Project no. TREN/05/FP6EN/S07.51327/006255

act2

Action to mainstream energy efficient building and renewable energy systems at a city level across Europe

Integrated Project

D 2.2 Guidelines for measurement input and consumption of energy flows, economical, environmental and comfort levels (ISO 7730)

Due date of deliverable: m9
Actual submission date: m12

Start date of project: jan 2006 Duration: dec 2010

Organisation name of lead contractor for this deliverable: proKlima

Revision [1]

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
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. General aspects

In the following, the monitoring guidelines and collections schemes for the EU Concerto project act2 for measures in Hannover and Nantes will be described. The guidelines contain the actual state of discussion, which for Hannover is already available in a rather detailed manner, while for Nantes clarifications and special adaptations have to be worked out.

The existing paper therefor is the basis for the monitoring, which contains the principles, definitions and procedures, as they are known today. However, details may have to be further developed and if necessary to be changed during the project progress, in order to fulfil the project requirements. Therefor, the existing paper will be updated.

1.1. Intentions and needs of monitoring

The monitoring guidelines shall codify the basic principles for the raising of all necessary data and their evaluation and analysis. Main target is, to derive as meaningful and precise characteristic values and indicators from the raw data as possible with as little effort for collection and evaluation as possible. The indicators to be defined have to ensure the following aspects:

- an evaluation of project success on the level of the Concerto area as well as
- the interpretation and benchmark of the measures and their results on the basis of the single demonstration objects.

The monitoring shall allow the assessment of the taken measures in the demonstration objects and compare them among each other (on the national level) and with national requirements or ambitious standards (BPT/BAT). A direct comparison of demonstration objects in Hannover and Nantes will often be difficult because of the different local conditions and is not obligatory. Nevertheless it is the aim to make a comparison of at least a few main indicators possible at the end of the project time.

Thus it is necessary to get an overview of all the different measured variables which play a role during the entire process from the data acquisition to the interpretation of the results as comprehensive as possible. Many of these basic conditions and parameters are associated to others and affect each other mutually directly or indirectly. Aspects, which seem to be subordinated at the first glance, can have substantial influence on the monitoring guidelines. An example: according to the act2 contract (objectives, p. 10) the "costs per m² of the energy saving measures adopted in each building" have to be evaluated. It is not accurately defined whether the evaluation should refer to the floor space of the reconstructed buildings or the surfaces of retrofitted components. In the case of component surfaces however it would be necessary to raise these data from the beginning of the project and to document them for each building. A subsequent collection at the end of the project period would cause substantial additional effort.

Thus it is very important to develop precise definitions and a clear understanding and use of all raw values and derived indicators. Starting from these requirements the data sources, the technical equipment and the tools to be used can be established.

The descriptions in the following chapters have been developed mainly according to the conditions in Hannover, but should always apply for Hannover and Nantes. If it is obvious so far, that due to the specific conditions in France or the terms for the demonstration objects in Nantes different definitions or procedures might become necessary in the two municipalities, this is explicitly mentioned. If the specific regulations for Nantes are already fixed, they are described in contrast to those for Hannover. In some cases - when local conditions are not clear enough in detail so far or if further discussions are necessary - the regulations for the objects in Nantes will have to be fixed later.

The project partners in Hannover and Nantes will be responsible for the monitoring of their particular objects concerning all steps from defining the standards in detail, gathering of data and calculating the energy consumption to the analysis of the results and determining of the indicators according to the principles and requirements as described in this guidelines. The WP leader Hannover will be responsible for the interregional analysis on basis of these results from both municipalities.

1.2. Auxiliary means and interdependencies

As figure 1 shows, the numerous parameters and conditions with a direct or indirect influence on monitoring can be summarised to a few groups and their connections to each other.

In the **centre of monitoring** there are first of all the demonstration objects and the measures accomplished. Data as the energy consumption and/or its development (as well as the impact on the environment caused by them) and the costs necessary to realise the measures can directly be assigned to the demonstration objects. This group of data can be regarded as the centre of monitoring and has to describe the measures and their effects as well as the metering equipment necessary for data acquisition.

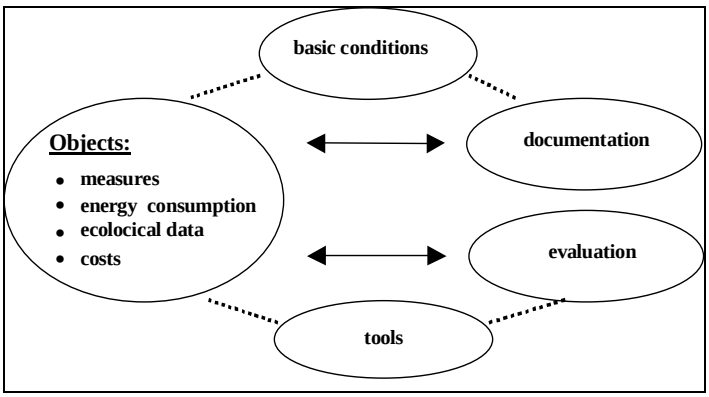

figure 1: auxiliary means and interdependencies

On the other hand there is a group of targets, which shall be achieved with the evaluation of data: these targets are mainly the clear documentation of the measures including the number, kind and place of the used metering instruments or the sources used for the collection of data. As the raw energy consumption data are not very meaningful without an interpretation or

comparison to a common reference, characteristic values or indicators have to be defined as well as a methodology used for evaluating them.

This centre of the monitoring is affected by some **auxiliary means and requirements**. The most important are:

- the precise **definition** of all used data, derived indicators and the relevant basic conditions (cp. 2.1),
- the definition of the **system boundaries**, to which the energy flows refer (cp. 2.1.3),
- the **baseline** to compare the data and indicators with (cp. 2.2),
- the definition of **standards**, which the measures have to fulfill to be certified as a Concerto demonstration object ("best-tables") and
- the comparison of the results of the evaluation with the defined Concerto standards as well as with more **ambitious standards**, which could be achieved with more advanced technologies (best practice technology BPT, best available technology BAT, cp. 2.3).

In addition there is a set of **tools** used for gathering and processing of data, whose suitability and availability must be specified and their concrete use must be defined:

- **metering** instruments (existing and to be installed),
- software tools and **calculation** methods to be used,
- available and used **data sources**.

Many of the enumerated parameters are well known in principle and/or already fixed. In detail however clarifying discussions are in many cases necessary, which may be either of fundamental nature on project level or depend on the specific characteristics of the individual objects. Therefore some of the definitions or procedures described in the following may change in the sequence of the project.

1.3. Tasks and methods of monitoring

According to the "monitoring impact assessment agreement" [1], which describes the collaboration between Concerto communities and Concerto PLUS regarding monitoring and impact assessment, "*monitoring refers to every kind of survey or inquiry targeted to deliver rough data. Depending on the type of data monitored and their source, monitoring can be divided into the following* ***categories****:*

- ***metering****: measurement of physical data during a defined time period at a defined time step*
- ***collection****: enquiry of data at energy consumers or providers. The origin of data is metering, but is not undertaken in the framework of CONCERTO activities*

- ***calculated****: calculation of data following a defined methodology (e. g. space heating energy demand). The origin of data is collection or metering (example: calculation of heating consumption per month from metered consumption per year via heating degree days)*

- ***estimation****: assessment on basis of statistical analysis. The origin of data might be metering, collection or calculation.*

- ***documentation****: description of buildings, systems, measures…*

Impact assessment *is realised using indicators calculated on the basis of the monitoring results."*

Based on this definition, the tasks and methods of monitoring and impact assessment will be defined here in a bit more comprehensive way. According to this the monitoring process will consist of five steps:

- a short **documentation**, containing descriptive text of the demonstration objects, the EE- or RES-measures realised and the main technical data including the used metering instruments,

- getting raw **boundary data** like actual weather and long term meteorological conditions, etc. by metering or collection,

- getting raw object related, **primary data** (e.g. energy production or consumption, costs, etc.) by metering, collection, calculation or estimation,

- deriving **secondary data** (e.g. dividing the heat energy consumption into space heating and hot water preparation or quantifying the ecological effects) by calculation or estimation,

- **analysing** and interpreting data by composed characteristic values, i.e. calculate indicators and compare them with each other or with the baseline or benchmarks (e.g. BPT/BAT).

It will be necessary to differentiate between three different kinds of demonstration objects:

- RES-objects, which will produce or generate (electrical or thermal) energy, see building category 1 (RES) in chapter 2.1.2),

- EE-objects with energy consumption, which will reduce the consumption by measures of increasing efficiency, see building category 3 (EE) in chapter 2.1.2, and

- mixed EE- and RES-objects (category 2 (RES+EE) in chapter 2.1.2).

In EE objects the consumption of electricity and/or of fuel for heating/cooling has to be metered in order to evaluate the amount of reducing the energy input reduction. In RES objects the generated energy may be fed into the electricity or district heating network and/or it may reduce the input of conventional energy into the object.

2. General Conditions

2.1. Definitions

2.1.1. Concerto area

Most of the indicators defined in chapter 6.3 refer to the so-called “Concerto area”. According to the Concerto PLUS agreement [1], *"depending on the community considered, the CONCERTO area might be:*

- *the whole community (city or metropolitan area)*
- *a restricted area including all the CONCERTO demonstration projects and buildings concerned by awareness campaigns*
- *an area made up only of CONCERTO demonstration projects"*

Because the data availability for energy consumption outside the demonstration objects will be very difficult, most of the results of impact assessment only refer on the demonstration objects. Therefore the Concerto area will be defined on three different levels, depending on the purpose of evaluation:

- The **community level** will consist of the area of the whole municipality or region respectively and will be used only for the evaluation of the effect of political strategies etc. This community level is mainly relevant for the work packages 1 (processes and planning), 3 (dissemination) and 6 (training). Because of the rather few demonstration buildings the physical effect of Concerto will be rather small on this level and it will be rather difficult respectively to estimate the indirect effects of the project.
- The **district level** will be used for evaluating the changes of total energy consumption in those parts of the city or region, in which the Concerto projects take place.

  In Hannover these are the following city quarters: Vinnhorst, Vahrenwald, Hainholz and Ahlem. In Nantes, the district level refers to the Île de Nantes. Analysis will be led to evaluate the energy savings obtained in the frame of the large urban renewal program led on this area.

  The district level will be important e.g. for monitoring the effect of the energy advice campaign (WP 4.3.5). The evaluation will be mainly performed on basis of calculated and estimated figures.
- On the **object level**, i.e. the summary of all Concerto demonstration projects, the data availability will be relatively good. This definition of Concerto area will be used for the technical monitoring (WP 2) as described in this guideline. All indicators defined in chapter 6.3 and 6.4 will refer to this definition level.

  According to this definition of object level, Concerto area will include all buildings and energy systems, whose (re-) construction or refurbishment was co-financed by Concerto funds. In

cases, where demonstration objects consist of several separate buildings, only those directly affected buildings will be regarded, which are retrofitted by Concerto EE-measures and/or supplied with energy by a Concerto funded energy system.

2.1.2. Object categories

During the Concerto project, different measures are realised in different types of buildings and energy systems, respectively. The evaluation requires different individually adapted monitoring tools and evaluation procedures. Hence, as definitions of object categories are necessary, they are presented in the following. The distinction is based upon the Concerto Plus agreement [1], but is carried out here with more details. In the case of object level the Concerto area is defined as the sum of all objects, which are treated by energetic measures supported by Concerto, and therefore buildings without financial support from Concerto, being defined within the Concerto Plus agreement, are not considered here. That is why from the 8 building categories defined in [1], only the following are relevant for the monitoring in Hannover and Nantes:

1. *"Demonstration buildings **RES**: Buildings receiving financial support from CONCERTO programme to use RES (e. g.: buildings getting connected to a district heating network based on biomass, buildings getting solar thermal collectors to support hot water preparation)*

2. *Demonstration buildings **RES+EE**: Buildings receiving financial support from CONCERTO programme to implement EE measures and to use RES[1] (major part of CONCERTO demonstration buildings). These buildings are defined as "eco-buildings".*

3. *Demonstration buildings **EE**: Buildings receiving financial support from CONCERTO programme to implement only EE measures (e. g.: buildings getting thermally refurbished keeping their gas based heating system) …*

4. *Other categories: Other buildings and system not considered in the previous categories, but part of the CONCERTO area."*

The relevance of the categories and their subcategories for the Hannover objects will be described in the following. For the Nantes projects, the categories and subcategories have to be checked and added, if needed. Their relevance has to be discussed, as well.

In general, the buildings of the above categories will be divided into subcategories according to the following distinction in order to assign the building types, used in the evaluation, to them:

i. Distinction old versus new

   a. old (subcategory "o") - i.e. already existing and modernised - buildings and systems and

   b. new ("n") - to be planned and installed - buildings and systems[2]

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[1] Inclusive connection to district heating of biomass in Hannover

[2] The distinction old or new refers only to the part of the demonstration object (co-)funded by Concerto, i.e. an old building, which gets a new planned photovoltaic system as only measure without retrofitting, is category "new". In

ii. Distinction of building utilisation

   a. detached/semidetached houses ("dsh"),
   b. multi-occupancy houses and ("moh")
   c. non-residential buildings ("nrb")[3]

The building types according to the above subcategories will be used for the technical indicator 3 (cp. 6.3.1) for RES+EE and EE objects). The following subcategory is only for additional distinction and may be used for non obligatory additional indicators or differentiation.

iii. In case of RES an additional distinction will be made for the different energy sources and systems:

   a. biomass ("bm"),
   b. solar energy by photovoltaic systems ("pv"),
   c. solar energy by thermal solar collectors ("sc")
   d. and maybe further technologies, if necessary

This will lead to the following categories, which are indicated with the above keys for a short identification:

1. Category RES

In **Hannover** mostly new systems in residential and public buildings are planned. In WP 4.3.5 (integrated measures) RES objects in residential buildings[4] are possible (but so far not planned).

The further distinction for Hannover RES buildings is as follows:

a. Solar electricity by new photovoltaic systems on non-residential buildings (category RES-n-nrb-pv) in WP 4.1.3
b. New solar heating systems for own consumption like in public outdoor swimming pool (category RES-n-nrb-sc) in WP 4.1.4
c. New wood fuel heating systems for public buildings (category RES-n-nrb-bm) in WP 4.1.2
d. New solar systems or biomass combustion in residential buildings (RES-n-dsh/moh-pv/sc/bm) in WP 4.3.5

In **Nantes**, there are two objects planned:

a. A pv power plant on a car park (category RES-n-nrb-pv) and
b. New solar collectors on multi-occupancy houses (RES-n-moh-sc)

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the case of combined RES+EE measures the distinction always refers to the retrofitting measures, i.e. an old building, which is retrofitted with better insulation and windows and gets a new photovoltaic system, is category "old"

[3] in Hannover these are all public buildings, in Nantes it is considered to make a further distinction between tertiary sector, commercial buildings and hotels

[4] In this WP also buildings with not 100% residential usage but mostly similar characteristics may be funded.

2. Category RES+EE

Most of the demonstration objects belong to this category. In **Hannover**:

a. Most of the multi-occupancy buildings with EE measures (WP 4.1.1, 4.2.1, 4.2.2 and 4.3.1) will be supplied by RES (biomass heat from the district heating system, adapted to the measured or expected consumption). This is regarded as a calculative RES supply into the buildings heating systems (category (RES+EE)-o-moh-bm).
b. Furthermore old (semi-)detached buildings, which are retrofitted (WP 4.3.5) may be equipped with RES systems like solar thermal, PV, wood combustion (category (RES+EE)-o-dsh-sc/pv/bm).

In **Nantes**[5]:

a. New multi-occupancy houses with EE (e.g. solar collectors): category RES+EE-n-moh-sc,
b. new non residential buildings with EE (e.g. solar collectors): category RES+EE-n-nrb-sc.
c. old multi-occupancy houses to be retrofitted with additional EE systems (e.g. solar collectors): category RES+EE-o-moh-sc.

3. Category EE

Hannover:

a. An existing public ecobuilding (WP 4.2.3), not found so far (category EE-o-nrb),
b. existing multi-occupancy buildings (WP 4.2.1, category EE-o-moh) and (semi)detached houses (WP 4.3.5, category EE-o-dsh) may be participating, as far as planned up to now.

Nantes:

a. An existing shopping center to be retrofitted (category EE-o-nrb),
b. existing multi-occupancy buildings to be retrofitted (category EE-o-moh)

4. Category "Other buildings or objects"

This category includes the buildings or objects, which may not be allocated to the above-described categories 1 to 3. These buildings or objects are not included in the determination of the indicators, but may be documented and analysed seperately.

In Hannover for instance, the wood energy centre (WP 4.3.2) with its activities of promotion and distribution of combustible wood to the public has a separate position, which may not be handled within the well-defined categories 1 to 3. The biomass (co-) combustion in the CHP-plant of Stadtwerke Hannover in Stöcken (WP 4.3.1) and supply to district heating network is no separate demonstration object, because its energetic effect is regarded with the supplied objects (see above, category RES+EE-o-moh-bm). Nevertheless the measure should be described and documented in the category "others".

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[5] The RES technologies to be used in the listed objects are not clear so far, so the RES subcategories are to be understood as examples

2.1.3. System boundaries

According to the Concerto PLUS agreement [1], "*it is supposed that CONCERTO communities will implement a detailed monitoring for the demonstration buildings …, meaning that yearly values for energy consumption will be delivered for every energy source and presented for heating, cooling and other applications… If hot water is prepared with another system as the one used for space heating (e. g. electrical or separated gas boiler), the corresponding energy consumption has to be monitored separately… Electricity consumption should be divided into the parts needed for heating and cooling systems (energy use and auxiliary energy) and the parts needed for other applications (e.g. lighting, ventilation if not combined with heating and cooling, appliances…)."*

All energy flows to be metered will thereby refer to the single Concerto demonstration objects. In order to have a precise system boundary in the case of central heating systems, providing several buildings, "**object**" will here be defined as "all buildings and/or parts of a building provided with heating energy from one heating system (boiler or district heating station)". That means, that in the case of large multi-occupancy buildings usually an object consists of more than one "building" (i.e. of more than one street number), no matter if there is a space between separate buildings or not (row houses). The energy consumption of the dwellings in multi-occupancy buildings might be metered or calculated in those cases, where it is possible, but not in all objects.

For impact assessment it is very important to consider *all* energy flows entering and leaving the system boundaries. This consideration is necessary because the energy flow differs in some objects between the status before and after a refurbishment.

Example: in case of replacing the electrical hot water preparation in the single dwellings by a central gas boiler or district heating station, each modification of energy source must as well be evaluated as all changes of the system efficiency, the auxiliary energy or the energy losses. The system boundaries must therefore be defined in such a way that all changes take place inside the boundaries. Then an impact assessment with precise conclusions concerning the energy efficiency is possible by monitoring the energy input into the system as well as the useful output, leaving the system (compare figure 2).

On the other hand the different building categories according to chapter 2.1.2 (EE, EE+RES, RES) require the distinction between energy consumption and energy production, because it is possible that the production from renewable energies reduces the consumption of conventional energy without reducing the total energy demand (because of conversion and energy saving losses it is even possible, that the total energy consumption rises).

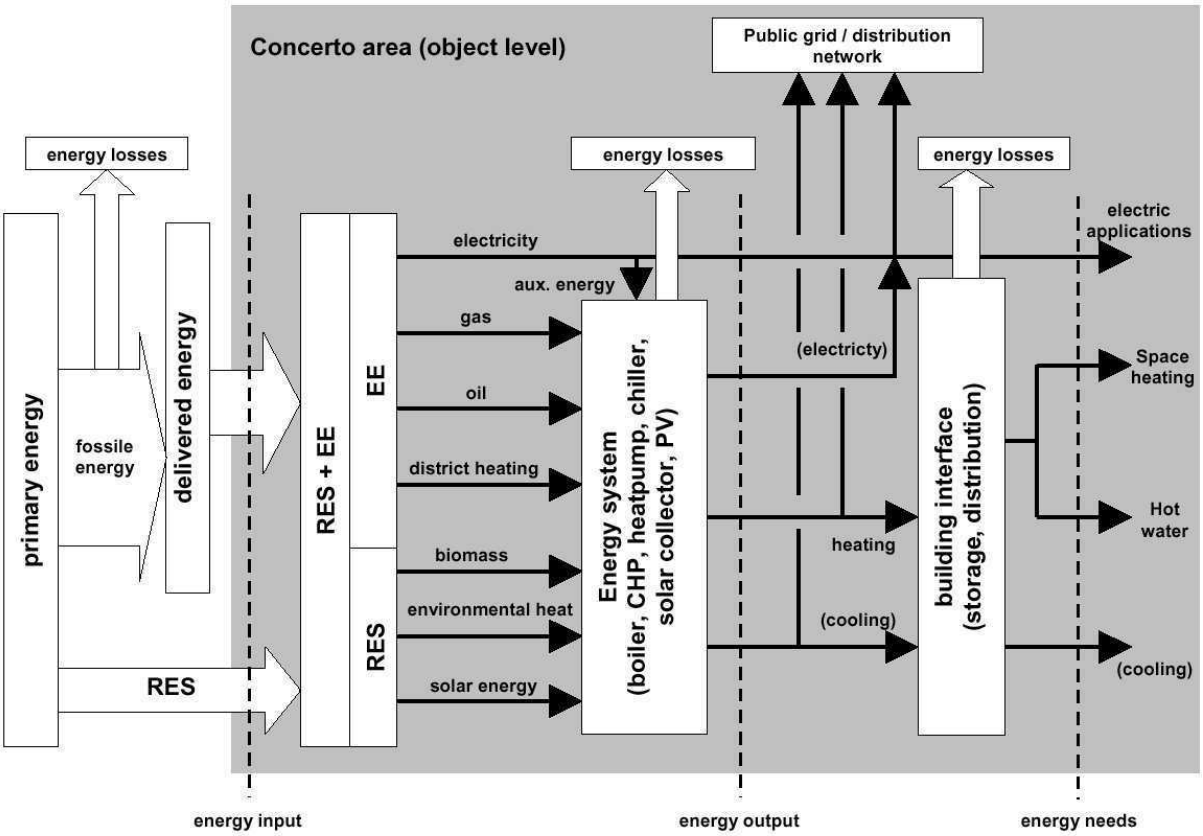

figure 2: Energy flows in Concerto area (object level)

For a consistent terminology in accordance with the indicators defined in chapter 6 it is necessary to define all energy flows in a precise way as follows:

- **Energy consumption** is the real consumption of energy (metered or collected separately for the different energy sources) in contrast to the **energy demand** (calculated with theoretical standard conditions). It may appear at different levels as shown in figure 2: energy input to the energy system (used for the indicators, cp. 6.3), energy output from the energy system and energy needs after the building interface

- **Energy input** means the energy consumption (gas, oil, electricity etc.) of the energy system (boiler, heat pump, CHP, etc.). In the case of conventional energy this delivered energy is not the original energy source (e.g. crude oil), but has yet been transformed (to fuel oil) and transported (see also chapter 6.4.1). In the case of RES the energy input is usually (except biomass) primary energy. In most cases the energy input can easily be metered.

- **Energy output** is the amount of energy in the form of heat, cooling and/or electricity (in the case of CHP and PV), which comes from the energy system. For RES-systems in particular, according to the Concerto PLUS agreement [1] *"for building energy systems, heating and cooling energy outputs … are defined as:*

  - for solar thermal collectors, the amount of thermal energy delivered directly by the collectors to the primary circuit;

- for biomass boilers or RES-CHP, the amount of thermal energy delivered directly by the boiler at the heat exchanger level;
- for heat pumps, the amount of thermal energy delivered in the condenser (heating mode) or abstracted in the evaporator (cooling mode);
- for absorption or adsorption chillers, the amount of thermal energy abstracted in the evaporator."

- During the process in the energy system there are **energy losses**, which leave the system and can usually not be metered directly, but in some cases calculated from the difference between input and output.
- In some energy systems like CHP and photovoltaic systems (PV) there is an **energy production** in the form of electricity, which reduces either the electrical power feed (delivery) from the grid or which may be fed into the electricity grid.
- The **energy system** is the technical system (boiler, CHP, heat pump solar collector, etc.), used in the demonstration objects to provide them with space heating, domestic hot water or cooling.
- Beside the main energy source all energy systems need **auxiliary energy**, mostly in the form of electricity. It can be metered in principal, but because of economical reasons this is mostly not realised. Therefore it usually must be calculated according to technical data and procedures or estimated statistically.
- The **building interface** is the additional system in the building, which is necessary to make useful energy (in the dwellings or rooms) from the energy at the output side of the energy system. It generates additional energy losses for storage, distribution and delivering devices, which can only be measured, if additional heat or flow meters are installed.
- The last steps in the energy chain are the **energy needs** in the form of useful energy. This level of energy consumption is the intended purpose of the whole procedure. The useful energy consumption can be divided (by metering in principal, but actually in most cases by calculation or estimation) into the services space heating, domestic hot water preparation and cooling. Additionally there is the electricity used for lighting, communication and other electrical devices, which - except for some special cases - directly comes from the energy distributor and does not depend on the building energy system.

In all cases, where the energy system changes due to the Concerto measures, it may be necessary to regard the effects in detail in order to adjust the resulting indicators and to make a correct interpretation possible respectively. For example the centralisation of the heating system by the substitution of gas heating systems and electrical hot water generator in the flats of a multi-occupancy house through a central district heating system for combined supply with space heating and hot water not only leads to a reduction of electricity consumption in the dwellings as a result of the missing pumps and an increase of the energy distribution losses, but also makes the substitution of the former gas cookers by electrical ones necessary, when the gas distribution to the building terminates.

For further explanations, how to get or calculate the different energy flows exactly, see chapter 3.

2.1.4. Object size

For interpretation of the energy consumption or the costs of the measures it is helpful, to define indicators or benchmarks, relating to the size of the object, where the energy is used. Depending from the kind of building the following definitions for the scale basis are used:

- in residential buildings: the useful area (in Hannover objects "Wohnfläche" according to German Wohnflächenverordnung[6], in Nantes the definition has still to be cleared in detail),
- in non-residential buildings: the gross area and/or gross volume (in Hannover objects "Bruttogrundfläche" BGF and/or "Bruttorauminhalt" BRI according to DIN 277, in Nantes the definition has still to be cleared in detail)
- for outdoor swimming pools: the pool area

In most cases it will not be possible to make a difference between the heated and not (directly) heated part (like stair cases) of the building, because the exact data will not be available. But in the case of the regarded Concerto demonstration objects the part of the non-heated area and also the resulting mistake is expected to be small. The useful area is the most important parameter, the housing societies deal with - no matter, which part of it is heated.

In addition to the object size it may be helpful, especially regarding the costs of refurbishment, to refer to the size of the reconstructed components (see chapter 2.4 and 6.3.2).

2.2. Baselines

All energy consumptions and indicators have to be compared with a baseline as reference to make a useful interpretation possible. According to the regulations of the act2-contract and the BEST-tables in its Annex, different baselines are defined as follows, depending on the building category and the taken measures. In any case values of energy *consumption* will be taken as baseline. Only if there are no metered data available, a simulation with a software tool (cp. 3.1) basing on the theoretical energy *demand* will be made.

According to the BEST-tables (cp. 2.3) the following baselines have to be defined:

- Energy-reference 1**: status before Concerto measures**.
  - 1a) In the case of **refurbishment** data of heating energy and electricity consumption will be collected by the local energy distributor on the building level (data of dwellings accumulated) in the case of multi-occupancy buildings and from the building owner in the case of (semi-)detached houses and non-residential buildings. If available, the average of the last three years will be taken as energy input according to figure 1 and used as

[6] "Wohnfläche" will be used for data analysis according to chapter 6, the legal standard in Germany according to EnEV refers to a different definition (heated gross volume multiplied with factor 0,32)

baselines for each object and each energy source. For heating energy a climate correction (cp. 5.2.1) will be made. If hot water is prepared by the heating system, an adjustment to the space heating fraction according to the metered results (if existing) has to be undertaken, otherwise by calculation or estimation (cp. chapter 5).

- 1b) In the case of **new buildings** the average values for heat energy consumption of comparable new buildings will be taken as the base line, defined by the requirements of the national regulations (RT2005 regulations for objects in Nantes, in Hannover there will be no new buildings) and a gas condensing boiler as standard heating system. This value of an energy demand has to be transferred to the corresponding heat energy consumption (input) by software simulation or the algorithms of RT05 calculation method (cp. 3.1) with local standard climate conditions.

- 1c) In the case of objects with **renewable energies** (funded by Concerto) the baseline will be defined by the reference value of an average building or system with no RES contribution (in the case of photovoltaic systems an electricity consumption which is equivalent to the solar feed to the grid of a standard PV system of the same area is defined as baseline).

The baseline of the energy references 1a-1c will be necessary for calculating the technical indicators 1-4 (cp. 6.3.1)

- Energy-reference 2: **legal requirements** for existing buildings in the case of retrofit and for new buildings, respectively (EnEV2004/2007 in Germany, RT2000 and RT2005 for new buildings – regulations for existing buildings in France will be published in 2007). This baseline is necessary for the comparison in the BEST files and is defined as follows:

  - for Hannover the EnEV requirements are defined as the maximum specific transmission heat loss (H_t' in W/m²K). Additionally the specific primary energy demand (Jahresprimär-energiebedarf Qp" in kWh/m²a) according to the EnEV calculation method must not be higher than the limits tabulated in EnEV. In the case of retrofit both values may be 40% higher than for a new building.
    The resulting value of an energy demand has to be transferred to the corresponding heat energy consumption (input) by software simulation (cp. 3.1) with the real heating system before retrofitting and local standard climate conditions[7].

  - For Nantes the definitions and calculation procedures have still to be cleared in detail…

2.3. Standards defined by Concerto

The Concerto standards for the EE demonstration objects are defined in the act2-contract and the BEST-tables in its Annex:

[7] The EnEV refers to a German standard climate (degree days per year or monthly average temperature respectively), which differs from local conditions in Hanover *(less a problem in France and for Nantes : the RT2005 defines 8 climatic zones in France)*

- in **Hannover** three levels of Concerto standards are defined, depending on the building category and the taken measures:

  1) Retrofitting to new building standard (**EnEV-new**): the Concerto standard for retrofitting existing buildings at this level corresponds to the EnEV requirements for new buildings, referring to the maximum specific transmission heat loss H_t', which is 29% less then the EnEV retrofit requirements. Because the criterion only refers to the transmission heat loss, the heating system has no relevance for the standard.

  2) Retrofitting to a standard, following the **Kronsberg** standard, first practised in the EXPO demonstration quarter on the Kronsberg in Hannover. It is defined as a maximum final energy consumption for space heating of 55 kWh per m² floor area (definition of EnEV). This value has to be proven with the value for final energy demand for heating (Heizenergiebedarf Q_H) according to the EnEV and DIN 4108-10 with the old heating system under standard local climate conditions.

  3) Retrofitting to halve the heating energy use (**50% saving)**: this standard is used for public buildings, in which the final energy consumption for space heating has to be reduced by retrofitting the insulation and ventilation system (without regard to changes of the heating system) to less than 50% of the consumption before the measures (see baseline definition in 2.2). The energy saving has to be proven according to the EnEV calculation method with the old heating system under standard local climate conditions.

  The above defined Concerto standards (=requirements) will not be energetically evaluated within the monitoring procedure. They are used as a threshold value, which has to be gone below in order to receive the Concerto funding. The claimed values (H_T' or energy demand and consumption, respectively, see items 1 to 3) will be compared within the documentation with the specific object related values which have been achieved.

  It is task of the monitoring to compare the predicted energy consumption, resulting from the measures taken to fulfil the standards, with the measured consumption before and after the Concerto activities (cp. chapter 6). As all standards refer to a calculated energy *demand* for space heating under standard conditions, therefor the result has to be transferred for each object to the predicted energy *consumption* including domestic hot water (DHW) under realistic conditions (cp. chapter 5.2). Therefore software simulations (cp. 3.1.1) (of the realised construction, not the standard) with Hannover climate and the heating system of the retrofitted object will be made.

  The necessary data will be delivered by the planners of the measures via the community of Hannover.

- The standards in **Nantes** differ between new and existing buildings. For **new buildings**:

  1) Housing and Office: 23 to 25% Energy saving on space heating in comparison to the previous French regulation RT2000. It could correspond to the HPE (Haute Performance Energétique: High Energetic Performance) standard in reference to the new French regulation RT2005 (10% global energy saving).

2) Office: EcoTech: 63% Energy saving on space heating in comparison to the previous French regulation RT2000.

3) The standards for Hotels and commercial are note defined yet.

Existing buildings:

4) 80 kWh/m²yr for the total space heating. As regulations in existing buildings do not yet exist in France, the standard has be defined in comparison to a test building of the 20 th century.

For further details and the manner of calculation of the EE standards also see the file "standard.xls" in the collection schema (see annex). For RES demonstration objects there are no explicit standards to be reached.

In addition to the above described Concerto standards, which must be fulfilled to be funded by Concerto, more advanced standards/technologies will be regarded and analysed to benchmark the demonstration objects:

- **Best practice technology (BPT)**: there will be an evaluation of best practice examples for **retrofitted buildings**, which will be taken as a reference standard in dependency of the building type. For residential buildings this will probably be the energetic retrofit program of the Deutsche Energie-Agentur (dena) "NEH im Bestand" (www.neh-im-bestand.de), for non-residential buildings the online documentation of BINE (www.energie-projekte.de) for Hannover objects. The BPT-standard for the objects in Nantes still have to be defined.

- For **new buildings** BPT is defined by the Passive House standard, which requires a maximum heating energy consumption of 15 kWh/(m²a) and (in the case of residential buildings) a maximum primary energy consumption for heating, hot water and electricity of 120 kWh/(m²a).

- For **RES** demonstration objects the BPT standard has to be defined specifically. A proposal is undertaken for some systems as follows[8]:
  - small solar thermal systems meet the BPT requirements, if their solar fraction for domestic hot water is at least 60%[9]. In this case, the solar system is in normal (semi-) detached houses able to cover the demand during at least 4 summer months by 100%.
  - large solar thermal systems (e.g. multi-occupancy houses) should be designed for a minimum thermal yield. It is proposed, that the thermal output per year (under mean meteorological conditions) is at least 350 kWh/m².
  - outdoor solar swimming pool heating systems with cost efficient unglazed plastic absorbers should come up to a thermal output of 200 kWh/m²a (between 15. May to

[8] Especially for solar thermal systems it is not possible to postulate a singular figure, due to the strong dependency of solar fraction and thermal yield. The balance between both is fixed during the design process and therefore no quality indicator.

[9] Solar fraction defined as the portion of useful energy, that has not to be delivered to the solar storage tank.

15. September), at a base temperature of 22℃ [10] or 250 kWh/m²a at a "solar only operation" mode.

- for biomass burner and vessel combinations, the maximum yearly average losses in % will be defined as a function of the load.
- for PV systems, a minimum performance ratio (PR) of 75% is proposed as BPT[11].

- The **best available technology (BAT)** is defined as the Passive House standard for new and retrofitted buildings.

- For **RES** demonstration objects the BAT standard cannot be defined in case of the solar systems, as a wide variety of products groups is available, with a wide variety of costs. Thus, the BAT is in most cases too expensive to be reasonably used as standard. The BAT, however, could be derived from the above listed BPT values, with higher yield or efficiency values.

2.4. Costs of Concerto projects

Several indicators to be evaluated refer to the costs of measures (see 6.3.2). To convince housing societies and private building owners to invest in energy efficiency measures it is one of the main targets of Concerto to prove, that it is economically possible and reasonable to do more than the national legislation requires in the case of the construction or refurbishment of a building. Therefor, if available data make it possible, the investment costs to reach the Concerto standard shall (at least in some representative objects) be evaluated in comparison to the baselines defined in 2.2. Costs can be verified as specific values either in

- € per m² retrofitted surface for each measure,

- additional as an accumulated value for all measures in € per m² useful area or gross area respectively,

- in € per kW installed for heating (power of boilers or solar collectors), cooling (power of cooling generator) or electricity (PV generators) or

- in € per kWh saved (EE objects) or produced (RES objects) in comparison with the different baselines.

All costs are restricted to investment costs, running costs for maintenance, repair, etc. are neglected in this evaluation. The data needed have to be collected from the planners, the housing societies or building owners.

If possible the evaluation will (at least in some representative objects) differ between:

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[10] The base temperature is a minimum value achieved permanently via a conventional burner/vessel combination, which heats the pool if the solar radiation is not sufficient. It is only of importance in bivalent pools. Without conventional backup heater, it is named "solar only" operation.

[11] The PR value is the ratio of the measured yield divided by the product of peak power and irradiation. It is describing the quality of a system and is independent of the location.

- the total costs for all measures[12],
- the additional costs only for energetic improvement without the costs for reparation measures with no relation to energy aspects (e.g. a new paint including the costs for the scaffolding are not included in these additional costs),
- the costs for the measures realised additionally (compared with the legal requirements) to fulfil the Concerto standard .

It is obvious in the moment, that this additional cost evaluation may only be carried out by estimations, because it is not possible to receive real data for the theoretical intermediate states "neglection of the necessary repairing measures and cost comparison between legal and Concerto requirements".

2.5. Period of monitoring

The monitoring period shall start as quickly as possible after termination of the (re)construction measures and last at least for one year. With regard to data availability in the best case a monitoring period up to four years until the end of the Concerto project will be possible.

From a practical point of view the energy data will be collected as yearly values and additionally - depending on the data availability - as monthly values for some objects (see 5.1). In general the decision has to be taken, whether calendar years or the heating years (e.g. from June to May) shall be used as reference period. If the energy consumption data are collected from the local energy company in a time sequence, that differs from the chosen reference period, there will be a climate correction necessary in the case of heating energy. Furthermore a time correction to 365 days has to be made, if the collection or metering period is shorter or longer than one year (cp. 5.2).

3. Auxiliary Means

3.1. Software tools

3.1.1. Software for calculation of the energy demand (EE objects)

The calculation of the expected energy demand for heating and hot water including auxiliary electric energy has to be carried out with appropriate software programmes. The calculations are performed with different objective targets, i.e. the results of the calculations are used for different purposes, as follows:

1. Calculation of the expected energy saving, which

[12] Only for measures referring to energetic refurbishment in any manner, i.e. incl. planning and additional attendance of tenants, but without new bathrooms or similar measures.

- may be done with a calibration of the users by adapting the calculated to the real consumption of the past by varying the behaviour of the users. In this case the energy saving by measures may be calculated under the assumption of equal user behaviour.
- Or, secondly, which may be done without taking into account the recent consumption values. In this case, only relative saving figures should be derived from the calculations, like the indication of the percentage of the former consumption will be saved.

2. Assuring the compliance with given standards like the Concerto baselines (see cp. 2.2) and the Concerto standards (see cp. 2.3), especially the given legal requirements and the EU contract based BEST tables.

3. Inter- and extrapolation of measured consumption data (where required, of calculated demand values, too) in cases, where no measured data for partial or intermediate results are available. This will be the case, if e.g. for an existing system the auxiliary energy consumption has to be determined, but no electricity metered values are available or the input for a domestic hot water system at a given output has to be determined.

A couple of software tools have been regarded and discussed up to now. Further tools will come to use, especially for the calculation of the legal requirements in France and, if and where necessary, programmes which calculate the cooling, ventilation and lighting energy demand.

1. EPA-ED

   EPA-ED (see www.epa-ed.org) is software that calculates the energy demand of residential buildings. It has been developed within a EU project, as well to be used for the issue of the energy consumption identification.

   Assessment:

   - The documentation is not sufficient, so it is not clear what in detail the programme calculates.
   - While the building physics seems to be presented well, the energy system behaviour is not simulated in a sufficient way. Here, yearly mean values have to be fed by the user into the programme, whereby the task of such a programme from our point of view is to calculate the system behaviour from given construction data. I.e., EPA-ED is not appropriate in this project.

2. PHPP **2004** (Passivhaus-Projektierungs-Paket, Passive House Planning Package)

   PHPP (see www.passiv.de) is software especially developed for the calculation and simulation of the energy consumption of Passive Houses, in order to support the design process and to certify the building. It is based upon EN 832 (building physics) and describes the heating, ventilation and hot water systems in detail. It may be applied to houses with a lower standard, if so, however, showing some restrictions, and it is available in different languages. Because of its high accuracy (for very good insulated buildings) PHPP has been chosen from proKlima before the elaboration of the monitoring concept has started.

   Assessment:

- The accuracy of the calculated results is proven for many realised objects and for a very high efficiency standard (Passive Houses an comparable) is better than that of other programs.
- PHPP may be used from EXCEL experts. It is consisting in 32 tables, not always very clearly linked. Because of the realisation as EXCEL sheet all calculation algorithms are fully transparent in principal.
- PHPP may be used for the calculation of the expected energy saving (target 1). Important is to select reasonable boundary conditions.
- Some calculation algorithms (especially concerning the heating system) are only valid for passive houses (or buildings with a comparable low energy consumption)
- There is an integrated EnEV-calculation tool (for buildings with passive house suitable heating systems)

To make the programme more suitable in handling and adapt it to the special conditions of Concerto, a modified version will be made available by proKlima.

3. Software according to the German Energy Saving law **EnEV** 2004/2007

   The German Energieeinsparverordnung, EnEV, contains calculation procedures, which have been transposed in several calculation programmes. With these programmes, which should be certified, both the verification of the law and the Concerto standards (and with some restrictions the calculation of the predicted energy demand) may be carried out. The software containing the EnEV procedure is generally available among the German energy consultants.

   Assessment:

   - EnEV software is widely spread and accepted.
   - It must be used for the legal building certificate and may be used for the prediction of the energy demand and energy saving. However, the latter requires an accurate selection of the boundary conditions. It could furthermore be used for the inter- and extrapolation of measured data.

State of discussion is, to use EnEV software (preferable with the integrated tool in PHPP) for the proof of Concerto requirements and the PHPP algorithms for comparing the expected energy saving with the monitored consumption for all objects[13] in Hannover. This requires the adaption to the special conditions of the Concerto objects as mentioned above.

4. Software according to the French Energy Saving law **RT2005**- RT2007

   The french Energy saving regulation RT2005 for new buildings concerns the global energy consumption of the building (heating, hot water preparation, electricity consumption due to ventilation, heating, lighting or cooling). The regulation defines therefore a calculation algorithm Th-C-E. This procedure, in particularly, contains the calculation of the energy demand (that includes the loss due the distribution, regulation, stocking of hot water and the loss due to the heat emission). Software containing the Th-C-E procedure is available among all the French energy consultants. In France, the calculation is compulsory for every

[13] For WP 4.3.5 (integrated measures) the use of PHPP is recommended but not obligatory

new building (except One Family Building). **In Nantes, it is planned to use this calculation procedure**, with a comparison to the EnEV one, to have comparable data.

3.1.2. Software for Special and Renewable Energy systems (RES)

Special systems and RES and their annual behaviour can normally not be simulated with the available software for the energy demand of buildings[14]. In this case, appropriate software has to be used.

This will be the case for

1. solar thermal heating systems for domestic hot water (for both Hannover and Nantes),
2. solar thermal swimming pool heating (only for Hannover) and
3. solar photovoltaic systems (for both Hannover and Nantes).

The target for this software is, following cp. 3.1.1,

1. Calculation of the expected energy production during the planning process,
2. Inter- and extrapolation of measured production data, especially to standard weather and consumer conditions, in order to compare with expected and BPT values.

In agreement with the final definition of objects and the related design process it has to be decided, if a simulation is necessary and which software will be selected.

3.2. Data sources

In the following chapters the data sources for the monitoring of the Hannover demonstration objects are described. For the objects in Nantes they are not clearly defined in detail so far, but the procedures will be very similar.

3.2.1. Energy consumption in EE objects

For the multi-occupancy residential buildings the energy consumption will be measured by metering. According to the end energy delivered (i.e. the energy input into the object) the heat or the gas delivered are to be measured by calorimetric heat meters or natural gas counters. In addition, electric counters will measure the electric energy for common use (light in staircases etc.). The electricity consumption of the apartments is usually not available. It has to checked, whether the aggregated consumption data for the whole building can be taken from the so-called MAP-INFO database of the Stadtwerke Hannover AG (SWH). The concept of data acquisition including the list and arrangement of meters, already existing or to be installed, and

[14] RE and special systems, which normally may be simulated with the standard building software (see ch. 3.1.1), are heat pump systems, ventilation systems and systems with wood fired heating boilers. Not to be directly evaluated by the software are solar thermal heating and solar PV systems, CHP systems, systems with long-term storage etc. It therefore has to be decided carefully, if new software has to be applied.

the frequency of readings will be contained in the data file "documentation_ee.xls", which will be available for each of the EE objects. This EXCEL sheet is available as an example in the collection schema (see annex).

For the (semi-) detached houses, only the delivered energy input into the building (district heat or gas and electricity) will be metered. It will be decided by proKlima, whether the meter readings are performed by the occupants and sent to the monitoring office or, if possible, the consumption data are taken from MAP-INFO database.

The energy consumption of those buildings, where RES are installed, has also to be measured with appropriate meters. For these objects, the concept of data acquisition including the list and arrangement of meters and the frequency of readings is contained in the data file "documentation_res.xls", which will be available for each of the RES objects. An example of this EXCEL sheet is available in the collection schema (see annex).

In case of the data for the years before the Concerto measures (status quo ante), it is planned, that the information will be delivered by the Stadtwerke Hannover AG via proKlima for both the multi-occupancy and (semi-) detached houses.

Statistical data and methods will be applied in order to come to an estimation of the energy consumption development at the district or community level. The Landeshauptstadt Hannover and the Stadtwerke Hannover AG will deliver these data.

3.2.2. Energy production in RES objects

The energy production of RES will be metered and read, according to the concept of data acquisition, which is described in the data file "documentation_res.xls" in the collection schema (see annex), including the arrangement of meters and the frequency of readings (see cp. 3.2.1).

RES are not measured, if they are small RES systems within an energy consuming system and their task is mainly to reduce the energy consumption of the object or the effort of installing and reading special meters would be too high[15]. Then the RES supply will be calculated beside the EE analysis using the software tools of cp. 3.1.2 or using rules of thumb.

3.2.3. Climate and Weather Data

The climate and weather data as well have to be distinguished between

- long term values, which are typical for the site (climate),
- the actual values before the Concerto measures (related to the energy consumption of the status quo ante) and the actual values during the monitoring period after the Concerto measures (weather).

[15] This is usually the case at small solar domestic hot water systems. Anyway for the city of Hannover the solar quality assurance package of proKlima is recommended, which includes a metering equipment for the hot water production (cold water meter and hour meter in package "basis" and additional caloric heat meter in package "plus"). In this case the building owners should perform the reading of the meters.

Important for the monitoring of energy data are

- the ambient air temperature and
- the solar radiation, i.e. the global irradiation (on horizontal surface).

Further meteorological parameters like wind velocity are not considered up to now, but may become necessary, if an accordingly application would enter the project.

1. Long-term meteorological data for sites

   The ambient temperature must be available on a daily basis for the calculation of the degree-days, and the global irradiation must be available on a monthly basis. These data have to be taken from national regulations or standards.

   In **Germany**, this is DIN 4710 (2003) for temperatures and irradiation. Long-term values for degree-days are contained in DIN 4710, VDI 3807-1 and DIN 4108-6 (cp. 5.2.1). Additionally the DWD publishes values for several weather stations including Hannover in the internet[16] . The long-term climate conditions, used in EnEV calculation method or in the software tool PHPP do not explicit refer to degree-days, but are related to monthly mean temperatures. If necessary, these temperatures will be modified to ensure that all climate correction procedures (see also chapter 5.2.1) will refer to the same long-term climate.

   The data sources for long-term meteorological data for **Nantes** have to be researched.

2. Actual meteorological data

   The heating degree days for evaluation and correction purposes may be calculated individually (i.e. adapted indoor temperature and maximum outdoor temperature of a heating day) using the available ambient temperatures (see also chapter 5.2.1).

   Data for **Hannover**:

   a. The daily mean ambient temperature is available for Hannover from the data of Deutscher Wetterdienst (DWD, www.dwd.de), for the station of Hannover Langenhagen since 1991 with only a few days of delay.

   b. The solar global irradiance is not available for Hannover so far. The DWD source contains only the sunshine hours for Hannover Langenhagen. In the neighbour city Braunschweig (80 km to the east) the global and diffuse irradiation on a horizontal receiver plane is measured by DWD. This data may be bought in an hourly basis and be regarded as Hannover values[17].
   Having done this, a radiation model (Hay/Davies or modified) will be applied to the data for the horizontal surface and the irradiation data for the inclined and differently oriented

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[16] It is recommended not to use the data from DIN or VDI, because the long term period, used in VDI 3807-1 is from 1951-1971 and no longer representative for the nowadays climate. The time period, used in and DIN 4108-6, is not specified. Therefor the data published by the German weather service DWD in the internet should be used and converted to the proposed definition of degree day of VDI 3807-1 (see ch. 5.2.1)

[17] Up to now, it seems unrealistic to correct the Braunschweig data to Hannover conditions, using the available sunshine hours, as they are only available on a daily basis for Hannover instead of required hourly values and the Braunschweig data have to be calculated from radiation data. Due to the resulting uncertainty and the high data acquisition and correction effort, it is desired to have a meteorological station with solar radiation measurement in Hannover (global and diffuse). This is still an open discussion with proKlima.

surfaces will be calculated. This procedure requires global an diffuse radiation data at least on an hourly basis.

The availability of **data for Nantes** must still be clarified in detail. A priori, only daily mean temperatures are available. Data on the local irradiance are available at Meteo France. Some can also be collected by setting adapted instrumentation when implementing solar systems (both PV and solar thermal ones).

3.3. Metering Equipment

3.3.1. Quantities to be measured

The coordinating group of Concerto Plus [1] worked out three main requirements for metering, which are listed and discussed as follows:

1. *"Yearly measured values of energy production and energy consumption should be provided for at least two years to Concerto PLUS in kWh/yr."* This has to be done in a summary for the Concerto area, defined on the object level (see cp. 2.1.1). That means, that the single objects have to be metered in an adequate way.

2. *"Daily average value of ambient air temperature and ideally hourly global solar radiation on the horizontal in the Concerto area should be provided for the same period when the metering is taking place"*. The discussion about climate and weather data including the heating degree-days is presented in chapter 3.2.3, see also footnote 17.

3. "*For RES-plants and cogeneration plants, the yearly energy balance should be provided considering RES-input, non-RES input, auxiliary energy input and heating, cooling and electrical energy output.*

For demonstration buildings, CONCERTO communities will deliver the metered values for the data points", defined in the agreement. These are the input of RES (in case of solar the yearly irradiation onto the solar aperture), of non renewable energy like a backup gas boiler, and the auxiliary electricity for pumps etc. and on the other hand the output energy quantities for heating, cooling and electricity, respectively (see also figure 2).

Especially in the case of EE objects, the focus is directed to the energy input, which is combustible material or district heat and electricity. Not in all cases the heat output of a vessel for instance may be measured. Details are to be found in the object specific documentation files (see cp. 3.2).

3.3.2. Measuring instrumentation for energy consumption and production

1. The electricity input will be measured using electricity meters. Where applicable auxiliary electricity (for the energy and building interface system) and the normal household electricity for lighting, communication etc. will be measured separately.

2. The object thermal end energy input (non RES) will be measured by gas meters or calorimetric heat meters whichever is applicable[18].

3. The object internal transport and distribution of heat will be measured by heat meters and heat cost allocators, where applicable. This is e.g. the case with multi-occupancy houses, where the individually to each flat delivered heat shall be determined, if possible. The hot water consumption, in case of a central hot water system will be determined using water meters. The hot water supply temperature must be known.

4. The aforementioned items 1 to 3 are correspondingly to be applied for the RES production objects. Heat production will be measured with calorimetric heat meters[19], electricity production with electricity meters.

5. Instruments for meteorological data may be foreseen, especially solar radiation, if no other reasonable source will be available (cp. 3.2.3).

6. The time-based dissolution of data will be at least once per year, however, in some objects a higher frequency of data acquisition (once per month) is planned to be realised. The technical procedure of data acquisition may be very different; a range from reading to electronic remote readout is given. Details are described within the object documentations (cp. 3.2.1 and 3.2.2).

4. Documentation of objects and measures

- Primarily, the documentation of all projects and all measures has to be carried out in a way that the main information of all projects and measures are summarised, i.e. one file contains all projects including links to the files with detailed data.

- For each object one related data file will show the characteristics in a widely unique format to enable a fast overview.

The following set of data files will be used[20] (for the allocation to the workpackages see the file workpackages.xls in the collection schema):

1. An **overview over all demonstration buildings** (RES, EE, RES+EE) with Concerto co-funding will be given in the data file "objects.xls" (see example in the collection schema in the annex). It contains a short description and classification of the specific objects, including

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[18] Delivered not pipeline-bound end energy like oil or wood must be counted in the moment of delivery. The yearly consumption has to take into account the stock content (measurement, even if only possible with high uncertainty). Instantaneous consumption data may be derived from the transport device or the burner/vessel combination using a meter for the hours of operation, if applicable and calibrated.

[19] only in case of large RES systems

[20] The documentation schema as described has worked out only for Hannover so far. It has to be adapted and modified in detail for the demonstration objects in Nantes. It is the aim, that the documentation schema will be as similar as possible.

links to the object related files. Furthermore, the reference to the indicators to be determined (which indicators have to be determined in which way and which frequency) will be given.

2. **Object characteristics for EE measures** are described for each object in a specific data file (see example "documentation *ee*.xls" in the collection schema).

   The object specific documentation files contain the overall short description of the building, its purpose, size, inhabitants etc, the building surfaces and their insulation capability, the energy system for distribution of heating, cooling, ventilation energy and hot water. The measures are described as precise as necessary, i.e. shortly but with the essential key figures (areas, insulation thickness, energy system changes etc.), but not containing every detail[21]. Furthermore, the costs of the measures and the monitoring details will be available in these files.

   Due to the fact that in all EE objects comparable measures will be realised, the information will be given in a standard schema that can be used for all EE buildings. These tables contain an overview, the measure description, the cost evaluation and the monitoring concept including the metering procedure.

3. **Object characteristics for RES measures** are described for each object in a specific data file (see example "documentation *res*.xls" in the collection schema).

   Although some of the RES projects comprise similar measures, single description files have been created for every RES demonstration object. Although the structure is comparable to the EE object files they have to be adapted to the special RES measures.

4. The description of **object characteristics for combined EE+RES measures** depends on the measures in detail. In many cases, for example the retrofitting of residential buildings in Hannover (=EE), which are combined with the connection to district heating from biomass (=RES), it will be possible to use the same description schema as for EE measures.

5. Data acquisition and correction

5.1. Data acquisition methods

The methods to get the data are metering, collection, calculation or estimation, as defined by Concerto PLUS (cp. chapter 1.3).

Whereas metering is done by measurements in the Concerto demonstration objects (cp. 3.3), collection is on the one hand the delivery of anyway existing data e.g. of the housing companies (owner) or the energy supplier or on the other hand meteorological data from e.g. weather services. Statistical data from the local energy supply company, the community or other organisations are to be collected, too, in order to assess changes on the district or community level.

The following types of data have to be gathered:

[21] Technical drawings are not included as well as detailed descriptions of thermal bridges or the air tightness concept. As this is not part of the energetic monitoring, special efforts are only shortly summarised.

- Thermal energy for heating, cooling and ventilation, whereas in Hannover only heating occurs, metered as monthly or yearly sums after the Concerto measures and collected as yearly sums before the measures, on the object level.

- Thermal energy for hot water preparation. Direct calorimetric or volumetric metering of the hot water or the input into the hot water system may be used, where equipment is available. Missing values of the hot water system may be extracted from summer heat consumption, where applicable; and missing system losses may be calculated from the EnEV procedure (cp. 3.1.1). The documentation files (cp. 4) contain the necessary energy system data.

- Auxiliary electricity demand for heating/cooling/ventilation and hot water system will be calculated and estimated, respectively, according to the EnEV- procedure.

- Electricity consumption, which is not used for the energy systems, (lighting, machines, communication etc.) will be collected via Stadtwerke Hannover AG on the object level.

- Electricity production by RES or CHP will be metered directly on the object level (production facility), at least on a yearly basis.

- Heat production by RES or CHP delivered to a larger distribution system (district heating or multi-occupancy building heating system) will be metered directly on the object level (production facility), at least on a yearly basis[22].

- The costs of measures will be collected from the planners and construction managers on the object level. If possible, a more detailed differentiation in energetic improvement vs. non-energetic parts (repair, renovation, modernisation, esthetical measures etc.) will be done by estimation.

Precise definitions of the source of the measured and collected data and the way to accumulate (who, which data, how often) and the way of data calculation and estimation, where applicable, are summarised within the object specific files (see as examples the files "documentation_ee.xls" and "documentation_res.xls" in the collection schema in the annex).

5.2. Data correction procedures

The energy consumption and energy production respectively is influenced by the specific meteorological conditions and the user situation in a distinct year of monitoring. In order to compare with long-term results (the expected ones for the future or the former ones before the Concerto measures) the acquired raw data have to be corrected to standard conditions.

[22] While electricity from RES will normally be fed into the public grid, heat from RES may be used to reduce the supply of conventional end energy, without delivering it into a pipeline based supply network. This will often be the case for solar domestic hot water systems. Then the measure is both a measure of production of heat by RES and a measure of reducing the energy consumption, i.e. one of the EE measures. Both considerations will be carried out. At small systems, the RES production will typically be calculated or estimated, whereas the reduction of consumption caused by all EE measures will be metered.

5.2.1. Heating degree-day correction

The measured energy consumption for heating may be corrected to a yearly value at standard weather conditions by applying the heating degree-day and time correction. It is proposed to use the German correction method for the objects in Hannover as well as in Nantes[23]. This correction method is described in VDI 3807 Blatt 1. It deals both with the degree-day correction and the period length correction[24].

A different method, basing on a room temperature of 20 ℃, is the VDI 2067 part 1 method [25].

The following correction method with a room temperature of 20℃ and a heating limit temperature of 15℃ [26] will be used:

$$number\,of\ \deg ree-days = Gt_{R,\,Hg} = \sum_{n=1}^{z}(T_{room} - T_{ambient})$$

for all days with $T_{room} < T_{heating\ limit}$

with n = number of days, z = number of heating days below heating limit temperature

As long term values it is recommended for Hannover to use the data published by DWD in the internet[27]. For Nantes the data sources have still to be researched.

5.2.2. Solar irradiation correction

The measured output of a PV- system may be corrected according the rule of proportion (i.e. equal performance ratio). That means, the measured yield will be corrected with the ratio of long term irradiation and actual irradiation, both as annual values.

For solar thermal systems, no widely accepted correction method is available. For a system with a very small solar fraction, the rule of proportion may be applied, too. For swimming pool

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[23] Rules for calculation of the heating degree days may not be the same in Germany and in France. Precisions will be brought later

[24] Characteristic values of energy consumption in buildings, part 1: Fundamentals; VDI Richtlinien, Juni 1994. The maximum mean ambient temperature at a heating day is set to 15℃ (heating limit acc. VDI 3807), may how ever be adapted to a lower value. According to DIN V 4108-6 (basis for EnEV procedure) the heating limit is regarded to be at 10℃ for new buildings. The room temperatu re in VDI 3807 is defined to 15℃ (because of the in ternal and solar gains, assumed to be high enough to cover the difference to the real room temperature of 20°C).

[25] VDI 2067 in its actual version does not contain any more the definition of degree-days. The new draft of VDI 3807 from February 2005 however comes back to the former VDI 2067 definition. DIN 4108-6 uses the same definition, but the room temperature there is set to 19℃.

[26] this differs from the definition in the BEST-tables with a room temperature of 19 ℃, but is according to the definition of Concerto PLUS [1] and the actual degree-days published by the DWD

[27] www.dwd.de/de/wir/Geschaeftsfelder/KlimaUmwelt/Leistungen/Statistiken/GTZ_aktuell.pdf. The long term average refers to the years 1991-2000, which means for Hannover a value of 3652 Kd/a. This differs from that one in the BEST-tables (3998 Kd/a according to VDI 2067), but is much more suitable to actual weather conditions.

heating systems and typical domestic hot water systems, a correction using simulation tools may be performed.

5.2.3. Further corrections

Further corrections may be applied, carried out carefully and justified reasonably. Some already discussed examples are mentioned below.

- The consumption values of heating gas have to be corrected if after the measures cooking will be carried out on an electrical kitchen stove (cooker). The same has to be done with the electric energy consumption.
- The reorganization of hot water production from electricity to a central gas or district heating delivery has to be considered (method cp. 3.1.1).
- The vacancy of flats will be considered by a lower room temperature of e.g. 15℃. For instance, the percentage of the vacant area per year will lead to a proportional reduction of the effective mean room temperature, thus resulting in a lower heating demand. The hot water demand, if not measured, will be regarded as well.
- The change of tenants will not be taken into account, as there might be effects of both increasing and reducing the energy demand, which roughly are considered to compensate each other. The time and effort and the uncertainty of this correction are both assumed to be too high.

6. Data presentation and analysis

6.1. Primary data presentation

The measured data are to be presented in a yearly basis, taking into account the corrections discussed in chapter 5.2. The data presentation will therefore contain the results of the "raw" or primary data (see definition in chapter 1.3), which among others are the annual or monthly consumption or production values of the different energy types, without and with correction. A derivation of further (combined) magnitudes, the calculation of indicators, their interdependency and analysis is not part of this primary data presentation. These derived data have been defined as secondary data according to chapter 1.3, and they are determined and presented in chapter 6.2.

The primary data presentation is the documentation of the project output data, as there are the different types of energy consumption (heating, hot water, auxiliary, electricity consumption) and the energy production (RES heat production, RES electricity production), the costs and, if applicable, further project results (comfort parameters, sociological results). This presentation will give the opportunity to understand the acquired data and to check their plausibility.

It is planned, to feed all-embracing data files with these data, which serves as a source for the object related documentation files. Due to the different building categories and their special conditions (e.g. multi-occupancy houses with EE measures, cp. 2.1.2), the systematic of presentation will specifically follow these categories.

6.2. Data analysis

The collection and presentation of raw data alone does not fulfil the requirements of monitoring and impact assessment. The evaluation of the success (or failure) of single measures and the whole project respectively is only possible, if these data are interpreted and compared with baselines or targets in the form of standards to reach. That is why several technical and non-technical indicators have to be defined, that allow the evaluation of the measures. These indicators may be divided into two main categories:

- **Obligatory indicators** are defined in Annex of act2 contract and the Concerto PLUS agreement on monitoring and impact assessment. Basing on a group of object related energy data to collect, they usually refer to the Concerto area (object level) or a partial area (e.g. summary of a specific building type). All obligatory energy indicators refer to energy consumption (not demand) and production respectively, adapted to standard climate conditions.

- **Additional indicators** are voluntary and shall be used for a deeper analysis. They may refer to single objects, building categories or the total Concerto area (object level) and may differ in reference to time (monthly or yearly) and/or spatial basis (complete building or apartment).

For further information compare the files "indicators.xls" and - for the object related aspects - the file "object matrix.xls" in the collection schema (see annex).

6.3. Obligatory indicators

6.3.1. technical indicators

According to Concerto PLUS agreement on monitoring and impact assessment [1] *"absolute values of energy consumption and energy production from RES will be used as a basis for the technical impact assessment. These figures will describe the dimension of the single projects but not their impact, because they won't be related to a defined area. That is why four indicators will be used for technical impact assessment."* The first two indicators are related to objects with renewable energy supply, whereas the last two are related to objects with energy efficiency measures (eco buildings):

1. **"Increase in % of renewable energy in electricity consumption of CONCERTO area".** More precisely it may be expressed as "increase of the ratio of RES-e production in the total electricity consumption of the CONCERTO area".

2. **"Increase in % of renewable energy in heating / cooling energy consumption of CONCERTO area".** More precisely it may be expressed as "increase of the ratio of RES-heating / cooling energy production in the total heating / cooling energy consumption of the CONCERTO area".

3. **Reduction in energy consumption per m²** of each building type (efficiency measures). The indicators have to be calculated separately for different types concerning the type of a

building (e.g. (semi-) detached-houses, apartment buildings and non residential buildings) and whether they are new or retrofitted. The indicator should be subdivided into two indicators concerning the electricity consumption (3a) and heating/cooling energy (3b).

4. "Overall **reduction in conventional energy consumption** in the CONCERTO area". The reduction results from the accumulated effect of efficiency gains (EE) and renewable energy supply (RES)[28]. The indicator has been subdivided into the basic value referring to delivered energy consumption (4a) and an extended value referring to primary energy consumption (4b), cp. figure 2.

In all indicator definitions heating is always understood as “space heating” and “hot water preparation” cumulated to a total consumption. Additional benchmarks are defined in 6.3.3, which present the consumption for space heating and hot water preparation in a separated way.

Some consequences from these indicator definitions (see also figure 2), to be regarded within the evaluation, are:

- Energy systems losses are considered in the energy balance, i.e. an improvement of systems efficiencies is taken in consideration
- The contribution of CHP towards the reduction of electricity imports is taken in consideration. It might result in an increase of gas consumption.
- The use of absorption chillers with COP<1 will result in an increase of gas or district heating consumption and the use of electric heat pumps or chillers will cause an increase of electricity consumption.
- The energy produced in RES or CHP plants will be regarded as part of the Concerto area even if it is not consumed in the same object but delivered to a pipeline bound network (district heating or cooling) or the electric grid. Thus the regarded energy consumption in such objects may even reach negative values, if the amount produced by the RES/CHP plant is greater than the consumption of the building was before

6.3.2. Non technical indicators

According to Concerto PLUS agreement on monitoring and impact assessment [1] there are six main non-technical indicators to be calculated:

1. Costs (a), subsidies (b) (if any) and prices (c) per kWh of each form of **renewable electricity** produced[29], including any variations with the season or the time of the day[30],

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[28] Remark: because of the additional conversion and storage losses of the RES system and the changing efficiency of the remaining additional conventional system the supply of renewable energy is not identical to the reduction of conventional consumption caused by RES. Thus, a RES-energy assessment with regard to the saving of delivered energy (or primary energy) has to be carried out, or, alternatively, the sum of efficiency gains and renewable energy supply is not exactly the mentioned overall reduction of conventional energy consumption.

[29] In the Annex of the Concerto contract it says "consumption" instead of "production" for all following indicators, which is regarded to be wrong.

2. Costs (a), subsidies (b) (if any) and prices (c) per kWh of each form of **renewable heating and cooling energy** produced[29], including any variations with the season or the time of the day,

3. m² of **new high performing eco-buildings** (a) constructed (with signed certificates), and costs per m² of the energy saving measures[31] (b) adopted in each building. If these data are not available, it should alternatively be possible to compare the total construction costs per m² with the average costs per m² for comparable 'standard' buildings of the same type[32].

4. m² of **refurbished high performing eco-buildings** (a) constructed (with signed certificates), and costs per m² of the energy saving measures[31] (b) adopted in each building. If these data are not available, it should alternatively be possible to compare the total construction costs per m² with the average costs per m² for comparable 'standard' buildings / renovations of the same type[32].

5. MW (a) of new **renewable electricity generators** commissioned (with signed certificates), and costs per MW installed (b),

6. MW (a) of new **renewable heating / cooling** commissioned, including poly-generation systems and district heating schemes (with signed certificates), and costs per MW installed (b).

All indicators are calculated for each object and additionally aggregated to common indicators for the main types of buildings / plants. For the collection or calculation of costs also see chapter 2.4.

6.3.3. Object related energy data and benchmarks

According to the act2- contract (WP 2: Monitoring and evaluation) the following data, necessary for evaluating the above indicators, have to be metered or calculated for each demonstration object with the time-and space-based delimitations as follows:

- Electricity consumption[33] per building/apartment on a monthly basis
- Space heating consumption per building/apartment on a monthly basis
- Water heating consumption per building/apartment on a monthly basis
- Cooling consumption on a monthly basis
- Electricity supply from each renewable electricity generator on a monthly basis

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[30] It is not clear yet, what the variation refers to in concrete and how to calculate that. This will be neglected.

[31] Additional costs for energetic improvement according to chapter 2.4

[32] The area in m² is meant here to refer to the useful area or gross area respectively

[33] In the original definition it always says "demand", which is not congruent to the definitions in chapter 2.1.2 and 6.2

- Energy supplied by each renewable heating system on a monthly basis

These object related energy data will be collected and documented with their absolute value (kWh) and additionally transferred to specific benchmarks in kWh per m² reference area (e.g. useful area or gross area). The method for disaggregating from yearly to monthly basis or from the whole building to single apartments will depend on data availability and will be either metering or calculation (cp. chapter 5.1). The monthly basis will be made available for the whole building, whereas data for single apartments will only be evaluated on a yearly basis.

6.4. Additional indicators

The following indicators are not obligatory according to the act2 contract, but will be used (as far as possible due to data availability) for a deeper evaluation. For more information see the file "object matrix.xls" in the collection schema (see annex).

6.4.1. Technical indicators

- Apart from the energy saving itself, expressed with indicator 4 in 6.3.1, the **environmental benefits** of the measures will be evaluated, i.e. the reduction in primary energy consumption per m² of each building type (efficiency gains and renewable energy) and the reduction of air polluting emissions (CO_2, NO_x, SO_2, dust). Primary energy and emissions will be calculated with the software GEMIS[34] including the whole energy chain based on the energy data of indicator 4[35]. The indicator will be calculated for each object as part of the documentation. The evaluation as part of the data analysis will refer to the Concerto area (object level).

- In addition to the indicators 2 and 3 b from chapter 6.3.1, which refer to the total energy for "heating" a disaggregation will be made for **space heating** and **hot water** preparation as separate indicators.

Furthermore it is planned, depending on the availability of data, to evaluate for some selected flats a bundle of more detailed indicators, which usually refer to single objects:

- a "**comfort-coefficient**" for each building-type:

  To obtain objective information on the comfort level, several thermal comfort parameters according to DIN EN ISO 7730 will be measured in 20 refurbished flats. From these measurements thermal comfort indicators like “Predicted Mean Vote” (PMV) and “Predicted Percentage of Dissatisfied” (PPD) can be derived. If those parameters are within certain limits, it can be assumed, that a high satisfaction with the ambient atmosphere conditions will be archieved.

  Additionally recorded measured data of air quality and surface temperatures of outer walls allow a more comprehensive description of the achieved thermal comfort standard as well

[34] http://www.oeko.de/service/gemis/de/index.htm

[35] For electricity the national average energy-mix (Germany for Hannover, France for Nantes) will be used, no matter how the exact local conditions are.

as a assertion of the risk of mould growth. A comparison with 10 measurements in flats which have been refurbished to a higher level of energy efficiency allow the analysis of the existing potential of comfort level in refurbishments.

For more details see the separate monitoring concept of thermal comfort measurements in the annex.

- the efficiency of the heating system / solar collector,
- the energy losses for pipes and storage,
- the auxiliary electric energy needed for pumps, fans, control etc.
- an analysis of the monthly heating energy consumption in relation to the outside air temperature, thus calculating the heating period expressed as the outside temperature (heating limit temperature), which will give important hints on a false regulation and/or high distribution energy losses as well as the air ventilation rate.
- solar indicators like solar fraction, PV performance ratio or solar gain

To get an impression of the energetic quality reached, the above indicators will be compared with the baselines and the standards, defined in chapter 2.2 and 2.3.

The indicators for EE measures refer to the real energy consumption. On the contrary the energy demand, calculated with standard user parameters by software tools like PHPP or EnEV programmes will lead to different results. For selected objects an analysis will be made to explain the differences.

6.4.2. Non technical indicators

From the cost related indicators 3 and 4 from 6.3.2, which only refer to the object area, it is possible to derive a much more meaningful indicator for the EE objects, expressing the costs in € to be paid per kWh saved in comparison with the different baselines, as it is made with indicators 1 and 2 for RES objects. This indicator can be compared with actual and estimated future energy prices in order to directly rate the economic efficiency of an energetic measure.

Furthermore for some selected objects it will be examined, whether the available data will be sufficient for a disaggregation of the indicator 3 and 4 into the additional costs related to the different energy standards on the one hand and to refer to the m² surface of the single components instead of the m² object area.

Finally it is intended to make some conclusions, in what amount the rent inclusive the heating costs will rise or decrease, if the investment for the measures is allocated to the rental fee.

This will lead to the following additional indicators:

- **costs per kWh** saved for each building-type and/or measure

- **additional costs** (in % and €/m²) for Concerto-standard for each building-type (a) and/or measure (b)
- **increase/decrease of rent** inclusive heating-costs in %

All indicators are calculated for each object and additionally aggregated to common indicators for the main types of buildings. For general explanations referring to the collection or calculation of costs also see chapter 2.4.

7. References

[1] Arsenal (Susanne Geissler, Doris Österreicher, Olivier Pol), 4.12.2006: monitoring impact assessment_agreement_061204_v3.pdf

8. Glossar

50% saving	Concerto-standard in Hannover: saving of 50% heating energy by insulation
act2	Action to mainstream energy efficient building and renewable energy systems at a city level across Europe
BAT	best available technology
BEST	Building Energy Specification Table
BGF	Bruttogrundfläche (gross area)
bm / pv / sc	subcategories biomass / photovoltaic / solar collector
BPT	best pratice technology
BRI	Bruttorauminhalt (gross volume)
CHP	combined heat an power (plant)
COP	coefficient of performance (of heat pumps)
DHW	domestic hot water
DIN	Deutsches Institut für Normung (German institute of standardisation)
dsh / moh / nrb	subcategories detached or semitetached house / multi-occupancy house / non-residential building
DWD	Deutscher Wetterdienst (German weather service)
EE	Energy efficiency
EnEV	Energie-Einspar Verordnung (German energy saving order)
EnEv-new	Concerto-standard in Hannover: retrofitting of buildings according to the requirements of EnEV for new buildings energy
GEMIS	Globales Emissions-Modell Integrierter Systeme (global emission model of integrated systems
HPE	Haute Performance Energétique: High Energetic Performance

H_t'	specific transmission heat loss (according to German EnEV)
Kronsberg	Concerto-standard in Hannover referring to a max. final energy demand for space heating of 55 kWh/m²a
NEH	Niedrigenergiehaus (low energy house)
o / n	subcategories old / new
PHPP	Passivhaus-Projektierungs-Paket (Passive House Planning Package)
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
PV	photovoltaic
Q_H	final energy demand for heating (according to German EnEV)
Q_p''	specific primary energy demand (according to German EnEV)
RES	Renewable energy system
RT2000/RT2005	Réglementation thermique (french order for reglementation of thermal energy)
VDI	Verein Deutscher Ingenieure (society of German engeneers)
WP	work package

9. Annex

The following descriptions refer to monitoring of the demonstration objects in Hannover. The monitoring of the objects in Nantes is planned to be performed in a similar way. There may be differences in detail due to the local conditions or data availability, but the basic concept will not be changed, so that the results in both communities may be compared as good as possible.

The following descriptions furthermore describe the state of the discussion. It may not be excluded that corrections or additions have to be applied to the guidelines and schemes.

The description files listed below are presented in a separate report "Collection schema for monitoring and evaluation"

9.1. Energy, cost and environmental parameters

- Definition of standards (standard.xls)
- List of demonstration objects (objects.xls)
- Overview of objects and allocation to workpackage numbers (workpackage.xls)
- Example of documentation of a demonstration object with energy efficiency measures (documentation_ee.xls)
- Example of documentation of a demonstration object with renewable energy measures (documentation_res.xls)
- Definition of indicators (indicators.xls)
- Overview of how to get the indicators in the demonstration objects (object matrix.xls)

9.2. Comfort parameters

- Measurement guidelines
- Collection scheme