CODE 2

Cogeneration Observatory and Dissemination Europe

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Executive Summary

The CODE 2 project worked with national experts across 27 European Union Member States to identify a growth path for combined heat and power (CHP) in each country and to project the likely results on Europe's energy and climate goals of a suitable policy structure around CHP.

The project roadmaps estimate that in 2030 CHP could generate 20% of the EU's electricity highly efficiently on a range of increasingly renewable fuels. 15% of the EU's heat today comes from CHP[1] (850 TWh). The CODE 2 project estimates that this heat volume will increase by around half to 1,264 TWh in 2030. The CHP Roadmap projections estimate that new and upgraded CHP capacity beyond 2012 would further reduce total inland energy consumption by 870 TWh and additionally reduce CO_2 emissions by 350 Mt in 2030[2].

The roadmaps include separate bio-energy based roadmaps showing that the fuel mix for CHP is shifting to renewable fuels, making innovation and the reliability of these supply chains an important factor for the sector. A micro-CHP analysis for each sector shows the potential to increase micro-CHP in Europe before 2030 in response to industry reducing the product cost to a competitive level.

CHP is embedded across Europe's economy: hospitals, universities, industries, and district heating schemes are providing heat and generating electricity. This guarantees energy savings at the energy network level but does not guarantee a return on investment for the CHP operator. The roadmaps reinforce that the main challenge for CHP remains to achieve a good business proposition for CHP operators.

[1] Source: EEA based on Eurostat

[2] The entire CHP fleet could deliver in 2030 total primary energy savings and CO_2 reductions of around 1,700 TWh and 685 Mt of CO_2. For a detailed account of the "substitution methodology" used to estimate these figures, please see Annex I.

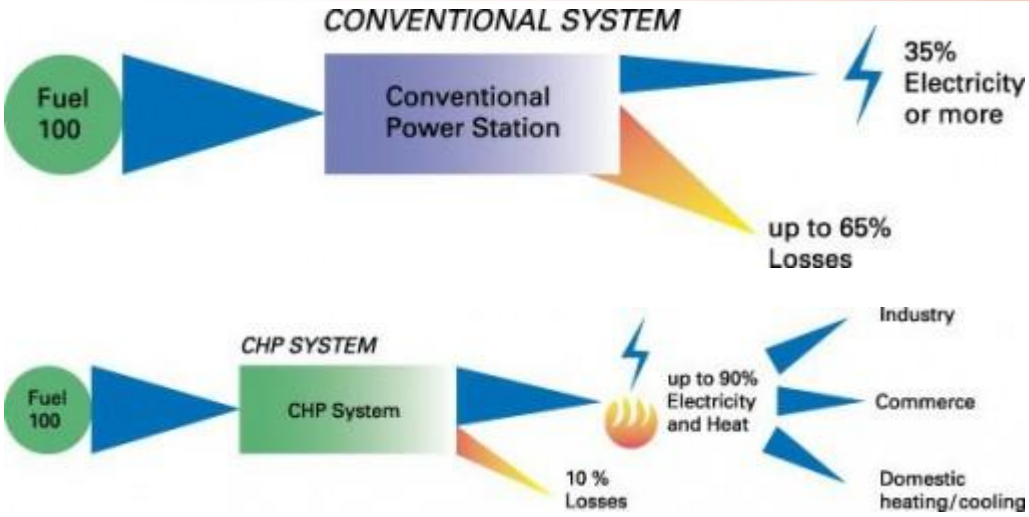


Figure 1: The cogeneration principle (Source: COGEN Europe)

The roadmaps highlight four major barriers to extending CHP in Europe:

- The electricity and heat markets do not consistently reward CHP for its energy savings at the energy system level. There is a market failure for the CHP operator.
- Regulatory uncertainty arising from the significant changes in recent years in both the electricity market and the energy market make CHP investment high-risk.
- Issues relating to grid connection, network charges, permitting and bureaucracy continue for CHP despite legislation to the contrary since 2004.
- The absence of appropriate consideration of heat in general energy and climate policy hampers CHP, as does the weakening focus on primary energy compared to energy end use in EU energy efficiency policy.

All the CODE 2 roadmaps recognise the new policy developments of the European Energy Efficiency Directive (EED). All say that the EED must be rigorously and thoughtfully implemented if the energy savings and CO2 reductions projected for 2030 are to be achieved.

SMEs are encouraged to consider CHP where their heat demand is appropriate and where the electricity market conditions are favourable for a good economic return. The project has published 32 new best practice cases showing the role of CHP across the economy and provided and online tool for customers interested in CHP to quickly evaluate their position backed with a How-to Guide showing key considerations and sources of information.

European policy is also scrutinised in the project for its impact at the national level and for its appropriateness to really promote CHP to achieve its potential. The European Policy report uses examples of successful member state policy to

highlight that well-targeted, committed actions will generate the desired investment and that the member state has a range of successful policy approaches to choose from.

The project has fulfilled an important consultation on the EED and highlighted the potential significance of this piece of legislation in promoting CHP. In doing so it has created a database of information on the CODE 2 website which makes available for the first time a central resource on CHP for industry and stakeholders alike. At the member state level it has sometimes strengthened networks and sometimes triggered new connections and where possible it has brought forward 'Thought Leaders' to continue the discussions and the work on CHP across member states.

Introduction covering background to project and objectives

The CODE 2 project is an initiative co-funded by the European Commission (Intelligent Energy Europe – IEE) and eight project partners who are all stakeholders in the combined heat and power (CHP) and energy sectors.

The aim of the project was to create a CHP roadmap for each Member State giving concrete projections for the further development of CHP in that country and tabling proposals for national policymakers and CHP stakeholders as to the priority areas to address in order to move CHP forward. A European CHP roadmap and Policy Report summarised the outcomes and made recommendations for an EU-level energy and climate policy framework that allows CHP to achieve the potential identified in the member-state roadmaps.

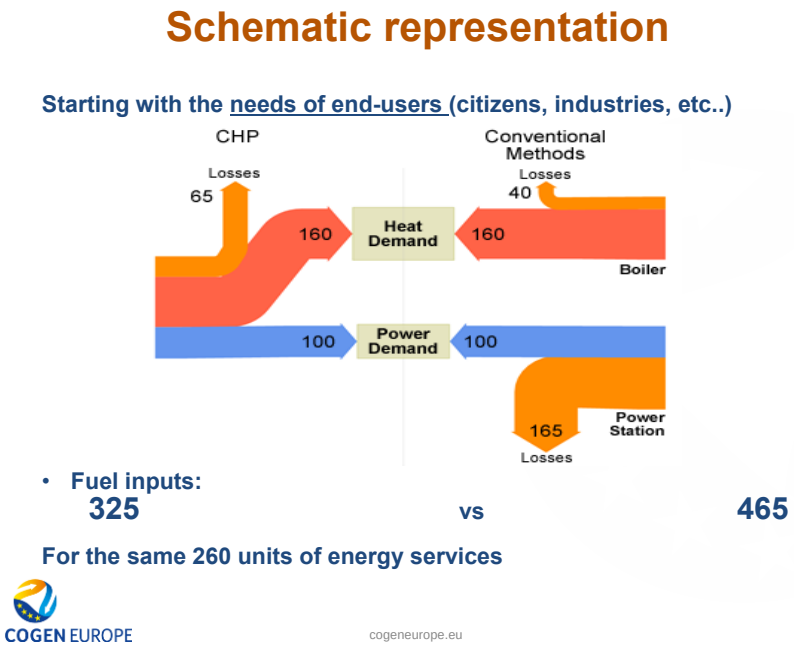


Figure 2: Schematic of showing the basic principle of simultaneous production of useful heat and power known as cogeneration (CHP)

Cogeneration is the simultaneous production of heat and electricity (Figure 2) and has been supported in EU legislation since 2014 under the original CHP Directive 2004/08/EC. The legislation supported CHP and made it (eventually) eligible for state aid due to its very high efficiency in converting primary energy to heat and power. Europe supported CHP for its contribution to improving energy efficiency and security of supply. Currently all member states have some level of policy framework for CHP based on the 2004 Directive. 2012's Energy Efficiency Directive (EED) absorbed the EU's legislative clauses related to CHP and moved them forward into a concept of energy efficiency all along the energy supply chain, from gross inland energy consumption to final energy demand.

Cogeneration produces around 15% of Europe's heat and 11% of its electricity. As Figure 2 shows, the use of CHP varies widely across member states and behind these differences lie very different energy histories and climate and energy challenges faced by these countries.

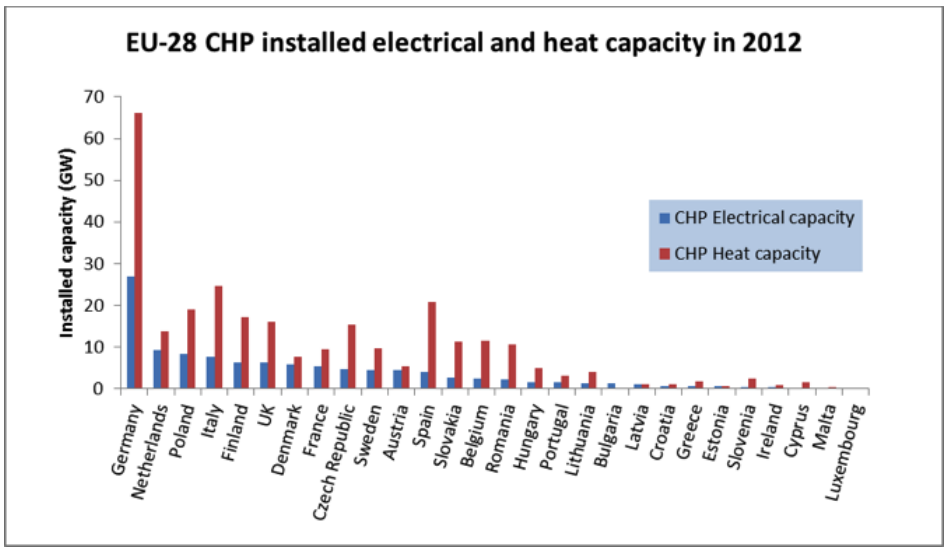


Figure 3: EU-28 countries showing heat and electricity generated in CHP mode in 2012 (Source: COGEN Europe based on Eurostat data).

The CODE project (2009-2011) came in the wake of member states' response to the original CHP Directive and was the first to reveal the total potential which member states had highlighted in their own analysis: namely that CHP could double its penetration in the EU by 2020 in a cost-effective manner.

CODE proposed that to help realise this potential, roadmaps should be generated for each member state. CODE also proposed a structure for these CHP roadmaps that would address the project's findings: namely that policy action alone or market effort alone would not bring about growth in the sector. CODE suggested looking at the more complex elements of the CHP proposition (Figure 4) and

analysing market policy and awareness.

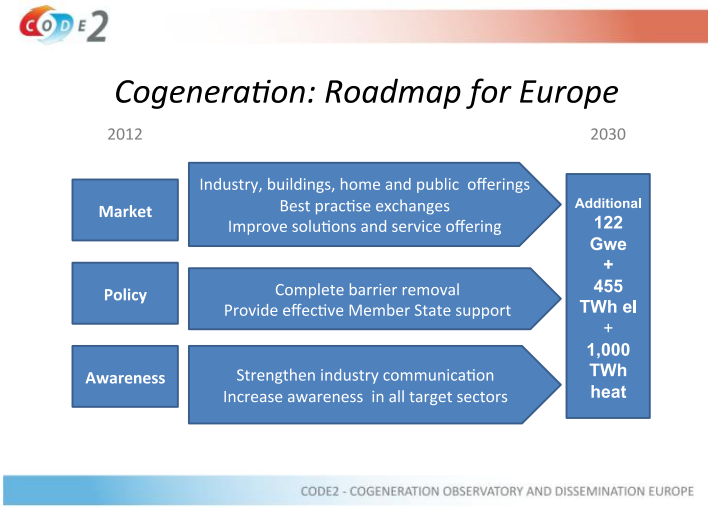


Figure 4: The CODE 2 project – developing a new roadmap for Europe

The CODE 2 project took on the role of developing the new roadmaps. The project aims to provide a better understanding of key markets and policy interactions around cogeneration, and to accelerate cogeneration's penetration into industry. By adding bio-energy CHP and micro-CHP analysis to member-state projections for cogeneration to 2020, it also gave special consideration to SMEs and their role in future CHP growth.

The CODE 2 partners led and structured a wide market consultation on CHP (2012-2014) across the European Union which gathered expert input into how CHP should be developed. When the proposal was being drafted and during the early stages of the project, the EED was in the final stages of being defined and transferred into law. CODE 2 tested the opportunities presented by the EED with member states as they themselves were considering the new Directive, drawing conclusions regarding the effectiveness of the legislation seen from this point of view.

The broader strategic objectives for the project are to improve documentation of the situation for CHP in advance of member-state reporting and crucially to improve the effectiveness of policymaking to ensure that Europe's CHP potential contributes effectively to the EU's Energy and Climate goals.

A project team was assembled with a balance of CHP industry stakeholders and skilled analysts.

Project Team:

- COGEN Europe (BE): Policy, market and technical expertise
- Hellenic Association for the Cogeneration of Heat and Power (EL): Policy, market and technical expertise
- Jožef Stefan Institute (SI): Policy, market and technical expertise
- Federazione delle associazioni scientifiche e tecniche (IT): Policy, market

and technical expertise
- COGEN Vlaanderen (BE): Policy, market and technical expertise
- Energy Matters (formerly Cogen Projects), NL: Market and technical expertise
- Berliner Energieagentur (DE): Market and communication expertise

1) Applied approach and methodology

The project brought together existing published information on CHP in EU member states. Major sources for this included: national government statistics and reports under 2004's CHP Directive, Eurostat data, industry associations' information and projections, and period publications on the sector by experts and consultants.

Information on CHP is often inconsistent and difficult to interpret: even though the 2004 Directive clearly defines high-efficiency CHP, the statistics and numbers reported in different member states use different approaches to their calculation[3].

For the purposes of CODE 2, Europe was divided into CODE 2 regions, each with a responsible project partner.

Table 1: CODE 2 Regions

South Eastern	HACHP	Bulgaria, Cyprus, Greece and Romania
Eastern	JSI	Czech Republic, Estonia, Hungary, Latvia, Lithuania, Slovakia, Slovenia and Poland
South Western	Federazione delle associazioni scientifiche e tecniche	France, Italy, Malta, Portugal and Spain
Western	COGEN Vlaanderen	Belgium, Ireland, Luxembourg, Netherlands, United Kingdom
Northern	KWK Kommt	Austria, Denmark, Finland, Germany, Sweden

Six member states – Poland, Slovenia, Italy, Greece, Ireland, Germany and the Flanders region – were used as pilot countries in order to develop an approach to information-gathering and expert exchanges as well as to developing the

[3] Presentation by John Dulac, Energy Analyst, Energy Technology Policy Division, International Energy Agency (IEA) at the EU conference 'Heating and Cooling in the European Energy Transition', 27-27 February 2015, Brussels.

structure of the roadmaps themselves. At each stage efforts were made to link early with national experts, take their input and ask for direct feedback on sections of draft documents. The pilot countries also held workshops for real-time feedback on the roadmap and wider discussion of the barriers and opportunities for CHP.

It was important for the project team that the work done under CODE 2 should have a continuity and durability beyond the project's lifespan. Efforts were made to maintain contact with and between experts and at each workshop to encourage the participants to continue their exchanges around CHP and the EED beyond the workshop. The project also sought to identify 'thought leaders' who are prepared to be quoted and take a more visible role in the future of the sector.

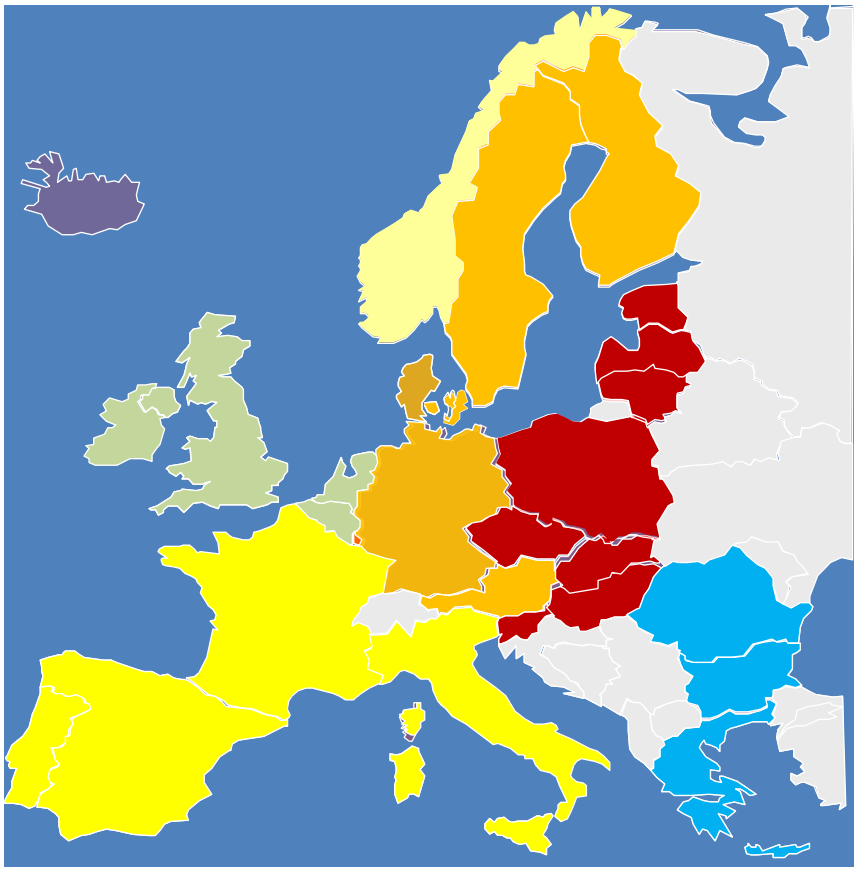


Figure 5: CODE 2 regional structure for Europe

All of the reports under the project were developed in a co-operative fashion by the partners.

Roadmaps

The aim of each roadmap was to give readers a clear understanding of the extent of CHP use in each member state, the policy situation, the opportunities and barriers to further growth, and the main next steps to promote the sector.

Micro and Bio-CHP roadmaps
In the case of both the micro- and bio-CHP roadmaps, an initial estimate of possible market penetration – based for micro on the evolution of the boiler market and for bio on the member states' own projections for bio-CHP – were modified with a score card of key influencing factors rated 1-5 to introduce an estimate of confidence regarding likely real penetration. A simple one-page format for each member-state roadmap was developed to ensure that policymakers could grasp the main points at a glance.

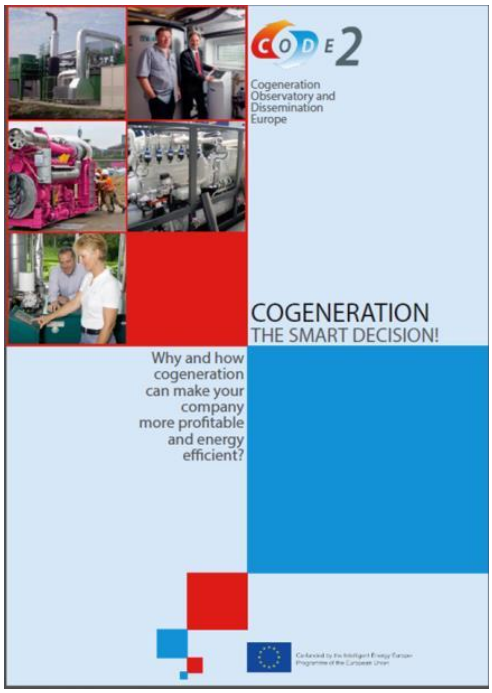
European Roadmap
The European roadmap summarises the main points of the full set of national roadmaps in a tabular format. To keep the roadmap clear and actionable, the project decided to focus only on top four universal barriers to CHP which exist in the European Union.

European Policy Report
The policy report builds on the European Roadmap and highlights the policy options which are available to address the barriers raised. It particularly links to the implementation of the EED, as this is the main policy tool available to member states and the EU at the time of writing.

Case Studies
The Case Study format was based on the CODE format adapted to suit the needs of CODE 2. Case Studies were selected with the help of national experts and other project members. Willingness to participate by the CHP being profiled was a significant limiting factor.

How-To Guides
The How-To Guides went through several versions: the aim of delivering a short, attractive document relevant to SMEs required several iterative attempts. In addition, the team built a web-based tool to more readily engage with potential CHP users, and to simplify and clarify the key investment parameters for new customers.

For all the roadmaps, reports and other deliverables, critical external feedback was sought and the feedback suitably incorporated into the text.



Methodologies used to calculate saving of primary energy and CO_2 emissions in CHP Roadmap

Two established methodologies were employed to determine the primary energy savings (PES) and CO_2 emission reductions of the CHP fleet in 2030: the EED method and the substitution method .

The CODE 2 2030 Roadmap primary energy savings (PES) and CO_2 emission reductions (Figure 5) were calculated using the 'Substitution Method', which project partners assessed as adequate for the purposes of this analysis. Yet for considerations of thoroughness, the project partners performed the analysis using the EED Method as well.

	Substitution Method	**EED Method**
Total PES (TWh/year)	1714	980
Additional PES (TWh/year)	870	497
Total CO_2 (Mt/year)	686	392
Additional CO_2 (Mt/year)	348	199

Table 2: Comparison of PES and CO_2 reductions delivered by CHP in 2030 calculated using the Substitution Method and EED Method[4]

While the EED Method benefits from recognition in the CHP community, the Substitution Method has the advantage of providing a more accurate estimation

[4] Additional PES and CO_2 emission reductions refer to the savings delivered by new CHP installations beyond 2012.

of real energy savings and CO_2 emission reduction potential. The total primary energy savings potential in 2030 (i.e. that delivered by the entire CHP fleet, taking into account both plants that exist today and new CHP installations) could reach 980 TWh when employing the EED methodology[5] and up to 1,700 TWh under the Substitution Method.

Based on the assessed PES, total CO_2 savings could reach between 390-680 Mt CO_2, calculated with the specific CO_2 emission factor 0.4 Mt CO_2/TWh of PES[6].

Results, findings and Impacts achieved

The European Union picture: What are the advantages of CHP for the European Union in its Energy Efficiency Strategy and what can CHP deliver to 2030?

Putting together the findings of all 27 CODE 2 Member State roadmaps estimates that in 2030 CHP (Table 2) could generate 20% of the EU's electricity highly efficiently on a range of increasingly renewable fuels. 15% of the EU's heat today comes from CHP[7] (850 TWh). The CODE 2 project estimates that this heat volume will increase by around half to 1,264 TWh in 2030. The CHP Roadmap projections estimate that new and upgraded CHP capacity beyond 2012 would further reduce total inland energy consumption by 870 TWh and additionally reduce CO_2 emissions by 350 Mt in 2030[8].

The roadmaps include separate bio-energy based roadmaps showing that the fuel mix for CHP is shifting to renewable fuels, making innovation and the reliability of these supply chains an important factor for the sector. A micro-CHP analysis for each sector shows the potential to increase micro-CHP in Europe before 2030 in response to industry reducing the product cost to a competitive level.

CHP is embedded across Europe's economy: hospitals, universities, industries, and district heating schemes are providing heat and generating electricity. This guarantees energy savings at the energy network level but does not guarantee a return on investment for the CHP operator. The roadmaps reinforce the point

[5] An average PES factor of 1.3 was used to calculate the primary energy savings from CHP electricity generation (based on an estimated fuel and technology structure of CHP in 2030).
[6] The factor used is the average CHP roadmap specific CO_2 savings factor following the Substitution Method where realistic PES and CO_2 savings were calculated for each member state (high share of RES in future CHP generation is the reason why specific CO_2 savings per PES exceed the specific CO_2 factor for fossil fuels as the achieved real CO_2 savings with the replacement of fossil fuel used for heat and electricity generation should be calculated from the whole replaced fuel volume and not just from the PES.
[7] Source: EEA based on Eurostat
[8] The entire CHP fleet could deliver in 2030 total primary energy savings and CO_2 reductions of around 1,700 TWh and 685 Mt of CO_2. For a detailed account of the "substitution methodology" used to estimate these figures, please see Annex I.

that the main challenge for CHP remains achieving a good business proposition for CHP operators.

Table 3: Potential energy contribution and efficiency gains from CHP in 2030

EU totals from CODE 2 roadmaps[9]	2030
EU Total CHP Heat Delivered [10]	1260 TWh (108 Mtoe)
EU Total CHP Electricity Delivered	750 TWh (64.5 Mtoe)
EU Total Electricity Delivered [11]	3,650 TWh (55.8 Mtoe)
Primary Energy Savings (TWh) (replacement of condensing power, refurbishment of old plants, and new builds)	**870 TWh (74.8 Mtoe)**
CO_2 savings	**350 Mt**

The roadmaps highlight four major barriers to extending CHP in Europe:

- The electricity and heat markets do not consistently reward CHP for its energy savings at the energy system level. There is a market failure for the CHP operator.
- Regulatory uncertainty arising from the significant changes in recent years in both the electricity market and the energy market make CHP investment high-risk.
- Issues relating to grid connection, network charges, permitting and bureaucracy continue for CHP despite legislation to the contrary since 2004.
- The absence of appropriate consideration of heat in general energy and climate policy hampers CHP, as does the weakening focus on primary energy compared to energy end use in EU energy efficiency policy.

All the CODE 2 roadmaps recognise the new policy developments of the European Energy Efficiency Directive (EED). All say that the EED must be rigorously and thoughtfully implemented if the energy savings and CO2 reductions projected for 2030 are to be achieved.

The industry itself is adapting to the demands of a high intermittent renewables electricity grid, and new designs will consider electricity services market participation or sizing for on-site demand. SMEs are encouraged to consider CHP

[9] PES and CO_2 emission reductions refer to further savings from the new CHP plants compared to the existing installed fleet in 2012. The Roadmap figures were obtained using the substitution method, described in Annex I of the CODE 2 European Cogeneration Roadmap: http://www.code2-project.eu/wp-content/uploads/CODE-2-European-Cogeneration-Roadmap.pdf

[10] Average 0.6 power to heat factor was used, higher than 0.44 average factor in 2012 due to expected CHP technology improvements.

[11] European Commission, 2013. EU Energy, Transport and GHG emission trends to 2050 (Reference scenario 2013)

where their heat demand is appropriate and where the electricity market conditions are favourable for a good economic return. For industry and district heating, more needs to be done regarding the policy framework and access to capital in order to deliver the high energy savings these sectors could provide.

The national roadmaps and what they reveal (by region)

North-Western Europe CODE 2 Region Belgium (pilot), Ireland (pilot), Luxembourg, Netherlands and the United Kingdom

The barriers to CHP and how to move to growth

The major barrier in all member states within this region is the weak business case for CHP. This is due to a combination of reasons:

- High gas prices and low electricity prices (low spark spread).
- Low economic value of primary energy savings and/or carbon emissions savings.
- Investors demand high returns for investments such as CHP which are non-core activities:
    - Uncertainty in investment climate due to low economic growth.
    - Uncertainty in the energy markets (as a result of energy market liberalisation).
- Most member states (except Belgium) are reducing financial support for fossil CHP due to the negative impact of CHP on emission targets.
- Overcapacity in the case of the Netherlands.

Opportunities are located in:

- Smaller CHP installations (50 kWe-1 MWe) in applications with a high amount of hot water and electricity like hospitals, homes, leisure centres, etc. These kinds of application typically have higher electricity prices than the energy-intensive industry.
- Bio-CHP: most member states still provide financial support for renewable energy, including bio-CHP.

Overview of current situation in member states in Northern CODE 2 Region

Regional Summary for the CODE 2 Project Northern Europe Region

Germany (pilot), Austria, Denmark, Finland, Sweden

The barriers to CHP and how to move to growth

Keeping CHP's benefits visible in the energy policy agenda at both the EU and MS level is important if policy action is to result; MS implementation of the CHP measures in the EED is an immediate opportunity therefore to encourage investments in highly efficient and flexible CHP plants. The EED provides a policy framework for member states to support CHP systems; strengthen information on CHP and its opportunities; support know-how building for professionals (planners, consultants, installers); and encourage CHP implementation by ESCOs.

To achieve the EU's Third Energy Package and long-term energy and climate policy objectives, the current lack of price signals for long-term investment in high-efficiency, low-carbon dispatchable power must be addressed at the EU level through improved electricity market design/operation. The European Commission consistently supports CHP; however, it has failed with the 2004 Directive to achieve the targeted efficiency gains through CHP. Should there be similarly poor progress with the EED, the EU should consider a special communication on CHP to reinforce and improve the EED provisions. Try and strengthen the ETS, e.g. via minimum CO2 prices, or alternatively CO2 taxation.

Regional Summary for the CODE 2 Project Eastern Region

Slovenia (pilot), Poland (pilot), Czech Republic, Estonia, Hungary, Latvia, Lithuania, Slovakia.

The barriers to CHP and how to move to growth

Current unfavourable energy market conditions are a key barrier for future CHP development without there being additional policy support in place. Preserving or establishing stable, predictable incentive support in accordance with state aid guidelines and member-state energy and climate objectives is the key challenge in almost all member states in the region.

The lack of member-state financial resources for support schemes is a key barrier and most often the reason for the reduction even of successful support instruments. A gradual introduction of additional market incentives for CHP to provide ancillary services to the electricity network and demand response could improve the current disadvantageous market position of CHP plants, especially of medium and small-scale CHP units, which are not yet supported in several member states. There is a clear positive turn toward renewable cogeneration, although at least limited support should be maintained for efficient recent fossil-fuelled CHP plants, where the integral implementation of new EU transmission infrastructure for diversification of the natural gas supply is crucial to reducing the current huge dependency and risks for the supply of natural gas from Russia.

Investment subsidies from EU structural funds for the energy retrofit of existing district heating systems are potentially a very important instrument used in several member states in the region to increase the efficiency and competitiveness of district heating compared to other heating alternatives. Similarly, investment subsidies for switching from fossil fuels (mainly coal; in Baltic States natural gas too) to renewables enable faster environmental retrofitting of existing old CHP units and sustainable growth of cogeneration. The future economic operation of district heating systems is crucial for the majority of the existing CHP capacity in the region.

Lack of investment resources and difficulty accessing affordable funds are serious barriers for industry and SMEs in the current unstable economic situation. Faster development of ESCO service offerings and specific financial products for cogeneration could significantly ease this problem in those member

states where the ESCO market is still at an early stage and suitable finance is lacking.

Fast and rigorous implementation of the EED could significantly contribute to:

- more consistent local heating planning and the setting of accurate priorities in heat supply based on a comprehensive assessment and cost benefit analysis;
- standardisation and simplification of network connection procedures and standards, especially for small-scale and micro-CHP units, where simplification and reduction of costs is an important factor to increase their competitiveness, and;
- faster access for CHP plants to the ancillary services market and demand response and the design of these markets to allow the full participation of non-utility (electricity-only generators) such as CHP.

Regional Summary for CODE 2 Project South-West Europe Region

Italy (pilot), France, Malta, Portugal, Spain

The barriers to CHP and how to move to growth

The common theme through practically all the member states is that the economic crisis has increased investor uncertainty, due to a fall in industrial heat demand. Inadequate policy responses regarding tariffs, taxation and incentives have rapidly produced a non-profitable position for operating CHPs on gas. At the same time there is general overcapacity in the electrical system (in Italy it exceeds 50%) caused by a reduction in energy demand and by the powerful entry of some renewable energy sources.

New regulation in the legal framework – led by the implementation of the EED – focuses in the text with active requirements mainly for large CHP >20MW. However the roadmaps have shown that other sectors like micro-/small-scale cogeneration, domestic space heating and the tertiary industry sector, district heating, and gas or biomass-fuelled CHP may be able to offer quicker paths to create activity in the cogeneration sector. Particularly under the current financial and electricity market conditions now operating, the challenges to established CHP plants established under historic market and electricity market conditions may be greater.

Regional Summary for the CODE 2 Project South-East Europe (SEE) Region

Greece (pilot), Bulgaria, Cyprus, and Romania. How to move to growth for CHP:

The barriers to CHP and how to move to growth

The transposition of the 2004/8/EC Directive for high-efficiency CHP gave a boost to the promotion of CHP in all member states, especially Cyprus, where it gave an impulse for the first CHP units with biofuel/biogas in the agricultural

sector.

The Energy Efficiency Directive represents an opportunity for member states in the CODE 2 SEE region to review CHP policies. Member states in the SEE region should pay particular attention to thoroughly implementing the EED requirements of Article 15, and of Article 14 where a "comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling" and a territory level cost-benefit analysis based on socio-economic and ecologic criteria are required.

The further development of industrial CHP in Romania and to some extent Bulgaria requires more pronounced economic activity in general plus active policy action to remove key barriers to CHP growth. Investment in the renovation and upgrade of district heating is a significant concern. In Greece and Cyprus, industrial cogeneration can be an asset, but the promotion of CHP should primarily target the tertiary and agricultural sector, as tourism is a major economic sector. The promotion of CHP in these sectors should thus aim to increase penetration of tri-generation, allowing CHP units to operate for more than 7,000 hours annually.

The growth of Bio-CHP

The member states have already indicated through their National Renewable Energy Plans what their expectations for bio-energy use and bio-energy in CHP are. CODE 2 took the analysis further using a wider range of sources and considering various CHP policy scenarios to better understand what the position of Bio-CHP might be in 2030.

The CODE 2 analysis projects that by 2030 around one third (conservatively 27%) of EU CHP will be bio-fuelled.

Bio-energy CHP potential analysis EU-27

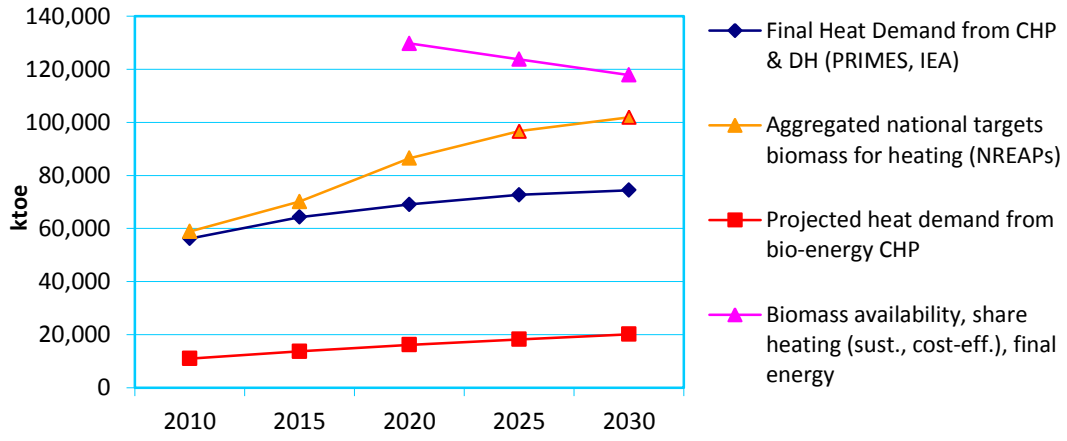


Figure 6: Bio-energy CHP potential – analysis to 2030

The main trends are:

- There will be a steady increase in CHP heat demand in the EU until 2030.
- The strong increase in biomass for heating as stipulated in the MS' NREAPs will also support the development of bio-energy CHP.
- The expected penetration rate of bio-energy CHP in CHP markets is expected to reach 27.1% in 2030 (up from 19.5% in 2009)[12].
- The framework conditions – politically, economically, regarding awareness – for (bio-energy) CHP vary greatly throughout the EU.
- Under optimum framework conditions on national level, the penetration rate could reach 33% in 2030.
- For the projected development, sufficient cost-efficient and sustainably produced biomass resources are available on a national level for further growth of bio-energy CHP. Again, the situation varies greatly between member states. In densely populated countries the nationally available biomass resources may fall short of the demand.
- To maximise the potential, technological progress towards the use of the whole range of biomass fuels should be promoted.

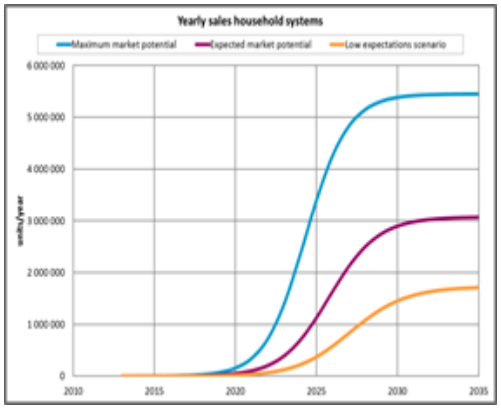
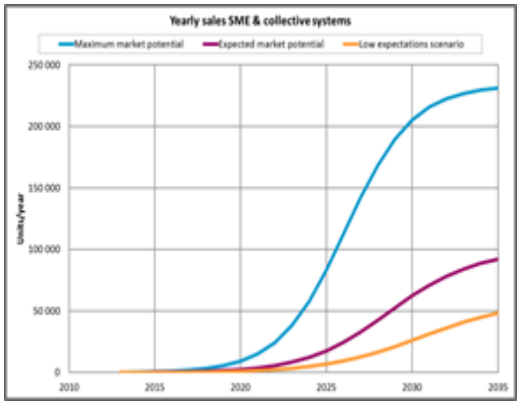
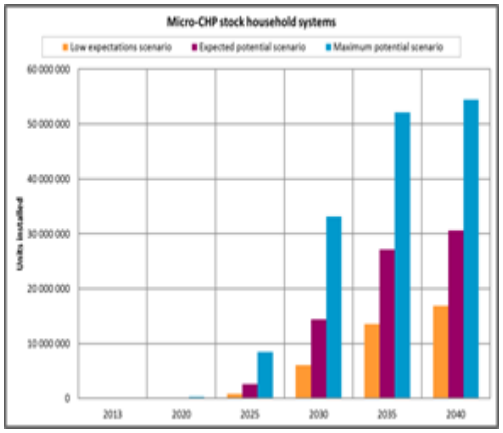
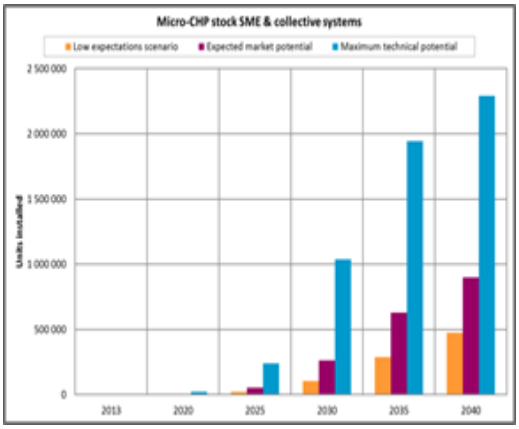
The opportunity for Micro-CHP

CODE 2 produced the first dedicated micro-CHP roadmap for each member state. These reports which are in an easily accessible one page format give direct input to the Member States' work on assessing the Heating and Cooling potential under EED Article 14 which requires micro-CHP to be specifically considered.

Different policy and market scenarios were considered to dictate penetration rates of micro-CHP into the European market and penetration rates ranging from 37% to 19% of the boiler market are well within reach in target countries. Key considerations for the industry are to move immediately to further reduce product cost and to consider whether the policy environment could support faster uptake. All major European boiler manufacturers are currently investing in micro-CHP, which with the right policy environment could join the innovative green technologies with good prospects for generating economic wealth in the coming years.

12 The three countries Germany (large CHP market by volume), Sweden and Finland (both good CHP markets with high biofuel share) account for 76% of the bio-CHP heat demand in EU-27 (2009).

Table 4: Summary of results of micro-CHP potential for EU 27: residential, SME and collective sectors

Residential systems (±1 kWe) ***Boiler replacement technology***	***SME & Collective systems (±40 kWe)*** ***Boiler add-on technology***
Present market (2013) Boiler stock: 101 300 000 units Boiler sales: 8 100 000 units/year	**Present market (2013)** Boiler stock: 8 200 000 units Boiler sales: 599 000 units/year
Micro-CHP potential (expected potential scenario)	***Micro-CHP potential (expected potential scenario)***
Yearly sales	***Yearly sales***
Sales in 2020: 52 000 units/year **Sales in 2030: 2 900 000 units/year**	Sales in 2020: 2 700 units/year **Sales in 2030: 68 000 units/year**
	
Stock	***Stock***
Stock in 2020: 103 000 units **Stock in 2030: 14 400 000 units** Stock in 2040: 30 500 000 units	Stock in 2020: 18 000 units **Stock in 2030: 290 000 units** Stock in 2040: 950 000 units
	
Potential savings in 2030	***Potential savings in 2030***
Primary energy savings: 300 PJ/year 7 100 ktoe/year (0,6% of EU-27 PEC [1] (2010)) **GHG-emissions reduction:** 13 Mton $CO_{2,eq}$/year (0,3% of EU-27 GHG emission	**Primary energy savings:** 240 PJ/year 5 800 ktoe/year (0,5% of EU-27 PEC) **GHG-emissions reduction:** 14 Mton $CO_{2,eq}$/year (0,3% of EU-27 (2010)

[1] PEC; Primary Energy Consumption

Policy Challenges

As highlighted in the methodology, member states already have elements of a policy framework for CHP in place today. However, one of the challenges for the CODE 2 project was to identify why this wealth of policy is not being effective. The project brought existing member-state experience to bear of major barriers to growth for the sector as identified in the Roadmaps. It also highlighted the specific national policy steps which could be taken to address these, as well as several successful CHP policy frameworks which already exist in member states. A range of different approaches along the spectrum of market liberalisation, regulation and support exist across the EU.

For each of the four main barriers identified in the European Roadmap:

- The electricity and heat markets do not consistently reward CHP for its energy savings at the energy system level. There is a market failure for the CHP operator.
- Issues relating to grid connection, network charges, permitting and bureaucracy continue for CHP despite legislation to the contrary since 2004.
- Regulatory uncertainty arising from the significant changes in recent years in both the electricity market and the energy market make CHP investment high-risk.
- The absence of appropriate consideration of heat in general energy and climate policy hampers CHP, as does the weakening focus on primary energy compared to energy end use in EU energy efficiency policy.

Reward CHP: There are clear policy successes which can be invoked in promoting CHP. The key aspect of all these mechanisms is that they recognise that promoting CHP beyond its current position requires attracting new potential operators who at the moment are not considering or are possibly unaware of CHP. These new operators have to find a business case or public-good necessity to adopt CHP. In practice the business case is the driver.
The economics of CHP – which straddles the heat and electricity markets – are vulnerable to impacts from all of the heat, fuel and electricity markets. However, examples from the Germany, Flanders, Italy, and recently the UK show that promotion is possible through market as well as direct national support.

More interestingly, the provisions of Article 15 of the Energy Efficiency Directive (EED) [13]and the need to develop a new European electricity market model are

[13] DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL)

opening up the possibility of CHPs taking on a role in the electricity ancillary services market. As a controllable, highly efficient electricity source, many CHP plants will be interested in offering services to the electricity network. These services will both help to stabilise the grid and enhance the efficiency of the overall network supply.

Issues relating to the electricity grid: The challenges for CHP and indeed all distributed generation connecting to the electricity network have remained consistently in place despite legislation to alleviate them for CHP dating back to 2004. CODE 2 warns that these problems have an impact on project cost and create uncertainty, further hampering new take-up of CHP.

Regulatory uncertainty: The biggest challenge to any operator on the European electricity market at the moment is uncertainty of policy and regulation. Several member states, including Italy, Spain and Germany, have introduced grid charges on the electricity consumed by CHPs on- site: so-called 'self-consumed' electricity. At the same time, government policy structure for CHP has changed radically. To succeed in a sector with long investment cycles such as CHP, member states must make firm time commitments to their policies with transparent review processes triggered by a clear set of criteria. Only in this situation can potential investors feel comfortable enough to invest.

Primary Energy Savings and Heat in EU policy: The European Union has successfully introduced the concept of efficiency along the energy supply chain through the Energy Efficiency Directive. However, by focusing increasingly on final energy savings the substantial losses of energy in the transformation sector become invisible and the role of CHP – which saves primary energy at the energy system level (across both the heat and power it produces) – becomes marginalised. CODE 2 sees a risk that Europe is losing focus on the primary energy savings imperative. The project recommends strong governance of the EED's implementation across Europe with a firm linkage of savings to PES. Until the end of 2014, heat was remarkably absent from EU energy policy thinking. There are now clear signs that this is being recognised and addressed – with a High-Level EU Conference on 'Heating and Cooling in the European Energy Transition held in Brussels in February 2015 and an EU Heat Strategy set to emerge by the end of 2015. This is vital for the growth of CHP in the European Union.

The policy opportunity represented by the EED was highlighted in all of the member-state roadmaps as the obvious next step to address growth in CHP, given that the legislation is currently in the process of implementation (Table 5 below). However, all the partners expressed concern that member states would not fully implement the terms of the EED but rather take a pragmatic "path of least resistance" approach to the Directive, treating the trickier Articles 14 and 15 (the most relevant to CHP) as scoping and planning exercises with longer time frames.

Table 5: The opportunity to address major CHP barriers through EED implementation.

	Barrier	EED article	Potential Impact
1	Market failure to reward energy efficiency savings	14- Promotion, CBA, measures 15-Balancing and DRM 7 – Energy efficiency obligation 18-Energy Services 20 EE National Fund	Good
2	High regulatory risk		Poor
3	Economic and non economic barriers to DG	8- Audits 9-Metering 12-Small consumers 15-Energy transformation	Good
4	Policy focus on Heat/Primary Energy Demand	3-Report PES 14- Comprehensive Assessment 24 –national EEAP reporting	Good heat/Poor on Primary Energy

The project concluded that full implementation of the EED should be insisted upon by industry and stakeholders in all member states and that the European Commission should adopt a suitable process of governance to make sure that the legislation around CHP is fully implemented.

Impact

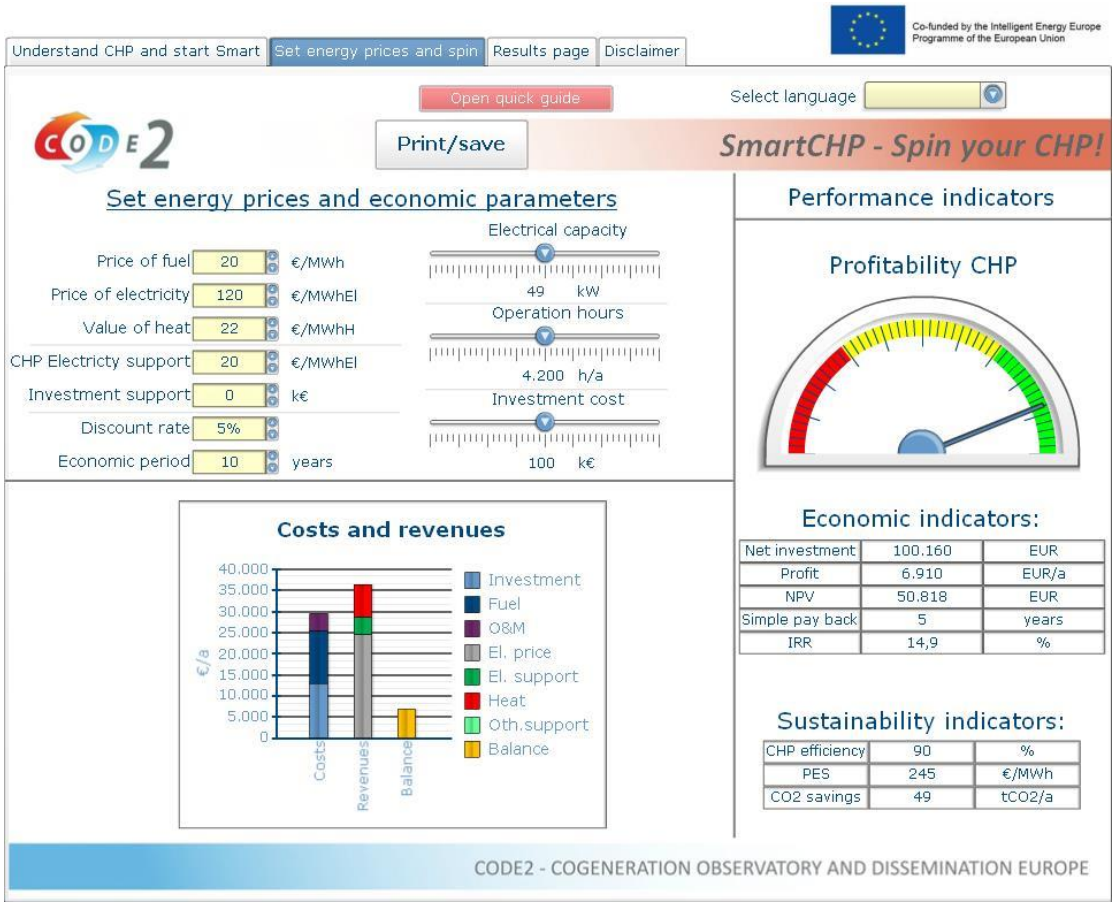
The timing of the CODE 2 project, which ran from 2012-2014 just as the Energy Efficiency Directive was being adopted and implemented, meant the project topic was very much alive in the minds of national policymakers. This significantly helped to trigger national interest in the project workshops and raised awareness among national policymakers of the role played by CHP in achieving the EU's energy and climate policy goals and the EED discussion. The activity around CODE 2 and the dissemination activity at member state levels helped to bring forward interest in the articles directly relating to cogeneration (Art. 14 & 15) in the Directive even though these largely had longer implementation dates than other Articles.

It was possible for the CODE 2 project to present initial thoughts and findings at the Concerted Action for the EED in Athens in April 2014. CODE 2 introduced first the opportunities for CHP in SMEs and industry, both areas which were not

heavily represented in the Concerted Action and secondly the alternative method for calculating CO_2 and Primary Energy Savings which was used in the project. At the time it was not possible to hold a full discussion on the Comprehensive Assessment but it was possible to introduce the resources of the project website, the bio- and micro study findings, and the case studies.

The networks which have been established under CODE 2 form a strong basis for supporting CHP stakeholder activity in the member states. However the resources of the project were insufficient to support any national level activity for more than the planned workshops. Discussion is ongoing within the COGEN Europe membership as to how to maintain the roadmaps as living documents and these considerations include the ongoing possibility of using the national networks and now the five thought leaders in the different member states.

The materials from the project – the How-to Guides, the online tool and case studies – are of high quality and have been well received by target groups such as SMEs, particularly as they are available in national languages. The one-page format of the micro and bio roadmaps, and similarly the case studies, make them easy to use and show to third parties. The materials will continue to be available on the website until the end of 2017/2018.



5) Conclusions and recommendations

The CODE 2 project has brought together in one database a wealth of valuable resources for industry and member states alike seeking to understand the current position of the CHP sector in the economy and policy and how policy might influence its future out to 2030.It is doubtful that such a comprehensive summary at this level of detail has existed before for the EU. This database includes wholly new analysis of the awareness of different socio-economic groups of CHP and a fresh range of examples of the wide use of CHP in the EU economy. It also contains the first analysis of the potential for micro-CHP and the increasing role of bio-CHP in the EU. The project took a wholly new look at the way Primary Energy Savings and CO_2 savings from CHP growth should be assessed and highlighted the differences thrown up by different calculation methods. On this basis CODE 2 can claim to have moved the understanding of the sector forward at a time when Europe is turning its attention to the role of both energy efficiency and heat in EU energy and climate strategy.

The recommendations from the project are built on the operational project successes and the difficulties which we encountered.

The first recommendation is that projects considering such work based on a regional structure, i.e. without a dedicated knowledgeable national representative in each member state, should plan either:

- Additional budget for funded hours of national specialists, or;
- Include in the budget an additional one year of elapsed time and effort for establishing national contacts in member states in a region through personal exchanges with the regional leader (including travel).

In reality the basis built under CODE was a help in the internal operation of the group but not in making the external expert links easier. The intention was that the latter would also be the case.

The second recommendation is that project officers continue to show flexibility regarding sensible re-scheduling of activities where clearly the original plan was overoptimistic. This first 12 months of the CODE project was full of activities which required original thinking, testing and iteration of ideas. These were often on the critical path. Two work packages had been scheduled to overlap although they were not inter-dependent nor did the second one have a hard deadline. Recognising the issue and redistributing the work early in the project was important for the final positive outcome of both work packages and the project timeline as a whole.

The final recommendation is to routinely involve target groups (SMEs) as critical partners in the project and having the UEAPME assistance in evaluating materials was very important in creating good quality outputs for the SME sector. The target group quickly establishes the scope and norms of their sector which is important in defining the language form and style of the different deliverables.