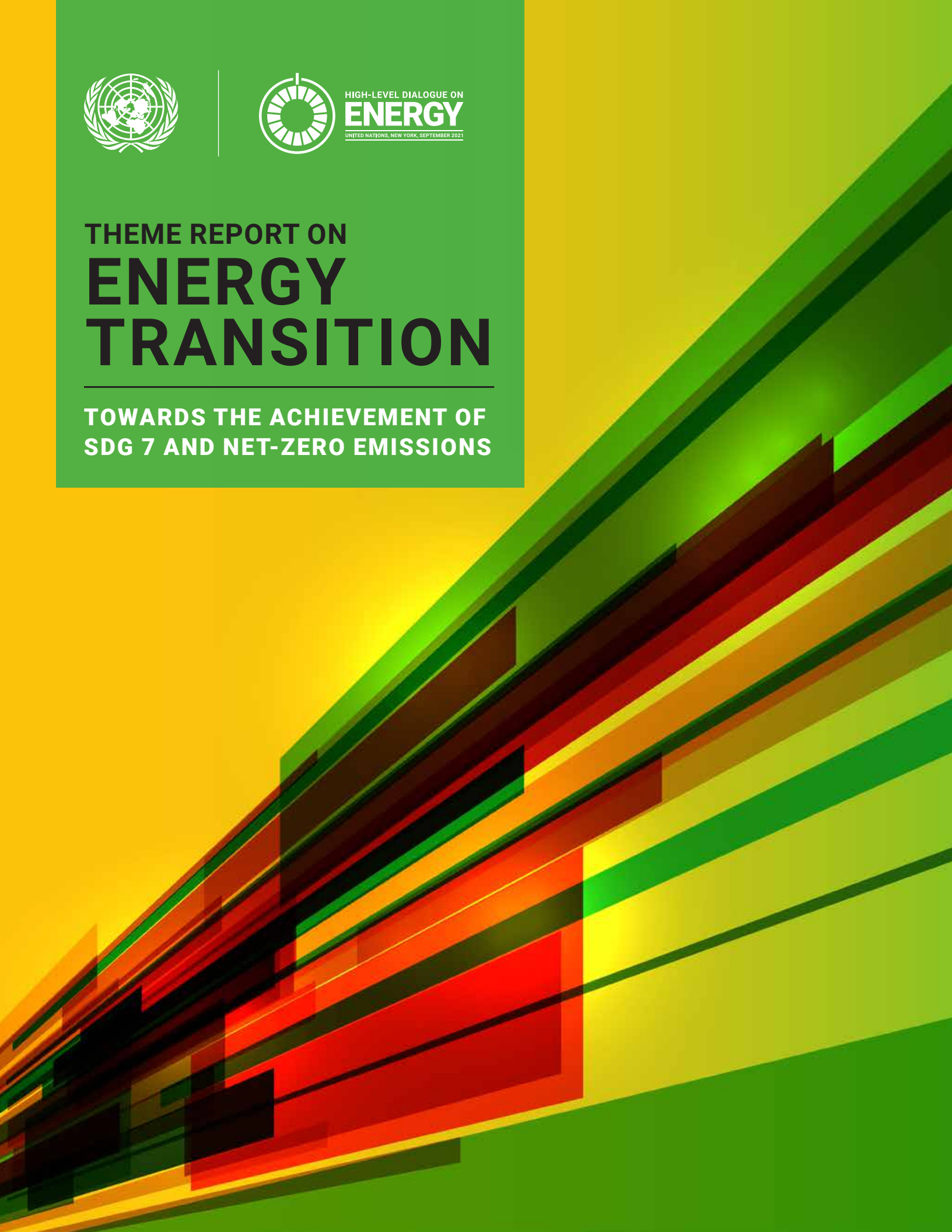
HIGH-LEVEL DIALOGUE ON
ENERGY
UNITED NATIONS, NEW YORK, SEPTEMBER 2021

THEME REPORT ON ENERGY TRANSITION

TOWARDS THE ACHIEVEMENT OF SDG 7 AND NET-ZERO EMISSIONS



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The report was prepared based on a series of interactive meetings of the TWG, which were chaired by the Co-leads, to discuss draft versions in the period of February to May 2021. This was complemented by multiple rounds of written feedback on the drafts.

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PREFACE

Energy can create transformational opportunities. For the 759 million people in the world who lack access to electricity, the introduction of clean energy solutions can bring vital services such as improved healthcare, better education and affordable broadband, creating new jobs, livelihoods and sustainable economic value to reduce poverty. In regions such as sub-Saharan Africa where half of secondary schools and a quarter of health facilities have no power, clean energy access will help save lives, and offer opportunities for prosperity at a transformative scale.

An energy revolution based on renewables and energy efficiency is urgently needed not just to accelerate economic progress and development, but also to slash emissions that are rapidly warming our planet. The energy sector today, dominated by fossil fuels, accounts for 73 per cent of human-caused greenhouse gas emissions. Global CO_2e emissions must be halved by 2030 to avoid an increasing frequency and severity of dangerous and unprecedented weather extremes, including heatwaves, devastating floods and droughts, risks to food and water security, population displacement, and loss of lives and livelihoods.

As governments start to define a pathway out of the COVID-19 crisis, we must now ensure that all countries have the chance to be part of an energy transition that seizes the opportunity to significantly improve the wellbeing of people, and planet.

This will not be an easy task. To ensure a just transition, we must support countries and communities to adapt to a green economy through social protection and new skills, ensuring all who need to be are equipped to take advantage of the 30 million new green jobs expected by 2030.

To generate the vital momentum needed for this transition, the UN Secretary-General is convening the High-Level Dialogue on Energy in September 2021, the first such meeting in 40 years. The landmark event will offer a global stage for countries to attract new investments and forge new impact focused partnerships to drive forward this energy revolution.

As a foundation for informed deliberations, five Technical Working Groups were established on the five key themes of the High-level Dialogue: (1) Energy Access, (2) Energy Transitions, (3) Enabling SDGs through Inclusive, Just Energy Transitions, (4) Innovation, Technology and Data, and (5) Finance and Investment. These Technical Working Groups brought together leading experts on these subjects from across the world to identify key recommendations for a global roadmap towards the achievement of SDG7 and the climate objectives of the Paris Agreement.

This proposed roadmap illuminates a way forward for how the world can achieve a sustainable energy future that leaves no one behind. We hope that it will help to inspire the actions needed to get there.

Mr. Liu Zhenmin
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Mr. Achim Steiner
UNDP Administrator and Co-chair of the Dialogue and UN-Energy

Ms. Damilola Ogunbiyi
Special Representative of the UN Secretary-General for Sustainable Sustainable Energy for All and Co-Chair of Dialogue and UN-Energy

FOREWORD

As co-leads of the Technical Working Group on the Energy Transition theme, the International Renewable Energy Agency (IRENA), United Nations Environment Programme (UNEP) and United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) jointly prepared the Theme Report to provide an insight into the global energy landscape and highlight opportunities and challenges in navigating the energy transition. Drawing from the knowledge and expertise of IRENA, UNEP, and UN ESCAP, and with input from Champion Countries and a diverse group of experts of the Technical Working Group, we have outlined the collective action necessary in the coming decade that would make a lasting difference for people, planet and prosperity.

It has been long recognised that the global energy system needs to change. But if there ever was any doubt, the COVID-19 pandemic has cemented that resolve. The Covid crisis has demonstrated the weaknesses of the existing energy system, and exposed the consequences of energy poverty experienced by billions of people worldwide. Achieving SDG7 can fundamentally change this reality. The energy transition is a crucial enabler of sustainable development and climate resilience. Forward-looking actions will create new jobs, stimulate growth and harvest social and health benefits.

The energy transition is not a uniform, one-size-fits-all process. It reflects diverse priorities and entails a combination of abilities, technologies, policies, finance and resources. While the specific path to the end goal depends on individual circumstances, the destination is common. The process must be just, inclusive and systemic to ensure that no one is left behind. International and regional cooperation is essential to facilitate the sharing of experiences and good practices.

The preparation of this report has been an exciting and insightful journey - a stellar example of inter-Agency cooperation that has further cemented our relationship and established new ways of communication and collaboration. The transition path we propose is neither exhaustive nor prescriptive. Each country will shape its energy future. It is our hope that this report, along with those developed by other Technical Working Groups, will help navigate the challenging road ahead. Collectively, we are convinced that the United Nations High-level Dialogue on Energy in September 2021 will be a turning point, re-igniting ambitions and boosting collaborative actions for a better future for all.

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CONTENTS

1 PRIORITY RECOMMENDATIONS

INTRODUCTION

Over the next decade, every aspect of national energy systems will be affected by changes in climate and energy policy, and financing, continuous technological advancement, and shifts in energy supply and demand. The rapidly falling costs of renewable technologies have opened up previously unimagined possibilities across the globe. Ongoing developments in many countries offer a promising outlook for the security, inclusiveness, and sustainability inherent in a transformed energy sector. However, the transition needs to speed up significantly and broaden its scope to achieve SDG 7 and align with the goals of the Paris Agreement on climate change, while at the same time achieving implementation of the 2030 Agenda for Sustainable Development.

The energy transition can thus no longer be limited to incremental steps. It must become a transformational effort, a system overhaul, based on the rapid upscaling and implementation of all available technologies to innovate for the future. This is the right moment to reassess long-standing assumptions, perceived barriers, and default decisions. The emerging energy system must promote resilient economies and societies for a more inclusive and equitable world. Ambitious and targeted actions are needed now and throughout the coming decades to ensure the goals of SDG7 are fulfilled and a decarbonized energy system achieved by 2050.

RECOMMENDATION 1

Rapidly scale-up deployment of available energy transition solutions to reach 8000 GW[1] of renewables by 2030 with due consideration to different contributions by individual countries. The abundance of cost-effective renewable potentials worldwide makes them a scalable option that is essential to the decarbonization of the entire economy across all sectors. For many countries, this translates a technical and economic challenge into a set of investment, regulatory and societal opportunities.

RECOMMENDATION 2

Increase the average annual rate of energy efficiency improvement from the current 0.8% to 3% through the implementation of all available technologies while supporting further innovation. Energy efficiency opportunities are readily available and have positive effects on employment; however, they often need policy support to be implemented. Efficiency measures and strategies must address the main barriers to the adoption of energy efficiency measures and promote structural and

behavioural change. Further, they must be considered across different sectors and areas, for instance, standards and norms for buildings and appliances, transport, industrial uses, and heating and cooling, among others.

RECOMMENDATION 3

Invest in physical infrastructure to enable the energy transition. Updating ailing infrastructure or investing in expansion is an integral part of the energy transition and an enabler of modern technologies. Public finance can be used to attract private investment in the infrastructure needed, which will help create jobs. Investments in infrastructure must be aligned with long-term plans and be reflective of broader strategies, including regional market integration.

RECOMMENDATION 4

Countries of the Organisation for Economic Co-operation and Development (OECD) should phase out coal by 2030 and redirect international energy financing towards the transition. Non-OECD countries should phase out coal by 2040, noting that many will require support for this process. Coal phase-out will reduce the risk of stranded assets, improve energy independence, and bring about significant health and fiscal benefits. Countries should enact time-bound strategies to manage the social and economic aspects of the coal phase-out.

RECOMMENDATION 5

Mainstream energy policies into economic, industrial, labour, educational, and social strategies. Policy measures and investments for recovery from COVID-19 must drive a broader structural shift aligned with plans for long-term energy sector transformation. To deliver on energy ambitions and avoid, reduce, or anticipate challenges, coherent, cross-ministerial policymaking is required.

RECOMMENDATION 6

Establish medium and long-term integrated energy planning strategies, define decarbonization targets, and adapt policies and regulations to shape energy systems that boost sustainable development. Long-term energy scenarios, including net-zero mid-century scenarios, can be used to facilitate the dialogue needed to help reach consensus among all relevant stakeholders. When preparing energy transition, the ambitions of the nationally determined contributions (NDC) should be raised and short-term challenges identified. Engaging sub-national and city-level decision-makers in transition planning and implementation will be essential, given rapid urbanization and the decentralized nature of the modern energy system.

RECOMMENDATION 7 (INTERLINKAGES WITH SDG 9)

Create regional energy markets to facilitate the integration of renewables, promote cross-border power grid connectivity and trade, and further reduce costs through economies of scale. Regional approaches to energy transition can reduce costs and enhance access to reliable and affordable electricity supply through expanded and smarter grid infrastructure; security of supply should be achieved through resource diversification. Regional integration can also enhance the resilience of energy systems to extreme weather patterns, climate variability and climate change, and the reduction of carbon emissions, and generally foster green economic development and employment.

RECOMMENDATION 8 (INTERLINKAGES WITH SDG 10)

Intensify international co-operation on energy transition to meet the 2030 Agenda for Sustainable Development and avoid future catastrophic climate change impacts. A common learning curve will be accelerated through cooperative action and exchange of experiences and best practices across the power and end-use sectors. Underpinned by global solidarity, an overriding priority is to strengthen public resolve and to ensure that no one is left behind.

RECOMMENDATION 9 (INTERLINKAGES WITH SDG 9 AND SDG 11)

Develop sustainable transport roadmaps. Based on an "avoid–shift–improve" approach. Country-specific plans that include urban strategies should include time-bound roadmaps for all modes of transport, with full consideration of mobility needs, efficiency, and renewable options. Across all regions, plans must include solutions such as electrification, sustainable bioenergy or green hydrogen, enhanced public transport and shared mobility, and promotion of regional and international cooperation and action.

RECOMMENDATION 10 (INTERLINKAGES WITH SDG 4 AND SDG 8)

Tailor labour and social protection policies to the specific needs of each region and country. Although clear global gains in job creation will be made, the structural and labour-market impacts of energy transition will vary among locations, job types, and sectors. In cooperation with all involved stakeholders, countries should enact strategies for a just transition, maximizing opportunities, and minimizing hardship for individuals and communities.

RECOMMENDATION 11 (INTERLINKAGES WITH SDG 7)

Make the energy transition a participatory enterprise. Participatory approaches that meaningfully engage all actors, multi-stakeholder coalitions, and public–private partnerships will help shape the desired energy futures and also manage expectations. The private sector must play a significant role in the implementation of the energy transition. Equally important is the empowerment of citizens, youth, local governments, research institutions, and indigenous communities to become part of the energy system.

2 RESULTS AND ACTIONS MATRIX

PRIORITY RESULTS	PRIORITY ACTION AREAS	STAKEHOLDER ACTIONS				MILESTONES		
		Public	Private	Civil Society and Communities	International and Regional Institutions	2025	2030	Towards 2050
Create comprehensive and holistic plans/ strategies and regulatory frameworks	Consult all stakeholders across government, the private sector, academia, and local communities Release strategies with clear, time-bound targets and budgets Strategize to promote a circular economy Promote regional energy markets combined with ambitious clean energy targets Set out roadmaps for a just transition	Set holistic, cross-sectoral policy, regulatory, and legal frameworks, aligned with NDC targets Hold timely, wide-ranging consultations to ensure link-up across government entities at all levels Conduct grid master-planning based on least-cost social options	Feed into government consultations Set branch strategies on climate action and decarboniz-ation targets Align investment with SDG7 and decarboniz-ation priorities	Feed into government consultations Promote public awareness and activism Support ambition-raising	Compile data and provide analyses of trends Assist with strategy development Link up across sectors Devise global and regional roadmaps/pathways Ensure sharing of data and best practices Scale up capacity-building and technical-assistance efforts	All countries have a compre-hensive energy- transition strategy in place 100 countries have targets for 100% clean power	100 countries have achieved an annual energy efficiency increase of 3% 100 countries have targets for 100% renewable energy (power, transport, building, and industry) There are 100 million jobs in the energy sector (compared with 58 million today). These include 60 million jobs in renewables and efficiency (22.5 million today)	All countries have implemented decarbonization energy strategies Education and labour policies support a clean energy workforce Coal has been phased out of the power system

PRIORITY RESULTS	PRIORITY ACTION AREAS	STAKEHOLDER ACTIONS				MILESTONES		
		Public	Private	Civil Society and Communities	International and Regional Institutions	2025	2030	Towards 2050
Accelerate deployment of available solutions across the renewables, efficiency, and auxiliary sectors, while innovating for the future	Identify and map available resources Remove barriers to investment for the private sector Provide stability and continuity through targets/strategies Identify gaps where innovation is needed, including the use of digital technologies Identify where clean energy will be utilized in the end-use sector	Set enabling policies for public–private partnerships Channel public funds towards sustainable infrastructure Support nascent sustainable technologies. Implement the international standard on smart energy and energy efficiency	Commit to energy transition strategies for all operations. Invest in R&D Stop investment in and use of non-sustainable energy	Advocate for clean energy Support nature-based solutions Opt for public transport, energy-efficient buildings, vehicles, and appliances Participate Individually in the sphere of energy supply /demand Develop international standard for improving energy efficiency across sectors	Share timely data and analyses Provide tailor-made financial derisking to catalyze investments Link public and private investors to opportunities Provide technical support and capacity building Propose and implement regional and national projects Enhance observation and monitoring systems	Sustainable energy investmen-ts are at least doubled Zero new coal plants are in the pipeline All all major emitter countries have adopted a minimum of 50% of govern-ment purchasing/ procure-ment targets for higher perfor-mance appliances, vehicles/ transport fleets, and buildings All major oil and gas companies have verified net-zero commit-ments	Reduce fossil fuel share to 30% from current 60% 8000 GW installed RE capacity Alternatives to rare earth metals are commercialized There is targeted use of sustainably sourced biomass, particularly as a replacement for high -energy-density fuels All countries have adopted minimum international appliance, transport and buildings standards and related national programmes	92% of power in 2050 comes from renewable technologies (33% in 2018) Energy demand has stabilized due to increased energy efficiency and the circular economy Electricity is a key energy carrier exceeding 50% of final energy use by 2050 There is expanded production and use of green hydrogen and synthetic fuels and feedstocks, in pursuance of indirect electrification
Promote international cooperation and support, including knowledge-sharing	Collate and share data Support strategy development Support transition of workers to future skills Highlight inequalities and injustices Acknowledge climate adaptation needs	Engage internationally Support regional development Share best practices	Build coalitions, and identify shared knowledge /needs Share best practices Support global industrial development	Exert pressure for global action and government accountability Push for clear labelling on products Promote stakeholder participation Formulate and advocate for the value of nature-based solutions	Provide platforms for global and regional actions Convene governments and stakeholders Provide empirical and analytical input Assist in tracking and priority-setting aimed at leaving no one behind	NDCs that raise energy- transition ambition have been enhanced	Energy ambition has been raised in NDCs aligned with decarboniz-ation of the energy system by 2050	

3 GOAL: THE RATIONALE FOR ENERGY-SECTOR TRANSITION

Within the overall structure of the preparations for the High-level Dialogue on Energy, the energy transition theme focuses on why a major transformation of the energy sector is required and how it can be implemented in a just manner that reflects different national circumstances and opportunities. Energy access issues are addressed in a separate thematic paper, as are links to other SDGs and cross-cutting issues such as technology, innovation, and finance. These aspects are thus referenced here, but not addressed in depth manner.

A transformation of the energy sector offers opportunities for sustained economic development, social inclusion, energy security, improved health, job creation, and other societal benefits. Such opportunities will be achieved only if the transformation is implemented in a just and inclusive manner. Although governments need to take the lead on goalsetting and process, involvement of the private sector, cities, and wider civil society, including youth, is essential for the design of a balanced and just transition process that is aligned with SDG7 and meets multiple economic and social priorities.

The need to address climate change is the major driver for a transition from an energy sector dominated by fossil fuels to one based on renewable energy sources. The energy sector is currently the main emitter of greenhouse gas emissions (GHGs). To meet the goals of the Paris Agreement, GHG emissions from that sector need to be reduced quickly and eliminated by mid-century.

Fundamental technology changes and rapid reductions in technology costs are providing a foundation for emerging energy-sector transitions in many countries. This process is supported by market-driven growth of renewable energy installations and increased focus on energy efficiency, including in end-use sectors like industry, agriculture, buildings, appliances, and transport. Digital technology solutions provide new opportunities for integrating supply and demand, thereby accelerating the shift towards electrification of more end uses, including parts of the transport sector.

The energy sector is facing a series of interlinked challenges:

- Rising populations and economic growth are increasing demand for energy services.
- Providing access to modern energy for the roughly 700 million people who are currently unserved will require new power capacity and infrastructure expansion in countries with limited means of financing the required investments.

- The energy sector accounts for approximately 75% of total global GHG emissions;[2] these need to be reduced dramatically, and eventually eliminated, to meet the goals of the Paris Agreement.
- Energy systems must become increasingly resilient to future economic and environmental shocks.
- A massive shift from a highly centralized energy sector to increasingly decentralized energy production brings new participants into the energy value chain—including citizens—who can both produce and consume energy.
- Increased electrification of end-uses, such as transport, will significantly increase electricity demand.

To meet these challenges, a major transition of the energy sector is required in all countries. Massive efforts will be needed to increase energy efficiency and productivity, facilitate changes in consumption patterns and lifestyle choices, and expand renewable energy for power supply and direct use within and across regions. Simultaneously, there is a need to change and expand the electricity sector infrastructure to allow for increased use of variable sources, system flexibility, and electrification of new services, mainly for transport. The good news is that many solutions already exist, and in some countries and regions, transitions are already under way and being expanded and scaled up. It is recognised, however, that the pace and scale of transition is country-specific, reflecting each country's circumstances, including the finance available. Moreover, expanded innovation in technologies, business models, and market solutions is needed to continuously improve the existing options and fill the gaps for a decarbonized energy system by 2050.

Energy sector goals for 2030 have generally been defined in SDG7:

- 7.1 Ensure access to affordable, reliable, sustainable and modern energy for all.
- 7.2 Increase substantially the share of renewable energy in the global energy mix.
- 7.3 Double the global rate of improvement in energy efficiency.

To support the transformation processes, enhanced international cooperation is essential to facilitate the sharing of experiences and access to clean energy research and technology, including renewable energy, energy efficiency, and advanced hydrogen and biofuel technologies. Regional collaboration on integrated power markets and investment in regional integration of energy infrastructures is emerging in several parts of the world and needs to be strengthened. In this regard, South–South cooperation can play a significant role, especially in the exchange of experiences and best practices.

It is vital for concrete progress towards the SDG7 goals to be achieved by 2025, as the ability to advance other sustainable development goals hinges on energy. A successful energy sector transition stimulates economic growth and creates new employment opportunities. The International Renewable Energy Agency (IRENA) estimates that reaching some 8000 GW[3] of global renewable capacity by 2030 from today's 2799 GW[4] would enable the 2030 Agenda and provide a decisive shift towards a decarbonized system in 2050. The International Energy Agency (IEA) makes a similar estimate in its recent report on net-zero pathways.[5] Achieving such a target would boost global gross domestic product (GDP) by an average of 1.3% per year between 2020 and 2030.[6] Importantly, improvements in human welfare—including its economic, social, and environmental aspects—will generate benefits far beyond those captured by GDP. It is, however, necessary to translate this global picture into nuanced regional, national, and subnational plans to ensure that the transition is just and leaves no one behind.

It is important to understand the underlying baseline and implementation-path assumptions for the three goals (in SDG7) to assess how achieving them would contribute to meeting the temperature goals set out in the Paris Agreement. For the energy sector globally, this would imply a 25–30% reduction in emissions by 2030 to stay on a below–2°C trajectory and a 50% reduction for a 1.5°C trajectory. This is in alignment with the statement by the Intergovernmental Panel on Climate Change (IPCC)[7] that global net anthropogenic CO_2 emissions need to decline by about 45% from 2010 levels by 2030, and reach net zero around 2050 for there to be no, or limited, overshoot of the 1.5°C target by 2100.

The annual emissions Gap Report by the United Nations Environment Programme (UNEP) provides an assessment of how much the implementation of the NDCs would contribute to global mitigation by 2030; and it compares this with the realistic emissions level needed to stay on track to 1.5°C and 2°C by the end of the century. The 2020 Gap Report shows that countries are far from being on track, with a few exceptions. The recent Synthesis Report on NDCs by the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) concludes that new or updated NDCs submitted before the end of 2020 present positive increases in ambition, but nowhere near what is required to get on track. The Synthesis Report specifically notes that "domestic mitigation measures for renewable energy generation were most frequently mentioned by Parties, followed by measures for energy efficiency improvement," thereby indicating an emerging focus on energy sector transition. IRENA estimates that over 90% of the solutions in 2050 will involve renewable energy through direct supply, electrification, energy efficiency, and green hydrogen. From today's perspective, other technologies, such as bioenergy with carbon capture and storage (BECCS), fossil-based CCS, and nuclear energy will also play a yet undetermined global role in 2050 given technological and political uncertainties.

With the slow increase in short-term mitigation actions and ambitions, there is a greater focus on longer-term target setting aligned with the Paris Agreement goals; a large number of countries, cities, and private sector actors have announced "net zero emission" targets for 2050. Such targets may take longer for many developing countries to achieve and will require financial and technological support. The terminology used in this respect varies between climate neutrality, carbon neutrality, GHG neutrality, or net zero emissions; nevertheless, to remain feasible and credible, these commitments must be urgently translated into strong near-term policies and actions, with realistic roadmaps being reflected in future NDCs.[8]

The COVID-19 pandemic has had large short-term impacts on energy sector development, with big variations being noted between countries. The fiscal stimulus packages that many countries have launched or are putting in place represent a huge opportunity to "build back better" and invest in low-carbon policies and programmes with significant positive benefits for employment and the environment. Overall, renewables-based systems have proven to be more resilient during the pandemic. They have demonstrated once more that technologies for rapid upscaling of climate-compatible options exist today. Preliminary assessments of recovery packages indicate that most are having no discernible effects on GHG emissions. Significant stimulus investments are still to be designed: there is still an opportunity, therefore, to make such investments more supportive of the energy sector transition.[9]

Another important tool for accelerating the transition is public and private procurement and contracting. Some current examples include cities purchasing low-emission buses for public transport and globally leading businesses having committed to 100% renewable electricity coming together in the RE100 Initiative.[10]

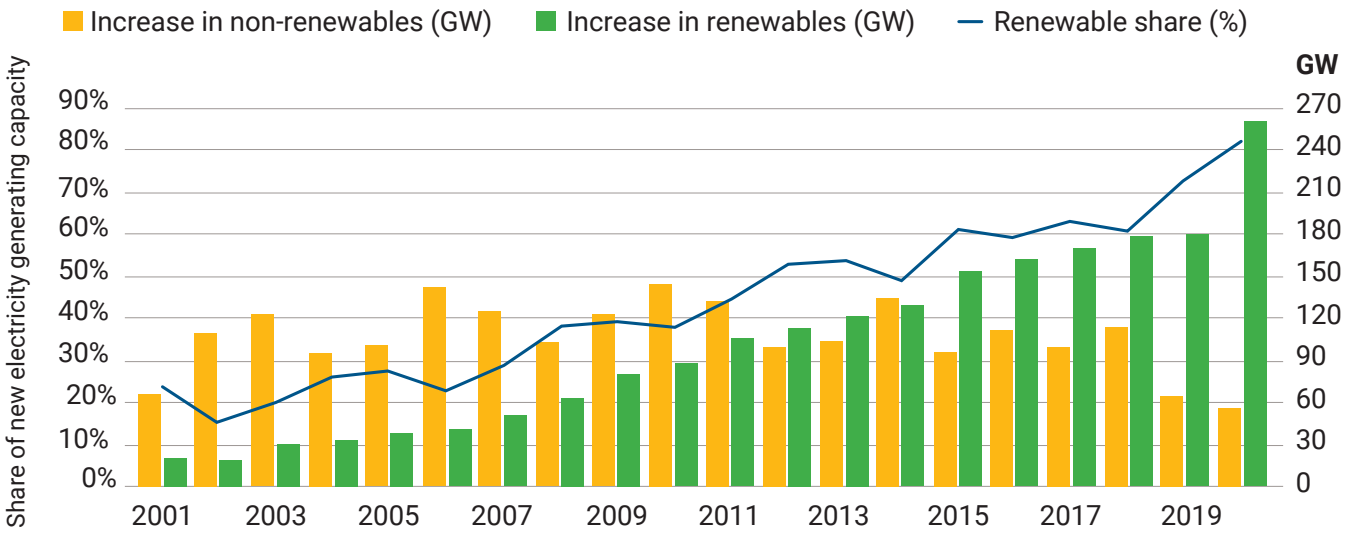
For the transition to successfully reach the SDG7 targets and pave the way for strategies to achieve net zero emissions by 2050, there must be: urgent and strong political leadership at the local, national and international levels; clear national targets and timetables; broad stakeholder engagement; and enabling policy frameworks that focus on job creation, economic wins, and environmental benefits, while ensuring that the transition is a “just” one, in the broadest sense.

4 CONTEXT

How we achieve these goals and the extent to which their achievement supports sustainable, long-term economic development depends on actions taken in the next few years. Energy transitions can provide solutions to many global issues, including efforts against climate change, the achievement of sustainable development, and improvement of human wellbeing by reducing air, water, and land pollution. As these drivers converge—along with policies, innovations, and investments—they are creating a dynamic and inevitable path; and while the contours of a new energy system are still unclear, certain trends are now apparent.

According to IRENA,[11] capacity additions to the global power mix have been consistently dominated by renewables in recent years. In 2020, new renewable capacity addition reached 82% of the total installed capacity, compared to 73% in 2019 (Figure 1).

FIGURE 1. RENEWABLES NOW MAKE UP THE MAJORITY OF ANNUAL POWER CAPACITY ADDITIONS



Source: IRENA

Geographical trends remain uneven. Places where energy access needs are the greatest continue to show an unacceptably low rate of progress. Energy efficiency progress has also been lagging. For example, in the buildings, heating and cooling, and transport sectors, primary energy intensity improvement has declined over the last few years and is now only around 1% per year.

Government plans in place today call for investing almost USD 98 trillion in energy systems over the coming three decades.[12] Economic stimulus packages announced to date would direct USD 4.6 trillion[13] into sectors that have a large and lasting impact on carbon emissions, namely, agriculture, industry, buildings, waste, energy, and transport. Less than USD 1.8 trillion of this investment is green. Significant investments need to flow into an energy system that prioritises renewables, electrification, energy efficiency, and associated energy infrastructure. At the same time, investments must not lead to lock-in effects incompatible with sustainable development and climate priorities. The energy system and the financing of the energy sector must therefore be considered as a totality, from supply through to end-use.

Climate change and its impacts must be at the centre of every energy decision in the coming years. Not all energy transitions will move at an equal pace, and many developing countries will require technical and financial support. However, all segments of society need to play a part and have the opportunity to do so. In an energy sector that is partly deregulated and increasingly financed by the private sector, it is becoming more important to maintain government control and formalise consumer opportunities to choose sustainable energy. This concerns not only individual customers, but also large international manufacturers, governments, public transport services, capital funds, and other entities that aim to go green. “Green energy” procurement can be a strong driver for transformation. Plans must take into full consideration changing demand patterns, technology advances, and available finance, and avoid locking energy systems into inefficient, expensive, and obsolete technologies. In many countries, cities can play an important role as implementers of integrated urban energy systems that provide system flexibility by linking electric power with heating and cooling, waste management, transport, and other sectors.

Regional collaboration, including the creation of regional energy markets, offers opportunities for rapid energy transitions and multiple associated socio-economic benefits. The Plan of Action for Energy Cooperation (APAEC) 2016–2025 drawn up by the Association of Southeast Asian Nations (ASEAN)[14] is one example of countries working together to increase their collective ambitions. The region has set a target of 23% of renewables in the energy mix by 2025. Regional energy market integration, including a regional power grid, will enable the free flow of clean energy products, services, and investment, as well as skilled labour, fostering sustainable growth in the framework of the ASEAN Economic Community. Similar regional approaches are under way or should be adopted in other parts of the world, including Africa, Europe, and Latin America, among others.

Connectivity, or the integration of power systems across political, institutional, and geographic boundaries, allows countries to leverage their natural diversity and strengths, enabling a faster, more affordable, and more secure energy transition than would otherwise be possible.

The UN Secretary-General has called for countries to cancel all planned coal projects and has appealed for an end to international financing for coal power generation, while providing greater support to developing countries to ensure a just transition to renewable energy. The number of coal-fired power plants planned around the world is falling, a reflection of a tougher economic climate for coal plant

developers, concerns over climate change, and the need to protect human health. As the IEA states in its recent report, Net Zero by 2050: "The rapid drop in oil and natural gas demand in the net zero scenarios means that no fossil fuel exploration is required and no new oil and natural gas fields are required beyond those that have already been approved for development. No new coal mines or mine extensions are required either."

Market trends reflect that a transition from fossil fuels to clean energy is necessary and widely supported by shareholders and investors, as well as by consumers. For example, BlackRock, the world's largest asset manager, is incorporating climate impacts into its investment decisions.[15] With BlackRock moving away from investing in fossil fuels, awareness of climate change and its associated impacts are clearly not only increasing, but also influencing decisions in the finance sector and markets.

IRENA finds that more than half of the renewable capacity added in 2019 achieved lower electricity costs than new coal. New solar and wind projects are also undercutting the cheapest existing coal-fired plants. Replacing the costliest 500 gigawatts of coal capacity with solar and wind would cut annual system costs by up to USD 23 billion per year. Replacing the costliest coal capacity with renewables would also reduce annual carbon dioxide (CO_2) emissions by around 1.8 gigatons, or 5% of the 2018 global total.[16] IRENA's World Energy Transitions Outlook finds that coal generation must be reduced by half by 2030 to stay on a 1.5°C pathway.[17]

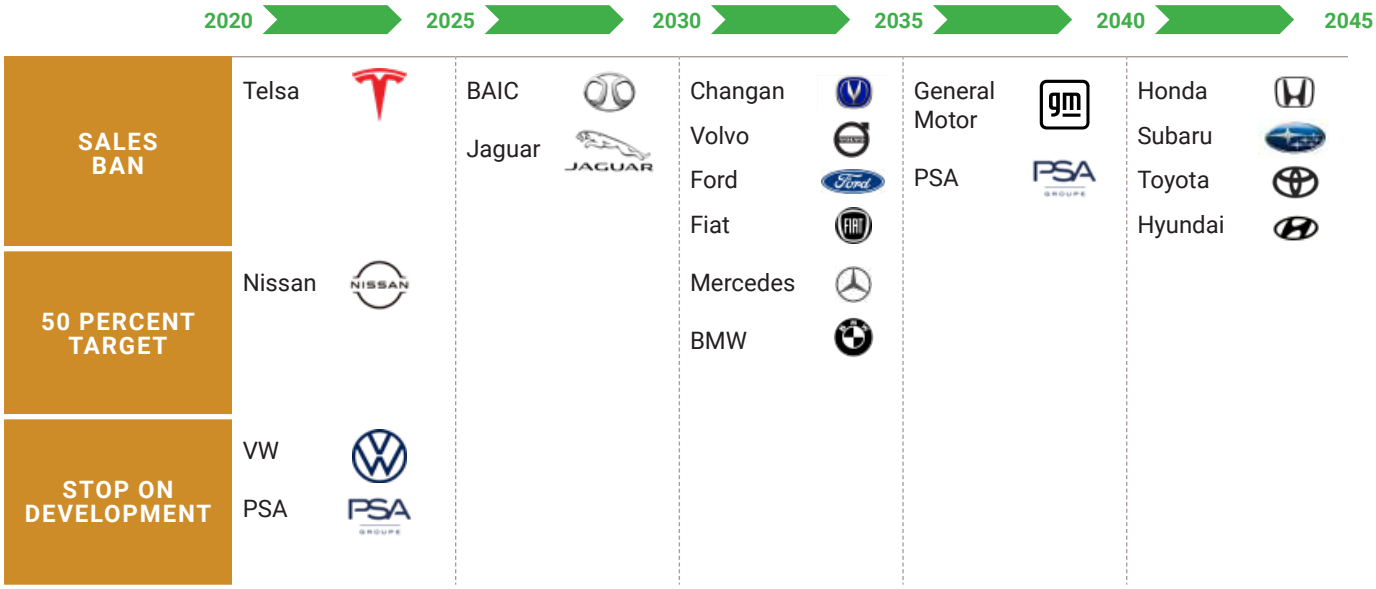
As well as BlackRock, more than 80 financial institutions (banks and investors) worldwide have publicly committed to transitioning their entire financing to net-zero emissions by 2050, with intermediary targets every five years. Their commitment means that the most GHG-intensive sectors, including coal, oil, and gas, need to be transformed: targets are informed by the most authoritative and ambitious science, as established by the IPCC and other bodies. Financing for activities that are inconsistent with such pathways will consequently shrink significantly in the coming years.

Many companies are already capturing and realizing the economic opportunity presented by energy transitions. One example of the above-mentioned procurement drive by many companies, is the signing in January 2020 by Google and NV Energy of a power-purchase agreement (PPA)[18] that sets an example for other corporate solar PPAs in the United States. The agreement will power Google's data centre in Nevada with 350 MW of solar power and 250–280 MW of storage procured by NV Energy. Another example on the power utility side is EDP—Energias de Portugal. S.A.—a leading global utility, which has committed to becoming zero carbon by 2030,[19] bringing forward its carbon neutrality target by 20 years.

Policymakers need to be proactive in order to influence rapidly shifting markets and avoid losing investments, businesses, and industrial development opportunities. As part of the long-term framing of political conditions, it is important to note that the movement towards net-zero targets by 2050 became mainstream in 2020. For example, 31 countries and the European Union, representing 53% of the global economy, have set net-zero targets by 2050.[20] Further, the Race to Zero campaign[21] is mobilizing 471 cities, 23 regions, 1,675 businesses, 85 of the biggest investors, and 569 universities. Collectively, these actors currently account for nearly 25% of global CO_2 emissions and over 50% of GDP.

Many sectors are already moving, motivated by economic calculations and a sense of social and moral obligation that is often expressed as maintaining a "social license to operate." For example, automakers worldwide are ramping up electric vehicle production as technology improves and governments impose

FIGURE 2. AUTOMAKERS LEAVING INTERNAL COMBUSTION ENGINE MARKET



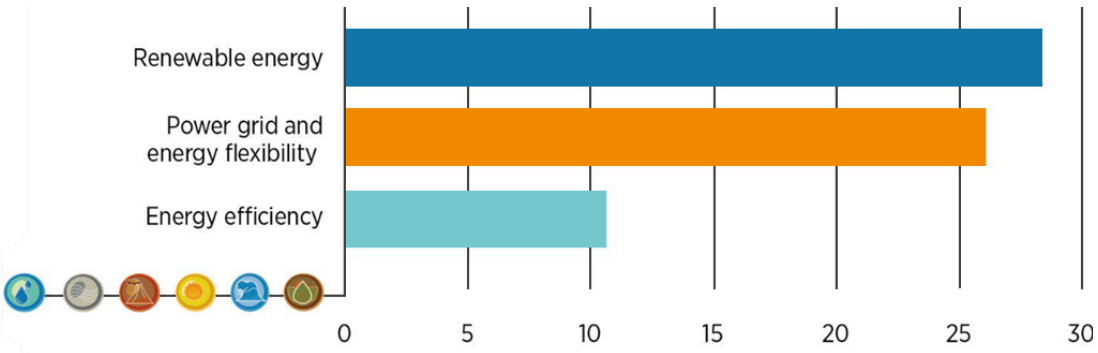
Source: Transformative Urban Mobility Initiative (TUMI).

stricter pollution regulations. Figure 2 shows the planned timing for different major automakers to stop producing cars with internal combustion engines; it will clearly be important for other producers to make this shift to stay in business.

More evidence is emerging of the socio-economic impacts of energy transitions. IRENA estimates that of 58 million energy workers worldwide, 11.5 million worked in renewables in 2019.[22] Moreover, investing in the energy transition would create three times more jobs than similar investment in fossil fuels.[23] Each USD 1 million invested in renewables or energy flexibility creates at least 25 jobs, while each million invested in efficiency creates about 10 jobs (Figure 3).[24]

FIGURE 3. GLOBAL AVERAGE EMPLOYMENT INTENSITIES OF INVESTMENTS IN RENEWABLE ENERGY, ENERGY EFFICIENCY, AND ENERGY FLEXIBILITY

Jobs/USD million



Source: IRENA.

We are in the early stages of a major transition that will radically change the way energy is produced and consumed. As the energy transition will therefore affect many parts of society, it is important for all stakeholders to participate in shaping the new system and making it fit for future generations. Cooperation at all levels of society will be necessary to build awareness and capacity at a pace that leaves no one behind.

The transition process requires careful management and broad engagement in order to protect workers and communities. Some countries are closing coal mines due to non-compliance with environmental policies or because mines are nearing the end of their commercial lives. This brings to the fore the vulnerability of workers, communities, government sectors, and enterprises. It also highlights the necessity for comprehensive and coherent policies and measures to address the multifaceted challenges involved and to pursue environmentally sustainable growth, while at the same time ensuring a just transition for those affected. Employment gains in energy sectors that are transitioning will continue to grow, outweighing losses in traditional sectors. However, the skills required for the energy transition do not necessarily match the skills of workers directly impacted by changes. There are special concerns in oil- and gas-producing countries that depend fiscally on these sectors, and different concerns in countries with coal resources, where local employment is a significant factor. It will thus be important to enable countries to benefit from the local production of technologies as part of the transition. South Africa is an example of a country that has initiated a just transition of the power sector, moving gradually out of coal towards a renewables-based electricity system. The following elements were found to be critical for success for South Africa[25] and provide elements of learning for other countries (Figure 4).

FIGURE 4. GLOBAL AVERAGE EMPLOYMENT INTENSITIES OF INVESTMENTS IN RENEWABLE ENERGY, ENERGY EFFICIENCY, AND ENERGY FLEXIBILITY.

- Clearly articulate the **Just Transition Vision** – not just in terms of coal exit and use of renewables, but also how job losses will be mitigated.
- Decide which **entity** that will take accountability for the planning and implementation of the Just Transition, working with the various identified stakeholders.
- Ensure **capacity** exists to manage the coal mine and power plant closures and consider a closure agency.
- Determine **funding** needs of the Just Transition and design innovative funding mechanisms to support it.
- Consider **reskilling hubs** to take advantage of the opportunities renewables offer across the energy value chain to mitigate job losses.

Source: RES4Africa Foundation, A Just Energy Transition in South Africa

5 CHALLENGES AND ACTIONS

5.1. Policy framing

5.1.1 CHALLENGES

There is an urgent need to create and implement policy and regulatory frameworks that facilitate accelerated energy transitions worldwide. The COVID-19 pandemic has proved that governments can rise to challenges and handle issues quickly when facing an urgent need to do so. However, energy transitions will not progress at the same pace in every country or region. They need to reflect national needs, priorities, and abilities and to take into account all stakeholder groups, including all levels of government, regulators, utilities, cities, and civil society, including youth.

Energy policymakers who work in isolation risk creating energy policy that slows energy-access gains, decelerates economic growth, and mitigates one environmental impact while provoking another. Broad stakeholder engagement is therefore important. Engagement with the private sector is also critical, and public capital providers (such as multilateral and national development institutions) have an important role to play in mobilizing private sources. The existing frameworks underpinning, for example, the electricity sector, were originally designed for large-scale and technically complex conventional power-generation and transmission systems, designed and built primarily by regulated entities: this has resulted in high transaction costs and prolonged project-development and finance timelines. These conventional structures hinder the deployment of modern decentralized solutions. They will need to be changed to provide for many decentralized and variable energy sources, including the large number of consumers who have taken on their new role of prosumers. This implies transformational change for economies and societies in the short-term while securing long-term sustainability.

Another major challenge for policymakers is to increase and channel private-sector investment to the areas where it is most needed. Private finance has flooded into renewable energy projects in recent years, with several high-profile investment funds now divesting from fossil fuels. The task now is to ensure that this finance reaches across the clean energy system, from production through to transmission and end use. Grid investments, for example, are imperative as electricity demand grows and the move to more variable sources of energy accelerates. Ensuring these investments are made in the right sequence and at the necessary scale is a significant challenge.

Increased investment should, in turn, help tackle the challenge of ensuring that the technologies needed for energy transitions are affordable. While costs have fallen significantly in many places, this trend is yet to take hold in all countries. In particular, support is needed for the poorest and most vulnerable countries to gain access to affordable modern technologies and build local capacities for effective use.

Policymakers will need to successfully balance multiple technical, economic, and social aspects of energy transitions. The falling prices of renewables, rapid innovation, and knowledge-sharing have made this balance more straightforward than in the past. Yet, the challenge of balancing short-term needs with long-term impacts in an uncertain global economic environment should not be underestimated, given the heavy reliance of the global economy on fossil fuels.

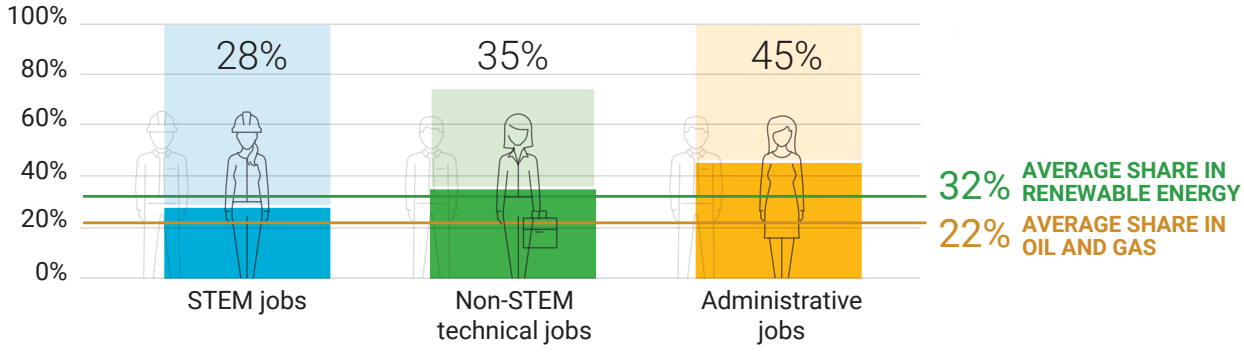
To foster a just transition, labour and social-protection policies must be tailored to the specific needs of each region and country. A dialogue must be established among government, employers, workers, and civil society to guide the transition process. Labour-market interventions can include short-term employment services, such as matching jobs with qualified applicants, facilitating on- and off-job training, and providing safety nets. An obvious example is matching the skillsets of displaced offshore oil and gas workers to the needs of the offshore wind sector, and, where necessary, providing relocation grants and other measures that aid labour mobility. Longer-term programmes should focus on the education system at large to ensure that curricula match the future needs of society. Social equity considerations, in particular gender and youth aspects, must be integrated into policy and programme design to fully tap into societal potential and ensure that no one is left behind. IRENA estimates that women currently represent 32% of the renewable energy workforce, which is substantially higher than the 22% average reported for the global oil and gas industry (Figure 5).

5.1.2 ACTIONS

To further the energy transition and attract the investments needed in the long and short term, ambitious climate and clean-energy targets are essential at the national and sub-national levels within the frameworks of sustainable development and climate priorities. Targets need to be backed by clear and transparent governance frameworks that ensure accountability and increase investor confidence. In addition to the laws passed or proposed around net-zero emissions in many jurisdictions, ambitions expressed in NDCs must not be confined to just the power sector, but cover all energy end uses too.

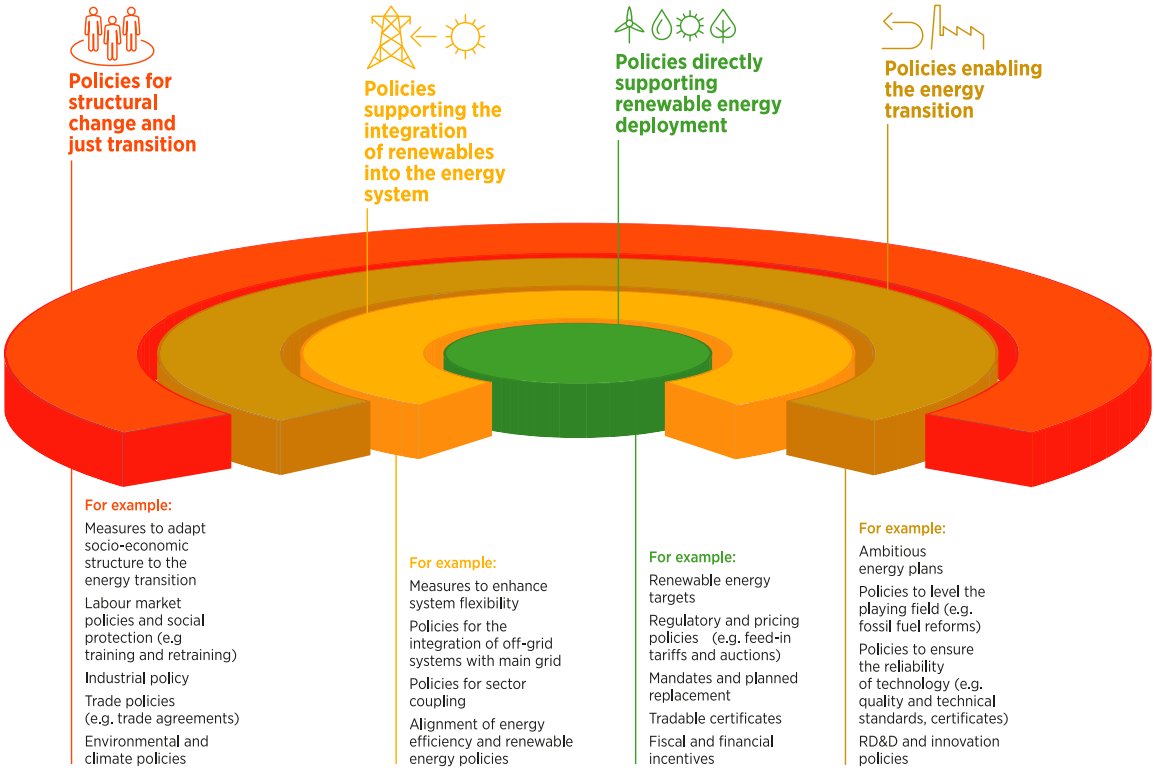
FIGURE 5. SHARE OF WOMEN IN WORKFORCE

% shares of women



Source: IRENA

FIGURE 6. ENABLING POLICY FRAMEWORK FOR A JUST ENERGY TRANSITION



Source: IRENA

Targets can be effective only within a holistic policy framework, where deployment policies that combine financial and fiscal incentives with market-pull mechanisms (e.g., regulatory and pricing policies such as auctions) and technology-push mechanisms (e.g., mandates) go hand in hand with enabling policies, such as measures to ensure the reliability of technology- and systems-integration policies. Fundamental changes to the prevalent organizational structure of electricity systems that were designed mainly for conventional, centralized power generation are required so as to accommodate the increasing share of variable renewable energy (VRE), such as solar and wind, and the rise of decentralized power. This new paradigm will require a huge effort in distribution-network reinforcement, digitalization, and flexibility. Accelerating the energy transition thus calls for a deep rethinking of the very structure of existing energy-market designs.

Policies supporting and enabling deployment and integration of renewable energy and energy efficiency must go hand in hand with a broader set of policies which ensure that industrial and other economic capabilities are aligned with the COVID-19 recovery, development, and climate priorities, as well as with other environmental objectives. Industrial policies will play a vital role in providing the productive structures that underpin green energy industries, especially in developing countries lacking related capabilities and where market forces may hinder optimal outcomes. In this regard, renewable energy offers favourable prospects for localized inputs because of the comparative ease of technology transfer and the labour intensity of its low- and medium-skilled work segments. As noted previously, policies must also foster a just transition through labour, skills, education, and social protection measures (Figure 6).[26]

The energy transition now under way is driven by increasing energy and development needs and enabled by technology developments, falling costs, and digitalization. Markets and investments are already responding. It is up to policymakers to create enabling frameworks that reflect this and that set a path for transition-aligned planning and infrastructure. As there is no single policy that can achieve climate and development objectives in a socially sustainable manner, a set of mutually reinforcing policies, tailored to specific country contexts and objectives, have to be placed at the core of the transition. Examples of these policies, starting from the inner circle in Figure 6, include:[27]

- **Deployment policies** that steadily enhance the energy transition by accelerating the deployment of existing solutions and related infrastructure, while simultaneously innovating to address incomplete solutions. This includes:
  - **Push policies**, such as binding targets, quotas, and obligations, as well as efficiency standards, codes, and mandates.
  - **Pull policies**, including pricing policies, public procurement, tradable certificates, and renewable energy regulations that create markets for various technologies. These are also crucial to counteract and balance the effects of push policies.
  - **Financial and fiscal measures**, such as tax incentives, subsidies, and grants, in addition to concessional financing for renewable energy technologies and integrated energy systems. Governments should consider environmental-impact reporting and tying finance to the achievement of climate and other sustainable development goals.
- **Integration policies** that stimulate the modernization of energy services and planning in terms of medium- to long-term policy goals. As part of a broader energy transition approach, planning must look beyond the power sector and include links to other sectors, sector-coupling opportunities, and, in particular, the accelerated electrification of sectors like transport.
- **Enabling policies** that ensure that the energy transition is implemented in broadly beneficial ways and that avoid or minimize dislocations for individuals, communities, countries, and regions.
- **Structural policies** that adapt the socio-economic structure to the energy transition so that a just, orderly, and inclusive transition, engaging a wide group of stakeholders, is ensured. It is critical to establish a long-term vision for a just transition that is then reflected in a broad set of relevant policies (including economic policies, structural change, labour policies, skills development, reskilling, etc.).

A holistic assessment must inform energy system planning, economic policymaking, and other policies necessary to ensure a just and inclusive energy transition at the global, regional, national, and local levels. Planning should work backwards from the goal and consider the steps needed to achieve the SDGs and build circular economies. The specifics will vary from country to country, but a comprehensive package will have to include a broad mix of policies and interventions and view the energy system as a whole, focused not only on the power sector but on the variety of end uses and end users.

5.2 Infrastructure including power systems and integration

5.2.1 CHALLENGES

The variable nature of some renewable technologies means that energy systems will need to be more flexible to ensure that supply can always meet demand. Sufficiently robust transmission and distribution networks are needed to deal with an increase in power demand resulting from growing access to and electrification of end-use sectors, such as transport, heating, and cooling. Energy systems also must adapt to accommodate localized energy generation, which presents both challenges and opportunities for energy planners and network operators.

Rapidly growing investment in clean energy production requires parallel spending on infrastructure. To modernize the ailing energy system and ensure access to it for those who lack it today, a significant increase in clean energy finance is needed. As mentioned in the policy challenges, (see 44 below) significant effort is needed to ensure that this finance scales up to the levels needed and reaches across the entire energy system. At the same time, the increasing use of distributed generation, together with storage facilities and charging needs for e-mobility, will lead to challenges in network planning and operation that have their own costs. To ensure a sustainable, climate-safe, and more resilient future, substantial investments need to flow into an energy system that prioritizes renewables, electrification, efficiency, and associated energy infrastructure. Care must be taken that those investments do not lead to lock-in effects, which are incompatible with the Paris Agreement. IRENA's 1.5°C scenario shows that the cumulative investments of over USD 24 trillion already planned should be redirected from fossil fuels to energy-transition technologies during the period to 2050.[28]

The development of national infrastructure should be coupled with political, regulatory, and operational cooperation between neighbouring countries and sub-regions. Some countries with very high renewable energy potential are expected to become net exporters and could facilitate transitions in countries with less abundant renewable resources. Cross-border integration can also provide a unique opportunity to connect remote regions to power supplies. The abundance of different energy sources across regions means greater connectivity capable of providing reliable and economic energy supplies throughout the year and of lowering electricity prices in the home country while creating export revenue for it. New interconnections between states are increasing. These will increase renewable energy integration and improve resilience. Infrastructure investments also involve digitalization and energy storage solutions to help manage demand and ensure a stable supply of energy. These can also help so-called sector coupling: for instance, emerging innovations in smart charging for electric vehicles (EVs). Such solutions span not just technologies but also business models and regulatory frameworks. They will be crucial to the transition to flexible, integrated systems that rely primarily on renewable energy sources.

5.1.2 ACTION

The first step towards meeting these evolving needs is to instil a culture of effective and continuous planning based on robust data and comprehensive stakeholder engagement. Poor planning can lock countries into expensive, polluting systems that hinder development and decrease gains in wellbeing. Countries must consider all options and plan long-term to build the most resilient and economic systems, while adapting to meet technological, financial, and demand changes. The challenge at hand must be supported by an adequate strengthening and mobilization of resources and institutional capacity.

Sector coupling will also be an important component, as governments encourage different sectors to ensure that resources are preserved and used effectively. Moreover, reusing and repurposing existing infrastructure can contribute to the technical, financial, and social benefits of energy transitions.

Underpinning everything must be robust and up-to-date data. Policymakers must put structures in place to enable effective data collection and use, calling on the international community to support this process and to share relevant data. All planning must be continuous and transparent, reacting to changes in the market and ensuring objectives are being met, in other words, giving industry the confidence to invest.

A major action area is to build the capacities amongst utility staff, in particular, power system planners, system operators, etc., to understand and apply the technical options available to manage the new challenges of the changing power system. This is a long-term process which should be structured to match the progressing penetration levels of variable renewables. Creating these capacities within utilities, particularly in countries less advanced in the energy transition, will be a prerequisite for a smooth integration of renewables. It will also be an important contribution in overcoming incumbent resistance.

Planners also need to engage at regional and global levels. The growing importance of the effective use of resources at an aggregate level, together with the new possibilities of energy trade with an increased number of producers, signify just how much these interconnections are needed. Policymakers should collaborate with regional and international institutions to identify where interconnections will work well and facilitate their introduction. The increasingly important role of the local level needs to be recognized; with rapid urbanization in most regions, city-level planning is becoming a more important factor in the energy transition. Decentralized renewables will increasingly shift power generation to the local level, and the role of local distributors and municipal utilities, for example, will become even more important.

Appropriate financing is needed to realize transition plans. According to IRENA's World Energy Transitions Outlook,[29] the annual investments of USD 3.4 trillion planned to finance the energy transition should increase to USD 4.4 trillion, if global temperature rise is to be limited to 1.5°C. Public investment must continue to help support new technologies, spread risk, and encourage private investment where it is most needed. Large upfront investment is necessary for accelerated deployment of renewable energy technologies, the massive electrification of transport, expansion of heating and cooling applications, and, among others, the infrastructure needed for large-scale green hydrogen projects to meet the energy needs of hard-to-abate sectors. Appropriate oversight and review are also necessary to ensure public investment is having the desired impact.

Additionally, if the goal is to build the most efficient energy systems, then energy planners need to embrace innovation. Planners need to ensure that policies and procedures encourage innovation that increases the energy efficiency of existing products and services. Innovation is not limited to invention and design and development (D&D). Business models, operational practices, and markets also need to evolve to accommodate the rise of renewables and promote efficiency. They must incorporate new technology and modelling into their work so as to better forecast power needs. This includes supporting the rollout and effective use of smart metering, platform business models, and demand-side management, which will enable grid operators to better balance the grids and to ensure that the right clean energy solutions are introduced. Innovation is critical to drive progress on clean energy solutions across uses, especially in end uses that lack non-fossil alternatives. This innovation extends to market instruments that support the supply and purchase of clean energy. Regulators need the right legal instruments to enforce rules and regulations, to mitigate risk. Strong utilities and network operators are required to maintain investment in the grid and ensure that consumers have the power they need when they need it.

5.3 Supply: Renewable energy and other options (nuclear, gas, CCS) and finance

5.3.1 CHALLENGES

Every nation is striving to build resilient energy systems that underpin sustainable development in their country. The fuels and technologies driving these systems have evolved over time and will need to continue to evolve in the coming years. The world stands at a turning point as it begins to pivot away from the energy systems and supply chains that have dominated recent generations. Global energy supply dynamics are shifting, creating significant opportunities and challenges for all.

The growth of renewable energy over the past decade suggests that nations relying on fossil fuel revenue to drive their economies will be challenged by falling demand and increased pressure to decarbonize. With renewable power often being the most economic option and end-use sectors investing large sums in decarbonization, the role of fossil fuels in global energy will dwindle. In response, many oil-rich states have looked at diversifying their economies and investing in clean energy sources, such as green hydrogen.

While the migration away from fossil fuels presents challenges for some countries, it provides opportunities for all. The energy transition gives nations the opportunity to harness their native resources and move towards greater energy independence. It provides a chance for countries to establish new trade links through regional power collaboration. Flexible energy systems mean that interconnected and integrated markets can respond quickly to shift supply to meet demand. Many developing countries will require international technical and financial support to implement the transition, and this will be more readily available, as an increasing number of multilateral and bilateral development finance institutions have announced a halt to investments in coal.

A further challenge for many nations will be to ensure that their energy supply meets growing demand. According to the World Bank, more than 10% of the world's people still have no access to electricity. This must change. Even where energy access rates are high, demand for electricity will grow significantly as transport, heating and cooling, and industrial processes increasingly electrify.[30] This growing demand, together with the changing dynamics of the international energy supply, will provide challenges for governments looking to forecast and plan for secure supplies.

There are plenty of opportunities. Demand for energy efficiency is growing, and renewable energy technologies are proving to be hugely promising markets for industries. Those that position themselves at the forefront of the energy transitions through innovation, services, or resources will reap rich rewards.

Hydropower and nuclear energy in 2018 accounted for around 15% and 10% of global power generation, respectively. Most projections stipulate limited or no expansion of capacity in these two areas. The upcoming trends will depend heavily on decisions in a small number of economies. Factors such as resilience and cost-competitiveness will play a strong role in determining which low-carbon solutions will prevail in different settings. Moreover, given the length of time required for the development of new nuclear power stations, they are unlikely to play a significant role in the decade to 2030.

The necessary action in the next decade will largely be undertaken, using already existing technologies while more RD&D work is needed on solutions that enable last-mile decarbonization efforts in sectors such as steel and cement. Advanced biofuels and green hydrogen and ammonia produced with

renewable energy supply are receiving increased attention, especially for heavy duty transport, shipping, and aviation, and other hard-to-abate sectors. Natural gas-based hydrogen production with Carbon Capture and Storage (CCS)—blue hydrogen—is also being considered, using existing infrastructure. This avoids stranding of assets in the petrochemical industry. Some countries consider blue hydrogen a necessary step in the build-up of capacity to produce sufficient green hydrogen for a potentially rapidly growing market.

Governments will need to be attuned to these challenges and opportunities to ensure that they pursue the right course for their country to meet the changing patterns of energy demand while avoiding the very real risk of stranded assets. Failing to develop forward-looking policies, ignoring market signals, favouring short-term thinking, and failing to challenge the status quo threatens their economic development, energy security, and the health benefits of newer, cleaner energy supplies.

5.3.2 ACTION

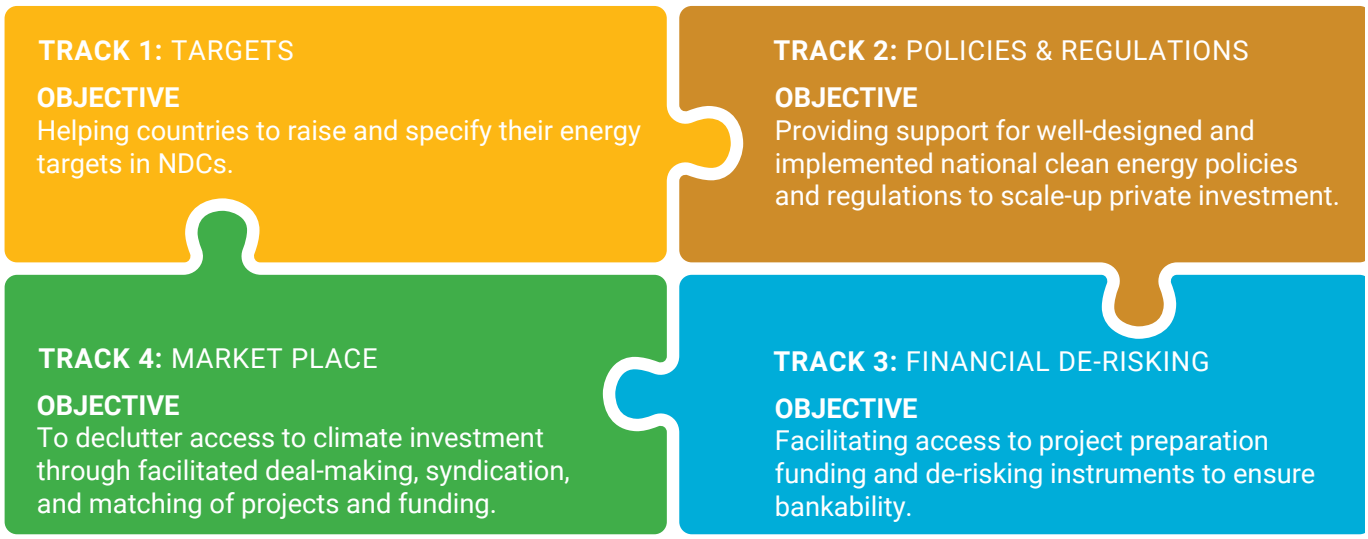
There is no single route to cleaner, fairer, and more sustainable energy systems. Each country must pursue its own path, using data and evidence to make informed, long-term decisions while coordinating with each other. Countries must consider the direction of energy markets, investments and technology, together with the changing needs of their citizens. They must embrace the principles of creating circular economies as an important route to economic development and climate preservation. Resources should be focused where there are the most synergies with socio-economic and environmental policies, such as air quality, water, and waste policies.

Countries will need to examine the spectrum of solutions available and map them against short-, medium-, and long-term needs. A staged approach is recommended, so that mature technologies can be deployed quickly to initiate the transition in the short to medium term without creating the risk of stranded assets, while also pragmatically starting work on solutions for hard-to-abate sectors. Governments need to accelerate the deployment of options that will ensure the achievement of the Sustainable Development Goals. The challenges of balancing energy security, economic development, and climate concerns must be accepted, and the paths must be sought that promote each of these simultaneously. Such paths exist and it is the task of policymakers to find them or risk hindered economic growth, vulnerable communities, and weakened health systems.

Policymakers at the national level must steer country-wide, stakeholder-driven, roadmap-development efforts, focusing on the opportunities for all actors and what would be needed to secure full implementation. This will have to be accompanied by a holistic set of policies to maximize benefits and minimize adverse impacts, along with fiscal reforms that tackle issues such as a phase-out of fossil fuel subsidies.

To enable this process, governments need to actively disincentivize new investments in outdated infrastructure and technology. As noted earlier, a growing number of governments and financial institutions across the world have already committed to halting the financing of fossil fuels. This is a vital step and more governments will need to follow suit. Institutions providing financial instruments such as climate and green financing and climate bonds should also avoid concentrating only on mature technologies and markets so that they can focus on getting other technologies and systems up to speed—including advanced bioenergy and biofuels, and green hydrogen and its derivates. There is also a

FIGURE 7. CLIMATE INVESTMENT PLATFORM (CIP)[31]



need for financial instruments to improve the bankability conditions for renewable energy in developing countries where currency risk, off-taker non-payment risk, and other forms of risk are high, especially in the wake of COVID-19 (Figure 7)

Established instruments can be complemented by innovative sustainable-impact investment mechanisms that go beyond traditional project-focused green finance. SDG-linked bonds are a recent example of linking investment returns with companies' sustainability performance. In this area, the success of the launch of the first SDG-linked bond in New York in September 2019 attests to the investor community's level of interest in exploiting the potential of impact investments.

Public procurement and green taxation are other important ways in which governments can help increase demand for clean technologies and reduce the cost of energy transitions.

To enable the supply of clean energy, governments need to support innovation and emerging technologies. The role of emerging technologies must be integrated into sector roadmaps and point to research and development initiatives on specific technologies and fuels. Done well, energy strategies give investors clarity and can kick-start the growth of a sustainable industry. For example, numerous countries have released green hydrogen strategies over the past few years, giving a good sense of direction in that area. Storage technology is another key area where many countries and private companies are putting large R&D efforts in place.

However, these strategies must be accompanied by enabling policies and regulations, together with investment in supporting infrastructure. The international community must come together in key areas of joint interest to provide mutual support in preparing these plans and in building the right conditions for new technology to mature.

Where new technology is adopted, regulators and governments, national and local, need to ensure that it is installed properly and performing to the expected standard. Governments often find it challenging to adopt new innovative technologies without documented large-scale implementation, proven success

in other countries, and where in-country technical capacity and expertise are lacking. In this regard, a "sandbox" approach can be useful, where governments allow implementation or testing of a new technology or solution on a small scale, often combined with the lifting of some of the regulatory barriers. In this way, it can be seen whether or not adopting the technology and scaling it up is going to be beneficial.

5.4 Demand, energy efficiency, and finance

5.4.1 CHALLENGES

According to the IEA, demand-side efficiency improvements represent around 40% of the total emissions abatement opportunity needed to deliver the Paris Agreement goals, particularly in the near term; demand-side abatement also offer economic, employment, and social benefits.[32] Yet, the rate of improvement in energy intensity has declined for three years in a row. There is an urgent need to reverse this trend to have any chance of reaching the SDG 7 goal for efficiency and to keep the global community on track to reaching the Paris Agreement goals. Moreover, increasing the share of renewables must be accompanied by aggressive efficiency strategies. The SDG 7 target of doubling the annual improvement rate of energy efficiency was, at the time of its establishment, 2.6% per year. Recent studies by IRENA and the IEA referenced in this document use respectively 2.7% and 3.2% as average improvements from 2020 to 2050 in their scenarios for net-zero. With these different estimates on the annual rate of improvements, there seems to be a convergence of views around a rate of 3% per annum.[33]

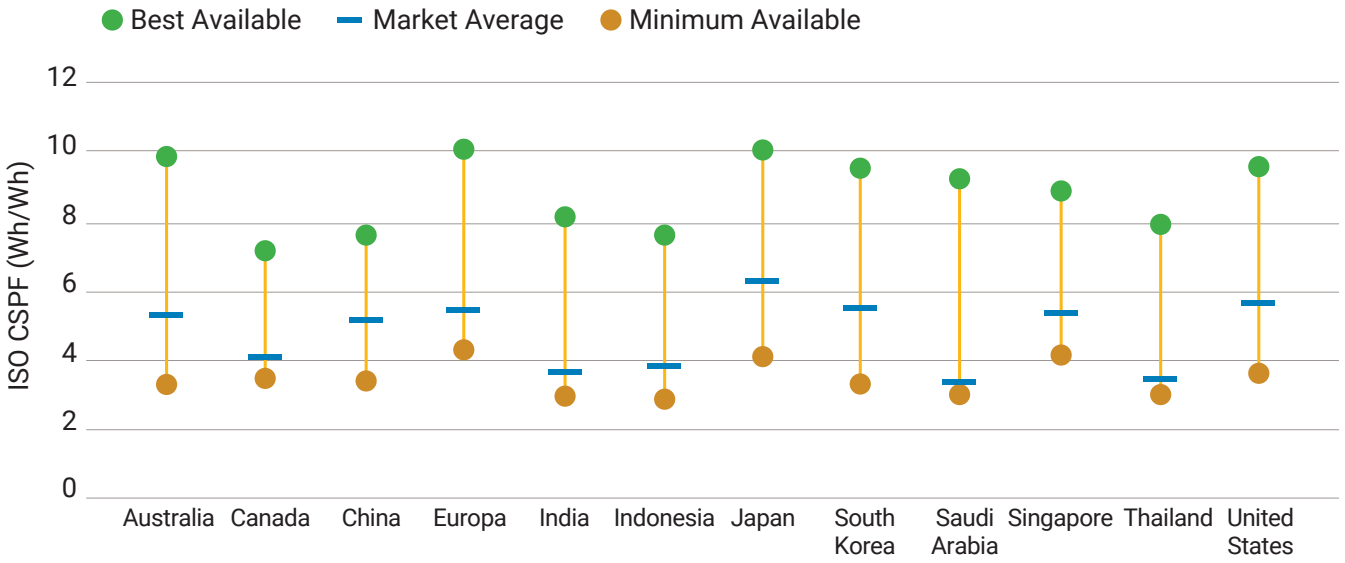
However, only a few countries have taken an in-depth look at the energy-efficiency opportunities available to reduce their future emissions and have included energy efficiency in their first NDCs. The recent synthesis report[34] from the UNFCCC Secretariat assessing the updated NDCs from 75 Parties indicated an increased focus on energy efficiency, but not with the necessary level of ambition.

The key challenge is that increasing energy efficiency involves all sectors, including households, commercial and service buildings, industries, heating and cooling, transport, etc. In most cases, technologies are available and affordable, but new incentive structures will need to be put in place through government policy to accelerate market uptake. Key barriers are linked to inadequate energy infrastructure, regulatory systems, behavioural norms, demand management, and poor financial incentive structures. Acceleration of energy efficiency needs to be implemented via cross-cutting, action-oriented efforts.

UNEP's Emissions Gap Report 2017[35] examined the key areas with the highest abatement potential and presented the potential across all main sectors and options. In addition to the issues discussed pertaining to the transport and hard-to-abate chapters, the major energy-efficiency potentials clearly lie in appliances and lighting, buildings—including heating and cooling—and in industrial motors and other equipment.

With the increasing availability of renewables-based power capacity, many end uses will be electrified as part of the sector transformation. In many cases, there are mature or emerging technologies that can deliver significant energy-efficiency benefits compared to incumbent fossil fuel technologies. Examples are electric vehicles compared to internal combustion engine vehicles, or heat pumps compared to conventional fossil fuel boilers.

FIGURE 8. AIR CONDITIONER EFFICIENCIES IN SELECT COUNTRIES



Source: IEA[39]

Cities are critical actors for decarbonization, as they account for 70% of global emissions. This percentage will rise without action. Urbanization is increasing rapidly, with up to 68% of the global population expected to live in cities by 2050, compared to 55% today.[36]

The building sector is key to energy efficiency, especially in cities, and opportunities for efficiency measures exist in both new and existing buildings—including high efficiency insulation, windows, and building materials; high efficiency heating, cooling, hot water, and lighting systems; and smart energy management services. Increased recycling of building materials will reduce much of the need for new concrete and steel, which will contribute to reduced emissions from these sectors. This opportunity is described in greater detail below.

The general potential and barriers are illustrated with one example in an area that is receiving increased attention—cooling. Cooling is a holistic issue, which cuts across various sectors: buildings (space cooling), transport (mobile AC), food cold chain, health cold chain (transportation and storage of medicines, vaccines, space cooling in hospitals) and industry (process cooling). Many countries are developing cooling action plans. These need to be closely integrated with the energy sector transformation, as energy use for cooling is increasing rapidly.

Globally, an estimated 3.6 billion cooling appliances are in use, projected to increase to 9.5 billion by 2050 because of growing populations, greater affordability, and a warming world.[37] District cooling, better housing design, and passive cooling efforts can contribute to solving part of this challenge, but most space-cooling services will still be air conditioners (AC). According to the IEA,[38] around 2000 TWh annually are used for cooling devices. This is almost 10% of global power demand and is set to increase with the projected number of new appliances. This demand typically occurs during peak hours, increasing the pressure on power capacity in many developing countries.

It is therefore very important that new ACs are as efficient as possible. Figure 8 shows that the average energy efficiency of ACs is only a fraction of that of the best available equipment on the market in

most countries, so there is clearly much room for improvement. An important issue from a climate perspective is that more efficient ACs can also be linked to the phase-out of high–Global Warming Potential refrigerant gases, in line with the Kigali Amendment to the Montreal Protocol.

This illustrates one of the basic issues involved in promoting energy efficiency. Upfront costs are often higher but, in most cases, this cost difference is more than compensated for by savings over the lifetime of the equipment. Simple financing schemes will need to be made available for customers, and regulation will be needed to overcome the split incentives between, for example, building owners and users.

5.4.2 ACTION

Given the diverse nature of energy efficiency, it is very important to engage actors in all sectors of society and for national-, local-, and city-level government to both regulate and incentivize action.

A long list of tested and proven policy options is available, including:

- **Regulation**, such as building codes, minimum energy performance standards for equipment, and import restrictions on sub-standard products. These remove the poorest performing systems from the market.
- **Information**, such as endorsement labels or comparison labels, product databases, capacity building and training courses for a wide range of market actors, including policymakers, producers, workers, and end users. This information should also feature conservation and demand reduction, where options for changing behaviour are available.
- **Incentives**, such as tax schemes, subsidies, or rebates that increase the uptake of high efficiency products, or those with low global-warming-potential (GWP) refrigerants.
- **Aggregating demand**, through public procurement and private buyers' clubs, can accelerate the uptake of best available technologies and drive down the cost of energy-efficient and climate-friendly equipment.

In common with other parts of the energy sector transformation, it is important for actions to be based on an integrated strategy with clear goals. Energy efficiency and other demand-reduction measures will need to be analysed together with supply expansions to find the best balance in terms of both service delivery and costs. It is critical to ensure that the opportunities offered by new digital technologies are fully utilized to enhance the efficient interaction of ever-more integrated energy system supply and demand elements.

In relation to COVID-19 recovery actions, energy efficiency offers a number of opportunities. Recovery programmes can support existing jobs and create new ones in key labour-intensive sectors, such as construction and manufacturing, by stimulating energy efficiency actions. At the same time, such actions will typically reduce energy costs for society and contribute to lowering GHG emissions and other pollutants.

Beyond government policies and regulation, there is a general issue with financing for energy efficiency. Finance institutions often lack the necessary expertise to evaluate and prepare an investment in energy efficiency. Many activities are too small-scale to interest commercial or development finance. There are several ways of overcoming this barrier. As well as assuming the policy role described above, governments can partner with private finance institutions to address market failures, share risks, and ensure the participation of low-income groups.

Aggregation or bundling of activities, combined with assistance for project development, has proved effective because many project promoters, like cities, local authorities, individuals, and businesses, frequently do not have the skills or capacity to develop, implement, and finance energy efficiency projects.

A recent example is the Argentinian Network of Municipalities against Climate Change (RAMCC), which has established a common fund to attract financing and support retrofitting of street lighting to over 200 municipalities. This approach aims to address the problems of small scale and poor technical capacity faced by each city and facilitate solutions to a common problem.

Energy Service Companies (ESCOs) are another approach, in which a private or public entity provides comprehensive energy solutions; for example, by offering energy saving services against payment, and therefore limiting the investment risk of the customers, with the shared goal of improving efficiency. One example of a publicly owned ESCO is Energy Efficiency Services Limited (EESL), owned by the Government of India. This is the world's largest public ESCO and offers energy-saving services across a range of sectors through a large portfolio of activities.

International collaboration is important for promoting energy efficiency. Standard and norm setting is a key area for collaboration, allowing experiences to be shared and adapted to local conditions. For example, two years ago the Caribbean Community (CARICOM) announced new common standards for energy-efficient buildings for its member countries. These standards were developed with international support.

Several international programmes have been established over the years to support energy efficiency. A few examples are included in chapter 4, as they are relevant for compact commitments.

5.5 Transport

5.5.1 CHALLENGES

According to the IEA,[40] global CO_2 emissions from transport in 2019 were approximately 8.2 GT, which is close to one quarter of total global CO_2 emissions. Emissions have been rising steadily by around 2% per year since 2000, but increased by less than 0.5% in 2019, mainly due to efficiency improvements, electrification, and greater use of biofuels.

For many years, there have been rising concerns about e-health impacts from emissions of particles and other air pollutants from transport. The World Health Organization (WHO)[41] estimates that more than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels exceeding WHO-recommended limits. The problem is global, but pollution levels and associated health impacts are generally worse in developing countries, and are the main cause of millions of premature deaths.

Overall demand for transport services—both passenger and freight—is projected to roughly double between 2005 and 2050 if current trends continue. The global vehicle fleet is set to multiply three- or four-fold in the next few decades, with most of this growth set to occur in developing countries. In 2050, two thirds of the global vehicle fleet is expected to be in non-OECD countries.

The transport sector has been one of the hardest hit by the COVID-19 pandemic. In 2020, aviation in particular saw a dramatic, and continuing, decrease in activity. Shipping and road transport activities both initially suffered a rapid downturn but have gradually come back to former levels in many countries.

Road transport currently accounts for nearly three quarters of transport CO_2 emissions. Up to 2019, however, emissions from aviation and shipping were growing faster. They are predicted to continue this trend in the next decades. Depending on post COVID-19 recovery trends, this prediction may change. The transformation of global value chains and political concerns about high import dependency may bring changes to intercontinental shipping. Similarly, holiday patterns may change, as may some business travel, as the world shifts to rely more on virtual meetings, etc.

No matter how post-COVID developments impact transport demand, there is still an urgent need to transform the transport sector to improve mobility, especially in developing countries, and, at the same time, to reduce the energy consumption and associated emissions of CO_2 and other air pollutants. Such a transformation will require sustained policy efforts by all countries to address the challenges facing the different parts of the sector. The electrification of private transport is showing signs of disruptive transition— global sales of electric cars in 2020 grew by 43% compared to 2019, reaching 3.2 million units and accounting for 4.2% of global new car sales. Key enabling technologies, such as battery packs and cells for mobility applications, saw rapid cost reductions from an average of USD 181/kWh in 2018 to USD 137/kWh in 2020 (the lowest-cost applications were under USD 100/kWh).[41] At the same time, the use of electric two-wheelers and public transport is increasing as alternatives to private cars. It is important to underline that electrification of transport needs to be closely linked to renewable energy expansion and growth in the charging infrastructure. An interesting option to explore is how the growing pool of vehicle batteries might provide important, short-term storage flexibility to the power system.

Electrification using presently available technologies is not currently a scalable option for heavy-duty transport, shipping, and aviation. This may change with innovation, but in the short term, there is a focus on increased use of sustainable biofuels and clean hydrogen in these sectors.

Beyond the direct energy consumption associated with the transport service provided, there needs to be consideration of how broader life-cycle issues can be integrated into planning and policy. Several options are available for reducing both direct and indirect energy use. Many of these are gaining increased interest, such as making vehicles with less or lighter material, increasing the recycling of different material components and extending the total lifetime of vehicles.

How relevant different elements will be for transport sector transformation in each country depends on national circumstances. Suggestions regarding how to turn challenges and opportunities into action plans are presented in the next section.

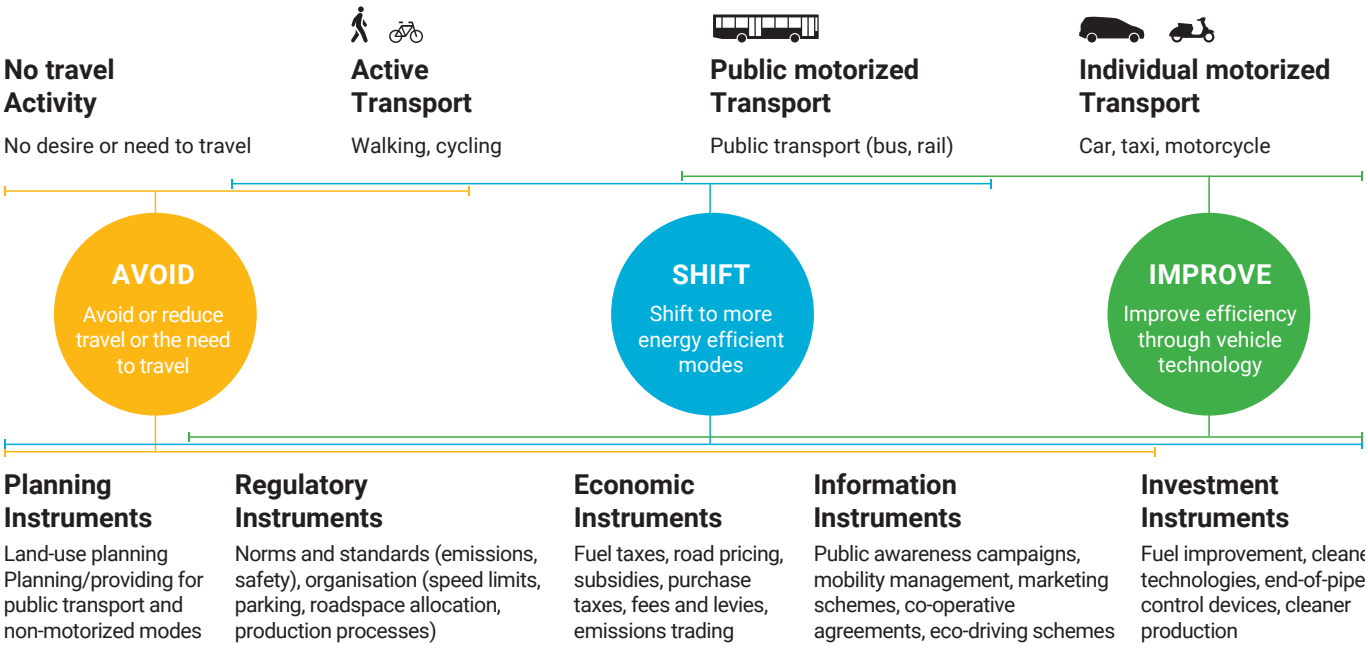
5.5.2 ACTION

From the challenge discussion, it is clear that transforming the transport sector is an important part of the overall energy sector transition. The current high dependence on fossil fuels in the sector needs to be reduced quickly to make it part of an overall net-zero GHG emissions path.

Governments need to establish a transport sector plan of action as part of an integrated energy- sector transformation strategy, engaging actors at both national and local/city level, the private sector, civil society, and others. From the outset, such a process needs to establish and agree on mid- and long-term targets aligned with national sustainable development plans and 2050 net-zero strategies.

It is important in the strategy process to analyse different paths for reaching the targets and identify the main requirements for success. An implementation plan should include requirements for policy and institutional development, necessary labour skills enhancements, and financing and infrastructure needs.

FIGURE 9. ILLUSTRATION OF THE AVOID–SHIFT–IMPROVE APPROACH[42]



Source: TUMI

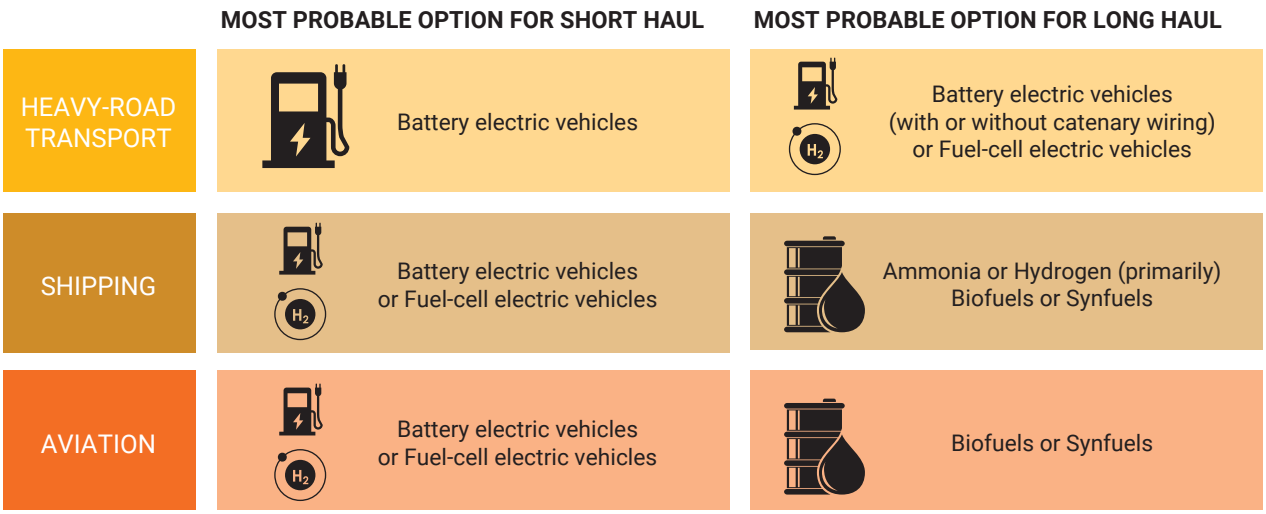
Governments should adopt a comprehensive "avoid-shift-improve" approach, where reducing demand, changing transport modes and improving the energy efficiency of mobility are considered in an integrated manner (Figure 9).

- **Avoid**—Managing travel demand can be done in many direct and indirect ways. Options include infrastructure design, for example, building higher-density cities and local integration of workspaces and domestic dwellings. Pricing in different forms is also important, including taxes on vehicles, fuels, and parking; road use levies; freight handling charges in harbours; and departure/arrival taxation in airports.

- **Shift**—Stimulating use of the least energy-intensive modes of transport by, for example, creating favourable conditions for pedestrians, building bike lanes, and strengthening public transport and car-pooling choices through subsidies, and constructing fast track lanes in congested places. Integration of different transport modes benefits end users and enhances system efficiency. Electrification of both private and urban public transport, where possible, and creating fast electric train connections between major cities is another option.

- **Improve**—Increasing energy efficiency of vehicles and motorized two-wheelers through design, engine improvements, efficient air conditioners, and the use of more efficient electrical motors. For land and sea freight and aviation, exploring and promoting the use of modern biofuels, hydrogen, or ammonia where electrification is not relevant will be critical. Policy tools like vehicle efficiency norms and fuel standards are documented to encourage the adoption of more sustainable transport technologies. Vehicle and fuel pricing are also efficient tools, particularly when combined with a functional charging infrastructure for electrical vehicles. To realize climate benefits, the electricity would need to be "green". The same is true for hydrogen.

FIGURE 10. OPTIONS FOR SHORT AND LONG-HAUL TRANSPORT TRANSFORMATION



Source: ETC

With all major manufacturers of vehicles moving quickly to put electrical vehicles on the market, combined with rapid cost reductions in batteries and drive systems, it seems increasingly clear that the electrification of private and public transport will become the dominant medium-term option in industrialized countries and emerging economies like China and India. The build-up will take time, and it is unlikely that low-income developing countries will be able to move nearly as quickly, due partly to affordability and insufficient power supply and infrastructure. There will therefore continue to be a need to manage travel demand, improve the efficiency of cars running on fossil fuels, and increase the use of sustainable biofuels.

Shipping, aviation, and parts of heavy-duty land freight transport are not equally well suited for electrification, at least with current technologies and costs. Here, biofuels, hydrogen, ammonia, and other synthetic low-carbon fuels are generally seen as the main options for decarbonization, supported by demand management and fuel efficiency improvements.

The Energy Transition Commission[44] has summarized the options in the following figure (Figure 10).

In the process of developing compacts, it is important to consider whether existing initiatives could be strengthened instead of new compacts being created. Examples of such initiatives are presented in chapter 4. A detailed mapping of initiatives has been conducted under the Paris Process on Mobility and Climate (PPMC).

5.6 Hard-to-Abate Sectors

5.6.1 CHALLENGES

With the 2030 focus of the SDGs and NDCs, there is a natural emphasis on the most effective short-term opportunities. However, with increased political commitment for net-zero emissions targets by 2050, there is growing understanding of the need to also look at what are generally called "hard-to-abate" sectors. There is no definition of this term, but it typically includes heavy industry (cement and lime; iron and steel; petrochemicals and chemicals; aluminium), road freight transport, and shipping and aviation. Iron and steel alone accounts for around 9% of energy and process CO_2 emissions, followed by cement (7%) and chemicals and petrochemicals (5%). Together, those seven sectors could account for 38% of energy and process emissions and 43% of final energy use by 2050, unless major policy changes are pursued now.[46]

As transport issues have been discussed above, the focus here is on the various industry sub-sectors. As well as being energy-intensive, these sub-sectors are characterized by being large-scale, complex, often located in larger, integrated industrial settings, and frequently directly linked to infrastructure like energy supply (power or gas), harbours, or railways for easy and large-scale transport access. Production facilities are generally large-scale and capital-intensive and will normally only be replaced if economies of scale justify doing so, or significant efficiency or cost improvements can be realised.

Most of these industries operate in competitive global markets, which makes it hard to impose costs associated with a national climate policy unilaterally, as this would affect the competitiveness of domestic industries. Most countries have therefore only recently started to engage these industry sectors in climate policy discussions, and only a few of the NDCs include plans for emission reductions in these sectors. The best way for governments to change this is to engage relevant companies in a dialogue aimed at a joint plan for the long-term decarbonization of their operations, making it clear how the different elements can be realized and where and what type of government support is needed. This engagement should be part of the wider just transition process.

Attempts at the global level to create common or collaborative sector approaches and avoid competitiveness concerns have so far largely focused on voluntary initiatives. For example, the Global Cement and Concrete Association has established a Climate Ambition for its members to deliver carbon-neutral concrete by 2050. A roadmap on how to achieve this goal is being developed in collaboration with governments, investors, researchers, end users and financial institutions, and will be published in 2021.

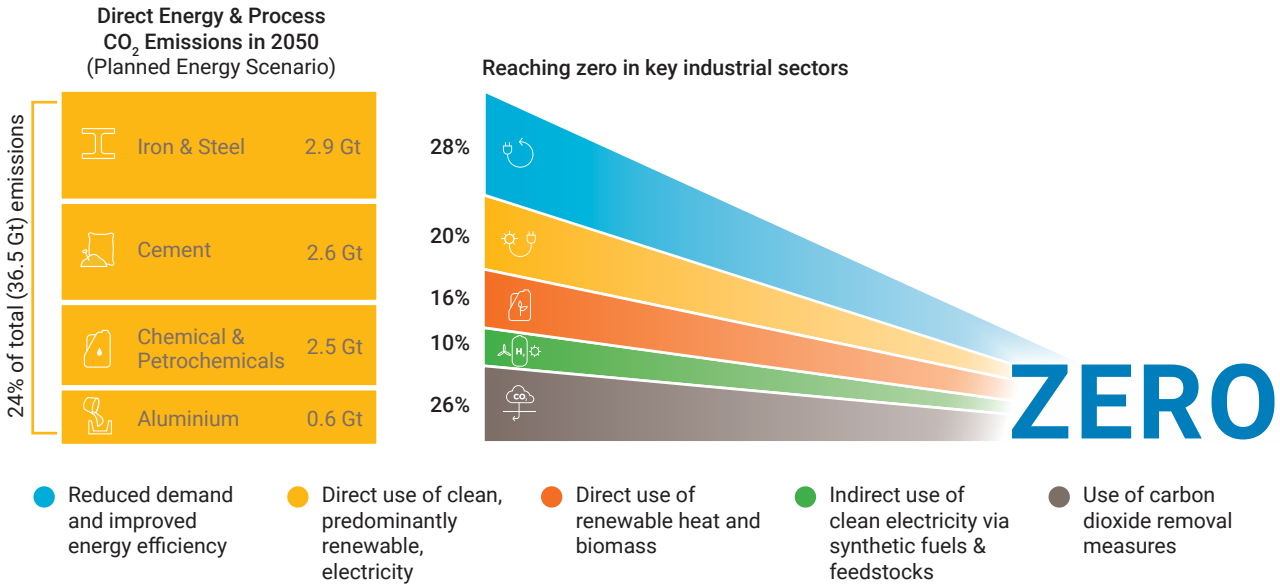
Over and above energy-related GHG emissions, the cement industry has the additional problem that more than half of the emissions from cement clinker production are a by-product of the chemical reaction and cannot be reduced by changing fuels or increasing factory efficiency. As this is not an energy issue, it will not be addressed in any detail here. However, one of the abatement options is Carbon Capture and Storage (CCS), which may influence how cement companies deal with their direct emissions from energy use.

5.6.2 ACTIONS

Options for reducing emissions from hard-to-abate industries structurally resemble possibilities in other product sectors, and include demand reduction, increased energy efficiency, and shifting to clean energy sources. How such possibilities can contribute to decarbonization in each of the industrial

FIGURE 11. OPTIONS FOR REDUCING EMISSIONS FROM HEAVY INDUSTRY SECTORS

Energy-intensive industries: Options for reaching zero



Source: IRENA

sectors differs according to national and local circumstances. When examining different assessments of the most cost-effective paths to decarbonization for these industries, the priorities differ according to the underlying assumptions about future technology options and costs. In all cases, there is a strong need to support cost-effective technology transfer to the developing world to enhance national ability to accelerate decarbonization efforts.

IRENA[47] has analysed how the different abatement options may contribute to decarbonization (Figure 11).

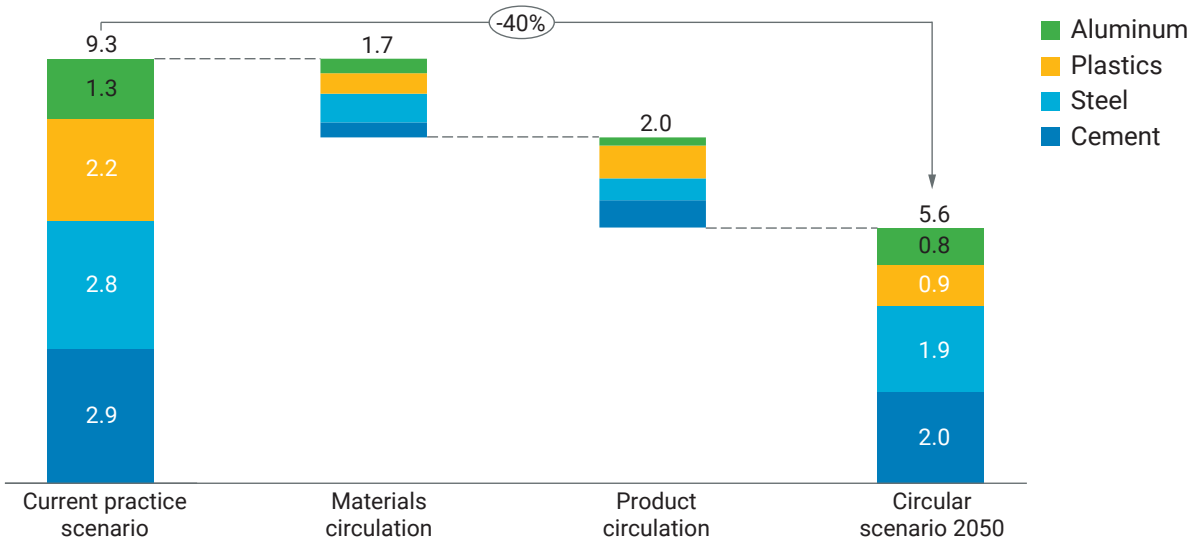
A closer look at the different measures clearly shows that reducing demand is important. The main challenge, however, is that most of the products from these industries are used as inputs in other value chains. Change will require strong collaboration with customers, likely stimulated by government regulation or incentives. Some key areas would be expanded recycling and reuse of materials, combined with reduced requirements for the materials in main value chains such as buildings, vehicles, and consumer goods. This could be done by improving product design, extending product lifetimes, and developing new business concepts around sharing or leasing, as is occurring with vehicles in many urban areas.

The Energy Transitions Commission (ETC)[48] performed a similar analysis of how to reach net-zero emissions in hard-to-abate sectors. It emphasised the same general areas as the IRENA study, but with a stronger focus on demand reduction and circularity. The analysis suggested that up to 40% of emissions could be abated through these two actions. Details of how the different sectors could reduce emissions are presented in Figure 11.

As discussed throughout this paper, energy efficiency is important across all sectors. Many of the large-scale process industries have traditionally had a strong focus on energy efficiency, pushed by market

FIGURE 12. CIRCULAR ECONOMY OPTIONS FOR REDUCING EMISSIONS

Global emissions reductions potential from a more circular economy
Gt CO_2 per year



Source: ETC

competition and the need to reduce energy costs. There are, however, opportunities for improvement in many older facilities, including through the use of new digital control and measurement technologies. The ETC estimates that short-term gains from efficiency could help abate up to 15–20% of current emissions. Above and beyond the introduction of direct efficiency measures, industries may themselves contribute to system effectiveness; for example, fertilizer production and desalination plants can utilise surplus electricity from variable renewable energy supply, and in that way, complement storage needs.

The main challenge for most of these industries, however, will be to substitute the current use of fossil fuels directly, both in their production processes and in their energy supply. With the framing of a net-zero target by 2050, a clear focus is needed on this objective when options are evaluated. The IRENA report has articulated this very precisely: "Technologies and processes that cannot eventually lead to zero or close-to-zero emissions are only worth pursuing if they either greatly reduce the scale of the challenge for true zero-emission solutions, or if they will be replaced in the next 40 years or are a stepping-stone to successfully implementing zero-emission solutions."[49]

Within this framing, technology avenues include:

- Electricity based on clean sources, primarily from renewables.
- Renewables-based heat from solar, geothermal, or sustainable biomass.
- Hydrogen, ammonia, and other synthetic fuels produced from renewables (green hydrogen).
- Carbon dioxide removal either through Biomass with Carbon Capture and Storage/Utilization or emerging direct capture technologies (Figure 12).

As mentioned earlier, the relevance of the different options varies between countries. As some of the proposed solutions are still not fully commercial at the scale required, further support for innovation will be needed. The pace of decarbonization of these hard-to-abate industries will depend on the speed of the overall energy sector transition. The pace at which renewable power capacity is expanded and made available will partly determine the new power sector structures, the relevance of fossil fuels with the use of CCS, and to some extent the use of green or blue hydrogen (decarbonized fossil gas with CCS).

For decarbonization to accelerate in these hard-to-abate industry sectors, there is a strong need for government engagement and enhanced international collaboration. In an investment context characterized by rapid technological and political change, investment and policy decisions will need to be made regarding the risk of stranding assets. One recent example is the Swedish state-owned LKAB iron mining company, which has initiated a transition to zero-carbon iron production using green hydrogen and other fossil fuel–free technologies, with an annual investment of EUR 1– 3 billion over the next 20 years.[50] This effort is expected to create around 3,000 new jobs.

Hydrogen will offer a solution to industry and transport needs that are hard to meet through direct electrification, mitigating close to 12% and 26% of CO_2 emissions, respectively, according to IRENA's[51] 1.5°C scenario. Today, around 120 metric tonnes (Mt) (14 EJ ([exajoules]) of hydrogen are produced annually, but almost all of this comes from fossil fuels or from electricity generated by fossil fuels, with a high carbon footprint: less than 1% is green hydrogen. As electrolyser costs go down, combined with further reductions in renewable electricity costs, green hydrogen will be less expensive than the estimated cost of blue hydrogen in many locations within the next 5 to 15 years.

6 RECOMMENDATIONS

RECOMMENDATION 1

Rapidly scale-up deployment of available energy transition solutions to reach 8000 GW[3] of renewables by 2030 with due consideration to different contributions by individual countries.

The abundance of cost-effective renewable potentials worldwide makes them a scalable option that is essential to the decarbonization of the entire economy across all sectors. For many countries, this translates a technical and economic challenge into a set of investment, regulatory and societal opportunities.

RECOMMENDATION 2

Increase the average annual rate of energy efficiency improvement from the current 0.8% to 3% through the implementation of all available technologies while supporting further innovation.

Energy efficiency opportunities are readily available and have positive effects on employment; however, they often need policy support to be implemented. Efficiency measures and strategies must address the main barriers to the adoption of energy efficiency measures and promote structural and behavioural change. Further, they must be considered across different sectors and areas, for instance, standards and norms for buildings and appliances, transport, industrial uses, and heating and cooling, among others.

RECOMMENDATION 3

Invest in physical infrastructure to enable the energy transition.

Updating ailing infrastructure or investing in expansion is an integral part of the energy transition and an enabler of modern technologies. Public finance can be used to attract private investment in the infrastructure needed, which will help create jobs. Investments in infrastructure must be aligned with long-term plans and be reflective of broader strategies, including regional market integration.

RECOMMENDATION 4

Countries of the Organisation for Economic Co-operation and Development (OECD) should phase out coal by 2030 and redirect international energy financing towards the transition. Non-OECD countries should phase out coal by 2040, noting that many will require support for this process.

Coal phase-out will reduce the risk of stranded assets, improve energy independence, and bring about significant health and fiscal benefits. Countries should enact time-bound strategies to manage the social and economic aspects of the coal phase-out.

RECOMMENDATION 5

Mainstream energy policies into economic, industrial, labour, educational, and social strategies.

Policy measures and investments for recovery from COVID-19 must drive a broader structural shift aligned with plans for long-term energy sector transformation. To deliver on energy ambitions and avoid, reduce, or anticipate challenges, coherent, cross-ministerial policymaking is required.

RECOMMENDATION 6

Establish medium and long-term integrated energy planning strategies, define decarbonization targets, and adapt policies and regulations to shape energy systems that boost sustainable development.

Long-term energy scenarios, including net-zero mid-century scenarios, can be used to facilitate the dialogue needed to help reach consensus among all relevant stakeholders. When preparing energy transition, the ambitions of the nationally determined contributions (NDC) should be raised and short-term challenges identified. Engaging sub-national and city-level decision-makers in transition planning and implementation will be essential, given rapid urbanization and the decentralized nature of the modern energy system.

RECOMMENDATION 7

Create regional energy markets to facilitate the integration of renewables, promote cross-border power grid connectivity and trade, and further reduce costs through economies of scale.

Regional approaches to energy transition can reduce costs and enhance access to reliable and affordable electricity supply through expanded and smarter grid infrastructure; security of supply should be achieved through resource diversification. Regional integration can also enhance the resilience of energy systems to extreme weather patterns, climate variability and climate change, and the reduction of carbon emissions, and generally foster green economic development and employment.

RECOMMENDATION 8

Intensify international co-operation on energy transition to meet the 2030 Agenda for Sustainable Development and avoid future catastrophic climate change impacts.

A common learning curve will be accelerated through cooperative action and exchange of experiences and best practices across the power and end-use sectors. Underpinned by global solidarity, an overriding priority is to strengthen public resolve and to ensure that no one is left behind.

RECOMMENDATION 9

Develop sustainable transport roadmaps.

Based on an "avoid–shift–improve" approach. Country-specific plans that include urban strategies should include time-bound roadmaps for all modes of transport, with full consideration of mobility needs, efficiency, and renewable options. Across all regions, plans must include solutions such as electrification, sustainable bioenergy or green hydrogen, enhanced public transport and shared mobility, and promotion of regional and international cooperation and action.

RECOMMENDATION 10

Tailor labour and social protection policies to the specific needs of each region and country.

Although clear global gains in job creation will be made, the structural and labour-market impacts of energy transition will vary among locations, job types, and sectors. In cooperation with all involved stakeholders, countries should enact strategies for a just transition, maximizing opportunities, and minimizing hardship for individuals and communities.

RECOMMENDATION 11

Make the energy transition a participatory enterprise.

Participatory approaches that meaningfully engage all actors, multi-stakeholder coalitions, and public–private partnerships will help shape the desired energy futures and also manage expectations. The private sector must play a significant role in the implementation of the energy transition. Equally important is the empowerment of citizens, youth, local governments, research institutions, and indigenous communities to become part of the energy system.

7 EXISTING INITIATIVES AND POSSIBLE COMPACTS

7.1 Climate Action Pathways for Energy: Existing Initiatives

As already outlined in this paper, many initiatives exist in almost all areas of the energy sector. Some of the major ones, both global and regional, are briefly introduced below. This can facilitate a discussion of which compacts could provide useful foundations on which to build with strengthened commitments, and where there are gaps that new compacts could usefully address. The listing is not all-inclusive but provides some key examples.

RENEWABLES-BASED POWER SYSTEM

Energy Transition Council: A global coalition of leaders from across the energy landscape committed to achieving net-zero emissions by mid-century, in line with the Paris climate objective of limiting global warming to well below 2°C and ideally to 1.5°C.

Energy Storage Partnership: The World Bank Group and 29 organizations are working together to help develop energy storage solutions tailored to the needs of developing countries.

Renewables for Latin America and the Caribbean (RELAC): A regional initiative that aims to reach an installed capacity of 70% of renewable energy in the region by 2030. This initiative is led by the governments of Chile, Colombia, and Costa Rica and supported by the Inter-American Development Bank (IADB) (acting as the Technical Secretariat), the Organización Latinoamericana de Energía (OLADE), and IRENA. Ten countries in the region have already committed to the initiative, namely, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Paraguay, and Peru.

The Africa Renewable Energy Initiative (AREI): A transformative, Africa-owned and Africa-led inclusive effort to accelerate and scale up the harnessing of the continent's huge renewable energy potential. Under the mandate of the African Union, and endorsed by African Heads of State and Government on Climate Change (CAHOSCC), the Initiative is set to achieve at least 10 GW of new and additional renewable energy generation capacity by 2020 and to mobilize the African potential to generate at least 300 GW by 2030.

HYDROGEN

Green Hydrogen Catapult: The "Green Hydrogen Catapult" initiative will see green hydrogen industry leaders, including ACWA Power, CWP Renewables, Envision, Iberdrola, Ørsted, Snam, and Yara, target the deployment of 25 gigawatts of renewables-based hydrogen production through 2026, with a view to halving the current cost of hydrogen to below USD 2 per kilogramme.

IRENA's Collaborative Framework (CF) on Green Hydrogen: IRENA's CF on Green Hydrogen is an initiative to provide a platform for IRENA Members and other partners of the Framework (including the private sector) to have a dialogue, collaborate, and share information and best practices on green hydrogen deployment.

IRENA's Collaborative Framework (CF) on High-Share of Renewables: IRENA's CF on High-Share of Renewables is an initiative to provide a platform for IRENA Members and other partners (including the private sector) to have a dialogue, collaborate, and share information and best practices on systems with high-share of variable renewables such as solar and wind.

International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE): IPHE is an inter-governmental organization with a membership of 20 member countries focused on bringing together governments to advance worldwide progress in hydrogen and fuel cells.

International Energy Agency's Hydrogen Technology Collaboration Program (IEA TCP): IEA Hydrogen has facilitated and managed research, development, and demonstration activities on hydrogen.

Hydrogen Initiative of the Clean Energy Ministerial (CEM): CEM is a global forum created to promote policies and programmes and to share lessons learned and best practices in the transition to a global clean energy economy.

Mission Innovation: Mission Innovation is a global initiative of 24 countries and the European Commission working to accelerate clean energy innovation. The goal of Innovation Challenge 8 (IC8) goal is to identify and overcome key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale.

Fuel Cells and Hydrogen Joint Undertaking of the European Commission (FCH-JU): The FCH-JU is a public-private partnership supporting research, technological development and demonstration activities in fuel cell and hydrogen energy technologies in Europe. The three members of the FCH–JU are the European Commission, Hydrogen Europe, and Hydrogen Europe Research

Hydrogen Council: The Hydrogen Council represents 81 energy, transport, and industry companies with a united vision and the long-term ambition of acknowledging hydrogen's relevance for the energy transition and supporting its development.

European Clean Hydrogen Alliance: The European Clean Hydrogen Alliance aims for an ambitious deployment of hydrogen technologies by 2030: it brings together renewable and low-carbon hydrogen production, the demand for hydrogen in the industry, mobility, and other sectors, and hydrogen transmission and distribution. With the alliance, the EU wishes to build its global leadership to support the EU's commitment to reaching carbon neutrality by 2050.

COAL PHASE OUT

Powering Past Coal Alliance: The members of the Powering Past Coal Alliance work together to share real-world examples and best practices to support the phase-out of unabated coal. These include the use of climate finance and the adoption of practical initiatives to support this transition, for example, through the development of clean energy plans and targets. The commitment is informed by science-based benchmarks which show that EU and OECD countries must phase out unabated coal-fired electricity generation by no later than 2030, with the rest of the world following by no later than 2050 in order to limit global warming and the impacts of climate change.

Clean Air Fund: The Clean Air Fund calls for all relevant organizations, Multilateral Development Banks, philanthropists, and donor countries to increase financing for resilient health systems and air quality. It has raised USD 50 million of its USD 100 million target. Donors include IKEA Foundation, Children's Investment Fund Foundation, Bernard Van Leer Foundation, Oak Foundation, Saint Thomas Charity, and FIA Foundation.

OIL AND GAS

Science-Based Targets Initiative for Oil and Gas: The Science-Based Targets Initiative encourages companies to set targets for their carbon reductions based on scientific evidence and aligned with 1.5°C trajectories. A methodology for the oil and gas sector is in development (at time writing in late 2020).

Mineral Methane Initiative: The Mineral Methane Initiative by the UNEP-led Climate and Clean Air Coalition promotes deep cuts in methane from the oil and gas sector, focusing on transparency, science and policy.

Oil and Gas Climate Initiative: The Oil and Gas Climate Initiative (OGCI) supports emission reductions in the oil and gas sector. OGCI aims to increase the ambition, speed, and scale of company initiatives to reduce the greenhouse gas footprint of the core oil and gas business, and to explore new businesses and technologies.

The World Bank's Global Gas Flaring Reduction Initiative: The World Bank's Global Gas Flaring Reduction Partnership (GGFR) is a Multi-Donor Trust Fund composed of governments, oil companies, and multilateral organizations working to end routine gas flaring at oil production sites across the world. The Partnership helps identify solutions to the many technical and regulatory barriers to flaring reduction by developing country-specific flaring reduction programmes, conducting research, sharing best practices, raising awareness, increasing the global commitments to end routine flaring and advancing flare measurements and reporting.

Global Methane Alliance: The Global Alliance to Significantly Reduce Methane Emissions in the Oil and Gas Sector by 2030, or Global Methane Alliance, brings together governments, financing institutions, international organizations and NGOs, and industry to support ambitious methane reduction targets from the oil and gas industry.

Climate and Clean Air Coalition and its Oil & Gas Methane Partnership (OGMP): The Climate and Clean Air Coalition is a voluntary partnership of governments, intergovernmental organizations, businesses, scientific institutions and civil society organizations committed to protecting the climate and improving air quality through actions to reduce short-lived climate pollutants. OGMP is a multi-stakeholder partnership working on systematic methane emissions reporting.

International Methane Emissions Observatory (IMEO): UNEP in 2021, in collaboration with the European Commission, launched IMEO to engage with governments and companies around the world to accelerate reductions of methane emissions globally using the OGMP reporting as foundation. Already 62 companies with assets on five continents, representing 30% of the world's oil and gas production, have joined the partnership.

ENERGY EFFICIENCY

Cool Coalition: The Cool Coalition is a global multi-stakeholder network that connects a wide range of key actors from government, cities, international organizations, businesses, finance, academia and civil society groups to facilitate knowledge exchange, advocacy and joint action towards a rapid global transition to efficient and climate-friendly cooling. The Cool Coalition is now working with over 100 partners, including 23 countries.

Super-efficient Equipment and Appliance Deployment (SEAD): SEAD is a voluntary collaboration among governments working to promote the manufacture, purchase and use of energy-efficient appliances, lighting and equipment worldwide. SEAD is an initiative under the Clean Energy Ministerial (CEM) and IEA.

United for Efficiency (U4E): United for Efficiency (U4E) is a global effort led by UNEP and funded by the Global Environment Facility, supporting developing countries and emerging economies to move their markets to energy-efficient appliances and equipment. U4E is a public-private partnership that works with companies and stakeholders with a specific interest in moving markets.

Global Alliance for Buildings and Construction (GlobalABC): The GlobalABC works towards a zero-emission, efficient, and resilient buildings and construction. With over 150 members, including 30 countries, the GlobalABC is a leading global platform for governments, the private sector, civil society and intergovernmental and international organizations to increase action towards a zero-emission, efficient and resilient buildings and construction sector.

Zero Carbon Buildings for All: The Zero Carbon Buildings for All Initiative unites leaders across sectors in a strong international coalition to decarbonize the building sector and meet climate goals.

District Energy in Cities: A multi-stakeholder partnership involving local and national governments, city organizations, private sector and civil society. It promotes enabling policies for low-carbon and climate resilient district energy systems.

TRANSPORT, INCLUDING BIOFUELS

Partnership on sustainable low-carbon transport (SLOCAT): The partnership engages an international, multi-stakeholder group of over 90 entities across transport sectors associations, knowledge and academia, governments, multilateral organizations, NGOs, philanthropy and industry, as well as a large community of world-class experts and change-makers.

Global Fuel Economy Initiative (GFEI): The Global Fuel Economy Initiative (GFEI) was founded in 2009 with the purpose of promoting and supporting government action to improve energy efficiency of the global light-duty vehicle fleet.

Global Bioenergy Partnership (GBEP): GBEP brings together public, private and civil society stakeholders in a joint commitment to promote bioenergy for sustainable development.

Transport Decarbonization Alliance: The Transport Decarbonization Alliance is a collaboration of countries, cities/regions, and companies working to transform the transport sector into a net-zero emission mobility system before 2050.

Transformative Urban Mobility Initiative (TUMI): TUMI is a global implementation initiative on sustainable mobility formed through the union of 11 partners. TUMI supports transport projects all around the world and enables policymakers to transform urban mobility.

Biofuture Platform: The Biofuture Platform is an action-oriented, country-led, multi-stakeholder mechanism for policy dialogue and collaboration among leading countries, organizations, academia and the private sector that are conscious of the need to accelerate development and scale up deployment of modern sustainable low carbon alternatives to fossil fuel–based solutions in transport, chemicals, plastics, and other sectors.

Getting to Zero Coalition: The Getting to Zero Coalition is an alliance of more than 140 companies within the maritime, energy, infrastructure, and finance sectors, supported by key governments and intergovernmental organizations. The Coalition is committed to getting commercially viable deep sea zero-emission vessels powered by zero emission fuels into operation by 2030.

CITIES

Mobilize your city: A partnership between countries and cities focusing on supporting sustainable mobility planning

C40: C40 is a network of the world's megacities committed to addressing climate change. C40 supports cities to collaborate effectively, share knowledge, and drive meaningful, measurable, and sustainable action on climate change.

ICLEI-Local Governments for Sustainability: ICLEI is a global network of more than 2,500 local and regional governments committed to sustainable urban development. It is active in 125+ countries on sustainability policy and local action for low-emission, nature-based, equitable, resilient, and circular development.

Global Covenant of Mayors for Climate and Energy (GCoM): GCoM is the largest global alliance for city climate leadership, built upon the commitment of over 10,000 cities and local governments.

7.2 Broader SDG7 & 13 initiatives

In the last few years, an increasing number of global, regional, and national initiatives have emerged that promote the energy transition as a solution to climate change, while galvanizing cooperation at different levels. Many of these initiatives are using the upcoming COP26 (in November 2021) as a time frame to set the world on a climate-safe pathway.

Marrakech Partnership for Global Climate Action: Under the leadership of the High-Level Climate Champions, the Marrakech Partnership for Global Climate Action[52] supports implementation of the Paris Agreement by enabling collaboration between governments and the cities, regions, businesses, and investors that must act on climate change. Promoting the higher ambition of all stakeholders to collectively strive for the 1.5°C goal and a climate-neutral and resilient world, the High-Level Champions have led the development of Climate Action Pathways[53] for several sectors, including energy. The Energy Pathway provides an overview of the transformational actions and milestones needed for the power sector, green hydrogen, coal phase-out, end-use sectors, and the oil and gas sectors. The pathways also highlight the synergies and interlinkages across the thematic and cross-cutting area that assist all actors to take an integrated approach to achieve 1.5°C by 2050.

COP26 Energy Transition Council: The COP26 Energy Transition Council, co-chaired by the UK Government and Sustainable Energy for All (SEforAll), brings together global leaders from politics, finance, and technology to accelerate the global transition from coal to clean power as part of a green economic recovery. The Council focuses on improving the international offer of support for clean power to developing countries, making it the most attractive new power-generation option and enabling coal-intensive economies to equitably transition from coal. The overall purpose of the Council is to facilitate an effective dialogue between countries that are looking for greater support in their energy transition and the major international actors offering that support, so that solutions can be found and implemented more rapidly. The Council has recently launched a Rapid Response Facility to provide technical assistance to developing countries requesting support to develop plans for an energy transition.

SIDS Lighthouses Initiative: The Small Island Developing States (SIDS) Lighthouses initiative (LHI),[54] coordinated by IRENA, is a framework for action to support SIDS in the transformation to a renewables-based and resilient energy system through the implementation of enhanced NDCs. The initiative addresses all elements of the energy transition, from policy and market frameworks to technology options and capacity building. SIDS LHI brings together 36 SIDS as well as 29 other partners, including regional and international organizations, development agencies, private companies, research institutes, and non-profit organizations.

Three Percent Club for Energy Efficiency: The Three Percent Club[55] comprises countries, businesses, and international organizations that are committed to working together to drive a 3% global increase in energy efficiency each year—a move that can help limit climate change and increase global prosperity. Launched at the UN Climate Action Summit in New York in 2019, the Three Percent Club builds on IEA research showing that the right efficiency policies could deliver over 40% of the emissions reductions needed to reach the goals of the Paris Agreement, without new technology being required.

Economic Commission for Africa (ECA) SDG7 Initiative for Africa: Many developing countries have identified clean energy actions in their NDCs based on conditional and unconditional climate finance. In light of the tightening fiscal space for many countries to raise the resources needed, additional investments need to be mobilized from the private sector. The Economic Commission for Africa's

SDG7 Initiative[56] aims to align the interests of Member States, private sector, project developers and development partners to combine scale and speed in order to accelerate clean energy investments for energy access and enhanced climate action in Africa. It is based on three pillars: (i) sustainability, where countries commit to revising their NDCs to increase bankable clean energy actions, (ii) governance, where countries commit to addressing policy and regulatory barriers to investment, and (iii) finance, where finance is sourced from capital markets.

The NEXTSTEP Initiative of the Economic and Social Commission for Asia and the Pacific (UN ESCAP) for SDG7 Planning in the Asia Pacific: UN ESCAP is developing a tool—the National Expert SDG Tool for Energy Planning (NEXSTEP)— to support the development of SDG7 roadmaps at national and local levels. This tool would enable policymakers to make informed policy decisions to support the achievement of SDG7 and emission reduction targets. NEXSTEP assists countries and cities to achieve SDG7 targets through an integrated system approach by considering the synergies between its constituent elements, namely, by increasing access to modern energy services, improving energy efficiency, reducing emissions from the energy sector, and increasing the share of renewable energy. The resulting national SDG7 implementation roadmap provides guidance for policymakers on what is required to achieve SDG7 and NDC targets and offers a set of policy recommendations based on suggested energy transition pathways.

8 IMPACTS

The COVID pandemic has forced a dramatic break with business as usual. It has exposed the vulnerabilities inherent in an economic system that puts relentless stress on natural resources and at the same time leaves many people behind. The pandemic has also exposed structural connections between the current COVID-19 crisis and the less immediate but no less urgent climate crisis. Piecemeal responses will not suffice in either case. The global sustainable development agenda needs to be comprehensive, systemic, and transformative.

Energy transition strategies offer a vehicle for navigating the rapidly changing world, understanding trade-offs, and devising actions that meet broader sustainable development as well as climate objectives. Governments must find ways to harness the technical, economic, social, and environmental expertise available across all parts of society and ensure cohesion and unity of purpose. True solutions demand wisdom and a holistic view, just as much as they require nuts-and-bolts technical understanding. Similarly, international cooperation is indispensable to drawing on the capabilities and resources of countries around the world, making certain that lessons and solutions are shared, and ensuring that no region, country, or community is left behind.

The assessment and recommendations presented in this paper show the actions required by the global community to deliver on SDG7 targets for renewable energy and energy efficiency; it also shows what is additionally required in order to stay on track to meet the goals of the Paris Agreement.

ENDNOTES

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