Energy Performance Indicators for Building Stocks

First version / starting point of the EPISCOPE indicator scheme (to be developed during the project)

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EPISCOPE website: www.episcope.eu

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1 Introduction

A major objective of the EPISCOPE project is to lay a basis for the tracking of the energy refurbishment progress of housing stock entities in the field of thermal protection and heat supply (heating and hot water) against the background of energy saving and climate protection needs. During the project different residential building stocks are analysed in 16 European countries – from local housing portfolios to regional or national housing stocks.

In this paper a first and preliminary version of an indicator scheme is introduced which makes possible comparisons between national actions of energy performance tracking (within and beyond EPISCOPE). Moreover, it is intended to define a generally applicable set of quantities which – in case of a regular update – can deliver the basic information which is necessary to observe and understand the development of energy performance in residential building stocks[1].

Against that background the EPISCOPE indicator system intends to deliver a kind of common language for the exchange of information on international level. It does not provide any limiting rules with respect to the national pilot projects which are carried out autonomously by the partners. But the results of the individual projects will have to be translated to the common indicator system so that a comparison will be possible.

Carrying out energy performance analysis of a building stock is in principle a two step process. This has accordingly to be considered by the indicator scheme:

1. Monitoring: Reliable data of the building stock have to be collected and updated regularly (by representative surveys). Basic information is characterised by **monitoring indicators.**

2. Scenario analysis: A model of the building stock is established and scenario analysis of possible future development (refurbishment and new buildings) is carried out. **Scenario indicators** describe basic assumptions and the most important results.

During the EPISCOPE project special attention is paid to the first step. The question has to be answered in how far reliable data about the European residential building stocks (here represented by the national pilot actions) are actually available and – in case of deficiencies – how the information basis could be improved and regular monitoring systems could be established. The assigned indicator scheme ("monitoring indicators") intends to deliver the necessary basic information about thermal protection and heat supply on the one hand; on the other hand the applied quantities must be compatible to the information which can be collected by practicable, reliable surveys. Moreover, the monitoring indicators should directly reflect the monitoring results, i. e. they should not (or only to a very small extent) depend on additional (more or less unproved) model assumptions. All in all the monitoring aims at laying an objective basis for further analysis.

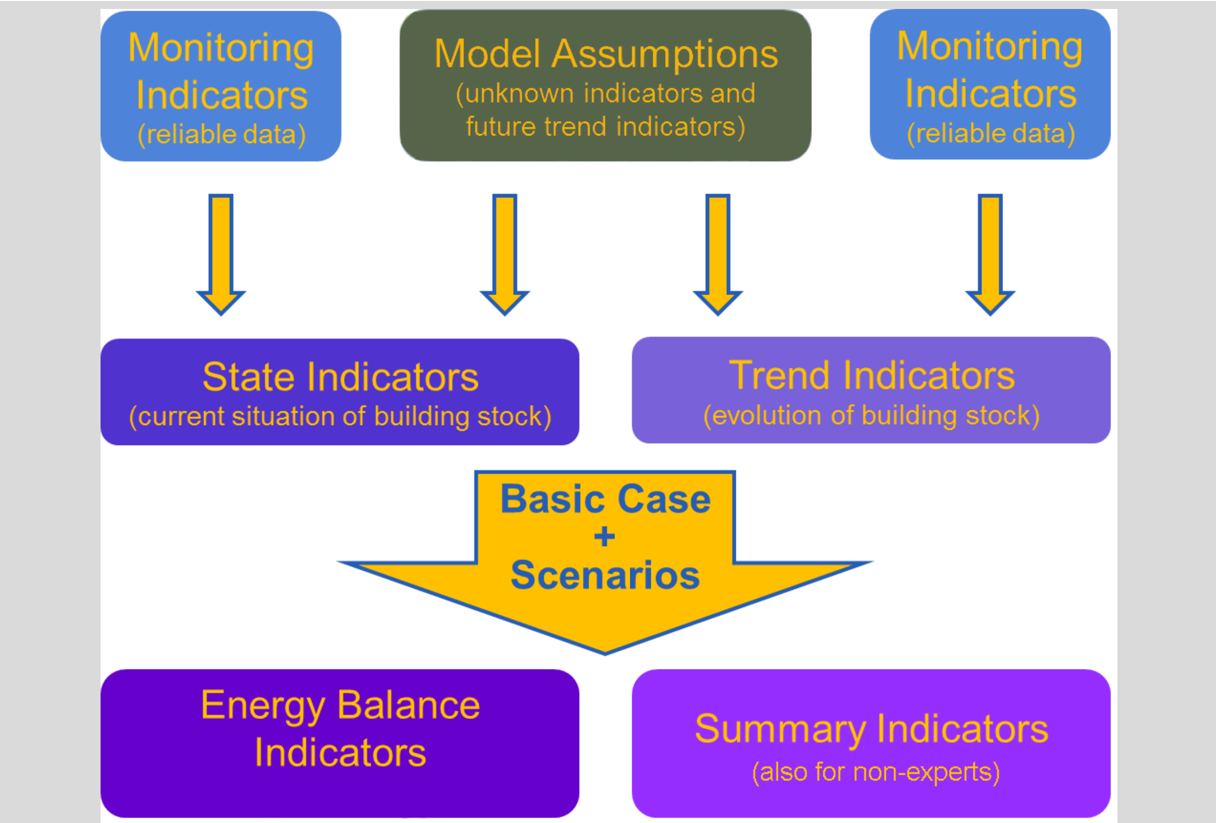
Some vital questions cannot be directly answered by the monitoring, for example "How far are we away from reaching our CO_2 targets in the building stock? Which future development of the building stock would reach the targets?" To analyse this kind of problems a second step is necessary which includes model development and trend/scenario analysis. Model development will be based on monitoring results but additional assumptions will have to be made by the analysts to draw a coherent picture of the existing building stock and its future development. Scenario indicators, which are based on monitoring data as well as on additional settings, serve to make the basic assumptions and the results of the analysis transparent and comparable.

[1] Building stock analysis during the EPISCOPE project is to some extent connected to the building typologies, which were developed during the TABULA and EPISCOPE projects (also documented on the joint EPISCOPE and TABULA website www.episcope.eu). Nevertheless, defining indicators for building stocks is different from describing example buildings of a typology, so for the EPISCOPE indicator scheme a new approach had to be made.

Building stocks are characterised by a large diversity of houses and heat supply systems, accordingly the number and variety of possible classification systems and indicators is very large as well. The draft indicator scheme, which is described in the following chapters, tries to keep the problem manageable by focussing on basic parameters. Later extensions during the project are possible.

The following picture provides a more detailed overview of the different types indicators which will be introduced in the following chapters.

Figure 1: Overview of the EPISCOPE scheme of building stock energy performance indicators



The monitoring indicators (blue boxes) provide a reliable data basis for the establishment of building stock modelling, but they will have to be accompanied by model assumptions to close information gaps and to describe the future development. The complete indicator set describing the building stock in its actual state ("basic case") and in future conditions is called the scenario indicators (purple boxes). They include the "structural" data of the building stock, which means information about the state at a certain year (state indicators) as well as time development in a certain period (trend indicators) of thermal building insulation and heat supply systems. This structural data is a basis for the modelling of the energy balance (including greenhouse gas emissions), which results in the energy balance indicators. Whereas state, trend and energy balance indicators deliver quite detailed information, results of general meaning will be shown as summary indicators, which are also dedicated to non-experts.

In the course of the project a further development of the indicator scheme will be carried out. In that process the options of extending the scheme (e.g. to improve the level of detail) and of improving harmonisation (for a better cross-country comparability) will have to be considered along with the target of a sufficiently good and universal applicability of the concept.

2 Monitoring Indicators

For the collection of reliable statistical information surveys are necessary. At best they cover the complete building stock (complete inventory count like a census) but usually sample surveys will be available, which must be representative and deliver statistically significant results. The interviewees must be people who know the information to be collected (e.g. house owners better then tenants), maybe expert interviewers can also collect information on-site.

The data in question concern structural data about the thermal protection of the buildings as well as heat supply systems. Both “state indicators” and “trend indicators” have to be considered: Whereas the state indicators describe the current situation in the building stock (e. g. the distribution of different quality levels of wall insulation), the trend indicators are related to the actual dynamics (e.g. annual rates of wall insulation). In other words: State indicators provide information about the progress of energy efficiency which has been made in the past whereas trend indicators provide information about the current velocity of movement towards better energy efficiency and climate protection.

Besides structural data of thermal protection and heat supply which provide detailed information of the progress and the processes in the building stock also energy consumption values of the observed building stock in the recent years should be collected to make possible an adjustment of the later model calculations (see chapter 3).

Only reliable data should be presented as monitoring indicators. Detailed information about the used data sources and adaptations of the original data (if necessary) will have to be documented. The project will stress the question of representativeness, significance and reliability of such survey results. In the later project reports (to which all partners will contribute) a detailed documentation of the applied data sources, of data reliability, and of own model approaches to adapt the data will have to be given (Synthesis Reports 2, 3 and 4 - D3.4, D3.5, D4.4).

It may be the case that in some pilot projects information gaps occur, that means that not all statistical data are available to create an empirically justified building stock model (and to fill in the complete monitoring tables which follow). Carrying out additional surveys (complementary to the available data sources) is mostly beyond the range of EPISCOPE[2] so that such information gaps will have to be closed by model assumptions. But this will be part of the model development (in chapter 3) whereas the monitoring indicators described in chapter 2 should indeed be kept empty in such a case: One of the major aims of EPISCOPE is to draw a realistic picture of available basic data of building stocks, to discover information gaps and compare them internationally and to develop concepts for the future implementation of regular monitoring systems which collect all necessary data. So the system of monitoring indicators will make possible a review of the existing situation of data availability[3].

2.1 Basic data of the building stock

The first monitoring table (Table M.1) delivers basic data of the building stock, e. g. from the census (if available) in case of a national stock.

[2] But for example in the Irish pilot action the carrying out of a survey is included.

[3] On the other hand it has to be considered that (reliable) statistical data of national building stocks were already collected during the TABULA activity (see “country pages” at www.episcope.eu/country). If applicable, this data can be used for the EPISCOPE scheme of monitoring indicators as well. In contrast to the TABULA statistical data the EPISCOPE scheme of monitoring indicators is a more clearly structured approach, which was chosen to facilitate the application of monitoring indicators for model development and scenarios (i.e. to carry out a transformation from the monitoring indicators to the scenario indicators of chapter 3).

According to the EPISCOPE project tasks it is intended that also interesting subgroups of the building stock will be observed. In the proposed scheme it is foreseen that besides the complete building stock also a subgroup "old building stock" and another one "new buildings" is considered[4].

The partners can choose the definition of the age bands of the two subgroups individually. The intention of monitoring new buildings separately is to learn about the actual trends in the new building sector. A special subset "old building stock" is considered for two reasons: First it is assumed that old buildings up to a certain construction period (which may be different in different countries and building stocks) have an above-average energy consumption (if they are not yet renovated for energy upgrading) and so this part of the building stock will be of special interest for exploiting the energy saving potentials. Secondly it is a relatively stable subgroup: In contrast to the complete building entirety the old building stock is not affected by new construction of houses but only by demolition (with usually relatively small annual rates). So it is proposed that every partner separately analyses and presents an "old building stock" subset (including a major part of the existing building stock) in his analysis[5].

Table 1: M.1 Basic data of the building stock

M.1 Basic data of the building stock	Complete building stock	Old building stock	New buildings
	e.g. $bs_{...2012\|2012}$	e.g. $bs_{...1980\|2012}$	e.g. $bs_{2011\text{-}2012\|2012}$
number of buildings			
number of apartments			
national reference area [m²]			
sources / remarks			

In the above and the following tables there is a field sources/remarks for the documentation of the origin of the data and for additional remarks. Here, a short cross reference to the original data source and – if necessary – some explanations that are necessary for the understanding of the data should be given.

Excursus: building stock nomenclature

Building stocks are changing because of new construction and demolition of buildings. For a clear definition of the observed residential building stocks the following writing is proposed:

$bs_{\{construction\ period\}|\{time\ of\ observation\}}$, *e.g.:*

$bs_{...1980|2012}$: *building stock (bs) composed of all residential buildings constructed until end of 1980 as a subgroup of the residential building stock of the year 2012*

$bs_{2011\text{-}2012|2012}$: *all residential buildings constructed in the years 2011-2012 as a subgroup of the residential building stock 2012*

$bs_{...2012|2012}$ *(or shortcut* bs_{2012}*): complete residential building stock 2012*

$bs_{2012|2020}$ *: all residential buildings constructed in the year 2012 as a subgroup of* bs_{2020}

If in later chapters not monitoring data but the results of model calculations are presented, a shortcut for the scenario variant may be added if necessary (That means if the building stocks of the scenarios are not the same because different construction and demolition rates are assumed). For example:

$bs_{...1980|2030|S1}$: *all residential buildings constructed until 1980 as a subgroup of the residential building stock in the year 2030 according to a scenario called S1.*

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4 Of course, further subgroups may be defined and observed by the partners. The same applies to all other classifications and indicators: In the national pilot actions much more detailed information may be collected and presented. But with the EPISCOPE building stock indicators a common scheme of data presentation is defined which makes possible comparisons between the projects and which – as far as possible – should be followed by each partner.

5 In the following table all buildings erected until 1980 are included in the old building stock, but this is just an example.

2.2 Building insulation

Table M.2.1 documents basic information about energy-related building modernisation (renovation for thermal upgrading)[6]. The four different building elements wall, roof, ground floor and windows are considered. Information is given about the state of the building stock (Which percentage of walls has already been modernised?) and about the current trend (What is the annual rate of wall insulation?). Because it can be assumed that new buildings (erected in recent years) are not affected by refurbishment measures (until “now” or the time of monitoring) they are not included in the table.

Table 2: M.2.1 Building insulation: State and trends of modernisation

M.2.1 Building insulation: Basic information state and trends of modernisation			
	Complete building stock	Old building stock	percentages related to....
walls			
insulation improved (from original state)	20,4%	25,3%	(e.g.) building number
insulation improved (area-weighted)	15,0%	19,4%	element area
average thickness of improved insulation	4,7 cm		average of element area
annual rate of insulation improvement	0,65%/a	0,82%/a	(e.g.) building number
annual rate of insulation improvement (area-weighted)	0,51%/a	0,63%/a	element area
average thickness of insulation (recent modernisation)	8,4 cm		average of element area
roofs / upper floor ceilings			
table like walls	...	...	...
ground floors / cellar ceilings			
table like walls	...	...	...
windows *{example of minimum standard:}* (improvement to at least thermal protection double glasing)			
table like walls	...	...	...
sources / remarks	complete/old stock: percentages related to $bs_{...2010\|2010}$ / $bs_{...1980\|2010}$ [1] annual rates/recent insulation thickness: mean values 2007-2010		

The documented information is typical for house owner surveys in which the interviewees are asked which modernisation measures have already been carried out at the building and if they were carried out during a recent time period (so that up-to-date average annual rates can be calculated). An example of the complete table is given for the walls, in case of the other elements the tables would have the same format.

The last column indicates the reference parameter of the percentages; in the first row it is the building number. For example it is indicated that at 25,3 % of the buildings of the old building stock (buildings constructed until 1980) a thermal modernisation of the wall has already been carried out. Accordingly, the annual rate of 0,82 %/a means, that on average in a recent time period (here: 2007-2010, see “sources/remarks”) every year wall insulation measures were carried out at 0,82 % of the buildings.

Apart from the pure information if any modernisation has been carried out also area-weighted numbers of the already achieved progress of thermal refurbishment (19,4 %) of the observed modernisation rate (0,63 %/a) can be documented in the table. They give clearer information about the actual progress of thermal modernisation, but of course they can only be filled in if reliable data about the coverage area of insulation measures is actually available, e.g. if in the house owner survey the question was asked which fraction of the total wall area had been insulated.

Also the average values of the thickness of insulation applied to the walls by refurbishment can be documented if the information is available (typically from house owner surveys). In the given example mean values of insulation thickness are 4,7 cm for all energy-related wall refurbishment measures carried out in the past and 8,4 cm for the recent measures (average value of the years 2007-2010). Those values are only available for the complete building stock and not separately for the old buildings so that the respective fields were kept empty.

[6] The example numbers here and in the further tables are just given to illustrate the scheme. They are hypothetical, not related to any real (also not the German) building stock.

Project partners may define minimum standards for the refurbishment measures which are counted in table M.2.1, if applicable. If so, the used definition should be stated in the table. For example, it might be argued that insulation layers below a certain thickness (e.g. 1 cm) should not be taken into consideration[7].

Table M.2.2 gives additional, more detailed information about the distribution of different levels of wall insulation. The project partners can define the number and the boundaries of the levels. Later in the project we will examine opportunities to harmonise levels.

Again for simplification the detailed information is given for walls only, for the other elements the tables would in principle have the same format. In contrast to table M.2.1 not only thermal modernisation of elements of the building envelope (that means improvement in later years after building construction) is documented but a general overview of the quality of building insulation is provided. On the other hand, there is no information about the trends of thermal modernisation.

Table 3: M.2.2 Building insulation levels

M.2.2 Building insulation: Detailed information of the actual state *number of levels and boundaries defined by partners (maybe later harmonisation?)*			
	Complete building stock	Old building stock	New buildings
levels of wall insulation (area-weigthed):			
level 0 (U > 0,7 W/m²K)	60%	80%	0%
level 1 (0,7 W/m²K >= U > 0,3 W/m²K)	25%	10%	25%
level 2 (0,3 W/m²K >= U > 0,20 W/m²K)	12%	9%	60%
level 3 (U <= 0,20 W/m²K)	3%	1%	15%
roofs / upper floor ceilings			
similar to walls (different system of levels)	...	...	...
ground floors / cellar ceilings			
similar to walls (different system of levels)	...	...	...
windows			
similar to walls (different system of levels)	...	...	...
sources / remarks	percent numbers related to element areas numbers related to the following building stocks:		
	$bs_{...2010\|2010}$ [6]	$bs_{...1980\|2010}$ [6]	$bs_{2011-2012\|2012}$ [7]

A typical source for providing data to Table M.2.2 could be a representative survey of energy performance certificates or energy audits. In this case probably even more detailed information could be given, for example the mean U-value (heat transfer coefficient) for every level and building element. The project partners may of course document this in more detailed reports, but for the time being it was not included in the common scheme for two reasons:

Firstly, it must be recognised that results from energy certificates or energy audits are not completely objective measurements but usually depend on the (often empirically unproved) assumptions of the related energy balance models. This is even the case for basic parameters like U-values, at least for non-refurbished walls: The exact U-value cannot be measured but it is assigned to the element on basis of a simplified scheme (e.g. U-values of walls are estimated by the type and age of the wall as in the TABULA typology approach).

Secondly, there is the possibility to fill in the table (at least partly) even if not a survey of energy certificates or audits but a house owner’s survey is available: Of course the house owners will not be able to tell exact U-values but they deliver some basic information (again type and age of the wall as well as information about insulation layers) that will make possible an assignment of the walls to the different insulation levels.

So this might be an example where basic model assumptions have to be applied even in the framework of monitoring indicators. General criteria to define an exact border between the

7 In our German project we will prospectively use such a definition only in case of windows (see example in the table): Thermal protection glazing (low-e-glazing, not simple double glazing) will be introduced as a minimum standard of modernisation measures because in the past single glazing was already almost entirely replaced by double glazing in the German building stock.

"objective" and empirically proved monitoring indicators and the model-dependent scenario indicators cannot be given[8]. The decision, if data is sufficiently reliable to be classified as monitoring data (and the justification of this setting) is kept to the project partners. If any possible, statistical errors of the monitoring data should be calculated and documented.

Comparing the tables M2.1 and M2.2 and the basic data table M.1.1 it turns out that they are not completely related to the same building stocks: For example, in M1.1 the old building stock is described from a 2012 point of view ($bs_{1980|2012}$) whereas in M.2.1 and M.2.2 data from the year 2010 is documented ($bs_{1980|2010}$). This exemplary setting aims at making clear again that monitoring data should be related closely to the original data. If only primary data sources from different years are available they should be documented as they are, model-based data processing should be restricted to a necessary minimum. Of course, for the formation of building stock models the processing of the monitoring data will be necessary to construct a coherent image of the building stock at a certain time as a starting point for trend and scenario analysis. This modelling task will have to be carried out by all partners, but according to the given definition it will be no longer part of building stock monitoring but the first step of model development, so the results will not be documented as monitoring but as scenario indicators (see "Basic Case" in chapter 3).

2.3 Heat Supply

Table M.3.1 indicates basic information of the applied heat supply systems for space heating. The centralisation grade of the system, the main energy carrier and the type of heat generation are considered separately.

The left part of the table shows the observed state of the complete, the old and the new building stock; in the right part modernisation rates of the complete and old building stock are documented.

Table 4: M.3.1 Main heat supply system for space heating

M.3.1 Main Heat Supply Systems for Space Heating	state of the building stock			modernisation trends	
	Complete building stock	Old building stock	New buildings	Complete building stock	Old building stock
M.3.1.1 Centralisation of space heating system				net modernisation rates	
district heating	12%	10%	15%	+0,1%/a	...
building / apartment heating	80%	75%	83%	+0,3%/a	...
room heating	8%	15%	2%	-0,4%/a	...
	100%	*100%*	*100%*	*0%*	
M.3.1.2 Main energy carrier for space heating				net modernisation rates	
district heating	12%	...	...	+0,1%/a	...
gas (natural / liquid gas)	42%	...	...	+0,3%/a	...
oil	32%	...	...	-0,3%/a	...
coal	2%	...	...	-0,1%/a	...
wood/biomass	5%	...	...	+0,2%/a	...
electricity	7%	...	...	-0,2%/a	...
	100%	*100%*	*100%*	*0%*	
M.3.1.3. Main heat generation system for space heating				gross modernisation rates	
district heating	12%	...	...	+0,1%/a	...
combustion of fossil fuels: "level 0" systems: stoves, non-condensing boilers	52%	...	...	+0,2%/a	...
combustion of fossil fuels: "level 1" systems: gas/oil condensing boilers	24%	...	...	+2,5 %/a	...
combustion of fossil fuels: "level 2" systems gas/oil driven heat pumps / chp systems	1%	...	...	< +0,1%/a	...
combustion of wood/biomass: "level 0" systems: simple/old/unefficient stoves and boilers (mostly split log)	3%			0%/a	
combustion of wood/biomass: "level 1" systems: modern boilers and stoves (mostly wood pellets, wood chips)	2%	...	...	+0,3 %/a	...
direct electric heating	4%	...	...	0%/a	...
electric heat pumps	2%	...	...	+0,1%/a	...
	100%	*100%*	*100%*	**+3,2%/a**	...
sources / remarks	percentage numbers related to apartments numbers related to the following building stocks:			percentage numbers related to apartments numbers are mean values 2007-2011 [8]	
	$bs_{...2011|2011}$ [8]	$bs_{...1980|2011}$ [8]	$bs_{2011-2012|2012}$ [7]		

In M.3.1.3 the systems driven by fossil fuels are assigned to three classes (levels 0, 1, 2). Level 0 includes old, comparably inefficient systems, level 1 is assigned to a typical "state of

8 In fact there might also be an overlap: (Reliable) monitoring indicators may be applied as scenario indicators at the same time. But on the other hand scenario indicators which are not empirically justified may not be applied as monitoring indicators.

the art" standard and level 2 includes forward-looking systems which are not yet established at the market of heating systems but will prospectively be needed in the future. A similar scheme of levels was applied to biomass systems.

The definition of such levels is just an example at the moment: For carrying out model analysis more detailed information will be necessary in the individual projects. But the indicator system aims at giving an overview only and the definition of levels is proposed here to keep the number of quantities manageable. Project partners are invited to check if they can also define suitable levels in a similar way and during the project it will be examined if a harmonised approach is possible. Alternatively, the different system types will have to be listed separately and in more detail in table M.3.1.3. For a start it will probably be the best solution not to simplify too much, so everybody should find a way to categorise the main heat generation systems in a suitable way that draws a sufficiently clear picture of the variety of systems but on the other hand is not too detailed (so that later cross-country comparison is also still clear and easy).

In the right part of the table two types of modernisation rates are considered: For centralisation and energy carriers net modernisation rates and for the system types gross modernisation rates are documented. The net rates indicate structural changes, for example in the table it is shown that the fraction of systems which use gas as the main energy carrier is growing by 0,3 % every year. But this number does not provide information of the number of gas systems which is modernised every year, because if a gas driven system is replaced by a new one (again driven by gas) this is not indicated. In contrast, for the modernisation of heat generation systems the gross modernisation rates are documented. For example it is indicated that every year 2,5 % level 2 fossil systems (gas or oil condensing boilers) are installed. So this number indicates the total modernisation activities, but it cannot provide information about the net growth of condensing boilers in the building stock (because it might be that just old condensing boilers are replaced by new ones). Accordingly the gross rates of all heat generation systems sum up to the complete modernisation rate of heat generation systems in the observed building stock (in the above example 3,2 %/a for the complete building stock), whereas net modernisation rates always add up to zero.

Of course, in principle both types of information are of interest – gross as well as net modernisation rates. But again, it is intended to keep the overview tables manageable and so it was decided to make a choice: In case of centralisation and energy carriers the net development appears more interesting because it illustrates the structural changes. On the other hand the necessary complementary information of gross modernisation activities must also be given and it appears to be best suited to do this in the framework of the heat generation systems, because here the gross rates give a detailed picture of the modernisation effort which is made by the house owners: For example, the investment costs for new systems are closely related to both the gross rates and to the type of applied systems[9].

The next table M 3.2 provides information about additional systems, which might be of special interest concerning heating and hot water supply. Again gross modernisation rates are considered for the energy generation systems.

[9] The question of gross or net rates also has to be clarified in case of thermal modernisation measures in table M.2.1. Here we define that gross rates are documented, so that a picture of the total modernisation activities of building insulation is drawn.

A difference between gross and net rates occurs only if building elements (e.g. walls) which have already been modernised by thermal insulation measures in the past are now modernised again. At the moment it can probably be assumed, that those cases do not play a major role in most observed building stocks, but in later years it might become more important. So in the documentation of scenarios the difference will have to be considered. (See later in chapter 3.2: Also there gross modernisation rates are indicated for thermal insulation and the main heat generation systems, but the information of net changes is not lost because it can be derived from the comparison of the state indicators (chapter 3.1) of different years.)

Table 5: M.3.2 Special Systems

M.3.2 Special Systems (additional systems of special interest for space heating, hot water supply, ventilation, including photovoltaics)					
	state of the building stock			**modernisation trends (gross rates)**	
	Complete building stock	Old building stock	New buildings	Complete building stock	Old building stock
solar thermal systems	14%	...	...	+ 1,1%/a	...
...for hot water supply only	*11%*	...	...	+ 0,8 %/a	...
...for heating and hot water supply	*3%*	...	...	+ 0,3 %/a	...
photovoltaic systems	12%	...	...	+0,7%/a	...
ventilation systems *(for buildings/apartments, not only kitchen/WC ventilation)*	4%	...	...	+ 0,3%/a	...
....with heat recovery	*1%*	...	...	<+0,1 %/a	...
...without heat recovery	*3%*	...	...	+ 0,3 %/a	...
additional systems of special interest for the observed building stock may be defined by the partners					
sources / remarks	percentage numbers related to apartments numbers related to the following building stocks:			...	
	$bs_{...2011|2011}$ [8]	$bs_{...1980|2011}$ [8]	$bs_{2011-2012|2012}$ [7]		

Besides solar thermal systems also photovoltaic systems at the buildings are considered. Although they do not directly produce heat, they are of general interest for building stock development and – depending on the algorithms applied by the partners – they can play a role even in the energy balance for heat supply because they produce electricity which might be used in electric heat pumps, for example. Ventilation systems – especially those with heat recovery - are also linked to the buildings' energy consumption for heat supply.

The partners, if applicable may add further systems, which are not yet considered in the table.

The applied main systems of hot water generation (apart from solar thermal systems) are considered in table M.3.3. This table is called "optional" because it is assumed that reliable survey data about hot water generation (which usually plays a minor role compared to space heating) might often not be available. For simplification only state indicators and no trend indicators (modernisation rates) are considered and a break down of the cases with hot water generation by the heating system is not given (but might be added, if information is available).

Table 6: M.3.3 Main system of hot water supply

M.3.3 Main System of Hot Water Supply apart from additional solar thermal systems (see above)			
	Complete building stock	Old building stock	New buildings
M.3.3.1 Main Energy carrier for hot water supply			
district heating	10%	...	...
gas	42%	...	...
oil	32%	...	...
coal	2%	...	...
wood/biomass	5%	...	...
electricity	9%	...	...
	100%	*100%*	*100%*
M.3.3.2 Main heat generation system for hot water supply			
hot water generation combined with heating system:	71%		
separate system of hot water generation:		...	...
- direct electric heat generation	21%	...	...
- electric heat pump	1%	...	...
- combustion of fossil fuels	6%	...	...
- combustion of wood/biomass	1%	...	...
	100%	*100%*	*100%*
sources / remarks	percentage numbers related to apartments numbers related to the following building stocks:		
	$bs_{...2011|2011}$ [8]	$bs_{...1980|2011}$ [8]	$bs_{2011-2012|2012}$ [7]

Solar thermal systems are not treated here but above in M.3.2. They are interpreted as "additional systems" because they can generally not work alone (even if they often produce around or even more than 50 % of the hot water energy in a year). They must be accompanied by other basic systems, which generate the hot water when the sun is not shining and which are here interpreted as the main systems (even if the contribution of the solar thermal system might be higher)[10].

[10] In contrast to this assumption it might be the case that within a building stock there is a considerable number of buildings/apartments, which are only supplied by solar thermal (with no accompanying system). In such a case the respective solar systems would have to be treated as an additional category of main hot water systems.

2.4 Energy Consumption

The collection of measured data of the total energy consumption of the observed building stock (final energy consumption distinguished by energy carriers) during recent years will be necessary to test if the applied calculation models deliver realistic results and to make possible an adjustment of such models. An example for the presentation of collected data is given in Table M.4.

Table 7: M.4 Observed final energy consumption (Example table)

M.4 Final Energy balance: Measured values energy consumption in TWh/a (10^9 kWh/a)	Complete building stock
district heating	...
gas	...
oil	...
coal	...
wood/biomass	...
electricity	...
sources / remarks mean annual values of the years 2009-2011 for the national residential building stock [10,11] energy consumption for all household appliances (heating, hot water, cooking, electric appliances, other) fuel consumption is indicated by the gross calorific value	

According to the TABULA definition the gross calorific value is applied to indicate fuels (see also the remarks in chapter 3.3 to this question)

The appearance of this table might be different depending on the available information. In general it must be considered that information will often not be available for the heat supply of residential buildings separately. For example gas consumption for cooking and the electric energy consumption for all household appliances will often be included in the numbers. Additional analysis for making the given numbers comparable to the energy balance calculations of the observed building stocks (including also weather / climate corrections) will usually be necessary. But this will be done later during model analysis and it is not a part of the monitoring. So in table M.4 the available data should be documented as it is.

3 Scenario Indicators

3.1 State Indicators of building insulation and heat supply

A first step of model analysis will be the construction of a coherent building stock at a certain starting point, for example at the end of the year 2013 ($bs_{2013|2013}$). Presumably this building stock defines a basic case with a special meaning because it will be the starting point for all following trend and scenario analysis. Indicating this “Basic Case” may be done with the letter B when appropriate, for example $bs_{2013|2013|B}$.

To ensure a close link of monitoring indicators and scenario indicators (e.g. to make possible an evaluation of the model assumptions by future monitoring activities) the same quantities as in chapter 2 are applied here. The following table summarises all indicators of basic building stock data, thermal protection and heat supply in an abbreviated way (explaining the structure but not showing all details).

Table 8: State Indicators of the Basic Case

Basic Case *(Starting Point of Trend and Scenario Calculation)* **: Building Stock 2013**			
Basic Data	Complete building stock $bs_{...2013\vert 2013\vert B}$	Old building stock $bs_{...1980\vert 2013\vert B}$	
number of buildings			
number of apartments			
national reference area [m^2]			
TABULA/EPISCOPE reference area [m^2]			
Building insulation: state of modernisation			
walls			percentages related to ....
insulation improved (from original state)			building number
insulation improved (area-weighted)			element area
roofs/ground floors/windows: in the same way			
Building insulation: Detailed information			
levels of wall insulation (area-weigthed):			percentages related to....
level 0 ($U > 0,7$ W/m^2K)			element area
level 1 ($0,7$ $W/m^2K >= U > 0,3$ W/m^2K)			
level 2 ($0,3$ $W/m^2K >= U > 0,20$ W/m^2K)			
level 3 ($U <= 0,20$ W/m^2K)			
roofs/ground floors/windows: in the same way			
Main Heat Supply Systems for Space Heating			
Centralisation of space heating system			percentages related to....
district heating			apartment number
building / apartment heating			
room heating			
Main energy carrier for space heating			percentages related to....
district heating			...
gas (natural / liquid gas)			
.... (and so on: oil, biomass....)	...	...	
Main heat generation system for space heating			percentages related to....
district heating			....
combustion of fossil fuels: "level 0" systems: stoves, non-condensing boilers			
....(and so on)	...	...	
Special Systems			percentages related to....
solar thermal systems		...	...
...(and so on)		...	
(optional): Main Energy carrier for hot water supply			percentages related to....
district heating			...
gas			
...(and so on)			
(optional:)Main heat generation system for hot water supply			percentages related to....
hot water generation combined with heating system:			
...(and so on)			

Numbers are given for the complete and the old building stock, whereas indicators of new buildings are not included in the table because they have more the character of trend than of state indicators: The modelling of the new buildings is related to construction periods and not to a certain year, so the related quantities are later considered in 3.2 as trend indicators.

The basic building stock data includes now also the TABULA/EPISCOPE reference area, which depends on model assumptions so it was not considered in the monitoring indicators of chapter 2.

The documentation of state indicators is not restricted to the basic case (in the example: the year 2013), of course. The results of trend and scenario analysis of certain years can be shown in the same way. Years of special interest like 2020, 2030, 2040 and 2050 which are in many countries “anchor years” of energy saving and climate protection targets should be documented in the same way.

In this context it has to be considered that the results do not only depend on the observed year but also on the scenario in question. It is assumed that each partner will provide a suitable individual numbering of scenarios (for example S1, S2, …) for a clear documentation of model calculations.

For illustration the head of the table of state indicators is shown for a hypothetical scenario S2 in the year 2030:

Table 9: State Indicators of Scenario S2 observed in the year 2030

Scenario S2: Building Stock 2030			
Basic Data	Complete building stock	Old building stock	
	bs$_{\ldots 2030 \vert 2030 \vert S2}$	bs$_{\ldots 1980 \vert 2030 \vert S2}$	
number of buildings			
number of apartments			
national reference area [m²]			
TABULA/EPISCOPE reference area [m²]			
Building insulation: state of modernisation			
walls			percentages related to ....
insulation improved (from original state)			building number
...(and so on)	...	...	...

3.2 Trend Indicators of building insulation and heat supply

Like the state indicators of chapter 3.1 also the trend indicators of model analysis are defined in correspondence to the monitoring indicators of chapter 2. In contrast to the state indicators they are not related to a certain year (2013, 2020, 2030, …) but to the time period in between. The following example shows the trend indicator table (again abbreviated) for the first period after the basic year 2013 of scenario S2:

Table 10: Trend Indicators of Scenario S2 for the period 2014-2020

Scenario S2: Trend Indicators of the period 2014-2020					
Basic Data	**complete building stock (contructed until 2013)** $bs_{...2013\|2014\text{-}2020\|S2}$	**old building stock** $bs_{...1980\|2014\text{-}2020\|S2}$		**new buildings** $bs_{2014\text{-}2020\|2014\text{-}2020\|S2}$	
construction and demolition	**demolition rates**		percentages related to....	**construction rate**	percentages related to....
demolition/ construction of apartments	0,2%/a	0,3 %/a	apartment number 2013	0,8 %/a	apartment number of $bs_{2013\|2013}$
Building insulation: modernisation trends					
walls	**mean annual modernisation rates**		percentages related to		
insulation improved (from original state)	1,2%/a	...	building number in 2013		
insulation improved (area-weighted)	1,0%/a	...	element area in 2013		
roofs/ground floors/windows: in the same way					
Building insulation: Insulation levels	**distribution of modernised elements**			**distribution of new buildings' elements**	
levels of wall insulation (area-weigthed):			percentages related to....		percentages related to....
level 0 (U > 0,7 W/m²K)	0%		element area of modernised elements	0%	element area of new houses' elements
level 1 (0,7 W/m²K >= U > 0,3 W/m²K)	20%	...		5%	
level 2 (0,3 W/m²K >= U > 0,20 W/m²K)	60%	...		55%	
level 3 (U <= 0,20 W/m²K)	20%	...		40%	
roofs/ground floors/windows: in the same way					
Main energy carrier for space heating	**net modernisation rates**		percentages related to....	**distribution of energy carriers**	percentages related to....
district heating	+0,1 %/a	...	apartment number 2013	15%	number of new apartments
gas (natural / liquid gas)	+ 0,3%/a	...		65%	
...(and so on)	....	...		...	
Main heat generation system for space heating	**gross modernisation rates**		percentages related to....	**distribution of systems**	percentages related to....
district heating	0,5/a%	...	apartment number 2013	15%	number of new apartments
combustion of fossil fuels: "level 0" systems: stoves, non-condensing boilers	0%/a	...		0%	
....(and so on)	...	...		...	
Special Systems	**gross modernisation rates**		percentages related to....	**application of systems**	percentages related to....
solar thermal systems	1,5%/a	...	...	35%	...
...(and so on)	...	...		...	
remarks	annual rates are mean values of the period				

The left part of the table shows the development of the building stock of the year 2013 (complete and "old" part of the stock). All annual rates are mean values of the period. Demolition rates are new in this context, but the other quantities are well known from the monitoring indicator tables of chapter 2. Again it is important to define the reference quantities of percentage numbers. In the given example annual rates are related to the building stock of a definite year (here: 2013). This is a convenient definition for scenario analysis because the volume of existing building stocks (e.g. number of apartments) is changing by demolition so that relating the modernisation rate to the volume of the building stock of a fixed year (i.e. to a clearly defined total number of apartments) means that the annual volume of modernisation measures (e.g.: How many apartments get a new solar system every year?) can clearly and easily be derived from the documented rates.

For simplification the net changes of the centralisation of the heat supply systems were not included in the table because the net development (e. g. the net increase or decrease of district heating systems or room heating systems) can easily be derived from a comparison of the state indicators of the beginning (2013) and the end (2020) of the period[11]. In principle this applies also to the net development of energy carriers (like gas, oil, …) but here it appears convenient to see this information which is very important for the development of CO_2 emissions at a glance. Besides, the information of energy carrier distribution in the new buildings section in the right part of the table has to be documented anyway.

Those new buildings, which were erected in the observed period, are documented in the right part of the table. In contrast to the existing building stock the development of heating systems is not described by annual rates but by percentage fractions, which are related to the total number of new buildings (or here: apartments) of that period. Modernisation of new houses (erected and modernised in the tabled period, here 2014-2020) can probably be neglected in the scenarios; at least it is not foreseen to document any numbers in the table.

[11] Accordingly also the net development of building insulation and modernisation of heat generation as well as special systems can be derived for a comparison of the state indicators. So it is valuable additional information if in the table of trend indicators the gross rates are documented in those cases.

3.3 Energy Balance Indicators

Within the indicator system it is intended to document some basic information of the energy balance calculations of model and scenario analysis. The related quantities should be documented at least for the Basic Case (e.g. 2013) and for the anchor years of scenario analysis (e.g. 2020, 2030, 2040, 2050). For simplification of the harmonised approach it is assumed that the numbers will be shown for the complete building stock of those years only, but of course it would be possible to document subsets (e. g. the old building stock) in the same way, if applicable.

The following table shows (for the basic case as an example) the demand-side energy balance including the heat demand (energy need) for space heating and domestic hot water and the heat losses of the distribution and storage systems inside the buildings, altogether adding up to the total heat demand Q_{total}. In addition, the total demand of electric auxiliary energy (for system control, pumps and fans of the heating and ventilation systems) is shown as well.

Table 11: "Demand-side" energy balance: heat demand of space heating and domestic hot water including distribution and storage losses)

Basic case ($bs_{2013|2013|B}$): heat and auxiliary energy balance		10^6 kWh
Heat balance		
$Q_{nd,h}$	Building energy need for heating*	11600
$Q_{d+s,h}$	heat losses of distribution and storage systems for space heating ($q_{d+s,h}=q_{d,h}+q_{s,h}$)	2700
$Q_{nd,w}$	energy need for domestic hot water (dhw)	3200
$Q_{d+s,w}$	heat losses of distribution and storage systems for dhw ($q_{d+s,w}=q_{d,w}+q_{s,w}$)	2900
Q_{total}	**total heat demand for space heating and hot water supply: $q_{total} = q_{nd,h}+q_{d+s,h}+q_{nd,w}+q_{d+s}$**	**20400**
Electric auxiliary energy demand		
$Q_{del,aux}$	total heat demand for space heating and hot water supply: $Q_{total} = q_{total}$·$qA_{C,ref}$	1350
** heat recovery by ventilation systems is not considered by $Q_{nd,h}$ according to TABULA definition*		

The energy balance of the heat supply systems is shown on the following page. The balances of final energy, primary energy and greenhouse gas emissions are shown side by side in one table to illustrate the principles. Later it will probably be more convenient to show the numbers one below another in one column in separate tables (so that different columns can be used for different anchor years or scenarios, for example). From the left to the right the final energy balance[12], the primary energy balance and the greenhouse gas emissions are shown[13].

Lines 1 and 2 indicate on the left the final energy demand of district heating ($200x10^6$ kWh = 200 GWh) and electricity (500 GWh) delivered to the buildings from district heating systems or the public electric grid, respectively, for the purpose of heating and domestic hot water supply[14]. In the primary energy balance at the middle of the table district heating and electricity are not directly considered (because they are not primary energy carriers) but they are considered by separate columns so that a break-down of fuels and renewables which are used for district heating an electricity production can be shown (if the information is available).

[12] The term "final energy" is at least widely similar to the "delivered energy" of prEN 15603 (which is dealing with the energy performance of buildings, not of building stocks). In the norm it is a matter of (national) definition if the contribution of renewables is included in the delivered energy balance. In EPISCOPE we include the renewables but indicate them separately, so that both perspectives are enabled.

[13] It is assumed here that CO_2 emissions as well as CO_2 equivalent emissions of other greenhouse gases are included. Details of a harmonised definition of emissions (as well as primary energy) will have to be discussed among the partners.

[14] Auxiliary energy for heating and ventilation is included; other household appliances are not included in the volume of electric energy.

Table 12: "Supply-side" energy balance: Final energy / Primary energy / Emissions

#	Basic case (bs...2013|2013|B): Primary energy / end energy / emissions	final energy	primary energy				Greenhouse gas emissions	
		on-site energy balance	on-site fuels and renewables	district heating	electricity (public grid)	total primary energy	related to final energy	related to primary energy
		10^6 kWh	10^6 kWh	10^6 kWh	10^6 kWh	10^6 kWh	10^6 kg CO2e	10^6 kg CO2e
1	district heating	200					46	
2	electric energy from the public grid (used for heat supply)	500					311	
	fossil fuels / nuclear							
3	natural gas	7000	7700	80	400	8180	1540	1636
4	liquid gas	500	550			550	116	116
5	oil	7000	7700		50	7750	2541	2558
6	coal	500	520	70	500	1090	218	458
7	nuclear			10	200	210		
	biomass							
8	wood /biomass	1500	1650	22	100	1772	66	71
9	*- in that: renewable energy*	*1500*	*1500*	*20*	*90*	*1610*		
	renewables (without biomass)							
10	electric energy produced by pv / wind (used for heat supply)	100	100	0	40	140		
11	energy delivered by solar thermal systems	400	400	10		410		
12	environmental heat	600	600	10		610		
	bonus electricity (not used for heat supply but considered in the primary energy or emissions balance)							
13	bonus (negative value) of electric energy produced by pv/wind and/or chp (if applicable)		-150	-20	0	-170	-15	-15
14	**total energy demand / total emissions: sum of above lines 1-13 (excluding line 9)**	**18300**	**19070**	**182**	**1290**	**20542**	**4823**	**4823**
15	non-renewable energy demand (including dh and el,publ): line 14 - line 16	15700	16470	142	1160	17772		
16	renewable energy demand: sum of lines 9-12	2600	2600	40	130	2770		
17	fraction of renewables: line 16/ line 14	14,2%	13,6%	22,0%	10,1%	13,5%		
18	demand of energy carriers: sum of lines 1 - 8	17200						

remarks:
auxiliary electric energy for control, pumps, fans of heat supply and ventilation systems is included
fuel demand is indicated by the gross calorific value

Lines 3 to 8 show the consumption of fuels in the buildings (final energy balance) and the related primary energy demand (left column of primary energy balance). The fuel consumption for district heating and electricity generation can be documented in the next two columns of the primary energy balance. The amount of primary energy consumption must correspond to the amounts of district heat (200 GWh) and electricity (500 GWh), which are indicated in the final energy column[15]. At the end the sum of all primary energy carriers used for the heat supply of residential buildings is shown. It is the sum of the primary energy carriers, which are applied on-site or in the district heating systems or for electric energy supply.

It might be the case that project partners do not operate with detailed models of district heating and electricity supply. In such a case the break down of different primary energy carriers cannot be given for district heating and electricity. Nevertheless, comprehensive primary energy factors will have to be applied so that at least the total primary energy demand of district heating and electricity (bold numbers in line 14, here: 182 and 1290 GWh) can be documented.

According to the TABULA definition (and also to the approach of draft prEN 15603, May 2013) always the gross calorific value is applied to measure the fuel energy demand (at the level of final energy as well as primary energy)[16]. In case of biomass the renewable part of energy demand is indicated separately in line 9, so that at the end (in lines 16 and 17) the renewable fraction of end and primary energy can be calculated.

Lines 10 to 12 indicate the section of renewable energy (excluding biomass) of the end and primary energy consumption. It is assumed that the definition of counting 1 kWh of electric energy from photovoltaics or wind engines as 1 kWh of final energy and 1 kWh of primary energy at the same time is common for all partners. The same applies to 1 kWh thermal energy from solar thermal systems or 1 kWh environmental energy (heat extracted from the environment by heat pumps).

In line 10 only electric energy, which is directly used for the heat supply (e.g. feeding electric heat pumps or supplying auxiliary energy), may be considered[17]. Further electric energy which is used for other purposes (on-site or in the public grid) is not considered or – in case that the applied energy balance method includes a bonus system for that kind of external effects – this has to be indicated in line 13 in the primary energy or emission balance[18]. Such bonus values of primary energy or emissions are listed as a negative primary energy demand or negative emissions.

To give an example for a single building: If there is a photovoltaic system producing electric energy the applied energy balance method might include an algorithm to calculate the fraction of that electric energy which can be used for the heat supply of the building (e.g. if there is an electric heat pump or for auxiliary energy use). If so, this amount should be listed in line 10 (there: not for a single building but for the complete building stock, of course).

On the other hand it might be the case that the applied method defines a bonus system, which means that the electricity produced by the PV system can be considered in the energy

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[15] In the example 1290 GWh of primary energy are necessary to produce 500 GWh of electric energy.

[16] This is at least the starting point of the concept. Problems might occur, if national energy balances are mostly related to the net calorific value. In this case a change of the concept might be discussed among the partners. So the partners should be prepared to provide the opportunity of switching between the gross and the net calorific values.

[17] Concerning the column "final energy" the following has to be considered: In line 10 of that column only the amount of electric energy may be counted which is not already included in line 2 (electric grid). So line 10 of the column "final energy" applies typically for "on-site" and "nearby" produced electricity from renewable sources (e.g. PV on the roofs) which is applied for heat supply. But keeping in mind that we are talking about large (sometimes national) building stocks, it may also include "distant" generation of electricity from renewables which is assigned to heat supply and not already included in line 2 (see the definition of "on-site", "nearby" and "distant" in prEn 15603, May 2013).

[18] It is assumed here that such bonuses are only defined at the level of primary energy demand and greenhouse gas emissions, not at the level of final energy demand. If this does not apply to all partners, please tell us.

balance of heat supply by negative values of primary energy or emissions. In this case the primary energy bonus, which is related to on-site photovoltaic systems, should be indicated in the first column “on-site fuels and renewables” of the primary energy balance in line 13 and line 10 should be kept empty.

Of course, also a combination of both methods could be documented, if applicable (so that numbers unequal to zero may appear in line 10 as well as in line 13). But if the applied method does not provide any rules for considering photovoltaic systems both lines should be kept empty.

The situation is even more complicated in case of chp systems (cogeneration, combined heat and power systems). In those systems the input of fuel (e. g. gas) is used for the generation of two products (heat and electric energy) at the same time. So the question is again how the fraction of final energy demand, the primary energy demand and emissions, which are assigned to building heat supply (and not to power generation for the public grid), can be calculated and indicated. Different methods exist and later in the project we will have to discuss how we can classify and indicate them to reach a satisfactory level of transparency. For the moment in the given table the following rules apply:

- If the applied method defines a split of fuel input to both products (heat and power) only the fraction of fuel demand which is assigned to heat production (for residential buildings) should be considered in the final energy, primary energy and emission balance (e. g. in line 3, if natural gas is used). If however a part of the electric power is also assigned to the heat supply of the residential buildings (e.g. directly feeding electric heat pumps or used for auxiliary energy) the corresponding part of fuel input should also be considered in line 3. In such a case the electric energy is only an interim product (on the way from gas to heat) and for that reason– in contrast to electric power from PV in line 10 (which represents the input of external solar energy to the heat supply system) - it is not considered separately.
- If on the other hand the electric energy produced by chp plants is considered by a bonus method the corresponding (negative) bonus values can be considered in line 13 (together with the bonus of PV/wind systems). In that case the complete fuel demand of chp systems (used for heat and power production) has to be indicated in the respective lines at the level of final energy, primary energy and emissions (e.g. line 3 in case of gas use).

At the right of the table the greenhouse gas emissions are indicated. As far as possible a harmonised definition should be found so that everybody is talking about the same quantity (for example: greenhouse gas emission of CO_2 and all other greenhouse gases (counted as CO_2-equivalents) related to the consumption of energy carriers, including emissions inside the country and emissions related to the exploitation of the energy carriers in other countries, emissions of producing heat generation system and building/insulation materials are not included).

In principle, a detailed approach of four columns as for primary energy would be possible but here for simplification only two columns are introduced: The first showing the emissions related to final energy consumption, the second showing the emissions related to fuel consumption. The sum is the same because it is a breakdown of the same amount of total emissions in two different ways.

Also a comparison of the final energy balance of the basic case according to the above table with actual energy consumption values according to table M.4 will have to be given, maybe resulting in adaptations of the calculation method to attain more realistic results. It can be assumed that a direct comparison of both tables will often not be possible (e.g. the observed values of M.4 might not deliver a separation of electricity consumption for heating purposes (as in the above table) and other household appliances, or a weather/climate correction of the M.4 values might have to be carried out). So a fixed scheme for carrying out the comparison cannot be given here, model calculations will have to be carried out (and documented) by the partners in an individually suitable way.

3.4 Summary Indicators

The indicator scheme documented in the chapters 2 and 3.1 - 3.3 aims at finding a common approach of data presentation to make possible comparisons of monitoring data as well as basic assumptions and results of model and scenario calculations between different projects in different countries. Although an attempt was made to reduce the number of indicators to a basic set (providing the information which is necessary to draw a transparent picture of the observed building stocks) the resulting scheme is quite complex and on an “expert level”.

In addition there should be a way of presenting some basic results of the building stock analysis in a much easier way which is meaningful also for “non-experts” or those who do not have the opportunity for getting into details. Also the comparison of the scenario results with target values (e. g. of example greenhouse gas reduction) has to be considered here.

In the project enough time should be taken to find a suitable way of presenting that kind of basic information – last not least an as far as possible self-explanatory display of graphs and diagrams should be developed for the project reports and the project website.

At the moment as a first step a basic set of summary indicators should be discovered. A preliminary approach which has to be concretised in the course of the project is described here:

- The development of total greenhouse gas emissions is of central importance and probably it will the most important “summary indicator”. In contrast to Table 12, the area-related value “$m_{GHG,total}$“ (related to the common TABULA/EPISCOPE reference area A_{Ref}) should be documented to ensure a better comparability of different building stocks[19].
- A clear and simple way of documenting the different contributions to greenhouse gas reduction by energy saving measures at the buildings on one hand and measures of efficient and renewable heat generation on the other hand is provided by the following equation:

  $m_{GHG,total} = q_{total} \times f_{GHG,gen}$ with:

  $m_{GHG,total}$: Total greenhouse gas emissions of the buildings stock (related to A_{Ref}), see above

  q_{total}: Total heat demand (see Table 11), related to A_{Ref}: $q_{total}=Q_{total}/A_{Ref}$

  $f_{GHG,total}$: Total greenhouse gas emission factor of heat generation

  So the documentation and illustration of those three quantities for the Basic Case and the observed scenarios can provide basic information of the development of emission reduction and at the same time of the role of both building-related measures as well as heat generation systems. Also other approaches would in principle be possible, e.g. taking the total demand of final energy as a reference point (instead of q_{total}). But in this case assessment problems related to CHP or other bonus systems would be included in the “building-related” quantity. Against that background q_{total} appears to be a clearer or “more objective” choice.
- Also the national and international targets of energy saving and emission reduction in the building stock should be documented and compared for different years. Besides the greenhouse gas emissions also other quantities may be important. On EU level the 20/20/20 targets for the year 2020 are of interest: Besides a 20 % greenhouse gas reduction also a 20 % fraction of renewables and a 20 % reduction of energy consumption are considered. A basis for providing the necessary data in the project is delivered by the energy balance indicators of chapter 3.3: The fraction of renewables is documented on the primary and final energy level, the reduction of energy demand can be followed on the level of heat demand, final energy demand and primary energy demand (total or only non-renewable), respectively. One of the project’s tasks will be to

[19] In Table 12 area-related values are not considered because they cannot be clearly defined or would probably be puzzling because of the split of different energy carriers in the building stock.

select those among the different options, which are best suited for a harmonised presentation of the results. Also the aim of a clear and equal definition of the quantities will have to be kept in mind.

- On the other hand, there might be limits of harmonisation: Different target quantities might be common in the participating countries. For example in one country the reduction of energy consumption is measured by final energy, in another country by primary energy. Also the target values will be different: The 20/20/20 targets can give a rough orientation for international comparison in 2020 but in fact they are average values of the whole EU and so they can not be directly transferred to single countries (or regional building stocks). So apart from the intrinsic indicators (energy demand, emissions) also more general approaches to measure the extent of target-keeping. In this context the relation of the achieved and the desired values might be the suitable point of view. For example, it could be indicated that in pilot project A the trend scenarios result in exceeding the target values of energy demand in 2020 by 20 %, whereas in pilot project B an overstepping of only 10 % is expected by trend analysis.
- Even if probably not considered by official international target systems the quality of building insulation in a building stock is a question of special interest, which should be considered separately. A comparison could be carried out on the basis of the heat demand $q_{nd,h}$ (see Table 11, $q_{nd,h} = Q_{nd,h} / A_{Ref}$)[20] or on the basis of a mean U-value (heat transfer coefficient) of all building elements and all buildings in the observed building stock, for example. A common reference value for international comparison might be the quasi ideal “passive house level” (proposed by Bill Sheldrick)[21].
- Apart from energy balance indicators also structural indicators should be considered as summary indicators, because they are less dependent from model assumptions and could be more directly checked by later monitoring activities. In the case of building insulation the achieved progress of modernising the thermal envelope of the buildings is of special interest (also for interested persons which are less familiar with energy or emission quantities). Based on Table 2 (M 2.1) at page 5 which defines the progress for each of the elements (walls, roofs,…) separately, for the summary indicator an area-weighted value of all building elements can be defined to indicate the total average progress of improving building insulation. For example, a value of 40 % would indicate that 40 % of the total “thermal envelope” area of the building stock (= total area of all walls, roofs, windows, cellar ceilings) will have been modernised by insulation until a certain year according to scenario assumptions. Accordingly a modernisation rate of 2 %/a means that 2 % of the total element area are insulated every year in the observed period.
  It should be checked if also structural summary indicators for heat generation systems can be defined. The fraction of buildings with solar systems installed might be an example. Concerning the main heat generation systems there is the question how a comprehensive and illustrative approach might look like will have to be discussed: For example, defining an easy classification scheme of system quality (e. g. level 1:“old, inefficient and/or very CO_2-intensive”, level 2: “standard”, level 3 “forward-looking, very efficient, low CO_2 emissions”) might be a solution, if comparable approaches can be identified by the participating partners[22].

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[20] This is not far away from observing q_{total} which is carried out anyway (see above), but q_{total} also includes the heat demand for hot water and the heat losses of distribution and storage within the building, so that it is not directly related to building insulation.

[21] If the comparison is based on the energy demand of space heating it will have to be discussed if for that purpose not $q_{nd,h}$ (which is a gross value not considering contributions of ventilation heat recovery) but better the net value $q_{nd,h,net} = (q_{nd,h}$ – heat recovery from ventilation) should be considered because heat recovery is a part of the passive house concept.

[22] The given example would be even more generalised and simplifying than the similar system proposed in chapter 2.3 (Table 4, M 3.1.3) because it would not only be restricted to fuel driven but to all heat generation systems. On the other hand generalisation will probably be necessary for a global “summary indicator”.