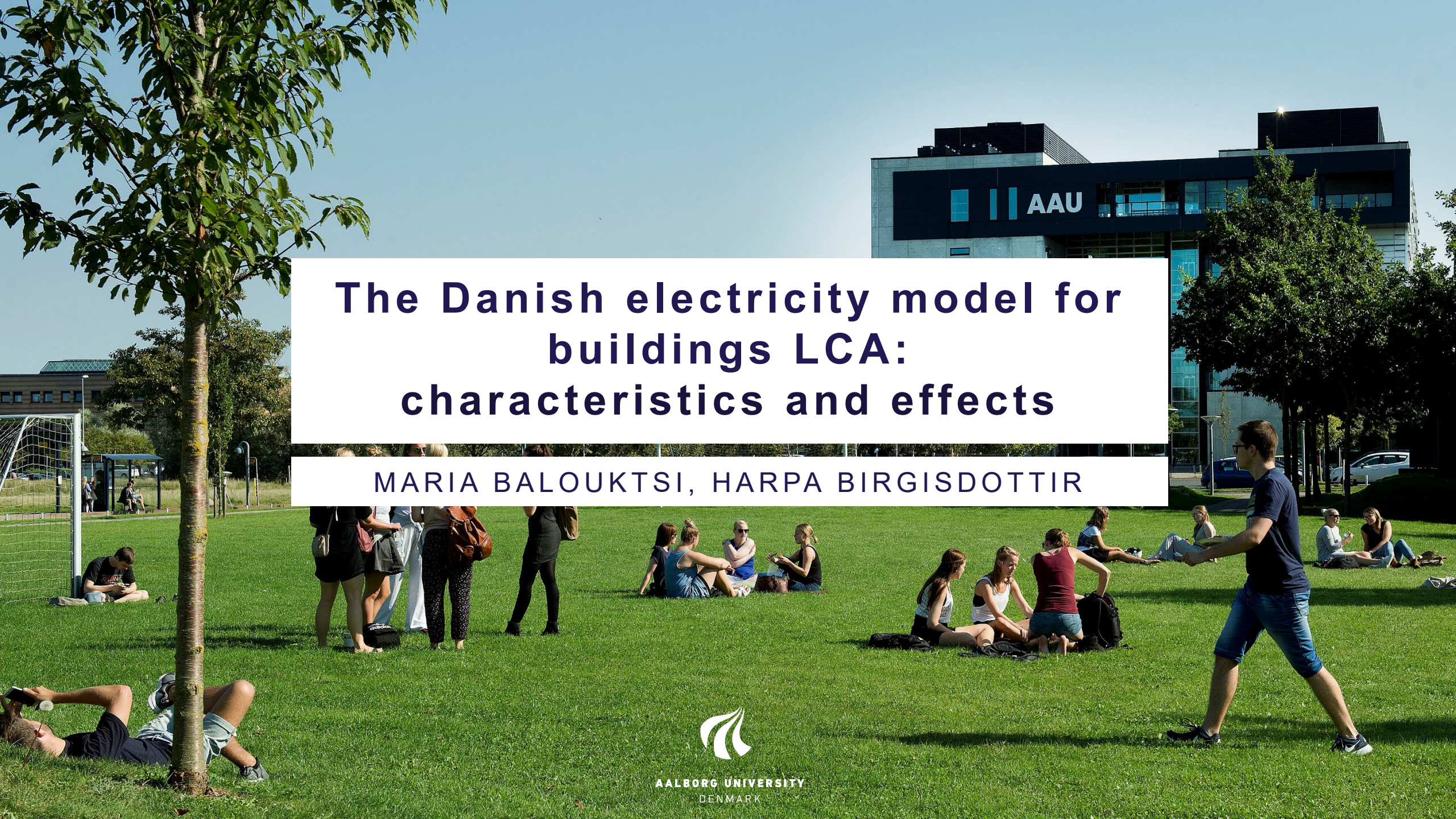

The Danish electricity model for buildings LCA: characteristics and effects

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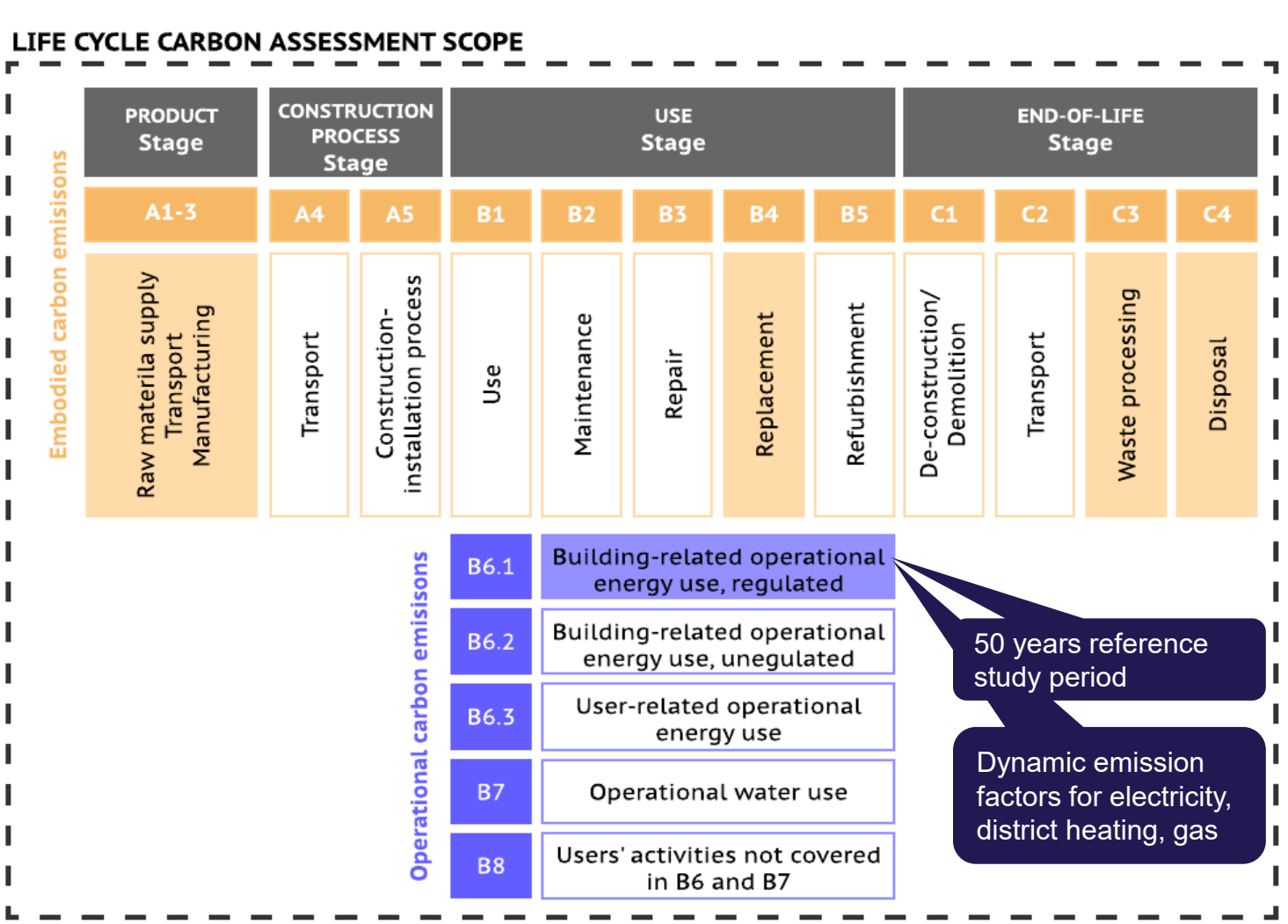
Background: Danish Building Regulation (BR18)

- **12 kgCO_2eq/m^2/yr limit value from January 2023** for new buildings (>1,000 m^2)
- **Tightening of the limit value** at two-year intervals, no building size limit from 2025
- **Overall national goal**: 70% GHG reduction compared to 1990 level by 2030, climate neutrality by 2050 (2045)

Source: The Danish Housing and Planning Authority, The National Strategy for Sustainable Construction. 2021, p.12-13

Background: System Boundary

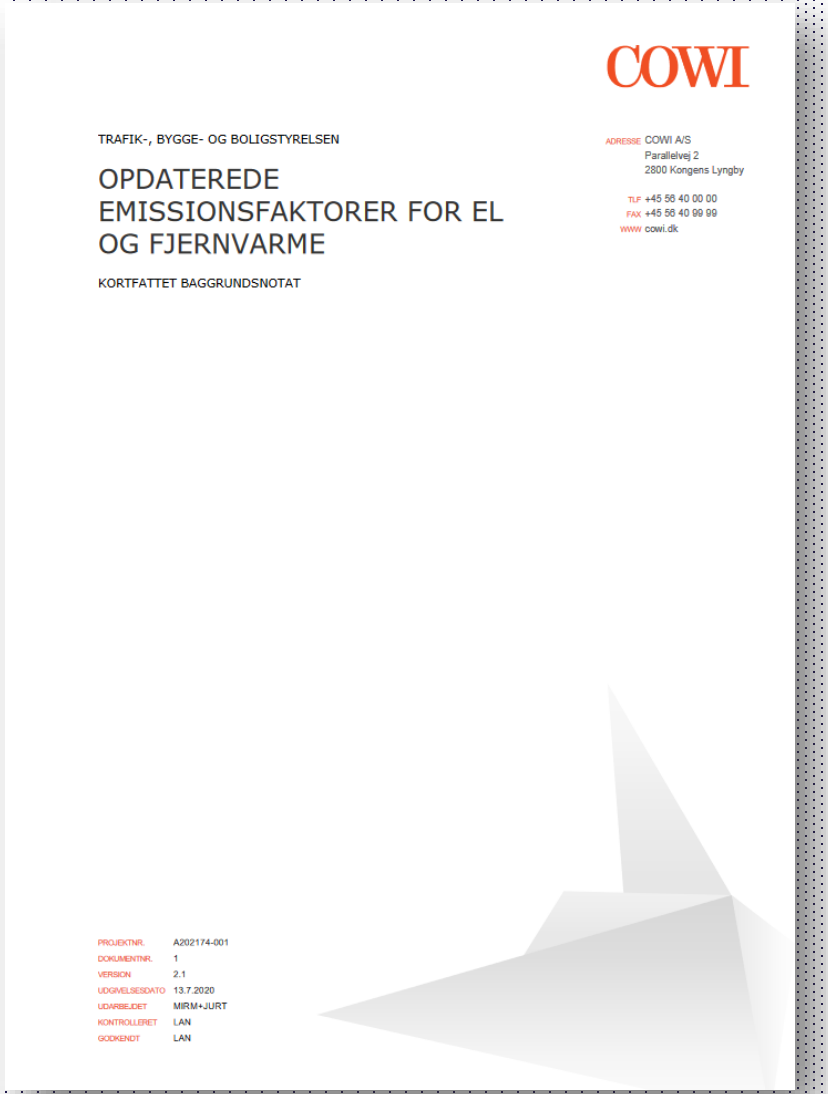


Source: Appendix 2, Table 8 in BR18

År	Energiform	Emissionsfaktorer (GWP)
		kg CO2-ækv./kWh
2023	El	0,187
	Fjernvarme	0,105
	Ledningsgas	0,225
2025	El	0,135
	Fjernvarme	0,0878
	Ledningsgas	0,189
2030	El	0,0470
	Fjernvarme	0,0713
	Ledningsgas	0,105
2035	El	0,0414
	Fjernvarme	0,0688
	Ledningsgas	0,105
2040	El	0,0403
	Fjernvarme	0,0680
	Ledningsgas	0,105

BR18 (2023): Current factors

- **developed and published by COWI in July 2020** (update of a first dataset published in 2016)
- **The factors represent future annual average mixes for electricity and district heating with projections up to 2040** and are founded on data from ”Danmarks Energifremskrivning 2018”.
- **background data from sphere (GaBi)** for the various energy sources, adapted to Danish conditions where possible


COWI

TRAFIK-, BYGGE- OG BOLIGSTYRELSEN

OPDATEREDE EMISSIONSFAKTORER FOR EL OG FJERNVARME

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UDARBEJDET MIRM+JURT
KONTROLLERET LAN
GODKENDT LAN

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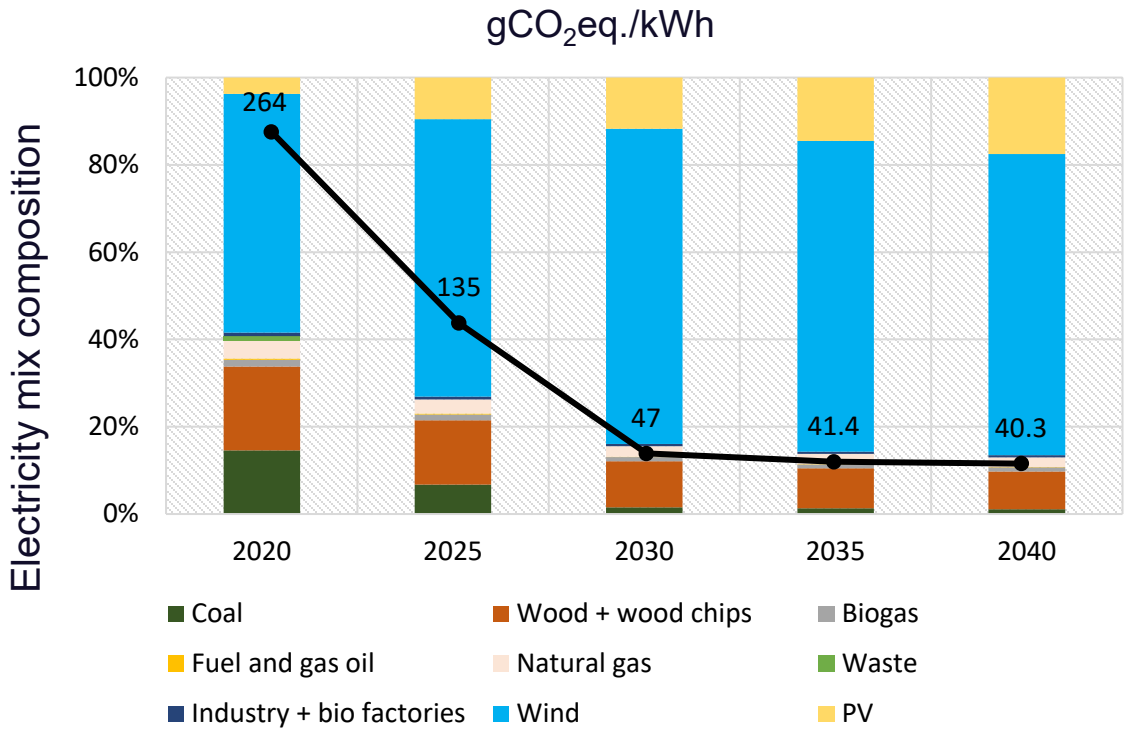
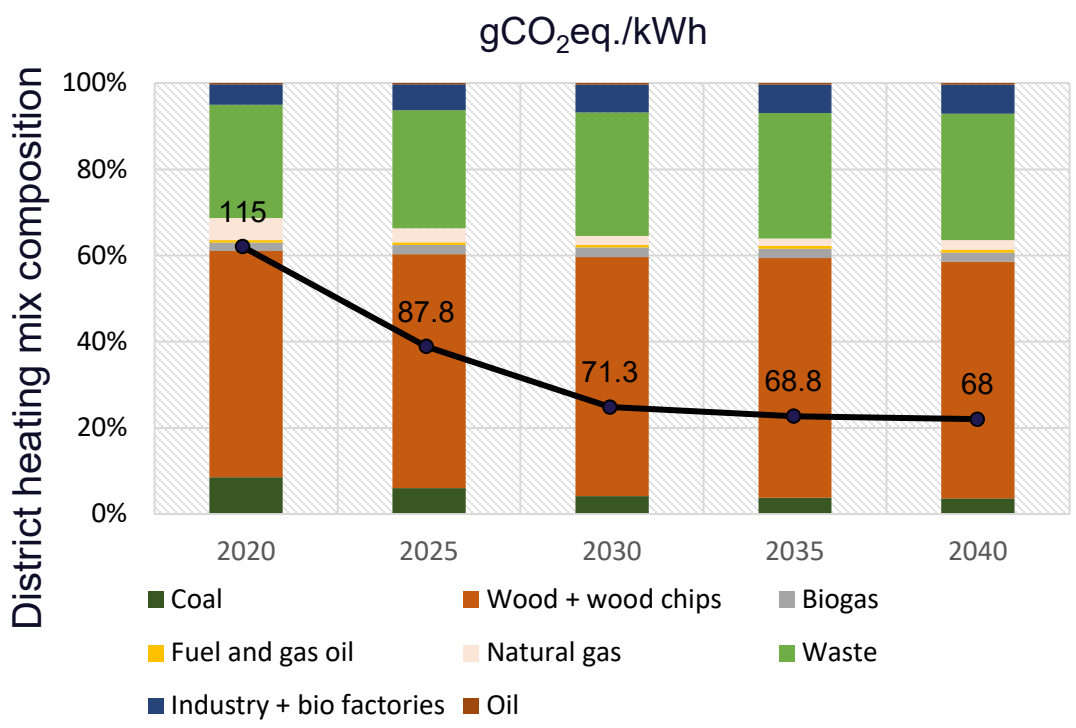
DENMARK

Current Factors: Considered Projections





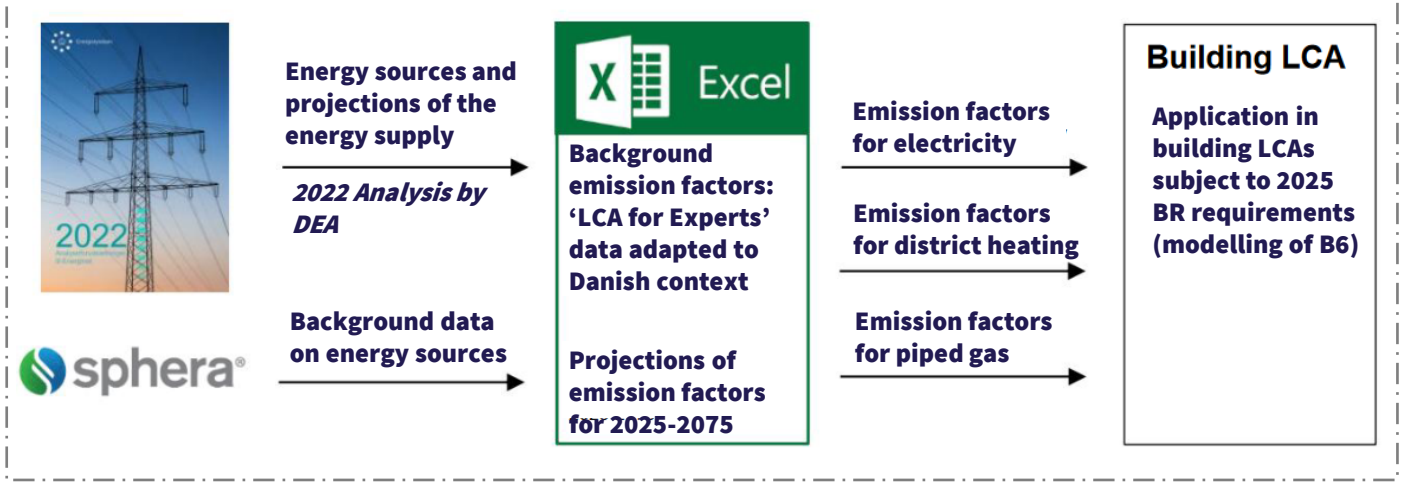
Model Characteristics of the Current Factors

- **Future annual average mix, dynamic projection from 2023 to 2040, static consideration from 2040**
- **Calculation based on the production technologies that are used today**.
  It is thus assumed that a potential production expansion will be possible with the existing production equipment or equipment that corresponds to this.
- **No change in efficiency levels for the individual types of plant** over time from 2020 to 2040
- **Import and export of electricity are not taken into account**

Updated Factors for BR 2025

- developed and published by ARTELIA in June 2023
- founded on 2022-2050 projections by the Danish Energy Agency (DEA)

Preparation process for emission factors for electricity, district heating and piped gas



Source: Figure 6 in Artelia's report (Nilsson et al. 2023), adapted and translated

Updated factors: Background

AF22 model by the Danish Energy Agency
extrapolation of the Danish energy system from 2022 to 2050, considering approved investments (short-term), and political objectives (longer term):

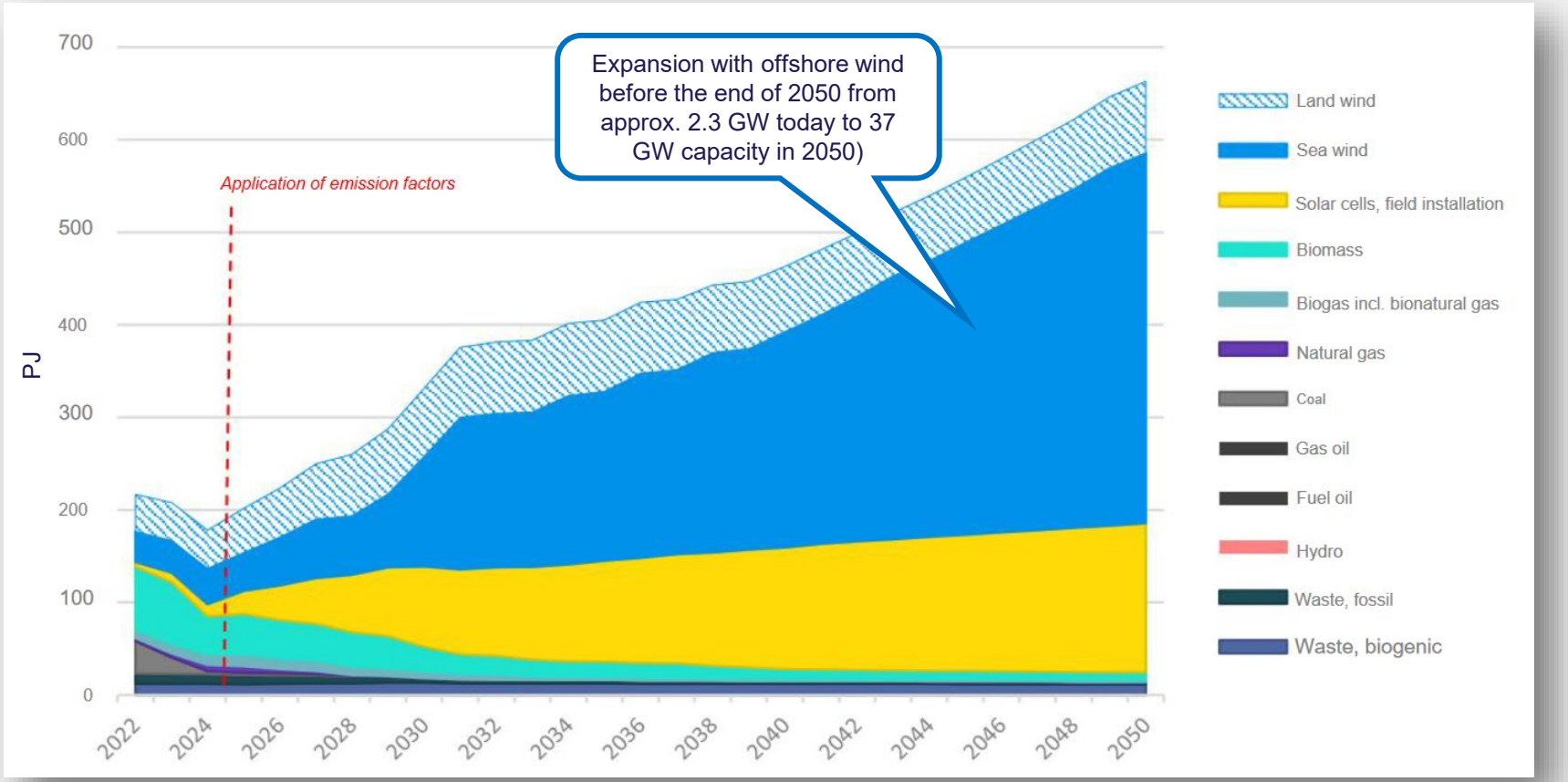
- **70% GHG emission reduction by 2030 compared to 1990**
  (the objective of climate neutrality in 2045 is not incorporated)
- **strategy concerning self-sufficiency**
  (*Esbjerg declaration* of 18 May 2022)
- **strategy concerning an expansion of Power to X (PtX)**
  (*Development and promotion of hydrogen and green fuels (Power-to-X strategy*) of 15 March 2022)
- **strategy concerning renewable energy that exceeds domestic demand and allows for export** *(Climate agreement for green electricity and heat* of 25 June 2022)

Updated electricity factor: Background

Excluded energy sources from ARTELIA's report:

- **rooftop solar cells** since they are included in buildings' LCA to avoid double-counting
- **excess electricity from industry** since it is considered "waste", i.e. assumed included in the previous product system

Expected territorial electricity production in PJ divided by energy sources



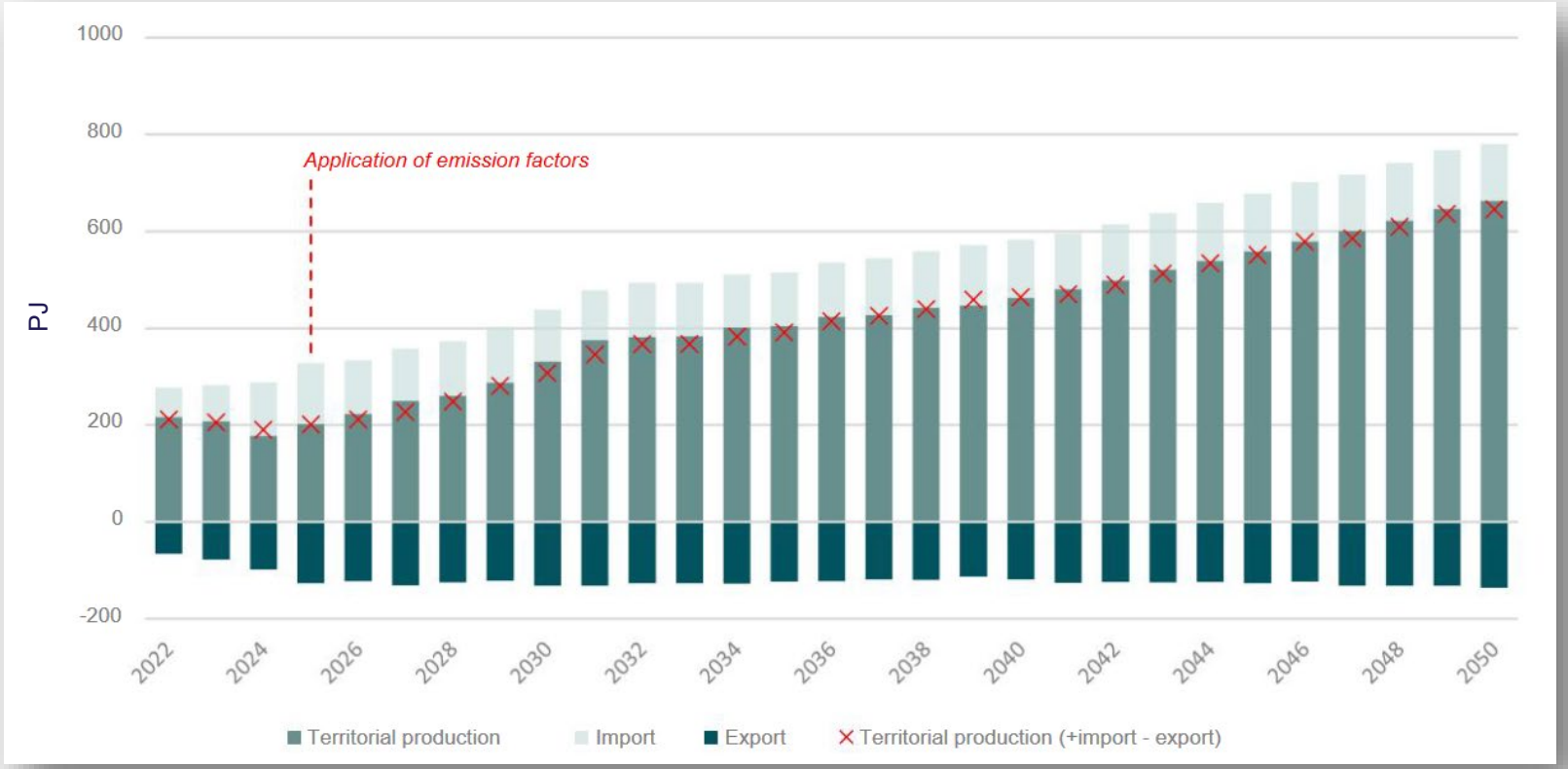
Source: Figure 4 in Artelia's report (Nilsson et al. 2023), based on Danish Energy Agency's AF22 Analysis, adapted and translated

Updated electricity factor: Background

- **Power exchange:** DE, UK, NL, NO and SWE
- **Exported electricity:** average annual emission factor for electricity, based exclusively on the territorial production.
- **Imported electricity**: emission factor based on a weighted average for the importing countries – the exchange countries' emission factor for electricity modeled based on the 2022 National Trend scenario in the Ten-Year Network Development Plan (TYNDP 2022, ENTSO-E & ENTSOG)

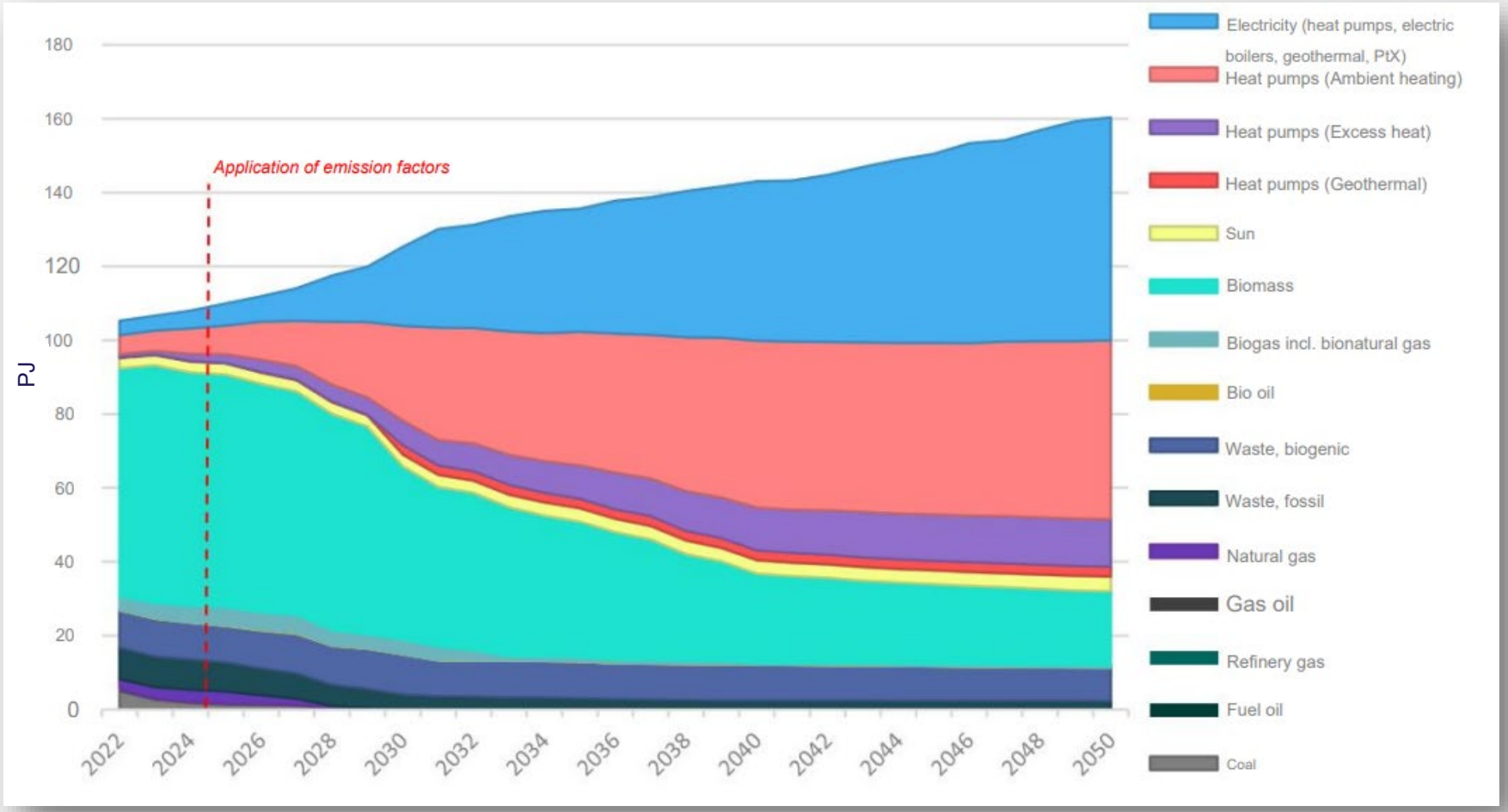
Electricity production in PJ - Territorial, imported, exported

(the energy sources rooftop solar cells, and surplus electricity from industry are not included in the territorial production)



Source: Figure 3 in Artelia's report (Nilsson et al. 2023), based on Danish Energy Agency's AF22 Analysis, translated

Updated district heating factor: Background



Expected territorial district heating production in PJ divided by energy source (excl. excess heat from industry)

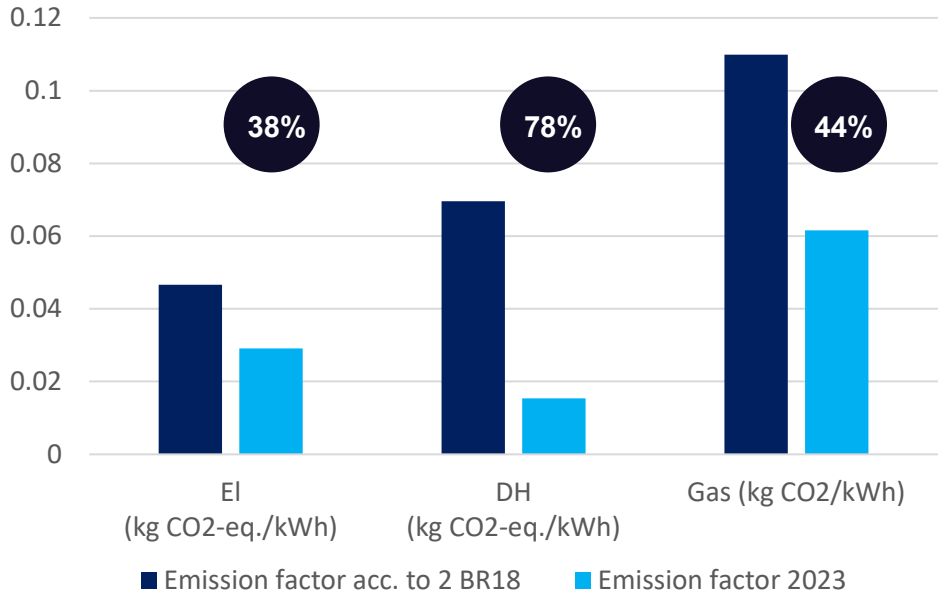
Source: Figure 4 in Artelia's report (Nilsson et al. 2023), based on Danish Energy Agency's AF22 Analysis, translated

Model Characteristics of the New Factors

- **Future annual average mix, with dynamic projection for the first 25 years, static consideration from 2050.** Long-term political objectives are considered.
- **Production + Import – Export**
- **Excludes impacts associated with energy produced from rooftop solar cells** due to potential double-counting since they are included in buildings' LCA (Building Regulation allows the allocation of impacts and savings of maximum 25 kWh/m²/year generated energy to building LCA)
- **Excludes excess energy from industry** due to lack of information for the industries producing excess energy (conservative approach)
- **No consideration of the influence of green certificates (Guarantees of Origin - GOs) on the emission factor**. As the sale of green certificates is not projected, it has not been possible for ARTELIA to include this perspective in the preparation of emission factors

BR18 Factors vs New Factors

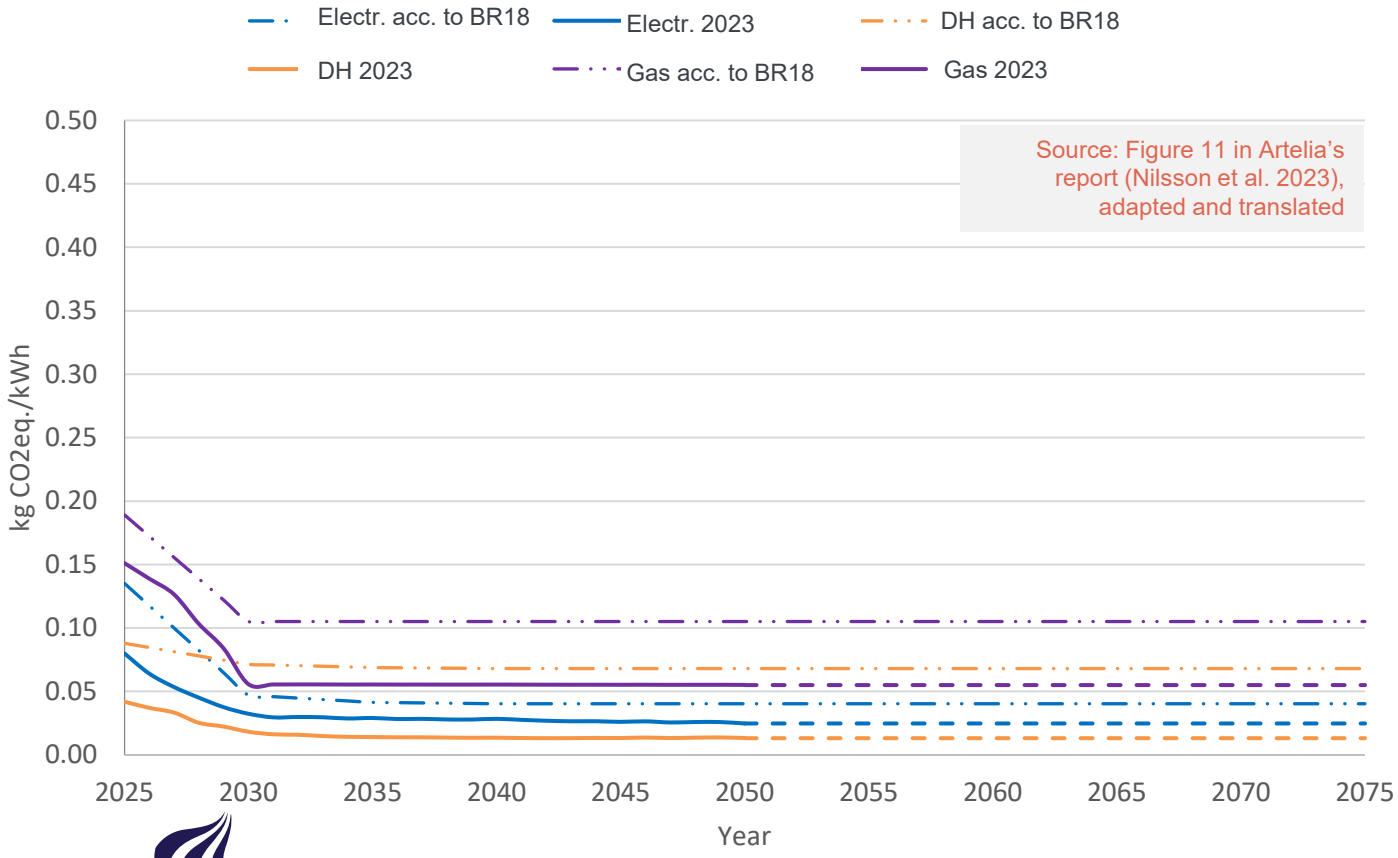
Change in average emission factors



Values of new factors ($kgCO_2eq./kWh$)

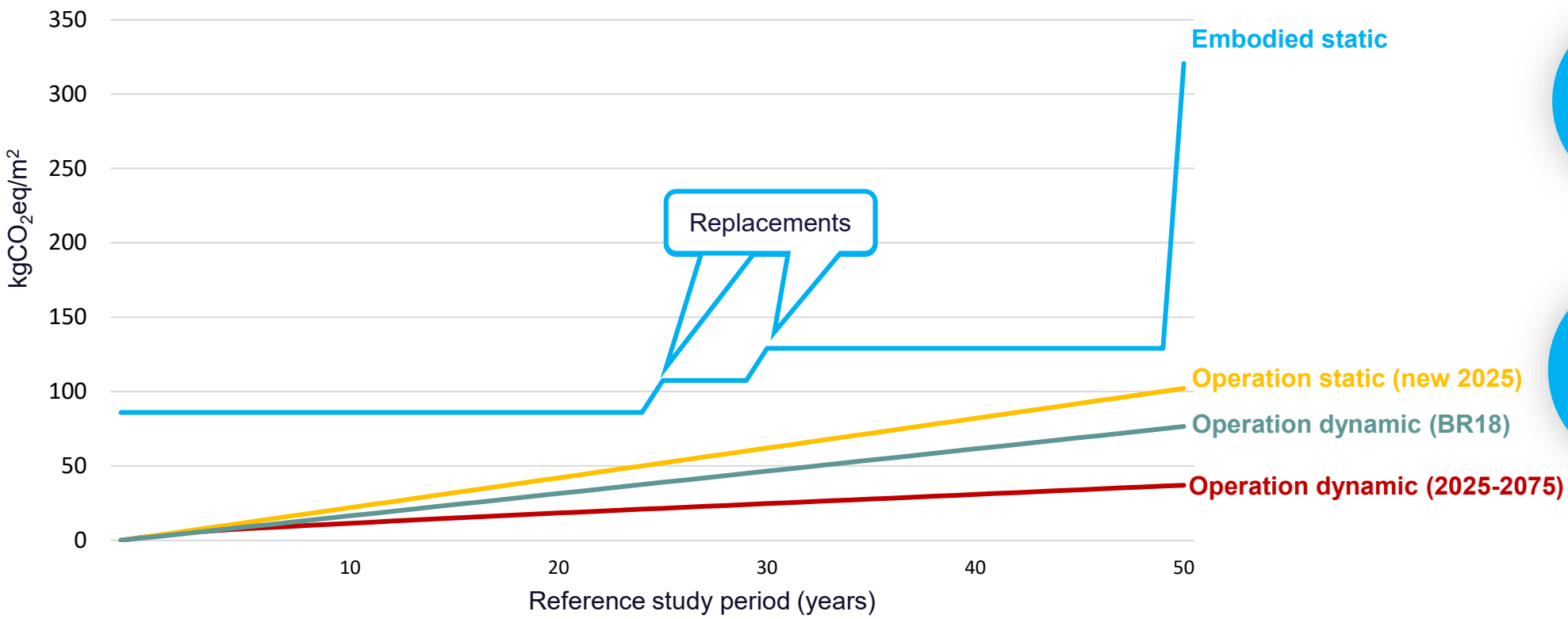
Energy source	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Electricity	0.0801	0.0325	0.0291	0.0285	0.0261	0.0248
District heating	0.0418	0.0181	0.0140	0.0134	0.0132	0.0132
Piped gas	0.1510	0.0557	0.0554	0.0554	0.0552	0.0551

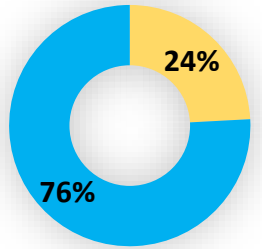
Projection of emission factors

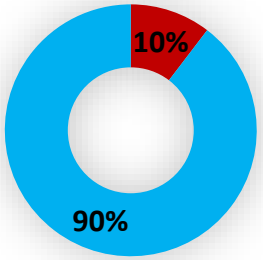


Effects on Module B6: Example 1

New single-family house, timber structure, 178.5 m^2, all-electric (heat pump), low energy class

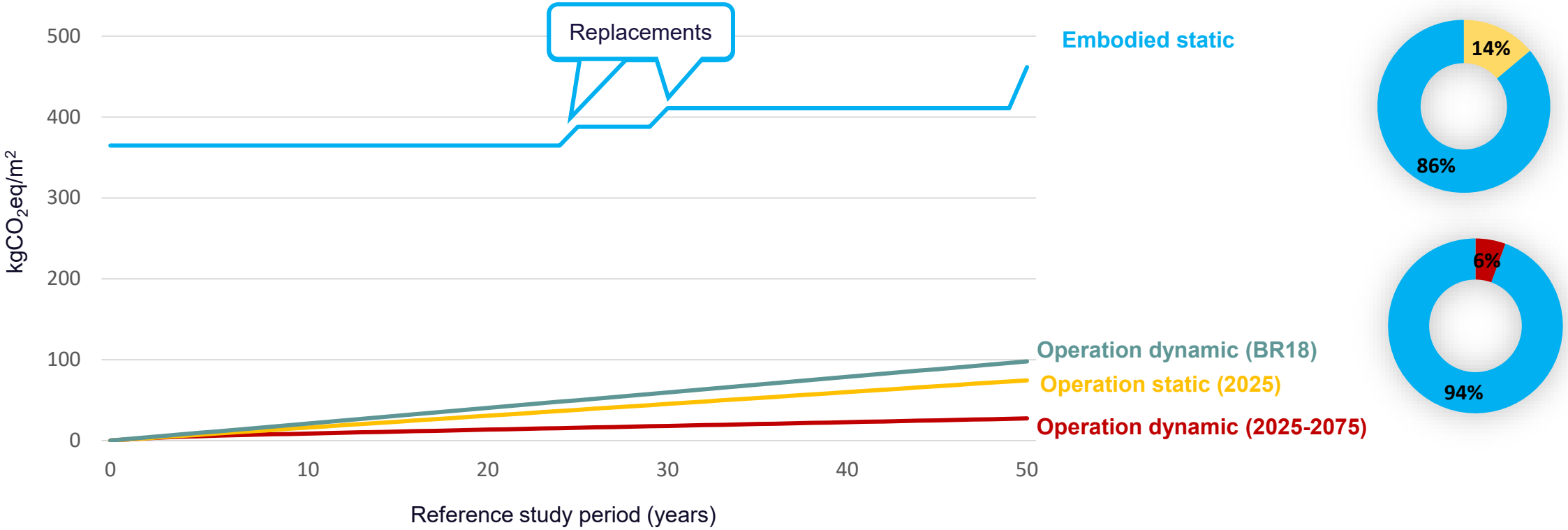






Effects on B6: Example 2

New office building with PV installation, concrete structure, 6375 m^2, district heating, low energy class



Conclusions

- **Effect of updated factors**: In Denmark, decarbonisation is happening faster than expected especially for the district heating; While the currently applied annual average emission factors seem to favour heat pumps, the new factors encourage district heating as a choice to reduce operational climate impact.
- **Static vs dynamic factors**: When using recent static factors, operational carbon share is already quite lower than the embodied share, while dynamic factors can lead to shares of less than one tenth. However, dynamic factors may include political goals which may not be reached, i.e. higher uncertainty.
- **Modelling and updates**: it is important to update the factors frequently (e.g. in line with the update on carbon limits, i.e. every two years in Denmark) and report the methodological choices in a transparent manner.

Thank you
for your attention!