Reporting framework of equivalence according to the Directive 2010/31/EU on Energy Performance of Buildings Article 14 Paragraph 4 & Article 15 Paragraph 4

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1 Scope

This is a framework for an “equivalence report” to help Member States that have chosen the option of alternative measures rather than compulsory inspections of either Article 14 or Article 15 of the EPBD Directive. The first “equivalence reports” under the recast Directive to the European Commission were due in June 2011 and the second report falls due in June 2014.

The purpose of the framework is to facilitate comparable reports using standardized methods. The equivalence report for Article 14 (heating systems) contains headings for the main points that need to be considered such as; an outline of the methodology, suitable assumptions and the basis for comparison between scenarios. For Article 15, due to the individual differences, the framework had to be restricted to an outline of the method and a description of the main issues of equivalence reporting. Most parts of the procedures are applicable to both article 14 and 15, but the obstacles are quite different – see chapter 5 for further explanations.

The reader should be aware that the framework covers a large number of variables for calculating the equivalence. It is unlikely that Member States will have access to all the statistics covered and consequently they will need to make a number of assumptions to complete the equivalence.

2 Concerned obligations according to the Directive

The provisions concerning the equivalence are given in the Directive using nearly the same wording for heating systems and AC-Systems in paragraphs 4 of Article 14 and Article 15 respectively:

2.1 Heating systems:

Article 14 paragraph 4 allows Member States to take measures to ensure the provision of advice to users concerning

- the replacement of boilers,
- other modifications and
- alternative solutions to assess the efficiency and appropriate size of the boiler.

The overall impact of this approach shall be equivalent to that arising from the provisions set out in paragraphs 1, 2 and 3.

Where Member States choose to apply the measures referred to in the first subparagraph, they shall

- submit to the Commission a report on the equivalence of those measures to measures referred to in paragraphs 1, 2 and 3 of this Article by 30 June 2011 at the latest
- submit these reports to the Commission every three years.

The reports may be included in the Energy Efficiency Action Plans referred to in Article 14(2) of Directive 2006/32/EC.

The equivalence is due to be proved in comparison to the primary approach via a compulsory inspection scheme described for boilers in Article 14 paragraphs 1 to 3 with the following issues:

- Article 14 paragraph 1 states that the inspection scheme
  - shall be regular
  - has to cover the accessible parts of systems used for heating buildings such as
    - heat generator
    - control systems
    - circulation pumps
  - shall apply to boilers of an effective rated output for space heating purposes of more than 20 kW
  - shall include an assessment of the boiler sizing compared with the heating requirements, which will not need to be repeated as long as no changes were made to the heating system or as regards the heating requirements of the building in the meantime.

- Concerning the frequency of inspections, according to Article 14 paragraph 2 member states are free to choose depending on

  – the type
  – and the effective rated output of the heating system
  taking into account
  – costs of the inspection of the heating system and
  – estimated energy cost savings that may result from the inspection.

  According to paragraph 1 – last sentence – Member States may reduce the frequency of such inspections or lighten them, as appropriate, where an electronic monitoring and control system is in place.

- Special provisions concerning the interval of inspections are given in paragraph 3 for heating systems with boilers of an effective rated output of more than 100 kW:

  – in general at least every two years and
  – in case of gas boilers at least every 4 years.

2.2 Air-conditioning systems

- Article 15 paragraph 5 allows Member States to take measures to ensure the provision of advice to users concerning

  – replacement of air-conditioning systems or
  – other modifications to the air-conditioning system
  – which may include inspections to assess the efficiency and appropriate size of the air-conditioning system

  The overall impact of this approach shall be equivalent to that arising from the provisions set out in paragraphs 1, 2 and 3.

  Where Member States choose to apply the measures referred to in the first subparagraph, they shall

  – submit to the Commission a report on the equivalence of those measures to measures referred to in paragraphs 1, 2 and 3 of this Article by 30 June 2011 at the latest
  – submit these reports to the Commission every three years.

  The reports may be included in the Energy Efficiency Action Plans referred to in Article 14(2) of Directive 2006/32/EC.

The equivalence is due to be proved in comparison to the primary approach via a compulsory inspection scheme described in Article 15 paragraphs 1 to 3 with the following issues:

- Article 15 paragraph 1 states that the inspection scheme

  – shall be regular
  – must cover the accessible parts of the air-conditioning systems
  – shall apply to air-conditioning systems of an effective rated output of more than 12 kW and
  – shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building, which will not need to be repeated as long as no changes were made to this air-conditioning system or as regards the cooling requirements of the building in the meantime.

- Concerning the frequencies of inspections, according to Article 15 paragraph 2 member states are free to choose depending on

  – the type
  – and the effective rated output of the air-conditioning system
  – taking into account
  – costs of the inspection of the heating system and
  – estimated energy cost savings that may result from the inspection.
  – According to paragraph 1 – last sentence – Member States may reduce the frequency of such inspections or lighten them, as appropriate, where an electronic monitoring and control system is in place.

- Paragraph 3 encourages the member states to combine these inspections, as far as is economically and technically feasible, with

  – the inspection referred to in Article 14 and
  – the inspection of leakages referred to in Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases

3 General approach

Paragraph 4 both in Article 14 and 15 foresee the need to compare a fictive “compulsory inspection scenario” to a scenario describing the alternative measures the Member State has chosen to apply.

In both scenarios it is recommended to take into account the underlying development of the stock of systems that is caused by other reasons, mainly replacement of systems and parts thereof due to natural end-of life and of market trends (e. g. change of energy carriers for economic reasons), see chapter 3.2.

Depending on the availability of data and the possibilities to make suitable assumptions, one has to choose how to carry out the calculation. Generally, the framework describes two approaches on how the calculations could be carried out: a top-down and a bottom-up approach.

Completely different methods of calculation are conceivable as well as combinations of the top-down and the bottom-up approach. When combining the two approaches one has to pay attention to only combine data with the same boundaries, i. e. data used for the calculations must regard the same time-frame and the same conditions for both approaches.

3.1 Steps of calculation

First of all, available data has to be collected, preferably from existing sources. Once collected, the datasets must be analysed based on their applicability for the intended case.

Parallel to collecting data one should clarify which scenarios are required in order to carry out the calculation and prove the equivalency of measures to the Commission. The required scenarios for this report would be

1. a baseline scenario (identifying the changes and replacements without any measures taken),
2. an “inspections” scenario (with inspections according to Article 14 of the Directive) and

3. an “alternative measures” scenario (that takes into account and evaluates the measures taken or that are already in place in the reporting country). Detailed information how these scenarios should be carried out is to be found in the next subchapters.

The scenarios are partly projections of future years respectively years without consolidated databases, since the requirement of the respective paragraphs 4 seemingly implies an “ex-ante”-comparison. This could enhance the need to obtain a baseline-scenario.

Possible levels of comparison between scenarios 2 and 3 are CO_2-emissions, primary energy, delivered energy and energy costs. The timeframe for all scenarios must be the same.

A sensitivity analysis should be performed to prove the range of validity for the equivalence when the outcomes of the “inspections” scenario and the “alternative measures” scenario have been compared. The greater the amount of assumptions within the scenarios, the greater emphasis must be put on the sensitivity analysis.

3.2 Baseline scenario

It is realistic to assume that some boilers would be replaced due to end-of-life or dwindling reliability even without any measures taken. The replacement of a heat generator normally includes several other measures such as replacement of central controls and pumps, hydraulic balancing of the system and proper sizing of the new boiler. The result of this affects the data – especially those used to determine the impact of the inspections. A refurbished system would not be expected to receive any recommendations in case of an inspection.

The baseline scenario describes the “natural” change in numbers of systems of a certain age, fuel and type. The “inspections” scenario and “alternative measures” scenario should therefore be derived from the baseline scenario to have appropriate numbers for the upcoming years of reporting.

When using a bottom-up approach (see chapter 4.2) a number of assumptions must be made for the baseline scenario and must be written down. The most important assumptions with the greatest impact are:

- the number of boilers at the beginning of the reporting period, grouped by size, fuel, age and technology, as far as these cannot be taken from databases,
- the age at which a boiler is “naturally” taken out of service as average value, perhaps with differences to the groups determined above,
- any market trends that result in a further change of the numbers (e. g. tendencies to other fuels or to heat from renewable sources, increase of district heat grids, changes of the number of buildings due to demographic effects etc.)

Additional assumptions might be necessary depending on the countries specifics.

A baseline scenario might significantly affect the impact of inspections in future reporting periods. The number of new boilers and “alternative solutions” tend to increase over time and the number of due inspections could decrease as boilers with a rated output over 20 kW are replaced by properly sized boilers below this threshold.

3.3 “Inspections” scenario

The main characteristics of the hypothetical inspection scheme must be defined in order to prove the equivalence of alternative measures chosen by Member States.

The Directive stipulates a few general requirements but many assumptions must be made in order to calculate the hypothetical scenario of inspections. The Directive states that the inspection scheme must be regular with stipulated frequencies for heating systems, and states that all accessible parts of the system must be inspected.

In order to determine what the impact of an inspection would be, it is necessary to know the precise properties, and areas of use, of the installations that should be inspected (type, fuel, age, power). If a top-down method is chosen (see § 4.1 for further details), energy consumption data for space heating according to energy is necessary.

Since the "inspection" scenario is completely fictive, a number of assumptions will have to be made, often to the full extend for the bottom-up-approach.

Parameters to study

- Assumed intervals of inspections

The frequency of the assumed intervals of inspections is the first criteria to be determined. It is of high importance since compromises must be made to avoid additional costs due to either too short or too long intervals that would reduce expected energy savings. Information on performance decrease must be taken into account in order to determine an optimal frequency. The interval directly influences the number of systems due for inspection in a certain year of the reporting period. If e. g. the interval is "4 years", 25 percent of the total number of boilers will be due in a certain year. But the interval should not be too short; further inspections of a system would then not result in new recommendations compared to the previous inspection. Consequently if the previous recommendations have already caused improving measures, there might not be any new recommendations at all.

The definition of frequency of inspections not only impacts the possibility that improvements are found, but also the whole setup of the system (choice and available number of experts, costs).

The Directive does not determine a fixed interval except for heating systems with boiler of an effective rated output of more than 100 kW with fuels other than gas. Considering the interval for these large boilers being set at "2 years" and for large gas boilers at "4 years", an appropriate choice for other boilers might be "4 years" or longer. Longer periods are not excluded by the text of the Directive.

- The depth of the inspections

For each system it would be essential to specify how much detail the inspection should cover. This would enable the Member States to define recommendations that can be provided to the owners/users). Advice has to be proposed according to the installation and the building. The detailed description of what the inspection should cover would enable experts to deduce expected energy savings. A very detailed inspection – e. g. using detailed measurements and giving advice with calculated saving potentials – needs a highly skilled and well-equipped expert and will be costly for the operator of the inspected system. Measurements and detailed expertise are not required by the Directive.

Some issues might not be dealt with, if the inspector does not get free and complete access to the building. In some cases special legal arrangements might be needed and perhaps – due to additional visits to get access to rented-out flats – the typical cost of an inspection could increase, which according to Article 14 Paragraph 2 and

Article 15 Paragraph 2 should be considered in the setup of an inspection scheme. To complete the definition of the hypothetical inspection scheme the profession of the inspector must be known (e.g. chimney sweepers).

Consequently the definition of the subjects of the inspection not only has an impact on the possibility to detect improvements, but also on the whole setup of the system (choice and available number of experts, costs).

Setting up the hypothetical inspections, it is recommended to fully follow the targets given in Article 14 paragraph 1. The current CEN-standard covers a wider scope.

- Building performance

The building performance of the building in which the systems are installed is also a required input. It is of importance to assess the energy usage of equipment. It is however one of the most difficult things to obtain data on, in particularly when wishing to link it to the performance of the installation itself. Energy performance certificates, which – if available – can be a good information source to link the equipment to the building, might be a possible way to obtain the information. Otherwise, assumptions must be made.

- Probability of implementation

Advice does not influence the energy use for heating without implementation by owners or users. Consequently the probability of implementation has to be introduced into the calculations. The probability of implementation is a complex factor to define because it deals with the prediction of human behaviour which is hardly possible, especially within a framework of a hypothetical situation. But nevertheless without it the calculations cannot be made.

- Available data

Member States could rely on manufacturer's databases or studies, energy performance certificates or maybe statistics on heating consumption from studies conducted by the government.

Ideally all Member States would have data concerning all these criteria, ensuring reliable results. However, not even Member States with very good databases have access to enough data.

Consequently Member States are forced to make assumptions when data is not available. When a hypothesis is included in the calculation, it brings impreciseness to the final results. That is the reason why; if Member States are forced to make too many assumptions, a detailed approach could become misguiding.

3.4 "Alternative measures" scenario

Member States that have chosen alternative actions in order to comply with Article 14 paragraph 4 have chosen various alternative measures to achieve the same objective as a fictive inspection scheme would have. These measures can be divided mainly into funding, guided and requested personalized advice as well as legal measures. The complete list of alternative measures– as indicated by the Member States – comprises:

- Building regulations
- Other legal regulations

- Information campaigns
- Mandatory regular maintenance
- Campaigns for voluntary regular maintenance
- Personalized advice to owners, supplied by public funding
- Financial incentives
- Other national energy policies (eg, supplier obligations (like White Certs))

These types of measures all include to a certain extent the provision of advice to the owners/users of a system (even if in the case of some regulations this advice does not leave much room for individual decisions).

To what extent the effect of the measures can be monitored, and the differences reported, differs. When the effect is calculated it is necessary to consider the "baseline" i.e. what would have happened on the market or the installed systems if no measures had been taken by the Member State. The required amount and precision of data depends on the chosen method, please refer to chapter 4 for more information.

Building regulations or other legal regulations could include mandatory improvement such as old boilers being replaced at a certain age, mandatory update of pipe insulation, controls etc. The effect of some of these regulations could be measured by statistics recorded in course of the legal enforcement of the requirements or by monitoring the number of newly installed boilers (using a database if available). Especially in case of a stringent legal enforcement one can assume that a requirement would be totally obeyed and therefore in the end the whole population of systems affected by the requirement would be improved in the required way. Methods are needed to evaluate the impact of **information campaigns**. Examples of previously executed campaigns by the Member States are campaigns to promote "low cost measures" and government-funded internet consulting. The impacts of these are difficult to evaluate, especially in terms of energy. Campaigns are often most efficient in combination with other measures such as legal regulations or funding.

One example of **personalized advice** to owners of heating systems from the UK is a simple checklist provided by the government to be used by a technician when servicing a boiler. This includes very simple inspection of controls, hot water storage vessel and pipe insulation. In Sweden for example there are local energy advisors that register the energy use at the time of advice which can later be followed up upon to measure the effect of advice given.

In the case of **funding programs** the experience (or even detailed records) from current funding cases must be extrapolated to the future since the report applies to future years. This implies that changes in "baseline" and funding conditions must also be considered.

Some measures only impact part of the systems. This means that this part must either be calculated or estimated. Possible sources of data for measuring effects need to be identified or - if no such data exists - one must formulate a reasonable assumption. There is seldom enough data concerning the quality of the building or terms of use for the system in question. This is another area where assumptions must be made.

3.5 Comparison of impacts

Articles 14 and 15 in the Directive state that if a Member State decides to transpose the requirements by using alternative measures, «the overall impact of this approach shall be equivalent to that arising from the provisions set out in paragraphs 1, 2 and

3». According to the Commission, the equivalence has to be proven in terms of energy savings. Therefore the results must be presented from an energy point of view by for example considering primary energy or delivered energy. It is however also possible to include results expressed with a CO_2-emission indicator or show a cost assessment. This will however remain optional and will not be sufficient to prove the equivalence.

The calculation of the equivalence should take into account the impacts of inspections and alternative measures that take place during the three years of the reporting period.

Two important notions should be considered prior to attempting to demonstrate the equivalence.

Firstly the results of an action must be considered within the three year period. The Commission does not want Member States to include effects outside the term. For example, if an action consists on the replacement of equipment the energy savings calculated for the whole lifetime of the system should not be considered as an effect.

Secondly Member States must be cautious when estimating effects of their actions. If it is assumed that an action has an effect the year after its implementation, impacts of actions that are carried out the third year will not be included in the assessment of this time-frame. A recommendation would therefore be to use the hypothesis that an action is implemented immediately and therefore has impacts within the year of the inspection that results in this advice; later actions would not be assigned as follow-ups to an advice.

3.6 Sensitivity analysis

As far as any scenario is based on assumptions, the results should be verified by a sensitivity analysis. First it must be determined within which range the assumption can be expected to vary under reasonable circumstances.

If e. g. one has to take into account the impact the energetic quality of the building has on the energy savings achieved by replacement or improvement of its boiler, one could determine the limits by first calculating this kind of boiler in combination with a building of very good quality and then in combination with a building of poor quality. Thus, one gets the range of possible deviations if for all buildings supplied by this kind of boiler the thermal quality is assumed as average. Having determined this range, one could show the reliability of calculations based on this assumption.

The larger the number of assumptions taken during a calculation, the more effort has to be put into the sensitivity analysis. Since two scenarios have to be compared, the assumptions taken in both scenarios should be consistent. If so, the influence of deviations will be diminished since one can mostly assume that they will have roughly the same influence in both scenarios.

The critical assumptions that need to be mainly dealt with are those that might probably influence the results in favour of the “alternative measures” scenario. If on the other hand a deviation is in favour of the “inspections”-scenario, there is no need to evaluate its influence. If it can be proven that the equivalence is given even with the – under reasonable circumstances – worst set of assumptions, the results cannot be debated.

4 Methods to calculate impacts

The following chapter describes two solutions that serve as examples of how one could calculate the effects. These could be mixed, so that the top-down approach is used for the fictive inspection system and the bottom-up approach for the alternative measures or vice versa. There could also be other appropriate solutions, e.g. using studies of certain improvements and to extrapolate these to the entire population of systems.

4.1 Top-down approach

The top-down approach is an appropriate way to proceed for member states that do not have a lot of data concerning the heating- or AC system stock. The approach consists of using aggregated data on consumption of the whole stock as a basis to prove the equivalence. It is assumed that the proportion of measures that are carried out directly correlates to the level of energy efficiency that is reached.

The steps that member states must go through are broadly the same as in the bottom-up approach but with a different starting point and point of view.

4.1.1 "Inspections" scenario (see flowchart 1A)

<u>Step 1: Determine energy use of the stock targeted by Article 14</u>

The first step is to collect energy data that excludes energy use for the industrial sector. If this is impossible, the top-down approach would then include too great of an uncertainty and it would be better to use the bottom-up approach.

It is necessary to have energy data for heating only; it can be necessary to assume what fraction of energy that is used to heat water. Unlike energy needed for heating, energy used for hot water might be easier to approximate, because the determining factor depends mainly on the number of occupants of the building, which is loosely related to building size.

Energy usage data includes all systems, whereas there is a threshold for Article 14. It is therefore necessary to subtract the energy use of systems not included in the scope of the default approach described in the Directive.

For this purpose data is needed concerning the repartition of the stock, according to output. It is then possible to consider an average energy use of a system that is included in the scope and multiply this by the total number of systems not concerned by the requirement of the inspection. Data from energy performance certificates can be of use to Member States. Hence the knowledge of the scope does not need to be as accurate as in the case of a bottom-up approach and does not required linked data for each system. The output is sufficient.

This permits the use of isolated data that only concern the energy use of the systems included in the scope of Article 14.

<u>Step 2: Inspection scheme</u>

This step is broadly the same as that of the bottom-up approach. It is possible to deduce from the Directive the main characteristics of the inspection scheme although Member States must set some parameters, such as the interval between inspections.

Member States must determine the time it would take to inspect all systems, which in turn will help Member States to estimate the fraction of the energy usage that is affected each year.

Step 3: Define measures to represent recommendations, their impact in terms of energy savings and the range of owners who will undertake them

Inspectors should present recommendations to the owner/user after completing an inspection. It is therefore necessary to determine the types of measures and associate them with energy savings. The principle is to manage and assess the impacts and then to make assumptions about how many measures will be carried out. The best approach is to test different scenarios to take into account unavoidable uncertainties concerning human behaviour.

For example in France, three different types of action were considered:

- No action is taken: inspection does not imply that suggested measures will be carried out. It has been observed within previous frameworks for other measures where recommendations are presented to the owner/user that it is difficult to convince him/her to go through with the improvement (the same case as a recommendation in energy performance certificates).

And if an action is implemented it can consist of:

- An adjustment of the performance of the system: slight actions that allows the owner to carry out energy saving measures without spending great sums of money.
- Replacement of the system: this action will generate the highest level of increased energy efficiency but it will only be implemented in a few cases due to high investment costs.

Step 4: Calculating the impact of the hypothetical inspection scheme

To calculate the level of energy efficiency it is necessary to go through the following steps:

- By considering the inspection period for the whole scope, it is possible to deduce the fraction of energy use for heating that is expected to change during the year.
- Then, for each scenario of human behaviour and action taken, calculate the fraction of the total energy use affected by this action. This fraction corresponds to the energy use of systems belonging to owners who will carry out the action.
- For each action, the previous fraction has to be multiplied by the percentage of energy savings of the action in question.
- Finally by adding all the savings, the total impact of the year is calculated.

4.1.2 “Alternative measures” scenario (see flowchart 1B)

Step 1: The scope

For each alternative measure, the scope of the systems concerned has to be described. By using the energy data for heating mentioned in Chapter 4.1.1 for the reference scenario, it is possible to deduce the energy use related to each measure.

In France, for example, alternative measures are the following:

- Information campaigns: it was impossible to evaluate the energy savings caused by these.
- A mandatory regular maintenance scheme: the same kind of approach as the one used to assess the impact of the hypothetical inspection scheme was chosen. And these schemes were compared directly.
- Financial incentives: zero rated loan, a tax credit and the mechanism of white certificates. Thanks to monitoring systems the impact of all these schemes could be assessed.

Step 2: Define possible actions implemented caused by alternative measures and their impact

For each alternative measure, the types of possible resulting actions must be specified and a percentage of energy savings associated.

The associated percentage can come from specific studies or a database. Otherwise assumptions must be made and the best solution in this situation can be to consider a range of possible values and test these.

Step 3: Implementation of alternative measures

Ideally the data is provided by monitoring system for each measure; otherwise assumptions must be made to identify the fraction of owners that will try to improve the performance of their installation.

- Legal regulations:

In this particular situation, it is legitimate to assume that all owners/users obliged to do so will meet the requirements. So in terms of energy use, the same fraction of the energy use as the one of the scope that is targeted by the obligation should be considered.

- Information campaigns:

It is difficult to find data to assess information campaigns. Member States are yet to come up with a method to assess the effects of an information campaign.

- Mandatory regular maintenance:

Directly correlates to an action (mainly an adjustment of the performance) since it is included in the service provided. Compared with the outcome of an inspection scheme, more owners will take action. The maintenance effects might be smaller in term of energy savings than expected from an inspection, since actions implemented due to a maintenance visit are slighter and it can be assumed that most owners will limit themselves to that.

The percentage of implementation depends on whether or not the measures are mandatory.

- Personalized advice to owners supplied by public funding :

To deal with this case it is necessary to have an idea of number of owners/users who get the personalized advice, the actions that they take after that and their impact in terms of energy savings. Maybe these data can be found if there is a monitoring system linked with the public funding, or if owners send back a questionnaire several months later to inform of what they have done following the advice. Otherwise assumptions must be made but Member States should base these on some studies to be able to define a coherent order of magnitude. Then the percentage of owners has to be converted into a percentage of the energy use for heating to assess the impact.

- Financial incentives :

There is usually a monitoring system for the measure and the kind of actions that are implemented, in particularly to assess the cost of the support scheme, which enables Member States to deduct the percentage of owners that carry out each possible action.

Step 4: Avoid double counting

If certain actions can depend on several alternative measures, it is necessary to define the fraction of the scope affected by different alternative measures to avoid double counting. Possibly owner behaviour studies can be used as the basis for assumptions about how many owners follow a certain scheme when there are more schemes available.

Step 5: Sum-up of alternative measures

All the impacts must be summed-up to permit the comparison to the inspection scheme.

4.2 Bottom-up approach

The bottom-up approach is mainly suitable for Member States with sufficient data for systems concerned with either Article 14 or Article 15. The main advantage of this approach is that differences between systems (e. g. concerning age, applicability of certain measures and impact on energy savings) can be considered more detailed compared to a top-down approach. Furthermore, with a bottom-up approach there is no need to analyse and allocate fractions of total energy use from other sources with respect to scope of the obligations stated in the Directive. It might also be easier to make and prove assumptions on the impact of individual inspections and alternative measures using this approach. On the other hand a top-down approach might be easier and at least equal in validity of results if an extensive amount of data is missing – especially concerning the current stock of targeted systems. The more assumptions that are required in order to fill gaps in the data, the less reliable the calculation will become. This issue will partially be accounted for by means of a sensitivity analysis.

4.2.1 "Inspections"-scenario (see flow-charts 2 A to C)

Step 1: Determine the total number of concerned systems

- Determine the total number of systems at the beginning of reporting period
  Possible sources (examples):
  - – cadastre / mandatory register of boilers,
  - – extrapolation from national epc-database
  - – extrapolation from representative polls
  - – extrapolation from manufacturer's / installer's data-pools

- If the total number of systems does not present sufficiently detailed fractions concerning age, type and size of the boilers/AC-systems, assumptions should be made. A starting point might be the equal division of the total number of systems into the needed fractions (age, type, size with respect to the obligations of the Directive).
- Determine the total number of systems at the beginning of every single year of the reporting period using the “baseline”-scenario, in order to pay account to the “anyway”-development (affected by end-of-life-replacements, increase / decrease of number of buildings, market tendencies – e. g. change of energy-carrier)

Step 2: Define an inspection scheme that would meet the obligations of the Directive

The Directive provides focus areas and goals of the inspections, but does not determine

- The exact interval of inspections
  The interval directly influences the number of systems due for inspection in a certain year of the reporting period, see chapter 3.3.

- The depth of the inspections

  The depth of inspections must at least fulfil the needs that are defined by the Directive, see chapter 2.1. On the other hand, inspections are also described in CEN standards, for heating systems in EN 15378: 2007. This standard offers inspections covering many more aspects than are required by the Directive. Thus, a fictive application of a scheme with the extensive full inspections suggested by the standard might lead to considerably higher impacts than those required by Article 14.

Step 3: Define measures or packages of measures to represent recommendations

The results of an inspection according to Article 14 Paragraph 1 and 3 and/or Article 15 Paragraph 1 and 3 are recommendations on how to improve the system, which become the subject of a report addressed in Article 16. Due to the fact that the inspection scheme that serves as reference to prove equivalence is fictive, assumptions are needed concerning the recommendations. Such recommendations depend strongly on the system’s age, type, size and perhaps fuel.

It is suitable to define typical packages of recommendations suitable for several systems with similar conditions.

Step 4: Assign energy savings to each package of measures

To assign possible energy saving impacts to the packages of measures, assumptions concerning the heat load of the supplied building and of the operation of the system must be made. The impact also depends on the assumed starting quality of the system parts that are subject of improvement or replacement in a certain package.

Step 5: Define probabilities of the recommendations

Since the packages cannot be assumed to be suitable for all of the carried out inspections, a probability has to be assumed for each of the packages. (If e. g. a package relates to the replacement of a circulator pump in a heating circuit, the probability of such a recommendation is restricted to systems with separate pumps, and furthermore only to systems that have not recently been installed or updated.)

Step 6: Define probabilities of the realisation of an improvement by the owner / operator

It should be considered that the recommendations given in course of an inspection scheme are nothing but unasked-for advice to the owner. The owner alone decides on this basis whether or to what extend these recommendations will be carried out to improve the system.

The system of equivalence reporting does not allow any measures realised later than the current reporting time frame to be included. Thus, a probability has to be defined for each "package" of recommended measures, whether or to what extent owners might follow the recommendations with immediate actions.

Above all, this fraction of probable actions depends on the owner himself: If the owner benefits from the measure, the probability of realisation is higher than in the case that only others – mainly the tenants – benefit. There might also be differences between corporate, private and public ownership.

The cost-benefit ratio and the costs of the measure also affect the probability of realisation. The shorter the estimated pay-back time, the more owners will be expected to follow a certain recommendation. The higher the costs of investment, the fewer owners will be able to finance a measure. On the other hand (especially in case of corporate or public ownership), certain low- (but not zero-) cost measures might be postponed in order to include these measures into larger renovations planned for later realisation.

Considering the above mentioned influences, the probability that the owner follows a recommendation immediately, will be below ten percent and probably varies for different assumed measures.

Step 7: Calculate the impact of each measure and summarize the impact for each year of the reporting period

The total impact of measures carried out in course of a fictive inspection scheme can be calculated as follows:

$$\Delta Q_{total} = \sum_{i} \Delta Q_i \cdot k_i \cdot p_i \cdot n_{total}$$

with

ΔQ_{total}	impact of implemented recommendations in a certain year
i	index for summation of part impacts
ΔQ_i	assumed impact of the package of measures "i"
k_i	percentage of the stock where the package "i" is assumed to be a reasonable recommendation
p_i	percentage of owners/users assumed to realise the package of recommendations "i" immediately
n_{total}	number of heating systems for which an inspection would be required in Art. 14 in the certain year (from baseline scenario)

The summation should be carried out on the level of energy use that is intended for comparison (see chapter 3.5).

4.2.2 “Alternative measures” scenario (see flow-chart 2 D)

Step 1: Define the scope of each alternative measure to be calculated

- Building codes and other legal Regulations, mandatory regular maintenance:

In case of a legal regulation, there is a scope given within the regulation itself often completed by certain exemptions.

Example: The current German obligation to replace old boilers by new ones refers to a certain date of installation (before 1st January 1985) which defines the scope in general, but excludes low-temperature and condensing boilers. It is furthermore completed by a regular enforcement which includes “advice” concerning the applicability of the requirement to the boiler in question.

- Financial incentives: funding programs including funded personalized advice

Funding programs are normally restricted to certain well-defined cases (e. g. replacement of circulator-pumps of a certain age or a certain range of size). Some programs might be restricted to a certain group of owners (e. g. private owners), which makes assumptions normally unavoidable about the ownership of the addressed heating systems.

In case of incentives by reduced taxes the scope is wide, but the determination of the impact of the incentive towards realisation is difficult – some groups of owners might not, or not significantly, benefit from the tax incentive and should be discounted from the total scope of application of such a measure.

- Information Campaigns

For campaigns, the bottom-up approach is normally not recommendable, since all possibilities to evaluate their impact can only be done at the top-level. It does not help to determine any scope.

Step 2: Determine for each alternative measure to be calculated the relevant fraction of the total number of systems

The total number of affected systems is calculated using the results of step 1. The main issue will be to determine this number in the cases where the scope is affected by the role of the owner (restricted applicability of a measure e. g. funding only addressed to private owners, tax incentive only useful for owners who are subject of taxation).

Step 3: Define improvements initiated by the alternative measure

Apply Step 3 from chapter 4.2.1 as far as appropriate. Some alternative measures – especially legislative requirements and funding schemes – do not leave much space to determine the improvements, since they are mandatory or a prerequisite to get the funding.

Step 4: Assign energy savings to each improvement caused by an alternative measure to be calculated

Follow Step 4 from chapter 4.2.1 as far as applicable. In many cases it will be unavoidable to assume a certain energetic quality of the building supplied by the heating systems.

Step 5: Determine the probability for the realisation of each improvement described in step 4

The probability varies greatly with respect to the kind of alternative measures. Some hints to determine the probabilities are given below.

Legal obligations:

It seems reasonable to assume that the vast majority of owners are law-abiding, which results in a high percentage of immediate realisation.

Funding programs:

Since any funding will normally be linked with a proof that the funded measure is really carried out, the implementation rate in relation to assumed cases will normally be the above mentioned high percentage (even 100 %).

Personalized advice:

For personalized advice the provisions about implementation of a given recommendation apply as in case of the regular inspections, see chapter 4.2.1 Step 6.

Information campaigns:

For campaigns, the bottom-up approach is normally not recommendable, since all possibilities to evaluate their impact can only be done on top-level. It so far does not help to make any assumptions about the fraction of measures immediately carried out.

Compulsory or intensified maintenance:

For compulsory maintenance, the same applies as to legal obligations. In addition, there should be also some measures that are carried out because of advice given by the expert / craftsman performing the maintenance. This aspect should be dealt with as an additional "personalized advice" on top of the benefits achieved by mandatory regular maintenance.

As far as the maintenance is not compulsory but introduced by a campaign, the two aspects (results of the maintenance itself and the additional advice given by the technicians) should in principle be treated as with compulsory measures, but with a significantly lower percentage of realisation. It should be taken into account that a certain part of the stock would be subject of regular maintenance even without any obligation or stipulation.

Step 6: Calculate the impact of each measure and summarize the impact for each year of the reporting period

Apply the calculation given in chapter 4.2.1 Step 7.

5 Differences between Articles 14 and 15

5.1 Impacts and conditions to be considered in scenarios

The assessment of impacts of a hypothetical inspection scheme versus alternative measures in the case of Article 15 EPBD can be carried out with the same approach as in the case of Article 14 EPBD.

With AC-systems there are however several issues that make any calculations and set-up of scenarios much more difficult:

1. AC systems are used for a wide range of purposes. Normally,
   - internal heat loads caused by use (human occupation, installed electrical appliances etc.)
   - external heat loads caused by outside conditions (solar radiation through the windows, outside air temperature)
   - sensory loads (smell, used-up indoor air with too high CO_2-percentage)

   have to be removed by AC-systems when combined with ventilation (as is often the case). The individual extent to which these purposes determine the layout and operation of the system vary. In many cases, very specific indoor conditions are needed throughout the year (e. g. in museums, laboratories, IT-server-rooms and industrial production plants); these can only be provided by a system with an appropriate custom design and not by the standard types of systems.
2. The building's technical features, especially solar shading and type of glazing, to a large extent affect the external loads.
3. Changes in the internal loads (e. g. because of new, more efficient IT systems or exchange of lighting to more efficient sources) also affect the operational conditions of AC-systems as along with the activities within the buildings and regular times of use.
4. The systems in question differ greatly in terms of overall efficiency. Unfortunately not all systems are suitable for every case of use or every building situation (e. g., very efficient systems with adiabatic cooling cannot be installed if the specific cooling load exceeds a certain amount.). There are
   - systems conditioning the supplied air,
   - systems cooling the room directly (e. g. cooling ceiling combined with ventilation),
   - systems operating centrally as well as
   - systems operating locally for a single room (e. g. split systems) or for a group of rooms (multi-split systems).

As a consequence, for the purpose of calculating the impacts a detailed database will be required expressing the cross-relations between the type of system, the building's technical features, the purpose of air-conditioning (heat removal, ventilation, stability of indoor conditions) and the conditions of use (internal loads, terms of operation). Otherwise, neither total consumption nor potential savings (due to applied advice from inspection or due to alternative measures) can be calculated.

5.2 Typical recommendations for AC-systems

If the inspection interval is not too short, it is likely that either the technical features of the building (solar shading, type glazing), the terms of the building's use or the system´s operation have changed since the date of installation or the most recent inspection. In that case, a considerable amount of energy saving can be obtained even without larger investments just by a better adjustment of controls, by installation of improved control devices, through better software for operation or by turning off certain functions that are no longer needed. On the other hand, those improvements are influenced by the issues described in chapter 5.1 and therefore quite different from case to case.

Of course, all AC-systems need a proper maintenance mostly with intervals much shorter than the intervals that would disclose the above mentioned changes in use or building performance. Some member states with an inspection scheme (e. g. Portugal, Germany) therefore have introduced a mandatory maintenance scheme (to keep the original performance of a system e. g. by replacing filters, gaskets, belts etc.) separate from the main inspection scheme with considerably longer intervals.

5.3 Bottom-up approach

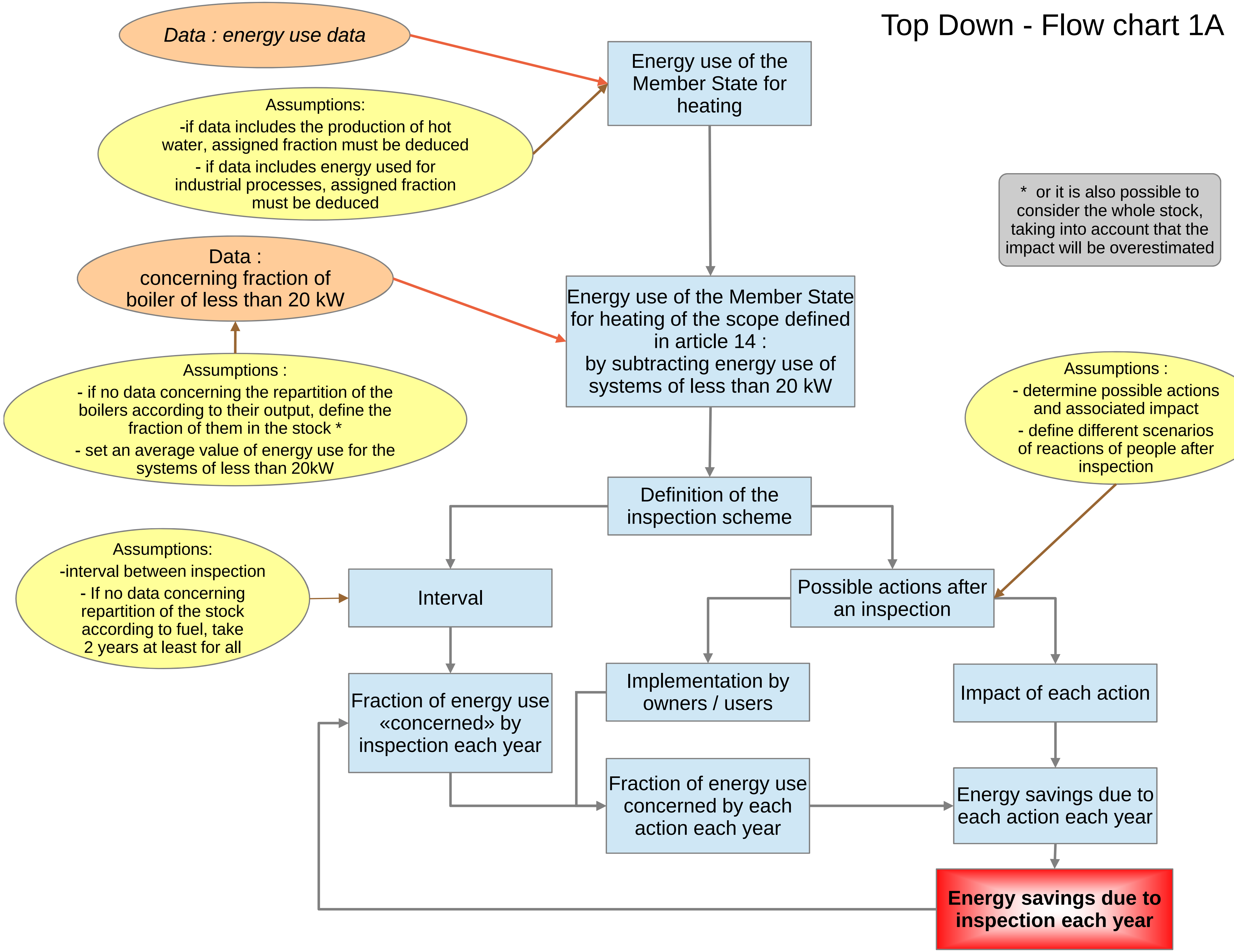
Databases with the extent of information described in chapter 5.1 are rare. Therefore, to apply a bottom-up approach it is deemed useful to explore the relations between type of system, relevant building features, purpose of air-conditioning and typical conditions of use for a representative sample of buildings. The results of such a sample study can be extrapolated to the whole stock of AC-systems or to the whole stock of buildings that are most likely equipped with AC-systems. Since the sample is not only suitable to provide the above mentioned basic information but also typical “packages” of recommendations, such an approach also shows the extent of potential savings. On the other hand, field studies of this layout are quite costly to perform. A large amount of time is needed to obtain usable results.

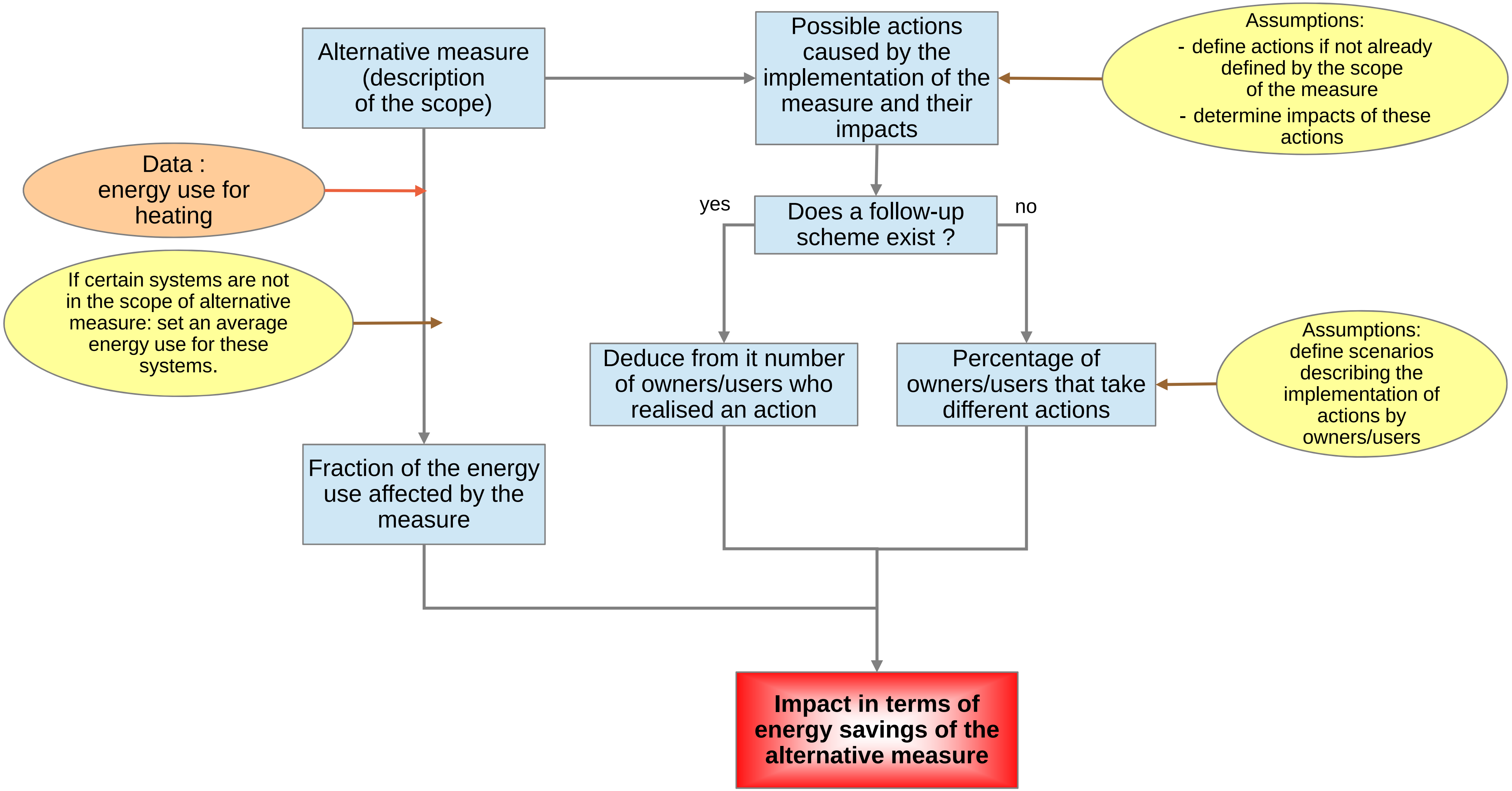
5.4 Top-down approach

AC-systems normally use electricity as an energy source. The total amount of energy consumption of AC-systems is therefore hidden in the total amount of electric energy usage of the buildings of the sectors “residential”, “industrial” and “tertiary”. These figures are normally not suitable to be subdivided to find the amount to be assigned to AC-systems.

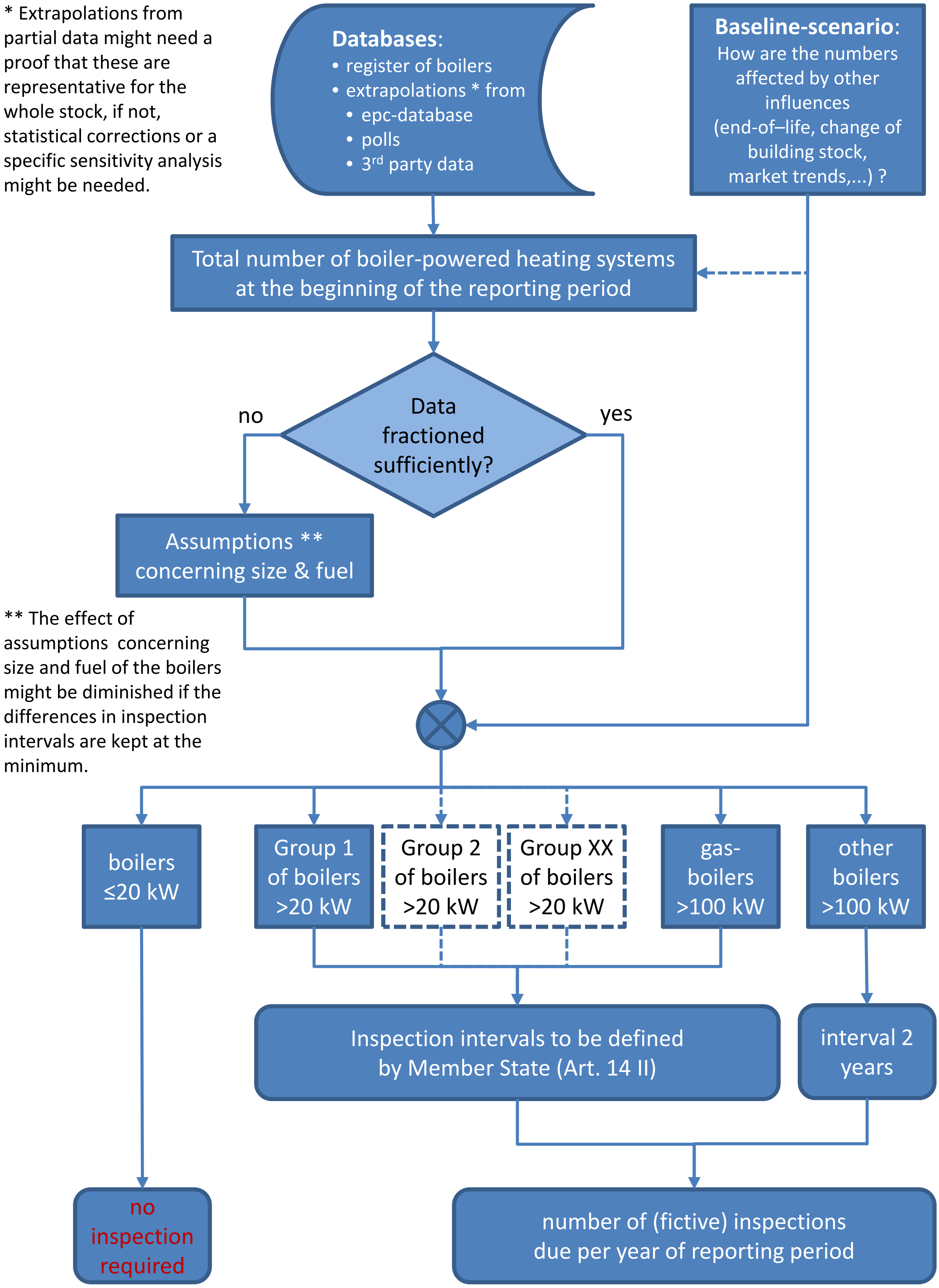
In northern countries AC-appliances are most often found in industrial and tertiary sectors. These sectors are known to have a large electricity usage assigned to other purposes than the operation of the building that is not easily determined. In addition, lighting – also part of the electricity usage – plays a major role in these buildings and therefore in the figures of total usage to.

Because of these issues, the application a top-down approach will most likely need a study of representative samples of buildings. The previously mentioned advantages and disadvantages of such a field study apply to this case as well.

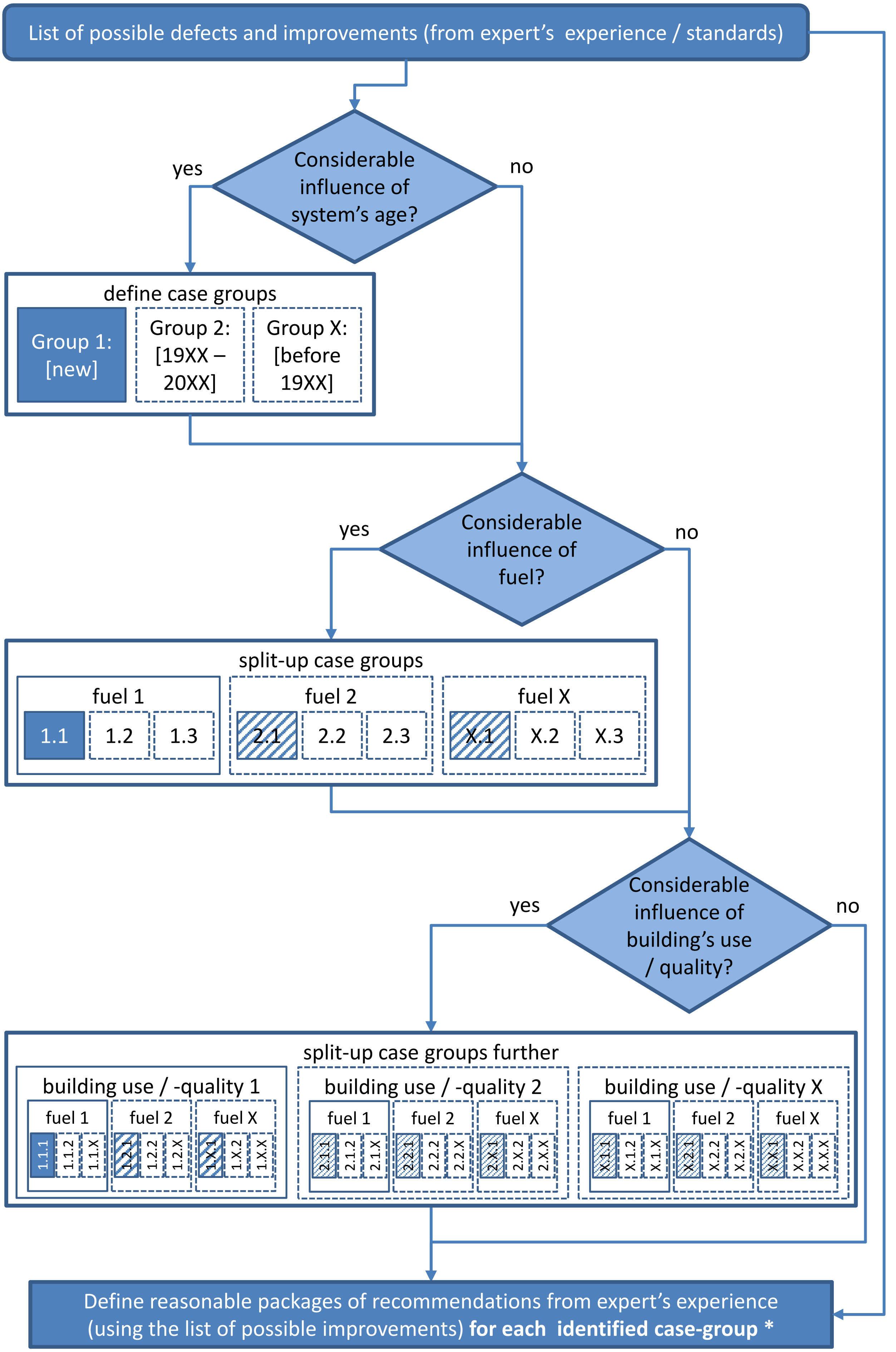

Top Down - Flow chart 1A
Data : energy use data
Energy use of the Member State for heating
Assumptions:
-if data includes the production of hot water, assigned fraction must be deduced
- if data includes energy used for industrial processes, assigned fraction must be deduced
* or it is also possible to consider the whole stock, taking into account that the impact will be overestimated
Data : concerning fraction of boiler of less than 20 kW
Energy use of the Member State for heating of the scope defined in article 14 : by subtracting energy use of systems of less than 20 kW
Assumptions :
- if no data concerning the repartition of the boilers according to their output, define the fraction of them in the stock *
- set an average value of energy use for the systems of less than 20kW
Assumptions :
- determine possible actions and associated impact
- define different scenarios of reactions of people after inspection
Definition of the inspection scheme
Assumptions:
-interval between inspection
- If no data concerning repartition of the stock according to fuel, take 2 years at least for all
Interval
Possible actions after an inspection
Implementation by owners / users
Impact of each action
Fraction of energy use «concerned» by inspection each year
Fraction of energy use concerned by each action each year
Energy savings due to each action each year
Energy savings due to inspection each year



Top Down-Approach -
Flow chart 1B

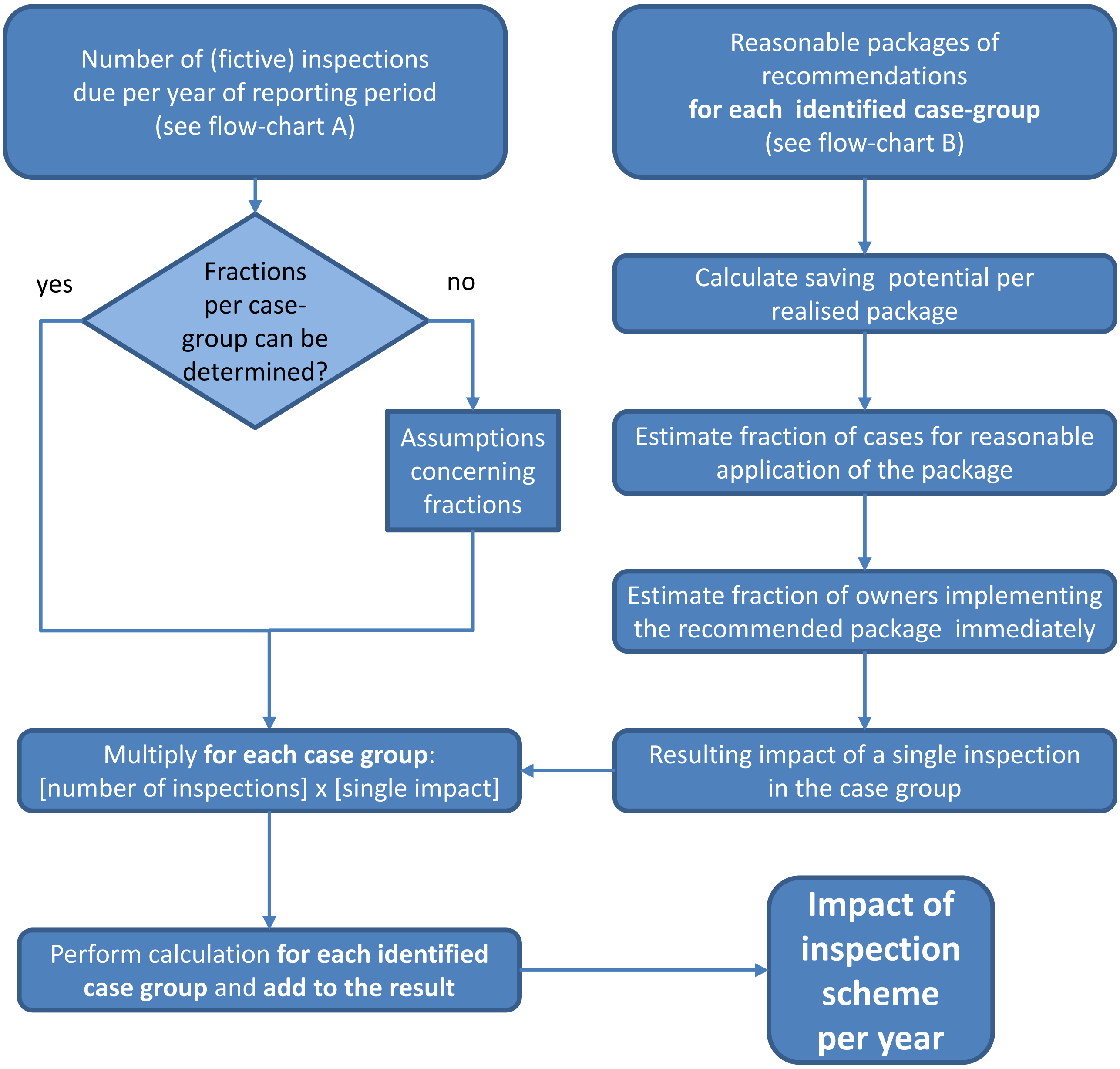


Bottom-Up-Approach - Flow chart 2A:
Determination of number of fictive inspections



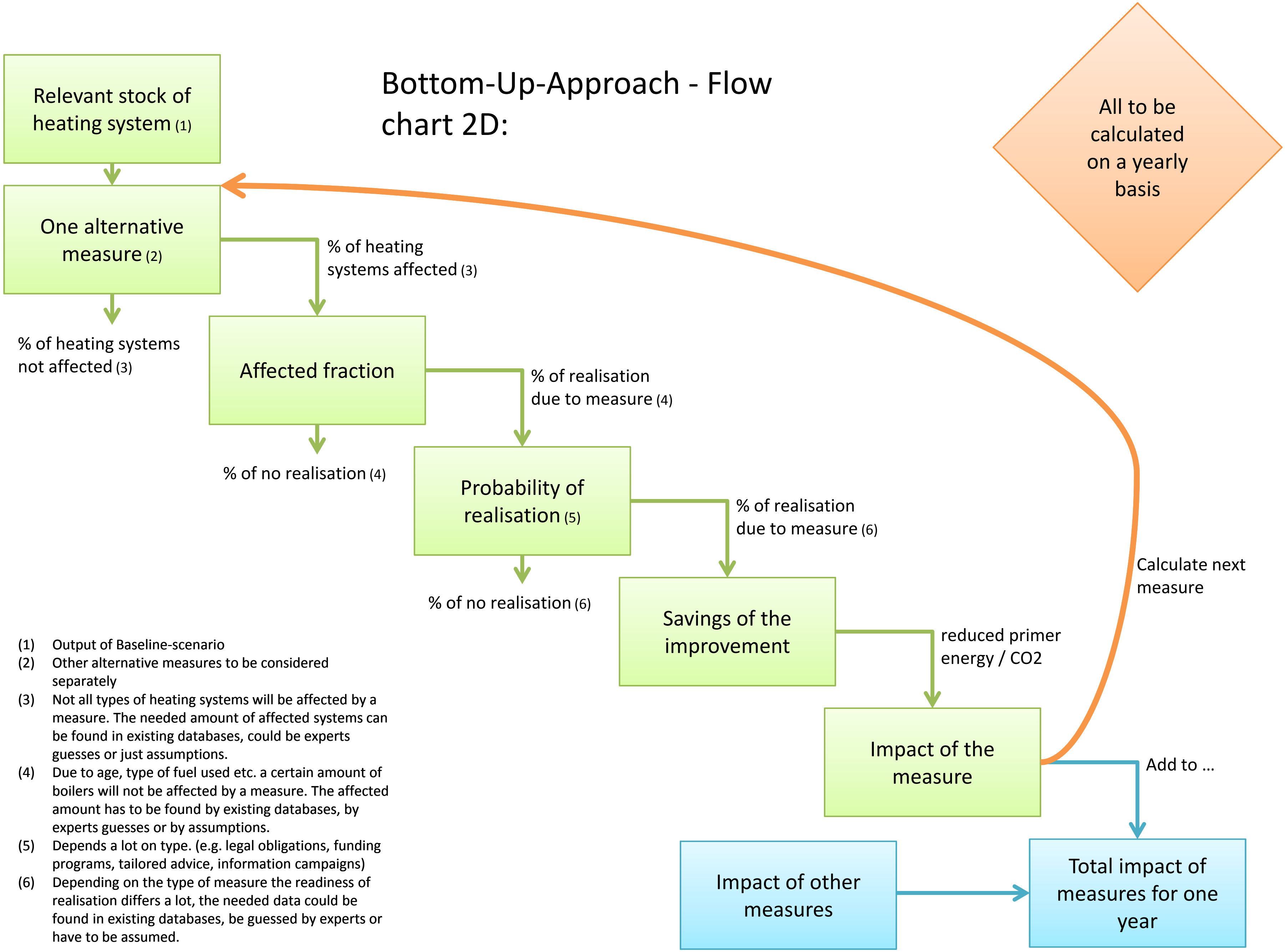
* to reduce the effort, it is recommended to combine groups in a reasonable manner

Bottom-Up-Approach – Flow-Chart 2B:
Determination of potential recommendations



Bottom-Up-Approach – Flow-Chart 2C:
Calculation of the expected impact of a fictive inspection scheme

Bottom-Up-Approach - Flow chart 2D:



(1) Output of Baseline-scenario
(2) Other alternative measures to be considered separately
(3) Not all types of heating systems will be affected by a measure. The needed amount of affected systems can be found in existing databases, could be experts guesses or just assumptions.
(4) Due to age, type of fuel used etc. a certain amount of boilers will not be affected by a measure. The affected amount has to be found by existing databases, by experts guesses or by assumptions.
(5) Depends a lot on type. (e.g. legal obligations, funding programs, tailored advice, information campaigns)
(6) Depending on the type of measure the readiness of realisation differs a lot, the needed data could be found in existing databases, be guessed by experts or have to be assumed.