CODE2

Cogeneration Observatory and Dissemination Europe

D5.2 Cogeneration Roadmap

Member State: ***SLOVENIA***

Leading CODE2 Partner: ***Jozef Stefan Institute***

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Introduction to CODE2 and summary

This roadmap has been developed in the frame of the CODE2 project, which is co-funded by the European Commission (Intelligent Energy Europe – IEE) and is part of an important market consultation for developing 27 National Cogeneration Roadmaps across Europe. These roadmaps are built on the experience of the previous CODE project (www.code-project.eu) and in close interaction with the policy-makers, industry and civil society in each member state through research and workshops.

The project aims to provide a better understanding of key markets, policy interactions around cogeneration and acceleration of cogeneration penetration into industry. By adding a bio-energy CHP and micro-CHP analysis to the Member State projections for cogeneration to 2020, the project consortium is proposing a concrete route to realise Europe's cogeneration potential.

For more details and other outcomes of the CODE2 project see: www.code2-project.eu

Roadmap methodology

This roadmap for CHP in Slovenia is written by the Energy Efficiency Centre from Jozef Stefan Institute and has been based on a range of studies (see list of sources) and has been developed through a process of discussion and exchanges with experts.

The first draft of the roadmap was discussed and reviewed on an interactive workshop with stakeholders on 26th November 2013 in Ljubljana. The input from the workshop and any additional input from experts have been used to produce the current version.

Acknowledgement

Jozef Stefan Institute and the CODE2 team would like to thank all experts involved for their contributions to develop this roadmap, which has been valuable regardless of whether critical or affirmative. It has to be stressed that the statements and proposals in this paper do not necessarily reflect those of the consulted experts.

Summary

With the established new CHP support scheme in 2009, Slovenia has triggered a stable moderate growth of the CHP generation in the recent years reaching 7,5% share in the total electricity generation. Around 300 new CHP units have been installed in the last decade with around 125 MWe total capacity and 450 GWh electricity generation. Majority of new units are located in district heating and services with more than 40% share of biogas and biomass and the natural gas as the major fuel used.

Up to 500 MWe of new additional CHP capacity with the 2,6 TWhe of electricity generation and at least 2,5 TWh of the useful heat supply could be installed in Slovenia till the year 2030. New units could provide around 50% of the indicative national target of the primary energy savings till the year 2020 and up to 2,7 million ton of the CO_2 emissions reduction till 2030.

Fast revision of the CHP support scheme and establishing a long term stable incentive framework for cogeneration is a key precondition for further development of cogeneration, with the largest existing potential in industry. Roadmap implementation would have several positive effects on the development of new energy services, manufacturing of CHP technology, new jobs creation, increase of competitiveness and other significant benefits for the whole economy in the sensitive period of a sustainable economic crisis recovery.

1. Where are we now? Background and situation of cogeneration in Slovenia

1.1 Current status: Summary of currently installed cogeneration

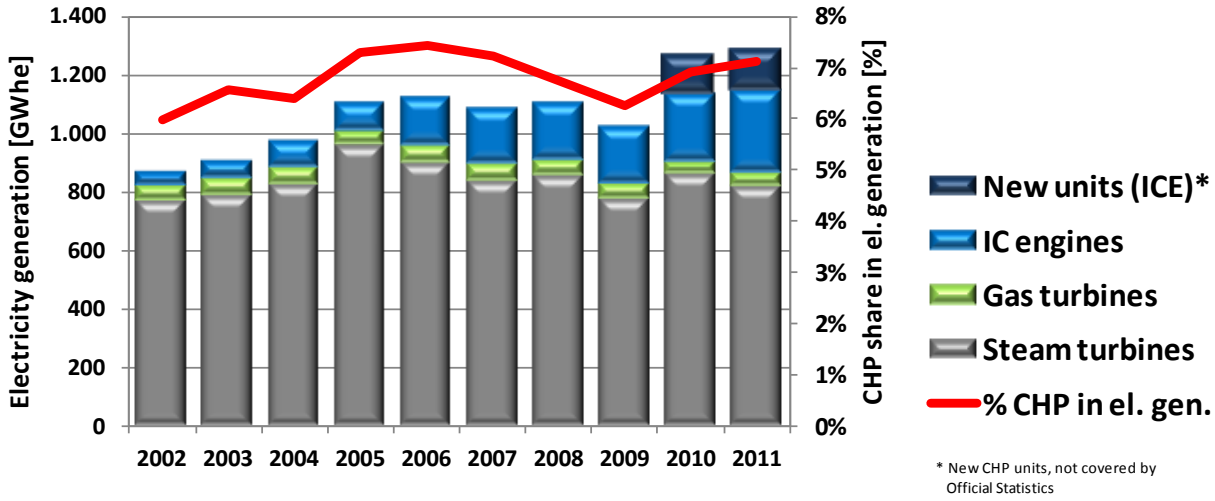
According to the official statistical data[1], the production of electricity from 36 CHP plants with installed capacity of 337 MW_{el} in 2011 equalled 1.145 GWh, which is 0,9% more than a year before and 31,3% more than in 2002. CHP electricity generation share in total gross electricity generation in Slovenia is growing and was 7,5% in the year 2012. Useful heat production in 2012 was 2.985 GWh with a slight decrease trend compared to the previous years, as shown in Table 3.

Table 1: National statistics on cogeneration in Slovenia 2008 - 2012

	Installed CHP capacity (MW_{el})	**Total CHP electricity generated** (GWh)	**Total CHP heat supplied** (GWh)	**Total electricity generated** (GWh)	**Total CHP share on electricity** (%)
2008	335	1.106	3.325	16.398	**6,7**
2009	327	1.025	3.119	16.401	**6,3**
2010	333	1.135	3.223	16.433	**6,9**
2011	337	1.145	3.042	16.056	**7,1**
2012	346	1185	2.985	15.729	**7,5**

Source: Statistical Office of Republic of Slovenia

Steam turbines are still a prevailing CHP technology in Slovenia although with decreasing electricity generation due to the stop of old autoproducers plants in industry (autoproducers have 20% share in total capacity and electricity generation) as shown in Figure 1. Almost all new CHP plants are powered by internal combustion engines, where not all new units are covered by the national statistics[2].



[1] Statistical office of the republic of Slovenia. Data is prepared following the EUROSTAT methodology for CHP.

[2] National statistics is not yet covering small scale CHP units in tertiary sector, although some data are available from the Borzen who is managing the support scheme.

Figure 1: CHP technology development in Slovenia

Coal has still almost 60% share in CHP fuel consumption, followed by growing other fuels shares (23% of natural gas, 13% of wood biomass and 5% of biogas) as shown in Figure 2.

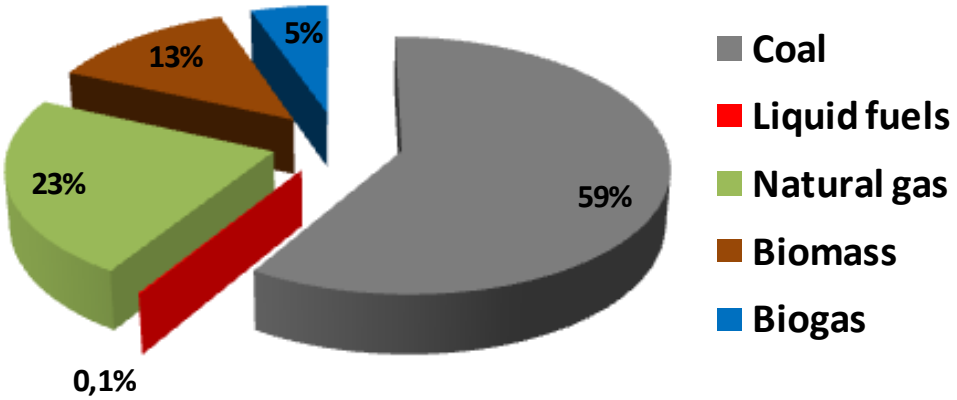


Figure 2: Fuel structure of CHP plants in Slovenia in year 2011

Slovenia has an old tradition of district heating (DH) with the DH networks operating in 49 municipalities with 734 km of DH network and 1 km of district cooling network. The share of CHP heat supply is growing and is close to 80% in recent years (more than 95% in two largest DH systems in Ljubljana and Velenje, less in other smaller DH systems), as shown in Figure 3.

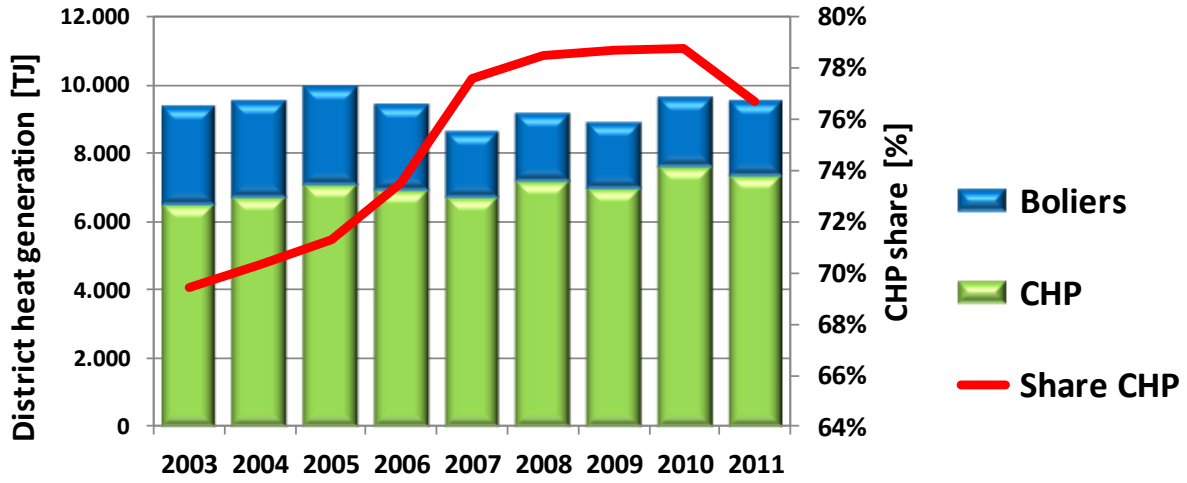


Figure 3: Structure of district heating heat supply – share of CHP

1.2 Energy and Climate Strategy of Slovenia

One of the most important challenges we face today is also to ensure a reliable, competitive and environmentally sustainable energy supply and energy services to all consumers. In Slovenia already the Energy Law from 1999 has followed these goals. Nowadays Slovene national energy policy is more and more influenced by the common EU energy policy and therefore national goals are very often derived from the goals on the EU level.

The fundamental document for CHP and energy policy in general in Slovenia is the **Energy Law**[3], which transposes CHP Directive into Slovenian legislation. It introduces also a feed-in support scheme, which is then more in detail defined in a special act on electricity support from high efficiency CHP[4]. This act is the main CHP support instrument in Slovenia.

The first goal for cogeneration was included in the first national energy programme ReNEP[5] from 2004 – CHP electricity production should have doubled from 800 to 1.600 GWh yearly in the 2000-2010 period. This goal was not achieved, as the electricity production from cogeneration in 2010 reached only 1.135 GWh (Table 1). The CHP goals until 2020 have not yet been adopted. In the proposal for the new national energy programme NEP for the period until 2030[6], the goals were set to 18% share of cogeneration in the gross final energy consumption until 2020 and to 23% share until 2030.

Despite the fact that there are currently no CHP goals adopted on a national level, the extent of support for cogeneration in different economic sectors and using different fuels is included in several strategic documents:

- **The national renewable energy action plan for the 2010-2020 period (NREAP)**[7] is introducing 80% share of heat produced from RES, CHP or waste heat in the district heating systems by 2020 and exclusive use of RES, CHP or district heating in all buildings with installed heat capacity over 250 kW from 2012 onwards.
- **The national energy efficiency action plan for the 2008-2016 period (NEAP 1)**[8] defines the development of CHP in sectors, which are not included in EU ETS. According to this plan energy savings achieved by implementing CHP in households and tertiary sector should reach 102 GWh per year by 2016. In 2010 the achieved savings were estimated to 9,1 GWh, i.e. only 26,7% of the NEAP 1 goal[9]. Total savings due to the efficient use of RES and installation of new CHP systems are estimated to app. 3% of all final energy savings planned by the plan. Support for CHP installed by autoproducers in industry is not a part of this action plan.
- **The proposal of the new national energy efficiency action plan for the 2011-2016 period (NEAP-2)**[10]**:** a further support of CHP systems within the feed-in support

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[3] Energetski zakon (EZ), Ur.l. RS, 27/2007-UPB2, 70/2008, 22/2010, 37/2011 Odl.US: U-I-257/09-22, 10/2012, 94/2012-ZDoh-2L, Latest revision EZ-1**:** Ur.l. RS, 17/2014.

[4] Uredba o podporah električni energiji, proizvedeni v soproizvodnji toplote in električne energije z visokim izkoristkom, Ur.l. RS, št. 37/2009, 53/2009, 68/2009, 76/2009, 17/2010, 81/2010.

[5] Resolucija o nacionalnem energetskem programu, Ur.l. RS, 57/2004.

[6] Osnutek predloga Nacionalnega energetskega programa Republike Slovenije za obdobje do leta 2030: »Aktivno ravnanje z energijo« (http://www.mzip.gov.si/fileadmin/mzip.gov.si/pageuploads/Energetika/Zelena_knjiga_NEP_2009/NEP_2010_2030/NEP_2030_jun_2011.pdf).

[7] Akcijski načrt za obnovljive vire energije za obdobje 2010–2020 (AN OVE); http://www.energetika-portal.si/fileadmin/dokumenti/publikacije/AN_OVE/AN_OVE_2010-2020_final.pdf.

[8] Akcijski načrt za učinkovito rabo energije za obdobje 2008-2016 (AN URE 1); http://www.energetika-portal.si/fileadmin/dokumenti/publikacije/AN_URE/AN_URE1.pdf.

[9] AN URE 1 goal for 2010 was defined by using a linear interpolation of the goal planned for 2016.

[10] Drugi nacionalni akcijski načrt za energetsko učinkovitost za obdobje 2011–2016 (AN URE 2); http://www.energetika-portal.si/fileadmin/dokumenti/publikacije/AN_URE/AN_URE2.pdf.

scheme is foreseen. In the 2010-2016 period all together 55 MWe of newly installed CHP electrical capacity in industry, service sector and households is planned, while the final energy savings are estimated to reach 307 GWh per year by 2016, out of which 95 GWh in the service sector and households, which is little less than predicted by NEAP 1. The total installed electrical capacity of the new CHP systems is planned to reach 92 MWe by 2020 and the total final energy savings are estimated to 490 GWh per year (industry 325 GWh, service sector 126 GWh, households 39 GWh).

- **Operational programme for greenhouse gases mitigation until 2012 (OP TGP)**[11]: The action plan has foreseen cogeneration between other measures for GHG emissions reduction, where installation of new CHP systems in district heating plants, industry and building sector and installation of biomass cogeneration should contribute 313 kt $CO_{2\text{-eq}}$ of GHG emissions savings in the year 2012.

The key public institutions responsible for cogeneration policy and support implementation in Slovenia are:

- **Ministry of Infrastructure of the Republic of Slovenia** as the main regulative body for cogeneration;
- **Energy Agency of the Republic of Slovenia – JARSE** as energy regulator, which is issuing declarations for CHP units (GoO) and provisions for the CHP support;
- **Borzen** – a centre for the RES and CHP support, which acts as market operator and is managing also the feed-in support scheme.

1.3 Policy development

New support scheme as the key CHP support instrument triggered a significant number of new CHP investment and established favourable environment for the CHP development in all sectors in Slovenia.

New feed-in support scheme approved in 2009 is the main CHP support instrument in Slovenia, managed by Borzen - a centre for the RES and CHP support[12]. The level of the CHP support depends on the type of fuel, unit's capacity and number of working hours (Table 1). After entering the scheme the units are entitled to receive the support for 10 years (15 years for RES CHP).

Power plant owners have the option of choosing between two types of support:

[11] Operativni program zmanjševanja emisij toplogrednih plinov do leta 2012 (OP TGP); http://www.energetika-portal.si/fileadmin/dokumenti/publikacije/OP_TGP/OP-TGP_2012.pdf.

[12] By the latest revision of the Energy law (EZ-1) approved in February 2014, the entrance to the support scheme has been stopped with 22.9.2014 and at the moment the support scheme is under revision. Main change will be introduction of the tender procedure for the entrance to the scheme and some minor corrections are foreseen but the basic concept of the support should not change.

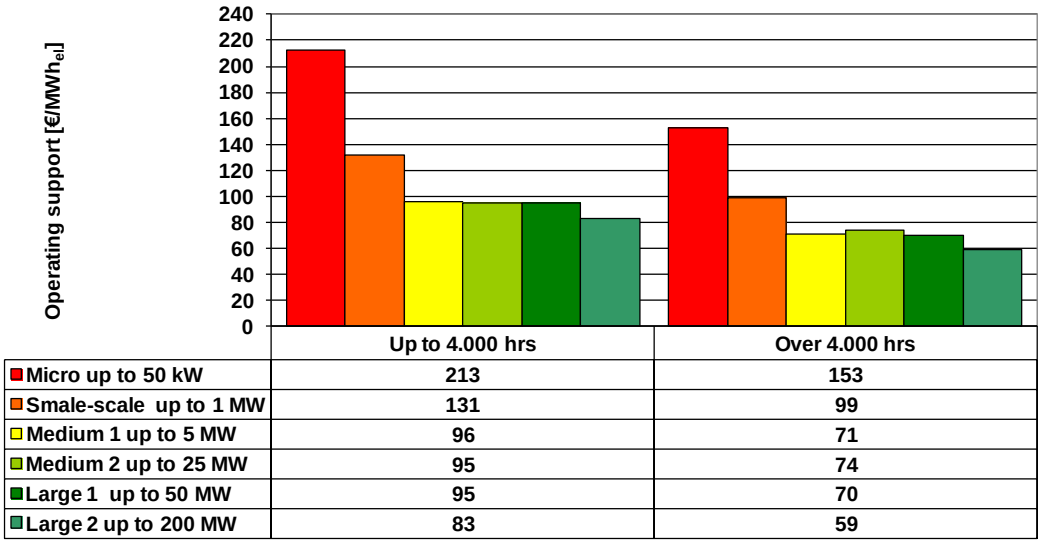
- **"guaranteed purchase"**, where Borzen takes over the total produced electricity (the producer is included in the special balance group, operated by Borzen)
- **"operating premium"**, where the producer sells electricity on the market or consume it on site and get paid premium as a difference between the full ("guaranteed purchase") price and the market price, which is determined ex ante on a yearly level.

CHP producers with installed capacity over 1 MWe can only receive the "operating premium" type of support. Level of premiums in the year 2013 is shown in Figure 4 and Figure 5.

Table 1: Structure of the feed-in support scheme for CHP units

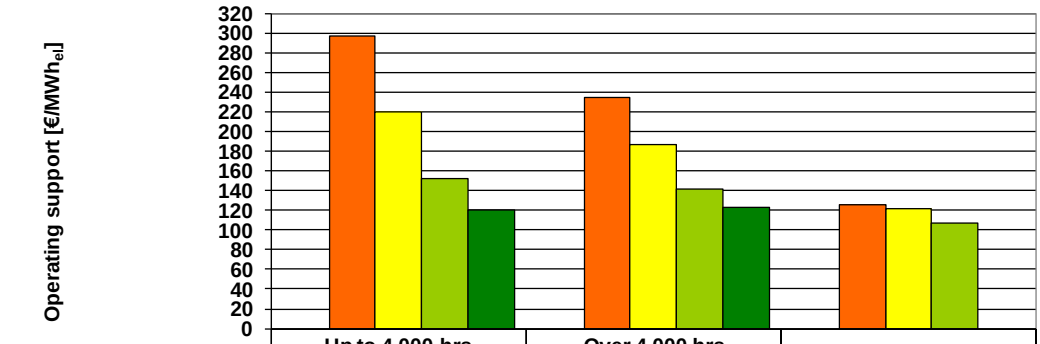
Type of fuel	Number of working hours	Unit's capacity	
Biomass **Fossil fuel**	**≤ 4.000 h/year** **> 4.000 h/year**	**Micro**	(≤ 50 kWe)
		Small	(≤ 1 MWe)
		Lower middle	(1 to 5 MWe)
		Higher middle	(5 MWe to 25 MWe)
		Lower big	*(25 MWe to 50 MWe)*
		Higher big	*(50 MWe to 200 MWe)*

Note: By latest on-going revision only CHP units up to 20 MWe are eligible for the support (up to 10 MW if using RES)



	Up to 4.000 hrs	Over 4.000 hrs
Micro up to 50 kW	213	153
Smale-scale up to 1 MW	131	99
Medium 1 up to 5 MW	96	71
Medium 2 up to 25 MW	95	74
Large 1 up to 50 MW	95	70
Large 2 up to 200 MW	83	59

Figure 4: Feed-in premium for fossil CHP in the year 2013.



	Wood biomass		Biogass
	Up to 4.000 hrs	Over 4.000 hrs	
Micro up to 50 kW			
Smale-scale up to 1 MW	297	235	126
Medium 1 up to 5 MW	220	186	121
Medium 2 up to 25 MW	152	142	108
Large 1 up to 50 MW	120	122	

Figure 5: Feed-in premium for wood biomass and biogas CHP in the year 2013.

The feed-in system is based on the guarantees of origin. All producers included in the scheme must issue and transfer to Borzen guarantees of origin as proof of the RES / CHP production.

The feed-in scheme is financed through dedicated add-on charges on the network fee bills of all users of electricity in Slovenia.

Introduction of the feed-in support scheme in Slovenia in 2009 has contributed to the installation of quite some number of new small scale CHP units especially in the service sector, including public sector. According to the data of BORZEN, there were 42 new CHP units with a total installed capacity of 6,7 MWe included in the scheme at the end of 2011 (Figure 6). The capacity of vast majority of these units (81%) was smaller or equal to 50 kWe.

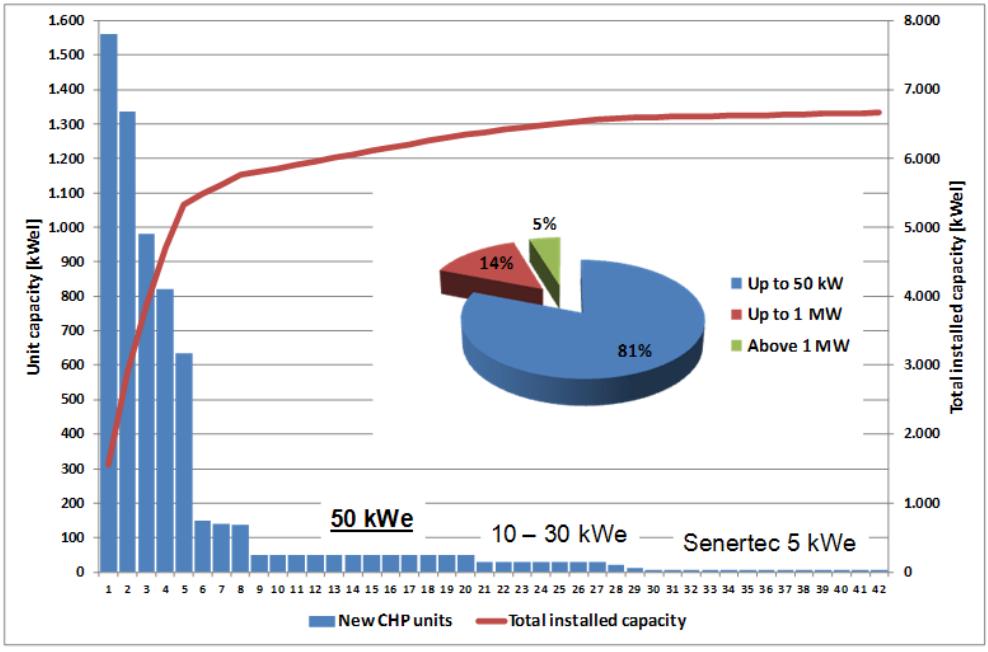


Figure 6: New CHP units included in the feed-in support scheme at the end of 2011

Complete development of CHP plants in the period 2003 – 2014 in Slovenia is shown in Figure 7 where constant moderate growth of CHP investments is evident over the whole period. By the provisional data for the 2014, 300 CHP units with the 126 MWe of the installed capacities were included in the support scheme[13].

Fossil fuelled CHP units (mainly natural gas and LPG) have 57% share in the total installed capacity followed by 24% share of biogas and 18% of wood biomass CHP plants (Figure 8).

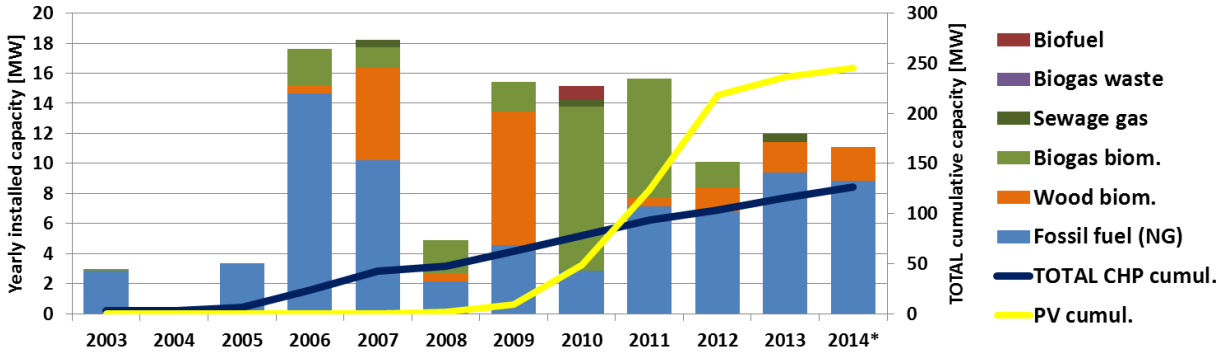


Figure 7: Yearly installed CHP capacities in Slovenia (2014* provisional data for ¾)

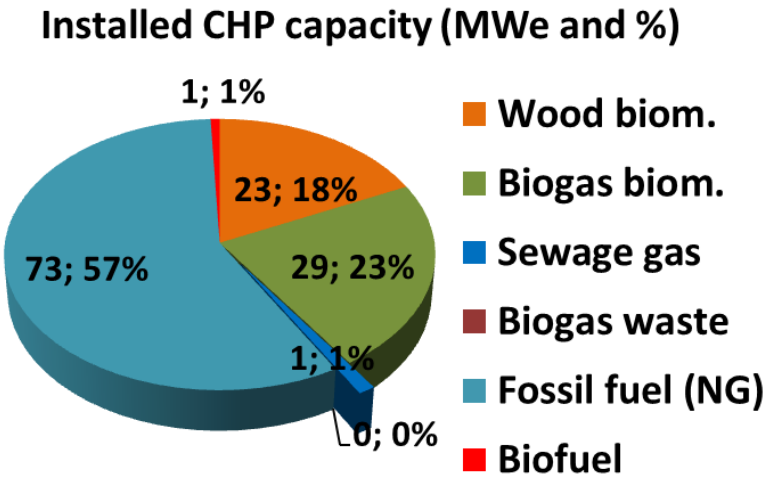


Figure 8: Structure of the total 126 MWe installed CHP capacity in period 2003 – 2014*

All new CHP plants supported through the new support scheme in 2013 produced 450 GWh of electricity (56% of total electricity generation in the RES&CHP support scheme). Total CHP support costs in 2013 were 52 million EUR (44% of all RES&CHP support costs) with average level of support 115 €/MWhel (125 €/MWhel for RES support).

[13] Borzen data status on 3.quarter 0f 2014, total new installed CHP capacity in 2014 is larger as till several new CHP units were installed till the end of support on 22.9.2014 and were registers later till the end of 2014.

1.4 Awareness

The main reason for the actual evident raise of awareness about cogeneration in Slovenia is dissemination of good practice of successful implementation of CHP projects triggered by incentive environment of the feed-in support scheme.

Cogeneration investments rely on a commercial proposition and a functioning market for the application of cogeneration. The policy intervention of the European Union to support cogeneration and assist the removal of market barriers is an important element of creating a good commercial proposition. However in itself it will not be sufficient to grow sales of cogeneration, if the customers are unaware or misinformed and lacking support within influencing groups or and if the supply chain of skills and suppliers does not exist.

A final buying decision by a customer is the result of a set of complex interactions, involving the supplier, the supply chain and the customer. External conditions influence the process as do the market structure and the policy structure. A mature market for a product is characterized by a high degree of awareness among all the relevant players in the market and ongoing buying and selling activity.

The following 4 groups of socio-economic actors can play an important role in the cogeneration market, either by direct involvement or by creating the appropriate economic and market structure:

- **Customers:** utilities (DH), industry, households, SMEs (services);
- **Market and supply chain:** manufacturers, installation companies, grid operators, consultants, architects, banks/leasing, ESCOs;
- **Policy structure:** energy and climate legislators on all levels of various institutions on state, regional and local level, energy agencies, planners;
- **Influencers:** sector organisations, general public, media, academic area, NGOs, research.

The list is not exhaustive but contains all the most relevant players.

An assessment of awareness of cogeneration among key market actors in Slovenia has been developed through performing interviews with a sample of the key actors dealing with cogeneration in Slovenia (state and local public administration, interest groups and cogeneration providers). Final results of the four groups of the socio-economic actors for cogeneration awareness assessment are shown in **Figure 9** (more information is presented in **Annex 1**)

Figure 9: Assessment of four groups of the socio-economic actors' awareness of cogeneration in Slovenia

General public awareness about cogeneration is low in Slovenia. Except for the professional public and technical enthusiasts most of the people have never heard about this technology and if they did, they very often see it as a complicated and expensive technology causing additional noise, emissions etc. Compared to the cogeneration leading member states (Germany and Belgium) we have identified next key differences in the awareness:

- **Firm governmental and political support and awareness** about advantages and contribution of cogeneration to the energy policy targets is still not yet present. Although cogeneration is properly positioned in several strategic documents and supported by a very incentive feed-in support scheme, mid and long term perspectives are still not clear and causing uncertain environment for the investors. Lack of financial resources for the support scheme and consequently uncertain future support is a key barrier at the moment.

- **Lack of awareness in banks and financial institutions:** the financial sector is regarding cogeneration still very cautious (lack of proper knowledge/understanding, too complicated, too high risks), which makes borrowing money from banks for CHP projects much more difficult compared to the other investments, like PV plants. This is crucial in the moment of financial crisis in Slovenia, where access to the financing resources is one of key issues for the successful project implementation.
- **Proper knowledge and awareness in the whole chain responsible for successful CHP project implementation:** this is a large challenge for several indicated actors, which is crucial for wider quality CHP project implementation, especially in services ad households sector.

1.5 The economics of CHP

Current feed-in support scheme enables good economic conditions for new CHP investments with a foreseen 12% return of investment for the majority types of CHP projects in Slovenia in spite of current very unfavourable energy market prices conditions.

Current energy market trends are very unfavourable for cogeneration in Slovenia:

- Recent decrease of electricity prices, linked to the EEX prices is especially influencing district heating CHP plants selling electricity on the competitive electricity market[14].
- Increase of natural gas prices which are in general on a higher level compared to other EU member states[15]
- Ratio between electricity and natural gas price is around 1.5, which is far from the necessary level around 2.5

Recent natural gas and electricity prices by Eurostat consumers groups and the ratio between electricity and natural gas prices (CHP Energy price ratio) are shown in the following Figure 10. **Additional support of existing and new CHP units through the feed-in support scheme is a key instrument, essential for both the CHP operational cost recovery and the necessary return of investment of new CHP plants in current unfavourable energy market conditions. Without the support we do not expect any new CHP investments and stop of operation of existing units would happen.**

Feed-in support scheme according to the EU state-aid rules enables "normal return on capital" where 12% discount rate was used for setting the level of support[16]. That means that in general we can presume **12% return of investment** for the majority of CHP projects in Slovenia where investment and operation costs do not vary significantly from the reference costs from the Methodology[16] (lower return is expected in the revised support scheme). Yearly support adjustment mechanism considering electricity, natural gas and wood biomass market prices assures stable return of investment over the 10 years supporting period.

Current unfavourable market conditions request additional small operation support to cover the difference between larger operational costs and electricity market price for CHP units older than 10 years as well.

[14] On the other hand final end use electricity prices are growing (additional fees on RES, CHP, etc.).

[15] After the log period of growing, negative trends of natural gas prices have happened in 2013.

[16] Methodology for Determining the Reference Costs for High-Efficiency Cogeneration, Ljubljana, 2009. http://www.mg.gov.si/fileadmin/mg.gov.si/pageuploads/Energetika/Sprejeti_predpisi/Methodology_CHP.pdf

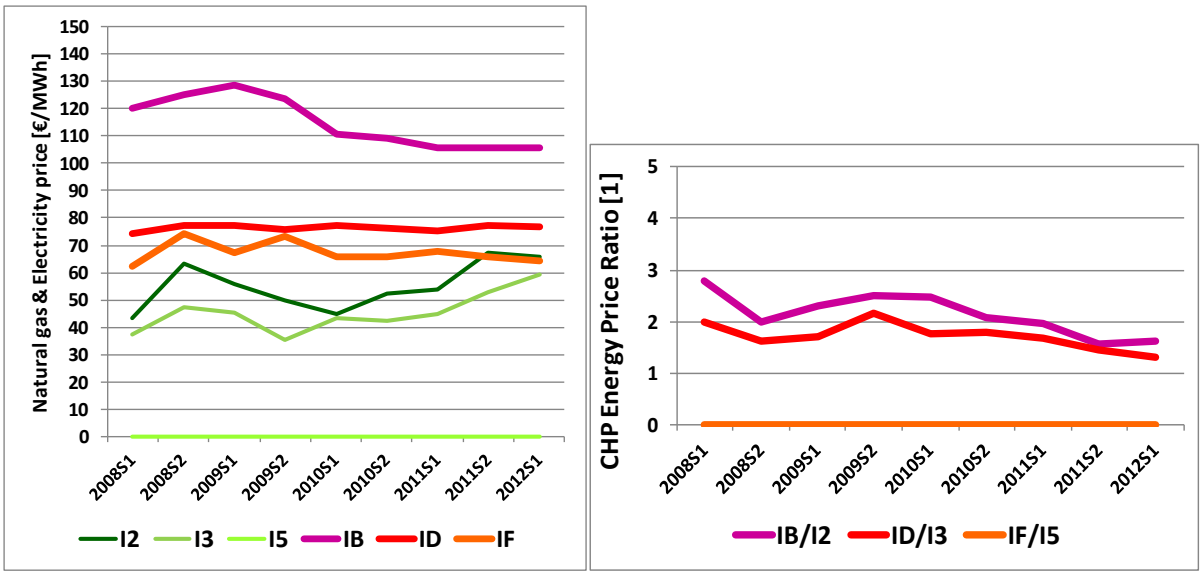


Figure 10: Recent natural gas and electricity prices and the CHP Energy Price Ratio for Slovenia

Economic assessment of four typical CHP projects for Slovenia[17] in market conditions in the year 2012 proved the guaranteed profitability by the support scheme (Figure 11). Economic indicators (IRR and simple payback time) of micro and small scale CHP units are even slightly better than these results whereas district heating and biogas CHP units are close to the foreseen 12% IRR. More information about the CHP economic assessment you can find in Annex 2.

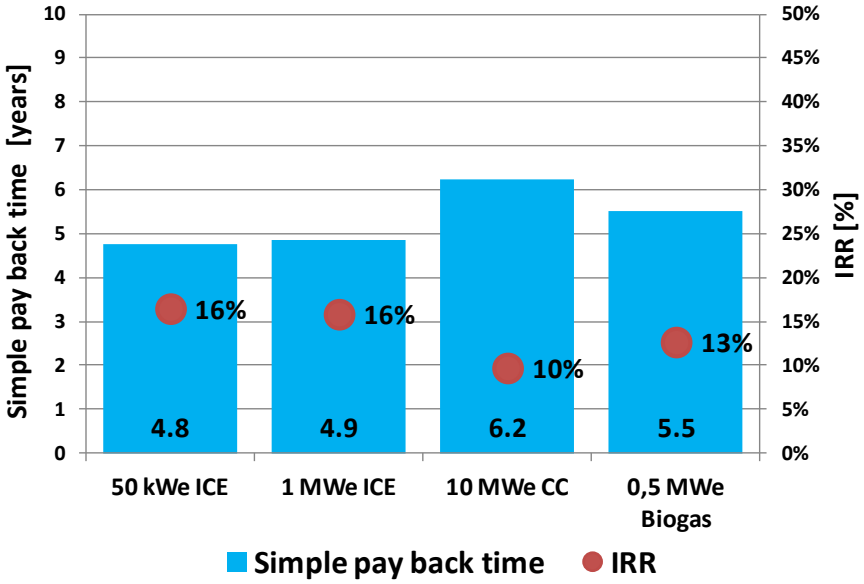


Figure 11: Economic indicators of typical CHP projects in Slovenia in year 2012

[17] Micro CHP unit with 50kWe gas engine, 1 MWe gas engine in industry and services, 10 MWe combined cycle unit in district heating and 50 kWe biogas unit.

1.6 Barriers to CHP

Barriers noted in the 2007 report to the Commission

In the report to the Commission[18] in 2007 Slovenia presented results of survey on barriers to the development of cogeneration plans by potential investors and highlighted the five main barriers for realization of CHP investment plans as shown in Figure 12.

Generally too high risks and poor economics of CHP projects at that time were main obstacles for the investors beside lack of resources, administrative procedures and still poor awareness and access to the information. The high expectations in terms of the payback period, the risk involved were highlighted and the preference for investors to make profit more easily by other forms of investment emerged as a barrier. These high expectations in terms of yield appear to be the major obstacle to the expansion of cogeneration in Slovenia before the approval of new CHP support scheme in 2009.

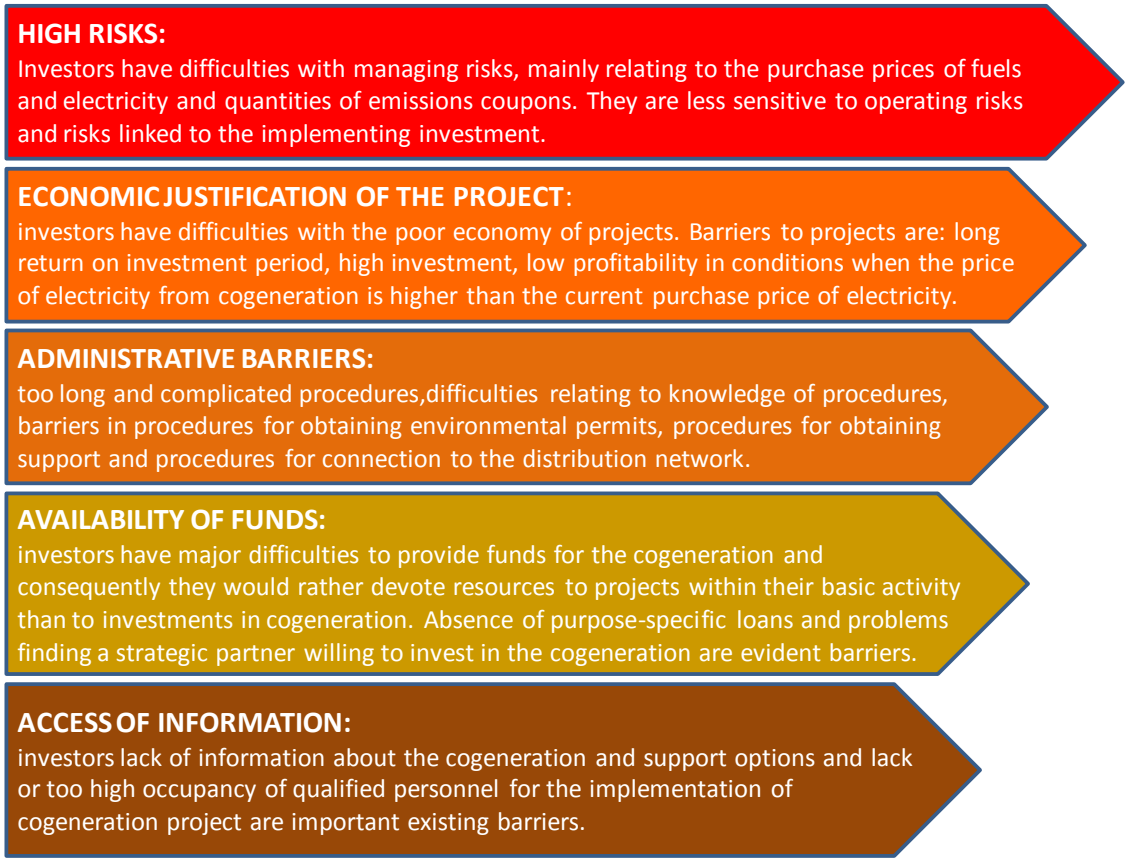


Figure 12: Main highlighted barriers from potential CHP investor's survey in 2007

General barriers independent of the application area

Although the conditions and the investment framework for cogeneration have significantly changed since 2007, we are still facing important barriers preventing faster development of CHP investments in Slovenia as presented in the following subchapters.

[18] Analysis of the potential for the application of high-efficiency cogeneration of thermal energy and electrical energy in Slovenia, Report to the European Commission in accordance with Article 6 and Annex IV of Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand, Ljubljana, July 2007

Uncertain CHP support scheme stopped and postponed several projects in 2013

Too fast recent growth of PV plants in Slovenia has caused a significant burden for financing the RES and CHP electricity support scheme. Strong resistance of large industrial consumer to the necessary increase of fee for scheme financing resulted in issuing the amendment of the Energy law in February 2014 (EZ-1) which is changing the current feed-in support model to the limited tender support model. As the entrance to the current support scheme expired in mid-September, missing sub-law legislation and uncertain situation about the future support implementation completely stopped planning and implementation of new CHP investments in Slovenia[19] as due to the current unfavourable energy market conditions, a proper support level is the key precondition for the economic operation and feasibility of all CHP plants.

After five years of application **the evaluation results of the past operation should be introduced into the** scheme revision **to improve the cost-effectiveness and to remove some noticed problems and inconsistencies** (especially linked to the micro CHP units and individual treatment of new CHP technologies[20]).

Absence of the support for CHP plants older than 10 years is threat for stopping of the operation of several modern CHP plants

Introduction of supporting framework also for depreciated CHP units (older than 10 years) is not allowed according to the EU State aid guidelines. How to solve this problem is the huge challenge, where most probably the solution should be found on the EU level (Following current guidelines such support is allowed only for wood biomass CHP plants, if plant operation costs are higher than the electricity market prices). Very limited and low operating support would enable further economic operation of several modern high efficiency CHP units, installed 10 years ago.

Lack of the private investment funds is a key reason for absence of new larger CHP investment

A very difficult access to financial resources (bank loans) in the current economic crisis is a key barrier for exploitation of huge economic CHP potential in industry and large CHP investment (100 MW_e CC on natural gas) in the Ljubljana district heating (TE-TOL)[21]. Uncertain future operation of the industrial companies and their high level of indebtedness is a key obstacle for the banks and potential ESCO entry in CHP project implementation. Current uncertain support framework, lack of knowledge and support

[19] Several number of smaller CHP units is under installation in 2014 but the planning of larger CHP projects stopped.

[20] Project based individual setting of the support level after the plant installation is used in current support scheme for new market immature CHP technologies. Despite of a higher support the uncertainty about the guaranteed support level (not known in advance) have been recognized as a risk between the potential investors.

[21] Implementation of partial switch from coal to natural gas by new combined cycle unit installation (100 MWe) in TE-TOL in Ljubljana is still uncertain, due to huge problems with closure of bank financing portfolio. Absence of certain CHP support as key requested guarantee for the project from banks is the main reason for moving away the start of the project with all necessary permissions and licences for implementation.

to the energy contracting model in industry and limited experiences and knowledge on CHP in the financial institutions is amplifying the problem of financing new CHP investments nowadays in Slovenia.

Weak energy policy is reflecting in non-consistent measures and local energy planning destroying the potential for cogeneration

As the new National energy programme (NEP) for the period until 2030 has not yet been approved, Slovenia has no explicit target for the CHP except the CHP measures included in the National energy efficiency action plan, the National renewable energy action plan and the Operational programme for greenhouse gas emissions mitigation. Lack of consistent policy and priorities for further development of district heating & cooling systems is even more serious as it is reflecting in inconsistent support measures[22] and local conflict of other heat supply options in the area of district heating networks.

Rigid heat prices regulation for district heating is an obstacle for economic operation and development of district heating systems

An additional obstacle is a very rigid state regulation of heat prices in district heating systems, which is not adapted to the cogeneration specifics, especially in current situation with very low electricity market prices which, need some additional allocation of costs on the heat price. Current situation is not giving proper foundation and framework for necessary retrofit and optimisation of existing DH systems or even planning of extensions and future development of DH&C in Slovenia.

Poor general awareness is reflected on wrong decisions and bad public opinion

A general public awareness about cogeneration in Slovenia is low. Except for the professional public and technical enthusiasts most of the people have never heard about this technology and if they did, they very often see it as a complicated and expensive technology causing additional noise, emissions etc. and not as, if properly designed, an efficient way for the heat and electricity production or a green technology contributing to the lower primary energy consumption and greenhouse gas emissions.

The poor general awareness is reflected in non-optimal energy solutions of decision makers on different levels (national and local planning, companies and institutions, architects, smaller investors, installers, etc.), low confidence of the financial institutions to provide financing to CHP project and in some cases also people oppose to the proposed CHP project implementation due to the unfounded fear of CHP influence on the environment[23] (noise, emissions, etc.).

[22] Cohesion found subsidies programs are giving preference to the RES utilisation without distinction if the object is connected on the district heating network (several wood biomass boilers and heat pumps were subsidized although installed in the buildings supplied by the district heat).

[23] One larger environmental NGO was performing campaign against use of gas engines in cogeneration plants due to danger of formaldehyde emissions. Local initiative was organised in smaller municipality to stop the CHP unit installation in smaller local boiler house concerned by the potential low frequency noise emissions.

Long administrative procedures and high grid connection costs is getting an important highlighted obstacle for a larger development of micro CHP

Current still complex, numerous and time consuming administrative procedures mainly linked to the grid connection and for the acquiring of feed-in support is still a significant barrier, especially for a more broad small scale and micro CHP development[24]. The grid connection costs are getting higher and higher share in the total investment costs on the micro level[25].

2. What is possible? Cogeneration potential and market opportunities

2.1 Potentials and market opportunities

Up to 500 MWe of a new additional CHP capacity with 2,7 TWhe electricity generation and at least 2,5 TWh of the useful heat supply could be installed in Slovenia till the year 2030. This market potential is only 50% of the assessed technical potential, which is growing by the new market CHP technology development.

An overall **technical CHP potential** in Slovenia assessed in 2007[26] is **more than 1.000 MW_e** (4 TWh_e), with the highest potential in industry (350 MW_e), households (260 MW_e), services (210 MW_e) and district heating (210 MW_e). Especially the micro and small scale CHP potential in households and services could be significantly higher by the application of recent new efficient CHP technologies which would systematically replace the existing heating boilers with the more than 90% exergy losses.

The present (2009) feed-in support scheme offers proper economic conditions for the further market development of a fossil and renewable cogeneration in all sectors. **An overall market potential till the year 2030 could reach up to 500 MW_e of a new additional CHP capacity and a 2,7 TWh_e electricity generation (23% share in gross electricity consumption in the year 2030) as assessed in the recent (2011) analysis for NEP**6**:**

1. **Industry:** the largest potential (up to 120 MWe) is in paper, rubber and chemical industry with new, repowering and replacing of existing expired steam turbines with new gas turbines and combined cycle CHP plants. Additional up to 130 MW_e of smaller CHP units could be installed in different industrial companies, of that at least 10 MW_e fired on the wood biomass.

[24] Two step procedure in application of the support managed by Agency of Energy : 1. Application for obtaining a declaration for the production facility, 2. Application for the support, could be merged to one uniform procedure to simplify and speed up the process. Lack of staff at Energy agency is bottleneck for the issuing of the support resulting in several months necessary for getting the support.

[25] The connection costs and technical requirements for the CHP units from 1 to 999 kWe are almost the same, resulting in a more and more high share of connection costs in the total investment costs of the micro CHP units.

[26] Analysis of the potential for the application of high-efficiency cogeneration of thermal energy and electrical energy in Slovenia, Report to the European Commission, Ljubljana, July 2007.

2. **District heating:** at least 100 MW_e of the CC plant on the natural gas is planned to be installed in the CHP plant Ljubljana (TE-TOL) to replace one of the existing units (B2) on the imported coal. After 2020 an additional CHP unit is planned on site, dependent on the future construction of an incineration CHP plant in Ljubljana (at least 10 MW_e) and future conditions for operation of the existing units on coal with wood biomass co-firing. A substantial market potential exists also in other smaller district heating systems (at least 35 MW_e), incentivised by provision of the EZ-1[3] for obligatory 75% share of the heat produced from RES and CHP in the district heating systems.

3. **Services:** the market potential of small scale CHP units is more than 50 MW_e with at least 150 small scale and double more micro CHP units in all sectors with access to the natural gas network.

4. **Households:** the potential is divided in the two size categories:
   - **small scale CHP units - 15 MW_e** in the multifamily houses and block of flats without district heating connected to the natural gas distribution system (at least 150 units).
   - **Micro CHP units (1–3 kW_e) - 30 MW_e** in single family houses linked to the natural gas distribution system (at least 5.000 – 10.000 units), where a market availability of technology at acceptable price or an additional (investment) support mechanism is crucial for the wider expansion.

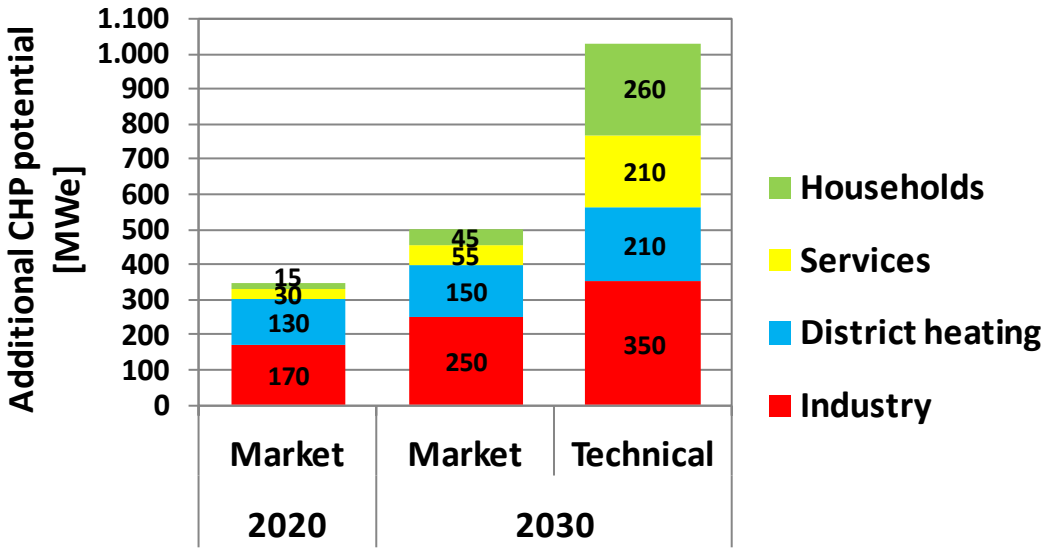


Figure 13: Additional market and technical CHP potential till the year 2030

A further development and market breakthrough of micro CHP technologies could have a significant influence on the size of expected market potential, where the span between the assessed technical and market potential is the largest. Faster recent development of the efficient fuel cells could play an important role here[27]. The assessed market and technical potential of micro CHP fits well with the CODE2 micro CHP potential analysis where the

[27] More than 50.000 fuel cell CHP units installed in Japan since 2009 and reduced investment costs of technology speed up the market breakthrough of fuel cells, which is expected already in 2015. EU pilot project Ene.field with planned deployment of up to 1,000 residential Fuel Cell units in the 12 key member states is a strong support for the push of the European industry (Fuel Cells: Technology Update & Market Outlook, John Murray, Delta Energy & Environment, 2013).

potential sales in the year 2020 are assessed on 270 units (of that 260 units or 10 MWe annually in services) which are in accordance witho the current CHP investments in Slovenia. Significant growth of sales is expected till 2030 when availability of market competitive micro CHP technologies is expected and could result in total up to 2000 units sale yearly (1000 or 1 MWe in households and the rest in services). More information you can find in **Annex 3**.

New market proven technologies for the gasification of wood biomass or other small scale biomass technologies could bias the broader use of wood biomass fired CHP plants (up to 40 MW_e) in industry and use of the cogeneration also in areas that are not covered by natural gas distribution grid (substantial part of Slovenia). A limited potential for the small scale CHP application on biogas from the medium farms agriculture waste and sewage water treatment plants could be exploited too. The CODE 2 Bio-energy CHP Potential Analysis for Slovenia assessed the potential of RES CHP heat generation in the year 2030 on the level of 115 ktoe (1.336 GWh) which is 12% about the presented market CHP potential[6] and seems a realistic estimate considering expected role of new biomass CHP technologies. (More information you can find in **Annex 4**)

In parallel with the fast development of heat pumps applications in Slovenia, CHP can provide a necessary additional electricity production in winter period as shown in **Figure 14**, when the condensing coal power plants are the only source for the increased winter electricity demand driven by heat pumps.

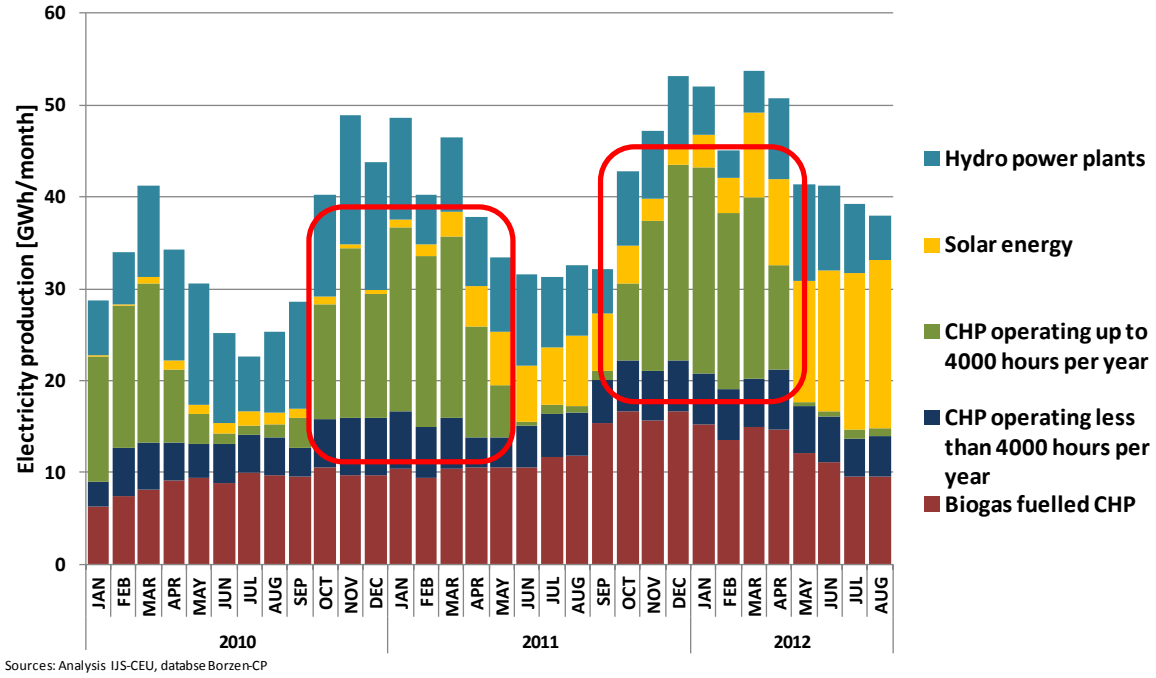


Figure 14: Dispersed electricity generation development 2010 – 2012 – important role of CHP generation in winter period for heat pumps electricity supply

Different types of CHP units could have a substantial role in planned development of the smart grid in Slovenia as predictable and flexible operation units for offering the system services (balancing of the PV and other RES plants, e-mobility, etc.).

2.2 Considering the framework of the EED

We assume that the EED implementation is a very exacting task which should be well coordinated and carried out as part of the whole energy policy process with integration of the large number of relevant stakeholders. The successful implementation of EED should have several positive effects on the CHP development in Slovenia.

The efficient heating and cooling as a new objective of the Energy Efficiency Directive (EED) could bring important benefits to the future planning and utilization of the heat market in Slovenia with benefits for further development of the cogeneration as well:

- **Lack of the clear priorities in the heat supply** – a new comprehensive approach as basis for the shaping of the national and local legislative rules could stop the current anarchy situation in the investments in the new heat supply.
- **New assessment of heating and cooling potential** could bring new information of the real technical potential and advantages of CHP and DHC options. CBA for market potential could contribute to better awareness of the CHP opportunities in all sectors and potential contribution to the national strategic climate energy goals with approval of necessary additional adequate measures for the CHP support.
- **Assessment of energy efficiency potential in gas and electricity infrastructure**: as cogeneration has a positive influence on better infrastructure utilisation, decrease of losses and load balancing, assessment should better position the role and contribution of CHP units to the energy efficiency in gas and electricity grids.
- **Article15: Access to electricity networks and priority of dispatch -** implementation could introduce several important improvements and new issues for CHP units:
    - enable conditions for introduction of system services from CHP (demand response, balancing, etc.)
    - simplification of administrative procedures for micro CHP - **simple notification "install and inform"**, net metering, etc.
- **Article 7: Energy efficiency obligation schemes –** energy supplier's programmes to fulfil 1.5% energy saving target per annum will most probably include also cogeneration and will accelerate new investments.
- **Article 8, 9, 18: Promotion and obligation of energy audits, energy management, energy services and individual metering** will improve the conditions for better planning and implementation of CHP projects in all sectors (better data availability, raise of awareness, better support, etc.)

3. How do we arrive there? The Roadmap

3.1 Preliminary remarks

Having in mind that the good return on investment for cogeneration units in Slovenia is fundamental for further investments. The positive picture of the Slovenian CHP economics matrix (**Table 2**) is a strong basis for developing scenarios for the future. The matrix suggests that for the majority of CHP categories (green) there are ***"normal"*** – *acceptable economic conditions* provided by the existing support scheme which has triggered interest and new investments. In spite of a generally positive picture, the position for micro CHP in households (red) is not yet favourable, while the coal is excluded from the support[28]:

- **Micro fossil CHP:** economics for the smallest house micro CHP units (nano 1 – 5 kW_e) is still "**modest**" – very marginal due to still high investment costs of the technology,
- **Micro RES CHP:** economics is in general "**poor**" and is not enabling proper return on investments (too high costs of market premature technology).

Table 2: CHP economics matrix

Slovenia	Micro		Small & Medium		Large		
	up to 50kW		*up to 10 MW*		*more than 10 MW*		
	NG	RES	NG	RES	NG	Coal	RES
Industry							
District heating							
Services							
Households							

Legend:

"normal"	CHP Investment has **good economic benefits**, return on investment acceptable for the investors, **interest for new investment exists**; there are no significant economic barriers for the implementation.
"modest"	CHP Investment has **modest/limited economic benefits** and return on investment(Y?), **limited interest for new investments**.
"poor"	CHP Investment has **poor or negative return on investment (Z?) or is not possible due to other limitations**, **no interest/possibilities for new investments**.
	Not applicable for the sector
NG	**Natural Gas** or appropriate fossil fuel
RES	**Renewable energy sources** (wood biomass, biogas, etc.)

[28] As coal CHP units can not fulfil 600 kg CO_2/MWh_{el} ; they are not eligible for the support and in current market conditions coal CHP Investment has poor or negative return on investment.

3.2 Overcoming existing barriers and creating a framework for action

In accordance with the Energy law, the new Energy strategy (National energy programme - **NEP**[6]) should be approved in Slovenia with a special emphasis on the energy efficiency and RES to achieve EU goals for the year 2020 and 2030 and with the long term perspective till the year 2050.

According to the **NEP** sub-strategy on cogeneration and presented economic cogeneration potential, we propose the **Strategy for development of cogeneration till the year 2030** with next three key quantitative goals for cogeneration (**Figure 15**):

1. **CHP electricity generation should supply at least 18% of gross final electricity demand in the year 2020 and 23% in the year 2030;**
2. **Till the year 2020, 75%[29] of all district heat production in existing district heating systems should be supplied by high efficiency cogeneration, RES or waste heat utilisation. At least 20% of heat should be supplied from RES.**
3. **Sustainable heat supply for all new and renovated buildings should be provided by district heat, RES, waste heat or cogeneration.**

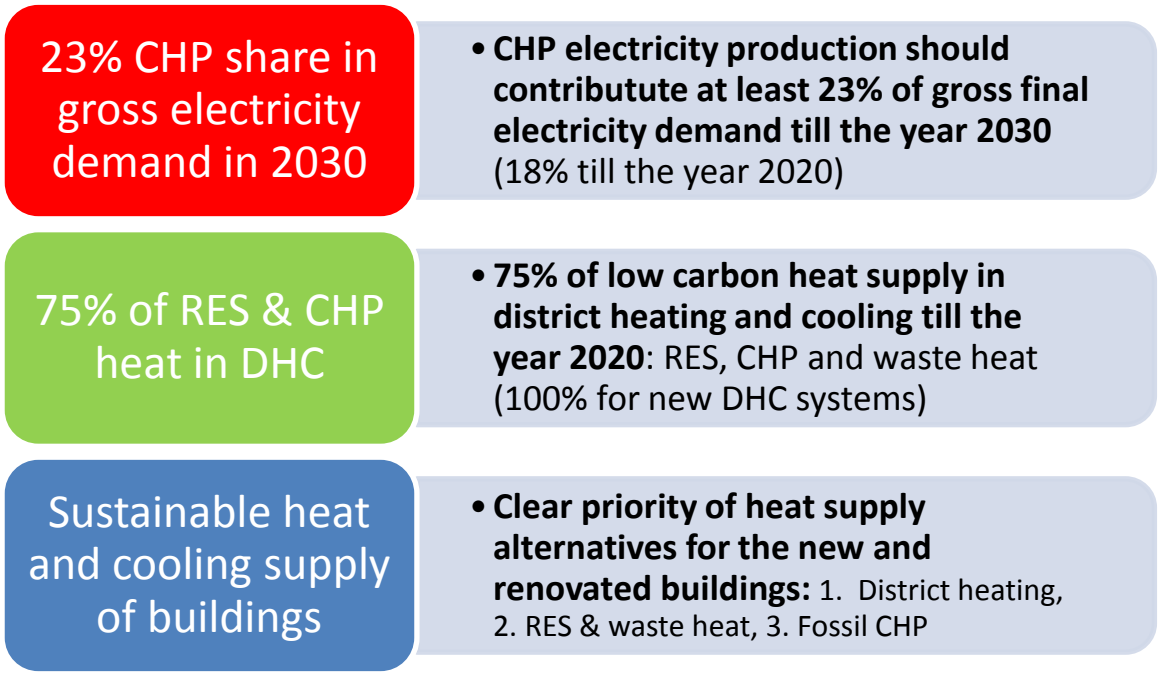


Figure 15: Key goals of the Strategy for development of cogeneration till the year 2030

The main requirement to achieve these measurable goals of the cogeneration strategy is to establish a **proper supporting framework with the following different specific measures to address the barriers identified and to fill policy and market gaps.**

[29] For all new district heating systems this share should be 100%.

Stable, predictive and effective support framework for high efficiency cogeneration

Fast approval of the new support scheme and providing stable CHP support also in the future

Ministry of infrastructure and spatial planning should as soon as possible prepare the executive legislation requested by the new Energy law (EZ-1) and define the new CHP support scheme. Based on the successful experiences of existing support scheme we propose to keep the well accepted "Feed-in premium" support model with necessary modifications based on the deep evaluation of past operation, new market conditions and prescribed tendering procedure. As we consider a tendering procedure as a huge additional administrative barrier for the micro CHP units we propose to exclude these units from tenders and keep the current entrance regulation for them[30]. Fast preparation and approval of the executive legislation by the Government (scheme and tendering procedure definition) is crucial to overcome current uncertainty for the investors by announced changes of legislation and end of the entrance to the current support from mid-September 2014.

Revision and regular evaluation & optimisation of the support scheme

Directorate of energy should provide regular evaluation and optimisation of the support scheme to provide efficient operation and effective use of financial resources by next measures:

- Enforcing the institution responsible for scheme performing (Agency of Energy, Borzen, Ministry responsible for energy) and establish better actors' coordination for prompt solving of actual problems and scheme failures.
- Establish yearly evaluation of the scheme operation and necessary revisions and optimisation of the support level following the actual market conditions and development (prices of energy, technology, etc.) to assure financially supportable and effective operation.
- Solving perceived existing problems:
    - **Setting continues (curve) level of reference costs** of electricity for smaller CHP classes.
    - **Shaping new proper support for old and reconstructed CHP plants** in accordance with EU State aid guidelines (common initiative on the EU level)
    - **Setting level of support for micro CHP units on wood biomass**
    - **Simplification of setting support level for the new market immature CHP technologies**

Providing necessary finance resources for stable support scheme operation

Directorate of energy in cooperation with the Ministry of Finance and Ministry of Economic Development and Technology should assure necessary finance resources to enable stable support scheme operation by yearly adaptation of the existing fee paid by

[30] Special quota could be settled on the yearly base for the entrance of the micro CHP units to the support scheme to avoid too fast development exceeding the available financial resources.

energy consumers (on electricity and other fuels) and introduction of new financing sources: climate fund, state budget, EU cohesion funds for potential new investment supports, etc., for stable scheme operation.

Simplification and unification of network connections rules is an important step toward faster development of micro cogeneration

Directorate of energy in cooperation with the Agency of Energy, DSO (SODO) and TSO (ELES) should continue the process of simplification and unification of network connections requests (technical - metering specifications, standard costs, etc.) especially for the small scale CHP units, where current high requirements result in disproportionate share of investment costs. Activities should go in line with the development of "smart grid" concept and new innovative implementation and support mechanism (simple notification "install and inform", net metering, etc.). Micro CHP units should be excluded from the tendering procedure for entrance to the support scheme.

Establishing sustainable heating and cooling is a key prerequisite to fulfil EU targets in Slovenia

Assuring sustainable heat supply is prerequisite for further developing and economic operation of district heating and cooling systems (DHC) in Slovenia.

To enable a future development of DHC in line with the strategic goals and decarbonisation of energy supply, proper support instruments should be introduced (subsidies, soft loans, etc.) for DHC systems transformation to the efficient DHC, prescribed by the revision of the Energy law (EZ-1):

- at least **50% of RES heat** or
- **50% of waste heat** or
- **75% of heat from CHP** or
- **75% combination** of above heat sources

Sustainable heat supply in DHC systems assure obligatory connections to the DHC and enables competitive heat supply compared to other individual heating alternatives[31]. Ministry for infrastructure and Ministry for environment and spatial planning should prepare all needed executive legislation for the efficient implementation of this provision[32]

Preparation of legislation acts for setting the heating mode priorities on local and building level is crucial for the future development of DHC and cogeneration.

Directorate for energy should prepare clear rules (Energy law provision) for setting heating mode priorities in the local energy concepts and for the new and renovated individual buildings consequently:

[31] Following EU state aid guidelines we can provide proper support for the modernisation of DHC systems and to enable their economic and competitive operation.

[32] Necessary update of the Rules for energy efficiency in buildings, proper treatment of DHC and CHP in the Action plan for the close to zero energy buildings, a proper issuing of permits for new DHC systems, local energy concepts preparation, etc.

1. **District heating & cooling**
2. **RES** (CHP and other technologies) **& waste heat,**
3. **Fossil CHP** (with low carbon fuels <0,23kgCO_2/kWh_f)

Clear priorities will enable future development of the DHC and set evident conditions for the investors and local energy suppliers which will avoid often disputes between them.

Raise of awareness and promotion to enable wider application of cogeneration

Support for development of new financing & business models is a key for the project implementation facing lack of private capital in the economic crisis

A further development and support of the energy contracting and new innovative business models is very important to facilitate the CHP project implementation in the sectors having limited capital and problems with access to the financial resources (bank loans) in the current economic crisis. Ministry of finance and Directorate of energy should:

- remove a noticed legislative uncertainties,
- prepare the guidelines for implementation of the energy contracting projects in the public sector,
- implement several demonstration projects to educate all involved actors (public sector, banks, ESCO's),
- provide a proper inclusion of cogeneration in the green public procurement,
- provide a better quality assurance for the CHP projects implementation
- establish the technical office as facilitator and support for the CHP projects in cooperation with the Ministry responsible for public administration.

General promotion campaign of cogeneration to qualify potential decision makers and raise awareness for the advantages of cogeneration

A current very low general awareness on the advantages of the cogeneration requests implementation of a wide promotion campaign in Slovenia. The campaign steered by the Directorate of Energy should be implemented in cooperation with the Local energy agencies and other interested market actors with special focus on the good practice exchange.

The Ministry of Education and Science should provide better incorporation of the cogeneration in education and research programs.

The Ministry of Economic Development and Technology should strengthen the international cooperation and establish support of the domestic equipment providers.

Precise overview of needed actions, deadlines and responsibilities for the implementation of **the Strategy for development of cogeneration till the year 2030** is shown in **Table 3.**

Table 3: Actions, terms and responsibilities for implementation of the CHP strategy

Actions	Deadline	Responsibilities
Fast approval of the new support scheme and providing stable future CHP support.	2014	Ministry responsible for energy;
Revision an regular evaluation and optimisation of the Feed-in CHP & RES electricity support scheme	2014, yearly	Ministry responsible for energy;
Effective performing of the support scheme: Providing necessary financial resources Permanent improvements of administrative procedures Simplification and unification of network connections rules	2014 2015	Ministry respons. for energy, Ministry of economic development and technology Ministry of Finance DSO, Agency of energy
Obligatory 75% of sustainable heat supply in DHC systems and larger buildings **Setting the heating mode on local and building level:** Update of Rules for energy efficiency in buildings Proper treatment of DHC and CHP in the Action plan for the close to zero energy buildings	2015 2014	Ministry responsible for energy Ministry responsible for spatial planning
Support for development of new financing & business models Necessary update and clear legislation interpretation (Public procurement and Public private partnership) Proper inclusion of CHP in Green public procurement Education and support activities for potential investors, demonstration projects. Quality assurance Establishing technical office	2015	Ministry of finance, ECO Fund, SID Bank Ministry of finance, Ministry responsible for energy Ministry resp. for public administration
Raise of awareness and promotion of cogeneration Promotion activities, good practice exchange Incorporation of cogeneration in education and research. International cooperation and support of domestic equipment providers	2015	Ministry responsible for energy, Local energy agencies, etc. Ministry of education and science Ministry of economic development and technology

Expected measurable results of the proposed Strategy for development of cogeneration till the year 2030 are shown in **Table 4**, to enable intermediate checking of the Strategy implementation success.

Table 4: Expected results of the Cogeneration strategy

CHP	Expected new additional el. capacity
New installed high efficiency CHP units:	
Industry	165 MW till 2020 and additional 95 MW till 2030
DHC (without TE-TOL)	20 MW till 2020 and additional 6 MW till 2030
Services	28 MW till 2020 and additional 27 MW till 2030
Households	11 MW till 2020 and additional 25 MW till 2030

3.3 Roadmap impact assessment

The advantages of the proposed Road map strategy are evident, as the cogeneration could contribute more than ¼ of the future electricity and heat demand compared to only 10% to 15% in the business as usual expected CHP development.

A significant part of the assed CHP economical potential presented in chapter 2.1 could be economically exploited by further use of the already established support mechanisms till the year 2030 as **"business as usual"** but the potentials will be far away from being completely fulfilled using this approach.

With the proposed **Roadmap Cogeneration strategy** implementation we can significantly improve the environment for the CHP development and facilitate a faster and more balanced growth of CHP utilisation in all applicable areas: district heating, industry, services and households, including small scale and micro CHP. We have used the following standard energy and environmental indicators for the Roadmap impact assessment:

- **Electricity generation from CHP:** CHP generation could be more than doubled till the year 2030 to 3,7 TWh from current 1,1 TWh in 2011.
- **Share of CHP electricity in gross final electricity demand[33]:** in the year 2030 CHP could contribute at least 23% of gross final electricity demand compared to the current 8% share.
- **Heat generation from CHP:** 2,8 TWh of the current CHP heat generation could be increased to 5,3 TWh in the year 2030.
- **Share of CHP heat in gross final heat demand[34]:** one quarter of the expected heat demand in the year 2030 could be supplied by CHP compared to the current 12% share.
- **RES electricity generation:** 0,7 TWh or 22% of electricity from high efficiency cogeneration in the year 2020 will be generated from RES, contributing more than 20% to the planned increase of RES electricity to fulfil obligation of 25% share of RES in final energy demand till 2020 from RENEAP.

Graphical presentation of the used heat and electricity indicators for the Business as usual and Roadmap scenario is shown in **Figure 16** and **Figure 17**.

[33] Same indicator is used for calculation of RES electricity contribution to the set goal in the year 2020. Gross final electricity consumption includes final energy demand, network losses and power plants own consumption.

[34] Same indicator is used for calculation of RES heat contribution to the set goal in the year 2020. Gross final heat demand includes total final heat and fuel consumption (also heat not appropriate for CHP) and distribution losses).

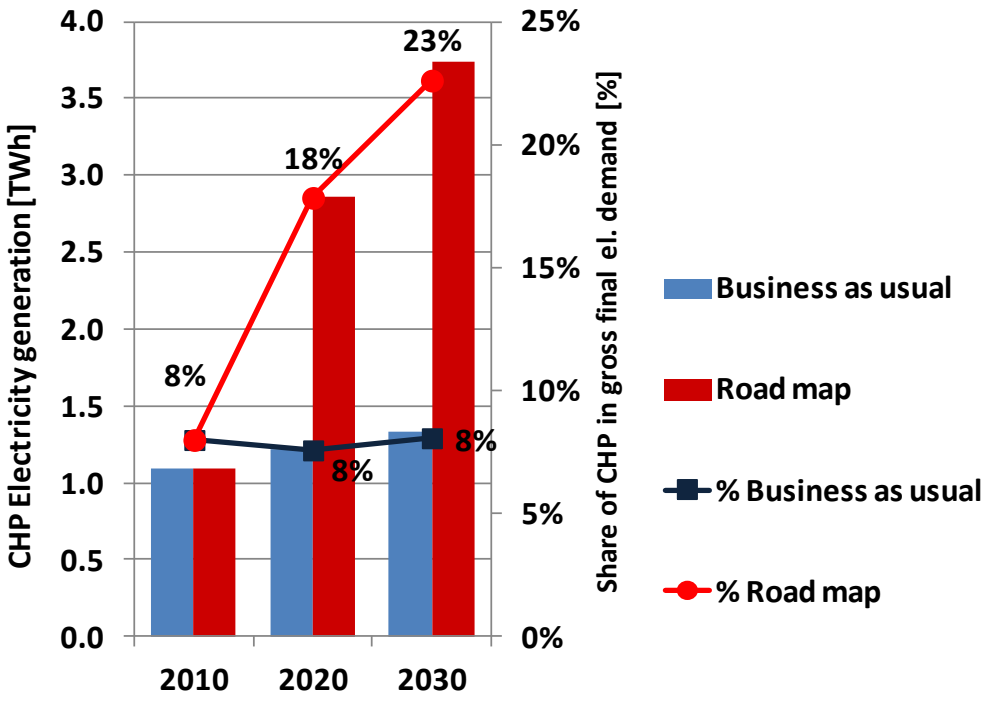


Figure 16: CHP Electricity indicators for the Roadmap and both scenarios

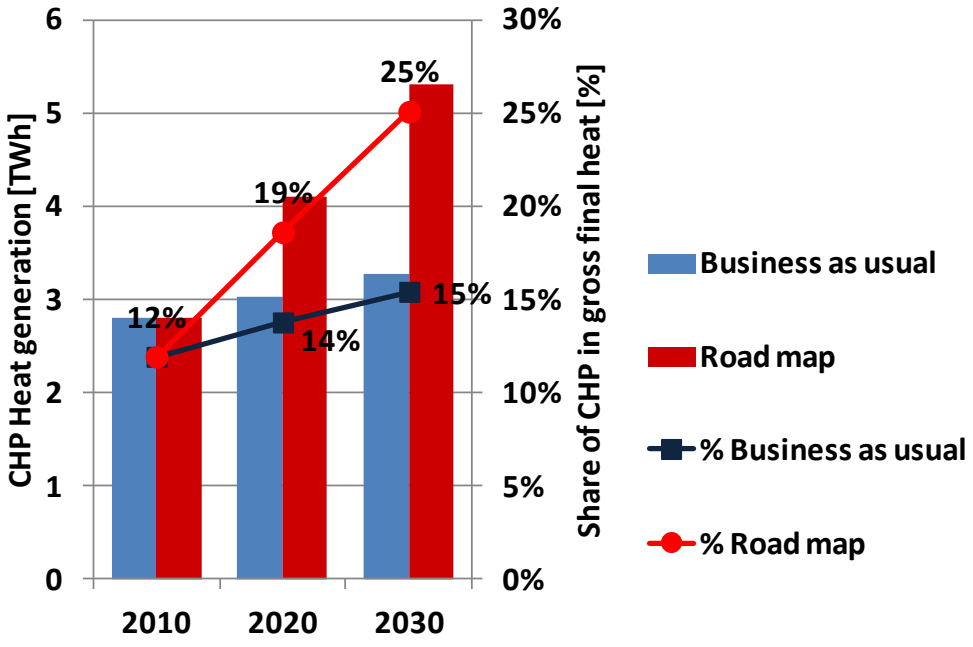


Figure 17: CHP Heat indicators for the both scenarios

3.4 Saving of primary energy and CO_2 emissions by the CHP roadmap

Within the CODE2 project two approaches for assessment of primary energy savings (PES) and CO_2 emissions savings are used to demonstrate advantages and contribution of CHP technology to the reduction of energy use and CO_2 emissions:

1. **Methodology prescribed by EED** (according to Annexes I and II) [35]
2. **Substitution method –** new developed method for assessment of actual achieved savings[36]

New CHP generation proposed by the Roadmap would contribute **3,2 TWh PES** calculated by the EED methodology or **up to 5,6 TWh of PES (20 PJ)** calculated by the substitution method as shown in Table 5. Especially reconstructed existing CHP plants which are replacing the existing old steam turbine mainly on coal plants and condensing electricity generation from coal contribute the majority of the potential PES which is important from the perspective of national goals till the year 2020 and 2030. Real potential savings by the substitution method are for almost 60% larger than assessed savings by the EED methodology where comparison to the best available alternative technology for separate electricity and heat generation do not reflect the actual savings in the country (replacing of old coal power plants).

The assessed PES potential of CHP till 2020 (2,1 to 3,8 TWh till 2020) is around 50% of the 5,4 TWh set indicative national target of primary energy savings in the year 2020 in NEAP 2014 [11] which means that implementation of the CHP roadmap can contribute a significant part or even increase the foreseen national goals for the year 2020 and additionally contributes to the new goals for the year 2030.

By using the same approach, potential real achievable CO_2 savings by the substitution method are 2,7 Mt of CO_2, much higher than 0,5 Mt CO_2 savings by the EED methodology[37] as shown in Table 5. By increasing the share of renewable energy in cogeneration, a potential CO_2 savings would be even higher.

[35] **EED method** is used at a member state level today for national reporting to the European Commission and at project level for determining if a specific CHP plant is highly efficient. In the methodology, the efficiency of each cogeneration unit is derived by comparing its actual operating performance data with the best available technology for separate production of heat and electricity on the same fuel in the market in the year of construction of the cogeneration unit using harmonized reference values which are determined by fuel type and year of construction.

[36] **Substitution method** has been developed within the project and estimates the amounts of electricity, heat and fuel which are actually replaced by additional new CHP based on a projection of the supply base changes in the member state supply over the period are calculated. The situation in 2030 is compared to the current status in the country.

[37] CHP plants using renewable energy are not achieving CO_2 savings by EED methodology (compared to separate renewable generation), but in reality all new CHP plants are replacing current coal generation.

Table 5: Saving of the primary energy and CO_2 by the CHP roadmap for Slovenia

	Substitution method		EED method	
	Business as usual	Road map	Business as usual	Road map
PE saving	0,5 TWh/a	**5,6 TWh/a**	0,3 TWh/a	**3,2 TWh/a**
CO_2 saving	0,2 Mio t/a	**2,7 Mio t/a**	0,04 Mio t/a	**0,5 Mio t/a**
- per kWh_{el}*[38]	0,99 kg/kWh_{el}	**1,04 kg/kWh_{el}**		

4. Conclusions

Presented Cogeneration Roadmap for Slovenia proved several advantages and benefits of the exploitation of the assessed 500 MWe of economic potential of the high efficiency cogeneration in Slovenia. By removing of the listed barriers and facilitating a faster and more balanced growth of high efficient cogeneration utilisation in all applicable sectors till the year 2030, cogeneration in Slovenia could:

- **Supply 4 TWh or more than 20% of the gross final electricity demand**
- **Provide more than 5 TWh of heat or ¼ of the gross final heat demand**
- **Generate more than 20% of the requested electricity generation from RES**
- **Reduce CO_2 emissions for more than 2,5 miot CO_2**
- **Contribute around 50% of the set indicative target of the primary energy savings till the year 2020.**

Roadmap implementation would have several other positive effects on the development of the new energy services and Slovenian CHP technology providers, on the new jobs creation, on the reduction of energy imports and would have significant benefits for the whole economy in the sensitive period of a sustainable economic crisis recovery.

[38] This value represents the CO_2 reduction of the power generation. It includes the avoided CO2 emissions from fuel savings for separate heat generation in boilers; it must not be confused with the considerably lower CO2 emissions of the substituted condensation electricity or with even lower emissions of compared power production according to the BAT approach in accordance with the EU CHP directive reference values.

Sources

The following list covers main sources used:

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Annex 1: Stakeholder group awareness assessment

Table 6: Ratings of CHP awareness of different influential groupings

Users	
Industry	The level of awareness about cogeneration in industry is in general high. The emphasis is on the CHP gas systems, while there is still only limited information available on the biomass cogeneration. However, lately there were no major new CHP units installed, mainly due to the lack of money as also technology providers are reluctant to offer cogeneration in industry via a business model of energy supply contracting (ESC) as their risks are perceived too high.
Utilities	The cogeneration is especially well developed in the district heating systems, but well-known also among other utilities. More and more utilities provide cogeneration as energy service for the consumers.
SMEs	Awareness about the cogeneration in SMEs, with emphasis on the service sector (including public sector), is still on a relatively low level, but improving fairly fast. This is proved by the fact that the service sector is in last four years seeing a fast installation of smaller units (up to 200 kWe) in restaurants, hotels, shopping malls, schools and homes for retired people. A lot of these projects were implemented using contracting offered by technology providers.
Households	CHP is an energy efficiency measure which is in comparison to an energy efficient building envelope retrofit or an installation of a solar photovoltaic system not that easy to be seen, so the word about CHP goes mainly from mouth to mouth in a limited group. The level of a general public awareness about CHP is therefore low, but it is expected to be improved with micro CHP units becoming more competitive.
Market and supply chain	
Manufacturers/ Technology providers	In Slovenia there are at the moment only two manufacturers of CHP systems, but several technology providers, which act as main cogeneration promoters, planers and often also as ESCOs for the implementation of CHP projects.
Installation companies	The awareness about CHP is on a quite low level, but is growing with the number of CHP installations.
Grid operators	With increasing number of smaller CHP units also a level of awareness about CHP among grid operators has risen. However, it is quite often that CHP users complain about long and complicated process for the connection of a CHP system to the electrical grid.
Consultants	Consultants are in principle acquainted with CHP, but often a detailed know-how is missing.
Architects	The awareness about CHP is on a quite low level.
Banks, leasing	The financial sector is regarding cogeneration still very cautious (lack of proper knowledge/understanding, too complicated, too high risks), which makes borrowing money from banks for the CHP projects very difficult.
ESCOs	Most of the ESCOs, which are offering ESC, are at the same time also CHP technology providers, and thus main cogeneration promoters. Also among ESCOs, which are primarily offering EPC is the awareness about CHP high.

Policy	
Policy makers on different levels	Regulation and support related to cogeneration are in Slovenia centrally controlled and so far this support has been good. The main actors for CHP promotion on a state level are Ministry of infrastructure as the main regulative body for cogeneration, Energy Agency of the Republic of Slovenia as regulator and Borzen as a centre for the RES and CHP support, which is managing also the feed-in support scheme which is the key driver for new CHP investments (facing problems on scheme financing today). Lack of knowledge and expert capacities are key reasons for still rather low awareness on cogeneration in large number of smaller municipalities in Slovenia.
Energy agencies	Energy agencies are the most important organisations promoting CHP among potential technology users as well as technology providers, constructors and designers of building technology systems on the local level. It is especially important that these agencies emphasize the importance of proper design of CHP units and thus support the sustainability of cogeneration projects.
Planners	CHP is in principle known, but the project initiators are technology providers not planers.
Influencers	
Sector organisations	Among the main actors in promoting cogeneration in Slovenia are Jožef Stefan Institute - Energy Efficiency Centre (JSI-EEC) as COGEN Slovenia - Slovenian national member in COGEN Europe, Economic interest grouping of natural gas suppliers (GIZ DZP), which is promoting use of natural gas and Slovenia District Energy Association (SDDE), which links companies and individuals working in the field of district energy supply. The largest share of heat supply delivered by cogeneration in Slovenia comes from the district heating sector.
General public	General public awareness about cogeneration in Slovenia is low. Most of the people have never heard about this technology and if they did, they very often see it as a complicated and expensive technology and not as an efficient way for heat and electricity production or a green technology. It is expected that the level of awareness will improve with micro CHP units becoming more competitive.
Media	There is almost no information regarding CHP in media for the general public. Professional media focuses mainly on small scale/micro CHP.
Academic area/ Research	In Slovenia there is no direct research on cogeneration. The most active research institutions in this area are Jožef Stefan Institute, Energy Efficiency Centre, as the COGEN Slovenia, and Faculty of Mechanical Engineering at the University of Ljubljana, which has specialised in bigger trigeneration units and district cooling.
NGOs	Among environmental NGOs CHP is in principle known, but usually not in details, some NGO are more focused on RES.

Legend:

- Active CHP market
- Interest in CHP
- Early CHP awareness
- Low CHP awareness
- Poor CHP awareness

Annex 2: Economic assessment of typical CHP projects in Slovenia

Sector		Heating in services and multifamily houses	Industry and service process heat and heating supply	District heating	Bio gas CHP (agriculture, waste, industrial wastewater or sewage treatment)
		50 kWe ICE	1 MWe ICE	10 MWe CC	0,5 MWe Biogas
Technology		**ICE**	**ICE**	**CC**	**ICE**
Power	**MW_{El}**	**0,05**	**1**	**10**	**0,5**
Efficiency-el.	Eff_{EL}	34%	40%	46%	38%
Efficiency-th.	Eff_{H}	56%	45%	42%	37%
Efficiency-sum.	Eff_{SUM}	90%	85%	88%	75%
Operation	**h/a**	**4.000**	**6.500**	**3.500**	**7.500**
Fuel	MWh	588	16.250	76.087	9.868
Electricty	MWh	200	6.500	35.000	3.750
Heat	MWh	329	7.313	31.957	3.651
Investment	**EUR**	**115.000**	**1.100.000**	**9.500.000**	**2.000.000**
	€/kWel	2.300	1.100	1.000	4.000
O&M costs	% of Inv.	5%	7,0%	3,5%	4%
	€/MWh	28,8	11,8	9,5	21,3
Price of fuel	€/MWh	71	64	59	20
Value of electrcity	€/MWh	106	65	58	
Other market revenues	€/MWh				
Value of heat	€/MWh	78	71	66	15
Support					
Electricty	€/MWh_{El}	122,44	61,84	63,75	156,31
Other support or benefits	€/a				
Investment subsidy	€				
Costs & revenues					
Fuel	€/a	-41.482	-1.042.600	-4.504.348	-197.368
Electricty	€/a	21.140	422.500	2.030.000	0
Heat	€/a	25.811	521.300	2.102.029	54.770
Support	€/a	24.488	401.960	2.231.250	586.163
Other market revenues	€/a	0	0	0	0
O&M costs	€/a	-5.750	-77.000	-332.500	-80.000
TOTAL	**€/a**	**24.207**	**226.160**	**1.526.431**	**363.564**
SPB	**years**	**4,8**	**4,9**	**6,2**	**5,5**
IRR	**%**	**16%**	**16%**	**10%**	**13%**

Annex 3: CODE 2 micro CHP potential analysis for Slovenia

Country statistics

Population: 2 050 000 (2010)
Number of households: 760 000 (2010)
GDP per capita: € 21 000 (2010)
Primary energy use: 5 000 ktoe/year (2010)
GHG-emissions: 20 Mton $CO_{2,eq}$/year (2010)

Household systems (±1 kWe)
Boiler replacement technology

Present market (2013)
Boiler stock: 262 000 units
Boiler sales: 25 000 units/year

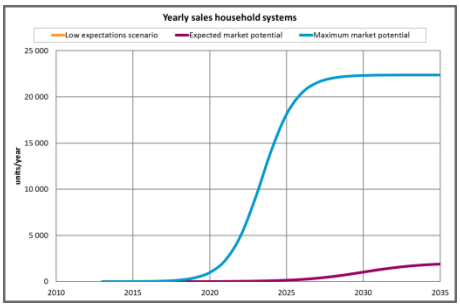
Potential estimation

Indicator	*Score*
Market alternatives	0
Global CBA	0
Legislation/support	1
Awareness	0
Purchasing power	1
Total	**2 out of 12**

Expected final market share: 8% of boiler sales in Household sector

Yearly sales

Sales in 2020: 10 units/year*
Sales in 2030: 1 000 units/year*



Stock

Stock in 2020: 30 units*
Stock in 2030: 3 300 units*
Stock in 2040: 18 200 units*

Potential savings in 2030

Primary energy savings:
0 PJ/year*
2 ktoe/year*
GHG-emissions reduction:
0.0 Mton $CO_{2,eq}$/year*

SME & Collective systems (±40 kWe)
Boiler add-on technology

Present market (2013)
Boiler stock: 82 500 units
Boiler sales: 7 800 units/year

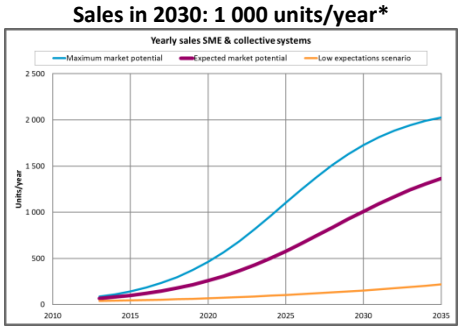
Potential estimation

Indicator	*Score*
Market alternatives	0
Global CBA	3
Legislation/support	3
Awareness	1
Total	**7 out of 9**

Expected final market share: 15% of boiler sales in SME & Coll. sector

Yearly sales

Sales in 2020: 260 units/year*
Sales in 2030: 1 000 units/year*



Stock

Stock in 2020: 1 800 units*
Stock in 2030: 7 000 units*
Stock in 2040: 14 000 units*

Potential savings in 2030

Primary energy savings:
5 PJ/year*
121 ktoe/year*
GHG-emissions reduction:
0.1 Mton $CO_{2,eq}$/year*

*Corresponding to the expected potential scenario.

The score card is used to assess the relative position of an EU country based on current regulations, markets and economics. The score itself functions as input to the

implementation model to 2030.

±1 kWe systems (Households) Boiler replacement technology	±40 kWe systems (SME & Collective systems) Boiler add-on technology
Scorecard	**Scorecard**

Indicator	Score
Market alternatives	0
Global CBA	0
Legislation/support	1
Awareness	0
Purchasing power	1
Total	**2 out of 12**

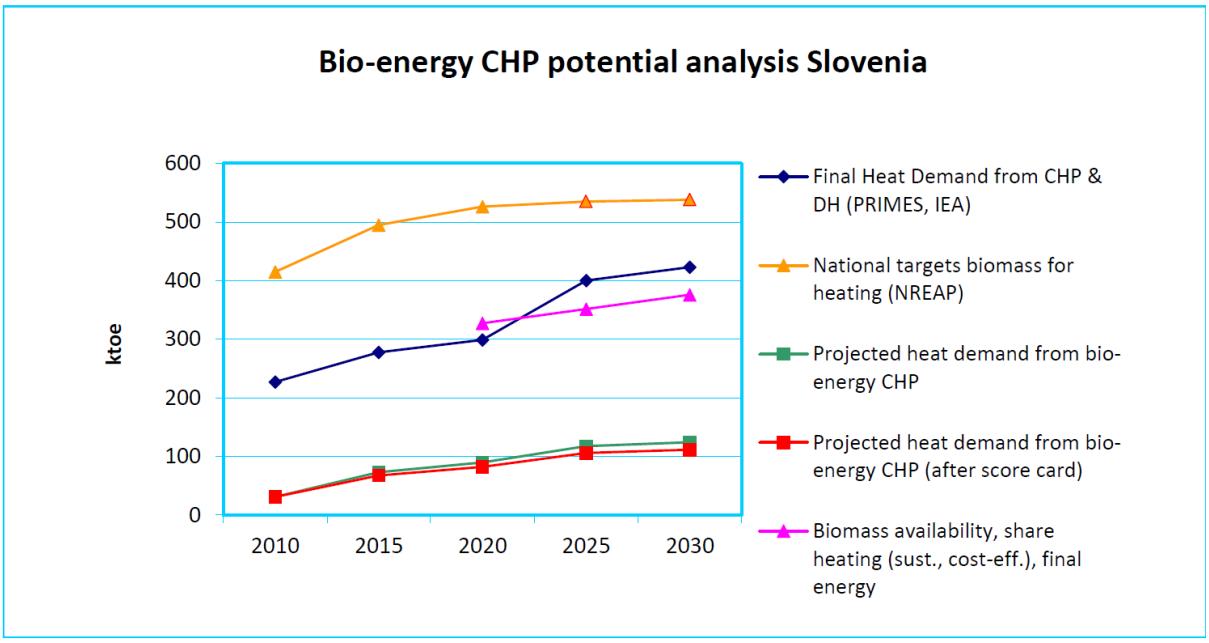
Indicator	Score
Market alternatives	0
Global CBA	3
Legislation/support	3
Awareness	1
Total	**4 out of 9**

Market alternatives	Market alternatives
*There is **strong competition of other heating technologies in households**: heat pumps (low electricity prices, natural gas is available only in more dense populated area), wood biomass (cheap fuel, subsidies available), district heating systems in towns.*	*There is **strong competition of other heating technologies in services**: district heating systems in towns, heat pumps (low electricity prices, natural gas is available only in more dense populated area)..*
Global CBA	**Global CBA**
*SPOT: **16 years***	*SPOT: **5 years***
Legislation/support	**Legislation/support**
***Current incentives on micro CHP are not yet sufficient** for the economic project implementation in households*	***Current incentives on micro CHP offers good incentives for this size** CHP project implementation in service sector which resulted in **several new unit investments in last three years.***
Awareness	**Awareness**
*Due to the too high investment costs and not sufficient support for the economic implementation, **current awareness of micro CHP technologies for households is still very low** or poor on all levels.* ***Manufacturers are not yet active in the market.***	*With proper support and several number of successful CHP projects in recent years, **awareness in services is growing and is on medium – early awareness level.***
Purchasing power	
*GDP: **€ 21 000 per year***	

Annex 4: CODE 2 Bio-energy CHP Potential Analysis for Slovenia

Bio-energy CHP potential analysis Slovenia

Figures (projections)	2010	2020	2030
Final heat demand from CHP and DH (PRIMES, IEA), ktoe	227	299	423
(Projected) heat demand from bio-energy CHP and DH (after score card), ktoe	31	82	112
Bio-energy penetration rate in CHP markets (2009: EEA, Eurostat)	13,6% (2009)	27,4%	26,4%
Biomass availability, share heating (sust., cost-eff.), final energy (Biom. Futures), ktoe		327	376



Framework Assessment (Score card)	Score	Short analysis
Legislative environment	++ 3 (of 3)	Support for CHP and RES; Ambition goals for CO_2 reduction
Suitability of heat market for switch to bio-energy CHP	+ 2 (of 3)	Potential in paper and chemical industry; 50% of heat use directly in industrial process (cement, steel…), not appropriate for CHP.

Share of Citizens served by DH	+ 2 (of 3)	17% citizen served by DH; 77% share of heat from CHP in DH systems mostly from coal; Obligatory 20% heat for DH from RES (proposed)
National supply chain for biomass for energy	++ 3 (of 3)	More than 60% of Slovenia covered by forests; Support to for the processing of fuel wood biomass; Support for the establishment of energy crops
Awareness for DH and CHP	++ 3 (of 3)	Biomass association, association for sustainable development; Public campaign, workshops and conferences; Several new small and micro DH on wood biomass (too small for available CHP technologies).

Comments on country analysis

General comments

- The national framework assessment through the scorecard results in a good score (13 of 15 possible points).
- Thus, it is projected that the growth potential for bio-CHP until 2030 will be exploited to 87%.
- The possible bio-CHP penetration rate in 2030 (2030 dot of green curve) under ideal framework conditions is seen at 29,3%
  (the country's RE target according to RED (28/2009) is at 25% in 2020)
- The share of bio-fuels in CHP (bio-energy penetration rate in CHP markets) is expected to grow from 13,6% (2009) to 26,4% (2030)
- The national biomass availability (cost-efficient, sustainable; pink curve) is sufficient to enable the projected growth; however, these biomass resources include types of biomass which are currently not usually used in CHP, but are expected to be utilisable by 2030
- For the fuelling of the expected bio-CHP, the shown biomass resources are sufficient, but for meeting the national targets for biomass for heating, biomass has to be either imported or taken from sources not meeting strong sustainability criteria

Specific issues

- The projected development of CHP heat demand (PRIMES, blue curve) foresees a steady growth with a stronger growth between 2020 and 2025
- National targets for biomass for heating (yellow curve) see a growth, which is becoming less strong afer 2020
- The growth projections of the bio-energy CHP heat demand (green and red curves) apply the average growth rates of both the blue and the yellow curve (weighting 50:50)

Annex 5: Methodologies used to calculate the saving of primary energy and CO_2 emissions under the roadmap.

Substitution method

This method has been developed in the CODE2 project. In doing this, two other approaches have been considered: 1) the "replacement mix method[39]" from the Munich FfE institute, which however cannot be used directly for a long term comparison as needed in CODE2; 2) a method used to calculate the CO_2 saving resulting from a voluntary commitment of the German industry for CO_2 reduction[40], however this method has been considered as too simple. Therefore the following more differentiated approach has been developed:

Based on an estimate of the increase in cogeneration electricity the thereby caused decrease of CO_2 emissions and primary energy consumption is estimated. In this approach, an attempt is made to determine the actual quantities saved compared to the base year (e.g. 2010). Hence it refers to the actual saving of fuels for the production of the amounts substituted by modern CHP plants

a) of electricity and heat in the replaced or retrofitted old CHP plants

b) of electricity in power plants

c) of heat in boilers.

The savings result from a combination of three effects:

- CHP effect
- Technology effect (improved CHP technologies)
- Fuel switching (e.g. lower carbon content of natural gas compared to coal, CO_2 neutrality of bioenergy)

The results show the savings actually induced by the expansion of CHP compared to the situation in the base year.

This approach differs fundamentally from the methods for checking the high-efficiency according to the CHP Directive or in accordance with ANNEX II of the EED (Directive 2012/27/EU on energy efficiency), in which a comparison between CHP and the best available Technology (BAT) of separate production of electricity and heat produced is carried out strictly on a same-fuel basis.

This procedure is considered to be inappropriate to deliver an estimate of the actual fuel saving quantities by CHP over a longer period, which is considered a relevant value, representing meaningful the contribution of CHP to the long-term objectives of the EU to reduce CO_2 emissions and primary energy consumption. The BAT approach of the CHP Directive has been developed to verify the high efficiency of individual plants, but not to determine actual saved CO_2 emissions and primary energy quantities by CHP expansion.

In fact, the CHP expansion is closely associated with a replacement of old cogeneration technologies by new ones and a change in the structure of fuel away from coal to natural gas and bio-energy. These three developments,

- replacement of separate generation by cogeneration
- replacement of old cogeneration technologies by new ones
- replacement of carbon-rich by low-carbon fuels,

can be usefully seen only as an integrated process.

To account for the uncertainties in particular with regard to fuel shares and technology development, a window of possible developments with an upper value and a lower value of emission reduction and savings has been determined. The different levels of results are due to assumptions about key parameters such as current share of electricity from cogeneration, which is replaced by electricity from new or retrofitted units, fuel shares in the replaced CHP plants, power plants and boilers as well as in the new CHP plants.

The results have been calculated based on the following input values: growth of CHP power production, share of current old CHP to be replaced by new installations and retrofitting, fuel efficiency and electric efficiency of new CHP and replaced CHP for different fuels, electric efficiency of replaced power from conventional power plants for different fuels, heat efficiency of replaced heat from boilers, corresponding fuel shares.

[39] 10. FfE Forschungsstelle für Energiewirtschaft e.V., Energiezukunft 2050; http://www.ffe.de/die-themen/erzeugung-und-markt/257

[40] The calculation has been made by the VIK Verband der Industriellen Energie- und Kraftwirtschaft e.V., 2010, Unpublished.

EED method

The Primary Energy Savings methodology of the EED is used at a country level for national reporting to the Commission, and at project level for determining if CHP is highly efficient. In the methodology, each cogeneration unit is compared with the best technology for separate production of heat and electricity on the same fuel on the market in the year of construction of the cogeneration unit and the harmonized reference values are determined by fuel type and year of construction.

The underlying principle is that, knowing that regularly new investments have to be made in new energy production units, it is necessary to compare CHP with the centralized production installation which could be built using the same fuel rather than assuming a displacement of a different fuel or introduction of a new fuel. It is a logical approach when looking at the decision making process of investors or a member state government. By investing in or supporting CHP, a certain electricity generating capacity will be produced by CHP and NOT by centralized production based on the same fuel (= principle of 'avoided production').

For the timeframe of the roadmap (between 2010 and 2030), and especially in countries where there is no overcapacity, it is relevant to compare installing a certain capacity (at national level) of CHP compared to installing new capacity with another technology (power plant + gas boiler). Older installations being replaced with state-of-the-art technology.is a typical reinvestment decision. New CHP-plant (or combination of smaller installations) would not necessarily lead to less production in older production installations, but would rather preempt investments in e.g. new CCGT investments.