Contract number ENER/FP7/260039/BEEMUP

BEEM-UP

Building Energy Efficiency for Massive market UPtake

Integrated Project

EeB-ENERGY-2010.8.1-2
Demonstration of Energy Efficiency through Retrofitting of Buildings

Deliverable D.3.1
Common guideline for the monitoring program

Actual submission date: 2012-05-31

Start of the project: 2011/01/01 **Duration:** 48 months

Organisation name and lead contractor: Nobatek

Revision: final

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination Level		
PU	Public	PU
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)	

Deliverable description

The BEEM-UP project aims at demonstrating the economic, social and technical feasibility of retrofitting initiatives, drastically reducing the energy consumption in existing buildings, and laying the ground for massive market uptake.

Energy conservation measures are various: retrofitting the envelope, providing new heating systems, improving energy management through ICTs, improving construction work quality, improving retrofitting design process, etc.
They are implemented on three pilot sites: social housing buildings in Delft (NL), Alingsås (SE) and Paris (Fr).

The design and implementation work is complemented by a range of actions allowing improving both retrofitting process efficiency and results, whether it is on technical social and economical matters.

Performance monitoring is a key point for an energy efficient refurbishment program and is fully integrated in the BEEM-UP project. It aims at verifying the true results of the implementation on the site.
The information to be delivered from such monitoring are the general performances of the implemented solutions, but also the detailed performances of each action undertaken in the project in each pilot. It will allow assessing the performance of the buildings as well as identifying discrepancies between forecasted performance and actual results.

To insure the right quality for this assessment, it has to be based on a clear evaluation methodology. This report aims at describing the monitoring guidelines supporting the monitoring and evaluation approach of the BEEM-UP project. These guidelines define a set of actions proposed as a common performance evaluation process to be implemented in monitoring processes for refurbishment projects. It is also the basis for the definition of the monitoring programs for each pilot site.

Guidelines are based on two main dimensions:

- A monitoring procedure : it allows identifying clearly each step of the monitoring program implementation and detail when necessary specific tools required.
- The use of the IPMVP (International Performance Measurement and Verification Protocol) as the framework for the monitoring programme content, insuring both quality of the assessment to be done and homogeneity between each pilot sites.

Table of content

Chapter 1 Monitoring procedure

A chronological procedure is proposed for the implementation of the monitoring program. It allows defining clearly the main steps to be followed for the implementation of the methodology which content is detailed in the next chapter.

The main steps of the procedure are:

1. Context and objectives integration
2. Site analysis
3. Proposition of a measurement and verification plan
4. Monitoring equipements installation
5. Data collection and analysis
6. Reporting

1.1 Context and objectives integration

It is of first importance to clearly understand the context and objectives of the refurbishment project to take them into account for the monitoring plan. Numerous key parameters are defined there; in the case of the BEEM-UP project, the following key parameters have to be integrated in the monitoring programme:

- Demonstration project: experimentation + replication
- European dimension
- Three pilots sites in different countries
- An holistic approach, based on multiple technological solutions but also on process improvements (improvement in the design process, in the decision making, in the implementation process and in tenants involvement, but also on economic and social aspects managements)
- Common building type target: social housing
- 75% energy (demand) savings as the main objective, but assessing the impact of each solution is also expected
- A monitoring program aiming at assessing the performance of the operation but also at identifying discrepancies between forecasted performance and actual results
- Performance assessment includes the evaluation of :
  - Energy consumptions variables
  - Indoor environments parameters
  - Green house gases emissions
- Two years monitoring period, excepted for the site of Paris (one year) due to its specific refurbishment calendar
- Specific reporting format: according to Concerto database

1.2 Site analysis

The site to be monitored has to be deeply analysed before the definition of the monitoring plan. This is done through:

- Site documentation analysis
- Site visit

Documentation analysis:

Documentation includes

- Information about the building: architectural plans, electricity and fluids plans, description of HVAC systems, description of counters.
- Information about the refurbishment plan to be implemented: architectural plans, HVAC modifications, envelope modifications, counters modifications, ICT systems description if they are installed, + all the pertinent information concerning the operation

Site visit:

Site visit allows integrating clearly all the technical details and issues that cannot or have not been taken into account from the documentation analysis. It allows also meeting local stakeholders than deliver interesting “qualitative” information.

A specific site visit process and template is proposed in Annex 1.

Sampling the dwellings to equip can also be defined from the site visit, in close relationship with the building owner (sampling depending on technical + social + budget criteria, and the willingness of the tenants to participate).

1.3 Proposition of a measurement and verification plan

Once both the site and project objectives are clearly integrated, a formal monitoring plan (hereafter called Measurement and Verification Plan, M&VP, as mentioned in the IPMVP), is proposed for the whole project. It is proposed in BEEM-UP to use the IPMVP (International Performance Measurement and verification Protocol) as the main framework to set up this plan. It insures to integrate the right information in the M&VP. In the case of the BEEM-UP project, a first monitoring plan is proposed in the present document as being the “monitoring guidelines”. It will be completed site by site with specific local details in a second M&VP for each pilot site.

This plan has to be agreed between stakeholders in charge of the monitoring process and implementation and building managers.

1.4 Monitoring equipment installation

The equipment mentioned in the M&VP are calibrated and installed on-site, with careful verification about communication between equipment and correct data acquisition.

Equipment installation has to be realised with qualified professional and the necessary authorizations, especially for electricity and fluids monitoring.

Installation process has also to be agreed with the building owner and local stakeholders when necessary: housekeeper and tenants.

1.5 Data collection and analysis

Data collection starts as soon as the equipment are installed. It is advised to store data on two physically separated servers and to define a clear quality insurance process (cf. point 13 of the M&VP) in order to avoid data losses.

In BEEM-UP, two levels of analysis are realized:

1. First data analysis aiming at local reporting, realized by local monitoring responsible

2. Second data analysis aiming at project reporting, realized by the project’s monitoring leader (for Beem-UP: Nobatek).

1.6 Reporting

Reporting is to be realized periodically, for different targets:

- Local stakeholders (in agreement with the awareness campaigns): tenants, housekeepers, local building managers, construction companies involved in the refurbishment process, architects and the technical design team.

- Project stakeholder + larger audience (in agreement with the diffusion strategy): project partners, stakeholders targeted for BEEM-UP results diffusion

Report format is precised in the M&V plan for these targets as well as reporting frequency.

Chapter 2 Common guidelines

The IPMVP (International Performance Measurement and Verification Protocol) is used as a framework for the BEEM-UP monitoring program. IPMVP allows integrating a global analysis for the monitoring program, from requirements to reporting. It brings coherence to the measurements realized and insures results quality.

IPMVP can be implemented through a Measurements and Verification Plan (M&VP) for the project and for each of the pilots. An M&VP is based on 13 points to be fulfilled in order to set up a clear and coherent monitoring plan. These 13 points are used in the following sub-chapters to present the BEEM-UP monitoring guidelines.

2.1 Energy conservation measures intent

BEEM-UP proposes a full range of energy conservation measures dedicated to dwellings buildings, as for example:

- Replacing building envelope: advanced thermal insulation solutions (Neopor, vacuum insulation panels), advanced glazing,
- Replacing HVAC system + new systems (heat recovery form waste water, solar air collectors)
- New elevators
- ICTs for building energy management and/or individual energy management
- Etc.

Energy savings objectives are common in the BEEM-UP project but there is no common basis for the technological means to be used to generate those savings. The refurbishment program and the exact definition of energy efficient solutions to be implemented are site specifics. They will be integrated then in detail in the M&VP of each site (Deliverable 3.2)

The BEEM-UP project proposes however a common innovative framework for the refurbishment process. :

- Integrated design process
- Performance analysis (economical+social+environmental)
- Tenant involvement for energy savings
- Quality insurance in the work implementation

These four methodological improvement works should also impact on the energy savings generated in the project. It might be interesting as well to asses it specifically.

2.2 IPMVP option and measurement boundary

Option A, Option B, and Option C are appropriate in BEEM-UP. They will be applied in the following general manner.

Option C (Whole Facility). Whole facility monitoring and measuring will be the primary method for the calculation of energy savings. This is appropriate because:

- Multiple innovative ECMs are used and many of them might not be correctly taken into account by simulation tools
- Smart metering deployment is the only way to evaluate objectively behavioral change form tenant involvement actions
- it is low cost (given that we are conducting smart metering)

In general, we are interested in energy savings as much as we are concerned about what caused the energy savings and promoting specific refurbishment measures as a way to obtain them. Hence where interest to do so is identified, ECMs will be isolated and compared (**Option A & B (Retrofit Isolation)).**

2.3 Baseline: Period, energy and conditions

The baseline period will be established through the following means depending on data availability and monitoring options on each site, in priority order:

1. Energy bills + full measurements (energy consumption differenciated by energy type and consumption source, + comfort paramters) on a representative sample of dwellings to be retrofitted. Measurement period should be preferably one year or should include at least a cold and a warm period.

2. Partial measurements (e.g. global energy consumption) on a representative sample of dwellings to be retrofitted. Measurement period should be preferably one year or should include at least a cold and a warm period.

3. Energy bills analysis when measurements are not possible

4. Dynamic thermal simulation if bills are not available

When possible, technical analysis should be completed by a set of tenant's interviews on their living conditions, level of satisfactions concerning specific issues (e.g.

temperature) and their way of using their dwelling (such action is to be realized in WP5).

Baseline period: at least one year

Independent variables:

- Exterior temperature (number of heating degree days)

Static factors:

- Interior comfort temperature reference
- Domestic hot water production temperature
- Building enveloppe caracteristics
- Building sytems caracteristics
- Area and volume of heated spaces
- Occupation rate (m2 occupied dwellings/total m2 of dwellings)
- Number of occupants
- Ventilation rate
- Building rules concerning common spaces (lighting, interior temperature, etc.)
- Tenants awareness to energy savings (if a specific training and awareness programme is proposed for example)

The detailed description of the site has to be inserted here in order to mention clearly all the influent parameters (to be inculded in the M&VP of each site)

2.4 Reporting period

- Measurement period: at least one year, if possible two years

- Raw parameters to be measured::

Energy consumption:

- For the building (optional)
- For each monitored dwelling (compulsory)
- For each source of energy: electricity, gas, etc., and from the grid or from district supply (compulsory)
- For each application (heating, DHW, ventilation, lighting, appliances) (compulsory for heating)
  NB: for domestic hot water it is advised to measure the following parameters: volume of hot water, electricity consumption, input and output temperature)

Energy generation:

- Per renewable source

Indoor environment parameters:
- Temperature and humidity (compulsory, at least one measurement point per dwelling, two if the dwelling is on two floors)
- Occupation, air quality (CO2 content) and windows openings (optional)
- Luminance (optional)

Outdoor parameters:
- Temperature and humidity (compulsory if no detailed local weather data is not available)
- Wind force and direction, sun (optional)

Outdoor parameters can also be collected from local weather station database if such data is accurate enough

- Definition of reference variables:
- Per building
- Per dwelling
- Per tenant
- Area of reference: it has to be clearly defined for each site (cf. D3.2), in relationship with local superficie calculation rules and also with the superficie definition used for simulations (for further comparisons)

- Number of dwellings to be monitored

The number of dwellings to be monitored has to be representative of the whole building characteristics, in terms of:
- Main facade exposition
- Floor
- Size
- Family typology (if pertinent)
- Specific technical caracteristics (if pertinent; for example in the case of various HVAC system)

We consider 10 dwellings as a minimum to establish a correct mean evaluation of the savings, 20 dwellings being preferable (for building with less than 100 dwellings).

- Data acquisition frequency:
- Heating, ventilation and domestic hot water energy consumption: 1h
- Comfort parameters and air quality: 30 min
- Outdoor parameter: 30 min
- Electricity for apliances : 10 min (in this case the reference period can be reduced to one month in winter, one in mid-season, one in summer)

- Occupation and windows openings: 5 min

2.5 Basis for adjustments

Independent variables:

- Exterior temperature

The influence of exterior temperature can be adjusted using the following correction formula:

$C_{adj} = C_{bas} * DD_{bas}/DD_{ref}$

C_{adj} : Adjusted energy consumption
C_{bas} : Baseline energy consumption
DD_{bas} : Number of heating degree days during the baseline period
DD_{ref}: Number of heating degree day during the reference period

Static parameters:
Adjustments will be calculated ***according to the proportional evolution*** **of** the following parameters

Static parameter	Value to be adjusted
Interior comfort temperature reference	No adjustment on energy consumption if the interior temperature is superior to comfort temperature. Adjustment on heating energy consumption if the interior temperature for the baseline was inferior to comfort temperature
Domestic hot water production temperature	DHW energy consumption
Building envelope characteristics	Energy conservation measure to be evaluated> no adjustment
Building systems characteristics	Energy conservation measure to be evaluated> no adjustment
Area and volume of heated spaces	Heating energy consumption
Occupation rate (m2 occupied dwellings/total m2 of dwellings)	Heating energy consumption

Static parameter	Value to be adjusted
Number of occupants (per dwelling)	DHW energy consumption
Ventilation rate	Heating energy consumption (unless ventilation includes heat exchange system)
Building rules concerning common spaces : lighting management, interior temperature	Energy conservation measure to be evaluated> no adjustment

2.6 Analysis procedure

The analysis procedure can be based on the calculation of the following indicators from the collected data (including the adjustments).

2.6.1.1 First level indicators

>Purposes: to understand the energetic behavior of the building, of each flat, of the tenants + to set baselines

1. Final energy consumption / m2 (and /habitant) for each flat
   - For the whole building (i.e. with a certain degree of extrapolation)
     - ➢ Total for one full year
     - ➢ For representative weeks (winter, summer, mid-season)
   - Per apartment (hourly measurement, for the whole year)
     - ➢ Total for one full year
     - ➢ For representative weeks (winter, summer, mid-season)
     - ➢ Identifying mean consumption and extreme consumptions
   - Per applications (heating, DHW, light, appliances ; hourly measurements, for the whole year)
     - ➢ For the whole building (total for one year+ analysis of representative weeks)
     - ➢ Per flats (representative weeks) + for heating: typical moments (long cold period, transition in few days from cold to warm and from warm to cold)

2. Comfort level (number of hours of uncomfortable temperature during one full year; for example 19°C >T° int. >26°C), for each flat (reference comfort temperature have to be defined country per country).

3. Specific analysis
   - Heating response (per flat, winter season)
     - Heating consumption / T° int. / T° ext.
   - Lighting consumption (per flat)
     - Light consumption / Exterior conditions (sunlight)
   - Occupation and use (specific weeks)
     - T° int. / T°ext (summer)
     - T°int. / T°ext + window openings + occupation + CO2 air quality

<u>Key periods for assessing the envelope refurbishment impact:</u>
We can identify several typical scenarios where it will be important to have a specific look at the collected data during that period to understand the impact of the refurbishment work:

Scenarios	Season	Conditions	To be observed	To be concluded	Interesting?
Scenario 1	Winter	Stable low temperature and cloudy	Heating demand	Static behavior of the building	+++
Scenario 2	Winter	Fast transition period from stable temperatures and sunny to stable low temperatures and cloudy	Heating demand	Dynamic behavior of the building	++
Scenario 3	Mid-season	Fast temperature decrease generating heating demand	Heating demand	Response time of the heating system	+
Scenario 4	Mid-season	Mean winter weather	Heating demand + comfort parameters differences between high floors and low floors	Heat sharing in the building	++
Scenario 5	Mid-season	Large temperature amplitude between day and night	Heating demand + comfort issues	Efficiency of the mid-season management	+
Scenario	Summer	Sunny + stable	Comfort parameters	Comfort	+++

Scenarios	Season	Conditions	To be observed	To be concluded	Interesting?
6		high temperature		response of the building	
Scenario 7	Winter	Typical winter month	Comparison (global energy consumption) between energy efficient aware tenants Either same tenants before and after awareness campaigns or household with awareness campaign and other without	Impact of the awareness campaign	++

2.6.1.2 Opportunity indicators

>Purpose: to identify opportunities of energy +CO_2 emissions savings using ICT and awareness campaigns

1. Useless heating
   - Heating on + T°ext. > T°comfort (hourly measurement, in each flat, during cold season)
   - Heating on + window opened (10 min measurements, in each room equipped with window openings sensors, during cold season)
   - Heating on + T°int > T° comfort (hourly measurement, in each flat, during cold season)
   - Heating on + no occupation + T°int > T°"no occupation" comfort (hourly measurement, in each flat, during cold season ; to be analyzed depending on time, building inertia, and heating system)

2. Useless lighting
   - Light on + no occupation (10 min measurements, in each room equipped with lighting sensors, during the whole year)
   - Light on + Luminancy int.> Luminancy reference

3. Useless specific electricity
    - No occupation + abnormally high level of specific electric consumption (level to be defined for a reference consumption, might be basic night consumption + washing machine) (hourly measurement, in each flat, during the whole year)

4. Low comfort
    - Heating on + T°int. < T°comfort (hourly measurement, in each flat, during cold season)
    - T°int. > T°comfort (hourly measurements, in each flat, during warm season)
    - Air quality: high CO2 content during several hours (hourly measurements, in each flat, during the whole year)

5. “Abnormal” consumption
    - Flat energy consumption (/m2 or /habitant) >> mean flat energy consumption in the same building (/m2 or /habitant)
        - > to be done also by application for further details: heating, DHW

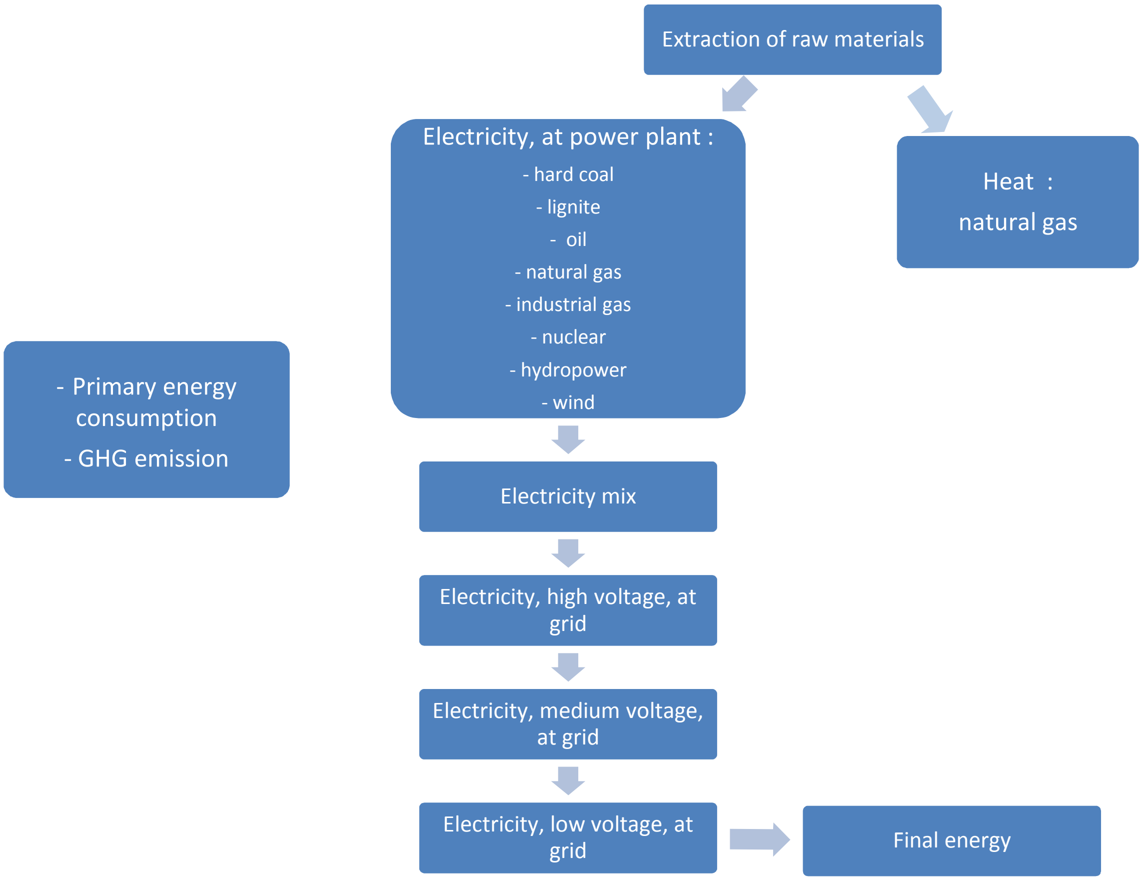
6. Greenhouse gases emission peaks
    - Electric consumption peak + High CO2 content electricity mix (at the same moment) (10min measurement, in each flat, to be done on several “typical” days, in winter, mid-season, and summer)

2.6.1.3 Greenhouse gases emissions calculation

Calculating greenhouse gases emissions may be executed through more or less précised methods. When evaluating peak load shaving (PLS), which is an important lever for CO_2 emission decrease, it may be important to control details of such calculation in order to get PLS impact information.

A detailed calculation is presented in Annex 2. It is based on life cycle analysis methodologies, tools and databases and will be used for CO2 emissions calculation.

The calculation proposed goes from final energy consumptions, as measured in each pilot, to GHG emissions. National context is important, especially for electricity production as it may have great impact on CO2 content in energy.



Details about the calculation and data to be used are presented in Annex 2.

2.7 Energy prices

This information is site specific (depending on each country), to be mentioned in the M&VP of each site:

- Unit price for each energy consumed in the site
- Formula to be used for calculating the energy price evolution (if necessary)

2.8 Meter specifications

This information is site specific, to be mentioned in the M&VP of each site.

2.9 Monitoring responsibilities

Task	Time period	Responsible
M&V Plan	Baseline + reference	Site specific
Equipment proposal	Baseline + reference	Site specific
Equipment validation	Baseline + reference	Site specific
Equipment installation	Baseline + reference	Site specific
Equipment maintenance and replacement	Baseline + reference	Site specific
Local communication verification	Baseline + reference	Site specific
Data recording	Baseline + reference	Site specific
Data sharing	Reference	Project monitoring coordinator
Data analysis	Reference	Project monitoring coordinator
Local Reporting	Reference	Site specific
Project reporting	Reference	Project monitoring coordinator

2.10 Expected accuracy

Uncertainties are related to the following parameters:

- Equipment uncertainties
- Adjustments and calculation protocols

For the equipment to be installed in the dwellings, its uncertainty will be specified (cf. M&VP of each site).

2.11 Budget

This information is site specific, to be mentioned in the M&VP of each site.

2.12 Report format

For project reporting, two formats will be used:

- Concerto Format for a diffusion of the results on the concerto diffusion website (this format is planned to be defined in September 2012)
- Detailed reporting framework taking into account project objectives and specificities;

In the case of Beem-UP the following elements should be mentioned in the reporting:

- Impact of refurbishment solutions (taking into account the indicators mentioned earlier)
- Discrepancies between forecasted performance and real results
- Lessons learnt, site by site but also common conclusions

The local reporting format has to be defined for each site depending on local targets and local objectives. Besides monitoring measurements results it may be interesting to integrate in such report elements from "one shot measures" (realized before and after refurbishment) aiming at understanding qualitative envelope and indoor improvements:

- Blower door test
- Infrared thermography analysis
- Sound insulation measures
- Indoor environment diagnosis

2.13 Quality insurance

It is recommended to assure proper data storage through a double saving strategy, for example using a local server and an external server for that purpose.
Moreover periodic validation allowing to check if the data is recorded properly is also recommended.

Annex 1: Site visit template

Site visit template Procedure		
Step by step	Tasks	Comments
Before site visit		
1	Preliminary data collection about the project (context, objectives, innovations, budget, etc.)	
2	Preliminary data collection about the building (maps architecture, electricity, plumbering, HVAC, satttelite photo, access map, etc.)	Fill sheet A
3	Propose a first monitoring plan based on a first project analysis	
	- Data to be measured	
	- Sensors + meters foreseen	
	- On site communication scheme (number and localization of dataloggers + routers)	
	- Data collection process (on site, via internet, other...)	
	- Compatibility with available budget	
4	Prepare the RDV (who to contact, letter of the building owner with details explanations of the intervention and its consequences, document to show to the tenants, RDV schedule, access for electricity and plumbering, caretaker presence, sensors samples to show, etc.)	Aims at decreasing the "intrusion" feeling for the tenants
5	Prepare the equipements for the audit (toolbox, sensors, documentation, camera, etc.)	
During the visit		
1	Global visit of the site and presentation of the local stakeholders (who we are, our mission, our visit)	
2	Per monitoring unit (building, apratments, offices, etc.), identify the systems to be considered for the monitoring plan, and verify there are no other issues to take into acount	Fill sheets B, C
3	Identify possible barriers or issues for sensors installation	Fill sheet D
After the visit		
1	Report of the site visit (using sheets A, B, C, D) + complementary documents	
2	Fully described and justified monitoring plan	

Site visit template

A : Site context and data

Project (Details and objectives > why monitoring?)

Budget

xxxx €

Adress and photo

Number of buildings

Building typology (tertiary/industrial/<u>dwellings/</u>housing)

Number of dwellings per buildings and number of rooms per dwelling

Surface (liveable/total)

Synthesis of the equipments and if possible localization

Heating	
DHW	
Ventilation	
Air conditonning	
Renewables	
Lighting	
Electric system	
ICT/BEM	
Security	
Others	

Maps of the building (to include in the report)

	YES	NO
Reference		

Maps of the networks (electricity / plumbing / ventilation) (PR001 à PR100) - to include in the report

RDV

	Contact person	Contact done?	Participation to the visit?
Project manager Nobatek			
In charge of the monitoring			
Building owner			
Caretaker			
Tenants/ Users			

Date first visit

Letter of presentation sent ?

Site visit template

B : Common equipments

Parameters	Specifications	Comments / possibility of monitoring
Heating / AC	Brand/Model/reference	
	Power	
	type of energy	
	counter	
	localization	
DHW	Brand/Model/reference	
	type of energy	
	Power	
	cumulus	
	counter	
	localization	
Ventilation	Brand/Model/reference	
	Counter	
	localization	
Renewable	type	
	Brand/Model/reference	
	localization	
	counter	
Common areas		
Specific equipments	Type :	
	Power:	
	Number:	
Particular pathologies (humidity,...)		
Counters		
Other comments		
Photo		

Site visit template

C - Apartments : main parameters and equipments check-list

Place	Parameters	Specifications	Comments / possibility of monitoring
Appartment 1	Typology		
	Dimensions		
	Localization		
	Occupation / occupiers		
	Heating / AC	Brand/Model/reference	
		type of energy	
		individual or collective	
		type /number of heaters	
		counter	
		localization	
	DHW	Brand/Model/reference	
		type of energy	
		individual or collective	
		cumulus	
		counter	
		localization	
	Ventilation		
	Renewable	type	
		Brand/Model/reference	
		individual or collective	
		localization	
		counter	
	Electrical board	Type	
		Outputs 1	
		Outputs 2	
		Outputs 3	
		Outputs 4	
		Outputs 5	
		Outputs 6	
		Outputs 7	
		Outputs 8	
		Outputs 9	
		Outputs 10	
		Outputs 11	
		Outputs 12	
		Localization	
	Lightings	Type :	
		Power:	
		Number:	
	ICT		
	Windows	Type:	
		Dimension:	
		Orientation:	
		Localization:	
	Appliances	TV / hi-fi / video	
		Computer	
		washing machine	
		drying machine	
		Oven	
		Fridge	
		Freezer	
		...	
	Wall structure		
	Internet connection		
	Particular pathologies (humidity,...)		
	Other comments		
	Photo		

Site visit template

D : Local restrictions for sensors

Place / Equipements	Foreseen sensors	Specific demands to verify on site	Verification, validation and comments
Sensors Meters weather station data loggers communication equipements local servers …	Sensor 1: Hobo U12-012		
	Sensor 2		
	Sensor 3		
	Sensor 4		

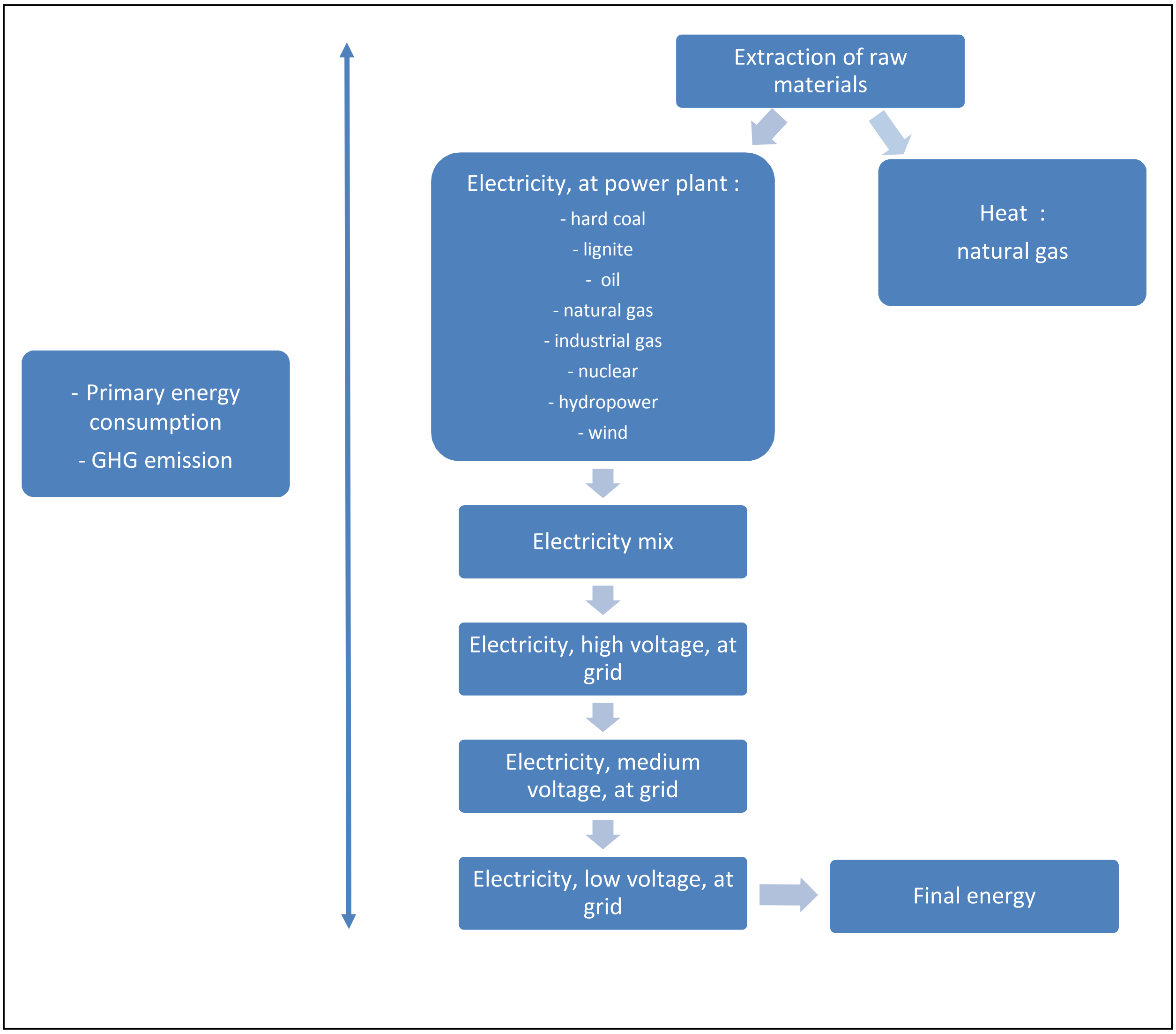
Site visit template

Memo : Material

Numéro	Material
1	Fiche A, Fiche B, Fiche C, Fiche D
2	Informations and documents
3	Block note + stylo
4	Camera (to verify battery/memory)
5	Telemeter and meter
7	Monitoring toolbox
8	sensors samples or technical documentation with photos
9	Letter of presentation for the building owner / manager

Annex 2 – Greenhouse gases emissions calculation

Energy consumption > GHG emissions: life cycle elements to be considered in the calculation, from raw materials extraction to final energy.



The analysis presented hereafter is based on life cycle analysis (LCA) approach and European LCA tools and database (Ecoinvent 2.0). It allows calculating the transformation from primary energy to final energy and evaluating greenhouse gases from the energy mix really used.

1. France

Content of the French pilot building energy consumption:
[DHW + Specific electricity + ventilation + lighting] = electricity
[Heating] = gas

French energy mix:
France is the second largest consumer of electricity in Europe, with a share of nuclear generation by 80%, which is a peculiarity of this country. France imports all of its oil, gas and coal needs. France is also the second European country for production of renewable energy. CO2 emissions in France are among the lowest in IEA countries.
The share of gas is expected to increase in the energy mix, particularly in electricity generation (France has diversified its supplies, including liquefied natural gas).[i]

CO2 emissions related to electricity production:

	Primary energy (TWh)	[primary energy / final energy][ii]	Electricity generation (TWh) [iii]	% mix	GHG emissions (kg CO2 eq/kWh) [iv]	Source (LCA Ecoinvent database)	GHG emissions (t CO2 eq)	% GHG emissions
Coal	92,389	3,581	25,8	4,5 %	1,078	*Electricity, hard coal, at power plant/FR U*	27 812 400	57,7 %
Oil	18,709	3,171	5,9	1 %	0,765	*Electricity, oil, at power plant/FR U*	4 513 500	9,4 %
Natural gas	51,134	2,412	21,2	4 %	0,496	*Electricity, natural gas, at power plant/FR U*	10 515 200	21,8 %
Nuclear	1733,189	3,867	448,2	78 %	0,01159	*Electricity, nuclear, at power plant pressure water reactor/FR U*	5 194 638	10,7 %
Hydropower	78,078	1,183	66	11,5 %	0,00359	*Electricity, hydropower, at power plant/FR U*	155 694	0,3 %
Other			5,2	1 %				

Additional analysis:

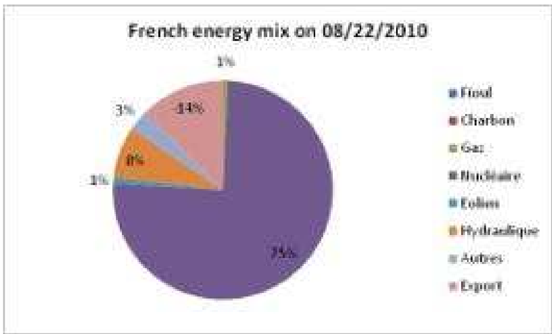
Energy mix of different suppliers of electricity in France[v]:

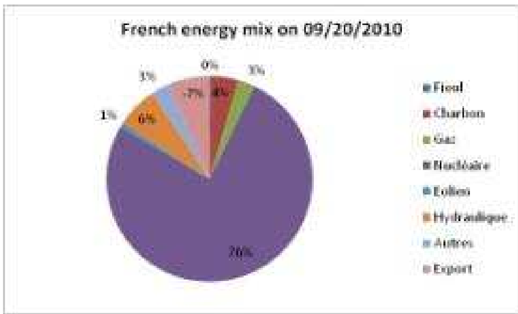
	Enercoop	Planète oui	Direct énergie	Proxelia	Alterna	Poweo	GEG Source d'Energie	EDF	GDF Suez
Activity	Retailer				Retailer Producer				
Year of the datas	2008	2010	2006	2007	2010	2006	2006	2006	2008
Hydraulic	95,4	95	5	44,25	100	5	39	5	18
Wind	3	5		0,01		1	1,5	1	1
Photovoltaic	1,6								
Biomass									1
Nuclear			85,7	48,06		85	54	85	17
Gas			8,4	7,03		3	1	3	50
Oil						1,5	0,5	1,5	
Coal						3,5	1	3,5	12

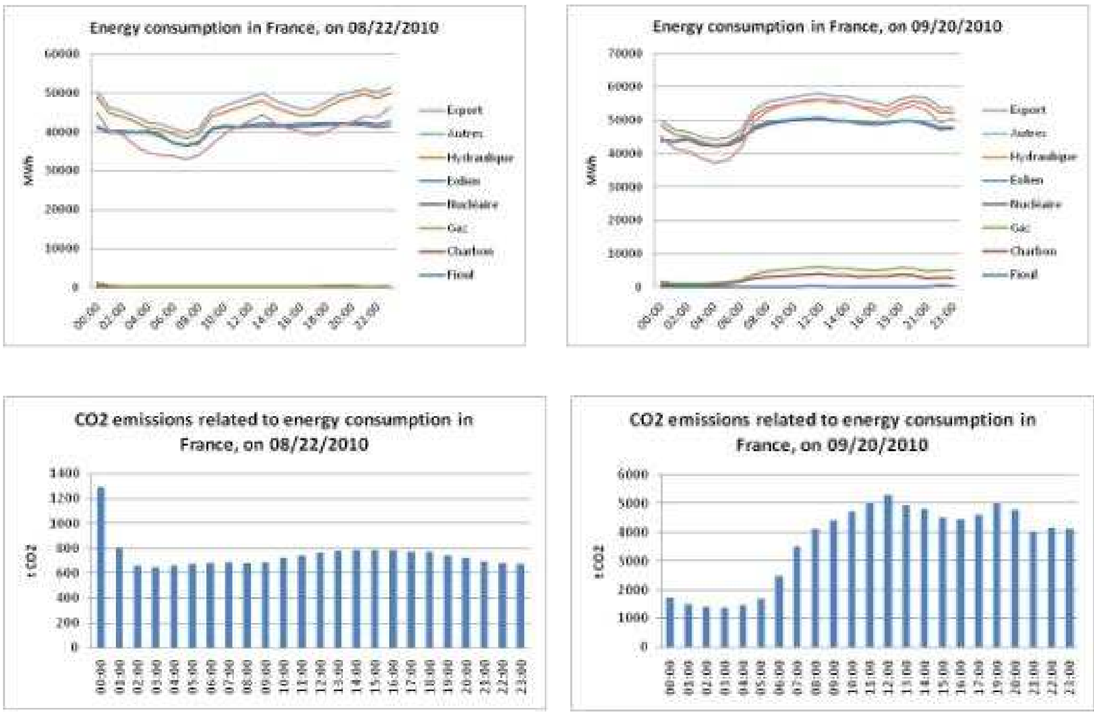
Variations in the French energy mix :

Both the energy mix and the electric consumption change drastically during a day (for example the consumption peak at 7 PM) and all over the year depending on climatic conditions.

RTE (Réseau de Transport d'Electricite) [vi] delivers data on the daily production of electricity (production mix and quantity), it allows to calculate accurately GHG emissions corresponding to the real mix and consumption. Examples:







Examples of profiles of the French energy mix

CO_2 emissions data can help to analyze the peaks phenomena: eg at the end of the day when there is a higher need for electricity, while nuclear plants are already in operation, the additional requirement is filled by other sources, like coal plants, which emit important quantities of CO_2.
(NB. This phenomenon is not observed on the previous graphs because it is rather characteristic of the winter heating needs.)

2. Sweden

Used energy in the Swedish building site

Electricity = 100% hydropower. The owner of the Swedish pilot building site has decided to only use hydropower in Brogården.
Heating = DHW

Swedish electricity mix[1, 2]

The Swedish electricity mix is mainly based on hydropower and nuclear. Electricity based on hydropower stand for 47%, the share for nuclear was 42% of the total electricity production in Sweden 2009.

	Produced electricity (2009)	PEF*	GWP	GHG emissions	Primary energy
	(TWh)	(cradle to elec)	(g CO_2-eq/kWh elec)	(Mton CO_2-eq)	(TWh)
Wind	2.0	0.05	13,2	0.03	0.1
Hydro	68.4	1.1	4,5	0.31	75.6
Nuclear	61.3	2.95	3,5	0.21	178.8
CHP, industrial	6.3	2.15	329	2.07	13.6
CHP, district heating	7.2	1.35	242	1.74	9.7
Condensing power	0.8	2.51	654	0.55	2.1
Totally produced	**146.0**			**4.9**	**280**
Import (+)/Export (-)	-2.0				
Losses (dist. Net)	-11.0				
Elec. Use Sweden	**133**				
Specific emissions incl. import/export (g CO_2-eq/kWh) or (kWh/kWh)				**36.4**	**2.1**

* PEF= Primary energy factor = primary energy / final energy

The Swedish energy mix in 2009.

District heating in Alingsås[3, 4]

The district heating system in Alingsås is manly based on bio fuels. During 2010 142 GWh district heat was produced and delivered to approximately 800 customers. The fuel mix 2010 was:

[1] Gode Jenny, et.al., Miljöfaktaboken 2011, report A08-833, Värmeforsk, ISSN 1653-1248, 2011
[2] Swede Energy, The Electricity year Operations 2010, http://www.svenskenergi.se/upload/Statistik/Elåret/ENG_Sv%20Energi_elåret2010.pdf, 2011
[3] Energimarknadsinspektionen, http://www.energimarknadsinspektionen.se/For-Energiforetag/Fjarrvarme/Inrapporterade-data/
[4] Alingsås Energi, http://www.alingsasenergi.se/

Bio fuels	93%
Gas from landfill	4%
Oil	3%

The greenhouse gas emission for the district heating in Alingsås is calculated with the internet based calculation tool Effem[5], which makes it possible to calculate the impact related to a specified mix of fuels. The specific CO_2-eq for the district heating in Alingsås is 25 g CO_2-eq/kWh delivered heat. The figure is based on the assumptions that the greenhouse gas emissions related to gas from landfill is equal to the emission related to combustion of waste. The distribution losses are assumed to be 12%.

[5] Effem Kalkyl, http://www.effektiv.org/miljobel/default.asp

4. The Netherlands

CO2 emissions related to electricity production:

		Primary energy (TWh)	[primary energy/ final energy][6]	Electricity generation (TWh)[7]	% mix	GHG emissions (kg CO2 eq/kWh)[8]		Source (LCA Ecoinvent database)	GHG emissions (t CO2 eq)	% GHG emissions
	Coal	82,95	3,53	23,5	23%	1,09341		*Electricity, hard coal, at power plant/NL U*	25 695 135	36,75%
	Oil	8,45	3,02	2,8	2,78%	0,72441		*Electricity, oil, at power plant/NL U*	2 028 348	2,90%
Gas	Natural gas (96%)	195,86	3,19	63,8	63,29 %	0,59841	0,65581	*Electricity, natural gas, at power plant/NL U*	41 840 678	59,85%
	Industrial gas (4%)		0,07			2,03341		*Electricity, industrial gas, at power plant/NL U*		
	Nuclear	13,61	3,58	3,80	4%	0,0213		*Electricity, nuclear, at power plant/UCTE U*	81 092	0,12%
Renewables	Wind (67%)	18,64	1,20	6,70	7%	0,0251	0,04	*Electricity, at wind power plant/RER U*	269 501	
	Cogen (33%)		5,99			0,0709		*Electricity at cogen ORC 1400 kWth, wood, allocation exergy/CH U*		
	Other			0,2	0,20%					

[6] Datas from calculations with SimaPro software, ecoinvent processes, and the method "Cumulative Energy Demand"
[7] http://ec.europa.eu/energy/energy_policy/doc/factsheets/mix/mix_nl_en.pdf
[8] Datas from calculations with SimaPro software, ecoinvent processes and the method "IPCC 2007 GWP 100a"

CO2 emissions related to gas consumption:

Gas consumption in the use of buildings, also generates CO2 emissions:

2010 gas consumption (m3)[9]	Gas efficiency (MJ/m3)	2010 energy consumption by gas (MJ)	GHG emissions (kg CO2 eq/MJ) [10]	GHG emissions (t CO2 eq)
48,6 E9	38,7	18,8 E11	0,0763	143 506 566

i http://www.developpement-durable.gouv.fr

ii Datas from calculations with SimaPro software, ecoinvent processes, and the method "Cumulative Energy Demand"

iii http://ec.europa.eu/energy/energy_policy/doc/factsheets/mix/mix_fr_en.pdf

iv Datas from calculations with SimaPro software, ecoinvent processes and the method "IPCC 2007 GWP 100a"

v http://www.energies-renouvelable.com/nouvelle/dossier,fournisseur,electricite.html

vi http://www.rte-france.com/fr/developpement-durable/maitriser-sa-consommation-electrique/consommation-production-et-contenu-co2-de-l-electricite-francaise#telechargement

9 http://www.indexmundi.com/fr/pays-bas/gaz_naturel_consommation.html

10 Data from calculation with SimaPro software, ecoinvent process "heat, natural gas, at boiler Modulating <100kWh/RER U" (to model a small boiler), and the method "IPCC 2007 GWP 100a"