CODE2
Cogeneration Observatory and Dissemination Europe

D5.1 Final Cogeneration Roadmap
non pilot Member State: Portugal

Date: July 2014

Leading CODE2 Partner: FAST – Federazione delle associazioni scientifiche e tecniche

Portugal is part of non-pilot Member States of the South-West CODE2 Region. The CODE2 Region ‘South-West’ comprises the following Member States: France, Italy, Malta, Portugal, Spain

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Introduction

The CODE2 project

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 and one European Cogeneration Roadmap. 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 through research and workshops.

The input of all experts has informed these roadmaps. The content of the roadmaps and opinions expressed reflect the conclusions of the CODE2 project only. 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.

Draft roadmap methodology

This roadmap for CHP in Portugal is written by CODE2 partner FAST – Federazione delle associazioni scientifiche e tecniche, based on a range of studies and consultation. It has been developed through a process of discussion and exchange with experts.

Acknowledgement

FAST and the CODE2 team would like to thank all experts and policy-makers who on different level have been asked to give their valuable contribution to this roadmap. It has to be stressed anyway that the statements and proposals in this paper do not necessarily reflect those of the consulted experts.

N.B.

The roadmap was written over the period April 2013 – March 2014. The national policy framework around CHP has continued to evolve in Portugal and this should be taken into account when using the material in the roadmap.

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

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1. Executive Summary

Cogeneration was first used in Portugal around 1930. In 1990 the installed capacity had grown to 530 MWe, with applications embedded in industrial plants of several active sectors. Only in 1982, with the aim to promote the auto production of electricity, the Government defined the conditions for CHP plants interconnecting with external grid and the remunerative principles to sell the surplus power. Until end 2011 the installed capacity was around 900 MWe burning gas with overall equivalent electrical efficiency higher than 65%. At present (2014) the total installed CHP capacity is around 1300 MWe, generating approximately 14% of the electricity supplied in Portugal. There is still a large CHP potential in the industrial sector and in the tertiary and residential sectors, according to the report prepared by Portuguese Government for European Commission, following Art. 6 of Directive 2004/8/CE.

Cogeneration applications in Portugal are major industrial activities where heat at suitable conditions is required. There are few applications in buildings and in district heating and there is no CHP in the household sector.

The evolution of EU policies regarding energy efficiency and the promotion of CHP combined with successful initiatives and action by associations and industries, contributed to establishing a transparent and stable legal framework for CHP in Portugal over the period 1996–2012. At the time of writing (2014), the situation of CHP in Portugal is not as positive as in the period to 2012. In 2010, the Government used the implementation of cogeneration directive (2004/8/CE) to start making changes in existing legislation. A new legal framework on energy was completed by 2012 including measures showing negative impacts on CHP promotion and development. New investments became no longer economically viable and several existing plants have shut down or are shutting down. Although the newly enforced regulation establishes a feed-in-tariff, it is currently not possible to obtain a permit for a new plant. All cogeneration stakeholders are concerned about the legislative position which has emerged from these changes. The changes appear no to be in line with spirit and requirements of the Energy Efficiency Directive.
2. Where are we now? Background and situation of cogeneration in Member State

1.1. Current status: Summary of currently installed cogeneration

After a long increasing series the evolution of CHP electric capacity presents a stop in 2012 followed by a sudden significant drop in 2013, passing from 1.45 to 1.3 GW. At present the situation of CHP cannot considered positive and, due to remuneration and regulation changes intervened in 2012 after the adoption of the new legal frame ruling the energy compartment, new investments are hindered and operation in several existing plants is no longer economically viable.

Systems of combined heat and power have a long history in Portugal, starting around 1930, based on steam generators and backpressure turbines, burning coal, fuel oil or biomass. CHP deployment in the period to 1990 grew to 530 MWe capacity, with applications embedded in industrial plants of several active sectors.

In 1982, with the aim to promote the auto production of electricity, the Government defined the conditions for CHP plants interconnecting with the external grid and the remunerative principles to sell the surplus power.

The evolution of EU policies regarding energy efficiency and the CHP promotion combined with successful initiatives and action by associations and industries, contributed to a transparent and stable legal framework for CHP over the period 1996 – 2012. The legal framework was based on avoided costs of generation, transmission and distribution of conventional electricity as a result of the operation of the CHP plants. The investors were confident and new industry projects were implemented, mainly in order to reduce the costs of goods for exportation to markets where energy was less expensive than in Portugal. The CHP growth was also dependent on fuel availability and electrical interconnecting access, whenever heat demand for process or heating purposes justified technically and economically a combined heat and power system.

In the nineties there 64 CHP plants were installed with reciprocating diesel engines, burning heavy fuel oil, with a total installed capacity around 350 MWe and equivalent electrical efficiency higher than 55%.

Since 1997, with the introduction and distribution of natural gas in Portugal, there were opportunities to realize the potential of CHP on natural gas. Several new projects were completed using Otto cycle engines and gas turbines and some existing CHP plants were upgraded in order to improve the efficiency and reduce the emissions or to increase the output in combined cycles. In the last 10 years, a share of the diesel engines was replaced or converted to natural gas. At the end of 2011 the installed capacity was around 900 MWe burning gas with overall equivalent electrical efficiency higher than 65%. This capacity is heavily concentrated at major industrial activities. Few applications are in buildings or in district heating; no CHP is found in the household sector.

The total installed CHP capacity, at the moment, is around 1300 MWe, generating approximately 14% of the electricity demand in Portugal. There is still a large CHP potential in the industrial sector and in the tertiary and residential sectors, according to the report prepared by Portuguese Government for European Commission, following Art. 6 of Directive 2004/8/CE.²

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2007</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP Electrical capacity, GW</td>
<td>1.08</td>
<td>1.07</td>
<td>1.31</td>
<td>1.43</td>
<td>1.45</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Tab.1.1 CHP installed Electrical capacity in Portugal

Source: Eurostat


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At present, the situation of CHP in Portugal is not as positive as in previous years. In 2010, the Government used the transposition of the cogeneration directive (2004/8/CE) to make changes in existing legislation. A new legal framework was completed by 2012 showing worse impacts on CHP promotion and development. At the time of writing new investments are no longer economically viable and several existing plants will be shutdown. All cogeneration stakeholders operating in the market are particularly concerned about the direction of these legislative changes which appear not to be in line with the attest European legislation contained in the Energy Efficiency Directive and currently being transposed in all member states.

The contribution of high efficiency CHP to the energy supply of Portugal is shown in Tab. 1.2.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP electricity generation, TWh</td>
<td>5,42</td>
<td>5,82</td>
<td>6,36</td>
<td>6,64</td>
<td>6,50</td>
</tr>
<tr>
<td>CHP in total electricity generation %</td>
<td>11,6</td>
<td>12,3</td>
<td>11,8</td>
<td>12,7</td>
<td>13,9</td>
</tr>
<tr>
<td>CHP Heat production, PJ</td>
<td>59,61</td>
<td>62,99</td>
<td>67,22</td>
<td>69,27</td>
<td>66,85</td>
</tr>
<tr>
<td>Fuel used for CHP, PJ</td>
<td>103,71</td>
<td>106,10</td>
<td>113,87</td>
<td>114,65</td>
<td>114,24</td>
</tr>
</tbody>
</table>

Tab. 1.2. CHP generation parameters

The following diagrams represent the actual distribution of CHP units by application sector and by technology in 2013.

Fig. 1.1 CHP distribution by sector in 2013

Fig. 1.2 CHP distribution by technology in 2013

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1.1. Energy and climate Strategy

The Government, through the implementation of PNAEE 2016 and PNAER 2020, intends to pursue the continuity of measures to ensure the development of an energy model which could guarantee sustainable energy costs, without compromising the competitiveness of enterprises as well as the quality of life of citizens while maintaining a substantial energy efficiency improvement.

1.1.1. Overall Energy background

The Directive 2006/32/EC of 5 April 2006 on end use energy efficiency and energy services, transposed by Decree-Law 319/2009 of November 3, set the objective to achieve energy savings of 9% for the ninth year of the Directive application (2016) by comparison with the period 2001-2005. It also established the obligation for Member States to submit periodically to the European Commission the National Energy Efficiency Action Plan (PNAEE).

In this context, the first PNAEE 2008-2015 was approved by Resolution of the Council of Ministers 80/2008 of 20 May.

On the other hand, Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources, obliges each Member State to approve and notify to the European Commission a National Renewable Energy Action Plan (PNAER), setting national targets for the share of energy from renewable sources consumed by electricity, heating and cooling and transport by 2020. In this frame it was approved on 30 July 2010 the PNAER3 2010, which was subject of notification to the European Commission on 10 August 2010.

The Decree Law 141/2010 of 31 December, as amended by Decree Law 39/2013 of 18 March established national targets for the use of energy from renewable sources in gross final consumption of energy and power consumption in transport by 2020 of 31% and 10 % respectively.

Analyzing the implementation of PNAEE 2008 -2015 and PNAER 2010 it’s possible to conclude that, Portugal has an energy intensity of primary energy use in line with the European Union in terms of energy efficiency of the economy, , but this value hides a less positive aspect when the energy intensity of final energy is measured. The high investment made by Portugal in renewable energy and reduced energy consumption in the residential sector, compared to the rest of Europe hides an energy intensity of the productive economy of 27 % above the European Union average. This result reinforces the need to intensify efforts directly influencing the final energy use within the PNAEE.

1.1.2. New National Energy Strategy: Main points

According to the Resolution of the Council of Ministers 20/2013 of 10 April, in the framework of European targets "20-20-20" which aims to achieve in 2020:

(i) 20% reduction in emissions of greenhouse gases compared to 1990 levels,
(ii) 20% share of energy from renewable sources in gross final consumption and
(iii) 20% reduction of primary energy consumption by increasing energy efficiency,

a general goal of reduction in primary energy consumption of 25% was established for Portugal by 2020 and a specific goal for the Public Administration of 30% reduction. It is intended that the objectives defined regarding the utilization of energy from renewable endogenous sources , in 2020, of 31 % of gross final energy consumption and 10% of the energy used in transport from renewable sources are met at the lowest cost for economy. At the same time, it is intend to reduce Portugal’s energy dependency and ensure security of supply, by promoting a balanced energy mix.

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3 Special Regime Production regards the model for the development and financing of energy production based on renewable sources as well as cogeneration. [http://ec.europa.eu/europe2020/pdf/nrp/nrp_portugal_en.pdf](http://ec.europa.eu/europe2020/pdf/nrp/nrp_portugal_en.pdf)


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Jointly the PNAEE and PNAER triggered measures to ensure substantial improvement in energy efficiency in Portugal through the implementation of PNAEE 2016 and PNAER 2020.

Six specific areas of action have programs and measures established under PNAEE 2008, PNAEE 2016: transportation, residential and services, industry, state, behaviors agriculture. These areas put together a total of 10 programs, which comprise a range of energy efficiency improvement measures based on energy demand to achieve the proposed objectives.

There are explicit opportunities for the application of cogeneration in industry. This sector is covered by the program “Energy Efficiency System in Industry”, which includes the revision of the Management System of Intensive Energy Consumption (SGCIE) and its implementation, namely through measures arising from the implementation of mandatory energy audits and involving cross-cutting measures in the industrial sector and other specific measures for efficiency in the industrial process. Cogeneration is presented as a cross-sector measure in heat and cooling with potential savings resulting from new cogeneration projects.

Other opportunities may come as a result of specific programs regarding the establishment of measures, possibly affecting micro and mini CHP development, based on the fact that:

- Residential and services area integrate energy efficiency improvement programs, namely Energy Efficiency in Buildings System, which includes measures resulting from energy certification process in buildings;
- Portuguese Public Administration has a program, called Energy Efficiency in the Public Administration, which defines a set of measures intended to introduce energy certification of Public Administration buildings regarding a total of 2,225 buildings by 2020.

1.2. Policy development

1.1.1. Current situation

At present, the situation of CHP in Portugal is not as positive as it was before 2012. In 2010, the Government used the transposition of the cogeneration directive (2004/8/CE) in order to start making changes in existing legislation. A new legal framework was completed by 2012 with high negative impacts on CHP promotion and development. At the moment all the existing plants stop having support after 20 years of operations, but most are stopped at the end of the 15th year of operation, when they become eligible for the new remuneration regime. Because the pool price is artificially low, in particular, to the marginal price of RES, it is not possible to operate a CHP plant without some kind of regulated tariff or premium, aiming to internalize the advantages such a plant would bring to the electrical system. 10%-15% of installed capacity is stopped but this figure will rise as more units reach the 15 year limit.

New tariffs apply to all new plants and existing plants are out of regulated tariff after 20 years. In these conditions investments both on new plants construction and old plants restructuring seem not economically viable.

Cogen Portugal, the Portuguese industry association for cogeneration, and all cogeneration stakeholders are particularly concerned about the legislative changes, which are not in line with EU Energy Efficiency Directive.

The actions by Portugal to address the current tariff deficit of the Portuguese Electricity Sector are undoubtedly the most critical factor which has impacted potential growth in cogeneration. A revision of support mechanisms across electricity generation resulted in cuts in the remuneration to cogenerators through the disruption of the avoided cost principle in place within the previous regulation, which threaten the ability of the sector to deliver the potential national energy savings of which it is capable.
The tariff deficit within Portuguese electrical sector is a result of various policy measures and regulatory decisions that prevented the real global costs of the electrical system from being directly reflected to the end consumers. The resulting debt to the regulated distribution operators has been deferred in time as a way to politically soften the electricity tariff increases, transferring this burden that is now pressuring the electricity prices for the next six to ten years.

The tariff deficit reflects all sort of system costs that have not been duly accounted in the tariff calculation in recent years, namely, the income of regulated system operators, other costs of General Economic Interest (CIEG), which are policy costs, including a calculated overcost of production in Special Regime (PRE), the overcost of production in Ordinary Regime (PRO), rents to the municipalities and other system costs.

It should be referred that the calculated production overcost, either in PRE or in PRO, are determined with reference to the market wholesale price that, not only does not reflect the real total cost of electricity, but does not account all the remuneration of the market production operators that have been labelled as general system costs (CIEG).

Within the new reform of regulation of the electrical system, which is set up for the future, in accordance with Article 18 Decree-Law 29/2006 of 15 February, in the wording given to it by Decree-Law 215-A/2012 of 8 October, PRE is considered to be the activity subject to special legal regimes, including the production of electricity through cogeneration and endogenous resources, renewable and non-renewable, the micro and mini cogeneration and the electric production without power input to the grid, as well as the production of electricity from endogenous resources, renewable and non-renewable not subject to special legal regime.

The PRE is remunerated through a purchase tariff administratively established and the impact of these payments in the allowed remuneration is determined as the reference price of electricity traded on the regulated market and recovered by the Global Use Tariff of the System applicable to all consumers regardless of their supplier.

It is a fact that PRE has been increasing its share in the sector representing a significant part of the total electricity consumed in Portugal, as it can be seen on Energy Services Regulatory Authority (ERSE) data on Special Regime Production in April 2012 and from which the following table has been extracted:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP RES</td>
<td>104,2</td>
<td>1331,1</td>
<td>1519,4</td>
<td>1542,6</td>
<td>1733,9</td>
<td>1810,8</td>
<td>1788,9</td>
<td>1861,4</td>
</tr>
<tr>
<td>CHP other</td>
<td>1147,7</td>
<td>25,39,5</td>
<td>3010,8</td>
<td>3590,4</td>
<td>4480,4</td>
<td>4768,4</td>
<td>4847,2</td>
<td>5285,3</td>
</tr>
<tr>
<td>Wind</td>
<td>152,8</td>
<td>17,28,2</td>
<td>5690,8</td>
<td>7480,1</td>
<td>9031,9</td>
<td>9128,1</td>
<td>10014,5</td>
<td>11748,7</td>
</tr>
<tr>
<td>Hydro PRE</td>
<td>601,7</td>
<td>393,3</td>
<td>658,6</td>
<td>816,2</td>
<td>1374,1</td>
<td>1016,8</td>
<td>619,3</td>
<td>1327,7</td>
</tr>
<tr>
<td>RSU</td>
<td>446,7</td>
<td>471,5</td>
<td>441,4</td>
<td>457,6</td>
<td>454,3</td>
<td>485,6</td>
<td>394,6</td>
<td>470,5</td>
</tr>
<tr>
<td>Biomass</td>
<td>6,9</td>
<td>59,7</td>
<td>146,2</td>
<td>304,9</td>
<td>611,9</td>
<td>687,8</td>
<td>741,8</td>
<td>683,9</td>
</tr>
<tr>
<td>Biogas</td>
<td>0,1</td>
<td>25,3</td>
<td>59,1</td>
<td>70,6</td>
<td>92,2</td>
<td>152,3</td>
<td>202,3</td>
<td>239,4</td>
</tr>
<tr>
<td>PV</td>
<td>0</td>
<td>0</td>
<td>33,4</td>
<td>139,5</td>
<td>167,0</td>
<td>188,7</td>
<td>221,1</td>
<td>257,4</td>
</tr>
<tr>
<td>% CHP/total</td>
<td>50,9</td>
<td>80,3</td>
<td>39,2</td>
<td>35,6</td>
<td>34,6</td>
<td>36,1</td>
<td>35,2</td>
<td>32,7</td>
</tr>
</tbody>
</table>

Tab. 1.3 Annual delivered electrical energy to the grid per technology (GWh) (Source ERSE)

Given the assumptions of the Memorandum of Understanding of May 17 2011, signed under the European program of financial assistance, the Council of Ministers of 17 May 2012 approved a package of measures to eliminate the tariff deficit, which was in that time € 3,2 billion.

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The resulting adjustments in tariff have been applied:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Amount (€m)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP: Reduction of feed in tariff to producers of cogeneration electricity (Ordinance 140/2012)</td>
<td>996</td>
<td>2012 to 2025</td>
</tr>
<tr>
<td>Wind: Agreement to reduce costs reached with wind producers who benefiting from remuneration regime prior to 2005 (Decree-Law 35/2013)</td>
<td>151</td>
<td>2013 to 2020</td>
</tr>
<tr>
<td>Small Hydro: Introduction of a 25 year limit for the duration of the guaranteed tariff (Decree-Law 35/2013)</td>
<td>285</td>
<td>2013 to 2030</td>
</tr>
</tbody>
</table>

Tab. 1.4 Subsidies cuts according sector

As can be seen taking into account the above Tab. 1.3 data, the CHP sector is strongly penalized in absolute and relative value.

Reducing costs through CMEC (adjustable financial compensation scheme) (€205M) and Power Warranty (€ 443M) complete the measures for savings of € 2.080 million for the National Electricity System in order to eliminate the tariff deficit.

In order to eliminate completely the tariff deficit that Portuguese electricity sector has been accumulating in the last years a new package of measures between 1010 and 1390 €mil has to be foreseen in short time.

Currently, new cogeneration plants up to 100 MW may be licensed under a “special regime” (PRE) framework within Portuguese electrical sector.

A CHP plant licensed under the special regime Decree-Law 23/2010 must comply with the efficiency requirements of the EU Cogeneration Directive (2004/8/CE) and the new Efficiency Directive 2012/27/UE, specifically in what concerns the Primary Energy Savings (PES) over 10% required for a plant to be considered a High Efficient Cogeneration.

An installation which presents a positive PES, although under the 10% threshold is considered efficient cogeneration plants under the cogeneration Decree-Law.

The operators granted with a cogeneration license may choose during the licensing process to adopt one of the two remuneration schemes.

1) General remuneration scheme.

Under this alternative, the operator may choose to sell the electricity production in the pool market or through bilateral contracts with the thermal consumer host or with third parties, either consumer(s) or an energy commercial company.

Under this regime, the CHP operator sells the electricity at the price agreed with third parties, or at the pool price and, additionally, is entitled to receive from the system operator (CUR - Last Resort Supplier) a market premium which corresponds to 50% of the regulated tariff and varies between 32 and 45 €/MWh.

Nevertheless, the CHP operators under this scheme are obliged to pay grid access tariffs, even in the case where the electricity is sold to the consumer on site, which roughly represent a cost of 40% to 50% of the market premium.

2) Special remuneration tariff.

The CHP operators may, under certain circumstances and subject to the Administration discretion over the granting of grid connection capacity, choose to sell their electricity production to the system operator (CUR) at a regulated feed-in tariff which is set according to fuel consumed and installed capacity. The special regime is valid for a 10 year period with the possibility for a renovation for second 10 year period with a degraded tariff. However, new permits under this regime are currently retained.
The reference feed-in tariff has been setup according to the following classes:

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Power MW</th>
<th>Reference tariff €/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG and liquid fuel</td>
<td>&lt;10MW</td>
<td>89,89</td>
</tr>
<tr>
<td></td>
<td>10MW&lt;P&lt;20MW</td>
<td>80,44</td>
</tr>
<tr>
<td></td>
<td>20&lt;P&lt;50MW</td>
<td>70,33</td>
</tr>
<tr>
<td></td>
<td>50&lt;P&lt;100</td>
<td>63,95</td>
</tr>
<tr>
<td>Heavy fuel oil</td>
<td>&lt;10MW</td>
<td>89,12</td>
</tr>
<tr>
<td></td>
<td>10&lt;P&lt;100</td>
<td>79,96</td>
</tr>
<tr>
<td>Renewable fuel</td>
<td>&lt;2</td>
<td>81,17</td>
</tr>
<tr>
<td></td>
<td>2&lt;P&lt;100</td>
<td>65,92</td>
</tr>
</tbody>
</table>

Tab. 1.5 Feed-in reference tariff

Additionally the plants receive an efficiency premium, depending on the audited PES of the plant, which is generally between 5 to 10 €/MWh for Natural Gas plants and could be up to 18 €/MWh for high efficiency renewable CHP plants.

Renewable CHP plants are also entitled to a Renewable Premium up to 10% of the Reference Tariff, and proportional to the percentage of renewable fuel consumption in the plant.

The Feed in tariffs are adjusted quarterly according to the rules set up in a Ministerial Order. The adjustment parameters include CPI variation and also Brent and USD exchange rate prices, but the adjustment formulas have been deficiently setup to properly adjust to the variation in the natural gas prices.
1.2. Awareness

Apart from closest operators involved in the cogeneration sector, the awareness level is poor, unlike other concepts as renewable and energy efficiency, that media are used to largely disseminate.

1.2.1. Role of key actors

1. Poor  
2. Low  
3. Early awareness  
4. Interest  
5. Active market

1.1.1. General consideration on CHP awareness

The actual perception of the cogeneration in Portugal from part of active stakeholders reflects what occurred in the country in last years, i.e. a decline of the presence of cogeneration in the industrial sector, which was the main and booming sector before the economic crisis. Awareness and perception of cogeneration is also affected by the incapacity of the policy makers to propose a firm and farsighted path for the growth and sustainability of the sector.

Apart from closest operators involved in the cogeneration sector, that is industry from one side and manufacturers, installers, engineering companies, consultants and CHP promoter or ESCO’s from the other side the awareness level is poor. Awareness in media and general public is almost inexistent.
and all the attention is focused on renewable sources and even the broader concept of energy efficiency meets difficulties to be accepted. The last interventions of policy makers show the low awareness that cogeneration could be part of the solution and help the country in matching the targets required by the European directive together with an improvement of the relation between users and energy market.
1.2. The economics of CHP

The current environment in the Portuguese cogeneration sector is extremely adverse. After the last remuneration reductions, tight and unsecured return rate discourage any investments in new plants and even in upgrading the old ones. District heating is practically non-existing and poor gas grid infrastructure penalizes households application interest.

Table 1.6, that offers a view of the current market economic situation of cogeneration in Portugal, shows only one segment with potential to still provide interesting economic benefits to investments. This segment refers to industrial natural gas installation up to 10 MW.

But at the same time it has to be recalled that new investments have almost stopped, mainly due to the recent review of the regulated remuneration scheme, and not to any decline of industrial activities.

Micro CHP deserves a special mention, because the regulating legislation is missing or in the best case, is inadequate to promote small scale CHP installations, despite this segment shows good potential for development in services and households, where is practically non-existing up to the moment.

<table>
<thead>
<tr>
<th>Portugal</th>
<th>Micro</th>
<th>Small &amp; Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>up to 50kW</td>
<td>up to 10 MW</td>
<td>more than 10 MW</td>
</tr>
<tr>
<td>Industry</td>
<td>NG</td>
<td>RES</td>
<td>NG</td>
</tr>
<tr>
<td>District heating</td>
<td>NG</td>
<td>RES</td>
<td>NG</td>
</tr>
<tr>
<td>Services</td>
<td>NG</td>
<td>RES</td>
<td>NG</td>
</tr>
<tr>
<td>Households</td>
<td>NG</td>
<td>RES</td>
<td>NG</td>
</tr>
</tbody>
</table>

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, limited interest for new investments.
- “poor” CHP Investment has poor or negative return on investment 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.)
1.3. Barriers to CHP

The most serious barrier for CHP in Portugal is that the new regulation for the sector does not correctly account for the widely accepted benefits of CHP, thus resulting in an inadequate economic framework for CHP operators. The lack of access to the electricity network for new CHP projects, a longstanding barrier which the new regulation was expected to address, remains in place, without clarification or any apparent rational.

Despite the known advantages that could be related to Cogeneration, encompassing reduction of primary energy consumption and CO₂ emissions necessary to achieving the targets set by the EU Comission, the increased associated reliability and security of energy supply, the reduction of electric network losses and generally an increase of economic competitiveness of enterprises, there are several barriers that hinder a bigger penetration into the market.

Beyond the general heavy economic panorama that have been affecting for the last 7 years the industry and consequently the demand of useful heat which has depressed the cogeneration sector and determined the revision of cogeneration potentials forecasts, there are some barriers not only caused by the actual persisting economic crisis but also by some regulatory barriers that strongly impact the economic sustainability of CHP operations.

About this the main barriers are here identified and listed in descending order of importance.

**Barrier 1: Current legal frame.**

The current legal frame is by far the main barrier for the development of cogeneration. As a matter of facts in a year and half from June 2012, when the Decree 140/2012 entered into force, up to December 2013 almost 12,5 % of CHP capacity has been lost and 150 MW from cogeneration are estimated to be out of work since that date. The current legal frame is permitting a remuneration substantially lower than with the previous tariff scheme, failing to recognise the actual avoided costs to the system, and jeopardising the competitiveness of the industry, especially the exporting sectors, exposed to international competition. Indeed, the present incentive is felt as a dis-incentive for the investments in cogeneration by the sector operators.

The regulated tariff was established to deliver back to CHP operators some of the value of the savings which they create at the electricity system level. There are changes within the new regulation which are arbitrary within this framework of calculation and which merit specific mention.

- The regulated tariff concept is based on actual calculated savings at system level (avoided network costs). The calculation principle that calculates the avoided cost was based on a comparison with the conventional electrical production using the same fuel source (in the case of natural gas, a combined cycle gas turbine). But in the new regulation scheme, this principle has changed to a mixture of a combined cycle gas turbine and a wind farm. This is hardly understandable and contradicts the principles set out on the Directive.. There are two drawback arising from it: it results in a lower tariff and it does not allow the remuneration to be properly indexed to the fuel price, with the consequence of inducing a severe fuel price risk to the project, which is a considerable disincentive to investment.

- The actual tariff system doesn’t fully reflect the avoided cost of fuel.

The economic and financial features, generated by the new remuneration scheme, hinder investments in cogeneration both of new plants and of substitution and revamping of older ones. This is clearly demonstrated by the fact that in the last 4 years approximately a dozen of licences for installation of CHP plants have been issued, but none of them have started construction.

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6 Regulation Sept/Oct 2012...

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Barrier 2: Fuel price.
At present high fuel price risk, especially in what concerns natural gas price, new investments have almost stopped, as a consequence of the poor rate of return caused by fluctuating fuel price. Furthermore the low wholesale electricity/fuel ratio constitutes a serious barrier not only for new or revamped plants but even for operating the existing ones.

Barrier 3: Connection costs.
Other prices related to cogeneration are increasing as the access tariff to gas transport and distribution network. In particular is evident the discrimination in operating costs for connection to gas grid between conventional generation plants and CHP plants due to the fact that normally the latter ones are located on secondary pipelines, generating an additional cost of 3 €/MWh when compared to a conventional combined cycle gas turbine plant. This measure, based on the reason to reflect extra costs of running ancillary grids, constitutes a strong disincentive to operate CHP pants, when these plants are already competing with central generation plant as regards charges per kWh. Moreover, there is also a strong disincentive for CHP producers to sell electricity to the host thermal consumer. In this case, the CHP electricity delivered directly to the consumer has to bear grid access costs, despite the fact that this energy is not delivered to the public grid.

Barrier 4: Bureaucracy on access points.
Despite the simplification of the procedures introduced during the implementation of the Directive 2004/8/EC, there are in practice very few available points for gas and electric network connections and application procedures are long and laborious. In the case of a new access point to the electric grid under the new feed-in-tariff regime, it is impossible to obtain a permit.

In conclusion, it has to be pointed out that unfortunately the more time passes without clear lines of intervention the more cogeneration plants are to shut down and almost certainly in an irreversible way and it seems that, the things so standing, cogeneration will not receive the appropriate recognition as a contributor to the electrical system as a whole, and awareness as to the fact that cogeneration is not merely a matter of energy policy but also an industrial policy issue will remain low. Following the EU EED could help to reorganize the energy policy having a global economic outlook.
2. What is possible? Cogeneration potential and market opportunities

The Ministry of Economy carried a deep study on high efficiency cogeneration preceded by a detailed characterization of the cogeneration units stock in Portugal, bringing to two development scenarios, which show in the optimistic case an increase of installed power of 68% between 2007 and 2020. Unfortunately this study was carried out in 2009 before the economic crisis.

According the Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC requiring all the Member States to conduct a study on the national potential for high-efficiency cogeneration, the Ministry of Economy, Innovation and Development carried a deep study on high efficiency cogeneration in Portugal7, preceded by a detailed characterization of the cogeneration units stock in Portugal which analytically confirmed that Cogeneration represented a major share of electricity production, reaching about 13% of the produced electricity. In the same time it was carried out an extensive characterization of the consumption of electricity and thermal energy by conducting surveys in the industrial sector and in the services sector with support of DGEG (General Direction of Energy and Geology).

The cogeneration potential has been calculated based on the 2007 cogeneration data, considered as starting points of the extrapolation assumption.

The Study commissioned by the Ministry of Economy began building up a big matrix with data regarding all existing cogeneration units and applying the following main assumptions

- Replacing the heat and cold produced traditionally produced using NG and electricity with heat from cogeneration, whenever primary energy savings results
- Replacing the use of fuel oil as the primary fuel
- Revamping existing cogeneration plants, with lifecycle within the timeframe 2020
- Using the recovery potential from residual heat sources for electrical energy production

On this basis a CHP potential of heat demand was calculated for each sector.

1.1. Industry

The industrial sector will remain the domain of application with most potential, either in number or in size with typical applications in small and medium manufacturing capacity typically below 10 MW, supported mainly in the production of heat and cold, or mostly cold (through absorption chiller) in trigeneration. The typical case of applications just mentioned aim at the satisfaction of a decentralized demand, focused on a range of different thermal consumers especially addressing the needs of air treatment, in support of industrial processes lacking in heat and/or cold.

In Industry sector has been identified a potential of 1.377 MWe shared between 677 MWe from conversion of fuel oil to natural gas and 700 MWe corresponding new capacity to be installed. Adding to the existing 1.368 MWe in 2007, accounts in 2020 an installed electrical capacity of 2.068 MWe.

1.2. Services

The activities related to the services sector show a greater number and geographic dispersion of the points of consumption and smaller size of the installations. Its energy consumption profile mainly focuses on meeting the needs of air conditioning, then cogeneration potential is found in the production of heat and cold, with particular emphasis on the first.

Despite long time existing cogeneration systems in the service sector, typically district heating/cooling, hospitals, shopping centres, swimming pools, etc., the expansion foreseen by 2020

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7 Ministerio da Economia, da Inovação e do desenvolvimento – Estudo do potencial de cogeneração de elevada eficiência em Portugal – February 2010

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will be focused on investments in the production of heat and cold, in roll-out of networks of energy distribution (cold and heat), in supporting and complementing the conventional HVAC systems.

In this sector a potential of 252 MWe of installed capacity by 2020 is forecast, due to an increase of 221 MWe with respect to 2007 capacity amounting to only 31 MW.

1.3. Residential sector
Taking into account the state of the art cogeneration technologies for the residential sector, particularly its economic viability when compared with other options in the market for heating and/or cooling, the increasing quality of the thermal envelope of buildings, as well as the mild climate of the country, it was concluded that there is no significant potential for the penetration of high-efficiency cogeneration in this sector by 2020.

1.4. Scenarios
In the Figure 2.5 are shown two scenarios of evolution of the estimated economic potential assessed by the year 2020. For this were used data provided by REN (National Energy Network), including the evolution of GVA of each of the major sub-sectors of economic activity.

In the optimistic scenario, in addition to the higher level of economic growth, a proactive prevailing logic in terms of development of cogeneration market, focusing on achieving the level CHP can play in satisfying energy demand, adequately covered by a suitable system of incentives that favours the replacing the need for useful heat and cold through cogeneration.

The pessimistic scenario was also based on a sectoral analysis, taking into account the prospects of more moderate economic growth of each sector where there is an installed capacity of cogeneration.

![Evolution scenarios of Economic Potential of HE Cogeneration](image)

**Fig. 3.1 Evolution scenarios of Economic Potential of HE Cogeneration**

<table>
<thead>
<tr>
<th>Year</th>
<th>Optimistic (MWe)</th>
<th>Pessimistic (MWe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1750</td>
<td>1697</td>
</tr>
<tr>
<td>2015</td>
<td>2065</td>
<td>1862</td>
</tr>
<tr>
<td>2020</td>
<td>2320</td>
<td>1979</td>
</tr>
</tbody>
</table>

**Table 3.1 Economic potential in 2010, 2015, 2020 according scenarios**

In the following figure it’s represented the conversion of the energy potential into installed electric power.
In the optimistic scenario it’s possible to observe that the national economic potential of high-efficiency cogeneration is identified at 2.320 MWe.

It is estimated an increase in capacity of about 221 MWe in the services sector, joining the existing 31 MWe in 2007, totalling 252 MW of installed capacity.

In Industry is possible to increase the installed capacity of 700 MWe, while the remaining 677 MW of oil-fired power stations will be converted in its entirety, for natural gas by 2020, considering an extreme situation where any difficulty that might subsequently find is overcome.

This was the last official economic potential estimation for cogeneration in Portugal, as a matter of facts the Second progress report to the Commission reports the following answer regarding the progress in national potential “The economic and financial crisis which has been affecting Portugal, together with the recent establishment of the current Government, has been reflected – in the specific case of cogeneration – in the need to review the existing proposals relating to Orders and support schemes, in particular the reference tariff and premiums and other procedures contained in Decree Law No 23/2010 of 25 March 2010. This crisis has also been reflected in industry, particular in the demand for useful heat, which has contributed to decreasing the potential of high-efficiency cogeneration initially identified. In addition to this situation, the assessment which results from the measures provided for in Portugal’s Memorandum of Understanding on Specific Economic Policy Conditionality involves reviewing and reformulating, across the board, many of the measures which are in force and planned. Thus, it is not possible at the moment to correlate the data between the legislation and the production of high-efficiency cogeneration, and the previous rules which existed before the current law remain in force, namely the allocation of the subsidised tariff”

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3. How do we arrive there? : The Roadmap

After an eight year delay in implementing the Cogeneration Directive the new Energy Efficiency Directive risks to enter in a window onto a panorama not yet stable and shaken by the effects of the economic crisis and a legal frame that has not been able to mitigate the negative consequences. Nevertheless the suggested step of this Roadmap should find force in the adoption of the EED obligations.

1.1. Overcoming existing barriers and creating a framework for action

This chapter is based on the considerations developed in the previous chapters, mainly those referring to the barriers and market potential, aiming to arrive to propose a Roadmap that indicates a possible path to implementing CHP potential or at least mitigate the effects of the economic crisis and the detrimental actual legal frame in Portugal.

As long as possible, a scheme similar to that applied to barriers identification is adopted to suggest the relevant measures indicating, when adaptable, the articles of the EED helping or at least affecting the implantation of the proposed measures.

The basic policy framework around cogeneration in Portugal today sets the scene for the roadmap:

- PNAEE National Energy Efficiency Action Plan 2016\(^9\) (ch. 2.2.2)
- PNAER National Renewable Energy Action Plan 2020\(^10\) (ch. 2.2.)
- EED Energy Efficiency Directive\(^11\)
- EU Energy roadmap 2050\(^12\)

 together with the legislation acts concerning cogeneration and energy efficiency.

The document presents measures and suggestions, well keeping in mind that CHP is only a part of the big puzzle of energy, energy efficiency and decarbonisation that any measure has impacts at technical, economic and social level.

In particular manner the Roadmap intends to propose concrete and focused measures, discussed and agreed with the experts, in order to overcome or at least reduce the negative effects of some barriers, especially those due to a cumbersome and plethoric legislation.

It is our opinion that, given the present economic crisis in Portugal and the reduced availability of resources, any proposal should require and regard organization and regulatory initiatives, in order to get a feasible level of acceptability.

In any case we would like to put as a premise of this Roadmap a general warning regarding the implantation of the EED, based on the fact that Portugal carried out the implementation of the CHP directive 2004/8/EC only in 2012 the new Directive on Energy Efficiency is coming in a just settled, complex and farraginous framework and though it brings new opportunities, there is a concrete risk that it will introduce further confusion in the sector, unless well managed. As a matter, even if most of its provisions should have been implemented by 5 June 2014, the Directive at July 2014 has not been implemented nor there is any official forecast fixing a date.

The hope is that this Roadmap document will be a concrete basis to follow the right steps.

\(^9\) http://dre.pt/pdf1sdip/2013/04/07000/0202202091.pdf
\(^10\) http://dre.pt/pdf1sdip/2013/04/07000/0202202091.pdf
\(^12\) http://ec.europa.eu/energy/energy2020/roadmap/index_en.htm

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1.1. Possible paths to growth

1.1.1. Setting up global vision of CHP within energy challenge

(EED art. 3, 14, 18, 19)

In crisis periods like the present one, started in 2009, it’s even more compelling, especially for policymakers, not only having a theory global vision of energy challenge in the country, but putting down this vision into the current situation, inside the frame of energy efficiency and renewable sources, being able to prioritize interventions and to carry out selections focusing resources in few sectors where the possibility to maximize the results is seen, even if this operation is not free of risks.

To this regard policymakers need to recognize the importance of the role of cogeneration, beyond the main energy efficiency intrinsic characteristic, in network balancing and in obtaining emission reductions.

it is of the upmost importance, when measures are designed and supports allocated, that the advantages and impacts of the different technologies (wind, photovoltaic, cogeneration, etc.) be analyzed and compared and that the objective results from test sites be the basis of any decision.

HECHP has been clearly identified in the EED as the significant measure for improving transformation efficiency.

The European EED, that shall be adopted by Member State by June 2014, constitutes a good opportunity to carry out the task of re-launching positive actions around CHP, given its compelling force toward a more efficient way to utilize energy, provided that the switching from the former 2004/8 directive will be carried out gradually.

As cogeneration is an important part of the EED, a global vision should be taken over in 2013/2014 on how cogeneration will contribute to energy efficiency targets where EED should be used to establish a consistent framework to achieve these targets.

1.1.2. Stakeholders aggregation

(EED art. 7)

It’s believed very important that all the stakeholders find any form of aggregation which could be entitled, thanks to its capability to represent the variegated interests coming from energy organizations, manufacturers, users and services, to interact and support in primary role the appointed governmental and institutional bodies, increase awareness level and support deploying information dissemination programs on cogeneration presenting successful case studies in the sectors with highest potential.

1.1.3. Policy

Despite the fact that practically all measures that could be proposed have an aspect connected with policy and recognizing that the problem is intrinsically complex as it requires time, constant political directions, constant and real will to simplify the intricate jungle of norms and acquired privileges, our opinion is that there are some organization and structural measures that policymakers can take with immediate effect.
1.1.1.1. Modify the supporting scheme and the tariff regulation system
(EED art. 3, 7)
Given the sudden worsening of the cogeneration plants especially in 2012-2013, a shock intervention on supporting and defining new regulation for tariffs for cogeneration is requested to stop as soon as possible the plants shutdown, improving feasible operations providing a temporal stability to assure an adequate return on investment on upgrading plants and design new plants and network infrastructures, while taking care of the sustainability of the system.

1.1.1.2. Review taxation system
(EED art. 3, 7)
As per point 4.2.2.1 it’s important to review actual taxation system, including other direct costs, namely networking, permitting and certificate of origin costs.

1.1.1.3. Moving resources
(EED art. 14, 20)
Moving resources, as soon as possible and feasible, in a structural way to increase competitiveness and performance of industry and tertiary sector on long periods with positive repercussions onto economy.
This action should be taken directly by policymakers using a large strategic vision on energy market, privileging sectors who present potential characteristic of growth.

1.1.1.4. Differentiate the Special Regime
(EED art. 7, 14, 15)
It’s advisable to differentiate CHP plant from plants working under Special Regime (PRE): this will facilitate to identify the peculiarity of this technology in setting up a framework of incentives and energy taxation related to the cost benefit analysis of cogeneration plants, compared to other technology or other fuel used) taking into account the significant saving in primary energy and CO₂ emissions.

1.1.1.5. Promote cross-border cooperation
(EED art. 7)
Given the strong integration of Iberian electricity market and the similarity of problems affecting both electric market and technology used, it’s very likely that the problems, even those referring to legal frame and tariff systems, could not be tackled without a continuous cooperation and procedures harmonization.

1.1.1.6. Facilitate permitting procedures
(EED art. 7, 12, 17, 19)
Policymakers, in strict co-operation with stakeholder representatives, should define the measures to homogenize the permitting procedures followed by different bodies (administrative, health, safety, fire) improving the certainty of the outcomes regarding applications for new energy plant installation and for restructuring works. This action shall deal with this striking non-economic barrier that has proven its effectiveness in discouragement and even abandon of the installation projects and investment from part of the user or the investor. Two kinds of activities are envisaged:
• promote a standardization of procedures across the country eliminating discretion decisions and facilitating the bureaucratic process simplifying the installation requests
• institute a unique office to apply projects and licenses.
It is important to not underestimate the importance of this point especially in the case of the development of micro-CHP in the residential market and of bio-energy utilization, where simplification is a determinant factor.
1.1.4. Industrial and Tertiary sectors

1.1.1.7. Facilitate interconnections
(EED art. 7, 12, 17, 19)

The grid connection permits should be defined and granted in a way to balance between production and local consumption. In conducting the evaluation studies of the impact associated with the connection network of independent producers, it should be accounted the positive impacts resulting by the balance between the generation of cogeneration and local consumption of electricity (s) member (s) of heat, namely for its contribution for grid stability, avoided grid cost and avoided energy losses.

1.1.1.8. Database maintenance
(EED art. 7)

Create databases to enable the expansion of renewable cogeneration making it comparable to the support framework set out in the legislation for the promotion of renewable energy equivalent origin. Given their potential for expansion of renewable cogeneration, coordinated actions must be implemented to promote the sustainable expansion of the ranks of economic activities of the forestry sector. Seems of great importance to the rehabilitation of abandoned areas with high potential impact on economic and social development of the region.

1.1.1.9. Strengthen the role of ESCO’s
(EED art. 18, 20)

Important indirect action to sustain the market is definitively to strengthen the presence of ESCOs, as foreseen in the art. 18 of EED, that constitutes a key part to realize the foreseen potentials in industry, DH and commercial or community centers and explicitly welcome and supported even at normative level. Due to the fact that ESCOs, offering the contractual guarantee of the energy performance of interventions, assume the financial risk involved in the investment, they could access to the National Funds for Energy Efficiency through a specific regulation.

1.1.1.10. Intervention on Public Estate
(EED art 4, 5, 14, 20)

A specific measure relevant for buildings could be represented by investing, even through special regulation, from part of the public administration in its own facilities, as explicitly suggested in the EED (art 4, 5), also in a progressive form. Given the enormous public estate this will
• strongly boost the market and facilitate the creation of new specialist jobs
• bring high saving figures
• become a model for other installations and become the real “case study” for its intrinsic characteristic to constitute a microcosm of the entire economy in that there is a complete range of opportunities to use CHP in office buildings, schools, leisure centers, military premises and distributed energy systems.

This operation could be carried out together with ESCOs and international financial institutions to facilitate funds raising.

1.1. Saving of primary energy and CO2 emissions by the CHP roadmap

Primary energy saving (PES) and CO$_2$ emissions saving projections resulting from increased use of CHP require assumptions about not just what types of fuel and technology are displaced, but also their operation on the market. Within CODE2 two approaches are developed, which represent two different analytic considerations which are summarised here and more fully explored in Annexe 4.
1) **Methodology according to Annexe s I and II of the EED.** This 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.

2) **Substitution method.** This 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.

According both methodologies PES in Portugal implementing the roadmap for CHP is estimated at 29-30 TWh per year corresponding to 11% and CO2 emission reduction is estimated 11 Million tons per year in 2030. The actual saving is particularly dependent on the efficiency increase through upgrading both current power plant and CHP technology efficiencies. The final share of bio energy in additional CHP has a major impact on the CO2 savings which can be anticipated. The CO2 reduction achieved is mainly due to fuel switching towards low carbon (natural gas) or non-carbon (bio energy) fuel and in smaller extent to higher energy efficiency, but any change is anyway subject to the adoption of new policy objectives and actions.

Table 6: Saving of primary energy and CO2 according EED methodology

| Total CO2 reduction, Mio. t/a | -11 |
| Share in total energy-related CO2 emissions | 20% |
| Share in energy sector CO2 emissions | 32% |
| **Primary Energy Saving, TWh/a** | -30 |
| Decrease of PE, % | 11% |
| Bio Energy Share in CHP Fuels 2030 | 94% |
| Share of modernised and replaced CHP plants in CHP power growth up to 2030 | 62% |

Table 7: Saving of primary energy and CO2 according Substitution mix methodology

| Total CO2 reduction, Mio. t/a | -11 |
| Share in total energy-related CO2 emissions | 20% |
| Share in energy sector CO2 emissions | 32% |
| **Primary Energy Saving, TWh/a** | -29 |
| Decrease of PE, % | 11% |
| Bio Energy Share in CHP Fuels 2030 | 94% |
| Share of modernised and replaced CHP plants in CHP power growth up to 2030 | 77% |

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Annexes

1. Stakeholder group awareness assessment
2. Micro CHP potential assessment
3. Bio CHP potential assessment
4. Methodologies used to calculate the saving of primary energy and CO₂ emissions
5. Sources and contacts
Annex 1: Stakeholder group awareness assessment

<table>
<thead>
<tr>
<th>Group</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customers</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>Industry is the backbone of CHP and maintain its interest despite crisis and adverse legal frame</td>
</tr>
<tr>
<td>Utilities</td>
<td>The main electricity utilities are ignoring or even oppose</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
</tr>
<tr>
<td>Households</td>
<td>Micro-CHP is not yet economically feasible for households, so this kind of products is not promoted and there is no interest from the sector</td>
</tr>
<tr>
<td>Market and supply chain</td>
<td></td>
</tr>
<tr>
<td>Manufacturers</td>
<td>The stock of manufacturer is not large and many are foreign European branches. The interest is high and the commercial presence continuous.</td>
</tr>
<tr>
<td>Installers</td>
<td>Installers and maintenance companies are a big presence in the country, even if generally not working only on CHP plants. Their interest is high</td>
</tr>
<tr>
<td>Grid operators</td>
<td>Even if sufficiently informed, demonstrate unenthusiastic interest</td>
</tr>
<tr>
<td>Consultants</td>
<td>There is enough knowledge and experience among consultants</td>
</tr>
<tr>
<td>Engineering companies</td>
<td>There is enough knowledge and experience among engineering companies</td>
</tr>
<tr>
<td>Architects</td>
<td>Very low interest, Micro-CHP is not yet proposed as option</td>
</tr>
<tr>
<td>Banks</td>
<td>The knowledge is very basic and the topic is not taken into account at present</td>
</tr>
<tr>
<td>CHP promoter/ESCOs</td>
<td>The knowledge is relatively high and the interest is lively</td>
</tr>
<tr>
<td>Policy</td>
<td></td>
</tr>
<tr>
<td>National</td>
<td>The government knows the benefits and the status of cogeneration but, being at present it not a priority, thinks to maintain the present status</td>
</tr>
<tr>
<td>Regional</td>
<td>No relevant knowledge nor interest</td>
</tr>
<tr>
<td>Local</td>
<td>No relevant knowledge nor interest</td>
</tr>
<tr>
<td>Urban &amp; Regional</td>
<td>No relevant knowledge nor interest in district heating</td>
</tr>
</tbody>
</table>
### Influencers

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planners</td>
<td>The CHP technology is known but there is a lack of promotion of the related technologies. They are more focused on energy efficiency system in general</td>
</tr>
<tr>
<td>Energy agencies</td>
<td>The CHP technology is known but there is a lack of promotion of the related technologies. They are more focused on energy efficiency system in general</td>
</tr>
<tr>
<td>Sector organisations</td>
<td>The sector organisations are very active to defend the results obtained in Portugal up to now and to promote CHP at national and regional level</td>
</tr>
<tr>
<td>General public</td>
<td>General public does not know cogeneration</td>
</tr>
<tr>
<td>Media</td>
<td>Energy efficiency and renewable energies are common discussion, but CHP is occasionally and briefly mentioned as technology. Specialised media give more space to cogeneration as efficient alternative</td>
</tr>
<tr>
<td>Academia</td>
<td>Cogeneration technology is only part of energy courses in the Faculty of Engineering.</td>
</tr>
<tr>
<td>Research</td>
<td>There are research centres not specifically focused on CHP</td>
</tr>
</tbody>
</table>
Annex 2: Micro CHP potential assessment

Country statistics

| Population: 10 500 000 (2010) |
| Number of households: 4 200 000 (2010) |
| GDP per capita: € 19 500 (2010) |
| Primary energy use: 18 200 ktoe/year (2010) |
| GHG-emissions: 71 Mton CO$_{2}$eq/year (2010) |

Household systems (±1 kW)  
Boiler replacement technology

| Present market (2013) |
| Boiler stock: 288 000 units |
| Boiler sales: 64 000 units/year |

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

| Present market (2013) |
| Boiler stock: 101 000 units |
| Boiler sales: 23 000 units/year |

Potential estimation

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market alternatives</td>
<td>1</td>
</tr>
<tr>
<td>Global CBA</td>
<td>2</td>
</tr>
<tr>
<td>Legislation/support</td>
<td>3</td>
</tr>
<tr>
<td>Awareness</td>
<td>1</td>
</tr>
<tr>
<td>Purchasing power</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>7 out of 12</td>
</tr>
</tbody>
</table>

Expected final market share: 37% of boiler sales in Household sector

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market alternatives</td>
<td>2</td>
</tr>
<tr>
<td>Global CBA</td>
<td>0</td>
</tr>
<tr>
<td>Legislation/support</td>
<td>3</td>
</tr>
<tr>
<td>Awareness</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>4 out of 9</td>
</tr>
</tbody>
</table>

Expected final market share: 19% of boiler sales in SME & Coll. sector

Yearly sales

| Yearly sales Household systems |
| Sales in 2020: 360 units/year* |
| Sales in 2030: 22 000 units/year* |

| Yearly sales SME & Collective systems |
| Sales in 2020: 100 units/year* |
| Sales in 2030: 2 700 units/year* |

Stock

| Stock Household systems |
| Stock in 2020: 730 units* |
| Stock in 2030: 106 000 units* |
| Stock in 2040: 235 000 units* |

| Stock SME & Collective systems |
| Stock in 2020: 700 units* |
| Stock in 2030: 11 000 units* |
| Stock in 2040: 39 000 units* |

Potential savings in 2030

| Primary energy savings: |
| 2 PJ/year* |
| 53 ktoe/year* |
| GHG-emissions reduction: |
| 0.2 Mton CO$_{2}$eq/year* |

| Primary energy savings: |
| 9 PJ/year* |
| 221 ktoe/year* |
| GHG-emissions reduction: |
| 0.7 Mton CO$_{2}$eq/year* |

*Corresponding to the expected potential scenario.

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Annex 3: Bio-CHP potential assessment

In the context of the CODE2 project, a potential analysis for bio-CHP was elaborated for the EU-27 countries in aggregate and per member state.

The national bio-CHP potential analysis is based on figures from the PRIMES database, Eurostat, the National Renewable Energy Action Plan (NREAP), and the project Biomass Futures. The analysis has been discussed and, where necessary, refined in consultations with national energy experts.

The complete EU-27 analysis is found at http://www.code2-project.eu/wp-content/uploads/CODE2-D2.6-European-report-on-potential-of-bio-energy-CHP.pdf

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### Bio-energy CHP potential analysis Portugal

<table>
<thead>
<tr>
<th>Figures (projections)</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final heat demand from CHP and DH (PRIMES, IEA), ktoe</td>
<td>366</td>
<td>1.027</td>
<td>1.174</td>
</tr>
<tr>
<td>(Projected) heat demand from bio-energy CHP and DH (after score card), ktoe</td>
<td>145</td>
<td>200</td>
<td>209</td>
</tr>
<tr>
<td>Bio-energy penetration rate in CHP markets (2009: EEA, Eurostat)</td>
<td>39.6% (2009)</td>
<td>19.4%</td>
<td>17.8%</td>
</tr>
<tr>
<td>Biomass availability, share heating (sust., cost-eff.), final energy (Biom. Futures), ktoe</td>
<td>1.906</td>
<td></td>
<td>1.639</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Framework Assessment (Score card)</th>
<th>Score</th>
<th>Short analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legislative environment</td>
<td>1 (of 3)</td>
<td>Legal framework demotivating; grid access very limited; financing difficulties.</td>
</tr>
<tr>
<td>Suitability of heat market for switch to bio-energy CHP</td>
<td>1 (of 3)</td>
<td>Industrial plants with continuous heat demand are: pulp and paper using already biomass; chemical not suitable for bio-energy</td>
</tr>
<tr>
<td>Share of Citizens served by DH</td>
<td>0 (of 3)</td>
<td>No National supply chain; Main users are pulp/paper and wood industries, as raw material and residual fuel; Remaining biomass is expensive.</td>
</tr>
<tr>
<td>National supply chain for biomass for energy</td>
<td>1 (of 3)</td>
<td></td>
</tr>
<tr>
<td>Awareness for DH and CHP</td>
<td>0 (of 3)</td>
<td></td>
</tr>
</tbody>
</table>
Annex 4: Methodologies used to calculate the saving of primary energy and CO₂ emissions.

**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.

**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” 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 CO₂ saving resulting from a voluntary commitment of the German industry for CO₂ reduction, however this method has been considered as too simple. Therefor the following more differentiated approach has been developed:
Based on an estimate of the increase in cogeneration electricity the thereby caused decrease of CO₂ 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, CO₂ 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 relevant value, representing meaningful the contribution of CHP to the long-term objectives of the EU to reduce CO₂ emissions and primary energy consumption. The BAT

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13. FfE Forschungsstelle für Energiewirtschaft e.V., Energiezukunft 2050; http://www.ffe.de/die-themen/erzeugung-und-markt/257
14. The calculation has been made by the VIK Verband der Industriellen Energie- und Kraftwirtschaft e.V., 2010, Unpublished.
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 by new cogeneration technologies 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 by new cogeneration technologies
- 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.
Annex 5: Sources

Sources
ADENE: Agencia para a Energia  www.adene.pt
Ministerio da Economia e do Emprego, Direcção Geral de Energia e Geologia www
- PNAEE  Plano nacional de Ação para Eficiencia Energética 2016
- ECO.AP  Programa de eficiencia energética para a Administração Pública
COGEN Portugal  www.cogenportugal.com
Universidade de Coimbra : Estudo do potencial de cogeneração de elevada eficiencia em Portugal
Universidade de Aveiro - Potencial da Micro-cogeração nos sectores Residencial e de Serviços
Departamento de Ambiente e Ordenamento APREN : AssociaçãoPortuguesadeEnergiasRenováveis
www.apren.pt
ERSE : Entidade Reguladora dos Serviços Energeticos  www.erne.pt  – Annual Report to the European Commission
EDP - Energias de Portugal, S.A  www.edp.pt
Odyssee MURE - Energy Efficiency Policies and Measures in Portugal 2010
GALP Power – CHP Projects
Anuario Estatistico 2012 de Portugal

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