Global Climate Action
United Nations Climate Change

Marrakech Partnership

CLIMATE ACTION PATHWAY

ENERGY

Vision and Summary

2021

VISION

It is 2050 and energy systems worldwide have been decarbonised thanks to a range of innovative solutions, investments and policy choices that set us on the pathway decades earlier. The response to the COVID-19 pandemic was a milestone in the shift to a decarbonised and resilient energy system due to behavioural changes and investments in a green recovery. Institutional, legal and regulatory frameworks have put in place decarbonised energy sectors, including electricity, transport, heating and cooling. 100 million people work in the energy sector in well-paid, stable jobs that rely on sustainable and indigenous resources.

The energy we use is primarily electric and at least 90% of our electricity is being generated from renewable energy sources, and remaining 10% from carbon neutral sources. Energy demand and intensity has been dramatically reduced. The energy infrastructure now in place is more resilient to market shocks and the impacts of climate change than the heavily centralised fossil- and nuclear-fuelled systems of the past. The global energy system has become people-centred, with the participation of millions of people who produce, trade and consume energy in market structures that are fit for purpose.

There is universal access to energy services, enabled by affordable, reliable, sustainable and modern energy sources. While the early phases of the transition were somewhat tumultuous, ultimately a fair and just transition was achieved. Societies are thriving as a result.

The future beyond 2050 looks bright, despite the challenges of our changing climate. The global energy system is decarbonised, resilient and efficient, providing the necessary services for further economic development in service to inclusive societies. Human welfare has improved, most notably public health and well-being as air pollution from fossil fuel combustion has dramatically decreased.

THEORY OF CHANGE

In energy, decarbonisation happens through aggressive efficiency measures, a mass expansion of renewables, electrification of end use sectors and a shift from fossil to carbon neutral liquid and gaseous fuels. Decarbonisation of the power system is already occurring in most locations due to the shift to a renewables-based power system, but this must accelerate. End-use sectors see greater electrification as the primary decarbonisation route, for example in road transport and heating and cooling, with a supplementary role for green hydrogen and other zero emission technologies. Structural change occurs within the fossil fuel industries, with coal power phase-out and drastic reductions in oil and gas use, replaced by green fuels, for example in long-haul, heavy duty transport. Addressing climate impacts and ensuring the climate resilience of energy systems is also a key priority.

Increased integration of high shares of renewables is enabled by greater grid flexibility through technology and market solutions. Investment in infrastructure, continuous innovation, along with broader public participation by prosumers, businesses, and communities facilitate widespread deployment. The electricity sector is critical for the energy transition - in 2018, emissions from power were 13Gt CO2, making up 40% of global energy-related carbon emissions. With the growing share of renewables in the energy mix and greater electrification of end use sectors, integration is essential.

Progress is under way in the transition to renewable power – renewables have made up the majority of capacity additions for the last nine years.[1] Many renewable energy technologies are mature and costs have tumbled with increased deployment in the last decade. Renewables are now cheaper to build than fossil fuel power plants in 85% of the world. But renewables deployment needs to accelerate further, by a factor of five to six, on latest estimates. The exponential rate of change seen in wind and solar technologies shows that this is possible; growth in generation from these technologies is already on Paris-compliant trajectories (see 'S curves' in Facts and Figures below). Relatedly, electric utility companies are increasingly committing to decarbonisation, with 15% of major utilities by revenue having already joined the Race to Zero, as of May 2021.

In **finance**, renewable energy projects are now mainstream, but project pipelines need to be scaled up and financial flows need to increase, including to developing countries. **Policy** measures to facilitate renewables must be further improved, including by setting clear ambitious targets for deployment (especially in the heating and cooling and transport sectors, which are plagued by weak policy frameworks), implementing 'investment grade' enabling frameworks to facilitate access to markets (including renewable power auctions for mature technologies) and enabling enhanced grid flexibility and investment. **Technology providers** should continue to innovate to reduce the cost and environmental footprint of key renewable technologies. **Businesses** can increase demand for renewables through committing to source 100% renewable energy and set targets for reduced intensity of their operations. **Civil society** supports deployment through advocacy efforts and raising public awareness of the benefits of renewable energy.

[1] IRENA "Renewable capacity statistics 2021"

By 2030, the industry should aim to **achieve the Race to Zero breakthrough outcome of at least 60% renewable energy share in power generation**,[2] up from 29% in 2020. The tipping point to a decarbonised power system has arguably already passed, with power sector emissions having peaked in 2018 and renewables accounting for 90% of new power capacity expansion in 2020, The next ten years should focus on increased deployment towards achieving a decarbonised power system in developed countries by 2035 and globally by 2040.

A low-cost, reliable, resilient, and zero carbon energy system before 2050 is possible with sectoral integration across energy and industry sectors, the built environment and transport. First, tripling energy productivity gains relative to improvements over the last decade is crucial to achieving an efficient and more sustainable path to resilience and 1.5°C; the less energy required, the less needs to be decarbonised and integrated. To set off on an exponential rate of improvement, policymakers, businesses, and consumers must channel COVID-19 recovery spending to key energy efficiency measures (see other Thematic Pathways for end-use sectors). Exponential growth in electrification of remaining end-use sector demand can reach 60% by 2050, driven by 2030 milestones of 20% in passenger vehicles, 50% in buildings, and 30% in industry and heavy transport.[3]

For the fossil fuel industry, structural change is needed to address the decarbonisation challenge, and progress to date has been limited. CO_2 emissions from fossil fuels totalled 33Gt in 2018. The emerging energy system is not a fuel replacement, and technology, market and behavioural changes are reshaping the existing production, distribution and use. Deployment of the existing solutions such as renewable power or electric mobility needs to be accelerated. There are also emerging solutions for sectors such as sustainable aviation and shipping fuels, industrial heat, but further innovation is needed to bring technical feasibility or economic viability. Fossil fuel production needs to dramatically decrease and business models of fossil fuel firms need to embrace decarbonisation strategies to adapt to the evolving global energy system. In the short-term, reducing methane leaks should be a first-order priority for all.

By 2030, the industry should aim to achieve a 40% reduction in oil and gas production from 2019 levels, as per the Race to Zero breakthrough outcome.[1] Progress is too slow to achieve these milestones; mass deployment of new and smarter end-use technologies – like smart water heaters, high efficiency pumps, and electric vehicles – must be accompanied by investment in enabling infrastructure and improved **policy**. **Electricity system regulators** at local, regional and national levels bear responsibility for speedily evolving market designs to support resilient, smart, renewables-electrified economies.

Green hydrogen and its derivatives produced from renewable electricity must meet the bulk of the needs where direct electrification of end-use is limited—particularly, long-haul transport and high temperature applications. As was the case with solar and wind, policy frameworks and initial public support triggered **private sector innovation** and deployment, creating a virtuous circle of economies of scale and cost reductions. The same will be true in hydrogen—but in ten years, not thirty—by harnessing cost reduction "learning" curves to realise exponential growth.

[2] IEA, "World Energy Outlook 2020", IRENA, "World Energy Transitions Outlook, 2021", UNFCCC "Race to Zero Breakthroughs: Transforming Our Systems Together"
[3] Rocky Mountain Institute, "Seven Challenges for Energy Transformation"

By 2030, responding to those demands, businesses, investors, and international policymakers must work together to **expand cumulative green hydrogen deployment** in line with the UNFCCC Race to Zero Breakthrough Target. As such, in the next five to six years, 25 gigawatts (GW) capacity and USD 100 billion should be deployed, leveraging concessional funding and catalytic subsidies; pre-competitive collaboration to industrialise manufacturing, expand infrastructure, align technical and safety standards, and inform integrated market structures; and the transmission of policy best practices between regions and countries. This will enable businesses, investors, and employees to realise **500-800 GW deployment, USD 1 trillion investment, and 6 million jobs by 2030 on a climate-aligned pathway**.[4]

Public and private **procurement processes**, transparency in commodity trading, businesses' appetite for market growth, national strategies for industrial development, labour unions' pursuit of **high-quality job opportunities**, and citizens' **preferences for clean air and climate action** drive accelerated information, skills, and technology diffusion to support the scale-up of green energy markets.

Policy must support weaning off the fossil fuel sector, by halting investment in new fossil fuel exploration and development, setting carbon pricing, phasing out fossil fuel subsidies, reducing fossil fuel demand (e.g coal power and international combustion engine phase out dates), restricting fossil fuel infrastructure, planning for and supporting economic diversification in producing countries and supporting a just transition for workers and communities, while reducing impact on biodiversity.

OECD countries should phase out coal by 2030 and immediately redirect the international financing towards the energy transition. Non-OECD countries should phase out coal by 2040, recognising that many developing countries will require support for this process. Coal phase-out will reduce risks of stranded assets, improve energy independence, and bring significant health and fiscal benefits. Countries should enact time-bound strategies to manage the social and economic aspects of the coal phase-out.

In **business,** no new unabated coal fired power plants should be built after 2021. Oil and gas end users must signal the desire to transition from fossil fuels to sustainable alternatives, encouraging oil and gas companies to make commitments to net zero and transitioning to low carbon business models. According to the International Energy Agency, no new oil or gas fields are necessary beyond those already under development. New fossil fuel infrastructure presents a serious financial risk of stranded assets as the renewable energy transition accelerates and policy moves away from fossil fuels.

Within the **financial community,** investors must make commitments to invest in energy transition assets and infrastructure and reallocate capital and banks' lending to 1.5°C trajectories, given the risks of high-carbon investments, including stranded assets. **Civil society** has a role in advocating for phase-out and ensuring a just transition for workers and communities.

To achieve this energy pathway **by 2030,** developed countries should have **phased out coal power** and **oil and gas companies should have made significant progress in their zero carbon transitions.**

This pathway should be read in conjunction with other relevant thematic pathways, such as transport, human settlement, land use, oceans and coastal zones, water, industry, as well as finance and adaptation and resilience.

[4] Hydrogen Council "Path to Hydrogen Competitiveness", Energy Transitions Commission "Making Mission Possible", and IRENA "Hydrogen from Renewable Power", IEA "Sustainable Recovery".

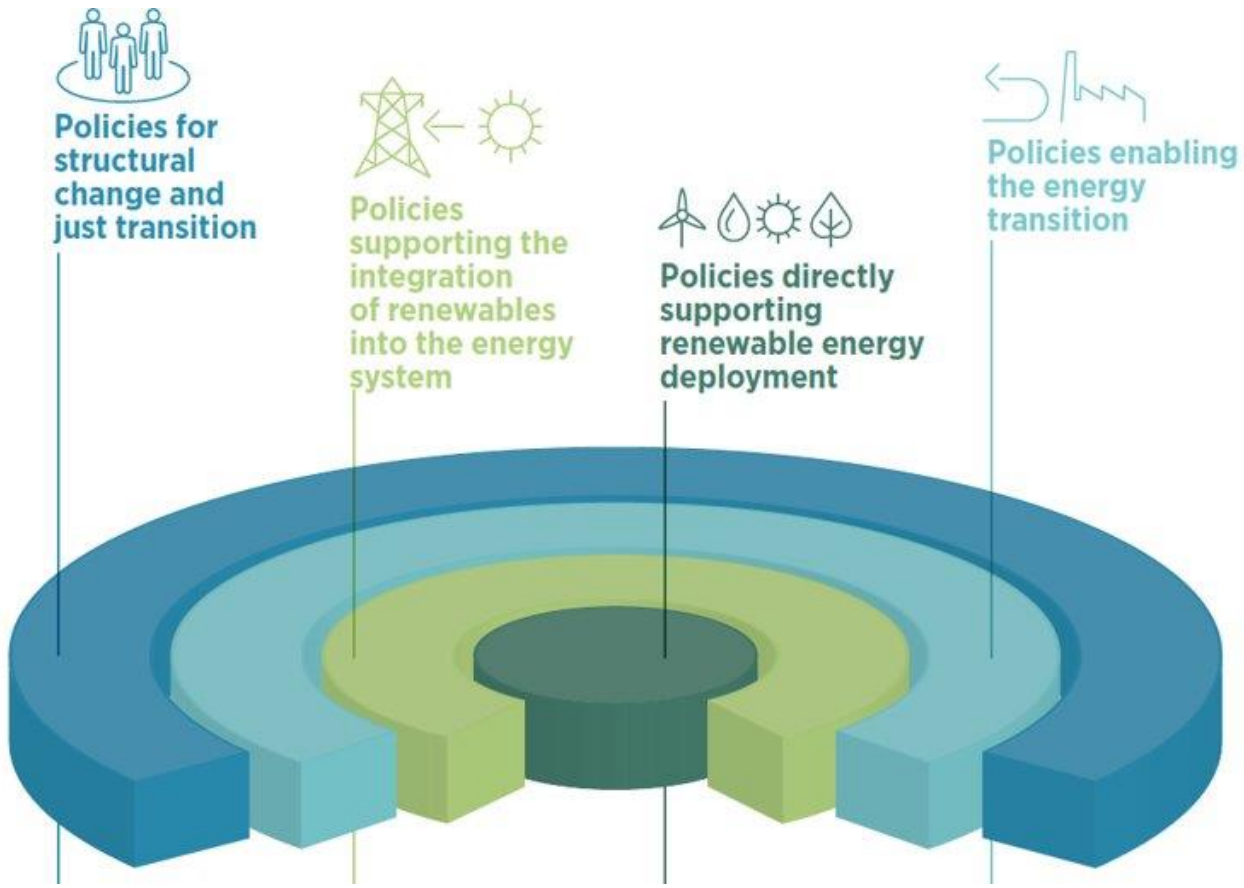
MILESTONES TOWARDS 2050

	By 2021	By 2025	By 2030	By 2040
Decarbon -ised Power	• 20% of major utilities by revenue join the Race to Zero	• 100 countries have targets for 100% clean power	• At least 60% global renewable energy share in power generation, in line with UNFCCC Race to Zero Breakthroughs	• Global decarbonised power system
Sectoral Integration	• Majority of new COVID recovery funding supports efficiency, integration technologies such as heat pumps and EVs, and demonstration and deployment of smart technologies	• Green hydrogen 25 GW capacity under construction, achieving $1.5/kg, in line with UNFCCC Race to Zero Breakthrough	• 51% of energy end-use is electrified – including electrification of 20% of passenger vehicles, 50% in buildings, and 30% in industry and heavy transport. • Green hydrogen deployment of 500-800 GW capacity, achieving $1.5/kg and cumulative investment of USD 1 trillion	• Green hydrogen and innovative production routes are mature and mainstreamed
Fossil Fuel Structural Change	• No new unabated coal power plants are being approved for development anywhere in the world • No exploration for new oil resources is required and, other than fields already approved for development, no new oil fields are necessary.	• At least 20% of major oil and gas companies have verified science based 2050 net zero targets, are taking steps to transition to low carbon business models, and reduced methane emissions by over 40% from 2020 values	• All OECD countries have successfully phased out unabated coal in their power sectors and emerging economies are well advanced in their phase out plans • Oil and gas companies have made significant progress in their transition strategies, including a 75% reduction in methane emissions (from 2020 values) • All major O&G companies have verified science based 2050 net zero targets and are have made significant progress transitioning to low carbon business models.	• All countries have phased out unabated coal power • The O&G industry is playing a critical role in scaling clean energy technologies such as, green hydrogen and offshore wind and CCS.

PROGRESS

Overall, the energy transition to a decarbonised system has begun, but much greater progress must be made to get on track for a 1.5°C pathway.

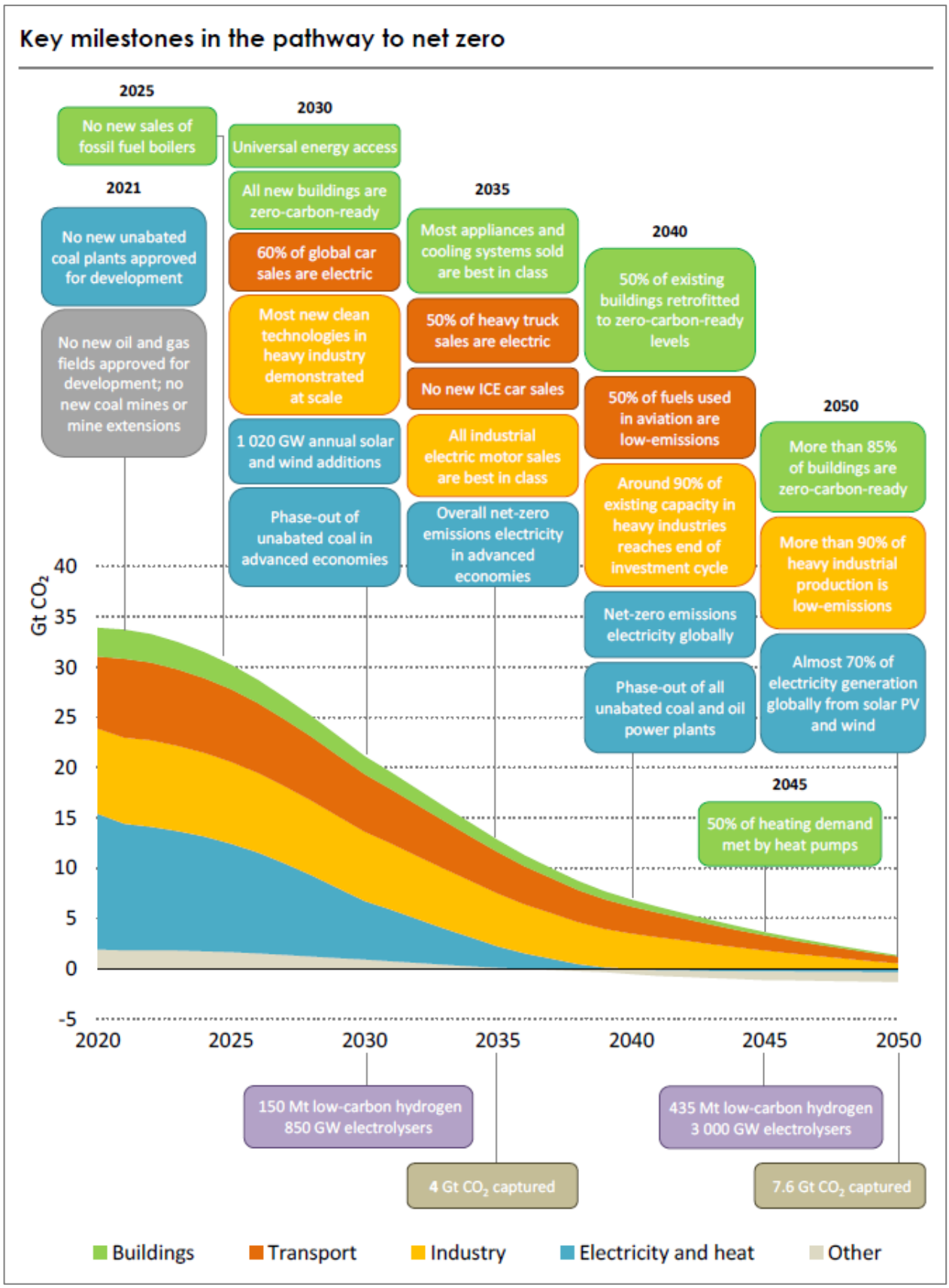
Progress has been made in recent years in decarbonising power through renewable energy deployment, with increased capacity additions and significant cost reductions. Greater progress must be made in end-use sectors, including via energy efficiency, direct renewable energy use, electrification and deployment of technologies, such as heat pumps and electric vehicles. Structural change is needed in the fossil fuel sector, including development and deployment of alternative technologies to meet demand, and retirement/avoidance of fossil fuel infrastructure, such as coal power plants. Importantly, a holistic approach to policy making is necessary to ensure that energy transition is not only rapid, but also just and inclusive.



Enabling policy framework for a just energy transition

A broad set of policy measures is required to align the short-term recovery with longer-term transition, climate and socio-economic development objectives. [5]

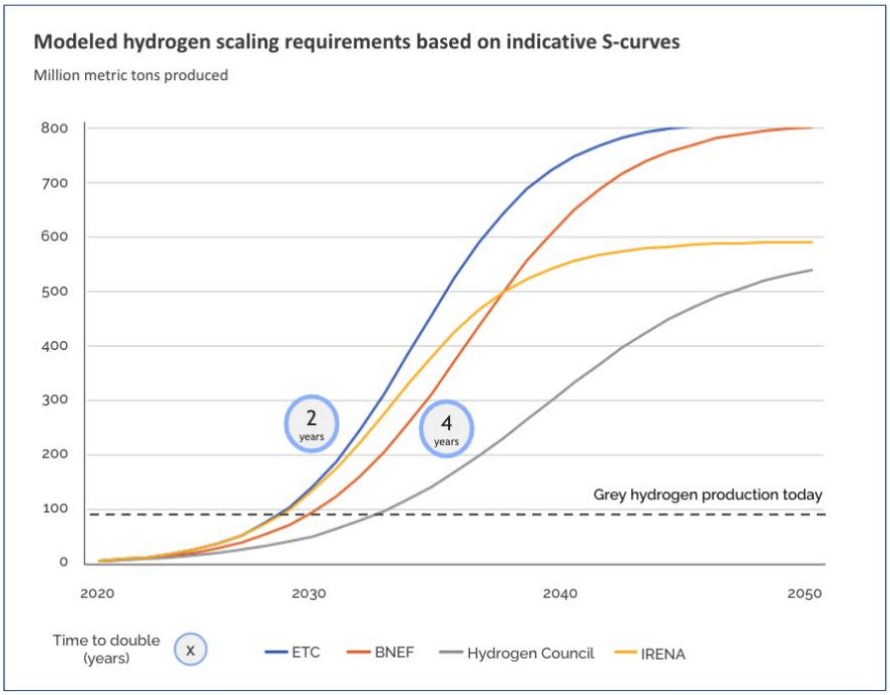
[5] IRENA (2021), World Energy Transitions Outlook: 1.5°C Pathway, International Renewable Energy Agency, Abu Dhabi.

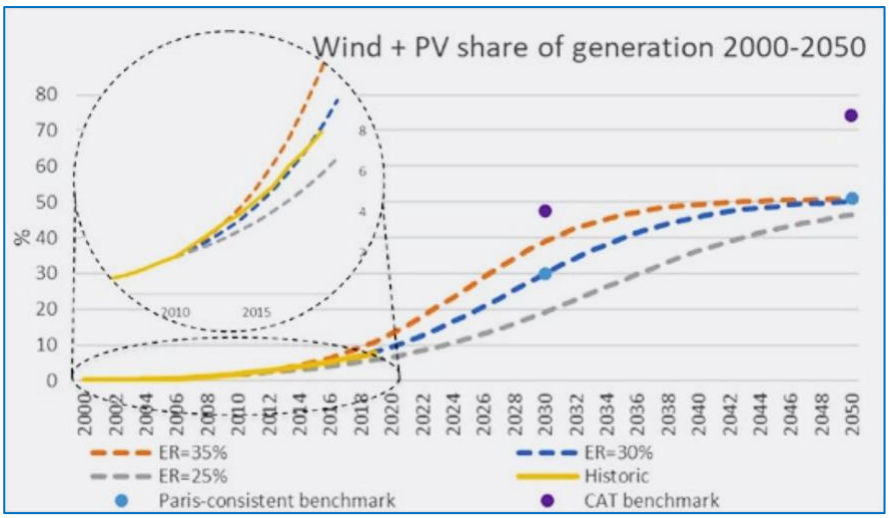


IEA's proposals for Governments to reach their net zero goals.

FACTS & FIGURES

History has shown that sectoral transformations, whether they be horse and cart to automobile, coal power to gas or adoption of telecommunication technologies, do not occur linearly, but rather slowly in an emergence phase, and then exponentially in a diffusion phase. This dynamic process can be captured in an 'S-curve'. S-curves in green hydrogen[6] and renewable electricity[7] are presented below and covered in further detail in the respective Action Tables.

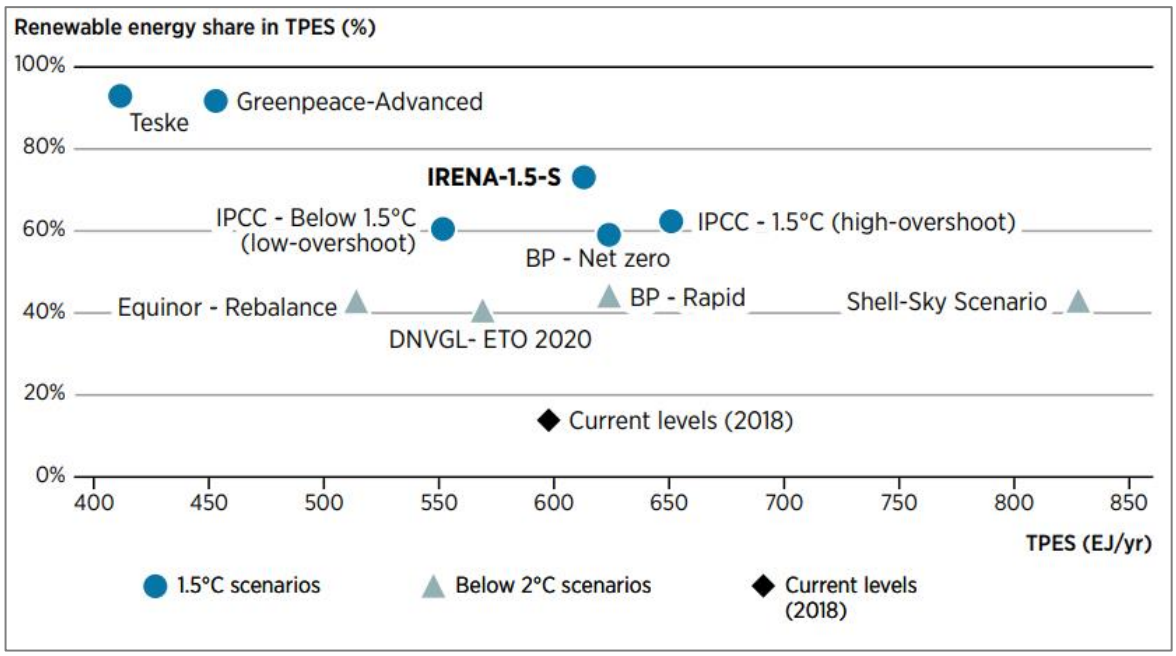




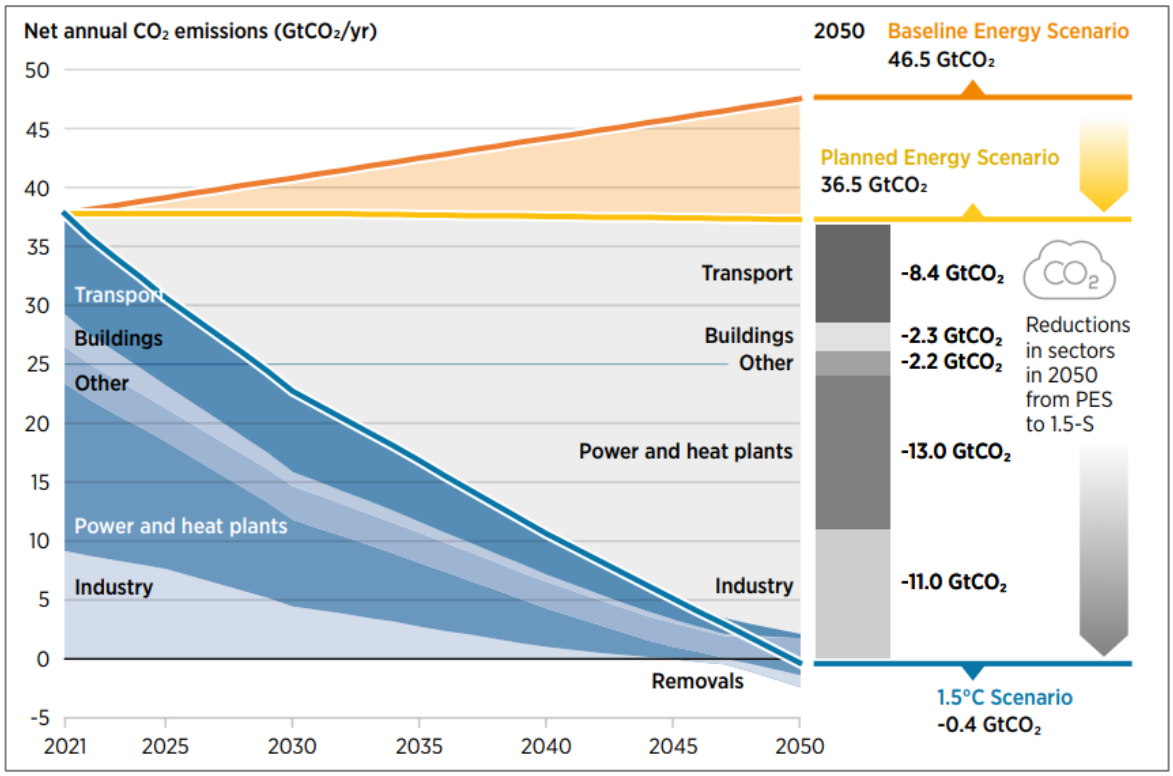
[6] Hydrogen – Climate Champions (2020);
[7] Wind/PV – Grub et al, The Shape and Pace of Change in The Electricity Transition: Sectoral Dynamics and Indicators of Progress (2020)

Emerging consensus on the role of renewable power (IRENA, World energy transitions outlook: 1.5C pathway (preview))

Shares of renewables in total primary energy in 2040 and 2050 in various climate scenarios



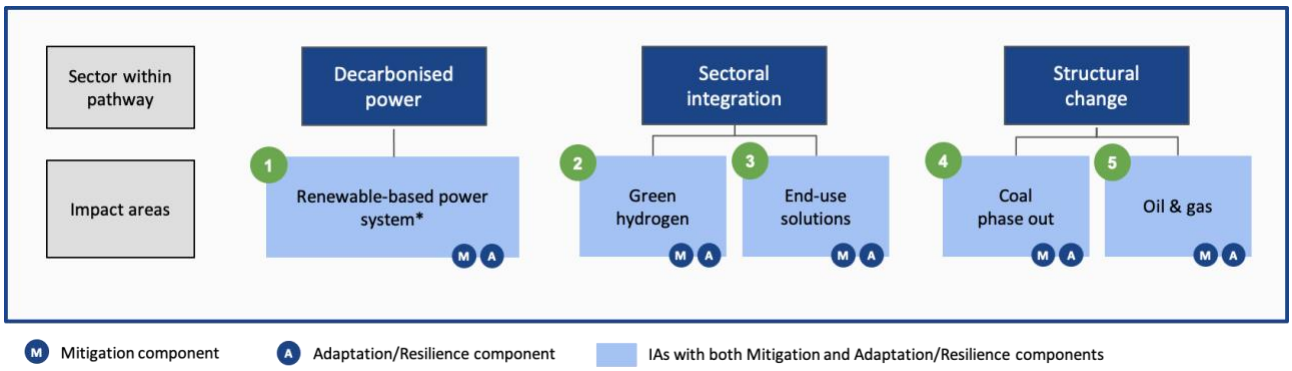
The bulk of emission reductions: renewables and efficiency (IRENA, World energy transitions outlook: 1.5C pathway (preview))



CLIMATE ACTION TABLE - STRUCTURE

This executive summary should read together with the more detailed Energy Action Tables. This outlines, across key milestones of 2021, 2025, 2030 and 2040, what actions key actors should take in order to achieve an energy transition consistent with 1.5°C.

The diagram below shows the structure of the Energy Action Tables. These are split into three sub-sectors (dark blue boxes) and five impact areas (light blue boxes).



KNOWLEDGE BASE

The below key sources were used to inform the present document:

- BloombergNEF, Hydrogen Economy Outlook (2020).
- BloombergNEF, *Scale-up of Solar and Wind Puts Existing Coal, Gas at Risk* (April 28, 2020), https://about.bnef.com/blog/scale-up-of-solar-and-wind-puts-existing-coal-gas-at-risk/.
- Energy Transition Commission, Making Mission Possible: Delivering a Net-Zero Economy (2020).
- Grub et al, The Shape and Pace of Change in The Electricity Transition: Sectoral Dynamics and Indicators of Progress (2020).
- Hydrogen Council, Path to Hydrogen Competitiveness: A Cost Perspective (2020).
- International Energy Agency (IEA), A Sustainable Recovery Plan for the Energy Sector (2020).
- International Energy Agency (IEA), Net Zero by 2050: A Roadmap for the Global Energy Sector (2021)
- International Energy Agency (IEA), Renewable Energy Market Update 2021 (2021)
- International Energy Agency (IEA), World Energy Outlook (2020).
- International Renewable Energy Agency (IRENA), Global Renewables Outlook: Energy Transformation 2050 (2020).
- International Renewable Energy Agency (IRENA), Hydrogen: A Renewable Energy Perspective (2019).
- International Renewable Energy Agency (IRENA), Power Generation Costs in 2019 (2020).
- International Renewable Energy Agency (IRENA), Renewable capacity statistics 2021 (2021).
- International Renewable Energy Agency (IRENA), World Energy Transitions Outlook: 1.5C Pathway (Preview) (2021).
- International Union for Conservation of Nature (IUCN), Mitigating biodiversity impacts associated with solar and wind energy development (2021)
- REN21, Renewables 2020 Global Status Report (Paris: REN21 Secretariat)
- Rocky Mountain Institute, Seven Challenges for Energy Transformation (2019).
- UNFCCC, Race to Zero Breakthroughs: Transforming Our Systems Together (2021)