required to have an energy result (environmentally friendly energy produced/saved) of minimum 0.5 GWh in order to be eligible for the funding. The evaluation process of the applications sees ENOVA assessing the technical potential for energy saving/generation and the relevant costs and benefits described in the application.

The technically feasible projects are subject to a detailed financial assessment according to the following steps:

- Enova ensures that the aid amount is calculated in accordance with the extra cost method and is within the intensities laid down in the EAG[23].
- Enova evaluates the projects' net present value ("NPV"). The main reason for rejection is that the projects could be developed with a lower amount of aid than what the applicant requested. In this case, Enova tries to limit the amount of aid to the minimum necessary through negotiations with the applicants.
- The projects are evaluated on the efficiency ratio of kWh energy generated/saved per NOK of aid granted.

Only the extra cost related to the investment in environmental protection is eligible for aid. If it is not clearly identified in the total investment cost, the extra investment cost must be established by comparing the investment with the hypothetical situation in the absence of aid

[19] EFTA Surveillance Authority – Decision of 9 February 2011 on the aid to Finnfjord AS for an energy recovery system.

[20] From "Regulations for Energy Fund - Establishment of the Energy" : the Fund has a background in law on amendments to the Act 29 June 1990 No. 50 relating to the generation, transmission, trading and distribution of energy etc. (Energy Act), § 4-4, cf. No. 35 (2000-2001) and inst O. No. 59 (2000-2001).

[21] Enova webiste: www.enova.no/about-enova/259/0

[22] More information are available in ENOVA Annual Report 2011.

[23] Authority's guidelines on state aid for environmental protection (EAG) are available on the website of EFTA Surveillance Authority at www.eftasurv.int/media/state-aid-guidelines/State-aid-Guidelines.pdf

(without incentive)[24]. After determining the eligible extra cost of the project, Enova applies the NPV method in order to limit the amount of aid to what is necessary to start the project. The NPV calculation is based on the following predetermined conditions:

- With the aid, the NPV (including a reasonable return on capital) cannot exceed zero.
- The rate of return cannot exceed the level of what can be considered as a normal return.
- The value of the energy results of all projects is evaluated according to the same criteria.
- The lifetime of all projects is set according to the same criteria.

According to the Environmental Aid Guidelines[25], investment grants exceeding the threshold fix in point 160(b)(i) Part III of € 7.5 million must be individually notified. In any case, Enova requires the industry to share the acquired "know how", and in this way the Authority finds it unlikely that the technology will provide the industry and other Norwegian producers with a "first mover" advantage.

In its Annual Report 2011[26] Enova looked at the possibility for making energy available, particularly electricity, through more efficient energy use in industry. Several studies show a significant potential for energy efficiency in the industry. Up to 2020, between 10 and 15 TWh could be released if the industry implements all potential efficiency measures. Enova will place emphasis on addressing the potential for waste heat recovery, particularly from power production. Since its creation in 2001, ENOVA tried to increase efforts within power production from low temperature waste heat.

[24] In case of a medium-sized enterprise, the eligible costs must be calculated net of any operating benefits and costs related to the first three years of the life of the investment and the aid intensity cannot exceed 70% of the costs.
[25] The EAG are available on the website of EFTA Surveillance Authority at www.eftasurv.int/media/state-aid-guidelines/State-aid-Guidelines.pdf
[26] ENOVA Annual Report 2011.

2.7 Poland[27]

In Poland a direct promotion for the electricity generation from waste heat recovery does not exist at the moment. The Polish White Certificate scheme, set up by the Energy Efficiency Act of 11/4/2012 considers among the measures also the energy recovery in industrial processes, but doesn't include the installations within EU Emission Trading.
The White Certificates can be obtained through an open public tender for energy saving measures. To participate to the tender it is compulsory an energy audit. A further ex post energy audit is required for yearly savings over 100 toe (ton of oil equivalent).
For electricity savings the equivalence is 11.63 MWh=1 toe.

Poland's Certificates of Origin system supporting energy from renewable and low carbon sources such as biomass, biogas and CHP does not explicitly recognise WHR. WHR could be only subjected to the white certificate system, as established by Energy Efficiency Law that should be implemented soon in the next future.

A kind of support is available for programmes regarding the promotion of energy efficiency in industrial sector, provided by the National Fund for Environmental Protection and Water Management. As stated in the specific rules regulating the Fund[28]:

"Regulamin konkursu - o dofinansowanie ze środków NFOŚiGW przedsięwzięć w ramach programu priorytetowego Efektywne wykorzystanie energii Część2) Dofinansowanie zadań inwestycyjnych prowadzących do oszczędności energii lub wzrostu efektywności energetycznej przedsiębiorstw". "Program Priorytetowy - Tytuł programu: Efektywne wykorzystanie energii, Część1) Dofinansowanie audytów energetycznych i elektroenergetycznych w przedsiębiorstwach."	"Program priority -Title of the program: Efficient use of energy, Part 1) Grants for energy audits and power in enterprises". "Contest rules - a grant from the National Fund projects within the priority program Efficient use of energy Part 2) Funding of investments leading to energy savings and increased energy efficiency companies".

Under this Fund, the "Efficient use of energy" programme has been created with the aim of supporting energy efficiency investments in the most energy intensive Polish enterprises. The total budget is PLN 820 million[29] for the period 2011-2015 and comes from substitute fees and penalties imposed on enterprises by relevant laws and gathered by the same programme. It is divided into two parts, and the first one concerns co-financing energy audits (around 200 audits in total) and activities as:

- energy audits of technological processes,
- energy audits of heat sources,
- energy audits of heating and cooling internal and external networks,
- energy audits of industrial buildings,

[27] Priority Programme "Efficient use of energy. Part I" - Grants for energy audits in industrial enterprises and "Efficient use of energy. Part II" - Soft loans support for investments decreasing energy consumption, www.nfosigw.gov.pl

[28] Program Priorytetowy "Efektywne wykorzystanie energii - Część1) Dofinansowanie audytów energetycznych i elektroenergetycznych w przedsiębiorstwach" and Regulamin Konkursu "o dofinansowanie ze środków NFOŚiGW przedsięwzięćw ramach programu priorytetowego Efektywne wykorzystanie energii - Część2) Dofinansowanie zadańinwestycyjnych prowadzących do".

[29] Corresponding to around € 200 million.

- audits of electricity.

The monitoring body is the Minister of Environment and main beneficiaries for this first part of the Fund are industries with a consumption of more than 50 GWh/year. The period of implementation began in January 2011, will end on 31 December 2014, and the budget for co-financing of energy audits is PLN 40 million (around € 9.400.000). Under this program, industries receive a grant of 70 % of total audit. Audit will be co-financed if it indicates at least 7% of energy consumption reduction, otherwise the audit will be co-financed but the enterprise is obliged to execute the investment of the same volume of the grant to decrease energy consumption.

Regarding the second part, the beneficiaries of the program are industries with an energy consumption over 20 GWh/year. Taking part in to the program is subject to a compulsory energy audit. Investment activities include:
• Implementation of energy management systems and energy quality control,
• Efficient use of electricity,
• Efficient use of heat and gas,
• Modernization of industrial processes.

The period of implementation began in July 2011,will end on 31December 2015 and the budget is PLN 780 million[30]. The funding will be provided in the form of loans covering up to 70% of eligible costs of investment, ranging from PLN 3.5 to 42 million[31]. The minimum eligible project cost is PLN 5 million and the foreseen impact of expected energy savings in 2016 will be equal to 2,900 GWh.

In the 2011 NEEAP it is described an "Overview of measures in industry and SMEs" regarding waste heat recovery. In fact, "a company may participate in the programme on the condition that it carries out an energy or electrical energy audit before; it is not required however for the audit to be carried out within a priority programme of the National Fund for Environmental Protection and Water Management ... the material scope of investments will include also recuperation and heat recovery from processes and devices". Also under the White certificates scheme it is possible to receive support for "energy-efficient investments, such as modernisation of local heating grids and heat sources, buildings, lighting, household appliances, as well as energy recovery and modernisation of industrial devices and installations."

[30] Corresponding to around € 190 million.
[31] 1 Polish Zloty = € 0.24.

2.8 Spain

The use of wasted heat to generate electricity is an activity listed in the special regime for electricity generation regulated by the Royal Decree 661/2007. Eligible under the special scheme provided in this decree are the power production facilities under Article 27.1 of the Law 54/1997 of 27 November[32]:

"Artículo 27. Régimen especial de producción eléctrica. 1. La actividad de producción de energía eléctrica tendrá la consideración de producción en régimen especial en los siguientes casos, cuando se realice desde instalaciones cuya potencia instalada no supere los 50 Mw: a) Autoproductores que utilicen la cogeneración u otras formas de producción de electricidad asociadas a actividades no eléctricas siempre que supongan un alto rendimiento energético. b) Cuando se utilice como energía primaria alguna de las energías renovables no consumibles, biomasa o cualquier tipo de biocarburante, siempre y cuando su titular no realice actividades de producción en el régimen ordinario. c) Cuando se utilicen como energía primaria residuos no renovables. También tendrá la consideración de producción en régimen especial la producción de energía eléctrica desde instalaciones de tratamiento y reducción de los residuos de los sectores agrícola, ganadero y de servicios, con una potencia instalada igual o inferior a 25 Mw, cuando supongan un alto rendimiento energético. 2. La producción en régimen especial se regirá por sus disposiciones específicas y, en lo no previsto en ellas, por las generales sobre producción eléctrica en lo que le resulten de aplicación. La condición de instalación de producción acogida a este régimen especial será otorgada por los órganos correspondientes de las Comunidades Autónomas con competencia en la materia."	"Article 27. Special scheme for electricity production. 1. The activity of electricity production will be considered a special regime in the following cases, when performed from plants with installed capacity not exceeding 50 MW: a) Autoproducers using cogeneration or other forms of electricity production associated with activities involving electrical always high energy performance. b) When used as a primary energy from non-renewable energy supplies, biomass or any type of biofuel, provided that the holder does not produce in the ordinary scheme. c) When nonrenewable waste energy is used as primary energy. Also will be considered under the special regime the electricity production from waste treatment and waste reduction in the agricultural, livestock and service, with an installed capacity exceeding 25 MW, where there is a high energy efficient. 2. The special regime is governed by specific provisions, and in matters not covered by them, by general electricity in what may apply. The condition of production facility of this special scheme will be granted by the relevant bodies of the Autonomous Communities with competence in the subject".

These facilities are classified into different categories, groups and subgroups, depending on the primary energies used, production technologies employed and energy yields obtained. Under Category A are included producers using cogeneration or other forms of electricity

[32] Ley 54/1997, de 27 de noviembre, del Sector Eléctrico: www.boe.es/boe/dias/1997/11/28/pdfs/A35097-35126.pdf

production energy from waste. In particular, these facilities are listed in the group a.2 regulated in Article 2:
"Instalaciones que incluyan una central que utilice energías residuales procedentes de cualquier instalación, máquina o proceso industrial cuya finalidad no sea la producción de energía eléctrica y/o mecánica"
"Facilities that include a plant that uses waste energy from any installation, machine or industrial process whose purpose is not the production of electrical or mechanical energy".

As established in article 24 of the same decree, in order to sell, totally or partially, their production the producers shall choose one of the following options (see Table 7):
a) supply the electricity to the system via transmission or distribution network with a regulated rate expressed in cents per kilowatt-hour (*tarifa regulada*), or
b) Sell the electricity freely to the market and get a "premium" (*prima de referencia*). In this last case, the selling price of electricity will be the price that is on the organized market or the price freely negotiated by the owner or representative of the facility, plus a "premium" in euro per kilowatt-hour.

Summarizing, such facilities have the following, important rights under Article 17 of the same Royal Decree:
- Perception of a regulated tariff or premium over market price in the price of electricity fed into network;
- Right of access and connection to the electricity grid;
- Guarantee of purchase of electricity generated.

Today in Spain there are about 68 MW installed under this kind of regime, but no plant of electricity generation from waste heat recovery.

From an economic point of view, if we consider 1MW plant which works 4.000 h/year and produces 4.000.000 kWh/year, the incentive will be equal to 4.000.000*0,046€ = 184.000 euro with the regulated tariff. If the producer decides to sell the energy directly to the market he will not receive the regulated tariff but the premium one, and in this case the premium will be equal to 4.000.000*0,019344€ = 77.376 euros.

Group	Subgroup	Fuel	Power	Regulated tariff c€/kWh	Premium c€/kWh
a.2			P≤10MW	4,600	1,9344
			10<P≤25MW	4,2100	1,1622
			25<P≤50MW	3,8300	0,6142

Table 7 - Regulated tariff and Premium, c€/kWh

At present there are installed in Spain about 68 MW total electric power with thermal recovery technology for electrical use, almost all operating on a market + premium system.

The mechanism is only applicable to existing plants starting up January 2012, as the RDL 1/2012[33] suspended the economic system for new installations from this date on. Currently there are no estimates of new special economic regimes for such uses.

[33] www.boe.es/boe/dias/2012/01/28/pdfs/BOE-A-2012-1310.pdf

2.9 Sweden

The most important policy measure to promote industrial power generation from heat recovery is the tax legislation. An important policy measure is a substantially lower CO_2 taxation within EU-ETS for heat production in CHP plants compared to the only heat production. CHP-heat meets a 7% carbon tax rate (of 105 öre[34]/kg CO^2) instead of the 94% as seen in the only heat production. Moreover, energy taxation for CHP-heat is lower: 2,4 öre/kWh compared to 8 öre/kWh only for heat production. The CHP carbon tax level was set down on January 1st 2012 from 15%, while the energy taxation is entirely new. Outside the EU-ETS CO_2-taxation for CHP, heat production was increased from 21% to 30%.

An extract from the Swedish tax law:

"Lagens ändamål är att främja en effektiv användning av energi. I detta syfte innehåller lagen bestämmelser som ger energiintensiva företag en möjlighet att delta i femåriga program för energieffektivisering i utbyte mot en befrielse från energiskatten på elektrisk kraft i enlighet med bestämmelser i lagen (1994:1776) om skatt på energi[35]."	"Purpose of the Act is to promote the efficient use of energy. For this purpose, the Act contains provisions that allow energy-intensive companies an opportunity to participate in the five-year program for energy efficiency in exchange for an exemption from energy tax on electricity in accordance with the provisions of the Act (1994:1776) on the taxation of energy."

The increase CHP production over the years is a notable change also in the development of the district heating market. CHP development is primarily incentivized by the electric certificate system as well as substantially lower rates of CO_2-taxation in relation to heat-only boilers. In 2009 CHP amounted to 38% of the total district heating generated. The Figure 8[36] clearly put on evidence how the weight of waste heat as energy input in district heating has been growing starting from the middle of the eighties.

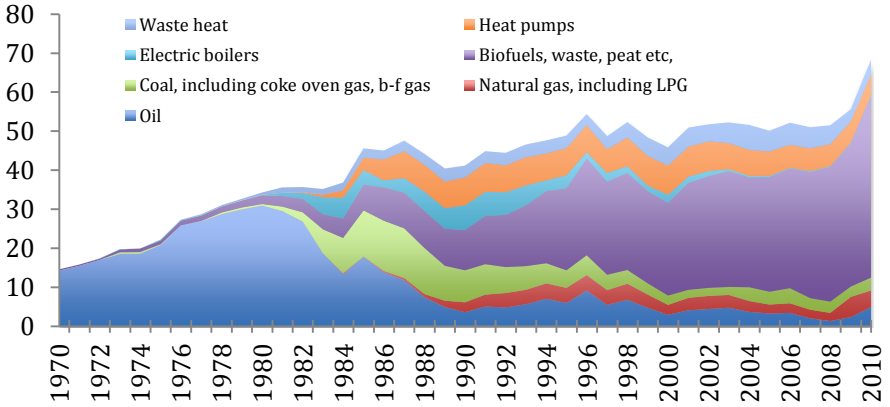

Figure 8 - Energy input for district heating, 1970–2010, TWh, State Power in numbers

The electric certificates system[37] was launched in May 2003. The effects of the system initially meant a shift from fossil to biofuel and the last few years a total increase in CHP investments.

[34] 100 öre = 1 SEK, and 1SEK corresponds to € 0.11.
[35] From the text of Tax legislation
[36] Source: Energiläget i siffror 2011 (ET 2011:42).
[37] "The electricity certificates scheme 2011", Swedish energy agency, available at www.energimyndigheten.se

The Programme for Improving Energy Efficiency[38] (PFE) is another support for energy-intensive industries. It is a voluntary, five years programme created in 2004 that addresses energy-intensive industries and offers a tax credit in exchange for improvements in electrical efficiency. When a company applies to the programme, it commits itself to improve the electrical efficiency, to carry out an energy review, to implement a certified energy management system, and to the establish and implement procedures for the purchasing and planning activities that affect its energy use. The Swedish Energy Agency administers and supervises the programme, while the Swedish Tax Agency ("Skatteverket") handles the aspect regarding tax reduction.
Participation in PFE requires a company to implement and certify a standardised energy management system[39] within the first two years of the programme, and it helps the company to work in order to achieve continuous improvements in their energy efficiency.

[38] Programme for Improving Energy Efficiency - Experiences and results after five years with PFE.
39 The EMS functions as a management tool that helps to plan, implement, monitor and improve a company's energy performance.

2.10 United Kingdom

At the end of 2013 there is no specific UK Government support for electricity generation from waste heat recovery. In 2013 the Department of Energy and Climate Change commissioned to a consultancy company a report estimating the quantities of waste heat recoverable from the heat-intensive industries, but the results at the end of 2013 are not yet public.
This work will inform any subsequent decisions the Government makes regarding support for the utilisation of recoverable heat, including electricity generation technologies such as ORCs.

Consultation on the transposition of article 8 of the 2012/27/EU Energy Efficiency Directive, the Energy Savings Opportunity Scheme (ESOS), published on July 2013, asked among other if the ESOS assessment should cover all energy use, including waste heat recycling. Consultation ended at beginning at October 2013, the results have been analyzed and presented to relevant stakeholders, but are not public.

The Department of Energy and Climate Change published in 2012 a report "The Future of Heating: A strategic framework for low carbon heat in the UK"[40].

[40] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48574/4805-future-heating-strategic-framework.pdf

3. Heat mapping

In Europe there are various examples of heat mapping tools, developed to spread the information on the availability of heat from industry, district heating and in some cases also from renewables, to foster the use of this heat in other industrial processes, in agriculture or for heating and cooling buildings. The scale of these tools is different, from city (e.g. Berlin), region, up to the entire country. The information and tools associated to the internet maps are more or less wide and in some cases it is also present a heat exchange section or there is information on the generation of electricity from waste heat.
This kind of tools can be of interest for electricity generation from waste heat recovery since they give data on the temperature and quantity of heat available in certain zones or in some cases also with the address of the industry and the contact person. The implementation of the 201/27/EU Directive art. 14.1 will probably stimulate the diffusion and further developments of these tools.

3.1 Bavaria, Germany

Various sections are present for different users, from households to public administration to industry. There are pages and manuals dedicated to the possible solutions for industry (comprehending also the electricity generation from waste heat recovery) and on how to calculate the amount of energy. It is also present a heat exchange market to meet supply and demand.

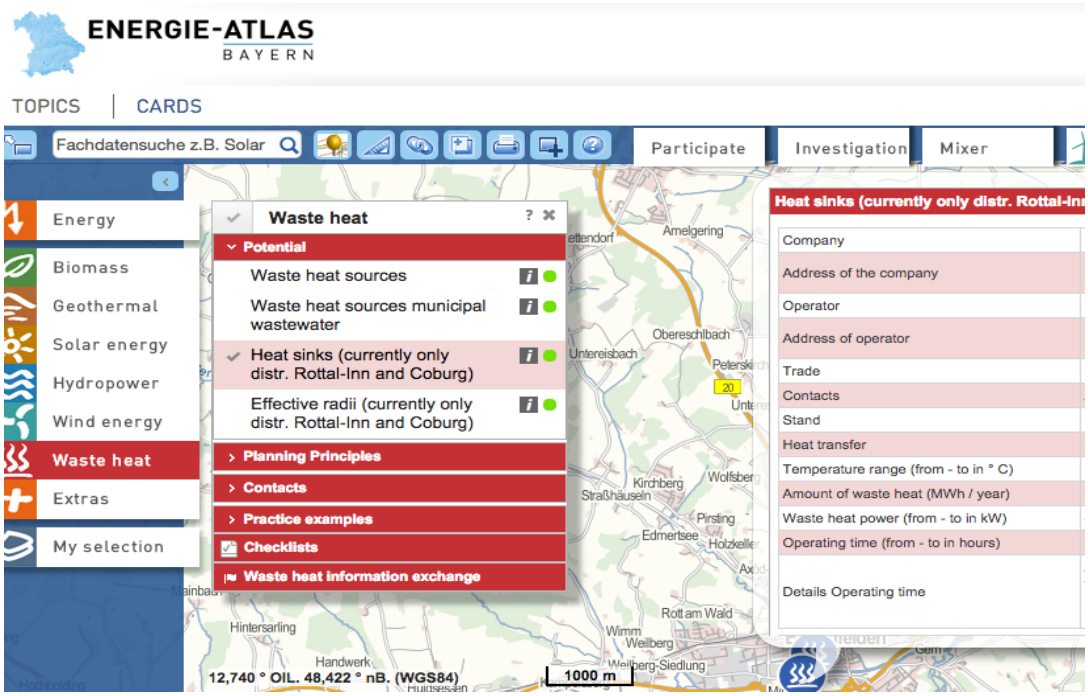

Figure 9 Waste heat sinks and information from www.energieatlas.bayern.de (translated with a web tool)

3.2 Netherlands

Heat potential:

- Waste heat of all large industrial and power plants (one point per plant) with indication of temperature (<120°C, 120-200°C and >200°C) and of amount of heat (<50 TJ, 50-500 TJ and >500 TJ per year)
- Potential Geothermal heat
- Potential Biogas

The open source platform was developed in the framework of Inspire Directive (2007/2/EC)

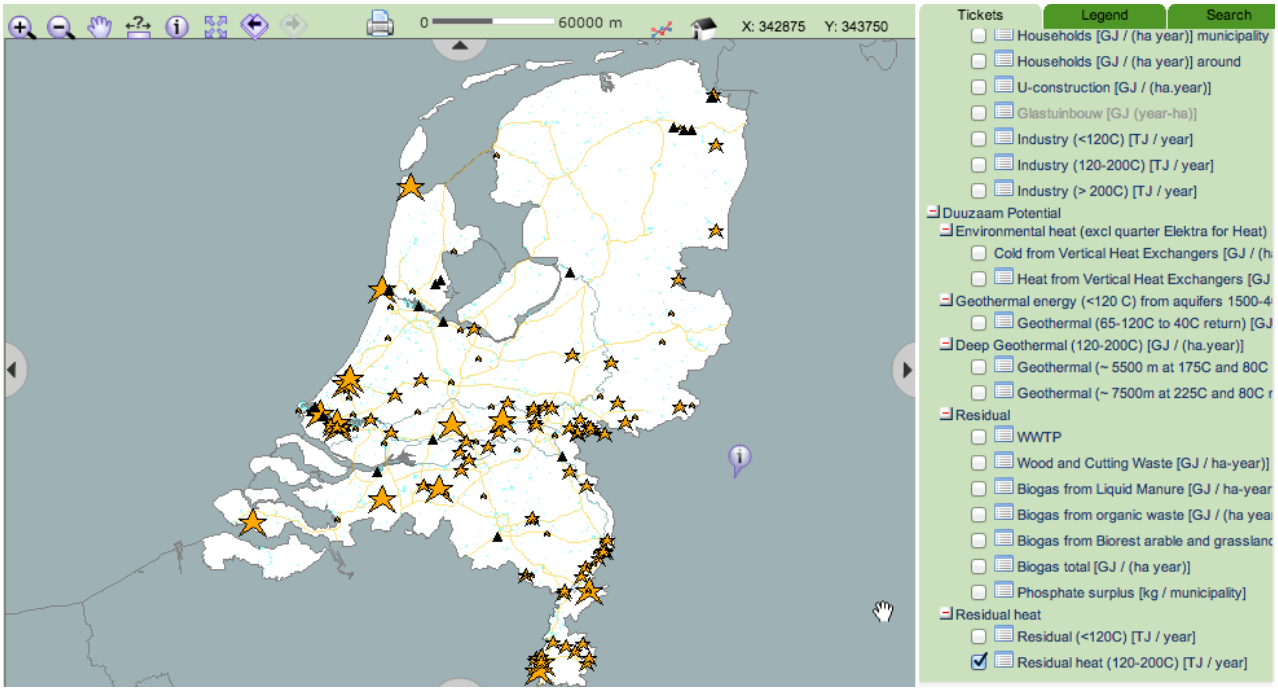

Figure 10 Heat map of the Netherlands, with the indication of the industrial heat potential in the range of 120-200°C. (www.warmteatlas.nl website, translated with an automatic web-toool)

3.3. United Kingdom

The national heat map shows (Figure 11) heat demand density (kWh/m^2 year) - for space, water and process - and potential heat supply. There are

The section on heat demand is very detailed, with data on building type, heat supply and physical constraints. It is modelled at block level, with a bottom-up approach through an algorithm taking in account the characteristics of buildings (size, age, built form, tenure, etc.), zone energy and gas consumption (data from building energy meters only for public authority buildings), energy performance certificate (only for non residential buildings), etc.

The instrument in UK is more oriented to the local heat networks/linking. Heat networks were popular in 1960/70s for new housing developments and due to the rising gas prices there is a resurgence interest in heat networks. Heat sources at the moment are only electric power station and CHP plants, but the supply section will be enlarged to biomass and biogas.

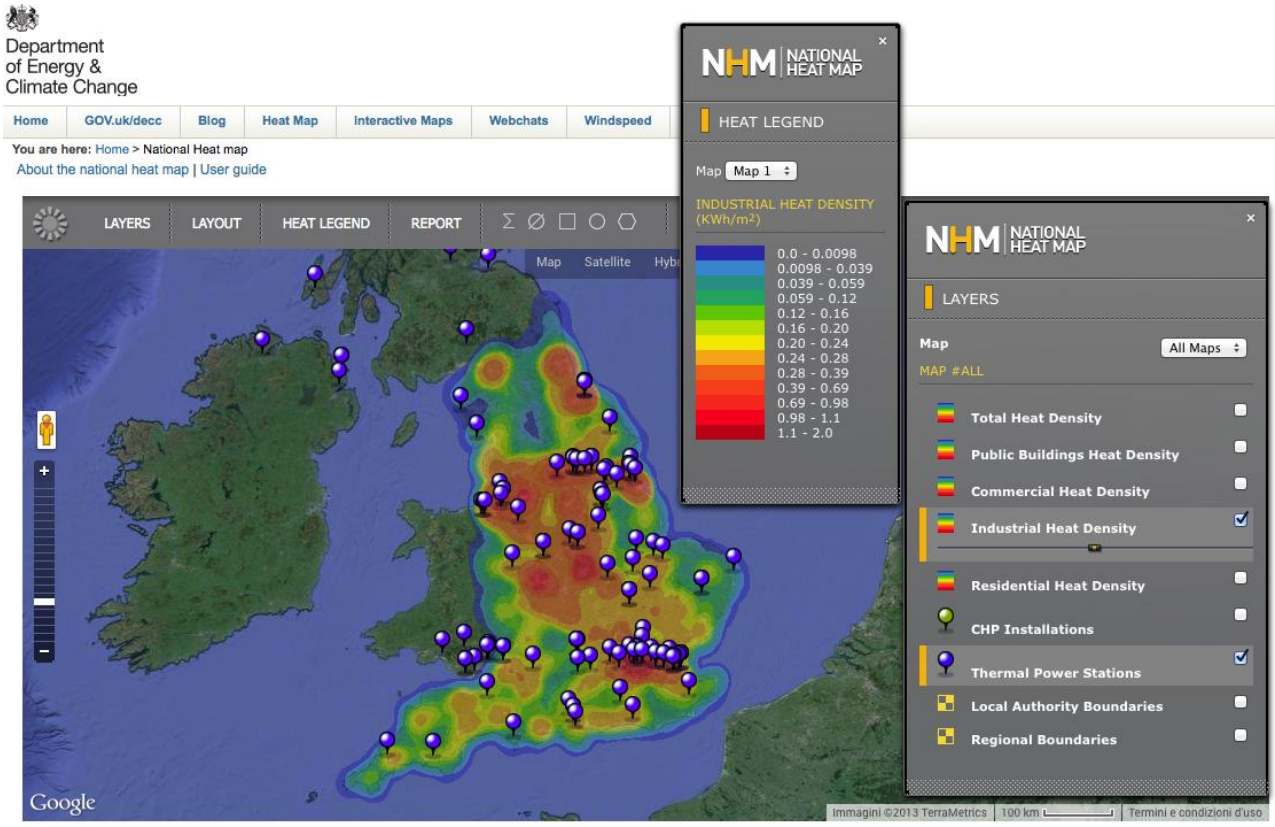

Figure 11 National heat map, with industrial heat density indications (http://tools.decc.gov.uk/nationalheatmap)

4. Authorisation procedures for the construction of a waste heat to energy plant

The authorisation process for a waste heat recovery for steam and electricity generation can be divided in two main separate parts, the Integrated Environmental Authorisation evaluating all the influences on the environment, concerning mainly the interaction with the outside, and the assessment of conformity of the pressure devices, the correct operations, etc. mainly related to the health and safety policy in the workplace.
Those aspects are regulated by the European directives and, for the pressure devices, also by the harmonised European technical standards. Each Member State transposes the directives according to its specific situation and, frequently, a part of the authorisation process and the related legislation depends on the local authority. Consequently, even if the reference framework is the one set by the related directives, the authorization process might be different among the Member States and even within the same Member State.
A summary of the authorisation process of the waste heat recovery with steam generation and electricity production via ORC, realised in Riesa, Free State of Saxony, Germany, at the ESF steel workshop is presented as follows.

4.1 European directives concerned

To prevent and reduce the emissions from industrial activities, the European Union set up common provisions with the Directive 96/61/EC "concerning integrated pollution prevention and control". The Directive requires a mandatory integrated permission for the industrial activities listed in annex 1 in order to achieve a high level of protection of the environment.
This Directive and the following recasts 2008/1/EC and the 2010/75/EU Industrial Emission Directive, set up the Integrated Environmental Authorisation, Integrated Environmental Evaluation, etc. taking in consideration all the environmental aspects: air, water, soil, waste, etc.

European Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, codified by the 2011/92/EU and amended by 2014/52/EU, requires that projects likely to have significant effects on the environment undergo an assessment with regard to their direct and indirect effects on population, fauna, flora, soil, water, air, climate, landscape, material assets, the cultural heritage and their interactions.
The public shall be informed as soon as information can reasonably be provided and have the opportunity to participate in the environmental decision-making procedures.
All the projects in Annex I are subject to the Environmental Impact Assessment (EIA), while for the projects in Annex II the decision is up to each Member State.
Member States may provide a single procedure fulfilling also the requirement of the aforementioned emission directive.

The Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work, also known as workplace Directive is the framework directive for the Occupational safety and health (OSH).
The directive states the principles for the protection of safety and health of private and public workers, the prevention, assessment and elimination of the risks. Moreover requires information and training, consultation and participation of the workers. A number of specific directives has been adopted on the basis of the 89/391/EEC, among the others the Directive 92/58/EEC on the minimum requirements for the provision of safety and/or health signs at work, is the 9th individual Directive within the meaning of article 16 of Directive 89/391/EEC.

Directive 2009/104/EC on minimum safety and health requirements for the use of work equipment by workers at work, is within the meaning of art. 16 Directive 89/391/EEC. The Directive requires that (art. 4) employers provide work equipment (any machine, apparatus, tool or installation used at work) which complies with the provisions of any relevant EU Directive which is applicable to it and shall also take the measures necessary to ensure that, throughout its working life, work equipment is kept compliance by means of adequate maintenance. The Directive requires (art. 6) the restriction to designated workers of the use/maintenance of work equipment involving specific risks, information/instruction (art. 8) and training (art. 9) of workers.

The directive 97/23/EC on the approximation of the laws of the Member States concerning pressure equipment was introduced to eliminate the technical barriers to trade within the European community equipment subject to a pressure hazard concerns such as boilers, steam generators, heat exchangers, piping, pressure accessories, etc. It is a new approach directive, based on to harmonised technical standards, developed through the participation of the stakeholders.

4.2 Germany - Free State of Saxony

A.Environmental authorisation

A waste heat recovery for steam and electricity generation (WHRSEG) installation doesn't introduce major changes to the plant on the point of view of environmental impact legislation, in particular:

- It doesn't increase the productive capacity,
- It doesn't impact on existing emission sources (flue gases, noises, odours, waste production, etc.)[41],

Moreover, the electricity production via heat recovery will lower the amount of electricity withdrawn from the grid whereas, the steam generated from the recovered heat will substitute the one produced burning another fuel leading to lower CO_2 emissions.
These considerations are taken into account for the emissions authorisations and the environmental impact authorisation.

In Germany the reference law for the environmental authorisation is the Federal Pollution Control Act (BImSchG Bundes-Immissionsschutzgesetz), a Federal law published in 1974. The law itself defines only the basic requirements, while the main technical details, essential for the application, are outlined in a number of other implementing regulations (BImSchV Bundes-Immissionsschutzverordnungen - Federal Emission Control Regulations). BImSchG and various BlmSchV have been modified to take into account the aforementioned European directive on industrial emissions.
In particular, the authorisation process of a WHRSEG refers to 4 BImSchV (Ordinance on installations subject to licensing) and 9 BlmSchV (Regulation on the approval process).

The authorisation process follows the BImSchG § 10 (Approval process) in conjunction with § 16 (Substantial changes to installations subject to licensing).
It is possible to ask for an early start permission, according to BImSchG § 8, to start the realization of some parts of the plant, typically for the first steps of longer works (e.g. foundations of civil works), before the completion of the authorisation process.

[41] Since there are new machines, it has to be demonstrated that the new noise sources are opportunely controlled and managed, to meet the previously approved noise levels.

Moreover, upon request of the applicant, it is possible to have no public notice of the project according to BImSchG § 16 paragraph 2, since for a WHRSEG projects the modifications to the plants are unlikely to bring significant adverse effects on the protected resources.

The authority responsible for issuing the license (Land), according to BImSchG § 10 par. 5, has to coordinate all the authorities involved in the phases of the authorization process of the project (e.g. Municipality, Department of Occupational Health and safety, water management authority, etc.). Moreover, according to § 13, the licence shall include other official decisions related to the installation, such as building permit for the power station building, the steam piping, etc.

The silicon working fluid of the ORC turbo generator and the lubricat oil might represent an hazardous for water if not properly managed. VAwS (Verordnung über Anlagen zum Umgang mit wassergefährdenden Stoffen - Regulation for plants handling substances hazardous to water) contains in § 3 the basic requirements to avoid the dispersion of hazardous substances in the water.
This latter, together with local ordinance on water, define the classification of the site and the required measures (e.g. contention volumes, etc.).

Other Directives and laws
The authorisation of infrastructures, industrial activities, etc. can be subject to the Environmental Impact Assessment (EIA), European Directive 85/337/EEC, codified by the 2011/92/EU and transposed in Germany by the UVPG (Umweltverträglichkeitsprüfung - law on Environmental Impact Assesment). In this specific case, the plant was subject to a general preliminary examination (§ 3c sentence 1) as indicated in annex 1, "list of projects subject to EIA", column 2 for 3.3.1 "Construction and operation of a plant for the production or smelting of pig iron and steel including continuous casting, even if concentrates or secondary raw materials are used, with a melting capacity of 2.5 or more tons of pig iron or steel per hour".
No EIA was carried out, according UVPG to § 12, since the proposed changes weren't considered responsible of causing any significant adverse effects on the environment.

The plant is subject to the emission trading, European Directive 2003/87/EC (as amended by 2009/29/EC), transposed in Germany by the TEHG (Gesetz über den Handel mit Berechtigungen zur Emission von Treibhausgasen - Law on trade with permissions to the emission of greenhouse gases).
According to TEHG § 4 (emission permit) par. 5 the operator must notify to the DEHSt (Deutsche Emissionshandelsstelle - German Emissions Trading Authority) any planned change of the activity at least one month prior to their implementation is completed.

During this authorisation process the documents regarding the authorisation process for pressure devices, health and safety measures for the workers (e.g. lighting levels, explosion protection, etc.), might also be required. See also section **Errore. L'origine riferimento non è stata trovata.**.

History
A request was presented on February 2012 to the Saxony Land, pursuant to § 16 of BImSchG for modification of the steel and rolling mill and the construction and operation of a power unit and a steam piping.
The main measures in the request were:

- construction of a new high-performance heat exchanger in parallel to the existing water quenche,
- construction of a heat exchanger, a waste heat to energy power station with a ORC and the a building for the power station,
- construction of a steam drum and a steam piping,

- transfer of the generated steam in an external heating systems,
- supply of electric energy produced in the local network,
- noise protection measures.

3 Additional provisions
3.1 General
The approval, according to BImSchG § 18 Section 1 No. 1, expires if operation of the power station doesn't begin within three years of the approval.
It is required to write to the Land Directorate at least 14 days before commissioning of the power station.

3.2 Pollution
Pollution
Also the ORC fluid requires leakage monitoring for the working fluid and the supply and refil of the ORC unit exclusively by trained personnel.

Noise
Noise control study for the generation of steam and electric power, including new cooling tower(s), automatic cleaning of the heat exchanger,
(Noise control during the construction phase and low noise construction methods are prescribed)

3.3 Water
The system is designed to suit the requirements of § § 1-3 VAwS (Verordnung über Anlagen zum Umgang mit wassergefährdenden Stoffen und über Fachbetriebe - Regulation for plants handling substances hazardous to water) to operate.

Justifications and ancillary provisions
The rapid cooling of the primary exhaust gas flow is maintained in principle at constant emission parameters. The use of this new hardware requires no further technical changes to the emission control system. The existing water quench is kept constantly ready for use. With an automatic control valve, the primary gas stream can be directed to the heat exchanger or to the water quench.

B.Worker safety and pressure devices

The BetrSichV (Betriebssicherheitsverordnung - Ordinance on Industrial Safety) is the German transposition of the Work Equipment Directive 2009/104/EC. The articles more relevant in relation to the authorisation process of a WHRSEG are:
Section 2 Common requirements for work equipment, § 6 explosion protection document, Section 3 Special provisions for installations requiring surveillance, § 12 Operating (monitoring equipment requirements), § 13 Conditional authorisation, § 14 pre-commissioning test, § 15 In-service inspections and§ 20 Notice of Defects.

The TRBS (Technische Regeln für Betriebssicherheit - Technical rules for operational safety) are hazard-oriented rules for the practical implementation of the BetrSichV, realised by the ABS (Ausschuss für Betriebssicherheit - Committee on operational security), under the supervision of the BAuA (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin - Federal Institute for Occupational Safety and Health) in accordance to BetrSichV § 24.
The TRBS of interest for a WHRSEG plant are:
TRBS 1111 "Risk assessment and safety assessment"
TRBS 2141 "Hazards by steam and pressure - General requirements"

TRBS 2152 part 2 "Prevention or restriction of hazardous explosive atmospheres"
TRBS 2210 "Hazards through interactions"
(Apart TRBS 2152 the others are expressly referred in LV 49, see below)

According to the BetrSichV § 13 the permit application must contain – for certain types of plants, for instance the steam generators with temperatures above 110°C – the opinion of an experienced professional from an accredited inspection agency (zugelassenen Überwachungsstelle -ZÜS) consequent to the evaluation of the documentation and the verification that the plant's installation, construction and operation meet the requirements of this ordinance. In this specific case, three main site visits and some other visits have been done by the approved inspection agency. Every year there will be two site visit of the ZÜS.

The ArbStättV (Arbeitsstättenverordnung - workplace regulations) is the German transposition of the Workplace Directive 89/654/EEC and safety and/or health signs at work 92/58/EEC, etc. It establishes the minimum requirements for the safety and health of employees in the workplaces.
The ASR (Technische Regeln für Arbeitsstätten - Technical rules for the workplace) realised by the BAuA describes measures and tools for the practical implementation assuming the complete conformity with the requirements of the ArbStättV.
The ASR of interest for a WHRSEG plant are:
ASR A2.3 "Emergency routes and exits, escape and rescue plan"
ASR A3 4 "Lighting"

AD2000 contains both the essential safety requirements to be met in Germany in order to comply with the European Pressure Equipment Directive (97/23/EC) and to implement the safety requirements in practice. The AD 2000 pressure vessels' code is drawn up by the AD (Arbeitsgemeinschaft Druckbehaelter - German Pressure Vassel Association), an agreement of FDBR (German Association of Steam Boiler, Pressure Vessel and Piping Manufacturers), DGUV (German Statutory Occupational Accident Insurance), VCI (Association of the German Chemical Industry), VDMA (German Engineering Federation e.V.), VDEh (German Steel Institute), VGB Power Tech e. V. and VdTUEV (German Association of Technical Inspection Services e. V.).
In a WHRSEG project the main parts of the system involved in the CE marking process are: the steam cooled offgas ducts, the waste heat boiler, the steam drum, the feed water tank and the steam accumulator. A BS (Benannte Stelle - notified body), different from the ZÜS follows the CE marking process.

The LASI (Länderausschusses für Arbeitsschutz und Sicherheitstechnik - Länder Committee for Occupational Safety and Health), part of the ASMK (Arbeits- und Sozialministerkonferenz - Employment and Social Affairs Conference) issues various publications, the LV (LASI-Veröffentlichungen – LASI publication).
The LV 49 of 2008 "Quality of the expert opinion as part of the approval procedure according to BetrSichV § 13" defines the minimum contents and the way to draw up an expert opinion, as to show that the system's installation, construction and operation satisfy the requirements of the BetrSichV. It contains checklists for different kinds of installations (steam boiler plants, etc.). It also underlines the absence of conflict of interest, explains how to formulate the comments, etc.

Other technical standards and rules of interest

The DDA (Deutschen Dampfkesselausschuß - German Boiler Committee) und VdTÜV (Verband der Technischen Überwachungs-Vereine - Association of Technical Inspection Agencies) publish the TRD (Technische Regeln für Dampfkessel - Technical rules for steam boilers).

The relevant TRD for a WHRSEG plant are mainly:
TRD 604 Sheet 1 "operation of steam boilers with steam generators of the group IV without constant supervision"
TRD 611 "feed water and boiler water of steam generators of the group IV"

lighting levels and optical safety:

- LASI publication, LV41 "Guidance for workplace lighting",
- the BAuA Technical rule for workplaces ASR A3.4 "Lighting",
- DIN EN 12464-1 "Light and lighting. Lighting of work places. Indoor work places",
- EN 1838:2013 "Lighting applications. Emergency lighting".

DIN 2403 Identification of pipelines according to the fluid conveyed

Rescue and escape routes:

- The technical regulation for workplaces ASR A2.3 "Emergency routes and exits, escape and rescue plan" by Federal Institute for Occupational Safety and Health (BAuA - Bundesanstalt für Arbeitsschutz und Arbeitsmedizin).
- DDA 12/2002 information on the installation and operation of steam boilers steam / hot water generators with CE-marked type of water-tube boilers

EN 50156 Electrical equipment for furnaces and ancillary equipment.

EN 60947-5-1 Low-voltage switchgear and controlgear. Control/circuit devices and switching elements. Electromechanical control circuit devices

EN 10204 Metallic products. Types 3.2 certificate: issued by the manufacturer under the surveillance of a third party inspector (material's identification and traceability).

EN 12952 Water-tube boilers standards
EN 12952-6 "Water-tube boilers and auxiliary installations - Part 6: Inspection during construction; documentation and marking of pressure parts of the boiler". 4.3 competency of the manufacturer (refers to Annex F of EN 12952-5:2011)
EN 12952-7 Water-tube boilers and auxiliary installations. Requirements for equipment for the boiler
EN 12952-12 Water-tube boilers and auxiliary installations. Requirements for boiler feedwater and boiler water quality

(See Appendix 2)

5. Conclusions

The aim of the study was to draft a framework of the current support and incentive schemes and policies to waste heat recovery to electricity generation in some EU countries whit an interesting potential for the diffusion of this measure.

At the moment there are no specific policies to support this measure and even if some existing policies also apply and in some case with an interesting incentive (e.g. the Italian white certificate system), the results in term of market penetration are very low. Only France is studying an ad hoc mechanism to start and sustain the realization of these plants.

Going over the EU Member States cases of interest, some barriers came out from the analysis: first of all, WHR to electricity generation is not strongly diffused because the "potential" of each country and data are unknown to the main actors operating in the different states as public authorities in charge of creating *ad hoc* policies to develop energy efficiency in this field.

Second, the economic obstacle is another important issue: investment payback time for the implementation of technologies related to WHR to electricity generation are usually too long for the industrial sector, for this reason the creation of ad hoc incentives mechanism or the inclusion in existing supporting schemes (e.g. white certificates or CHP) could help in overtaking this barrier.
Another possible solution is the third party financing, with an energy service company (ESCO) designing, financing, realizing and operating the plan in the user facility. At the moment the market of ESCOs is still not well developed around Europe, but it is a focal issue for the 2006/32/EC directive and its recast 2012/27/EU. Among the instruments to support ESCOs market, a guarantee fund has been indicated as very promising.

In some promising fields there are no applications at all, and the realization of the first plant is always more difficult, because much more uncertainties are perceived.
HREII DEMO aims to demonstrate the feasibility of WHR to electricity in the Iron and steel industry, with a Demo plant under construction in Germany, and in general to support the electricity generation from waste heat recovery in energy intensive industries and other promising sectors around Europe.

Appendix 1

Some interesting examples of project supporting ORC and waste heat recovery to power generation in Europe are the following ones:

DE:

- BINE project on how to transform waste heat in electricity with ORC technology . Information available at www.bine.info/en/press/press-releases/archive-press-releases/pressemitteilung/abwaerme-zu-strom-veredeln/

BE:

- From waste heat to electricity - Heat recovery using Organic Rankine Cycle': this is the title of the TETRA project currently running at Hogeschool West-Vlaanderen. Information available at www.orcycle.be/index.php
- ORCNext – information available at www.orcnext.be/

FR:

- CERES project (Energy pathways for waste heat recovery in industrial systems), financed by the French National Research Agency, aims at developing a decision-making tool to optimize waste heat recovery in industrial process. Information available at www.agence-nationale-recherche.fr/en/anr-funded-project/?tx_lwmsuivibilan_pi2[CODE]=ANR-10-EESI-0001

European projects

Foundenergy (www.foundenergy.eu) Waste Heat Recovery Power Generation Based on Organic Rankin Cycle (ORC) Technology in Foundry Industry.

LOVE (http://love.epfl.ch) LOw-temperature heat Valorisation towards Electricity production.

4. *Appendix 2:* plant construction timeline and milestones

Date	Milestones
2009	First reflections on a heat recovery at the electric arc furnace by generating steam from the waste heat of the waste gas
mid 2010	First meetings with Stadtwerke Riesa for steam use and steam sales to the tire plant (Good Year Dunlop tires) as process steam
mid 2011	First considerations for power generation after the Organic Rankine Cycle Process --> ORC, power generation from saturated steam (Company Turboden)
end 2011	Preparation of technical specifications for the construction of a heat recovery system at the electric arc furnace (iRecovery-system) by Tenova ReEnergy
	Preparation of design documents for construction of a steam and condensate line between Elbe-Stahlwerke Feralpi and Stadtwerke Riesa and Good Year Dunlop Tires
	Contract signed with Tenova ReEnergy. Contract signed with Turboden (electricity generation by ORC system 3 MW)
February 2012	Signing of a steam delivery contract with Stadtwerke Riesa
	Preparation and filling of permit documents for the construction of a steam generating plant to the State Directorate Dresden (after Bundesimmisionsschutzgesetz (BImSchG §16))
mid 2012	Grant of the early commencement by the State Directorate Dresden and Construction of the steam line and the energy center (boiler house III and turbine house)
October 2012	Installation of the steam drum in the boiler house II and the beginning of the assembly activities on the plant of Elbe Stahlwerke Feralpi
November 2012	Elbe Stahlwerke Feralpi received by the State Directorate Dresden permision to build a steam generating plant (according to "BImSchG")
December 2012	Completion of the steam and condensate line between Stadtwerke Riesa and Elbe Stahlwerke Feralpi (lenth of the steam and condesate line: 1,6 km)
January 2013	The beginning of the pipeline installation between the individual components of the steam plant at the area of Elbe Stahlwerke Feralpi
	Start with the declaration of conformity process (CE-process) after PED (Pressure Equipment Directive)
February 2013	Assembly the steam accumulator, the feed water tank and the ORC turbine in the energy center (boiler house III and turbine house)
May 2013	Assembly of the waste heat boiler in boiler house II
November 2013	Five-week production shutdown to change the water-cooled ducts with the steam cooled ducts and connection to the waste heat boiler
2nd December 2013	Start of the trial operation of the iRecovery cooling system
22nd December 2013	Start the trial operation of the ORC-Turbine