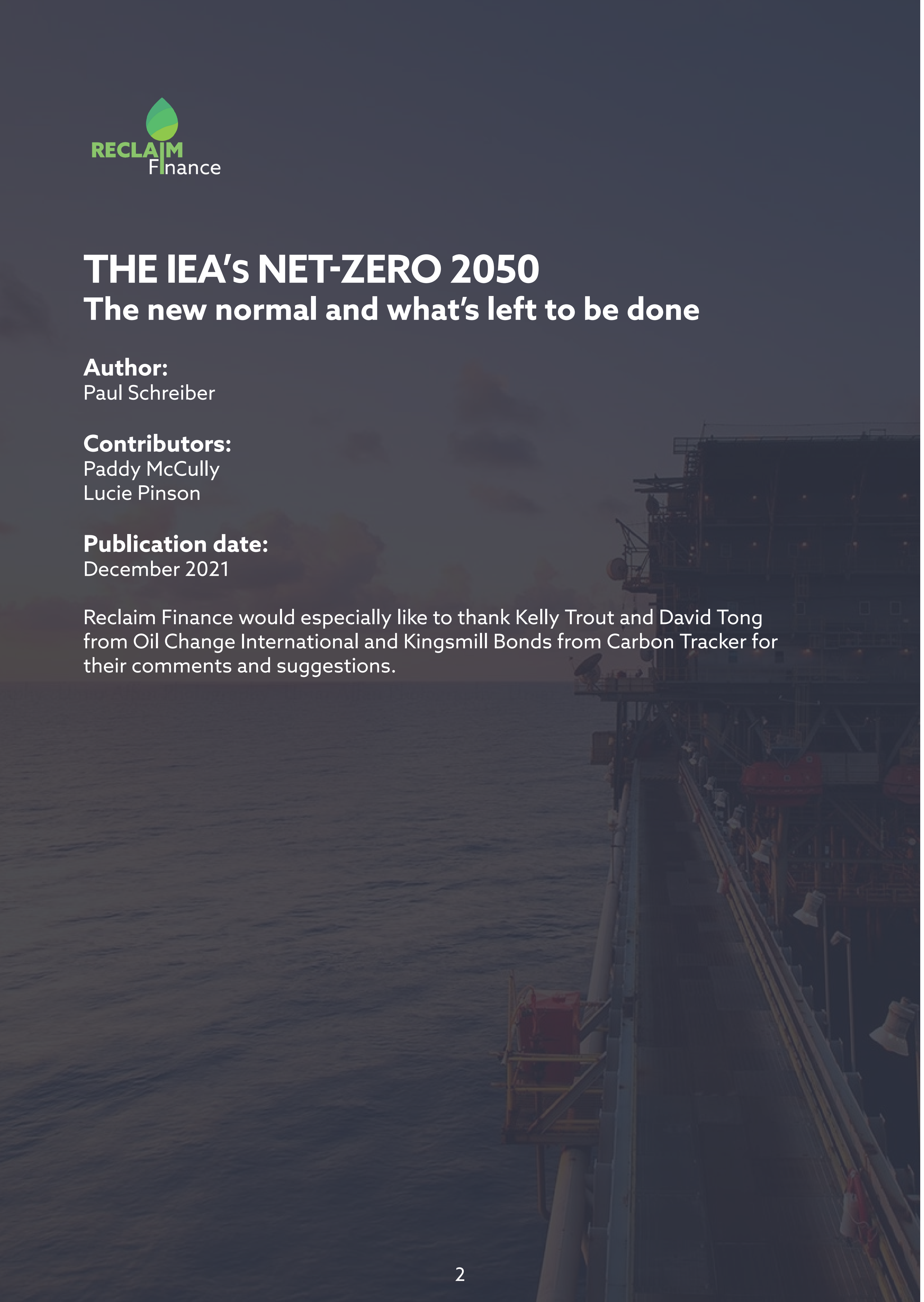
THE IEA's NET-ZERO 2050

The new normal and what's left to be done

RECLAIM Finance



THE IEA's NET-ZERO 2050
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EXECUTIVE SUMMARY

The World Energy Outlook (WEO) 2021 was intended to be the International Energy Agency's (IEA) "guidebook" to COP26. Published just weeks before the climate gathering, it **centered the IEA's "Net Zero by 2050" (NZE) scenario and highlighted the gaps between this 1.5°C trajectory and the current international and national pledges and policies.**

By doing so, **the IEA sets the new normal for the energy sector: a swift shift from fossil fuels to renewable energies, with an immediate end to new fossil fuel supply projects and a power system speeding up toward carbon neutrality. New exploration, drilling or mining projects are explicitly incompatible with the IEA's 1.5°C scenario, while current liquified natural gas (LNG) development should be drastically limited and fossil-running power plants face a rapid demise, making financing new plants a risky bet.** To avoid exceeding 1.5°C, coal, oil and gas production must be reduced significantly by 2030 and must drop by 2040. Production of fossil gas must be cut in half by 2040.

In this new normal, methane emissions from fossil fuel operations are cut by 75% by 2030. A major improvement, which would require making **limiting flaring and leaks a "top priority".** The reduction of fossil fuel production makes up for a significant share of methane reduction efforts, even though Reclaim Finance underlines that this share could grow if the closure of unconventional oil and gas reserves were to be prioritized or if the fossil fuel production trends of the NZE were to be aligned with the UN Production Gap Report.

While oil and gas investment have significantly fallen in 2020 and 2021 as the result of the Covid crisis, **the level of fossil fuel investment in the NZE from 2021 to 2030 - and even more so after 2030 - represents only a fraction of the investment in the sector made in the last decade. More importantly, oil and gas companies are still heavily investing in new supply projects that are incompatible with the NZE.** As the IEA underlines, investments must urgently be redirected from fossil-heavy activities to clean alternatives if we are to meet NZE goals that require "a surge in global energy investment to $5 trillion by 2030, with 85% of spending directed to clean energy". Most of this funding will come from the private sector, underlining the need for financial players to step away from fossil fuel developers and champion renewable energy development.

The IEA logically puts renewable energies at the forefront of transition, making their development one of the key features of the NZE. Solar and wind power supply rises from 10.4 exajoules (EJ) in 2020 to 60.5 EJ in 2030 and 190 EJ in 2050. **Solar power capacity is multiplied by almost six from 2020 to 2030 and wind power capacity by five.** Hydropower progressively rises and geothermal and marine energy triples from 2020 to 2030 to reach 31.8 EJ in 2050. The IEA underlines that **the development of renewable energies – along with the electrification that goes with it – plays a key role in containing the rise of energy bills worldwide and will help absorb fossil fuel price shocks in the future.**

However, the IEA has a long track record of underestimating renewable energy development. **In the NZE, the IEA assumes limited cost reductions for wind and solar compared to the cost reduction trends of recent years.** The WEO 2021's cost estimates for renewables are above those of other analyses and the reduction of these costs is oddly slow after 2030. These assumptions for renewables drive **the IEA to bet big on the development of technologies that have already shown major limitations, are highly uncertain and can have major environmental impacts.**

High reliance on carbon capture and storage (CCS/CCUS) and carbon dioxide removal (CDR) enables the IEA to allow higher production and consumption of fossil fuels than other 1.5°C scenarios, and to prolong their use up to 2050 and beyond. Despite major uncertainties regarding the viability of large-scale use of CCS/CCUS, which are acknowledged by the IEA itself, **the volume of carbon captured increases 41 times from 2021 to 2030,** notably enabling the use of "abated" coal and gas power plants.

The volume of carbon removed by direct air capture (DAC) and bioenergy with carbon capture and storage (BECCs) is multiplied by more than 300 times by 2030 from today's extremely low level. Together, **CCUS and CDR allow the NZE to feature a slower reduction of coal, oil and gas production levels than highlighted by the UN Production Gap Report 2021.** In the NZE CCUS plays an essential role in the scale up of hydrogen production, used to decarbonize the industry and transport sectors. **Hydrogen from natural gas with CCS – so called "blue hydrogen" – is forecast to have a high global warming impact, but in the NZE makes up as much as half of "low carbon" hydrogen production in 2030** and almost 40% in 2050.

The IEA classifies biomass as "renewable", sidelining major concerns around its overall carbon footprint and impact on global land-use. Biomass is used to both capture a significant amount of emissions and to generate a great deal of energy. Biomass becomes a major energy source in the NZE, rising from 62 EJ in 2020 to 102 EJ in 2050 (19% of total energy supply). **The total land area dedicated to bioenergy production increases from 330 million hectares (Mha) in 2020 to 410 Mha in 2050, the size of India and Pakistan combined** and more than a fourth of total available cropland. This would likely have major negative impacts on food production, small farmer and Indigenous land rights, and biodiversity.

The NZE features a significant increase in nuclear power capacity, especially in emerging markets and developing economies. Nuclear provides 41.4 EJ in 2030 – a 41% increase compared to current levels – and reach 60.6 EJ in 2050. Much of the increase up to 2030 is due to projects that have already entered the construction phase. If the IEA mentions that nuclear development will not always be acceptable, it **fails to underline the various sustainability concerns it brings.** Nuclear energy poses major issues around the disposal of radioactive waste and potential incidents. Because building new reactors takes many years – currently usually more than a decade – and is costly, nuclear energy could also delay the overall transition to a clean economy.

RECOMMENDATIONS

Taking stock of the WEO 2021, financial institutions, companies and political leaders must:

1. **Immediately end their support to new fossil fuel supply, unabated fossil fuel power plants[1] and LNG projects[2] and to the companies that develop them;**
2. **Ensure fossil fuel production plans feature a swift and significant drop in fossil fuel supply and a drastic cut in methane emissions;**
3. **Redirect their investments to support clean energy alternatives.[3]**

The IEA itself must go further than the latest WEO and the NZE, notably by:

1. **Providing all the regional data for the NZE;**
2. **Significantly limiting the WEO and NZE's reliance on CCUS and CDR by adopting a precautionary approach to these uncertain approaches, thus implying an even more rapid phase-out of fossil fuel production and use;**
3. **Limiting the NZE's reliance on biomass to consider competing uses, ensure sustainable production, and not require an expansion in land-use, notably by avoiding the use of biomass for power generation;**
4. **Limiting the global development of nuclear energy to projects currently under construction.**

> ***No new oil and gas fields are required beyond those already approved for development***
>
> *IEA, WEO 2021*

INTRODUCTION

The NZE: setting the new normal

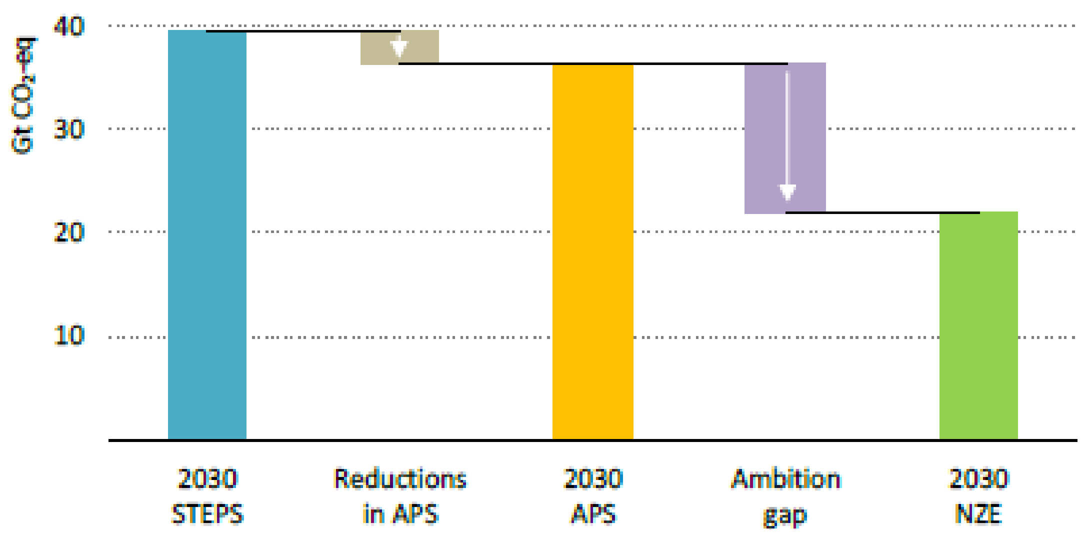
Political leaders, CEOs, bankers, insurers... A lot of people were anxiously waiting for the International Energy Agency to drop its World Energy Outlook 2021 (WEO), and rightfully so. Ahead of COP26, **the IEA's flagship publication was scheduled to include for the first time the IEA's recent "Net Zero Emission by 2050" scenario (NZE).** This scenario, released in May 2021, sent shockwaves through the energy sector by explicitly calling for an end to fossil fuel expansion.

While the IEA has long advertised its WEO as "the energy world's most authoritative source of analysis and projections" – an assessment shared by many in the political, economic and financial world – this year's issue is **presented upfront as a "guidebook to COP"**. A book that "provides stark warnings about the pathway that we are on, but also clearheaded analysis of the actions that can bring the world onto a path towards a 1.5 °C future – with a strong affirmation of the benefits that this yields". And indeed, in the WEO, **the NZE becomes the "benchmark for assessing global progress towards the 1.5°C target and other energy-related sustainable development goals"** and is compared to other scenarios based on countries' actual pledges (APS) and stated policies (STEPS) (see G1 and Box – IEA's WEO 2021 scenarios).

The IEA focuses on the "ambition gap" between current policies and announced pledges – modelled respectively in the STEPS and APS – and the NZE. Several crystal-clear takeaways can be extracted from this comparison:

- **We must strive to limit global warming to 1.5°C,** failing to do so would have severe human and economic consequences while doing it would deliver clear benefits. The NZE would notably generate 24 million "net" new jobs by 2030 while reducing deaths from household air pollution by 1.9 million each year and delivering electricity to all (see Box – The benefits of the NZE trajectory).

G1. CO_2 and methane emissions from energy and industrial processes in the three scenarios, 2030



Source: WEO 2021

> ***The main normative scenario is the Net Zero Emissions by 2050 Scenario, which outlines a narrow but achievable pathway to a 1.5 °C stabilisation in global average temperatures.***
>
> *IEA, WEO 2021*

- **Limiting global warming to 1.5°C can be done** but requires immediate and ambitious actions, as well as action to ensure a just transition. We have all the technologies we need to fast forward this transition and can already solve 40% of the ambition gap with zero-cost technologies.
- **Key milestones are defined by the IEA to monitor our progress toward the 1.5°C target,** these milestones have major climate impacts and testify of the transition of the energy sector.
- **Current pledges and policies are far from aligned with a 1.5°C trajectory.**

The fact that the IEA now focuses on 1.5°C and is underlining the deep implications of this trajectory for the fossil fuel sector sends a strong signal about the seriousness of the emergency we are in. The IEA has been a trendsetter in the energy sector for decades and wields considerable influence in the political and financial spheres. The organization was initially created in the wake of the 1973-1974 energy crisis with the explicit goal of securing the oil supplies of OECD countries. It has long focused on energy security, and interpreted this to largely mean a secure supply of fossil fuels. Coal, oil and gas companies, as well as the major fossil fuel-consuming countries, have been continuously involved in the IEA's work. Financial institutions like JP Morgan, Société Générale and ING have used the IEA's past "Sustainable Development Scenario" (SDS) to claim an alleged alignment of their climate policies with the Paris Agreement, or justify their continued support of fossil fuel companies (see Annex). As discussed below, the IEA is largely supportive of the large-scale use of negative emissions, a risky and expensive approach that could impede climate action and that has been aggressively pushed by coal interests[4] and the oil and gas majors. **In brief: the IEA is not an activist body or "anti-fossil fuels", its NZE is far from extreme and should be rather considered a middle-of-the-road pathway. By putting the NZE at the center of its WEO, the IEA sets the new normal for the energy sector and its backers.**

Box 1 – IEA's WEO 2021 scenarios

The IEA uses four scenarios in its WEO 2021:

- **Net-Zero Emissions by 2050 (NZE):** which sets out a pathway for the global energy sector to achieve net-zero CO2 emissions by 2050. In this scenario, temperatures peak at just over 1.5°C in 2050 and decline to around 1.4°C by 2100 (with 50% probability[5]).
- **Sustainable Development Scenario (SDS):** which achieves key energy-related United Nations Sustainable Development Goals related to universal energy access and major improvements in air quality and reaches global net zero emissions by 2070. In this scenario, temperatures exceed 1.5°C by the early 2030s and reach a peak of 1.7°C around 2050 (with 50% probability).
- **Announced Pledges Scenario (APS):** which assumes that all climate commitments made by governments around the world, including Nationally Determined Contributions (NDCs) and longer-term net-zero targets, will be met in full and on time. In this scenario, global warming exceeds 1.5°C by around 2030 and leads to a 2.1°C increase by 2100 (with 50% probability).
- **Stated Policies Scenario (STEPS):** which reflects current policy settings based on a sector-by-sector assessment of the specific policies that are in place, as well as those that have been announced by governments around the world. In this scenario, global warming exceeds 1.5°C by around 2030 and leads to a 2.6°C increase (and rising) by 2100 (with 50% probability).

Temperature rise in the WEO-2021 scenario (°C)

Scenario	2030		2050		2100	
Confidence level:	50%	33% – 67%	50%	33% – 67%	50%	33% – 67%
Stated Policies	1.5	1.4 – 1.6	2.0	1.8 – 2.1	2.6	2.4 – 2.8
Announced Pledges	1.5	1.4 – 1.6	1.8	1.7 – 2.0	2.1	1.9 – 2.3
Sustainable Development	1.5	1.4 – 1.6	1.7	1.5 – 1.8	1.6	1.4 – 1.7
Net Zero Emissions by 2050	1.5	1.4 – 1.5	1.5	1.4 – 1.7	1.4	1.3 – 1.5

Note: Shows the maximum temperature rises with 33%, 50% and 67% confidence levels.

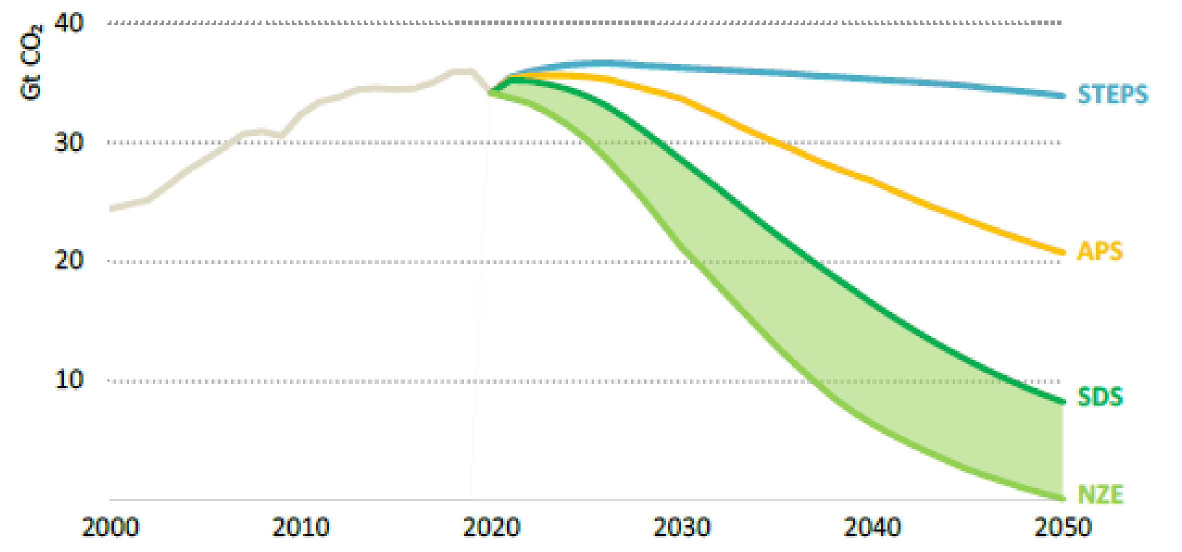
Source: IEA analysis based on outputs of MAGICC 7.5.3.

Source: WEO 2021

While the SDS is still present in the WEO 2021, it virtually disappears from the core of the report, is not even mentioned in the executive summary, and not cited as one of the "main scenarios" in the Outlook. The NZE effectively replaces the SDS as the benchmark for climate progress. As shown by the figure below, following the SDS means emitting significantly more CO2 than in the NZE and failing to reach carbon neutrality by 2050. According to the IEA itself, this additional CO2 could push global warming above 2°C in unfavorable scenarios.

Though the NZE is now the central scenario in the WEO, it is not yet featured in the regional data tables at the end of the report. If we can assume that this is due to a lack of time, **swiftly providing these data should be a priority for the IEA** to ensure that the NZE is fully and easily usable by all.

CO_2 emissions in the WEO-2021 scenarios over time



The APS pushes emissions down, but not until after 2030; the SDS goes further and faster to be aligned with the Paris Agreement; the NZE delivers net zero emissions by 2050

Note: APS = Announced Pledges Scenario; SDS = Sustainable Development Scenario; NZE = Net Zero Emissions by 2050 Scenario.

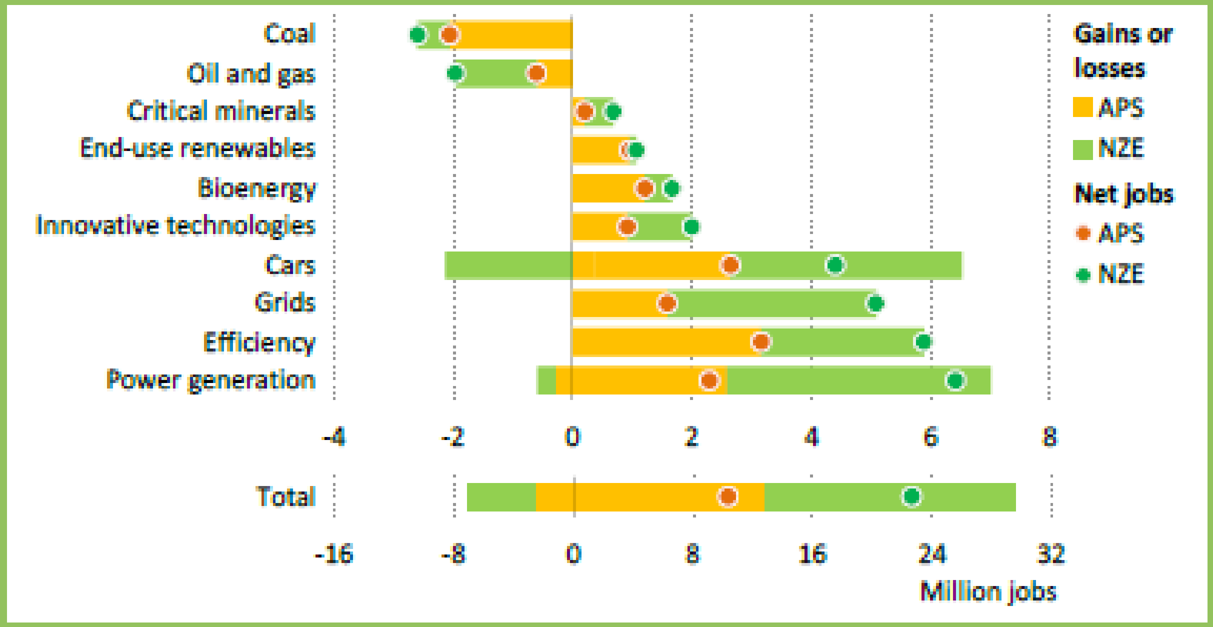
Source: WEO 2021

Box 2 – The benefits of the NZE trajectory

If these priorities require a major economic and political shift, the IEA estimates following them and limiting global warming to 1.5°C would deliver immense human, social and economic benefits.

In total, **26 million jobs are created in the clean energy sectors by 2030 in the NZE.**[6] While employment diminishes in the fossil fuel sector, the NZE would still generate about 24 million "net" jobs by 2030.

Employment growth in clean energy and related areas to 2030



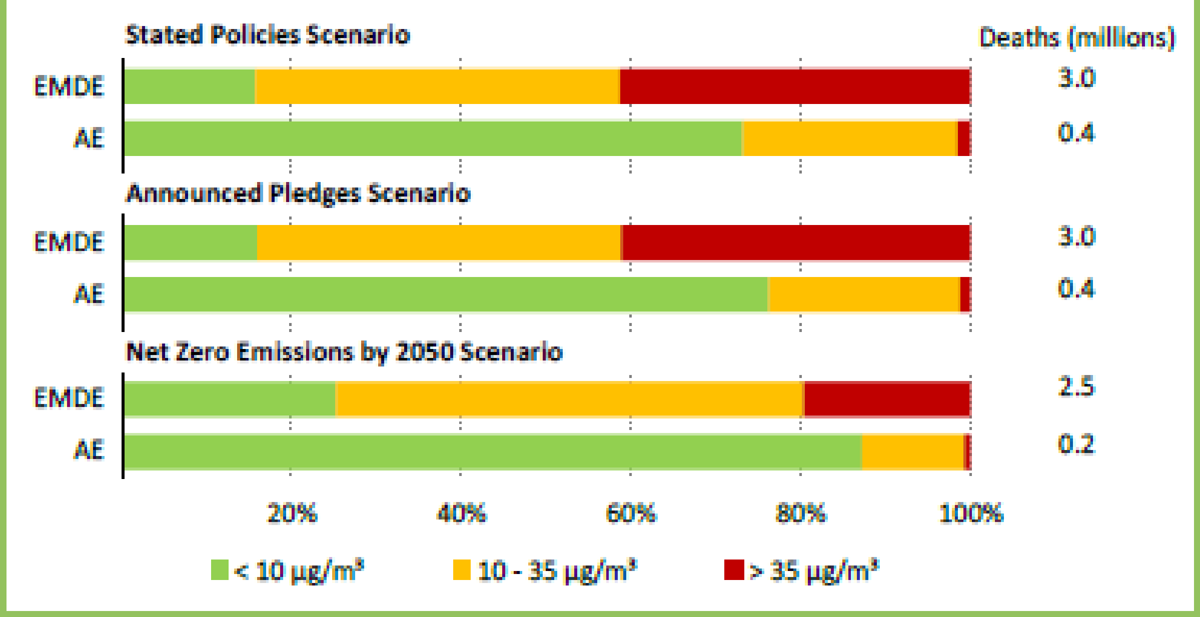
Source: WEO 2021

While the STEPS and the APS see a rising number of premature deaths from ambient pollution during the next decade, the NZE leads to dramatic reductions: **by 2030 there are 1.9 million fewer premature deaths[7] from household air pollution per year than in 2020,** with over 95% of the reduction occurring in emerging market and developing economies.

The NZE **"offers a pathway to deliver electricity to all by 2030",** through either grid connection or the development of mini-grids and stand-alone systems.8 By 2050, almost every consumer will be connected to the power grid. **All will have access to clean cooking by 2030 in the NZE,** while 2.1 billion people are still without access to clean cooking in 2030 in the STEPS and APS.

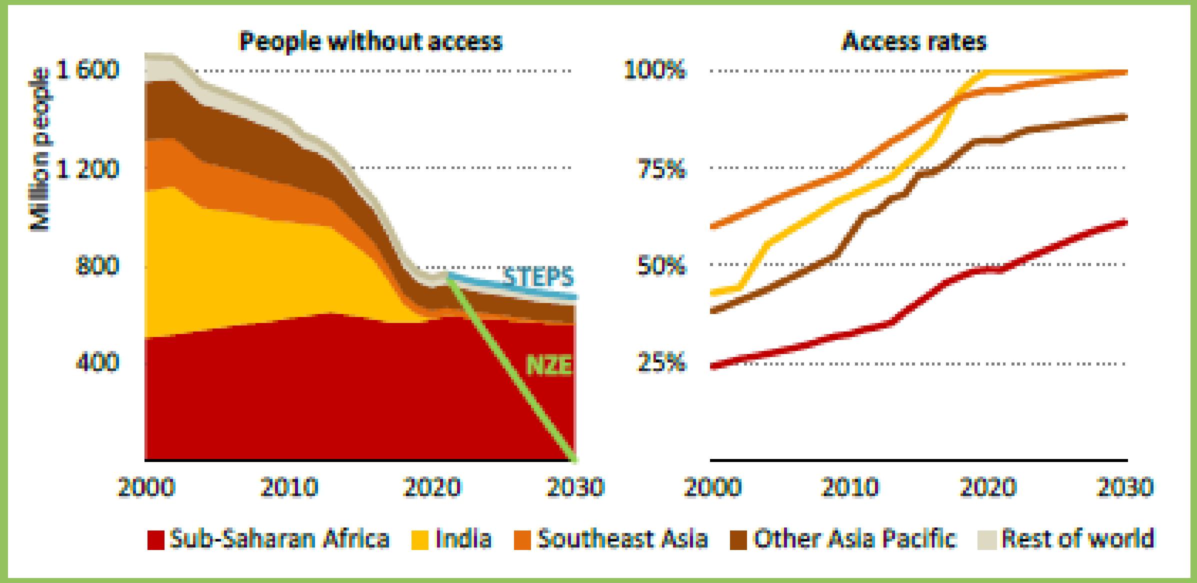
The IEA also notes that progress on building energy efficiency and heating/cooling can "foster good physical and mental health by creating indoor living environments with healthy air temperatures, humidity levels, noise levels and improved air quality". It especially underlines that "energy efficiency retrofit programmes for low-income housing deliver the greatest benefits, while highly energy-efficient workplaces and schools have also demonstrated positive impacts on productivity". Overall **improvements in energy efficiency contribute to increase productivity and living standards.**

Share of the population exposed to various $PM_{2.5}$ concentrations and premature deaths from ambient air pollution in 2030



Source: WEO 2021

People without access to electricity ad access rates by region in the Stated Policies and Net Zero Emissions by 2050 scenarios, 2020-2030



Source: WEO 2021

1. THE NEW NORMAL FOR FOSSIL FUELS

For the fossil fuel sector and those that finance it, the WEO sets two unavoidable prioritizes: putting an end to fossil fuel development and ensuring that methane emissions are massively reduced.

a. Ending fossil fuel development

In its May 2021 "roadmap" to net zero by 2050, the IEA clearly stated that its NZE scenario meant that "no new oil and natural gas fields" and "no new coal mines or mine extensions" are "required beyond those that have already been approved for development". **The WEO 2021 confirms this, stating that NZE has "no new investments in supply projects beyond those already announced or under construction".** Concretely, this means that any investment in new coal mines or oil and gas fields after 2021 are incompatible with a 1.5°C trajectory. These new investments would risk becoming stranded and increase the asset-stranding risk for other mines and fields by widening the gap between fossil fuel production capacity and the remaining carbon budget. The IEA notably warns that additional investment in oil fields "would be surplus to requirements in the NZE and could struggle to return the capital invested."

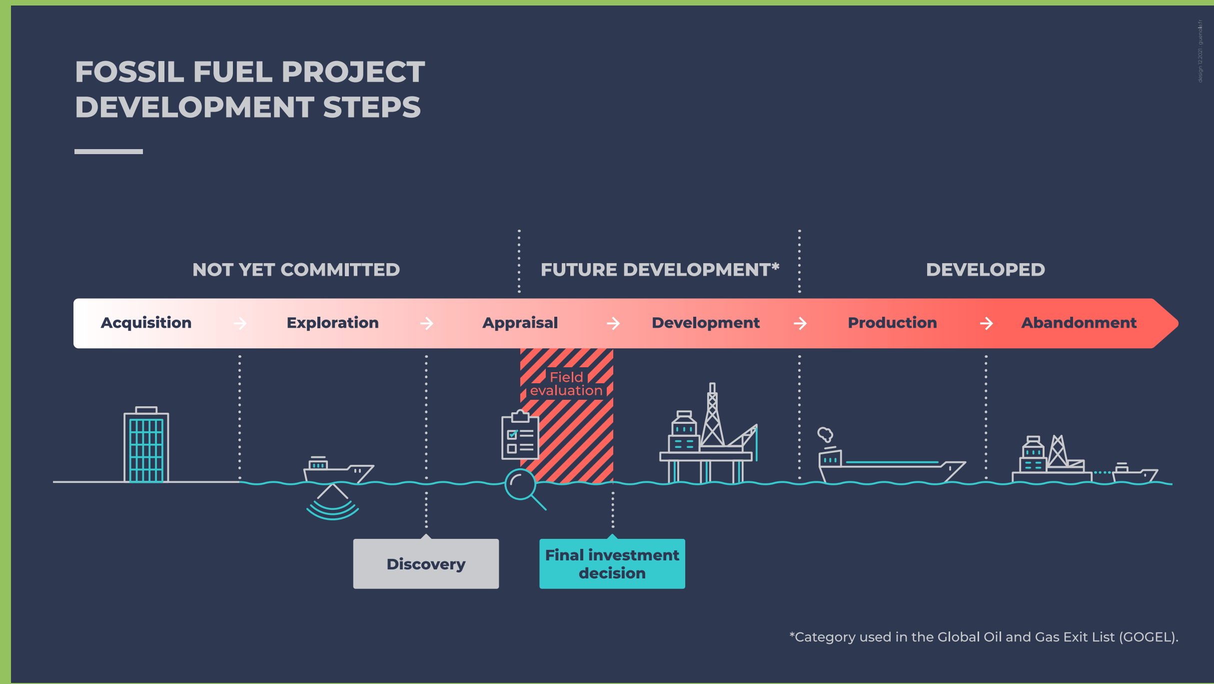
While the IEA notes several times that the drop in fossil fuel production and immediate end to new supply projects in its NZE is predicated on strong policy actions to reduce demand, it also underlines that "actions on the supply side remain crucial to orderly and rapid energy transitions." In fact, the transition must rely on both supply and demand action. Over the past decades, policymakers have focused on measures to increase clean energy supply or reduce fossil fuel demand, largely ignoring the fossil fuel supply side, a strategy that has not been paying results because new fossil fuel production effectively locks in future carbon emissions.

The IEA's conclusion is logical and derives from the great mismatch between the amounts of CO2 that would be released by exploiting and consuming the already developed fossil fuel reserves and our remaining carbon budget. Based on data from Rystad Energy, even if coal would be phased out overnight, current oil and gas reserves under exploitation already total 1.277 trillion barrels of oil equivalent (boe) and consuming them would emit about 475 GtCO2, enough to exceed by as much as 75 GtCO2 our remaining carbon budget to have a 67% chance to limit global warming to 1.5°C. Reserves under development or field evaluation – last stage of the appraisal phase - scheduled to be exploited within 0 to 7 years, reach 186.2 billion boe, a 14.6% increase that could add between 58.6 and 77.9 GtCO2 to the atmosphere.[9] **Together, oil and gas reserves exploited and under development would result in an overshoot of our carbon budget to have a 67% chance to limit global warming to 1.5°C by at least 33.4%.** Despite still allowing significant amounts of carbon capture and removals (see part 2.a), **the study Unextractable fossil fuels in a 1.5°C world underlines that nearly 60% of oil and fossil gas, and 90% of coal developed and undeveloped reserves must remain unextracted to keep within a 1.5°C carbon budget.** While these numbers may seem impressive, the researchers themselves stress that they "probably present an underestimate of the production changes required, because a greater than 50% probability of limiting warming to 1.5°C requires more carbon to stay in the ground and because of uncertainties around the timely deployment of negative emission technologies at scale."

Fossil fuel supply projects are not the only type of projects that are incompatible with 1.5°C. As the IEA has underlined, **already planned liquified natural gas (LNG) projects are not "necessary" in the NZE** (see G2). This conclusion stems from the fact that **the GHG footprint from the full LNG life cycle (including extraction, liquefaction, transport, and re-gasification) effectively doubles the GHG emissions generated by solely the combustion of fossil gas.[10]** While LNG trade "peaks in the mid-2020s at 475 bcm and falls to 2020 levels of 390 bcm by 2030", around 600 bcm of LNG liquefaction capacity already exists today and 180 bcm is under construction. By 2030, the LNG liquefaction capacity would therefore be twice the demand. According to the IEA,

Box 3 – No new fossil fuel supply investment: what does the IEA mean?

One of the key messages of the Net Zero by 2050 roadmap is that "fossil fuel use falls drastically in the Net Zero Emissions Scenario by 2050, and no new oil and natural gas fields are required beyond those that have already been approved for development". As the graph below shows, several stages can be identified in the planning and building of new projects.



Source: Reclaim Finance

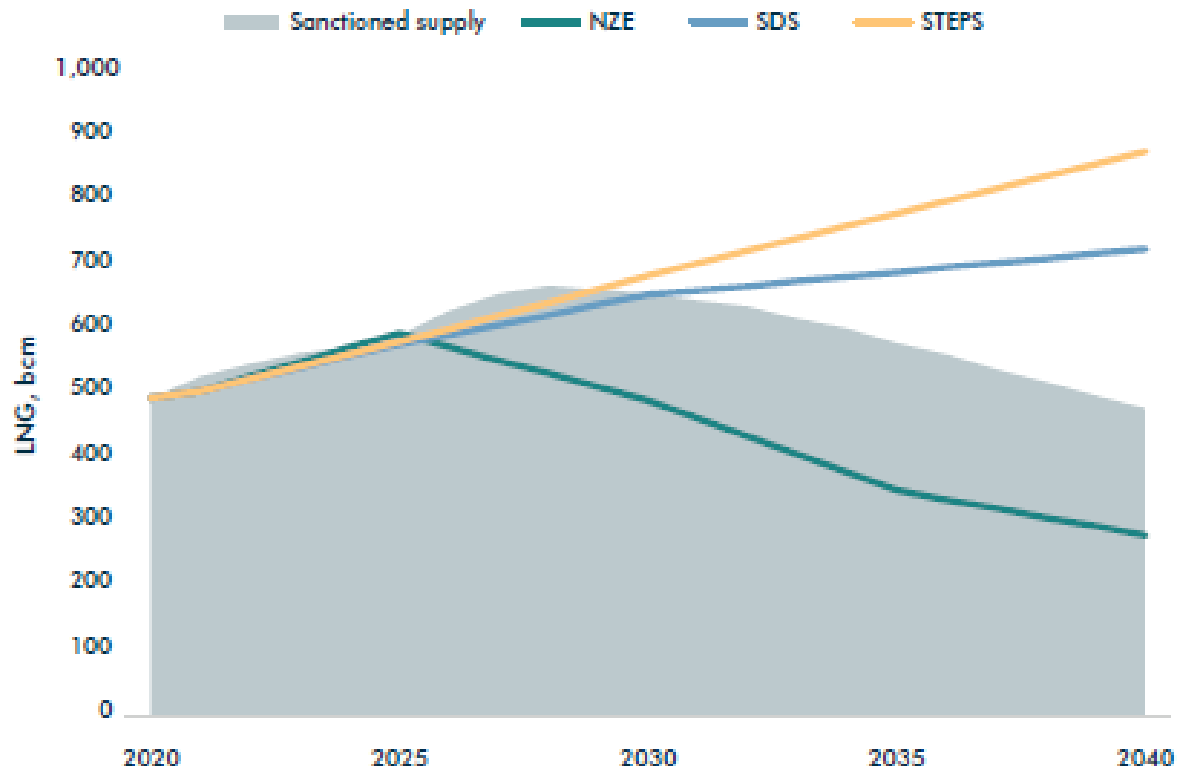
The final investment decision – after the "appraisal" phase in the above graph – is the point at which a project is considered "approved for development" in standard industry practice. This is when government permits are in hand, financing in place, and construction begins in earnest to bring a project into operation. **Any field development not yet approved by a final investment decision as of 2021 would therefore be incompatible with the NZE scenario.** It follows that governments and companies should stop exploring for not-yet-discovered reserves and stop development of any reserves beyond fields already producing or under-construction as of 2021. Before the final investment decision, projects enter «field development». As this step entails significant investments and operational progress, such projects are accounted for in the Global Oil and Gas Exit List (GOGEL) «future development» metric that represents, for each company, the total resource of projects that will enter the production stage in the near term.

While some investment in existing oil and gas fields is assumed in the NZE to slow down declines in production and reduce the carbon intensity of operations, this is within an overall context of winding down production and capital investment in production, not expanding it.

"most of the 200 bcm worth of LNG projects currently under construction do not recover their invested capital" resulting in "stranded capital estimated at USD 75 billon[11]". The gap between the already sanctioned LNG capacity and the demand for it in the NZE increases rapidly after 2025.[12] According to Climate Analytics, following the NZE would require a much faster drop of LNG production in Australia, which is still developing 44 new gas projects with the largest volume of production designated for export as LNG.[13] Focusing solely on economic and financial factors, IEEFA finds that 62% of LNG terminals and 66% of gas-fired power plants projects in seven Asian countries developing LNG-to-power projects are not viable.

Similarly, the power sector undergoes drastic changes in the NZE: **electricity sector emissions fall by close to 60% by 2030, to reach carbon neutrality by 2035 in "advanced economies"[14] and 2040 worldwide.[15]** The power sector must drastically speed-up its decarbonization: in 2020, 38% of electricity generation came from "low-carbon technology" but to align with the NZE this must jump to over 70% by 2030. This notably entails **immediately "halting the approval of new unabated coal plants[16] and closing around 40% of the existing coal power fleet by 2030,[17] on the way to phasing out unabated coal plants by 2040.[18]** However, coal plants are not the only ones on the spot: gas-fired plants are also directly affected. Indeed, **unabated gas electricity production drops by 30% from 2020 to 2030 in advanced economies in the NZE – and slightly diminishes globally - and almost disappears by 2050.[19]** Gas-fired power generation - whether abated or unabated - is less than a third of 2020's levels in 2040, with unabated gas-fired power generation falling by 90%. Furthermore, **considering the high cost of CCUS**, the current failures to operate

G2. Global LNG demand under different IEA scenarios, and future supply from sanctionned projects



Source: Rystad Energy, IEA, Carbon Tracker analysis.
Note: The fact that the NZE outstrips both the SDS and STEPS in 2025 likely reflects that it is a newer scenario. We expect the latter two scenarios to catch up in the next iteration of the WEO.

Source: Adapt to survive, Carbon Tracker

or finance CCUS plants, **and the overall uncertainty surrounding its deployment, companies should simply refrain from building new gas power plants if we are to reach the carbon neutrality objectives laid out by the IEA.**

While fossil fuel power generation plays a large role now in providing power system flexibility, it is not the only, nor the best, resource available for doing so. In the NZE scenario, fossil fuels would be replaced by "dispatchable low emissions sources" and be only marginally used to ensure the flexibility of the power system in 2050[20] (see G3). Going further than the IEA NZE, Jacobson and al underline that a 100% renewable energy power system with storage in the US would significantly reduce the cost of energy while avoiding blackouts and ensuring energy flexibility.

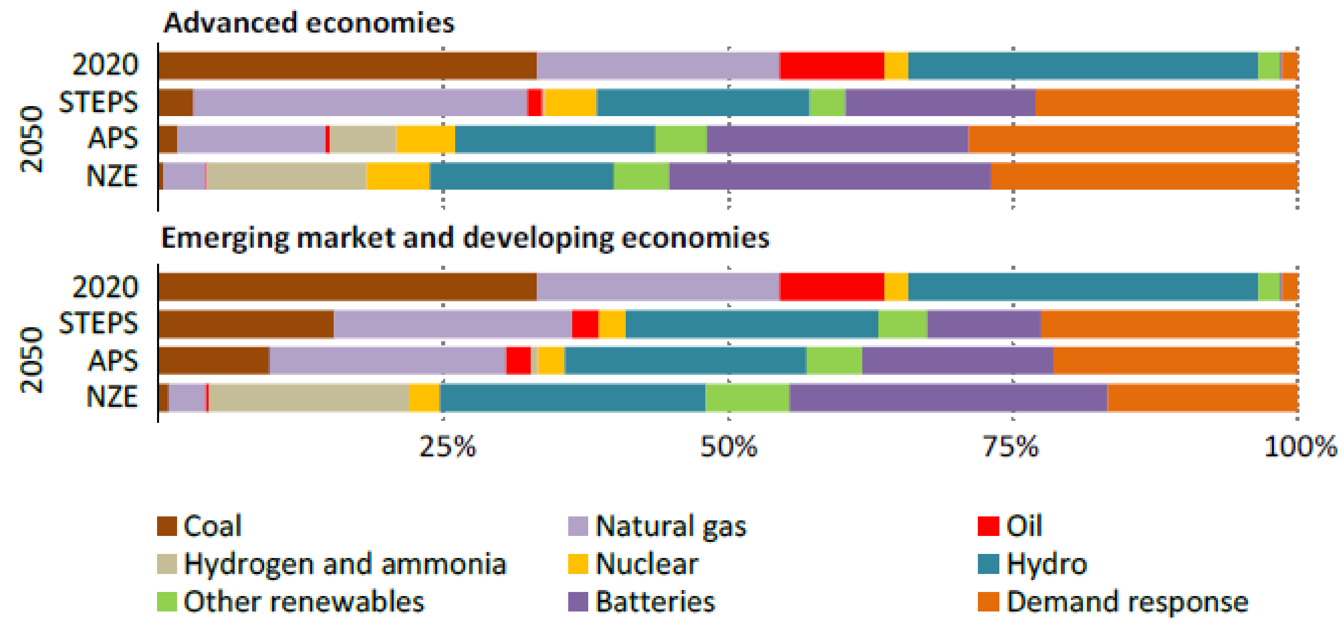
Globally, the fossil fuel production trends shown in the NZE are at odds with current trends. **Coal, oil and gas supplies decrease from 2020 to 2030 and are massively slashed by 2050** (see G4). Even the APS scenario requires a reduction of the **production of fossil fuels by 2050. Production of fossil gas starts declining after 2025 and drops by 46% from 2020 to 2040 and 56% to 2050** (compared to a 38% rise in BP's energy outlook). Following these trends, **fossil fuel companies that do not adopt plans to significantly scale down their production are clearly incompatible with the NZE.[21]**

b. Drastically cutting methane emissions

Reducing fossil fuel use and production is also vital to achieve one of the key targets of the NZE: **the reduction of methane emissions by 75% by 2030[22]** (see G5). Reducing production plays an important role in driving down methane emissions from coal, oil and gas and is key to achieving the IEA's objective. Declining **fossil fuel production makes up a third of the methane reduction** necessary to achieve the IEA's goal. The IEA stresses that "the most effective way to reduce (methane) emissions from coal is to produce less."

However, the IEA underlines that reducing production alone won't be sufficient. **Minimizing methane leaks and flaring should be "a top priority"[23]** in the quest to reduce emissions from fossil fuel operations. About 45% of current oil and gas methane emissions could be avoided at "no net cost" given the

G3. Electricity system flexibility by source and scenario, 2020 and 2050

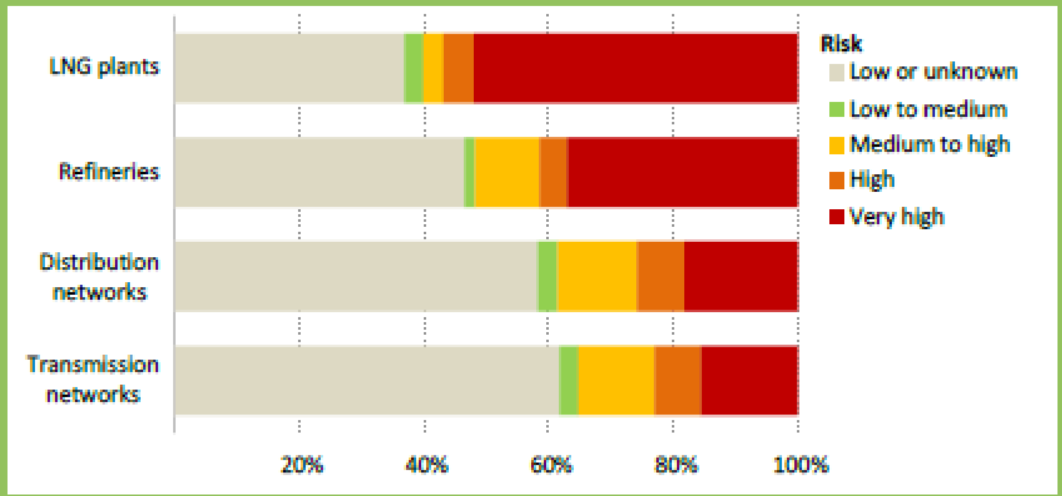


Source: WEO 2021, IEA

Box 4 – Dirty energy vulnerable to physical risks

LNG plants, refineries and thermal power plants are all significantly exposed to physical risks stemming from climate change. Around 13% of the world's coastal thermal power plants, 25% of onshore LNG plants and 10% of coastal refining facilities are already at risk of experiencing severe coastal floods. More broadly, over 50% of LNG plants and 35% of refineries are exposed to very high risks from violent storms.

Share of energy infrastructure capacity at risk of destructive cyclones, 2020

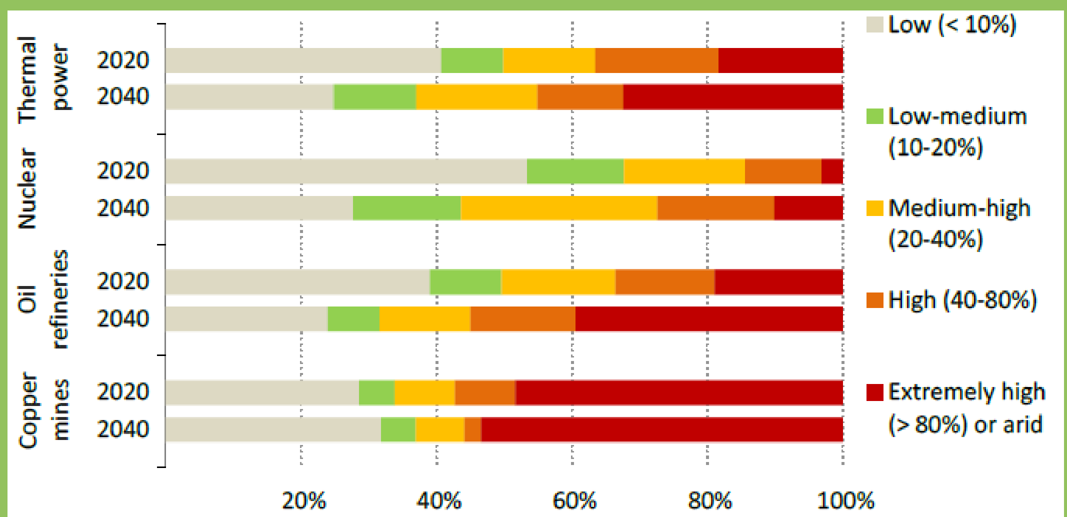


Source: WEO 2021, IEA

Mines, refineries, thermal power plants and nuclear plants are also impacted by water stress.

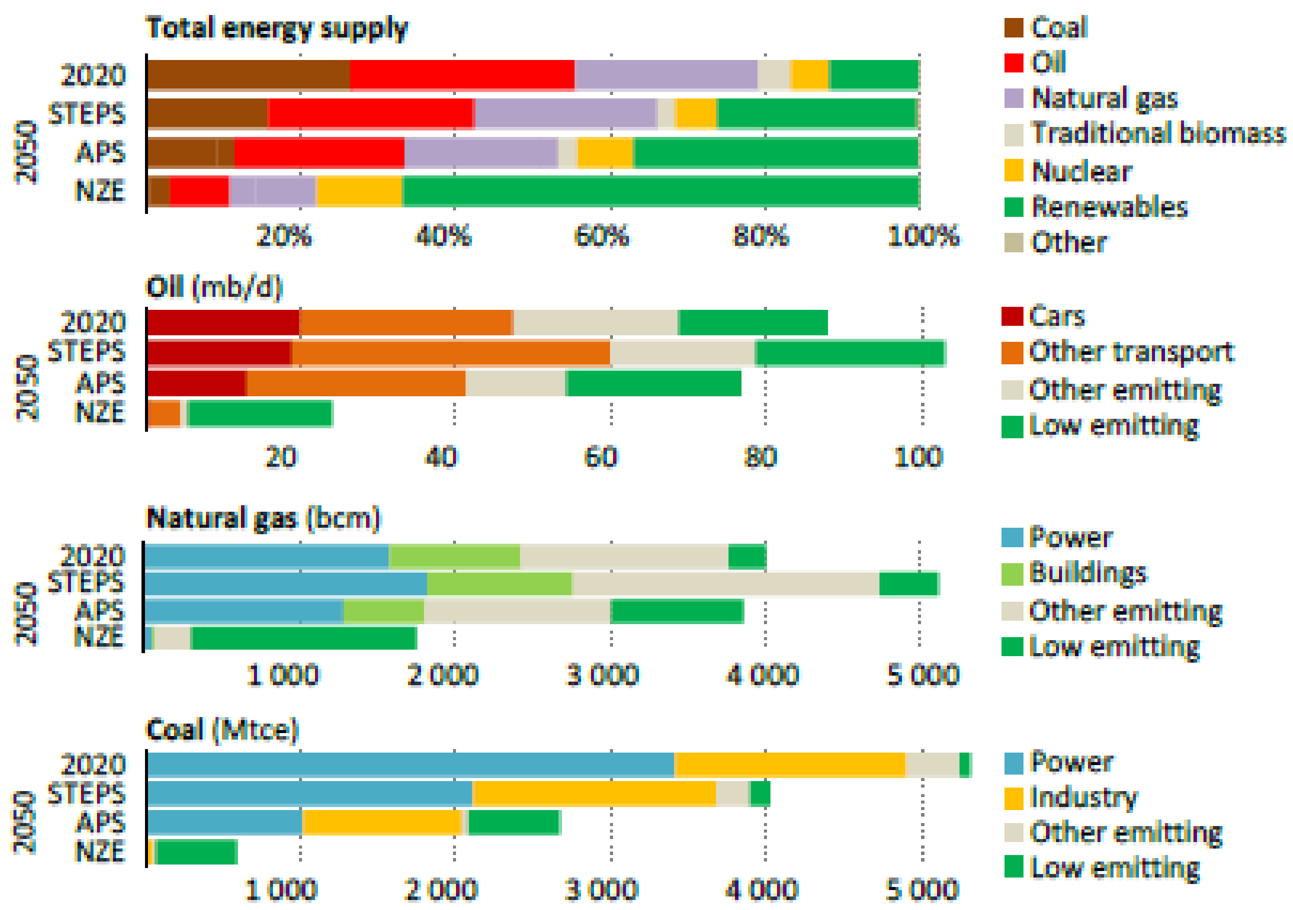
Around a third of existing thermal and nuclear power plants using freshwater cooling are located in high water stress areas, and this share is set to increase over time due to climate change to reach 40% by 2040 according to the IEA.

Share capacity by water stress level



Source: WEO 2021, IEA

G4. Energy supply and demand by fuel and sector, 2020 and 2050



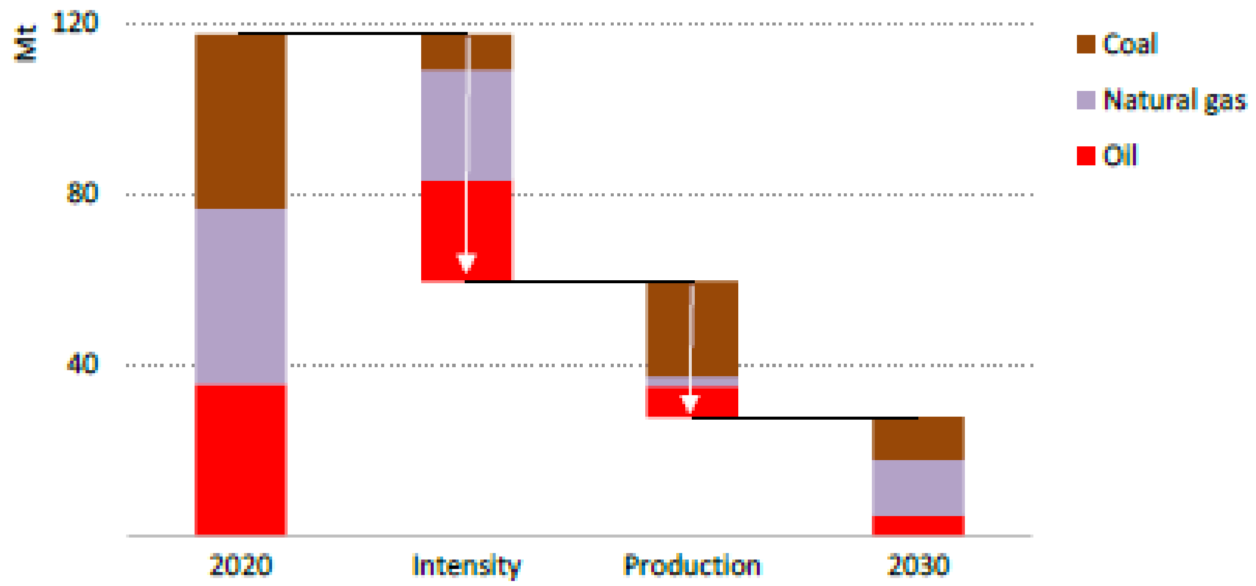
Source: WEO 2021, IEA

value of the gas that would be captured – and then sold – in the process.

Reducing methane reduction by 75% by 2030 requires actions from governments but the IEA stresses that companies alone can achieve most of this reduction by implementing voluntary measures all along their supply chain (see G6). Concretely, this means that **fossil fuel companies and those that finance them have no excuse not to prioritize methane abatement, along with the general reduction of fossil fuel production**. Reducing methane emissions would help maintain production from existing oil and gas wells and could easily fit into a 1.5°C alignment strategy that immediately puts an end to new fossil fuel supply projects and progressively and significantly lowers fossil fuel production.
Of course, **further methane reductions could be achieved from reducing fossil fuel production at a faster pace**. As we underline later in this analysis (see part 2.a), the NZE still relies on important quantities of fossil fuels. Furthermore, methane emissions have been chronically underestimated in the past[24] and major leaks are regularly discovered.[25]

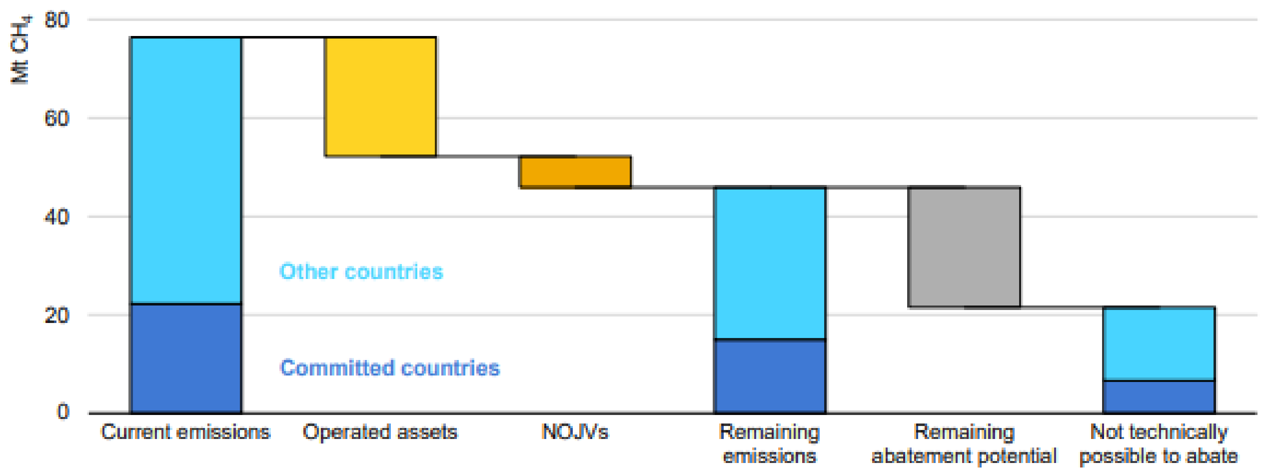
Shale oil and gas disproportionately contribute to global methane emissions, notably due to the process of fracking used to extract them. Fracked oil and gas have been a key driver of the rise of methane emissions in the past decade. In the world's largest site of shale oil and gas expansion, the U.S. Permian Basin, 3.7% of extracted methane may leak into the atmosphere, making Permian gas more dangerous for the climate than coal. Therefore, in addition to what the IEA is promoting, **the swift reduction of unconventional oil and gas production must be a central part of strategies to reduce methane emissions**[26] (see G7).

G5. Methane emission from fossil fuel operations and reductions to 2030 in the Net Zero Emissions by 2050 Scenario



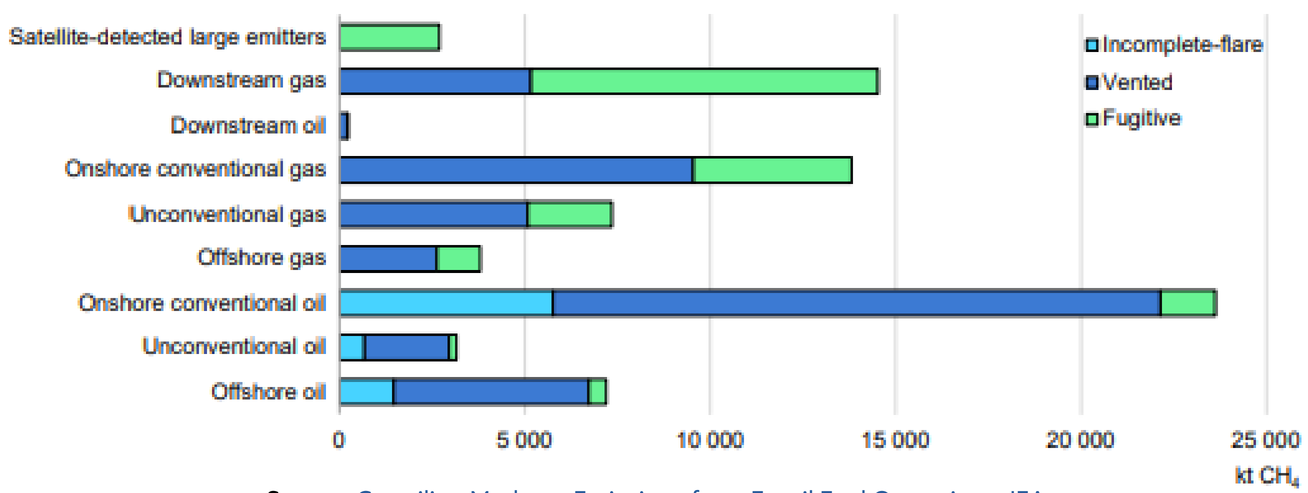
Source: WEO 2021, IEA

G6. Potential methane reduction from voluntary company action

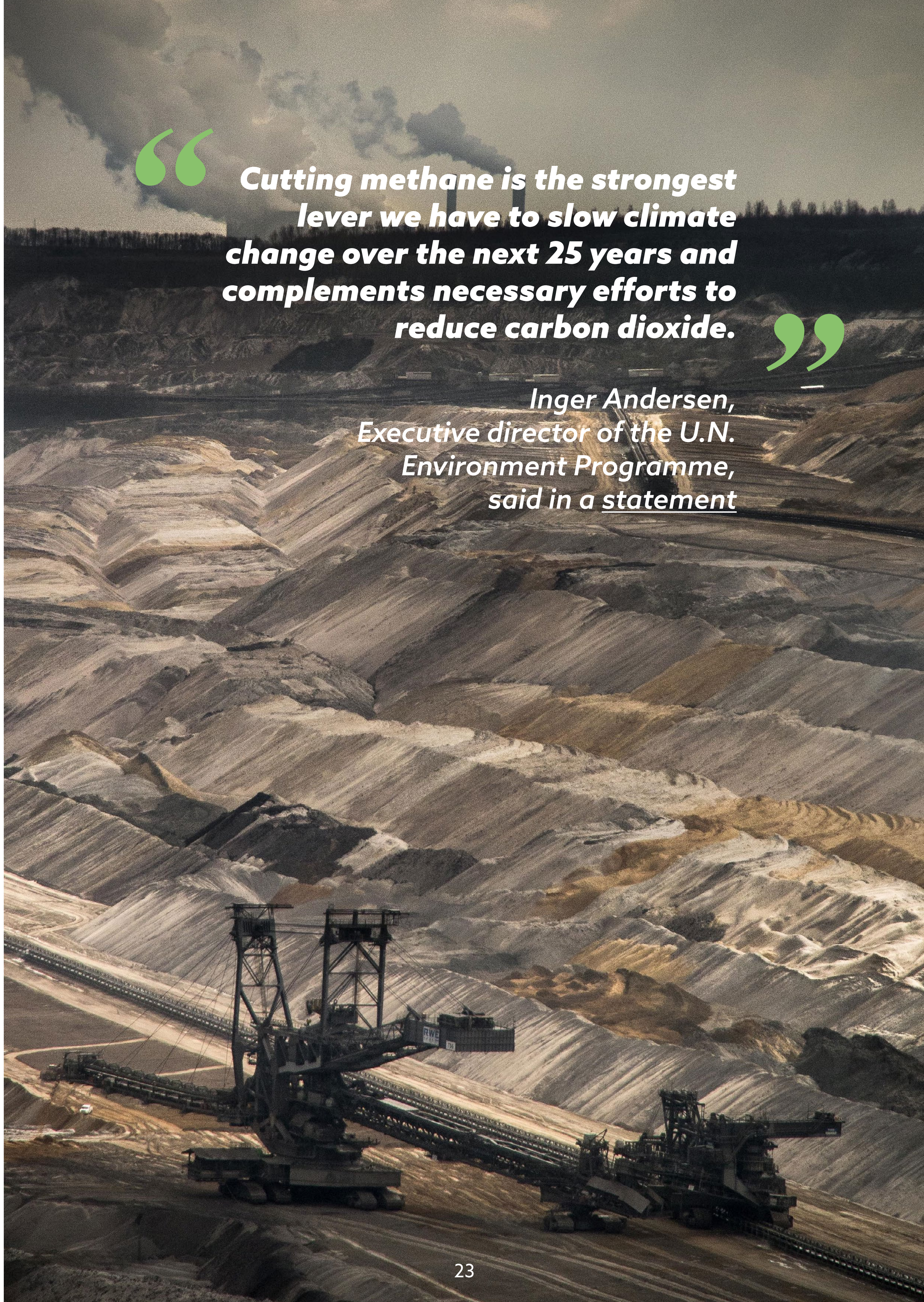


Source: Curtailing Methane Emissions from Fossil Fuel Operations, IEA

G7. Oil and gas methane emissions by source, 2020



Source: Curtailing Methane Emissions from Fossil Fuel Operations, IEA



“Cutting methane is the strongest lever we have to slow climate change over the next 25 years and complements necessary efforts to reduce carbon dioxide.”

Inger Andersen,
Executive director of the U.N. Environment Programme,
said in a statement

2. THE OLD FOSSIL FUEL HABIT DIE HARD

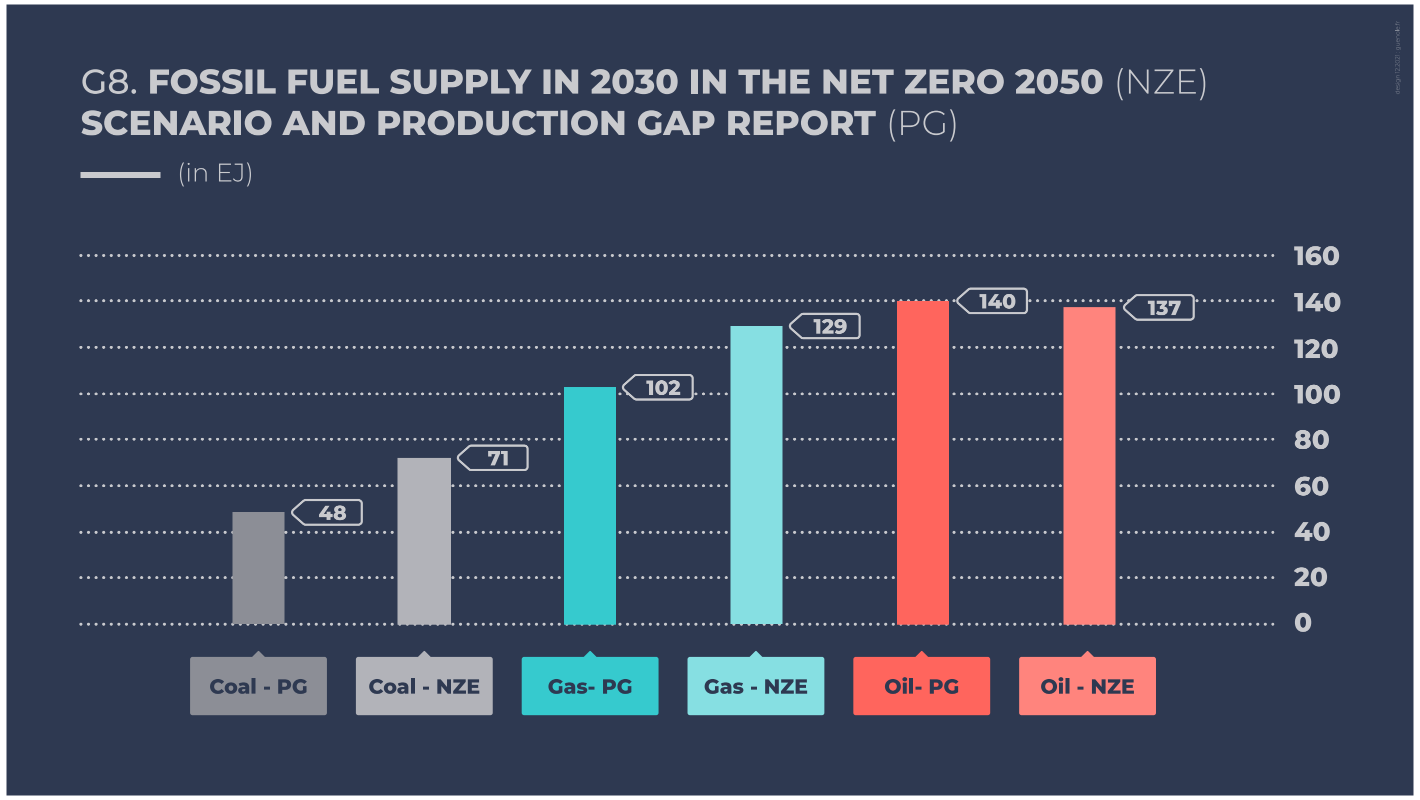
While the WEO requires a major shift from the fossil fuel sector, the IEA foresees higher levels of fossil fuel use than other 1.5°C trajectories by relying on significant levels of carbon capture and carbon removal. Furthermore, the IEA's framing of remaining fossil fuel investment is surprising and largely misleading.

a. The carbon capture and removal trick to preserve fossil fuels

While the WEO requires a major shift away from the fossil fuel sector, the IEA's NZE scenario nonetheless maintains unnecessary and dangerous levels of fossil fuel reliance by assuming significant deployment of carbon capture and carbon removal. **In the short term, the IEA allows for substantially more coal and gas use than the 2021 UN Production Gap Report**[27] (see G8):

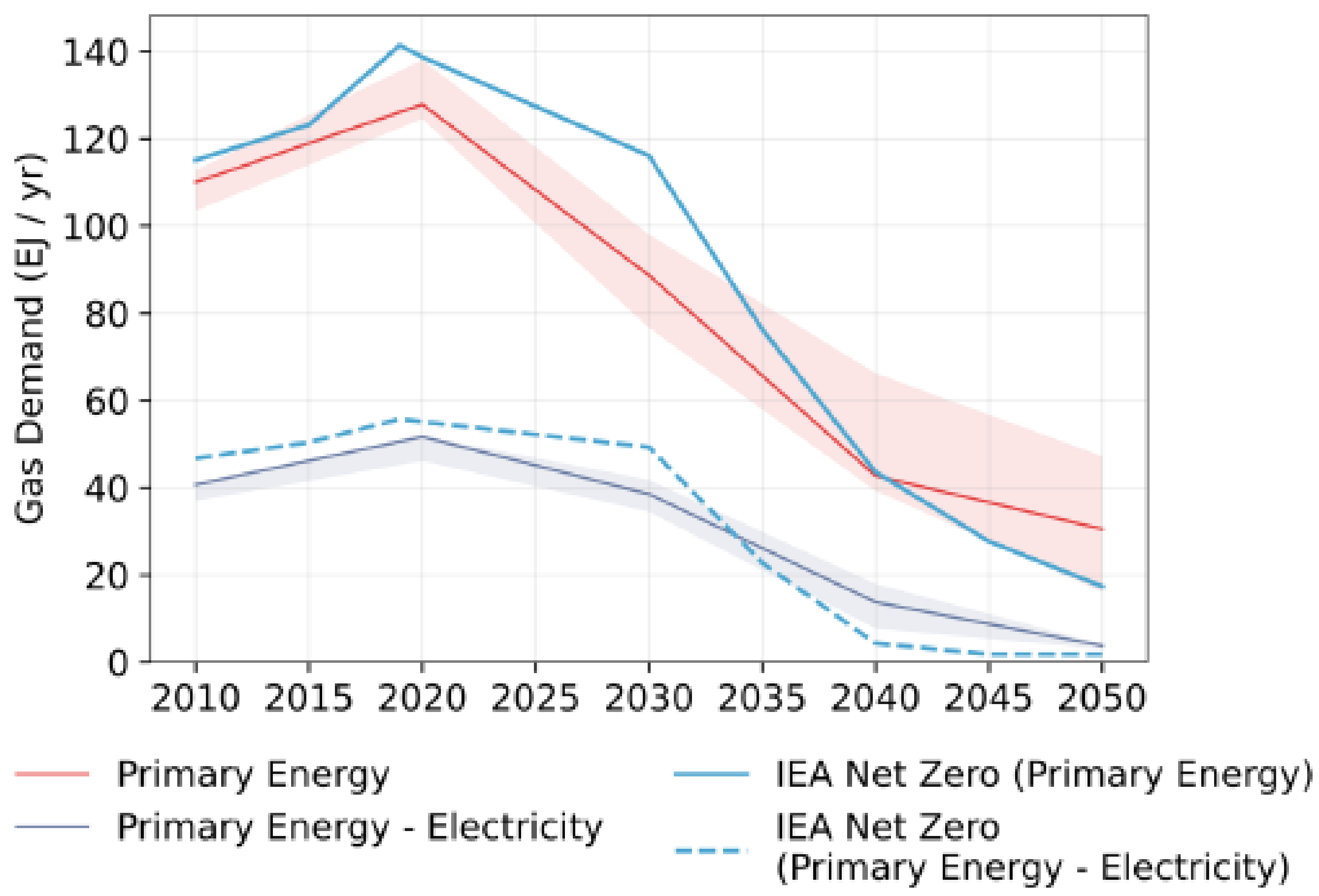
- In the NZE scenario, coal supply[28] declines by only 56.7% from 2020 to 2030 to reach a level of 71.9 EJ ; in the Production Gap Report it drops 11% a year to reach less than 50 EJ in 2030.
- In the NZE, fossil gas supply[29] declines by a total of 7% from 2020 to 2030 (129.4 EJ). The Production Gap Report states that gas needs to decline by 3% each year up to 2030 to reach about 102 EJ in 2030. The accelerating decline of gas after 2030 – with a 42.3% decline from 2030 to 2040 - never makes up for the gap accumulated from 2020 to 2030. This gap is largely caused by an increase in gas use from 2020 to 2025.

However, in the NZE, oil supply declines by 19.8% from 2020 to 2030 to reach 137.4 EJ in 2030, just below the Production Gap's 140 EJ. The NZE significantly over relies on gas from 2020 to 2035, even though it was the largest source of the growth of fossil CO2 emissions (42%) in the last decade and is responsible for about 60% of methane emissions from fossil fuel production.[30] Like the Production Gap Report, **1.5°C-compatible scenarios from the IPCC show that the unabated use of natural gas in primary energy supply should already be declining globally and needs to drop by more than 30% below 2020 levels by 2030, and 65% below 2020 levels by 2040.**[31] The NZE fails to match this trajectory (see G9).

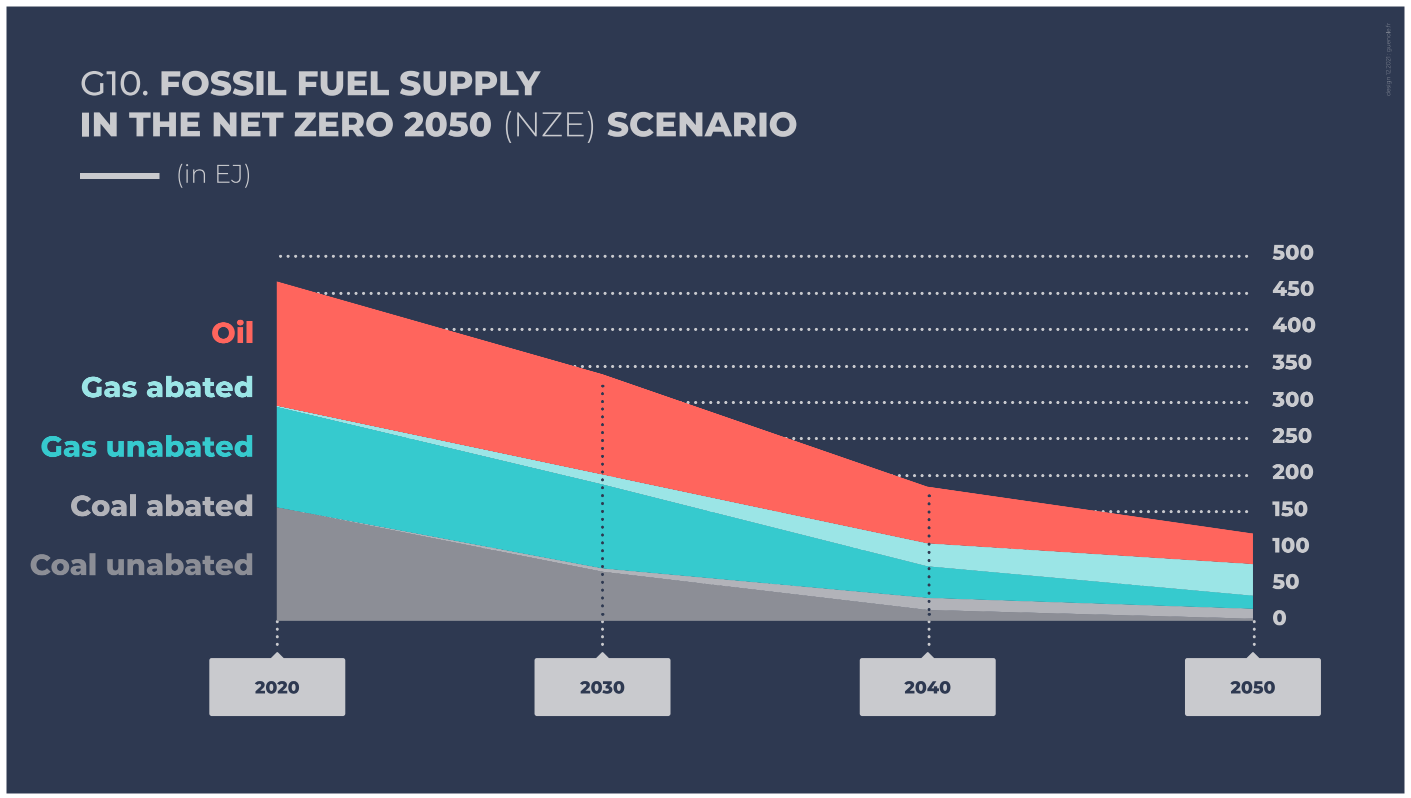


Source: Reclaim Finance based on data from WEO 2021 and Production Gap Report 2021

G9. Unabated natural gas use (total primary energy and demand for power) under 1.5°C compatible scenarios compared with the IEA's NZE pathway



Source: Why Gas is the new coal, Climate Analytics



Source: Reclaim Finance based on data from WEO 2021

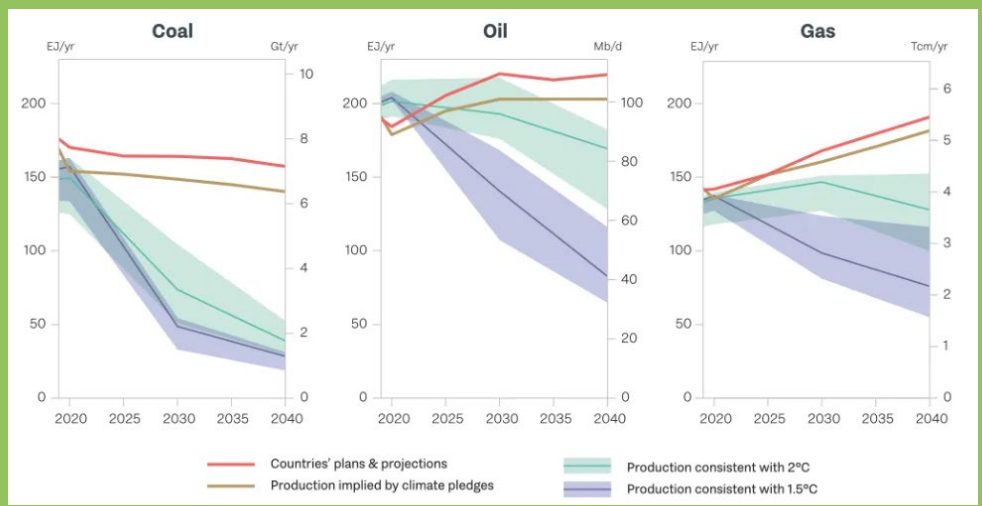
Box 5 – The Production and coal gaps

The UN Production Gap Report 2021 states that, with current national energy plans and projections, **fossil fuel production would be 110% higher in 2030 than what would be consistent with limiting global warming to 1.5°C**, and 45% more than would be consistent with limiting warming to 2°C. **By 2040, this excess grows to 190% and 89%.**

The report underlines that **the production gap is "widest for coal in 2030", with production plans and projections that would lead to around 240% more coal, 57% more oil, and 71% more gas than would be consistent with limiting global warming to 1.5°C.**

The Production Gap Report is based on IPCC SR1.5 scenarios. Its 1.5°C trajectory is the median of IPCC scenarios with at least a 50% likelihood of limiting warming to below 1.5°C by end-of-century. This scenario is constrained by how much carbon removal is deployed, ensuring that they sequester an average of less than 5 GtCO2 per year from BECCS and less than 3.6 GtCO2 per year between 2040 and 2060[33]. These levels of removal are equivalent to the upper limits of the sustainability ranges that can be found in the scientific literature.[34] The report points out that **"if carbon dioxide removal technologies fail to develop at large scale [...] the production gap would be wider".**

The production gap



Source: Production Gap Report 2021

If the coal sector is increasingly under the spotlight for its impact on climate it continues to expand significantly. The 2021 Global Coal Exit List - published by Urgewald and 40 other NGOs including Reclaim Finance – estimates that 503 of the 1,030 companies that form the bulk of the global coal mining and power industry are planning new mines, power plants or other coal infrastructure. The proposed projects represent up to 480 GW of new coal-fired power capacity and 1.8 billion tonnes of coal a year. Only 32 coal companies have announced coal exit dates consistent with achieving the goals of the Paris Agreement but may only sell their coal assets instead of retiring them. Looking at country-level pledges and plans before COP26, Ember identified 44 governments that have committed to no new coal, 40 governments that have no proposed new coal projects, and 37 countries that still have proposed coal projects. Even if the number of countries committing to phase-out coal increased at COP26,[35] the challenge remains immense: TransitionZero estimates about one coal power unit should be closed each day between now and 2030 – 3000 in total - to be consistent with the IEA NZE.

In the IEA NZE, fossil fuels continue to account for a significant portion of the energy mix in 2050, making up for 120 EJ in 2050, the equivalent of 60% of the energy provided by wind and solar power and 22% of the total energy supply.[32]

To allow continued reliance on fossil fuels, and first and foremost on gas, the IEA forecasts large-scale deployment of carbon capture and storage (CCS / CCUS) and the use of negative emissions such as biomass energy with carbon capture and storage (BECCS) and direct air capture (DAC).

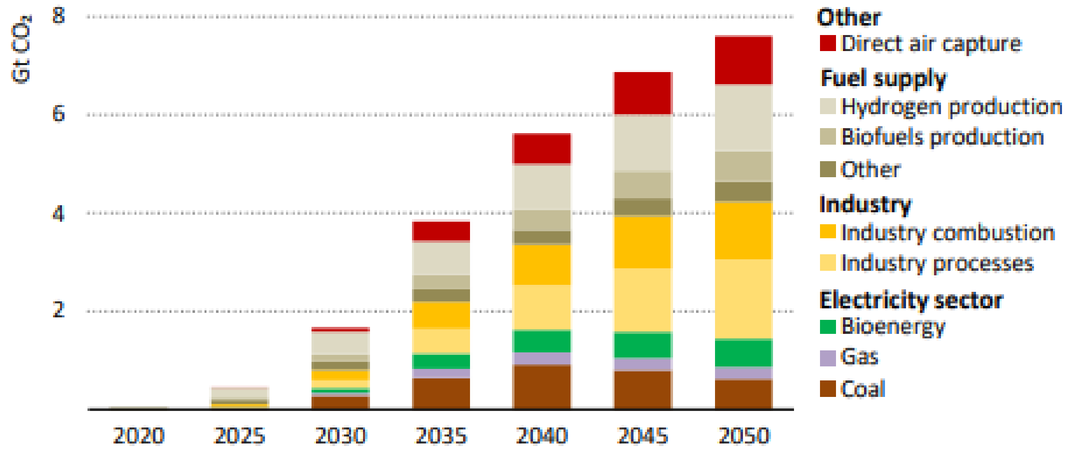
The use of unabated fossil fuels still generates 1689 MtCO2 emissions in 2050, which are supposed to be entirely offset by BECCS and DAC. In fact, BECCS and DAC remove 1934 MtCO2 from the atmosphere in 2050 and 317 Mt as soon as 2030,[36] compared to 1 Mt today.[37] **The electricity and heat sector even become CO2 negative in 2040** in the NZE and contribute to reducing CO2 by 369 Mt in 2050 thanks to BECCS and despite still relying on some coal and gas. This is achieved thanks to the parallel use of CCUS: **in 2040, 49% of the remaining coal supply and 41% of gas is used with CCS, these numbers reach respectively 81% and 71% in 2050** (see G10).

The projection for CCS deployment seems particularly unrealistic (See Box – The CCS illusion). **Of a total 7.6 GtCO2 captured[38] and stored in 2050,** 70% comes from CCS (rising from close to zero today) and 25% from BECCS and DAC (see G11). **1665 MtCO2 are captured in 2030, more than three times the level of the IPCC's P2 pathway and more than 41 times current levels.[39]**

In its May report, the IEA indicated that 55% of CCS emission reductions comes from such unproven technologies (see Box – The CCS illusion), and implicitly recognized that this level of CCS deployment is unrealistic by presenting a "low CCS" case where CCS capacity does not expand beyond current and already planned infrastructure.[40] If the IEA choose not to present this case in its WEO, it still **identifies CCUS deployment as one of the main technological challenges to be overcome,** underlining the mismatch between current deployment and NZE requirements. The agency underlines that closing this gap will require "breakthrough programmes" (see G12).

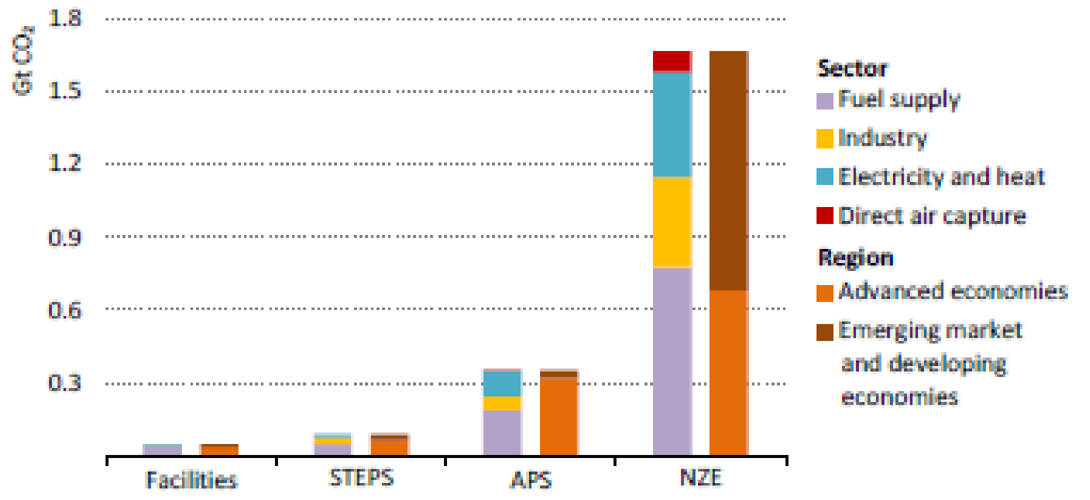
A large share of this CCS deployment in the NZE is used to abate emissions from industry[41] and to enable a **huge buildup of so-called "low carbon" hydrogen production, much of it produced from coal and gas: 46% of the hydrogen output in 2030, and 38% in 2050**. Hydrogen-based fuels and fossil fuels equipped with CCUS account for 3% of total final consumption by 2030, up from almost nothing today. This is highly problematic as the efficiency and availability of CCUS is highly uncertain and the greenhouse gas emissions from fossil-fuel based hydrogen with CCUS – so-called "blue hydrogen" – could be only 9 to 12% lower than without CCUS and even 21% greater than simply burning natural gas or coal for heat according to a study by Robert Howarth and Mark Jacobson (see G13).

G11. Global CO^2 capture by source in the NZE



Source: Net Zero by 2050, IEA

G12. CO^2 capture capacity by project and scenario, 2030



Source: WEO 2021, IEA

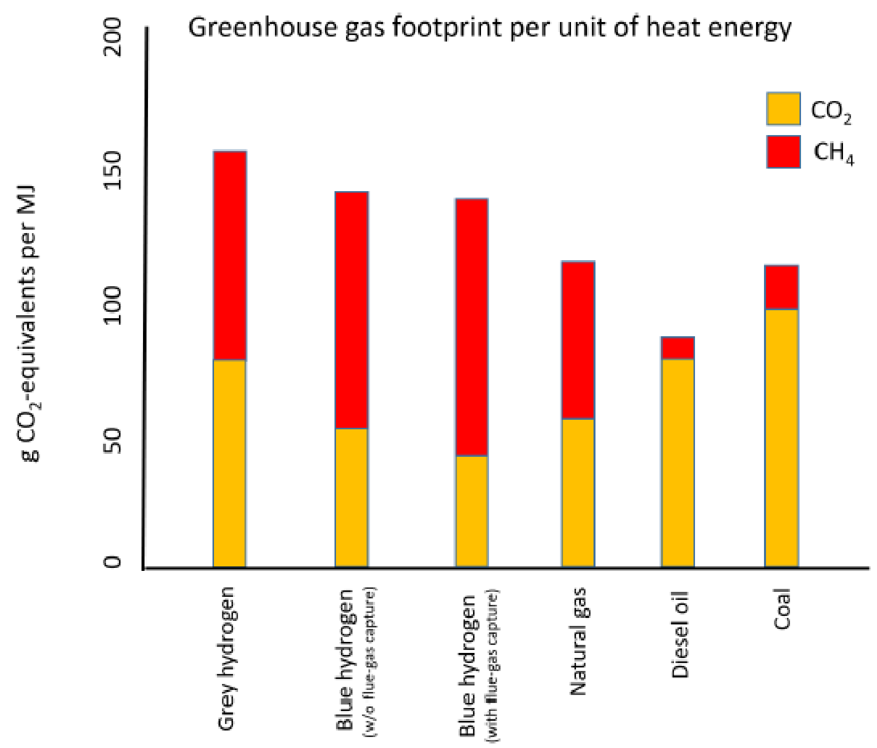
As the IEA underlined in its May report, **lower reliance on CCUS and CDR is possible: it requires a much-faster drop in fossil fuel production and build-up of renewable energy capacity and renewable hydrogen production**. Furthermore, we note that **the IEA could also have opted for a pathway with overall reduced reliance on hydrogen by better prioritizing its uses[42]** and notably reducing the reliance on hydrogen for the transition of the power sector.

b. Fossil fuel investments still unaligned

Despite the end to new fossil supply projects in the NZE, fossil fuels continue to benefit from significant investments to maintain current infrastructures and reserves. Capital spending on oil and gas supply still amounts to $365 billion per year from 2021 to 2030 – a level only 30% below that of recent years and above expenditures in 2020.[49] After 2030, oil and gas supply expenditures fall to $171 billion per year. **On average, $235 billion are spent annually on fossil fuels in the NZE from 2021 to 2050.** Furthermore, only a small portion of these investments – about $13 billion a year – is required to put all methane abatement measures in place (cf part 2.b).

The IEA mentions that projected investment in oil and gas is now aligned with the changes

G13. Greenhouse gas footprint per unit of heat energy



Source: How Green is blue hydrogen?, Robert W. Howarth and Mark Z. Jacobson

needed to reach net zero emissions of greenhouse gases by 2050.[50] This conclusion seems to be drawn from the fact that **oil and gas investment fell significantly in 2020 and early 2021.** However, **this fall is the result of the Covid crisis** - not of new company plans or a policy drive shift – while the previous fall in oil and gas investment was caused by the oil price crash in 2015. Oil and gas investments have been slightly increasing in the latter part of 2021 and will likely continue to do so in 2022.

From 2016 to 2018, $719.4 billion were spent annually on "high carbon liquids and gases".

In 2019, global investment in upstream oil and gas and in the coal supply was still $574 billion[51] before dropping in 2020. **For upstream oil and gas alone, 2019 investments exceed the 2021-2030 annual investment under the NZE trajectory by as much as $110 billion (30%). To summarize, the level of fossil fuel investment required in the NZE represents only a fraction of the investment in the sector made in the last decade** (see G14).

According to the Global Oil and Gas Exit List, over the past three years oil and gas companies spent $168 billion on exploration for new oil and gas resources.[52] Capital expenditures

Average annual upstream oil and gas investment by scenario

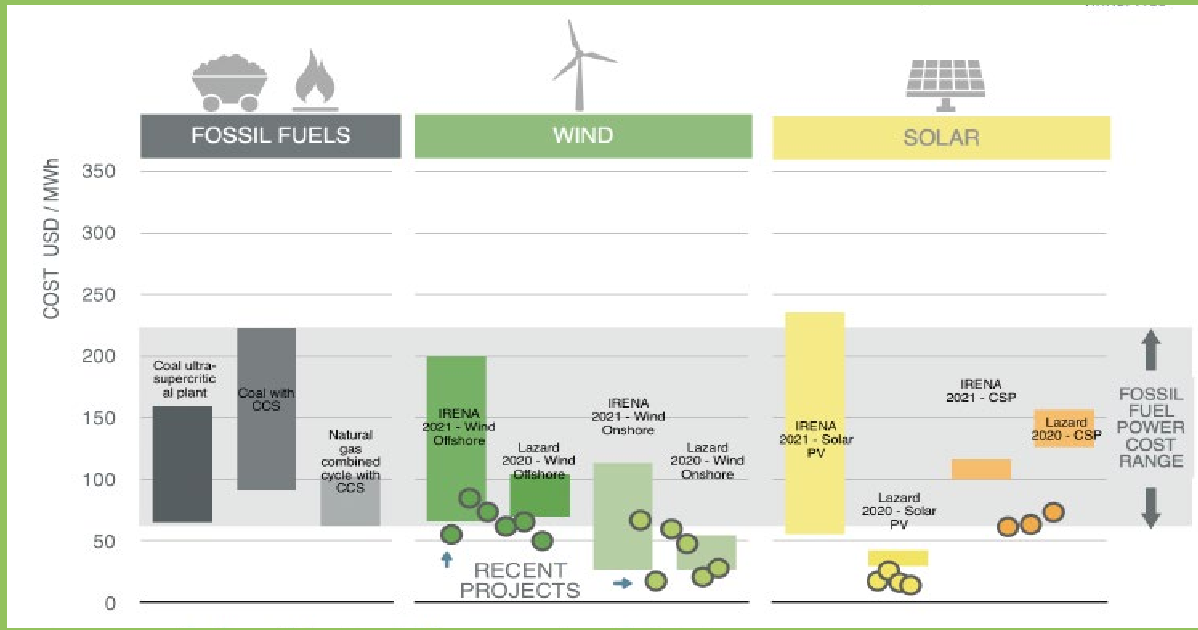
USD billion (2020)	2020	STEPS 2021-2030	STEPS 2031-2050	APS 2021-2030	APS 2031-2050	NZE 2021-2030	NZE 2031-2050
Existing fields		244	255	240	204	288	171
New fields		403	436	331	251	77	0
Total	330	647	691	572	455	365	171

Source: WEO 2021, IEA

Box 6 – The CCS illusion

As major industry leaders like the CEO of the energy company Enel has emphasized, **the energy industry tried hard in the last decades to develop CCS but "it doesn't work".** CCS projects – like Chevron's Gorgon project in Western Australia, touted as a flagship CCS project in the oil and gas industry - repeatedly failed[43] to capture significant amounts of GHG in the past, leading to higher GHG emissions. **The cost of CCS has also been a prohibiting factor,[44] making its use especially uncompetitive compared to renewable alternatives.**

Recent market prices Levelised Cost of Electricity 2020



Source: Why Gas is the new coal, Climate Analytics

The cost reductions in renewables are increasingly eroding the value CCS and CCUS in the power sector and for hydrogen production.[45] The Climate Action 100+ underlines that "the stubbornly high costs of CCUS in the power sector make it a risky and potentially expensive decarbonization strategy" and underlines that "power companies should focus primarily on minimizing the use of fossil fuels".

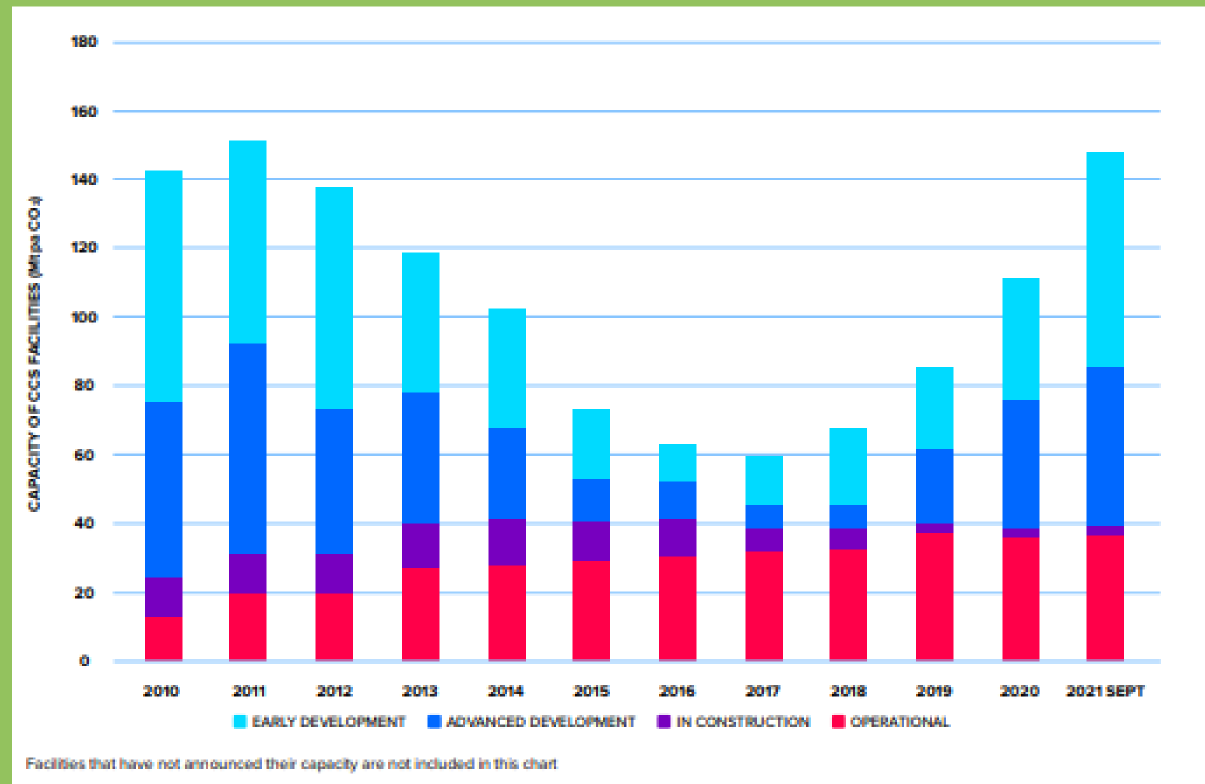
Globally, **CCS capacity only slightly increased from 2010 to 2021 and only a very small fraction of planned CCS capacity entered operation.** Indeed, while more than 140 MtCO2 were being developed in 2010, only 40 Mt are operational or under construction more than 10 years later.[46] **Only 27 CCS facilities are operational** today with 4 under construction.

Furthermore, **carbon capture is an energy intensive process**:[47] capturing CO2 emissions from a gas plant requires burning more gas and capturing a high proportion of CO2 emissions requires a massive increase in energy consumption. In the US, due to additional energy consumption, carbon capture contributed to an increase – and not reduction – in CO2 emissions. From 15 to 25% more energy could be required to capture CO2 from a power plant.

The climate and environmental impact of carbon capture can be especially negative in the event of leaks, where carbon is released into the atmosphere or contaminate groundwater and the soil. Safe storage sites are expected to be a limited resource and not evenly distributed across the world. In 2020, the rupture of a CO_2 pipeline in Mississippi required residents to seek medical treatment and affected local plants and wildlife.

To summarize, as the Climate Action Network (CAN) underlines, **CCS "at scale" is largely unproven and its potential to deliver significant emissions reductions is limited.** CCS is especially not needed to decarbonize the power sector[48] and diverts investments for renewable energy development. The IEA notably fails to integrate the potential environmental and climate impacts of CCS. As the IEA's own publication shows, its confidence in CCS development is mainly based on its opinion that there is a "momentum" around CCS deployment and that investments are being made in the technology, not on the technology itself or past experiences.

Pipeline of commercial CCS facilities from 2010 to September 2021 by capture capacity



	OPERATIONAL	IN CONSTRUCTION	ADVANCED DEVELOPMENT	EARLY DEVELOPMENT	OPERATION SUSPENDED	TOTAL
Number of facilities	27	4	58	44	2	135
Capture capacity (Mtpa)	36.6	3.1	46.7	60.9	2.1	149.3

FIGURE 6 COMMERCIAL CCS FACILITIES IN SEPTEMBER 2021 BY NUMBER AND TOTAL CAPACITY

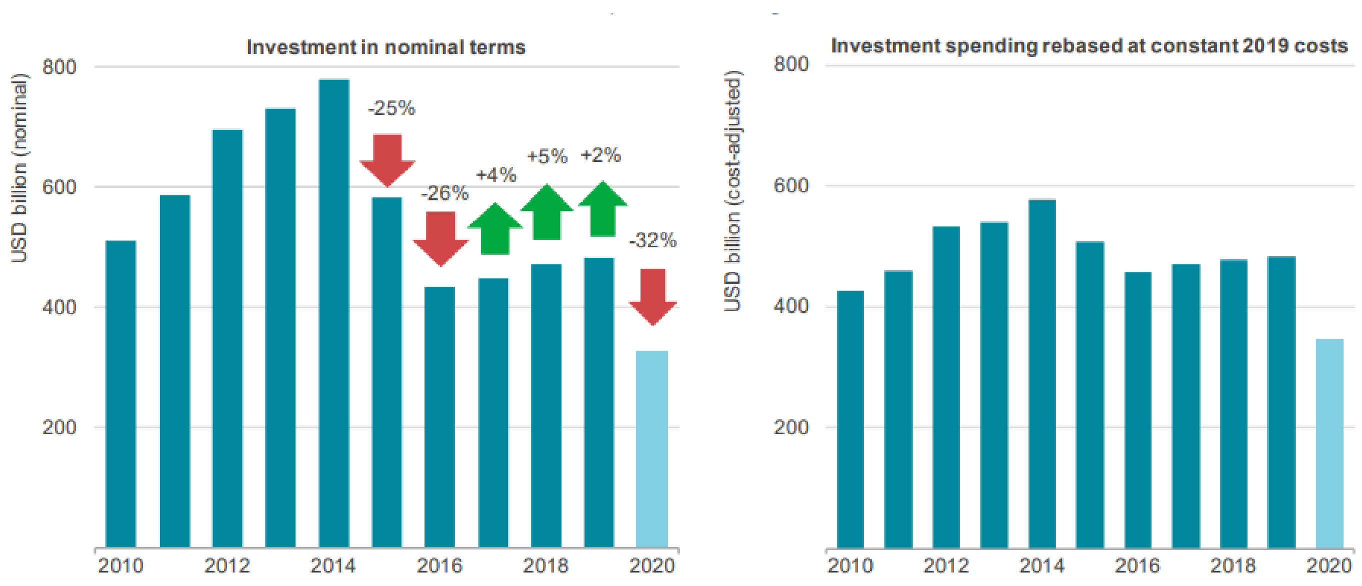
Source: Global Status of CCS 2021, Global CCS Institute

on new projects outside of core oil and gas supply by large companies accounted only for $2.1 billion in 2019, 0.8% of their capital investment. **The IEA fails to underline that oil and gas companies are still heavily investing in new supply projects** that are incompatible with the NZE. Indeed, the Global Oil and Gas Exit List identifies massive expansion plans from oil and gas majors and Carbon Tracker's analysis show that **their capex plans are not even aligned with the IEA's STEP scenario** (see G15).

As underlined in part II.A, the NZE is not aligned with the Production Gap Report and 1.5°C alignment trajectories with only limited reliance on carbon capture and storage. **Aligning with such a precautionary pathway could notably be done by using the natural decline rate of the production of wells** that reaches 4.4% for oil.[53] **This decline rate largely varies depending on the type and localization of the wells and is particularly high for unconventional oil and gas extraction with a very high environmental impact.**[54]

As the IEA underlines, investments must urgently be redirected from fossil-heavy activities to clean alternatives (see G16) if we are to meet the NZE goals that **require "a surge in global energy investment to $5 trillion by 2030,** with 85% of spending directed to clean energy."[55] **Investment in power generation should notably increase from around $0.5 trillion over the past five years to nearly $1.7 trillion in 2030, higher than the record year for investment in fossil fuel supply.**[56] **Most of this funding – 70% according to the IEA - will come from the private sector, underlining the need for financial players to step away from fossil fuel developers and champion renewable energy development.**

G14. Global upstream oil and gas investment



Source: WEI 2020, IEA

Box 7 – Energy Return on Investment: an increasingly bad business?

Energy Return on Investment (EROI) is a ratio to measure energy produced in relation to the energy used to do so. For example, this ratio can illustrate how much energy is used to produce oil relative to how much useable energy is created. This indicator plays a key role in the oil and gas sector as it helps to identify which energy sources are cheaper and more efficient.

Research suggests that the EROI for oil and gas have been steadily dropping over the years. According to Louis Delannoy and al., the energy necessary for the production of oil liquids represent today 15.5% of the energy production of oil liquids. This percentage is growing at an exponential rate: "by 2050, a proportion equivalent to half of the gross energy output will be engulfed in its own production".

EROI and energy required to produce oil from 1950 to 2050

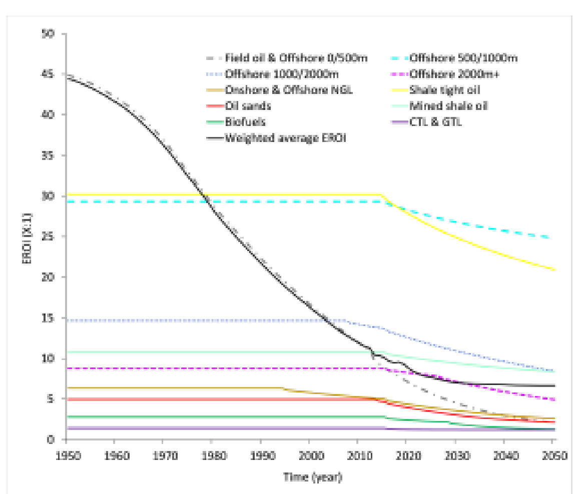


Figure 2: Evolution of each liquid standard EROI and the weighted average EROI, from 1950 to 2050.

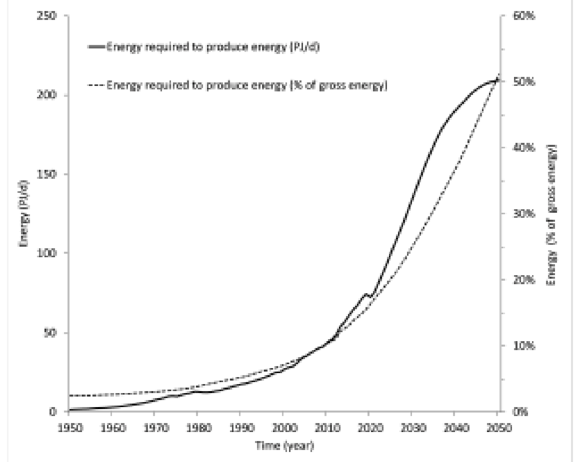


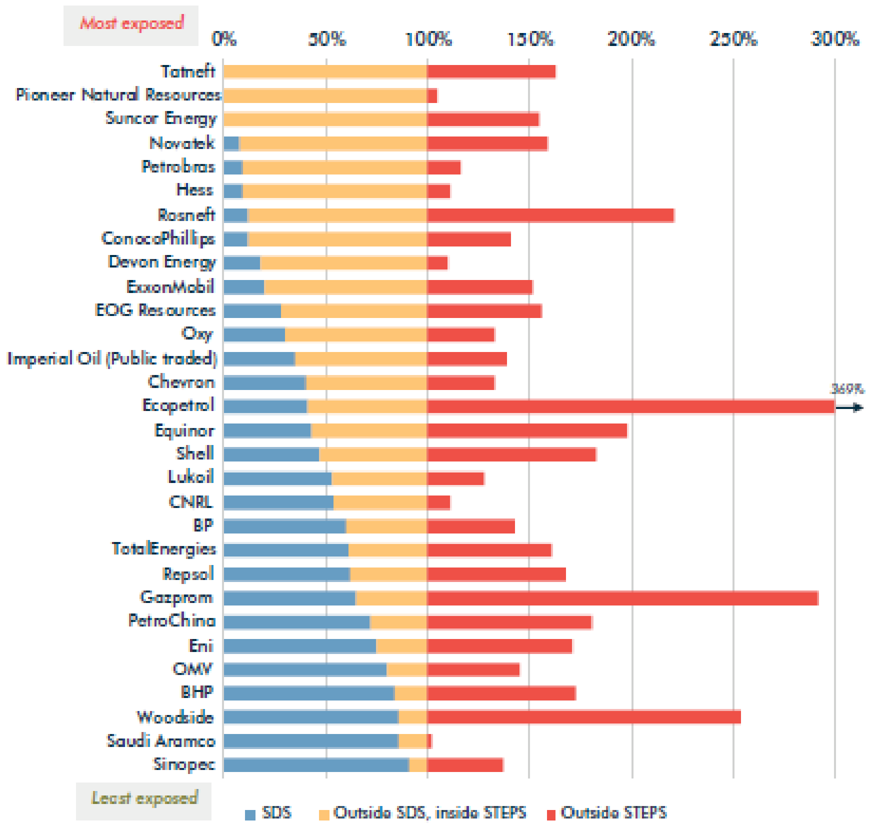
Figure 3: Evolution of energy required to produce oil liquids, from 1950 to 2050.

Source: "Peak oil and the low-carbon energy transition: a net-energy perspective", Delannoy and al.

Sources with low EROI are difficult to access and often the ones that are the most GHG-emitting and detrimental to the environment, and especially unconventional oil and gas. As IEA's assumption in the NZE that fossil fuel supply will be concentrated in a few countries suggests, unconventional oil and gas sources are often costly to exploit and would therefore logically be the first to be affected by the transition.

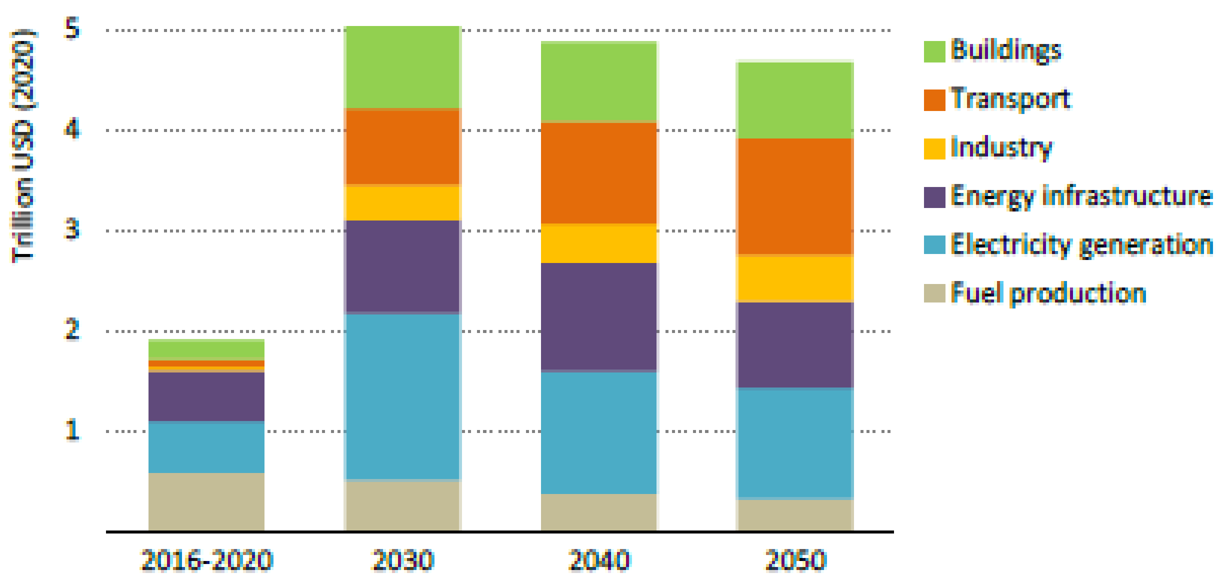
The sharp decline in the EROI of fossil fuels are bringing them closer to – and even below - what is often measured for renewable energies. As the EROI for fossil fuels continues to decline, the gap between these polluting energies and renewables will widen.[57] The EROI for biomass remains low and can be just above 1 but significantly varies depending on the biomass usage. According to W. Prananta and al. in Indonesia the EROI is 3.92 from biofuels from palm oil and 3.22 for other biofuels.

G15. 2021-2030 unsanctioned capex by scenario (% of steps unsanctioned capex) - selected companies

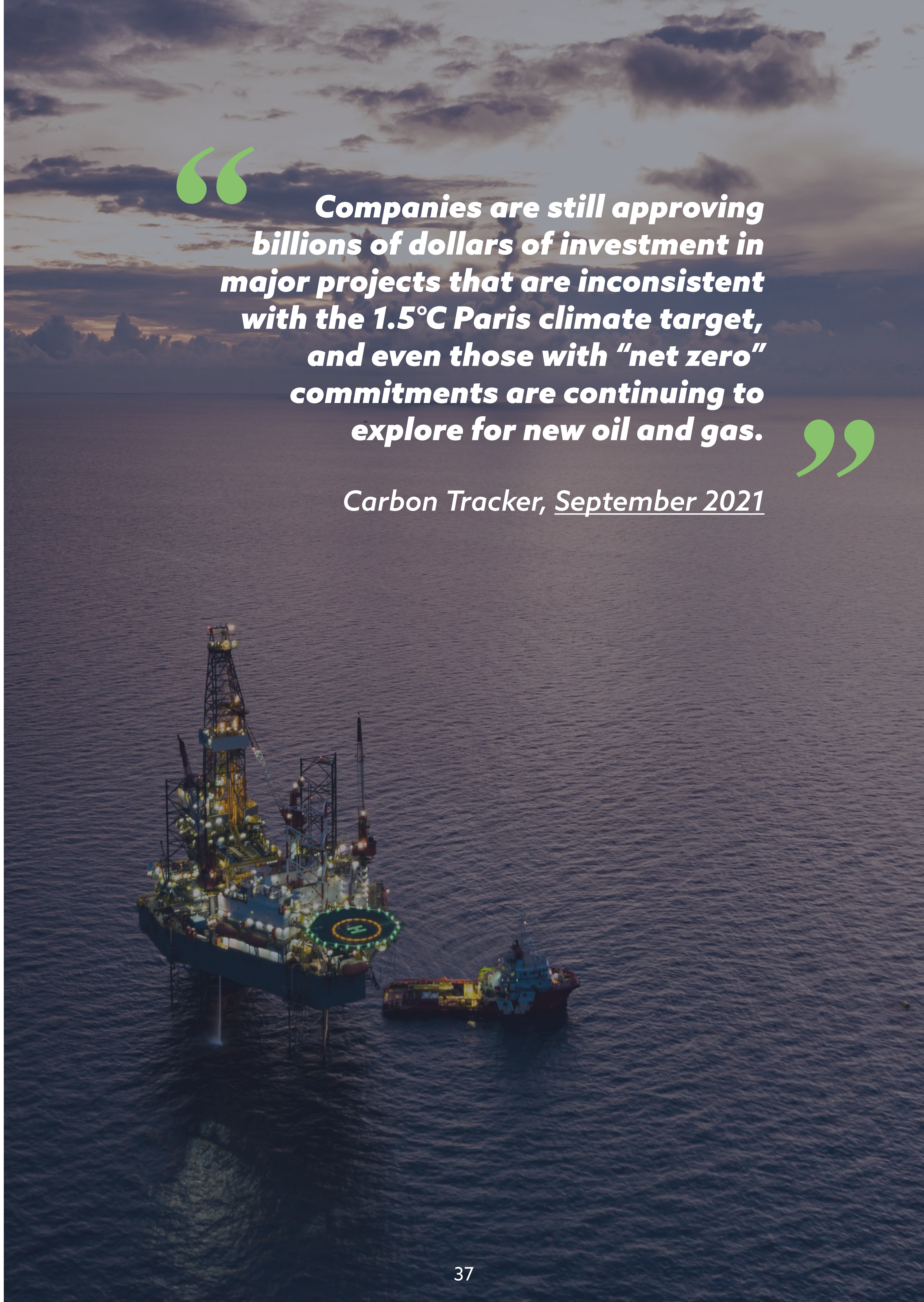


Source: [Adapt to survive](), Carbon Tracker

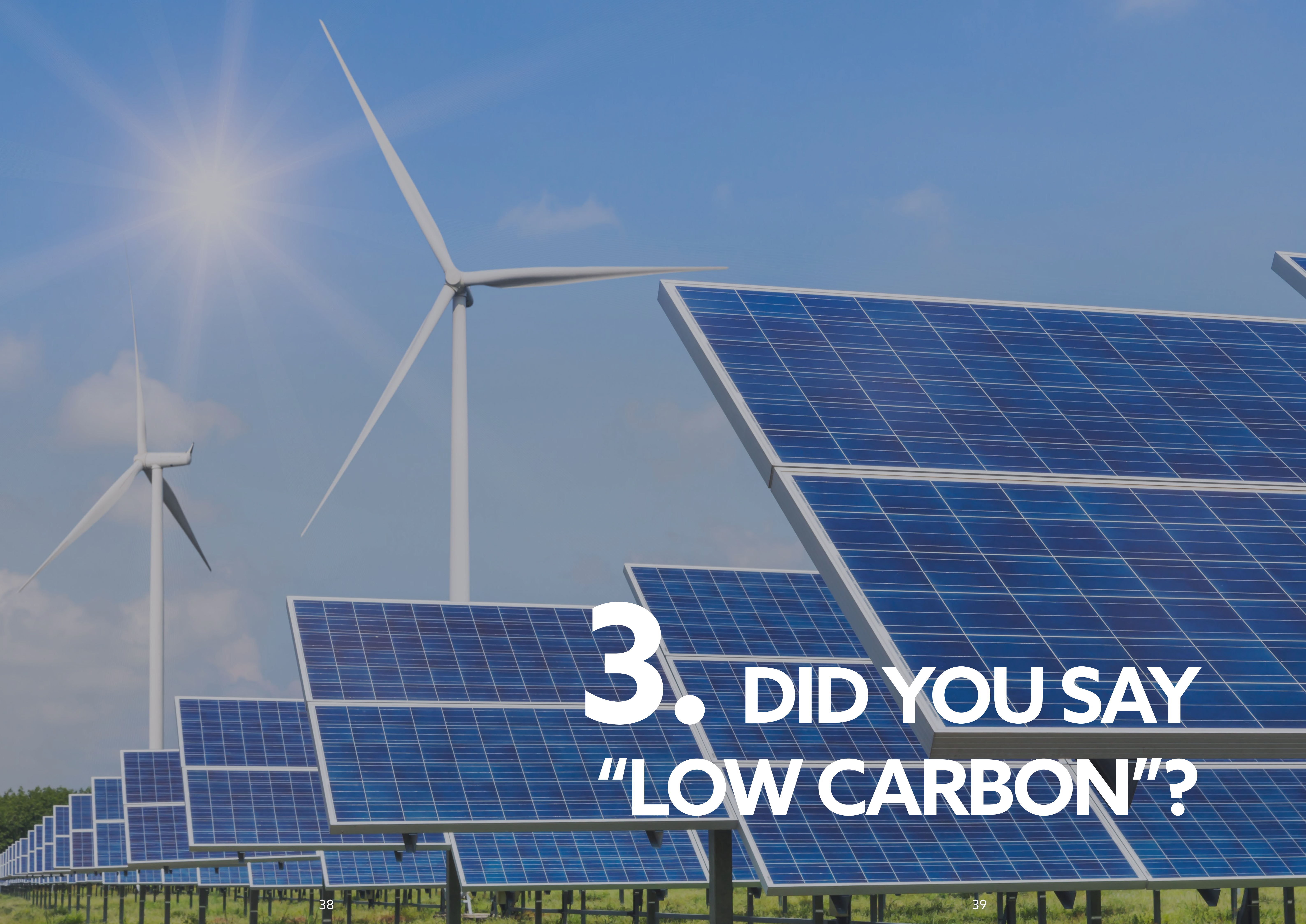
G16. Average annual energy investment 2016-2020, and in the Net Zero Emissions by 2050 Scenario



Source: [WEO 2021](), IEA



> ***Companies are still approving billions of dollars of investment in major projects that are inconsistent with the 1.5°C Paris climate target, and even those with "net zero" commitments are continuing to explore for new oil and gas.***
>
> *Carbon Tracker, [September 2021]()*



3. DID YOU SAY "LOW CARBON"?

The NZE fails to provide a truly sustainable pathway by massively relying on biomass. It also fails to account for the various risks and limitations of nuclear energy. This means that the NZE undermines the role played by renewable energies in the global transition.

a. The biomass risky gamble

In the NZE, **biomass becomes a major energy source by 2050, rising from 62 EJ in 2020 to 102 EJ in 2050** (see G17), thus making up for 19% of total energy supply and almost as much as solar energy (109 EJ). "Modern biomass" swiftly replaces traditional uses that are phased-out by 2030.[58] **The total land area dedicated to bioenergy production in the NZE increases from 330 million hectares (Mha) in 2020 to 410 Mha in 2050,[59] the size of India and Pakistan combined and more than a fourth of total available cropland.[60]** While the bulk of the increase in biomass use is due to modern solid biomass, the NZE also features a significant role for biofuels – the production of which nearly triples by 2030[61] - and biogases – that more than double by 2030.[62]

The NZE relies on BECCS to capture 1.3 $GtCO_2$. While this amount falls within the sustainability range from the IPCC's SR1.5 (0.5-5 $GtCO_2$), it still raises questions regarding its impact on land-use and its feasibility in a context of overall massive carbon capture development (see part 2.a). Furthermore, **the NZE is more reliant on bioenergy than other 1.5°C scenarios**. It greatly exceeds the amounts of bioenergy used in IPCC P1 and P2 scenarios (see D1).

Furthermore, **biomass use for power generation can emit large quantities of CO_2, a fact that does not seem to be accounted for in the NZE.** Notably, the use of wood and forest biomass could generate greater emissions per unit than coal and contribute to deforestation worldwide.[63] However, biomass is broadly considered as a renewable energy by the IEA, accounting for 28% of the renewable energy production in 2050. **More than half of the IEA's bioenergy comes from forest and wood (55 EJ). The IEA also mentions biomass as a "low emission fuel" that can be used to reduce emissions from coal power plants,** despite the fact that the European Academies' Science Advisory Council (EASAC) underlines that "it is of considerable concern that scientific analyses indicate that, far from reducing GHG emissions, replacing coal with biomass for electricity generation is likely to initially increase emissions of CO2 per kWh".

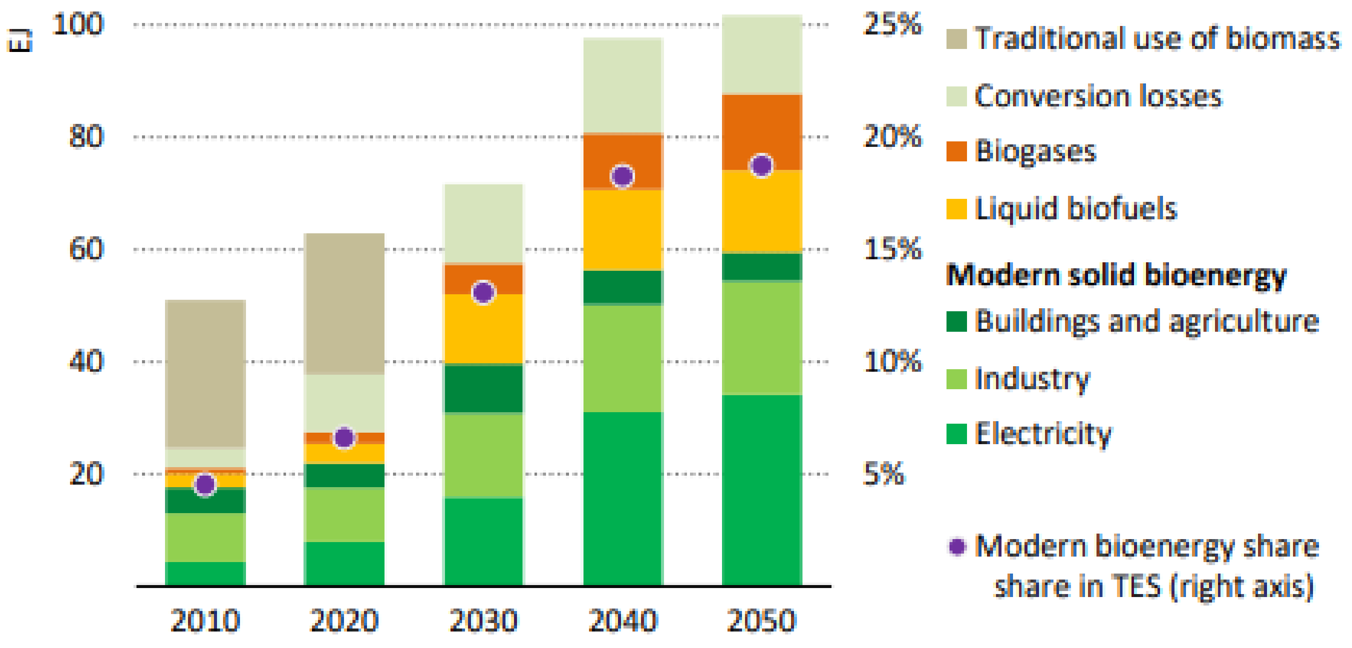
The IEA integrated a "low biomass" case in its May report, where land use for dedicated bioenergy crops and forestry plantations remains at today's level (330 Mha) in 2050 and biomass produces 90 EJ of energy in 2050. It admits that it is possible to achieve net-zero without expanding land use for bioenergy but indicates that it would require additional investments – notably in solar, wind and energy networks – and come at an overall significantly higher cost. However, **this "low biomass" case has not informed the WEO 2021**. The IEA's preference for massive – and seemingly unsustainable and unviable – biomass use seems to emanate from the fact that it allows for the continued use of existing fossil infrastructure, and therefore minimizes the risk of stranded assets and limits the need for new investments.

According to the Energy Transitions Commission (ETC), 40 to 60 EJ of sustainable biomass could be generated globally each year by 2050, compared to 62 EJ of biomass energy in 2020 and 102 EJ in 2050 foreseen in the NZE. The ETC underlines that producing sustainably 60 EJ of biomass would require radical changes to free-up land and develop new biomass sources. Following the ETC's recommendations, it is clear that biomass production should be reduced – not increased – at the global level. The ETC also underlines **the necessity to consider the competing uses of biomass, and thus to opt for sustainable alternatives where they are available, such as in the power sector**.

b. Renewable energy: the key to the transition

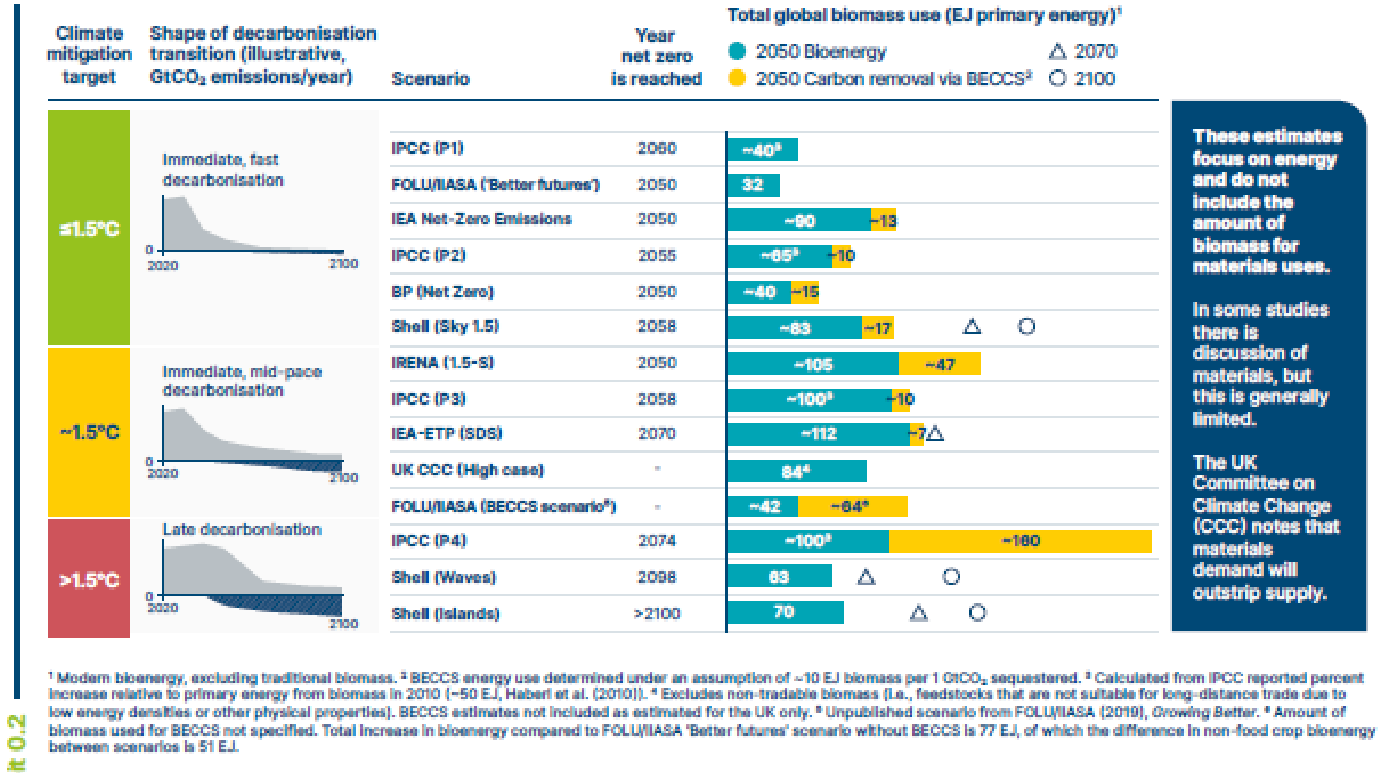
The IEA logically puts renewable energies at the forefront of transition, making their massive development one of the key milestones of

G17. Total bioenergy supply in the NZE



Source: Net Zero by 2050, IEA

D1. Comparison between bioenergy reliance in various climate scenarios



Source: Bioresources within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible, Energy Transitions Commission

the NZE. The IEA states that **"solar PV and wind lead the way, thanks to low costs, widespread availability and policy support [...] their capacity more than triples over the next decade**, which is nearly enough to meet all electricity demand growth to 2030", and their share of generation rises from under 10% in 2020 to nearly 30% in 2030 (see G.18).

Concretely, in the NZE (see G19):

- **Solar and wind power supply rises from 10.4 EJ[64] in 2020 to 60.5 EJ in 2030[65] and 190 EJ in 2050. Solar power capacity is multiplied by almost six from 2020 to 2030 and wind power capacity by five.**
- Hydropower slightly increases from 2020 to 2030[66] (+ 35%) and continues to rise to nearly double by 2050 to reach 30.5 EJ.[67]
- Other renewables - geothermal, and marine (tide and wave) energy for electricity and heat generation – also significantly increase. It triples from 2020 to 2030 – from 4,5 to 13,2 EJ – and reach 31,8 EJ by 2050.

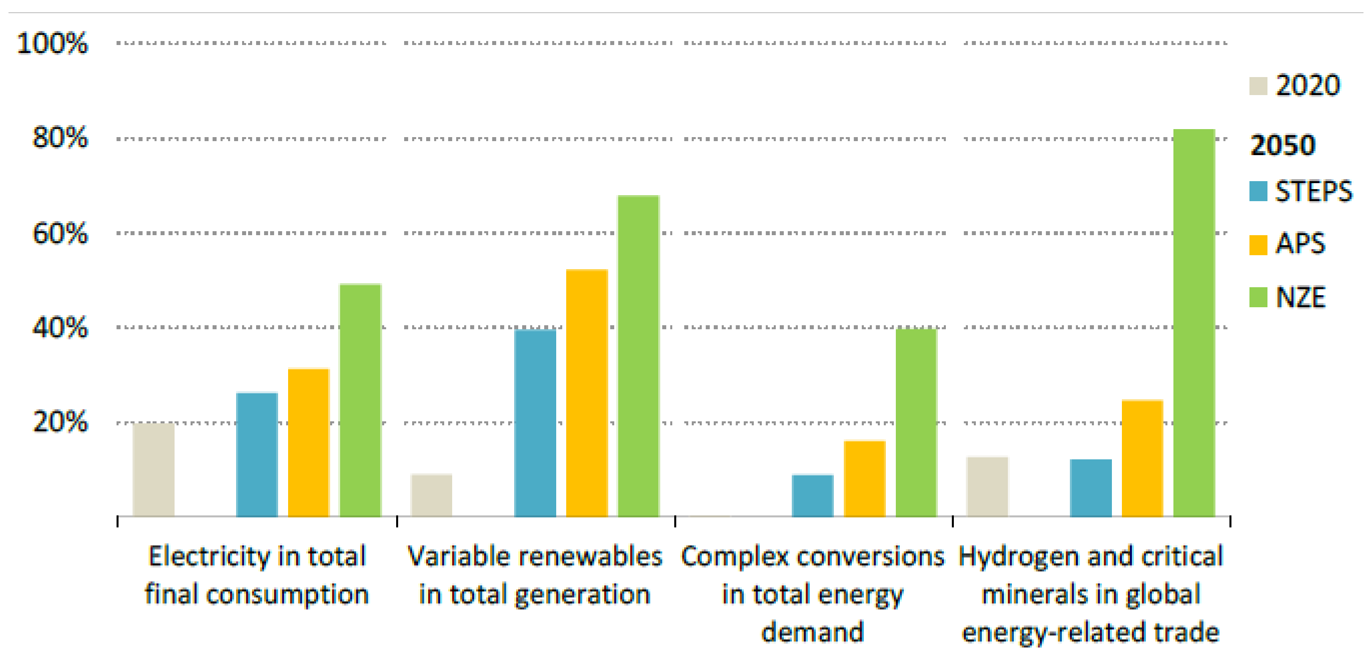
While the projected increase in solar and wind capacity is massive (see G19), it relies on several assumptions that limit renewable energy deployment.

The IEA has a long track record of underestimating renewable energy development. **While the IEA projects an annual growth of solar power of 21% from 2020 to 2030, this then slows down so that overall average growth from 2020 to 2050 is only 11%.** Similarly for wind energy, NZE shows annual growth of 17% in the current decade but only 9.6% annual growth over the period to 2050. This slowdown in renewable energy buildup after 2030 appears totally unjustified. It could be explained by the relatively limited place of electricity – which makes up 49% of total energy consumption in 2050 compared to 70% in the Energy Transition Commission work - the aforementioned bets on CCS (see part 2.a) and biomass (see part 2.c), and the development of nuclear energy (see part 3.b). Together these limit renewable development for electricity generation, heat generation and the production of "green" gases.

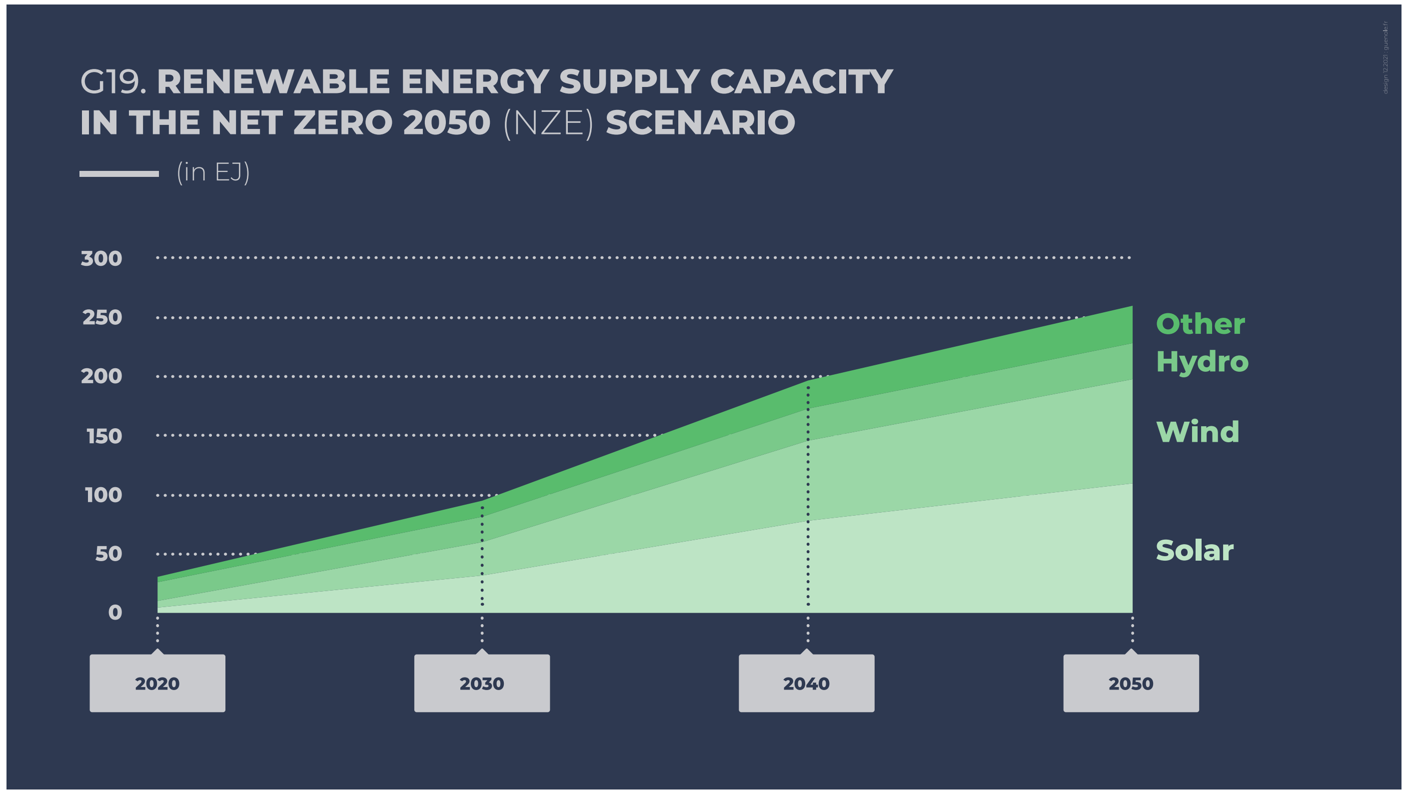
It is worth noting that **global and regional renewable energy potential largely exceed the energy demand (see D2), meaning 100% renewable energy is doable. Several scenarios already opt for such pathways,[68]** for example:

- The "One Earth Climate Model" features global 100% renewable energy pathways

G18. Key indicators of energy system change by scenario



Source: WEO 2021, IEA



G19. **RENEWABLE ENERGY SUPPLY CAPACITY IN THE NET ZERO 2050** (NZE) **SCENARIO**

Source: Reclaim Finance based on data from WEO 2021

(see Box - The One Earth Climate Model (OECM) sectoral pathways).

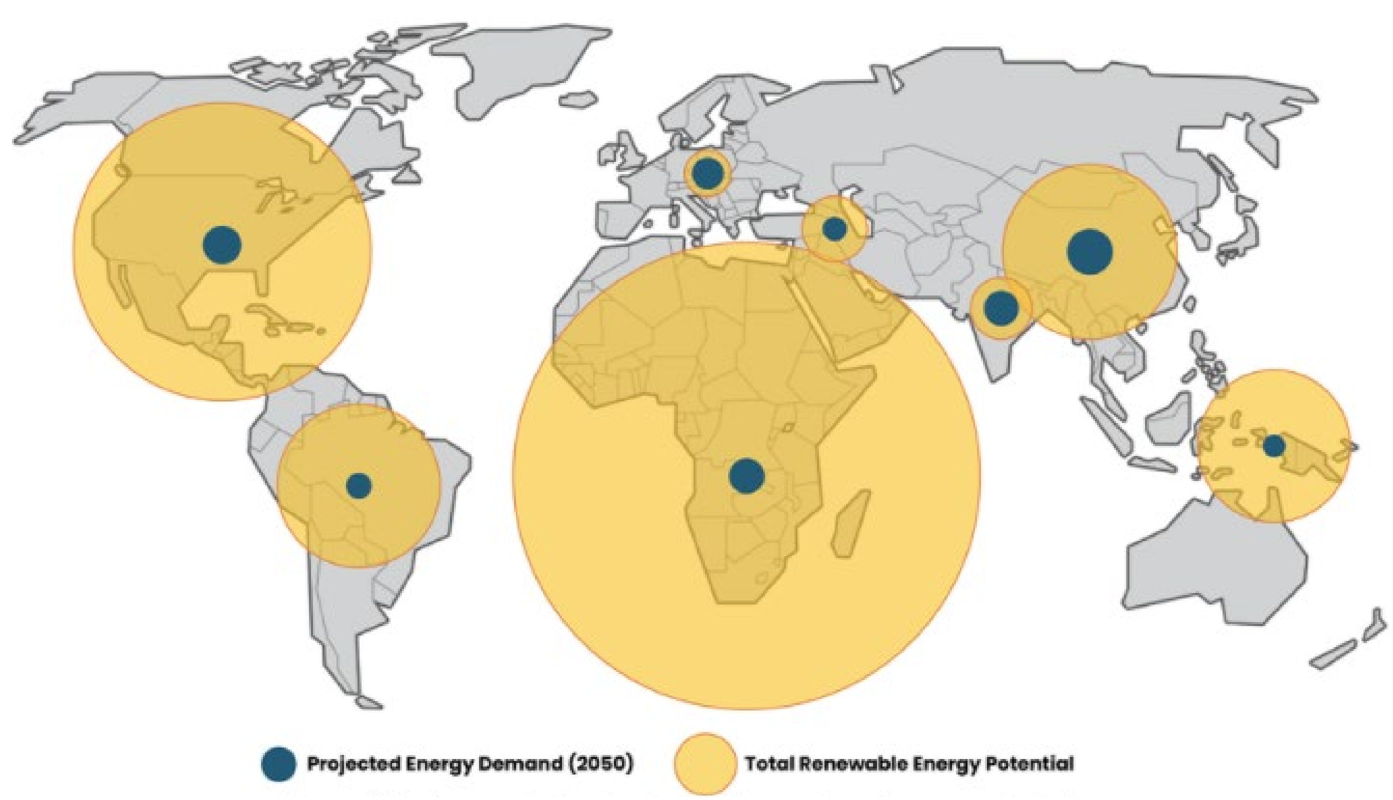
- Climate Analytics' 1.5°C pathway explorer provides 100% renewable trajectories for 40 countries worldwide.
- For Europe:
  - The LUT University and Solar Power Europe provided 100% renewable scenarios for Europe, including a scenario enabling a fossil fuel phase-out by 2040.[69]
  - The "Paris Agreement Compatible Scenarios for Energy Infrastructure" (PACS) from CAN, EEB, RGI and REN21 aim at reducing greenhouse gas emissions by 65% by 2030, reaching net-zero greenhouse gas emissions by 2040 with 100% renewables in all sectors.
  - Climate Analytics developed 1.5°C pathways for the EU and 9 Member states with a GHG emissions reduction target of between 61-74% below 1990 levels by 2030, a share of renewable power generation in 2030 of between 76-90% and of unabated fossil gas in the power sector of between 3-8%, coal phased out by 2030 and net-zero GHG emissions between 2040 and 2050. The scenario reaches 100% renewable energy by 2040.
- Several national roadmaps for 100% renewable energy have been proposed by the World Future Council, UTS and partners. Notably for Bangladesh, Costa Rica and Tanzania.
- Negawatt proposes a 96% renewable pathway for France[70] and RTE proposes several transition scenarios including a 100% renewable scenario.[71]

These scenarios require greater efforts to reduce global energy consumption but their scope and the assumptions underpinning them vary drastically. For example: Negawatt's scenario for France divides primary energy consumption by three by 2050, focusing on energy efficiency and conservation as well as renewable energy development,[72] and integrates detailed modelling on the land sector[73] while RTE looks solely at the energy sector, with energy efficiency and conservation reducing by 34% electricity consumption in 2050.[74] **While conservation ultimately depends on a choice between**

different models of society[75] **it is clear that the energy transition requires unprecedented progress on energy efficiency as highlighted by the IEA in its Energy Efficiency 2021 report.** Today, much of the energy produced - an estimated 54% of the UK electricity supply and 66% of the electricity generated in the US - is lost before being consumed due to the inadequacy of distribution networks. Improving the network could therefore significantly reduce the need for new power production infrastructures.

In the last WEO, the IEA underlined that world's best solar power schemes now offer the "cheapest electricity in history". However, the IEA has repeatedly been **criticized over many years for repeatedly underestimating the rate at which renewable costs have declined.** It seems to have repeated this error in NZE with cost assumptions that undermine renewable energy development: the costs of solar and batteries fall at only 5% a year from 2020 to 2030, and then 1-2% a year after 2030, whereas these costs have fallen by much more in recent years.[76] In the US, the IEA uses a levelized cost of energy (LCOE) of solar PV of $50/MWh in 2020, $30 in 2030 and $20 in 2050 while Lazard already situate solar LCOE between $28 and $41/MWh in 2021[77] (see G20). Similarly, the IEA's 2020 LCOE for US offshore wind reaches $115/MWh, 28% higher than Lazard's median estimate ($83/MWh)[78](see G20). The high assumptions on the cost of renewables (and batteries) notably contributed to raising the projected cost of the "low CCS", "low nuclear"[79] and "low biomass" cases featured in the IEA NZE report by undermining the competitiveness of these technologies compared to fossil-based alternatives – even retrofitted with costly and uncertain CCS – or nuclear energy. Grant and al. found that low-cost renewable energies would significantly erode the value of CCS, making it uneconomic in the power sector and for hydrogen production. With solar power and batteries diminishing by respectively 72 and 80% from 2020 to 2030,

D2. Regional renewable energy potential compared to projected energy demand in 2050



Source: Fossil fuel exit strategy, Sven Tesk and Sarah Niklas

RethinkX underlines that reaching a 100% renewable US power system by 2030 is the cheapest option and make further investment in coal, gas or nuclear unviable. These findings are corroborated by Australia's national science agency - CSIRO - that estimates renewables are far cheaper than alternatives after allowing for integration costs of storage, transmission and grid services.

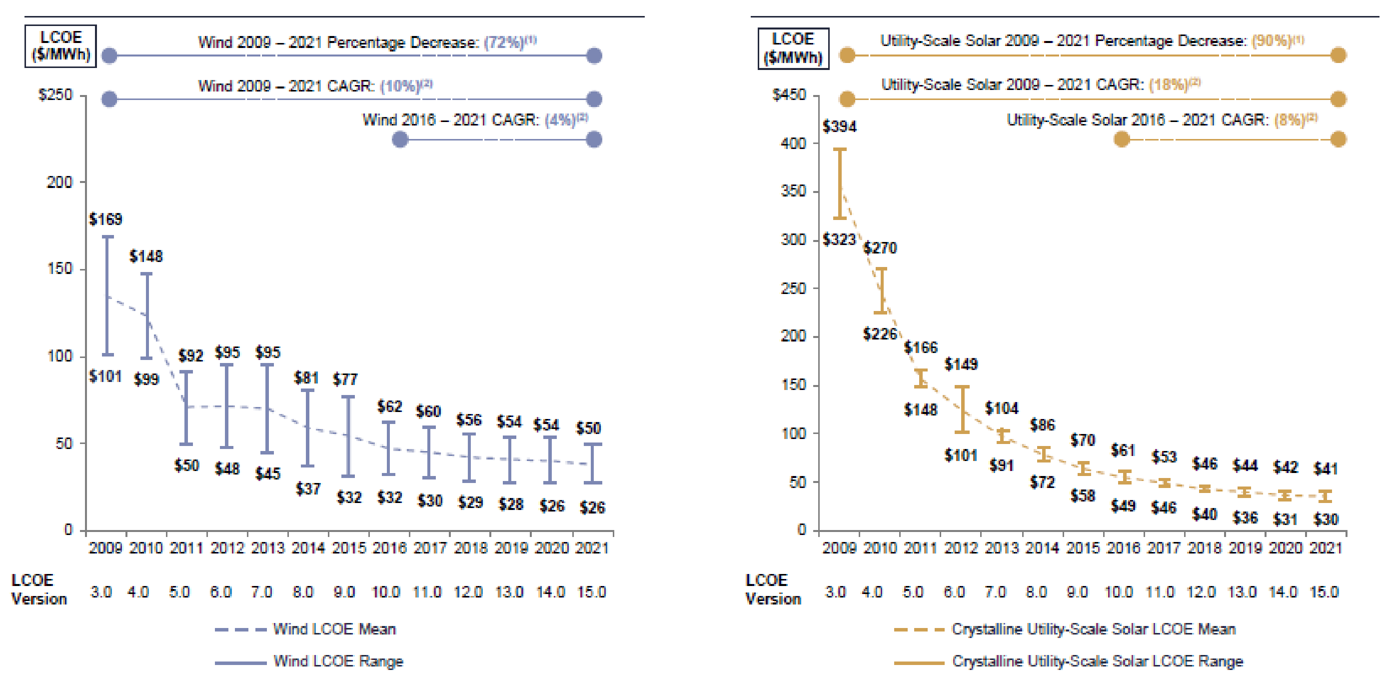
It is worth noting that – **even following the IEA's cost assumptions - solar and onshore wind energy already produce cheaper electricity than fossil fuel or nuclear and that this gap will increase in the coming years in all scenarios.** The IEA itself writes that "low technology costs and the availability of low-cost financing in many markets means that policy makers could establish enabling conditions in which **up to 60% of the additional generation of solar and wind in the NZE could be achieved at no additional cost to consumers".**

The IEA has emphasized that the late 2021 energy price spike is not caused by the increasing role of renewables in the energy mix but is rather the consequence of a rapid economic recovery "putting major strains on parts of today's energy system, sparking sharp price rises in natural gas, coal and electricity markets". While renewable energies actually contributed to protect consumers from higher energy prices, the rise of energy bills is directly linked to higher competition for fossil fuel energy and constrained supply.[83]

The WEO 2021 shows that, in advanced economies, overall energy bills are on average nearly 10% lower in the NZE than in the STEPS in 2050. In emerging market and developing economies, the total household energy bill is lower in the NZE than in the STEPS in 2030 (see G21) and ends up broadly the same in the two scenarios by 2050. Households no longer need to pay for "natural gas for heating and oil for cars".

Taking stock of the current energy price situation, the IEA also modelled the impact of a fossil fuel price shock in 2030 on household energy bills in the STEPS and NZE.[84] It found that, **in the NZE, the additional cost to households in advanced economies**[85] **is nearly 40% less than in the STEPS, and in emerging market and developing economies it is 20% lower** (see G22). The IEA explains that "the impact of higher commodity prices

G20. Unsubsidized LCOE for wind and solar power - 2009-2021



Source: Levelized cost of energy analysis V.15, Lazard

Box 8 – Critical minerals: no crisis in sight

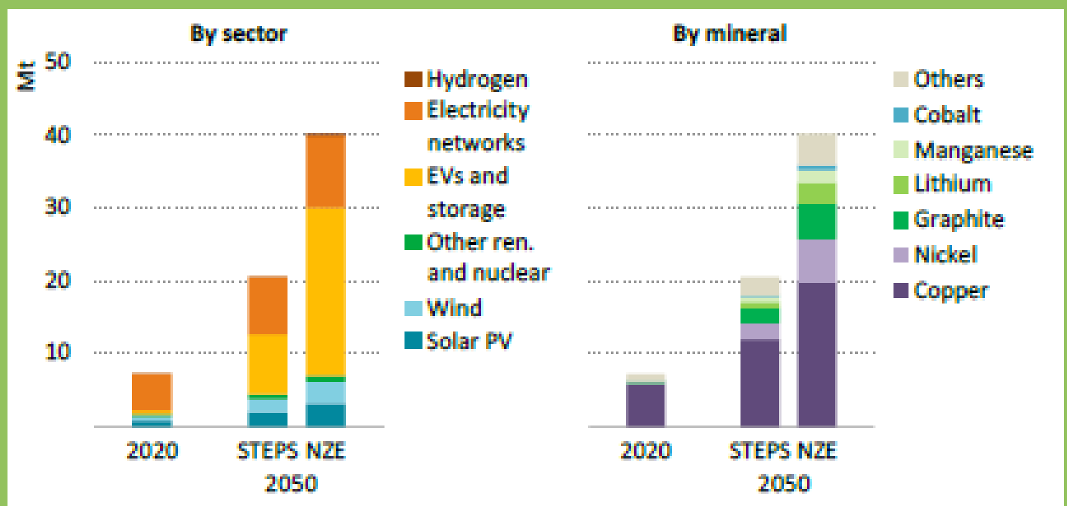
The IEA stresses that "higher or more volatile prices for critical minerals could make global progress towards a clean energy future slower or more costly" and indicates that recent price rallies[80] for critical minerals "could make solar panels, wind turbines, EV batteries and grid lines 5-15% more expensive". According to the NZE, the prices will be determined by how industry and governments invest in new supply and how consumers respond to rising prices

In its report devoted to critical minerals, **the IEA clearly acknowledges that the world has ample critical mineral reserves.**[81] For example, the IEA notes that we have 170 times as much lithium reserves as annual demand and that our lithium reserves have increased by 42% over the last eight years as higher prices and the prospect of rising demand have drawn out new investment.

If the IEA rightfully stresses that a clean energy system will require much more critical minerals than a fossil-based system, it forgets to underline that it will massively reduce the need for other materials to be extracted. According to Carbon Tracker, demand for fossil fuels in 2019 was over 13,000 million tonnes (mt), and global demand for critical minerals in the renewable sector in 2020 was 7 mt. Under the IEA's NZE scenario, demand for critical minerals in the renewable sector will rise to 40 mt in 2050. **The fossil-fuel system requires 325 times more material than its NZE alternative.**

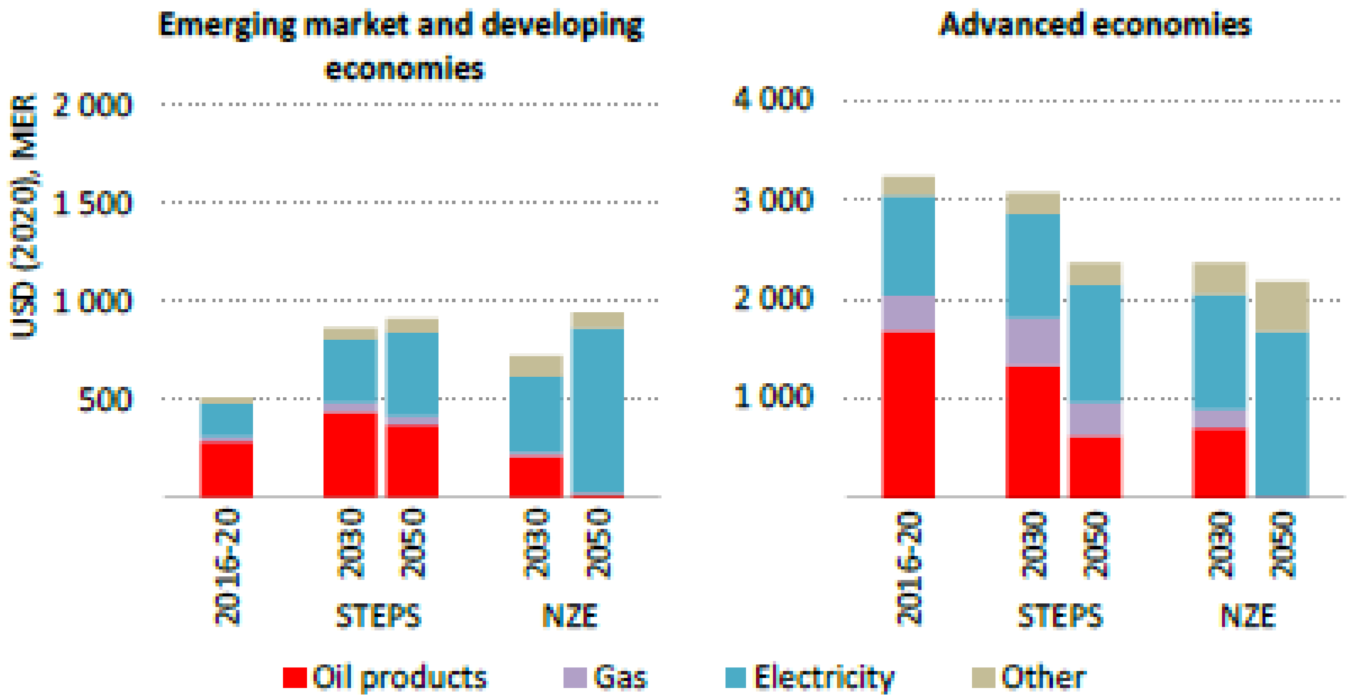
While the rise in critical mineral demand should be monitored and be anticipated, it can be overcome by major investments in their exploitation and will significantly contribute to lowering other mining and drilling operations. Furthermore, **critical minerals can and should be recycled**[82] **to lower production needs and their environmental impacts and initiatives should be taken to prioritize the use of critical minerals and avoid inefficient uses. If the supply were to be limited at some point, the IEA itself notes that unlike for oil and gas - where a supply shortage can immediately lead to price spikes and shortage for consumers - "a shortage or spike in the price of a mineral affects only the supply of new EVs or solar plants".**

Mineral requirements for clean energy technologies by scenario



Source: WEO 2021, IEA

G21. Average household energy bills by fuel in the Stated Policies and Net Zero Emissions by 2050 scenarios

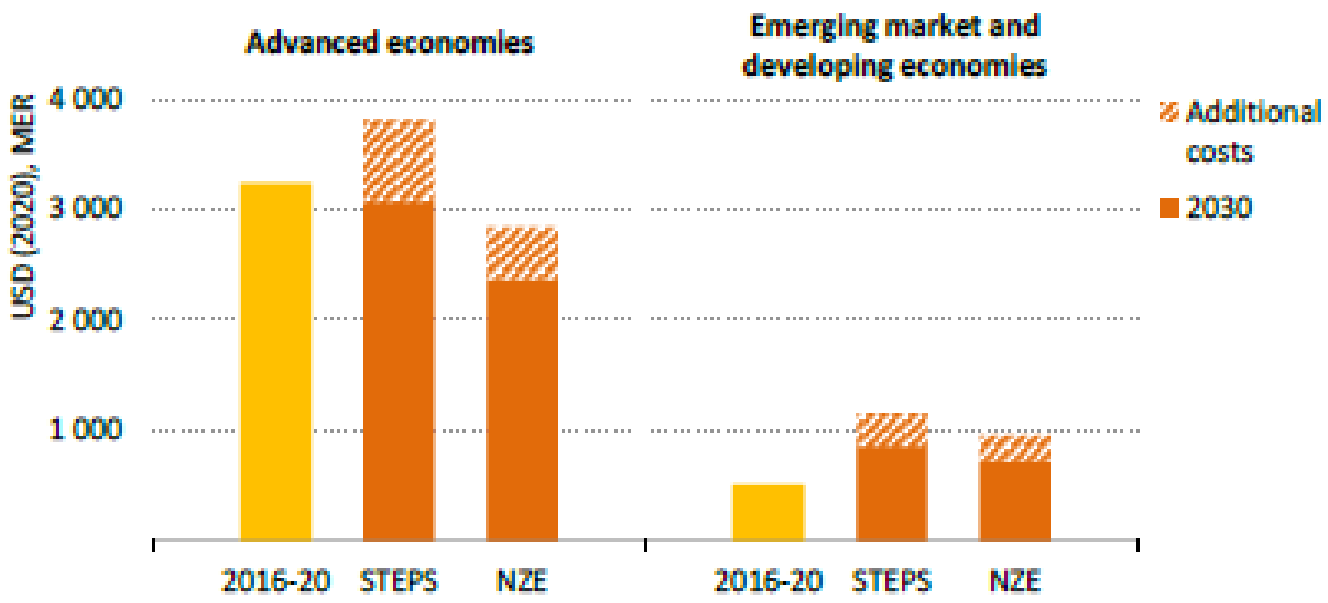


Source: WEO 2021, IEA

is dampened by more rapid efficiency gains, by reduced direct use of oil and gas, and by electricity having a higher share in total household energy expenditure". In advanced economies, the price shock still leaves total costs to consumers in the NZE below the level of costs in the STEPS without a price shock.

An analysis from Polish think-tank Instrat, indicates that switching from coal to

G22. Impact of a commodity price shock on average household energy bills in 2030 by scenario



Source: WEO 2021, IEA

renewable energies would allow Polish households to save €100-170 a year by 2030. The Instrat scenario does not rely on more gas plants that those already operating or under construction in Poland, thus improving the country's energy security and covering all of its electricity needs with renewable energy only almost 50% of the time.

c. Nuclear at a crossroads

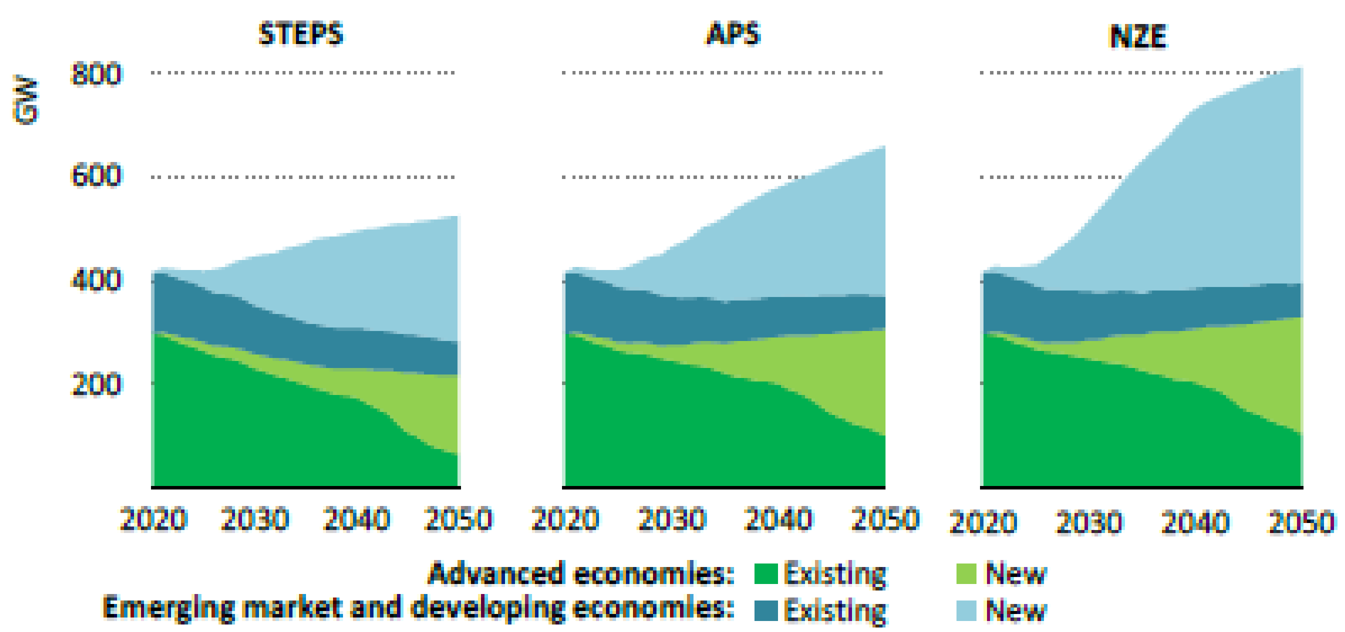
The NZE features a significant increase in nuclear power capacity, especially in emerging markets and developing economies. Nuclear provides 41.4 EJ in 2030 - a 41% increase compared to current levels - and reaches 60.6 EJ in 2050 (see G23).

Much of the increase up to 2030 is due to the nearly 60 GW of capacity under construction at the start of 2021. Beyond 2030, there are over 100 GW of planned projects that have not entered the construction phase and **higher uncertainty for already ageing reactors**. By 2040, about three-quarters of the current nuclear fleet in advanced economies will exceed 50 years of operations, thus leading to a wave of retirements. The IEA also sees prospects for technologies such as small modular reactors, though it underlines the need to accelerate innovation in the area.

Apart from generating major concerns around the disposal of radioactive waste and potential incidents,[86] the IEA's reliance on nuclear energy could be risky for the overall transition for several reasons:

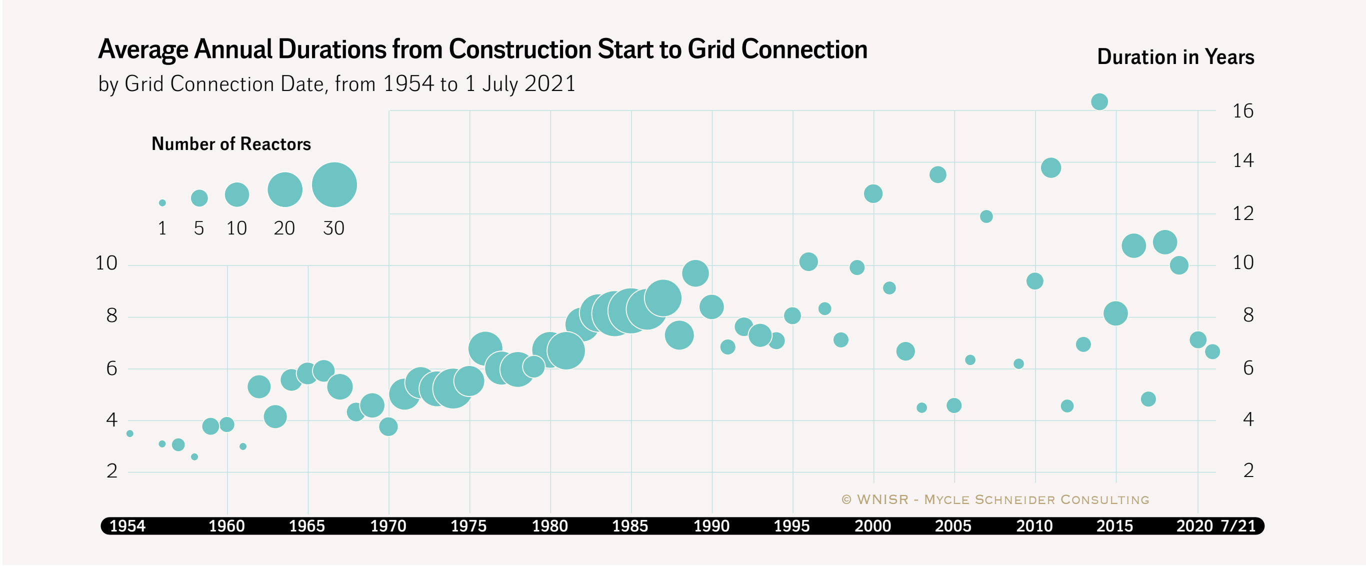
- Building new nuclear reactors takes many years, and often considerably more time than initially planned.
- In its 1.5°C special report, the IPCC points to the fact that "the current time lag between the decision date and the commissioning of plants is observed to be 10-19 years". In recent years, a large majority of nuclear plants took more than eight years since their construction start to be connected to the energy grid (see G24). This means that a major shift to nuclear power would imply that many of the current fossil-fueled power plants would stay in operation (with their lifetime possibly extended) during the long reactor development period, making it impossible to achieve climate targets.
- Over the years, nuclear has proven to be an expensive energy source that fails to keep up with cost reductions for renewables and may require massive unexpected public spending in the coming years. According to the World Nuclear Report 2021, and

G23. Nuclear power capacity by scenario, 2020-2050



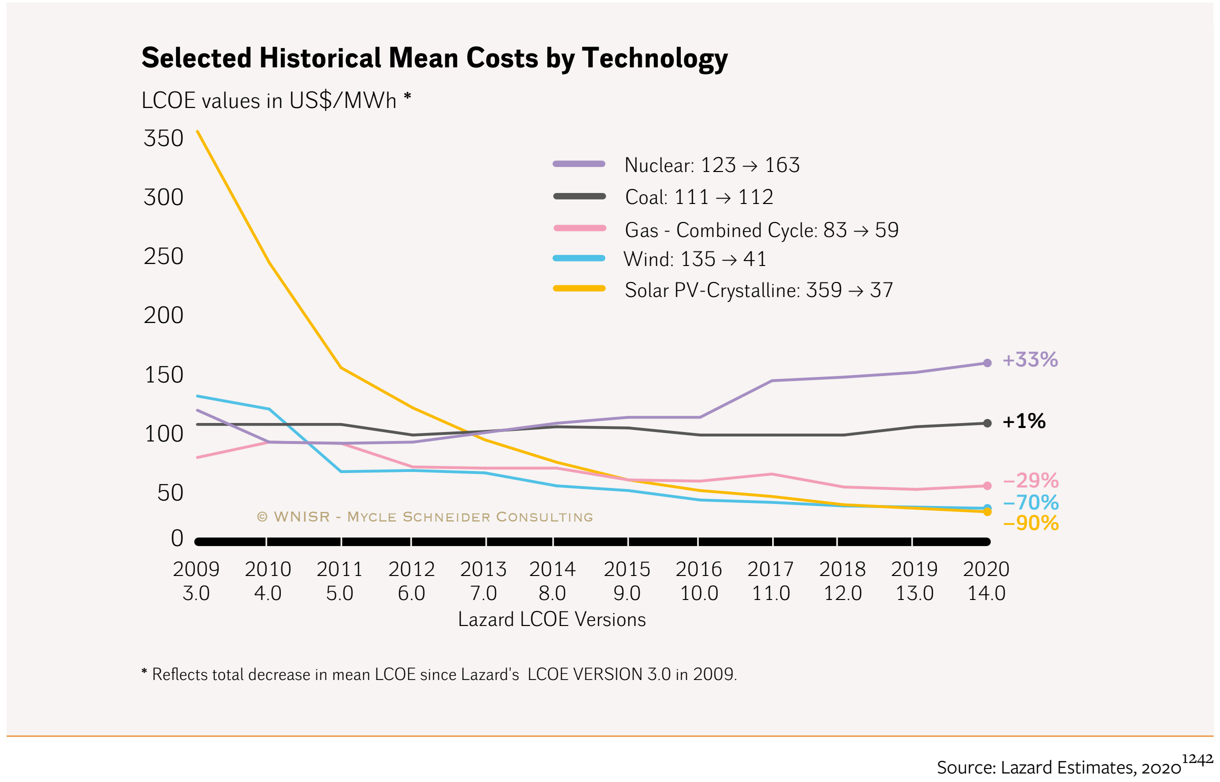
Source: WEO 2021, IEA

G24. Average annual construction times in the world



Source: World Nuclear Industry Status Report 2021

G25. The declining costs of renewables vs. traditional power sources



Notes

LCOE=Levelized Cost of Energy

*This graph reflects the average of unsubsidized high and low LCOE range for a given version of LCOE study. It primarily relates to the North American renewable energy landscape but reflects broader/global cost declines.

Source: World Nuclear Industry Status Report 2021

Box 9 – Fossil fuel subsidies still going strong

The increasing competitiveness of renewables energies and the benefits of developing these clean energies for consumers should be compared to the continued high level of financial and policy support governments devote to fossil fuels. The IEA underlines **that fossil fuel consumption subsidies are bouncing back - after a sharp decline due to the slow down of economic activities in 2020 – to reach a projected $440 billion in 2021.**

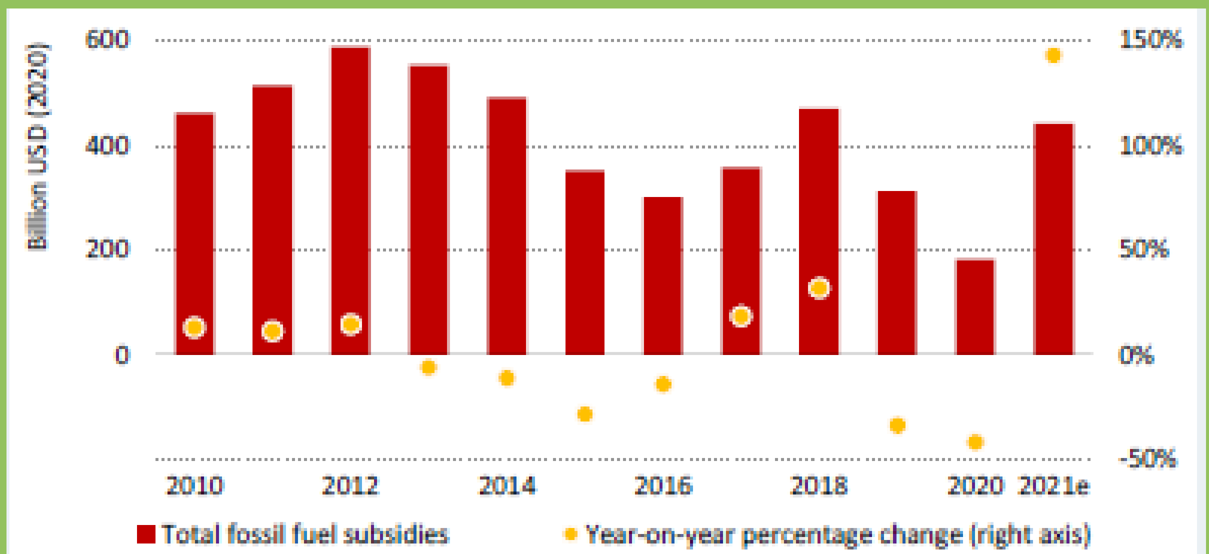
The Production Gap Report also underlines that **G20 countries have directed "around $300 billion in new funds towards fossil fuel activities since the beginning of the COVID-19 pandemic** — more than they have toward clean energy".

IRENA underlines that in 2017 "the costs of unpriced externalities and the direct subsidies for fossil fuels" reached $3.1 trillion, including $447 billion in direct fossil fuel subsidies, compared to $128 billion for renewable power generation.

These subsidies are only the tip of the iceberg when it comes to total public support to fossil fuels – the **IMF estimates global fossil fuel subsidies rose to $5.9 billion in 2020**. They significantly contribute to increasing the competitiveness of fossil fuels compared to renewable energies.

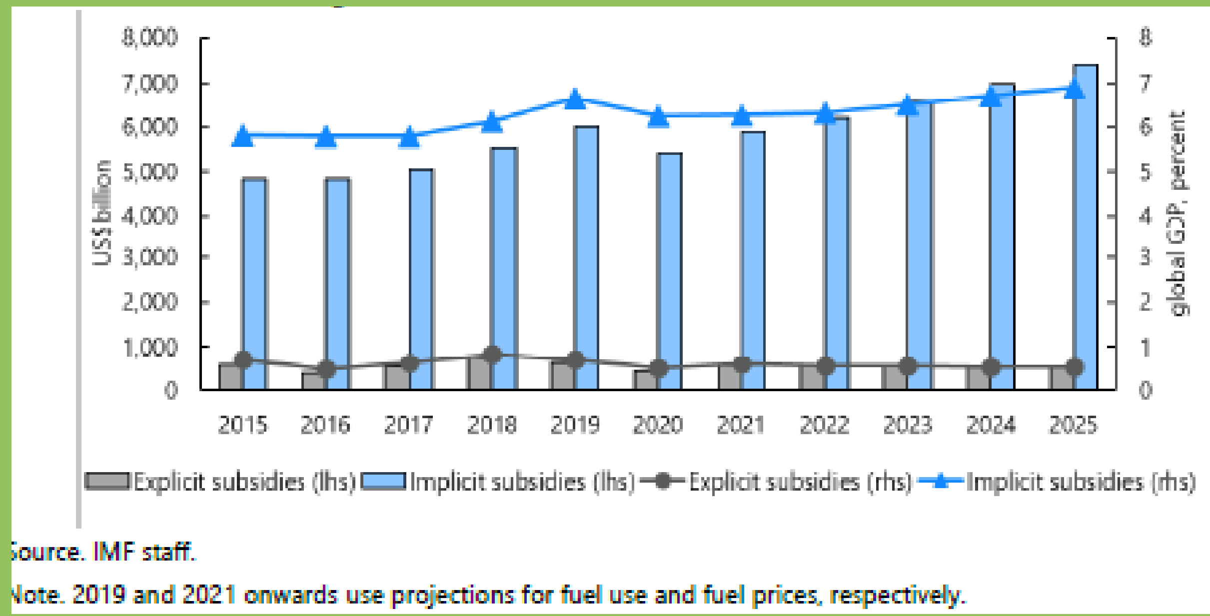
Fossil fuel advocates are quick to argue that massive renewable energy development requires significant subsidies and public support. While this is only partially true, with a large share of renewable energy deployment being already cost effective – as shown by Energy Watch for the German power system - **a major step in the right direction can be achieved by shifting public subsidies away from fossil fuels and toward clean alternatives. In fact, with the rebalancing of energy subsidies from fossil fuel to renewable energies, IRENA estimates that global fossil fuel subsidies could be 45% lower in 2050 than without any change to current plans and policies.**

IEA - Global fossil fuel consumption subsidies, 2010-2021



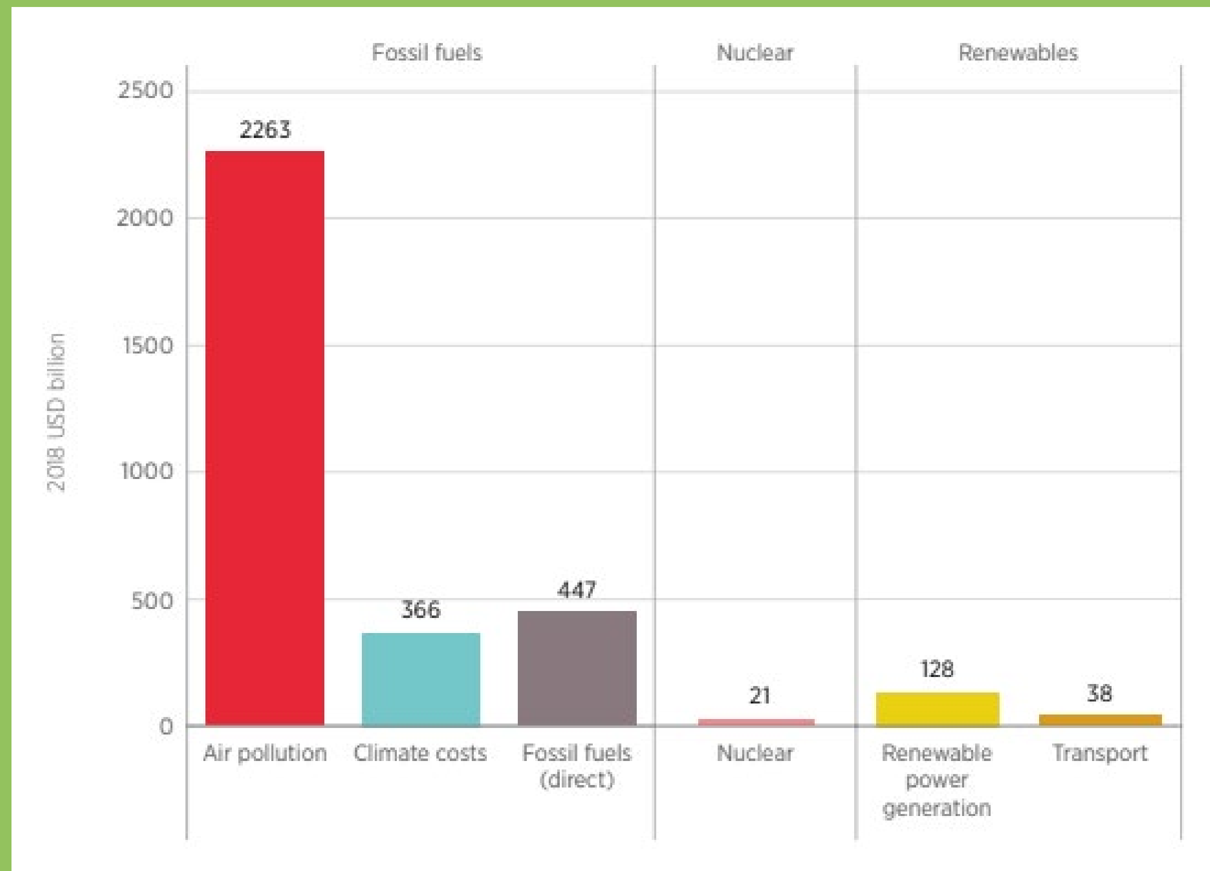
Source: WEO 2021, IEA

IMF - Global fossil fuel subsidies over time



Source: Still Not Getting Energy Prices Right: A Global and Country Update of Fossil Fuel Subsidies, IMF

IRENA - Total energy sector subsidies by fuel/source and the climate and health costs, 2017

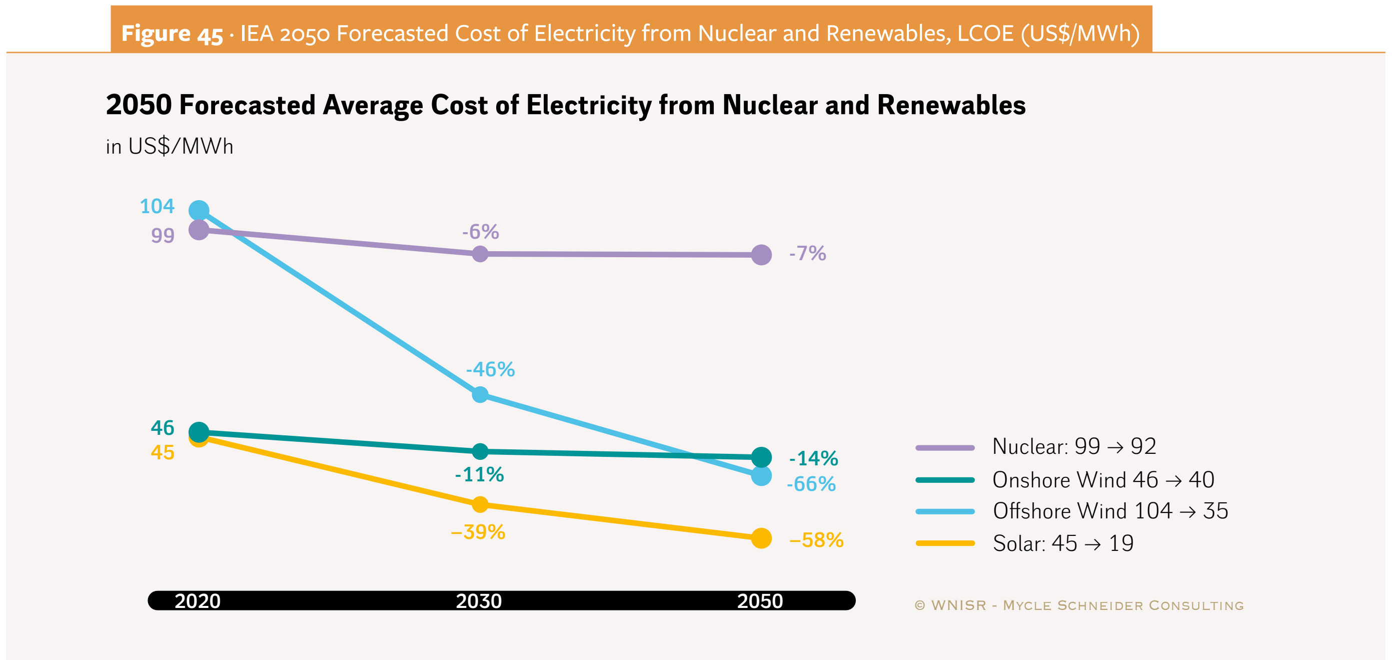


Source: Energy subsidies, IRENA

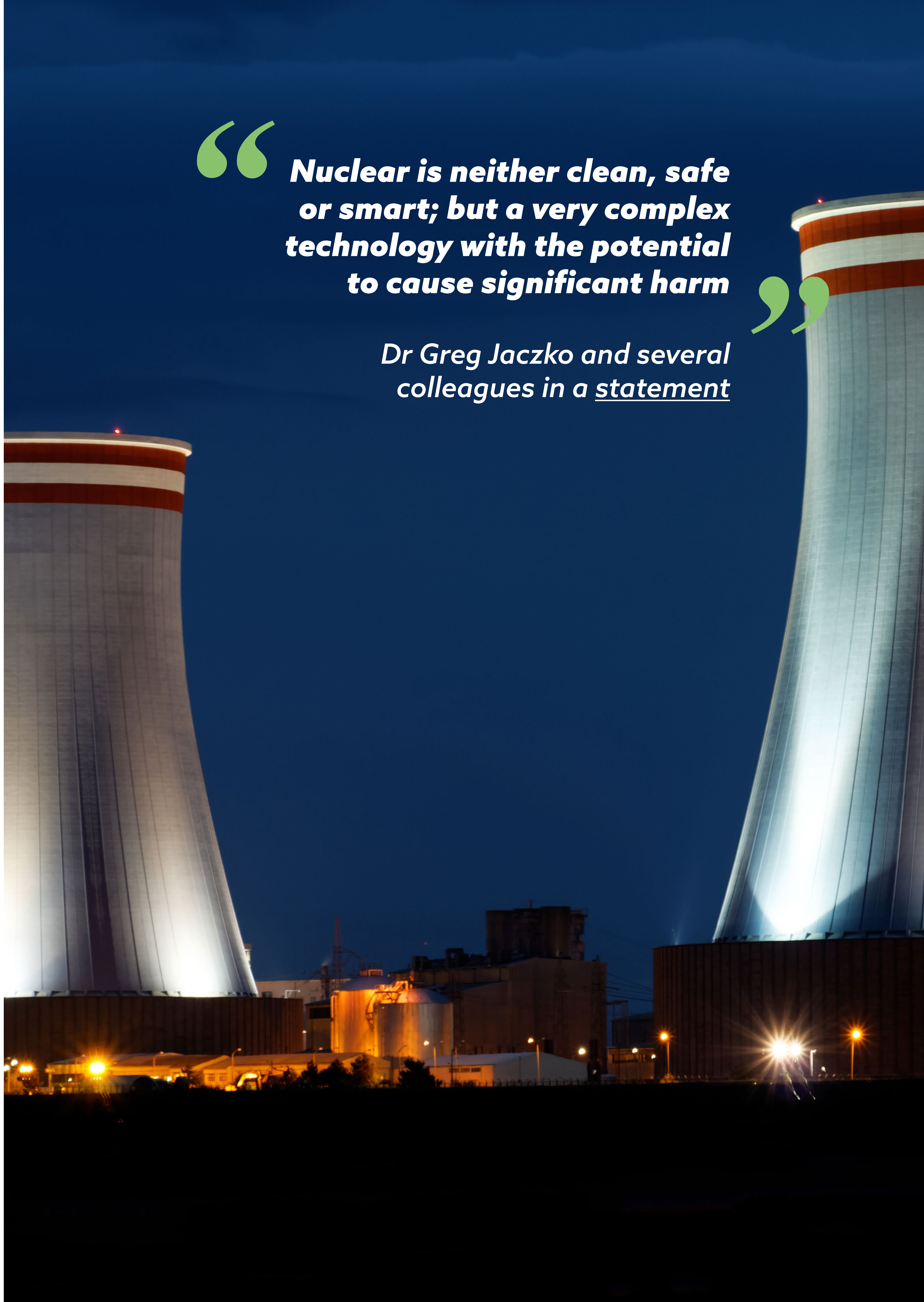
based on data from Lazard (see G25), **over the past decade levelized cost estimates for nuclear energy in the US increased by 33%, while costs for utility scale solar and wind dropped by respectively 90 percent and 70%.**[87] **The IEA WEO 2021 cost estimates themselves show an average cost of nuclear power well-above the cost of renewable energies** (see G26). Furthermore, **in recent years, costs have soared for EPRs, the most recent generation of nuclear reactors.** The French Court of Accounts slammed the lack of government oversight of the Flamanville-3 EPR construction project, which is at least ten years behind schedule and recalculated the cost at over €19.1 billion.[88] Furthermore, nuclear cost estimates often fail to consider the growing cost of nuclear waste disposal and decommissioning.

- The World Nuclear Report 2020 underlined that small modular reactors (SMRs) — often presented as a key area of development by the industry — show "few signs that would hint at a major breakthrough [...] either with regard to the technology or with regard to the commercial side". **The 2021 version of the report indicates that "the evidence so far suggests that the smaller reactor projects may suffer from many similar challenges as large nuclear reactors and maybe from some new ones" and underlines that "the amplification of the talk about SMRs and related media coverage over the past year is not reflected by any major industrial achievements on the ground".** In fact, according to the report, "SMRs, like large reactors, will continue to be subject to delays and cost overruns, and the high likelihood that they would not be economical even under the most favorable circumstances".
- **Nuclear reactors are potentially vulnerable to climate change.** Climate change – by affecting cooling systems or generating damages through extreme weather events – can require the shutdown of nuclear reactors. Climate-related unavailabilities reduced electricity production from French nuclear reactors by 1.4 Twh annually in the past six years and 3 Twh in 2020.

G26. IEA 2050 forecasted cost of electricity from nuclear and renewables, LCOE (US%/MWh)



Source: World Nuclear Industry Status Report 2021



CONCLUSION

After WEO 2021

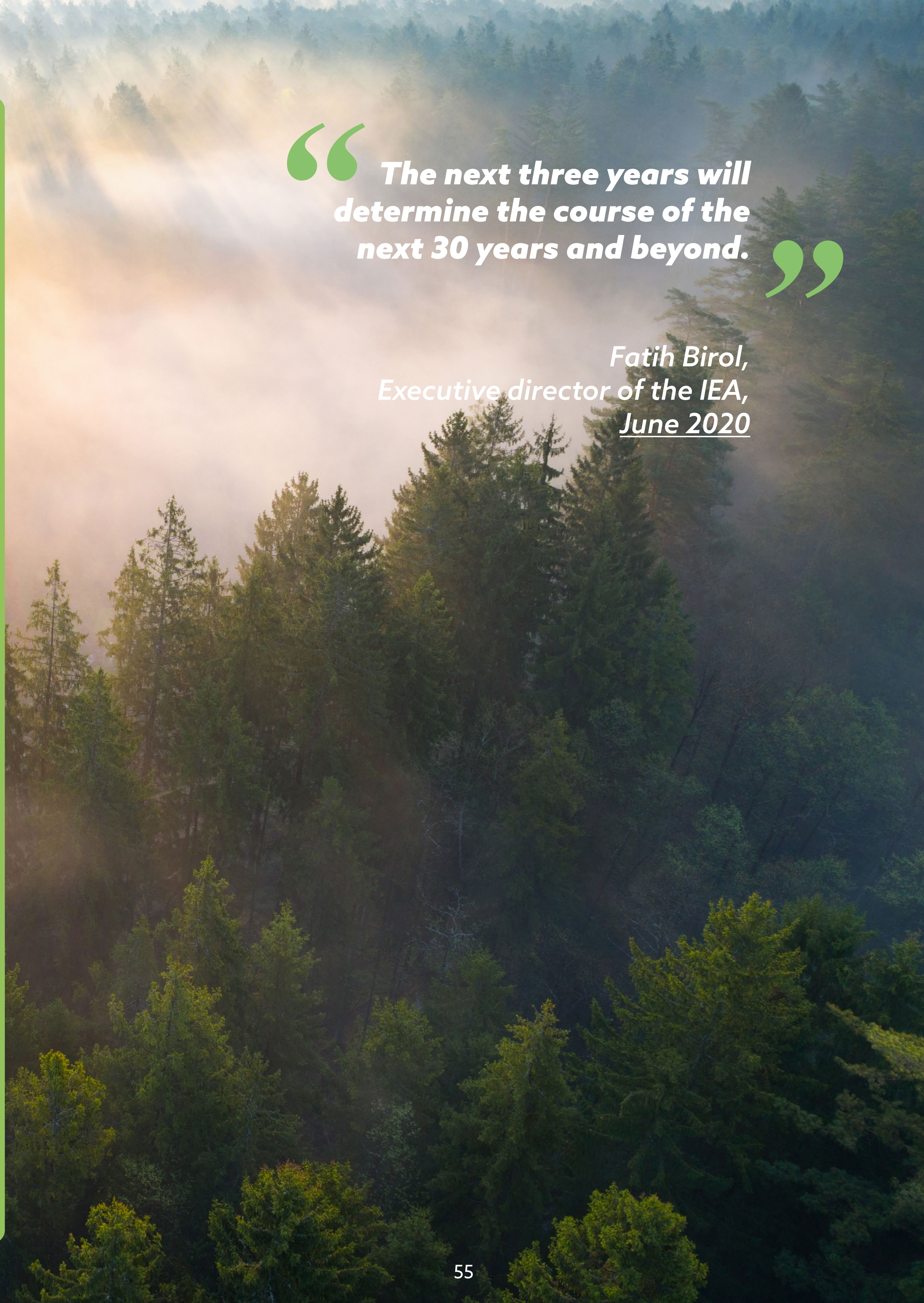
With its WEO 2021, the IEA sends a strong signal to political leaders, companies and financial institutions. **By prioritizing 1.5°C and acknowledging the need to immediately put an end to new fossil fuel supply and thermal coal projects, the agency makes decisive progress in addressing the climate crisis and sets a new climate-aware norm for the political, economic and financial world to follow.** Getting in line with the NZE will require a massive transformation of companies in many sectors, with only 3% of the 4400 companies analyzed by Moody's having targets aligned with this 1.5°C scenario and oil and gas companies aiming at 3°C.

The European Union's commitment to push "for oil, coal and gas to stay in the ground, including in Arctic regions" is a first step in the right direction. Taking stock of the IEA's conclusions, the EU Commission aims "not to allow any further hydrocarbon reserve development in the Arctic or contiguous regions, nor to purchase such hydrocarbons if they were to be produced". However, **many political leaders, companies and financial institutions have already proved reluctant to follow the IEA's call to end fossil fuel development**. Companies and financial institutions have also strived to find ways to accept the IEA's conclusions while simultaneously opening doors to keep on developing oil and gas, as the recent oil and gas alignment framework from the investor group IIGCC exemplifies. **With the WEO 2021, they have no excuse left not to act.**

Of course, **the IEA still falls short of charting a truly sustainable path to fulfill the 1.5°C goal of the Paris Agreement. Old habits die hard, and the IEA still massively relies on CCUS, CDR and biomass, while betting on significant nuclear growth**. The IEA itself identified its reliance on such technologies as risky, notably stressing that failing to reach the NZE milestones on CCUS, hydrogen and electrification could bar it from reaching its carbon neutrality goal. **The One Earth Climate Model provides an alternative to the NZE for those that want to adopt a precautionary approach to these uncertain and costly technologies (see Box 10 - The One Earth Climate Model (OECM) sectoral pathways).**

Furthermore, the NZE scenario does not yet provide the **regional-level data by sector that is available for the three other WEO scenarios**. If we believe this is largely due to time constraints, the IEA should swiftly disclose these data to allow actors to fully leverage the NZE.

While the WEO 2021 marks a turning point for the energy sector and the IEA, much remains to be done to get on track to meet the 1.5°C objective of the Paris Agreement. **On one hand, political leaders, companies, and financial players must stop fighting the main conclusions of the NZE and follow them. On the other, the IEA must continue its work to provide a sustainable and low risk pathway to reach 1.5°C.**



Box 10 – The One Earth Climate Model (OECM) sectoral pathways

The One Earth Climate Model (OECM) from the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS) proposes 1.5°C pathways for 12 industries, including energy utilities and fossil fuel companies, with disaggregated scope 1, 2 and 3 emissions and regional breakdowns. The latest OECM research methodology, assumptions and data will be published late 2021 or early 2022 and the full datasets will be made available as open source.

The OECM scenario **stays within a 400 GtCO2 carbon budget** for energy-related emissions, 60 Gt less than the IEA's NZE. It is based on a "IPCC P1" scenario, where **afforestation is the only CDR option considered and neither fossil fuels with CCS nor BECCS are used**. Therefore, only 5 GtCO2 would be removed by 2050 and 86 by 2100 thanks to nature-based sinks in the OECM. This should be compared to the almost 120 Gt CO2 removed through carbon capture (89.5 Gt from CCUS and BECCS and 29.4 from DACCS) and 40 GtCO2 removed with land-use changes in the NZE until 2050.

In the OECM, **investment in fossil power plants ends after 2030** and coal power plants are phased-out between 2030 and 2035 in Europe and North America. Electricity accounts for 65% of total energy consumption in 2050, with a 206% increase from 2020 to 2050. While electricity makes up for a higher share of consumption in the OECM than in the NZE in 205089 total power generation remains lower, showing that the OECM relies more on energy efficiency and lower energy consumption while still requiring a massive development of solar and wind power.

The OECM also requires a swift and major reduction of global fossil fuel production: **"new fossil fuel projects cannot go ahead" and "existing oil and gas fields and coal mines are phased out at an average annual decrease rate of at least 8.5%, 3.5% and 9.5% respectively".** To replace fossil fuels, **biomass plays a lesser role than in the NZE,** with "sustainable biomass" producing 85 EJ per year in 2050. **The OECM notes that companies and financial institutions should set and implement 1.5°C no/low overshoot alignment strategies and immediately stop new oil, coal and gas projects.**

Global scope 1, 2 and 3 emissions for the primary and secondary energy industry

Subsector	Unit	2019	2025	2030	2050
Global			Projection		
Total Energy, Gas, Oil & Coal Sector -					
Energy Sector - Scope 1: Total CO_2 equivalent	[Mt CO2 eq./a]	4,527	2,744	1,961	254
Change to 2019	[%]		-39%	-57%	-94%
Energy Sector - Scope 2: Total CO_2 equivalent	[Mt CO2 eq./a]	487	324	219	35
Change to 2019	[%]		-33%	-55%	-93%
Energy Sector - Scope 3: Total CO_2 equivalent	[Mt CO2 eq./a]	33,827	23,874	16,222	463
Change to 2019	[%]		-29%	-52%	-99%
Total Utilities Sector					
Utilities - Scope 1: Total CO_2 equivalent	[Mt CO2 eq./a]	1,986	1,364	1,150	496
Change to 2019	[%]		-31%	-42%	-75%
Utilities - Scope 2: Total CO_2 equivalent	[Mt CO2 eq./a]	287	226	179	9
Change to 2019	[%]		-21%	-38%	-97%
Utilities - Scope 3: Total CO_2 equivalent	[Mt CO2 eq./a]	21,356	15,840	11,447	478
Change to 2019	[%]		-26%	-46%	-98%

Source: OECM

Box 11 – Eternal growth in a world without a climate crisis?

When it comes to hypothesizing future growth, the IEA scenarios are constructed using analysis from the International Monetary Fund (IMF) and Oxford University that feature significant and continued global economic growth from 2020 to 2050. Indeed, during this period, global GDP will supposedly grow by an average 3% per year. Following this trend, reaching "net zero" emissions by 2050 requires a massive drop of the carbon intensity of GDP: by 56% from 2020 to 2030 and 91% from 2020 to 2040.

The close link between economic growth and energy use is largely ignored and, depending on the scenario, energy consumption will continue to grow, stagnate, or decrease and energy prices will rise or diminish with no impact on growth projections. This characteristic reinforces the need to focus on energy efficiency and measures to reduce energy consumption.

Beyond this, one can question the reality of growth conceptualized as infinite, without considering planetary limits. The consequences of global warming and environmental degradation are excluded from the economic analysis.

ANNEX

Financial institutions relying on the IEA's SDS

Many in the financial sector have used the IEA's work to justify their fossil fuel production plans or – for financial players - their support to companies drilling and digging new wells and mines. In recent years many have relied on the IEA's Sustainable Development Scenario (SDS) that does not aim at limiting global warming to 1.5°C[90] and is disqualified as a "climate" scenario in the IEA's WEO 2021. **If their confidence in this scenario was genuine at the time, they have no choice but to take onboard the IEA's key conclusions resulting from the NZE.**

A few cases of financial institutions explicitly relying on the SDS or other IEA scenarios to define their strategy are given below.[91]

Société Générale

In its Climate Strategy, published in October 2020, Société Générale commits to "pro-actively aligning our financing portfolios with the IEA Sustainable Development Scenario (SDS)". The bank underlines that "alignment efforts must draw on benchmark climate scenarios and robust methodologies for measurement" and that the SDS fulfills these requirements. It also compared a reduction of the exposure of its portfolio to oil and gas extraction by 10% by 2025 to the trajectory of the SDS.

Crédit Agricole

The French institution indicates that the SDS is the "scenario used at Group level to set the main axes" its strategy to align with the Paris Agreement. It compared its "energy mix" to the one of the SDS, noting that for several of its activities it "outperforms the energy mix of the International Energy Agency's (IEA) Development Scenario (SDS) 2020 projected in 2040 for fossil fuels".

BNP Paribas

BNP Paribas uses the IEA SDS as part of its Paris Agreement Capital Transition Assessment (PACTA) alignment work. The bank mentions that its coal exit deadline is aligned with the SDS and that its commitment to reduce its exposure to oil and gas upstream activities is "more ambitious" than the SDS. It also compares the carbon intensity of its portfolios to the SDS, effectively using it as a benchmark for aligning its energy activities with the Paris Agreement.

JPMorgan Chase

JPMorgan Chase has developed its own alignment tool "Carbon Compass" to "measure and track progress" against its climate targets. The bank indicates that its targets "are based on credible third-party energy and emissions scenarios, such as the International Energy Agency's Sustainable Development Scenario (IEA SDS) and the Energy Technology Perspectives Beyond 2°C Scenario (ETP B2DS)". The bank clearly mentions the IEA SDS on its website as the main source of transition pathways for its Carbon Compass tool.

ING

In its "climate alignment" report, ING compares to the SDS various indicators related to its financial services to the energy supply sector. The bank emphasizes that its commitment is "calibrated to the SDS" and that "if the SDS transition pathway requires a greater decline in oil and gas production, at a faster rate, that scenario will guide the direction that ING will take". It indicates several times that it makes "progress in supporting our clients' and the sector's energy transition towards the carbon intensity milestones that mark the energy transition pathway set out by the IEA's Sustainable Development Scenario (SDS)".

REFERENCES

1. The NZE explicitly requires the end to new unabated coal power plants projects. The end to new unabated gas is derived from the NZE objective to reach carbon neutrality by 2035 in advanced economies and 2040 worldwide and of the sharp drop in electricity produced from fossil gas.
2. LNG projects not approved by the end of 2021. The IEA underlines that a large share of the LNG projects currently planned are not needed. Furthermore, many of these projects will transport gas from unconventional sources whose exploitation generates high methane emissions incompatible with the IEA's methane target.
3. Renewable energies, energy efficiency and energy storage solutions are to be prioritized.
4. The work of the IEA's own Coal Industry Advisory Board (CIAB) has been largely focused on promoting CCS with coal since the signature of the Paris Agreement.
5. The NZE leads to energy-related emissions reaching 460 GtCO2 between 2020 and 2050 while the IPCC indicates that to limit global warming to 1.5°C with a 50% chance the carbon budget would be 500 Gt and 400 Gt with a 67% chance.
6. The IEA estimates that "a quarter of energy employment is tied to supply chains that may be located in other countries, particularly in the case of solar PV, wind, batteries, grid components and vehicle components". IRENA estimates that renewable energy already created 12 million jobs globally.
7. The IEA estimates air pollution causes over 5 million premature deaths a year today. Coal has been known to be one of the main contributors to air pollution worldwide for years and reducing its use in power plants alone would significantly improve the health of a billion people worldwide as shown by Dan Tong and al.
8. The IEA specify that "just under half of households gaining access to electricity do so with a grid connection, while mini- grid and stand- alone systems account for 30% and 25% of new connections respectively". These solutions largely rely on renewables in the short term: "over 90% of off- grid and around 70% of grid solutions deployed between now and 2030 are sourced from renewables".
9. Estimates from Reclaim Finance based on data from Rystad Energy and emission calculation method from Kjell Kühne, Energy Research & Social Science, Volume 79, September 2021.
10. See: Bill Hare and al, Why gas is the new coal, 2021, Climate Analytics
11. The IEA also notes that "any LNG projects with a break-even price of more than USD 5 per million British thermal units (MBtu) would be at risk of failing to recoup their investment costs in this scenario."
12. The graphic uses data from the WEO 2020 for SDS and STEPS.
13. See: Bill Hare and al, Why gas is the new coal, 2021, Climate Analytics.
14. The IEA defines advanced economies as "OECD regional grouping and Bulgaria, Croatia, Cyprus, Malta and Romania". Emerging market and developing economies are "all other countries not included in the advanced economies regional grouping".
15. The RESET project provides an analysis of the environmental impacts of various energy techniques for the power sector. It notably shows that renewable energies – including wind, solar, and geothermal - have the highest sustainability potential. The references it provides could help to chart the path for a carbon neutral power sector by 2040.
16. The IEA indicates that "Approvals of new coal-fired plants have slowed dramatically in recent years, stemmed by lower cost renewable energy alternatives, rising awareness of environmental risks, and increasingly scarce options for financing. Yet some 140 GW of new coal plants are currently under construction and more than 400 GW are at various stages of planning."
17. According to the IEA, meeting the goals of the NZE requires annual retirements averaging over 90 GW from 2021 to 2030.
18. In the NZE, there is still some residual coal by 2050. Global coal use drops by 90% from 2020 to 2050, and around 80% of remaining coal use is in facilities equipped with CCUS by 2050. The IEA devoted a specific report to the coal phase-out.
19. The production of electricity by unabated gas plants diminishes by 95% from 2020 to 2050.
20. The IEA stresses four ways to ensure the flexibility of the power system: power plants, storage technologies, demand side response and electricity networks.
21. Carbon Tracker compared the fossil fuel production and investment plans from oil and gas companies to the requirements of the NZE and other IEA scenarios. It notably concluded that the production from these companies would need to shrink in an NZE scenario, while they currently plan investments that would be incompatible with all IEA scenarios.
22. The IEA published a report highlighting the solutions to reach this objective.
23. The IEA indicates that "on average, we estimate that 8% of natural gas and natural gas liquids entering flares are not combusted and leak into the atmosphere. This is more than double previous estimates, and suggests that flaring resulted in more than 500 Mt CO2-eq GHG emissions in 2020, which is more than the annual CO2 emissions from all cars in the European Union".
24. See for example: Joannes D. Maasakkers et al., "2010–2015 North American methane emissions, sectoral

contributions, and trends: a high-resolution inversion of GOSAT observations of atmospheric methane", 2021, Atmos. Chem. Phys.; Robert Mc Sweeney, "Methane emissions from fossil fuels 'severely underestimated'", 2020, Carbon Brief; Aaron Clark, Glencore's Australian mines revealed as super emitters, 2021, Bloomberg.

25. See for example: NASA Jet Propulsion Laboratory, "Study Identifies Methane 'Super-Emitters' in Largest US Oilfield", 2021, NASA; A. Clark and al, "Gazprom admits to massive methane leaks", 2021, Bloomberg.
26. The IEA notably identifies the decline in unconventional gas production as one of the drivers of the gas production contraction in the NZE.
27. The Production Gap Report takes into account significant carbon removal levels (see box – The Production and coal gaps).
28. From both unabated and abated coal.
29. From both abated and unabated gas.
30. See: Bill Hare and al, Why gas is the new coal, 2021, Climate Analytics.
31. See: Bill Hare and al, Why gas is the new coal, 2021, Climate Analytics.
32. Solar and wind account for 198 EJ in 2050 while the global energy supply reaches 543 EJ.
33. See appendix B of the Production Gap Report for more detail. The Production Gap Report does not put any specific limitation on potential for CCUS or DAC.
34. The sustainable range for BECCS is estimated to be 0.5-5 GtCO2 and for afforestation 0.5 to 3.6 GtCO2. The Production Gap Report refers to the Climate Action Tracker to justify its thresholds.
35. Country and company pledges relying on the UK's Powering Past Coal Alliance (PPCA) are not fully aligned with the Paris Agreement and can hide dangerous policies that prolong the use of coal worldwide, as explained in Reclaim Finance's report published in April 2021.
36. The IEA describes three types of CO2 removals:
    1. Captured and stored emissions from the combustion of bioenergy and renewable wastes.
    2. Captured and stored process emissions from biofuels production.
    3. Captured and stored CO2 from the atmosphere, which is reported as direct air capture (DAC).

    The first two can be reported as BECCS. For more information on carbon removal and utilization methods, read the study "The technological and economic prospects for CO2 utilization and removal" in Nature.
37. 1186 Mt come from "industry removals" made of 553 Mt from biofuel production and 633 Mt from direct air capture. The remaining 748 come from bioenergy and waste.
38. The IEA indicated that "Total CO2 captured includes the carbon dioxide captured from CCUS facilities (such as electricity generation or industry) and atmospheric CO2 captured through direct air capture, but excludes that captured and used for urea production".
39. 40 Mt of CO2 are captured by existing and currently in construction CCS projects.
40. In this case, a much faster build-up of renewable energy capacity and renewable hydrogen production is needed, at a higher overall cost. As the NZE has been designed to "minimize stranded assets", the IEA noted that limited CCS deployment could in return lead to $90 billion of coal and gas plants becoming stranded in 2030 and up to $400 billion in 2050.
41. The IEA writes that: "After 2030, end-use sectors decarbonise in the NZE by switching to the use of electricity, hydrogen-based fuels, CCUS in industry, or advanced bioenergy. CCUS is critical to addressing process emissions from cement, natural gas-based hydrogen and biofuel production, for the production of synthetic fuels, and to reach negative emissions from bioenergy with carbon capture and storage and direct air capture with storage. In the electricity sector, most of the heavy lifting is done by renewables in the NZE, but bioenergy, CCUS and hydrogen-based fuels play a critical role in providing low-emissions dispatchable capacity and delivering negative emissions when CCUS is combined with bioenergy."
42. For elements on prioritization of hydrogen uses, see the study 12 insights on Hydrogen by Agora Energiewende and the "Clean hydrogen ladder" from Micheal Liebreich.
43. See for examples the Barendrecht CO2 storage, the Petra Nova plant and San Juan coal plant.
44. S. Garcia Freites and al, A Review of the Role of Fossil Fuel Based Carbon Capture and Storage in the Energy System, 2021
45. N. Grant and al, Cost reductions in renewables can substantially erode the value of carbon capture and storage in mitigation pathways, 2021, One Earth
46. Data from the Global Status of CCS 2021 Report from the Global CCS Institute.
47. See: Tom Baxter, "It's time to accept carbon capture has failed – here's what we should do instead", 2017, The Conversation.
48. See: Greenpeace UK, Net Expectations, 2021; CAN, "Position: Carbon Capture, Storage and Utilisation", 2021.
49. Fossil fuel investments were especially low in 2020 due to the Covid pandemic ($330 billion according to the IEA).
50. Fatih Birol notably told the Financial Times.that "projected investment in oil and gas was now aligned with the changes needed to reach net zero emissions of greenhouse gases by 2050."
51. $475 billion for upstream oil and gas and $99 billion for coal supply.
52. Many oil and gas companies are notoriously untransparent, when it comes to reporting on their expansion plans. GOGEL therefore uses the Rystad Energy database to determine which new oil and gas assets companies are preparing to bring into production in the near future. According to this analysis, 506 upstream oil and gas producers are planning to add 190 billion barrels of oil equivalent (bboe) to their production portfolios within the next one to seven years. 14 companies are responsible for over half of this enormous expansion (see annex). The top five are: Qatar Energy (20 bboe), Gazprom (17 bboe), Saudi Aramco (15 bboe), ExxonMobil (7 bboe) and Brazil's Petrobras (7 bboe).
53. This decline rate calculated by Rystad assumes some infill drilling and continued capital investment in those existing fields. Without any investment, the decline rate would be higher.
54. According to Carbon Tracker, between 2020 and 2040 the end of the development of new fossil fuel projects required in the NZE would notably trigger a 78% reduction in shale/tight gas production and a 86% reduction in shale/tight oil.
55. In the NZE, total energy sector capital spending increases from around 2.5% of GDP per year in recent years to around 4.5% of GDP in 2030, before easing to 2.5% in 2050.
56. $1.2 trillion in 2014.
57. The study by Paul E. Brockway and al. quantifies the EROI for fossil fuels at 6:1 when the EROI for renewables is often below 10:1. M. Raugei and al. estimate the EROI for solar power is between 9 and 10.
58. Traditional biomass uses still represent 24.1 EJ in 2020.
59. This data comes from the IEA NZE report and is not available in the WEO 2021.
60. 26.4% using a conservative estimate of about 1550 Mha of available cropland, close to current use.
61. Modern liquid bioenergy rises from 3.8 EJ in 2020 to 12.5 EJ in 2030.
62. Modern gaseous bioenergy rises from 2.2 EJ in 2020 to 5.4 EJ in 2030.
63. Read the deep-dive "Biomass is promoted as a carbon neutral fuel. But is burning wood a step in the wrong direction?" in The Guardian.
64. 4,7 EJ for solar power and 5,7 EJ for wind.
65. 32 EJ for solar power and 28,5 EJ for wind.
66. From 16,6 EJ in 2020 to 21,1 EJ in 2030.
67. The IEA does not discuss the negative social and environmental impacts of hydropower; its serious vulnerability to climate change, including low/zero production during droughts, and the safety impacts from increasingly severe floods; and questions over whether reservoir hydro can be considered as "renewable" due to the problem of reservoir sedimentation.
68. An analysis by Jacobson and al. published in 2017 evaluated the possibility of such scenarios for 139 countries.
69. The 100% renewable energy scenarios mentioned rely on very different assumptions about energy demand and consumption.
70. In this scenario, fossil fuels are nearly phased-out by 2050 in France and the last nuclear reactor closes in 2045.
71. RTE notably stress that opting out of nuclear requires a much more significant increase of renewable energy capacity.
72. Biomass is used as renewable energy in the scenario from Negawatt. However, none of the biomass used for energy needs comes from dedicated forestry. Similarly, biogas is not produced thanks to dedicated land but mainly from residues and waste.
73. The Afterres scenario 2050 from Solagro - used in Negawatt's 2022 scenario - charts the transition of the agricultural, forestry and food sectors.
74. RTE considers that energy conservation is largely a social choice and does not take into account significant shifts in its reference scenarios. Conservation/efficiency is considered in a specific scenario.
75. In France, the ADEME published various transition scenarios that depend on very different assumptions regarding social and political behavior. They range from a scenario relying on drastic changes in the way people live to a scenario relying on major technological breakthroughs.
76. This analysis is based on the NZE report published in May by the IEA. Renewable energy has undergone a cost revolution in recent years. According to IRENA, Solar PV module prices have fallen by around 90% since the end of 2009, while wind turbine prices have fallen by 55-60% since 2010. Similarly, Lazard shows a sharp decline in renewable energy costs, with declines for solar PV projects of over 10% a year in recent years. In the US, utility-scale battery storage costs decreased nearly 70% between 2015 and 2018.
77. Unsubsidized costs for utility-scale solar PV projects.
78. The IEA also puts the LCOE of onshore wind at $35/MWh in 2020 and 2030 and $30/MWh in 2050 but Lazard's estimates show a cost between $26 and $50/MWh today. Lazard estimates are unsubsidized LCOE costs.
79. It should be noted that the IEA's cost assumptions for nuclear seems relatively low. In the US, the IEA estimates a LCOE of $105/MWh in 2020 increasing to $110 in 2030 and 2050 while Lazard already situates this cost between $131 and $204/MWh.
80. The IEA indicates that "Many mineral commodities started 2021 with strong price rallies, with some reaching multiyear highs. Copper prices broke the symbolic USD 10 000/tonne barrier in May 2021, hitting an all-time high, and nickel prices rose by 50% from pre-pandemic levels, reaching their highest level since 2012. Lithium and cobalt prices are also resuming an upward trajectory. The recent price rallies were mainly driven by a combination of demand recovering faster than supply, stock building activities, ultra-loose monetary policies and expectations for strong future demand growth as a result of accelerated energy transitions".
81. A similar conclusion is reached by the Energy Transition Commission.

82. Proposals to develop the recycling of rare minerals were made by the Cewaste Project in the EU. See IClima's article on battery recycling more specifically.
83. For a detailed analysis of the evolution of the gas market leading to the crisis in the EU, see the Quaterly Report on European Gas Market from the DG Energy.
84. The IEA used the highest oil, natural gas and coal prices reached in each region over the period from 2010 to 2020.
85. The additional cost would be $470 in advanced economies.
86. An intense debate around the sustainability of nuclear energy as notably emerged in the EU in the context of the EU sustainable taxonomy. The most contentious issue was the current inability to safely store radioactive waste.
87. The IEA's WEO cost estimates also show that the nuclear energy does not follow the cost reduction trend of renewable energies.
88. The World Nuclear Report 2021 provides a summary of the Flamanville-3 project.
89. Total power generation will reach 53 500 TWh in the OECM and 72 000 TWh in the NZE in 2050.
90. See: Bill Hare and al., Why Gas is the new coal, 2021, Climate Analytics
91. Many other financial institutions use IEA scenarios to conduct risk analysis on their activities and are not included in this list.

Credits

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THE IEA's NET-ZERO 2050
The new normal and what's left to be done

Reclaim Finance is an NGO affiliated with Friends of the Earth France. It was founded in 2020 and is 100% dedicated to issues linking finance with social and climate justice. In the context of the climate emergency and biodiversity losses, one of Reclaim Finance's priorities is to accelerate the decarbonization of financial flows. Reclaim Finance exposes the climate impacts of some financial actors, denounces the most harmful practices and puts its expertise at the service of public authorities and financial stakeholders who desire to to bend existing practices to ecological imperatives.

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