Energy Efficiency Obligation Scheme CHP Guidance Document

Guidance on claiming savings from CHP projects

Contents

1. Executive Summary

The purpose of this document is to provide guidance to Energy Efficiency Obligation Scheme (EEOS) participants applying for energy credits with combined heat and power (CHP) technologies. The Excel tool is intended for use in the calculation of energy credits for the purposes of the EEOS. Please note that SEAI will *only* accept savings from CHP projects that have been calculated using this tool. No other method of calculation will be accepted. Also note that projects with positive primary energy savings will be considered. As negative primary energy savings inherently mean that the CHP is less efficient then having separate heat and electricity production and is not eligible for energy credits.

1. Legislative context

1.1. Energy Efficiency Obligation Scheme

The purpose of this Guidance document is to inform obligated energy suppliers of their requirements pursuant to the Energy Efficiency Obligation Scheme ('EEOS') which has commenced operation from 1st January 2014.

The EEOS is being implemented pursuant to the Energy Efficiency Directive 2012, Article 7. The Directive imposes a legal obligation on Member States to achieve new savings each year from 1 January 2014 to 31 December 2020 of 1.5% of the annual energy sales to final customers of all energy distributors and all retail energy sales companies by volume, averaged over the most recent three-year period prior to 1 January 2013. The target is cumulative, which means that it is based on incremental annual savings that deliver a total volume of savings at the end of the obligation period in 2020.

Ireland has chosen to effect the provisions of Article 7(9) of the Directive, opting to combine alternative policy measures and an energy efficiency obligation scheme to meet the national target. Obligated parties under the EEOS are energy distributors and retail energy sales companies that have market sales in Ireland of greater than 600 GWh final sales in any relevant year, regardless of the sector they supply.

Obligated parties' targets are allocated according to their proportion of energy market sales volume in Ireland. Member States are obliged to put in place measurement, control and verification systems to verify savings by obligated parties. The positions against targets for each year are to be achieved, audited and finalised by 31 March of the following year. The target allocated to obligated parties is 550 GWh PPE, which is sub-sectoralised as 75% non-residential, 20% residential and 5% fuel poverty residential. The minimum achievement for the period 2014-2016 is Year 1 60%, Year 2 75% cumulative and Year 3 90% cumulative. From Year 4 onwards, the minimum cumulative achievement will be 95%.

Obligated parties can choose to achieve energy savings independently or through partnerships with service providers in the market. The scheme permits the exchange of validated savings between obligated parties in certain circumstances. Obligated parties can buyout up to a maximum of 30% of their total cumulative target, whether or not they have achieved their minimum cumulative target. For any portion of the minimum annual target not achieved, exchanged or bought out, a penalty will be imposed. The price of buyout and penalty will be set and published by the Minister and reviewed as appropriate.

1.2.Directive 2004/8/EC

The aim of Directive 2004/8/EC of the European Parliament and of the Council is the promotion of cogeneration based on a useful heat demand in the internal energy market. This directive set forth the methodology of calculating the primary energy savings (PRIMARY ENERGY SAVINGS) associated with installation of CHP units. This methodology was adapted by EU member states in 2004 and reviewed every five years. The latest revision was in 2015, i.e. 2015/2402/EC. This latest revision has been used to generate an Excel tool which aims to provide its user with a cost effective means of calculating the PRIMARY ENERGY SAVINGS associated with a CHP project.

1.3. Guide to Using Excel Tool

Thermal and electrical generation must be adequate to meet on-site demand. Electrical exports are not deemed eligible for energy credits and must be excluded from the calculations. This section provides a guide for Obligated Parties (OPs) using the Excel tool developed by SEAI. This tool generates the primary energy savings based upon the user's selection and information inputted.

The Excel tool has been designed to provide ease of use and transparency for the user. This tool will be used by both the OPs when applying for EEOS credits and SEAI when examining the applications. The PRIMARY ENERGY SAVINGS calculated depends upon the user's inputs and selections with regard to the drop down menus. The description of these options and drop menus is detailed in the subsequent sections. Please note that SEAI will *only* accept savings from CHP projects with this tool. No other method of calculation will be accepted.

1.3.1. CHP Data Approach

The OP must follow the derogation tree in the EEOS guidance on claiming energy credits document.[1] The applicant must determine which data approach applies to their application. The two approaches are as follows; (i) No Metered Data approach and (ii) Metered Data approach. The applicant would use the no metered data approach if *less than* six months of operational metered data is available. Please note that for the same operational hours and same electrical output both approaches output the same PRIMARY ENERGY SAVINGS.

1.3.1.1. No Metered Data Approach

Given the complexity around calculating accurately the electrical and thermal output of CHP units without substantial metered data SEAI have taken the following approach. The applicant must provide the following information when calculating the PRIMARY ENERGY SAVINGS associated with their project.

Projected Annual Operational Hours of the CHP unit

---

[1] http://www.seai.ie/EEOS/Guidance-on-authenticating-and-claiming-energy-credits.pdf

The projected annual operational hours should reflect the thermal load of the site pre-installation. This should include projected downtime for the unit. In the absence of this data the OP can use the default value of 4,800 hours which will be accepted by SEAI. SEAI will accept operational hours up to a maximum of 8,400 hours as this allows for scheduled downtime of the CHP unit.

Rated Electrical Output (kW) of the CHP unit

The rated electrical output of the CHP unit can be found on the specification sheets of the CHP and generator. It is recommended that the OP contact the contractor for this information.

Rated Thermal Efficiency (%) of the CHP unit.

The rated thermal efficiency of the CHP unit can be found on the specification sheets of the CHP. It is recommended that the PRIMARY ENERGY SAVINGS contact the contractor for this information.

Rated Electrical Efficiency (%) of the CHP Unit

The rated electrical efficiency of the CHP unit can be found on the specification sheets of the CHP. It is recommended that the PRIMARY ENERGY SAVINGS contact the contractor for this information.

Using the above user inputted information the following information is automatically calculated.

Projected Annual Electricity Generated Consumed On-Site (kWh)

The equation below contains the formula for the automated calculation of the projected annual electricity generated by the CHP which is consumed on site. This approach was chosen as the most accurate method given the complexities of not having reliable substantial metered data.

$$Projected\ Annual\ Electricty\ Generated(kWh)$$
$$= Rated\ Electrical\ Output\ (kW)\ \times Projected\ Annual\ Operational\ Hours$$

Projected Annual Fuel Input (kWh)

The equation below contains the formula for the automated calculation of the projected annual fuel input of the CHP. This approach was chosen as the most accurate method given the complexities of not having reliable substantial metered data.

$$Projected\ Annual\ Fuel\ Input\ (kWh) = \frac{Projected\ Annual\ Electricty\ Generated(kWh)}{Rated\ Electrical\ Efficiency\ of\ the\ CHP\ unit\ (\%)}$$

Projected Useful Heat Generated Consumed on site (kWh)

The equation below contains the formula for the automated calculation of the projected useful heat generated by the CHP which is consumed on site. This approach was chosen as the most accurate method given the complexities of not having reliable substantial metered data. It is important to note that the application must access the portion of heat generated which is dumped. SEAI may request verification of the proportion claimed. The OP must input this factor into Excel tool as seen below. The inputted percentage is then used when calculating the heat load required, i.e. useful heat (see below).

Information Provided By Applicant

Operational Metered Data Approach

Figures	Action Required	Comment
-	User Input	Metered Annual Operational Hours
-	User Input	Metered Annual [kWh] Electricity Generated Consum
#DIV/0!	Automated	Metered Annual Fuel Input [kWh] - NCV
#DIV/0!	Automated	Metered Annual Useful Heat Generated Consumed c
0%	User Input	Rated Electrical Efficiency
0%	User Input	Rated Thermal Efficiency
-	User Input	Rated Electrical Output kW of CHP Unit
Percentage of Heat Generated by CHP which is Dumped	User Input	Heat Dumped (%)
#DIV/0!	Automated	Power to Heat Ratio

Power to Heat Ratio	C	#DIV/0!	

	CHP Unit	
Overall Efficiency	0%	
Percentage of Heat Generated by CHP which is Dumped	10%	%
Heat load required (i.e. "useful")	397,354	kWh
Electricty Generated	367,920	kWh
Total Fuel input - CHP	1,051,200	kWh
Useful heat out / total fuel input: CHP Hη	38%	%
Electricity out / total fuel input: CHP Eη	35%	%
PES	35%	

Note:

$$Projected\ Annual\ Useful\ Heat\ Generated(kWh) = Rated\ Thermal\ Efficiency \times Projected\ Fuel\ Input$$

1.3.1.2. Metered Data Approach

For this approach the OP must provide the metered electricity generated by the CHP which was consumed on site for six consecutive months. This generally provides more accurate and greater savings.

Metered Annual Operational Hours of the CHP unit

OPs can get metered operational data from their BMS or metered electrical and thermal output. Other methods will be accepted but may be queried by SEAI. The metered annual operational hours should reflect the actual metered operational hours of the CHP for the past 12 months of operation. In the case where between six and twelve months of metered operational data is available the OP can scale the operational data to a pro rata value. SEAI will accept this but may request further information. Downtime for the unit should be clearly explained in Form A of the application. SEAI will accept operational hours up to 8,400. Beyond this point SEAI will required a detailed explanation as this contradicts industry norms.

Rated Electrical Output (kW) of the CHP unit

The rated electrical output of the CHP unit can be found on the specification sheets of the CHP and generator. It is recommended that the OP contact the contractor for this information.

Rated Thermal Efficiency (%) of the CHP unit.

The rated thermal efficiency of the CHP unit can be found on the specification sheets of the CHP. It is recommended that the PRIMARY ENERGY SAVINGS contact the contractor for this information.

Rated Electrical Efficiency (%) of the CHP Unit

The rated electrical efficiency of the CHP unit can be found on the specification sheets of the CHP. It is recommended that the PRIMARY ENERGY SAVINGS contact the contractor for this information.

Using the above user inputted information the following information is automatically calculated.

Metered Annual Electricity Generated Consumed On-Site (kWh)

The OP must provide at least six months of metered electrical generation data of the unit. The equation below contains the formula for the automated calculation of the projected annual electricity generated by the CHP which is consumed on site.

Metered Annual Fuel Input (kWh)

The equation below contains the formula for the automated calculation of the projected annual fuel input of the CHP. This approach was chosen as the most accurate method given the complexities of not having reliable substantial metered data.

$$Projected\ Annual\ Fuel\ Input\ (kWh) = \frac{Metered\ Annual\ Electricty\ Generated (kWh)}{Rated\ Electrical\ Efficiency\ of\ the\ CHP\ unit\ (\%)}$$

Metered Useful Heat Generated Consumed on site (kWh)

The equation below contains the formula for the automated calculation of the metered useful heat generated by the CHP which is consumed on site. This approach was chosen as the most accurate method given the complexities of not having reliable substantial metered data. It is important to note that the assumption made is that all heat generated is useful, i.e. no dumping of heat.

$$Metered\ Annual\ Useful\ Heat\ Generated(kWh) = Rated\ Thermal\ Efficiency\ \times Metered\ Fuel\ Input$$

1.3.2. Fuel Category

According to 2015/2402/EC the user of the methodology must specify the composition of the fuel input into the CHP unit, i.e. the fuel category. The options available are (i) Solids, (ii) Liquids, (iii) Gaseous and (iv) Other. Figure 1 represents a snapshot of the drop down menu in the PRIMARY ENERGY SAVINGS Excel tool. This selection is important when determining both the harmonised efficiency reference value for separate production of electricity and heat, *Annex I and Annex II of 2015/2402/EC*.

Figure 1 Fuel Category Drop Down Menu in Excel PRIMARY ENERGY SAVINGS Model

1.3.3. Type of Fuel

According to 2015/2402/EC the user of the methodology must specify the type of fuel that is being inputted into the CHP unit. The options available to the user will change in accordance with the fuel category. To see a full list of the available options please see *Appendix A*. Figure 2 represents a snapshot of the drop down menu in the PRIMARY ENERGY SAVINGS Excel model. This selection is important when determining both the harmonised efficiency reference value for separate production of electricity and heat, Annex I and Annex II of 2015/2402/EC.
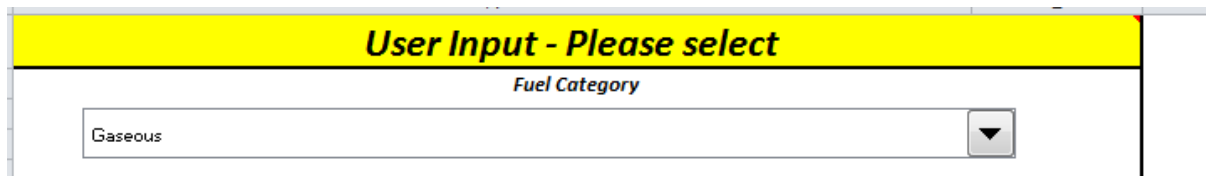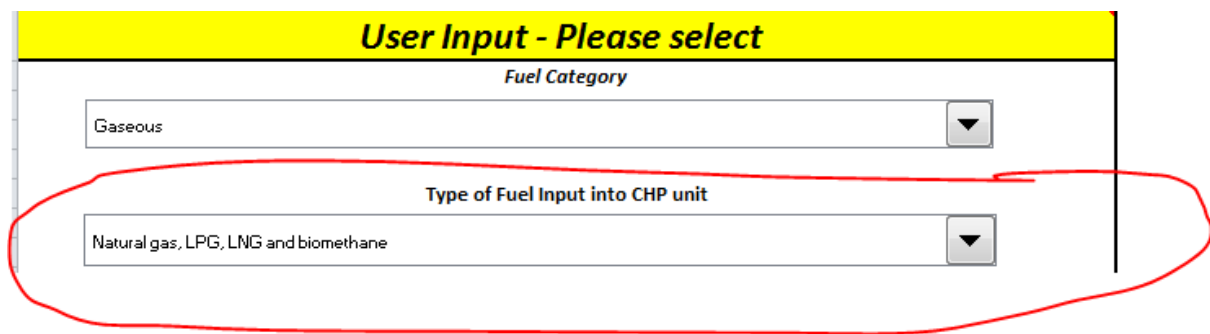

Figure 2 Type of Fuel Drop Down menu in Excel PRIMARY ENERGY SAVINGS Model

1.3.4. Year of Construction

According to 2015/2402/EC the user of the methodology must specify the year of construction of the CHP unit. The year of construction is defined as the following '*…a cogeneration unit's year of construction is the calendar year during which the unit first produces electricity…*' is according to 2015/2402/EC. The age of the existing heating plant is not relevant.

The user must select an option from both of the drop down menus. The first drop down menu gives the user two options (i) Before 2016 and (ii) From 2016. The second drop down menu provides the user with three options; (i) Before 2012, (ii) 2012 – 2015, and (iii) From 2016. It is very ***important*** that both selections are aligned. For example, a user of the Excel model with a CHP unit which produces electricity for the first time in 2014 would select (i) Before 2016 and then (ii) 2012 – 2015.

Figure 3 represents a snapshot of the drop down menu in the PRIMARY ENERGY SAVINGS Excel tool. This selection is important when determining both the harmonised efficiency reference value for separate production of electricity and heat, *Annex I and Annex II of 2015/2402/EC*.

Figure 3 Year of Construction Drop Down Menus in Excel PRIMARY ENERGY SAVINGS Tool

1.3.5. Proposed Use of Heat by CHP unit

According to 2015/2402/EC the user of the methodology must specify the purpose of the useful heat generated by the CHP unit. The following are the three options as outlined in 2015/2402/EC, (i) Hot Water, (ii) Steam, and (iii) Direct Use of Exhaust Gases. For the case where more than of the purposes are applicable the OP must select the most dominate and record this in Forma A.

Figure 4 represents a snapshot of the drop down menu in the PRIMARY ENERGY SAVINGS Excel model. This selection is important when determining both the harmonised efficiency reference value for separate production of heat, Annex II of 2015/2402/EC.

Figure 4 Proposed Use of Heat by CHP unit Drop Down Menus in Excel PRIMARY ENERGY SAVINGS Tool

1.3.6. Onsite Voltage levels

According to 2015/2402/EC the user of the methodology must specify the onsite voltage levels of the local grid which the CHP electrical output is connected. The following are the seven options as outlined in 2015/2402/EC, (i) <0.45 kV, (ii) ≥ 0.45 - < 12 kV, (iii) ≥ 12 - < 50 kV, (iv) ≥ 50 - < 100 kV, (v) ≥ 100 - < 200 kV, (vi) ≥ 200 - < 345 kV and (vii) ≥ 345 kV.

Figure 5 represents a snapshot of the drop down menu in the PRIMARY ENERGY SAVINGS Excel model. This selection is important when determining both the harmonised efficiency reference value for separate production of heat, *Annex IV of 2015/2402/EC*.

Figure 5 Onsite Voltage Drop Down Menus in Excel PRIMARY ENERGY SAVINGS Tool

2. Examples of Applications

This section contains two examples of EEOS projects submitted by fictional OPs. Section 2.1 contains an example application of a new CHP unit being installed in a nursery to replace an existing boiler unit. Section 2.2 contains an example application where a current CHP unit is being overhauled to become more efficient overall. Please note that both examples make the assumption to zero heat has been dumped.

Required Documents with All Applications

SEAI EEOS team require the following documents where appropriate to be submitted with each project application.

1. Form A and Form B completed as per standards of EEOS Guidance Document.[2]

2. Specification sheets of the CHP unit displaying the rated thermal, electrical efficiencies, electrical output and fuel type of CHP.

3. A minimum of six months of metered electrical output data of the CHP (when using 'metered data' approach).

4. In order to verify the projected operational hours claimed when using the 'no metered' data approach SEAI require either 52 weeks of data points or 24 months of data points illustrating the thermal load profile of the site. SEAI are willing to accept gas bills but would prefer accurate data from a BMS.

5. A measurement and verification report completed as per standards of the EEOS Guidance Document. Please note the applicant should refer to the EEOS Guidance derogation tree.

6. Any other calculations were appropriate to substantiate claims.

---

[2] http://www.seai.ie/eeos/

2.1.Example 1 – New CHP Installation

A Wexford Hotel has completed a project in 2015 in partnership with OP X, in which their old natural gas boiler unit was replaced with a new biogas CHP unit .The CHP unit will provide heat for purpose of hot water and electricity which is all consumed onsite. OP X only has four months of operational data and therefore chooses the no metered data approach.

Table 1 below is a summary of the inputs OP X enters into the Excel tool to calculate the PRIMARY ENERGY SAVINGS associated with the project. Given there is only four months of sufficient metered data available OP X *must* use the 'no metered data' approach. It should be noted that although the original boiler used natural gas the new CHP uses biogas and therefor the reference heat and power generations are assumed to be fuelled by biogas. This like for like comparison is one of the underlying assumptions of the Excel tool.

CHP Data Approach	No Metered Data
Fuel Category	Gaseous
Type of Fuel Input into CHP unit	Biogas produced from anaerobic digestion
Year of Construction of CHP unit	2015
Proposed Use of Heat Generated by CHP unit	Hot Water
Onsite Voltage	<0.45 kV
Projected Operational Hours	5,000
Rated Thermal Output (kW$_{th}$)	65
Rated Electrical Output (kW$_e$)	37
Rated Electrical Efficiency (%)	25.52
Rated Thermal Efficiency (%)	44.83

Table 1 Example 1 Project Data – New CHP Installation

Figure 6 is the translation of the information from Table 1 below into the Excel tool. As we can see the OP has only to select the options relevant to them from each drop down menu.

Figure 6 Snapshot of Example 1 User Input based upon information in Table 2 (update)

Next the user must input the following information into the Excel model in order to calculate the primary energy savings associated with this project; (i) Projected Annual Operational Hours, (ii) Rated Thermal Efficiency, (iii) Rated Electrical Efficiency, and (iv) Rated Electrical Output. As previously outlined the following information is calculated automatically: (i) Projected Annual Electricity Generated which is assumed is consumed on site, (ii) Projected Annual Fuel Input and (iii) Projected Useful Heat Generated Consumed on-site. Figure 7 below contains the summary of the user inputted data.

Information Provided By Applicant		
Rated Values Approach		
Figures	**Action Required**	**Comment**
5,000	User Input	Projected Annual Operational Hours
-		
185,000	Automated	Projected Annual [kWh] Electricity Generated Consumed On-Site
724,922	Automated	Projected Annual Fuel Input (kWh) - NCV
324,982	Automated	Projected Useful Heat Generated Consumed on site[kWh]
26%	User Input	Rated Electrical Efficiency
45%	User Input	Rated Thermal Efficiency
37	User Input	Rated Electrical Output kW of CHP Unit

Figure 7 Snapshot of Example 1 Applicant information inputted into Excel model

Figure 8 is auto populated using the data from Figure 7. As we can see the CHP has an overall efficiency of 71% and is projected to consume 711,538 kWh of Biogas is order to meet its projected electrical and heat outputs.

	CHP Unit	
Overall Efficiency	71%	
Heat load required (i.e. "useful")	320,192	kWh
Electricty Generated	185,000	kWh
Total Fuel input - CHP	711,538	kWh
Useful heat out / total fuel input: CHP Hη	45%	%
Electricity out / total fuel input: CHP Eη	26%	%
PES	21%	

Figure 8 Summary of CHP from Example 1

Figure 9 is auto populated using the data from Figure 6. As we can see the total fuel that would be required to generate the same projected electrical and thermal outputs of the CHP from separate production facilities is 902,369 kWh.

Separate Production - Reference Units		
CHP Useful Heat / Ref Hη - Fuel Input to reference boiler (To produce CHP usefule heat)	457,418	kWh
Electricty Generated by CHP / Ref Eη - Fuel Input to reference Power plant (To produce CHP electricty)	444,951	kWh
Total Reference Input	902,369	kWh

Figure 9 Separate Production Reference Values from Example 1

Figure 10 displays the total PRIMARY ENERGY SAVINGS associated with this project. This PRIMARY ENERGY SAVINGS of 190,830 kWh is calculated using the formula below and eligible for credits under the EEOS.

$$Energy\ Savings\ (PEE)kWh\ =\ Total\ Fuel\ Input\ CHP\ *\left(\frac{PES}{1-PES}\right)$$

PES x Total Reference Input	190,830	kWh

Figure 10 Total Primary Energy Savings from Example 1

Overall OP X can apply for the PRIMARY ENERGY SAVINGS of 190,830 kWh though the current PEP system.

2.2.Example 2 – CHP Upgrades

Phoenix Park hotel have completed a project in partnership with OP Y in 2016, whereby their CHP received various upgrades (new gaskets, liners, bearings, oil pump, heat exchanger, insulation improvement, O rings etc) which increased both its thermal and electrical efficiencies .OP Y has both eight months of baseline operational data and eight months of reporting period operational data. Both baseline and reporting period's data overlap in terms of seasonality.

Table 2 below is a summary of the inputs OP Y enters into the Excel tool to calculate the PRIMARY ENERGY SAVINGS associated with the baseline period. Table 3 below is a summary of the inputs OP Y enters into the Excel tool to calculate the PRIMARY ENERGY SAVINGS associated with the reporting period project. In order for OP Y to claim improvements in the overall efficiency of the CHP unit the OP must provide at least six months of baseline and reporting period's operational data (metered electricity generated and metered fuel input). It is essentially both data sets overlap in seasons. Using these metered data sets the OP is required to provide SEAI with calculations of the operational efficiency for both the baseline and reporting periods. SEAI recommends that OPs should consult SEAI first when submitting such an application.

CHP Data Approach	Metered Data
Fuel Category	Gaseous
Type of Fuel Input into CHP unit	Natural Gas
Year of Construction of CHP unit	2014
Use of Heat Generated by CHP unit	Hot Water
Onsite Voltage	<0.45 kV
Actual Operational Hours	15 hours a day, seven days a week - 5,475
Metered Average Daily Electrical Output (kWh)	1,467
Metered Annual Electricity Generated (kWh)	8,031,825 (1,467 x 5,475)
Metered Electrical Efficiency (%)	27.70
Metered Thermal Efficiency (%)	45.30

Table 2 Example 2 Project Data –CHP before Overhaul

CHP Data Approach	Metered Data
Fuel Category	Gaseous
Type of Fuel Input into CHP unit	Natural Gas
Year of Construction of CHP unit	2014
Use of Heat Generated by CHP unit	Hot Water
Onsite Voltage	<0.45 kV
Actual Operational Hours	15 hours a day, seven days a week - 5,475
Metered Average Daily Electrical Output (kWh)	1,480
Metered Annual Electricity Generated (kWh)	8,103,000 (1,480 x 5,475)
Metered Electrical Efficiency (%)	27.90
Metered Thermal Efficiency (%)	45.70

Table 3 Example 2 Project Data - CHP after Overhaul

Figure 11 below represents the results of inserting Table 2 baseline data into the Excel tool. As we can see before the overhaul the CHP was producing per annum PRIMARY ENERGY SAVINGS of 3,636,097 kWh. Figure 12 represents the results of inserting Table 3 reporting data into the Excel tool. After the CHP overhaul PRIMARY ENERGY SAVINGS of 3,372,977 kWh are achieved. In total this project is eligible for savings of 263,120 kWh, i.e. 3,372,977(reporting) – 3,6363,097(baseline) = 263,120 kWh.

Worked Calculation as per figure 1		
Calculation of Electricty and Heat Reference Values as per EU CHP Directive		
Grid Loss Correction Factor		0.85
Harmonised Reference Value fo Separate Electricty Production	(%)	52.5%
Climate Adjustment	(%)	0.6%
Harmonised Reference Value fo Separate Heat Production	Ref Hη (%)	90%
Efficiency of grid electricity generation	Ref Eη (%)	45.19%
Power to Heat Ratio	C	#DIV/0!

	CHP Unit	
Overall Efficiency	74%	
Heat load required (i.e. "useful")	13,272,656	kWh
Electricty Generated	8,103,000	kWh
Total Fuel input - CHP	29,043,011	kWh
Useful heat out / total fuel input: CHP Hη	46%	%
Electricity out / total fuel input: CHP Eη	28%	%
PES	11%	
Separate Production - Reference Units		
CHP Useful Heat / Ref Hη - Fuel Input to reference boiler (To produce CHP usefule heat)	14,747,395	kWh
Electricty Generated by CHP / Ref Eη - Fuel Input to reference Power plant (To produce CHP electricty)	17,931,712	kWh
Total Reference Input	32,679,108	kWh
PES x Total Reference Input	3,636,097	kWh

Figure 11 Example 2 – Baseline Period PRIMARY ENERGY SAVINGS Calculations

Worked Calculation as per figure 1		
Calculation of Electricty and Heat Reference Values as per EU CHP Directive		
Grid Loss Correction Factor		0.85
Harmonised Reference Value fo Separate Electricty Production	(%)	52.5%
Climate Adjustment	(%)	0.6%
Harmonised Reference Value fo Separate Heat Production	Ref Hη (%)	90%
Efficiency of grid electricity generation	Ref Eη (%)	45.19%
Power to Heat Ratio	C	#DIV/0!

	CHP Unit	
Overall Efficiency	73%	
Heat load required (i.e. "useful")	13,135,078	kWh
Electricty Generated	8,031,825	kWh
Total Fuel input - CHP	28,995,758	kWh
Useful heat out / total fuel input: CHP Hη	45%	%
Electricity out / total fuel input: CHP Eη	28%	%
PES	10%	

Separate Production - Reference Units		
CHP Useful Heat / Ref Hη - Fuel Input to reference boiler (To produce CHP usefule heat)	14,594,532	kWh
Electricty Generated by CHP / Ref Eη - Fuel Input to reference Power plant (To produce CHP electricty)	17,774,204	kWh
Total Reference Input	32,368,735	kWh

PES x Total Reference Input	3,372,977	kWh

Figure 12 Example 2 - Reporting Period PRIMARY ENERGY SAVINGS Calculations

Appendix A - Annex I of 2015/2402/EC

ANNEX I

Harmonised efficiency reference values for separate production of electricity

(referred to in Article 1)

In the table below the harmonised efficiency reference values for separate production of electricity are based on net calorific value and standard atmospheric ISO conditions (15 °C ambient temperature, 1,013 bar, 60 % relative humidity).

Category		Type of fuel	Year of construction		
			Before 2012	2012-2015	From 2016
Solids	S1	Hard coal including anthracite, bituminous coal, sub-bituminous coal, coke, semi-coke, pet coke	44,2	44,2	44,2
	S2	Lignite, lignite briquettes, shale oil	41,8	41,8	41,8
	S3	Peat, peat briquettes	39,0	39,0	39,0
	S4	Dry biomass including wood and other solid biomass including wood pellets and briquettes, dried woodchips, clean and dry waste wood, nut shells and olive and other stones	33,0	33,0	37,0
	S5	Other solid biomass including all wood not included under S4 and black and brown liquor.	25,0	25,0	30,0
	S6	Municipal and industrial waste (non-renewable) and renewable/bio-degradable waste	25,0	25,0	25,0
Liquids	L7	Heavy fuel oil, gas/diesel oil, other oil products	44,2	44,2	44,2
	L8	Bio-liquids including bio-methanol, bioethanol, bio-butanol, biodiesel and other bio-liquids	44,2	44,2	44,2
	L9	Waste liquids including biodegradable and non-renewable waste (including tallow, fat and spent grain).	25,0	25,0	29,0
Gaseous	G10	Natural gas, LPG, LNG and biomethane	52,5	52,5	53,0
	G11	Refinery gases hydrogen and synthesis gas	44,2	44,2	44,2
	G12	Biogas produced from anaerobic digestion, landfill, and sewage treatment	42,0	42,0	42,0
	G13	Coke oven gas, blast furnace gas, mining gas, and other recovered gases (excluding refinery gas)	35,0	35,0	35,0
Other	O14	Waste heat (including high temperature process exhaust gases, product from exothermic chemical reactions)			30,0
	O15	Nuclear			33,0
	O16	Solar thermal			30,0
	O17	Geothermal			19,5
	O18	Other fuels not mentioned above			30,0

Appendix B – Annex II of 2015/2402/EC

ANNEX II

Harmonised efficiency reference values for separate production of heat

(referred to in Article 1)

In the table below the harmonised efficiency reference values for separate production of heat are based on net calorific value and standard atmospheric ISO conditions (15 °C ambient temperature, 1,013 bar, 60 % relative humidity).

Category		Type of fuel:	Year of construction					
			Before 2016			From 2016		
			Hot water	Steam (*)	Direct use of exhaust gases (**)	Hot water	Steam (*)	Direct use of exhaust gases (**)
Solids	S1	Hard coal including anthracite, bituminous coal, sub-bituminous coal, coke, semi-coke, pet coke	88	83	80	88	83	80
	S2	Lignite, lignite briquettes, shale oil	86	81	78	86	81	78
	S3	Peat, peat briquettes	86	81	78	86	81	78
	S4	Dry biomass including wood and other solid biomass including wood pellets and briquettes, dried woodchips, clean and dry waste wood, nut shells and olive and other stones	86	81	78	86	81	78
	S5	Other solid biomass including all wood not included under S4 and black and brown liquor.	80	75	72	80	75	72
	S6	Municipal and industrial waste (non-renewable) and renewable/bio-degradable waste	80	75	72	80	75	72
Liquids	L7	Heavy fuel oil, gas/diesel oil, other oil products	89	84	81	85	80	77
	L8	Bio-liquids including bio-methanol, bioethanol, bio-butanol, biodiesel and other bio-liquids	89	84	81	85	80	77
	L9	Waste liquids including biodegradable and non-renewable waste (including tallow, fat and spent grain).	80	75	72	75	70	67
Gaseous	G10	Natural gas, LPG, LNG and biomethane	90	85	82	92	87	84
	G11	Refinery gases hydrogen and synthesis gas	89	84	81	90	85	82
	G12	Biogas produced from anaerobic digestion, landfill, and sewage treatment	70	65	62	80	75	72
	G13	Coke oven gas, blast furnace gas, mining gas, and other recovered gases (excluding refinery gas)	80	75	72	80	75	72

Appendix C – Annex III of 2015/2402/EC

ANNEX III

Correction factors relating to the average climatic situation and method for establishing climate zones for the application of the harmonised efficiency reference values for separate production of electricity

(referred to in Article 2(1))

(a) Correction factors relating to the average climatic situation

Ambient temperature correction is based on the difference between the annual average temperature in a Member State and standard atmospheric ISO conditions (15 °C).

The correction will be as follows:

0,1 %-point efficiency loss for every degree above 15 °C;

0,1 %-point efficiency gain for every degree under 15 °C.

Example:

When the average annual temperature in a Member State is 10 °C, the reference value of a cogeneration unit in that Member State has to be increased by 0,5 %-points.

(b) Ambient temperature correction applies only to gaseous fuels (G10, G11, G12, G13).

(c) Method for establishing climate zones:

The borders of each climate zone will be constituted by isotherms (in full degrees Celsius) of the annual average ambient temperature which differ at least 4 °C. The temperature difference between the average annual ambient temperatures applied in adjacent climate zones will be at least 4 °C.

Example:

If, for example, for a given Member State the average annual ambient temperature is 12 °C in a certain location and 6 °C in a different location within the Member State, then the Member State has the option to introduce two climate zones, separated by an isotherm of 9 °C:

A first climate zone between the isotherms of 9 °C and 13 °C (4 °C difference) with an average annual ambient temperature of 11 °C, and

A second climate zone between the isotherms of 5 °C and 9 °C with an average annual ambient temperature of 7 °C.

———

Appendix D– Annex IVof 2015/2402/EC

Correction factors for avoided grid losses for the application of the harmonised efficiency reference values for separate production of electricity

(referred to in Article 2(2))

Connection voltage level	Correction factor (Off-site)	Correction factor (On-site)
≥ 345 kV	1	0,976
≥ 200 - < 345 kV	0,972	0,963
≥ 100 - < 200 kV	0,963	0,951
≥ 50 - < 100 kV	0,952	0,936
≥ 12 - < 50 kV	0,935	0,914
≥ 0,45 - < 12kV	0,918	0,891
< 0,45 kV	0,888	0,851

Example:

A 100 kWel cogeneration unit with a reciprocating engine driven with natural gas generates electricity at 380 V. Of this, 85 % is used for own consumption and 15 % is fed into the grid. The plant was constructed in 2010. The annual ambient temperature is 15 °C (so no climatic correction is necessary).

After the grid loss correction the resulting efficiency reference value for the separate production of electricity in this cogeneration unit would be (based on the weighted mean of the factors in this Annex):

$$\text{Ref E}\eta = 52{,}5 \% \times (0{,}851 \times 85 \% + 0{,}888 \times 15 \%) = 45{,}0 \%$$

Appendix E – Primary Energy Savings Formula Derivation

Please note that this derivation was generated by SEAI.First Principles for Micro-Generation Primary Energy Savings

$$\begin{matrix} primary \\ energy \\ saving \end{matrix} = \begin{matrix} fuel\ consumed\ by \\ by\ original \\ power\ generation\ device \end{matrix} - \begin{matrix} fuel\ consumed \\ in\ micro\ generation \\ device \end{matrix}$$

$$PES = E_{in,ref} - E_{in,micro}$$

$$PES = \frac{E_{out}}{Ref_\eta} - \frac{E_{out}}{Micro_\eta}$$

1.1.1. Verification of First Principles

Considering these first principles in relation to a CHP, where fuel in to a combined heat and power unit is displacing fuel into separate thermal and electrical generation units

$$\begin{matrix} primary \\ energy \\ saving \end{matrix} = \begin{matrix} fuel\ consumed\ in\ separate \\ thermal\ and\ electrial\ power \\ generation\ devices \end{matrix} - \begin{matrix} fuel\ consumed \\ in\ CHP \\ unit \end{matrix}$$

$$PES = E_{in,boiler} + E_{in,generator} - E_{in,CHP}$$

$$PES = \frac{E_h}{Ref\ H_\eta} + \frac{E_e}{Ref\ E_\eta} - \frac{E_h}{CHP\ H_\eta}$$

This equation will now be re-arranged to arrive at the CHP equation in the energy efficiency directive. Dividing across by the 'fuel consumed in separate thermal and electrical power generation devices':

$$\frac{PES}{E_{in,boiler} + E_{in,generator}} = \% \, PES = 1 - \frac{E_{in,CHP}}{E_{in,boiler} + E_{in,generator}}$$

$$\% \, PES = 1 - \frac{\dfrac{E_h}{CHP \, H_\eta}}{\dfrac{E_h}{Ref \, H_\eta} + \dfrac{E_e}{Ref \, E_\eta}}$$

Multiplying the numerator and denominator of the large fraction by $\dfrac{CHP \, H_\eta}{E_h}$

$$\% \, PES = 1 - \frac{\dfrac{E_h}{CHP \, H_\eta}}{\dfrac{E_h}{Ref \, H_\eta} + \dfrac{E_e}{Ref \, E_\eta}} * \frac{\dfrac{CHP \, H_\eta}{E_h}}{\dfrac{CHP \, H_\eta}{E_h}}$$

$$\% \, PES = 1 - \frac{1}{\dfrac{E_h}{Ref \, H_\eta}\dfrac{CHP \, H_\eta}{E_h} + \dfrac{E_e}{Ref \, E_\eta}\dfrac{CHP \, H_\eta}{E_h}}$$

Replacing the second $\dfrac{CHP \, H_\eta}{E_h}$ with $\dfrac{CHP \, E_\eta}{E_e}$ because the following relationship holds that $E_{in,CHP} = \dfrac{E_h}{CHP \, H_\eta} = \dfrac{E_e}{CHP \, E_\eta}$

$$\% \, PES = 1 - \frac{1}{\dfrac{E_h}{Ref \, H_\eta}\dfrac{CHP \, H_\eta}{E_h} + \dfrac{E_e}{Ref \, E_\eta}\dfrac{CHP \, E_\eta}{E_e}}$$

Cancelling out similar terms

$$\% \, PES = 1 - \cfrac{1}{\cfrac{CHP \, H_\eta}{Ref \, H_\eta} + \cfrac{CHP \, E_\eta}{Ref \, E_\eta}}$$

Which is the equation in the Energy Efficiency Directive to calculate the percentage energy savings from co-generation.