



PRIORITIZING ENERGY RENOVATION
IN THE CEE COUNTRIES

WELCOME!

Towards Carbon-Neutral Buildings in the V4 region: Heating Decarbonisation and Life-cycle GWP of Buildings

Online workshop
June 12, 2025



Who we are

Visit the project website at
<https://mehi.hu/percee/>



The project is co-financed by the International Visegrad Fund <https://www.visegradfund.org/>

About the project

PERCEE – Prioritizing Energy Renovation in the CEE countries

- The project aims at implementing an ambitious EPBD by collecting **good policy examples** (measures, programs, program elements) of building renovation from the CEE region.
- The CEE region is not typically at the forefront of exemplary renovation policies and programs, still, some good practices are already in place, worth sharing and upscaling.
- The project aims to present good practices, be those on the **local, regional or national level**, and **make recommendations** for expanding or upscaling.
- Output: **four policy briefs on four major EPBD topics**, combined into one report.
- 2 online webinars where we showcase the results to a wider set of local, regional and EU stakeholders.

We have selected four main EPBD themes

Webinar #1 - April 9, 2025

- Financing of building renovations (Ch4B)
- Mitigating information barriers (B4F)

Webinar #2 – 12 June 2025

- Heating decarbonization (MEHI)
- Whole-life carbon requirements (PLGBC)

Agenda

- 13:00 - 13:10 Introduction of the project
- 13:10 - 13:25 Heating Decarbonization, overview (MEHI, Hungary)
- 13:25 - 13:40 Heating Decarbonization - Experiences from other CEE Countries
- 13:40 - 14:00 Discussion
- 14:00 - 14:15 Life-Cycle GWP of Buildings – Examples from leading European countries (PLGBC, Poland)
- 14:15 - 14:30 Life-Cycle GWP of Buildings - Experiences from other CEE Countries
- 14:30 - 14:45 Discussion
- 14:45 - 15:00 Q&A and closing

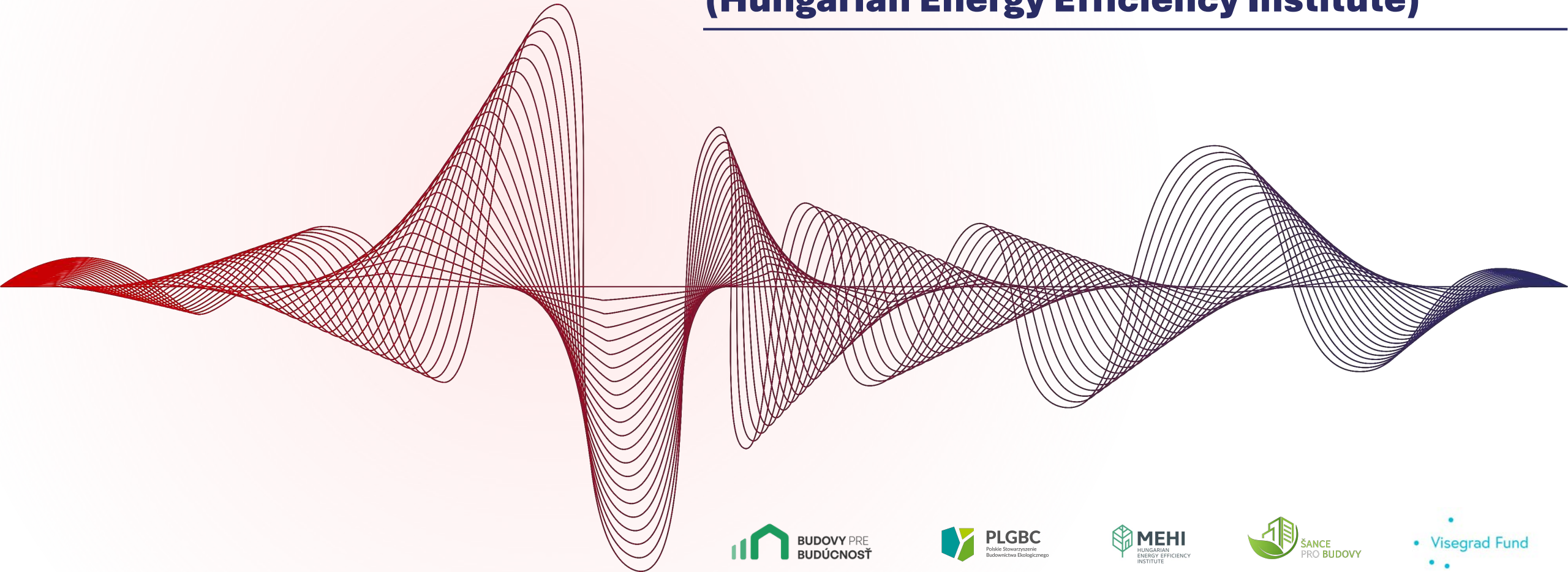
Speakers: Adrienn Tóth (MEHI), Gabriella Szalai (Daikin Hungary), Zsuzsanna Szalay (Budapest University of Technology and Economics), Dorota Bartosz (PLGBC), Anna Jurczak (PLGBC), Juraj Melichar (CEE Bankwatch), Kristína Korčeková (Slovak Environment Agency), Petr Zahradník (Ch4B), Anikó Pálffy (MEHI),



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Heating decarbonisation in the V4 countries

Adrienn Tóth
(Hungarian Energy Efficiency Institute)



Policy context

Energy Efficiency Directive:

- Promotes energy savings through improved energy efficiency
- Sets a binding EU target to reduce final energy consumption by 11.7% by 2030 compared to projected levels, and to achieve verified energy savings

Energy Performance of Buildings Directive:

- All new buildings should be zero-emission buildings by 2030, broadening to all buildings by 2050
- All fossil fuel boilers have to be phased out by 2040
- No national subsidies for standalone fossil fuel boilers after 2025
- Minimum energy performance standards for buildings, addressing the worst performing buildings first

Policy context

Renewable Energy Directive:

- Binding EU-level target: to reach 49% renewable energy in heating & cooling by 2030
- Binding MS-level targets:
 - Yearly increase of renewables share in H&C
 - Increase renewables in DH systems

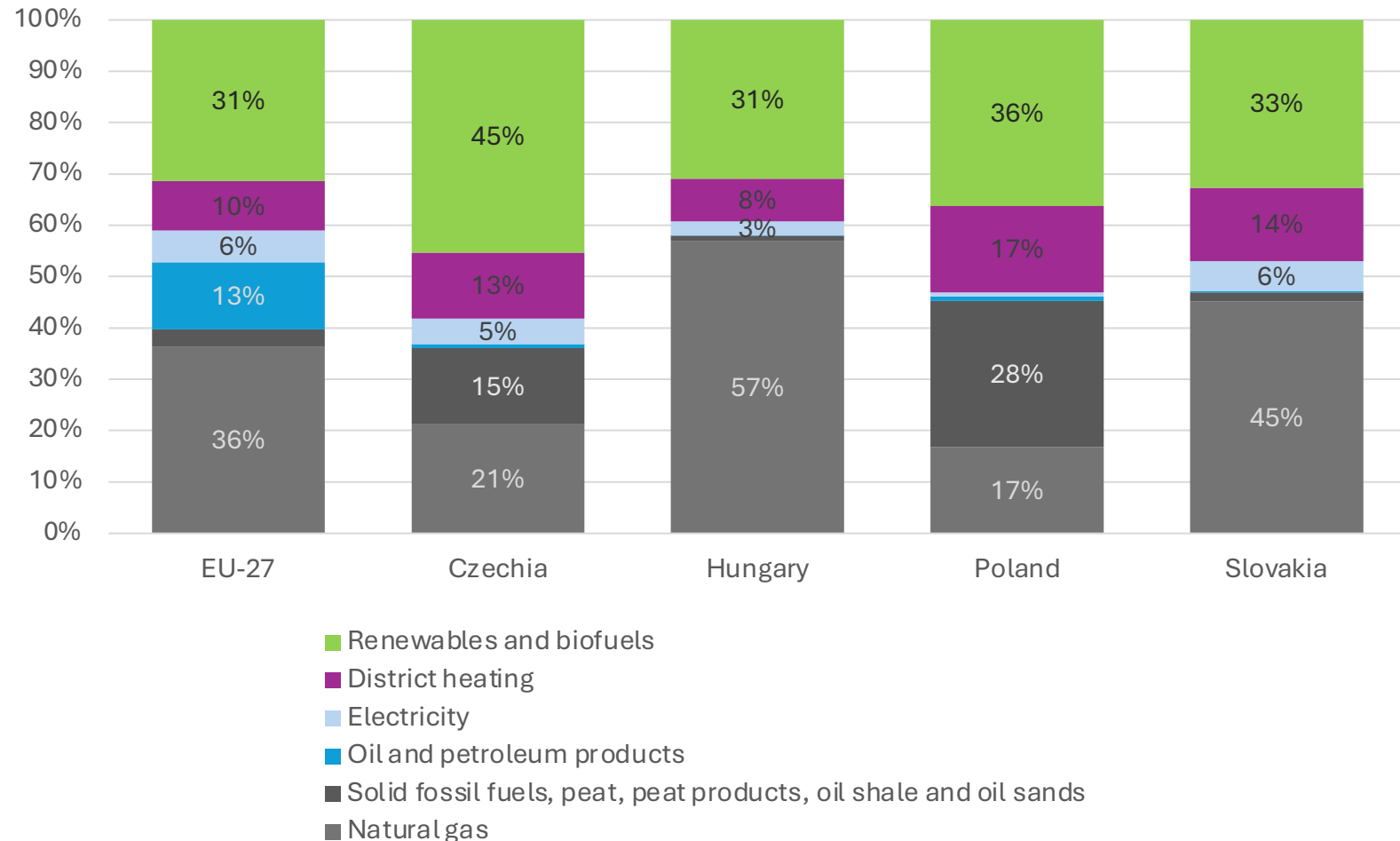
The new emissions trading system (ETS2) will address CO2 emissions from fuel combustion in buildings & road transport

Social Climate Fund (SCF): From 2026 to 2032, the SCF will allocate €86.7 billion to compensate vulnerable households for extra burden and ensure that energy renovations and clean heating are affordable for them. The SCF will pool revenues from the EU ETS, ETS2 and national contributions.

Regional energy landscape in heating

- **High fossil fuel dependency and aging, inefficient infrastructure**
- **Hungary & Slovakia** rely mainly on **natural gas**
- **Czechia & Poland**: lower gas use, but high share of **solid fossil fuels**
- **District heating** in the V4 is heavily **reliant on fossil fuels**: coal + gas account for (2021):
 - 60% in Slovakia,
 - 68% in Czechia,
 - 69% in Hungary,
 - 90% in Poland

FUEL MIX OF HOUSEHOLD SPACE HEATING IN THE V4, 2022



Source: Eurostat

Alternatives to fossil fuel heating

Individual level

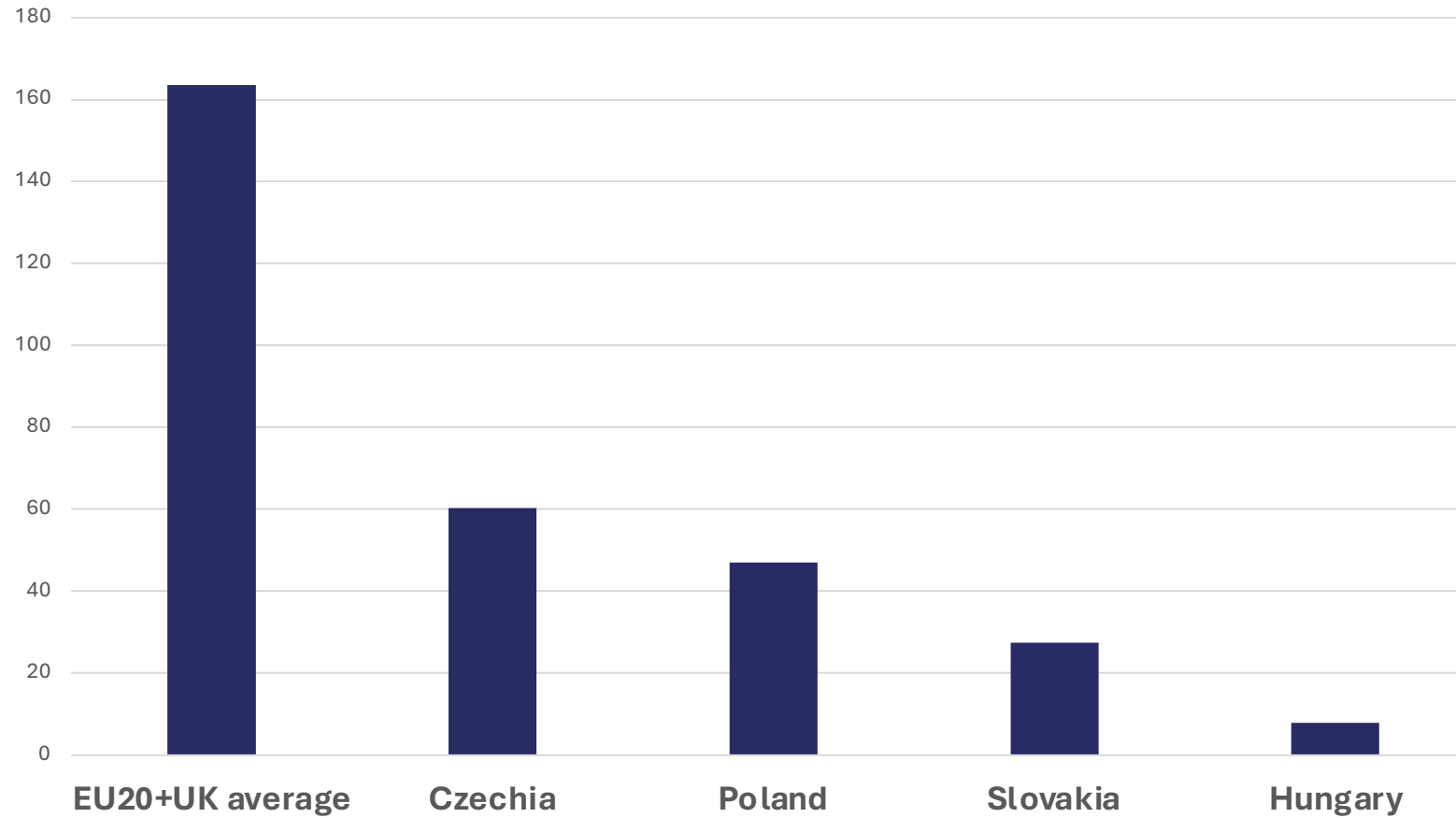
- Electrification through **heat pumps**
- In some cases, sustainable **biomass** boilers
- Energy efficiency improvements (insulation, doors and windows upgrade)

District heating level

- Shift to **renewable sources** (biomass, solar thermal, geothermal)
- Use of **waste heat** from industry, data centers, etc.
- Integration of **large-scale heat pumps**

Heat pump penetration in the region

Heat pump units stock per 1000 households, 2023

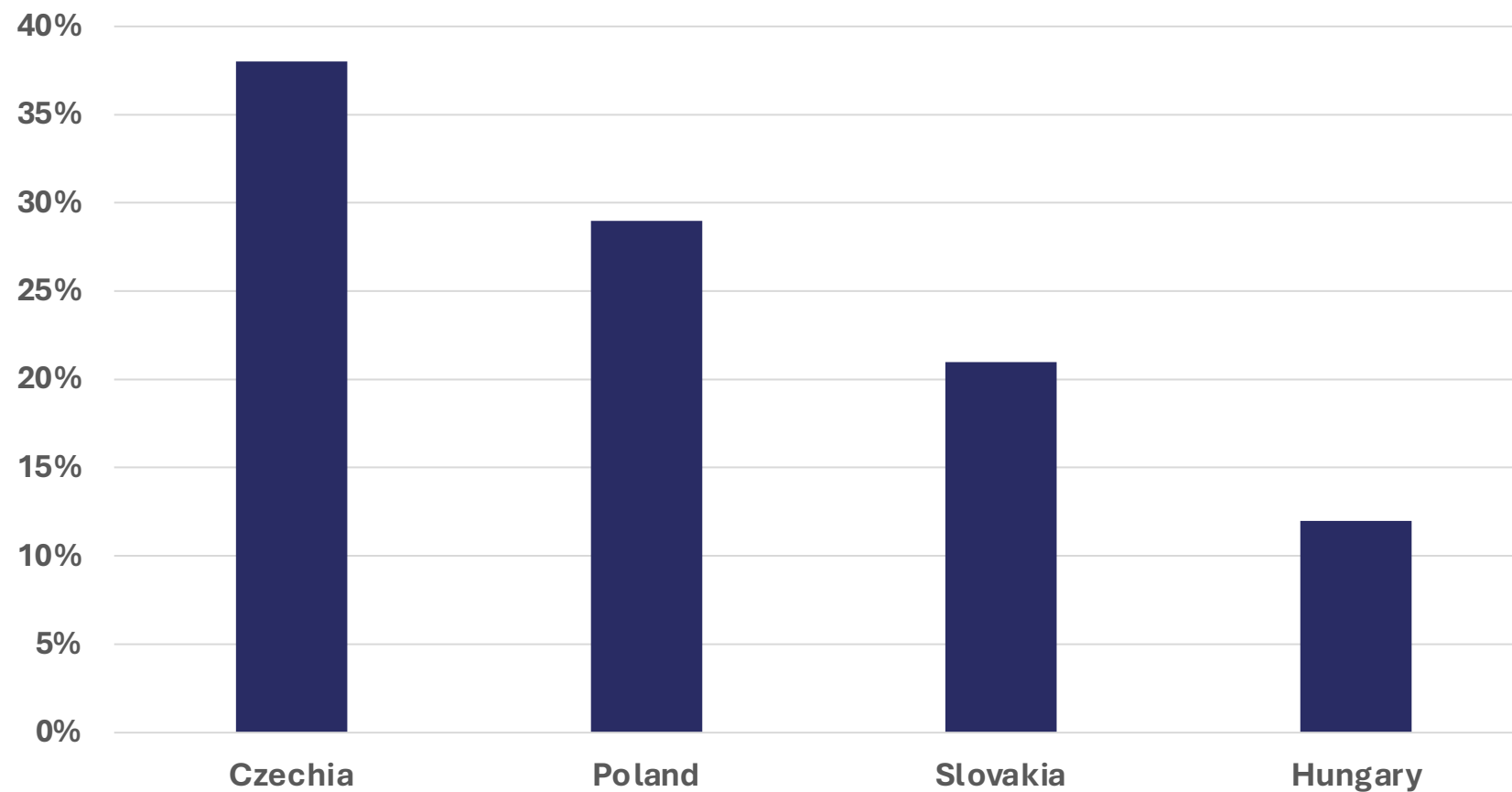


EU20: EU without BG, RO, HR, GR, SI, CY, MT and LU

Source: EHPA

Heat pump penetration in the region

Heat pump market shares, in % of combined sales of gas boilers and heat pumps, 2023



Source: EHPA

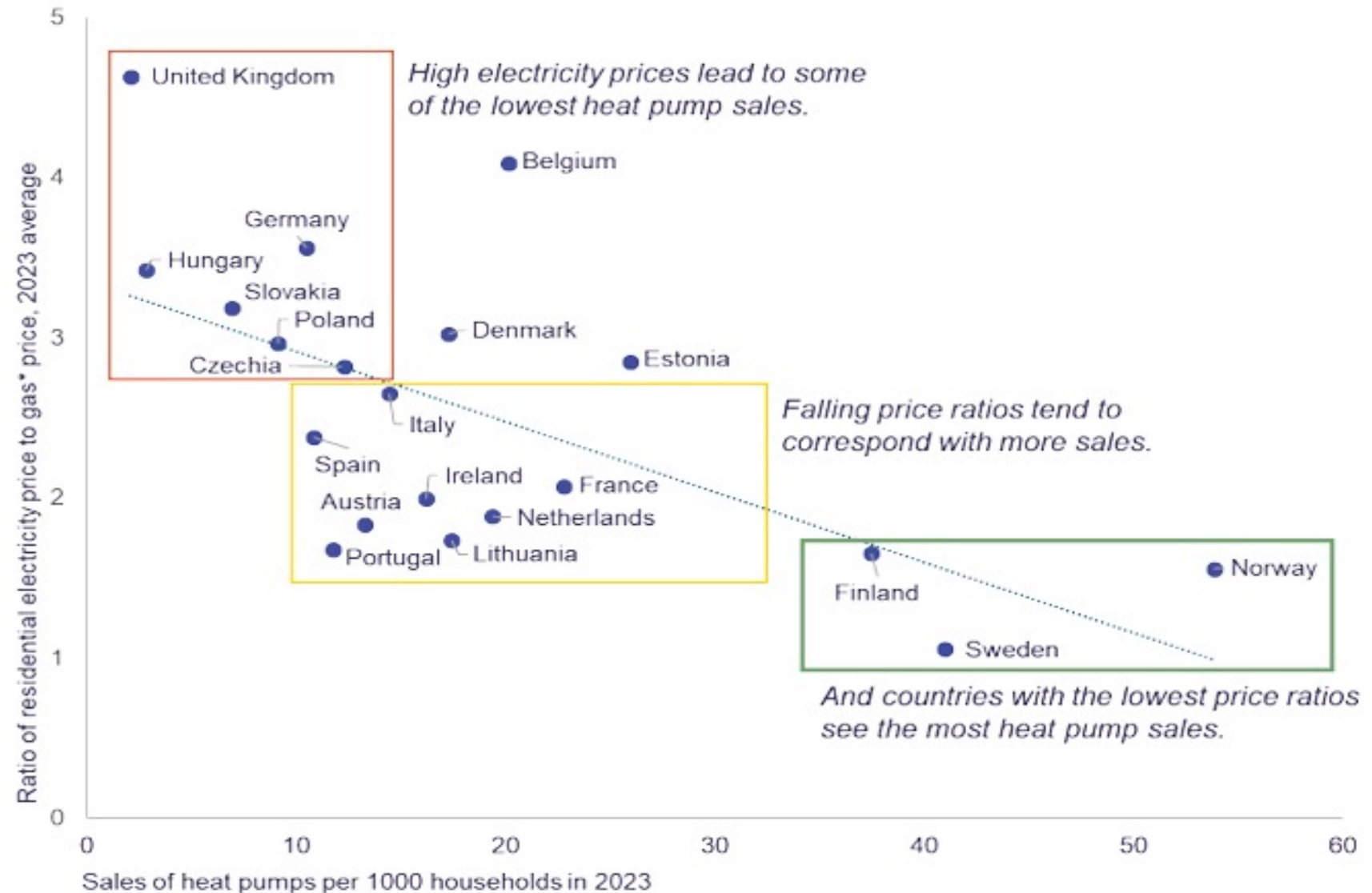
Barriers to heat pump deployment – financial barriers

- High electricity-to-gas price ratio leads to relatively high operating costs.
- High upfront costs: equivalent to 6 monthly salaries in Slovakia and Hungary, 4 in Czechia, and 3 in Poland.



Long payback period

Source: EHPA



Other barriers to heat pump deployment

- Low awareness and public trust in the new technology
- Shortage of skilled workers
- Technical challenges: for old buildings, significant renovations are necessary for a heat pump to operate efficiently
- Inconsistent and/or insufficient policy support

Discounted Electricity Tariff for Heat Pumps ("H Tariff") in Hungary

- For **households** using **heat pumps or split ACs**
- Seasonal tariff: **Oct 15 – Apr 15** (nationwide since 2010)
- Requires **SCOP ≥ 3.4**

Energy prices in Hungary:

Consumer Type	Gas Price	Electricity Price
≤ average consumption	~ 2,5 eurocent/kWh	~ 9 eurocent/kWh
> average consumption	~19 eurocent/kWh	~ 17 eurocent/kWh
H Tariff (heat pumps)	—	~ 6 eurocent/kWh

- In the case of **SCOP ≥ 3.4**
 - Final heating cost: **~1,7 eurocent/kWh**
 - **Cheaper than subsidized gas**

Obstacles

- Extra cost for dedicated meter installation
- Bureaucratic application process

The Szeged Geothermal Project for DH

Project overview

- Largest geothermal DH system in the EU (launched in 2023)
- Supplies heat to **28,000 homes** and **400 public buildings**
- Replaces fossil-based DH with **deep geothermal energy**
- Hybrid system: **geothermal + natural gas (backup)**

Key facts

- Water temperature: **85–90°C** from **~2,000 m depth**
- Cuts gas use by **50%**
- Improves **urban air quality** (↓PM, ↓NO_x)

Replication potential

- Model for other Hungarian cities (e.g. **Győr, Békéscsaba**)
- Shows that geothermal DH is **viable, scalable & fundable**

Financing

- A combination of **public and private** sources
- Total cost: **€70 million, €23 million EU grant** from the Cohesion Fund
- Long-term heat purchase contracts = investment security

Success Factors

- Favourable **geology**
- Strong **municipal leadership**
- Supportive **policy & regulation** (NECP, KEHOP, **permit reform**)



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Thank you!

The project is co-financed by the governments of Czechia, Hungary, Poland and Slovakia through Visegrad Grants from the International Visegrad Fund (<https://www.visegradfund.org/>).



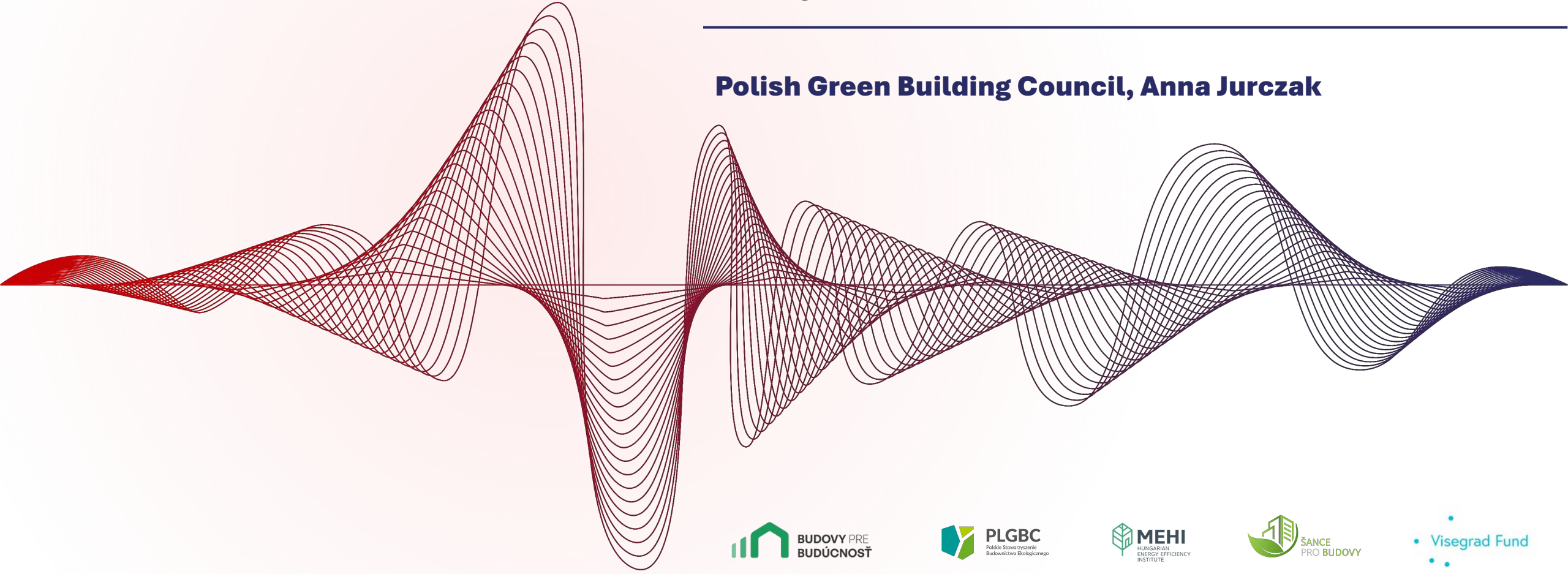


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Poland

Heating Decarbonization

Polish Green Building Council, Anna Jurczak



Heating decarbonization - Poland

Strategy for district heating until 2030 with an outlook to 2040

- under development by the Ministry of Climate and Environment,
- main goals by 2030:
 - 85% efficient district heating systems,
 - increase the share of RES in the sector to 28.4%,
 - reduce GHG emissions – e.g. decrease CO₂ emissions by 34% compared to 2019,
 - eliminate solid fossil fuels from individual heating,
 - increase the role of cogeneration (5.1 GWe of new capacity),
 - connect 1.5 million households to the district heating network,
 - develop new service delivery models and new tariff principles,
 - implement new technologies - lowering carrier temperature, network cooling, thermal waste conversion; heat storage, decarbonized gases, heat pumps.

Heating decarbonization - Poland

Implementation of national heating decarbonization plans and strategies at local level.

Municipality of Gliwice

- City Development Strategy “Gliwice 2040” adopted in 2022
- decarbonization activities related to the production and distribution of heat within the city are included, aimed at safe and non-polluting energy production from waste, as well as the use of municipal wastewater energy

Heating decarbonization - Poland

Municipality of Gliwice

Projects implemented within the strategy:

- Green Energy Park (Park Zielonej Energii):
 - Steam grate boiler (25 t/h steam, 420 °C, 40 bar) burning municipal waste, pre-RDF, sewage sludge and solid waste.
 - The unit will be equipped with additional installations: a two-stage flue gas condensation heat recovery installation, which will enable additional heat extraction from flue gases, a short-term heat storage facility, and a heat pump installation enabling further cooling of flue gases and heat recovery from them.
 - Industrial construction of a multi-format solar field producing heat for the needs of Gliwice residents.

Heating decarbonization - Poland

- Green Energy Park (Park Zielonej Energii):
 - Construction of a photovoltaic farm with the installation of a battery for electricity.
 - Construction of an installation for the recovery of heat contained in municipal wastewater, together with accompanying infrastructure, is planned at the wastewater treatment plant in Gliwice. The project involves the installation of heat pumps that will be powered by the heat generated during the treatment of municipal wastewater. All recovered heat will be directed to the city's district heating network.
 - The chimney is to serve as an observation tower (50 m with an elevator), the highest point in Gliwice.
 - In addition, educational paths and an environmental awareness center will create social and educational access.

Heating decarbonization - Poland

- Green Energy Park (Park Zielonej Energii):

Environmental and economic benefits:

- Reduction in CO₂ and dust emissions, saving ~30,000 t of coal/year
- Reduction in weight of landfilled waste by ~28,000 t/year.
- Stopping the increase in heat prices (~15% increase by stabilization, among other things)
- Lower waste management costs - saving ~ PLN 1.5 million per year

Heating decarbonization - Poland

- Green Energy Park (Park Zielonej Energii):

The investment plan has been structured to achieve the status of an Efficient District Heating System, and the total CO₂ reduction as a result of ongoing investments and intentions is expected to result in a 70% reduction in CO₂ emissions compared to 2022.

The 2040 strategy of Gliwice in the area of heat supply received the Energy Transformation Leader Award at the 2024 Climate Congress in Warsaw. It is also nominated in the competition for the Green Product Award 2025, which will be announced during the international congress LET'S TALK ABOUT IT on November 6, 2025.

<https://parkzielonejenergii.pl/>

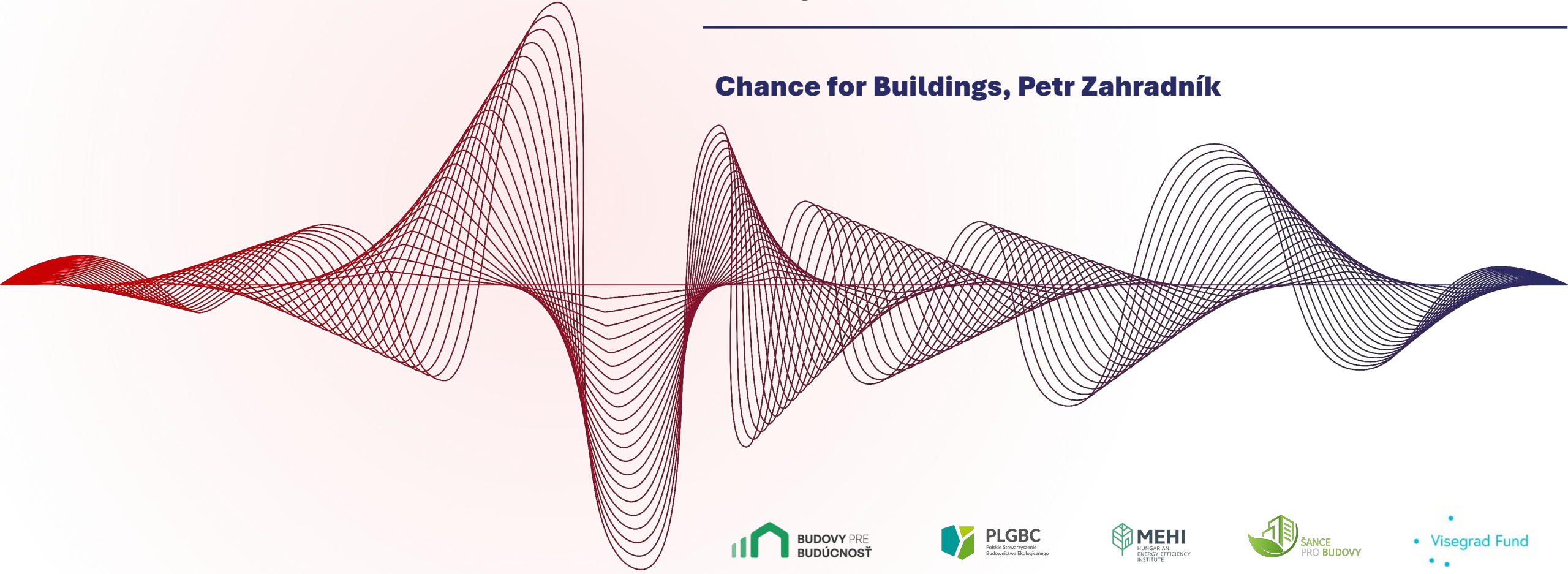


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Czechia

Heating Decarbonization

Chance for Buildings, Petr Zahradník



Czechia's Strategy for Heating Decarbonization

Key Goals

Phase-out of coal by 2033; oil and gas by 2050

→ The Czech government plans a full transition away from fossil fuels in heating, starting with coal, then oil and natural gas.

Compliance with EU directives (EED, EPBD4, RES3, EU ETS)

→ National legislation aligns with key EU energy and climate directives to support emissions reduction and efficiency.

Main Instruments

Regulations: Emissions limits and fossil fuel bans

→ Based mostly on EU directives.

Financial incentives: Subsidies for households and municipalities

→ Robust funding programs aim to reduce upfront costs and encourage investments in sustainable heating.

Major Programs

New Green Savings Program: Up to 50% subsidy for renewables

→ The program supports households in installing heat pumps, biomass boilers, solar systems with direct financial subsidy.

Operational Program Environment: Focus on public buildings and centralized systems

→ Funding is directed to schools, hospitals, and similar buildings for heat recovery, efficient distribution, and renewable energy upgrades.

Technologies & Projects Driving the Transition

Supported Technologies

Heat pumps (air, ground-source)

→ A variety of heat pumps are eligible for support, contributing to widespread electrification of heating.

Biomass heating (wood chips, CHP units)

→ Biomass-based systems, including combined heat and power (CHP), offer a viable alternative to coal.

Geothermal energy (pilot in Prague)

→ The capital is testing geothermal sources such as metro tunnels and rivers to supply urban heat.

Waste heat recovery (from wastewater, data centres)

→ Untapped heat from industrial and urban sources is being redirected into district heating systems.

Flagship Projects

Brno: €75M EIB loan for biomass CHP and modernized grid

→ Brno is investing in a cleaner district heating system that combines biomass with new distribution infrastructure.

Prague: Heat recovery and geothermal studies underway

→ The city's "heat detox" efforts include using waste heat and reducing reliance on coal-based plants.

Hradec Králové: Carbon-neutral residential energy community

→ A new neighbourhood development uses photovoltaics, heat pumps, and smart controls to achieve near-zero emissions.

Decarbonizing District Heating

Progress & Impact

10+ plants switched from coal: 600,000 tons of CO₂ saved yearly

→ Recent conversions have significantly reduced emissions and improved air quality in many regions.

110,000+ households already benefit from cleaner heat

→ Residents are experiencing lower-carbon heating through district systems now powered by renewables.

By 2040, one-third of heat could come from large heat pumps

→ Modeling suggests a major role for low-temperature sources like rivers and wastewater if investments continue.

Investment Needs

>200 billion CZK needed to fully replace coal in district heating

→ This includes fuel switching, infrastructure modernization, and network integration.

52 billion CZK required for large heat pump systems by 2040

→ Of this, 14 billion CZK is expected to be invested before 2030 to meet interim targets.

Local Innovations

Mělník: Transitioning to gas, biomass, and modern technologies

→ As Czechia's largest district heating source, the Mělník site is being transformed to cut emissions by 2030 (from coal).

Dětmarovice: New biomass-gas plant to replace coal

→ The upgraded plant will secure long-term heating for nearby cities while reducing environmental impact.

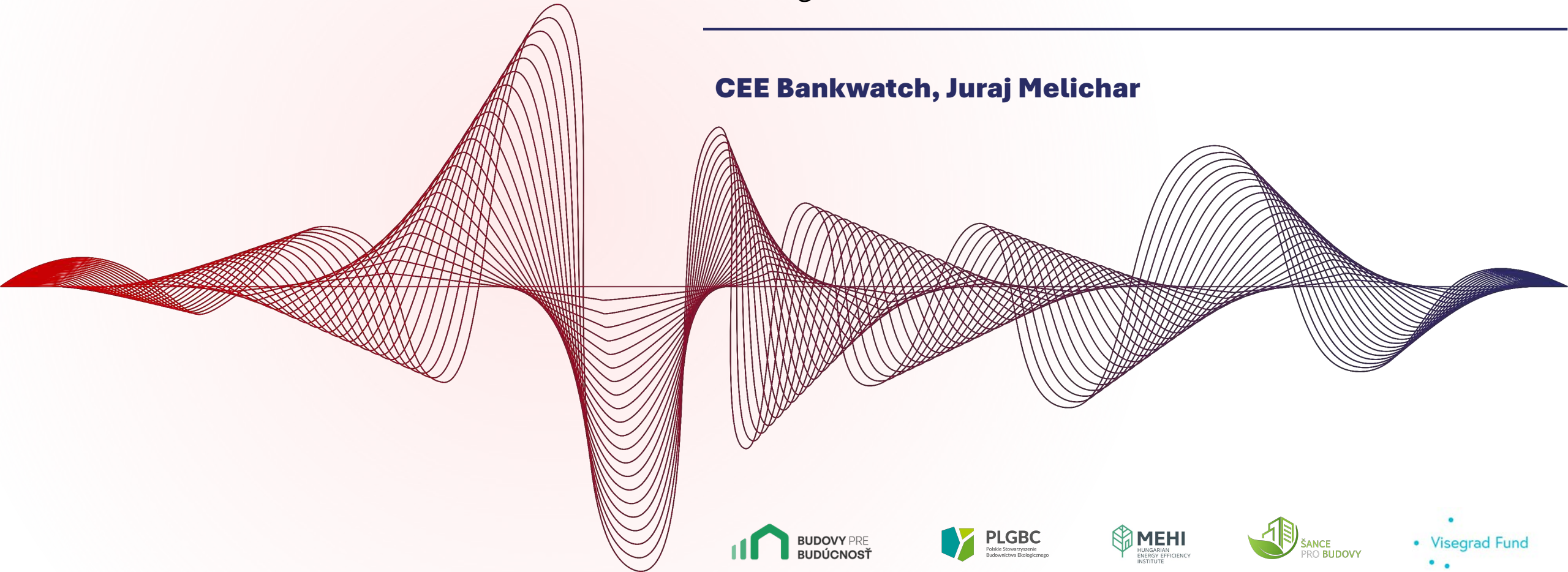


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Slovakia

Heating Decarbonization

CEE Bankwatch, Juraj Melichar

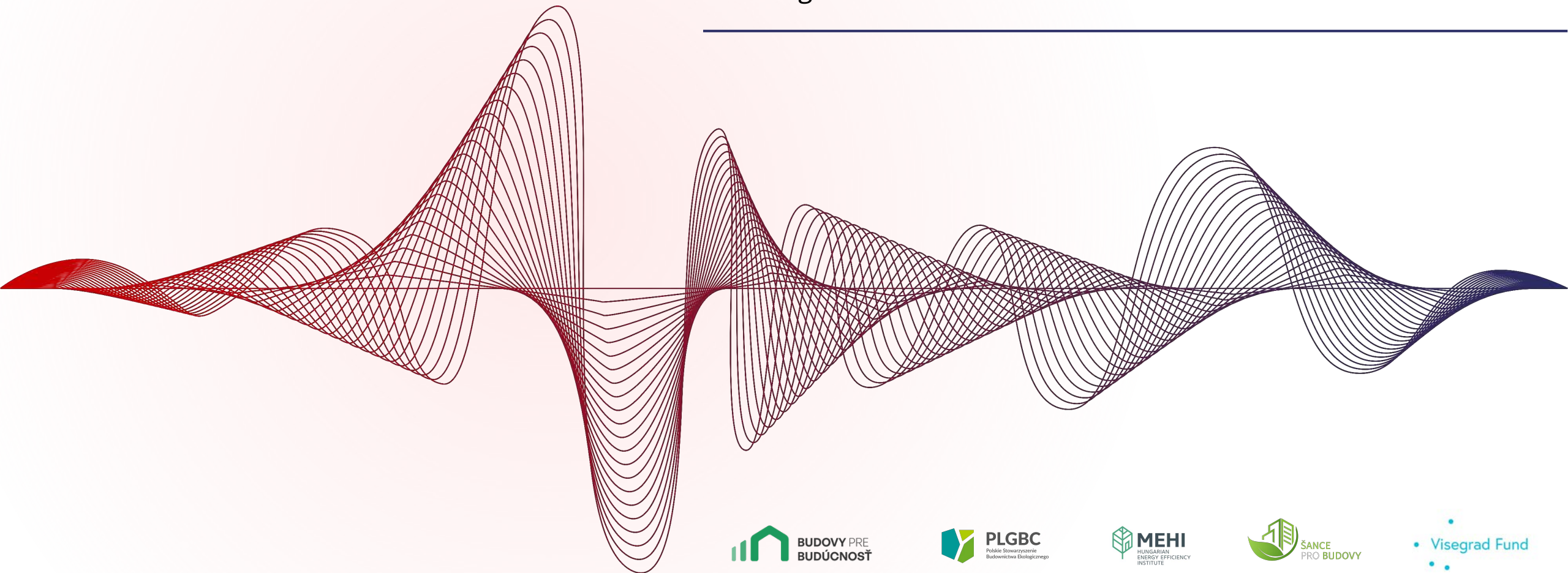




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Q&A

Heating Decarbonization



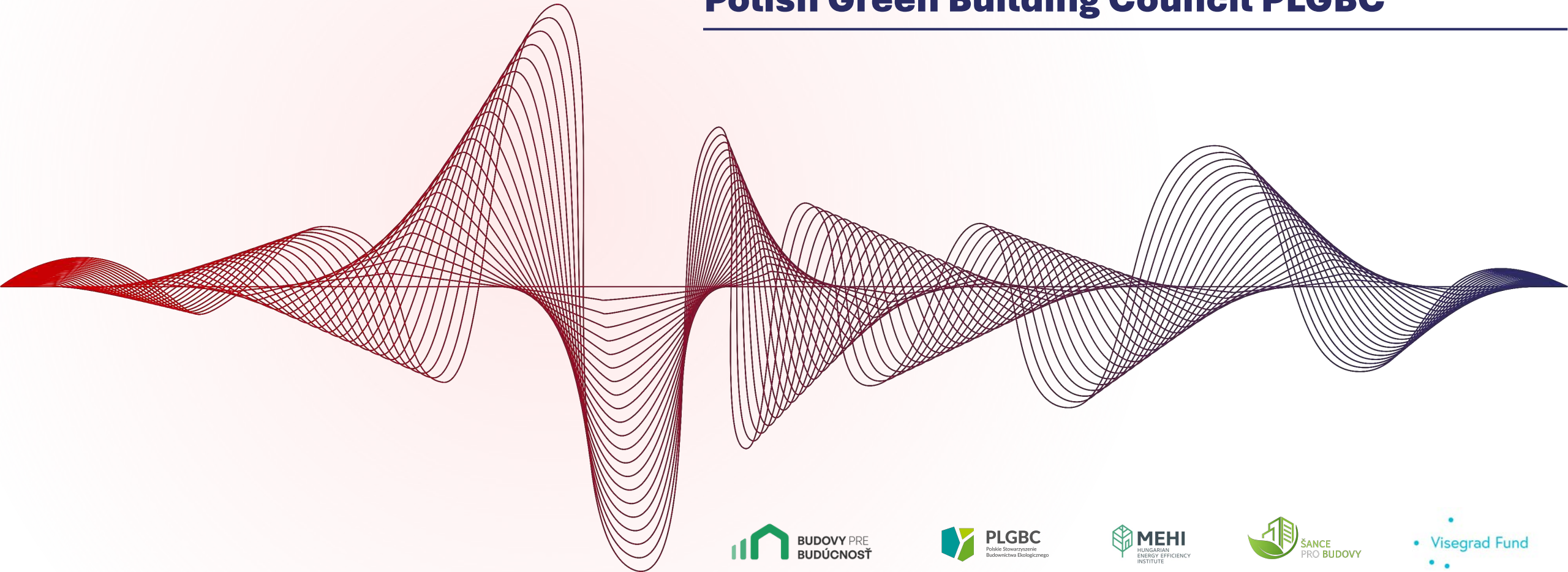


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Life-cycle GWP of buildings

Dorota Bartosz, PhD

Polish Green Building Council PLGBC



TOWARDS CARBON-NEUTRAL BUILDINGS

EPBD

Member States shall ensure that the life-cycle GWP is calculated in accordance with Annex III and disclosed in the energy performance certificate of the building:

- **from 1 January 2028, for all new buildings with a useful floor area larger than 1 000 m²**
- **from 1 January 2030, for all new buildings.**
- For the calculation of the life-cycle GWP of new buildings pursuant to Article 7(2), the total life-cycle GWP is communicated as a numeric indicator for each life-cycle stage expressed as kgCO₂eq/(m²) (of useful floor area) calculated over a reference study period of 50 years.
- The data selection, scenario definition and calculations shall be carried out in accordance with EN 15978 (EN 15978:2011 Sustainability of construction works - Assessment of environmental performance of buildings. Calculation method
- The scope of building elements and technical equipment is as defined in the Level(s) common EU framework for indicator 1.2.
- Where a national calculation tool or method exists or is required for making disclosures or for obtaining building permits, that tool or method may be used to provide the required disclosure.
- Other calculation tools or methods may be used if they fulfil the minimum criteria established by the Level(s) common EU framework.

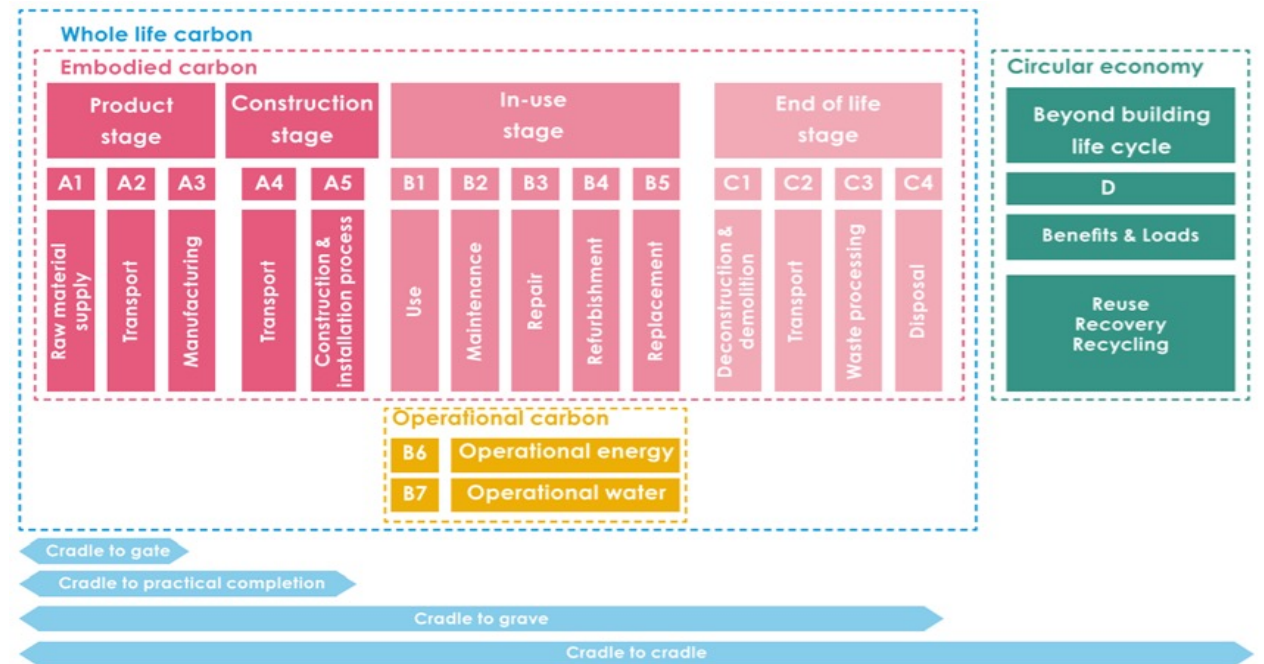
The Commission is empowered to adopt delegated acts in accordance with Article 32 to amend Annex III to set out a Union framework for the national calculation of life-cycle GWP with a view to achieving climate neutrality. The first such delegated act shall be adopted by 31 December 2025.

TOWARDS CARBON-NEUTRAL BUILDINGS

GWP - ESTIMATING THE CARBON FOOTPRINT OF BUILDINGS

The life-cycle GWP calculation process, including the selection of data and scenarios, must comply with EN 159784, which is performed using LCA analysis, according to which greenhouse gas emissions (GHG) are calculated for different phases of a building's life-cycle. There are mostly 17-18 phases divided into four main modules - A, B, C and D:

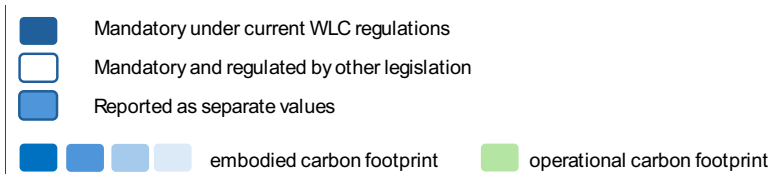
- Product and construction stage (A1-A5)
- In-use stage (B1-B7)
- End of life stage (C1-C4)
- Beyond building life-cycle (D, or sometimes D1-D2).



TOWARDS CARBON-NEUTRAL BUILDINGS EUROPEAN COUNTRIES

- In all countries, the regulations always apply to **new residential and office buildings**
- In the **scope of building elements that is take into account** across countries. Foundations, load-bearing structures, ceilings and facades are listed everywhere as major contributors to embodied carbon emissions and are required to be included in calculations in all countries. Internal installations can also produce high levels of GHG emissions and are often included as well.

		A					B							C				D
		Products			Construction process		Use stage							End of life				Beyond system boundary
Definition of floor area	Reference lifetime of the building	Raw materials	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy	Operational water	Demolition works	Transport	Water management	Final disposal	Reuse, recovery, recycling potential
m ²	yr	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D



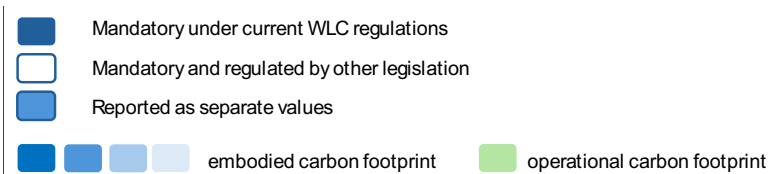
GFA - area of the building
¹ – usable area not including some parts of the building, e.g. ramps, garages
² – internal area of the building
³ – total usable area of the building, taking into account areas other than residential and office space

Denmark	GFA ¹	50	[Dark Blue Bar]							[Dark Blue Box]		[Dark Blue Box]					[Dark Blue Box]	[Dark Blue Box]	
Finland	NHA	50	[Dark Blue Bar]							[Dark Blue Box]				[Dark Blue Box]	[Dark Blue Box]	[Dark Blue Box]	[Dark Blue Box]	[Dark Blue Box]	
France	LA/UA	50	[Dark Blue Bar]											[Light Blue Box]	[Dark Blue Box]	[Dark Blue Box]	[Dark Blue Box]		
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Sweden	GFA ³	-	[Dark Blue Bar]										[Light Blue Box]						

TOWARDS CARBON-NEUTRAL BUILDINGS EUROPEAN COUNTRIES

- **The building area** used as the reference unit for calculating emissions per m² is determined based on different ranges. The most common is gross floor area (GFA), while Finland and France use heated or net habitable floor area, excluding dimensions of wall thickness and parts of the building maintained at outdoor temperature. However, GFA is also not calculated in the same way in other countries

		A					B							C				D
		Products			Construction process		Use stage							End of life				Beyond system boundary
Definition of floor area	Reference lifetime of the building	Raw materials	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy	Operational water	Demolition works	Transport	Water management	Final disposal	Reuse, recovery, recycling potential
m ²	yr	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D



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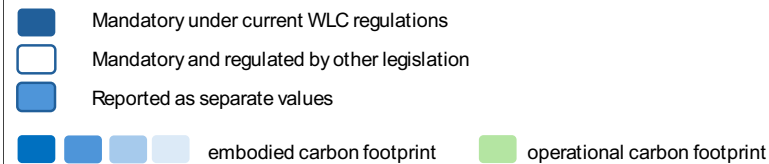
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Sweden	GFA ³	-	[Dark Blue Bar]										[Light Blue Box]					

TOWARDS CARBON-NEUTRAL BUILDINGS EUROPEAN COUNTRIES

- **Databases of emission factors for construction products and processes vary.** They contain impact factors for all materials for which environmental product declarations (EPDs) are not used. The use of product-specific data increases the accuracy of calculations and also encourages the selection of materials with relatively low carbon footprints. In France and Sweden, the use of product-specific data is supported by a factor that corrects default average values.

		A					B						C				D	
		Products			Construction process		Use stage						End of life				Beyond system boundary	
Definition of floor area	Reference lifetime of the building	Raw materials	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy	Operational water	Demolition works	Transport	Water management	Final disposal	Reuse, recovery, recycling potential
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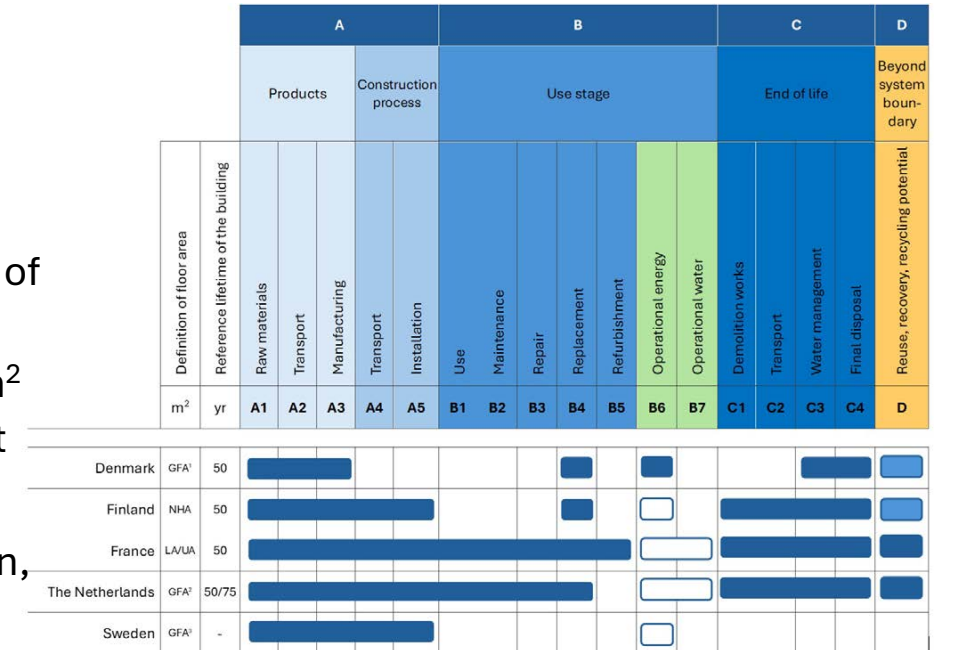
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TOWARDS CARBON-NEUTRAL BUILDINGS

EUROPEAN COUNTRIES - DENMARK

- The regulations are in the form of a supplementary act to the building regulations and came into effect in January 2023
- A new Danish regulation on mandatory calculation of the climate impact of new buildings applies to all types of buildings that are covered by the existing energy consumption regulation. However, buildings over 1,000 m² must meet the limits. For buildings less than 1,000 m², calculations must still be made, but they do not have to meet the limits.
- **Life-cycle range:** A1-A3, B4, B6, C3, C4, D (D is mandatory for calculation, but is not included in the total, which is compared with the limits)
- Since its entry into force, the limit is 12 kgCO₂/m²/year



Mandatory under current WLC regulations
 Mandatory and regulated by other legislation
 Reported as separate values
 embodied carbon footprint operational carbon footprint

GFA - area of the building

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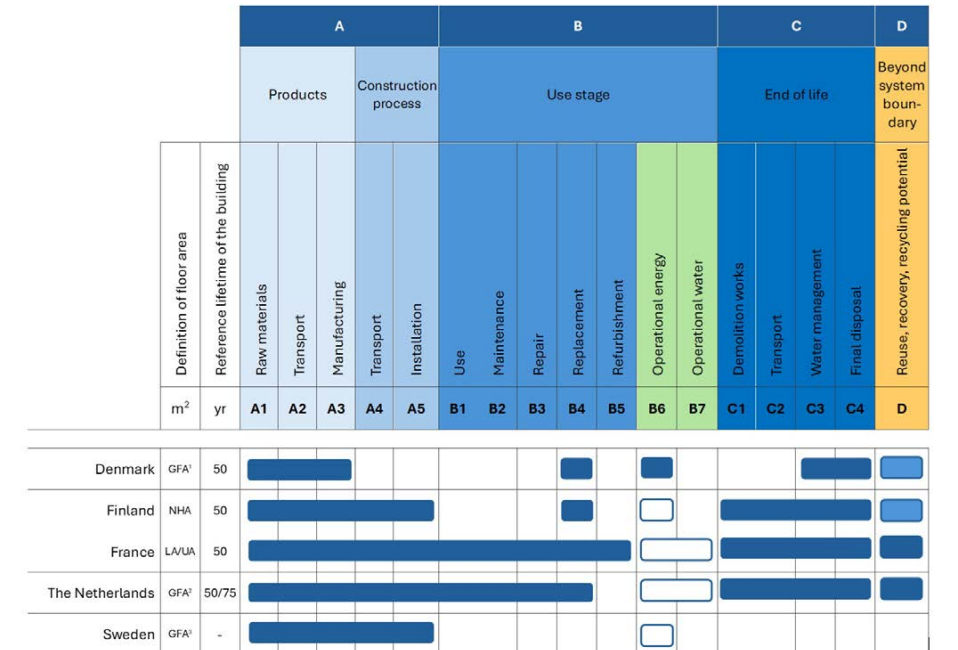
³ – total usable area of the building, taking into account areas other than residential and office space

TOWARDS CARBON-NEUTRAL BUILDINGS EUROPEAN COUNTRIES - DENMARK

■ New limits

Kg CO ₂ e/m ² /year	2025	2027	2029
Average limit value	7.1	6.4	5.8
Holiday homes under 150 m ²	4.0	3.6	3.2
Single-family houses, row houses, tiny houses, and holiday homes at least 150 m ² *	6.7	6.0	5.4
Apartment buildings	7.5	6.8	6.1
Office buildings	7.5	6.8	6.1
Institutions (e.g., schools)	8.0	7.2	6.4
Other new constructions	8.0	7.2	6.4
Independent limit value for the construction process	1.5	1.3	1.1
Total limit including construction process	8.6	7.7	6.9

*The 150 m² limit only accounts for holiday homes



Mandatory under current WLC regulations
 Mandatory and regulated by other legislation
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 embodied carbon footprint operational carbon footprint

GFA - area of the building

¹ - usable area not including some parts of the building, e.g. ramps, garages

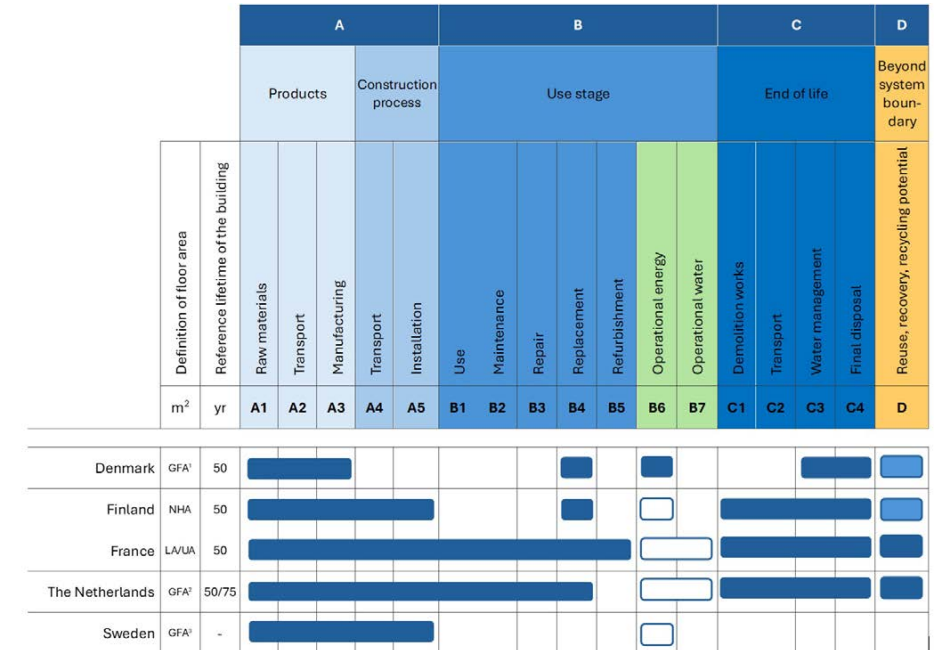
² - internal area of the building

³ - total usable area of the building, taking into account areas other than residential and office space

TOWARDS CARBON-NEUTRAL BUILDINGS

EUROPEAN COUNTRIES - FRANCE

- RE2020 is a national law that applies directly to new buildings and those designing and developing existing projects. It was adopted in 2021 and has been in effect since January 2022
- Life-cycle range: A-D**
- RE2020 sets mandatory GHG emission limits by operational carbon (OC) and embodied carbon (EC).
 - OC values for benchmarks and building performance are expressed in kWh/m²/year and kgCO₂eq/m².
 - EC values for benchmarks and building performance are expressed in kgCO₂eq/m².



Mandatory under current WLC regulations
 Mandatory and regulated by other legislation
 Reported as separate values
 embodied carbon footprint operational carbon footprint

GFA - area of the building

¹ – usable area not including some parts of the building, e.g. ramps, garages

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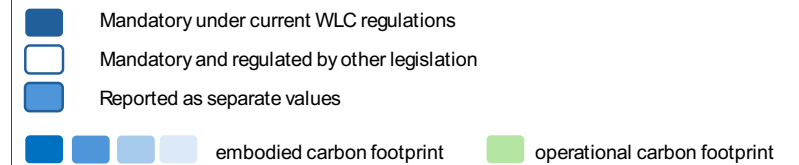
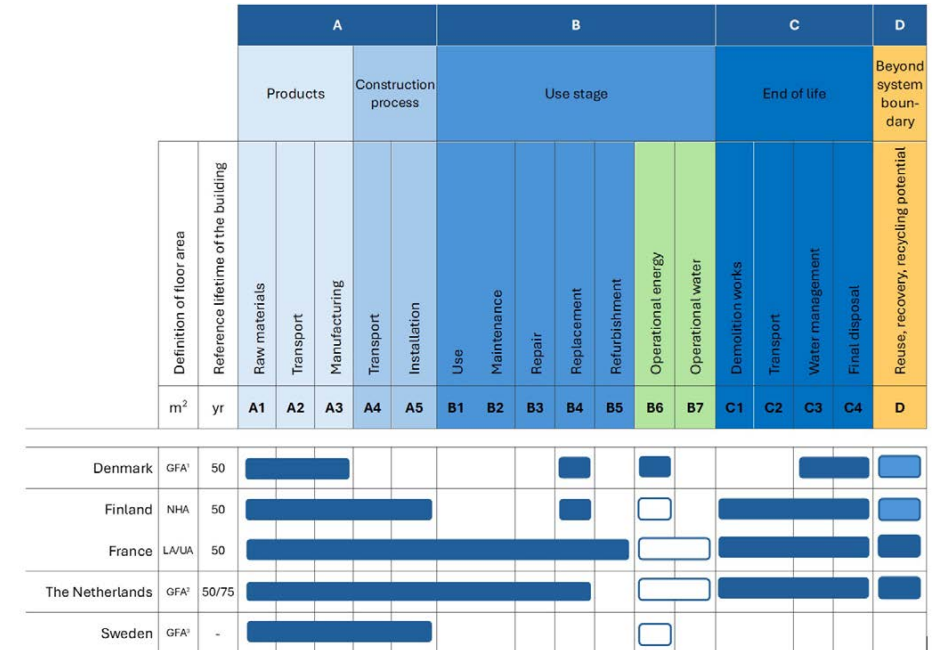
³ – total usable area of the building, taking into account areas other than residential and office space

TOWARDS CARBON-NEUTRAL BUILDINGS

EUROPEAN COUNTRIES - FRANCE

Limit values	Single-family residential buildings	Multi-family residential buildings
2022-2024 r.	640 kg CO ₂ /m ²	740 kg CO ₂ /m ²
2025-2027 r.	530 kg CO ₂ /m ²	650 kg CO ₂ /m ²
2028-2030 r.	475 kg CO ₂ /m ²	580 kg CO ₂ /m ²
From 2031 r.	415 kg CO ₂ /m ²	490 kg CO ₂ /m ²

Limit values	Single-family residential buildings	Multi-family residential buildings
2022-2024 r.	160 kg CO ₂ /m ²	560 kg CO ₂ /m ²
2025-2027 r.	160 kg CO ₂ /m ²	320 kg CO ₂ /m ²
From 2028 r.	160 kg CO ₂ /m ²	260 kg CO ₂ /m ²

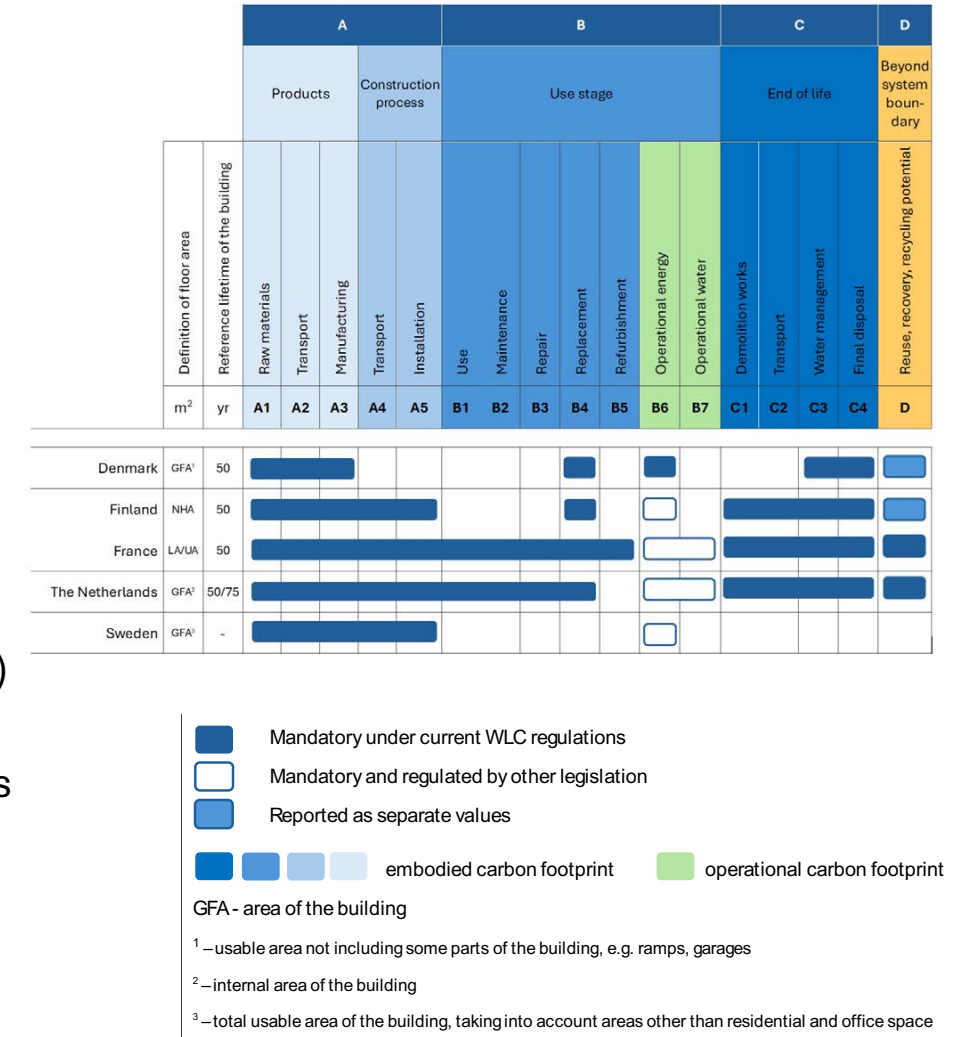


GFA - area of the building
¹ – usable area not including some parts of the building, e.g. ramps, garages
² – internal area of the building
³ – total usable area of the building, taking into account areas other than residential and office space

TOWARDS CARBON-NEUTRAL BUILDINGS

EUROPEAN COUNTRIES - SWEDEN

- **Life-cycle range:** A1-3, A4-5, in accordance with EN15978:2011
- Extension of the introduction to the analysis of the other phases most likely from 2027.
- **Sources of environmental data:** a database of EPDs and general data is available from the Boverket. Values are set about 25% higher than the average value calculated for the product group to discourage the use of default values.
- **LCA calculation tool:** the Swedish Environmental Protection Agency (IVL) has developed a calculation tool with which LCAs can be submitted directly to the Boverket. However, the tool is not mandatory, so other tools or forms can be used.
- **Reporting indicator:** kg CO₂/m²/year.



TOWARDS CARBON-NEUTRAL BUILDINGS POLAND

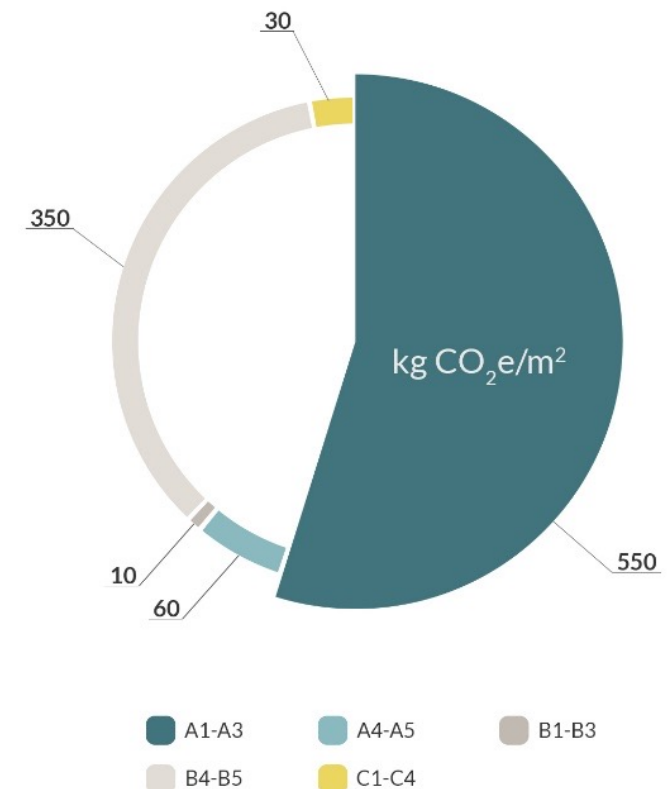
- **#BuildingLife** initiative is an international project focused on decarbonization of the built environment through development of national decarbonization roadmaps and implementation of actions by the industry and governments across the EU countries.
- Under the project PLGBC has developed a **methodology to estimate carbon footprint of buildings**, published as [“Estimating the carbon footprint of buildings. Whole Life Carbon Roadmap for Poland 2050”](#).
- It consists of two approaches – simplified method (recommended as a starting point for Poland) and full method.



TOWARDS CARBON-NEUTRAL BUILDINGS

the results for the various life cycle stages determined for a typical building with an embodied carbon footprint of 900 kgCO₂e/m²

- The largest share of the building's embodied carbon is accounted for by the modules related to the product stages **A1-A3**. Their share usually **exceeds 50%**.
- The modules that make up the construction stage **A4 and A5**, on average contribute **no more than 5% of the embodied carbon**, of which road transport of materials within the country accounts for about 1%. For sites requiring very extensive earthworks and temporary works, the values set for the A5 module will be higher.
- It can be assumed that in typical buildings, **the upfront carbon (modules A1-A5) represents around 60% of the embodied carbon**. This value will be lower for buildings of lightweight construction, where a larger share will be represented by elements to be replaced over the considered lifetime of the building, such as finishes and equipment, fixtures and fittings or the facade.
- For modules **B1-B3**, related to use, maintenance and repair, there are not many data and studies, but their **contribution to the whole building** is mostly estimated at 0.5-1%. Modules B1-B3 in the building life cycle have the largest share within the building installations group, due to leakage of refrigerants from the installations and maintenance or repair of equipment.
- Modules **B4 and B5**, i.e. replacement and refurbishment, account for a **large share of the embodied carbon**, as much as **35-40%**. In practice, module B5 can be considered the same as B4.
- The end-of-life stage of the building, i.e. modules **C1- C4**, mostly contributes to the embodied carbon footprint at half the values specified for modules associated with the construction phase (A4-A5). This means that, in typical buildings, their total contribution can be taken as **2%**.



TOWARDS CARBON-NEUTRAL BUILDINGS

POLAND

SIMPLIFIED METHOD

takes into account

A1-A3

responsible for emissions
embedded in the product
phase

and

operational emissions (B6)
converted to CO₂e.

- It takes into account phases A1-A3 which represent embodied emissions in the product phase and phase B6 - operational emissions in use phase.
- The product phase, which is represented by modules A1- A3 in LCA, is the most significant contributor to a building's life-cycle's emissions and typically exceeds 50% of the embodied carbon footprint, so correctly estimating values for this phase is crucial to the accuracy of the results. The calculation of the emissions for these phases is very simple and comes down to summing the emissions for each of the building components included in the analysis. A quantitative summary of building materials and equipment should be used for the calculations, as well as averaged (generic) or detailed (specific - from EPD declarations) data for products.
- In the B6 phase, operational emissions should be assumed on the basis of calculations of final energy demand according to the current methodology for developing energy performance certificates (EPCs) for the building, depending on the type of energy carrier. The emission value given as GWP must take into account all greenhouse gases and should be determined for one year, based on the most recent data on the energy carriers used.

TOWARDS CARBON-NEUTRAL BUILDINGS

POLAND

FULL METHOD

takes into account

A1-A5, B1-B4, C1-C4

responsible for emissions
embedded in the product
phase

and

operational emissions (B6)
converted to CO₂e.

- Takes into account phases A1-A5, B1-B4, B6, C1-C4 which cover embodied emissions in the product, use and end-of-life phases, and operational emissions.
- Phases A1-A3 should be calculated the same as in the simplified method.
- Phase A4 (transport-related emissions), should be calculated based on monitoring the distance between the factory and the construction site, the type of transport with the emission factor (kgCO₂/kg/km), the weight of the material transported, and the loading degree of the carrier.
- Phase A5, which covers emissions from the construction process, should be determined by indicator.
- Phase B1 includes emissions from building materials and equipment during the life of the building. Emissions related to maintenance and refrigerant leaks from installations and equipment repairs should be included in the calculations.
- Phase B2 refers to CO₂ emissions associated with maintenance of the roof, exterior walls, windows, exterior doors, finishes and installations.

TOWARDS CARBON-NEUTRAL BUILDINGS

POLAND

FULL METHOD

takes into account

A1-A5, B1-B4, C1-C4

responsible for emissions
embedded in the product
phase

and

**operational emissions (B6)
converted to CO₂e.**

- Phase B3 takes into account emissions from all activities related to repairing a building component including used products.
- Phase B4 addressing the replacement of building components is related to the need to assume standard lifetime of the building component, installation or equipment.
- Phase B6 (operational emissions) should be calculated the same as in the simplified method.
- To calculate phases C1 (emissions from building deconstruction and demolition), C2 (emissions from waste transportation), C3 (emissions from reusing or recycling materials at the end of a building's life), and C4 (emissions from disposing of materials that are not recovered for reuse or recycling), emission factors developed at the national level should be used.

TOWARDS CARBON-NEUTRAL BUILDINGS

POLAND

WE NEED

The implementation of the full method will require the development of national databases of unit emission factors for:

- construction products,
- equipment and technical systems, including end-of-life phase,
- the type of transport of construction products and fuels used and average transport distances specific to the country,
- the phase of construction of different types of buildings taking into account the various energy carriers needed in the construction process to power machinery and construction facilities, and the share of construction waste for each group of materials,
- energy carriers.

TOWARDS CARBON-NEUTRAL BUILDINGS

CONCLUSIONS

- The pursuit of climate neutrality also in the construction sector through, among other things, the EPBD 2024 obliges EU member states to develop and implement a life-cycle GWP calculation methodology for buildings.
- This action is a gradual process that requires overcoming common difficulties.
- The transposition of the EPBD is done by developing WLC benchmarks and generating relevant analysis and stakeholder support to establish national WLC methodologies.
- The undisputed value in this process is the experience and lessons learned from countries that have already implemented relevant measures or have introduced regulations that oblige the building sector to report WLC.

**Recommendations for
a methodology for
life-cycle GWP calculation.**

**Recommendations
for
data collection**

**Stakeholder
engagement**

**Recommendations for
defining
life-cycle GWP limits**



PRIORITIZING ENERGY RENOVATION
IN THE CEE COUNTRIES

Thank you

The project is co-financed by the governments of Czechia, Hungary, Poland and Slovakia through Visegrad Grants from the International Visegrad Fund (<https://www.visegradfund.org/>).





LIFE CYCLE GWP IN HUNGARY

PERCEE WEBINAR

Zsuzsa Szalay PhD

2025.06.12.



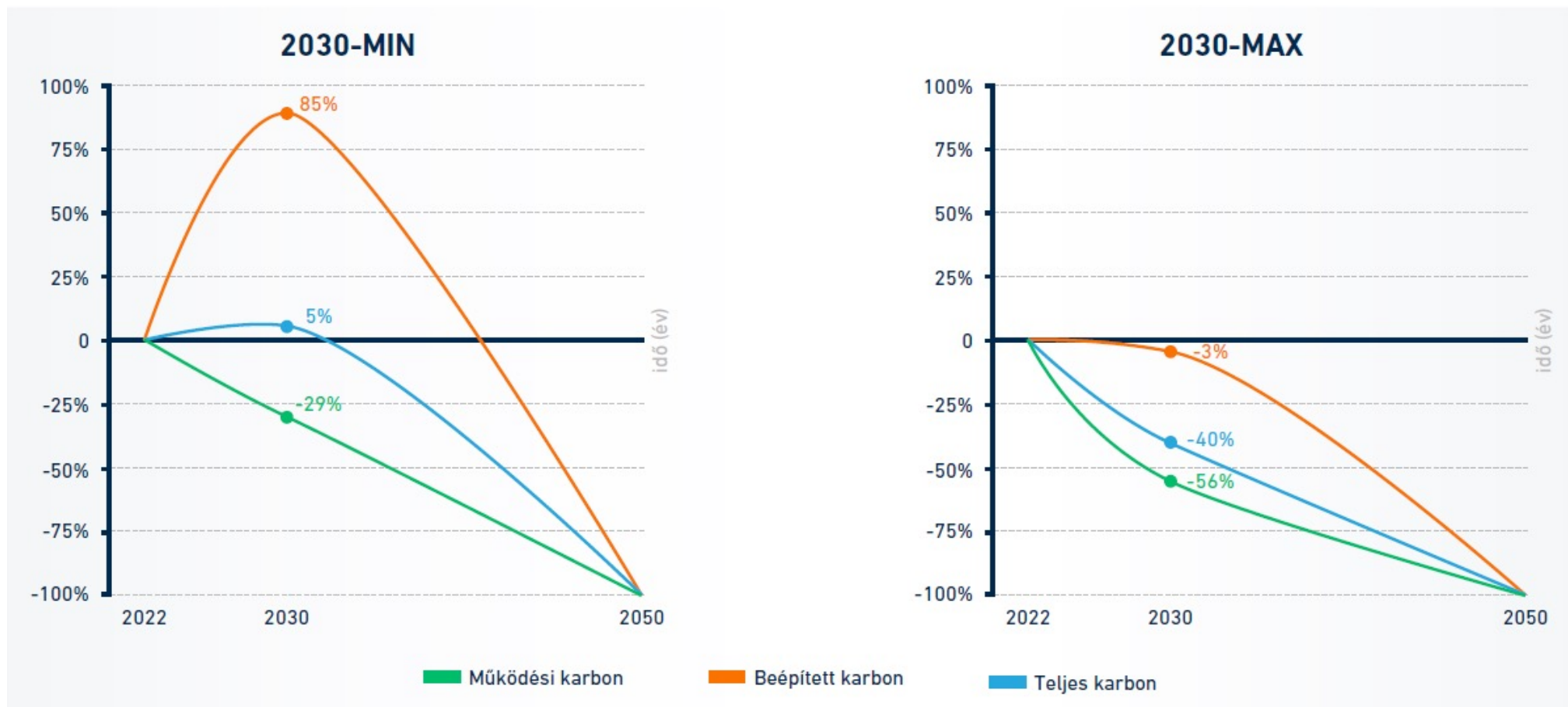
**BUDAPESTI MŰSZAKI
ÉS GAZDASÁGTUDOMÁNYI EGYETEM**

Építőmérnöki Kar - építőmérnöki képzés 1782 óta

Építőanyagok és Magasépítés Tanszék

Decarbonisation roadmap for the building sector

#BUILDINGLIFE



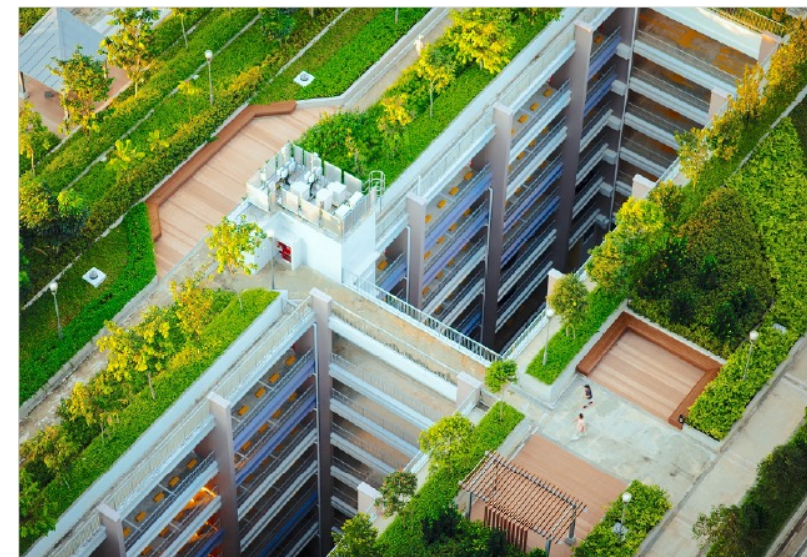
GreenPolicy Center: Szakértői háttéranyag: A karbonmentes építési ágazat nemzeti útiterve c. dokumentumhoz, 2024



Net zero carbon definition in Hungary

Net zero carbon building:

„A net-zero carbon building is a highly energy-efficient building whose operational energy needs are met to the maximum extent possible by on-site renewable energy and whose whole life cycle GHG emissions are minimal, with the remaining emissions being compensated by on-site or off-site renewable or fossil-free energy sources and offsets.”



MAGYAR KÖRNYEZETTUDATOS ÉPÍTÉS EGYESÜLETE (HUGBC)

Zéró Karbon Ajánlás

EGYEZTETÉSI MUNKAANYAG • 2023. FEBRUÁR



Magyar Környezettudatos Építés Egyesülete
Hungary Green Building Council



ADVANCING
NET ZERO



WORLD
GREEN
BUILDING
COUNCIL



European
Climate
Foundation

LCA related research projects

International projects:

- IEA EBC Annex 72 – Assessing Life Cycle Related Environmental Impacts Caused by Buildings
- IEA EBC Annex 89 – Ways to Implement Net-zero Whole Life Carbon Buildings

National projects:

- National implementation of EPBD
- Research projects related to LCA of buildings

The International Journal of Life Cycle Assessment
<https://doi.org/10.1007/s11367-024-02322-w>

BUILDING COMPONENTS AND BUILDINGS

A parametric approach for developing embodied environmental benchmark values for buildings

Zsuzsa Szalay¹

Received: 7 August 2023 / Accepted: 1 May 2024
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Abstract

The production and construction of buildings cause significant environmental impacts besides those arising from their operation. Recently, some European countries have started introducing a method for new buildings, and it is foreseen that by 2030 this will be a legal minimum value.

Methods Extensive databases on the embodied impacts of buildings, which impacts, are still missing. This paper proposes an approach for determining a sample of "technically feasible" new buildings. Its parameters describing a building are determined and the ranges are defined. A large building sample is generated, an determined for typical construction solutions to assess environmental performance. **Results and discussion** The method is demonstrated by calculating the embodied GWP for single-family houses and 9.1–14.3 kg CO₂-eq/m²yr for multi-family buildings in Hungary. The results show a baseline embodied GWP of 9.1–14.3 kg CO₂-eq/m²yr for multi-family buildings. **Conclusions** This method is suitable for estimating the environmental impact in large pool of real building data is not yet available.

Keywords Life cycle assessment · Benchmark · Building · Embodied carbon

1 Introduction

Buildings and the construction sector as a whole were responsible for 36% of final energy use and 37% of energy-related carbon dioxide emissions in 2020 (United Nations 2021). Whilst the operation of buildings was the largest emitter (27%), the manufacturing of construction materials such as steel, cement and glass also accounted for approximately 10% of the emissions.

Communicated by Alexander Passer.

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Published online: 18 June 2024

Efficient regulation

2010, 20 building new building vision for the future

How to improve efficiency

Heslin's light on Green Building

They can't operate



Modular approach to multi-objective environmental optimization of buildings

Benedek Kiss^{1,*}, Zsuzsa Szalay¹

¹ Department of Construction Materials and Technologies, Budapest University of Technology and Economics, Műegyetem rkp. 3, 1111 Budapest, Hungary

ARTICLE INFO

Keywords: Life cycle assessment, Optimization, Parametric design, Building, Multi-objective

ABSTRACT

The application of heuristic algorithms with life cycle assessment (LCA) is a promising approach to efficiently optimize the building and minimize the environmental impact even in a very large design space. In this paper, a modular parametric optimization framework combining advanced building modeling, LCA, energy calculation and single- and multi-objective environmental optimization was developed and applied to a multi-apartment house in Hungary. The variables comprise geometry, envelope, fixtures, as well as the heating energy source. The objective is the life cycle environmental impact expressed in terms of the six most common LCA indicators. The results show that a relatively compact shape, large windows to south equipped with shading and very high levels of insulation are optimal from an environmental perspective. It was also proven that focusing only on the embodied or operational impact leads to a suboptimal solution, and the choice of the energy source for the operation of the building has a significant influence on the achievable optimum. Through the optimization, significant environmental savings of 60–80% were achieved compared to the initial design options showing the potential for the application of such methods in architectural design.

1. Introduction

The built environment is the largest industrial sector in economic terms, and also the largest in terms of resource flow [1]. Buildings are responsible for about 40% of total final energy consumption in Europe [2] and this ratio is similar in other parts of the world. The improvement of the energy efficiency in both new and existing buildings is crucial to reach climate and energy targets and to increase energy security [3–5]. Energy saving may be achieved through different combinations of measures, including thermal insulation, high-performing windows, efficient and controllable technical systems and renewable energy sources [6]. However, a reduction in operational expenditures usually generates higher investment costs and this is generally also true for the embodied energy and environmental impacts, such as greenhouse gas emissions [6–8]. The research question arises what the optimum trade-off between embodied and operational environmental impacts is and where the minimum is found if we consider not only the operational phase, but the whole life cycle of a building.

The potential environmental impact of a product can be evaluated with the life cycle assessment (LCA) method [9]. There has been an exponential growth in the application of LCA to buildings in the recent years [10–12]. Environmental optimization, which refers to the search for the minimum impact of a building, is complicated, however, by the

fact that the number of alternatives in the design phase is very large. Even if we consider only a few variables, these can take many different values (e.g. material types, insulation thickness, window types, etc.), which results in a large number of combinations. The scientific literature often compares a limited number of design options and this approach is called 'optimization' [13–16], but this does not allow for comprehensive conclusions.

The tools of applied mathematics are increasingly applied to such problems. Mathematical optimization is the minimization or maximization of one or more objectives that are functions of some variables [17]. In single-objective optimization, there is one objective, while in multi-objective optimization two or more conflicting objectives are optimized simultaneously [18,19]. If the number of combinations is low, even simple tools may be suitable, such as a dynamic parametric analysis tool [20]. However, due to the large design space and the non-linear nature of the calculations, classical optimization techniques are usually not suitable for solving building-related problems. Efficient derivative-free algorithms can be applied instead. There is a growing body of scientific literature on the application of mathematical optimization to building design [21–23]. The objectives can be the minimization of costs [24–26,27], energy use [28,29] or the maximization of thermal comfort [30,31]. However, there exists a limited number of optimization studies related to the life cycle environmental impact of

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Education and courses

- University courses: awareness raising
- Handbook and case studies for everyday people
(IS-SusCon project - LCACenter)
- Online courses for professionals
(Advancing Net Zero project - HuGBC)



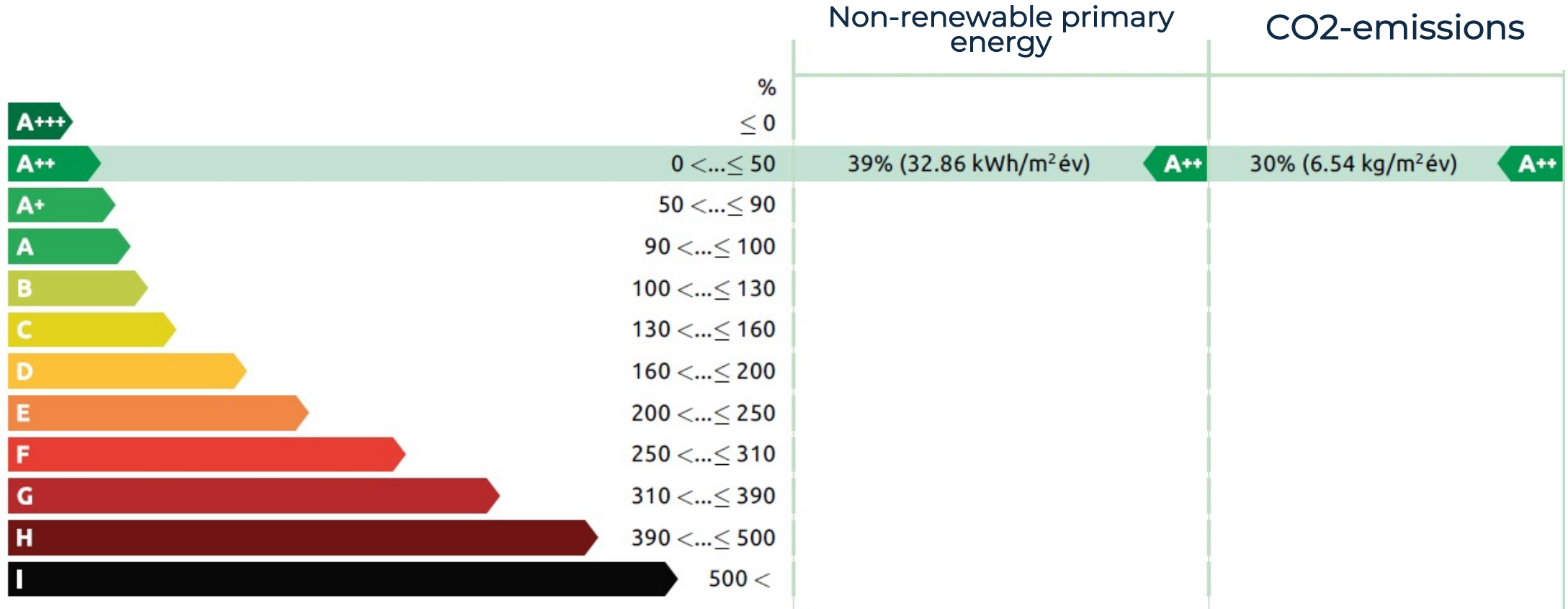
www.howtobuildgreen.eu



www.hugbc.hu



New energy performance certificate and requirements (from 2023)



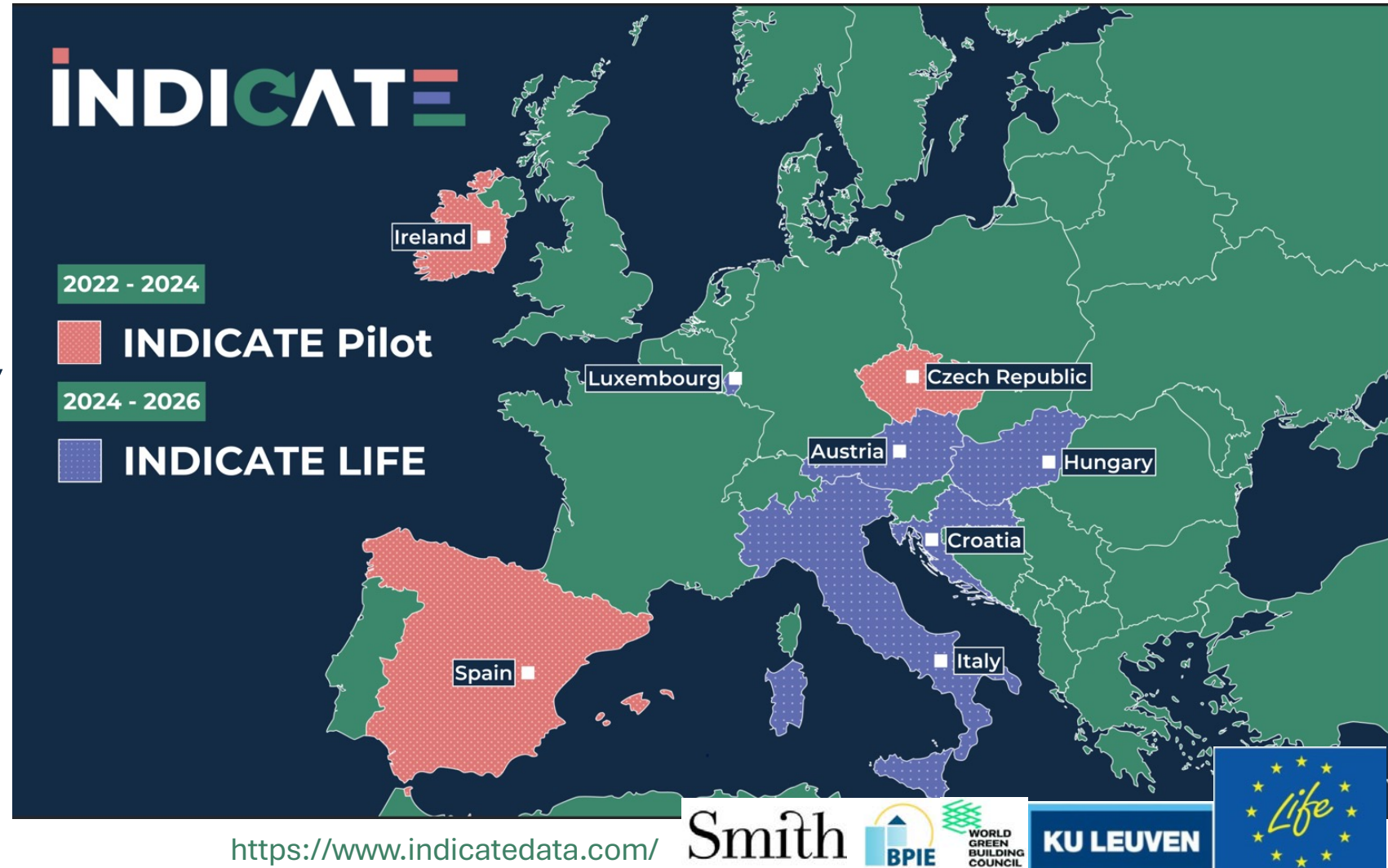
Only operational energy and CO2
CO2 life cycle based (GWP), ecoinvent

INDICATE LIFE (2024-2026)

Goals:

- WLC (whole life carbon) policy support
- LCA methodology „Benchmark” definition

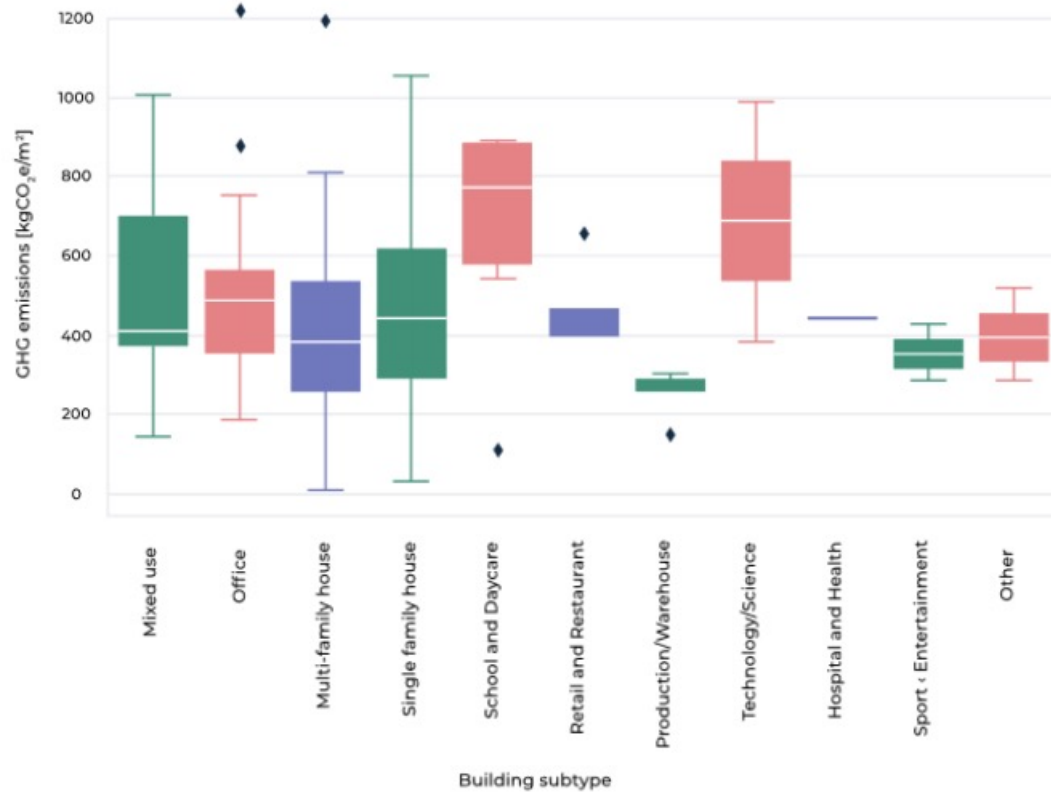
Hungary (HuGBC):
follower status



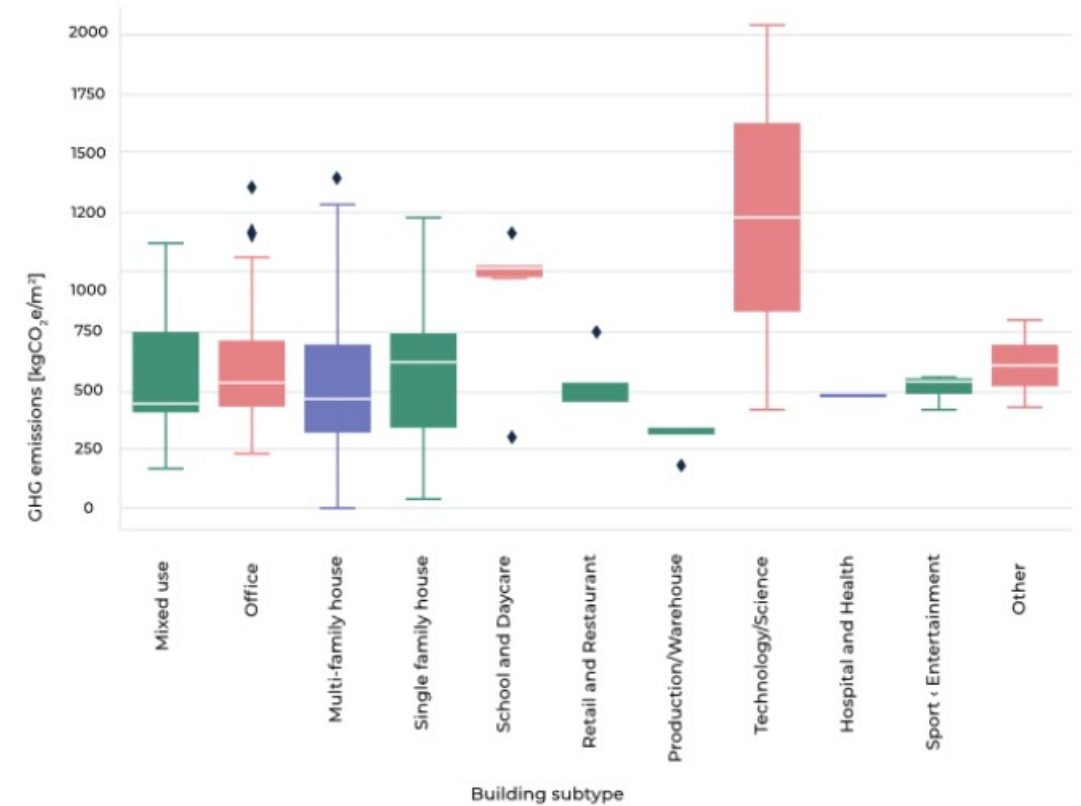
Previous INDICATE results

Analysis of large building samples (min. 50 buildings/ country)

a) Production embodied carbon (A1-A3; Cradle-to-gate*)



b) Whole life embodied carbon (A1-C4; Cradle-to-gate*)



Status Quo analysis Hungary (2025)

Consultancy firms:

- LCA done as part of green certification (LEED/ BREEAM)
- 2-10 years experience
- about 90-100 projects with LCA: office buildings, industrial buildings, logistic halls, public buildings, sport facilities

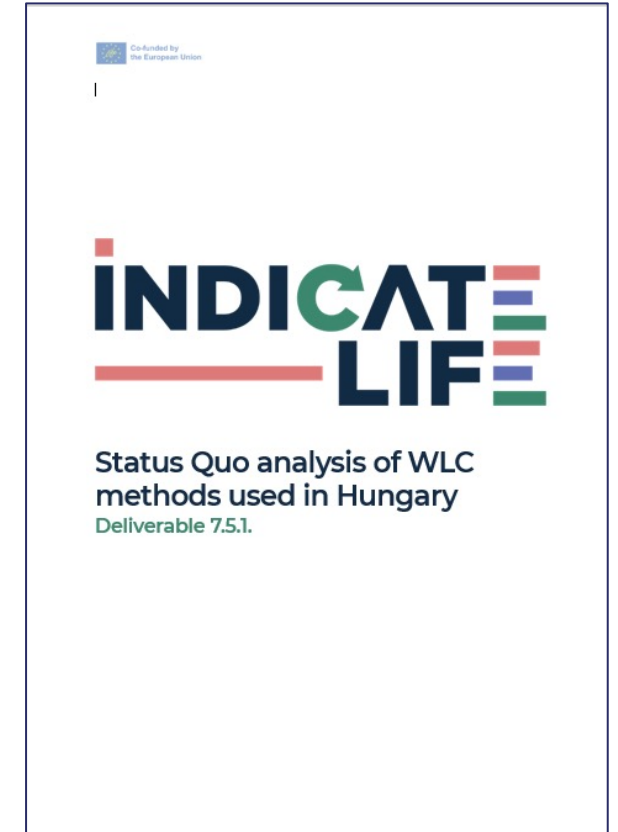
Architectural offices – pioneers:

- LCA is an integral part of the design practice, design optimization
- 27 and 3 years experience
- About 30 projects assessed: mostly detached houses, new and refurbished

Researchers:

- Virtual buildings, archetypes, reference buildings
- Mostly residential buildings

LCA applications in an increasing number but not used in standard architectural practice



Methodology and tools

- Methodology:
 - No official national methodology
 - Methods exist in academia
 - In line with LCA standards (EN 15978)
 - As required by the certification scheme
 - Sometimes Level(s) and RICS standard applied
 - Assumptions: usually One Click LCA default values
 - Several open methodological questions
- Tools:
 - One Click LCA is the most common tool
 - In research, self-developed spreadsheet, Grasshopper, Python, etc.
 - Excel-based tool, with potential to be further developed into a professional tool

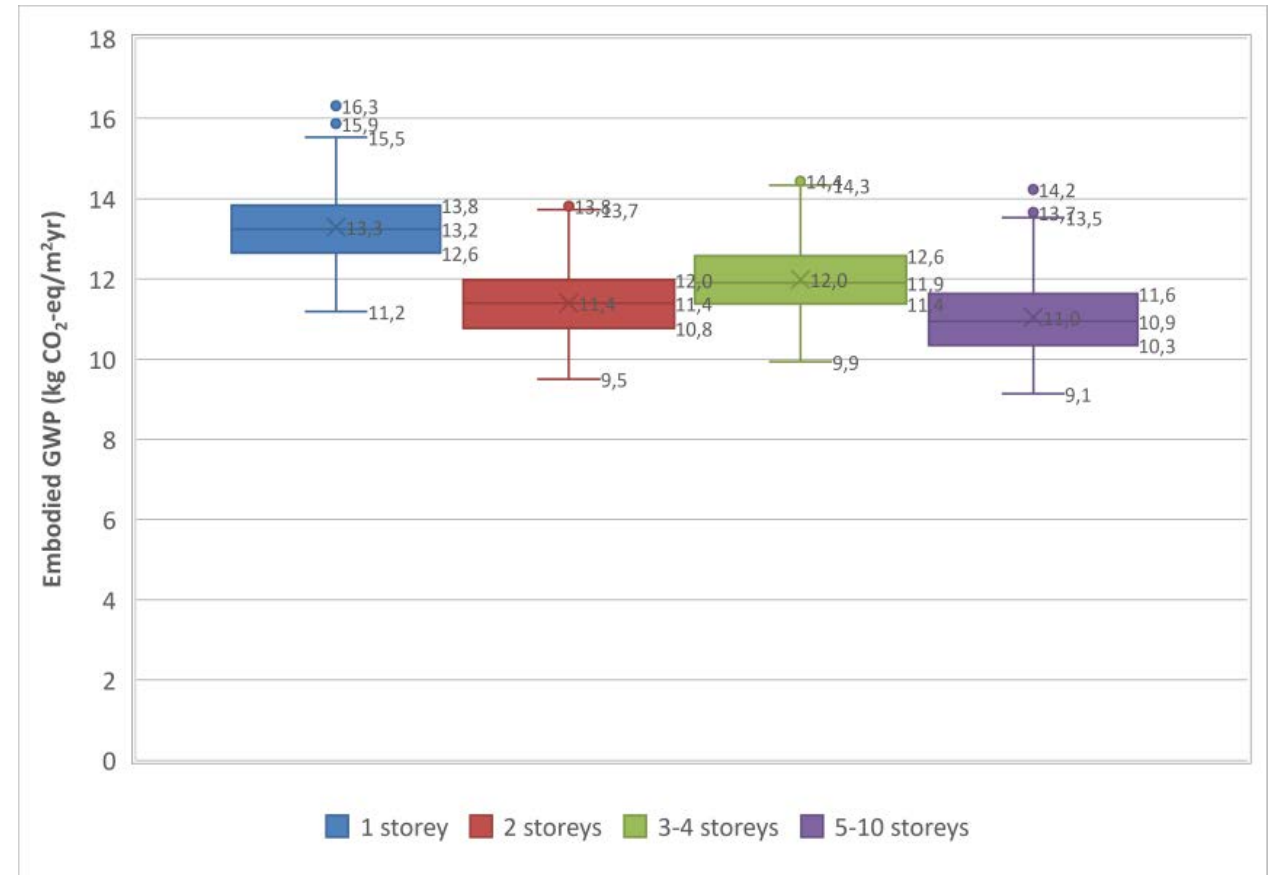
Data

- No national database
- In academic research ecoinvent (adapted) or Ökobaudat
- Limited but growing number of EPDs in the last few years (at least 50 products)
- No EPD programme operator



Benchmarks

- No official national benchmarks
- Preliminary benchmark development for residential buildings: random sample is generated based on building parameters



Szalay, Zsuzsa A parametric approach for developing embodied environmental benchmark values for buildings INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESSMENT 29 : 9 pp. 1563-1581, (2024)

database – methodology – benchmarks

decarbonisation roadmaps



Thank you for your attention

Zsuzsa Szalay

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<http://www.seppo.net/cartoons/displayimage.php?album=16&pid=779>

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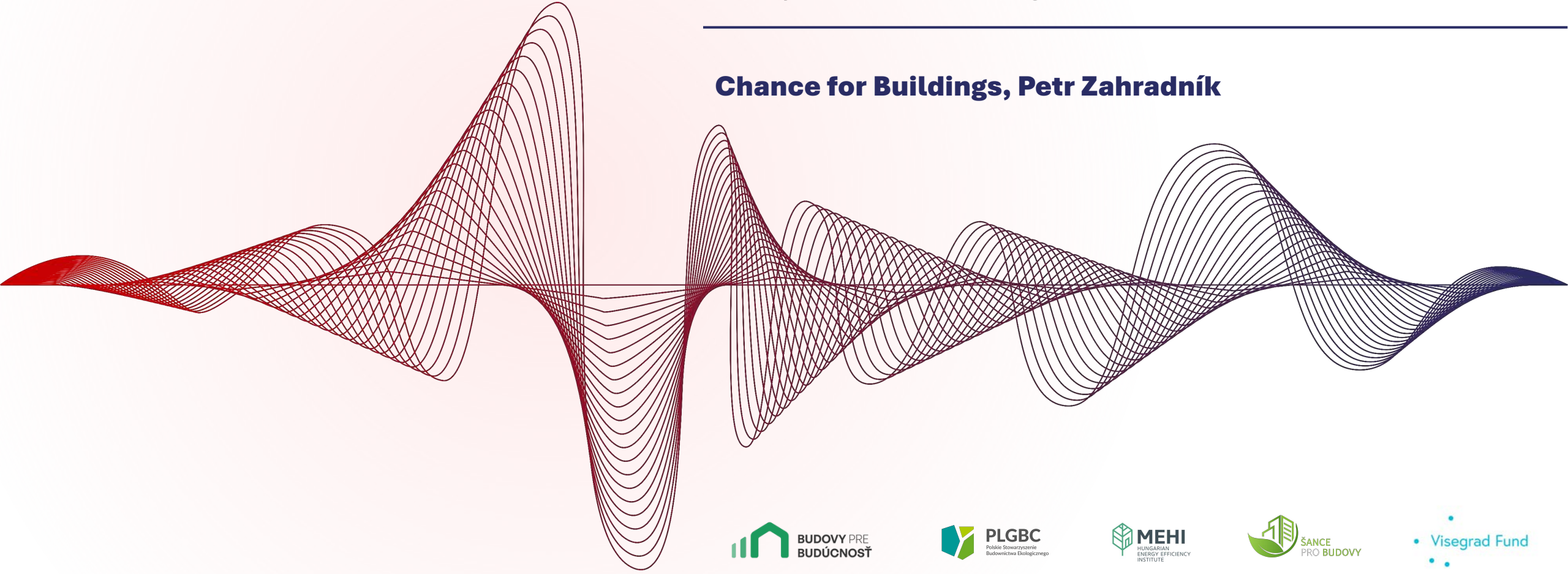


PRIORITIZING ENERGY RENOVATION
IN THE CEE COUNTRIES

Czechia

Life-cycle GWP of buildings

Chance for Buildings, Petr Zahradník



Current Status of LCA and GWP in Czechia

No binding national regulation yet

→ Life Cycle Assessment (LCA) and Global Warming Potential (GWP) are not mandatory in Czech building legislation, which still focuses primarily on energy consumption.

Energy performance assessment based on non-renewable primary energy

→ Current building assessments measure energy efficiency using non-renewable primary energy, excluding embodied emissions or life cycle impacts.

GWP and embodied carbon not included in official methodology

→ Neither the carbon footprint nor global warming potential across building life stages is part of the legal framework, leaving a major data gap.

First benchmarking efforts via the Indicate project

→ The Indicate project analysed LCA data for ~50 buildings, aiming to define a future national methodology and limits.

Lack of consistent and verified material data (e.g., EPDs)

→ A key obstacle is the absence of Environmental Product Declarations (EPDs) and databases for accurate, localized LCA.

No national methodology balancing simplicity and precision

→ A unified framework that enables easy yet reliable assessments is still missing and is a major barrier to mainstream LCA use.

Emerging Tools, Initiatives, and Applications

Joint Indicate – INCIEN (Institute for Circular Economy) initiative promotes national WLC strategy

→ Their position paper urges the government to adopt a whole-life carbon (WLC) strategy, including benchmarks and goals.

WLC reference values proposed for new and renovated buildings

→ Preliminary values from case studies offer a starting point for standard-setting in both construction and renovation sectors.

Circular economy emphasized for embodied carbon reduction

→ INCIEN advocates embedding circularity into building design and renovation, to cut emissions from construction materials.

New Green Savings Program rewards low-GWP materials

→ A bonus of up to €1,200 is available for thermal insulation and window replacements using demountable, recycled, or low-carbon products. Environmental Product Declarations with low GWP are key criteria in accessing these bonuses, encouraging greener material choices.

Application mainly in private commercial projects with certifications

→ LCA is primarily applied where market demand or certification (LEED, BREEAM) exists, not due to regulatory obligation.

ESG and EU taxonomy drive LCA in real estate finance

→ Developers seek LCA to improve ESG ratings and meet EU taxonomy requirements, unlocking better financing terms.

Waste Management, Recycled Materials, and Pre-Demolition Audits

Decree 273/2021 on waste management governs recycled construction materials

→ The law defines how materials (e.g. concrete or bricks) exit the waste regime, but transitional rules apply until 2027 with some temporary criteria. The situation is leaving uncertainties in the use of recycled materials.

“Recyklujme stavby” initiative promotes secondary raw materials

→ The Czech Technical University UCEEB-led platform shares guidance and a catalogue of recycled products and encourages their integration into public procurement. www.recyklujmestavby.cz It includes a voluntary catalogue for products with secondary content. Manufacturers can list recycled-content products by submitting detailed documentation for a full transparency.

Pre-demolition audits recommend reuse and on-site recycling

→ Audits help identify reusable materials before demolition and prioritize local reuse to minimize emissions from transport. The audits include deconstruction guidance containing structured advice on how to dismantle buildings to maximize reuse and ensure compliance with future reuse laws.

Hierarchy for managing construction waste is promoted

→ Reuse on-site is prioritized, followed by nearby processing, and only lastly by external transport and recycling.

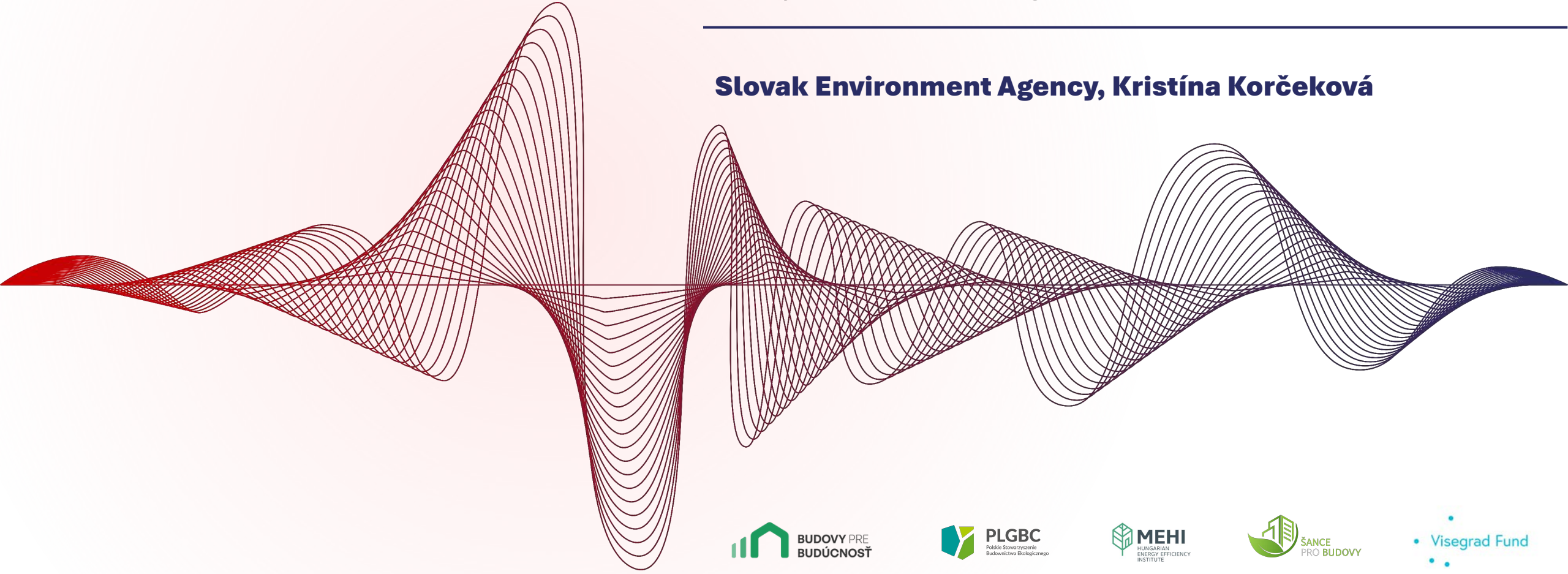


PRIORITIZING ENERGY RENOVATION
IN THE CEE COUNTRIES

Slovakia

Life-cycle GWP of buildings

Slovak Environment Agency, Kristína Korčeková





PRIORITIZING ENERGY RENOVATION
IN THE CEE COUNTRIES

Thank you!

Towards Carbon-Neutral Buildings in the V4 region: Heating Decarbonisation and Life-cycle GWP of Buildings

Online workshop
June 12, 2025

