Bruce Young

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1 Introduction

The Energy Performance of Buildings Directive (EPBD) requires regular inspection of heating and air-conditioning systems so that owners can be informed of their condition and be prompted to take action to improve or replace them. This helps to meet concerns about the large number of systems, the very large amount of energy used by them, and widespread ignorance of what can be done to reduce their energy consumption. There are many elderly and inefficient systems in use, and substantial energy savings are possible if their owners can be persuaded to replace them.

The recast EPBD made important changes to the requirements for regular inspection, which need to be borne in mind to avoid confusion when looking at earlier papers and reports written about the original EPBD. In regard to heating, regular inspection for the original EPBD of 2002 was confined to boilers, with a one-off whole system inspection after 15 years. In the recast Directive of 2010, the scope of regular inspection was changed to all the accessible parts of heating systems with boilers (rather than boilers themselves), and the range of qualifying boilers was enlarged. Advice and other measures as an alternative to regular inspection of boilers in the original EPBD had to be shown to have an overall impact that was "broadly equivalent". In the recast Directive the overall impact of alternative measures had to be "equivalent", and the option of alternative measures was allowed for inspection of air-conditioning systems as well.

For the Member States who choose to implement 'alternative measures' (meaning alternatives to regular inspection), there is an obligation under the recast Directive to submit to the European Commission a report on equivalence every three years, the first of which became due on 30 June 2011. The reports may

be included within the Energy Efficiency Action Plans required by the Energy Services Directive (now replaced by the Energy Efficiency Directive).

Apart from these formal requirements, there is nothing in the EPBD to say how the overall impact of alternatives to inspection should be measured and reported. It is left to individual Member States to develop their own methodology and write reports that satisfy the European Commission. The Directive does, however, allow the Commission to request further specific information regarding the equivalence of alternative measures, in which case the Member State concerned must provide it within 9 months.

Thirteen (13) Member States have chosen alternative measures in place of heating system inspection, and 7 have chosen alternative measures in place of air-conditioning system inspection. Not surprisingly, the question of equivalent impact and how to measure and report it has been the subject of considerable attention within the CA EPBD, and five meetings between 2011 and May 2014 have devoted time to this subject.

2 Impact on energy consumption

2.1 Inspection schemes

Inspection, like advice or similar alternative measures, is a stimulus to further action and does not of itself save energy. The meaning of inspection is to examine closely, and the term does not imply measurement, adjustment, or repair. Furthermore, there is no obligation on the recipient of the inspector's report to follow its recommendations and thereby reduce energy consumption.

In consequence, the impact of inspection is uncertain, as it is not known in how many cases the owner of the heating or cooling system will have taken action on the improvements recommended in the inspection report. The impact of inspection schemes does not have to be assessed and reported to the European Commission, and CA enquiries have not found any Member States who have commissioned studies in which it has been measured.

2.2 Alternative measures

Alternatives to inspection can take many forms, such as:

- general advice (rather than installation-specific advice) on how to reduce energy consumption, usually through written or online guidance in publications and help from energy advice centres;
- minimum standards, imposed by national regulations;
- grant schemes and other financial incentives;
- early replacement schemes (especially for old boilers);
- energy supplier obligations (also known as 'white certificates').

These have to go further than the minimum requirements imposed by other Directives, otherwise they cannot legitimately be regarded as a substitute for inspections under the EPBD.

The energy saving impact of financial incentives and supplier obligations can be measured with reasonable confidence, as data will be collected on the type and number of actions taken. The effect of minimum standards may be measurable too, if there is a time series of commercial data reflecting market changes. General advice is far more difficult to assess, as it will not be known how many building owners read, understand, and act upon it. There have been a small number of studies on the impact of energy advice schemes[1], usually not limited to advice about heating and cooling alone. In this respect, the uncertainty is comparable with advice following inspection, though it is a reasonable assumption that an inspection report (if written in the right style and terms) will have greater impact because it has been tailored to the particular installation inspected. Inspection reports may have additional influence in cases where they are delivered in person by the inspector, with the possibility of an accompanying explanation and discussion.

[1] For example, the International Energy Program Evaluation Conference (IEPEC) in Paris, June 2010 – see http://www.iepec.org/conf-docs/papers/2010PapersTOC/2010TOC.htm

2.3 Combined inspection and alternative measures

It was noted by the CA in May 2011 that in practice there was no sharp distinction between the two options, some Member States applying a combination of both. A combination of inspections and alternative measures can be regarded as limited-scope inspection with alternative measures to make up the shortfall in coverage. The European Commission later advised that an equivalence report is still required. The report should make clear in what circumstances inspections are carried out, and, provided inspection complies in full with the terms of the Directive[2], there is no need to evaluate the impact. Equivalent impact has to be demonstrated for the measures introduced as alternatives to inspection.

2.4 Quantified impact

For the purpose of comparison, the energy saving impact of both inspection and the alternatives have to be estimated in quantified terms. This is doubly difficult in the case of inspection, as there is no real inspection scheme in place. Comparison can be made only with a hypothetical inspection scheme that would have complied with the requirements of the Directive had it been introduced. Firstly, there is the uncertainty of how the inspection scheme would have been designed and operated, how many recommendations for improvement would have been made, and what the recommendations were. Secondly, there is uncertainty (as with a real inspection scheme) about how many of the recommendations from the inspection report would have been taken up.

To help demonstrate that the impact of the alternative measures is at least as great as inspection, the hypothetical inspection scheme should be designed to meet only the minimum requirements of the Directive. That means using the narrowest definition of what type of system would have had to be inspected, and making the intervals between regular inspection the longest that can reasonably be allowed. Nevertheless, the hypothetical inspection must cover all accessible parts that have an influence on energy performance and include an assessment of system efficiency and size relative to building needs. The hypothetical inspection report must include recommendations for cost-effective improvement to energy performance.

3 Principles of comparative assessment

The quantified assessment of impact has to rely on an analytical model of some kind, in which key assumptions will determine the outcome in numerical terms. The principal components of a general assessment model are summarised in Table 1 and discussed further below.

Table 1: Principal components of the general assessment model

Scenarios	no intervention
	inspection
	alternative measures
Data	building stock model
	boiler system or air-conditioning system stock model
	energy usage by these systems
Assumptions	improvements that might be recommended
	the energy-saving value of each type of improvement, and its duration
	how many of each type were recommended, and how many were carried out

[2] This includes compliance with Article 16 (reports on the inspection), Article 17 (independent experts) and Article 18 (independent control system).

3.1 Scenarios

Scenarios are identified so that impact can be evaluated and compared on clear terms, and the differences found. The energy consumption of systems that would qualify for inspection needs to be examined under three scenarios: no intervention (sometimes called 'business as usual'), a hypothetical inspection scheme conforming to minimum requirements of the Directive, and alternative measures. Energy should be accounted as primary energy, in preference to delivered energy. The energy accounting period should correspond to the reporting period, although it is important to remember that some measures might have an effect spanning more than one reporting period. The comparator model should therefore have the capability to carry over figures from one accounting period to another.

Where alternative measures include inspection for some types of system but not others, and the partial inspection regime is compliant with the Directive, the impact of inspection can be included under both the 'inspection' and 'alternative measures' scenarios and will cancel each other when the comparison is made. Although more analytical work is required, this may be preferable to restricting the analysis to systems that have not been inspected and the alternatives applicable only to them, the advantage being that the overall impact of inspection and the alternatives can then be seen in the context of national energy saving plans.

3.2 Data

Figures are needed for:

- the number of buildings containing heating or cooling systems that qualify for inspection;
- the heating/cooling demand of those buildings;
- the number of qualifying heating/cooling systems;
- their effective rated output and fuel used;
- their likely efficiency, as indicated by age, type, and fuel used;
- the annual energy consumed by those systems.

This data may not be available with satisfactory accuracy, or at all. Reasonable estimates are necessary for calculations to proceed and a variety of sources can be used, such as building stock data accumulated from energy performance certificates (EPCs) or land registration or tax purposes, sales or installations of boilers and air-conditioning systems, and annual energy bills. Member States have found market information to be weak, with very little information on system types, and in many cases it is not even known where systems are. Information might be sought from installer associations to identify the installations where an inspection should take place.

Only systems that qualify for inspection need be counted, which means those with an effective rated output above a specified threshold. For heating systems, it is the rated output of the boiler *for space heating purposes* that is the qualifying condition for the EPBD. A large number of boilers in dwellings provide both space heating and water heating services and have been sized for instantaneous water heating with a rated output exceeding 20 kW (the threshold in the EPBD); however, many of them are installed in small buildings or apartments for which a far lower output is used for space heating. In these installations, the boiler may have a lower limit on output for space heating and it can be found in the manufacturer's literature. Alternatively, for boilers with modulating burners, it can reasonably be argued that space heating is provided at well below maximum power and the figure to be used is the rated output that would have applied if the boiler had been sized for space heating alone. It is not known if these arguments are being deployed to reduce the number of installations undergoing inspection: clear instructions would be needed on how to determine the effective rated output of the boiler for space heating purposes in such cases.

3.3 Assumptions

A repertoire of feasible improvements to heating and cooling systems is needed, together with an estimate of their value in terms of higher efficiency or other energy savings and some indication of the circumstances in which they are likely to be cost-effective. Examples are:

- cleaning and adjustment;
- replacement of filters;
- correct setting of controls;
- additional controls;
- installation or repair of insulation (to pipes, ducts, etc.);
- replacement of boiler, chiller, or other major component;
- replacement of whole system.

These are not always cost-effective and their energy saving value is difficult to assess, with little consistency between the Member States who have tried. For example, boiler maintenance has been assessed as saving 8% to 12% in some countries and almost nothing in others. Where inspection is combined with annual maintenance, cleaning and adjustment will have been carried out anyway and this will not be a recommendation in the inspection report. For heating systems, it is early replacement of an old and inefficient boiler that has the greatest benefit, but that is not always cost-effective. Reasons for poor cost-effectiveness include high boiler installation cost (creating an economic incentive to maximise the operational life), low usage (in warmer countries), and any accompanying requirement for system re-configuration that is disruptive and an additional expense. Other actions on heating systems usually have a far smaller effect on energy consumption. Savings from some types of improvement are not permanent, and should be subject to a formula under which their value reduces gradually over a number of years.

Estimates are needed of the numbers of each type of recommendation made, and the proportion of them that were carried out. There is limited evidence[3], discussed at the CA, showing that take-up of recommendations is low, with the main reasons given as cost, disruption and long payback times.

In practice, it is unlikely that robust data can be found for these figures, and they are better regarded as assumptions relying on expert technical judgment. They should, however, be clearly stated. The underlying justification for them, supported by whatever evidence can be found, should be retained to show they are fair and reasonable. They also provide material for comparing implementation in different countries, prompting questions about the reasons for inconsistency. The IEE 'MOVIDA' project[4] is one source of information on the recommendations and actions taken by building owners following inspection of heating systems in the 7 Member States who were the project partners.

4 Reports requested by the European Commission

In August 2012, the European Commission wrote to Member States setting out their expectations for the content of equivalence reports. In summary, they were:

1. Presentation of a hypothetical regular inspections scheme, compliant with Article 14/15 clauses (1) to (3) and taking into account the revised scope of the EPBD-recast.
2. Description of the alternative measures taken to provide advice concerning improvements to the heating/cooling plant and assessment of its efficiency and size relative to needs of the building.
3. Presentation of a reliable methodology and of data to assess the overall impact, in units of energy or primary energy, of both scenarios. Data should be supported by references and a sensitivity analysis of each assumption undertaken.
4. Results of the assessment of both scenarios, showing whether or not the overall impact of the 'alternative measures' is at least as great as the hypothetical regular inspection scheme.

It was made clear that, for heating systems, the scope of hypothetical inspections must cover all accessible parts and that (unlike the original EPBD) this extended to boilers using any fuel, including gas and renewable fuels. For air-conditioning systems, which are defined as '*a combination of the components required to provide a form of indoor air treatment, by which temperature is controlled or can be lowered*', inspections must also cover all accessible parts and must not be limited to the cooling production. The recast Directive does not mention ventilation-only systems specifically, and only active cooling systems with a chiller are regarded as within scope.

[3] This applies to recommendations in EPCs , but was considered indicative of recommendations in inspection reports as well.
[4] http://www.movida-project.eu/

For both heating and cooling systems, inspections have to be regular, meaning that all systems under the scope of the Directive should be inspected more than once during their lifetime. Although 'lifetime' is not defined, it would probably be accepted that typical figures should be used (e.g., 15 years for a boiler, which is the principal component of a heating system). For alternative measures there should be a distinction between EPBD-specific regulation and 'natural regulation' (for other purposes not specific to the EPBD). Using this classification, the Commission would probably not accept the impact attributed to 'natural regulation' if it is already being counted as a contribution to other Directives or independent national policy initiatives.

The Commission understands that if a Member State has not implemented a regular inspection scheme in full compliance with clauses (1) to (3) of Articles 14 or 15 and Articles 16-18, then it is implementing alternative measures. Thus there is either 'full inspection' or 'alternative measures', with no half-way position. Where there is some element of inspection but not a fully compliant scheme or full coverage, the Member State is expected to provide an equivalence report on alternative measures.

At that time (August 2012), it was apparent that there was little uniformity in the approach by Member States to either advice or inspections, and that no standard methodology had yet emerged for any of the items listed above.

5 Reports sent to the European Commission

All Member States with alternative measures should have produced their first two equivalence reports under the recast EPBD by June 2011 and June 2014. After these are studied by the European Commission, further information may be sought for clarification or justification, and amendments requested. The likely need for this was foreseen in the recast Directive, and Articles 14(5) and 15(5) state that the Member State concerned must provide the requested information or proposed amendments within nine months of the request.

The national reports[5] that are available in English have been examined briefly to see how well they follow the requirements of the Directive. However, only five of the second set of reports, due in June 2014, have been published. None are written in English and the reactions to them by the European Commission are not yet known.

The following remarks therefore apply only to the first set of reports, due in June 2011. Thirteen (13) reports have been published together with reactions from the European Commission and further material in the form of additional information and amendments. The reports vary greatly in the approach taken and level of detail provided. They range from short statements about national energy strategies to comprehensive reports containing substantial amounts of data and the results from energy modelling exercises. The alternative measures described in the reports include advice, subsidies, differential fuel tax (to encourage replacement of boilers by heat pumps), minimum standards of system performance, and building renovation schemes. Some, but not all, the reports take a methodological approach to evaluating and comparing impact, and this usually has recognisable elements of the principles outlined above in Chapter 3 of this report.

In almost every case, the initial report has been challenged by the European Commission and further information or amendments have been requested. It is clear that general statements of national energy strategy are unacceptable, even where they are focused on measures affecting heating and air-conditioning systems. The Directive requires that the equivalent impact of alternatives to regular inspection is conscientiously demonstrated. Other deficiencies in the national reports are noted in the follow-up letters sent by the Commission. The most common of them are:

- referring to Article 8 (inspection of boilers, in the original EPBD) rather than Article 14 (inspection of heating systems, in the recast EPBD);
- omitting to describe the alternative measures and the hypothetical inspection scheme with which the impact is compared;
- not quantifying and comparing impact, in units of energy;
- failing to describe a reliable methodology and the underlying data;

[5] See http://ec.europa.eu/energy/efficiency/buildings/implementation_en.htm for reports lodged at the EC

- making questionable assumptions about the data, or treatment of the data;
- ignoring the effect of regular inspection;
- considering improvements to boilers alone, rather than the outcome of inspecting all accessible parts of heating systems;
- considering heating systems with boilers having a restricted range of fuels, rather than all types of fuels (including renewables);
- drawing the scope of alternative measures too widely, rather than limiting it to improvements to heating or air-conditioning systems;
- including the effects of alternative measures that were not operational within the designated period for the equivalence report;
- including measures that were introduced to meet the requirements of Article 8 of the recast EPBD (technical building systems);
- including measures that were introduced to meet the requirements of other Directives, such as the Energy Efficiency Directive or Energy Related Products Directive.

Not unreasonably, the follow-up letters sent by the Commission often repeat the expectations that were set out in their letters to all Member States in August 2012 (see Chapter 4 above). Most initial reports had not been received by August 2012, even though due in June 2011.

As a result of the follow-up letters, many of the first set of reports were re-written and re-submitted. With learning from experience, it seems likely that the second set of reports will require less revision, especially in view of the developments to produce a more coherent reporting framework as described below.

6 Developments in inspection-related topics

6.1 Relevant topics

A range of topics associated with measuring and reporting equivalence has been studied by Member States in CA meetings. Topics include building stock models, boiler stock models, data sources, hypothetical inspection, regular intervals for inspection, components to be inspected, trust and confidence in inspectors, types of alternative measures, recommended improvements, the energy-saving value of improvements, and the barriers to take-up of recommendations.

6.2 Cost-effectiveness

Some Members States have investigated cost-effectiveness, which has informed their decisions on what types of systems should be inspected and what types should be subject to alternative measures.

It has often been concluded that if inspection can be combined with attendance on site by a trained expert for another reason (for example, maintenance, servicing, chimney sweeping, or statutory safety checks), then it can be done at low additional cost and is probably worthwhile for most classes of system. Where this is not the case, universal inspection is very expensive relative to the likely benefits.

6.3 Reporting framework

A recent achievement is the production of a framework for equivalence reporting. This was produced by a Working Group of the CA in May 2014 and is intended to serve as a guide to Member States starting to prepare their equivalence reports. Initially the CA had proposed to create a template, with headings and spaces for all the aspects of equivalence that had to be dealt with, but the Working Group found that was impractical and a framework[6] was produced instead.

[6] See the framework developed by the Working Group at:
http://www.epbd-ca.eu/wp-content/uploads/2015/06/CA-EPBD-Reporting-framework-to-equivalence.pdf

The framework states the scope of the hypothetical inspection scheme needed for comparison and describes the scenarios to be evaluated. It draws an important distinction between the 'top-down' and 'bottom-up' approaches to evaluation.

'Top-down' starts with national energy statistics and disaggregates them into components for buildings, heating/cooling systems, systems that qualify for inspection, and those that have or have not been improved as a result of inspection or advice. Flow chart 1A of the framework is shown here as Figure 1, illustrating this approach for inspection schemes. The same can be done for alternative measures, although not shown here.

'Bottom-up' has broadly the same steps as 'top-down' but takes a different point of view and starts from a different position. It is better suited to Member States who already have reasonably good data for the building stock and system stock. Flow chart 2D of the framework is shown here as Figure 2, illustrating this approach for alternative measures. The same can be done for inspection schemes, although not shown here.

The framework proceeds to describe each step in the data-building and calculation processes, both for inspection schemes and alternative measures. It includes a sensitivity analysis of the main assumptions to test how large an effect they will have on the final results. Information gathered from Member States enabled the framework and accompanying report to gain insight to the difficulties encountered in practice, the availability of data, and the accuracy of results.

Figure 1: Illustration of the top-down approach applied to inspection

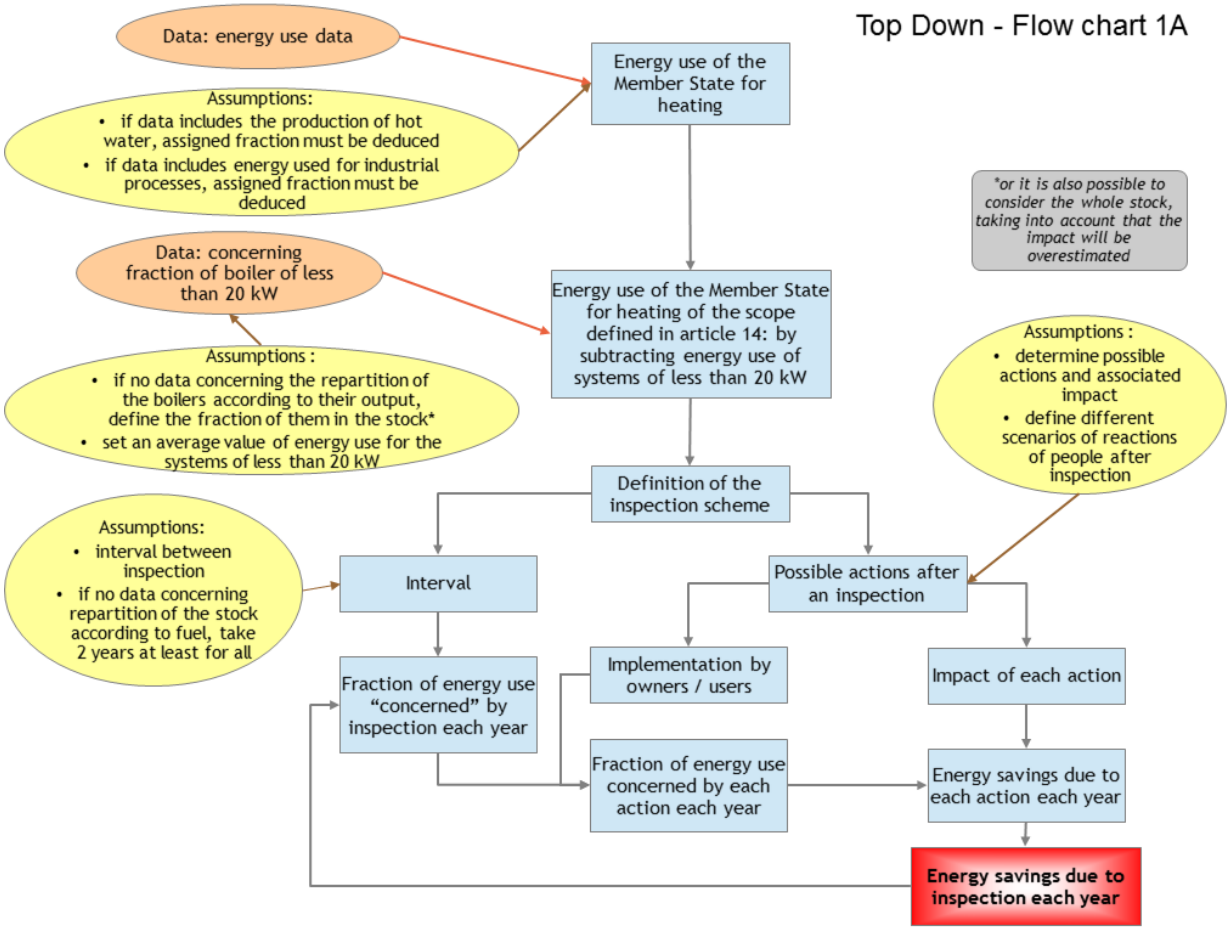
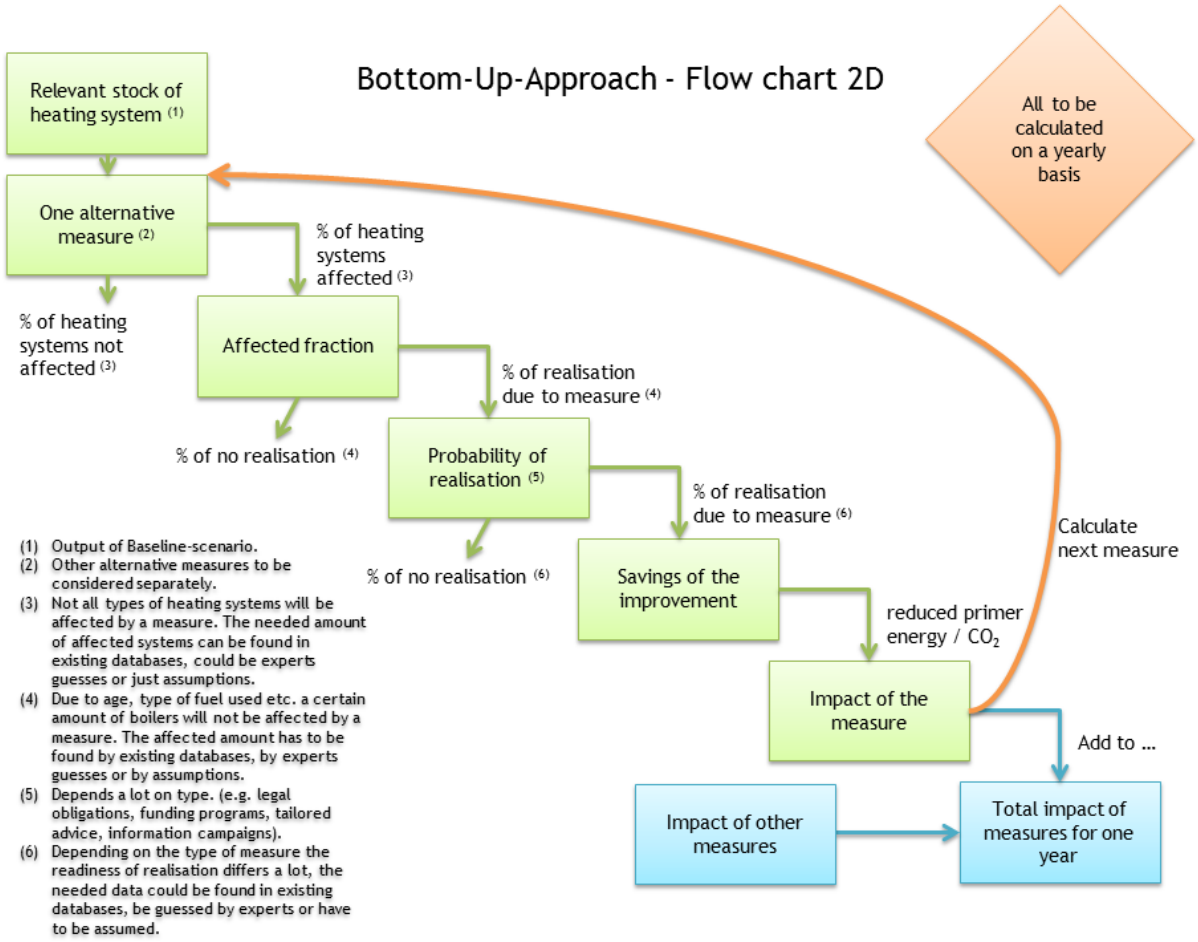


Figure 2: Illustration of the bottom-up approach applied to alternative measures



7 Conclusions

The methodology for evaluating the impact of alternative measures and comparing with a hypothetical inspection scheme remains immature, although considerable progress has been made since 2011. The introduction of a framework for assessment and reporting is a helpful step forward, and should encourage greater uniformity of approach for the third report due in June 2017.

However, there remain causes of concern and areas of uncertainty that require further attention. They are primarily:

- Development of alternative measures for air-conditioning systems. This is newer than alternative measures for heating systems as it became allowable only under the recast EPBD. At present there is very little information on what the alternative measures might be and how their impact is being evaluated.
- Lack of robust data. A quantified assessment of impact and meaningful comparison between alternatives is not possible without good data on buildings, systems, and system types (described in Chapter 3 and summarised in Table 1).
- Inadequate knowledge about the effect of advice (whether installation-specific or general), the number and types of improvement carried out in consequence, and the effect on (primary) energy consumption. This is a severe weakness of the current methodology, and the position is unlikely to improve until major research projects are commissioned to investigate.
- The large number of assumptions that have to be made in the absence of sufficient data and knowledge. CA surveys have shown substantial inconsistencies between Member States concerning the assumed benefits of advice and consequential action, for reasons that are unclear.

- The sensitivity of the conclusions in the equivalence report to those assumptions. The combination of a large number of assumptions, necessitated by poor or non-existent evidence, leads to results with considerable uncertainty. Other assumptions of similar credibility could produce significantly different conclusions.

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