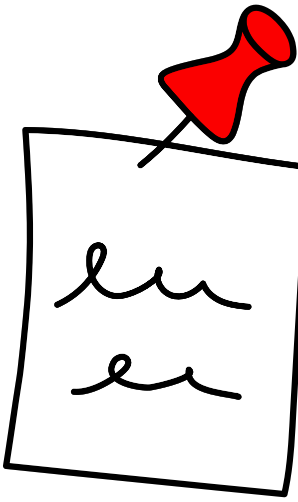
Future green investments

Emerging energy transition infrastructure beyond renewables

UBS



Abstract

Renewable energy has been one of the most popular target sectors for infrastructure investors in recent years. With the rising maturity of renewables, returns of traditional projects such as wind and solar have compressed significantly, typically offering single digit Internal Rate of Returns (IRR) in mature markets. Investors that are looking for higher returns in this rate environment are keen to explore other technologies. For example, energy storage has become increasingly popular among investors, which we explored in a previous paper[1], and is also maturing rapidly as an asset class. The natural question for energy transition investors is – what's next?

Beyond traditional renewables, energy storage and grid infrastructure, there is a world of clean energy investments that sits in non-electricity industries. The electricity and heat sectors only account for 32% of global greenhouse gas (GHG) emissions, which means there are many other sectors, such as industrials, transportation, agriculture, and buildings that could potentially attract USD 2 trillion of annual investments in the future to enable a full energy transition, according to the International Renewable Energy Agency (IRENA)[2].

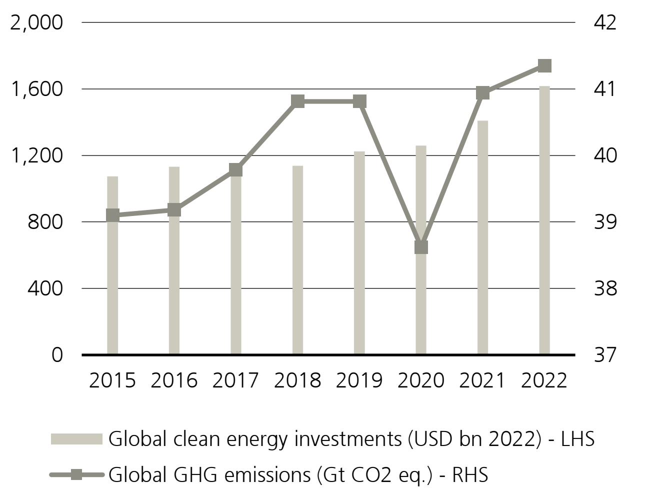
This paper will provide an overview of the most promising technologies to reduce greenhouse gases (GHG) at each of these industries. We will touch on the business cases for carbon, capture, utilization and sequestration (CCUS), hydrogen, fuel cell electric vehicles (FCEVs), clean transportation fuels, renewable natural gas (RNG), energy-as-a-service (EaaS), and others. Most importantly, we will discuss the potential for infrastructure investors to allocate capital in these new segments.

[1] Energy storage: At a tipping point; March 2022 *link*
[2] World Energy Transitions Outlook 2023; June 2023 *link*

Renewable energy alone will not help us achieve net zero

Energy transition has recently become one of the most important secular trends across all asset classes. Global clean energy investments have increased five years in a row and will likely surpass USD 1.7 trillion in 2023. However, global greenhouse gas (GHG)[3] emissions have also increased significantly from five years ago, painting a somewhat sobering picture despite the major investments (see Figure 1).

Figure 1: Clean energy investments vs GHG emissions



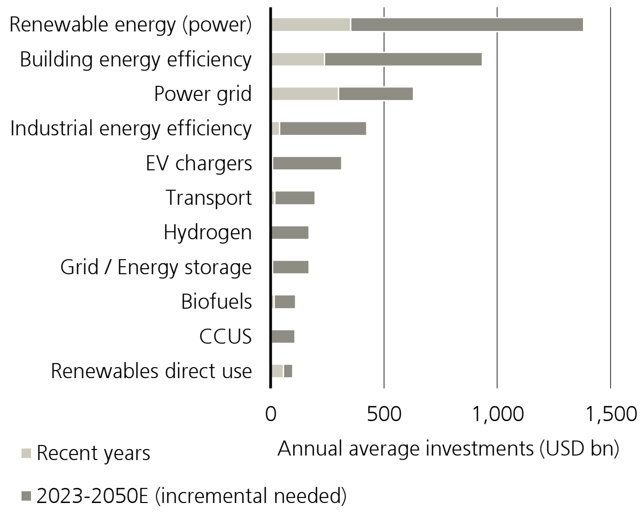
Source: IEA, CO_2 Emissions in 2022, May 2023.

IRENA highlighted the required investments in all sectors and technologies between now and 2050 that the world needs, in order to reach net zero and keeping the global temperature rise to 1.5 °C (see Figure 2).

Not surprisingly, current investment trends are simply insufficient to meet these goals across the board. High level government policies such as the US Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL), together with the European Green Deal and Fit for 55 legislation will help bridge this gap. But another important piece to the puzzle is simply to educate investors and the broader public about different clean technologies and why they are needed.

Under the broad spectrum of energy transition investments, well understood technologies such as wind, solar and energy storage deservingly receive the most attention, and will continue to attract significant investments in the next decade, as shown by IRENA, and as we have highlighted in our previous research[4].

Figure 2: Recent annual investments and incremental annual investment needs in 2023-50E (1.5°C Scenario)



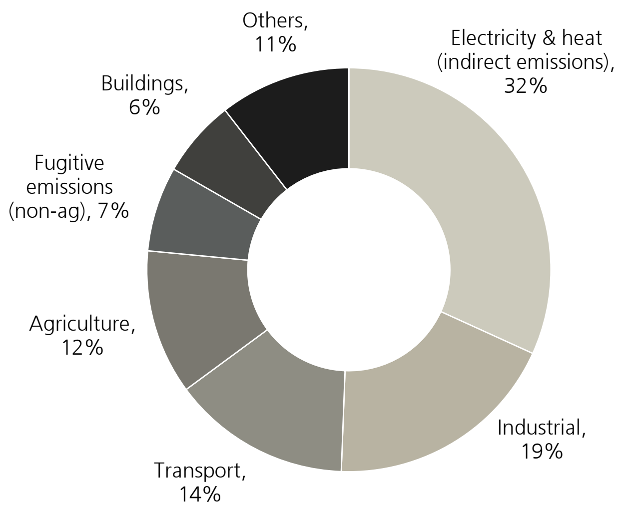
Source: IRENA, World Energy Transitions Outlook, June 2023

However, according to the World Resources Institute , the electricity and heat sectors only account for 32% of GHG emissions (see Figure 3). This means even if the world's electricity grid were to use 100% renewable energy, there are significant GHG emissions that remain unaddressed.

For example, one large emitter of GHG is the industrial sector, which includes hard-to-abate industries such as steel and cement, and accounts for 16% of global GHG. The daily operations of these businesses tend to be very emission-intensive due to specific industrial or chemical processes that are integral to production. Simply relying on electricity from a cleaner grid alone will not be enough to displace these emissions.

[3] Note that GHG includes CO_2 as well as other non-CO_2 emissions such as methane, nitrous oxide and hydrofluorocarbons
[4] Is 2023 the year for renewables? *link*; US Inflation Reduction Act: Top 5 takeaways *link*

Figure 3: World GHG emissions in 2019 by sector



Source: World Resources Institute, June 2022.
Note: Electricity & heat shown above has already been allocated to the end consuming sectors (i.e. it includes Scope 2 indirect emissions from electricity & heat purchased by other sectors such as industrials, transport etc.); Emissions from non-electricity & heat sectors are direct emissions from in-house energy generation, industrial processes, or other fugitive emissions

Another example is the transportation sector, which accounts for 14% of global GHG emissions (20%+ of global CO_2 emissions) and needs decarbonization solutions across land, sea and air.

Surface transport is making the most progress with 26 million electric vehicles on the road at the end of 2022 according to the IEA, mostly passenger cars. The take-up in the commercial vehicles has been lower with fleet users hesitant to electrify given the high upfront costs and inconvenience of switching.

Agriculture emissions and other fugitive emissions are also important sources of GHG. What is unique about these sectors is that these emissions often contain methane gas, which is 80+ times more potent than CO_2 in its impact on global warming over a 20-year period. Tackling methane emissions therefore provide a great bang-for-buck in reducing climate change impact.

Finally, the building sector is a significant emitter of CO_2. Although technologies and businesses already exist to reduce building emissions, economies-of-scale is a bigger challenge for infrastructure investors as these businesses tend to be smaller and more fragmented.

This paper expands on recent work that we have already done on energy transition and clean energy technologies. In the following sections, we will examine the potential pathways to reduce GHG across different sectors, including industrials, transportation, agriculture, and buildings.

We will discuss how new technologies such as carbon, capture, utilization and sequestration (CCUS), hydrogen, renewable natural gas (RNG), energy-as-a-service (EaaS) businesses, and more. We will also discuss the current and future investment opportunities in these markets.

Potential investments in industrials –

Carbon Capture Utilization and Sequestration (CCUS), Hydrogen

Many industrial activities such as ironmaking, steelmaking and cement production have carbon intensive processes embedded in their daily operations.

For example, ironmaking requires the use of metallurgical coke (made from coking coal) for the direct reduction process, while blast furnaces for steelmaking often use pulverized coal injection to increase heat and performance. Cement production also emits significant carbon emissions due to an unavoidable chemical process that creates clinker (an intermediary product for cement) under extreme heat.

Carbon capture, utilization, and sequestration (CCUS)
One potential solution to tackle the emissions of these hard-to-abate industries is carbon capture, utilization, and sequestration. CCUS "captures" the CO_2 by chemical or physical methods, transports it, and stores it underground, or sells it to other industrial customers for extra revenues.

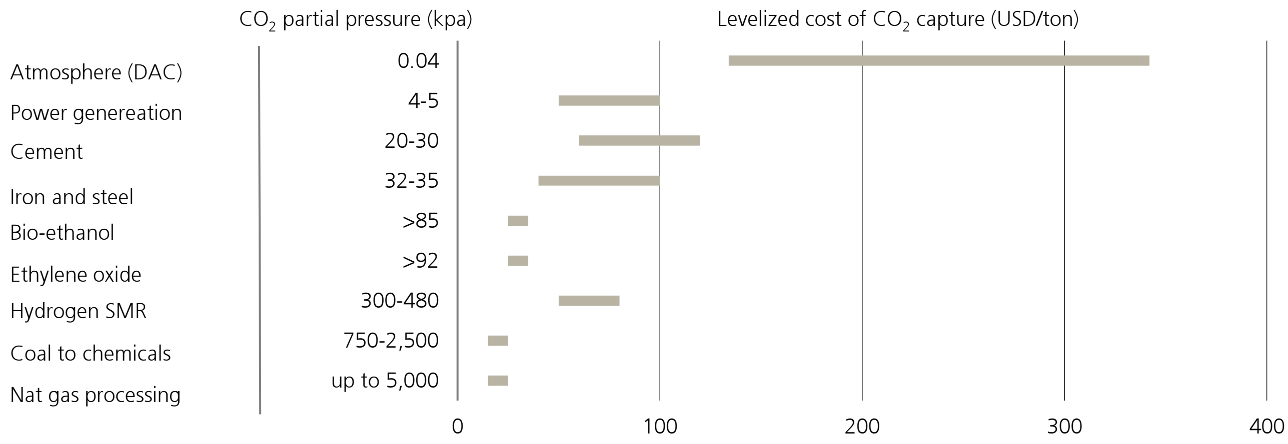
There are various carbon capture technologies that are available right now:

- Post-combustion capture: Capturing CO2 from the flue gas or emission stream after a fuel has already combusted, usually by using a chemical solvent.
- Oxy-Fuel combustion capture: When a fuel is combusted with a mixture of oxygen and flue gas, it generates easily separated steam, water, and CO_2.
- Pre-combustion capture: Chemically decomposing a fuel (e.g., coal) to produce synthetic gas, which is further processed to separate the CO_2.
- Direct Air Capture (DAC): Large fans directly draw in air from the atmosphere to filter out the CO_2.

Without going into the technical details, intuitively, it makes sense that higher concentrations of CO_2 are easier to capture than lower concentrations. It is more cost effective to capture carbon at a gas processing facility that releases significant amounts of high purity CO_2, than capturing CO_2 directly from the atmosphere (see Figure 4).

Naturally, the current CCUS investments that we see in the market mainly target fossil fuel and chemicals industry, as it is easier to capture CO_2 at these plants. These facilities are also often consumers of CO_2 themselves and have existing CO_2 pipeline infrastructure in place, which makes CCUS more economically viable as the captured CO_2 can be reused locally without significant new infrastructure.

Figure 4: Levelized cost of CO_2 capture and CO_2 concentration by sector



Note: CO_2 partial pressure is a reflection of the concentration levels of CO_2 at the emission source
Source: IEA, Global CCS Institute, March 2021

In recent years, large industrial and energy companies are accelerating the development of CCUS projects. For example, BHP (a global mining company) is piloting different CCUS technologies with China's HBIS Group (one of the world's largest steelmakers) at HBIS's steel operations[5]. The captured CO_2 will be used in food and industrial sectors. In Europe, HeidelbergCement is also commissioning the world's first carbon capture project at a cement production facility in Norway in 2024, which would cut 50% of the emissions from the cement produced at the plant[6].

Another investment opportunity is CO_2 transportation (e.g., pipelines or ships) and storage infrastructure (e.g., salt caverns), which needs to be built to complete the CCUS value chain. However, one major controversy around CCUS is around the utilization of CO_2, because currently, much of the CO_2 that is captured by these facilities is reused in energy and petrochemical industries. For example, the oil industry uses CO_2 in enhanced oil recovery (EOR) operations, where they pump CO_2 into mature oil wells to boost production.

Some critics therefore argue that this is contrary to the spirit of the energy transition, as CCUS directly supports traditionally high emitting industries by prolonging the useful life of fossil fuel production. The counterargument to this is that CCUS still provides a net reduction to emissions compared to the status quo, so it is still supportive of the energy transition and provides a gateway for scaling up CCUS infrastructure and potentially new applications for captured CO_2.

Green hydrogen

Aside from CCUS, another promising solution for reducing GHG emissions in the industrial sector is to use hydrogen as a clean alternative to fossil fuels, especially for processes that require significant heat. Hydrogen is a combustible gas that is carbon-free and is mainly produced from natural gas via a carbon intensive process known as steam-methane reforming (SMR), which produces significant GHG emissions. The hydrogen produced from SMR is known as "grey hydrogen." To lower the carbon emissions of this process, SMR facilities can be paired with the CCUS to produce what the industry calls "blue hydrogen."

We can even take this a step further. As renewable costs continue to fall and with the support of subsidies (such as the US IRA's hydrogen production tax credit), cheap and clean electricity can perform electrolysis on water to create hydrogen by splitting the molecule into hydrogen and oxygen using electrolyzers, thus entirely bypass the SMR process.

Hydrogen produced via renewable electricity and electrolysis is known as "green hydrogen." Alkaline electrolyzers are currently the mainstream technology to produce green hydrogen, while polymer electrolyte membrane (PEM) electrolyzers have more potential in the future due to scalability and flexibility.

Currently, grey hydrogen production costs around ~USD 1/kg in the US and ~USD 3/kg in Europe, while green hydrogen is generally more expensive depending on the availability of cheap electricity and electrolyzer costs (See Figure 5). A major tailwind for the industry was the introduction of a USD 3/kg tax credit for green hydrogen under the U.S. IRA, which brought US green hydrogen costs in some regions to parity with grey hydrogen, especially around the Gulf Coast where there is existing hydrogen infrastructure and relatively cheap electricity.

As a first step, green hydrogen can potentially replace SMR-produced grey hydrogen in traditional industrial applications such as in refining and chemical production. For example, TotalEnergies recently signed an agreement with Air Liquide for the supply of green hydrogen to a refining and chemical facility in France starting in 2026[7], which would replace the use of grey hydrogen.

[5] BHP signs Carbon Capture and Utilization pilot agreement with China's HBIS Group; March 2023 *link*

[6] HeidelbergCement to install the world's first full-scale CCS facility in a cement plant; December 2020 *link*

[7] TotalEnergies and Air Liquide join Forces on Green Hydrogen to Decarbonize the Normandy Platform; September 2023 *link*

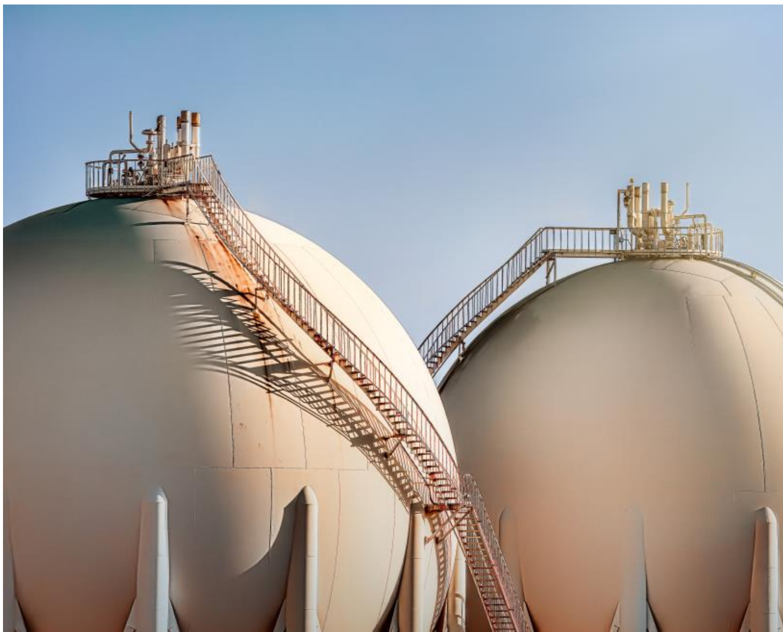
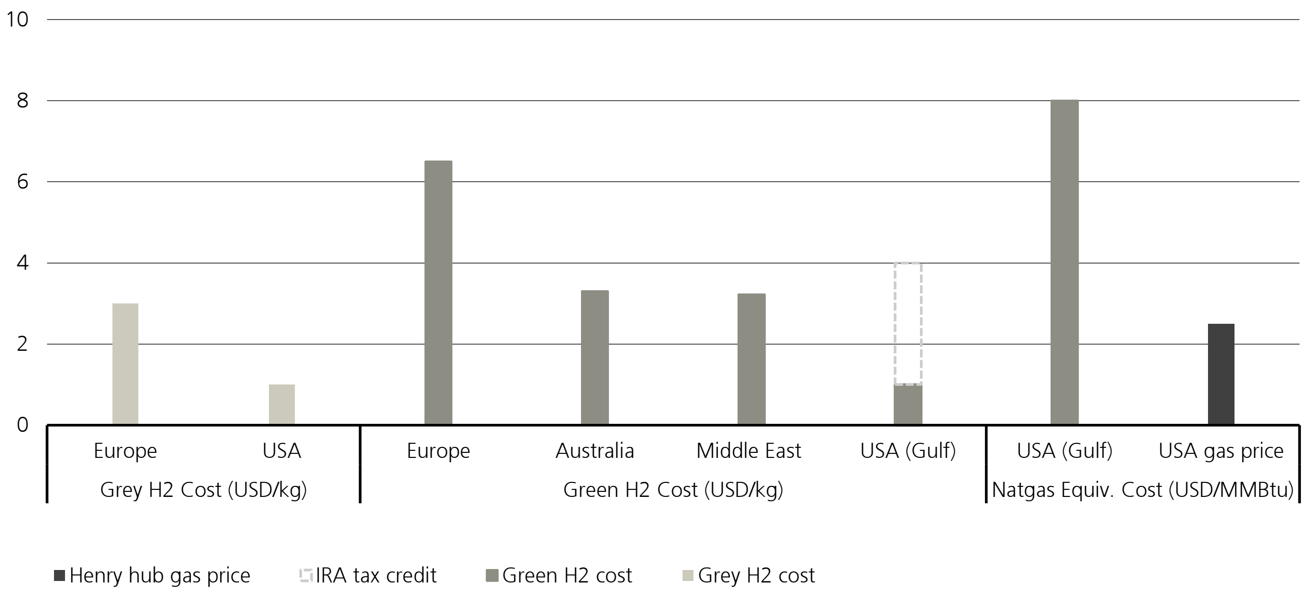


Figure 5: Hydrogen cost comparison (USD/kg and USD/MMBtu)



Source: Reuters, S&P, ICIS, UBS Asset Management, September 2023

Another interesting opportunity is to produce ammonia (NH_3) using hydrogen. Ammonia is an important fertilizer and is currently produced from natural gas. Green hydrogen can be processed into green ammonia, which does not release any carbon emissions during the synthesis process.

In addition, ammonia is easier to transport than hydrogen on ships due to its higher energy density (by volume), which could create a globalized hydrogen market with ammonia shipping as a way to indirectly export and import hydrogen. For example, Iberdrola, the Spanish power company, announced a green ammonia project[8] that will supply ammonia to Trammo, a shipper and exporter.

Ultimately, the goal is for green hydrogen to replace natural gas in combustion processes. This can be in a cement plant, a steel mill, or even in power generation. However, these opportunities are longer term.

Even at USD 1/kg, US green hydrogen may be cheap compared the other hydrogen production processes, but that is still ~USD 8/MMBtu on a natural gas equivalent basis (see Figure 5), which is significantly higher than the current USD 2.5/ MMBtu Henry Hub natural gas price, and limits the domestic usage of green hydrogen as a natural gas replacement.

This is why under the US Department of Energy's hydrogen roadmap[9], hydrogen will not replace natural gas in steel, cement, and power generation sectors until the "second wave" and "third wave" of hydrogen development, which in their definition means after 2030.

On the other hand, at USD 8/MMBtu equivalent, US green hydrogen could potentially be exported to other countries that have higher natural gas prices (e.g. European natural gas price is currently ~USD 12/MMBtu). But this is also a long-term proposition as the transportation and export infrastructure still needs to be built out. As discussed before, it could make sense for the US to export hydrogen indirectly by first converting it into ammonia.

Hydrogen transportation infrastructure such as pipelines therefore could also be an investment opportunity. Traditional natural gas pipelines made of steel can only blend a certain amount of hydrogen before they face "embrittlement" (i.e. hydrogen causes metals to reduce in strength and potentially crack over time). New or retrofitted pipelines made by plastics such as polyethylene could counter the embrittlement issue.

Finally, hydrogen can also be used in vehicles that are equipped with fuel cells or specialized combustion engines, which we will discuss in more detail later in this paper under the "Transportation" section next.

[8] Trammo and Iberdrola Sign Agreement for Purchase and Sale of Green Ammonia; June 2023 *link*
[9] U.S. National Clean Hydrogen Strategy and Road Map, Department of Energy, June 2023

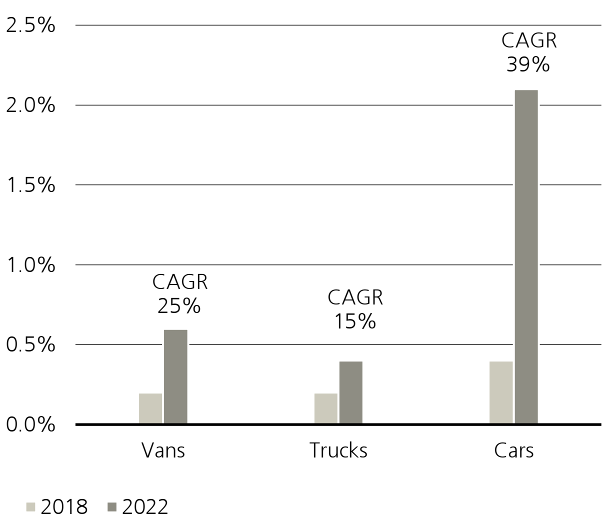
Potential investments in transport – electrification, clean fuels

The transport sector, often classified as a hard-to-abate segment, consists of surface, sea and air sub-sectors. Overall emissions are growing and the sub-sectors are decarbonizing at different paces, but since 2010, the sector's emissions have increased faster than for any other end-use sector, averaging +1.8% annual growth[10], highlighting the need for urgent investment. The decarbonization of transport benefits from converging tailwinds: falling technology costs, supportive policies and stakeholder pressure to reduce emissions.

Surface transport

Surface accounts for ~70% of transport emissions, within which, the passenger segment makes up ~45% while freight accounts for ~29%. The transition to zero emissions vehicles in the personal autos space is well underway with BEV reaching 9.4% of global sales in 2022. BEV sales in the commercial vehicles segment are less than 3% globally, and as of 2022, almost all of the fleet is powered by diesel powered ICE vehicles (Figure 6).

Figure 6: Share of EV in total vehicles stock (%)



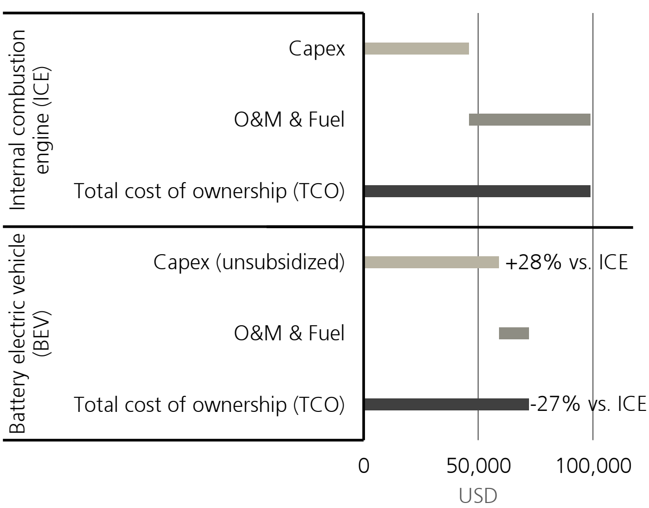
Source: IEA, April 2023

This trend is driven by supportive public policies, changing consumer preferences and the improvement in the total cost of ownership (TCO) – a metric which looks at the cost of the electric vehicle, including fuel and maintenance over the useful life of the asset. This is driven by falling battery costs of 90% over the past decade[11].

The electric take-up is lower for commercial applications, with vans and trucks representing less than 3% electric sales. Given freight makes up 30% of transport CO_2 emissions, this represents a significant opportunity for investors looking at accelerating the transition to zero emission transportation. We expect battery electric vehicles to be dominant for road transport except for long-distance trucks where a clear technology winner has not yet emerged.

Figure 7 shows that despite higher upfront capex of commercial Battery Electric Vehicles (BEVs), the combination of fuel savings and lower maintenance cost can deliver a significantly lower total cost of ownership (TCO). In the case of a last mile delivery van, we estimate a ~27% saving in the US and a 30-40% saving in Europe.

Figure 7. Light duty vehicle sample TCO comparison[12]



Source: UBS Asset Management, OEM catalogue, EIA, Transport & Environment, September 2023

10 IPCC AR6 WGIII, Chapter 10, November 2021
11 Lazard's Levelized Cost of Energy Analysis 16.0
12 Example for Mercedes Sprinter van

BEVs require new infrastructure to deliver the fuel, i.e., the charging stations. Closed-loop applications are low hanging applications for electrification as charging can be centralized at the base, allowing lower capex, higher utilization and removing the dependence of public charging infrastructure.

Aside from BEVs, hydrogen fuel cell electric vehicles (FCEVs) have zero tailpipe emissions, and have a number of advantages over BEVs, such as shorter charging times and less impact on weight. Most importantly, FCEVs have longer ranges, which makes them more suitable for commercial vehicles that are typically driven over greater distances and for longer periods of time per day.

As discussed in the previous section, green hydrogen is produced through electrolysis using renewable electricity and can be used as a source of fuel for FCEVs. However, currently, the cost of hydrogen and the cost of the fuel cell are prohibitive compared to diesel and BEVs.

Nevertheless, we expect to see hydrogen take up where the users' purchase decisions are driven by factors other than cost, such as the range, time to recharge or weight considerations. Some practical examples where hydrogen may offer a solution are standby assets, e.g. emergency response vehicles, highly seasonal farming or municipal equipment, or back up range extenders.

Marine

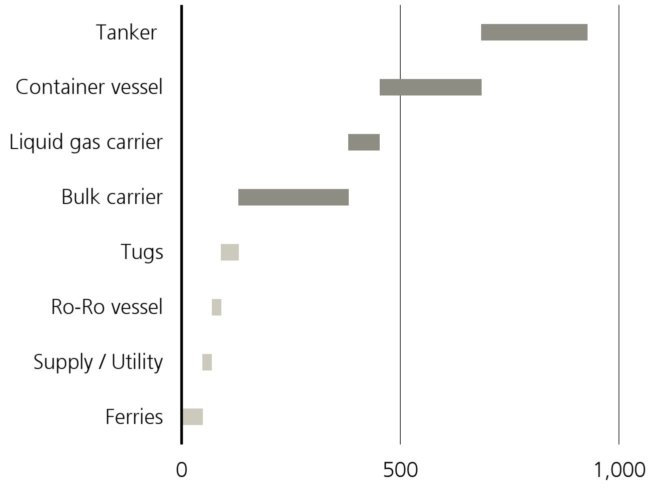
The decarbonization pathway of the marine sector is set by the International Maritime Organization (IMO) regulation which targets a reduction of 40% by 2030, pursuing efforts towards 70% by 2050 versus 2008 levels.

Of the ~1 billion tons of CO_2 annual emissions from the marine sector, short-haul vessels make up ~13%, the rest can be attributed to long haul (primarily ocean going) vessels (see Figure 8).

From a technology perspective, there is no clear consensus on the winning technologies, with market leaders opting for different solutions, headed by Maersk that seems to be betting on E-methanol. This gives investors less certainty and increases stranded asset risk.

Methanol is controversial as it is still a carbon-based fuel and so there is much debate on whether it should be considered green. A potential alternative is ammonia (discussed in previous section), which does not contain carbon and could be combusted in an internal combustion engine.

Figure 8: CO_2 equivalent emissions in marine segment, 2022 (Mt)



Source: BCG, 2022

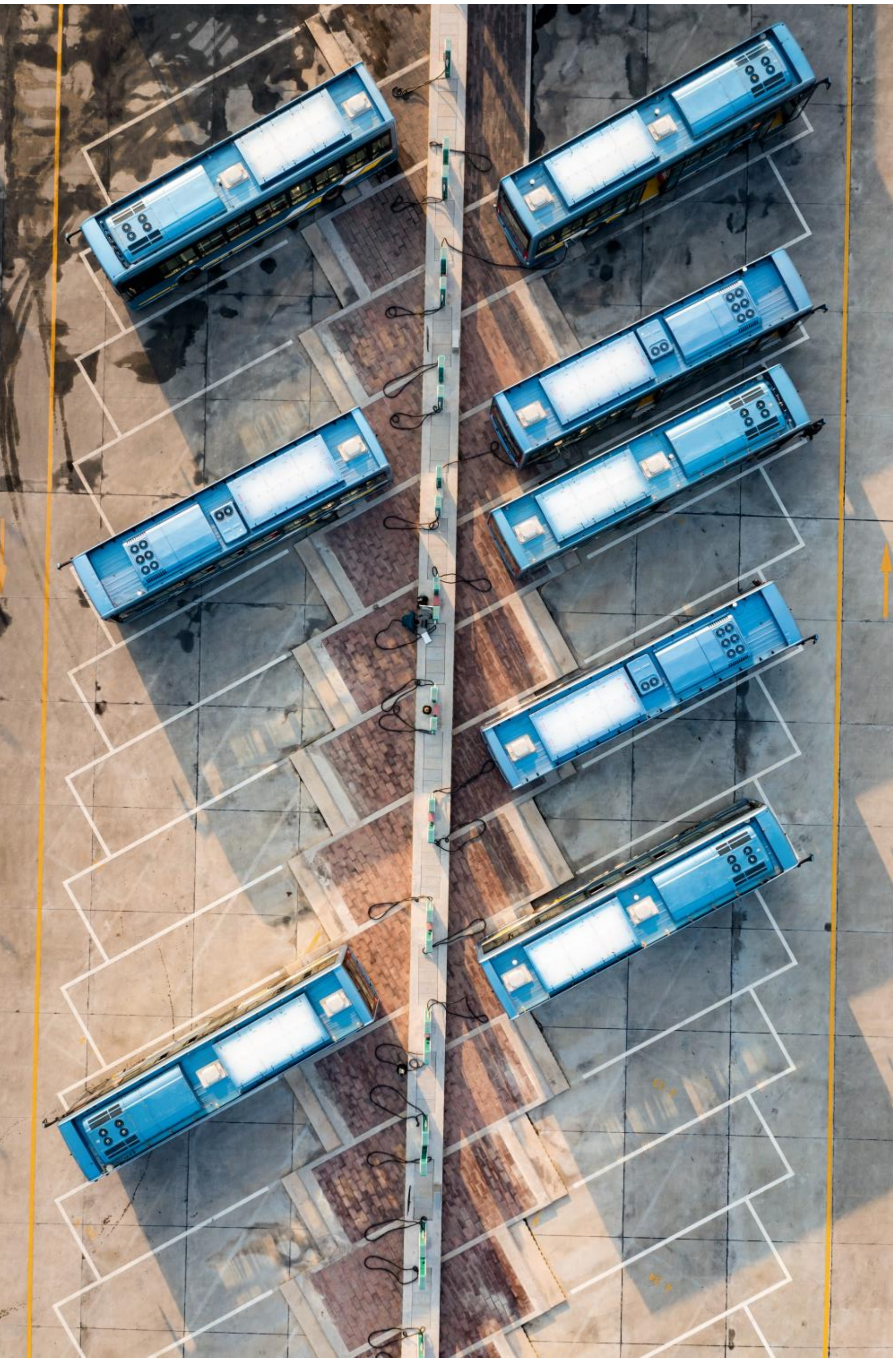
However, to date, there is no commercially available engine technology that can burn ammonia. The main challenge with ammonia is its high toxicity, creating high safety requirements.

Electrification is another pathway for decarbonizing the marine sector. However, electrification is not suitable for long-haul shipping, and to date, the batteries that are being commercially deployed onto vessels are all less than 10 MWh. The use of larger batteries is limited by cooling requirements and volume restrictions of the hull.

Near shore vessels such as tug boats and utility vessels could be better candidates for electrification. Some jurisdictions (e.g., California, Rotterdam, Antwerp, Singapore, Auckland) have introduced laws requiring electrification of tugboats since they are typically a major source of local pollution.

One clearer short-term opportunity is for port infrastructure. For example, ports generate 6-7% of the total maritime emissions[13], can invest in commercially proven technologies such as on-shore power (OSP) and through the electrification of port equipment.

[13] Figures for the European Union from European Parliament, "European ports becoming 'fit for 55'", April 2022



Aviation

The air sector contributes a similar share of emissions as marine, albeit it has been growing at a faster pace. There are limited options to decarbonize airplanes, as the weight and range of batteries make moving to electric power challenging while the low energy density of hydrogen creates space limitations.

Sustainable aviation fuel (SAF) is the only credible option to decarbonize air at scale. At present, SAF makes up around 0.1% of aviation fuel demand and it cost 2-4 times more than jet fuel[14]. Upstream production of SAF needs to be scaled up to meet vast demand aligned with strong policy measures contained in the ReFuelEU Aviation (part of RePowerEU policy).

The US IRA, which provides a SAF subsidy of up to USD 1.75/gal, could also support the industry. Like many other energy transition technologies, we are also seeing large corporate offtakers (e.g. United Airlines is the largest SAF buyer in the world) who are willing to pay a premium for SAF due to its environmental attributes.

A more immediate opportunity in the air sector is the decarbonization of ground service equipment (GSE) at airports. Although some of this is already electric (e.g. baggage tractors), there are opportunities to further reduce emissions through the adoption of fixed electric ground power (FEGP) and the electrification of other GSE such as push-back tractors for certain planes.

[14] IATA, SAF Policy 2023

Addressing fugitive emissions –

Renewable natural Gas (RNG), specialized leak detection and repair (LDAR)

Unlike the industries that we previously discussed, a significant amount of GHG emissions come from fugitive emissions, often in the form of methane gas (CH_4). The problem with methane is that it is over 80 times more potent than CO_2 in its ability to trap heat and contribute to climate change over a 20-year period[15]. One source of methane emissions is from the agricultural sector in the form of biogas from livestock. Another is from methane leakages at fossil fuel and petrochemical production facilities. We will address both issues in the section.

Renewable natural gas (RNG) in agriculture
One way to remove GHG from the agricultural sources such as livestock is with renewable natural gas (RNG) or biomethane. RNG or biomethane both describe biogas produced from anaerobic digesters that converts and upgrades organic feedstocks into a gas that is chemically identical to natural gas. Aside from livestock at farms, biogas is also produced from various sources, including landfills, food waste, and wastewater treatment facilities.

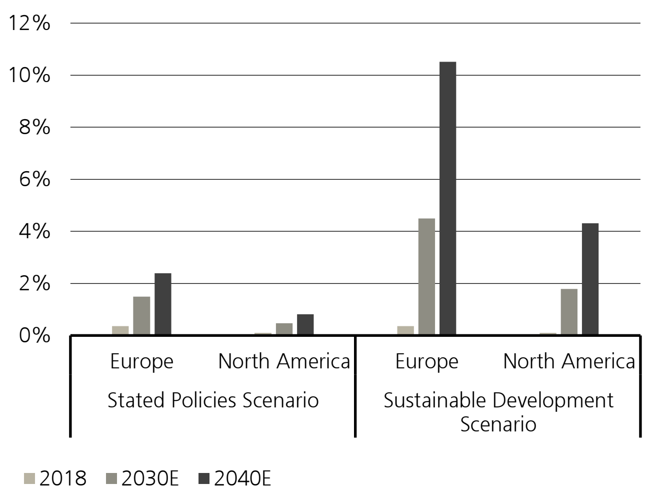
Demand for RNG is slated to grow rapidly around the world, albeit starting form a low base (see Figure 9), as natural gas demand remains strong despite the energy transition. The ability to substitute conventional fossil natural gas with RNG is therefore a pragmatic solution.

Although RNG is chemically identical to fossil natural gas, the impact from its emissions is only a fraction of what the impact would have been if the methane is released directly into the atmosphere. RNG therefore has one of the lowest lifecycle GHG intensity of any clean energy sources based on its climate change impact[16].

Currently, RNG has attracted significant capital from both strategic and financial investors. In 2022, the sector has closed almost 60 deals amounting to USD 7.6 billion of investments globally, according to Inframation. The reason for this is because RNG project economics are attractive. In the US, RNG developers often discuss project payback periods of around 3-5 years, significantly faster than typical infrastructure projects.

[15] IEA Methane and climate change; Jan 2021 *link*
[16] Energy & Power – Biofuels: Renewable Natural Gas, Stifel Equity Research, March 2021

Figure 9: Biomethane/RNG as % of gas demand



Source: IEA World Energy Outlook, October 2022

Project costs vary significantly depending on the source of feedstock. For example, based on a study commissioned by the California Energy Commission in 2022, producing RNG using landfill gas is the cheapest method at around USD13/MMBtu, while producing RNG with manure from livestock costs USD 26/MMBtu (see Figure 10).

A major part of this is due to scale – based on this study, the facility using landfill gas produces almost 15x more RNG than the facility that uses livestock emissions. Project capex can also vary from USD 10s of millions to USD 100s of millions depending on project size and feedstock.

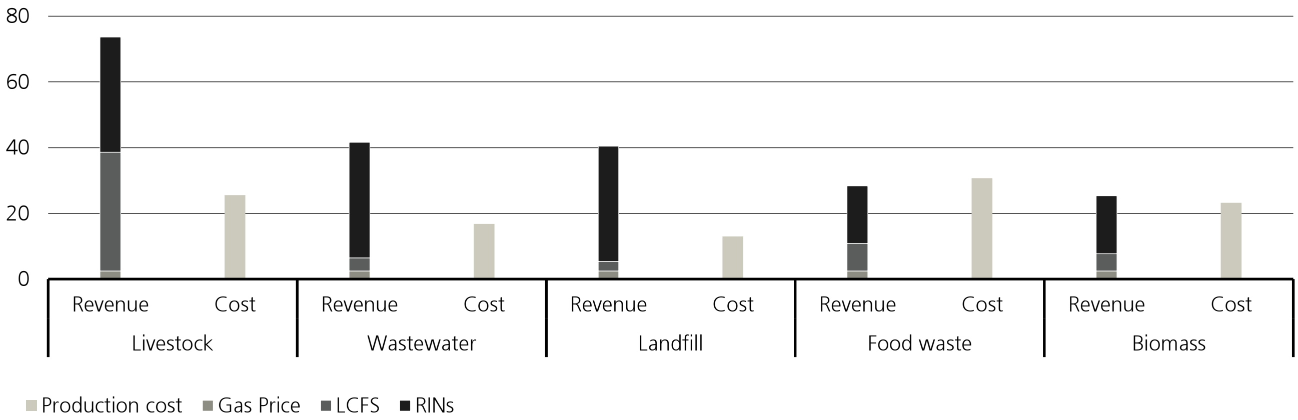
Revenues across projects can also vary significantly, and are highly dependent on the prices of clean energy credits, which could vary depending on feedstock. The two main credits in the US are California's low-carbon fuel standard (LCFS), which is awarded to RNG that is sold in California (even if the RNG is not produced in-state), and Federal level renewable identification number (RIN), which is a part of the Federal government's Renewable Fuel Standard.

As observed in Figure 10, these clean energy credits account for most of the revenues. Without them, the current USD 2.5/MMBtu natural gas price would hardly help recover the USD 10-30/MMBtu production costs.

Although these clean energy credits are very lucrative, they are also a key source of risk. Prices can fluctuate significantly – for example, LCFS prices have fallen by 60% in the last 2 years. Some RNG developers actually opt for longer term offtake contracts with customers to lower their exposure to these highly volatile clean energy credits, regardless of how attractive they currently are.

For example, RNG can be combusted to generate electricity that is backed by long term power purchase agreements. Some European countries also have Feed-in-Tariffs (basically a government guaranteed price) for biomethane used for electricity generation or injected into the gas grid.

Figure 10: Biomethane/RNG unit revenues and costs in US by feedstock (USD/MMBtu)



Source: California Energy Commission, UBS Asset Management, September 2022

Methane leakages

Methane leakages are fugitive emissions that are intentionally or unintentionally released through the day-to-day operations of a business (mainly in the fossil fuel industry). For example, unintentional leakages during extraction and transportation of oil and gas, and intentional venting of fossil fuels due to excess production.

Oil and gas companies have touted the switch from coal and oil to natural gas as their contribution to decarbonization in the last ten years. Yet poor methane emissions management could invalidate their argument given the potency of this GHG. According to the World Resources Institute, 2% of US natural gas production is currently leaked, which is the equivalent to the annual emissions of roughly 120 million cars[17].

The unintentional leakages can be tackled by increased monitoring by using technologies such as specialized leak detection and repair (LDAR), satellite imaging or drone equipped with sensors, while applying penalties if needed. For example, the IRA introduced a methane emissions charge on the oil and gas industry that starts at USD 900 per ton of methane, increasing to USD 1,500 after two years, which is equivalent to USD 36-60 per ton of CO_2.

The IRA also includes USD 850 million of grants, rebates and loans to improve and deploy new industrial equipment and processes to monitor and mitigate methane leaks, and USD 700 million to support marginal conventional wells.

This brings an element of active asset management, as owners of these infrastructure projects will have to navigate the government programs as well as work with various suppliers to upgrade and retrofit the equipment. The potential to mitigate GHG emissions is also significant.

The intentional venting of methane is a different story. This usually happens when there is not enough pipeline or storage capacity for excess natural gas that has been produced (e.g. natural gas is often a byproduct of shale oil wells). The result is that much of this natural gas is often wasted by flaring (burning at the wellhead), which produces both methane and CO_2 emissions.

Ironically, the most practical solution is to build more midstream infrastructure that can take away this excess gas, which may raise some environmental concerns, but is still a better outcome than having the gas wasted and released directly into our atmosphere.

Another solution is to consume the excess natural gas on site. This involves combusting the gas in generators to produce electricity for local demand. There have already been announcements of data centers and crypto miners being built near oil and gas wells to take advantage of this as a sustainability angle[18]. CO_2 is still produced through this process, but once again, it is better than flaring or venting.

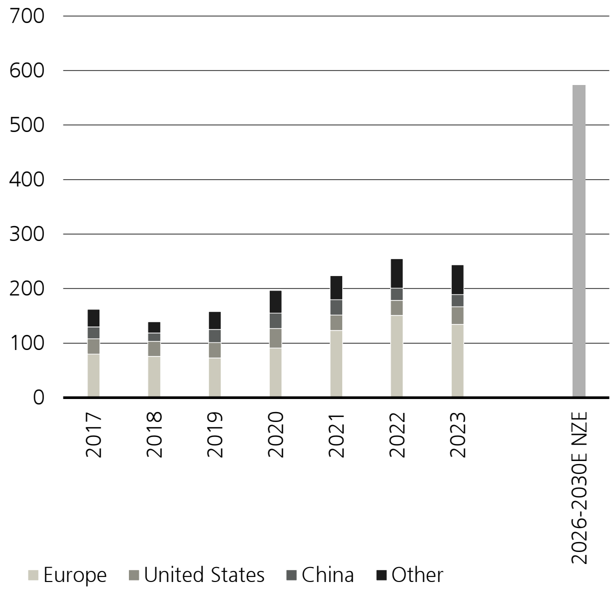
17 Capturing the Fugitives: Reducing Methane Emissions from Natural Gas; April 2023 *link*
18 Data centers that run on gas flares; December 2021 *link*

Reduction of emissions in buildings –

Energy efficiency, Energy as a Service (EaaS)

One last industry that has large GHG-emission reduction potential is real estate. Improving building energy efficiency is an important pathway to reduce GHG, yet it currently underinvested in according to the IEA based on current net zero targets (see Figure 11).

Figure 11: Annual investment in energy efficiency in the buildings sector vs. 2026-30E investment needs



Source: IEA Annual Energy Investments 2023, June 2023

Historically, energy efficiency is focused on reducing energy demand, which includes upgrading insulation, lighting, HVAC, etc. and electrifying certain appliances to reduce emissions. In the last 10 years, the improvements in technology mean that there has been is now also a focus on improving energy supply, such as rooftop solar panels, batteries and heat pumps, and optimizing operations using advanced analytics from data collected from smart meters.

As distributed energy resources become more integrated with the grid, buildings can also engage in utility demand response programs or virtual power plants (VPPs)[19], which gives buildings the ability to generate extra revenues by ramping down demand or selling electricity to the grid, which adds to the energy cost savings.

Many enterprises have aggressive GHG emission reduction targets. However, they do not have the in-house expertise to meet their own green ambitions, especially with the rising complexities of various energy transition technologies and applications that we mentioned above.

Energy-as-a-service (EaaS) and similar[20] business models are therefore becoming more popular. EaaS firms design, build and install all the systems for buildings with their own capital, manage the different suppliers and technologies, and then optimizes the building's energy supply and demand over a contracted period. The customer then makes periodic payments to the EaaS company based on the amount of energy savings and other KPIs.

This becomes a win-win situation, as a customer with no energy management expertise can still save on energy costs and increase its green attributes, without incurring upfront capital investments. On the other hand, the EaaS company owns all the equipment and receives stable and periodic payments from their customer, as long as they deliver on the KPIs.

A challenge for the EaaS business is the customers are relatively fragmented. For example, it costs only several USD 100,000s to upgrade a simple building with latest distributed resources and energy efficiency technologies.

An EaaS provider therefore either have to work with many customers, or with single large customers to build sufficient scale. For example, some EaaS companies work with retail or hotel chains with have large real estate footprints, large data center operators that are major consumers of electricity, major universities, or infrastructure assets such as ports or airports, in order to achieve sufficient scale for their businesses.

[19] VPPs pools distributed resources together (using software) as a single entity to buy electricity from and sell electricity to the grid, which adds flexibility to the grid, while generating revenues for the building owners
[20] These types of business models have many names aside from EaaS, including energy service companies (ESCO), energy management, energy efficiency, micro grids etc.

Carbon markets and policy support

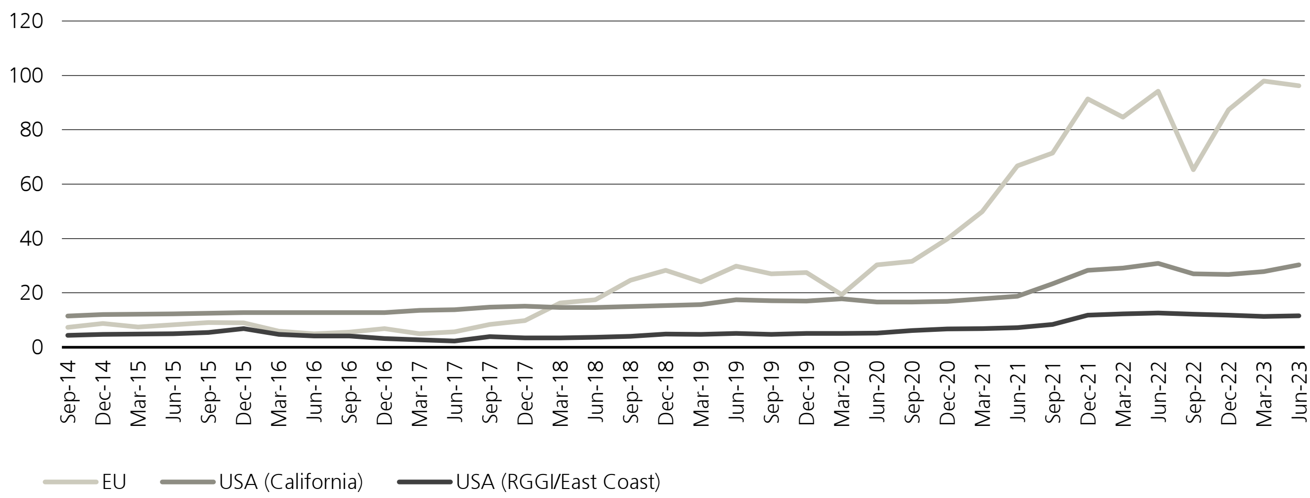
The energy transition cannot happen without strong government policy support. These often come in the form of subsidies, grants or local mandates. However, one powerful but at times underappreciated tool to accelerate clean energy investments is the availability of a large scale carbon market, as well as high carbon prices.

Europe is ahead of the US as the EU Emissions Trading System (EU ETS) is the largest and most comprehensive carbon market in the world, covering industries such as electricity generation, manufacturing, and even aviation. More importantly, EU carbon prices have tripled since 2019 due to more aggressive climate policies (see Figure 12).

When the cost of emitting carbon is as high as it is in Europe, all the technologies that we previously discussed become more compelling.

The US does not have a national level carbon market. Instead, it relies on a patchwork of local markets such as the Regional Greenhouse Gas Initiative (RGGI) that is focused on the East Coast, and another one in California run by the California Air Resource Board (CARB). Carbon prices at these markets are significantly lower than European carbon prices, although they have trended upward in recent years.

Figure 12: Carbon prices (Europe vs. US) **– USD/mt**



Source: Bloomberg, September 2023

Although the US lags Europe in its development of carbon markets, and the Federal government has generally displayed a lack of commitment to national level clean energy mandate, the US has been remarkably successful in rolling out clean energy tax credit programs. For example, the IRA enacted in 2023 was arguably the most important, comprehensive and impactful US clean energy legislation in history, and has the potential to generate over a trillion dollars of incremental clean energy investments over the next decade.

The extension of wind and solar energy tax credits and the new standalone storage tax credits rightfully attracts a lot of attention. But one impressive aspect of the IRA is the scope of GHG emissions that it covers. Figure 13 summarizes incentives (and penalties) across various industries, which covers almost all the technologies that we have discussed in this paper.

Figure 13: Inflation Reduction Act – "beyond renewables" tax credits and penalties

	Inflation Reduction Act (IRA) tax credits (and penalties)
Hydrogen	Production tax credit (PTC) up to USD 3/kg
Carbon capture, utilization & sequestration (CCUS)	USD 85/ton 45Q credit (previously USD 50/ton); USD 180/ton for direct air capture
Electric vehicle charging	ITC up to 30% for chargers; USD 7,500 EV credit extended (up to USD 4,000 for used cars)
Sustainable aviation fuel (SAF)	USD 1.25/gal if GHG reduced by at least 50%, plus USD 0.01/gal for every percentage point above 50% up to USD 1.75/gal
Renewable natural gas (RNG)	Investment tax credit (ITC) up to 50%
Energy efficiency, heat pumps, insulation	Up to USD 5 per square ft. for energy efficient commercial buildings 30% ITC up to USD 2,000 for heat pumps, up to USD 1,200 for qualified insulation, boilers and air conditioning Up to USD 14,000 home energy rebates for low-income households
Methane emissions	Penalty up to USD 1,500/t of methane by 2026 (USD 60/t CO_2 equivalent)

Source: US Government, UBS Asset Management, September 2023

Focus areas when investing in new businesses

With the maturity of traditional renewable investments such as wind and solar, the new technologies highlighted in this paper may offer the next wave of green investment opportunities. Since many of these emerging segments are currently still in the earlier stages of development, investors should focus on several factors that could make these assets more investable and provide them with more infrastructure-like characteristics:

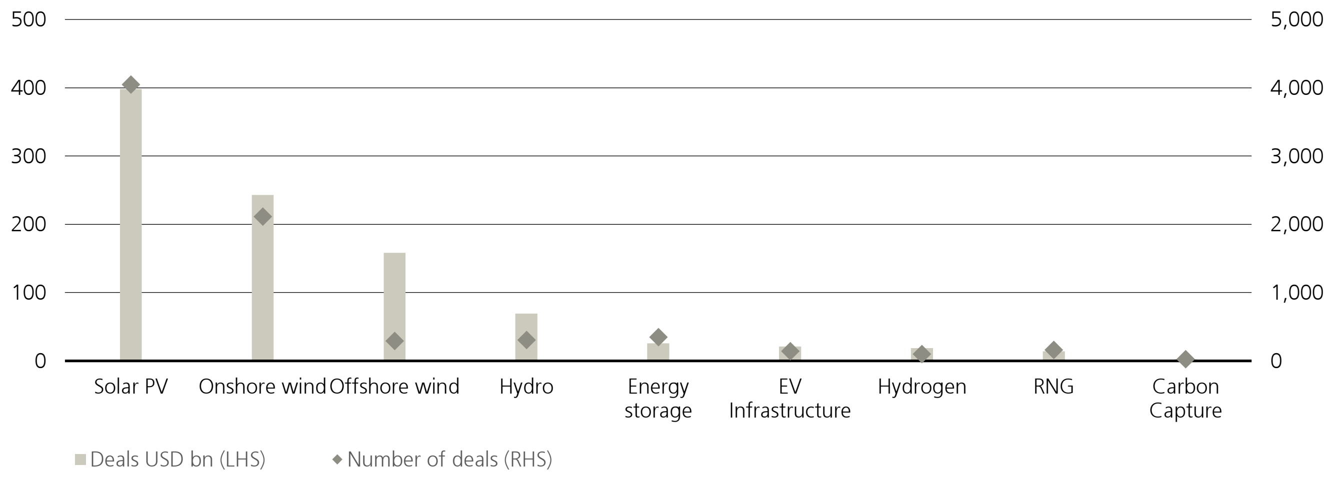
Attractive offtake agreements:
Despite frequent cost comparisons between "newer and cleaner" vs. "older and dirtier" technologies, in reality, if there is a large creditworthy counterparty who is willing to pay a premium for cleaner energy with an offtake agreement, project economics immediately become more attractive as revenues are de-risked. With significant corporate interest in climate issues, we could see more long-term contracts even for newer businesses and technologies.

Technological maturity:
Combining mature technologies with emerging decarbonization investments may seem like an oxymoron. The truth is, a lot of these technologies are already mature, including alkaline electrolyzers for hydrogen, and anaerobic digesters for RNG. They simply have not been scaled up enough to enjoy the cost savings that other technologies such as wind, solar and batteries have experienced. As a useful reminder – lithium ion technologies were already mature years before the popularization of grid-scale energy storage. Investors should therefore avoid unnecessary risk when examining various technological options.

Predictable regulatory revenues:
Since project economics of new technologies often depend heavily on tax credits and policies – the stability of supporting regulations is an important factor. Sometimes, revenues supported by regulations can also be volatile. As we discussed, the price for LCFS credits in California have fallen 60% since 2019, despite strong regulatory support. Investors should therefore have a deep understanding of the many drivers behind these "regulated" revenues.

Credible strategic partners:
In any new infrastructure business models, having a credible partner that has the expertise in development and operations of new projects will improve investment outcomes. In many of the businesses that we highlighted in this paper, there are already large corporates that are experienced in these segments, and they could potentially look for financial partners to support their growth.

Figure 14: Private clean energy transactions (last 5 years ending September 2023)



Source: Inframation, September 2023

For more information, please contact:

UBS Asset Management
Real Estate & Private Markets (REPM)
Research & Strategy – Infrastructure

Alex Leung
+1-212-821 6315
alex-za.leung@ubs.com

Follow us on UBS Asset Management

To visit our research platform, scan me!

www.ubs.com/infrastructure

This publication is not to be construed as a solicitation of an offer to buy or sell any securities or other financial instruments relating to UBS Asset Management Switzerland AG or its affiliates in Switzerland, the United States or any other jurisdiction. UBS specifically prohibits the redistribution or reproduction of this material in whole or in part without the prior written permission of UBS and UBS accepts no liability whatsoever for the actions of third parties in this respect. The information and opinions contained in this document have been compiled or arrived at based upon information obtained from sources believed to be reliable and in good faith but no responsibility is accepted for any errors or omissions. All such information and opinions are subject to change without notice. Please note that past performance is not a guide to the future. With investments in real estate / infrastructure / food and agriculture / private equity / private credit (via direct investment, closed- or open-end funds) the underlying assets are illiquid, and valuation is a matter of judgment by a valuer. The value of investments and the income from them may go down as well as up and investors may not get back the original amount invested. Any market or investment views expressed are not intended to be investment research. **The document has not been prepared in line with the requirements of any jurisdiction designed to promote the independence of investment research and is not subject to any prohibition on dealing ahead of the dissemination of investment research.** The information contained in this document does not constitute a distribution, nor should it be considered a recommendation to purchase or sell any particular security or fund. A number of the comments in this document are considered forward-looking statements. Actual future results, however, may vary materially. The opinions expressed are a reflection of UBS Asset Management's best judgment at the time this document is compiled and any obligation to update or alter forward-looking statements as a result of new information, future events, or otherwise is disclaimed. Furthermore, these views are not intended to predict or guarantee the future performance of any individual security, asset class, markets generally, nor are they intended to predict the future performance of any UBS Asset Management account, portfolio or fund. Source for all data/charts, if not stated otherwise: UBS Asset Management, Real Estate & Private Markets. The views expressed are as of October 2023 and are a general guide to the views of UBS Asset Management, Real Estate & Private Markets. All information as at October 2023 unless stated otherwise. Published October 2023. **Approved for global use.**

© UBS 2023. The key symbol and UBS are among the registered and unregistered trademarks of UBS. Other marks may be trademarks of their respective owners. All rights reserved.

UBS