crossCert

Next-generation of Energy Performance Assessment and Certification

D3.7 Multi-criteria grading of proposed innovations for use in next-generation EPCs

Task 3.5 Are new EPC paradigms a significant improvement?

WP3 Deriving Technical Guidelines for EPCs

Authors: David Jenkins, Mahsa Sayfikar

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EXECUTIVE SUMMARY

This report, by noting the variation in EPC methodologies, proposes a set of criteria that could be used to categorise those differences such that EPC frameworks can be better understood and compared. The criteria are designed with both current and next-generation use of EPCs in mind. They are then applied to a selection of current and next-generation EPCs to illustrate how a multi-criteria framework for reviewing EPC methodologies may aid our understanding of how to use those EPCs, and where they are less suitable. The final results show multiple occasions where EPC methodologies have to find a balance between different ambitions, such as that between detail and replicability of methodology. Where EPC frameworks take different choices on this balance, this should inform our choice of when and where to apply this framework.

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1 Introduction

The crossCert project has reviewed a number of existing EPC methodologies across Europe, whilst also investigating proposed next-generation metrics and innovations that could enhance EPCs for specific end-users. With such a wide selection of EPC approaches, with considerable variation in calculation methodology, application, assessment protocols, and assessor background, it is important to reflect on what an EPC is actually for and at what point proposed innovations may take EPCs away from their original purpose.

Furthermore, a current (and certainly next-generation) EPC is multi-purpose both in terms of outputs provided and users being targeted. Often, there is a balance to be made when choosing this information (and the techniques behind generating that information). For example, by moving towards a more detailed energy assessment (in terms of input gathering and application of building physics), an EPC may be able to generate advice and metrics in areas that were not possible before. However, in turn, this may limit the standardisation and consistency of that EPC approach and create barriers for running that assessment at scale and communicating with non-expert users.

Taking this wide selection of current and future EPC approaches, it is possible to see different assessments with subtly different purposes. It is overly crude to identify a "best" approach; guidelines from the Energy Performance in Buildings Directive (EPBD) are broad enough to suggest all these approaches may meet the requirement of that Directive, but they do so in different ways with varying priorities.

The purpose of this report is to present a framework for categorising and comparing different EPC approaches. Based on previous work by the authors[1], translated and applied for purposes of crossCert, a set of criteria are proposed that are deemed useful for understanding the type of EPC assessment under consideration. These criteria are a combination of current EPBD requirements and likely future directions of EPCs. They are informed by the review work of crossCert across different EPC methodologies, but also discussions with end-users about the requirements of EPCs moving forward and the type of information that needs to be delivered to offer decision-support in key areas.

The final proposed criteria and framework are intended for understanding how EPCs are developed with end goals in mind and, therefore, how harmonisation of EPCs (and supporting methodologies) is challenging when trying to meet such a broad range of end goals.

2 Understanding purpose

EPCs were introduced as a way of encouraging market transformation in the built environment by rating the energy efficiency of building assets in a standardised way. The EPBD requires a standardised, replicable approach to assessing buildings (usually) through an asset rating under standardised conditions and occupancies[2]. Although elaborated on in the Directive (and various recasts and updates), this starting point is crucial; it necessitates a relatively simple approach to energy calculation that is versatile enough to accommodate a range of different energy use categories across different countries. In turn, as evidenced by the calculation methodologies of various European countries, the choice of building physics usually gravitates (particularly for residential properties) towards steady-state models with standardised building inputs.

Standardisation and consistency are therefore key tenets of an EPC approach. Whilst some methodologies in application may not always achieve this (and some studies have shown how very standardised approaches can cause unexpected inconsistences once applied by assessors[3,4]), the design of the assessment framework is often to make compromises on empirical accuracy in favour of a scheme that allows for mass roll-out in a replicable fashion.

It can be seen (later in this report and crossCert work elsewhere[5]) that the responses of different countries to this generally common purpose are varied. However, the proposed innovations and new metrics of next-generation EPCs do somewhat shift that purpose. Rather than only looking to generate basic energy or carbon metrics (for purposes of asset rating) alongside generic energy efficiency recommendations, future EPCs are likely to have a broader list of goals and, relating to that, users. This is seen with the introduction of the Smart Readiness Indicator (SRI) and other next-generation indicators, more detailed building renovation pathways, consideration of alternative forms of calculation methodology, and more dynamic/interactive forms of information dissemination.

These innovations could result in an even wider range of EPCs across European countries, with those designing EPC frameworks having to make more choices about how to meet those new requirements (in terms of assessment procedure, calculation choices, and forms of dissemination). On the assumption that, already, there is limit to harmonisation of current EPCs, it is unlikely that further changes will increase this level of harmonisation. The premise of this report is, therefore, that a systematic approach is needed to distinguish between these methods. By clarifying this, we can understand what EPCs are trying to do, why they are different, and the implications of these differences. It may also allow, through a process of categorisation, for a more meaningful comparison between different EPC approaches, ensuring that EPCs with similar purposes are being compared rather than fundamentally different assessment frameworks with different end goals.

3 Approaches available for assessment

The EPBD[6] provides a common starting point for EPC approaches across Europe. However, the flexibility provided for individual countries to respond to this is considerable. For example, the directive requires that "energy performance of a building shall be determined on the basis of the calculated or actual energy that is consumed to meet the different needs associated with its typical use". Whilst this provides some guidance on the purpose of EPCs (where "typical use" implies something generalisable, and the importance of rating the actual building), the statement and supporting documentation allows for considerable variation in calculation of an energy rating or, indeed, the use of measured energy consumption.

It is therefore unsurprising to see such a varied selection of approaches to EPC generation (as noted above). A report commissioned by the EU[7] noted, at that time, 28 member states of the EU had 35 EPC calculation methodologies in place for new and existing buildings. Since then, the number of methodologies has grown further, with next-generation EPCs potentially adding to this selection.

The crossCert project has investigated the ways in which these methodologies can be different – as well as the impact of those differences. When considering the guidance of the EPBD, it is possible to imagine even further options for constructing an EPC (and next-generation equivalent) – and some ideas are evident in the work of other Horizon projects[8,9,10].

3.1 Calculation of metrics

Whether producing current (e.g. kWh or $kgCO_2$) or next-generation (e.g. SRI) EPC metrics, there is an underlying calculation architecture which may be partly hidden to the user (or even the assessor themselves). As already reviewed by crossCert[5], steady-state models are most commonly used for current EPCs but a role for more detailed dynamic simulation modelling and/or use of empirical data has also been proposed (and is allowable within the EPBD). This choice has an implication on key aspects of EPCs and building modelling more generally, such as limiting the Performance Gap (between measured and modelled energy consumption), the type of output metric possible (e.g. dynamic simulation allows for more granularity as a function of time compared with the annual metrics of steady-state models), and using EPCs as a vehicle to disseminate next-generation metrics (often having more complex data requirements than current EPCs). It raises the possibility that two EPBD-compliant assessment approaches may not be equally capable of generating the same output metrics, due to the calculation process being fundamentally different.

It could also be argued that the methods used by EPCs do not always reflect state-of-the-art options for modelling energy consumption of buildings. This can, in part, be justified by the need to ensure a simple, replicative energy assessment methodology that is suitable for use by a range of different energy assessors. Other work by the authors of this study[1] has noted alternative options that could be implemented into energy assessment frameworks that make use of mode advanced data science and/or building simulation. Projects working on methods for calculating next-generation metrics have also proposed alternative and, in some cases, more advanced calculation approaches, recognising that some output metrics are not commensurate with existing calculation methodologies[8,9,10].

3.2 Assessment and assessor protocols

In addition to assessment approaches having to be suitable for specific output metrics, they also must reflect the background of assessors running those assessments. As discussed by crossCert[11], there is a link between the complexity of the assessment methodology and the education/training background of the assessors in that country. Should changes be made to the assessment methodology (e.g. in order to generate new forms of output metric), this either needs to be limited to the existing competencies of the assessor workforce, or the assessor training programme in that country would have to be updated. It is possible, in the event of significant changes in calculation methodology and/or assessment protocols (e.g. collection and measurement of building inputs), that the mandatory training and education requirements of assessors would have to rise; this in turn could limit the number of assessors available to run assessments and/or impact the replicability of the proposed method.

This is a good example of one of the balance points that exist when designing EPC assessment frameworks; increasing detail and complexity could achieve more useful results in terms of the range of output metrics available, but this in turn could provide an obstacle to producing EPCs at the number required to support changes to the entire building stock of a country.

3.3 Use of outputs

The crossCert project has a particular focus on user requirements of EPCs. The output metrics generated by EPCs must have value to a diverse range of user groups, and be appropriate for informing decisions at country-scale relating to building policy and regulation. The project has already investigated the needs of different users, and what that might mean for future EPC design[12]. However, the nature of the calculation engine and overall assessment of a given approach has a direct effect on the outputs that are possible from that methodology. This is particularly important when designing next-generation EPCs; whilst users may desire certain forms of feedback to aid specific decisions, an evaluation must first be carried out to ensure that the EPC framework being studied is able to deliver on that form of output.

4 Proposing criteria for categorising assessment

Noting some of the distinct differences in EPC approaches of Section 3 (and the work of crossCert more generally), there is a question of how we translate these categories of difference into something that can be used as criteria to evaluate an EPC methodology. Even assuming that such a methodology complies with the EPBD (which is a separate consideration), an additional layer of analysis can highlight the form of EPC framework being used in a country – or, for next generation EPCs, being proposed. It may also be a way of critiquing the strengths and weaknesses of these different methods.

This report proposes six such criteria. These range from the ability of an assessment to represent a real building, to the ease of scalability of a method (two factors that can be at odds with each other). The adaptability of that framework to new metrics and technologies is also used as a way of understanding the possibility of incorporating key parts of next-generation metrics and innovations.

The descriptions of the criteria will make reference to how the different calculation engines might be used to generate a metric, as this is key to understanding the ability of a method to satisfy a certain criteria.

4.1 Alignment with reality (Criterion 1)

For EPCs, and the ambitions of the EPBD, it is important to note the ambitions of such an energy assessment is generally not to predict energy bills with any degree of accuracy. The majority of EPC frameworks attempt to simplify and standardise energy behaviours of occupants, to the extent that it should not be expected that an EPC-modelled energy consumption should match closely with a monitored equivalent. Furthermore, in terms of building physics, the transient nature of air flow, heat transfer, and thermal mass can only be addressed by steady-state models through considerable simplifications and proxy coefficients. Dynamic building simulation can attempt to calculate such factors more explicitly, but will still be subject to a series of assumptions (again, not least the actions and behaviours of occupants). This criterion is therefore about the specificity of an overall method, making a judgement on the ability of the calculations being used to reflect a real building.

4.2 Quantifying new metrics (Criterion 2)

Some next-generation EPC metrics and innovations proposed go beyond just re-imagining current outputs. They potentially have new input data requirements, assessment practices, and calculation procedures. Therefore, this criterion is concerned with the flexibility of a method to generate a wider range of metrics. For example, the SRI metric is proposed as a way of summarising the ability of a building to use smart controls and provide some level of demand flexibility to an energy network. Steady-state modelling is not capable of directly quantifying dynamic aspects of energy use and, therefore, cannot be used to explicitly model demand flexibility – though the current SRI approach attempts to do this more indirectly (i.e. rather than modelling at high temporal resolution). Dynamic modelling, with higher temporal resolution, can in theory model drivers of flexibility (such as thermal mass, thermal storage, and occupancy control/behaviour), though only with considerable changes in how the building is specified. Monitored energy consumption could reflect demand flexibility depending on the resolution of collected data (e.g. from smart meters), but this also suggests a deviation from current assessment practices. This comparison of calculation methods could be similar to several other metrics – simpler methods will provide more constrained outputs that are best used for current metrics. Other forms of calculation may be suitable for more novel metrics, particularly those that might be seen as a function of time.

4.3 Accommodating new technologies (Criterion 3)

The definition of a current or new technology will be aligned to the requirements of an EPC methodology. EPC assessors, across all countries studied, will therefore be used to annual or (at best) seasonal averages of heating and cooling systems. A new technology will not necessarily require more detailed input, but some key technologies for the zero-carbon transition (such as heat pumps, district heating, free cooling, onsite storage and home-charged electric vehicles) may require performance to be specified in a different way in order to capture the benefits of those technologies. By understanding the limitations (and data requirements) of a methodology, a judgement (for this criterion) could be formed in terms of the ability of that approach to account for a wider range of performance metrics (some of which may be transient in nature).

4.4 Suitable for punitive action in policies (Criterion 4)

EPCs have a growing use as a way of enforcing action, rather than just advisory information. This is happening due to countries implementing EPC rating targets within national policy specifically for that purpose, but also (following that) the required EPC level for certain settings becoming more ambitious (and therefore more likely to require action from a building owner than a less challenging EPC rating). A move from advisory to mandatory (and potentially punitive, depending on national policy) action should, arguably, be cause for reflection on the framework in place in terms of its suitability for enforcing individuals to adopt certain measures. The simple steady-state models used for many EPCs were not designed to provide accurate energy bill predictions, whereas more advanced forms of modelling (noted in Section 3 and elsewhere) may be more suitable for capturing specific characteristics of buildings that could explain higher-than-mandated energy consumption – or even provide a case for exemption/alteration. For example, dynamic modelling (with the ability to model at higher temporal resolution) could be used to explore why and when certain energy uses are higher, providing some level of accountability and explanation for punitive action. If an EPC methodology relied on actual energy use (i.e. empirical evidence that energy is high in a property) that could be proposed as a higher level of proof and accountability – though this would have to be part of a standardised method suitable for replicability and benchmarking.

4.5 Extrapolating and standardising (Criterion 5)

One reason for the ubiquity of steady-state models in EPCs across Europe is the ease of replication and standardisation that this provides. The inputs are simpler (allowing for harmonising, for example, building inputs by building age) and the relatively simple calculation process more amenable to extrapolation (being used by a wider range of assessors and building professionals). Dynamic building physics models have more complex inputs and, potentially, a higher level of training required for energy assessors. However, methods of replicable dynamic simulation could be used (and in some countries are used – such as the UK approach to more complex non-domestic buildings) within a standardised EPC framework. Operational Energy Ratings are already being proposed as a method of using measured energy data as part of the EPC document, but the use of real energy data to directly produce an EPC rating could place a challenge on standardisation; such data correlates to the specific decisions of the householder(s), unlike asset-based theoretical models. There may therefore be a compromise required on either the level of standardisation, or a new approach to rating buildings that is linked to different household (as well as building) categories.

4.6 Quality of input information (Criterion 6)

Simpler assessments, designed for replication at scale across a large building stock, may have to make compromises on accuracy of input data. This may include the use of generic "look-up" tables rather than building-specific, measured inputs). However, with such standardisation, there is an argument that quality control of that input may be easier than more complex methods. Dynamic simulation gives more scope for, and indeed requires, building-specific information to be collated - this may involve the quality of input data being higher (in terms of its ability to accurately represent a real building), but the quality control procedures may be challenging to manage. The use of real energy consumption data for energy classification could better represent real energy characteristics (and the building itself), albeit with standardisation and normalisation procedures to allow for cross-comparison between buildings. There is potentially a link between Criteria 5 and 6; achieving reliable (and accurate) input information for individual dwellings can create standardisation challenges if that input data requires more stringent procedures and/or greater requirements on the assessor workforce.

5 Applying a framework for critiquing EPC assessments

The described criteria are now used to critique a range of current and next-generation EPC frameworks, to illustrate the comparative exercise that these criteria can deliver. Whilst the judgement has a high degree of subjectivity, this is based on an in-depth review of the described methodologies and the wider work of the crossCert project. However, due to that subjectivity, the results of the assessment are merely categorised as Low, Medium, and High. Clearly, it is possible to imagine further criteria to form part of this overall framework, but the justification for the chosen criteria is described in Section 4. Table 1 gives an overview of applying that process to four distinct types of current EPC approaches and a selection of next-generation methods (labelled as Categories 1 to 9).

Previous work in the crossCert project has concluded that EPC methodologies can be categorised based on various criteria. One criterion discussed in other crossCert publications[5] is the use of standardised inputs in EPC calculation methodologies. Some methodologies, such as the UK and Austrian methodologies, use pre-defined standard values and profiles for calculation inputs, including temperature setpoints, HVAC operation, and occupant behaviour. Others, such as the Bulgarian and Polish methodologies, use tailored inputs specific to the building being assessed. Using steady-state or dynamic models in EPC calculations is another criterion for categorising methodologies. In addition, categorising a method based on whether they use operational (EPC ratings based on actual energy consumption data) or asset ratings (EPC ratings based on calculations) allows for distinct groupings. Using these categorisation criteria, the current and next-generation EPCs are divided into groups, and Table 1 applies the proposed process for critiquing EPCs to these categories.

The methodologies in Category 1 (highly standardised, steady-state EPCs) use pre-defined and default values for many calculation inputs. This, along with the simplified steady-state model used, leads to a lower alignment with reality and a lower quality of input information, which makes these not ideal candidates for basing punitive actions on. These methodologies are also not capable of reflecting drivers of flexibility due to the lack of reliable, transient calculations to quantify new metrics or accommodate new technologies. However, the simplicity of steady-state models and standard input values make this category more appropriate for extrapolation and standardisation.

On the other hand, highly tailored, steady-state EPC methodologies (Category 2) use higher-quality input data that are more aligned with the actual building conditions. This is particularly the case for methodologies that calibrate the model to actual energy consumption (such as Bulgaria), making it more suitable for use in implementing policies and punitive actions. However, because they use steady-state models, similar to the first category, these methodologies are not capable of catering to new technologies or quantifying new metrics. Using dynamic simulations, as is the case for some non-residential EPCs in the UK and some methodologies in Spain, makes the EPC more aligned with reality and suitable for accommodating new technologies and quantifying new metrics. However, due to these methodologies still relying highly on standard inputs, this is deemed less so than the previous category. Using standard inputs leads to a higher potential for extrapolating and standardising but decreases the quality of information used in these EPCs. Nonetheless, the quality of information is considered higher compared to the first category, as it requires hourly weather and operation profiles.

Some crossCert countries, including Denmark, Poland, and Slovenia, allow the use of energy bill data for EPC calculation for certain building types[13]. These methodologies (Category 3) are highly aligned with reality due to being based on energy bill data and, therefore, suitable for implementing policies and punitive actions. While they use higher quality inputs that are based on the actual building operation, these methodologies are not able to accommodate new metrics and technologies due to using only monthly energy bill data which does not reflect changes in consumption throughout the day or week.

While the above methodologies are currently being used across Europe, there are new methodologies also proposed by other Horizon projects. Two examples are proposed by ePANACEA[9] and D2EPC[10]. The ePANACEA proposed methodology includes three routes for EPC calculations: a steady-state model based on ISO 52016, and calibrated dynamic simulation and operational rating.

The D2EPC project also uses both asset (based on dynamic simulation) and operational ratings for calculating EPCs. However, the D2EPC operational rating is based on sensor data rather than bill information (which is the case for ePANACEA). Using sensor data compared to the energy bills data allows the D2EPC methodology to cater to new technologies and metrics in a more effective way. Both methodologies have a route using dynamic simulation, which reflects the flexibility in demand and allows the incorporation of new metrics. The ePANACEA M3 route is also calibrated against energy bill data, making it more aligned with reality compared to Category 3 methodologies. However, since the inputs to the methodology can be chosen from a set of default values, or manually entered by the assessor, the quality of the input data is highly variable and the methodology doesn't facilitate comparison and standardising. The results of the assessment using the ePANACEA M3 route are calibrated against bill data and, therefore, more suitable for punitive actions in policy, whereas the D2EPC dynamic simulation methodology uses inputs extracted from the building's BIM files, which can be based on standardised values and not necessarily the actual building operation.

The ePANACEA M2 methodology is similar to the methodologies in Category 1; however, it includes SRI calculations and a calibration step. These additional steps make this methodology more aligned with reality and more suitable for punitive actions compared to Category 1 methodologies. However, because the inputs to this methodology are either taken from pre-defined values/profiles or defined by the assessor, its potential to standardise and extrapolate is deemed less than those of Category 1 methodologies.

Table 1. Degree that criteria are satisfied when applied to a range of EPC frameworks

	(1) Highly standardised, steady-state EPCs	**(2) Highly tailored, calibrated steady-state EPCs**	**(3) Standardised dynamic EPCs**	**(4) EPCs using operational rating**	**(5) ePANACEA M3 Route (Dynamic simulation)**	**(6) ePANACEA M2 Route (steady-state simulation)**	**(7) ePANACEA M1 Route (operational rating)**	**(8) D2EPC Asset rating**	**(9) D2EPC Operational rating**
Examples	UK, Austria, Malta	Bulgaria	UK non-residential category 5 buildings, Spain	Certain buildings in Slovenia, Denmark and Poland	As above	As above	As above	As above	As above
Criterion 1- Alignment with reality	Low	High	Medium	High	High	Medium	High	Medium	High
Criterion 2- Quantifying new metrics	Low	Low	Medium	Low	High	Medium	Low	High	High
Criterion 3- Accommodates new technology	Medium	Low	High	Medium	High	Medium	Medium	High	High
Criterion 4- Suitability for punitive action	Low	Medium	Medium	High	High	Medium	High	Low	High
Criterion 5- Extrapolating and standardising	High	Low	Medium	Low	Low	Medium	Low	High	Medium
Criterion 6- Quality of input information	Low	High	Medium	High	High	Medium	High	Medium	High

6 Conclusions

A framework has been proposed for providing a clearer picture on what an assessment is for, what priorities have been used in the formulation of that assessment, and how different EPC approaches compare with each other (or, indeed, whether they can be compared directly at all).

This framework has been applied to nine different approaches to EPC generation: four currently in use, and five proposed by projects within the Horizon-funded next-generation EPC cluster. The study does not suggest a single method that achieves all criteria equally well. The previously described balance between detail of building description (and some measures of accuracy) and ability to extrapolate the method is in evidence in some of the ratings proposed. With more onus placed on detail of assessment (whether through additional data or calculation requirements, or both), the challenges of widespread adoption become more significant. In turn, the suitability of that method for stock-wide policy guidance (where most, and ultimately all, buildings may require that assessment) becomes questionable.

For next-generation EPCs, this means that consideration must be given, from the beginning of method development, about whether a proposed innovation is seen as something to be applied for all standard EPCs, or a relatively niche (or optional) addition that may only be required for some buildings. If the former, then Criteria 4 and 5 would have to be met to a high degree – on the assumption that resultant ratings would be compared to national targets, and across different building types. However, for less widespread adoption of that method (providing specific advice for a sub-section of the building stock), Criteria 2, 3, and 6 are likely to be more important.

This also raises questions in relation to harmonisation of EPCs across Europe. Should all methods meet the same criteria, or should it be accepted that different current and next-generation EPC approaches have different end goals (and end-users)? Some of the work of this study, and the crossCert project more generally, suggests there may be value in categorising EPC methods into designated groupings to accommodate the spectrum of differences that have been observed – whilst trying to avoid treating each EPC method as an entirely unique approach to energy assessment. Such decisions must be informed by the needs of different end-users, but also remember the original purpose, and limitations, of EPCs.

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