ESG Thema

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Carbon-efficient technologies in the race to Net Zero

Amundi
ASSET MANAGEMENT

Key takeaways

- Although its decarbonisation has been under way for several years now, as highlighted by the strong growth in renewable power capacities, **the power sector still accounts for 38% of global energy- and industry-related CO_2 emissions.**
- **The decarbonisation pace of this crucial sector remains too slow** compared to scenarios consistent with limiting global warming to +1.5°C.
- Although renewable energies such as wind and solar remain the central piece of the equation, **close to 20% of global power supply would need to come from alternative low-carbon power solutions in 2040** according to the IEA NZE 2050.
- In this paper, we assess the decarbonisation potential of four types of solutions and technologies: **nuclear power, carbon capture and storage (CCS), woody biomass and low-carbon hydrogen.**
- **Safe nuclear power** has a role to play in the race to Net Zero. However, a nuclear "renaissance" cannot happen without policy support and long-term visibility.
- Although its application to the fossil power sector should remain at margin, **Carbon Capture and Storage (CCS)** is a much-needed technology in the race to Net Zero. The IEA Roadmap counts on it to deliver 9% of the emissions cuts needed by 2035.
- **Biomass power capacity** needs to rise significantly in almost all scenarios consistent with the 1.5°C temperature target. However, evidence increasingly reveals that woody biomass is on a thin rope to deliver positive contribution to climate goals while limiting risks to ecosystems at the same time.
- We see **clean hydrogen** as much needed in some hard-to-abate sectors such as steel or chemicals. A great number of key economic and regulatory obstacles have yet to be overcome though, to prove its sustainability case compared to other low-carbon alternatives in several applications.

Low-carbon power: a look beyond wind and solar

- Although its decarbonisation has been under way for several years now, as highlighted by the strong growth in renewable power capacities, **the power sector still accounts for 38% of global energy- and industry-related CO_2 emissions.**
- **The decarbonisation pace of this crucial sector remains too slow compared to scenarios consistent with limiting global warming to +1.5°C.** The IEA Net Zero 2050 scenario for instance requires the power sector to reach carbon neutrality as early as 2040. The sector should therefore remain on top of the agenda of investors.
- Although renewable energies such as wind and solar remain the central piece of the equation, **close to 20% of global power supply would need to come from alternative low-carbon power solutions in 2040 according to the IEA NZE 2050.**
- In this paper, we will focus on the following solutions and technologies:
  - Nuclear power
  - Carbon capture and storage (CCS)
  - Woody biomass
  - Low-carbon hydrogen
- Although needed, each of these technologies raise specific challenges that require enhanced due diligence and monitoring by investors for them to actually deliver expected carbon benefits and/or not compromise other sustainable development goals.

	Wind & Solar	Nuclear	CCS fossil fuel plants	Biomass	Hydrogen
Share in global power generation (current / 2040)	**9% - 63%**	**10% - 9%**	**0% - 3%**	**3% - 5%**	**0% - 3%**
Annual investments (current / 2030s)	**327 - 1129** (all renewable power incl. biomass)	**36 - 94**	**0 - 30**	**n/a**	**2 - 222** (incl. end-use investments)
On track?	●	●	●	●	●
Key sustainability challenges	- Land use	- Safety - Water needs	- Water needs - Caputure rate	- Actual CO2 benefits - Land use & ecosystems	- Actual CO2 benefits (blue H2)

Source: Amundi, IEA Tracking Clean Energy Progress, IEA Net Zero 2050 Roadmap

Nuclear: Can the Net Zero priority mark a possible renaissance?

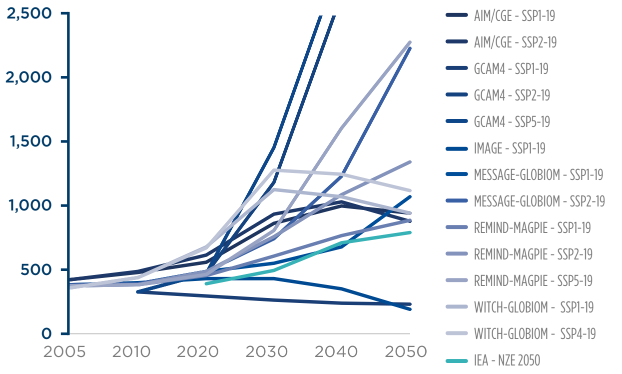
Nuclear power is the use of nuclear reactions to produce electricity. According to the IEA, nuclear energy will be key to achieving global net zero objectives, combined with renewable energy sources and other low-carbon solutions.

What role in the race to Net Zero? Do we need nuclear energy to fix global warming?

When complex integrated assessment models are asked to solve the 1.5°C equation, **they tend to point towards the need for increased nuclear capacities:**

- Out of the 13 pathways generated by these models applied to different socioeconomic scenarios (SSPs), only 2 simulate a reduction in global nuclear power generation capacity by 2050, when the 11 others point to significant increases, ranging from +40% up to +700% of current capacities.
- 'Net zero' 2050 modeling made by the IEA or BP also suggest a need to accelerate the deployment of nuclear capacities. For example, the IEA Net Zero scenario requires a tripling of annual capacity additions.

Worldwide Nuclear Power Capacity in Various 1.5°C Scenarios (in GW)



Source for chart: IIASA, Amundi

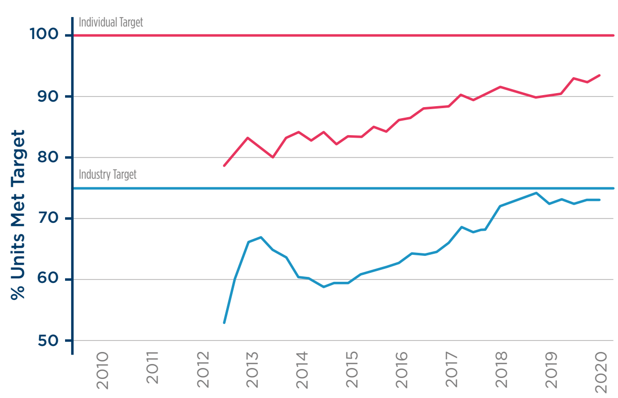
10 years after Fukushima: Where do we stand?

The Fukushima accident was a dire reminder of the high-impact-low-probability risks attached to nuclear energy. With higher safety requirements inflating costs and political decisions to phase out nuclear power in Germany, Belgium, Switzerland and Spain, we have gone through ten years of downward revision of capacity forecasts:

- The IEA cut its 2030 forecast by a quarter between 2010 and 2021, and
- The levelised cost of energy for nuclear power currently stands at 50+% higher than in 2010, according to Lazard's estimates. This is so despite the tailwind of lower interest rates.

On the other hand, we have to note that investments in safety seem to have borne fruit: the readiness of important safety systems has improved, and the frequency of unplanned stoppages has decreased[1].

Unplanned Total Scrams per 7,000 Hours Critical



Source: Wano 2021

1. https://www.wano.info/getmedia/b99fb36c-0806-4c62-b175-1ccaa30c5d04/2104-WANO-Performance-Indicator-Electronic-Document-6pp.pdf.aspx

What are the main pros and cons of nuclear power?

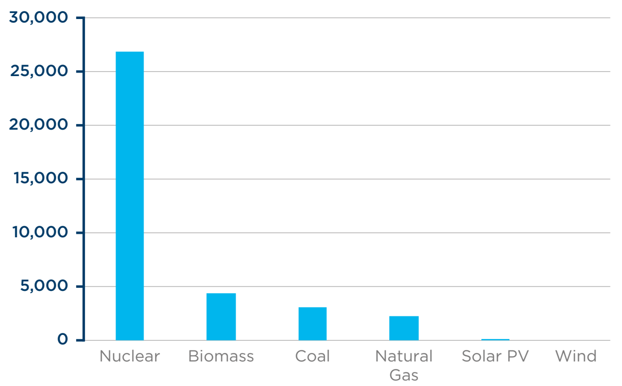
We list in the table below some key advantages and challenges of nuclear energy.

Pros / Advantages	Cons / Challenges
- A low CO2-intensity on a life-cycle basis, similar to wind and solar PV (<100kgCO2/MWh) - Lower materials requirements than renewable energies, per unit of output - By far the power generation technology with the lowest land footprint (<10 ha/TWh/y in average) - Baseload power with possibility to operate in flexible mode to balance electricity systems with high penetration of intermittent power sources (solar, wind)	- Hazardous radioactive waste: c.3% of annual used fuel generated is classified as high-level waste. Requires safe handling and long-term (>100,000 years) storage solutions - Risks of high and long-lasting impacts in case of major accident, and impact on technology acceptance - Operational and safety challenges heightened by the changing climate - Costs: high upfront costs and recurring construction delays, relatively higher generation costs than renewable energy technologies, still limited historical data on decommissioning costs and site repurposing. - Ageing skilled workforce, engineering expertise gap

Operational and safety challenges heightened by climate change

- The design and location choice for assets with a 60-year lifetime is made even more complex by climate change, hence a need to anticipate possibly more acute future flooding risks for instance.
- In particular, nuclear is the most water-intensive technology due to high cooling needs (8-12x higher water use than coal and gas plants in average). This makes water scarcity and thermal pollution particularly strong challenges with operational risks attached[2].

Blue water withdrawal of operation (median, L/MWh)



Source: Amundi

What are the technological developments investors should keep an eye on?

Two new nuclear technologies gained attention this year: small modular reactors (SMRs) and nuclear fusion.

- **SMRs** are advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit, or about one-third of traditional nuclear power reactor. Two SMRs are in operations and 70 others are at various development stages from conceptual design to under construction. Their smaller size and modular design are expected to reduce some of the above-mentioned risks (construction and decommissioning costs, safety, water use, etc.). The business case has yet to be demonstrated though, and existing legal frameworks and safety standards need to be adapted to accommodate this new technology.
- The MIT announced a significant technological advance in **nuclear fusion** in 2021, opening the way for a demonstration plant as early as 2025. Another demonstration plant is planned in the United Kingdom for 2025. Nuclear fusion greatly reduces safety risks associated to nuclear fission.

2. https://www.sciencedirect.com/science/article/pii/S1364032119305994

Conclusion

- **Safe nuclear power has a role to play in the race to Net Zero.** However, the economics of the technology imply that a nuclear renaissance cannot happen without policy support and long-term visibility.
- While a number of governments including France, the United States and South Korea warm up to nuclear energy as they try to solve the energy security and Net Zero equation, **we expect a strong divide to remain on the risk/benefit ratio of the technology,** as highlighted by the lack of consensus in the European Union over a potential inclusion of nuclear power in the EU taxonomy.
- Despite clear improvements in safety performance, another major accident cannot be discarded and such events would likely dent public acceptance of nuclear power.

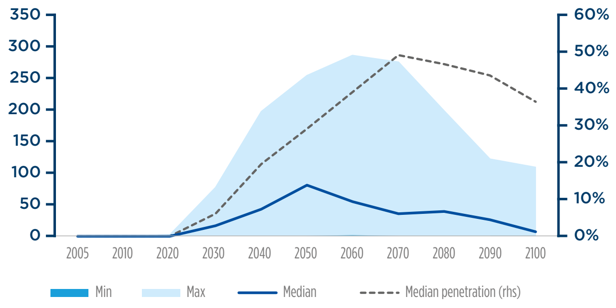
Can Net Zero be achieved without Carbon Capture & Storage technology?

Carbon Capture and Storage involves the capture, transportation and storing of carbon dioxide from large point sources, including power generation or industrial facilities that use either fossil fuels or biomass for fuel. This suite of technologies can play an important and diverse role in meeting global energy and climate goals.

When complex integrated assessment models are asked to solve the 1.5°C equation, **they tend to count on Carbon Capture & Storage (CCS) applied to coal- and gas-fired power capacities,** with a penetration rate of the technology above 24% in 9 out of 13 models by 2050.

- This should not hide another key outcome of these models, which is that most of them require a sharp decline in global fossil power capacity from 2020 onwards.
- **For fossil fuel power plants, CCS therefore appears as a transitory solution:** global CCS-equipped power capacity will peak in 2050-60, even in models relying the most on this technology. In the IEA NZE 2050 scenario, less than 2% of global electricity supply in 2050 comes from CCS-equipped fossil fuel plants.
- CCS is nonetheless a much needed technology in the race to Net Zero as its usefulness extends to industrial applications, biomass power and direct air capture, with the two latter technologies due to deliver net negative emissions to offset residual fossil fuel-related emissions. The IEA Net Zero Roadmap counts on CCS to deliver 9% of the emissions cuts needed by 2035, and to capture and store 2.7x more CO_2 annually from industrial and fuel transformation applications than from the power sector.

Worldwide Fossil Power equiped with CCS in Various 1.5°C Scenarios (in EJ, and % of total fossil capacity)



Source: IIASA, Amundi

Where do we stand?

Clearly, the technology development is far from being on track. Although the world counts 26 commercial-scale facilities equipped with CCS and capturing 40mtCO_2 pa, there is only one commercial power project currently operating, located in the US.

Eight projects are under advanced development (4 on coal power, 3 on gas power, and 1 waste-to-energy). **But, when accounting for the current development pipeline, the IEA still reckons a massive 86% gap to its Net Zero roadmap for CCUS[3] in the power sector by 2030.**

CO_2 capture projects in power generation, operating and in advanced development

Source: https://www.iea.org/reports/ccus-in-power

What are the key challenges?

Carbon Capture and Storage is a relatively costly technology in the CO_2 abatement curve. Norwegian company Aker Carbon Capture communicated on an indicative range of levelised cost of carbon capture of €75-100/t CO_2[4]. While one can expect costs to vary greatly by project type and location, what is important to keep in mind is that the additional operational costs of the plant and the costs related to the CO_2 transportation and storage can each outweigh the extra capital expenditures (with an indicative range of €30-60/tCO_2 for transportation & storage alone). This shows the benefits of creating CCS hubs pooling smaller industrial CCS projects with a large power CCS project to spread transportation costs.

Although the EU CO_2 price recently reached levels close to €80/t, rare are the jurisdictions where CO_2 prices or taxes high enough to incentivize CCS projects. **However, policy support for CCUS is on the rise.** In the EU, the €10bn Innovation Fund will be able to support CCUS projects, and in the US, the Infrastructure Investment and Jobs Act includes more than $12bn of support for carbon management CCUS (including $6bn for R&D, and $2bn to set up a loan programme). Still, the higher operational costs of CCS plants would require specific policy support.

3. Carbon Capture, Utilization, and Storage (CCUS)
4. https://akercarboncapture.com/wp-content/uploads/2021/09/Aker-Carbon-Capture-Capital-Markets-Day-09092021.pdf

Infrastructure Investment and Jobs Act (Selected energy RD&D programs, $ in millions)

Carbon management	
Regional direct air capture hubs	3,500
Carbon capture demonstration and pilot programs	3,474
Carbon storage commercialization	2,500
Carbon dioxide transportation infrastructure loans	2,100
Industrial decarbonization demonstration projects	500
Carbon utilization program	310
Direct air capture prizes	115

Source : https://www.aip.org/fyi/2021/new-infrastructure-law-provide-billions-energy-technology-projects

Higher water needs are required. A research paper released in 2020 found that a third of the global coal-fired power plant capacity experiences water scarcity for five or more months per year[5]. As global warming is due to exacerbate water scarcity in some regions of the world, and most common solvent-based CCS increase the water withdrawal needs of the plants, carbon capture may not be sustainably deployable for retrofit on many existing power plants.

Capture rate and storage permanency should be monitored. Operating power plants equipped with CCS have showcased capture rates of close to 90%, higher than some blue hydrogen applications for instance. Achieving capture rates of 99% appears feasible at limited incremental costs[6]. Storage permanency will have to be monitored, but the US National Energy Technology Laboratory came to the conclusion that *"considerable experience with the injection of CO_2 for enhanced oil recovery (EOR), underground storage of natural gas, and continuous monitoring at several large-scale CCS injection projects around the world indicates that CO_2 injection is expected to be safe[7]."*

Conclusion

- CCS is a much-needed technology in the race to Net Zero. **While closing coal power plants should be the priority, a transitory and targeted application to fossil fuel power plants (for abating emissions of the youngest coal power plants notably) can also create economies of scale needed for its adoption for other industrial and net negative emissions applications.**
- Policy support is on the rise and appears critical to the development of a technology with high CO_2 abatement costs
- Water needs can be a serious limiting factor, hampering the development of the technology in water-stressed areas and requiring enhanced scrutiny.

5. https://www.nature.com/articles/s41893-020-0532-7
6. IEA
7. https://netl.doe.gov/coal/carbon-storage/faqs/permanence-safety

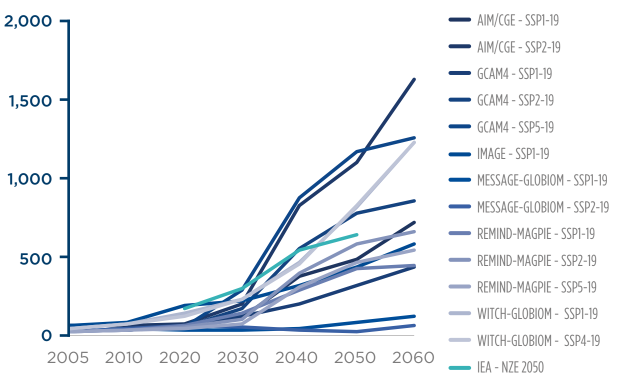
Woody biomass: is time not on its side?

Woody biomass refers to biomass derived from trees. Woody biomass is a renewable energy source, as new forests can be grown through afforestation and appropriate maintenance. While it possesses important energy production potential, the scientific literature contains contrasting findings about the effects of forest bioenergy on climate.

What role in the race to Net Zero?

- **Biomass power capacity has to rise significantly in almost all scenarios consistent with the 1.5°C temperature target.**
- The IEA Net Zero 2050 scenario for instance requires a more than three-fold expansion of global capacity by 2040.

Worldwide Biomass power Capacity in Various 1.5°C Scenarios (in GW)



Sources: IIASA, IEA, Amundi

Where do we stand?

- **A rare technology whose development is 'on track':** Bioenergy power generation is a rare technology whose development is deemed on track with capacity targets required in the IEA Sustainable Development Scenario[8].
- **The market outlook is positive:** US company Enviva, the world's largest supplier of wood pellets, foresees a strong growth in international demand of pellets for heat & power generation (5.5% CAGR over 2020-30), notably driven by the UK, Europe and Asia. Enviva also anticipates industrial applications to add significant demand by 2030[9].

Doubts over the actual positive impacts of biomass energy are growing however: does woody biomass actually have a positive contribution to Net Zero objectives?

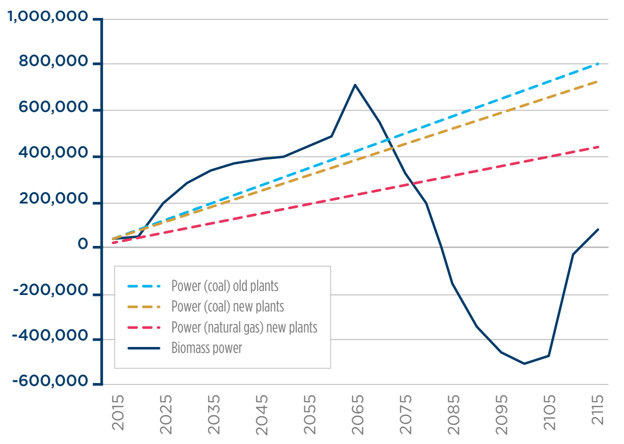
Although emissions from biomass energy are counted as nil in national greenhouse gas inventories and in the EU Emissions Trading Scheme for accounting purposes, the literature agrees on the fact that considering wood biomass as climate neutral by default is over simplistic and even false.

To be carbon neutral, an amount of CO_2 emissions equal to those released during the processing, transport and combustion of the biomass has to be (re)captured. **Depending on the type of wood sourced and on forestry management, there can be a considerable time lag before CO_2 emissions are recaptured.**

8. https://www.iea.org/reports/tracking-bioenergy-power-generation-2020
9. https://s28.q4cdn.com/898203682/files/doc_presentation/2021/10/EVA-Simplification-Investor-Presentation-Oct-15-Final.pdf

Payback time matters! The carbon benefits of the use of woody biomass therefore need to be assessed over time. Payback time is the time required for cumulative lifecycle CO_2 emissions of the woody biomass to go below those of an alternative scenario (use of coal for example). **It is only after this payback time that biomass generates carbon emissions savings.** Carbon parity is achieved only once forest regrowth has totally offset cumulative emissions. **In this illustrative chart, it takes more than six decades to happen.** Even once achieved, the pattern is not neutral for global warming as front-loaded emissions can contribute to a temporary overshoot of targeted CO_2 concentration levels in the atmosphere, hence of temperature targets.

An illustration of payback time and carbon parity (cumulative emissions, in $MgCO_2e/MW$)

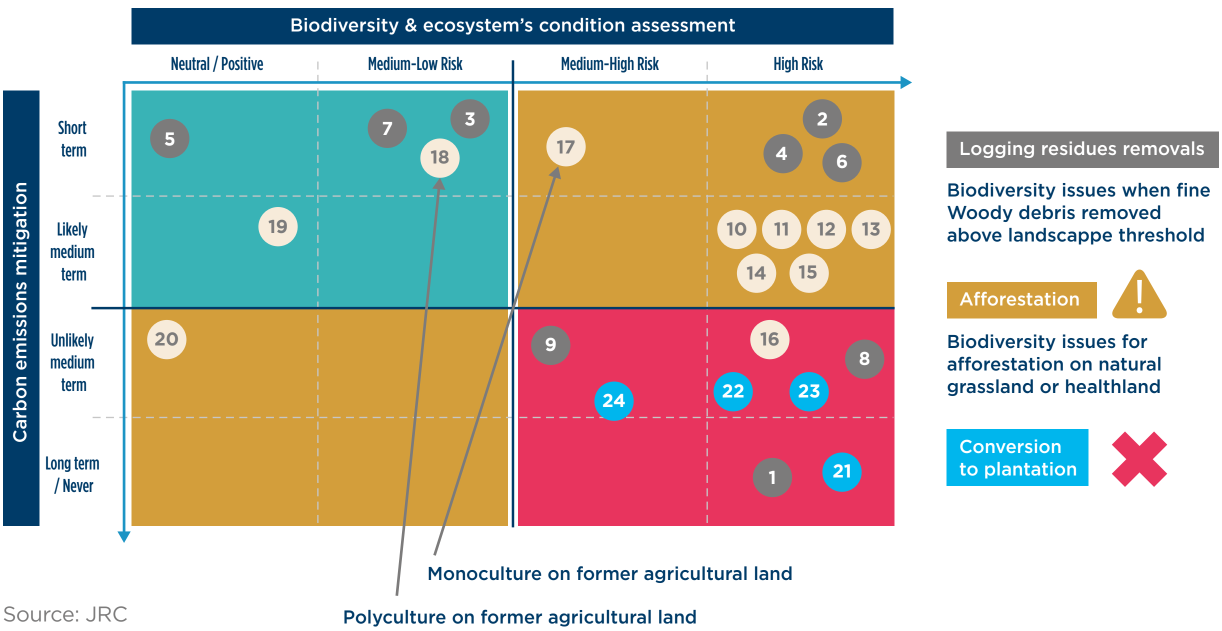


Source: NRDC

Which practices should be encouraged, and which should not?

- Carbon payback time is a relevant indicator that is nonetheless influenced by many complex methodological and biomass characteristics factors that can vary from one study to the other.
- This mapping made by The Joint Research Center of the European Commission (EU JRC) provides good insights and reveals that **out of 24 types of wood sources, only 4 are expected to deliver short-term carbon benefits (within one or two decades) while not creating significant risks to ecosystems.** This mostly consists in the use of logging residues removals and polyculture afforestation on former agricultural land. Conversely, converting forest lands into plantations has only very long-term if not uncertain carbon benefits, and at the same time poses critical biodiversity risks. **This type of analysis should inform investors' engagement with their investee companies involved in biomass energy.**

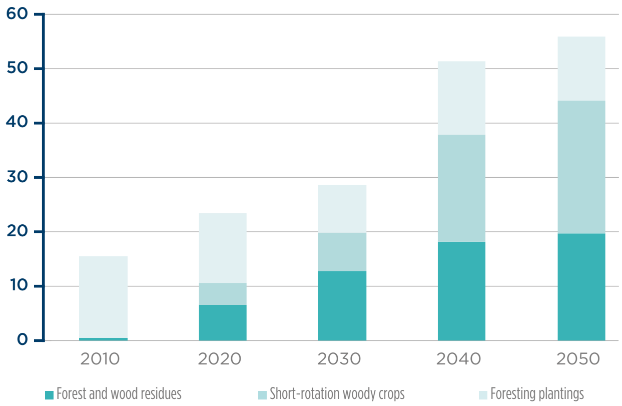
Infrastructure Investment and Jobs Act (Selected energy RD&D programs, $ in millions)



Source: JRC

- The IEA Net Zero Emissions 2050 scenario clearly encourages the use of **wood residues and short-rotation woody crops** over forestry plantings, with the two first types required to cover 98% of incremental supply by 2040[10].
- **Sustainability conditions are attached to each category:** for forestry plantings for instance, it implies that forests are managed in order to ensure that the carbon stock and carbon absorption capacity of the forest is enhanced or remains unchanged. Moreover, new plantations and tree plantings must be integrated with agricultural production via agroforestry systems that do not conflict with food production or biodiversity. This is a positive point of the IEA scenario, in that it takes into account risks of tensions related to land-use and arising from competition with food production.

Woody biomassy supply in the IEA Net Zero scenario (in EJ)



Source: IEA

- Finally, just like coal, power generation from biomass emits air pollutants such as NOx, SO2 and particulate matters that have to be as much as possible captured to mitigate adverse impact on air quality. This is yet another dimension to be monitored by investors. We note for instance that a UK operator showcases air pollutants intensities for its biomass generation 2.5x to 6x lower than for coal power.

Conclusion

- Scientific evidence increasingly reveals that woody biomass is on a thin rope to deliver positive contribution to climate goals while limiting risks to ecosystems.
- This requires enhanced monitoring by investors of the type of wood sourced and the associated impacts on forestry management. Conversion of existing forests to plantations appears as a "no go" for instance.
- **Investors should be prepared to see increasingly distinctive supporting policies on biomass**, creating clear risks of subsidy removals for unsustainable biomass projects. Recent evolutions in the Netherlands should be seen as a bellwether and the outcome of the ongoing update of the EU Renewable Energy Directive (REDIII) will be another key test.

10. Short-rotation woody crops (SRWCs) are fast-growing hardwood tree species harvested specifically for energy production after three to eight years of planting, on existing croplands, but also on pastures or marginal lands that cannot be used for food crops (such as poplar, willow, eucalyptus, silver maple, green ash, black walnut, and sycamore).

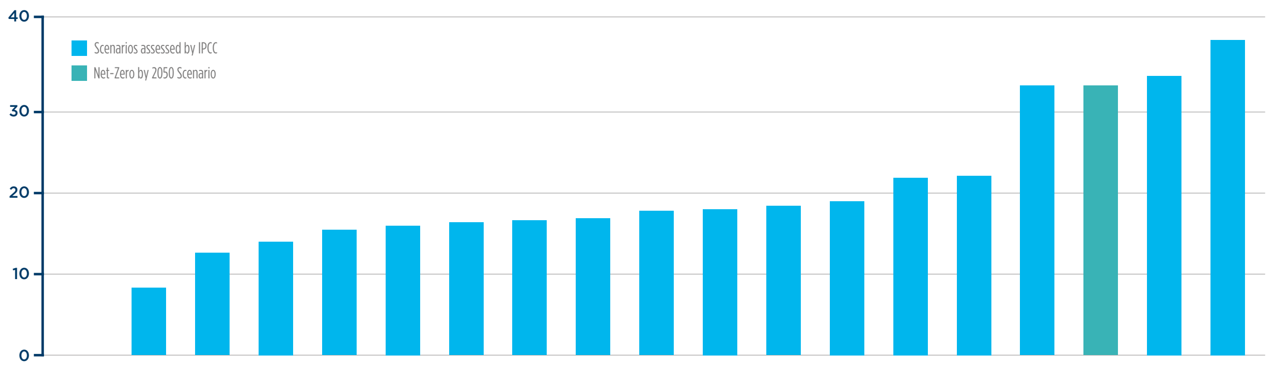
Hydrogen: a true beginning after several false starts?

Hydrogen can be produced from almost all energy resources, though today's use of hydrogen in oil refining and chemical production is mostly covered by hydrogen from fossil fuels. Clean hydrogen, being produced from renewables, nuclear or fossil fuels with CCUS, could help to decarbonise a range of sectors.

What role in the race to Net Zero?

- **The 18 IPCC scenarios that have Net Zero CO_2 energy sector and industrial process emissions in 2050 have a median recourse to hydrogen of 18EJ in 2050.** The range is wide – from 0 to 39EJ – likely reflecting major uncertainties over the potential of still-immature low-carbon H2 technologies and applications. In the NZE Scenario however, 33EJ of hydrogen is used in final consumption in 2050.

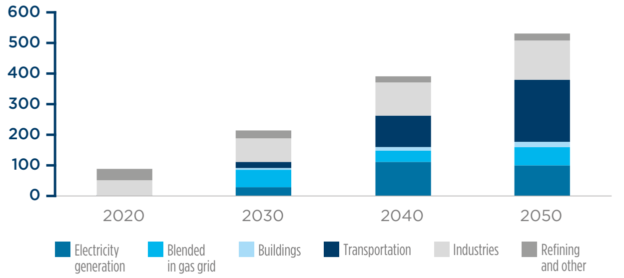
Comparison of hydrogen in total final consumption in the IPCC scenarios and the NZE in 2050



Source: IEA

- **The IEA Net-Zero by 2050 scenario appears in the optimistic camp when it comes to the potential of clean hydrogen in various applications.** In this scenario, the utilities sector retains a minority but still significant share of total H2 demand in 2050 (20% for electricity generation and 11% for the gas grid), in comparison with the demand from hard-to-abate sectors (e.g. heavy trucks, aviation and shipping, chemicals, iron and steel). Its role in electricity generation remains fairly limited on the long-term at 2+% of the total global supply, but is comparable for instance to the contribution from fossil fuel plants equipped with CCS in 2050. In this scenario, the purpose of hydrogen's use in gas-fired power plants and stationary fuel cells is to help balance increasing generation from variable renewables and to work as an energy storage solution.

Hydrogen demand by application in the IEA Net Zero 2050 Scenario (mt)

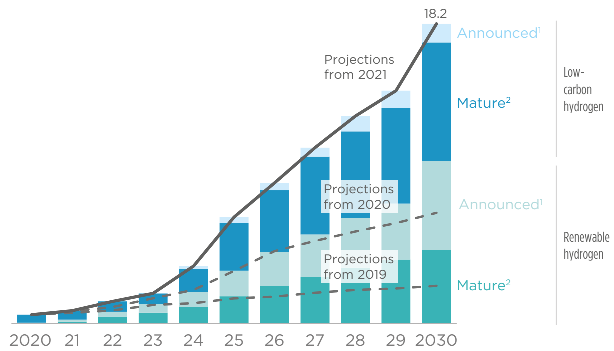


Source: IEA

Where do we stand?

- The significant momentum in policy support in recent years provided visibility to economic agents on subsidies and targeted capacities. This triggered a significant increase in interest and project announcements.
- **As at November 2021, the Hydrogen Council listed 520 announced large-scale hydrogen projects.** Those considered the most mature (at least at the planning stage) would already require $84bn of investments.
- In just two years, the institution raised by 8 times its estimate of announced clean hydrogen production capacity by 2030 up to 18mtH2. This still falls far short of the 150 mt required in the IEA Net Zero by 2050 Roadmap however.
- 70% of the announced production capacity comes from renewable energy sources (electrolysis-based green hydrogen), with the rest coming from blue hydrogen projects (fossil fuels combined with carbon capture & storage).

Announced clean hydrogen production volume by pathway

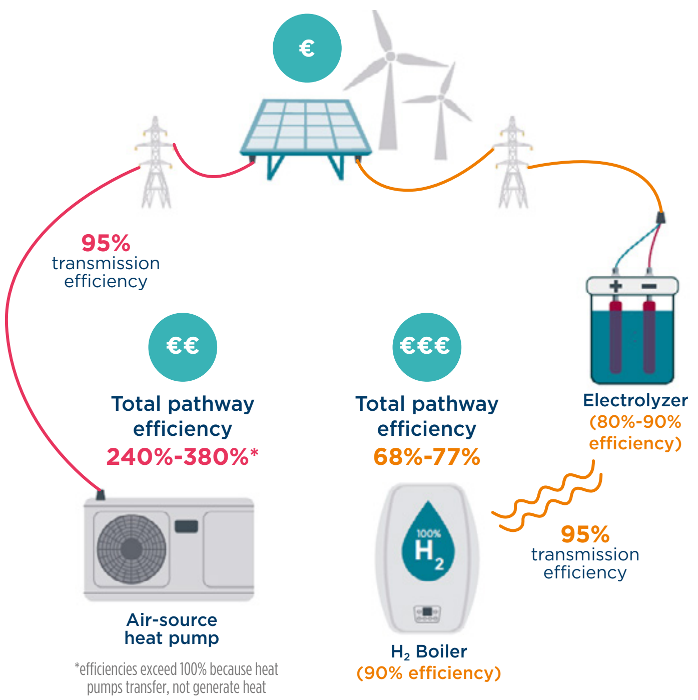


1. Preliminary studies or at press announcement stage
2. Feasibility study, front-end engineering and design stage, final investment decision has been taken, under construction, commissioned or operational

Source: Hydrogen Council

What are the key challenges?

A relatively low energy efficiency: The International Council on Clean Transportation (ICCT) estimates that the total pathway efficiency of using green hydrogen in boilers for residential heating is close to 4x lower than using heat pumps (see chart). Similarly, due to significant energy losses from well to wheels, hydrogen is not an energy-efficient solution compared to battery electric cars. A hydrogen car consumes 2-3 times more electricity for the same distance than a battery car for instance. As long as battery manufacturers are able to improve range, a technology shift towards hydrogen is very unlikely in our view.



Source: ICCT

Life-cycle carbon impact of blue hydrogen: Even when equipped with carbon capture and storage, the production of hydrogen from steam methane reforming (or blue hydrogen) is not carbon neutral. According to the ICCT for instance, the use of blue hydrogen in lieu of fossil natural gas would translate in greenhouse gas emissions savings of 42–61% only[11]. **To be truly low-carbon, blue hydrogen projects must demonstrate high capture rates and low methane leaks across the value chain.** Existing projects globally have capture rates of 40-60% but rates of more than 90% are technically feasible though.

Huge electricity and infrastructure needs: Green hydrogen needs envisaged in the IEA NZE 2050 scenario require massive amounts of additional green electricity production. The numbers are sobering. **By 2030, 3,850TWh of green electricity would be needed for green hydrogen production alone.** This is equivalent to the total increase in electricity production of China in the last decade. This also adds to huge grid-connected green power capacity additions requirements. Importantly, electrolyser-tied renewable projects should not cannibalize grid-tied ones, as the risk would be to slow down the decarbonisation of power grids.

The infrastructure challenge is also massive. As stressed by the IEA *"Developing the infrastructure for hydrogen at the pace required in the NZE would involve considerable investment risks along the value chain of production, transport and demand ranging from hydrogen production technologies through to low-emissions electricity generation and CO_2 transport and storage".*

A need to adapt regulations and standards: Hydrogen blending (high rate) and transportation in natural gas grids would require the adaptation of existing regulatory limits on hydrogen blending and the adaptation of some assets. Current limits on hydrogen blending in natural gas networks range from 0% to 6%.

Optimistic cost reduction scenarios have yet to be validated: A 2020 report funded by the ICCT concludes that the promising outlook for green hydrogen cost competitiveness pushed by research from the IEA, BNEF or IRENA is based on over optimistic assumptions and largely ignore total system costs of electrolysers. The report expects production costs for green hydrogen in Europe to fall at a CAGR of 1,4% over 2020-50, or three times less rapidly than in the IRENA's outlook.

Conclusion

- Clean hydrogen currently benefits from an unprecedented policy support that has triggered a flurry of project announcements with high associated investment requirements.
- We see clean hydrogen as much needed in some hard-to-abate sectors such as steel or chemicals.
- A great number of key economic and regulatory obstacles have yet to be overcome though, while clean hydrogen in general, and blue hydrogen in particular, **has yet to prove its sustainability case compared to other low-carbon alternatives in several applications, in our view.**

11. https://theicct.org/sites/default/files/publications/Hydrogen-heating-UK-dec2020.pdf

SECTORAL FOCUS

Reaching Net Zero in the Utilities Sector

Key takeaways

- Electrification of end-use sectors, including heat, and increased demand of electricity significantly magnify the need for power sector decarbonisation.
- Reaching Net Zero implies a complete phase out of unabated coal by 2040 with only 0.4% of electricity generation coming from unabated gas in 2050.
- In such a scenario, renewables increase multi-fold and constitute almost 90% of electricity production in 2050. Solar and wind lead the way.
- Heat pumps play a significant role in decarbonising the heating sector. Simultaneously, there is increased uptake of onsite renewables like solar thermal heaters and biomass boilers to meet global heating demand.
- The decarbonisation of the sector must be accompanied by an expansion of networks; sources of flexibility; increased investment and innovation; enabling government intervention; and a 'Just Transition'.

Note: 'The scenario' refers to the IEA Net Zero Emissions (NZE) by 2050 Scenario hereunder.

The electricity and heat sectors were responsible for almost 40% of global CO_2 emissions in 2020, where coal was the highest contributor followed by natural gas. **Up to 2030, approximately 60% of the emissions reductions come from these two sectors, primarily driven by a reduction of coal usage and eventually natural gas.**

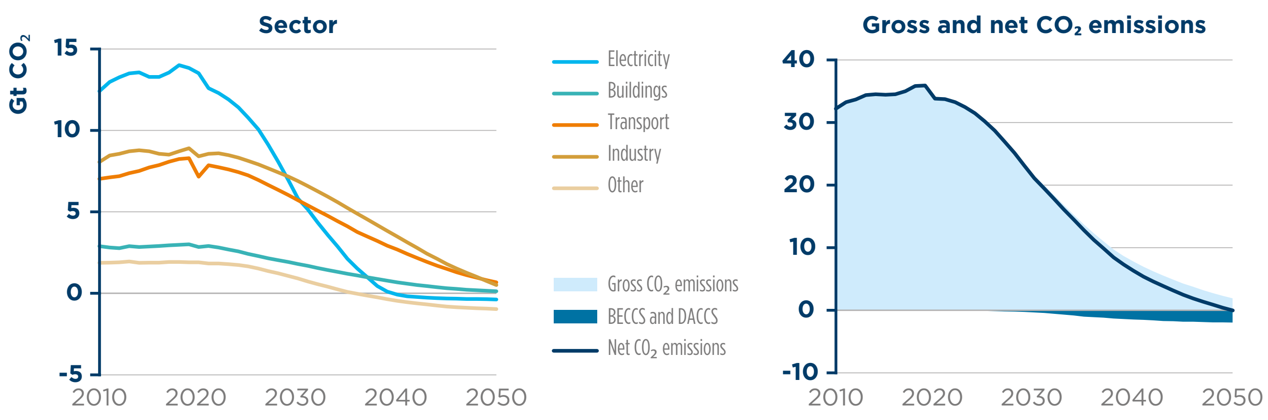
Power sector decarbonisation is the most aggressive, in that it reaches net zero before any others. Whilst challenging since it requires a significant revamp of existing company assets, it is possible due to the current availability, maturity and low cost of technologies to drive these emissions cuts. Under the scenario, emissions from the sector become net zero in advanced economies by 2035 and globally by 2040. The scenario is driven by a number of components, as discussed below.

Accelerated electrification and increased demand

Over the next three decades, the demand for electricity increases substantially, driven by factors such as a much larger population (2 billion higher than today) and a bigger global economy that more than doubles by 2050, electrification of end-use sectors (including heating), as well as the expansion of hydrogen production from electricity. **Under the scenario, global electricity demand more than doubles by 2050 implying an annual increase of 3.2%, with a consequent and proportional rise in generation.** Further, the share of electricity in overall energy consumption rises to approximately 50% by 2050 compared to 20% today. Given this predicted increase in overall electricity demand and generation, it becomes even more critical to decarbonise the sector by using renewables and other low emissions sources.

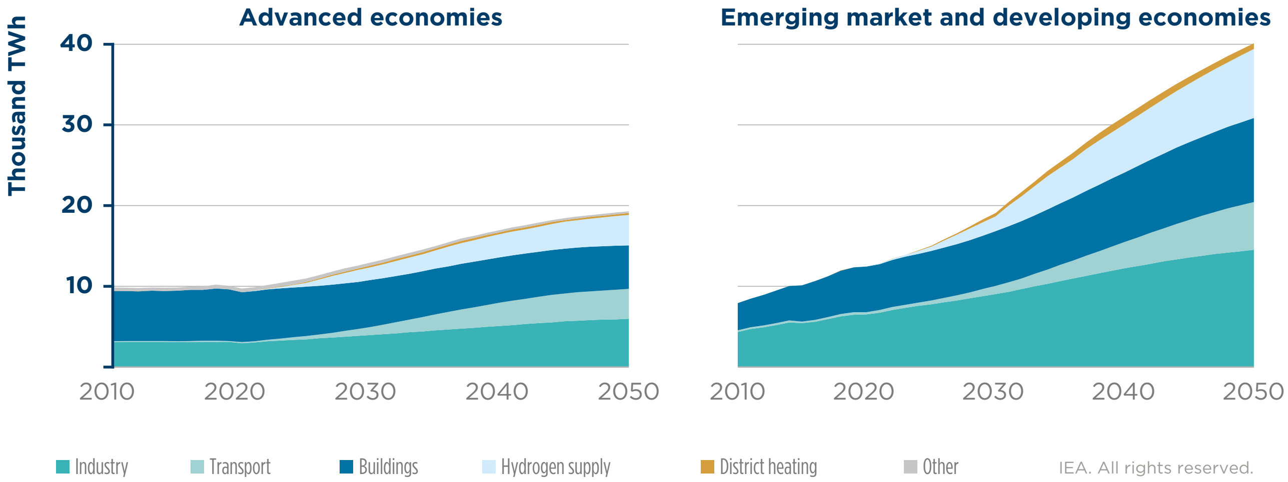
Electrification of heating also leads to an increased demand for electricity. Demand for electricity due to end use electrification including heating increases 35% between 2020 and 2050 in buildings. By 2050, two thirds of residential buildings in advanced economies and almost 40% of those in emerging and developing economies utilise a heat pump. Further, electricity accounts for 40% of heat demand by 2030, rising to 65% by 2050.

Global net-CO_2 emissions by sector, and gross and net-CO_2 emissions in the NZE



Emissions from electricity fall fastest, with declines in industry and transport accelerating in the 2030s. Around 1.9 Gt CO2 are removed in 2050 via BECCS and DACCS.

Electricity demand by sector and regional grouping in the NZE



Electrification of end-uses and hydrogen production raise electricity demand worldwide, with a further boost to expand services in emerging market and developing economies.

Renewables and low carbon sources

The need to deploy renewables and other low carbon sources, to meet increasing demand and simultaneously cutting emissions, is unprecedented in scale. The cost of renewables has declined significantly over the last decade and continues to fall, making them competitive with, and oftentimes cheaper than, their fossil fuel counterparts. This allows their mass deployment to be both economical and prudent. **To meet the Net Zero goal and limit temperature rise to 1.5°C, renewables must overtake coal by 2026 and oil and gas before 2030[12].**

Under the scenario, renewables make up over 60% of electricity generation in 2030 and over 90% by 2050 (with a majority of the remainder coming from nuclear), in contrast to 29% in 2020. Solar and wind become leading sources of generation before 2030 and constitute almost 70% of production by 2050. CO_2 intensity of electricity generation i.e. kgs of CO_2 emitted per kWh produced – indicative of how green a generation asset is – declines from 0.438 in 2020 to 0.138 by 2030 and becomes slightly negative (-0.005) by 2050.

While hydropower is the leading low carbon source today, solar and wind are set to lead the way going forward. Solar photovoltaic (PV) capacity increases 20-fold between now and 2050, while wind power increases 11-fold. Annual wind and solar capacity additions between 2020 and 2050 are five times higher than the average over the last three years. To ensure the success of these technologies, a few of their associated or possible impediments will need to be tackled, including:

- Intermittency of the technologies
- Geographic location/placement
- The presence of enough skilled labour
- Adequate supply chain capacity
- Land use and community acceptance, along with impacts on biodiversity

Dispatchable renewables will be required to manage intermittency from solar and wind, such as hydropower, bioenergy, CSP and geothermal. These will be essential for energy security, and consequently balancing any supply vs. demand discrepancies.

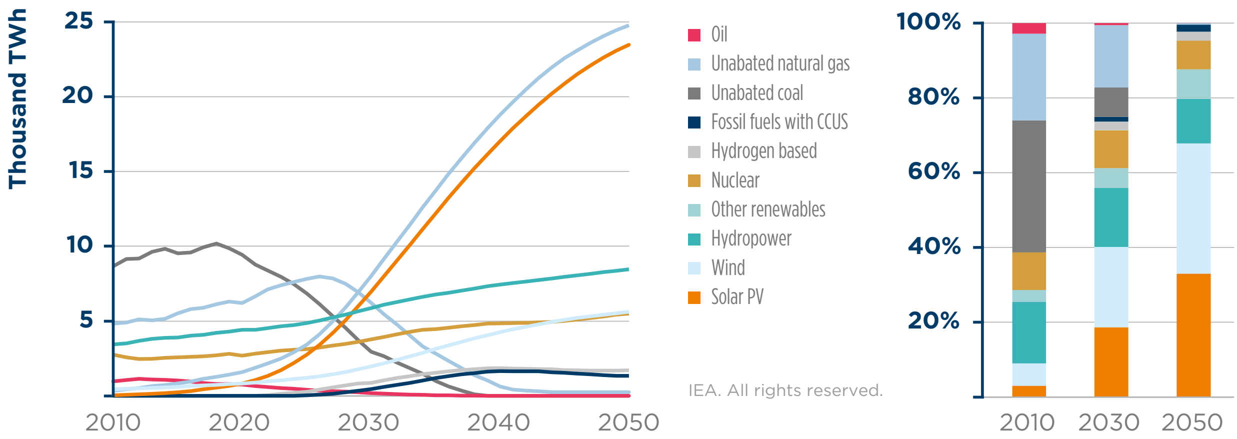
12. https://www.carbonbrief.org/iea-renewables-should-overtake-coal-within-five-years-to-secure-1-5c-goal#:~:text=This%20would%20see%20renewable%20energy,nearly%2090%25%20of%20electricity%20generation.

Nuclear also plays a vital role as a low carbon source in the scenario. It is the largest generation source after renewables, with output rising by 40% up to 2030 and 2x by 2050 (albeit overall share of generation stays below 10% in 2050).

The role of low carbon or green hydrogen becomes more prominent in a Net Zero scenario. It is used in both power plants for electricity production and for end-use such as heating. After 2030, hydrogen and hydrogen-based fuels make up an important source of system flexibility, through retrofitting power plants to co-fire with hydrogen or ammonia. Under the scenario, hydrogen-based fuels produce almost 2.5% of electricity in both 2030 and 2050.

Heat pumps play a significant role in decarbonising the heating sector. Simultaneously, there is increased uptake of onsite renewables like solar thermal heaters and biomass boilers to meet global heating demand.

Global electricity generation by source in the NZE



Solar and wind power race ahead, raising the share of renewables in total generation from 29% in 2020 to nearly 90% in 2050, complemented by nuclear, hydrogen and CCUS.

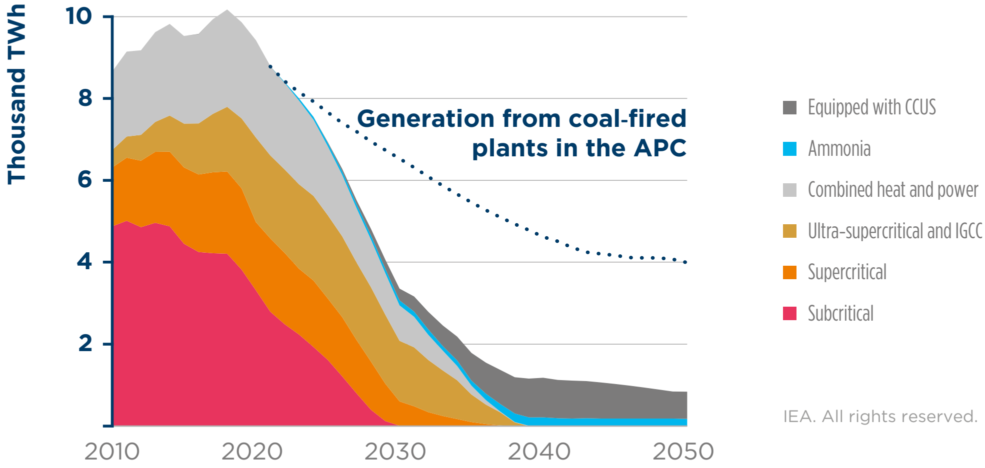
Decline of coal and the role of natural gas

Under NZE, the share of unabated coal based generation declines from 35% today to zero in 2050. Starting 2021, there is no place for the development of new unabated coal plants, and unabated coal fired generation falls by 70% up to 2030. The least efficient plants should be phased out by 2030 and those that remain in use must be retrofitted by 2040. Additionally, such plants should be phased out in advanced economies by 2030 and all other regions by 2040. Unabated oil power plants are phased out by this timeframe as well.

For unabated gas, the figure declines from 23% today to 0.4% in 2050. The use of natural gas without carbon capture rises in the near term to compensate for some of the diminished coal capacity, but this must only be for a short period, even in coal dependent economies like in South Asia. This figure begins to fall by 2030 at 17% of total electricity generation, and is 90% lower in 2040. The belief that gas can act as a transition fuel is diminishing, and gas-fired power plants are now being increasingly assessed from a stranded asset risk perspective, with some calling gas 'the new coal'.

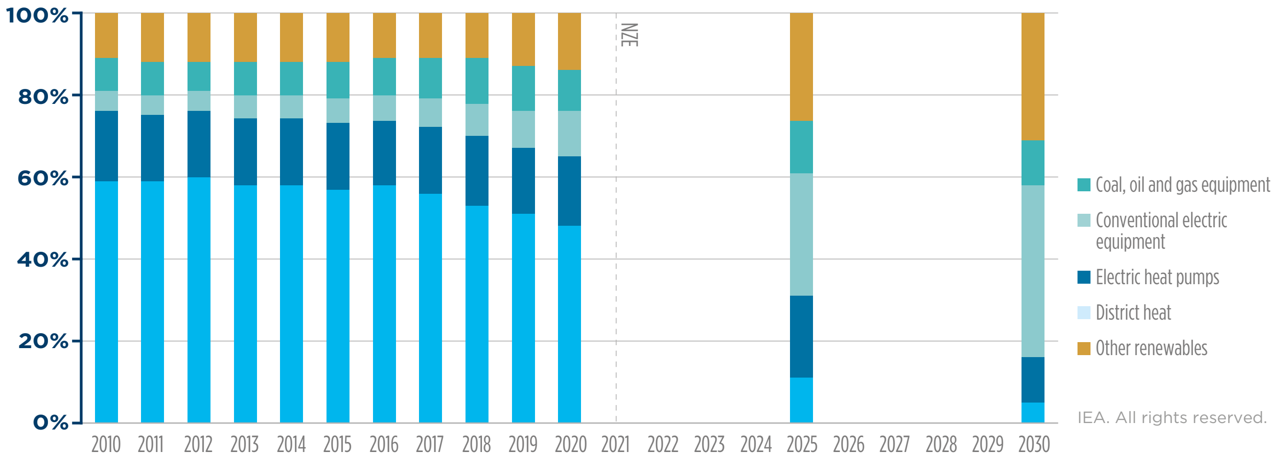
The role of gas for heating diminishes as well, with the phase out of fossil fuel boilers by 2025, and the widespread adoption of heat pumps, as 50% of heat demand will be met by heat pumps in 2045. Other options for heating are at different stages of maturity, and include solar thermal heating, biomass boilers, hydrogen (but supply is forecasted to be constrained), geothermal, nuclear etc. The decarbonisation of heat will have sizeable and strategic implications for gas utilities.

Coal-fired electricity generation by technologiy in the NZE



Coal-fired power accounted for 27% of global energy CO2 emissions in 2020, and in the NZE, all subcritical plants are phased out by 2030 and all plants without CCUS by 2040.

Heating technologies sold globally for residential and service buildings in the Net Zero Scenario, 2010-2030



Importance of networks

To ensure a smooth transition to Net Zero, global electricity networks must double in total length by 2040 and increase by another quarter up to 2050. To put this into perspective, current networks took over a century to build. The annual investment in the grid increases from approximately USD260 billion today to USD800 billion in 2030, climbs to almost a trillion in 2040 and drops to similar level in 2050 as in 2030.

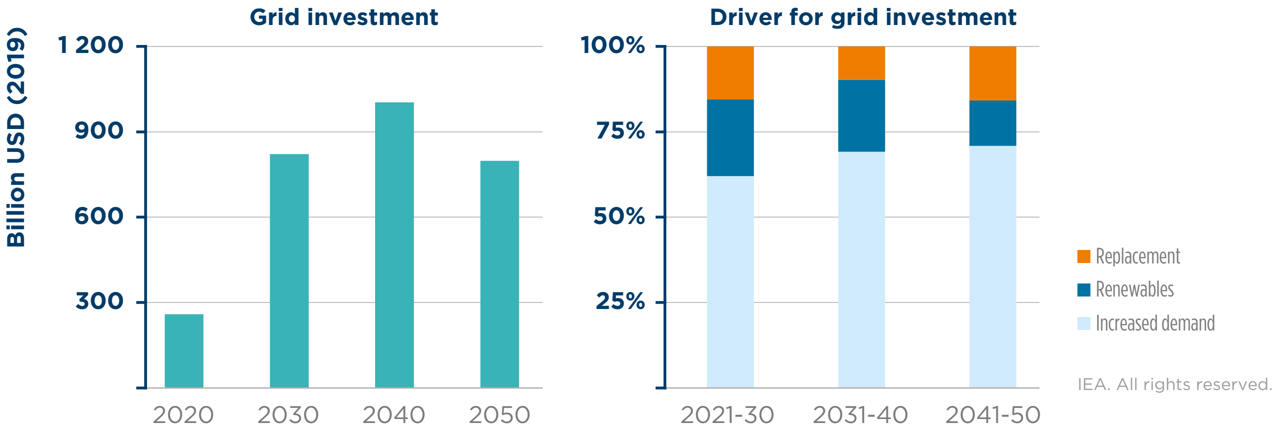
Expanding power networks comes with its own set of challenges:

- Building transmission lines is time consuming
- Exposure to, and management of, physical risk due to increasing frequency of extreme weather events
- Rise in fugitive sulphur hexafluoride (SF6) emissions with the expansion of connections to the grid. Currently, not many alternatives to SF6 exist.
- Land use and community acceptance, along with impacts on biodiversity

Managing these challenges to ensure smooth construction will require work from public and private actors, and governments alike.

Gas utilities will have to transform their distribution lines, making them fit to carry green or low carbon hydrogen or other low carbon gases like bio-methane. A sizeable challenge that gas utilities face today, and that will need intervention in the future as well, is of leaks from damaged, old or inefficient infrastructure.

Global investment in electricity networks in the NZE



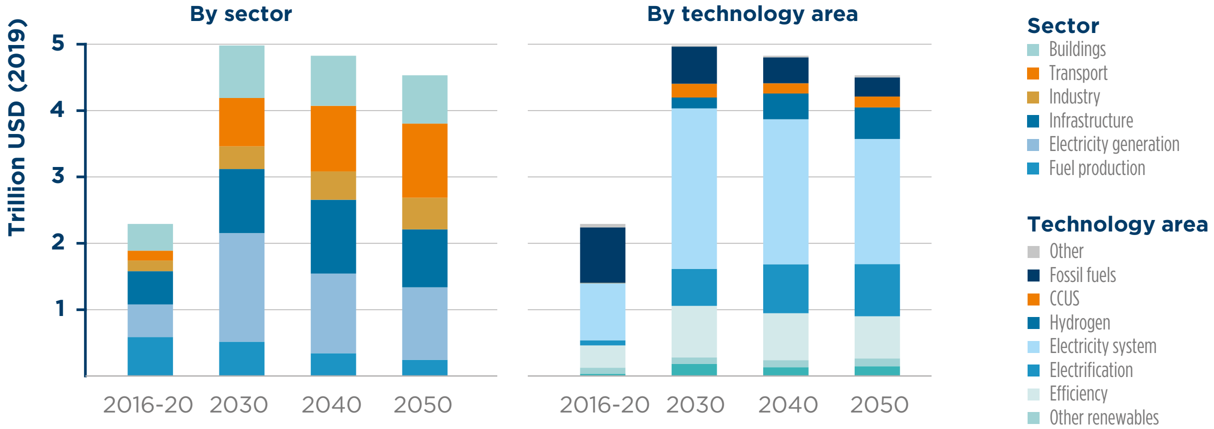
Electricity network investment triples to 2030 and remains elevated to 2050, meeting new demand, replacing ageing infrastructure and integrating more renewables

Investment, innovation and the role of governments are key

Achieving Net Zero does not come cheap, or easy. In fact, the investment figures stated for the sectors are staggering. As is indicated in different sections throughout this paper, **annual investment numbers for various technologies, from R&D to deployment, and infrastructure need to substantially increase.** Further, the overall pathway described by the IEA leverages available and deployable-at-scale technologies to drive global emissions reductions up to 2030 (primarily solar and wind). But almost half the emissions reductions that come between the time periods of 2030-50 are from technologies that either don't exist or are in prototype or demonstration stage, including those needed by power and gas utilities. Examples of such technologies include carbon dioxide removal technologies (CCUS, BECCS, DACCS), green or low carbon hydrogen, and advanced batteries. Work in various sources of flexibility like demand response, flexible power plants, smarter grids will need to be ramped up as well.

For innovation, investment, and large-scale deployment of both current and future technologies, **the right mechanisms will need to be put in place by governments around the world.** Regulation, policies and laws, for example carbon taxes and prices, directives, federal and state level action plans, clean energy programmes, emissions targets enshrined into law etc. will be required to make Net Zero a reality overall, as well as for power and gas utilities. Market pricing mechanisms for the power sector will also have to evolve as the energy transition progresses.

Annual average capital investment in the NZE



Capital investment in energy rises from 2.5% of GDP in recent years to 4.5% by 2030; the majority is spent on electricity generation, networks and electric end-user equipment

Energy security and system flexibility

With increased electrification, rising demand, intermittency of renewables, diminished capacity of dispatchable fossil fuel plants and increasing frequency of extreme weather events, the concept of reliability becomes all the more important. **Energy security will only result from a strategic transition that is supported by the right planning, policies, investments and innovation.**

Two critical components to ensure energy security will be expanding and strengthening the grid (i.e. making it more resilient to current and emerging threats), and integrating sources of flexibility. A number of possible and innovative solutions are being considered, for example grid interconnections, distributed generation, increased digitalisation, increased penetration of dispatchable renewables and flexible low carbon power plants, green/low carbon hydrogen, advanced battery storage, fossil fuel plants with CCUS, etc. The demand side also plays its role in ensuring flexibility through conventional and new ways of demand response.

The social dimension

We cannot forget the social dimension when it comes to achieving the NZE Scenario. The transition must be:

- **Fair**: Governments and companies need to ensure that the right measures are put in place to make this process as inclusive and smooth for all employees as possible, bringing about the concept of a 'Just Transition'.
- **Equitable, ensuring contribution to SDG 7**[13]: Under the scenario, there is universal access to electricity and clean cooking by 2030.
- **Affordable**: The transition must be cost effective and keep energy bills stable and affordable for all consumers.

13. Ensure access to affordable, reliable, sustainable and modern energy.

What we expect from companies

There are certain actions that we, as Amundi, strongly encourage investee companies to take, amongst others, in the race to Net Zero:

- To phase out coal in line with Amundi's thermal coal policy and with the prescribed pathways for OECD (2030) and non-OECD (2040) countries.
- To put in place a comprehensive decarbonisation plan, subject to change as the technological and regulatory landscape evolves, to achieve Net Zero. This should include targets for the relevant emission scopes and timeframes, which can be absolute and/or those related to intensity, as well as a prescribed pathway. We also welcome external certification conforming alignment with climate science, such as by the Science Based Targets Initiative (SBTi).
- To achieve this transition, Amundi has the following order of preference – **Reduction** followed by **Removal** and finally by **Offset**.

Key milestones in transforming global electricity generation

Category	
Decarbonisation of electricity sector	- Advanced economies in aggregate: 2035. - Emerging market and developing economies: 2040.
Hydrogen-based fuels	- Start retrofitting coal-fired power plants to co-fire with ammonia and gas turbines to co-fire with hydrogen by 2025.
Unabated fossil fuel	- Phase out all subcritical coal-fired power plants by 2030 (870 GW existing plants and 14 GW under construction). - Phase out all unabated coal-fired plants by 2040. - Phase out large oil-fired power plants in the 2030s. - Unabated natural gas-fired generation peaks by 2030 and is 90% lower by 2040.

Category	2020	2030	2050
Total electricity generation (TWh)	26 800	37 300	71 200
Renewables			
Installed capacity (GW)	2 990	10 300	26 600
Share in total generation	29%	61%	88%
Share of solar PV and wind in total generation	9%	40%	68%
Carbon capture, utilisation and storage (CCUS) generation (TWh)			
Coal and gas plants equipped with CCUS	4	460	1 330
Bioenergy plants with CCUS	0	130	840
Hydrogen and ammonia			
Average blending in global coal-fired generation (without CCUS)	0%	3%	100%
Average blending in global gas-fired generation (without CCUS)	0%	9%	85%
Unabated fossil fuels			
Share of unabated coal in total electricity generation	35%	8%	0.0%
Share of unabated natural gas in total electricity generation	23%	17%	0.4%
Nuclear power	*2016-20*	*2021-30*	*2031-50*
Average annual capacity additions (GW)	7	17	24
Infrastructure			
Electricity networks investment in USD billion (2019)	260	820	800
Substations capacity (GVA)	55 900	113 000	290 400
Battery storage (GW)	18	590	3 100
Public EV charging (GW)	46	1 780	12 400

Note: GW = gigawatts; GVA = gigavolt amperes.

References

Sources

- https://www.researchgate.net/publication/325382044_Electricity_generation_technologies_Comparison_of_materials_use_energy_return_on_investment_jobs_creation_and_CO2_emissions_reduction
- https://www.researchgate.net/publication/350358598_Land-use_intensity_of_electricity_production_and_tomorrow's_energy_landscape
- https://www.iea.org/reports/nuclear-power
- https://www.lazard.com/media/451905/lazards-levelized-cost-of-energy-version-150-vf.pdf
- https://www.oecd-nea.org/jcms/pl_57979/small-modular-reactors-challenges-and-opportunities?details=true
- Biomass Air Pollution Briefing. Biofuelwatch
- Does household use of solid biomass based heating affect air quality? IEA
- Energy Technology Perspectives 2017, IEA
- Evaluation of the Life Cycle Greenhouse Gas Emissions from Different Biomass Feedstock Electricity Generation Systems, Kadiyala & al (2016)
- Carbon accounting of forest bioenergy, JRC (2014)
- Life cycle impact of biomass electricity in 2020. UK Department of Energy & Climate Change (2014)
- Applying a science-based systems perspective to dispel misconceptions about climate effects of forest bioenergy. IEA Bioenergy TCP (2021)
- What does net-zero emissions by 2050 mean for bioenergy and land use? IEA (2021)
- Forest bioenergy, carbon capture and storage, and carbon dioxide removal : an update. EASAC (2019)
- The use of woody biomass for energy production in the EU. JRC (2021)
- The burning question, EMBER (2020)
- Net Zero by 2050 : A roadmap for the Global Energy Sector, IEA (2021)
- IEA (2021), Net Zero by 2050, IEA, Paris https://www.iea.org/reports/net-zero-by-2050

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