COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Work package 3
Comparison of member state approaches

Compiled

Report produced within the CODE project

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COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Contents

Introduction

Work package 3 'Comparison of member state approaches' provides standardised cogeneration plant scenarios providing a theoretical financial assessment of the investment case with and without financial support mechanisms provided in each Member State (MS) under the EU Cogeneration Directive.

Each MS, as part of their implementation of the Cogeneration Directive, must ensure that support for cogeneration is based on meeting useful heat demand and delivering primary energy savings compared to separate heat and power generation. It is, however, very difficult in the abstract to anticipate the actual stimulus that will be achieved in the market and whether removal of the identified barriers will in itself be enough to improve the take-up of cogeneration. Barriers, support mechanisms, finance, economic climate, and wider policy can result in an apparently favourable set of policy instruments having no real effect on implementation.

The standard tool used by commerce and industry to evaluate whether or not an investment may be worthwhile is the Internal Rate of Return (IRR) and simple payback periods. It incorporates, in a transparent but consistent way, effects such as cost of capital, competing investment opportunities, and actual support in specific circumstances. The analysis models an anticipated rate of return on investment which to base the investment, and compare the investment across member state boundaries.

At the project outset three cogeneration scenarios were originally considered; a 50kW and 1MW gas engine and 50MW combined cycle gas turbine (CCGT) CHP. In consultation with the regional project partners and the Commission, these were revised and extended in the early stages of the project to; 50kWe gas engine CHP, 1MWe gas engine CHP, 1MWe diesel (gas oil) engine CHP, 12MWe coal fired heat recovery steam turbine CHP, and 66MWe CCGT CHP. These sizes and fuel types represent a range of real life plant and the 12MW and 66MW in particular were specified using plant design software GT pro. To create a basis for comparison it has not been possible to capture the reality in every MS.

It is important to note that whilst biomass fuelled cogeneration is a significant energy conversion technology in a number of MS; it was beyond the scope of this project to model a range of biomass scenarios. It is recommended that this be modelled as a subsequent project.

Assumptions

To ensure an equal basis for comparison, a number of assumptions have been made in these theoretical models of construction and maintenance. These are as follows:

- 2007 price data were used throughout (thereby ensuring complete dataset available) this includes the effect of EU ETS modelled as at 2007. Originally 2009 data was used.
- Data supplied directly from MS were the preferred source, but where this was not available published (fuel electricity and tax data) Eurostat or International Energy

Agency (IEA) data were sought. Where construction and maintenance costs were not available UK sourced data were used

- The cost of land purchase was not included within the model
- An assumed weighted average cost of capital (WACC) was modelled at 8%
- Benefits and financial support mechanisms were spread across each operating year until the support finished. In some cases support at the beginning of the year is higher (to help address capital costs) and this falls with increasing cumulative output. The model was not sufficiency refined to address this.
- Writing down allowance (WDA) standardised at 13% across all MS
- All electricity modelled as used on site with the exception of the 66MW which is modelled to export
  60% electricity
- The plant life was modelled to be 20 years
- Where electricity wholesale price data were not available, the wholesale price was calculated to be 70% of the industrial supply price based on the ratio between UK Government long term industrial supply and wholesale price data.

Methodology

The analysis was undertaken in the following stages:

- Five plant scenarios agreed with CODE project team (Cogen Europe and project leaders detailed below)
- IRR calculation spreadsheet developed and tested for UK
- Data input template sent to CODE regional leaders (CHPA UK, HACHP Greece, Anima Italy and Jožef Stefan Institute Slovenia) to gather data from individual MS
- IRR calculations undertaken by CHPA and where data not available from MS, remaining input data sourced from Eurostat and IEA
- Calculation sheets returned to MS via regional leaders for approval
- Two page country written descriptions of calculations written by CHPA and sent to MS for approval
- Regional overviews written by regional project leaders
- European overview written by Cogen Europe

Work package deliverables

- D3.1 Country IRR calculations and reports x27
- D3.2 Region comparative reports x4

- D3.3 European overview of results
- D3.4 Case studies for handbook

Possible futures uses for the IRR calculation spreadsheets

- Model specific engine sizes, more relevant to a given MS situation
- Model outputs for other countries
- Refine modelling to date
- Model changes in tax, support and legislation
- Model biomass / bioenergy support
- Model differing export scenarios
- Examine support effects on cost inflation by supply chain

European summary

The Cogeneration Directive

The Cogeneration Directive 2004/08/EC outlines an enabling policy framework for the European Union to expand the deployment of cogeneration in Member States. The Directive was passed by the European Parliament in 2004 and encourages the use of cogeneration in the production of heat and power as a successful and well developed technique delivering primary energy savings. The background policy objectives in 2004 were security of supply and energy savings. The climate agenda which has grown in importance since 2004 has added further impetus to the wider use of cogeneration. Cogeneration is a highly energy efficient, technologically mature approach to generating electricity and providing useful heat. It is a key enabler for improving the efficiency of electricity production from fossil fuels.

One of the main achievements of the Cogeneration Directive has been to codify for Europe what is meant by high efficiency cogeneration. Any plant now carrying this status will in operation save a minimum of 10% primary energy compared to separate production of heat and electricity based on the same fuel. Using the framework of the Cogeneration Directive, promoting cogeneration to meet additional electricity needs gives a Member State a quantifiable primary energy saving per unit of electricity generated.

The CODE project

The CODE project was established in October 2008 by COGEN Europe under the EU's Intelligent Energy Europe (IEE) programme. The objectives of CODE are to have stakeholders in the sector independently monitor the implementation of the Cogeneration Directive and to use stakeholder input to assess the progress being achieved through Member State initiatives. The project runs until 2011 and will report in sequence on 1) the identified European potential for cogeneration; 2) the barriers and support mechanisms for cogeneration existing across the Member States; 3) best practise and progress in Member States; and 4) a draft CHP roadmap for Europe.

Executive summary

The WP3 financial comparison of five projects across all member states has documented the considerable existing policy which impacts CHP in Europe today. It has also shown that much of the legislation in place does not in fact result in a positive financial stimulus for cogeneration. The use of the IRR approach also highlights the substantial relative differences in returns which can be expected across capacity sizes of projects and the potential absolute impact of the details of sale or use of the electricity generated in the process.

The analysis shows that growth in CHP can be triggered through different support approaches in member states however successful approaches share the characteristic of lowering the return period to below a specific threshold. In the case of the currently modelled projects, and assumptions, this threshold is 3 years. Using the best case example of Flanders which uses a market mechanism of green certificates to stimulate investment, it is clear that project development and implementation can follow rapidly.

The IRR work also shows that suitable support mechanisms and an attractive IRR are not of themselves sufficient to trigger market growth. Substantial non-financial barriers in terms of market access, permitting, authorisation delay and barriers to entry exist for new entrants wishing to invest in the cogeneration sector. The best case practise also highlights the need for consistent long-term policy strategy around CHP and clear communication and outreach on its benefits.

1. CHP installed capacity in Europe in 2008

The map in figure 1 illustrates the percentage of total electricity generated in each Member State in CHP mode. Countries in dark green use over 30% of cogenerated electricity those in pale yellow use less than 5% cogenerated electricity. The average penetration level across Europe is 11%.

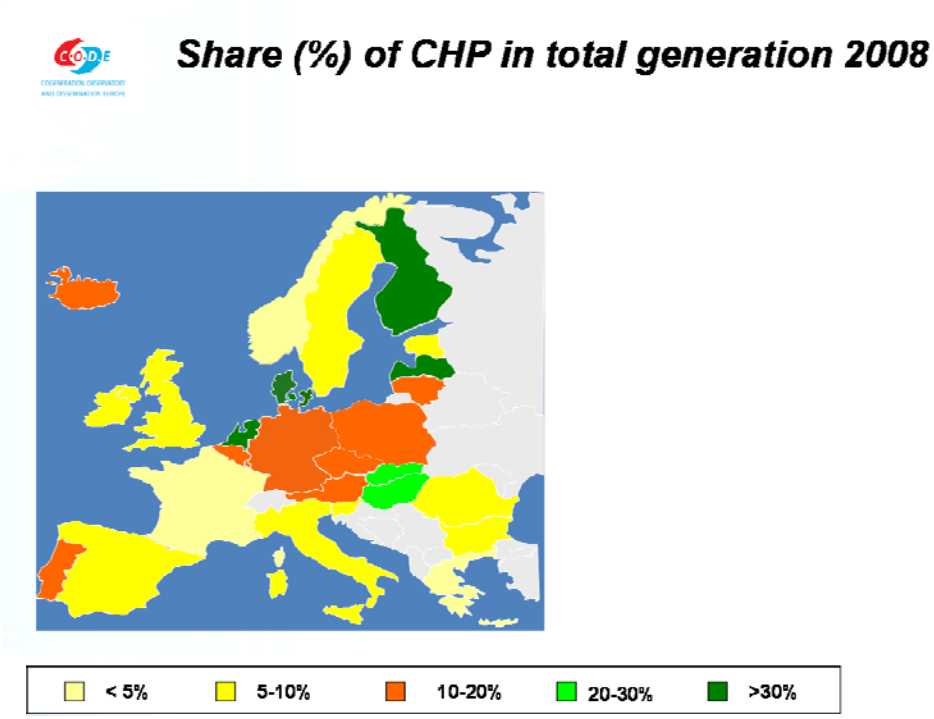


Figure 1 Map showing the percentage of CHP electricity in the delivered electricity by EU Member State

The European Commission analysis (2010) of the growth of the total installed CHP capacity in Europe between 2004 and 2008 shows that growth was 0.5% per annum on average. However the average masks a wide variation across member states in CHP activity. The CHP Directive was passed by the European Parliament in 2004 and finalisation of the Directive at the EU level took until the end of 2007. Given the time required for legislation to be translated from the European level into Member State law, there are only a few countries where national legislation arising from the CHP Directive in the years 2004 to 2008 can be gauged to be directly effective on the market. The period 2004-2008 saw only a few Member States really increase their CHP capacity above what could be considered as "business as usual" driven largely by basic economic growth factors and normal replacement cycles. The Belgian region Flanders stands out in this period as a region with exceptional growth in cogeneration installations. From 2000 to 2004 CHP grew in Flanders at roughly 2% per annum. Between 2004 and 2008 it grew at a level of over 20% per annum. In the Netherlands in the same period there were 500MW per year of new cogeneration added and all in the greenhouse sector. Elsewhere there were pockets of growth largely stimulated by bio-energy support mechanisms. Flanders is the subject of the case study later in this text.

2. WP3 CODE Project: description of the work carried out

In WP3 of the CODE project comparisons of Member States approaches to support has been modelled through calculation of the IRR of a group of common CHP applications (see Annex 1)

Five projects were modelled:

Notional Electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66GW**
Primary generator	Gas engine	Gas engine	Diesel engine	Coal turbine	CCGT
Typical use	Community site	commercial Installation, power space heating and hot water		Industrial sites with need for high grade heat (steam)	

Table 1 The five standard projects used in the CODE project to compare the effects of Member State support on the IRR of cogeneration projects

The 50 kW application is the type of CHP to be found in a small school building. The 1 MWe applications included both gas and diesel fuel to allow for regional variations. At 1 MW this unit could be found for example in a commercial installation powering space heating and hot water. The 12 MWe unit could provide the process heat of an industrial application for CHP where the heat is provided as high grade steam to an industrial process a sizeable brewery or a small district heating scheme.

2007 was selected as a reference year, as the most recent year which the project could analyse and for which more reliable statistical data are available. The analysis, therefore, represents a snapshot in time, and at a point where the CHP Directive was still in the process of implementation rather than fully implemented.

WP3 looks at a range of fossil fuel support mechanisms but did not cover bio-energy. Reliable data on bio-energy plants for CHP are only beginning to emerge in 2010. An increased focus on the sector has been promoted through the Renewables Directive and Member States have been asked to submit National Renewable Energy Plans which include biofuel for both heat, power and heat and power applications. Reliable bio-energy information on fuel costs particularly and on the very few plants in operation in the reference year of 2007 was not available and considered too project specific to be useful in a general discussion. A bio-energy example was therefore not included in this analysis.

The same 5 theoretical CHP projects were compared across all Member States. By using a consistent analysis approach across all Member States and including the existing support mechanisms and costs in the calculations, the CODE project team gained insight into both the effectiveness of Member State support mechanisms under general economic conditions and whether support mechanisms are sufficient to stimulate market activity or whether other aspects also play a significant role in the growth of CHP.

The analysis compares the overall financial impact of different mechanisms estimating the potential financial impact under the assumed standard conditions. The analysis compares a

base case IRR and payback in years with a supported case showing the effects of the various Member State support mechanisms which apply (table 2). The 5 standard scenarios provide a “level playing field” for EU-wide comparison with a single set of assumptions used and applied to all Member States. A key assumption in the modelling is that all electricity produced by the plant (50 kW-12 MW) is used on site except in the case of the 66 MW unit where 60% of the electricity produced is assumed to be exported. This means that the significant additional financial impact (either positive or negative as can be the case in reality) of sales of electricity is missing from the IRR calculation. In practise most units of the 1 MW scale, which were analysed were sited in locations with relatively high electricity supply prices. The export value (without support) is often very low in the Northern Region. As a result, the modelled assumptions tend to give particularly high IRRs to CHP plant which may not be reflected in reality.

Allowing for the model’s basic assumptions, certain common features emerge among those member states which have been successful in promoting CHP and which can be traced back to actual effect on the market. These features require further examination and refinement but they are a useful first indicator in assessing existing and planned support mechanisms.

There is no regulatory risk assumed in the IRRs. The CODE project team did not try to estimate how individual project investments might be effected by perceived uncertainties generated by uncertainties in regulation and support. In general, regulatory risk is a significant additional cost on an investment further compressing the period for what is considered an acceptable pay back. The closeness of the remaining modelled financial performance to actual financial assessment by a potential plant operator will depend heavily on the mode of operation of the plant concerning electricity use and sales and to any other of the fundamental standard project assumptions. The IRR calculations are illustrative of the relative effect of support mechanisms between plant sizes in one country and between different countries and not the absolute effect in a Member State in 2007.

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Internal Rate of Return (IRR) without benefits					
Base case					
	50kWe	1MWe	1MWe	12MWe	66MWe
Austria	23.80%	42.79%	66.82%	21.03%	20.26%
	2.6	1.4	0.9	3.2	3.2
Bulgaria	0.00%	0.00%	0.00%	8.59%	0.00%
	-7.4	26.9	-1.2	7.6	-14.2
Cyprus			0%		
			-4.3		
Czech Rep	5.71%	9.86%	-0.49%	18.08%	8.45%
	7.4	4.7	7.4	3.7	6.3
Denmark	0.00%	16.75%			53.44%
	11.2	3.1			1.1
Estonia	0.00%	0.00%	0.00%		0.00%
	107,5	117,6	-8,6		-158,7
Finland	2.60%	27.89%	11.26%	19.98%	22.57%
	6.3	2	3.9	3.3	2.8
Flanders	2.55%	13.91%		28.54%	12.32%
	8.9	2.6		2	4.2
France	2.67%	1.93%			11.58%
	10.2	11.7			5.4
Germany	17.43%	79.20%	71.34%		34.26%
	3.4	0.7	0.7		1.7
Greece	0.00%	17.60%	0.00%		
	17.5	2.8	11		

Internal Rate of Return (IRR) with benefits					
Supported					
	50kWe	1MWe	1MWe	12MWe	66MWe
Austria	23.80%	69.29	66.82	21.03%	20.26%
	2.6	0.8	0.9	3.2	3.2
Bulgaria	0.00%	11.17%	0.00%	12.71%	18.70%
	-7.4	6.2	-1.2	5.8	4
Cyprus			0%		
			-4.3		
Czech rep	0%	0%	0%	21.53%	9.20%
	-58.1	72.2	69.3	3.6	6
Denmark	0.00%	16.75%			53.44%
	11.2	3.1			1.1
Estonia	0.00%	12.97%	0.00%		0.00%
	14.3	5.8	16.2		-158.7
Finland	2.60%	27.89%	11.26%	19.98%	22.57%
	6.3	2	3.9	3.3	2.8
Flanders	12.91%	47.58%		51.17%	22.16%
	4.4	1.3		1.1	2.6
France	25.30%	52.90%			76.41%
	2.7	1.2			0.7
Germany	29.77%	98.49%	82.77%		37.19%
	2.2	0.6	0.6		1.6
Greece	2.92%	26.33%	0.00%		
	11.4	1.8	7.2		

Hungary	0%	0%	0%	5,70%	1,86%
	1.248,7	44,5	-12,6	7,3	9,6
Ireland	0.00%	10.63%	0.00%		
	-23.1	4.5	-5.7		

Hungary	0%	6,72%	0%	16,61%	9,58%
	42,8	5,5	10,4	3,9	5,8
Ireland	0.00%	10.63%	0.00%		
	-23.1	4.5	-5.7		

	50kWe	1MWe	1MWe	12MWe	66MWe
Italy	10.05%	29.08%	0.00%		23.03%
	5.4	1.8	-3.3		2.7
Latvia	0%	1.13%	0%		2.77%
	18,0	7,5	16,3		9,2
Lithuania	0%	0%	0%		-6,62%
	19,7	16,2	-263,6		16.9.0
Luxembourg	26.59%	51.94%	48.34%		46.00%
	2.3	1.1	1.2		1.3
Malta			0%		
			-1		
Netherlands	-0.29%	16.09%			2.45%
	13.1	4.1			8.2
Poland	0.00%	0.00%	0.00%	13.52%	1.52%
	15.6	9.5	12	4.6	9.9
Portugal	0.00%	2.40%	2.35%	25.62%	-9.49%
	80.4	4	4	1.8	6.9
Romania	2.87%	0.00%			0.00%
	12.6	5.4			-24.8
Slovakia	9.24%	17.73%	21.08%	25.46%	8.13%
	6	3.4	2.8	2.7	6.4

	50kWe	1MWe	1MWe	12MWe	66MWe
Italy	19.73%	57.94%	43.45%		54.08%
	3.4	1.2	1.1		1.1
Latvia	0%	1.13%	0%		6.14%
	18,0	7,5	16,3		7,3
Lithuania	0%	14,48%	9,17%		24,16%
	12,9	3,8	4,7		2,8
Luxembourg	26.59%	51.94%	52.12%		46.00%
	2.3	1.1	1.2		1.3
Malta			0%		
			-1		
Netherlands	6.12%	34.52%			7.98%
	8	2.4			6
Poland	4.36%	14.87%	13.23%	14.92%	22.23%
	8.1	3.8	3.9	4.3	3.1
Portugal	0.00%	2.40%	2.35%	25.62%	-9.37%
	80.4	4	4	1.8	6.9
Romania	5.62%	16.73%			20.79%
	10	3.4			3.6
Slovakia	15.35%	36.21%	32.80%	30.34%	24.54%
	4.4	2.2	1.9	2.3	2.8

Slovenia	0%	0%	0%		9.01%
	192.3	-124.6	54.3		6
Spain	23.63%	30.91%	-7.00%		18.51%
	3	2.2	30.4		3.8
Sweden	0.00%	0.00%	49.04%		15.25%
	-45.1	12	1.3		4
UK	-4.34%	13.44%		9.08%	11.99%
	8.6 yrs	3.5 yrs		6.1 yrs	4.8 yrs

Slovenia	19.98%	13.52%	14.15%		19.93%
	3.6	4	3.7		3.4
Spain	30.75%	37.73%	8.05%		23.84%
	2.3	1.9	7		2.9
Sweden	0.00%	0.00%	49.04%		15.25%
	-45.1	12	1.3		4
UK	1.24%	24.87%		12.36%	16.21%
	6.8 yrs	3.4 yrs		5.7 yrs	3.9 yrs

Table 2 Internal Rate of Return (IRR) without and with benefits

3. Overview of CHP support mechanisms across Europe

In 2007 there was a wide range of support mechanisms for CHP operating across Europe. Member States generally favoured some form of special tariff on electricity supplied to the grid (Feed-in Tariff: FiT), a generation bonus on the total electricity generated in CHP mode or fuel related tax concession. These forms of support aimed at providing working capital on an ongoing basis to support cogeneration revenue, reducing the risk of the investment by indicating a level of guaranteed return. This approach is particularly successful when the time horizon for the support is clear and sufficiently long term to cover the near term life of the plant. Some sort of capital grant or allowance targeted at growing particular capacity sizes of CHP is also a preferred approach but selectively applied and less wide spread. Capex support is effective particularly for smaller applications, where investment costs tend to be higher and more variable. The main methods of support are covered in Figure 2 below under the headings: tax, FiT (incl generation bonus), Certificate Scheme, Capital grant. The “Other” category of support contains a range of detail and added complexity to these schemes which is not considered to be centrally motivating for the sector. The “Other” category also contains support mechanisms for bio-energy (see Annex 2).

Country	Tax support	Feed in tariff	Certificate scheme	Capital grant	Other
Austria		√			√
BE - Flanders	√		√		√
Bulgaria		√			√
Cyprus					√
Czech Republic		√			√
Denmark					
Estonia					√
Finland				√	√
France		√			√
Germany		√			√
Greece	√	√			√
Hungary		√			√
Ireland				-	√
Italy	√	√		√	
Latvia		√			√
Lithuania		√			√
Luxembourg	√				√
Malta	√				√
Netherlands	√	√		√	√
Poland			√		
Portugal				√	√
Romania		√		√	
Slovakia		√			
Slovenia		√			√
Spain	√	√			√
Sweden				√	√
United Kingdom	√	√		√	

Figure 2: Overview of support CHP support mechanisms for fossil fuel based CHP in the European Union in 2007.

4. Overview of CHP support mechanisms and taxes

Austria:
Legal framework: Austrian Federal Law on the Promotion of CHP (KWK-Gesetz), issued by National Council on the 8th August 2008, entered into force on the 9th August 2008 and 23rd February 2009 respectively.
Policy approach: Fossil fuel CHP is supported in Austria through a generation based FiT, the 'übersicht-einspeisetarife'. The FiT applies to CHP of 2 MW and below. There is no support for fossil CHP of over 2 MW.

Belgium:
Legal framework: There is a law on the promotion of CHP issued by the Flemish government (7th July 2006), a law on the promotion of CHP issued by the Walloon Region (30th November 2006) and a law on the promotion of CHP issue by the Brussels Region (6th May 2004).
Policy approach: Support for CHP in Flanders is accrued through a number of different mechanisms. The capital costs of CHP are supported through an Ecological premium and tax reduction which significantly reduces the investment cost. The CHP certificate can be traded for the duration of the plant life and is calculated based on the emissions saved. These two support mechanisms account for the majority of the support in Flanders. For smaller scale CHP, there are payments made to reflect the reduction in grid losses from decentralised generation. At the federal level, there is also tax reduction for CHP.

Bulgaria:
Legal framework: Energy Act of Bulgaria created in 2003 and amended in 2006.
Policy approach: Financial support is in the form of a FiT paid on all generated electricity. Ahead of a proposed legislation to provide a system for Green Certificates, the support schemes available for CHP in Bulgaria is based on a mechanism of mandatory purchase of electricity for preferential prices. There are two funds supporting cogeneration projects: one set up by the Bulgarian state and a second one is called the Energy Efficiency Fund and the main donor is the World Bank. FiT paid on all generated electricity has a marked effect on all plants. where the support is available.

Cyprus:
Legal framework: Law on the Promotion of Cogeneration and Heat (2006)
Policy approach: A new grant scheme for investment subsidies for CHP is expected to be adopted in Cyprus. The previous scheme (2006) offered subsidies for cogeneration up to 30% of eligible investment costs for enterprises and biomass-fired CHP. The Energy Authority of Cyprus defines the purchase tariffs for cogenerated electricity which are linked to the fuel price.

Czech Republic:
Legal framework:

- Energy Act No, 458/2000 Coll.
- Public notice No, 439/2005 Coll.
- Decree on electricity market rules and other conditions No,541/2005 Coll.

Policy approach: Since 1st January 2006 a new support scheme has been introduced for CHP units, based on a feed-in premium on top of the market price of electricity for cogenerated electricity paid by network operators (distribution or transmission). The premiums are divided into three categories according to the installed electric capacity: up to 1 MWe, 1 MWe to 5 MWe and above 5 MWe. The premium is higher if producers sell electricity only in peak time. Producers can sell electricity to the

market or use it themselves. The system of price regulation is controlled by the Energy Regulatory Office (not as state aid).

Denmark:
Legal framework: Electricity Supply Act and Heat Supply Act.
Policy approach: There is no governmental support for fossil fuel CHP in Denmark

Estonia:
Legal framework: Amendments to the Electricity Market Act (1 May 2007).
Policy approach: New support scheme implemented in 2007 with FiT for CHP using renewable energy sources and other units of efficient cogeneration replacing boiler houses with capacity up to 10MWe. Two options are available:
1. Purchase obligation with feed-in tariff; or
2. Subsidised tariff (premium)
The support will be provided for CHP facilities with capacity less than 100 MW, CHP units using peat, waste or shale gas and CHP units replacing old boiler houses with capacity up to 10 MWe. There is support for fossil CHP units up to 10MWe. Relatively low feed-in tariffs make new renewable investments very difficult. A voluntary mechanism involving green energy certificates was also created by the grid operator in 2001.

Finland:
Legal framework: Law on the excise taxation of specific fuels 30.12.1996/1260.
Policy approach: Investment support for biomass based CHP plants. No fossil fuel support.

France:
Legal framework: Consolidated Cogeneration law: Arrêté du 31 juillet 2001 consolidé au 23 août 2005.
Policy approach: A two part feed in tariff one part paid on total electricity generation and a second tranche paid on electricity exported to the grid only. No capital grant or tax based supports available.

Germany:
Legal framework:
- CHP Law (unofficial consolidated version on the basis of the Federal Law Gazette published on 25.10.2008)
- CHP Law – changes from 21.08.2009. The changes mainly concern the clarification that belong to the eligible consumers leaving the heat network Law to accelerate the development of high voltage electricity network
- Erneuerbare-Energien-Gesetz (EEG)
- Erneuerbare-Energien-Wärmegesetz (EEWärmeG)
- Energiesteuergesetz
- Stromsteuergesetz

Policy approach: The main support for CHP in Germany is a stepped FiT in which the first kWh generated in a given year are rewarded at a higher level than subsequent generation. The result of such a mechanism is that fixed costs can be accounted for during the initial run time and therefore the investment presents less of a risk for developers. The model used here is unable to reflect the value of this feed in tariff design as it smoothes value over total annual generation.

Picture 1 Siemens SGT-400 Gas Turbine generator (14 MW) set in Cogeneration application at Psyttalia - Sewage Treatment Plant - Greece

Greece:

Legal framework:

- Law on Generation of Electricity using RES and High-Efficiency CHP and Miscellaneous Provisions (2006)
- Law on Promotion of CHP and other Provisions (2009)
- Ministerial Decree on Methodology for calculating the co-generated electricity from high efficiency CHP (2009)
- Law on Acceleration of the development of RES for handling climate change and other provisions (2010)

Policy Approach:

The FiTs are differentiated according to the location of the CHP unit. They also apply for biomass power plants. A CHP plant running on biomass cannot combine these tariffs, i.e. they remain the same. There is support for small scale CHP. Investment subsidies are available within the framework of the Development Act. They vary, but they can reach 55 % (especially in case of SMEs).

Hungary:

Legal framework: Act No. CX of 2001 on Electricity came into effect on 1 January 2003, amended in 2005. Much of the current legal framework applicable to cogenerators is derived from this Act, together with Act XVIII/1998 on district heat supply.

Policy approach: There is a CHP Support (Feed-in obligation). Fixed purchase prices for sold electricity to the network. Prices vary by unit size and hours of selling electricity (peak, valley, deep valley). The future of support scheme is uncertain after 2010. A green certificate scheme was

introduced with the Electricity Act (2001, as amended in 2005). This act gives the Government the right to define the start date of implementation. At that time,
the feed-in tariffs will cease to exist. Investment subsidies are potentially provided by KIOP (mainly for renewable projects).

Picture 2 Wärtsilä 18V34SG gas CHP application (12 MW) in Györhö, Hungary

Ireland:
Legal framework:

- Energy (Miscellaneous Provisions) Act 2006
- Electricity Regulation Act 1999 (Appointment of Person to Calculate Power to Heat Ratios of Combined Heat and Power Units) Order 2009

Policy Approach: There are no supports mechanisms for new CHP plant modelled. There is a grant support system to assist the deployment of small scale (less than 1 MWe) fossil-fired CHP and biomass (anaerobic digestion and wood residue) CHP systems. Financial tax incentives are available through the Accelerated Capital Allowance (ACA) scheme to encourage the purchase of plants that are highly efficient.

Italy:
Legal framework: Decreto Legislativo 8 febbraio 2007, n.20
Policy Approach: CHP plants are granted a FiT as well as a reduction in the tax paid in gas input fuels and, at the smallest scale (50 kW) a payment to account for the benefit of decentralised generation to the grid.

Latvia:
Legal framework:

- Law on Electricity Market (2005), adopted on 5 May 2005

- Regulation No. 221 of Cabinet of Ministers on Electricity Production and the Price Regulation in Cogeneration, adopted on 10 March 2009

Policy approach: The Latvian FiT is paid on all electricity generation and applies to all fossil CHP. Purchase price differs depending on the installed electric capacity and fuel used (for natural gas calculated according to a fixed price formula as natural gas price multiplied by factor, individually calculated). Investment support for renewable CHP units is available from the EU Structural Funds.

Lithuania:

Legal framework: Rules on Issue of Guarantees of Origin of Electricity produced from High-efficiency Cogeneration (2008). Official Gazette 2008, No 59-2254.The Regulations for Public Service Obligations approved by the Minister of Economy

Policy approach: Lithuania has a FiT with purchase obligation on all generation is controlled by National Control Commission for Prices and Energy (level of support sets annually and differs between plants).

Luxembourg:

Legal framework:

- Law on the rational use of energy (5th August 1993)
- Regulation on CHP and electricity generation from RES for units with a maximum capacity of 1.5MWe (30 May 1994)

Policy approach: There was no support modelled for fossil fuel fired CHP.

Malta:

Legal framework: Subsidiary Legislation 423.27

Policy approach: Malta lacks a FiT for CHP and there is also a lack of incentives and local expertise. These tariffs are directly linked to avoided costs in terms of new generation equipment, avoided fuel, O&M and network costs, avoided CO2 costs and finally a factor accounting for network losses.

Netherlands:

Legal framework:

- Electricity Act 1998, EIA Energy list 2010, Arrangement for Guarantees of Origin electricity production
- The Act ‘Wet belastingen op milieugrondslag’ (environmental taxes)

Policy approach: There is a tax credit: extra depreciation of 44% of the investment; applicable tax rate 25.5%; subsidy 0.44*25.5% = 11.2% of the investment temporarily subsidy for the exploitation of co-generation, only applicable to the CO_2-free kWh (approximately 30% of the production first two cases, 20% for the last).

Poland:

Legal framework:

- Amended Energy Law and Environmental Act 2007 (Green Certificates from 1. July 2007)
- Issuing GoO (Energy Regulatory Office): Ordinance on issuing CHP GoO, 2007

Policy approach:

Certificates of origin (“Green Gertificates”) are issued separately for two groups of cogeneration units:

1. Gaseous fuels or with total installed electrical capacity below 1MW

2. All remaining sources (4,8 €/MWh).

Certificates carry a range of purchase obligations and a different level of substitute fee. The level of the substitute fee is determined each year by the President of the Energy Regulatory Office. The support system will remain in force until 31 March 2013.

Portugal:

Legal framework:

- Decree-Law nº. 23/2010
- Law nº. 19/2010

Policy approach: Cogenerated electricity exported to the grid benefits from feed-in tariffs. These feed-in tariffs are applied for a period of ten years and it is indexed to the price of oil, to reduce fuel-price risks. As the price of oil rises, so will the feed-in tariff for cogenerated electricity. Micro-CHP in Portugal benefits from a higher level of support than larger cogeneration.

Romania:

Legal framework:

- Electricity Law (2007)
- Government Decision on the promotion of co-generation based on the effective thermal energy demand (2007)
- Government Decision on the approval procedure for issuing guarantees of origin for electricity produced by high efficiency cogeneration (2008)

Policy approach: The support mechanism operating in Romania is in the form of a two stage FiT; one part paid on all generation and worth 1.5 cents per kWh across all fuel types and plant sizes. There is also a support paid on exported generation and this varies from between 0.5 and 0.43 cents per kWh exported power. For CHP installations running on renewable fuels, cogenerated electricity receives Green Certificates. Systematic CHP support in Romania is not developed yet and it is only subject to special (EU) funds and programmes. Two funds are available for energy efficiency improvements: the Romanian Energy Efficiency Fund (FREE) and the Environmental Fund.

Slovakia:

Legal framework: Act on promotion RES and High Efficiency Cogeneration (309/2009)

Policy approach: Support for CHP in Slovakia comes in the form of an operation support as fixed purchase price composed of electricity price for losses and surcharge (varies by size and type of technology). Fixed purchase price is paid for all sold electricity to the network operator, whereas surcharge is paid on all other generated electricity. Investment subsidies from EU structural found are available in the period 2007 – 2013 (if plant is granted from 30 – 50% of total acquisition costs, the fixed electricity price is reduced from 4% to 16%).

Slovenia:

Legal framework:

- Energy Law
- Decree on Support for Electricity Produced in High-Efficiency Cogeneration (Off. Gaz.of RS No. 37/09)

Policy approach: Support scheme was approved in 2009 with higher and more stable support for cogeneration as fixed purchased prise for units up to 1 MW or premium on all generated electricity for

all plants for a 10 year period. Separate support for fossil fuel and wood biomass plants and different support levels for different size classes. Higher level of support for units with up to 4,000 operation hours per year (heating). Predictable methodology for yearly adjustment of supports based on forecast of natural gas and wood biomass market price and electricity market price minimise market risks for the investors.

Spain:

Legal framework:

- Royal Decree 616/2007, entered into force on 11 May, on the Promotion of CHP
- Royal Decree 616/2007, entered into force on the 25th of May, on the regulation of electricity produced on special regime

Policy approach: The support for CHP is in the form of a reduction on the tax applied to the input fuel and a generation based FiT which is smaller per kWh generated the larger the size of the plant.

Sweden:

Legal framework: Lag (2003:113) om elcertifikat (Law on Green Electricity Certificate (2003:113) revised 2010.

Policy approach: There is no support for new fossil fired CHP in Sweden. New CHP plants are bio-energy.

United Kingdom:

Legal framework: Energy Act 2008

Policy approach: Enhanced Capital Allowances (ECAs) enable a business to write off capital cost of investment, against their taxable profit FiTs offer financial support for gas-fired CHP up to 2 kW (and renewable electricity up to 5MW). Climate Change Levy Exemption Certificates (CHP LECs) operate for high efficiency CHP sources. Electricity suppliers are required to source a proportion of their electricity from renewable sources. Suppliers acquire Renewable Obligation Certificates (ROCs) from eligible generators when purchasing electricity, in order to demonstrate the proportion of renewable supply delivered to customers. CHP operators receive Embedded Benefits payments to refund the costs incurred in the charging system which assumes use of the transmission network.

5. Regional Overview

CODE Northern Region (Austria, Belgium, Denmark, Finland, Germany, Ireland, Netherlands, Sweden, UK)

The Northern Region contains some of Europe's biggest CHP countries, including the leader in CHP, Denmark. In some of these countries there is already a penetration of CHP in their electricity supply system of upwards of 20%. In the Nordic countries (Denmark, Finland Sweden), there is limited support for fossil CHP as the focus has already moved to renewable and lower carbon solutions.

In the remaining countries in the region some very complicated support mechanisms exist possibly reflecting sensitivity to strongly liberalised markets and a desire by national governments to apply only the minimum required stimulus. Such complexity can act as a barrier to entry and a further cost penalty on new entrants who need to invest to understand the system.

Belgium (Flanders) and Germany are the two EU Member States which have shown convincing promotion of CHP. The support mechanisms in these countries both show an advantage over the basic rate of return of upwards of 10%. For the large plant in Germany this is not the case and in fact this part of the market is not progressing at a parallel pace to the smaller systems where stimulus is clear.

A common theme across the Northern Region members with significant CHP support is the combination of capital support (through grants or tax liability reduction) with generation/power export support.

CODE Eastern Region (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia)

FiTs and bonuses on electricity are the strongest CHP promotional support used in all countries in this CODE region. The details of FiTs in range covered, period, setting, etc are unique to specific countries but the consistent choice of FiT may reflect the more managed electricity markets which still exist. Full market liberalisation is still ahead.

More market oriented FiT with premium on all generated electricity is the most successful mechanism in the countries with average/higher end users electricity prices (Slovenia, Slovakia, Czech Republic, Hungary) with the fastest recent development (except Slovenia with new support from 2010). For the Baltic countries, with still very low wholesale prices and lower end users prices, the fixed purchase price approach to support seems to be a better option. A fixed purchase price is a good option for supporting the competitiveness of district heating plants on the electricity market. District heating applications incorporating cogeneration are a dominant cogeneration sector in the CODE Eastern region.

Coal is a significant fuel in several Member States and the price data which are available are difficult to verify. This region is also characterised by very high upfront costs and capital costs for the smaller units. In a time of limited access to capital this is an issue for new projects.

CODE South East Region (Bulgaria, Cyprus, Greece, Romania)

There are two quite separate experiences of CHP in this region: two of the countries Bulgaria and Romania have considerable district heating investments, some with CHP; in Greece and Cyprus

district heating applications are very limited and CHP is in general not a prominent energy efficiency method in key sectors where it would exist in other countries.

None of the Member States in this region have support mechanisms to encourage micro-CHP or smaller building and small process sites.

In general, the profitability of CHP across this region is heavily affected by the relatively low level of market liberalisation. The electricity supply price data for Bulgaria for example shows that the electricity price is lower than the basic fossil fuel price. Market liberalisation issues in Greece effect market access and competition around basic fuel. Despite support mechanisms which could stimulate the market in Greece the bureaucracy for obtaining permits from many different state organisations are time consuming and act as a barrier to entry for new participants. The volatility of fuel prices, and frequent changes in the policy structures around the electricity market and CHP in recent years has added to the investment risk.

CODE South West Region (France, Italy, Luxembourg, Malta, Portugal, Spain)

Similarly to the CODE Northern Region, the countries of the South West region are relatively advanced in market liberalisation. For cogeneration support mechanisms this means that the support mechanisms tend to be complex to reflect the structure of the market with gas and electricity prices built up in tranches.

The supported IRRs in both France and Italy benefit by well over 10% uplift however despite the apparently attractive returns these markets are not showing the growth that might be expected as a result. In France the limited application and duration of new support contracts mean that there is in reality only investment in replacement plant. In Italy additional costs to cogenerators, local legislation and local taxes restrict development adding risk cost to this basic IRR calculation.

6. Discussion of the findings and main drivers for success

The WP3 CODE modelling highlights a basic fact of the CHP sector which is that the impact of fuel price and electricity price are very significant within the IRR. Volatility in both or either of these prices impacts the IRR and increases the uncertainty of return. To standardise the analysis the CODE team chose to model plants with only one assumption on electricity use/generation i.e. that all the self generated electricity in modelled projects apart from the 66 MWe project was consumed on sight. As sales (or not) of electricity are a key element of profitability of a project, these assumptions must always be taken into account in using the results of the modelling. The impact of these assumptions also has a bearing on support mechanism design as support mechanisms can either encourage or discourage sale of electricity to the grid from CHP, hence influencing the size of plant an investor will choose to install and the overall energy efficiency gains in the end.

There is also a clear impact of the degree of market liberalisation on the IRR result (see modelling of Romania and Bulgaria). Liberalised markets add complexity to the electricity trading and hence require additional sophistication from support mechanisms. Non-liberalised markets artificially effect fuel or electricity prices requiring a compensating support mechanism to address the resulting lack of profitability.

The high capital cost of the smaller CHP units has a large overall impact on IRR. This increased capital cost is partially a result of lacking the advantages of scale of the other bigger units but also the relative immaturity of this part of the market results in high prices through a lack of competition on individual projects.

Several aspects of overall project cost are difficult to model and the fiscal risk which is missing from the current IRR was particularly mentioned in the South Eastern Region as a barrier to development. However attractive a support mechanism is for a short period investors are reluctant to invest if there is a history of frequent changes to detail or the overall legislation. Stability of the support structure to give clarity to investors is very important for long term investments of this kind. South Eastern Region mentions need for consistent policy and not frequent changes of mechanisms.

7. Case study: Use of certificate scheme in Flanders to promote CHP

Flanders has been uniquely successful in promoting CHP over the period 2004-2010. The region has established a target for CHP and put a multi-layered set of support mechanisms in place to encourage growth in CHP installations. The schemes have been successful across a range of installation capacity from large industrial sites down to small sized CHPs. The exception is units in the micro CHP capacity at 50kWe and under.
The support mechanisms available for CHP in Flanders are:

- Premium for ecological investment (until January 2011)
- Tax reduction
- 20% investment support for micro-CHP (until June 2010)
- Demonstration support for micro-CHP
- CHP Certificates (CHPC)

Premium for ecological investment:
This support applies to all enterprises that realise ecological investments in Flanders. The funds are administered under a "call for projects" system with 3 calls per year. The total budget for the 3 calls 2010 was 120 million €. Projects are ranked by means of a performance factor. Only the best ranked projects receive support. The support is granted only for additional investment in a project to incorporate CHP not for investment which would have been undertaken for normal business reasons. Support is differentiated by the size of enterprise and by the type of fuel used with bio-energy CHP attracting 50% support. Funds are limited to a maximum of 1.75 million € per call. A rejected project cannot be submitted in a next call. Since 2007 fossil fuel CHP projects were often ranked too low to have support. Biomass CHP was more successful in gaining the premium for ecological investment.

Tax reduction:
There is a tax reduction available to cogenerators on taxable profit associated with investments in energy savings. This applies to investment in CHP. The extra reduction is 10% and is cumulative with the ecological premium. Basis reduction dependent on index:

- Investments 2009: 5,5% → 15,5%
- Investments 2010: 3,5% → 13,5%

20% investment support for micro CHP:
Support is available for all micro CHP which qualify under the conditions of the CHP Directive. Twenty percent of the costs for installation is provided by a government grant. The beneficiaries can be from a range of economic sectors, provinces and municipalities, public centres and governments, schools and universities, hospitals and rest-homes, non-profit organisations. Cumulative with other financial support. Total budget: 200,000 € per year. The support ended in June 2010.

Demonstration support:
There is a support scheme for demonstration projects with micro-CHP (< 50 kW_e) in residential applications. The schemes are granted a maximum of 50% of the costs of the innovative part of the new technology, exclusive of VAT to a maximum of 250,000 € per year. The results of the project are published for reference by other potential users.

CHP certificate principal:
The government of Flanders has set a up a cogeneration target which is the basis of activity to grow cogeneration capacity (19% electricity supply from high efficient CHP by 2010). This target is related to an obligation on all electricity companies to realise a certain amount of primary energy savings by means of high efficiency CHP sources. Each company has to be able to deliver proof of having realised the primary energy savings, increasing year on year, by delivering CHP certificates against the quota which the company has been tasked to deliver. Any producer of high efficiency CHP applies for CHP certificates to the regulator and can trade these in a CHP certificate market where they are bought by the electricity companies tasked with the quota. One CHP certificate is given for every MWh of primary energy savings delivered through high efficiency CHP. The government provides a guaranteed minimum price for the certificates of 27 Euro (for installations connected to the distribution grid) and if a supplier should fail to meet their obligation in providing the regulator with the correct quota of certificates the regulator will fine the supplier 45Euros per missing certificate.

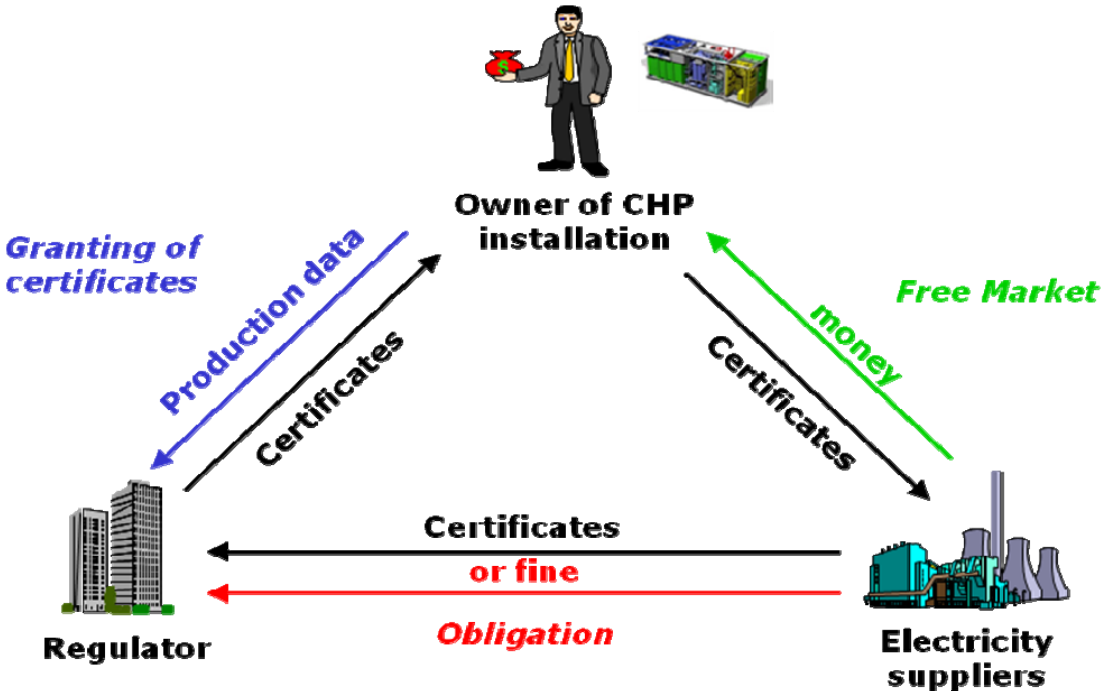


Figure 3 The Green certificate scheme for promotion of CHP in Flanders

All electricity suppliers have an obligation to supply a fixed amount of CHP electricity to their customers. The number of CHP certificates to be handed in each year are a percentage of amount of delivered electricity to end-users in the preceding year. If the supplier cannot hand in the correct number of certificates they are fined per CHP certificate of shortage.

The only section of the market which has not so far responded to the range of schemes available is the micro-CHP sector.

The WP3 model shows that with all the support mechanisms currently in place the 50 kWe project has the lowest internal rate of return and the longest payback of all projects modelled. There is a large difference between the apparent payback of the 1 MWe and the 12 MWe projects and that of the 66 MWe showing that selling electricity to the network for the 66 MWe case is not as attractive as being able to use all of the electricity on site as in the 12 MWe case. However even without government support the internal rates of return for the 1 MWe to the 66MWe plants gives a payback running at less

than 5 years.

The overall effect of support is different for each capacity of plant. For both the 1 MWe and the 12 MWe plants the support mechanisms are equivalent to an improvement on the modelled IRR of over 25%. This sector of the market is in fact showing the highest levels of expansion. The effect of the support for the 66 MWe and the 50 kWe is to raise the IRR by around 10 percentage points, bringing the payback period on the 66 MWe plant down to 2.6 years. This sector of the market has also seen substantial growth since 2007. On the 50 kWe the government support lowers the period for a return on investment from 8.9 years to 4.4 years. At this time this is not sufficient to drive investment on its own.

Notional electrical capacity	**50 kWe**	**1 MWe**	**12 MWe**	**66 MWe**
Financials without benefits				
Simple payback without benefits	**8.9**	**2.6**	**2.0**	**4.2**
Internal rate of return (IRR) without benefits	**2.55%**	**13.91%**	**28.54%**	**12.32%**
Financials with benefits				
Simple payback with benefits	**4.4**	**1.3**	**1.1**	**2.6**
Internal rate of return (IRR) with benefits	**12.91%**	**47.58%**	**51.17%**	**22.16%**
Effect of benefits on financials				
Effect of benefits on simple payback	**-4.5**	**-1.3**	**-1.0**	**-1.7**
Effect of benefits Internal rate of return (IRR)	**10.35%**	**33.67%**	**22.63%**	**9.84%**

Table 3 Overall effects of support

The growth of the installed capacity of cogeneration in Flanders is shown in figure 4 below. The support mechanisms were introduced in 2004 and have achieved a high level of activity across the market particularly in the small and medium sized applications. Industry and agriculture have seen considerably expanded use of CHP.

The Flanders scheme also exhibits the type of characteristics of generally successful support regimes with a well defined, easy to follow structure for the main funding mechanism, a near and medium term commitment to the support scheme and visibility of likely development going forward. The presence of an overall target underpins the member state commitment to the process.

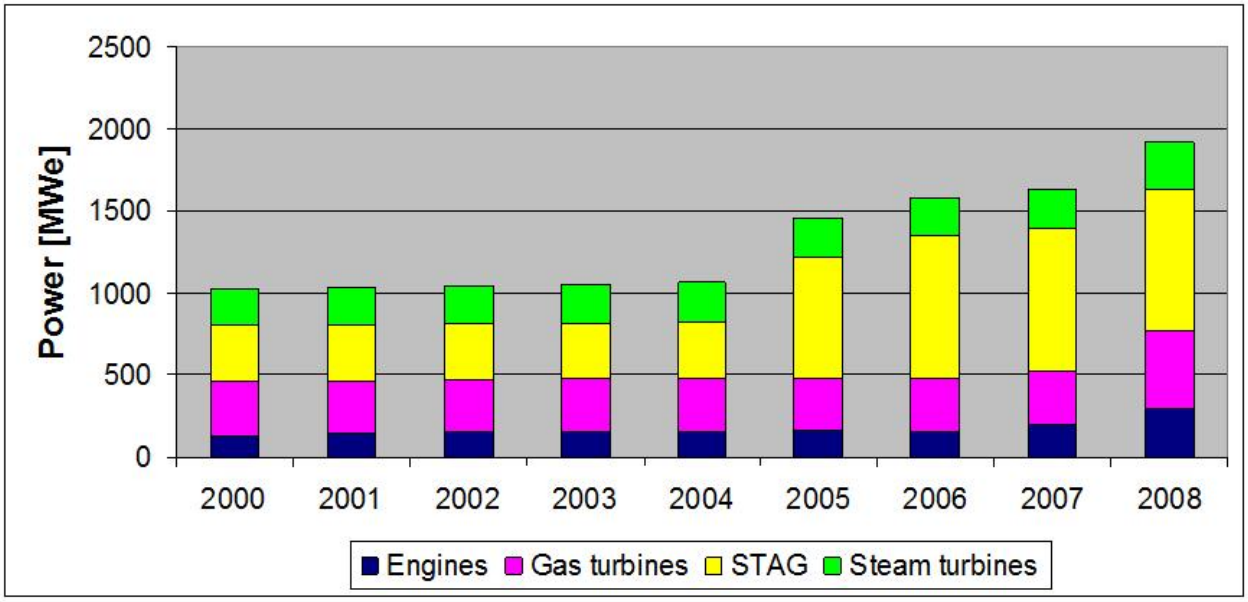


Figure4. Growth of installed cogeneration by technology type in Flanders 2000 to 2008. Support mechanism were started in 2004

There are several barriers for micro-CHP in buildings:

In this best case example there is both a substantial uptake of the support offered combined with using an array of planning tools and a supportive local government in every sense. This highlights that while suitably crafted financial support is often necessary to grow CHP in a member state this is not sufficient on its own. In both Flanders and Germany (another best case example in Europe) there has been considerable work by local and central government and by energy agencies on barrier removal in the structure of existing permitting and connection processes and in the general communication of the usefulness and appropriateness of CHP as an energy efficiency approach for many applications.

The one sector which has not been effectively stimulated by the support system in Flanders is micro-CHP. The modelling shows that with the current support structure in place the pay-back period for a micro-CHP installation at 50 KWe will be 4.4 years which is three times the length of payback period for the 1 MW and 12 MW plants modelled and double that for the 66 MWe plant. While the absolute values would take closer modelling of the plants to be taken as accurate the relative values are indicative of a scheme which favours larger installations. The lack of activity in Belgium with a standardised 4.4 years of return is consistent with no activity in the market for this type of return period. Further investigation into the barriers preventing wider deployment of micro-CHP in buildings highlights the following basic problems in buildings:

- It is not possible to sell the electricity in apartments. This has a big impact on the profitability of the project
- Heat demand is not sufficiently known, or too small, to install a profitable CHP
- Profitability is very project dependent. The calculation from the CODE project is just one general case, and certainly representative for all micro-CHP projects
- For the very small installations (< 5 kWe) the availability of CHP installations is a barrier. The

support by CHP certificates is also very small for micro-CHP

- Photovoltaic is supported very well in Flanders. This can also have an impact on the lower interest in micro-CHP (for the electricity side)

There is considerable literature covering the surprisingly high rate of return expected by consumers and small end users for energy efficiency investments. This suggests that in general support mechanisms to stimulate the smaller more distributed CHP investments need to be carefully constructed to give a suitably attractive and short payback period.

8. Conclusions on WP3 modelling

The IRR analysis gives useful information for further developing successful support mechanisms for CHP and for approaching the question of why CHP is not growing in some Member States.

1) The model shows the ability of mechanisms to stimulate particular sectors of the CHP market in one member state. The IRR results indicate successfully which areas will be stimulated relative to others.

2) In the case where no other barriers exist or the market barriers to CHP are low the model gives a good indication of whether a specific set of support mechanisms will be successful or not.

- Germany and Belgium (Flanders) are countries with relatively low levels of additional market barriers for CHP projects. The model predicts that the CHP sector which will be the least successfully stimulated by the current support mechanisms in Flanders is micro-CHP and that the very large CHP units will be the least successfully stimulated under the German scheme.
- The model also produces a consistent predictor of support uplift which seems to trigger action in these two countries. In both cases an uplift of a minimum of 10% is needed to trigger a response from the market. In the model's terms this relates to a payback time of less than 3 years.

3) In the case where a suitable uplift is provided by a Member State scheme but there is still no CHP market response it is a good indication that other market barriers exist.

- Both France and Italy have support mechanisms which should lift a large part of the industrial market into a positive return rate above the 10% support lift and with a return in under 3 years. However, in France over the period since 2007 the support mechanism has been steadily withdrawn and restricted as France moves to focus its support exclusively on renewables. This exclusive focus is virtually complete at the time of writing and existing CHP is being scrutinised for even renewal support. In Italy there is still much change in the policy around CHP itself leading to a high level of investment uncertainty which coupled to the still considerable permitting and access issues deter investment.

4) The support mechanisms in several member states have no effect at all on the return on investment in CHP. This suggests that best practise in designing support mechanisms could usefully be transferred between Member States.

5) The 50 KWe micro-CHP yielded the most challenging IRRs due to the relatively high capital cost of the plant. As this is also the most demanding sector of the market in terms of expected rate of return special effort is required to lower costs and to improve financial performance through the support mechanisms for such applications.

6) The IRR of CHP is heavily dependent on the structure of the primary energy market and the electricity market in a member state. The degree of market liberalisation is one of the key factors in determining a successful return on investment.

7) The use of IRR modelling as an indicator of impact of support is a useful tool in combination with other analysis. In interpreting the results an understanding of the complex detail of particular member

states markets is key to correct modelling

- Models need regular updating/refining – limitations are still found
- Industry specific support very difficult to quantify

Annex 1: Methodology for IRR calculation under WP3 of CODE

Work Package 3 'Comparison of member state approaches' provides standardised cogeneration plant scenarios providing a theoretical financial assessment of the investment case with and without financial support mechanisms provided in each Member State under the European Cogeneration Directive.

Each Member State, as part of their implementation of the Cogeneration Directive, must ensure that support for cogeneration is based on meeting useful heat demand and delivering primary energy savings compared to separate heat and power generation. It is, however, very difficult in the abstract to anticipate the actual stimulus that will be achieved in the market and whether removal of the identified barriers will in itself be enough to improve the take-up of cogeneration. Barriers, support mechanisms, finance, economic climate, and wider policy can result in an apparently favourable set of policy instruments having no real effect on implementation.

The standard tool used by commerce and industry to evaluate whether or not an investment may be worthwhile is the IRR and simple payback periods. It incorporates, in a transparent but consistent way, effects such as cost of capital, competing investment opportunities, and actual support in specific circumstances. The analysis models an anticipated rate of return on investment which to base the investment, and compare the investment across member state boundaries.

At the project outset three cogeneration scenarios were originally considered; a 50 kW and 1 MW gas engine and 50 MW combined cycle gas turbine (CCGT) CHP. In consultation with the regional project partners and the Commission, these were revised and extended in the early stages of the project to:

- 50 kWe gas engine CHP
- 1MWe gas engine CHP
- 1 MWe diesel (gas oil) engine CHP
- 12MWe coal fired heat recovery steam turbine CHP; and
- 66MWe CCGT CHP

These sizes and fuel types represent a range of real life plant and the 12 MW and 66 MW in particular were specified using plant design software GT pro. To create a basis for comparison it has not been possible to capture the reality in every Member State.

It is important to note that whilst biomass fuelled cogeneration is a significant energy conversion technology in a number of Member States; it was beyond the scope of this project to model a range of biomass scenarios. It is recommended that this be modelled as a subsequent project.

Assumptions

To ensure an equal basis for comparison, a number of assumptions have been made in these theoretical models of construction and maintenance. These are as follows:

- 2007 price data were used throughout (thereby ensuring complete dataset available) this includes the effect of EU ETS modelled as at 2007. Originally 2009 data was used
- Data supplied directly from Member States were the preferred source, but where this was not available published (fuel electricity and tax data) Eurostat or International Energy Agency (IEA) data were sought. Where construction and maintenance costs were not available UK sourced data were used

- The cost of land purchase was not included within the model
- An assumed weighted average cost of capital (WACC) was modelled at 8%
- Benefits and financial support mechanisms were spread across each operating year until the support finished. In some cases support at the beginning of the year is higher (to help address capital costs) and this falls with increasing cumulative output. The model was not sufficiency refined to address this
- Writing down allowance (WDA) standardised at 13% across all Member States
- All electricity modelled as used on site with the exception of the 66MW which is modelled to export 60% electricity
- The plant life was modelled to be 20 years
- Where electricity wholesale price data were not available, the wholesale price was calculated to be 70% of the industrial supply price based on the ratio between UK Government long term industrial supply and wholesale price data.

Methodology

The analysis was undertaken in the following stages:

- Five plant scenarios agreed with CODE project team (COGEN Europe and Regional Project Leaders detailed below)
- IRR calculation spreadsheet developed and tested for UK
- Data input template sent to CODE Regional Project Leaders (CHPA in United Kingdom, HACHP in Greece, FAST in Italy and JSI in Slovenia) to gather data from individual Member States
- IRR calculations undertaken by CHPA and where data not available from Member State, remaining input data sourced from Eurostat and IEA
- Calculation sheets returned to Member State via Regional Project Leaders for approval
- Two page country written descriptions of calculations written by CHPA and sent to Member State for approval
- Regional overviews written by Regional Project Leaders
- European overview written by COGEN Europe

Work package deliverables

- D3.1 Country IRR calculations and reports x27
- D3.2 Region comparative reports x4
- D3.3 European overview of results
- D3.4 Case studies for handbook

Possible futures uses for the IRR calculation spreadsheets

- Model specific engine sizes, more relevant to a given Member State situation
- Model outputs for other countries
- Refine modelling to date
- Model changes in tax, support and legislation
- Model biomass/bioenergy support
- Model differing export scenarios
- Examine support effects on cost inflation by supply chain

Annex 2 National Support Schemes

Country	Tax support	Feed in tariff	Certificate scheme	Capital grant	Other
Austria		√			√
BE - Flanders	√		√		√
Bulgaria		√			√
Cyprus					√
Czech Republic		√			√
Denmark					
Estonia					√
Finland				√	√
France		√			√
Germany		√			√
Greece	√	√			√
Hungary		√			√
Ireland				-	√
Italy	√	√		√	
Latvia		√			√
Lithuania		√			√
Luxembourg	√				√
Malta	√				√
Netherlands	√	√		√	√
Poland			√		
Portugal				√	√
Romania		√		√	
Slovakia		√			
Slovenia		√			√
Spain	√	√			√
Sweden				√	√
United Kingdom	√	√		√	

Table 4: Overview of support CHP support mechanisms for fossil fuel based CHP in the EU in 2007

The details of minor support mechanism and qualifications on the existing systems are contained in the column “Other” of figure 3. These are listed in more details here:

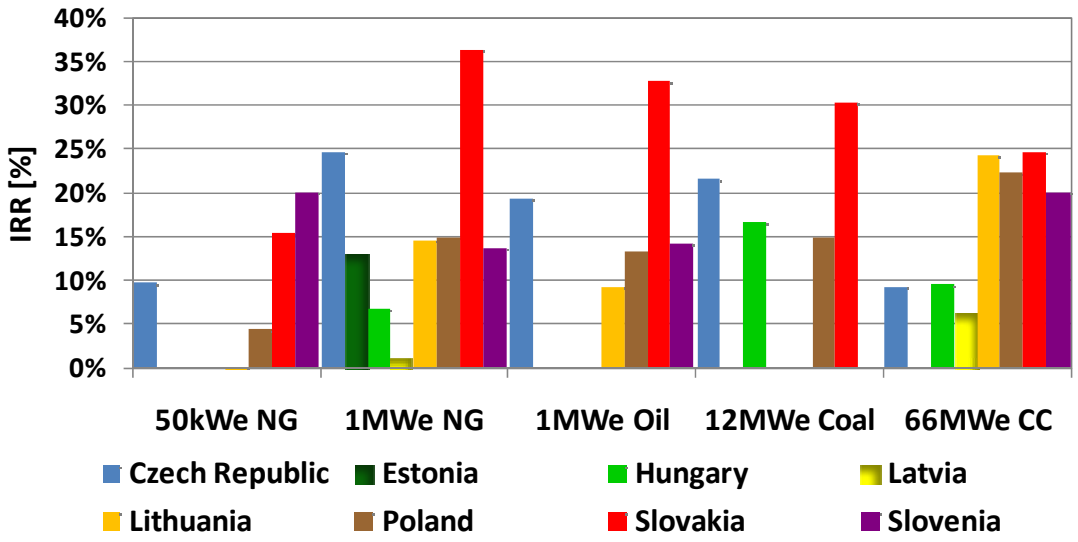
Austria: There is no financial support for fossil CHP > 2 MW
Belgium: For smaller scale CHP there are payments to reflect the reduction in grid losses.
Bulgaria: Comment from regional representative: There is need for governmental support.
Cyprus: There is a lack of available data on fuel.
Czech Republic: The paybacks for the CHP were all low ranging, besides the 66 MW gas CHP plant.
Estonia: There are supporting mechanisms for renewable and efficient cogeneration electricity producers.
Finland: No evidence of govt support for fossil fuelled CHP, there is investment support for biomass based CHP plants.
France: Comment from regional representative: Positive impact of FiT on the plants, IRR increased.
Germany: Comment from regional representative: The result of the stepped FiT is that fixed costs can

be accounted for during the initial run time and therefore, the investment presents less of a risk for developers.
Greece: The support modelled was a reduction in capital costs for installing plants.
Without government support, small scale CHP modelled for Greece are 0 for the 50kW and 1MW gas oil plant.
Hungary: Comment from regional representative: CHPA unable to source the value of FiT
Ireland: Given no support mechanisms for new CHP plant, returns calculated were based on unsupported financial case
Latvia: IRR increased or decreased depending on the plant.
Lithuania: IRR increased or decreased depending on the plant.
Luxembourg: High IRRs and short paybacks; it was difficult to obtain MS data for Luxembourg.
Malta: It was not possible to source fossil fuel price data for Malta, thus the ITT for the 5 plants could not be drawn.
Netherlands: The model presented is unable to account for the value of the support system in Netherlands.
Portugal: No quantitative details of support mechanisms used; strong spark spread.
Slovenia: Comment from regional representative: FiT has led to unusually high IRRs with the assumptions modelled
Spain: Increase in IRR because of reduced fuel tax and generation tariff.
Sweden: New CHP plants are bioenergy (based on biomass, peat)

Region name	**Eastern Region**
Contact organisation	Jozef Stefan Institute, Slovenia
Contact name	Stane Merše

1. Region comparison of IRR results

Effect of benefits on Internal rate of return (IRR)	50kWe Natural Gas	1MWe Natural Gas	1MWe Gas Oil	12MWe Hard Coal	66MWe Natural Gas
Czech Republic	0.00%	0.00%	0.00%	3.45%	0.75%
Estonia	0.00%	0.00%	0.00%	~	0.00%
Hungary	0.00%	6.72%	0.00%	10.91%	7.72%
Latvia	0.00%	0.00%	0.00%	~	3.38%
Lithuania	0.00%	14.48%	9.17%	~	30.78%
Poland	4.36%	14.87%	13.23%	1.41%	20.71%
Slovakia	6.11%	18.49%	11.72%	4.89%	16.41%
Slovenia	19.98%	13.52%	14.15%	~	10.91%



2. Comparison of region characteristics

Feed-in tariffs, proven to be the most successful support mechanism for high efficiency cogeneration, are implemented in all Eastern region Member States (MS) except in Poland which has a certificate and quota obligation. Feed-in support has a number of formats across the region; as a 'fixed purchase price for sold electricity' (Hungary, Latvia and Lithuania), 'premium on the generated electricity' (Czech Republic and Slovakia) or combination of both mechanisms (Estonia and Slovenia). Although the common feed-in support concept is prevailing in the region, the support systems are not easy to compare due to their differences (setting and adjusting the level of support, criteria for eligibility, period of the support, etc.).

Investment subsidies are potentially available in some MS (Hungary, Latvia and Slovakia) but are focused mainly on the renewable cogeneration units. Due to this uncertainty it was not included in the analysis and would have significant positive influence if used.

Excise tax exemption from fuel used for cogeneration/electricity generation exists in several MS (Czech Republic, Slovak Republic and Slovenia) but due to low excise taxes the influence is small.

3. Comparison of IRR calculations with and without support mechanisms across region

Due to the infancy of the market and consequent high investment costs, the smallest 50kW cogeneration unit is not economically feasible without the extensive support. This is highest in Slovenia and Slovakia (internal rate of return [IRR] 20% and 15%) and moderate in Czech Republic (IRR 10%). In all other MS the IRR is negative.

Except in Latvia, 1MWe gas engine is the most uniform economic option with existing support in the region, with an IRR of around 15% (Slovakia 35%, Hungary 7% and Latvia 1%). Without support the economics of this unit is limited only in Slovakia and Czech republic, mainly due to the high cost of consumers' electricity prices.

Higher gas oil fuel prices compared to natural gas result in lower economic indicators for 1MWe gas oil engine with a positive change in IRR ranging from 9% to 33%, (these units are not feasible in Estonia, Hungary and Latvia) whereas without support the IRR is only positive in Slovak Republic.

The coal cogeneration unit is only modelled for Hungary, Poland, Slovakia and Czech Republic, with a rather high IRR (from 15% to 30%) even without support (IRR from 6% to 25%). The main reason is competitive fuel price of coal and tradition in these MS.

The largest combined cycle cogeneration unit with the existing support schemes is the most attractive option for investment in the region with IRR from 20% to 25% in Slovenia, Poland, Lithuania and Slovakia, and IRR close to 10% in Hungary and Czech Republic, followed by Latvia with 6%. Sensibility to the support is significant as without support the IRR is less than 10% in all MS and economically viable only (IRR between 8% and 9%) in Slovenia, Slovakia and Czech Republic.

4. The effect of these support mechanisms across the region

More market oriented FiT with Premium on all generated electricity is the most successful mechanism in the MS with average/higher end users electricity prices (Slovenia, Slovakia, Czech Republic also Hungary could be added) with the fastest recent development (except Slovenia with new support from 2010). For Baltic region with still very low wholesale prices and lower end users prices the fixed purchase price is better option at the moment. Fixed purchase price is good option for the competitiveness of district heating plants on the electricity market which are the dominant cogeneration sector in the region. Predictable and incentive support is key issue for the success with removal of other barriers for cogeneration

Region name	**Northern Region**
Contact organisation	CHPA
Contact name	Tim Rotheray

1. Region comparison of IRR results

Effect of benefits on Internal rate of return (IRR)	50kWe Natural Gas	1MWe Natural Gas	1MWe Gas Oil	12MWe Hard Coal	66MWe Natural Gas
Austria	0.00%	26.5%	26.5%	0.00%	0.00%
Belgium (Flanders)	10.35	33.67%	0.00%	22.63%	9.84%
Denmark	0.00%	0.00%	~	~	0.00%
Finland	0.00%	0.00%	0.00%	0.00%	0.00%
Germany	12.34%	19.29%	11.43%	~	2.93%
Ireland	0.00%	~	0.00%	~	~
Netherlands	6.41%	18.43%	~	~	5.53%
Sweden	0.00%	0.00%	~	~	0.00%
UK	5.58%	11.43%	~	3.27%	4.22%

2. Comparison of region characteristics

The countries of the northern region fall into two distinct groups – the Nordic countries of Finland, Sweden and Denmark and the remaining countries Austria, Germany, Ireland, Netherlands and the UK.

In the Nordic countries, there is limited support for fossil CHP as the focus has already moved to renewable and lower carbon solutions. In Denmark, for example, the CHP market is well served and much of the market is to replace existing units to serve extensive heat networks. Operators may often offer grid services such as demand response and, therefore, the operational dynamics may be very different from that modelled for this project. In Sweden, the emphasis is entirely on renewable generation and as a result fossil fuelled CHP is not supported at all. There is substantial uptake of CHP in Sweden but this will be increasingly replaced with renewable CHP. The lack of data for coal and (less so) for gas oil indicates the relatively high penetration of natural gas in the northern region countries

The other countries of the Northern region represent generally liberalised markets with a range of market players. The range of support mechanisms are generally complex reflecting the complexity of the markets in which they operate. It is rare that there is only one form of support but more normally a combination of capital support through taxation benefits, reduction in fuel taxes and/or support for electricity generation or electricity export exist.

3. Comparison of IRR calculations with and without support mechanisms across region

Improvement in the rate of return through government support mechanisms generally falls in models of larger plant. This may well be that such plant can often compete for better spark spread (gas:power price ratio) than smaller plant. As a result, the initial financials for larger scale projects as modelled were frequently relatively high compared to the smallest plant. It may be that State support has been designed to ensure that support is adequate whilst avoiding excessive rents for CHP developers. Ireland and Sweden have no dedicated support for new fossil CHP plants. Modelled support for CHP in the Netherlands (as modelled) employed a combination of capital support, alleviation of input fuel taxes and electricity generation support. The combination of support led to an improvement in the investment case for CHP. Since 2007, however, support for CHP in the Netherlands has been removed with a consequential negative impact on CHP market growth.

Both the Belgian (Flanders) and German support mechanisms had a significant impact on improving the investment case for CHP with the exception of the German modelled 66MW plant where a modest 3% improvement on the IRR is seen. Both Flanders and Germany have made explicit commitments on the value of CHP and this has been reflected in the support schemes that exist.

4. The effect of these support mechanisms across the region

The key growth areas for CHP in the northern region have been the Netherlands, Belgium and Germany. The removal of support for CHP in Netherlands has had a significant slowing impact on market growth. In the UK, the most significant market growth is generally seen at the small scale 1-5 MW plant and this is reflected in the IRR calculations for the UK.

In all cases, the impact of support was greatest on the 1MW gas engine. This is principally due to relatively good spark spreads (low gas prices relative to the value of electricity not purchased through normal supply) combined with the modelling assumption that all electricity generated is used onsite (i.e. there was no export). Whilst units of the 1MW scale are sited in locations with relatively high electricity supply prices, the export value (without support) is often very low in the Northern Region. As a result, the modelled assumptions tend to give particularly high IRRs to CHP plant which may not be reflected in reality. The effect of support mechanisms on financials which are already high is far more pronounced than if the initial financials were poor. As a result, the effect of support mechanisms can be to provide unrealistically high IRRs which would lead to a stronger uptake of CHP than has been seen in reality. Northern Region members highlighted the importance of treating the results for the 1MW CHP plant with caution.

In the UK, a proactive stance in London, using an array of planning tools and a supportive local government, has led to much significant uptake of CHP. In Flanders, the support scheme has been highly effective in driving industrial CHP uptake although the white certificates market is at risk of becoming saturated and prices may crash if the Government does not intervene. A common theme across the Northern region members with significant CHP support is the combination of capital support (through grants or tax liability reduction) with generation/power export support. This appears to be a powerful driver limiting Government's liability (compared to using only capital cost support) whilst also supporting investment and ongoing operation from developers.

Region name	**South Eastern Region**
Contact organisation	HACHP, Greece
Contact name	Costas Theofylaktos

1. Region comparison of IRR results

Effect of benefits on Internal rate of return (IRR)	50kWe Natural Gas	1MWe Natural Gas	1MWe Gas Oil	12MWe Hard Coal	66MWe Natural Gas
Bulgaria	0.00%	11.17%	0.00%	4.12%	18.70%
Cyprus	~	~	0.00%	~	~
Greece	2.92%	8.73%	0.00%	~	~
Romania	2.75%	16.73%	~	~	20.79%

2. Comparison of region characteristics

The South-East EU M-S countries are divided into two distinct categories, regarding CHP; those, like BUL and RO, with long tradition in fossil-fuel CHP systems, mainly for district heating systems, and those, like CY and GR, with limited experience in CHP. Today, all M-S policies for CHP are characterized of a variety of support mechanisms for the promotion of CHP and especially High Efficiency one. One common point for all the region is that the applied support mechanisms are changing quite often, creating, at least, confusion to potential investors and the market.

A typical example is Greece, where, until the end of 2008, the support mechanisms include both FiT for the cogenerated electricity, given to the Network and incentives, up to 35% of the total cost of the investment, mainly through CSF. This can be characterised as a “cross-subsidies” but, even though, the final results were poorly, as the bureaucracy for obtaining the permits from many different state organizations were time consuming, the existing spark ratio inappropriate for CHP. So, the final results at the end of the 3rd CSF can be characterised as dismal results. The situation changed with a new legislation, passed in 2010 (L.3851/10) where only a high premium F-i-T was given for small-scale HECHP systems, no subsidies for construction and operation of the system, but with fuel reduction policy for micro- and small-scale CHP units by the local NG Co, as a promotional policy.

In CY the support mechanism for CHP is based on the “de minimis” policy and is divided on two different supporting schemes; one for individuals and legal entities and the other for institutions of Public Sector that does **not** practise economic activity. The subsidy is 45% on the eligible budget under the restriction of maximum eligible expenses.

However, the drawing places biggest sum of sponsoring from the Cypriot government to the investor is max 85,425 €. Despite the efforts, the existing energy prices that applied in Cyprus, as long as the lack of NG in the energy system of the country, the ignorance of technical world and of the investors of the CHP technology and its advantages, have created the current situation, where the penetration of CHP in the energy system is almost inconsequential, despite the existing potential.

For BUL the types of incentives are given as: *Incentives relative to mandatory purchase of electric power generated by CHP plants*, where until 1.1.2010 the electricity generated by CHP plants is subject to mandatory purchase, even if not in conformity with the high-efficiency reference values. *Incentives relative to pricing of the electric power generated by CHP plants*, where the approach to support CHP provided by the Energy Law envisaged two types of incentives in two successive stages; the first stage, obligatory purchase at preferential prices of the electricity from HECHP generation, for 8 years, and the second stage, sets up a system for issuing and trading with green certificates. The preferential prices of the cogenerated electricity are based on "the plant-specific operating costs and a top-up allowance" with criteria as: prevailing nature of the basic thermal load ; type of the used fuel; CHP technology; capacity of the plant/installation. *Incentives relative to building of CHP plants*, where the law mandates that, upon declared heat demand, new installations with capacity over 5 MW and using natural gas as fuel shall be built after CHP generation. *Connection by priority*, where the transmission and the distribution companies are obligated to connect by priority all CHP plants with installed capacity below 10 MW.

In Romania, a support scheme based on green certificates (GC) was implemented for electricity produced from RES and CHP. The provisions of the Law no. 220/2008 that are applicable are related to: minimal and maximal values for trading green certificates, the fee that should be paid by electricity suppliers if they fail to fulfil their mandatory yearly quota of green certificates and the allocation of the amounts of money resulting from supplier's failures to comply with the mandatory yearly quota.

3. Comparison of IRR calculations with and without support mechanisms across region

The categorization of the paragraph 2 is having a vital effect in the IRR calculations for SE European CHP policies, as the models of larger plant are not applicable, mainly in GR and for CY.

Particularly for CY it is notable the absence of natural gas in the energy mixture, the lack of previous knowledge on CHP. It is significant that the CHP applications with biomass in agricultural sector, are the only ones operating in the island, with profit.

For GR there are two barriers, existing in all laws regarding CHP, one stating that support mechanisms, including F-i-T, are applicable only for CHP units up to 35 MW_e-an arbitrary number- and the other is that the today state policy for the hard coal stockpiles which are considered as state property and only PPC can use them. This policy is under revision, but still is unclear the regulatory and legal environment on this issue. These barriers are responsible for the high IRRs for large scale CHP plants.

For BUL and RO the larger plant calculations show that there is a need for improvement in the rate of return through government support mechanisms. In these countries, as well as in GR, there is no specific policy for the promotion of micro- and small-scale CHP units in housing sector and for trigeneration.

It is absolutely clear from the results of the above mentioned model that the promotion of CHP, particularly of micro-, small-scale and trigeneration in all SE European countries is heavily based on well designed support mechanisms (F-i-Ts, tax reduction, better spark spread, etc) and on their energy markets that they should be fully liberalized.

4. The effect of these support mechanisms across the region

It is essential to note that many gas-fuelled CHP plants, in GR, built even with “cross-subsides” – incentives for the total cost of the installation and feed-in-tariff for cogenerated electricity to the network – were out of operation, due to the high price of natural gas and the low electricity price, offered by PPC, until the introduction of a new method calculating the F-i-T, where the price of natural gas of the previous month played an important role. This can be seen as a major issue, especially for M-S with incomplete liberalized market.

Also Bulgaria is the only country in Europe, where heat-supplying companies sell heat not to a building but to each apartment. So, it is impossible to interrupt heat supply to a separate apartment, that it does not pay its bills. This has the consequence that the heat distribution plants have huge unpaid sums, huge losses that cannot overcome. This unique situation has an effect on CHP, as the heat-producing companies are unable to invest on CHP. In order to ensure the development of the CHP, it is necessary the price of heat to be competitive with the prices of alternative ways of heating. The investors’ interest to build cogenerating plants has to be fostered by the price of electricity that will ensure the return of the invested resources and the profit of the enterprises.

In conclusion, from the analysis of the existing situation in SE European M-S it can be seen that there is no growth for CHP, despite of the support mechanisms. This is mainly due to the fact that in the liberalization of the energy market in these M-S is incomplete, each M-S is facing inappropriate spark spread (gas to power price ratio), lengthy bureaucratic procedures for permits from qualified bodies, etc.

Region name	**South West Region**
Contact organisation	Italcogen / FAST
Contact name	Alessandro Fontana

1. Region comparison of IRR results

Effect of benefits on Internal rate of return (IRR)	50kWe Natural Gas	1MWe Natural Gas	1MWe Gas Oil	12MWe Hard Coal	66MWe Natural Gas
France	22.63%	50.96%	~	~	64.83%
Italy	9.68%	28.86%	43.45%	~	31.05%
Luxembourg	0.00%	0.00%	3.78%	~	0.00%
Malta	~	~	0.00%	~	~
Portugal	0.00%	0.00%	0.00%	0.00%	0.12%
Spain	7.12%	6.82%	15.06%	~	5.33%

2. Comparison of region characteristics

Analysis of fuel costs, plant installation costs and benefits, we can see that SW region invests in medium size plants. Plants up to 1 MW_e represent the highest percentage (84%) of installations.

Across the region the predominant fuel type for cogeneration is natural gas (92%) as its use is incentivised making it cheaper than gas oil.

Italy and Spain have invested more in cogeneration than other countries in the region as the effect of benefits on financials is more evident.

Portugal seems well disposed towards hard coal fired plants, the only scenario with a positive Internal Rate of Return (IRR).

In Luxembourg investment in 50 kW_e CHP plants is more favourable due to the low Installed Construction Costs in comparison with other SW region countries.

Malta did not give significant results because only one 1 MW_e gas oil CHP plant is under construction.

3. Comparison of IRR calculations with and without support mechanisms across region

France has an IRR of 65% for the 66 MWe plant. The application of the feed in tariff had a substantial impact on all three plants with an increase in IRR between 23% and 65% and corresponding reductions in payback periods. The investment return on CHP in France is very high: its IRR is double that of Italy.

Without benefits, the IRR for a 50 kW_e plant in Italy is about 10%, while for 1 MW_e plant it is about 29% when fired by natural gas and 0% if gas oil is used. A 66MW_e plant has an IRR of 23%. If the financial benefits for investment are considered the IRR values almost double.

Spain produces interesting results for smaller plants (50 KWe and 1 MWe). The relatively low capital cost combined with a high spark spread led to a 24% IRR for the 50kWe plant. The two 1MWe plants give very different results depending on the fuel: 31% with gas and -7% for a gas oil unit without state support. The reason for the difference is that the gas oil price is over twice the gas price while the capital cost of the gas oil unit is only marginally higher.

In contrast to other the other MS, the IRR for Luxembourg's 50kW$_e$ plant is high, with a positive IRR of 27%. This is due in part to the wide spark spread creating a high value for generated electricity. The high rate of return was more pronounced for the 1MW$_e$ gas and gas oil plants which yielded an IRR of 52% and 48% respectively. These high IRRs are accompanied by very short payback periods of just over 1 year. The 66 MW$_e$ plant also yields a high rate of return of 46% with a 1,3 year payback.

Except Portugal, none of the MS in the SW region invest in coal fired plants. Four of the five modelled examples returned a very low or negative IRRs, this is particularly pronounced for the 50kW$_e$ and 66 MW$_e$ plants. The 50kW$_e$ plant returns a low IRR because of the high capital costs which erode the value given by the net benefit in operating the plant. The high operational expenditure has impact on the low returns for the 1 MW$_e$ plant. The only plant returning a substantially positive IRR is the 12 MW$_e$ coal fired plant with a 2 year payback and 26% IRR.

No calculations were made for Malta due to a lack of suitable data.

4. The effect of these support mechanisms across the region

As discussed above cogeneration is in it's infancy in the SW region and current installations are predominantly found in the industrial sector with several medium to large size plants. The choice of plant and appropriate capacity depend on several factors such as full utilization, optimization of results and objectives of the involved subject.

The Effects of Benefits on Financials are important:

- France sees the largest improvement in IRR from the addition of support. Investments look attractive for theoretical plants powered by natural gas, where in all cases the IRRs increase significantly.
- Italy has similar results to France: its IRR doubles with benefits.
- Gas oil plants are not viable without benefits, due to the high cost and taxes for this fuel.
- In Spain CHP seems economically very attractive, unlike France and Italy where the benefits don't change the results significantly.
- For Italy the only significant change is for plants powered by gas oil: in this case the IRR with benefits increases by 15%.
- Portugal and Luxembourg have the same results with or without benefits.
- The data suggest that Italy and Spain are investing in medium size, natural gas plants (1-5MWe).

An important factor to be considered during project development is connection to the electricity grid, which has the potential to contribute significantly to the size of investment required.

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Austria**
Organisation providing data	CHPA and GE Jenbacher
Contact name providing data	Nicky Butterworth and Lukas Welser

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€40,352	€1,515,421	€1,195,428	€11,200,090	€51,891,840
Heat value from CHP with benefits	€21,696	€653,268	€444,015	€8,021,195	€29,445,471
Electricity value from CHP no benefits	€40,352	€1,195,428	€1,195,428	€11,200,090	€51,891,840
Heat value from CHP no benefits	€21,696	€653,268	€444,015	€8,021,195	€29,445,471
Fuel cost to CHP with benefits	€42,226	€1,318,502	€896,163	€8,835,909	€59,860,910
Fuel cost to CHP no benefits	€42,226	€1,318,502	€896,163	€8,835,909	€59,860,910
Annual running costs (non-fuel)	€3,750	€64,908	€64,908	€941,232	€2,563,200
Total cost for CHP with benefits	€45,976	€1,383,410	€961,071	€9,777,141	€62,424,110
Total cost for CHP no benefits	€45,976	€1,383,410	€961,071	€9,777,141	€62,424,110
Total value from CHP with benefits	€62,048	€2,168,689	€1,639,443	€19,221,284	€81,337,311
Total value from CHP no benefits	€62,048	€1,848,696	€1,639,443	€19,221,284	€81,337,311
Net benefit of CHP with benefits	€16,072	€785,279	€678,372	€9,444,143	€18,913,201
Net benefit of CHP no benefits	€16,072	€465,286	€678,372	€9,444,143	€18,913,201
Capital costs	€42,000	€1,515,421	€1,195,428	€30,000,000	€60,000,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**2.6**	**1.4**	**0.9**	**3.2**	**3.2**
Internal rate of return (IRR) without benefits	**23.80%**	**42.79%**	**66.82%**	**21.03%**	**20.26%**
Financials with benefits					
Simple payback with benefits (years)	**2.6**	**0.8**	**0.9**	**3.2**	**3.2**
Internal rate of return (IRR) with benefits	**23.80%**	**69.29%**	**66.82%**	**21.03%**	**20.26%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**-0.6**	**0.0**	**0.0**	**0.0**
Effect of benefits Internal rate of return (IRR)	**0.00%**	**26.5%**	**0%**	**0.00%**	**0.00%**

1. Overview of CHP support mechanisms and taxes

Austrian Federal Law on the Promotion of CHP (KWK-Gesetz), issued by National Council on the 8th August 2008, entered into force on the 9th August 2008 respectively 23rd February 2009

Fossil CHP is supported in Austria through a generation based Feed in Tariff (FiT) the 'übersicht-einspeisetarife'. The Feed in tariff applies to CHP of 2MW and below. There is no support for fossil CHP of over 2MW.

2. Description of the IRR calculations and effect of the support mechanisms

The principle driver of the relatively high IRRs and short payback times as modelled for all CHP plant is the substantial spark spread i.e. the large difference between the price of the input fuel and the cost of supplied electricity.

The support mechanism operating in Austria is a generation based tariff. The CHPA obtained data on the value of this tariff for 1MW gas engines and this is worth ca. €0.05 per kWh electricity generated. Under the modelled conditions the support mechanism substantially improved the IRR by 26.5%. The effect of the FiT is more profound due to the modelling assumptions that all generated electricity is used onsite.

3. Data sources and assumptions

Data for all scenarios sourced by CHPA principally using Eurostat and IEA data. These scenarios utilise the following sources and assumptions:

- Construction costs: UK Manufacturers' estimate and consultants' papers
- Maintenance: Estimate from CHPA
- Operating cost: Based on 1.5% of Capital Cost
- Natural gas wholesale and supply prices: Eurostat Gas domestic and industrial half-yearly prices New methodology from 2007 onwards: epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Natural gas oil wholesale and supply prices: IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil – industry
- Natural hard coal wholesale and supply prices: IEA 2007 Steam coal national currency
- Electricity prices and taxation: IEA 2007 national currency
- Fuel and electricity taxation: IEA
- Tax rate 25.0%: EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Flanders - Belgium**
Organisation providing data	COGEN Vlaanderen
Contact name providing data	Tine Stevens

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€27,040	€665,496		€7,859,712	€38,253,600
Heat value from CHP with benefits	€12,444	€289,399		€7,548,613	€15,866,667
Electricity value from CHP no benefits	€27,040	€665,496		€7,859,712	€38,253,600
Heat value from CHP no benefits	€12,444	€289,399		€7,548,613	€15,866,667
Fuel cost to CHP with benefits	€24,220	€584,098		€8,315,328	€32,256,000
Fuel cost to CHP no benefits	€24,220	€584,098		€8,315,328	€32,256,000
Annual running costs (non-fuel)	€4,120	€121,200		€745,920	€4,092,000
Total cost for CHP with benefits	€28,340	€705,298		€9,061,248	€36,348,000
Total cost for CHP no benefits	€28,340	€705,298		€9,061,248	€36,348,000
Total value from CHP with benefits	€47,164	€1,132,996		€20,378,259	€63,587,886
Total value from CHP no benefits	€39,484	€954,895		€15,408,325	€54,120,267
Net benefit of CHP with benefits	€18,824	€427,697		€11,317,011	€27,239,886
Net benefit of CHP no benefits	€11,144	€249,596		€6,347,077	€17,772,267
Capital costs	€99,000	€653,000		€12,768,000	€75,485,520
Effective capital costs	€82,576	€574,640		€12,001,920	€70,271,754
Financials without benefits					
Simple payback without benefits (years)	**8.9**	**2.6**		**2.0**	**4.2**
Internal rate of return (IRR) without benefits	**2.55%**	**13.91%**		**28.54%**	**12.32%**
Financials with benefits					
Simple payback with benefits (years)	**4.4**	**1.3**		**1.1**	**2.6**
Internal rate of return (IRR) with benefits	**12.91%**	**47.58%**		**51.17%**	**22.16%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-4.5**	**-1.3**		**-1.0**	**-1.7**
Effect of benefits Internal rate of return (IRR)	**10.35%**	**33.67%**		**22.63%**	**9.84%**

1. Overview of CHP support mechanisms and taxes

Support for CHP in Flanders is accrued through a number of different mechanisms. The capital costs of CHP are supported through an Ecological premium and tax reduction which significantly reduces the investment cost. The CHP white certificate can be traded for the duration of the plant life and is calculated based on the emissions saved. These two support mechanisms account for the majority of the support in Flanders.

For smaller scale CHP, there are payments made to reflect the reduction in grid losses from decentralised generation.

2. Description of the IRR calculations and effect of the support mechanisms

The support mechanisms available in Flanders improve the IRR and simple payback in all four modelled cases (the Gas Oil 1MWe plant would not be built in Flanders). The model indicates particularly high levels of support for the 1MW gas and 12MW coal with a 33.67% and 22.63% increase in IRR when support measures are accounted for. In Flanders it would be unusual for a 1MW gas plant to run with 6,000 run hours. If run with more usual load of 4,000 hours, this would reduce the effect of the support to a more realistic level.

The costs for developing CHP in Flanders indicate the need for such a high level of support.

3. Data sources and assumptions

The scenarios utilise the following sources and assumptions:

- Construction and maintenance costs: From Onrendabele Toppenberekening VITO (2009) several manufacturers
- Fuel and electricity wholesale and supply and boiler fuel price prices: Onrendabele toppenberekening VITO – electricity prices still under discussion
- Electricity generation charges: CREG approved tariffs and taxes
- Tax rate: 34.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Bulgaria**
Organisation providing data	HACHP, Greece
Contact name providing data	Costas Theofylaktos

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€15,142	€553,348	€448,594	€6,995,144	€45,977,501
Heat value from CHP with benefits	€33,746	€391,961	€907,882	€13,278,011	€28,393,400
Electricity value from CHP no benefits	€15,142	€448,594	€448,594	€5,786,713	€26,776,411
Heat value from CHP no benefits	€33,746	€391,961	€907,882	€13,278,011	€28,393,400
Fuel cost to CHP with benefits	€65,678	€791,101	€1,832,394	€14,626,662	€57,722,112
Fuel cost to CHP no benefits	€65,678	€791,101	€1,832,394	€14,626,662	€57,722,112
Annual running costs (non-fuel)	€1,400	€18,000	€61,620	€491,232	€1,663,200
Total cost for CHP with benefits	€67,078	€809,101	€1,894,014	€15,117,894	€59,385,312
Total cost for CHP no benefits	€67,078	€809,101	€1,894,014	€15,117,894	€59,385,312
Total value from CHP with benefits	€48,888	€945,308	€1,356,476	€20,273,155	€74,370,901
Total value from CHP no benefits	€48,888	€840,554	€1,356,476	€19,064,724	€55,169,811
Net benefit of CHP with benefits	-€18,190	€136,207	-€537,538	€5,155,261	€14,985,589
Net benefit of CHP no benefits	-€18,190	€31,453	-€537,538	€3,946,830	-€4,215,501
Capital costs	€135,000	€845,000	€630,000	€30,000,000	€60,000,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**-7.4**	**26.9**	**-1.2**	**7.6**	**-14.2**
Internal rate of return (IRR) without benefits	**0.00%**	**0.00%**	**0.00%**	**8.59%**	**0.00%**
Financials with benefits					
Simple payback with benefits (years)	**-7.4**	**6.2**	**-1.2**	**5.8**	**4.0**
Internal rate of return (IRR) with benefits	**0.00%**	**11.17%**	**0.00%**	**12.71%**	**18.70%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**-20.7**	**0.0**	**-1.8**	**-18.2**
Effect of benefits Internal rate of return (IRR)	**0.00%**	**11.17%**	**0.00%**	**4.12%**	**18.70%**

1. Overview of CHP support mechanisms and taxes

Energy Act of Bulgaria created in 2003 and amended in 2006.

2. Description of the IRR calculations and effect of the support mechanisms

With the exception of the 12MW coal plant, the modelled price of the input fuel was higher than the electricity supply price. In such circumstances, it is impossible for a CHP plant or indeed any electricity generating plant to operate profitably without some for of Government support. As a result, the 50kW gas and 1MW gas oil plant for which no support was available were modelled to operate at a negative rate of return and payback. In addition the 1MW gas and 66MW gas CHP plant were also modelled to be loss making in the face of no government support. Only the 12MW coal returned a positive rate of return without support.

The financial support, in the form of a feed in tariff (FiT) paid on all generated electricity has a marked effect on all plants where the support was available, increasing the IRR from between 4% and 19%. The 66MW gas CHP was the most affected with the simple payback moving from negative 14 years to positive four and an IRR of 19%. The investment case for the 12MW coal plant improved the least under the mechanism.

The result of the FiT was to create an investment case of between 11% and 19% for the different plant. This highlights the manner in which support is modulated across CHP types returning similar final IRRs despite very different initial investment scenarios where support was absent.

3. Data sources and assumptions

Data for all scenarios provided by Bulgarian contact. The scenarios utilise the following sources and assumptions:

- Construction costs: Provided by Bulgarian contact
- Maintenance: Provided by Bulgarian contact
- Fuel and electricity wholesale and supply prices: Pavel Sotirov, Bulgaria CHPA
- Boiler fuel price: Provided by Bulgarian contact
- Tax rate: 10.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Cyprus**
Organisation providing data	HACHP, Greece
Contact name providing data	Costas Theofylaktos

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits			€969,283		
Heat value from CHP with benefits			€1,033,119		
Electricity value from CHP no benefits			€969,283		
Heat value from CHP no benefits			€1,033,119		
Fuel cost to CHP with benefits			€2,085,161		
Fuel cost to CHP no benefits			€2,085,161		
Annual running costs (non-fuel)			€64,908		
Total cost for CHP with benefits			€2,150,069		
Total cost for CHP no benefits			€2,150,069		
Total value from CHP with benefits			€2,002,401		
Total value from CHP no benefits			€2,002,401		
Net benefit of CHP with benefits			-€147,667		
Net benefit of CHP no benefits			-€147,667		
Capital costs			€630,000		
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)			**-4.3**		
Internal rate of return (IRR) without benefits			**0%**		
Financials with benefits					
Simple payback with benefits (years)			**-4.3**		
Internal rate of return (IRR) with benefits			**0%**		
Effect of benefits on financials					
Effect of benefits on simple payback (years)			**0**		
Effect of benefits Internal rate of return (IRR)			**0%**		

1. Overview of CHP support mechanisms and taxes

Law on the Promotion of Cogeneration and Heat (2006).

2. Description of the IRR calculations and effect of the support mechanisms

In the absence of available fuel data it was only possible to model the 1MW gas oil CHP plant. No support is provided and the investment case does not support development of this size plant.

3. Data sources and assumptions

Data from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Manufacturers' estimate and consultants' papers
- Maintenance: Estimate from CHPA
- Operating cost: Based on 1.5% of Capital Cost
- Fuel and electricity wholesale prices: Gas oil - IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil - industry
- Tax rate: 10.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

Country name	Czech Republic
Organisation providing data	Jozef Stefan institute, COGEN Czech
Contact name providing data	Stane Merse, Vlado Murar

IRR calculations

Please note that unlike other countries, Czech Republic uses 2009 prices and regulations

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€32,739	€711,711	€711,711	€9,677,270	€33,404,818
Heat value from CHP with benefits	€11,922	€285,040	€419,229	€11,473,892	€20,252,213
Electricity value from CHP no benefits	€28,829	€595,865	€595,865	€9,500,427	€32,806,066
Heat value from CHP no benefits	€11,922	€285,040	€419,229	€11,473,892	€20,252,213
Fuel cost to CHP with benefits	€20,922	€520,147	€656,646	€12,007,283	€37,224,490
Fuel cost to CHP no benefits	€20,922	€520,147	€765,018	€12,007,283	€37,224,490
Annual running costs (non-fuel)	€4,797	€99,619	€98,079	€1,212,817	€3,181,200
Total cost for CHP with benefits	€25,719	€619,766	€754,724	€13,220,099	€40,405,690
Total cost for CHP no benefits	€25,719	€619,766	€863,097	€13,220,099	€40,405,690
Total value from CHP with benefits	€44,661	€996,751	€1,130,940	€21,151,163	€53,657,031
Total value from CHP no benefits	€40,750	€880,905	€1,015,094	€20,974,319	€53,058,279
Net benefit of CHP with benefits	€18,941	€376,985	€376,215	€7,931,063	€13,251,341
Net benefit of CHP no benefits	€15,031	€261,139	€151,997	€7,754,220	€12,652,589
Capital costs	€111,800	€1,232,400	€1,129,700	€28,456,368	€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**7.4**	**4.7**	**7.4**	**3.7**	**6.3**
Internal rate of return (IRR) without benefits	**5.71%**	**9.86%**	**-0.49%**	**18.08%**	**8.45%**
Financials with benefits					
Simple payback with benefits (years)	**-58.1**	**72.2**	**69.3**	**3.6**	**6.0**
Internal rate of return (IRR) with benefits	**0%**	**0%**	**0%**	**21.53%**	**9.20%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-65.6**	**67.5**	**61.9**	**-0.1**	**-0.3**
Effect of benefits Internal rate of return (IRR)	**0%**	**0%**	**0%**	**3.45%**	**0.75%**

1. Overview of CHP support mechanisms and taxes

Energy Act No, 458/2000 Coll.

Public notice No, 439/2005 Coll.

Decree on electricity market rules and other conditions No,541/2005 Coll.

Since 1st January 2006 a new support scheme has been introduced for CHP units, based on a feed-in premium on top of the market price of electricity for cogenerated electricity paid by network operators (distribution or transmission). The premiums are divided into three categories according to the installed electric capacity: up to 1MWe, 1MWe to 5MWe and above 5MWe. The premium is higher if producers sell electricity only in peak time. Producers can sell electricity to the market or use it themselves. The system of price regulation is controlled by the Energy Regulatory Office (not as state aid).

2. Description of the IRR calculations and effect of the support mechanisms

Even without support the modelled internal rate of return (IRRs) and payback periods for the CHP plants on natural gas were all positive ranging between 5,7% and 10%, higher for coal unit (18,1%) and negative for fuel oil unit.

A single feed in premium support mechanism (18,8 €/MWh for units up to 1MW and 1,8 €/MWh for larger units), is applied to all electricity generated. In most cases the support mechanism improved the IRR and reduced the simple payback period. 12MW unit IRR values are at a very attractive level of around 20%. The support premium has a positive effect on the IRRs for 1MW engines.

3. Data sources and assumptions

Please note that unlike other countries, Czech Republic uses 2009 prices and regulations. Data for all scenarios provided by Czech Republic contact and other statistical sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Common estimate for the region, based on Slovenian and Slovak data
- Maintenance: Common estimate for the region, based on Slovenian and Slovak data
- Operating cost: Common estimate for the region, based on Slovenian and Slovak data
- Fuel and electricity wholesale and supply prices: Eurostat 2009, IEA (Coal price - Slovakia)
- Fuel and electricity taxation: IEA
- Boiler fuel price: Eurostat 2009
- Electricity CHP Benefit: COGEN Czech
- Tax rate: 19,0%
  http://ec.europa.eu/taxation_customs/taxinv/getcontents.do?mode=normal&kw1=corporate%20income%20tax&kw2=-&kw3=-&year=2010&coll=CZ+-+Corporate+income+tax
- Writing Down Allowance: 13,0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Denmark**
Organisation providing data	Birger Lauersen
Contact name providing data	Dansk Fjernvarme

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000 hrs	6,000 hrs	6,000 hrs	8,400 hrs	8,400 hrs
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€25.00	€25.00
Electricity value from CHP with benefits	€52,173	€1,545,622			€76,595,999
Heat value from CHP with benefits	€47,213	€1,251,736			€20,969,038
Electricity value from CHP no benefits	€52,173	€1,545,622			€76,595,999
Heat value from CHP no benefits	€47,213	€1,251,736			€20,969,038
Fuel cost to CHP with benefits	€91,888	€2,526,400			€42,628,820
Fuel cost to CHP no benefits	€91,888	€2,526,400			€42,628,820
Annual running costs (non-fuel)	€3,750	€64,908			€2,563,200
Total cost for CHP with benefits	€95,638	€2,591,308			€45,192,020
Total cost for CHP no benefits	€95,638	€2,591,308			€45,192,020
Total value from CHP with benefits	€99,386	€2,797,358			€97,565,037
Total value from CHP no benefits	€99,386	€2,797,358			€97,565,037
Net benefit of CHP with benefits	€3,748	€206,050			€52,373,017
Net benefit of CHP no benefits	€3,748	€206,050			€52,373,017
Capital costs	€42,000	€630,000			€60,000,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**11.2 yrs**	**3.1 yrs**			**1.1 yrs**
Internal rate of return (IRR) without benefits	**0.00%**	**16.75%**			**53.44%**
Financials with benefits					
Simple payback with benefits (years)	**11.2 yrs**	**3.1 yrs**			**1.1 yrs**
Internal rate of return (IRR) with benefits	**0.00%**	**16.75%**			**53.44%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**0.0**			**0.0**
Effect of benefits Internal rate of return (IRR)	**0.00%**	**0.00%**			**0.00%**

1. Overview of CHP support mechanisms and taxes

Electricity Supply Act and Heat Supply Act.

2. Description of the IRR calculations and effect of the support mechanisms

New investments in fossil fuel CHP do not attract any production or capital subsidy in Denmark and, therefore, there are no support systems to be modelled in the analysis as carried out. Danish CHP operators install CHP based on the real unsupported investment case.

The analysis revealed that, using Eurostat and IEA energy price data, the 1MW gas, 1MW gas oil plant and 66MW gas plant all show positive IRRs ranging between 17% and 91%. The IRRs for the 66MW and 1MW gas oil CHP are so high as to be implausible. This is probably due to the very high electricity supply price compared to a comparatively low input fuel price. The model is limited by available data from Eurostat and IEA.

3. Data sources and assumptions

Majority of data from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: UK Manufacturers' estimate and consultants' papers
- Maintenance: Estimate from CHPA UK
- Operating cost: Based on 1.5% of Capital Cost
- Fuel wholesale prices and taxation: Gas - Eurostat Gas domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Fuel wholesale prices: Gas oil - IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil – industry
- Electricity wholesale prices and taxation: IEA 2007 national currency
- Electricity supply prices: Eurostat Electicity domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Tax rate: 25.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

Country name	Estonia
Organisation providing data	Jozef Stefan Institute, Slovenia
Contact name providing data	Stane Merše

IRR calculations
Please note that unlike other countries, Estonia uses 2009 prices and regulations

Notional electrical capacity	50kWe	1MWe	1MWe	12MWe	66MWe
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€19,716	€509,536	€509,536		€18,760,896
Heat value from CHP with benefits	€9,404	€240,799	€414,346		€19,185,973
Electricity value from CHP no benefits	€12,938	€308,716	€308,716		€18,760,896
Heat value from CHP no benefits	€9,404	€240,799	€414,346		€19,185,973
Fuel cost to CHP with benefits	€16,504	€439,415	€756,109		€35,264,692
Fuel cost to CHP no benefits	€16,504	€439,415	€756,109		€35,264,692
Annual running costs (non-fuel)	€4,797	€99,619	€98,079		€3,181,200
Total cost for CHP with benefits	€21,301	€539,034	€854,188		€38,445,892
Total cost for CHP no benefits	€21,301	€539,034	€854,188		€38,445,892
Total value from CHP with benefits	€29,120	€750,334	€923,882		€37,946,869
Total value from CHP no benefits	€22,342	€549,515	€723,063		€37,946,869
Net benefit of CHP with benefits	€7,819	€211,301	€69,695		-€499,023
Net benefit of CHP no benefits	€1,040	€10,481	-€131,125		-€499,023
Capital costs	€111,800	€1,232,400	€1,129,700		€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**107,5**	**117,6**	**-8,6**		**-158,7**
Internal rate of return (IRR) without benefits	**0%**	**0%**	**0%**		**0%**
Financials with benefits					
Simple payback with benefits (years)	**14.3**	**5.8**	**16.2**		**-158.7**
Internal rate of return (IRR) with benefits	**0%**	**12.97%**	**0%**		**0%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-93.2**	**-111.8**	**24.8**		**0**
Effect of benefits Internal rate of return (IRR)	**0%**	**0%**	**0%**		**0%**

1. Overview of CHP support mechanisms and taxes

Amendments to the Electricity Market Act (1 May 2007).

New support scheme implemented in 2007 with feed-in tariffs for CHP using renewable energy sources and other units of efficient cogeneration replacing boiler houses with capacity up to 10MWe. Two options are available:

1. **Purchase obligation with feed-in tariff:** around 73 €/MWh for fossil fuels and 52 €/MWh for renewable energy (approved by the Energy Market Inspectorate)
2. **Subsidized tariff (premium):** around 32 €/MWh for fossil fuels and 53 €/MWh for renewable energy (approved by the Energy Market Inspectorate)

2. Description of the IRR calculations and effect of the support mechanisms

As Estonia is in the early stages of opening an electricity market, the wholesale prices are very low (30,4 €/MWh in the closed part of the market in 2009) and the end use prices are the lowest in the region (Eurostat 2009). This is the main reason that cogeneration projects without additional support are not economically feasible at all.

With the support for fossil CHP units up to 10MWe (32 €/MWh) only 1MWe gas engine has positive internal rate of return (IRR) 13% and attractive simple payback period close to six years.

More than 70% higher fuel oil price than natural gas is the main reason that the gas oil engine is not economically viable even with support (the simple payback time is more than 16 years).

As the theoretical combined cycle unit is not eligible for the support (it exceeds the 10MW threshold) in spite of competitive natural price (the lowest in the region) low electricity prices are the main reason that such investment is economically feasible.

New coal cogeneration are not foreseen as Estonia is focussing on cogeneration with biofuels, waste and gaseous fuel[1] with target 20% of electricity generated in cogeneration in gross electricity consumption till 2020.

3. Data sources and assumptions

Please note that unlike other countries, Estonia uses 2009 prices and regulations. Data for all scenarios sourced from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Common estimate for the region, based on Slovak and Slovenian data,
- Maintenance: Common estimate for the region, based on Slovak and Slovenian data,
- Operating cost: Common estimate for the region, based on Slovak and Slovenian data,
- Fuel and electricity wholesale and supply prices: Eurostat 2009, wholesale electricity price - Eesti Energia - yearly report 2009 (price on closed electricity market)
- Boiler fuel price: Eurostat 2009
- Electricity CHP Benefit : National Control Commission for Prices and Energy (Regulator)
- Tax rate: 21% http://ec.europa.eu/taxation_customs/taxinv/getcontents.do?mode=normal&kw1=corporate%20income%20tax&kw2=-&kw3=-&year=2010&coll=EE+-+Corporate+income+tax

[1] Development Plan of the Estonian Electricity Sector until 2018, Ministry of Economic Affairs and Communications

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Finland**
Organisation providing data	Energiateollisuus ry
Contact name providing data	Lauri Muranen

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€23,899	€708,014	€708,014	€11,288,511	€45,438,624
Heat value from CHP with benefits	€14,258	€326,163	€473,399	€12,564,699	€21,086,800
Electricity value from CHP no benefits	€23,899	€708,014	€708,014	€11,288,511	€45,438,624
Heat value from CHP no benefits	€14,258	€326,163	€473,399	€12,564,699	€21,086,800
Fuel cost to CHP with benefits	€27,749	€658,300	€955,468	€13,840,898	€42,868,224
Fuel cost to CHP no benefits	€27,749	€658,300	€955,468	€13,840,898	€42,868,224
Annual running costs (non-fuel)	€3,750	€64,908	€64,908	€941,232	€2,563,200
Total cost for CHP with benefits	€31,499	€723,208	€1,020,376	€14,782,130	€45,431,424
Total cost for CHP no benefits	€31,499	€723,208	€1,020,376	€14,782,130	€45,431,424
Total value from CHP with benefits	€38,157	€1,034,176	€1,181,412	€23,853,210	€66,525,424
Total value from CHP no benefits	€38,157	€1,034,176	€1,181,412	€23,853,210	€66,525,424
Net benefit of CHP with benefits	€6,658	€310,969	€161,036	€9,071,080	€21,094,000
Net benefit of CHP no benefits	€6,658	€310,969	€161,036	€9,071,080	€21,094,000
Capital costs	€42,000	€630,000		€30,000,000	€60,000,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**6.3**	**2.0**	**3.9**	**3.3**	**2.8**
Internal rate of return (IRR) without benefits	**2.60%**	**27.89%**	**11.26%**	**19.98%**	**22.57%**
Financials with benefits					
Simple payback with benefits (years)	**6.3**	**2.0**	**3.9**	**3.3**	**2.8**
Internal rate of return (IRR) with benefits	**2.60%**	**27.89%**	**11.26%**	**19.98%**	**22.57%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Effect of benefits Internal rate of return (IRR)	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

1. Overview of CHP support mechanisms and taxes

Law on the excise taxation of specific fuels 30.12.1996/1260.
Investment support for biomass based CHP-plants.

2. Description of the IRR calculations and effect of the support mechanisms

The modelling of the 50kW natural gas plant yielded a very low Internal Rate of Return (IRR) of 3% caused by a relatively narrow spark spread. The remaining four plant modelled, however, yielded higher IRRs of between 11% (1MW Gas oil) and 22% (66MWe).

The CHPA obtained no evidence of Finnish Government support for fossil fuelled CHP.

Data sources and assumptions

Data for all scenarios sourced from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: UK Manufacturers' estimate and consultants' papers
- Maintenance: Estimate from CHPA UK
- Operating cost: Based on 1.5% of Capital Cost
- Fuel wholesale prices and taxation: Gas - Eurostat Gas domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Fuel wholesale prices: Gas oil - IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil – industry
- Fuel wholesale prices and taxation: Hard coal - IEA 2007 Steam coal national currency (Euros) per tonne.
- Electricity wholesale prices and taxation: IEA 2007 national currency
- Electricity supply prices: Eurostat Electicity domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Tax rate: 26.0% (Community tax) EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**France**
Organisation providing data	ATEE - Club Cogénération
Contact name providing data	Patrick Canal

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€44,304	€1,078,350			€97,810,099
Heat value from CHP with benefits	€17,778	€263,947			€19,833,333
Electricity value from CHP no benefits	€25,584	€369,720			€31,046,400
Heat value from CHP no benefits	€17,778	€263,947			€19,833,333
Fuel cost to CHP with benefits	€34,600	€532,728			€40,320,000
Fuel cost to CHP no benefits	€34,600	€532,728			€40,320,000
Annual running costs (non-fuel)	€1,875	€18,750			€795,287
Total cost for CHP with benefits	€36,475	€551,478			€41,115,287
Total cost for CHP no benefits	€36,475	€551,478			€41,115,287
Total value from CHP with benefits	€62,082	€1,342,297			€117,643,433
Total value from CHP no benefits	€43,362	€633,667			€50,879,733
Net benefit of CHP with benefits	€25,607	€790,819			€76,528,146
Net benefit of CHP no benefits	€6,887	€82,189			€9,764,446
Capital costs	€70,000	€960,000			€52,800,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**10.2**	**11.7**			**5.4**
Internal rate of return (IRR) without benefits	**2.67%**	**1.93%**			**11.58%**
Financials with benefits					
Simple payback with benefits (years)	**2.7**	**1.2**			**0.7**
Internal rate of return (IRR) with benefits	**25.30%**	**52.90%**			**76.41%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-7.4**	**-10.5**			**-4.7**
Effect of benefits Internal rate of return (IRR)	**22.63%**	**50.96%**			**64.83%**

1. Overview of CHP support mechanisms and taxes

Consolidated Cogeneration law : Arrêté du 31 juillet 2001 consolidé au 23 août 2005. A two part feed in tariff one part paid on total electricity generation and a second tranche paid on electricity exported to the grid only. No capital grant or tax based supports available.

2. Description of the IRR calculations and effect of the support mechanisms

The work for France modelled only the gas fired plant as the gas oil and coal fired plant would not be built in this member state. Without any state support, the model indicated that small scale generation would return between 1%-3% Internal Rate of Return (IRR) whilst the large 66MW plant would return 12%. The low returns for the smaller scale CHP are due to a relatively low spark spread leading to low net benefits for CHP plants compared to boiler operation and purchase of grid electricity.

The application of the feed in tariff had a substantial impact on all three plant modelled, with an increase in IRR between 23% and 65% and corresponding falls in payback periods. The highest IRR, for the 66MW plant, is surprisingly large and in reality this level of reward may not be seen although this would require further analysis.

3. Data sources and assumptions

Data for all scenarios provided by French contact.

- Construction costs: Provided by French contact
- Operating cost: Provided by French contact
- Electricity wholesale prices: Provided by French contact
- Electricity generation benefit: Provided by French contact
- Tax rate: 33.0%
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Germany**
Organisation providing data	Bundesverband Kraft-Wärme-Kopplung (B.KWK)
Contact name providing data	Wulf Binde

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€49,908	€1,309,212	€1,309,212		€71,631,042
Heat value from CHP with benefits	€17,778	€377,067	€377,067		€19,833,333
Electricity value from CHP no benefits	€39,520	€1,170,780	€1,170,780		€67,636,800
Heat value from CHP no benefits	€17,778	€377,067	€377,067		€19,833,333
Fuel cost to CHP with benefits	€34,600	€761,040	€761,040		€40,320,000
Fuel cost to CHP no benefits	€34,600	€761,040	€761,040		€40,320,000
Annual running costs (non-fuel)	€4,160	€61,620	€61,620		€3,960,000
Total cost for CHP with benefits	€38,760	€822,660	€822,660		€44,280,000
Total cost for CHP no benefits	€38,760	€822,660	€822,660		€44,280,000
Total value from CHP with benefits	€67,686	€1,686,279	€1,686,279		€91,464,375
Total value from CHP no benefits	€57,298	€1,547,847	€1,547,847		€87,470,133
Net benefit of CHP with benefits	€28,926	€863,619	€863,619		€47,184,375
Net benefit of CHP no benefits	€18,538	€725,187	€725,187		€43,190,133
Capital costs	€62,500	€513,500	€513,500		€74,250,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**3.4**	**0.7**	**0.7**		**1.7**
Internal rate of return (IRR) without benefits	**17.43%**	**79.20%**	**71.34%**		**34.26%**
Financials with benefits					
Simple payback with benefits (years)	**2.2**	**0.6**	**0.6**		**1.6**
Internal rate of return (IRR) with benefits	**29.77%**	**98.49%**	**82.77%**		**37.19%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-1.2**	**-0.1**	**-0.1**		**-0.1**
Effect of benefits Internal rate of return (IRR)	**12.34%**	**19.29%**	**11.43%**		**2.93%**

1. Overview of CHP support mechanisms and taxes

CHP Law (unofficial consolidated version on the basis of the Federal Law Gazette published on 25.10.2008)

CHP Law – changes from 21.08.2009. The (in the text marked in red) changes mainly concern the clarification that belong to the eligible consumers leaving the heat network

Law to accelerate the development of high voltage electricity networks

Erneuerbare-Energien-Gesetz (EEG)

Erneuerbare-Energien-Wärmegesetz (EEWärmeG)

Energiesteuergesetz

Stromsteuergesetz

The main for of support for CHP in Germany is a stepped feed in tariff in which the first kWh generated in a given year are rewarded at a higher level than subsequent generation. The result of such a mechanism is that fixed costs can be accounted for during the initial run time and therefore the investment presents less of a risk for developers. The model used here is unable to reflect the value of this feed in tariff design as it must smooth value over total annual generation.

2. Description of the IRR calculations and effect of the support mechanisms

The very high reported electricity supply price relative to the gas supply price combined with a low cost of plant development (particularly the 1MW units) lead to exceedingly high IRRs for all but the smallest of CHP plant modelled. The 50kW engine was modelled to have a return of 17%. Such high returns are unlikely to be the seen in practise and there is a clear limitation in the data or model design here presented.

Despite the model limitations, the addition of feed in tariff payments in the model led to a significant reduction in the payback rate and increase in the IRRs for small scale CHP. This effect may be exacerbated by the high levels of return generated when modelled without support. For the 66MW the support mechanism modelled a limited increase in IRR and payback of 3% and -0.1 years respectively.

3. Data sources and assumptions

Data for all scenarios provided by German contact. The scenarios utilise the following sources and assumptions:

- Construction costs: Provided by German contact
- Maintenance:
- Fuel wholesale transmission price: VEA Netznutzungsentgeltvergleich I/2010
- Fuel wholesale prices: Gas oil - IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil – industry
- Electricity wholesale prices: VEA Strompreisvergleich I/2010
- Electricity transmission and distribution prices: VEA Netznutzungsentgeltvergleich I/2010
- Electricity Generation Distribution Benefit: Embedded benefit
- Tax rate: 31.7%
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Greece**
Organisation providing data	HACHP, Greece
Contact name providing data	Costas Theofylaktos

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€20,467	€606,341	€606,341		
Heat value from CHP with benefits	€10,773	€304,481	€466,724		
Electricity value from CHP no benefits	€20,467	€606,341	€606,341		
Heat value from CHP no benefits	€10,773	€304,481	€466,724		
Fuel cost to CHP with benefits	€20,968	€614,540	€941,996		
Fuel cost to CHP no benefits	€20,968	€614,540	€941,996		
Annual running costs (non-fuel)	€1,607	€73,944	€73,944		
Total cost for CHP with benefits	€22,574	€688,484	€1,015,940		
Total cost for CHP no benefits	€22,574	€688,484	€1,015,940		
Total value from CHP with benefits	€31,241	€910,822	€1,073,064		
Total value from CHP no benefits	€31,241	€910,822	€1,073,064		
Net benefit of CHP with benefits	€8,666	€222,338	€57,124		
Net benefit of CHP no benefits	€8,666	€222,338	€57,124		
Capital costs	€152,000	€630,000	€630,000		
Effective capital costs	€98,800	€409,500	€409,500		
Financials without benefits					
Simple payback without benefits (years)	**17.5**	**2.8**	**11.0**		
Internal rate of return (IRR) without benefits	**0.00%**	**17.60%**	**0.00%**		
Financials with benefits					
Simple payback with benefits (years)	**11.4**	**1.8**	**7.2**		
Internal rate of return (IRR) with benefits	**2.92%**	**26.33%**	**0.00%**		
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-6.1**	**-1.0**	**-3.9**		
Effect of benefits Internal rate of return (IRR)	**2.92%**	**8.73%**	**0.00%**		

1. Overview of CHP support mechanisms and taxes

Law on Generation of Electricity using RES and High-Efficiency CHP and Miscellaneous Provisions (2006)

Law on Promotion of CHP and other Provisions (2009)

Ministerial Decree on Methodology for calculating the co-generated electricity from high efficiency CHP (2009)

Law on Acceleration of the development of RES for handling climate change and other provisions (2010)

2. Description of the IRR calculations and effect of the support mechanisms

Without Government support small scale CHP modelled for Greece the IRRs are zero for the 50kW and 1MW gas oil plant. The 1MW gas plant modelled a return of 17.6% and a payback of 2.8 years and this is due to the lower cost of plant compared to the 50kW gas.

Whilst the CHPA believes that a feed in tariff exists in Greece, we were unable to source reliable quantitative data for the modelling so that has been omitted. The only support modelled, therefore, was a reduction in capital costs for installing plant. For the 50kW plant, the support reduced the payback period by six years but the initial financials were too constrained to provide an IRR above 3%. The 1MW gas oil plant also suffered from initial financials and support did not raise the investment case to a positive IRR. The1MW gas plant, however, modelled a reduction in payback of one year and an IRR of 26.33%.

3. Data sources and assumptions

Data for all scenarios sourced from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Provided by Greek contact
- Maintenance: Provided by Greek contact
- Operating cost: Provided by Greek contact
- Fuel wholesale prices: Gas - Eurostat Gas domestic half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Fuel wholesale prices and taxation: Gas oil - IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil – industry
- Electricity supply prices: Eurostat Electicity domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Tax rate: 25.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Hungary**
Organisation providing data	Jozef Stefan Institute, Slovenia
Contact name providing data	Stane Merše

IRR calculations

Please note that unlike other countries, Hungary uses 2009 prices and regulations

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€19,165	€567,751	€567,751	€9,052,172	€34,287,510
Heat value from CHP with benefits	€15,568	€293,897	€437,770	€11,473,892	€20,809,768
Electricity value from CHP no benefits	€16,640	€369,720	€369,720	€5,649,168	€28,828,800
Heat value from CHP no benefits	€15,568	€293,897	€437,770	€11,473,892	€20,809,768
Fuel cost to CHP with benefits	€27,321	€536,310	€798,854	€12,007,283	€38,249,301
Fuel cost to CHP no benefits	€27,321	€536,310	€798,854	€12,007,283	€38,249,301
Annual running costs (non-fuel)	€4,797	€99,619	€98,079	€1,212,817	€3,181,200
Total cost for CHP with benefits	€32,118	€635,929	€896,932	€13,220,099	€41,430,501
Total cost for CHP no benefits	€32,118	€635,929	€896,932	€13,220,099	€41,430,501
Total value from CHP with benefits	€34,732	€861,648	€1,005,521	€20,526,064	€55,097,278
Total value from CHP no benefits	€32,208	€663,617	€807,490	€17,123,060	€49,638,568
Net benefit of CHP with benefits	€2,614	€225,719	€108,589	€7,305,965	€13,666,777
Net benefit of CHP no benefits	€90	€27,688	-€89,442	€3,902,961	€8,208,067
Capital costs	€111,800	€1,232,400	€1,129,700	€28,456,368	€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**1.248,7**	**44,5**	**-12,6**	**7,3**	**9,6**
Internal rate of return (IRR) without benefits	**0%**	**0%**	**0%**	**5,70%**	**1,86%**
Financials with benefits					
Simple payback with benefits (years)	**42,8**	**5,5**	**10,4**	**3,9**	**5,8**
Internal rate of return (IRR) with benefits	**0%**	**6,72%**	**0%**	**16,61%**	**9,58%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-1.205,9**	**-39,1**	**23,0**	**-3,4**	**-3,9**
Effect of benefits Internal rate of return (IRR)	**0%**	**6,72%**	**0%**	**10,91%**	**7,72%**

1. Overview of CHP support mechanisms and taxes

GoO: Hungarian Energy Office (Magyar Energia Hivatal)

CHP Support (Feed- in obligation): Hungarian Energy Office

Fixed purchase prices for sold electricity to the network. Prices vary by unit size and hours of selling electricity (peak, valley, deep valley). The future of support scheme is still uncertain (after the year 2010).

Investment subsidies are potentially provided by KIOP (mainly for renewable projects).

2. Description of the IRR calculations and effect of the support mechanisms

The CHPA is aware that a feed in tariff (FiT) operates in Hungary although we understand that it is fixed purchase price based set by Hungarian Energy Office (the average level of cogeneration support as difference between the wholesale price and fixed purchase price in year 2009 was 44 €/MWh) and therefore, sites where CHP electricity is consumed do not derive any benefit from the FiT if electricity is not exported. In the analysis with the support we assumed that all electricity is sold to the grid at the fixed purchase price calculated from the published structured FIT (peak, valley, deep valley) for the year 2009.

Without FIT support the smaller engine unite are not economical viable, the IRR of combined cycle unit has minimal value (1,9%) and only coal CHP units results in IRR close to 6%.

With the FIT support the economic benefits are improved for all units again with the highest IRR for coal unit (16,6%) followed by combined cycle unit with IRR 9,6%.The economics of 1MW gas engine is still attractive with IRR 6,7% and simple payback 5,5 year which could be marginal for some investors.

Higher cost of fuel oil is main reason for bad economic results for fuel oil engine with simple payback time more than 10 years. High capital costs of the 50kW unit compared to electrical and heat output lead to a negative IRR of the smallest unit.

Potential investment support (in range from 130 – 290 €/kWel) would have significant positive influence on IRR of the units.

3. Data sources and assumptions

Please note that unlike other countries, Hungary uses 2009 prices and regulations. Data for all scenarios provided by Energia Központ Nonprofit Kft and different sources from Hungary and other statistical sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Common estimate for the region, based on Slovak and Slovenian data
- Maintenance: Common estimate for the region, based on Slovak and Slovenian data
- Operating cost: Common estimate for the region, based on Slovak and Slovenian data
- Fuel and electricity wholesale and supply prices: Eurostat 2009 (coal price for Slovakia), wholesale electricity price from Energy regulator report for 2009 (EEX+10€/MWh),
- Fuel and electricity taxation: IEA 2009
- Boiler fuel price: Eurostat 2009
- Electricity CHP Benefit : Hungarian Energy Office
- Tax rate: 20,6% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13,0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Ireland**
Organisation providing data	Irish CHP Association (ICHPA)
Contact name providing data	Conor Gouldsbury

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€31,158	€728,965	€728,965		
Heat value from CHP with benefits	€14,247	€303,256	€829,547		
Electricity value from CHP no benefits	€31,158	€728,965	€728,965		
Heat value from CHP no benefits	€14,247	€303,256	€829,547		
Fuel cost to CHP with benefits	€27,728	€612,066	€1,674,288		
Fuel cost to CHP no benefits	€27,728	€612,066	€1,674,288		
Annual running costs (non-fuel)	€27,000	€120,000	€120,000		
Total cost for CHP with benefits	€54,728	€732,066	€1,794,288		
Total cost for CHP no benefits	€54,728	€732,066	€1,794,288		
Total value from CHP with benefits	€45,406	€1,032,220	€1,558,511		
Total value from CHP no benefits	€45,406	€1,032,220	€1,558,511		
Net benefit of CHP with benefits	-€9,323	€300,154	-€235,777		
Net benefit of CHP no benefits	-€9,323	€300,154	-€235,777		
Capital costs	€215,000	€1,350,000	€1,350,000		
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**-23.1**	**4.5**	**-5.7**		
Internal rate of return (IRR) without benefits	**0.00%**	**10.63%**	**0.00%**		
Financials with benefits					
Simple payback with benefits (years)	**-23.1**	**4.5**	**-5.7**		
Internal rate of return (IRR) with benefits	**0.00%**	**10.63%**	**0.00%**		
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**0.0**	**0.0**		
Effect of benefits Internal rate of return (IRR)	**0.00%**	**0.00%**	**0.00%**		

1. Overview of CHP support mechanisms and taxes

Energy (Miscellaneous Provisions) Act 2006

Electricity Regulation Act 1999

Energy (Miscellaneous Provisions) Act 2006 (Commencement of Section 6) Order 2009

Electricity Regulation Act 1999 (Appointment of Person to Calculate Power to Heat Ratios of Combined Heat and Power Units) Order 2009

2. Description of the IRR calculations and effect of the support mechanisms

There are no supports mechanisms for new CHP plant modelled and, therefore, returns calculated are based on the unsupported financial case.

For the 50kW plant the very high cost of development (€215,000) led to a negative net benefit and therefore negative Internal Rate of Return (IRR). For the 1MW gas oil plant, the high cost of gas oil created a narrow spark spread and also led to a negative net benefit compared to separate purchase of electricity and heat from an onsite boiler (90% efficiency).

A strong spark spread for the 1MW gas plant overcame high investment costs to yield a positive IRR of 10% and a 4.5 year payback.

3. Data sources and assumptions

Data for all scenarios provided by Irish contact. The scenarios utilise the following sources and assumptions:

- Construction costs: Provided by Irish contact
- Operating cost: Provided by Irish contact
- Tax rate: 12.5% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Italy**
Organisation providing data	Anima, Italy
Contact name providing data	Alessandro Fontana

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€47,727	€1,158,371	€1,158,371		€77,098,499
Heat value from CHP with benefits	€16,399	€344,534	€948,568		€22,751,293
Electricity value from CHP no benefits	€37,737	€919,370	€919,370		€47,219,046
Heat value from CHP no benefits	€16,399	€344,534	€948,568		€22,751,293
Fuel cost to CHP with benefits	€31,295	€676,733	€1,307,999		€44,528,763
Fuel cost to CHP no benefits	€31,916	€695,378	€1,914,510		€46,252,040
Annual running costs (non-fuel)	€4,576	€123,240	€166,374		€2,605,680
Total cost for CHP with benefits	€35,871	€799,973	€1,474,373		€47,134,443
Total cost for CHP no benefits	€36,492	€818,618	€2,080,884		€48,857,720
Total value from CHP with benefits	€64,125	€1,502,905	€2,106,939		€99,849,791
Total value from CHP no benefits	€54,136	€1,263,904	€1,867,938		€69,970,339
Net benefit of CHP with benefits	€28,255	€702,932	€632,565		€52,715,349
Net benefit of CHP no benefits	€17,644	€445,286	-€212,946		€21,112,619
Capital costs	€95,000	€820,000	€700,000		€57,750,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**5.4**	**1.8**	**-3.3**		**2.7**
Internal rate of return (IRR) without benefits	**10.05%**	**29.08%**	**0.00%**		**23.03%**
Financials with benefits					
Simple payback with benefits (years)	**3.4**	**1.2**	**1.1**		**1.1**
Internal rate of return (IRR) with benefits	**19.73%**	**57.94%**	**43.45%**		**54.08%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-2.0**	**-0.7**	**4.4**		**-1.6**
Effect of benefits Internal rate of return (IRR)	**9.68%**	**28.86%**	**43.45%**		**31.05%**

1. Overview of CHP support mechanisms and taxes

Decreto Legislativo 8 febbraio 2007, n.20

In Italy CHP plant are granted a feed in tariff as well as a reduction in the tax paid in gas input fuels and, at the smallest scale (50kW) a payment to account for the benefit of decentralised generation to the grid.

2. Description of the IRR calculations and effect of the support mechanisms

For the 50kW plant the modelled spark spread was sufficient to deliver a positive IRR of 10% without Government support. The addition of the support through a reduction in the tax on input fuel and the feed in tariff as well as the 'embedded benefit payment' for decentralised generators led to an increase in the IRR of 10% to 20% and a two year reduction in simple payback.

For the 1MW gas the feed in tariff combined with the, less substantial, input fuel support improved an already positive IRR (30%) to 58%. It may be that the model, which assumed all generated electricity was used onsite, yields an exaggerated initial IRR and resultant increase. In many circumstances such a CHP plant may export power to the grid and this would attract a lower total value.

The 1MW gas oil suffered from a very poor spark spread due to the high price of input fuel. The substantial reduction in input fuel costs and the feed in tariff had a very pronounced effect on the IRR leading to a modelled result of 43%.

The 66MW CHP plant yielded positive result for both the supported and non-supported CHP plants. State support increased the IRR by over 30%.

3. Data sources and assumptions

Data for all scenarios provided by Italian contact. The scenarios utilise the following sources and assumptions:

- Construction costs: Provided by Italian contact
- Maintenance: Provided by Italian contact
- Operating cost: Based on 1.5% of Capital Cost
- Fuel metering, distribution process and taxation: http://www.autorita.energia.it/it/dati/gp30_08.htm
- Electricity Generation Transmission Benefit value: From Italian D.Lgs 56/2010 and L. 99/2009
- Tax rate: 27.5% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

Country name	Latvia
Organisation providing data	Jozef Stefan Institute, Slovenia
Contact name providing data	Stane Merše

IRR calculations

Please note that unlike other countries, Latvia uses 2009 prices and regulations

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€20,114	€514,527	€514,527		€30,259,152
Heat value from CHP with benefits	€12,081	€289,825	€414,083		€20,205,883
Electricity value from CHP no benefits	€20,114	€514,527	€514,527		€28,762,272
Heat value from CHP no benefits	€12,081	€289,825	€414,083		€20,205,883
Fuel cost to CHP with benefits	€21,203	€528,879	€755,628		€37,139,332
Fuel cost to CHP no benefits	€21,203	€528,879	€755,628		€37,139,332
Annual running costs (non-fuel)	€4,797	€99,619	€98,079		€3,181,200
Total cost for CHP with benefits	€26,000	€628,498	€853,706		€40,320,532
Total cost for CHP no benefits	€26,000	€628,498	€853,706		€40.320.532
Total value from CHP with benefits	€32,195	€804,352	€928,610		€51.101.209
Total value from CHP no benefits	€32,195	€804,352	€928,610		€48,968,155
Net benefit of CHP with benefits	€6,195	€175,854	€74,903		€10.780.676
Net benefit of CHP no benefits	€6,195	€175,854	€74,903		€8.647.622
Capital costs	€111,800	€1,324,830	€1,222,130		€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**18,0**	**7,5**	**16,3**		**9,2**
Internal rate of return (IRR) without benefits	**0%**	**1.13%**	**0%**		**2.77%**
Financials with benefits					
Simple payback with benefits (years)	**18,0**	**7,5**	**16,3**		**7,3**
Internal rate of return (IRR) with benefits	**0%**	**1.13%**	**0%**		**6.14%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0**	**0**	**0**		**-1.8**
Effect of benefits Internal rate of return (IRR)	**0%**	**0%**	**0%**		**3.38 %**

1. Overview of CHP support mechanisms and taxes

Law on Electricity Market (2005), adopted on 5 May 2005.

Regulation No. 221 of Cabinet of Ministers on Electricity Production and the Price Regulation in Cogeneration, adopted on 10 March 2009.

The Latvian feed in tariff is paid on all electricity generation and applies to all fossil CHP. Purchase price differs depending on the installed electric capacity and fuel used (for natural gas calculated according to a fixed price formula as natural gas price multiplied by factor, individually calculated).

Investment support for renewable CHP units is available from EU structural founds.

2. Description of the IRR calculations and effect of the support mechanisms

As Latvian support is a fixed purchase obligation (a trader shall purchase from a cogeneration unit only the surplus of electricity produced in cogeneration) and the latest level of the support was not available the level of the support in year 2007 was used (between 38 €/MWh an 44 €/MWh) which is lower than final electricity supply prices, the use of support mechanism for analysed investment cases is appropriate only for the largest unit for 60% sell of generated electricity (for other cases end user electricity prices were used in calculation).

The investment case for the 50kW CHP plant with and without support is too poor to yield a positive IRR with the simple payback time 18 years. This is principally due to a relatively high cost of plant and a very weak spark spread.

The 1MW gas plant yielded a minimum positive IRR (1,13%) without support with marginal simple payback time 7,5 years. Higher fuel oil price results in even worse economic results for fuel oil engine.

The support of the feed in tariff effects only the combined cycle 66MW plant with minimal 2,8% IRR (simple payback 9,2 years) is improved to IRR 6,1% (simple payback 7,3 years). The main reason for low profitability of this investment is again low level of wholesale electricity prices in Baltic region (39 €/MWh in 2009 in Latvia).

Due to primary orientation toward renewable cogeneration in Latvia new coal cogeneration are not foreseen.

3. Data sources and assumptions

Please note that unlike other countries, Latvia uses 2009 prices and regulations. Data for all scenarios provided by country. The scenarios utilise the following sources and assumptions:

- Construction costs: Common estimate for the region, based on Slovak and Slovenian data
- Maintenance: Common estimate for the region, based on Slovak and Slovenian data
- Operating cost: Common estimate for the region, based on Slovak and Slovenian data
- Fuel and electricity wholesale and supply prices: Eurostat 2009, wholesale electricity price - Eesti Energia - yearly report 2009 (price on closed electricity market)
- Boiler fuel price: Eurostat 2009
- Electricity CHP Benefit: Fixed purchased price (estimate for 2009)
- Tax rate: 15.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Lithuania**
Organisation providing data	Jozef Stefan Institute, Slovenia
Contact name providing data	Stane Merše

IRR calculations

Please note that unlike other countries, Lithuania uses 2009 prices and regulations

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€22,145	€656,033	€656,033		€41,917,603
Heat value from CHP with benefits	€11,515	€284,817	€383,836		€16,973,208
Electricity value from CHP no benefits	€19,157	€410,389	€410,389		€22,087,296
Heat value from CHP no benefits	€11,515	€284,817	€383,836		€16,973,208
Fuel cost to CHP with benefits	€20,209	€519,741	€700,433		€31,197,529
Fuel cost to CHP no benefits	€20,209	€519,741	€700,433		€31,197,529
Annual running costs (non-fuel)	€4,797	€99,619	€98,079		€3,181,200
Total cost for CHP with benefits	€25,006	€619,360	€798,511		€34,378,729
Total cost for CHP no benefits	€25,006	€619,360	€798,511		€34,378,729
Total value from CHP with benefits	€33,660	€940,850	€1,039,869		€58,890,811
Total value from CHP no benefits	€30,672	€695,207	€794,225		€39,060,504
Net benefit of CHP with benefits	€8,654	€321,490	€241,358		€24,512,082
Net benefit of CHP no benefits	€5,666	€75,846	-€4,286		€4,681,775
Capital costs	€111,800	€1,232,400	€1,129,700		€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**19,7**	**16,2**	**-263,6**		**16.9.0**
Internal rate of return (IRR) without benefits	**0%**	**0%**	**0%**		**-6,62%**
Financials with benefits					
Simple payback with benefits (years)	**12,9**	**3,8**	**4,7**		**2,8**
Internal rate of return (IRR) with benefits	**0%**	**14,48%**	**9,17%**		**24,16%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-6,8**	**-12,4**	**268,3**		**-14,1**
Effect of benefits Internal rate of return (IRR)	**0%**	**14,48%**	**9,17%**		**30,78%**

1. Overview of CHP support mechanisms and taxes

Rules on Issue of Guarantees of Origin of Electricity produced from High-efficiency Cogeneration (2008). Official Gazette 2008, No 59-2254.

The Regulations for Public Service Obligations approved by the Minister of Economy

Lithuania has a feed-in tariff with purchase obligation on all generation is controlled by National Control Commission for Prices and Energy (level of support sets annually and differs between plants).

2. Description of the IRR calculations and effect of the support mechanisms

Due to purchase obligation support the sell of whole CHP generated electricity by feed-in tariffs was used in the calculation. Lithuania had very low wholesale electricity prices (22 €/MWh in 2009) due to low cost Ignalina nuclear power plant production. Significant price increase is foreseen in 2010 after the closure of this plant.

The 50 kW investment case both with and without the state support of a feed in tariff was too poor as to yield a positive IRR (simple payback time 20 years and 13 years with the support). A high capital cost of plant combined with a weak spark spread contributed to such a poor IRR.

For the two 1MW gas plant the IRR without support is negative with 16 years payback time. Support has significant positive influence and results in 14,5% IRR and attractive less than 4 years simple payback time.

Higher price of the fuel compared to natural gas is the main reason for completely negative economic balance of 1MW fuel oil engine without support whereas the support improves the situation to the positive 9,2% IRR and less than 5 years payback period.

In the case of the 66MW CHP plant, due to very low wholesale electricity prices, the IRR without state support is negative (17 years simple payback time). The addition of the FiT is crucial in such environment and increased the IRR by an additional 30% to the very attractive 24% (payback period less than 3 years).

3. Data sources and assumptions

Please note that unlike other countries, Lithuania uses 2009 prices and regulations. Data for all scenarios provided from country. The scenarios utilise the following sources and assumptions:

- Construction costs: Common estimate for the region, based on Slovak and Slovenian data,
- Maintenance: Common estimate for the region, based on Slovak and Slovenian data,
- Operating cost: Common estimate for the region, based on Slovak and Slovenian data,
- Fuel and electricity wholesale and supply prices: Eurostat 2009, wholesale electricity price - Eesti Energia - yearly report 2009 (price on closed electricity market)
- Boiler fuel price: Eurostat 2009
- Electricity CHP Benefit: Feed in tariff (National Control Commission for Prices and Energy, plants support in 2009)
- Tax rate: 15.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Luxembourg**
Organisation providing data	Anima, Italy
Contact name providing data	Alessandro Fontana

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€34,216	€1,013,649	€1,013,649		€74,783,016
Heat value from CHP with benefits	€12,954	€343,432	€428,390		€24,932,880
Electricity value from CHP no benefits	€34,216	€1,013,649	€1,013,649		€74,783,016
Heat value from CHP no benefits	€12,954	€343,432	€428,390		€24,932,880
Fuel cost to CHP with benefits	€25,211	€693,155	€864,627		€50,687,078
Fuel cost to CHP no benefits	€25,211	€693,155	€864,627		€50,687,078
Annual running costs (non-fuel)	€3,750	€64,908	€64,908		€2,563,200
Total cost for CHP with benefits	€28,961	€758,063	€929,535		€53,250,278
Total cost for CHP no benefits	€28,961	€758,063	€929,535		€53,250,278
Total value from CHP with benefits	€47,170	€1,357,081	€1,442,039		€99,715,896
Total value from CHP no benefits	€47,170	€1,357,081	€1,442,039		€99,715,896
Net benefit of CHP with benefits	€18,209	€599,018	€512,504		€46,465,618
Net benefit of CHP no benefits	€18,209	€599,018	€512,504		€46,465,618
Capital costs	€42,000	€630,000	€630,000		€60,000,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**2.3**	**1.1**	**1.2**		**1.3**
Internal rate of return (IRR) without benefits	**26.59%**	**51.94%**	**48.34%**		**46.00%**
Financials with benefits					
Simple payback with benefits (years)	**2.3**	**1.1**	**1.2**		**1.3**
Internal rate of return (IRR) with benefits	**26.59%**	**51.94%**	**52.12%**		**46.00%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**0.0**	**0.0**		**0.0**
Effect of benefits Internal rate of return (IRR)	**0.00%**	**0.00%**	**3.78%**		**0.00%**

1. Overview of CHP support mechanisms and taxes

Law on the rational use of energy (5th August 1993)

Regulation on CHP and electricity generation from RES for units with a maximum capacity of 1.5MWe (30 May 1994)

There was no support modelled for fossil fuel fired CHP.

2. Description of the IRR calculations and effect of the support mechanisms

Contrary to much other data for the EU27, the IRR for the 50kW plant was modelled with a positive IRR of 27%. This was due in part to the wide spark spread that led to a high value for onside generated electricity. The high rate of return was more pronounced for the 1MW gas and gas oil plants which yielded an IRR of 52% and 48% respectively. These high IRRs were accompanied with short payback periods of just over one year. The 66MW plant also yielded a high rate of return of 46% with a 1.3 year payback.

The high IRRs and short payback period raise questions about the data quality. It may be that improved data would yield significantly different results. Obtaining suitable data for Luxembourg was a significant challenge and open source data had to be used in lieu of accurate Member State data.

3. Data sources and assumptions

Data for all scenarios sourced from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Based on UK data
- Maintenance: Based on UK data
- Operating cost: Based on 1.5% of Capital Cost
- Fuel wholesale prices: Gas - Eurostat Gas domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Fuel wholesale prices and taxation: Gas oil - IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil – industry
- Electricity wholesale prices: 70% of supply price (see Cyprus for further explanation)
- Electricity supply prices: Eurostat Electricity domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Tax rate: 29.6%
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Malta**
Organisation providing data	Anima, Italy
Contact name providing data	Alessandro Fontana

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits			€76,683		
Heat value from CHP with benefits			€627,345		
Electricity value from CHP no benefits			€76,683		
Heat value from CHP no benefits			€627,345		
Fuel cost to CHP with benefits			€1,266,180		
Fuel cost to CHP no benefits			€1,266,180		
Annual running costs (non-fuel)			€80,106		
Total cost for CHP with benefits			€1,346,286		
Total cost for CHP no benefits			€1,346,286		
Total value from CHP with benefits			€704,028		
Total value from CHP no benefits			€704,028		
Net benefit of CHP with benefits			-€642,259		
Net benefit of CHP no benefits			-€642,259		
Capital costs			€630,000		
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)			**-1.0**		
Internal rate of return (IRR) without benefits			**0.00%**		
Financials with benefits					
Simple payback with benefits (years)			**-1.0**		
Internal rate of return (IRR) with benefits			**0.00%**		
Effect of benefits on financials					
Effect of benefits on simple payback (years)			**0.0**		
Effect of benefits Internal rate of return (IRR)			**0.00%**		

1. Overview of CHP support mechanisms and taxes

Subsidiary Legislation 423.27

2. Description of the IRR calculations and effect of the support mechanisms

It was not possible to source fossil fuel price data for Malta and, therefore, the IRRs for the five plant could not be modelled for this Member State.

3. Data sources and assumptions

Data for all scenarios sourced from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Based on UK data
- Maintenance: Based on UK data
- Operating cost: Based on 1.5% of Capital Cost
- Fuel wholesale prices: Gas - Eurostat Gas domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Electricity wholesale prices: 70% of wholesale price, see Cyprus for further explanation
- Electricity supply prices: Eurostat Electicity domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Tax rate: 28.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Netherlands**
Organisation providing data	Cogen Nederland
Contact name providing data	Peter Steenbergen

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€27,724	€619,114			€40,387,274
Heat value from CHP with benefits	€13,580	€300,317			€25,878,753
Electricity value from CHP no benefits	€23,920	€554,580			€40,256,372
Heat value from CHP no benefits	€13,580	€300,317			€25,878,753
Fuel cost to CHP with benefits	€26,431	€553,657			€51,609,600
Fuel cost to CHP no benefits	€26,431	€606,136			€52,609,982
Annual running costs (non-fuel)	€2,912	€30,810			€4,092,000
Total cost for CHP with benefits	€27,945	€543,058			€53,384,208
Total cost for CHP no benefits	€29,343	€636,946			€56,701,982
Total value from CHP with benefits	€41,304	€919,432			€66,266,027
Total value from CHP no benefits	€37,500	€854,897			€66,135,125
Net benefit of CHP with benefits	€13,359	€376,374			€12,881,819
Net benefit of CHP no benefits	€8,158	€217,952			€9,433,142
Capital costs	€106,600	€895,544			€77,550,000
Effective capital costs	€94,661	€ 795,243			€68,864,400
Financials without benefits					
Simple payback without benefits (years)	**13.1**	**4.1**			**8.2**
Internal rate of return (IRR) without benefits	**-0.29%**	**16.09%**			**2.45%**
Financials with benefits					
Simple payback with benefits (years)	**8.0**	**2.4**			**6.0**
Internal rate of return (IRR) with benefits	**6.12%**	**34.52%**			**7.98%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-5.1**	**-1.7**			**-2.2**
Effect of benefits Internal rate of return (IRR)	**6.41%**	**18.43%**			**5.53%**

1. Overview of CHP support mechanisms and taxes

The Electricity Act 1998, EIA Energy list 2010, Arrangement for Guarantees of Origin electricity production.

The Act 'Wet belastingen op milieugrondslag' (environmental taxes)

Tax Credit: extra depreciation of 44% of the investment; applicable tax rate 25.5%; subsidy 0.44*25.5% = 11.2% of the investment temporarily subsidy for the exploitation of co-generation, only applicable to the CO_2-free kWh (approximately 30% of the production first two cases, 20% for the last).

2. Description of the IRR calculations and effect of the support mechanisms

The support system in the Netherlands (as of 2007) was a complex system of stepped tariffs operating on both input fuel and output electricity. The system ensured that the greatest payments were made for initial generation and therefore, the risk of investment is reduced through such a mechanism. The model here presented is unable to account for the value of such support.

Without support the 50kW and 66MW CHP plant yielded low IRRs of 0% and 2% respectively. The 1MW gas plant, however, yielded a 16% IRR without support. The model for the 1MW CHP engine assumes that all generation is consumed onsite which may not be best aligned with reality and, therefore yield an artificially high IRR.

The combination of support mechanisms led to an improved investment scenario for all three modelled plant although the improvement was most pronounced for the 1MW gas unit where the IRR increased by 14%. The 50KW and 66MW IRRs increased by 6% and 4% respectively and both of these had a low final IRR even with support.

3. Data sources and assumptions

Data for all scenarios provided by Dutch contact. The scenarios utilise the following sources and assumptions:

- Construction costs: Techno-economische parameters MEP/SDE WKK
- Maintenance: 2008 Jacbos Consultancy
- Fuel wholesale price: Based on average year forward price in 2006 for 2007 plus margin for energy company
- Fuel transmission price: Based on tariff system Gas Transport Services
- Fuel distribution price: Remuneration for the local grid (8 bar and lower)
- Fuel taxation: Energy tax is built up in tranches; all consumers have to start in tranche 1. Gas used for production of electricity with an electrical efficiency of at least 30% is exempted; installed capacity should be at least 60 kW however. Gas used for supplementary firing (without steam turbine) is not exempted.
- Electricity price: Endex Price differs mainly for differences in peak and off-peak shares
- Electricity supply transmission price: Prices depend on voltage level and number of operating hours, only applicable to consumption. For back-up at higher voltage levels there are specific arrangements possible
- Electricity supply taxation: Energy tax is built up in tranches; all consumers have to start in tranche 1. Electricity produced for use on site is exempted at the condition that the so called Sent errendement (Electrical efficiency + 2/3 x heat efficiency) is 65% or more. Electricity supply tax is only applicable to electricity consumed.
- Tax rate: 25.5% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	Poland
Organisation providing data	Jozef Stefan Institute, Slovenia
Contact name providing data	Stane Merše

IRR calculations (based on 2009 prices and regulations)

Notional electrical capacity	50kWe	1MWe	1MWe	12MWe	66MWe
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€28,870	€686,447	€686,447	€8,272,347	€45,830,030
Heat value from CHP with benefits	€13,573	€315,171	€360,380	€7,962,239	€20,179,544
Electricity value from CHP no benefits	€22,214	€489,263	€489,263	€7,800,764	€28,089,230
Heat value from CHP no benefits	€13,573	€315,171	€360,380	€7,962,239	€20,179,544
Fuel cost to CHP with benefits	€23,820	€575,132	€657,630	€8,332,382	€37,090,921
Fuel cost to CHP no benefits	€23,820	€575,132	€657,630	€8,332,382	€37,090,921
Annual running costs (non-fuel)	€4,797	€99,619	€98,079	€1,235,971	€3,181,200
Total cost for CHP with benefits	€28,617	€674,751	€755,708	€9,568,354	€40,272,121
Total cost for CHP no benefits	€28,617	€674,751	€755,708	€9,568,354	€40,272,121
Total value from CHP with benefits	€42,443	€1,001,618	€1,046,827	€16,234,586	€66,009,574
Total value from CHP no benefits	€35,787	€804,434	€849,643	€15,763,004	€48,268,774
Net benefit of CHP with benefits	€13,826	€326,867	€291,118	€6,666,233	€25,737,454
Net benefit of CHP no benefits	€7,170	€129,683	€93,934	€6,194,650	€7,996,654
Capital costs	€111,800	€1,232,400	€1,129,700	€28,456,368	€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**15.6**	**9.5**	**12.0**	**4.6**	**9.9**
Internal rate of return (IRR) without benefits	**0.00%**	**0.00%**	**0.00%**	**13.52%**	**1.52%**
Financials with benefits					
Simple payback with benefits(years)	**8.1**	**3.8**	**3.9**	**4.3**	**3.1**
Internal rate of return (IRR) with benefits	**4.36%**	**14.87%**	**13.23%**	**14.92%**	**22.23%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-7.5**	**-5.7**	**-8.1**	**-0.3**	**-6.8**
Effect of benefits Internal rate of return (IRR)	**4.36%**	**14.87%**	**13.23%**	**1.41%**	**20.71%**

1. Overview of CHP support mechanisms and taxes

CHP support: Amended Energy Law and Environmental Act 2007 (Green Certificates from 1. July 2007)

Issuing GoO (Energy Regulatory Office): Ordinance on issuing CHP GoO, 2007

Certificates of origin ("Green Gertificates") are issued separately for two groups of cogeneration units:

1. Gaseous fuels or with total installed electrical capacity below 1MW
2. All remaining sources (4,8 €/MWh).

Each type of certificate contains a separate range of purchase obligations and a different level of substitute fee. The level of the substitute fee is determined each year by the President of the Energy Regulatory Office. The new support system will remain in force until 31 March 2013.

2. Description of the IRR calculations and effect of the support mechanisms

The Green Certificates were modelled as a value that could be claimed for all electricity generated (not export only).

The support available for the 50kW CHP plant has significant impact on the investment case and shortened the simple payback period from 15,6 years to the 8,1 years with marginal IRR value of 4,4%.

The 1MW gas and gas oil plants led to a poor rate of return and long simple payback time (9,5 and 12,5 years) due to a weak spark spread and a relatively high capital cost of equipment. Support for CHP improved the investment case for both 1MW plant to the attractive 14,9% IRR for gas engine and 13,2% IRR for fuel oil engine with simple payback time less than 4 years.

For the 66MW plant, the investment case significantly improved from an IRR of 1,5% to the more than 22% with the application of white certificates (32 €/MWh). The payback period also fell from 10 years to three.

Even without support 12MW coal plant has very high IRR (13,5%) and payback time 4,6 years. Due to lower level of support (4,8 €/MWh), the positive effect are smaller but the economical indicators are slightly improved (IRR 14,9% and 4,3 years of simple payback period).

3. Data sources and assumptions

Data for all scenarios provided by country. The scenarios utilise the following sources and assumptions:

- Construction costs: From Slovak Republic & Slovenia data
- Maintenance: From Slovak Republic & Slovenia data
- Operating cost: From Slovak Republic & Slovenia data
- Fuel supply prices: Eurostat 2009, IEA
- Electricity wholesale and supply prices: Power exchange data 2009, Eurostat 2009
- CHP benefit: Green certificates
- Tax rate: 19.0% EC Corporate/corporation/business tax
  http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Portugal**
Organisation providing data	Cogen Portugal
Contact name providing data	Miguel Gil Mata

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€27,040	€708,630	€708,630	€8,842,176	€40,914,720
Heat value from CHP with benefits	€12,444	€263,947	€263,947	€19,626,395	€19,833,333
Electricity value from CHP no benefits	€27,040	€708,630	€708,630	€8,842,176	€40,914,720
Heat value from CHP no benefits	€12,444	€263,947	€263,947	€19,626,395	€19,833,333
Fuel cost to CHP with benefits	€24,220	€532,728	€532,728	€21,619,853	€40,320,000
Fuel cost to CHP no benefits	€24,220	€532,728	€532,728	€21,619,853	€40,320,000
Annual running costs (non-fuel)	€13,000	€184,860	€184,860	€1,754,400	€9,900,000
Total cost for CHP with benefits	€37,220	€717,588	€717,588	€23,374,253	€50,220,000
Total cost for CHP no benefits	€37,220	€717,588	€717,588	€23,374,253	€50,220,000
Total value from CHP with benefits	€39,484	€972,577	€972,577	€28,468,571	€60,748,053
Total value from CHP no benefits	€39,484	€972,577	€972,577	€28,468,571	€60,748,053
Net benefit of CHP with benefits	€2,264	€254,989	€254,989	€5,094,318	€10,528,053
Net benefit of CHP no benefits	€2,264	€254,989	€254,989	€5,094,318	€10,528,053
Capital costs	€182,000	€1,027,000	€1,027,000	€9,356,800	€72,600,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**80.4**	**4.0**	**4.0**	**1.8**	**6.9**
Internal rate of return (IRR) without benefits	**0.00%**	**2.40%**	**2.35%**	**25.62%**	**-9.49%**
Financials with benefits					
Simple payback with benefits (years)	**80.4**	**4.0**	**4.0**	**1.8**	**6.9**
Internal rate of return (IRR) with benefits	**0.00%**	**2.40%**	**2.35%**	**25.62%**	**-9.37%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Effect of benefits Internal rate of return (IRR)	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.12%**

1. Overview of CHP support mechanisms and taxes

Decree-Law nº. 23/2010

Law nº. 19/2010

2. Description of the IRR calculations and effect of the support mechanisms

The CHPA believes that there is a support mechanism for fossil CHP in Portugal but we have not been able to obtain quantitative details and, therefore, this has not been included in the analysis.

Four of the five modelled examples returned a very low or negative IRR. This was particularly pronounced for the 50kW and 66MW plant. The 50kW plant returned a low IRR due to the high capital costs which eroded the value of the net benefit of operating CHP. The high operational expenditure for the 66MW plant prevented a positive modelled investment return. High operation expenditure also accounted for the low returns for both the 1MW plant.

The only plant returning a substantially positive IRR was the 12MW coal plant with a two year payback and 26% IRR. In this case relatively lower capex and opex costs drove this result.

The data for Portugal highlight a relatively strong spark spread.

3. Data sources and assumptions

Data for all scenarios provided by Portuguese contact. The scenarios utilise the following sources and assumptions:

- Tax rate: 26.5% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Romania**
Organisation providing data	HACHP, Greece
Contact name providing data	Costas Theofylaktos

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€25,314	€566,904			€35,814,240
Heat value from CHP with benefits	€8,960	€237,552			€18,960,667
Electricity value from CHP no benefits	€22,194	€474,474			€18,184,320
Heat value from CHP no benefits	€8,960	€237,552			€18,960,667
Fuel cost to CHP with benefits	€17,438	€479,455			€38,545,920
Fuel cost to CHP no benefits	€17,438	€479,455			€38,545,920
Annual running costs (non-fuel)	€1,610	€72,000			€856,800
Total cost for CHP with benefits	€19,048	€551,455			€39,402,720
Total cost for CHP no benefits	€19,048	€551,455			€39,402,720
Total value from CHP with benefits	€34,274	€804,456			€54,774,907
Total value from CHP no benefits	€31,154	€712,026			€37,144,987
Net benefit of CHP with benefits	€15,225	€253,001			€15,372,187
Net benefit of CHP no benefits	€12,105	€160,571			-€2,257,733
Capital costs	€152,000	€870,000			€56,100,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**12.6**	**5.4**			**-24.8**
Internal rate of return (IRR) without benefits	**2.87%**	**0.00%**			**0.00%**
Financials with benefits					
Simple payback with benefits (years)	**10.0**	**3.4**			**3.6**
Internal rate of return (IRR) with benefits	**5.62%**	**16.73%**			**20.79%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-2.6**	**-2.0**			**-3.6**
Effect of benefits Internal rate of return (IRR)	**2.75%**	**16.73%**			**20.79%**

1. Overview of CHP support mechanisms and taxes

The Electricity Law (2007)

Government Decision on the promotion of co-generation based on the effective thermal energy demand (2007)

Government Decision on the approval procedure for issuing guarantees of origin for electricity produced by high efficiency cogeneration (2008).

2. Description of the IRR calculations and effect of the support mechanisms

The support mechanism operating in Romania is in the form of a two stage feed in tariff (FiT); one part paid on all generation and worth 1.5 cents per kWh across all fuel types and plant sizes. There is also a support paid on exported generation and this varies from between 0.5 and 0.43 cents per kWh exported power and has been modelled as being paid in addition to the wholesale price for electricity.

The high capital cost of the 50kW CHP unit (over €3000/kW) meant that even with Government support the IRR remained low at 6% with a 10 year payback. The FiT did however raise the IRR by 3%.

The 1MW gas plant did not yield a positive IRR when modelled without support but this rose to 17% and a three year payback when the FiT was applied. The FiT was important in increasing the effective spark spread in the model.

The most pronounced effect of the state support was for the 66MW plant in which the FiT increased the IRR from a negative investment case to 21% with a four year payback.

The flat rate of the FiT led to a more pronounced effect for larger scale CHP plant.

3. Data sources and assumptions

Data for all scenarios provided by country contact. The scenarios utilise the following sources and assumptions:

- Fuel wholesale prices: Gas - Eurostat Gas domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Electricity wholesale prices: Based on 70% of supply prices, see Cyprus for further explanation
- Electricity supply prices: Eurostat Electicity domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Tax rate: 16.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

Country name	Slovak Republic
Organisation providing data	Ministry of Economy of the Slovak Republic, Jožef Stefan Institute
Contact name providing data	Igor Jašurek, Stane Merše

IRR calculations

Please note that unlike other countries, the Slovak Republic uses 2009 prices and regulations

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€41,078	€964,291	€964,291	€14,362,641	€55,456,632
Heat value from CHP with benefits	€15,061	€371,976	€331,819	€11,473,892	€29,797,600
Electricity value from CHP no benefits	€34,653	€773,947	€773,947	€12,339,748	€40,559,904
Heat value from CHP no benefits	€15,061	€371,976	€331,819	€11,473,892	€29,797,600
Fuel cost to CHP with benefits	€26,021	€667,438	€605,510	€12,007,283	€53,806,945
Fuel cost to CHP no benefits	€26,433	€678,791	€605,510	€12,007,283	€54,769,345
Annual running costs (non-fuel)	€4,797	€99,619	€98,079	€1,212,817	€3,181,200
Total cost for CHP with benefits	€30,818	€767,057	€703,589	€13,220,099	€56,988,145
Total cost for CHP no benefits	€31,230	€778,410	€703,589	€13,220,099	€57,950,545
Total value from CHP with benefits	€56,139	€1,336,268	€1,296,110	€25,836,533	€85,254,232
Total value from CHP no benefits	€49,714	€1,145,923	€1,105,766	€23,813,640	€70,357,504
Net benefit of CHP with benefits	€25,321	€569,211	€592,521	€12,616,434	€28,266,087
Net benefit of CHP no benefits	€18,484	€367,514	€402,177	€10,593,541	€12,406,959
Capital costs	€111,800	€1,232,400	€1,129,700	€28,456,368	€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**6.0**	**3.4**	**2.8**	**2.7**	**6.4**
Internal rate of return (IRR) without benefits	**9.24%**	**17.73%**	**21.08%**	**25.46%**	**8.13%**
Financials with benefits					
Simple payback with benefits (years)	**4.4**	**2.2**	**1.9**	**2.3**	**2.8**
Internal rate of return (IRR) with benefits	**15.35%**	**36.21%**	**32.80%**	**30.34%**	**24.54%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-1.6**	**-1.2**	**-0.9**	**-0.4**	**-3.6**
Effect of benefits Internal rate of return (IRR)	**6.11%**	**18.49%**	**11.72%**	**4.89%**	**16.41%**

1. Overview of CHP support mechanisms and taxes

Act on promotion RES and High Efficiency Cogeneration (309/2009)

Support for CHP in Slovenia comes in the form of a operation support as fix purchase price composed of electricity price for losses and surcharge (varies by size and type of technology). Fixed purchase price is paid for all sold electricity to the network operator, whereas surcharge is paid on all other generated electricity.

Investment subsidies from EU structural found are available in the period 2007 – 2013 (if plant is granted from 30 – 50% of total acquisition costs, the fixed electricity price is reduced from 4% to 16%).

2. Description of the IRR calculations and effect of the support mechanisms

Due to relative high final electricity prices (used data from Eurostat 2009) IRR for all CHP plants is above 8% even without support, around 20% for 1MW engines and coal unit. The lowest IRR 8,13% is for the largest combined cycle unit, following with the micro unit (9,24%).

Support surcharges (30,1 €/MWh for engines, 20,59 €/MWh for steam turbine and 26,87 €/MWh for combined cycle unit) have additional significant positive influence on improvement of the units IRR (from 5 to 18 additional percentage points).

Rather high investment costs is the main reason for the lowest IRR for 50kW unit (15,35%) with attractive less than five years simple payback period. For all other units the IRR is very high, close to 25% for combined cycle unit and above 30% for 1MW gas engines and coal unit.

Considering very high profitability indicators the most uncertain data are final electricity prices reported by Eurostat, which have significant influence on the final profitability of CHP projects in Slovakia.

3. Data sources and assumptions

Please note that unlike other countries, the Slovak Republic uses 2009 prices and regulations. Data for all scenarios provided by Ministry of Economy of the Slovak Republic and other statistical sources.
The scenarios utilise the following sources and assumptions:

- Construction costs: Common estimate for the region, based on Slovak and Slovenian data
- Maintenance: Common estimate for the region, based on Slovak and Slovenian data
- Operating cost: Common estimate for the region, based on Slovak and Slovenian data
- Fuel and electricity wholesale and supply prices: Eurostat 2009, IEA (Coal price)
- Fuel and electricity taxation: IEA 2009
- Boiler fuel price: Eurostat 2009
- Electricity CHP Benefit: Ministry of Economy of the Slovak Republic
- Tax rate: 19,0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm. Since 2005 investment incentives in Slovakia are assigned to the government approved rules (dependent e.g. on region, unemployment rate…). The investment incentives are given according to the decision on the granted incentives of the Slovak Ministry of economics. The investment incentives are given in compliance with the EU law and have to be approved by the European Commission and Slovak government.
- Writing Down Allowance: 13,0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	Slovenia
Organisation providing data	Jozef Stefan Institute, Slovenia
Contact name providing data	Stane Merše

IRR calculations

Please note that unlike other countries, Slovenia uses 2009 prices and regulations

Notional electrical capacity	50kWe	1MWe	1MWe	12MWe	66MWe
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€48,612	€750,593	€750,593		€46,652,760
Heat value from CHP with benefits	€17,230	€427,311	€391,943		€23,879,333
Electricity value from CHP no benefits	€18,387	€442,185	€442,185		€36,353,117
Heat value from CHP no benefits	€17,230	€427,311	€391,943		€23,879,333
Fuel cost to CHP with benefits	€29,827	€768,413	€739,686		€43,891,302
Fuel cost to CHP no benefits	€30,239	€779,767	€715,227		€43,891,302
Annual running costs (non-fuel)	€4,797	€99,619	€98,079		€3,181,200
Total cost for CHP with benefits	€34,624	€868,032	€837,765		€47,072,502
Total cost for CHP no benefits	€35,036	€879,386	€813,306		€47,072,502
Total value from CHP with benefits	€65,842	€1,177,904	€1,142,537		€70,532,093
Total value from CHP no benefits	€35,617	€869,496	€834,128		€60,232,450
Net benefit of CHP with benefits	€31,218	€309,872	€304,772		€23,459,592
Net benefit of CHP no benefits	€581	-€9,890	€20,823		€13,159,948
Capital costs	€111,800	€1,232,400	€1,129,700		€79,200,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**192.3**	**-124.6**	**54.3**		**6.0**
Internal rate of return (IRR) without benefits	**0%**	**0%**	**0%**		**9.01%**
Financials with benefits					
Simple payback with benefits (years)	**3.6**	**4.0**	**3.7**		**3.4**
Internal rate of return (IRR) with benefits	**19.98%**	**13.52%**	**14.15%**		**19.93%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-188.7**	**128.6**	**-50.5**		**-2.6**
Effect of benefits Internal rate of return (IRR)	**19.98%**	**13.52%**	**14.15%**		**10.91%**

1. Overview of CHP support mechanisms and taxes

Energy Law

Decree on Support for Electricity Produced in High-Efficiency Cogeneration (Off. Gaz.of RS No. 37/09)

New support scheme was approved in 2009 with higher and more stable support for cogeneration as fixed purchased prise for units up to 1MW or premium on all generated electricity for all plants for a 10 year period. Separate support for fossil fuel and wood biomass plants and different support levels for different size classes. Higher level of support for units with up to 4.000 operation hours per year (heating). Predictable methodology for yearly adjustment of supports based on forecast of natural gas and wood biomass market price and electricity market price minimise market risks for the investors.

2. Description of the IRR calculations and effect of the support mechanisms

The current market situation is Slovenia is not enabling the economic implementation of CHP projects without additional support. Except the largest unit with an internal rate of return (IRR) of 9% for all other units the IRR is negative and simple payback is extremely long or even negative without additional support.

The support for CHP in Slovenia is in the form of a feed in tariff (premium) and this has been modelled as payable on all generation. With the new support scheme, for all projects the economic indicators are attractive with IRR close to 20% for 50kW unit and the largest combined cycle unit and around 14% for 1MW gas and fuel oil unit. The simple payback time is less than 4 years.

Relative high profitability of gas oil units is time specific (low oil prices in 2009) and is expected to decrease with increase of taxes on fuel oil in next years.

The support of coal CHP units is not foreseen in the new support scheme.

Influence of support is significant for all plants. As eligible period for the support of new units is only 10 years, presented IRR values are slightly higher than in 10 years economic period of projects.

3. Data sources and assumptions

Data for all scenarios provided by Jozef Stefan Institute and Ministry of Economy (Methodology for Determining the Reference Costs for High-Efficiency Cogeneration). The scenarios utilise the following sources and assumptions:

- Construction costs: Slovenian data (Methodology and other sources)
- Maintenance: Slovenian data (Methodology and other sources)
- Operating cost: Slovenian data (Methodology and other sources)
- Fuel and electricity wholesale and supply prices: Slovenian data (Methodology and other sources)
- Fuel and electricity taxation: Slovenian legislation.
- Boiler fuel price: Methodology 2009
- Electricity CHP Benefit : Decree (values for 2009)
- Tax rate: 20% EC Corporate/corporation/business tax
  http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
  Investment allowance - a taxable person can use the reduced tax base in the amount of 30% of the amount invested in equipment or intangible assets however not exceeding the amount of 30,000 EUR and only up to the amount of taxable base. Equipment does not include furniture and office equipment and motor vehicles except cars and buses on hybrid or electrical drive, and trucks meeting the EURO V (for years 2008, 2009 and 2010) and EURO VI emission requirements as well as buses meeting the EURO IV (for years 2008, 2009 and 2010) emission requirements.

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Spain**
Organisation providing data	Anna Higueras
Contact name providing data	COGEN Spain

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€50,336	€1,238,562	€1,238,562		€54,663,840
Heat value from CHP with benefits	€25,244	€570,313	€1,084,067		€37,683,333
Electricity value from CHP no benefits	€47,216	€1,176,942	€1,176,942		€54,109,440
Heat value from CHP no benefits	€25,244	€570,313	€1,084,067		€37,683,333
Fuel cost to CHP with benefits	€46,018	€1,093,995	€2,092,860		€72,576,000
Fuel cost to CHP no benefits	€49,132	€1,151,073	€2,187,990		€76,608,000
Annual running costs (non-fuel)	€1,716	€21,054	€25,675		€297,000
Total cost for CHP with benefits	€47,734	€1,115,049	€2,118,535		€72,873,000
Total cost for CHP no benefits	€50,848	€1,172,127	€2,213,665		€76,905,000
Total value from CHP with benefits	€75,580	€1,808,875	€2,322,629		€92,347,173
Total value from CHP no benefits	€72,460	€1,747,255	€2,261,009		€91,792,773
Net benefit of CHP with benefits	€27,846	€693,827	€204,094		€19,474,173
Net benefit of CHP no benefits	€21,612	€575,129	€47,344		€14,887,773
Capital costs	€65,000	€1,283,750	€1,437,800		€56,100,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**3.0**	**2.2**	**30.4**		**3.8**
Internal rate of return (IRR) without benefits	**23.63%**	**30.91%**	**-7.00%**		**18.51%**
Financials with benefits					
Simple payback with benefits (years)	**2.3**	**1.9**	**7.0**		**2.9**
Internal rate of return (IRR) with benefits	**30.75%**	**37.73%**	**8.05%**		**23.84%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**-0.7**	**-0.4**	**-23.3**		**-0.9**
Effect of benefits Internal rate of return (IRR)	**7.12%**	**6.82%**	**15.06%**		**5.33%**

1. Overview of CHP support mechanisms and taxes

Royal Decree 616/2007, entered into force on the 11th of May, on the Promotion of CHP.

Royal Decree 616/2007, entered into force on the 25th of May, on the regulation of electricity produced on special regime.

The support for CHP is in the form of a reduction on the tax applied to the input fuel and a generation based feed in tariff which is smaller per kWh generated the larger the size of the plant.

2. Description of the IRR calculations and effect of the support mechanisms

The relatively low capital cost of combined with a high spark spread led to a 24% Internal Rate of Return (IRR) for the 50kW plant independent of government support. This rose by 7% to 31% following the application of the reduced fuel tax and generation tariff. The model design (with all electricity generated being consumed onsite) may lead to an artificially high IRR.

Whilst the two modelled 1MW gas engines are identical save for input fuel, the analysis returned very different results with the gas fired unit modelling a return of 31% and the gas oil fired unite a return of -7% without state support. The reason for the difference is that the gas oil price was over twice the gas price and the capital cost of the gas oil unit was marginally higher. Support improved the IRRs for both units to 38% for the gas and 8% for the gas oil.

The 66MW gas plant saw in increase of 5% in IRR with the application of state support in the model. This led to a final IRR of 24% up from 19%.

3. Data sources and assumptions

Data for all scenarios provided by Austrian contact. The scenarios utilise the following sources and assumptions:

- Construction costs: Cogen Spain Statistics
- Maintenance: Cogen Spain Statistics
- Operating cost: Cogen Spain Statistics
- Fuel prices: Cogen Spain Statistics and Gas Natural Import Cost (Quarterly published in BOE)
- Fuel benefit: Cogen Spain Statistics
- Electricity wholesale prices, supply prices and taxation: Cogen Spain Statistics
- Tax rate: 28.0% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**Sweden**
Organisation providing data	Svensk Fjarrvarme
Contact name providing data	Erik Larsson

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€33,776	€1,000,605	€1,000,605		€54,384,781
Heat value from CHP with benefits	€32,714	€867,340	€425,580		€35,681,150
Electricity value from CHP no benefits	€33,776	€1,000,605	€1,000,605		€54,384,781
Heat value from CHP no benefits	€32,714	€867,340	€425,580		€35,681,150
Fuel cost to CHP with benefits	€63,670	€1,750,566	€858,955		€72,537,680
Fuel cost to CHP no benefits	€63,670	€1,750,566	€858,955		€72,537,680
Annual running costs (non-fuel)	€3,750	€64,908	€64,908		€2,563,200
Total cost for CHP with benefits	€67,420	€1,815,474	€923,863		€75,100,880
Total cost for CHP no benefits	€67,420	€1,815,474	€923,863		€75,100,880
Total value from CHP with benefits	€66,490	€1,867,944	€1,426,185		€90,065,931
Total value from CHP no benefits	€66,490	€1,867,944	€1,426,185		€90,065,931
Net benefit of CHP with benefits	-€930	€52,470	€502,322		€14,965,052
Net benefit of CHP no benefits	-€930	€52,470	€502,322		€14,965,052
Capital costs	€42,000	€630,000	€630,000		€60,000,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits (years)	**-45.1**	**12.0**	**1.3**		**4.0**
Internal rate of return (IRR) without benefits	**0.00%**	**0.00%**	**49.04%**		**15.25%**
Financials with benefits					
Simple payback with benefits (years)	**-45.1**	**12.0**	**1.3**		**4.0**
Internal rate of return (IRR) with benefits	**0.00%**	**0.00%**	**49.04%**		**15.25%**
Effect of benefits on financials					
Effect of benefits on simple payback (years)	**0.0**	**0.0**	**0.0**		**0.0**
Effect of benefits Internal rate of return (IRR)	**0.00%**	**0.00%**	**0.00%**		**0.00%**

1. Overview of CHP support mechanisms and taxes

Lag (2003:113) om elcertifikat (law on Green Electricity Certificate (2003:113) revised 2010.

There is no support for new fossil fired CHP in Sweden. New CHP plants are bioenergy.

2. Description of the IRR calculations and effect of the support mechanisms

Both the 50kW and 1MW gas plants modelled returned a 0% Internal Rate of Return (IRR) due to a low spark spread. The 1MW gas oil plant modelled a very high IRR of 49% due to the cost of gas oil being modelled at a third the cost of natural gas, substantially improving the spark spread. Use of IEA/Eurostat data may have led to such an artificially high IRR.

The 66MW plant modelled a return of 15% and a simple payback over four years.

3. Data sources and assumptions

Data for all scenarios sourced from publicly available sources. The scenarios utilise the following sources and assumptions:

- Construction costs: Based on UK figures
- Maintenance: Based on UK figures
- Operating cost: Based on 1.5% of Capital Cost
- Fuel wholesale prices: Gas - Eurostat Gas domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Fuel wholesale prices and taxation: Gas oil - IEA 2007 in national currency (Euros)/1,000 litres Light fuel oil – industry
- Electricity wholesale price: IEA 2007 national currency
- Electricity supply prices: Eurostat Electricity domestic and industrial half-yearly prices New methodology from 2007 onwards: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- Tax rate: 26.3% EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%

COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

Country name	**United Kingdom**
Organisation providing data	CHPA
Contact name providing data	Paul Gardiner

IRR calculations (based on 2007 prices and regulations)

Notional electrical capacity	**50kWe**	**1MWe**	**1MWe**	**12MWe**	**66MWe**
Primary generator	Reciprocating	Reciprocating	Reciprocating	Steam Turbine	Gas Turbine
Heat recovery method	Exchanger	Exchanger	Exchanger	Boiler	Heat Recovery Steam Generator
Secondary generator	None	None	None	None	Steam Turbine
Fuel type	**Natural Gas**	**Natural Gas**	**Gas Oil**	**Hard Coal**	**Natural Gas**
Electrical output	52 kWe	1,027 kWe	1,027 kWe	11,696 kWe	66,000 kWe
Heat output	80 kW	1,414 kW	1,414 kW	80,878 kW	85,000 kW
Heat transport medium e.g. steam/hot water	Hot water	Hot water	Hot water	Steam	Steam
Fuel input, low heating value (LHV)	156 kW	2,867 kW	2,867 kW	94,042 kW	173,593 kW
Fuel input, high heating value (HHV)	173 kW	3,171 kW	3,171 kW	98,992 kW	192,000 kW
Full load hours (hours)	4,000	6,000	6,000	8,400	8,400
Thermal efficiency (avoided boiler) NCV basis	90.00%	90.00%	90.00%	90.00%	90.00%
Proportion of electricity sold offsite	0.00%	0.00%	0.00%	0.00%	60.00%
Proportion of heat sold offsite	0.00%	0.00%	0.00%	0.00%	0.00%
EUA price	N/A	N/A	N/A	€ 25.00	€ 25.00
Electricity value from CHP with benefits	€17,919	€419,522		€6,688,821	€28,851,758
Heat value from CHP with benefits	€9,807	€172,745		€7,843,590	€11,193,406
Electricity value from CHP no benefits	€17,919	€419,522		€6,688,821	€26,756,126
Heat value from CHP no benefits	€9,807	€172,745		€7,843,590	€11,193,406
Fuel cost to CHP with benefits	€17,841	€341,804		€8,340,914	€22,174,929
Fuel cost to CHP no benefits	€19,087	€348,653		€8,640,265	€22,755,537
Annual running costs (non-fuel)	€3,750	€64,908		€941,232	€2,563,200
Total cost for CHP with benefits	€21,591	€406,712		€9,282,146	€24,738,129
Total cost for CHP no benefits	€22,837	€413,561		€9,581,497	€25,318,737
Total value from CHP with benefits	€27,726	€592,267		€14,532,411	€40,045,165
Total value from CHP no benefits	€27,726	€592,267		€14,532,411	€37,949,533
Net benefit of CHP with benefits	€6,135	€185,554		€5,250,265	€15,307,036
Net benefit of CHP no benefits	€4,889	€178,705		€4,950,913	€12,630,796
Capital costs	€42,000	€630,000		€30,000,000	€60,000,000
Effective capital costs					
Financials without benefits					
Simple payback without benefits	**8.6 yrs**	**3.5 yrs**		**6.1 yrs**	**4.8 yrs**
Internal rate of return (IRR) without benefits	**-4.34%**	**13.44%**		**9.08%**	**11.99%**
Financials with benefits					
Simple payback with benefits	**6.8 yrs**	**3.4 yrs**		**5.7 yrs**	**3.9 yrs**
Internal rate of return (IRR) with benefits	**1.24%**	**24.87%**		**12.36%**	**16.21%**
Effect of benefits on financials					
Effect of benefits on simple payback	**-1.7 yrs**	**-0.1 yrs**		**-0.3 yrs**	**-0.8 yrs**
Effect of benefits Internal rate of return (IRR)	**5.58%**	**11.43%**		**3.27%**	**4.22%**

1. Overview of CHP support mechanisms and taxes

Enhanced Capital Allowances (ECAs) enable a business to write off the whole of the first-year capital cost of investment, against their taxable profits of the period during which they make the investment.

Feed in Tariffs (FiT) offer financial support for gas-fired CHP up to 2 kW (and renewable electricity up to 5MW), providing a guaranteed return on investment for generating low-carbon electricity.

The Climate Change Levy is chargeable on non-domestic supplies of energy. CHP Levy Exemption Certificates (CHP LECs) demonstrate the amount of electricity supplied from good quality CHP sources.

Electricity suppliers are required to source a proportion of their electricity from renewable sources. Suppliers acquire Renewable Obligation Certificates (ROCs) from eligible generators when purchasing electricity, in order to demonstrate the proportion of renewable supply delivered to customers.

Embedded benefits are a payment made to generators connected to the distribution network as a recognition that their electricity does not flow on the transmission network. The payment is designed to refund the costs incurred in the charging system which assumes use of the transmission network.

2. Description of the IRR calculations and effect of the support mechanisms

Without the support mechanisms available for CHP in the UK, the small scale CHP (50kWe Natural Gas) scenario is unable to generate a positive return on investment, whereas the remaining four scenarios (from 1-66MWe) appear more viable, with pay back periods of between 3.5 to 6.1 years and IRRs of 9-13%.

The positive impact of support mechanisms predominantly stem from Climate Change Levy exemptions on input fuel and the enhanced capital allowance. The cumulative effect of the support mechanisms improves IRRs by between 3-11% with the most significant impact on the 1MWe scenarios. Pay back periods are reduced by a modest 0.1 – 0.8 years.

The highest IRR is that for the 1MW gas plant which was modelled with a 25% IRR when support was applied. It should be noted that if the operator were to export power to the grid the IRR would fall significantly due to the low value received for power exported at this scale. It is also important to note that the capital allowance system only benefits companies that are operating at a profit in the year of installation and electricity suppliers are not permitted to access ECAs.

3. Data sources and assumptions

Data for all scenarios provided by UK contact. The scenarios utilise the following sources and assumptions:

- Construction costs : Manufacturers' estimate and consultants' papers
- Maintenance: Estimate from CHPA
- Operating cost: Based on 1.5% of Capital Cost
- Fuel and electricity wholesale and supply prices: from UK energy price model - 2007
- Fuel and electricity taxation: Climate Change Levy @ 100% for 50kWe & 20% for others
- Boiler fuel price: Based on Boiler fuel price including CCL @ 20% except 50kWe plant
- Electricity CHP Benefit : Embedded Benefit @ £0.74/MWh and LECs at £4.51/MWh on Electricity sold
- Tax rate 28.0%: EC Corporate/corporation/business tax http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm
- Writing Down Allowance: 13.0%