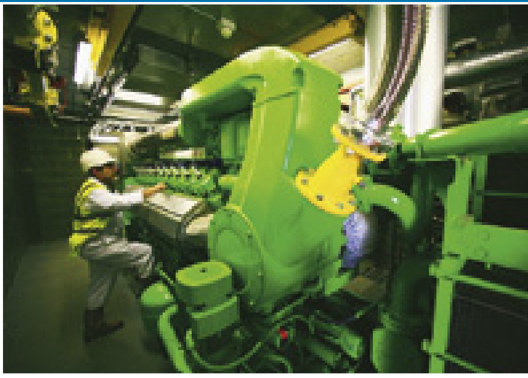
CODE Project



Cogeneration Case Studies Handbook

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COGENERATION OBSERVATORY AND DISSEMINATION EUROPE

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FOREWORD

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DESIGN/LAYOUT: Boris Jurca, Schwarz, d.o.o. (SI)

PRINTING: Schwarz, d.o.o. (SI)

DATE: March 2011

CIRCULATION: 1.000 copies

This publication is printed on recycled paper.

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

620.9(4)

COGENERATION case studies handbook : code project / [prepared by Stane Merše ... et al.]. - Ljubljana : Institut Jožef Stefan, 2011

ISBN 978-961-264-031-6
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255352576

Foreword

The CHP Directive 2004/08/EC outlines an enabling policy framework for the European Union to expand the deployment of cogeneration in member states. CHP is a highly energy efficient approach to generating electricity and providing useful heat. It is a key enabler for improving the efficiency and sustainability of electricity production from all fuels.

One of the CHP Directive's main achievements has been to deliver a clear Europe-wide statement on the potential for further CHP growth. The European member states have identified the opportunity to double CHP, thereby contributing a minimum primary energy saving of 35 mtoe to Europe's economy and contributing a full 10% plus to Europe's overall saving target of 20% by 2020.

The question remains: how is this to be achieved?

By focusing on the identification of potential, non-economic barriers, financial modelling and identification of best practices, the CODE project can begin to answer this question. CODE is an IEE-sponsored project which looks at implementation of the CHP Directive in all 27 member states. The project's first phase assessed how well the CHP Directive had been implemented in member states and analysed studies of its potential reported across Europe. The CODE project was the first to show that European member states believe there is the economic potential to double CHP in Europe by 2020. This means that 22% of Europe's delivered electricity would be generated in the CHP mode by 2020. A following phase examined the economic incentives for CHP available in Europe. The study looked at standard projects and their financial return in each member state, highlighting the diversity of funding approaches and the difficulty in designing a support scheme to stimulate the full capacity range of projects.

The subject of this report is the best practice cases identified in the CODE project and they provide an important insight into what drives a successful CHP project. The case studies show the wonderful diversity of CHP applications and how this enables new energy behaviours and its role close to citizens embedded in the economy and the community. These studies also allow us to explore why in some cases, despite the competitive, economic and communication barriers, a project will be built, allowing us to better understand where action by industry, suppliers, communicators and policymakers should be prioritised.

Fiona Riddoch
COGEN Europe
Managing Director

Summary of Success Factors and Main Barriers Identified

The aim of the CODE project was to collect and present both examples of cogeneration projects from different EU member states highlighting successful policies for promoting cogeneration as well as cases providing insights into those areas of policies which are not achieving their desired targets. On one hand, the case studies therefore confirm that temporary policies are heading in the right direction in certain areas while, on the other, they also remind us that some questions still need to be answered to foster the further development of cogeneration in the EU.

Success Factors

The main factors (Figure 1) which enabled the successful implementation of different CHP projects can be divided into policy-related success factors and specific success factors related to particular issues of certain systems. The most often mentioned policy-related success factors are:

- investment subsidies and subsidies for demonstration projects (Belgium, Greece, Spain);
- a feed-in tariff scheme (Slovenia, UK, Cyprus, Greece);
- a green certificates scheme (Belgium, Poland);
- third party financing (UK, Greece); and
- policy favouring the use of RES (Cyprus).

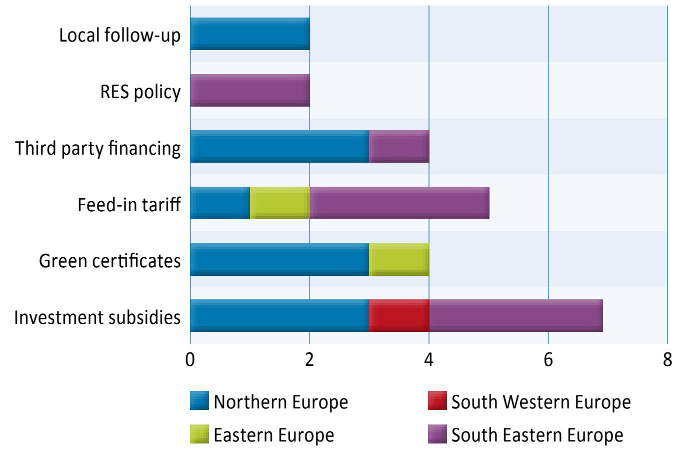


Figure 1: Overview of the most common success factors

Specific success factors are largely case-dependant. Of these, an environmentally-friendly-orientated customer organisation (Belgium, UK), good access to the energy infrastructure (Germany), an obligatory feasibility study assessing the merits of connection to district heating in comparison to other heat supply solutions for new developments (UK), the local availability of follow-up, service and maintenance of the system (Belgium) etc. were mentioned.

Main Barriers

While a number of success factors support the implementation of new CHP projects, there are still some barriers (Figure 2) that prevent faster development in this area:

- an agreement for a connection to the electrical grid is sometimes difficult to obtain (Slovenia, Belgium, Spain, Italy, Ireland);
- high or volatile natural gas prices make a project's economic feasibility unfavourable or uncertain (Slovenia, Greece, Belgium);
- in certain locations strict noise and other environmental rules have to be followed (Finland, UK, Ireland);

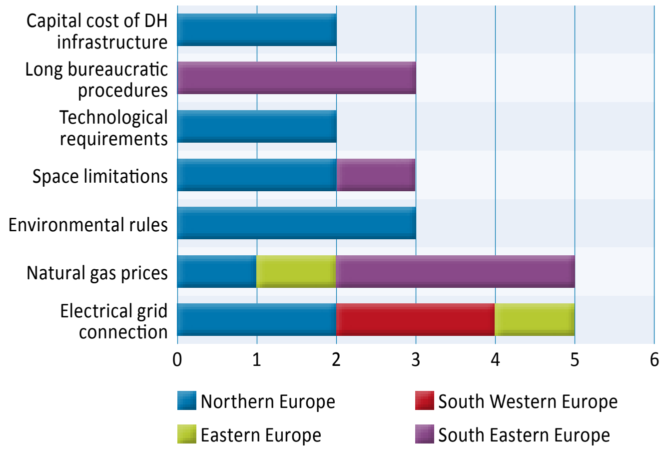


Figure 2: Overview of the most common main barriers

- due to space limitations a special design of CHP system is sometimes needed (UK, Belgium, Greece);
- the high capital cost of district heating infrastructure leads to high network connection costs for consumers (UK);
- in communities there is a lack of incentives for the use of district heating (Cyprus);
- the negotiation phase of TPF-financed CHP projects tends to be (too) long (UK);
- specific technological requirements demand specific, usually more expensive solutions (Germany, Belgium);
- long bureaucratic procedures are delaying the implementation of projects (Greece).

We may therefore conclude that in general the policies involved in the observed cases support the development of cogeneration quite well and could also be successfully used in other countries. Most of the barriers reflect a resistance to changes (grid operators, potential district heat consumers…), long bureaucratic procedures and specific characteristics of the CHP systems that are needed.

Case Studies Selection Criteria

Introduction

Although cogeneration is a mature technology, these days we are still encountering the very rapid evolution of the technology and related applications. The main advantage of cogeneration – the highest overall efficiency for the conversion of fuel to heat and electricity – is the reason the new solutions and improvements are putting cogeneration units in new roles, faced with challenges to contribute to global energy and environment goals.

"The real success of a policy is found in its effects in the real world." This was the CODE project's main motivation in its collection and presentation of EU cogeneration case studies from different member states with the aim to:

- highlight policy successes and policy issues;
- make cogeneration visible and tangible through best practice cases;
- promote and disseminate knowledge of cogeneration to potential customers and suppliers of cogeneration in regional EU markets; and
- contribute to an enhanced understanding of the success factors and barriers to promoting cogeneration in the EU and proposals on how to overcome the latter.

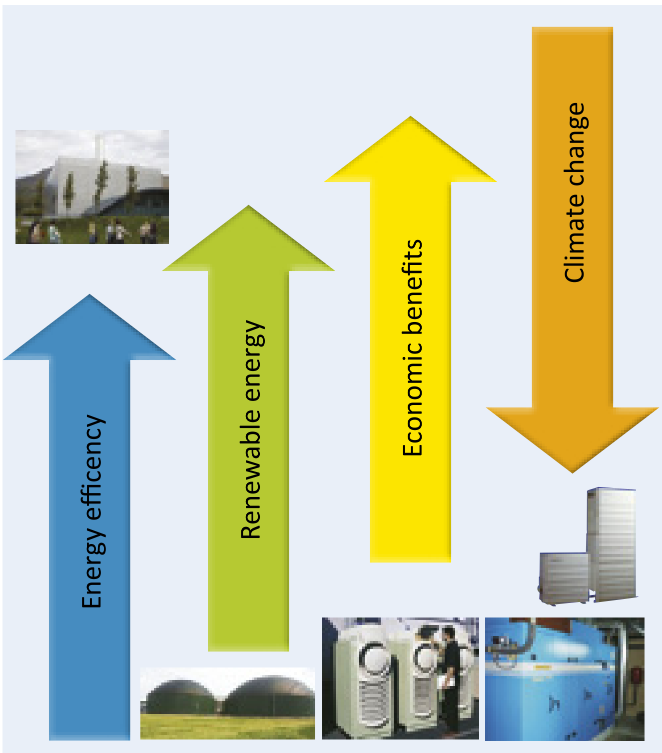


Figure 3: Key role of the future cogeneration

Best Practice Criteria

Linked to the current energy and climate policy targets and the feasible contribution of cogeneration to their fulfilment, we have shaped two clusters of "best practice" criteria to select the most interesting and successful cogeneration cases from the EU.

First of all, we applied the following general selection criteria:

- **Success cases from several aspects:** environmental, energy, technology, economic
- **New advanced/promising technologies and approaches** in cogeneration
- **A diversity of cogeneration applications** in different EU regions:
  - **Different sectors** (industry, district heating, buildings, agriculture etc.)
  - **Fuel diversity:** renewable fuels/hybrid solutions
- **High potential/no development, far from targets**

Based on today's cogeneration market applications, and bearing in mind the policy targets and all the collected cases, we have shaped the following best practice criteria for the final selection of 20 cases for the Handbook:

- **Sustainable highly efficient use of renewable energy sources:**
  - Biomass (solid, gas, liquid…)
  - Hybrid Solar & CHP unit
  - Dual fuel CHP (co-firing wood biomass, biogas…)
- **Highly efficient industrial applications:**
  - Close to a zero carbon footprint
  - Replacing old CHP with new BAT units
  - E-mobility – CHP as a source for charging electric cars
  - Efficient agricultural solutions
  - Prevention of pollution (efficient waste use)
- **Energy efficiency in buildings and the public sector:**
  - Highly efficient trigeneration plants (heat, electricity and cool supply)
  - Environmental and energy retrofit of CHP plants for district heat supply
  - Efficient heat supply with micro- and small-scale CHP units in buildings
  - Improved availability and reliability of energy supply
  - Energy contracting solutions

A very colourful palette of up-to-date cogeneration applications within the EU is already visible from the diverse best practice selection criteria, although a more detailed picture of cogeneration benefits, success factors and barriers emerges in the following chapters.

Statistics of Collected Case Studies

Statistics Overview

No. of Case Studies	35
Electrical Capacity Installed	899,1 MWe
Prevailing Region	
Northern Europe	57%
Prevailing Sector	
Industry	26%
Prevailing Technology	
Gas engine	71%
Prevailing Fuel Used	
Natural gas	68%
Prevailing System's Size	
From 1 to 10 MWe (Medium CHP)	37%

Statistics by Region

As part of the CODE project 35 case studies were collected, representing a variety of CHP systems of different sizes from different European regions and sectors that use different cogeneration technologies and fuels. The majority of cases (57%) come from the most developed Northern European Region, mainly from the United Kingdom and Belgium, covering sectors from industry and waste management to health and residential. Yet the case studies from Northern Europe contribute just 23% of the total 899.1 GWe electrical capacity installed, while the Eastern Region with its three presented cases, including the biggest one, accounts for more than 69%. The cogeneration boom seen in recent years in the South Eastern Region of Europe is represented by nine case studies from Greece and Cyprus, mainly from the hospitality and waste management sector, while the South Western Region contributed the remaining three case studies, two of which are medium and one large.

Out of 32 cities where observed CHP systems were installed, 10 (12 case studies) have signed the Covenant of Mayors:

- all three cities from the South Western Region of Europe (Madrid, Barcelona, Tavagnacco);
- one city each from the Eastern and South Eastern European Regions (Warsaw, Serres); and
- five cities which represent 35% of all case studies from the Northern European region (London, Brussels, Milton Keynes, Newcastle-upon-Tyne, Hamburg).

Statistics by Sector

One-quarter of the case studies come from industry, with food and beverages and pulp and paper production as the most common areas of cogeneration applications. Cases from industry typically involve an electrical capacity that exceeds 1 MWe, using gas engines or gas turbines as the main cogeneration technologies for efficiently providing heat to industrial processes. A further 29% of the case studies come from waste management, mainly in the South Eastern Region, and district heating where the cases are spread among all four regions. The CHP plant Siekierki from Poland which, with its 622 MW of electrical and 1,193 MW of thermal capacity, is the biggest of all the cases, is an example taken from the district heating sector. Despite the small share of cases from this particular sector, this sector represents 72% of all electrical capacity installed, demonstrating the big potential for cogeneration in district heating networks. Other cases cover the public sector, mainly from the Northern Region, as well as the health, residential and hospitality sectors (Figure 4).

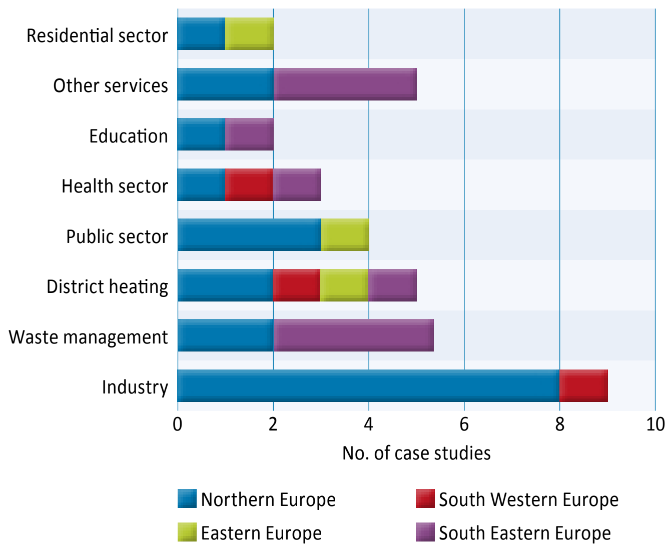


Figure 4: Number of case studies per sector and region

Statistics by Technology and Fuel Used

By far the most common cogeneration technology is the gas engine (71%; Figure 6) and the most commonly used fuel is natural gas (68%; Figure 5). The 25% share of cases involving the use of renewable energy either as the sole fuel or in combination with fossil fuels is encouraging.

Statistics of Collected Case Studies

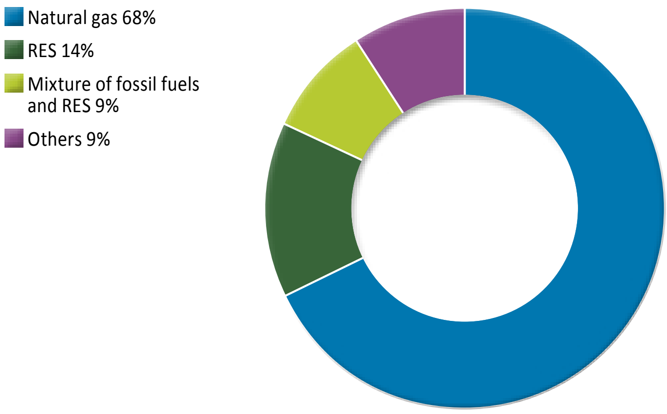


Figure 5: Share of different fuels used

Steam and gas turbines and combined cycle are applied in the industry, waste management, wastewater treatment and district heating sectors and the 12 steam turbines from four case studies represent 87% of all electrical capacity installed. Only in two cases are biofuel engines, using rapeseed oil and biodiesel, respectively, in operation. Next to rapeseed oil and biodiesel, black liquor is also used in the Finnish case from the pulp and paper industry and biogas in the Andriana and Tersefanou CHP plants from Cyprus. In 9% of all cases a mixture of fossil fuels and RES is used and in 6% municipal solid waste is used. Both cases where municipal solid waste is used as a fuel come from Northern Europe and both are large CHP systems.

The CHP systems from the collected case studies were produced by 23 different companies.

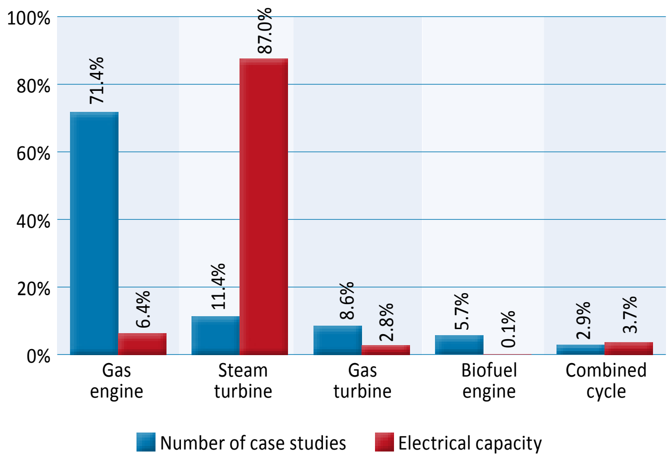


Figure 6: Share of case studies and electrical capacity installed per type of technology

Statistics by Size of the System

As regards the size of the system, the case studies may be divided into four groups:

- micro CHP (< 50 kWe);
- small CHP (50 kWe ≤ size < 1 MWe);
- medium CHP (1 MWe ≤ size < 10 MWe) and
- large CHP (≥ 10 MWe).

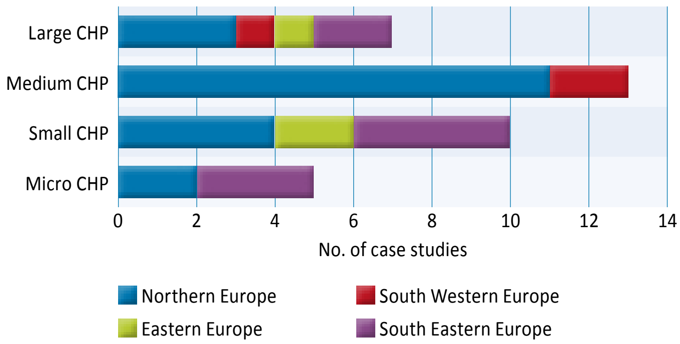


Figure 7: Number of case studies of different sizes per region

Most of the cases, 37% and 28%, respectively, are medium or small in size, while the smallest number of cases, only five, involves micro systems, mainly from the hospitality sector in Greece (Figure 7). However, it is interesting that one of the micro systems (12 kWe) also comes from industry – in Belgium they developed a very interesting demo mini-cogen unit where electric power for charging electric car batteries is a by-product of buildings' central heating systems.

Financing

Own financial sources were most commonly, in 15 cases, used for funding the installation of CHP systems. Together with a combination of own resources and loans (26%) and third party financing (20%), they represent almost 89% of all financial resources for the case studies (Figure 8).

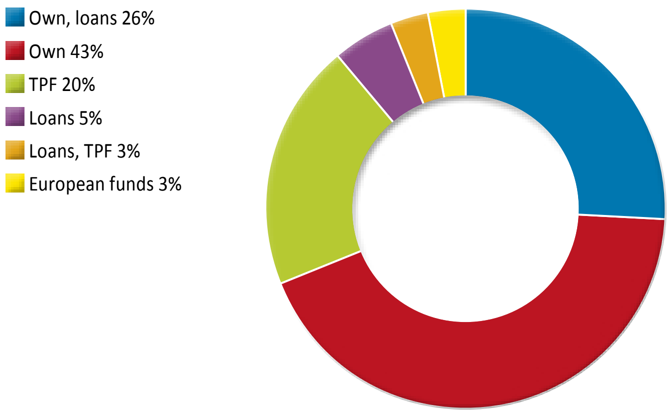


Figure 8: Share of different financial resources used

Statistics of Collected Case Studies

Most investments (23%) were supported by two different kinds of state support; for example, with green certificates and a tax reduction or investment subsidy and a feed-in tariff and a tax reduction or investment subsidy. In six cases the investors claim they did not receive any kind of state support and in 14% of the cases the support was only given through the feed-in tariff scheme.

As regards the costs for 1 kW of installed electrical capacity (Table 1; Figure 9), they vary from 640 €/kWe for the medium-size case in Belgium to almost 10 times more for a micro CHP system in Greece.

Table 1: Average costs in € per kW of electrical capacity installed *

	N Europe	SW Europe	E Europe	SE Europe	Total
Micro CHP	2.772			5.267	4.269
Small CHP	1.309		2.216	2.557	1.990
Medium CHP	1.623	1.788			1.650
Large CHP	3.273	758		1.662	1.838

* Due to their specific technology, two large systems using municipal solid waste as a fuel were excluded from the calculation of specific costs.

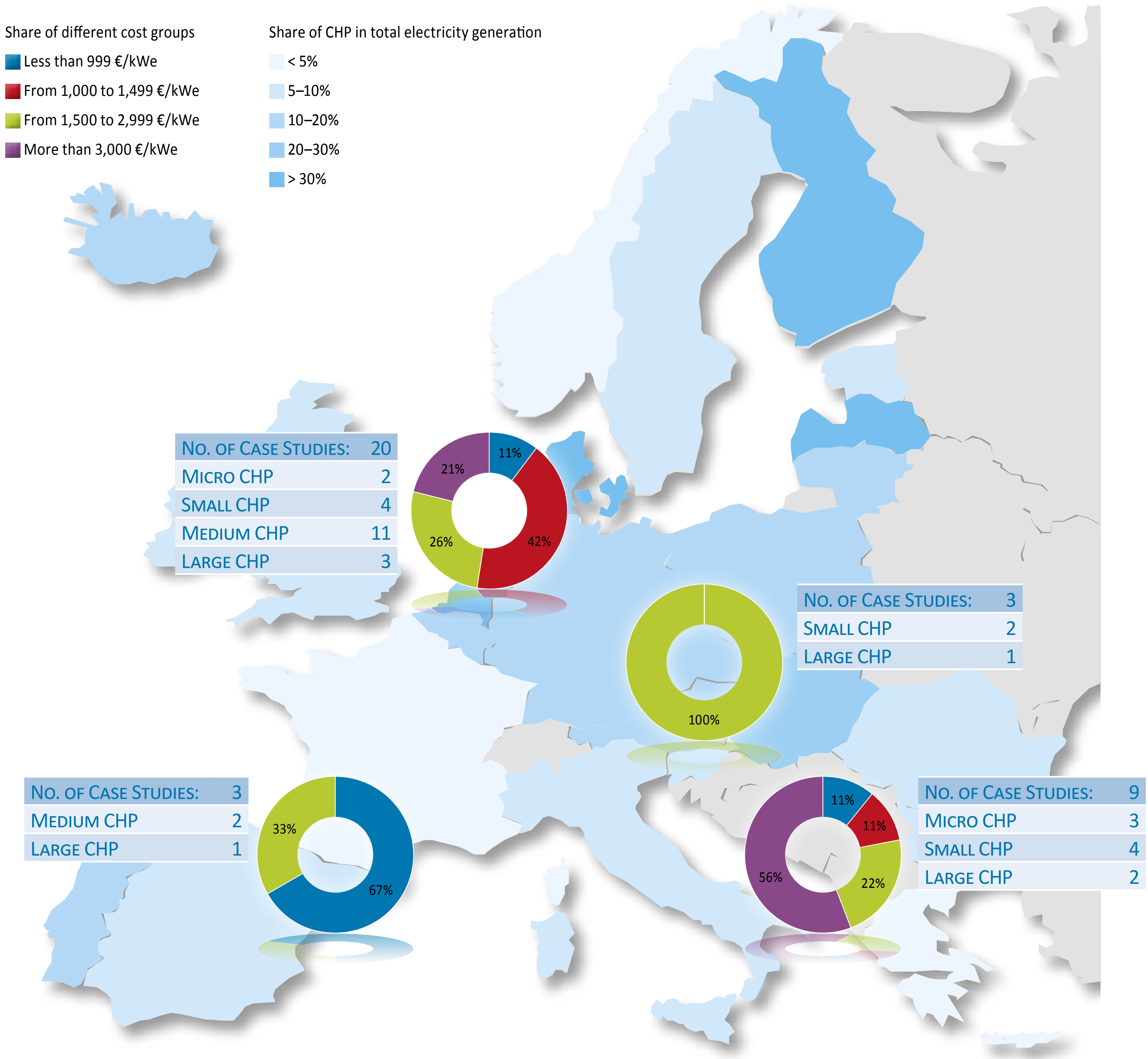


Figure 9: Share of different cost groups (€ per kW of electrical capacity installed) in different region; share of CHP in total electricity generation (map in the background)

PRICEWATERHOUSECOOPERS, 7 MORE – LONDON

PROFESSIONAL SERVICES

GENERAL DESCRIPTION

Each system comprises a 400 kWe biodiesel reciprocating engine coupled with a multi-energy chiller mounted directly above the engine enclosure to create a "double decker" configuration. The units are fully integrated with the site BMS control system to meet all the electrical and thermal load requirements.

MAIN INDICATORS

ELECTRICAL CAPACITY (TOTAL)	0.8 MWe
HEAT CAPACITY (TOTAL)	0.83 MWth
TECHNOLOGY	Biodiesel reciprocating engine
NO. OF UNITS	2 x 0.4 MWe
MANUFACTURER	Dresser-Rand Company Ltd
TYPE OF FUEL	Biodiesel
ELECTRICITY (YEARLY GENERATION)	2.5 GWh
HEAT (YEARLY GENERATION)	9,323 GJ
YEAR OF CONSTRUCTION	2009
TOTAL INVESTMENT COST	EUR 1.3 million
FINANCING	Own funds
STATE SUPPORT	Feed-in tariff, tax reduction, planning
LOCATION	London, UK http://www.morelondon.com
INFORMATION	http://www.dresser-rand.com/products/CHP/aircogen.php

Roger Preston & Partners were responsible for designing all of the base build engineering services and systems for the building. The tenant, PricewaterhouseCoopers (PwC), together with its designers BDP, is committed to reducing corporate carbon footprint targets. 7 More London Riverside's sustainable base build credentials were a key to helping them maintain and deliver this ethos.

SUCCESS FACTORS

7 More London Riverside is the first office building in England to achieve the BREEAM "Outstanding" rating. BREEAM (Building Research Establishment Environmental Assessment Method) is an environmental standard for buildings which determines best practices in sustainable design and in the UK is used to describe a building's environmental performance.

The key design aspect that assisted in obtaining the "Outstanding" rating was the implementation of Dresser-Rand's bio-diesel fired combined cooling heating & power (CCHP) trigeneration system which has been used to provide a low carbon source of cooling, heat and power to the building. This has resulted in 74% less CO_2 emission than that required under the 2006 Part L2 Building Regulations.

MAIN BARRIERS

The unique challenge for Dresser-Rand was designing a dual-level system to accommodate the space restrictions in the plant room. The integration of a biodiesel reciprocating engine and multi-effect chiller was the first of its type within the UK.

Mini CHP for E-Mobility

Manufacturing

Main Indicators

Electrical capacity (total)	12 kWe
Heat capacity (total)	24 kWth
Technology	Motor engine
No. of units	1
Manufacturer	E. Van Wingen NV
Type of fuel	Natural gas
Electricity (yearly generation)	30 MWh
Heat (yearly generation)	60 MWh
Year of construction	2009
Total investment cost	EUR 35,000
Financing	Own funds
State support	Investment subsidy, green certificates, tax reduction
Location	EVW, Evergem, Belgium

General Description

While cogeneration is not a new technology, EVW has innovated the concept by establishing a link with e-mobility. By regarding the power needed to drive an e-vehicle as a by-product of a building's central heating system, impressive reductions in CO_2 emissions can be achieved.

The demo mini-cogen unit at EVW shows that 42% of primary energy can be saved on electric driving if a car's battery is charged with electricity derived from cogeneration. The company uses ten times more energy for driving than for meeting daily electricity needs. Since EVW's power consumption pattern will not be too different from that of an average SME, the 42% economy on primary energy in terms of mobility is realistically within reach of almost any company. At EVW it translates into the same result as if reducing electricity consumption by one-third.

Success Factors

The concept of combined heat (mobility) and power has received very positive acclaim from the champions of cogeneration, academics, engineering consultants and business managers alike.

Main Barriers

The main barrier is the price of the obligatory mains coupling protection equipment from 10 kWe onwards. This limit should be raised.

Recommendations

Adding e-mobility to the concept of combined heat and power deserves a separate financial impetus. Without green credits, the pioneers of electric driving might overlook that the independent and efficient generation of electricity is both beneficial and necessary. This is an opportunity not to be missed to give a real boost to the green economy.

De Clare Court, Haverfordwest

Residential Sector

General Description

De Clare Court is a development of 40 flats offering extra care facilities for older people. The client, the Pembrokeshire Housing Association, engaged the services of the consulting engineer, Chris Le Breton, who advised on the most suitable low carbon technology. Two Dachs mini-CHP units were installed in the main plant room to meet the building's base heating and electrical requirements.

Each of the Dachs generates 5.5 kW of 3-phase electricity and the 12.5 kW thermal output is passed into the building's primary central heating system to supplement the peak load boilers. The Dachs has an integrated grid interface which complies with the G83/1 Engineering Recommendation and the electricity generated is passed directly into the building circuits, thereby displacing an equivalent amount of grid-supplied electricity; any electricity shortfall is made up by the grid and any excess generated is exported to the grid without the need for any external grid protection equipment.

An MSR2 controller sequences the operation of the two Dachs units and ensures they operate efficiently and reach their maintenance time simultaneously. An integrated modem allows comprehensive off-site monitoring and service notification and also enables the end-user to interrogate and download operational data from the CHP plant via SenerTec's web-based DachsPortal link.

Success Factors

The Dachs installation at De Clare Court has proved to be extremely successful and is averaging 20 hours/day running time throughout the year, saving around 25 tonnes of CO_2. In addition, the financial savings are meeting expectations and will continue to increase as the cost of grid-supplied electricity rises.

Main Indicators

Electrical capacity (total)	11 kWe
Heat capacity (total)	25 kWth
Technology	4-stroke, single cylinder internal combustion engine
No. of units	2
Manufacturer	SenerTec GmbH
Type of fuel	Natural gas
Electricity (yearly generation)	80 MWh
Heat (yearly generation)	182 MWh
Year of construction	2006
Total investment cost	New build project – CHP investment approx. £25,000
Financing	Capital purchase by end-user client
Location	Haverfordwest, Pembrokeshire, UK
Information	http://www.baxi-senertec.co.uk http://www.pembs-ha.co.uk

Main Barriers

No barriers were encountered.

Recommendations

The highly satisfactory operation of the Dachs mini-CHP installation at De Clare Court was achieved by ensuring that the heating system temperatures were suitable for the optimum plant operation and that the control strategy for the whole heating plant was correctly designed.

The Dachs operates on heat demand and it is vital to make sure that any heat-led CHP is scheduled to operate first, before the boilers are switched on, so as to be allowed to keep up with the heat demand for as long as possible. This will promote maximum running time which will optimise the electricity generation potential. These conditions were implemented at De Clare Court and have resulted in an installation profile which has been successfully repeated in many similar projects throughout the UK.

Docent Katholieke Hogeschool Kempen, "Hortipower"

Education and Agriculture

Main Indicators

Electrical capacity (total)	8.6 MWe
Heat capacity (total)	9.54 MWth
Technology	Motor engine
No. of units	1
Manufacturer	Rolls Royce
Type of fuel	Natural gas
Electricity (yearly generation)	34 GWh
Heat (yearly generation)	142.5 PJ
Years of construction	2009 – 2010
Total investment cost	EUR 5.5 million
Financing	Loans
State support	Investment subsidy, certificates
Location	Merksplas "koekhoven", Belgium

Success Factors

It is expected that gas and electricity prices, combined with the Belgian certificate prices, will enable the CHP plant to run profitably on minimal running hours. The CHP will run for Hortipower for 5,500 hours a year.

General Description

In the initial phase of the greenhouse-complex development a "Hortipower" biomass burner of 4.9 MWth was installed (9.6 ha). In the second phase (towards 15 ha) a CHP engine (Rolls Royce) of 8.6 MWe was installed.


Both installations deliver heat to the greenhouse as well as CO_2-nutrion for the tomatoes. As the fuel is natural gas, a SCR catalyst can purify the exhaust gases so that they can be utilised in the greenhouse for the tomato plants. The main goal of installing a CHP engine was to reduce the overall energy costs and the electricity is mainly sold.

Main Barriers

The Rolls Royce engine runs on gas pressure of 4.5 bar; however, the Belgian regulation only permits 0.5 bar at a greenhouse site. An expensive booster has therefore been installed to increase the pressure. In addition, connection to the electrical grid took time and a lot of communication.

Recommendations

Undertaking financial calculations before the start of the project is the key. Government support makes efficient energy use possible and it is important to reach the 20-20-20 goals.

MVR RUGENBERGER DAMM HAMBURG

WASTE MANAGEMENT

GENERAL DESCRIPTION

The MVR plant is situated in the south-western part of Hamburg, in the port area of Hamburg-Altenwerder.

Plant details:
- throughput of approx. 320,000 t/a of waste;
- two lines in operation with a waste throughput of 21.5 tonnes per hour and line;
- one extraction condensing turbine;
- steam parameters 400 °C / 40 bar;
- production of process steam, district heat, electricity; and
- hydrochloric acid, gypsum, slag and metal scrap recovery.

SUCCESS FACTORS

The local government's aim was to end a landfill of untreated waste (legally required in Germany since 01.06.2005).

Construction of the MVR plant was primarily based on the experiences of a similar plant in Hamburg (MVB).

The MVR plant was constructed according to state-of-the-art specifications and therefore meets the highest standards of safety, workplace safety, environmental protection and availability.

Operating efficiency is increased through close co-operation with sister companies (intensive collaboration, exchange of information).

The chosen location is well connected with regard to access to energy infrastructure.

MAIN INDICATORS

ELECTRICAL CAPACITY (TOTAL)	29 MWe
HEAT CAPACITY (TOTAL)	70 MWth
TECHNOLOGY	Steam turbine
NO. OF UNITS	1
MANUFACTURER	AE&E
TYPE OF FUEL	Municipal solid waste
ELECTRICITY (YEARLY GENERATION)	75 GWh
HEAT (YEARLY GENERATION)	48 GWh district heating 480 GWh process steam
YEAR OF CONSTRUCTION	1999
TOTAL INVESTMENT COST	EUR 254 million
FINANCING	Own funds, KfW-Loans
STATE SUPPORT	KfW-Loans
LOCATION	Hamburg, Germany

MAIN BARRIERS

Residents were concerned about a possible increase in waste disposal fees.

RECOMMENDATIONS

- The participation of local residents from an early stage of the project.
- Reliability: contracts ensuring long-term, secure and sustainable waste management.
- A favourable location: access to the grid (electricity) and infrastructure (heat and process steam).

MUSEUM OF LIVERPOOL

PUBLIC SECTOR

MAIN INDICATORS

ELECTRICAL CAPACITY (TOTAL)	2.3 MWe
HEAT CAPACITY (TOTAL)	2.4 MWth
TECHNOLOGY	Motor engine
NO. OF UNITS	4
MANUFACTURER	2 x Scania, 2 x MTU
TYPE OF FUEL	2 x natural gas, 2 x biodiesel
ELECTRICITY (YEARLY GENERATION)	2.39 GWh
HEAT (YEARLY GENERATION)	–
YEAR OF CONSTRUCTION	2010
TOTAL INVESTMENT COST	EUR 4.4 million
FINANCING	Third party financing, contracting
STATE SUPPORT	Certificates, tax reduction
LOCATION	Liverpool, UK
INFORMATION	http://www.hilldickinson.com

GENERAL DESCRIPTION

National Museums Liverpool required a contractor to design, build, finance and operate a new energy facility, complete with a plant that would provide heat, cooling and electricity at the new Museum of Liverpool, which was already under construction.

The project had to be off-balance-sheet under current UK accounting rules and needed to be repaid through guaranteed savings. All the finance had to be provided by the supplier and the contract had to provide for the supplier to take full responsibility for all maintenance, repairs and upgrades for the life of the contract.

The solution had to meet the entire heat supply of low pressure hot water for the museum (estimated at 1,200 kW peak), supply a peak electrical load of approx. 2 MW, and supply chilled water of between 600 (base load) and 1,400 kW (peak load) of cooling capacity.

Hill Dickinson was responsible for drafting a complex series of agreements between National Museums Liverpool and Ener-G Combined Power (the contractor chosen under the competitive dialogue procurement process). The contracts set out Ener-G's commitment to design and install its proposed energy solution for the new museum by early 2010 and then to operate and maintain the installation for a term of 17 years. The contract includes a clause from the contractor that guarantees £500,000 of energy and operational costs will be saved annually against the energy expenditure which NML had projected it would have spent at the new museum, had it not outsourced its requirements in this way.

These sets of agreements guarantee both parties certainty as to their rights and obligations throughout the contractual period. Hill Dickinson's in-depth experience of energy projects of this nature projects made this process far quicker, easier and cost effective.

Under the contract Ener-G has installed and will operate a modern, trigeneration CCHP system predominantly comprising:
- 2 x MTU 768 kWe gas CHP engines;
- 2 x Scania 340/385 kWe bio-diesel CHP engines;
- a Carrier screw chiller with a cooling capacity of 998 kW;
- a Carrier absorption chiller with a cooling capacity of 1,000 kW; and
- the associated bio-fuel store, heat exchangers, pumps, LPHW pipework, controls, valves, thermal insulation and wiring.

The project will make use of the adjacent historical Great Western Railway building, turning it into the energy centre for the newly-built museum building, with glass fronting meaning the equipment itself can be viewed as part of the exhibition.

SUCCESS FACTORS

More than £500,000 of guaranteed savings each year – as the project relates to the provision of energy facilities for a newly-built museum, identifying a saving in energy consumption is not possible as there is no benchmark year of consumption to make savings against. However, on-site generation is far more efficient than grid-sourced electricity and supplementary heating boilers/electric coolers since the heat generated during electricity generation is put to good use. As a result, National Museums Liverpool has been able to secure from Ener-G a financial guarantee of more than £500,000 of annual energy and operational savings.

Public Private Partnership (PPP) – a complex PPP agreement was drawn up by Hill Dickinson whereby Ener-G would assume the financial, technical and operational risk of the energy project. Ener-G arranged its finance through the Co-operative Bank, which prides itself on being one of the leading financial institutions lending to this sector. Using a PPP structure in this way meant there was no requirement for any capital outlay by National Museums Liverpool.

Reduced greenhouse gas emissions – similarly to calculating financial savings, calculating the reduction in CO_2 and other gas emissions is difficult for a new build as there is no benchmark year for comparison. However, three main features of the project lead to reduced greenhouse gas emissions:

Museum of Liverpool

Public Sector

- Total efficiency of nearly 80% for CHP compared to less than 40% for individual heat or electricity generation means more energy is utilised for the same amount of fuel burnt, resulting in fewer emissions.
- The plants used to create the biodiesel fuelling some of the CHP units have absorbed CO_2 from the air during their lifetime, meaning this fuel produces less additional carbon dioxide when it is burnt.
- On-site electricity generation reduces the transmission losses associated with grid-sourced electricity, making it more carbon friendly.

Use of innovative technology – the CHP system uses absorption chillers to provide cooling during warmer months. This technology utilises the heat produced by the CHP units to produce chilled water (which can be used in air conditioning), allowing the CHP engines to be run with high efficiency even during summer when heat would otherwise go to waste.

Greater reliability and lower risk – Hill Dickinson helped National Museums Liverpool secure a guarantee that their required level of heating, electricity and cooling will be available 100% of the time – if this level of reliability cannot be met by the CHP equipment and absorption chillers, then Ener-G must ensure there is adequate standby equipment to prevent service disruption. Failure to do so will result in financial recompense to NML.

Main Barriers

The new museum is located on a UNESCO World Heritage site, a status which is highly valued by the city. Therefore, several views across the site are protected, and there are many listed buildings in the vicinity, so Hill Dickinson had to advise on limiting the effect of the new museum on the surroundings. One example of how this has been done is through the innovative lack of a tall chimney for the facility, with smaller flues and clean burn technology being utilised to good effect.

The waterfront position and historic buildings surrounding the new museum have meant that the new museum is isolated from gas and electricity mains. Hill Dickinson advised National Museums Liverpool on linking the new facility into the national electricity and gas networks and increasing the capacity of these links to provide sufficient capacity for the new museum.

Whilst the new museum was being built several other developments were also taking place on the adjacent sites. Particular consideration had to be given to integrating the energy facilities with the new Leeds-Liverpool canal link, which runs directly alongside the energy centre and museum, effectively sandwiching the museum between the canal and the River Mersey.

It was part of National Museums Liverpool's brief that the project remained off the balance sheet of the Department for Culture, Media and Sport (DCMS), despite the introduction of new financial reporting rules (most notably IFRIC 12). Hill Dickinson managed to structure the project under these new rules so that the project remains off the DCMS balance sheet, avoiding capital charges and depreciation for National Museums Liverpool.

Recommendations

Recommendations are to seek advice from consultants that have delivered several of these types of projects in the past, and to make sure that you are achieving the best value for money and terms and conditions. This includes seeking advice from specialist lawyers who can ensure that each party's rights and obligations are clearly set out in the contract, ensuring that each party keeps to their part of the bargain. In addition, specialist lawyers can assist public sector organisations in the navigation of the complex public procurement regulations which usually apply to these types of projects.

Whilst it is possible for an organisation to fund a project directly, or to borrow funds to purchase CHP equipment, it is usually far more desirable for an organisation to transfer the design, installation, financial and operational risk to a specialist contractor which has the experience and resources necessary to ensure that the equipment is run as efficiently as possible. In most cases, this risk transfer comes at no additional net cost to the consumer as the higher efficiencies afforded by specialist contractors pay for themselves.

Hospital Central de la Defensa "Gómez Ulla"

Health Sector

Main Indicators

Electrical capacity (total)	5.8 MWe
Heat capacity (total)	6.1 MWth
Technology	Motor engine
No. of units	2
Manufacturer	Deutz (MWM)
Type of fuel	Natural gas
Electricity (yearly generation)	45 GWh
Heat (yearly generation)	47 GWh
Year of construction	2003
Total investment cost	EUR 5.5 million
Financing	Own funds, loans
State support	Feed-in tariff
Location	Madrid, Spain

General Description

Built in the Central Hospital "Gómez Ulla", the plant was projected and set up by "La Energía, S.A. and Gas Natural Electricidad SDG" in 2003. The installation consists of a 5.8 MWe motor engine plant and covers the electric and thermal demands of the whole hospital 24 hours per day. Heat is used to generate steam for the kitchens, laundry and sterilisation of materials, hot water for heating, sanitary hot water and cold water for climatisation.

Success Factors

The main benefits of the plant's construction and the operation carried out by La Energía S.A. are:

- a significant reduction of electricity costs (EUR 2.8 million in 2008);
- the minimisation of greenhouse gas emissions; and
- the renovation and updating of energetic installations, increasing their energy efficiency, availability, reliability and maintenance parameters.

The legal framework in which the plant was developed is the one previous to the EU 2004/8/CE Directive implementation. In Spain the main RD in force at that time for regulating CHP plants was RD 841/2002.

A factor that should be taken into account was the granting of a €500,000 subsidy by the state organisation "IDAE" that substantially reduced the total investment. This type of subsidy is no longer granted. There is a grant line from IDAE for individual innovation projects, but not for projects similar to this one (only for an innovation and a non-industrial CHP project), even if the performance of the plant is really good.

Engine room

Main Barriers

No relevant barriers were encountered during implementation of this project.

Conclusions

Thanks to the combined electricity and heat production, 16% of primary energy is saved along with a high percentage of greenhouse gas emissions. These kinds of projects have great success and should be applied in many other installations in the health and services sector.

Heat recovery boiler

"Hypo Alpe Adria" Trigeneration Plant

District Heating and Cooling

General Description

The "Hypo Alpe Adria" trigeneration plant is located in Tavagnacco (UD) in the north-eastern part of Italy.

In the northern part of the district of Udine, a residential area with several public and private buildings, including a swimming pool, a hotel, an Italian bank's headquarters and other facilities in the service of the community, has been developed.

With a view to rational energy use, rather than providing each building with a single heating system to produce hot water for heating and cold water for air conditioning, AMGA Calore & Impianti srl proposed and subsequently funded a trigeneration plant that can produce both thermal and cooling energy. CHP involves a natural application for producing electricity to be supplied to the Italian public network, using thermal energy to heat buildings during winter and producing cold water in summer by means of an absorption chiller. The "Hypo Alpe Adria" plant includes a CHP motor engine with 1 MW of electrical and about 1.3 MW of heat capacity. In addition, two heat boilers with 1.2 and 2.0 MW of heat capacity have been installed. The cooling plant includes two chillers with 1 MW of cooling capacity and an absorption chiller with 0.5 MW of cooling capacity.

Success Factors

The "Hypo Alpe Adria" trigeneration plant was the first of its kind to be installed in the district of Udine, although other projects including cogeneration and district heating are now in an advanced development state. High-level engineering enabled minimisation of the time needed and problems with commissioning the plant. Thanks to the widespread use of an electronic PLC the plant can operate unmanned. Remote control through the Internet network allows the operating parameters to be monitored and modified in real time. The attendance of maintenance personnel is only required if clearly needed.

Main Barriers

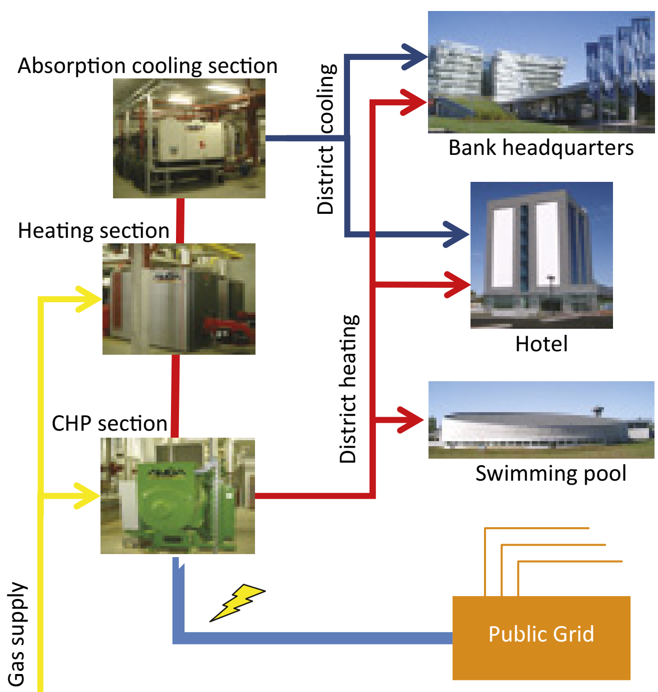
The main barriers encountered in the diffusion of this technology relate to the many laws and regulations in force in Italy. Moreover, the nation is emerging from a long period in which electricity was a nationalised good. New power plants can therefore supply electricity to several users, either adjoining or in different regions, but they have difficulties complying with the various regulations.

Main Indicators

Electrical capacity (total)	1.06 MWe
Heat capacity (total)	1.27 MWth
Technology	Motor engine
No. of units	1
Manufacturer	Jenbacher
Type of fuel	Natural gas
Electricity (yearly generation)	2.37 GWh
Heat (yearly generation)	2.57 GWh
Year of construction	2006
Total investment cost	EUR 2.8 million
Financing	Own funds
State support	Certificates, tax reduction
Location	Tavagnacco, Italy

Recommendations

This project is an example of good implementation and shows it is also possible to make other plants with the same technology. Before starting such projects, feasibility studies must be carried out in any case, followed by good engineering. The management and maintenance of such plants should be performed regularly by skilled personnel.



UIPSA Cogeneration Plant

Paper Production

Main Indicators

Electrical capacity (total)	33 MWe
Heat capacity (total)	52.6 t/h
Technology	Combined cycle
No. of units	1
Manufacturer	GE
Type of fuel	Natural gas
Electricity (yearly generation)	250 GWh
Heat (yearly generation)	265 GWh
Year of construction	2008
Total investment cost	EUR 25 million
Financing	Loans
State support	Feed-in tariff
Location	La Pobla de Claramunt, Barcelona, Spain

The preliminary study also received a state subsidy that was not significant in terms of the overall project investment but interesting in order to promote innovation and high efficiency studies in Spain.

General Description

The installation is associated with the UIPSA paper plant and is based on a combined cycle with an aeroderivated 28 MW gas turbine (GE LM2500), a 3.9 MW steam back-pressure turbine and a 1.7 MW condensation turbine (to modulate excess steam). The steam generator (from exhausted gases) produces high and low pressure steam and has a biogas post-combustion stage.

Main Barriers

The main barrier encountered during execution of the project was the connection to the electrical grid. Although the electrical connection available in the plant before the modification had enough power for the new CHP plant, the electrical company demanded a new exclusive connection at a higher voltage. This detail increased the investment significantly and caused a longer execution phase.

Success Factors

The installation was built to replace the old CHP plant (7 MW) at the end of its life. The new plant is bigger and was designed after taking account of the paper plant's growth perspectives and using the latest high efficiency technologies and best equipment available. The legal framework in force during the construction (RD 661/2007), as well as the future energy scenarios were really positive and guaranteed the plant's technical and economical viability.

Recommendations

The adopted technical solution is considered really successful and efficient for all plants with similar requirements. This CHP installation provides a benchmark for the Spanish paper sector due to its efficient performance and the savings achieved.

We strongly recommend taking into account potential problems of connection to the electrical grid already in the first steps of the study.

CHP Plant Siekierki, Warsaw

District Heating

General Description

CHP Siekierki is the biggest cogeneration plant in Poland based on hard coal, supplying district heating to the EU's largest district heating system in Warsaw. Its basic production facilities include eight steam boilers and nine steam turbines with a total electrical capacity of 622 MW and 2,078 MW of total heat capacity. Additional units include six peak water boilers (884 MW). Some significant improvements have been made at the Siekierki CHP plant in the last 10 years:

- reconstruction of a K-2 boiler with a $DeSO_x$ installation;
- replacement of two old turbines (Tz9 and Tz10) for increasing the cogeneration capacity (2009);
- ecological investments in the modernisation of electrostatic precipitators to reduce ash emissions (50 mg/Nm^3, 50% less than the legally binding standard), installation of low NO_x burners and an ongoing $DeSO_x$ programme (200 mg/Nm^3),
- a heat accumulator (capacity 5,760 GJ) is improving the cogeneration ratio (2009); and
- a biomass co-combustion installation for 70 kt of biomass yearly.

Success Factors

The new market situation (economic, ecological) is the main driving force behind the continuous improvements. The "green certificate" supporting scheme is helping to develop the cogeneration and renewable energy sources market in Poland.

Main Indicators

Electrical capacity (total)	622 MWe
Heat capacity (total)	1,193 MWth
Technology	Steam turbine
No. of units	9
Manufacturer	Rafako/Siemens/Alstom/Zamech
Type of fuel	Coal, biomass (2009)
Electricity (yearly generation)	2,000 GWh
Heat (yearly generation)	5.82 PJ
Year of construction	1961, improvements in the 2001-2009 period
Total investment cost	Unknown due to historical conditions and modernisation in the meantime
Financing	Own funds, loans
State support	Green certificates
Location	Warsaw, Poland

Main Barriers

- Lack of an efficient support scheme for CHP.
- The age of the equipment.

Recommendations

There is still a lot of potential for further improvements; CHP Siekierki also intends to replace turbines in the block part. Further, there are plans to construct a modern high-efficiency power unit (480 MWe, 500 MWth, 45% net electric efficiency) in the future so as to replace the worn-out collector part. There is still huge potential in Poland for the retrofit of old CHP plants in district heating systems to bolster the economic competitiveness of heat supply and reduce environmental pollution.

CHP Plant in the Novo mesto Boarding School

Public Sector

Main Indicators

Electrical capacity (total)	50 kWe
Heat capacity (total)	81 kWth
Technology	Motor engine
No. of units	1
Manufacturer	Viessman
Type of fuel	Natural gas
Electricity (yearly generation)	204 MWh
Heat (yearly generation)	324 MWh
Year of construction	2010
Total investment cost	EUR 110,000
Financing	Own funds (25%), loans (75%)
State support	CHP legislation
Location	Novo mesto, Slovenia

General Description

In the Novo mesto boarding school, the renovation of a boiler plant and installation of a CHP plant with a capacity of 50 kWe and 81 kWth was carried out by the company Energen, d. o. o. The fuel used is natural gas. Before installing CHP, heat consumption was greater than initially planned, heating system losses were large and the building was energy wasteful. By installing CHP, better energy efficiency and lower losses than before were achieved, while energy costs and CO_2 emission levels were also reduced. Heat is used for the heating and preparation of sanitary hot water on-site only, while 80% of the electricity is used on-site and 20% is sold to the grid.

Success Factors

By means of legislation or state support for electricity production in CHP plants, the Novo mesto boarding school achieves significant savings. Two kinds of support are available: guaranteed electricity purchase if electricity is only produced and sold to the grid, and financial help for the operation of those plants where electricity is used on-site. Such supports are ensured for a period of 10 years.

Main Barriers

The main barriers encountered when undertaking this project are related to obtaining an agreement for the connection of an individual building where CHP is installed to the electrical grid. Namely, this procedure takes a lot of time since distributors do not have suitable knowledge as regards the legislation and novelties in the field of financial support.

The second important barrier is the high price of natural gas because even greater savings could be made if the price was lower and this would thereby also reduce the investment payback period.

TROJA BLOCK OF FLATS

HOUSEHOLDS

GENERAL DESCRIPTION

More than 80% of the electricity consumption and more than 50% of the heat consumption of 650 flats is covered by electricity and heat produced in CHP units installed inside the block of flats. Electricity from CHP is distributed directly to consumers through a local grid and the shortfall of electricity is bought from the regional distribution grid. The CHP output power is regulated according to electricity consumption. The maximum power demand of the connected buildings is 360 kWe. The heat produced is used to prepare warm water. Additional heat to heat the building is bought from a district heating system.

CHP units with heat accumulators are placed in the parking area of the building.

The price of electricity from this CHP plant is equal to that of Prague's main electricity seller, while the price of the heat is significantly less (25%) than the price of the main heat seller in Prague.

The CHP units can be used as a back-up power supply.

MAIN INDICATORS

ELECTRICAL CAPACITY (TOTAL)	300 kWe
HEAT CAPACITY (TOTAL)	450 kWth
TECHNOLOGY	Motor engine
NO. OF UNITS	2
MANUFACTURER	TEDOM
TYPE OF FUEL	Natural gas
ELECTRICITY (YEARLY GENERATION)	1.5 GWh
HEAT (YEARLY GENERATION)	7.5 TJ
YEAR OF CONSTRUCTION	2002
TOTAL INVESTMENT COST	EUR 670,000
FINANCING	Own funds
STATE SUPPORT	Investment subsidy (30%), feed-in tariff
LOCATION	Prague, Czech Republic
INFORMATION	tomas.bicak@rwe.cz

SUCCESS FACTORS

- The main success factor of the project is the direct sale of electricity and heat to the flats and small commercial premises.
- A significant success factor in the legislation is a power bonus which is guaranteed by law for a minimum of 6 years.

MAIN BARRIERS

- The number of electricity consumers and their changes of electricity seller.
- The decrease in the number of electricity consumers is causing lower utilisation of the CHP unit and therefore increasing the price of heat.

RECOMMENDATIONS

- A main agreement with the flat owners and the delivery of information are necessary.

Aegean & Egnatia Hotels

Hospitality Sector

Main Indicators

Electrical capacity (total)	40 kWe
Heat capacity (total)	86 kWth
Technology	Motor engine
No. of units	2
Manufacturer	PowerTherm Energie Systeme GmbH
Type of fuel	Natural gas
Electricity (yearly generation)	145 MWh
Heat (yearly generation)	360 GJ
Year of construction	2006
Total investment cost	EUR 142,700
Financing	Own funds
State support	Investment subsidy
Location	Thessaloniki, Greece
Information	http://www.estiaconsulting.gr

General Description

ESTIA Consulting & Engineering S.A. installed 2 micro CHP units in the "EGNATIA" and "AEGEAN" hotels, situated within the city centre of Thessaloniki, Greece.

The micro CHP unit is based on a natural gas engine, coupled with a synchronous electrical generator and heat exchangers.

Hot water for the hotels is produced by recovering heat. Hot water is used continuously as sanitary hot water throughout the whole year, while during winter it is also used for space heating, saving light fuel oil.

The micro CHP units work together with a system of solar collectors for hot water production and are among the first "hybrid RES & CHP" installations in Greece.

Finally, the annual estimated profit from this micro CHP project is about €14,000 per hotel, thus making the investment viable.

Success Factors

Implementation of the CHP project in the "EGNATIA" and "AEGEAN" hotels is deemed successful. State support was crucial to the viability of the project, despite the barriers.

ESTIA Consulting & Engineering S.A. aims to implement other similar projects in Greece, either with state support or private funds.

Since the legislation on renewable energy sources in Greece is becoming mature, cogeneration is becoming ever more attractive as an investment.

Main Barriers

The barriers encountered in this project are mainly bureaucracy and the price of natural gas (2006).

In Greece bureaucracy is the main obstacle for such investments and a considerable amount of time is needed to deal with it. The price of natural gas, which affects the profitability of the investment, depends on the supplier's tariff policy.

Recommendations

With its technical experience in cogeneration, ESTIA Consulting & Engineering S.A. aims to install new applications in hotels, buildings and complexes.

ESTIA is also active in the industrial sector and plans to implement a CHP plant in a heavy clay industry.

CHP in Educational – Athletic – Conference Facilities

Education

General Description

Founded in 1917, Doukas S.A. is an organisation that facilitates all three stages of compulsory education, as well as the up-to-date top ranking Athletic & Conference Centre "Dais".

Always sensitive to environmental issues and innovative technologies, management focused on the reduction of energy consumption and decided to exploit primary energy from a CHP unit installed in its facilities under a third party financing scheme. The energy produced (electrical and thermal) is currently self-consumed, while in the near future excess electricity will be sold to the grid.

The 340 kWe CHP unit is a perfect example of maximum energy efficiency, deriving from the top quality equipment that is installed and integrated in the existing building infrastructure.

Main Indicators

Electrical capacity (total)	340 MWe
Heat capacity (total)	680 MWth
Technology	Motor engine
No. of units	1
Manufacturer	Dresser Waukesha
Type of fuel	Natural gas
Year of construction	2009
Total investment cost	EUR 450,000
Financing	Third party financing
State support	-
Location	Athens, Greece
Information	http://www.doukas.gr

Success Factors

Leading the way in applying innovative financing practices (third party financing, TPF) in the Greek energy market, the project not only offers cheaper energy to its end-user without investment costs, but the end-user also acquires the actual equipment at the end of the time period in the contract.

Due to the supply of heat from CHP, the operation of existing gas boilers is limited to emergency cases, thus reducing air pollutants and increasing overall efficiency.

Under the given scheme, the supply company – Heliostat Ltd. – undertakes maintenance and fuel costs and delivers green energy.

Applications of such environmentally friendly technologies are in line with the company's ambition to nourish and cultivate students' ecological consciousness.

Main Barriers

Given that the national energy policy has been undergoing reform in the last few years, it has been difficult to create a "win-win" formula for both the supply company and the end-user. Results of the first trial operating period indicated that further improvements are needed on the contractual side in order to cover more operation modes of the unit (i.e. feed-in electricity).

Recommendations

The application of CHP under the TPF scheme is suitable for consumers that wish to utilise first quality energy without further considerations of maintenance and operational costs or investment risk.

Tersefanou Biogas CHP Plant

Waste Management and Electricity Production

Main Indicators

Electrical capacity (total)	500 kWe
Heat capacity (total)	500 kWth
Technology	Motor engine
No. of units	2
Manufacturer	Dreyer & Bosse Gmbh
Type of fuel	Biogas
Electricity (yearly generation)	3.47 GWh
Heat (yearly generation)	2.55 GWh
Year of construction	2007
Total investment cost	EUR 1.8 million
Financing	Own funds (50%), loans (50%)
State support	Feed-in tariff
Location	Tersefanou, Cyprus

General Description

Every day the plant treats 100 tons of waste (95% is pig manure and 5% poultry wastes and very small quantities of dairy wastes). The volume of the anaerobic digester is 3,000 m^3, the temperature of operation 38 °C and the retention time 20 days. There are also four surface mixers for periodic mixing and sulphur removal. It is estimated that 1,800-2,000 m^3 of biogas is produced daily. Two CHP units have been installed, each with a capacity of 250 kW. The first engine is dual-fuelled and the second one is a biogas-fuelled engine. The overall thermal efficiency is estimated to be 35% and the electrical efficiency is estimated to be 40%.

Success Factors

The factors of success are mainly:

- Minimisation of waste transport costs (the biogas plant is located very close to the pig farm).
- The governmental support scheme which was in force in 2008. The feed-in tariff for electricity produced from biomass is 0.135 €/kWh (0.1179 €/kWh plus 0.0171 €/kWh for those cases described in the support scheme), including long-term contracts (20 years).
- The legislative framework, including IPPC and policy for the promotion of renewable energy sources.

Main Barriers

The main barriers encountered are the following:

- Variations in the quantity and quality of the organic feedstock.
- The absence of a coherent policy for the useful utilisation of the heat produced.
- A lack of incentives for district heating/cooling of the nearby communities.

Recommendations

- To ensure the minimisation of waste transport costs taking the available quantities and quality of the organic feedstock into account.
- To install trigeneration units.

UPM Kymi Recovery Island

Pulp and Paper Production

General Description

UPM's Kymi Mill involves the integration of modern pulp, energy and paper production. The Kymi pulp mill's new recovery boiler replaced two old recovery boilers. The new recovery line consists of a new evaporation plant, a recovery boiler, auxiliary and NCG boilers, a turbine and turbogenerator, causticisation, a lime kiln, a sludge treatment plant and chip handling modifications.

Success Factors

The new recovery boiler helped the mill achieve a considerable CO_2 reduction of 107 kt/a. It is top-class in energy efficiency terms and the Kymi mill now boasts the lowest airborne emissions in the industry. The mill's electricity self-sufficiency increased from 60% to 80% as the mill is able to generate 60 MWe more power. The share of biofuels in total energy production increased to over 90%.

Main Indicators

Electrical capacity (total)	110 MWe
Heat capacity (total)	630 t/h
Technology	Recovery island with a steam turbine
No. of units	1
Manufacturer	Metso
Type of fuel	Black liquor
Years of construction	2006-2008
Total investment cost	EUR 360 million
Financing	Own funds, loans
State support	None
Location	Kuusankoski, Finland

Main Barriers

The mill's central location sets limits on the emissions and non-odorous operation is therefore crucial. All vents and DNCGs are burnt in the recovery boiler and all CNCGs are burned either in the recovery boiler or in a separate incinerator according to the needs of the biosulphite production.

Recommendations

The renewal made Kymi an extremely competitive integrated mill site producing pulp, energy and fine paper. During the first year of operation Kymi met all permitted environmental limits for air emissions. Substantial improvements were achieved instantly in sulphur dioxide, particle and malodorous gas emissions. The low air emissions result from the further developed evaporation and recovery boiler burning processes. Thanks to the new plant and by implementing the energy efficient operation mode, Kymi has a good opportunity to move very close to a zero carbon footprint. This is a significant step towards papermaking that is carbon dioxide neutral.

Psyttalia

Waste Treatment

Main Indicators

Electrical capacity (total)	12.9 MWe
Heat capacity (total)	17.3 MWth
Technology	Gas turbine with Dry Low Emissions technology WHRG
No. of units	1
Manufacturer	Siemens Ind. Turbomachinery Ltd.
Type of fuel	Natural gas
Year of construction	2009
Total investment cost	EUR 9 million
Financing	European funding
State support	Investment subsidy
Location	Psyttalia island, off the coast of Athens, Greece
Information	geraldine.roy@siemens.com

General Description

In 2007 the Greek Government commissioned an on-site "total energy" plant using gas-turbine-based cogeneration technology for Europe's largest wastewater treatment plant.

The sludge drying plant on Psyttalia Island off the coast of Athens is fuelled by natural gas and converts the sludge into a granular product, dried to less than 10% of water content, which is then supplied to the cement industry to be used as a low calorific value fuel.

The CHP plant not only meets the thermal load requirements of the sludge drying plant, but also covers most of the electrical load requirements for the whole island. The waste heat from the turbine exhaust gases has replaced the previous gas-fired heaters, thus improving fuel efficiency and providing significant savings in total operating costs.

The chosen solution was based on the very latest package design of Siemens' SGT-400. With an ISO-rated power output of 12.9 MWe and simple-cycle electrical efficiency of 35%, this system is one of the most efficient of its type currently available.

Designed to operate on base load conditions, the SGT-400 was ideally matched to both the drying plant's thermal power needs and the wastewater treatment plant's total electrical load. The high temperature of the exhaust gases from the gas turbine, enabled by sophisticated materials technology, was one of the key features of this system.

The capability to generate exhaust gases in excess of 136 tons per hour at more than 550° C enabled the heat exchangers for the sludge dryer to be kept small, therefore saving space and achieving a guaranteed thermal efficiency of 46.7%.

The combustion system of the twin-shaft gas turbine is based on six reverse-flow can-annular combustors and features Siemens' Dry Low Emissions (DLE) technology, which provides a very significant reduction in exhaust emissions of carbon monoxide and nitrogen oxides to levels far below even the minimum statutory requirements. Another key advantage of this system is the full compatibility of the power-monitoring and control system for the plant with the existing computer-based SCADA network for the wastewater treatment automation systems.

The new package design represents a completely new approach to machine development. The main drivers of this development were a need to reduce the total time required from the initial order to the final installation, the provision of a simplified package with greater standardisation and a reduction of non-conformance costs by increased quality. A benchmark design was thus created, taking the best of Siemens' experiences from around the globe. The total number of available options for modular ancillaries was reduced by more than 60% without compromising the ability of the final package unit to meet the customer's requirements.

As most of these systems can be assembled and factory-tested individually, parallel to the main turbine assembly, the total build-time of the complete package was slashed by half. Since the pre-tested systems also significantly reduce on-site installation time, the project timescale was reduced to a remarkable 18 months. Just one week after completing the new "plug and play" cogeneration plant, surplus electricity was already being fed into the grid.

Psyttalia

Waste Treatment

Success Factors

- Provision of all the heat needed by the sludge drying plant.
- Provision of the majority of electricity for the island.
- The efficient use of plant space.

Main Barriers

- The volatility of fuel prices.

Recommendations

The project is an example of good implementation. The new, independent and dedicated base load cogeneration power plant meets the island's total energy requirements and ensures the secure and reliable operation of the Psyttalia wastewater treatment facility.

Belgomilk Langemark

Food and Beverages

Main Indicators

Electrical capacity (total)	7.35 MWe
Heat capacity (total)	13.8 MWth
Technology	Gas turbine
No. of units	1
Manufacturer	Turbomach
Type of fuel	Natural gas, biogas
Electricity (yearly generation)	57.3 GWh
Heat (yearly generation)	430 TJ
Year of construction	2009
Total investment cost	EUR 7 million
Financing	Own funds, loans
State support	Investment subsidy, certificates
Location	Langemark, Belgium
Information	http://www.belgomilk.be

General Description

The CHP plant consists of a Solar/Turbomach natural gas turbine with a Taurus 70 generator. The heat of the exhaust gases is led through a waterpipe heat recovery boiler to produce 25 tons/h steam at 22 barg (incl. additional firing). The CHP plant is mostly full-load driven, but a partial load is possible. The main benefits are a reduction of 5,150 tons/year CO_2 production and a primary energy reduction of 19.35%.

100% of the generated heat is used as steam for the dairy plant (milk powder, butter, cheese, whey products and ice cream production).

85% of the generated electricity is used for the dairy plant; 15% is injected into the public grid (sold to a power supplier).

Success Factors

The main success factors are:

- primary energy reduction of 19.35%;
- a CO_2 reduction of 5,150 tons/year;
- the CHP certificates; and
- the lower total price of electricity due to the local production (no transport costs).

Main Barriers

The main barriers are:

- the price of natural gas and
- the price of electricity.

Recommendations

In view of the local consumption of electricity there is also a need for support by the allotment of CHP certificates to make the project profitable.

Warsteiner Brauerei

Food and Beverages

General Description

The cooling water from the two natural gas driven engines, which is heated as part of the combustion process, supplies the heat for an energy storage system through a primary heat exchanger. From there, the water is pumped to several secondary energy circles in the brew house. For optimised delivery and to minimise acquisition costs it was necessary to integrate three preliminary, already existing old water tanks from the defunct plant as new storage tanks. The electricity generated by this process is utilised completely by the brewery itself. The most important factor of the project is that the total amount of heat obtained from the combustion process can be used by the brewery, which was the main aim of calculations for the cogeneration plant.

For this project Warsteiner was awarded the Energy Master 2010 Award: http://business-masters.econique.com/486.html?L=0.

Success Factors

- The reduction of CO_2 emissions by 5,200 t/year.
- The reduction of energy expenses.

Main Indicators

Electrical capacity (total)	2.3 MWe
Heat capacity (total)	2.3 MWth
Technology	Motor engine
No. of units	2
Manufacturer	AGO AG & MWM
Type of fuel	Natural gas
Electricity (yearly generation)	15 GWh
Heat (yearly generation)	15 GWh
Year of construction	2009
Total investment cost	EUR 3 million
Financing	Own funds
State support	-
Location	Warstein, Germany
Information	http://www.warsteiner.de

Main Barriers

- The interaction of individual hydraulic engine heat circles.
- Rapid changes in the returning temperature.

Recommendations

- Cogeneration plants provide economic benefits for the company while also reducing CO_2 emissions.
- All factors related to the proposed plant should be carefully calculated.

Bailieboro CHP Plant, Lakeland Dairies

Food and Beverages

Main Indicators

Electrical capacity (total)	5 MWe
Heat capacity (total)	18.5 MWth
Technology	Gas turbine & Waste heat recovery boiler (WHRB)
No. of units	1
Manufacturer	Centrax – Gas turbine Wulff – WHRB
Type of fuel	Natural gas
Electricity (yearly generation)	30 GWh
Heat (yearly generation)	115 GWh
Year of construction	2009
Total investment cost	EUR 6.3 million
Financing	Contracting
State support	None
Location	Bailieborough, Ireland
Information	http://www.lakeland.ie

General Description

The design, procurement and installation of a 5 MWe gas turbine, 28 t/hr boiler, control equipment and associated works were carried out within this project. The project also involved interfacing with the current boiler control system at Lakeland Dairies.

After the installation of a new dryer and evaporator the steam and electricity requirements at the host site increased. The CHP facility now supplies the majority of the site steam and electricity requirements, while guaranteeing energy cost savings and reliability to the host site. A limited amount of excess electricity is exported back to the grid.

The system incorporates state-of-the-art control technology and automation software. A site-specific SCADA system monitors an extensive range of plant parameters with an SMS-based callout for alarm notification.

System availability will be in excess of 96%.

Success Factors

The main success factor of this project was the support received from the Commissioner for Energy Regulation (CER) allowing the electrical interconnection of the host site.

Main Barriers

- The main barrier for this project was the electrical connection to the grid. The original host site was divided by a public road and had two separate grid connections at 10 kV. The grid operator would not allow the host site to rationalise the 10 kV connections to one single grid connection and connect the two sites privately via an underground cable. This matter was appealed to the Commissioner for Energy Regulation (CER) who allowed the host site to have a single electrical connection and allowed the sites to be connected privately.
- Another barrier is the limit on electricity exports to the grid. This export restriction limits the output of the turbine during certain periods of the year. The export limit is currently restricted due to a transformer capacity rule which the grid operator is enforcing. Discussions are ongoing to resolve this issue.
- Due to a large energy users (LEU) rebate being applied only to electricity imported from the grid, the savings offered by the CHP are significantly reduced. This anomaly is being addressed by the Department of Communications, Energy and Natural Resources (DCENR).
- A carbon tax is imposed on gas consumed by a CHP on-site. CHP plants should be exempted from this carbon tax, similar to any other electricity generation.

Internal view

Bailieboro CHP Plant, Lakeland Dairies

Food and Beverages

External view

Recommendations

The CHP has been running successfully since December 2009. In order for future potential CHPs to be developed, the following should be implemented:

- Electricity generated by CHP needs to be included in the LEU rebate.
- Gas consumed by a CHP site should be exempted from carbon tax as happens with other electricity generators.
- CHP support incentives (approximately 1 c/kWh electricity generated) should be made available to develop future CHPs.
- Smart metering should be implemented to relax export restrictions and increase the export level when the grid can accommodate it.

Summary of IRR Calculation for Different Scenarios and Countries

Introduction

In WP3 of the CODE project comparisons of member states' approaches to cogeneration support have been modelled through a calculation of the IRR of a group of common CHP applications. Five standard CHP projects were modelled (as shown in Table 2) and compared across all EU-27 member states. By applying a consistent analysis approach across all member states and including the existing support mechanisms and costs in the calculations, a better insight is enabled into the effectiveness of member state support mechanisms in general economic conditions, whether the support mechanisms are sufficient to stimulate market activity, or whether other aspects also play a significant role in the growth of CHP.

The 50 kWe application is the type of CHP to be found in a small school or hotel building. The 1 MWe applications included both gas and diesel fuel to allow for regional variations. At 1 MWe this unit can be found, for example, in a commercial installation powering space heating and hot water or at a smaller industrial site. 12 MWe and 66 MWe units can provide the process heat of an industrial application for CHP where the heat is provided as high-grade steam to an industrial process or a small district heating scheme.

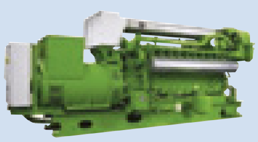
2007 was selected as the reference year as the most recent year the project could analyse and for which more reliable statistical data are available. The analysis therefore represents a snapshot in time, and considers a period when the CHP Directive was still in the process of being implemented rather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

Analysis

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 (Tables 3 and 4). The five standard scenarios provide a "level playing field" for an 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 kWe-12 MWe) is used on site, except in the case of the 66 MWe 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 electricity sales is missing from the IRR calculation. In practices, most units of the 1 MWe 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 a 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 an impact in the market. These features require further examination and refinement but they are a useful initial indicator for assessing the existing and planned support mechanisms.

Table 2: The five standard projects used in the CODE project to compare the effects of member state support on the IRR of cogeneration projects

Notional electrical capacity	50 kWe	1 MWe	1 MWe	12 MWe	66 MWe
Primary generator	Gas engine	Gas engine	Diesel engine	Coal/fired steam turbine	Combined cycle gas turbine
					
Typical use	Services, public sector	Commercial installation, power space heating and hot water		Industrial sites with a need for high-grade heat (steam)	

No regulatory risk is 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 entails 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 plant's mode of operation concerning electricity use and sales and on 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.

Results of the Analysis

The main analysis results, IRRs and simple payback periods are shown in Tables 3 and 4. Support for micro cogeneration is still quite limited as only in 10 member states do the existing mechanisms result in an IRRs of around 10% (Figure 10).

The cogeneration gas engine 1 MWe unit was modelled to be the most attractive project in the analysis as its IRR is close to or more than by investors usually expected margin in more than 20 member states. Exceptions are mainly seen in the Mediterranean region with lower cogeneration potential (Figure 10). The results for the largest project of 66 MWe CCGT (Figure 11) are similar.

Diesel engine and steam coal turbine projects enjoy limited support in the majority of member states and seem not to be a highly graded development alternative in the EU.

Methodology for the IRR Calculations

The standard tool used by commerce and industry to evaluate whether or not an investment is worthwhile is the **IRR and simple payback periods.** In a transparent but consistent way, it incorporates effects such as the cost of capital, competing investment opportunities, and actual support in specific circumstances.

Main assumptions

To ensure an equal basis for the comparison of cogeneration economic indicators in the EU-27, the following assumptions were made in these theoretical models of construction and maintenance:

- 2007 price data were used throughout (thereby ensuring a complete dataset was available)
- Data supplied directly from member states were the preferred source, but where these were unavailable, published (fuel, electricity and tax data) Eurostat or International Energy Agency (IEA) data were sought Where construction and maintenance costs were unavailable, UK or other regionally sourced data were used
- An assumed weighted average cost of capital (WACC) was modelled at 8%
- The plant life was modelled to be 20 years
- Benefits and financial support mechanisms were spread uniformly across the plant's lifetime
- The writing down allowance (WDA) was standardised at 13% across all member states
- All electricity was modelled as used on site, with the exception of the 66 MWe unit which is modelled to export 60% of the electricity produced
- Where electricity wholesale price data were unavailable, 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

A detailed calculation model was built for calculating economic indicators for five selected cogeneration projects with and without support in the EU-27.

The analysis focused only on fossil fuel support mechanisms as reliable bio-energy information on fuel costs in particular and on the very few plants in operation in the reference year of 2007 was unavailable. Reliable data on bio-energy plants for CHP are only beginning to emerge in 2010 (through the Renewables Directive and MS submission of National Renewable Energy Plans).

More information can be found in the report ***»European Summary Report on CHP support schemes«*** and the CODE project web page www.code-project.eu.

Summary of IRR Calculation for Different Scenarios and Countries

Table 3: Internal rate of return (IRR) for the five standard projects in EU-27: Without and with support

	Internal Rates of Return (IRRs) in %									
	Base case					Supported – with benefits				
	50 kWe	1 MWe	1 MWe	12 MWe	66 MWe	50 kWe	1 MWe	1 MWe	12 MWe	66 MWe
Austria	23.8	42.8	66.8	21.0	20.3	23.8	69.3	66.8	21.0	20.3
Bulgaria				8.6			11.2		12.7	18.7
Cyprus										
Czech Rep.	5.7	9.9	-0.5	18.1	8.5	9.7	24.6	19.3	21.5	9.2
Denmark		16.8			53.4		16.8			53.4
Estonia							13.0			
Finland	2.6	27.9	11.3	20.0	22.6	2.6	27.9	11.3	20.0	22.6
Flanders	2.6	13.9		28.5	12.3	12.9	47.6		51.2	22.2
France	2.7	1.9			11.6	25.3	52.9			76.4
Germany	17.4	79.2	71.3		34.3	29.8	98.5	82.8		37.2
Greece		17.6				2.9	26.3			
Hungary				5.7	1.9		6.7		16.6	9.6
Ireland		10.6					10.6			
Italy	10.1	29.1			23.0	19.7	57.9	43.5		54.1
Latvia		1.1			2.8		1.1			6.1
Lithuania					-		14.5	9.2		24.2
Luxembourg	26.6	51.9	48.3		46.0	26.6	51.9	52.1		46.0
Malta										
Netherlands	-	16.1			2.5	6.1	34.5			8.0
Poland				13.5	1.5	4.4	14.9	13.2	14.9	22.2
Portugal		2.4	2.4	25.6	-		2.4	2.4	25.6	-
Romania	2.9					5.6	16.7			20.8
Slovakia	9.2	17.7	21.1	25.5	8.1	15.4	36.2	32.8	30.3	24.5
Slovenia					9.0	20.0	13.5	14.2		19.9
Spain	23.6	30.9	-		18.5	30.8	37.7	8.1		23.8
Sweden			49.0		15.3			49.0		15.3
UK	-	13.4		9.1	12.0	1.2	24.9		12.4	16.2

Note: - negative value of IRR

Summary of IRR Calculation for Different Scenarios and Countries

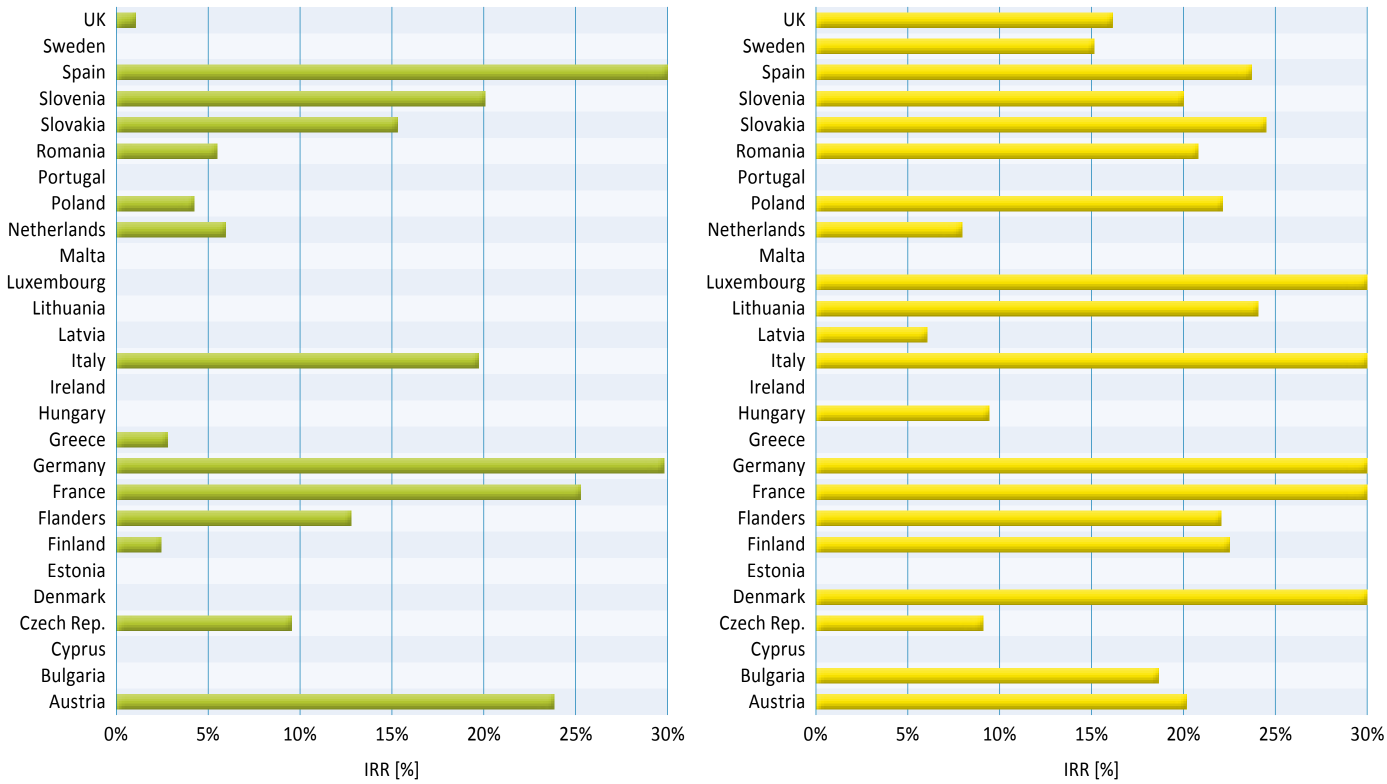


Figure 10: IRR with support for the 50 kWe and 1 MWe gas engine project in the EU-27

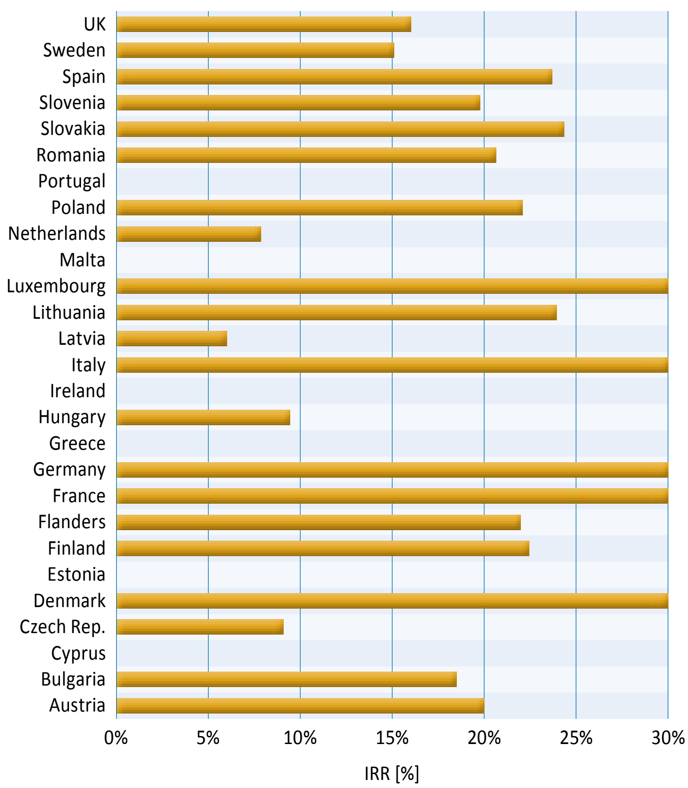


Figure 11: IRR with support for the 66 MWe CCGT project in EU-27

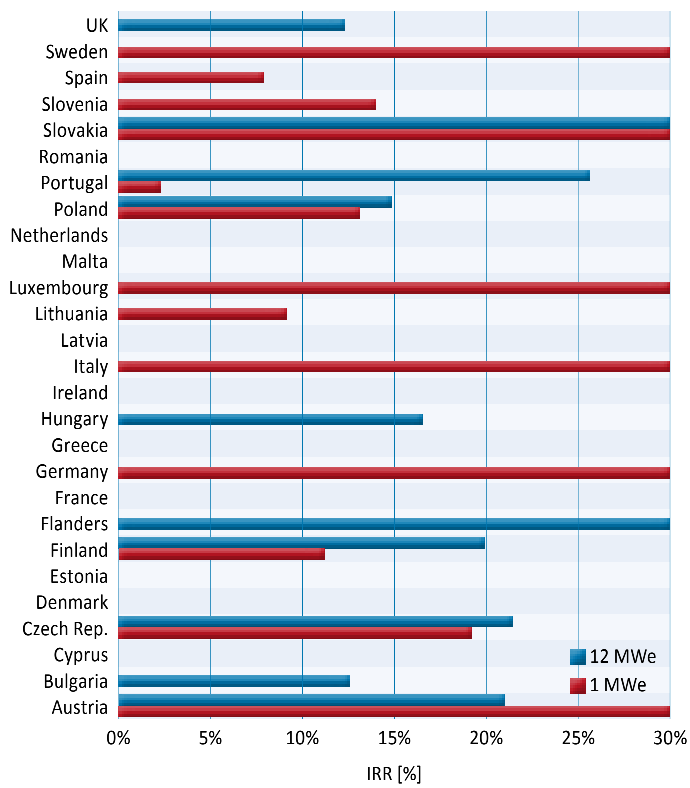


Figure 12: IRR with support for the 1 MWe Diesel engine and 12 MWe steam coal turbine projects in the EU-27

Summary of IRR Calculation for Different Scenarios and Countries

Table 4: Simple payback period for the five standard projects in EU-27: Without and with support

	Simple payback time in years									
	Base case					Supported – with benefits				
	50 kWe	1 MWe	1 MWe	12 MWe	66 MWe	50 kWe	1 MWe	1 MWe	12 MWe	66 MWe
Austria	2.6	1.4	0.9	3.2	3.2	2.6	0.8	0.9	3.2	3.2
Bulgaria	-	>10	-	7.6	-	-	6.2	-	5.8	4.0
Cyprus			-					-		
Czech Rep.	7.4	4.7	7.4	3.7	6.3	5.9	3.3	3.0	3.6	6.0
Denmark	>10	3.1			1.1	>10	3.1			1.1
Estonia	>10	>10	-		-	>10	5.8	>10		-
Finland	6.3	2.0	3.9	3.3	2.8	6.3	2.0	3.9	3.3	2.8
Flanders	8.9	2.6		2.0	4.2	4.4	1.3		1.1	2.6
France	>10	>10			5.4	2.7	1.2			0.7
Germany	3.4	0.7	0.7		1.7	2.2	0.6	0.6		1.6
Greece	>10	2.8	>10			>10	1.8	7.2		
Hungary	>10	>10	-	7.3	9.6	>10	5.5	>10	3.9	5.8
Ireland		4.5	-			-	4.5	-		
Italy	5.4	1.8	-		2.7	3.4	1.2	1.1		1.1
Latvia	>10	7.5	>10		9.2	>10	7.5	>10		7.3
Lithuania	>10	>10	-		>10	>10	3.8	4.7		2.8
Luxembourg	2.3	1.1	1.2		1.3	2.3	1.1	1.2		1.3
Malta			-					-		
Netherlands	>10	4.1			8.2	8.0	2.4			6.0
Poland	>10	9.5	>10	4.6	9.9	8.1	3.8	3.9	4.3	3.1
Portugal	>10	4.0	4.0	1.8	6.9	>10	4.0	4.0	1.8	6.9
Romania	>10	5.4			-	10.0	3.4			3.6
Slovakia	6.0	3.4	2.8	2.7	6.4	4.4	2.2	1.9	2.3	2.8
Slovenia	>10	-	>10		6.0	3.6	4.0	3.7		3.4
Spain	3.0	2.2	>10		3.8	2.3	1.9	7.0		2.9
Sweden	-	>10	1.3		4.0	-	>10	1.3		4.0
UK	8.6	3.5		6.1	4.8	>10	3.4		5.7	3.9

Note: - negative value

Summary of IRR Calculation for Different Scenarios and Countries

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 the 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 the desire of 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 demonstrated 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 the 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)

Feed-in Tariffs (FiTs) and bonuses on electricity are the strongest CHP promotional support used in all countries in this CODE region. The details of FiTs in the 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 yet to occur, especially in the Baltic region.

More market-oriented FiT as a premium on all generated electricity is the most successful mechanism in those 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 in 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 were difficult to verify. This region is also characterised by very high upfront costs and capital costs for the smaller units. At a time of limited access to capital this is an issue for new projects.

CODE South Eastern 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 generally 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, show that the electricity price is lower than the basic fossil fuel price. Market liberalisation issues in Greece effect market access and competition as regards basic fuel. Despite support mechanisms which could stimulate the market in Greece, the bureaucratic hurdles involved in 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 concerning the electricity market and CHP in recent years have added to the investment risk.

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

Similarly to the CODE Northern Region, the countries of the South Western region are relatively advanced in market liberalisation. In relation to 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 from a well over 10% uplift. However, despite the apparently attractive returns these markets are not showing the growth that might then be expected. In France, the limited application and duration of new support contracts mean there is in reality only investment in replacement plant. In Italy, additional costs to cogenerators, local legislation and local taxes restrict development adding risk costs to the basic IRR calculation.

Summary of IRR Calculation for Different Scenarios and Countries

CHP Support Mechanisms Across Europe

In 2007 there was a wide range of support mechanisms for CHP operations 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 the CHP mode or a 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 is selectively applied and less widespread. Capex support is particularly effective for smaller applications, where investment costs tend to be higher and more variable. The main methods of support are presented in Table 5 below under the headings: Tax support, FiT (incl. generation bonus), Certificate scheme, and Capital grant. The "Other" category of support encompasses a range of detailed and added complexity to these schemes which is not considered to be centrally motivating for the sector. The "Other" category also includes support mechanisms for bio-energy.

Table 5: Overview of CHP support mechanisms for fossil fuel based CHP in the European Union in 2007

	Support mechanisms				
Country	Feed-in tariff	Tax support	Certificate scheme	Capital grant	Other
Austria	■				■
Bulgaria	■				■
Cyprus					■
Czech Rep.	■				■
Denmark					
Estonia					■
Finland				■	■
Flanders		■	■		■
France	■				■
Germany	■				■
Greece	■	■			
Hungary	■				■
Ireland					■
Italy	■			■	
Latvia	■				■
Lithuania	■				■
Luxembourg		■			■
Malta		■			■
Netherlands	■	■		■	■
Poland			■		
Portugal				■	■
Romania	■			■	
Slovakia	■				
Slovenia	■				■
Spain	■	■			■
Sweden				■	■
UK	■	■		■	

Conclusions

The financial comparison of the five projects across all member states has documented the considerable existing policy which impacts on CHP in Europe today. It has also shown that much of the legislation in place does not, when modelled, result in a positive financial stimulus for cogeneration. Use of the IRR approach also highlights the substantial relative differences in returns which can be expected across projects' capacity sizes 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 by different support approaches in member states, although the 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 employs a market mechanism of white 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 alone are not 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 practice also highlights the need for consistent long-term policy strategy on CHP and clear communication and outreach concerning its benefits.

CODE Project

The CODE (Cogeneration Observatory and Dissemination Europe) project was established in October 2008 by COGEN Europe under the EU's Intelligent Energy Europe (IEE) programme and is an EU-wide independent assessment of the progress of the Cogeneration Directive 2004/08/EC. In offering a rapid assessment of the Directive's deployment, the CODE project supports early corrective action. By building a regional knowledge basis and providing best practice examples, the project enables faster market development.

The CODE project aims to:

- support implementation of the Directive;
- enhance local/regional capacity for the successful development of cogeneration projects by developing clear case study data on successful cogeneration projects under the new Directive framework on a regional basis;
- raise awareness and provide information through a high-profile European-wide information and know-how transfer among cogeneration associations, suppliers, local and regional energy agencies and other networks;
- accelerate the market penetration of cogeneration technologies by producing a European Cogeneration Roadmap based on national potential studies; and
- showcase good practice and potential growth in key market sectors.

To achieve these goals a central database of European cogeneration policy has been created which is the first complete summary of high efficiency cogeneration across Europe and the baseline measure for future studies. The CODE project used a regional structure of four regional groupings to systematically review and report on the member states' progress providing comparative information to governments and giving early information on the real effects of the measures implemented. The regional groupings have prepared member state and regional summaries starting with high efficiency cogeneration national potential followed by support mechanisms, barriers and the Guarantees of Origin process. A regional view has been taken on progress and a handbook of case studies has been developed to speed up market penetration through referential marketing and the spread of best practices. Another challenging task has been the comparison of 27 national policy approaches against the five standard test cases. All of the results have been used to produce a European Cogeneration Roadmap leading to 2020.

The project is led by COGEN Europe and the project partners are member organisations from Italy, Slovenia, Greece and the United Kingdom.

PROJECT PARTNERS

COORDINATOR

COGEN Europe

NORTHERN REGION
AT, BE, DK, FI, DE, IRL, NL, SE, UK

Combined Heat and Power Association (CHPA)

SOUTH WESTERN REGION
ES, FR, IT, LU, MT, PT

Federation of the Scientific and Technical Association (FAST)

EASTERN REGION
CZ, EE, HU, LV, LT, PL, SK, SI

Jožef Stefan Institute (JSI) Energy Efficiency Centre

Institut "Jožef Stefan"
Center za energetsko učinkovitost

SOUTH EASTERN REGION
BG, CY, EL, RO

Hellenic Association for the Cogeneration of Heat and Power (HACHP)

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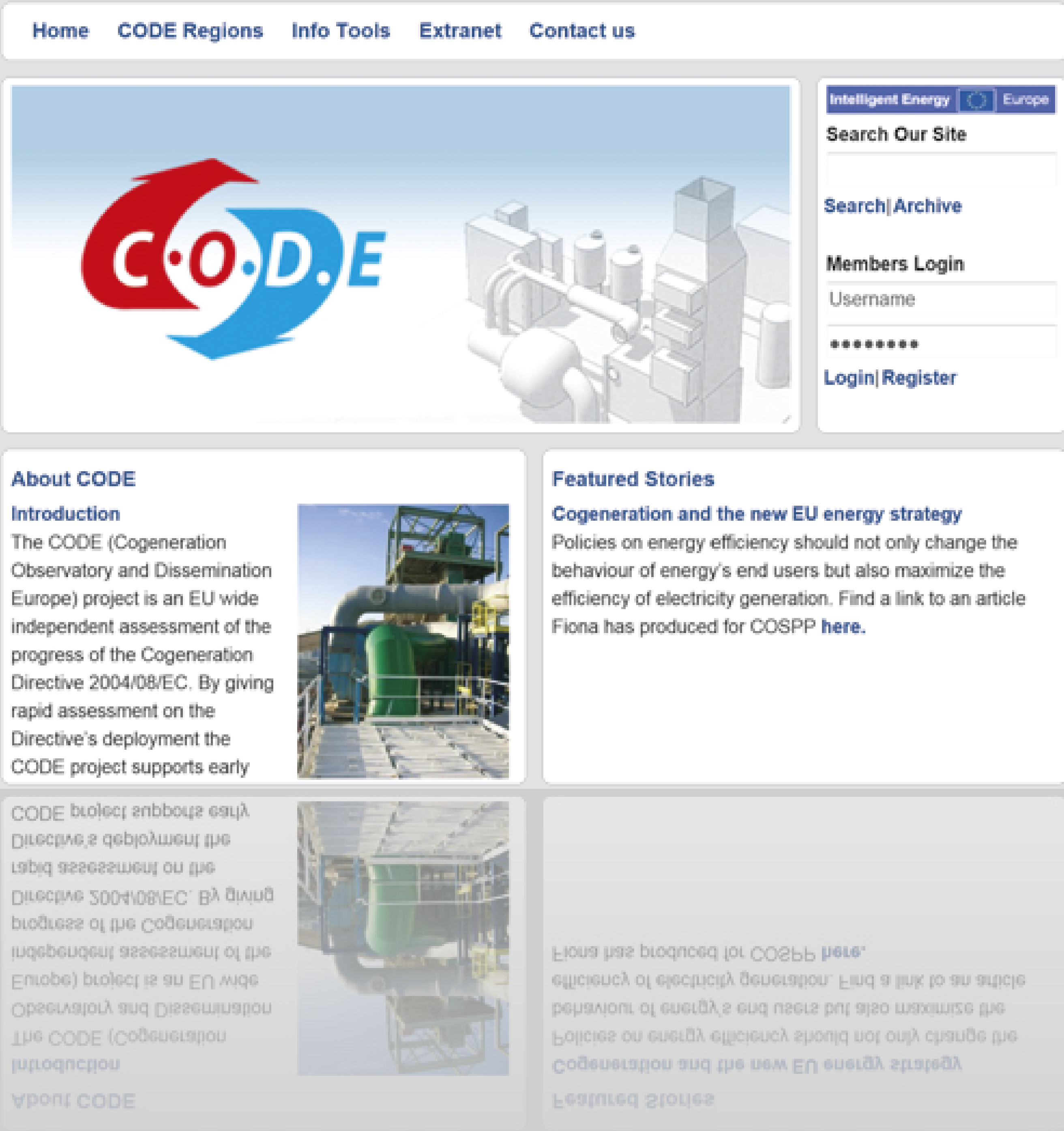
More information about the CODE project
is available on the website:

http://www.code-project.eu/



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