Energy Transitions Commission

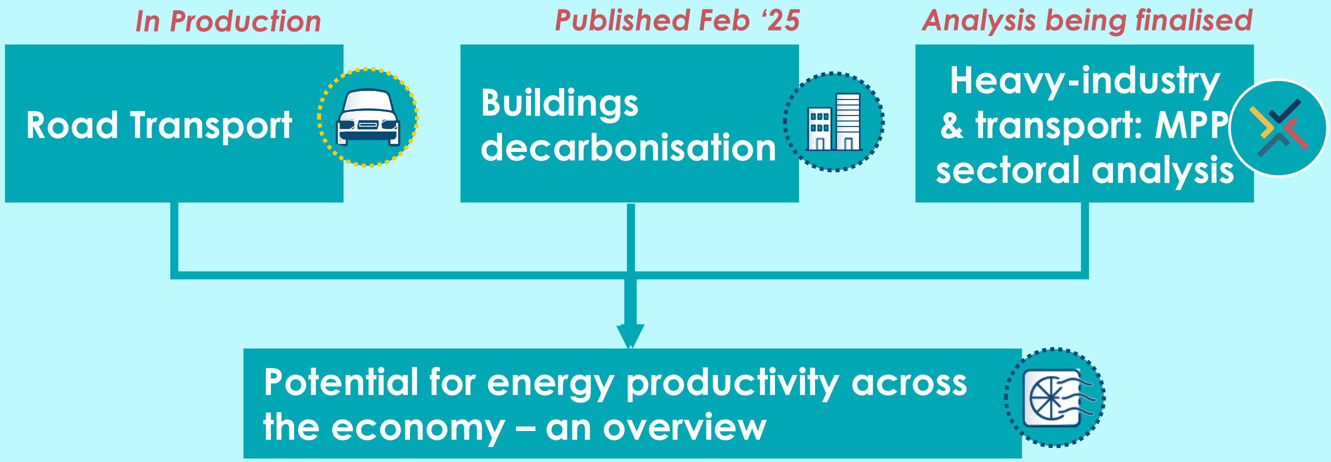
Accelerating energy productivity

ETC Representatives Meeting

15th May 2025

Energy productivity work builds on three detailed areas

2025 ENERGY PRODUCTIVITY SERIES



The overview of energy productivity potential will draw on three inputs:

- **Road transport**, covering both passenger and freight aspects.
- **Buildings**, encompassing both in-use structures and those under construction.
- **Industry and long-distance transport**, consolidating insights from the Mission Possible Partnership (MPP) analysis.

Next Steps

- ETC to incorporate discussions from this workshop
- Briefing draft to be circulated among ETC members and experts for revision and inputs – by **End of May**

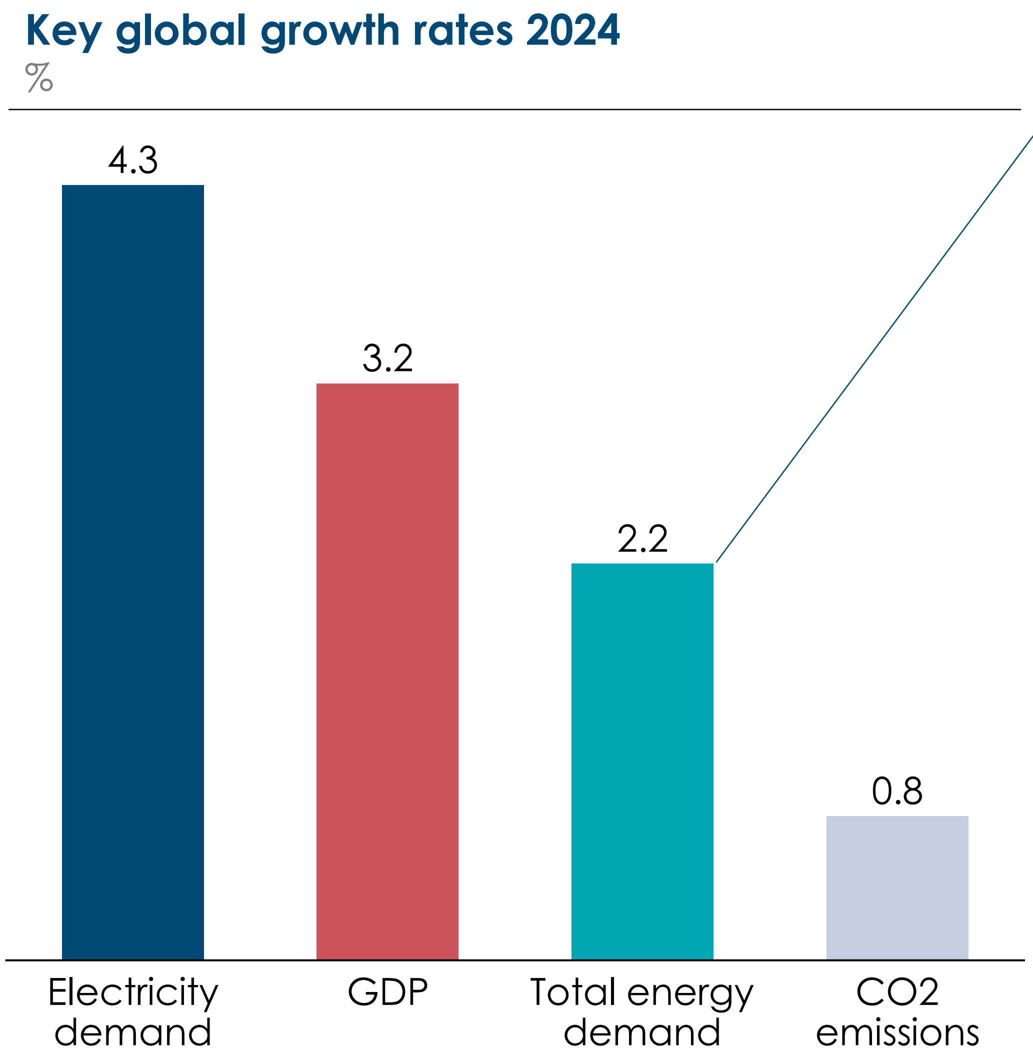
Workshop Agenda

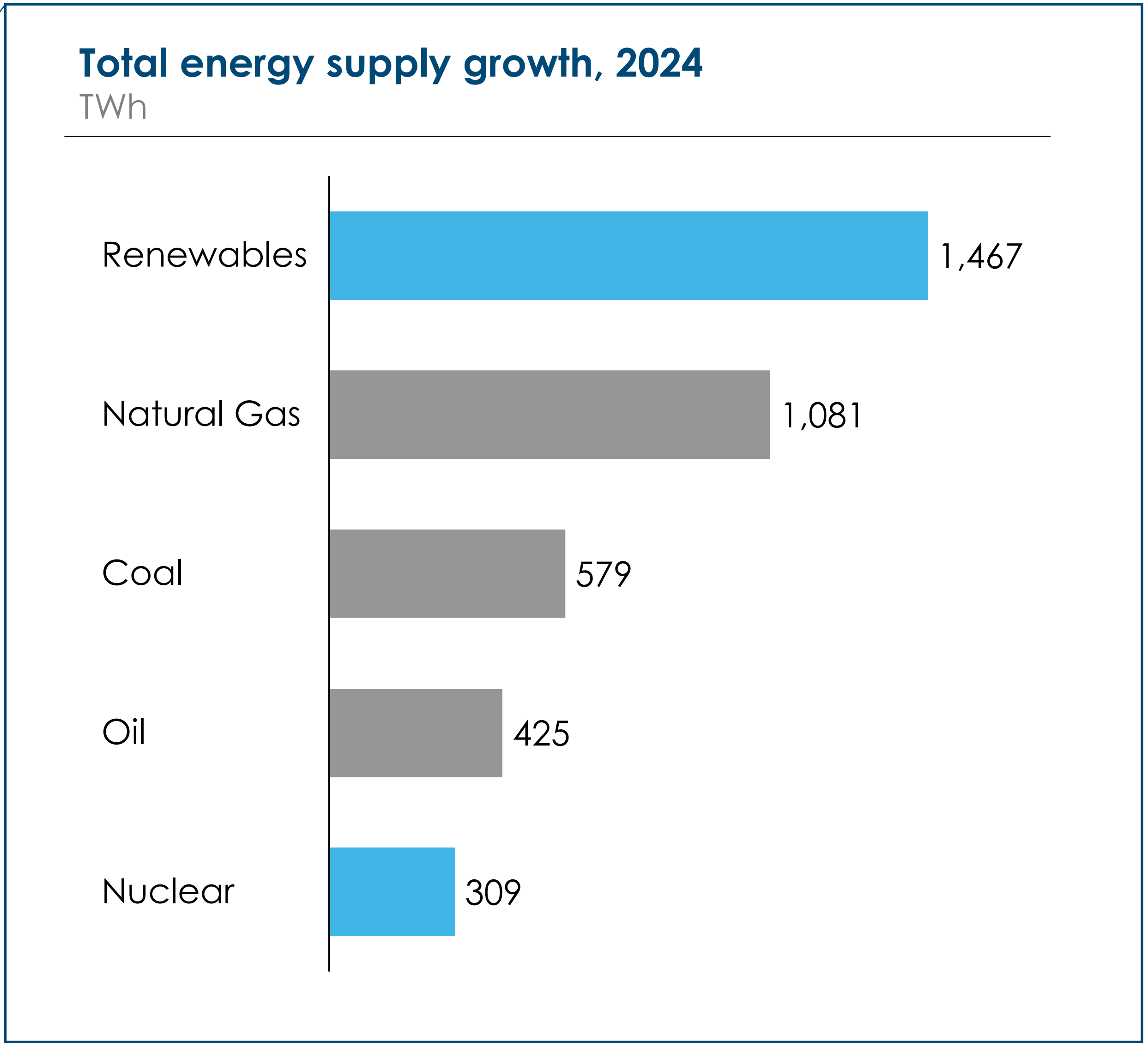
Session	Discussions	Suggested time
Context: Importance of energy productivity	▪ Defining energy productivity ▪ Role of energy productivity in decarbonised systems ▪ Historical trends	**Session: 15 min** **Q&A: 10 min**
ETC assessment of EP potential to 2050 & sectoral deep dive	▪ Key levers to maximise energy productivity ▪ Sectoral deep dive	**Session: 20 min** **Q&A: 45 min**
Summary conclusion & key priorities	▪ Key actions to scale potential ▪ Overall benefits that energy productivity can deliver	**Session: 10 min** **Q&A: 20 min**

Agenda

- **Context: Importance of energy productivity**
- ETC assessment of EP potential to 2050 & sectoral deep dive
- Summary conclusion & key priorities

Energy demand continues to grow, with electricity demand soaring and most of added demand being met by low-carbon generation



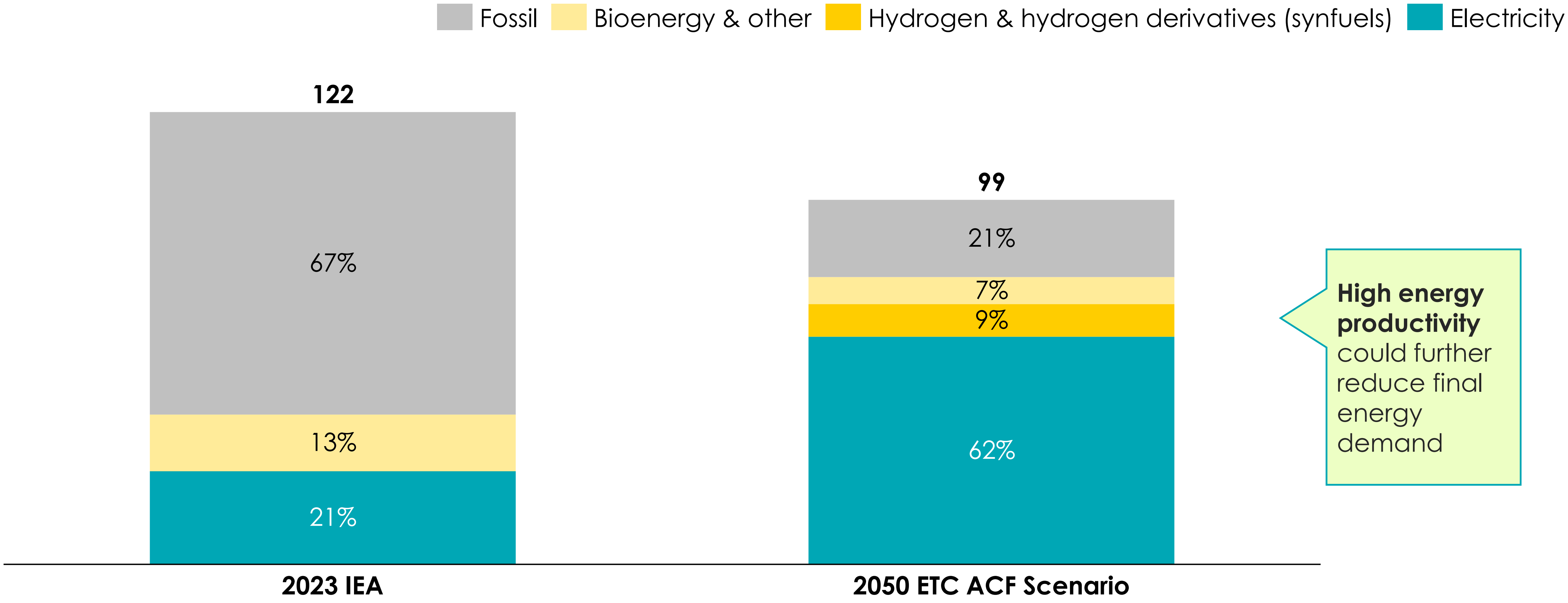


Source: IEA (2025) Global Energy Review

Net zero pathway relies on massively expanding clean electrification and delivering expanded energy services, but with less energy use overall

Global Final Energy demand mix

TWh



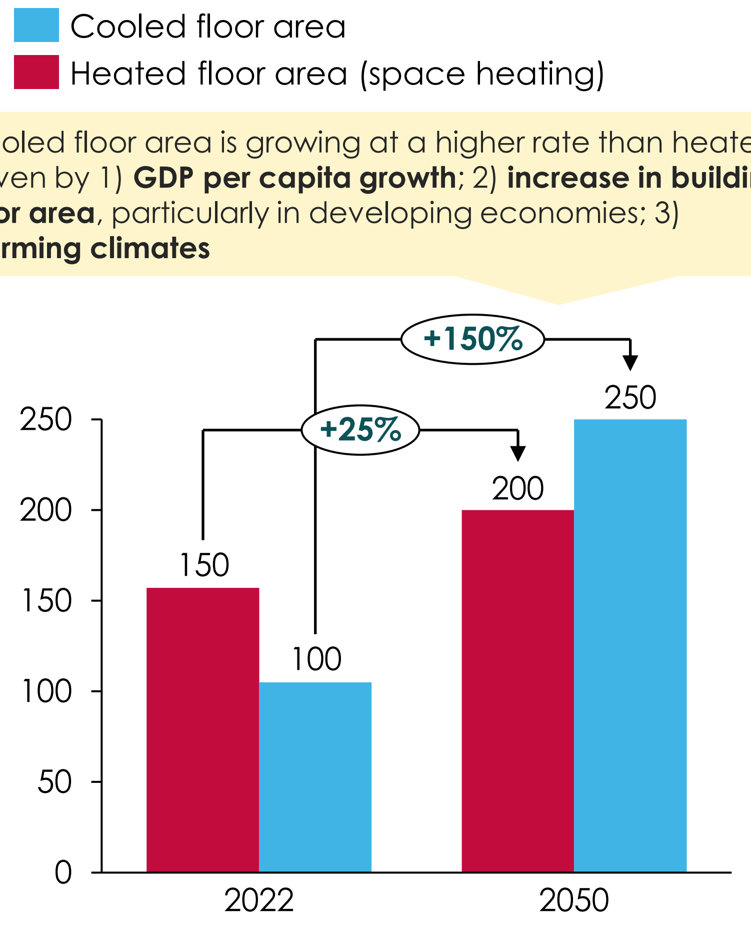
High energy productivity could further reduce final energy demand

Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq analysis for ETC.

ETC ACF scenario assumes growth in energy services across sectors

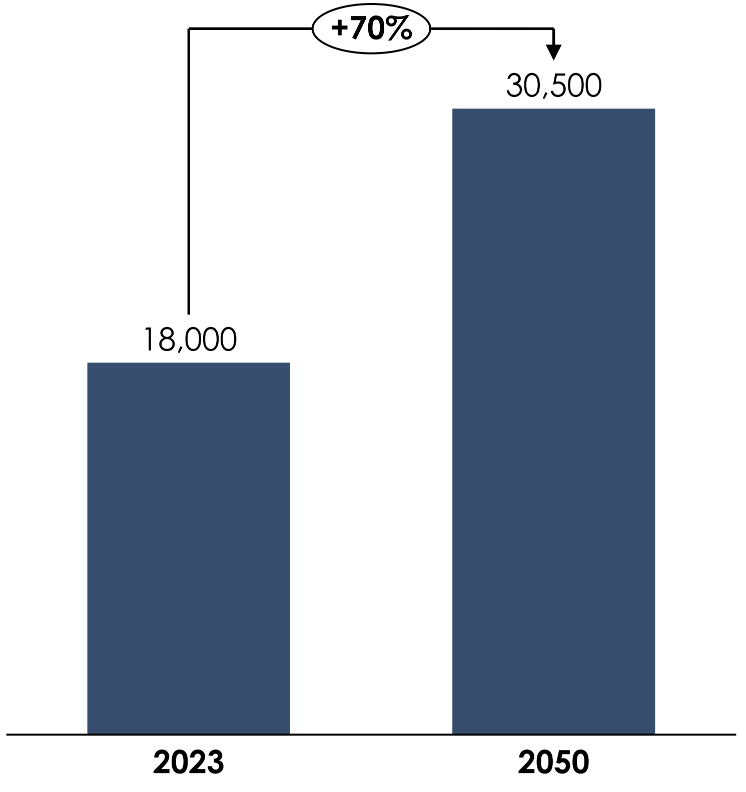
Heated floor area vs. cooled floor area

Billion m2; IEA NZE Scenario; residential + commercial



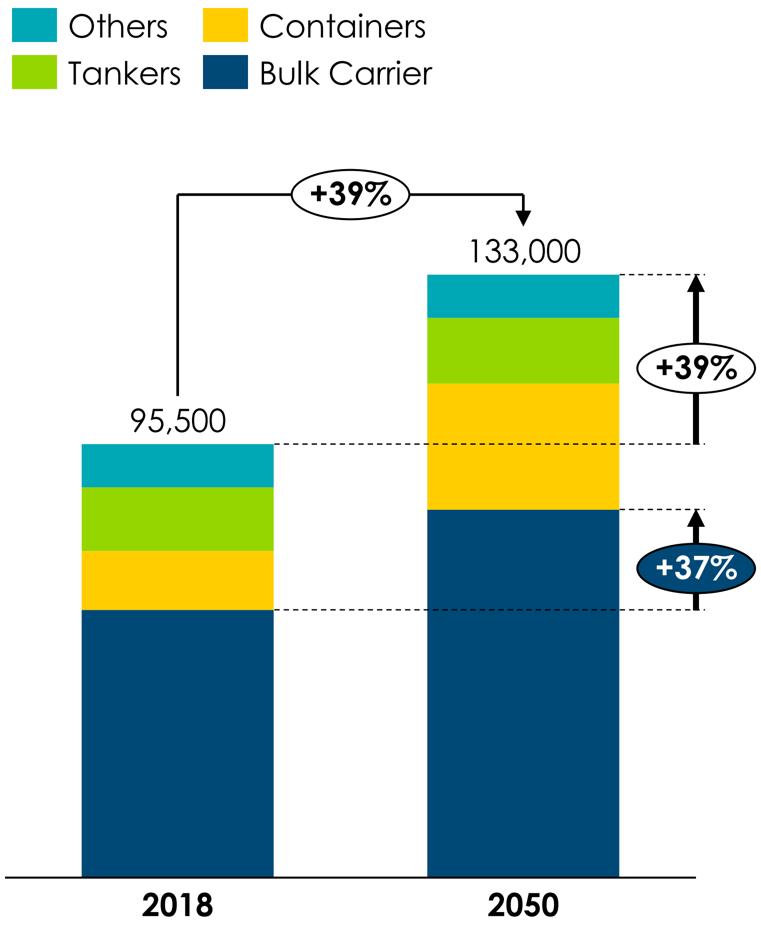
Demand for passenger road transport

Billions of km; ETC ACF scenario



Shipping demand

Billions-tonnes miles

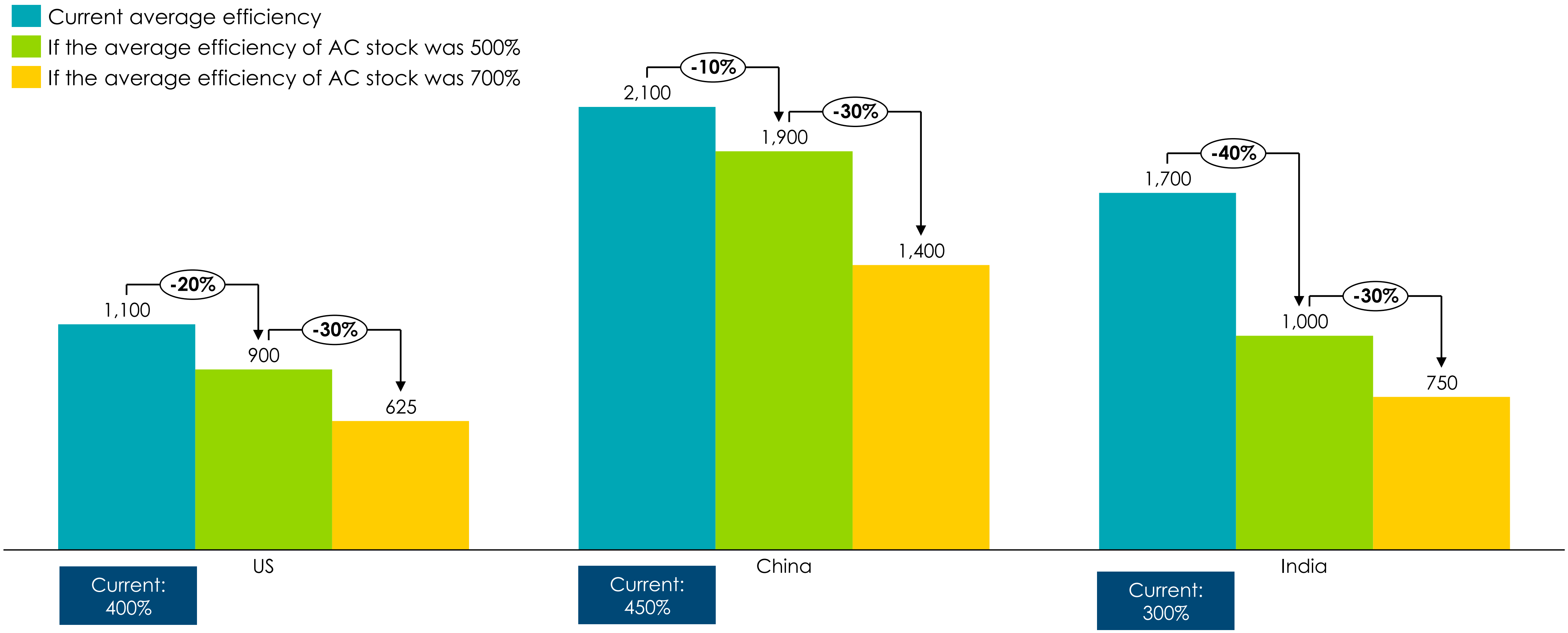


Source: IEA (2023), *World Energy Outlook 2023*; Systemiq analysis for the ETC (2023), *Fossil Fuels in Transition; Committing to the phase-down of all fossil fuels, available at https://www.energy-transitions.org/publications/fossil-fuels-in-transition/; Maersk Mc-Kinney Moller Center for Zero Carbon Shipping (2022), We show the world it is possible.*

Raising average efficiency of the AC stock could reduce overall electricity requirements for cooling by 40-70%, for same level of energy services

Cooling energy demand under different AC efficiency scenarios, applied to IEA estimates of the number of ACs in 2050

TWh



Sources: Systemiq analysis for the ETC (2024); IEA (2023), World Energy Outlook 2023

Note: US average household AC energy consumption assumed at 2,000 kWh/year; for India and China, 1,500 kWh/year is assumed.

Multiple levers to increase energy productivity

Target figure	Key lever		Guiding question	Reduced quantity	Example
Energy Productivity[1] (energy input per unit of GDP) =	Technical energy efficiency ×		How can we decrease the energy input per (production) process?	Process energy	Shift to less energy-intense production technology, incremental energy efficiency increase
	Service efficiency	Demand efficiency ×	How can we decrease the demand without sacrificing living standard?	Demand (for specific service)	Behavior changes, e.g. switch to train journey instead of airplane
		Product efficiency	How can we increase the utilization of the product?	Product	Reuse, sharing of products, increased product lifetime
	× Material efficiency		How can we decrease the material input per product?	Material	Recycling and use of recycled content, reduce primary material use while maintaining specs of product

1: Energy productivity also referred as energy intensity by the IEA
Source: Systemiq analysis for the ETC.

Establishing a common language on energy efficiency is key to enable and coordinate action effectively

Key terms

Energy Productivity

The impact of reducing global energy consumption without compromising living standards (e.g. via using less/other goods, less/other materials)

Energy Efficiency

Is a part of productivity that focus on the energy input of production processes

How to measure progress?

- **Energy productivity[1]:** Energy input per unit of GDP

  E.g. KWh/$ GDP

- **Energy productivity improvement:** Yearly change to energy productivity

$$\frac{\Delta\, Energy\ productivity}{Energy\ productivity_{t-1}}\ (\%)$$

Where we want action

Primary Energy

Energy before conversion, including losses during transformation and distribution

Energy consumed by end users, e.g. electricity or petrol

Final Energy

Energy to generate the desired output, e.g. move a vehicle

Useful Energy

1: Energy productivity also referred as energy intensity by the IEA

Maximising energy productivity levers (even beyond electrification) can bring significant benefits to the global energy system

Maximising energy productivity can bring significant benefits to the system

Lower costs, e.g. less investment needed as overall system size is smaller

Lower carbon, e.g. a less energy intensive pathway can reduce emissions during the transition to net-zero energy supply

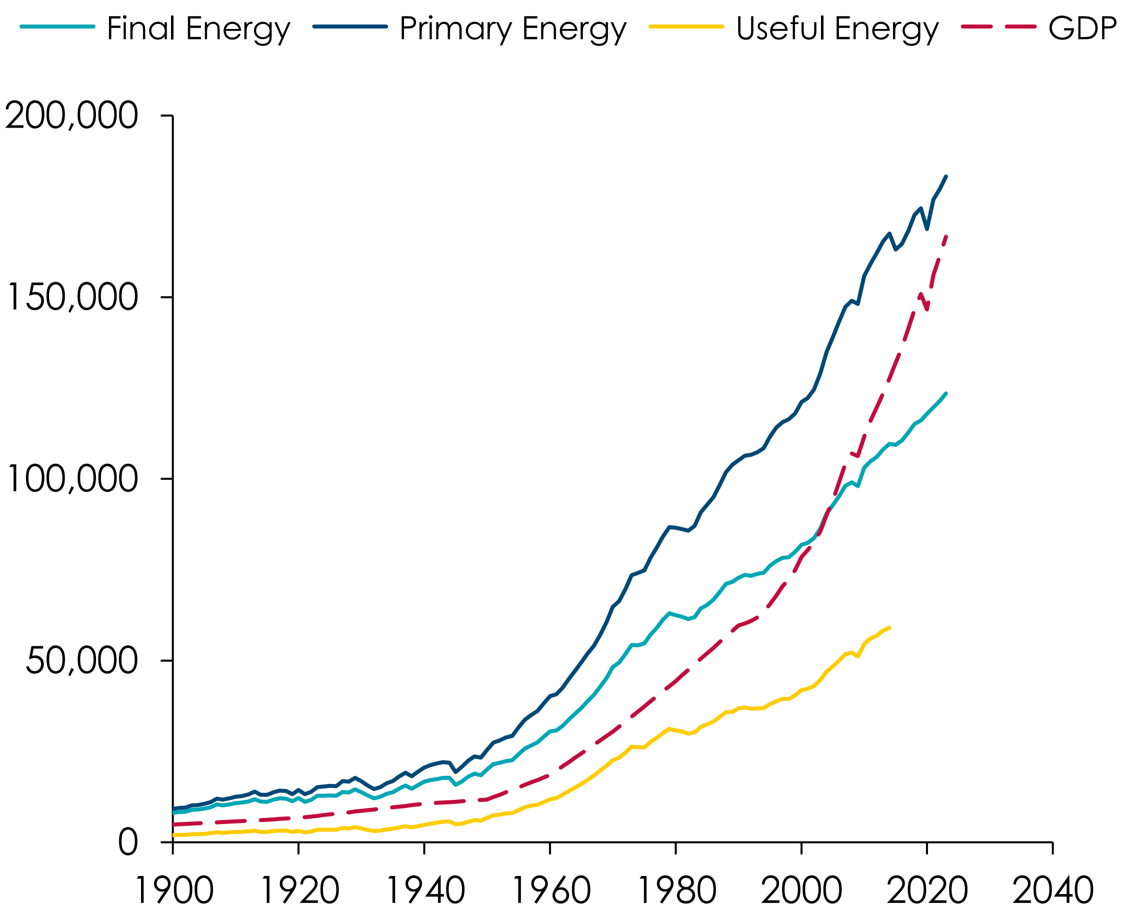
Lower impact on planetary boundaries, reducing land use and metal extraction due to a smaller system

Lower import needs, (i.e. increase energy security) as a less energy intensive pathway would overall require less imported energy

Despite improvements in energy productivity, primary and final energy demand still grows with GDP

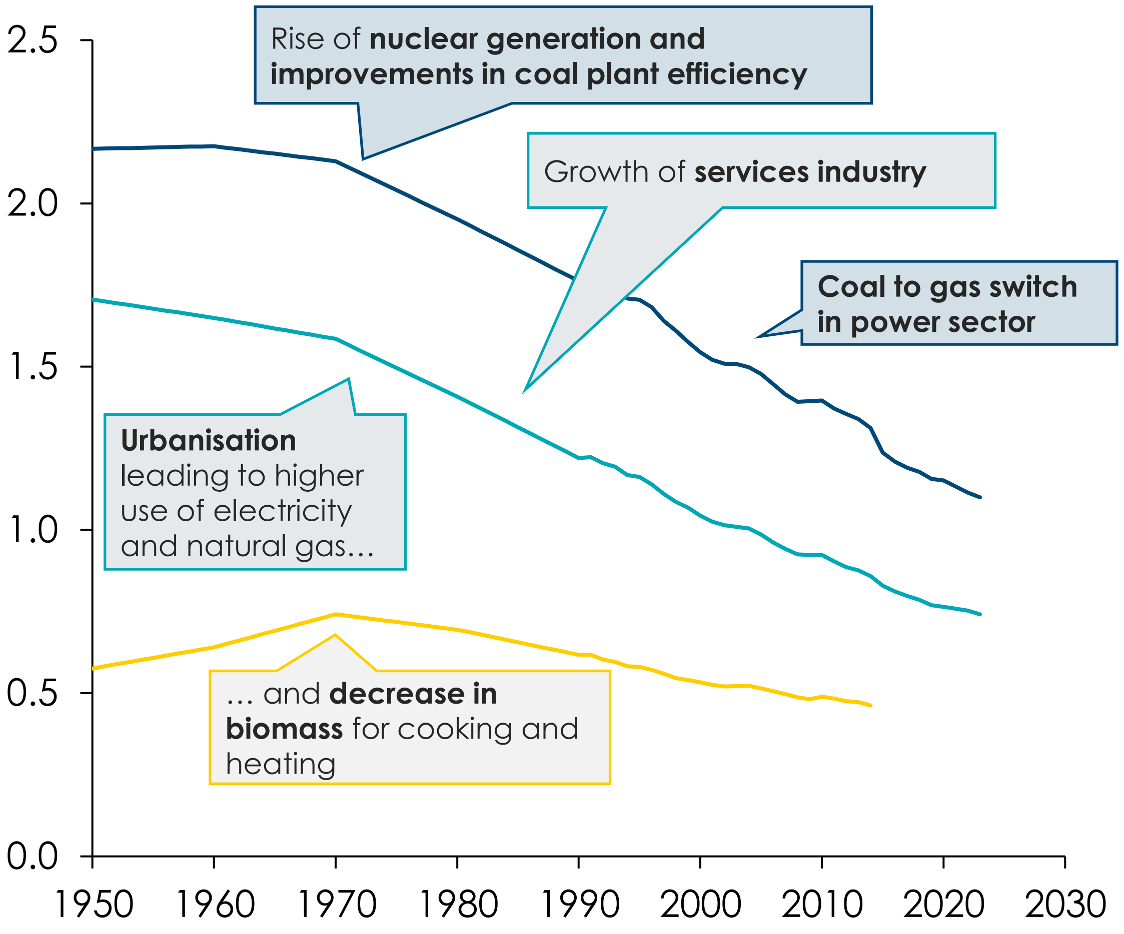
Total GDP vs. Energy Demand, 1900 - 2023

GDP in constant 2021 Bn.US$, Energy Demand in TWh



Energy Productivity, 1950 - 2023

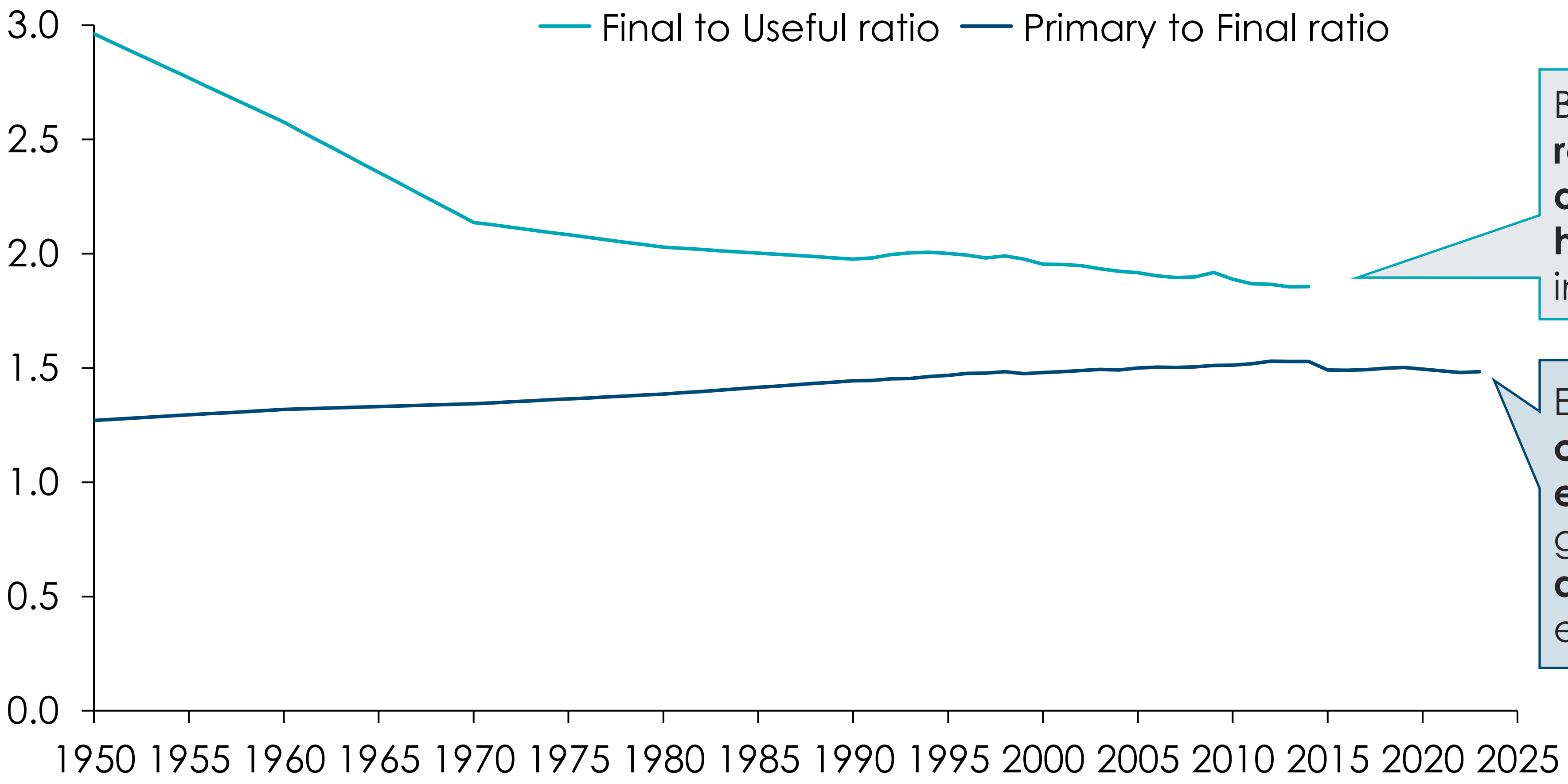
kWh/$ 2021 PPP



Source: Systemiq analysis for the ETC; World Bank Group; Our World in Data; IEA (2024), World Energy Outlook 2024; IIASA PFU Dataset

The ratio of final to useful energy improved dramatically, while the ratio of primary to final energy has only begin to come down in 2015

Energy ratios, 1950-2023
kWh/kWh



Between 1950 -1970 **reduced use of biomass and coal in cooking and heating** led to a huge gain in final to useful ratio

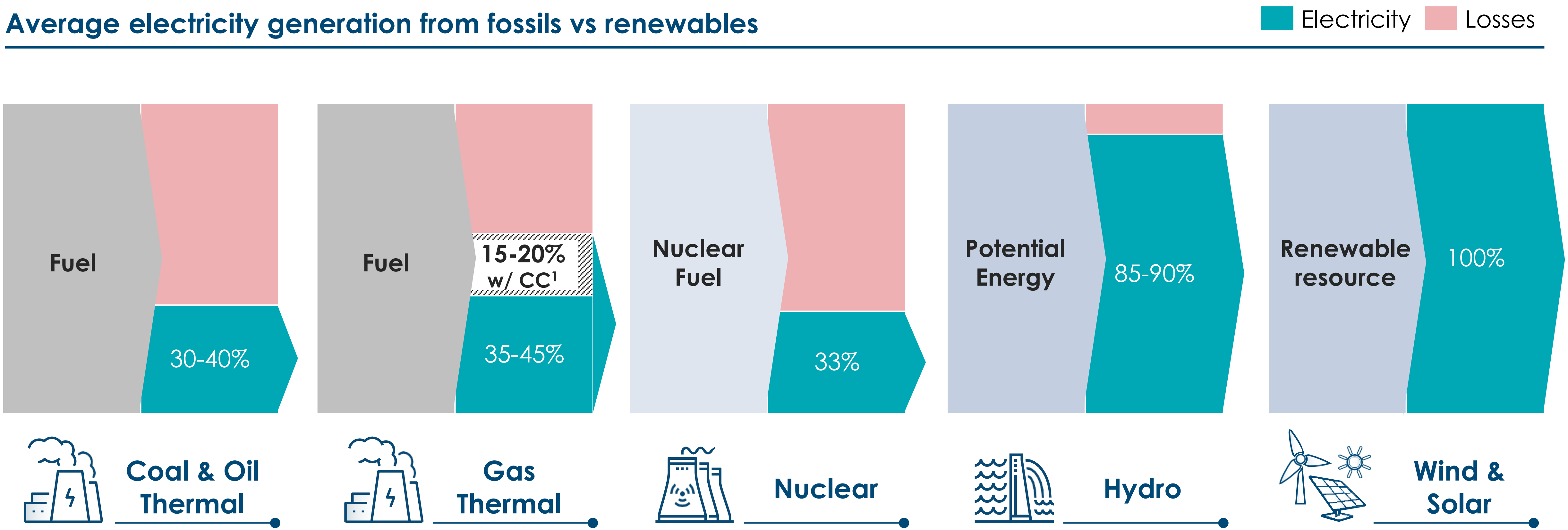
Energy **demand increase outweigh technical efficiency gains** in thermal generation; **electricity is just a small share** (20%) of energy supply

Source: EIA, Our World in Data; IEA (2024), *World Energy Outlook 2024; IIASA PFU Dataset*

Generating electricity with renewables compared to fossil fuels is 2-3 times more efficient

Primary

Average electricity generation from fossils vs renewables



2-3x more efficient than Fossil

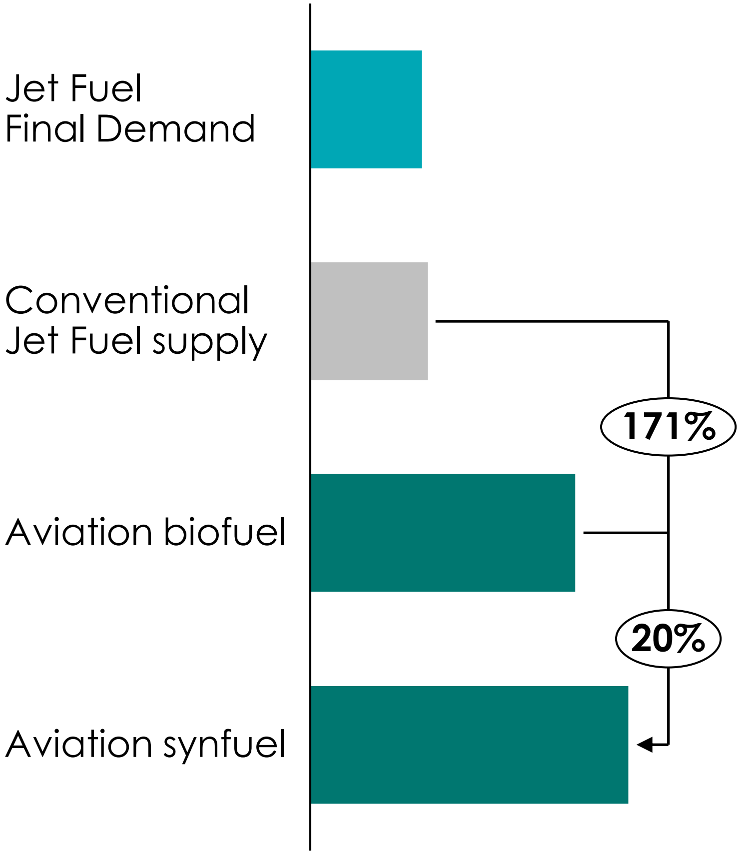
1. Combined Cycle

Source: RMI (2024), *Clean Tech Revolution; PCI Energy Solutions, IEA (2008) Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels*

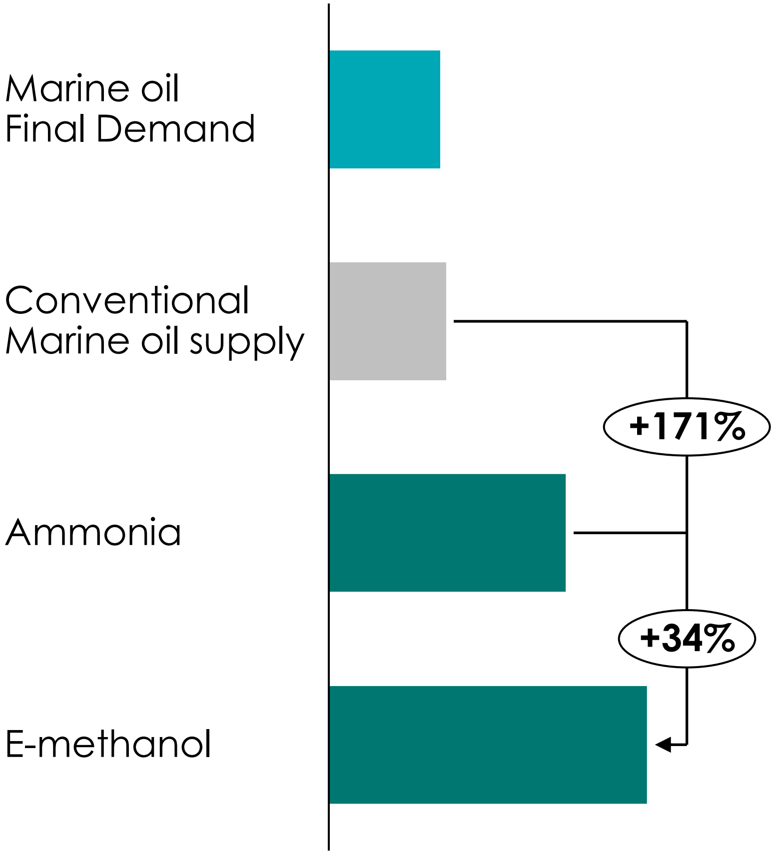
However, decarbonisation in some sectors (through switching to new fuels and CCS) will increase primary energy needs

Primary

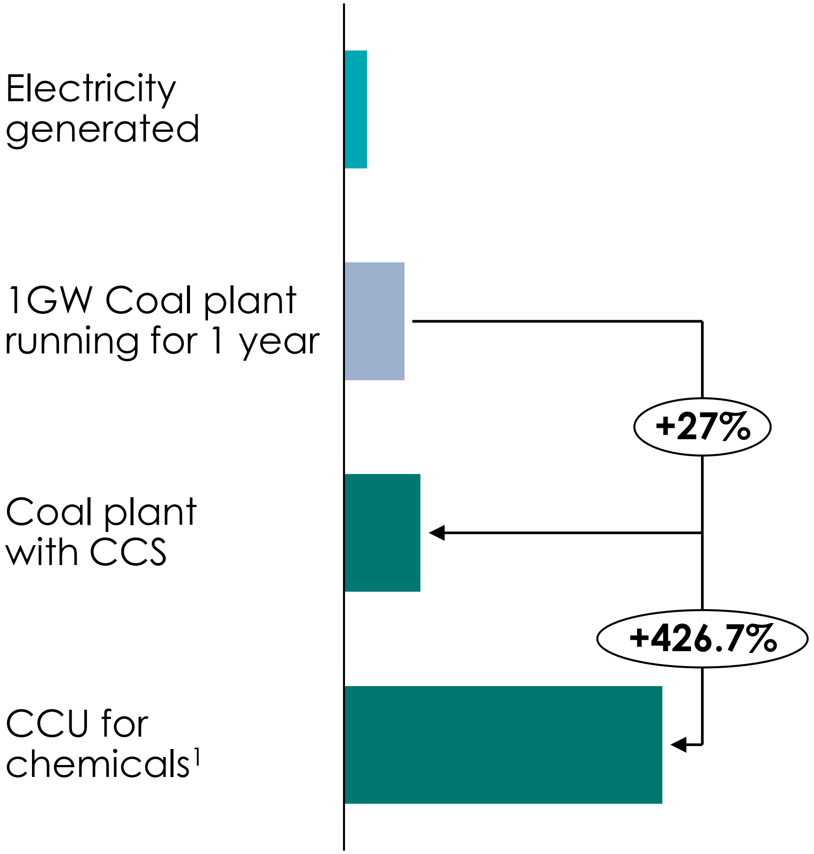
Aviation Case Study
TWh



Shipping Case study
TWh



CCS Case study
TWh



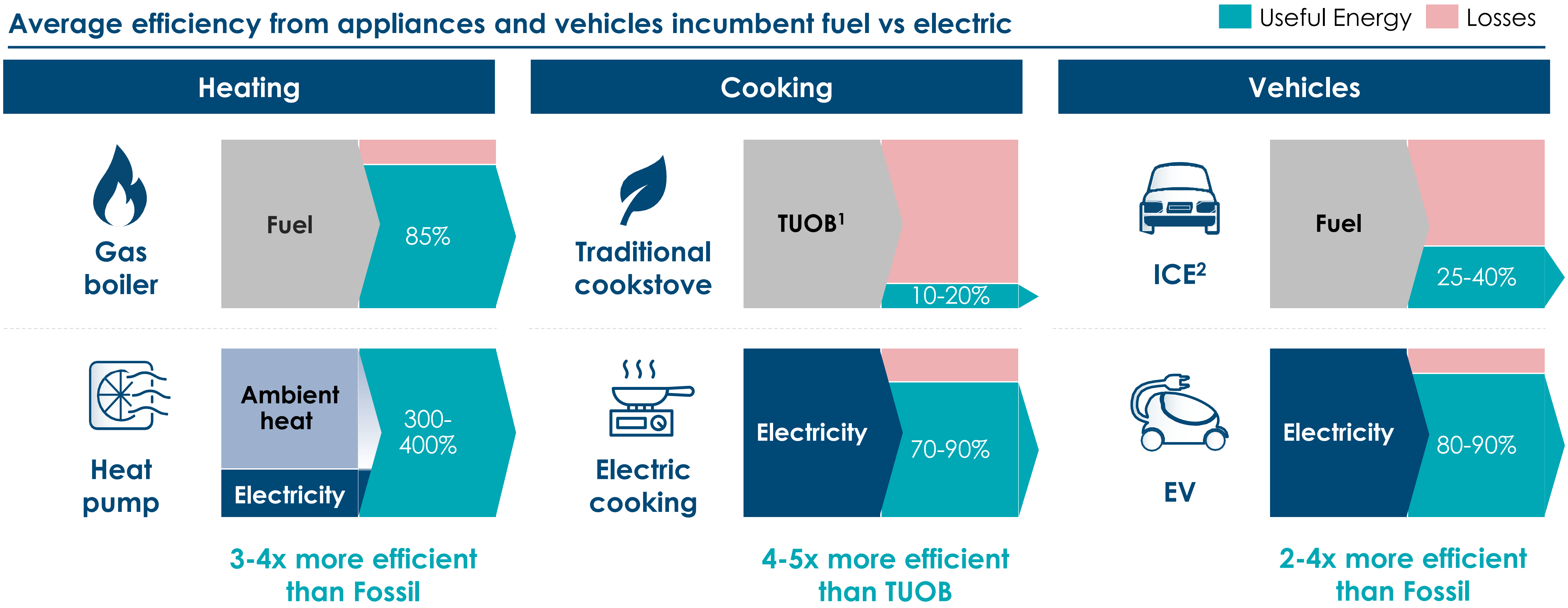
1 Additional steps for CCU include hydrogen production via electrolysis (50-55 kWh/kg of H2), CO2 capture and compression (0.5-1.5 KWh/kgCO2) and methanol synthesis (1-2 Kwh/kg MeOH); 100% capture and conversion to methanol is assumed (theoretical maximum)

Sources: Mission Possible Partnership (2023) Sector Transition Strategy, World Resources Institute (2022) *6 Things you Know About Direct Air Capture; IEA (2013). Technology Roadmap: Carbon Capture and Storage, IEA (2019). The Future of Hydrogen, ECN (2017). Techno-economic and environmental assessment of methanol synthesis using captured CO_2 and renewable hydrogen*

Electrification is energy efficiency – heat pumps, electric cooking and EVs use 2-5 times less energy

Final

Average efficiency from appliances and vehicles incumbent fuel vs electric

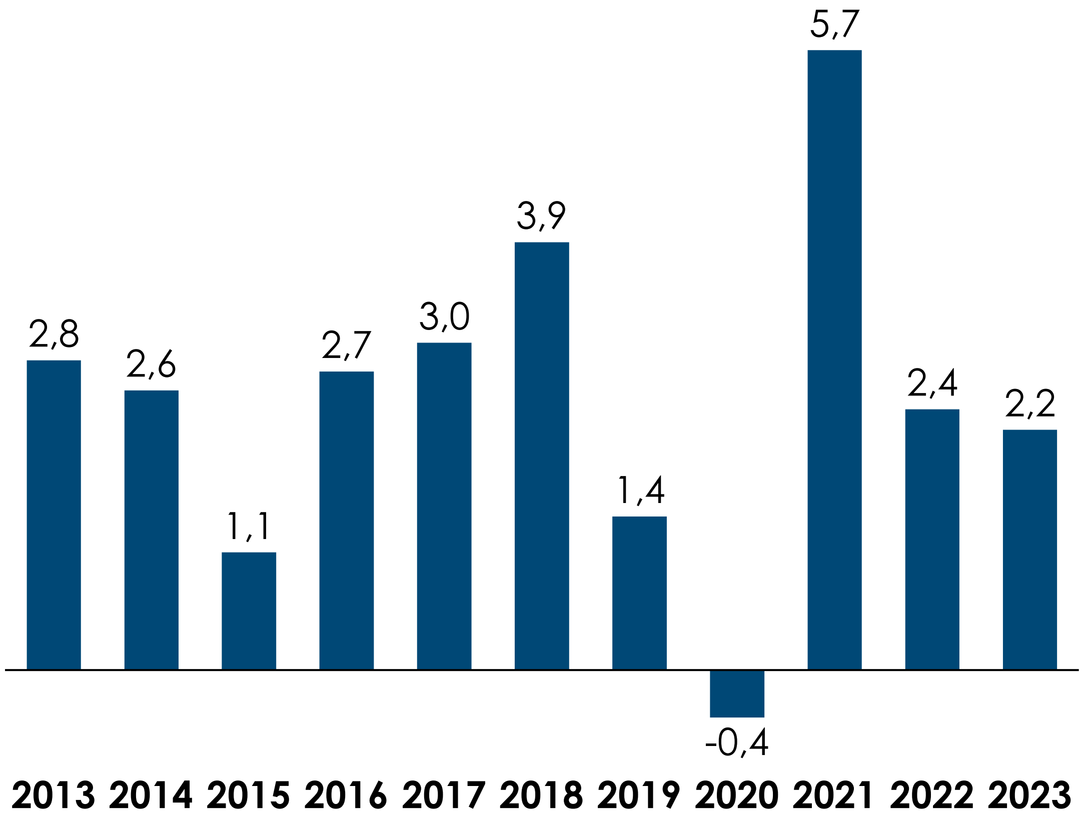


1. Traditional use of biomass; 2. Internal combustion engine
Source: RMI (2024), *Clean Tech Revolution; ETC (2025) Achieving Zero-Carbon Buildings.*

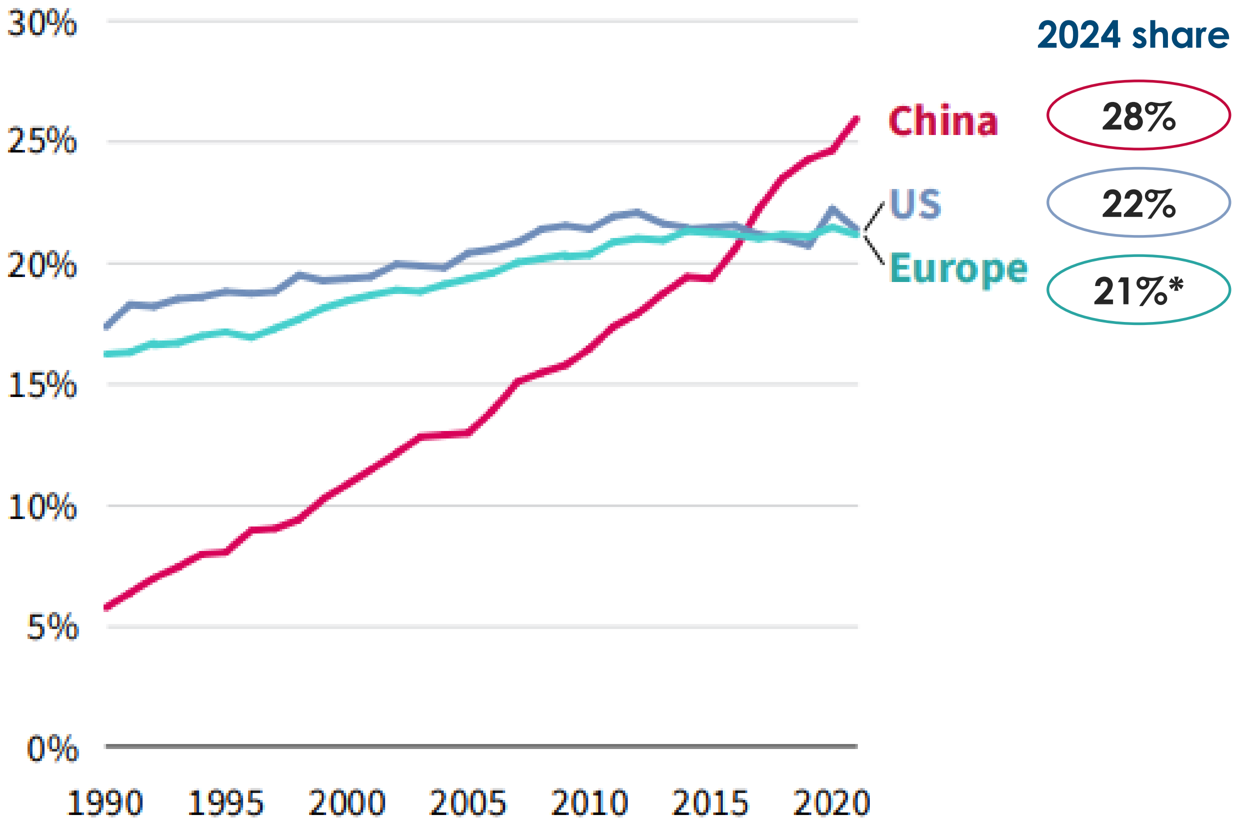
Electricity use has grown globally over the last decade, led by electrification in China

Final

Annual electricity growth rate
%



Electricity share of total final energy consumption
%



* For European Union
Source: Our World in Data, Ember, RMI (2024) The Race to the Top in Six Charts and Not Too Many Numbers, IEA (2025) Electricity 2025

Agenda

- Context: Importance of energy productivity
- **ETC assessment of EP potential to 2050 & sectoral deep dive**
- Summary conclusion & key priorities

Two challenges in energy productivity: reducing final energy demand while growing useful energy, and closing the gap between primary and final

Reducing final energy demand while growing useful energy

=

Using less energy per **building**, **transport** and **industry** while improving living standards

Closing the gap between primary and final energy demand

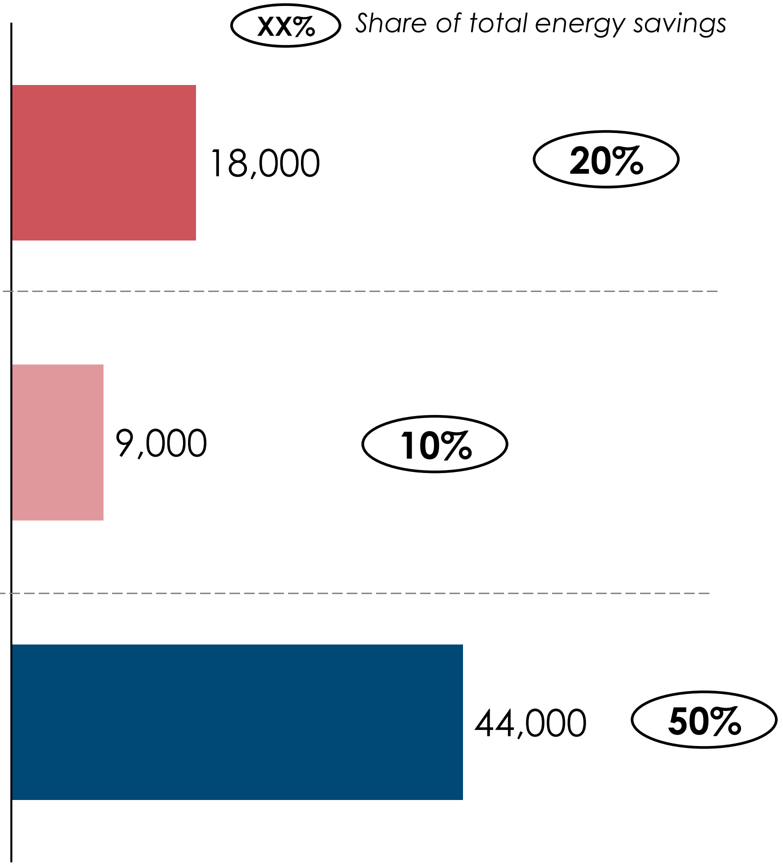
=

Reducing energy losses in the **power system**

Three key productivity levers: electrification, efficiency of appliances and vehicles and grid decarbonisation

	Main productivity levers	Key drivers
Final Energy	1 **Electrification**	• Electrification of heating and cooking in buildings • Switch to EVs
Final Energy	2 **Improvements in the efficiency of electrical appliances and vehicles**	• Efficiency standards on main household appliances (e.g. refrigerators, AC, lightning) • Improvements in heat pumps • Improvements in EVs
Primary Energy	3 **Grid decarbonisation**	• Higer share of renewable generation in the grid • Grid expansion

Annual energy saving
(Annualized 2023-2050 TWh)



Source: Systemiq analysis for ETC

Two challenges in energy productivity: reducing final energy demand while growing useful energy, and closing the gap between primary and final

Reducing final energy demand while growing useful energy

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Using less energy per **building**, **transport** and **industry** while improving living standards

Closing the gap between primary and final energy demand

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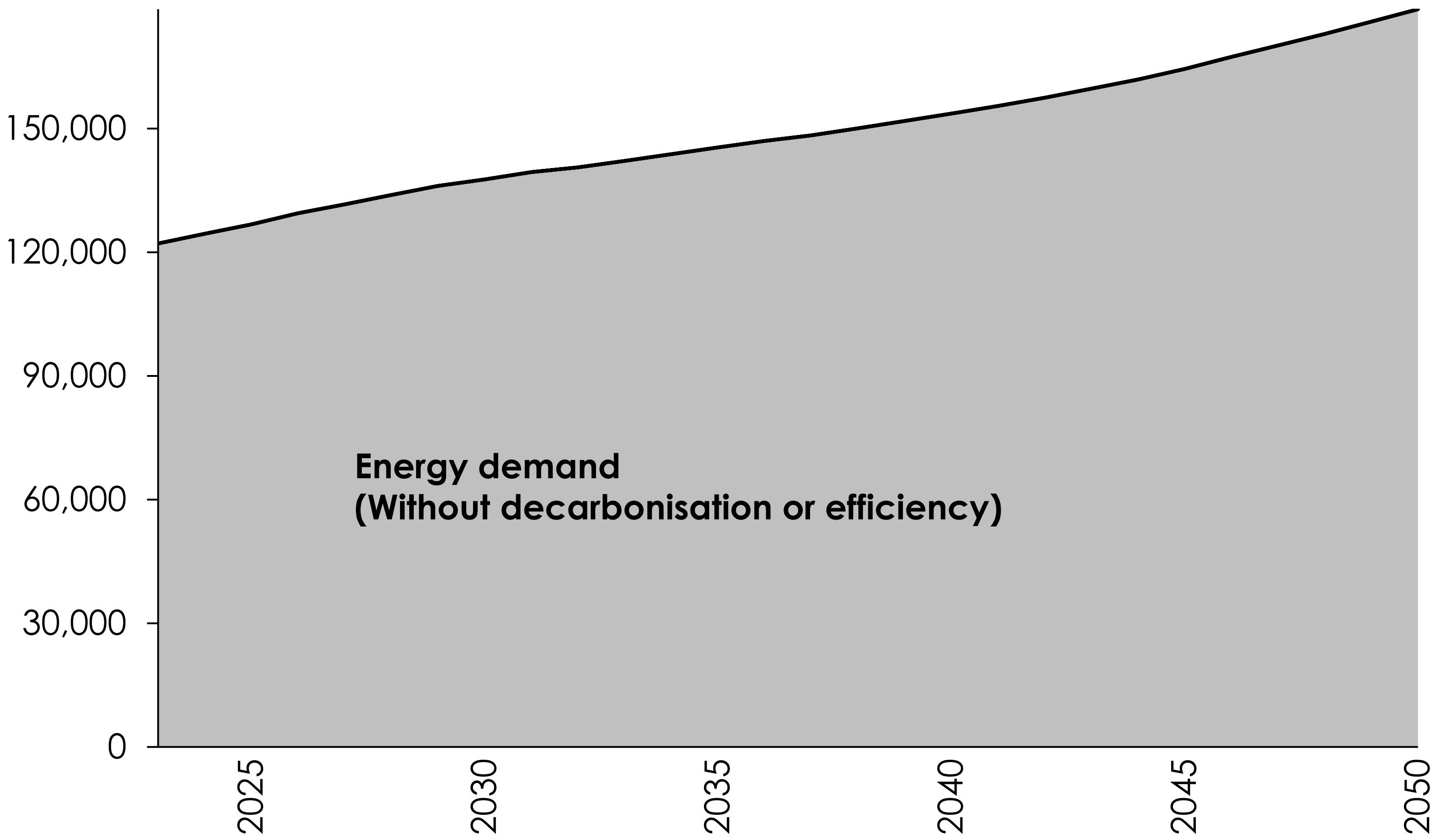
Reducing energy losses in the **power system**

Baseline. Without any decarbonisation or productivity levers, rising energy demand

Final Energy demand vs. Productivity levers
TWh

% Reduction potential compared to 2050 Energy use without efficiency or decarbonisation

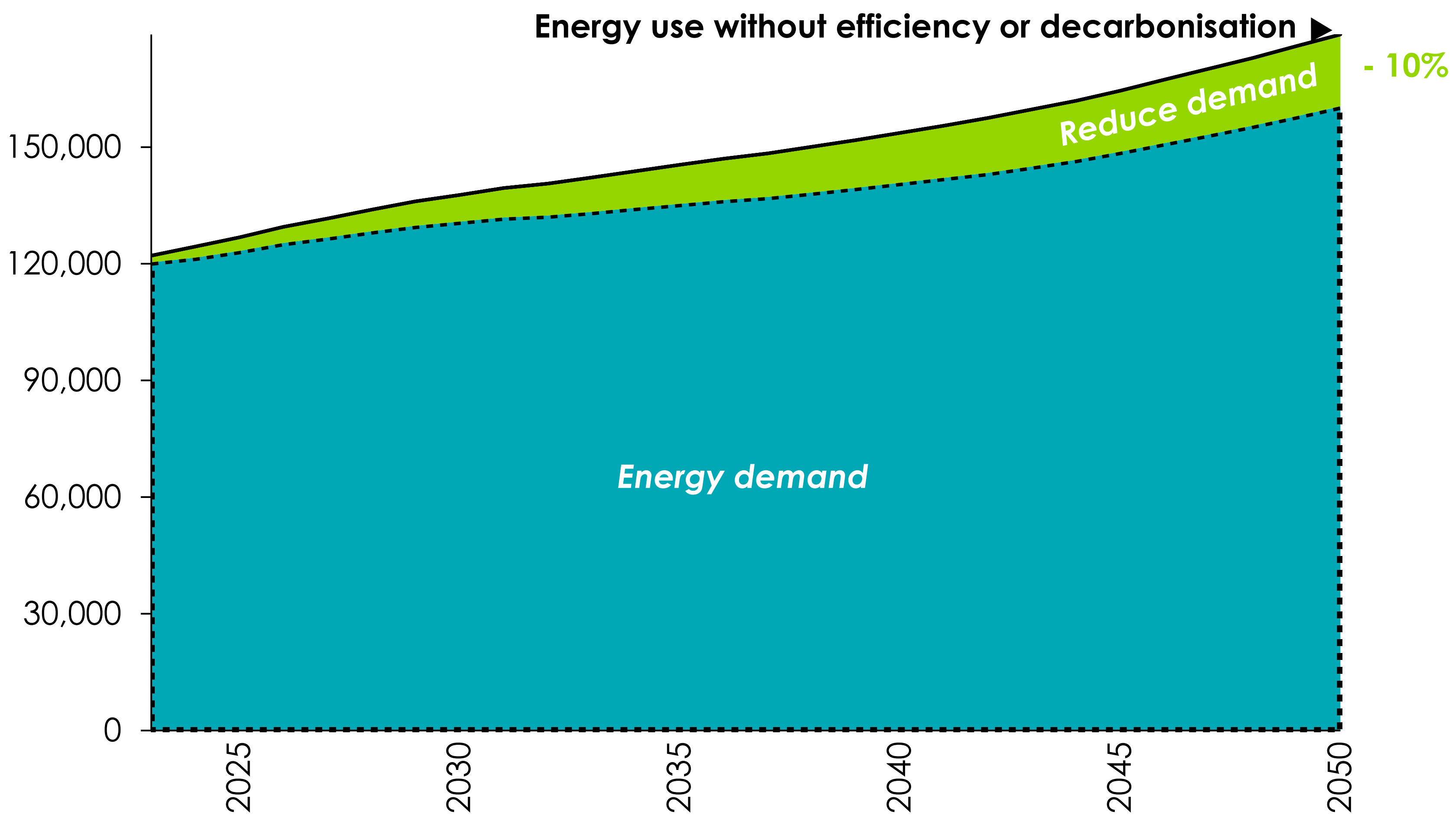


Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022) Planet Positive Chemicals; Systemiq analysis for ETC.

Reduce demand. 7% less energy could come from behavioural shifts and material efficiency

Final Energy demand vs. Productivity levers
TWh

% Reduction potential compared to 2050 Energy use without efficiency or decarbonisation



Key actions

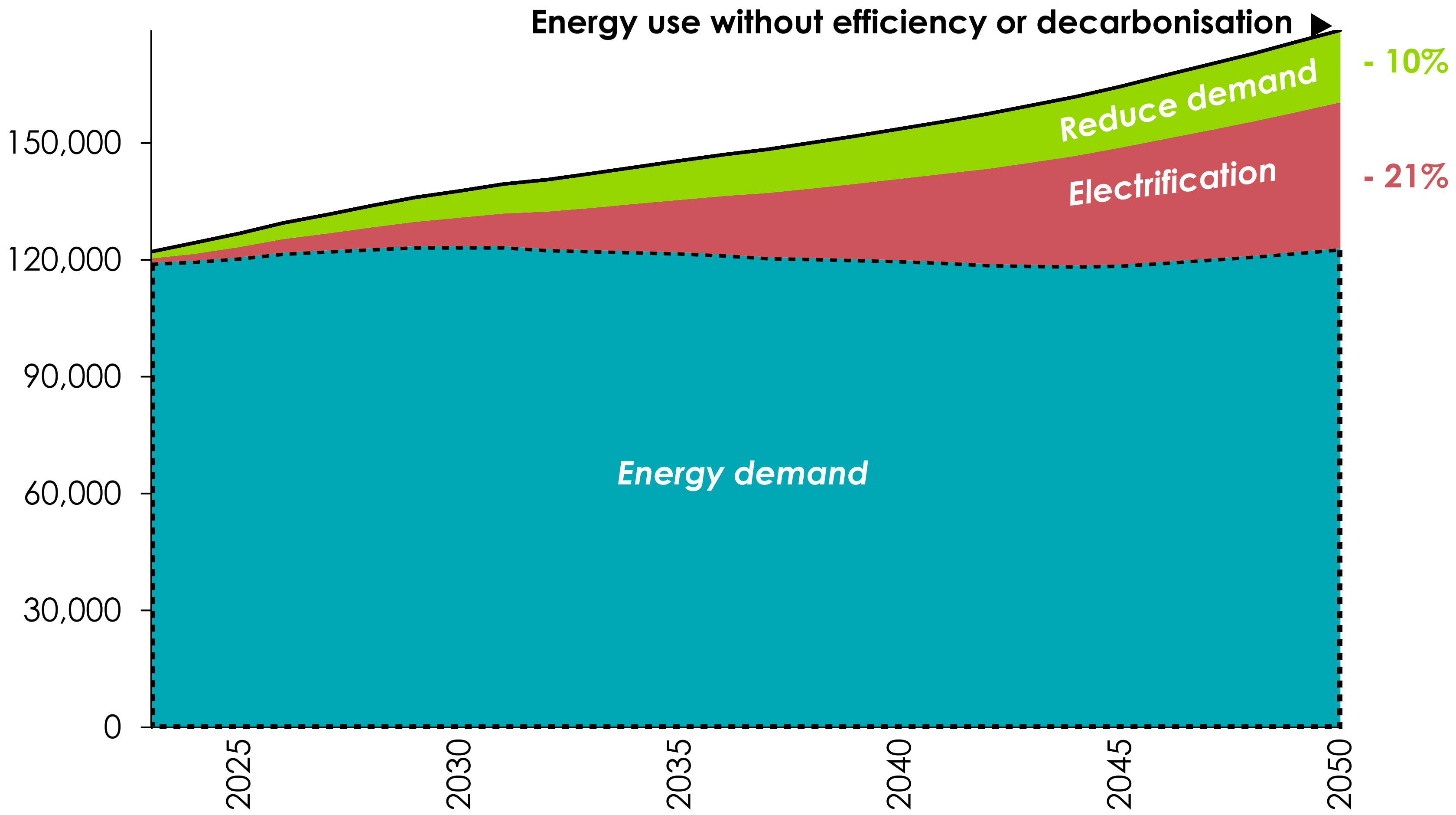
Demand reduction: services (e.g. public transport), reducing & re-using (e.g. petro-chemicals) and better operations (e.g. aviation)

Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022) Planet Positive Chemicals; Systemiq analysis for ETC.

Electrification = efficiency. ~30% less energy can be consumed with electrification and demand reduction combined

Final Energy demand vs. Productivity levers
TWh

% Reduction potential compared to 2050 Energy use without efficiency or decarbonisation



Key actions

Demand reduction: services (e.g. public transport), reducing & re-using (e.g. petro-chemicals) and better operations (e.g. aviation)

Electrification: switching to electric vehicles, electric heating and cooking

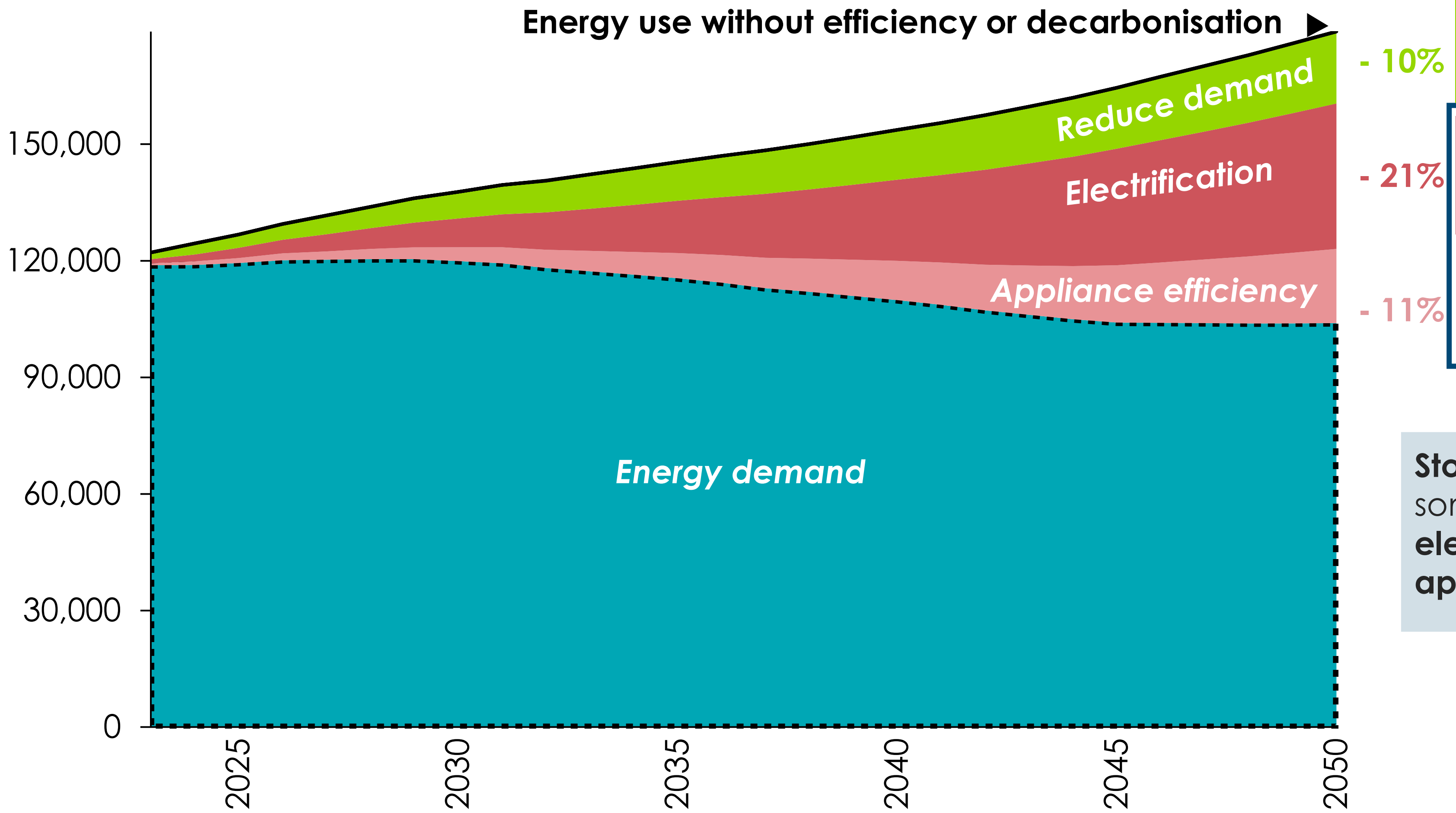
-31%

Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022) Planet Positive Chemicals; Systemiq analysis for ETC.

Improve electrical appliances and vehicles efficiency. 40% less energy is required with electrification, reduced demand and appliance improvements

Final Energy demand vs. Productivity levers
TWh

% Reduction potential compared to 2050 Energy use without efficiency or decarbonisation



Key actions

Demand reduction: services (e.g. public transport), reducing & re-using (e.g. petro-chemicals) and better operations (e.g. aviation)

Electrification: switching to electric vehicles, electric heating and cooking

Improving efficiency of key electrical appliances: AC, heat pumps, EVs, lighting and other home appliances

-42%

Stock turnover will drive some of the potential for **electrification and appliance efficiency**

Detailed next

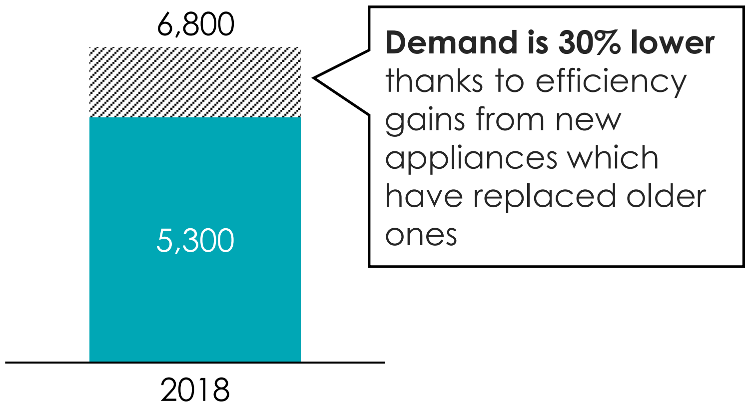
Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022) Planet Positive Chemicals; Systemiq analysis for ETC.

The stock turn-over effect: example on road transport and appliances standards

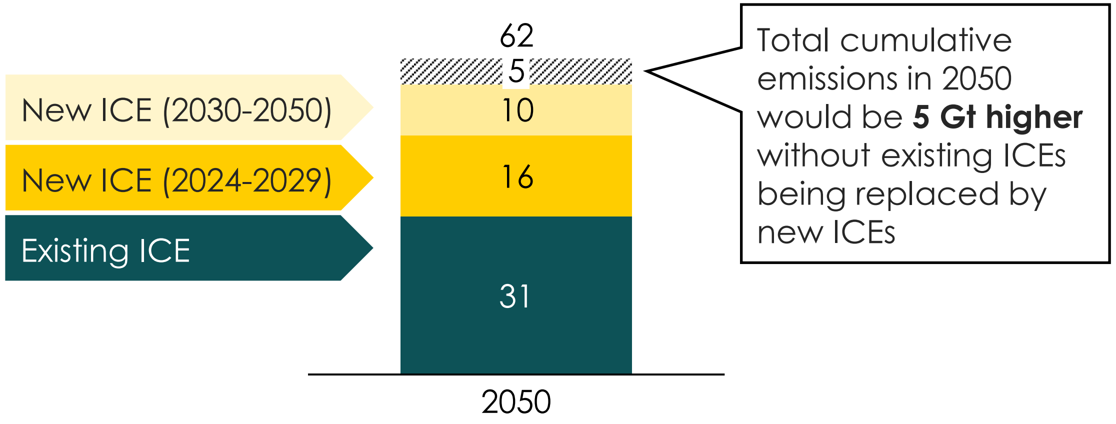
Improving efficiency of key electrical appliances: AC, heat pumps, EVs, lighting and other home appliances

Historical	Outlook
Appliances	**Road transport**

Impact of stock turn-over on appliances final energy demand
TWh



Impact of stock turn-over on projected cumulative CO2 emissions from ICEs
2023-2050 Gt CO2



Continuous efforts in **Energy Efficiency Standards and Labelling Programmes (EES&L)** resulted in a **30% annual decrease in appliances energy demand** relative to BAU

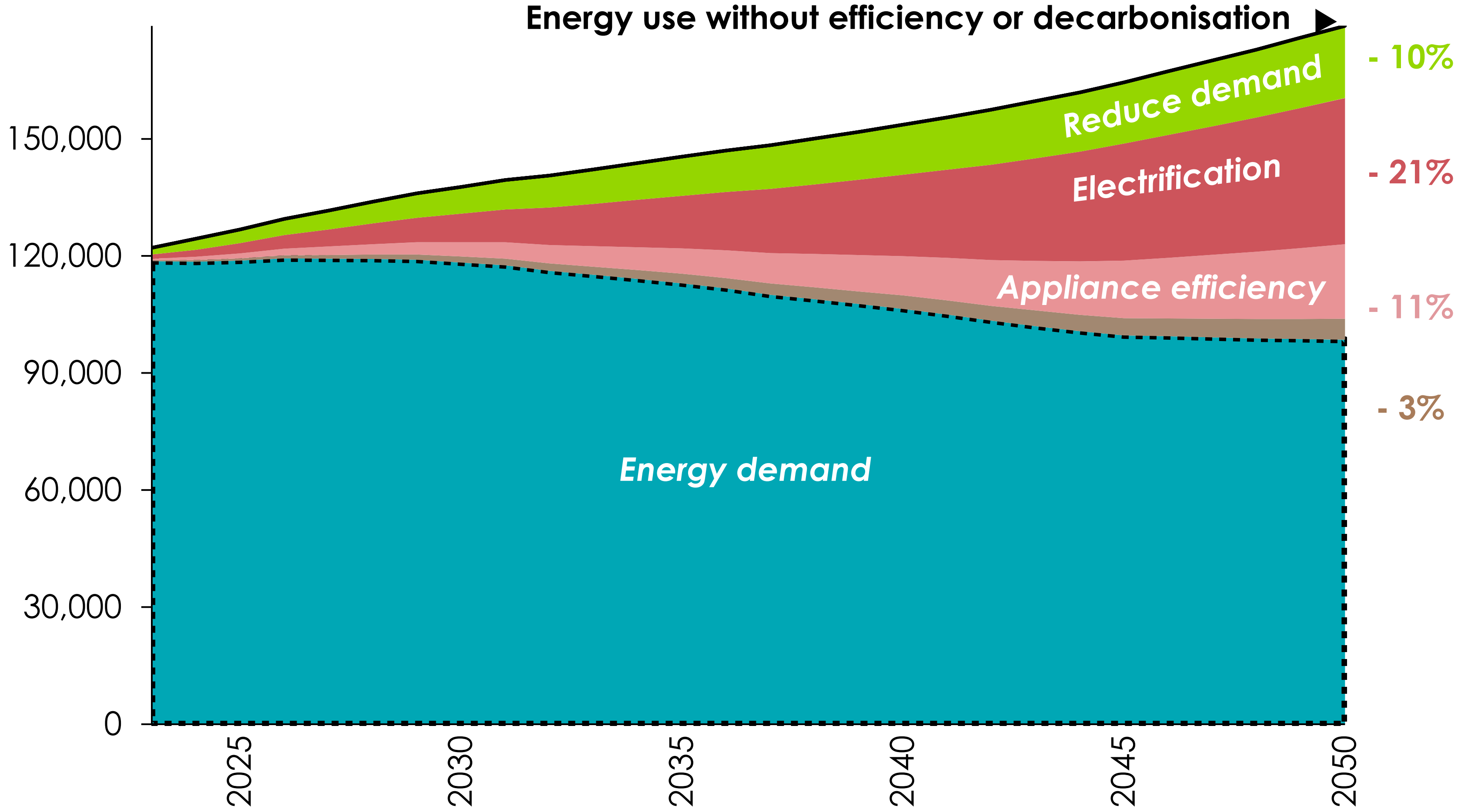
Today, cars on the road typically last around **18 years**
A 2006 vehicle retiring in 2024 would be **consuming approximately 37% more fuel** than a **new 2024 ICE** vehicle.

Note: ICE means Internal Combustion Engine Vehicles, EV means Electric Vehicles. We consider that the combustion of a barrel of oil equivalent results ~405 kg CO_2.
Source: Systemiq analysis for the ETC; ETC (2023), *Fossil Fuels in Transition: Committing to the phase-down of all fossil fuels; IEA (2018) Achievements of Energy Efficiency Appliance and Equipment Standards and Labelling Programmes; ETC (2025) Buildings report, IEA (2022) Energy Efficiency*

Insulation. 45% less energy can be consumed, if combined with appliance efficiency, lower demand & better buildings insulation.

Final Energy demand vs. Productivity levers
TWh

% Reduction potential compared to 2050 Energy use without efficiency or decarbonisation



Key actions

Demand reduction: services (e.g. public transport), reducing & re-using (e.g. petro-chemicals) and better operations (e.g. aviation)

Electrification: switching to electric vehicles, electric heating and cooking

Improving efficiency of key electrical appliances: AC, heat pumps, EVs, lighting and other home appliances

Better insulation in buildings: better buildings codes and fabric improvements

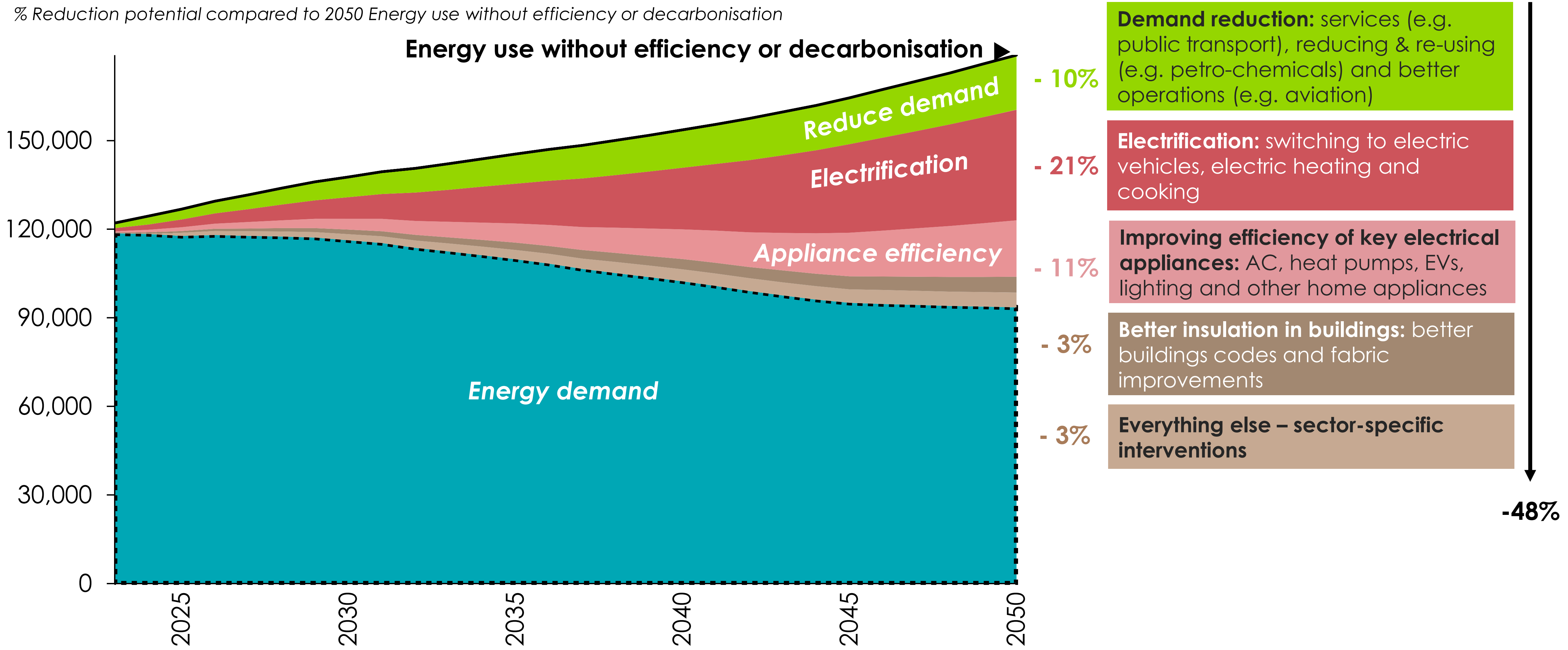
-45%

Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022) Planet Positive Chemicals; Systemiq analysis for ETC.

Overall, ~50% less energy can be consumed, with all efficiency levers combined

Final Energy demand vs. Productivity levers
TWh

Key actions



Demand reduction: services (e.g. public transport), reducing & re-using (e.g. petro-chemicals) and better operations (e.g. aviation)

Electrification: switching to electric vehicles, electric heating and cooking

Improving efficiency of key electrical appliances: AC, heat pumps, EVs, lighting and other home appliances

Better insulation in buildings: better buildings codes and fabric improvements

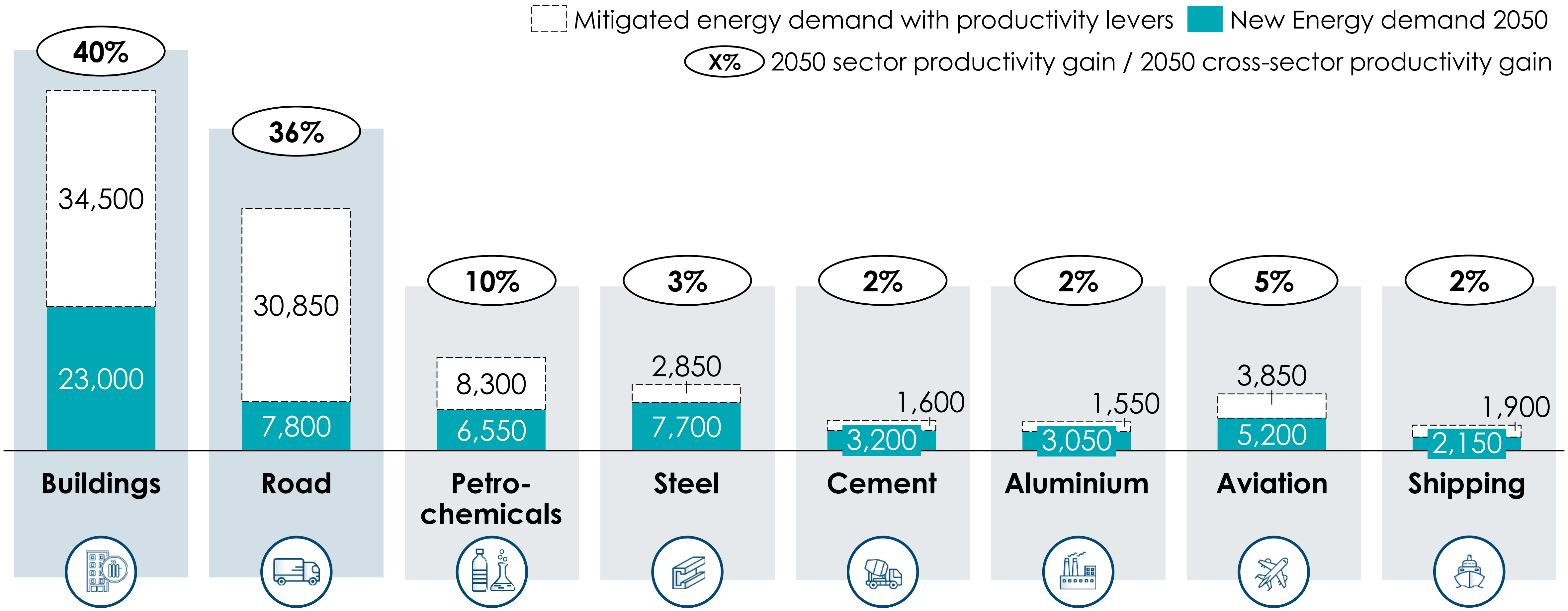
Everything else – sector-specific interventions

Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022) Planet Positive Chemicals; Systemiq analysis for ETC.

Buildings and road transportation hold the biggest opportunity: together they hold 75% of the potential productivity gain in final energy demand

Final energy demand in 2050

TWh



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Two challenges in energy productivity: reducing final energy demand while growing useful energy, and closing the gap between primary and final

Reducing final energy demand while growing useful energy

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Using less energy per **building**, **transport** and **industry** while improving living standards

Closing the gap between primary and final energy demand

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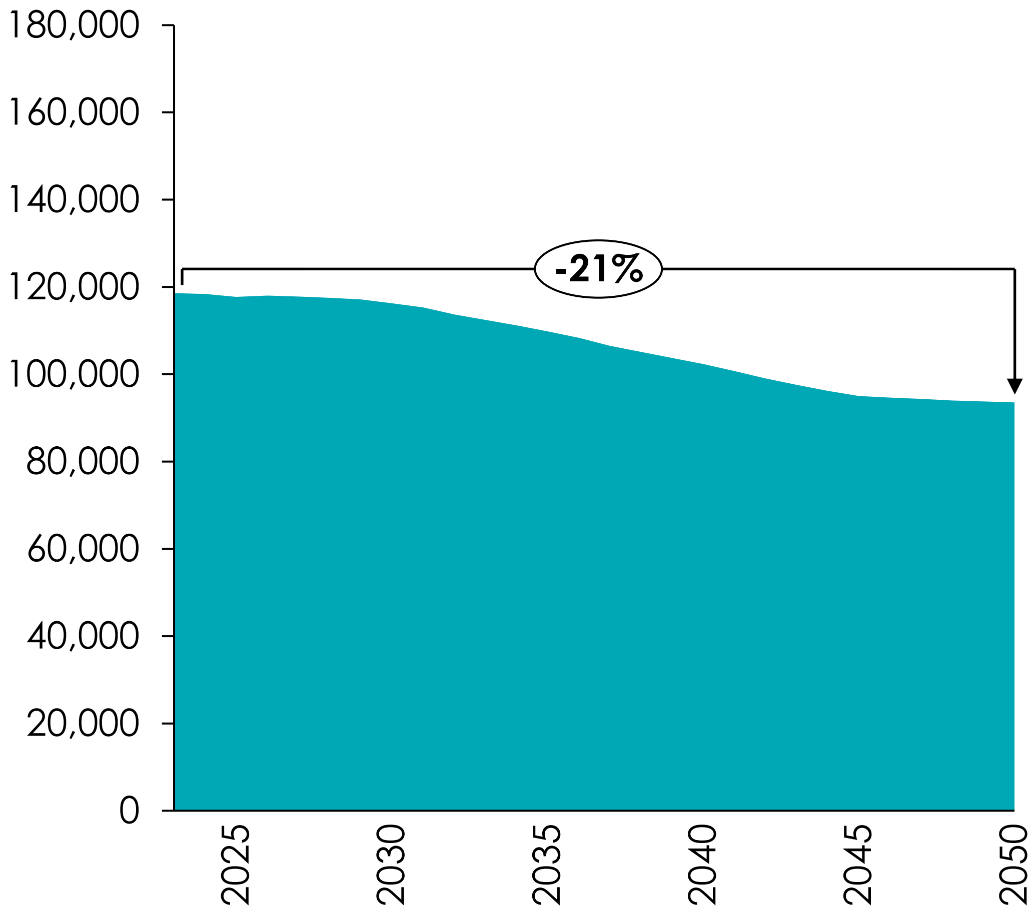
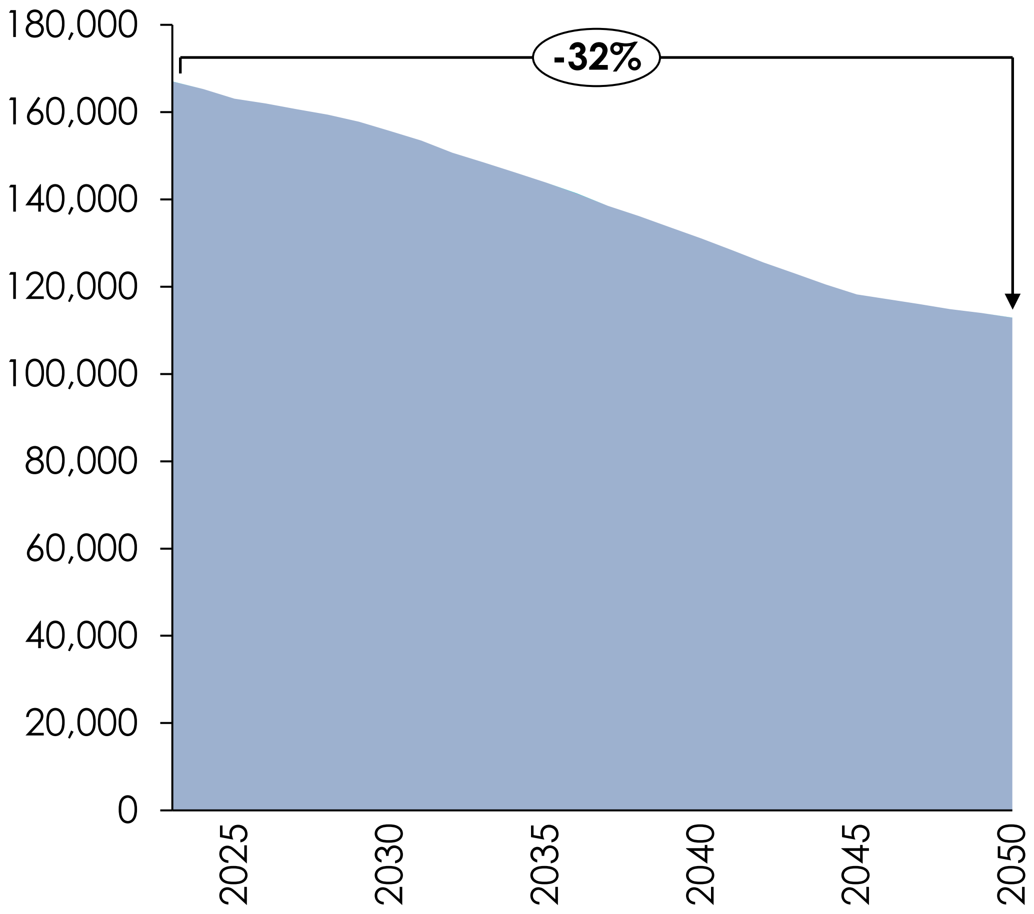
Reducing energy losses in the **power system**

Primary energy demand decreases even more drastically than final energy demand due to clean electrification

NZ Final Energy with Productivity levers
TWh



NZ Primary Energy demand with Productivity levers
TWh



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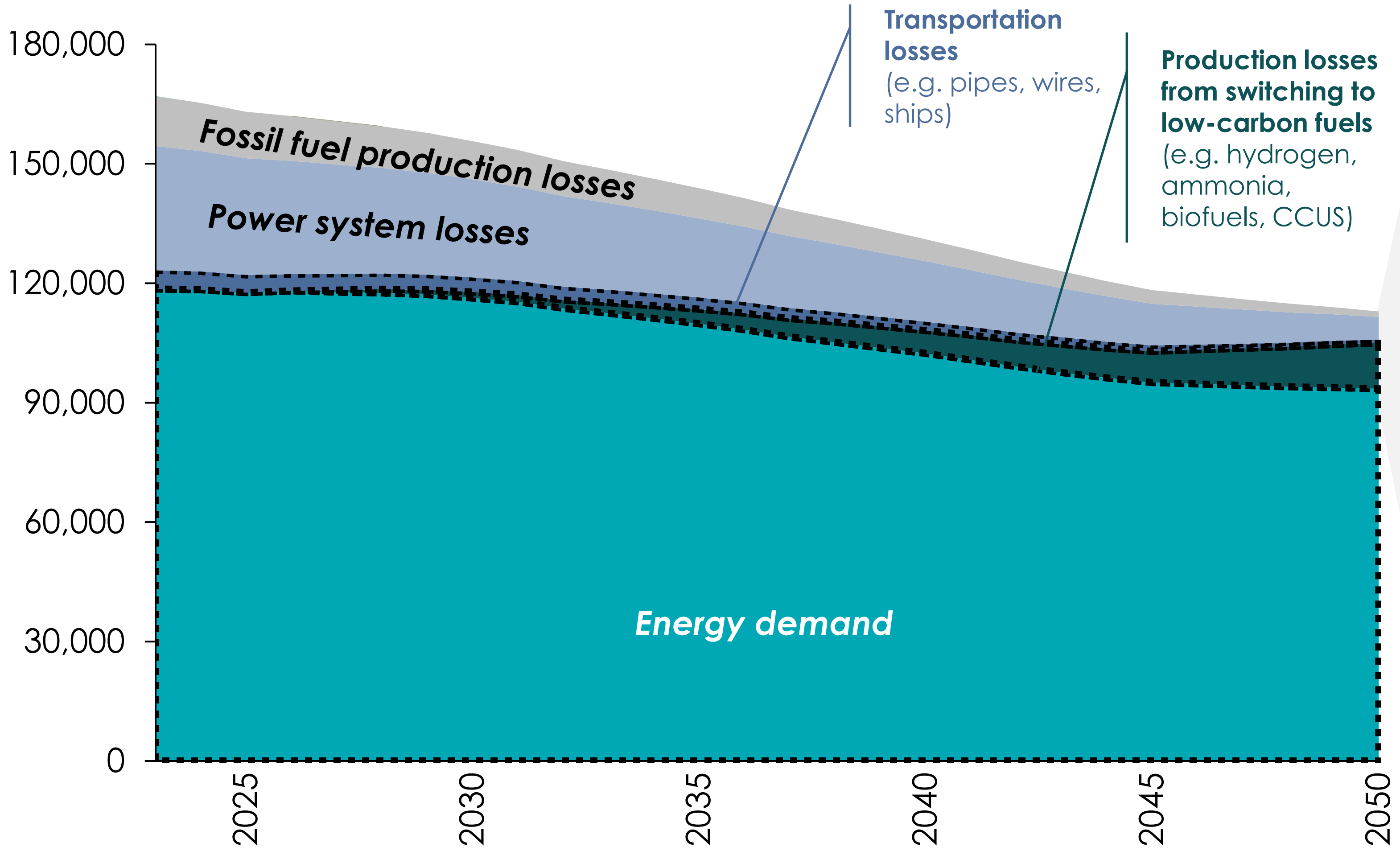
Growth of the power system as fossil consumption phases down, along with power decarbonisation, is main driver to reduce primary energy demand

Primary energy demand
TWh



Reductions on primary losses driven by:

- **Growth of renewables in the power system**, which are more efficient than fossil generation
- **Lower fossil fuel production losses** (e.g. in refining) decline as fossils phase down

Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022); Planet Positive Chemicals; RMI (2024) The Incredible Inefficiency of the Fossil Energy System; Systemiq analysis for ETC.

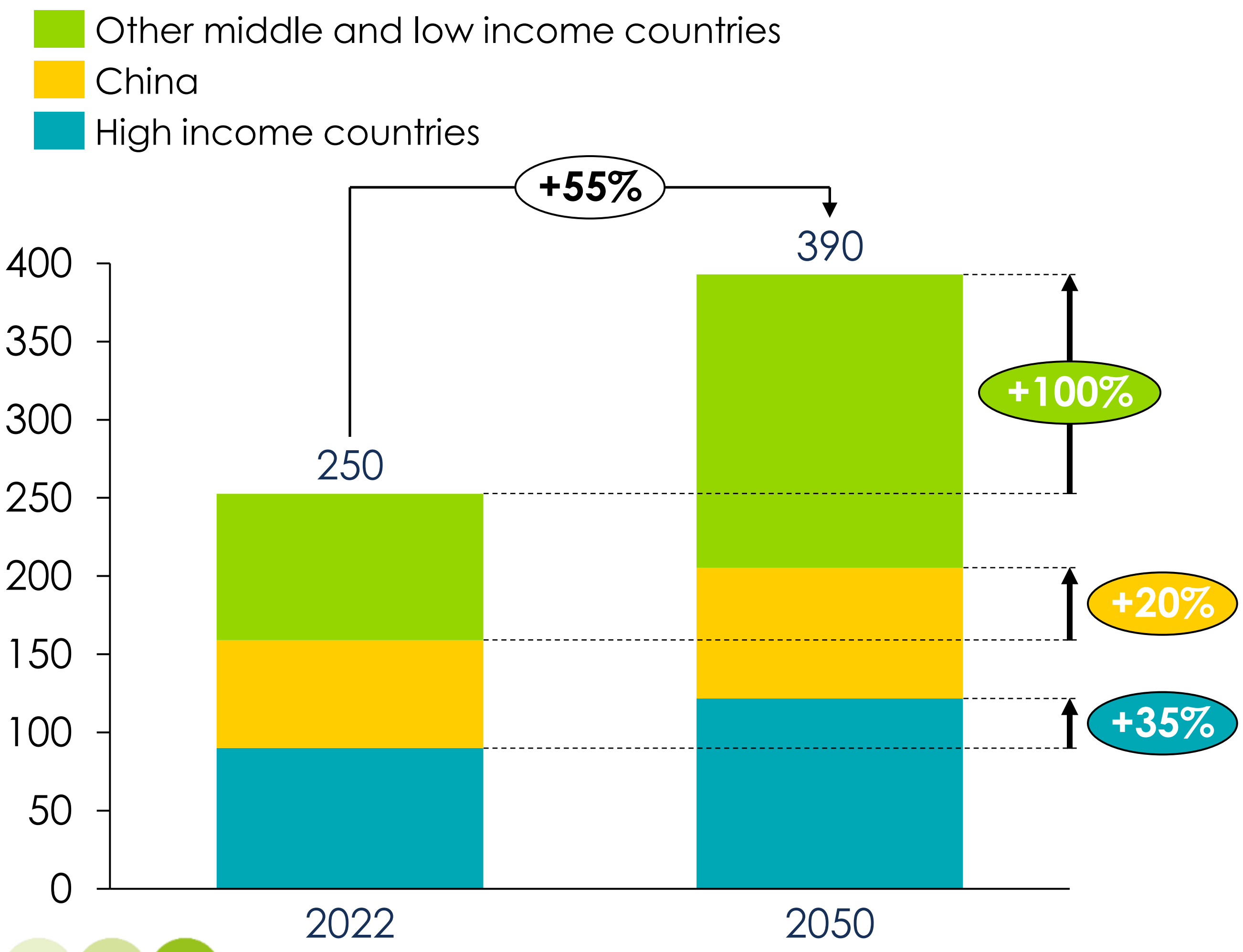
Sectoral deep-dives

Buildings

The buildings energy demand challenge: a 50% increase in global floor area and the electrification of fossil fuel heating will create significant demands for electricity grids

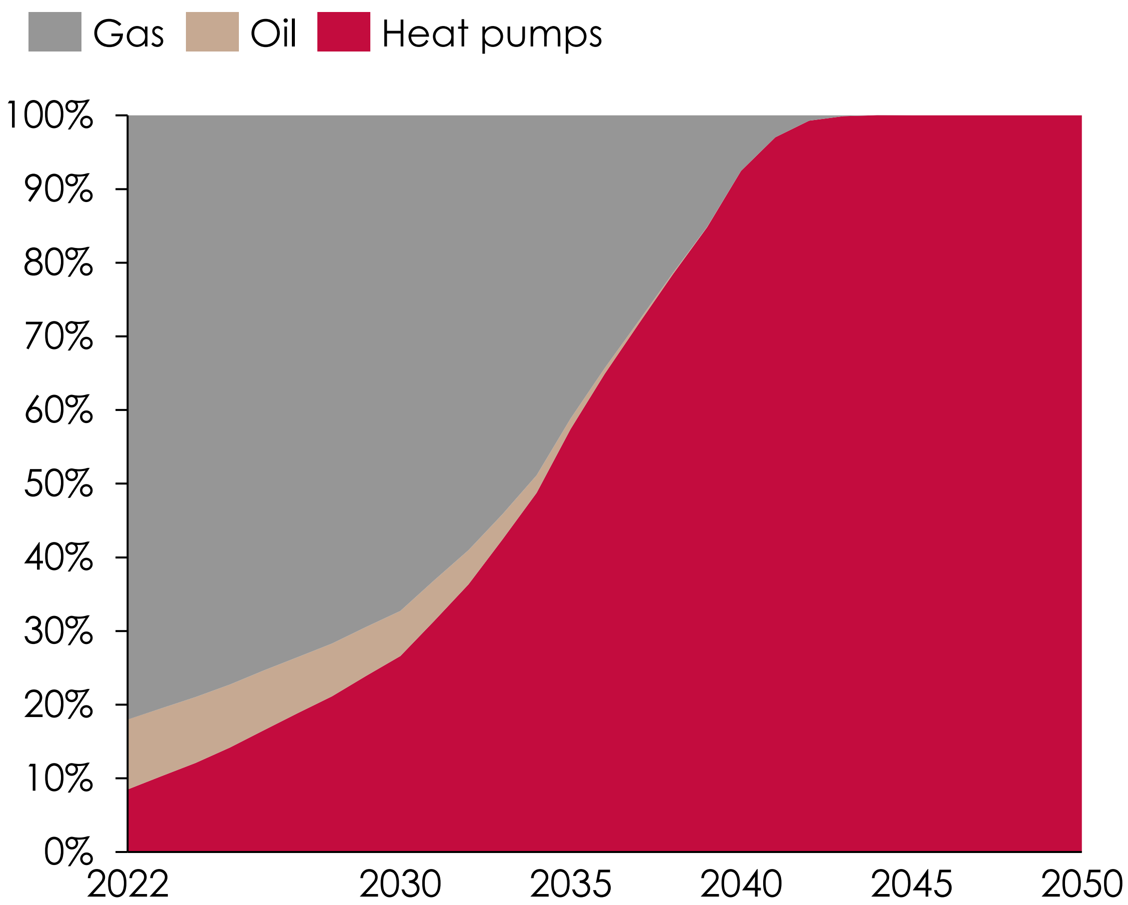
Growth in global floor area by region

2022-2050; Billion m2; IEA NZE Scenario



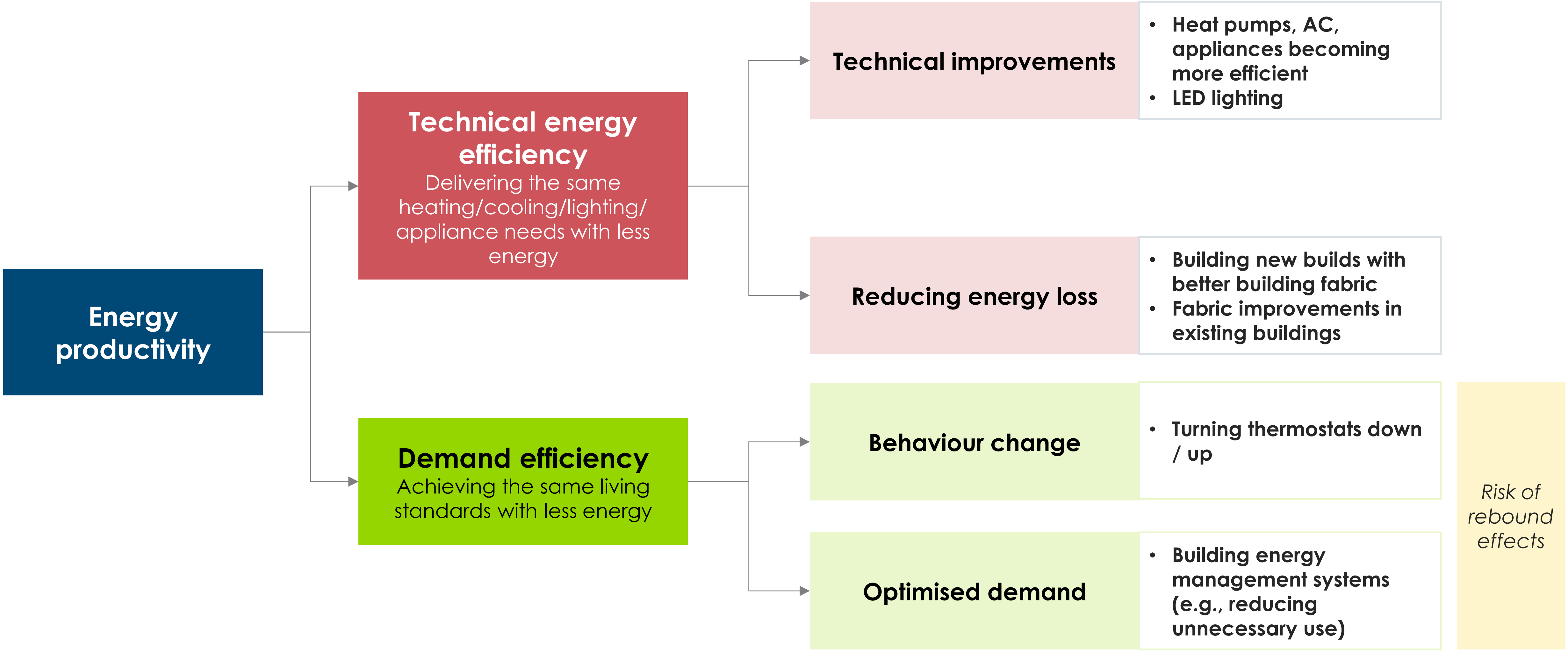
Transition of existing gas and oil boiler stock to heat pumps in Europe and North America – ETC projections

% of stock of existing



Source: IEA (2023), *World Energy Outlook 2023*; Systemiq analysis for the ETC (2023), *Fossil Fuels in Transition.*
Note: RHS is ETC's Ambitious but Clearly Feasible scenario.

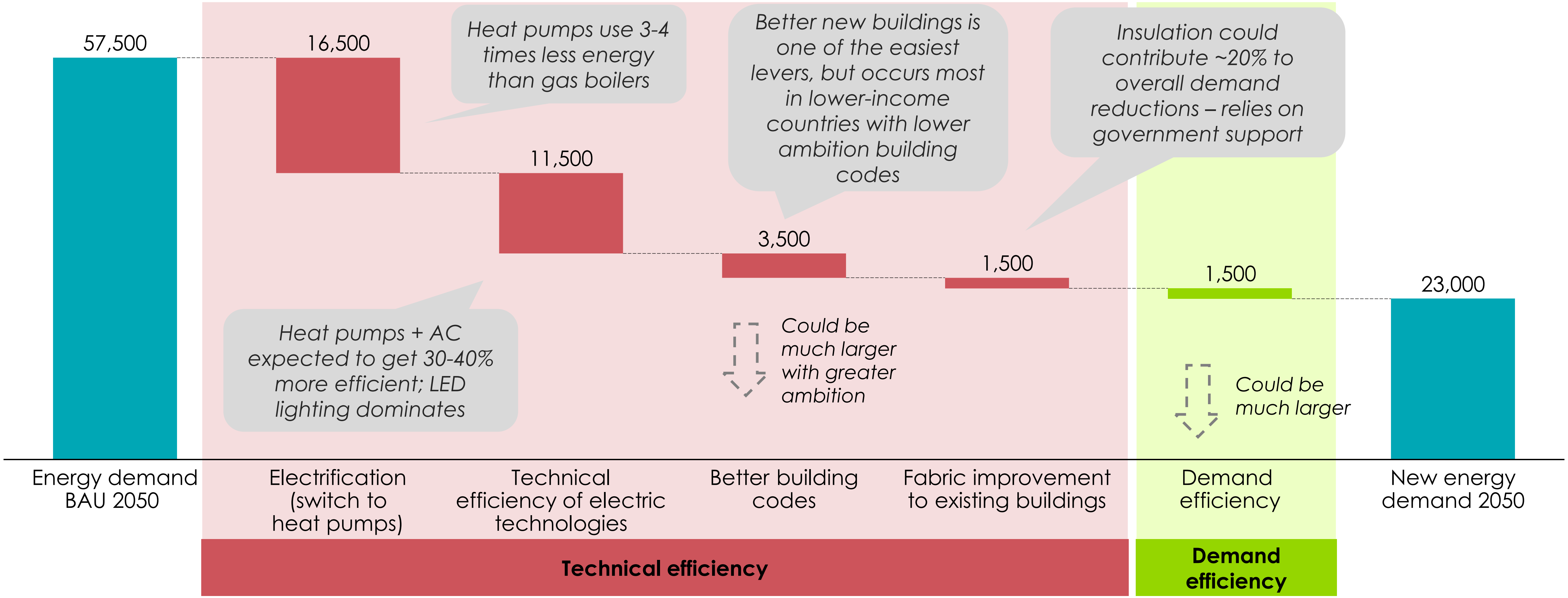
Beyond electrification of fossil fuel heating, there are many energy productivity levers possible for buildings operational energy



Note: OEM stands for Original equipment manufacturer
Source: Systemiq analysis for the ETC.

Energy consumption can be decreased by 60% in buildings

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



Sources: Systemiq analysis for the ETC (2024); IEA (2023), World Energy Outlook 2023; IEA (2021), *Net Zero by 2050*.
Note: building cooking energy excluded from analysis. For primary energy conversion, 83% efficiency is assumed for renewables power (e.g., electricity conversion and transmission losses), and 85% for fossil fuels to boilers.

Increasing technical energy efficiency is the largest lever enabled by heating electrification and increased efficiency in electrical appliances

Efficiency lever	Efficiency lever description
Technical energy efficiency	• Electrification of heating and cooking • Improvements in the efficiency of electrical appliances (such as ACs, heat pumps, cooking stoves, refrigerators, lightning, etc.) • Better insulation (in new and existing buildings)
Demand efficiency	• Behaviour change (e.g. thermostat changes) • Optimised demand (e.g. energy management systems)

Efficiency enablers

1. **Targeted heat pump deployment** and clear bans on fossil fuel heating and cooking, supported by local street-by-street delivery plans; providing time-limited subsidies for key technology deployment.
2. **Rebalance gas and electricity prices and** manage peaky electricity demand with time-of-use tariffs
3. Set **minimum energy performance standards and labelling regulations,** and encourage the uptake of **smart systems.**
4. Deliver a fair transition for households, with targeted support for low-income households, **clear regulations on the energy efficiency of rented properties,** and education and awareness of **low-cost passive heating and insulation improvements.**

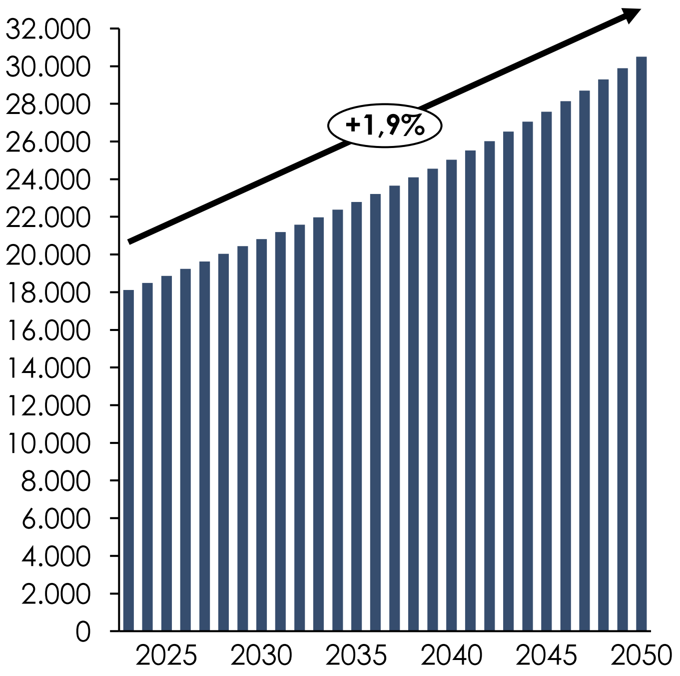
Source: ETC (2025) Achieving Zero-Carbon Buildings

Road

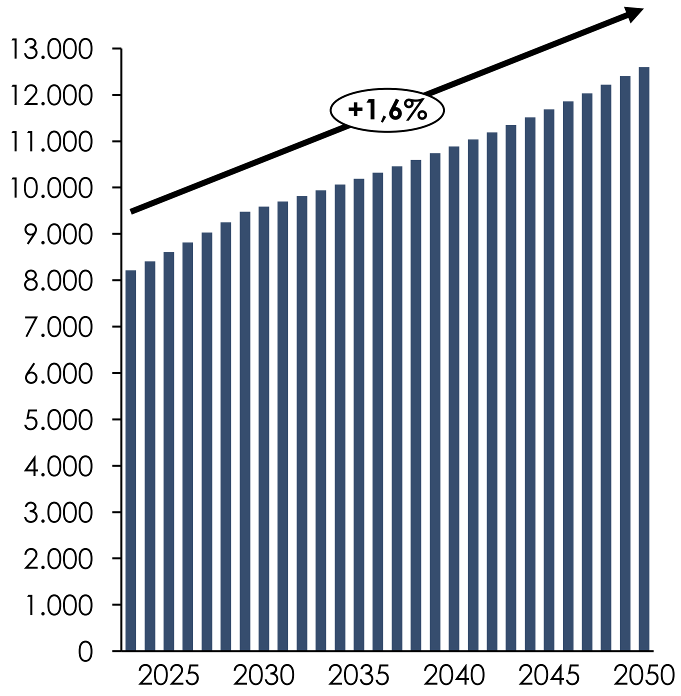
Passenger demand for transport is expected to grow by 1.9% annually, with commercial vehicles increasing by 2.4% annually

Demand for passenger km and freight transport km in the ACF[1] scenario
Billions of km

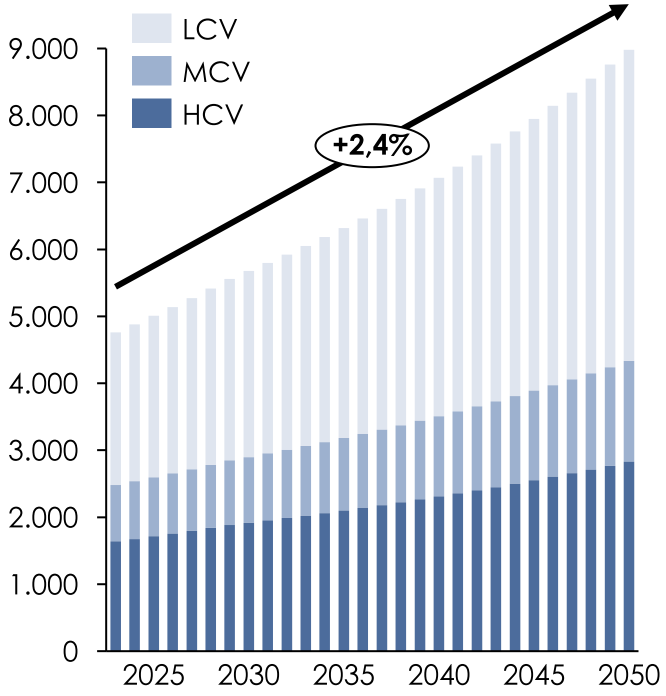
Fossil fuels in Transition report: Accelerated by clearly feasible scenario



Passenger vehicles



Two-Three-wheelers

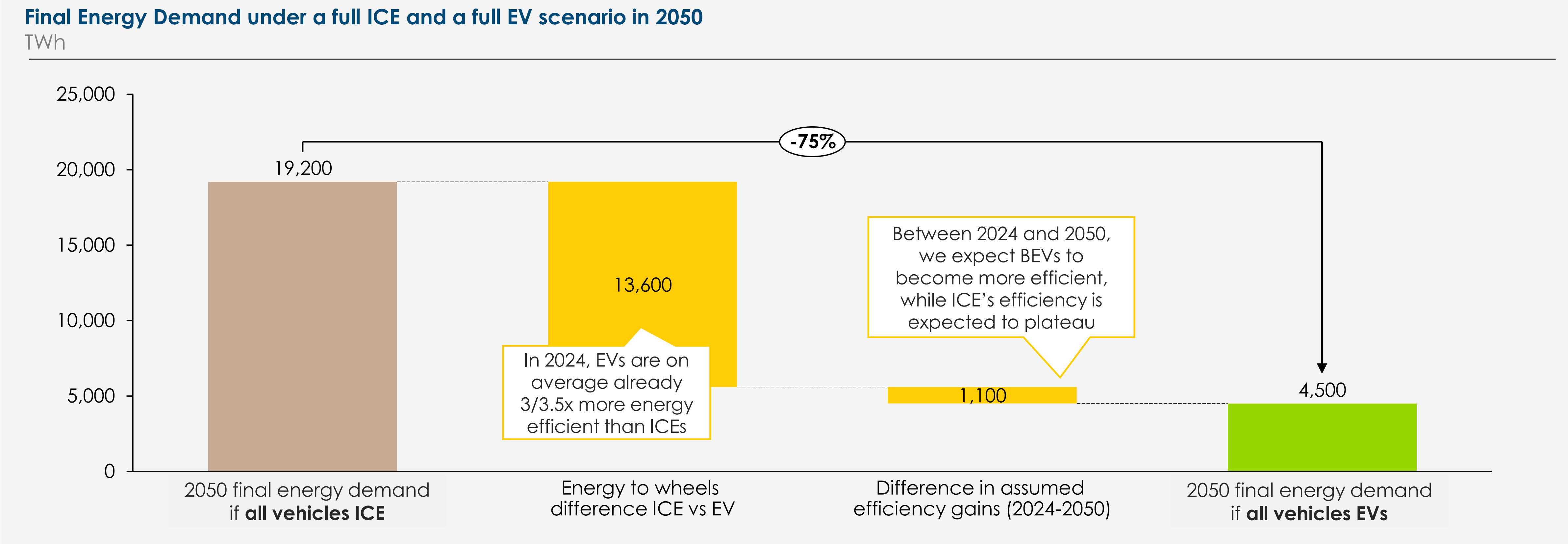


Commercial vehicles[3]

Note: 1. Accelerated but Clearly Feasible (ACF); 2. Zero-emission vehicles; 3. Commercial vehicles include light, medium and heavy commercial vehicles (e.g., LCV, MCV, HCV).
Source: Systemiq analysis for the ETC; ETC (2023), *Fossil Fuels in Transition: Committing to the phase-down of all fossil fuels,* available at https://www.energy-transitions.org/publications/fossil-fuels-in-transition/.

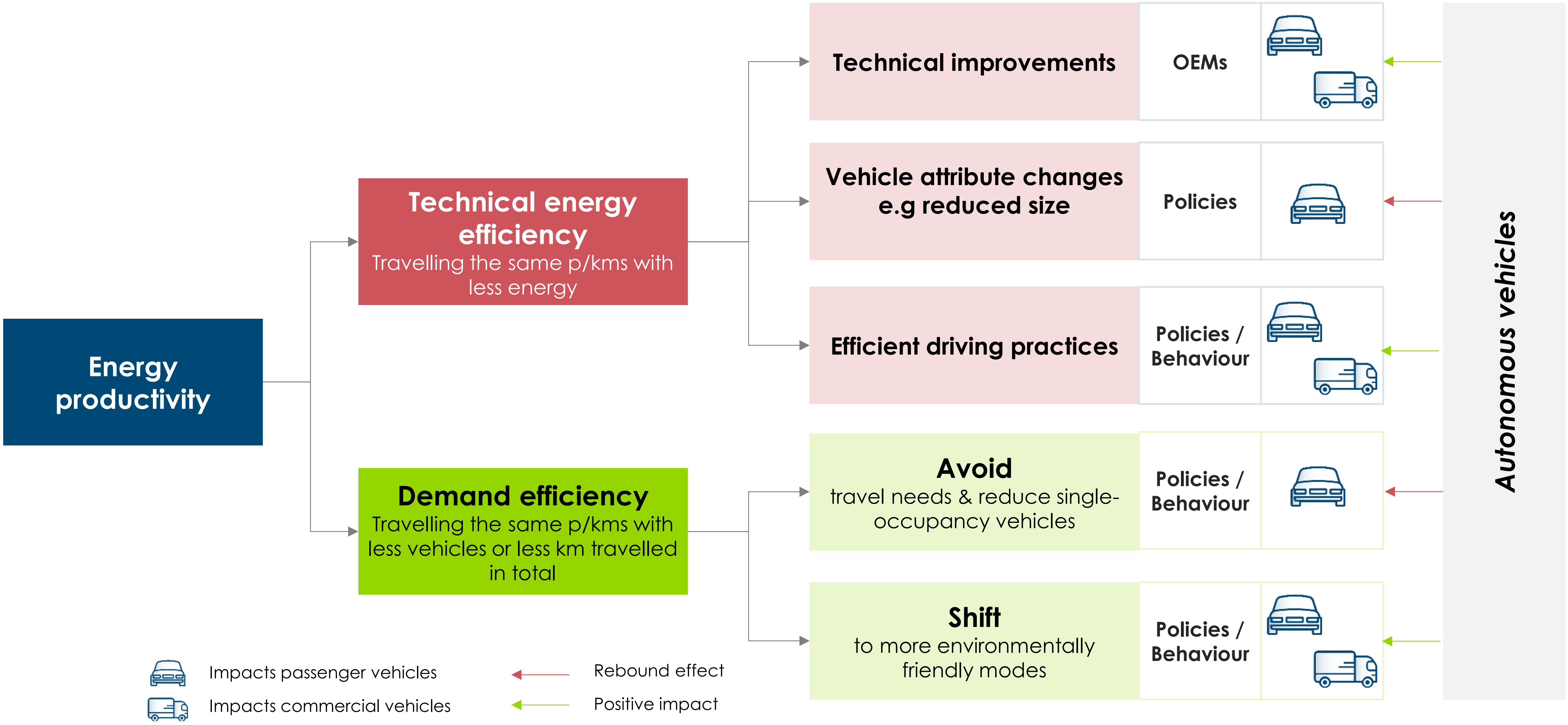
Electrifying road transport would reduce final energy demand by 75% without any other energy productivity improvements

Electric vehicles are already on average 3 times as efficient as gasoline, and could become 4 times as efficient by 2050



Notes: For Final Energy Demand, demand for transport of ~30,500bn km in 2050, with a fleet of 1.8Bn vehicles; In 2024, new BEVs consume on average 20 kWh/100km, and new ICEs 7.4 Lge/100km. We consider efficiency improvements of 1.6% p.a. for BEVs and 0.7% p.a. for ICEs, respectively reaching 12.9 kWh/100km and 6.1 LGE/100km in 2050. There are 9.3 kWh per Lge (Liter of gasoline equivalent). 5% electricity efficiency losses are assumed as well.
Sources: Systemiq analysis for the ETC.

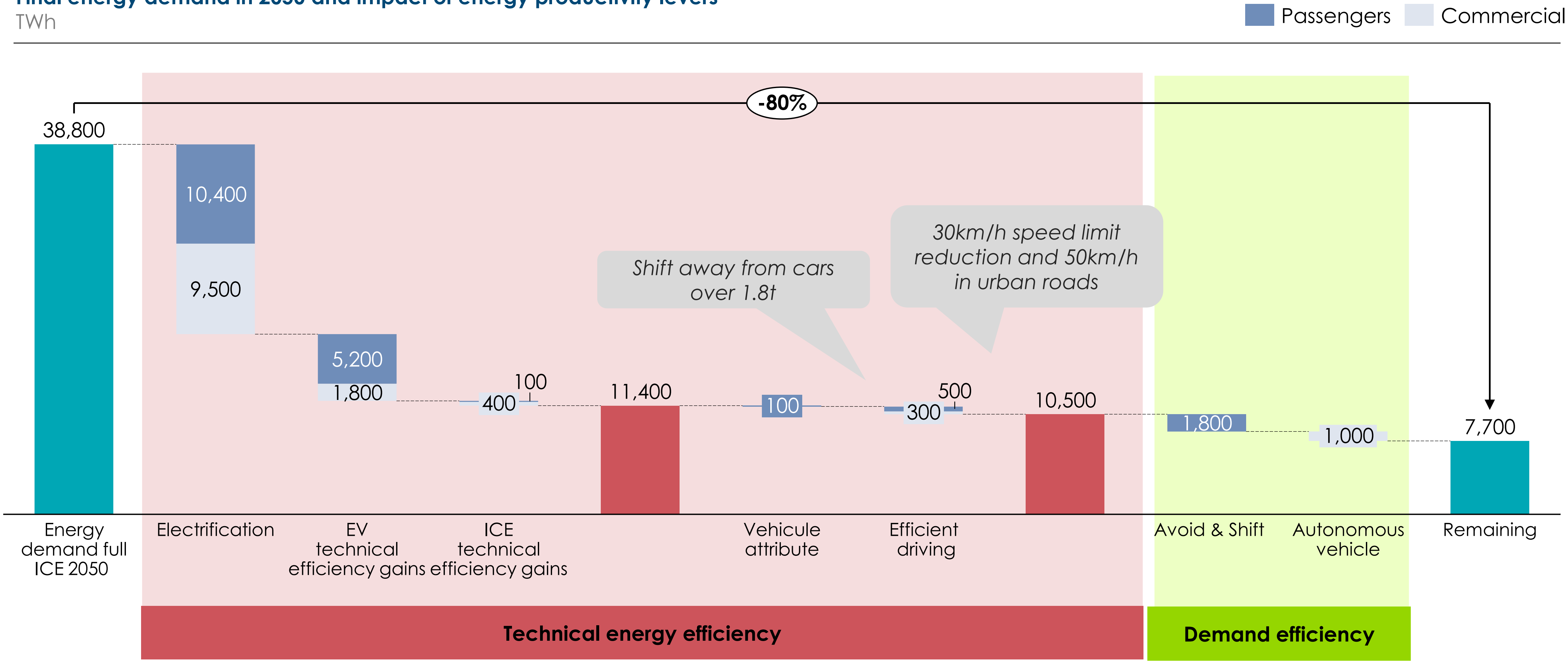
Road transport productivity report will explore levers beyond electrification



Note: OEM stands for Original equipment manufacturer
Source: Systemiq analysis for the ETC.

Switching to electrification is the most crucial factor in reducing energy consumption for road transport by 2050

Final energy demand in 2050 and impact of energy productivity levers
TWh



Note: ICE means internal combustion engine vehicles, EV means electric vehicles. Productivity levers: 20% efficiency gains for ICEs by 2050, 50% efficiency gains for EVs by 2035, 20 km/h speed limit reduction on highways and 30 km/h speed limit in urban areas, 36% demand reduction by 2050 through Avoid & Shift levers. Final Energy Demand attributed by lever with LMDI (logarithmic mean divisia index) methodology. For Primary Energy Demand, energy efficiency of 85% from fossil fuel extraction to tanker, and for renewables power (e.g., electricity conversion and transmission losses) is taken.
Source: Systemiq analysis for the ETC; ETC (2023), *Fossil Fuels in Transition: Committing to the phase-down of all fossil fuels.*

Increasing technical energy efficiency is the largest lever enabled by electrification and technical efficiency gains in EVs

Efficiency lever	Efficiency lever description
Technical energy efficiency	• Electrification (both in passengers and commercial transport) • Efficiency improvements in electrical vehicles • Lightweighting vehicles • Stricter speed limits
Demand efficiency	• Avoid & Shift (decrease km travelled per person or travel more sustainably) • Autonomous vehicles (for commercial use mainly)

Efficiency enablers

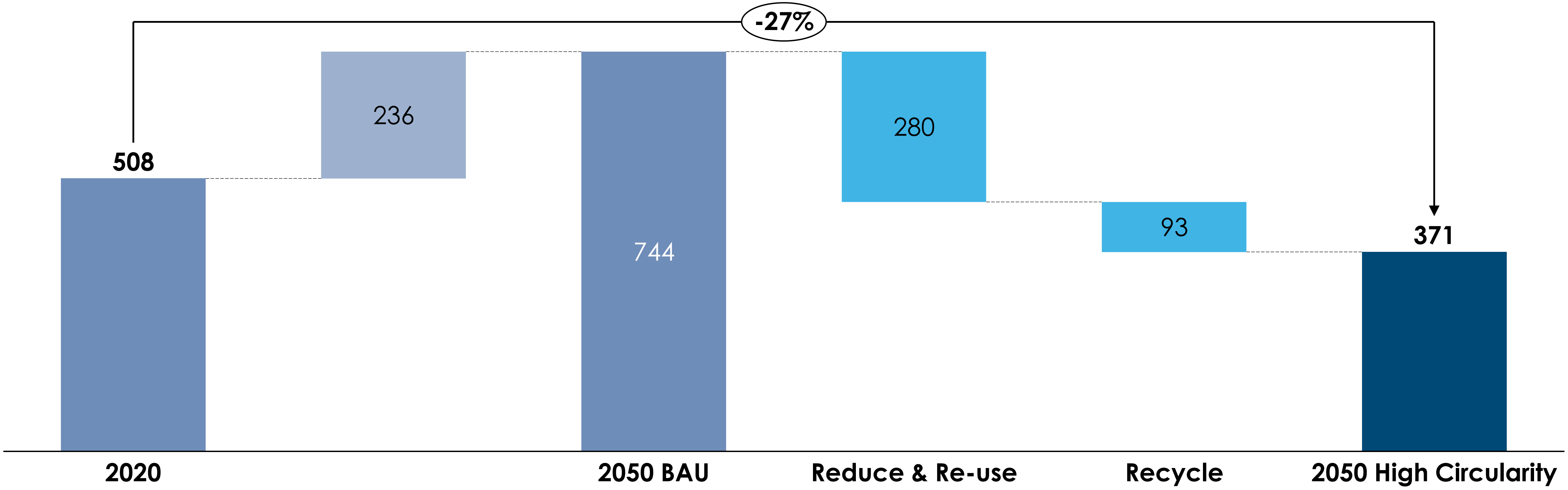
1. **Set and uphold ambitious ICE sales bans**
2. Roll out grid expansion and reinforcement aligned with the **deployment of charging infrastructure**
3. Create **financial incentives for EV adoption,** and enhance consumer awareness
4. Deploy **scrappage schemes**
5. Develop comprehensive and accessible **mobility plans, including low-emissions zones and reduced speed limits**
6. Encourage **smaller vehicles**
7. **Set early standards for AVs,** including energy consumption of software and cybersecurity measures

Source: ETC (2025) The Road Ahead

Petro-chemicals

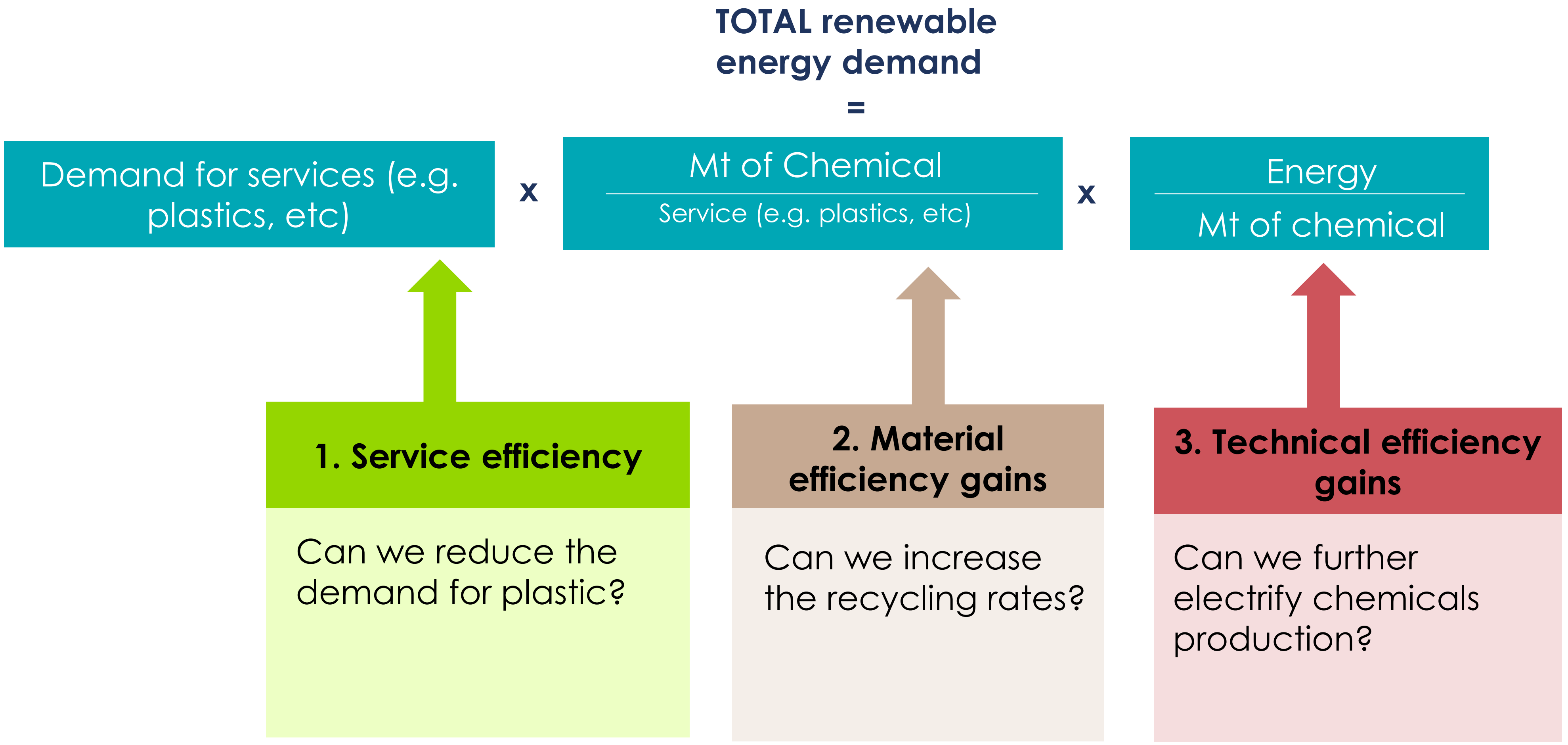
Petro-chemicals demand set to increase in BAU, but high circularity can revert the trend by 2050

Basic chemical demand analysis between 2020 and 2050
Mt



Source: Systemiq (2022) Planet Positive Chemicals

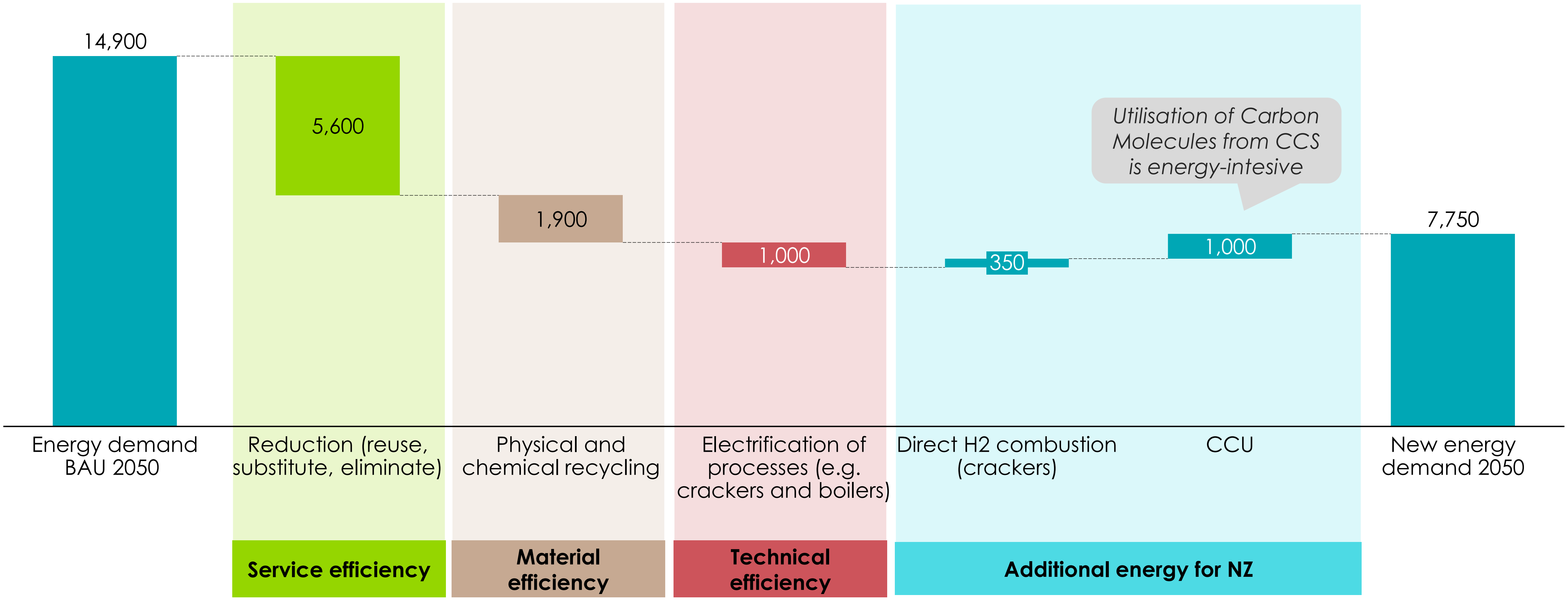
All 3 efficiency levers can reduce energy demand in the petro-chemical sector



Service and material efficiency drive productivity in petro-chemicals and help offset energy demand for the utilisation of carbon molecules

Preliminary

Primary energy demand in 2050 and impact of productivity levers
TWh



Source: Systemiq (2022) Planet Positive Chemicals

Increasing service and material efficiency is enabled by demand reduction and increased recycling

Efficiency lever	Efficiency lever description
Service efficiency	• Demand reduction of plastics through reusage, substitution or elimination
Material efficiency	• Increase in chemicals recycling rates
Technical energy efficiency	• Further electrification of chemicals production (e.g. steam cracking and electric boilers)

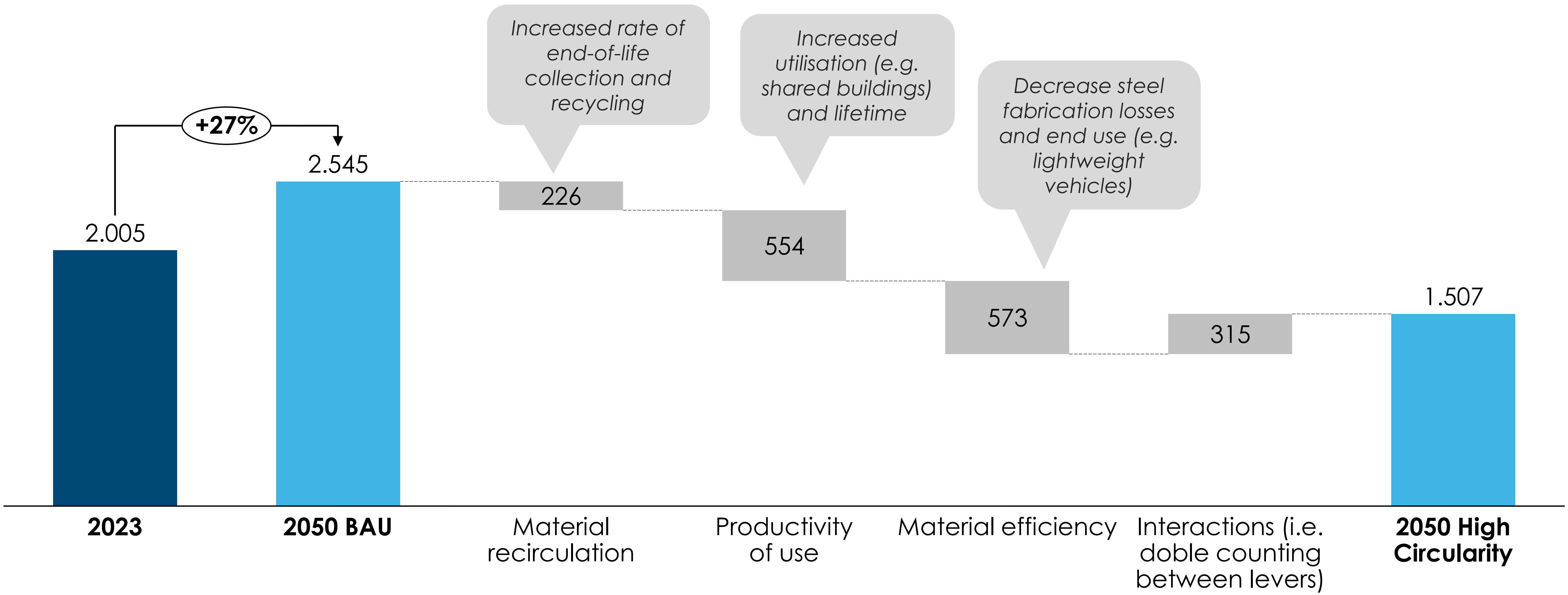
Efficiency enablers

1. **Provide the right incentives for circularity** by setting targets for recycled content and banning/including fees in single-use items
2. **Support infrastructure that enables re-use and recycling** by supporting scale-up of re-use models (e.g. overcome high upfront costs) and scaling up collection and sortation infrastructure for recycling
3. **Implement policies to support the business case** via Extended Producer Responsibility (EPR) schemes, which attributes responsibility for the entire lifecycle of products to producers, and carbon pricing, extending it to incineration to limit waste on unabated linear systems
4. **Foster Collaboration Across Value Chains** via R&D, partnership with recyclers, data sharing for traceability, etc.

Steel

Steel business-as-usual demand is set to grow to 2050, but demand can be abated by higher circularity

Crude Steel demand BAU vs. High Circularity scenario
Mt of Steel



Source: Mission Possible Partnership (2022) Steel Sector Transition Strategy

There are 2 main efficiency levers to reduce energy demand in the steel sector

TOTAL renewable energy demand

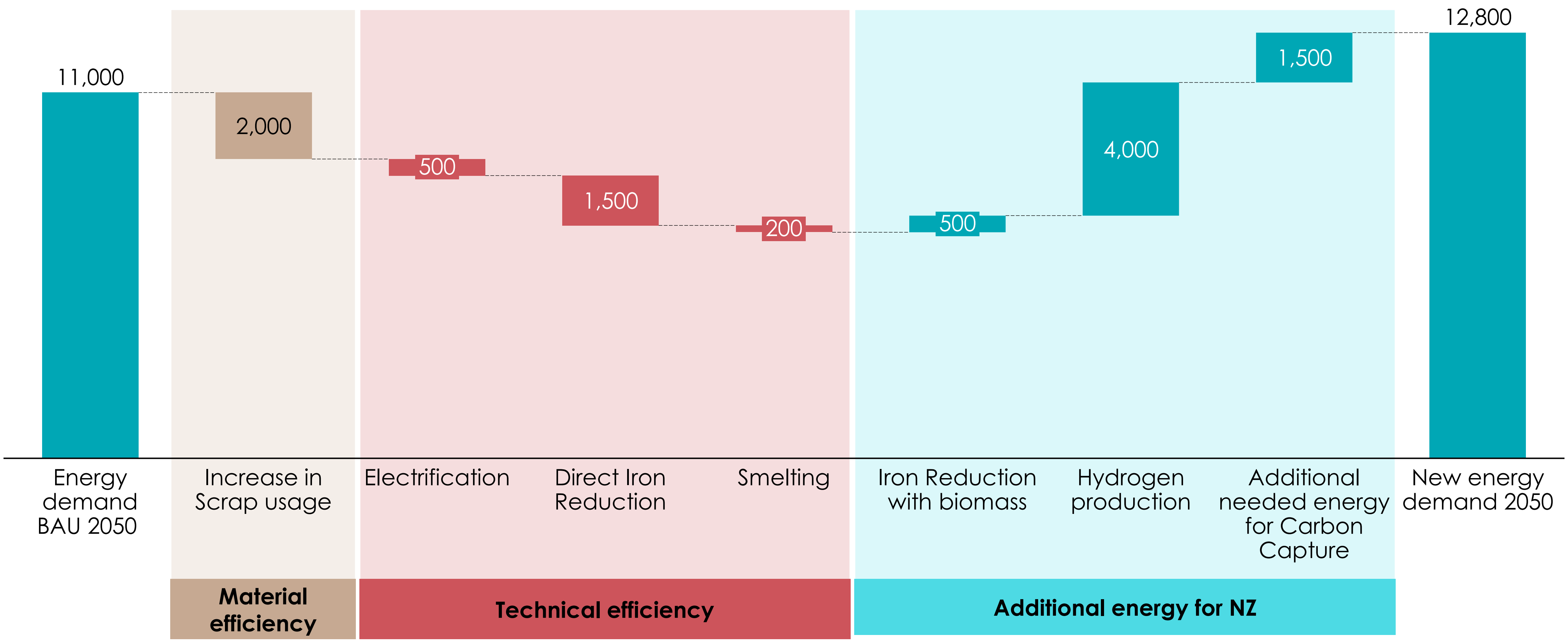
=

Demand for services (e.g. buildings, cars, etc) **x** $\frac{\text{Mt of Steel}}{\text{Service (e.g. car, buildings)}}$ **x** $\frac{\text{Energy}}{\text{Mt of aluminium}}$

1. Demand reduction	2. Product efficiency gains	3. Material efficiency gains	4. Technical efficiency gains
Not relevant: demand set to increase with buildings and EVs	Not relevant: no foreseeable product efficiency	Can we increase the rate of scrap in steel?	Can we electrify while decarbonise iron reduction?

Material efficiency offers the biggest productivity potential in steel; but H2 production and CCUS offsets productivity gains

Primary energy demand in 2050 and impact of productivity levers
TWh



Source: Mission Possible Partnership (2022) Steel Sector Transition Strategy

Increasing material efficiency is the largest lever enabled by increased use of scrap in primary steel production

Efficiency lever	Efficiency lever description
Material efficiency	• Scrap usage increase (increase secondary production and primary production scrap intake)
Technical energy efficiency	• Energy efficiency gain from EAFs and electrowinning in steelmaking compared to the average BOF • Energy efficiency gain from direct iron reduction (with natural gas, biomass or hydrogen) compared to the average BF • Energy efficiency gain from smelting compared to the average BF-BOF

Efficiency enablers

1. Policy incentives to **increase scrappage collection and recycling**
2. **Stricter rules on scrap exports** to countries with lower environmental standards
3. Increase electrification, especially downstream iron reduction on **steelmaking process**, by increasing **EAFs production share**

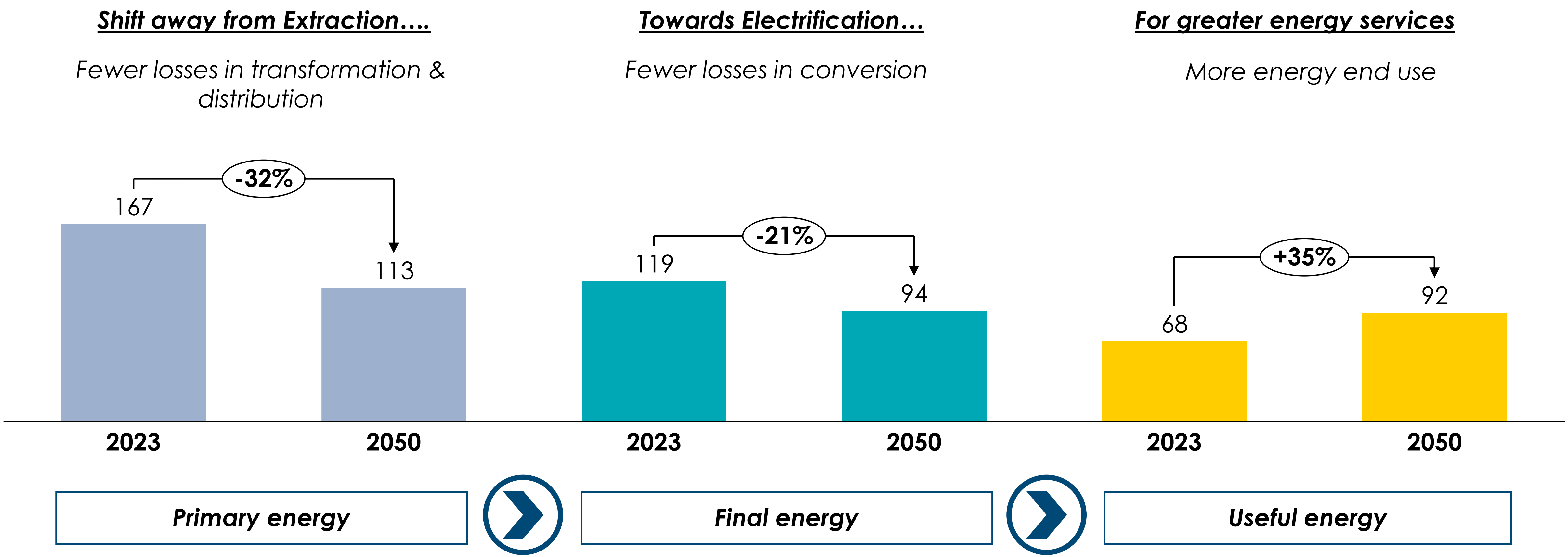
Source: Mission Possible Partnership (2022) Steel Sector Transition Strategy

Total energy

While primary and final energy demand decreases with productivity levers, useful energy, i.e. energy services, increases by 2050

NZ Energy demand with Productivity levers

000 TWh

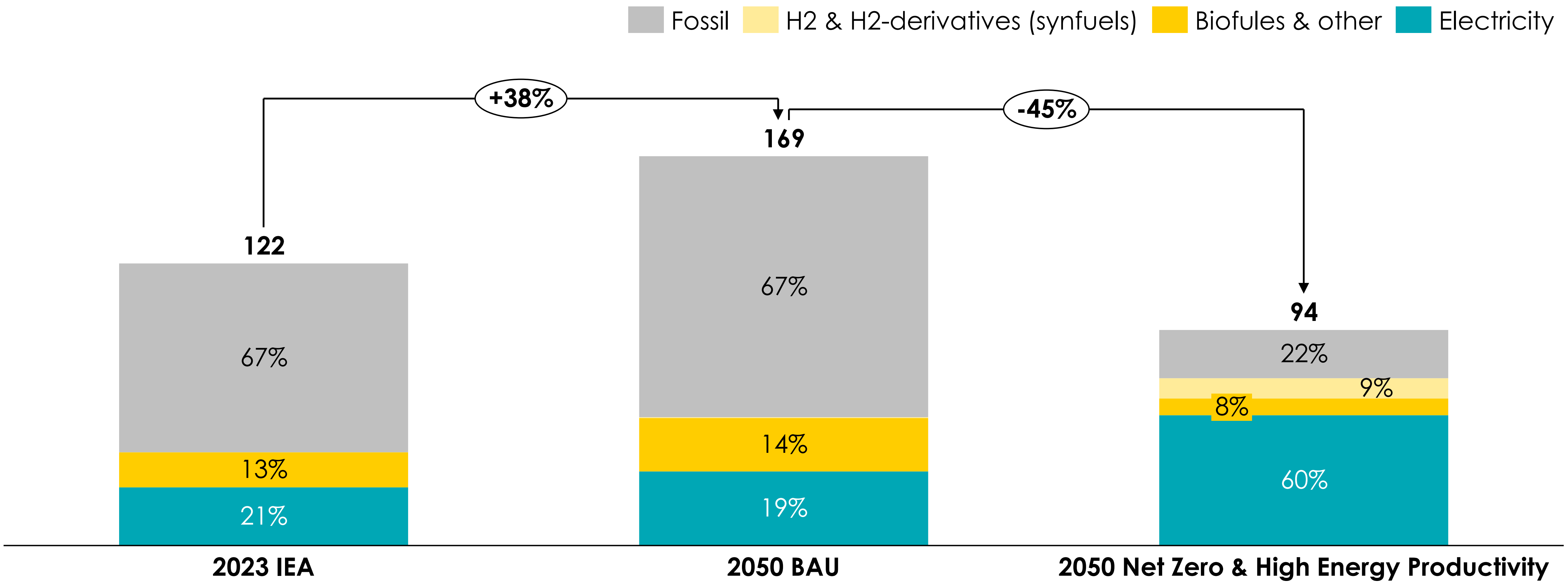


Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022); Planet Positive Chemicals; Systemiq analysis for ETC.

Reaching net-zero whilst maximising energy productivity gains can lead to lower energy demand without compromising on living standards

Global Final Energy demand

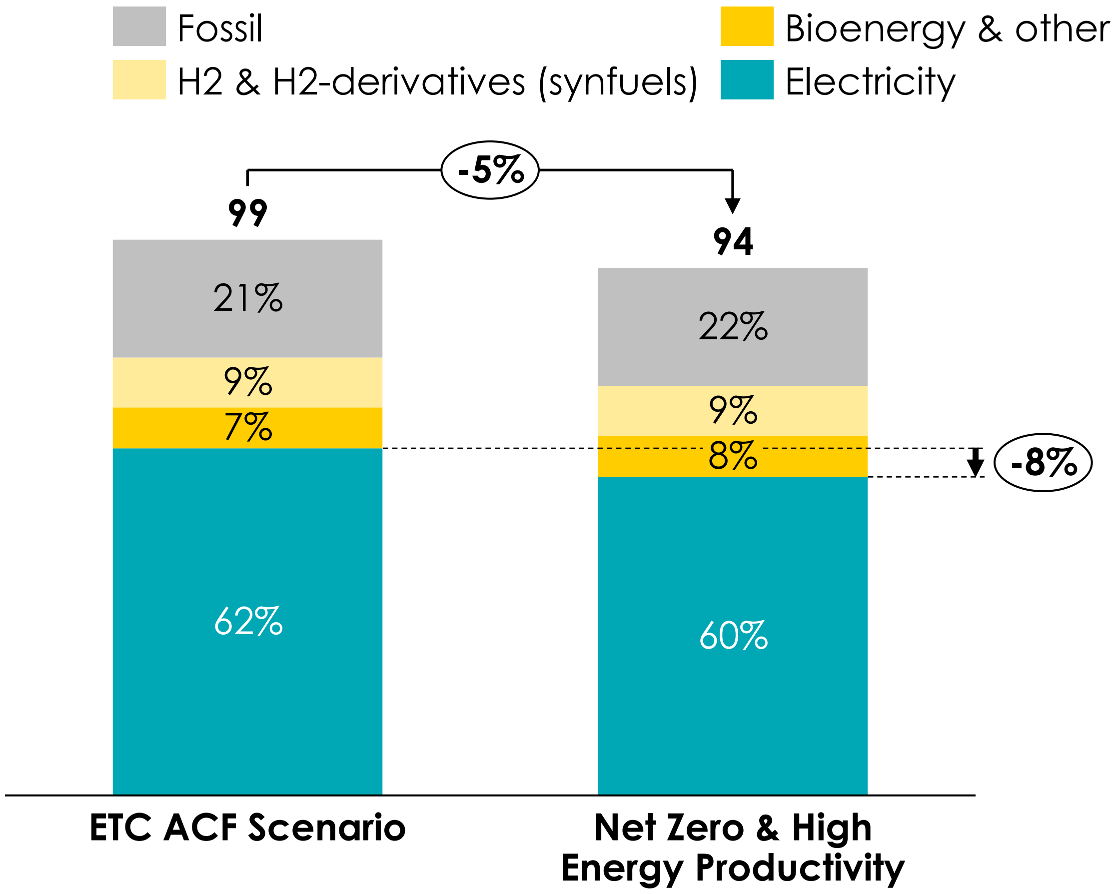
000 TWh



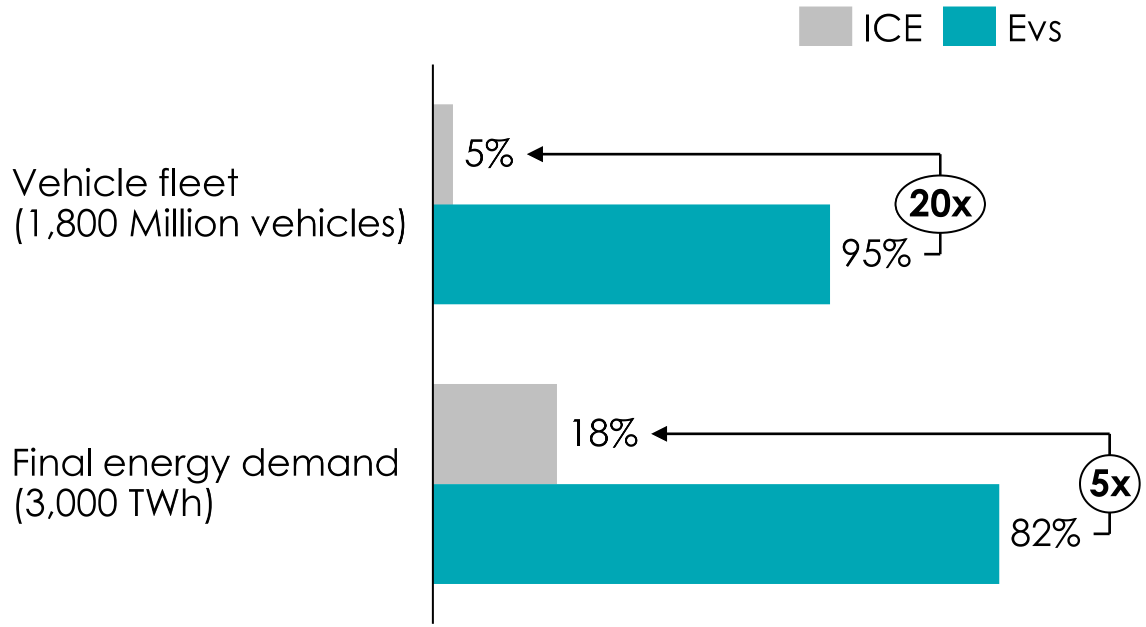
Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq (2022); Planet Positive Chemicals; Systemiq analysis for ETC.

The electricity conundrum: Electricity has a self-limiting nature in total energy demand due to its high efficiency

2050 Global Final Energy demand scenarios
000 TWh



Case study: Passenger road transport in 2050
Billion Km; TWh



A global **electrical fleet that is 20x the size** of global ICE fleet has a **final energy demand that is just 5x that of ICE**

Source: ETC(2023), Fossil Fuels in Transition; ETC (2025) The Road Ahead; Systemiq analysis for ETC.

Agenda

- Context: Importance of energy productivity
- ETC assessment of EP potential to 2050 & sectoral deep dive
- **Summary conclusion & key priorities**

Key messages

Key messages	Comment
A decarbonized, high energy productivity system can reduce overall energy demand while providing growing standards of living	▪ Technical, material and behavioral levers **can deliver ~50 % savings in 2050 vs BAU final energy demand**, with a decarbonised, electrified economy which can meet growing standards of living
Electrification and appliance efficiency are game changers	▪ Switching from fossil fuels to electricity in buildings, transport, and industry—paired with improvements in the efficiency of electric appliances and vehicles—**could decrease BAU 2050 final energy demand by a third**
Hard to abate sectors need productivity levers to offset energy intensive fuel switch	▪ **Supply-side decarbonisation technologies will be more energy intensive** in aviation, shipping, cement, aluminium, steel and chemicals, which makes the role of energy productivity even more relevant - material efficiency, process innovation and better design can offset the impact of fuel switches and CCUS.
Clear strategic vision supported by policy is needed to drive action	▪ Actions, such as regulatory direction, support for stock turnover, stronger efficiency standards, targeted electrification strategies, and integrated planning, must be rapidly implemented—**especially in developing economies**—to deliver equitable and scalable impact
Energy productivity delivers a lower cost and more secure energy transition	▪ By reducing overall energy demand, energy productivity **cuts system costs, eases pressure on renewable deployment and strengthens energy security** by lowering reliance on imported fuels and minimizing exposure to price volatility.

Priority actions to drive energy productivity

	Main productivity levers	Key actions
Final Energy	1 Electrification	• **Set and uphold ambitious ICE sales bans** • Develop **charging infrastructure** by investing in **fast chargers** and expanding the charging network at all levels • **Deploy scrappage schemes** to accelerate phase out of highest emitting cars
Final Energy	2 Improvements in the efficiency of electrical appliances and vehicles	• **Set ambitious efficiency standards** on new vehicles, main household appliances (e.g. refrigerators, air conditioning), and overall buildings performance • Roll out **scrappage schemes** for the oldest appliances/vehicles targeted to lower income households
Primary Energy	3 Grid decarbonisation	• Establish specific goals to **reduce grid carbon emissions**, set **renewable deployment capacity + coal phase out targets** • Planning for grid expansion + deployment of storage and flexibility
Cross cutting	4 Integrated and sector specific interventions	• **Pursue sector specific efficiency gains**, e.g. vehicle lightweighting, new tyres • **Seek integrative design intervention to improve efficiency, alongside electrification** (e.g. reduce friction in pipes when installing heat pumps, adding cycling lanes when opening roads to install charging infrastructure, etc.)

The role of targeted policies in energy productivity can re-shape energy use at scale

Condensing boiler market transformation

- In 2003, UK regulated that condensing boilers were made mandatory from 2005
- Estimated savings over the whole boiler stock of **~40TWh/year of gas** and emissions of **8 $MtCO_2$/year**
- Previous policy instruments (e.g. grants, suppliers' obligations) allowed **the technology to be proven and costs to fall**
- Transition in 2 years enabled by public-private funded training programme that **accredited 65,000 installers**

UJALA Programme – Deploying LED bulbs

- Affordable LEDs for all scheme (UJALA), launched in 2015 in India, deployed over **368 million LED bulbs** nationwide
- **Energy annual savings are estimated at 47.9 billion kWh**, avoiding 9,586 MW of peak demand and 38.8 million tonnes of CO2 emissions per year.
- Around **$2.3 billion was saved in households** annual electricity bills

Source: Nick Eyre (2020) The story of condensing boiler market transformation; India Brand Equity Foundation

Energy productivity through - and in addition to - electrification can ensure lower costs and impact on planetary boundaries and more energy security

Maximizing additional energy productivity *beyond* electrification can achieve:

- **Lower cost,** by reducing **from $3.5 to $2.7 trillion / year** the annual amount of energy infrastructure and investment needed
- **Lower materials footprint,** by reducing the cumulative material requirements for the energy transition by 2050 down from 6.5 billion tonnes of end-use materials to as low as 4.6 billion tonnes and reducing the cumulative **embodied carbon emissions** of these materials from **35 $GtCO_2e$ to as low as 4.6 $GtCO_2e$**
- **Lower impact on planetary boundaries,** by reducing clean energy system requirements for water and land use by 4 billion m^3 and 0.05 million km^2 respectively, which is equivalent to **Tunisia's annual water consumption** and the **land size of Costa Rica**.

Maximising energy productivity *alongside* electrification can:

- **Increase energy security,** reducing overall needs for energy can reduce needs for imports, reducing the impact of price volatility; e.g. in Germany primary energy imports in 2023 added up to around 70% of the country's energy demand at the cost of 80 billion euros. By 2035, with electrification and further energy productivity levers, **imports could drop by 20%, reducing the import bill by 16 billion euros in 2023 prices.**

Source: ETC (2023) Material and Resource Requirements for the Energy Transition; ETC (2025) Achieving Zero-Carbon Buildings; ETC (2025) The Road Ahead; ETC (2024) NDCs, NCQG, and Financing the Transition: Unlocking Flows for a Net-Zero Future; Eurostat; Clean Energy Wire (2025) Fossil fuel imports to Germany go down as costs increase