Coordination and Support Action

H2020-LC-SC3-EE-2019

# Training to support streamSAVE replication towards other MS

**Deliverable D4.5**

Version N°1

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This project has received funding from the Horizon 2020 programme under grant agreement n°890147.

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# Document Information

| | |
|---|---|
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# Table of Contents

# Keywords

Energy Efficiency Directive, Training, Capacity Support, Replication, Priority Actions, standardized saving estimations

# Introduction

## About streamSAVE

Energy efficiency is one of the five key dimensions of the Energy Union, and consequently of the Member States' National Energy and Climate Plans. The Energy Efficiency Directive sets the 2020 and 2030 energy efficiency targets and a series of measures that contribute to their achievement within the Union. The streamSAVE project streamlines energy savings calculations and provides the support needed to increase Member States' chances of successfully and consistently meeting their energy efficiency targets. The streamSAVE project specifically focuses on Article 3 and 7 of the EED which are devoted to energy efficiency targets and national energy savings obligations, respectively.

Given the importance of deemed savings approaches in Member States' EED reporting, streamSAVE focuses on streamlining bottom-up calculation methodologies of standardized technical actions. streamSAVE offers these savings methodologies in a transparent and streamlined way, not only to improve the comparability of savings and related costs between Member States (MS), but also between both EED articles. The savings actions are targeted at measures with high energy saving potential and considered as priority issues by Member States, the so-called *Priority Actions*.

More broadly, the project aims at fostering transnational knowledge and dialogue between public authorities, technology experts, and market actors. The key stakeholders will improve their energy savings calculation skills and ensure thus the sustainability and replicability of the streamSAVE results towards all European Member States.

## Replication to other Member States

streamSAVE aims to ensure the long-term sustainability of its support beyond the project timeline and its replicability across Europe, extending beyond the partner Member States involved in the project. To achieve this, streamSAVE provides the necessary resources and conditions for scaling up the use of the streamSAVE platform, which serves as both a working instrument and an integrator of the streamSAVE outputs.

The resources dedicated to supporting replicability include:

- Training: Member States outside the consortium are introduced to the main outcomes of streamSAVE through a comprehensive presentation. This presentation covers the Knowledge Facility, the Knowledge Exchange via the dialogues and the Capacity Support offered in the ten partner countries.
- Replication guidance: A guide is developed, outlining the methodologies employed by streamSAVE. This guide will assist Member States in implementing these methodologies into their own energy efficiency policies, thereby promoting increased energy savings for Priority Actions.

This report includes the Training Presentation, which serves as a valuable resource for facilitating the replication of streamSAVE's initiatives.

## What can you find in this report?

The Training presentation serves as a comprehensive compendium of knowledge on streamlined energy-saving calculation methodologies developed by the streamSAVE project. It covers the ten Priority Actions (PA) for energy savings and provides insights on how to calculate savings in alignment with Article 3 and Article 7 of the Energy Efficiency Directive, as well as greenhouse emissions reductions. The Priority Actions under analysis are:

- Heat recovery (district heating and excess heat from industry);
- Building Automation and Control Systems (BACS);
- Commercial and Industrial refrigeration system (C&I Refrigeration);
- Electric vehicles (private & public EVs);
- Lighting systems and public lighting;
- Accelerated motor replacement;
- Providing feedback about energy use and tailored advice towards households:
- Behavioural changes;
- Energy efficiency actions alleviating energy poverty;
- Modal shift in freight transport (from road to rail);
- Small-scale renewable central heating technologies.

It is recommend using this slide deck as a primary reference for all streamSAVE content. It offers a concise overview for each Priority Action, along with an introduction to the calculation methodologies employed and key lessons learned from the capacity support and dialogue activities conducted between 2020 and 2023.

# Training presentation to support streamSAVE replication

# Replication of streamSAVE to other Member States:
# Training presentation

Authors: Václav Šebek (SEVEn), Elisabeth Böck (AEA), Paula Fonseca (ISR), Pedro Moura (ISR), Christos Tourkolias (CRES)

streamSAVE

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# Introduction

- This slide deck presents a compendium of knowledge on streamlined energy saving calculation methodologies developed by the streamSAVE project.
- It encompasses 10 Priority (energy saving) Actions (PA) and introduces how savings could be calculated in compliance with Art.3 and Art.7 of Energy Efficiency Directive, next to greenhouse emissions reductions.
- It is recommended to use this slide deck as a reference for all streamSAVE content. It includes a brief overview for each PA as well as an introduction to the calculation methodologies and lessons learnt from the project activities 2020-2023

# Resources

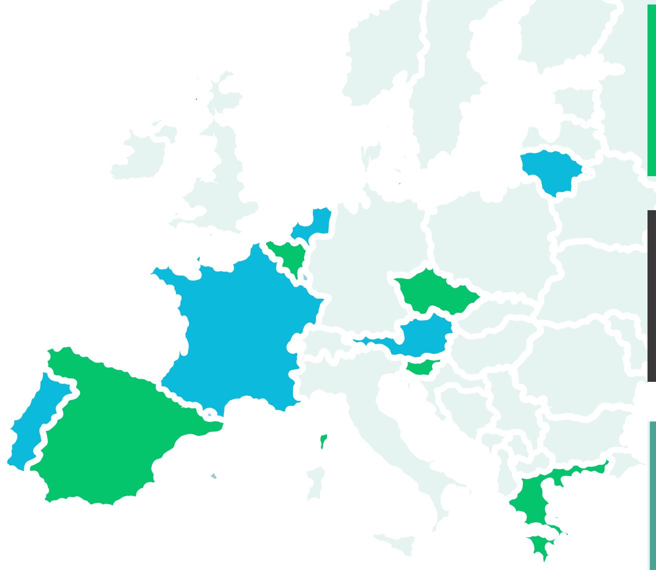
To access more detailed information, please refer to the links below:

- Project webpage https://streamsave.eu/
- streamSAVE online forum https://streamsave.flexx.camp/forum
- All streamSAVE publications, including Status of energy savings calculations for priority actions in European countries and guidance on Standardized saving methodologies can be found at the resources section of the project website.
- Learnings from Dialogue meetings and workshops can be found in the Knowledge and support facility
- Training tool with on-line calculators and template Excel sheets (upon registration) https://streamsave.flexx.camp/training

# Who are we?

**2020**
START
SEPTEMBER 1, 2020

**2023**
END
AUGUST 31, 2023



| | |
|---|---|
| COORDINATOR | vito; Energy Ville |
| RESEARCH & POLICY INSTITUTIONS | vito; IEECP (Institute for European Energy and Climate Policy); ISR; circe; Jožef Stefan Institute |
| ENERGY AGENCIES OR RELATED | Austrian Energy Agency; ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie); КАПЕ CRES; Lietuvos Energetikos Agentūra; SEVEn7 |
| CONNECTORS TO MARKET & TECHNOLOGY ACTORS | Cu European Copper Institute Copper Alliance; LGi sustainable innovation |

**12 PARTNERS**
**10 COUNTRIES**

# What do we aim for?

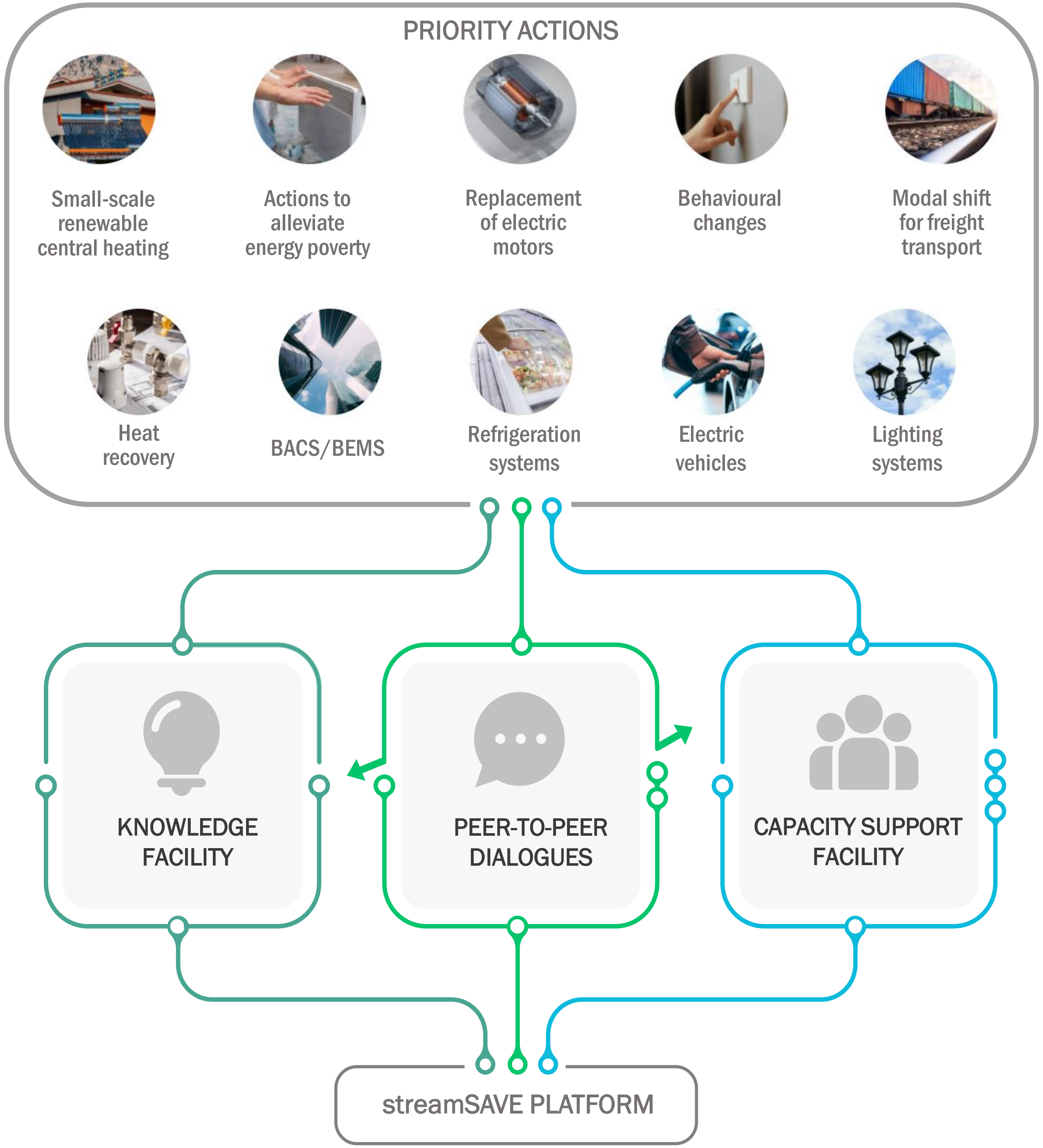
- Building capacity among public authorities on Article 3 & Article 7 of the Energy Efficiency Directive:

  *streamSAVE builds capacity through the creation of an open dialogue that will focus on streamlining calculation methodologies to estimate bottom-up savings and cost effectiveness of technical energy savings actions. The project targets priority actions i.e., new actions with high energy saving potential and considered as a priority issue by national public authorities.*

- Address additional efforts in EU Member States in realizing energy savings by 2030 under Article 3 & Article 7 of EED.
- More information here: https://streamsave.eu/

# Our workflow

- 10 Priority actions
- Knowledge facility:
  - Repository of existing deemed savings methodologies in EU-27
  - Guidance standardized savings
- Exchange of experiences & knowledge in dialogue groups
- Capacity support in 10 partner countries and 3 replication countries
- All included into the platform



# Overview of standardized savings methodologies

Energy, $CO_2$ savings and costs

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# Structure of the overview

**Contents:**

General aspects of:

- Estimation of energy savings:
  - Differences in savings calculation for Article 3 & Article 7;
  - Definition of a baseline;
  - Approaches for cumulating energy savings under Article 7;
  - Correction for behavioural effects;
- Estimation of relevant costs connected to energy savings actions;
- Estimation of GHG savings.

# Bottom-up methodologies for our 10 Priority Actions

**First round of Priority Actions**

- 8 newly developed methodologies for calculations of energy, $CO_2$ savings and costs:
  - Heat recovery for on-site use in industry - feedback of excess heat into a process;
  - Heat recovery for on-site use in industry - use of excess heat for on-site applications;
  - Heat recovery for feed-in to a district heating grid;
  - Building Automation and Control Systems in residential and non-residential buildings;
  - Energy efficient compression refrigeration units;
  - Fuel Switching to Electric Vehicles;
  - Energy efficient road lighting systems – engineering approach;
  - Energy efficient road lighting systems – simplified approach.

# Bottom-up methodologies for our 10 Priority Actions

**Second round of Priority Actions**

- 8 newly developed methodologies for calculations of energy, $CO_2$ savings and costs:
  - Anticipated motor replacement;
  - Feedback and tailored advice in residential sector;
  - Thermally improved building envelope of refurbished buildings of energy poor households;
  - Small-scale renewable energy systems in buildings for energy poor households;
  - Behaviour measures addressing energy-poor households;
  - Freight Transport: modal shift potentials from road to rail per Member State;
  - Heat pumps for heating and domestic hot water;
  - Biomass boilers for heating and domestic hot water.

# Definition of final energy savings

- Article 7 requires the implementation of measures to save final energy.
- Reason: Energy that is not needed in the first place does not have to be produced.
- The term "final energy" is defined in the standardized specifications for energy statistics and can be described as energy delivered to final costumers (households, agriculture, industry, services, transport).

# Principle of final energy savings

- Final energy savings are calculated as the difference between final energy consumption before and after the implementation of the saving action.

$$\boldsymbol{FES = FEC_{Baseline} - FEC_{Action}}$$

| | |
|---|---|
| FES | Final energy savings |
| FEC | Final energy consumption |
| Baseline | Index for the situation before implementing the energy saving action |
| Action | Index for the situation after implementing an energy saving action |

# Calculation of total final energy savings (Article 7)

- Example calculation formula:

$$TFES = n \cdot Pc \cdot h_{FL} \cdot \left(\frac{1}{\mathrm{SEPR}_{Ref}} - \frac{1}{\mathrm{SEPR}_{Eff}}\right) \cdot f_{BEH}$$

(Formula taken from « Energy efficient compression refrigeration units » For details, see respective section below)

- Indicative calculation values
  - For all terms where it was possible and reasonable to identify concrete values, including lifetime of savings
  - If possible: including a value to account for behavioural effects
- Explanation of methodological aspects
  - Explaining the rationale behind the methodology: How are the savings calculated?
  - What boundaries are there to use this methodology and values? (e.g., values are only valid for applications in a certain range of power)
- List of data sources
  - Explanation on how the indicative calculation values were defined, what sources were used and what additional calculations were performed?

# Calculation of impact on energy consumption (Article 3)

- In case relevant: explanation on different mode of calculation of final energy savings
- Formula for converting final energy savings to primary energy savings:

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} \left(share_{ec,Baseline} \cdot f_{PE,ec}\right) - FEC_{Action} \cdot \sum_{ec} \left(share_{ec,Action} \cdot f_{PE,ec}\right)$$

- EU27 average for shares of energy carriers for relevant applications
- EU27 average values for $f_{PE}$ per energy carrier are available in chapter 1.1.1 of the *Standardized saving methodologies* report

# Overview of costs related to the action

- Sources for general information on cost components (e.g., fuel costs, labour costs per EU MS) are listed in chapter 1.2.1.
- Indicative values for the following cost components per methodology:
  - Investment costs
    (Total investment costs, Design and Engineering work (labour costs), Installation work (labour costs), Training of personnel (labour costs), Production downtimes, …)
  - Variable operational costs
    (Fuel costs, Costs saved by fuel demand reduction, Cooling water costs, …)
  - Fixed operational costs
    (Maintenance (labour costs), Production downtimes, …)
  - Revenues
    (potential revenues generated by the implementation of an action)
  - Lifetime of savings

# Calculation of greenhouse gas savings

- Formula for converting final energy savings to GHG savings:

$$GHGSAV = \left[FEC_{Baseline} \cdot \sum_{ec} \left(share_{ec,Baseline} \cdot f_{GHG,ec}\right) - FEC_{Action} \cdot \sum_{ec} \left(share_{ec,Action} \cdot f_{GHG,ec}\right)\right] * 10^{-6}$$

- EU27 average for shares of energy carriers for relevant applications
- EU27 average values for $f_{GHG}$ per energy carrier are available in chapter 1.3 of the *Standardized saving methodologies* report

PRIORITY ACTION

# Heat Recovery in Industry

Created by

Christoph Ploiner, Austrian Energy Agency

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# Definition of heat recovery

*Heat recovery = reutilization of thermal energy from excess heat as well as waste heat generated from transformation processes.*

Some examples:

- Economizer to improve efficiency in thermodynamic cycles;
- Waste heat from engines and compressors;
- Waste heat from chemical reactions;
- Recuperators or buffer storage for reusing heat in shift operations;
- Heat exchanger in ventilation systems.

# Why focusing on industry

- High potentials
  - 26% of final energy consumption in EU27
  - $^{2}/_{3}$ thereof heat related
- High temperature levels
- High energy quantities in individual industrial facilities
- Potential of improving competitiveness of affected implementer
- Broad range of use cases
- Calculation methodologies were developed for three use cases:

Heat recovery for (1) feeding back into the process, (2) feeding another application
(3) feeding into district heating networks

# Terms on-site & same process

- Same process: Energy flows within a production chain.

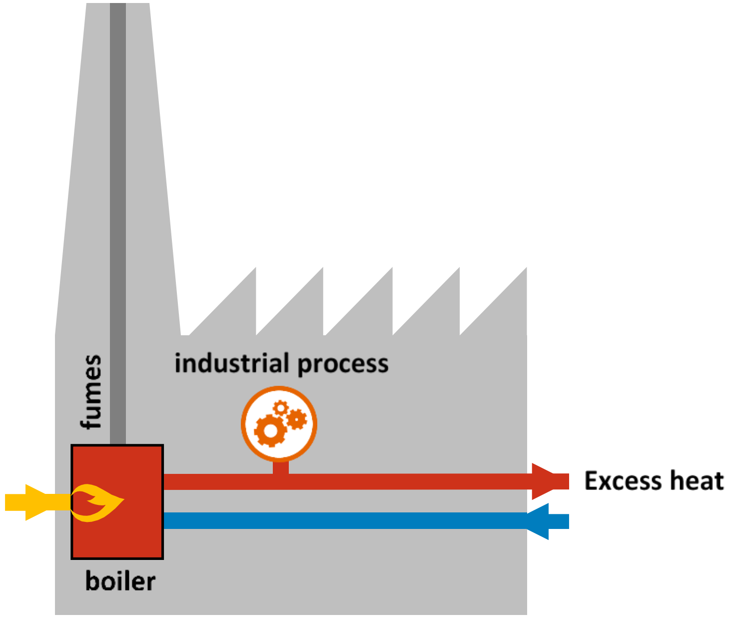
  Example food production: Consecutive heating and cooling process steps → Use energy derived from cooling.

- On-Site: The heat is recovered and used within the same company, without using commercial heat networks.

  Example: The waste heat from compressed air systems is used to heat the office rooms.

# Baseline situation

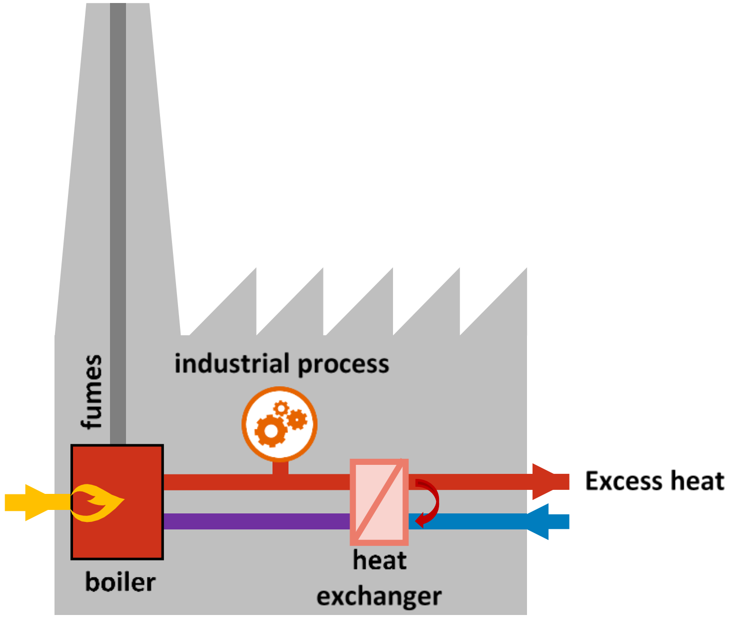
- Heat production to operate an industrial process.
- Excess heat will be cooled down or get lost due to:

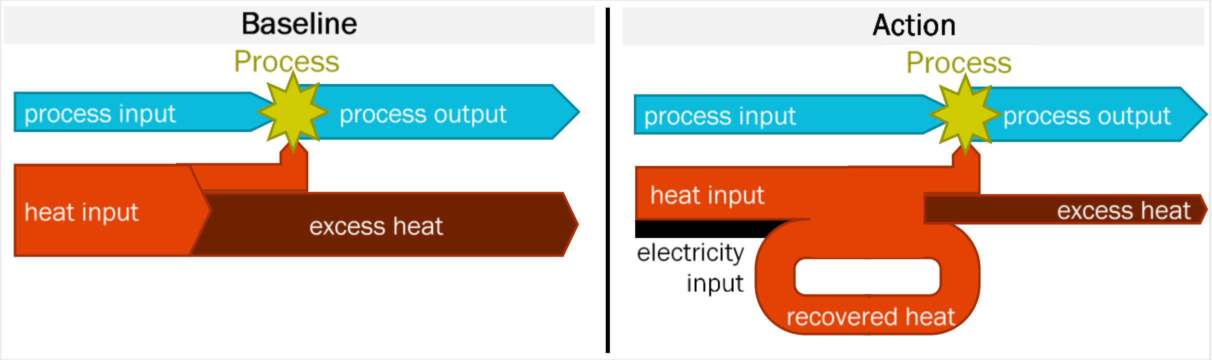



  - unusable temperature level after the process
  - different temperature levels in-between production steps
  - timely discontinuity of process cycles (e.g. shift operation of production)

# Heat recovery | feedback into the process

- Reduces the energy input by feeding back excess heat into the same process.
- Final energy saving within the affected process



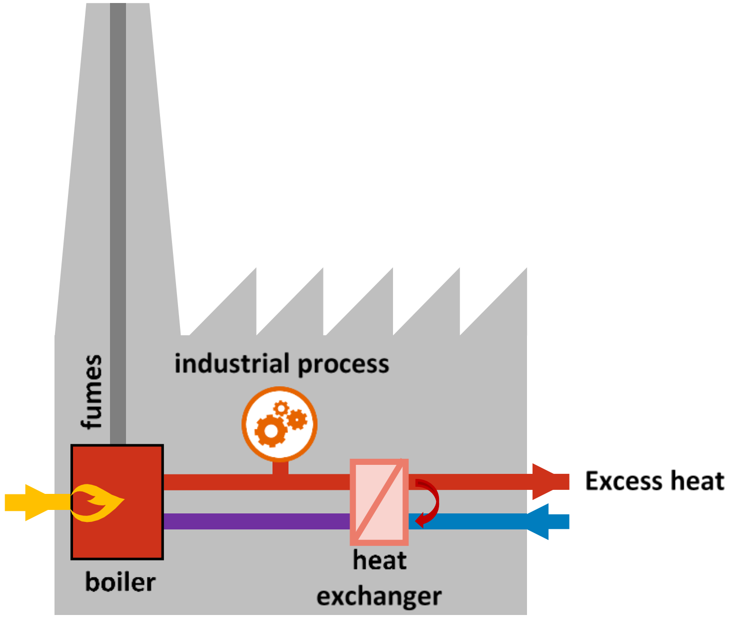
# Heat recovery | feedback into the process

Do not forget the power inputs of auxiliary systems (i.e., additional pumping energy)

## Calculation formula

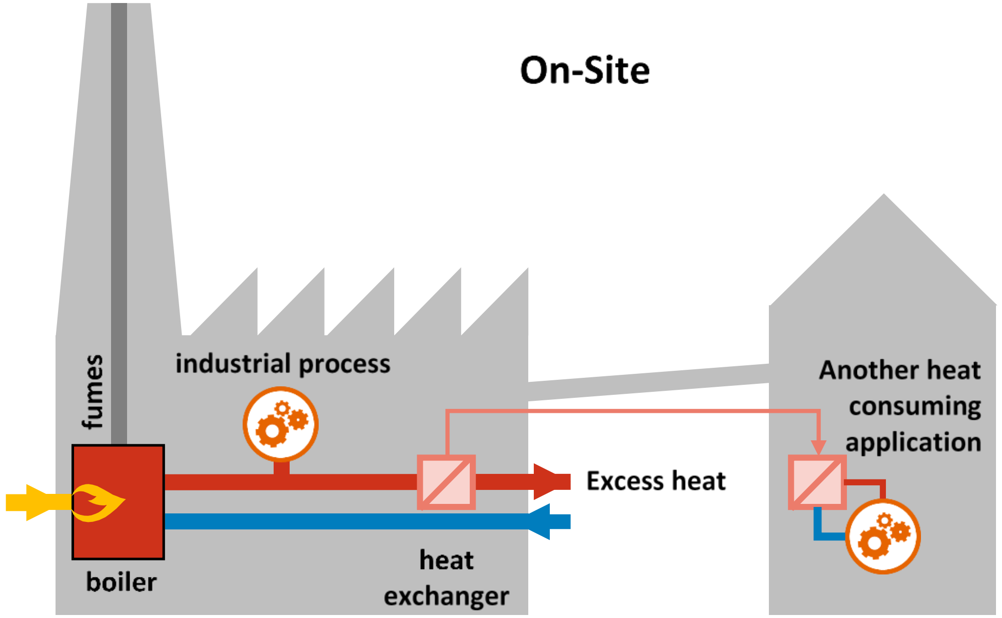
$$TFES = \left(\frac{FEC_{Baseline}}{po_{Baseline}} - \frac{FEC_{Action}}{po_{Action}}\right) \cdot \mathrm{po}_{Action}$$

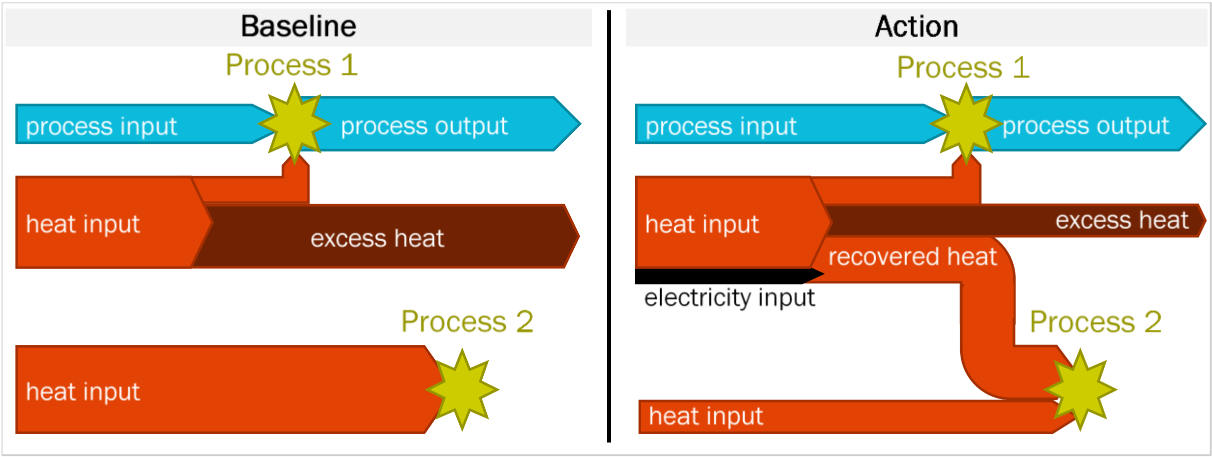
| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| FEC | Final energy consumption [kWh/a] |
| po | Production output [units/a] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after implementing the action |



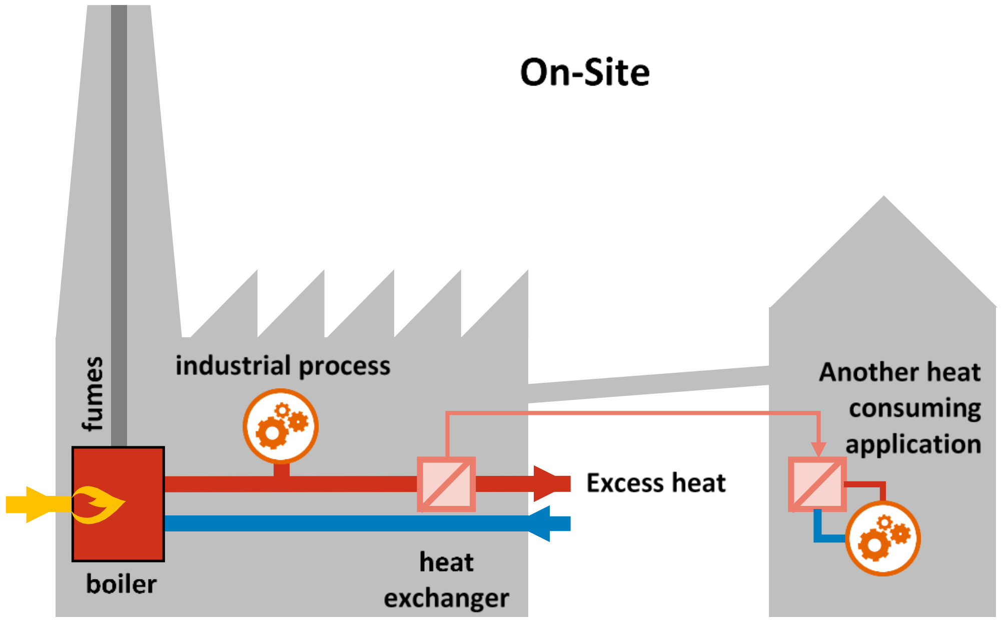
# Heat recovery | feeding another application

- Reduces the energy input of another heat consuming application (e.g. space heating of on-site buildings, drying plants)
- Final energy saving on-site



# Heat recovery | feeding another application




## Calculation formula

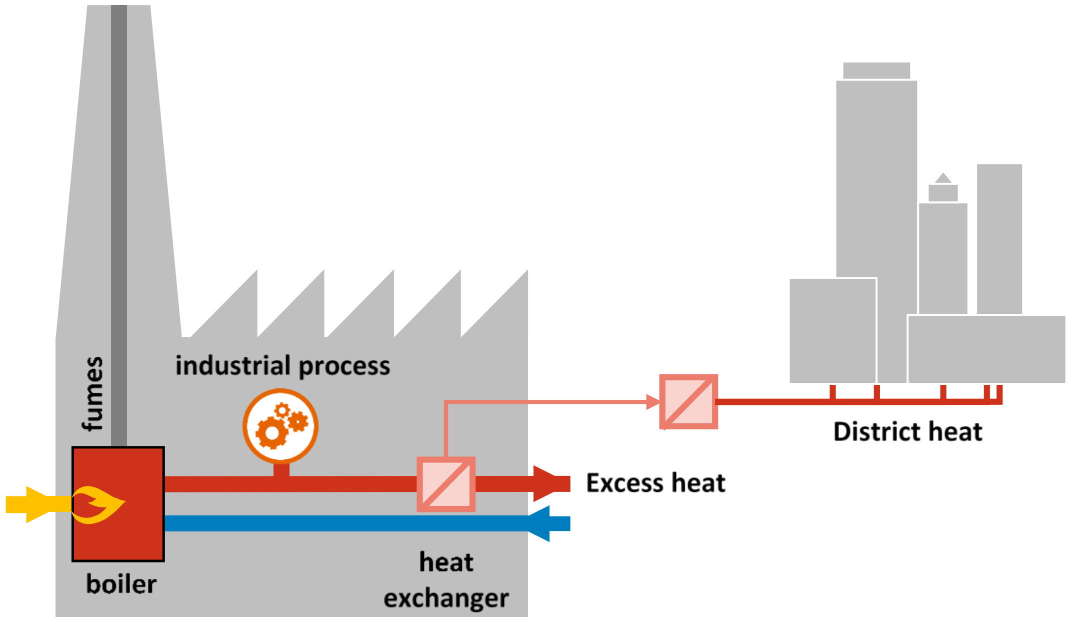
$$TFES = Q_{rec} \cdot \frac{1}{eff_{mhs}} \cdot f_{BEH}$$

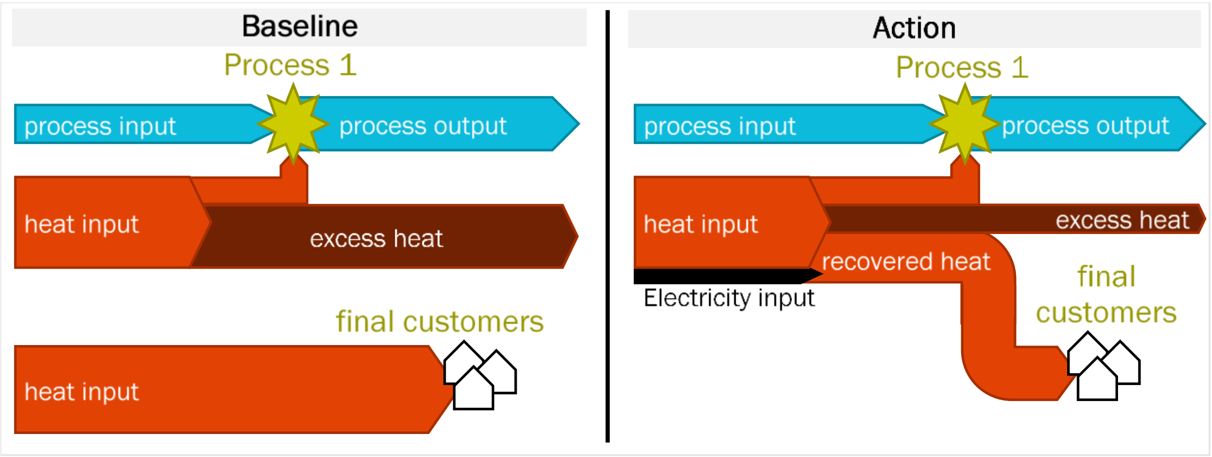
| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| $Q_{rec}$ | Recovered heat consumption of the application [kWh/a] |
| $eff_{mhs}$ | Conversion efficiency of the main heating system of the relevant application [dmnl] |
| $f_{BEH}$* | Factor for correction of behavioural effects [dmnl] |

* in case relevant; e.g., increased space heating temperature

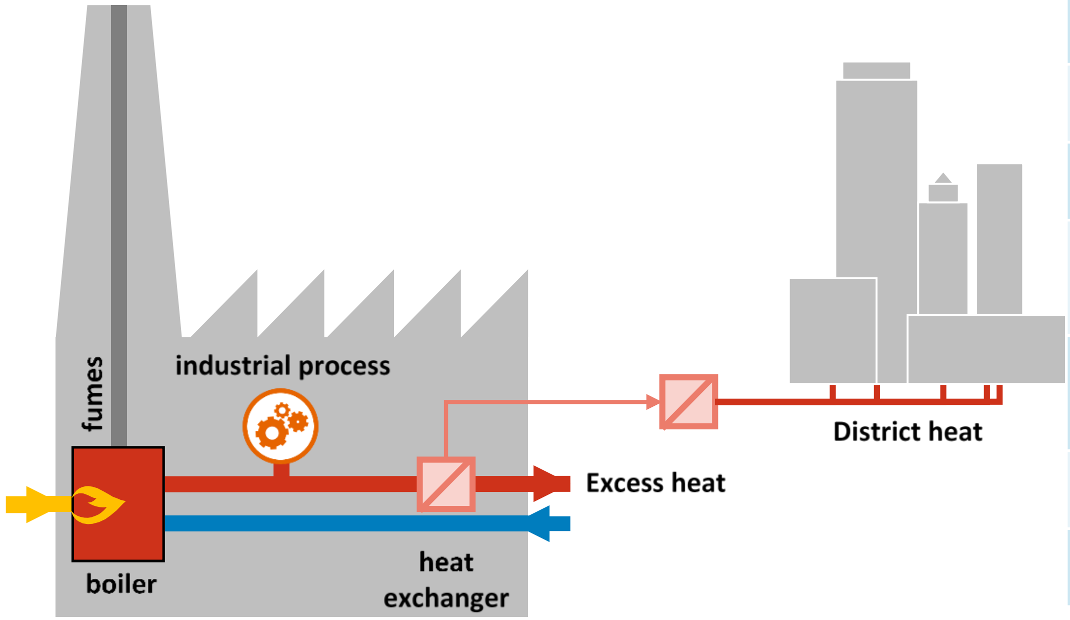
# Heat recovery | feeding into district heat

- Reduces the energy input of final customers (difference to reference heating system)
- Final energy savings occur at the final customer



# Heat recovery | feeding into district heat




## Calculation formula

$$TFES = Q_{EH} \cdot (1 - HL_{DHG}) \cdot \left(\frac{1}{eff_{Baseline}} - \frac{1}{eff_{Action}}\right) \cdot (1 - f_{ei}) \cdot (1 - f_{BEH})$$

| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| $Q_{EH}$ | Excess heat fed into the district heating grid [kWh/a] |
| $HL_{DHG}$ | Heat losses in the district heating grid [dmnl] |
| $eff_{Baseline}$ | Conversion efficiency of the reference heating systems [dmnl] |
| $eff_{Action}$ | Conversion efficiency of the district heat consuming heating systems [dmnl] |
| $f_{ei}$ | Factor to calculate extrinsic incentives [dmnl] |
| $f_{BEH}$ | Factor to calculate rebound effects [dmnl] |

# Practical experience based on country support

- Higher preference on deemed method compared to the metered method in order to minimize the administrative burden and facilitate the calculation of the energy savings, but the implementation of deemed methods is not easy due to the difficulty to specify indicative value for the different types of industrial units and the application of metered method for energy efficiency interventions in the industrial sector is suggested.
- There is a need for more information on the required control and verification procedures focusing on the specifications of the metering systems for the case of metered method.

PRIORITY ACTION

# Industrial & Commercial Refrigeration

Created by

María López (CIRCE), Juraj Krivošík and Michal Staša (SEVEn)

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# Introduction (1)

- The scope of the methodology: focus on new installations or the replacement of air-chilled or water-chilled central compression refrigeration units, and high temperature process chillers.

# Introduction (2)

- Eurovent's ESEER index seemed to be outdated and not used anymore
- Ecodesign regulation for air heating and cooling products (EU) 2016/2281 - using new set indicators SEER (Seasonal Energy Efficiency Ratio) or SEPR (Seasonal Energy Performance Ratio)
- Discussions and polls suggest that methodologies will be based on SEPR value

# Introduction (3)

- The standard EN14825:2018* may include complementary indicative values that could be relevant for the streamSAVE methodology.

* full title of the standard: “Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance”

# Scope of the methodology

- The savings calculation methodology targets:
  - New installations or the replacement of air-chilled or water-chilled central compression refrigeration units;
  - High temperature process chillers: "capable of cooling down and continuously maintaining the temperature of a liquid, in order to provide cooling to a refrigerated appliance or system, the purpose of which is not to provide cooling of a space for the thermal comfort of human beings; delivering its rated refrigeration capacity, at an indoor side heat exchanger outlet temperature of 7ºC, at standard rating conditions"[5]
- Limitations:
  - Central compression refrigeration units with compressors power by electrical energy.
  - Cooling systems using free cooling or heat recovery are not covered.
- Sources:
  - Austrian catalogue on bottom-up calculation methodologies[1]
  - multEE project[2]

[1] Anlage 1 BGB1. II, Nr. 172 (2016). Verallgemeinerte Methoden zur Bewertung von Energieeffizienzmaßnahmen, 100–103. https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2016_II_172/COO_2026_100_2_1241958.pdfsig

[2] Document with general formulae of bottom-up methods to assess the impact of energy efficiency measures. https://multee.eu

[5] Comission Regulation (EU) 2016/2281 implementing Directive 2009/125/EC of the European Parliament and of the Council establishing a framework for the setting of ecodesign requirements for energy-related products, with regard to ecodesign requirements for air heating products, cooling products, high temperature process chillers and fan coil units.

# Data sources for indicative values

**New system data**

$$TFES \text{ or EFE} = n \times Pc \times h_{FL} \times \left(\frac{1}{\text{SEPR}_{Ref}} - \frac{1}{\text{SEPR}_{Eff}}\right)$$

**Baseline system data**

* variables are described on the next slide

| For air-chilled coolers | [-] |
|---|---|
| $\text{SEPR}_{Ref}$ | 5.62 |
| $\text{SEPR}_{Eff}$ | 6.00 |
| For water-chilled coolers | [-] |
| $\text{SEPR}_{Ref}$ | 8.76 |
| $\text{SEPR}_{Eff}$ | 11.41 |
| Lifetime of savings | [a] |
| Lifetime of savings | 8 |

Database of Eurovent certified air-chilled and water-chilled refrigeration units under the LCP-HP (Liquid Chilling Packages and Heat Pumps)[4]:

- $\text{SEPR}_{Ref}$: average of all units in the market.
- $\text{SEPR}_{Eff}$: average of units exceeding reference value.

⟶ Data obtained from Eurovent website

→ Commission Recommendation about transposing the energy savings obligations (Indicative lifetime for commercial refrigeration)[5]

[4] https://www.eurovent-certification.com/en/third-party-certification/certification-programmes/lcp-hp

[5] Commission Rrecommendation (EU) 2019/1658 on transposing the energy savings obligations under the Energy Efficiency Directive

# Data sources for indicative values

New system data

$$TFES \text{ or EFE} = n \times P_c \times h_{FL} \times \left(\frac{1}{\text{SEPR}_{Ref}} - \frac{1}{\text{SEPR}_{Eff}}\right)$$

Baseline system data

* variables are described on the next slide

| For air-chilled coolers | $[P_c]$ |
|---|---|
| Cooling power | ≤ 600 kW |
| **For water-chilled coolers** | $[P_c]$ |
| Cooling power | ≤ 1.500 kW |
| **Full-load hours** | $[h_{FL}]$ |
| Full-load hours | Project specific |
| **Number of cooling systems** | [n] |
| Number of cooling systems | Project specific |

LCP-HP (Liquid Chilling Packages and Heat Pumps) Programme by Eurovent:

→ Capacity limits of certified units: air- and water-chilled, cooling mode

→ Full-load hours are project specific.

→ Number of units for specified cooling power ($P_c$). Depends on project specification.

# Data sources for indicative values

- Variables description:

| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| N | Number of cooling systems installed at a specific cooling power [dmnl] |
| $P_c$ | Installed cooling power of the cooling system [kW] |
| $h_{FL}$ | Full-load hours related to the maximum installed cooling power [h] |
| $SEPR_{Ref}$ | Seasonal Energy Performance Ratio of the reference compression refrigeration system [dmnl] |
| $SEPR_{Eff}$ | Seasonal Energy Performance Ratio of the more efficient compression refrigeration system [dmnl] |
| $f_{BEH}$ | Factor to calculate behavioral aspects [dmnl] |

# Overview of costs related to Refrigeration systems

- The cost associated with the conversion to a more efficient refrigeration system include the following cost components:
  - Investment costs

    Considers the purchase cost of the equipment, accounting for process chiller, equipment transport to the site, construction, assembly, equipment rental, as well as labour and contractor fees.
  - Variable operating costs

    The operating cost are due to electricity
  - Repair and maintenance costs

TAXES ARE NOT INCLUDED

# Overview of costs related to Refrigeration systems

| **Investment costs** | **[euro2010]** |
| --- | --- |
| Air-Cooled | [2,354 – 2,999] |
| Water-Cooled | 1,610 – 3,689] |
| **Operating costs** | [euro/a] |
| Electricity | Prices for electricity have been included in the guidedance |
| **Maintenance costs** | [euro2010/a] |
| Air-cooled | [1,007 – 3,107] |
| Water-cooled | [840 – 7,340] |
| **Lifetime** | [a] |
| | 8 years |

# Overview of costs related to Refrigeration systems

- Some considerations:
  - These values are indicator and in no case should be taken as an estimated value for design;
  - The investment cost is strongly dependent on the selected capacity of the process chiller;
  - The values presented have been annualized, taking into account the life time of the equipment (8 years, considering 4,380 load hours per year);
  - The indicative cost values are based on preparatory studies in frame of the Ecodesign Directive.

TAXES ARE NOT INCLUDED

PRIORITY ACTION

# Building Automation and Control Systems (BACS)

Created by

Kelsey van Maris (VITO/EnergyVille)

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# Building Automation and Control Systems (BACS)

Definition (Ecodesign preparatory study, 2020):

*“All products and engineering services for automatic controls (including interlocks), monitoring, optimization, for operation, human intervention and management to achieve energy–efficient, economical and safe operation of building services. The term ‘controls’ also refers to ‘processing of data and information’.”*

- Heating ventilation and Air Conditioning (HVAC)
- Domestic hot water (DHW)
- Lighting
- Metering
- Technical building management
- Access control
- Security
- Fire safety

# Methodology

- Detailed method vs. **BACS factor method**

- BACS factors:
  - Rough estimation of impact of BACS on thermal and electrical energy demand of the building according to the BACS efficiency classes A, B, C and D

- Combining the *BACS efficiency classes* with the *end use* and the *building type* → BACS efficiency factor
  - e.g.: heating BACS, efficiency class C, in an office building → BACS factor of 1

# Formula

- Using the BACS factor method, the formula we propose, is:

$$\boldsymbol{TFES_x = (FEC_{before,x} - FEC_{after,x}) \cdot f_{BEH} \cdot cf_x}$$

$$FEC_{before,x} = FEC_{floor,before,x} \cdot A$$

$$FEC_{after,x} = \frac{BAC_{after,x}}{BAC_{before,x}} \cdot FEC_{floor,before,x} \cdot A$$

End-uses: heating, cooling, DHW, lighting, ventilation

BAC factor *before* versus *after*

| | |
|---|---|
| $TFES$ | Total final energy savings for end-use type x [kWh/a] |
| $FEC_{before,x}$ | Final energy consumption for end-use x, before implementation of the action [kWh/a] |
| $FEC_{after,x}$ | Final energy consumption for end-use x after implementation of the action [kWh/a] |
| $f_{BEH}$ | Factor to calculate behavioural effects for end-use type x [dmnl] |
| $cf_x$ | Regional or climate factor for end-use type x [dmnl] |

| | |
|---|---|
| $FEC_{floor,before,x}$ | Final energy consumption for end-use, before implementation of the action, per unit floor area [kWh/m²/a] |
| $A$ | Total floor area of building [m²] |
| $BAC_{after,x}$ | BAC energy efficiency factor after BACS upgrade for end-use type x [%], based on EN15232 |
| $BAC_{before,x}$ | BAC energy efficiency factor before BACS upgrade for end-use type x [%], based on EN15232 |

# BACS factors: baseline & indicative values

- Distribution of BACS factors in base year per end use per climate region
  - End uses: heating, cooling, DHW, ventilation and lighting
  - Building types: SFH, MFH, offices, retail outlets, education establishments, hospitality sector buildings, healthcare sector buildings, other
  - Climate regions: North, West and South*

**Estimated average stock of BAC factors for 2020 by end-use and building type, for North climate region – $BAC_{before,x}$**

| North Region | SFH | MFH | Offices | Wholesale/ Retail | Education | Hospitals/ Healthcare | Hotels | Restaurants | Other |
|---|---|---|---|---|---|---|---|---|---|
| Space heating | 1.010 | 1.004 | 1.195 | 1.139 | 1.128 | 1.000 | 1.000 | 1.000 | 1.109 |
| Hot water | 1.109 | 1.109 | 1.019 | 1.092 | 1.030 | 0.992 | 0.992 | 0.992 | 1.030 |
| Cooling | 1.173 | 1.163 | 1.082 | 1.003 | 0.805 | 0.617 | 0.617 | 0.617 | 1.200 |
| Ventilation | 1.091 | 1.084 | 1.138 | 1.071 | 0.966 | 1.000 | 1.000 | 1.000 | 1.154 |
| Lighting | 1.079 | 1.079 | 0.989 | 0.991 | 0.991 | 1.000 | 1.000 | 1.000 | 1.000 |
| Space heating pumps | 1.008 | 1.006 | 1.121 | 1.103 | 1.072 | 1.038 | 1.038 | 1.038 | 1.073 |
| Hot water pumps | 1.109 | 1.109 | 1.018 | 1.092 | 1.029 | 0.991 | 0.991 | 0.991 | 1.029 |

Source: Ecodesign preparatory study for BACS, 2020

- Expected impacts from EPBD on baseline
  - Non-residential buildings with installed HVAC capacity > 290 kW : the BACS capabilities required under art. 14-15 EPBD could correspond to B-class BACS as defined in EN 15232.

*European (climate) regions: North (Czech Republic, Denmark, Estonia, Finland, Latvia, Lithuania, Poland, Slovakia, Sweden), West (Austria, Belgium, France, Germany, Ireland, Luxemburg, Netherlands) and South (Bulgaria, Croatia, Cyprus, Greece, Hungary, Italy, Malta, Portugal, Romania, Slovenia, Spain).

# $FEC_{before}$: baseline

- Energy consumption per building type and end use per climate region
  - Possibilities:
    - *Building specific* FEC per end-use, based on EPC score
    - *Average* FEC of building stock per end-use and building type, based on *average EPC scores* per climate region
    - *Average* FEC of building stock per end-use and building type, based on *energy statistics (e.g., national energy balances)*

# Calculation of impact on energy consumption (Article 3)

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} \left( share_{ec,Baseline} \cdot f_{PE,ec} \right) - FEC_{Action} \cdot \sum_{ec} \left( share_{ec,Action} \cdot f_{PE,ec} \right)$$

| | |
|---|---|
| EPEC | Effect on primary energy consumption [kWh/a] |
| FEC | Annual final energy consumption [kWh/a] |
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{PE,ec}$ | Final to primary energy conversion factor of the used energy carrier [dmnl] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after the implementation of the action |
| ec | Index of energy carrier |

# Overview of costs related to the action

- Indicative costs (excl. VAT) of BACS as function of the building type and BACS class A and C. The lower bound represents renovation of existing buildings; upper bound of new buildings

| Upgrade to BACS class C | SFH | MFH | Offices | Wholesale/ Retail | Other non-residential |
|---|---|---|---|---|---|
| Product cost [€2020/m² floor area] | 1.5-3.0 | 1.5-3.0 | 9.0 | 7.0 | NA |
| Investment costs, incl. installation [€2020/m²] | 2.8-5.6 | 2.8-5.6 | 21.2 | 16.5 | NA |
| Maintenance & repair [% per year] | 3% | 3% | 3% | 3% | 3% |
| **Upgrade to BACS class A** | | | | | |
| Product cost [€2020/m² floor area] | 4.7-7.1 | 4.3-7.0 | 13.3-14.7 | 12.0-13.2 | NA |
| Investment costs, incl. installation [€2020/m²] | 11.1-16.8 | 10.1-16.5 | 31.2-34.6 | 28.2-31.1 | 30 (6-60) |
| Maintenance & repair [% per year] | 3% | 3% | 3% | 3% | 3% |

SFH: Single-Family house - MFH: Multi-Family House

# Calculation of greenhouse gas savings

$$GHGSAV = \left[FEC_{Baseline} \cdot \sum_{ec}\left(share_{ec,Baseline} \cdot f_{GHG,ec}\right) - FEC_{Action} \cdot \sum_{ec}\left(share_{ec,Action} \cdot f_{GHG,ec}\right)\right] \cdot 10^{-6}$$

| | |
|---|---|
| GHGSAV | Greenhouse gas savings [t $CO_2$/a] |
| FEC | Annual final energy consumption [kWh/a] |
| share | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{GHG}$ | Emission factor of final energy carrier [g $CO_2$/kWh] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after implementation of the action |
| ec | Index of energy carrier |

# Practical experience based on country support

- Difficulties in applying the developed BACS methodology to the national circumstances for the case of non-residential buildings due to the lack of non-standardized calculation values on the total floor area and final energy demand of the different types of the buildings in the tertiary sector.
- Considerable usefulness of BACS method, e.g., BACS factors before and after implementation of an action, both for new installation and upgrades of BACS, while the provisions of Art. 14 and 15 of the Energy Performance of Buildings Directive (EPBD) are also considered.
- Focus on the development of specialized data collection procedures to collect national reference values for the implementation of the developed methodology.
- Facilitate the access to existing data sources, which are not easily accessible.

PRIORITY ACTION

# Lighting systems including public lighting

Created by

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# Calculation of final energy savings (Article 7)

- First formula follows a *"Project-based approach"*:

$$TFES = \left[ \left( N_{ref} \times \sum_{i=0}^{n} \frac{\left(P_{ref} \times t_{ref\,i} \times D_{ref\,i}\right)}{1000} \right) - \left( N_{eff} \times \sum_{i=0}^{n} \frac{\left(P_{eff} \times t_{eff\,i} \times D_{eff\,i}\right)}{1000} \right) \right] \times f_{BEH}$$

- Second formula a more *"Simplified approach"*:

$$TFES = \left[ \sum_{j=1}^{n} \left(N_j \times ES_j \times LC_j\right) \right] \times f_{BEH}$$

# Calculation of final energy savings (Article 7)

- *"Project-based approach"*:

$$TFES = \left[\left(N_{ref} \times \sum_{i=0}^{n} \frac{(P_{ref} \times t_{ref\ i} \times D_{ref\ i})}{1000}\right) - \left(N_{eff} \times \sum_{i=0}^{n} \frac{(P_{eff} \times t_{eff\ i} \times D_{eff\ i})}{1000}\right)\right] \times f_{BEH}$$

Baseline system data — New system data — effects

| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| $N_{ref}$ | Number of light points in the old/inefficient system |
| $N_{eff}$ | Number of light points in the new/efficient system |
| $P_{ref}$ | Power of each light point of the old/inefficient system, including lamp and other components on the luminaire (e.g.: control gear and communication/control units) (W) |
| $P_{eff}$ | Power of each light point of the new/efficient system, including lamp and other components on the luminaire (e.g.: control gear and communication/control units) (W) |
| $t_{ref\ i}$ | Annual operating time (h/a) of light points of the old/inefficient system in diming level "i" ($D_{ref\ i}$) |
| $D_{ref\ i}$ | Percentage of working light points power, of the old/inefficient system, during the diming level "i" |
| $t_{eff\ i}$ | Annual operating time (h/a) of light points of the new/efficient system in diming level "i" ($D_{ref\ i}$) |
| $D_{eff\ i}$ | Percentage of working light points power, of the new/efficient system, during the diming level "i" |
| $f_{BEH}$ | Factor for correction of behavioural effects (rebound, spill-over effect and free-rider effect) |
| i | Diming levels "i", being "0" the lighting full power mode |
| n | Total number of diming levels |

# Calculation of final energy savings (Article 7)

## "Project-based approach":

$$TFES = \left[\left(N_{ref} \times \sum_{i=0}^{n} \frac{(P_{ref} \times t_{ref\,i} \times D_{ref\,i})}{1000}\right) - \left(N_{eff} \times \sum_{i=0}^{n} \frac{(P_{eff} \times t_{eff\,i} \times D_{eff\,i})}{1000}\right)\right] \times f_{BEH}$$

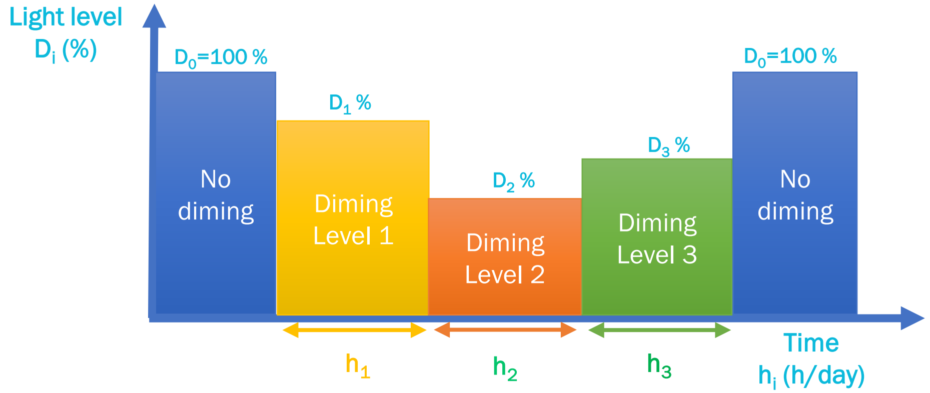
Baseline system data

New system data

effects

## Diming/Lighting controls strategies:

– Defined by each MS for old and new technology.



# Calculation of final energy savings (Article 7)

## *“Project-based approach”* – Indicative values

| Total annual operating time | [h/a] |
|---|---|
| Total annual operating hours of lighting system (sum of time with and without diming, that must be equal to $\sum_{i=0}^{n} t_{ref\ i}$ and $\sum_{i=0}^{n} t_{eff\ i}$) | 4015 |
| **Factor for correction of behavioural effects** | **[no dimension]** |
| Factor for correction of behavioural effects ($f_{BEH}$) | 1 |
| **Lifetime of savings** | **[years]** |
| Lifetime of savings | 13 years |

| Power of the light source ($P_{ls}$) W | Minimum control gear efficiency ($\eta_{control\ gear}$) % |
|---|---|
| $P_{ls} \leq 30$ | 78 |
| $30 < P_{ls} \leq 75$ | 85 |
| $75 < P_{ls} \leq 105$ | 87 |
| $105 < P_{ls} \leq 405$ | 90 |
| $P_{ls} > 405$ | 92 |

Indicative values for the control gear efficacy according to Ecodesign

$$P_{ref} = \left(\frac{P_{ls}}{\eta_{control\ gear}}\right)$$

# Calculation of final energy savings (Article 7)

## *"Simplified approach"*

$$TFES = \left[\sum_{j=1}^{n} N_j \times ES_j \times LC_j\right] \times f_{BEH}$$

Pre-calculated savings    effects

| | |
|---|---|
| TFES | Total final energy savings (kWh/a) |
| $N_j$ | Number of light points in the lighting system "j" |
| $ES_j$ | Indicative value for the Energy Savings of each light point in the lighting system "j", according to the table below (kWh/a) |
| $LC_j$ | Factor to account for the savings according to the lighting control strategy used in the lighting system "j", according to the table below.<br><br>In the absence of light control technologies, this factor is "1". |
| $f_{BEH}$ | Factor for correction of behavioural effects (rebound, spill-over effect and free-rider effect) |
| j | Lighting system "j" |
| n | Total number of lighting systems |

## *Indicative values*

| Old/inefficient light point | | New/efficient light point | | Energy savings ($ES_j$) [kWh/a] | Value for the ratio ($LC_j$) | |
|---|---|---|---|---|---|---|
| Technology | Lamp power (W) | Technology | Light point power (W) | | Diming to 50% for 7 h/day | Diming to 50% for 5 h/day |
| High-Pressure Sodium (HPS) | 400 | Light Emitting Diode (LED) with at least 120lm/W | 250 | 777.76 | 1.41 | 1.29 |
| | 250 | | 160 | 471.12 | 1.43 | 1.31 |
| | 200 | | 125 | 388.88 | 1.41 | 1.29 |
| | 150 | | 95 | 286.68 | 1.42 | 1.30 |
| | 100 | | 60 | 219.76 | 1.35 | 1.25 |
| | 70 | | 40 | 169.40 | 1.30 | 1.22 |
| | 50 | | 30 | 115.28 | 1.33 | 1.24 |
| Metal-Halide (MH) | 400 | Light Emitting Diode (LED) with at least 120lm/W | 300 | 577.76 | 1.66 | 1.47 |
| | 250 | | 180 | 391.12 | 1.59 | 1.42 |
| | 175 | | 125 | 277.76 | 1.57 | 1.41 |
| | 150 | | 110 | 226.68 | 1.62 | 1.44 |
| | 70 | | 50 | 129.40 | 1.49 | 1.35 |
| **Factor for correction of behavioural effects** | | | | **[no dimension]** | | |
| Factor for correction of behavioural effects ($f_{BEH}$) | | | | 1 | | |
| **Lifetime of savings** | | | | **[years]** | | |
| Lifetime of savings | | | | 13 years | | |

# Calculation of impact on energy consumption (Article 3)

- Formula:

$$\text{APES} = TFES \times PEF_{Electricity}$$

| | |
|---|---|
| APES | Annual primary energy savings [kWh/a] |
| TFES | Total final energy savings [kWh/a] |
| $PEF_{Electricity}$ | Primary Energy Factor for electricity |

- Indicative values for the PEF are prepared for EU level, but national values can be used.

| Primary Energy Factor ($PEF_{Electricity}$) | [-] |
|---|---|
| Electricity (EU value) | 2.281 |

# Calculation of greenhouse gas savings

- Formula:

$$GHGSAV = TFES \times f_{GHG,electricity} \times 10^{-6}$$

| | |
|---|---|
| GHGSAV | Greenhouse gas savings [t $CO_2$e p.a.] |
| TFES | Total final energy savings (kWh/a) |
| $f_{GHG,electricity}$ | Emission factor for electricity [g $CO_2$e/kWh] |

- Indicative values for the “emission factor for electricity” are prepared for EU level, but national values can be used.

| $f_{GHG,electricity}$ | [g $CO_2$e/kWh] |
|---|---|
| Electricity (EU value) | 133.3 |

# Overview of costs related to the action

- Indicative values for costs:

| Cost category | Range of the costs per light point (EURO2015/2016/2017 incl. VAT) |
|---|---|
| Investment costs | [235 to 764] €/ light point |
| Operating costs | [6 to 50] €/ light point/year |
| Maintenance costs | [12 to 31] €/ light point/year |

Factors with direct on costs: light source power, design, quality aspects and level of added features (intelligence, communications, constant light output), need for new poles and new power connections establishment.

Source: Streetlight-EPC European Project, www.streetlight-epc.eu

PRIORITY ACTION

# Electric Vehicles and Related Infrastructure

Created by

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stream SAVE

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

# Scope of the methodology

- **Target:**
  - Fuel switching between conventional and electric vehicles;
  - Savings ensured with higher conversion efficiency;
  - Fuel switching between fossil fuels and electricity, which is increasingly generated based on renewable resources.

- **Objective:**
  - To develop a common uniform methodology to calculate the savings with electric vehicles (fuel switching);
  - Considering different types of vehicles (cars, vans, buses, trucks) and different options of fuel (including hybrid options).

# Calculation of final energy savings (Article 7)

## Total Final Energy Savings

$$TFES = \left(sFEC_{ref} - sFEC_{eff}\right) * \frac{DT}{100} * n * f_{BEH}$$

Reference Vehicle | Efficient Vehicle | Distance & Quantity | Behavioural Effects

| | |
|---|---|
| $TFES$ | Total final energy savings [kWh/a] |
| $sFEC_{ref}$ | Specific final energy consumption of the reference vehicle [kWh/100 km] |
| $sFEC_{ref}$ | Specific final energy consumption of the efficient vehicle [kWh/100 km] |
| $DT$ | Average yearly distance travelled with the vehicle [km/a] |
| $n$ | Number of efficient vehicles purchased [dmnl] |
| $f_{BEH}$ | Factor for correction of behavioural effects (e.g., rebound effects) [%] |

# Calculation of final energy savings (Article 7)

## Conversion of Fuel Consumption

– Including Hybrid Options

$$sFEC = sFC * NCV * (1 - Share_{DT,E}) + sEC * Share_{DT,E}$$

Fuel Consumption (sFC * NCV) · Electricity Consumption (sEC) · Share of the Demand ($Share_{DT,E}$)

| | |
|---|---|
| $sFEC$ | Specific final energy consumption of the vehicle [kWh/100 km] |
| $sFC$ | Specific fuel consumption of the vehicle [l/100 km] |
| $sEC$ | Specific electricity consumption of the vehicle [kWh/100 km] |
| $NCV$ | Net Calorific Value for the fuel used in the vehicle [kWh/l] |
| $Share_{DT,}$ | Share of the distance travelled using electricity in the vehicle [%] |

# Calculation of final energy savings (Article 7)

## Indicative Values

- Based on the $CO_2$ emission standards

| Year | Cars $gCO_2/km$ | Vans $gCO_2/km$ |
|---|---|---|
| 2020 | 95.0 | 147 |
| 2025 | 80.8 | 125 |
| 2030 | 59.4 | 103 |

EC (2021) $CO_2$ Emission Performance Standards for Cars and Vans. https://ec.europa.eu/clima/policies/transport/vehicles/regulation_en

- The methodology ensures a regular update of values and the most recent data of monitoring of $CO_2$ emissions can be used

EEA (2021) Monitoring of $CO_2$ emissions from passenger cars – Regulation 2019/631
https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-18
EEA (2021) Monitoring of $CO_2$ emissions from vans – Regulation 510/2011
https://www.eea.europa.eu/data-and-maps/data/vans-14

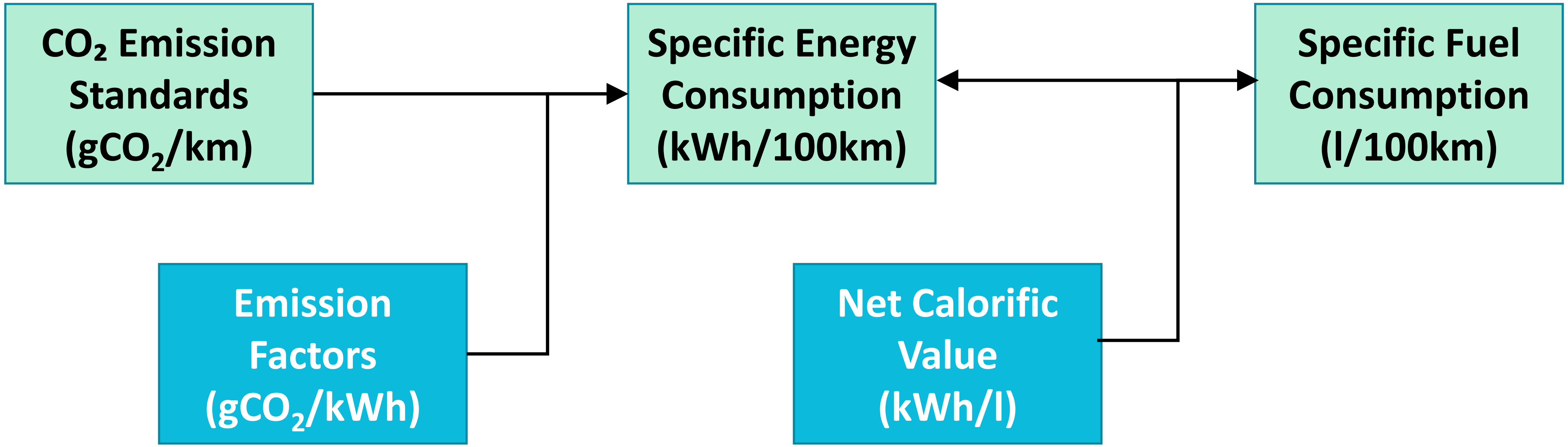
- For buses and trucks, the preliminary average $CO_2$ baseline for heavy-duty vehicles was used (56 $gCO_2/tkm$)

ACEA (2020) $CO_2$ emissions from heavy-duty vehicles Preliminary $CO_2$ baseline (Q3-Q4 2019) estimate.
https://www.acea.be/uploads/publications/ACEA_preliminary_CO2_baseline_heavy-duty_vehicles.pdf

# Calculation of final energy savings (Article 7)

## Indicative Values

- The $CO_2$ emissions values can be replaced by national values or even by specific values for the replaced vehicles
- The specific energy consumption can also be calculated with fuel consumption data
- An excel tool is provided to ensure the savings calculations and the use of national values



# Calculation of final energy savings (Article 7)

## Indicative Values

### Net Calorific Value

| $NCV$ | [kWh/l] |
|---|---|
| Petrol | 9.23 |
| Diesel | 10.27 |
| Liquefied petroleum gases | 7.23 |
| Natural gas liquids | 6.25 |

### Specific $CO_2$ Emissions

| $f_{GHG,ec}$ | [g $CO_2$e/kWh] |
|---|---|
| Motor gasoline | 249.48 |
| Gas/Diesel oil | 266.76 |
| Liquefied petroleum gases | 227.16 |
| Natural gas liquids | 231.12 |
| Electricity | 133.3 |

## Data Source

- Annex VI of the Regulation on the monitoring and reporting of greenhouse gas emissions (2018/2066/EU). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.334.01.0001.01.ENG

# Calculation of final energy savings (Article 7)

## Indicative Values

**Specific energy consumption of the reference vehicle:**

| $sFEC_{ref}$ | [kWh/100 km] |
|---|---|
| Car – Petrol (2020) | 38.08 |
| Car – Diesel (2020) | 35.61 |
| Car – LPG (2020) | 41.82 |
| Car – LNG (2020) | 41.10 |
| Car – PHEV (2020) | 25.29 |
| Car – Petrol (2025) | 32.39 |
| Car – Diesel (2025) | 30.29 |
| Car – LPG (2025) | 35.57 |
| Car – LNG (2025) | 34.96 |
| Car – Petrol (2030) | 23.81 |
| Car – Diesel (2030) | 22.27 |
| Car – LPG (2030) | 26.15 |
| Car – LNG (2030) | 25.70 |
| Van - Diesel (2020) | 55.11 |
| Van - Diesel (2025) | 46.86 |
| Van - Diesel (2030) | 38.61 |
| Truck and Bus - Diesel | 312.53 |

# Calculation of final energy savings (Article 7)

## Indicative Values

**Specific energy consumption of the efficient vehicle**

| $sFEC_{eff}$ | [kWh/100 km] |
|---|---|
| Car BEV | 12.4 |
| Van BEV | 24.6 |
| Truck and Bus BEV | 130.2 |

## Data Sources

- Cars - JEC (2020) Tank-to-Wheels Report v5: Passenger cars (link)
- Vans - EV-database (2021) Energy consumption of full electric vehicles. Electric Vehicle Database (link)
- Truck and Bus - JEC (2020) Tank-to-Wheels Report v5: Heavy duty vehicles (link)

# Calculation of final energy savings (Article 7)

## Indicative Values

**Distance travelled**

| $DT$ | [km/a] |
|---|---|
| Car | 13740 |
| Van | 17480 |
| Bus | 55570 |
| Truck | 77800 |

## Data Sources

- Road traffic statistics by type of vehicles Eurostat (2021) Transport Database. https://ec.europa.eu/eurostat/web/transport/data/database
- Number of vehicles by type ACEA (2021) Vehicles-in-use-Europe 2021. European Automobile Manufacturers' Association https://www.acea.be/uploads/publications/report-vehicles-in-use-europe-january-2021.pdf

**Behavioural aspects**

- Direct rebound effects occur when a decrease in the cost of using a product results in increased use.
- More efficient engines make it possible to build more economical vehicles → Engines become more powerful or when the vehicle is driven more frequently or at a higher speed.
- Highly dependent on the specific technology, users, prices, etc, and are preferably based on empirical data (e.g., surveys).

# Calculation of impact on energy consumption (Article 3)

## Final Energy Consumption of the Reference Vehicle

$$FEC_{ref} = sFEC_{ref} * \frac{DT}{100} * n * f_{BEH}$$

## Final Energy Consumption of the Efficient Vehicle

$$FEC_{eff} = sFEC_{eff} * \frac{DT}{100} * n * f_{BEH}$$

| | |
|---|---|
| $FEC$ | Final energy consumption [kWh/100 km] |
| $sFEC$ | Specific final energy consumption of the vehicle [kWh/100 km] |
| $ref/eff$ | Reference/efficienc vehicle |
| $DT$ | Average yearly distance travelled with the vehicle [km/a] |
| $n$ | Number of efficient vehicles purchased [dmnl] |
| $f_{BEH}$ | Factor for correction of behavioural effects (e.g., rebound effects) [%] |

# Calculation of impact on energy consumption (Article 3)

## Total Final Energy Savings

$$TFES = \left(sFEC_{ref} - sFEC_{eff}\right) * \frac{DT}{100} * n * f_{BEH}$$

## Total Primary Energy Savings

$$TPES = FEC_{ref} * \sum_{ec}\left(share_{ec} * PEF_{ec}\right) - FEC_{eff} * \sum_{ec}\left(share_{ec,} * PEF_{ec}\right)$$

| | |
|---|---|
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $PEF_{ec}$ | Primary Energy Factor of the used energy carrier [dmnl] |

# Calculation of Greenhouse Gas Emissions Savings

## Greenhouse Gas Emissions Savings

$$GHGSAV = FEC_{ref} * \sum_{ec} \left( share_{ec,ref} * f_{GHG,ec} \right) - FEC_{eff} * \sum_{ec} \left( share_{ec,eff} * f_{GHG,ec} \right)$$

| | |
|---|---|
| $share_{ec}$ | Share of final energy carrier on final energy consumption [%] |
| $f_{GHG,ec}$ | Emission factors of final energy carrier [t $CO_2$e/kWh] |

# Overview of costs related to the action

## Indicative values for costs:

| [euro2021] | Investment costs |
|---|---|
| Small Car – ICE | 16,855 |
| Small Car – BEV | 25,510 |
| Mid-Size – ICE | 22,690 |
| Mid-Size – BEV | 30,690 |
| Large Car – ICE | 50,840 |
| Large Car – BEV | 81,610 |
| Van – BEV | 53,660 |
| Bus – BEV | 235,200 |

| [euro2021/a] | Maintenance costs |
|---|---|
| Car – ICE | 794 |
| Car – BEV | 397 |

Indicative values for the several cost components, excluding taxes

## Data Sources

– LeasePlan (2020). 2020 Car Cost Index. Link, accessed on 2023/07/13

# Practical experience based on country support

- There is non-uniform practice among MS in relation to evaluate energy savings, in particular:
  - concerning practicalities such as conversion to soft modes, hypotheses of scrapping and import percentages;
  - compliance with the additionality criteria;
  - discrepancies of the actual lifetime of vehicles with the theoretical ones as specified in the respective legislative documents.
- Lack of a standardized and robust data exchange procedure is transversal among the countries and the existing data sources are not easily accessible.
- There is a need to establish a standardised data collection mechanism based on a robust and independent monitoring and verification structure.

PRIORITY ACTION

# Accelerated replacement of inefficient electric motors

Created by

João Fong (ISR, University of Coimbra)

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

# Anticipated motor replacement

- <u>Definition:</u>
  - *Replacement of old inefficient electric motors before their end-of-life.*

- <u>Scope:</u>
  - <u>Sector:</u> Industry / Tertiary
  - 3-Phase Motors in the scope of The Ecodesign Regulation (EC Regulation 2019/1781)
    - Only between 0,75kW and 1000kW (exclude “small motors”)

# Calculation of final energy savings (Article 7)

- The energy consumption of an electric motor results from its nominal output power, the operating hours, the average load and its efficiency. The final energy savings result from the improvement in efficiency.
- With the installation of Variable Speed Drives (VSDs), additional savings can be estimated and added to the TFES.
- Use real characteristics of a motor whenever possible.

$$\text{TFES} = n \times P_n \times h \times \left(\frac{1}{\eta_c} - \frac{1}{\eta_{he}}\right) \times LF \times 100$$

$$\text{TFES}_{VSD} = n \cdot \frac{P_n}{\eta_{he}} \cdot 100 \cdot h \cdot f_{VSD}$$

| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| $\text{TFES}_{vsd}$ | Total final additional energy savings from VSD [kWh/a] |
| n | Number of motors replaced [dmnl] |
| $P_n$ | Nominal power as indicated in the nameplate [kW] |
| h | Annual operating hours [h] |
| $\eta_c$ | Efficiency of conventional motor [%] |
| $\eta_{he}$ | Efficiency of high-efficiency motor [%] |
| LF | Load factor [dmnl] |
| $f_{VSD}$ | Factor to account for additional savings generated by the installation of a variable speed control (VSD) [dmnl] |

# Indicative values

- Indicative values: Motor power and efficiency

| Power range [kW] | Avg. Power | IE1-IE2 Avg | IE3 | IE4 |
|---|---|---|---|---|
| 0,75 - 7,5 | 3.2 | 81.9 | 86.5 | 89.1 |
| 7,5 - 75 | 34.3 | 91.2 | 93.3 | 94.6 |
| 75 - 375 | 201.5 | 94.3 | 95.7 | 96.4 |
| 375 - 1000 | 587.5 | 94.5 | 95.9 | 96.6 |

- Indicative values: Load Factor and Lifetime

| Load Factor | |
|---|---|
| Load factor | 0.60 |
| Lifetime of savings | [a] |
| Lifetime of savings | 10 years |

# Indicative values

- Indicative values: annual operating hours

| Type of activity | [h/a] |
|---|---|
| Industry, 1 shift, 5 days/week | 1,920 |
| Industry, 2 shifts, 5 days/week | 3,840 |
| Industry, 2 shifts, 6 days/week | 4,608 |
| Industry, 2 shifts, 7 days/week | 5,376 |
| Industry, 3 shifts, 5 days/week | 5,760 |
| Industry, 3 shifts, 6 days/week | 6,912 |
| Industry, 3 shifts, 7 days/week | 8,064 |
| Industry, 3 shift, continuously | 8,760 |
| Tertiary | 1,480 |

# Indicative values

- Indicative values: VSD average default savings factor

| End-Use | $f_{VSD}$ |
| --- | --- |
| Pumps | 0.28 |
| Fans | 0.28 |
| Air Compressors | 0.12 |
| Cooling compressors | 0.12 |
| Conveyors | 0.12 |
| Other Motors | 0.12 |

# Calculation of impact on energy consumption (Article 3)

- Effect on primary energy consumption depends on the country specific conversion factors from final to primary energy

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} \left(share_{ec,Baseline} \cdot f_{PE,ec}\right) - FEC_{Action} \cdot \sum_{ec} \left(share_{ec,Action} \cdot f_{PE,ec}\right)$$

| | |
|---|---|
| EPEC | Effect on primary energy consumption [kWh/a] |
| FEC | Annual final energy consumption [kWh/a] |
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{PE,ec}$ | Final to primary energy conversion factor of the used energy carrier [dmnl] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after the implementation of the action |
| ec | Index of energy carrier |

# Calculation of Greenhouse Gas Emissions Savings

## Methodology:

– *Greenhouse gas savings =>*

$$GHGSAV = \left[FEC_{Baseline} \cdot \sum_{ec} \left(share_{ec,Baseline} \cdot f_{GHG,ec}\right) - FEC_{Action} \cdot \sum_{ec} \left(share_{ec,Action} \cdot f_{GHG,ec}\right)\right] * 10^{-6}$$

| | |
|---|---|
| GHGSAV | Greenhouse gas savings [t $CO_2e$ p.a.] |
| FEC | Annual final energy consumption [kWh/a] |
| share | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{GHG}$ | Emission factor of final energy carrier [t $CO_2$/kWh] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after implementation of the action |
| ec | Index of energy carrier |

# Practical experience based on country support

- Indicative values are useful for the cost-benefit analysis of early motor replacement using a more sophisticated methodology (ROI) calculation instead of using another conventional approach (e.g. payback period)
- It is recommended to extend the scope of the interventions beyond the replacement of the motor alone and include careful consideration and analysis of other parts of the drivetrain (e.g. variable speed drives, etc.)

PRIORITY ACTION

# Behavioural Changes

Created by

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streamSAVE

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

# Feedback and tailored advice for behaviour changes
## Definition and scope

- Definition (source: Energy Efficiency Directive, Appendix VI):
  - *“Behavioural measures” cover any type of policy measure or intervention aimed at saving energy by changing end-users' behaviour or systems.*
- Scope of the streamSAVE:
  - measures targeting the residential sector;
  - behaviour changes related to using energy and not for investment decisions (e.g., adopting a new technology);
  - examples of measures are presented on the methodology.

# Feedback and tailored advice for behaviour changes

## Definition and scope

- Specifically addresses behaviour measures that are based on “feedback” (direct feedback) and “feedback including tailored advice” (indirect feedback)

| Type of measure | Type of feedback measure |
|---|---|
| Feedback | “Direct feedback” campaigns, immediate (real time) and easily accessible consumption feedback from:<br>– Self-meter-reading (visible energy meter/smart meter)<br>– Information display<br>– Real-time consumption on a webpage<br>– Ambient devices (which by light or sound can inform consumers about their energy consumption level) |
| Feedback including tailored advice | Feedback including information which has been processed in some way before the consumer receives:<br>– More informative frequent bills<br>– Historical energy consumption comparison<br>– Energy consumption rewards<br>– Information on a webpage<br>– Direct e-mail and SMS<br>– Energy audits or reports<br>– Energy Efficiency advice tailored to the consumer |

# Methodology formulas (Article 7)

$$TFES = \mathrm{N} \times \mathrm{UFEC} \times \mathrm{S} \times \mathrm{dc}$$

| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| N | Number of participants [dmnl] |
| UFEC | Unitary Final Energy Consumption per household (electricity or gas) [kWh/a] |
| S | Energy saving factor [%] |
| dc | Double-counting factor [%] |

# Methodology formulas (Article 3)

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} \left( share_{ec,Baseline} \cdot f_{PE,ec} \right) - FEC_{Action} \cdot \sum_{ec} \left( share_{ec,Action} \cdot f_{PE,ec} \right)$$

| | |
|---|---|
| EPEC | Effect on primary energy consumption [kWh/a] |
| FEC | Annual final energy consumption [kWh/a] |
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{PE,ec}$ | Final to primary energy conversion factor of the used energy carrier [dmnl] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after the implementation of the action |
| ec | Index of energy carrier |

# Methodology formulas (GHG emissions)

$$GHGSAV = \left[FEC_{Baseline} \cdot \sum_{ec}\left(share_{ec,Baseline} \cdot f_{GHG,ec}\right) - FEC_{Action} \cdot \sum_{ec}\left(share_{ec,Action} \cdot f_{GHG,ec}\right)\right] \cdot 10^{-6}$$

| | |
|---|---|
| GHGSAV | Greenhouse gas savings [t $CO_2$/a] |
| FEC | Annual final energy consumption [kWh/a] |
| share | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{GHG}$ | Emission factor of final energy carrier [g $CO_2$/kWh] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after implementation of the action |
| ec | Index of energy carrier |

# Indicative Values

## (Unitary Final Energy Consumption - UFEC)

- Grouped by final use:
  - Electricity;
  - Electricity for heating;
  - Gas for heating.
- Data sources:
  - Eurostat database (Eurostat, 2019a);
  - JRC IDEES database (JRC, 2018);
  - values are weather normalized using Heating Degree Days (HDD).
- For detailed description, please refer to the Standardized saving methodologies, section 9.3

| Country | Electricity | Electricity for heating | Gas for heating |
|---|---|---|---|
| Austria | 4,654.58 | 7,583.86 | 11,742.55 |
| Belgium | 3,838.40 | 6,443.27 | 12,502.88 |
| Bulgaria | 3,754.16 | 2,956.74 | 3,823.72 |
| Croatia | 4,216.25 | 5,062.84 | 9,951.72 |
| Cyprus | 5,328.79 | 2,561.23 | 5,484.02 |
| Czechia | 3,206.90 | 8,567.80 | 11,458.61 |
| Denmark | 3,927.40 | 5,571.89 | 12,060.06 |
| Estonia | 3,225.80 | 9,673.39 | 10,202.56 |
| Finland | 8,309.44 | 7,980.90 | 17,598.05 |
| France | 5,314.94 | 5,973.06 | 7,554.68 |
| Germany | 3,134.18 | 7,242.33 | 9,685.01 |
| Greece | 3,738.15 | N/A | N/A |
| Hungary | 2,816.84 | 8,670.03 | 10,150.66 |
| Ireland | 4,304.29 | 9,642.40 | 11,158.54 |
| Italy | 2,523.44 | 4,347.70 | 7,826.44 |
| Latvia | 1,905.04 | 7,867.61 | 9,414.13 |
| Lithuania | 2,226.32 | 7,031.34 | 7,165.31 |
| Luxembourg | 3,564.20 | 7,169.80 | 18,797.65 |
| Malta | 4,199.31 | 925.50 | 1,392.58 |
| Netherlands | 2,948.68 | 5,577.07 | 7,808.56 |
| Poland | 2,016.41 | 7,700.80 | 9,049.61 |
| Portugal | 3,187.76 | 809.58 | 1,158.78 |
| Romania | 1,729.78 | 5,705.91 | 6,344.90 |
| Slovakia | 2,697.64 | 5,824.78 | 6,776.09 |
| Slovenia | 3,717.77 | 6,125.92 | 8,068.41 |
| Spain | 3,889.06 | 2,398.70 | 3,543.40 |
| Sweden | 8,268.64 | 7,219.05 | 14,843.62 |

All values in [kWh/a]

# Indicative Values (Energy Savings Factor (S)

- Recommended to *"use the randomized controlled trials (RCT)"* approach:
  - which involves collecting data on metered or monitored energy consumption before and after the action.
- streamSAVE indicative values for Energy Savings Factor (S) should be considered as EU-wide benchmarks (more than 40 studies were assed in terms quality).

| Final use | Type of measure | Energy Savings factor (S) [%] |
|---|---|---|
| Electricity | Feedback | 2.30 % |
| | Feedback including tailored advice | 3.50 % |
| Electricity for heating | Feedback | 2.00 % |
| | Feedback including tailored advice | 3.00 % |
| Gas for heating | Feedback | 3.40 % |
| | Feedback including tailored advice | 3.60 % |

# Indicative Values (Lifetime of savings)

- The existing scientific literature is unable to provide a solid suggestion;
- streamSAVE methodology
  - focusses on yearly average savings;
  - assumes that an implemented action in this area must be reported each year with the actual number of households that received feedback about the energy consumption.

| Lifetime of savings | [a] |
|---|---|
| Lifetime of savings | 1 year |

# Indicative Values (share of energy carriers)

- Please keep in mind that these values are based on EU-wide data and will need to be adjusted to national circumstances;
- Calculated using the (JRC, 2018) EU28 final energy consumption disaggregation by final end use and energy carrier.

| $share_{ec,Baseline}$ | | |
|---|---|---|
| Target end-use | Energy carrier | Share of energy carrier (%) |
| Electricity | Electricity | 100 % |
| Electricity for heating | Electricity | 100 % |
| Gas for heating | Natural gas | 74 % |
| | Gas/Diesel oil | 25 % |
| | Liquefied petroleum gases | 1 % |
| $share_{ec,Action}$ | | |
| Target end-use | Energy carrier | Share of energy carrier (%) |
| Electricity | Electricity | 100 % |
| Electricity for heating | Electricity | 100 % |
| Gas for heating | Natural gas | 74 % |
| | Gas/Diesel oil | 25 % |
| | Liquefied petroleum gases | 1 % |

# Practical experience based on country support

- There is a vast list of behavioural measures and therefore a BU methodology is difficult to apply if there is no standardization of the type of measures.
- Need to standardise the type of the educational and counselling measures to be able to uniform parameters for the calculation of the delivered energy savings using a BU methodology.
- Mainly discrepancies were found in the assumed lifetime of the measures, highlighting the need to provide common values for all MS.

PRIORITY ACTION

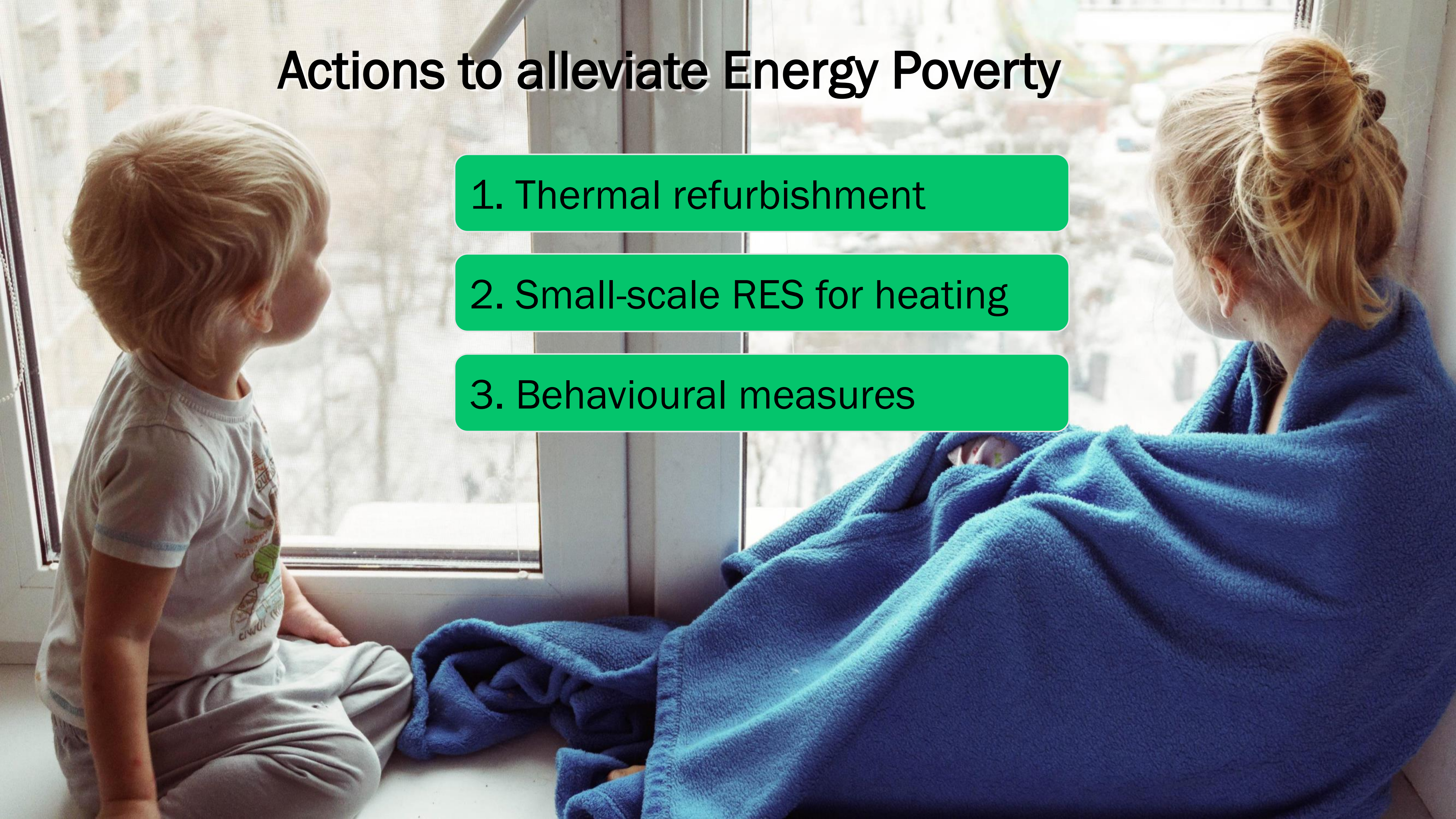
# Actions alleviating energy poverty

Created by

Guillermo Borragán (VITO/EnergyVille)

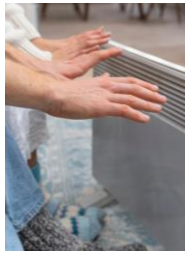
This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

# Actions to alleviate Energy Poverty



1. Thermal refurbishment
2. Small-scale RES for heating
3. Behavioural measures

# Calculation methodology – Art. 7 Thermal refurbishment



$$TFES = (FEC_{baseline} - FEC_{action}) \cdot (1 - f_{BEH})$$

$$TFES = A \cdot \left( \frac{SHD_{baseline} \cdot (1 - f_{prebound\,EPOV}) + DHW}{eff} - \frac{SHD_{action} + DHW}{eff} \right) \cdot (1 - f_{BEH})$$

| | |
|---|---|
| TFES | Total Final Energy Savings [kWh/a] |
| $FEC_{baseline}$ | Final energy consumption for end-use, before the action [kWh/a] |
| $FEC_{action}$ | Final energy consumption for end-use, after the action [kWh/a] |
| A | Useful floor area of the dwelling [$m^2$] |
| SHD | Specific space heating demand of the dwelling [$kWh/m^2/a$] |
| HWD | Specific domestic hot water demand of the dwelling [$kWh/m^2/a$] |
| $eff_{baseline}$ | Conversion efficiency of the reference heating system [dmnl] |
| $eff_{action}$ | Conversion efficiency of heating system after the action [dmnl] |
| $f_{prebound\ EPOV}$ | Factor for adjusting baseline consumption of average household to energy poor household [dmnl] |
| $f_{BEH}$ | Factor to adjust for rebound effects of the action [dmnl] |

# Calculation methodology – Art. 7 Thermal refurbishment

- Rebound effects (0,25) & prebound effects (0,35): based on literature review; median of all scores reported (n=5 for prebound; n=14 for rebound)
- Conversion efficiency of heating systems EPOV: less efficient systems
- EU indicative values to be adjusted to national circumstances!

| $f_{BEH}$ | [dmnl] |
|---|---|
| Residential – average* and EPOV | 0.25 |
| $f_{prebound\ EPOV}$ | [dmnl] |
| Residential – average* | 0.00 |
| Residential - EPOV[4] | 0.35 |
| eff | [dmnl] |
| Residential – average | 0.712 |
| Residential - EPOV | 0.630 |
| $SHD_{baseline}$ | [kWh/m² useful floor area a] |
| Residential | 92.1 |
| $SHD_{action}$ | [kWh/m² useful floor area a] |
| Residential | Depending on type and degree of refurbishment |
| HWD | [kWh/m² useful floor area a] |
| Residential | 19.2 |
| Lifetime of savings | [years] |
| Lifetime of savings | >25 |

*__Note:__ Average represents the indicative values for an average, EU27 household, while EPOV is representing values specifically for energy poor households.

# Calculation methodology – Art. 7
# Small-scale RES for heating

$$TFES = (FEC_{baseline} - FEC_{action}) \cdot (1 - f_{BEH})$$

$$TFES = A \cdot \left(SHD \cdot \left(1 - f_{prebound\ EPOV}\right) + HWD\right) \cdot \left(\frac{1}{eff_{baseline}} - \frac{1}{eff_{action}}\right) \cdot \left(1 - f_{BEH}\right)$$

| | |
|---|---|
| TFES | Total Final Energy Savings [kWh/a] |
| $FEC_{baseline}$ | Final energy consumption for end-use, before the action [kWh/a] |
| $FEC_{action}$ | Final energy consumption for end-use, after the action [kWh/a] |
| A | Useful floor area of the dwelling [$m^2$] |
| SHD | Specific space heating demand of the dwelling [$kWh/m^2/a$] |
| HWD | Specific domestic hot water demand of the dwelling [$kWh/m^2/a$] |
| $eff_{baseline}$ | Conversion efficiency of the reference heating system [dmnl] |
| $eff_{action}$ | Conversion efficiency of heating system after the action [dmnl] |
| $f_{prebound\ EPOV}$ | Factor for adjusting baseline consumption of average household to energy poor household [dmnl] |
| $f_{BEH}$ | Factor to adjust for rebound effects of the action [dmnl] |

# Calculation methodology – Art. 7
# Small-scale RES for heating

| $f_{BEH}$ | [dmnl] |
|---|---|
| Residential – average* and EPOV | 0.25 |
| $f_{prebound\ EPOV}$ | [dmnl] |
| Residential – average* | 0.00 |
| Residential - EPOV | 0.35 |
| $eff_{baseline}$ – heating system | [dmnl] |
| Residential – average | 0.712 |
| Residential - EPOV | 0.630 |
| $eff_{action}$ – heating system | [dmnl] |
| Residential – average* and EPOV: Biomass boiler | 0.92 |
| Residential – average* and EPOV: Air source HP | 2.6 |
| Residential – average* and EPOV: Ground source HP | 3.2 |
| Residential – average* and EPOV: Groundwater HP | 3.5 |
| SHD | [kWh/$m^2$ useful floor area a] |
| Residential – average* and EPOV | 92.1 |
| HWD | [kWh/$m^2$ useful floor area a] |
| Residential – average* and EPOV | 19.2 |
| Lifetime of savings | 10 (air to air)<br>15 (air to water)<br>25 (geothermal)<br>20 (biomass boiler) |

* Average represents the indicative values for an average, EU27 household, while EPOV is representing values specifically for energy poor households.

# Calculation methodology – Art. 7 Behavioural measures

- Feedback and feedback including tailored advice

$$TFES = N \times UFEC \times f_{prebound} \times S \times dc$$

| | |
|---|---|
| **TFES** | Total final energy savings [kWh/a] |
| **N** | Number of participants [dmnl] |
| **UFEC** | Unitary Final Energy Consumption of an average household (electricity or gas) [kWh/a] |
| **$f_{prebound\ EPOV}$** | Factor for adjusting consumption of average household to energy poor household [dmnl] |
| **S** | Energy saving factor [%] |
| **dc** | Double-counting factor [%] |

- Indicative values – cf. PA behavioural changes:
  - UFEC: from Odysee-MURE, 2019 values per EU country
  - Saving factors:

| Final use | Type of measure | Energy savings factor (S) [%] |
|---|---|---|
| **Electricity** | Feedback | 2.30% |
| | Feedback with tailored advice | 3.50% |
| **Electricity for heating** | Feedback | 2% |
| | Feedback with tailored advice | 3% |
| **Gas for heating** | Feedback | 3.40% |
| | Feedback with tailored advice | 3.60% |

# Impact on energy consumption (Article 3)

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} (share_{ec,Baseline} \cdot f_{PE,ec}) - FEC_{Action} \cdot \sum_{ec} (share_{ec,Action} \cdot f_{PE,ec})$$

| | |
|---|---|
| EPEC | Effect on primary energy consumption [kWh/a] |
| FEC | Annual final energy consumption [kWh/a] |
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{PE,ec}$ | Final to primary energy conversion factor of the used energy carrier [dmnl] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after the implementation of the action |
| ec | Index of energy carrier |

# Calculation of CO2 savings

$$GHGSAV = \left[FEC_{Baseline} \cdot \sum_{ec}\left(share_{ec,Baseline} \cdot f_{GHG,ec}\right) - FEC_{Action} \cdot \sum_{ec}\left(share_{ec,Action} \cdot f_{GHG,ec}\right)\right] \cdot 10^{-6}$$

| | |
|---|---|
| GHGSAV | Greenhouse gas savings [t $CO_2$/a] |
| FEC | Annual final energy consumption [kWh/a] |
| share | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{GHG}$ | Emission factor of final energy carrier [g $CO_2$/kWh] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after the implementation of the action |
| ec | Index of energy carrier |

# Practical experience based on country support

- streamSAVE calculation methodology requires the collection of data, which are not easily accessible and available for the case of energy poor households highlighting the **need to establish appropriate data collection procedures**
  - the collection of specific data is problematic for the area of the improved building component, the space heating demand and hot water demand, the conversion efficiency of the reference heating systems and the U-values of the building components
- The definition of energy poverty needs to be analysed to include other parameters than the income; appropriate energy poverty indicators, using multidimentional criteria, need to be considered.

PRIORITY ACTION

# Modal Shifts in Freight Transport

Created by

Elisabeth Böck (Austrian Energy Agency)

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

# Concept of the methodology

- No provision of savings achieved by a single action implemented, as impossible to define standardized values
- Instead: analysis of overall shift potential per Member State, to offer a first assessment of savings that can be achieved
- Option to enter the amount that will actually be shifted, either of total freight transport or a specific sector or distance class

# Calculation of the modal shift potential
# Transport volume

Basis:

**Road freight transport volume (tv)**

- Per Member State
- Per type of good
- Per distance class

Data was taken from EUROSTAT freight transport statistics.
Data quality varies among Member States.

# Calculation of the modal shift potential
# Transport volume

$$tv * f_g * f_{dc}$$

**Transport volume multiplied by:**

- Factor for the modal shift potential per type of good ($f_g$)
  - Depends on usual packaging, potential for quick transfer, packing density:

| Modal shift potential per group of goods | $f_g$ [dmnl] |
|---|---|
| Agricultural products and live animals | 0,25 |
| Foodstuff and animal fodder | 0,35 |
| Solid mineral fuels | 0,00 |
| Petroleum products | 0,37 |
| Ores and metal waste | 0,10 |
| Metal products | 0,35 |
| Crude and manuf. minerals, building materials | 0,15 |
| Fertilizers | 0,30 |
| Chemicals | 0,63 |
| Machinery, transport equipment, manufactured articles | 0,68 |

# Calculation of the modal shift potential
# Theoretical potential

$$tv * f_g * f_{dc}$$

**Transport volume multiplied by:**

- Factor for the modal shift potential per distance class ($f_{dc}$)
  - Longer transport distances are more reasonable to shift:

| Modal shift potential per distance class | $f_{dc}$ [dmnl] |
|---|---|
| 0 - 50 km | 0,00 |
| 50 - 149 km | 0,05 |
| 150 - 499 km | 0,40 |
| > 500 km | 1,00 |

# Calculation of the modal shift potential
# Technical potential

$$tv * f_g * f_{dc} * f_{nd}$$

Takes into account the rail network density ($f_{nd}$)

- Approach: freight transport volume on rail will at a maximum be doubled until 2030
- Comparison of current rail freight transport with theoretical potential
- Calculation of a factor for maximum technical potential

# Network density per Member State

| Factor for network density | $f_{nd}$ [dmnl] | Factor for network density | $f_{nd}$ [dmnl] |
|---|---|---|---|
| Belgium | 0,71 | Latvia | 1,00 |
| Bulgaria | 0,57 | Lithuania | 1,00 |
| Czechia | 1,00 | Luxembourg | 0,17 |
| Denmark | 1,00 | Hungary | 1,00 |
| Germany | 1,00 | Netherlands | 0,99 |
| Estonia | 1,00 | Austria | 1,00 |
| Ireland | 0,07 | Poland | 0,71 |
| Greece | 0,09 | Portugal | 0,33 |
| Spain | 0,18 | Romania | 1,00 |
| France | 1,00 | Slovenia | 0,56 |
| Croatia | 1,00 | Slovakia | 0,91 |
| Italy | 1,00 | Finland | 1,00 |
| Cyprus | 0,00 | Sweden | 1,00 |

# Calculation of final energy savings

$$TFES = tv * (FEC_{road} - FEC_{rail}) * f_g * f_{dc} * f_{nd} * f_{nt} * share$$

- Technical shift potential * **difference in energy consumption per transport mode** $(FEC_{road} - FEC_{rail})$

| Final energy consumption FEC [kWh/tkm] | 0 – 500 km | > 500 km |
|---|---|---|
| Road Transport | 0.833 | 0.194 |
| Rail transport | 0.061 | |
| **Lifetime of savings [a]** | | |
| Lifetime of savings | 2 years | |

Share of potential to be shifted by an implemented action [%]

- Inclusion of a factor $f_{nt}$ for **long distance transportation**, to take into account international transport

# International freight transport

- For international freight transport:
  - Only savings achieved on national territory can be accounted;
  - Take into account substituted tank fillings on national territory;
  - Hypothesis: first tank filling happens at start of the cargo transport;
  - About 2.000 km can be travelled with one tank filling;
  - All distances above 2.000 km are only accounted for partly.

# Total savings potential per MS

| Member State | Final Energy Savings [GWh/a] | Member State | Final Energy Savings [GWh/a] |
|---|---|---|---|
| Austria | 1.320 | Italy | 7.190 |
| Belgium | 2.118 | Latvia | 777 |
| Bulgaria | 655 | Lithuania | 2.408 |
| Croatia | 814 | Luxembourg | 75 |
| Czechia | 2.039 | Netherlands | 3.610 |
| Denmark | 653 | Poland | 14.538 |
| Estonia | 260 | Portugal | 448 |
| Finland | 1.581 | Romania | 2.477 |
| France | 7.862 | Slovakia | 1.835 |
| Germany | 16.330 | Slovenia | 915 |
| Greece | 108 | Spain | 2.466 |
| Hungary | 1.512 | Sweden | 2.088 |
| Ireland | 40 | TOTAL | 74.120 |

# Effect on primary energy consumption

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} (share_{ec,Road} \cdot f_{PE,ec}) - FEC_{Action} \cdot \sum_{ec} (share_{ec,Rail} \cdot f_{PE,ec})$$

| | |
|---|---|
| EPEC | Effect on primary energy consumption [kWh/a] |
| FEC | Annual final energy consumption [kWh/a] |
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{PE,ec}$ | Final to primary energy conversion factor of the used energy carrier [dmnl] |
| ec | Index of energy carrier |

## EU averages:

| $share_{ec}$ – Road freight transport | [%] |
|---|---|
| Diesel | 100 % |
| $share_{ec}$ – Rail Freight Transport | [%] |
| Electricity | 64 % |
| Diesel | 36 % |

# $CO_2$ savings

$$GHGSAV = \left[ FEC_{Baseline} \cdot \sum_{ec} \left( share_{ec,Road} \cdot f_{GHG,ec} \right) - FEC_{Action} \cdot \sum_{ec} \left( share_{ec,Rail} \cdot f_{GHG,ec} \right) \right] * 10^{-6}$$

## EU averages:

| $share_{ec}$ – Road freight transport | [%] |
| --- | --- |
| Diesel | 100 % |
| **$share_{ec}$ – Rail Freight Transport** | **[%]** |
| Electricity | 64 % |
| Diesel | 36 % |

# Cost components

- Indicative values for:
  - Fixed costs (Asset leases, Insurance, Interest, Maintenance)
  - Variable costs (Fuel, Bunkering, Stores & supplies, Maintenance)
  - Staff costs (Wages, Social security and pension contributions, Accomodation)
  - Mode-specific costs (Usage of Infrastructure, supporting services, permits & certification)
  - General operating costs (Administration, Real estate & infrastructure, Wages for other personnel, IT & communications, Overhead)
- All values are presented in €/tkm
- Cost data from a study in the Netherlands was used, so adjustments to national circumstances might be necessary

# Use & Limitations

- Member States can assess overall potential and enter a share to be shifted by actions implemented, either for:
  - The total shift potential
  - For a certain group of goods or distance class
- Economic feasibility is not considered in the methodology, but data on relevant cost components has been prepared

# Practical experience based on country support

- A deemed method is acceptable to minimize administrative costs and facilitate the calculation of the energy savings. But the developed streamSAVE methodology is more a top-down than a BU method.
- There is a lack of national data avoiding the actual evaluation of the developed methodology:
  - the lack of data is perceived as one of the main constraints for applying the streamSAVE calculation methodology and limiting standardized savings methodologies across Europe.
- More support was asked about the required control and verification procedures, focusing mainly on the determination and approval of the shifted tonne-kilometres.

# Practical experience based on country support

- The energy saving potential delivered is rather competitive, taking into consideration the required costs and limited savings;
- Need to establish a procedure to collect data for assessing the delivered energy savings, such as the consumed energy, the type and quantity of goods transported, the tonne kilometres travelled and other factors which may affect consumption;
- It is recommended to take into consideration various parameters (e.g., by means of a multi-criteria analysis), such as various restrictions (route of the rail network) and the destination country and region in the country since these parameters may influence the economic viability of modal shifting.
- Need to understand what are the drivers and barriers for modal shift for freight, through the conduction of a targeted survey to assess why logistic operators do not use rail or combine different means of transport and keep using mainly trucks.

PRIORITY ACTION

# Small scale renewable heating

Created by

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# Definition and scope

- Definition

  Small-scale renewable heating technologies are systems that supply central heating without polluting emissions, in this case, to cover the heat demand of buildings and provide domestic hot water

- Scope of the streamSAVE:
  - Measures targeting residential sector and non-residential sector
  - Methodologies prepared for following technologies:
    - Heat pumps for heating and domestic hot water
    - Biomass boilers for heating and domestic hot water

# Heat pumps for heating and domestic hot water (DHW)

[residential and non-residential buildings]

# Calculation methodology – Art. 7
# Heat pumps

$$TFES = A \cdot (SHD + HWD) \cdot \left(\frac{1}{eff_{baseline}} - \frac{1}{eff_{action}}\right) \cdot f_{BEH} \cdot cf_x$$

| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| A | Useful floor area of the building or dwelling [m²] |
| SHD | Area specific heating demand of the building or dwelling [kWh/m²a] |
| HWD | Area specific hot water demand of the building or dwelling [kWh/m²a] |
| $cf_x$ | Climate correction factor |
| $eff_{baseline}$ | Conversion efficiency of a reference heating system [dmnl] |
| $eff_{action}$ | Conversion efficiency of the heat pump [dmnl] |
| $f_{BEH}$ | Factor to calculate behavioural aspects [dmnl] |

# Calculation methodology – Art. 7
# Heat pumps

| Action type | Indicative lifetime (years) |
|---|---|
| Heat pumps for residential buildings | 10 (air-to-air) |
| Heat pumps for non-residential buildings | 15 (air-to-water); |
| Heat pumps | 25 (geothermal) |

(Appendix VIII of Commission Recommendation (EU) 2019/1658)

EUR-Lex - 32019H1658 - EN - EUR-Lex (europa.eu)

| $cf_x$ | [dmnl] | | |
|---|---|---|---|
| | North | West | South |
| Residential | 1.21 | 1 | 0.76 |
| Non-Residential | 1.16 | 1 | 0.70 |
| $f_{REH}$ | [dmnl] | | |
| Residential | 0.75 | | |
| Non-Residential | Not available | | |
| Lifetime of savings | [years] | | |
| Lifetime of savings | 10 (air to air)<br>15 (air to water)<br>25 (geothermal) | | |
| $eff_{Baseline}$ – reference heating system | [dmnl] | | |
| Residential | 0.887 | | |
| Non-Residential | 0.947 | | |
| SHD | [kWh/m² useful floor area a] | | |
| Residential | 92.1 | | |
| Non-Residential | 106.9 | | |
| HWD | [kWh/m² useful floor area a] | | |
| Residential | 19.2 | | |
| Non-Residential | 18.1 | | |

# Calculation of impact on energy consumption (Art3)

## Heat pumps for heating and DHW (residential and non-residential buildings)

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} (share_{ec,baseline} \cdot f_{PE,ec}) - FEC_{Action} \cdot \sum_{ec} (share_{ec,Action} \cdot f_{PE,ec})$$

| | |
|---|---|
| EPEC | Effect on primary energy consumption [kWh/a] |
| FEC | Annual final energy consumption [kWh/a] |
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{PE,ec}$ | Final to primary energy conversion factor of the used energy carrier [dmnl] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after the implementation of the action |
| ec | Index of energy carrier |

# Calculation of impact on energy consumption

## Indicative values for the share of energy carriers for Article 3: Heat pumps

| $Share_{ec}$ space heating & domestic hot water preparation | | Reference heating system [%] | Heat Pump [%] |
|---|---|---|---|
| Residential | Solids | 5% | / |
| | Liquefied petroleum gases | 2% | / |
| | Gas/Diesel oil | 16% | / |
| | Natural gas | 37% | / |
| | Wood/wood waste | 19% | / |
| | Geothermal energy | 0% | / |
| | District heat | 11% | / |
| | Electricity | 9% | 100% |
| | Solar | 1% | / |
| Non-residential | Solids | 2% | / |
| | Liquefied petroleum gases | 1% | / |
| | Gas/Diesel oil | 21% | / |
| | Natural gas | 44% | / |
| | Wood/wood waste | 2% | / |
| | Geothermal energy | 0% | / |
| | District heat | 13% | / |
| | Electricity | 18% | 100% |
| | Solar | 0.2% | |

# Overview of cost related to the action

## Heat pumps

Indicative costs (excl. taxes or fiscal incentives) for heat pumps and reference heating systems:

| [euro2020] | Investment costs (single family house - SFH) | |
|---|---|---|
| | SFH existing stock | SFH newly built |
| District heat | 14,731 | 14,731 |
| Gas condensing boiler | 9,223 | 8,607 |
| Oil condensing boiler | 14,615 | 12,993 |
| Firewood boiler | 15,286 | no data |
| Wood pellet boiler | 16,655 | 15,899 |
| Heat pump – air | 15,785 | 12,372 |
| Heat pump – ground probe | 25,426 | 20,002 |
| [euro2020/a] | Variable operational costs | |
| Costs of reduced fuel input | Energy prices from chapter 1.2.1 of D2.2 (fuel prices before/after for household consumers) | |
| [euro2020/a] | Fixed operational costs: Maintenance | |
| District heat | 1.15 % | |
| Gas condensing boiler | 1.15 % | |
| Oil condensing boiler | 2.12 % | |
| Firewood boiler | 2.55 % | |
| Wood pellet boiler | 2.62 % | |
| Heat pump – air | 2.35 % | |
| Heat pump – ground probe | 2.25 % | |
| [euro2021] | Revenues | |
| | No revenues | |
| [a] | Lifetime | |
| Lifetime | 10 | |

# Calculation of $CO_2$ savings

## Heat pumps

- Based on Article 7 savings

$$GHGSAV = \left[FEC_{Baseline} \cdot \sum_{ec}\left(share_{ec,Baseline} \cdot f_{GHG,ec}\right) - FEC_{Action} \cdot \sum_{ec}\left(share_{ec,Action} \cdot f_{GHG,ec}\right)\right] * 10^{-6}$$

| | |
|---|---|
| GHGSAV | Greenhouse gas savings [t $CO_2$e p.a.] |
| FEC | Annual final energy consumption [kWh/a] |
| share | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{GHG}$ | Emission factor of final energy carrier [t $CO_2$/kWh] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after implementation of the action |
| ec | Index of energy carrier |

| $f_{GHG}$ | Greenhouse [g $CO_2$/kWh] |
|---|---|
| Emission factor of the reference heating system | 158.6 |

# Biomass boilers for heating and domestic hot water (DHW)

[residential and non-residential buildings]

# Calculation methodology – Art. 7
# Biomass boiler for heating

$$TFES = A \cdot (SHD + HWD) \cdot \left(\frac{1}{eff_{baseline}} - \frac{1}{eff_{action}}\right) \cdot f_{BEH} \cdot cf_x$$

| | |
|---|---|
| TFES | Total final energy savings [kWh/a] |
| A | Useful floor area of the building or dwelling [m²] |
| SHD | Area specific heating demand of the building or dwelling [kWh/m²a] |
| HWD | Area specific hot water demand of the building or dwelling [kWh/m²a] |
| $cf_x$ | Climate correction factor |
| $eff_{baseline}$ | Conversion efficiency of a reference heating system [dmnl] |
| $eff_{action}$ | Conversion efficiency of the biomass boiler [dmnl] |
| $f_{BEH}$ | Factor to calculate behavioural aspects [dmnl] |

# Calculation methodology – Art. 7
# Biomass boiler for heating

Indicative calculation values for Article 7 of biomass boilers for heating

| $cf_x$ | [dmnl] | | |
| --- | --- | --- | --- |
| | North | West | South |
| Residential | 1.21 | 1 | 0.76 |
| Non-Residential | 1.16 | 1 | 0.70 |
| $f_{BEH}$ | [dmnl] | | |
| Residential (Space heating) | 0.75 | | |
| Non-residential | Not available | | |
| Lifetime of savings | [years] | | |
| Residential | 20 | | |
| Non-Residential | 25 | | |
| $eff_{Baseline}$ – reference heating system | [dmnl] | | |
| Residential | 0.887 | | |
| Non-Residential | 0.947 | | |
| $eff_{Action}$ – biomass boilers | [dmnl] | | |
| Biomass boiler | 0.920 | | |
| SHD | [kWh/m² useful floor area a] | | |
| Residential | 92.1 | | |
| Non-Residential | 106.9 | | |
| HWD | [kWh/m² useful floor area a] | | |
| Residential | 19.2 | | |
| Non-Residential | 18.1 | | |

# Calculation methodology – Art. 7
# Biomass boiler for heating

| $eff_{action}$ | Conversion efficiency |
|---|---|
| Oil-fired boiler | 0,77 |
| Biomass-fired boiler with minimum efficiency | 0,75 |
| Biomass boiler (best technology available on the market, estimated from product catalogues/certification schemes) | 0,92 |

(Appendix X of Commission Recommendation (EU) 2019/1658)

EUR-Lex - 32019H1658 - EN - EUR-Lex (europa.eu)

# Calculation of impact on energy consumption (Art.3)

## Biomass

$$EPEC = FEC_{Baseline} \cdot \sum_{ec} \left( share_{ec,Baseline} \cdot f_{PE,ec} \right) - FEC_{Action} \cdot \sum_{ec} \left( share_{ec,Action} \cdot f_{PE,ec} \right)$$

| | |
|---|---|
| EPEC | Effect on primary energy consumption [kWh/a] |
| FEC | Annual final energy consumption [kWh/a] |
| $share_{ec}$ | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{PE,ec}$ | Final to primary energy conversion factor of the used energy carrier [dmnl] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after the implementation of the action |
| ec | Index of energy carrier |

# Calculation of impact on energy consumption (Art.3)

Indicative values for the share of energy carriers for heating and DHW preparation for residential and non-residential buildings

| $Share_{ec}$ space heating & domestic hot water preparation | | Reference heating system [%] | Boiler(biomass) [%] |
|---|---|---|---|
| Residential | Solids | 5 % | 0 % |
| | Liquefied petroleum gases | 2 % | 0 % |
| | Gas/Diesel oil | 16 % | 0 % |
| | Natural gas | 37 % | 0 % |
| | Wood/wood waste | 19 % | 100 % |
| | Geothermal energy | 0 % | 0 % |
| | District heat | 11 % | 0 % |
| | Electricity | 9 % | 0 % |
| | Solar | 1 % | 0 % |
| Non-residential | Solids | 2 % | 0 % |
| | Liquefied petroleum gases | 1 % | 0 % |
| | Gas/Diesel oil | 21 % | 0 % |
| | Natural gas | 44 % | 0 % |
| | Wood/wood waste | 2 % | 100 % |
| | Geothermal energy | 0 % | 0 % |
| | District heat | 13 % | 0 % |
| | Electricity | 18 % | 0 % |
| | Solar | 0.2 % | 0 % |

Biomass

# Overview of costs



Indicative costs (excl. VAT) for biomass boilers and reference heating systems

| [euro2020] | Investment costs (single family houses - SFH) | |
|---|---|---|
| | SFH existing stock | SFH newly built |
| District heat | 14,731 | 14,731 |
| Gas condensing boiler | 9,223 | 8,607 |
| Oil condensing boiler | 14,615 | 12,993 |
| Firewood boiler | 15,286 | no data |
| Wood pellet boiler | 16,655 | 15,899 |
| Heat pump - air | 15,785 | 12,372 |
| Heat pump - ground probe | 25,426 | 20,002 |
| [euro2020/a] | Variable operational costs | |
| Costs of reduced fuel input | Energy prices from chapter 1.2.1 (fuel prices before/after for household consumers) | |
| [euro2020/a] | Fixed operational costs: Maintenance | |
| District heat | 1.15 % | |
| Gas condensing boiler | 1.15 % | |
| Oil condensing boiler | 2.12 % | |
| Firewood boiler | 2.55 % | |
| Wood pellet boiler | 2.62 % | |
| Heat pump - air | 2.35 % | |
| Heat pump - ground probe | 2.25 % | |
| [euro2021] | Revenues | |
| | No revenues | |
| [a] | Lifetime | |
| Lifetime | 20 - 25 | |

# Calculation of $CO_2$ savings

- Mainly $CO_2$ savings, when installing biomass boiler
- Based on Art. 7 savings:

$$GHGSAV = \left[FEC_{Baseline} \cdot \sum_{ec} \left(share_{ec,Baseline} \cdot f_{GHG,ec}\right) - FEC_{Action} \cdot \sum_{ec} \left(share_{ec,Action} \cdot f_{GHG,ec}\right)\right] * 10^{-6}$$

| | |
|---|---|
| GHGSAV | Greenhouse gas savings [t $CO_2e$ p.a.] |
| FEC | Annual final energy consumption [kWh/a] |
| share | Share of final energy carrier on final energy consumption [dmnl] |
| $f_{GHG}$ | Emission factor of final energy carrier [t $CO_2$/kWh] |
| Baseline | Index for the baseline situation of the action |
| Action | Index for the situation after implementation of the action |
| ec | Index of energy carrier |

| $f_{GHG}$ | Greenhouse [g $CO_2$/kWh] |
|---|---|
| Emission factor of the reference heating system | 158.6 |

# Practical experience based on country support

- The European average values provided by streamSAVE constitute a solid basis for comparing the obtained results with the existing methodologies at national level. However, to obtain more accurate results it is recommended to use national values for the parameters in the savings calculations:
  - the replacement of conventional boilers by biomass boilers in buildings, especially in non-residential, leads to lower energy savings compared to heat pumps due to the lower efficiency.
- Lack of data on cooling demand.

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