EXECUTIVE SUMMARY

The recast Energy Performance in Buildings Directive issued in 2018 aims to further improve the energy efficiency of buildings. In recognition that its predecessor (the 2010 version) only included rather indirect or ambiguous encouragement to improve building energy performance through better control of technical building systems (space heating, space cooling, sanitary hot water, ventilation and lighting) the revised Directive addresses this deficiency by adding a number of policy measures that target better monitoring and control of building energy systems.

BACS policy measures in the recast EPBD

Explicitly, the recast energy performance in buildings directive (EPBD)[1] includes a number of new provisions that concern the deployment and use of Building Automation and Control Systems (BACS). In summary, these are:

- Mandatory requirements for installation and retrofit of BACS in non-residential buildings (existing and new) with effective rated output of over 290 kW, by 2025 *(within the amended articles 14 and 15)*
- Incentives for installation of continuous electronic energy performance monitoring and effective HVAC controls in existing and new multifamily buildings *(within the amended articles 14 and 15)*
- Requirements for the installation of individual room temperature controls such as TRVs and IZC in new buildings and alongside the replacement of heat generators in existing buildings *(within the amended article 8)*
- Non-residential and residential buildings equipped with BACS and electronic monitoring, respectively, are exempted from physical inspections of Heating and Air-Conditioning Systems *(within the amended articles 14 and 15)*
- Optimization of performance under typical or average (real-life) part load operating conditions including dynamic hydraulic balancing *(mentioned in the Recitation)*
- Reinforced requirements on optimizing the performance of technical building systems (TBS) i.a. with controls *(within the amended article 8)*
- Definition of BACS according to the European Standards in the Directive *(within the amended article 2)*

Impact analysis and scenarios

The accompanying Impact Assessment to the recast EPBD did not explicitly assess the impact of these measures and rather they were bundled into the overall impacts reported for the recast Directive. However, it is important for policy makers and others with responsibility for implementing the Directive at the Member State level to understand the contribution that these new measures will bring to the overall energy savings target, as this helps to clarify the relative importance of these actions in the ensemble of measures put forward in the revised EPBD.

The current study presents a detailed analysis of the expected impacts associated with the implementation of the recast EPBD BACS measures. It makes use of a detailed bottom-up simulation

[1] DIRECTIVE (EU) 2018/844 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency

tool, developed specifically for the purpose, to assess the contributions to energy savings made by BACS measures under three scenarios:

- The ***EPBD compliant*** scenario (where all the BACS measures are appropriately implemented)
- The ***EBPD compliant without BACS*** scenario (where the BACS policy measures are not implemented but all other EPBD measures are)
- A ***Frozen BACS*** scenario, which is aligned to the recast EPBD recast, with the exception that the energy performance of BACS is static

These scenarios are projected from 2018 to 2050, i.e. the same period assessed in the official recast EPBD impact assessment (Ecofys 2016).

It should be noted that the *EPBD compliant* scenario is identical to the central "Agreed Amendments" scenario in the EPBD impact assessment which results in very substantial energy savings in the EU building stock to 2050. It assumes an array of measures, including those that will substantially improve the efficiency of the building fabric and the BACS measures also contribute to the net savings delivered.

The *EBPD compliant without BACS* (where the BACS measures are not implemented but all other EPBD measures are) is a scenario where all non-BACS measures are implemented just as in the EPBD *Agreed Amendments* scenario, but in the case of BACS the recast EPBD measures are not implemented and rather the BACS performance evolves as would be expected under the previous (non-recast) version of the EPBD. In this sense the title of the scenario is something of a misnomer because the scenario is only compliant with the parts of the recast EPBD that do no address BACS, in the case of BACS it assumes the same progression as would have been expected had the EPBD not been recast (amended). Nonetheless, this scenario is necessary to isolate the impact of the BACS related policy measures within the recast EPBD from the other policy measures.

The *Frozen BACS* scenario is the same except that in this case the energy performance of the BACS systems used remains constant i.e. at exactly the same levels as were exhibited at the beginning of the scenario period, 2018. Thus, with regard to the control of building energy systems the Frozen BACS scenario is a no-improvement case, the *EBPD compliant without BACS* scenario is a Business as Usual case, and the *EPBD compliant* scenario is the case where the new BACS policy measures in the recast EPBD are implemented in line with the specifications. The impact of the recast EPBD BACS measures (in terms of energy, CO_2 emissions and economic impacts) is thus the difference between the *EPBD compliant without BACS* scenario and the *EPBD compliant* scenario.

Methodology

To analyse these scenarios a detailed bottom-up Excel model was developed to simulate the European building stock. Just like the recast EPBD's impact assessment It is primed with detailed building stock data and energy data from the official statistics as reported in the EU Building Stock Observatory, which is a database established by the DG Energy to monitor the energy performance of buildings across Europe. The model projects the evolution of the building stock forward in time using exactly the same assumptions as reported in the recast EPBD impact assessment so that the floor area by building type, the choice of fuels/energy sources, the fabric materials and composition, the usage profiles, the type of technical building systems and the efficiency of the technical building systems all evolves in line with the official impact assessment. The innovation of the current study is to explicitly analyse and overlay the evolution of the energy performance of the building energy system controls (the BACS) onto this progression and then to examine how the evolution in the BACS performance would vary were the measures in the EPBD regarding BACS not to be implemented, while all other measures are.

The approach used is to apply the simplified BACS factors from the European standard EN15232. This classifies BACS into energy performance classes, from D (lowest energy performance) to A (highest energy performance). Under EN15232 average energy performance indices (BACS factors) are associated with these classes and can be applied to scale the energy consumption of the technical building systems that are being controlled. Thus, a class C BACS will have a BACS factor of 1, whereas a class D will be higher than 1 and class B or A lower than 1. These BACS factors have been derived by analysis of a very extensive set of detailed building energy performance simulations, based on the known properties of control systems and the technical building systems they control. The BACS energy performance classes, and associated BACS factors, are associated with step changes in the functionality of the BACS in question. E.g. from a simple manually controlled light switch (class D) to lighting which is controlled by presence detectors and is self-dimming in response to rising daylight levels (class A). Similar functionality descriptions apply to the BACS classes and factors applicable to each technical building system and all the solutions currently used to deliver the service. In addition, the BACS factors are calibrated as a function of the type of building being considered (e.g. single-family housing, multi-family housing, offices, education buildings, retail, etc.). Thus, overall there is a very extensive array of building types, technical building system solutions, and BACS functionality levels that can be applied – each combination of which gives rise to a specific BACS factor under EN15232.

The simulation model used in this study has been set up to treat all of these combinations and project them forward in time in response to the stimuli to evolution in BACS functionality inherent in each of the three scenarios. The starting point, i.e. the distribution of BACS energy performance class per TBS solution and building type, was determined by applying extensive survey information compiled for the study by eu.bac members in conjunction with earlier data reported in the literature.

While the Frozen BACS scenario is straightforward in that the distribution in BACS energy classes do not change over the course of the scenario period, for the other two scenarios the distribution of BACS by energy performance class is expected to improve over time. To estimate the expected trends under the *EPBD compliant scenario without BACS* scenario an analysis was conducted of historic improvement rates per BACS renewal event and these are then assumed to continue into the future.

For the *EPBD compliant* scenario the impact of the measures in the recast EPBD is overlaid over these trends in a manner that is wholly consistent with the EPBD requirements. In general, this roughly equates to moving to class B BACS functionality for BACS renewal/fresh installation events whenever such events are in response to a specific policy measure in the recast EPBD, but otherwise adopting the same evolution as in the *EPBD compliant without BACS* scenario.

The energy impacts of these trends are derived by applying the BACS factor evolution to the energy consumption of each technical building system per the approach described above. The fuel mix, energy prices, primary energy factors and CO_2 emissions factors assumption are fully aligned with those used in the official EPBD impact assessment.

Energy savings and other impacts from improved BACS under the recast EPBD

Overall, the analysis finds that appropriate implementation of the BACS related policy measures in the recast EPBD will save 14% of total building primary energy consumption by 2038.

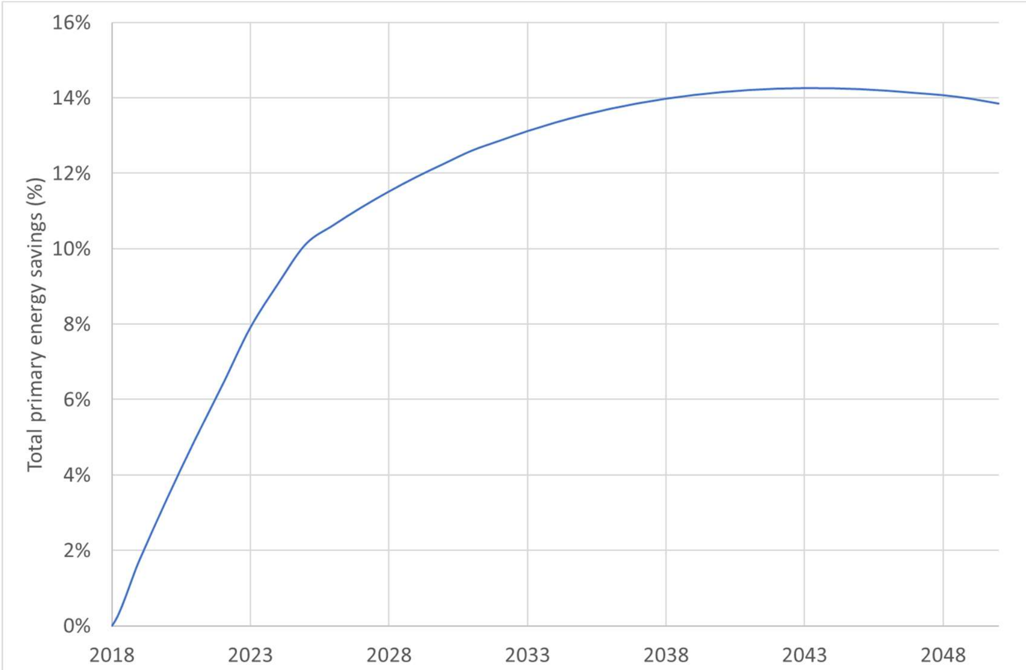

Figure ES1 – Total primary energy savings for all buildings for the *EPBD compliant* scenario compared to the *EPBD compliant without BACS* scenario

This gives rise to over 450 TWh of annual final energy savings (Figure ES2) peaking in 2035 despite this occurring in the context of a sharply declining overall building stock energy consumption due to the ensemble of the recast EPBD policy measures. Figure ES3 shows the general trends in EU building stock energy consumption under the three scenarios.

In terms of CO_2 emissions, the *EPBD compliant* scenario leads to annual savings that peak at 64 Mt in 2030.

The investments necessary to deliver these BACS rise sharply to an annual peak of ~€7.4 billion in 2022 but decline rapidly thereafter. The value of the energy bill savings triggered by these investments rises sharply to about €32 billion in 2025 and then more gradually to a peak of €36 billion in 2035 before gently declining thereafter. Overall the value of the energy savings far exceeds the cost of the investments. Over the whole scenario period the value of energy savings exceeds the value of investments by a factor of 9 (comprised of a factor of 8.1 for residential buildings and 10.4 for non-residential buildings).

Implications

The analysis reported in this study complements the formal impact assessment to the recast EPBD by adding missing detail on the expected impact of the BACS-related policy measures. It shows that an important part of the energy saving impact of the recast EPBD can be attributed to the policy measures that concern the accelerated deployment of improved building automation and controls; which justifies the additional focus given to them in the recast EPBD. Nonetheless although energy savings of over 14% of total primary energy savings for the building stock are associated with the full implementation of these measures, significantly deeper energy savings could be achieved from using even higher performance BACS i.e. those consistently at the class A energy performance level.

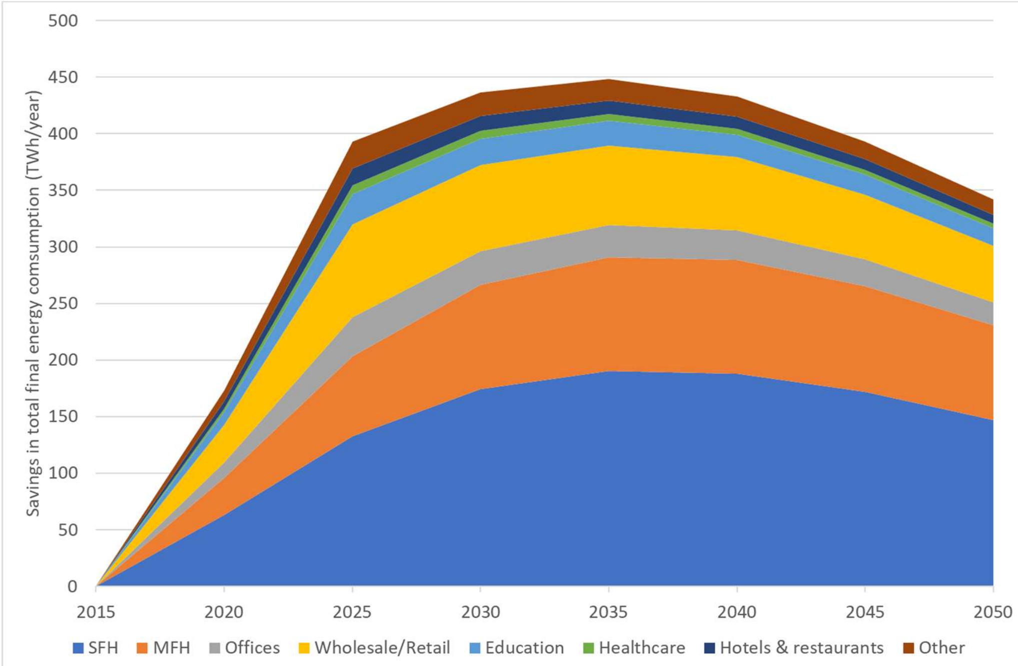

Figure ES2 – Savings in total final energy consumption of EU buildings for the *EPBD compliant* compared to the *EPBD compliant without BACS* scenario

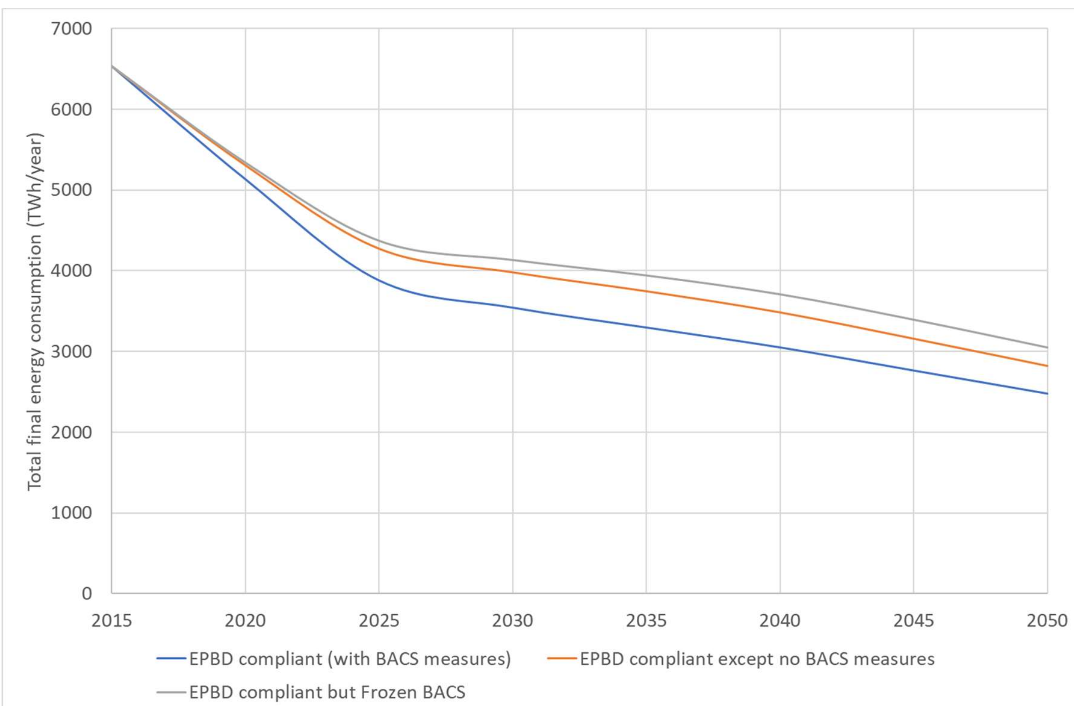

Figure ES3 – Total final energy consumption for EU buildings by scenario