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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 - tonne of oil equivalent
WHR - Waste Heat Recovery
WHRPG - Waste Heat Recovery Power Generation

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

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, Norway, Poland, Spain and Sweden.

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.

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Belgium – Walloon region¹

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^{o2}, it is considered electricity produced from renewable energy or high efficiency cogeneration:

<p>“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).”</p>	<p>“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).”</p>
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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 CO₂ avoided. The electrical production or CHP is compared to standard combined cycle gas turbines plants (CCGT) with emission factor of 456³ kg/MWh and standard boiler with 279⁴ kg/MWh. When the CO₂ 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 CO₂ 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 CO₂ during the electricity production takes into account the fuel used for the process, in this case no CO₂ saving compared to a CCGT, then no support. What it is still under evaluation is that this CO₂ is produced for the process and then there is no extra CO₂ 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.

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 into account the existing European and international policies in this field as it is considered an effective measure to reduce CO₂ emissions.

Germany⁶

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:

<p>“KWK-Anlagen im Sinne dieses Gesetzes sind Feuerungsanlagen mit Dampfturbinen-Anlagen (Gegendruckanlagen, Entnahme- und Anzapfkondensationsanlagen) oder Dampfmaschinen, Gasturbinen-Anlagen (mit Abhitzeessel oder mit Abhitzeessel und Dampfturbinen-Anlage), Verbrennungsmotoren-Anlagen, Stirling-Motoren, ORC (Organic Rankine Cycle)-Anlagen sowie Brennstoffzellen-Anlagen, in denen Strom und Nutzwärme erzeugt werden. Bei KWK-Anlagen werden die KWK-Anlagen durch eine thermisch angetriebene Kältemaschine ergänzt.”</p>	<p>“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”.</p>
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To be clearer, ORC - as said in the article above⁷ - can be considered as CHP and then eligible for incentives only if the heat that is used to produce 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 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

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.

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 association¹⁰ 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.

An interesting chance for demonstration projects is represented by the “Environmental Innovation Program” (Umweltinnovationsprogramm) from the Ministry of Environment¹¹ 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.

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/

¹¹ More information can 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/foerderung/foerderung/umweltinnovationsprogramm-inland/





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 Agency¹².

¹² www.umweltbundesamt.de



Poland¹³

In Poland a direct promotion for the electricity generation from waste heat recovery does not exist at the moment. 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 Fund¹⁴:

<p>"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."</p>	<p>"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".</p>
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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 million¹⁵ 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,
- 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,

¹³ 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

¹⁴ Program Priorytetowy "Efektywne wykorzystanie energii - Część1) Dofinansowanie audytów energetycznych i elektroenergetycznych w przedsiębiorstwach" and Regulamin Konkursu "o dofinansowanie ze środków NFOŚiGW przedsięwzięć w ramach programu priorytetowego Efektywne wykorzystanie energii - Część2) Dofinansowanie zadań inwestycyjnych prowadzących do".

¹⁵ Corresponding to around € 200 million.

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 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 and it will end on 31 December 2015 and the budget is PLN 780 million¹⁶. 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 million¹⁷. 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."

¹⁶ Corresponding to around € 190 million.

¹⁷ 1 Polish Zloty = € 0.24.

Norway¹⁸

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.

<p>“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 påslaget grunnlag, størrelse og innkreving fastsettes av Olje- og energidepartementet i forskrift.¹⁹”</p>	<p>“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. ”</p>
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The fund is managed by Enova SF²⁰ (“Enova”), a state owned administrative body²¹, 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 EAG²².
- 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

¹⁸ EFTA Surveillance Authority – Decision of 9 February 2011 on the aid to Finnjord AS for an energy recovery system.

¹⁹ 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).

²⁰ Enova webiste: www.enova.no/about-enova/259/0

²¹ More information are available in ENOVA Annual Report 2011.

²² 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)²³. 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 Guidelines²⁴, 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 2011²⁵ 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.

²³ 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.

²⁴ The EAG are available on the website of EFTA Surveillance Authority at www.eftasurv.int/media/state-aid-guidelines/State-aid-Guidelines.pdf

²⁵ ENOVA Annual Report 2011.



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 November²⁶:

<p>“Artículo 27. Régimen especial de producción eléctrica.</p> <p>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:</p> <p>a) Autoprodutores que utilicen la cogeneración u otras formas de producción de electricidad asociadas a actividades no eléctricas siempre que supongan un alto rendimiento energético.</p> <p>b) Cuando se utilice como energía primaria alguna de las energías renovables no consumibles, biomasa o cualquier tipo de biocombustible, siempre y cuando su titular no realice actividades de producción en el régimen ordinario.</p> <p>c) Cuando se utilicen como energía primaria residuos no renovables.</p> <p>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.</p> <p>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.</p> <p>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.”</p>	<p>“Article 27. Special scheme for electricity production.</p> <p>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:</p> <p>a) Autoproducers using cogeneration or other forms of electricity production associated with activities involving electrical always high energy performance.</p> <p>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.</p> <p>c) When nonrenewable waste energy is used as primary energy.</p> <p>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.</p> <p>2. The special regime is governed by specific provisions, and in matters not covered by them, by general electricity in what may apply.</p> <p>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”.</p>
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These facilities are classified into different categories, groups and subgroups, depending on the primary energies used, production technologies employed and energy yields obtained.

²⁶ Ley 54/1997, de 27 de noviembre, del Sector Eléctrico: www.boe.es/boe/dias/1997/11/28/pdfs/A35097-35126.pdf

Under Category A are included producers using cogeneration or other forms of electricity 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 3):

- 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 $4.000.000 \times 0,046\text{€} = 184.000$ 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 $4.000.000 \times 0,019344\text{€} = 77.376$ 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 3 - 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 1/2012²⁷ suspended the economic system for new installations from this date on. Currently there are no estimates of new special economic regimes for such uses.

²⁷ www.boe.es/boe/dias/2012/01/28/pdfs/BOE-A-2012-1310.pdf



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 CO₂ 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 öre²⁸/kg CO₂) 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 CO₂-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 energi²⁹.”

“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 CO₂-taxation in relation to heat-only boilers. In 2009 CHP amounted to 38% of the total district heating generated. The Figure 1³⁰ 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.

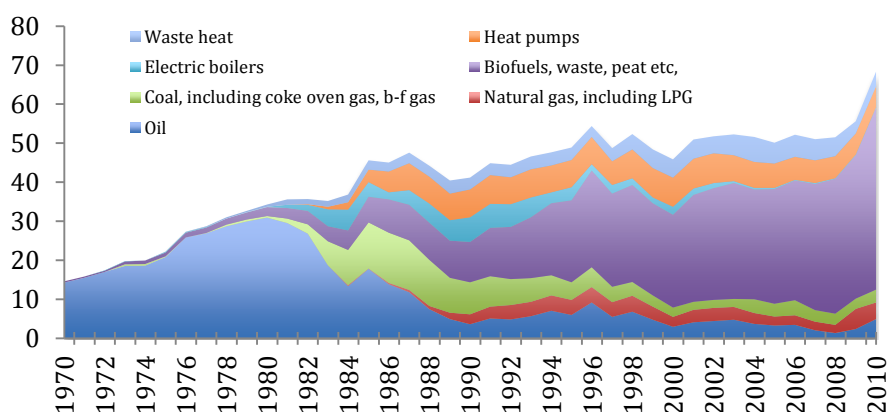


Figure 1 - Energy input for district heating, 1970–2010, TWh, State Power in numbers

²⁸ 100 öre = 1 SEK, and 1SEK corresponds to € 0.11.

²⁹ From the text of Tax legislation

³⁰ Source: Energiläget i siffror 2011 (ET 2011:42).

The electric certificates system³¹ 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.

The Programme for Improving Energy Efficiency³² (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 system³³ 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.

³¹ "The electricity certificates scheme 2011", Swedish energy agency, available at www.energimyndigheten.se

³² Programme for Improving Energy Efficiency - Experiences and results after five years with PFE.

³³ The EMS functions as a management tool that helps to plan, implement, monitor and improve a company's energy performance.

Italy

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 (tonne 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.

Conclusion

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 with 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 terms 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 overcoming this barrier.

Another possible solution is the third party financing, with an energy service company (ESCO) designing, financing, realizing and operating the plant 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

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](http://www.agence-nationale-recherche.fr/en/anr-funded-project/?tx_lwmsuivibilan_pi2[CODE]=ANR-10-EESI-0001)