Theme Assessment of Cleantech

– Renewable energy and energy storage
– Energy efficiency of buildings
– Carbon capture and storage

Customer version | Swiss edition

Zürcher Kantonalbank

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Summary

Clean technologies (Cleantech) are an effective tool for decarbonisation and achievement of the net-zero emissions target, and therefore enjoy political support, as well as healthy growth prospects. A declaration of climate neutrality (net-zero emissions) by 2050 is now part of almost any political agenda. Governments worldwide have recognised that investing in Cleantech effectively reduces emissions and creates jobs. The great interest in this topic is also reflected in the inflows into Cleantech funds, which are racing from one record high to the next.

According to the International Renewable Energy Agency (IRENA), average annual investments of USD 4,400 billion will be needed over the next 30 years to achieve the target of no more than 1.5°C global warming. Approximately USD 1,700 billion (39 %) of this investment would need to be spent on energy generation, while a further USD 2,300 billion (52 %) would need to be spent on improving energy use in industry, buildings and transport.

Several clean technologies, such as solar photovoltaics (solar power) and wind turbines (wind power), are already very mature in technological terms and have among the lowest levelized cost of electricity (LCOE) of any power generation technology in the world. With low power generation costs of up to USD 22/megawatt hour (MWh) for solar power and wind power, equity returns of at least 9 % can already be achieved today.

The generation of electricity from renewable energy sources is frequently subject to a certain degree of volatility, so as solar and wind power increase in the electricity mix, the ability to store electricity temporarily will also need to increase sharply. Annual growth in battery energy storage systems will increase by 525 % (~25 gigawatts per year) by 2025 alone, compared to 2020 levels (~4 gigawatts per year). Lithium-ion technology dominates the market and will most likely further consolidate its position in the coming years through greater scale economies and configuration advances (e.g. lower content of rare earth elements).

Even if the decarbonisation of power generation can already eliminate a large proportion of global greenhouse gas emissions, there is still a significant proportion of these emissions, for example from heavy industry (steel, cement, aluminium, etc.), that can only be reduced to a certain extent. To prevent these emissions from further heating the atmosphere, carbon capture, utilisation and storage (CCUS) technologies are needed. CCUS technologies are deployed on a very small scale today and will need to grow strongly in the coming decades (~1,150 % by 2030) to meet the 1.5°C target. However, the cost of CCUS will still need to decrease significantly through technology improvements and economies of scale, while the price of emitting a tonne of CO_2 will have to increase significantly, for CCUS to become economically attractive.

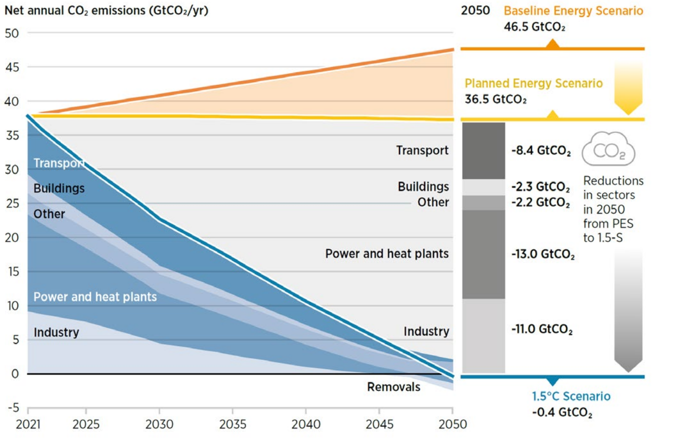
The probably most neglected area of decarbonisation is building infrastructure, which is responsible for around 35 % of global energy demand and around 40 % of global greenhouse gas emissions. The technologies for decarbonising buildings (insulation, heat pumps, etc.) are already very mature, but in many cases are still economically unattractive, for example because the initial investment is high and payback periods are long. Rising fossil fuel prices give insulation and heat pumps a relative advantage; but without government incentives (subsidies) and regulation to improve building energy efficiency, these technologies will have a rather difficult path.

Identifying these profitable and sustainable themes and fundamentally attractive investment opportunities is a key aspect of our global research activity.

1 The path to less than 1.5°C lies in decarbonisation

Around 38 gigatonnes of net CO_2 emissions ($GtCO_2$) per year are currently emitted worldwide. According to estimates by the International Renewable Energy Agency (IRENA), this volume must decrease to around 22.5 $GtCO_2$/year by 2030 and to a negative ~0.4 $GtCO_2$/year by 2050, to keep the average global temperature increase below the Paris Agreement target of 1.5°C compared to pre-industrial levels (Figure 1). This significant reduction of global annual net CO_2 emissions will require massive efforts, especially in the construction, transport, power and heat, and manufacturing sectors, as these are by far the largest emitters.

Figure 1: Potential scenarios for reducing global CO_2 emissions



Source: International Renewable Energy Agency, IRENA

Note (Source IRENA): The blue-shaded areas in the figure represent the remaining net CO_2 emissions in the corresponding sectors in the 1.5°C scenario, and the grey area represents the reduction in CO_2 emissions in the 1.5°C scenario compared to the Planned Energy Scenario (PES). The Planned Energy Scenario takes into account all government climate ambitions and strategies adopted by 2020. "Industry" includes energy and process-related CO_2 emissions. "Other" includes emissions from non-energy uses and other sectors such as agriculture, forestry, etc. Emissions in "Industry" and in "Power and heat plants" include CO_2 emissions captured by carbon capture, bioenergy/biomass and other carbon capture measures. As a result, these two sectors become net negative by 2050, meaning that the CO_2 captured more than offsets the remaining CO_2 emissions in these sectors. Overall, net CO_2 emissions in the 1.5°C scenario would reach -0.4 Gt in 2050. Gt CO_2 / year = gigatonnes of carbon dioxide per year

Cleantech is the key driver of decarbonisation

Cleantech offers some of the most compelling attributes to drive decarbonisation. This is because Cleantech:

– Receives political support, partly because it is a job engine (e.g. "EU Green Deal", "Biden Climate Plan");
– Is constantly improving through innovation and is decarbonising the economy effectively;
– Benefits from a broad sustainability trend in society;
– Attracts financing from investors in a market where sustainability aspects are playing an increasingly important role; and
– Is very attractive from an economic point of view (i.e. from a cost-effectiveness perspective) – and this is already the case worldwide.

Generally, technologies can be divided into those that have been "established" for many years or even decades, and those that are just "emerging" and not (yet) ready for the mass market. Established Cleantech has most of the above characteristics (i.e. political support, effectiveness in decarbonisation, cost competitiveness, etc.), while this is much less clear for emerging Cleantech.

Established Cleantech includes most renewable energy sources (i.e. solar, wind, hydro, geothermal, etc.), as well as materials and products to increase the energy efficiency of buildings (i.e. insulation, heat pumps, LEDs, etc.) and, to some extent, electric vehicles.

Emerging Cleantech includes biofuels (e.g. hydrogen and renewable natural gas), carbon capture, utilisation and storage (CCUS), and photonics. Each of these technologies is currently at a different stage of development and is therefore more or less socially and economically viable. In contrast to established Cleantech, the emerging technologies will be of particular importance in a later phase of the global decarbonisation process, when they are more technically mature.

Battery storage is a technology that has all the prerequisites to play a significant role in decarbonisation. The technology has existed for some time, but has not (yet) achieved significant market penetration in the electricity, commercial and residential sectors. However, the technology is well on its way to gaining market share and thereby becoming a viable component of decarbonisation. CCUS will be required to eliminate the final portion of emissions that would otherwise be difficult or impossible to prevent, paving the way to achieving the global net-zero emissions target.

Table 1 divides the various technologies into established and emerging technologies, although the boundaries are far more fluid than such a table would suggest. The different development stages of selected technologies are discussed in more detail below.

Table 1: Various cleantech technologies

Established Cleantech	Emerging Cleantech
– Solar power	– Hydrogen
– Wind power	– Carbon capture, utilisation and storage (CCUS)
– Hydropower	– Ocean power (tidal)
– Geothermal power	– Renewable natural gas and biofuels
– Biomass	– Photonics (energy efficiency)
– Building insulation / Heat pumps	– Battery energy storage
– LED lighting	
– Electric vehicles and charging infrastructure	

Source: Zürcher Kantonalbank

2 Theme identification

The technologies analysed in this study play a key role in the global energy transition (i.e. the decarbonisation of energy production and use) that will be required to achieve the following Sustainable Development Goals (SDGs) (Figure 2):

– Affordable and Clean Energy (SDG 7),
– Industry, Innovation, and Infrastructure (SDG 9),
– Sustainable Cities and Communities (SDG 11), and
– Climate Action (SDG 13).

Figure 2: Sustainable Development Goals (SDGs) addressed in this theme assessment

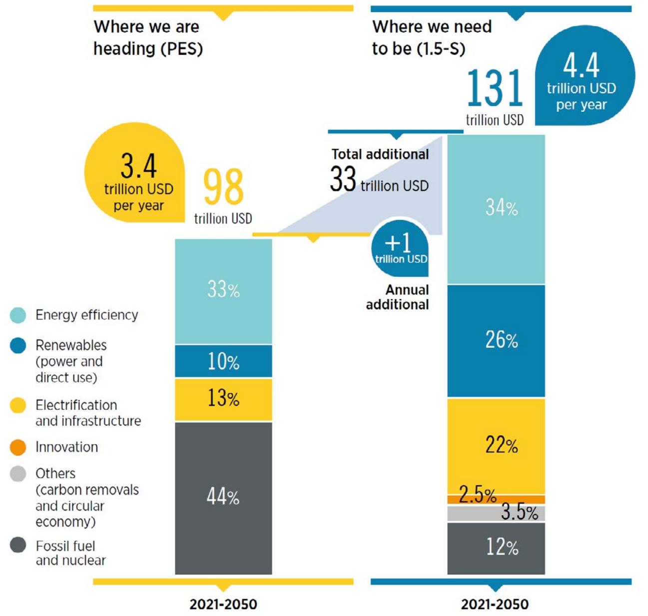
Source: United Nations

3 The necessary investments open up new opportunities

The global public and private investments required to achieve the required decarbonisation and the 1.5°C target are enormous. Not only must significant amounts of money be allocated to Cleantech, but the share of money flowing into fossil-fuel-related technologies should also decrease significantly. Currently, 44 % of the world's USD 3,400 billion annual energy-related investments flow to fossil fuel and nuclear technologies (Figure 3). According to an IRENA estimate, this share of investment in fossil fuel and nuclear technologies should decrease to an average of 12 % over the 2021–50 period.

At the same time, the share of investment in renewables would have to increase from 10 % to 26 %, and the share of funds allocated to electrification and infrastructure from 13 % to 22 %. Any such change in the distribution of investments would mean that energy efficiency, renewables and electrification/infrastructure would become the most important drivers of decarbonisation. Finally, total annual global investment would need to increase from the current USD 3,400 billion to USD 4,400 billion, in order to meet the 1.5°C target.

Figure 3: Enormous investments (about 5 % of global GDP) in renewable energy, energy efficiency and electrification are required



Source: IRENA

Example 1:
Investments in power generation and grids
One of the most viable and efficient ways to reduce emissions is to decarbonise the power sector and then invest in grid infrastructure to transmit electricity to where it is needed, or to store it flexibly when needed (Figure 4). IRENA estimates that the largest amounts of money for power generation and grids will go to solar, wind and grid infrastructure. While most of the money is already being invested in these areas, the relative annual amount will need to increase significantly in 2021–50, compared to 2017–19 levels, namely:

- From USD 118 billion to USD 321 billion for solar photovoltaics and concentrated solar power (+172 %);
- From USD 98 billion to USD 329 billion for wind power (+236 %) (especially offshore); and
- From USD 271 billion to USD 600 billion for the network infrastructure (+121 %).

In the IRENA scenario, spending on other energy sector technologies such as hydropower, biomass, marine energy, etc. is also increased significantly, but at a far lower level. Flexibility measures (e.g. energy storage) are generally seen as a very important contributor to solving the intermittency problem in electricity generation from renewables. IRENA estimates that the required investment in energy storage will increase from USD 4 billion per year in 2017–19 to USD 133 billion per year in 2021–50, a massive increase of 3,225 %.

Figure 4: Investments in clean power generation and grids must be increased significantly

Power

		Annual average investments USD billion/yr – Historical 2017-19	Annual average investments USD billion/yr – 1.5S 2021-50
Power generation capacity	Hydro - all (excl. pumped)	22	85
	Biomass (total)	13	69
	Solar PV (utility and rooftop)	115	237
	CSP	3	84
	Wind onshore	80	212
	Wind offshore	18	177
	Geothermal	3	24
	Marine	0	59
Grids and flexibility	Electricity network	271	600
	Flexibility measures (*e.g.* storage)	4	133

Bemerkung: CSP = Concentrated Solar Power (engl. für konzentrierte Solarkraft)

Quelle: IRENA

Example 2: Investments in energy end-use

Another interesting area in terms of economic potential is investment in energy end-use – especially in the areas of the energy efficiency of buildings and transport (Figure 5). These two areas are also the two main priorities under the EU Green Deal. IRENA estimates that average annual investments in the energy efficiency of buildings and transport need to increase from USD 139 billion to USD 963 billion (+593 %) and from USD 45 billion to USD 385 billion (+765 %), respectively, to reach the 1.5°C target.

In the same way as for the energy sector, investments in other technologies, namely hydrogen, CCUS, and bioenergy with CCUS, would need to increase significantly. All of these technologies saw less than USD 1 billion in investment in 2017–19, and average annual investment needs to increase substantially, to the high double-digit billions (about USD 75 billion each per year). These technologies are clearly key technologies for decarbonising industries where emissions are difficult to abate (such as heavy industry and materials), and should therefore be part of any energy transition scenario.

Figure 5: Investments in the end use of electricity and heat need to be increased significantly

End uses and district heat

		Annual average investments USD billion/yr – Historical 2017-19	Annual average investments USD billion/yr – 1.5S 2021-50
Renewables end uses and district heat	Biofuels - supply	2	88
	Renewables direct uses and district heat	31	84
Energy efficiency	Buildings	139	963
	Transport	45	385
	Industry	65	157
Electrification	Charging infrastructure for electric vehicles	2	131
	Heat pumps	12	102
Innovation	Hydrogen - electrolysers and infrastructure	0	78
	Bio-based ammonia	0	22
	Bio-based methanol	0	12
Carbon removals	Carbon removals (CCS, BECCS)	0	78
Circular economy	Recycling and biobased products	0	70

Note: CCUS = carbon capture, utilisation and storage; BECCUS = bioenergy with CCUS

Source: IRENA

4 Viable technologies for decarbonisation exist

According to IRENA, the global energy transition strategy could consist of five key areas:
1. Renewable energy (25 % contribution to decarbonisation)
2. Energy storage and efficiency (25 % contribution to decarbonisation)
3. Electrification in end-use sectors (20 % contribution to decarbonisation)
4. Hydrogen (10 % contribution to decarbonisation)
5. Carbon capture, utilisation and storage (CCUS) and other carbon removal (20 % contribution to decarbonisation)

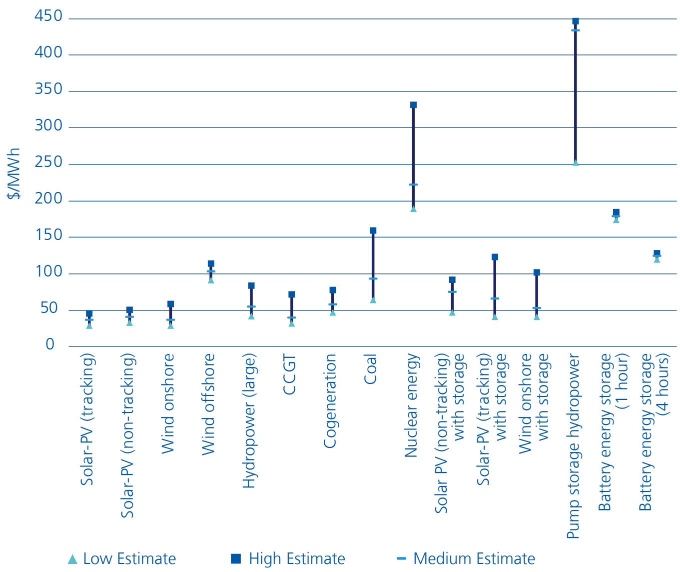
These five key sectors, combined, are capable of effectively decarbonising the economy by leading to savings of around 36.9 gigatonnes of CO_2 per year by 2050, according to IRENA. This study looks at three of the five key areas (highlighted in bold).

Renewable energy sources present significant cost advantages

Technologies must first grow out of their infancy and become cost competitive with traditional, existing technologies before they can prove disruptive. Technology examples that have already achieved this cost competitiveness for several years are solar photovoltaics (solar PV) and onshore wind power. The unsubsidised Levelized Cost of Electricity (LCOE)[1] of solar PV and onshore wind currently ranges from USD 29/MWh to USD 59/MWh in the USA, making them highly competitive with, for example, Combined-Cycle Gas Turbines (CCGT), which currently range from USD 32/MWh to USD 72/MWh (Figure 6). Not to mention new coal and nuclear power plants, which are far from being competitive with alternative energy sources when the costs of CO_2 emissions and decommissioning (i.e. total life-cycle costs) are also taken into account.

It is important to note that these figures are for new projects, factoring in full life-cycle costs, which are based on several assumptions such as efficiency (i.e. capacity factors) or long-term fuel prices (e.g. gas, coal) that are generally difficult to predict. It is likely that fully depreciated CCGT power plants (depending on geographical location and regional gas prices) generate electricity at a similar cost to solar or wind, which is why they are still widely used. In addition, efficient CCGT power plants have the major advantage of providing flexible power, which helps mitigate the intermittency problem for renewable energy. Efficient CCGT power plants are therefore likely to be an important part of the energy transition for quite some time to come.

Figure 6: Current range of levelized cost of electricity (LCOE) per type of electricity generation in the USA



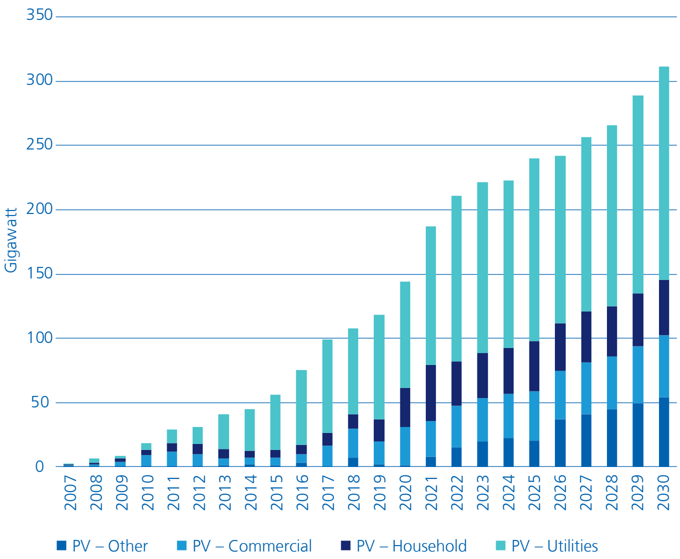
Data source: Bloomberg New Energy Finance, BNEF

Renewable energy: Solar PV

Solar photovoltaics is one of the fastest growing power generation technologies. Market research firm Bloomberg New Energy Finance (BNEF) forecasts a cumulative annual growth rate of 11 % in solar PV installations by 2025, compared to 2020 (Figure 7). This is equivalent to three to four times global GDP. However, steadily increasing climate policy ambitions and the record low cost of electricity from solar PV provide additional tailwinds and could lead to upward revisions of forecasts in the future – as has occurred several times in the past.

[1] LCOE is the long-term purchase price that a project developer needs in order to recover all project costs (capital expenditures, operating costs, taxes and financing) and achieve the investment target (cost of equity). The cost of electricity shown in the chart assumes financing in 2021 and is solely for the USA. However, the overall picture is similar in many countries around the world.

Figure 7: Estimates for annual new installations of solar PV in gigawatts

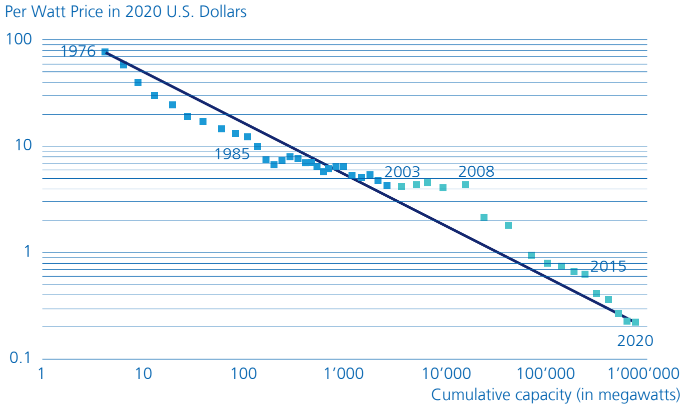


Source: BNEF

Efficiency improvements in the production of solar modules have led to a significant decrease in costs and prices over the last decades. While solar module prices were around USD 80 per watt in 1976, solar modules can now be offered for around USD 0.20 per watt (a price decrease of –99.75 %; Figure 8). The two most important drivers of the efficiency gains were the improvement in technology and the significantly higher production scale and associated economies of scale.

On the one hand, the decline in solar module prices makes photovoltaics as a technology more attractive compared to conventional power generation technologies (see record-low LCOE). On the other hand, the profit margins of, for example, solar module manufacturers can come under considerable pressure if prices fall faster than their costs (e.g. if raw material prices rise or competition increases unexpectedly). However, further product innovations (e.g. more efficient/higher performance modules) could reduce the cost pressure, at least for certain manufacturers with corresponding production capacities.

Figure 8: Increase in efficiency of solar modules

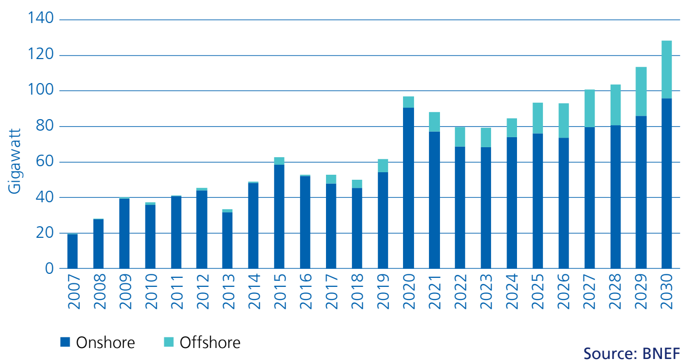


Source: BNEF

Renewable energy: Wind power

Wind capacity additions will be high overall in 2021-25, compared to the previous five years (2016-2020) (+48 %; 427 GW for 2021-25 compared to 289 GW for 2016-20) (Figure 9). Compared to the 2020 record year (97 GW), however, new global installations are expected to decline for the first time in 2021. The year 2020 was primarily characterised by booming installations in China, as developers rushed to secure subsidies that expired at the end of 2020. Annual growth in wind power capacity will slow somewhat in the first half of the decade, due in part to declining subsidies (e.g. in the USA). However, growth will remain at a high level and will gain momentum in the second half when more large-scale offshore wind turbines are connected to the grid from 2024/25.

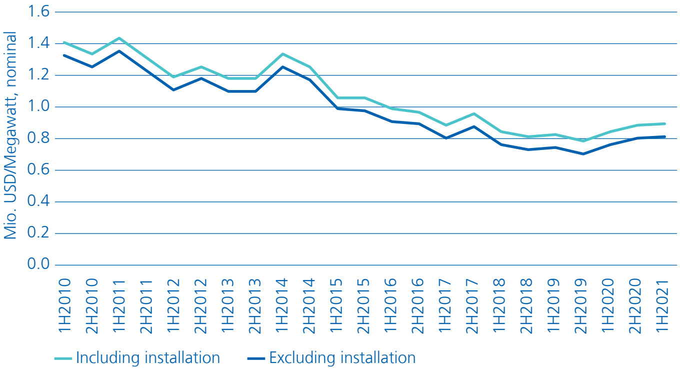
Figure 9: Estimates for annual new wind power installations in gigawatts



Source: BNEF

Wind turbine prices have declined from USD 1.4 million per megawatt (MW) in 2010, to USD 0.8 million in the second half of 2019, representing a 43 % decline (Figure 10). The average turbine price per megawatt for contracts signed in the first half of 2021 was USD 0.83 million (+1 % compared to 2020), bringing prices back to 2017 levels. The main driver of higher turbine prices in the short term was higher prices for raw materials such as steel, and for logistics/transportation. In the long term, however, turbine prices are expected to continue to decline, as significant efficiency gains (i.e. more electricity per dollar invested) can typically be achieved with increasingly larger turbines and improvements in technology.

Figure 10: Price index for onshore wind turbines by date of contract signature in USD



Source: BNEF

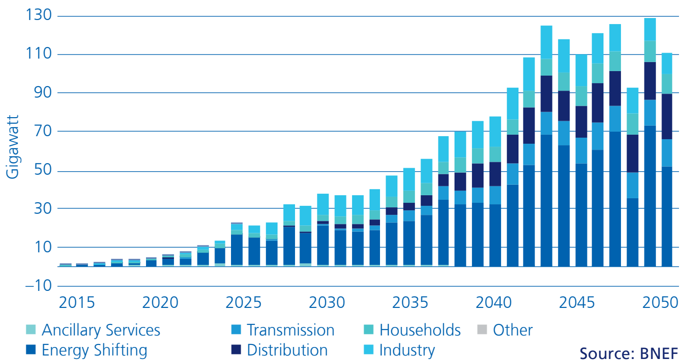
The market for wind turbines in Europe and North America is dominated by such manufacturers as Vestas, Siemens Gamesa, Nordex and General Electric. In China, western manufacturers hardly play any role at all, and the market is mainly served by large Chinese manufacturers such as Xinjiang Goldwind, Ming Yang Smart Energy and Shanghai Electric.

Battery Energy Storage Systems

The decentralised power generation from renewable energy sources (e.g. wind, solar) is naturally subject to significantly greater variation than is the case for fossil energy sources (e.g. coal or gas). This problem presents an opportunity for Battery Energy Storage Systems (BESS), as wind and solar power are very likely to become the dominant form of electricity generation within the foreseeable future. This shift in the generation mix contributes to decarbonisation, but also makes the power grid more complex and volatile. Energy supply will be less predictable, so there will be more instances of an oversupply or undersupply of electricity. The power grid will need to be able to handle additional loads through active energy management and energy shifting, which is why these two applications are expected to be the main use of BESS in the future.

According to a recent forecast for global energy storage installations by BNEF, the market will expand at a cumulative average growth rate of 18 % per year until 2050 (Figure 11). The market will reach a cumulative volume of 1,676 gigawatts (GW) by 2050, a significant increase from 11 GW in 2020. BNEF estimates that this will attract USD 964 billion in investment over the next three decades.

Figure 11: Estimate for global new installations by application

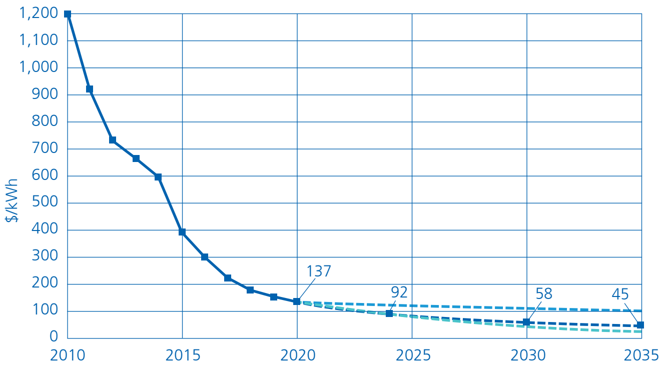


Source: BNEF

Currently, lithium-ion configurations may be best used for medium-duration applications. Due to their excellent energy-to-performance ratio. For certain longer-term applications, however, fuel cells (hydrogen) and compressed air configurations may be the right choice, due to their higher energy density (i.e. higher economic efficiency and longer discharge times).

As for other Cleantech solutions, the cost of stationary battery energy storage systems has declined dramatically over the past decade. For lithium-ion configurations, for example, the cost of the battery pack has dropped from about USD 1,200 /kWh in 2010 to USD 137/kWh in 2020 (Figure 12). BNEF further estimates that costs will drop to USD 92/kWh by 2024, USD 58/kWh by 2030, and USD 45/kWh by 2035. Whether these cost targets are met depends on advances in battery chemistry, economies of scale, material recycling, and the elimination of critical materials (such as rare earth elements).

Figure 12: Cost development for lithium-ion battery packs



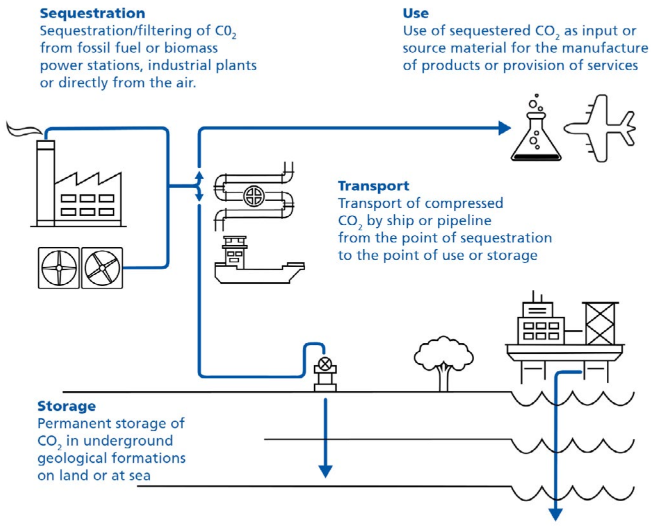
Source: BNEF, RBC Capital Markets

Note (source BNEF/RBC): This diagram only shows the cost development for the battery pack (not to be confused with the total installed cost of the battery energy storage system). The green line shows a positive scenario, with an average annual cost reduction of 9 % (compared to 7 % for the baseline scenario), and the brown line shows a negative scenario, with an average annual cost reduction of only 2 %.

Carbon Capture, Utilisation and Storage (CCUS)

CCUS refers to the process of capturing CO_2 from a range of sources (including air) and transporting it by pipeline or ship for utilisation or permanent storage. CCUS encompasses a range of technologies that involve the capture of CO_2 from large point sources, including power generation or industrial facilities that use either fossil fuels or biomass as fuel. If the captured CO_2 is not used on-site, it is compressed and transported by pipeline, ship, rail or truck for use in a variety of applications, or it is injected into deep geological formations (e.g. depleted oil and gas reservoirs) for permanent storage (Figure 13).

Figure 13: Schematic diagram of CCUS



Source: International Energy Agency (IEA)

The utilisation of compressed CO_2 for industrial purposes can be a potential source of revenue for CCUS facilities. The vast majority of existing CCUS projects rely on revenue from the sale of CO_2 to oil companies for enhanced oil recovery (EOR). However, CO_2 can also be used as a feedstock to produce synthetic fuels, chemicals and even construction materials.

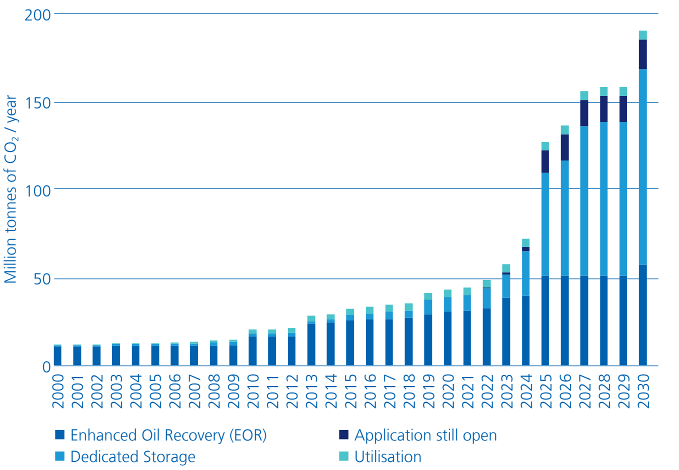
Capture and storage of CO_2 is needed primarily in industries where emissions are difficult to abate, due to economic or technological barriers. These industries include cement, iron and steel production, hydrogen production and waste-to-energy.

CCUS is by no means a "new" technology. Some CCUS plants have been in operation since the 1970s/80s (e.g. natural gas processing plants in the Val Verde region of Texas). However, the first large-scale CO_2 storage facility was commissioned in 1996 at the Sleipner offshore gas field in Norway, with capacity of around 1 million tonnes of CO_2/year, and where more than 20 million tonnes of CO_2 are now stored. This project was made economically viable by a CO_2 tax on the offshore activities of oil and gas companies introduced by the Norwegian government in 1991.

This example illustrates a very important point: the economic attractiveness of CCUS is inextricably linked to CO_2 pricing and taxation. The International Energy Agency (IEA) claims that CCUS is not economically viable without incentives or emissions sanctions (especially if captured CO_2 cannot be sold as an industrial feedstock). Another obstacle to large-scale implementation of CCUS projects is occasional public opposition to onshore storage.

BNEF estimates that global CCUS capacity will increase to 130 megatonnes per year by 2025 (from 40 megatonnes per year in 2020), a 225 % increase over five years (Figure 14). BNEF's growth forecast can be considered to be rather conservative, given the massive expansion required according to energy transition scenarios such as that of IRENA.

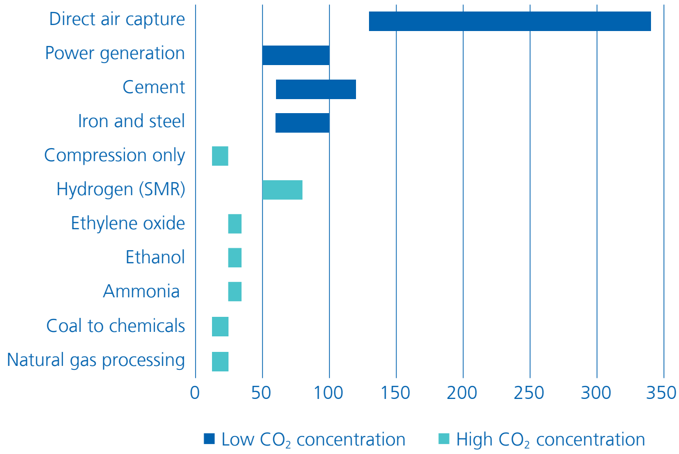
Figure 14: Global annual CCUS capacity



Source: BNEF

The total cost of CCUS is composed of capture, transport and storage. Currently, the cost of CO_2 capture ranges from about USD 330/t for direct air capture (DAC) to about USD 20/t for natural gas processing (Figure 15). The high variability of costs is mainly due to the different CO_2 concentrations. Not surprisingly, higher CO_2 concentrations generally result in lower costs per tonne, and vice versa. The cost of capture also depends on the location and integration of the CO_2-emitting plant, as well as on the energy and heat supply.

Figure 15: Levelized cost of CO_2 capture by sector and CO_2 concentration



Source: IEA und GCCSI

Note (source IEA and GCCSI): CO_2 capture costs for hydrogen are for production by steam methane reforming (SMR) of natural gas. The wide cost range reflects the different CO_2 concentrations: the lower end of the cost range applies to CO_2 capture from the concentrated "process" stream, and the upper end applies to CO_2 capture from the more diluted stream. Cost estimates are for the USA. All capture costs include compression costs.

In addition to the cost of CO_2 capture, there is the cost of transportation (about USD 30/t) and storage (about USD 10 /t). The total cost of CCUS in the USA is therefore currently about USD 80/t (average capture cost for cement, steel and power generation) + USD 30/t (transportation) + USD 10/t (onshore storage) = USD 120/t.

Comparing this figure with common CO_2 prices such as the European Emission Allowances (EUA), which traded at a price of around EUR 60 in November 2021, CCUS is not economically competitive at present and without appropriate incentives. As long as it is cheaper to emit one tonne of CO_2 into the atmosphere, there is little incentive to capture and sequester the same tonne.

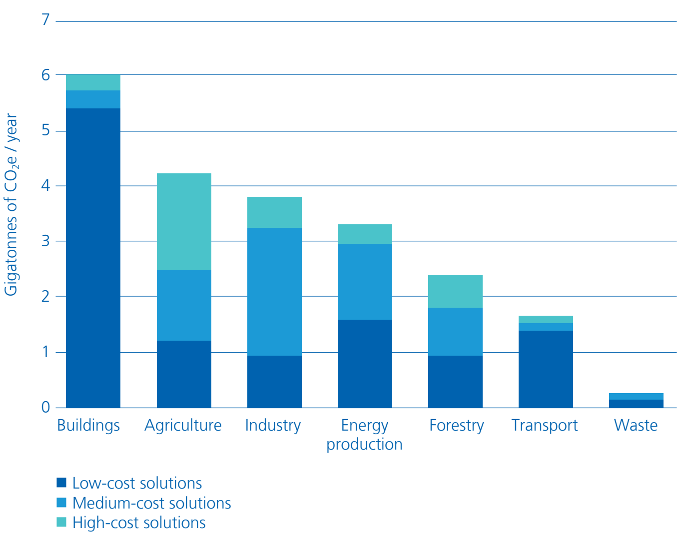
The total cost of CCUS will most likely decrease in the coming years due to technological improvements and larger production volumes, especially the capture component. However, it remains highly uncertain whether and when the total cost of CCUS will fall below the reference values for global CO_2 prices, which should ultimately substantially increase the economic attractiveness of the technology.

Building energy efficiency

The two most important technologies for increasing energy efficiency in buildings are heat pumps and insulation. The use of heat pumps is generally far more energy efficient than heating with oil and gas, and therefore heat pumps have the potential to decarbonise space heating and hot water in buildings. Retrofitting buildings with insulation mitigates energy loss within a building and thereby its CO_2 emissions.

Investments in building infrastructure are both climate-friendly and cost-effective (Figure 17) since, for example, insulating buildings is generally relatively inexpensive. Insulation is also one of the few areas where end users experience the benefits directly through lower energy bills (5 to 15 % of total household spending is on energy bills, and about 60 % of these costs are for heating and cooling).

Figure 16: Estimated potential to reduce emissions by area and type of investment

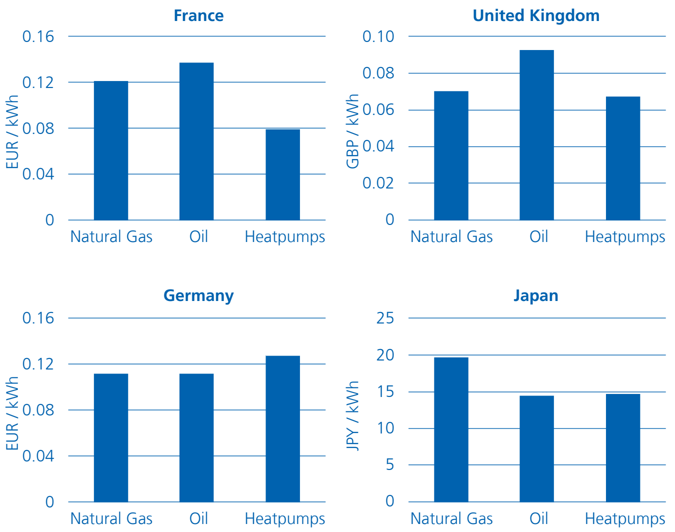


Source: EURIMA, World Research Institute

The environmental benefits of building insulation are clear. A scientific study published in 2018 in the International Journal of Life Cycle Assessment concluded that insulating residential buildings in the USA has an average environmental payback time of just 1.9 years in the case of CO_2. In other words, the CO_2 emissions released by the production and installation of insulation materials are saved within less than two years.

Electrification of building heat through heat pumps represents the second major lever for decarbonising buildings. In 2021, heat pumps in countries such as the UK, France and Japan are already competitive with oil and increasingly also with gas heating (Figure 17). In countries such as the USA and Germany, however, this is not (yet) the case. However, the increasing CO_2 pricing (e.g. in the form of emission certificates) creates very promising opportunities for heat pumps and building insulation to become even more economically attractive in the future. For example, the European Commission is currently considering whether the building sector should be included in the existing emissions trading system or be subject to a new form of CO_2 levy.

Figure 17: Heat generation costs by technology and country in 2021



Source: BNEF

Note: In countries such as the UK and France, subsidies are already leading to significantly lower investment costs for heat pumps.

5 Cleantech presents major opportunities, but also risks

Cleantech companies have consistently contributed to the outperformance (alpha generation) of sustainable investment portfolios in recent years. At the same time, given the huge investment required to achieve the net-zero emissions target by 2050, the area offers a huge economic growth opportunity that will last for several decades. The area could benefit significantly from increased political ambition at climate summits and other supranational agreements.

However, the cleantech theme is also associated with several risks, including:

- Net-zero policy goals are not being met as expected or are even being reversed (see climate policy under Trump).
- Technological problems are occurring more frequently and in more severe forms (e.g. problems with submarine cables in offshore wind turbines).
- Significantly increasing material costs that cannot be sufficiently offset by advances in materials science (e.g. use of copper, lithium, rare earth elements, etc.)
- Medium- to long-term pressure on electricity prices from abundant renewable electricity with "zero variable costs" that are not sufficiently hedged (e.g. via power purchase agreements or auctions).
- Slower-than-expected declines in technology costs and electricity generation costs (i.e. the competitiveness of Cleantech solutions relative to conventional technologies is diminished).

A report by Swiss Re ("The economics of climate change: no action not an option", 2021) estimates the negative impact on global GDP of various scenarios for reducing greenhouse gas emissions by 2050, compared to a world without climate change:

- minus 18 % if no mitigation measures are taken (3.2°C global warming);
- minus 14 % if some mitigating measures are taken (2.6°C global warming);
- minus 11 % if further mitigating measures are taken (2°C global warming); and
- minus 4 % if the goals of the Paris Agreement are achieved (global warming below 2°C).

These figures suggest that the issue not only presents a major economic opportunity, but also poses significant economic risks if companies and society fail to get a grip on climate change.