Energy
Transitions
Commission

Net-zero buildings: summary conclusions from the ETC's work on buildings heating, cooling, lighting, appliances and embodied carbon

ETC Representatives Meeting

19th September 2024

Agenda

	10.50-12.50
• Introduction and the buildings decarbonisation challenge • Heating	25 mins
Discussion	15 mins
• Cooling • Cooking • Lighting and appliances • Commercial buildings • Refrigerant leakage and venting • Managing electricity demand + the importance of flexible and efficient buildings	30 mins
Discussion	20 mins
• Strategies to reduce embodied carbon • Actions for policymakers and industry	15 mins
Discussion	15 mins

Our report contributes to the wider literature in 5 main ways

1. Considers **operational** energy and **embodied** carbon

2. Outlines the clear technical and economic feasibility of clean heating technologies
   - **Challenges** the notion that **deep insulation is a pre-requisite** to installing a heat pump
   - Recognises that, while there is **no one-size-fits-all solution**, there is **huge value** in identifying what **technologies will likely be used** across different types of buildings to guide policy decisions

3. Treats **energy productivity** as a core part of the solution set

4. Considers how actions at a building/household level impact the wider energy system, including the potential for **demand-side flexibility**

5. Provides a robust evidence base for how, with the right policies, the buildings energy transition can go hand in hand with **lower energy bills, higher living standards and greater social equity**

Structure of ETC *Buildings decarbonisation* report

1. **The buildings decarbonisation challenge:** energy use, emissions, key challenges

Section A: the net zero transition for operational energy use

2. **Heating**: clean technologies, passive heating
3. **Cooling:** technologies, efficiency, passive cooling
4. **Cooking:** transition to clean cooking
5. **Appliances:** energy efficiency + power demand
6. **Lighting:** energy efficiency + power demand
7. **Commercial buildings**
8. **Refrigerant leakage and venting:** risks and actions
9. **Managing electricity demand:** the balancing challenge, demand-side flex, better building codes, implications for energy demand

Section B: the huge opportunity to reduce embodied carbon of the next generation of new buildings

10. **Embodied carbon**: lifecycle emissions and sources
11. **Decarbonising upfront embodied carbon:** decarbonising material production, demand efficiency levers, implications for new construction
12. **Use phase and end of life embodied carbon:** retrofits, the rebuilding question
13. **Actions to drastically reduce embodied carbon**

Section C: actions for policymakers and industry

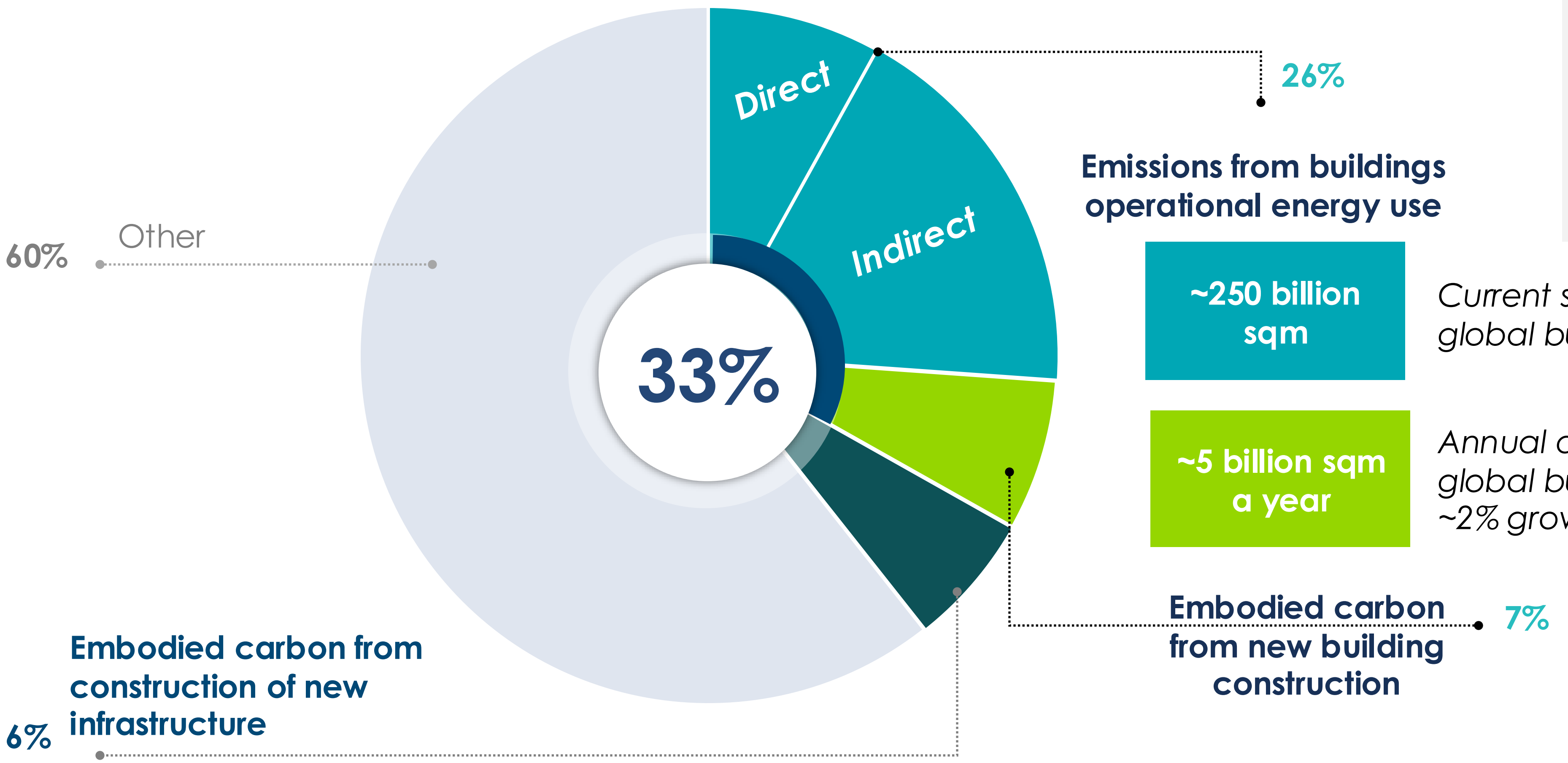
The buildings decarbonisation challenge

Buildings account for 33% of global emissions; around three-quarters of this relates from energy use to operate buildings, a quarter is from the annual construction of new buildings

Global emissions by sector, 2022

GtCO2

Total buildings emissions 12.3 $GtCO_2$



Direct use *of fuels in buildings (e.g., coal or gas heating, TUOB for cooking)*

Indirect use *of fuels used to generate electricity for power and heat in buildings*

~250 billion sqm	*Current stock of global buildings*
~5 billion sqm a year	*Annual additions to global building stock - ~2% growth*

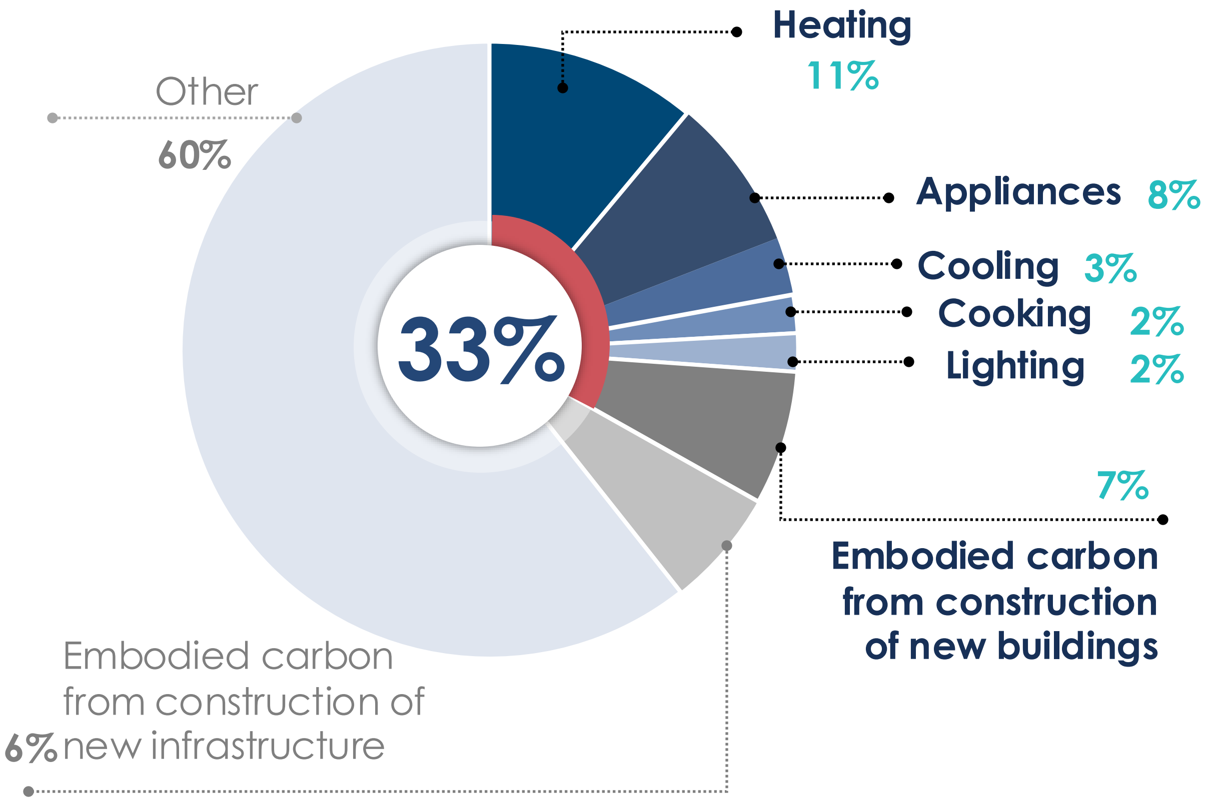
Embodied emission from construction, including manufacturing and processing of cement, steel, and aluminium for buildings

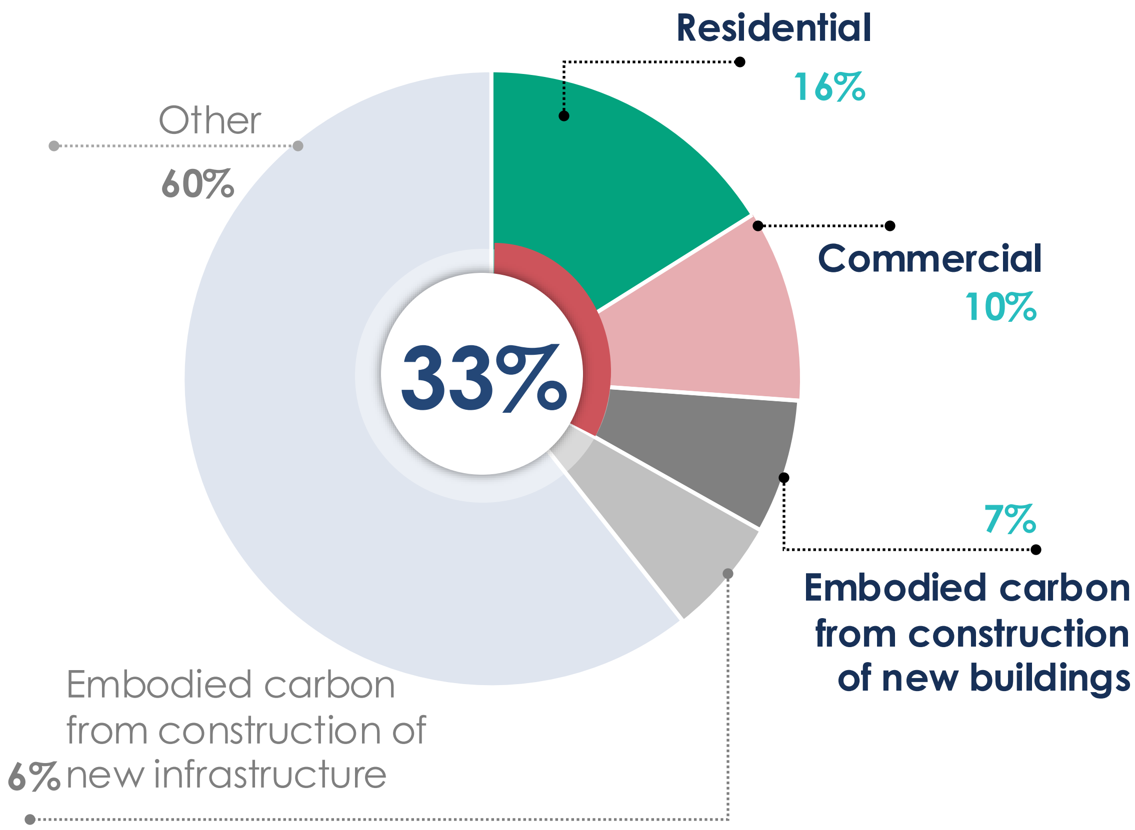
Note this shows annual carbon flows as opposed to stock. Direct GHG emissions are from sources that are owned or controlled by the reporting entity (e.g. on-site fuel combustion – scope 1) whereas indirect GHG emissions are a consequence of the activities of the reporting entity but occur at sources owned or controlled by another entity (e.g. electricity purchased from the grid – scope 2)
Sources: IEA (2023), *The energy efficiency policy package: key catalyst for building decarbonisation and climate action*

Heating and appliances are the biggest sources of operational emissions; residential buildings account for 16% of global emissions, compared to 10% from commercial

Global emissions by end-use (LHS) and building type (RHS), 2022
GtCO2

Total buildings emissions 12.3 $GtCO_2$





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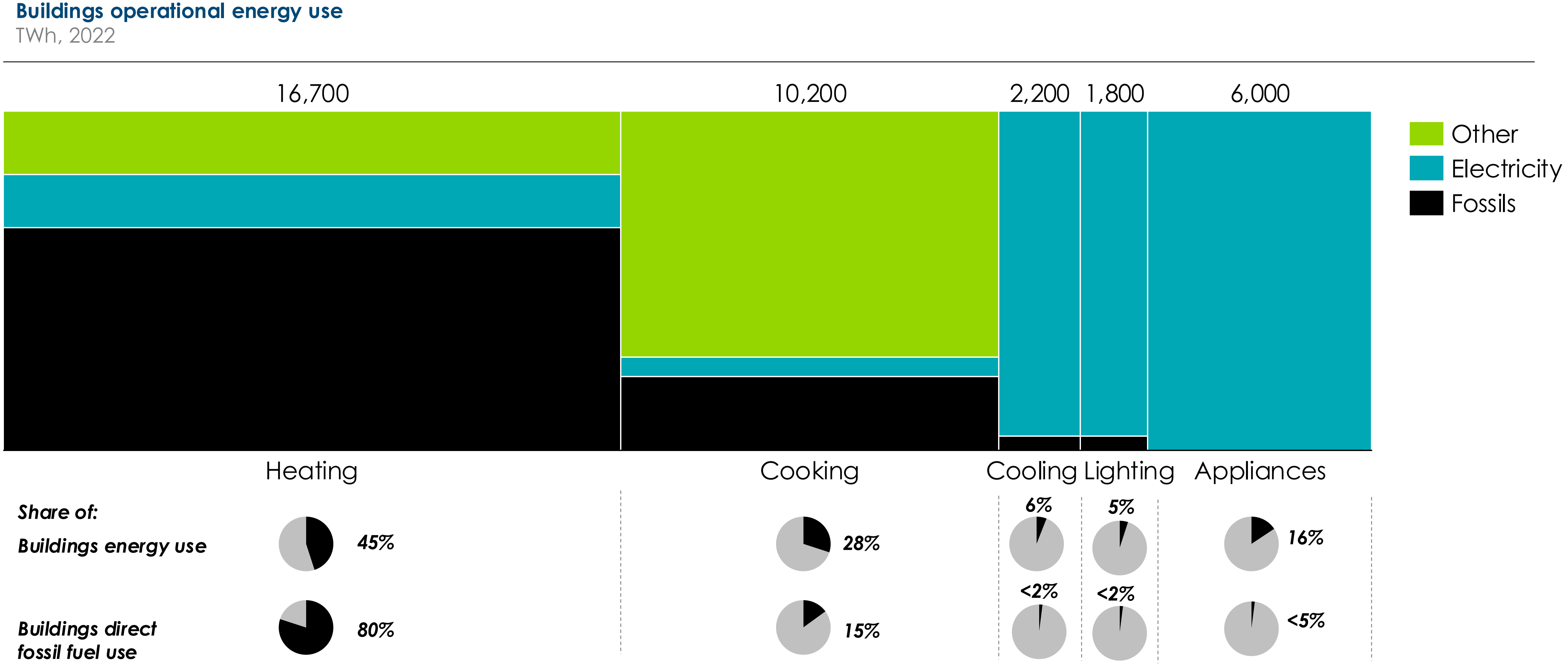
Sources: IEA (2023), *The energy efficiency policy package: key catalyst for building decarbonisation and climate action*

Heating accounts for 45% of global buildings energy use, but 80% of direct fossil fuel use; cooling, lighting and appliances are ~100% electrified

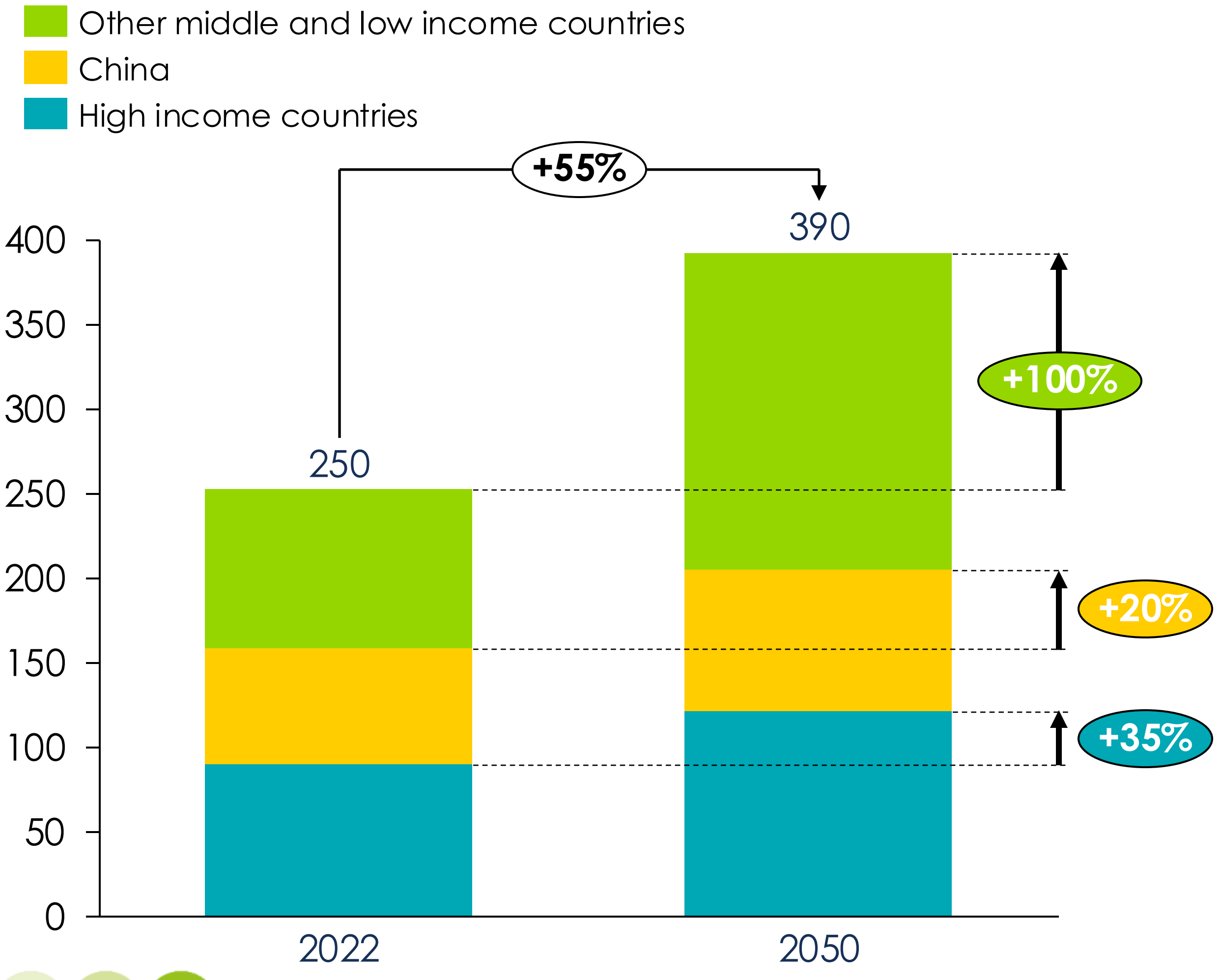


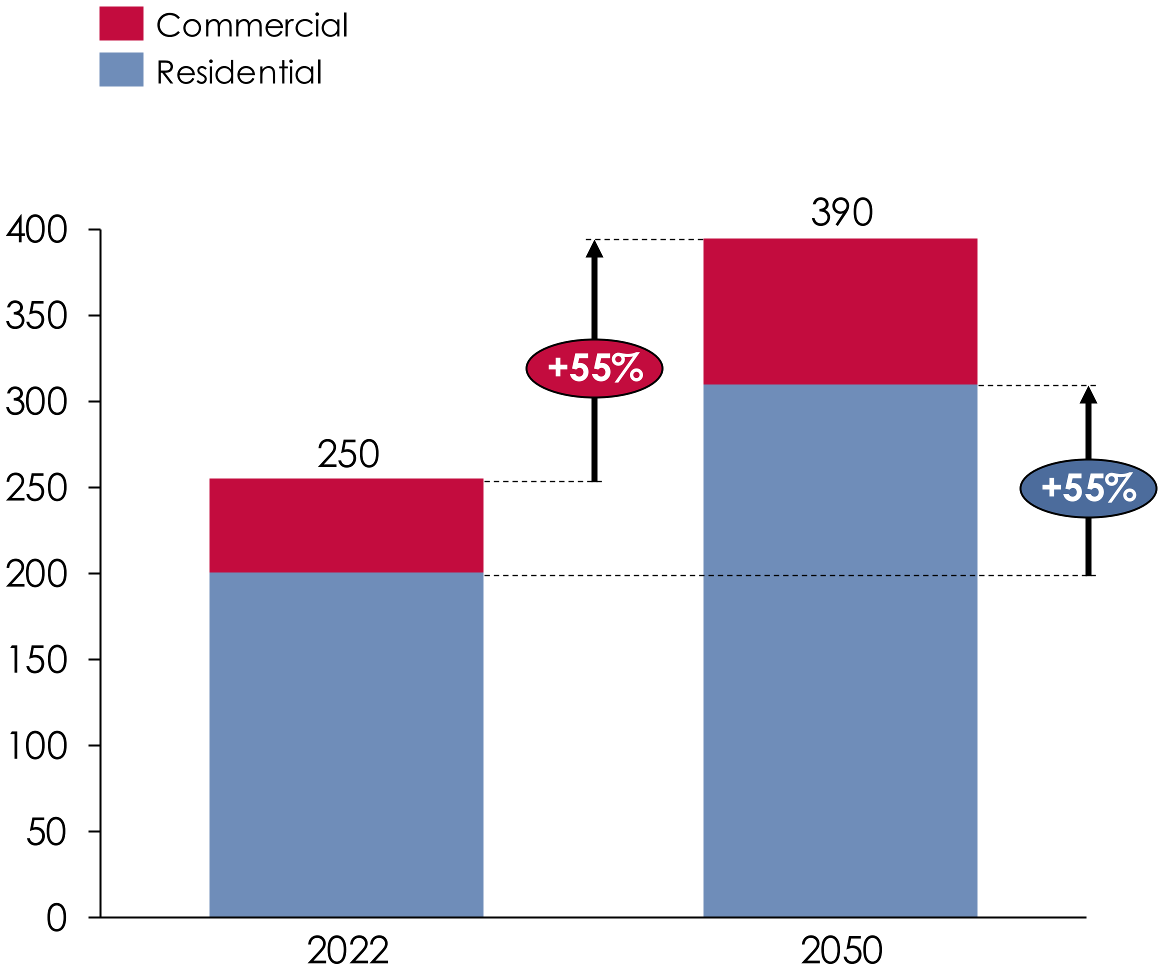
Source: IEA (2022), *World Economic Outlook 2021*; IEA (2023), *World Economic Outlook 2022*.
Note: Shares of building energy by end use from 2021 applied to 2022 actuals. Heating includes both space and water heating. Other includes district heat, renewables and traditional use of biomass.

Global floor area is set to increase by 50-60% by 2050, driven by a more than doubling of the building stock in middle- and low-income countries

Growth in global floor area by type

2022-2050; Billion m2; IEA NZE Scenario





Source: IEA (2023), *World Energy Outlook 2023.*

Section A: the net zero transition for operational energy use

Heating

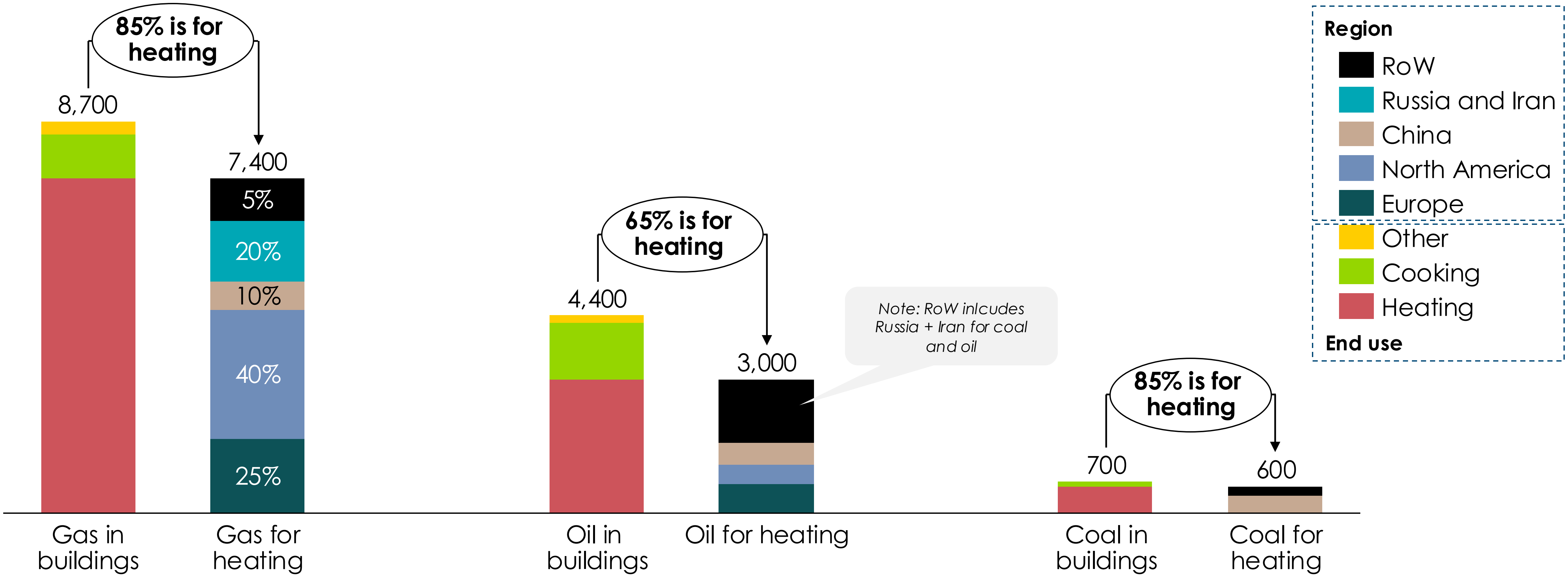
Key messages

- Building heating can and should be **almost entirely electrified**, primarily with heat pumps, either in individual homes or within heat networks which deliver a major technology development. There is, however, no one-size-fits-all solution; a range of technologies will be used to solve the challenges of specific building types and climates.
- **Hydrogen is not a viable alternative** to replace gas heating; it is much **less efficient** (e.g., green hydrogen would requiring 5-6 more electricity than heat pumps), would still require **substantial retrofit** to boilers and the gas network, and would **not be scalable** until the mid-2030s.
- **The insulation need for heat pumps has generally been overstated**, challenging the "fabric first" approach for the average existing building. In most cases, radiator upsizing and/or light insulation will provide sufficient comfort at a reasonable cost. Heat pump deployment should not be held back by an over rigid commitment to a fabric first approach…
- …However, the "fabric first" approach should **always be the default in new buildings** and in the **least efficient** properties.
- While not a pre-requisite for heat pumps, there is a suite of **passive heating** retrofits, many of which are relatively low-cost (e.g., DIY draught proofing) which can massively improve living standards, energy bills and ease peak energy demand

The building heating story is predominately one of how fast gas use in Europe, North America and Russia can be electrified

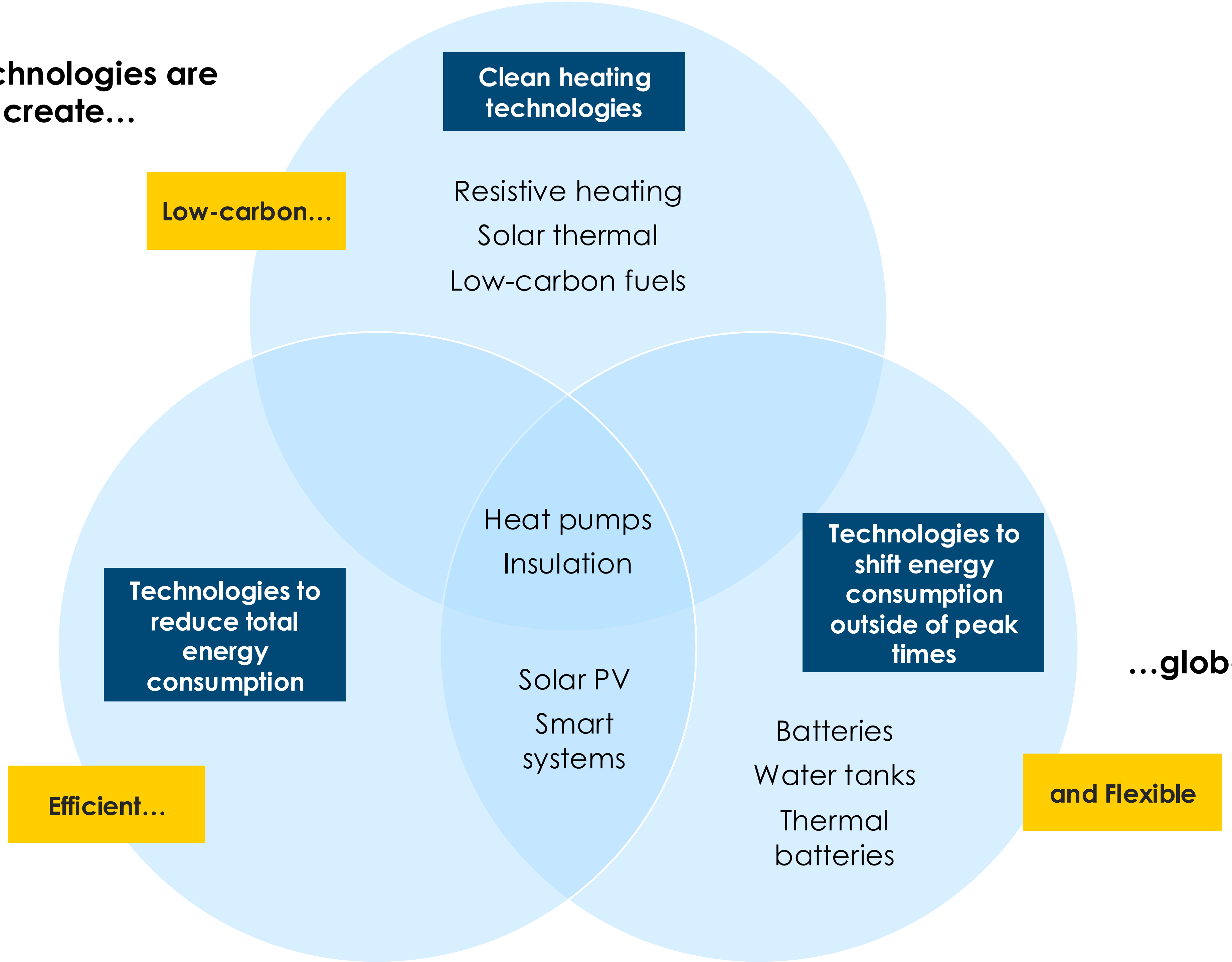
Fossil fuel use in buildings by end use and region
TWh, 2022

Total fossil fuel energy use for heating ~11,000 TWh



Source: ETC analysis for Systemiq (2023) of IEA (2022), *World Economic Outlook 2021*; IEA (2023), *World Economic Outlook 2022*; IEA (2023), *World Energy Balances dataset*; IEA (2023), *Energy Efficiency dataset*; Tsinghua Building Energy Research Center, *Annual Report of Building Energy in China.*
Note: Heating includes both space and water heating. Other includes building cooling, lighting and appliances.

3 sets of technologies are required to create…

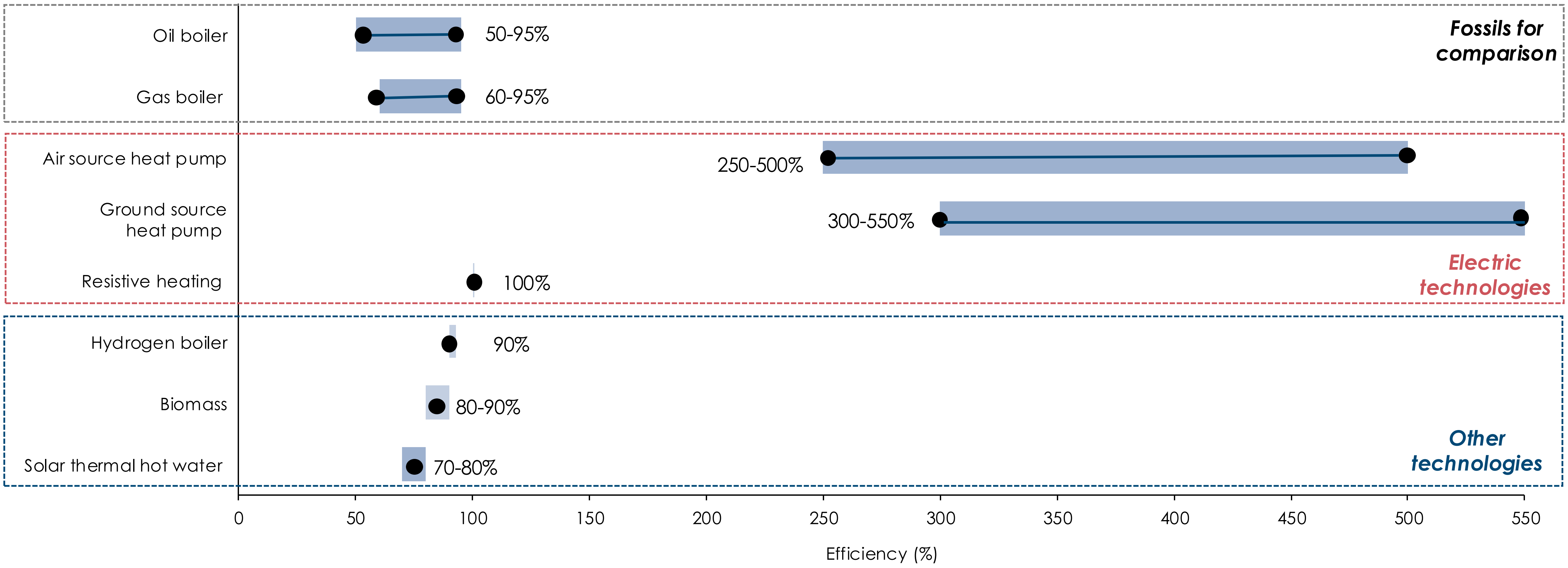


…global buildings

Clean heating technologies

Heat pumps are 3-5 more efficient than a gas boiler, while resistive heating converts 100% of electric energy to heat

Efficiency of space heating technologies
%



Sources: Systemiq analysis for ETC (2024); IEA (2022), *Future of Heat Pumps*; IRENA (2022), *Heat Pump Market and Costs;* IEA (2021) *NZE.*; IEA (2023), *Energy Efficiency Database*.

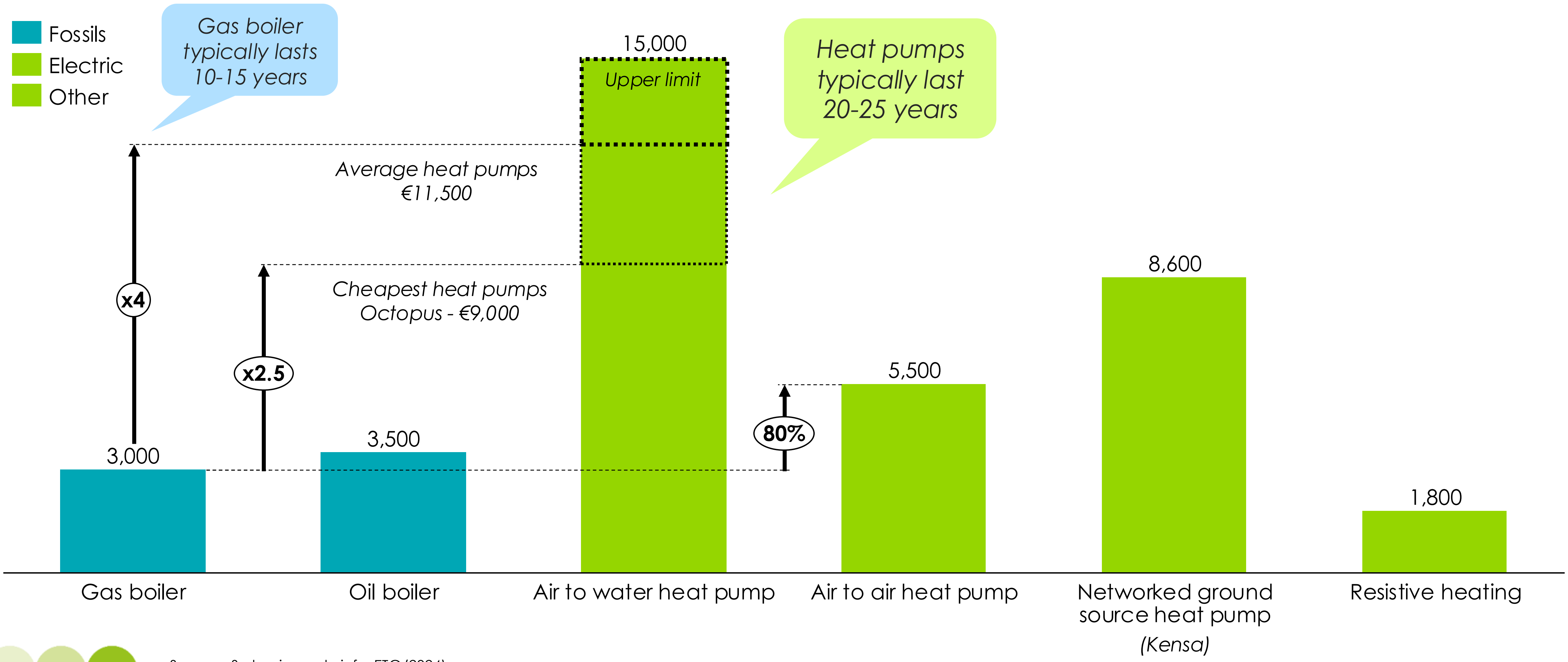
Heat pumps are not just one technology – there are a number of different types depending on the heat source and heat sink

	Description	Cost (relative to other heat pumps	Efficiency (relative to other heat pumps)	Can it deliver cooling?	Can it be integrated into wet heating systems?
Air-to-air	A reverse AC which blows hot air into a room	Lowest	Medium COP of 3-5	Yes – if heat pump is reversible	No
Air-to-water	Heats water which is circulated via radiators	Medium	Lowest COP of 3-4	No	Yes
Ground-source **Water-source**	Extracts heat from the ground or water – can be delivered to a room via hot air or hot water	Highest	Highest COP of 5-6	Yes (ground)	Yes
Networked ground source	Heat extracted from the ground via a shared ground array, to induvial heat pumps in homes	Medium	Highest COP of 5-6	Yes	Yes

Air-to-water heat pumps cost ~4 times more than gas boilers to install, but have a longer asset lifetime; resistive heating has the lowest upfront capex cost

Average capex cost in Europe (technology and installation)

€



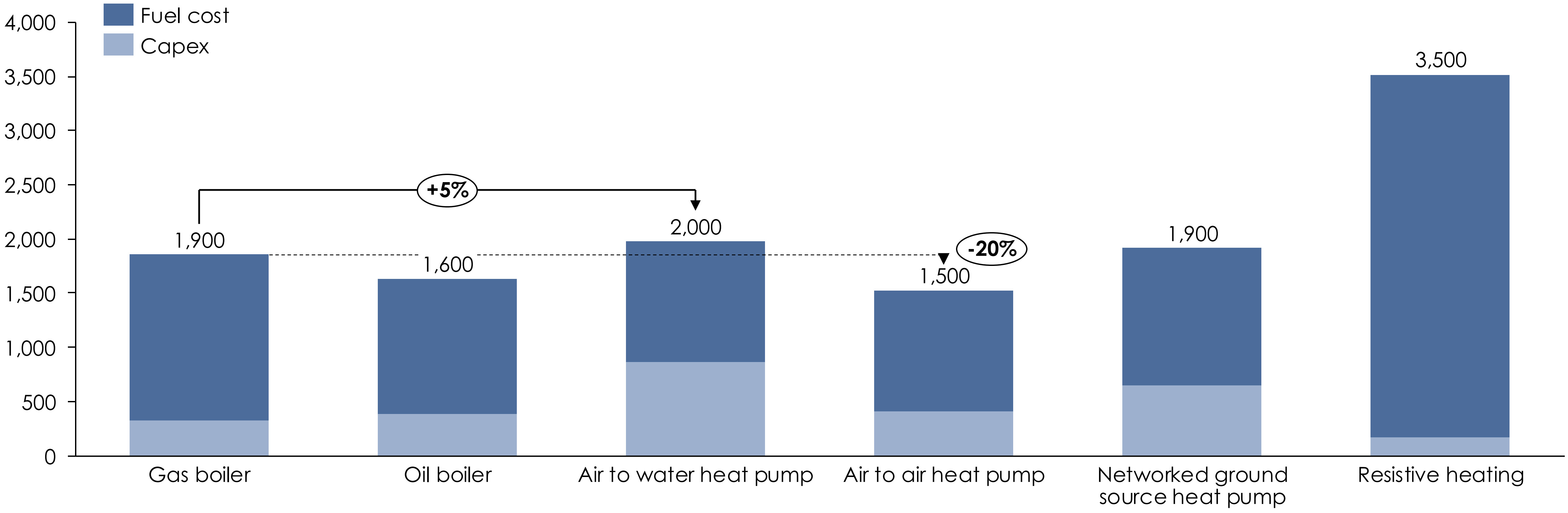
Sources: Systemiq analysis for ETC (2024).

Note: figures presented represent the average of costs from ETC literature review. Costs do not include the cost of retrofit measures or any subsidies.

At European prices and on a total cost of ownership basis, air-to-water heat pumps with an average efficiency of 300% are virtually cost competitive with gas boilers today

Equivalent annual cost of ownership (technology + installation and running costs) – European average
€ per year

Assumes electricity prices are 2.5x higher than gas



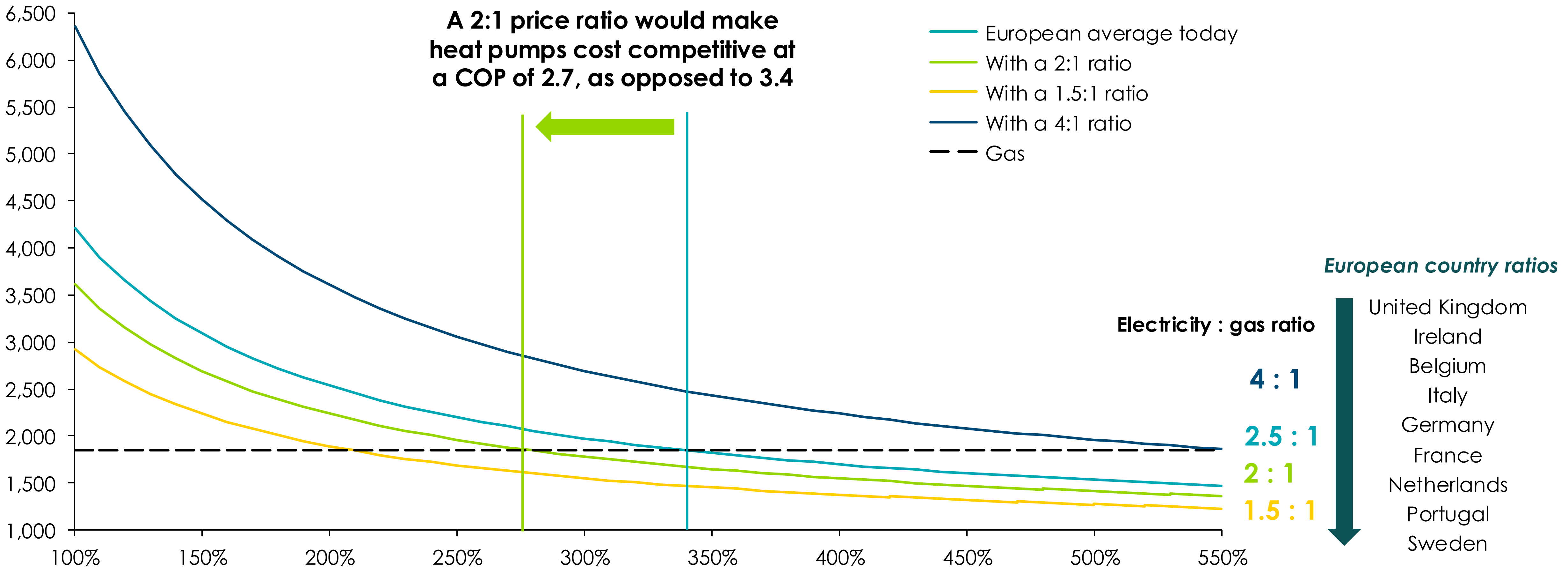
Efficiency assumption	Gas boiler	Oil boiler	Air to water heat pump	Air to air heat pump	Networked ground source heat pump	Resistive heating
	90%	**90%**	**300%**	**300%**	**500%**	**100%**

Fossils / Electric / Other

Sources: Systemiq analysis for ETC (2024); Eurostat for Europe electricity and gas prices.
Note: Assumes an average heat demand of 11,500 KWh a year per household, based on an average across the US and select European countries. Fuel prices reflect averages from 2023; no carbon price on gas is assumed. Assumes 5% discount rate. Excludes subsidies or any other cost (e.g., retrofit or maintenance).

The smaller the differential between gas and electricity prices, the lower efficiency a heat pump needs to achieve for cost parity

Equivalent annual costs (capex + fuel costs) at different electricity to gas price ratios
€ a year

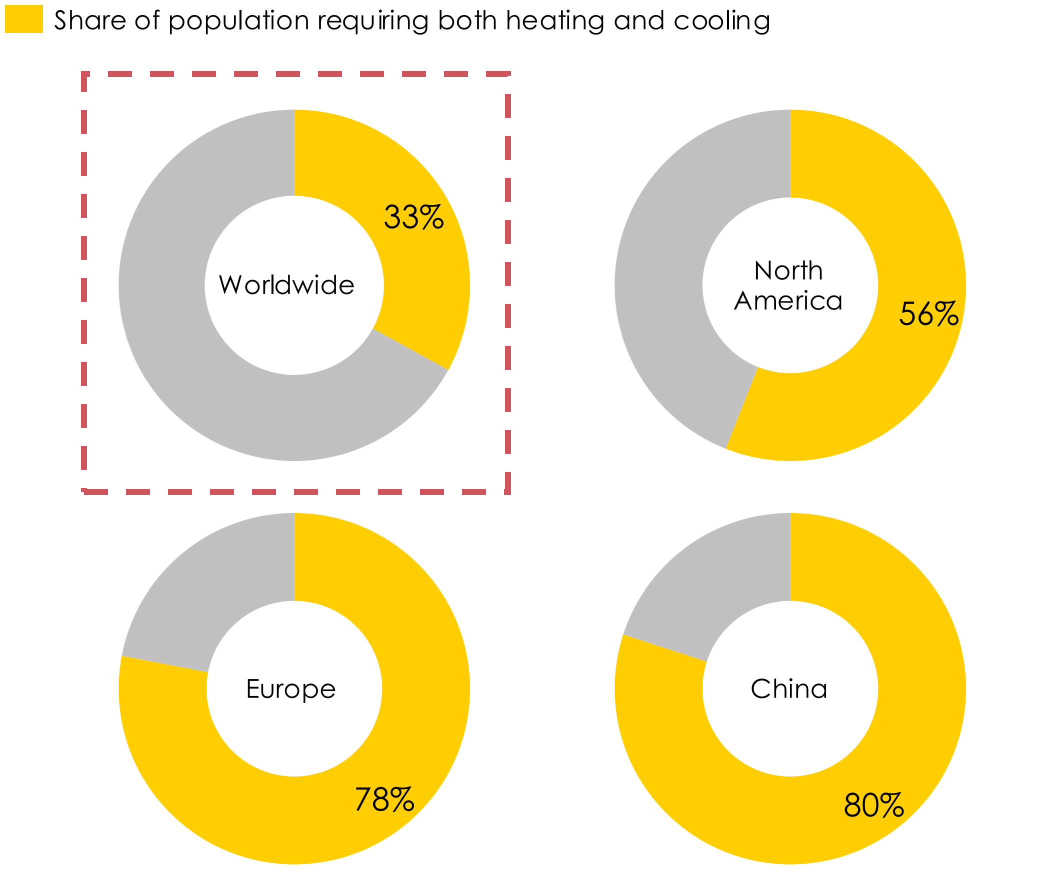


Sources: Systemiq analysis for the ETC (2023); Eurostat for Europe electricity and gas prices; Energy Information Administration for US prices.
Note: Assumes an average heat demand of 11,500 KWh a year per household, based on an average across the US and select European countries. Fuel prices reflect averages from 2023. Assumes a discount rate of 5%.

When accounting for both heating and cooling energy consumption, air-to-air heat pumps are increasingly cost competitive with gas boilers, as it avoids a second capex cost for AC

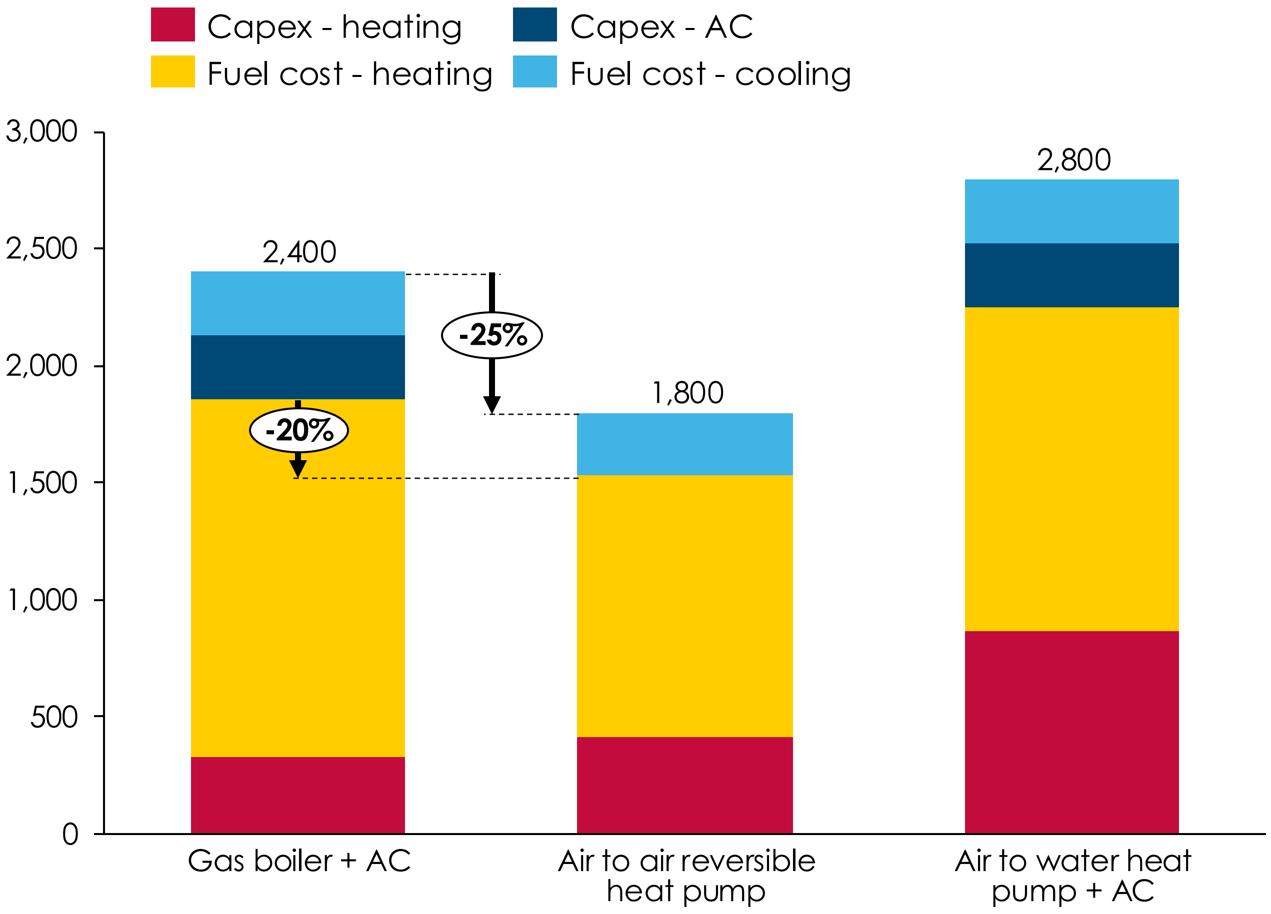
Share of population requiring both heating and cooling over the course of a year

%, 2020



Equivalent annual cost of ownership (technology + installation and running costs) – European average

€ per year



Sources: Systemiq analysis for ETC (2024); Eurostat for Europe electricity and gas prices; Odyssee-Mure (2021), *Unit consumption of air conditioning;* IEA (2020), *Is cooling the future of heating?*

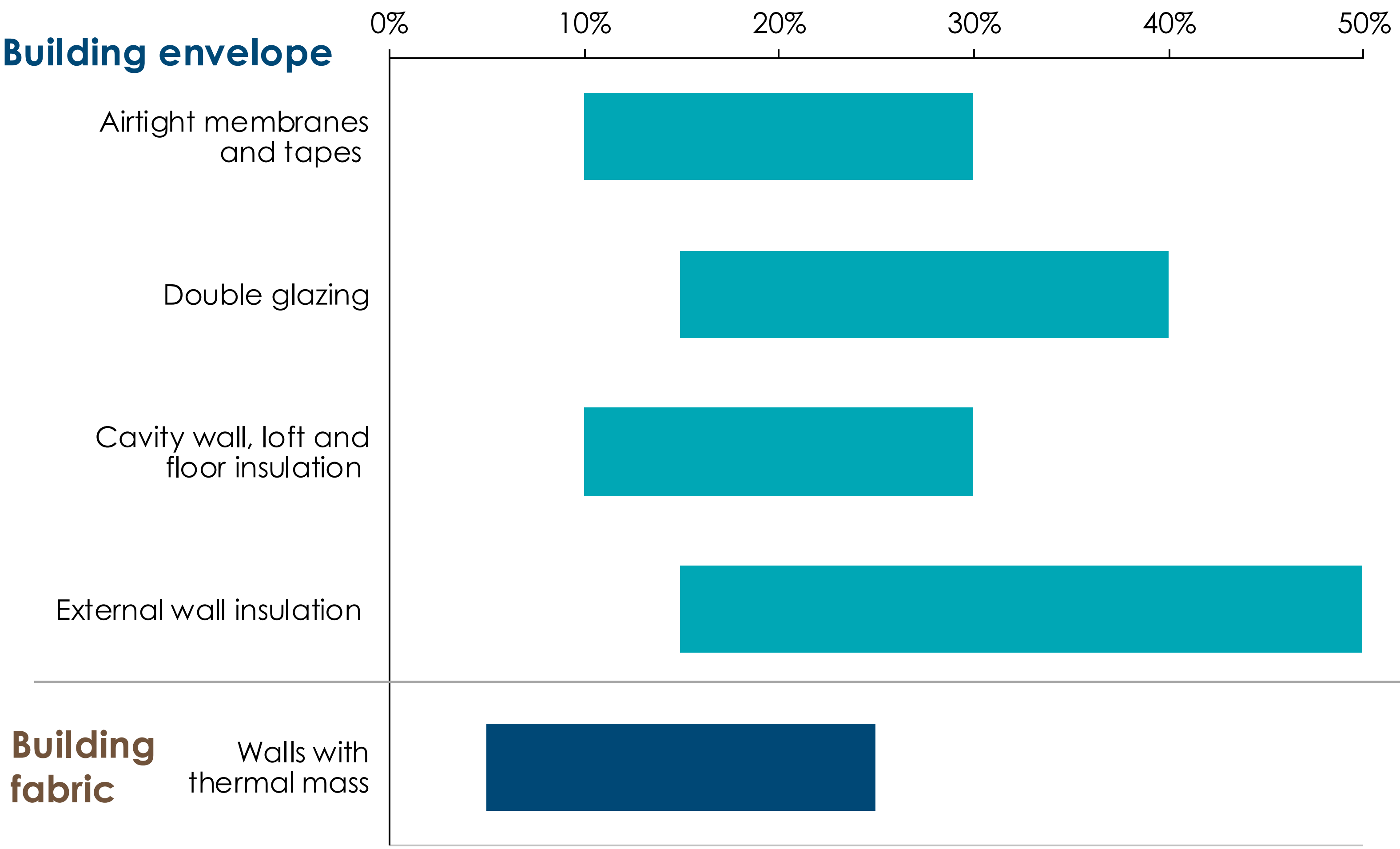
Note: Assumes an average heat demand of 11,500 KWh a year per household, based on an average across the US and select European countries. Fuel prices reflect averages from 2023; no carbon price on gas is assumed. Assumes 5% discount rate. Cooing annual energy consumption based on Greece, Cyprus and Malta. Cooling efficiency assumed at 300%.

Passive heating

Passive techniques in new buildings can reduce heating energy consumption by 15-30% on average

Heating energy consumption reduction by passive techniques

%, based on an average single-family house of 100 m2



	Expected average cost to developer ($ 000s)	IRR (assessment of developer costs and household energy bill savings in Europe)
Airtight membranes and tapes	Low 0.5 - 2	High 20%
Double glazing	Medium 2.5 - 5	Medium 5%
Cavity wall, loft and floor insulation	Medium 0.5 – 1.5	High 30%
External wall insulation	High 1 - 5	High 30%
Walls with thermal mass	High 2.5 – 10	Low <5%

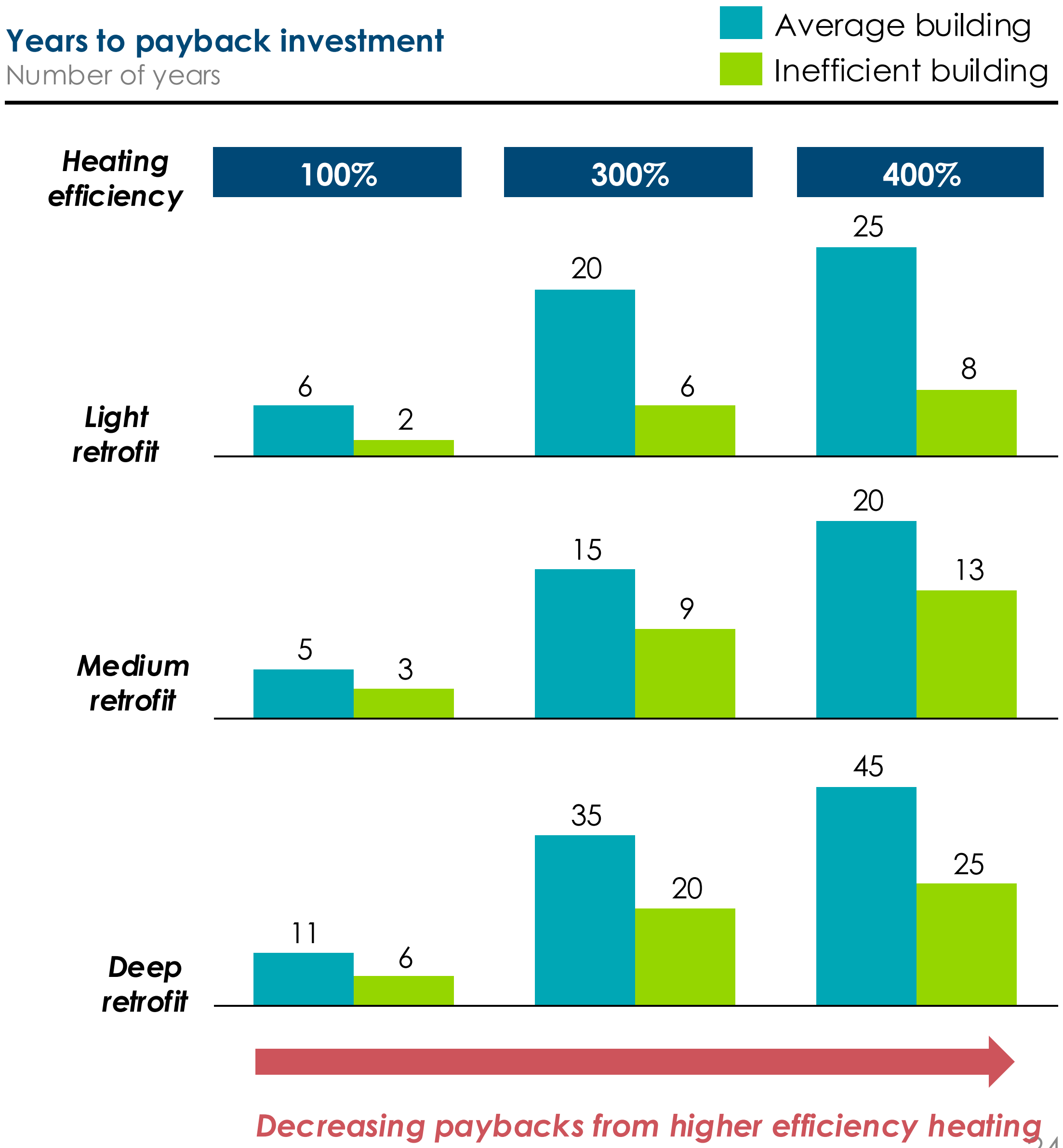
Sources: Systemiq analysis for the ETC (2023); Energy Saving Trust; Checkatrade; The Eco Experts; Department of Energy and Climate Change (2014), National Energy Efficiency Data-Framework; Kattenberg, L., et al. (2023), The Efficacy of Energy Efficiency: Measuring the Returns to Home Insulation; Adan, H.,Fuerst, F. (2016), Do energy efficiency measures really reduce household energy consumption? A difference-in-difference analysis. Energy Efficiency 9, 1207–1219; Hamilton, I., et al. (2013), Energy Efficiency in the British Housing stock; Tuohy et al. (2005), Thermal mass, insulation and ventilation in sustainable housing - An investigation across climate and occupancy. Note: IRR analysis assumes a discount rate of 5% over 50 years.

There is a clear opportunity for light and medium insulation in inefficient buildings, but without government support, the average household is unlikely to invest in deeper insulation

Illustrative cost and energy savings for different insulation options

	Light	Medium	Deep
	Draught proofing, loft insulation	*Cavity wall, floor insulation*	*External wall insulation, double glazing*
% reduction in energy consumption	€1,000	€2,500	€10,000
Average property	5%	15%	25%
Very inefficient property	15%	25%	50%

Years to payback investment
Number of years



The "Fabric first" approach should always be the strategy in new builds, but there is growing recognition that this may not always be the right approach for existing buildings

Fabric first approach

1. **Building fabric improvements**
2. **Heating system changes**

What's changed?

1. **Urgency of net zero timelines:** retrofits are lengthy + skills shortages → we don't have time for every property to retrofit before replacing their gas boiler
2. **Relative gas / electricity prices:** higher gas prices have reduced the electricity/gas ratio reducing the need for retrofit for electric solutions to be cost-effective; with appropriate power market design that enables renewables to set electricity prices, this ratio should fall further
3. **Carbon intensity of electricity:** this has declined in many countries with a heating challenge, so replacing a gas boiler is by far the most important measure

Is this still the right strategy?

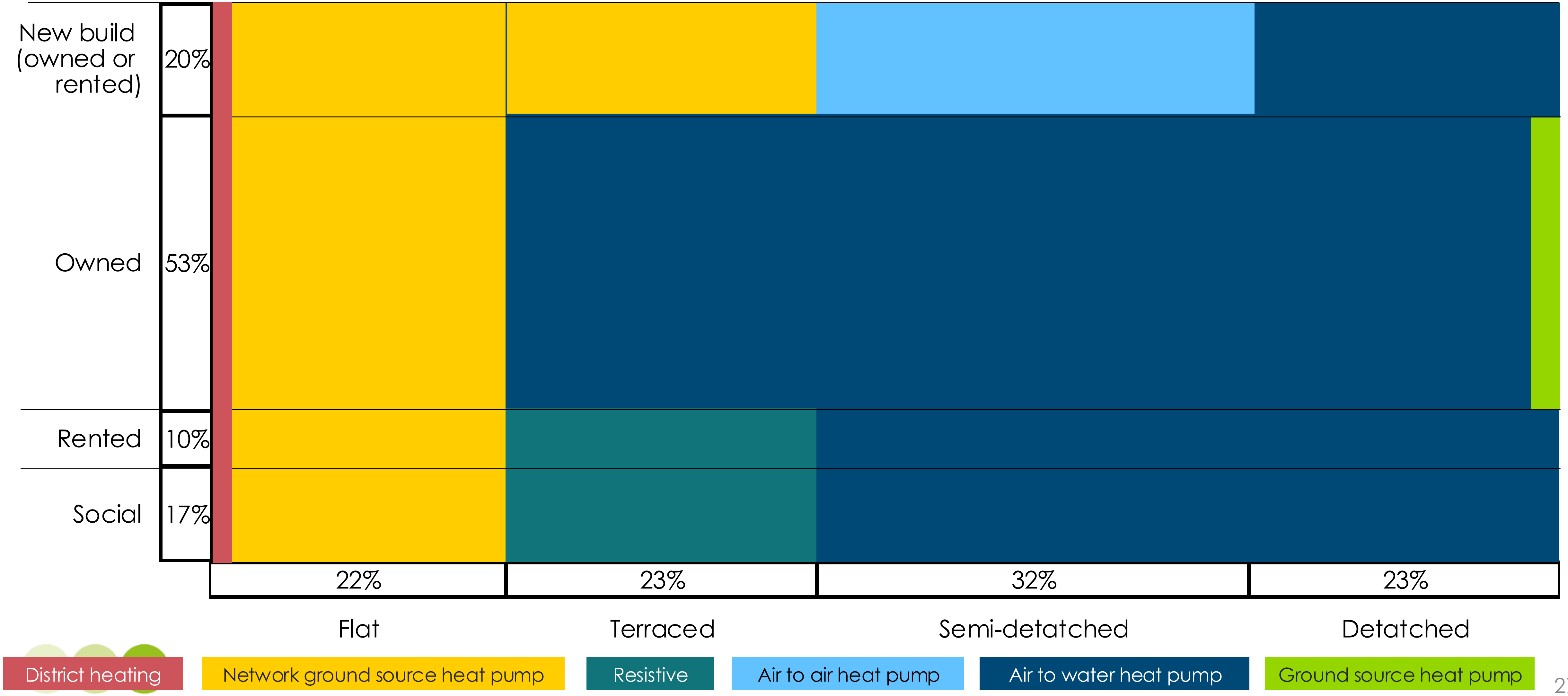
New builds + extensions	In the least efficient properties and where low-cost efficiency measures can be deployed	The average property
Always ✓	In most cases ✓	No ✗

Implications for technologies and energy demand

While it is not possible to estimate an exact technology, there is huge value in understanding the broad trajectory of the transition to guide policy, investment and skills

Illustration of probable dominant solution across different building archetypes and ownership – UK

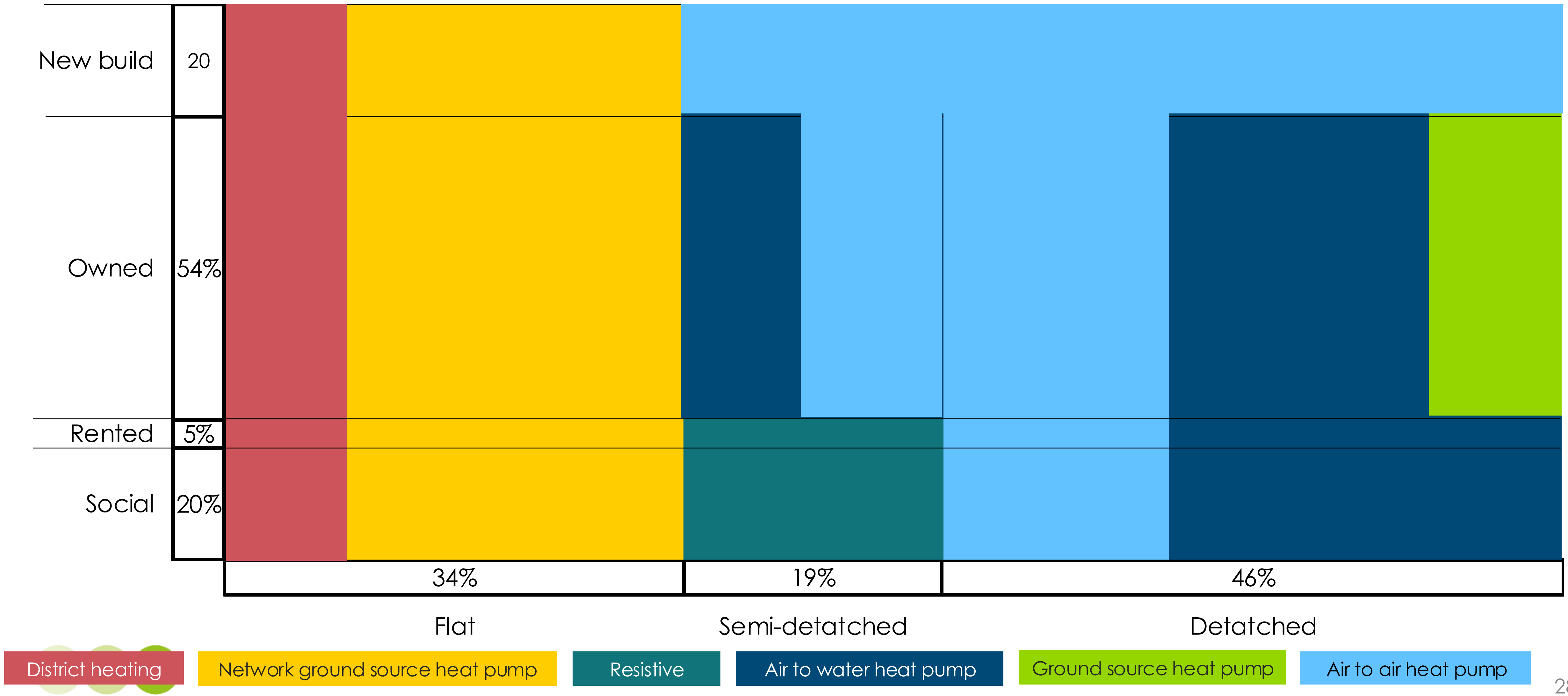
% of stock in 2050



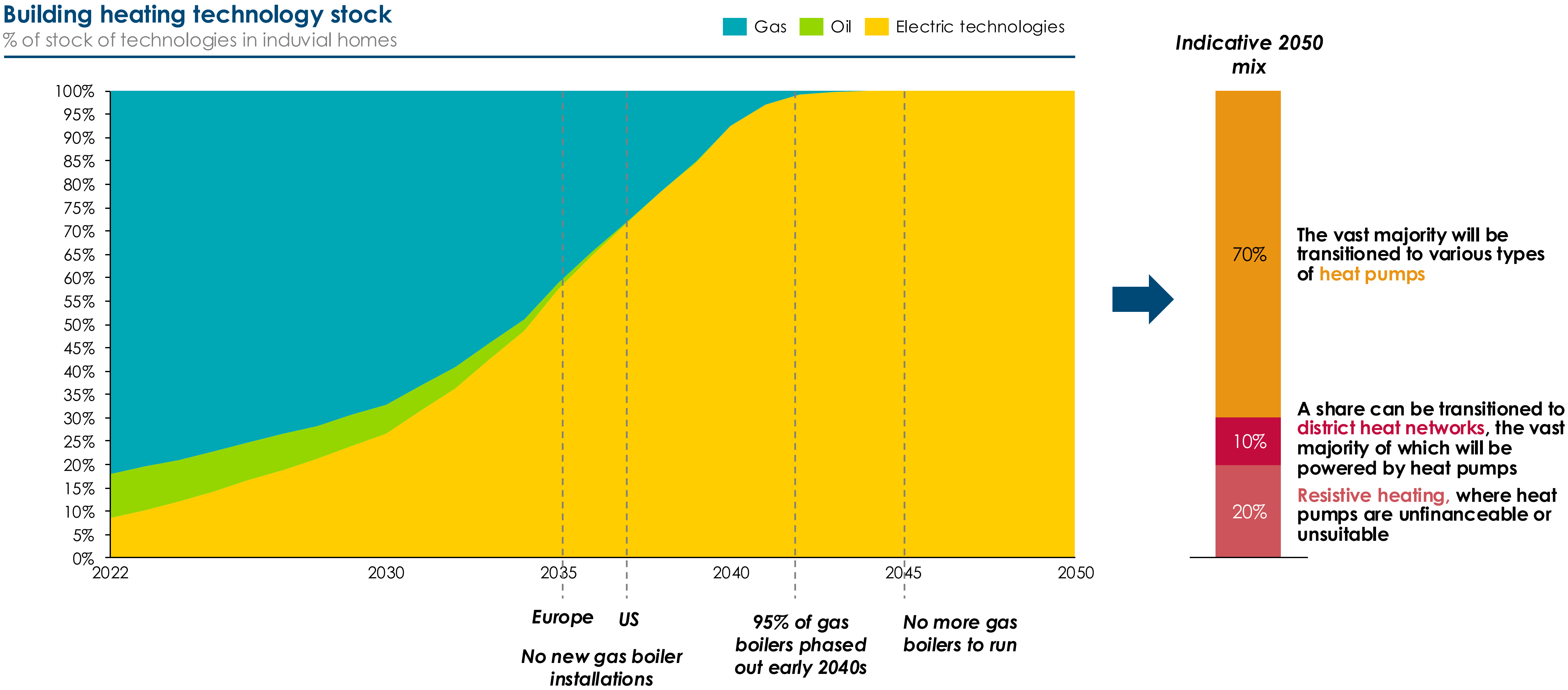
In France, cooling needs could see more air-to-air heat pumps and existing district heating capabilities can be built upon

Illustration of probable dominant solution across different building archetypes and ownership – France

% of stock in 2050



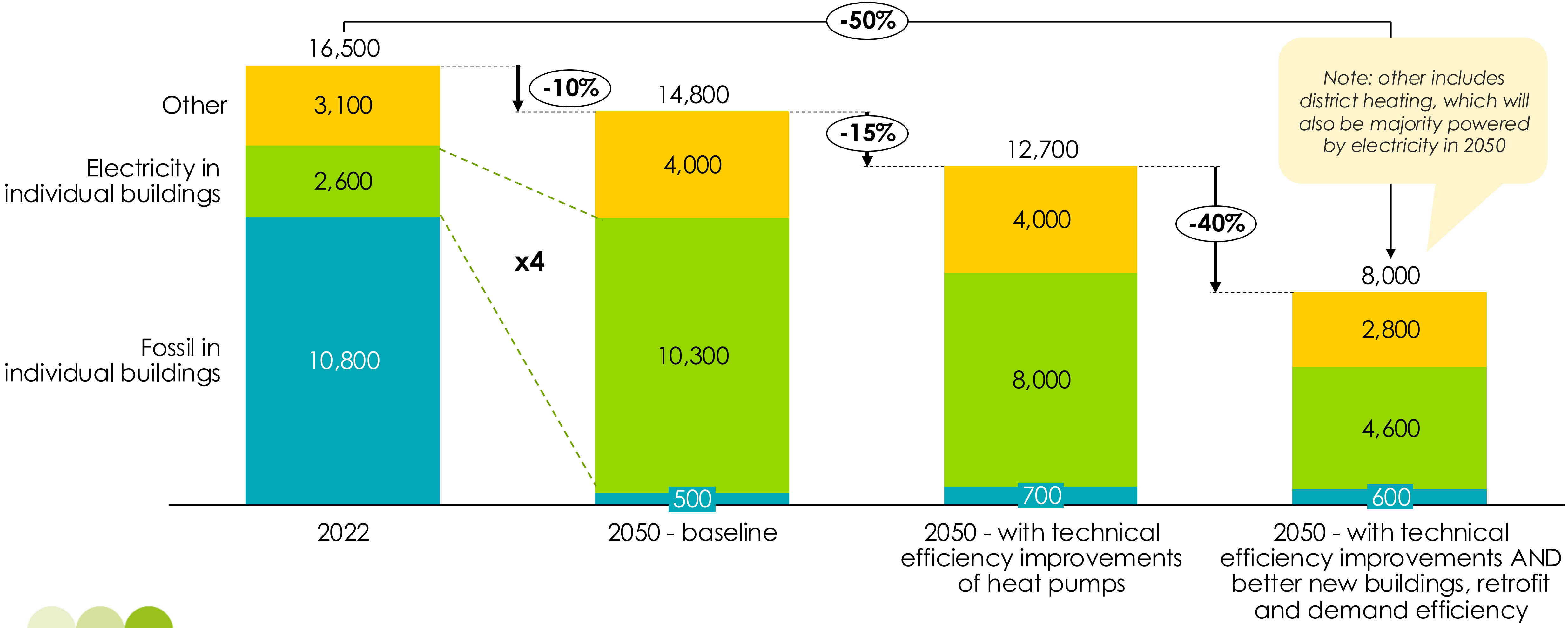
In Europe and the US, 95% of gas boilers could be phased out by the early 2040s, with no more gas boilers to run by 2045



Source: Systemiq analysis for the ETC; IEA (2022), *World Energy Outlook 2022*; IEA (2023), *World Energy Outlook 2023*; IEA (2023), *World Energy Balances dataset*; IEA (2023), *Energy Efficiency dataset*; Tsinghua Building Energy Research Center, *Annual Report of Building Energy in China*.

Electricity demand from heating could be 4 times higher than it is today, but with strong action on energy productivity, the increase could be less than double

Final energy demand for heating by fuel, global
TWh

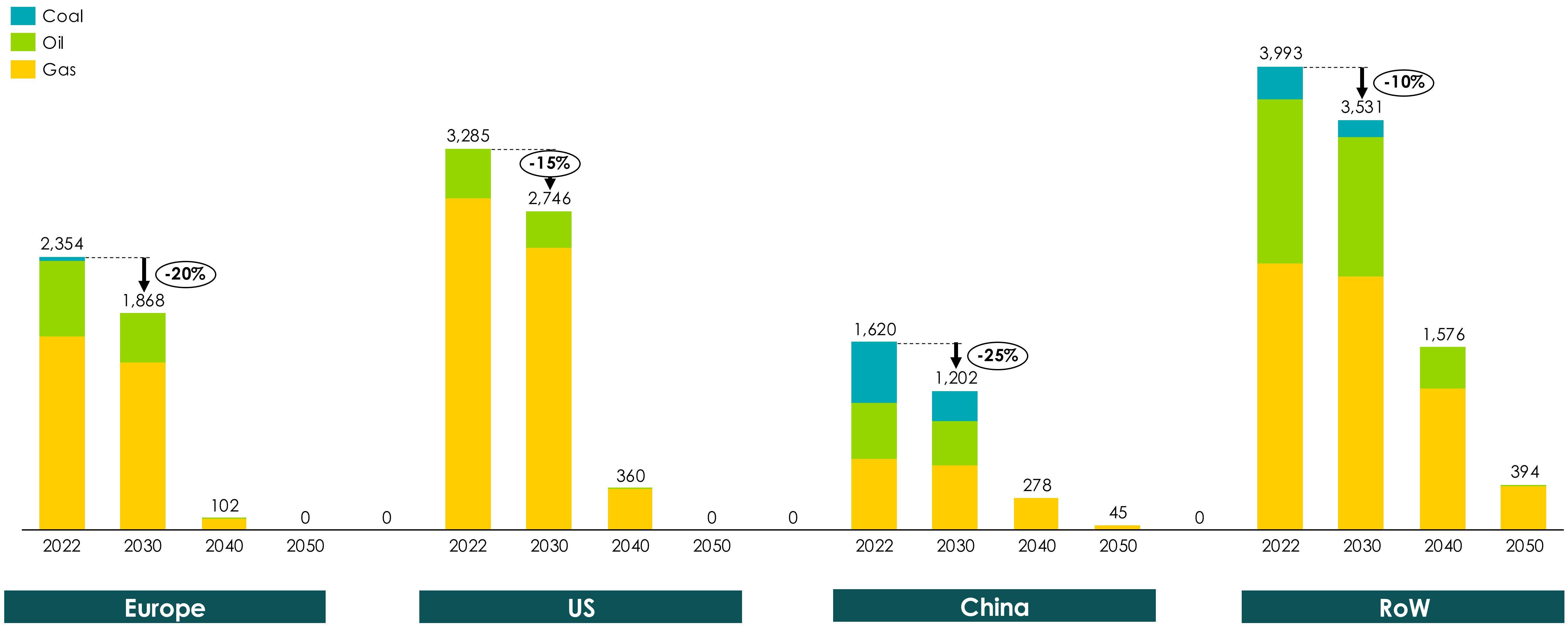


Sources: Systemiq analysis for the ETC (2024); IEA (2023), World Energy Outlook 2023; IEA (2021), *Net Zero by 2050.*
Other includes district heating and renewables

Fossil fuel demand for building heating could fall by 10-25% across different regions by 2030, with falls of over 90% by 2040 in Europe and the US

Fossil fuel demand for building heating

TWh



Note: Values are rounded.

Source: Systemiq analysis for the ETC; IEA (2022), *World Energy Outlook 2022*; IEA (2023), *World Energy Outlook 2023*; IEA (2023), *World Energy Balances dataset*; IEA (2023), *Energy Efficiency dataset*; Tsinghua Building Energy Research Center, *Annual Report of Building Energy in China*.

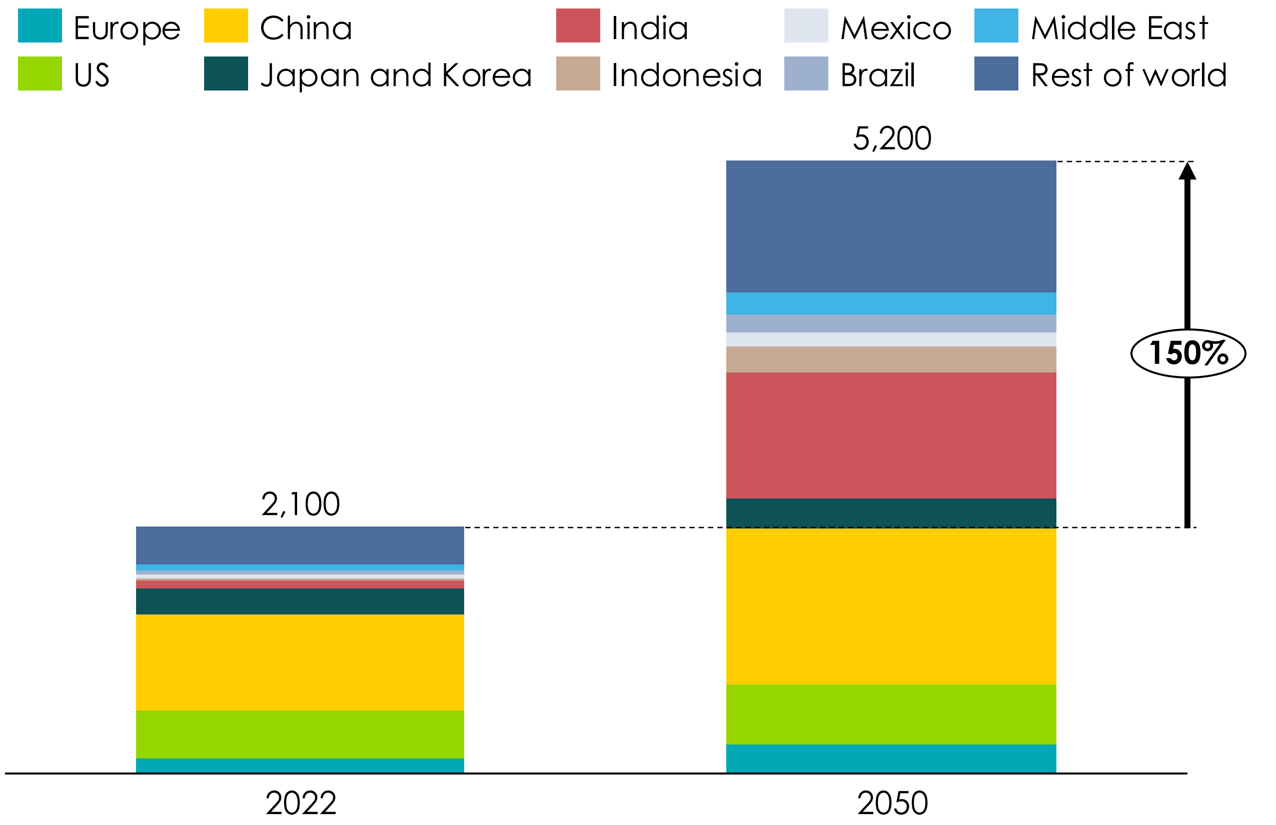
Cooling

Key messages

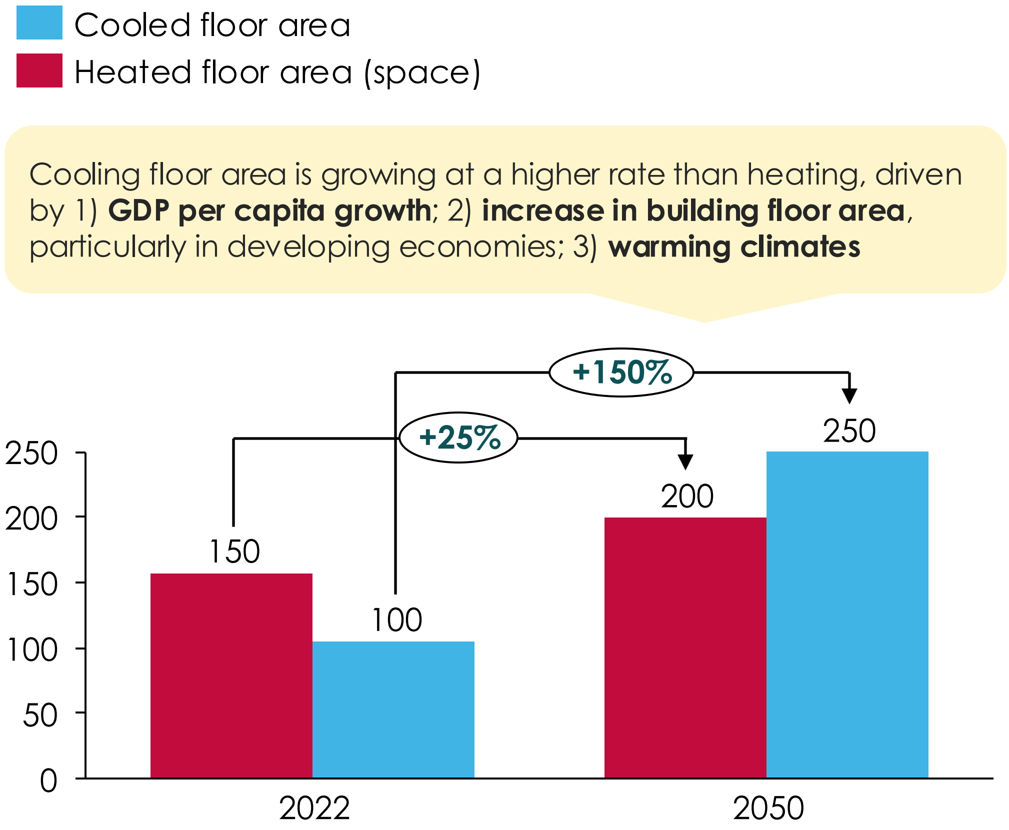
- Demand for cooling is set to **more than double** by 2050 from 2,000 TWh to 5,000 TWh, but current projections may actually be **underestimating the potential increase**
- Air conditioning will be by far the dominant cooling technology, but we are **potentially at the start of innovation** in space cooling technologies, for example evaporative cooling and the combination of dehumidifiers**.**
- **Passive cooling and better urban planning** can reduce a building's cooling energy needs by **25-40%**. Many of these are **low-cost**, such as external shading by planting trees and painting roofs white. Getting this right in new buildings is critical; better building codes **could reduce global electricity needs for cooling by around 20%.**
- AC use will exacerbate urban island heat effects - the more that cooling needs can be reduced by passive cooling, the greater the benefits for electricity grids, health and equality.
- The **single most effective lever** to reducing electricity needs for cooling is to improve the **efficiency of the stock of ACs**, with the market average sold today being far below the best available technology. Combined with behaviour change (e.g., turning thermostats up to reasonable levels), this could **more than offset** the increase in demand.

Cooling is the fastest growing building energy use, with cooled floor area set to overtake heated floor area by 2050

Space cooling (residential + commercial) energy consumption by region, IEA baseline scenario, 2022-50, TWh



Heated floor area vs cooled floor area (residential + commercial) 2022-50 Billion m2; IEA NZE Scenario



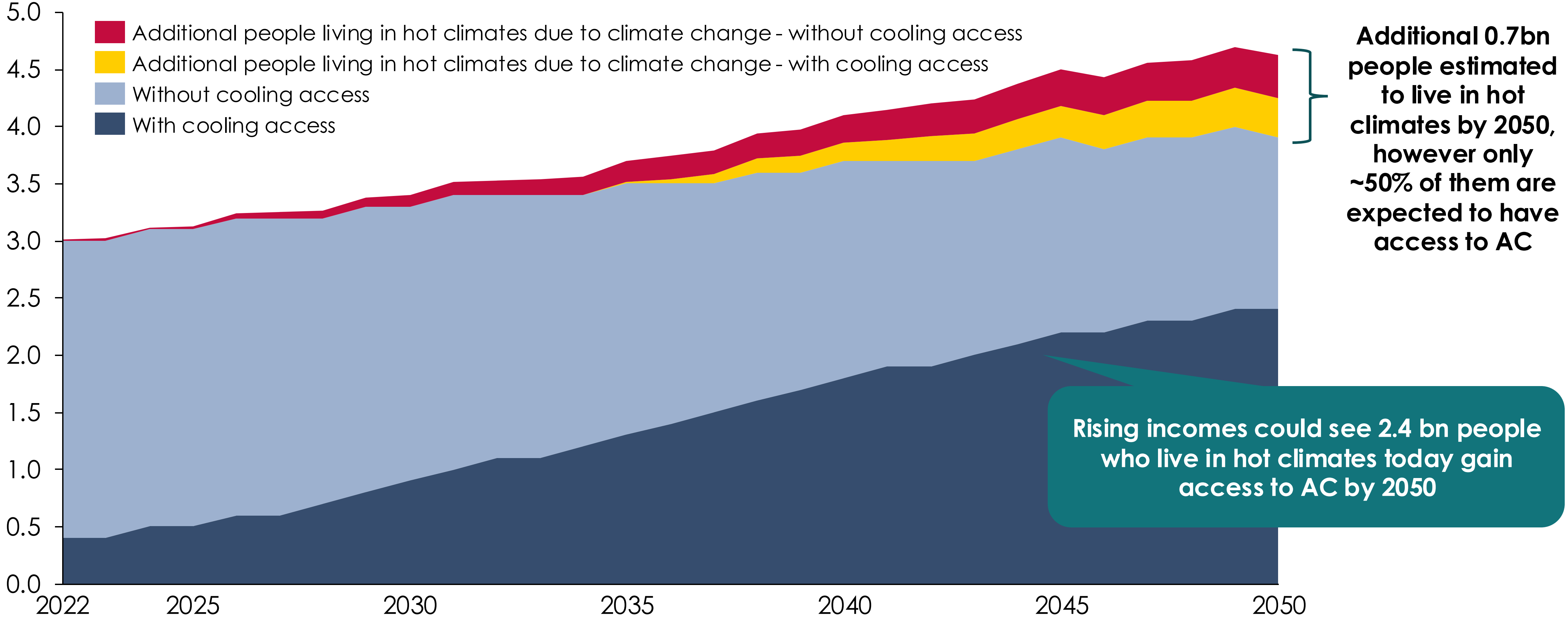
Rapid growth in cooling demand in countries with dirtier electricity grids highlights the impetus to rapidly scale up renewables across the world

Source: IEA (2023), *World Energy Outlook 2023*

Note: We use IEA numbers on year 2020 and 2022 and linear interpreted the forecasted figures based on IEA graphs and models, using IEA AC stock projections to derive regional split. The IEA AC stock data originally classify regions as United States, China, Japan and Korea, European Union, India, Indonesia, Mexico, Brazil, Middle East and Rest of world

Climate change will result in additional 0.7 billion people needing cooling by 2050, yet more than 40% of people living in hot climates are expected to have no access to cooling

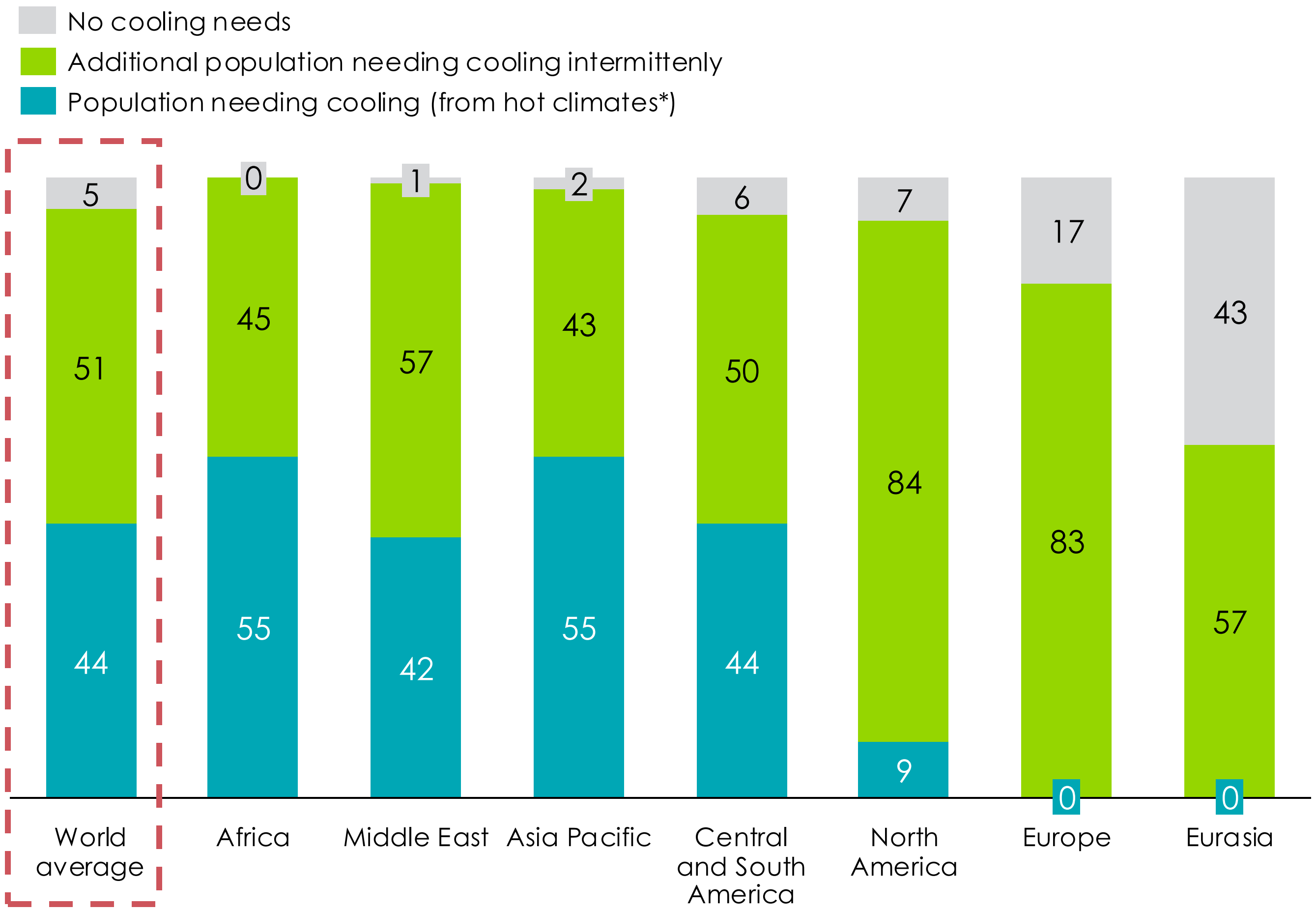
Population living in hot climates with and without access to AC, and estimated additional people due to climate change
Billion people



IEA (2019), *Helping a warming world to keep cool*
Note: A climate is assumed to be "hot" when the sum total of the difference between the daily mean outdoor temperature and the base temperature of 10°C (cooling degree days with base temperature of 10°C) adds up to at least 5 000 over the course of one year

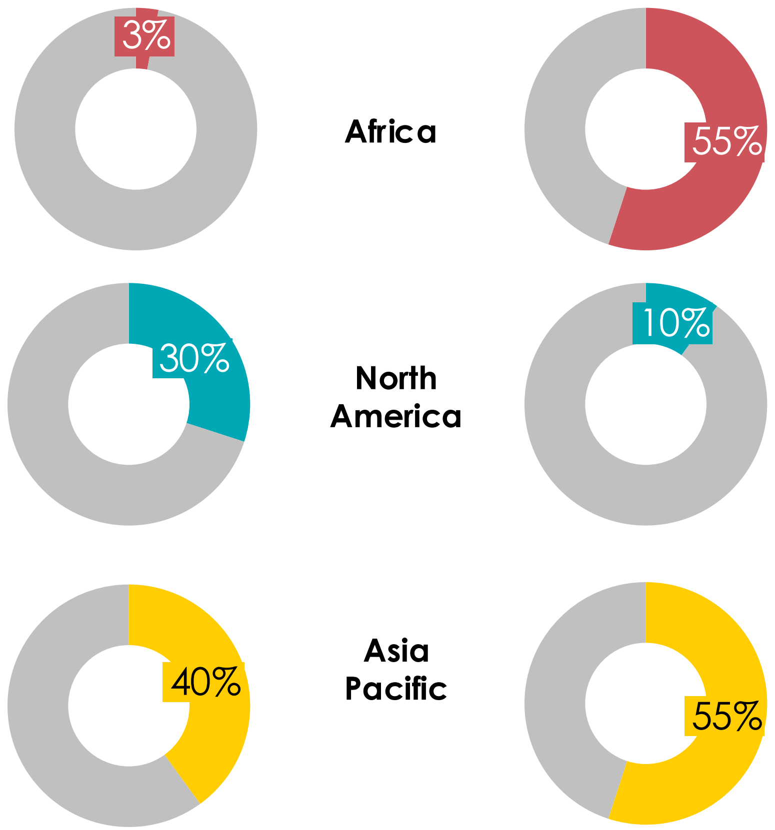
Nearly half of the global population live in hot climates, but lots of this cooling need is unmet – Africa accounts for just 3% of global cooling energy

Share of population living in a hot climate and share of additional population requiring cooling intermittently, 2022
%



Share of global cooling energy consumption, 2022

Share of population living in hot climate, 2022

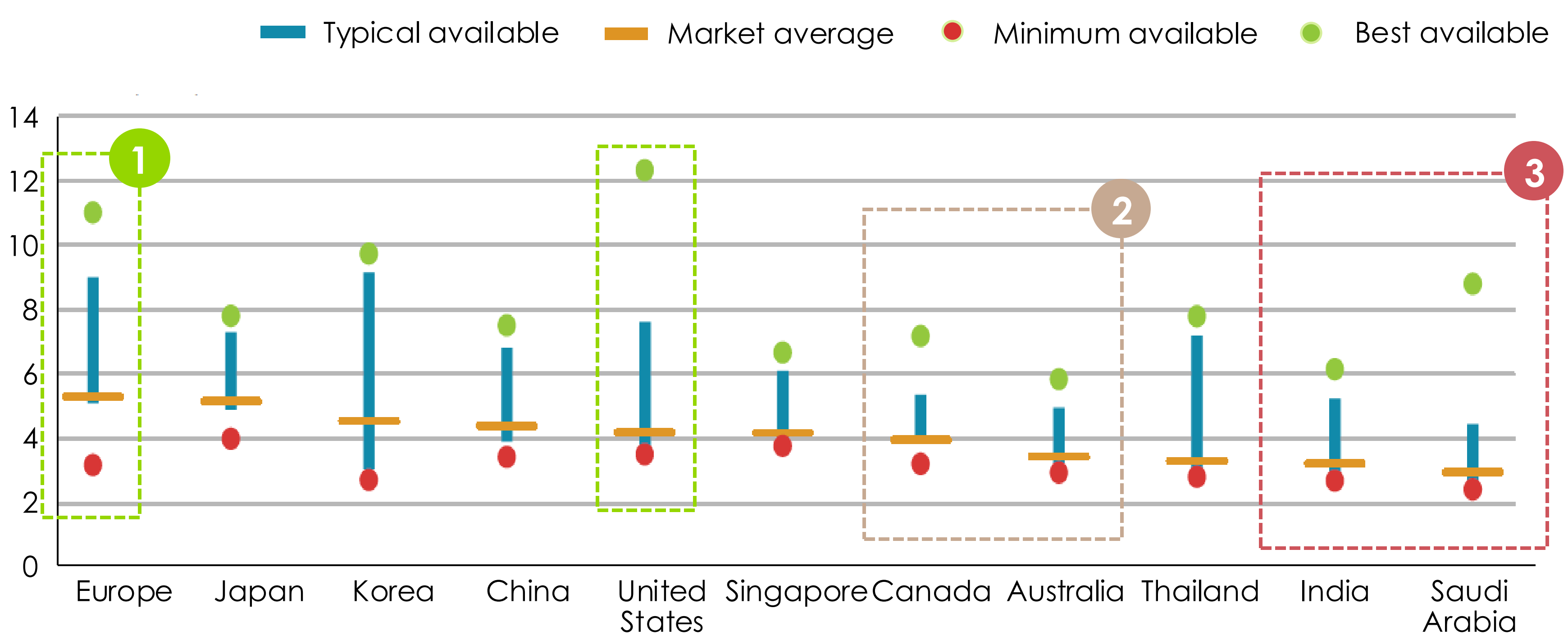


Source: IEA (2022), *Share of population living in a hot climate*; IEA (2020), *Is cooling the future of heating?*
Note: Similar to HDD, CDD is an index measuring the amount of energy required for cooling. A climate is assumed to be "hot" when the sum total of the difference between the daily mean outdoor temperature and the base temperature of 10°C (cooling degree days with base temperature of 10°C) adds up to at least 5 000 over the course of one year

There is a huge opportunity to increase the average efficiency of ACs on the market, with the best available technology typically twice as efficient as the market average

SEERs of market available residential AC units in selected regions, 2018

SEER, Watt of output per Watt of input



1 There is a substantial ambition gap in European and US regulation – the market average is ~3 times less efficient than the best available tech

2 Some developed countries, such as Australia and Canada, have low market average. Improvements in developed markets could drive progress in less developed countries

3 Countries with lower average efficiencies tend to be ones with weaker regulations but also those with higher cooling needs

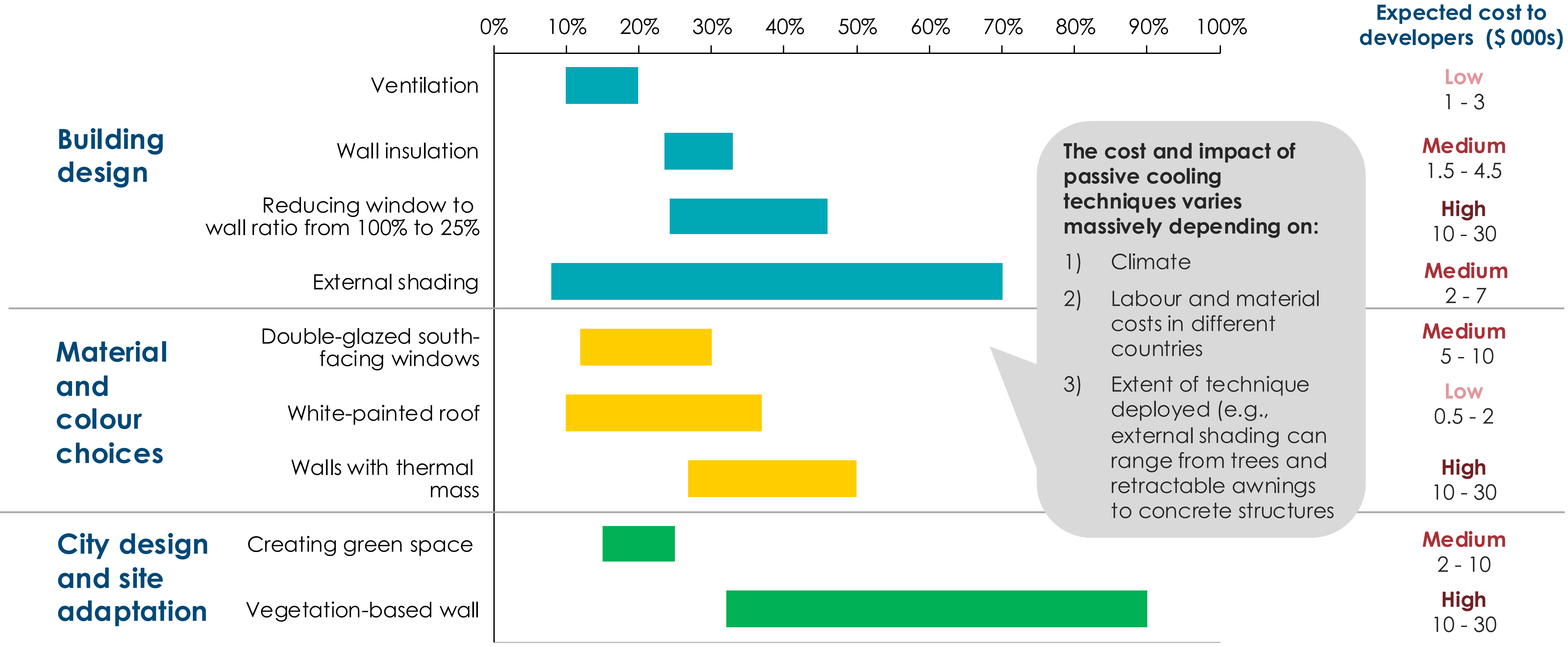
In all countries, noticeable variation exists – in some countries this reflects price dynamics, but in other countries a low efficiency AC can cost the same as a very efficient one

Source: IEA (2018), *The Future of Cooling*

Passive techniques can reduce cooling energy consumption by 25-40% on average and many of these are very low-cost, such as painting roofs white

Cooling energy consumption reduction by passive techniques

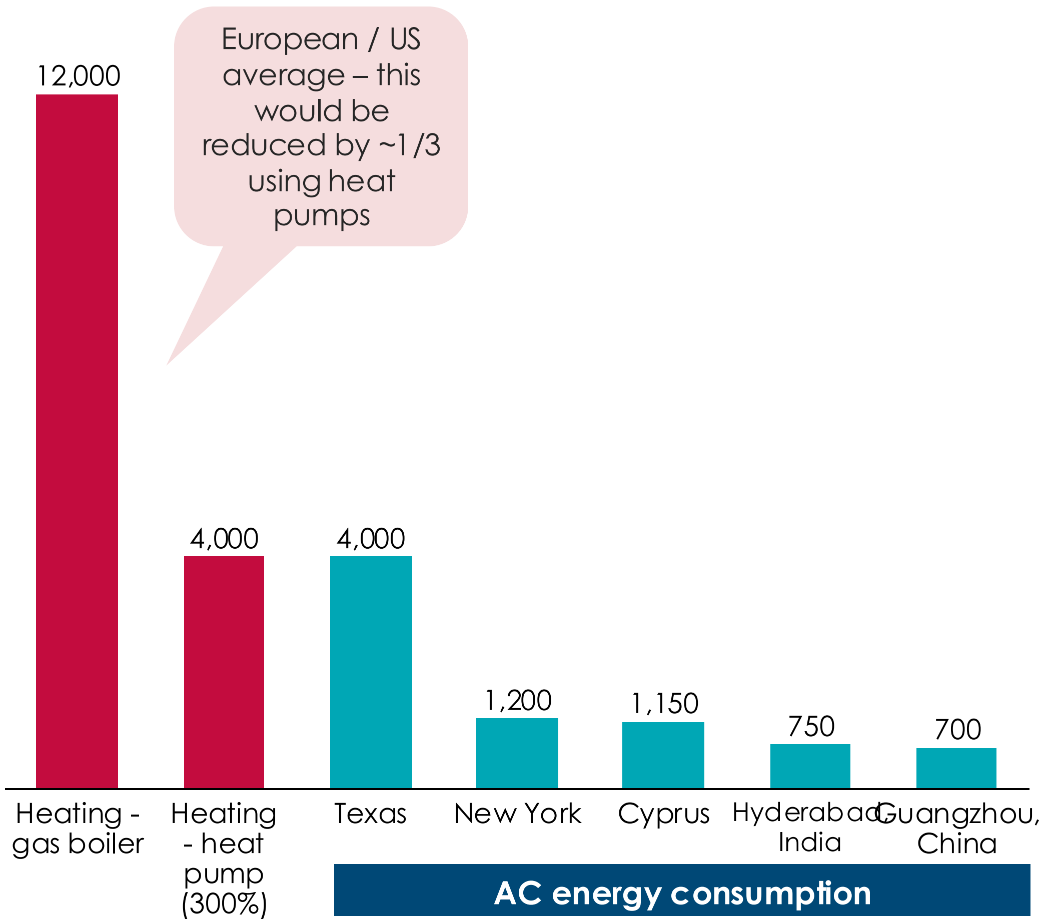
%, based on an average single-family flat/house of 60–80 m2



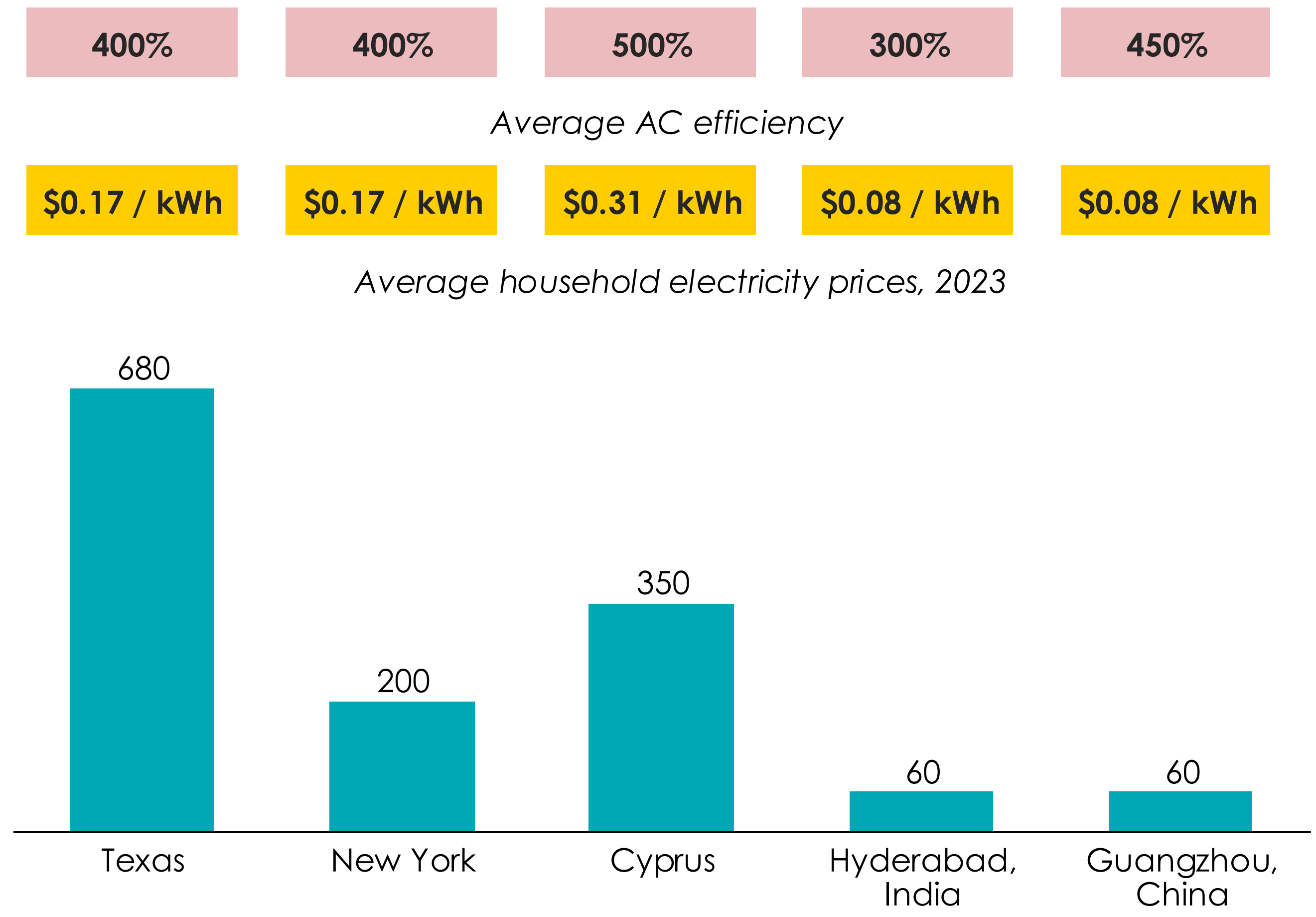
Source: Ahmed et al. (2023), The impact of window orientation, glazing, and window-to-wall ratio on the heating and cooling energy of an office building: The case of hot and semi-arid climate; Song et al. (2021), A review on conventional passive cooling methods applicable to arid and warm climates considering economic cost and efficiency analysis in resource-based cities

Household energy bills for cooling are generally smaller than heating, meaning the incentives to invest in retrofitting buildings are lower

Average annual household energy use – heating and cooling
kWh / year



Average annual household energy bills for cooling
$ / year

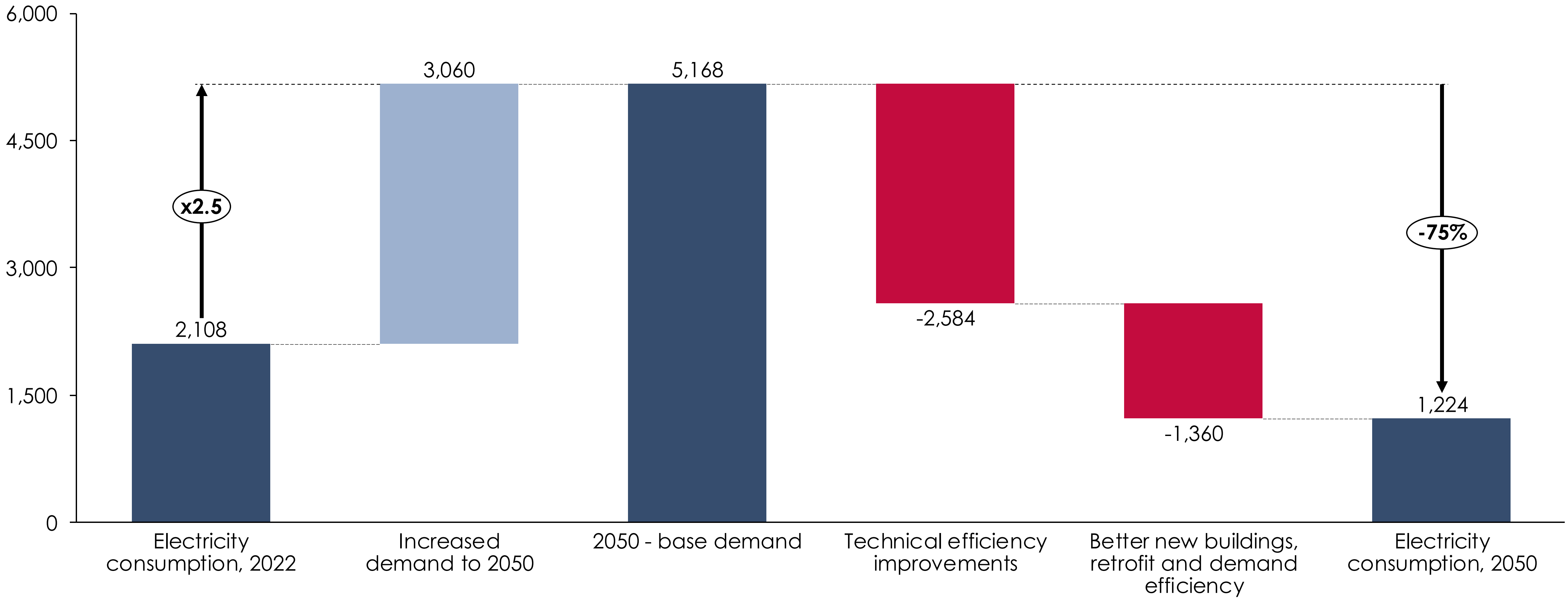


Sources: Thunder Said Energy; EIA; Statista (2023), *Household electricity prices 2023;* UE EIA (2020), Residential Energy Consumption Survey; Odyssee-mure (2023), Sectoral profile – households; Florides et. Al (2000) Modeling of the modern houses of Cyprus and energy consumption analysis; Lawrence Berkeley National Laboratory (2004), A Tale of Five Cities: The China Residential Energy Consumption Survey; Guo et al. (2022), Extreme temperatures and residential electricity consumption: Evidence from Chinese households; Energy Informatics (2022), Investigation on air conditioning load patterns and electricity consumption of typical residential buildings in tropical wet and dry climate in India

Realising technical efficiency improvements in AC and passive cooling techniques in new buildings could more than offset the increase in demand

Global electricity consumption from cooling, 2020 to 2050

Annual TWh



Sources: Systemiq analysis for the ETC (2024); IEA (2021), *Net Zero by 2050*.

Cooking

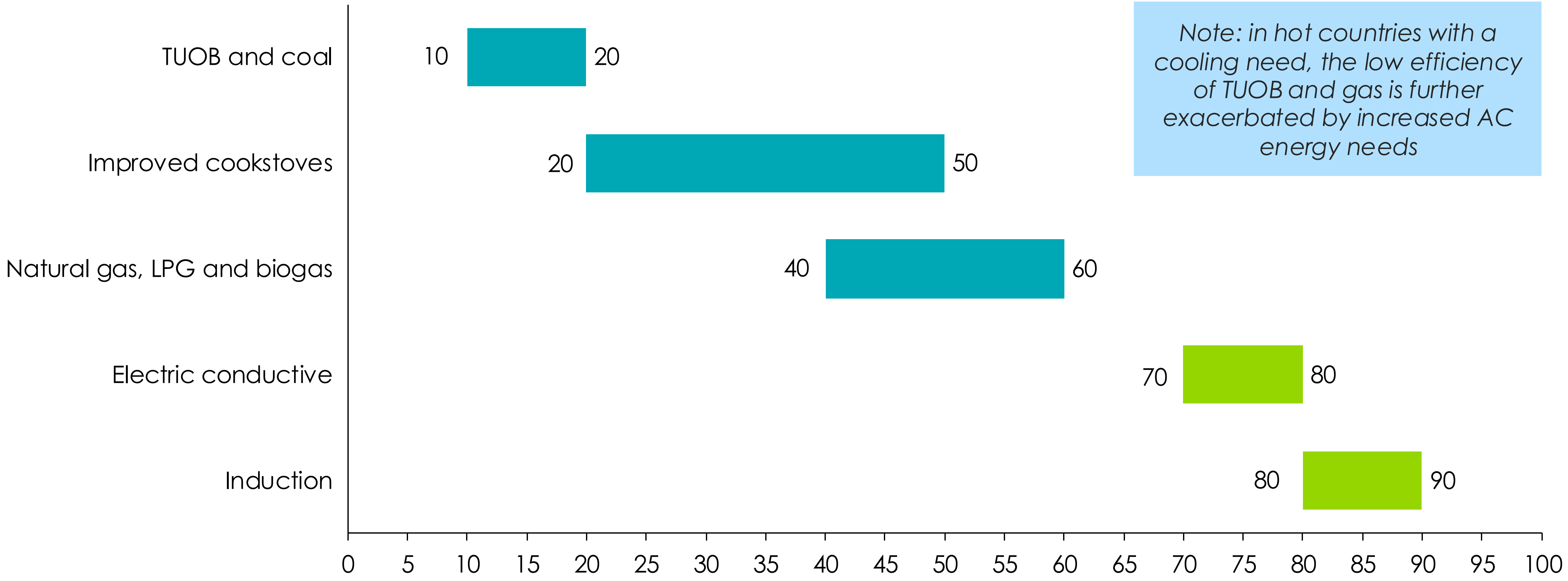
Key messages

- High-income countries should entirely electrify cooking by the early 2040s, and China by 2050; electric cooking is healthier, far more efficient and it can be cost competitive with gas/LPG.
- The imperative is to eliminate the use of traditional use of biomass, which has adverse health impacts and is also incredibly inefficient
  - A crucial interim solution in the 2030s is to install improved cookstoves and then transition to clean cooking fuels.
  - Liquefied Petroleum Gas (LPG) will be the dominant transition fuel, with electric cooking and modern forms of bioenergy being too expensive.
- By 2050, higher incomes and improved access to electricity should enable the vast majority of the world's population to transition away from fossil fuel cooking.

High-carbon cooking fuels are also the least efficient; electric induction hobs are by far the most superior cooking technology

Energy efficiency of different cooking fuels and technologies

% efficiency



In lower-income countries, the transition will likely follow several stages, with improving air quality and health the most important objective

1. Improved cookstoves

- TUOB (transitional use of biomass) accounts for 70% of final energy demand for cooking
- Crucial interim solution in the 2030s – improved cookstoves with insulated combustion chamber above and around the fire which reduces heat loss and chimneys which prevent indoor pollution
- Much more efficient and safer
- Emit less emissions

2. Cleaner cooking fuels

- LPG will likely be the dominant fuel in the transition away from TUOB
- Cheaper than electric cooking and other clean fuels
- Does not rely on access to electricity
- 70% of those who gained access to clean cooking did so through LPG

3. Greener cooking fuels

- Electricity with rising access to power and falling costs
    - Key challenge is challenging social norms (e.g., cooking with a wok not using an open flame)
- Other forms of bioenergy (e.g., bioethanol and biomethane) → cost currently very prohibitive

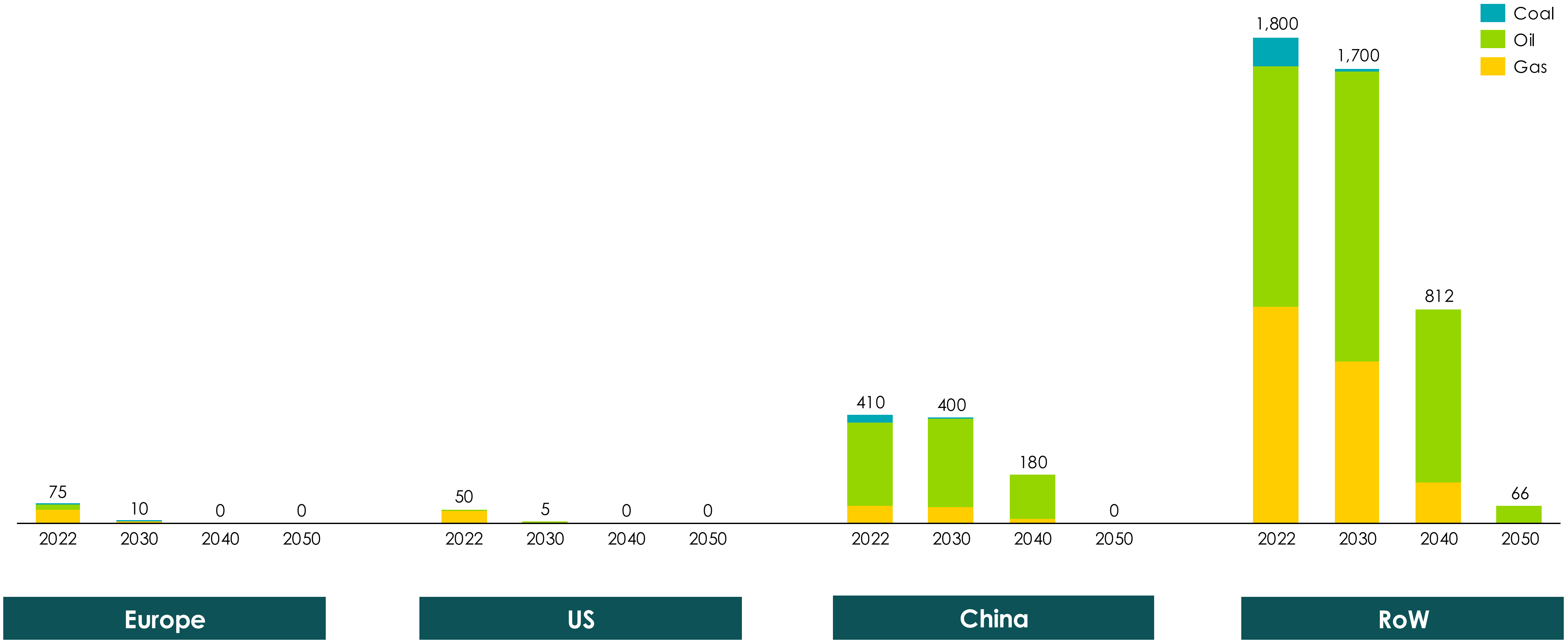
Key policies:

- Subsidised stoves and gas canisters
- Awareness and behaviour change (e.g., demonstrations, local pilots)
- Improved access to reliable electricity → grid or rooftop solar
- Scale up of international finance to support access to clean cooking

Fossil fuel demand for cooking by region, 2022-2050

Fossil fuel demand for cooking

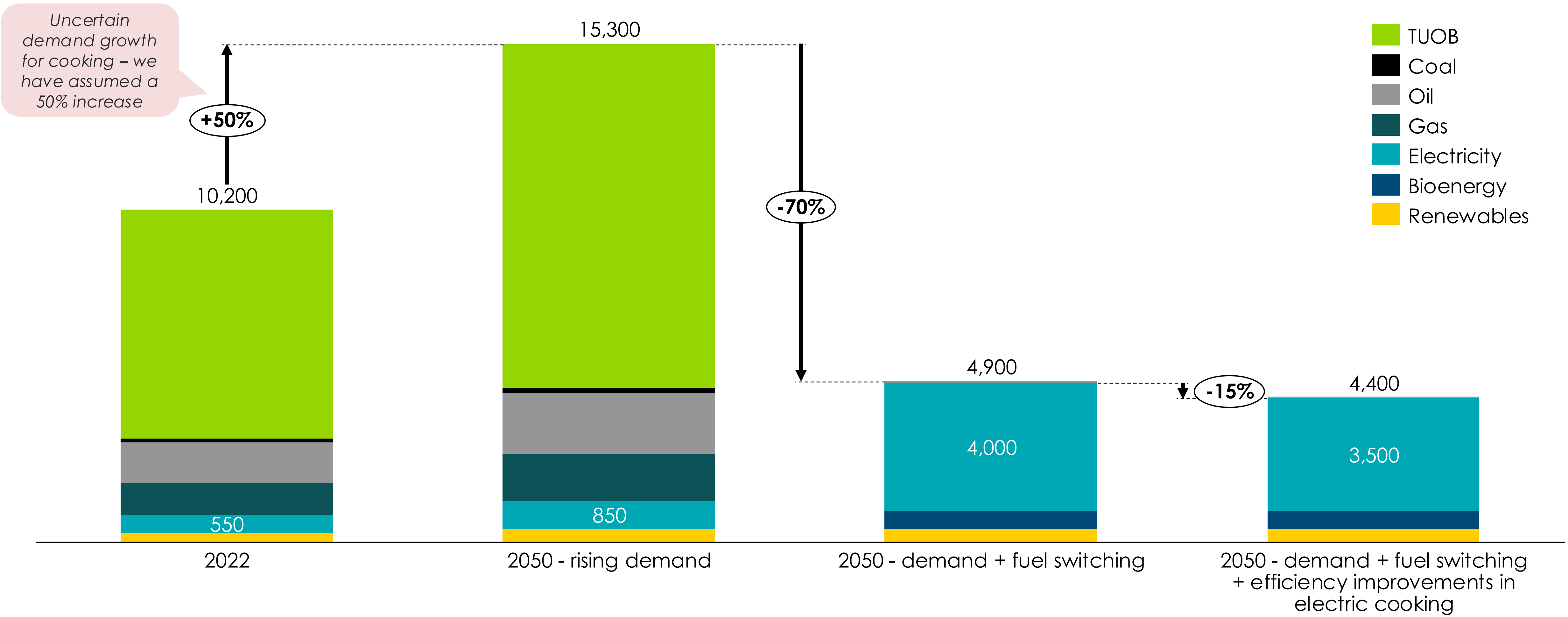
TWh



Note: Values are rounded.
Source: Systemiq analysis for the ETC; IEA (2022), *World Economic Outlook 2022;* IEA (2023), *World Economic Outlook 2023;* IEA (2023), *World Energy Balances dataset;* IEA (2023), *Energy Efficiency dataset;* Tsinghua Building Energy Research Center, *Annual Report of Building Energy in China.*

The transition away from inefficient biomass to electric cooking will more than halve final energy consumed for cooking, but electricity demand could increase 7-fold relative to today

Global cooking energy demand by fuel, 2022 and 2050
TWh



Systemiq analysis for the ETC (2024); IEA (2023), *A Vision for Clean Cooking for All*

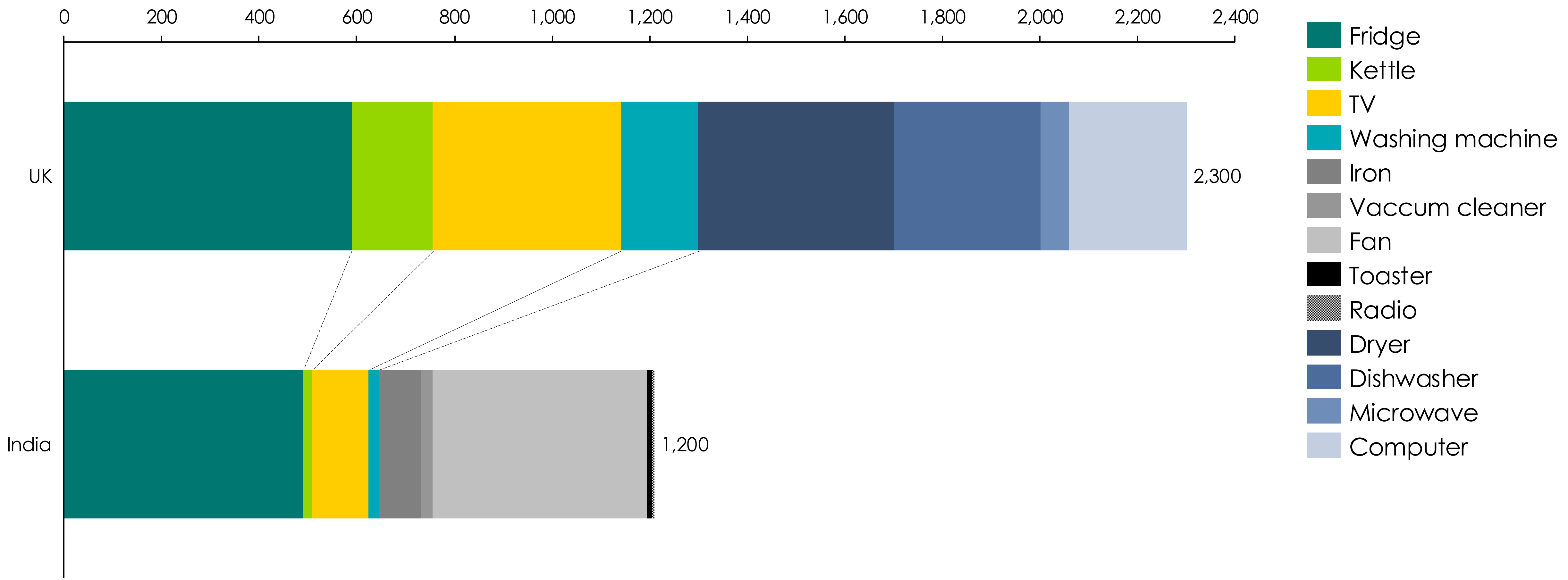
Appliances

Key messages

- Without any action to improve efficiency, electricity demand for household appliances could double, from ~6,000 TWh, to almost 12,000 TWh; but it could be even higher as economies digitalise faster (e.g., AI and smart appliances in commercial buildings).
- However, improving the technical efficiency of appliances through minimum energy performance standards and labelling could offset 70% of the increase in electricity demand.
- Realising efficiency gains in hot countries is critical, as appliances produce heat which then lead to greater AC use.
- Accelerating the stock turnover of older, less efficient appliances through financial incentives should be targeted at large, energy-consuming white goods, especially fridges and freezers which have high GWP refrigerant. This must be accompanied by investment in recycling and reuse facilities, with retailers obliged to offer trade-in schemes.

Appliances covers a wide range of household, kitchen and digital electronics which improve productivity, living standards, access to information and health

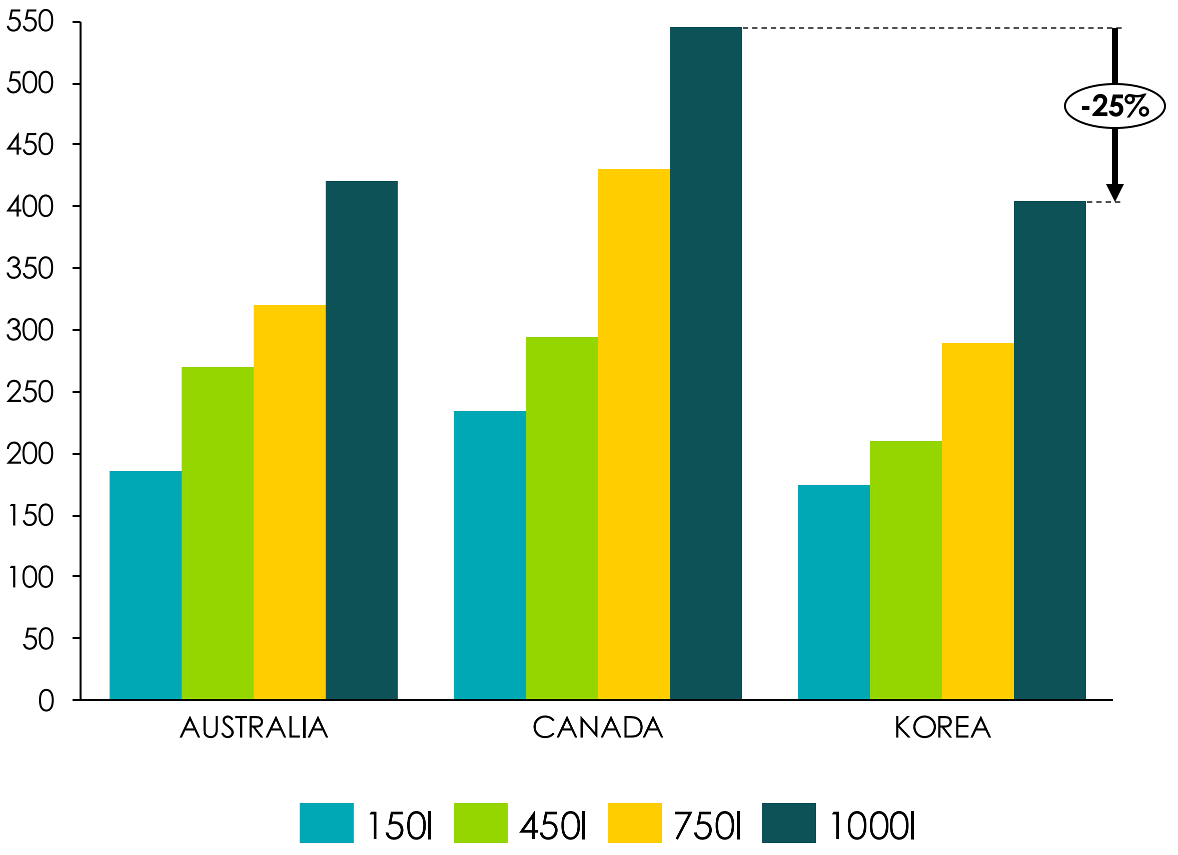
Average energy use from common appliances in the UK and India
kWh/year



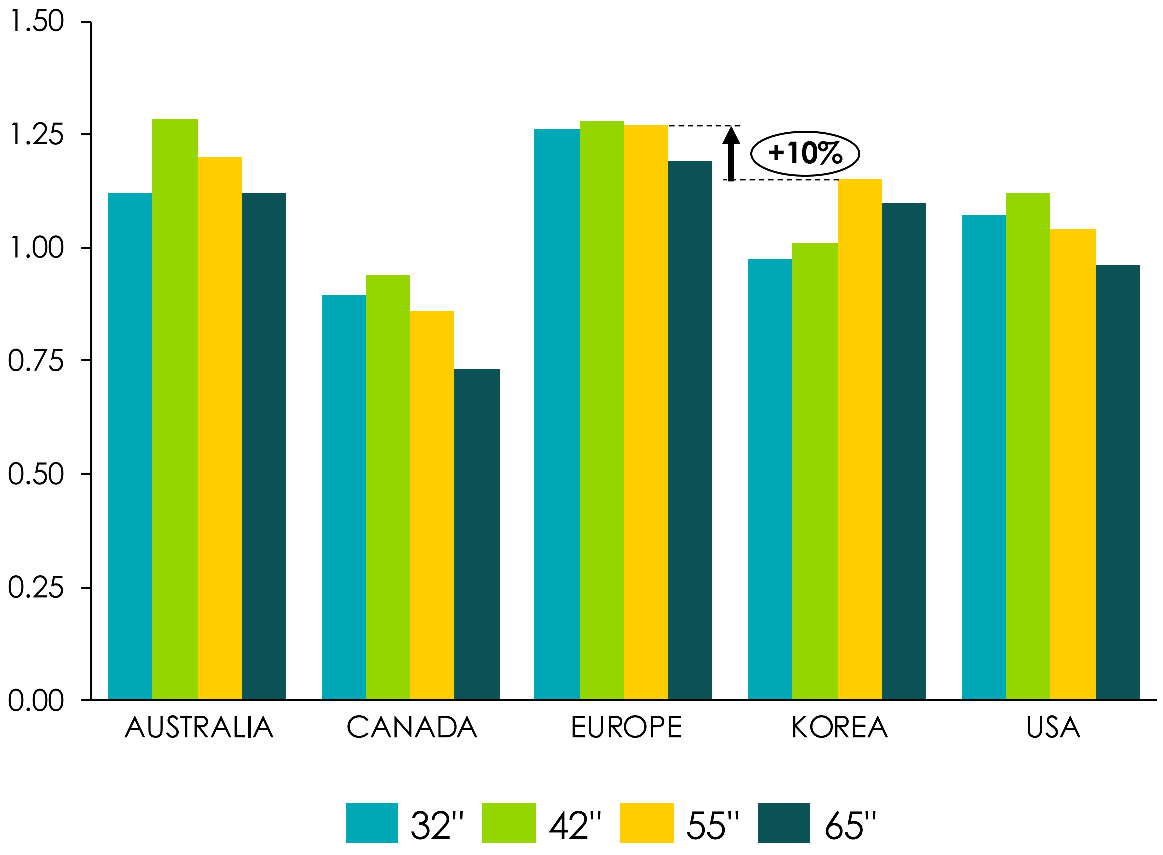
Source: Intertek (2012), *Household Electricity Survey: A Study of Domestic Electrical Product Usage;* Narasimha Murthy, K.V., et al. (2001), *End Uses of Electricity in Karnataka Households.*

There are large differences in the efficiency of appliances across countries; fridge-freezers of the same size can be 25% more efficient in Korea than Canada

Average annual energy consumption for refrigerator-freezers by size, 2019
kWh/year



Average efficiency of TVs by screen size, 2018
W/dm2

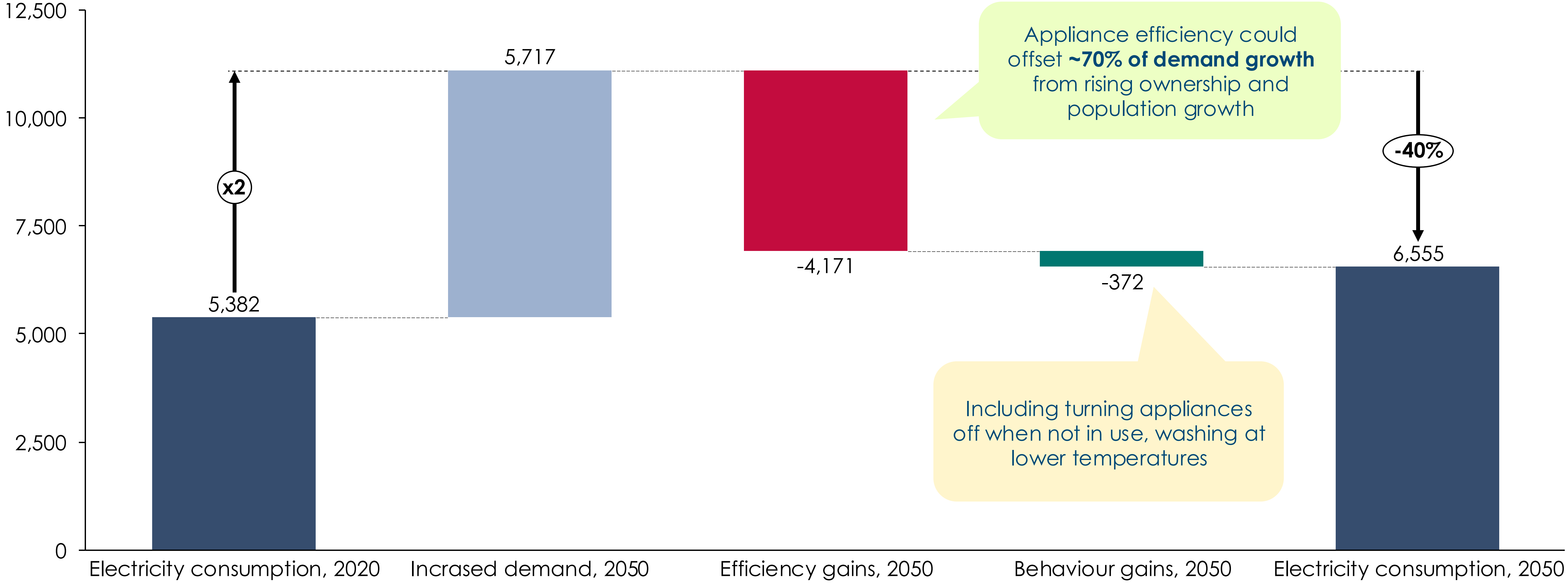


Source: Technology Collaboration Programme on Energy Efficient End-Use Equipment (2021), *PEET Efficiency Trends Analysis.*

Improving the technical efficiency of appliances could offset 70% of rising energy demand

Global electricity consumption by appliances and equipment, 2020 to 2050

Annual TWh



Sources: Systemiq analysis for the ETC (2024); IEA (2021), *Net Zero by 2050*.

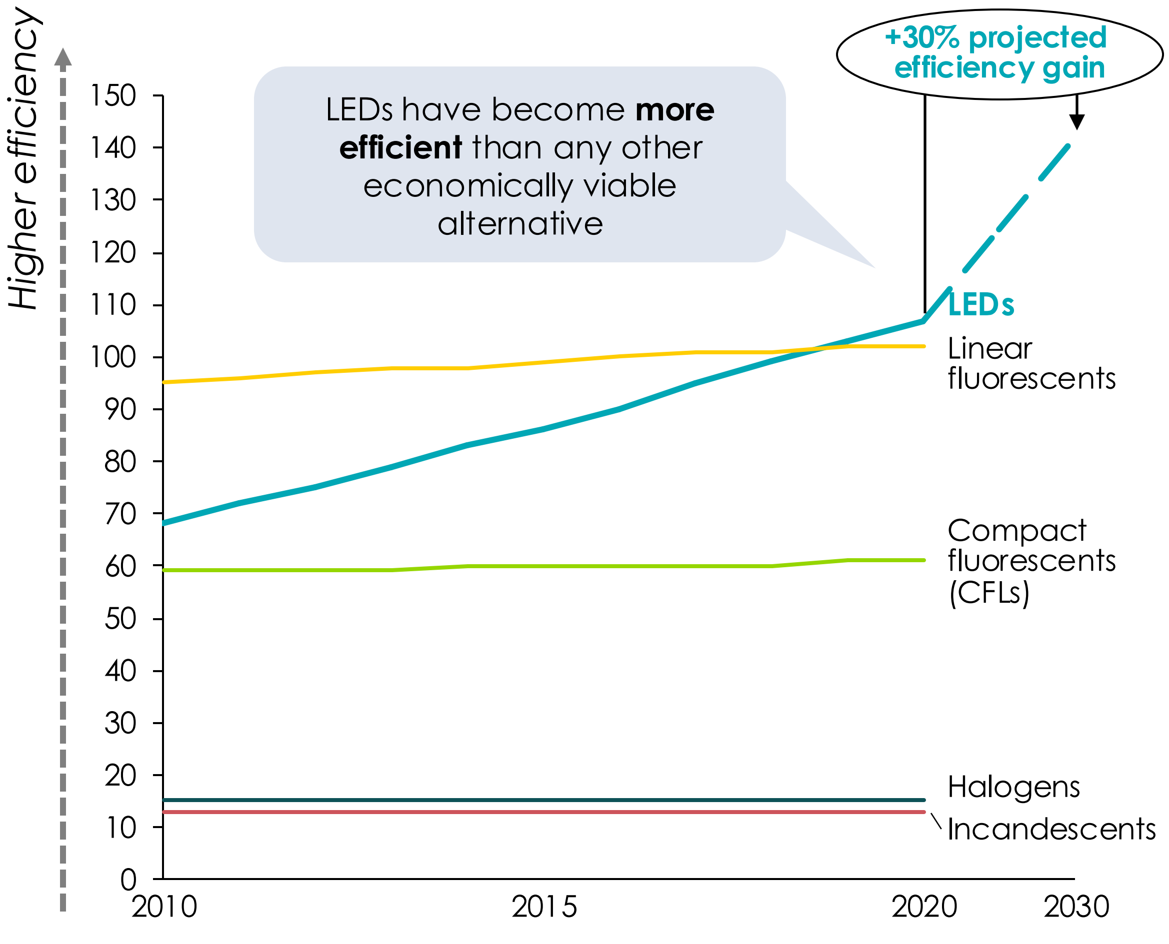
Lighting

Key messages

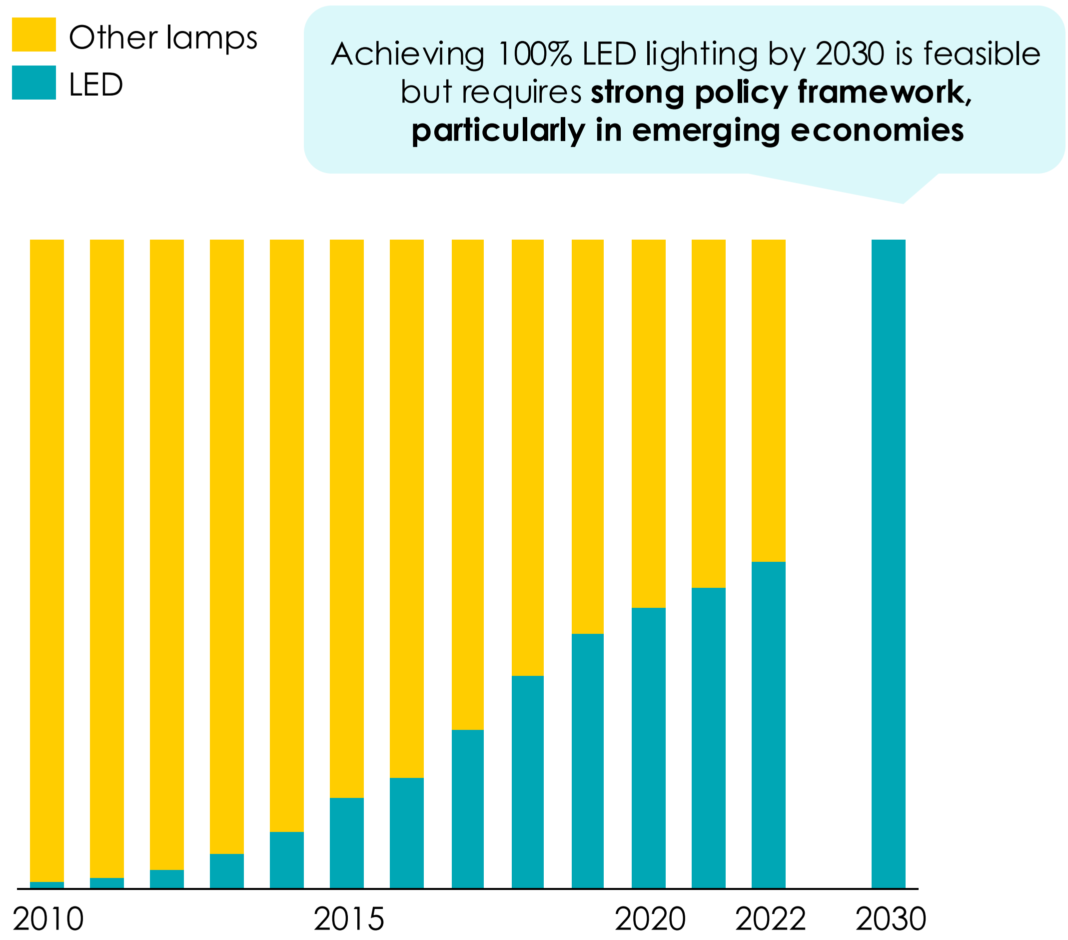
- Without action on energy efficiency, electricity demand for lighting could double, from 1,800 TWh to 3,600 TWh in 2050.
- If all lighting demand could be delivered with LED light bulbs, electricity requirements could be even lower than they are today, at 1,600 TWh in 2050. LED light bulbs are over 80% more efficient than incandescent lighting, they run for 30-50 times longer, and have significantly lower lifetime costs.
- Government bulk procurement has proven to be very successful at rapidly growing the market for LEDs and lowering retail costs (e.g., in India).

LEDs are the leading lighting technology, but only account for half of global sales – with well-designed policies and incentives, this could be 100% by 2030

Global lighting efficacies
Lumens/Watt



Global residential lighting sales share by technology
Proportion of sales (%); IEA NZE; 2010 – 2030

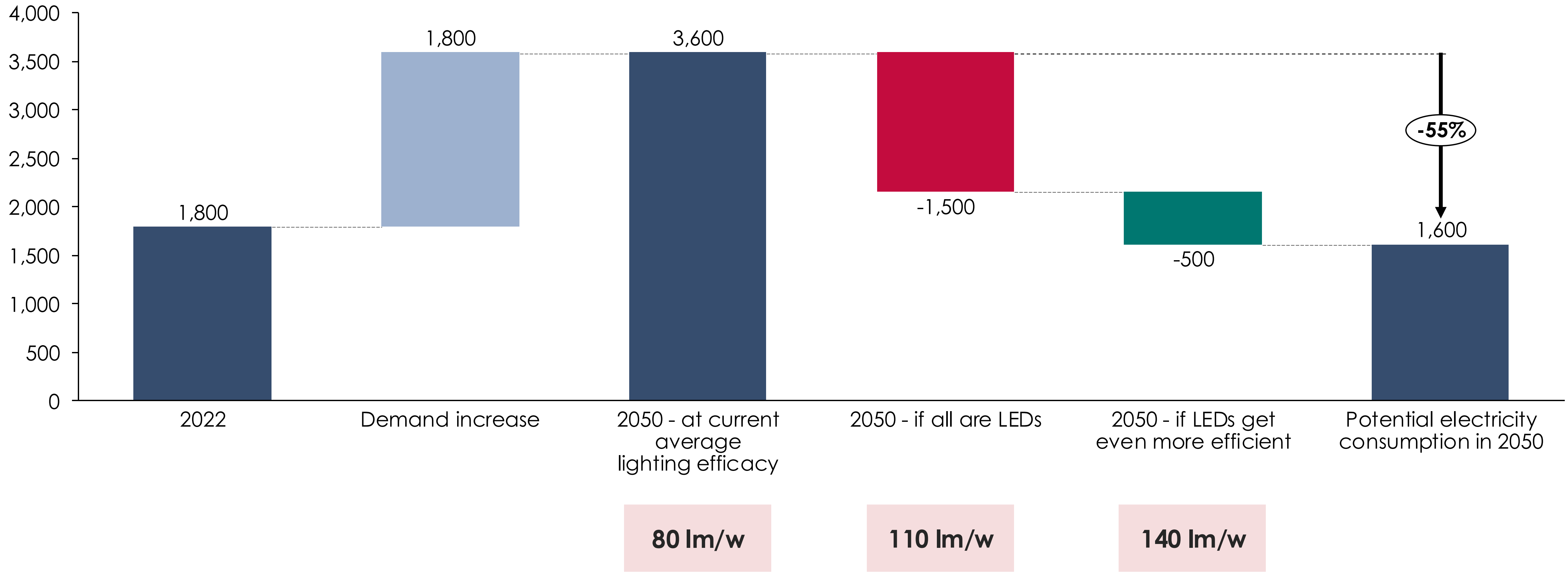


Source: IEA (2023), *Global residential lighting sales share by technology in the Net Zero Scenario, 2010-2030*; IEA (2023), *Lighting efficacy by technology in the Net Zero Scenario, 2010-2030.*
Note: efficacy is a measure of how much light is produced compared to the electricity put in.

With action to limit sales of non-LED lightbulbs and continued improvements to LED efficacy, efficiency improvements could more than offset the rise in demand for lighting

Global annual lighting electricity consumption, 2022 to 2050

TWh



Sources: Systemiq analysis for ETC (2024); IEA (2023), *Global residential lighting sales share by technology in the Net Zero Scenario, 2010-2030*; IEA (2023), *Lighting efficacy by technology in the Net Zero Scenario, 2010-2030*; IEA (2021), *Net Zero by 2050.*

Commercial buildings

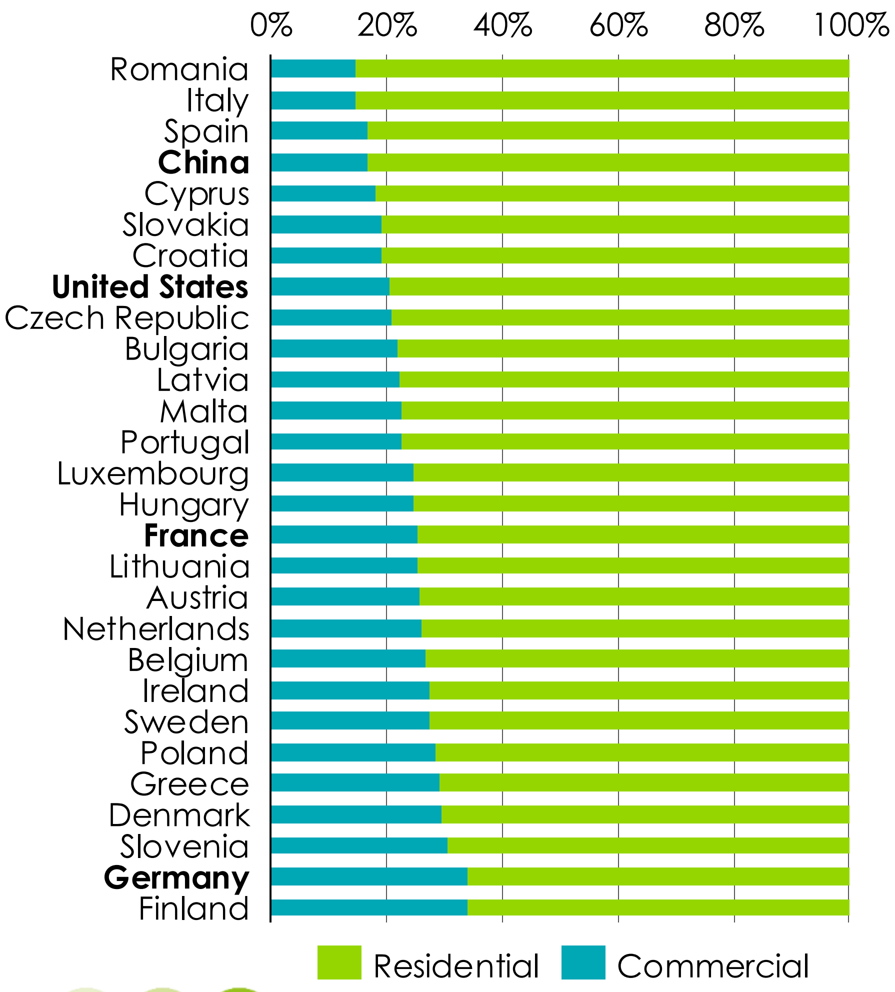
Key messages

- In commercial buildings, electrification and heat pumps will also win out – but there is even less of a one-size-fits-all solution
- Commercial buildings can be installed with more sophisticated HVAC systems, which are able to simultaneously heat and cool different parts of a building, with huge efficiency gains.
- Installing heat pumps and retrofitting existing commercial buildings is challenging, due to the need to dismantle existing systems often with tenants in the building. Just as with residential buildings, the fabric first approach does not need to be the default for the average building.
- Installing a building management system is a no-regrets solution which can reduce energy consumption by 10-20% (e.g., sensors and predictive AI to flex energy consumption according to occupancy, the weather and energy prices).

“Commercial buildings” refers to a very large and heterogenous group of sectors; offices only account for 25-40% of building stock, with schools and wholesale/retail also key

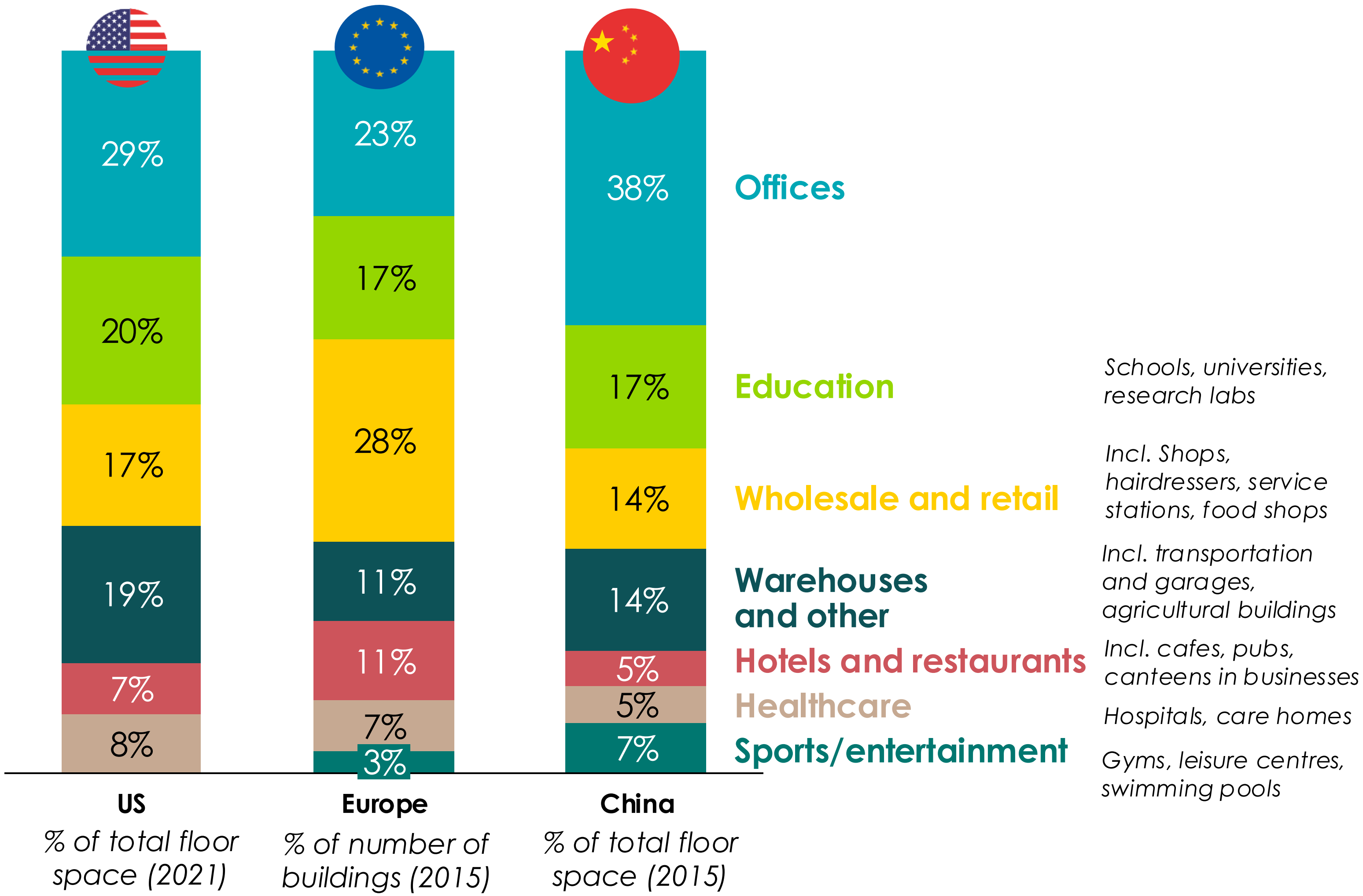
Built floor area by residential / commercial

% of total floor area, 2015



Commercial buildings by sector

% of total floor area for the US and China, % of number of buildings for Europe

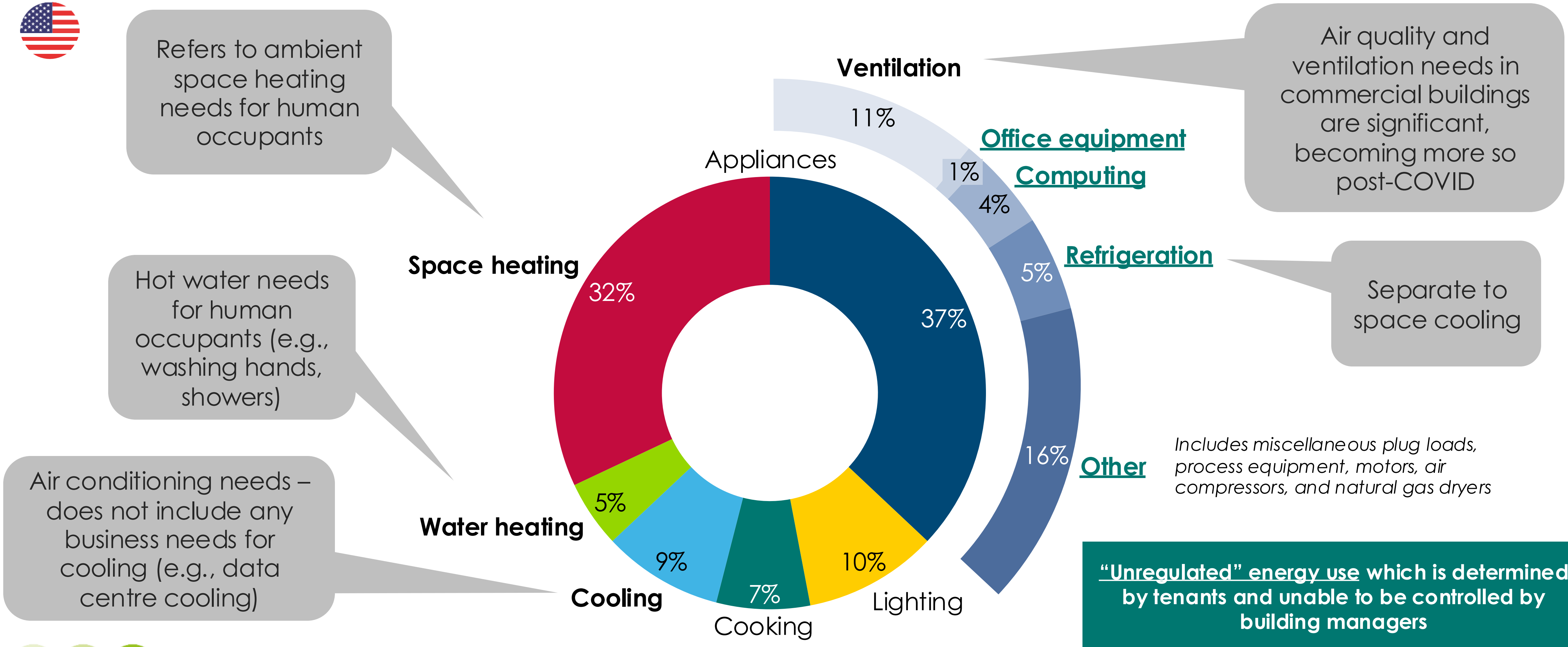


Sources: US National Renewable Energy Laboratory; Building Performance Institute Europe (2015), *Europe's Buildings Under the Microscope*; Baijiahao (2018), *Real estate and constructions: What are the sub-sectors? What are the sizes?*; EU Building Stock Observatory for Europe; National Renewable Energy Laboratory for United States; Pan L, Zhu M, Lang N, Huo T. (2020), *What Is the Amount of China's Building Floor Space from 1996 to 2014?* Note: For the US, sports facilities is included in “warehouses and other”

Heating, cooling and ventilation accounts for ~60% of commercial building energy use; heating and cooling refers to creating comfortable room temperatures for human occupants

Commercial buildings energy consumption by end-use in the US
% of energy consumption

Heating, ventilation and air conditioning (HVAC) in bold

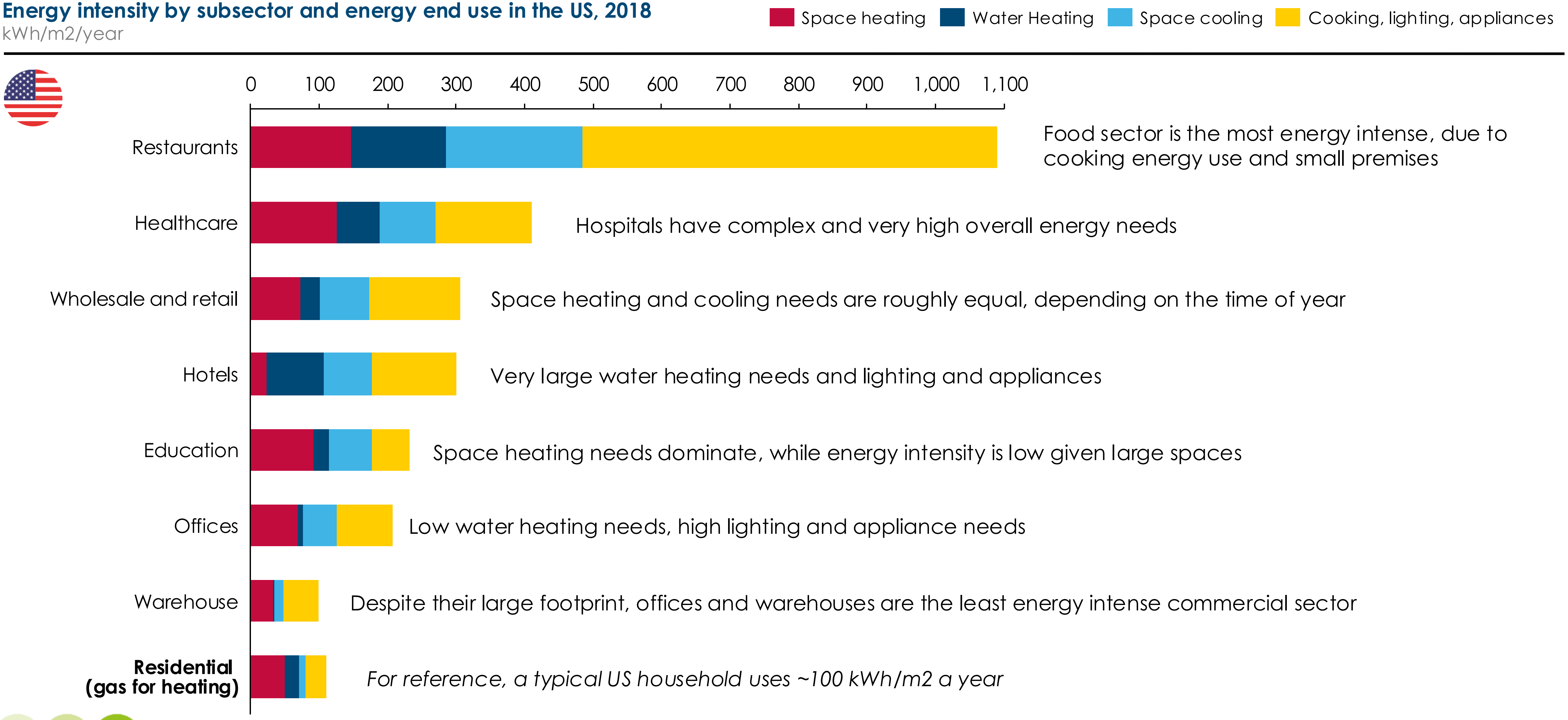


"Unregulated" energy use which is determined by tenants and unable to be controlled by building managers

Sources: US Energy Information Administration (2018), *2018 Commercial Buildings Energy Consumption Survey.*

Energy needs differ significantly across different types of commercial building; there are no one-size-fits all technologies

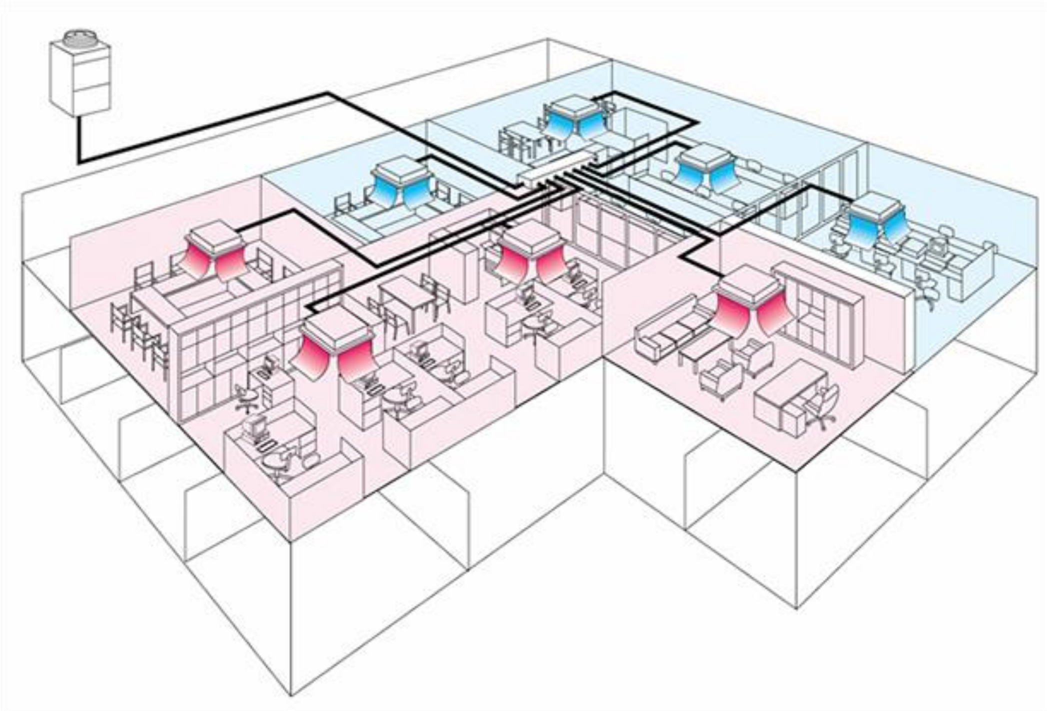
Energy intensity by subsector and energy end use in the US, 2018
kWh/m2/year



Sources: National Renewable Energy Laboratory

Variable refrigerant flow systems offer huge opportunities for efficiency gains from combined heating and cooling systems by utilising waste heat

Illustration of heating and cooling in a VRF system



When heating demand is greater than cooling > Additional heat from air to water is used to make up for the gap

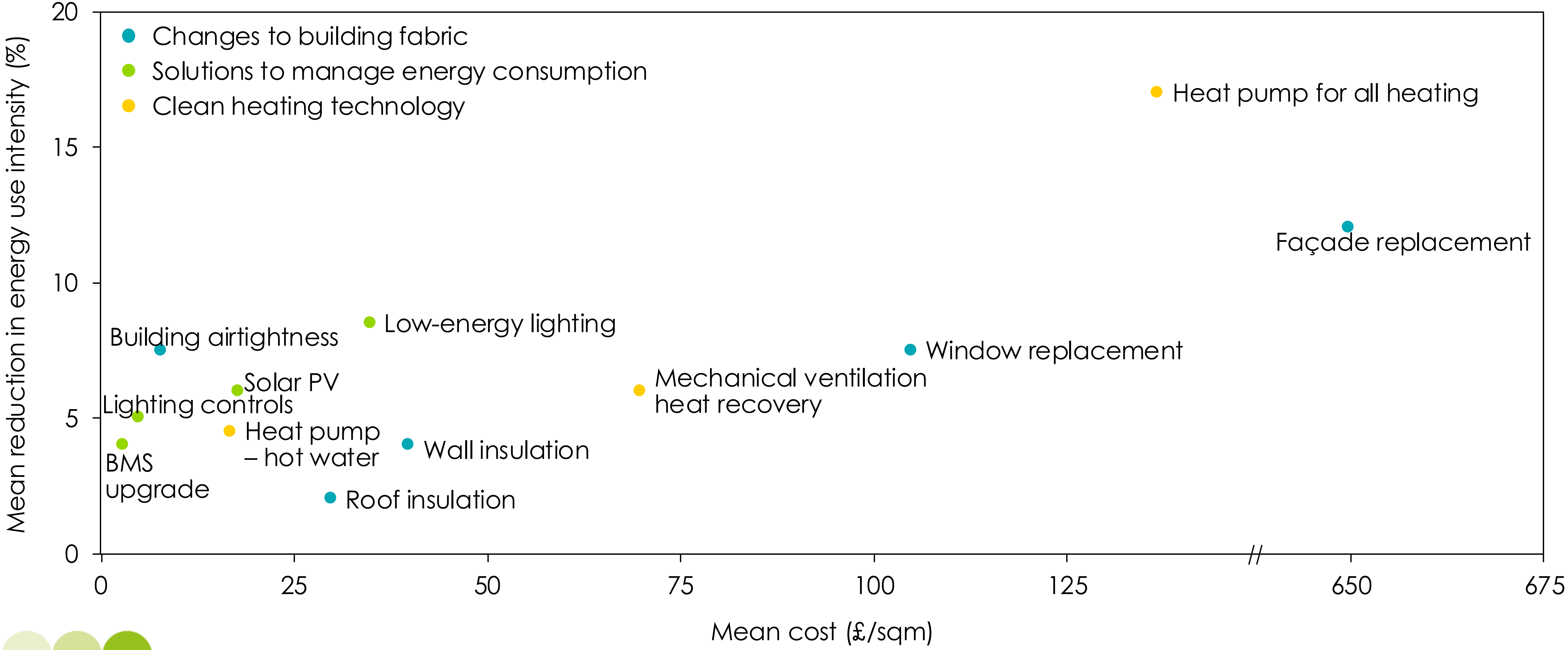
When cooling demand is greater than heating < Excess heat is ejected into the atmosphere

When heating demand is equal to cooling = No heat is being ejected into or extracted from the environment

There are also many low hanging fruit options for reducing energy intensity, which do not involve costly building fabric improvements

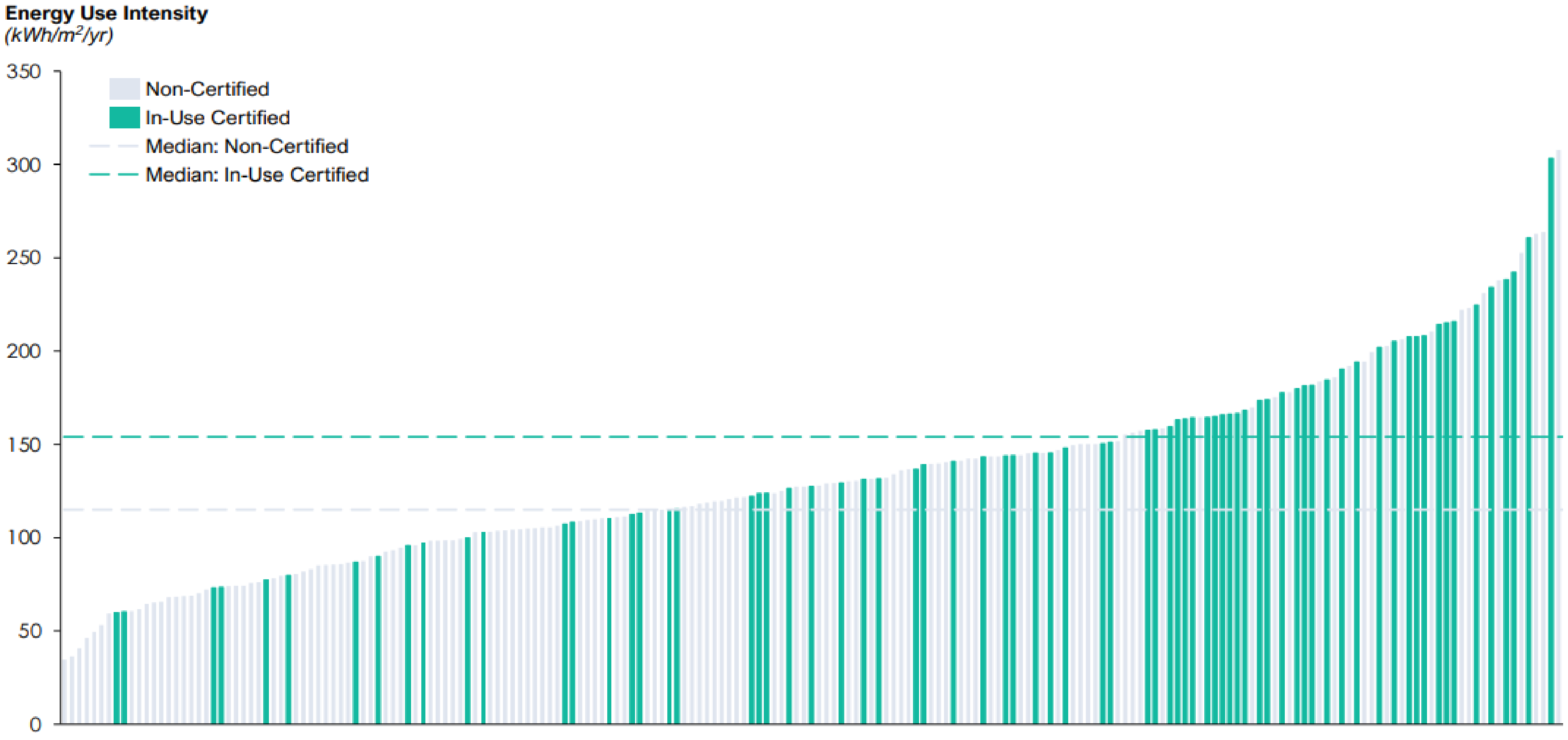
Cost effectiveness of individual retrofit measures in UK offices (based on actual project data)

Average cost (£/sqm) vs average reduction in energy use intensity (%)



Sources: UK Green Building Council (2024), *Retrofitting Office Buildings*

There is currently no correlation between green building certifications and energy performance



Note: Contains whole building EUI data on 203 LOTUF office buildings across Europe and the US. Includes a mixture of data from 2021-2023, only normalised for floor area and asset type. In-use certifications include LEED, BREEAM, DGNB, BOMA/ BEST and others.

Refrigerant leakage

Key messages

- Refrigerants can have a high global warming potential (GWP) relative to CO_2 if they leak or are intentionally released (vented) into the atmosphere. Currently, around 2-5% of refrigerant in heat pumps and air conditioners leaks every year, and 90% is vented at end of life.
- Emissions from refrigerant leakage and venting could be almost 1 $GtCO_2$ in 2030, rising to 2 $GtCO_2$ in 2050; this is equivalent to 15% of today's annual emissions from buildings.
- Emissions could be halved in 2050 with regulations and incentives for proper disposal of refrigerant at end of life, skills certifications to improve the quality of installations and maintenance, and with a faster transition to lower-GWP refrigerants.
- International agreements and national regulation are already driving an industry transition towards natural refrigerants, such as propane, but action needs to accelerate.

There are two ways to reduce the refrigerant challenge – reduce how much refrigerant is leaked and released into the atmosphere, and transition to those with lower GWP

AC and heat pumps contain refrigerants, which can contribute to climate change if leaked and/or vented – however there is a transition towards refrigerants which have a low Global Warming Potential (GWP)

Industry transition

HFCs (Hydroflourocarbons)

Most used today

R-134a	GWP 1430
R410a	GWP 2088
R-32	GWP 675

Driven by the Kigali Agreement from 2016, to phase out high GWP HFCs

Low-GWP HFOs (Hydrofluoroolefins)

Alternatives to HFCs

R1234ze	GWP 7

Natural Refrigerants

Best solutions not readily available

CO_2	GWP 1
Propane	GWP 3
Ammonia	GWP 0

Refrigerant leakage occurs when refrigerants escape from AC and heat pump systems through leaks or improper handling, depending on:

- **Equipment size, age and condition**
- **Quality of installation**
- **Quality of maintenance**

It is estimated that, on average, the annual refrigerant leakage rate is around 2-5%

Refrigerant venting occurs when refrigerants are intentionally released into the atmosphere, typically during servicing, maintenance, or disposal of AC + heat pumps

- **Improper servicing practice**
- **Technicians' lack of training and awareness**
- **Weak or inadequate regulations and enforcement for end-of-life**

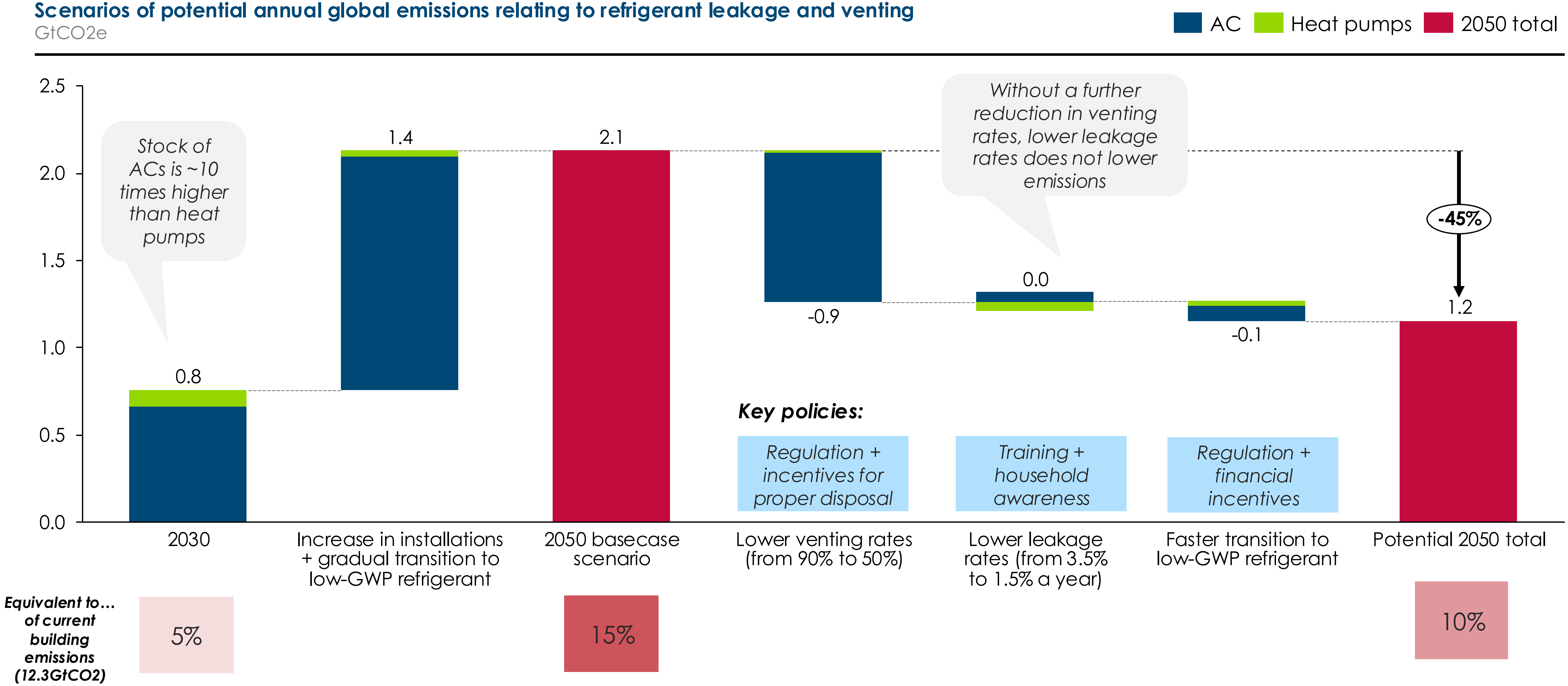
Today, industry estimates that close to 90% of ACs at end-of-life are vented in the US. In the developing world, the number is likely even larger

Note: GWP – global warming impact relative to the impact of the same quantity of carbon dioxide over a 100 year period

Sources: IEA (2023), *Energy Technology Perspectives*; BSRIA (2020), *BSRIA's view on refrigerant trends in AC and Heat Pump segments*; Net Zero Carbon Guide, *Refrigerants and their Contribution to Global Warming*; IEA (2018), *The Future of Cooling*; Carbon Containment Lab (2022), *Managing Refrigerants in a Warmer World*

Emissions from refrigerant leakage and venting in 2050 could be equivalent to 15% of today's total building emissions, but could be 50% lower with well-designed policies

Scenarios of potential annual global emissions relating to refrigerant leakage and venting
GtCO2e



Source: Systemiq analysis for the ETC (2024), BSRIA (2020), *BSRIA's view on refrigerant trends in AC and Heat Pump segments*; Net Zero Carbon Guide, *Refrigerants and their Contribution to Global Warming*; IEA (2018), *The Future of Cooling*; UNEP Ozone Secretariat (2015), *Fact sheets on HFCs and Low GWP Alternatives*.
Note: the figures are based on reasonable assumptions about refrigerant technology today and the IEA's AC projections. Assumes an average of 10lb refrigerant charge and a 15 year lifetime for equipment.

Flexible and efficient buildings

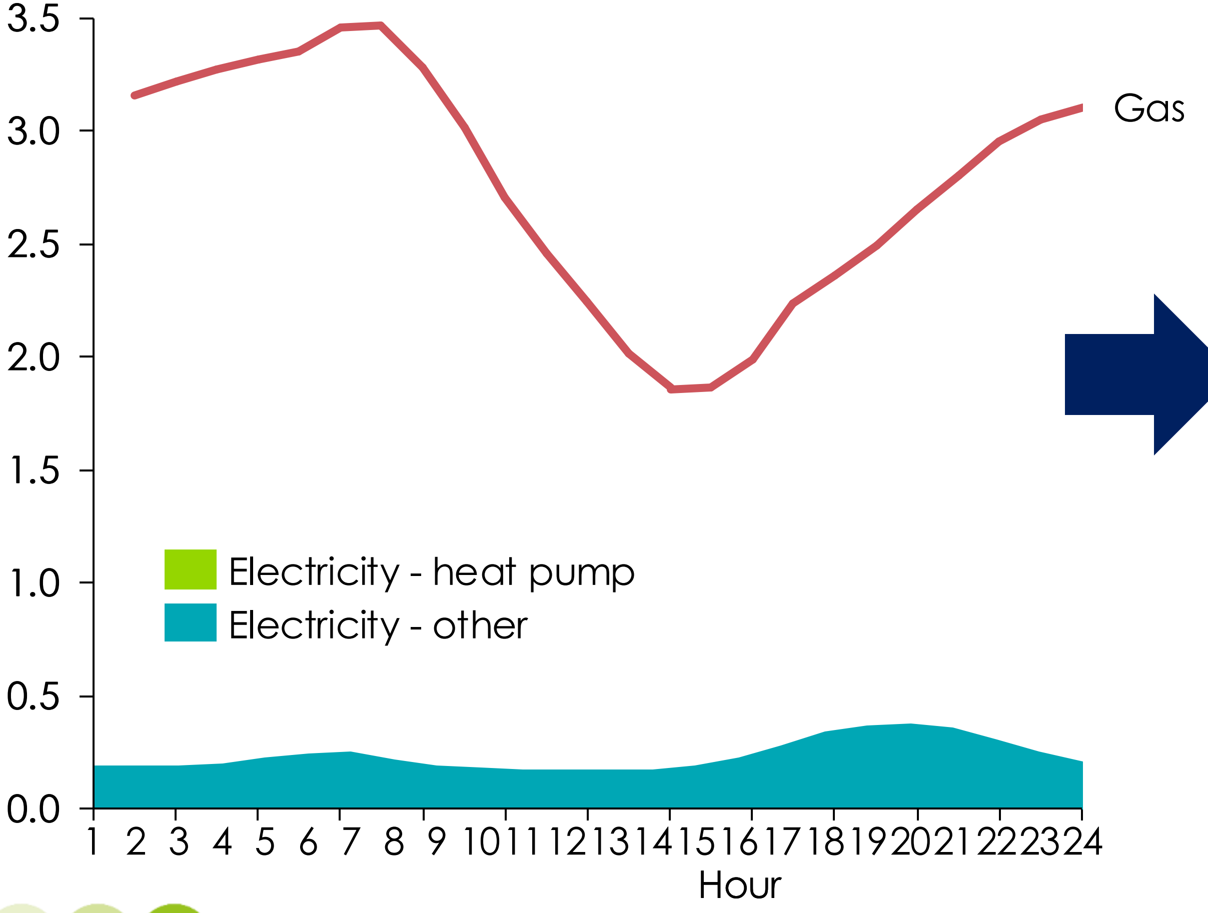
Key messages

- Electrification in itself will deliver efficiency, but this implies a huge increase in electricity demand which needs to managed –
- Annual electricity requirements for buildings in 2050 could be 2.5 times higher than today, from 13,000 TWh to 35,000 TWh
- This could be lowered to 18,600 TWh by:
  - Technical efficiency improvements in heat pumps, AC, appliances and the shift to LED lighting and induction hobs.
  - Improving the building fabric of new and existing buildings
  - Demand efficiency, for example from the use of smart systems or behaviour change to limit thermostats
- However, there will still be significant daily and seasonal peak challenges for the electricity grid.
  - For the daily challenge, absence of action at the buildings level may lead to expensive solutions at the grid level. There is huge untapped potential for demand-side flexibility from insulation, water storage, smart systems, solar PV and batteries to shift peak demand. Time of use tariffs are critical to incentivising this demand-side flexibility.
  - For seasonal peaks, action in buildings can reduce their size (and subsequent need for backup capacity) but will not remove the need for system-level action in certain geographies: a suite of grid-level storage and flexibility solutions will still be needed.

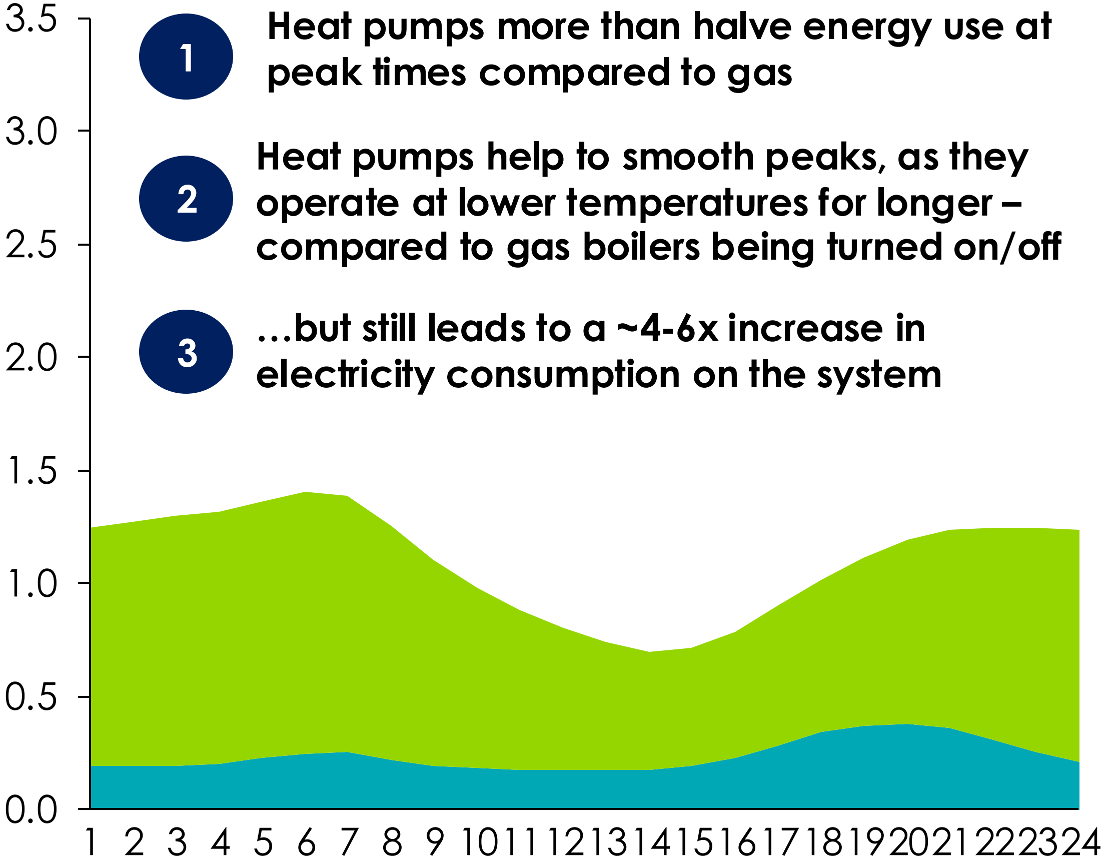
The daily challenge: Heating in the winter months, along with other household electricity use for lighting and appliances, creates demand peaks in the morning and evening…

Hourly electricity and gas use, typical European house
kWh

Energy consumption with a gas boiler



Energy consumption with a heat pump

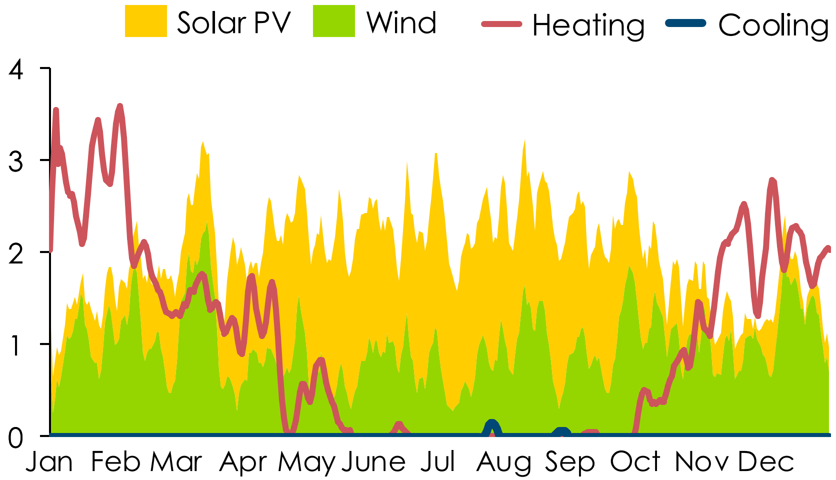


1. **Heat pumps more than halve energy use at peak times compared to gas**
2. **Heat pumps help to smooth peaks, as they operate at lower temperatures for longer – compared to gas boilers being turned on/off**
3. **…but still leads to a ~4-6x increase in electricity consumption on the system**

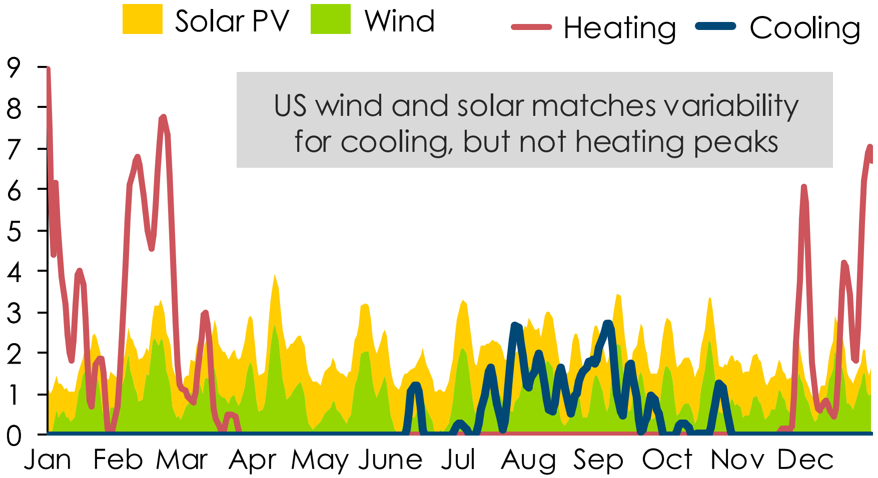
Source: Systemiq analysis for the ETC (2024) of Schneider Electric Sustainability Research Institute
Note: data based on a large residential house in France, scaled down to typical average household gas heating consumption

Wind and solar patterns are variable and don't always align with winter seasonal heating demand changes…

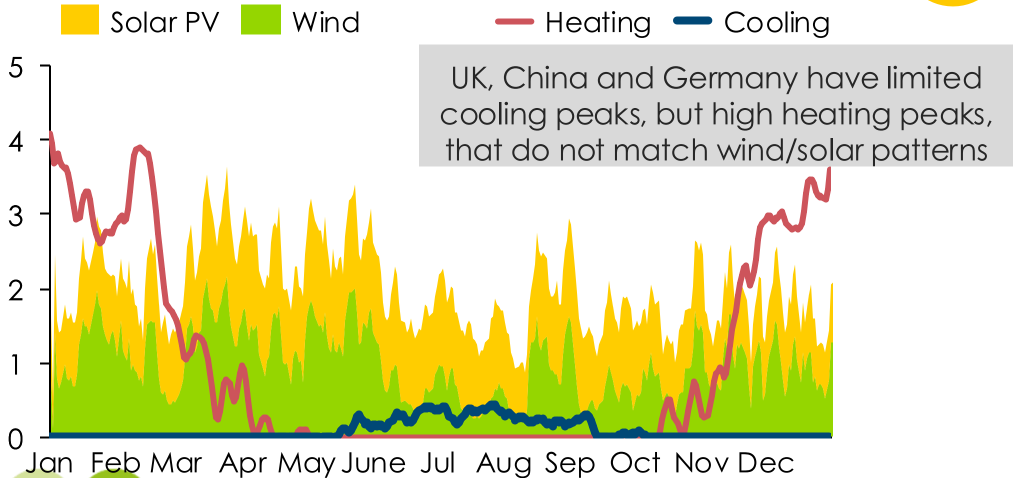
Theoretical renewables and heating and cooling demand patterns (UK[a]) Index*



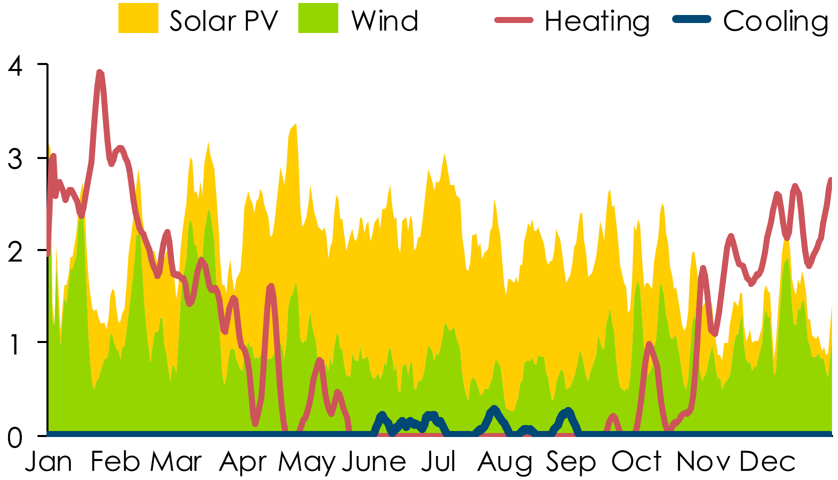
Theoretical renewables and heating and cooling demand patterns (US[b]) Index*



Theoretical renewables and heating and cooling demand patterns (China[c]) Index*



Theoretical renewables and heating and cooling demand patterns (Germany[d]) Index*

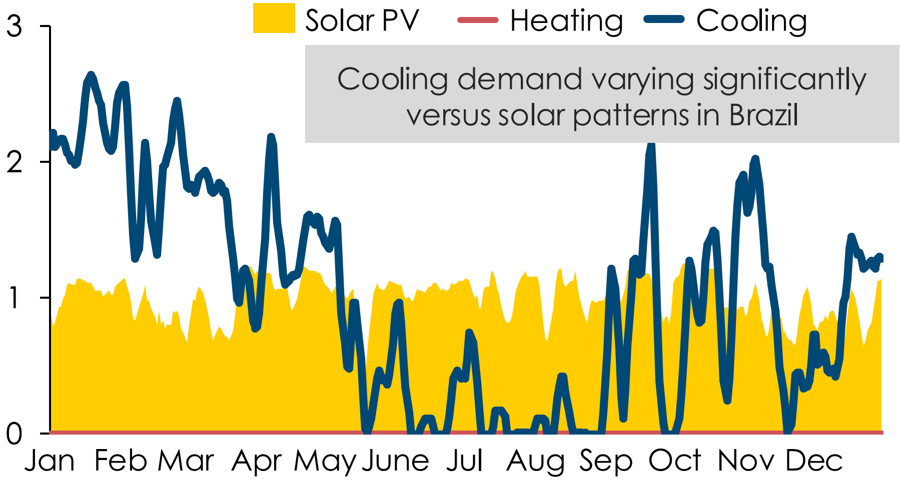


Potential solar and wind supply patterns are based on 2019 weather data

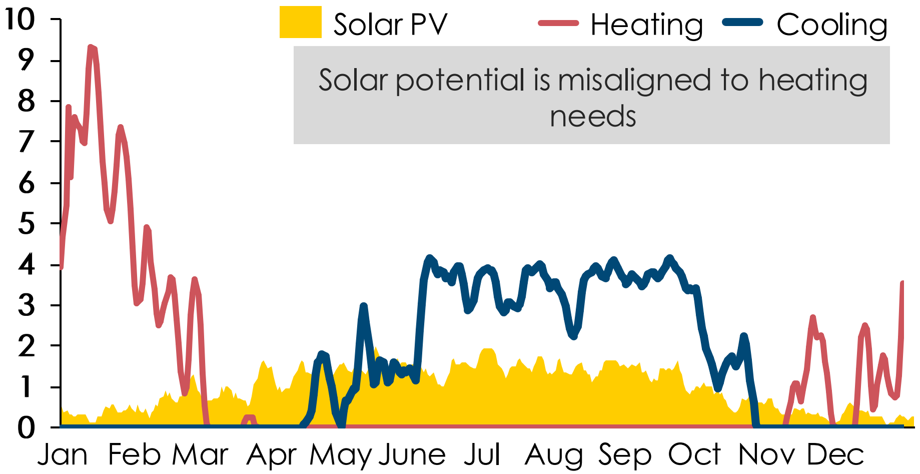
*Wind and solar potential indexed to 2019 daily average supply pattern based on weather patterns, using a five day rolling average. Cooling and heating indexed to 2019 daily average potential demand pattern based on weather and temperature patterns. Daily averaged based on five-day rolling averages. a. UK figures based on London. b. US figures based on Los Angeles. c. China based on Beijing. D. Germany figures based on Berlin. Source: Renewables Ninja 2024

…or with seasonal cooling needs

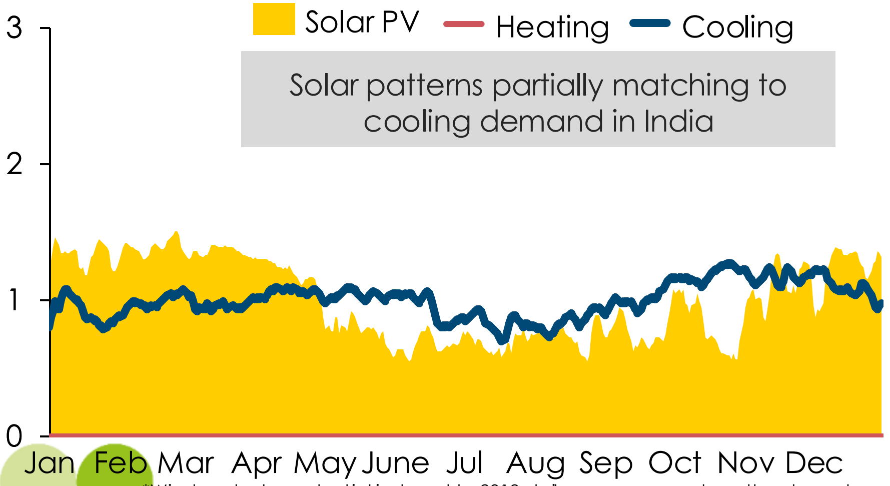
Theoretical renewables and heating and cooling demand patterns (Brazill[a]) Index*



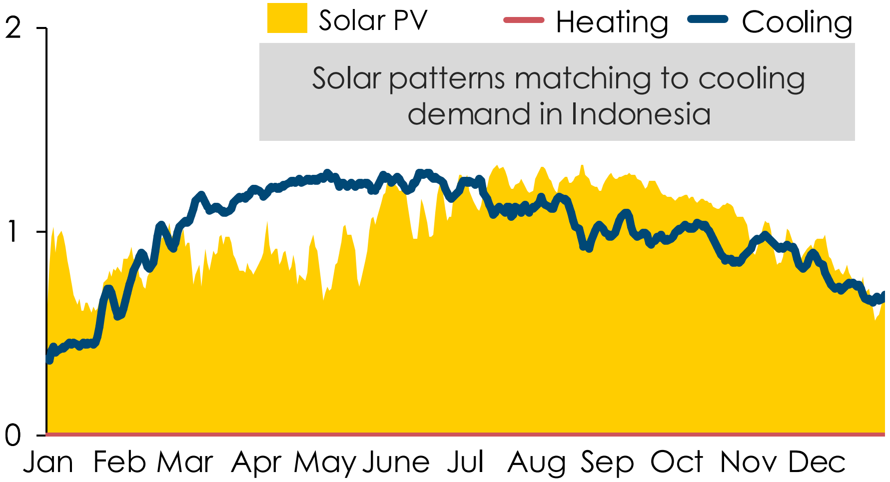
Theoretical renewables and heating and cooling demand patterns(Italy[b]) Index*



Theoretical renewables and heating and cooling demand patterns (India[c]) Index*



Theoretical renewables and heating and cooling demand patterns (Indonesia[d]) Index*



Potential heating and cooling demand patterns based on temperature and weather in 2019.

Variations in solar PV supply patterns can vary significantly from the cooling demand patterns across different regions

*Wind and solar potential indexed to 2019 daily average supply pattern based on weather patterns, using a five day rolling average. Cooling and heating indexed to 2019 daily average potential demand pattern based on weather and temperature patterns. Daily averaged based on five-day rolling averages. a. Brazil figures based on Rio De Janeiro. b. Italy figures based on Rome. c. India figures based on Chennai. D. Indonesia figures based on Jakarta: Renewables Ninja 2024

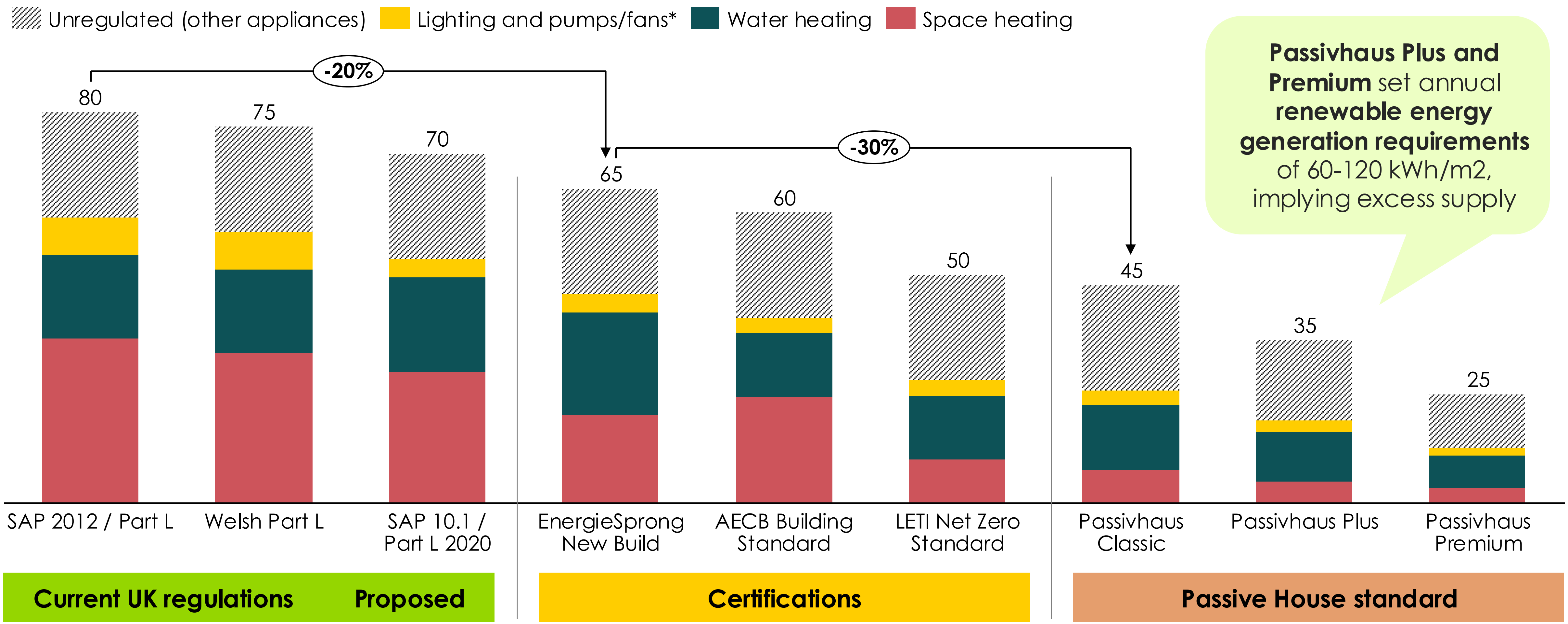
There are various household-level solutions that can reduce final and peak energy consumption without impacting living standards

	1 Use less energy for the same output	2 Reduce energy needs and losses	3 Household demand-side flexibility		
	Technical efficiency improvements	**Better building design and envelopes**	**Smart systems**	**Solar PV**	**Storage solutions**
Impact on final energy consumption	More efficient technologies consume less energy	Passive heating/cooling reduce energy needs, and insulation reduces energy loss	Optimise energy consumption according to need and/or incentivise household behaviour change	Reduces the need for electricity imports from the grid	Only able to time shift demand, but does not reduce the amount of energy needed
Impact on peak energy consumption	Reduces scale of peaks, but unable to load-shift	Enables households to pre-heat their homes ahead of peak times	Time shift energy consumption based on needs around peak times	Unable to shift demand with a battery	Batteries, hot water storage, or heat storage enable time shifting of energy use to cheaper times

Certified and passive house standard buildings consume 20-50% less energy per m² with the biggest potential reduction from space heating and better insulation

Final energy per m2 by end use by building energy standards (UK)

Annual kWh/m2 for a 3-bedroom semi-detached house; air source heat pump as the heat source for heating and hot water

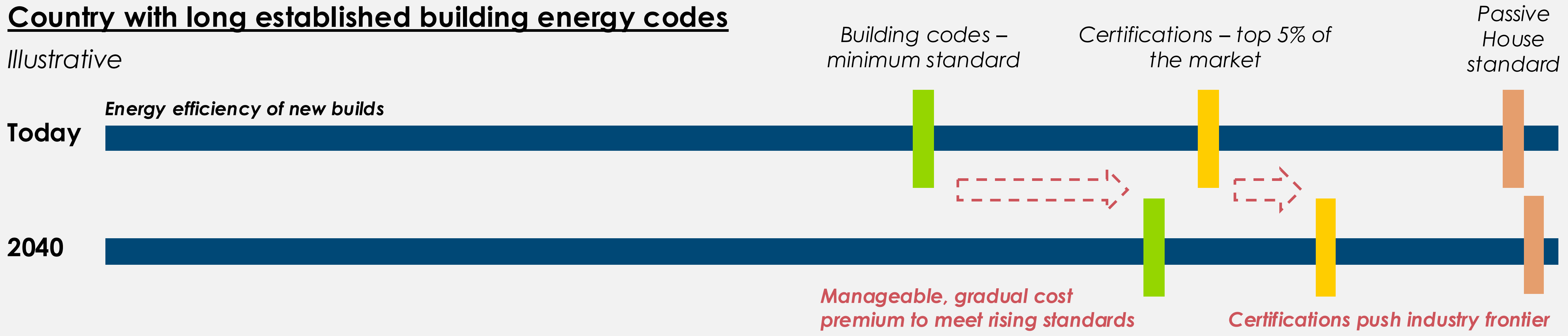


Note: Pumps/fans – energy use associated with the HVAC system besides space and water heating
Source: Good Homes Alliance & Woodknowledge Wales (2020), *Building Standards Comparison*

Building codes should therefore aim to move towards certification level over time, driving the industry frontier; Passive House standards define technical potential

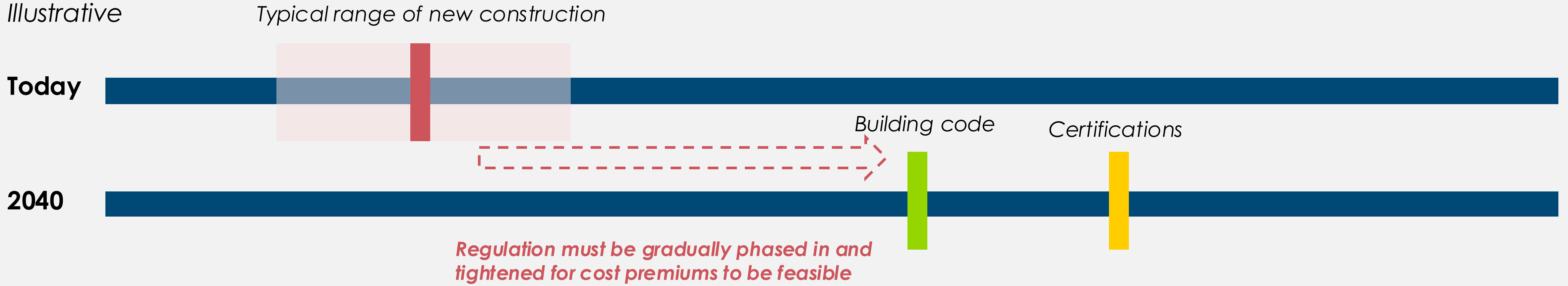
Country with long established building energy codes

Illustrative



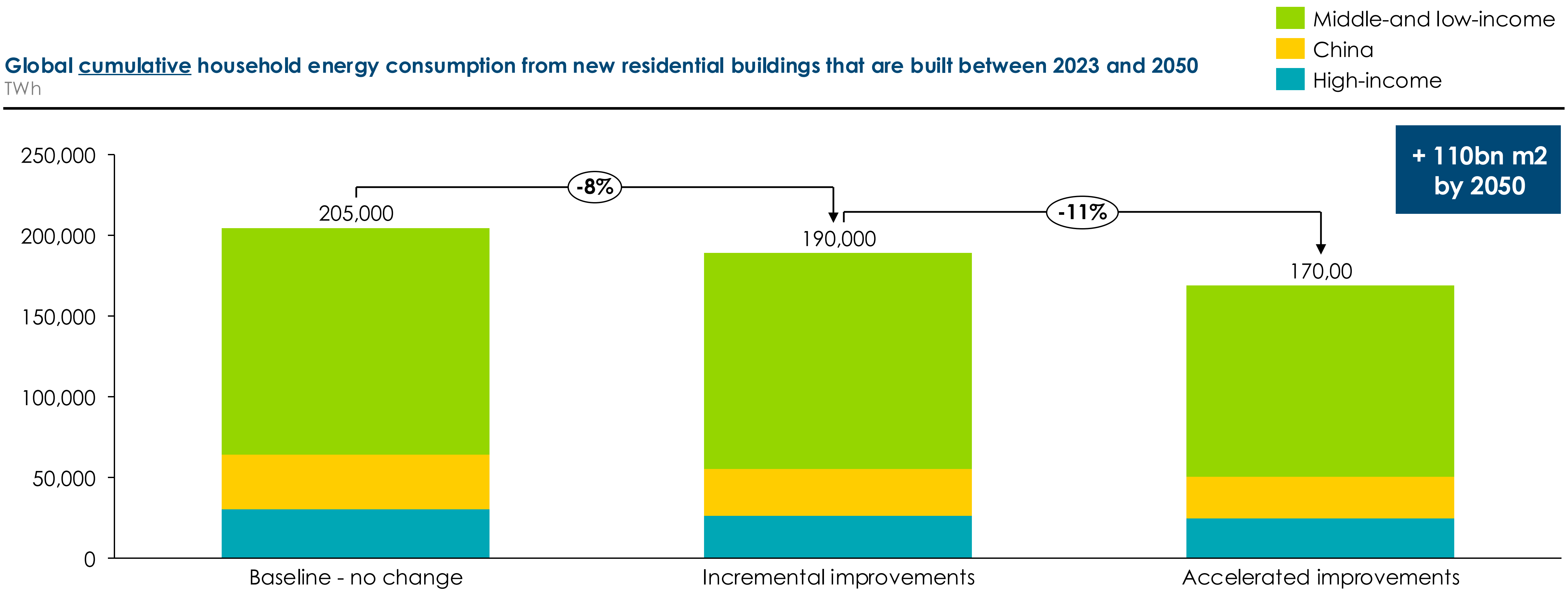
Country with no established building energy codes

Illustrative



Introducing and tightening building regulations could reduce overall energy consumption from new buildings by 10-20%

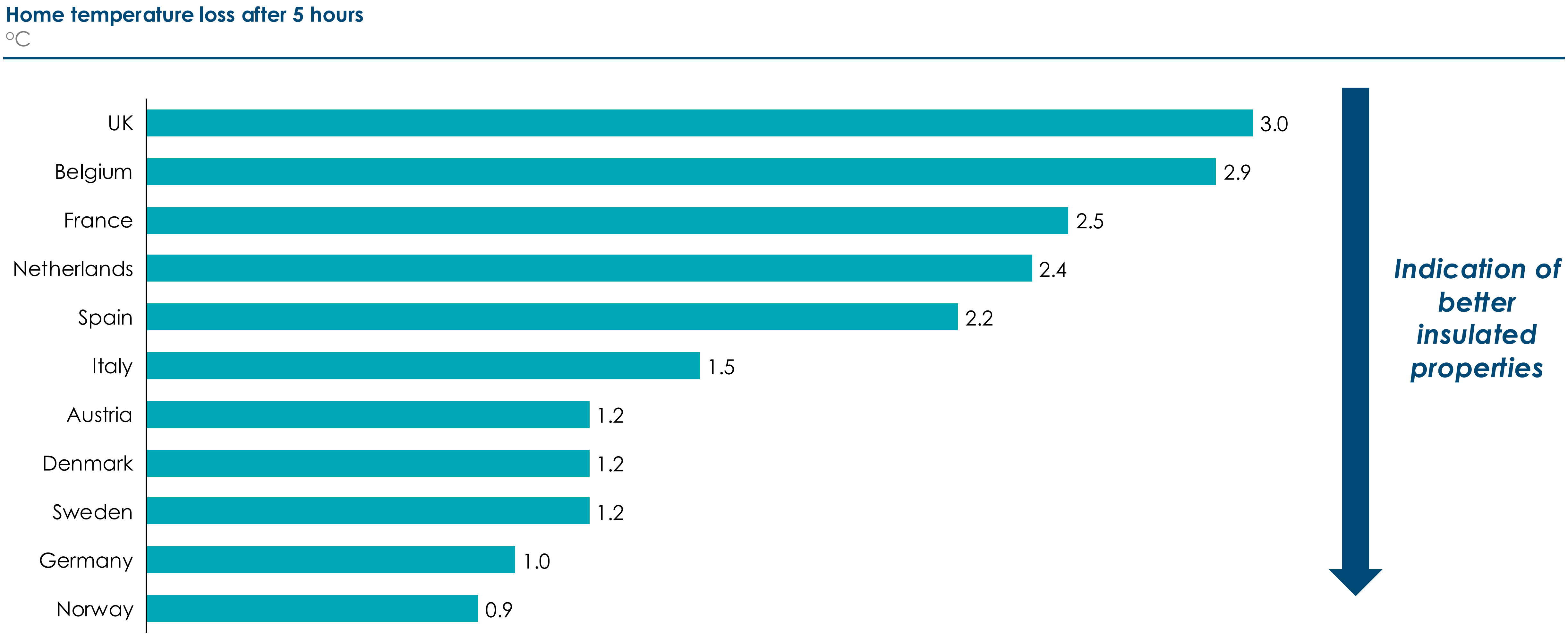
Global cumulative household energy consumption from new residential buildings that are built between 2023 and 2050
TWh



	Today	2050	2050
Middle/low income	150	120	80
China	110	60	50
High-income	80	55	45

Source: Systemiq analysis for the ETC (2024); IEA (2023), *World Energy Outlook 2023*.
Note: assumes a flat growth rate in residential floor space to 2050.

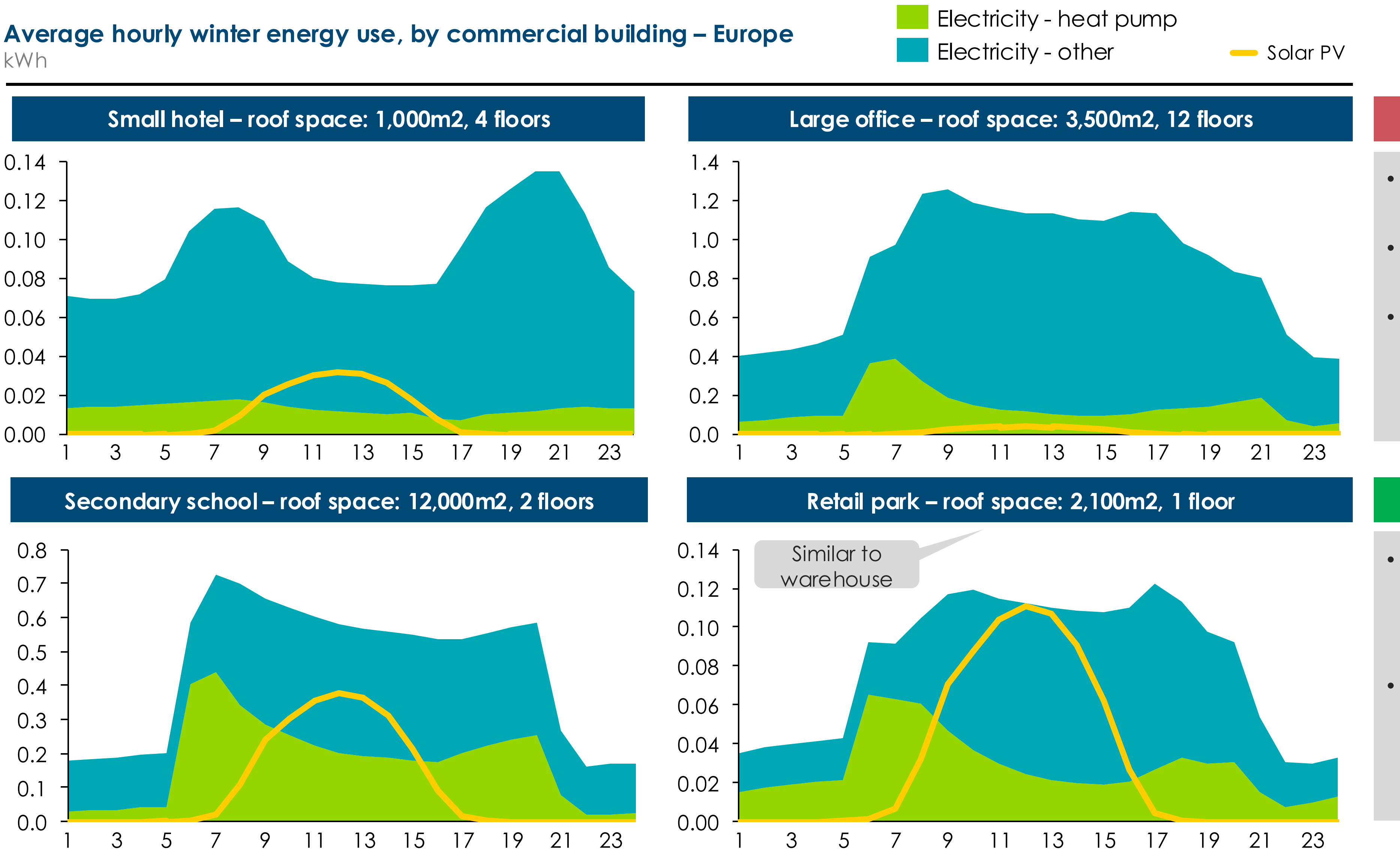
Homes vary significantly in terms of their ability to retain heat, with big implications for the ability of households to "pre-heat" their homes ahead of peak needs



Source: Tado
Note: tested in 2019/20 with a temperature of 20C inside and 0C outside

The payback to solar PV depends heavily on available roof space; generation is only able to meet a tiny share of many multi-story commercial buildings needs

Average hourly winter energy use, by commercial building – Europe
kWh



Likely poor paybacks

- Small roofs relative to floor space (roof:floor ratio <20%)
- Roof space further limited by HVAC equipment
- Solar PV can meet:
  - ~10% of needs in small hotel
  - ~1% of needs in large office

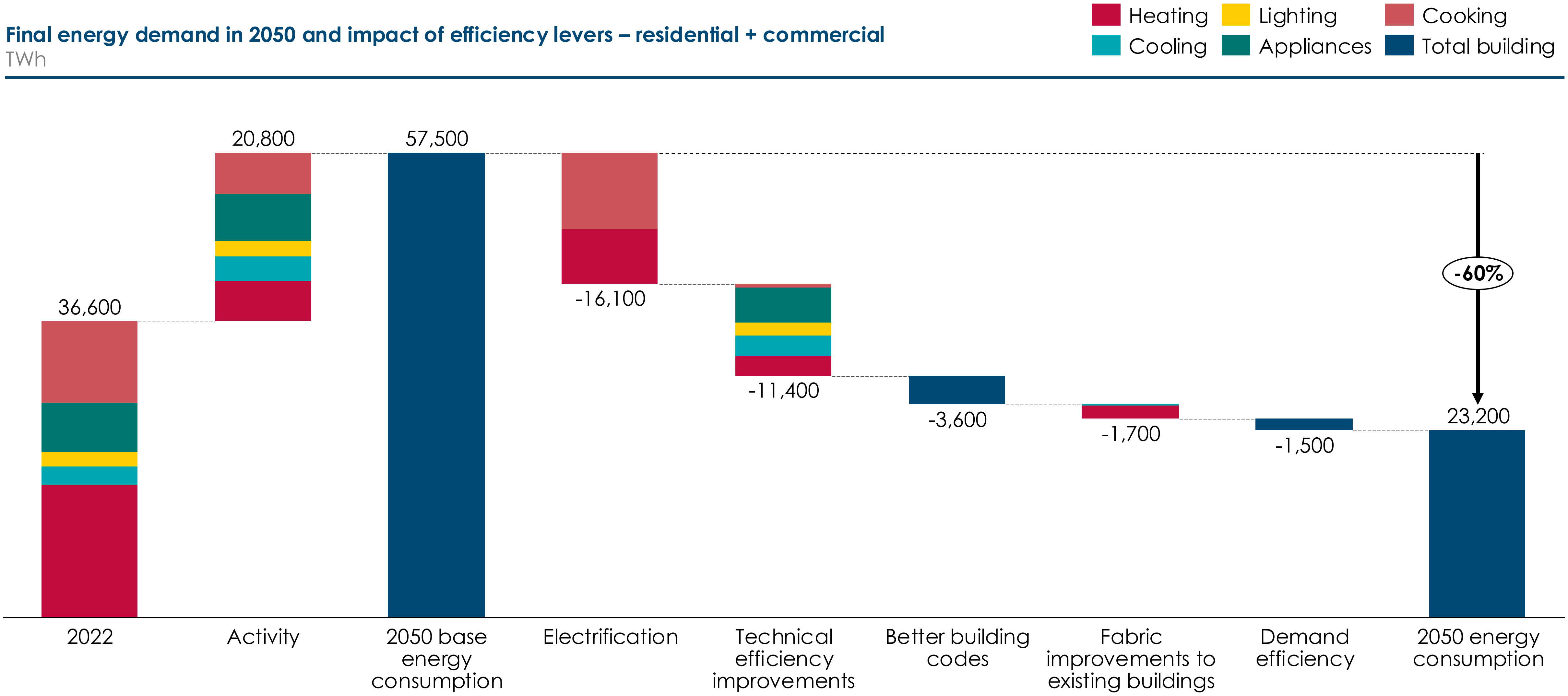
Likely reasonable paybacks

- Much larger roof space relative to floor space → retail parks (and warehouses) have a 100% roof to floor ratio
- Solar PV can meet:
  - 25% of needs in secondary school
  - 35% of needs in retail park

Source: Systemiq analysis for the ETC (2024) of Schneider Electric Sustainability Research Institute
Note: winter is defined as November to February

Electrifying heating + cooking, efficiency improvements in heat pumps + AC + LED lighting + appliances, and improving building fabric could reduce final energy demand by 60%

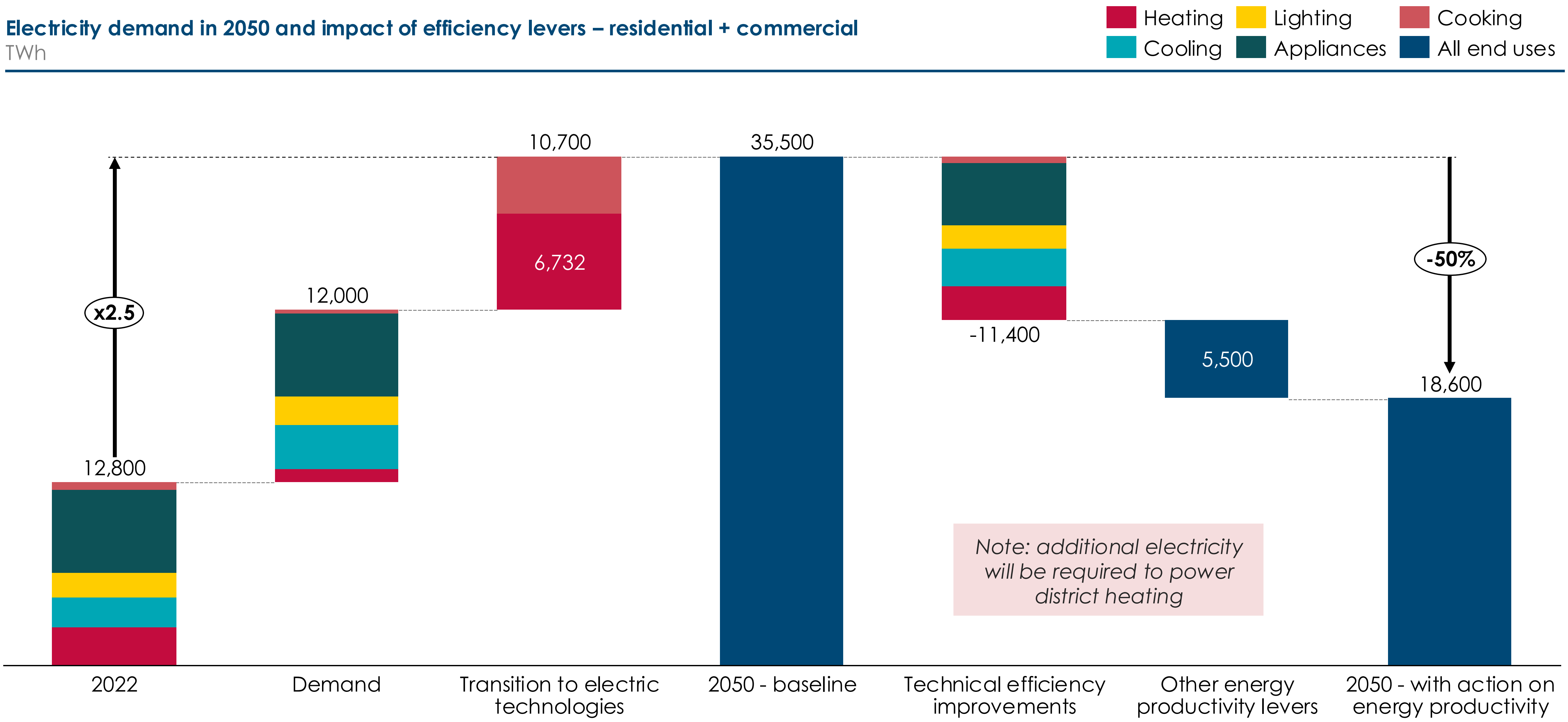
Final energy demand in 2050 and impact of efficiency levers – residential + commercial
TWh



Sources: Systemiq analysis for the ETC (2024); IEA (2023), World Energy Outlook 2023; IEA (2021), *Net Zero by 2050.*

Global electricity demand more than double by 2050 with rising demand and the electrification of heating – but action on energy efficiency could cut this in half

Electricity demand in 2050 and impact of efficiency levers – residential + commercial
TWh

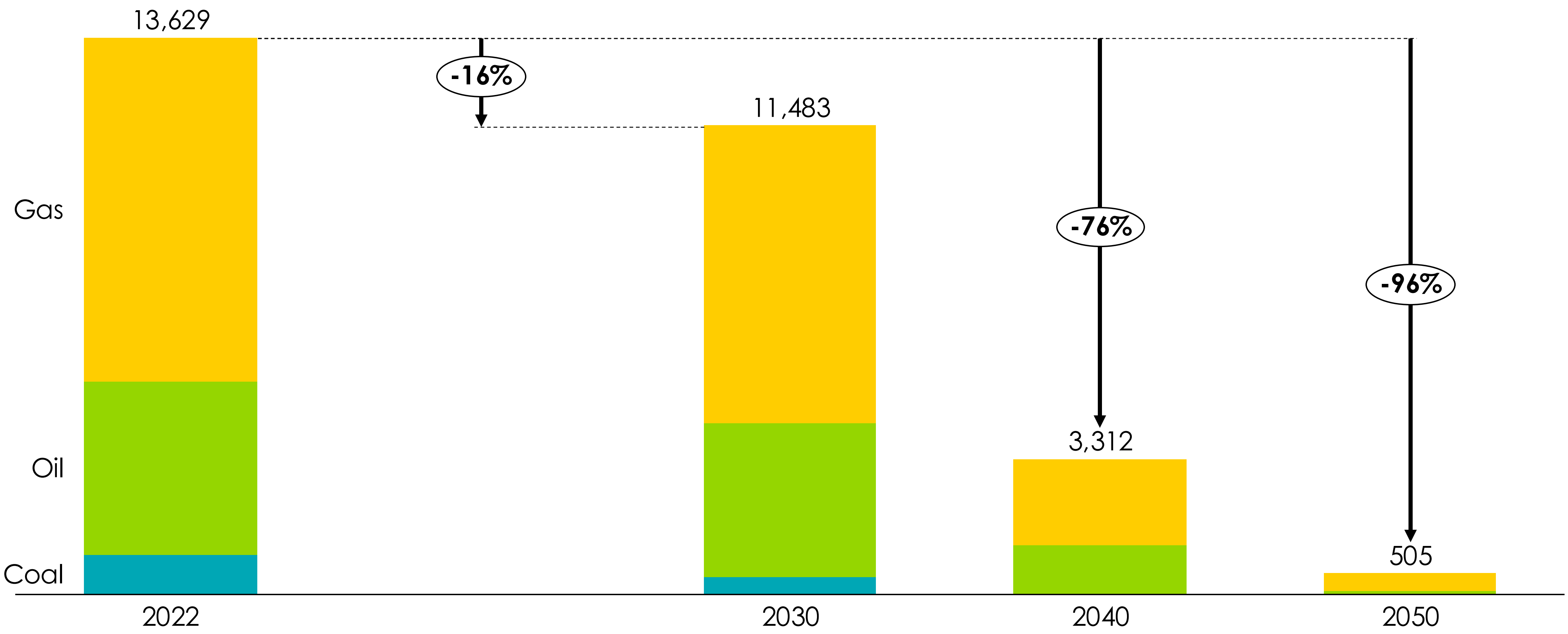


Sources: Systemiq analysis for the ETC (2024); IEA (2023), World Energy Outlook 2023; IEA (2021), *Net Zero by 2050.*

The direct use of fossil fuels in buildings could be virtually eliminated by 2050, with a reduction of 15% by 2030 and 75% by 2040 as heating and cooking electrify

Fossil fuel demand in buildings

TWh



Note: values are rounded.

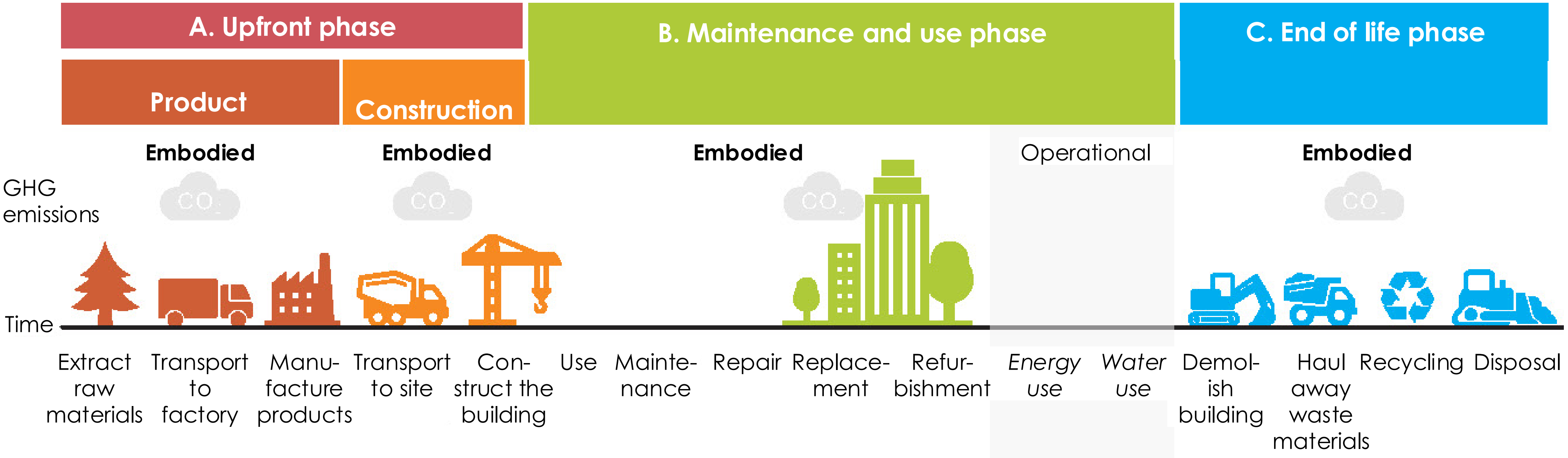
Source: Systemiq analysis for the ETC (2023); IEA (2022), *World Economic Outlook 2022*; IEA (2023), *World Economic Outlook 2023*; IEA (2023), *World Energy Balances dataset*; IEA (2023), *Energy Efficiency dataset*; Tsinghua Building Energy Research Center, *Annual Report of Building Energy in China*.

Section B: embodied carbon

Understanding emissions across the building lifecycle

Embodied carbon refers to the emissions from any process relating to the construction, maintenance and demolishing of buildings

Sources of embodied and operational carbon emissions across building life cycle stages



- Fuel + process emissions from making steel, cement, and wood
- Fossil fuels / fossil fuel power used in factories and transportation to site

- Fossil fuels / fossil fuel power used for machinery and transportation

- Production and construction emissions relating to retrofitting materials and equipment
- Emissions relating to the production of new heating systems and equipment

- Heating
- Cooling
- Cooking
- Lighting
- Appliances

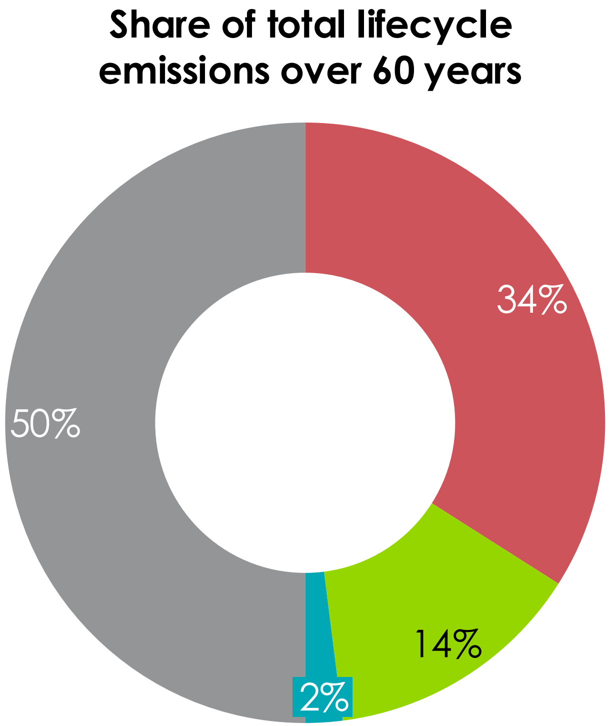
Fossil fuels / fossil fuel power used for:
- Demolition
- Transportation of waste
- Recycling or disposal processes

Source: New Buildings Institute, *Embodied Carbon*

Embodied emissions are one-off bursts at a few points in a building's lifecycle, while operational emissions are long-term and recur every year

Whole life carbon emissions over time

$kgCO_2e/m^2$, average distribution across 6 buildings in Europe



- There is a lack of data and **no consensus** on embodied carbon baselines today
- Case studies suggest that embodied carbon accounts for **~50% of a building's lifecycle emissions**
- The **vast majority** of embodied carbon emissions are in the **upfront stages (product + construction)**

Source: WBCSD & Arup (2023), *Net-zero buildings Halving construction emissions today*; RMI (2023), *Embodied Carbon 101: Building Materials*

Upfront embodied carbon

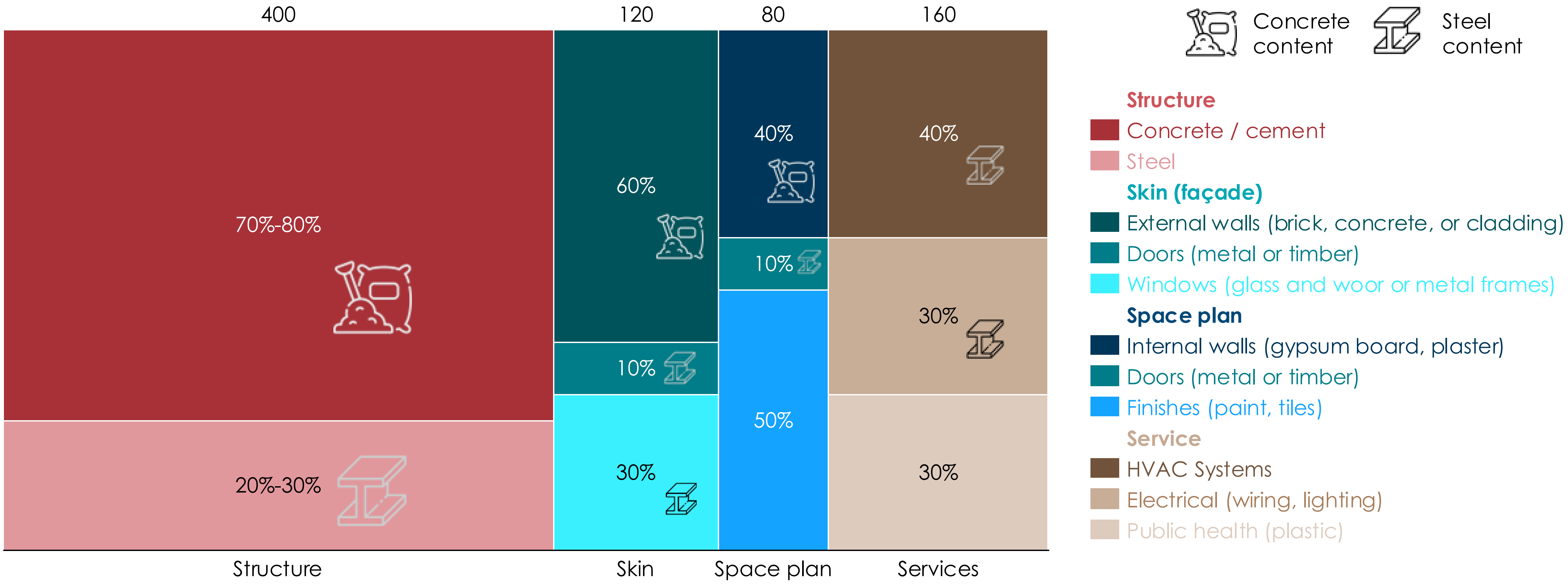
Key messages

- Embodied carbon is often overlooked, but can account for up to half of a building's lifecycle emissions. As heating is electrified and electricity grids are decarbonised, embodied carbon will become an even bigger share of emissions
- With global floor area set to more than double by 2050, action to reduce embodied carbon during the transition is critical; new construction could release 75GtCO2, or 40% of the remaining carbon budget for 1.5C
- By far the biggest source of embodied carbon is from the production of material inputs to construction, namely cement, concrete and steel
- The Mission Possible Partnership's sector transition strategies have challenged the belief that it was not possible to fully decarbonise the so-called "hard to abate" sectors by 2050, setting out the suite of technologies available today
- But to reach net zero by 2050, material efficiency and substitution is required, involving innovative building design strategies, using alternative materials such as timber, and better urban planning

A building's structure accounts for over half of its embodied emissions, driven by steel and cement/concrete

Estimated typical upfront embodied carbon distribution for a building in Europe

Total of 760 kgCO2e/m2; % share

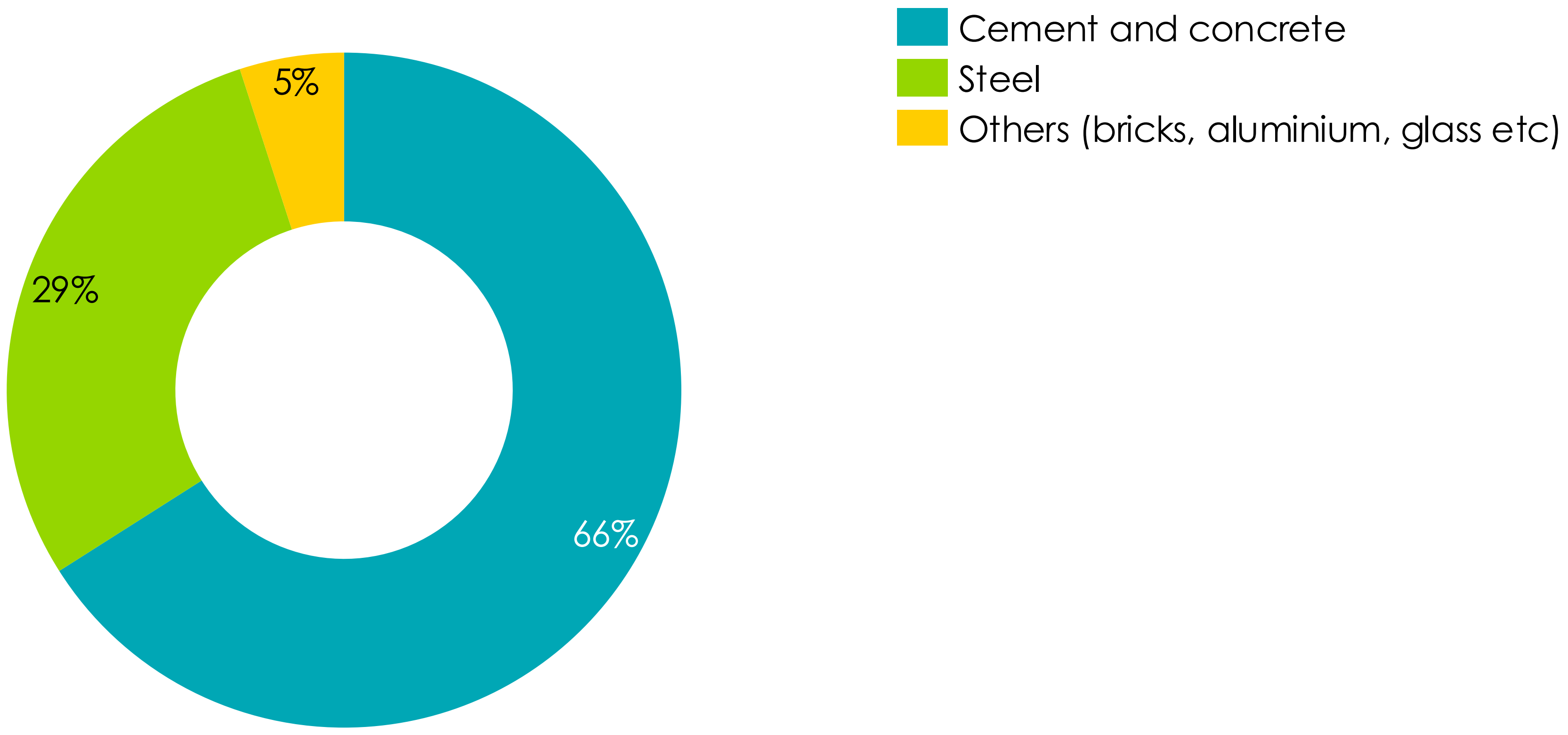


Source: Typical upfront embodied carbon and the building layers spilt from WBCSD & Arup (2023), *Net-zero buildings Halving construction emissions today*; material split from literature review, including ArchDaily (2021), *How to Approach Embodied Carbon Reduction within an Architectural Project*

Cement, concrete and steel account for 95% of embodied emissions

Cement and steel contribution to global construction material carbon impact

%



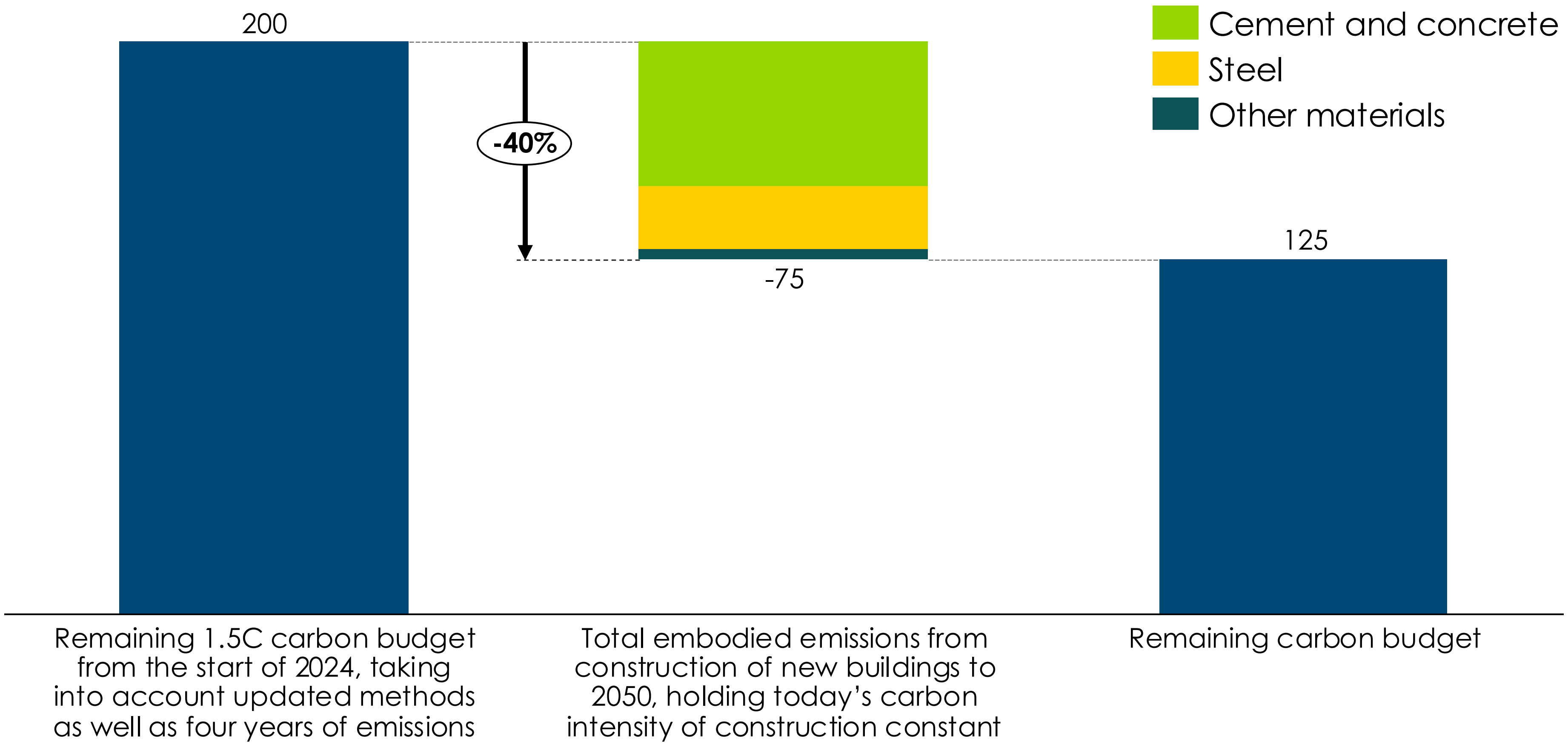
Source: WBCSD & Arup (2023), *Net-zero buildings Halving construction emissions today*

At today's embodied carbon intensity, total emissions from construction of new buildings could amount to ~75 Gt CO2e, or 40% of the world's remaining 1.5°C carbon budget

Global cumulative embodied emissions, 2023 – 2050, compared to remaining carbon budget
Gt CO2e

New floor space to 2050:
140 bn m2

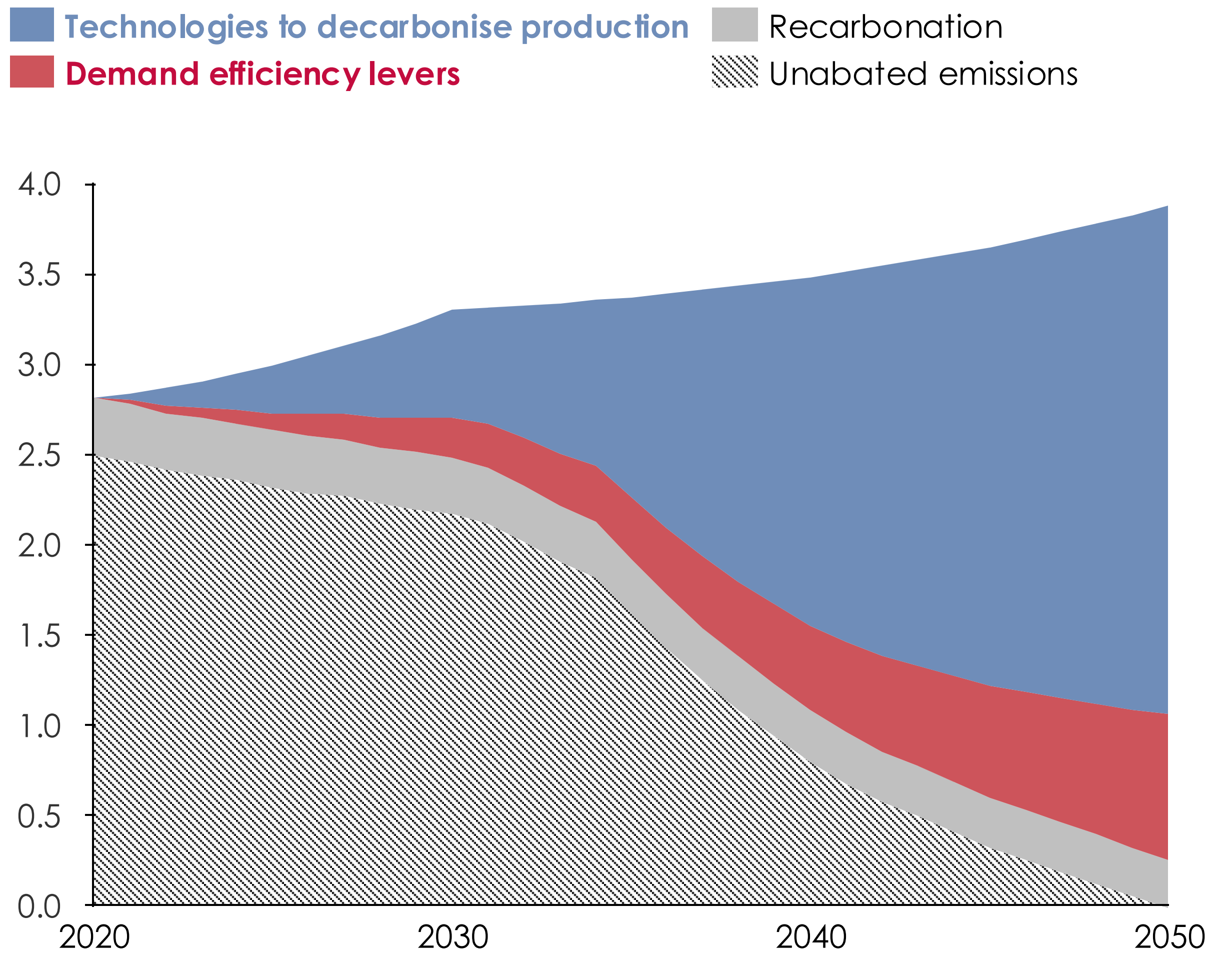
Current embodied carbon intensity:
540 kg CO2 / m2



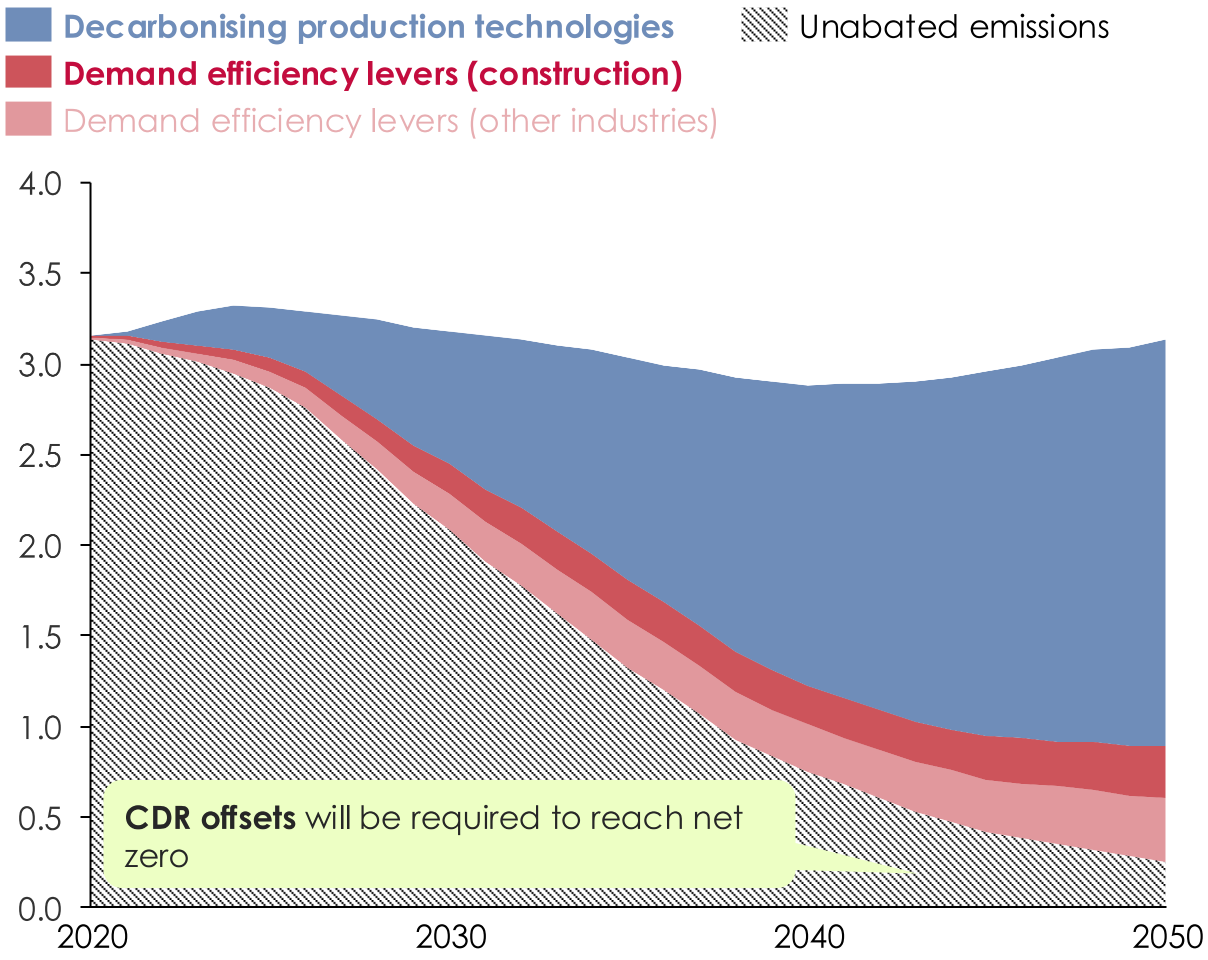
Sources: Systemiq analysis for ETC (2024); IEA for global floor area and emissions; Forster et. Al (2024) *Indicators of Global Climate Change 2023: annual update of key indicators of the state of the climate system and human influence*
Note: current embodied carbon intensity calculated from 2.6GtCO of annual embodied carbon emissions, divided by 4.6bn m2 of new floor space

The MPP strategies show that, while reducing demand is important, addressing process and production emissions will have the biggest impact on mitigating emissions

Net zero, 1.5 degree aligned concrete and cement sector
GtCO2 / year



Net zero, 1.5 degree aligned steel sector
GtCO2 / year

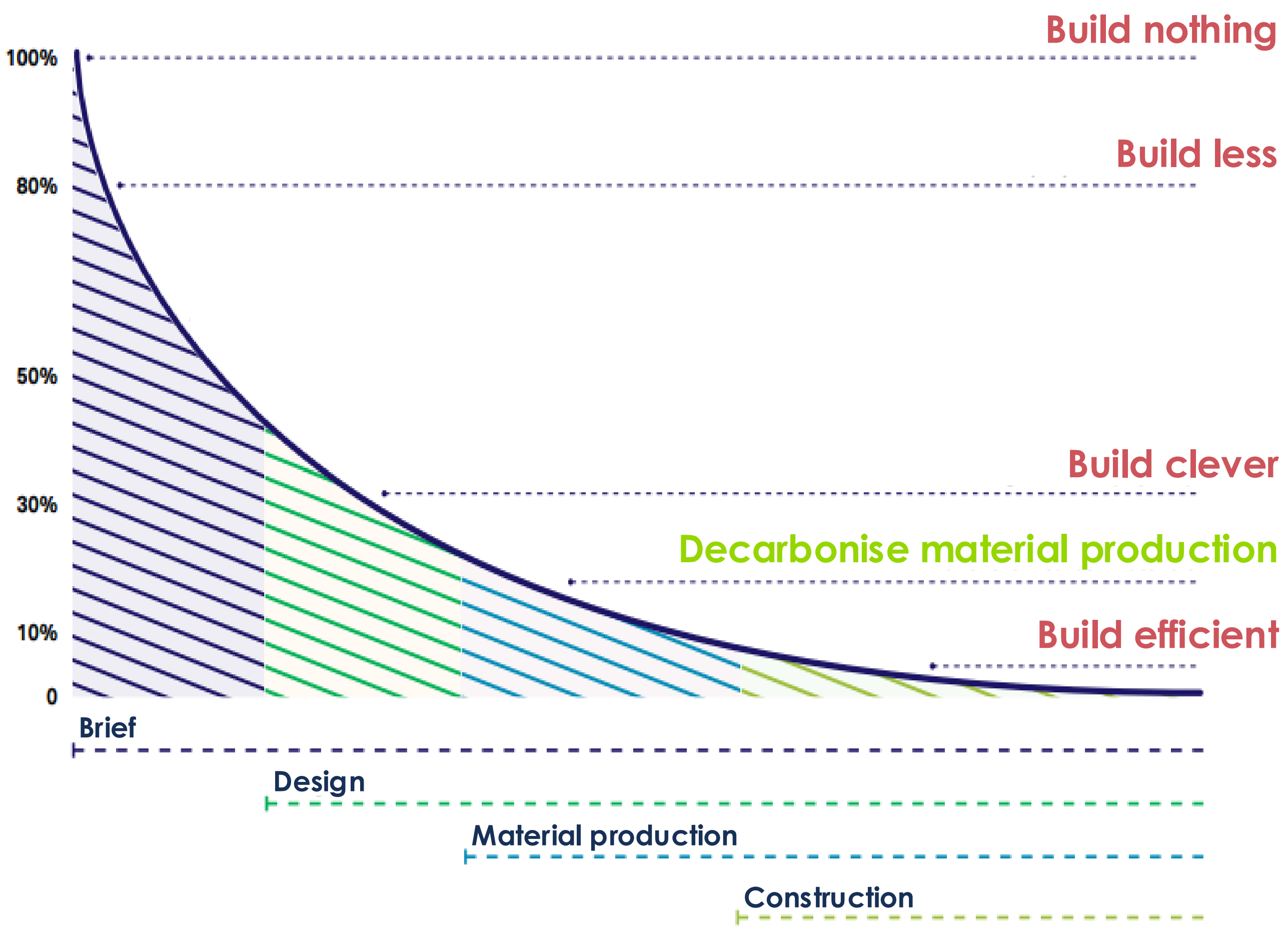


Source: Mission Possible Partnership (2023), *Making Net Zero Concrete and Cement Possible;* Mission Possible Partnership (2022), *Making Net Zero Steel Possible.*

Demand efficiency levers

The biggest opportunity to reduce embodied carbon is to build less; but there are many ways to “build clever” and “build efficient” which are much easier to implement

Impact of decision-making on embodied carbon reduction strategies Embodied carbon reduction potential, %



Build nothing
- Re-use or extend use of existing buildings

Build less
- Optimise building use and service efficiency
- Better urban planning

High impact – but much harder to implement

Build clever
- Material intensity
- Innovative construction solutions
- Material substitution

Build efficient
- Efficient construction methods
- Circularity approach

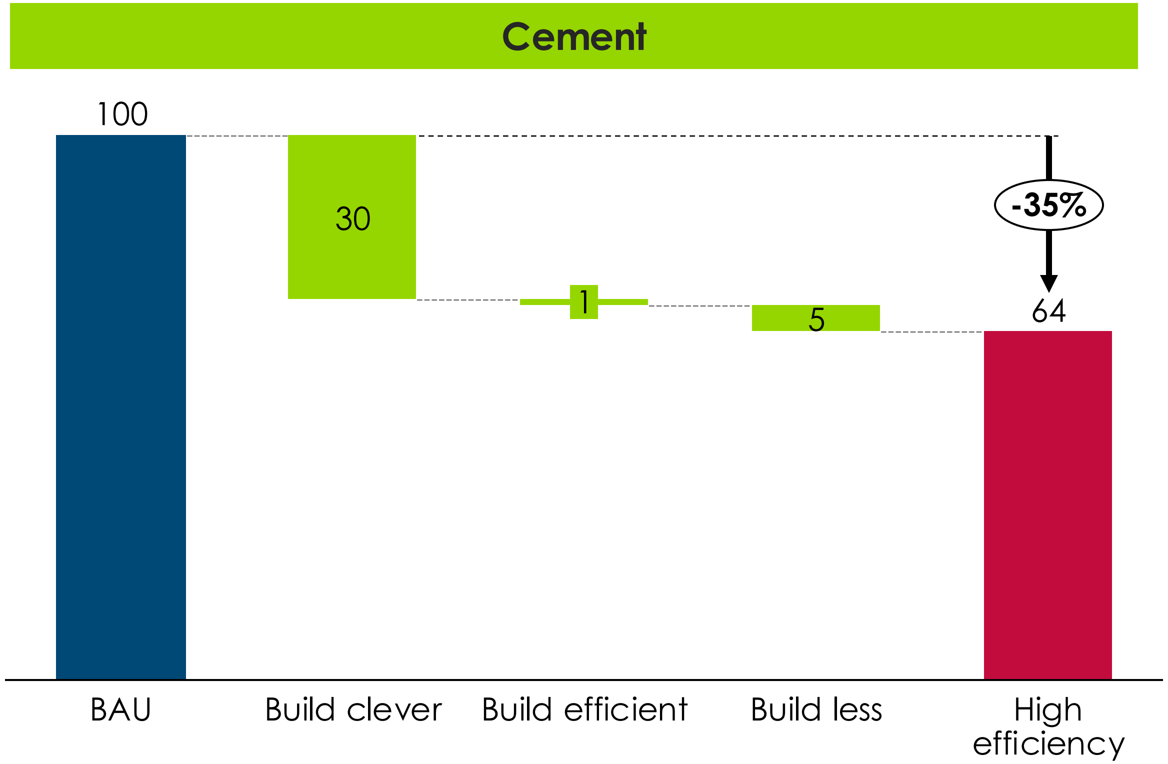
Relatively lower impact – but easier to implement

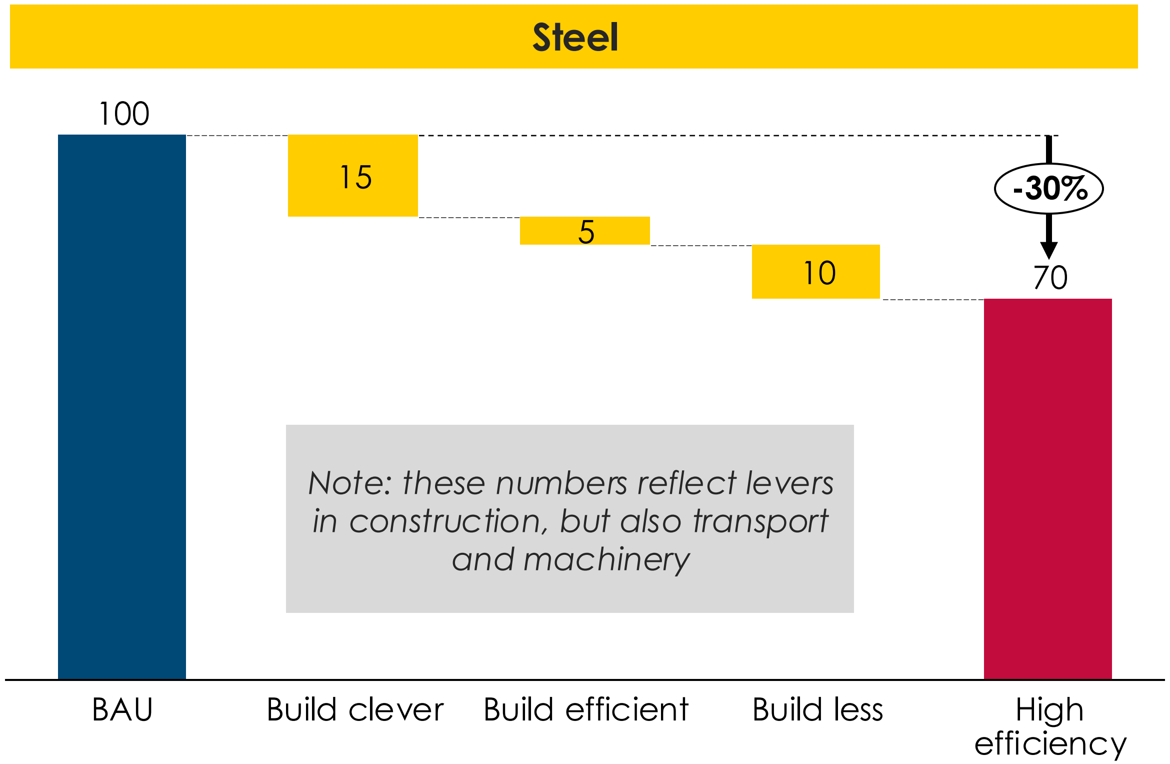
Source: WBCSD & Arup (2023), *Net-zero buildings Halving construction emissions today*

Strategies to reduce material demand, minimise waste and extend building lifetimes could cut demand for cement and steel by 30-35% to 2050

Potential percentage reduction in demand for cement and steel to 2050 with material efficiency and substitution levers

% material demand, cumulative to 2050





Build clever: Building design choices; Innovative construction solutions; material substitution

Build efficient: Efficient construction methods; circularity approach

Build less: extend building lifetimes

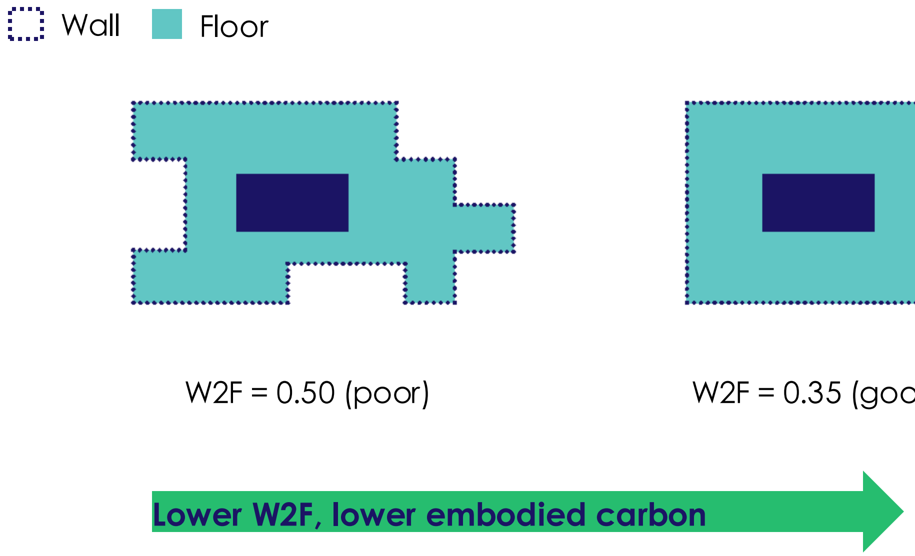
Source: Mission Possible Partnership (2023), *Making Net Zero Concrete and Cement Possible;* Mission Possible Partnership (2022), *Making Net Zero Steel Possible*

Taller buildings have a higher embodied carbon intensity, requiring significantly more material for structural support; buildings that minimise wall to floor ratios have lower emissions

Wall to floor ratio

Wall-to-floor (W2F) ratio comparison

W2F

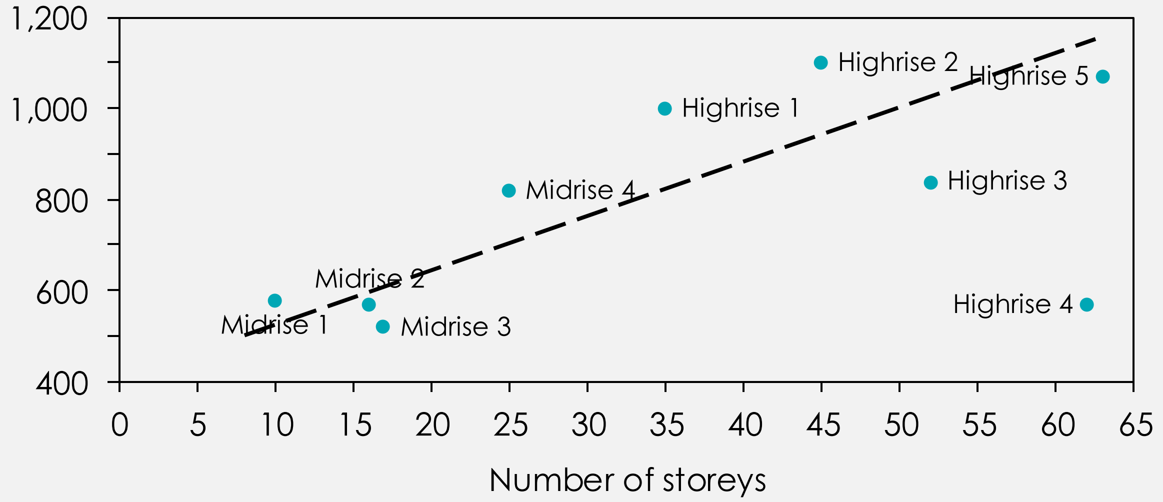


- W2F ratio can typically vary from about **0.3 to 0.5**
- At its upper end, it can represent **more than 60% of additional façade area**, driving additional embodied carbon into the design

Building height

London mid/high-rise buildings benchmarking

Upfront embodied carbon intensity, kgCO2e/m2 GIA



Taller buildings typically require more structure (thicker core walls, bigger columns, larger foundations, etc.) **and more space and equipment** associated with vertical movement of people (lifts ad stairs) **and building services** (risers, interstitial plant provision, etc.)

Embodied carbon per m2 can be **50% higher** to provide the same net useable area between high-rise and low-rise construction

Source: WBCSD & Arup (2023), *Net-zero buildings Halving construction emissions today; Saint-Gobain & Arup, Carbon footprint of façades: significance of glass*

There are many low-carbon alternative materials, with bio-based materials in most cases able to be carbon negative as long as they are dealt with properly at end of life

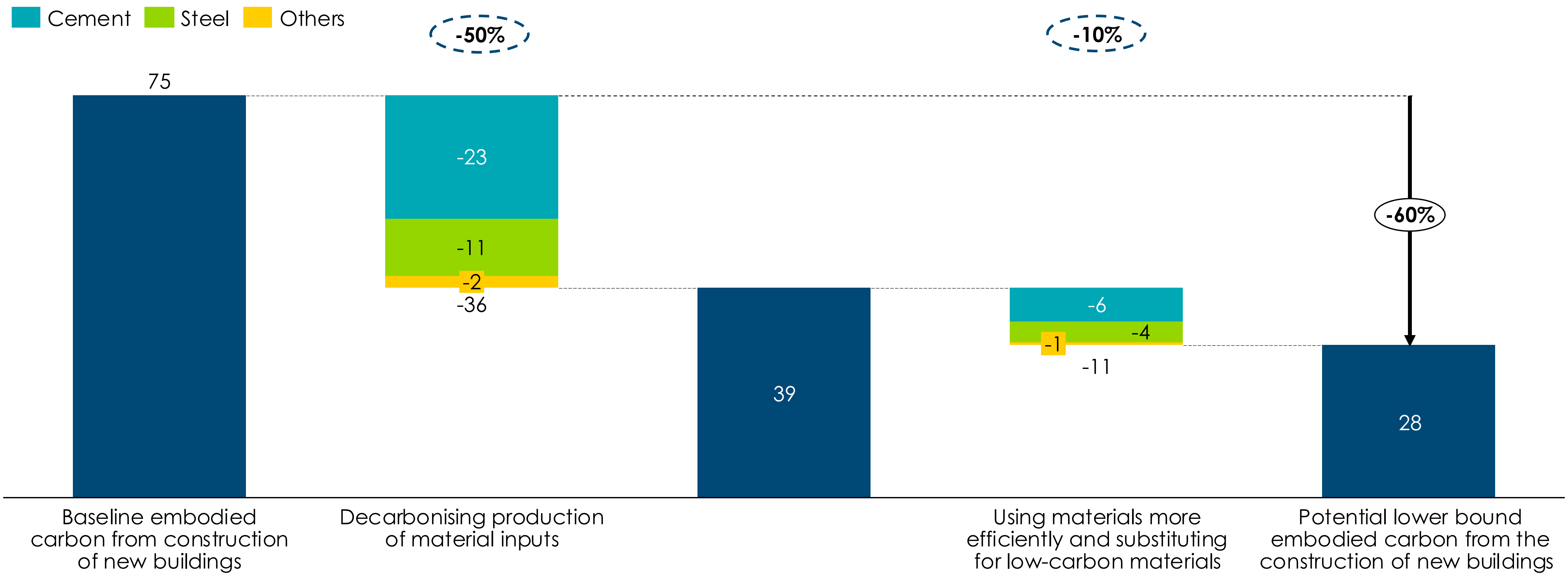
Alternative materials	Applicable building layers	Details and carbon impact		Barriers
Hempcrete	Skin (façade); internal wall	 	• A mix of hemp fibres, lime, and waste • **More atmospheric carbon is locked away in material** for the lifetime of the building than used in its production	• Not suitable for structural use • Limited awareness • Limited building codes compliance
Rammed earth	Structure; internal wall		• Compressed natural soil, sometimes stabilized with cement • Requires **significantly less energy** and produces minimal waste during construction comparing to conceate • **Excellent thermal mass** property to reduce operational emissions	• Labor-intensive (requires skilled labour) • Potential for cracking
Timber	Structure; skin (façade)		• **Lower overall GHG emissions** than traditional concrete and steel, in particular in regions with ample sustainable forestry • Potential to sequestration	• Supply constrained • Susceptible to fire, rot, and pests • Needs sustainable forestry practices
Bamboo	Structure; skin (façade)		• **Very low carbon footprint**	• Limited building codes compliance • Low performance for operational emissions • Risk of destruction of habitats (e.g., for pandas)

Non-exhaustive

The total embodied carbon from building 140bn m² by 2050 could be reduced by 60% with action to decarbonise inputs, and material efficiency and substitution

Potential reduction of embodied carbon from the construction of new floor space, cumulative emissions 2023-50

Gt CO2e



Note: *Assuming productions of other materials will decarbonise at the rate of how aluminium production decarbonises, and the efficiency and substitution rate as steel rate

Sources: Systemiq analysis for ETC (2024)

Section C: actions for policy and industry

Across both existing and new buildings, there are 5 strategic priorities for policymakers and industry

1. Set out a clear vision for the building energy transition
2. Underpin incentives for clean, electric technologies
3. Ensure the next generation of new buildings and cities are net-zero, flexible and efficient
4. Manage new and peaky electricity demand with flexible and efficient buildings
5. Deliver a fair and just transition for households

Set out a clear vision for the building energy transition

Policymakers

- Targets for heat pump deployment + training
- Clear bans on fossil fuel heating and cooking
  - Bans in new buildings – 2025 in high-income countries
  - Bans on the sale of new fossil fuel boilers – 2035 in high-income countries
  - Timeline to switch off the gas grid – 2045 in high-income countries
- Street-by-street decarbonisation strategies
- Timelines for the increasing stringency of building code

Industry and financial institutions

- Voluntary commitments to
  - Reduce financed emissions from buildings
  - Reduce embodied carbon of new builds
  - Build new builds to much higher efficiency standards
  - Decarbonise building stock and invest in energy efficiency (e.g., hotel chains and professional services companies)

Underpin incentives for clean and electric technologies

Policymakers

- Create demand for low carbon technologies
  - Quantitative mandates
  - Green procurement
- Rebalance gas and electricity prices – shift levies to gas or general taxation
- Power market design to drive electrification and enable consumers to benefit from low-cost renewables
- Time limited subsidies for heat pumps, clean cooking and energy efficiency improvements
- Education and awareness of the benefits

Industry and financial institutions

- Voluntary commitments to increase sales of heat pumps
- Invest in quality training of heat pump installers
- Financial institutions to design products to increase access to finance (e.g., mortgage top ups for heat pumps)
- Industry collaboration to fund networked heat pumps

Ensure the next generation of new buildings and cities are net-zero, flexible and efficient

Policymakers

- Improve the ambition and enforcement of building codes (e.g., increase kWh/m2 requirements towards the level of green building certifications over time)
- Regulation to play an education role in lower income countries (e.g., prescriptive building designs and considerations)
- Develop frameworks to define and measure embodied carbon
    - Harmonisation of these across countries
- Regulate that new buildings must complete a whole life carbon assessment

Industry and financial institutions

- Improve the transparency of green building certifications
    - Publicly available targets and assessments
    - Measure performance using actual, not modelled, data
    - Science-based targets

Manage new and peaky electricity demand with flexible and efficient buildings

Policymakers

- Power market design and regulation
  - Contracts for difference
  - Time of use pricing
- Investment and incentives for insulation, rooftop solar and batteries, storage, smart systems
- Minimum energy performance standards and regulations on labelling for appliances, lighting and heating/cooling technologies

Industry and financial institutions

- Scale up the provision of time of use pricing and deployment of smart meters
- Promote education and behaviour change
- Improved energy efficiency labelling

Deliver a fair and just transition for households

Policymakers

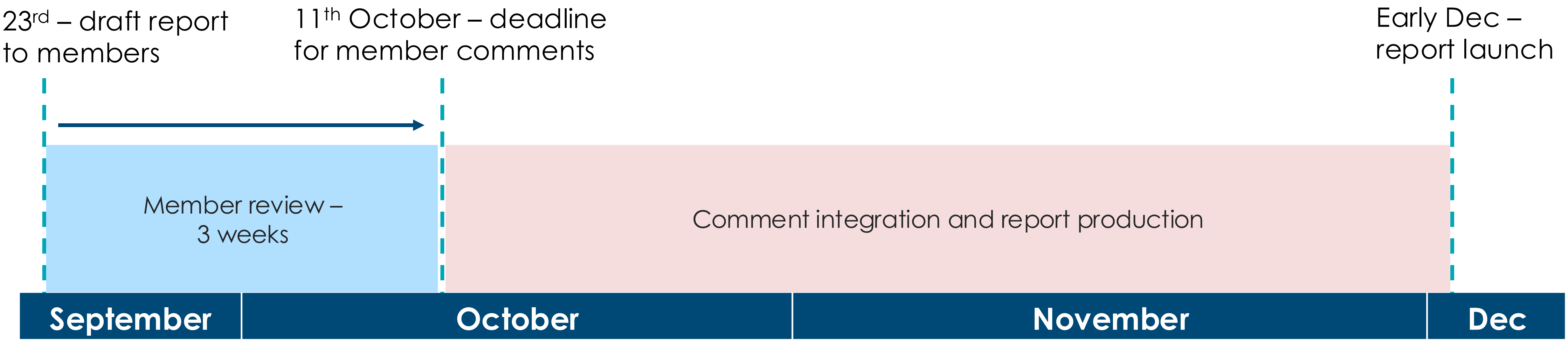
- Targeted financial support for low-income households for
- Investment in social housing energy efficiency improvements
- Better urban planning to reduce urban island heat effects
- Forward planning for any gas grid shut off
- Minimum energy performance standards for rental properties
- Education and awareness of low-cost and DIY passive heating and cooling, and of cleaner cooking fuels

Industry and financial institutions

- Industry engagement and forward planning for switching the gas grid off
- Utility companies to support vulnerable customers with financial support and advice on energy efficiency upgrades
- Utility companies to deploy smart meters in all households

Next steps

Key dates for members



Energy
Transitions
Commission