Energy Productivity: Unlocking Growth and Savings

The Energy Transitions Commission's insights briefing, ***Energy productivity: Increasing efficiency in an expanded, electrified energy system,***[1] highlights a major opportunity for the world to more than double the global economy by 2050 while using 24% less energy input. Over this period the growth of "energy services" will continue to grow rapidly, with cooling and aviation demand up 150% while road transport grows 70%. But improved efficiency, delivered mainly through electrification, means that much less energy input is required to deliver these benefits. Seizing this opportunity will enable the world to dramatically cut the use of fossil fuels and the resulting emissions, while reducing the resource needs and costs of the new electrified energy system.

1. The economy can grow while using less energy input and displacing fossil fuels

As global prosperity rises, so too will demand for energy services. By 2050, floor area heated could grow 25%, the cooled area by 150%, passenger road kilometres travelled by 70%, and aviation passenger kilometres by 150%. In addition, demand for materials will grow with 100% more aluminium, 70% more plastic use and 25% more steel. These increases will result from and will make possible a doubling of global GDP.

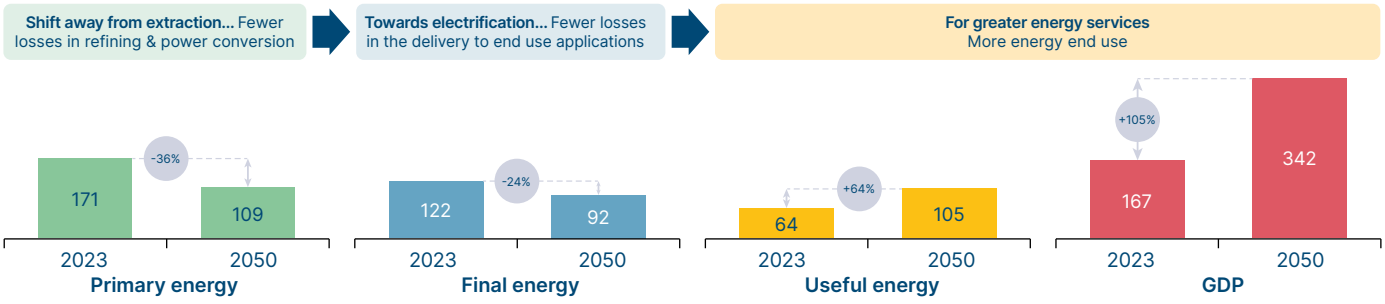
Energy productivity = 2× GDP with ¼ less energy demand

But this dramatic growth in energy services can be delivered while using 24% less final energy[2] (i.e. the energy input into vehicles or appliances) and 36% less primary energy[3] (i.e. energy inputs before conversion losses in power stations and refineries) [Exhibit 1].

Exhibit 1

Clean electrification and efficiency lead to a 25-35% reduction in primary and final energy, a 65% increase in useful energy, and a doubling of GDP

Net-zero energy demand with energy productivity levers
Energy in '000 TWh; GDP in constant 2021 $ Trillion



NOTE: Useful energy in 2050 was estimated by applying specific efficiency assumptions to each category of final energy demand. For electrified end uses, such as heating and cooling, assumed efficiencies reflect average performance of available technologies - e.g., 350% for heat pumps, 600% for air conditioners, and 80% for electric cooking. In road transport, EVs were modelled with 85% efficiency. Lighting efficiency was also assumed at 85% based on widespread LED adoption. For shipping and aviation, tank-to-wheel efficiencies remained unchanged at today's levels (30% and 40%). In industry, a decreasing final-to-useful energy ratio (starting from 1.4 in 2023 and falling 1% annually) reflects continued process improvements.

SOURCE: Systemiq analysis for the ETC; 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), *Electric Vehicle Outlook*; Systemiq (2022), *Planet Positive Chemicals*.

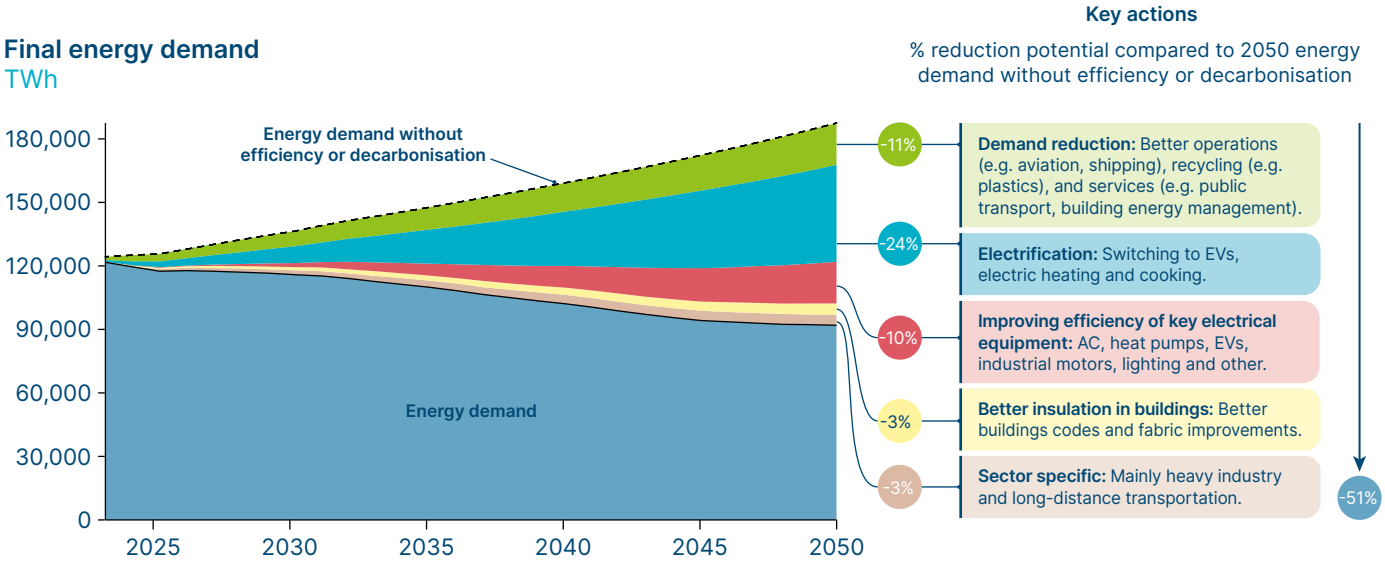
1 **Energy Productivity:** The amount of economic output (GDP) generated per unit of energy. This is the inverse of "Energy Intensity" which is the amount of energy consumed per unit of economic output (GDP). Energy productivity increases with efficiency improvements, while energy intensity falls.

2 **Final Energy:** A measure of how much energy is used at the point of application, e.g., the electricity used in appliances, gasoline in a fuel tank, or gas burned in a boiler. It is less than primary energy because of conversion losses in power generation, fuel refining, transmission and other processes.

3 **Primary Energy:** A measure of how much energy has to be put into the energy system before any conversion processes.

Exhibit 2

Productivity actions can reduce final energy demand 25% from today; 50% compared to business as usual



SOURCE: Systemiq analysis for the ETC; 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), *Electric Vehicle Outlook*.

At the final energy level, the 24% fall would represent a 50% reduction relative to business as usual [Exhibit 2] and is primarily made possible by:

- **Electrification,** which enables dramatic increases in the ratio of useful to final energy. Electric vehicles, for instance, turn around 90% of the electricity input into kinetic energy in the wheels, while internal combustion engines achieve only 25%, and heat pumps can deliver four times as much heat per kilowatt hour of energy input as can gas boilers.
- **Increased efficiency of electrical equipment.** Air conditioning, heat pumps, EVs, motors, lighting and overall consumer appliances continue to improve in efficiency, with significant further gains already advancing. Newer industrial motors, for instance, are 40% more efficient than those of two standards ago.
- In addition, there are important opportunities to reduce the demand for energy inputs while delivering the same end service, for instance, by improving aviation operational efficiency, recycling plastics, or improving building insulation.

At the primary energy level, a still higher 36% reduction is possible because the move away from fossil fuels will eliminate the heat and other conversion losses currently incurred in power stations and oil refineries.

Many of these actions are already cost-effective or low-cost; some will require an upfront investment, which can deliver savings over time [Exhibit 3]. Overall, the energy productivity opportunity represents $15 trillion in possible savings on energy investment globally over the next 25 years and a fundamental shift in thinking: prosperity can grow while energy demand falls.

Exhibit 3

Typical cost effectiveness of different actions[1]

✓ Cheaper than current alternative ✓ Comparable or slightly higher than the current alternative ✓ Considerably higher than the current alternative

Main productivity actions

		Example of main technologies	Capital cost	Running cost	Total cost
Final Energy	Electrification	• Passengers EVs • Heat Pumps • Electric cooking[2]	✓ ✗ ✓	✓ ✓ ✓	✓ ✓ ✓
Final Energy	Equipment/vehicle efficiency improvement	• Efficient air conditioners • Industrial motors • LEDs	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓
Final Energy	Better insulation in buildings	• New buildings: envelopes and fabrics • Retrofit buildings: envelopes and fabrics	✓ ✗	✓ ✓	✓ ✓[3]
Final Energy	Heavy industry + long distance transportation	• Lightweight aircrafts • Aerodynamic vessels • Heat recover in heavy industry	✓ ✓ ✗	✓ ✓ ✓	✓ ✓ ✓
Final Energy	Reduced demand	• Plastics recycling (mechanical) • New public transportation and/or cycling lanes • Buildings smart energy system	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓
Primary Energy	Power sector decarbonisation	• Clean power generation & balancing	✓	✓	✓
Primary Energy	Low-carbon fuels	• Hydrogen and derivatives • Biofuels	✗ ✓	✗ ✗	✗ ✗

NOTE: 1. Scores represent typical cost impact for each category of action, but with significant variation by individual circumstance. Cost indications are before the impact carbon prices to offset any green cost premium / 2. Cooking counterfactual in the table is biomass, for gas costs should be comparable. / 3. Can be cost effective for specific well designed combinations of measure.

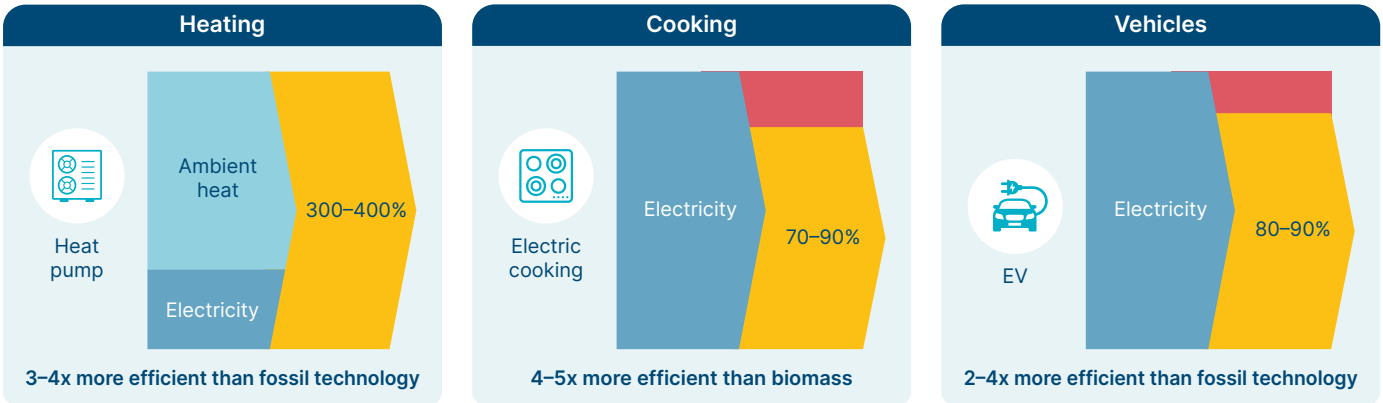
SOURCE: Systemiq analysis for ETC; IEA (2025), *Global EV Outlook 2025;* ETC (2025), *Achieving Net-Zero Buildings;* CLASP (2025), *World's Best MEPS.* Available at: https://www.clasp.ngo/tools/worlds-best-meps/ [Accessed July 2025]; ICCT (2013), *Long-term potential for increased shipping efficiency through the adoption of industry-leading practices;* MPP (2022), *Making Net-zero Aviation Possible;* Systemiq (2022), *Planet Positive Chemicals.*

Exhibit 4

Heat pumps, electric cooking and EVs use 2–5 times less energy than alternative technologies

Average efficiency from appliances and vehicles incumbent fuel vs. electric

Useful Energy Losses



NOTE: Biomass here refers to Traditional Use of Biomass (TUOB), predominantly wood; ICE = Internal combustion engine.

SOURCE: RMI (2024), *Clean Tech Revolution;* ETC (2025), *Achieving Zero-Carbon Buildings.*

2. Electrification of cars, building heating and cooking offer ~70% of total energy productivity gains

Electric vehicles are up to three times more efficient at turning energy into distance travelled than petrol cars. As ETC analysis shows, they can also be made up to 50% more efficient in the future compared with today.[4] In 2025, over 20 million EVs are expected to be sold, accounting for 1 in every 4 new cars purchased.

Heat pumps can provide three to four times more heat than gas boilers from the same amount of energy input. The market is starting to shift: in 2024, around 6 million heat pumps were sold globally, exceeding gas boiler sales in some key markets (e.g., by 30% in the United States). Electric cooking is 4-5 times more efficient than traditional use of biomass for cooking.

Beyond efficiency at the point of use, electrification also eliminates the large conversion losses from refining and transporting fossil fuels, amplifying the overall gains.

3. Efficient appliances and material recycling cut waste and costs

Beyond electrification, upgrading everyday appliances and equipment (such as electric vehicles, air conditioners, light bulbs and industrial motors) to more energy efficient models can do the same job with less energy and cut global energy demand by around 10% by 2050. In many cases, these improvements come at little or no extra cost, often recovering upfront costs through reduced energy use.

Zero additional cost

Stock turnover is crucial: efficient appliances and vehicles only deliver benefits if old, inefficient models are retired. Policies can accelerate this shift, for example,

Kenya and Ghana ban imports of second-hand vehicles over 8 and 10 years old, respectively, improving fleet efficiency.

In 2024, China's trade-in programme scrapped 120 million old and inefficient appliances, including 2.9 million vehicles, leading to over 720 billion RMB, ~$100 billion, in retail sales of newer models.

In industry, smarter material use and recycling to minimise waste could reduce energy needs by 44% in plastics, 33% in cement, and 27% in steel, while meeting strong output growth projections. For example;

Producing aluminium from recycled scrap, uses around 90% less energy than producing new metal and could be used to make cars, aircraft, and smartphones.

4. Energy productivity means getting more done with less energy, saving money, land, water and other natural resources

Productivity improvements can make energy work harder and:

Lower investment need: $600 billion of investment every year for new electricity generation and storage.

Lower impact on the planet: About 0.2 million km² of land that would have otherwise been required for renewable energy, an area the size of Ecuador or the UK.

Lower energy imports: Productivity improvements can strengthen energy security. For example, Germany could cut energy imports by 25% by 2035 and reduce the import bill by €20 billion annually (in 2023 prices).

Save $600 billion every year

Lower consumer costs: EVs, heat pumps and efficient appliances repay their upfront costs through lower bills and deliver lifetime savings; even ambitious plastics recycling targets would have minimal impact on product prices.

4 *The Road Ahead: Electrification, Design, and Mobility Choices for Efficient Transport* will be published by the ETC in December 2025.

5. A one-off opportunity, long-term trends and AI

At COP28, 118 countries pledged to double the rate of energy efficiency improvement from around 2% per annum in recent years to 4% by 2030. The ETC's analysis this could be made feasible by rapid electrification, with the higher rate of improvement maintained for around two decades.

Beyond then, however, as an electrification of the economy reaches completion, energy demand is likely to grow again, given the huge benefits which energy use delivers to human welfare. And it is possible that energy demand growth could be higher than our projections over the next two decades as a result of:

- Rebound effects, in which the reduced cost of energy encourages increased energy use: for instance, with consumers taking the benefits of more efficient air conditioners in the form of more extensive cooling services rather than reduced cost.
- The growth of AI, which will both help deliver several forms of energy efficiency improvement, but also create significant power demand for training and inference. The extent of this demand growth is inherently uncertain. Data centres – including for AI use - already consume around 350 TWh of electricity each year, and in 10 years, estimates show demand could rise to anywhere between 700 TWh (IEA) and 2,500 TWh (Thunder Said Energy).

These potential drivers of additional energy demand make it still more important to improve energy productivity as much as possible.

6. Action to seize the opportunity

To seize the opportunity for faster energy productivity improvement, countries should:

- Electrify road transport and building heating, by phasing out petrol cars and gas boilers, and supporting the adoption of electric vehicles and heat pumps.
- Raise minimum efficiency standards on appliances, encourage accelerated equipment turnover, and incentivise recycling and circular design.
- Decarbonise electricity systems by phasing out coal and subsequently gas, scaling up renewables, and investing in grids and storage.

Countries are beginning to act, but progress is uneven. Priorities differ by region:

- In all countries, electrifying road transport offers a major opportunity to cut oil use in many countries, reducing energy imports.
- In high-latitude regions (e.g., Europe, Canada, Northern China), the focus must also be on replacing gas boilers with electric heat pumps, as well as continuing to improve the strong product standards that have driven efficiency advances to date.
- In developing, primarily low-latitude nations, priorities include a combination of efficient air conditioning and more efficient, better insulated buildings designed to reduce peak electricity demand, increasing electrical appliance efficiency standards and the stock turnover of old, inefficient equipment, and replacing traditional biomass with cleaner cooking fuels or electricity, which can also deliver major health gains.

2x pace of efficiency improvement – from 2% to 4% per annum, maintained for two decades

Energy Transitions Commission