Infrastructure Research

October, 2023

Transforming European Energy: Alternative Fuels

October, 2023

IN A NUTSHELL

— The Energy Transition would continue to offer the greatest scope for infrastructure investors to deploy capital over the coming years as Europe looks to improve the security, affordability and sustainability of its energy supply.

— In light of strong policy making over 2022 in particular, there are a growing number of energy sectors which have become more attractive with the potential to provide investors with infrastructure-style returns. The trajectory of solar and wind sectors provides a potential pathway for newer, smaller energy sources to scale, de-risk and form part of infrastructure portfolios in the same way.

— Hydrogen and biomethane represent two of the crucial alternative fuel types which present long-term opportunities in Europe. While hydrogen has some way to go in terms of becoming a market that infrastructure investors can feel comfortable operating in, we believe that biomethane presents an immediately attractive entry point into alternative, low-carbon energy sources.

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1 / Energy Security, Resilience & Decarbonisation

1.1 Energy Transition To Remain Key For Infrastructure Investors

DWS's major report on European Transformation concluded that a deep transformation is needed to maintain Europe's sustainable prosperity. [1] The need for energy security and decarbonisation is at the centre of the need to transform the European economy into a sustainable, digitised and – crucially – resilient, market.

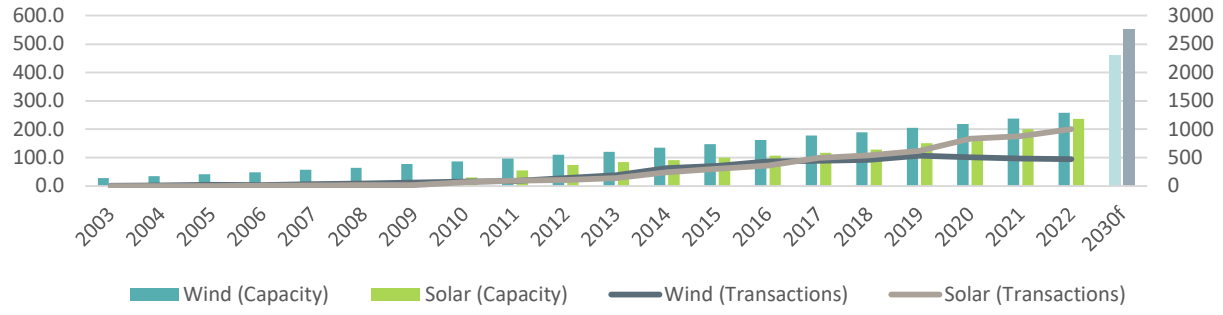
Europe has led the way in the roll out of key renewables technologies and there is now significant scope for the region to again take global leadership across other alternative energy sources and fuels. This presents significant opportunities for investors in most major asset classes and our report focuses on the opportunity for infrastructure investors.

The Energy Transition is the most active area of the global infrastructure market. Private market infrastructure transactions across the Power, Renewables and Energy sectors totalled over EUR600bn in 2022 and represented 67% of total transaction volume.[2] Despite a tremendous amount of activity already, the global transition to alternative energy sources we believe will remain the main focus for infrastructure investors over the long-term. This market already boasts an actively growing pipeline of opportunities as well as providing one of the most direct routes for investors to facilitate decarbonisation through the development and operation of assets, while meeting their own low-carbon targets.

There has been a continued improvement in the policy environment surrounding the energy transition, particularly in 2022 with the introduction of REPowerEU, part of Europe's response to the energy crisis stemming from the loss of Russian gas supplies. Previously peripheral energy sectors now have a pathway to enjoy a similar scaling up of investment as seen in solar and wind sectors.[3] To date, most private capital deployed has flown into wind and solar technologies, which have consequently enjoyed dramatic annual growth rates in markets around the world, with Europe leading the way with regard to subsidising and encouraging the scaling and de-risking of those sectors.

Rapid Capacity Growth Creates Investment Opportunities

Europe - Installed Capacity, GW (LHS) and Number of Infrastructure Transactions (RHS), by Sector



Source: BMI, Infralogic, DWS. f=BMI forecast .

As the solar and wind markets have scaled and become more competitive, the returns on offer have concurrently moderated in line with a reduction in the risk-profile of those technologies and business models. Prices are now competitive for operating solar and wind assets given they are now considered Core assets by institutional investors.

[1] DWS, December 2022 https://www.dws.com/insights/global-research-institute/a-framework-for-european-transformation/
[2] Infralogic, September 2023
[3] European Commission, https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

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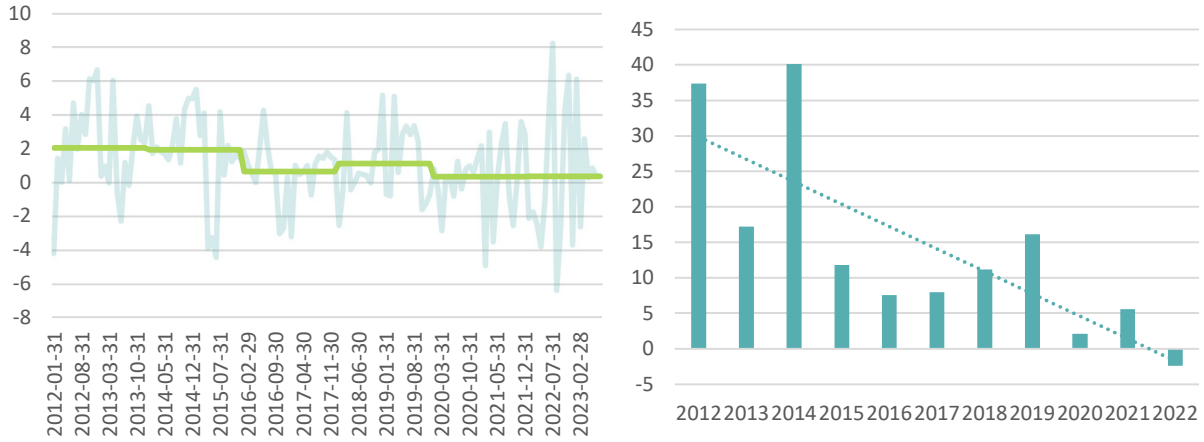
The EDHEC InfraGreen index tracks the performance of private wind and solar assets and has seen a gradual reduction in year-on-year returns over the last decade, in line with the transition of those sectors from Value-add businesses without mature regulatory landscapes and undergoing rapid technological change, into some of the most Core infrastructure assets available. There are few Core infrastructure investors which do not now have renewables as part of their portfolio and – while there has been more power price volatility to their performance in recent years as feed-in tariffs have expired – the market has become more stable, in part because of increased contracting under PPA (as discussed below).

Higher Returns Potential In Early Stages

InfraGreen Equity Index Year-on-Year Total Returns, Monthly (Two-Year Average) (LHS) & Annual (RHS), %



Source: EDHEC Scientific Infra, September 2023. Note: The infraGreen equity index represents the performance of unlisted infrastructure companies in the wind and solar sectors.

Having grown from a marginal contributor to supplying over 22% of Europe's electricity in 2022, there have been a variety of mechanisms developed to encourage investment and ramp-up installation rates and capacity in renewables.[4] From attractive Feed-in-Tariffs and revenue top-ups to preferential access to grid networks, subsidised capex and the growth of the power purchase agreement (PPA) market, returns for investors have stabilised and developed a degree of certainty which allowed for capital to flow into the sectors. The current policy environment in Europe is creating the potential to replicate this trajectory for other technologies. We believe this creates significant opportunities for infrastructure investors looking to target a higher return profile, with a view to be part of a sector's scaling and de-risking.

[4] Ember, European Electricity Review 2023, January 2023

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1.2 Which Sectors Are Next In Line?

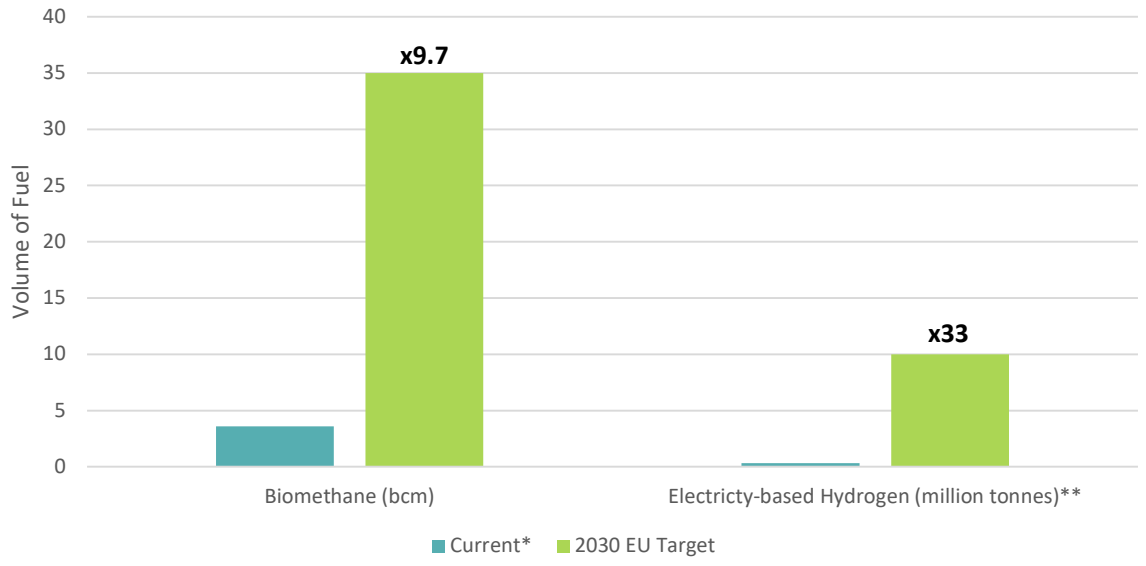
The challenge for infrastructure investors in the future will be the identification of sectors which will track a similar trajectory i.e., attractive risk-adjusted returns as a business is grown, de-risked and transitioned into a Core-profile asset. This is particularly challenging given the nature of the energy transition; as with any transition, there are likely to be winners and losers. There are significant investment requirements for the success of the energy transition across many technologies and, as such, the problem for infrastructure investors becomes selecting sectors that will remain relevant and attractive over the long term. Even in areas such as energy storage, which seems poised to play a clear role in smoothing a more volatile energy production profile, a significant time and resource commitment is required to establish business models that can work for infrastructure investors.

For investors looking to deploy capital now while at the same time navigating the risks of the transition within energy over the coming decades, it will be crucial to identify assets which form part of an existing, robust, and long-term value chain. Two sectors within the energy transition exemplify this challenge for infrastructure investors: hydrogen and biomethane. Both alternative fuel types have a significant role to play in Europe's future decarbonised energy mix and have benefitted from REPowerEU and Fit for 55 policy objectives. Both sectors are expected to have a growing pipeline of capital deployment opportunities for infrastructure investors.

However, hydrogen infrastructure opportunities expose investors to a higher degree of uncertainty and risk given the need for a larger market to develop, whereas biomethane is positioned for more immediate contributions towards meeting low-carbon energy security needs, given multiple uses for biomethane in generation and transportation markets under established and improving contractual frameworks, and the fact that anaerobic digestion technology is already well advanced with a long operating history, carries low perceived technology risk, and available at relatively low cost (much like solar and wind today).

Significant Targets Underpin Infrastructure Investor Interest

Europe – Current Production Volumes and EU 2030 Production Targets



Source: Sia Partners Benchmark Europe Biomethane, European Commission. *Biomethane production as of end-2021, Hydrogen production as of March 2023. **10mn tonnes of renewable energy-based hydrogen is the EU target.

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2 / Hydrogen

2.1 Hydrogen's Hollow Hype, For Now

Green hydrogen and green ammonia are expected to form a core part of the future global energy mix. These sectors are likely to be viewed in the same way LNG is today, whereby there is a global market for the commodity by the 2040s, with demand potentially reaching 460 million tonnes per annum (mtpa) by 2050 in a Net Zero scenario.[5] Both green hydrogen and green ammonia remain nascent with a strong growth trajectory, meaning selecting the correct market entry point will be critical for infrastructure investors given the uncertain timescales for wide adoption across economies.

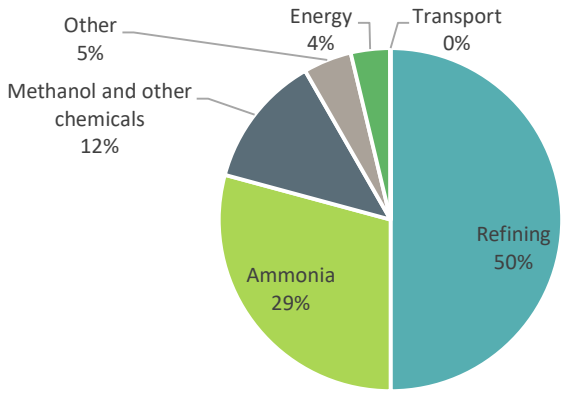
These sectors present several considerations that are likely to give infrastructure investors pause, given how they might impede the generation of infrastructure returns:

Robust Demand: There is a mismatch between the current marketplace for hydrogen and the ambitions to ramp up production, driven by government targets for decarbonisation. The demand for hydrogen in Europe stood at 8.7mt in 2020 and was largely confined to industrial processes like refining and fertilizer production. Together, refining and ammonia consumed 79% of the total hydrogen in the EU, EFTA, and the UK.[6]

There are efforts to stimulate demand to match the production ambitions within Europe, notably in the form of the European Hydrogen Bank, which is an auction system that provides renewable hydrogen production with a fixed price payments for ten years[7]. This model has been noted in the US as a model for stimulating demand to match the potential growth in production. However, currently the economics of utilising hydrogen in other sectors are not yet attractive, particularly given the high costs of producing (where far from competitive renewable energy sources), transporting, storing, converting, and compressing hydrogen. This is particularly the case where electrification options offer a more immediate and cost-effective solution to decarbonising many sectors within transportation, power production and building heating or cooling.[8]

Currently, Hydrogen Has Limited Use Outside Industry

Europe – 2020 Share of Total Hydrogen Demand By Sector, %



Source: Hydrogen Europe based on work for Fuel Cells and Hydrogen Observatory. Note: Transport share <1%, equal to 1453 tonnes.

[5] BP, Energy Outlook: 2023 Edition, July 2023
[6] Hydrogen Europe, Clean Hydrogen Monitor, October 2022
[7] European Commission, March 2023 https://energy.ec.europa.eu/news/commission-outlines-european-hydrogen-bank-boost-renewable-hydrogen-2023-03-16_en
[8] See - The Clean Hydrogen Ladder, Liebreich Associates (concept credit: Adrien Hiel/Energy Cities)

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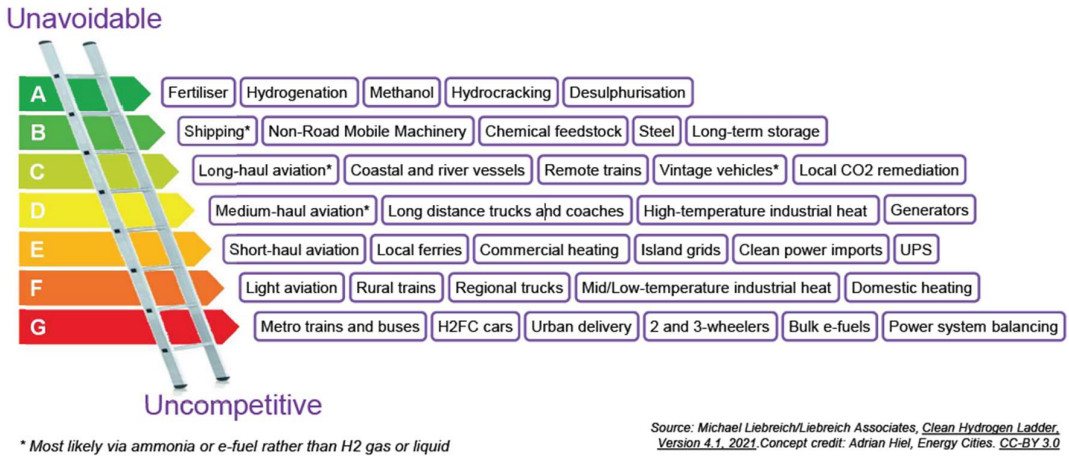
Demand Will Grow: This is not to say that there will not be robust opportunities to supply green hydrogen. For several major hard-to-abate industries with high energy intensity requirements that electrification will struggle to meet, signing offtake agreements for green hydrogen will be key for meeting decarbonisation targets. This includes sectors such as refining and ammonia production that currently use grey hydrogen, produced using fossil fuels.

Infrastructure assets that can supply imported or produce green hydrogen on-site would have a ready market from steel, building materials and other industrial manufacturers. There will also be opportunities to develop hydrogen assets within the power and transportation sectors, but these are much more likely to be ad-hoc or unique assets that make sense from the perspective of the individual business involved, rather than a sector-wide adoption; examples include certain logistics and shipping routes such as ferries, public transport routes, or business' on-site energy storage.

Similar to the electric vehicle (EV) charging infrastructure sector, there is broad acknowledgement that demand for hydrogen is expected to increase over time, but as an infrastructure investor looking at the market today, it is challenging to identify solid, contractual demand to underpin long-term stable and predictable cashflows.[9]

Difficult To Extend The Reach Of Hydrogen Across Economies

The Clean Hydrogen Ladder



Source: The Clean Hydrogen Ladder, Liebreich Associates (concept credit: Adrien Hiel/Energy Cities)

Competitiveness: Within the hydrogen sector, there remains a significant amount of uncertainty in how production costs and technology costs will develop over the next decade. Consensus is that costs for green hydrogen will fall, but how far and where remains uncertain. This creates risks for infrastructure investors, most of which have long-term investment horizons and therefore look to limit technology and price risk to avoid holding uncompetitive assets at the end of their hold period.

Cost competitiveness is one of the key barriers to the adoption of green hydrogen as a source of energy. As discussed above, the strongest use cases for green hydrogen in the short-to-medium term are in hard-to-abate sectors that already use hydrogen and where carbon permits will become an increasing cost burden for them as large carbon emitters. As it stands, green hydrogen's cost of production is significantly higher than that of grey hydrogen currently used, although this is set to increasingly swing in green hydrogen's favour over the mid-2030s as electrolyser manufacturing costs fall and carbon prices rise.[10] However, blue hydrogen is being strongly pursued by major hydrogen consuming industries (such as refining) as an alternative as it allows for them to produce low carbon hydrogen using existing carbon-based fuels. Given that such players are also the major consumers of hydrogen and typically

[9] DWS, Transforming Transportation https://www.dws.com/insights/global-research-institute/transforming-transportation March 2023
[10] BNEF, https://about.bnef.com/blog/2023-hydrogen-levelized-cost-update-green-beats-gray/

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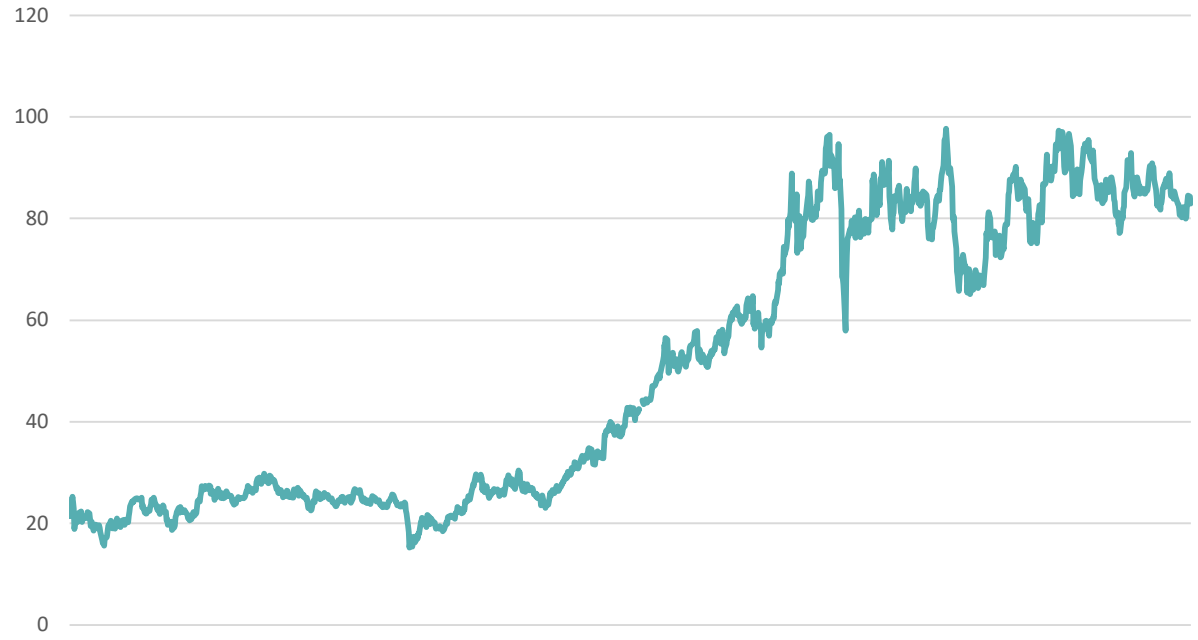
have a nexus with the major international energy companies which are most likely to ultimately dominate the hydrogen market, it is hard to see a scenario where smaller, localised green hydrogen producers are competitive.

Carbon Burden To Increase Need For Clean Hydrogen

Europe – Carbon Price (EUR/Tonne), 2018-2023YTD



Source: Bloomberg, As of 26/9/2023

Furthermore, hydrogen producers in Europe may also have to compete internationally in the long-term. This is not necessarily an issue for investors at this stage given transportation costs and constraints of existing infrastructure, as well as the EU's strict rules on how green hydrogen is produced.[11] However, assets may ultimately become uncompetitive as the global market for hydrogen develops, leading to stranded asset risk. In key demand centres, such as Europe, it is unlikely that large production capacities can be created in the short-to-medium term, given land constraints and the prioritisation of renewable energy development to support the decarbonisation of the power sector. Large-scale floating offshore wind is likely the key to unlocking European-sourced green hydrogen at scale (where the combination of lower cost production and shorter distance transport could create a competitive advantage). As such, international markets with large i.e., low-cost production potential such as those in North Africa, Gulf states, Australia, and Chile will likely develop hydrogen production capacity geared towards exports.

It is also likely that there will be greater adoption of Chinese electrolyser technology, which it is estimated will make green hydrogen cost-competitive with blue hydrogen by 2028, five years earlier than Western manufactured electrolysers, further intensifying the competition within international markets. BNEF estimates the levelised cost of green hydrogen ranges from $2.38-5.89/kg if using Chinese alkaline electrolysers, $4.18-11.07/kg from Western-made alkaline equipment, and $4.57-12/kg with proton exchange membrane (PEM) technology.[12]

While a lack of international certification for green hydrogen and transportation costs we expect will be a barrier in the short term, the readily available wind and solar resource, cheap land availability for renewables deployment and, in many cases, existing

[11] European Parliament, EU rules for renewable hydrogen: Delegated regulations on a methodology for renewable fuels of non-biological origin, April 2023
[12] BNEF, https://about.bnef.com/blog/2023-hydrogen-levelized-cost-update-green-beats-gray/, September 2023

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hydrocarbons infrastructure would create competitive export hubs. Europe's hydrogen goals include a 10mnt green hydrogen imports target, but there is a risk that imported hydrogen becomes increasingly attractive and erodes European-produced hydrogen's market share.

Infrastructure investors have already moved into the hydrogen sector, and it is expected to continue to be an active area of transaction activity and fundraising. However, given the long-term market will likely be dominated by large players benefitting from economies of scale, finding an attractive market position in the short-to-medium term is crucial. It is likely that these will include businesses where one or a combination of the below factors exist:

- Supply clusters of industries that need to decarbonise or already have hydrogen use in their value chain, where transportation of hydrogen is unnecessary and where renewable energy is readily available. Most markets pursuing hydrogen industrial development have identified 'hydrogen hubs' where there is co-located industrial demand, renewable energy and existing hydrogen carbon infrastructure, with ports often acting as an anchor.

- Businesses with limited electrolyser technology risk where efficiency continues to improve, and costs are forecast to reduce further. Developers benefiting from an asset development pipeline but are not the asset owners are a good example of limiting electrolyser risk.

- Provide an option for decarbonisation where electrification is not possible or economical.

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3 / Biomethane

While renewable electricity, energy efficiency and electrification of energy demand (i.e. electric vehicles and electric heat pumps) form other components of plans to ensure decarbonised and secure energy supplies, most emission reduction scenarios involve use of different bioenergy in addition to hydrogen. In light of growing policy support, opportunities for infrastructure investors exist in the biomethane sector, particularly when targetting heating or heavy transport markets.

The broad term biomass may refer to organic material from plants or animals including agricultural and energy crops, wood and forestry residues, organic waste from municipal and industrial sources and algae. Biomass can be burned directly for heat or electricity or, as is the case with biomethane, converted in some chemical or biological manner to produce different solid, gaseos or liquid fuels. Not all biomass is sustainable as there are competing uses for land, food and material requirements, and important biodiversity and soil health considerations. Biomass can only contribute to emission reductions if it is sustainably sourced, accounting for the full lifecycle of emissions including any direct or indirect landuse change.

3.1 Biomethane Boom

Biomethane, produced through upgrading biogas or from wastes and residues, benefits from similarly ambitious scaling targets as hydrogen and was one of the major winners from the 2022 REPowerEU plan, with the EU looking to increase its biomethane production tenfold by 2030 to improve energy security.

Biomethane, as well as having numerous direct applications such as use by industry or creating heat or combined heat and power (CHP) solutions, has the significant advantage over hydrogen in that it is indistinguishable from natural gas. To utilise hydrogen in the gas transmission infrastructure networks in Europe will require significant capital expenditure; hydrogen advocates propose a 53,000 km European Hydrogen Backbone pipeline network which requires an estimated total investment of €80-143 billion for transportation alone, excluding production costs.[13]

Conversely, biomethane can be utilised immediately as part of existing natural gas demand, thus removing a significant risk for infrastructure investors as the assets form an immediate part of an established value chain. Furthermore, unlike largescale electrolysers for green hydrogen production, biomethane produced from anaerobic digestion is also a well-established technology, removing some of the greenfield asset development risk for investors. The EU estimates that €37bn is needed to scale up biomethane production.[14]

Biomethane represents about 0.1% of natural gas demand today; however, an increasing number of government policies are supporting its injection into natural gas grids and for decarbonising transport. Natural gas demand in Europe is set to moderate over the coming decades, driven by the European Climate Law, which mandates a reduction of fossil gas demand by 35% by 2030 compared to 2019.[15] However, this is unlikely to result in reduced demand for biomethane. As part of the incentives for producing biomethane, many markets – including Germany – give preferential access to the transmission networks to biomethane producers. As a result, there would be demand for biomethane as long as there is demand for natural gas.[16] Even under a Net Zero by 2050 scenario, natural gas will still be used in Europe.[17]

[13] European Hydrogen Backbone, https://ehb.eu/page/estimated-investment-cost
[14] European Commission 2023 https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biomethane_en
[15] European Union, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119, 2021
[16] REGATRACE, Mapping the state of play of renewable gases in Europe, 2020
[17] BP, Energy Outlook: 2023 Edition, July 2023

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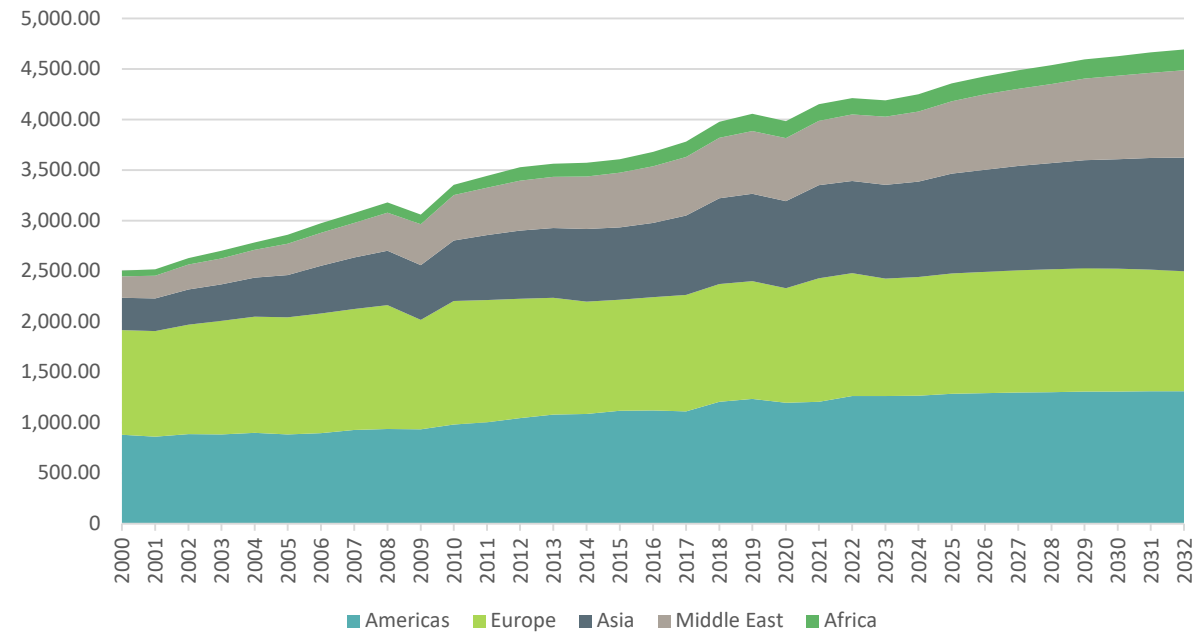
Europe Gas Demand To Peak In 2030

Annual Natural Gas Consumption By Region (bcm)



Source: BMI. 2023-2032 = forecasts.

3.2 Transport – A Route To Value

While an attractive backstop for biomethane businesses, selling biomethane on the open market through injecting it into the gas network will expose a business to volatility in gas prices. As such, producers are likely to look to tap into the more lucrative market to decarbonise transport sectors through both regulated and voluntary carbon reduction markets. Germany, Italy, the Netherlands, and the United Kingdom have all introduced support for biomethane in transport.[18]

Benefitting from a combination of (i) green certificates, which prove carbon has been removed, and (ii) private offtake contracts, biomethane producers will be a key avenue for the transportation industry to lower carbon emissions to meet increasingly stringent targets. Given the moderate pace of transportation electrification and questions over the suitability of electrified heavy-haulage or aviation, biomethane's transportation-related formats such as bio-CNG and bio-LNG, both already utilised today across the sector, will keep demand robust in such sectors.[19]

Other biofuels have previously been supported across Europe and have subsequently faced changing dynamics given shifting perspectives on the use of food crops to produce fuel or land-use changes that are negative from biodiversity or carbon stock perspective. Biomethane has the benefit of forming part of the circular economy, offering a waste-to-value opportunity which is supported by the Renewable Energy Directive (RED II) in Europe. The value of biomethane produced is higher when utilising feedstock from animal manure, given its results in more greenhouse gas (GHG) emissions being prevented from entering the atmosphere. RED II scales the financial benefits of utilising waste, with manure being the most valuable, followed by organic municipal food waste, and finally agricultural by-products and waste. While burning biomethane produces the same amount of carbon dioxide and other

[18] IEA, 2020, https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/an-introduction-to-biogas-and-biomethane,
[19] Systemiq, 2022 https://www.energy-transitions.org/energy-transitions-commission-warns-demand-for-biomass-likely-to-exceed-sustainable-supply/

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greenhouse gases as burning the conventional natural gas, it only produces the same quantity of greenhouse gases as if the organic matter would be left to decompose in nature.[20]

Given its prominence in the REPowerEU plan, its role in providing a waste-to-value service and offering decarbonisation without requiring significant new value chains to be created, it is likely there will be significant infrastructure investor interest in the biomethane sector. While currently there is only visibility on regulation supporting the sector up to 2030, it is highly unlikely, given the positive impacts the industry has, that the policy environment will change before the end of that timeframe (and there is good potential for continued support beyond that time frame). Even so, there are a number of key issues investors should consider when looking to tap into the biomethane growth story to create an optimal and attractive returns structure and manage sector risks:

- The biomethane sector is currently predominantly made up of small-scale producers, often at the farm level, utilising waste produced onsite. Access to feedstock volumes is critical to scale a business and improve the reliability of its returns. Areas of high agricultural production in markets which incentivise the use of animal manure, such as Germany, are likely to have more stable biomethane business revenues than businesses which rely on municipal organic waste collection, with many markets lacking well-established organic waste management. Consequently, there are less numerous opportunities to identify suitable projects and scale up the business model).

- Securing offtake from industrial users or selling to the transportation sector is preferable to purely supplying renewable natural gas to the grid, given that it both stabilises the revenue stream through fixed prices, as well as taps into the demand stemming from the need to decarbonise.

- To add further revenue upside, assets can sell by-products of the biogas upgrading and biomethane production processes: for example, green-Co2 which can be sold to the food sector, with the substrate subsequently sold back to the agricultural sector as fertiliser. These supplementary revenue streams underline the importance of asset location in order to maximise the offtake market and limit transportation costs.

[20] European Biogas Association, https://www.europeanbiogas.eu/about-biogas-and-biomethane/

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