INTERNATIONAL ENERGY AGENCY NET ZERO EMISSIONS SCENARIO (NZE)

This briefing note, for Climate Action 100+ (CA100+) signatories and IGCC members, provides an overview of the recently updated International Energy Agency (IEA) Net Zero Emissions scenario (NZE), compares NZE to other IEA and 1.5°C scenarios, and highlights some of the key risks and opportunities faced by the Australian oil and gas and heavy industry sectors.

Overall, NZE is valuable resource for investors and companies alike. It provides a significantly more ambitious decarbonization pathway than other IEA scenarios, and tests assumptions that may impact the energy mix to 2050 e.g. the development and uptake of carbon capture, utilization and storage (CCUS). In compliment to analysis undertaken by IEA, a comparison between NZE and a subset of Intergovernmental Panel on Climate Change (IPCC) scenarios finds that NZE global primary coal supply is below or equivalent to the IPCC average to 2050, and NZE gas supply is above the IPCC average to the early 2030s and then below to 2050.

Given growing commitments to net-zero by 2050, investors engaging with energy and heavy industry companies should encourage companies to consider NZE in their decarbonisation strategies, capital allocation, scenario analysis, emission reduction targets and just transition plans in line with the CA100+ Net-Zero Company Benchmark. While declining fossil fuel demand may present a risk to revenue and shareholder returns, increasing clean energy demand and technologies such as hydrogen and CCUS provide significant opportunity.

INTRODUCTION

Ambition to reach net-zero carbon dioxide (CO_2) emissions by 2050 and limit global surface temperature rise to 1.5°C in line with the Paris Agreement, has continued to grow, with commitments from 44 countries and the European Union as of April 2021. IEA NZE was first released in September 2020[1] and, while welcomed, the scenario was met with some concerns around the limited time frame, lack of regional data and potential overestimation of coal and gas demand[2]. The updated NZE scenario, released May 2021, addresses some of these apprehensions in IEA Net Zero by 2050: A Roadmap for the Global Energy Sector[3] ("Roadmap") and will continue to guide future work and feature in the IEA's annual World Energy Outlook.

NZE outlines the pathway to reach net-zero by 2050 for energy and industrial process emissions that IEA views as the most technically feasible, cost-effective and socially acceptable. Given the popularity of IEA scenarios with energy companies, this is an important resource for investor engagement on climate change (e.g. through CA100+). Scenarios enable companies to credibly demonstrate how their decarbonisation strategies, capital expenditure (CAPEX) and emissions reduction targets align with net-zero by 2050, as required in the CA100+ Net-Zero Company Benchmark[4]. Increasingly, investors and companies are also considering the implications of transition on communities and how to best support a just transition.

While NZE covers a broad scope of considerations for the transition to net-zero, this briefing note focuses on the implications most relevant to Australian investors engaging with energy and heavy industry companies including changing supply of fossil fuels and the roles of hydrogen and CCUS.

NET ZERO EMISSIONS SCENARIO

NZE provides a detailed pathway to achieve net-zero energy-related and industrial process CO_2 emissions globally by 2050, including:

- **Energy demand:** Improvements in energy intensity mean that by 2030, the economy is 40% larger but uses 7% less energy and by 2050, the economy is more than double today's size but global energy demand is 8% less.
- **Fossil fuels:** Only one-fifth of total energy supply in 2050 is from fossil fuels and is in goods where the carbon is embodied in the product (e.g. plastics), facilities fitted with CCUS or sectors where low-emissions technologies are scarce.
    - No additional new final investment decisions should be taken for new unabated coal plants, the least efficient coal plants are phased out by 2030 and the remaining are retrofitted.
    - Beyond projects already committed as of 2021, no new oil and gas fields or coal mines or mine extensions should be approved for development.
    - Methane emissions from fossil fuel supply should fall by 75% over the next 10 years.
- **Renewables:** Two-thirds of total energy supply in 2050 is from wind, solar, bioenergy, geothermal and hydroenergy. Annual additions of 630 GW solar PV and 390 GW wind are required to 2030.
- **Electricity:** Accounts for almost 50% of total energy consumption in 2050 and total electricity generation increases by over 2.5 times by 2050.
- **Low-emission technologies:** All the technologies needed to achieve global emissions reductions by 2030 already exist, however in 2050, almost half the reductions come from technologies that are currently at the demonstration or prototype phase.
    - The biggest innovation opportunities are in advanced batteries, hydrogen electrolysers and direct air capture and storage.
    - In 2050, there is 1.9Gt of CO_2 removal, 7.6 Gt CO_2 of CCUS, and 520 Mt of low-carbon hydrogen demand.
- **Investment:** Total annual energy investment surges to USD 3 trillion by 2030, bringing significant economic benefits and creating millions of jobs in clean energy, energy efficiency, engineering, manufacturing and construction.
    - Annual investment in transmission and distribution grids expands from USD 260 billion to USD 820 billion in 2030.
    - Annual investment in CO_2 pipelines and hydrogen enabling infrastructure increases from USD 1 billion to USD 40 billion in 2030.

IEA SCENARIOS

To place NZE in context of other IEA scenarios, the Roadmap explores global energy supply to 2050 in three long-term scenarios:

- **Stated Policies Scenario (STEPS):** incorporates announced policy intentions and targets, where they are backed up by detailed measures for their implementation. This would lead to a temperature rise of around 2.7°C by 2100 (with 50% probability).
- **Announced Pledges Case (APC):** assumes that all announced national net-zero pledges are achieved in full and on time, whether or not they are currently underpinned by specific policies. This would lead to a temperature rise of around 2.1°C in 2100 (with a 50% probability).
- **NZE:** describes how energy demand and the energy mix will need to evolve if the world is to achieve net-zero global carbon dioxide (CO_2) emissions by 2050. This would limit temperature rise to 1.5°C (with 50% probability)

Table 1 compares changes in global energy supply and net CO_2 emissions of each IEA scenario to 2050. While coal supply decreases under all scenarios to 2050, oil and gas supply varies between scenarios. Oil increases above 2019 in STEPS and then plateaus to 2050, while in APC and NZE, oil supply decreases on average from 2019 to 2050. Gas supply increases in STEPS to 2050 and increases to 2030 in APC before plateauing. In NZE, gas supply increases to 2025 before decreasing to 2050. Renewables and nuclear supply increases across all scenarios, with greater supply in lower emission scenarios. This comparison highlights that the difference between a 1.5°C scenario (NZE) and 2°C scenario (APC) is especially important for the gas sector.

	2019	2030			2050		
		STEPS	APC	NZE	STEPS	APC	NZE
Coal	160	147	116	72	127	76	17
Oil	190	200	179	137	203	151	42
Gas	140	160	150	129	199	152	61
Nuclear	30	34	37	41	39	51	61
Renewables	67	120	144	167	192	250	362
Net CO_2 emissions	36	36	30	21	36	22	0

Table 1: Total energy supply by source (EJ) and CO_2 emissions (Gt CO_2) under IEA scenarios: STEPS, APC, NZE. Shading of the cell indicates whether values have increased or decreased since the last time step, where light blue is increasing, and darker blue is decreasing. Data from 2019 was used as a baseline due to the impacts of COVID-19 in 2020. Data from International Energy Agency (2021), Net Zero by 2050, IEA, Paris.

COMPARING NZE TO IPCC SCENARIOS

While NZE is clearly more ambitious than APC or STEPS, it is important to assess whether it over relies on unproven technologies like CCUS and carbon dioxide removal (CDR) to extend the demand for fossil fuels. IEA provides some analysis of NZE in comparison to similar 1.5°C scenarios assessed by the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C[6] (IPCC SR1.5). The Report identifies that while IPCC SR1.5 includes 90 scenarios that have at least a 50% chance of limiting warming in 2100 to 1.5°C, only 18 of the scenarios reach net-zero CO_2 energy sector and industrial process emissions in 2050. Therefore, the analysis is limited to those 18 scenarios ("IPCC scenarios") and some key results of include:

- **Use of CCUS:** IPCC scenarios have a median of around 15 Gt CO_2 captured using CCUS in 2050, double the level in NZE (7.6 Gt CO_2).
- **Use of CDR:** CO_2 emissions captured and stored from bioenergy with carbon capture and storage (BECCS) and direct air capture with carbon capture and storage (DACCS) in the IPCC scenarios range from 3.5-16 Gt CO_2 in 2050, compared to 1.9 Gt CO_2 in NZE.
- **Hydrogen**: The IPCC scenarios have a median of 18 EJ hydrogen in total final consumption in 2050, compared with 33 EJ in NZE.

When NZE was first released last year, analysis comparing NZE to Science Based Target Initiative[6] (SBTi) approved IPCC scenarios found that coal and gas demand was higher than the average of the SBTi scenarios[2]. For consistency, the comparison in this document uses the same IPCC subset as in the IEA Roadmap.

Figure 1 shows primary energy supply from coal decreases from 2020 to 2050 under NZE and all IPCC scenarios but one. NZE follows a similar trajectory to the IPCC mean, but with supply on average 9 EJ lower, until 2045. From 2045 to 2050, supply is almost identical. This provides some assurance that coal supply has not been overestimated in NZE. Figure 2 shows more varied trajectories between scenarios for primary energy gas supply. While in 2020 NZE gas supply is approximately equal to the IPCC mean, in 2025 NZE has the highest supply of gas of any scenario. By 2035, NZE has a lower gas supply than the mean of the IPCC scenarios and remains lower until 2050. This may indicate that NZE overestimates gas supply from now to the early 2030s.

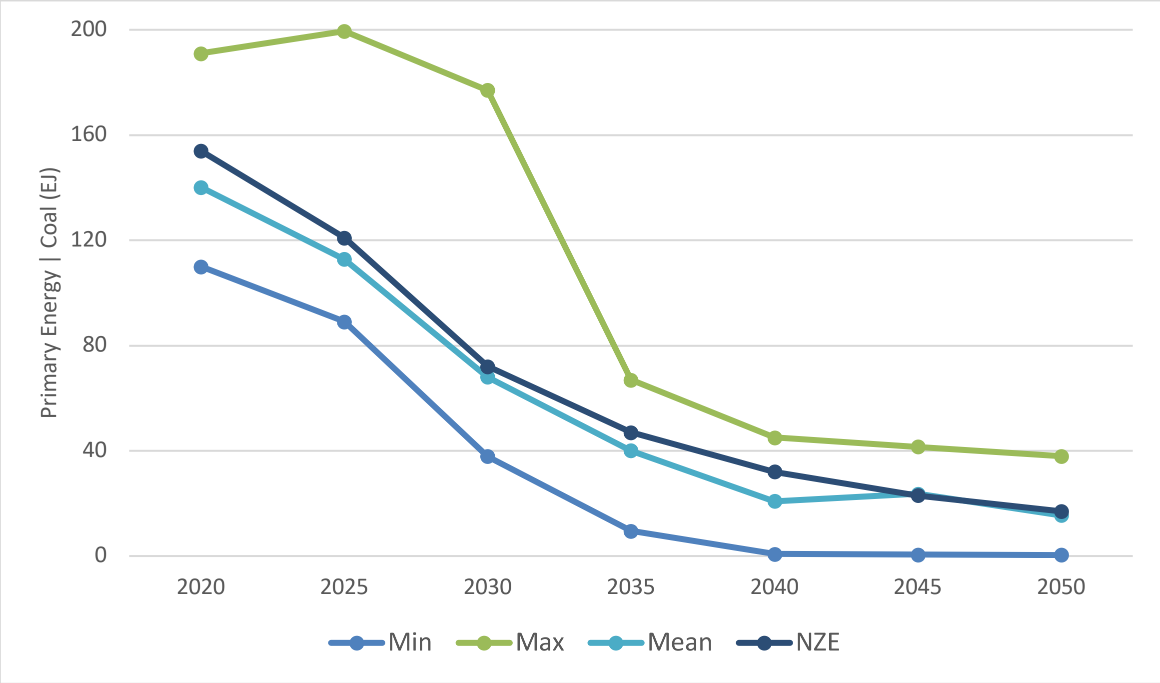

Figure 1: Primary energy supply of coal (EJ) under NZE and the minimum, maximum and mean values of a subset of IPCC 1.5°C scenarios from 2020-2030. NZE data is from International Energy Agency (2021), Net Zero by 2050, IEA, Paris. IPCC data is from IAMC 1.5°C Scenario Explorer hosted by IIASA (https://data.ene.iiasa.ac.at/iamc-1.5c-explorer).

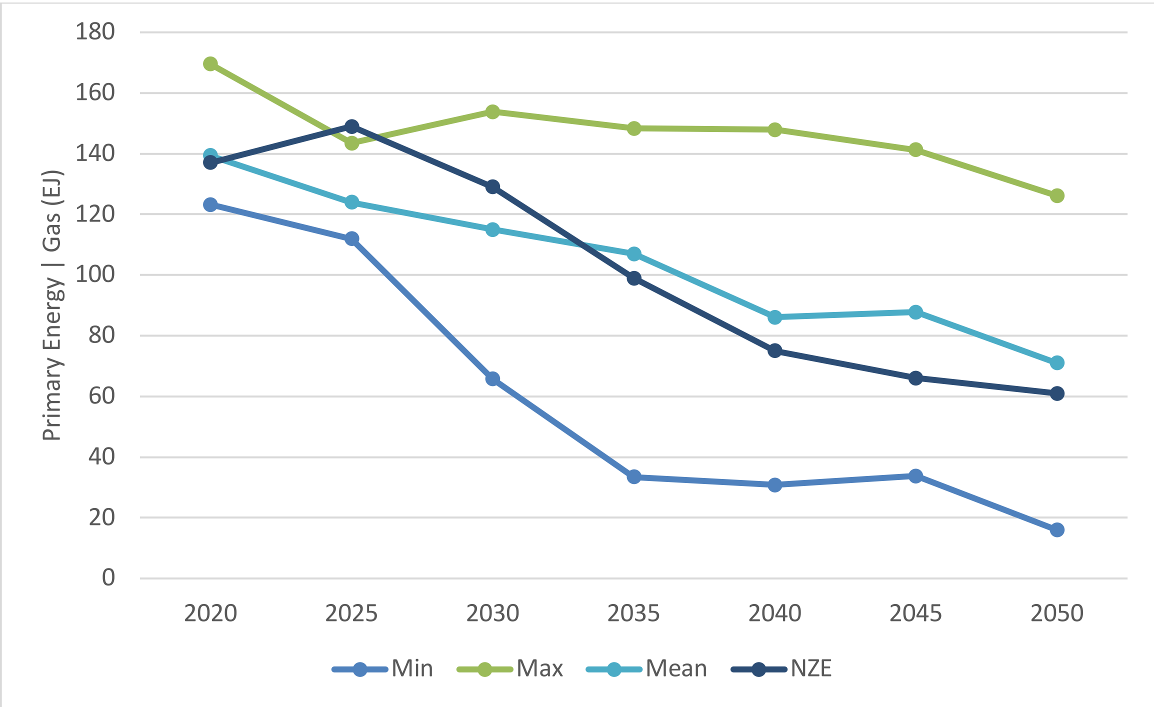

Figure 2: Primary energy supply of gas (EJ) under NZE and the minimum, maximum and mean values of a subset of IPCC 1.5°C scenarios from 2020-2030. NZE data is from International Energy Agency (2021), Net Zero by 2050, IEA, Paris. IPCC data is from IAMC 1.5°C Scenario Explorer hosted by IIASA (https://data.ene.iiasa.ac.at/iamc-1.5c-explorer).

GAS AND HEAVY INDUSTRY

Some of the key uncertainties for Australian investors engaging with energy and heavy industry companies, which together make 80% of Australian CA100+ focus companies, have included:

- The role of gas the transition to net-zero by 2050. There has been significant political discussion on gas as part of the economic recovery from COVID-19, policies and mechanisms to lower the price of gas domestically for industry, and new climate targets from key Australian LNG export markets.
- The technical and economic feasibility of hydrogen and CCUS as opportunities for energy companies (providers) and heavy industry (users).
- Heavy industry, especially chemicals, steel and cement, is seen as a hard-to-abate sector as many of the technologies required to decarbonise, including hydrogen and CCUS, have not been proven at scale yet. This has led to less information available for both companies and investors on decarbonisation pathways aligned with net-zero by 2050.

This section deep dives into the decarbonisation pathway outlined for energy and heavy industry companies under NZE and the opportunities associated with hydrogen and CCUS for these sectors.

Gas demand

In NZE, while gas quickly rebounds from the dip in demand in 2020 and rise through to the mid-2020s, between 2020 and 2050, gas traded as liquified natural gas (LNG) falls by 60% and trade by pipeline falls by 65%. In the short-term, a key milestone in NZE is that beyond projects already committed in 2021, no new gas fields should be approved for development. During the 2030s, global gas demand declines by more than 5% per year on average, and some fields may be closed temporarily or prematurely. Declines in gas demand slows after 2040, and more than half of gas globally in 2050 is used to produce hydrogen in facilities with CCUS.

In 2020, Australia was the second largest exporter of LNG globally (Figure 3). However, while the global percentage of LNG exports provided by Australia will stay approximately the same (25%), the absolute quantities LNG exports will be less than a third of those in 2020 by 2050 under NZE. Additionally, as nearly all LNG exports will come from the lowest cost and lowest emissions producers, gas companies will need to reduce emissions from their supply chains or risk becoming uneconomic with carbon prices. This will lead to the end of all flaring, use of CCUS with centralised sources of emissions, and significant electrification of upstream operations using off-grid renewable energy sources. In NZE, total methane emissions from fossil fuels also fall by around 75% between 2020 and 2030. Around a third of this is due to the reduction in fossil fuel consumption and the rest comes from emissions reduction measures and technologies, which leads to the elimination of all technically avoidable methane emissions by 2030.

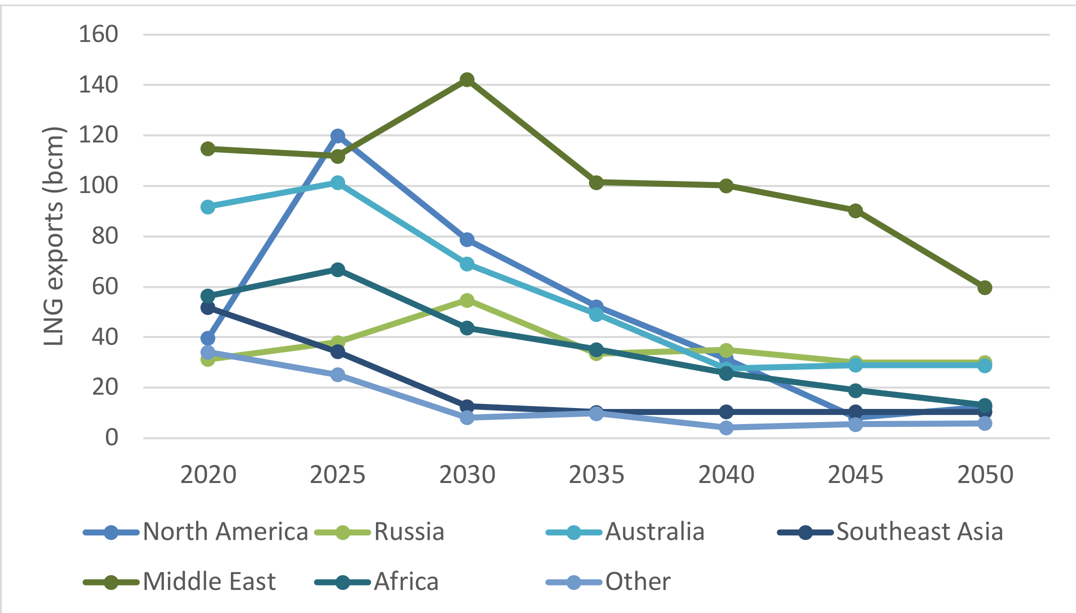

Figure 3: Global LNG exports (bcm) by region under NZE from 2020 to 2050. Data is from International Energy Agency (2021), Net Zero by 2050, IEA, Paris.

Low-Carbon Hydrogen

While some countries and companies will compete to supply the reducing amount of gas demand, the gas sector also has the opportunity to play a key role in developing clean energy technologies such hydrogen and CCUS. In NZE, the initial focus for hydrogen is the conversion of existing uses of fossil energy to low-carbon hydrogen in ways that do not immediately require new transmission and distribution infrastructure, including use in industry, refineries and power plants, and blending hydrogen into gas. Global hydrogen use expands from less than 90Mt in 2020 to more than 200 Mt in 2030, and the proportion of low-carbon hydrogen rises from 10% in 2020 to 70% in 2030. Of this low-carbon hydrogen, around half comes from electrolysis (i.e. green hydrogen) and the rest from coal and gas with CCUS (i.e. blue/grey hydrogen with CCUS) in 2030 (Figure 4). After 2030, low-carbon hydrogen expands in all sectors and global trade develops with large volumes exported from renewables rich areas like Australia. In 2050, hydrogen demand has increased almost sixfold to 530 Mt.

Figure 4 illustrates the production of hydrogen by fuel type to 2050 and demonstrates that by 2050 the majority of hydrogen is from low-carbon sources i.e. electricity (green) or fossil fuels with CCUS (blue/grey with CCUS). However, it is worth noting that low-emissions fuels are defined by IEA as those that do not emit any CO_2 when used and also emit very little when being produced. Therefore, for hydrogen produced with fossil fuels to be competitive, companies must minimize operational CO_2 and methane emissions to reduce the cost of CCUS and reduce emissions which may incur a carbon price. Additionally, if hydrogen produced from fossil fuels even has a small amount of emissions not captured, then it will likely be less attractive to end-users who are trying to reduce their own scope 1 and 2 emissions. For gas with CCUS, production of hydrogen in NZE costs around USD 1-2/kg of hydrogen in 2050, with gas typically accounting for 15-55% of total production costs. In comparison, the average cost of producing hydrogen from renewables is USD 1-2.5/kg in 2050, with electricity accounting for 50-85% of the production costs. Despite this similar price per kg, the more competitive fuel will likely vary regionally, depending on the availability of cheap renewable energy, gas and/or CCUS. In 2050, over 60% more hydrogen is produced from electricity (321 MtH_2/yr) than fossil fuels with CCUS (198 MtH_2/yr) in NZE (Figure 4).

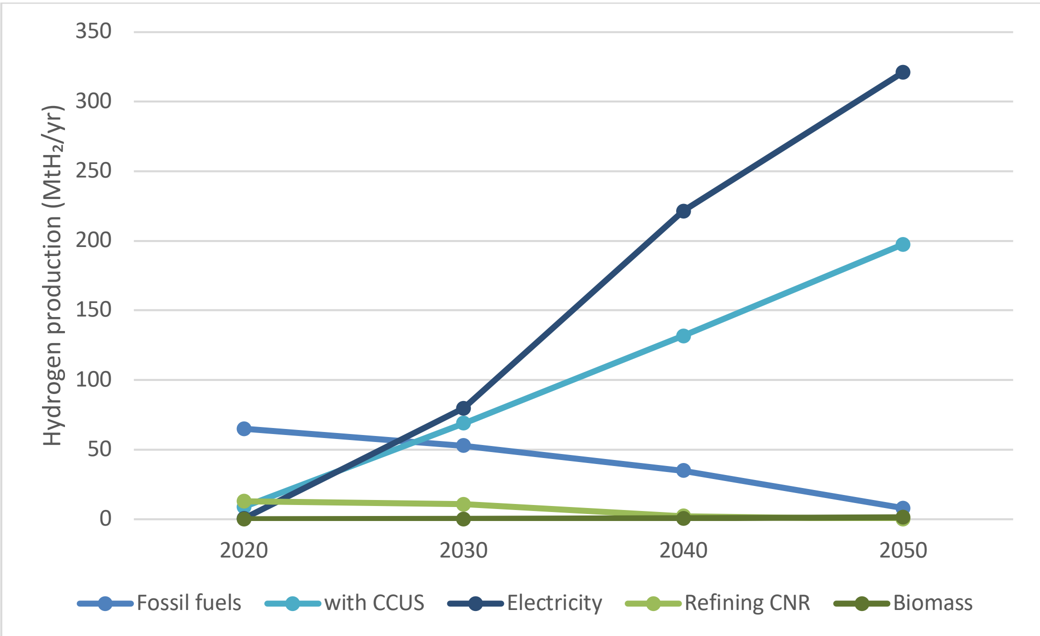

Figure 4: Global production of hydrogen by fuel in the NZE. Data is from International Energy Agency (2021), Net Zero by 2050, IEA, Paris.

Carbon Capture and Storage

Alongside its use in producing low-carbon hydrogen, CCUS is required in NZE to tackle emissions from existing assets, address emissions from some of the most challenging sectors (including heavy industry) and allow for CO_2 removal from the atmosphere through BECCS and DACCS. Rapid expansion from 2025 to 2030 is expected and by 2030, 1.6 Gt CO_2 is captured globally, rising to 7.6 Gt CO_2 in 2050. Of this, 95% is captured in permanent geological storage and 5% is used to provide synthetic fuels.

IEA also describe a Low CCUS Case (LCC) in the Roadmap, where no fossil fuel CCUS projects are developed beyond those already under construction or approved for development. In LCC, the CO_2 emissions captured from fossil fuels are only around 0.15 Gt CO_2 in 2050, compared to 3.6 Gt CO_2 in NZE. While this reduces fossil fuel and CCUS demand, it also necessitates additional electricity, renewables and storage as outlined in Table 2.

	2030		2050	
	NZE	LCC	NZE	LCC
Electricity (Thousand TWh)				
Hydrogen	3779	6527	15014	23893
Industry	12721	12721	17910	20338
Capacity (Thousand GW)				
Solar PV	4956	6232	14458	19190
Wind	3101	3755	8265	10524
Electrolysers	846	1473	3586	5613
Batteries	585	764	3097	3755

Table 2: Impacts of achieving net-zero emissions by 2050 without expanded fossil fuel-based CCUS on electricity (Thousand TWh and capacity (Thousand GW) demand). Data is from International Energy Agency (2021), Net Zero by 2050, IEA, Paris.

While around USD 650 billion of investment in fossil-fuel based CCUS in NZE would be avoided in LCC, the additional investment in wind, solar and electrolyser capacity, electricity-based routes in heavy industry, and expanded electricity networks and storage would require USD 15 trillion more investment than in NZE. Additionally, there is a higher risk of stranded assets in LCC with up to USD 90 billion of existing coal and gas-fired capacity stranded in 2030 and up to USD 400 billion by 2050. This implies that it is more cost-effective to use CCUS than to not, however it is worth noting that because CCUS has not been proven at this scale, the costs of development are an assumption.

For gas companies, this case study highlights both the opportunity and strategic advantage of developing or supporting CCUS:

1. Lower emissions gas (i.e. with renewables and CCUS to minimize scope 1 and 2 emissions) is most likely to be competitive during the decline in demand for gas.
2. Demand for low-carbon hydrogen (including blue with CCUS) will continue to increase to 2050 and is a key business opportunity.
3. If CCUS isn't able to be commercially deployed, then gas companies have a higher risk of stranded assets.
4. Gas companies have the skills to develop and implement CCUS and this will be in high demand for sectors that are more challenging to decarbonise (e.g. steel and cement).

Heavy Industry

CO_2 emissions from heavy industry decline by 20% by 2030 and 93% by 2050 in NZE. While this reduction includes optimising the operational efficiency, adopting the best available technologies for new capacity additions and improving material efficiency, almost 60% of the emissions reductions in 2050 are from technologies that are still under development or have not been proven at scale. Therefore, one of the key milestones in NZE is that by 2030, most new clean technologies in heavy industry have been demonstrated at scale. From 2030, all new industry capacity additions are near-zero emissions and each month the world equips ten new and existing heavy industry plants with CCUS, adds three new hydrogen-based industrial plants and adds 2GW of electrolysers capacity at industrial sites. In 2050, 63% of hydrogen produced (excluding synthetic fuels and ammonia) is used in iron, steel and chemicals production. Despite these new technologies, heavy industry has a small level of residual emissions in 2050 from mainly emerging market and developing economies (80%), which are offset using BECCS and DACCS in NZE. Some key milestones for the chemicals, steel and steel industries are outlined in Table 3.

	2020	2030	2050
Chemicals			
Share of recycling: Reuse in plastics collection Reuse in secondary production	 17% 8%	 27% 4%	 54% 35%
Hydrogen demand (Mt H_2) With on-site electrolysers capacity (GW)	46 0	63 38	83 210
Share of production via innovative routes	1%	13%	93%
CO_2 captured (Mt CO_2)	2	70	540
Steel			
Recycling, reuse: scrap as share of input	32%	38%	46%
Hydrogen demand (Mt H_2) With on-site electrolysers capacity (GW)	5 0	19 36	54 295
Share of primary steel production: Hydrogen-based DRI-EAF Iron ore electrolysis-EAF CCUS-equipped processes	 0% 0% 0%	 2% 0% 6%	 29% 13% 53%
CO_2 captured (Mt CO_2)	1	70	670
Cement			
Clinker to cement ratio	0.71	0.65	0.57
Hydrogen demand (Mt H_2)	0	2	12
Share of production via innovative routes	0%	9%	93%
CO_2 captured (Mt CO_2)	0	215	1355

Table 3: Key milestones in transforming global heavy industry sub-sectors (chemicals, steel, cement). Note: DRI = direct reduced iron; EAF = electric arc furnace. Information is from International Energy Agency (2021), Net Zero by 2050, IEA, Paris.

Another challenge for decarbonizing heavy industry is the average lifetimes of emission-intensive assets such as blast furnaces and cement kilns, which is around 40 years. This means a key risk is if innovative near-zero emissions industrial technologies do not reach markets within the next decade, as this would have a major negative impact on the pace of emissions reductions. For individual companies, decarbonisation will likely be a step change rather than a steady decline and will depend on when their assets reach the end of their lifetime unless there is significant political, market or investor pressure to change earlier.

IMPLICATIONS FOR INVESTORS

Given the complexity and uncertainty associated with transforming the energy sector to net-zero by 2050, NZE is a valuable resource for investors. This section highlights some key uses and considerations.

Corporate engagement

NZE is particularly useful for investors engaging with energy and heavy industry companies on climate change (e.g. through CA100+) given the IEA's strong standing with energy companies. No energy company will be unaffected under NZE or a similar scenario, and all parts of the fossil fuel industry must decide how to respond. In line with this and the CA100+ Net-Zero Company Benchmark[4], investors should encourage companies to consider NZE in reference to:

- **Decarbonisation strategies:** Demand for all fossil fuels declines after the mid-2020s under NZE. This means that companies (and countries) where this is a significant portion of their revenue or a key input will need to demonstrate how their business strategy aligns with their emission reduction targets and changing energy demand to ensure returns for investors. For example, diversified energy companies may move into renewables, whereas upstream oil and gas companies may decide low-carbon hydrogen and CCUS is a better fit for their expertise. SBTi's Oil and Gas Methodology[7] provides a detailed description of transition options for oil and gas companies.
- **Capital alignment:** Companies will need to demonstrate that their CAPEX is aligned to net-zero by 2050. NZE has provided some clear milestones for this, such as no new oil and gas approved for development and no new coal mines or mine extensions other than those already committed in 2021. The NZE milestones provides investors with clear time frames for reduced investment in fossil fuels and companies should be prepared to align their strategy and CAPEX to these. Additionally, CAPEX in clean energy technologies demonstrates commitment to companies' decarbonisation strategy.
- **Scenario analysis:** NZE provides a detailed, ambitious trajectory to net-zero by 2050 for the energy sector. Companies that haven't disclosed 1.5°C scenario analysis should use NZE where possible and companies that have disclosed 1.5°C scenario analysis should ensure the scenario used is at least as ambitious as NZE in fossil fuel supply reductions and has similar or less CCUS and CDR or be prepared to explain why they have chosen a less ambitious scenario. While it should be expected that fossil fuel producers would see value destruction under this scenario, it is important for investors to be able to understand how the company's strategy fares under a range of futures.
- **Emissions reduction targets:** As per the CA100+ Net-Zero Company Benchmark[4], companies should align their short-, medium- and long-term targets to 1.5°C. Additionally, NZE requires methane emissions from upstream oil and gas companies that occur during operations fall by 75% between 2020 and 2030 and flaring is eliminated. Companies should disclose their efforts to meet this and similar milestones.
- **Just transition:** While clean energy employment increases by 14 million to 2030, employment in fossil fuels declines by around 5 million and job gains do not always occur in the same place or with the same skill set as job losses. As part of companies' decarbonisation strategies, they should consider and disclose impacts on their employees and the communities they operate within and the company's planned approach to address these impacts. Best practice on how investors and companies can promote a just transition is still developing and should continue to be a topic of engagement.

These considerations should be seen as complimentary and not additional to the asks of CA100+ Net-Zero Company Benchmark[4].

Capital allocation and private financing

Net-zero commitments in the finance sector are becoming more common, as are initiatives and commitments designed to catalyse the transition to net-zero emissions by 2050 in the finance sector. Some examples of this include the Net-Zero Asset Owner Alliance, the Net Zero Asset Managers Initiative, and the Net Zero Investment Framework.

However, a barrier to date has been the absence of scenarios to sit behind portfolio measurement and capital allocation plans that align with a 1.5°C pathway. Many scenarios produced have also been highly reliant on technology assumptions that may not come to pass. NZE can now provide this scenario to underpin capital allocation frameworks, assessment tools and strategies, both at portfolio level and for the investment sector more broadly.

In its Roadmap, the IEA is clear that NZE requires substantial investment from private and public sources, much of it in the current decade to 2030, to achieve its key milestones (e.g. Figure 5). The substantial increase in investment in electricity, infrastructure and end-use sectors will require investment from all parts of the economy. NZE requires clean energy investment to triple to 2030 to 4 trillion USD and remain high to 2050. For example:

- NZE requires widespread electrification, therefore a huge increase in expansion and modernisation of transmission and distribution infrastructure is required.
- Investment in hydrogen enabling infrastructure increases from 1 billion USD to 40 billion by 2030.
- There is also a large increase in investment in the electrification of end-use sectors, including batteries, heat pumps and electricity-based industrial equipment.
- There is also an increase in global investment in CCUS (annual investment exceeds USD 160 billion by 2050).
- Investments in energy efficiency including retrofits and efficient appliances in industry and building reach USD 640 billion annually by 2050.

While public capital is an important source of investment particularly for development of new infrastructure projects and accelerating innovation in emerging technologies, the majority of the investment needs to arise from the private sector.

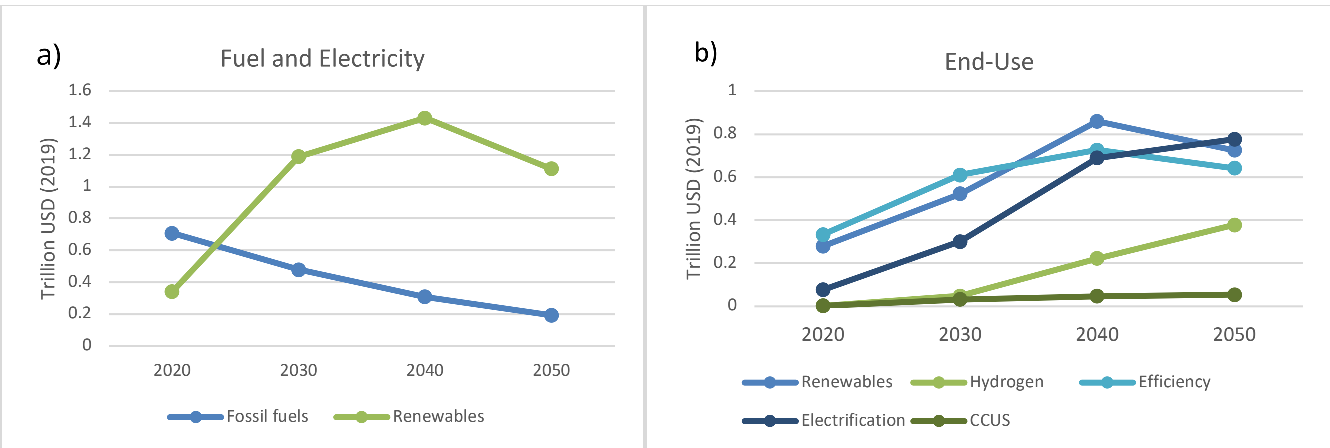

Figure 5: Global average annual energy investment needs in NZE for a) fuel and electricity and b) end-use. Data is from International Energy Agency (2021), Net Zero by 2050, IEA, Paris

CONCLUSIONS

NZE is a welcome addition to IEA's suite of scenarios and provides a more ambitious decarbonisation pathway than STEPS and APC with extensive detail on the transition to net-zero by 2050. While there have been some concerns of IEA and other 1.5°C scenarios using unrealistic amounts of CCUS and CDR to extend fossil fuel demand, IEA demonstrates that CCUS use was around half the IPCC median and CDR was less than all IPCC scenarios considered. In this document, this analysis is supplemented with a comparison of coal and gas supply and showed that NZE was similar to the IPCC mean except for gas between 2020 and early 2030s where gas supply was greater than the mean, with a maximum difference of 25 EJ at 2025. This suggests that gas supply may be overestimated in NZE during this period.

IEA has confirmed that NZE will continue to guide future work and feature in the IEA's annual World Energy Outlook. In these future publications, IEA should provide more regional data for NZE and more explicit modelling of non-CO_2 emissions.

Investors engaging with energy and heavy industry should encourage companies to consider NZE in reference to their decarbonisation strategies, capital allocation, emission reduction targets and just transition plans. These considerations align closely with the CA100+ Net-Zero Company Benchmark[4]. Additionally, NZE can assist investors with their own capital allocation and investment approaches.

RESOURCES

1. **World Energy Outlook 2020 (IEA)**
2. **Net Zero Emissions by 2050 Scenario Briefing Paper (IGCC/CA100+)**
3. **Net Zero by 2050: A Roadmap for the Global Energy Sector (IEA)**
4. **Net-Zero Company Benchmark (CA100+)**
5. **Special Report on Global Warming of 1.5°C (IPCC)**
6. **Foundations of Target Setting (SBTi)**
7. **Guidance on setting science-based targets for Oil, Gas and Integrated Energy companies (SBTi)**

ABOUT

Climate Action 100+ is an investor initiative to ensure the world's largest corporate greenhouse gas emitters take necessary action on climate change. More than 575 investors with more than $54 trillion USD in assets collectively under management are engaging companies on improving governance, curbing emissions and strengthening climate-related financial disclosures. The companies include 100 systemically important emitters, accounting for two-thirds of annual global industrial emissions, alongside more than 60 others with significant opportunity to drive the clean energy transition. Follow us on Twitter: @ActOnClimate100

CONTACT

Laura Hillis
Director, Climate Action 100+
IGCC
E: **laura.hillis@igcc.org.au**