Appendix B – Building/Construction Sector Methodology

April 2024

EGDC ICT Methodology

EUROPEAN GREEN DIGITAL COALITION

Funded by the European Union

Deliverable name: Building/Construction Sector Methodology

Dissemination Level: Public

Published: April 2024

The European Green Digital Coalition (EGDC) is an initiative of companies, supported by the European Commission and the European Parliament, based on the request of the EU Council, which aims to harness the enabling emission-reducing potential of digital solutions to all other sectors.

The secretariat of the European Green Digital Coalition is managed by the consortium of the European Parliament Pilot Project for the EGDC, funded by the European Commission, namely the leading associations GeSI, the European DIGITAL SME Alliance, DIGITALEUROPE, ETNO and GSMA, working together with Carbon Trust, Deloitte, Sustainable ICT.

This deliverable has been produced by the consortium of the European Parliament Pilot project for the EGDC.

Global Enabling Sustainability Initiative (Coordinator)

DIGITALEUROPE

European Telecommunications Network Operators' Association

European DIGITAL SME Alliance

SUB-CONTRACTORS

Carbon Trust

Deloitte

GSMA

Sustainable ICT Consulting

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In addition, the case studies used in this methodology were received from the following organisations: Schneider Electric and Inteligg

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Introduction

To ensure the digital transition reinforces the green transition, the European Green Digital Coalition (EGDC) was formed in March 2021 supported by the European Commission and the European Parliament, based on the request of the EU Council. The main aim of the EGDC is to maximise the sustainability benefits of digitalisation within the ICT sector, while supporting sustainability goals of other key sectors such as energy, transport, agriculture, and construction. EGDC members commit to contributing to the success of the green digital transformation of the EU and beyond by taking action in the following areas:

- To invest in the development and deployment of greener digital technologies & services that are more energy and material efficient,
- To develop methods and tools to measure the net carbon impact of green digital technologies on the environment and climate by joining forces with NGOs and relevant expert organisations,
- To co-create with representatives of other sectors recommendations and guidelines for green digital transformation of these sectors that benefits environment, society, and economy.

As a cross-cutting sector, the EGDC recognises that the ICT sector can deliver emissions reductions in other sectors through the development and deployment of new solutions that would otherwise not be possible and replace existing solutions with high associated emissions.

In order to affirm, communicate and maximise the intended impact of the solutions that are being enabled by digital technologies, it is crucial that their impact is being measured in a robust and consistent way. Responding to this need and following from the EGDC Declaration, the EGDC's "Net Carbon Impact Assessment Methodology for ICT Solutions" was developed to provide a methodology for the ICT sector to develop methods and tools to measure the net impact of ICT solutions on the environment and climate.

While this methodology is sector agnostic and aims to provide a set of requirements for assessing the net carbon impact of ICT solutions in any implementation context, there are many sector specific challenges and specificities that need to be considered. This document aims to support users of the EGDC methodology with developing net carbon impact assessments for ICT solutions implemented across different sectors, by offering a demonstration of how the individual requirements from the EGDC methodology can be applied using practical examples from sector specific case studies.

The aim of this document is therefore to demonstrate the application of the EGDC methodology for ICT solutions implemented in the building and construction sector. To achieve this aim, the following ICT solutions that have been developed into case study calculators as part of the EGDC Pilot Project will be used:

- **Schneider Electric High-Performance Building Management System (BMS) –** This solution automates management processes to enable emissions savings from energy reduction in non-residential buildings.
- **Inteligg – c-BEMS –** c-BEMS is a cloud-based SaaS (software-as-a-service) tool for the Building energy management system (BEMS) that achieves high energy savings for any kind of buildings through building automation technologies by implementing remote control of multi-zonal heating/cooling and lighting systems via Wi-Fi connected sensors in a unique IoT platform by employing AI algorithms and Model Predictive Control to automate the energy/lighting consumption behaviour detection, thermal modelling of the building, energy demand prediction and optimization.

While these case studies do not necessarily illustrate best practice applications of the EGDC's "Net Carbon Impact Assessment Methodology for ICT Solutions", they provide a realistic application that aims to demonstrate how the methodology can be used under different circumstances. Furthermore, this document highlights where a case study has not fulfilled the criteria and details steps that would need to be taken in order for the criteria to be fulfilled.

How to use this document

This document mirrors for the most part the requirements laid out in sections 3, 4 and 6 of the EGDC's "Net Carbon Impact Assessment Methodology for ICT Solutions. As such, it should be used in conjunction with the requirements and guidance laid out in the EGDC's "Net Carbon Impact Assessment Methodology for ICT Solutions and used as a reference point to illustrate how each requirement can be applied in practice for solutions in the building and construction sector. Note that while the examples provided in these documents could be applied to other ICT solutions in this sector, they are not prescriptive and other approaches to meeting the requirements in the "Net Carbon Impact Assessment Methodology for ICT Solutions" can be applied if appropriate.

Methodology Application in the Building and Construction Sector

This section outlines all requirements in the EGDC's "Net Carbon Impact Assessment Methodology for ICT Solutions" that impact emissions in the building and construction sector. The application for each requirement is shown using two ICT solutions that impact the emissions in the building and construction sector. Certain requirements are combined if it made sense to illustrate the application of these requirements together. This may also affect the order of the requirements in some cases.

Defining the Assessment

Assessment Objective

The assessor shall define the following:

(A) Assessment aim: Describe the intended use of the output from the assessment

Schneider Electric, High Performance BMS

The assessment intent is to determine to what extent the Schneider Electric High Performance Building Management System (BMS) solution can have a net positive impact on the building sector when implemented in both a specific context, as well as across a number of theoretical office locations across different European locations through predictive modelling. Furthermore, the aim of the assessment was also to test the EGDC ICT Sector Guidance for Net Carbon Impact Assessments and identify sector-specific methodological considerations.

Inteligg, c-BEMS

The assessment intent is to understand the net carbon impact of the implementation of the c-BEMS solution in an office building and two residential apartments. Furthermore, the aim of the assessment was also to test the EGDC ICT Sector Guidance for Net Carbon Impact Assessments and identify sector-specific methodological considerations.

(B) Assessment type: Define if the assessment will consider a single implementation context or if multiple contexts will be carried out.

Schneider Electric, High Performance BMS

The assessment considers the implementation in a single context of Schneider Electric's Technopole building in Grenoble, France, as well as in multiple implementation contexts in commercial buildings of different sizes across different European countries.

Inteligg, c-BEMS

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The assessment considers multiple implementation contexts. One context is an office building in Belgium, while the other context is two residential apartments in Greece.

(C) Assessment perspective (actual / potential effect): Determine if an ex-post or ex-ante assessment is to be carried out.

Schneider Electric, High Performance BMS

The assessment aims to determine the actual, ex-post impact of the solution in Schneider Electric's Technopole building, as well as the ex-ante impact across commercial buildings in several European countries based on archetype data.

Inteligg, c-BEMS

The assessment aims to determine the ex-post impact of the solution in two different implementation contexts.

Solution Description & Boundary

The ICT solution to be assessed shall be clearly defined including:

(A) A description of the ICT solution and its functionality.

Schneider Electric, High Performance BMS

The High-Performance BMS allows for control of air quality, temperature, occupant comfort, lighting and heating in buildings. These commercial systems provide high levels of control which optimises space, time and energy use. It saves energy by heating, cooling and lighting, when and where it is needed in the building.

Inteligg, c-BEMS

c-BEMS works by measuring temperature, humidity, and the occupancy rates of various spaces within a building. Using AI, it calculates and optimises energy consumption behaviour, thermal modelling of the building, and energy demand.

This way, c-BEMS reduces overall energy demand, therefore reducing GHG emissions.

B) The key mechanism(s) by which the ICT solution is expected to result in changes to GHG emissions.

Schneider Electric, High Performance BMS

Energy reductions, and therefore GHG emissions, arise from the additional implementation and use of IoT sensors in the High Performing BMS. These sensors increase the efficiency of the

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occupancy, CO2 monitoring, light and blind controls, while enabling HVAC and light demand to be controlled based on occupancy. The High Performing BMS allows for real-time monitoring of power consumption and uses, reductions in base consumptions and optimized energy control. Due to these capabilities, the High Performing BMS has a larger carbon saving impact in comparison to both the Advanced BMS and Standard BMS.

Inteligg, c-BEMS

Inteligg's c-BEMS uses Artificial Intelligence to estimate when to turn on and off the heating. It does this by measuring data on occupancy levels, humidity, and a building's heat profile. By predicting and optimising energy demand in specific spaces, the solution reduces the overall amount of time the house is heated, cutting natural gas use and also GHG emissions.

(C) The sector(s) in which the ICT solution is expected to be implemented in.

Schneider Electric, High Performance BMS

The solution is implemented in the buildings sector. It can be rolled out across many different types of commercial buildings, in particular it is very relevant in buildings where you have sub-partitions such as hospitals, hotels and to a lesser extent education buildings.

Inteligg, c-BEMS

The solution is implemented in the building and construction sector and has been used in residential buildings, offices, restaurants, and public buildings (including a church and town hall).

(D) Any limitations to the use of the solution (e.g., geographical, technical, operational, etc.).

Schneider Electric, High Performance BMS

The solution requires network infrastructure to allow for data transmission, as well as existing HVAC equipment, metering infrastructure, valves, and dampers. Furthermore, the solution requires an understanding of energy management to ensure the solution is installed and operated correctly.

Inteligg, c-BEMS

The solution requires, at a minimum, a stable Wi-Fi connection to function as well as previously installed heating systems, including boilers and radiators.

(E) The ICT solution boundary as a description of all components comprising the solution.

Schneider Electric, High Performance BMS

Digital components:

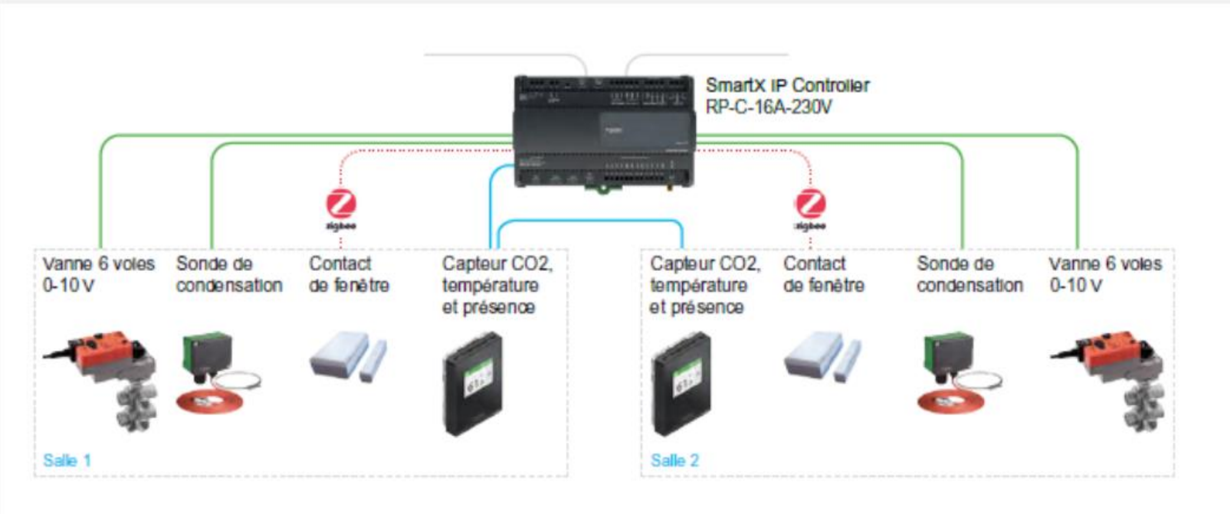
- Controllers

    - Global controller
    - Local controller BCL (RPC)*
    - Remote control
- Sensors
    - Light level/Occupancy multi-sensor (Infrared motion detection sensor)
    - CO2 measurement in a rH + T°C sensor
- IT infrastructure (Network and servers (on-site) used for data storage and transmission)
- Usage of laptop devices and software required to operate the BMS
- Metering
    - Electricity use and thermal energy meters

Non-digital components:

- Actuators
    - Valves
    - Dampers
    - Office Buildings
    - HVAC equipment

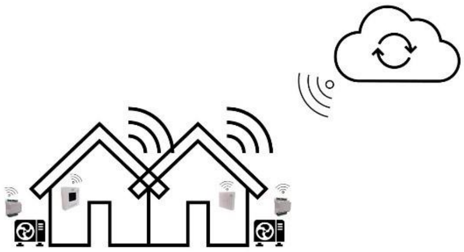
Note: the RPC Controller is not present in the Standard BMS Reference scenario but is present in the Advanced BMS Reference Scenario.



Inteligg, c-BEMS

The solution requires a smart controller module, smart thermostat module and at least one smart sensor module. Inteligg has partnered with DVC-co to provide these. The associated embodied emissions are included into the calculations for the reference scenario. The solution also consumes server energy. Since in other case studies the embodied emissions associated with server usage were insignificant, they have not been taken into account in the calculations for the reference scenario.

Non-digital components include a previously installed heating system, including boilers and radiators.



Functional Unit

(A) The functional unit for the assessment shall be defined including descriptions of its:

- (i) Function relevant to both reference and ICT solution scenarios
- (ii) Unit quantity
- (iii) Performance

Schneider Electric, High Performance BMS

The chosen functional unit is energy savings per square meter in an office building. The building control architecture is distributed and measured by 'zone', which is 17sqm. One zone is defined as the width of 2 window frames, equivalent to 4-6 desks, and consists of 1 combined light level/occupancy sensor, a combined temperature relative humidity and CO_2 sensor, and 1 zone controller (RPC). This is a suitable functional unit as the floor area is often a key metric used to measure the energy intensity of buildings.

The function provided is the monitoring and control of the office environment, including temperature and lighting.

The unit quantity is the floor area (square meter) which the solution covers.

The performance would be around the energy consumed to achieve a comfortable office temperature and lighting environment.

Inteligg, c-BEMS

The chosen functional unit is kWh per degree day per year.

The choice for kWh reflects the way energy is generally presented on energy bills and allows for a comparison across geographies and building types.

Degree days are used to account for different climates and weather conditions. Whilst it is part of the functional unit, it is not provided as an output in the calculator, but it is embedded in the back-end calculations of the model.

The unit of years is chosen to control for the yearly cyclical nature of energy consumption, allowing for a comparison of measurements taken in different seasons and with different outside temperatures.

The function provided is the monitoring and control of the building temperature.

The unit quantity is the amount of energy consumed in kWh.

The performance is the amount of energy used to provide the desired building temperature.

Assessment Boundary

The assessment boundary determines which activities should be included in the net carbon impact assessment and therefore which emissions are included in the calculation.

(A) All GHGs covered by the Kyoto Protocol shall be included in the assessment and reported in a single CO2e value in alignment with common greenhouse gas reporting standards.

Schneider Electric, High Performance BMS

The emission factors used to calculate the net carbon impact of the ICT solution cover all GHG emissions covered by the Kyoto Protocol and are reported in terms of CO2e.

Inteligg, c-BEMS

The emission factors used to calculate the net carbon impact of the ICT solution cover all GHG emissions covered by the Kyoto Protocol and are reported in terms of CO2e.

(B) The assessor shall define the time boundary for the assessment.

Schneider Electric, High Performance BMS

There are two separate calculation boundaries for this assessment, each with different time boundaries.

Route 1 has a time boundary of one year and assesses the impact across several European countries.

Route 2 has a time boundary of two years, comparing 2019 and 2021 building consumption at the Schneider Electric's Technopole building in Grenoble, France.

Inteligg, c-BEMS

The time boundary for the assessment is a 24-month period. For both implementation contexts (1 building and two apartments), the yearly energy consumption was measured before the solution and a year after. This was from December 2021 to December 2022. This timeframe was chosen to control for the seasonal variance in energy demand.

(C) The assessor shall define the geographical boundary for the assessment.

Schneider Electric, High Performance BMS

The geographical boundary for this assessment is several European countries (Route 1), as well as Schneider Electric's Technopole building in Grenoble, France (Route 2).

Inteligg, c-BEMS

The geographical boundary for this assessment is one office building in Belgium and two residential apartments in Greece.

(D) The assessor shall define the implementation context for the assessment.

Schneider Electric, High Performance BMS

The solution has been rolled out globally and can be rolled out across many different types of commercial buildings, in particular it is very relevant in buildings where you have sub-partitions such as hospitals, hotels and to a lesser extent education buildings. The assessment has considered the modelled implementation of the solution across several European countries in offices buildings of different sizes. The buildings in this modelled scenario use electricity and gas.

The assessment has also considered the actual implementation of the solution in the Schneider Electric's Technopole building in Grenoble, France, which was completed in 2017 and occupies a total area of around 38,000 m2, which constitutes a mix of laboratories and tertiary activities. The building uses electricity and a heat pump for heating.

Inteligg, c-BEMS

The solution is currently deployed in multiple European countries, including Belgium, Greece, and Luxembourg. It has been used in residential buildings, offices, restaurants, and public buildings (including a church and town hall). The assessment considered one office building in Belgium and 2 residential apartments in Greece, as reference data existed for these locations. All three run on natural gas. No further information was provided about the buildings.

Reference Scenario Definition

(A) The reference scenario shall be determined as what the most likely alternative scenario in the event the solution is not/was not implemented, and it shall:

(i) Have equivalent or less functionality than the ICT solution.

(ii) Be relevant to the given implementation context.

(iii) Be relevant to the time in which the ICT solution is being assessed.

(B) The most likely scenario is determined as either:

(i) Continued use of the known system that was previously in place.

(ii) Use of the average alternative solution/method that solution users would select to achieve the same service.

Schneider Electric, High Performance BMS

There are two reference scenarios for this solution: Standard BMS (Ref I) and Advanced BMS (Ref II). Ref I is used for route 1 only, while Ref II is used for both route 1 and 2.

Ref I: Standard BMS

Reference scenario I is a standard BMS made up of a more basic BMS system that provides less savings than both an Advanced BMS and a High performing BMS solution. Under route 1, the actual reference scenario is unknown therefore the reference scenario needs to represent the market average approach for fulfilling the same function. This reference scenario reflects the basic type of BMS present in most office buildings and was deemed by Schneider Electric to represent the market average.

Ref II: Advanced BMS

The reference scenario II reflects a commonly implemented Advanced BMS system to showcase how the High performing BMS system supersedes it through additional carbon saving capabilities. Consequently, the High Performing BMS enables more carbon savings per sqm of a zone than an Advanced BMS. This reference scenario reflects an alternative option available in the market that is better than the basic type of BMS in Ref I.

Under route 2, Ref II also reflects the actual reference scenario in place.

Inteligg, c-BEMS

The reference scenario is no active management of the heating consumption in the assessed buildings. The market average scenario was not researched in this assessment because the specific reference scenario was known.

(C) The reference scenario shall include multiple scenarios if necessary to accurately represent the most likely alternative scenario.

Schneider Electric, High Performance BMS

Under route 1, two different scenarios have been used to represent the reference scenario. Under one scenario (Ref I), the reference scenario includes the implementation of a Standard BMS. Although not needed, as the Standard BMS is considered to be the market average by Schneider Electric, a second scenario (Ref II) was included in the assessments which defines the reference scenario as a commonly implemented Advanced BMS system.

Under route 2, this requirement is not relevant for this assessment because the known reference scenario for the specific implementation context is used.

Inteligg, c-BEMS

This requirement is not relevant for this assessment because the known reference scenario for the specific implementation context is used.

(D) The assessor shall describe how the function is fulfilled in the reference scenario.

Schneider Electric, High Performance BMS

Ref I: Standard BMS

Reference scenario I is a standard BMS made up of a more basic BMS system that provides less savings than both an Advanced BMS and a High performing BMS solution. Under this reference scenario, heating is optimised via a basic type of BMS present in most office buildings.

Ref II: Advanced BMS

The reference scenario II reflects a commonly implemented Advanced BMS system to showcase how the High performing BMS system supersedes it through additional carbon saving capabilities. Consequently, the High Performing BMS enables more carbon savings per sqm of a zone than an Advanced BMS. This reference scenario reflects an alternative option available in the market that is better than the basic type of BMS in Ref I.

Inteligg, c-BEMS

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In the reference scenario, there is no technology-enabled heating optimisation, and all optimisation is done manually.

Identifying Effects

Identifying Reference and ICT Solution Scenario Activities and Emission Sources

(A) Identify the activities under the reference and ICT solution scenarios.

Schneider Electric, High Performance BMS

The following activities were identified under the reference and ICT solutions:

Activities in reference scenario	Activities in ICT enabled scenario
Manage building gas consumption	Manage building gas consumption
Gas consumption	Gas consumption
Manage building electricity consumption	Manage building electricity consumption
Electricity consumption	Electricity consumption

Inteligg, c-BEMS

The following activities were identified under the reference and ICT solution scenarios:

Activities in reference scenario	Activities in ICT enabled scenario
	Manage building gas consumption
Gas consumption	Gas consumption
Electricity consumption	Electricity consumption

(B) Identify potential GHG emission sources related to the activities.

Schneider Electric, High Performance BMS

Activities in reference scenario	Potential GHG emission sources	Activities in ICT enabled scenario	Potential GHG emission sources
Manage building gas consumption	Global controller Remote controller Thermal energy meters Valves Dampers HVAC equipment	Manage building gas consumption	Global controller Remote controller Thermal energy meters Valves Dampers HVAC equipment Local controller Multi-sensor CO2 measurement sensor IT infrastructure (Network and servers) Laptops Software
Gas consumption	Office Building HVAC equipment	Gas consumption	Office Building HVAC equipment
Manage building electricity consumption	Global controller Remote controller Thermal energy meters	Manage building electricity consumption	Global controller Remote controller Thermal energy meters

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	Valves Dampers HVAC equipment		Valves Dampers HVAC equipment Local controller Multi-sensor CO2 measurement sensor IT infrastructure (Network and servers) Laptops Software
Electricity consumption	Office Building HVAC equipment Lighting Electric devices	Electricity consumption	Office Building HVAC equipment Lighting Electric devices

Inteligg, c-BEMS

Activities in reference scenario	Potential GHG emission sources	Activities in ICT enabled scenario	Potential GHG emission sources
		Manage building gas consumption	Smart controller module Smart thermostat module Smart sensor module.

			IT infrastructure (Network and servers)
Gas consumption	Office Building HVAC equipment Radiators Boilers	Gas consumption	Office Building HVAC equipment Radiators Boilers
Electricity consumption	Office Building HVAC equipment Lighting Electric devices	Electricity consumption	Office Building HVAC equipment Lighting Electric devices

Identifying Potential Effects of Solution Implementation

(A) Identify potential effects generated by the implementation of the ICT solution.

Schneider Electric, High Performance BMS

Activities in reference scenario	GHG emission sources	Activities in ICT enabled scenario	GHG emission sources	GHG emission impacts
Manage building gas consumption	Global controller Remote controller Thermal energy meters Valves Dampers	Manage building gas consumption	Global controller Remote controller Thermal energy meters Valves Dampers HVAC equipment	Emissions from Local controller, Multi-sensor, CO2 measurement sensor Emissions from server usage – only in-use

	HVAC equipment		Local controller Multi-sensor CO2 measurement sensor IT infrastructure (Network and servers) Laptops Software	Emissions from network– only in-use Emissions from laptops and software – only in-use
Gas consumption	Office Building HVAC equipment	Gas consumption	Office Building HVAC equipment	Reduction in gas consumption
Manage building electricity consumption	Global controller Remote controller Thermal energy meters Valves Dampers HVAC equipment	Manage building electricity consumption	Global controller Remote controller Thermal energy meters Valves Dampers HVAC equipment Local controller Multi-sensor CO2 measurement sensor IT infrastructure (Network and servers) Laptops Software	Emissions from Local controller, Multi-sensor, CO2 measurement sensor Emissions from server usage – only in-use Emissions from network– only in-use Emissions from laptops and software – only in-use

Electricity consumption	Office Building HVAC equipment Lighting Electric devices	Electricity consumption	Office Building HVAC equipment Lighting Electric devices	Reduction in electricity consumption

Inteligg, c-BEMS

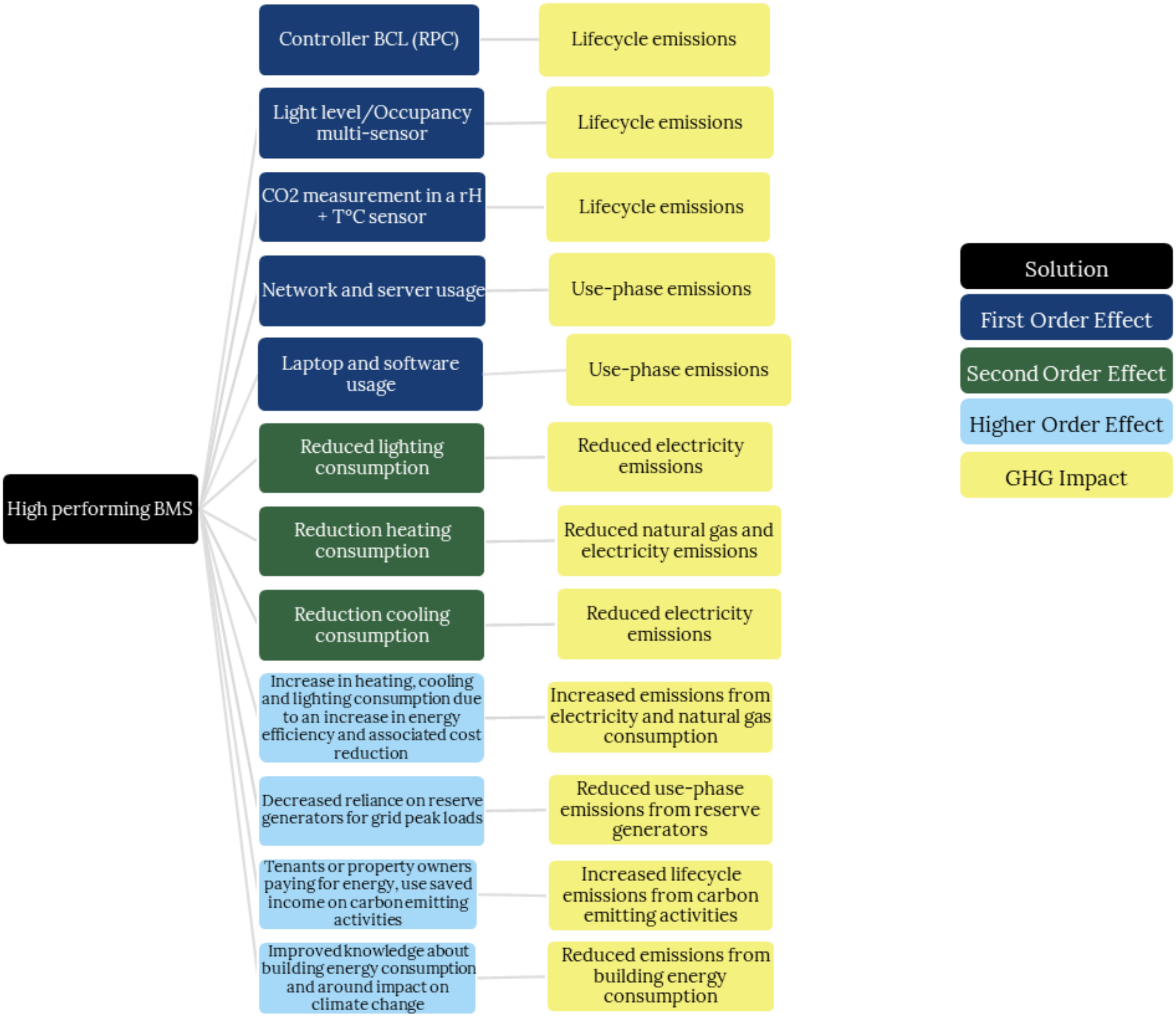
Activities in reference scenario	Potential GHG emission sources	Activities in ICT enabled scenario	Potential GHG emission sources	GHG emission impacts
		Manage building gas consumption	Smart controller module Smart thermostat module Smart sensor module. IT infrastructure (Network and servers)	Emissions from smart controller module, smart thermostat and smart sensor module Emissions from server usage – only in-use Emissions from network– only in-use

Gas consumption	Office Building HVAC equipment Radiators Boilers	Gas consumption	Office Building HVAC equipment Radiators Boilers	Reduction in gas consumption
Electricity consumption	Office Building HVAC equipment Lighting Electric devices	Electricity consumption	Office Building HVAC equipment Lighting Electric devices	No change, as electricity not managed by solution

Mapping Effects in a Consequence Tree

(A) Map out all first, second, and higher order effects and GHG impacts in a consequence tree.

Schneider Electric, High Performance BMS



Inteligg, c-BEMS

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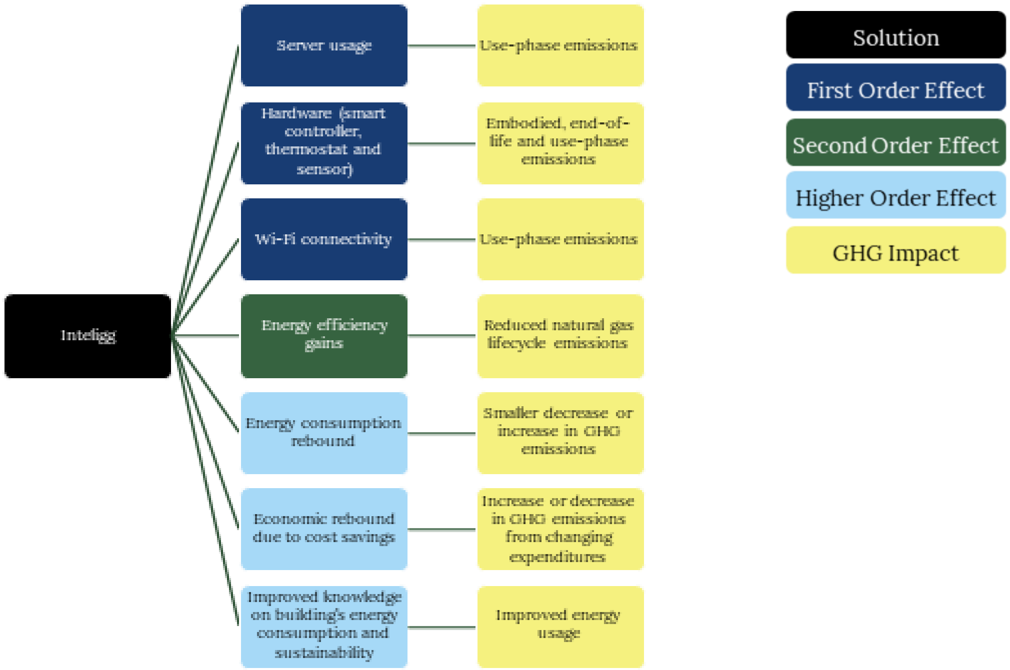

Identify First Order Effects

(A) All first order effects shall be identified that occur within the boundary of the ICT solution as defined in section 3.2.2 of the "Net Carbon Impact Assessment Methodology for ICT Solutions".

(B) The GHG impact of first order effects shall consider the full life cycle emissions of the ICT solution, that are not excluded by (C). This includes upstream emissions relating to solution's manufacture and transportation (embodied emissions), life cycle emissions from use and maintenance, and end of life treatment.

(C) Embodied and end-of-life emissions from ICT equipment or hardware that can be justified as already in existence without the solution implementation can be excluded from the calculation of first order effects with justification.

Schneider Electric, High Performance BMS

Lifecycle emissions of all controllers:

- Local controller BCL (RPC)

Lifecycle emissions of all sensors

- Light level/Occupancy multi-sensor (Infrared motion detection sensor)

- CO2 measurement in a rH + T°C sensor

IT infrastructure (Network and servers (on-site) used for data storage and transmission)

- Only the in-use emissions from servers are considered as 1st order effects, as it was assumed that the embodied emissions were already in existence without the solution implementation.

Usage of laptop devices and software required to operate the BMS

- The marginal increase in in-use emissions from laptop and software usage is not part of the reference scenario and therefore should be considered as first order effects.
- It is assumed that the embodied (incl. transport) and end-of-life emissions of laptops are already in existence even without the implementation of the solution in place, as they are unlikely to be built solely for this solution. These emissions are therefore excluded from the calculation of first order effects.

Note: The RPC Controller is not present in the Standard BMS Reference scenario, but is present in the Advanced BMS Reference Scenario

Inteligg, c-BEMS

Lifecycle emissions of smart controller module, smart thermostat and smart sensor module

IT infrastructure (Network and servers (on-site) used for data storage and transmission)

- Only the in-use emissions from servers are considered as 1st order effects, as it was assumed that the embodied emissions were already in existence without the solution implementation.

Identify Second & Higher Order Effects

(A) All second order effects shall be identified.

(B) All higher order effects shall be identified.

Schneider Electric, High Performance BMS

The following second and higher order effects were identified:

Second order effects:

Energy reductions, and therefore GHG emissions, arise from the additional implementation and use of IoT sensors in the High Performing BMS. These sensors increase the efficiency of the occupancy, CO_2 monitoring, light and blind controls, while enabling HVAC and light demand to be controlled based on occupancy. The High Performing BMS allows for real-time monitoring of power consumption and uses, reductions in base consumptions and optimized energy control. Due to these capabilities, the High Performing BMS has a larger carbon saving impact in comparison to both the Advanced BMS and Standard BMS.

Higher order effects:

- **Direct rebound emissions from an increase in energy consumption due to an increase in energy efficiency and associated cost reduction** – this higher order effect should be reflected in the percentage reduction of emissions based on energy consumption data and was therefore not considered separately.
- **Decreased reliance on reserve generators for grid peak loads** – this higher order effect is likely to happen in the short-term and could have a significant emissions impact. However, a large number of buildings would need to be using the solution to achieve this impact. The combined impact of using this solution in multiple buildings has not been assessed.
- **Tenants or property owners paying for energy, use saved income on carbon emitting activities** – the impact of this higher order effect is very uncertain, as saved income could be spent on very carbon intensive carbon activities or carbon saving activities. Furthermore, it will be difficult to establish a causal link between the saved income and the spend on certain activities and the associated emissions.
- **Improved knowledge about building energy consumption and around impact on climate change** - the impact of this higher order effect is very uncertain, as it is unknown how the increased knowledge will be turned into action and the magnitude of these actions. Furthermore, it will be difficult to establish a causal link between the increased knowledge and any resulting carbon reduction actions.

Given the potential system-wide scope of higher order effects, it should be acknowledged that this is not necessarily an exhaustive list and other higher order effects may be identified.

Inteligg, c-BEMS

Second order effects:

A reduction in emissions from heating due to optimisation of heating consumption.

Higher order effects:

There is some literature demonstrating a rebound effect when energy efficiency improvements are made, including for energy management systems that incentivise the user turning on the heating more often (e.g., Belaïd, Bakaloglou & Roubaud, 2018[1]; Belaïd, Youssef & Lazaric, 2020[2]).

An economic rebound effect may result from saved costs on heating which can be used for carbon intensive or carbon saving activities and products.

Improved knowledge on the building's energy consumption, and sustainability in general may help users make environmentally beneficial decisions.

Given the potential system-wide scope of higher order effects, it should be acknowledged that this is not necessarily an exhaustive list and other higher order effects may be identified.

Calculating Effects

Estimating the Relative Magnitude of Effects

(A) An estimation of the magnitude of effects included in the assessment should be carried out for all identified GHG impacts resulting from first, second, and higher order effects.

Schneider Electric, High Performance BMS

First order effects:

Lifecycle emissions of local controller BCL (RPC) – the emissions from this controller were assumed to be small based on the weight, as well as the long lifetime of the device, ~10 years, which further shrinks the contribution to the annual net impact. The calculations should still aim to include this effect but may rely on secondary or proxy data if necessary.

Lifecycle emissions of all sensors (Light level/Occupancy multi-sensor (Infrared motion detection sensor), CO2 measurement in a rH + T°C sensor) - the emissions from these sensors were assumed to be small based on their weight, as well as the long lifetime of these devices, ~10 years, which further shrinks the contribution to the annual net impact. The calculations should still aim to include this effect but may rely on secondary or proxy data if necessary.

[1] Fateh, Belaid, Bakaloglou, Salomé and Roubaud, David, (2018), Direct rebound effect of residential gas demand: Empirical evidence from France, Energy Policy, 115, issue C, p. 23-31.

[2] Fateh, Belaid, Youssef, Adel Ben and Lazaric, Nathalie, (2020), Scrutinizing the direct rebound effect for French households using quantile regression and data from an original survey, Ecological Economics, 176, issue C, number S0921800920306698.

In-use emissions of IT infrastructure (Network and servers (on-site) used for data storage and transmission) – it is assumed that the in-use emissions from the IT infrastructure is relatively small, as the assessment only considers the emissions from the marginal increase in energy consumption.

Usage of laptop devices and software required to operate the BMS - it is assumed that the in-use emissions from the laptop are relatively small, as the assessment only considers the emissions from the marginal increase in energy consumption and it is assumed that the software only requires a minimal amount of energy compared to the overall consumption of a laptop.

Second order effects:

The results from Schneider Electric's Internal Sustainability Tool demonstrate savings between 6% and 30%, while the average energy consumption per building lies between 5,000 kWh and over 1 million kWh depending on size and region. While the emissions savings will vary by building and region, the second order effect is still likely to account for a large part of the GHG savings, and high data quality should therefore be a priority for this effect.

Higher order effects:

- **Direct rebound emissions from an increase in energy consumption due to an increase in energy efficiency and associated cost reduction** – this direct higher order effect could have a significant impact as it could negate the impact of the second order effect. It should therefore be assessed using high data quality. It is also likely that the same data provided for the second order effect will demonstrate this higher order effect.
- **Decreased reliance on reserve generators for grid peak loads** – this higher order effect is likely to have a significant short-term impact on emissions. However, a large number of buildings would need to be using the solution to achieve this impact and the combined impact of using this solution in multiple buildings has not been assessed. Given the potential significance of this effect, high quality data should be used to assess its impact.
- **Tenants or property owners paying for energy, use saved income on carbon emitting activities** – it would be very difficult to establish a causal link between the saved income and the spend on certain activities and the associated emissions. The impact of this effect could be positive or negative and could range widely in terms of magnitude. A conservative approach should be taken to only include this effect if high quality data is available that is used in a model that is able to determine the causal relationship.
- **Improved knowledge about building energy consumption and around impact on climate change** - it would be very difficult to establish a causal link between the increased knowledge and any resulting carbon reduction actions, as well as the expected magnitude of the effect. As the impact of this effect could be significant and

further increase the savings potential of the solution, a conservative approach should be taken to only include this effect if high quality data is available that is used in a model that is able to determine the causal relationship.

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First order effects:

Lifecycle emissions of smart controller module, smart thermostat and smart sensor module – based on the weight of these devices (between 0.044kg and 0.138kg), it is assumed that the emissions impact of these devices would be relatively small compared to the second order effect. Therefore, proxy and/or secondary data can be used to estimate the impact of these devices.

In-use emissions from IT infrastructure (Network and servers (on-site) used for data storage and transmission) - it is assumed that the in-use emissions from the IT infrastructure is relatively small, as the assessment only considers the emissions from the marginal increase in energy consumption.

Second order effects:

Based on the impact of similar solutions, which see reduction in heating consumption of up to 50%[3], it is assumed that this effect would be significant to the total net impact and therefore high-quality data should be used for its assessment.

Higher order effects:

The rebound effect resulting from energy efficiency improvements could have a significant impact as it could negate the impact of the second order effect. The effect should therefore be assessed using high data quality. It is also possible that the same data provided for the second order effect will demonstrate this higher order effect.

However, for the economic rebound effect, it would be very difficult to establish a causal link between the cost reduction and the spend on certain activities and the associated emissions. The impact of this effect could also be positive or negative and could range widely in terms of magnitude. A conservative approach should be taken to only include this effect if high quality data is available that is used in a model that is able to determine the causal relationship.

The impact from an improved knowledge on the building's energy consumption, and sustainability could be significant, but it would be very difficult to establish a causal link between the increased knowledge and any resulting carbon reduction actions, as well as the expected magnitude of the effect. As the impact of this effect could be significant and further increase the savings potential of

[3] https://www.researchgate.net/publication/263926501_Effect_of_Building_Management_System_on_Energy_Saving

the solution, a conservative approach should be taken to only include this effect if high quality data is available that is used in a model that is able to determine the causal relationship.

Data Collection

Identifying Key Activities for each Effect

(A) For all effects identified under section 3.3 of the "Net Carbon Impact Assessment Methodology for ICT Solutions", suitable activities and activity emission intensities should be identified that can be used to estimate the GHG impact of each effect.

Schneider Electric, High Performance BMS

Effect	Description	Activities
First Order	Lifecycle emissions of local controller BCL (RPC)	• Number of controllers per functional unit • Cradle to grave footprint of controllers • Material breakdown of controllers • Likely disposal method of controllers • Material and end-of-life emission factors • Location of origin and destination, likely transport modes • Energy usage per controller over lifetime • Power consumption of controllers and usage profile • Electricity emission factors
First Order	Lifecycle emissions of light level/Occupancy multi-sensor (Infrared motion detection sensor)	• Number of sensors per functional unit • Cradle to grave footprint of sensor • Material breakdown of sensor

		• Likely disposal method of sensor • Material and end-of-life emission factors • Location of origin and destination, likely transport modes • Energy usage per sensor over lifetime • Power consumption of sensor and usage profile • Electricity emission factors
First Order	Lifecycle emissions of CO2 measurement in a rH + T°C sensor	• Number of sensors per functional unit • Cradle to grave footprint of sensor • Material breakdown of sensor • Likely disposal method of sensor • Material and end-of-life emission factors • Location of origin and destination, likely transport modes • Energy usage per sensor over lifetime • Power consumption of sensor and usage profile • Electricity emission factors
First Order	IT infrastructure (Network and servers (on-site) used for data storage and transmission)	• Total data transmitted for solution over assessment period • Energy consumption of servers per data transferred • Network energy intensity per data transferred

		• Location of server/network and/or electricity tariff emissions intensity of server • Electricity emission factors
First Order	Usage of laptop devices and software required to operate the high-performing BMS	• Marginal energy consumption of laptops due to operation of Schneider Electric's high-performing BMS • Electricity emission factors
Second order	A reduction in gas and electricity consumption due to heating optimisation.	• Gas and electricity consumption with and without implementation of the solution • Location of buildings where solution is implemented • Electricity and gas emission factors
Higher order	Direct rebound emissions from an increase in energy consumption due to an increase in energy efficiency and associated cost reduction.	• Gas and electricity consumption with and without implementation of the solution • Location of buildings where solution is implemented • Electricity and gas emission factors
Higher order	Decreased reliance on reserve generators for grid peak loads.	• Emissions from affected reserve generators before and after implementation of solution
Higher order	Tenants or property owners paying for energy, use saved income on carbon emitting activities.	• Spend patterns and amounts of tenants or property owners before and after implementation of solution.

Higher order	Improved knowledge about building energy consumption and around impact on climate change.	• Spend patterns and amounts of tenants before and after implementation of solution. • Carbon footprint of tenants before and after implementation of solution.

Inteligg, c-BEMS

Effect	Description	Activities
First Order	Lifecycle emissions of smart controller module, smart thermostat and smart sensor module	• Number of devices per functional unit • Cradle to grave footprint of devices • Material breakdown of devices • Likely disposal method of devices • Material and end-of-life emission factors • Location of origin and destination, likely transport modes • Energy usage per device over lifetime • Power consumption of devices and usage profile • Electricity emission factor
First Order	IT infrastructure (Network and servers (on-site) used for data storage and transmission)	• Total data transmitted for solution over assessment period • Energy consumption of servers per data transferred • Network energy intensity per data transferred

		• Location of server/network and/or electricity tariff emissions intensity of server • Electricity emission factor
Second order	A reduction in gas and electricity consumption due to heating optimisation.	• Gas consumption with and without implementation of the solution. • Gas emission factor
Higher order	Direct rebound emissions from an increase in energy consumption due to an increase in energy efficiency and associated cost reduction.	• Gas consumption with and without implementation of the solution • Gas emission factor
Higher order	Economic rebound due to cost savings	• Spend patterns and amounts of property users before and after implementation of solution.
Higher order	Improved knowledge about building energy consumption and around impact on climate change.	• Spend patterns and amounts of property users before and after implementation of solution. • Carbon footprint of property users before and after implementation of solution.

Data Quality and Availability Assessment

(A) A data availability and quality assessment should be carried out for all activities and activity emission intensities identified for each effect included in the assessment. The assessment shall be used to select the most appropriate data sources for the assessment.

(B) The data availability and quality assessment can then be used to select relevant data sources for the net carbon impact assessment by considering the following:

(i) The data quality and availability for each activity under both the reference and ICT solution scenario.

(ii) The ITU L1410 guidance for data quality and data quality review guidance.

(iii) The relative magnitude of the effect.

(C) All data sources and assumptions used when selecting applicable data should be documented and reported.

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Description	Activities	Data for activity available	Data quality?
Lifecycle emissions of local controller BCL (RPC)	Number of controllers per functional unit Cradle to grave footprint of controllers Material breakdown of controllers Likely disposal method of controllers Material and end-of-life emission factors Location of origin and destination, likely transport modes Energy usage per controller over lifetime Power consumption of controllers and usage profile Electricity emission factors	Number of controllers per functional unit Cradle to grave footprint of controllers	Good Good
Lifecycle emissions of light level/Occupancy multi-sensor (Infrared	Number of sensors per functional unit	Number of sensors per functional unit	Good

motion detection sensor)	Cradle to grave footprint of sensor Material breakdown of sensor Likely disposal method of sensor Material and end-of-life emission factors Location of origin and destination, likely transport modes Energy usage per sensor over lifetime Power consumption of sensor and usage profile Electricity emission factors	Cradle to grave footprint of sensor	Good
Lifecycle emissions of CO2 measurement in a rH + T°C sensor	Number of sensors per functional unit Cradle to grave footprint of sensor Material breakdown of sensor Likely disposal method of sensor Material and end-of-life emission factors Location of origin and destination, likely transport modes Energy usage per sensor over lifetime Power consumption of sensor and usage profile	Number of sensors per functional unit Cradle to grave footprint of sensor	Good Good

	Electricity emission factors		
IT infrastructure (Network and servers (on-site) used for data storage and transmission)	Total data transmitted for solution over assessment period Energy consumption of servers per data transferred Network energy intensity per data transferred Location of server/network and/or electricity tariff emissions intensity of server Electricity emission factors	Emissions from data transmission (from server to terminals PC) - Consultation PC for 30min / day/year through fixed network)	Good
Usage of laptop devices and software required to operate the high-performing BMS	Marginal energy consumption of laptops due to operation of Schneider Electric's high-performing BMS Electricity emission factors	Emissions from data transmission (from server to terminals PC) - Consultation PC for 30min / day/year through fixed network)	Good
A reduction in gas and electricity consumption due to heating optimisation.	Gas and electricity consumption with and without implementation of the solution Location of buildings where solution is implemented Gas and electricity emission factors	Route 1: Building Archetype Data and Modelled Savings Default values for floor area, average electricity consumption per year and average natural gas	Very good Good

		consumption per year Route 2: building consumption before and after implementation of solution Gas and electricity emission factors	Very good Very good
Direct rebound emissions from an increase in energy consumption due to an increase in energy efficiency and associated cost reduction.	Gas and electricity consumption with and without implementation of the solution Location of buildings where solution is implemented Gas and electricity emission factors	Route 1: DOE Building Archetype Data and Modelled Savings Default values for floor area, average electricity consumption per year and average natural gas consumption per year Route 2: building consumption before and after implementation of solution Gas and electricity emission factors	Very good Good Very good Very good
Decreased reliance on reserve generators for grid peak loads.	Emissions from affected reserve generators before	No data available	N/A

	and after implementation of solution		
Tenants or property owners paying for energy, use saved income on carbon emitting activities.	Spend patterns and amounts of tenants or property owners before and after implementation of solution.	No data available	N/A
Improved knowledge about building energy consumption and around impact on climate change.	Spend patterns and amounts of tenants before and after implementation of solution. Carbon footprint of tenants before and after implementation of solution.	No data available	N/A

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Description	Activities	Data for activity available	Data quality?
Lifecycle emissions of smart controller module, smart thermostat and smart sensor module	Number of devices per functional unit Cradle to grave footprint of devices Material breakdown of devices Likely disposal method of devices Material and end-of-life emission factors Location of origin and destination, likely transport modes	Number of devices per functional unit Weight of devices Main type of material of devices Plastics emission factor Energy consumption of a Google Nest module and assumed use	Good Good Fair Good Fair

	Energy usage per device over lifetime Power consumption of devices and usage profile Electricity emission factors	profile used as proxy. Electricity emission factor	Very good
IT infrastructure (Network and servers (on-site) used for data storage and transmission)	Total data transmitted for solution over assessment period Energy consumption of servers per data transferred Network energy intensity per data transferred Location of server/network and/or electricity tariff emissions intensity of server Electricity emission factors	Wi-Fi connectivity energy consumption were estimated using secondary data Electricity emission factor	Fair Very good
A reduction in gas and electricity consumption due to heating optimisation.	Gas consumption with and without implementation of the solution. Gas emission factor	Gas meter readings before and after implementation of solution Assumption of gas consumption going towards heating. Number of degree days Gas emission factor	Fair Fair Good Very good

Direct rebound emissions from an increase in energy consumption due to an increase in energy efficiency and associated cost reduction.	Gas consumption with and without implementation of the solution Gas emission factor	Gas meter readings before and after implementation of solution Assumption of gas consumption going towards heating. Number of degree days Gas emission factor	Fair Fair Good Very good
Economic rebound due to cost savings	Spend patterns and amounts of property users before and after implementation of solution.	No data available	N/A
Improved knowledge about building energy consumption and around impact on climate change.	Spend patterns and amounts of property users before and after implementation of solution. Carbon footprint of property users before and after implementation of solution.	No data available	N/A

First Order Effects

(A) The GHG impact of all first order effects shall be calculated for each implementation context within the boundary conditions except for those excluded by the cut-off criteria.

(D) First order effects shall be calculated for all life cycle phases of the solution.

(i) Embodied and end-of-life emissions shall be allocated equally across the lifetime of the solution and included according to the time period of the assessment

(ii) Use-phase emissions shall be calculated for the time period of the assessment.

(E) First order effects shall be calculated in relation to the functional unit and for the level of activity defined by the functional unit performance. If the functional unit requires multiple units of the solution or its components for the level of activity, as many units as required will be calculated.

(F) A conservative approach should be applied for all calculations of first order effects, i.e. emissions should rather be overstated than understated.

Schneider Electric, High Performance BMS

The solution emissions are obtained by adding the embodied and annual in-use emissions from electricity consumption of its components per zone (data transmissions and storage, Controller RPC, CO2 sensor and two infrared motion detection sensors) and multiplying this by the total number of zones, based on the floor area. Embodied emissions include manufacturing, transportation and end-of-life, except for the sensors, which only include manufacturing emissions. Given that the end-of-life and transportation emissions for the controller contributes less than 1% to the total embodied emissions, and assuming they would be similar for the sensors, these emissions have been excluded.

The emissions from network and laptop/software usage have also been included based on the data quantity transmitted to servers over 1 year in ko and stored for 3 months, as well as assuming a consultation of the laptop for 30min per day through fixed network.

Inteligg, c-BEMS

The weight and material of each component was noted and multiplied by the respective GHG material and end-of-life conversion factors to calculate the associated lifecycle emissions. As a conservative approach, the entire lifetime emissions of the devices are included. Their use-phase emissions were estimated using the energy consumption of a Google Nest module running 24 hours a day, 365 days a year, multiplied by the country's lifecycle electricity grid emission factors to obtain GHG emissions.

It is assumed that whilst every building needs one smart thermostat module and one smart controller module, an additional smart sensor module is required for every 50 square metres (rounded to the closest 50, so that 124 m2 requires one smart sensor module, but 125 m2 requires two).

The emissions related to the use of Wi-Fi connectivity were estimated using Yuksel, 2020's research. It was assumed to run 24 hours a day, 365 days a year. The power consumption was multiplied with the electricity grid emissions factor to obtain GHG emissions.

(B) Cut-off criteria for first order effects:

(i) Solution components common between the reference and solution scenarios where the GHG impact has not been modified.

(ii) Where data availability prevents calculation of the GHG impact, first order effects may be excluded from the net carbon impact assessment if they can be demonstrated to be less than 5% of the total net carbon impact or net carbon impact per functional unit.

(iii) If multiple first order effects are considered for cut-off, the total effect must remain less than the 5% threshold.

(C) Exclusions of any first order effects from net carbon impact assessments shall be supported by clear justification and supporting calculation.

Schneider Electric, High Performance BMS

The end-of-life and transportation emissions for the sensors have been excluded, as these emissions contribute less than 1% to the total embodied emissions of the controller, and it is assumed that they would be similar for the sensors.

Inteligg, c-BEMS

The manufacturing and transportation emissions of the devices (smart controller module, smart thermostat and smart sensor module) were excluded due to lack of data availability. Assuming these usually contribute around 5% to the total lifecycle carbon footprint of the devices, this would equate to around 0.04kgCO2e, which is around 0.02% of the total net carbon impact and can therefore be excluded.

The emissions from the marginal increase in energy consumption from the laptop use has also been excluded. Assuming the total usage emissions of a laptop per year equates to around 6.9kgCO2e (5.7% of 482 kgCO2e divided by a 4-year lifetime for the Dell Latitude 9510 laptop[4]), this would equate to 4% of the total net carbon impact. The actual marginal impact is likely to be much smaller and can therefore be excluded.

Second Order Effects

[4] https://www.dell.com/en-us/dt/corporate/social-impact/advancing-sustainability/climate-action/product-carbon-footprints.htm#tab0=1&pdf-overlay=//www.delltechnologies.com/asset/en-us/products/laptops-and-2-in-1s/technical-support/latitude-9510.pdf

Funded by the European Union

(A) The GHG impact of all identified second order effects (positive and negative changes to the reference scenario) shall be calculated for the same implementation context except for those excluded by the cut-off criteria.

(C) The GHG impact of second order effects shall be calculated with a life cycle perspective.

(D) The second order effect calculation shall exclude additional rebound usages in the quantification of the GHG impact.

(E) The second order effect calculation shall exclude existing occurrence of the second order effect from other similar ICT solutions.

(F) Second order effects shall be calculated in relation to the functional unit and for the level of activity defined by the functional unit performance.

(G) If a net carbon impact assessment is to be used for public claims of a solutions' impact (including annual reporting) primary data should be used for either the reference or ICT solution scenario, or both.

(H) A conservative approach should be applied for all calculations of second order effects i.e. net positive emissions should rather be understated than overstated.

Schneider Electric, High Performance BMS

Two different calculation routes are available:

Summary of Routes:

Route 1 is based on the US Department of Energy Building Archetype Data and Modelled Savings Derived from the Schneider Electric Sustainability Tool. Within this route there are two calculation options, detailed below.

Route 2 is based on measured reductions, comparing 2019 and 2021 building consumption at the Schneider Electric's Technopole building in Grenoble, France. Using their BEM Assessment Tool, 4 additional simulations were run, 'placing' the Technopole in 4 other cities in 4 other climate regions, to assess the impact varying climates have on the savings.

Route 1:

Route 1, Option 1: Annual Building consumption (kWh)

Inputs for country, office size, and reference scenario are chosen. Based on these parameters, default values are identified for floor area, average electricity consumption per year and average natural gas consumption per year. The enabled percentage reductions of electricity and gas consumption is determined by the input parameters, and these percentage reductions are applied to the consumption data to obtain annual kWh savings, which are then converted into kgCO2e to get the total enabled reduction in gas and electricity emissions per year (kgCO2e/year). This calculation route includes the option to manually override the default energy consumption input if primary data is available. In addition, it is possible to override the Climate Region, which is based on different countries in Europe, broadly representing 6 different climate regions, as well as percentage of electricity consumption from onsite renewables.

Route 1, Option 2: Building area (m2)

Inputs for country, office size, and reference scenario are chosen. Based on these parameters, default values are identified for floor area, average electricity consumption per year and average natural gas consumption per year. The enabled percentage reductions of electricity and gas consumption is determined by the input parameters, and these percentage reductions are applied to the consumption data to obtain annual kWh savings, which are then converted into kgCO2e to get the total enabled reduction in gas and electricity emissions per year (kgCO2e/year). This calculation route includes the option to manually override the default building area (sqm) input if primary data is available. In addition, it is possible to override the Climate Region, which impacts the average energy used for heating and cooling throughout the year, as well as percentage of electricity consumption from onsite renewables.

Route 2:

This route is focused on comparing the reference scenario of Advance BMS to High Performing BMS, for buildings with electricity and heat pump heating. Inputs for country, annual electricity consumption for the building (kWh/year) and office floor area (m2) are added in to generate the savings. It is possible to override the Climate Region, which impacts the average energy used for heating and cooling throughout the year, as well as percentage of electricity consumption from onsite renewables.

Inteligg, c-BEMS

Using data from Eurostat, the average household natural gas energy consumption that goes to space-heating was tabled for each European country. This percentage is multiplied with the input energy consumption for apartments. For offices, the assumption is made that 90% of energy use from natural gas goes towards heating. For apartments, it is assumed to be 60%.

By combining the yearly reduction in energy usage with that year's amount of local degree days (baselined at 15.5°C), a calculation was made of the average reduction in kWh per degree day (DD). Two different kWh/DD reduction factors were noted for apartment and office building types.

For each European country, monthly degree days were tabled for the years 2019, 2020, and 2021. The 2022 values (which were not yet released at the time of writing) were estimated using the three-year averages of each month in 2019-2021.

The average energy consumption per degree day (kWh / DD) before the solution was measured by dividing the inputted energy consumption by the amount of national degree days in that month or year (depending on whether monthly or yearly energy metre readings are provided).

To calculate the reduction in energy usage, the energy consumption per degree day is multiplied by the reduction factor appropriate for the building type.

The yearly expected energy consumption after the solution is calculated by multiplying the new energy consumption per degree day with the 5-year average yearly degree days for that location, divided by the previously used assumption of energy use from natural gas that goes towards heating (60% for apartments, 90% for offices).

If a monthly metre reading is given, an additional calculation is provided to estimate the energy usage that could have been saved were the solution in place for that particular month. That is done by multiplying the reduced kWh / DD with the yearly degree days for that location and year, with the percentage that month was responsible for the year's overall degree days.

The difference between the (expected) yearly energy usage before and after the solution is multiplied with the conversion factors for natural gas to calculate the carbon savings enabled.

(B) Cut-off criteria for second order effects:

(i) GHG impacts from identified second order effects may be excluded from the net carbon impact assessment if they can be demonstrated to be less than 5% of the total net carbon impact or net carbon impact per functional unit. Positive second order effects of any magnitude may also be excluded (typically due to data availability).

(ii) If multiple second order effects are considered for cut-off, the total effect must remain less than the 5% threshold.

(iii) Cut-offs of any second order effects from net carbon impact assessments shall be supported by clear justification and supporting calculation.

Schneider Electric, High Performance BMS

No second order effects that were identified were excluded from the calculation.

Inteligg, c-BEMS

No second order effects that were identified were excluded from the calculation.

Higher Order Effects

(A) A qualitative assessment shall be undertaken for all identified higher order effects, including how and where they would occur, within what timeframe, the expected magnitude, and the likelihood of the effect occurring. The strength of the relationship between the solution and the higher order effect should be considered and ideally be demonstrated by academic research.

Schneider Electric, High Performance BMS

Qualitative assessment of identified higher order effects:

Higher order effects	How and where they would occur	Timeframe	Expected magnitude (Low, Medium, High)	Likelihood of effect occurring (Low, Medium, High)	Causal relationship to solution?
Direct rebound emissions from an increase in energy consumption due to an increase in energy efficiency and associated cost reduction.	Would occur if tenants make manual adjustments to change energy consumption following the initial reduction in energy and the associated cost reductions.	Short to medium-term	Medium	High	Maybe, solution is automatic, so would not necessarily enable a rebound effect.
Decreased reliance on reserve generators for grid peak loads	Would occur if solution was implemented in a significant number of buildings within the same location at relevant reserve generators.	Short-term	Medium - High	Low	Maybe, but difficult to determine

Tenants or property owners paying for energy, use saved income on carbon emitting activities	Would occur with tenants or property owners who pay for the energy consumption, if the reduced costs associated with the energy savings leads to increase in consumption.	Medium-term	Low - High	Medium	Maybe, but difficult to determine
Improved knowledge about building energy consumption and around impact on climate change can improve fuel usage/energy consumption in other areas of the users, reducing emissions.	Would likely occur with tenants of the building, if they engage with the solution and apply learnings elsewhere (i.e., at home).	Long-term	Low - High	Low	Maybe, but difficult to determine

Inteligg, c-BEMS

Qualitative assessment of identified higher order effects:

Higher order effects	How and where they would occur	Timeframe	Expected magnitude (Low, Medium, High)	Likelihood of effect occurring (Low, Medium, High)	Causal relationship to solution?

Rebound effect from users turning on heating more often as a result of efficiencies	Would occur if the users of the solution prefer a hotter space over cost savings	Medium term	Medium - High	Low	Because the solution is run automatically there is not much the user can adjust which reduces the likelihood of the higher order effect occurring.
Rebound effect from saved costs which can be spent on carbon intensive or carbon saving products and activities	Would occur if the user spends the saved costs elsewhere	Medium term	Low	Low	Difficult to ascertain as it is influenced by many factors
Improved knowledge on the building's energy consumption, and sustainability in general may help users make environmentally beneficial decisions.	Would occur if drivers are actively engaged in the climate benefits of the solution and decide to use acquired knowledge elsewhere in their lives	Long term	Low	Low	Difficult to ascertain as it is influenced by many factors

(B) Where a quantitative assessment is possible, the GHG impact of all identified higher order effects (positive and negative) should be calculated for each implementation context within the boundary conditions.

(i) Significant effects shall not be excluded from quantitative assessment if robust data and knowledge of the effect exist.

(ii) Effects deemed significant but not quantifiable shall be supported by clear justification and reported alongside the net carbon impact quantitative results.

(iii) Effort should be made to collect necessary data or carry out necessary studies with the intention of quantitatively assessing the effect in the future and the exclusion shall be re-evaluated during the recalculation assessment**Error! Reference source not found.**.

(C) The GHG impact of higher order effects shall be calculated with a life cycle perspective, where it is feasible.

(D) Higher order effects shall be calculated in relation to the functional unit and for the level of activity defined by the functional unit performance.

(E) A conservative approach should be applied for all calculations of higher order effects, i.e. net positive emissions should rather be understated than overstated

Schneider Electric, High Performance BMS

No identified higher order effects were included in the calculation.

Inteligg, c-BEMS

No identified higher order effects were included in the calculation.

Net Carbon Impact Calculation

(A) The total net carbon impact of the solution shall be calculated including all quantified first, second, and higher order effects included in the assessment, for the time boundary of the assessment

Schneider Electric, High Performance BMS

Net GHG impact calculation:

The solution emissions for the building are subtracted from the sum of the yearly enabled reductions of energy emissions to get the net avoided emissions. This figure is then divided by the building floor area to get the net enabled avoided emissions per m2.

Results will vary based on country.

Ref I: Standard BMS for the EU (average) (using Route 1):

Large commercial buildings:

1st order effect: 56 tCO2e/year

2nd order effects: 524 tCO2e/year

Total carbon saving impact: 468 tCO2e / year

Savings from reference scenario (%)

- % Electricity savings: 13%

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- % Gas savings: 29%

Saving per functional unit: 0.01 tCO_2e / m2 / year

Medium commercial buildings:

1st order effect: 6 tCO_2e/year

2nd order effects: 42 tCO_2e/year

Total carbon saving impact: 36 tCO_2e / year

Savings from reference scenario (%)

- % Electricity savings: 18%
- % Gas savings: 28%

Saving per functional unit: 0.007 tCO_2e / m2 / year

Small commercial buildings:

1st order effect: 0.6 tCO_2e/year

2nd order effects: 4 tCO_2e/year

Total carbon saving impact: 3.4 tCO_2e / year

Savings from reference scenario (%)

- % Electricity savings: 20%
- % Gas savings: 30%

Saving per functional unit: 0.007 tCO_2e / m2 / year

Ref II: Advanced BMS for the EU (average) (using Route 1):

Large commercial buildings:

1st order effect: 10 tCO_2e/year

2nd order effects: 235 tCO_2e/year

Total carbon saving impact: 225 tCO_2e / year

Savings from reference scenario (%)

- % Electricity savings: 7%
- % Gas savings: 11%

Saving per functional unit: 0.005 tCO_2e / m2 / year

Medium commercial buildings:

1st order effect: 1 tCO_2e/year

2nd order effects: 18 tCO_2e/year

Total carbon saving impact: 17 tCO_2e / year

Savings from reference scenario (%)

- % Electricity savings: 9%
- % Gas savings: 11%

Saving per functional unit: 0.003 tCO_2e / m2 / year

Small commercial buildings:

1st order effect: 0.1 tCO_2e/year

2nd order effects: 1.8 tCO_2e/year

Total carbon saving impact: 1.7 tCO_2e / year

Savings from reference scenario (%)

- % Electricity savings: 10%
- % Gas savings: 11%

Saving per functional unit: 0.003 tCO_2e / m2 / year

Inteligg, c-BEMS

Net carbon impact results:

Apartments, Greece

1st order effect: 16 $kgCO_2e$/year

2nd order effect: 771 $kgCO_2e$/year

Total carbon saving impact: 755 kg CO_2e / year

Savings from reference scenario (%): 36% energy

Saving per functional unit: 0.5 kWh / DD / year

Office, Belgium

1st order effect: 6 kg CO_2e/ year

2nd order effect: 53 kgCO2e/year

Total carbon saving impact: 47 kg CO2e / year

Savings from reference scenario (%): 3% energy

Saving per functional unit: 0.02 kWh / DD / year

(B) Significant changes to the calculated GHG impacts of first, second, or higher order effects during the time period of the assessment shall be included in the assessment.

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Any changes during the time period of the assessment, such as changes in emission factors, have been considered in the calculation.

Inteligg, c-BEMS

Any changes during the time period of the assessment, such as changes in emission factors, have been considered in the calculation.

Uncertainty and sensitivity analysis

(A) A sensitivity analysis should be carried out for all key parameters as part of the net carbon impact assessment.

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Sensitivity analysis results for implementing the solution compared to an Advanced BMS:

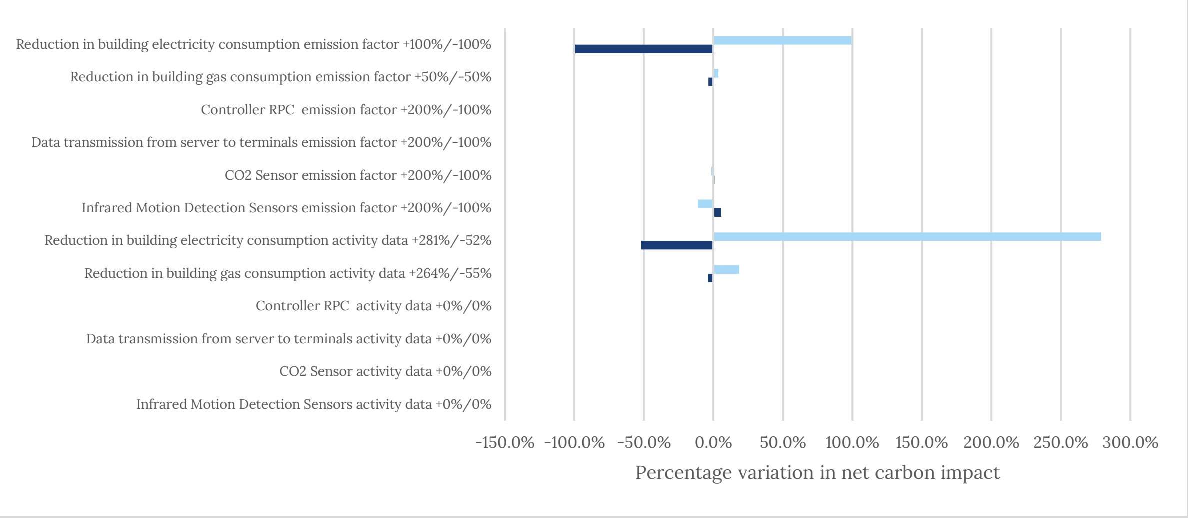
The results are the most sensitive to the electricity percentage savings and the electricity emission factor.

As the electricity savings are based on modelled savings, which take into account several parameters and are based on archetype data, there is some uncertainty around whether these saving percentages are translated into real world savings. Assuming the electricity savings are 5% as a minimum and 40% (reducing the percentage saving parameter by 33% to -83%) as a maximum, as indicated by other studies assessing the impact of BEMS, this would change the results by an average of ~50% to +300% respectively for a building in Europe, depending on the size of the building. The gas percentage savings have a much lower impact on the overall net carbon impact as the gas consumption is much lower than electricity consumption for the buildings in this case study.

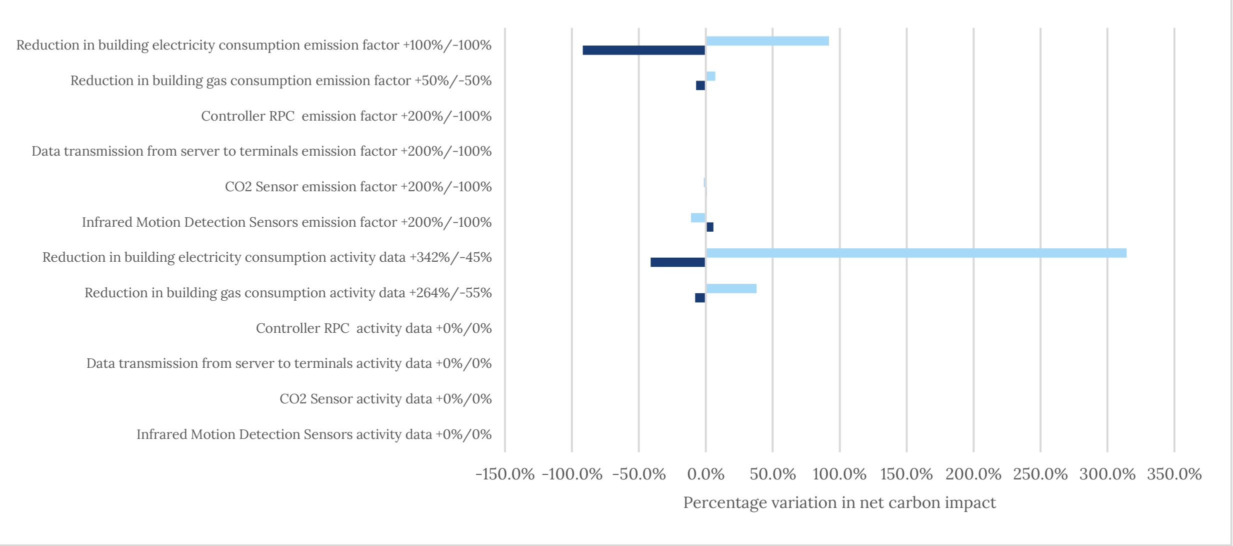
While the data quality of the emissions factors is good to very good, the sensitivity to this parameter highlights how the results could vary across different countries, or in buildings that are using 100% renewable electricity, which would reduce the savings by nearly 100%.

Although there is some uncertainty around the data quality of the first order effects, these tend to have a very minimal impact on the overall results and even a doubling of these emissions would reduce the overall net impact by no more than ~11% on average.

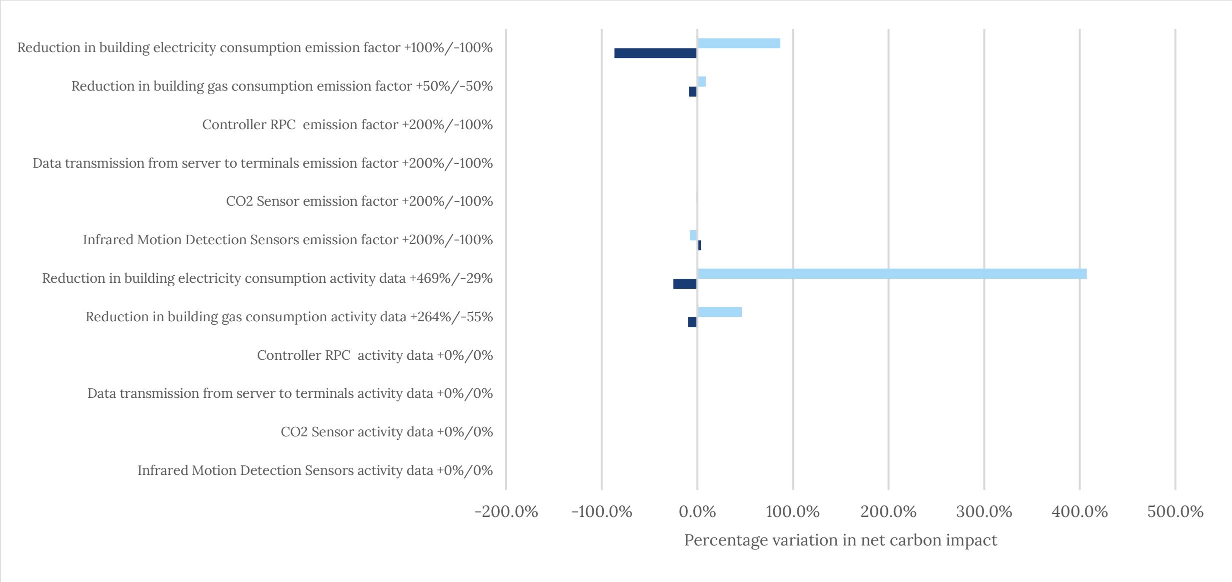
Sensitivity analysis for small office buildings using EU (Average) emission intensities, comparing the implementation of the solution to an Advanced BMS:



Sensitivity analysis for medium office buildings using EU (Average) emission intensities, comparing the implementation of the solution to an Advanced BMS:



Sensitivity analysis for large office buildings using EU (Average) emission intensities, comparing the implementation of the solution to an Advanced BMS:



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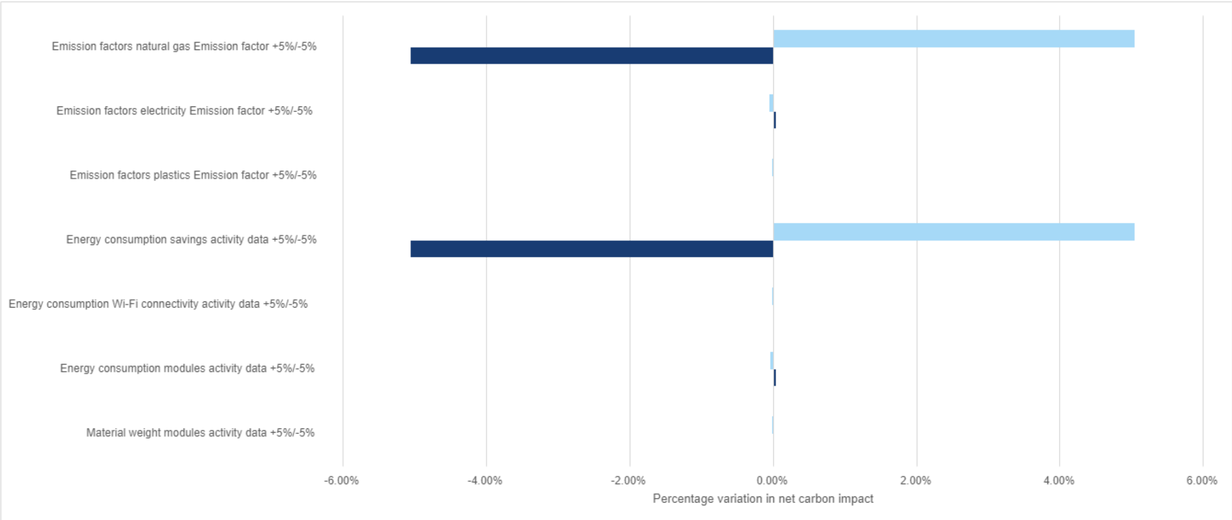
The sensitivity analysis demonstrates that the outcome of the calculations shows a low sensitivity to the 1st order effects (<1%). The second order effect has a higher sensitivity (~5%). To improve the reliability of the calculator, 2nd order effect data needs to become more reliable.



(B) A net carbon impact assessment should include an uncertainty analysis of the results.

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The qualitative uncertainty analysis for route 1 and 2 illustrate good to very good data quality across all effects.

Data type	Impact effect	Description of effect	Activity	Time	Geography	Reliability	Completeness
Activity Data	1st order	Infrared Motion Detection Sensors	Good	Good	Good	Good	Good
	1st order	CO2 Sensor	Good	Good	Good	Good	Good
	1st order	Data transmission from server to terminals	Good	Good	Good	Good	Good
	1st order	Controller RPC	Good	Good	Good	Good	Good
	2nd order	Reduction in building gas consumption	Very Good	Very Good	Very Good	Good	Very Good
	2nd order	Reduction in building electricity consumption	Very Good	Very Good	Very Good	Good	Very Good
Emission factors	1st order	Infrared Motion Detection Sensors	Very Good	Very Good	Very Good	Good	Very Good
	1st order	CO2 Sensor	Very Good	Very Good	Very Good	Good	Very Good
	1st order	Data transmission from server to terminals	Very Good	Very Good	Very Good	Good	Very Good
	1st order	Controller RPC	Very Good	Very Good	Very Good	Good	Very Good
	2nd order	Reduction in building gas consumption	Good	Very Good	Good	Very Good	Good
	2nd order	Reduction in building electricity consumption	Very Good	Very Good	Good	Good	Very Good

It should be noted that the analysis performed is not a quantitative uncertainty analysis. By providing a more granular view of data quality, which builds on the data quality assessment, this analysis highlights areas of uncertainty within the calculation using a qualitative assessment framework. It can however be used to feed into a quantitative uncertainty analysis using guidance from the Greenhouse Gas Protocol on Quantitative Inventory Uncertainty: https://ghgprotocol.org/sites/default/files/2022-12/Quantitative%20Uncertainty%20Guidance.pdf

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The qualitative uncertainty analysis illustrates the relatively poor 2nd order effect data, which has a significant impact on the reliability of the results of the calculator. There is also considerable uncertainty around the activity data of the modules' energy consumption and Wi-Fi connectivity.

Data type		Description of effect	Activity	Time	Geography	Reliability	Completeness
Activity Data	First order	Material weight modules	Very good	Very good	Very good	Good	Good
		Energy consumption modules	Fair	Very good	Very good	Good	Fair
		Energy consumption Wi-Fi connectivity	Poor	Good	Very good	Good	Fair
		Gas metre readings	Fair	Very good	Very good	Fair	Poor

	Second order	Degree days	Good	Very good	Very good	Good	Very good
		Assumption on % energy towards heating	Fair	Very good	Good	Fair	Poor
Emission factors	First order	Plastics emission factors	Fair	Very good	Very good	Good	Very good
		Electricity emission factor	Good	Very good	Very good	Good	Very good
	Second order	Natural gas emission factors	Good	Very good	Very good	Good	Very good

It should be noted that the analysis performed is not a quantitative uncertainty analysis. By providing a more granular view of data quality, which builds on the data quality assessment, this analysis highlights areas of uncertainty within the calculation using a qualitative assessment framework. It can however be used to feed into a quantitative uncertainty analysis using guidance from the Greenhouse Gas Protocol on Quantitative Inventory Uncertainty: https://ghgprotocol.org/sites/default/files/2022-12/Quantitative%20Uncertainty%20Guidance.pdf

Recalculation

(A) It may be suitable that an assessment calculated for one year can be repeated in following years without changes, however, the reference scenario, implementation context, assumptions, exclusions, methods, and data used shall be reviewed annually to be applicable before continuing to use the results of an assessment.

(B) If the review identifies necessary changes to the assessment that could change the results by more than 5%, recalculation in whole or part will be necessary.

(C) Recalculation of the assessment should take place at a maximum of three years after the original assessment to ensure its validity.

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Any changes to the Technopole building that would change its energy consumption significantly (e.g., change in use of building, refurbishments, etc.) would require a review of the assessment.

Furthermore, the electricity emission factor should be updated on an annual basis to reflect changes in the emissions intensity of the grid across relevant countries.

Finally, for reference scenario I, it is advised to review to what extent a standard BMS can still be considered the market average across the relevant European countries.

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Any changes to the buildings included in the assessment that would change their energy consumption significantly (e.g., change in use of building, refurbishments, etc.) would require a review of the assessment.

Other considerations for a net carbon impact assessment

Do No Significant Harm

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No negative impacts on any of the EU Taxonomy's environmental nor social objectives are being foreseen, and the solution strongly supports objective 1: Climate change mitigation. The Advanced BMS is scalable, while also having the potential to improve quality of life and human comfort.

Inteligg, c-BEMS

The solution is not expected to cause significant harm in other ESG areas.

Using Results in Other Implementation Contexts

(A) The new implementation context shall have the same ICT solution scenario and reference scenario as the original net carbon impact assessment.

(B) The parameters of the original net carbon impact assessment should be adjusted to reflect the new implementation context.

(C) Where it is not possible to adjust the assessment parameters, the results should only be used in other implementation contexts if a review determines that the changes are not expected to significantly change the results or overestimate a positive impact.

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The following includes a list of implementation parameters that may need to be adjusted in different implementation contexts:

- **Location of buildings** – the location of buildings would impact the emissions intensity of both the electricity due to a changing grid mix, as well as the emissions intensity of natural gas. Adjustments would be needed and could be addressed by using location-specific emission factors. The location of buildings would also have an impact on the emissions from the IT infrastructure. However, given the immateriality of these emissions to the overall net carbon impact, if data is not available or the new suppliers are unknown, the assessment could be used within this context without the need for adjustments.

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- **Energy source of heating and electricity** – if the solution was applied in a building with a different energy source for heating (e.g., heat pumps, electricity, district heating) this would impact the overall saving potential, due to the different emission intensity of the heating source. In order to take this into account, the emission factor would need to be adjusted for the different heating source. Furthermore, the energy input vs energy outputs and efficiency of heating equipment would need to be considered and potential adjustments would need to be made. Furthermore, if the electricity was provided via on-site renewables rather than from the grid, this would again change the emissions associated with energy consumption and therefore the potential emission savings.
- **Type and use of buildings** – the type and use of the buildings will have a significant impact on the consumption of the buildings. The current assessment considers the implementation of the solution in office buildings of different sizes, but the solution may have a different impact in factories, residential buildings or warehouses due to the different energy consumption patterns and intensities of these buildings. As it would be difficult to make sufficient adjustments to take these differences into account, a new assessment would need to be carried out to assess the impact of the solution in these types of buildings. The extent to which the energy consumption would differ, would determine whether a new assessment is required. For example, the assessment could still be applicable in office buildings of different types of companies. This also applies if the energy performance of the building is different. The current impact of the solution is based on the infrastructure of the Technopole building, as well as a set of defined parameters for the modelled impacts. If the energy performance differs due to legislations or improvements made to buildings, such as insulations, equipment upgrades, etc., that would change the energy consumption of the buildings and therefore the potential savings that could be achieved.
- **Different controller and sensor suppliers** - If the suppliers of the hardware differ in the new implementation context, this could be updated and adjusted in the assessment. However, given the immateriality of these emissions to the overall net carbon impact, if data is not available or the new suppliers are unknown, the assessment could be used within this context without the need for adjustments.

Inteligg, c-BEMS

The following includes a list of implementation parameters that may need to be adjusted in different implementation contexts:

- **Location of buildings** – the location of buildings would impact the emissions intensity of natural gas. Adjustments could be made by using location-specific emission factors. However, it is unlikely that the emissions intensity of natural gas differs significantly across different countries given the current low percentage of biomass content in natural gas across countries. The location of buildings would also have an impact on the emissions from the IT infrastructure. However, given the immateriality of these emissions to the overall net carbon impact, if data is not available or the new suppliers are unknown, the assessment could be used within this context without the need for adjustments. Furthermore, the location of the buildings could also impact the number of degree days, as the savings are currently dependant on the number of degree days per year and a changing climate, would reduce the number of days that require heating and therefore the impact of the solution.

- **Energy source of heating** – if the solution was applied in a building with a different energy source for heating, this would impact the overall saving potential, due to the different emission intensity of the heating source. In order to take this into account, the emission factor would need to be adjusted for the different heating source. Furthermore, the energy input vs energy outputs and efficiency of heating equipment would need to be considered and potential adjustments would need to be made.
- **Type and use of buildings** – the type and use of the buildings will have a significant impact on the consumption of the buildings. The current assessment considers the implementation of the solution in an office building and residential apartments, but the solution may have a different impact in office buildings of different sizes, factories or warehouses due to the different energy consumption patterns and intensities of these buildings. As it would be difficult to make sufficient adjustments to take these differences into account, a new assessment would need to be carried out to assess the impact of the solution in these types of buildings. The extend to which the energy consumption would differ, would determine whether a new assessment is required. For example, the assessment could still be applicable in office buildings of different types of companies.
- **Different controller, thermostat and sensor suppliers** - If the suppliers of the hardware differ in the new implementation context, this could be updated and adjusted in the assessment. However, given the immateriality of these emissions to the overall net carbon impact, if data is not available or the new suppliers are unknown, the assessment could be used within this context without the need for adjustments.

Communicating and Documenting Outcomes of a Net Carbon Impact Assessment

Communicating and documenting outcomes of a single ICT solution

Organisations communicating results from a net carbon impact assessment of a single ICT solution should disclose:

(A) The total net carbon impact, as well as a breakdown by first order, second order, and higher order effects included in the quantitative assessment.

(B) The qualitative assessment of all higher order effects deemed to be likely and/or of significant magnitude and any actions undertaken to mitigate the effect.

(C) Any other environmental impacts identified from the do no significant harm assessment and any actions undertaken to mitigate their effect.

(D) A description of the ICT solution and assessment including the reference scenario, assessment perspective (actual/potential), implementation context(s), and time period.

(E) The organisation's contribution to the ICT solution and limitations to the calculation.

Organisations communicating results from a net carbon impact assessment of a single ICT solution are encouraged to disclose or provide on request:

(F) Documentation for the assessment including the boundary, calculation methodology, rationales (e.g. justification of reference scenario), assumptions, data sources and uncertainty of the results.

(G) A relative metric for the net carbon impact in relation to the business operations, e.g. percentage of total revenue associated with the solution.

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The results of the assessment have been documented in a combined methodology document, which can be found here.

Inteligg, c-BEMS

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