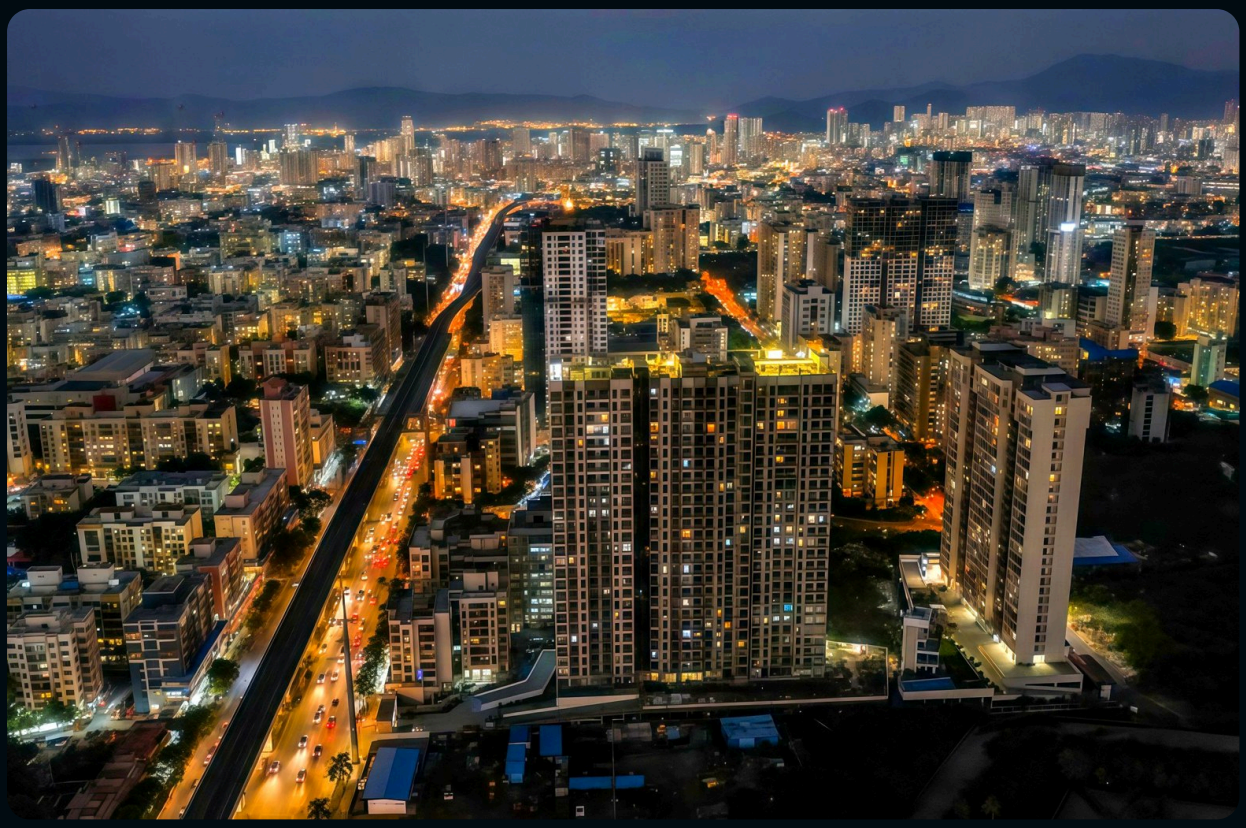


THE ELECTRIFICATION OPPORTUNITY

DELIVERING ENERGY SECURITY, DEVELOPMENT AND CLIMATE ACTION IN EMERGING MARKETS AND DEVELOPING ECONOMIES

SUSTAINABLE ENERGY FOR ALL

COP31 TÜRKİYE ANTALYA
IN PARTNERSHIP WITH AUSTRALIA

DISCLAIMER

This report was prepared by Sustainable Energy for All (SEforALL) in collaboration with the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) as a contribution to the COP31 Action Agenda on electrification.

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FOREWORD

As we gather in Antalya for COP31, we are focused on how everyone can seize the benefits of electrification. The global objective of increasing electricity's share in final energy consumption to 35% by 2035 provides a common direction. This report explores what this ambition means for emerging markets and developing economies.

Electrification is vital to meet growing energy demand, support economic development and reduce emissions, particularly when accompanied by sustainable sources. Furthermore, it can strengthen energy security, improve energy efficiency, expand access to reliable and affordable energy, and create new opportunities. Electricity use per person and income per person rise together. Electricity is an input to production, like labour and capital. Where it is scarce or unreliable, growth is held back. The evidence on jobs is just as clear. In Africa, where millions of young people enter the workforce each year, electrification can create new employment opportunities across a range of sectors.

Realising these benefits, particularly in emerging markets and developing economies, will require investment in infrastructure, access to finance and technology, and supportive policy frameworks. For EMDEs, especially those facing debt pressures, accelerating this transition is therefore essential. Each country, economy and region will have its own pathway and unique set of challenges. Some may electrify transport by focusing more on motorbikes than cars. Others may prioritise fitting buildings with electric stoves rather than heat pumps. Companies might need to electrify motors more than installing electrified industrial heating. And some grids need refurbishment, while others need installing to connect communities for the first time. We need to build awareness of the diversity of starting points, but, at its core, electrification should be everyone's mission.

Electrification now needs to be integrated into national energy and development planning. International collaboration is needed to boost the enabling conditions. At COP31, our priority is to translate this shared ambition into practical cooperation and action, building partnerships that can sustain progress well beyond Antalya. The growing collective support for the COP31 '35-by-35' global electrification objective reflects our shared determination to accelerate this agenda. I commend Sustainable Energy for All for its valuable contribution and invite governments, businesses, investors and international partners to work together to unlock the opportunities of electrification for all – from boosting global growth to keeping 1.5°C alive.

H.E. Murat Kurum

Minister of Environment, Urbanization and Climate Change
Government of Türkiye
COP31 President



FOREWORD

Electrification is one of the defining opportunities of the global energy transition.

As economies grow, cities expand, and demand for modern energy services increases, electricity will play an increasingly important role in meeting the world's energy needs.

For emerging markets and developing economies, it can strengthen energy security and put downward pressure on prices by reducing dependency on uncertain fossil fuel supply lines.

This report shows that electrification should be viewed as a strategic objective in its own right.

Electrification complements existing efforts to accelerate renewable energy deployment and improve energy efficiency. While renewables increase the supply of clean electricity, electrification enables electricity to power a greater share of economic activity. In addition to the economic opportunities, it means lower emissions and broader social benefits.

Accelerating electrification is also essential to reducing emissions at the scale required to keep 1.5 degrees within reach. While the Paris Agreement is working to bend the trajectory of global warming from 4 degrees of warming to 2.6 degrees today, we know every fraction of a degree matters and we must move faster.

As President of Negotiations, I've heard from countries across Asia, Africa, Latin America, and the Pacific about the opportunities and challenges of electrification. While every country will follow its own pathway, a common theme has emerged: electrification is good for the climate, economic development and energy security.

And there's more good news – as this report shows, the technologies we need to electrify transport, buildings and industry are already commercially available.

This year at COP31, we are working to accelerate electrification through effective planning, investment, enabling infrastructure, supportive policy frameworks and international cooperation. Because the tools for electrification are ready – and already here. Our task is to use them as effectively as possible.

Hon Chris Bowen MP

Australian Minister for Climate Change and Energy
COP31 President of Negotiations



ACKNOWLEDGEMENT

This report was prepared by Sustainable Energy for All (SEforALL) at the request of the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW).

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The report draws on SEforALL's Energy Transition and Investment Planning analysis, including regional and country pathways, as well as published research, policy documents and data from international organisations, national institutions and other stakeholders. We acknowledge the work of the researchers and institutions whose analysis has informed this publication.



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ELECTRIC BUS
Jak Lingko
Bus Listrik
transjakarta
MYS-22346
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BUS STOP

EXECUTIVE SUMMARY

The world is entering an age of electricity, but it is not electrifying fast enough to capture the full benefits of the energy transition. Electricity demand is rising as economies industrialise, cities expand, incomes increase, cooling needs intensify and more people seek access to modern energy services. Yet electricity's share of global total final energy consumption (TFEC) increased from 17.8% in 2010 to around 23% in 2025. The pace of change remains far below what is required to align economic development with global climate ambitions.

Electrification has emerged as a core climate priority for COP31. The COP31 Presidency's *35-by-35 Global Electrification Pledge*, raising electricity's share of global final energy consumption to 35% by 2035, provides a common direction for accelerating this transformation. Electrification is a whole-economy opportunity to deliver climate action alongside energy security, economic development, improved livelihoods and greater resilience. It enables countries to meet rising energy needs more efficiently, reduce dependence on fossil fuels, strengthen energy security and expand productive economic activity. For emerging markets and developing economies (EMDEs), it is also an opportunity to widen access to modern energy services and avoid locking new infrastructure into fossil-fuel-dependent systems.

This opportunity is particularly consequential for EMDEs as they will account for much of the world's future growth in electricity demand, driven by industrialisation, urbanisation, expanding energy access and rising demand for essential services. Thus electrification, in EMDEs, will advance through three simultaneous pathways: new electricity access, fuel-switching and new electric demand. Realising this opportunity requires a shift in how electrification is understood and planned.

In this context, the report examines, for EMDEs, the strategic case of electrification beyond its role in decarbonisation, capturing the opportunities for development, energy security and resilience, and the enabling conditions that would allow countries to accelerate it.

Key findings

1. **Electrification reinforces existing climate and development goals.** Electrification of end-use energy demand will create momentum for renewable energy deployment, while also unlocking significant energy efficiency as electric technologies are typically three times more efficient than the fossil equivalents they replace. Electrification therefore complements the commitments to triple renewable capacity and double energy efficiency improvement, and advances Sustainable Development Goal 7 (SDG7).

2. **Electrification enhances energy security and economic resilience.** Replacing imported fuels with domestic, largely renewable electricity reduces exposure to supply disruptions, price volatility and geopolitical risk. For example: in the ASEAN Energy Transition & Investment Roadmap, fossil fuel import dependence falls from 21% of primary energy supply in 2030 to 2% by 2050.
3. **Electrification is an economic and growth strategy.** It lowers energy costs, boosts productivity, strengthens industrial competitiveness and keeps energy spending within domestic economies.
4. **Electrification expands access and improves lives.** Some 655 million people still lack electricity and about 2 billion cook with polluting fuels. Grid and off-grid solutions can bring reliable power to underserved households, businesses, clinics and schools, with documented gains in women's employment, health outcomes and livelihoods, and greater resilience to climate shocks.
5. **Electrification is a deployment challenge, not a technology challenge.** Technologies available today can already electrify approximately 75% of global final energy demand across transport, buildings and industry. Rather than requiring technological breakthroughs, accelerating electrification depends on scaling deployment, mobilising finance, and upgrading power grids and enabling infrastructure to integrate these mature technologies at scale.
6. **The benefits are greatest when electrification is paired with clean power and enabling infrastructure.** The strongest economic, security and emissions outcomes come when end-use electrification advances alongside renewable deployment, modern grids, storage and demand flexibility.
7. **Planning and finance are the binding constraints.** Electrification is still too often treated as a downstream by-product of power-sector supply planning rather than a deliberate, economy-wide objective integrated into broader energy and development strategies. This lack of holistic planning is compounded by severe financing disparities: around 90% of global energy transition investment remains concentrated in advanced economies and China, while Africa receives only about 2% of clean energy investment despite accounting for a significant share of global demand growth.

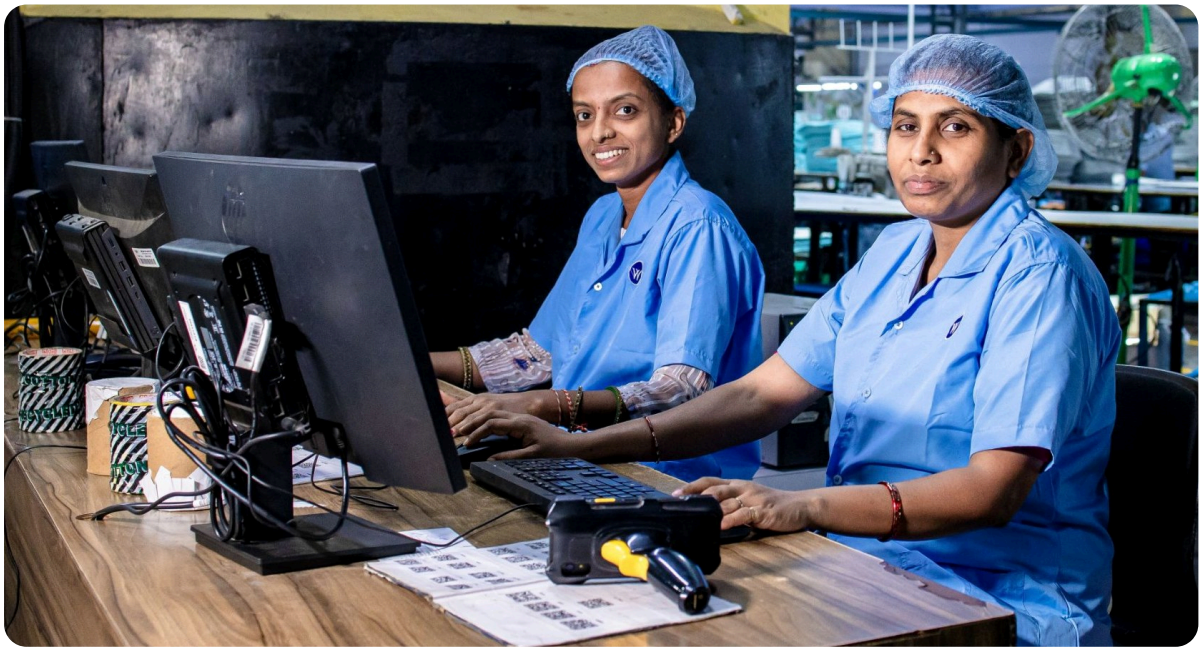
Enabling Conditions:

Delivering the electrification opportunity requires seven mutually reinforcing enabling conditions.

- → **Plan for electrification.** Make electrification a deliberate economy-wide objective, integrate power planning with Nationally Determined Contributions (NDCs) and with industrial, transport, cooking and agricultural strategies, align planning cycles and invest in the demand-side data.
- → **Mobilize finance and investment**. Reduce financing and currency risks, strengthen project preparation, expand consumer finance and use public and development finance strategically to crowd in private investments.

- → **Accelerate end-use electrification.** Remove barriers to the uptake of electric cooking, efficient cooling, electric vehicles, heat pumps and electric industrial heat etc. through efficiency standards, incentives, public procurement and enabling infrastructure.
- → **Scale clean electricity supply.** Translate electrification ambitions into renewable deployment pathways, supported by predictable procurement, bankable contracts and a mix of utility-scale and distributed renewable solutions.
- → **Expand grids, storage and system flexibility**. Anticipate demand growth, modernise transmission and distribution, accelerate grid connections, and invest in storage and regional interconnections that improve reliability and enable greater use of clean electricity. Reward flexible demand to reduce system costs and avoid curtailment of renewable generation.
- → **Create enabling policy, regulatory and market frameworks.** Align tariffs, taxes, regulation and market incentives with efficient electrification, system flexibility, investment certainty and consumer affordability.
- → **Build workforce and industrial capability.** Integrate workforce planning into electrification strategies, expand technical and vocational training, and support entrepreneurship with young people and women at its centre. Map critical technologies and supply risks, diversify equipment supply and develop competitive domestic and regional manufacturing where viable.

The 35-by-35 objective is achievable as a collective ambition, and its value for EMDEs will appear when it is pursued as a development opportunity in addition to a climate metric. Countries that plan for electrification deliberately, align it with their growth, security and access priorities, and mobilise the finance and institutions to deliver it will capture its benefits the most; those that treat it as a downstream outcome risk locking in fossil-fuel infrastructure for decades. As the international community moves from COP31 in Antalya towards COP32 in Addis Ababa, this report offers governments and their partners a practical evidence base and a set of enabling conditions to turn the global electrification objective into national action.





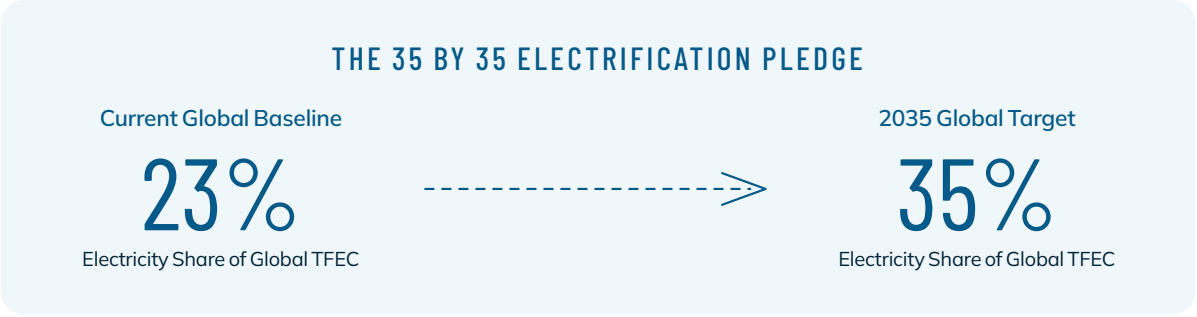
CHAPTER ONE

INTRODUCTION

> Globally, countries are turning to electrification as increasingly affordable and accessible electric technologies are delivering energy services, supporting economic growth and expanding energy access. This shift is already reshaping global energy demand: electricity use is growing faster than total energy demand, driven by industry, transport, cooling and digital infrastructure, with emerging and developing economies accounting for most of the increase. As power systems draw increasingly on renewable sources, electrification also provides a pathway to decouple economic growth from greenhouse gas (GHG) emissions.
>
> The COP31 *35-by-35 Global Electrification Pledge*, aiming to raise electricity to 35% of global final energy consumption by 2035, offers a clear and measurable goal. For emerging markets and developing economies, this pledge transcends mere decarbonisation; it presents a vital strategy to fulfill expanding energy needs with cleaner and more efficient technologies fuelled by locally available resources. In doing so, it helps prevent lock-in to fossil fuel infrastructure while enhancing access, productivity, resilience and sustainable economic transformation.
>
> Achieving it will require electrification to advance hand-in-hand with energy efficiency and infrastructure that supports it, from modernised centralised and decentralised grids to smart metering and charging, backed by unprecedented levels of finance, and implementation strategies tailored to each country's distinct starting position.

Electrification has emerged as a central pillar of the global climate and sustainable development agenda. As the international climate community convenes under the COP31 Presidency, the global energy dialogue is transitioning from high-level decarbonisation targets toward actionable, implementation-oriented pathways. A cornerstone of this shift is the *35-by-35 Global Electrification Pledge*, formalised in September 2026, aiming to increase electricity's share of total

final energy consumption (TFEC) to 35% globally by 2035, up from about 23% today[1]. The pledge establishes a shared benchmark while respecting differentiated national pathways corresponding to local circumstances, economic structure and starting points. It also recognises modern grids, energy storage and system flexibility as critical enablers of electrification, and highlights the urgent need for accessible and affordable finance for these investments, particularly in least developed countries, small island developing states and other developing economies.



Electricity is uniquely versatile. It is currently the only energy carrier that can be delivered efficiently across all sectors and generated from renewable resources in virtually every country in an increasingly cost-competitive manner. This makes electrification a central mechanism of an energy transition that delivers on climate commitments. Under IRENA's 1.5°C Scenario, electricity's share of global final energy consumption rises to 35% by 2035 and more than 50% by 2050, with solar and wind supplying over 80% of power by mid-century[2]. The IEA's Net Zero Emissions scenario points in the same direction, with electricity reaching 55% of final energy consumption by 2050, and the IEA estimates that clean power and widespread electrification together deliver two-thirds of the emissions reductions required by 2035[3]. Analysis of integrated assessment pathways by Climate Resource finds that a 35% global electrification rate by 2035 sits at the median of current lowest-overshoot 1.5°C pathways[4].

Yet electrification alone is not enough: its benefits depend on accelerated renewable power deployment, enhanced grid infrastructure, energy efficiency improvements and demand-side management. Pursued together, these measures can simultaneously reduce emissions, strengthen energy security, improve affordability and support green industrialisation and competitiveness.

The next phase of the energy transition will be defined not only by how rapidly the world builds clean electricity, but by how effectively that electricity is used across the economy. Nowhere is this more consequential than in emerging markets and developing economies (EMDEs), which are experiencing a significant upward trend in energy demand due to urbanisation, rising consumption, expanding industrial capacities, increasing cooling needs and expanding energy access.

1 United Nations Framework Convention on Climate Change (UNFCCC) (2026). 'COP31 Presidency announces new targets on global electrification, cutting waste, resilient cities'. Available at: https://unfccc.int/news/cop31-presidency-announces-new-targets-on-global-electrification-cutting-waste-resilient-cities

2 International Renewable Energy Agency (IRENA) (2026). World Energy Transitions Outlook 2026: 1.5°C Pathway. Abu Dhabi: IRENA. Available at: https://www.irena.org/Publications/2026/Oct/World-Energy-Transitions-Outlook-2026

3 International Energy Agency (IEA) (2025). World Energy Outlook 2025. Paris: IEA. Available at: https://www.iea.org/reports/world-energy-outlook-2025

4 Climate Resource (2026). 'Keeping 1.5°C within reach: New analysis on the role of electrification'. Available at: https://www.climate-resource.com/news/global_electrification_15

Electrification offers a proven mechanism to contribute to decoupling between emissions and socio-economic growth and development while advancing energy security. When paired with the rapid scale-up of renewable power generation, existing sets of technologies displace fossil fuels from end-use sectors through direct electrification and bring significant energy efficiency gains, resulting in overall reduced future energy demand. For EMDEs still building out their industrial base and infrastructure, this creates an opportunity to leapfrog fossil-intensive development. They can build electrified industries, transport systems and buildings from the outset, avoid locking in fossil fuel assets, and position themselves to compete in the clean industrial value chains that will shape the global economy.

For EMDEs, electrification is also essential for human development. Over 655 million people worldwide remained without access to electricity in 2024, and approximately 2 billion people relied on polluting, inefficient biomass and solid fuels for domestic cooking.[5] At the same time, millions of communities continue to be served by health and educational facilities with no or unreliable modern energy access, impeding critical public service delivery. Electrification therefore offers EMDEs a pivotal opportunity to expand access to modern energy services, strengthen energy security and support economic development, while delivering on their climate commitments.

1.1 Age of electricity

It is estimated that technologies available today could electrify approximately 75% of global final energy demand, including most transport and buildings and significant parts of industry.[6] As electricity accounts for a growing share of TFEC, overall final energy demand in 2050 could be about 6% lower than in 2020, reflecting efficiency improvements, increased renewable deployment and changes in consumption patterns. A decline in TFEC, despite economic growth and universal energy access, will be a significant outcome of electrification.

Global electricity demand is advancing through three distinct mechanisms, described in Box 1, capturing new and improved electricity access to unserved and underserved populations; fuel-switching from existing fuels to electric alternatives; and new electric demand created by growth, urbanisation and green industrialisation. The anticipated energy demand growth coincides with increasing availability and affordability of electric technologies, which offers strong opportunities for EMDE countries to leapfrog. In 2025, global electricity demand increased by around 3%, more than twice the 1.3% growth in total energy demand, indicating electricity is trending towards representing a higher share of overall energy demand[7]. Through 2030, electricity demand grows at least 2.5 times faster than total energy demand. EMDEs accounted for about 80% of global electricity-demand growth in 2025 and are expected to retain this momentum through 2030[8]. The anticipated growth is largely contributed by China, India and Southeast Asia.

5 Sustainable Energy for All (SEforALL) (2026). SDG 7 Tracking Report 2026. Available at: https://www.seforall.org/publications/tracking-sdg7

6 World Business Council for Sustainable Development (WBCSD) (2026). Closing the Electrification Gap: Six Priority Actions to Unlock Investment. WBCSD.

7 International Energy Agency (IEA) (2026). Global Energy Review 2026. Paris: IEA. Available at: https://www.iea.org/reports/global-energy-review-2026

8 International Energy Agency (IEA) (2026). Electricity 2026: Analysis and Forecast to 2030. Paris: IEA. Available at: https://www.iea.org/reports/electricity-2026

Box 1: Electrification pathways

Energy Access: The delivery of electricity services to previously unserved households, businesses or public institutions, delivered through grid connection, mini-grid, or standalone systems. Example: a rural household connected to a solar mini-grid, unlocking a range of electricity services including lighting and phone charging.

Fuel-switch: It includes replacement of a fossil-fuelled or traditional-biomass end-use technology with an electric alternative which delivers the same service. It increases electricity consumption while reducing total final energy consumption. Example: A textile factory replacing a gas-fired boiler with an industrial heat pump for low-temperature process heat, or households transitioning from charcoal or traditional biomass to electric cooking.

New Demand: Growth in electricity consumption from services that are newly demanded, driven by rising incomes, industrialisation, urbanisation, structural change in the economy, or newly viable productive uses. The electricity demand is new rather than unserved or switched. Example: households buying their first air conditioner due to rising temperatures and income, or a new aluminium smelter or data centre coming online.

Distributed renewable energy (DRE), including solar home systems, renewable mini-grids and other off-grid solutions, is extending electricity to communities in EMDEs, where conventional grid extension is slow, costly or physically difficult. DRE's contribution to electricity demand remains modest, however decreases in solar and storage costs, and more efficient appliances are opening up new uses for electricity, including electric cooking and productive activities.

However, the pace of global electrification remains slow. Over the past 15 years, (2010–2025), electricity's share of global final energy consumption grew from 17.8% to about 23%. The current pace of electrification needs further acceleration to meet the 35-by-35 globally electrification target. In a net-zero energy transition scenario, electricity exceeds 50% of TFEC by 2050 as discussed earlier, requiring new energy demand to be increasingly electric. EMDEs, with growing energy demand, will be the centre of action.

1.2 Electrification and climate commitments

Electrification connects the supply-side transformation of the power system with the demand-side transformation through the direct electrification of transport, buildings, industry and productive uses. It supports renewable energy growth by creating demand for clean electricity, and delivers energy-efficiency gains because electric technologies are inherently more efficient than the fossil-fuel technologies they replace. However, electrification is inherently not synonymous with decarbonisation. Electrification, even in fossil-fuel-dependent grids, will reduce emissions due to efficiency-gains, however, electrification together with clean power will maximise the emissions reduction aligned with climate commitments.

For much of the past decade, climate change mitigation has been framed principally around the decarbonisation of electricity generation, with a focus on accelerating renewable energy

deployment, energy storage capacity, coal retirement and modernising electricity. However, to reduce greenhouse gas (GHG) emissions and fulfil medium to long-term climate commitments, power sector decarbonisation must be built along with the electrification of the energy demand in all sectors of the economy. This will allow the rising energy demand, especially in EMDEs, to be met increasingly with clean power and ensure progressively lower emissions.

The relationship between electrification and energy efficiency is particularly important. Electric technologies deliver the same energy service with substantially lower energy inputs than their fossil-fuel alternatives. Heat pumps, for example, can provide three to five units of useful heat per unit of electricity consumed, substantially reducing the energy required compared with conventional gas boilers. Such efficiency gains can lower energy demand and operating costs while contributing to emissions reductions, including in many electricity systems that have yet to fully transition away from fossil fuels[9]. As electricity generation becomes cleaner, these benefits are further strengthened, and clean electrification could abate around 60% of global GHG emissions while also reducing costs[10].

In this context, the *35-by-35 Global Electrification Pledge* becomes a primary implementation mechanism for delivering climate commitments including tripling renewable energy capacity and doubling the global average annual rate of energy efficiency improvements by 2030, alongside accelerating the transition away from fossil fuels in energy systems.[11]

The timing of electrification choices is also consequential for countries considering the energy infrastructure and equipment installed today, as these assets are likely to operate for the next 20 to 30 years or more. Vehicles, buildings, industrial equipment, generation assets, transmission networks and urban infrastructure can therefore lock in patterns of energy use well beyond the current policy cycle. Building new fossil-fuel-dependent assets today will also increase future transition costs through premature retirement, costly retrofits or replacement before the end of useful life. Conversely, integrating electrification into investment decisions now can avoid unnecessary lock-in and align new infrastructure with the direction of a climate-compliant energy transition. Electrification and renewables are also mutually reinforcing. Higher electricity use could spread the fixed costs of electricity networks over more units of demand, lowering per-unit prices and strengthening the case for further electrification.

1.3 Common but differentiated country pathways to electrification

The global electrification opportunity is substantial, but the pathway will not be uniform. Countries will differ in their levels of electricity access, electricity consumption and energy intensity, as well as in their economic structures, urbanisation patterns, fossil-fuel dependence, climatic conditions, renewable-resource endowments, power-system maturity and access to capital.

Advanced economies exhibit mature grid infrastructures delivering uninterrupted power, with per capita electricity generation exceeding 9,000 kWh per year.[12] In these contexts, power systems are

9 Staffell, I. et al. (2026). 'Comment on "Reappraisal of paths to decarbonising British electricity generation in 2030"'. Environmental Research: Energy, 3, 048002.

10 Energy Transitions Commission (2026). Energy Transition Monitor 2026. Available at: https://www.energy-transitions.org/publications/energy-transition-monitor-2026/

11 United Nations Framework Convention on Climate Change (UNFCCC) (2023). 'COP28 Agreement Signals "Beginning of the End" of the Fossil Fuel Era'. Available at: https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era

12 Ember (2026); Energy Institute – Statistical Review of World Energy (2026)

mature and access to reliable electricity is universal, even though fossil fuel still dominates end-use sectors. The electrification challenge in advanced economies, with mature energy systems, slow growth in population and energy demand growth, and existing capital stock built around fossil fuels, is predominantly about fuel-switching: shifting light vehicle fleets from internal combustion engines to battery-electric drivetrains; replacing natural gas and oil-fired space heating with thermodynamic heat pumps; and converting low-to-medium temperature industrial steam processes to electric resistance, infrared, or microwave systems.

Middle-income developing economies occupy an intermediate and rapidly moving position. Across regions such as Southeast Asia and Latin America, electricity access rates have expanded rapidly over the past two decades, often approaching 95% or higher. However, electricity's share of TFEC remains between 18% and 24% due to the dominance of petroleum products in transport networks and coal and gas in heavy industrial heat processes. These nations face rising consumer demand driven by expanding middle classes, rapid urbanisation, and extreme ambient temperatures that necessitate active cooling.

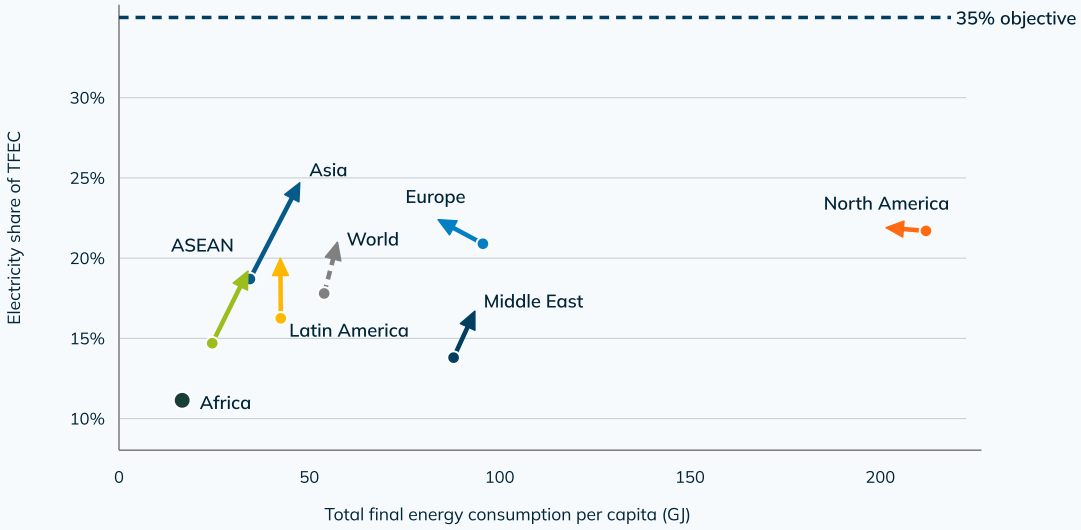
Conversely, in low-income economies, predominantly concentrated in Sub-Saharan Africa and island nations, per capita annual electricity consumption frequently remains below 300 kWh. In these regions, electricity represents less than 10% of TFEC.[13] The balance of final energy is dominated by raw, unrefined biomass (firewood, agricultural residues and charcoal) burned at low thermal efficiencies in domestic settings.

Figure 1 captures the relationship between energy consumption and electrification between 2010 and 2024. The direction of the arrow, 2010 being the tail and 2024 being the head, showcases the evolution of this relationship across the different regions. Asia and ASEAN are moving towards higher electricity shares while energy consumption per capita is also rising, reflecting industrialisation, urbanisation, cooling, appliances and expanding productive activity. South Asia, particularly India, faces a combination of rising household demand, cooling, mobility, manufacturing and digitalisation, making simultaneous expansion of generation and networks essential. ASEAN economies face similarly strong industrial and urban demand, alongside major opportunities for electric mobility and distributed solutions across archipelagic and remote areas.

Europe and North America start from much higher levels of energy consumption per capita and show more modest movement in the electricity share, indicating a deeper electrification challenge rather than an access challenge. Africa sits at a very different starting point, with much lower energy use per capita and a far smaller electricity base. In Africa, over the 2010–2024 period, the per capita TFEC and electricity share in TFEC have also remained stagnant, underscoring the importance of access, productive uses, distributed renewable energy and industrialisation. Latin America and the Caribbean occupy an intermediate but diverse position, with strong renewable-resource potential and opportunities to electrify transport, buildings and industry while strengthening regional integration.

13 African Energy Commission (AFREC) (2025). Key Africa Energy Statistics 2024. African Union. Available at: https://au-afrec.org/sites/default/files/2025-02/Digital%20KEY%20AFRICA%20ENERGY%20STATISTICS%20EN%20A5%20.pdf

Figure 1: Changes in energy consumption and electrification share in energy between 2010 and 2024, by region



Source: SEforALL analysis based on Enerdata's World Energy & Climate Statistics – Yearbook 2026[14] and World Bank's World Development Indicators[15] dataset. The World Energy & Climate Statistics – yearbook 2026 is used for "Share of electricity in total final energy consumption (%)" and "Electricity domestic consumption (TWh)" datapoints. The World Development Indicators dataset provides country population.

1.4 About this brief

This brief provides an overview of the electrification opportunity for EMDEs. It examines how the electrification agenda connects with other policy and development priorities, including climate action, energy security, energy access and livelihoods. In doing so, it aims to inform national and international discussions on the *35-by-35 Global Electrification Pledge* and how it can be implemented.

The brief draws on the latest international literature and data, and on SEforALL's Energy Transition and Investment Planning work with governments and regional institutions. That work spans Africa and Asia, including Ghana, India, Kenya, Nigeria, Sierra Leone and the ASEAN region, as well as small island developing states such as Barbados.

The brief first sets out the strategic case for electrification, showing how it supports economic development, energy security, human development, and climate adaptation and resilience (Chapter 2). It then examines electrification opportunities across buildings, transport, industry, and agriculture and productive use, drawing on country case studies to show how pathways differ with national circumstances (Chapter 3). Building on this analysis, it lays out priority actions to accelerate electrification, alongside the expansion of renewable electricity supply and the demand- and supply-side infrastructure needed to support it (Chapter 4).

14 Enerdata (2026). World Energy & Climate Statistics: Yearbook 2026. Available at: https://yearbook.enerdata.net

15 World Bank (2026). World Development Indicators: Population, Total (SP.POP.TOTL). Available at: https://data.worldbank.org/indicator/SP.POP.TOTL



CHAPTER TWO

THE STRATEGIC CASE FOR ELECTRIFICATION

The transformation of electricity supply with decarbonisation of end-use sectors makes electrification a central implementation pathway for the global transition away from fossil fuels. By replacing direct fossil-fuel combustion with electricity, electrification will improve energy efficiency and create demand for renewable energy.

The growing adoption of national net-zero ambitions reinforces the importance of this shift. According to the Climate Action Tracker, around 145 countries have announced or were considering net-zero targets as of October 2025, collectively covering close to 77% of global greenhouse gas (GHG) emissions. Many countries have established long-term ambitions extending towards mid-century, although target years and levels of commitment vary. Electrification will support countries to deliver on their respective net-zero ambitions by reducing fossil-fuel use in sectors where efficient electric alternatives are already available or emerging.

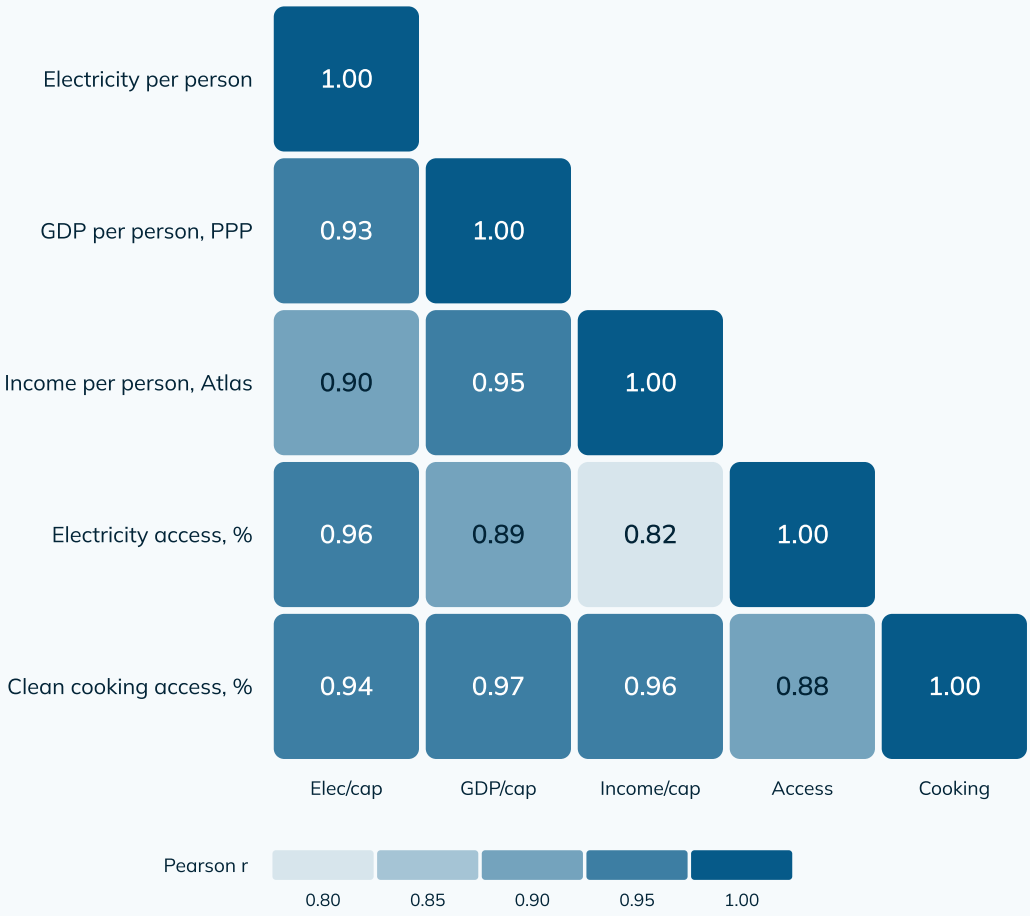
Sustainable Energy for All (SEforALL) Energy Transition and Investment Plans (ETIPs), developed with national governments and regional bodies, set out country-led pathways to net-zero energy systems and the investments needed to deliver them.[16] The ETIPs demonstrate that deep electrification is central to net-zero pathways for countries and regions, even when starting points and economic structures are different. This chapter discusses the linkages between electrification, socio-economic development, energy security and climate adaptation and resilience building on the evidence from the country and regional plans.

16 Sustainable Energy for All (SEforALL) (2026). Energy Transition and Investment Plans. Available at: https://www.seforall.org/our-work/initiatives-projects/energy-transition-plans

2.1 Electrification and economic development

Electricity is an essential input to production, alongside labour and capital. It powers the motors, machines, cold chains and digital services on which modern productivity depends, and where its supply is scarce or unreliable, growth is held back with it. SEforALL's national energy transition analyses across Sub-Saharan Africa and ASEAN consistently find that electricity use per person and income per person rise together, with Pearson correlation coefficients between 0.82 and 0.97 (Figure 2). For example the percentage of populations with access to clean cooking is highly correlated to per capita GDP, income and access to electricity. The higher the per capita electricity consumption, the higher the income, the higher the clean cooking share.

Figure 2: Electrification and economic growth correlation



Source: SEforALL assessment based on country and regional Energy Transition plans.

For emerging markets and developing economies, electrification lifts growth through four channels simultaneously: it lowers and stabilises the cost of energy for businesses and households; it delivers more output from every unit of energy; it opens industries and services that cannot exist without reliable power; and, by replacing imported fuels with domestically generated electricity, it

keeps energy spending, jobs and value within the national economy. Table 1 sets out the indicators through which this growth effect can be tracked.

Table 1: Economy and electrification growth indicators

Indicators	Growth Channel
Energy intensity of final demand (TFEC per unit of service)	Efficiency dividend (same output with less input). The lower the energy intensity to demand, the higher the efficiency and the higher the economic gain.
Electricity share of industrial final energy	Exposure of industry to fuel price volatility. Electrification of industrial energy supply hedges the risk of imported fossil fuel price volatility and corresponding impacts on price competitiveness of the manufactured items.
Electrified production routes (electric arc furnace, electric low-temperature heat processes)	Access to modern process technology. Higher electrified production processes require access to modern technology
Fossil import volume avoided	Balance of payments status stabilises for the countries depending on the cost of fuel imports purchased in trading currency such as the USD should the country enhance electrification of its energy supply.
Operating expenditure trajectory	The running-cost savings. Fuel shift towards electricity reduces operating costs due to discontinuation of use of imported fossil fuels and achieving overall system efficiency.

2.2.1 Development co-benefits

Electrification changes the cost structure of production in the economy, making it more cost effective and resource-efficient. A diesel generator, a furnace or a truck fleet converts a recurring, volatile, foreign-currency operating cost into output. For a manufacturer, electrification does three things simultaneously.

a) **Removes exposure to fuel price volatility from the cost base.** Once the capital is sunk, the marginal cost of production is a tariff set domestically rather than a commodity price set abroad.
b) **Delivers more services with less energy.** Electric drivetrains, motors and heat pumps convert a far higher share of input energy into useful work.
c) **Opens production routes that were previously unavailable.** Electricity opens up new industrial processes such as electric arc steel, induction melting, electrolytic chemicals, and precision process heat, that cannot be run on biomass or small diesel sets.

Avoiding Investment Lock-in. Building the new base for electrification of industries is always more economical than retrofitting. The marginal cost of choosing an electric furnace over a fossil fuel furnace is far more economical than the cost of replacing the latter mid-life.

Avoiding Human Capital Losses. Energy transition pathways for countries showcase reduced dependence on traditional biomass, leading to benefits well beyond energy outcomes. In Kenya, traditional biomass is projected to fall from 486 PJ to zero by 2030, and in Nigeria from 171 PJ to zero by 2035. This will free up time previously spent collecting fuel, improve health outcomes, support school attendance, and reduce deforestation and associated emissions. Many of these social, economic and environmental benefits are realised early in the electrification transition.

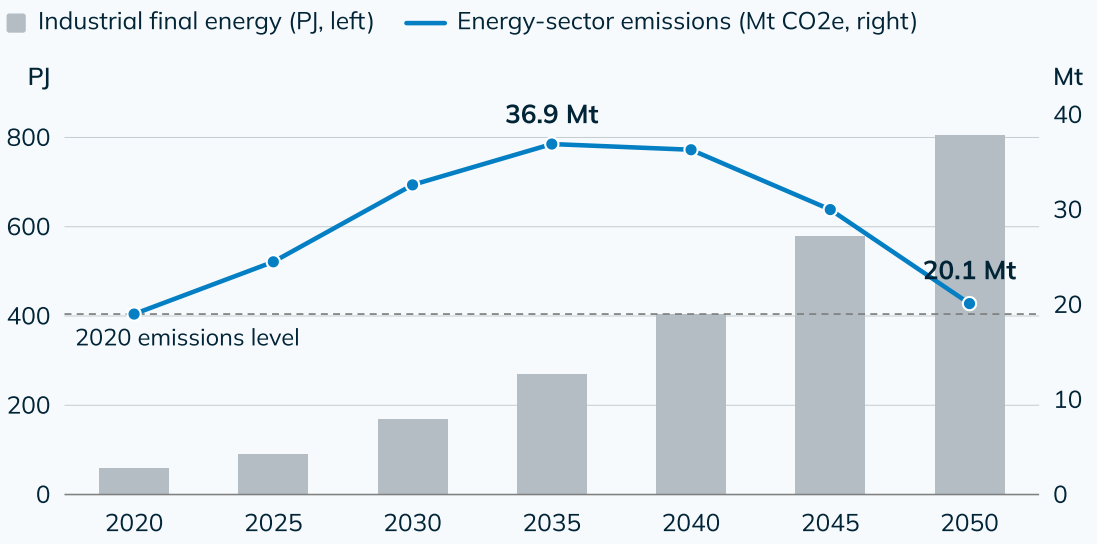
Opportunity of technology leapfrogging. Countries can also move directly to electric technologies, leapfrogging any intermediate technology and fuel. The transport sector, with rapid uptake of electric vehicles, is already witnessing one such leapfrog. In emerging markets and developing economies (EMDEs), when the vehicle fleet electrifies before it fully motorises, countries will avoid investment in building out the fuel distribution networks that more motorised economies now have to unwind.

The national net-zero pathways discussed further below illustrate these gains. In Nigeria, transport final energy is projected to halve between 2020 and 2050, from 1,191 PJ to 601 PJ, even as transport activity grows. The fuel savings are a direct outcome of Nigeria's transport sector reaching 95% electrification, in 2050. In Kenya, TFEC falls from 904 PJ to 821 PJ over the same period while the economy expands, as traditional biomass gives way to far more efficient electric end uses. For economies whose energy needs are still growing, this means electrification can expand energy services without a proportional rise in energy use or fuel imports.

Kenya: Electrification supporting industrialisation while decoupling emissions

Kenya's transition pathway shows an economy industrialising 13-fold on a grid that is already dominated by renewables; energy-sector emissions are projected to peak in 2035 and return to roughly their 2020 level by 2050 (Figure 3). It is the clearest case that electrification works as a development strategy rather than as a constraint on one.

Figure 3: Industrial energy consumption and carbon emission trajectory



Source: SEforALL analysis based on Kenya country Energy Transition Plan

Kenya's distinctive feature is that it starts with a clean grid and relatively small industrial base. Geothermal and hydro energy already supply over 94% of generation, so the question facing Kenya is not how to clean up its power sector but whether it can grow an industrial economy with this power system. The economy and the emissions curve move independently. Industrial energy demand is projected to rise 13-fold while total energy-sector emissions peak at 36.9 Mt in 2035 and fall back to 20.1 Mt by 2050, about 5% above the 2020 level. Kenya is not cutting emissions in absolute terms over the period. It is building an industrial economy that is several times larger without a proportional increase in emissions, which is a different and, for a developing economy, a more challenging task. ASEAN's regional energy demand is projected to reach 2.6 times its 2022 level by 2050. These economies are not simply retrofitting an industrial base, rather they are building new bases.

Nigeria: Electrification accelerating sectoral decarbonisation

In Nigeria, electricity was **1.9% of final energy** in 2020. Under the Nigeria Energy Transition and Investment Plan[17], electricity is projected to increase from 1.9% of final energy in 2020 to 14% in 2030 and **75.5% by 2050.** Generation rises from 30 TWh to 99 TWh to 400 TWh, capacity from 13.6 GW to 197 GW, with solar supplying 79% of generation by 2050. Industrial final energy grows 2.8-fold, from 200 PJ to 559 PJ. Domestic oil use in final energy falls 98%, from 1,227 PJ to 29 PJ.

Nigeria is the one country where electrification helps to reduce overall GHG emissions by displacing the direct use of fossil fuels. Energy-sector emissions drop from **105 Mt CO2e in 2020 to 29 Mt in 2050**, a 72% cut, with no peak above the 2020 level. Transport does most of the work, 46 Mt to 0.8 Mt, a 98% cut as road passenger activity goes 97% electric and energy intensity falls from 5.5 to 1.5 MJ per passenger-kilometre. Traditional biomass in final energy reaches zero by 2035, down from 171 PJ. Unlike Kenya, industry emissions rise, from 14 Mt to 20 Mt, and by 2050 industry is 68% of what remains. This differentiated impact of electrification highlights the structural differences between the economies across the regions and why electrification will have differentiated impacts on the system. While electrification solves Nigeria's transport and power emissions and leaves its industrial process emissions largely untouched, in Kenya it reduces emissions from industry by fuel shifting towards renewables.

Ghana: Turning energy access into electrification

Ghana is close to achieving universal electricity access, yet electricity still meets only a small share of its energy needs at only 17% of final consumption and less than a third of the population has access to clean cooking. Of the 23.2 TWh generation mix, about 63% comes from natural gas, 35% from hydro and under 1% from other renewables.

Ghana's Energy Transition and Investment Plan[18] sets a transition pathway to zero emissions by 2060. The electrification pathway shows roughly USD 182 billion of avoided fuel spending for the country. Four technology families: renewables, battery electric vehicles, clean cookstoves and efficiency, carry over 90% of the abatement, and three of the four are electrification. The

17 Government of Nigeria and Sustainable Energy for All (SEforALL) (2024). Nigeria Energy Transition and Investment Plan (ETIP 2.0). Available at: https://www.seforall.org/our-work/initiatives-projects/energy-transition-plans/nigeria

18 Sustainable Energy for All (SEforALL) (2025). Ghana Energy Transition and Investment Plan. Available at: https://www.seforall.org/our-work/initiatives-projects/energy-transition-plans/ghana

electrification process needs USD 4.4 billion for 2025–2030, of which USD 2.6 billion is expected from private capital. Ghana's energy transition highlights that access to electricity alone is not sufficient for the country to thrive; communities need to utilise it.

Transport represents 47.7% of Ghana's energy-related emissions – the largest single lever, and the one electrification reaches most directly. The national e-mobility roadmap's 1,000-bus programme implies cumulative savings of about 30 billion litres of gasoline-equivalent and 90 Mt CO_2 by 2050, with a further 27 Mt from car electrification. The extent of emissions displacement also relies on the decarbonisation of the grid. That is why the Ghana National Energy Compact commitment to move from 4% to 10% non-hydro renewable generation by 2030 (850 MW solar, 200 MW wind, 150 MW hydro) is a precondition for comprehensive gains[19].

2.2 Electrification and energy security

Energy security continues to be a key priority for EMDEs. Recent supply and price shocks have highlighted how energy security underpins a country's economic resilience and development goals. These shocks have prompted governments to adopt more ambitious targets to reduce reliance on imported fossil fuels and increase the use of domestic renewable energy resources. In this context, electrification plays a fundamental role by directly displacing fossil fuel use in transport, buildings and industry; expanding access to modern energy services; reducing reliance on fuel-based generators; and enhancing energy system resilience through sector coupling and improved efficiency.

Electrification influences energy security through four mechanisms:

a) **Direct substitution in end uses.** Direct substitution in end-use sectors reduces fossil fuel use at the exact point of consumption. When electric alternatives such as EVs, electric cookstoves or industrial electric furnaces replace fossil-fuelled equipment, they address vulnerability to commodity price volatility, supply chain disruptions and foreign exchange pressures. In EMDEs, this is particularly powerful in the transport sector, where refined petroleum products are largely imported. For example, in the ASEAN net-zero pathway, scaling transport electrification up to 61% by 2050 drastically cuts oil demand and serves as the single largest source of avoided fossil fuel imports, effectively decoupling economic mobility from external supply shocks.

   Similarly, shifting toward electric cooking replaces traditional fuels with domestically generated electricity, rather than with imported fuels such as LPG. Beyond enhancing energy security and relieving foreign exchange pressures, electric cooking delivers profound social and economic benefits. A national cost-benefit analysis shows that switching to electric cooking generates far more benefits than costs for society, with net social benefits of up to USD 710 per household per year through health, gender and environmental improvements. These benefits typically cover the upfront cost of the switch within the first year.

b) **Displacing fuel-based self-generation.** Where grid supply is unreliable, households and firms run diesel generators, and that diesel is imported at retail cost. Extending reliable

19 ibid

electricity access removes a fuel demand that rarely appears in official energy balances but is paid for in hard currency.

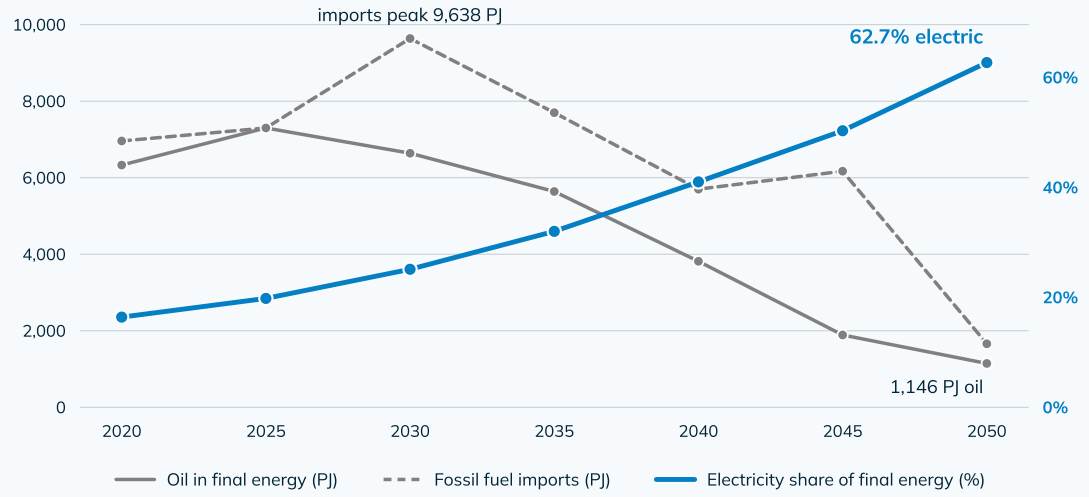
c) **Efficiency embedded in the conversion.** An electric motor delivers the same service from roughly a third of the energy input of an internal combustion engine, and a heat pump from a fraction of that of a boiler[20]. Electrified demand therefore falls even when the service level rises. Barbados shows this clearly. In its pathway, final energy consumption drops 19% between 2020 and 2050 while electricity consumption rises 56%.

The three cases presented here, ASEAN, Barbados and Sierra Leone, describe how electrification affects energy security in very different contexts.

ASEAN Pathway to net zero by 2050: The role of electrification and implications for fossil fuel imports

While several ASEAN countries are rich in fossil fuel resources, energy imports in 2024 marginally exceeded exports. Oil and associated products made up over 70% of imports[21]. According to the ASEAN Energy Transition and Investment Roadmap, electrification, across all end-use sectors, plays a key role in the region's net-zero pathway by 2050 with related reductions in fuel imports. Electricity rises from 16% of final energy in 2020 to around 32% in 2035 and 63% by 2050, and the fuel it displaces is overwhelmingly imported (Figure 4).

Figure 4: Oil demand and fossil fuel import trends in ASEAN



Source: Based on SEforALL, 2026[22]

20 International Energy Agency (IEA) (2023). World Energy Outlook 2023. Paris: IEA. Available at: https://www.iea.org/reports/world-energy-outlook-2023

21 ASEAN Centre for Energy (2026). ASEAN Energy Data & Statistics Dashboard. Available at: https://aeds-dashboards.aseanenergy.org/

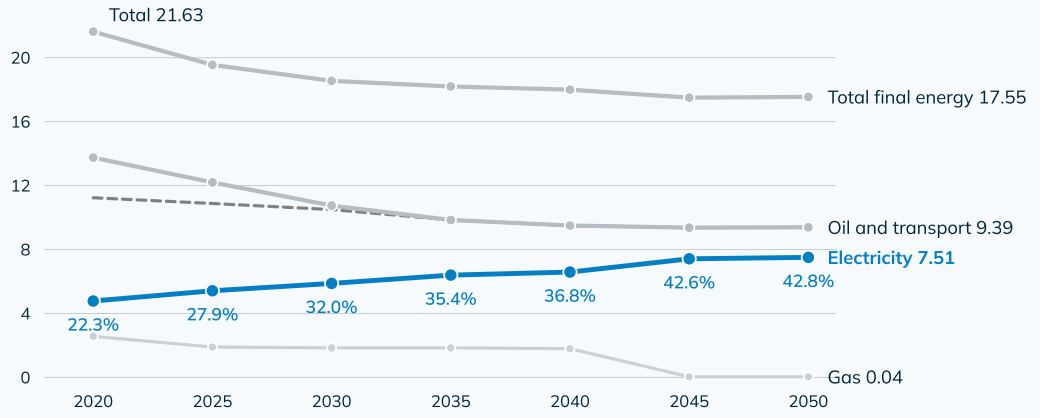
22 Sustainable Energy for All (SEforALL) (2026). ASEAN Energy Transition and Investment Roadmap. Available at: https://www.seforall.org/our-work/initiatives-projects/energy-transition-plans/asean

Electrification does not deliver import reduction benefits immediately, because the vehicle and equipment stock has to turn over first. After that the fall is steep: oil in final energy drops 84% from its 2025 peak to 2050, and fossil fuel imports drop 83% from their 2030 peak. Import dependence, measured as imports over total primary energy supply, falls from 21% in 2030 to 2% in 2050. The transport sector plays the most significant role. Electricity reaches 61% of transport final energy by 2050, which displaces refined oil product demand. Industry electrifies more slowly, from 22% to 47%, because of the limited role for direct electrification specifically in high-temperature heat processes.

Barbados: Reducing final energy demand and import dependency

Barbados imports virtually all of its fossil fuels and mirrors the experience of many **Small Island Developing States** (SIDS). The Barbados National ETIP[23], launched in 2025, demonstrates how renewable energy deployment and electrification can reduce fossil fuel dependence (Figure 5). Oil and gas use is projected to fall by 42% in 2050, while natural gas is effectively eliminated by 2045. As a result, TFEC declines by 19% in 2050 despite a 56% increase in electricity use, reflecting the efficiency dividend of electrification. At the same time, the share of clean electricity generation rises from 13% to 63%, driven mainly by the addition of wind generation, contributing to a halving of emissions over the period.

Figure 5: Evolution of final energy consumption, electrification and fuel mix, 2020–2050



Source: Ministry of Energy and Business, 2025[24]

Electrification has an overall impact on final energy demand. The decline in energy consumption is partially attributed to the electrification of industry, commercial and residential building, and agriculture. Industry accounts for 2.27 PJ of the total 4.08 PJ reduction in final energy demand; 3.24 PJ of fuel is displaced by 0.97 PJ of electricity, a ratio of 3.3 to one, which is the conversion-efficiency gain. Residential final energy actually *rises* because electricity grows faster than fuel falls – households are gaining energy services rather than saving energy, which is the desirable outcome

23 Ministry of Energy and Business, Government of Barbados (2025). Energy Transition and Investment Plan (ETIP). Available at: https://energy.gov.bb/publications/energy-transition-investment-plan-etip

24 ibid

and a reminder that lower final energy is not in itself the objective. Depending on the sectoral energy consumption profile, electrification in Barbados plays a critical role in reducing the consumption of imported fossil fuels.

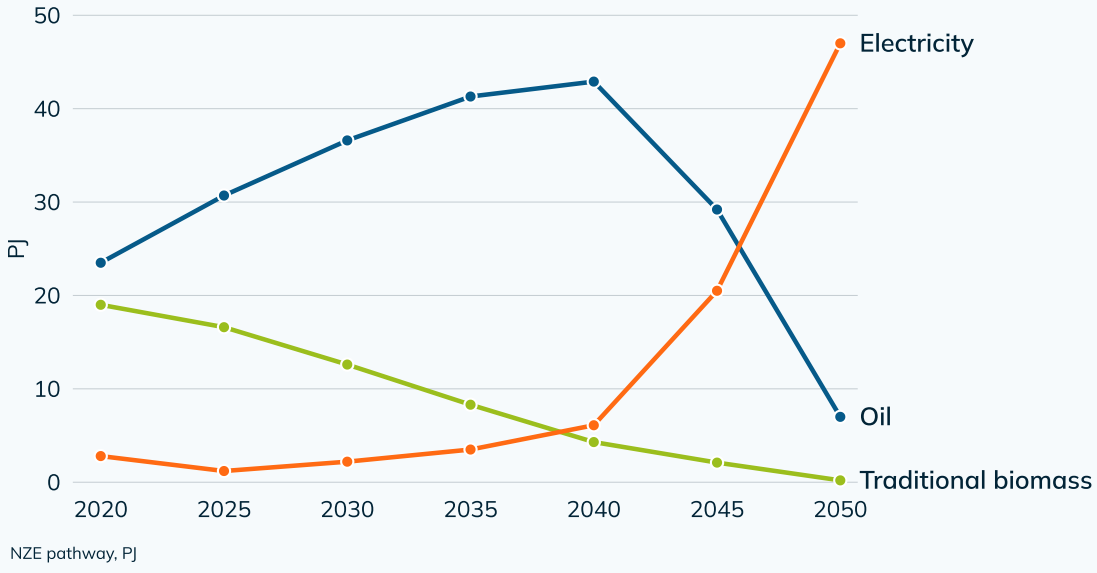
Sierra Leone: A story of energy independence through electrification

Sierra Leone begins from one of the lowest energy bases in the world. Access to electricity reached 39% of the population in 2024, but is heavily concentrated in Freetown: rural access is only around 25%. Traditional biomass accounts for an estimated 85% of total energy used, with the vast majority of households cooking with firewood or charcoal.

Import dependency is structural, not marginal. Sierra Leone relies almost entirely on petroleum product imports to meet its cross-sector energy needs. The exposure extends into the power sector itself: The country's functional installed capacity is roughly 100–150 MW, which falls far short of the 300–500 MW needed by 2030. Thermal generation bridges the gap. This includes offshore floating powerships in Freetown running on heavy fuel oil or liquefied natural gas (LNG), which have historically supplied around 80% of the dry season electricity supply. While the Bumbuna hydro project delivers about 50 MW in the rainy season, its output plummets in the dry months, creating a seasonal shortfall that has to be met by imported fuel.

Electrification, therefore, has significant implications. Connecting more households to a grid whose marginal supply is imported fuel oil moves the import bill rather than reducing it. The security benefit depends entirely on the generation being built alongside the demand; this is reflected in the 119-fold increase in domestic generation capacity in Sierra Leone (Figure 6).

Figure 6: Final energy by fuel type in Sierra Leone



Source: SEforALL analysis based on Sierra Leone Energy Transition net-zero pathway

2.3 Electrification as a human-centred development agenda

Access to reliable electricity underpins nearly every dimension of human development. Around 655 million people worldwide still lacked access to electricity in 2024, and over 2 billion people rely on polluting biomass and solid fuels for cooking[25] (IEA, IRENA, UNSD, World Bank and WHO, 2026). The cost of inaction is severe: lack of access to clean cooking alone is estimated to cost the global economy USD 2.4 trillion a year in combined health, gender and climate impacts[26] (ESMAP, 2020) – USD 791.4 billion annually in Sub-Saharan Africa[27] (African Energy Commission [AFREC], 2024).

This burden is concentrated overwhelmingly in rural, hardest-to-reach communities, where conventional grid extension alone may not be economically viable. Decentralised solutions like mini-grids, solar home systems and off-grid appliances can help bridge this gap while delivering benefits that extend well beyond basic electricity access. By enabling businesses to operate more productively; supporting agriculture and food systems; improving health and education services; reducing the time and labour associated with traditional fuels; and creating new economic opportunities, electrification can be a powerful driver of more inclusive human development.

These benefits are particularly visible in three interconnected areas:

- → **Stronger livelihoods and local economies.** Electrification for productive uses such as powering mills for grain and agricultural processing, cold storage for milk and agricultural produce, irrigation pumps for better yields, mechanical workshops and other productive equipment, can turn electricity access into increased incomes and employment. These uses can also strengthen the economic viability of decentralised energy systems by creating demand for electricity and generating additional revenues for mini-grid and off-grid providers. At the household level, access to electricity can enable new enterprises and income-generating activities, while at the community level it can support local value chains and reduce the economic pressures that contribute to out-migration.
- → **Greater opportunities for women and youth.** Electrification can improve economic, health and safety outcomes for women and girls by reducing time spent collecting fuel and managing household energy needs, while lowering exposure to indoor air pollution from traditional cooking fuels. Access to reliable electricity can enable greater participation in education, paid work, entrepreneurship and energy-related value chains. Evidence from South Africa, Nicaragua, rural India and Peru indicates that the likelihood of women finding jobs increases by 9 to 23 percentage points after electrification[28] (Pueyo and Maestre, 2019). Improved lighting in streets and public spaces, can also enhance safety and reduce the risk of gender-based violence (Bhukta et al., 2024).

  Electrification supports job creation for young people in rural areas by powering local industries and small businesses, modernising agriculture through irrigation, processing and cold chains, and enabling digital connectivity. For the urban youth, reliable round-the-clock

25 International Energy Agency (IEA), International Renewable Energy Agency (IRENA), United Nations Statistics Division (UNSD), World Bank and World Health Organization (WHO) (2026). Tracking SDG 7: The Energy Progress Report 2026. Washington, DC: World Bank.

26 Energy Sector Management Assistance Program (ESMAP) (2020). The State of Access to Modern Energy Cooking Services, Volume 1. Washington, DC: World Bank. Available at: http://documents.worldbank.org/curated/en/937141600195758792

27 African Energy Commission (AFREC) (2024). Sustainable Scaling: Meeting the Clean Cooking Challenge in Africa. Algiers: African Union. Available at: https://au-afrec.org

28 Pueyo, A. and Maestre, M. (2019). 'Linking energy access, gender and poverty: A review of the literature on productive uses of energy'. Energy Research & Social Science. Available at: https://www.sciencedirect.com/science/article/pii/S2214629618306145

electricity supply sustains digital, service and industrial jobs, while investment in energy infrastructure creates additional direct employment in research, innovation, technology and technical trades.

→ **Stronger health, education and essential services.** Reliable electricity can transform the quality and continuity of essential public services. In health facilities, electrification supports diagnostics, maternal and neonatal care, vaccine and medicine cold chains, communications, and emergency services. A study in the Democratic Republic of Congo found reliable electricity in health facilities was associated with a 41% reduction in mortality, a 17% increase in outpatient visits and a 24% increase in nurses' working hours[29] (McCord et al, 2026). In schools, reliable electricity enables lighting, digital learning and improved safety, while electricity access can also support water supply and other basic services including clean cooking. In households with reliable electricity, the burden of domestic work is reduced, freeing up time for studying. Research in Nigeria found that village-level access to electricity increased school enrollment rates by 55% (Nano, 2022).[30] The benefits extend beyond individual facilities, strengthening outcomes and opportunities across entire communities.



29 McCord, R., Miles, S.B., Mughuma, J.M., Kammen, D.M. and Kwong, L.H. (2026). 'Assessing the impacts of sufficient and reliable electricity in low-resource healthcare facilities'. Proceedings of the National Academy of Sciences, 123(38), e2538126123. Available at: https://doi.org/10.1073/pnas.2538126123

30 Nano, E. (2022). Electrifying Nigeria: The Impact of Rural Access to Electricity on Kids' Schooling. Working Paper HEIDWP03-2022. Geneva: International Economics Department, Graduate Institute of International and Development Studies.

Table 2 illustrates three case studies that highlight these human development benefits in practice.

Productive Use	Healthcare	Clean Cooking
India: Productive-use electrification as a livelihoods engine CEEW and Villgro's *Powering Livelihoods* initiative has deployed solar-powered productive-use appliances (silk-reeling machines, dryers, cold storage) to nearly 20,000 rural inhabitants since 2020, 70%+ of them women. A silk-reeler named Goyari switched to a solar-powered reeling machine, allowing her to produce 150–250g of yarn a day versus 50g by hand. This doubled her income and removed the physically harmful manual "thigh-reeling" technique, converting safety and dignity directly into higher earnings.	**Sierra Leone: Reliable power as the foundation of healthcare** Under the Sierra Leone Healthcare Electrification Project, the Government of Sierra Leone, supported by the UK Government and SEforALL, equipped 43 health facilities with 4.3 MWp of solar PV and storage, against a baseline where 38% of primary health facilities lacked reliable power. Electricity consumption at these facilities has risen 158%, and more than 100 staff members have undergone training (including 23 STEM trainees): reliable power translates directly into quality, around-the-clock healthcare, improved health outcomes, and improved livelihoods and productivity.	**Tanzania: Clean cooking as a multiplier for health, gender and education** To reduce the large dependence on firewood for cooking school meals and working towards the target of 80% clean cooking access by 2034 under the National Clean Cooking Strategy 2024–2034, the Government of Tanzania, supported by the World Food Programme and SEforALL, is equipping public primary grid-connected schools across four regions with clean eCooking kitchens. 50 schools are targeted initially, serving more than 25,000 students, with 5,000 more identified for scale-up. The programme cuts indoor air pollution exposure for cooks, teachers and students, and eliminates the firewood-collection burden disproportionately borne by women and girls, while schools are positioned as "agents of change" for household-level adoption – a single intervention compounding health, gender, education and youth-employment outcomes.

2.4 Electrification for climate adaptation and resilience

Electrification is not only an emissions-reduction tool; it is increasingly critical infrastructure for helping communities cope with a changing climate. As heatwaves, droughts, floods and storms intensify, reliable electricity can help keep people safe from extreme heat, protect livelihoods, maintain essential services, and enable communities to prepare for and recover from climate-related disruptions. This is particularly important in climate-vulnerable and hard-to-reach areas, where the decentralised energy systems can provide electricity closer to where it is needed and reduce reliance on centralised infrastructure that may be vulnerable to disruption.

Climate adaptation. Electrification helps communities adapt to a changing climate by enabling services that protect livelihoods, food, health and water. As heatwaves intensify, cooling is becoming a basic need with fans, efficient air conditioners and heat pumps required to reduce heat-related illness and death, and keep homes, schools, clinics and workplaces safe and productive. Cooling demand is rising fast in EMDEs. In the ASEAN region, for instance, cooling is projected to grow eight-fold between 2020 and 2050 (see Section 3.1.1). The rising cooling demand needs to be paired with efficiency standards, passive building design and demand flexibility to avoid electricity grid overload. Beyond cooling, electrification supports solar irrigation

for sustained farming as rainfall becomes erratic; cold storage for protecting food and medicines as temperatures rise; and electric pumping, purification and desalination for maintaining water supplies.

Climate resilience. Decentralised electricity can also strengthen the ability of communities and essential services to withstand and recover from climate-related shocks. Distributed generation can reduce dependence on vulnerable transmission and distribution networks, while appropriately designed systems can keep critical services, including healthcare, vaccine and medicine cold chains, water supply, communications and public cooling centres, operational when the wider grid is disrupted during a climate disaster. Heatwaves also strain power systems, as cooling demand peaks just when grids are most stressed; efficient cooling, storage and distributed solar, whose output coincides with peak heat, reduce the risk of outages when they are most dangerous. The value of electrification therefore depends not only on expanding access, but also on designing energy systems to withstand the hazards and service needs of the communities they serve.

Table 3 illustrates case studies highlighting the adaptation and resilience benefits of electrification.

Climate Adaptation	Climate Resilience
Indonesia: Community-financed solar irrigation against drought In Krincing Village, Central Java, where 30 of the village's 80 hectares faced dry-season water shortages, the village government committed more than half of its budget to a community-owned solar irrigation system. The system uses 64 solar panels and a pump drawing water from the Elo River, replacing diesel pumps whose fuel previously accounted for around 60% of operating costs. Designed to eventually irrigate 70–80 hectares, it currently reaches 15 hectares. For one farmer, the switch to a solar irrigation pump allowed two rice harvests a year instead of one, increasing annual production on a 1,250 m² plot from 1.7 tonnes to almost 5 tonnes[31] (One Earth, 2025). The case demonstrates how decentralised electricity can support agricultural adaptation while reducing exposure to fuel costs.	**Caribbean: Purpose-built resilience hubs** The Caribbean Resilience Initiative, implemented by Prosper Global (formerly Mercy Corps) has developed purpose-built resilience hubs in Puerto Rico, with microgrids designed to keep critical services including clinics, water systems and communications operating for at least three days following a disaster[32] (Prosper Global, 2025). The initiative is expanding to other climate-vulnerable Caribbean locations, demonstrating how decentralised energy can be incorporated into disaster preparedness rather than treated solely as part of post-disaster reconstruction. Another example is in Nicaragua, where a 2.1 MW solar mini-grid installed in Corn Island in 2019 with Inter-American Development Bank (IDB) financing, ensured stable electricity supply for disaster response and relief efforts during Hurricanes Eta and Iota, even as more than 114,265 homes lost power in the rest of the country (IDB, 2026).

31 One Earth (2025). 'Solar irrigation: How Indonesian farmers resist drought and save money'. Available at: https://www.oneearth.org/solar-irrigation-how-indonesian-farmers-resist-drought-and-save-money

32 Prosper Global (2025). '"Resilience Hubs" in Puerto Rico are vital in the wake of Hurricane Fiona'. Available at: https://www.prosperglobal.org/blog/resilience-hubs-puerto-rico-vital



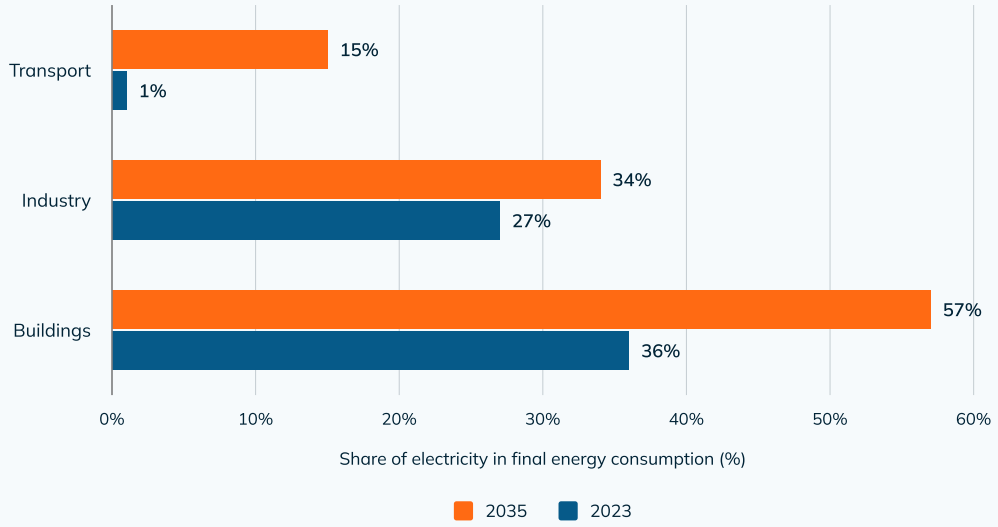
CHAPTER THREE

OPPORTUNITIES FOR ELECTRIFICATION: SECTORAL DEEP-DIVES

Reaching 35% electrification globally by 2035 does not mean every sector electrifies at the same pace. Each end-use sector starts from a different point and faces different technical and economic constraints, so each will contribute differently to the overall target. Under IRENA's 1.5°C Scenario, buildings, already the most electrified sector, would see electricity's share of final energy consumption rise from 36% in 2023 to 57% by 2035. Industry would rise more modestly, from 27% to 34%, reflecting the difficulty of electrifying high-temperature processes and non-energy uses. Transport would see the fastest relative change, from just 1% to 15%, as electric vehicles scale up (Figure 7).

Across these sectors, a common finding emerges: for most applications, the main barriers to faster electrification are now financial and institutional rather than technological. These barriers include limited access to capital, regulatory frameworks that do not yet support electric alternatives, and the high price of electricity relative to fossil fuels in many markets. This chapter discusses sector-specific electrification opportunities across buildings, transport, industry and agriculture. It draws on modelled pathways from SEforALL's Energy Transition and Investment Planning work in the ASEAN region, Ghana, Kenya, Nigeria and Sierra Leone and other emerging markets, alongside country case studies.

Figure 7: Sectoral pathways to 35% electrification by 2035 under IRENA's 1.5°C Scenario



Source: IRENA, 2026[33]

3.1 Electrification in buildings

The buildings sector is where electrification is cheapest, fastest and least technically contested. In practice it covers three kinds of change across residential homes, commercial buildings and social infrastructure such as fuel switching, meeting new electrical demand and efficient electrification. Buildings account for around 30% of global final energy consumption and 27% of energy sector emissions (IEA, 2023), yet electricity meets only about 35% of buildings' energy demand globally. The access to electricity gap is widest in emerging markets and developing economies (EMDEs). In these economies, building electrification is a predominant growth and access story followed by the retrofit story. The share of electricity in the residential sector, for instance, in Africa stood at 8.5% in 2023, 24.3% for non-OECD Asia (excluding China) and 36% in Central and South America. This compares to a 40% share for OECD countries and a 30% world average.

Three factors are making building electrification faster and more effective:

- → **The technology is available.** Induction hobs, electric cooking appliances (induction, pressure cookers and air fryers), heat pumps, LED lighting and efficient air conditioners are mature, mass-produced and in most cases already cheaper to run than what they replace.
- → **The capital stock turns over faster than in other sectors.** A modern cookstove lasts seven to ten years, a light bulb one to three, an air conditioner 10 to 15. An industrial furnace or a power plant lasts 30 to 50 years. Buildings therefore offer several natural replacement cycles before 2050, so electrification can happen at the point of ordinary equipment renewal rather than through early write-off.

33 International Renewable Energy Agency (IRENA) (2026). Transitioning Away from Fossil Fuels: A Roadmap Powered by Renewables, Electrification and Grid Enhancement. Abu Dhabi: IRENA. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2026/May/IRENA_OUT_TAFF_RE_electrification_grids_2026.pdf

→ **The decision-maker is the end user.** That makes the barrier upfront cost and access to finance, which policy can address directly through bulk procurement, on-bill financing or appliance standards – instruments that work far faster than industrial transition policy.

3.1.1 Space cooling

Cooling is the fastest-growing building load in warm climates and the one that most shapes the power system, because it peaks when the system is already stressed. In the ASEAN region it is estimated that the cooling demand will rise eight-fold between 2020 and 2050 from 443 TWh to 3,574 TWh along with the increase in regional per capita income. The electricity needed to deliver it rises almost five-fold. That gap (cooling demand compared to electrical energy demand) is the whole argument for treating cooling as an efficiency and electrification programme put together. Cooling efficiency improvement brings down the electricity requirement to the tune of 40% in the region (2020–2050).

Singapore's Marina Bay district cooling network is the world's largest underground system of its kind, serving Marina Bay Sands, Marina Bay Financial Centre, Asia Square, Gardens by the Bay and Marina One from a centralised plant rather than building-by-building chillers. This system is **more than 40% energy efficient for customers** than conventional in-building systems (SPGroup, 2023).

3.1.2 Cooking

Cooking carries the largest human-development return of any building end use yet has the lowest electrification rate in practice. Electric cooking encompasses a range of technologies, including rice cookers, electric pressure cookers, air fryers, electric ovens, electric coil stoves and induction cooktops. These technologies differ in their energy efficiency, upfront costs, suitability for different cooking practices and electricity supply requirements. Appliances such as rice cookers and electric pressure cookers can provide energy-efficient solutions for specific cooking tasks, while electric ovens and induction cooktops offer broader cooking applications but may face different affordability, infrastructure and household adoption barriers. Consequently, the transition to electric cooking requires solutions tailored to local cooking practices, household needs and electricity access solutions.

Electric cooking offers several advantages. First, modern appliances such as electric pressure cookers and induction hobs use a fraction of the energy of older hotplates, which makes electric cooking affordable at ordinary household tariffs (Box 2). Second, electricity access has moved faster than clean cooking access, so the barrier is increasingly the appliance, the tariff and the reliability of supply, not a new connection. Electric cooking also moves household spending from imported or informally traded fuels to domestically generated electricity. It adds a steady, predictable load that improves the revenues of utilities and mini-grid operators. Electric cooking is highly relevant for institutions such as schools and hospitals. These facilities can generate significant and relatively predictable electricity demand while reducing costs and improving local air quality for staff, students and patients.

Under energy transition plans, clean cooking increasingly integrates and showcases electric cooking as a key solution. The energy transition studies highlight the growing role of electric cooking, although the pace and scale of adoption vary across countries and regions. In the ASEAN Energy Transition and Investment Roadmap (ASEAN-ETIR 2026), electric cooking reaches 91% of

the stove stock by 2050, reflecting a long-term transition towards cleaner cooking technologies. In Kenya, the Energy Transition and Investment Plan (ETIP) projects electric cooking adoption of 60% by 2050, with improved biomass cookstoves continuing to play an important role in the transition. In Sierra Leone's Green Growth Plan, electric cooking reaches 22% by 2050, while improved biomass cookstoves and LPG remain important cooking solutions. These differences may reflect distinct national circumstances, including electricity access, affordability, cooking practices and infrastructure readiness, as well as differences in scenario objectives and modelling horizons.

Box 2: Electrification of cooking and cobenefits

The Modern Energy Cooking Services (MECS) Programme is a multilateral donor-funded programme led by the STEER Centre at Loughborough University that tracked electric pressure cooker adoption across Kenya, Tanzania and Uganda. The Kenya pilot sold 100 cookstoves to lower-income, grid-connected households in Nairobi, Kiambu and Machakos that cooked mainly with charcoal and tracked their cooking before and after purchase. Households paid around USD 70 upfront for the stove and saw their electricity bills rise by around USD 3.6 per month. On the other hand, they reduced their spending on cooking energy by almost 45% and recuperated the cost of the cookstove in less than eight months. On top of the direct financial incentives, 88% of households saved around an hour per day. Scaled to all of Kenya's grid-connected charcoal users, MECS estimates more than USD 1.7 billion in net social benefits over 10 years, more than 130 deaths avoided and 1.1 million tonnes of CO2e avoided each year.

3.2 Transport sector

Electricity can transform the transport sector by reducing the energy required to deliver mobility, displacing petroleum fuels and enabling lower-emission travel. The transport sector accounted for around 30% of total global energy consumption in 2024 and almost 15% (8.7 GtCO2e[34]) of energy-related emissions. Road transport represented nearly 90% of domestic transport energy demand, with domestic aviation, shipping and rail accounting for the remainder. Continued population and economic growth[35] are expected to increase transport demand, potentially leading to further increase in CO_2 emissions without additional decarbonisation measures[36],

The efficiency dividend is the best-evidenced claim for the electrification of the transport sector. For example, Kenya is estimated to have a passenger-kilometre rate of 1.44 MJ in 2050 against 5.58 MJ in 2020, a 74% reduction; in Nigeria the figure is 73% and in Sierra Leone 66%. This is not behavioural or a demand assumption – it is the thermodynamic difference between an electric drivetrain and an internal combustion engine, and it means the same mobility is delivered

34 United Nations Environment Programme (UNEP) (2024). Sectoral Solution to Climate Change: Transport. Industry and Economy Division. Available at: https://wedocs.unep.org/items/eddac4ff-eb1c-4ab1-8007-853ba5ed5520

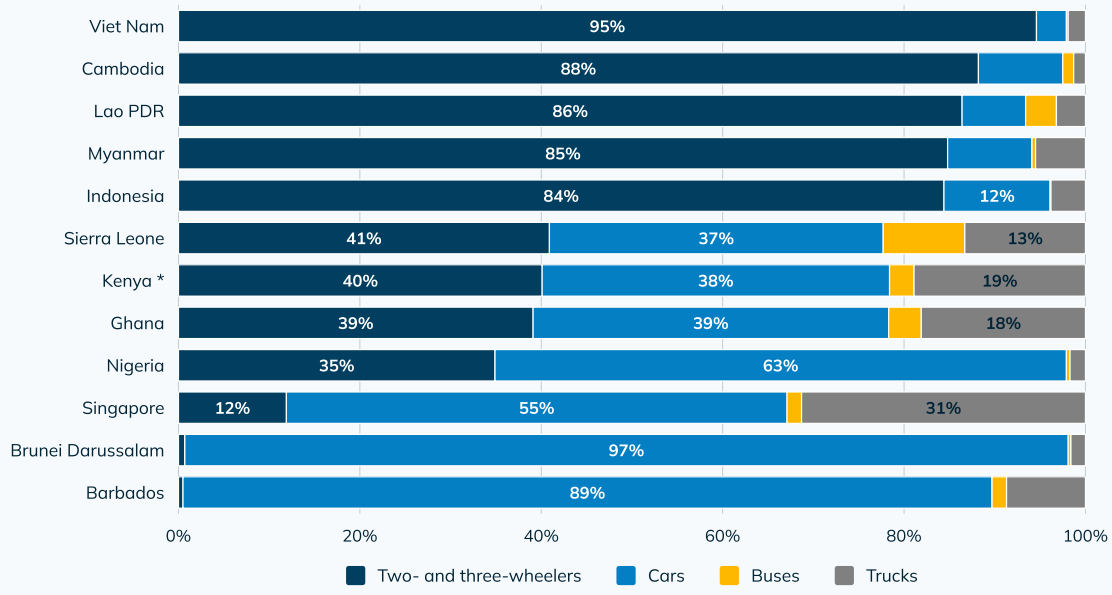
35 Jaramillo, P. et al. (2022). 'Transport'. In: Shukla, P.R. et al. (eds.) Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, Chapter 10. Available at: https://doi.org/10.1017/9781009157926.012

36 Dhakal, S. et al. (2022). 'Emissions Trends and Drivers'. In: Shukla, P.R. et al. (eds.) Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, Chapter 2. Available at: https://doi.org/10.1017/9781009157926.004

for roughly a quarter of the energy input. While reducing final energy consumption, transport sector electrification increases its electricity demand. The resulting emissions saving depends on the electricity generation mix, making the decarbonisation of transport and power mutually reinforcing priorities.

Electrification opportunities differ across vehicle categories and national contexts. Drawing on insights from the country's ETIP the composition of national vehicle fleets influences the opportunities and infrastructure requirements for transport electrification (Figure 8). In Cambodia, Indonesia, Lao PDR, Myanmar and Viet Nam, two- and three-wheelers dominate vehicle fleets, suggesting significant opportunities for electrification in this segment. In contrast, passenger cars account for the largest share of vehicles in Barbados and Brunei Darussalam, making passenger-car electrification particularly relevant. Ghana, Kenya and Sierra Leone have more diversified vehicle fleets, indicating the need for electrification strategies targeting multiple vehicle categories. Similarly, Nigeria's fleet is predominantly composed of passenger cars, alongside a substantial share of two- and three-wheelers. Singapore presents a different profile, with a relatively high share of trucks, highlighting the importance of considering freight electrification alongside passenger transport.

Figure 8. Vehicle fleet composition by vehicle category across selected countries (% of total fleet)



* Kenya: 2024; all other countries: 2020.

Source: SEforALL's country Energy Transition and Investment Plans[37]

However, vehicle numbers alone do not determine potential energy savings, emissions reductions or additional electricity demand. The share of transport energy consumption by vehicle segment provides a more representative indicator of electrification potential, as it accounts for differences in vehicle utilisation and energy intensity. Annual mileage, vehicle size, occupancy or payload, and

37 SEforALL 2026. Energy Transition and Investment Plans. https://www.seforall.org/our-work/initiatives-projects/energy-transition-plans

energy consumption are therefore important considerations. Buses and trucks can consequently have substantial electrification impacts despite representing smaller shares of the vehicle fleet. Integrated transport and power planning should combine fleet composition with energy consumption patterns and operational characteristics to identify priority applications and assess charging, generation and network requirements. Furthermore, the country's GDP per capita can influence the affordability of electric vehicles (EVs), particularly given their higher upfront purchase costs, although these may be offset by lower operating and maintenance costs over time.

Electrification of the transport sector can enhance energy security by reducing **dependence on fossil fuel imports**, particularly in countries lacking domestic oil reserves or refining capacity. Declining EV costs are making electrification increasingly competitive with conventional vehicles, while lower operating and maintenance costs can provide long-term economic benefits for consumers. Nevertheless, higher upfront purchase prices in some vehicle segments, limited access to affordable financing and the need for charging infrastructure can still present barriers to widespread adoption, particularly in EMDEs. Addressing these challenges through supportive policies, financing mechanisms and infrastructure investments will be important to accelerate the transition towards electric mobility.

As countries shift towards more affordable and energy-secured systems, energy sector reforms could be complemented by policies establishing minimum targets for clean vehicles in public procurement and public transport. In addition, governments could introduce stricter fuel economy standards to encourage the adoption of EVs and more efficient internal combustion engine vehicles, contributing to reduced fuel consumption and emissions.

Box 3. India: Electrification of Rail transport

Electrification Mechanism: Fuel-Switching

Indian Railways, which carries millions of passengers and much of the country's freight every day, has electrified almost its entire broad-gauge network within the last decade. By March 2026, 69,873 route kilometres, or 99.6%, were electrified, from 21,801 route kilometers in 2014. Some 46,900 km of this was completed after 2014, as the pace of work rose more than 10-fold, from 1.42 km a day in 2004–2014 to over 15 km a day in 2019–2025.[38] This resulted in railway's electricity rising from approximately 16.2 billion units in 2014–15 to 34.5 billion units in 2024–25, transferring fossil energy requirements into the power system.

The economic case was compelling, with electric traction around 70% cheaper to operate than diesel. The energy security case was equally strong. Electrification saved around 1.78 billion litres of diesel in 2024–25 alone, and diesel consumption has fallen by 62% since 2016–17, reducing exposure to oil import bills and price shocks.[39] Indian Railways reports that electrification has generated savings of approximately USD 0.7 billion. The

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38 Press Information Bureau, Government of India (2026), *Mission 100% Electrification: Powering the Future of Indian Railways*, 6 January 2026.

39 Carbon Copy (2026), "Near 100% electrification of Indian Railways strengthens domestic energy security", 6 March 2026.

railways are now pairing electrification with clean supply, with close to 900 MW of solar capacity installed by November 2025, much of it serving traction, as part of the goal of becoming a net-zero carbon emitter by 2030.

India's railway electrification programme demonstrates how a coordinated, infrastructure-led approach can shift a large transport system from direct fossil-fuel consumption to electricity while creating a substantial new electricity demand base. The case also shows that electrification and decarbonisation are distinct steps. On a grid still dominated by coal, the full climate benefit depends on how quickly the power supplying the network becomes clean.

3.3 Industry

Industrial activities encompass a wide range of energy- and non-energy-related processes, with varying potential for direct electrification. Energy-related processes include the provision of heat, mechanical power and other industrial services, while non-energy processes involve chemical reactions and the use of fuels as feedstocks or reducing agents. The potential to electrify these activities across sub-sectors depends on their temperature requirements, production technologies and the availability of suitable alternatives.

The most immediate opportunities for electrification are found in low- and medium-temperature industrial heat processes, where electric boilers, heat pumps and other electric heating technologies can replace fossil fuel-based systems. Electrification also offers opportunities across mining operations, mineral processing and manufacturing, including electric motors, material handling, crushing and grinding, and selected thermal processes. Some energy-intensive industrial activities already rely on electricity, including aluminium smelting and steel production using electric arc furnaces (EAFs) (Box 4). Beyond these established applications, emerging technologies such as high-temperature electric heating, electric kilns and advanced electrothermal processes could expand electrification into industrial activities that currently depend heavily on fossil fuels. Nevertheless, some industrial processes, particularly those involving chemical feedstocks, reducing agents or process emissions, may require complementary solutions, including hydrogen, sustainable bioenergy and carbon capture with storage (CCS).

Box 4 South Africa: Electric-Arc-Furnaces (EAF) for steelmaking

Electrification Mechanism: Fuel-Switching

South Africa's steel sector showcases the potential of industrial electrification at scale, accounting for approximately 1.5% of GDP and supporting approximately 200,000 jobs. The sector has historically relied heavily on the carbon-intensive blast furnace–basic oxygen furnace (BF-BOF) route, but EAFs already account for more than 2 million tonnes of annual steel production, equivalent to around half of national steel production. Transition to EAFs has resulted in an increased share of electricity in South Africa's iron and steel industry, accounting for 27% of final energy consumption.[40]

However, South Africa's electricity supply remains relatively carbon-intensive, so increasing EAF production alone does not deliver the full decarbonisation potential. Electrification must be accompanied by clean-power and grid investment.

The longer-term opportunity extends from scrap-based EAFs to renewable-hydrogen direct reduced iron (H_2-DRI) coupled with EAFs, allowing electricity and renewable hydrogen to replace fossil fuels deeper in the steelmaking process.

South Africa is already moving from an established electric-steel base toward deeper decarbonisation. The Accelerating South Africa's Steel Decarbonisation initiative is designed to support further EAF adoption, renewable electricity and eventually hydrogen-DRI.

Industrial electrification in developing and emerging economies rarely proceeds as a single conversion programme. It happens through four major routes: a) **replacing equipment at the end of its life**, so that a retiring fuel-oil boiler becomes a heat pump or an electric boiler rather than another boiler; b) **changing the production route** wherever technology allows it such as with scrap-based electric arc steel; c) **electrifying motive power and materials handling**, which in mining and bulk processing is where most of the diesel is burned; and d) **pairing new electric load with its own clean supply**, through captive solar, behind-the-meter storage and dedicated feeders into industrial parks. Each route has its own policy instrument. Equipment replacement responds to customs and tariff treatment of efficient machinery, minimum performance standards for motors, and leasing or energy-service contracts that convert a capital cost into a monthly one. Route change responds to scrap collection policy. Motive-power electrification responds to charging infrastructure at the mine or the port.

The benefits of electrification of industrial processes are larger in developing countries than in industrialised countries, for reasons that are primarily linked to expensive imports. Faster electrification could cut the energy import bills of fuel-importing countries by **more than USD 400 billion by 2035** against 2025 levels, and take electricity to 33% of world final energy by 2035 from 23% today (IEA, 2026). Fuel-oil, diesel, LPG and coal are mostly imported and priced in dollars, so

40 Department of Mineral Resources and Energy (DMRE), Republic of South Africa (2025). South African Energy Sector Preliminary Report 2025. Government of South Africa. Available at: https://www.dmre.gov.za/Portals/0/Resources/Publications/Reports/Energy%20Sector%20Reports/SA%20Energy%20Sector%20Report/2025-South-African-Energy-Sector-Preliminary-Report.pdf?ver=vj8mlFbD608QxnJWxaV2xw%3D%3D

every unit of process heat shifted to a domestic grid converts a recurring foreign-exchange cost into a one-off capital import and a local operating cost. A 1% real oil price rise worsens oil importers' current account by up to **0.08 percentage points of GDP** after five years (World Bank, 2023).

Also, electric process heat is more precisely controlled than combustion, which raises product quality and reduces waste – a direct competitiveness gain for manufacturers trying to enter export markets. Those export markets are themselves beginning to price embodied carbon, so an electrified and increasingly clean industrial base is becoming a condition of market access rather than a voluntary process. Local air quality improves where combustion leaves the factory floor. And industrial load is the customer class utilities most needed. Industrial electricity load is steady, creditworthy and high-volume. Industrial electrification is, in that sense, not only a demand-side measure, it is part of how the supply side becomes financeable.

National and regional energy transition plans illustrate how these technological opportunities translate into different industrial transition pathways across EMDEs. In the ASEAN region, electricity's share of industrial final energy consumption rises from approximately 19% to 47%, while industrial coal consumption declines from approximately 17,677 PJ to 1,006 PJ. This transition is accompanied by changes in industrial production technologies, including the deployment of hydrogen-based direct reduced iron and EAFs in steelmaking.

Other country studies demonstrate that industrial decarbonisation does not necessarily translate into equally large increases in direct electricity consumption. In Ghana, industrial electricity consumption rises from approximately 150 PJ under a business-as-usual (BAU) pathway to 243 PJ under a net-zero emissions (NZE) pathway in 2050, with electricity accounting for around 48% of industrial final energy consumption. The transition also involves hydrogen-based industrial processes and natural gas technologies equipped with CCS. Direct industrial CO_2 emissions decline from approximately 37 Mt CO_2 under BAU to 2 Mt CO_2 under NZE, reflecting the combined contribution of multiple decarbonisation technologies rather than electrification alone.

Similarly, Kenya's NZE pathway combines a more moderate increase in industrial electricity consumption, from approximately 43 PJ under BAU to 51 PJ in 2050, with substantial deployment of hydrogen and biofuels. Nigeria also exhibits an increase in industrial electricity consumption, from approximately 28 PJ under BAU to 51 PJ under NZE, alongside significant hydrogen deployment. These findings illustrate that even where clean electricity generation expands, industrial decarbonisation may rely on a combination of direct electrification and alternative low-carbon energy carriers, depending on the industrial processes and technologies represented in each pathway.

The diversity of industrial transition pathways is further illustrated by Barbados and Sierra Leone. In Barbados, industrial electricity consumption is lower under the transition scenario than under BAU in 2040, while biomass and CCS-equipped processes play a larger role. In Sierra Leone's Green Growth Plan (GGP), industrial electricity consumption remains broadly unchanged between BAU and the Green Growth scenario in 2050. As the latter is not a net-zero scenario, its results reflect a different set of development and climate objectives and should not be directly interpreted as a net-zero industrial pathway.

Taken together, these studies highlight the importance of tailoring industrial electrification strategies to national circumstances and industrial structures. Expanding access to reliable, low-carbon electricity can enable the adoption of electric industrial technologies, particularly for low-

and medium-temperature heat and mechanical processes. At the same time, complementary technologies and energy carriers will remain important for processes that are more difficult to electrify directly. An integrated approach that considers both established and emerging electrification technologies, alongside other industrial decarbonisation solutions, can support industrial development while reducing emissions.

3.4 Agriculture and productive use

As the global population continues to grow, agricultural production will need to increase to meet rising food demand, while the sector faces increasing challenges from climate change and changing weather patterns. Electrification can support agricultural productivity and mechanisation through the adoption of electric water pumps, processing equipment, refrigeration and tractors. These technologies can improve operational efficiency, reduce reliance on fossil fuels and enhance resilience to fuel price volatility and supply disruptions.

Renewable energy-power solutions, particularly solar irrigation systems, are increasingly being adopted in several countries, helping farmers improve access to irrigation, reduce dependence on rainfall and replace diesel-powered equipment (Box 5). In addition to these benefits, agricultural electrification can contribute to reducing greenhouse gas (GHG) emissions. Without additional mitigation measures, global agricultural emissions are projected to reach 14.4 GtCO2e by 2050, compared with 3.1 GtCO2e associated with a 1.5°C pathway.[41] Electrification can contribute to narrowing this gap, alongside other measures addressing emissions from agricultural production and land use.

Box 5: India: Agriculture sector electrification with solar

Electrification Mechanism: Energy Access and Fuel-Switching

In India there are about 32 million irrigation pumps, approximately 21 million of them electric and 9 million diesel. For many Indian farmers, irrigation has meant pumping water at night, when rotational supply reaches agricultural feeders, or paying for diesel. The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme, launched in 2019, aimed to address this by supporting standalone solar pumps to replace diesel sets, solarisation of grid-connected pumps and small solar plants on farmland.

As of August 2026, nearly 1.15 million standalone solar pumps had been installed, while 1.59 million agricultural pumps were covered through feeder-level solarisation. Around 1.73 GW of decentralised solar capacity had been commissioned on farmers' land, with more than 2.18 million farmers benefitting nationwide. During 2025–26, the programme added around 7.67 GW of capacity, doubled from 3.66 GW in FY2024–25, taking cumulative installed capacity to 13.11 GW. The government estimates that PM-KUSUM

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41 McKinsey & Company, 2023. The agricultural transition: Building a sustainable future.

had contributed to avoiding approximately 735 million litres of diesel and 12.6 million tonnes of CO_2 emissions by January 2026.[42]

The model has been enabled through capital subsidies, concessional financing and state-level implementation. Central support can cover 30% of benchmark or tender costs, rising to 50% in specified regions, with additional state support and bank financing reducing farmers' upfront investment. Farmers can also sell surplus electricity to distribution companies under eligible models.

The case illustrates how energy-access and new-demand pathways can converge in productive sectors: electrification is not simply providing farmers with electricity, but reshaping how irrigation energy is supplied, reducing fuel expenditure and emissions, and creating a decentralised renewable-energy asset base within the agricultural economy.

Drawing from regional and country insights, electrifying other end uses also matters in the agriculture sector. In **ASEAN**, electricity already accounts for about 60% of the represented pumping activity in 2050, but motive power remains entirely dependent on liquid fuels. Reaching net zero by 2050 electrifies both activities. In **Sierra Leone**, under the GGP pathway, reported electricity-based post-harvest activity reaches 1.985 PJ in 2050 over 267 times higher due to the Feed Salone Strategy where irrigation land increases. Irrigation activity is around 15 times higher. However, increasing electricity use does not automatically reduce agricultural emissions when fossil-fuel use grows alongside it.

Agricultural electrification requires coordination between energy, agricultural and water planning. Irrigation and equipment use can create seasonal electricity requirements, influencing the design of rural networks and decentralised systems. Solar pumping should be accompanied by water-management safeguards, since lower pumping costs can encourage excessive groundwater extraction.

42 Press Information Bureau (PIB), Government of India (2026). 'India Ranks Third Globally in Renewable Energy Installed Capacity: Shri Pralhad Joshi'. Available at: https://www.pib.gov.in/PressReleasePage.aspx?PRID=2250039&lang=2



CHAPTER FOUR

ENABLING CONDITIONS FOR ELECTRIFICATION

The electrification deployment gap is not a technology gap. Up to three-quarters of global energy demand can already be electrified with technologies commercially available today, and electric end-use technologies are typically around three times more efficient than the fossil-fuel equivalents they replace.[43] Realising the global electricity target and mid-century electrification ambitions would require fit-for-purpose policy, regulatory and market interventions, beyond achieving the technological parity with fossil fuels, capable of delivering infrastructure, investments and institutions needed to scale electrification.

The signs of electrification deployment gaps are visible across the energy system. More than 2,500 GW of renewable energy and storage projects were waiting in grid connection queues worldwide in 2025.[44] Around 90% of global energy transition investment continues to flow to advanced economies and China,[45] even though emerging markets and developing economies (EMDEs) account for roughly 80% of the growth in global electricity demand. In many markets, electricity still costs more than the fuel it is meant to replace, not because it is inherently more expensive, but because of how it is planned, taxed, tariffed and financed. The barriers hindering the pace are not technical and lie within the reach of policy.

43 International Energy Agency (IEA) (2026). Electrification 2026. Paris: IEA. Available at: https://www.iea.org/reports/electrification

44 ibid

45 International Renewable Energy Agency (IRENA) and Climate Policy Initiative (CPI) (2025). Global Landscape of Energy Transition Finance 2025. Abu Dhabi: IRENA and CPI.

This chapter outlines the enabling conditions that would allow electrification to advance at the pace the *35-by-35 Global Electrification Pledge* requires, and the practical actions that would move countries towards it.

4.1 Planning for electrification

***Goal**: Make electrification a deliberate, economy-wide objective of national development, energy and climate planning, aligning future electricity supply with the country's industrial, transport, cooking, agricultural and broader development priorities.*

Electrification is often treated as a downstream consequence of power-sector expansion rather than an explicit objective of economic and development planning. This can create a mismatch between the electricity system countries build and the energy services their economies need. Integrating electrification into national planning is essential to anticipate future demand, coordinate investment, and ensure that climate commitments and development ambitions translate into practical implementation pathways.

- → **Establish electrification as a formal objective within national development and energy strategies.** Governments should incorporate explicit electrification objectives into national energy plans, long-term development strategies and net-zero pathways, with clear institutional responsibilities for implementation. These objectives should cover the transformation of energy use across the economy, rather than focusing solely on electricity-generation capacity or the share of electricity in final energy consumption.
- → **Align power-sector planning with Nationally Determined Contributions (NDCs) and sectoral strategies.** Translate climate commitments and national priorities for industrial development, transport, clean cooking, buildings, agriculture and productive use into sector-specific electrification pathways. Power-sector plans should reflect the resulting demand, while sectoral strategies should account for the availability, cost and reliability of electricity required to deliver their objectives.
- → **Plan for all drivers of electricity demand, not only climate commitments.** Demand projections should capture four sources of growth: economic development, including industrial expansion, special economic zones and mineral processing; climate mitigation commitments, such as electric vehicle (EV) targets, industrial fuel switching and electric cooking; adaptation needs, including irrigation, water pumping and treatment, cooling and cold chains; and interactions across the water–energy–food nexus. Adaptation-driven demand is the most often overlooked.. Each source of demand has a distinct location and time profile, which should inform where and when generation and network investments are made.
- → **Assess supply options on a whole-system basis.** Generation choices should reflect resource endowment, seasonal and hydrological variability, and emissions, not fuel cost alone. Where seasonal shortfalls are met with costly imported fuel, as in hydro-dependent systems during the dry season, planners should compare thermal options against storage, complementary solar and demand shifting.
- → **Synchronise planning cycles, budgets and investment decisions.** Establish mechanisms for energy ministries, utilities, regulators, transport and industrial authorities, agricultural agencies, and local governments to coordinate planning assumptions and investment

timelines. Aligning national targets, infrastructure plans and public investment cycles can reduce implementation gaps and help ensure that generation, networks and end-use adoption advance in steps.

- → **Strengthen demand-side data and modelling capabilities.** Invest in data on existing energy use, fuel consumption, technology stocks, service gaps, operating costs and potential uptake of electric alternatives across sectors. Improve the spatial and temporal resolution of electricity-demand projections, supported by end-use surveys, utility data and engagement with businesses and consumers. Demand projections should be built up by driver (economic growth, mitigation commitments and adaptation needs) and by end use, rather than extrapolated from historical consumption trends. Regularly update these projections as economic conditions, technology costs and adoption patterns change.
- → **Establish monitoring and accountability mechanisms.** Track progress against sectoral electrification milestones, including the adoption of electric technologies, the quality and affordability of energy services, and the resulting changes in electricity demand. Monitoring should distinguish new electricity access, fuel-switching and new demand so that policies and infrastructure investments respond to different national and regional needs.

Box 6: How SEforALL's modelling approach supports integrated electrification planning

SEforALL's Energy and Investment Planning programme treats electrification as a central part of economy-wide planning, rather than as a by-product of power-sector expansion. At its core is SEforALL's Energy Modelling System (SEM), built on the open-source OSeMOSYS framework. SEM identifies least-cost transition pathways across power, transport, industry, buildings and agriculture, and is soft-linked to specialised tools that address specific planning challenges:

- → **Projecting all drivers of demand.** SEM builds electricity demand from population growth, economic development and sectoral activity, capturing electric technology adoption, fuel switching and efficiency gains. Where applicable, computable general equilibrium (CGE) modelling adds insight into economic growth and structural change.
- → **Planning access to electricity and modern energy services.** The Open Source Spatial Electrification Tool (OnSSET) identifies the least-cost mix of grid extension, mini-grids and standalone systems, based on population distribution, existing infrastructure and local demand. The Agricultural Cold Chain Analysis and Prioritization (AgCAP) tool identifies communities most likely to benefit from cold storage, linking electrification planning to productive use and food security. SEforALL's Integrated Energy Access Planning Tool for clean cooking assesses the potential for electric cooking, so that cooking demand is reflected in electrification planning.

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- → **Managing flexibility.** IRENA's FlexTool assesses how power systems can integrate variable renewables, storage and cross-border interconnections. SEforALL is also developing PyPSA-based analysis to capture demand-side flexibility, such as smart EV charging, heat pumps with thermal storage and other shiftable loads, so that flexible demand can be planned alongside generation, storage and grids.
- → **Accounting for climate and nexus risks.** The approach can incorporate rising cooling demand, electricity for water pumping and irrigation, and changes in hydropower availability. In the ASEAN ETIR, the InVEST model added an assessment of ecosystem services and environmental trade-offs.

By comparing current-policy and net-zero scenarios, the analysis shows what accelerated electrification means for generation, capacity, fossil fuel dependence, emissions and investment. This evidence also supports implementation. As Secretariat to the Mission 300 Joint Working Group, SEforALL supports countries plan and deliver their National Energy Compacts under the World Bank and African Development Bank initiative to connect 300 million people in Africa to electricity.

4.2 Accelerating end-use electrification

***Goal**: Accelerate the adoption of efficient electric technologies across transport, buildings, industry, cooking and agriculture by removing policy, financial and infrastructure barriers that prevent households and businesses from switching to electricity.*

The availability of electric alternatives does not guarantee their uptake. Households, businesses and industrial users may face high upfront costs, limited access to finance, inadequate charging or electrical infrastructure, uncertainty over operating costs, or a lack of awareness and technical support. These barriers can slow adoption even where electric technologies offer efficiency, productivity or lifecycle-cost advantages. Countries should establish clear, sector-specific measures that make efficient electric alternatives accessible and commercially attractive, while ensuring that new demand can be served reliably.

- → **Remove regulatory and market barriers to technology uptake.** Develop targeted roadmaps for end-use applications to promote electrification where technically and commercially viable. Review rules that unnecessarily constrain electric cooking, EVs, heat pumps, cooling technologies and industrial electric heating. Establish clear technical and safety standards, simplify permitting and approvals, and ensure that building codes, vehicle regulations and industrial policies do not inadvertently favour continued use of fossil-fuel equipment.
- → **Use standards, incentives and public procurement to accelerate adoption**. Strengthen minimum energy-performance standards and equipment labelling, and use targeted incentives, rebates and concessional support where upfront costs prevent adoption. Public procurement can create early markets for electric buses, government vehicle fleets, efficient cooling, electric cooking in public institutions and other technologies, helping demonstrate performance and supporting wider market uptake.

- → **Make enabling infrastructure available alongside electric technologies.** Coordinate the rollout of charging networks, building electrical systems, industrial connections and other application-specific infrastructure with expected adoption. For electric cooking and cooling, ensure that electricity supply and distribution networks can provide the level of service required; for industry, support technical assessments and upgrades needed to convert suitable processes.
- → **Tailor interventions to national circumstances and end-use needs.** In areas with limited electricity access, prioritise electric technologies alongside grid expansion and decentralised supply. In established power systems, focus on replacing fossil-fuel equipment and accelerating adoption in buildings, transport and industry. For industrial users, pair equipment incentives with technical assessments and investment support that address process-specific requirements and competitiveness.

4.3 Scaling clean electricity supply for electrification

Goal: *Ensure that the expansion of electricity demand is matched by a rapid increase in clean, reliable and affordable electricity supply, so that electrification becomes a mechanism for reducing fossil-fuel use and emissions rather than simply shifting energy demand into the power sector.*

Electrification benefits are maximised when the electricity behind them is clean, reliable and affordable.

- → **Set technology-diverse renewable deployment pathways aligned with projected electricity demand.** Translate national electrification scenarios, representing sectoral electrification ambitions, into explicit renewable generation requirements, including annual capacity additions, expected generation and technology mix. Solar and wind will provide the bulk of new capacity in many markets, but hydropower, geothermal, sustainable bioenergy and other technologies can provide firm or complementary supply where system conditions support them. Countries should scale technology-diverse portfolios according to resource endowments, system requirements and environmental and social considerations.
- → **Create predictable and competitive renewable procurement frameworks.** Establish multi-year procurement schedules with transparent capacity volumes, technology-specific auctions where appropriate, clear delivery timelines and standardised contracting. Long-term power purchase agreements and other bankable offtake arrangements should provide sufficient revenue visibility for developers, while permitting, land-access and environmental-review processes should be streamlined without weakening safeguards.
- → **Open space for customer-led supply.** Rooftop solar, captive generation and open access for consumers including households, farmers, and commercial and industrial establishments, allow supply to grow as quickly as demand, supported by clear rules on net billing, wheeling and banking.
- → **Develop both centralised and distributed renewable delivery models.** Utility-scale projects should be complemented by mini-grids, solar home systems, rooftop systems and community-scale generation where these provide a faster or lower-cost route to service delivery. Energy-access planning should explicitly assess grid extension, mini-grid and standalone options rather than assuming a single delivery model across all locations.

4.4 Strengthening grids, storage and interconnections

***Goal**: Make electricity networks an enabler of electrification rather than a constraint, through anticipatory investment in transmission, distribution, storage, digitalisation, resilience and cross-border interconnection.*

Generation alone cannot deliver electrification. Weak transmission and distribution networks can prevent renewable projects from connecting, constrain new electricity demand and increase congestion and curtailment. This bottleneck is becoming global with more than 2,500 GW of renewable, storage and large-load projects currently stalled in grid-connection queues. Meeting electricity-demand growth through 2030 will require annual grid investment to rise by roughly 50% from today's USD 400 billion.[46]

- → **Integrate transmission and distribution planning with electrification forecasts.** Utilities and system planners should identify where demand from EVs, electric heating, cooling, industry, data centres, agriculture, cooking and new urban development will emerge and incorporate those loads into network investment plans. Planning should be anticipatory, rather than waiting for demand to materialise before reinforcing the network. The planning should also actively incorporate climate risk to transmission and distribution infrastructure and plan for risk-proofing the network.
- → **Accelerate transmission investment and interconnection.** Prioritise transmission corridors connecting high-quality renewable resource areas with major and emerging demand centres, and strengthen cross-border interconnections where regional power trade can improve reliability and lower system costs. Regional planning should be used to identify infrastructure that delivers value across multiple countries rather than duplicating national investments.
- → **Modernise distribution networks for two-way power flows.** Distribution investment should anticipate rooftop solar, mini-grids, EV charging, electric cooking, heat pumps and other distributed resources. Smart meters, automated network management, advanced monitoring and digital controls should be deployed where they improve visibility and operational efficiency.
- → **Expand storage and other physical flexibility resources alongside grids.** Batteries, pumped storage and appropriate long-duration storage should be integrated into system planning based on the duration and characteristics of flexibility needs. Storage should be located strategically to relieve congestion, manage renewable variability and meet peak demand rather than being added independently of network planning.
- → **Use existing networks more efficiently while new infrastructure is being built.** Grid-enhancing technologies, dynamic line rating, improved forecasting, advanced power-flow management and connection reforms can unlock additional hosting capacity without waiting for major network projects to be completed.

46 International Energy Agency (IEA) (2026). Electricity 2026. Paris: IEA. Executive summary available at: https://www.iea.org/reports/electricity-2026/executive-summary

4.5 Improving energy efficiency and demand flexibility

***Goal**: Deliver efficient electrification by design, so that new electricity demand provides more energy services with less energy use while reducing the cost and infrastructure requirements of the transition.*

Electrification increases the role of electricity in the economy, but it does not need to increase electricity consumption in proportion to the energy services delivered. Efficient electric technologies can reduce the amount of electricity required for heating, cooling, transport, cooking, production and household services, while flexible demand can reduce the capacity required to meet short-duration peaks and shift electricity demand to renewable generation hours. Efficiency and flexibility should therefore be treated as core components of electrification strategy, not as secondary energy-policy measures.

- → **Adopt and continuously strengthen minimum energy-performance standards.** Establish mandatory efficiency standards for appliances, motors, pumps, air conditioners, refrigeration, electric cooking equipment and other major end uses, with scheduled tightening aligned to technological progress. Standards should prevent inefficient equipment from becoming locked into rapidly electrifying markets and fastest growing electricity end-use sectors such as cooling.
- → **Make buildings and industrial facilities progressively more electricity-efficient.** Introduce building energy-performance codes, retrofit programmes and industrial energy-management requirements that reduce demand for cooling, heating, lighting and process energy. New buildings and industrial facilities should be designed around efficient electric technologies rather than retrofitted later.
- → **Use targeted programmes to accelerate replacement of inefficient equipment.** Bulk procurement, rebates, on-bill financing and targeted support for low-income households and small businesses can overcome high upfront costs and accelerate market transformation. Public procurement can also establish demand for high-efficiency equipment at scale.
- → **Treat flexible demand as a planning resource.** Power-sector planning should account for the flexibility that new electric loads can provide, such as EV charging, water pumping, cold storage and industrial heat with thermal storage, rather than treating demand as fixed. Including demand flexibility alongside storage in capacity expansion planning can reduce the need for firm capacity and lower the cost of integrating renewables, provided that tariffs and controls allow flexible loads to respond to system conditions.
- → **Create markets for demand response and flexible consumption.** EV charging, water heating, agricultural pumping, cold storage, industrial processes, batteries and other controllable loads should be enabled to shift consumption away from system peaks or towards periods of high renewable generation. Regulators should establish the technical rules, metering and participation mechanisms necessary for consumers and aggregators to provide these services.
- → **Measure electrification by energy services, not electricity consumption alone.** National planning should track indicators such as kilometres travelled, useful heat delivered, agricultural output, cooling service and industrial production alongside electricity use. This allows governments to distinguish productive electricity consumption from avoidable demand caused by inefficient equipment.

4.6 Mobilising finance and investment

***Goal**: Build a large and investable pipeline of electrification projects by using public, concessional and private finance strategically to address specific risks and lower the cost of capital.*

Electrification requires capital across multiple asset classes and customer segments, but investment conditions vary sharply between markets. High financing costs, currency risk, weak utility balance sheets, limited project-development capacity and perceived regulatory risk can make technically and economically viable projects difficult to finance. As a result, in emerging and developing economies, the cost of capital for clean energy is at least double that in advanced economies, and two to three times higher for energy projects once country risk is priced in. The capital availability also becomes constrained. In 2024, only around a quarter of global energy investment of more than USD 3 trillion went to EMDEs outside China, while Africa received around 2% of global clean energy investment, despite rapid growth in electricity demand and a population representing around one-fifth of the world.

- → **Develop integrated national electrification investment strategies.** Governments should quantify investment needs across generation, grids, storage, distributed energy, charging infrastructure and end-use technologies, and translate these into investable pipelines. This should allow public finance institutions and private investors to identify where capital is required and where different instruments can be used.
- → **Use public and development finance to reduce risk rather than as a substitute for private capital.** Guarantees, political-risk insurance, credit enhancement, first-loss instruments and blended-finance structures should be targeted at barriers that prevent commercially viable investment. The objective should be to create investable markets that progressively require less concessional support.
- → **Expand access to local-currency and affordable long-term finance.** Renewable generation and electrification infrastructure typically involve high upfront capital costs and long asset lives. Development finance institutions and domestic financial institutions should expand local-currency lending, hedging facilities and longer-tenor financing to reduce exposure to exchange-rate and refinancing risks.
- → **Create dedicated financing mechanisms for end-use electrification.** Households, small businesses and industrial firms often face high upfront costs even where lifetime economics are favourable. Consumer finance, leasing, on-bill repayment, concessional credit lines and targeted incentives can accelerate adoption of EVs, heat pumps, electric cooking, efficient appliances and industrial equipment.
- → **Strengthen project preparation and transaction capacity.** Public institutions should provide early-stage support for feasibility studies, resource assessments, technical design, environmental assessments and transaction structuring. A lack of bankable projects can otherwise become as important a constraint as a lack of available capital.

4.7 Creating dynamic and adaptive electricity markets

***Goal**: Establish electricity markets and regulatory frameworks capable of accommodating rapidly changing demand, high renewable shares, distributed resources and flexible consumers, while maintaining affordability and reliability.*

As electricity becomes a larger share of final energy consumption, markets must accommodate increasingly variable renewable generation, distributed resources, flexible loads and new electricity-intensive consumers. Existing market structures can create distortions where electricity is priced in ways that discourage electrification or fail to reward flexibility.

- → Align electricity tariffs with the objectives of electrification. Review taxes, levies and regulated charges that make electricity disproportionately expensive relative to competing fossil fuels, while protecting vulnerable consumers through targeted support rather than broad price distortion. Tariff reform should ensure that efficient electrification is economically attractive.
- → Introduce time-of-use and dynamic tariffs where system conditions justify them. Price signals should encourage consumers to shift flexible electricity demand toward periods of abundant renewable generation and away from system peaks. Regulators should introduce these mechanisms gradually, supported by smart metering and consumer-protection measures.
- → Create clear revenue streams for flexibility services. Electricity markets should compensate batteries, demand-response providers, aggregators and other flexible resources for services such as balancing, reserve provision and congestion management. This will allow flexibility to become a market-based resource rather than relying solely on network operators to procure it administratively.
- → Enable distributed energy resources to participate in electricity markets. Appropriate rules should allow rooftop solar, batteries, EVs, mini-grids and aggregated flexible loads to participate in wholesale or local flexibility markets where technically feasible. Connection, settlement and metering rules should reflect two-way electricity flows.
- → Establish predictable market and regulatory frameworks for investment. Long-term policy stability, transparent licensing, independent regulation and clearly defined responsibilities between utilities, regulators and system operators are essential for investment in a rapidly changing power system. Regulatory sandboxes can allow new business models to be tested without delaying broader market reform.

4.8 Building resilient technology supply chains and industrial capacity

***Goal**: Use electrification to create resilient technology supply chains, reduce excessive import dependence and build domestic and regional industrial capabilities around the technologies required for the transition.*

The electrification transition will create rapidly expanding demand for equipment ranging from transformers and cables to batteries, EVs, heat pumps, efficient appliances, motors and power electronics. Supply constraints, long equipment lead times and dependence on concentrated manufacturing bases can therefore become bottlenecks to deployment. At the same time, the transition offers countries an opportunity to build domestic and regional manufacturing capabilities and capture new economic value.

- → **Identify critical technologies, minerals and supply-chain vulnerabilities**. Governments should map national demand for key electrification technologies and identify critical minerals and equipment for which shortages could delay deployment, particularly

transformers, switchgear, cables, batteries, charging equipment and specialised electrical components. Procurement strategies should diversify suppliers and reduce excessive dependence on individual markets.

- → **Develop competitive domestic and regional manufacturing where there is a viable economic case**. Industrial policy should focus on segments where countries have relevant resources, markets, capabilities or trade advantages rather than attempting to localise every technology. Regional value chains can provide greater scale while reducing supply risks.
- → **Use standards, certification and public procurement to build technology markets**. Governments should establish common technical standards and quality requirements and use public procurement to create early demand for efficient appliances, electric buses, charging infrastructure and other technologies. Strong standards are particularly important in emerging markets where poor-quality equipment can undermine consumer confidence and increase lifetime costs.
- → **Support technology transfer, demonstration and local adaptation.** Countries should establish programmes that help firms and institutions test, adapt and deploy technologies suited to local operating conditions, particularly for industrial electrification, agricultural applications and distributed energy systems. Research and development support should focus on gaps where commercially available technologies are not yet well adapted to local needs.

4.9 Building skilled workforce and investing in youth

***Goal**: Build the technical, entrepreneurial, managerial and institutional workforce required to deploy, operate and continuously improve electrification systems at scale, with particular attention to youth and workers transitioning from fossil-fuel-intensive sectors.*

Africa adds 10 to 12 million young people to its workforce annually, while 12 to 15 million young people enter the workforce annually in India. Electrification offers the opportunity to absorb the workforce as it requires not only infrastructure and technologies but also the people capable of designing, installing, operating and maintaining them. The workforce challenge spans electricians, technicians and construction workers as well as engineers, system planners, digital specialists, energy managers and industrial workers. The renewable-energy sector alone accounted for 16.6 million jobs globally in 2024; this figure could reach 40 million jobs by 2050, and total energy-sector employment could reach around 140 million. This underscores the scale of the emerging labour market, skilled workforce and the opportunities for youth.

- → **Integrate workforce planning into national electrification strategies.** Governments should estimate future demand for technicians, engineers, installers, equipment operators and other occupations alongside infrastructure and technology targets. Skills shortages should be treated as an implementation risk in national electricity and industrial plans.
- → **Expand competency-based technical and vocational education and training (TVET)**. TVET institutions should establish recognised curricula and certification for solar installation, electrical work, EV maintenance, charging infrastructure, cooling, heat pumps, industrial electrical systems and grid technologies. Training should be developed jointly with employers to ensure that qualifications correspond to actual market demand.

- **Link training to apprenticeships, employment and enterprise development**. Public training programmes should continue beyond certification. Apprenticeships, wage subsidies, placement programmes and links to local contractors can provide pathways from training to employment, while access to small-business finance and procurement opportunities can enable young people to establish service enterprises.
- **Support reskilling and occupational mobility for workers affected by the fossil-fuel transition**. Existing workers should be supported to transfer skills into renewable energy, electrical infrastructure, equipment maintenance and other expanding sectors. Recognition of prior learning can reduce retraining time and preserve valuable technical experience.
- **Make youth and female participation and inclusion explicit objectives of electrification programmes**. Women represent around a third of the renewable energy workforce, and the share is even lower in technical roles. Public investment and procurement frameworks should create opportunities for young men and women and entrepreneurs, while removing barriers that limit participation by women and other underrepresented groups. This can convert the electrification transition into a broader inclusive employment and economic-development opportunity.



APPENDIX A:

The Global Electrification Divide

Table A1: The Global Electrification Divide: Comparative Metrics

Metric	Advanced Economies (OECD Average)	Middle-Income EMDEs (e.g., Emerging Asia, Latin America)	Low-Income / Energy-Access Deficit Economies (Sub-Saharan Africa)	Global Target (2035 Milestone)
Electricity Share of TFEC (%)	22% - 26%	18% - 24%	5% - 12%	35%
Per Capita Annual Electricity Consumption (kWh/person)	7,000 - 13,000	2,000 - 4,500	150 - 600	N/A (Context-dependent)
Foundational Electricity Access Rate (%)	~100%	90% - 98%	30% - 55%	100% (SDG 7.1.1)
Clean Cooking Access Rate (%)	~100%	65% - 85%	10% - 25%	100% (SDG 7.1.2)
Systemic Transmission & Distribution Losses (%)	4% - 7%	8% - 15%	20% - 45%+	<8% (Optimal grid benchmark)
Primary Fuel Sourcing for Thermal Demand	Fossil gas, light oil, district steam	Coal, fuel oil, LPG	Traditional solid biomass, charcoal, kerosene	Clean power, green hydrogen, heat pumps





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