



Ecodesign preparatory study for Building Automation and Control Systems (BACS) implementing the Ecodesign Working Plan 2016 -2019

Task report on scoping

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List of Abbreviations and Acronyms

AC	Alternating Current
AP	Acidification Potential
avg	Average
BACS	Building Automation and Controls System
BAS	Building automation system
BAT	Best Available Technology
BAU	Business As Usual
BC	Base Case
BEE	Bureau of Energy Efficiency
BEMS	Building Energy Management System
BMS	Building Management System
BNAT	Best Not yet Available Technology
BOM	Bill of Materials
CA	Control Accuracy
CEM	Customer Energy Manager
CEN	European Committee for Normalisation
CENELEC	European Committee for Electro technical Standardization
CHP	Combined Heat and Power
DHW	Domestic hot water
ED	Ecodesign Directive
eDR BACS	Explicit Demand Response
EE	Energy Efficiency
EED	Energy Efficiency Directive
ELR	Energy Labelling Regulation
EMS	Energy management system
EPBD	Energy Performance and indoor climate for Buildings Directive
EV	Electrical Vehicle
GPP	Green Public Procurement
HBES	Home and building electronic systems
HP	Heat Pump
HVAC	Heating Ventilation Air Conditioning
I/F	Interface
IAQ	indoor air quality
iBACS	integrated Building automation and control system
iDR BACS	Implicit Demand Response BACS
IHG	Internal Heat Gains
kWp	kilowatt peak (power output of PV panels)
IBAC	local building controls
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LEB	Low Energy Buildings
MEErP	Methodology of Energy related Products
MFH	Multi-Family House
niBACS	non integrated Building automation and control system
NZEB	Nearly Zero Energy Building

PEF	Primary energy factor
PID	proportional–integral–derivative controller
PV	Photo-voltaic panels (solar panels)
RES	Renewable Energy Sources
SCOP	Seasonal Coefficient of Performance
SEER	Seasonal Energy Efficiency Ratio
SFH	Single Family House
SG	Smart Grid
SHW	Sanitary Hot Water
SRI	Smart Readiness Indicator
TABS	Thermo Active Building Systems
TBM	Technical building management
TBS	Technical Building System
WAN	Wide Area Network

Executive Summary

The purpose of this study is to develop the scope for a full Ecodesign preparatory study for building automation and controls systems (BACS). It builds on the recommendations of the study for the Ecodesign working plan 2016-2019, which identified building automation control systems in non-residential buildings as a specific product focus; however, it also considers BACS that apply to the residential building environment within its scope. This Executive Summary presents a summary of the study's findings.

Building Automation and Controls Systems - description and functionality

Building Automation and Control Systems (BACS) are defined in European and International standards as “comprising all products and engineering services for automatic controls (including interlocks), monitoring, optimization, for operation, human intervention and management to achieve energy-efficient, economical and safe operation of building services”. The term “controls” also refers to “processing of data and information”. In practice, BACS present a wide range of services related to systems that provide Heating Ventilation Air Conditioning (HVAC), domestic hot water (DHW), lighting, electrical power distribution, metering, technical building management, systems for communications, access control, security, fire safety, etc. Hence, BACS cover a wide range of heterogeneous product types.

It is also possible to categorize BACS according to their function. The standard EN 15232-1:2017, which was developed within the context of the EPBD¹, defines categories of building energy-related BACS functions that influence the energy use of Technical Building Systems (TBS). Under this standard, a **BAC control function** is “the BAC effect of programs and parameters. BAC functions are referred to as control functions, I/O (input/output), processing, optimization, management and operator functions”. As it will be explained later, the categorization of BACS by their control function it is of vital importance for a full preparatory study and subsequent policy measures.

BACS, in some form or other, are present in all buildings. Very simple BACS, such as basic thermostats and light switches, have been incorporated in buildings for many decades. BACS that offer centralised control of multiple TBSs such as Building Management Systems (BMS), of which Building Energy Management Systems (BEMS) are a subset, have been in use since the 1980s and the early days of mass computers. However, along with other electro-technical digital communications technologies, many aspects of BACS technologies and services are evolving rapidly, which reflects their central role in the facilitation of smart buildings. They can operate within self-contained systems but have been increasingly using internet of things (IoT) technologies and remote management via the internet.

Potential energy and environmental impact of BACS and barriers to be addressed

From the energy and environmental perspective, BACS offer an impressive, cost-effective potential to reduce building energy consumption through the provision of

¹ <http://epb.center/support/documents-introduction>

improved management of energy-related TBSs. Various studies² have reported that the optimisation of a building's operation with BACS can generate an average net savings potential across the EU of 15% to 22% from all building energy consumption. This results in a net incremental savings potential of about 58 Mtoe of primary energy consumption, and 126 Mt of CO₂ in 2030. Benefit-cost ratios of 9 to 13 have been reported from the proper specification, deployment and operation of BACS, delivering energy cost savings worth over €5 billion per year by 2030. One study³ has estimated that there is a potential net employment creation benefit of 1.3 to 2.1 million jobs by 2030 across the EU, if an incentivising policy framework for EU-wide BACS deployment were to be adopted.

Optimised BACS can deliver these savings by ensuring energy is only used where it is needed, when it is needed and in the amounts required. This is achieved by better matching TBS activation and operation to:

- the actual occupancy of the building
- the climatic conditions
- the desired internal conditions and
- the performance characteristics of the TBSs.

This indirect energy savings potential from BACS is far greater than the potential to reduce their own energy consumption through improvement in the energy efficiency of the BACS design and specification. However, there may also be a significant potential to reduce the direct self-consumption of BACS too.

Nonetheless, various barriers need to be overcome to achieve these savings, including:

- limited awareness of the energy savings potential of BACS
- information barriers on how BACS can best be selected and specified
- confusion about the choices available and what benefits they bring
- limited willingness to invest in BACS when there are doubts about the performance benefits
- sub-optimal commissioning and re-commissioning practices.

² a) *Building Automation: the Scope for Energy and CO₂ Savings in the EU*, <http://www.leonardo-energy.org/resources/249/building-automation-the-scope-for-energy-and-co2-savings-in--57f7a23e8b452>

b) *Optimising the energy use of technical building systems – unleashing the power of the EPBD's Article 8*, <https://www.ecofys.com/files/files/ecofys-2017-optimising-the-energy-use-of-tbs-final-report.pdf>

c) Short Study Energy Savings Digital Heating (in German only), https://www.bdh-koeln.de/fileadmin/user_upload/Publikationen/energieeinsparungen_digitale_heizung_2017_01_12.pdf

³ Employment benefits from stimulation of demand for building automation and controls in the EU, <http://www.leonardo-energy.org/resources/1247/employment-benefits-from-stimulation-of-demand-for-building--59ef3f74038bd>

Policy instruments and the purpose of this study

Four existing European policy tools that can help contribute accessing these savings potentials are the:

- Energy Performance in Buildings Directive (EPBD)
- Energy Efficiency Directive (EED)
- Ecodesign Directive (ED)
- Energy Labelling Regulation (ELR).

Notably, Article 8 of the EPBD can be used to set minimum requirements for newly installed TBSs, which could include provisions for BACS, and the EED could be applied to help provide funding and accreditation and training needs.

The ED and ELR have an important role to play in:

- ensuring information is present to allow optimal BACS solutions to be specified and for their impact to be accurately calculated
- setting Ecodesign limits on accuracy and functionality levels of BACS product services
- setting limits on BACS self-consumption (i.e. the direct energy used by BACS)
- update the correction factors of BACS that are already included in some in existing ED/ELR Regulations, for example those already applied to temperature controls for space and water heaters.
- ensuring the interoperability and longevity of products.

Furthermore, the ongoing smart readiness indicator (SRI) study⁴ related to the EPBD review has identified that the establishment of a standardised BACS classification and information is a key element for the indicator's success.

Ensuring information is present to allow optimal BACS solutions to be specified and determining the policy scope for BACS products

There is potentially a significant waste of energy because the principal BACS functions are poorly understood in the market and therefore under specified. In addition, a considerable amount of energy is also lost due to inadequate commissioning, programming and tuning of BACS after their installation. The lack of clear and good quality standardised information is at the heart of this problem.

In particular, there is an opportunity for BAC hardware to be positioned in terms of their contribution to the overall BACS energy performance classes (A to D), as defined in the standard EN 15232⁵.

Therefore, a key need for the full BACS preparatory study will be to help define standardised informational needs for BACS that can be mandated via Ecodesign and/or energy labelling measures, so that the specification of BACS becomes easier and the

⁴ <https://smartreadinessindicator.eu/>

⁵ EN 15232-1:2017 Energy Performance of Buildings - Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10

outcomes expected more transparent. The EN 15232 standard can serve as an appropriate starting point for setting information requirements and the scoping of BACS product policy. This standard was developed in support of the Energy Performance in Buildings Directive (EPBD) and already provides a comprehensive list of the building services and BACS functions. For each service, the standard defines up to four functionality levels with the highest functionality level expected to produce the greatest energy saving impact.

The essential need is to ensure that the contribution from specific BACS products is clearly positioned, in terms of their impact on the building energy consumption. EN 15232 proposes two methods to achieve this. A detailed method 1, which provides a high accuracy, and a simplified “BACS factor”; and, method 2 which provides a rough estimate of impact for higher level BACS functions. Method 2 is less suited to determining the impact of specific products, or individual BACS functionality levels. Method 2 also defines BACS energy performance classes ranging from D to A, based on the BACS functionality levels grouped per TBS service domain (heating/cooling emission, distribution and generation; domestic hot water generation; ventilation; lighting; monitoring, scheduling and operation etc.). These same classes are also proposed within the SRI study. A prominent exercise for the full BACS preparatory study will be mapping the functionality and performance of specific BACS components to the services and functionality levels per TBS and BACS solution. In accordance with method 1, the full study could also investigate the possibility to introduce a smart online BACS energy savings calculator, as described later in this summary.

Hence, scoping and product definition according to the EN 15232 BACS functions can cover various BACS hardware, including those that: implement a single function or a group of functions, that have a bundled with a TBS, or are fully standalone. This function oriented approach would therefore provide a level playing field to all types of BACS products and their suppliers.

Moreover, this will allow Ecodesign information requirements to be set for BACS components that should greatly facilitate the specification of BACS solutions and thereby help unlock the indirect energy savings. This single aspect is likely to be the greatest contribution that Ecodesign measures can make i.e. if BACS Ecodesign information specifications help to unlock ~10% of the potential savings this is estimated to be worth approximately 2.2% of all TBS energy consumption in the EU or at least 83 TWh of primary energy in 2030.

Lastly, it is noted that following the EN 15232 and related EPBD standards for setting information requirements on BACS products would also facilitate the inclusion of BACS within the calculation of building energy performance certificates (EPCs)⁶, which is not usually done at present.

Setting Ecodesign limits on accuracy and functionality levels of BACS product services

Not all BACS products of a similar type provide the same degree of functionality or accuracy, and in some cases improving these can lead to significant energy savings, e.g. improving thermostat accuracy reduces overheating from heat emitters. Currently,

⁶ <http://epb.center/support/epbd>

few procurers and specifiers might even be aware of this potential and therefore they might still produce less efficient legacy products.

The present scoping study has identified 24 BACS functions, that could be suitable for minimum level of functionality specifications under Ecodesign regulations. It has also identified 13 BACS functions for which there are likely significant energy savings opportunities from Ecodesign limits on accuracy. These include:

- heating emission control – control accuracy & set point accuracy
- cooling emission control – control accuracy & set point accuracy
- room ventilation supply air flow control accuracy
- room air temperature control for all air systems
- monitoring, scheduling and operation – time recording & set point accuracy.

Examples of product groups providing these services and could be subject to such requirements are:

- electronic radiator valves and room temperature controllers
- room/zone temperature controls for different emission equipment, e.g. ventilation convector control valves,
- room/zone temperature controls that avoids concurrent heating and cooling emission
- air dampers combined with CO₂ or occupancy sensors
- air dampers combined with temperature sensors.

It is provisionally estimated that setting requirements for heating emission control accuracy alone would save at least ~ 1% of all EU heating demand, i.e., ~ 17 TWh of potentially realisable savings in 2030 (the figure could be substantially higher). Requirements for the other functions mentioned might lead to a similar order of magnitude of savings for all affected products combined. It may also be appropriate to consider the establishment of energy labelling measures for equipment product groups that provide these functions.

Reviewing temperature controls on space and water heaters

The Lot 1 and Lot 2 preparatory studies are conducting reviews of the Ecodesign and Energy Labelling requirements for space and water heaters. These regulations currently award bonuses of up to 5% for the provision of temperature controls. These bonuses appear to have been developed as an aside to the main focus of both studies and may not reflect the state of the art in terms of the savings potentials. For example, EN 15232 awards energy savings bonuses for weather compensation of 9% for residential space heating and even more for non-residential buildings. Overall, the bonuses currently presented in the Ecodesign and Energy Labelling regulations seem not to be aligned with EN 15232. Therefore, it is proposed that the full BACS study should review these bonuses aiming to establish more representative values, based on state of the art knowledge. This should be done in cooperation with the study team working on the review of Lots 1 and 2. The findings from these reviews are expected to be available in time for future deliberations on the revision of the Ecodesign and Energy Labelling requirements for space and water heaters.

Self-consumption

Although BACS help controlling TBSs, hence improving their energy management, they also need energy to do so. The amount of energy BACS consume in their operation is mostly much less than the amount that they help to save, nonetheless there may be scope to reduce their self-consumption (i.e. the energy they use to fulfil their function). There is currently a market failure because the self-consumption of BACS is barely reported and there is little incentive for suppliers to opt for products that minimises self-consumption, especially if it entails a slight increase in product cost.

In a recent Swiss research project⁷⁷ the self-consumption of BACS was examined in detail. It concluded that previously the energy consumed by BACS has generally been considered to be a negligible part of overall building consumption but the analysis showed that this was not necessarily correct. The annual electricity consumption of building automation systems was found to be a single or double-digit percentage as a proportion of the annual final energy demand of building equipment and appliances. In absolute numbers, the specific annual electricity consumption for room automation was found to be from 2 to 5 kWh/m²/year of final energy.

In principle, it may be possible to establish ranges of energy consumption per component function provided. In this way the energy budgets for BACS components can be established based on their function, e.g. by the establishment of maximum consumption limits for components that are common to most BACS (such as sensors, actuators, communications, displays etc.). These energy budgets could subsequently form a basis for prospective Ecodesign implementing measures. Potentially, this would allow modular energy budget limits to be established based on the set of components used. This approach has the merit of avoiding the need to define limits per higher level function, which might be too complex to be practicable, given the very wide array of potential BACS solutions available.

Clear product information on the self-consumption of BACS could also encourage adoption of low power BACS system designs (see the discussion on interoperability).

Establishing the exact energy savings potentials is a topic for investigation in the full preparatory study; however, the Swiss data suggest that it should be possible by such measures to reduce the self-consumption of BACS by an average of at least 1 kWh/m²/year in non-residential buildings. Were this to happen it would save ~9 TWh in final energy consumption across the EU.

Electrical Grid Flexibility impacts

In principle, BACS have the potential to support electricity network flexibility objectives by assisting with the remote management of TBSs, in a way that supports load management and grid storage. This has an important effect in decarbonising energy networks, by allowing the integration of a higher proportion of intermittent renewable energy. Some of this potential is being addressed under the on-going smart appliances preparatory study⁷, but said study does not address the overarching customer energy management (CEM) and distributed energy resources (DER) control of the building and of the TBSs as a whole; which are functions that can potentially be provided by BACS.

⁷ <http://www.eco-smartappliances.eu/Pages/welcome.aspx>

Currently, these services are not yet offered in the market and there is still a need to develop standards and protocols to support them.

The full preparatory study could continue to examine the gaps in the supporting standardisation framework so the BACS capability in this regard can be classified and established.

Interoperability

The degree of interoperability of BACS can be a limiting factor affecting the functionality of TBSs they manage. Currently, a variety of proprietary and open-source communication systems are used that can either hinder or facilitate the control of TBSs by BACS. While the pros and cons of interoperability can be complex, interoperability is important when the TBSs need to facilitate overarching management – this is often the case when they control the same service (for example heating, cooling, ventilation and lighting).

The common solution to provide overarching control for TBSs is to add gateways to the BACS system. Nevertheless, such gateways (e.g. via a Wide Area Network (WAN)) come at extra cost, consume power to function, and can be a source of system failure.

Accordingly, the full preparatory study will need to investigate the abovementioned interoperability issues and explore if and how Ecodesign measures could be established to discourage adding more gateways to provide BACS control of the various TBSs.

Lifespan and repairability

Aside from the interoperability issues summarised above, some other aspects that can affect the lifetime and sustainability of BACS are:

- reparability, which is affected by the potential lack of spare parts, due to a number of market derived reasons (e.g. potential bankruptcy of suppliers).
- upgradability, related to the degree in which the installed system can be adapted to future services provided by the manufacturer, or by third parties.

The full BACS preparatory study will need to assess the impact of such factors and consider suitable courses of action for specific BACS functions.

Differentiation by building type

Many of the same BACS components and product groups are found across building types, but some are targeted to specific building types. BACS tend to be substantially used more in non-residential than in residential buildings. However, they are used in all buildings to varying degrees, and there is a clear significant on-going deployment across the entire building stock. This is partly related to the digitalization of the economy, the further deployment of automated intelligence in all areas of human activity, and the spread of broadband.

BACS are found in both existing buildings and new-build. They are sold as standalone components, as components embedded in other products (and particularly within TBS elements), and as overarching management systems sitting above and coordinating numerous TBS within a building.

The deployment and replacement rate of BACS is partially driven by the new-build/major renovation cycle of the building stock. However, a significant part also occurs when a

TBS is replaced and also when a new add-on control technology becomes available. Thus, the BACS product cycle is faster than the cycle for the TBS itself, and the cycles for building renovation/renewal.

In large buildings, a modular installation of BACS and TBS is often used. In smaller residential and commercial buildings, part of the BACS are often supplied as a package with the TBS, which can reduce installation and after-service costs. It is also observed that some large energy retailers are extending their service offerings to include TBS maintenance and BACS leasing contracts.

Although the BACS functions are sometimes the same between different building types, the duty cycles that apply to them are not the same and therefore also not their energy impact. Thus, the full preparatory study will need to establish representative usage cases capturing the most essential distinctions for the BACS being considered. This will be most critical for BACS where limit values are being considered for setting Ecodesign requirements on accuracy and functionality. Some of these functions and their associated products are used more commonly in non-residential applications than residential applications. However, if 10 representative case studies were to be considered, there might be some instances where both residential and non-residential representative cases would need to be analysed.

Another aspect to consider is the distinction between new-build and existing buildings. The EPBD requires all new builds to be nearly zero-energy buildings (nZEB) from 2020. These buildings usually rely on more complex BACS. It is therefore not surprising that the analysis in this study found that the energy impacts from many BACS functionality levels could be different for nZEB than for the existing building stock. Noticeable heat pumps are expected to have a large share in future nZEB buildings, therefore nZEB could provide a significant contribution to the flexibility services of the electrical grid.

An on-line Energy Efficiency Index or ‘smart BACS energy saving calculator’

A new notion is to examine the potential derivation of an internet-based “smart BACS energy saving calculator”. This is countenanced because the range and variety of BACS, TBSs and building types that could be addressed are so diverse that a conventional energy efficiency index calculator for an energy label might not produce representative results. Moreover, to calculate the impact from this wide variety of BACS with an acceptable accuracy is not an easy task.

The complexity of estimating the energy impacts of BACS arises from the many components that influence the building energy balance in combination with a broad range of possible building technical properties, climate conditions and usage patterns. Ideally, the detailed method 1 set out in EN 15232-1:2017 should be used to the extent possible in preference to the simplified BAC factor method 2 in the same standard. This is because the latter only provides a rough estimate of impacts for a group of BACS functions but cannot be applied to assess individual functions or products. The development of a smart BACS energy saving calculator that could do this should enable the application of Ecodesign and energy labelling to individual EN 15232 BACS functions. Therefore it can also be applied to all types of products that incorporate them. The preparatory study would need to specify the concept and specifications for such a calculator.

In principle, a smart web-based BACS energy saving calculator could take into account the interplay between the different potential building types and climate zones, the

diverse TBSs and other BACS driven systems, interactive effects between various BACS functions while avoiding double counting of impacts. The level of detail in the input data supplied to such a smart calculator could be flexible and range from simple inputs selected by the end user up to the use of complex building-specific data drawn from the SRI and/or EPC calculations whenever they are available. The BACS technical data supplied at the product level should enable the calculation of an energy efficiency index, therefore enable energy savings from more advanced functionality to be estimated more accurately. It could also be mandated that BACS products should provide a direct standardised reference, e.g. via a QR code, to the website where the smart calculator can be found. Similarly, there may be options to use the smart BACS calculator in a manner that supports conformity assessment and market surveillance.

Components of the full preparatory study

As stated, a main focus for the study should be the development of harmonised information requirements for all BACS working with TBSs as referenced in the EPBD. To this end, part of the full study will therefore need to map all affected BACS products into this framework. This would be a major exercise but would need to not involve all the MEERP tasks.

With this information, policymakers and building owners would be able to see how BACS products influence the overall building energy performance and also how they affect the BACS efficiency classes (A to D) defined in EN 15232.

Additionally, there is a need to review the Ecodesign Lot 1 and Lot 2 temperature control corrections for space heaters and water heaters respectively, as well as potentially those applied in the work of Lot 20 related to local room heating products. This could be done in cooperation with the study teams preparing the review for these products.

A significant part of the rest of the full preparatory study will need to be focused with developing Ecodesign and energy labelling criteria for products that provide the specific BACS functions discussed earlier under the sub-section *Setting Ecodesign limits on accuracy and functionality of BACS product services*. For these, the usual Ecodesign MEERP Task 1 to 7 activities are envisaged, for which up to ten reference buildings and a subset of EN 15232 BACS functions would be investigated. The numbers of each will depend on priorities and allocation of available resources. The main focus of this work would be the derivation of prospective functionality and accuracy requirements but also self-consumption requirements should be examined for the common components. Note, the application of the MEERP will need to be tailored for these aspects. Potentially, the accuracy and functionality assessments would initially be done per primary BACS function, whereas the self-consumption of components could be assessed at the product level. Simplifications in the MEERP should be considered for Task 5 with respect to the bill of materials. This is because in practice, the BACS bill of materials can be neglected given that the functional approach can be implemented with a multitude of different hardware and assessing this would result in a disproportionate research effort. Also the cost optimisation analysis of the MEERP Task 6 is likely to be difficult to conduct due to the potential for bundled combinations of BACS products. Thus a simpler method could be countenanced, perhaps via a stakeholder enquiry to derive overall expected costs for BACS functional energy performance classes A to D, etc. It is also possible to focus within Tasks 3 to 6 on those functions from which most impact is expected and to consider extending the proposed policy to a wider set of functions in Task 7.

The additional non-full MEERP tasks foreseen in the full preparatory study are:

- a review of standardisation needs to support flexibility requirements
- a review of interoperability aspects and needs
- the establishment of the supporting technical needs for the development of a BACS calculator.

The various activities to be addressed in the full preparatory study and their relationship to the MEERp process are set out in Table ES-1. The table shows that not all activities follow the MEERp, because they do not all entail the establishment of limit values, but at times, they rather entail information requirements or development, and/or identification of methodological needs (e.g. standards or the on-line BACS calculator). The MEERp is followed for all the activities that might entail imposition of limit values or bonuses that affect limit values.

Table 1 Activities of the full preparatory study and relationship to the BACS products considered and the MEERp

	Subset of selected BACS functions for in-depth analysis	Temperature controls for Lot 1, 2 & 20 Products	All BACS products	Full MEERp using reference cases
Information requirements			Y	N
Self-consumption requirements per component module			Y	Y
Accuracy & functionality limits	Y	N	N	Y
Efficiency bonuses		Y		Y
Interoperability specifications			Y	N
Flexibility needs			Y	N
Non-energy requirements	Y	?	?	?
On line BACS calculator needs			Y	N

Key: Y = yes, N = No

0. Introduction to the study

The purpose of this study is to develop the scope for a full Ecodesign preparatory study into building automation and controls systems (BACS). It builds on the recommendations of the study for the Ecodesign working plan 2016-2019⁸ which identified building automation control systems in non-residential buildings as a specific product focus; however, it also considers BACs that apply to the residential building environment within its scope. Furthermore, this study additionally seeks to complement the on-going/recent studies addressing the development of a smart readiness indicator (SRI) for buildings under the Energy Performance in Buildings Directive (EPBD) and the smart appliances⁹ preparatory study under the Ecodesign Directive respectively.

Compared to many other products addressed under the Ecodesign Directive BACS are unusual in that they are enablers of energy savings in other energy using equipment and this effect is much more important than their own direct energy consumption. The preparatory study for the 2016-2019 Ecodesign working plan identified that the main energy savings for BACS are not achieved by reducing the standalone energy consumption of the BACS themselves, but are driven by the coordination of several controlled products with BACS e.g. by preventing heating and cooling in the same zone at the same time, or by improving the control of technical building systems and thereby saving energy. The main functions of energy optimised BACS are to ensure that Technical Building Systems (TBS) are only used when needed and operated to deliver the needed comfort services with the lowest energy demand. Inefficient BACS will simply provide on/off control but might not respond to changing needs such as occupancy neither do optimizations such as taking into account part-load efficiency. Poor BAC might also not allow dedicated control of comfort services such as heating to smaller areas (zoning) and hence might further waste energy.

BACS are electronic and sometimes electro-mechanical appliances that manage and control the operation of most technical building services such as heat generation and distribution, hot water systems, ventilation, cooling and air conditioning, lighting, communication systems, lifts, etc. Also, according to the findings of the Ecodesign study on smart appliances, some functions of BACS in residential environments can be seen to be equivalent to the services provided by the 'customer energy manager (CEM)' for demand response in smart grids (see section 1.2.5) with regard to coordinating the response of smart appliances to energy prices and grid stimuli.

BACS cover a wide range of heterogeneous products for which the significant energy saving potential is due to their interaction with other products/systems. BACS may provide several functions aimed at improved control, comfort, energy savings, security, fire safety, indoor air quality (IAQ), etc. Therefore, the indirect energy savings potentials for these products/systems will need to be determined next to the energy consuming impacts of the BACS themselves (direct self-consumption). Furthermore, in residential environments where BACS may operate in conjunction with smart appliances or equipment, there can be additional benefits from the creation of demand side flexibility, even at the expense of on-site energy savings. In thermal systems flexibility is often a trade off with on-site energy savings because of the thermal losses resulting from

⁸ <http://ec.europa.eu/DocsRoom/documents/20374>

⁹ <http://www.eco-smartappliances.eu/>

energy storage. This means that it may be difficult to clearly define product boundaries and to apply the MEErP to the letter. In addition, the large number of possible applications and functionalities of BACS creates additional complexity.

The primary aim of this preliminary scoping study is to define the product scope, to identify the focus areas and direction to take for the subsequent preparatory study and ultimately to identify potential policy options that could be implemented via and in conjunction with the Ecodesign Directive. Because the energy performance of BACS, or more specifically the contribution BACS can make to technical building systems energy performance, is also partially addressed by the EPBD it is important that the work in this scoping study is structured to help inform Ecodesign/ELR outcomes that are complementary to the EPBD including the work undertaken for the Smart Readiness Indicator¹⁰ for buildings, the provisions in Article 8 for TBS and BACS but is also complementary to the smart appliances¹¹ work conducted under the Ecodesign Directive.

The report is structured as follows:

- Chapter 1 provides definitions of BACS and other relevant terms. For BACS this is more important than for most other energy-related product groups considered so-far under the Ecodesign Directive and Energy Labelling Regulation because they are more complex and heterogeneous. The bulk of the chapter considers the factors that determine how the product group and its associated system boundaries could be defined in a full preparatory study. Finally, the chapter concludes with proposals for the primary functional unit against which their environmental impact can be assessed and a summary of stakeholders views on the preparatory study scope.
- Chapter 2 addresses screening of product groups and the application of the MEErP in line with the optional MEErP Task 0. The objective is to re-group or narrow the product scope, as appropriate from an Ecodesign point of view, for the subsequent analysis in Tasks 1-7. It discusses the impact from scoping on new versus existing buildings, residential vs non-residential, various EN 15232 BACS functions, self-consumption, etc.

¹⁰ <https://smartreadinessindicator.eu/>

¹¹ <http://www.eco-smartappliances.eu/>

- Chapter 3 provides an overview of potential policy measures that could be used to target the energy and environmental impacts of BACS and maps them to the available European policy instruments, most notably the ED/ELR, EPBD and the EED. It considers how these combinations of policy options can be structured to work together to be mutually reinforcing and then identifies the specific measures that would need to be implemented via the Ecodesign and Energy Labelling Regulations. These distinctions are highly pertinent because the barriers to deliver the energy savings can only be overcome by an holistic approach that uses the available policy tools in a coordinated manner. This reflects the fact that BACS operate as part of wider energy using systems and hence only a fraction of their environmental impact savings potentials will be accessible via Ecodesign and labelling measures.
- Chapter 4 presents a synthesis of the findings of the first three chapters to deliver recommendations on the potential options for the scope of a full BACS preparatory study. It sets out the most viable elements to be addressed and summarises how they should be evaluated in terms of the MEErP. The intention is that this will inform the Commission's deliberations about the scope of the full preparatory study.

1. Product group(s) definition and system boundaries with options for scoping a full preparatory study

1.1. Introduction

Aim

The purpose of this chapter is to consider the options to define the product group(s) and system boundaries to help set the scope for a full preparatory study. It provides an overview of the various ways that the product scope for BACS could be defined to be treated within the full preparatory study. As such it aligns with Task 1 of the Methodology for Ecodesign of Energy-related Products (MEErP)¹², as established in 2011. The MEErP was developed to allow the evaluation of whether and to what extent various energy-related products fulfil certain criteria according of the Ecodesign Directive that make them eligible for implementing measures.

BACS – definitions and a general introduction

BACS is a term that addresses a wide variety of hardware and functions so it is important for it to be properly defined. A number of European and international standards address BACS (see section 1.3 for details) and many of these are alluded to in the following text.

According to EN ISO 16484-2, BACS refers to “Building Automation and Control Systems comprising all products and engineering services for automatic controls (including interlocks), monitoring, optimization, for operation, human intervention and management to achieve energy-efficient, economical and safe operation of building services. Controls herein do also refer to processing of data and information”. As a consequence BACS cover a wide range of heterogeneous products.

For scoping purposes it helps to categorise BACS in terms of their capabilities. Figure 1 illustrates the different levels of energy-related BACS hardware that can be identified within the context of European energy policy and which are explored in the remainder of this chapter. It also indicates the **BACS functions** that have an energy impact as defined within the standard **EN 15232** (see section 1.2.4). The various definitions used within the figure are explained in the subsequent sections.

The **lowest level in the figure shows the hardware components of the technical buildings systems** (e.g. heat pumps, boilers, water heaters, air conditioners, lighting etc.) **or appliances** that provide various technical building services. These do not comprise a distinct BACS hardware level according to ISO 16482-2 (see below), because they are primarily designed to provide a non-BACS specific service, but they may incorporate such a level and/or interface to the general BACS hardware levels and hence have been included within the figure.

The three general **BACS hardware levels** defined in ISO 16484-2 which apply to BACS products are shown in the middle and top layers in Figure 1.

¹² <https://ecodesignbacs.eu/faq>

The **lowest level** is the **BACS hardware at the field level** (the second from bottom level in the figure) which is the interface that consists of gateways, inputs, outputs, sensors and actuators.

Above this is the **BAC hardware at the building automation level** or intermediate level, wherein most of the control tasks and functions are implemented.

The highest overarching level is the **BACS at the building management level**, which contains high level control functions and also the user interface. This top level shows the energy-related **BACS functions** that have an energy management impact. Products operating at this level may have an interface with the lower levels or can be bundled to incorporate parts of the full potential array of **BACS functionality**.

For this full set of BACS hardware, several BACS functions (see EN 15232 for definitions of these in the case of energy-related functions) can be identified. These are represented by vertical columns in Figure 1 and may overlay several BACS hardware levels. A full set of BACS functions that impact the energy consumption of technical building systems is defined in EN 15232 but for the purpose of this analysis particular subgroups of BACS functions (iBAC, niBAC, BM, CEM, IBAC) that are explained in section 1.2.1 are also shown within the figure.

Lastly, the figure also illustrates how the EU policy framework can apply to the various BACS hardware and functionality levels (this is discussed more in Chapter 3).

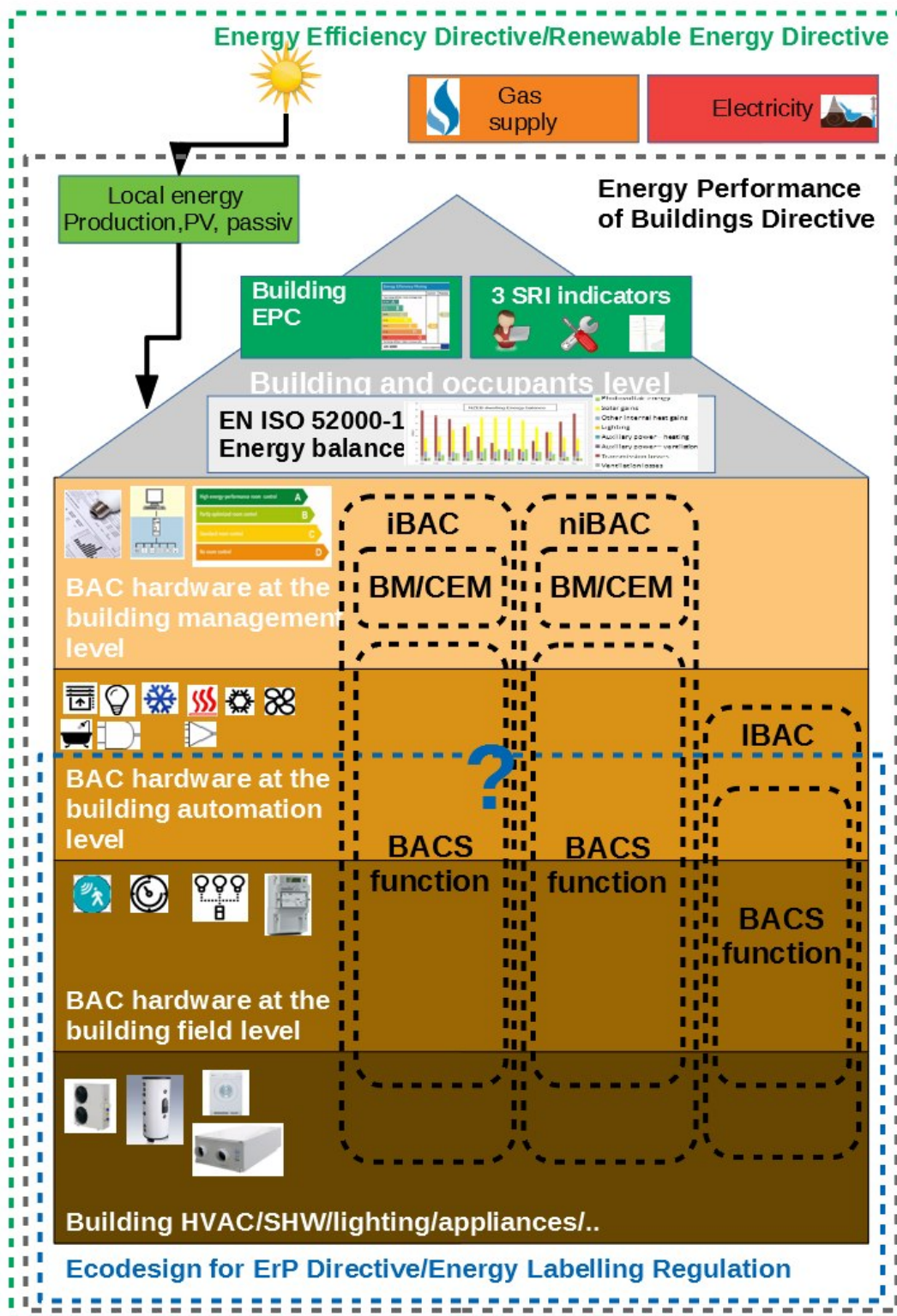


Figure 1 Different scoping levels BACS and its potential relationship to European Policy

1.2. Potential BACS product categories and definitions

Prior to considering product scope it is necessary to define product categories. The first step in doing this is the establishment of terminology and definitions as discussed in section 1.2.1.

1.2.1. Building Automation and Control Systems(BACS) terminology and definitions

The terminology and definitions that apply to the main BACS elements are as follows:

BACS, which according to EN ISO 16484-2 refers to “Building Automation and Control Systems comprising all products and engineering services for automatic controls (including interlocks), monitoring, optimization, for operation, human intervention and management to achieve energy-efficient, economical and safe operation of building services. Controls herein do not only refer to control but also to processing of data and information”.

BAC according to EN 15232 refers to building automation controls that are “products, software, and engineering services for automatic controls, monitoring and optimization, human intervention, and management to achieve energy-efficient, economical, and safe operation of building services equipment”.

Integrated BACS (iBACS), according to EN 15232 refers to “BACS designed to be interoperable and with the ability to be connected to one or more specified 3rd party building automation and control devices/systems through open data communication network or interfaces performed by standardized methods, special services and permitted responsibilities for system integration”.

Examples of integrated BACS are systems providing interoperability between 3rd party BACS devices/systems for HVAC, domestic hot water, lighting, electrical power distribution, energy metering, technical building management, elevators and escalators, and other plant, as well as systems for communications, access control, security, safety etc. Within this context, in particular, building management (BM) means the totality of services involved in the management operation and monitoring of buildings including plant and installations.

In contrast **non-integrated BACS (niBACS)** are simply all others which are not iBACS.

Note that the ongoing Review study on Standby Commission Regulation¹³ ((EC) 1275/2008) defined **local building controls (IBAC)** as ‘products that move or rotate access elements¹⁴ and/or climatic control elements used in buildings. These products incorporate electric motors or actuators and the control unit as one entity and are operated by the end user through wired and/or wireless controls or via a network, or controlled automatically with the use of sensors.’ It further states that ‘standby mode(s)’ means ‘a condition where the equipment is connected to the mains power source,

¹⁴ In this context “access elements” is referring to hardware such as doors that allow access in a building.

depends on energy input from the mains power source to work as intended and provides only the following functions, which may persist for an indefinite time being a reactivation function, or reactivation function and only an indication of enabled reactivation function, and/or information or status display’.

1.2.2. BACS hardware definitions according to EN ISO 16484-2

The EN ISO 16484-2 standard on building automation and control systems addresses BACS hardware and provides a useful overview of the **typical hardware definitions** (Figure 1-2) and how hardware is used in relation to: the field, automation/control and management level of BACS services.

This standard includes rudimentary and generic descriptions of BACS hardware terminology but does not include an extended hardware catalogue that can be linked to it. The hardware that relates to these levels therefore potentially encompasses a very large array of different products.

For the full study, PRODCOM categories¹⁵ also need to be considered for BACS hardware in accordance with the MEeRP. Generic economic data within the MEeRP refers to data that is available in official EU statistics (e.g. PRODCOM) and in principle this could help to identify and report on the EU BACS product consumption and market size. Moreover, in a later stage it could help to track the impacts of Ecodesign policy measures through analysis of the official Eurostat PRODCOM data. The text below presents a review of the applicable PRODCOM data and an assessment of how useful it could be for a BACS ED/ELR preparatory study and subsequent work to establish prospective policy impacts.

There are a **wide range of BACS products and consequently of applicable product codes**. A first screening exercise was done for this study and revealed as much as 141 products that could contain BACS functions. These include products that might contain BACS but that also provide other completely distinct functions.

This remains a very generic list that **does not contain sufficient disaggregation of BACS** to provide useful data. It is therefore suggested that a future update of Eurostat product classes might consider adding new subclasses for BACS. For example:

- 26.51.70.15 Electronic thermostats

Should be converted to comprise two newly created categories, such as:

- 26.51.70.15 Electronic thermostats (n.e.c. = not elsewhere classified)
- 26.51.70.16 Electronic thermostats for room temperature control

In this case electronic thermostats intended for use in ovens would remain in category 26.51.70.15 whereas those concerned with room temperature control would move over time to the 26.51.70.16 category.

As can be seen from the Annex E - there are a large range of product codes that would need to be converted to provide greater distinctions for the PRODCOM data on BACS products if this is to be useful for Ecodesign/ELR purposes.

¹⁵ <http://ec.europa.eu/eurostat/web/prodcom>

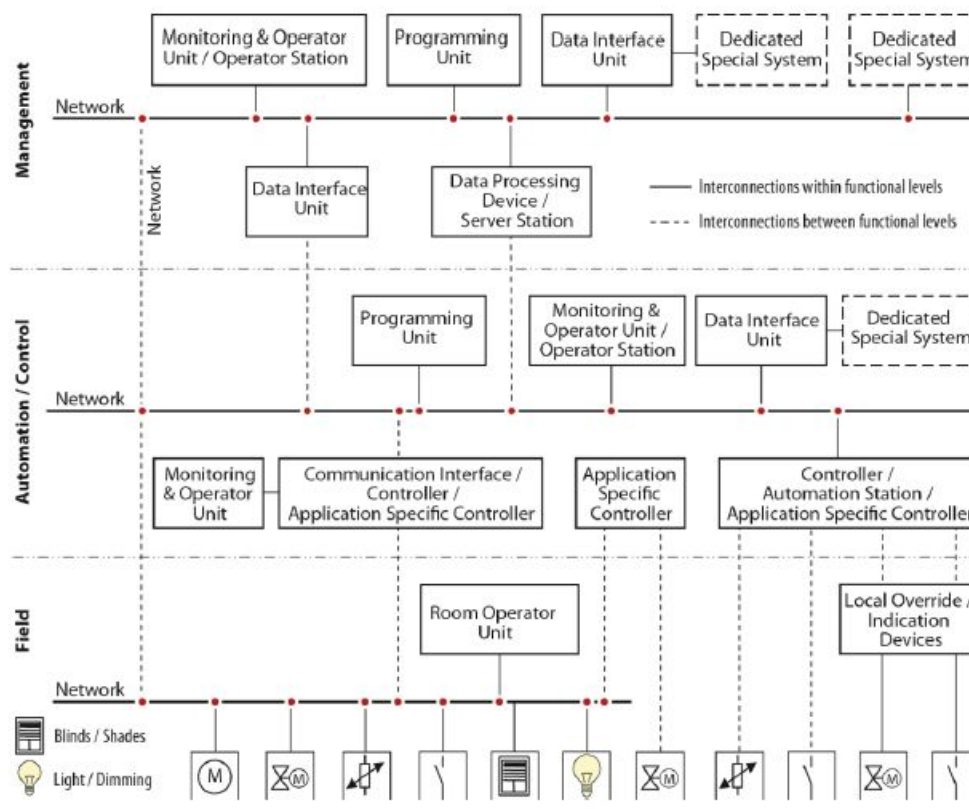


Figure 2 A generic architectural model of the BACS network and its different levels according to EN ISO 16484 part 2, which is often referred as the 'BACnet standard'¹⁶

It should also be noted that the individual **BAC components**, described in this section, are not always exclusively used for building automation purposes. For example a BAC programming unit or temperature sensor can be used for industrial processes (e.g. oven control) and vice versa. This is likely to be an important consideration when developing potential product policy measures (in the MEER P Task 7), because they could inadvertently have an impact outside the intended application area unless appropriately delimited.

Conclusions

The range of BACS hardware is very broad as well as their functions. This poses a challenge in a full preparatory study. If all potential product types are analysed using the full MEER P process, the number and variety of product reference cases risks being too numerous to be practicable.

Note that "Local Building Controls" (IBAC), were already included within the review study on Standby for Commission Regulation¹⁷ (EC) 1275/2008 and could therefore be excluded from consideration within the full BACS preparatory study. It should be noted

¹⁶ BACnet is a data communication protocol for BAC networks - see <http://www.bacnet.org/>

¹⁷ <http://www.ecostandbyreview.eu/>

that the standby mode is rarely relevant for BACS, because they are most often in an operational mode.

It can also be concluded that the PRODCOM **data is too generic** to be useful for ED/ELR purposes and is mixed up with a large range of products and PRODCOM codes that serve other non-BACS functions. In order to be useful Eurostat codes would need to be reviewed and specific sub categories added to address BACS.

1.2.3. The BACS scope defined according to the EN 15232 control functions

A possible option to scope the full preparatory study is according to the BAC control functions defined in EN 15232.

The standard EN 15232 defines a **BAC control function** as “the BAC effect of programs and parameters. BAC functions are referred to as control functions, I/O (input/output), processing, optimization, management and operator functions”.

This technical definition of a “BAC control function” is quite abstract and can be better understood with an example such as a room thermostat that implements the “heat emission control” function from EN 15232, i.e. function 1.1. Herein the “input” can be a temperature sensor signal that controls an “output” which is typically a 230V AC operated valve. The “control function” or “BAC effect of a program” should be to open or close the valve or “output” to fit to the local room temperature or “input”. Herein the local temperature is the most important control “parameter” together with the desired room temperature which is also called the room temperature “set point”. Other relevant “parameters” are control accuracy($\pm 0,2$ °C) and for example the PID (proportional, integral, derivative) controller¹⁸ parameters (P-value[%], I-value[t], D-value[t], temperature set point[°C], actual temperature[°C]). Complex BACS functions may have many more parameters, e.g. in the case of artificial intelligence control function parameters to model weather and user behaviour¹⁹.

Hereafter is a listing of all control functions that are included in EN 15232. Note that this standard was developed in the context of the context of the EPBD²⁰ and therefore only targets functions that are energy related and connected to the technical building system(TBS), this excludes some functions see also 1.2.3.4.

For heating control, typical BACS control functions are:

- “emission control”, e.g. individual room temperature control with BACS including schedulers and presence detection which can lower the general heat demand
- “control of distribution pumps in networks”, e.g. switching off circulation pumps when not required or modulating the flow to meet the system needs

¹⁸ <https://www.eurotherm.com/pid-control-made-easy>

¹⁹ <https://www.techemergence.com/artificial-intelligence-plus-the-internet-of-things-iot-3-examples-worth-learning-from/>

- “heat generator control for combustion and district heating”, e.g. reducing the return temperature based on load forecasting to increase boiler efficiency by condensation
- “heat generator control for heat pump”, e.g. controlling the exit temperature base on load forecasting
- “heat pump control system”, e.g. inverter driven variable frequency compressor depending on the load
- other functions are “sequencing of different heat generators”, “Thermal Energy Storage (TES)” or “control of Thermo Active Building Systems (TABS)”.

For domestic hot water (DHW) supply:

- reduce standby losses in hot water storage tank (if any) with automatic on/off control based on forecasted demand
- control of DHW pump (if any).

For cooling control:

- many of those functions are similar to heating (see EN 15232)
- “interlock between heating and cooling” to avoid simultaneous heating and cooling.

For air supply or ventilation (if any):

- demand driver variable outside air supply
- heat recovery unit, icing protection
- free air night time cooling mechanical by automatic opening windows and/or operating the ventilation unit
- humidity controls (if any).

For lighting controls:

- control the use of artificial lighting, e.g. based on presence detection and/or monitoring indoor luminosity by natural light
- indirectly, reducing the lighting energy demand by proper control can decrease the building cooling demand or increase the heating demand.

For blind control (if any):

- prevent overheating
- reduce glare
- controls can be combined with HVAC and lighting.

For the ‘Technical Building Management’ (TBM) function group²¹

²¹ These are always integrated BAC functions which according to EN 15232-1:2017 refers to: “the effect of programs, shared data points and parameters for multi-disciplinary interrelationships between various building services and technologies”. The Technical Building Management (TBM) functions are only described briefly in EN 15232

- set point management, e.g. web interface to heating/cooling temperature set points (20°C/26°C) with frequent resetting to default values where relevant
- run time management, e.g. predefined schedule (e.g. a night time set back temperature) with variable preconditions (e.g. no presence in the room)
- manage local renewable sources or CHP (Combined Heat and Power plants) to optimize own consumption and use of renewables
- control of Thermal Energy Storage or heat recovery (if available)
- smart grid integration
- detect faults in the Technical Building System (TBS), for example:
 - read out alarms (error codes) from the TBS (e.g. heat pump, gas boiler, etc.) and provision of comprehensible feedback to occupants and alarm(error codes) logging
 - continuous monitoring of SCOP (Seasonal Coefficient of Performance) or SEER (Seasonal Energy Efficiency Ratio) of a heat pump to verify maintenance needs (e.g. clogged heat exchanger, cooling fluid leakage, etc.)
 - regular checking sequence to verify the maximum power output of a heat pump or gas boiler to establish maintenance needs (e.g. contaminated gas burner, dirt on heat exchanger, valve errors, damage on pipe insulation, installation errors such as reverse connection of heat exchangers, correct control logic and set point of circulation pumps, etc.)
 - checking the power consumption of an Air Handling Unit (e.g. increased power consumption due to clogged filter or air inlet/outlet, leakages in or clogged ventilation duct work, broken air dampers/fans, etc.).
- Reporting energy consumption relative to indoor conditions:
 - displaying the current values and logged trends
 - calculation of performance parameters, e.g. it is possible to format data according to EN ISO 52003-1 & -2 that describes possible EPBD Indicators and therefore allows to track performance and eventually report any performance gaps. Therefore it could help to identify problems in the construction and commissioning of the building and its TBSs.

Note, that this BACS monitoring reporting feature could reveal design faults and/or help to increase the accuracy of building energy performance calculations (e.g. expressed in units of kWh/(m².y)). As a consequence, data collection and analysis can help to decrease the performance gap between the calculated Energy Performance Certificate (EPC) and the measured energy expenditure, which has been reported in many case studies^{22, 23}.

but it references a more detailed definition in the standard EN 16947 standard on “Energy Performance of Buildings” – see the main body of text.

²² <http://built2spec-project.eu/knowledge-center/>

²³ <https://www.ecn.nl/publicaties/PdfFetch.aspx?nr=ECN-E--16-056>

EN 15232 also refers to separate standards that are used to derive the energy performance impact of each building system sub-element, e.g.:

- heating, EN 15316-1 and EN 15316-4
- domestic hot water, EN 15316-3
- cooling, EN 15243
- ventilation, EN 15241
- lighting, EN 15193
- technical building management, EN 16947.

These standards often also describe more detailed control functions. For example, EN 15193 for lighting (see Annex A or the Lot 37 study).

1.2.4. BACS energy performance classes of EN 15232

The EN 15232 standard defines²⁴ BACS energy performance classes that range from D (less efficient) to A (more efficient) and that are an expression of the degree of sophistication that the BACS functionality provides. An example are the specifications for heat generation and heat pumps (Figure 1-3) wherein the shaded areas indicate the extent to which the described functionality attains the higher energy performance classes.

These BACS classes can be applied in the simplified BACS factor methodology (method 1) to derive estimated whole building energy impacts from the use of BACS with different energy performance functionalities (see section 1.4.1).

²⁴ <http://built2spec-project.eu/knowledge-center/>

			Definition of classes			
			Non residential			
			D	C	B	A
1.6	Heat generator control (combustion and district heating)					
	0	Constant temperature control				
	1	Variable temperature control depending on outdoor temperature				
	2	Variable temperature control depending on the load				
1.7	Heat generator control (heat pump, outdoor unit)					
	0	On/Off-control of heat generator				
	1	Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors)				
	2	Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)				

Figure 3 Requirements for heat generation and BACS classes according to EN 15232-1:2017

1.2.5. The BACS smart grid functionality for demand response and the potential role for Customer Energy Management (CEM)

In the future there is expected to be an increasing need for Demand Response Management (DRM) in buildings to support the Smart Grid^{25,26} to provide electrical load flexibility to cope with fluctuations in renewable energy supply, and to manage and dispatch local energy production, such as photovoltaics or storage. For appliances or plug loads, including domestic hot water (DHW) storage tanks, an Ecodesign preparatory study is already on-going²⁷ and therefore they can be left outside the scope of the BACS study. The smart appliance study does not however include the building and TBSs as a whole. Within the smart grid context the part of the BACS at building management (BM) level that is dedicated to DRM is called the **Customer Energy Management (CEM)**²⁸, see Figure 1-4. Obviously BACS can also play an important role for CEM **as a central management unit that integrates**: control of distributed energy resources (DER), the Home Automation Network (HAN) gateway, home building

²⁵

<https://www.cencenelec.eu/standards/Sectors/SustainableEnergy/SmartGrids/Pages/default.aspx>

²⁶ <http://smartgridstandardsmap.com/>

²⁷ <http://www.eco-smartappliances.eu/Pages/welcome.aspx>

²⁸ The CEM is defined by CENELEC as "internal automation function of the role customer for optimizations according to the preferences of the customer, based on signals from outside and internal flexibilities

EXAMPLE A demand response approach uses variable tariffs to motivate the customer to shift consumption in a different time horizon (i.e. load shifting). On the customer side the signals are automatically evaluated according to the pre-set customer preferences like cost optimization or CO₂ savings and appropriate functions of one or more connected devices are initiated."

integration bus, interfacing with the electricity meter, etc. For example the Home Automation Network gateway connects the building automation systems to the internet. The building automation bus²⁹ can be for example a twisted pair to connect BACS hardware, e.g. KNX TP³⁰.

Basically there are two types of Demand Response (DR) service categories³¹:

Implicit Demand Response (iDR BACS) refers to BACS services to participate in the wholesale energy market, it is mostly price driven with variable tariffs or peak load tariffs.

Explicit Demand Response (eDR BACS) refers to BACS services that support the grid operators to provide balancing or congestion management. It can be for example curtailment based on line voltage or grid frequency.

This technology and its implementation in BACS are still under development. Aside from the issues linked to the development of the technology the future added value of eDR in BACS will depend on:

- the DR service that buildings can offer and the degree to which electricity is used as a heat source
- the relative share of variable renewables (PV, Wind)
- the relative share of biofuels in electricity production
- the curtailment cost of renewables
- the roll out of smart meters
- competitiveness with DR in industry and
- the competitiveness versus other electricity storage solutions (e.g. hydro-stations, batteries, power to gas).

²⁹ In computer architecture, a bus (a contraction of the Latin omnibus) is a communication system that transfers data between components inside a computer, or between computers. This expression covers all related hardware components (wire, optical fibre, etc.) and software, including communication protocols.

³⁰ <http://www.knx.org> – note different technologies are available as a medium for transmission when using building automation bus systems: wireless communication, a 230 V power network, also known as “power line” and the two-wire bus line, often as a Twisted Pair, abbreviated to TP.

³¹ http://www.europarl.europa.eu/cmsdata/119722/3_JStromback_ITRE_300517.pdf

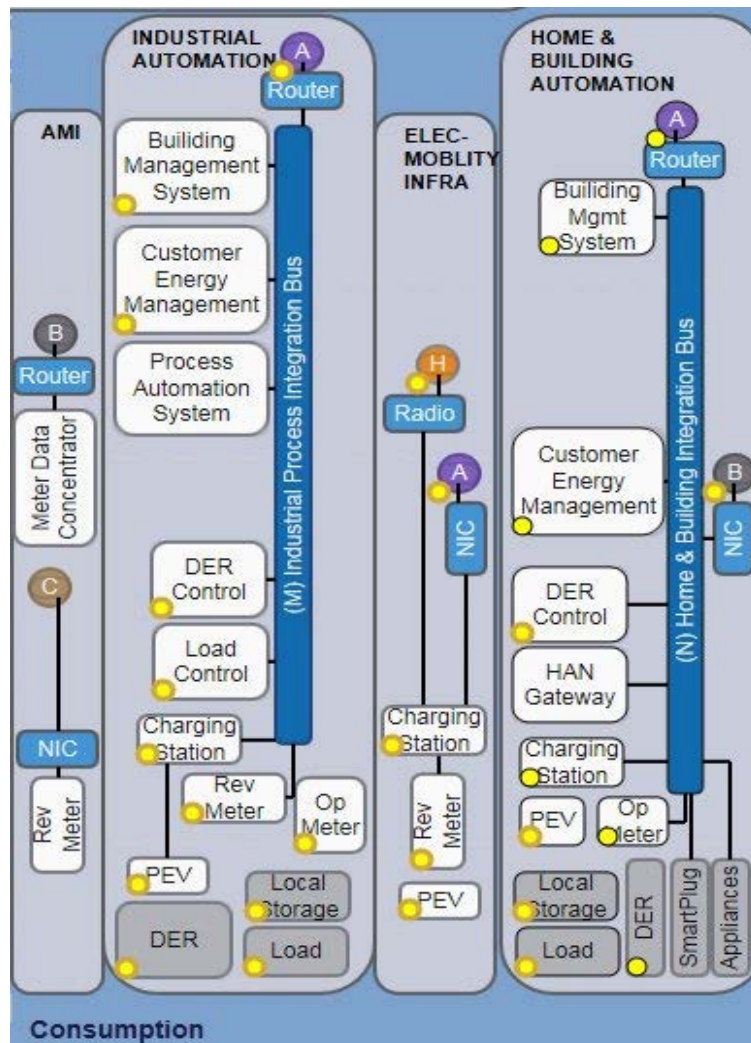


Figure 4 BACS and its role to support smart grids³²

Conclusion

Smart grid features for smart appliances and DHW storage tanks are already covered by the ongoing Ecodesign study on smart appliances. BACS are likely to play an important role in interfacing and controlling smart grid components via the **BACS CEM**.

Two types of Demand Response can be discriminated, **iDR BACS** and **eDR BACS**.

Demand response is also one of the domains being treated in the Smart Readiness Indicator (SRI)**Error! Bookmark not defined.** and it will be important for any necessary ED/ELR-related DR aspects of BACS required by the SRI e.g. information requirements, to be considered in the full study.

Lastly, as LEB or NZEB are quite likely to use heat pumps and these can offer flexibility in smart grids the DR aspects of BACS will be a **valuable aspect to consider for future proofing NZEB**.

³² <http://smartgridstandardsmap.com/>

1.2.6. Building application categories for BACS

The range of BACS or BAC hardware covered by the previous section 1.2.2 is very extensive. A possibility to do a further segmentation is according to their intended application. .

Building type definitions are available in Eurostat definitions: <http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Building>

Official building nomenclature can be found here: http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=CC_1998&StrLanguageCode=EN&IntPcKey=2984615&StrLayoutCode=

An overview is included in Figure 5 and the subcategories are discussed hereafter.

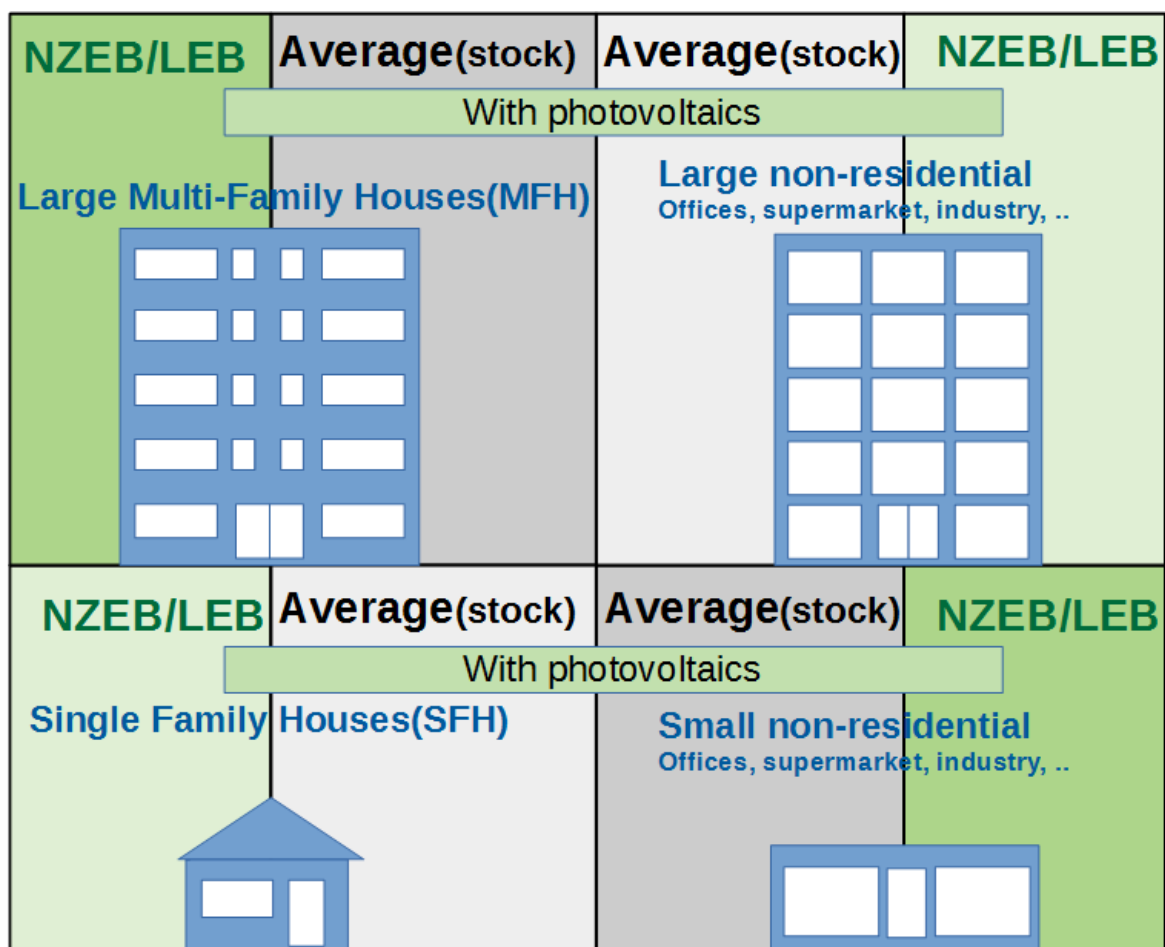


Figure 5 Overview of building categories for BACS

Residential versus non-residential

First, it is possible to discriminate **residential BACS** versus **non-residential building BACS**. Herein, residential buildings can be clearly discriminated from non-residential buildings when there are citizens registered at the address in the municipality.

A rationale for discriminating residential-sector BACS from non-residential sector BACS might arise from differences in products and market players, which could affect how the MEERp is applied. Larger non-residential buildings might typically use 'integrated BACS' that are interoperable with on-site assembled third party TBSs while small residential buildings might also often use 'sBAC' that often come together with preassembled TBSs. The latter solution often has a closed protocol which isn't always interoperable with a third party solution.

Within residential BACS there could also be significant differences between **multi-family houses (MFH BACS)** or apartments versus **single family houses (SFH BACS)** due to differences in the TBS (e.g. common infrastructure) and relative importance of transmission losses through the building envelope.

Within the non-residential BACS, a further distinction might be justified by building type (office, hotel, retail, school, hospital, etc.) is that the usage profiles can vary systematically, leading to very different averages, environmental impacts and cost-benefits. Despite all this, the previously described BACS hardware (see 1.2.2), are in many cases the same for residential and non-residential buildings which could provide a rationale to keep them all in the scope.

Existing, deeply renovated and new buildings

It is also possible to discriminate **existing** versus **deeply renovated** or **new** buildings wherein deeply renovated/new buildings are characterized by the need for EPBD compliance certification. Due to EPBD requirements, deeply renovated/new buildings will tend to be **Low Energy Buildings (LEB)** or **Near Zero Energy Buildings (NZEB)** and therefore often have more complex TBSs, a.o. they are likely to include mechanical ventilation due to air tightness requirements for energy savings. Due to the need for more complex TBSs they often have relatively greater auxiliary energy consumption (e.g. more and larger fans due to increased air tightness and the heat recovery ventilation heat exchanger, more and larger circulation pumps for low temperature radiators or underfloor heating, more control of shading devices and blinds, increased BACS self-consumption, etc..) while on the other hand their energy need for heating or cooling is significantly lower. Consequently, their saving potential in relation to the respective BAC control functions can be very different. Also, these NZEB may already have some form of BACS or sBAC due to the more complex TBS they are likely to use. This could result in systematic differences when considering MEERp case studies and eventually the resulting policy recommendations.

Conclusion

When considering the MEERp and potential policy measures it is possible to consider residential versus non-residential and existing versus deeply renovated or new buildings. Within residential buildings also SFH and MFH could be discriminated. Within the non-residential sector further differentiation might be needed to take into account different usage profiles, e.g. discriminating between offices, healthcare facilities, retail buildings, etc.

1.2.7.Special categories of BACS hardware and/or functions

This section maps specific subcategories of BACS hardware and/or functions, especially those who are only indirectly related to the Technical Building System(TBS) as specified in the EPBD. These special categories might be in- or excluded from the scope based on the evaluations in a full preparatory study.

1.2.7.1.Non-energy and non-EN 15232 related BACS functions and their classification according to impact

BACS can also serve other functionalities than those related to energy management, for example:

- to detect fire as described according to the EN 54 family of standards
- intruder alarm functions according to EN50131
- support building access control (perhaps via video)
- support multi-room audio.

Note, however, that the both the standard EN 15232 and the proposed functional unit later on in section 1.4 require to “satisfy the uses”, which means that the minimum indoor environmental quality is always delivered and therefore ‘comfort’ is indirectly addressed in the EN 15232 energy functions and the functional unit.

Conclusion

BACS can provide a variety of non-energy related services, which produce non-energy related impacts and it is also possible to classify them according to these. These were discussed with stakeholders in order to clarify the scope of the future work, however, as Ecodesign is explicitly concerned with energy-related products these will not be the focus of the full preparatory study.

1.2.7.2.Special categories of Home and Building Electronic Systems (HBES)

HBES are a special category of BACS hardware which can be applied at the appliances and/or field level of hardware.

The CEN committee CLC TC 205 on ‘Home and building electronic systems (HBES)’ provides an overview of HBES standards and maintains an active work plan. Home and building electronic systems is a very broad and generic umbrella that can include BACS components but also many other home electronic components not related to BACS. Their work also addresses standardisation for the communication systems used by BACS (for example, the EN 50090 series which are a set of KNX³³ standards). Note that not all HBES are necessarily BACS as defined in section 1.2.2 based on EN 15232. For example, HBES may also include intercom door openers, multi-room audio, etc. and thus do not necessarily concern energy-related functions. Therefore HBES extend beyond the scope of a potential BACS Ecodesign study and is only kept as a source of information in this report. Nevertheless, some of the standardization work of BACS technology components, such as a communication system, is defined within CEN TC 205.

³³ <https://www.knx.org/knx-en/knx/technology/standardisation/index.php>

1.2.7.3. TBS products bundled with BACS functions

These are BACS functions that are implemented in a bundle with (i.e. incorporated within) a Technical Building System product; for example, a gas boiler which includes a smart thermostat. This subcategory of 'TBS products bundled with BACS functions' can be a useful distinction to denominate products that are covered by existing policy applicable to the TBS product itself, see later section 3 on policy.

1.2.7.4. Smart appliances as BACS hardware

This sub-category refers to BACS functions which are implemented in a bundle within an appliance, for example a smart tumble dryer (see also Lot 33³⁴).

1.2.7.5. BACS functions related to EPBD or BACS plug load functions

EN 15232 defines **BACS EPBD** functions that mainly target the scope of the EPBD³⁵. They address **EPBD regulated loads** and consequently are concerned with the Technical Buildings Systems (TBSs) but not de facto with plug loads such as tumble dryers and other plug-in/portable appliances that are not addressed by the EPBD.

Therefore aside from these BACS EPBD functions consideration also needs to be given to **BACS plug load functions** that control electrical loads and/or appliances (e.g. floor lamps, set top boxes, etc.) and which are not taken into account by EPBD-related control functions. These may include smart appliances, see 1.2.3.3. There are several examples of BACS plug load functions that do not require the appliance to be smart. For example, a "home away BACS function", that shuts down wall outlets with one push of a button when you leave the house to reduce consumption. Such a 'home away BACS functions'³⁶ are a common feature in high end home automation systems; they also check if the doors are closed properly, shut down the water supply against leakage, put the ventilation system to its lowest setting, etc. Another example is demand response control of hot water storage tanks, which can also be implemented by externally installed smart relays³⁷ added to any existing (non-smart) storage tank.

1.2.7.6. BACS EV charging infrastructure connected to the building

Electric vehicle (EV) charging infrastructure is a special case of BACS hardware when it is connected behind the electricity meter and therefore part of the building electrical installation; hereafter, this will be called **BACS EV I/F** (I/F means interface). EV charging has no impact on the energy performance of a building and therefore it was not explicitly covered by the EN 15232 BACS functions but can be understood as a special case of the BACS function (7.7) which is smart grid user interaction. Coordinated charging of vehicles and potential feed-in to the grid or storage options are emerging building services for which standards like IEC 15118 are being developed. EV charging was also addressed in Lot 33 on smart appliances³⁸.

³⁴ <http://www.eco-smartappliances.eu/Pages/welcome.aspx>

³⁵ <http://epb.center/support/documents-introduction>

³⁶ <https://www.teletask.be/en/solutions/end-user/power-sockets/>

³⁷ <https://www.legrand.fr/pro/catalogue/31907-bipolaires-250-v/contacteur-domestique-cx3-silencieux-bobine-230v-2p-250v-25a-contact-2f-1-module>

³⁸ <http://www.eco-smartappliances.eu/Pages/welcome.aspx>

Conclusion

BACS EV charging can easily be defined and has a separate hardware and function when installed in connection to the technical building system. The EV charging control function requirements are not developed in detail in EN 15232 and might need more research to include them.

1.3. Overview of the most relevant European Standards

This section provides a short overview of the principal standards that apply to BACS.

1.3.1. Summary of the main standards committees

The main CEN standards committees developing standards for BACS are:

- CEN/TC 247 - Building Automation, Controls and Building Management (Business Plan)
- CEN/TC 247/WG 3 - Building Automation and Control and Building Management Systems
- CEN/TC 247/WG 4 - Open System Data Transmission
- CEN/TC 247/WG 6 - Electronic control equipment for HVAC applications, integrated room automation, controls and management systems

1.3.2. Standards on life time and interoperability of BACS components

According to ISO/IEC 2382-01 on 'Information Technology Vocabulary, Fundamental Terms', **interoperability** is defined as follows: "The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units". Despite this ISO/IEC 2382-01 definition there exist several other definitions of interoperability³⁹. For example several **levels of interoperability** were identified in an ETSI white paper⁴⁰ which is applied to a multitude of topics and applications:

- **Technical Interoperability** is usually associated with hardware/software components, systems and platforms that enable machine-to-machine communication to take place. This kind of interoperability is often centred on (communication) protocols and the infrastructure needed for those protocols to operate. (e.g. KNX TP~~Error! Bookmark not defined.~~, DALI⁴¹, SHIP⁴²; IPv6, MODBUS⁴³)

³⁹ http://www.internet-of-things-research.eu/pdf/IERC_Position_Paper_IoT_Semantic_Interoperability_Final.pdf

⁴⁰ <http://www.etsi.org/images/files/ETSIWhitePapers/IOP%20whitepaper%20Edition%203%20final.pdf>

⁴¹ <https://www.digitalilluminationinterface.org/>

⁴² <https://www.eebus.org/en/technology/communication-channels/>

⁴³ http://modbus.org/about_us.php

- **Syntactical Interoperability** is usually associated with data formats (e.g. BACNET (ISO 16484), XML⁴⁴, KNX^{Error! Bookmark not defined.}, DALI⁴⁵, SPINE⁴⁶, MODBUS⁴⁷).
- **Semantic Interoperability** is usually associated with the meaning of content and concerns the human rather than machine interpretation of the content (e.g. KNX Application layer^{Error! Bookmark not defined.}, DALI⁴⁸, Smart Appliances REference (SAREF) ontology⁴⁹, MODBUS⁵⁰, etc.)

Unfortunately, today there is not one universal overarching BACS operating system but there are several ecosystems on the market and a building can often include a multitude of them (e.g. KNX, DALI, IP user interface server). Interoperability between these systems is often a point of concern. The common solution for this is to add **gateways** or bridges to the BACS system, for example a DALI-to-KNX gateway to integrate lighting and KNX IP gateway and router for the user interface with a web browser. Nevertheless, such gateways come at extra cost and are also power consuming.

Ecodesign could also try to reduce the number of gateways needed for certain BACS functions in order to reduce energy consumption and/or extend the lifetime of the system. Herein, one could think of avoiding the use of BACS interoperable systems based on the internet or Wide Area Networks (WAN) and servers outside the building when they are not essentially needed for the BACS function. The rationale being that failures the internet and/or servers will also cause the BACS to fail. Therefore such solutions often become a weak spot and point of failure over the system lifetime and moreover consume additional energy. This arises because internet based solutions often rely on many gateways with protocol stacks, software translation layers, security encryption software and hardware. This means, for example, that the improper use of a WAN internet gateway by certain BACS control functions could be discouraged by ED/ELR measures.

Interoperability in the context of Smart Grids is also discussed in Lot 33 on Smart Appliances⁵¹. An issue for smart grid applications is that there is a need for data transfer between the appliance and the power systems, for which a multitude of solutions are researched most of them with an internet connection (see Lot 33). This would of course require an internet Wide Area Network (WAN) gateway in the building. The study researched and recommended semantic interoperability for this function.

Some other aspects that can play a role in the BACS life time and its sustainability are:

⁴⁴ <https://www.w3.org/TR/xml/>

⁴⁵ <https://www.digitalilluminationinterface.org/>

⁴⁶ <https://www.eebus.org/en/technology/data-model/>

⁴⁷ http://modbus.org/about_us.php

⁴⁸ <https://www.digitalilluminationinterface.org/>

⁴⁹ <https://sites.google.com/site/smartappliancesproject/ontologies/reference-ontology>

⁵⁰ http://modbus.org/about_us.php

⁵¹ <http://www.eco-smartappliances.eu/Pages/welcome.aspx>

- **Reparability**, this means that spare parts are available also in the event of manufacturer bankruptcy
- **Upgradability**, this means that the installed system can be adapted to future services from the manufacturer or third-party solutions.

Reparability and upgradability are addressed in the new Mandate M/543 request to the European standardisation organisations about Ecodesign requirements on material efficiency aspects for energy-related products to develop a generic standard that covers material efficiency aspects. CEN/CLC JTC10 WG3 is therefore developing a new standard PrEN 45554 on “General methods for the assessment of the ability to repair, reuse and upgrade energy related products” but it is in an early draft status and hence is not yet available.

With regards to interoperability, reparability and upgradability the following BACS classifications could also be relevant:

- **BACS single source provider** as opposed to **BACS multiple source providers** (e.g. KNX⁵²)
- **Public standard I/F BACS** (e.g. DALI⁵³), for which a public interface standard is available, versus **closed I/F BACS**, for which the system description is not publicly available and reserved for members or a single manufacturer (e.g. Opentherm⁵⁴).
- Within public standard I/F BACS it is also possible to discriminate between open standard free of charge (e.g. IPv4 according to IETF publication RFC 791) and paid membership BACS (e.g. KNX~~Error! Bookmark not defined.~~) and paid membership BACS with access protocol. An acceptance protocol means that existing members can decide which new members are allowed to participate. However this only relates to the BACS cost, market competition and funding for maintaining the activity and is therefore only indirectly related to the BACS life time. Nevertheless, it can play a role when considering policy requirements while maintaining market competition.

Conclusion

When considering the BACS life time and potential impact according to the MEERp; interoperability, reparability and upgradability can be important properties to consider for sustainability. Standards for reparability and upgradability are still in a draft status and could therefore be a point of concern.

It is also possible to put requirements on interoperability depending on the BACS functions.

1.3.3. Summary of main relevant standards

The principal standards addressing BACS are:

EN ISO 16484 Building automation and control systems (BACS)

⁵² <https://www.knx.org/be-nl/>

⁵³ <http://www.dali-ag.org/>

⁵⁴ <https://www.opentherm.eu/>

- Part 1: Project specification and implementation
- Part 2: Hardware
- Part 3: Functions
- Part 4: Control applications
- Part 5: Data communication protocol
- Part 6: Data communication conformance testing

EN 15232 Building automation, controls and technical building management

- Part 1: Impact of building automation, controls and technical building management (EN ISO 52120)
- Part 2: Accompanying Technical Report, this is currently not available (status 6/2018).

Note that because Part 2 is not yet available and will only be an accompanying report (if any), reference in this report is made in short to 'EN 15232' meaning EN 15232-1:2017 (Part 1).

Also the full set of standards that are included in the references of EN 15232 for details on control systems, such as EN 15316-2 on the method for calculation of system energy requirements and system efficiencies for space emission systems (heating and cooling).

EN 16947 Building management system

- Part 1: Building management system (EN ISO 52127)
- Part 2: Accompanying Technical Report

EN 16946 Inspection of building automation, controls and technical building management

- Part 1: Inspection of building automation, controls and technical building management
- Part 2: Accompanying Technical Report

EN 15500 Control for heating, ventilation and air conditioning applications

- Part 1: Electronic individual zone control equipment
- Part 2: Accompanying Technical Report

There are additional IEC and ISO standards which are reported in the resources chapter of REHVA GB 22 in cooperation with eu.bac 'Introduction to building automation, controls and technical building management' (<https://www.rehva.eu/publications-and-resources/eshop.html>)

1.4. Proposals for primary functional unit

1.4.1. Proposal for primary performance parameter or functional unit

Objective

Knowing the definitions of BACS as set out previously, we will now further explain what is considered to be the "functional unit" for BACS.

In standard ISO 14040 on life cycle assessment (LCA) the functional unit is defined as “the quantified performance of a product system for use as a reference unit in life cycle assessment study”. The primary purpose of the functional unit is to provide a calculation reference to which environmental impacts (such as energy use), costs, etc. can be related and to allow for comparison between functionally *equal* BACS.

Defining a “functional unit” is an important aspect of the MEErP Task 1 because other tasks, e.g. considering the improvement options will be scaled to this.

The first preferred option is:

The **BAC factor (f_{BAC}) or Energy Efficiency Index of the BACS** can be defined as the measured annual energy expressed in primary energy (E_P) as supplied to the technical building systems and plug loads to satisfy the uses relative to a reference BACS class C in EN 15232-1:2017, hence ($E_P, BACSC$) ($E_P = f_{BAC} \cdot E_P, BACSC$). The full details of the definition of a class C BACS are given in the standard EN 15232-1:2017, see also section 0 for an explanation of these classes.

Remarks:

- This overall BAC factor is defined in a similar way to method 2 in EN 15232-1:2017 where it is however defined in terms of delivered or final energy. The use of primary energy for the choice of functional unit requires that the delivered electrical energy is converted by means of a factor that takes into account energy conversions⁵⁵, therefore the proposed functional unit differs from EN 15232. The main reason to work with primary energy is to better cope with the local production of renewables and/or demand response.
- The term “**satisfies the uses**” means that the **minimum indoor environmental quality is delivered** according to EN ISO 17772-1:2017 which therefore includes thermal, lighting and Indoor Air Quality comfort during the occupied hours
- “Primary Energy” as defined in the EED (2012/27/EU) means gross inland consumption, excluding non-energy uses
- “Final energy consumption” means, according to EED (2012/27/EU), all energy supplied to industry, transport, households, services and agriculture. It excludes deliveries to the energy transformation sector and the energy industries themselves.

Rationale and pros and cons:

This functional unit is able to model the energy saving benefits from BACS but also from increased use of Renewable Energy Sources (RES) on the delivered energy to the building and/or Smart Grid (SG) as a whole.

In principle the main alternative for a primary BACS functional unit could simply be to satisfy the comfort requirements, or so called ‘uses’ of EN 17772-1 and to disregard the efficiency to achieve this. However, whilst this is a valid approach when only looking at the outcome of the BACS, the BACS are technical building systems which are mostly invisible to the occupants that aim to provide comfort as efficiently as possible and

⁵⁵ <http://ec.europa.eu/environment/eussd/buildings.htm>

therefore the proposal taking into account the energy consumption is considered more appropriate.

The proposed functional unit is able to model the building as a whole and therefore a potential limitation is also that this approach is less appropriate when there is no related energy efficiency improvement at the building level. In other words it might be insufficient or unsuitable for smart Grid BACS CEM functions or fire safety systems. In this case the potential energy efficiency improvement is only due to increasing the energy efficiency of the self-consumption related to those functions.

An alternative option is to consider a functional unit at product level:

This could be expressed in terms of the annual final energy consumption of the BACS hardware component itself (E_{BACS}) [in units of kWh/(m².y)]. Herein the following different operating modes could be defined: 'stand by', 'networked stand by', 'normal mode', 'maximum or peak power consumption'.

Rationale and pros and cons of this alternative option:

This is not the appropriate metric to model the indirect energy saving benefits attributable to BACS and hence would omit the largest impact of BACS; however for some BACS components that have no indirect impact on the building energy consumption it might be more suitable.

1.5. Stakeholders views on the scope

A project web site was set up wherein stakeholders could register to be informed about the project and to participate in a stakeholder meeting. 177 stakeholders registered (see https://ecodesignbacs.eu/registrations_website).

During the stakeholder meeting on 18/1/2018 the purpose of the BACS scoping study was explained including the expected challenges and difficulties (see the minutes of the meeting in Annex B -). The presentations and minutes were made available to all stakeholders. Afterwards, to hear the views of the stakeholders on the findings presented in the meeting an enquiry was launched to all the stakeholders who had registered on the website.

The enquiry received a total of 28 responses of which 14 came from NGOs and industry representatives and another 14 from: an installer association, 9 from individual companies, 1 from an individual installer, 1 from a university and 2 Member State public bodies.

The full report of the enquiry findings is presented in Annex D - ; however, the responses received were not well aligned and there was little evident consensus with regard to the focus for the study's scope. Some relevant feedback related to the scope to be considered were:

- only 7 stakeholders agreed that the study should be split between BACS as retrofits for existing buildings with poor or average energy performance versus new built low energy buildings, while most (15) disagreed or had no opinion (4). There was also no support to split the study between large (<1000 m²) and smaller buildings (5 vs 19)
- a minority, 9 out of 25, of stakeholders expressed a view that that the study should be split between residential and non-residential applications. Three did

not reply and two commented that Ecodesign is not the right policy instrument but rather that EPBD should be used

- most, 18 out of 28, stakeholders expressed a view that the study should focus on energy efficiency and postpone or ignore Demand Response functions in a future Smart Grid context.

In general most stakeholders agree that BACS are relevant products for energy savings and potentially ED/ELR.

In total 4 separate position papers were received, see annexes F-I). In general they support the idea of conducting a full preparatory study with the aim developing ED/ELR implementing measures but they differ with regard to how the products should be defined and to the potential ED/ELR policy options.

EU.BAC⁵⁶ supports the approach based on the functions of the EN15232 standard as the product boundary.

BEAMA⁵⁷ agree with the notion that the defined scope of a BACS product is broadly comprised of a control loop that consists of a sensor, an actor (valves or actuators) and a controller that executes the logics. The main components of this are: duct temperature sensors/ immersion temperature sensors, automation stations/ controllers, valves and actuators. They expressed concerns over using EN15232 as the product boundary. For non-residential systems with Building Management Systems (BMS) its fine but they do not believe it is appropriate for residential applications.

EHI⁵⁸ understands that BACS within the scope of Lot 38 are being dealt with as 'products'. This means that BACS are supposed to be rated and labelled from the moment that BACS are placed on the market. They assert that the installation and operational aspects should preferably be treated within the assessment of the whole building performance. EHI also referred to Lot 1 / 2 and proposed that any controls that are assessed as part of an ErP application should be kept out of scope of a BACS study. A bilateral meeting was organised wherein the concept of the proposed 'smart bacs calculator' was proposed but no formal feedback or position paper had been received at the time of writing.

Lighting Europe⁵⁹ also submitted a position paper, within which (amongst other aspects) they asked to align this Lot 38 study on requirements for BACS with the policy proposals from the ENER Lot 37 study on lighting systems wherever possible. They also insisted on requirements on functionalities that are technology neutral and do not impose a burden on industry by creating requirements on (control) devices, which is in line with EN 15232/EN15193. Note that the Lot 37 study also investigated the design process in lighting, which is an issue that is also important for other building services but not part of the BACS product itself (ventilation zoning, heating, etc.).

⁵⁶ <https://www.eubac.org/home/index.html>

⁵⁷ <http://www.beama.org.uk/>

⁵⁸ <http://www.ehi.eu/>

⁵⁹ <https://www.lightingeurope.org/>

2. SCREENING OF PRODUCT GROUPS AND MEERP RECOMMENDATION

2.1. MEErP screening

This chapter considers the potential application of the MEErP process to the assessment of BACS for prospective Ecodesign and ELR implementing measures.

2.1.1. Objective of the screening activity (Task 0) in accordance with the MEErP

According to the MEErP: "Task 0 is an optional task for the case of large or inhomogeneous product groups, where it is recommended to carry out a first product screening, considering the environmental impact and potential for improvement of the products as referred to in Article 15 of the Ecodesign Directive. The objective is to re-group or narrow the product scope, as appropriate from an ecodesign point of view, for the subsequent analysis in Tasks 1-7."

According to paragraph 2 of Article 15 of Ecodesign Directive 2009/125/EC energy-related products such as BACS have to:

1. represent a significant volume of sales and trade, indicatively more than 200000 units a year within the Community to the most recently available figures;
2. have a significant environmental impact within the Community – as specified in the Community strategic priorities as set out in Decision No 1600/2002/EC – considering the quantities placed on the market and/or put into service;
3. present significant potential for improvement in terms of its environmental impact without entailing excessive costs, taking into account in particular:
 - i. the absence of other relevant Community legislation or failure of the market forces to address the issue properly; and
 - ii. a wide disparity in the environmental performance of products available on the market with equivalent functionality.

These three criteria will be addressed in the quick scan as guiding principles to determine the potential of possible Ecodesign, energy labelling, and/or energy performance of buildings requirements.

Additionally, the provisions of the Ecodesign Directive 2009/125/EC require consideration of the (entire) life cycle of the product and all its significant environmental aspects (including energy efficiency during the use phase of the product) (article 15, paragraph 4, item (a)). Furthermore, implementing measures shall meet the following criteria (article 15, paragraph 5):

- a) there shall be no significant negative impact on the functionality of the product, from the perspective of the user;
- b) health, safety and the environment shall not be adversely affected;
- c) there shall be no significant negative impact on consumers in particular as regards the affordability and the life cycle cost of the product;
- d) there shall be no significant negative impact on industry's competitiveness;

- e) in principle, the setting of an Ecodesign requirement shall not have the consequence of imposing proprietary technology on manufacturers; and,
- f) no excessive administrative burden shall be imposed on manufacturers.

The overall impact of BACS and the purpose of the remaining sections on screening

The 2015 Ecodesign working plan study⁶⁰ was based on analysis of the 2014 study from Waide Strategic Efficiency on BACS⁶¹. It already concluded that there was likely to be a significant impact on energy use in the EU (see Table 2-1) from prospective Ecodesign implementing measures. Moreover, as BACS are composed of many individual components and are used in all buildings so a greater or lesser extent the numbers sold across the EU will easily exceed 200000 units in official product sales statistics such as PRODCOM. Therefore in addition to verifying significance, the EU potential for energy savings are comfortably above 2 TWh per year and hence can be considered to be significant compared to the total EU energy consumption⁶² within the terms applied for the Ecodesign Directive. Such rough first screening has already been done in Task 3 of the 2015 Ecodesign working plan study and BACS were already identified as being relevant based on evidence reported in the literature⁶³, see Table 2-1.

Table 2 Estimated additional annual energy savings compared to the Reference Scenario (TWh for final energy and PJ for primary energy) from hypothetical Ecodesign implementing measures - source: 2015 Ecodesign working plan study

Annual additional energy savings		
Year	Recommended Sc.	Optimal Sc.
2020	Low: 1.5 TWh / 13.6 PJ	Low: 2.7 TWh / 24.1 PJ
	Medium: 4.5 TWh / 40.8 PJ	Medium: 8.1 TWh / 72.3 PJ
	High: 7.5 TWh / 68 PJ	High: 13.5 TWh / 120.5 PJ
2030	Low: 4.0 TWh / 36.1 PJ	Low: 2.6 TWh / 50.2 PJ
	Medium: 12.0 TWh / 108.3 PJ	Medium: 7.8 TWh / 150.3 PJ
	High: 20 TWh / 180.5 PJ	High: 13 TWh / 251 PJ

Taking into account the existing screening from the working plan study and the current assignment **the focus of the screening process in this report will be on elaborating the details for scoping options discussed in the previous task, to verify whether refining the scope would not result in an overly significant part of the savings from being excluded.**

Note, it is likely that the Working plan study substantially underestimated the savings potentials (%) from ED and ELR measures for BACS as will be elaborated further on.

⁶⁰ <http://ec.europa.eu/DocsRoom/documents/20374>

⁶¹http://neu.eubac.org/fileadmin/eu.bac/BACS_studies_and_reports/2014.06.13_Waide_ECI_-_Energy_and_CO2_savings_BAT.pdf

⁶² http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy

⁶³http://neu.eubac.org/fileadmin/eu.bac/BACS_studies_and_reports/2014.06.13_Waide_ECI_-_Energy_and_CO2_savings_BAT.pdf

2.1.2. NZEB or LEB vs the existing stock building and the differences in impact from BACS

Issue

The impact of BACS can differ in low energy buildings (LEB) or renovated zero energy buildings (NZEB) from the case where BACS are retrofitted in the existing non energy-efficient building stock. The rest of this section describes the differences and considers how this might affect the conduct of a full Ecodesign preparatory study for BACS. We follow the logic of building application categories defined in section 1.2.7 on definitions.

How do NZEB or LEB differ from the existing building stock?

The role of BACS for NZEB's can be quite different⁶⁴ to that in the average existing building stock. The impact within NZEB is different in view of the small amount of energy used for heating or cooling the building and the complexity of other TBSs. Due to their more complex TBS, for example mechanical ventilation, they often require more auxiliary electrical energy in comparison to older buildings, for example with natural ventilation. In a poorly insulated home, the energy balance is dominated by heat transmission losses such that the savings potentials are dominated by measures that improve the insulation and keep the thermostat setting as low as possible. In a NZEB the heat requirement is much lower due to increased insulation and air tightness, whereas the demand for electricity for ventilation, circulation, shading devices, etc. will be higher and the control more intricate.

For example, the following characteristics of residential NZEB affect the type of BACS used and their energy requirements:

- a NZEB requires a greater number of measures to prevent overheating, in order to limit or eliminate the need for cooling (e.g. control of shading devices, automatic operation of windows and vents to allow for night time cooling, etc.)
- if active cooling is used, there is a large overlap in the period when cooling is needed and local electricity is produced by the PV panels and therefore an opportunity for increased self-consumption with BACS
- the increased risk of overheating in a NZEB home and the additional comfort offered by an air conditioning system will likely lead to increased interest in heat pumps. An additional advantage is that the pumps use electricity as their power source, which means less CO₂ is produced over time as the EU electricity system is progressively decarbonised. Buildings of this type can participate in smart electrical grids and demand side management (see 1.2.5)
- the thermal inertia of NZEB increases due to decreased transmission and ventilation losses, as a result of which fluctuations in the outdoor temperature have less of an impact on the indoor temperature. This means that night cooling is often a sustainable option. On the other hand the possibilities of BACS energy savings implementing night time set back temperatures are more limited. This thermal inertia also creates new BACS possibilities for controlling the heating or cooling delivery based on variable tariffs when heat pumps are used. In a home of this type, the losses from the heat buffer or from the heat directly stored in the building thermal mass will be smaller. The

⁶⁴ <https://www.ecofys.com/files/files/ecofys-2014-role-of-building-automation-in-nearly-zero-energy-buildings.pdf>

larger thermal inertia allows for greater flexibility in time shifting of heating or cooling loads by DR BACS despite their lower absolute need for energy. Note that in theory non-NZEB buildings could also participate in DR BACS, however, a prerequisite is that they have an electrical driven heat-pump.

- NZEB buildings tend to rely more on heat pumps for heating and those heat pumps most often also supply domestic hot water (DHW) with storage tanks⁶⁵. These water storage tanks can provide additional flexibility to the electrical grid and hence support demand response (DR BACS). Note that this function can also be implemented in the existing stock of less-efficient buildings.
- a modern, airtight home requires auxiliary power to operate the ventilation system. Smart controls can help to make savings in this regard using demand driven ventilation. The auxiliary power required for delivering the heating and cooling loads can differ in NZEB. Consider for example circulation pumps for low temperature underfloor heating which require more power than heating by means of high temperature radiators. This, however, can be offset by a reduction in time of the heating season and improved control of the circulation pumps. Here too, BACS can help to deliver energy savings.
- the situation for non-residential NZEBs is even more complex than it is for residential buildings. Many non-residential buildings (offices, schools, supermarkets, hospitals, etc.) can be characterised by much higher internal heat gains per m² resulting from human metabolic activity and other activities carried out in the building. Ventilation requirements can be much higher per m² in some types of non-residential buildings (offices, schools, hospitals) due to a relatively higher occupant density. In non-residential buildings minimum illumination requirements are set by standards (EN 12464) and are usually higher compared to amenity lighting in the residential sector, which can also result in larger internal heat gains. In general the energy intensity per m² tends to be much higher compared to residential buildings, e.g. due to a higher amount of ICT equipment and occupants per m². Therefore this will influence the energy balance of a building including from phenomena such as the heat replacement effect⁶⁶. Also the relative importance of ventilation, lighting and cooling is strongly dependant on the type of building use and the building design; e.g. when comparing a swimming pool, office, storage warehouse and library. A detailed assessment of BACS impacts will need to encompass sufficient differentiation for the distinct types of non-residential buildings.
- in many NZEB a battery for local storage is useful in order to increase the local use of the energy produced by the PV panels or other renewable electricity generators. In the event of a mains failure, such a battery can also provide the power required to operate systems such as the ventilation
- the energy balance and the energy management are determined by a number of factors. They depend not only on the outdoor temperature, but also on the

⁶⁵ Note: heat pumps are usually rated at lower power and therefore domestic hot water storage tanks are needed to supply hot water for showering, etc.

⁶⁶ <http://efficient-products.ghkint.eu/spm/download/document/id/579.pdf>

solar gains and other thermal gains. As a result, energy management becomes more complex

- the increased complexity of TBS and the prevalence of renewable energy consumption and energy storage spur the need for integrated control and monitoring systems, e.g. dashboards with the real time view of the status of the main parameters of the building such as temperature, actual PV gains, and level of charge of electricity or heat storage. Often these systems also allow for remote management, e.g. by smartphone applications
- the more complex BACS are required the greater the potential for self-consumption and stand by losses.

Apart from the residual HVAC energy demand other services will continue to use energy such as Domestic Hot Water (DHW), lighting, home appliances, ICT, multi-media equipment, surveillance, access control, EV charging, etc. Since the absolute heating or cooling demand is lower for NZEB buildings, these other services will account for a relatively larger share of the overall energy consumption. They can also be connected and controlled by the BACS system and they will interact with the building energy balance through being a source of internal heat gains which will bring a heat replacement effect.

Finally the energy bill of an NZEB is unlikely to be nullified because the relative increase in the share of electricity demand which is significantly more expensive per kWh compared to gas. Therefore effective BACS can still provide a pay back and assist in managing the complexity of the proper operation of such buildings with their relatively smaller but more complex energy balance.

This change in emphasis and need affects the nature and benefits of different BACS characteristics, for example, the impact of a smart thermostat is reduced for example, however new opportunities for smart energy management are created at the same time.

The relative savings from BACS can only be determined if the energy balance of a home is known and has been broken down into the individual components of the consumption, e.g. on a monthly basis.

Conversely, the impact of progressively higher BACS functionality on existing buildings is not independent of the building type either. The less efficient the building fabric the more thermal energy BACS can help to save as a function of their capabilities. Also within the EN15232 BACS energy performance classes the biggest energy savings attributable to moving up a single energy class arise from moving from class D to class C BACS functionality. Thus, even though class D BACS will be in a minority of the existing stock the savings potentials from their replacement are the greatest for any part of the stock. No comprehensive data has yet been found on how BACS energy performance classes are distributed as a function of building energy efficiency, but it seems likely that class D BACS will be rather more common in low efficiency buildings than in higher efficiency and more recently built or renovated buildings.

Can the simplified BAC factor method 2 from EN 15232-1:2017 be applied to NZEB buildings and what is the expected difference in impact?

The answer is, **potentially not**, because the BACS efficiency factors proposed in the standard do not differentiate between buildings as a function of their fabric efficiency and overall energy balance. A sensitivity analysis was done on building location, climate zone, and orientation to support the development of the standard, but it has not been

done for NZEB/LEB compared to average existing stock buildings. The reported BACS factor **savings that can be achieved with higher functionality BACS on electrical energy for cooling, ventilation and lighting are potentially underestimated** in the opinions of the authors of this study. For example, the LOT 37 preparatory study on lighting systems identified much greater savings from efficient lighting controls than are attributed in the BACS factors of EN 15232. This issue could be analysed in greater detail in a full preparatory study. The complexity of NZEB could also justify continuous monitoring with BACS combined with continuous/experimental fine tuning of the control functions or so-called continuous commissioning.

Potentially the performance of the **BACS system in NZEB/LEB buildings could be part of the explanation of the performance gap** that is currently reported for low energy buildings^{67, 68, 69}, wherein too many NZEB/LEB buildings are consuming more energy than they were predicted to. It may be that differences in BACS performance, which have not been adequately accounted for, are the principal factor behind this gap; however, it is certain that BACS can at least help monitor building performance and provide diagnostics to help to clarify and understand the causes of these gaps.

How significant a share of NZEB can be expected in the total building stock?

The future share of NZEB to other buildings will depend on the building renovation rates, the market for new building constructions and the impact⁷⁰ of the EPBD on NZEB construction levels. In general for residential buildings the share of NZEB in the total stock can be expected to rise relatively slowly because of low new build and major renovation rates. However, in some non-residential sectors (supermarkets, office buildings, industry, etc.) the renovation rate is linked to the continuous business transformation process, which usually follows a shorter cycle than is the case for renovations of residential buildings. Therefore one could expect both a larger share of NZEB in the non-residential sector but also of advanced TBS.

Furthermore, the relative importance of ventilation, lighting and cooling is strongly dependant on the type of building use and the building design; e.g. when comparing a swimming pool, office, storage warehouse and library. A detailed assessment of BACS impacts will need to encompass sufficient differentiation for the distinct types of non-residential buildings.

Conclusion

Even though NZEB consume less than typical buildings, BACS are likely to also provide significant energy savings for both existing buildings and NZEB. This is because NZEB tend to have more complex TBS and therefore more EN 15232 functions will apply. The source of their energy savings will tend to be found more in the electrical auxiliary energy of the TBS. The average projected electrical energy savings from using class A BACS in EN 15232 are likely to be an underestimate for NZEB and might need to be

⁶⁷ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/497758/Domestic_Building_Performance_full_report_2016.pdf

⁶⁸ <https://www.ecn.nl/publicaties/PdfFetch.aspx?nr=ECN-E--16-056>

⁶⁹ <http://www.greenconstructionboard.org/index.php/performancegap>

⁷⁰ https://ec.europa.eu/info/sites/info/files/swd-2016-408-final_en_0.pdf

reviewed. Nevertheless, due to the lower share of NZEB in the whole building stock the study could focus first on functions that affect both existing buildings and NZEB.

2.1.3. Differences in the residential versus non-residential market structure

Issue

The MEErP⁷¹ Task 2 involves investigating the market trends and production structure and consequently has implications for the product scope with regard to the distinctions between the residential and non-residential sectors. In particular, the distinctions could have an impact on the barriers and opportunities that apply to prospective future policy measures. Similarly, the MEErP Task 3 which is concerned with modelling Users could also reveal relevant differences by building sector. The aim of this section is to consider the implication of these factors on the study scope.

Discussion

There can be significant market differences between large non-residential and/or large residential buildings (MFH with central TBS) versus small residential buildings (SFH or MFH with individual TBSs per flat/apartment).

The main market difference are likely to be found in how these BACS are brought to the market:

- large non-residential and/or large residential BACS are assembled on site often with standardized components.
- small residential BACS come often pre-assembled and sometimes form part of the TBS (boiler, ventilation unit). They are easy to install but often lack some features such interoperability between different TBS (e.g. cooling and ventilation). The installation cost is a relatively more important factor.

In the non-residential sector the users are also professionals and therefore anything that can be automated offers a faster pay back on labour cost. In the residential sector some BACS installations can be done by the occupants themselves (DIY) which will offer them cost savings.

Also larger buildings with multiple occupants are more complex to operate and automation can therefore render more useful service, e.g. set point management.

Conclusion

There are significant market differences between the part of the residential building stock that uses packaged TBSs with integrated BACS and the rest of the building stock that might use centralised TBSs with non-integrated BACS. This function of integrated BACS appears also to belong to TBS with a lower rated power (e.g. 70 kW⁷²). Hence a possibility for the scoping of a full preparatory study is to focus first on non-integrated

⁷¹ <https://ecodesignbacs.eu/faq>

⁷² Note: according to our information 70 kW is a power limit that is also considered within the EPBD review, but the study can reexamine this limit.

BACS with rated power above 70 Kw. In this case the study would focus typically⁷³ on the larger non-residential buildings.

However, there was no consensus amongst stakeholders to focus the study on one or the other of these market segments, see 1.5. The rationale being that many products can go to both market segments.

2.1.4. Description of the BAT or potential improvement options in line with the EN 15232 functions and qualitative assessment of impact

Issue

This section addresses the potential MEeRP Task 4, in which the objective is to analyse technical aspects related to BACS and Task 6 for improvement options compared to the base case. It should be based on descriptions of typical products and systems on the market and alternative design options. Best Available Technologies (BAT) and Best Not yet Available technologies (BNAT) are analysed according to the definitions set out in the MEeRP methodology⁷⁴. As already proposed in section 1.2 the main proposal is to define product-groups through their functionality according to EN 15232. Within this standard functions are grouped according to their Technical Building System service domain (1-heating, 2 -domestic hot water, 3-cooling, 4-ventilation and air conditioning, 5-lighting, 6-shading/blinds, 7-technical home/building management). This results in a total of 45 functions whereby any one function can have from as little as 3 control parameters up to well above 10. The typical parameters of control functions are explained in section 1.2.4, they can be for example a humidity set point, a time schedule, etc.

Consequently this EN 15232 function based definition covers a very large product group. Especially large complex buildings with several control zones and a combination of various heating/cooling systems can easily have 500 to 1000 control system parameters and settings. Describing, modelling and considering all these parameters might be overly complex and time consuming for a full preparatory study. In particular, the key need is to ensure that the contribution that specific BACS products can make is clearly positioned in terms of their impact on the building energy consumption. Therefore, the full study will need to establish representative usage cases that capture the most essential distinctions for the BACS being considered. The section hereafter investigates what are the key functions for energy savings that should be considered.

Discussion

Due to the limited timeframe available for this scoping study modelling and analysing a large set of buildings to consider all the potential control functions was not possible. Calculating the impacts from this wide variety of BACS with an acceptable accuracy is not an easy task, especially considering that while a complete set of European Standards addressing building energy performance has been elaborated yet a comprehensive calculation code which embodies these is not publicly available.

⁷³ It should be noted that large TBS (>70 kW) can also occur in some large MFH with a central infrastructure, but this is practice is country specific in many countries the trend is to have a TBS per unit to lower distribution losses and avoid issues with common property.

⁷⁴ <http://ec.europa.eu/growth/industry/sustainability/ecodesign/>

The complexity for such an analysis arises from the many components that influence the building energy balance in combination with a broad range of possible building technical properties, climate conditions and usage patterns. Several variable factors can influence the energy balance such as: transmission losses, ventilation losses, humidification, auxiliary power for HVAC, solar gains, internal heat gains from people, appliances, lighting, etc. This results in complex interactive effects, for example the heat replacement effect wherein increasing the efficiency of an appliance reduces the internal energy loads and thus increases the need for heating (but lowers cooling needs). Many different energy savings techniques including improved BACS options can result in a similar effect; however, each kWh can only be saved once. For example, shading control to prevent overheating and night time ventilation can both provide the a cooling effect, etc. Moreover, the dynamic response of buildings to BACS can be quite different as a function of the technical characteristics of the building and its TBSs, and therefore the same improvement in BACS can produce a different scale of impact. For example a building having a longer thermal time constant due to better insulation will have lower energy savings from night time set-back of thermostatic set-point temperatures simply because the lower set points cannot be reached within the available night time period.

The preference hereafter is therefore to include only a qualitative review and avoid publishing already the impact saving calculation because we are aware of the complexity and do not want to trigger that this savings targets are used outside their context.

In order to establish a list of priority BACS functions the EU.BAC members were consulted to learn from their field experience and this input was complemented by the findings from a literature review (see the listing in Table 2).

This exercise allowed the 45 functions in the EN 15232 standard to be reduced to a list of the 26 functions with the highest energy savings impact and one additional function of hydronic efficiency which is not covered in EN 15232 but is in EN 15316-2. Table 3 shows these functions with examples of the products that provide them. All these functions have defined functionality levels and sometimes also have associated control and/or set point accuracy options that could potentially be the subject of ED/ELR implementing measure requirements, see Table 4.

In order to prioritize and further simplify work based on the findings from the literature review (Table 2) an educated guess was made of the relative importance of some of these functions, see Table 5. It was not possible to analyse all those functions in detail within this scoping study, however, as an example the energy impacts from function '1.1' heat emission control accuracy are significant. VHK(2014) report a calculated total EU space heating load of 2823 TWh and the study also discusses the importance of the so-called fluctuation and stratification losses which are related to heat emission control (Figure 1). In this study the EU average corrected⁷⁵ temperature differential for the heating season was 7.5°C, hence increasing control accuracy by 0.5 °C would save 6%. Also, for example the Lot 20 Regulation (EU) 2015/1188 on local space heaters has a correction factor for portable electrical local space heaters equipped with electronic room temperature control of 7%. CSTB (2012) report relatively higher savings from thermostatic control accuracy for new low energy buildings of up to 25 % when improving control accuracy from 1.8 °C to 0.2°C. This relatively higher importance of control accuracy for new low energy buildings can be explained by a decrease in average corrected temperature for the heating season, in such buildings e.g. from 7.5°C to

⁷⁵ Corrected for solar gains and other internal heat gains

2.5°C, due to relatively greater importance of internal heat gains. As a provisional conclusion for this exploratory study, achieving a 1 % savings on 2823 TWh would result in 28 TWh of energy savings would seem not to be overstated of which perhaps 17 TWh could be attained by 2030. Furthermore, the savings potential will likely remain at least as high even in scenarios with a much greater proportion of low energy buildings in the future.

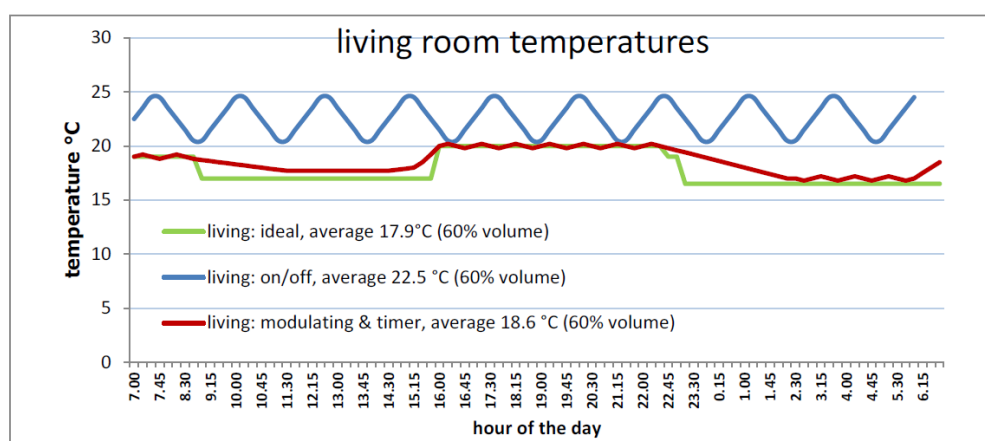


Figure 6 Typical indoor temperature lines for a low-efficiency on-off system, a high-efficiency modulation & timer system and the ideal temperature line (illustrative, source VHK(2014)⁷⁶)

Table 3 List of additional sources consulted for reviewing the impact of individual EN 15232 BACS functions

Impact ref.	short ref.	Title
1	EN 15232-1:2017	European Norm: 'Energy Performance of Buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10', 2017
2	Schramm(2017)	Proceedings ECEEE Summer Study: 'Optimizing the control of energy use in technical building systems – why energy and climate policies should fill regulatory gaps', H. Schramm et al., ECEEE, 2017
3	Ecofys (2014)	Project Report: 'Role of Building Automation related to Renewable Energy in nZEB's',Antonin van de Bree et. Al., Ecofys, 2014

⁷⁶

https://ec.europa.eu/energy/sites/ener/files/documents/2014_final_report_eu_buildin_g_heat_demand.pdf

4	VITO (2016)	Executive Summary for a section of the Final Report on the Smart Home project: 'The added value of smart energy management in the low-energy homes of the future', P. Van Tichelen et al., VITO report, 2016
5	CSTB (2012)	Rapport-diffusion libre (technical report): 'Impact du CA dans la RT 2012' (impact of control accuracy in RT2012), Nicolas COUILLAUD, Delphine DESTRUDEL, CSTB, 2012
6	ITG (2017)	Short study report: 'Kurzstudie Energieeinsparungen Digitale Heizung' (short study on digital heating systems), Prof. Oschatz et al., ITG, 2017
7	Ecofys (2017)	Study Report: 'Optimising the energy use of technical building systems – unleashing the power of the EPBD's Article 8', Jan Grözinger et al., Ecofys on behalf of Danfoss, 2017
8	Innovate UK (2016)	Project Summary: 'Building Performance Evaluation Programme: Findings from domestic projects Making reality match design', Innovate UK, 2016
9	Siemens (2011)	Manufacturer Technical note: 'Energy efficiency in building automation and control Proven applications for heating and cooling supply', Siemens, 2011
10	BE office building (2016)	Brochure Energy Helpdesk: 'Voorbeeld 1-Optimalisatie van het gebouwbeheersysteem in het provinciehuis Vlaams-Brabant' (sample: fine tuning of the BACS system in the office building of the province Vlaams-Brabant'), website 7/2018, https://www.vlaamsbrabant.be/binaries/helpdesk-energiezorg-voorbeeld1-provinciehuis_tcm5-83095.pdf
11	ES-SO (2006)	Study report: 'Energy Savings and CO2 reduction potential from solar shading and shutters in the EU25, ES_SO, 2006

Table 4 List of selected high impact EN 15232 BACS functions with some example products

EN15232 function reference number		Examples of BACS products which provide the function
	Function name	
Emission control		

1.1	heating emission control accuracy (note: ≠ set point management/night time set back)	room/zone temperature controls for different emission equipments (e.g. radiators, floor heating, fan coils, electronic radiation valve and room temperature controller, etc.)
1.1+7	set point scheduling of heating emission	smart room temperature controller with display and programming interface
3.1	cooling emission control accuracy (note: ≠ set point management)	room/zone temperature controls for different emission equipment, e.g. ventilo convector control valves,
3.1+7	set point scheduling of cooling	smart room temperature controller with display and programming interface
3.6	interlock between heating/cooling	room/zone temperature controls that avoids concurrent heating and cooling emission
4.1	room ventilation supply air flow control (note: impact calculated together with control of air handling unit 4.5)	air dampers combined with CO2 or occupancy sensor
4.2	room air temperature control for all air systems	air dampers combined with temperature sensor
4.3	VA supply air/water temp. control	
5.1+5.2	lighting occupancy Fo +Light level control Fd	presence detector and illumination sensor with controls
6.1	shading control	automatic blind control driven through solar radiation sensors
Distribution for H/C		
1.3	water temperature control for heat distribution network outside building occupied volume (where applicable)	demand based control of supply or return ToF hydronic circuit
1.4	control of distribution pumps for heating to avoid auxiliary energy	variable speed pump controller with constant pressure differential control loop

3.5	intermittant control of water T for heating/cooling	COMMENT: Intermittant control actually lowers supply water temperatures during non-occupancy with START-STOP Optimisation, operated as a function of external and/or internal temperature
NN	control of variable refrigerant flow (VRF) to recover heat from one zone to another	control of VRF valves to transfer heat between zones from cooling zones to heating zones
4.7	Humidity control (see set point management)	bathroom/kitchen exhaust fan
Generation for H/C		
1.6	heat generator return temperature control for combustion boiler to increase condensation	variable boiler return temperature control based on the outside temperature
1.7	heat generator supply temperature control for heat pump to increase COP/SEER	variable heat pump supply temperature control based on the outside temperature
4.5	air flow or pressure control at the air handler unit	pressure control loop in air handling unit
4.8	free mechanical cooling (e.g. night time cooling)	automatic window openers
Hydronic efficiency		
EN15316-2**	automatic balancing of hydronic circuit to optimize heat distribution in multi-family building with central heating	Automatic hydronic balancing valve for heat distribution grid in multi-family building with central heating-Pressure independent balancing and controls valves
Domestic hot water generation (DHW)		
2.2	Control of DHW storage tank charging with stand alone heat source	scheduled charging of domestic hot water storage tank taking into account night time
2.4	Control of DHW with combined heat sources such as solar collector	controller for domestic hot water tank with electric heater and connected to solar collector
Monitoring Scheduling and Operation		

7.1	set point management (note: calculated in part with 1.1 and 3.1)	capabilities from a central point influencing set points of the entire BACS (e.g. web servers, central operating units, etc.)
7.1b	set point management -case of humidity control set points with airco and central humidifier	capabilities from a central point influencing set points of the humidifier in aircon system
7.2	runtime management (note: calculated in part with 1.1 and 3.1)	capabilities from a central point influencing schedules/calendars of the entire BACS (e.g. web servers, central operating units, etc.)
7.3	detect TBS faults	clogged filter at the air handler unit, low pressure in the heat distribution system (from a leak), window or door left open leading to abnormal heat emission, etc.
7.4	reporting regarding energy consumption	capabilities from a central point accessing information about energy consumption and indoor conditions of the building

Table 5 List of selected EN 15232 BACS functions with their respective range of functionality levels defined and indication of relevance of having control and/or set point accuracy requirements

Product Group	EN15232 function reference number	Function name	Range of functionality level		Control Accuracy	set point Accuracy
			min.	max.		
Emission control						
	1.1	heating emission control accuracy (note: ≠ set point management/night time set back)	1	4	yes	
	1.1+7	set point scheduling of heating emission				Yes

	3.1	cooling emission control accuracy (note: ≠ set point management)	1	4	yes	
	3.1+7	set point scheduling of cooling				Yes
	3.6	interlock between heating/cooling	0	2		Yes
	4.1	Room ventilation supply air flow control (note: impact calculated together with control of air handling unit 4.5)	0	2	yes	
	4.2	Room air temperature control for all air systems	0	2	yes	Yes
	4.3	VA supply air/water temp. control	0	1		Yes
	5.1+5.2	lighting occupancy Fo +Light level control Fd	0	3		
	6.1	shading control	0	3		
Distribution for H/C						
	1.3	water temperature control for heat distribution network outside building occupied volume (where applicable)	0	2	yes	
	1.4	control of distribution pumps for heating to avoid auxiliary energy	1, 2*	3, 4	yes	
	3.5	intermittant control of water T for heating/cooling	1	3, 4		

	NN	control of variable refrigerant flow (VRF) to recover heat from one zone to another	NA	NA		Yes
	4.7	humidity control (see set point management)				Yes
Generation for H/C						
	1.6	heat generator return temperature control for combustion boiler to increase condensation	0	2		
	1.7	heat generator supply temperature control for heat pump to increase COP/SEER	0	2		
	4.5	air flow or pressure control at the air handler unit	1	4		
	4.8	free mechanical cooling (e.g. night time cooling)	1	3		
Hydronic efficiency						
	EN15316-2**	automatic balancing of hydronic circuit to optimize heat distribution in multi-family building with central heating	Non (0.6 K)	Dynamic (0.0 K)		
Domestic hot water generation (DHW)						
	2.2	Control of DHW storage tank charging with stand alone heat source	0	1		
	2.4	Control of DHW with combined heat sources such as solar collector	0	1		
Monitoring Scheduling and Operation						

	7.1	set point management (note: calculated in part with 1.1 and 3.1)	0	3		Yes
	7.1b	set point management -case of humidity control set points with airco and central humidifier	0	3		Yes
	7.2	runtime management (note: calculated in part with 1.1 and 3.1)	0	2	yes	Yes
	7.3	detect TBS faults	0	2		
	7.4	reporting regarding energy consumption	0	2	yes	

Table 6 List of selected EN 15232 BACS functions with an educated guess on their relative impact within different building segments (residential vs non residential, new NZEB vs existing) (** is high, * is medium, * is low, - means not relevant)(own estimate)

EN15232 function ref. number	Function name	Residential		Non residential	
		expected savings	expected savings	expected savings	expected savings
		Existing buildings	New NZEB	Existing buildings	New NZEB
Emission control					
1.1	heating emission control accuracy (note: ≠ set point management/night time set back)	***	***	***	***

1.1+7	set point scheduling of heating emission	***	*	***	**
3.1	cooling emission control accuracy (note: ≠ set point management)	*	***	*	***
3.1+7	set point scheduling of cooling	*	**	*	***
3.6	interlock between heating/cooling	-	***	*	***
4.1	Room ventilation supply air flow control (note: impact calculated together with control of air handling unit 4.5)	-	***	*	***
4.2	Room air temperature control for all air systems	-	*	*	**
4.3	VA supply air/water temp. control	**	**	**	**
5.1+5.2	lighting occupancy Fo +Light level control Fd	-	-	***	***
6.1	shading control	-	**	*	**
Distribution for H/C					
1.3	water temperature control for heat distribution network outside building occupied volume (where applicable)	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)
1.4	control of distribution pumps for heating to avoid auxiliary energy	**	**	**	**
3.5	intermittent control of water T for heating/cooling	**	**	**	**

NN	control of variable refrigerant flow (VRF) to recover heat from one zone to another	-	-	-	*** (only applies to small share)
4.7	humidity control (see set point management)	-	-	*	**
Generation for H/C					
1.6	heat generator return temperature control for combustion boiler to increase condensation	**	**	**	**
1.7	heat generator supply temperature control for heat pump to increase COP/SEER	**	**	**	**
4.5	air flow or pressure control at the air handler unit	combined with 4.1	combined with 4.1	combined with 4.1	combined with 4.1
4.8	free mechanical cooling (e.g. night time cooling)	-	**	*	**
Hydronic efficiency					
EN15316-2**	automatic balancing of hydronic circuit to optimize heat distribution in multi-family building with central heating	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)
Domestic hot water generation (DHW)					
2.2	control of DHW storage tank charging with stand alone heat source	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)

2.4	control of DHW with combined heat sources such as solar collector	*** (only applies to small share)	*** (only applies to small share)	*** (only applies to small share)	*** (only applies to small share)
Monitoring Scheduling and Operation					
7.1	set point management (note: calculated in part with 1.1 and 3.1)	see 1.1/3.1	see 1.1/3.1	see 1.1/3.1	see 1.1/3.1
7.1b	set point management -case of humidity control set points with aircon and central humidifier	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)	** (only applies to small share)
7.2	runtime management (note: calculated in part with 1.1 and 3.1)	see 1.1/3.1	see 1.1/3.1	see 1.1/3.1	see 1.1/3.1
7.3	detect TBS faults	*	**	*	**
7.4	reporting regarding energy consumption	***	***	***	***

Conclusion

A first screening exercise successfully reduced the 45 functions in the EN15232 standard to 24 functions, from which are expected to produce the highest energy savings impact. Table 4 covers 24 functions out of 45 from, in addition three combinatory functions of the 24 were added for the analysis which resulted in a list of 27. Table 4 has 8 functions with control accuracy requirements and 8 with potential control set point accuracy requirements. However, depending on the timeframe and budget for the full study this number might still be too large to be analysed into full detail within the preparatory study. It is also possible to focus within Tasks 3 to 6 on those functions which are expected to produce the most impact but to consider extending the proposed policy measures to a wider set of functions in Task 7. One possibility is to include in a detailed Task 3 to 6 analysis all the functions with a *** estimated impact and to then include a

smaller selection of ** impact functions. The selection could be elaborated in a future stakeholder consultation process.

2.1.5. Impact from improving the lifespan and interoperability of BACS components

Issue

Interoperability, reparability and upgradability can be important properties to consider for BACS sustainability in terms of their energy use and functionality (for interoperability) and lifespan and associated material efficiency (for interoperability, reparability and upgradability).

Definitions, examples and potential impacts were discussed in section 1.2.9.

A typical failure in a BACS system is an electromechanical relay, such that having these relays easily accessible via a relay socket, could potentially be a simple ED BACS repair requirement (see *Figure 7*). When a single relay fails it can be replaced without requiring the full system to be replaced, e.g. instead of all 8 relays with the printed circuit board (PCB) and housing.

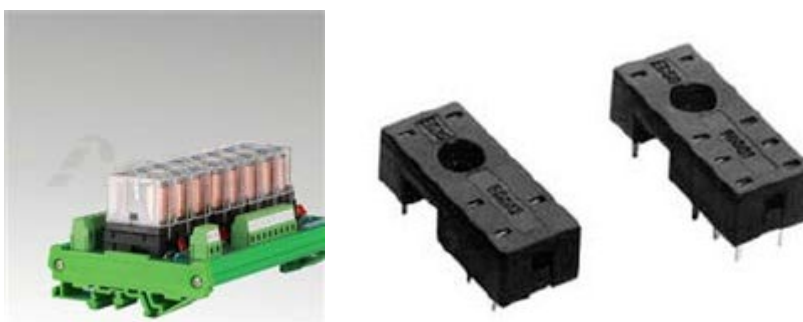


Figure 7 Relay for BACS system on sockets can easily be replaced, see control board with relay (left) and spare PCB relay sockets(right)

These aspects are important for the life cycle cost and return on investment.

Conclusion

Interoperability and life span are aspects that can be considered in a full preparatory study because of their impact on the life cycle cost and therefore benefit of the end user from BACS.

2.1.6. Reducing self-consumption of BACS

Issue

While the BACS help to control TBS systems and hence to better manage the energy used by TBSs they also consume some energy in doing so. This energy is mostly much less than the energy they help to save but nonetheless some technical solutions are likely to fulfil the BACS functions more efficiently than others and thus there may be scope to save on the self-consumption of BACS by specifying Ecodesign limits.

Screening

In a recent Swiss research project the self-consumption of BACS was examined in detail⁷⁷. Building automation has generally been considered to account for a negligible part of building electricity consumption compared to that taken by heating or the electricity consumption of cooling devices, ventilators, pumps and lighting. However, the analysis in the Swiss study showed that this view should be revised: the annual electricity consumption of building automation (room automation and primary building automation) was found to amount to a single or double-digit percentage as a proportion of the annual final energy demand of building equipment and appliances (heating, ventilation and air conditioning (HVAC) and lighting). In terms of absolute numbers, the specific annual electricity consumption for room automation resulted in 2 to 5 kWh/m²/year in final energy demand (without considering the overarching building automation management). The analysis also showed that the functionality of building automation and the electricity consumption of the automation equipment are barely correlated and that the specific product choice and the design of the system are much more relevant for the electricity consumption of the system.

The study also made recommendations for BACS designers/specifiers and manufacturers with regard to minimising the self-consumption of BACS. These include deploying strategies to reduce the power consumption via a reduction in the number of servers, gateways or vendor specific solutions. For components and actuators, it was recommended that the no power consuming mode be the most common status over the duty cycle, for example when the valve is mostly open it should be in the no power consumption mode (NO or Normally Open valve).

The same approach can be applied in lighting because it is also possible to **shut down the complete control gear and circuits when the building is unoccupied** to reduce their stand by power consumption. For electromechanical switches **bi-stable or latching relays are recommended** whenever they can be applied, the benefit is that these latching relays don't need any power to stay in their current state (open or closed) in contrast to traditional relays that need permanent power either in the off or on mode. Also for sensors and actuators it was recommended to **use energy harvesting technologies** for power supply such as solar cells, piezo actuators, etc.

Obviously also **the efficiency of the BACS power supply** (e.g. 24 VDC) is important. For example, it was also found that the BACS power supply (e.g. 24 VDC) is often over dimensioned which results in a low operational efficiency.

Conclusion

The self-consumption of BACS can easily consume up to 2-5 kWh/m² per year of electricity which is not negligible. In principle, it might be possible to establish ranges (from base case to best available technology (BAT)) of energy consumption per component function provided. In this way the energy budgets for BACS components could be established based on their function, e.g. by the establishment of maximum consumption limits for components which are common to most BACS (such as sensors, actuators, communications, displays etc.). These energy budgets could then inform prospective Ecodesign implementing measures. Potentially, this would allow modular energy budget limits to be established based on the set of components used. This would

⁷⁷ BFE (2016) Projekt: 'Eigenenergieverbrauch der Gebäudeautomation,(EEV-GA) Ergebnisbericht '

avoid the need to define limits per higher level function, which might be too complex to be practicable given the very wide array of potential BACS solutions available. Also clear product information on self-consumption can result in low power BACS system designs (see the discussion on interoperability).

The exact energy savings potentials will need to be investigated in the full preparatory study; however, the Swiss data suggest that it should be possible by such measures to reduce the self-consumption of BACS by an average of at least 1 kWh/ m²/year in non-residential buildings. Were this to happen it would save ~9 TWh in final energy consumption across the EU. Note, it may also be appropriate to consider the establishment of energy labelling measures or energy performance ratings that address the self-consumption of BACS equipment based on the relative efficiency of their principal components.

Expected impact on demand response

Issue

This section qualitatively discusses the expected impact of BACS on demand response and considers how the topic might be best addressed in a full BACS preparatory study.

Discussion

In principle BACS have the potential to support electricity network flexibility objectives by assisting with the remote management of TBSs to support load management and grid storage. Such flexibility can support the integration of renewable energy.

BACS and demand response options have been a focus of smart grids research since at least 2006⁷⁸; however, given the considerations discussed in section 1.2.5 it could take some time for BACS services to target eDR. Nevertheless, buildings and their BACS have a long lifespan and the readiness of buildings to implement these iDR or eDR BACS will be an important aspect of their sustainability over their life time. For new low energy buildings that rely on electricity as a heat source (e.g. via a heat pump) such flexibility options could be worth implementing. These aspects are also being investigated in the context of the potential introduction of a smart readiness indicator (SRI) for buildings⁷⁹.

Conclusion

Some of the BACS DR grid flexibility potential is being addressed under the on-going smart appliances preparatory study but this does not address the overarching customer energy management (CEM) and distributed energy resources (DER) control of the building and of the TBSs as a whole; which are functions that can potentially be provided by BACS. At this stage these services are not yet offered in the market and there is still a need to develop standards and protocols to support them. Standards are necessary to allow a common language and objectives to be articulated which will inform product offers and the evolution of any supporting policy framework.

The full preparatory study will need to examine the gaps in the supporting standardisation framework so that BACS capability in this regard can be classified and established.

⁷⁸ https://www.earpa.eu/earpa/39/etp_smartgrids.html

⁷⁹ <https://smartreadinessindicator.eu/>

2.1.7. Proxies for scaling impact to the EU level and main conclusions on scope and impact

Issue

In order to estimate the potential impacts of improved BACS at the EU level it is necessary to draw upon existing data and studies.

Data for proxies

This study has established a full list of potential data sources that can serve to support the assessment of the potential overall impact of improved BACS at the EU level, see Table 6. It should be noted that these sources often address different issues and the data they contain often focuses on different aspects. For example, the proxy values for non-residential floor area can vary a lot between studies making it difficult to extrapolate data between them. Also, they are incomplete in the way they disaggregate final energy demand into its respective components that are relevant to assess the impact of individual BACS functions. As a result combining them is not recommended as it could result in large errors by using data applied outside its intended modelling context. It will be challenge in a full preparatory study to do so and it is hoped for that accurate, suitable and complete EU reference building data (floor area, annual final energy by TBS, average BACS system installed, etc.) will be available in future from the European Building Observatory⁸⁰. This provisional data is reported here to begin to give an indication of the relative importance of the service domains and hence of the BACS functions that affect them. Combined with the various building stock estimates it can help to inform considerations of the importance of BACS functions within ED/ELR. For a first estimate on the impact associated with the heat emission function see section 2.1.5.

Table 7 Various sources of EU building stock data

Ref	short ref.	Title
1	VHK (2014)	Final report 'Average EU building heat load for HVAC equipment', Rene Kemna, VHK, 2014
2	Waide (2014)	Report 'The scope for energy and CO2 savings in the EU through the use of building automation technology Second edition', Paul Waide et al., 13 June 2014
3	IEA (2013)	Report 'Transition to Sustainable Buildings - Strategies and Opportunities to 2050', IEA, ISBN: 978-92-64-20241-2, 2013
4	CIBSE (2003)	Energy Consumption Guide 19 'Energy use in offices', CIBSE, March 2003
5	BPIE (2011)	Report 'Principles for nearly Zero-Energy Buildings Paving the way for effective implementation of policy requirements', Bogdan Atanasiu et. Al., BPIE, 2011

⁸⁰ <https://ec.europa.eu/energy/en/eubuildings>

6	Fraunhofer EC (2016)	Final Report, 'Mapping and analyses of the current and future (2020 - 2030) heating/cooling fuel deployment (fossil/renewables)', prepared European Commission under contract N°ENER/C2/2014-641, 2016
7	Ecofys EC (2016)	Final Report ' Assessment of policy options for the review of Directive 2010/31/EU', Prepared for the European Commission under contract ENER/C3/2012-409/FV2015-523, 2016
8	NL (2016)	Report: 'Monitor Energiebesparing Gebouwde Omgeving', Nederlands ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2016
9	EC Building Stock Observatory (2018)	web site consulted: https://ec.europa.eu/energy/en/eubuildings

Conclusion

Given the available data it is not yet been possible to have an accurate estimate of potential impact that can be reached by individual EN 15232 functions on a kWh/m² basis; rather, this will need to be examined in more depth in a full preparatory study..

3. Policy and scoping recommendations

3.1. Introduction and overview of potential BACS policy measures and product scoping

This chapter provides an overview of potential policy measures, i.e. most notably the ED/ELR, EPBD, and the EED but also Directives that affect non-energy related environmental characteristics, that could be used to target BACS energy and environmental impacts. It considers how these combinations of policy options can be structured to work together and be mutually reinforcing. For example recognising that Ecodesign Requirements for BACS products can complement EPBD- (e.g. as specified within Article 8, to calculate the Energy Performance Certificates (EPCs) or the Smart Readiness Indicator (SRI).

This review does not go into full details on all the ED/ELR options, as this analysis should be conducted in the full preparatory study, but simply aims to examine the issues sufficiently to allow the scope of the full preparatory study to be defined.

Currently, some of the non-energy related environmental impacts of BACS are covered by the WEEE, RoHS and REACH Directives while some of the energy-related aspects are addressed by the EPBD. BACS as a whole are not yet subject to Ecodesign, Energy Labelling or Ecolabel requirements with the exception of some product types that have BACS functions incorporated, these are:

- space heaters, water heaters and solid fuel boilers: EU Regulations No. 811/2013 , 812/2013 and 2015/1187
- local space heating products: EU Regulations No. 2015/1188, 2015/1185 and 2015/1186

The energy performance of BACS has been shown to be much lower than is technically and economically optimal due to an array of barriers including:

- lack of visibility of BACS energy performance
- low awareness of the potential for BACS to save energy, the value of the savings and the benefit-costs
- low priority given to BACS energy performance
- economic barriers including split incentives, capital scarcity and competing capital needs, and an unfavourable perception and treatment of investment risk due to awareness and knowledge limitations
- capacity constraints including: limited know-how on implementing BACS energy-saving measures, and limited public-sector to support implementation.

Among the generic policy measures which could be applied to overcome these barriers are the following (note, these include ED/ELR, EPBD and EED related measures):

- product level measures, such as: minimum Ecodesign performance limits (e.g. control accuracy), minimum Ecodesign compatibility requirements, information requirements or product energy labelling (under ELR)

- system level measures, such as: a system label similar to an installer label for heating systems (under the ELR), minimum installed system energy performance/functionality requirements or minimum performance and compatibility requirements for products installed within TBS systems (under ED and/or EPBD).
- EPBD related measures⁸¹ that could be implemented at the Member State level or addressed in a future review of the EPBD:
 - (i) minimum TBS efficiency specifications incorporating BACS requirements applied for new systems or at the moment of renewal of old ones (already encouraged under Article 8 of the EPBD but not yet widely implemented)
 - (ii) measures with a potential to be applied as an alternative to heating and air conditioning systems inspection measures considered under Articles 14 and 15
 - (iii) potential input for a new and common approach for evidence-based energy performance certificates (EPC) under Article 11 that could potentially help close the reported performance gap between measured data and calculated EPC performance values
 - (iv) information on how smart a building and its BACS are via the forthcoming Smart Readiness Indicator (SRI).

Also measures that might be considered in relation to the EED such as:

- (i) potential linkages to energy efficiency obligation schemes (EEOs) and related incentives under Article 7 plus some other articles addressing incentives
- (ii) linkages with training, certification and accreditation articles
- (iii) public procurement measures.

EED measures that could build on Ecodesign information requirements for BACS are:

- incentives to preferentially install BACS in new buildings or replace existing low performance BACS with higher functionality & higher performance BACS potentially supported in accordance with EED Article 7 or EPBD Article 20
- quality assurance measures, in order to ensure competence in service delivery and the quality of installed systems as well as of products, plus adequate commissioning, user handover & after sales support – these might include measures proposed in accordance with the EED's Article 16.
- considerations regarding the relationships between BACS – RES & Market Design.
- awareness raising campaigns
- green public procurement (GPP) measures (e.g EED Article 6 and 5)
- energy management related measures (e.g. EED Article 8)
- DSO and flexibility related measures.

Other measures including:

⁸¹ Links to proposed amendments can also be drafted.

- DR and flexibility related measures
- interoperability requirements
- considerations regarding the relationships between BACS – RES & Market Design.
- awareness raising campaigns.

Lastly, BACS also have a material efficiency environmental impact that could be partly reduced via:

- ED measures to maximise the ease of reparability of BACS products.

Although many of the measures listed above are not implemented through ED or ELR some can only be implemented through ED/ELR policy measures and many are facilitated by these measures. In particular, the major energy savings potentials arise from the specification of high functionality BACS systems as per the BACS classes in EN 15232 for the building as a whole. It has been estimated that moving from the current spectrum of BACS to universal class A BACS can save approximately 22% of total EU building energy consumption². However, this transition to class A BACS is not happening automatically and the establishment of Ecodesign information requirements on products with EN 15232 functions can make it far more transparent and simpler for buildings as a whole to move to EN 15232 BACS class A levels. In principle, products which are only compatible with the lower EN 15232 BACS class D or C levels could then either be directly prohibited via ED minimum functionality requirements or indirectly phased out by building codes and the influence of the energy performance certificate (EPC).

Lastly, it is noted that following the EN 15232 and related EPBD standards for setting information requirements in the EC on BACS products would also facilitate the inclusion of BACS within the calculation of building energy performance certificates (EPCs)⁸², which is not usually done at present.

Figure 7 shows an overview schematic that illustrates how these measures could be organised and work together. Within this, the dotted boundary number 1 indicates the potential ED/ELR product measures. Boundary number 2 delineates BACS products groups while boundary number 3 delineates the set of functions to which these products can be linked. Boundary number 4 contains the new notion of a “smart BACS energy saving calculator”, which could source functional data from the BACS products combined with other data sources such as SRI/EPBD data and/or user selected inputs. The smart BACS energy saving calculator is a new notion explained into more detail in section 3.10. This is countenanced because the range and variety of BACS, related TBSs and BACS controlled systems and building types that could be addressed are so diverse that a conventional energy efficiency index or even the simple EN 15232 energy performance class (A-D) method might not produce representative results and/or do not give impacts from individual functions in particular applications.

⁸² <http://epb.center/support/epbd>

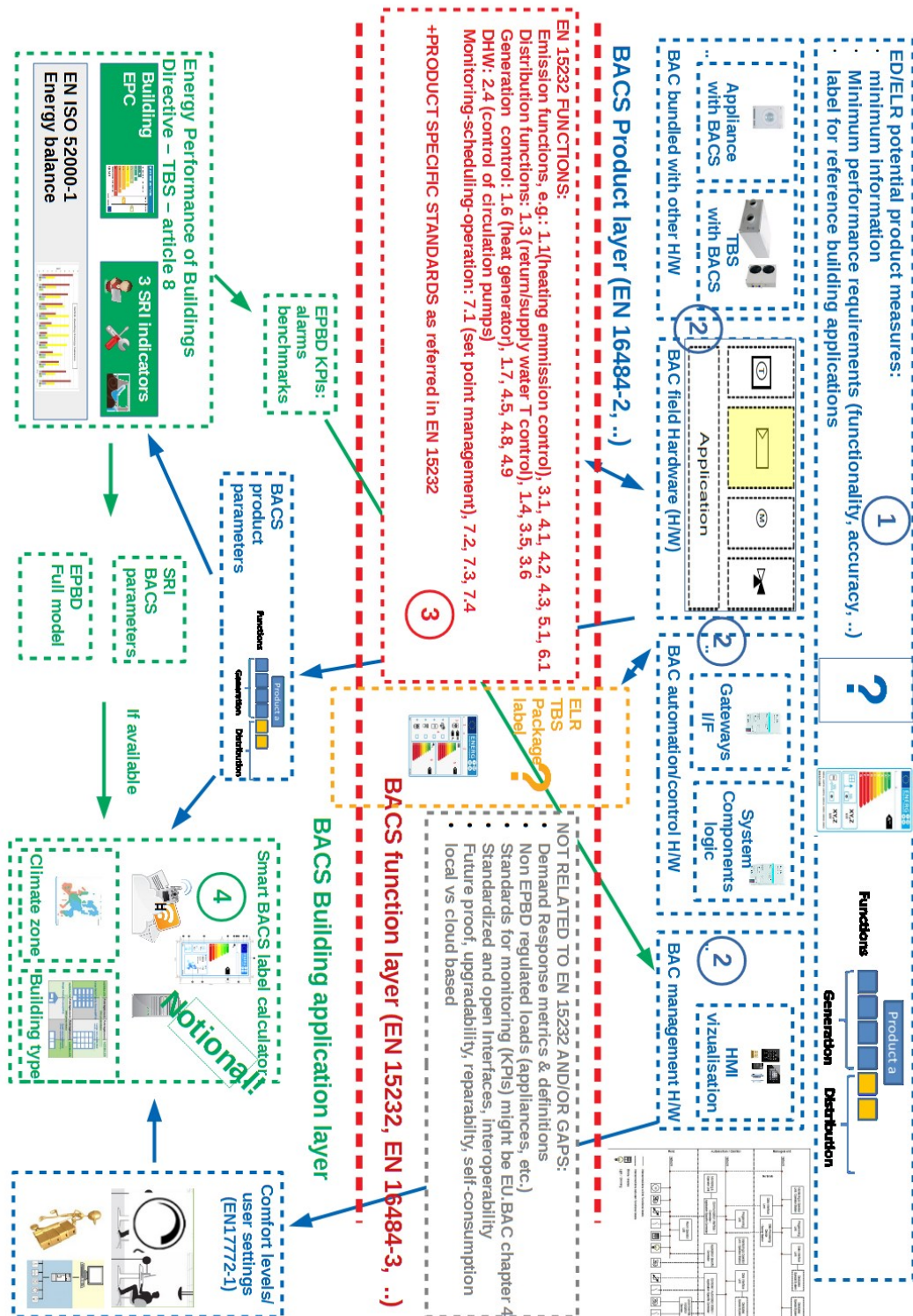


Figure 8 Potential ED/ELR policy context for BACS

The subsequent text summarizes these policy options and their context and provides some insight into their characteristics.

3.2. Typical BACS product-related requirements that could be specified within the ED/ELR

Prospective Ecodesign measures for BACS products include both generic information requirements and minimum performance requirements.

A non-exhaustive list of examples of potential generic information and/or minimum performance requirements for BACS could include the imposition of:

- mandatory harmonized reference to the designated BACS functions and parameters in accordance with EN standards (e.g. EN 15232⁸³, EN 15193, etc.)
- minimum compatibility requirements of the BACS product information with the methodology and tools to be used in the SRI (see below) and/or a prospective smart BACS energy saving calculator (see below; in principle the method could be ICT based - the full BACS preparatory study could elaborate a proposal for how this should be developed)
- minimum functionality requirements for certain BACS functions, e.g. a hypothetical requirement for the EN 15232 Emission Control (1.1) function to ensure that individual room control is enabled (whenever there are two or more rooms)
- minimum control accuracy requirements for certain BACS functions, e.g. heat emission room controller accuracy (as defined in EN ISO 52016-1)
- minimum requirements for interoperability to facilitate the interplay and life cycle or life time of BACS, e.g. require a EN standardized or open standard interface for certain control products.

There could also be the imposition of typical ED product-related requirements on the self-consumption/efficiency or reparability at the BACS products themselves, for example: when electromechanical relays are used then inclusion of a socket to facilitate easy repair and replacement could be required.

Energy labelling⁸⁴ measures could be developed for BACS in the context of the new Energy Labelling Regulation (EU) 2017/1369 (ELR). This could potentially include amongst others:

- energy labelling for BACS (set at the product level but potentially based on how well they deliver an energy saving function)
- a label associated with the smart BACS energy saving calculator (see section 3.10)
- the supply of product performance information to a database for market surveillance purposes and to support consumer decision making.
- Providing input into the review of existing energy labels that apply bonuses for BACS e.g. EU Regulation No 811/2013 on energy labelling for space heater packages, hot water storage tanks label Regulation No 814/2013, the on-going

⁸³ <https://www.downloads.siemens.com/download-center/Download.aspx?pos=download&fct=getasset&id1=A6V10258635>

⁸⁴ In the context of the Energy Labelling Framework Regulation (complete)

Ecodesign Lot 1 space heater review of EU Regulation No 813/2013, and the Lot 20 (EU Regulation No 2015/1188) for local space heaters.

3.3. BACS EN 15232 functions as a backbone for ED/ELR policy aiming to address the indirect energy impact

As mentioned in sections 1.2.4 and 1.2.6 the EN 15232 standard on *Energy Performance of Buildings - Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10* classifies BACS solutions in terms of the energy savings functionality they provide and offers two methods (a simplified and a complete) by which the impacts of these solutions on building energy performance can be assessed. The functionality classification applies to all types of technical building systems including: heating (emission, distribution and generation), domestic hot water, cooling (emission, distribution and generation), ventilation, lighting, and blinds as well as aggregate monitoring and control services.

The EN 15232 classifications mainly relate to loads or generators of the Technical Building System (TBS) and hence operate at a systems level that could be subject to regulations developed through the implementation of the Energy Performance of Buildings Directive. This means that plug loads such as home appliances are not included although they could also benefit from BACS, for example to minimize their standby losses when a building is in an unoccupied state or to control appliances for demand response (DR).

3.4. Ensuring information is present to allow optimal BACS solutions to be specified and determining the policy scope for BACS products

As discussed in the introduction, despite their significant savings potential, the principal BACS functions are poorly understood in the market and BACS systems are routinely under and/or poorly specified. This causes a significant waste of energy. In addition, a considerable amount of energy is also lost due to poor commissioning and tuning of the BACS after purchasing or installation.

The lack of clear, good quality, standardised information is at the heart of this problem. Currently, BAC hardware are sold with manufacturer reported technical data but usually without information about to what extent the product can fit within a BACS to deliver an overall energy outcome. In particular, there is a need for BACS products to be positioned in terms of their contribution to the BACS energy performance classes (A to D) defined in the standard EN 15232⁸⁵, so that their overall impact on building energy performance becomes apparent and the value proposition of higher efficiency BACS solutions can be communicated in a common, technology neutral and equitable manner to systems procurers and specifiers.

A better understanding with standardised information and functions can help installers and users to reduce their energy bill with minimum additional capital investments.

⁸⁵ EN 15232-1:2017 Energy Performance of Buildings - Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10

As such, a key need of the full BACS study will be to help define standardised informational needs for BACS via Ecodesign and/or energy labelling so that their specification becomes much easier and the outcomes expected more transparent.

BACS-products made available on the market can be characterized by their contribution to the BACS functionalities but also by their accuracy and quality. Hence, scoping and product definition according to the BACS functions can cover various BACS hardware, implementing a single function or a group of functions, a bundle with TBS, or be standalone. This function oriented approach therefore provides a level playing field to all kinds of BACS suppliers. The standard EN 15232 can serve as an appropriate starting point for setting information requirements and the scoping of BACS product policy. This standard was developed in support of the Energy Performance in Buildings Directive (EPBD) and already provides a comprehensive list of the building services and BACS functions that have an impact on the energy performance of buildings. For each service the standard defines up to four functionality levels with the highest functionality level expected to produce the greatest energy saving impact.

For the other characteristics of BACS that affect their quality and service provision, such as control accuracy and heat emission, the underlying EPBD standards such as EN15316-2 and EN15500 respectively can complement the EN 15232 standard.

In particular, the key need is to ensure that the contribution that specific BACS products can make is clearly positioned in terms of their impact on the building energy consumption. EN 15232 proposes two methods to do this. A detailed method 1 which provides a high accuracy, and a simplified "BACS factor" method 2 which provides a rough estimate of impact for higher level BACS functions but is less suited to determining the impact of specific products or individual BACS functionality levels. Method 2 defines BACS energy performance classes ranging from D to A based on the BACS functionality levels grouped per TBS service domain (heating/cooling emission, distribution and generation; domestic hot water generation; ventilation; lighting; monitoring, scheduling and operation etc.). These same classes are also proposed for use within the SRI being developed for the revised EPBD. A key exercise for the full study will be mapping the functionality and performance of specific BACS components to the services and functionality levels per TBS and BACS solution specified in EN 15232. In accordance with method 1 the full study could also investigate the possibility to introduce a smart online BACS energy savings calculator, as described later in section 3.10.

Also following the BACS functionalities and parameters defined in EN 15232 combined with the other relevant EPBD standards it refers to will facilitate the inclusion of BACS functions within the calculation of building energy performance certificates (EPCs)⁸⁶.

In principle, this will allow Ecodesign information requirements to be set for BACS components that should greatly facilitate the specification of BACS solutions and thereby help unlock the very substantial indirect energy savings that have been identified from the proper specification of BACS. This single aspect is likely to be the greatest contribution that Ecodesign measures can make e.g. if BACS Ecodesign information specifications help to unlock ~10% of the potential savings from proper specification of BACS systems this is provisionally estimated to be worth approximately 2.2% of all TBS energy consumption in the EU i.e. at least 83 TWh of primary energy in 2030.

⁸⁶ <http://epb.center/support/epbd>

3.5. Setting Ecodesign limits on accuracy and functionality levels of BACS product services

Not all BACS products of a similar type provide the same degree of functionality or accuracy and there are believed to be important energy savings potentials from improving both. A market failure currently arises because too few procurers and specifiers are aware of the potential to save energy from higher accuracy or functionality and in any case many would face split incentives that make them more likely to choose less efficient legacy products than products that would minimise energy costs over their lifecycle.

This scoping study has identified 24 BACS functions that could be suitable for minimum level of functionality specifications under Ecodesign regulations and also 13 BACS functions for which there are likely to be significant energy savings opportunities from Ecodesign limits on accuracy. Amongst this there are:

- heating emission control – control accuracy & set point accuracy
- cooling emission control – control accuracy & set point accuracy
- room ventilation supply air flow control accuracy
- room air temperature control for all air systems
- monitoring, scheduling and operation – time recording & set point accuracy.

Examples of product groups which provide these services and could be subject to such requirements are:

- electronic radiation valves and room temperature controllers
- room/zone temperature controls for different emission equipment, e.g. ventilation convector control valves,
- room/zone temperature controls that avoids concurrent heating and cooling emission
- air dampers combined with CO₂ or occupancy sensors
- air dampers combined with temperature sensors.

It is provisionally estimated that setting requirements for heating emission control accuracy alone would save at least ~ 1% of all EU heating demand i.e. ~ 17.5 TWh in 2030 (the figure could be substantially higher). Requirements for the other functions mentioned might lead to a similar order of magnitude of savings for all the affected products combined. Note, it may also be appropriate to consider the establishment of energy labelling measures for equipment product groups that provide these functions.

3.6. Setting Ecodesign requirements on self-consumption

While BACS help to control TBS systems and hence to better manage the energy used by TBSs they also consume some energy in doing so. This energy is mostly much less than the energy they help to save but nonetheless some technical solutions are likely to fulfil the BACS functions more efficiently than others and thus there may be scope to reduce the self-consumption of BACS by specifying Ecodesign limits. Again there is a market failure because the self-consumption of BACS is barely reported and there is little incentive for suppliers to opt for products that minimise this aspect, especially if it entails a slight increase in product cost.

As mentioned in 2.1.7 on the self-consumption of BACS found that the energy consumed by building automation systems was not negligible.

In principle, it may be possible to establish ranges (from base case to best available technology (BAT)) of energy consumption per component function provided. In this way the energy budgets for BACS components can be established based on their function, e.g. by the establishment of maximum consumption limits for components which are common to most BACS (such as sensors, actuators, communications, displays etc.). These energy budgets could then inform prospective Ecodesign implementing measures. Potentially, this would allow modular energy budget limits to be established based on the set of components used. This would avoid the need to define limits per higher level function, which might be too complex to be practicable given the very wide array of potential BACS solutions available. Also clear product information on self-consumption can result in low power BACS system designs (see the discussion on interoperability).

3.7. Other potential Ecodesign requirements that are not directly related to energy

As already mentioned in Chapter 2 there are also other potential BACS Ecodesign requirements that could produce beneficial environmental impacts. These include:

- potentially setting Ecodesign requirements for Demand Response, especially for BACS, or complementing and continuing the work done in Lot 33 on Smart Appliances
- potentially setting requirements for the interoperability of BACS.

Finally also consideration of the development of Ecodesign requirements on lifespan and reparability were recommended, for example with regard to the availability of spare parts, upgradability, etc. Note that reparability and upgradability are addressed by the new Mandate M/543 request to the European standardisation organisations with regard to Ecodesign requirements on material efficiency aspects for energy-related products.

3.8. The treatment of BACS functions within the space heating, hot water and solid fuel boiler package labels (EC Regulations 811/2013, 812/2013 & 2015/1187)

EU Regulations 811/2013, 812/2013 and 2015/1187 with regard to the energy labelling of space heaters, water heaters and solid fuel boilers respectively have introduced so-called *package labels* for the product systems they apply to, e.g. energy labelling requirements for heating systems that have to be implemented by the supplier or the dealer (in the case when the supplier only offers the components) of the system. Within these regulations the impact of controls is taken into account to the extent that they apply to the heating generator but not fully with regard to the distribution or emission of heat where many of the largest energy savings potentials arise.

The regulations for space and water heaters are currently under review. The project websites for the associated Lot 1 and Lot 2 review studies are <https://www.ecoboiler-review.eu/> and <https://www.ecohotwater-review.eu/study.htm>.

The existing package label defines 8 classes of temperature controller and attributes a saving percentage (-%) for the calculation of the space heating energy efficiency label. For example, class 1 is a mechanical on/off room thermostat that is ascribed a 1 % energy saving impact whereas class 8 is a multi-sensor room temperature control for

use with modulating heaters which is ascribed a 5 % energy saving impact. The highest savings bonus attributed to any type of temperature controls is 5%.

These bonuses were developed in the course of the respective Lot 1, Lot 2 and Lot 20 preparatory studies but appear to have been developed as an aside to the main focus of both studies and may not reflect the state of the art in terms of the savings potentials. For example, EN 15232 awards energy savings bonuses for weather compensation of 9% for residential space heating and even more for non-residential buildings, which is significantly greater than the bonus allocated in the space heater package label regulation.

Overall, the bonuses currently presented in the Ecodesign and Energy Labelling regulations seem not to be aligned with EN 15232. Therefore, it is proposed that the full BACS preparatory study should review these bonuses with an aim to establish more representative values based on state of the art knowledge. This should be done in cooperation with the study team that is working on the review of Lot 1 and 2. It is expected that the findings from this review should be available in time to inform future deliberations on the revision of the Ecodesign and Energy Labelling requirements for space and water heaters.

3.9. The broader scope of EPBD including linkages with the SRI and the EPC

The agreed text for the revised EPBD has clarified and strengthened the requirements on Member States regarding the imposition of minimum energy performance specifications for technical building systems (TBSs) that would apply whenever a TBS is replaced within a building. This includes the impact of BACS controlling the TBSs; which is likely to offer the greatest energy savings potential associated with the use of BACS.

In addition, the revised EPBD will introduce a new policy instrument, the Smart Readiness Indicator (SRI), whose methodology is being developed by the Commission and which is to be implemented on a voluntary basis by Member States. Details of the ongoing work to develop the SRI can be found at: <https://smartreadinessindicator.eu/>.

Since its inception the EPBD has required energy performance certificates (EPCs) to be issued for buildings whenever there is a change of ownership/occupancy of existing buildings as well as for new buildings. Many Member States use EPC calculation tools supported by a comprehensive suite of EN standards. In principle, these should require the input of BACS performance data and therefore the calculations would benefit from BACS data compiled in a standardised manner. Nevertheless, the energy savings potential from BACS solutions are not currently captured in many EPC calculation methods, which might in part be due to a current lack of effective functionality classifications and performance data for the various BACS solutions.

The evolving SRI methodology further classifies BACS performance into prescribed functionality levels in accordance with EN15232 (see below) and thus it will be important that BACS products supply product information that enables them to be positioned within this framework. Thus, here again, there is benefit from standardised BACS product functionality information and performance requirements which can be further developed under the ED/ELR.

3.10. Open issues for potential BACS product ED/ELR policy that are not covered by EN 15232 functions

The following topics are not covered or elaborated within EN 15232 and/or the EN standards to which it refers and hence would benefit from further attention:

- some Demand Response (DR) metrics and definitions are incomplete or missing (see also the Ecodesign Lot 33 smart appliances study)
- EN 15232 only addresses the TBSs and therefore the loads which can be regulated under the EPBD; therefore, functions that apply to home appliances are missing or incomplete, for example a prospective BACS function to deliver savings in standby losses by putting the whole property into standby mode
- today there are no EN standards that define Key Performance Indicators for building energy performance or the information to be displayed for building energy monitoring, therefore it is difficult to clearly define the 'building energy monitoring' function (which could be a useful subject for a future regulation) nor to precisely quantify its impact (which could be useful input for a smart BACS energy saving calculator – see below). So far, only the EU.BAC certification scheme has defined and included building Key Performance Indicators(KPI)⁸⁷.
- standardized and open interfaces for interoperability
- upgradability, reparability, future proofing and self-consumption of products
- issues regarding which BACS functions should run permanently within the building installed hardware versus temporarily on an external service solution (i.e. be cloud-based).

3.11. A prospective on-line Energy Efficiency Index or “smart BACS energy saving calculator”

A new notion is to examine the derivation of an internet-based “smart BACS energy saving calculator”. This is countenanced because the range and variety of BACS, related TBS and BACS controlled systems and building types that could be addressed are so diverse that a conventional energy efficiency index calculator for an energy label, as was used for lighting in Regulation (EU) No 874/2012, might not produce representative results. Moreover, to calculate the impact from this wide variety of BACS with an acceptable accuracy is not an easy task, considering that a whole set of European standards have been elaborated but that a full calculation code for this is not established or publicly available. The complexity arises from the many components that influence the building energy balance in combination with a broad range of possible building technical properties, climate conditions and use.

Several variable factors can influence the energy balance such as: transmission losses, ventilation losses, humidification, auxiliary power for HVAC, solar gains, internal heat gains from people, appliances, lighting, etc. This results in complex interactive effects; for example in the case of the heat replacement effect raising the efficiency of an

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https://www.eubac.org/cms/upload/downloads/system_documents/eubac_System_Presentation_2015-11-04.pdf

appliance reduces internal loads but simultaneously increases the need for heating (yet reduces cooling loads). Moreover the dynamic response of buildings to BACS can be very different due to the technical characteristics of the building and the TBSs and this can result in quite different impacts, for example a building with a longer thermal time constant due to better insulation will have disproportionally lower energy savings from night time set back of heating set-point temperatures compared to a less well insulated building because the lower set points cannot be reached within the period of the night time.

As a result, such a complex building ecosystem of fabric characteristics, TBSs and BACS can hardly be satisfactory modelled by a simple linear and cumulative approach wherein a single, or a group, of BACS functions is simply linked to average fixed saving factors. This means that the detailed method 1 set put in EN 15232-1:2017 should be preferred to the extent possible over the simplified BAC factor method 2, which is a rough estimate for a group of BACS functions but which cannot be accurately applied to individual functions or products.

In principle, a smart web-based BACS energy saving calculator could take into account the interplay with the different potential building types and climate zones, the diverse TBS and other BACS driven systems, interactive effects between various BACS functions and the avoidance of double counting of impacts. The level of detail in the input data supplied to such a smart calculator could be flexible and range from a selection of inputs by the end user at a simple level up to the use of building-specific data from the SRI and/or EPC calculations whenever they are available at a more thorough level. The BACS technical data supplied at the product level should be able to calculate an energy efficiency index and therefore estimate energy savings from more advanced functionality. A requirement could also be established for BACS products to provide a direct standardised reference (e.g. via a QR code) to the website where the smart calculator can be found. There may also be options to use the calculator to derive a BACS energy label and to support conformity assessment and market surveillance.

4. Potential options for the scope of a full BACS study

Considering the information presented previously the scope of the full BACS preparatory study will need to be considered and decided upon.

Greatest beneficial impacts

Overall it seems that the greatest beneficial impacts will be attained from:

- examining the development of Ecodesign information and/or ELR requirements on the functionality of BACS products. This will facilitate the specification of BACS in line with the energy performance classes(A-D) set out in EN15232 and the implementation of BACS-related TBS requirements under the EPBD. It would also enable the use of the proposed online smart BACS energy saving calculator. Very provisionally it is estimated that providing such information could generate energy savings worth 2.2% of all TBS energy consumption in the EU, i.e. at least 83 TWh of primary energy in 2030
- examining the development of Ecodesign limits on accuracy and functionality levels of BACS product services. It may also be appropriate to consider energy labelling measures for equipment product groups that provide these functions.
- reviewing the bonuses applied to packaged (bundled) BACS within the ED/ELR regulations for space heaters, water heaters and solid fuel boilers
- assessing the options to impose limits on the self (direct) energy consumption of selected classes of BACS products, potentially leading to annual energy savings of ~ 9 TWh of final energy across the EU.

Over the longer term there could also be considerable benefit in the study examining the scope and needs to develop an on-line smart-BACS energy saving calculator, compatible with the information requirements.

Potential Content of the study:

a main focus for the study should be the development of harmonized information requirements for all BACS working with the Technical Building System (TBS) as referred in the EPBD. To this end the full study will also map affected BACS products to the functions. This will be a major exercise, however, it is proposed not to involve all the MEErP Tasks (2-6) in detail for this process to ensure that the work load is achievable within the timeframe and budget and to focus on the essentials of BACS that can be addressed within the relevant policy framework.

With this information policymakers and building owners will easily see how products fit within the delivery of the BACS service classes (A to D) defined in EN 15232 for a group of BACS functions within a building.

A significant part of the rest of the study will be concerned with developing Ecodesign and energy labelling criteria for products that provide the specific BACS functions discussed under **setting Ecodesign limits on accuracy and functionality of BACS product services**.

In particular, there is a need to review the Ecodesign Lot 1 and Lot 2 temperature control corrections for space heaters and water heaters respectively and potentially also those applied in the Lot 20 work on *Local room heating products*. This could be done in

cooperation with the study teams who are preparing the review study for these products.

In addition the study can also address the following BACS aspects:

- interoperability for BACS
- BACS contribution to demand response and continue on remaining issues of Lot 33
- material efficiency options potentially via reparability requirements.

Within the study the level of depth in which the previous three BACS aspects are analysed according to the MEErP can be reduced to fit within the time and budget.

Application of the MEErP

In general, the MEErP is followed for establishing all the limit values or bonuses that affect limit values.

For setting Ecodesign limits on accuracy and functionality of BACS product services, the usual Ecodesign MEErP Task 1 to 7 activities are envisaged. For these it is proposed that a number (up to ten) of reference buildings and a number (subset of EN 15232) BACS functions would be investigated, the numbers depending on available resource allocations. The main focus of this work would be the derivation of prospective functionality and accuracy requirements. In addition, self-consumption and non-energy related impacts should also be examined for the common components. However, also for these requirements the application of the MEErP will need to be creative:

- it is likely, that the accuracy and functionality assessments would initially be done per primary BACS function, whereas the self-consumption of components could be assessed at the product level.
- simplifications of Task 5 with respect to the bill of materials (BOM). This is because the functional approach can be implemented with a multitude of different hardware. Therefore, assess the BOM would result in a disproportionate research effort. Nevertheless, many of the material efficiency issues can potentially be addressed horizontally and are similar to other product groups. Hence they can be sourced in these studies and considered in Task 7 without analysing them into detail in Tasks 5-6..
- the cost optimization of the MEErP Task 6 could be difficult to conduct due to the potential for bundled combinations of BACS products, thus a simpler method could be countenanced e.g. via stakeholder enquiry, using overall costs for BACS classes A to D, etc.

Requirements for which a non-full MEErP tasks are foreseen in the study are:

- a review of standardisation needs to support flexibility requirements
- a review of interoperability aspects and needs
- the establishment of the supporting technical needs for the development of a BACS calculator.

The various activities to be addressed in the full preparatory study and their relationship to the MEErP process are set out in Table 8.

Table 8 Activities of the full preparatory study and relationship to the BACS products considered and the MEeRP

	Subset of selected BACS functions for in-depth analysis	Temperature controls for Lot 1, 2 & 20 Products	All BACS products	Full MEeRP using reference cases
Information requirements			Y	N
Self-consumption requirements per component module			Y	Y
Accuracy & functionality limits	Y	N	N	Y
Efficiency bonuses		Y		Y
Interoperability specifications			Y	N
Flexibility needs			Y	N
Non-energy requirements	Y	?	?	?
On line BACS calculator needs			Y	N

Key: Y = yes, N = No

Annexes

Annex A - Lighting control functions defined in EN 15193-1:2017

Annex B - Minutes of the stakeholder meeting

Annex C - Powerpoint presentation of the stakeholder meeting

Annex D - Details of the stakeholder survey

Annex E - List of potential PRODCOM codes for BACS

Annex F - Stakeholder position papers EU.BAC

Annex G - Stakeholder position papers EHI

Annex H - Stakeholder position papers BEAMA

Annex I - Stakeholder position papers LE

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Note: all annexes are available in a separate document.