



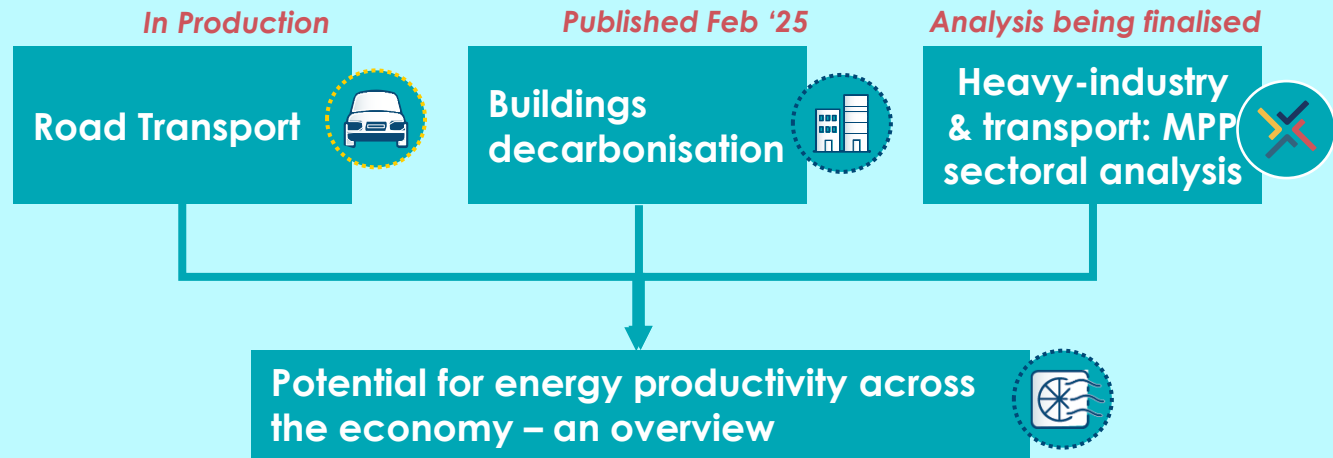
Energy
Transitions
Commission

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	<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">▪ Key levers to maximise energy productivity▪ Sectoral deep dive	Session: 20 min Q&A: 45 min
Summary conclusion & key priorities	<ul style="list-style-type: none">▪ Key actions to scale potential▪ Overall benefits that energy productivity can deliver	Session: 10 min Q&A: 20 min



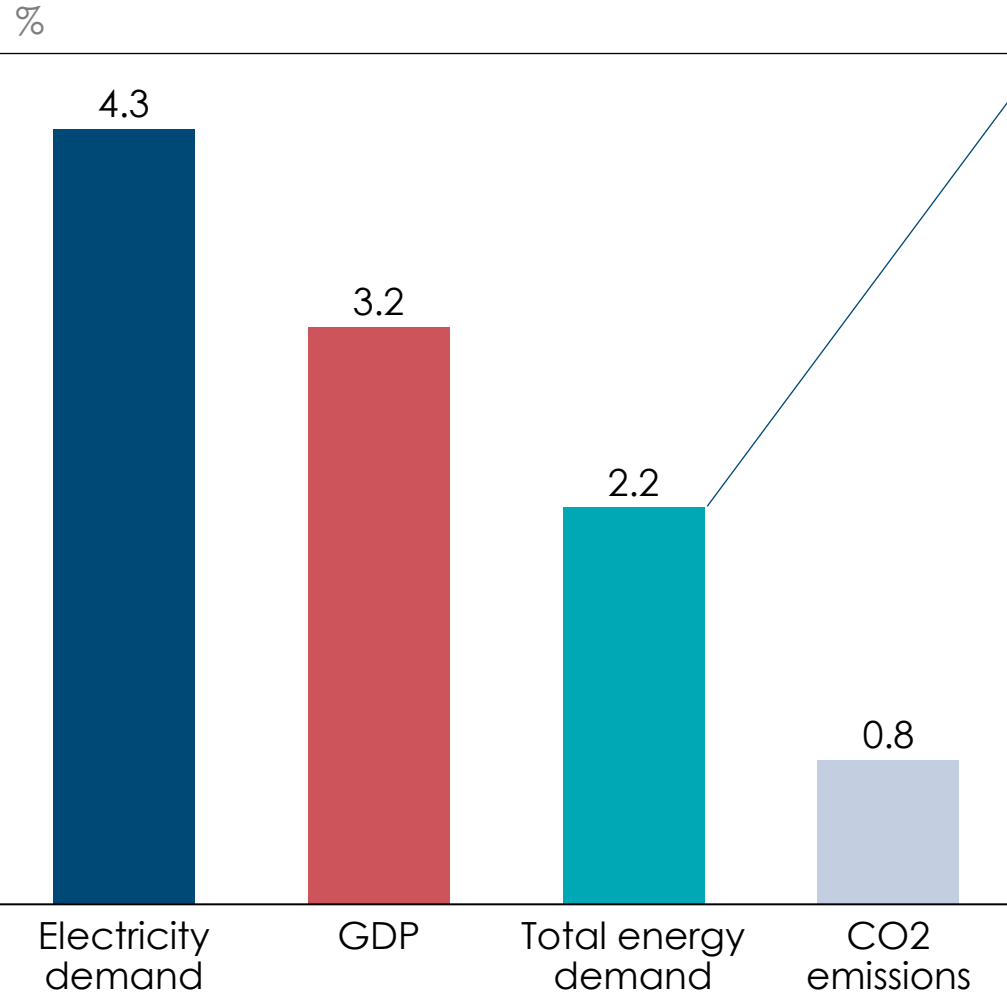
Agenda

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

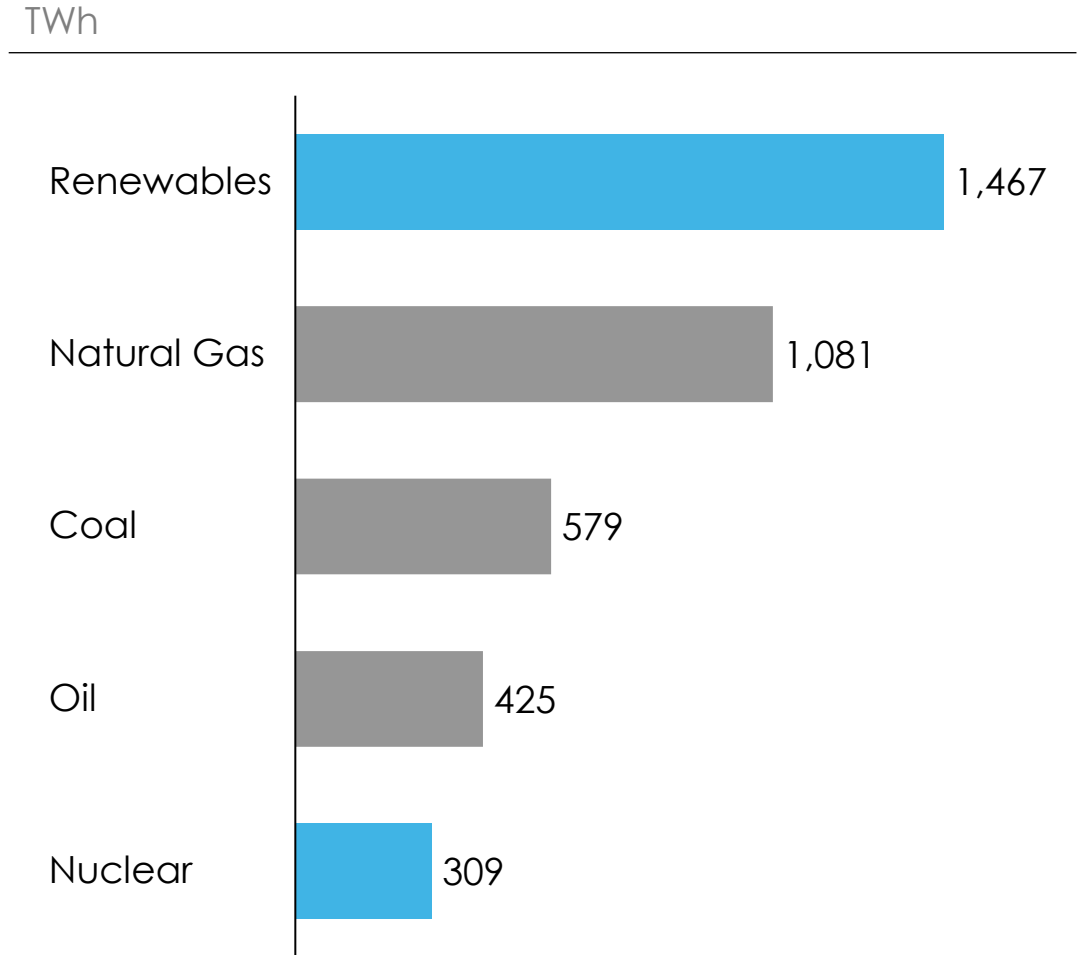


Energy demand continues to grow, with electricity demand soaring and most of added demand being met by low-carbon generation

Key global growth rates 2024



Total energy supply growth, 2024



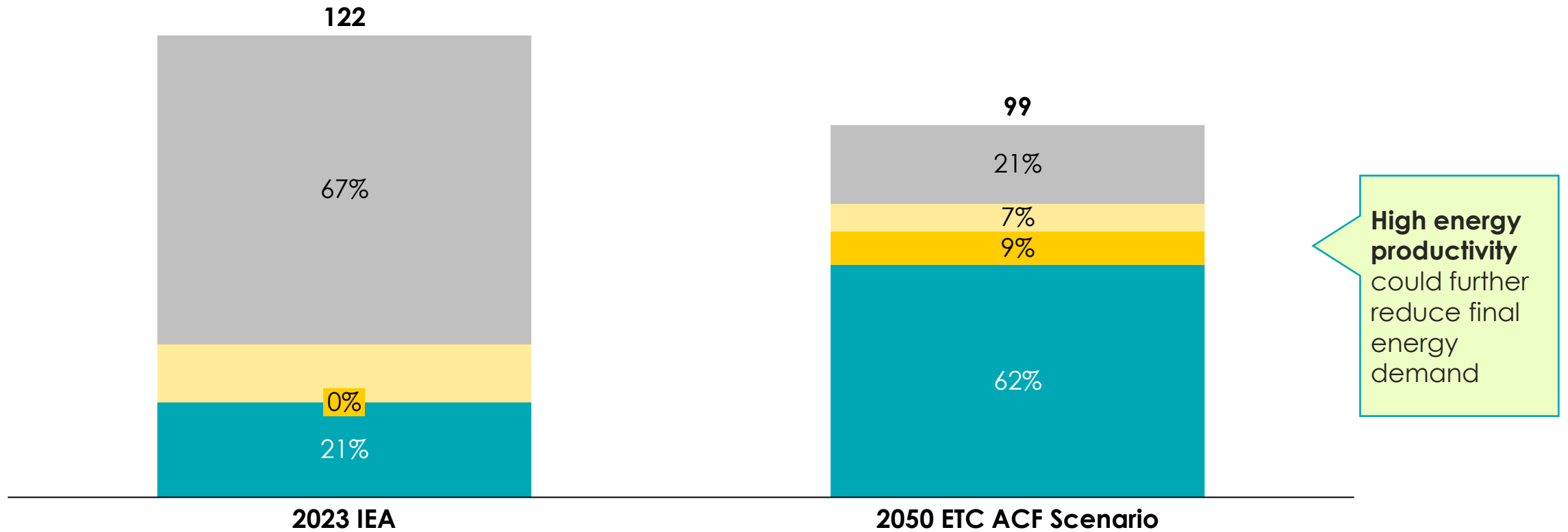
Source: IEA (2025) Global Energy Review

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

■ Fossil ■ Bioenergy & other ■ Hydrogen & hydrogen derivatives (synfuels) ■ Electricity



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.

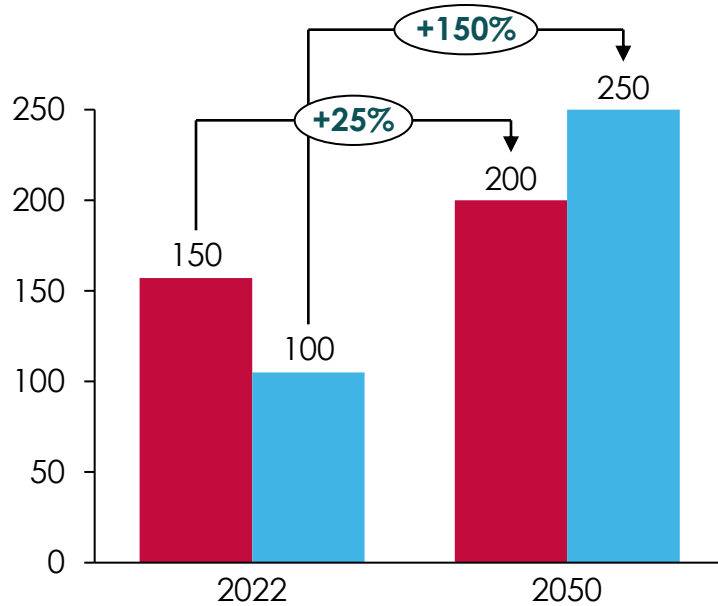
ETC ACF scenario assumes growth in energy services across sectors

Heated floor area vs. cooled floor area

Billion m²; IEA NZE Scenario; residential + commercial

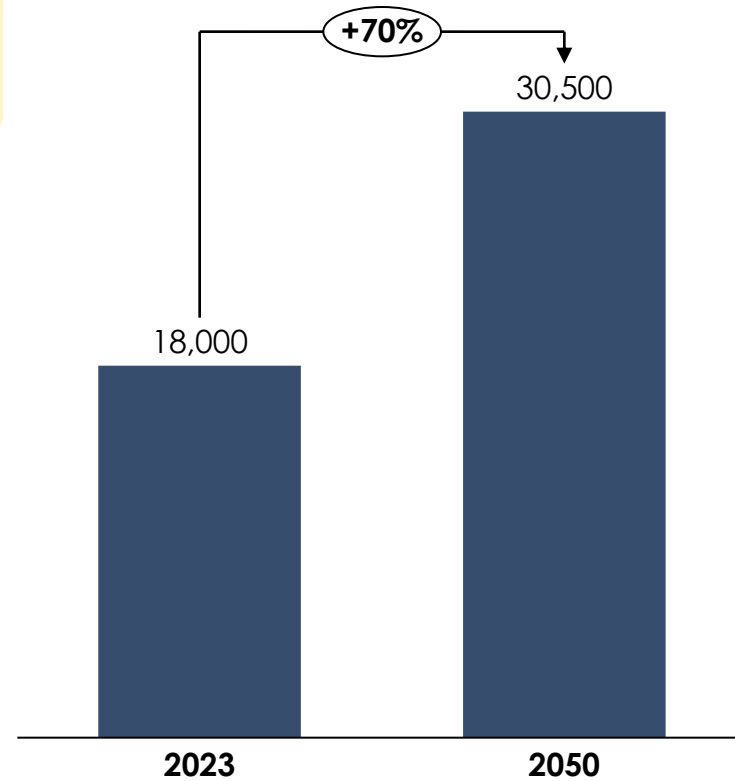
- Cooled floor area
- Heated floor area (space heating)

Cooled floor area is growing at a higher rate than heated, driven by 1) **GDP per capita growth**; 2) **increase in building floor area**, particularly in developing economies; 3) **warming climates**



Demand for passenger road transport

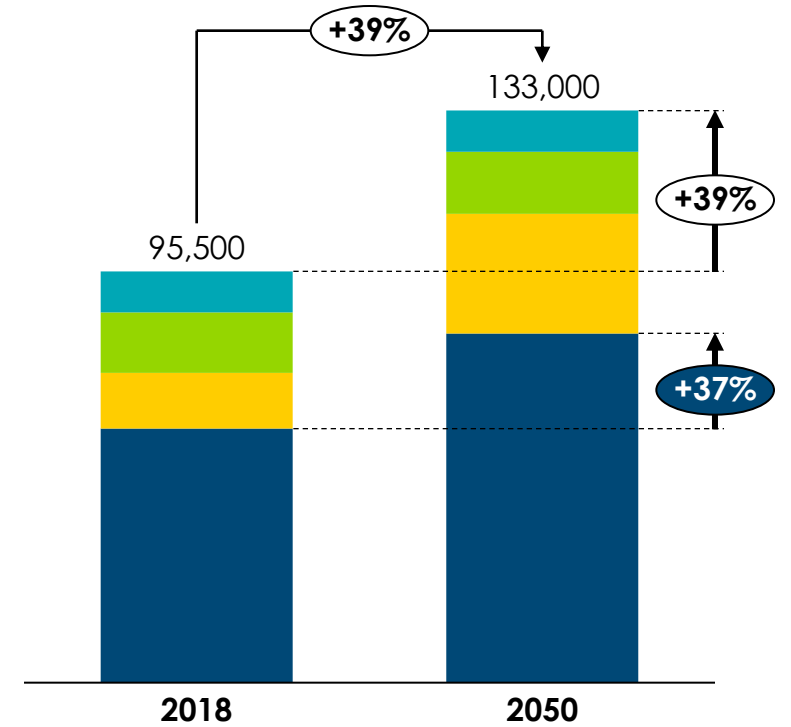
Billions of km; ETC ACF scenario



Shipping demand

Billions-tonnes miles

- Others
- Containers
- Tankers
- Bulk Carrier

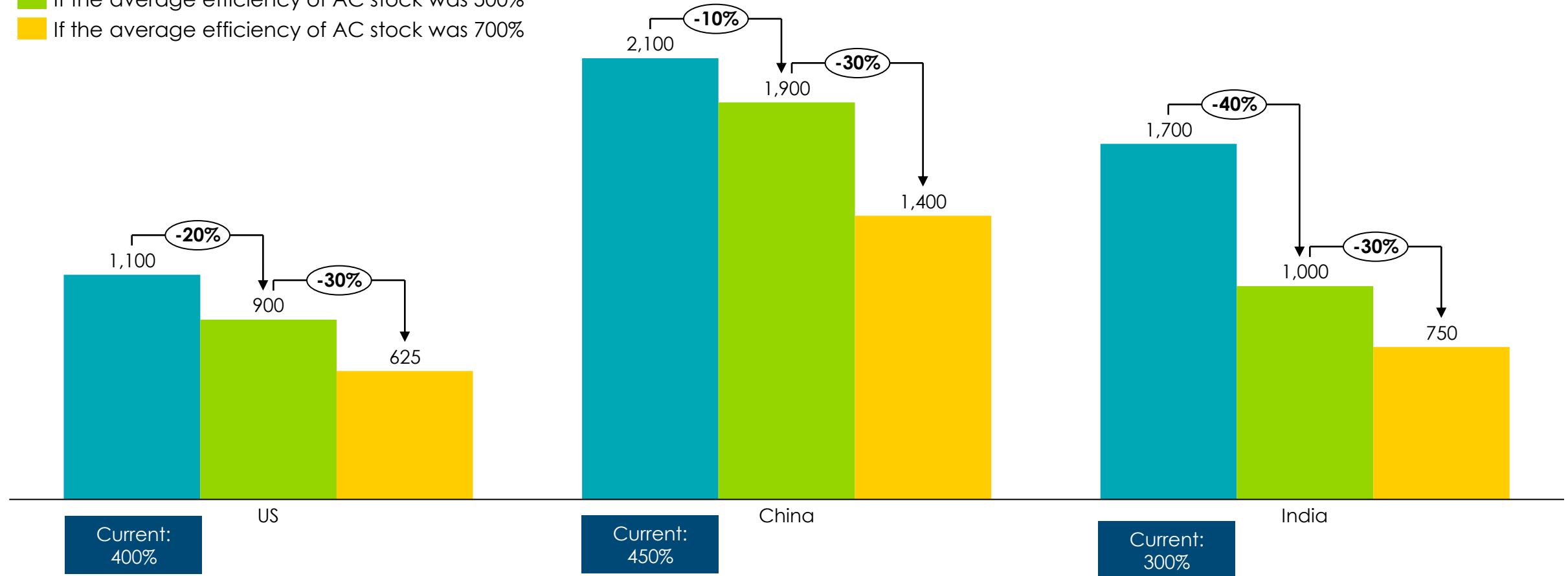


Raising average efficiency of the AC stock could reduce overall electricity requirements for cooling by 40-70%, for same level of energy services

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

TWh





- Current average efficiency
- If the average efficiency of AC stock was 500%
- If the average efficiency of AC stock was 700%



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 Productivity¹ (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-intensive production technology, incremental energy efficiency increase
	Service 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

$$\frac{\Delta \text{Energy productivity}}{\text{Energy productivity}_{t-1}} (\%)$$

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

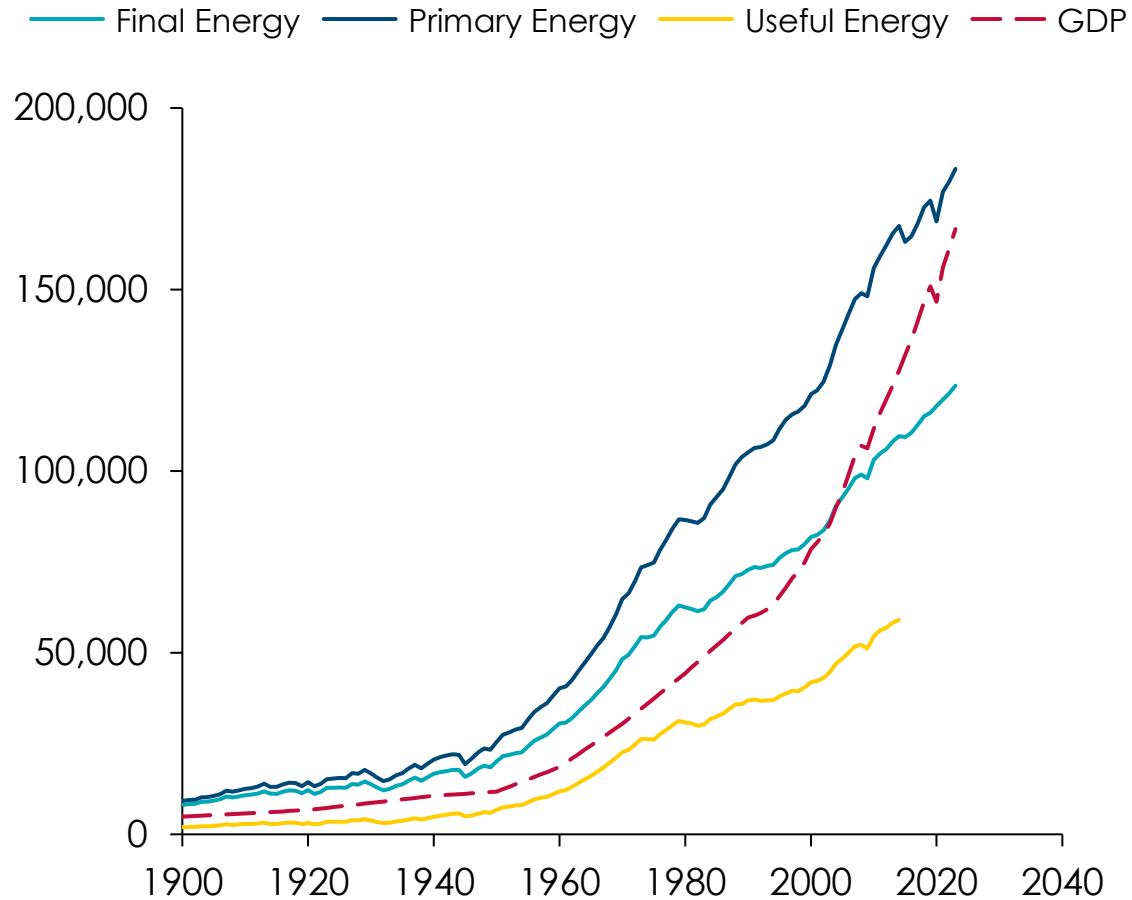
Lower import needs, (i.e. increase energy security) as a less energy intensive pathway would overall require less imported energy



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

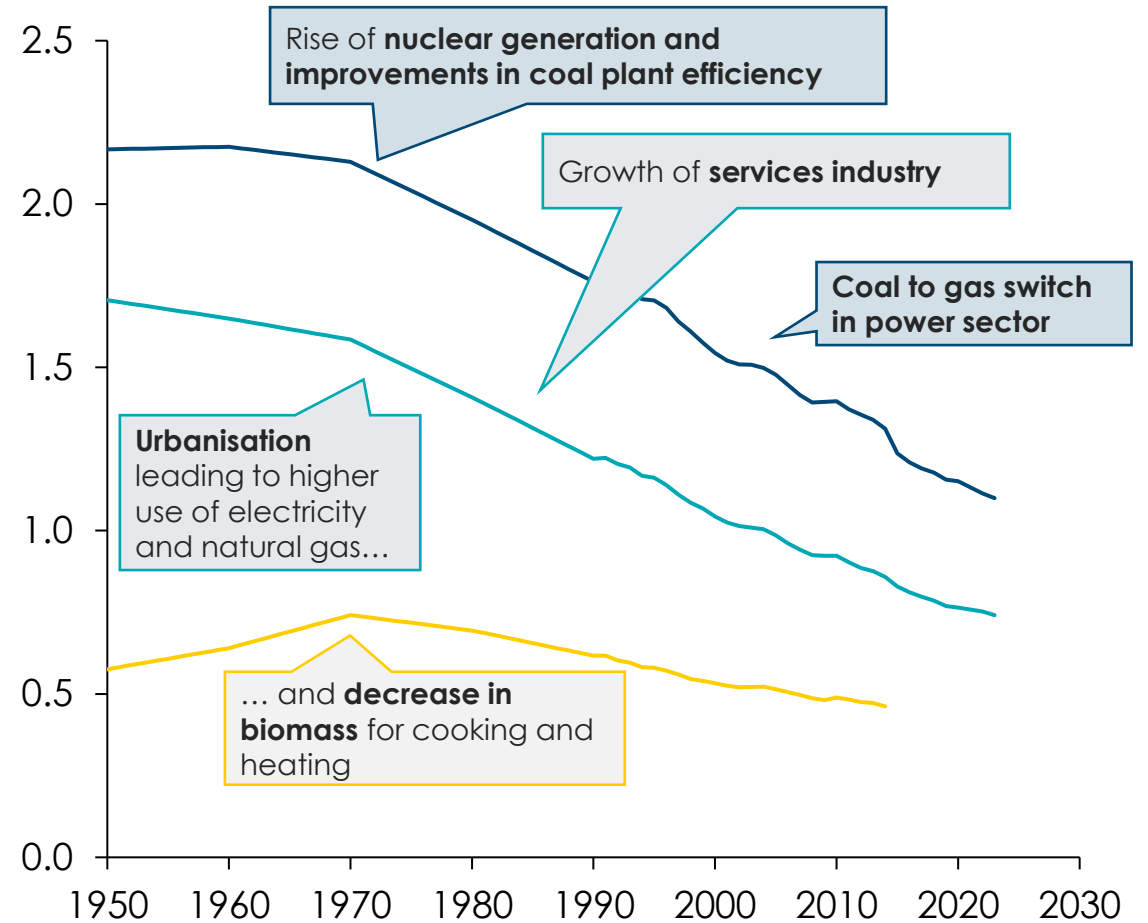
Total GDP vs. Energy Demand, 1900 - 2023

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



Energy Productivity, 1950 - 2023

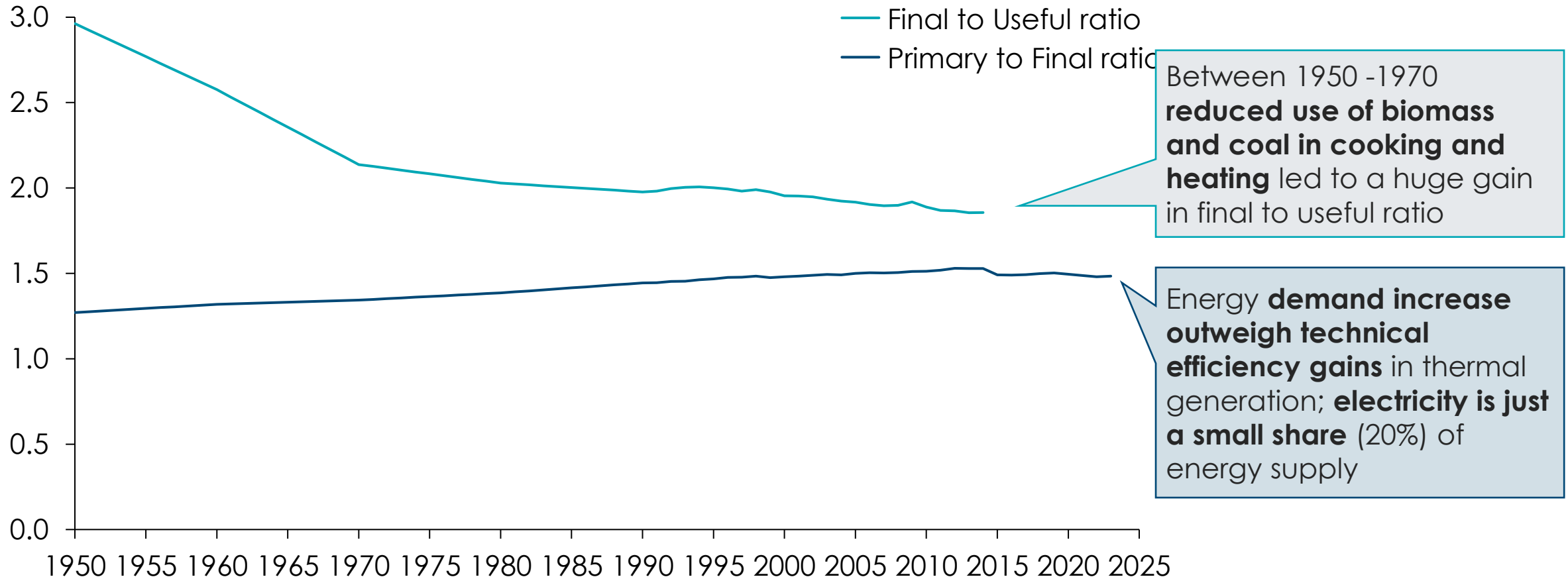
kWh/\$ 2021 PPP



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



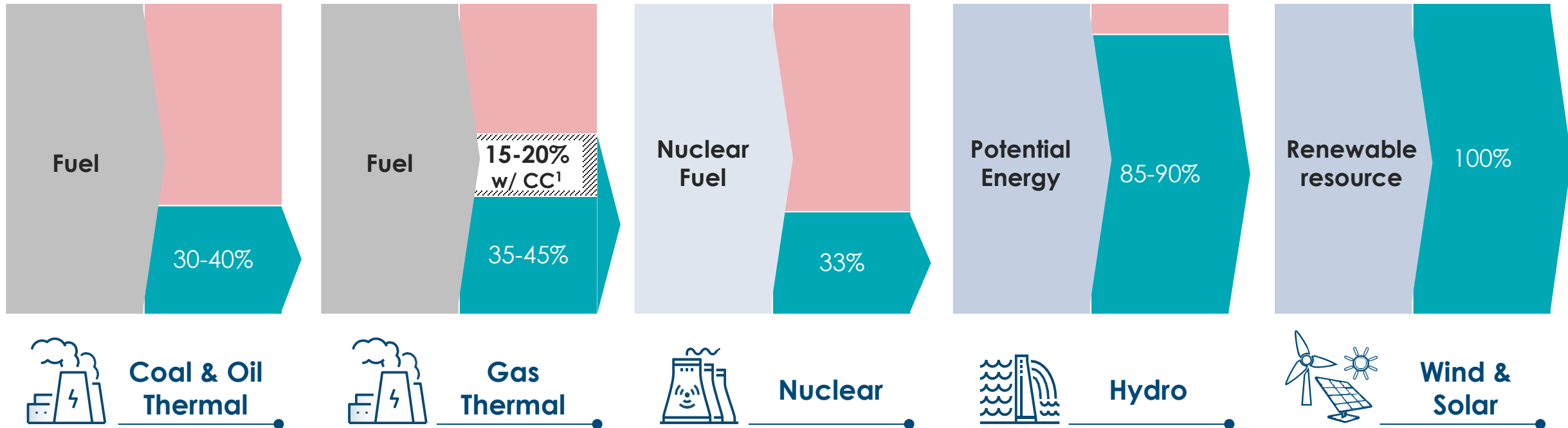
Source: EIA, Our World in Data; IEA (2024), World Energy Outlook 2024; IIASA PFU Dataset

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

Primary

Average electricity generation from fossils vs renewables

Electricity Losses



2-3x more efficient than Fossil



1. Combined Cycle

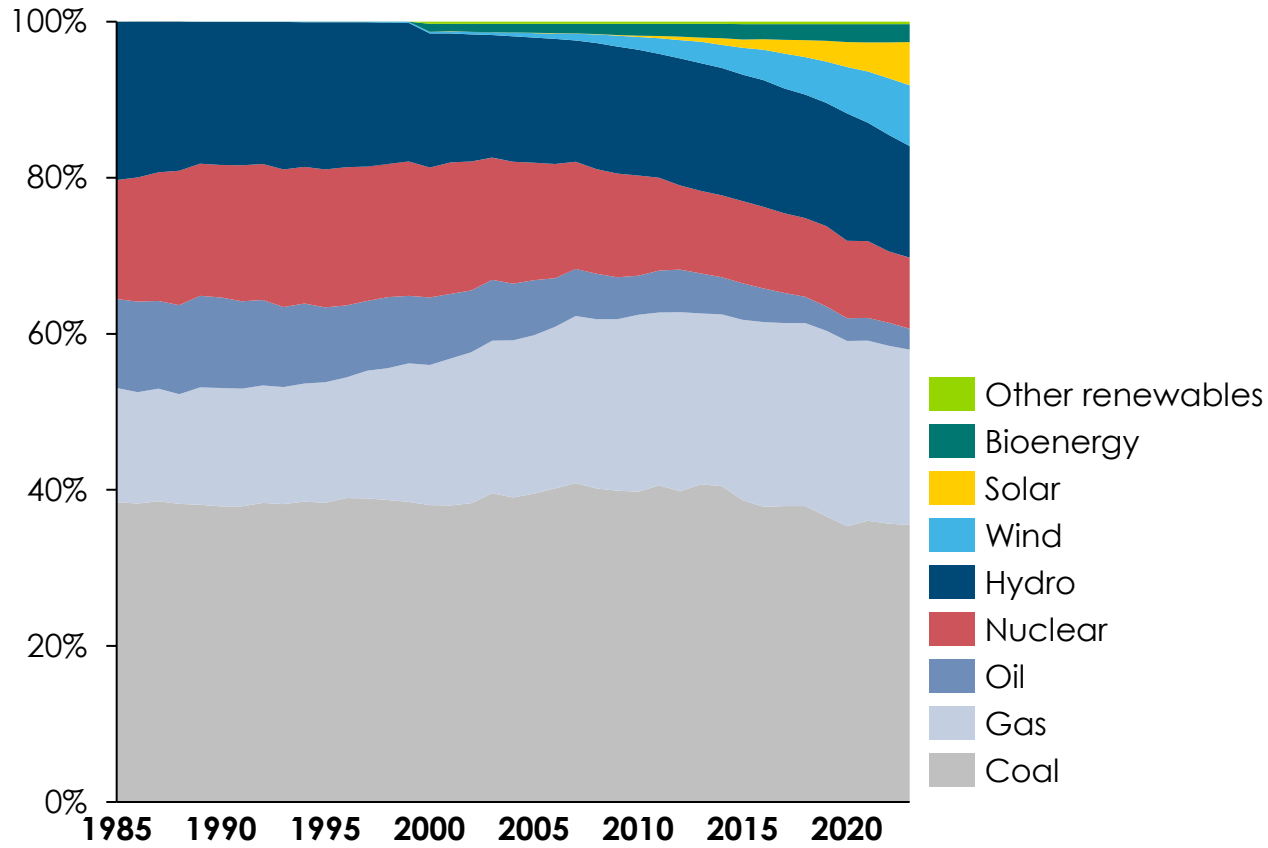
Source: RMI (2024), Clean Tech Revolution; PCI Energy Solutions, IEA (2008) Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels

Despite growth in solar and wind, fossil fuels make 60% of the world's electricity mix – with an average efficiency that is not higher than 50%

Primary

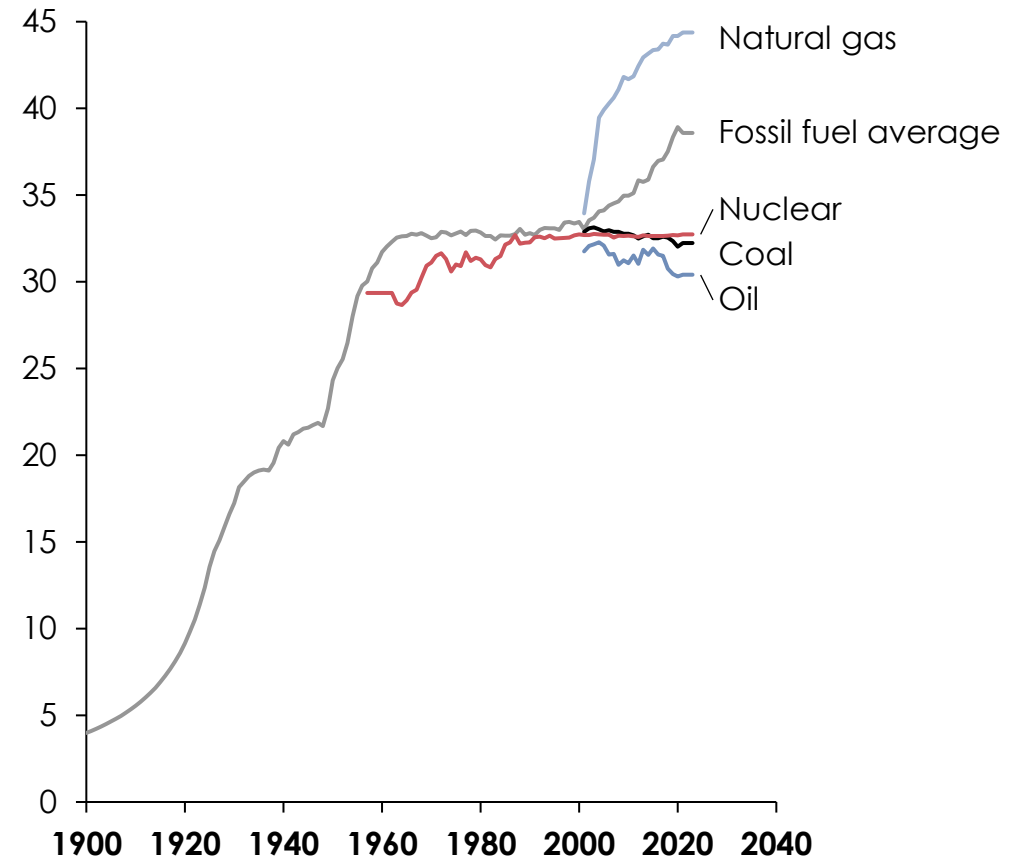
Global Electricity Production mix

%



Thermal power plant efficiency in the US

%



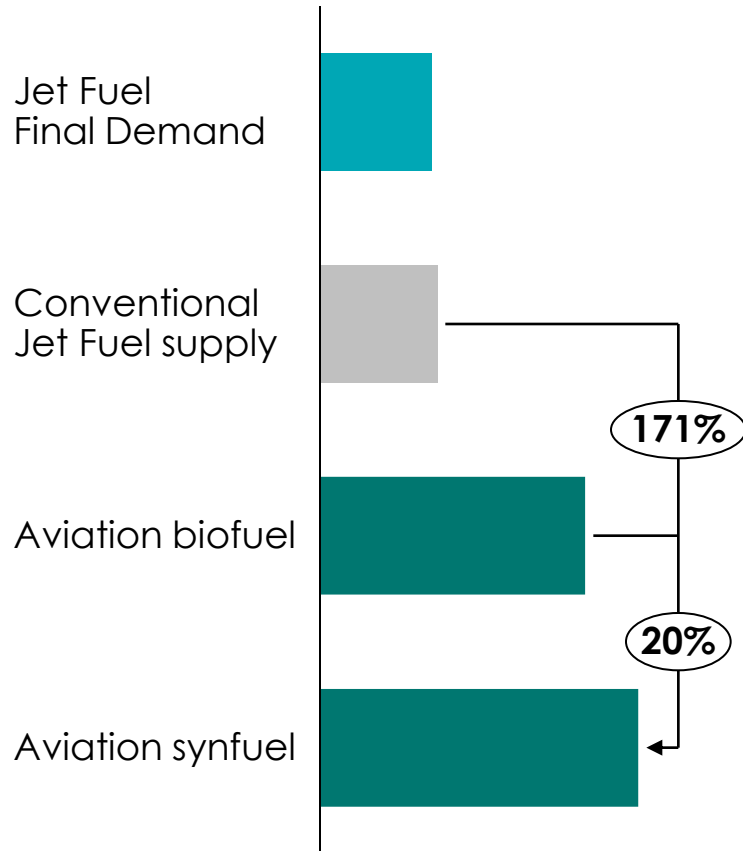
Source: Our World in Data, Ember, Boston University – Visualizing Energy

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

Primary

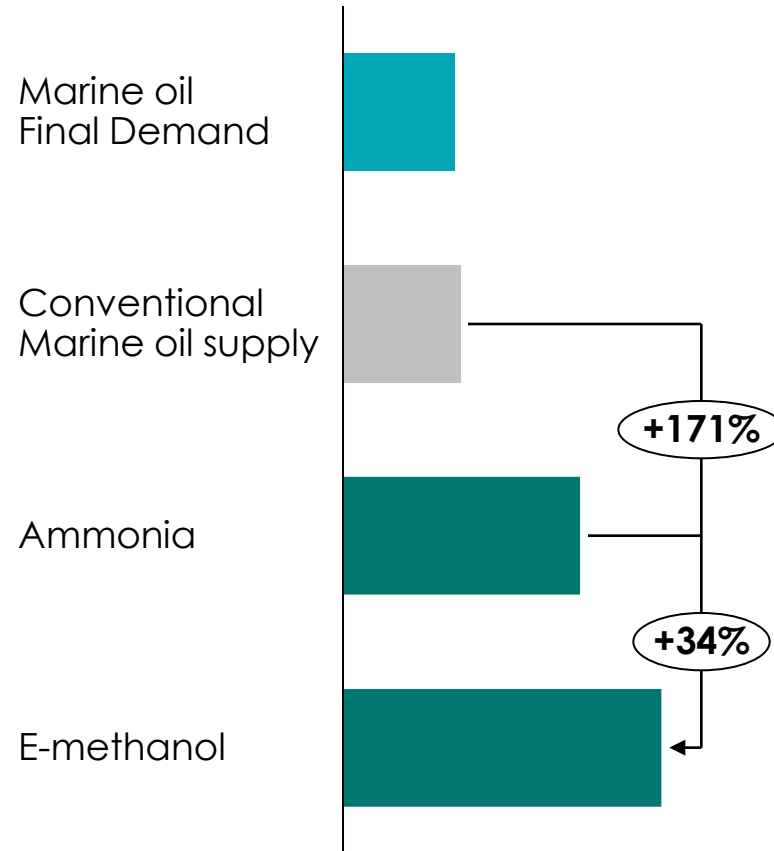
Aviation Case Study

TWh



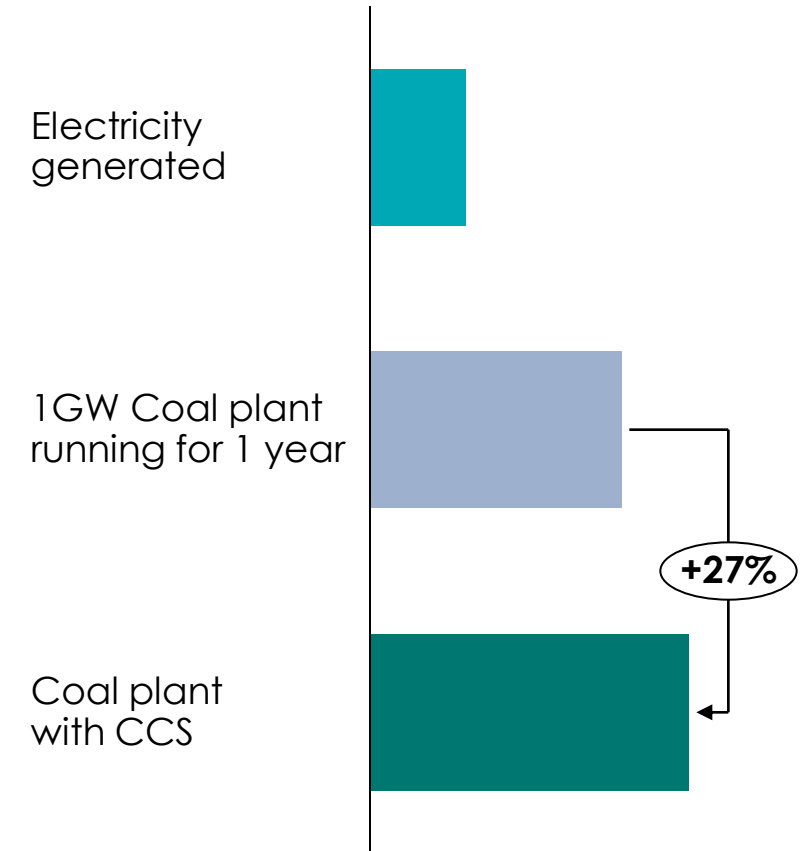
Shipping Case study

TWh



CCS Case study

TWh



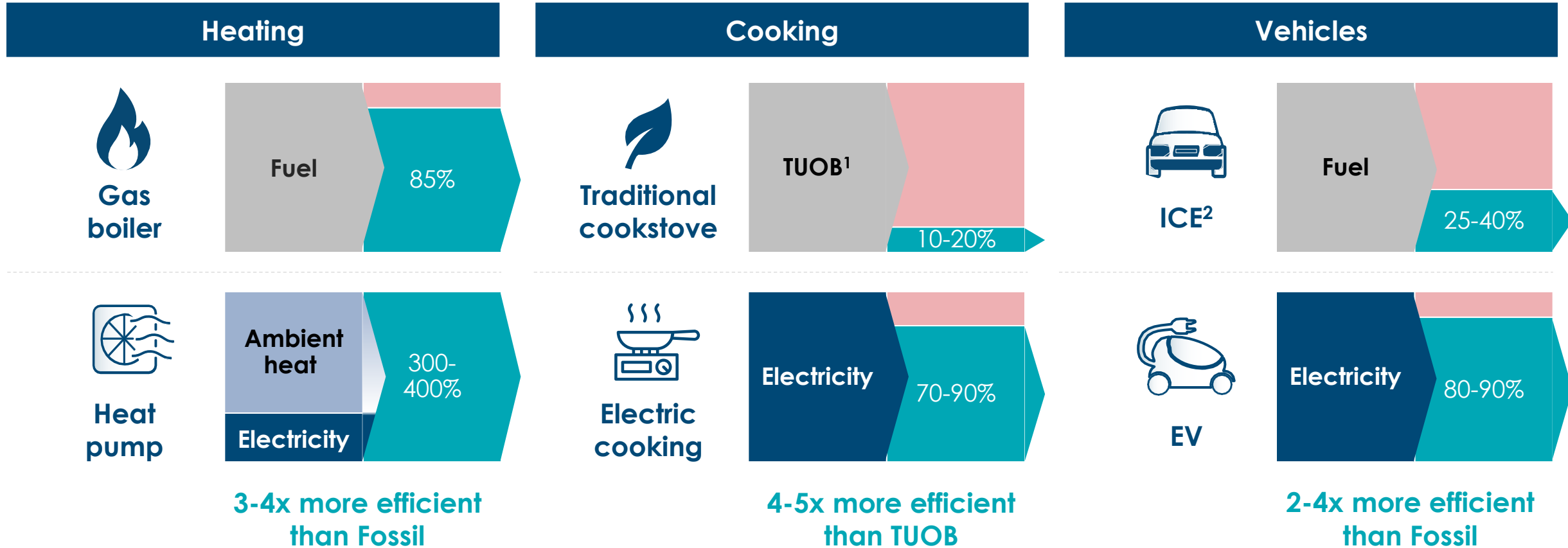
Sources: Mission Possible Partnership (2023) Aviation Sector Transition Strategy, World Resources Institute (2022) 6 Things you Know About Direct Air Capture

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



Average efficiency from appliances and vehicles incumbent fuel vs electric

Useful Energy Losses

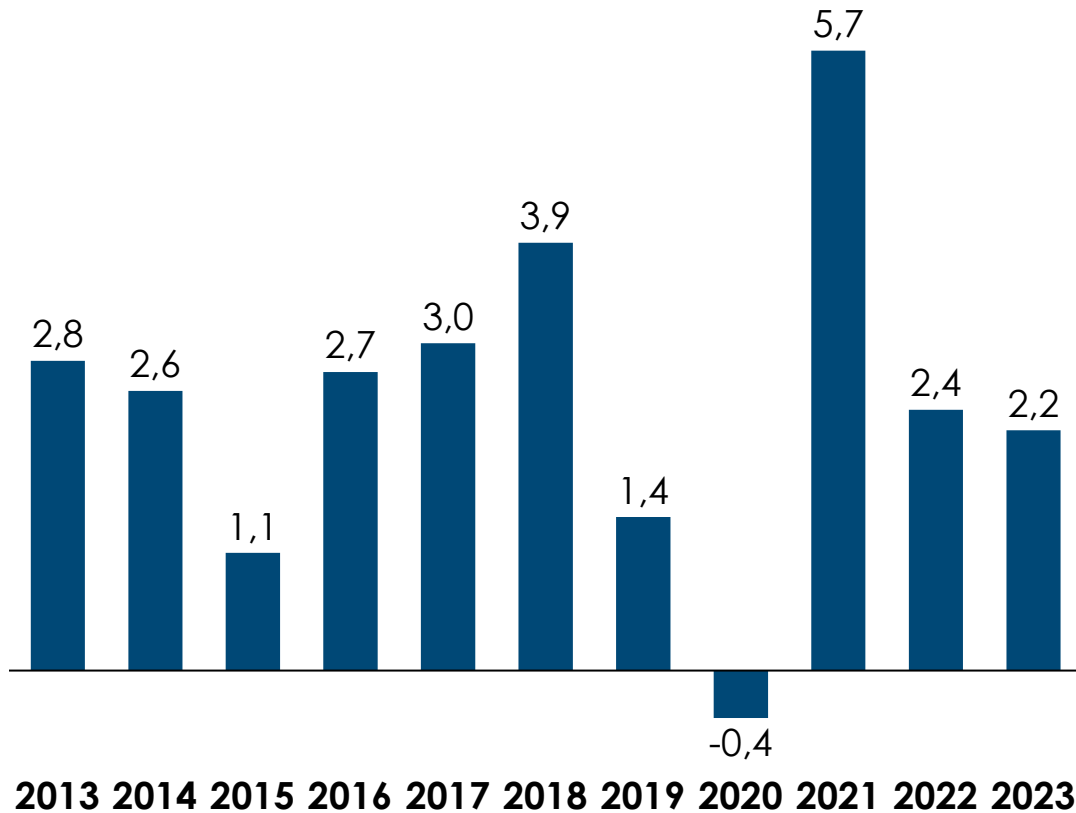


1. Traditional use of biomass; 2. Internal combustion engine
Source: RMI (2024), *Clean Tech Revolution*.

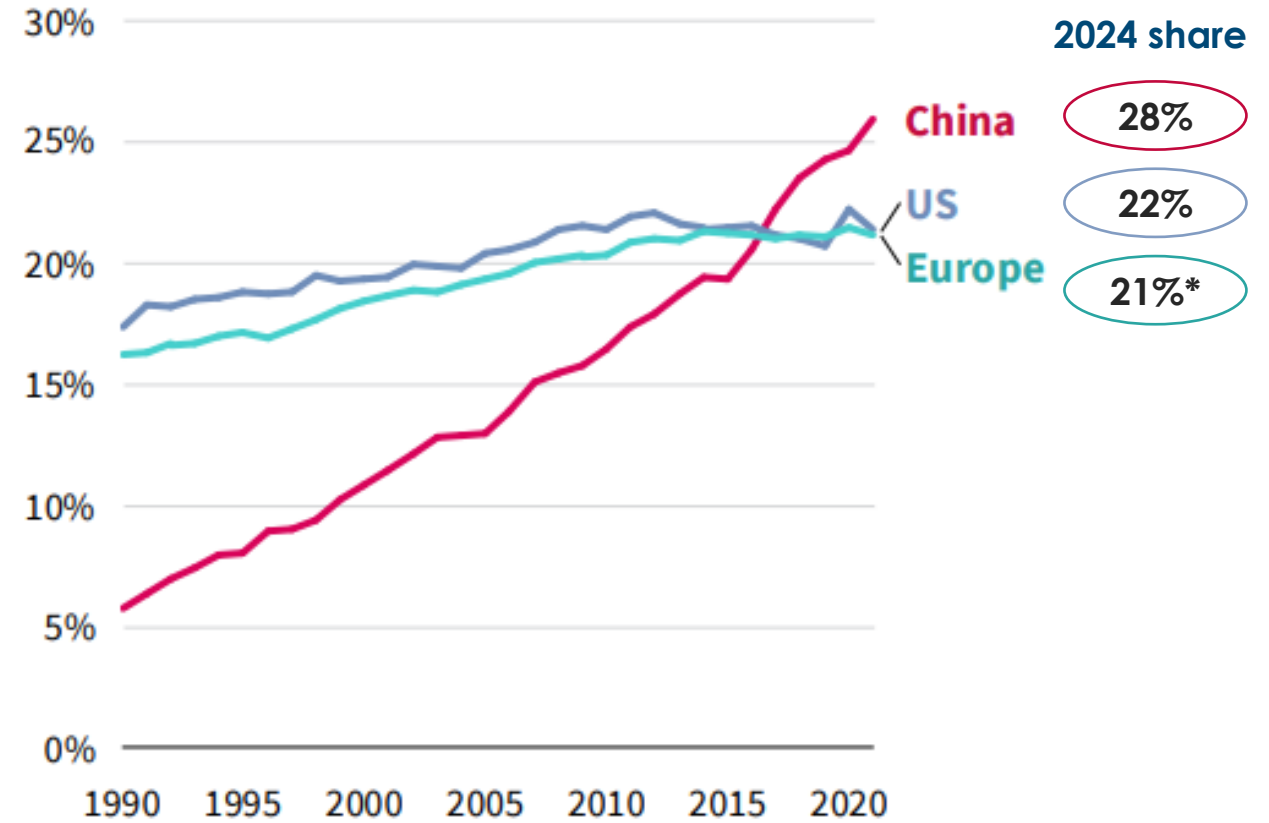
Electricity use has grown globally over the last decade, led by electrification in China



Annual electricity growth rate
%



Electricity share of total final energy consumption
%



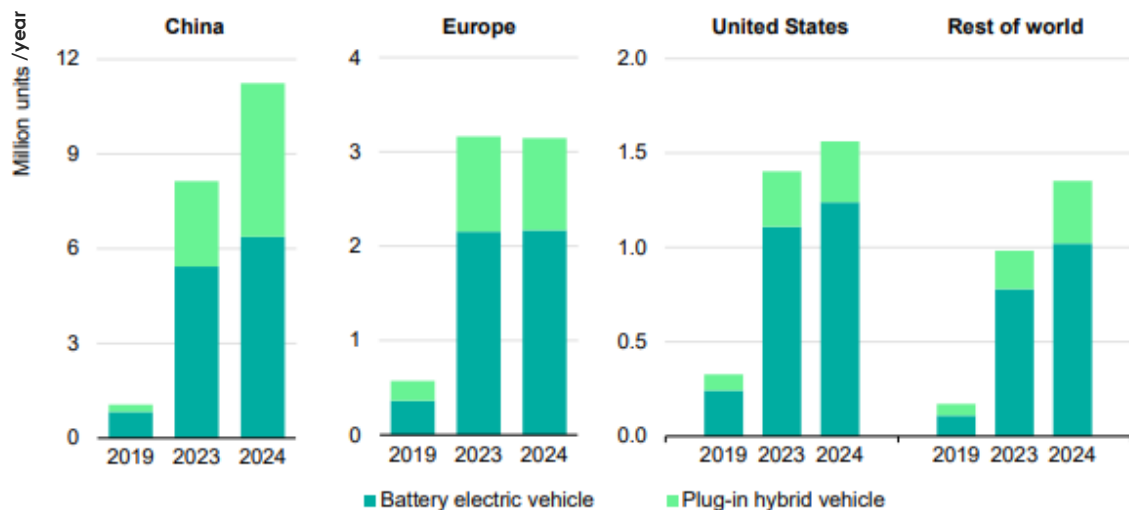
* For European Union

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

Key technologies for higher energy productivity, such as EVs and heat pumps, are picking-up globally: adoption increased from 2019 to 2024

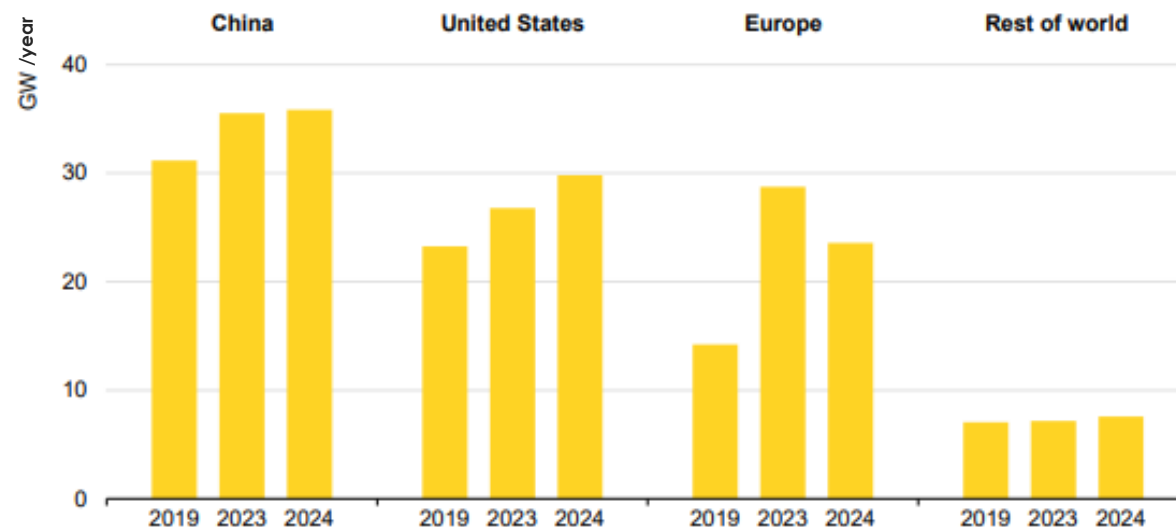
Final

Electric car sales in selected car markets



IEA. CC BY 4.0.

Heat pump sales for selected regions



EV global sales grew by 80% in 2024:

- China leads EVs sales, supported by a trade-in scheme to encourage consumer to replace older cars
- 10% growth in sales in the US supported by EV tax credits
- Slight fall in EU sales after removal of German subsidies
- Surge in emerging countries: Brazil and Indonesia saw growth of 140% and 190%

Heat Pumps sales fell by 1% in 2024:

- Stagnation of Chinese demand
- 15% increase in sales in the US, surpassing by 30% sales in natural gas boilers
- Decline in EU sales driven by high prices of electricity compared to gas, especially in Germany and France, and a slowdown in the construction sector`

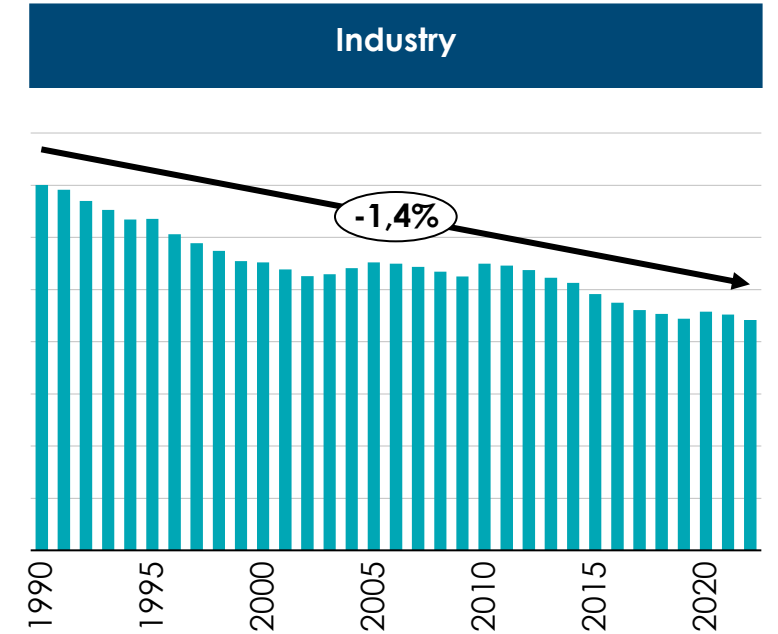
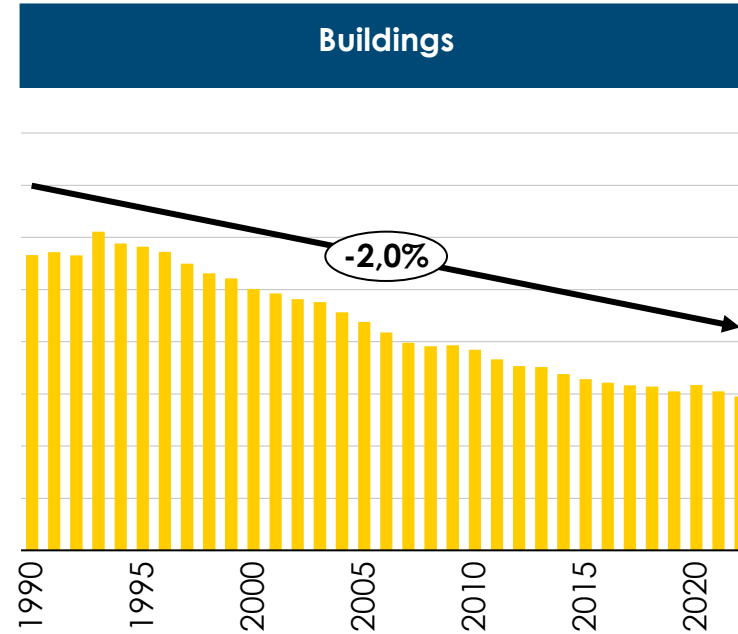
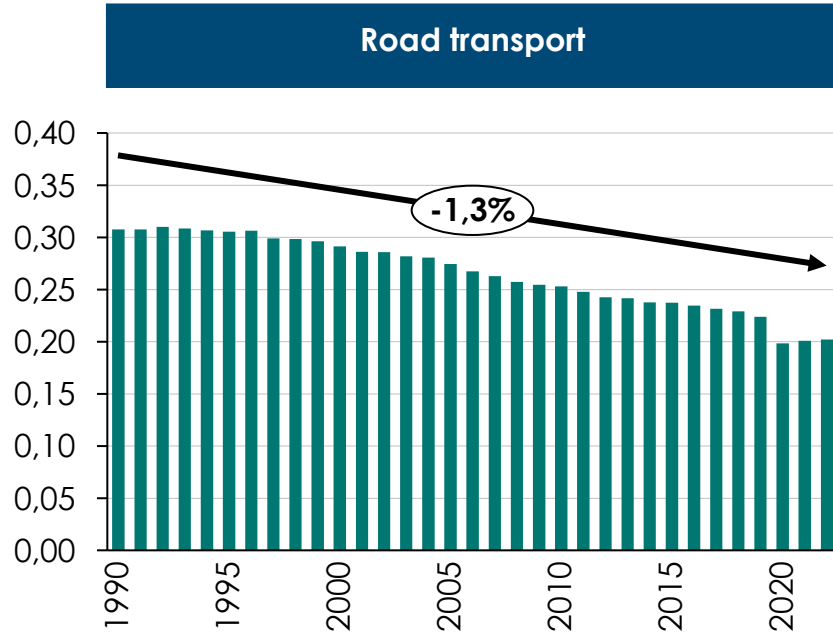


Source: IEA (2025) Global Energy Review

Final energy demand intensity has gradually improved across all sectors

Final

Global final energy demand intensity
Kwh/GDP \$ 2021 PPP



- **Improved efficiency in ICE engines and most recently electrification**, mainly in China – even if partially offset by larger, heavier SUV models

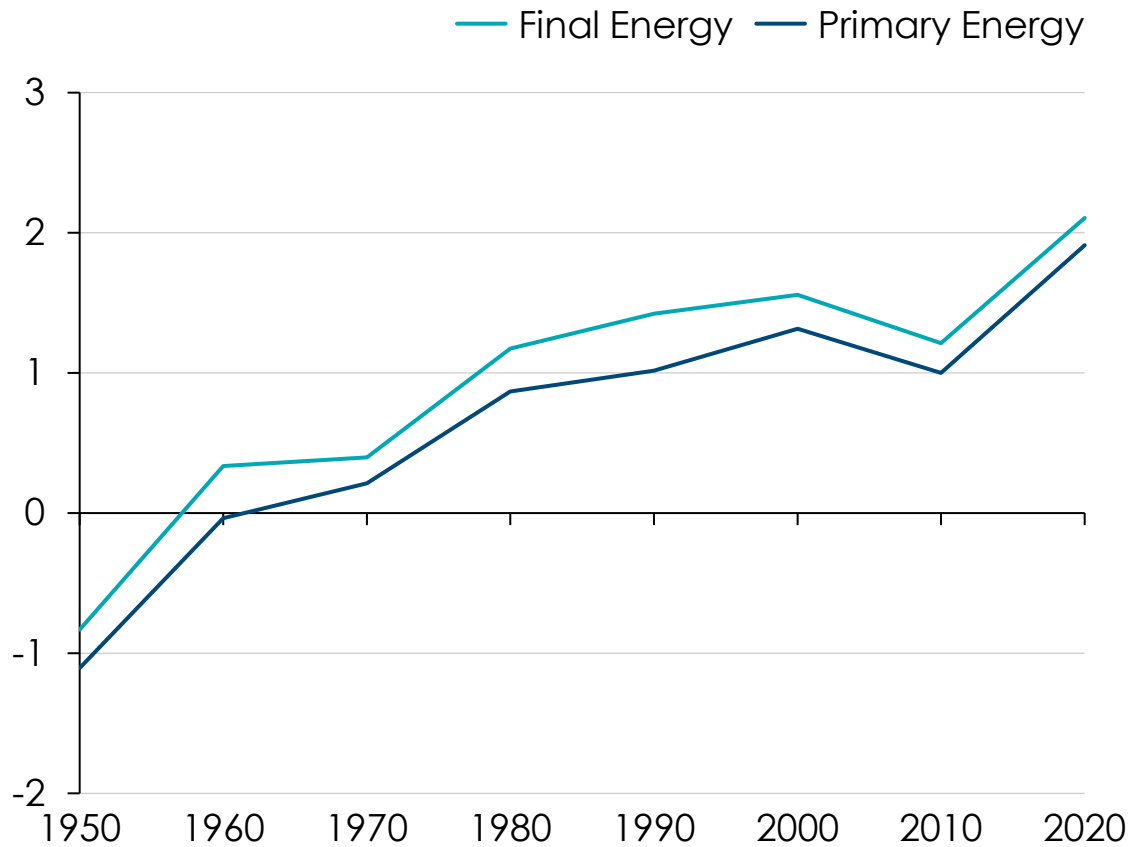
- **Appliance improvements** despite rises in use
- **Warmer winters** decreasing heating demand in developing economies

- **Technical improvements** in manufacturing processes (e.g lean manufacturing cutting on waste)
- Increase in **service economic activity** over industry

Steady progress in energy intensity in the long-run, however recent progress not entirely recovered from the effects of the pandemic

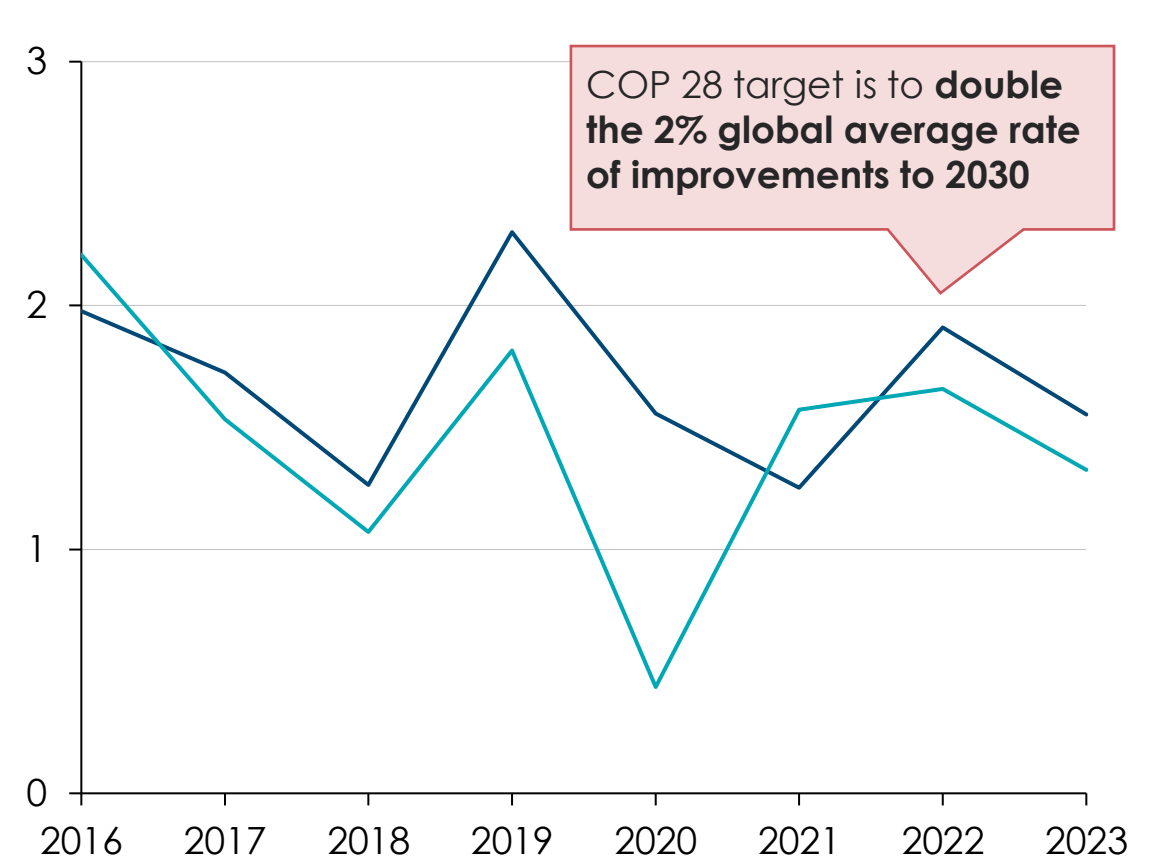
10 Year CAGR Energy productivity improvement (1940-2020)

%



YoY Energy productivity improvement (2016-2023)

%



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

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

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

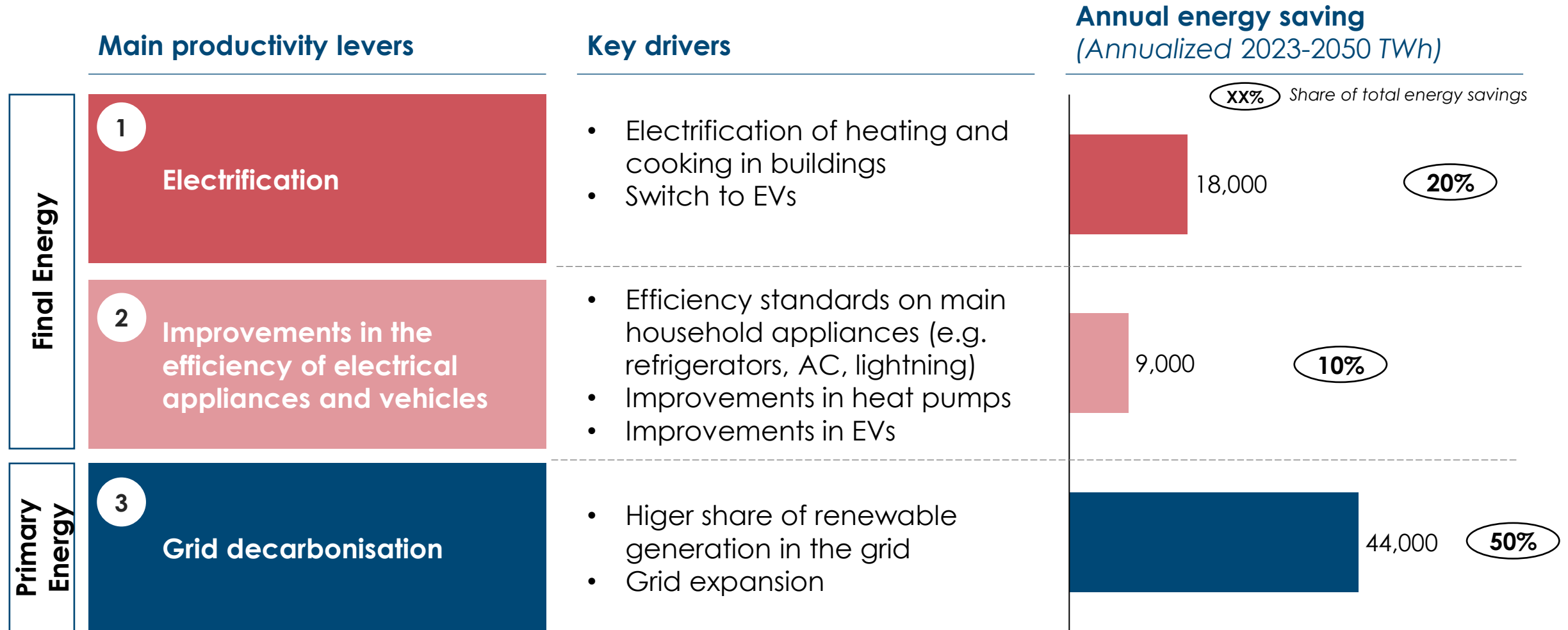
Closing the gap between primary and final energy demand

=

Reducing energy losses in the **power system**



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



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

=

Reducing energy losses in the **power system**

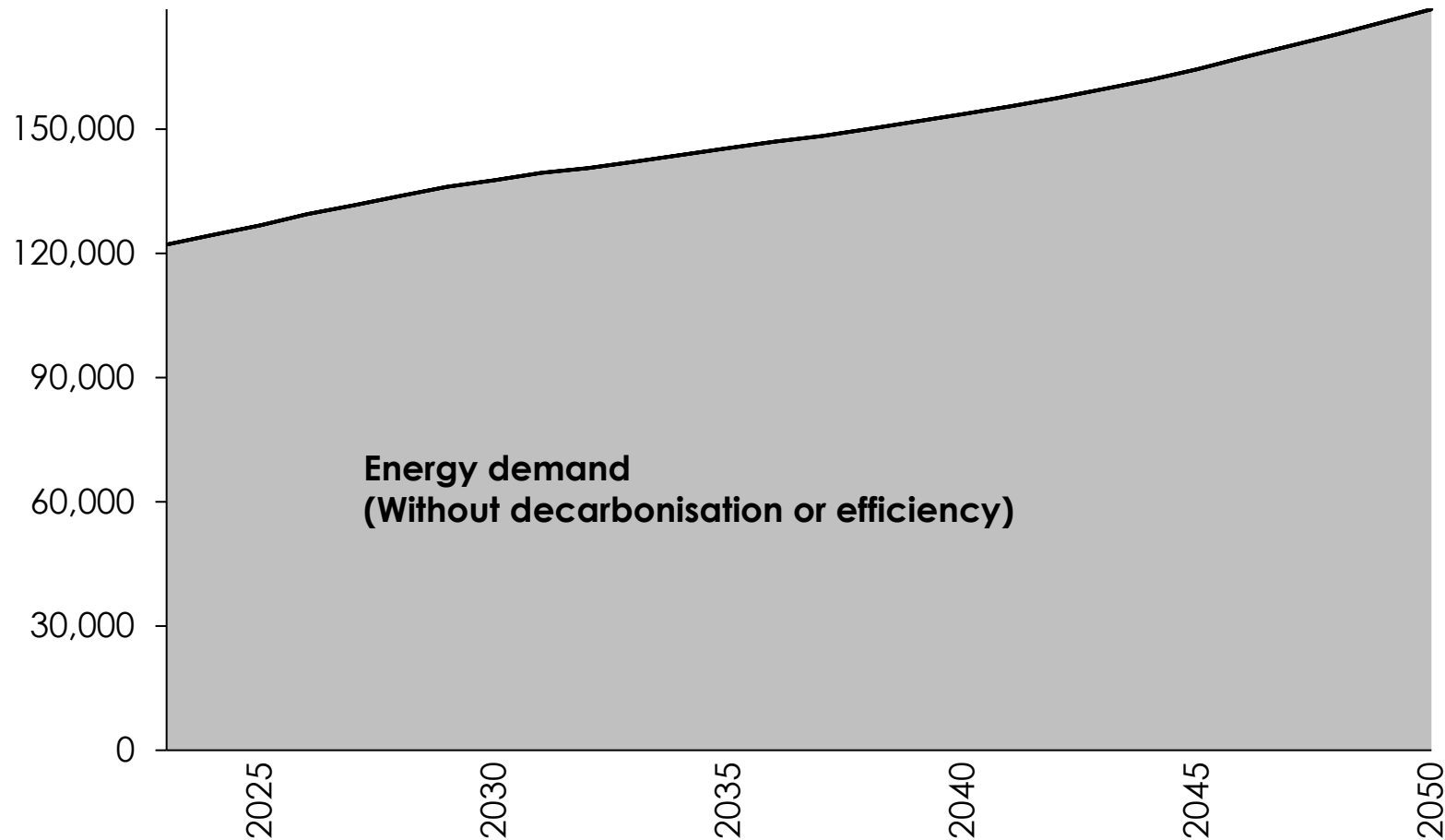


Baseline. Without any decarbonisation or productivity levers, rising energy demand

Final Energy demand vs. Productivity levers

TWh

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



**Energy demand
(Without decarbonisation or efficiency)**

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.



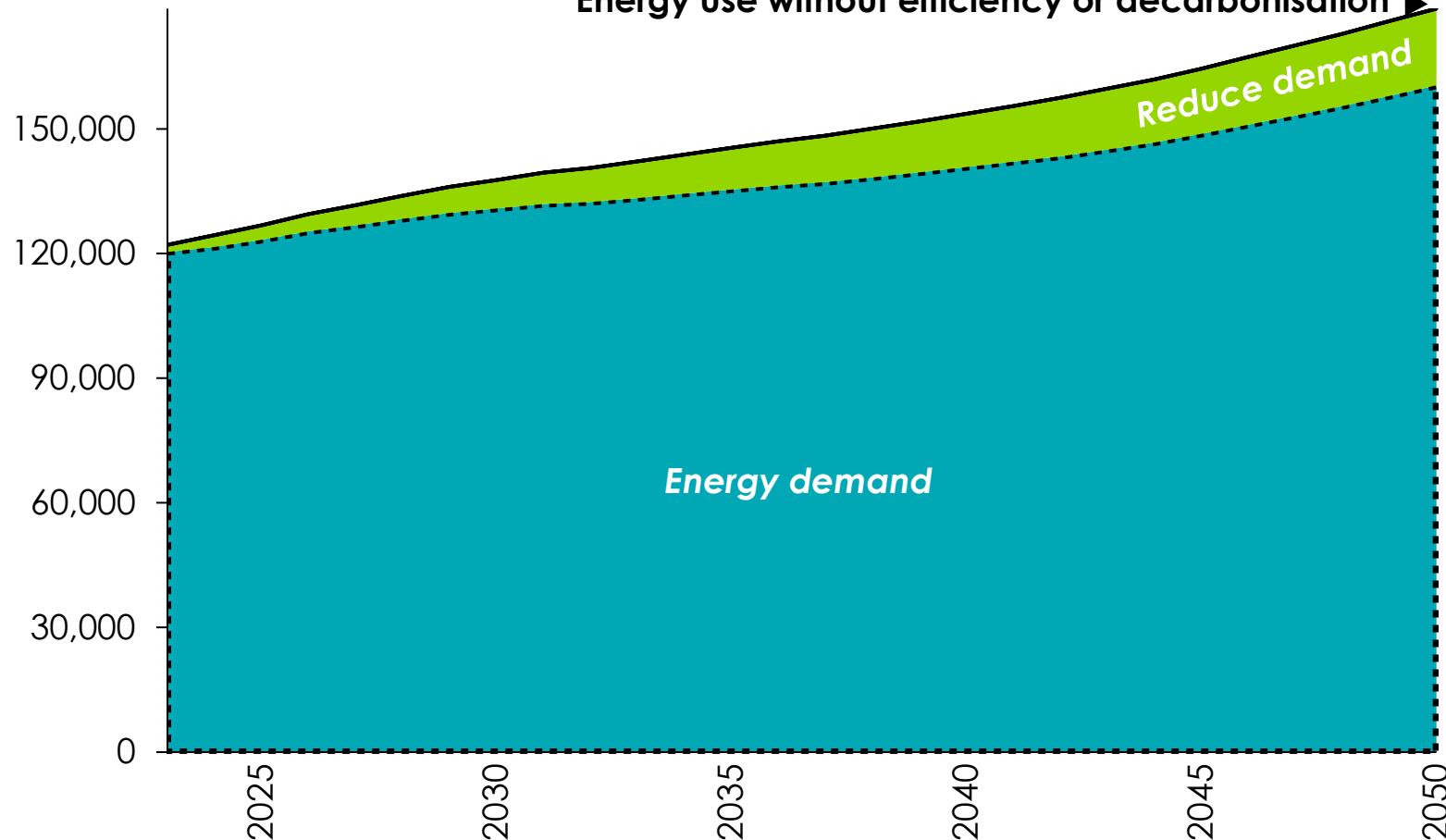
Reduce demand. 7% less energy could come from behavioural shifts and material efficiency

Final Energy demand vs. Productivity levers

TWh

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

Energy use without efficiency or decarbonisation



- 10%

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

Key actions



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.

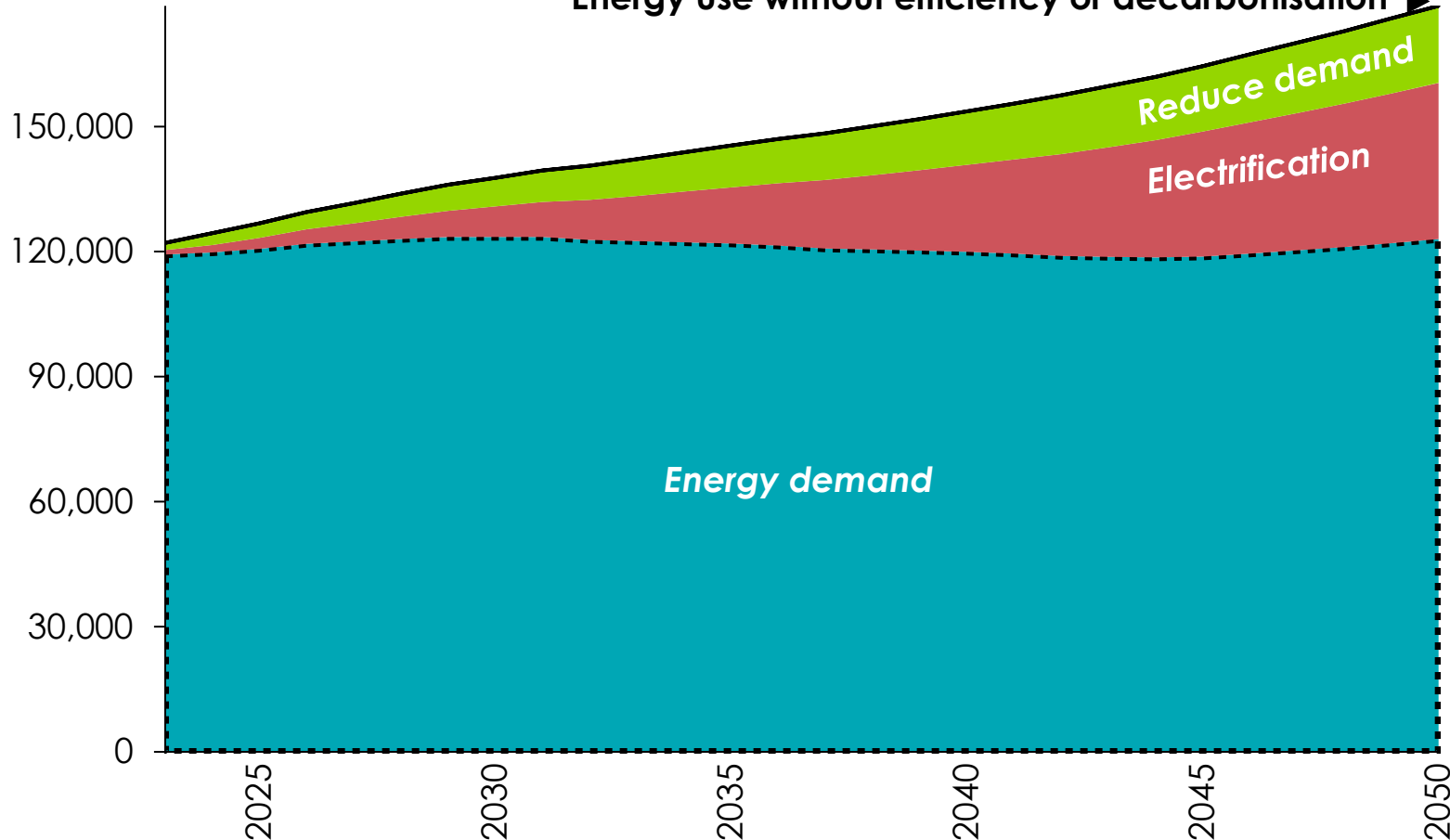
Electrification = efficiency. ~30% less energy can be consumed with electrification and demand reduction combined

Final Energy demand vs. Productivity levers

TWh

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

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)

- 10%

Electrification: switching to electric vehicles, electric heating and cooking

- 21%

-31%



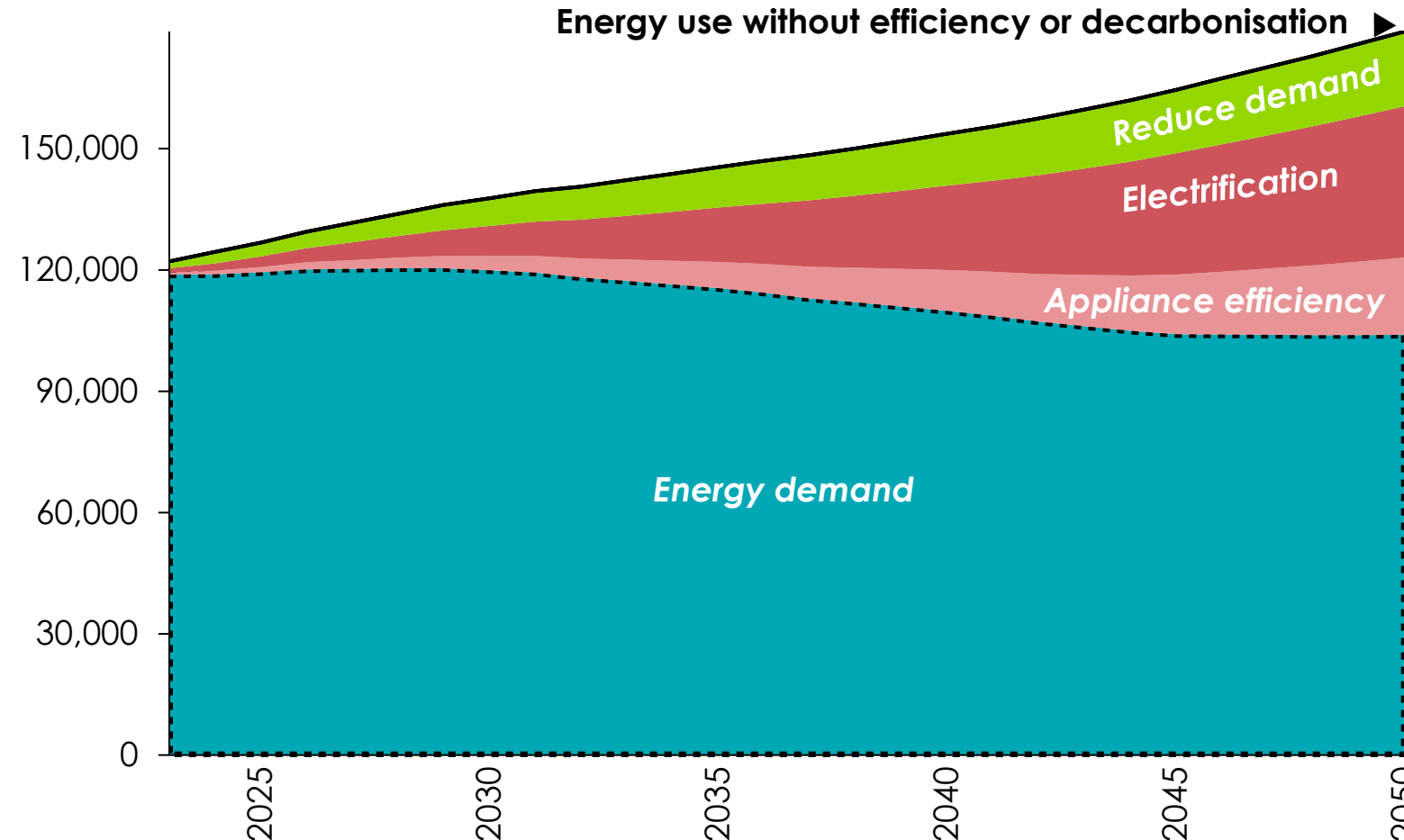
Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq analysis for ETC.

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

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

Detailed next

- 10%

- 21%

- 11%

-42%



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.

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

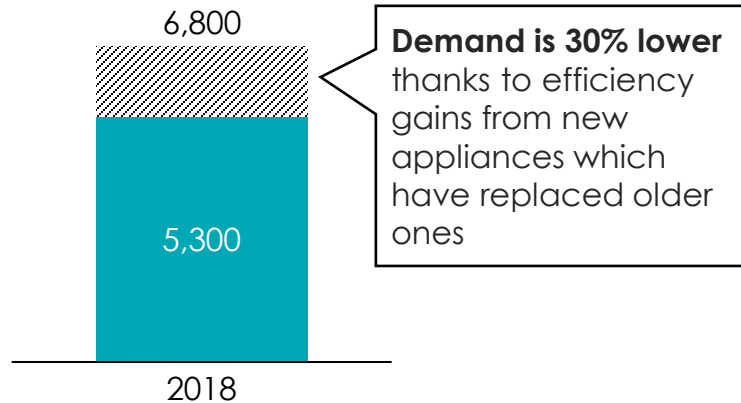
Improving efficiency of key electrical appliances: AC, heat pumps, EVs, lighting and other home appliances

Historical

Appliances

Impact of stock turn-over on appliances final energy demand

TWh



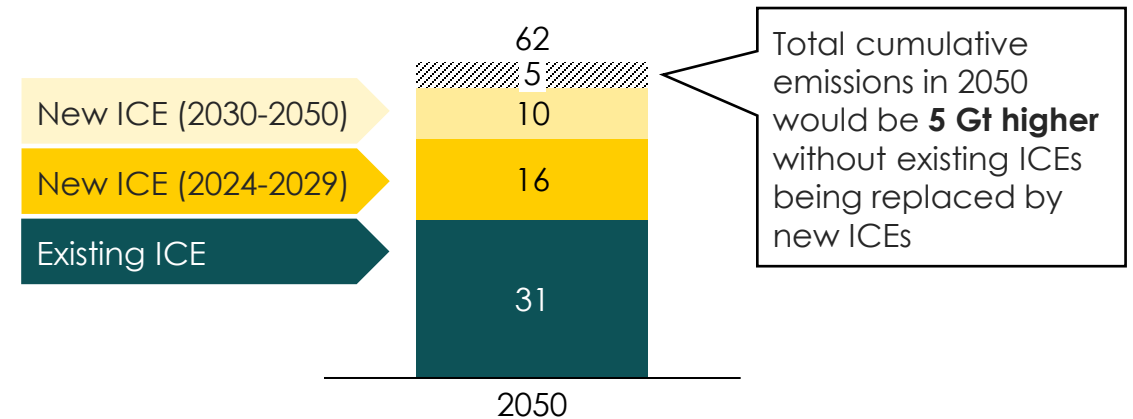
Continuous efforts in **Energy Efficiency Standards and Labelling Programmes (EES&L)** resulted in a **30% annual decrease in appliances energy demand** relative to BAU

Outlook

Road transport

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

2023-2050 Gt CO2



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.

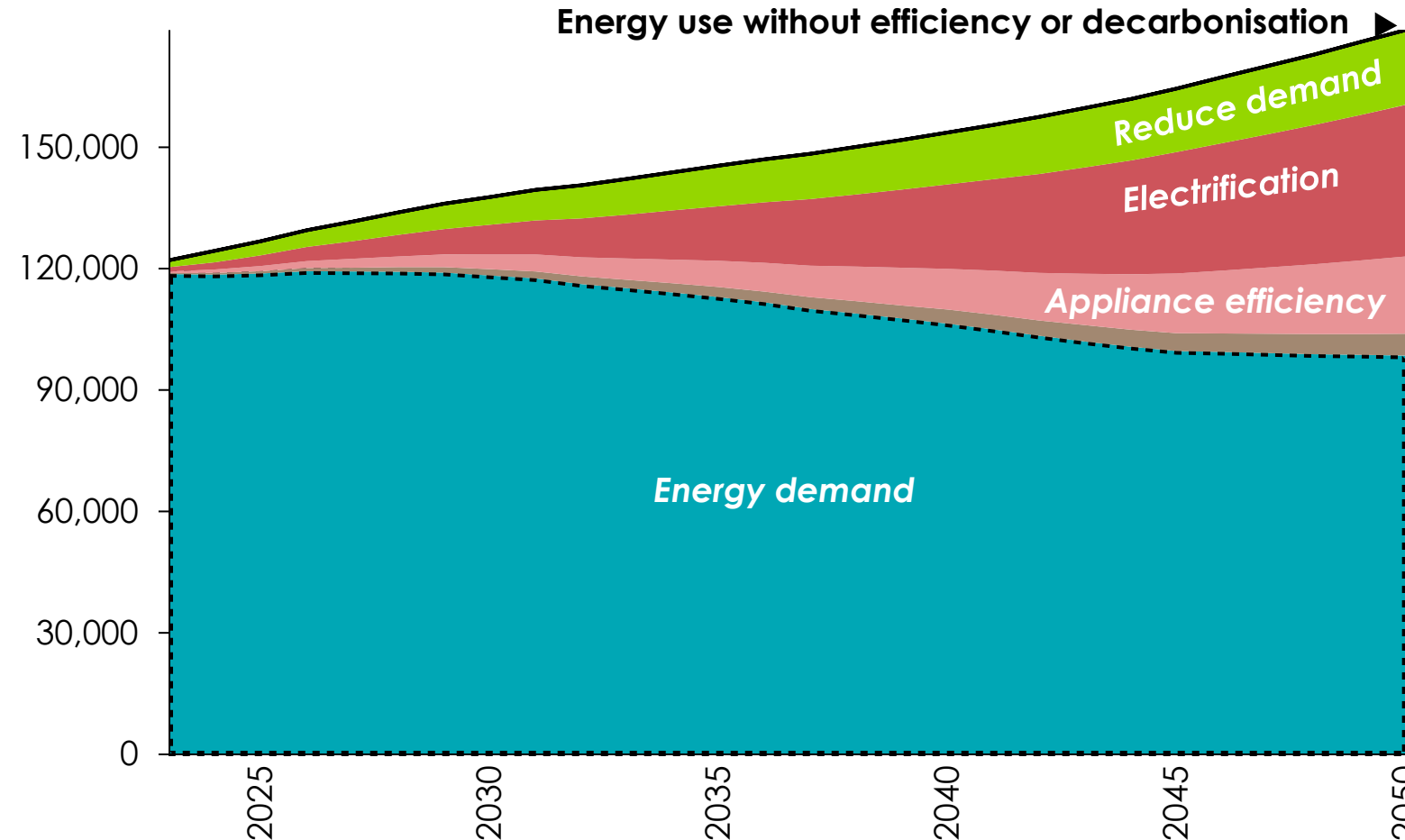
Note: ICE means Internal Combustion Engine Vehicles, EV means Electric Vehicles. We consider that the combustion of a barrel of oil equivalent results ~405 kg CO₂. Source: Systemiq analysis for the ETC; ETC (2023), *Fossil Fuels in Transition: Committing to the phase-down of all fossil fuels*; IEA (2018) *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.

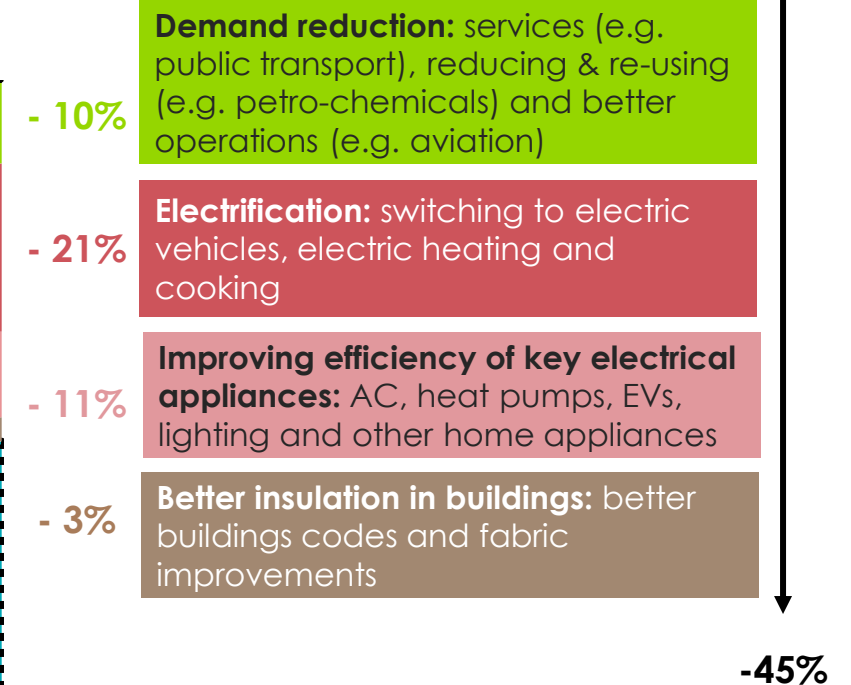
Final Energy demand vs. Productivity levers

TWh

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



Key actions



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.

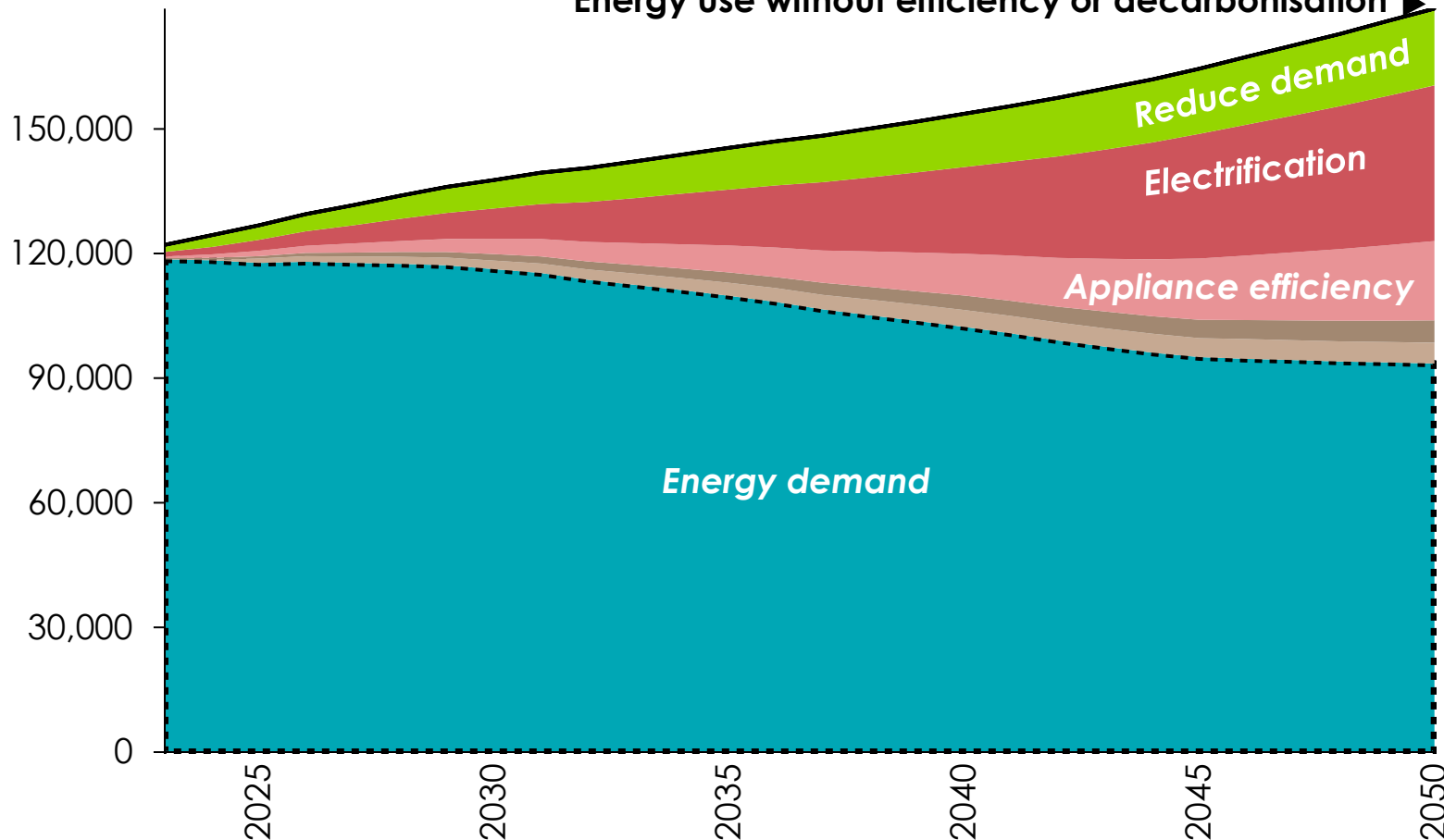
Overall, ~50% less energy can be consumed, with all efficiency levers combined

Final Energy demand vs. Productivity levers

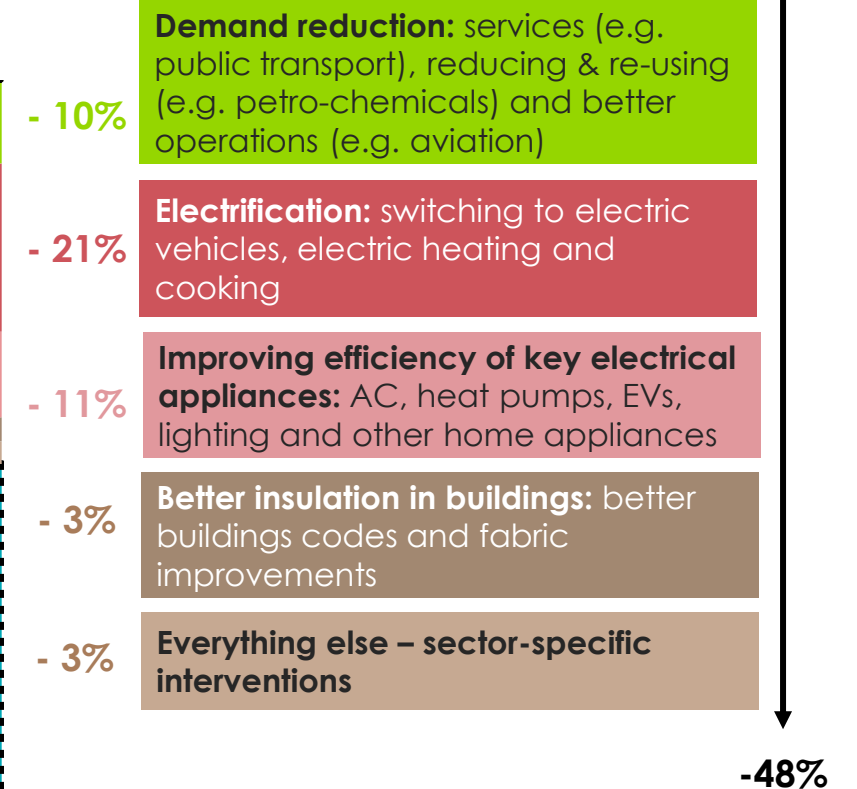
TWh

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

Energy use without efficiency or decarbonisation



Key actions



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.

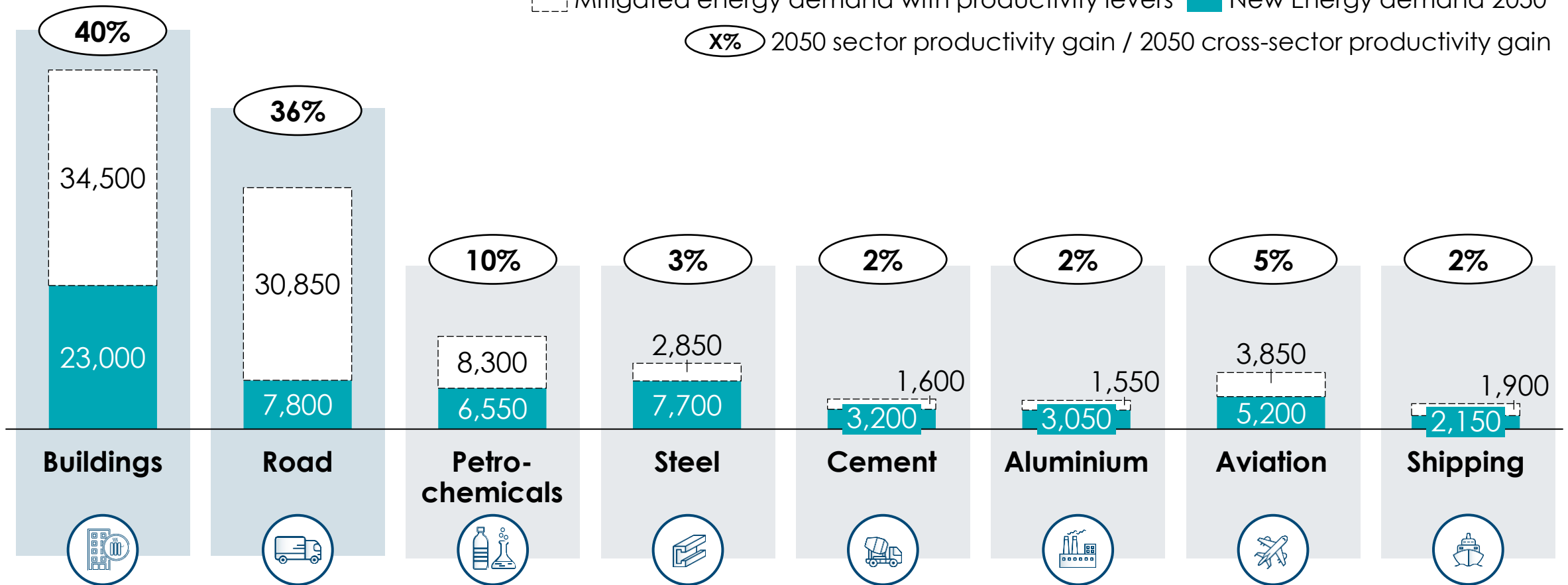
Buildings and road transportation hold the biggest opportunity: together they hold 75% of the potential productivity gain in final energy demand

Final energy demand in 2050

TWh

 Mitigated energy demand with productivity levers
 New Energy demand 2050

X% 2050 sector productivity gain / 2050 cross-sector productivity gain



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.

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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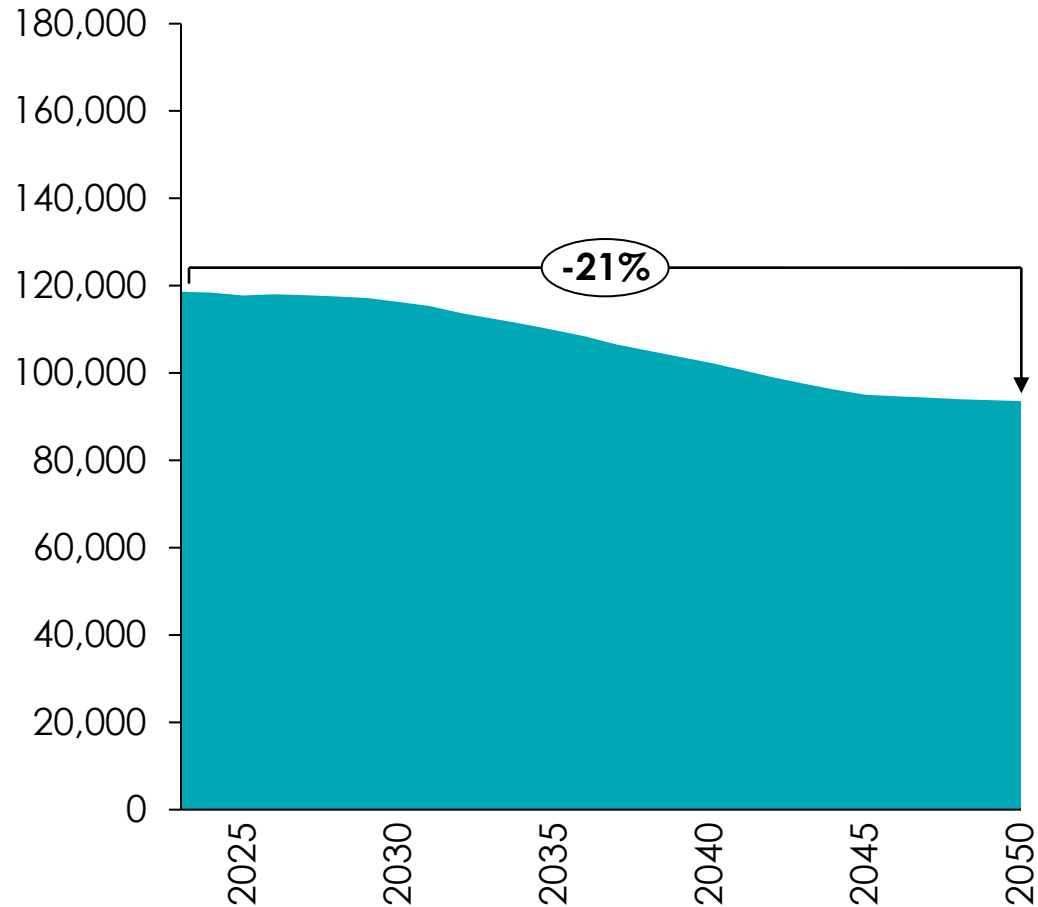
Reducing energy losses in the **power system**



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

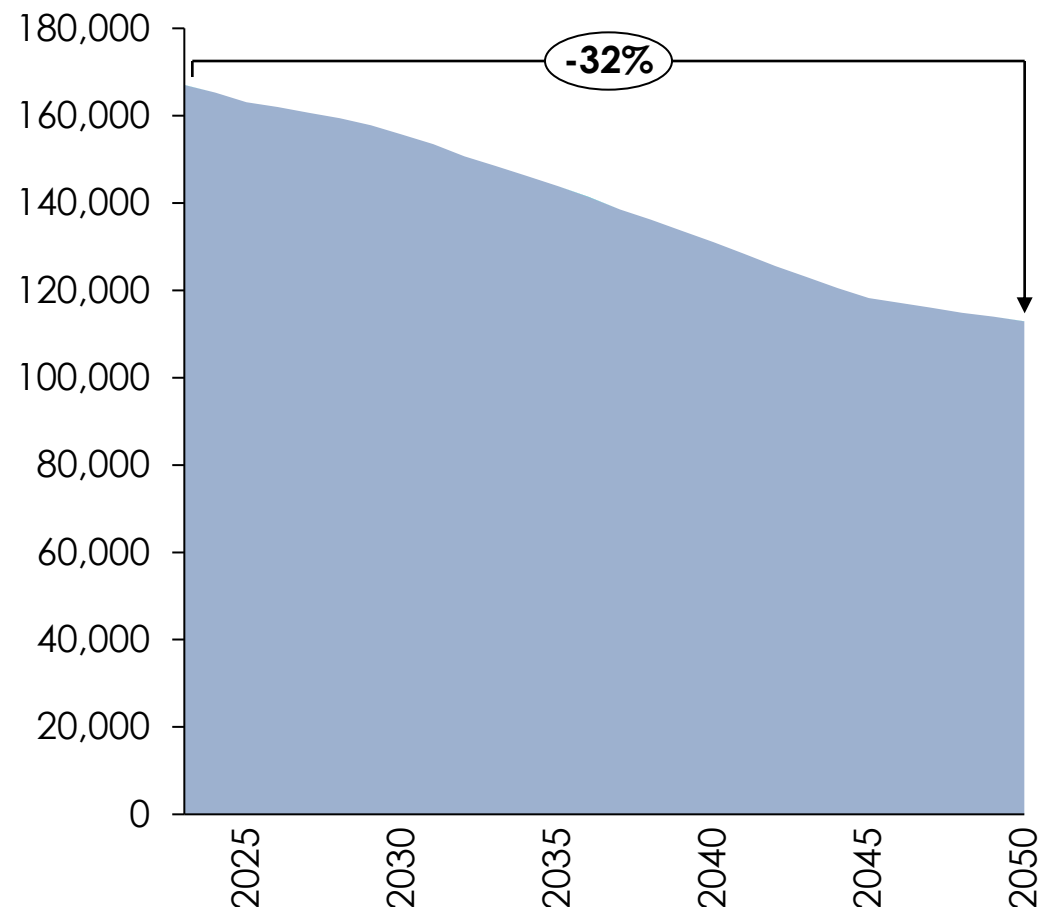
NZ Final Energy with Productivity levers

TWh



NZ Primary Energy demand with Productivity levers

TWh



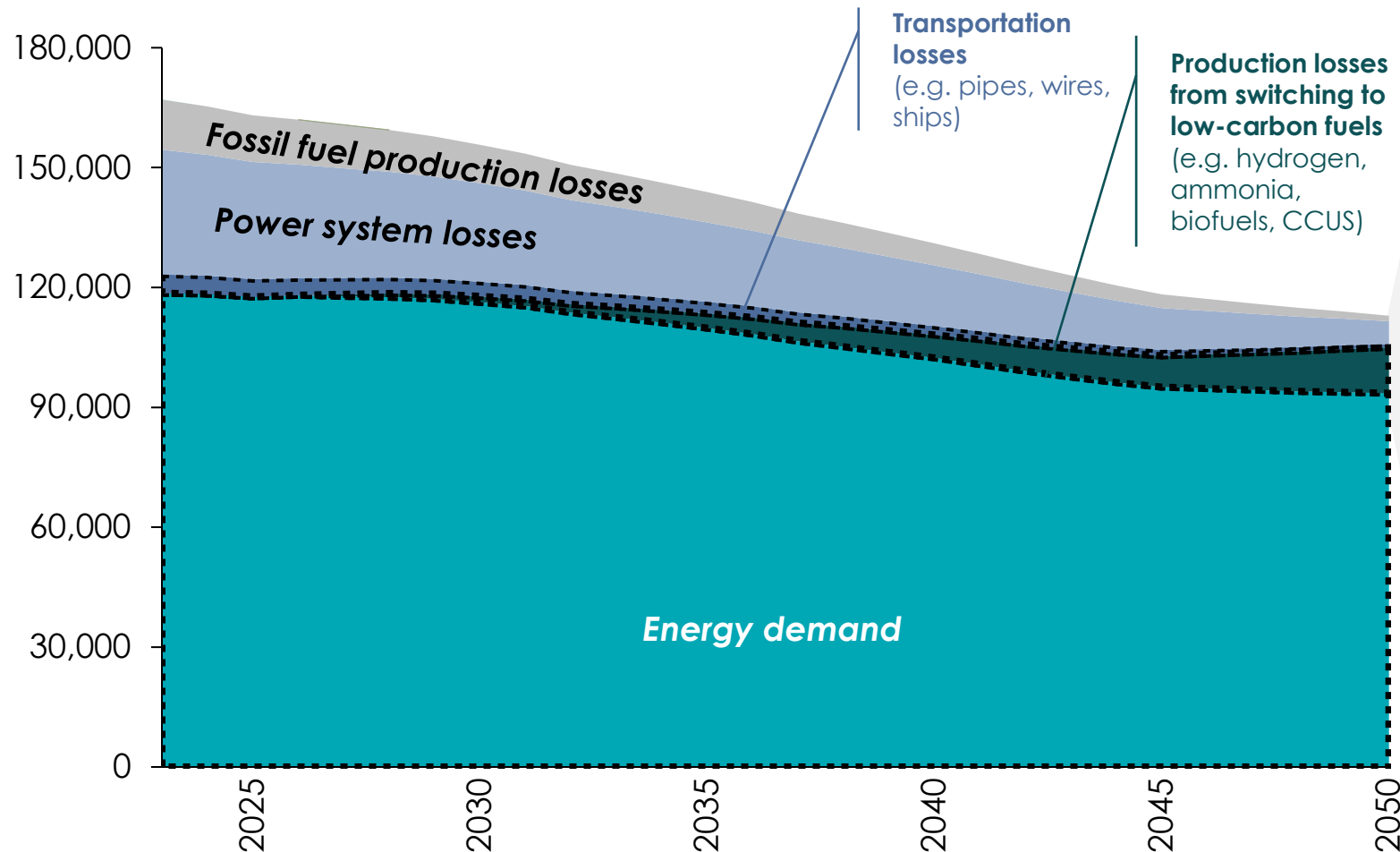
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Growth of the power system as fossil consumption phases down, along with power decarbonisation, is main driver to reduce primary energy demand

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; RMI (2024) The Incredible Inefficiency of the Fossil Energy System; Systemiq analysis for ETC.

Sectoral deep-dives



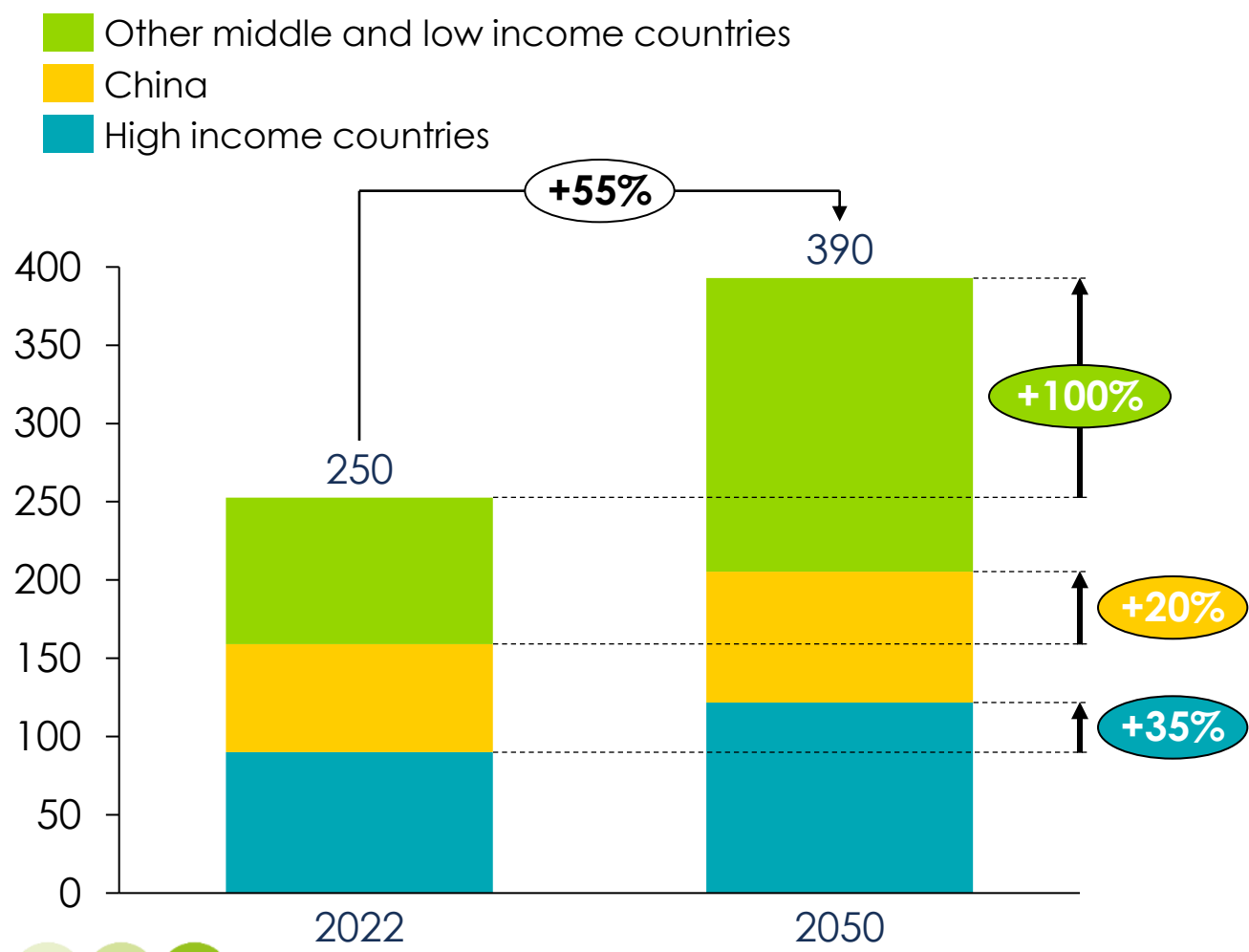
Buildings



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

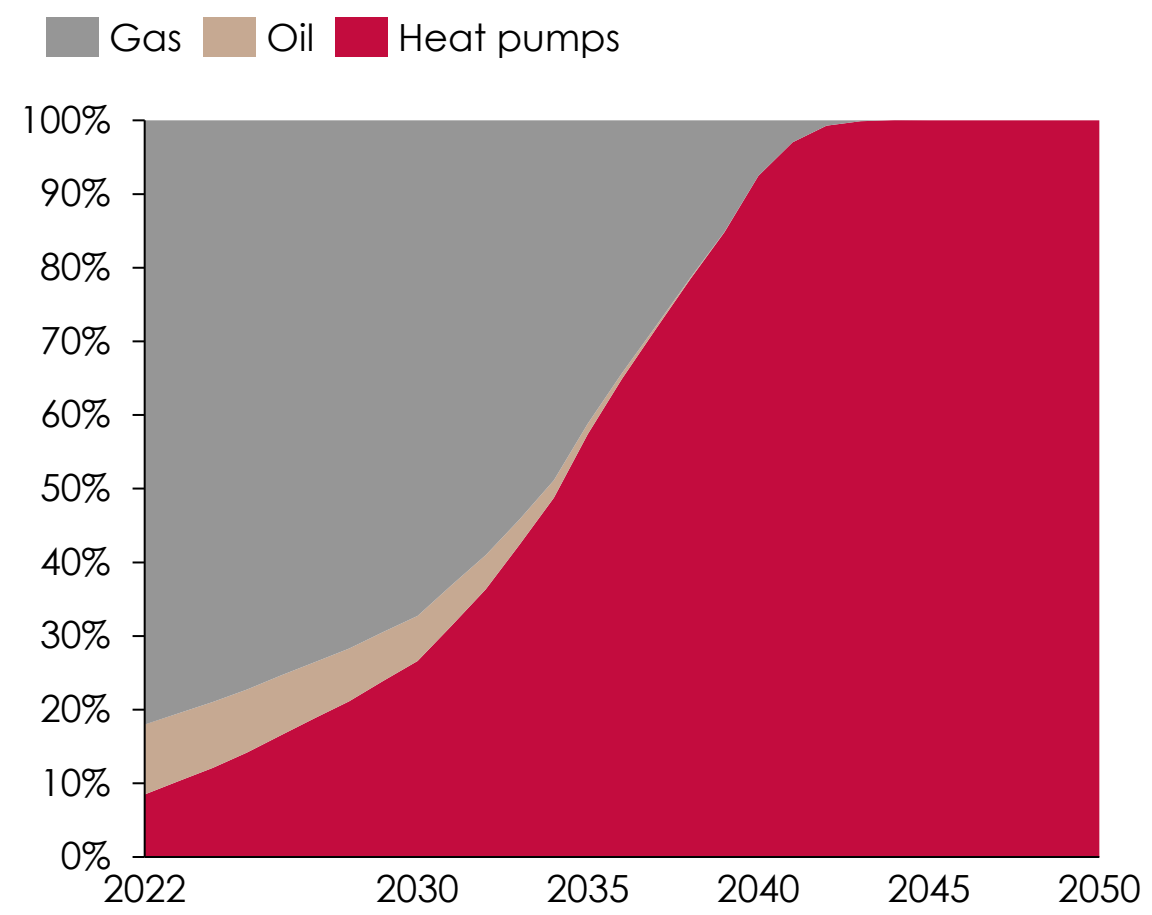
Growth in global floor area by region

2022-2050; Billion m²; IEA NZE Scenario



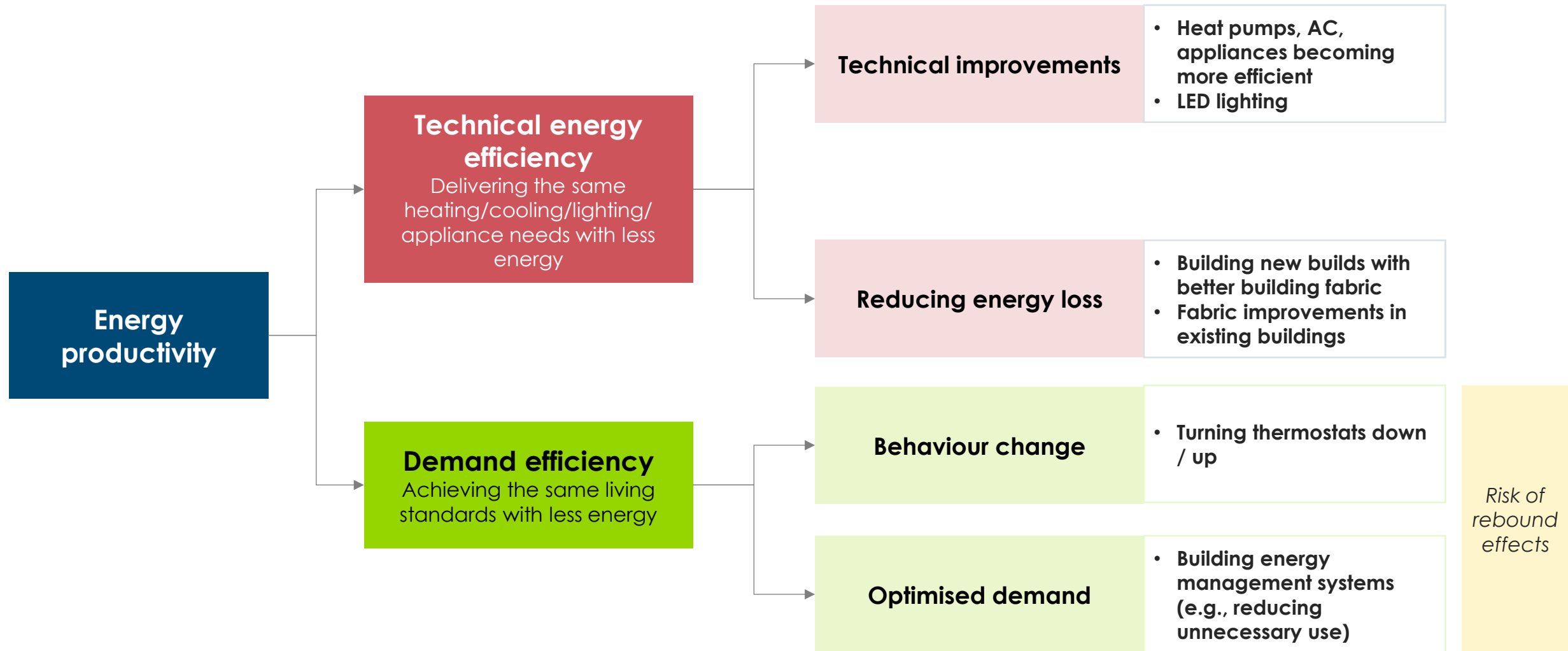
Transition of existing gas and oil boiler stock to heat pumps in Europe and North America – ETC projections

% 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 levels possible for buildings operational energy

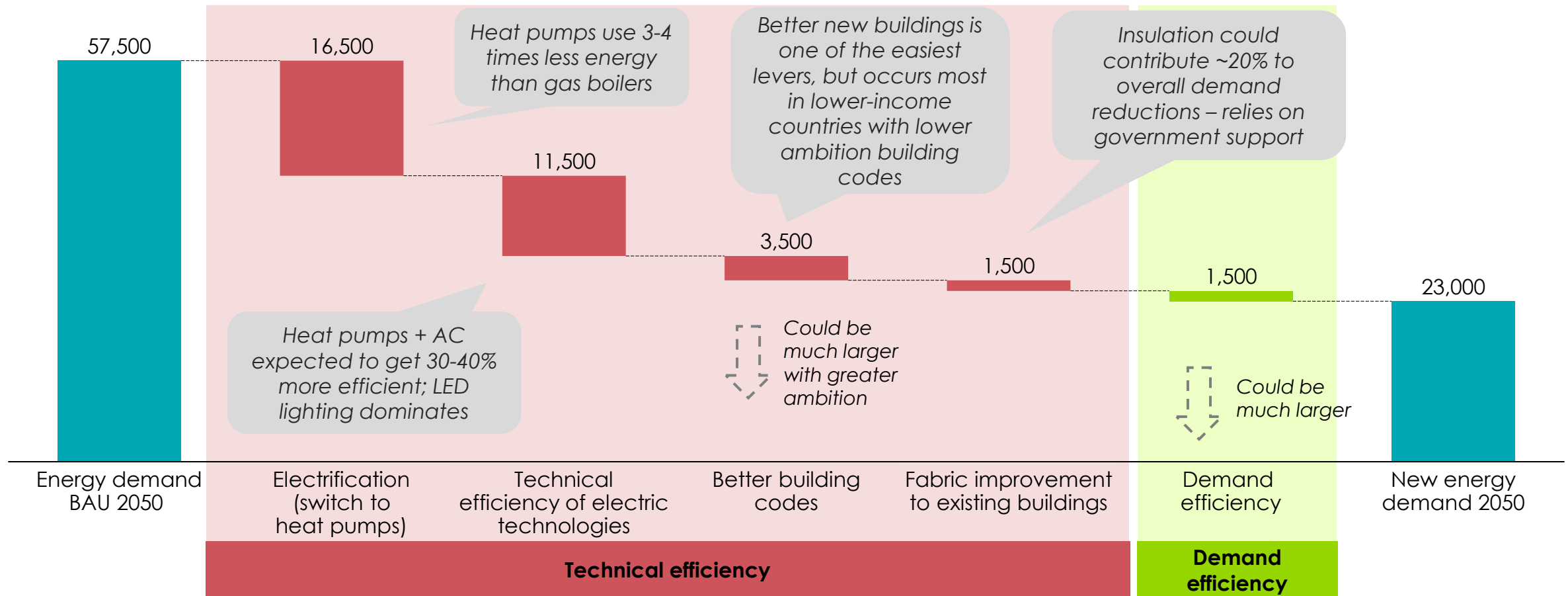


Note: OEM stands for Original equipment manufacturer
Source: Systemiq analysis for the ETC.

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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Behaviour change (e.g. thermostat changes) • Optimised demand (e.g. energy management systems)

Efficiency enablers
<ol style="list-style-type: none"> 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.



Road

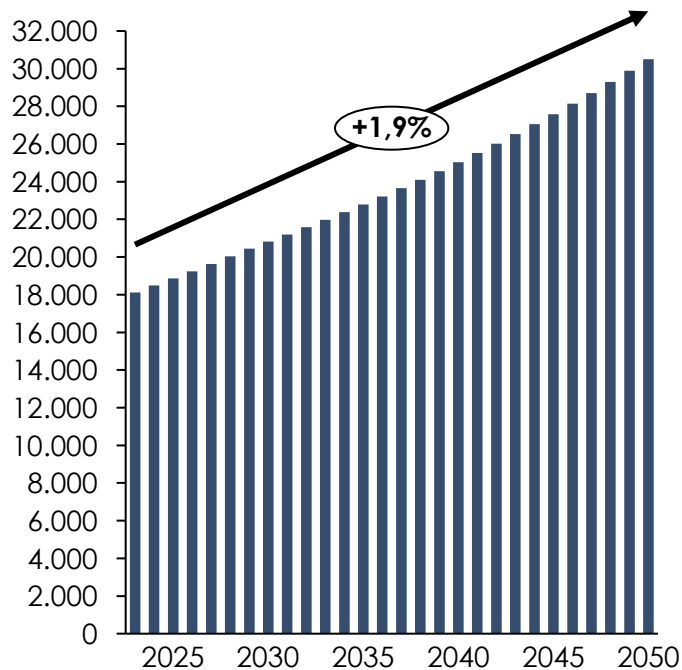


Passenger demand for transport is expected to grow by 1.9% annually, with commercial vehicles increasing by 2.4% annually

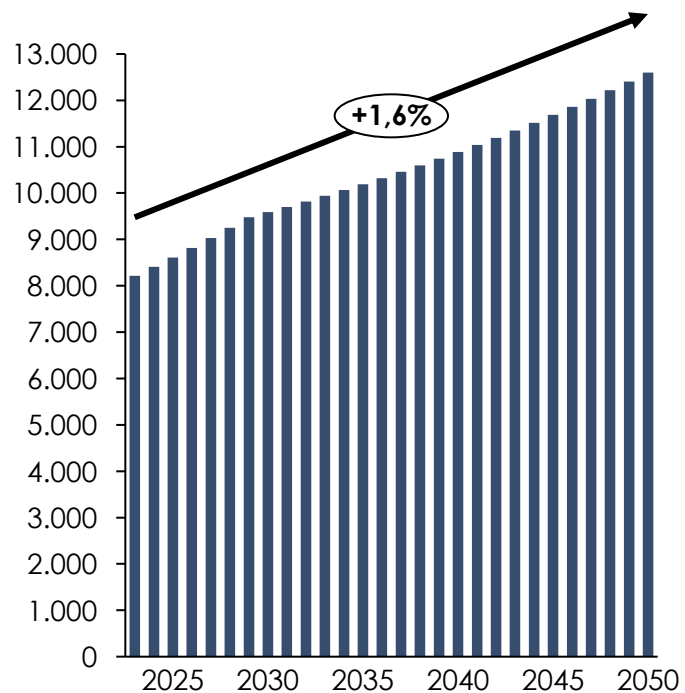
Demand for passenger km and freight transport km in the ACF¹ scenario

Billions of km

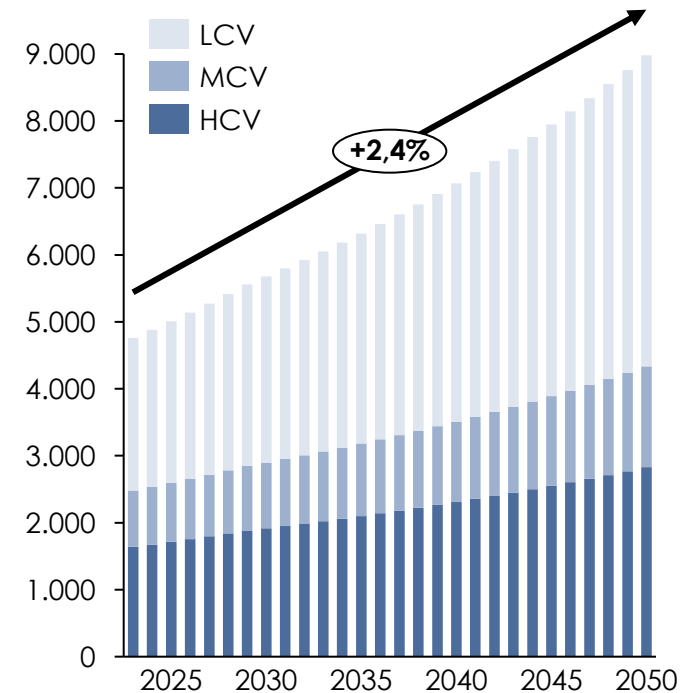
Fossil fuels in Transition report:
Accelerated by clearly feasible scenario



Passenger vehicles



Two-Three-wheelers



Commercial vehicles³

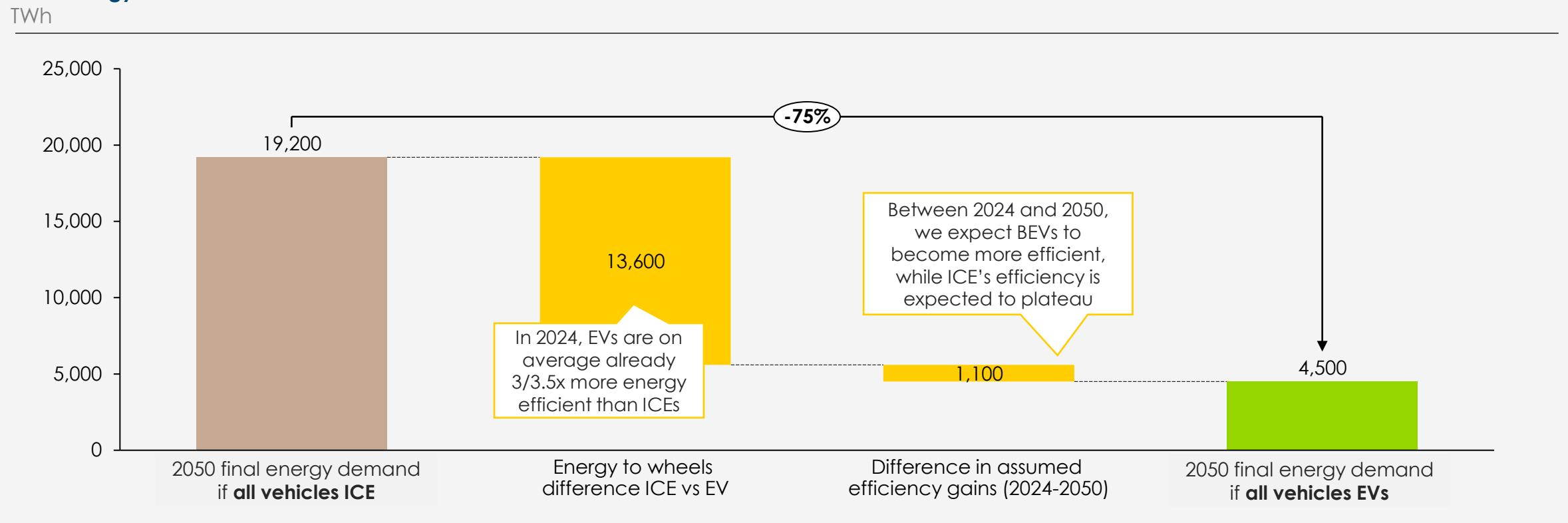
Note: 1. Accelerated but Clearly Feasible (ACF); 2. Zero-emission vehicles; 3. Commercial vehicles include light, medium and heavy commercial vehicles (e.g., LCV, MCV, HCV).
Source: Systemiq analysis for the ETC; ETC (2023), *Fossil Fuels in Transition: Committing to the phase-down of all fossil fuels*,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

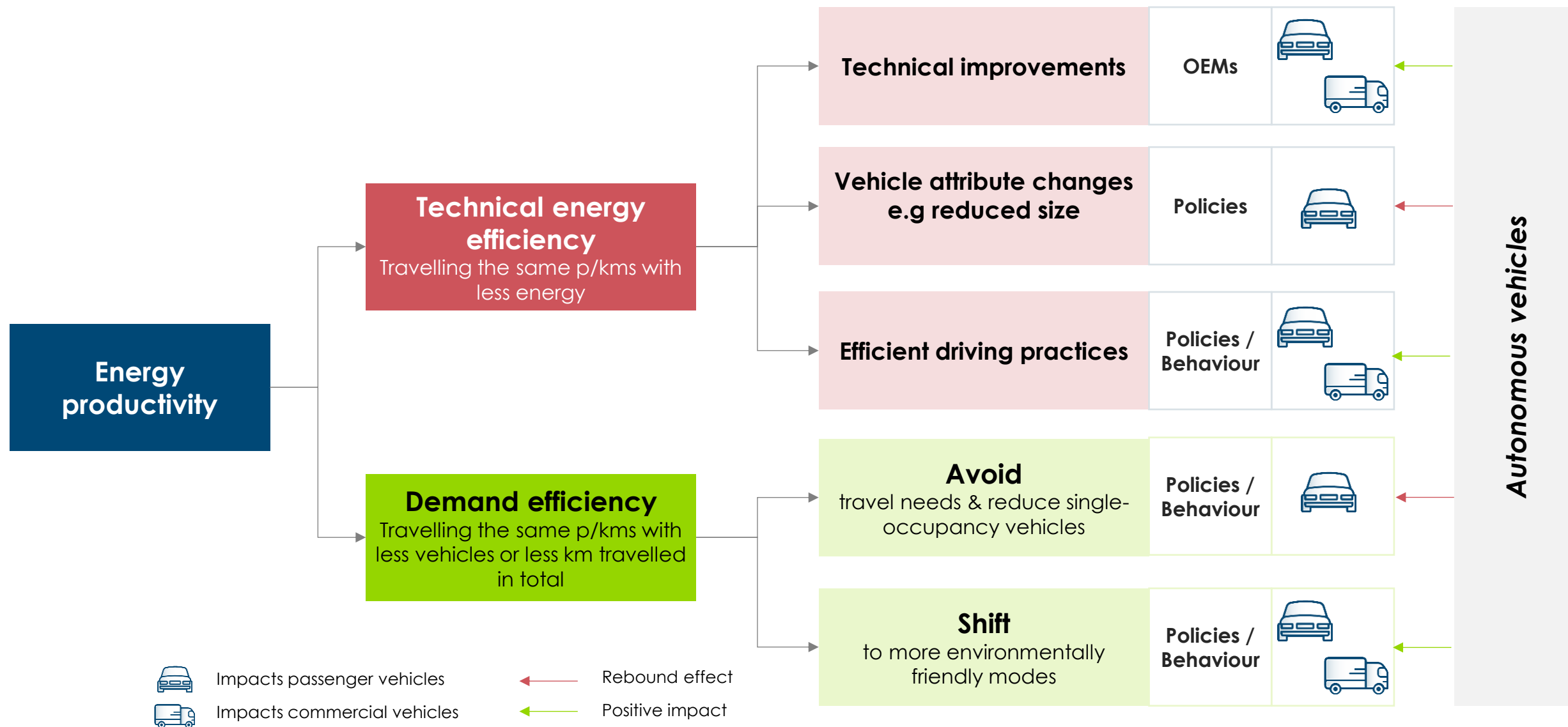
Final Energy Demand under a full ICE and a full EV scenario in 2050





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



 Impacts passenger vehicles ← Rebound effect
 Impacts commercial vehicles ← Positive impact

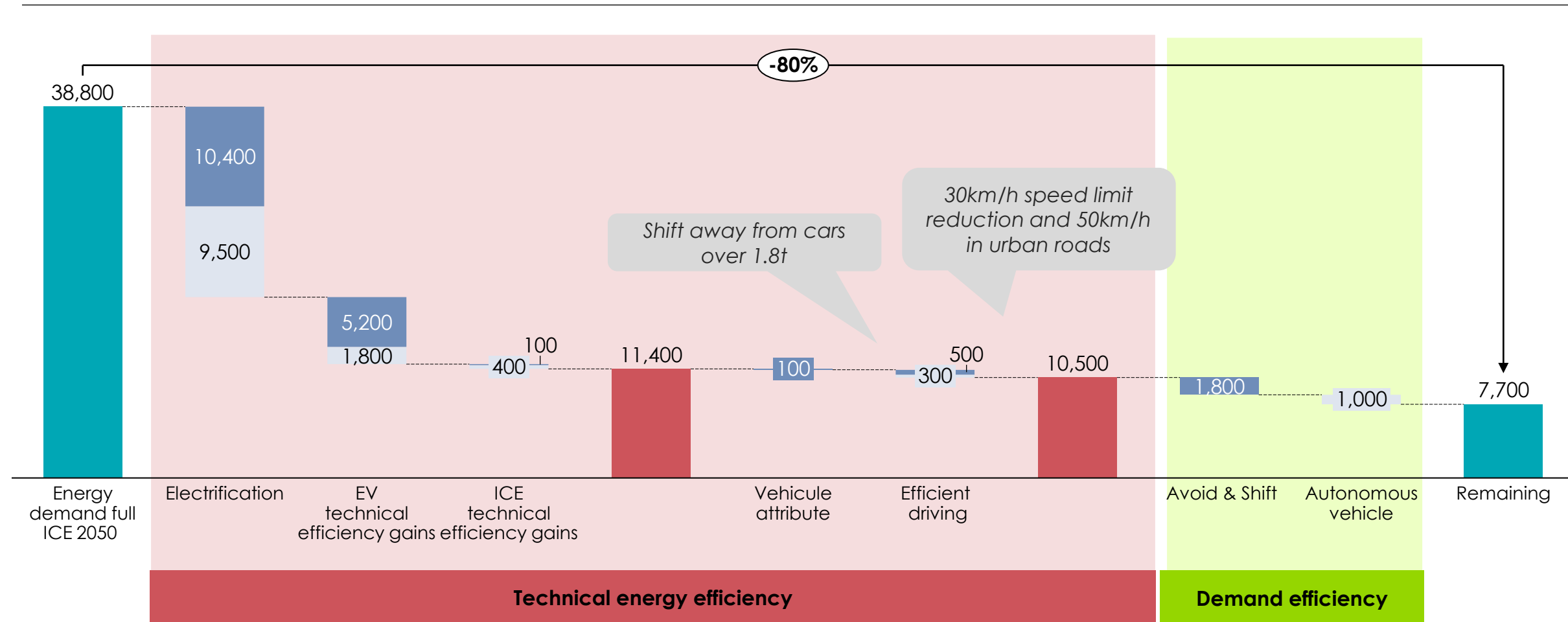
Note: OEM stands for Original equipment manufacturer
 Source: Systemiq analysis for the ETC.

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

Passengers Commercial



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	<ul style="list-style-type: none"> • Electrification (both in passengers and commercial transport) • Efficiency improvements in electrical vehicles • Lightweighting vehicles • Stricter speed limits
Demand efficiency	<ul style="list-style-type: none"> • 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)

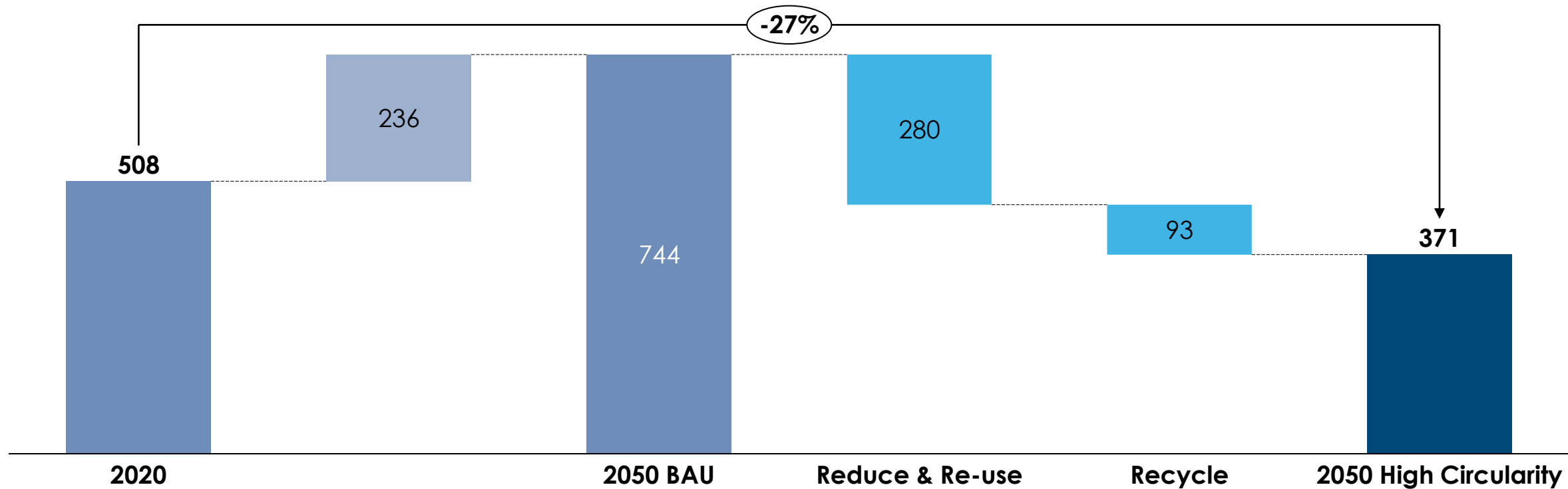
Petro-chemicals



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

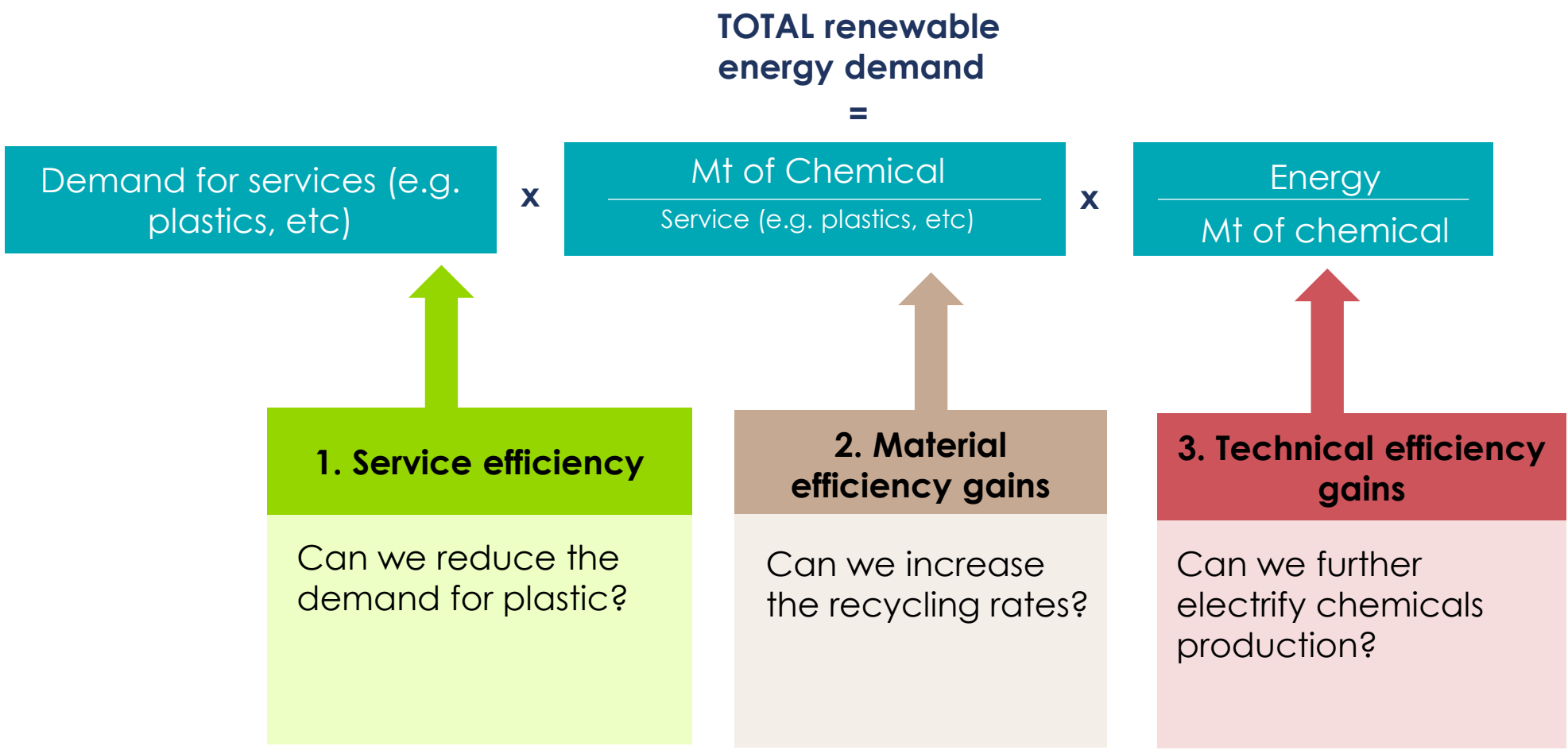
Basic chemical demand analysis between 2020 and 2050

Mt



Source: Systemiq (2022) Planet Positive Chemicals

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



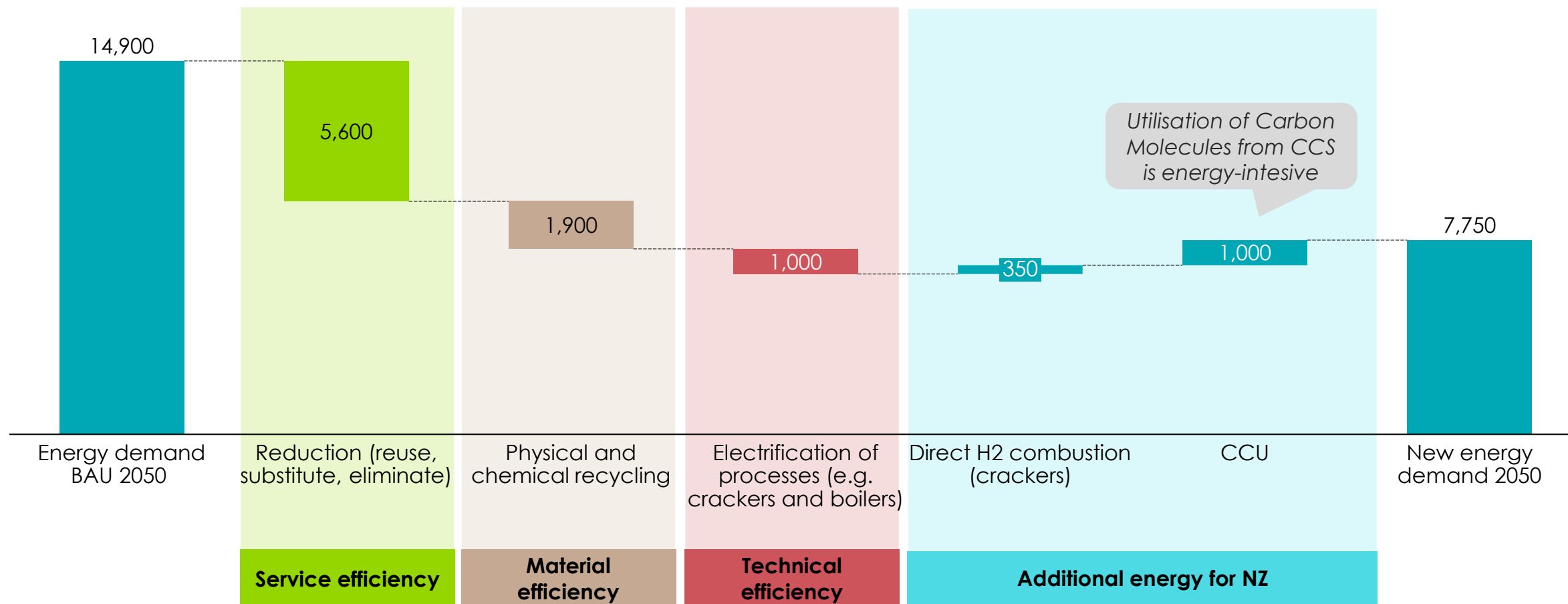
Source: MPP schematic

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



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

Efficiency lever	Efficiency lever description
Service efficiency	<ul style="list-style-type: none"> Demand reduction of plastics through reusage, substitution or elimination
Material efficiency	<ul style="list-style-type: none"> Increase in chemicals recycling rates
Technical energy efficiency	<ul style="list-style-type: none"> Further electrification of chemicals production (e.g. steam cracking and electric boilers)

Efficiency enablers
<ol style="list-style-type: none"> 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.



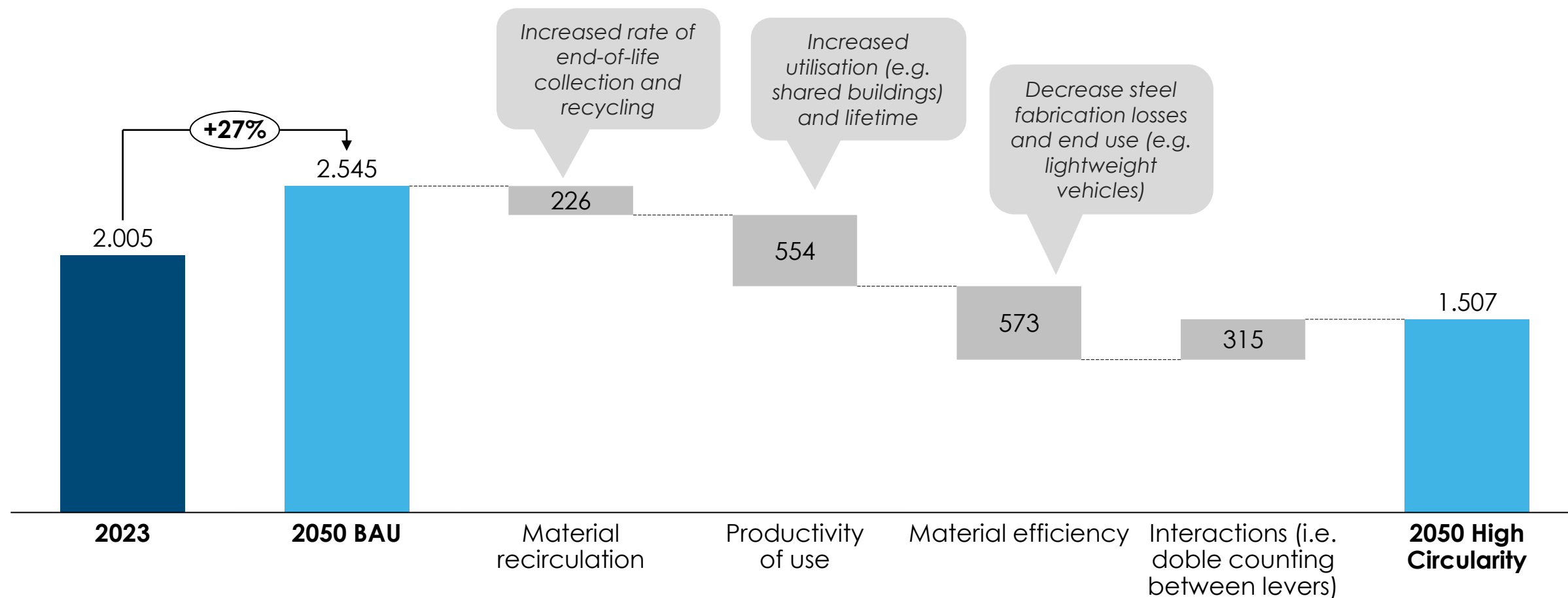
Steel



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

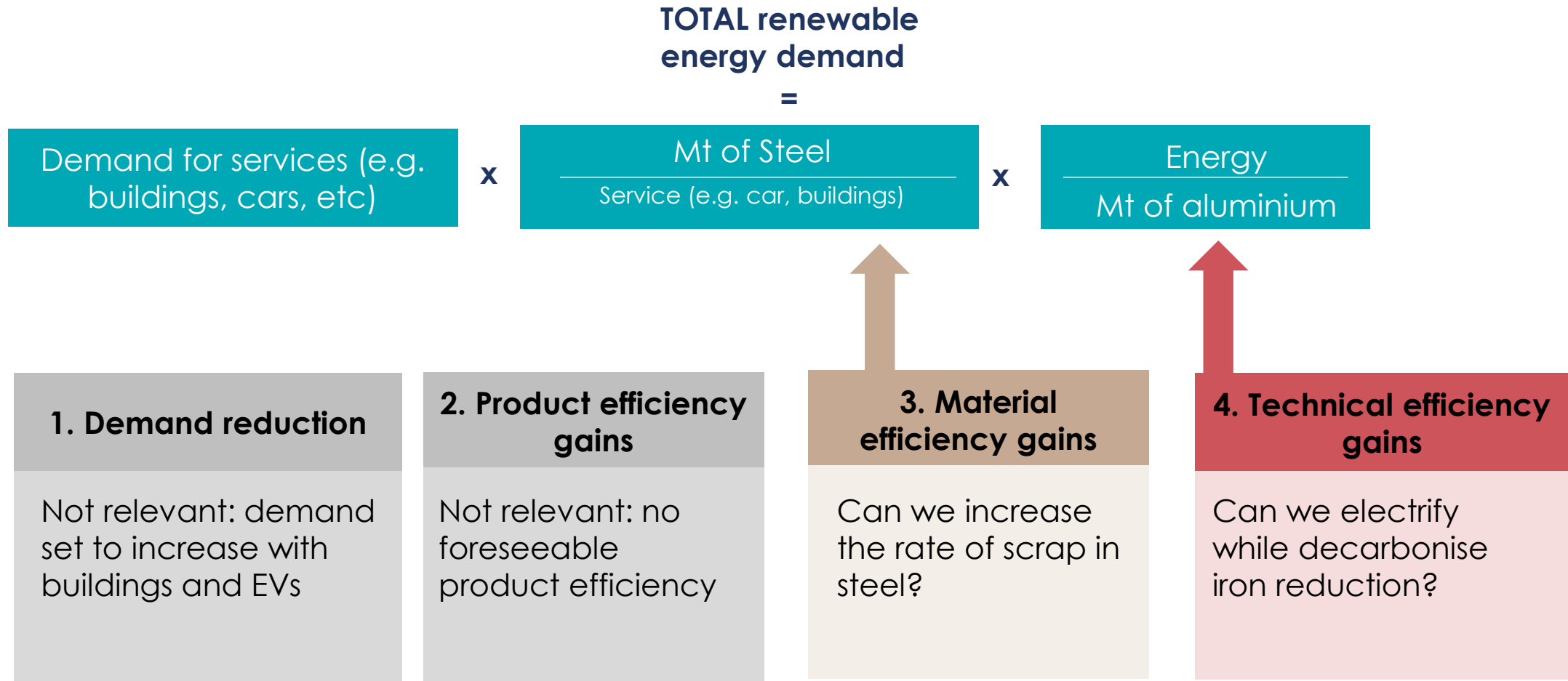
Crude Steel demand BAU vs. High Circularity scenario

Mt of Steel



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

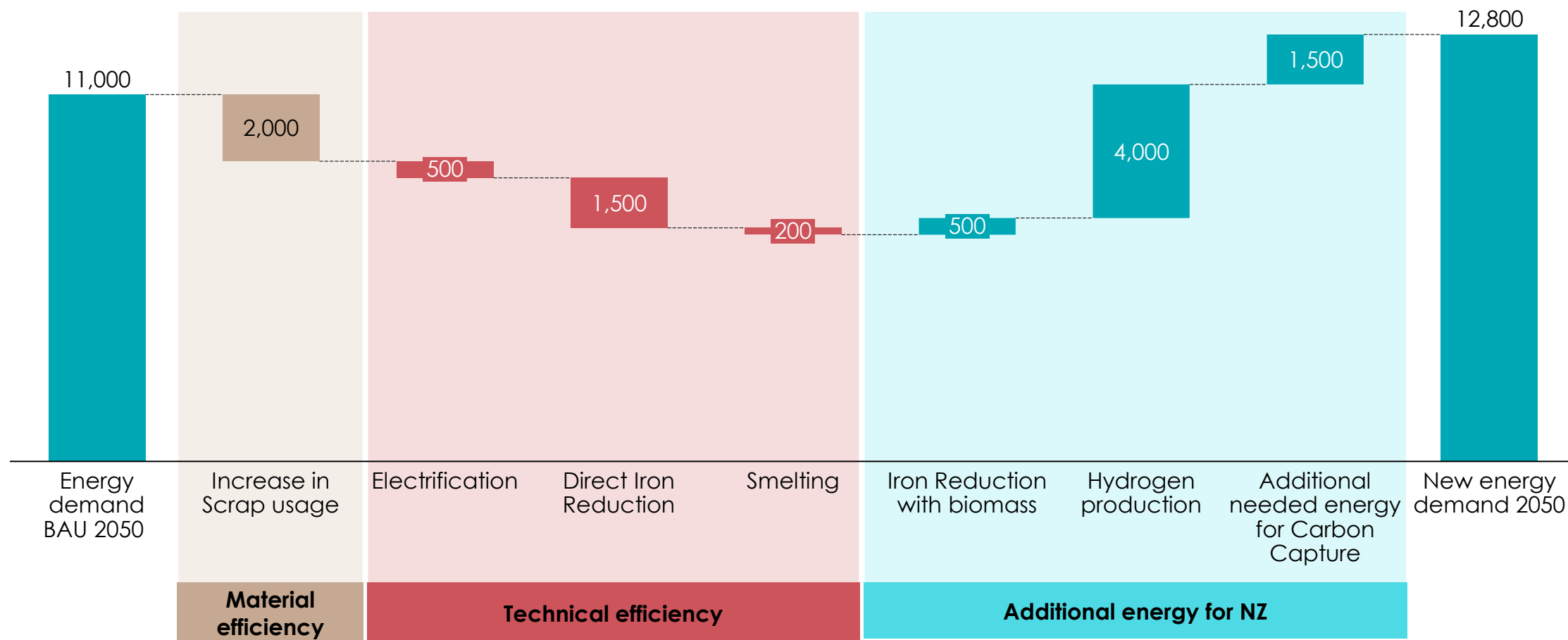
There are 2 main efficiency levers to reduce energy demand in the steel sector



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: MPP (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	<ul style="list-style-type: none"> Scrap usage increase (increase secondary production and primary production scrap intake)
Technical energy efficiency	<ul style="list-style-type: none"> 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
<ol style="list-style-type: none"> 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: MPP (2022) Steel Sector Transition Strategy

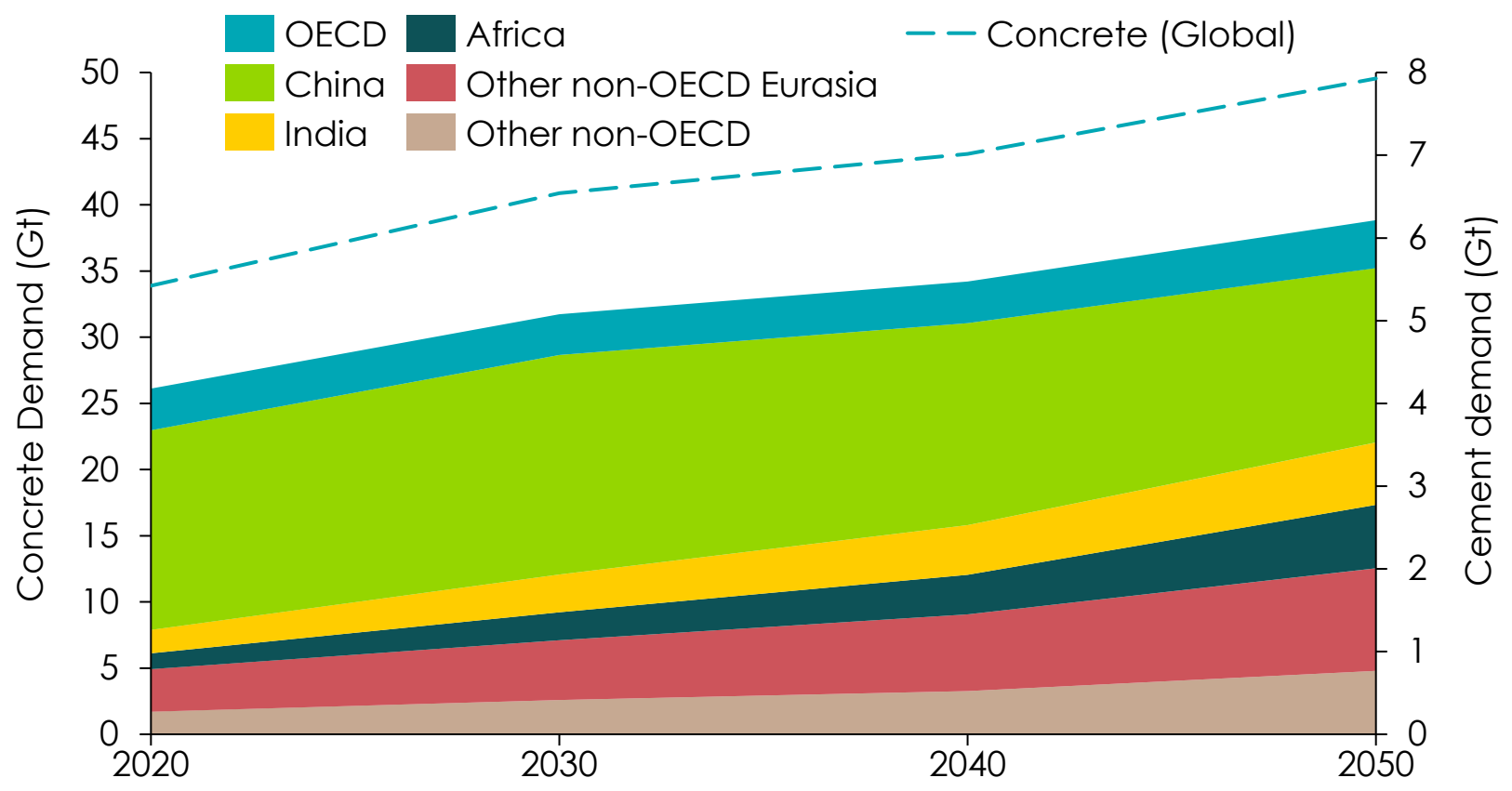
Cement



Housing and infrastructure growth in emerging economies drive demand in cement and concrete sectors

Cement – demand

Cement and concrete demand, Gt/yr in a no action scenario



- China's share of consumption is expected to reduce, as **consumption shifts to emerging economies** from today's industrialized regions
- Without efficiency gains, demand for cement is projected to increase 40% from 4.2 gigatons in 2020 to 6.2 gigaton in 2050

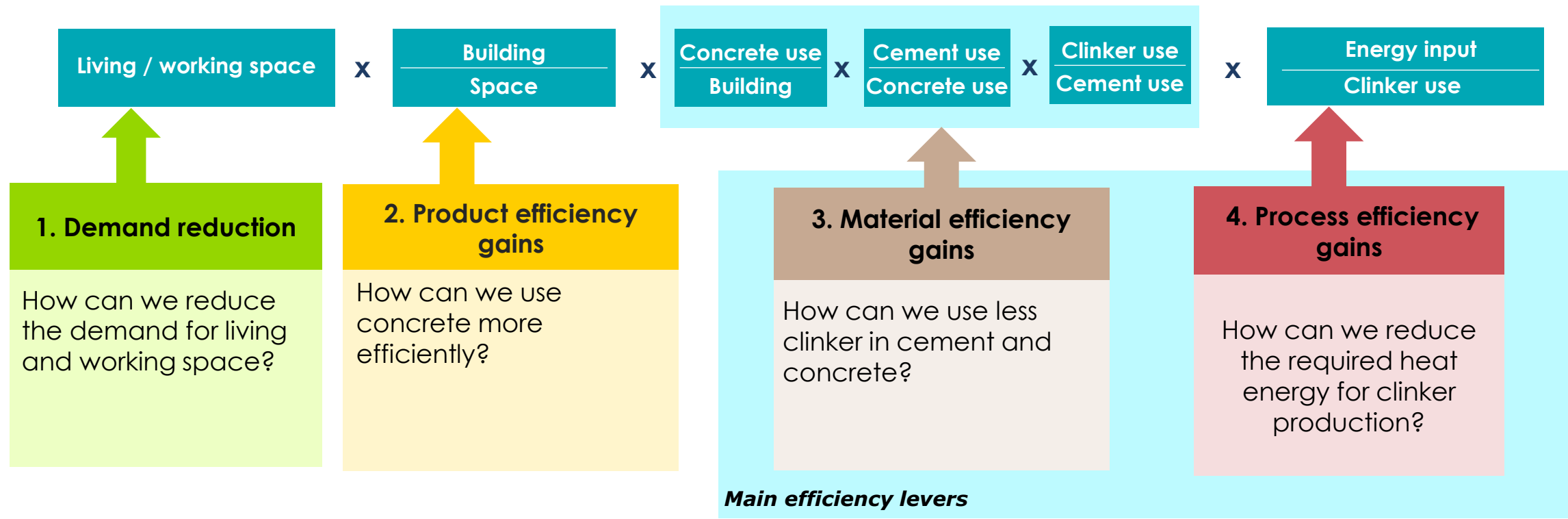


Source: Demand - GCCA Roadmap for total level cement demand, with estimations of region breakdowns based on Rhodium Group 2024, End use - Material Economics Industrial Transformation 2050, Cembureau 2021 Activity Report, WBCSD Low Carbon Technology Roadmap for the Indian Cement Sector: Status Review 2018, Climate Works Decarbonizing Concrete.

Product and material efficiency are most relevant to reduce energy demand in the concrete sector

Cement – efficiency levels

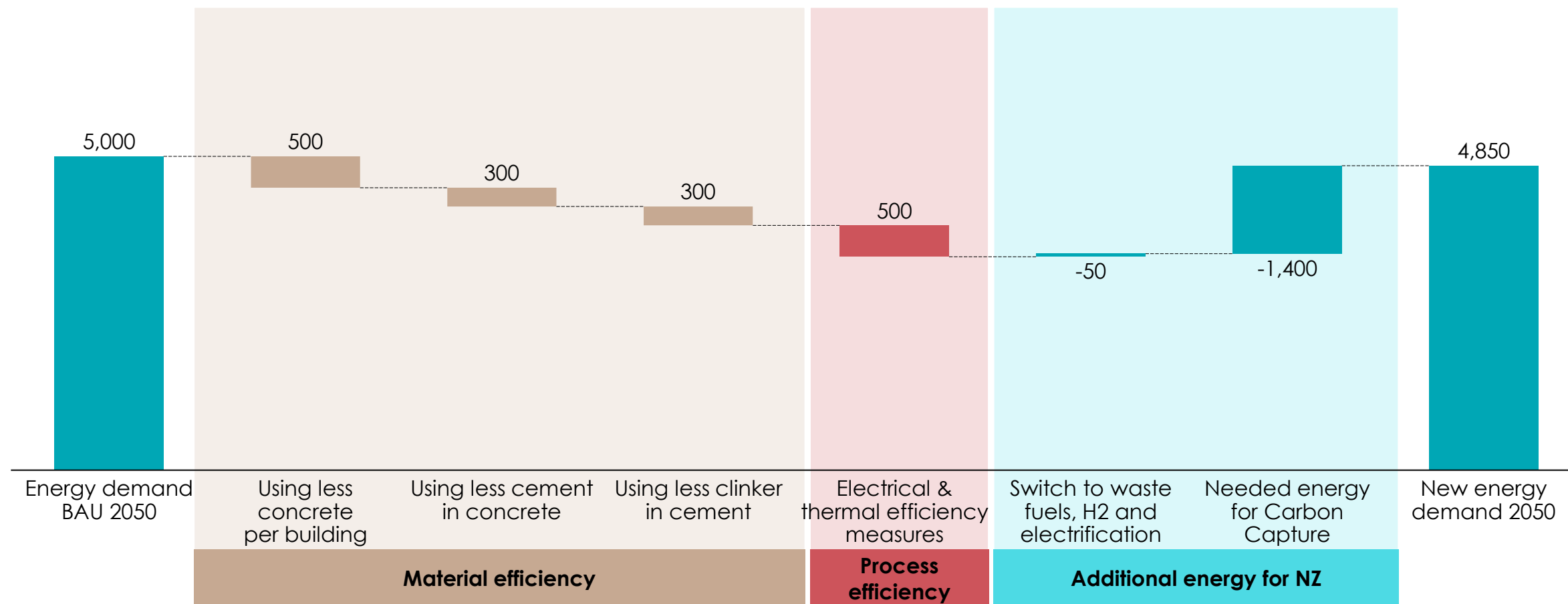
Total renewable energy demand \approx



Material efficiency most important lever to reduce energy demand for concrete

Primary energy demand in 2050 and impact of productivity levers

TWh



Source: Based on MPP Sector Transition Strategy

Reducing clinker content per building and required energy for clinker production critical to minimize renewable energy input for concrete

Efficiency lever	Efficiency lever description	Efficiency enablers
Material Efficiency	<ul style="list-style-type: none"> Using less concrete per building via better design Using less clinker in cement by partially replacing clinker with supplementary cementitious materials (SCMs) Using less cement in concrete through a more efficient mixing of cement 	<ol style="list-style-type: none"> 1. Set mandatory emission targets or via climate-aligned investment principles 2. Implement market based mechanisms (e.g. green procurement with standarts on buildings performance) to incentivize supply side material efficiencies 3. Investment into R&D for alternative chemistries 4. Investment into infrastructure for bulk cement mixing to reduce overapplication 5. Develop performance based standards reduce the clinker-to-concrete ratio effectively
Technical energy efficiency	<ul style="list-style-type: none"> Replacing wet kiln with dry klin technology Deploying waste heat recovery Switching to more efficient grinding 	



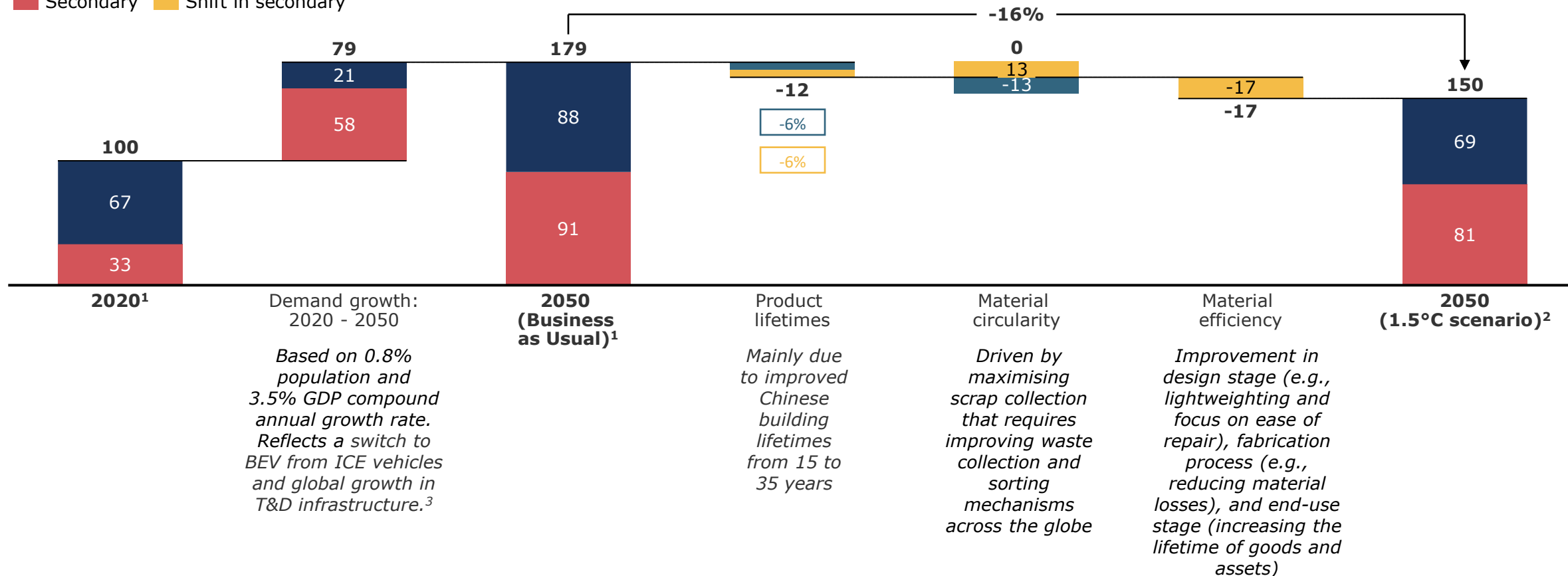
Aluminium



Majority of aluminium demand by 2050 is expected to be met by secondary aluminium in a 1.5°C scenario

Demand for aluminium, Mt per year

■ Primary ■ Shift in primary
■ Secondary ■ Shift in secondary



Based on 0.8% population and 3.5% GDP compound annual growth rate. Reflects a switch to BEV from ICE vehicles and global growth in T&D infrastructure.³

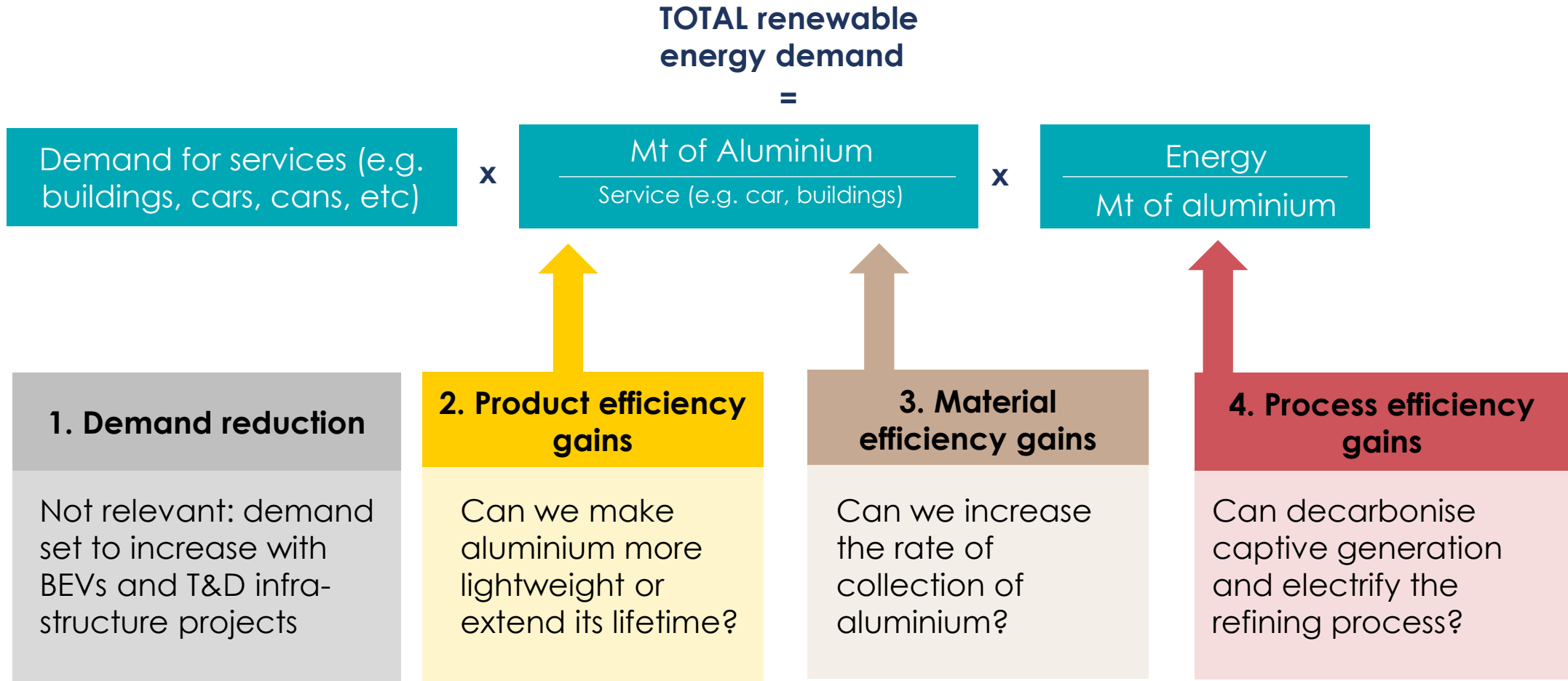
Mainly due to improved Chinese building lifetimes from 15 to 35 years

Driven by maximising scrap collection that requires improving waste collection and sorting mechanisms across the globe

Improvement in design stage (e.g., lightweighting and focus on ease of repair), fabrication process (e.g., reducing material losses), and end-use stage (increasing the lifetime of goods and assets)



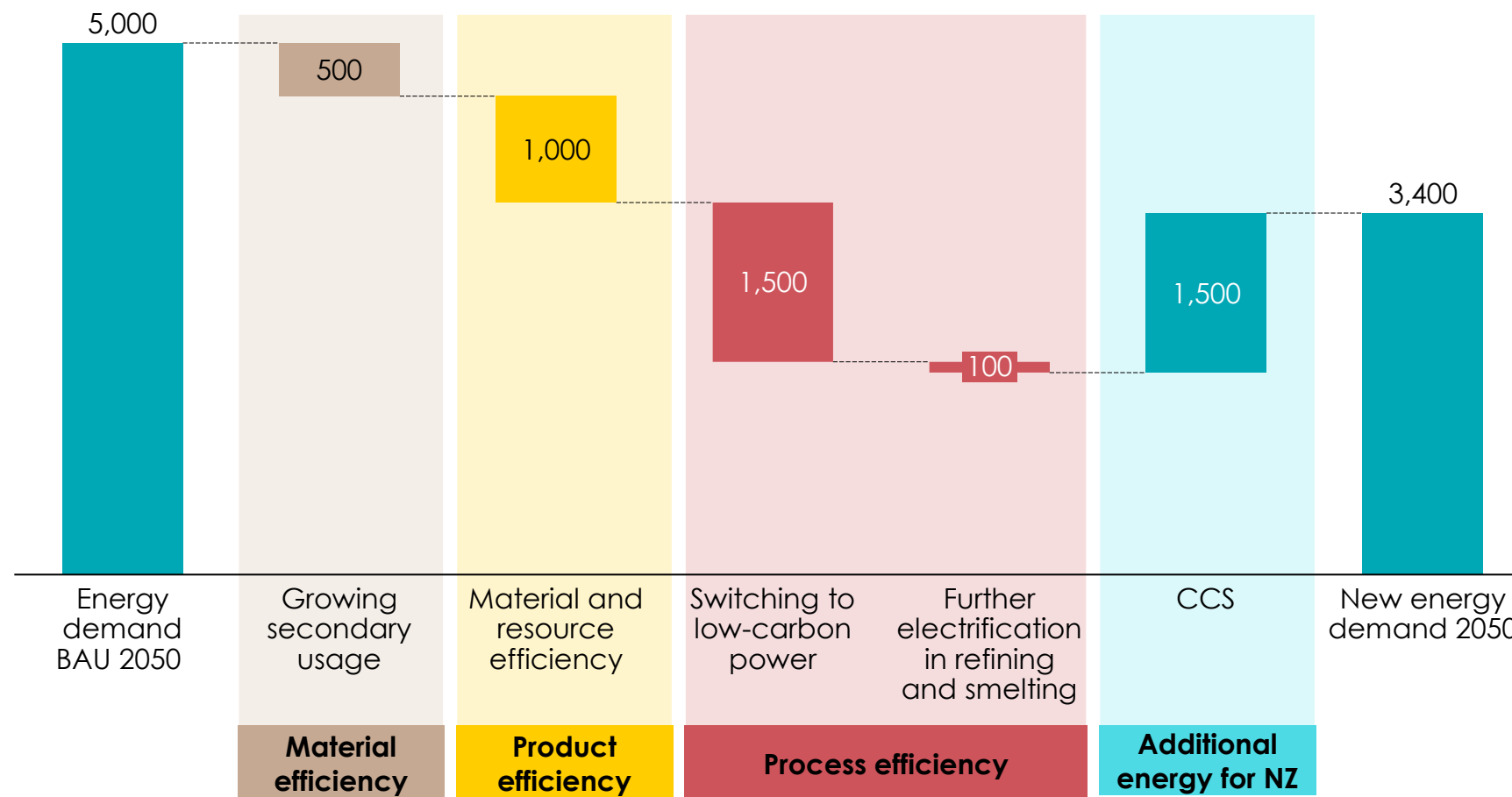
There are 3 main efficiency levers to reduce energy demand in the aluminium sector



No single efficiency lever in aluminium compensates an increase in energy demand from CCS; but levers applied together show efficiency gains

Primary energy demand in 2050 and impact of productivity levers

TWh



Carbon Capture and Storage (CCS) is particularly present in captive thermos plants in China. Albeit the regulatory, policy and technical challenges the alternative scenario of No-CCS could increase the case of continued coal use in a net-zero world by 2050.



Source: MPP (2022), Aluminium Sector Transition Strategy Model

Decarbonising power in smelting and refineries and increase material utilisation and recycling are key to reducing Aluminium energy demand

Efficiency lever	Efficiency lever description
Material Efficiency	<ul style="list-style-type: none"> Maximizing secondary production
Product Efficiency	<ul style="list-style-type: none"> Circular product design Fabrication loss reduction Increased product lifetimes End-of-life repair and reuse
Technical Energy Efficiency	<ul style="list-style-type: none"> Switch captive generation to renewable sources Deploying near-zero- emissions refining and smelting technologies (e.g. electric boilers, concentrated solar thermal, mechanical vapor recompression, electric calcination)

Efficiency enablers
<ol style="list-style-type: none"> Substitution of lower-performance materials with aluminum, preferably from secondary production, via industry commitments or government procurement Increase of cross-sectorial collection rates and scrap downcycling Development of site-specific plans for decarbonisation of power, particularly focusing on decarbonization of power over the next decade Work with producers and regulators to integrate aluminium smelters into electricity, CCS, and hydrogen grids to provide availability of transport and storage infrastructure for captured CO2 from smelting and power generation



Source: MPP (2022), Aluminium Sector Transition Strategy

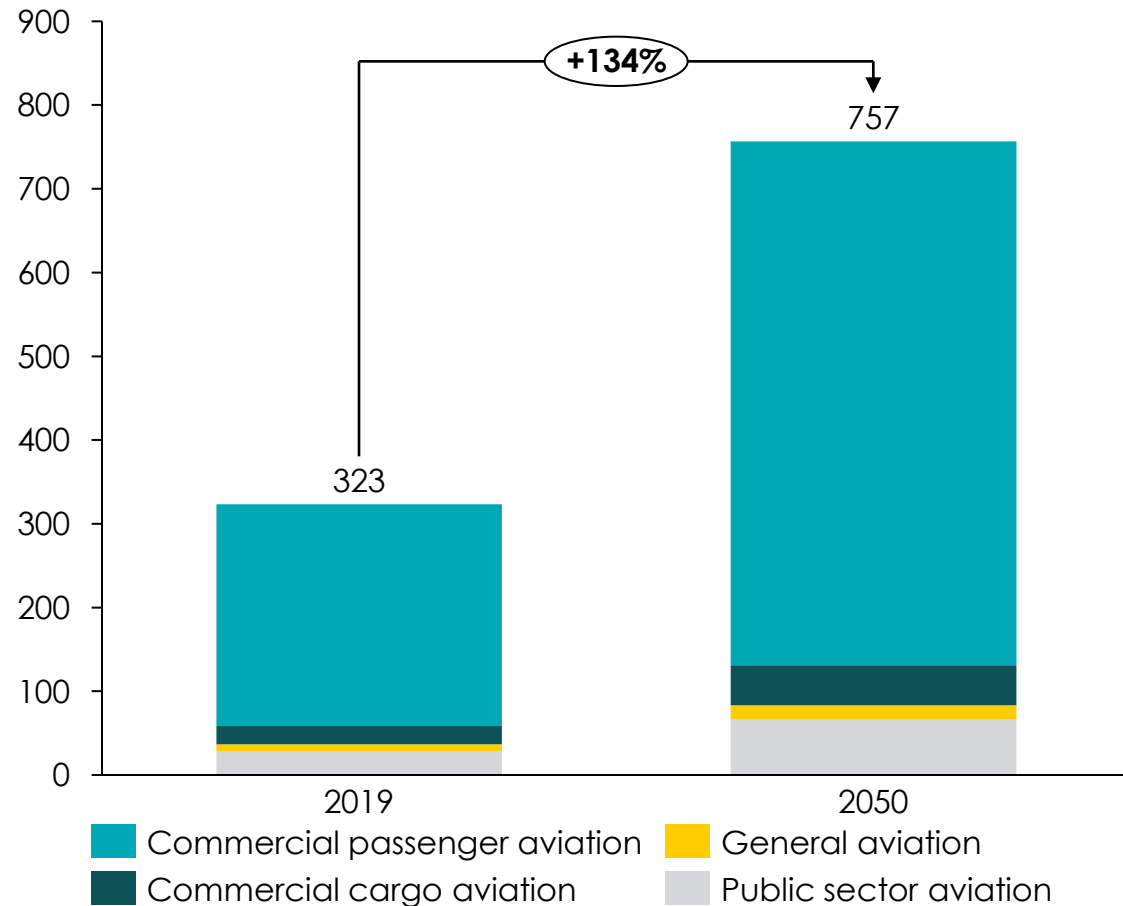
Aviation



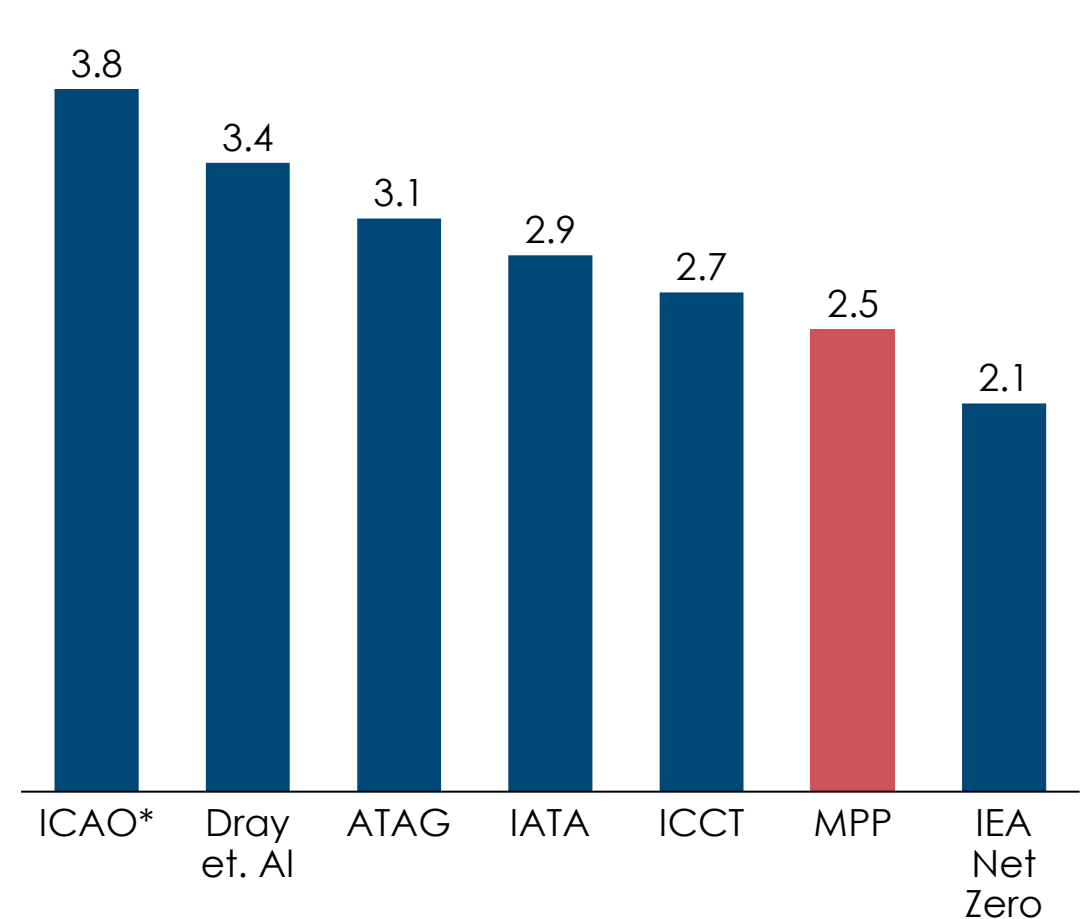
Jet fuel demand is expected to grow with an average CAGR of 2.5 % made up primarily by demand in the commercial sector

Aviation – demand

MPP Jet fuel equivalent demand (before efficiency levers) by region (BAU) 2019 and 2050, Mt



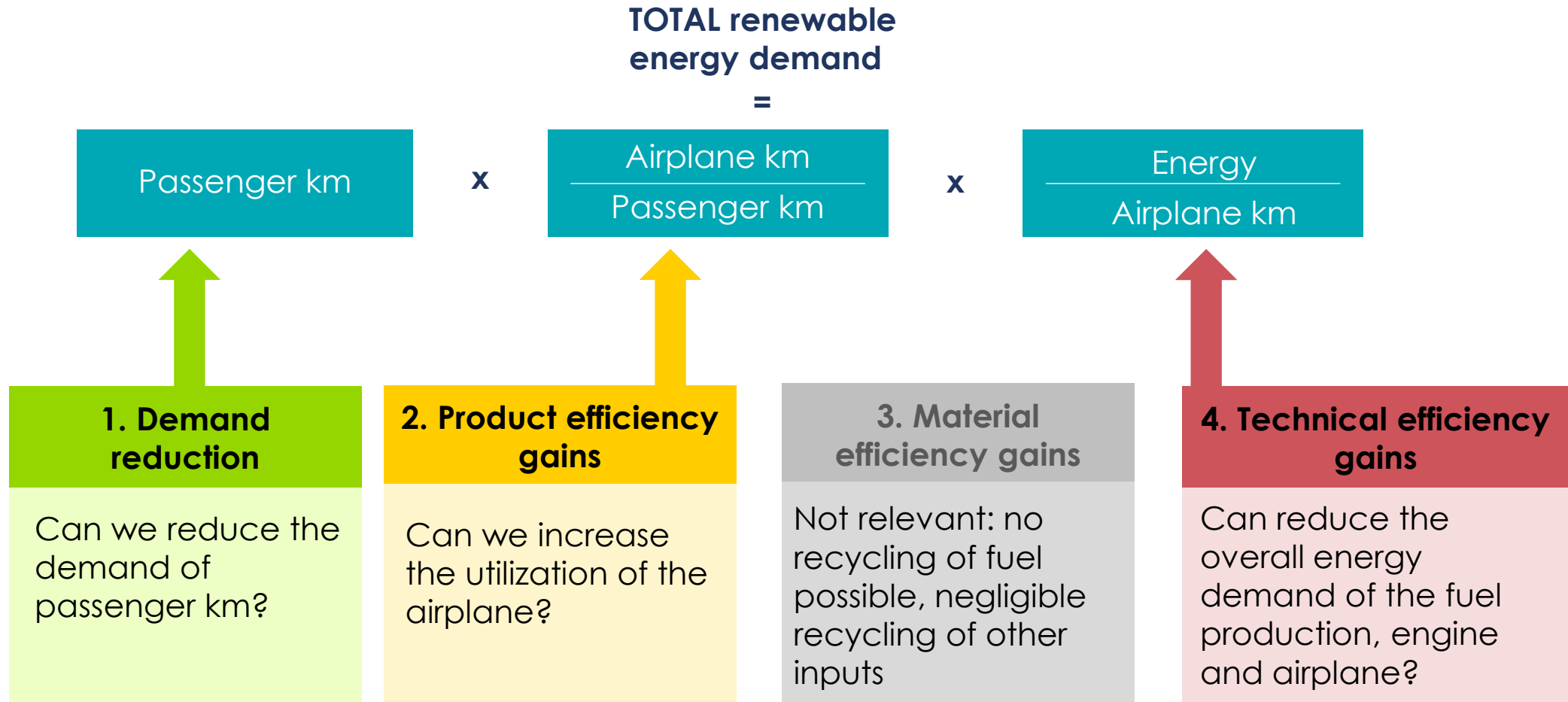
Assumed CAGR demand growth for commercial passenger aviation across different studies, CAGR (2019-2050)



Source: MPP analysis, comparison of CAGRs from IATA (2024) *Aviation Net-Zero Co2 Transition Pathways Comparative Review*. Note: ICAO = International Civil Aviation Organization, ATAG = Air Transport Action Group, IATA = International Air Transport Association, ICCT = International Council on Clean Transportation, MPP = Mission Possible Partnership, IEA = International Energy Agency. ICAO covers 2018-2050

There are 3 main efficiency levers to reduce energy demand in the aviation sector

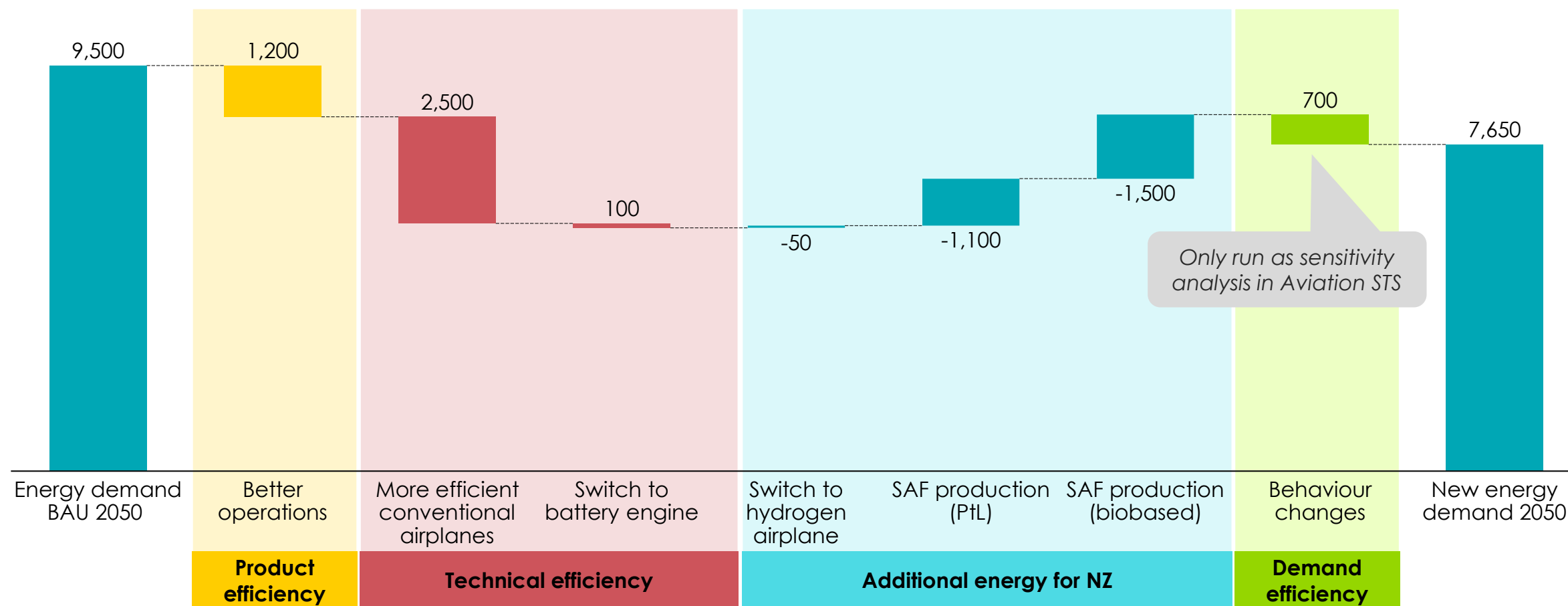
Aviation – Efficiency levers



Making conventional airplanes more efficient is single most important lever

Primary energy demand in 2050 and impact of productivity levers

TWh



Source: Schäfer, A. (2019). "Technological, economic and environmental prospects of all-electric aircraft". *Nature Energy*. 4 (2): 160–166., MPP analysis

Increasing energy process efficiency is the largest lever, enabled by SAF price premium and R&D investments

Efficiency lever	Efficiency lever description
Technical energy efficiency	<ul style="list-style-type: none"> • Engine efficiency improvements • Improvements in aerodynamics • Lightweighting of airplane
Product efficiency	<ul style="list-style-type: none"> • Optimized approach / departure procedures • Improved congestion management
Demand efficiency	<ul style="list-style-type: none"> • Modal shifts from regional flights to high-speed trains • Behavior shift from business travels to increase video conferencing

Efficiency enablers

- 1. Policy incentives to support R&D efforts:** R&D efforts needed from OEMS and engine/parts suppliers
- 2. Alternative to short-haul flights:** Investment into high-speed railway system to incentivize shift from airplane to train



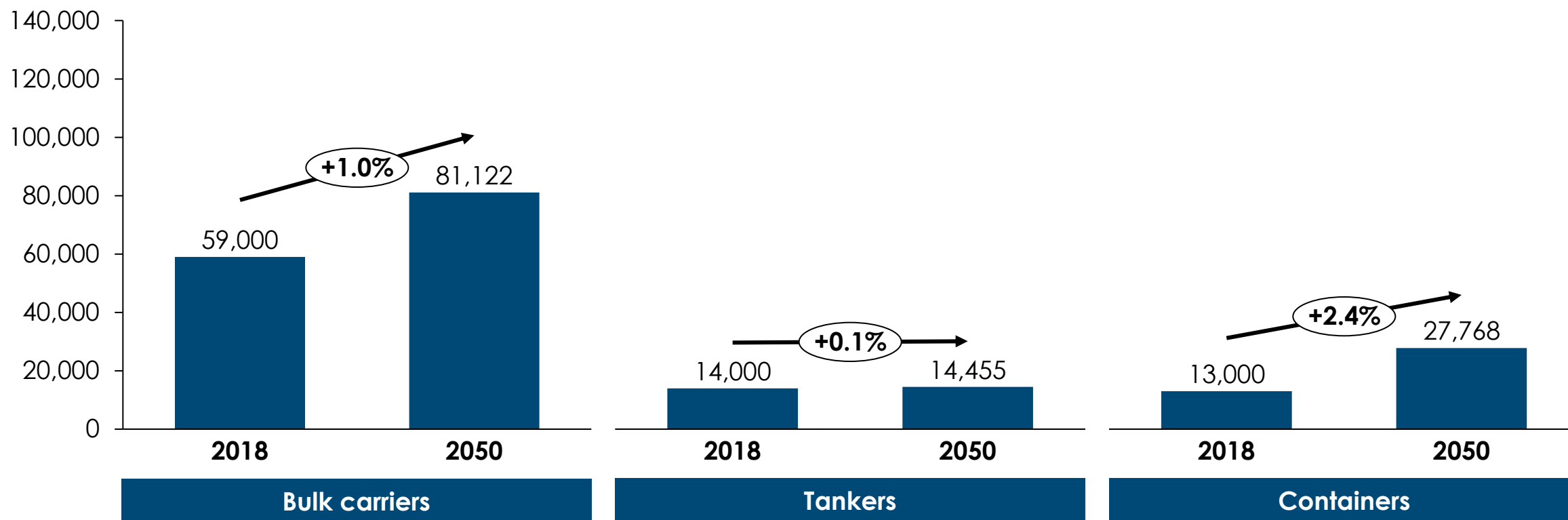
Shipping



Three segments – bulk, tanker and container – account for around 90% of industry volume and demand is set to increase by 2050

Demand for shipping

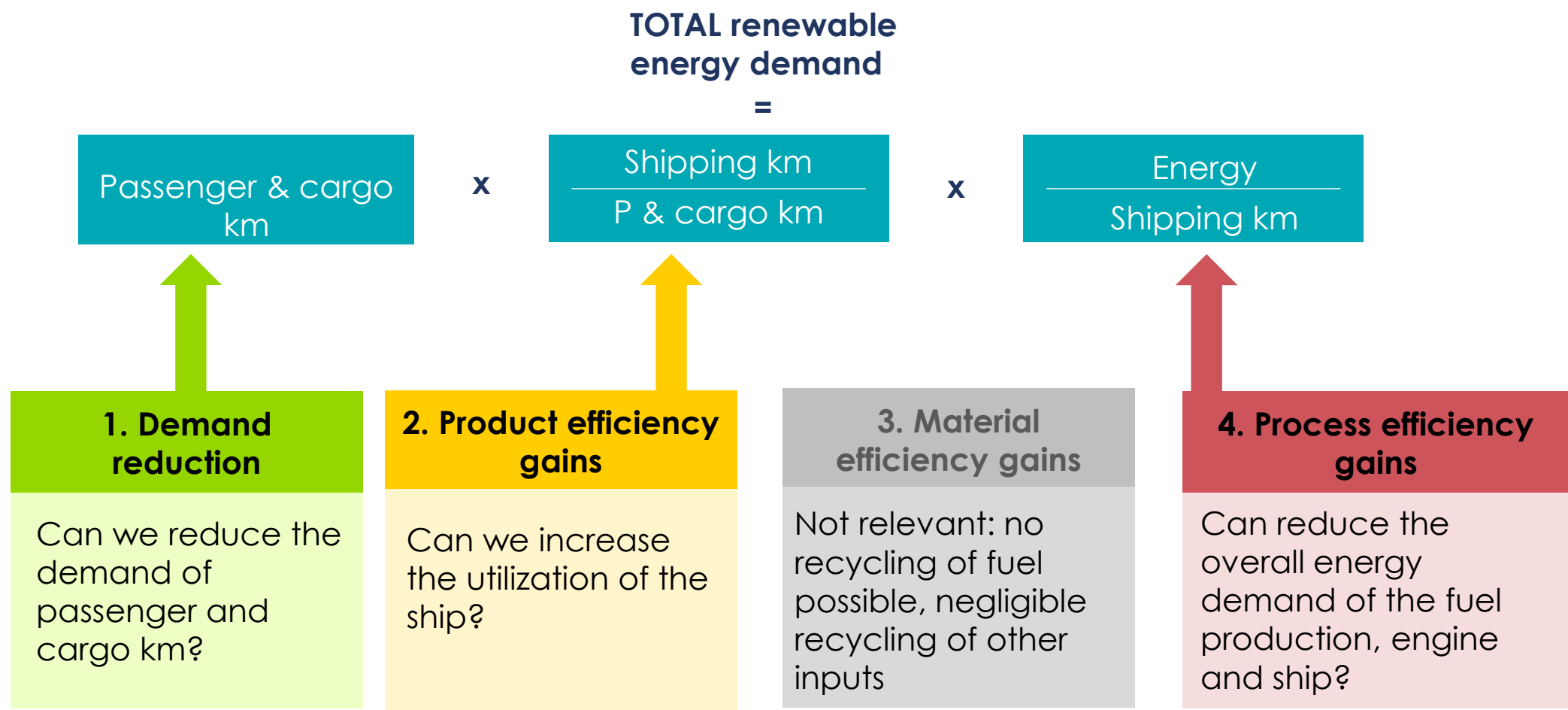
Billions-tonnes miles



Source: ETC (2022) Fossil Fuel in Transition; Maersk Mc-Kinney Moller Center for Zero Carbon Shipping (2022), We show the world it is possible.

There are 3 main efficiency levers to reduce energy demand in the shipping sector

Shipping – Efficiency levers

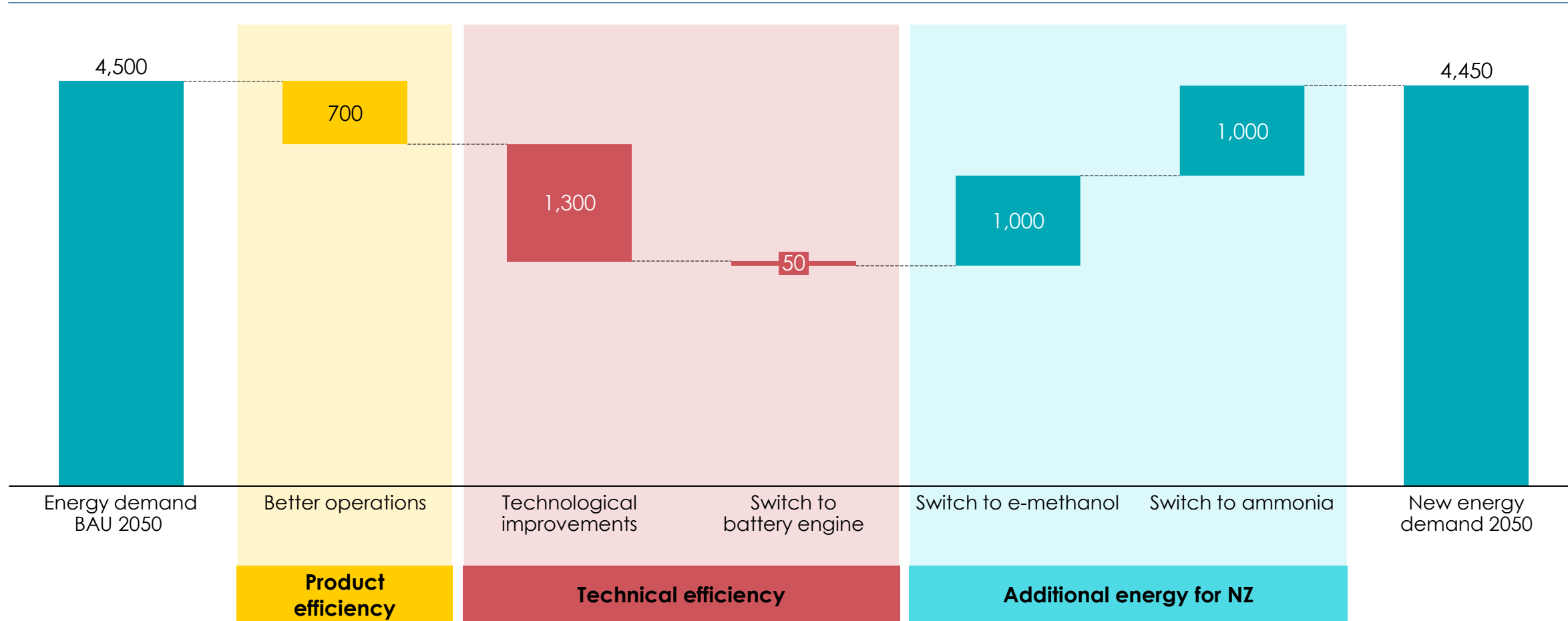


Source: MPP schematic

Efficiency gains in shipping counterbalanced by additional energy due to net zero technologies

Primary energy demand in 2050 and impact of productivity levers

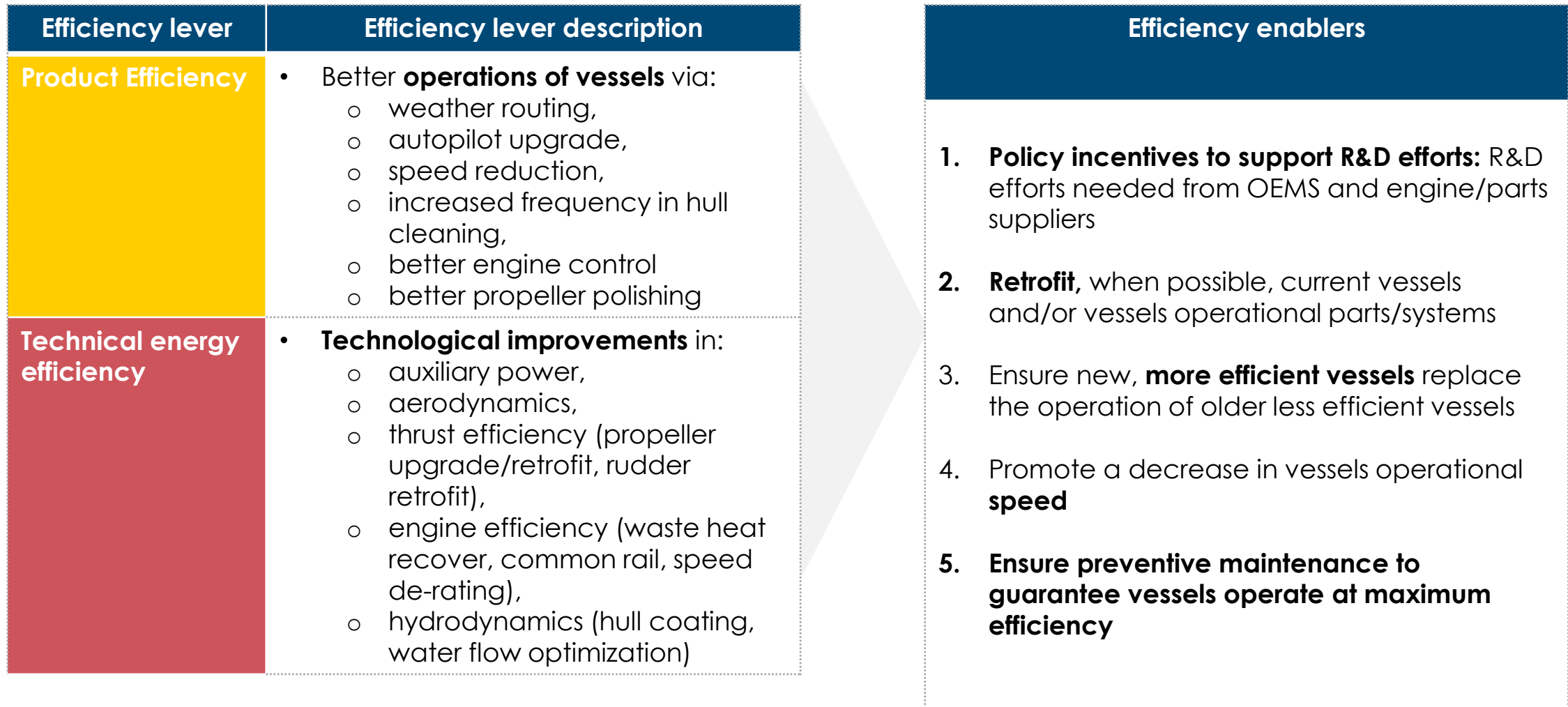
TWh



Source: Source: ICCT (2013) Long-term potential for increased shipping efficiency through the adoption of industry-leading practices, MPP analysis

Note: alongside e-methanol there may be a supplementary role for e-Natural Gas

Shipping vessels can be more efficient via better operations, better routing and maintenance, and technological improvements, in design and engines



Source: ICCT (2013) Long-term potential for increased shipping efficiency through the adoption of industry-leading practices

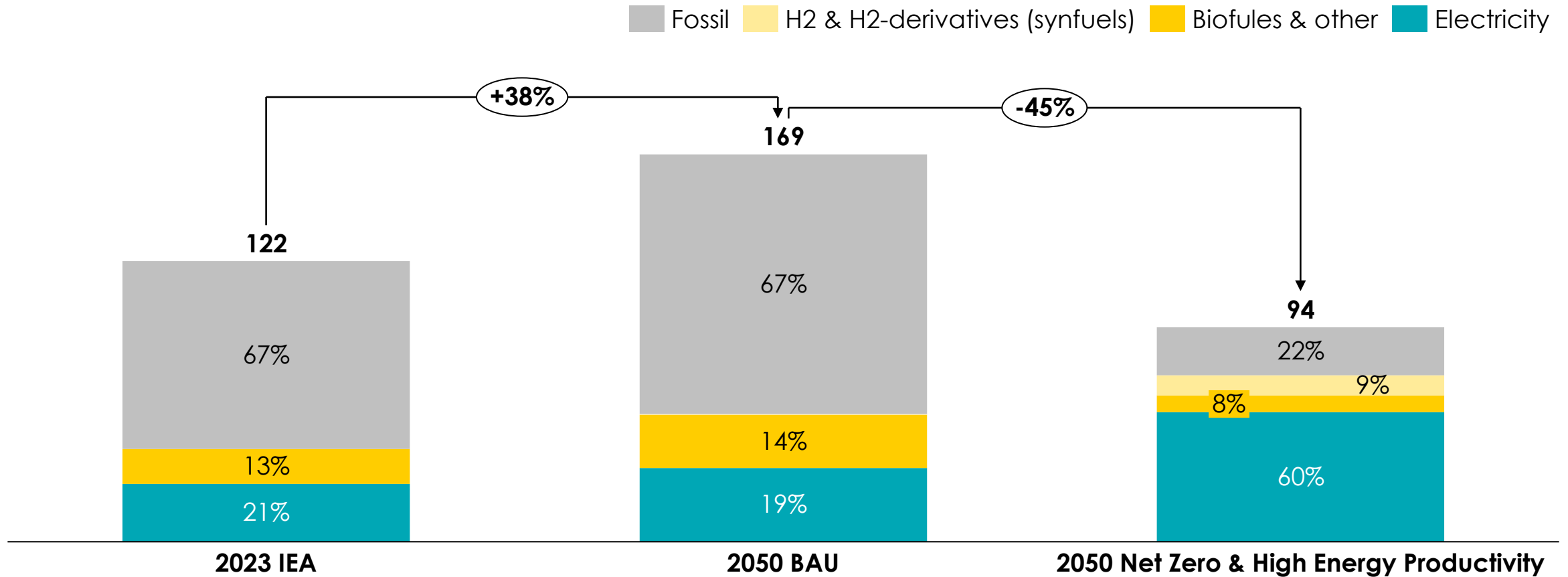
Total energy



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

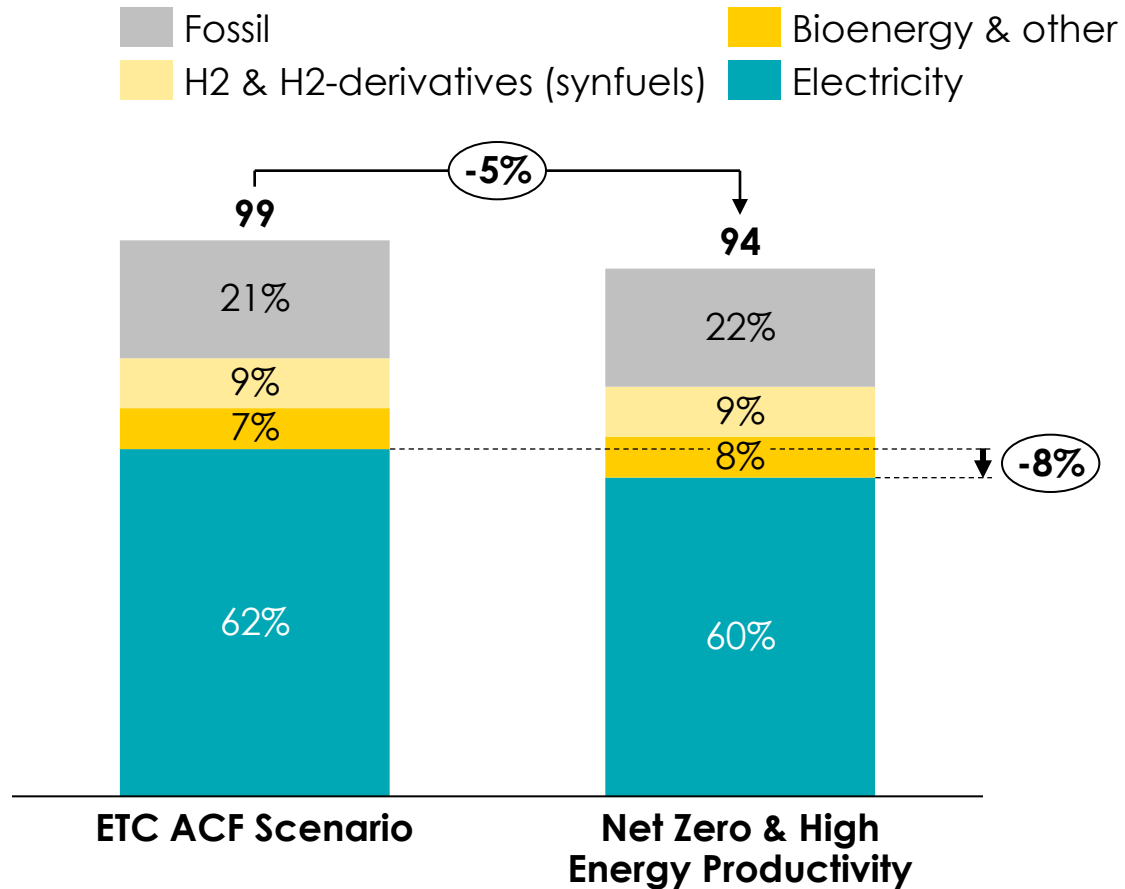


Source: IEA (2025) World Energy Outlook; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Achieving Zero-Carbon Buildings; ETC(2023), Fossil Fuels in Transition; BNEF (2023) Vehicle Outlook; Systemiq analysis for ETC.

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

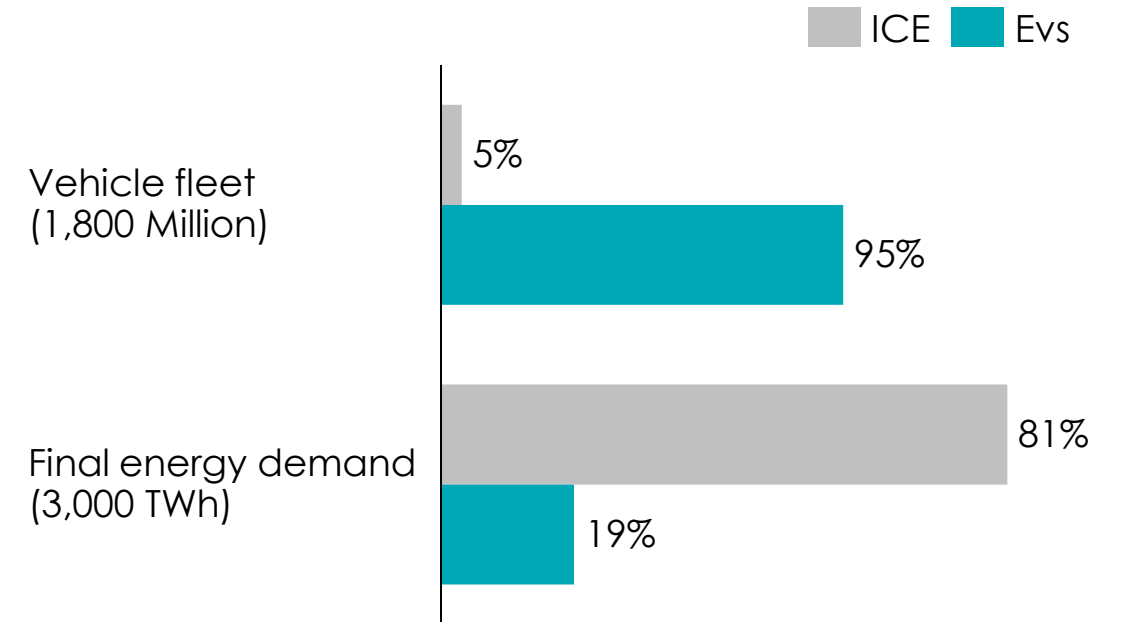
2050 Global Final Energy demand scenarios

000 TWh



Case study: Passenger road transport in 2050

Billion Km; TWh



Despite a **fleet that is 95% of Electric Vehicle**, **Electricity is still just less than 20%** of road passengers final energy demand

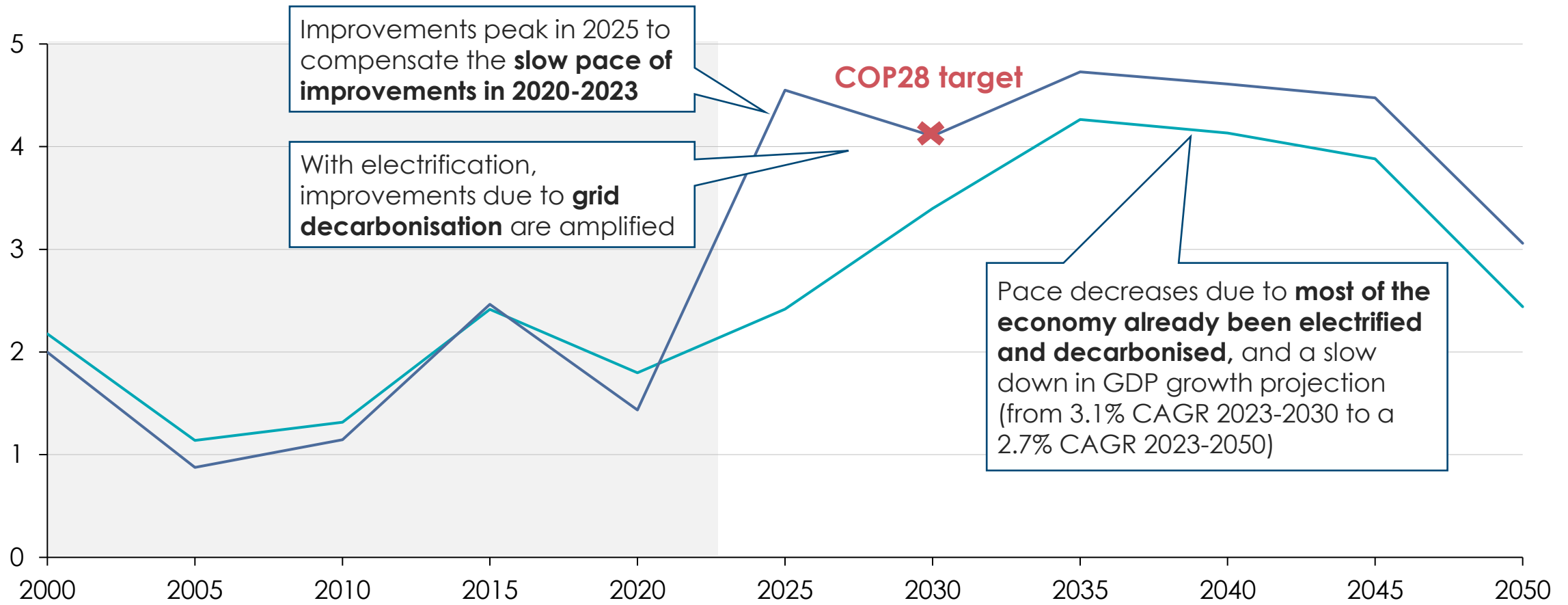


A 4% improvement in energy intensity by 2030, aligned to COP28 targets, will depend on immediately accelerating efforts in energy productivity

5-Year CAGR Energy productivity improvement projection

%

— Final Energy — Primary Energy

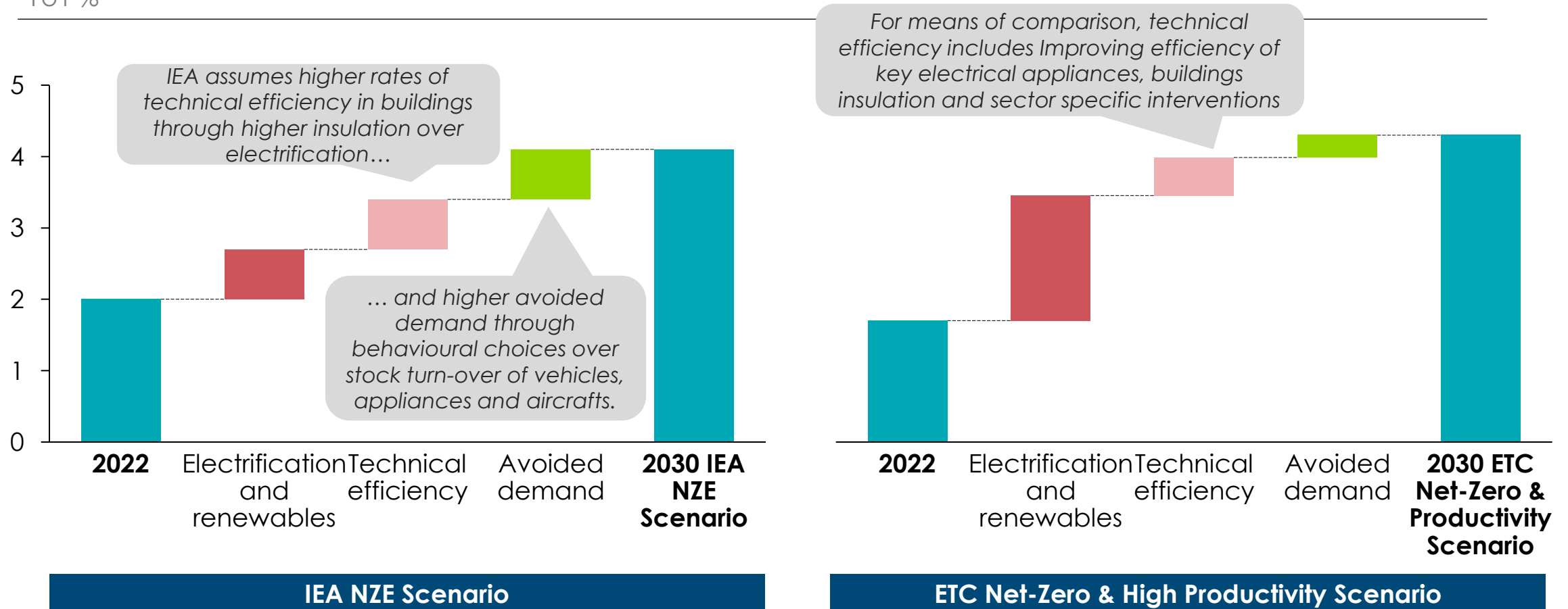


Source: Systemiq analysis for ETC, Our World in Data, World Bank, IMF Real GDP Annual Growth, IEA World Energy Outlook 2024

Despite changes in methodology, i.e. differences in electrification vs behavioural assumptions, IEA and ETC achieve COP28's 4% target by 2030

Primary energy productivity improvement by lever contribution

YoY %



Note:

Source: IEA (2025) World Energy Outlook; Systemiq analysis for ETC; MPP (2023) Hard-to-Abate Sector Transition Strategies; ETC (2025) Buildings, BNEF (2023) Vehicle Outlook

Agenda

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



Key messages

Key messages

A decarbonized, high energy productivity system can reduce overall energy demand while providing growing standards of living

Electrification and appliance efficiency are game changers

Hard to abate sectors need productivity levers to offset energy intensive fuel switch

Clear strategic vision supported by policy is needed to drive action

Energy productivity delivers a lower cost and more secure energy transition

Comment

- 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
- 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**
- **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.
- 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
- 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	<ul style="list-style-type: none"> • 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
	2 Improvements in the efficiency of electrical appliances and vehicles	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 MtCO₂/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



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 GtCO₂e to as low as 4.6 GtCO₂e**
- **Lower impact on planetary boundaries**, by reducing clean energy system requirements for water and land use by 4 billion m³ and 0.05 million km² 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**.

