Energy performance assessment of district energy systems

The upcoming revised European standard FprEN 15316-4-5:2016 "Heating systems and water based cooling systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-5: District heating and cooling" provides calculation methods and default values for primary energy factors, emission factors and the Renewable Energy Ratio (RER). These indicators can be used as external input data for the energy performance calculations for buildings.

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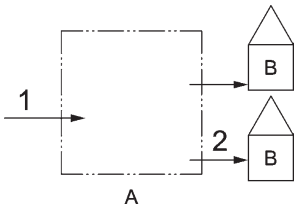
What is the scope of the standard?

The vast majority of district energy systems are district heating systems. So the standard is primarily written for heating systems. But there are also district cooling systems in Europe that are now in the scope of this revised standard. In some cases, there is an efficiency improvement or renewable energy potential that can only be realized on local or district level. So the European Commission asked for methods that facilitate the assessment of small district electricity systems. Thus the former district heating standard evolved to a more general standard with universal calculation methods applicable to various energy carriers.



Key
- **A** system boundary
- **B** energy consumer
- **1** E_{in} energy input to the system
- **2** E_{del} energy delivered from the system

Figure 1. Single-output district energy system as a black box.

$$f_{we;des} = \frac{\sum_{cr} E_{in;cr} \cdot f_{we;cr}}{\sum E_{del}} \quad (1)$$

where

$f_{we;des}$ weighting factor of the district energy system;

$E_{in;cr}$ energy content of input to the system of energy carrier *cr*;

$f_{we;cr}$ weighting factor of energy carrier *cr*;

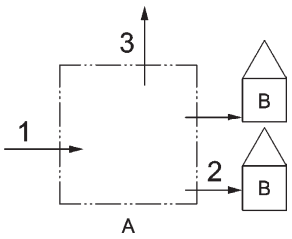
E_{del} delivered energy;

Weighting factor means e.g. primary energy factor or emission factor.

What is the universal approach of the standard?

The district energy system is regarded as a black box (see **Figures 1 and 2**). The energy performance indicators are determined as the ratio of weighted energy input to the system and energy delivered from the system.

Multi-output generation systems like cogeneration units or tri-generation of heating, cooling and electricity deliver more than one energy carrier. The energy carriers can be delivered to the same area or a different area or to another energy system. If the energy carriers are delivered to different areas or different systems, the exported weighted energy is counted as a bonus (see **Figure 2**). It represents the avoided production in the external system or area.



Key
- **A** system boundary
- **B** energy consumer
- **1** E_{in} energy input to the system
- **2** E_{del} energy delivered from the system
- **3** E_{exp} exported energy

Figure 2. Multi-output district energy system with exported energy.

$$f_{we;des} = \frac{\sum_{cr} E_{in;cr} \cdot f_{we;cr} - E_{exp} \cdot f_{we;exp}}{\sum E_{del}} \quad (2)$$

where

E_{exp} energy exported to an external system or area;

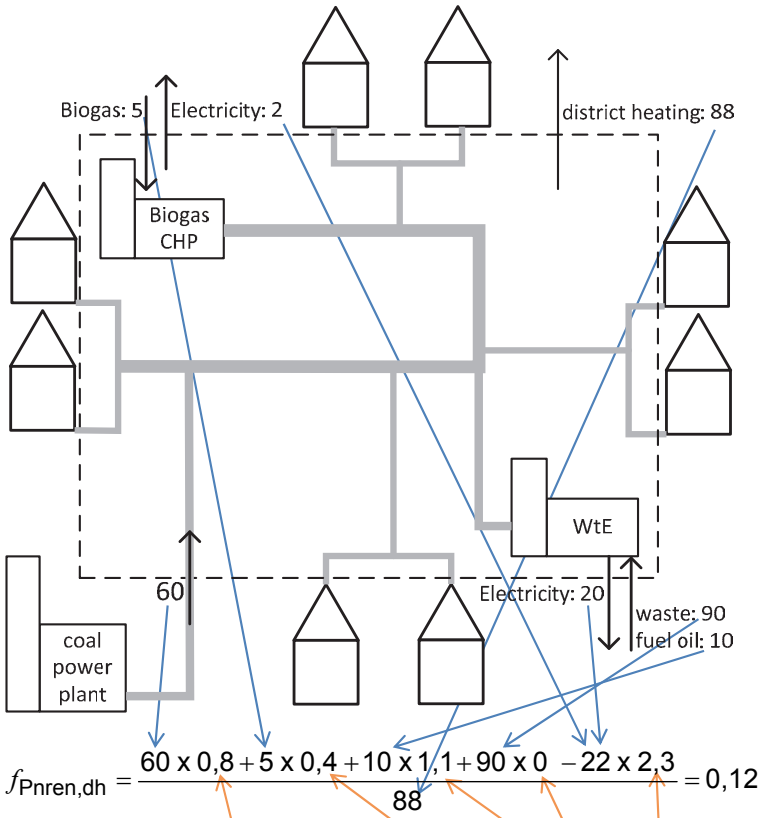
$f_{we;exp}$ weighting factor of the exported energy;

As long as the system boundaries are clearly defined and all energy carriers that cross the system boundary are considered, the black box approach leads to reasonable results. (Exception: district heating system exporting much electricity from non-cogeneration mode).

What is the purpose of default weighting factors?

District energy systems are supplied with energy from other energy systems. The required weighting factors of these systems can be calculated with the same black box approach. But in many cases this calculation is not possible due to lack of information. Therefore, the standard provides a set of default values that can always be used instead of calculating. **Figure 3** illustrates an example for a coal power plant outside the assessment boundary that delivers heat to the district heating system. This external heat delivery is weighted with the default value $f_{Pnren} = 0{,}8$. Though calculating system specific indicators is more accurate than using default values, the set of default values is a helpful means of appropriate simplification for complex tasks. ■

$$f_{Pnren,dh} = \frac{E_{in,heat,ext} \cdot f_{Pnren,heat,ext} + E_{in,biogas} \cdot f_{Pnren,biogas} + E_{in,oil} \cdot f_{Pnren,oil} + E_{in,waste} \cdot f_{Pnren,waste} - E_{el,exp} \cdot f_{Pnren,el,exp}}{Q_{del}}$$



default values										
	heat	f_{Pnren}	f_{Ptot}	f_{CO2}		**fuel**	f_{Pnren}	f_{Ptot}	f_{CO2}
from boilers	solid fossil fuel	1,7	1,7	530		solid fossil	1,1	1,1	360
	liquid fossil fuel	1,6	1,6	400		liquid fossil	1,1	1,1	290
	gaseous fossil fuel	1,5	1,5	310		gaseous fossil	1,1	1,1	220
	solid bio fuel	0,4	1,8	70		solid bio	0,2	1,2	40
	liquid bio fuel	0,7	2,1	110		liquid bio	0,5	1,5	70
	gaseous bio fuel	0,6	2,0	150		gaseous bio	0,4	1,4	100
from CHP	solid fossil fuel	0,8	0,8	500		waste	0	0	0
	liquid fossil fuel	0,7	0,7	330		sewage sludge	0	0	0
	gaseous fossil fuel	0,7	0,7	160		land fill gas	0	0	0
	solid bio fuel	0	1,8	0		mine gas	0	0	0
	liquid bio fuel	0	1,7	0					
	gaseous bio fuel	0	1,4	0		electricity	2,3	2,5	420
from	industrial process	0,4	0,4	90					
	waste-to-energy	0,2	0,2	50					
geothermal		0	0	0					

Figure 3. An example of a coal power plant outside the assessment boundary that delivers heat to the district heating system.