Engineering our way to a sustainable energy transition

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Introduction

The Paris Agreement on climate change, adopted in 2015 by 196 parties, created a new framework for emissions reductions, with an ambition to limit global warming to well below 2°C – ideally 1.5°C – compared with preindustrial times. The agreement has led to actions and commitments around the world by a wide spectrum of countries and companies, including ambitious declarations to achieve net-zero emissions. While there is a growing sense of urgency from the general body of climate science, the realities of the global energy system and the diversity of global economies create challenges to meeting these goals equitably. This spotlight will explore some of the challenges faced by engineers and the broader engineering capacity ecosystem to achieve a sustainable energy transition, as well as the roles played by professional engineers, government and industry. The next two spotlights explore the energy transition further, looking first at how to achieve safe and sustainable mining, and then at the challenges associated with the end of life of renewable infrastructure.

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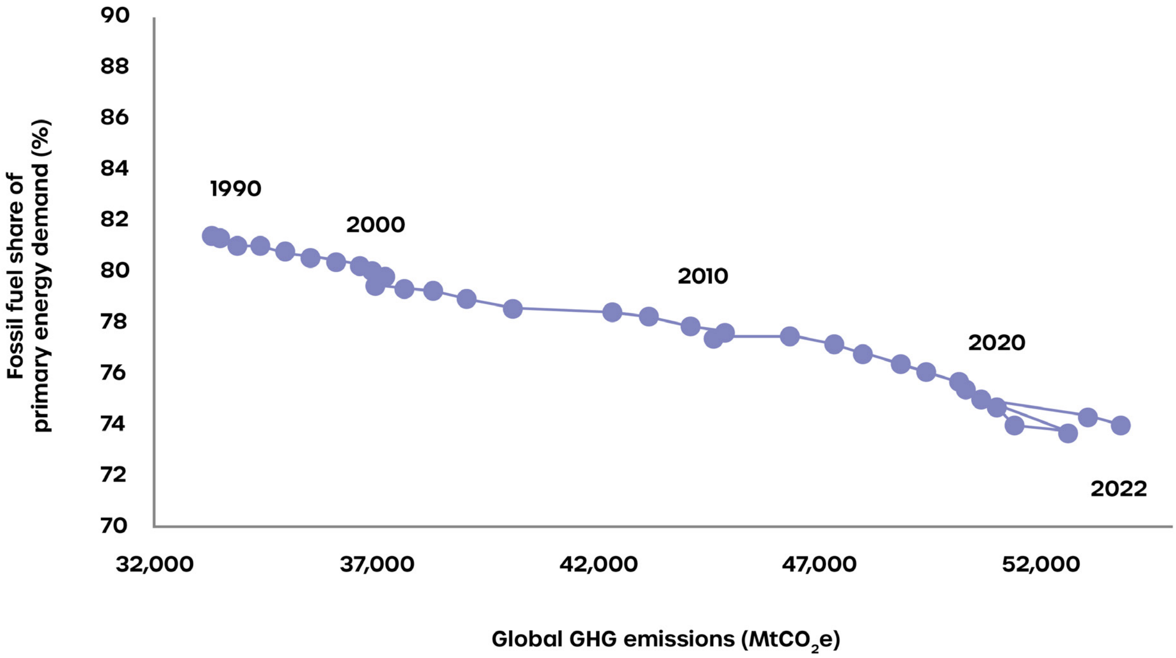
What are some of the key engineering challenges to achieving a sustainable energy transition?

Global fossil fuel emissions in 2023 grew by 1.1% compared to levels in 2022.[1] Curbing these emissions continues to raise financial, technological, social, and regulatory challenges. These challenges may be more acute in low- and middle-income countries, particularly those most affected by climate change, where there is an urgent need for climate adaptation as well as mitigation measures, such as cleaner energy, and a shortfall in climate financing.

Reducing emissions while facing growing demand

Despite the rise in climate ambition and supporting policies, in the last 30 years, the share of hydrocarbons in the global primary energy mix has hardly changed. The chart below shows global greenhouse gas emissions, which are estimated to have increased by 0.9% in 2022, hitting a new record of 53 billion metric Tonne.

Figure 1: Greenhouse gas emissions vs. fossil fuel share of primary energy demand, 1990–2022



As of June 2025.
Note: MtCO2e = million metric tonnes of carbon dioxide equivalent. Source: EDGAR (Emissions Database for Global Atmospheric Research) Community GHG Database (a collaboration between the European Commission, Joint Research Centre (JRC), the International Energy Agency (IEA), and comprising IEA-EDGAR CO2, EDGAR CH4, EDGAR N20, EDGAR F-GASES version 8.0, (2023) European Commission at https://edgar.jrc.ec.europa.eu/report_2023 and EDGARv8.0 website: https://edgar.jrc.ec.europa.eu/dataset_ghg80.

1 Emissions from Fossil Fuels Continue to Rise, NASA Earth Observatory, February 2023, at https://earthobservatory.nasa.gov/images/152519/emissions-from-fossil-fuels-continue-to-rise (retrieved 12 May 2025).

The current nationally determined contributions (NDCs) of the Paris Agreement would reduce global emissions by only 10% in 2030 relative to 2019 levels.[2] This compares with the 43% reduction that the Intergovernmental Panel on Climate Change set as the benchmark required to align with a 1.5°C pathway. S&P Global and the International Energy Agency developed emission scenarios to analyse the widening gap between current emissions trajectories and the pathway required to achieve net zero by 2050. The current baseline shows that emissions will fall by less than 25% by 2050. Achieving the 1.5°C goal will likely require a reduction of 90% or more. Reducing energy demand is proving elusive, driven partly by high levels of consumption in advanced economies and the rapid rise of new technologies such as AI, which demand large amounts of energy.[3] However, economic and population growth also have a large part to play.

Many emerging and lower-income economies are growing, allowing them to expand reliable and affordable energy access to hundreds of millions of people and create improved living standards. Increasing populations creates more energy users, while the continued move from rural to urban living[4] leads to increases in energy consumption, particularly driven by the need for new infrastructure, buildings and transport links.[5] Thus, despite progress, the Energy Alliance for People and Planet estimates that there are still 750 million people who lack any access to energy; 1.6 billion people who lack access that is reliable and affordable; and a further 1.25 billion people who do not consume enough electricity to make a meaningful difference to their economic prospects.[6]

The challenge, therefore, is how to bend the emissions curve while ensuring economic growth and improved livelihoods and continuing to increase energy access. The role of engineering in reducing emissions by creating the solutions for a transition to cleaner energy sources at scale and designing resilience and energy efficiency into both new and old equipment, buildings, transportation, and other infrastructure is critical.

The investment gap

Investment in renewable power and energy storage amounted to about $477 billion in 2022 and will average $700 billion per year through 2030, with the majority of investments currently centred in a handful of countries and regions (China, the EU and North America).[7] Despite the growing commitments and policies, there is still an estimated $25 trillion cumulative funding gap between forecast spending and the investment needed to achieve net zero by 2050.[8] This gap includes funding pledged for mitigation and adaptation for low-income countries, adding further challenges for the energy transition.

The African continent has enormous potential in renewable energy resources, particularly solar, yet it represents only 1% of global installed

2 S&P Global Commodity Insights.
3 The AI boom could use a shocking amount of electricity, Leffer, L., Scientific American, 13 October 2023, at https://www.scientificamerican.com/article/the-ai-boom-could-use-a-shocking-amount-of-electricity/ (retrieved 12 May 2025).
4 Urbanization and migration, Migration data portal, 10 June 2022, at https://www.migrationdataportal.org/themes / urbanization-and-migration (retrieved 12 May 2025).
5 "The impact of urbanisation on energy consumption: A 30-year review in China", Zhao, P., Zhang, M., Urban Climate 24(3), December 2017.
6 Let's Change Energy: an introduction to GEAPP, Global Energy Alliance for People and Planet, 2023, at https://energyalliance.org/wp-content/uploads/2024/03/GEAPP-Brochure-December-2023.pdf (retrieved 12 May 2025)
7 S&P Global Commodity Insights.
8 Energy Transition: Gaps in the Pathways, S&P Global, 13 January 2023, at https://www.spglobal.com/en/research-insights/special-reports/look-forward/energy-transition-gaps-in-the-pathways (retrieved 12 May 2025).

solar photovoltaic (PV) capacity,[9] and only 20% of the total installed electricity generation capacity in Africa in 2019 was based on renewable sources.[10] Hydropower makes up the biggest proportion of installed renewable energy capacity, but its relative share decreased to 67% in 2021 from 92% in 2010, with increased competition from other renewable technologies.[11] An extra 2 GW of new renewable energy capacity was added in Africa in 2019, increasing the installed capacity by 4.3% over the previous year and bringing the total capacity to 48 GW.[12] Many countries across Africa – including Morocco, Senegal, Egypt, South Africa, and Kenya – are demonstrating encouraging trends in terms of adding new renewable energy capacity. South Africa is leading the continent in installed renewable capacity, with 6.2 GW in 2022.[13] High levels of extra investment are required to support the continent to meet its renewable energy needs.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9 Africa Energy Outlook 2022, IEA, 2022, at https://www.iea.org/reports/africa-energy-outlook-2022/key-findings (retrieved 12 May 2025).

10 Global Renewables Outlook 2020, International Renewable Energy Agency, 2020, at https://www.irena.org /-/ media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Global_Renewables_Outlook_2020.pdf (retrieved 12 May 2025).

11 The Renewable Energy Transition in Africa: Powering Access, Resilience and Prosperity, KFW, GIZ, IRENA and Federal Ministry for Economic Cooperation and Development, 2020, at https://www.irena.org/-/ media/Files/IRENA/Agency/Publication/2020/Mar/IRENA_RE_Capacity_Highlights_2020. pdf?la=en&hash=B6BDF8C3306D271327729B9F-9C9AF5F1274FE30B (retrieved 12 May 2025).

12 Renewable capacity highlights, IRENA, 31 March 2020, at https://www.irena.org/-/media/Files/IRENA/Agency / Publication/2021/March/Renewable_Energy_Transition_Africa_2021.pdf (retrieved 12 May 2025).

13 Rystad Energy analysis shows Africa's renewable energy capacity is set for consecutive years of growth, Kamau, P., Africa Business Communities, 14 March 2023, at https://africabusinesscommunities.com/features/rystad-energy -analysis-shows-africas-renewable-energy-capacity-is-set-for-consecutive-years-of-growth/ (retrieved 12 May 2025).

What key roles do professional engineers, government and industry play in a safe and sustainable energy transition?

The three stakeholder groups outlined in the ECI 2025 – professional engineers, government and the engineering industry – play pivotal roles in addressing the challenges faced by the energy transition.

Professional engineers

Engineers have a central role to play in tackling the obstacles to achieving secure and sustainable energy. Engineering expertise is crucial in designing and optimising systems that harness energy from solar, wind, hydro, and other sources.

Many countries have outdated energy infrastructure that needs modernisation to support decentralised and renewable energy systems. This involves upgrading transmission lines and distribution networks. In addition to addressing ageing infrastructure, engineers have a critical role in enhancing the energy efficiency and reducing the emissions of industrial and building operations, as buildings contribute to nearly 28% of global greenhouse gas emissions.[14] Engineers can implement various strategic and technological solutions to incorporate renewable energy sources, thereby reducing environmental impacts and improving insulation. These solutions may include energyefficient retrofitting and design of the building envelope; effective and efficient heating, ventilation, and air conditioning (HVAC) systems; sustainably sourced and low-carbon materials; integration of renewable energy systems; use of advanced building information modelling (BIM) automation tools; and wider consideration for lifecycle assessment to contribute to a resilient built environment. For instance, Godrej Bhavan, an iconic office building in Mumbai built in 1962, was upgraded in 2010 to incorporate comprehensive energy efficiency and sustainability features. These included installing a green roof to reduce heat gain, using doubleglazed windows and shades for heat reduction and natural light, updating the HVAC system, and strategically placing trees and plants to improve air quality.[15]

Engineers are also working to address the critical challenges of managing the integration of variable renewable energy sources such as solar and wind by developing advanced grid management systems and energy storage solutions. These solutions must be able to handle fluctuations in supply and demand, overcoming the intermittent nature of renewable energy sources. Engineers are also focused on improving the performance and reducing the costs of batteries, pumped storage and other storage solutions.

The transportation sector highlights the complexity of the engineering challenges in the energy transition. While many countries are focused on increasing demand and supply of

14 Global energy-related emissions and energy consumption in buildings, International Energy Agency, 2024, at https://www.iea.org/energy-system/buildings (retrieved 12 May 2025).
15 5 Influential Examples of Retrofitting in Architecture. Jain, K., Rethinking The Future, n.d., at https://www.re-thinkingthefuture.com/rtf-fresh-perspectives/a3725-5-influential-examples-of-retrofitting-in-architecture / (retrieved 5 June 2025).

electric vehicles, decarbonising the transport sector requires a systems approach, involving engineers, industry and governments. This includes whole system transport planning which first prioritises a modal shift from private road vehicles to public and shared transport options or active travel (for example, from private cars to buses or trams, and on to walking and cycling) and toward shifting freight to the most efficient, low-carbon options (for example, from road to rail, or for interurban deliveries, from lorries to bikes).

There are key interdependencies between any one technological solution and wider energy systems and built environments. For example, in the case of electric vehicles, engineers are required to design and manufacture not only the vehicles but also the robust and extensive charging infrastructure needed to efficiently charge them. Electrical engineers must consider the high power levels required for fast charging, which can strain existing distribution networks. Power systems engineers are needed to plan and deliver network reinforcements alongside charging infrastructure rollout to ensure a stable power supply and prevent grid overload.

As an example of just one detailed technical challenge to overcome, rapid charging generates heat in batteries and connectors, accelerates battery degradation due to increased stress on cells, and introduces safety risks such as overheating, arcing or short circuits.[16] Mechanical engineers who can design cooling systems and thermal management solutions are therefore essential in managing the heat to prevent damage and maintain efficiency. Chemical engineers can help design batteries that are better suited for fast charging and with battery chemistries that avoid high levels ofcritical materials, which are in high demand and have highly constrained supply chains.[17]

As digitalisation becomes integral to the energy transition and infrastructure resilience, the reliance on smart grids and digital technologies makes energy infrastructure vulnerable to cyberthreats. Engineers must implement robust cybersecurity measures to safeguard energy systems from attacks, as disruptions to critical infrastructure can have serious and lasting impacts on the population.

Furthermore, engineers in regions with limited access to centralised grids face extra constraints, particularly in contexts with weaker infrastructure and limited resources. Engineers working in these geographies must address the challenges of decentralised energy systems, such as microgrids, which require engineering solutions for local energy generation, distribution and storage. Engineers need to identify alternative solutions or optimise the use of available resources based on geographical context, such as solar power in sun-rich regions and wind power in areas with strong wind resources. Household solutions can also help reduce carbon footprints. For example, engineers have designed efficient and clean cooking technologies that reduce reliance on traditional biomass fuels and indoor air pollution, thus reducing negative health impacts and the time required for cooking.[18]

16 A Comprehensive Review of Developments in Electric Vehicles Fast Charging Technology, Zentani, A., Almaktoof, A., and Kahn, M. T. Applied Sciences 14(11), 2024, 4728 at https://doi.org/10.3390/app14114728 (retrieved 12 May 2025).
17 Critical materials: demand-side resource efficiency measures for sustainability and resilience, National Engineering Policy Centre, October 2024, at https://nepc.raeng.org.uk/critical-materials (retrieved 12 May 2025).
18 echnology Innovation to Accelerate Energy Transitions, IEA, Paris June 2019, at https://www.iea.org/reports/technology-innovation-to-accelerate-energy-transitions (retrieved 12 May 2025).

Government

Governments at the supranational, national and local levels play pivotal roles in the energy transition, from establishing policy direction to investing in sustainable public infrastructure. They can also help set industry standards and protocols. While renewable energy and storage technologies are already cost-competitive, upfront capital expenditures and unfavourable regulatory frameworks can make fossil fuel alternatives more attractive for financing, potentially hindering the transition to cleaner energy sources. By reducing regulatory uncertainty, the government can lower the cost of financing and derisk investments in renewable energy and storage.

Net-zero declarations continue to grow. In 2024, 195 countries stated net-zero targets, with 33 countries embedding the targets into national law.[19] Policy developments such as REPowerEU[20] and the Green Deal Industrial Plan[21] in Europe, along with the Inflation Reduction Act[22] and the Infrastructure Investment and Jobs Act (IIJA)[23] in the US have the potential to turbocharge investments in a wide spectrum of clean energy technologies and mark the launch of a new era of industrial policy aimed at substantially reducing emissions within this decade.

REPowerEU is a plan launched by the EU to reduce the bloc's dependence on fossil fuel imports and accelerate the green transition. The measures in the plan include energy savings, diversification of energy supplies and the accelerated rollout of renewable energy to replace fossil fuels in homes, industry, and power generation. The Green Deal Industrial Plan aims to enhance the competitiveness of Europe's net-zero industry and accelerate the transition to climate neutrality.[24] It aims to do this by creating a more supportive environment for scaling up the EU's manufacturing capacity for net-zero technologies and products required to meet Europe's ambitious climate targets. Meanwhile, the IIJA was signed into law by US President Joe Biden in November 2021, authorising $1.2 trillion USD for transportation and infrastructure spending, with $550 billion USD of that going toward new investments and programmes. Funding from the IIJA is expansive, addressing energy and power infrastructure, access to broadband internet, water infrastructure, and more. On 16 August 2022, the Inflation Reduction Act was signed into US law, which offers funding, programmes, and incentives to accelerate the transition to a clean energy economy.

State-led investment can be important for driving the transition and incentivising further private investment, but this is lacking in some regions. For example, in Latin America, public investment in infrastructure remains low, on average below 2% of GDP as of 2023 (the

19 Race to Net Zero, Motive Power, 2024, at https://www.motive-power.com/visualized-emission-reduction-targets-by-country-in-2024/ (retrieved 12 May 2025).

20 REPowerEU: Europe's response to the energy crisis, European Commission, 2024, at https://commission.europa. eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainableenergy-europe_en (retrieved 12 May 2025).

21 The Green Deal Industrial Plan, European Commission, 2024, at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan_en (retrieved 12 May 2025).

22 Inflation Reduction Act of 2022, Inland Revenue Service, 2022, at https://www.irs.gov/inflation-reduction-act-of-2022 (retrieved 12 May 2025).

23 Infrastructure Investment and Jobs Act, H.R.3684, 117th Congress (2021–2022), 15 November 2021, at https://www.congress.gov/bill/117th-congress/house-bill/3684 (retrieved 12 May 2025).

24 ommunication: A Green Deal Industrial Plan for the Net-Zero Age, European Commission, 1 February 2023, at https://commission.europa.eu/document/41514677-9598-4d89-a572-abe21cb037f4_en (retrieved 12 May 2025).

last year of data available).[25] Upgrading and maintaining existing infrastructure must also be factored into government spending plans. Inadequate facilities and poorly maintained energy, road and port infrastructure can hinder energy security and increase operational costs, further complicating efforts to decarbonise the grid and reduce emissions. The government and permitting agencies at local and national levels must also have adequate capacity, guidelines and skills to enable timely approval of new energy infrastructure projects, which can be a slow and lengthy process.[26]

During the 2023 UN Climate Change Conference (COP28), the host government, the United Arab Emirates, prioritised keeping the 1.5°C temperature target alive, with President-Designate Sultan al-Jaber calling this target his 'North Star' throughout the negotiations. For the first time, governments (parties) were called on to assess progress on climate goals and step up action under the global stocktake (GST) framework[27] established through the Paris Agreement.

Notably, the GST document marks the first time that the future of all fossil fuels was acknowledged in an official agreement from the Conference of the Parties process. It also emphasises widespread support for accelerated deployment of zero-carbon power and energy efficiency measures, building on multilateral initiatives announced earlier in the negotiations.[28]

COP28 also saw progress on regulatory initiatives and public and private finance for reducing methane. Another milestone was consensus on the operationalisation of the proposed loss and damage funding mechanism that was reached during the opening plenary in a first for UN climate conferences.[29]

The GST encourages parties to increase ambition in alignment with the goals of the Paris Agreement but does not compel them to do so. While the 2023 conference gathered momentum around the need for collective action for a new global finance framework, progress on mitigation and adaptation goals still proved to be insufficient to fill funding gaps.[30] Governments must work with the private sector and multilateral organisations to fill these gaps.

However, while international talks can help galvanise action, it is at the national and subnational levels where the transitions will take place. The World Economic Forum suggests that readiness for energy transition is determined by factors including stability of the policy environment, level of political commitment, investment climate, access to capital, level of consumer engagement, and development and adoption of new technologies.[31] These factors all require expertise and coordination across the whole engineering ecosystem – professional engineers, governments and engineering and related industries – to make the transition a reality.

25 INFRALATAM. (n.d.). Home – INFRALATAM. https://www.infralatam.info/home/ (retrieved 26 June 2025). Note: only Bolivia, Peru, Paraguay, Nicaragua and Belize were above 2%.
26 Energy projects tend to move slowly in the US – here's what to do about it, World Economic Forum, 20 December 2023, at https://www.weforum.org/stories/2023/12/energy-projects-move-slowly-in-the-us/ (retrieved 12 May 2025).
27 Global Stocktake, UNFCC, 2024, at https://unfccc.int/topics/global-stocktake (retrieved 12 May 2025).
28 Unpacking COP28: Key Outcomes from the Dubai Climate Talks, and What Comes Next, Warskow, D., Srouji, J., Layke, J., et al, World Resources Institute, 17 December 2023, https://www.wri.org/insights/cop28-outcomes-next-steps (retrieved 12 May 2025).
29 Loss and Damage Fund Operationalized at COP28, ONU Migración Americas, 19 January 2024, at https://lac.iom . int/en/news/loss-and-damage-fund-operationalized-cop28 (retrieved 12 May 2025).
30 After COP28, questions remain for communities struggling with climate change, UN environment programme, 27 December 2023, at https://www.unep.org/news-and-stories/story/after-cop28-questions-remain-communities -struggling-climate-change (retrieved 12 May 2025).
31 Fostering Effective Energy Transition 2023, World Economic Forum, 2023, at https://www.weforum.org / publications/fostering-effective-energy-transition-2023/ (retrieved 12 May 2025).

Engineering industry

Engineering and engineering-intensive industries, such as mining, construction and manufacturing, play a crucial role in driving innovation, research and development, and investment in energy technology, and in implementing sustainable technologies at scale. This includes deploying renewable energy systems, energy-efficient practices and cleaner technologies in manufacturing processes. They also have a role to play in setting and adhering to standards to increase quality, safety and reliability.

A smooth energy transition requires significant private as well as public investments in expanding and modernising transmission and distribution infrastructure. Mini- and off-grid solutions are also needed to drive access, expansion and economic growth, and to enable the integration of more variable renewable energy, reduce losses and ensure financial sustainability in the sector. Building the necessary domestic human capacity and skills is critical in enabling countries to undertake their energy transition while boosting economic growth and job creation and reducing reliance on international companies. It is a common challenge for organisations to ensure their workforce grows and gains new skills at pace with changing technologies and needs, requiring a focus on talent growth and acquisition as well as continuous learning.

Industries can also be a convening force to drive local and international partnerships that can accelerate change. For example, Abu Dhabi National Oil Company (ADNOC) and Masdar, also of Abu Dhabi, have partnered with British Petroleum (BP) to explore blue and green hydrogen projects and municipal waste gasification for sustainable jet fuel, helping address energy transition challenges in sectors including industrial manufacturing and aviation.[32] Another example is LEAPS, a public– private partnership led by Purdue University in the US in collaboration with local industrial partners. The initiative aimed to identify and advance technologies in energy efficiency, recycling, indirect emissions, and renewable energy applications. LEAPS encompassed the full value chain across various industries, offering partners access to Purdue's innovative students, faculty and specialised facilities.[33]

While energy companies are responsible for financing, developing, and deploying the technologies necessary for the energy transition, it is the engineering associations and standards bodies at local, national and international levels that play a role in driving progress on governance. Industry governance is especially important for helping derisk new technology areas, such as those in the energy transition. Introducing norms, standards and quality benchmarks ensures adherence to performance, safety and reliability requirements, which reduces uncertainty and minimises unexpected risks during development, deployment, and operation. Many industry standards align with legal and regulatory requirements, which reduces legal risks and ensures compliance with industry norms.[34]

32 How cross-sector partnerships are enabling a clean energy transition, World Economic Forum, 31 August 2022, at https://www.weforum.org/agenda/2022/08/how-cross-sector-partnerships-enabling-clean-energy-transition / (retrieved 12 May 2025).

33 Leading Energy-Transition Advances and Pathways to Sustainability (LEAPS), Purdue University, 2024, at https://engineering.purdue.edu/Engr/AboutUs/News/Spotlights/2024/2024-0229-purdue-engineering-initiative-energy-transition-leaps (retrieved 8 June 2026). Further information on LEAPS is no longer available, however see: https://engineering.purdue.edu/Initiatives/IEI for other energy initiatives at Purdue University.

34 Transitioning to Renewable Energy: Three Governance Approaches That Can Drive Change, Verma, P., World Economic Forum, 10 May 2023, at https://www.weforum.org/agenda/2023/05/transitioning-to-renewable-energy-governance-approaches/ (retrieved 12 May 2025).

Standards can also be used to promote compatibility and seamless integration between different technologies, reducing the risk of system failures, costly modifications and lack of uptake because of limited interoperability. For example, different electric vehicle manufacturers currently use different connector types and protocols. Collaborating with industry associations and the government to establish universal standards for connectors and communication interfaces will be vital for the use of electric vehicles to scale and to ensure interoperability, enhance user experience and reduce the amount of costly charging infrastructure required.[35]

International organisations such as IEEE, ISO and IEC create international standards, including for renewable energy, grid integration and electric vehicles. Some examples include the Electric Machinery Committee (EMC) within IEEE Power & Energy Society (PES), which focuses on maintaining legacy industrial standards while supporting new initiatives in renewable energy and electrification.[36] Meanwhile, the Council of Engineers for the Energy Transition (CEET) recommends guidelines to support countries in implementing their NDCs aligned with the Paris Agreement. Their core activities focus on scaling key technologies to accelerate the global energy transition.[37]

Engineering associations and professional bodies are also an important vehicle for establishing partnerships between academia, industry and government. These partnerships can help drive sustainable energy solutions and reach energy policy goals. For instance, multilateral partnerships such as the International Energy Agency's (IEA's) Technology Collaboration Programme (TCP), which supports industry and government energy programmes, and Mission Innovation (MI), a multi-country initiative in collaboration with multilateral banks and energy agencies, both seek to accelerate research, development and commercialisation of energy solutions globally.[38]

Conclusion

As this report emphasises, stakeholders across the engineering capacity ecosystem, including engineers, governments, industry, and industry associations, all have critical roles to play in achieving a sustainable energy transition. From navigating regulatory environments and securing necessary funding for infrastructure development to addressing the technical demands of scaling new technologies and integrating renewable energy sources into existing grids, the road to a safer and more sustainable energy future is highly complex. Meeting increasing energy demand while reducing emissions requires strong public and private commitment and high levels of international investment, and a particular focus on financing for low- and middle-income countries to ensure this transition is not only safe and sustainable but also equitable. Engineers and engineering capacity, built on collaboration between industry and government, will be key.

35 Interoperability of Public Electric Vehicle Charging Infrastructure, Electric Power Research Institute, 6 August 2019, at https://www.epri.com/research/products/3002017164 (retrieved 12 May 2025).
36 Entity Annual Report 2020, IEEE Power and Energy Society Electric Machinery Committee, 2020, at https://site.ieee.org/pes-enews/files/2021/05/May_2021_IEEE-PES-EM-Committee-Annual-Report-2020.pdf (retrieved 12 May 2025).
37 Council of Engineers for the Energy Transition (CEET), United Nations Sustainable Development Solutions Network, n.d., at https://www.unsdsn.org/our-work/ceet (retrieved 12 May 2025).
38 Energy Technology Innovation Partnerships, IEA, Paris, June 2019, at https://www.iea.org/reports/energy-technology-innovation-partnerships (retrieved 12 May 2025)