D2.3 Calculation methodology template and guidelines

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0.7	08/01/2026	Review & comments	Buse Turna
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PROJECT PARTNERS

Partner	Country	Short name
UNIVERSITY COLLEGE CORK - NATIONAL UNIVERSITY OF IRELAND, CORK	IE	UCC-IERC
CITY OF DUBLIN ENERGY MANAGEMENT AGENCY LIMITED	IE	CODEMA
CARR COMMUNICATIONS LIMITED	IE	CARR
NOEL LAWLER GREEN ENERGY SOLUTIONS LIMITED	IE	LAWLER

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation / acronym	Definition
BMS	Building Management System
CHP	Combined Heat Power (cogeneration)
CDD	Cooling Degree Days
EPC	Energy Performance Contracting
ESCOs	Energy Service Companies
HDD	Heating Degree Days
HP	Heat Pump
IPMVP	International Performance Measurement and Verification Protocol
VSD	Variable Speed Drive

Executive Summary

This deliverable introduces a standardised Excel template for calculating energy, cost, and CO_2 savings resulting from the implementation of energy efficiency measures within EPC projects at Irish universities facilitated by EasyPro. The template has been developed to ensure transparency, consistency, and comparability across tender submissions, enabling fair evaluation of proposals. It covers a wide range of measures, such as upgrades of lighting system, water circulation pumps, chiller and air conditioning system, indoor heating system, ventilation system, replacement of a natural gas boiler or combined heat power unit with a heat pump, upgrades to building management system.

Key baseline assumptions such as running hours, energy tariffs, and emission factors are embedded within the template and cannot be modified, ensuring consistency and credibility in the calculations while allowing bidders to propose energy efficient project designs. Each worksheet of the template corresponds to a specific measure, and cells are colour-coded to distinguish between required bidder inputs, fixed assumptions, and calculated outputs. Required inputs include equipment specifications, operating hours, energy consumption, efficiency ratings, and energy demand for heating and cooling, which can be sourced from energy bills, manufacturer datasheets, supplier quotes, building management system logs, and maintenance records.

The template includes a summary worksheet that automatically aggregates results from all measures, providing a clear overview of the total energy, cost, and emissions savings for the proposed project. Accompanied by the utilisation guidelines included in this deliverable, the template serves as a comprehensive tool for both bidders and evaluators, promoting clarity, reliability, and confidence in the assessment of energy efficiency project proposals.

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1 Introduction

This deliverable presents a standardised template for calculating the energy, cost, and emissions savings arising from the implementation of energy efficiency measures. The template has been developed to support a transparent, consistent, and robust assessment of proposed EasyPro projects, enabling tender submissions to be compared on a like-for-like basis. The energy efficiency measures considered are: 1. Replacement of an existing lighting systems with an energy efficient system; 2. Upgrades to water circulation pumps; 3. Replacement of a natural gas boiler with a heat pump; 4. Replacement of a combined heat and power (CHP) unit with a heat pump; 5. Chiller and air conditioning system upgrades; 6. Upgrades to indoor heating system; 7. Upgrades to ventilation system; 8. Installation of photovoltaic generation; 9. Upgrades to building management system (BMS).

To ensure consistency and credibility in savings calculations, key parameters (such as running hours, CO_2 emission factors, energy tariffs) are embedded within the spreadsheet template and will not be editable by users. This approach reduces variability in assumptions across submissions and facilitates straightforward and fair comparison of tender responses. At the same time, the template allows sufficient flexibility for bidders to propose innovative and creative project designs, while remaining stringent enough to ensure equitable evaluation.

This report also includes guidelines on how to use the template, which provides clear instructions for bidders on completing the template accurately and consistently.

The template and accompanying guidelines form a comprehensive tool to support both bidders and evaluators, ensuring clarity, comparability, and confidence in the assessment of energy efficiency project proposals.

Table 1 – Suggested references for the considered energy efficiency measuresbelow shows the suggested references for the considered energy efficiency measures.

No	Energy Efficiency Measure	Section	References
1	Replacement of an existing lighting systems with an energy efficient system	2.2	Breisinger and Tagwerker, 2013; Goswami et al. 2016; Hall and Greeno, 2011; Wulfinghoff, 1999
2	Upgrades to water circulation pumps	2.3	Hall and Greeno, 2011; Schlobach, 2025; Wulfinghoff, 1999
3	Replacement of a natural gas boiler with a heat pump	2.4	Breisinger and Tagwerker, 2013; REHVA, 2023; SEAI, 2025a; SEAI, 2025b
4	Replacement of a combined heat and power (CHP) unit with a heat pump	2.5	European Commission (Eurostat) 2017; SEAI, 2020
5	Chiller and air conditioning system upgrades	2.6	ASHRAE, 2023; Hall and Greeno, 2011; Wulfinghoff, 1999

6	Upgrades to indoor heating system	2.7	ASHRAE, 2023; Hall and Greeno, 2011; Wulfinghoff, 1999
7	Upgrades to ventilation system	2.8	Hall and Greeno, 2011; Wulfinghoff, 1999
8	Installation of photovoltaic generation	2.9	Goswami et al. 2016; Kazmi and Zahedi, 2021
9	Upgrades to building management system (BMS)	2.10	Akbulut et al, 2025; Analytika, 2025; Australian Government Department of Climate Change, Energy, the Environment and Water, 2010; CIBSE, 2009; Hussain, 2024

Table 1 – Suggested references for the considered energy efficiency measures

2 Baseline energy consumption

The baseline energy consumption for a tendered EPC project will be established by the procuring body prior to launching its tender, using reliable and representative historical data, typically covering a period of 12–36 months. The baseline will be defined by clearly specifying the buildings, systems, energy carriers, and performance boundaries included in the contract. As energy consumption at a site may vary significantly from year to year due to factors such as weather conditions, occupancy levels, and operational changes, the baseline will be normalised for relevant variables including weather, occupancy, and operating hours. The baseline calculation methodology, together with the rules governing future adjustments, will be documented in the tender documents, in accordance with the IPMVP standard (EVO, 2026). Where appropriate, regression analysis will be applied to develop an adjusted baseline; for example, cooling-related projects may use CDD–based regressions, while heating or boiler projects may use HDD–based regressions (EnergyLens, 2026). Post-implementation energy consumption will be assessed against this adjusted baseline. All baseline data and methodologies will be communicated transparently to all ESCOs to ensure that energy savings estimates are referenced to the same baseline conditions. Baseline annual data (e.g. baseline energy consumption for heating and cooling systems) will be provided in the calculation templates and will not be editable by bidding ESCOs.

3 Calculation of energy savings and CO_2 emissions reduction for different energy efficiency measures

3.1 Constants used in the calculations

The constants used in the calculations are listed in Table 2 - Constants used in calculations The values of the constants will be defined in the template issued for each tender and will not be editable by bidders.

No	Constants	Units	Symbol	Value
1	Density of the fluid (water)	kg/m^3	ρ	1000
2	Gravitational acceleration	m/s^2	g	9.81
3	Specific heat capacity (water)	$\frac{J}{kg \cdot K}$	c_P	4180
4	Electricity price	€/kWh	C_{EL}	0.14–0.28[1]
5	Natural gas price	€/kWh	C_{NG}	0.035–0.055[1]
6	CHP fuel price (LPG)	€/kWh	C_F	0.11-0.17[1]
7	Grid electricity export tariff	€/MWh	$C_{EL,exp}$	120-150[2]
8	CO_{2eq} emission factor for electricity	$kgCO_{2eq}/kWh$	F_{EL}	0.2241[3]
9	CO_{2eq} emission factor for natural gas	$kgCO_{2eq}/kWh$	F_{NG}	0.1835[2]
10	CO_{2eq} emission factor for fuel used by CHP	$kgCO_{2eq}/kWh$	F_{fuel}	0.2293[2]

Table 2 - Constants used in calculations

3.2 Upgrade of lighting system

The calculation of energy savings for the lighting system uses the input parameters defined in Table 3 - Calculation of energy savings for lighting system - input parameters and the output parameters and formulas defined in Table 4 - Calculation of energy savings for lighting system - output parameters.

No	Input Parameter	Units	Symbol
1	No. of running hours per year before upgrade	Hrs/year	H_1
2	No. of running hours per year after upgrade	Hrs/year	H_2
3	Average consumption per existing lighting tube	Watts	W_1

[1] Estimated

[2] https://www.gov.ie/en/department-of-climate-energy-and-the-environment/publications/small-scale-renewable electricity-generation/

[3] https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors

4	Average consumption of energy efficient lighting tube	Watts	W_2
5	Total number of fittings to be replaced by energy efficient fittings	No.	N_R
6	Total number of excess lighting points to be disconnected	No.	N_D

Table 3 - Calculation of energy savings for lighting system - input parameters

No	Output Parameter	Units	Formula
1	Energy consumption of lighting system before upgrade	kWh/year	$E_{L,1} = \frac{H_1 \cdot W_1 \cdot (N_D + N_R)}{1000}$
2	Energy consumption of lighting system after upgrade	kWh/year	$E_{L,2} = \frac{H_2 \cdot W_2 \cdot N_R}{1000}$
3	Annual energy savings	kWh/year	$\Delta E_L = E_{L,1} - E_{L,2}$
4	Annual energy cost savings	€/year	$\Delta C_L = C_{EL} \cdot \Delta E_L$
5	Annual CO_2 emissions reduction	tCO_{2eq}/year	$\Delta CO_{2,L} = \frac{F_{EL} \cdot \Delta E_L}{1000}$

Table 4 - Calculation of energy savings for lighting system - output parameters

3.3 Upgrade of water circulation pumps

The calculation of energy savings obtained by the replacement of existing water circulation pumps with energy efficient ones uses the input parameters defined in Table 5 - Calculation of energy savings for water circulation pumps – input parameters, and the output parameters and formulas defined in Table 6 - Calculation of energy savings for water circulation pumps – output parameters Different groups of water circulation pumps characterised by different parameters will be defined in the template for each project bundle.

No	Input Parameter	Units	Symbol
1	Number of running hours per year before upgrade	Hrs/year	H_1
2	Number of running hours per year after upgrade	Hrs/year	H_2
3	Number of circulation pumps replaced	Number	N_P
4	Current power consumption of pump	kW	P_1
5	Current water flow rate	m^3/sec	F_1

6	Current head developed	M	$H_{D,1}$
7	Power consumption of new pump	kW	P_2
8	Water flow rate of new pump	m^3/sec	F_2
9	Head developed by new pump	M	$H_{D,2}$

Table 5 - Calculation of energy savings for water circulation pumps – input parameters

No	Output Parameter	Units	Formula
1	Current pump efficiency		$\eta_1 = \frac{\rho \cdot g \cdot H_{D,1} \cdot F_1}{P_1}$
2	New pump efficiency		$\eta_2 = \frac{\rho \cdot g \cdot H_{D,2} \cdot F_2}{P_2}$
3	Annual energy savings	kWh/year	$\Delta E_P = N_P \cdot (H_1 \cdot P_1 - H_2 \cdot P_2)$
4	Annual energy cost savings	€/year	$\Delta C_P = C_{EL} \cdot \Delta E_P$
5	Annual CO_2 equivalent emissions reduction	tCO_{2eq}/year	$\Delta CO_{2,P} = \frac{F_{EL} \cdot \Delta E_P}{1000}$

Table 6 - Calculation of energy savings for water circulation pumps – output parameters

3.4 Replacement of natural gas boiler with heat pump

The calculation of energy cost savings and CO_2 reduction obtained when replacing natural gas boiler with a heat pump uses the input parameters defined in Table 7 - Calculation of energy cost savings and CO_2 reduction obtained replacing a natural gas boiler with a heat pump – input parameters and the output parameters and formulas defined in Table 8 - Calculation of energy cost savings and CO_2 reduction obtained replacing a natural gas boiler with a heat pump – output parameters The template for a particular project bundle may define replacements of different boilers with heat pumps and add together energy cost savings and CO_2 reductions.

No	Input Parameter	Units	Symbol
1	Heat demand	kWh/year	Q_{heat}
2	Boiler efficiency	-	η_{bo}

3	Heat Pump Coefficient of Performance (COP)	-	COP

Table 7 - Calculation of energy cost savings and CO_2 reduction obtained replacing a natural gas boiler with a heat pump – input parameters

No	Output Parameter	Units	Formula
1	Electricity consumption by Heat Pump	kWh/year	$E_{HP} = \frac{Q_{heat}}{COP}$
2	Input energy to boiler	kWh/year	$E_B = \frac{Q_{heat}}{\eta_{bo}}$
3	Annual energy savings	kWh/year	$\Delta E_{BtoHP} = E_B - E_{HP}$
4	Annual energy cost savings	€/year	$\Delta C_{BtoHP} = C_{NG} \cdot E_{bo} - C_{EL} \cdot E_{HP}$
5	Annual CO_2 equivalent emissions reduction	tCO_{2eq}/year	$\Delta CO_{2,BtoHP} = \frac{F_{NG} \cdot E_B - F_{EL} \cdot E_{HP}}{1000}$

Table 8 - Calculation of energy cost savings and CO_2 reduction obtained replacing a natural gas boiler with a heat pump – output parameters

3.5 Replacement of combined heat power unit with heat pump

The calculation of energy cost savings and CO_2 reduction obtained replacing a CHP with a heat pump uses the input parameters defined in Table 9 - Calculation of energy cost savings and CO_2 reduction replacing a CHP with a heat pump – input parameters and the output parameters and formulas defined in Table 10 - Calculation of energy cost savings and CO2 reduction replacing a CHP with a heat pump – output parameters

No	Input Parameter	Units	Symbol
1	Heat demand	kWh/year	Q_{heat}
2	CHP thermal efficiency	-	$\eta_{CHP,th}$
3	CHP electrical efficiency	-	$\eta_{CHP,el}$
4	Heat Pump Coefficient of Performance (COP)	-	COP

Table 9 - Calculation of energy cost savings and CO_2 reduction replacing a CHP with a heat pump – input parameters

No	Output Parameter	Units	Formula
1	Energy consumed by CHP	kWh/year	$E_{CHP} = \frac{Q_{heat}}{\eta_{CHP,th}}$
2	Electricity produced by CHP	kWh/year	$E_{CHP,el} = \eta_{CHP,el} \cdot E_{CHP,fuel}$
3	CHP net running cost	€/year	$C_{CHP,net} = Q_{heat}\left(\frac{C_F}{\eta_{CHP,th}} - \frac{\eta_{CHP,el}}{\eta_{CHP,th}} C_{EL}\right)$
4	CHP CO_2 emissions	$kgCO_{2eq}$/year	$CO_{2,CHP} = E_{CHP} \cdot F_{fuel}$
5	Energy consumed by HP	kWh/year	$E_{HP} = \frac{Q_{heat}}{COP}$
6	Heat pump running cost	€/year	$C_{HP} = E_{HP} \cdot C_{EL}$
7	Heat pump CO_2 emissions	$kgCO_{2eq}$/year	$CO_{2,HP} = E_{HP} \cdot F_{EL}$
8	Annual energy savings	kWh/year	$\Delta E_{CHPtoHP} = E_{CHP} - E_{HP}$
9	Annual energy cost savings	€/year	$\Delta C_{CHPtoHP} = C_{CHP,net} - C_{HP}$
10	Annual CO_2 equivalent emissions savings	$kgCO_{2eq}$/year	$\Delta CO_{2,CHPtoHP} = CO_{2,CHP} - CO_{2,HP}$

Table 10 - Calculation of energy cost savings and CO2 reduction replacing a CHP with a heat pump – output parameters

3.6 Upgrade of chiller and air conditioning system

The calculation of energy savings and energy cost savings obtained from a chiller and air conditioning chiller upgrade uses the input parameters defined in Table 11 - Calculation of energy savings for chiller and air conditioning system upgrade - input parameters and the output parameters and formulas defined in Table 12 - Calculation of energy savings for chiller and air conditioning system upgrade - output parameters

No	Input Parameter	Units	Symbol
1	No. of running hours per year before upgrade	Hrs/year	H_1
2	No. of running hours per year after upgrade	Hrs/year	H_2
3	Average cooling load before upgrade	kW	Q_1
4	Average cooling load after upgrade	kW	Q_2

5	Old chiller COP	-	COP_1
6	New chiller COP	-	COP_2
7	Average power consumption by auxiliaries like chiller water pump, condenser water pump, cooling tower and fan coil units – before upgrade	kW	$E_{aux,1}$
8	Average power consumption by auxiliaries like chiller water pump, condenser water pump, cooling tower and fan coil units – after upgrade	kW	$E_{aux,2}$

Table 11 - Calculation of energy savings for chiller and air conditioning system upgrade - input parameters

No	Output Parameter	Units	Formula
1	Estimated electricity consumption of older chiller	kWh/year	$E_{C,1} = H_1 \cdot \left(\frac{Q_1}{COP_1} + E_{aux,1}\right)$
2	Estimated electricity consumption of new chiller	kWh/year	$E_{C,2} = H_2 \cdot \left(\frac{Q_2}{COP_2} + E_{aux,2}\right)$
3	Annual electricity savings	kWh/year	$\Delta E_C = E_{C,1} - E_{C,2}$
4	Annual electricity cost savings	€/year	$\Delta C_C = C_{EL} \cdot \Delta E_C$
5	Annual CO_2 equivalent emissions reduction	tCO_{2eq}/year	$\Delta CO_{2,C} = \frac{F_{EL} \cdot \Delta E_C}{1000}$

Table 12 - Calculation of energy savings for chiller and air conditioning system upgrade - output parameters

3.7 Upgrade of indoor heating system

The calculation of energy savings and energy cost savings obtained from an upgrade of the indoor heating system and hot water system uses the input parameters defined in Table 13 - Calculation of energy savings for indoor heating system and hot water – input parameters and the output parameters and formulas defined in Table 14 - Calculation of energy savings for indoor heating system and hot water – output parameters

No	Input Parameter	Units	Symbol
1	Total number of heaters before upgrade	Number	$N_{H,1}$
2	Power consumption of each heater before upgrade	kW	$P_{H,1}$

3	Operating hours per year for the room heating system before upgrade	Hrs/year	H_1
4	Energy consumption for hot water generation before upgrade	kWh/year	$E_{HW,1}$
5	Electricity consumption for water circulation pump and Fan Coil Units before upgrade	kWh/year	$E_{P,1}$
6	Total number of heaters after upgrade	Number	$N_{H,2}$
7	Power consumption of each heater after upgrade	kW	$P_{H,2}$
8	Operating hours per year for the room heating system after upgrade	Hrs/year	H_2
9	Energy consumption for hot water generation after upgrade	kWh/year	$E_{HW,2}$
10	Electricity consumption for water circulation pump and Fan Coil Units after upgrade	kWh/year	$E_{P,2}$
11	Cost of energy for hot water generation before upgrade	€/kWh	$C_{TH,1}$
12	Cost of energy for hot water generation after upgrade	€/kWh	$C_{TH,2}$
13	CO_{2eq} emission factor for heating system	$kgCO_{2eq}$/kWh	F_H

Table 13 - Calculation of energy savings for indoor heating system and hot water – input parameters

No	Output Parameter	Units	Formula
1	Baseline energy consumption of heaters	kWh/year	$E_{H,1} = N_{H,1} \cdot P_{H,1} \cdot H_1$
2	Annual energy cost for heating system – before upgrade	€/year	$C_{H,1} = C_{TH,1} \cdot E_{H,1} + C_{EL} \cdot E_{P,1}$
3	Total energy consumption of heaters after upgrade	kWh/year	$E_{H,2} = N_{H,2} \cdot P_{H,2} \cdot H_2$
4	Energy cost for heating system – after upgrade	€/year	$C_{H,2} = C_{TH,2} \cdot E_{H,2} + C_{EL} \cdot E_{P,2}$
5	Energy savings for heaters per year	kWh/year	$\Delta E_H = E_{H,1} - E_{H,2}$
6	Annual energy cost savings	€/year	$\Delta C_H = C_{H,1} - C_{H,2}$
7	Annual CO_2 equivalent emissions savings	$kgCO_{2eq}$/year	$\Delta CO_{2,H} = \Delta E_H \cdot F_H$

Table 14 - Calculation of energy savings for indoor heating system and hot water – output parameters

3.8 Upgrade of ventilation system

The calculation of energy savings obtained from an upgrade of the ventilation system uses the input parameters defined in Table 15 - Calculation of energy savings obtained from upgrades to ventilation system – input parameters and the output parameters and formulas defined in Table 16 - Calculation of energy savings obtained from upgrades to ventilation system – output parameters

No	Input Parameter	Units	Symbol
1	Volumetric airflow rate – before upgrade	m^3/s	Q_1
2	Total pressure rise across the fan – before upgrade	Pa	Δp_1
3	Air supply temperature – before upgrade	°C	$T_{supply,1}$
4	Indoor air temperature – before upgrade	°C	$T_{indoor,1}$
5	Fan efficiency – before upgrade	-	$\eta_{fan,1}$
6	Drive efficiency – before upgrade	-	$\eta_{drive,1}$
7	Motor efficiency – before upgrade	-	$\eta_{motor,1}$
8	Outdoor (make-up) airflow rate – before upgrade	m^3/s	$Q_{out,1}$
9	No. of running hours per year – before upgrade	Hrs/year	H_1
10	Heat recovery efficiency – before upgrade	-	$\eta_{hr,1}$
11	Volumetric airflow rate – after upgrade	m^3/s	Q_2
12	Total pressure rise across the fan – after upgrade	Pa	Δp_2
13	Air supply temperature – after upgrade	°C	$T_{supply,2}$
14	Indoor air temperature – after upgrade	°C	$T_{indoor,2}$
15	Fan efficiency – after upgrade	-	$\eta_{fan,2}$
16	Drive efficiency – after upgrade	-	$\eta_{drive,2}$
17	Motor efficiency – after upgrade	-	$\eta_{motor,2}$
18	Outdoor (make-up) airflow rate – after upgrade	m^3/s	$Q_{out,2}$

19	No. of running hours per year – after upgrade	Hrs/year	H_2
20	Volumetric airflow rate – after upgrade	m^3/s	Q_2
21	Heat recovery efficiency – after upgrade	-	$\eta_{hr,2}$
22	Unit cost of energy for heating	€/year	C_H
23	CO_{2eq} emission factor for heating system	$kgCO_{2eq}/kWh$	F_H

Table 15 - Calculation of energy savings obtained from upgrades to ventilation system – input parameters

No	Output Parameter	Units	Formula
1	Total efficiency of the ventilation system – before retrofit	-	$\eta_{v,1} = \eta_{fan,1} \cdot \eta_{drive,1} \cdot \eta_{motor,1}$
2	Fan electrical energy consumption – before retrofit	kWh/year	$E_{elec,1} = \frac{Q_1 \cdot \Delta p_1}{1000 \cdot \eta_{v,1}} \cdot H_1$
3	Ventilation thermal energy consumption – before retrofit	kWh/year	$E_{th,1} = \frac{\rho \cdot c_P \cdot Q_1 \cdot (T_{suppy,1} - T_{indoor,1}) \cdot H_1}{1000}$
4	Heat recovery from exhaust – before retrofit	kWh/year	$E_{rec,1} = \frac{\rho \cdot c_P \cdot Q_{out,1} \cdot \eta_{hr,1} \cdot (T_{suppy,1} - T_{indoor,1})}{1000} \cdot H_1$
5	Total efficiency of the ventilation system – after retrofit	-	$\eta_{v,2} = \eta_{fan,2} \cdot \eta_{drive,2} \cdot \eta_{motor,2}$
6	Fan electrical energy consumption – after retrofit	kWh/year	$E_{elec,2} = \frac{Q_2 \cdot \Delta p_2}{1000 \cdot \eta_{v,2}} \cdot H_2$
7	Ventilation thermal energy consumption – after retrofit	kWh/year	$E_{th,2} = \frac{\rho \cdot c_P \cdot Q_2 \cdot (T_{suppy,2} - T_{indoor,2}) \cdot H_2}{1000}$
8	Heat recovery from exhaust – after retrofit	kWh/year	$E_{rec,2} = \frac{\rho \cdot c_P \cdot Q_{out,2} \cdot \eta_{hr,2} \cdot (T_{suppy,2} - T_{indoor,2})}{1000} \cdot H_2$

9	Fan electrical energy monthly savings	kWh/year	$\Delta E_{elec} = E_{elec,2} - E_{elec,1}$
10	Ventilation thermal energy savings	kWh/year	$\Delta E_{th} = E_{th,2} - E_{th,1}$
11	Heat recovery from exhaust energy savings	kWh/year	$\Delta E_{rec} = E_{rec,2} - E_{rec,1}$
12	Annual energy savings	kWh/year	$\Delta E_V = \Delta E_{elec} + \Delta E_{th} + \Delta E_{rec}$
13	Annual energy cost savings	€/year	$\Delta C_V = C_{EL} \cdot \Delta E_{elec} + C_H \cdot (\Delta E_{th} + \Delta E_{rec})$
14	Annual CO_2 equivalent emissions savings	tCO_{2eq}/year	$\Delta CO_{2,V} = \frac{F_{EL} \cdot \Delta E_{elec} + F_H \cdot (\Delta E_{th} + \Delta E_{rec})}{1000}$

Table 16 - Calculation of energy savings obtained from upgrades to ventilation system – output parameters

3.9 Installation of Photovoltaic generation

The calculation of energy savings, energy cost savings and CO2 emissions reduction obtained from an installation of a PV-system uses the input parameters defined in Table 17 - Calculation of electricity savings obtained from installation of Photo-Voltaic system – input parameters and the output parameters and formulas defined in Table 18 - Calculation of electricity savings obtained from installation of Photo-Voltaic system – output parameters

No	Input Parameter	Units	Symbol
1	Number of PV modules	Number	N_m
2	Power rating of PV-module	kW	P_m
3	Soiling Losses	-	L_{So}
4	Shading Losses	-	L_{Sh}
5	Module Mismatch Losses	-	L_M
6	Wiring Losses	-	L_W
7	Inverter Losses	-	L_I
8	PV Degradation Losses	-	L_D
9	Temperature Losses	-	L_T

10	Other Losses	-	L_O
11	PV specific ideal yield	$\frac{\text{kWh}}{\text{kWp} \cdot \text{year}}$	Y_i
12	Fraction of PV-generated power that is self-consumed	-	F_{sc}

Table 17 - Calculation of electricity savings obtained from installation of Photo-Voltaic system – input parameters

No	Output Parameter	Units	Formula
1	Total PV efficiency	-	$\eta_{tot} = (1 - L_{So})(1 - L_{Sh})(1 - L_M)(1 - L_W)(1 - L_I)(1 - L_D)(1 - L_T)(1 - L_O)$
2	PV specific final yield	$\frac{\text{kWh}}{\text{kWp} \cdot \text{year}}$	$Y_f = \eta_{tot} \cdot Y_i$
3	PV system capacity	kWp	$P_{PV} = N_m \cdot P_m$
4	Annual energy production	kWh/year	$\Delta E_{PV} = P_{PV} \cdot Y_f$
5	Fraction of PV-generated power that is exported	-	$F_{exp} = 1 - F_{sc}$
6	Electricity cost savings	€/year	$\Delta C_{PV} = \left(F_{sc} C_{EL} + F_{exp} C_{EL,exp}\right) \Delta E_{PV}$
7	CO_2 emissions savings	tCO_{2eq}/year	$\Delta CO_{2,PV} = \frac{F_{EL} \cdot \Delta E_{PV}}{1000}$

Table 18 - Calculation of electricity savings obtained from installation of Photo-Voltaic system – output parameters

3.10 BMS upgrades

The BMS optimisation opportunities considered in this report are listed in Table 19 - BMS optimisation strategies below.

No	BMS optimisation	Description
1	Lighting system optimisation	Lighting system's energy consumption is optimised by using occupancy and daylight sensors to ensure lights operate only when needed and at appropriate brightness levels. Illumination is adjusted based on natural light availability, lights in unoccupied areas are dimmed or switched off, and lighting zones are managed to match real-time usage (Operational Intelligence, 2025).

2	Water circulation pumps optimisation	Water circulation pump energy consumption is reduced by adjusting pump operation and speed according to real-time demand, using data from flow, pressure, or temperature sensors to avoid unnecessary full-speed operation. Multiple pumps are sequenced efficiently and coordinated with HVAC equipment to ensure pumps run only when needed (Wilo Philippines, 2026).
3	Dynamic set-point optimisation for chiller and air-conditioning system	This is a coordinated strategy across both chillers and air-side equipment, allowing the BMS to balance thermal comfort and energy efficiency throughout the entire air conditioning system. Key setpoints of the chiller system, such as chilled water supply temperature, condenser water temperature, and chiller staging are dynamically adjusted based on real-time load, outdoor temperature, and system efficiency (Carter's Electrical Services, 2025; Cheng, 2018; Rohde et al., 2020; Hussain, 2024). This ensures the chillers operate at their most efficient point. Setpoints of the air conditioning system (AHUs, FCUs, and VAVs) such as supply air temperature, static pressure, and airflow rates are dynamically adjusted according to indoor conditions, occupancy, and zone demand. These dynamic adjustments maintain comfort while minimizing energy use.
4	Dynamic set-point optimisation for heating system	This BMS control strategy enables to continuously adjust target temperatures and heating output in response to real-time conditions to maximize energy efficiency while maintaining comfort. Indoor temperatures, outdoor weather, and, where available, occupancy patterns are used to modulate boiler or heat pump output, hot water flow, and fan coil operation (Carter's Electrical Services, 2025; Rohde et al., 2020). By implementing *zone-based heating control*, the strategy ensures that only occupied or actively used areas receive heat, allowing unoccupied zones to drift to lower temperatures. Supply water temperature, fan speed, and valve positions are dynamically adjusted to match demand in each zone, reducing energy waste, avoiding overheating, and maintaining consistent comfort throughout the building.
5	Demand-controlled ventilation	The amount of outdoor air supplied to the building is adjusted based on real-time occupancy or indoor air quality (typically CO_2 levels). Instead of running ventilation fans at full speed constantly, the BMS modulates airflow to match actual demand (Marston, 2023). This delivers electrical energy savings by reducing fan power, which is proportional to the cube of airflow. For thermal energy savings, less outdoor air reduces the load on heating or cooling systems, since the HVAC system does not need to heat or cool as much fresh air to maintain comfort.
6	Heat recovery optimisation	Parameters such as supply and exhaust air temperatures, airflow rates, and zone heating or cooling demand, are continuously tracked such that

		fans, dampers, and pumps can be adjusted to optimize the operation of heat recovery devices. Airflow through a heat recovery unit is increased when exhaust air is warmer (or cooler) than incoming air, preheating or precooling the fresh air to reduce the load on heating or cooling units. By coordinating these adjustments in real time, energy consumption can be reduced (Brookvent, 2026; Hewitt Consulting Engineers, 2025).
7	Economiser and free cooling optimisation	When the outside air is cooler or drier than the indoor setpoint, the BMS gradually opens the outdoor air dampers and adjusts fan speeds to bring in as much fresh air as needed to meet cooling demand, reducing chiller operation (economiser). For free cooling, the BMS can circulate cold outdoor air directly through the building or over the chilled water system to bypass chiller operation (ANDIVI, 2025; Sirus International, 2012). By adjusting airflow rates, dampers, and pumps in real time, the BMS ensures that the building uses free or economised cooling whenever possible, reducing chiller runtime, lowering electricity consumption, and maintaining comfort efficiently.
8	Chiller/boiler plant sequencing	This BMS strategy determines the most efficient combination and order of operation for multiple chillers or boilers to meet building thermal demand (Weathermakers, 2026; SEAI, 2015). Equipment is turned on or off and load sharing is adjusted based on real-time demand, system efficiency, and capacity. By operating only the number of units needed at optimal efficiency, sequencing minimises energy use, prevents short cycling, and maintains stable temperatures throughout the system.

Table 19 - BMS optimisation strategies

For each optimisation strategy the ESCO is requested to estimate the percentage of additional energy savings that the BMS optimisation can deliver on top of the installation of the retrofit measures. Input parameters for the energy savings calculation due to BMS upgrades are shown in Table 20 - Calculation of energy savings for upgrades to BMS – input parameters, whereas Table 21 - Calculation of energy savings for upgrades to BMS – output parameters shows the output of the calculation.

No	Input Parameter	Units	Symbol
1	Energy consumption of the lighting system after upgrades	kWh/year	E_L
2	Energy savings due to lighting energy system optimisation (percentage)	%	$S_{L,\%}$
3	Energy consumption of the water circulation pumps after upgrades	kWh/year	E_P
4	Energy savings due to water circulation pumps optimisation (percentage)	%	$S_{P,\%}$
5	Energy consumption of chiller system after upgrades	kWh/year	E_C

6	Energy consumption of air conditioning system after upgrades	kWh/year	E_{AC}
7	Energy savings due to dynamic set-point optimisation for chiller and air-conditioning system (percentage)	%	$S_{CAC,\%}$
8	Energy consumption of ventilation system after upgrades (electrical)	kWh/year	$E_{V,el}$
9	Energy consumption of ventilation system after upgrades (thermal)	kWh/year	$E_{V,th}$
10	Energy savings (electrical) due to demand-controlled ventilation (percentage)	%	$S_{Vel,\%}$
11	Energy savings (thermal) due to demand-controlled ventilation (percentage)	%	$S_{Vth,\%}$
12	Heat recovered after upgrades	kWh/year	E_{Hrec}
13	Energy savings due to optimised heat recovery (percentage)	%	$S_{Hrec,\%}$
14	Energy savings due to economiser and free cooling optimisation (percentage)	%	$S_{EFC,\%}$
15	Energy savings due to cooling units sequencing (percentage)	%	$S_{SeqC,\%}$
16	Energy savings due to heating units sequencing (percentage)	%	$S_{SeqH,\%}$
17	Total heating energy consumption after upgrades	kWh/year	E_H
18	Other BMS energy savings (not included in previous calculations) – electricity	kWh/year	$\Delta E_{O,BMS,el}$
19	Other BMS energy savings (not included in previous calculations) – thermal	kWh/year	$\Delta E_{O,BMS,th}$
20	Unit cost of energy for heating	€/year	C_H
21	CO_{2eq} emission factor for heating system	$kgCO_{2eq}$/kWh	F_H

Table 20 - Calculation of energy savings for upgrades to BMS – input parameters

No	Output Parameter	Units	Formula
1	Energy savings due to lighting energy system optimisation	kWh/year	$\Delta E_{L,BMS} = S_{L,\%} \cdot E_L$
2	Energy savings due to water circulation pumps optimisation	kWh/year	$\Delta E_{P,BMS} = S_{P,\%} \cdot E_P$

3	Energy savings due to dynamic set-point optimisation for chiller and air-conditioning system	kWh/year	$\Delta E_{CAC,BMS} = S_{CAC,\%} \cdot (E_C + E_{AC})$
4	Energy savings (electrical) due to demand-controlled ventilation	kWh/year	$\Delta E_{Vel,BMS} = S_{Vel,\%} \cdot E_{V,el}$
5	Energy savings (thermal) due to demand-controlled ventilation	kWh/year	$\Delta E_{Vth,BMS} = S_{Vth,\%} \cdot E_{V,th}$
6	Energy savings (total) due to demand-controlled ventilation	kWh/year	$\Delta E_{V,BMS} = \Delta E_{Vel,BMS} + \Delta E_{Vth,BMS}$
7	Energy savings due to optimised heat recovery	kWh/year	$\Delta E_{Hrec,BMS} = S_{Hrec,\%} \cdot E_{Hrec}$
8	Energy savings due to economiser and free cooling optimisation	kWh/year	$\Delta E_{EFC,BMS} = S_{EFC,\%} \cdot (E_C + E_{AC})$
9	Energy savings due to cooling units sequencing	kWh/year	$\Delta E_{SeqC,BMS} = S_{SeqC,\%} \cdot (E_C + E_{AC})$
10	Energy savings due to heating units sequencing	kWh/year	$\Delta E_{SeqH,BMS} = S_{SeqH,\%} \cdot E_H$
11	Total BMS energy savings	kWh/year	$\Delta E_{BMS} = \Delta E_{L,BMS} + \Delta E_{P,BMS} + \Delta E_{CAC,BMS} + \Delta E_{V,BMS} + \Delta E_{Hrec,BMS} + \Delta E_{EFC,BMS} + \Delta E_{SeqC,BMS} + \Delta E_{SeqH,BMS} + \Delta E_{O,BMS,el} + \Delta E_{O,BMS,th}$
12	Total BMS energy cost savings	€/year	$\Delta C_{BMS} = C_{EL} \cdot (\Delta E_{L,BMS} + \Delta E_{P,BMS} + \Delta E_{CAC,BMS} + \Delta E_{Vel,BMS} + \Delta E_{EFC,BMS} + \Delta E_{SeqC,BMS} + \Delta E_{O,BMS,el}) + C_H \cdot (\Delta E_{Vth,BMS} + \Delta E_{Hrec,BMS} + \Delta E_{SeqH,BMS} + \Delta E_{O,BMS,th})$
13	Total BMS CO_2 equivalent emissions reduction	tCO_{2eq}/year	$\Delta CO_{2,BMS} = F_{EL} \cdot (\Delta E_{L,BMS} + \Delta E_{P,BMS} + \Delta E_{CAC,BMS} + \Delta E_{Vel,BMS} + \Delta E_{EFC,BMS} + \Delta E_{SeqC,BMS} + \Delta E_{O,BMS,el}) + F_H \cdot (\Delta E_{Vth,BMS} + \Delta E_{Hrec,BMS} + \Delta E_{SeqH,BMS} + \Delta E_{O,BMS,th})$

Table 21 - Calculation of energy savings for upgrades to BMS – output parameters

3.11 Calculation of total energy savings, total energy cost savings and total CO_2 equivalent emissions reduction

The calculation of total energy savings, energy cost savings and CO_2 equivalent emissions reduction uses the input parameters included in Table 22 – Calculation of total energy savings, energy cost savings and CO_2 equivalent emissions reduction – input parameters (which have been calculated in the previous sections) and the output parameters in Table 23 - Calculation of total energy savings, energy cost savings, and CO_2 equivalent emissions reduction - output parameters

No	Input Parameter	Units	Symbol
1	Energy savings due to upgrades to the lighting system	kWh/year	ΔE_L
2	Energy savings due to upgrades to water circulation pumps	kWh/year	ΔE_P
3	Energy savings due to replacement of natural gas boiler with heat pump	kWh/year	ΔE_{BtoHP}
4	Energy savings due to replacement of combined heat power unit with heat pump	kWh/year	$\Delta E_{CHPtoHP}$
5	Energy savings due to chiller and air conditioning system upgrade	kWh/year	ΔE_C
6	Energy savings due to upgrade of indoor heating system	kWh/year	ΔE_H
7	Energy savings due to upgrades to ventilation system	kWh/year	ΔE_V
8	Energy savings due to installation of photo-voltaic generation	kWh/year	ΔE_{PV}
9	Energy savings due to BMS upgrades	kWh/year	ΔE_{BMS}
10	Energy cost savings due to upgrades to the lighting system	€/year	ΔC_L
11	Energy cost savings due to upgrades to water circulation pumps	€/year	ΔC_P
12	Energy cost savings due to replacement of natural gas boiler with heat pump	€/year	ΔC_{BtoHP}
13	Energy cost savings due to replacement of combined heat power unit with heat pump	€/year	$\Delta C_{CHPtoHP}$
14	Energy cost savings due to chiller and air conditioning system upgrade	€/year	ΔC_C
15	Energy cost savings due to upgrade of indoor heating system	€/year	ΔC_H
16	Energy cost savings due to upgrades to ventilation system	€/year	ΔC_V

17	Energy cost savings due to installation of photo-voltaic generation	€/year	ΔC_{PV}
18	Energy cost savings due to BMS upgrades	€/year	ΔC_{BMS}
19	CO_2 emissions reduction due to upgrades to the lighting system	tCO_{2eq}/year	$\Delta CO_{2,L}$
20	CO_2 emissions reduction due to upgrades to water circulation pumps	tCO_{2eq}/year	$\Delta CO_{2,P}$
21	CO_2 emissions reduction due to replacement of natural gas boiler with heat pump	tCO_{2eq}/year	$\Delta CO_{2,BtoHP}$
22	CO_2 emissions reduction due to replacement of combined heat power unit with heat pump	tCO_{2eq}/year	$\Delta CO_{2,CHPtoHP}$
23	CO_2 emissions reduction due to chiller and air conditioning system upgrade	tCO_{2eq}/year	$\Delta CO_{2,C}$
24	CO_2 emissions reduction due to upgrade of indoor heating system	tCO_{2eq}/year	$\Delta CO_{2,H}$
25	CO_2 emissions reduction due to upgrades to ventilation system	tCO_{2eq}/year	$\Delta CO_{2,V}$
26	CO_2 emissions reduction due to installation of photo-voltaic generation	tCO_{2eq}/year	$\Delta CO_{2,PV}$
27	CO_2 emissions due to BMS upgrades	tCO_{2eq}/year	$\Delta CO_{2,BMS}$

Table 22 – Calculation of total energy savings, energy cost savings and CO_2 equivalent emissions reduction – input parameters

No	Output Parameter	Units	Formula
1	Total energy savings	kWh/year	$\Delta E_T = \Delta E_L + \Delta E_P + \Delta E_{B,HP} + \Delta E_{CHP,HP} + \Delta E_C + \Delta E_H + \Delta E_V + \Delta E_{PV} + \Delta E_{BMS}$
2	Total energy cost savings	€/year	$\Delta C_T = \Delta C_L + \Delta C_P + \Delta C_{B,HP} + \Delta C_{CHP,HP} + \Delta C_C + \Delta C_H + \Delta C_V + \Delta C_{PV} + \Delta C_{BMS}$
3	Total CO_2 equivalent emissions reduction	tCO_{2eq}/year	$\Delta CO_{2,T} = \Delta CO_{2,L} + \Delta CO_{2,P} + \Delta CO_{2,BtoHP} + \Delta CO_{2,CHPtoHP} + \Delta CO_{2,C} + \Delta CO_{2,H} + \Delta CO_{2,V} + \Delta CO_{2,PV} + \Delta CO_{2,BMS}$

Table 23 - Calculation of total energy savings, energy cost savings, and CO_2 equivalent emissions reduction - output parameters

4 Guidelines on how to use the template

The energy and cost savings calculation template is provided as an Excel document designed to ensure consistency, transparency, and comparability across all project proposals. It is available on Teams: EasyPro_template_for_calculating_energy_and_cost_savings.xlsx

The template should be completed strictly in line with the guidance set out below.

Each worksheet within the Excel file corresponds to a specific energy efficiency measure and aligns with the measures described in the subsections of Section 2 of this document. A specific version of the template described in this deliverable will be issued for each tender, tailored to the measures included in the project bundle tendered.

The first worksheet of the template contains general instructions on how to use the file, including an overview of the calculation methodology, definitions of key parameters, and notes on the assumptions applied throughout the template. Users are strongly advised to review this sheet in full before entering any data.

Within each worksheet, cells are colour-coded to clearly indicate how they should be used. Input parameters that must be completed by the bidder are highlighted in green. These data include (before and after the upgrade) hours of operation per year, energy consumption, equipment operating parameters, efficiency or coefficient of performance, number of units to be replaced or eliminated, heat demand, cooling demand. The required input data can be sourced from energy bills, manufacturer datasheets, supplier quotes, building management system logs, and maintenance records.

Non-editable input parameters are highlighted in yellow and include fixed assumptions such as baseline conditions, energy tariffs, emission factors, and other standardised values that must not be altered. Output parameters are highlighted in yellow and present the calculated results, including energy savings, cost savings, and CO_2 reductions. These cells are automatically calculated and are not editable.

The final worksheet of the template provides a summary of total results, automatically aggregating the energy, cost, and emissions savings from all completed measure-specific worksheets. This sheet presents the overall project impact and should be used as the primary reference for the total calculated savings associated with the proposed project.

Appendix – Additional calculations

Lighting system

For lighting-related energy efficiency measures, the electrical power demand can be calculated based on luminous flux and luminous efficacy (ERCO, 2026). The following relationship is used in the calculations:

$$P = \Phi / \eta \qquad (1)$$

where P is the electrical power demand [W], Φ is the total luminous flux [lm] and η is the luminous efficacy [lm/W]. Calculating electrical power demand from luminous flux and luminous efficacy is useful when reliable data from existing and new luminaires are available, as it allows understanding how energy consumption and potential savings depend on changes in both luminous flux and luminous efficacy.

Variable-speed pumps

For variable-speed pump applications, the Pump Affinity Laws may be applied to estimate changes in pump performance and energy consumption resulting from variations in operating speed. The relationships between pump rotational speed and key performance parameters are expressed as follows (The Engineering ToolBox, 2026):

Flow rate: $$Q_2 / Q_1 = N_2 / N_1 \qquad (2)$$

Head: $$H_2 / H_1 = (N_2 / N_1)^2 \qquad (3)$$

Power: $$P_2 / P_1 = (N_2 / N_1)^3 \qquad (4)$$

Where Q_1 is the flow rate at the baseline condition, H_1 is the pump head at the baseline condition, P_1 is the electrical power input at the baseline condition, N_1 is the pump rotational speed at the baseline condition, Q_2 is the flow rate under the new operating condition, H_2 is the pump head under the new operating condition, P_2 is the electrical power input under the new operating condition, N_2 is the pump rotational speed under the new operating condition. These relationships assume operation within the pump's normal operating range and can be used for preliminary estimation of energy savings in VSD retrofit applications.

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