IRENA's submission of an input to the UNFCCC Secretariat for contributing to the COP 30 Presidency Roadmap on the Transition Away from Fossil Fuels in a Just, Orderly and Equitable Manner

Referring to the invitation from the UNFCCC Secretariat to submit contributions to the COP 30 Presidency Roadmap on the Transition Away from Fossil Fuels (TAFF), IRENA prepared an input with a **focus on the demand-side perspectives of energy transition**. Kindly be aware that IRENA is also in discussion with the COP30 Presidency of Brazil on its direct contribution to the development of the TAFF Roadmap. Therefore, this input to the UNFCCC Secretariat is a supplemental contribution focusing on the demand side of energy transition, with a highlight on the **renewables-based electrification solutions**.

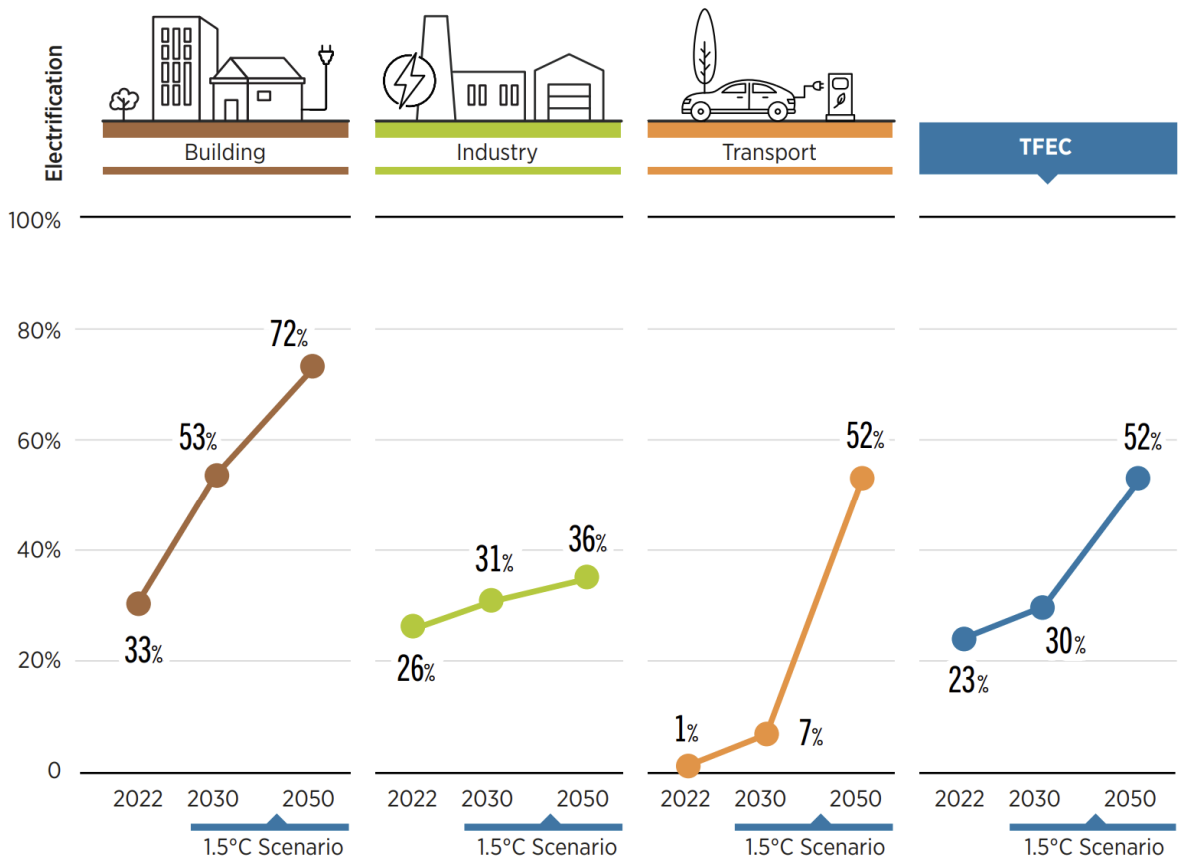
Introduction: demand-side perspective of energy transition – renewables-based electrification

Renewables combined with energy efficiency measures can help achieve the 1.5°C target. Reaching the global goal of tripling renewable power capacity and doubling energy efficiency by 2030, as agreed on the COP28 UAE Consensus- the 1st Global Stocktake outcomes, will be a key milestone to transition away from fossil fuels (TAFF). As a result of the continuous cost drop of renewable energy since 2010, 91% of all new renewable power projects in 2024 were more cost-effective than any new fossil fuel-fired alternative (IRENA, 2025a). Electrification is also accelerating power capacity additions from renewables.

Renewables-based end-use electrification at the demand-side is among the essential global efforts to accelerate TAFF in the growing global electricity demand. Electricity can become the main energy carrier by 2050 owing to its cost competitiveness and scalability because of a continuous decrease in the levelized cost of energy (LCOE) of renewables. Electrification not only supports the decarbonisation of end-use sectors, including building, transport and industry sectors, but also reduces energy consumption in those sectors.

In IRENA's estimate, globally, 30% of total final energy consumption (TFEC) will need to be electrified through renewables by 2030 to align with the Paris Agreement climate goals, or global net-zero ambition towards 2050 (IRENA, 2024). This means that direct electrification of end-use sectors would need to increase by 50% by 2030 from the level of 2022 (23%) and more than double by 2050 (52%). As Figure 1 displays, the building sector would need to lead the electrification to 53% by 2030, followed by industry (31%) and transport sectors (7%), while accelerated electrification of the transport sector can become a major factor to drive overall electrification towards 2050 from 2030.

In particular, G20 countries would need to accelerate the electrification of end-use sectors, raising the share of direct electrification from 25% in 2022 to around 32% by 2030 and to 55% by 2050—more than doubling current levels.



Source: Historical data from (IEA, 2024b)
Note: TFEC = total final energy consumption

Figure 1. Global electrification in end-use sectors and TFEC, 2022, 2030 and 2050 under the 1.5°C Scenario (IRENA, 2024)

Another promising area for supporting TAFF is **energy efficiency**. Achieving the energy transition requires adopting more energy-efficient technologies, securing structural and behavioural changes, and accelerating energy efficiency measures across all end-use sectors. Energy efficiency improvements have been negligible, at around 1% – well below the 4% required each year between 2022 and 2030 to achieve the doubling goal. Significantly more progress must be made to address this gap, particularly in end-use sectors such as transport, heat, buildings and industry (IRENA et al., 2025).

The remainder of this input addresses the four aspects for TAFF: a) critical barriers; b) levers; c) experiences and best practices; and d) just transition, highlighting perspectives from IRENA's recent country engagement in NDC support and national assessment for tripling renewable energy that have been undertaken in the IRENA member states.

(a) Critical Barriers to Transitioning Away from Fossil Fuels

Transitioning away from fossil fuels necessitates strong government commitments. While the United Kingdom achieved its coal power phase-out in 2024, other countries expressed their intentions to reduce or phase out the use of fossil fuels in power systems or other parts of the energy system, such as Brazil, Bangladesh, and others. Replacing fossil fuels with renewables-based electrification is important not only for the supply side but also for the demand side.

End-use sectors, including transport, industry and buildings, are major sources of CO2 emissions in many countries. As energy demand in the end-use sectors expands, it is increasingly important to replace fossil fuel use with renewables-based direct electrification where possible.

- **Buildings**: Urbanisation and a growing middle class further boost energy use, especially in commercial and residential sectors and services, with increased reliance on appliances and space cooling.
    - For instance, in **Viet Nam**, urbanisation with a growing middle class, end-use electrification, and higher living standards may drive more rapid growth than expected. Intensifying heat waves and rising temperatures drive higher demand for air conditioning, causing power peaks on hot days as a very large increase in the amount of indoor cooling required.
    - In **Pakistan**, Electricity and heat production, transport, industry, and residential sectors are the leading sources of CO2 emissions, totalling 201.3 Mt CO2. Adopting renewable energy for electrifying end uses is crucial to reach carbon neutrality by 2050. However, modern renewable energy, excluding traditional biomass usage in residential cooking and heating, accounted for only a small fraction of TFEC, highlighting the need for specific targets and policy measures to accelerate its deployment across sectors.

- **Transport**: The transport sector is among the largest contributing sectors to GHG emissions.
    - Electrification of the transport sector is an important driver for the transition away from fossil fuels, but the progress is still very nascent in many countries, while some countries have made great progress in recent years. Infrastructures, including grids and charging stations, need to be developed.

- **Industry**: Economic and industrial development is driving electricity demand. In addition, while energy efficiency in industrial processes is also an important measure in the industry sector, steel, cement, sugar industries, and others tend to demonstrate poor energy efficiency benchmarks. The increase in electricity demand is also expected in the ICT industry due to AI and datacentres.

Moreover, there are **financial and economic hurdles** across end-use sectors. The initial cost of renewable energy technologies and efficient technologies for end-users, such as electric vehicles and efficient appliances, has not yet been affordable and remains a deterrent. Additionally, many countries share concerns about a lack of financial incentives and a shortage of investment-ready project proposals for demand-side interventions. The absence of viable local markets for appliances is also another barrier.

Moreover, **fossil fuel subsidies** hinder the shift to renewables-based decentralised electrification. In many countries, subsidised fossil-fuel-based energy keeps household electricity tariffs artificially low. While this reduces bills for consumers, it also weakens the financial incentive for households to adopt energy-efficient lighting and appliances. Phasing out subsidies that indirectly favour fossil fuels would allow electricity tariffs to reflect real costs. In such a neutral pricing environment, renewables-based

end-use electrification and efficiency measures become more attractive and economically rational options for households.

Infrastructure limitations, such as outdated grid infrastructure and particularly distribution lines, also delay effective demand management. Without modernised networks and tools like smart meters, it is not feasible to implement advanced demand-response strategies, for instance. There are also gaps in applying smarter demand-side energy management between countries, as the institutional capacity and ICT devices are not readily available.

(b) Levers for Accelerating the Transition

Overall, renewables-based electrification combined with energy efficiency measures is an essential solution for TAFF in the end-use sectors' energy consumption. The support from policy, financial instruments and fiscal measures is needed to incentivise the investment.

First, the **building sector** has the potential of shifting to renewables-based electrification combined with energy efficiency, particularly through the adoption of rooftop solar PV with storage systems, electric cooking and heating technologies, and the implementation of energy-efficient appliances. Promoting energy efficiency standards and regulations, such as green/energy efficient requirements in building laws, especially for buildings and the residential sector, is important.

- For example, rooftop solar PV and efficient heating systems, such as solar water heaters and heat pumps, have high potential in many countries, like **Iraq** and the **Kyrgyz Republic**, to expand in the short term. Decentralised solutions like rooftop solar PVs can address the instability of the electricity supply in countries where the electricity grid has a gap in countries. The development of a regulation on net-metering and rules for connecting microgeneration facilities to the national electrical grid can incentivise solar PV installation at residential and commercial sectors.
- Moreover, an energy audit can help assess optimization of energy consumption. Still, the limited data availability is a challenge to undertake the audit in these countries. Adopting energy efficient appliances are among the important measures. For instance, incandescent light bulbs are prevalent in **Iraqi** buildings, especially in the residential sector. Applying energy-efficient technologies, such as compact fluorescent light bulbs (CFLs) and LEDs, is important to reduce electricity consumption and GHG emissions. As space cooling demand steadily rises over the years, adopting efficient cooling appliances through a more stringent minimum energy performance standard (MEPS) can reduce both energy consumption and emissions. Energy subsidy reform, energy efficiency standards (such as building codes), minimum energy performance standards for relevant appliances, such as refrigerators and air conditioners, and fiscal incentives to install energy-efficient appliances. The development of regulations and rules on the Energy Service Company (ESCO) model can encourage the mobilisation of investment.
- Heat pumps are instrumental as energy-efficient heating and cooling solutions for both large-scale district heating networks and smaller residential sectors. Financial incentives, such as subsidies, loans, or tax incentives, can encourage the adoption of heat pumps, while regulatory measures, such as building codes that require the adoption of heat pumps for new construction and innovation, will also promote the integration of heat pumps.

- Renewables-based electric cooking can expand and even become the major cooking technology towards 2050. In the short to medium term, electric cooking stoves are the most suitable long-term solution for urban areas with the expected increase of renewable power. However, electric cookstoves may not be ideal for households in rural areas in the short-term, as the additional demand from electric cookstoves strain balance with the electricity supply.

Second, regarding the **transport sector**, the electrification of light-duty vehicles and the use of higher biofuel blending for heavy-duty vehicles can support TAFF in the transport sector. Renewables-based electrification of light-duty vehicles and public transport modes like e-buses is an important solution to scale up for decarbonising the transport sector. For scaling up the adoption of e-bus as a public transport mode, public finance may play a role in covering the high upfront cost until its production cost falls with technological advancement. Once e-buses are in place, their O&M cost is lower than that of their conventional counterparts. The adoption of stringent fuel efficiency standards can encourage a shift to electric vehicles away from the use of oil in internal combustion engine cars, along with behavioural changes. Implementing incentive mechanisms for EVs, such as fiscal measures like tax incentives, and developing local repair and maintenance capabilities. Vehicle scrappage and end-of-life schemes for incentivising the shift from fossil fuel cars to cleaner alternatives are also among the important actions needing to be implemented to ensure a smooth transition. To support this transition, extensive development of electric charging infrastructure is also crucial. And, in the long-run, V2X (vehicle to grid/vehicle to load) could be a future flexibility power option from the demand side.

- As an example of fiscal incentives for transport electrification, the **Kyrgyz Republic** imposes a zero-tariff policy on imported electric vehicles to encourage their import and use. Additionally, electric vehicles are exempt from the annual registration tax. These tax incentives have lowered the purchase and operational costs of electric vehicles, enhancing their market competitiveness.
- Yet the electrification of the transport sector may be accelerated only from 2030 in some contexts. For instance, in **Iraq**, electrification of the transport sector would be increasingly important as renewable power is integrated into power systems only in the long-term. In the short to medium term, a modal shift from private vehicles to public transport, including bus rapid transit systems (BRT) and railways, is recommended rather than immediate electrification of the transport sector because of the expected shortage of power for transport electrification and consideration of short-term cost-efficient climate change mitigation measures.

Third, in the **industry sector,** increasing the renewable-based zero or low carbon fuels, and electricity shares is essential to replace the fossil fuel use and decarbonise the activity. The transition away from fossil fuels to renewables-based electrification and bioenergy is important, as seen in the **Philippines**' shift from coal to electricity in certain process activities in industry.

- While electricity can also be used in low-temperature heat and machine drive processes across industrial subsectors, those thermal energy-intensive sectors, such as brick kilns and cement manufacturing, which require high-temperature processes, are difficult to electrify directly with high efficiency. Possible solutions include the implementation of vertical shaft brick kilns and indirect electrification using green hydrogen once the technology is mature.
- Improved energy and materials efficiency, alongside circular economy practices and structural changes, lead to substantial reductions in energy consumption.

- Energy audits should be promoted for all industries to identify and realise the energy savings potential and energy efficiency in industrial operations. For instance, setting an energy standard for the cement industry and an energy audit requirement would support the uptake of heat recycling in cement production. Heat recycling technologies are effective and commercially well-deployed, making them suitable for the cement sector.
- Captive power plants, which are electricity generation for self-consumption, through renewables, are a decentralised renewable energy solution for industry to cope with grid instability, as their growth is seen in **Pakistan**. Captive solar power plants could be one of the decentralised renewable energy solutions for the industry sector, such as the extractives and mining. Alternatively, new mining farms / extractive facilities can be better located near renewable power generation sites, which would also make sense to reduce electricity losses during transmission.
- Carbon pricing can also be considered in countries to regulate the emissions or emission intensity of the industry sector, especially steel and cement.

(c) Roadmap Experiences and Best Practices

Several countries have successfully integrated demand-side strategies into their national roadmaps and climate commitments. In IRENA's review of NDCs 3.0, there have been countries that committed their targets and measures on the demand-side renewable use (IRENA, 2025b):

- **Buildings**: For energy efficiency of buildings, the minimum energy performance standards (MEPS) and the labelling of appliances and building codes are frequently mentioned by countries.
  In addition, clean cooking is a recurring theme in NDC 3.0 submissions, reflecting efforts to reduce emissions and improve health outcomes and gender equality. Many countries commit to transitioning households from traditional biomass to modern cooking solutions, including electric cookstoves. Interestingly, while **Nigeria** expressed its priority for non-electric cooking in the previous NDC, its new NDC 3.0 proposes that electricity can account for the largest share of cooking in urban households (55%) and commercial settings (37%) by 2035, with other energy sources intended for rural households. Other countries, such as Kenya, Nepal, Cambodia, Pakistan, Liberia and São Tomé and Príncipe, also include electric cooking as part of their NDC actions.
- **Transport**: There have been NDCs 3.0 committing to quantified targets on transport sector electrification. For instance, **Saint Lucia**'s NDC committed to increasing the EV share to 40% by 2035. As another example, **Nepal** is setting a target to increase the EV share of new private passenger vehicle sales to 95% by 2035, as well as advance electrification of public transport, such as electric buses and rail networks to 300 km by 2035 for public commuting and freight.
- **Industry**: Countries are also highlighting zero- and low-emission technologies in their NDCs for the industrial sector. **Somalia** intends to improve energy efficiency through cleaner production and integration of renewable energy, as well as waste-to-heat recovery by capturing and reusing heat for lower emissions in industry and its industrial processes. **Uruguay**'s NDC 3.0 mentions its intention to substitute fossil fuels with cleaner alternatives, such as biomass and green hydrogen, in pulp production and the cement industry.

Carbon pricing can also be instrumental in incentivising TAFF to cleaner alternatives in the end-use sectors. Numerous countries have been developing national carbon markets and taxation.

- For instance, **Viet Nam** is currently undergoing the process of establishing a domestic carbon market, with the pilot phase planned from 2025 to 2028, and full operation scheduled to start in 2029 with a view to accelerating the action towards the country's net-zero target by 2050. Viet Nam launched the pilot phase of ETS targeting three major industrial sectors, including steel, cement and thermal, to cut the CO2 emissions by the end of 2028. These three sectors, totalling about 150 enterprises, will receive emission allowances for the pilot phase and will shift to purchasing allowances through auction from the full ETS implementation phase starting in 2029. Viet Nam's ETS adopts an intensity-based cap that is emissions per unit of output rather than an absolute emissions limit.

There are emerging innovative financing solutions for TAFF. One example is the early retirement of coal-fired power plants by using carbon credits.

- **Singapore** is engaged in carbon pricing and the Article 6 market mechanism as part of its international partnership approach to reduce global emissions. Monetary Authority of Singapore (MAS) are exploring an innovative carbon finance solution to replace coal-fired power plants with renewables through Transition Credits Coalition (TRACTION) launched at COP28. With more than public and private organisations' support, TRACTION is moving into the implementation phase with frameworks and methodologies for high-integrity energy transition credits. As the first case of the TRACTION, ACEN Corporation, which is an energy firm under the Ayala Group in **the Philippines** and divesting from coal and investing in renewables in the ASEAN region, is looking into the transition credits for the early retirement of coal-fired plants of South Luzon Thermal Energy Corporation (SLTEC) from 2040 to 2030. This ACEN-SLTEC intends to bring forward the retirement of the 246MW coal-fired power plant by 10 years. Coal to Clean Credit Initiative (CCCI) methodology on transition credits has been approved by Verra in 2025, which can be used for early coal-fired power plant retirement and incentivise the full or partial replacement with clean power in the ACEN-SLTEC project and beyond. The income from the transition credits can compensate for foregone cash flows from the coal-fired plant, fund energy replacement through renewables and support a just transition for workers and affected communities. Moreover, broader work to apply Article 6.2 cooperative approach between Singapore and the Philippines is underway to create the transition credits, following the MOU signed by the two governments in August 2024. As communicated in Singapore's 2025 NDC, Singapore is committed to exploring the use of high-integrity transition credits to finance the early retirement of coal-fired power plants. (MAS, 2025)

(d) Just, Orderly, and Equitable Transition

Renewable-based end-use electrification must ensure a "just" outcome, addressing structural inequalities that have existed in fossil fuel-based energy systems. In its recent publication, IRENA provide a working definition of just energy transition: equitable distribution of benefits and burdens, grounded in inclusive processes and decision making, and committed to addressing the challenges experienced by affected and marginalised groups as well as preventing and repairing harm that may occur during the transition (IRENA, 2026).

Accordingly, renewable-based end-use electrification can provide solutions to address inequalities by offering more reliable and affordable energy services than fossil fuels. There are countries where

decentralised end-user solar PV installations addressed the crisis of reliability and affordability of fossil fuel-based energy systems:

- In **Pakistan**, solar PV installation has significantly expanded in recent years to replace highly expensive electricity from fossil fuel-dominant grids with self-consumption solar PV at end-users. The surge of solar PV adoption was driven by electricity tariff increases, which became unaffordable for residential sectors. Off-grid solar solutions offer affordable electricity options.
- On the other hand, **Lebanon**'s end-users rapidly increased the use of distributed rooftop solar PV to cope with the energy crisis in 2021 and the rising cost of diesel-generated electricity.

There are also sustainable development and socio-economic co-benefits from renewables-based electrification.

- Concerning agriculture and food, renewable-based electrification improves agricultural production, leading to enhanced lives and livelihoods. For instance, as highlighted in the National Adaptation Plan's priorities in **Papua New Guinea**, solar drying and cooling can improve the resilience of the Agri-value chain, leading to the improvement of the socio-economic livelihood of farmers. Moreover, solar PV can also meet the power demand of irrigation systems and groundwater extraction for agriculture and water sectors, as many countries include as a priority measure in their new NDCs.
- There are also health co-benefits from renewables-based electrification. Decentralised renewable energy can power healthcare facilities in rural settings, including the continuous operation of essential medical equipment and services, lighting, water supply and refrigeration for vaccines.

To benefit from the solutions of decentralised renewable energy, **local human skills** will need to be upgraded to design and implement demand-side energy-efficient measures in communities. There are countries making efforts to strengthen national capacities for energy transition, for instance:

- **Niue**'s NDC 3.0 recognises a growing need to strengthen higher education with skills-based technical courses, particularly in tourism and energy.
- **Barbados** intends to create a Renewable Energy Skills Council to guide implementation and to make recommendations for a just transition in the renewable energy sector.

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