Project no. 238889

BEST ENERGY PROJECT

1.1.1.1.1 Built Environment Sustainability and Technology in Energy

Competitiveness and Innovation Framework Programme

ICT Policy Support Programme (ICT PSP)

D1.4: Data to Indicators explanation

Due date of deliverable: 10th June 2009

Actual submission date: 18th December 2009

Start date of project: 01/02/09 Duration: 36 months

Organisation name of lead contractor for this deliverable: Viborg Municipality

Revision [1]

Project co-funded by the European Commission within the ICT PSP Programme		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1 Introduction

The BEST Energy project concept is based on the integration of building and lighting technology and state of the art ICT technology into innovative control and monitoring systems.

The main objective of this project is to improve the energy efficiency in public buildings and street public lighting, by the ICT-based centralized monitoring and management of the energy consumption and production, and to provide decision makers with the necessary tools to be able to plan energy saving measures.

The initially quantified objective is to achieve a 12% reduction on the energy consumption of the buildings, and at least a 30% reduction of the energy consumption of the public lighting systems.

This document contains a list of indicators used by the BEST Energy project as basis for the evaluation of the impact of the project and documentation that the project fulfils the overall objectives concerning energy savings.

The document describes for each of the pilots and replications how the panel of indicators which is described in Deliverable 1.2 is met.

Firstly in section 2, the general – or success – indicators are described. These are common for all the pilots and replication pilots, of course split into buildings and street lighting systems. However, the method of calculation is different in each case, due to the differences in the building energy systems. For each pilot, the calculation method is specifically described. In some cases references to appendices or Deliverable 1.1 are made.

Secondly in section 3, the secondary – or performance – indicators that are individual to the projects are described. Here the methodology to get the indicators is shown separately for each of the pilots and replication pilots.

Finally, an appendix is inserted for some of the pilots, if this has been deemed necessary to be able to enter descriptions that do not fit into the layout scheme which is otherwise used in the document.

2 From Data to Success Indicator

2.1 Indicator 1: Annual primary energy consumption

2.1.1 Description for building pilots and replications

The primary energy consumption is defined in EN 15603:2008 as "energy that has not been subjected to any conversion or transformation process" and further by the equation:

$$E_P = \sum \left(E_{del,i}\ f_{P,del,i} \right) - \sum \left(E_{exp,i}\ f_{P,exp,i} \right)$$

where

$E_{del,i}$ is the delivered energy for energy carrier i;

$E_{exp,i}$ is the exported energy for energy carrier i;

$f_{P,del,i}$ is the primary energy factor for the delivered energy carrier i;

$f_{P,exp,i}$ is the primary energy factor for the exported energy carrier i.

The primary energy factors are found from the following table, which can also be found from http://www.iwu.de/en/ using the Gemis calculation tool, which can be found on: http://gemis.de/. The primary energy factors are based on actual data from 2008, and are therefore the most recent that are available.

Kumulierter Energieaufwand verschiedener Energieträger und Energieversorgungen

Ergebnisse berechnet mit GEMIS Version 4.5

Energieart	Prozeß[1]	Kumulierter Energieaufwand [kWh_{Prim}/kWh_{End}] Gesamt	nicht regenerativer Anteil	regenerativer Anteil [4]	Treibhausgase CO2-Äquivalent [g/kWhEnd]
Brennstoffe [2]	Heizöl EL	1,11	1,11	0,00	302
	Erdgas H	1,12	1,12	0,00	244
	Flüssiggas	1,11	1,11	0,00	263
	Steinkohle	1,08	1,07	0,00	438
	Braunkohle	1,21	1,21	0,00	451
	Holzhackschnitzel	1,07	0,06	1,01	35
	Brennholz	1,01	0,01	1,00	6
	Holz-Pellets	1,16	0,14	1,03	41
Strom	Strom-mix	2,96	2,61	0,34	633
Fernwärme [3]	Fernwärme 70 % KWK	0,77	0,76	0,01	219
	Fernwärme 35 % KWK	1,15	1,14	0,01	313
	Fernwärme 0 % KWK	1,52	1,51	0,01	407
Nahwärme [3]	Nahwärme 70 % KWK	0,71	0,70	0,01	-79
	Nahwärme 35 % KWK	1,08	1,07	0,01	119
	Nahwärme 0 % KWK	1,46	1,44	0,01	318

[1] Vorgelagerte Kette für die Endenergie bis Übergabe im Gebäude inkl. Materialaufwand für Wärmeerzeuger, ohne Hilfsenergie im Haus
[2] Bezugsgröße: unterer Heizwert H_u

The actual values of the delivered energy for heating will be corrected with respect to heating degree days as described for indicator 3 in section 2.3. In case of missing factors, for instance heating supplied from a district heating grid, the primary energy factor will be based on National or local values.

Notice that the value will be given both as an absolute value for the entire pilot or replication pilot and as a specific value, taking the building's net floor area into account. For street lighting projects the specific value will take into account the number of luminaires.

2.1.1.1 Correction of measured data

The calculation of the primary energy consumption will also be corrected concerning climate data and time as described below. The description is based on VDI 3807.

Time correction

The energy consumption characteristic for the reference year must be referred to a period of one year:

$$E = E_g \cdot 365 / z$$

where:

E_V – corrected energy consumption [kWh/a]

E_g – measured energy consumption [kWh/a]

z_v – number of days during which the energy consumption was measured

Outdoor-temperature correction

For the data to be comparable, they shall be corrected for effects due to outdoor temperature. This does not apply to street lighting projects

The outdoor-temperature correction of characteristic values of heating-energy consumption is performed using degree days and covers a period of one year. A degree day is a difference between the average room temperature 20°C and the average outdoor temperature for one day. Only those days are considered in the calculation whose daily average temperature lies below 15°C.

$$G = (20°C - t_m) \cdot 1d, \text{ for } t_m < 15°C$$

G – degree day [K·d]

t_m– daytime average of outdoor temperature during one heating day (t_m<15°C)

Data for calculation will be received from local meteorological weather services or calculated based on locally calculated values.

$$E_H = E_{gH} \cdot \frac{G_m}{G}$$

where

E_H – corrected heating – energy consumption [kWh/a]

E_{gH} –heating – energy consumption [kWh/a], measured value

G – degree days [K·d]

G_m – long – term average of annual degree days [K·d/a]

However, notice that for some of the buildings, defining the baseline can be done based on at least 3 years of measurements, as it is stated in DIN EN 15603:2008 article 7.4 average that if data are available from at least 3 years do not have to be weather corrected.

2.2 Indicator 2: Annual delivered electrical consumption

The annual delivered electrical consumption will be based on billed or measured values for each of the pilots or replications.

$E_E = f(\text{measurement or billed value})$

Data will be corrected with respect to period, so that data for a twelve month period is presented.

Notice that the value will be given both as an absolute value for the entire pilot or replication pilot and as a specific value, taking the building's net floor area into account. For street lighting projects the specific value will take into account the number of luminaires.

2.3 Indicator 3: Annual delivered heating energy

Only applicable for building pilots and replications

The annual delivered heating energy will be found based on measured or billed values. In some buildings a mix of energy carriers is used for heating. In these cases, the sum of the delivered heating energy to the building will be reported.

$$E_{H,del} = f(\text{measurement or billed value})$$

The delivered heating energy will be corrected concerning climatic conditions and period. This means that data represents one year of consumption and for identical temperature conditions. According to DIN EN 15603:2008 article 7.4 average data from at least 3 years do not have to be weather corrected. See section 2.1.1.1 for details.

Notice that the indicator will be presented both as absolute values for the entire pilot and replication pilot and as a specific value, taking the net floor area of the buildings into account.

For street lighting projects the specific value will take into account the number of luminaires.

2.4 Indicator 4: Annual delivered cooling energy

Only applicable for building pilots and replications and not in B2, where there is no cooling.

Data will be based on measured data for cooling in the pilots or replication pilots.

$$E_{C,del} = f(\text{measurement or billed value})$$

Notice that the value will be given both as an absolute value for the entire pilot or replication pilot and as a specific value, taking the building's net floor area into account.

2.5 Indicator 5: Annual CO_2-emissions

Notice that the value will be given both as an absolute value for the entire pilot or replication pilot and as a specific value, taking the building's net floor area into account.

The annual CO_2 emission will be calculated based on the CO_2-production coefficient, *K*, which is shown in the table in section 2.1.1.

$$m_{CO2} = \sum\left(E_{del,i}\ K_{del,i}\right) - \sum\left(E_{exp,i}\ K_{exp,i}\right)$$

Where

$E_{del,i}$ is the delivered energy for energy carrier i;

$E_{exp,i}$ is the exported energy for energy carrier i;

$K_{del,i}$ is the CO_2 emission coefficient for delivered energy carrier i;

$K_{exp,i}$ is the CO_2 emission coefficient for the exported energy carrier i.

Again the delivered energy will be corrected with respect to time and climatic data as described above in section 2.1.1.1.

2.6 Indicator 6: Relative reduction of CO_2 emissions

The relative reduction of the CO_2 emission is found based on the CO_2 emission before the inclusion of the ICT solutions compared to the CO_2 emission after the inclusion. The CO_2 emission is calculated as described for Indicator 5, which is described in section **¡Error!No se encuentra el origen de la referencia.**

$$SAV_{CO_2} = \frac{m_{CO2,before} - m_{CO2,after}}{m_{CO2,before}} \cdot 100\%$$

See D1.1 for details on baseline data for each of the pilots or replication pilots. For the new buildings, where an existing baseline cannot be found, estimated values are used instead.

2.7 Indicator 7: Relative savings in primary energy

The relative reduction of the primary energy consumption is found based on the consumption of primary energy before the inclusion of the ICT solutions is compared to the primary energy consumption after the inclusion. The primary energy consumption is calculated as described for Indicator 1, which is described in section 2.1.1.

$$SAV_{Ep} = \frac{E_{p,before} - E_{p,after}}{E_{p,before}} \cdot 100\%$$

See D1.1 for details on baseline data for each of the pilots or replication pilots. For the new buildings, where an existing baseline cannot be found, estimated values are used instead.

2.8 Indicator 8: Energy cost savings using actual local energy prices

The cost of energy is found before and after the inclusion of the ICT solutions. The cost will be based on the billed value. Alternatively the cost of energy will be calculated based on the measured energy consumption for each energy carrier multiplied by the unit price of that specific energy carrier, including fixed prices if such exist. Actual local prices will be used to calculate the energy cost saving under the conditions in which the building is operated.

The indicator will be presented in both real cost saving and in percent of the original cost.

$$SAV_{€} = COST_{€,before} - COST_{€,after}$$

$$SAV_{€} = \frac{COST_{€,before} - COST_{€,after}}{COST_{€,before}} \cdot 100\%$$

The cost will be corrected to be of the same period of time (one year) both before and after. If the cost of energy is based on a calculated price, this will also be corrected with respect to climatic conditions, except for the street lighting projects, where this is not relevant.

Notice that the value will be given both as an absolute value for the entire pilot or replication pilot and as a specific value, taking the building's net floor area into account.

3 From Data to secondary Indicators

3.1 Indicator S1: Thermal Efficiency of Boilers

This indicator shows the efficiency of hot water boilers. Unit [%] $\eta_T = \frac{Q_{boilers}}{Gas_{boilers}} \cdot 100$

$Q_{boilers}$ – Heat delivered by hot water boilers [kWh]

$Gas_{boilers}$ - The amount of gas consumption by boilers. From the invoice meters [kWh]

3.2 Indicator S2: Cogeneration Electric Efficiency

This indicator shows the electrical energy produced per unit of gas consumption. Unit [%] $\eta_E = \frac{E_{E,cog}}{Gas_{cog}} \cdot 100$

$E_{E,cog}$ = Electrical energy generated by cogeneration [kWh]

Gas_{cog} = Cogeneration engine gas consumption [kWh]

3.3 Indicator S3: Cogeneration Thermal Efficiency

This indicator shows the heat recovered per unit of gas consumtion. Unit [%] $\eta_T = \frac{Q_{cog}}{Gas_{cog}} \cdot 100$

Q_{cog} = Heat recovered by cogeneration [kWh]

Gas_{cog} = Cogeneration engine gas consumption [kWh]

3.4 Indicator S4: Swimming Pools Thermal Consumption

This indicator shows the heat needed to maintain swimming pool´s water and environment temperature set points per unit of swimming pool volume. Unit [kWh/m3] $Q_{T,pool} = \frac{Q_{del,pool\ HVCA} + Q_{del,pool\ water}}{Pool\ volume}$

$Q_{del,pool\ HVCA}$ = Heat delivered by swimming pool´s HVCA [kWh]

$Q_{del,pool\ water}$ = Heat delivered by swimming pool´s water warming system [kWh]

3.5 Indicator S5: Swimming pool electric consumption:

This indicator shows the electrical energy used to maintain swimming pool´s conditions per unit of swimming pool volume. Unit [kWh/m3] $E_{E,pool} = \frac{E_{E,pool\ HVCA} + E_{E,pool\ dehu} + E_{E,pool\ pump}}{Pool\ volume}$

$E_{E,pool\ HVCA}$ = Electrical energy consumption by swimming pool´s HVCA [kWh]

$E_{E,pool\ dehu}$ = Electrical energy consumption by swimming pool´s dehumidifier [kWh]

$E_{E,pool\ pump}$ = Electrical energy consumption by swimming pool´s pumping system [kWh]

3.6 Indicator S6: Shower useful energy

This indicator shows the energy used for heat the shower water per user [kWh/user]. $Q'_{b,shower} = \frac{Q_{b,shower}}{user}$

$Q_{b,shower}$ = Energy used for heat the shower water

3.7 Indicator S7: Hot water consumption

This indicators shows the volume of hot water consumption per user $W_{\square} = \frac{f(\text{measured hot water consumptiondata})}{user}$

3.8 Indicator S8: The coefficient of performance of a cooling system

The COP indicates the efficiency of converting input energy into output cooling:

$$COP = \frac{E_{th}}{E_{el}}$$

where

E_{th} – total amount of electrical energy used by the cooling plant per year [kWh_{th}/a]

E_{el} – total amount of electrical energy used by the cooling plant per year [kWh_{el}/a]

$$COP\ redu\ (\%) = \frac{COP_{VB}}{COP_{va}}$$

where

COP_{VB} – cooling systems' coefficient of performance calculated for reference year

COP_{va} – cooling systems' coefficient of performance calculated for analysis year

3.9 Indicator S9: Electrical energy savings

Electricity consumption is a key parameter in public lighting since it is the main energy flow in the system and the one targeted when addressing energy efficiency measures. It is thus fundamental to assess impact of energy efficiency measures compared to a baseline.

The indicator will be presented in both real savings and in percent of the original energy consumption.

$$SAV_E = E_{E,before} - E_{E,after}$$

$$SAV_E = \frac{E_{E,before} - E_{E,after}}{E_{E,before}} \cdot 100\%$$

The electrical consumption will be corrected to be of the same period of time (one year) both before and after.

3.10 Indicator S10: Energy cost per luminaire

The calculation of the costs per luminaire is closely linked with indicators 8 and 9 (Energy cost savings) but looking at total energy costs per luminaire will be very useful to compare similar projects and check progress on an absolute costs basis.

The indicator wil be calculated with the quocient between the total costs on energy and the number of luminaries

$$COST_{€,Lum} = \frac{COST_{€}}{Lum}$$

3.11 Indicator S11: Luminous flux per energy consumption

The useful energy from street lighting is the luminosity produced by the lamps that reaches the surface to be lighten. It is a well know fact that introducing dimming technologies reduces the luminosity but in a lesser proportion than the energy savings achieved. This indicator will allow to evaluate this effect.

The indicator wil be calculated with the quocient between luminous flux and energy consumption on a dimming situation and with no dimming.

$$L_E = \frac{L}{E}$$

3.12 Indicator S12: CO_2 reduction cost per ton

By providing an associated cost with the tons of CO2 reduced, one will be able to define how the investment in ICT and energy efficiency measures compares with other types measures.

The indicator willl be calculated as the total investment cost expenditure minus cost savings compared to baseline divided by the tons of CO2 reduced, throughout lifetime of the system.

$$COST,SAV_{CO_2} = \frac{COST_{INV} - SAV_{del,E}}{\mathbf{SAV_{rel,CO2}} \times \mathbf{mCO2(baseline)}} \times life$$

3.13 Indicator S13: Electricity generated by renewable (PV cells)

This indicator shows the total annual electric energy production from renewables. Electricity is generated by PV panel installed in the buildings. The amount of electric energy is read monthly from the invoice meters.

E_{PV} - electric energy production by PV cells [kWh/a]

3.14 Indicator S14: Ratio of waste heat utilization (heat recovery system)

This indicator shows the efficiency of heat recovery system. Indicator will be calculated as a share of recovered heat on the total heat production.

$$r_{HX} = \frac{Q_{HX}}{Q_{HB} - Q_{HX}} \cdot 100\%$$

Q_{HX} – amount of heat recovered [kWh]

Q_{HB} – heat produced by all hot water boilers for space heating and domestic hot water [kWh]

3.15 Indicator S15: Energy used for heating

This indicator is used to find the energy which is used in the building. The energy used for heating is in many of the buildings not the same as the energy supplied to the building, due to on-site use of renewable energy sources such as for instance heat pumps and solar thermal.

The indicator will be found from measurements in the heat supply system of the building.

$$Q_{H,b} = f(\text{measured data for heating})$$

The energy used for heating will be corrected with respect to time and climatic data as described in section 2.1.1.1.

3.16 Indicator S16: Energy used for cooling

This indicator is used to find the energy which is used in the building. The energy used for cooling is not the same as the energy supplied to the building, due to the use of cooling machines to deliver cooling. Also on-site use of renewable energy sources such as for instance heat pumps and solar thermal and other types of free cooling means that the energy which is supplied and the energy which is used is not the same.

The indicator will be found from measurements in the cooling supply system of the building.

$$E_{C,b} = f(\text{measured data for cooling})$$

3.17 Indicator S17: Share of local renewable energy for heating

The share of local renewable energy for heating will be found from the following fraction:

$$r_{renew,heat} = \frac{Q_{H,del} - Q_{H,b}}{Q_{H,del}}$$

3.18 Indicator S18: Share of local renewable energy for cooling

The share of local renewable energy for cooling will be found from the following fraction:

$$r_{renew,cool} = \frac{E_{C,del} - E_{C,b}}{E_{C,del}}$$

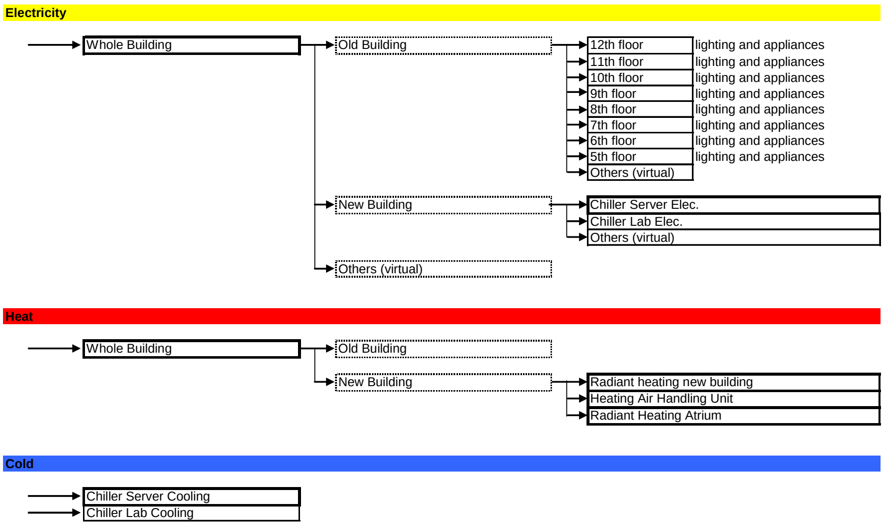
Appendix B2

Substantiation of the ¡Error!No se encuentra el origen de la referencia.

The cooling system coefficient of performance is crucial indicator of system's efficiency. According to it, it is possible to calculate the energy consumption required to meet cooling demand and compare total seasonal efficiency of the entire cooling system. It should include the effect of all energy consumption associated with the process such as fan and pump energy, chiller inefficiency, control equipment etc.

Methodology

The following graph shows the monitoring concept for the Centre of Informatics:



Measurement	All measurements shown in the graph will be metered continuously. In addition several appliances and lighting devices will be metered using plug and lighting meters. For heating and cooling the supply and return temperatures and flow rates will be metered.
Time step	All continuous measurements will be metered in 15 or 60-minute intervals. Additional Measurements will only be used to approximate the annual consumption by metering the consumption in a representative period of time.
Data Storage	All energy data will immediately be stored in the energy management system of the university (EnerGo+), all other data in the building management system (Siemens). These systems will be linked to the Energy-Navigator that imports the data carrying out several data checking procedures and transforming them into a format with equidistant time steps. From here all other services provided by the Energy-Navigator can be accessed. The frequency of the data transfer to the Energy-Navigator has not yet been determined.
Public Access	The access to the data can managed using different access rights, roles and logins. A special login for the public will be defined that can be accessed via internet. In addition to this individual access one or more TFT monitors will be

	placed in the entrances of the buildings presenting – among other contents – up to date information on the energy performance of the building.