RystadEnergy

The condensed version

Energy Transition Report

Energy Scenarios

Is 1.5 still alive?

Energy Transition Analytics

November 2022

Climate fund breakthrough at COP27 but is 1.5 degrees still alive?

Almost 200 countries came out of this year's climate summit with a historic agreement on a funding mechanism to compensate vulnerable nations for loss and damage from climate-induced disasters.

The COP27 participants also agreed the world needs to cut greenhouse gas emissions nearly in half by 2030 and reaffirmed the goal of keeping global warming to 1.5 degrees Celsius above pre-industrial levels.

However, can the world deliver on this mammoth task in the face of the great economic and political turmoil at present?

This month's Rystad Energy Transition Report dives into our energy scenarios moving towards decade-end and beyond.

Key findings from the November edition:

- Our analysis suggests the 1.5-degree scenario is a stretch but still possible, especially considering the allocation for methane emissions and deforestation in the carbon budget.

- The overall pace of climate policy has been slow. Although 33 nations have updated their nationally determined contributions over the past year, only two new countries pledged net zero targets for 2050. The noteworthy exception on policy development is the US with the Inflation Reduction Act, and the EU with the RePowerEU initiative, which boosted renewable energy topline capacity significantly.

- On the technology side, meanwhile, we see encouraging signs especially when it comes to the electric vehicle adoption rates that have been major steps forward in the evolution of the global energy system.

- The rapid expansion of the solar PV and wind supply chain is getting ready to match the expected demand spike for renewables – but room for progress remains as the burden now lies with countries to act as soon as possible and set ambitious installed capacity goals. Research suggests manufacturing capacity hikes are likely to support a 1.6-degree scenario, while a 1.5-degree scenario is within reach only with very aggressive annual growth rates.

- While private sustainable finance has grown, mobilization has been slow to scale. Regulatory overhaul and clear sustainable investment strategies are needed to quickly deploy capital that can have a high decarbonization impact.

- To keep 1.5-degree alive, oil and gas consumption must fall moving towards the end of the decade. As it did last year at the Glasgow summit, the Egypt gathering called for a phasedown of unabated coal power, and phase-out of inefficient fossil fuel subsidies, but did not call for a phase-out of all fossil fuels, including oil and gas.

- Decarbonization will largely require a very high electrification rate of industrial, residential and commercial heating, as well as the power sector through deployment of renewable energy. Based on electrification trends observed so far, we expect disruptions in the heat pump and renewable energy technologies to help upscaling to meet the requirements set out by our 1.5-degree scenario.

Our findings suggest the world needs to double down on climate action or risk making 1.5 a lost cause – as such, the energy transition requires additional incentives, thought-out policy, a blending of public and private investments, as well as a willingness to cooperate at an international level.

The carbon budget for the 1.5 DG scenario decreasing rapidly

The carbon budget is the total remaining amount of anthropogenic CO_2 emissions that will still hold global warming within acceptable ranges of temperature increase. Thus, as carbon emissions return to all time highs, a dwindling carbon budget is increasingly tangible.

The acceptable range of temperature increases is no further than 2.0 degrees Celsius, according to the Intergovernmental Panel on Climate Change (IPCC). With each incremental increase above 1.5 degrees, the severity of global warming worsens, bringing unforeseeable consequences that are likely devastating to the environment and economy.

Therefore, it is crucial to keep global warming to a minimum by adapting the global energy system and match it to the carbon budgets required to maintain temperatures as low as possible.

The trend to date has seen emissions rise each year, with the window to act in line with the 1.5-degree scenario to achieve net zero by 2050 closing rapidly. To make it a reality, very aggressive decarbonization strategies are needed.

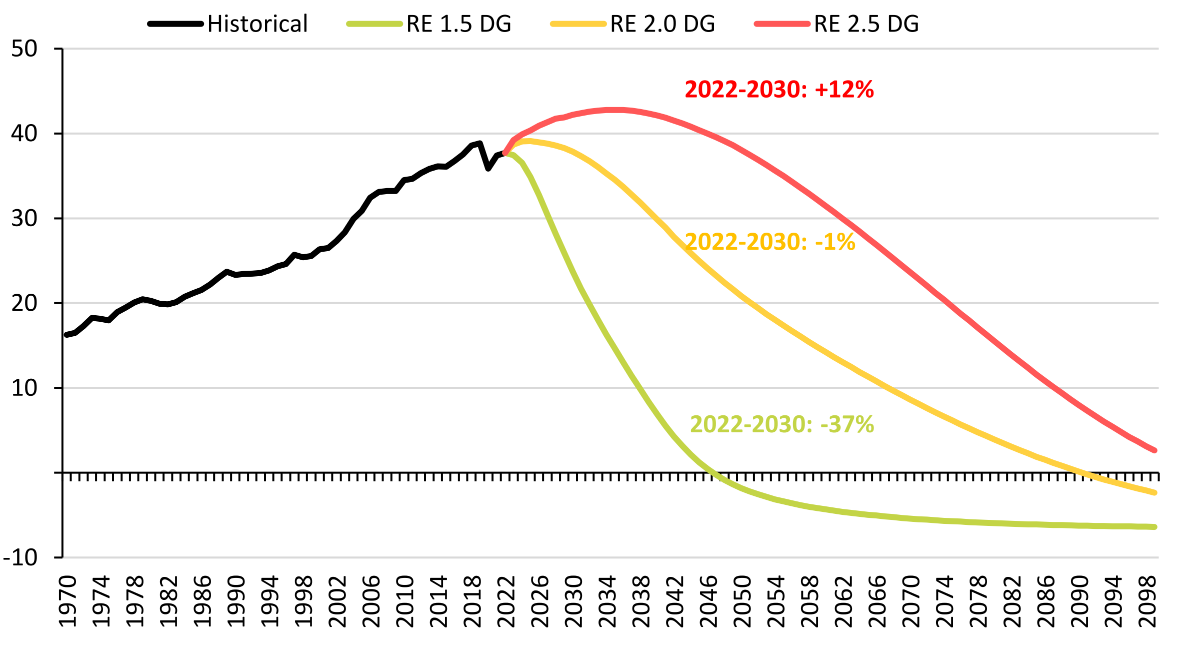
The remaining carbon budget corresponds to just five-six years of emissions at the current rate, meaning we need to reduce emissions by 37% (based on 2022 CO_2 only emissions) in the next eight years to stay on track for our 1.5 DG scenario.

The 2.0 DG scenario corresponds to global net zero in 2090 (at the current rate) and is not as aggressive, but still requires significant action. Although we assume emissions can be maintained at current levels for a few years, this would imply the need for much steeper decline in the 2040s and 2050s.

Then, the 2.5 DG scenario corresponds to global net zero after 2100 – the less aggressive scenario sees net zero only in the second half of the 22nd century, with emissions increasing 12% towards 2030 followed by a subsequent decline.

Global carbon dioxide emissions trajectory, 1970 to 2100

Gigatonnes (Gt)



Note: Includes carbon capture contribution in each scenario
Source: EDGAR, EPA, Rystad Energy Scenario Cube

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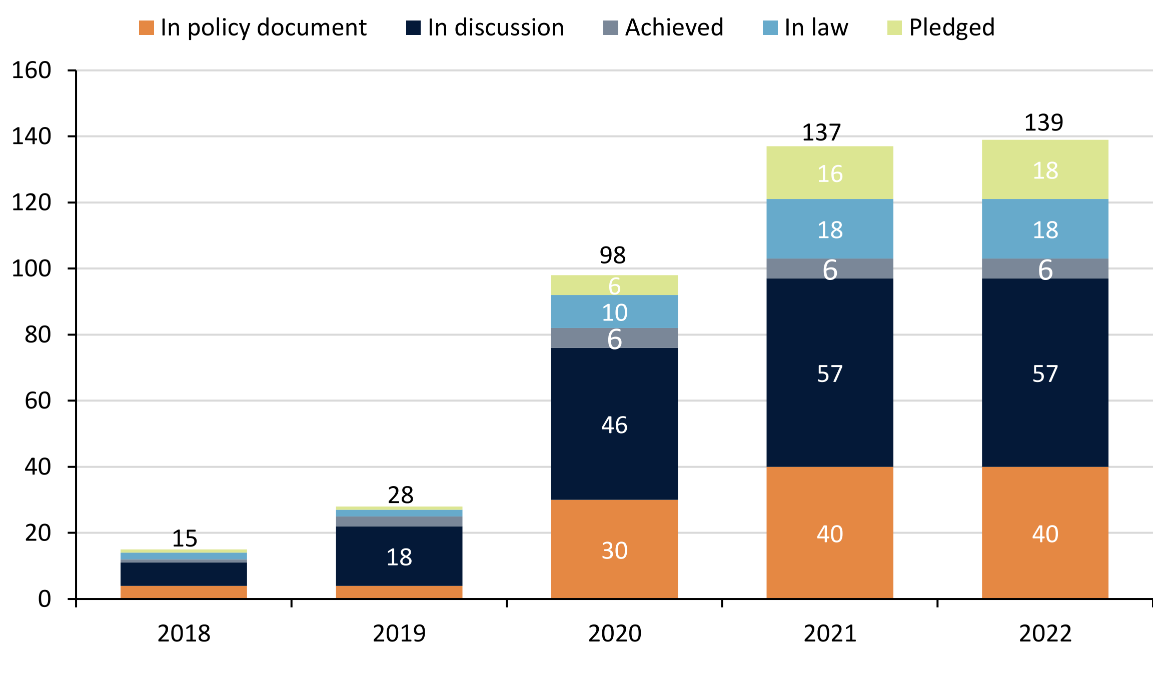
More than 70% of Paris Agreement signatories have net-zero targets

As part of the Paris Climate Agreements, countries were required to submit nationally determined contributions (NDCs) – a national plan that highlights climate change mitigation and greenhouse gas emission reduction measures. According to the UNFCCC, 195 countries have submitted NDCs out of the 196 parties. However, NDCs are non-binding documents. COP26 sought to ensure ironclad commitments on net zero emissions by around mid century, and leading up to the conference, commitments surged, with total net zero targets jumping from 98 to 137. But only one year down the line, the pace abruptly came to a halt, with only two countries pledging net zero – Australia and Oman. The tally now shows that out of the 196 parties that signed up to the Paris Agreement, 139 countries have made commitments to either carbon neutrality or net zero – resulting in a gap of 57 countries. Although some proportion of these countries have lofty decarbonization goals compared to business as usual – and the UNFCCC states that 90% of all parties have provided quantified mitigation targets – more nations need to step up and commit to net zero. Also, in addition to a slow increase in total net zero commitments during over the 2021-2022 timeframe, little progress has been made on moving these commitments towards legal obligations.

Most of the net zero pledges are still only in discussion phase. The same goes for the number of statements in the policy documents phase. Overall, more progress is needed to usher the net zero commitments towards being formalized as part of national legislation.

Net zero targets by year and implementation status

Number of countries



Note: Considers statements of carbon neutrality equivalent to net-zero
Source: Rystad Energy research and analysis, UNFCCC

Energy transition takes off on the back of the energy crisis

The past year has seen several macro economic, environmental and geopolitical crises, as well as draughts, record inflation, and geopolitical conflicts. Russia's invasion of Ukraine for instance caused extreme price volatility across the global energy market, and as a result, Europe, experienced fundamental structural changes to its energy system, and renewables are now seeing a pick-up in initiatives to fast-track their development. With the supply of Russian gas cut down to a fraction of its historical supply, gas prices spiked to record highs – and although prices have fallen since the early days of the war – they are expected to stay significantly higher than pre-Covid levels long term. Therefore, cheaper forms of energy are sought after, that can boost energy independence.

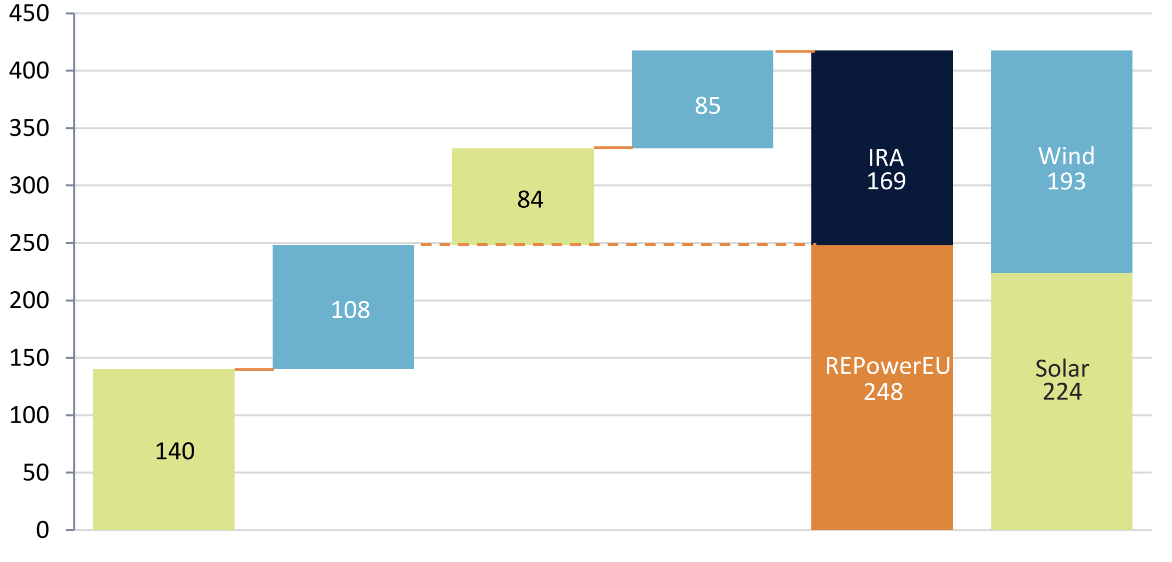
To facilitate this, REPowerEU emerged in the European Union. This initiative seeks to increase the share of renewables in the European energy mix drastically, and speed up the decarbonization of existing infrastructure, through means such as imposing strict emission limits for new gas capacity. Overall, it propels the European energy system towards a faster transition than what would otherwise have been the case if Russian gas continued to saturate European demand.

In addition to geopolitics, record levels of inflation facilitated a ramp-up of initiatives to expedite the move away from fossil fuels. In the US, the Inflation Reduction Act was launched as a policy instrument to tame inflation and led the US to increase its decarbonization efforts with initiatives that indirectly caused the inflation response to drive up renewable deployment. It is therefore clear that a record boost to the energy transition emerged from the global turmoil.

In the EU, we see that compared to our 2030 base case forecast, a 29.5% increase has been added to the topline renewable energy capacity after the REPowerEU initiative. Likewise, although to a lesser extent, when considering total capacity, the US Inflation Reduction Act facilitated a 43% topline boost for 2030 renewable energy capacity. However, if this capacity addition is to materialize in the future, it is critical that we see accelerated deployment through streamlined permitting and deployment processes.

Inflation Reduction Act + REPowerEU renewable additions by 2030

Gigawatts (GW)



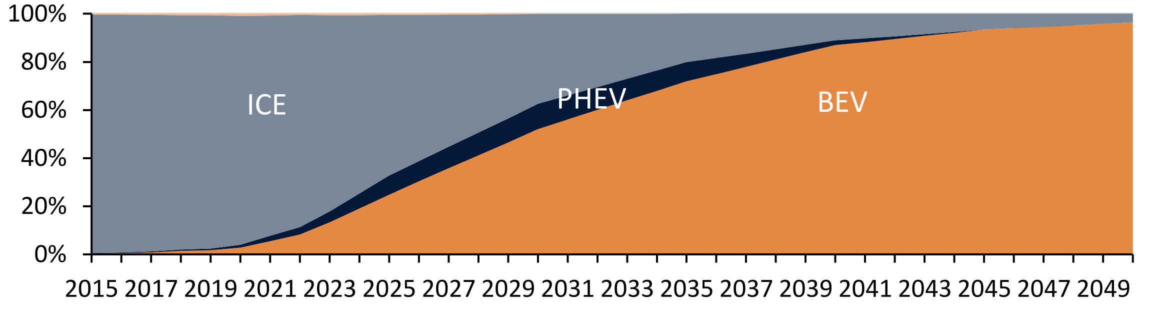
Source: Rystad Energy RenewableCube, Power Solution.

EV sales surged from 1.5% to 19% of global car sales in two years

Traditionally, disruptions occur according to s-curve shapes, and in line with historical trends observed across other technologies such as the internet, airplanes, smart phones and more, technologies usually grow slowly up until a market share of around 10%, before taking off.

Accordingly, we believe that EVs have reached a tipping point. In line with our high case forecast which expects EV penetration to make up >95% of all automotive sales by 2050.
This is supported by our close observation of monthly global EV sales.

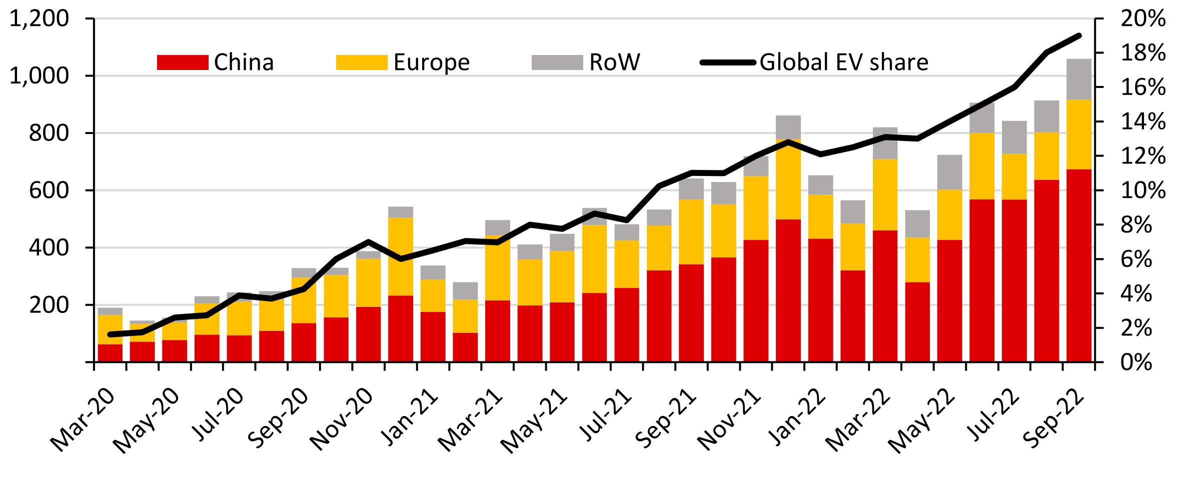
Historical and forecast vehicle sales
Percent (%)



EV sales have skyrocketed six times since March 2020, with monthly sales now comprise one out of every fifth car sold globally, up from only 1.5% less than three years ago. We expect this trend to continue; even though lithium prices might increase again over the coming months, we expect them to decrease strongly in 2023. This will have an equally strong effect on battery cell prices as lithium makes up more than 30% of the entire battery cell price.

EV* sales and market share, March 2020 to September 2022
Thousand units sold

Market share (%)



*EV includes battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV)
Source: Rystad Energy BatteryCube

Adaptation financing dominates COP27 – loss and damage agreement

COP27 held in Sharm El-Sheikh, Egypt concluded on 20 November. This year's COP has been dubbed both the "Implementation COP" and the "Africa COP". In contrast to COP26, the focus has been on getting countries to fully implement their pledges and to have the needs of developing African nations recognized in the global energy transition. For the first time at a COP meeting, "loss and damage" was officially on the agenda. The concept was put forth by the Alliance of Small Island States in 1991 and enshrined in the Paris Agreement in 2015. The latest IPCC AR6 WGII report showed that climate change has already caused losses and damages to systems and regions globally. Even with effective adaptation measures, additional losses and damages are unavoidable. Hence the increased focus on developed nations to commit additional funding to help affected developing nations to cope with climate disasters.

The annual "10 New Insights in Climate Science" report released at COP27 further highlighted the limits to adaptation and renews call to keep the 1.5 DG goal alive. The report also showed that private sector investments in sustainable finance have been growing but are critically insufficient to catalyze the rapid energy transition required to reach net zero in 2050. Even though the annual $100 billion funding promised by developed nations in 2009 has yet to be fulfilled, many new funding initiatives were launched at COP27. Notable developments include additional pledges for adaptation, increased mobilization of global financing in developing nations for energy transition and Africa centric initiatives to boost renewables within the continent. Financing from both public and private entities remains the key to unlock the implementation of NDCs across many developing nations.

Key agenda	
Keeping 1.5 alive	• The Paris Agreement goal to limit warming to 1.5-degree has been reaffirmed at COP27.
Fossil fuel phase out	• Reported efforts from India and EU to include stronger language to phase out fossil fuel failed • The relevant phrase in COP27 decision remains the same as COP26 - "*phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies*".
Loss and damage	• 200 nations agree landmark deal on funding facility to support the nations worst-hit by climate change. • A transitional committee will be setup to study the implementation of this funding agreement and is expected to present their recommendations at COP28.
Climate finance	• France and IMF signaled public support for the Bridgetown Initiative, a proposal led by Barbados to reform global financial institutions and to expand climate funding for vulnerable developing nations. • US launched the Energy Transition Accelerator funding, a new global carbon credit trading initiative to connect investments to renewable projects in developing countries • Various developed nations and Indonesia launched the Indonesia Just Energy Transition Partnership (JETP), a $20 billion financing package to accelerate Indonesia's power sector transition from coal to renewables.
Climate aid	• Additional $172 million new pledges for the Adaptation Fund, with US leading this year's pledges with $50 million • Additional $105.6 million funding announced for Global Environment Facility (GEF) for adaptation needs in least developed countries
Africa centric initiatives	• Launch of Africa Just and Affordable Energy Transition (AJAETI) to accelerate renewables adoption of 25% by 2027 through policy and technical support • Launch of Africa Carbon Markets Initiative (ACMI) to grow African voluntary carbon markets, with a target of 300 million carbon credits annually by 2030 and 1.5 billion by 2050

Source: Rystad Energy research and analysis, COP27, UNFCCC

In 1.5 DG-compliant world, primary energy mix is transformed

The historical trends of increasing GPD and population brought an unprecedented growth in global energy demand. This demand for energy to sustain a much larger population has been supplied by the key fossil fuel sources: oil, coal and natural gas. This led to the status quo, where renewables make up one out of every ten units of energy consumed, totaling 12% of the primary energy mix in 2022.

Although this has remained stable since the late 1990s, our short-term expectations is that we are at a precipice, where a critical mass has been reached, and renewables are about to become the primary source of energy powering the world for the coming generations.

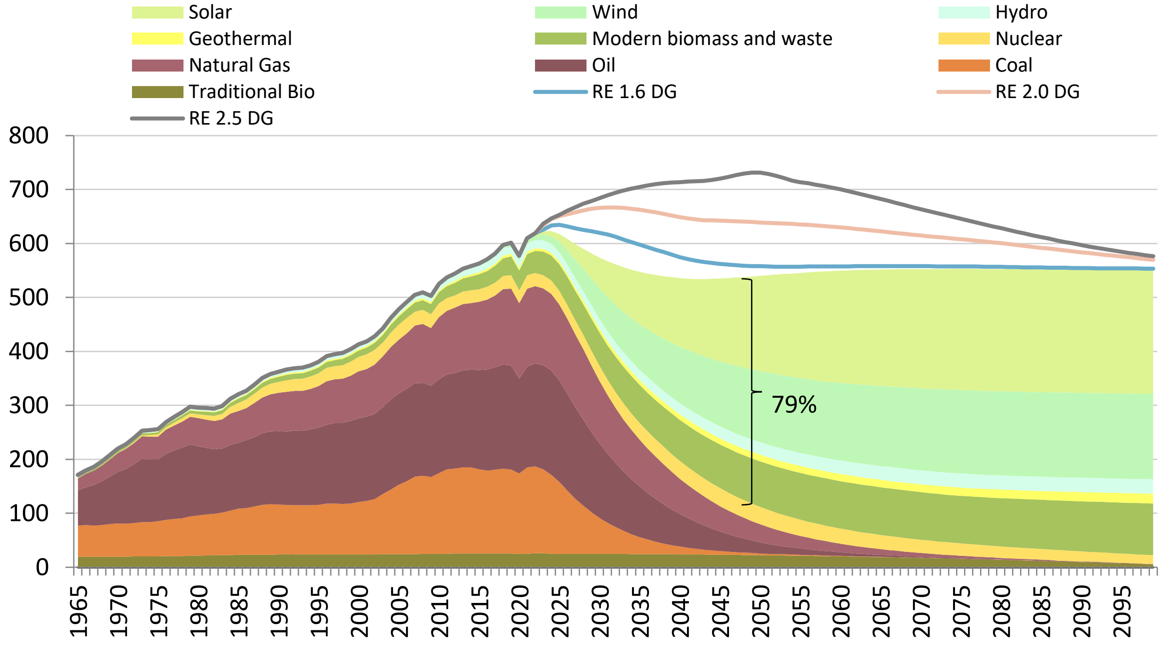
If we are to achieve net zero by 2050, and ensure the effects of climate change are avoided, we need to see a rapid rate of deployment. Specifically, renewables will need to climb at a 12% compounded annual growth rate (CAGR), increasing 1.7x from 73 EJ in 2022 to 219 EJ in 2030. However, despite increasing population and GDP, we expect a decrease of 13% in the total energy demand towards 2040. This is because electrification comes with considerable energy efficiency improvements compared to fossil fuels. Electrified systems lose much less energy to waste heat and can province significantly higher levels of efficiency.

For example, heat pumps, the main way to electrify heating, can be up to 600% efficient (state-of-the-art systems), meaning that per one unit of energy put into the system, six units of heat are returned. Hence, we see an overall lower primary energy demand required to meet the 1.5 DG scenario, despite the increase in end use.

But as renewables become increasingly available, we see no barrier to abundant adoption of clean energy across the globe, with total energy delivery increasing again towards 2050 and 2100.

Global primary energy mix 2010-2100, 1.5 DG scenario

Exajoules (EJ)

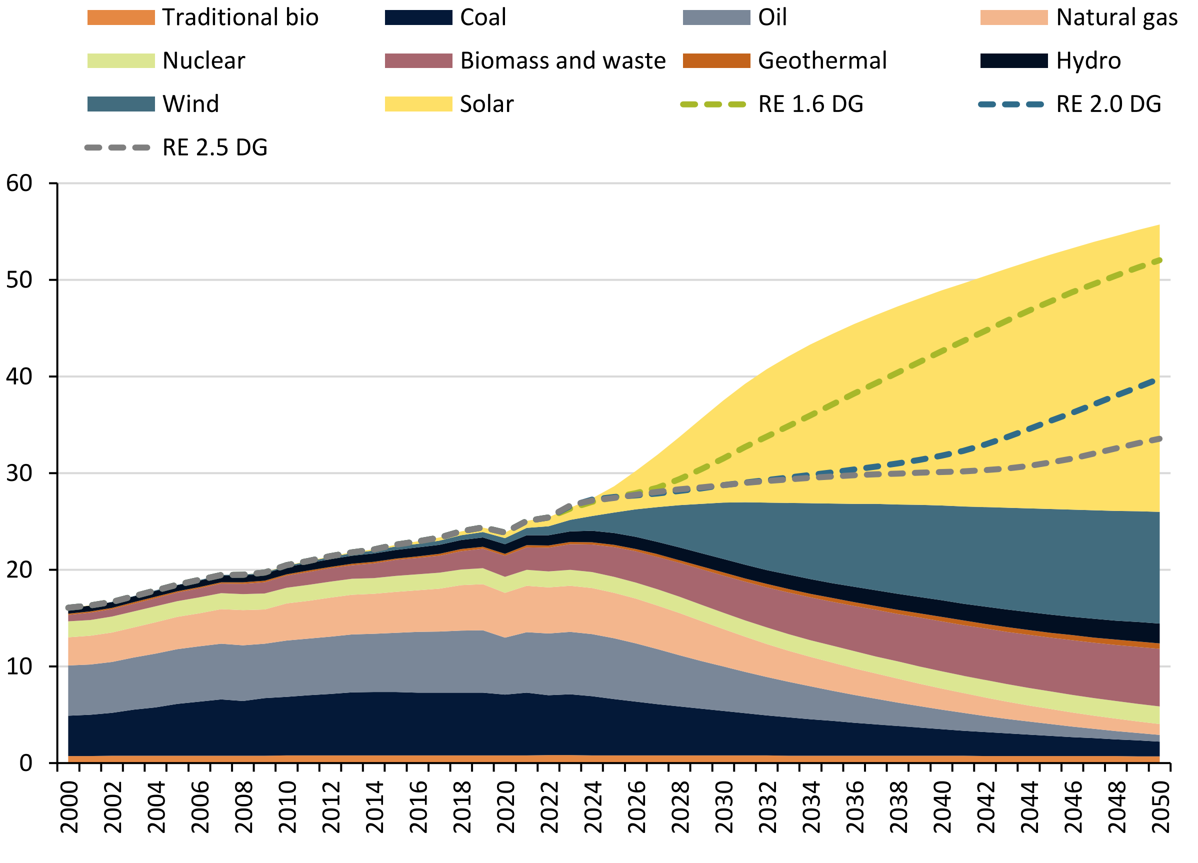


Source: Rystad Energy Scenario Cube

A 50-TW tsunami of new renewable capacity needed by 2050 for 1.5 DG

Current renewables capacity is one fifth of the global energy generation capacity. To meet out 1.5 DG scenario, we would need to see this increase around 7.5x towards 2050, making up a total of 89.5% of the global energy capacity.
While this is above and beyond any increase we have seen before – requiring a downshift of traditional fossil fuel capacity from 71.5% to 10.5% – we believe that despite the extremely tall order, it is still on the table.
However, it will require a fast–tracked, fundamental restructuring of the global energy system as well as international collaboration far beyond what we have seen to date – with developed nations responsible for catalyzing the energy transition in developing nations through equitable financing facilities.
This will be critical to decouple emissions from socio economic development and to ensure the new energy capacity brought online to support a growing population is renewable.
In addition, we will need to see a range of innovative decarbonization technologies (e.g., high efficiency heat pumps) achieve widespread adoption. As such, governments must home in their policy on expediting deployments by easing bureaucratic procedures, subsidies and upskilling the work force.
Moreover, to accommodate the vast increase in variable renewable energy sources, the global electricity grid must be upgraded, and vital storage capacity added.

Accumulated energy capacity required for 1.5 DG
Terawatts (TW)



Source: Rystad Energy ScenarioCube

Supply side ready – countries must rally demand to keep 1.5 DG alive

While the supply chain is up to task when it comes to ramping up, demand is not rising as fast, resulting in an oversupply at present. This means it is no longer down to the technology but rather to countries, which are not installing capacity quickly enough. In line with our current pathway, we see a shortfall in demand.

Despite renewables being cheaper and able to deliver more efficient forms of energy than fossil fuels, countries are struggling to let go of the latter.

For some countries, such as Germany or China, renewables deployment is relatively fast, whereas other countries are slower off the mark.

Some argue that capital is scares, and that support from private financial institutions is low.

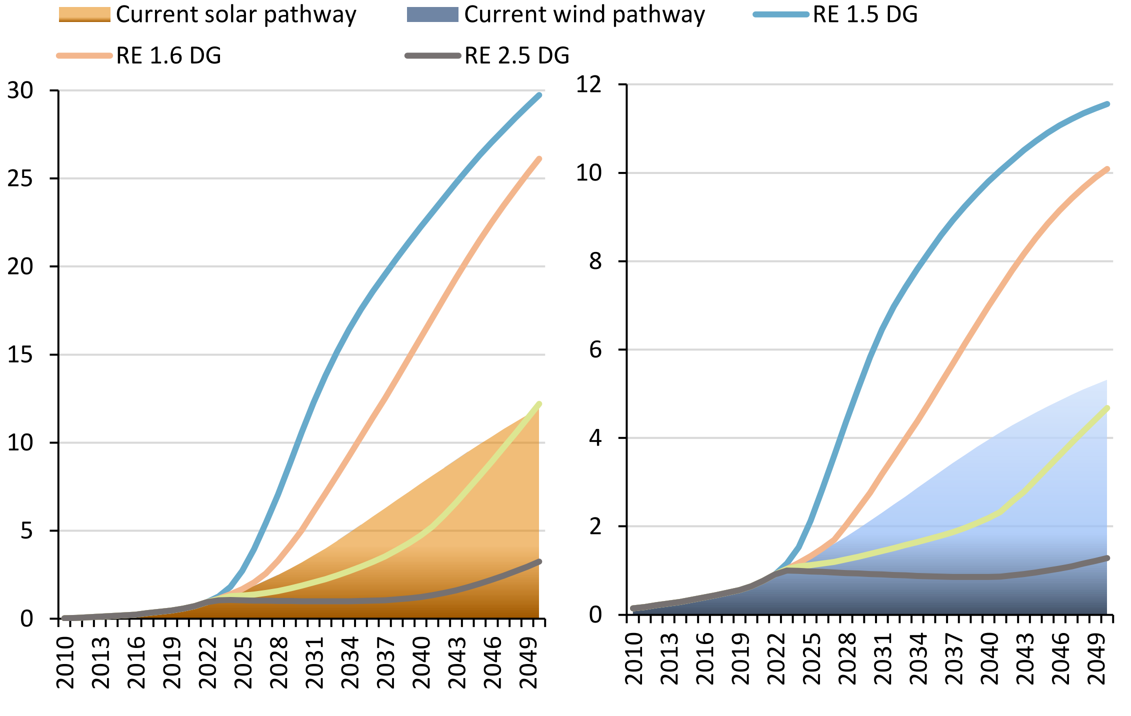
However, our primary research engaging with financial institutes and lenders show the contrary. Banks are ready, and so is the supply chain – policy is the main barrier. Other supportive arguments against the rapid deployment of renewables is that grid infrastructure is not ready and will not be able to scale fast enough.

This argument is miscommunicated – most countries are far off from having issues with grid capacity.

However, more grids will be needed, mainly on large scale grid infrastructure but exactly how much is needed in the long term, has not yet been determined.

In addition, storage and backup generation is also going to be needed. As such, the main lever that can drive this energy transition is policy, since it comes down to countries willingness to transition.

Global solar PV and wind demand, current pathway + scenarios
Terawatt (TW)



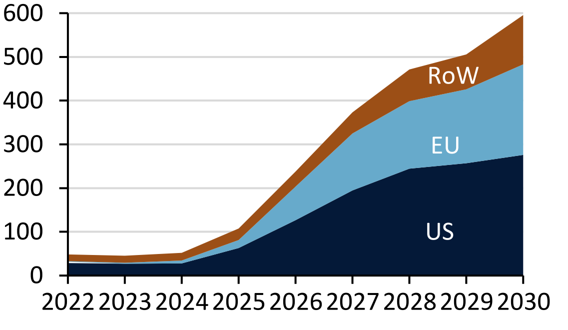
Source: Rystad Energy, Energy Scenario Cube, Renewables Cube

Around 8 Gt of CCUS needed to meet net zero by 2050

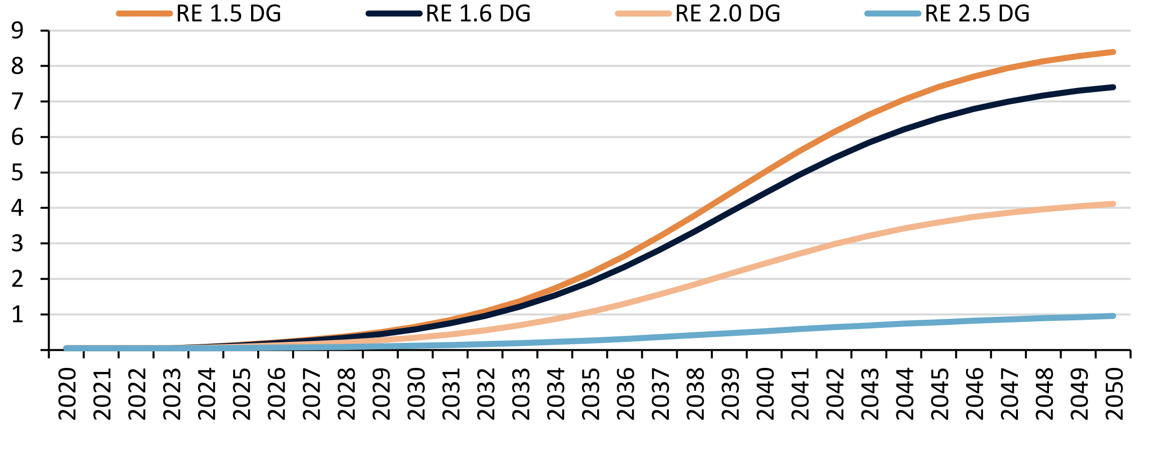
Although renewable energy takes the world part of the long way, gaps still need to be filled. In our 1.5 DG scenario, carbon capture, utilization and storage (CCUS) deployment is a must.
For example, we are seeing record investments in new technologies and processes that reduce the cost of deploying CCUS. One such example is the UK government announcing a $28 million investment to support next-generation CCUS technology. This includes direct air capture (DAC). A $350,000 grant was provided to the Dreamcatcher project, led by Storegga, which aims to deploy the UK's first large-scale DAC with accompanied storage facility.
In addition, following the Inflation Reduction Act in the US, we expect an upwelling of CCUS capacity in the country with the power sector alone able to reach about 190 million tonnes per annum by 2035 under a consistent policy scenario.
On the back of this, we expect that natural gas and selected coal power plants within the major industrial clusters will move forward with capture initiatives, like for instance CarbonCapture's Project Bison, which has a capture target of 5 million tonnes per year by 2030.
However, towards 2050, the scale off carbon capture worldwide needs to reach around 8 gigatonnes per annum for a 1.5 DG scenario.

We believe that in line with the s-curve nature of technological disruptions, this is possible. Currently, we see about 600 million tonnes per annum (tpa) by 2030 globally being captured – this is based on the current trajectory of the industry, the global project pipeline and policies. By comparison, our 1.5 DG scenario requires 578 million tpa by 2030, which based on the current pathway, is within the range of possibility. However, for the real increase to materialize between 2040 and 2050, we will need to see a lot more happen, in particular, countries must establish significantly more carbon credit markets.

Global CCUS by region (current pathway)
Million tonnes of CO_2



Global CO_2 capture requirement by scenario
Gigatonnes (Gt)



Source: Rystad Energy, Energy Scenario Cube CCUS Solutions

The role of natural gas continues, but must drop considerably

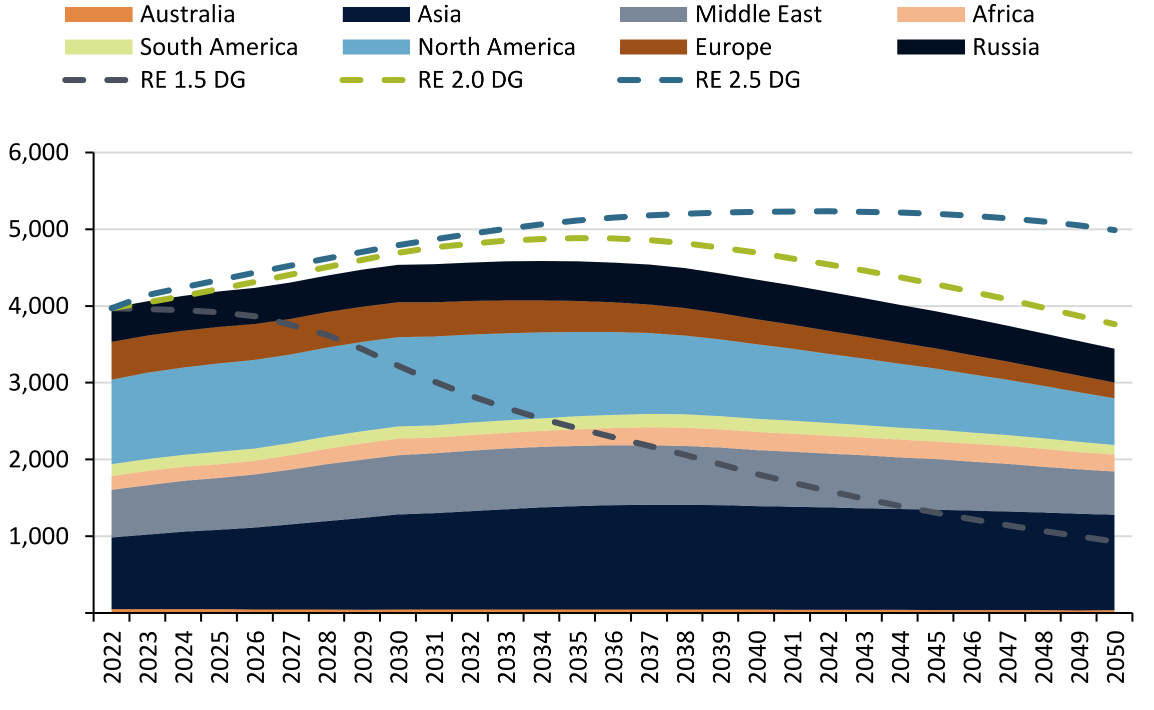
In most cases, the role of natural gas as a transition fuel towards a renewable global energy system is inevitable. Even in a world where 1.5 degrees are kept at bay through net zero by 2050, there is still need for more than 900 billion cubic meters (bcm) per annum. However, our current outlook sets out a 2050 demand of nearly four times this amount, closer to 3,500 Bcm.

To close the gap between our 1.5 DG scenario and the current pathway, Rystad Energy analysis shows that about 1,300 Bcm less gas must be used within 2030, with the gap increasing to 2,500 Bcm by 2050. These decreases must come from where the majority of gas is consumed, which is largely across North America and Asia. These regions combined account for more than 50% of global gas consumption per today. Thus, regional demand decarbonization strategies are necessary as the appetite for natural gas remains strong going forward in both regions.

The power sector is the biggest consumer of gas (34%) followed by industry (27%) and heating in buildings (21%).

This decarbonization will largely require a very high the rate of both electrification of industrial, residential and commercial heating, as well as the power sector through deployment of renewable energy. Based on what we observe in the trends of electrification, we consider it a possible future that disruptions in the heat pump and renewable energy technologies can scale to meet the requirements set out by our 1.5 DG scenario, but it will require a quantum leap in the evolution of the global energy system.

Global natural gas consumption by country, current pathway + scenarios
Billion cubic meters (Bcm)



Source: Rystad Energy Gas Market Cube, Energy Scenario Cube

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Global oil use set to peak this decade, but fastest drop in 1.5 DG scenario

Today the world runs on oil, but this will shift gradually, and then rapidly, in response to new technologies and the critical fight against climate change.

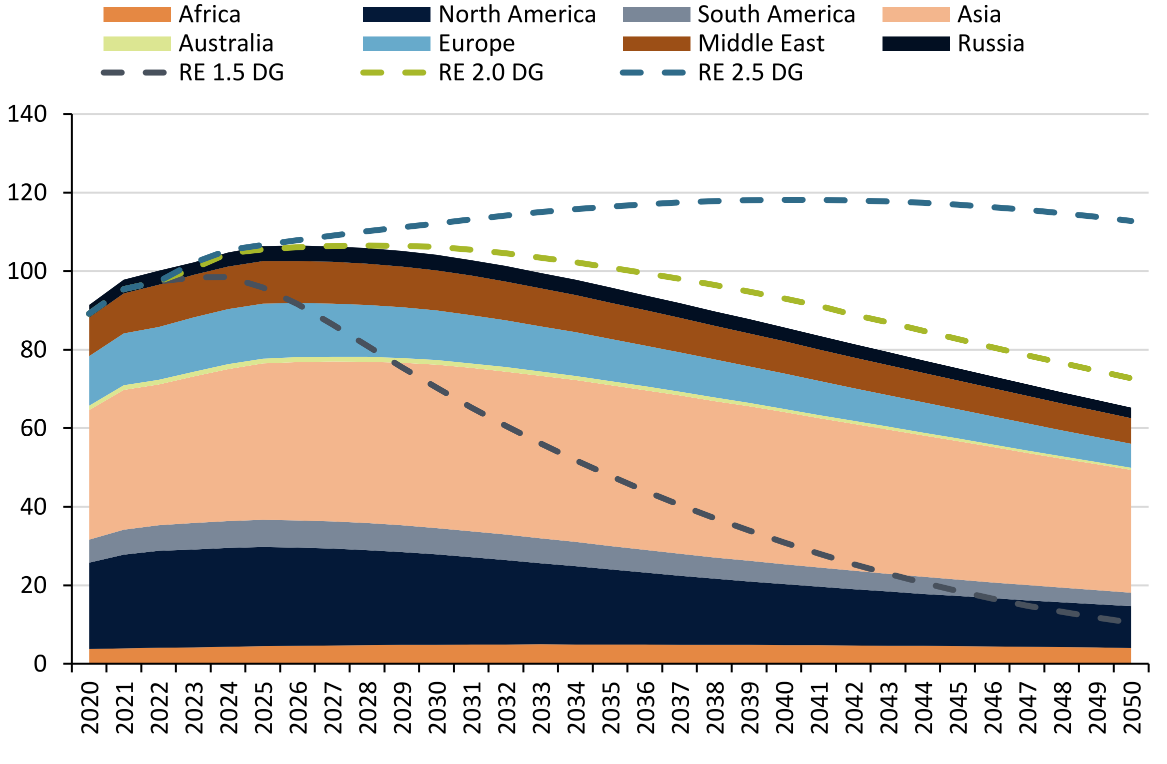
Rystad Energy's current oil demand outlook sees a peak at 107 million barrels per day (bpd) in 2026, followed by a decline towards 65 million bpd by 2050. However, 65 million bpd in 2050 leaves a 55 million bpd gap to limit global warming to 1.5 degrees by the end of the century.

Based on 2022 data, oil demand comprises 60% transport, 23% industry, 9% energy generation, 6% buildings and 3% other.

In the 2020s, the substitution of oil as a fuel for transportation kicks in with increasingly electric passenger vehicle and bus fleets, and then further accelerates as these industries more deeply penetrate markets globally, both in developed and developing economies.

To see oil demand meet requirements for 1.5 DG, a tectonic shift is required, foremost in the transport and industry sectors.

Global oil consumption by region, current pathway + scenarios
Million barrels per day



Source: Rystad Energy Oil Market Cube, Energy Scenario Cube

Paving the way for a decarbonized transport sector

EV adoption continues to increase despite global events like Covid-19 lockdowns, high inflation levels, and heatwaves. China, with the largest vehicles market in the world, has been leading the EV uptake in recent years. The Chinese market accounts for roughly 60% of global EV sales and currently has an EV adoption of around 30%. We estimate that by 2030 China will reach an EV adoption of 78% in our high case.

Other large markets such as Germany and the UK are also ramping up quickly. Norway, albeit a small market, has already reached around 90% EV adoption. However, to reach 1.6 DG, demand has to increase faster. Major markets such as the US and Japan must stimulate EV uptake as their adoption rate is only 7% and 4%, respectively. These countries have not announced any internal combustion engine (ICE) phase-out targets which is necessary to push governments to stimulate EV sales adequately. Furthermore, countries can stimulate demand via tax credits or other perks.

More countries need to announce ICE phase-out targets for (heavy-duty) trucks as well. This segment is more difficult to decarbonize due to the large battery packs required to reach similar load as well as range abilities as its ICE counterparts. However, many trucking companies such as Mercedes Trucks or Scania are already producing battery-electric heavy-duty trucks and other models will follow. A regulatory framework demanding a phase out would thus accelerate the already developing market.

The electrification of buses has sped up rapidly over the past years. The largest market China already has over 90% electric bus adoption. Many other countries are also decarbonizing bus fleets rapidly. However, buses only make up a fraction of emissions compared to trucks and passenger vehicles.

To reach the 1.5 DG scenario much more investments on the demand side – and especially on the supply side – is necessary. Even for our high case, more than 1.2 million tonnes of lithium and more than 3 TWh of battery cell output are lacking until 2030.

To bring down emissions further, an accelerated ramping of renewables is also needed which would have a strong impact on life cycle emissions due to the decrease in supply chain emissions as well as vehicle driving emissions.

Source: Rystad Energy research and analysis

Battery demand to hit 6.7 TWh in our high case – driven by transport

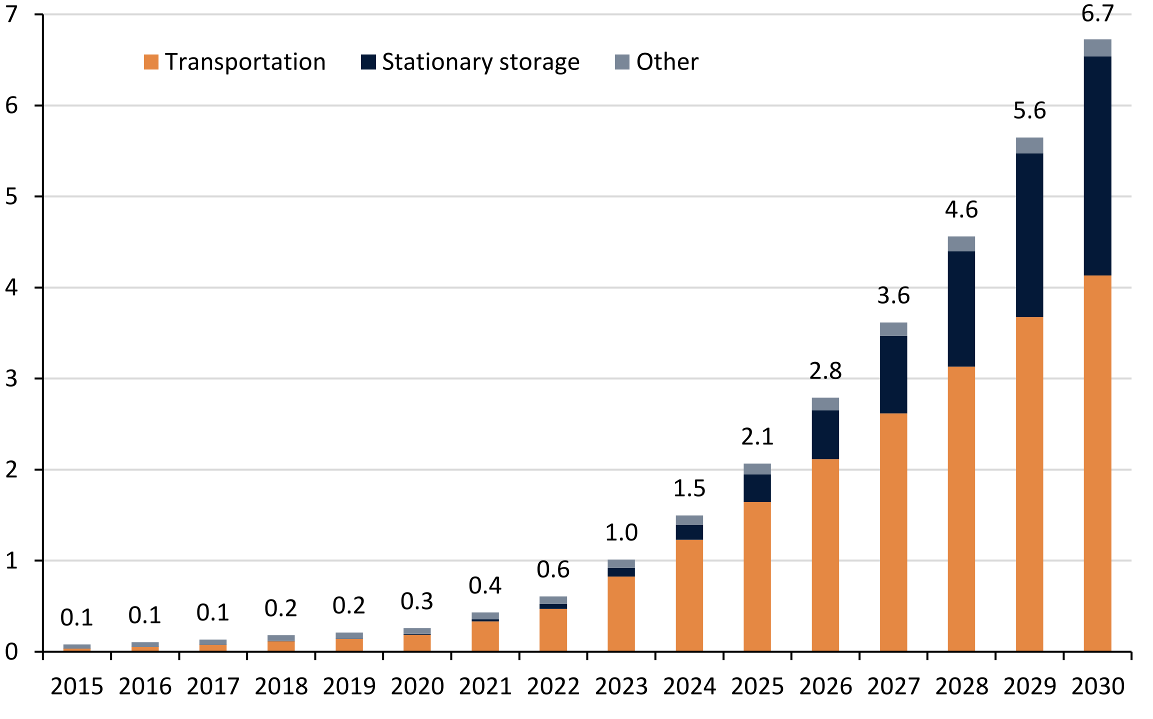
We expect that passenger vehicles will emerge as the largest battery demand segment for the coming years. More than 60% of cells will support the automotive sector. Battery pack sizes may differ but often range between 45-70 GWh per battery electric vehicle.

Furthermore, the stationary storage market will also demand batteries. As more intermittent renewable energy sources such as solar and wind are added to the power mix, the need to balance or shift the power generation to times when the power is needed most will become increasingly important and financially beneficial. Frequency control is especially profitable at present. However, this is expected to change to energy arbitrage in the coming years.

Other battery demanding sectors such as consumer electronics, power tools, two-and three wheelers, or portable energy storage only account for 25% in 2022 and will decrease in market share further until 2030 with the exponential developments in the stationary storage and automotive sector.

Battery demand high case

Terawatts (TW)



Source: Rystad Energy BatteryCube

Shipping transition now depends on fuel availability onshore

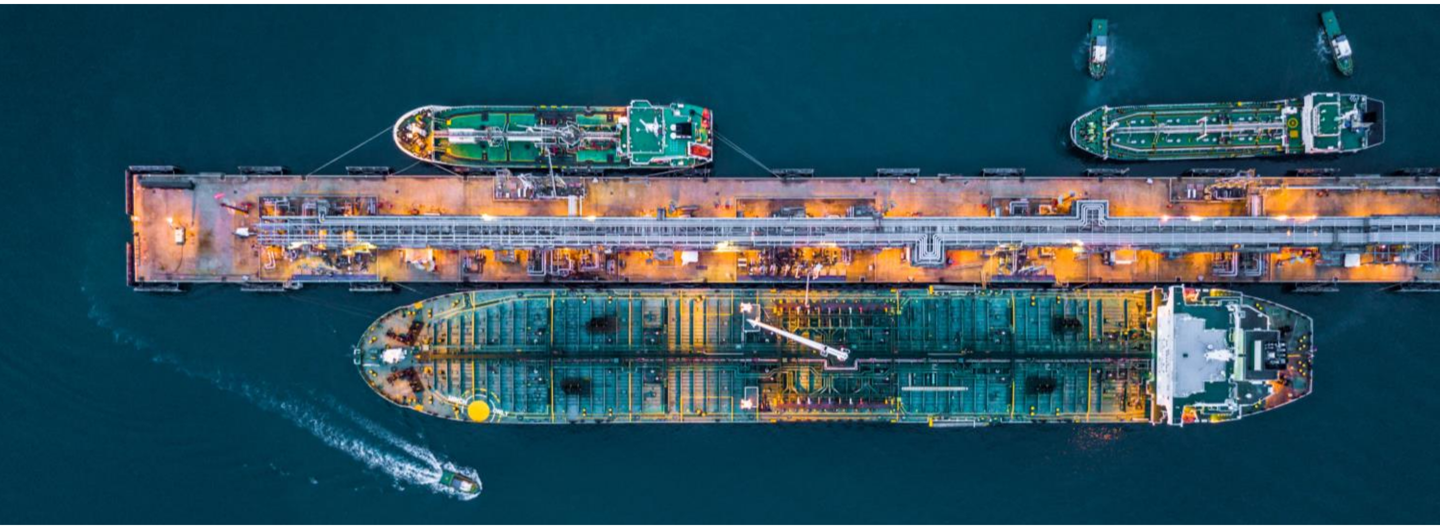
Shipping is responsible for about 3% of global emissions, which is roughly equivalent to the total emissions from Germany, the largest economy in Europe.

As with renewable energy, an opportunity for a faster transition towards zero and net-zero fuels is emerging on the back of the energy crisis for shipping. With LNG now seeing record high price outlooks from the energy crisis, sustainable alternatives appear a lot more attractive to shipping companies.

However, main challenge for shipping decarbonization now lies onshore – zero carbon fuel production and new bunkering infrastructure require massive investments, and a united policy approach is crucial to support the developments needed to meet climate targets.

The global retail sector is helping pull demand by adopting aggressive decarbonization targets - being shipping's largest customer, their demand for a zero-carbon supply chain is creating a large incentive for sustainable fuels. Initiatives such as the Clydebank declaration, alongside the Aspen Institutes Shipping Decarbonization Initiative, are pushing for zero carbon fuels (not net zero or carbon neutral).Most shipping companies are now including sustainable fuels as part of their strategy – we have seen many new commitments over the past year, with a few players still focusing solely on fossils – even fewer are excluding fossil fuels entirely.

As more vessels become compatible with new fuel alternatives, and record numbers of companies are ramping up commitments to zero/net-zero carbon fuels during the past 12 months, we need to see more investments in fuel production and bunkering infrastructure, and a united global regulatory approach that can leapfrog the transition from fossil fuels to sustainable alternatives, including fast tracking retrofits of fossil fuel vessels to run on sustainable fuels.

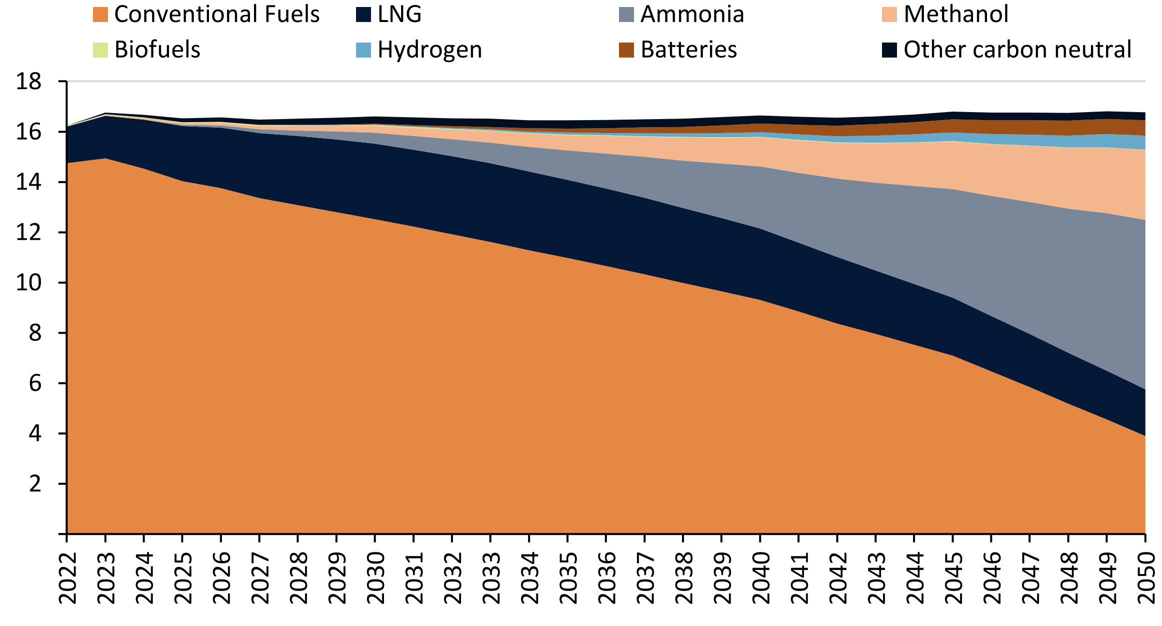


Source: Rystad Energy research and analysis

Multi-fueled approach crucial for shipping transition

When it comes to which pathway to net zero shipping will take, the fuel transition is often referred to as a race.
However, we believe collaboration is key, and expect that there will be many fuels playing a part in the future landscape.
Based on our findings, we expect zero carbon fuels to make up the largest share in the future.
This is supported by e.g., the Aspen Institutes Shipping Decarbonization Initiative, which sets an aim for signatories to have a zero emission (not net-zero) supply chain by 2040.
This significant initiative is signed by Amazon, Ikea, Inditex, and Unilever to name a few of the major global brands party to the initiative. Retail giants like these form the majority of global shipping demand.
As such, we believe that ammonia, which is the sole viable zero carbon candidate for deep sea shipping, is in for a demand surge from shipping. This is further substantiated by cost analysis for different fuels to assess financial viability – ammonia has the best outlook and can gain market share dominance. Also, fleet structuring strategies are aligning with ammonia seeing a drastic ramp-up in 2022, with now over 130 ammonia ready vessels in the order books, i.e., bottom up, we see a massive increase of interest in ammonia vessels.
As with shipyards, we also see large engine manufacturers are prioritizing ammonia ahead of other solutions, with several players looking start scaling production and retrofits in the short term.
Accordingly, we believe that while there certainly is room for other fuels like methanol, batteries and hydrogen – ammonia is set to make the largest contribution.
This leaves the major levers for a net-zero around 2050 in the hands of the regulators at the International Maritime Organization (IMO) and monetary policy makers.
To reach critical emission targets, shipping will require massive investments to scale zero emission infrastructure. This will need to happen on a scale that has never been seen before, to be able to accommodate the replacement of over 70% of the present-day conventional fuel supply.

Energy demand outlook from maritime fuels – 1.6 DG scenario
Exajoules (EJ)



Source: Rystad Energy, Energy Scenario Cube

Aviation abatement requires massive amounts of hydrogen to meet 1.6 DG

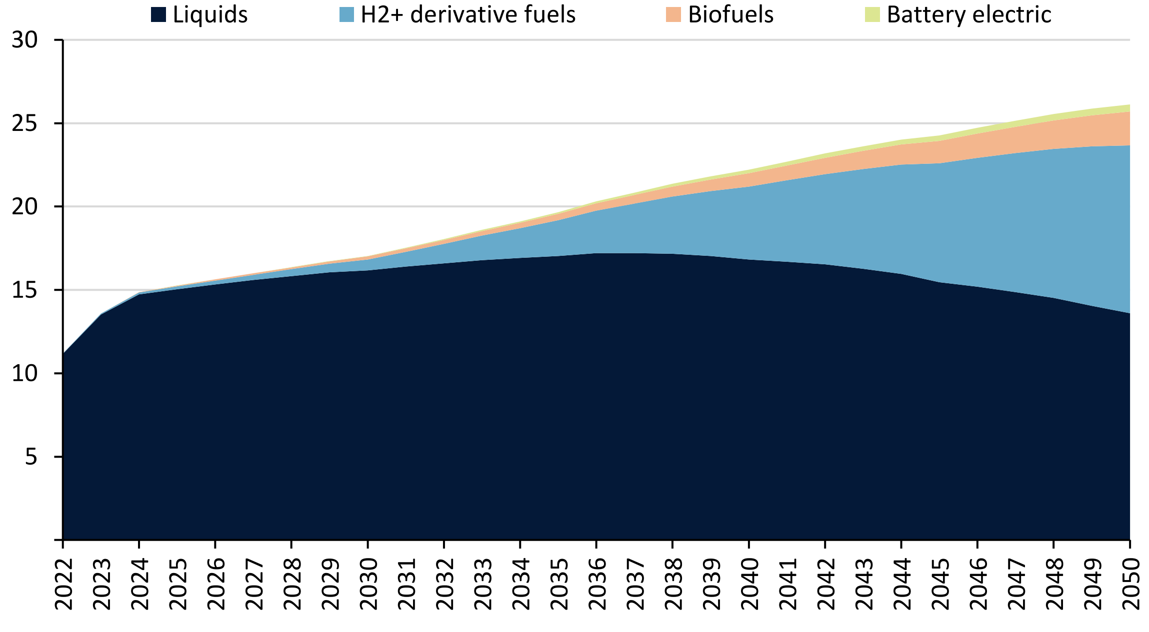
As with other hard-to-abate sectors such as long-range trucking, current progression observed in the aviation sector indicates that hydrogen alongside hydrogen-based derivates are the most promising alternative to decarbonize the sector. Although we believe it is possible for the sector to adapt to a 1.6 DG carbon budget, it will need to see all levers pulled if the sector is to make it in time. In particular, the supply of hydrogen-based fuel and derivatives such as e-kerosene must scale rapidly from zero today, to around 0.65 EJ in 2030, followed by a 14X surge in demand from 2030 towards 2050, resulting in a 10 EJ demand per annum. This will require unparallel mobilization of resources to build up supply chains that can accommodate the rise in demand.

However, it alone is not sufficient to reach decarbonization targets. Further emission reduction through efficiency improvements will be imperative. Historically, improvements have been around 1% per annum, which will need to increase twofold to flatten the demand to adequate levels. More Electric Aircrafts (MEA), such as the Airbus 380 and the Boing 787, are examples of these improvements, enabling 10% less combusted fuel.

Other low hanging solutions such as biofuels, can be used to effectively as drop-in fuels, which circumvent adaptations in aircraft engines and fuel handling at airports. Currently, bio-jet is mostly used compared to aviation e-fuels, which remain in their earlier development stages.

Regarding batteries, 75% of aviation CO_2 emissions are released during medium and long-haul flights carrying between 250 and 600 passengers. This complicates the use of batteries to effectively decarbonize the sector due to restrictive payload and power availability for longer distances. Batteries have a much lower energy density than other alternatives, which means that they cannot carry as much energy. However, we expect that batteries are likely to be implemented in short haul flights paths with a max range of 2,000 km and 120 passengers.

Global energy demand from aviation – 1.6 DG scenario
Exajoules (EJ)



Source: Rystad Energy, Energy Scenario Cube

RystadEnergy

Major push: Decarbonizing iron and steel

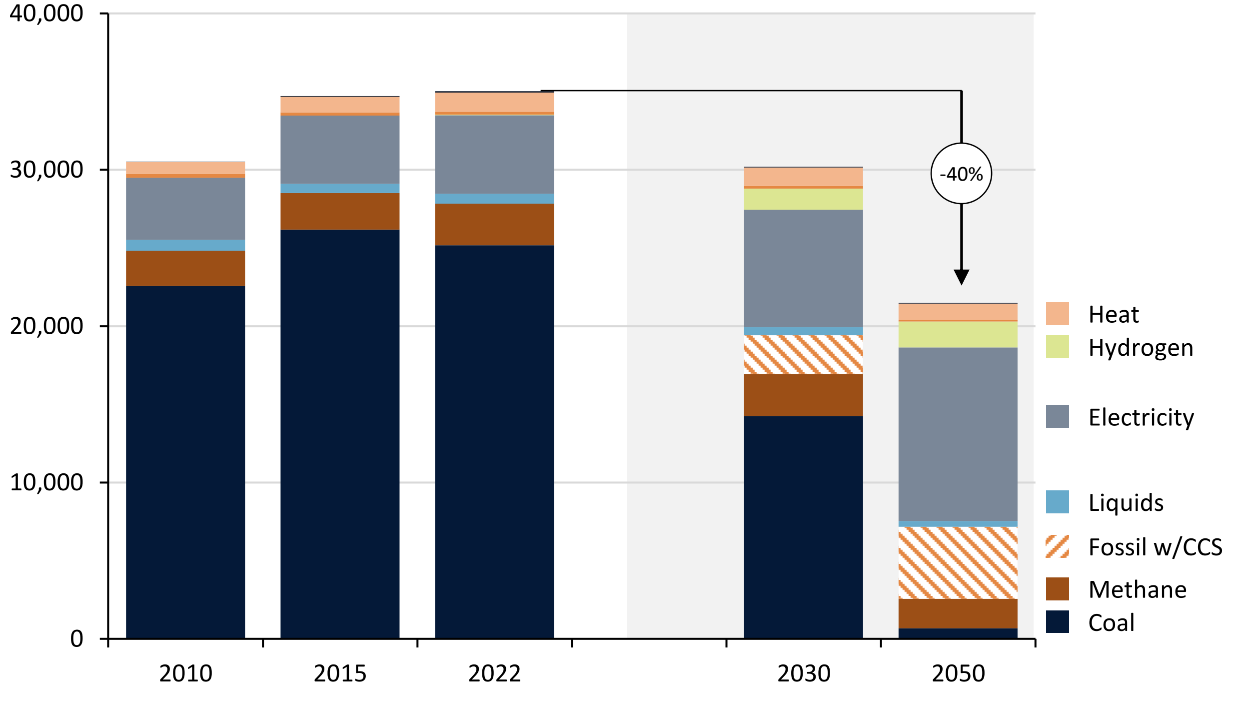
The global iron and steel sector currently consumes 35 exajoules (EJ) or 9,700 terawatt hours (TWh) every year. Coal contributes to 25 EJ of energy consumption as blast furnaces currently make up 72% of steel production.

Transitioning to higher use of scrap steel and green steel production methods will lower energy needs in the iron and steel industry by 40% in 2050 in our 1.5 DG scenario. Electricity will cover half of total energy consumption of 21.5 EJ as electric arc furnace becomes the dominant form of steel production.Direct emissions from the iron and steel industry currently sums up to 2.7 Gt CO_2 or 1.5 tonnes of CO_2 per tonne steel produced. Indirect emissions from electricity consumption adds an additional 0.7 Gt CO_2 bringing the total CO_2 footprint to 3.4 Gt CO_2. In the 1.5 DG scenario the emissions in intensity will decrease by 50% by 2030 and be closer to 100 kg per tonne by mid century.

As more steel is being produced by DRI-EAF the amount of natural gas increases by 50% in 2030 compared to the levels of today. By 2050 80% of emissions from fossil fuels combustion will have to be captured to achieve the 1.5 degrees scenario.

Retrofitting existing blast furnaces and direct reduced iron plants with CCUS capabilities is energy intensive and will increase electricity demand by 1,400 petajoules (PJ) by 2050. Hydrogen will play an important role to bring the iron and steel sector aligned with the goals of the Paris Agreement. Hydrogen consumption will be closer to 1,700 PJ in 2050, which equates to 14 million tonnes of hydrogen. In the second half of the century novel production methods like electrowinning and others could be more cost efficient than using hydrogen, since electricity is used directly in the steel making process and electrons are used as reduction agents.

Global iron and steel energy consumption by energy carrier (1.5 DG)
Petajoules (PJ)



Source: Rystad Energy Scenario Cube

Rapid deployment of CCUS required to decarbonize the cement industry

Direct CO_2 emissions from the cement industry is currently 2.2 gigatonnes (Gt CO_2). The largest part of this, close to 1.5 Gt CO_2 comes from the calcination process and 0.7 Gt CO_2 is a result of fuel combustion. The chemical process know as calcination occurs when limestone is heated and split into calcium oxide and CO_2.

CCUS will be needed to reduce CO_2 emissions from the cement production process. In our 1.5 DG scenario we estimate that 1.1 Gt of CO_2 will be captured using CCUS by 2050.

Production of clinker is the most energy intensive part of cement production, hence reducing the amount of clinker used in cement will bring down both energy consumption and emissions. However, the clinker is the binder in cement, and it must be kept at a level align with standards and quality requirements. Currently, the clinker ratios in the largest producers are close to 65%, and up to 80% in the US where standards currently are limiting less use of clinker.

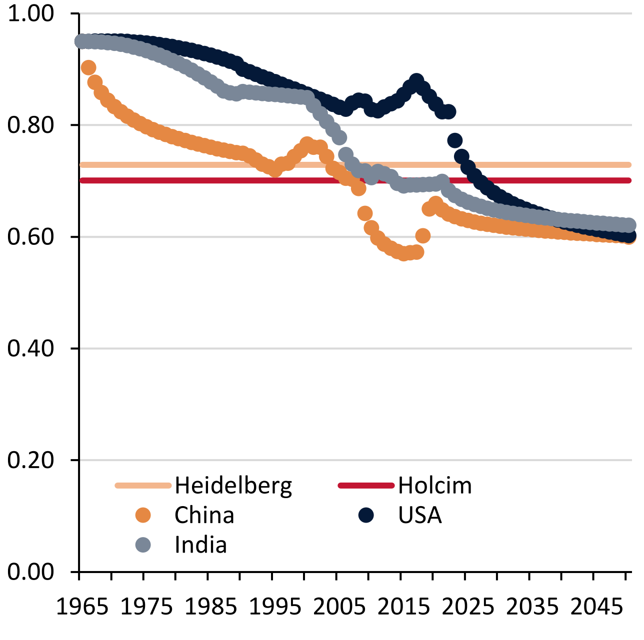
Large cement producers like Heidelberg and Holcim are targeting clinker ratios near 0.7 by 2030, and in the 1.5 DG scenario a further reduction towards 0.60-0.65 would be needed to achieve sufficient emissions reductions.

Reduction of clinker ratio could be achieved by blending blast furnace slag from iron production or by using fly ash from coal-fired power plants. As availability of these sources will decline in our 1.5 DG scenario due to deployment of cleaner technologies, it is possible to us volcanic rocks and calcined clay or other alternatives.

Historically we have seen improvements in energy efficiency through technology shifts in the cement industry. One example is the transition from wet to dry kilns which could bring a decrease in energy intensity of about 40%. Today it takes on average 2.8 gigajoules to produce one tonne of cement. In our 1.5 DG scenario the annual improvements in energy intensity is close to 0.5% as more efficient technologies are deployed.

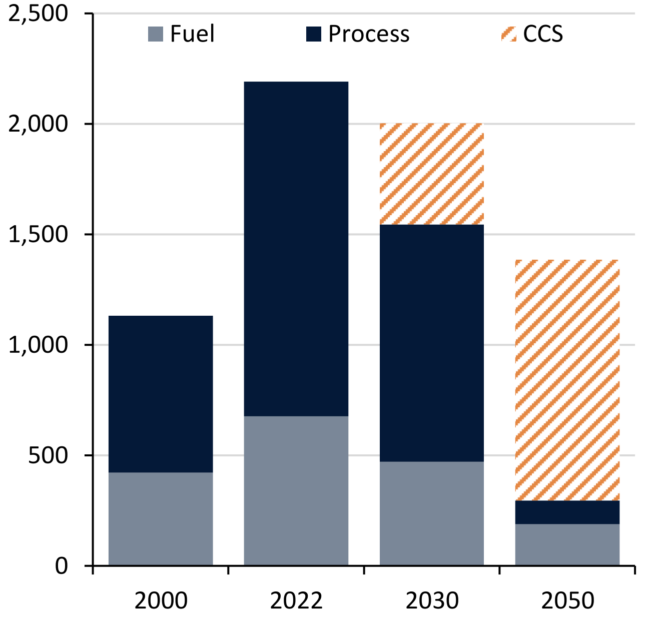
Clinker ratio

Clinker per tonne of cement



Direct CO_2 emissions and CCUS by CO_2 source, 1.5 DG

Million tonnes CO_2 (Mt CO_2)



Source: Rystad Energy Scenario Cube

1.5 DG still allows for 50% growth in global chemical market until 2050

Global production of primary chemicals has more than doubled since the start of the 21st century, significantly outperforming the underlying expansion of global economy and population growth rate. Production of core high-value chemicals (HVCs), ethylene and propylene increased from about 140 million tonnes in 2000 to ~329 Mt in 2022. On per capita basis global HVC production increased from 23 kg per person in 2000 to about 41.4 kg per person in 2022.

In our recent hard-to-abate report, we highlighted that demand-side measures are ultimately expected to bend global plastics consumption curve, yet we argue that 1.5 DG scenario still allows for a 35% increase in global use of ethylene and propylene both due to underlying expansion in end-product plastics demand and structural displacement of retiring naphtha crackers.

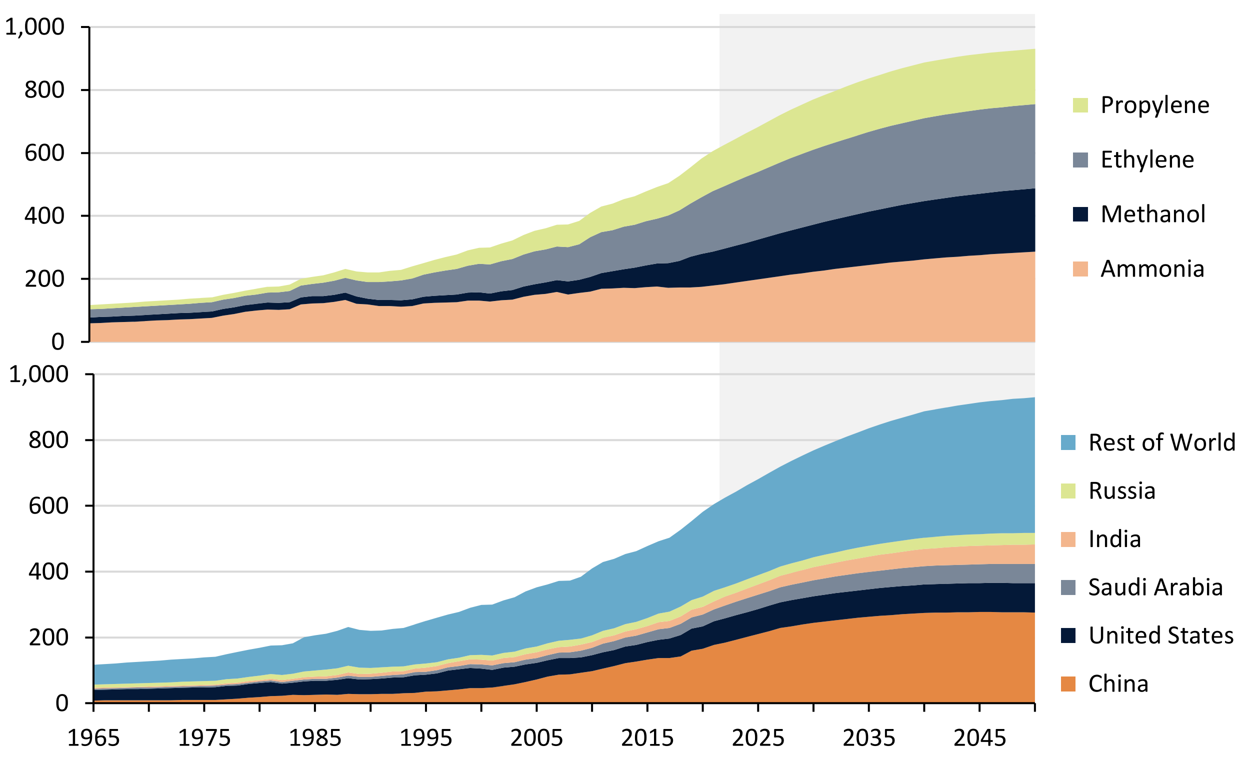
Among energy intensive primary chemical products, ammonia and methanol generally stand out with both significant production volume and high average process energy intensity with China dragging average ammonia intensity up due to high share of production coming from coal gasification.

We note that global ammonia production has generally followed global population growth since 1980s systematically staying in a narrow 20-25 kg per capita range.

This development is expected to persist with global ammonia demand for traditional application growing from about 180 million tpa in 2022 to more than 250 million tpa in 2050.

Meanwhile, methanol intensity in both global GDP and population increased dramatically in the last 30 years as methanol became preferred feedstock in the production process of secondary (and in some cases other primary) chemicals. Global consumption of methanol for traditional applications is expected to growth from about 110 million tpa in 2022 to 200 million tpa in 2050.

Global production for selected chemicals* (1.5 DG)
Million tonnes (Mt)



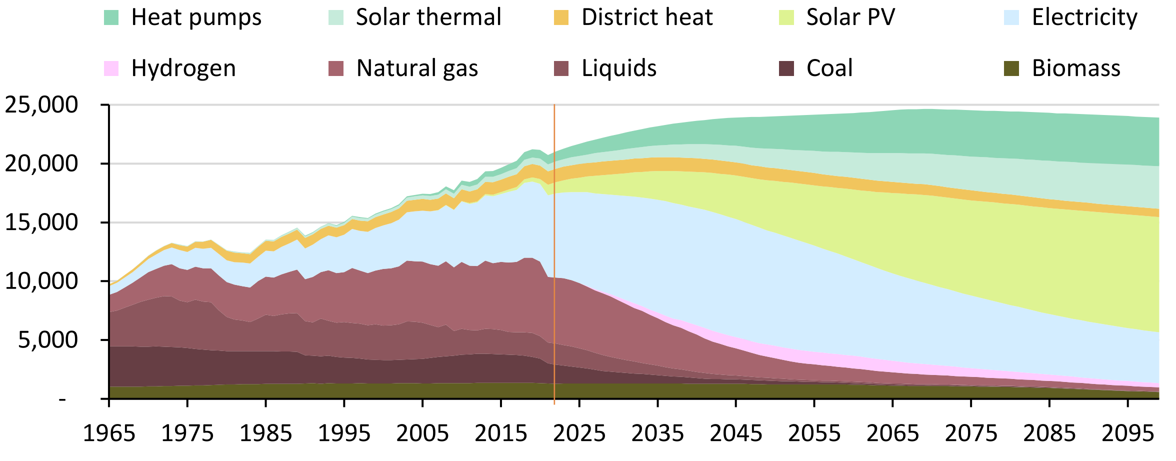
*Only traditional use cases of ammonia and methanol
Source: Rystad Energy Scenario Cube

Residential energy demand to grow 19% until 2070 – then decline

A major benefit of economic development is the boost in people's access to energy, including residential use, which in developing economies means better living standards and lower mortality.

In line with Rystad Energy's 1.6 DG scenario, residential energy demand grows to 24,000 TWh per year by mid-century – a 15% increase from 2021 levels – before starting to decline post-2070.

Global residential energy demand by energy carrier, 1.6 DG scenario
Terawatt-hours (TWh)



Residential use of fossil fuels faces a steep fall while sectors' demand is being met by electrons rather than molecules, strongly driven by benefits from residential building certification.

Natural gas is already at its lowest point of 1,700 TWh and is expected to be less than half by 2070 to 800 TWh. As such, coal, liquids and gas decline to account for a total of 4% of residential energy demand.

An additional effect of the electrification ramp up is that even though more people gain access to residential energy services, efficiency gains balance out the demand growth – alongside the peak in global population growth in most regions.

Source: Rystad Energy research and analysis, Scenario Cube

Disclaimer

Would you like to learn more?

This whitepaper is a condensed version of our latest Energy Transition Report. As part of our Energy Transition Analytics product, we publish comprehensive Energy Transition trend reports every month covering the latest updates and market trends.
If you want to know more about our Energy Transition solution, request a short demo session using the QR code below or contact Craig Jamieson directly.

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Navigating the future of energy

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