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Tapping into energy and CO2 savings in EU households through the use of building automation technology – a policy pathway to savings

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Abstract

This paper reports key findings from a recent study into the potential for building automated control systems (BACs) and related automated technology to save energy in Europe's households and from a follow-up analysis of policy options. The techno-economic savings potentials from greater adoption of simple but effective building automated control systems in Europe's homes is found to be ~1 357 Mtoe from 2015 to 2035; however, the analysis shows there are a variety of barriers that are inhibiting the realisation of this potential. This paper presents a portfolio of policy options designed to overcome these barriers including:

- building capacity among building energy controls service providers and engineers
- strengthening interoperability and standardisation
- raising market awareness and strengthening education along the supply chain
- developing targeted financial incentive mechanisms designed to stimulate supply and demand of quality BAC products and services at as fast a scale as can reasonably be sustained
- certification and accreditation of suppliers, designers and installers
- mandatory requirements regarding labelling, minimum performance and installed systems

Much of the above could be implemented by making use of and adapting existing policy levers, in the EPBD (Directive 2010/31/EU) and Energy Efficiency Directive (Directive 2012/27/EU), and practical routes for doing this are explored within the paper. Prior to this, however, the paper considers what policy actions designed to trigger savings from better use of BACs could be implemented through the Ecodesign Directive, which is of immediate relevance given the ongoing Ecodesign planning review.

The savings analysis estimates that full implementation of these measures would result in 498 Mtoe of cumulative energy savings and avoid 1.3 gigatonnes of CO_2 emissions from 2015 to 2035 for EU residential buildings compared to current trends. Some €95 billion of extra investments in BACs and related services would be needed to deliver these savings, at an average of €5 billion per year. Large as these incremental investments are, they are almost six times less than the value of the resulting savings in energy bills, which total €562 billion over the period, at an average of €28.1 billion per year.

Glossary

BACS = building automated controls

BAT = building automated technology

EED = Energy Efficiency Directive

EEO = Energy Efficiency Obligation

ELD = Energy Labelling Directive

EPBD = Energy Performance in Buildings Directive

EPC = Energy Performance Certificate

HEMS = home energy management system

MS = (EU) Member State

HVAC = heating ventilation and air conditioning

NEEAPS = National Energy Efficiency Action Plans

Introduction

Buildings are widely reported to consume 40% of all energy in Europe [1] of which residential buildings account for 71% of final energy consumption [2]. In recent years, they have received increasing attention by policymakers seeking means to reduce the energy requirements of the building stock. Much of the effort to date has focused on new construction and major alterations, tightening building regulations to improve the efficiency of the building fabric and the installed equipment. Legislation has also promoted renovation of the existing building stock, greater use of renewable energy, and the disclosure of energy performance (mostly modelled, not actual) via energy rating and labelling schemes. Very little attention has been paid to building automated technology and control systems, which is surprising given their potential to reduce building energy consumption substantially and rapidly, at relatively modest cost.

This paper presents the findings for the residential sector of an analysis commissioned by the European Copper Institute (ECI) to examine the potential of building energy controls to accelerate energy savings [2] and complements this with a more recent, as yet unpublished, analysis of the policies that could promote greater savings through building automated technology and controls. It demonstrates the undoubted potential of building automated technology (BAT) and controls (BACS) to save large amounts of energy, with a technical and economic potential of some 23% across the residential building stock, amounting to 9% of all EU energy use [2]. However, it also cautions that to achieve this potential will require considerable improvements, not just in the technology (which already has great capabilities and is advancing rapidly) but in its effective design and application in buildings. Too often, BAT/HEMS installations do not fulfil their promise, distancing users from the systems with which they need to interact. Effective deployment of BAT/HEMS in the residential sector is therefore as much about the calibre of professional services in designing, applying, integrating, installing, commissioning, and handing over BAT/HEMS as it is about the products themselves. This need for greatly improved deployment in both qualitative and quantitative terms is reflected in the recommendations in this paper.

Current technologies and barriers to their implementation

Modern building automated technology (BAT) brings the electromechanical hardware of sensors, actuators and thermostats together with ICT hardware such as controllers/outstations, programmers and central facilities such as personal computers (PCs) and data displays. Collectively these can be combined with appropriate software to provide home energy management systems (HEMS) for residential buildings; however, it is important to understand that varying degrees of integration and sophistication are used and that the most appropriate system will vary in response to the building and usage characteristics.

The HEMS market can be considered to be comprised of stand-alone systems, networked systems and in-home displays.

- Stand-alone systems will typically consist of sensors and an information display that communicates with the sensors and utility meters. More advanced systems will have a central management system that collects consumption data from multiple devices and enables their control via standard consumer IT devices, such as smartphones or PCs.
- Networked systems establish communication between HEMS and energy utilities and are designed to enable demand response, i.e. to enable consumers to modify demand in response to time-dynamic tariffs. Networked systems are more costly to install and require consumer willingness to cooperate with the utility to modify their energy use. While they have been trialled, they are currently much less common than stand-alone systems.

- In-home display systems simply display energy meter data in real time to show how much energy is being used in the home. They neither directly control the energy-using equipment nor display information on specific end uses, but they do allow consumers to attempt to correlate the consumption profile with the operation of equipment and thence make manual adjustments to equipment to regulate energy use.

In-home displays are thus a means for increasing information on home energy use; however, they are not really a building automated control technology as they do not control the energy-using equipment. Therefore, they are not really considered to be a full BAT system/HEMS.

The control provided by stand-alone and networked HEMS are supported by intelligent device controllers such as smart thermostats, also known as 'programmable communicating thermostats', which have the ability to send and receive information wirelessly. These are an example of building automated technology and should not be confused with the HEMS that can be used to program them from a central location according to a schedule. These smart thermostats can not only be remotely controlled via consumer ICT devices but can also be set to provide operation on demand, i.e. when a space is occupied. Similarly, plant such as boilers, air conditioning and ventilation systems can be managed by device-level controllers that connect and communicate via a standards communications technology and protocol. The more advanced HEMS will also have sensors/controllers that allow sensing, monitoring and control of other equipment besides HVAC, including lighting and appliances, but this functionality comes at an extra cost and its economic viability is less proven.

The savings potential from the use of these systems (controls and automated technology) comes about by avoiding heating or lighting in unoccupied rooms and by better scheduling of when heating starts and stops to take account of occupancy overlaid against the thermal response of the building. Building automated technology systems can be quite simple, for example in homes they principally concern ensuring that as many spaces as relevant have their own programmed thermostatic actuator capable of controlling the heat flow to that space (usually by being integrated into the heat emitter). Programming can be done centrally through a HEMS often via wireless communication. The more spaces where the demand for heat delivery is sensed and controlled individually rather than as an aggregate the greater the savings. The same systems should also employ optimum start/stop and weather sensing to avoid heating coming on unnecessarily early or staying on too long by learning the thermal response of each room.

There is a plethora of elements and systems configurations on the market with different levels of functionality and which use differing operational software, communication technology and protocols. The sheer variety of solutions that are available is one of the biggest hurdles to both broader adoption and improved implementation because the value proposition from automated controls becomes blurred between competing claims and is adversely affected by implementation problems that are exacerbated by insufficient standardisation. In part this diversity and complexity is also driven by the broader pace of developments in ICT more generally and simply reflects the widening array of possibilities that have become available as technology evolves; however, there is an ongoing tension between the emergence of new solutions and the need to standardise to facilitate deployment at scale and reduce implementation difficulties. In the residential sector there is also a need for solutions to require the minimum disturbance of inhabitants during installation and for aesthetic sympathy with the décor in the home.

Market trends

The European automated controls market has held steady throughout Europe's current economic recession, despite the fact that the natural installation opportunities are strongly related to new-build and renovation events, which are sensitive to broader economic trends. This is because renovation and renewal rates have increased slightly as building owners have become more sensitised to (i) the value of energy savings, (ii) the arrival of new technologies with additional value, and (iii) the impact of more proactive broader public policy measures, such as the EU's Energy Performance of Buildings Directive (EPBD), all of which have helped stimulate demand. Given these trends, penetration of HEMS is projected to rise from 2% of homes today to 40% by 2034 without additional policy intervention. This, rate of penetration may seem to be addressing the problem but in fact will leave a large proportion of the savings potentials untapped. Not least because the default system in most EU national markets is to have a single thermostat in the home used to control all the heat emitters, thus

very often when the building is occupied and heating is required in one room all heat emitters are activated.

Savings potentials

Three scenarios were developed in the ECI report [2] to assess the potential for additional energy savings:

- the **Reference Scenario**, which assumes a continuation of current trends regarding the adoption and installation of BAT/HEMS in the residential sector, with no significant improvement in installation and management procedures
- the **Optimal Scenario**, which assumes an optimal level of installation and operation of BAT/HEMS from a user cost-effectiveness perspective
- the **Recommended Action Scenario**, which assumes that the recommended actions outlined in the ECI report and elaborated upon here are implemented and that the BAT/HEMS are procured, installed and operated accordingly.

These scenarios were simulated for the European residential building stock in a purpose-built building energy stock model to estimate the expected impacts on building energy use and costs. The magnitude of savings achieved per installation obviously depends on the baseline level of controls, the functional sophistication of the new installation and the nature of the building and energy services being controlled. In a typical EU household where heating is the main source of energy use a sophisticated automation and control installation will bring in features such activation of each heat emitter only in response to demand rather than by default (usually based on room occupancy scheduling with manual override capability), optimum start functionality (which takes into account the heating time lag of the space to optimise the timing for when heating is initiated and deactivated), and weather compensation (that also helps to optimise how much heat should be is delivered to a space at what time). Collectively these control measures save considerable amounts of heating energy compared to a whole house thermostat and thermostatic radiator valve controls arrangement, which would be a typical default setting (see [2] for more details).

At the macro pan-EU scale the potential energy savings from greater and more effective deployment of building automated controls and technology is vast. The total techno-economic optimal savings potential as expressed through the Optimal Scenario is estimated to reach 23.4% of all residential building energy consumption by 2029 declining slowly thereafter; however, this is predicated on a rational and perfectly functioning market without serious constraints to effective service delivery. Under the Optimum Scenario the penetration of BAT/HEMS reaches 100% of homes in 2028. A more realistic depiction of the potential to deliver additional savings beyond the Reference Scenario (business-as-usual case) is offered by the Recommended Action Scenario. In this case, savings ramp up progressively over the scenario period to reach 11.3% of the Reference Scenario energy consumption by 2035 (Figure 1). This is associated with a steady but accelerated rate of penetration of BAT/HEMS rising from 20% of homes in 2020 to 83% in 2035.

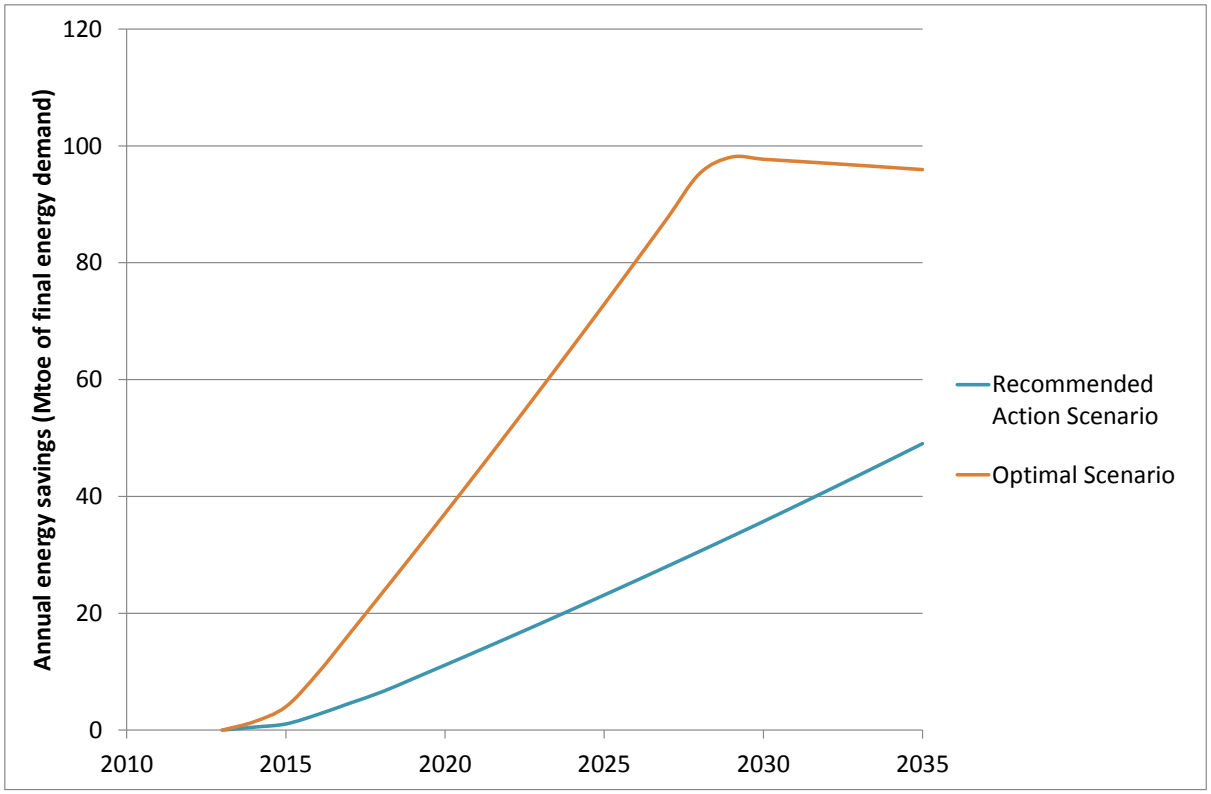

Figure 1. Building energy savings under the Recommended Action Scenario (RAS) and Optimal Scenario (OS) for European residential and service sector buildings compared with the Reference Scenario

The Optimal Scenario leads to some 1 357 Mtoe of cumulative energy savings from 2015 to 2035 compared to the Reference Scenario for residential buildings, while the Recommended Action Scenario leads to some 498 Mtoe of cumulative energy savings over the same period. For the Optimal Scenario this equates to cumulative CO_2 savings of 3.3 gigatonnes, with annual savings of 94 million tonnes of CO_2 in 2020 and 222 million tonnes in 2035[1]. For the Recommended Action Scenario the cumulative CO_2 savings are 1.3 gigatonnes with annual savings rising to 123 million tonnes of CO_2 in 2035.

Over the Recommended Action Scenario period (2013−2035), some €95 billion of extra investments in BAT/HEMS and related services are needed to deliver these savings, at an average of €4.8 billion per year. Large as these incremental investments are, they almost six times less than the value of the resulting savings in energy bills, which total €562 billion over the period, at an average of €28.1 billion per year (Figure 2).

[1] Assuming the same electricity sector fuel-mix and emissions factors as reported in the New Policies Scenario of the IEA's *World Energy Outlook 2012* [4].

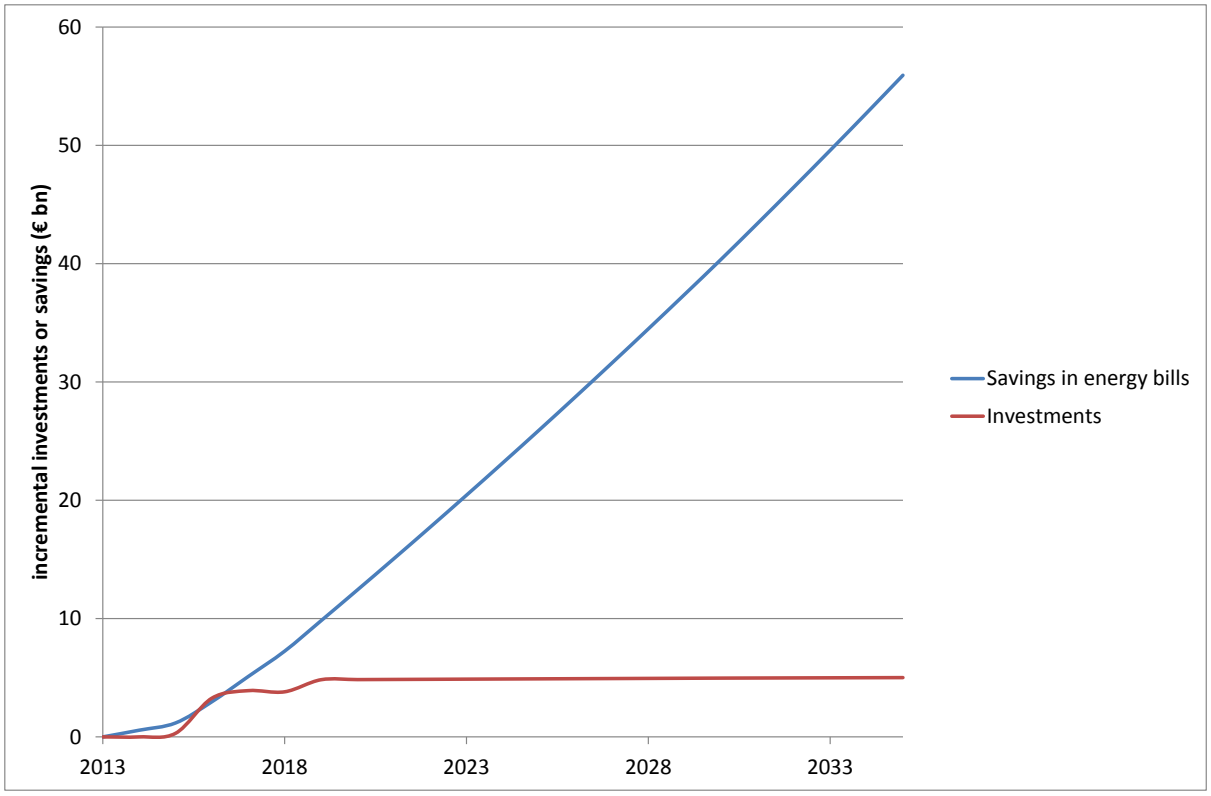

Figure 2. Investments and energy bill savings achievable with building automated controls and technology in European residential and service sector buildings under the Recommended Action Scenario

It is interesting to compare these figures to the cost of roll out of smart meter systems. These are set to cost approximately €95bn to roll out across European homes and are thought likely to produce savings worth about €147bn. Thus a mass EU wide programme to promote savings via BAT/HEMS would cost about the same as the EU's smart meter roll out but produce energy savings which are almost four times greater. Of course the two options are in no way mutually exclusive and should be designed to be complementary; however, it is surprising that the smart meters are much more advanced in the policy attention they receive and their roll out given the relative strengths of the value propositions.

Barriers to energy efficiency

Given this strong value proposition it might be considered surprising that BAT/HEMS are confronting barriers that prevent their more rapid adoption, but in reality they are very similar to other energy saving opportunities in the building stock in this regard. In the case of landlord-tenant arrangements split incentives separate the economic incentive for energy savings from those that procure services but there is an even more important barrier due to the split incentive between the current building owner occupier and the next. In this most common case the present owner occupier will only consider investing in an energy saving technology if they will still be the occupier at the time payback occurs. Given the uncertainty in many people's professional and personal circumstances this is often unknowable in advance. Probably the biggest barrier though is the pervasive lack of awareness of the technical savings opportunity and basic value proposition such that few people even consider such an investment as they're unaware the opportunity exists. Additional barriers relate to (i) access to qualified personnel to design, install and commission automated technology and controls, and (ii) the fact that poor implementation often goes undetected, (iii) lack of common standards enabling BAT/HEMS suppliers to develop more universal products, (iv) slow response from HVAC equipment manufacturers to incorporate advances into their packaged controls and communications and a propensity to use proprietary rather than open source communication protocols, (v) a poor standard of client briefing and technical specification, resulting in lowest-cost solutions regardless of the effect and leading to selection on the basis of lowest capital cost rather than highest value in operation, (vi)

the economic situation depressing demand, although perversely the economic situation would result in greater uptake of BAT/HEMS if clients were aware of the cost-benefits that can be achieved from appropriately specified and operated systems, (vii) the magnitude of upfront investment costs for what may seem to be an uncertain value proposition. In addition BAT/HEMS can fail to deliver their full potential because those specifying the system have limited understanding of how it will be operated and have little experience of operating the systems they have specified. In general, there is a need to move to a market where consultants, contractors and suppliers are selected on the basis of their ability to demonstrate that they understand how the BAT/HEMS will be used in operation, rather than just on their design experience.

Recommended actions

Impressive as the savings potentials for BAT/HEMS are, they will not be realised without firm and proactive measures to stimulate both good practice and higher rates of deployment. Very little policy attention has been paid to control systems, which is surprising given that building automated controls and technology have tremendous potential to save energy cost-effectively in Europe's building stock. All too often, however, the potential is squandered owing to poor design and implementation of the building automated control systems. In addition, uptake of automated energy-saving controls is far below the levels that are economically justified. Thus, fundamentally measures are needed that will:

- increase the reliability of the savings from BAT/HEMS
- increase the uptake of BAT/HEMS.

The recommendations in this section aim to address these needs and to stimulate a debate among energy-efficiency practitioners and policymakers about how best to meet these needs. They are not comprehensive but cover many of the most pressing needs; however, it is recommended that more detailed work be done to refine the analyses considered here (and the related recommendations) prior to any move toward implementation.

Objectives of an ideal policy package

What will an ideal policy package aim to do? On the one hand it needs to drive demand for effective BAT/HEMS installations to overcome market barriers and failures. On the other it needs to stimulate improvements in the practical design, specification and operation of BAT/HEMS to ensure they deliver the savings potential in practice. It is important to appreciate that these two aspects are related, however, as addressing the quality and reliability of savings delivered through BAT/HEMS will also help drive future demand through increasing market confidence in the value proposition of HEMS. There is therefore a feedback between these two objectives. Figure 3 sets out the needs that the various policy measures proposed in the remainder of the paper are intended to address.

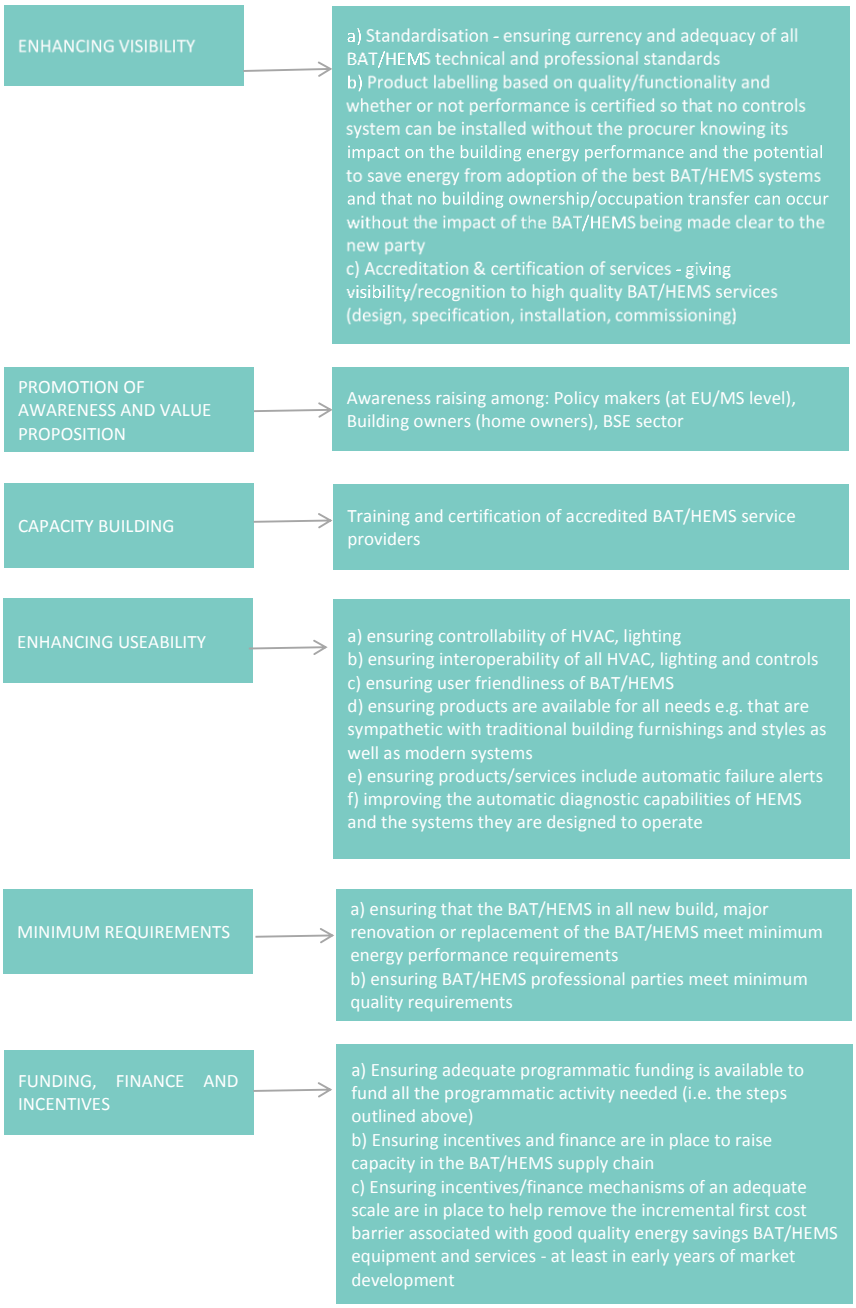

Figure 3. Measures needed to support energy savings from BACS/BAT within an ideal polcy framework

Measures to raise demand

Driving demand can be done through a mixture of mandatory provisions, incentives and awareness raising measures, see Figure 4. Demand can also be raised by improving the reliability of delivered savings.

Mandatory provisions

In principle mandatory provisions can be an effective way of obliging a certain level of service, functionality and performance for automated technology and controls and thus could be used to both drive demand and the quality of service delivered.

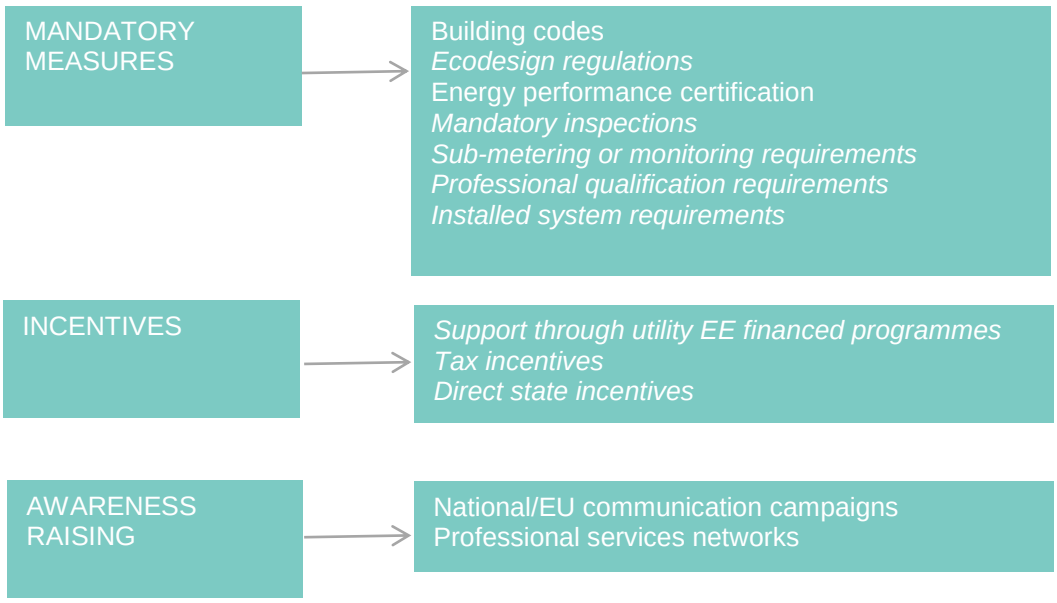

Figure 4. Measures to drive demand

Where they exist mandatory provisions for BAT and energy controls currently comprise installed performance and/or functionality specifications via building codes but could also include:

- Ecodesign requirements
- mandatory inspections
- requirements on building energy performance certification.

In theory they could also involve mandatory professional qualification requirements for BAT/HEMS specifiers and installers. They could further entail mandatory performance and functionality requirements applied to installed systems although such measures have only occasionally be applied for energy using products outside of building codes.

Policymakers will quite rightly only contemplate the adoption of mandatory measures if there is clear evidence of: a market failure that the measure would overcome, a significant net benefit from their adoption and that the measures are practical to implement and enforce. Thus any prospective measure has to satisfy these criteria. It is important to recognise though that mandatory measures can be among the most effective means of addressing split incentive barriers (that pervade the building sector) as well as other barriers such as low awareness and a reluctance to invest in upfront energy savings measures. Given the large scale of cost-effective savings potentials and the myriad barriers to be addressed mandatory measures are clearly appropriate for BAT/HEMS to the extent that they satisfy the criteria set out above.

Building codes

Building codes are designed to overcome first cost and awareness barriers and ensure a minimum level of service adoption; however, it is important to appreciate that they can only practically be applied to new build or major renovations and thus even under the most favourable circumstances will take many years to drive demand in the whole building stock. New build rates in the EU are typically around 0.5% of the building stock per year while major renovation probably applies to about 3% of the residential building stock per annum. Thus while codes are important drivers of demand even under an ideal implementation scenario they will take about 35 years to affect the BAT/controls installations in the majority of the residential sector building stock at best. Given real world implementation deficiencies it would probably be considerably longer in practice.

Furthermore, while all EU Member States have minimum energy performance specifications for whole building energy performance for new build and major renovations it is rare to have specific provisions for building automated technology and controls. This is a lost opportunity because it assumes an unrealistic level of project management and integration in building projects. A more robust policy

framework would recognise that there are many actors involved in the design and delivery of buildings and building services, and that each has a distinct role to play in affecting the delivered energy performance. Given the complexity of this arrangement it is better if each type of actor has clearly delineated requirements when these are important to the overall building energy performance. This is especially true for key building energy services such as: HVAC, lighting, and controls (BAT/HEMS). Good practice therefore involves the specification of both overall building energy performance requirements and the specification of separate minimum requirements for the key sub elements; however, this approach is only currently applied among some EU Member States.

The revised EPBD requires MS to determine their codes based on a cost-optimal approach which is supposed to take all energy savings options into account and to set requirements in line with the set of options that produce the least life cycle cost solutions. Inspection of a sample of the cost optimal assessments submitted by MS shows that in the case of building controls this assessment is being done in a very superficial manner at best. It is clear that the cost optimality assessment process within the EPBD is not currently being applied properly by MS for controls and as a result cost-effective energy savings options using BAT/HEMS are either not being considered at all when assessing the cost-optimality of energy performance codes or are being aggregated with other options in such a way that the true benefits are not properly accounted for. This results in both, a reduced appreciation of how much BAT/HEMS can contribute to energy savings objectives and in sub-optimal building codes. Both issues need to be addressed in greater depth in future assessments

Ecodesign regulations

Ecodesign requirements could apply to the BAT/HEMS products themselves were they to be developed. The nature of such requirements is an open question and would need to be investigated via a preparatory study and consultation process but they could include mandatory functionality, interoperability, operability, usability and performance specifications and thereby help to remove inadequate control technologies from the market. They could also include performance classification and disclosure requirements that are either applied through energy labelling (via the labelling Directive) or via information requirements implemented in the Ecodesign Directive. Such classification and disclosure requirements would help to address the low visibility and awareness barriers that currently lead to an under appreciation of the potential for savings from BAT/HEMS. There has been discussion about including BACS in the future Ecodesign working plan for 2015-17 [3] and it is to be hoped that they will be a clear priority. The inclusion of BAT/BACS within this Directive is more important than it may appear at first consideration because it is the best instrument to ensure that all necessary product performance specifications are measured and reported in a standardised manner, which is a necessary precursor to systems integrators being able to confidently specify products to achieve a given energy performance outcome.

Building energy performance certificates (EPC)

EPCs are already a mandatory requirement under the EPBD and each EU Member State has now implemented such measures. The key issue for EPCs with respect to controls is to ensure that the value of good quality BAT/HEMS is recognised and valued within the whole building energy performance rating system and that higher performance BAT/HEMS options are also proposed in the recommended actions within EPCs. In theory this is automatically the case when operational ratings i.e. those based on metered energy consumption, are used - as is the case in many EU countries. However, even here there is no direct attribution of the observed performance level to the BAT/HEMS characteristics and use, so in cases where there is an improvement in the EPC rated score due to the quality of the BAT/HEMS it is unlikely to lead to an appreciation of the contribution to the rating made by the BAT/HEMS. In the case of EPCs which used asset ratings it is important that the role of BAT/HEMS as a function of their capability and quality be adequately recognised within the rating. At present this is rarely the case albeit that the development of the EN 15232 standard [4] now makes it possible to classify and quantify the expected impact of BAT/HEMS on the overall building energy performance. In theory this should allow the gap between asset and operational based EPC ratings to become narrower although in practice there are many aspects of building energy use that are sensitive to occupancy and use factors that are independent of the BAT/HEMS systems used.

Mandatory inspections

Mandatory inspections of heating and AC equipment above 12kW are already a requirement within the EPBD so in principal the same type of requirement could be applied to ensure conformity of building automated controls. Nonetheless, this has been one of the more contentious provisions in the EPBD and it would be advisable to consider means by which the value-added of inspections could be maximised and the burden minimised before imposing new requirements. For BAT/BAC systems this could be done through a triage according to building energy use such that buildings with poor energy ratings and high energy use, as determined by the existing mandatory energy performance certificates could be subject to mandatory BAT/HEMS inspections to see that the level of control capability is sufficient and is properly implemented. Indeed, such a provision is likely to produce much greater savings if competently implemented than mandatory heating and AC systems inspections.

The EPBD was amended when it was recast in 2010 to permit MS to implement alternative measures to mandatory inspections providing that they produce equivalent energy savings as would have been expected from the inspections. The promotion of savings through BAT/HEMS could and should be supported as a principal means of complying with this provision.

Professional qualification requirements

Mandatory qualification requirements could be imposed for the providers of building energy services and controls. Indeed this already happens with respect to safety for gas and electrical equipment and the same principle could be extended to energy performance qualifications. Such requirements would help to raise the quality of service provision but they need to be managed carefully to ensure they stimulate improvements in professional design, specification, installation and operation of BAT/HEMS without creating a strong disincentive to operate within the market i.e. without creating a self-defeating barrier to entry in the BAT/HEMS services market. Often such requirements can be considered when a sufficiently strong professional base has been developed and can be staged in such a way as to progressively raise the bar so that the volume of service provision remains high while the quality is increased. In order to both minimise this risk and to create effective capacity more rapidly they can also be supported by incentives, such as the provision of free or heavily subsidised training and certification schemes. Professional qualifications can also be established for different parts of the supply chain and service sector e.g. in the residential sector training and certification could be developed for:

- BAT/HEMS service providers including designers, specifiers and installers
- BAT/HEMS inspectors and auditors.

Installed system requirements

Despite the inclusion of the “extended product” notion within the MEErP assessment methodology Ecodesign specifications usually apply to components and not to the installed system as a whole, while building codes will only address the quality and performance of BAT/HEMS in the event of new-build or major renovations. This leaves a large gap when new or replacement HVAC systems or their controls are installed that is not easily addressed with the currently implemented measures. This raises the scope, therefore, for a new type of policy instrument aimed at setting requirements for the energy performance of installed systems. It could be designed to apply to a host of systems types including lighting, HVAC, cables, motor systems etc. and if implemented at EU level would most likely would need to be structured with a subsidiarity principle embedded, i.e. more like the EPBD or EED than the Ecodesign Directive in that it could impose obligations on EU Member States to develop and enact installed system requirements according to a common set of principles rather than centrally specifying precisely what such specifications should be. This would reflect that the single market is only lightly involved in the market for installed systems as most service provision is at the local rather than transnational level. Such a Directive would clearly require considerable development work to establish the nature of such an EU driven process, however, the scale of potential savings are such that this effort would be justified and could help complete the EU’s portfolio of energy efficiency legislation. Even in the absence of such EU measures individual Member States could develop their own requirements should it not prove to be possible to develop a common EU framework. In principle Article 8 of the EPBD, which requires MS to specify requirements for technical building systems, including heating and lighting systems, could be implemented to fulfil this function.

Incentives

Incentives help overcome the first cost barrier, the awareness barrier and the split incentives barrier (both landlord tenant but also the split in incentives between the current owner/occupier and the next). They are thus a key instrument to help establish delivery at scale when mandatory measures are insufficient or only partially address the need. If applied appropriately they will be tied to clear quality of service requirements to favour and differentiate quality service providers over those that do not meet service quality requirements. This will create an incentive for BAT/HEMS service providers to demonstrate that they meet quality requirements and thereby raise the quality of service offered, which in turn will improve customer experience and hence drive repeat business and future demand. In this way they can help to increase the capacity to deliver good quality BAT/ HEMS and related services. Incentives can also be structured to:

a) Prime the market and raise capacity ahead of the adoption of mandatory measures – such as stricter building code specifications

b) Be staged to be relatively generous in the early stages of a market stimulus effort but subsequently phased down as the market volume builds, mandatory measures are locked in and confidence in the value proposition of BAT/ HEMS increases.

These two aspects echo previous market transformation initiatives that were successfully applied, for example, for gas condensing boiler technology in the UK and Netherlands wherein generous incentives introduced at the early market stage helped to both drive demand and build delivery and installation capacity, prior to being ramped down and locked-in via mandatory regulations once the capacity of the market to deliver a good quality product in all applications and at scale had been established.

In theory incentives can be applied to:

- bring down the cost of good quality energy saving BAT/ HEMS and drive demand
- build capacity in the supply chain
- encourage HVAC and lighting systems to be fully interoperable and controllable using HEMS
- support diversification of residential product offers so that the range of controls on offer (especially for heat emitters) are better adapted to the aesthetic sensibilities that exist in the European building stock (particularly for prevalent older building types and periods) and hence will have greater consumer acceptance.

Financing for incentives needs to be of a sufficient level and quantity over a sustained period if energy saving policy objectives are to be realised. In most economies public sector finance is likely to be too modest and unreliable to meet the scale required therefore it is likely to be more viable if the finance is derived from the value of avoided future energy bills. This can be implemented through mechanisms such as utility energy efficiency obligations which recover the cost of energy efficiency measures via modest increases in energy tariffs in such a way that net bills decline i.e. so energy bill payers are both the financer and net beneficiary on aggregate[2]. In principle the notion of a feed-in tariff applied to energy savings measures, such as BAT/ HEMS, could also serve this function.

Unfortunately a review of the existing energy efficiency incentive schemes applied to buildings in EU MS shows that very few appear to offer specific encouragement to BAT/ HEMS and thus it appears that in practice such incentive schemes are not yet being widely used to promote savings from this route. Much more work is clearly needed to determine what kind of incentives could be applied productively to what kind of BAT/ HEMS technologies under which conditions, however, given the vast scale of cost-effective savings potentials it clearly needs to be made a priority.

Awareness raising measures

Low awareness of the value proposition of BAT/ HEMS is a critical issue and is even more prevalent in the residential sector than the service sector, but very widespread in each. Therefore, efforts to

[2] This is the same model used to fund the roll out of smart meters

raise awareness of the value proposition are vital to drive demand. This is crucial to help address the visibility and priority barriers and thereby stimulate a more natural market for quality BAT/ HEMS and related services. First it is essential to spread the message about the value proposition of effective BAT/ HEMS so that organisations and individuals become more cognisant of how much they can save cost effectively from applying BAT/ HEMS more effectively. The development of a European and national communication strategy that explores the various media and networks that could be accessed to effectively convey the message would greatly support this objective. Such strategies would be likely to have much greater impact if they're linked to incentives supporting a mass roll out.

Improving the quality of delivered savings

Equally important to measures aimed at driving up demand are those aimed at improving the reliability of savings from BAT/ HEMS. Indeed the two are strongly related as the autonomous market demand for BAT/ HEMS will rise if the quality (reliability) of assured savings increases. Part of the process to raise the quality of delivered savings through BAT/ HEMS involves measures to raise the technical capacity of those involved in the supply and delivery of the savings i.e. of: the BAT/ HEMS systems specifiers and of the HVAC and lighting systems specifiers, installers and commissioners. In the residential sector continuous commissioning is not likely to be viable and regular energy audits can be difficult to implement effectively thus it is important to develop automatic diagnostic systems that can detect failures in control or operation and alert people to them. In the European building stock space heating is the largest end-use and its control should be the main focus of these efforts.

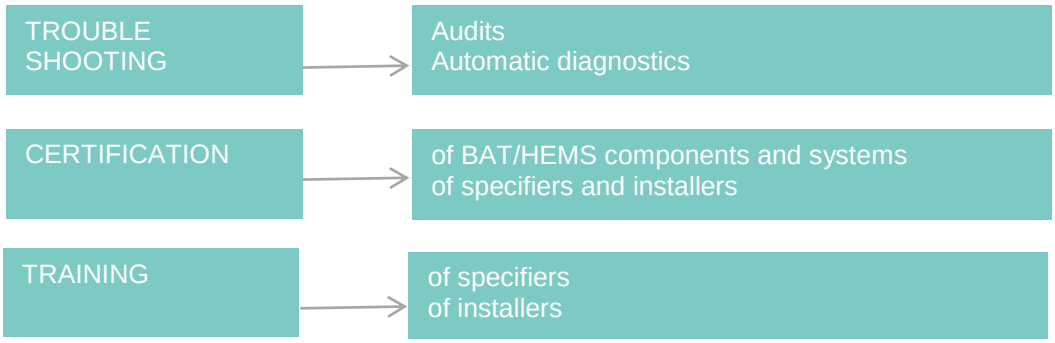

Figure 5. Measures to improve quality of residential BAT/HEMS energy savings

Regular audits

Regular audits (which can sometimes be grouped with regular commissioning or re-commissioning) will help to identify failures in the BAT/HEMS set-up and operation. Audits could be done purely to address such issues i.e. be dedicated BAT/HEMS audits or could be done to identify broader sets of energy savings opportunities including BAT/HEMS. The eu.bac BACS certification scheme promotes regular audits as a less costly version of continuous commissioning; however, these are focused on service sector rather than residential sector buildings.

Improving automatic diagnostics

Diagnostic and auditing systems are essential to ensure proper operation of complex control systems. Ideally these need to go beyond simple hardware and software solutions (albeit these are the core of the solution) to become fully embedded with corporate human organisational structures into a quality assurance process.

There is also a role for R&D designers to improve the automatic diagnostic capabilities of BAT/HEMS and the systems they are designed to operate. Methods to automatically highlight deficiencies in building services and associated controls performance are needed as it is unviable for experts to analyse system performance for all buildings on an ongoing basis from a practical and financial viewpoint. Excessive energy consumption can be identified with relatively simple rules, and there is considerable potential for expert and other rule-based automated diagnostic systems to identify wastage. Manufacturers and others have undertaken some development in this area, but little has yet been commercialised. In addition to expert systems, techniques such as data mining also have

considerable potential. These can identify patterns in the vast amounts of data available from HEMS and can identify when systems are not working as expected. They can assist in the ongoing analysis of systems to improve energy performance and, as with expert systems, identify when systems are performing poorly and the likely causes. It is therefore recommended that advanced data-analysis techniques and routes to market be developed.

Quality certification

Significant capacity constraints affect the proficient delivery of the energy savings potential of building automated controls involving at least the following:

- inadequate specification and installation of building energy controls and automation systems
- improper commissioning of BAT/HEMS
- insufficient knowledge of BAT/HEMS, options and practices among building code and energy performance certification requirement designers.

Consequently, it is recommended that structured efforts be made to develop a supply of high-quality service providers through the establishment of dedicated training, certification and accreditation efforts.

Certification of BACS and of specifiers and installers

It is extremely important to ensure the quality of the BAT/HEMS (components and systems), their specification and installation; and as a result it is highly desirable to promote and develop quality certification of all these aspects of the supply chain. The European Building Automation and Controls Association, eu.bac, has recently taken the lead in this and has developed a voluntary certification programme [5]. This is a commendable initiative but is relatively modest in the scale of its implementation as it is being rolled out among some eu.bac member companies in a few selected MS. It is therefore essential that public authorities engage with this initiative to increase its volume of application with the aim of ensuring all professional practitioners are suitably qualified in the future.

Training of building service engineers

The training of building service engineers involved in the design, specification and installation/commissioning of HVAC/lighting systems and BAT/HEMS also needs to be strengthened to take on board the controllability of the energy using systems, the options and features of BAT/HEMS and how to configure optimised systems. Programmes to deliver such training need to be designed, trialled, refined and then rolled out at scale.

How should the Commission implement the EPBD, EED and Ecodesign with respect to BAT/HEMS?

Most of the potential power of the EPBD to produce cost-effective savings through BAT/HEMS is currently untapped. To help address this it would be helpful were the Commission to:

- Ensure that the Article 8 provisions regarding setting energy performance requirements for technical building systems are properly elaborated for BAT/HEMS and appropriately implemented
- Ensure BAT/HEMS are included in MS calculations of whole building (or renovation) energy performance in a sufficient level of detail to capture the diversity of outcomes and to reward good practice so that their contribution can be properly accounted for in delivering prescribed whole building or renovation performance levels
- Encourage MS to take BAT/HEMS properly into account in the determination of rankings for energy performance certificates and to include BAT/HEMS options among the set of options recommended to improve performance
- Encourage MS to complement whole building (or renovation) energy performance requirements with minimum requirements for BAT/HEMS to ensure that building services are deploying cost-effective control strategies
- Ensure that the cost optimal methodological assessment used to define or justify the codes at MS level includes a proper assessment of BAT/HEMS differentiated by their various levels of

functionality and that these are not aggregated with other options that might be less cost effective to implement
- Develop guidelines regarding the design of programmatic actions to stimulate savings through BAT/HEMS as an alternative means of complying with Article 14 requirements on the inspection of heating systems
- Develop guidelines on how best to treat BAT/HEMS within EPCs
- Encourage MS to consider partially satisfying Article 10(2) requirements regarding financial support measures with measures that target effective BAT/HEMS deployment
- Encourage MS to amend their application of EPCs to analyse the difference between asset and operational ratings and using this to provide direct guidance on the need to improve the control strategy (as discussed in the EPC section above). If necessary, trial this concept and support the development of analytical tools to support this process.

In general it can be said that while provisions requiring the use of adequate controls in new buildings and renovations are necessary to stimulate uptake of energy-saving controls, there needs to be much greater reflection regarding how they should be framed and specified to ensure that they are clear, usable and encourage good practice. It is therefore recommended that an expert task force be established to prepare guidelines on these specifications and to review/critique existing specifications. To ensure that the recommendations reflect real application, the task force should include review from practitioners who would be expected to use the requirements and not just from experts in the control industry or researchers. Once clarity on the optimal regulatory specifications has been established, EU Member States should move to implement them fully in their building codes and to monitor implementation experience to ensure desired results are being achieved, making informed adjustments if not. The European Commission could facilitate coordination of this process.

The EED has a great many articles that could be applied to strongly promote energy savings through BAT/HEMS but at present there is very little evidence in MS submissions via the NEEAPS or other documents that they are applying these provisions to the realisation of savings through BAT/HEMS. In particular BAT/HEMS could be promoted through:

- Funding and incentives derived via Article 7 on Energy Efficiency Obligations
- The development of fully qualified professionals via Article 16 – Availability of qualification, accreditation and certification schemes
- The mobilisation of renovations for the existing building stock under Article 4 – Building Renovations

In the case of Ecodesign explicit implementing measures which could be developed to apply to BAT/HEMS products directly include:

- Requirements on interoperability (i.e. to ensure or encourage products to use open communication and control standards so that they can work with the maximum proportion of HVAC and other energy services equipment)
- Requirements on functionality (i.e. to ensure or encourage products to have sufficient functionality to enable significant savings to occur)
- Requirements on usability (i.e. to ensure or encourage products to be more user friendly, perhaps through adoption of common user interface templates in line with industry best practice, but also (depending on the product type) to provide alerts when extreme energy losses occur (e.g. when the same zone is being heated and cooled))
- Development of a common performance classification scheme leading to requirements on the disclosure of the classification perhaps via labelling or a rating disclosure process (either as components or within a larger system classification scheme)
- Requirements on the sensitivity and permitted tolerances of BAT/HEMS
- As a stimuli to repeat commissioning via a requirement for an inbuilt alarm when a set period has passed since the last system commissioning

A summary of the current status and potential for existing EU policy instruments to be applied to the support of BAT/HEMS is indicated in Table 1.

Table 1. Summary of current EU policy instruments as they are and could be applied to BAT/HEMS

Directive	**Measure**								
EPBD	**Building Energy Performance Codes**					**EPC**		**Incentives (Article 10(2))**	**Article 14. In place of HVAC inspection**
Scope	New build	Existing buildings	Residential	Non-residential	Cost optimal assessment (Article 5)	Residential	Non-residential	All buildings	All HVAC or equivalent measures
Status	Mixed, BACS mostly not treated explicitly	Mixed, BACS mostly not treated explicitly	Mixed, BACS mostly not treated explicitly	Mixed, BACS mostly not treated explicitly	BACS are mostly not assessed explicitly, if at all	No evidence any MS has considered applying this article to BAT/BACS explicitly	No evidence any MS has considered applying this article to BAT/HEMS explicitly	No evidence any MS has considered applying this article to BAT/HEMS explicitly	No evidence any MS has considered applying this article to BAT/HEMS
Notes	Should have specific BAT/HEMS requirements in all MS codes	Should have specific BAT/HEMS requirements in all MS codes	Should have specific BAT/HEMS requirements in all MS codes	Should have specific BAT/BACS requirements in all MS codes	Should treat BAT/HEMS explicitly and in sufficient detail to see cost-benefits	Should treat BAT/HEMS explicitly and be included in recommendations	Should treat BAT/BACS explicitly and be included in recommendations	Should treat BAT/HEMS explicitly	BAT/HEMS promotion are an ideal alternative means of meeting this Article
ECODESIGN/LABELLING	**MEPS**	**Classification/Labelling**	**Other requirements**						
Status	BACS under consideration for possible inclusion in work plan	BACS under consideration for possible inclusion in work plan	BACS under consideration for possible inclusion in work plan						
Notes	BAT/HEMS should be included	BAT/HEMS should be included	BAT/HEMS should be included						

Table 1. Summary of current EU policy instruments as they are and could be applied to BAT/HEMS continued

Directive	**Measure**							
EED	**Article 7. Utility energy efficiency obligations**	**Article 20. Energy Efficiency National Funds**	**Article 4 – Building Renovations**	**Article 8 – Energy Audits**	**Article 14 – Promotion of efficiency in heating and cooling**	**Article 16 – Availability of qualification, accreditation and certification schemes**	**Article 19 MS shall evaluate and remove barriers to EE**	
Status	Mixed/weak implementation. Not all MS have them. Many EEOs (almost all) are not yet designed to apply to BAT/HEMS	Mixed/weak implementation. Not all MS have them. Many funds (most) are additional and are not yet designed to apply to BAT/HEMS	Do they apply to BACS? Not all MS have them	No evidence any MS has considered applying this article to BAT/HEMS	No evidence any MS has considered applying this article to BAT/HEMS	No evidence any MS has considered applying this article to BAT/HEMS	No evidence any MS has considered applying this article to BAT/HEMS	
Notes	Measures targeting BACS could meet about half of the MS savings targets by 2020. EEOs could fund BACS including BAT/HEMS programmatic measures	These could be designed to support BAT/HEMS programmatic measures	Should include BAT/HEMS provisions	Should include BAT/HEMS provisions	Should include BAT/HEMS provisions	BAT/HEMS are in serious need of these and thus should be one of the first foci for this article	Each MS should assess barriers to BAT/HEMS savings and devise remedial actions accordingly	

Conclusions and the way ahead

Overall it is clear that the existing EU policy framework contains plenty of levers and opportunities that could be applied to the promotion of BAT/HEMS and that could treat almost all the ideal policy package needs. In practice though very little of this has actually been applied to the realisation of cost effective savings from BAT/HEMS. This is mostly because these policy levers are aimed at addressing a number of horizontal energy savings opportunities of which BAT/HEMS is but one (albeit one with a very large unexploited savings potential). In principle the approach taken with the existing measures might appear to make sense i.e. a policymaker might ask why should one be prescriptive about the means of reaching a savings objective if any number of measures are eligible and could meet the objective? However, the reality is that the vagueness about how to address the savings coupled with the lack of appreciation of the scale of opportunity posed by BAT/HEMS means that the topic simply hasn't received the attention it deserves, neither in Community-wide policy packages nor in MS implementation plans. This lack of focus is a missed opportunity because almost regardless of whether other energy savings opportunities are realised or not the cost effective potential from BAT/HEMS alone will remain of the order of 7% of EU final energy consumption and has a direct bearing on strategically important issues such as the dependency of the Community on imported gas. There are at least two potential remedies to this. One is to take all the existing EU policy levers (building codes; EPCs; HVAC inspections or equivalent savings measures; EE funds and incentives; EEOs or equivalent savings measures; availability of qualification, accreditation and certification schemes; energy audits; Ecodesign and labelling requirements) and ensure that they are applied directly and explicitly to deliver a coherent savings plan for BAT/HEMS. Alternatively a dedicated piece of legislation could be developed that targets BAT/HEMS savings explicitly. The best candidate for this latter option would be a dedicated piece of legislation to develop requirements on the energy efficiency of installed systems. This could focus on more than just BAT/HEMS but would be likely to produce additional benefits in terms of clarity of focus, implementation and outcome than might be expected from a proactive pursuit of the first option. However, this would also require political will with an agreed vision among MS and the Commission in order to bring this about, so practically it makes sense to pursue opportunities in both directions simultaneously in order to ensure meaningful action occurs via one route or another.

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