Energy Performance Contracting Plus

Technical Toolbox for Technical Measures for use in SPIN-constellations

Combined Heat and Power

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www.epcplus.org

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CONTENT

1. General description and explanation how-to-use

EPC+ aims at standardizing technical measures in order to make them predictable for other SPIN members (including the SPIN coordinator) and thereby to reduce transaction costs.

The toolbox can serve as a guide for the providers of EPC+-services for the standardization of the measures (design parameters, calculation method, process flow) and defines quality standards for the M&V-method. Text-modules of the descriptions may also be used for the communication with the client in order to create trust into the proposed measures.

Each measure is to be described on a general basis. Moreover the design parameters and the possibilities for application will be defined, last but not least including a list of situations, where the specific measure is not applicable.

Calculation method

If applicable the generic method of calculating effort for implementation, O&M and savings are to be described, ideally in form of a product-unspecific, open-source calculation tool.

Process flow

Because of the several players and interfaces in communication the process-flow-diagram should obligatory be done in the design of the ***service blueprint***.

2. Toolbox

All measures are being described in general and in detail. The measures are categorized in energy-efficiency and renewable energy measures.

Energy-efficiency-measures:

1. indoor lights: LED lights + control system
2. hydraulic adjustment of heating system
3. modernization of pumps
4. modernization of electrical motors
5. energy efficient ventilation and/or cooling
6. HVAC control systems, incl. integration of boilers
7. Programmers of BMS-systems of different suppliers: Siemens, Honeywell,...
8. Renovation/replacement of heating boilers

Renewable energy measures:

1. Solar DHW
2. Biomass heating systems
3. ***Combined Heat and Power (CHP)***
4. PV-panels
5. Wind-power
6. heatpumps

2.1. Combined Heat and Power (CHP)

2.1.1. Technical description

2.1.1.1. General description (PU)

What is CHP ?

'Cogeneration' or 'combined heat and power' (CHP) is the use of an engine (power station) to generate electricity and useful heat at the same time. Instead of burning fuel to merely heat space or water, some of the energy is converted to electricity in addition to heat. This electricity can be used within a building, or, if permitted by the grid management, sold back into the electric power grid .

The CHP-concept is available in various technologies and various power ranges:

- Micro-cogeneration engines (micro CHP), usually less than 5 kW electricity, which is likely to be appropriate in a house or small business.
- Reciprocating CHP engines (up to 4 MW);
- Gas turbines (up to several MW);

Within the framework of the EPC+ project, it is expected that CHP in the lower power range may be applicable, e.g. (Stirling) engines and gas turbines.

Why is co-generation attractive as energy conservation measure ?

Cogeneration is a thermodynamically efficient use of fuel. In separate production of electricity, some energy must be discarded as waste heat, but in cogeneration this thermal energy is put to use. CHP is most efficient when heat can be used on-site or very close to it.

2.1.1.2. Design parameters

- Heating required over time to provide thermal comfort in the reference scenario (heat profile)
- Electricity required over time to keep all processes running (electricity profile)
- Electricity price.
- Gas price.
- Electrical output of the CHP system
- Thermal output of the CHP system.
- % of waste heat recovered (thermal efficiency of the CHP system)
- Thermal efficiency of existing heating system.
- Operating time (load factor)

2.1.1.3. *Measure suitable for*

- Contexts where the demand profile for heat is well known, uninterrupted, and preferably rather stable, as CHP systems do not have the modulating flexibility of condensation heaters (these days certain technologies (e.g. gas engines) offer capacity modulation between 60-100%). As a consequence, CHP is preferably used for base load.
- Contexts where the demand profile for electricity and heat is well known and preferably *simultaneous*. [1]
- Contexts with expensive electricity and cheap gas
- Consumers with significant energy consumption (in order to offset the high O&M costs of CHP).
- Buildings that are well connected to the gas and electricity grid.
- Buildings where the existing hydraulic system is compatible with the new heat source (otherwise additional investments will have to be made).

2.1.1.4. *Measure not suitable for*

- Contexts where the heat must be transported over longer distances. This requires insulated pipes, which are expensive and inefficient (whereas electricity can be transmitted along a comparatively simple wire, and over much longer distances for the same energy loss).
- Cases where the plan is to entirely replace a classic boiler heating system by a CHP-system. This is because a CHP-system is dimensioned with focus on the need for heat in the average scenario (baseload), whereas a classic heating system is dimensioned with focus on the peak load.
- Buildings lacking sufficient space to accommodate the CHP.
- Jurisdictions where the cost of electricity is lower than the cost of gas (both converted in €/kWh). Rationale: Otherwise it would be advantageous buying the electricity rather than generating it through CHP.
- Buildings that still have a major energy saving potential. Rationale: All relevant energy saving measures (electricity, heat) have to be implemented before dimensioning a CHP.
- Buildings where the load profiles cannot be properly established as the future functional use may vary.
- Buildings where the need for electricity or for heat does not exceed 150 000 kWh for 3300 hours[2] per annum. Rationale: below the specified threshold, CHP is unlikely to be a viable option.

[1] • Alternatively, the excess electricity may be fed into the grid, the latter only being attractive if decent feed-in tariffs and regimes apply. As the EPC+ project focuses on energy-efficiency rather than generating renewable energy, exporting electricity to the grid is deemed outside the scope of this project, and not further considered in the business case.

[2] http://www.environment.nsw.gov.au/business/hvac-training.htm

2.1.2. Calculation method

From a methodological perspective, implementing a CHP-system is not merely replacing an old, non-efficient device with a new, better performing one. As a CHP system has limited modulation possibilities, it is likely that it will only foresee in the basic heating need of a building, and will be topped up (and/or backed up) by a 'classic' heating system (e.g. condensing boiler) at times when additional heating capacity is required. In other words, two reference scenarios are likely to be encountered:

1. An existing heating system is already in place, and is deemed sufficiently up to date, to be maintained in combination with the new CHP to be installed.
2. The existing heat production system is outdated, and has to be replaced anyway.

So, before stipulating the input data of the business case, the boundary conditions of the calculation method should be clear, both with respect to the reference scenario and with the target situation. We have assumed the following scenarios:

- **Reference scenario :**
  The existing heat production system is outdated, and has to be **entirely replaced**.
- **Target scenario:**
  The existing heat production system will be replaced by **a CHP system, backed up by a new – modulating – heat production device (e.g. condensing boiler)**, simultaneously with the installation of the CHP. This implies that the cost for the installation of the backup heating system has to be included in the business case analysis.

Another element of the business case should be clarified upfront, viz. how to deal with the electricity that is generated by the CHP system. Ideally, a CHP system will be dimensioned taking into account the need for both heat and electricity within a building, but trade-offs will have to be made. In practice, the **dimensioning will be based on the heating need.** This may result in electricity exchanges with the grid. Exporting electricity to the grid is likely to generate a certain revenue which has to be taken into account in the business case.

2.1.2.1. Expected savings

The relative cost savings that can be expected from running a CHP system to heat a building depend on a number of factors, including:

- The energy savings of the newly installed heat production system, relative to the reference situation.
- The cost of gas to fuel the CHP system.
- The quantity of electricity that is generated by the CHP system.
- The price of electricity that is bought from the grid in the reference situation.
- The price of the electricity that is generated, in other words this is the feed-in tariff of the excess electricity that is injected into the grid.
- The maintenance cost.

Taking into account the boundary conditions that are explained above, the expected energy savings are defined as:

Total savings = thermal savings + electrical savings : Thermal savings : (CHP thermal output * cost of gas/kWh * load factor * % of waste heat recovered/existing plant thermal efficiency) Electrical savings : (CHP electrical output * cost of electricity*load factor)

As the reference situation is not known, and as the target situation should be engineered on a case by case basis, it is difficult to come up with a standard calculation method.

2.1.2.2. Investment costs

Several CHP technologies exist, in various power ranges. So, no typical investment cost can be put forward in this toolbox. A pragmatic solution is to contact a specialized contractor (or spin coordinator) to provide a quote for the delivery and installation of a dedicated CHP-system.

An alternative system consists in calculating the overall cost by first searching the catalogue value of a CHP-system (= material cost= 100%), and then adding the various ancillary costs according to the listed percentages [3] below, e.g. : the construction cost amounts typically to 15-30% of the material cost.

- material cost: 100%
- construction : 15-30 %
- connection with gas grid : 10-14 %
- connection with electricity grid : 4-20%
- installation : 7-15%
- design and project management : 8-9%
- contingency 5-7%

On top of this comes the cost for installing a back-up heat production system, e.g. a classic condensing boiler.

2.1.2.3. Running costs

The running cost consists in the Operating and the Maintenance cost.

[3] http://www.cogenvlaanderen.be/publicatie-categorie-1/Basishandboek_WKK.php

The fuel cost is the major part of the running cost (up to 80%[4]). In small to midsized CHP projects (being the target of the EPC+ project), the **Operating cost** is calculated as explained in the formula underneath:

Operating cost = [Thermal capacity * yearly operating hours * gas price] / thermal efficiency of the CHP device

The **Maintenance cost** of a CHP device is related to its operating time, hence expressed as cost per operating hour. This cost may vary between 0.5 - 4 €/operating hour (expert judgement). Overhauls must be kept in mind (e.g. at 30 000 and 60 000 operating hours), since they represent a significant cost.

On top of this comes the cost for running a backup heat production system, e.g. a classic condensing boiler.

2.1.2.4. Expected life-span of the measure and resulting replacement-costs (if any)

The expected life-span of a CHP system is 15-20 years[5], depending on the type and quality of the fuel, as well as on the number of running hours per year.
The expected life-span of the backup heat production system is similar.

2.1.2.5. Discounted cash flow analysis and Net present value

In order to elaborate a discounted cash flow analysis, amortization rate and net present value of the investment, tools elaborated within the context of the project can be used, please check the European toolbox package at www.epcplus.org/energy-service-packages/.

Mandatory output parameters:

1. *Loan Amortization (€/year)*
2. *Debt repayment (€/year)*
3. *Interest paid (€/year)*
4. *Remaining amount (€/year)*
5. *Cash flow (€/year)*
6. *Cumulative present value (€/year)*
7. *Internal Rate of Return*

[4] http://www.cogenvlaanderen.be/publicatie-categorie-1/Basishandboek_WKK.php

[5] http://www.cogenvlaanderen.be/publicatie-categorie-1/Basishandboek_WKK.php

2.1.3. Options on measurement & verification in order to evaluate the performance in relation to the given performance guarantee[6]

The EPC+ project focuses on energy efficiency measures for SMEs. This setting does not allow for extensive M&V procedures. So, a balance has to be struck between gathering sufficient data to avoid disputes, and safeguarding the cost-effectiveness of the data gathering process.

IPMVP Option B is recommended : Retrofit isolation method, whereby both ‘performance’ and ‘operating time’ are taken into account when calculating the improved energy performance.

*2.1.3.1. Data to be measured in the **reference scenario**:*

The following data should be available for one, entire and representative heating season (year)

- Fuel consumption of the existing heat production system (e.g. gas consumption), and cost of fuel.
- Electricity consumption and pricing.
- Heating Degree Days during the reference period.
- Set points of the heating system (i.e. the indoor comfort parameters).

In case functional changes in the occupation of the building have taken place, or are being considered, these should be documented.

Ideally, information about the indoor comfort level in a building should be available as well: e.g. are there any complaints about the indoor comfort level ?

In case the fuel consumption profile is not available, estimates will have to be made based on assumptions and invoices.

*2.1.3.2. Data to be measured in the **target scenario**: CHP + backup system*

In the target scenario, the following data set should be obtained from one entire heating season (year):

- Fuel consumption of the CHP system as well as of the backup system, and cost of gas.
- Electricity generated by the CHP system, and cost of electricity.
- Heat produced by the CHP system (thermal efficiency).
- Electricity exported to the grid, and feed-in tariff.
- Heating degree days.
- Set points of the heating system.

[6] Criteria: minimum effort, but still a proper qualitative proof for solid implementation and a considering performance, not installation only

Functional changes in the occupation of the building have to be recorded, as well as any feedback with respect to the indoor comfort level in the building (if any).