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Argus Hydrogen and Future Fuels

Market news, analysis and prices

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Ukraine counts on H2 for post-war rebuild

The country hopes to realise its potential as a major renewable hydrogen producer and exporter once the fighting ends, writes Stefan Krumpelmann

As the first anniversary of Russia's invasion of Ukraine approaches, much has been made of the war's implications for the hydrogen industry globally. But the conflict has also naturally altered the outlook for Ukraine itself, where renewable hydrogen is seen as a key element of any post-war reconstruction effort.

Ukrainian government officials and energy company representatives have repeatedly touted the country's renewable hydrogen production potential, stressing the possibilities for an eventual "greener" rebuilding of the domestic economy and the vast scope for exports to the EU of hydrogen and its derivatives.

Ukraine's large steel and fertiliser industries — so far major consumers of fossil fuels — could alone deploy around 18GW of electrolyser capacity, according to estimates by DTEK, the country's largest private-sector energy firm. Major steelmaking facilities, such as the large Azovstal complex in the coastal city of Mariupol, which is currently under Russian occupation, have been severely damaged in fighting, but renewable hydrogen could play a key role in "re-industrialising" the country, DTEK says.

Despite the war, plans for developing renewable hydrogen production remain in place. Project developer H2U intends to set up a 100MW electrolyser at Reni in southern Ukraine, close to the borders with Moldova and Romania, hoping to capitalise on ample sunshine and high wind speeds in a region close to the Black Sea. Capacity at Reni could eventually be expanded to 3GW, H2U says. Separately, a 500MW project — that could feed a planned network of refuelling stations — is envisaged for western Ukraine. And projects might not be restricted to renewable hydrogen. During the UN Cop 27 climate summit in November, the US government announced plans to produce clean hydrogen and ammonia in Ukraine using nuclear energy from a small modular reactor via solid-oxide electrolysis, with a view to supporting the country's energy and food security.

The EU, meanwhile, has been eager to stress the potential for Ukraine to become a major supplier of renewable hydrogen for the bloc, most recently through a strategic partnership signed earlier this month. The REPowerEU plan — drawn up shortly after the invasion — foresees the establishment of an import corridor through Ukraine "as soon as conditions allow". And the European Hydrogen Backbone initiative by Europe's gas system operators sees potential for Ukraine to supply 12 TWh/yr, or 360,000 t/yr, of renewable hydrogen by 2030, rising to 50 TWh/yr by 2040 and 100 TWh/yr by 2050.

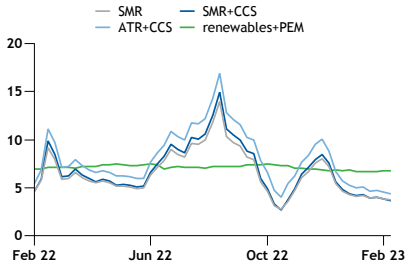
All these plans are, of course, heavily dependent on the future course of the war and the state that the country finds itself in once the fighting ends. The scope for building up hydrogen production and demand will depend crucially on the speed of Ukraine's economic recovery in a post-war scenario and the amount of investment that can be leveraged for the sector. And although Ukraine's extensive natural gas pipeline network — historically a key conduit for Russian gas flowing to Europe — could theoretically be repurposed to transport hydrogen, uncertainties remain over the state of the infrastructure after the war.

Some firms are also considering alternatives to pipeline delivery. H2U has suggested that initial supply could be shipped as compressed or liquid hydrogen on the Danube river, especially while production volumes are still too small to make pipeline transport economically feasible.

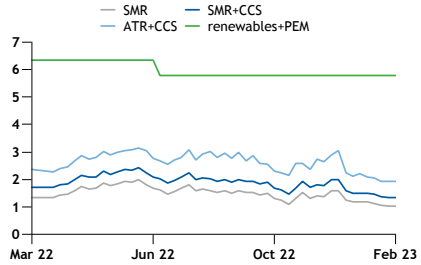
CONTENTS

HYDROGEN PRICES

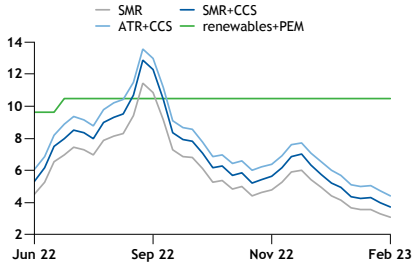
Northwest Europe average cost €/kg



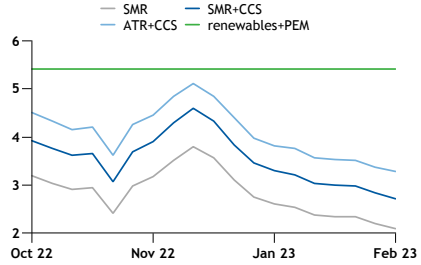
North America average cost $/kg



Northeast Asia average cost $/kg



Exporter average cost $/kg



Regional hydrogen cost markers						21 Feb
			Incl. capex		Excl. capex	
	Process	Unit	Cost	± 14 Feb	Cost	± 14 Feb
Baseline						
Northwest Europe	SMR	€/kg	3.72	-0.09	3.44	-0.10
Northwest Europe	SMR	$/kg	3.97	-0.11	3.68	-0.11
North America	SMR	$/kg	1.03	-0.01	0.74	nc
Northeast Asia	SMR	$/kg	3.05	-0.24	2.75	-0.25
Middle East	SMR	$/kg	2.70	-0.22	2.40	-0.22
BAT+						
Northwest Europe	SMR+CCS	€/kg	3.65	-0.14	3.17	-0.15
Northwest Europe	SMR+CCS	$/kg	3.90	-0.16	3.39	-0.16
North America	SMR+CCS	$/kg	1.34	-0.01	0.82	-0.01
Northeast Asia	SMR+CCS	$/kg	3.73	-0.27	3.20	-0.27
Middle East	SMR+CCS	$/kg	3.39	-0.24	2.86	-0.25
Low-C						
Northwest Europe	ATR+CCS	€/kg	4.37	-0.14	3.72	-0.15
Northwest Europe	ATR+CCS	$/kg	4.67	-0.16	3.97	-0.17
North America	ATR+CCS	$/kg	1.94	+0.02	1.23	+0.01
Northeast Asia	ATR+CCS	$/kg	4.42	-0.29	3.70	-0.29
Middle East	ATR+CCS	$/kg	3.95	-0.24	3.23	-0.24
No-C						
Northwest Europe	Island renewable+PEM	€/kg	6.77	+0.02	4.98	+0.01
Northwest Europe	Island renewable+PEM	$/kg	7.23	nc	5.32	nc
North America	Island renewable+PEM	$/kg	5.78	nc	3.90	nc
Northeast Asia	Island renewable+PEM	$/kg	10.48	nc	8.57	nc
Middle East	Island renewable+PEM	$/kg	5.55	nc	3.69	nc
Exporter						
Exporter baseline	SMR	$/kg	2.09	-0.10	1.80	-0.10
Exporter BAT+	SMR+CCS	$/kg	2.72	-0.11	2.20	-0.11
Exporter low-C	ATR+CCS	$/kg	3.28	-0.09	2.57	-0.09
Exporter no-C	Island renewable+PEM	$/kg	5.41	nc	3.45	nc

Argus hydrogen taxonomy			
	Purity	Pressure	tCO2e/tH2
Baseline	99.9%	30 bar	<11.3, >8.0
BAT+	99.9%	30 bar	<2.88, >1
Low-C	99.9%	30 bar	<1, >0.5
No-C	99.99%	30 bar	<0.01

CO2e emissions on a gate-to-gate basis

Pump prices, 70MPa			3 Feb
	Unit	Price	± 6 Jan
Japan			
Eneos	¥/kg	1,650.00	nc
Iwatani	¥/kg	1,210.00	nc
Germany			
H2Mobility	€/kg	12.85	nc

MARKET DEVELOPMENTS

EU approves more H2 state aid, eyes simpler rules

The commission hopes new measures will energise the sector, but there are concerns looser rules will unfairly benefit the larger economies, writes Aidan Lea

The European Commission has approved more state aid for green steel and hydrogen production projects in Spain, Germany and Denmark. But while it wants to make access to state aid easier by streamlining its system, not everybody welcomes the idea.

Under EU competition rules, state aid is generally prohibited in the single market. But the commission has approved more than €12bn ($12.8bn) of state aid for hydrogen projects over the past year, mostly using the Important Projects of Common European Interest (IPCEI) route.

Steelmaker ArcelorMittal stands to be the beneficiary of the most recent state aid approvals, as the commission last week gave Spain and Germany the go-ahead to support the company in decarbonising its processes using renewable hydrogen.

Spain is to provide a direct grant of €460mn to the company for construction of a €1bn direct reduced iron (DRI) plant at its steel production site in Gijon in the north of the country. In combination with an electric arc furnace, the DRI plant will replace the current blast furnace and enable natural gas to be phased out from the production process, the commission says. The plant is expected to start operations by the end of 2025 and could produce 2.3mn t/yr of DRI, avoiding 70.9mn t of CO_2 emissions in total, the commission says.

Meanwhile, Germany received the greenlight to provide €55mn to ArcelorMittal for a €110mn pilot project testing renewable hydrogen in steel production in Hamburg. ArcelorMittal plans to build a DRI unit that will produce 100,000 t/yr of iron to be fed into an electric arc furnace alongside scrap. The project will avert 700,000t of CO_2 emissions in total, according to the EU. ArcelorMittal aims to trial using hydrogen instead of natural gas to produce iron, and to discover how the carbon-free iron reacts in the electric furnace. But the expected start date for the plant has slipped to 2026 from 2025 as initially planned.

ArcelorMittal will use the experience gained to decarbonise its EU steel production on a larger scale and has committed to share technical lessons with European steel producers

ArcelorMittal will use the experience gained to decarbonise its EU steel production on a larger scale and has committed to share technical lessons with European steel producers, the commission says. The company is also considering using hydrogen at other sites including in France, Belgium and Bremen in Germany.

Many of the hydrogen projects that will benefit from the EU's €12bn in state aid target hard-to-abate sectors such as steel, including €1bn for German company Salzgitter that was cleared last year.

But some steelmakers are crucially still waiting for a decision on state aid requests. Germany's Thyssenkrupp said in September that it plans to invest €2bn in a 2.5mn t/yr green steel site in Duisburg, utilising a hydrogen-powered DRI unit. But a final investment decision hinges on approval for public funding, while Thyssenkrupp also has concerns over security and the affordability of hydrogen supply. The company faces a future in which energy accounts for 50-60pc of its production costs after it has transitioned to renewables and hydrogen, compared with 5pc at present, its head of government and regulatory affairs, Erika Mink, says. The transition to hydrogen means "a major shift in technology", Mink says, adding that "we practically have to build new steel plants while we still run the old ones in order to serve our customers".

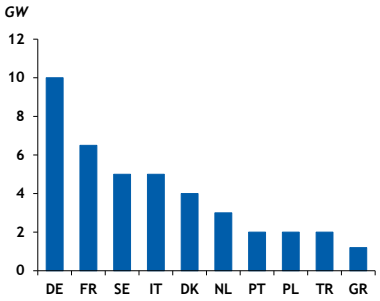
The state aid of Denmark

While state aid from Spain and Germany for ArcelorMittal will target the demand side, Denmark last week got the go-ahead for supporting domestic hydrogen production projects.

The commission approved a €170mn subsidy scheme that is to help sites for production of renewable hydrogen and its derivatives. The Danish government

MARKET DEVELOPMENTS

2030 minimum electrolyser targets



will award 10-year grants to projects selected through a competitive bidding process later this year, with a view to supporting 100-200MW of electrolysis capacity, the commission says.

The scheme is open to companies planning new electrolysis projects in Denmark that comply with the recently finalised EU definition of renewable hydrogen. The funds may also be used to build additional renewable electricity to feed the electrolysers. Denmark proposed the scheme last year and established a task force to guide project developers and local authorities. It is part of the country's plan to become a regional leader in the production of hydrogen and derived fuels for domestic and neighbouring markets. Denmark last year set an electrolyser capacity target of 4-6GW for 2030.

The commission approved the Danish proposal through its Guidelines on State Aid for Climate, Environmental Protection and Energy mechanism.

Less red tape for green schemes

State aid could become more readily available to European hydrogen project developers in the future, as the commission is planning to temporarily relax rules in a bid to boost competitiveness in the bloc's green industry.

It is consulting member states on the proposal which, according to commission executive vice-president Margrethe Vestager, is intended as a response "to the double challenges of the energy crisis and the Inflation Reduction Act of the US". The commission hopes more lenient rules will speed up decarbonisation efforts, but stresses that a "subsidy race" between member states must be avoided. It proposes making calculating state aid simpler, approvals faster, and broadening the scope of its Temporary Crisis Framework — adopted in the wake of the start of the conflict in Ukraine — to "support all possible renewable sources of energy".

The move will probably be welcomed by hydrogen industry participants who have long called for the commission to speed up decisions on state aid funding to avoid falling behind other regions. The commission previously acknowledged that it had to at times sacrifice speed for accuracy, pointing to its responsibility to taxpayers to get the decisions right.

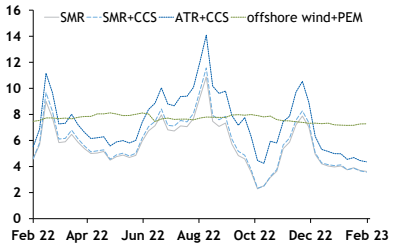
And not everyone in the hydrogen industry sees the push for more relaxed state aid rules in a positive light. State aid rules already unfairly benefit larger member states, and easing them further would be "disastrous" for companies in smaller countries, Danish electrolyser manufacturer Topsoe's chief executive, Roland Baan, says. Some state aid decisions are "completely distorting" the market, Baan says. While Topsoe is investing €400mn in a manufacturing facility in Denmark, a competitor has been awarded €200mn by the French government for a pilot plant "just to play around and de-risk their technology", he says.

Baan argues that Europe should instead merge various funding schemes into a sovereign wealth fund open to everyone "whether you're from Liechtenstein or Germany". This would be politically difficult, but the simplest solution from a business perspective, he says, adding that sovereign wealth funds are a "no-brainer".

Baan also dismisses the idea that recently announced EU plans are sufficient to match the US' Inflation Reduction Act. The commission insists that measures such as awarding fixed premiums to certain producers will have a similar effect to the US bill. But Baan says the bloc is still "nowhere near having an IRA-like instrument". Whereas US regulation is "big, simple, transparent and colourblind" — eschewing debates on production pathways and focusing on carbon intensity — Baan says Europe has a multitude of funding programmes and overly "academic" discussions, highlighted by the amount of time it took the EU to come up with a definition for renewable hydrogen.

NEWS

French H2 costs *€/kg*



EU rules give French hydrogen an edge: Industry body

The European Commission's definition of renewable hydrogen could boost the French hydrogen sector, even though it does not open the door for hydrogen produced with nuclear energy, according to industry body France Hydrogene.

The rules could enable extensive hydrogen production from French hydroelectric power, France Hydrogene says. This is because the regulations include a provision that exempt grids that are already largely decarbonised and have an emissions intensity of less than 18g of CO_2 equivalent/MJ (CO_2e/MJ) from the so-called additionality clause. This stipulates that, from 2028, hydrogen production will only count as renewable if the electricity supply comes from renewable installations operational for less than 36 months. This is intended to ensure that hydrogen production does not "cannibalise" existing renewable electricity production.

France's ample nuclear capacity could enable it to achieve emissions intensity of less than 18g of CO_2e/MJ, which would exempt the country's electrolysers from the additionality rule. And this could make a "considerable number of renewable energy installations in France eligible for hydrogen production", especially existing hydroelectric plants, France Hydrogene says. Hydroelectric plants can achieve higher load factors than other renewable sites, the association says. This ensures stable supply and cuts costs, making the output more competitive, it says.

But France Hydrogene also says the rules should not be considered "as an acknowledgement of the role of nuclear hydrogen". This is because hydrogen producers with grid-connected electrolysers would still need to conclude power purchase agreements for renewable electricity and adhere to temporal and geographical correlation rules. Hydrogen production from nuclear power would therefore not qualify as renewable and would not be eligible for mechanisms such as the planned European hydrogen bank, France Hydrogene says.

By Stefan Krumpelmann

EU to mandate 42pc renewable H2 in industry by 2030

The EU plans to mandate consumers of hydrogen to use 42pc renewable hydrogen in their processes by 2030 and 60pc by 2035, according to a draft proposal for the bloc's revised Renewables Energy Directive (RED III).

The draft proposal suggests that the European Commission, European Parliament and European Council — which represents the 27 member states — have reached a compromise on the mandate for renewable hydrogen use. The agreement roughly splits the difference between the negotiating positions, as the commission and parliament had pushed for a 50pc quota by 2030, while the member states had called for 35pc. Parliament had urged a 70pc target for 2035, with member states pushing for 50pc. The commission had not specified a 2035 target.

The quota will primarily affect the refining, fertiliser and chemical sectors, which are the main users of conventional fossil-derived hydrogen. It would apply to all hydrogen used for "final energy and non-energy purposes". Exceptions for the mandate apply to hydrogen that is made as a by-product and hydrogen as an intermediate product in production of conventional fuels and biofuels.

A 42pc mandate could create demand of around 3.75mn t/yr, based on industry body Hydrogen Europe's estimate that a 50pc mandate would require 4.5mn t/yr.

The final text of the document is expected to be confirmed around June, as the EU still has several other areas of debate to settle. But this particular section, now agreed, is unlikely to change. It will then fall to the member states to integrate the mandate into their national laws.

By Aidan Lea

NEWS

German hydrogen council sharply lifts demand forecasts

Forecasts for 2030 German H2 demand		
	t	*TWh*
Renewable H2		
Steel	600,000-840,000	20-28
Other process industries	30,000-90,000	1-3
Heavy-duty transport	510,000	17.0
Refineries	90,000	3.0
Aviation	90,000	3.0
Maritime	15,000-75,000	0.5-2.5
E-fuels	180,000	6.0
Heat	150,000-300,000	5-10
Power generation	0-600,000	0-20
Total	**1.6mn-2.7mn**	**53-90**
Gas-derived		
Chemicals	1.08mn	36.0
Overall		
Total	**2.7mn-3.8mn**	**89-126**

— German national hydrogen council

The German national hydrogen council has sharply raised its forecast for the country's renewable hydrogen demand in 2030, as more natural gas will be replaced with hydrogen as a result of the conflict in Ukraine and because of more ambitious EU targets for reducing CO_2 emissions.

The council, which advises the German government on its hydrogen strategy, expects renewable hydrogen demand in a range of 53-90TWh in 2030, or 1.6mn-2.7mn t. This is well up from previous forecasts of 44TWh, or 1.3mn t, before the conflict in Ukraine. The estimated demand is in addition to around 36TWh of grey hydrogen from natural gas that could still be required by the chemicals industry in 2030, according to the council.

A key driver for the upward revision to the forecast for renewable hydrogen demand is stronger consumption from the steel industry. Decarbonising the sector will be dependent on building up capacity for direct reduced iron. This might require natural gas as a bridge technology, but the scope for this has been significantly reduced, given that Germany — as with Europe as a whole — is looking to wean itself off Russian gas, the council says.

Another key area where the council sees the potential for much higher renewable hydrogen use is power generation. German and EU regulations for reducing CO_2 emissions — such as the EU's delegated act on taxonomy — mean much more extensive hydrogen co-firing might be needed, it says. Berlin has pushed for any new gas-fired power plants to be "hydrogen-ready", as it seeks to reduce future natural gas use. That said, there is still a large degree of uncertainty around use of hydrogen for power generation by the end of the decade.

Producing 53-90 TWh/yr could require electrolyser capacity of 22-37GW, either within Germany or abroad, the council says. Germany intends to establish 10GW of capacity by 2030, meaning it might need to import most of its renewable hydrogen. Germany could account for 8-14pc of the EU's overall renewable hydrogen demand in 2030, based on the bloc's target of producing 10mn t/yr domestically and importing 10mn t/yr.

By Stefan Krumpelmann

Adani puts new investments on hold, H2 plan in limbo

Adani Enterprises, the flagship unit of Indian conglomerate Adani, has decided to put on hold new investments, raising questions over its green hydrogen plans.

"We will not make new capex commitments untill the volatility in the market settles down," chief financial officer Jugeshinder Singh said last week.

A report by US-based investment firm Hindenburg Research alleging securities and corporate fraud at the conglomerate has wiped off over $100bn from its market value since 24 January. Adani has denied the allegations.

"Overall plans for airport, green hydrogen and logistics will continue as planned," Singh said. "However, we will moderate certain acceleration that we had budgeted." Adani's green energy arm, Adani New Industries, in January laid out plans to build 3mn t/yr of green hydrogen production capacity over 10 years, with a planned initial investment of $50bn.

Singh said last week that TotalEnergies is continuing work on the technical side of green hydrogen projects that are part of an initial agreement signed between Adani New Industries and the French energy major in May 2022. This followed comments from TotalEnergies earlier this month that it put on hold plans to develop renewable hydrogen projects with Adani until there is more clarity.

By Chiranjivi Chakraborty

NEWS

US developer to harness Wyoming renewables for H2

US renewables firm Focus Clean Energy plans to harness Wyoming's stranded wind and solar potential to produce green hydrogen, president Paul Martin told *Argus*.

Focus expects to reach a final investment decision on its 'Pronghorn H2' project in 2026 and targets the start of operations in 2028. The company is at "an advanced stage" in obtaining land use rights for the project, Martin says.

The project could have 1GW of renewable generation capacity in its initial phase and eventually ramp up to 5GW, he says, adding that wind will be the larger generation component.

Focus anticipates that the project would first produce hydrogen to be used in "downstream products" until demand becomes significant enough to sell it directly. Martin did not disclose which initial market it plans to target, but possible products could include biodiesel and sustainable aviation fuel, which use hydrogen in some production pathways, as well as hydrogen derivatives ammonia and e-methanol.

Wyoming's renewable potential is essentially a stranded asset, Martin says, but by converting renewable electricity to hydrogen, that energy could be transported in new ways while boosting Wyoming's economy.

Focus' project is one of a few announced in the US that is not contingent on funding from the Department of Energy's (DOE) hydrogen hubs programme, which will divide up to $7bn between as many as 10 projects. But the firm still plans to co-ordinate with the Western Interstate Hydrogen Hub, a coalition between Wyoming, Colorado, New Mexico and Utah that submitted a proposal to the DOE, so as to have a "complementary" project, Martin says. The coalition is planning an interstate hydrogen pipeline as part of its hub, which Focus will be "keeping an eye on" for the potential to utilise it as a shipper of hydrogen.

By Emmeline Willey

China's Longi says new electrolyser can cut H2 costs

China-based Longi Hydrogen has released an alkaline electrolyser that it says is 10pc more efficient and promises to trim renewable hydrogen production costs.

The company says it has trimmed the full-load power consumption of its latest generation of alkaline electrolysers to 4.0-4.3 kWh/normal m^3 (Nm^3) from the 4.5-4.6kWh/Nm^3 it says is the "current industry standard" for both alkaline and proton exchange membrane electrolyser types. This would translate to 82-89pc efficiency, given hydrogen's higher heating value of 3.54kWh/Nm^3.

Every reduction of 0.1 kWh/Nm^3 in power consumption can reduce the levelised cost of hydrogen production by around 2pc, Longi says, as "electricity price and energy consumption per unit of hydrogen production are the two most sensitive variables that determine levelised cost of hydrogen".

The performance has been verified by third-party organisations including Norway's DNV and Shanghai-based Dekai, Longi says, adding it is the first certificate issued by DNV in China for hydrogen energy products. The choice to employ a European certification provider may suggest Longi is targeting a market outside China for its electrolysers.

Longi Hydrogen is a 2021-founded subsidiary of solar company Longi Green Energy Technology and one of many Chinese companies to have recently released new electrolyser models.

European electrolyser companies recently called on the EU for more protection from foreign competition and said the bloc must learn lessons from losing control of the solar panel market to China.

By Aidan Lea

IN BRIEF

FFI targets five hydrogen FIDs in 2023

Australian green hydrogen developer Fortescue Future Industries (FFI) expects to take a final investment decision (FID) on five projects in five countries this year. "I can absolutely say we have certainty that we'll see five by the end of the year," FFI chief executive Mark Hutchinson says, while indicating that the US, Norway and Australia are likely locations for initial projects. FFI is also looking at Africa, specifically Namibia, Kenya and Morocco, while Brazil will be a focus country in Latin America, Hutchinson says, adding that in the Middle East, FFI has "made great progress in Egypt and Jordan". While at least five projects are to be moved towards FIDs this year, others could be advanced later, he says.

RWE, VTG to explore NW Europe ammonia rail network

German utility RWE and freight company VTG have signed an agreement to collaborate on a logistics study for an ammonia rail network in northwest Europe. The companies will explore the development of a tank wagon network to deliver ammonia from RWE's Brunsbuttel import terminal to consumers in Germany and the Netherlands. The agreement outlines plans to consider potential delivery routes and determine required transport capacity. Development of an ammonia rail network would be "advantageous for industrial customers, as no connection to a pipeline or inland port is required", the firms say.

HydrogenPro homes in on US market

HydrogenPro sales pipeline	*GW*
4Q22	18.5
3Q22	17.0
2Q22	15.4
1Q22	12.7

— HydrogenPro

Norwegian electrolyser maker HydrogenPro plans to focus on increasing its US production capacity in the short to medium term, according to chief executive Tarjei Johansen. The US Inflation Reduction Act has spurred an increase in demand for low-carbon hydrogen in the US, making it an attractive market, Johansen says. The company plans to add 500 MW/yr of electrolyser manufacturing capacity in the US and 500 MW/yr in Europe by the end of this year, as part of its goal to reach 5 GW/yr in the next five years. HydrogenPro currently has 300MW of capacity in Tianjin, China. The company's sales pipeline in the fourth quarter hit 18.5GW, worth $73.7mn, up from 17GW in the third quarter.

Enagas, Naturgy to start 280MW Spanish H2 plant in 2026

Spanish gas grid operator Enagas' renewable gases division and power and gas utility Naturgy plan to start producing green hydrogen at their 280MW La Robla hydrogen hub in northern Spain in 2026. The companies have formed the Robla Hub joint venture to develop the project, which is expected to cost €485mn ($517mn) and will be powered by 450MW of solar photovoltaic capacity. They decided to increase targeted electrolyser capacity at La Robla from an initial 60MW after agreements with potential local buyers — steelmaker ArcelorMittal and fertiliser producer Fertiberia — and the drafting of Spain's projected hydrogen transport network, which will be located close to the planned hub.

Cepsa to develop Spain-Netherlands clean ammonia export route

Spanish energy firm Cepsa has signed an initial agreement to supply green ammonia to the Netherlands, laying the groundwork for a clean hydrogen corridor between northern and southern Europe. Cepsa will export its green ammonia to the planned ACE import terminal at the port of Rotterdam that is to be developed by Dutch gas system operator Gasunie, bulk handling firm HES International and storage company Vopak. The supply will then be converted into green hydrogen to be used in shipping and other industries in northwest Europe. Exports are expected to begin in 2027.

COMPLETE HYDROGEN PRODUCTION COSTS

No-C Hydrogen									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 14 Feb	Price	Price in $/kg	± 14 Feb
Netherlands	Wind + PEM	Green	€/kg	5.94	6.35	nc	4.17	4.46	nc
Netherlands	Grid + GOO + ALK	Green	€/kg	11.08	11.84	-0.16	10.01	10.69	-0.16
UK	Wind + PEM	Green	£/kg	5.03	6.05	nc	3.48	4.19	nc
UK	Grid + GOO + ALK	Green	£/kg	12.31	14.81	-0.25	11.38	13.69	-0.25
Germany	Wind + PEM	Green	€/kg	7.09	7.57	nc	5.29	5.65	nc
Germany	Grid + GOO + ALK	Green	€/kg	11.57	12.36	-0.15	10.48	11.20	-0.15
France	Wind + PEM	Green	€/kg	7.28	7.78	nc	5.48	5.86	nc
France	Grid + GOO + ALK	Green	€/kg	14.09	15.05	+0.01	13.01	13.90	+0.02
Spain	Diurnal + PEM	Green	€/kg	4.73	5.05	nc	2.95	3.15	nc
Spain	Grid + GOO + ALK	Green	€/kg	10.07	10.76	-0.22	8.96	9.57	-0.22
US west coast	Diurnal + PEM	Green	$/kg	5.12	5.12	nc	3.29	3.29	nc
Canada	Wind + PEM	Green	C$/kg	8.65	6.43	nc	6.07	4.51	nc
Oman	Diurnal + PEM	Green	$/kg	5.45	5.45	nc	3.53	3.53	nc
Saudi Arabia	Diurnal + PEM	Green	$/kg	5.53	5.53	nc	3.61	3.61	nc
UAE	Diurnal + PEM	Green	$/kg	5.61	5.61	nc	3.83	3.83	nc
Qatar	Diurnal + PEM	Green	$/kg	5.59	5.59	nc	3.77	3.77	nc
Namibia	Diurnal + PEM	Green	$/kg	5.94	5.94	nc	3.61	3.61	nc
South Africa	Diurnal + PEM	Green	$/kg	5.90	5.90	nc	3.72	3.72	nc
Japan	Wind + PEM	Green	¥/kg	1,850	13.80	nc	1,590	11.86	nc
China	Diurnal + PEM	Green	Yn/kg	32.44	4.73	nc	19.55	2.85	nc
India	Diurnal + PEM	Green	Rs/kg	409.01	4.94	nc	243.42	2.94	nc
South Korea	Wind + PEM	Green	W/kg	16,676	12.92	nc	14,185	10.99	nc
Vietnam	Wind + PEM	Green	$/kg	7.86	7.86	nc	5.75	5.75	nc
Australia	Diurnal + PEM	Green	A$/kg	7.30	5.03	nc	4.61	3.18	nc
Brazil	Diurnal + PEM	Green	$/kg	5.41	5.41	nc	3.23	3.23	nc
Chile	Diurnal + PEM	Green	$/kg	5.40	5.40	nc	3.48	3.48	nc

Low-C hydrogen									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 14 Feb	Price	Price in $/kg	± 14 Feb
Netherlands	ATR + CCS	Blue	€/kg	4.35	4.65	-0.18	3.71	3.96	-0.18
UK	ATR + CCS	Blue	£/kg	3.82	4.60	-0.21	3.26	3.92	-0.21
Germany	ATR + CCS	Blue	€/kg	4.41	4.71	-0.18	3.74	4.00	-0.19
Spain	ATR + CCS	Blue	€/kg	4.22	4.51	-0.11	3.52	3.76	-0.11
France	ATR + CCS	Blue	€/kg	4.36	4.66	-0.12	3.70	3.95	-0.13
US Gulf coast	ATR + CCS	Blue	$/kg	1.86	1.86	+0.01	1.16	1.16	+0.01
Canada	ATR + CCS	Blue	C$/kg	2.70	2.01	+0.02	1.75	1.30	+0.02
Japan	ATR + CCS	Blue	¥/kg	610	4.55	-0.32	515	3.84	-0.31
South Korea	ATR + CCS	Blue	W/kg	5,524	4.28	-0.27	4,595	3.56	-0.27
Australia	ATR + CCS	Blue	A$/kg	4.90	3.38	+0.13	3.86	2.66	+0.12
Trinidad	ATR + CCS	Blue	$/kg	4.09	4.09	-0.11	3.02	3.02	-0.12
Qatar	ATR + CCS	Blue	$/kg	3.87	3.87	-0.24	3.15	3.15	-0.24
UAE	ATR + CCS	Blue	$/kg	4.02	4.02	-0.24	3.31	3.31	-0.24
Russia west	ATR + CCS	Blue	$/kg	1.84	1.84	-0.01	1.02	1.02	-0.01
Russia east	ATR + CCS	Blue	$/kg	1.72	1.72	-0.01	0.90	0.90	-0.01

COMPLETE HYDROGEN PRODUCTION COSTS

BAT+ hydrogen									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 14 Feb	Price	Price in $/kg	± 14 Feb
Netherlands	SMR + CCS	Blue	€/kg	3.68	3.93	-0.18	3.20	3.42	-0.18
UK	SMR + CCS	Blue	£/kg	3.12	3.76	-0.20	2.71	3.26	-0.20
Germany	SMR + CCS	Blue	€/kg	3.71	3.96	-0.18	3.23	3.45	-0.18
Spain	SMR + CCS	Blue	€/kg	3.57	3.81	-0.11	3.05	3.26	-0.11
France	SMR + CCS	Blue	€/kg	3.57	3.81	-0.12	3.08	3.29	-0.12
US Gulf coast	SMR + CCS	Blue	$/kg	1.35	1.35	nc	0.84	0.84	+0.01
Canada	SMR + CCS	Blue	C$/kg	1.78	1.32	-0.02	1.08	0.80	-0.02
Japan	SMR + CCS	Blue	¥/kg	503	3.75	-0.27	432	3.22	-0.27
South Korea	SMR + CCS	Blue	W/kg	4,789	3.71	-0.27	4,105	3.18	-0.27
Australia	SMR + CCS	Blue	A$/kg	3.99	2.75	+0.04	3.22	2.22	+0.03
Trinidad	SMR + CCS	Blue	$/kg	3.54	3.54	-0.12	2.76	2.76	-0.12
Qatar	SMR + CCS	Blue	$/kg	3.39	3.39	-0.24	2.86	2.86	-0.25
UAE	SMR + CCS	Blue	$/kg	3.39	3.39	-0.24	2.86	2.86	-0.25
Russia west	SMR + CCS	Blue	$/kg	1.31	1.31	-0.01	0.71	0.71	-0.01
Russia east	SMR + CCS	Blue	$/kg	1.20	1.20	-0.01	0.60	0.60	-0.01

BAT+ hydrogen							21 Feb
				Excl. capex			
	Process	Legacy colour	Unit	Price	Price in $/kg	± 14 Feb	
Netherlands	SMR + CCS retrofit	Blue	€/kg	3.36	3.59	-0.16	
UK	SMR + CCS retrofit	Blue	£/kg	2.83	3.40	-0.20	
Germany	SMR + CCS retrofit	Blue	€/kg	3.38	3.61	-0.17	
Spain	SMR + CCS retrofit	Blue	€/kg	3.21	3.43	-0.09	
France	SMR + CCS retrofit	Blue	€/kg	3.23	3.45	-0.12	
US Gulf coast	SMR + CCS retrofit	Blue	$/kg	0.81	0.81	nc	
Canada	SMR + CCS retrofit	Blue	C$/kg	1.17	0.87	-0.02	
Japan	SMR + CCS retrofit	Blue	¥/kg	429	3.20	-0.27	
South Korea	SMR + CCS retrofit	Blue	W/kg	4,105	3.18	-0.26	
Australia	SMR + CCS retrofit	Blue	A$/kg	3.19	2.20	+0.03	
Trinidad	SMR + CCS retrofit	Blue	$/kg	2.74	2.74	-0.12	
Qatar	SMR + CCS retrofit	Blue	$/kg	2.84	2.84	-0.24	
UAE	SMR + CCS retrofit	Blue	$/kg	2.84	2.84	-0.24	
Russia west	SMR + CCS retrofit	Blue	$/kg	0.69	0.69	-0.01	
Russia east	SMR + CCS retrofit	Blue	$/kg	0.58	0.58	-0.01	

BAT+ hydrogen											21 Feb
					Incl. capex			Excl. capex			
	Process	kcal/kg NAR	Legacy colour	Unit	Price	Price in $/kg	± 14 Feb	Price	Price in $/kg	± 14 Feb	
Australia	Coal gasification + CCS	5,500	Blue	A$/kg	4.61	3.18	nc	3.53	2.43	nc	
Australia	Coal gasification + CCS	6,000	Blue	A$/kg	5.79	3.99	-0.24	4.70	3.24	-0.25	
China	Coal gasification + CCS	3,800	Blue	Yn/kg	23.11	3.37	-0.11	17.83	2.60	-0.11	
China	Coal gasification + CCS	5,500	Blue	Yn/kg	23.11	3.37	-0.13	17.83	2.60	-0.13	
Indonesia	Coal gasification + CCS	5,500	Blue	$/kg	3.21	3.21	-0.10	2.38	2.38	-0.10	
Indonesia	Coal gasification + CCS	3,800	Blue	$/kg	2.97	2.97	-0.09	2.14	2.14	-0.09	
South Africa	Coal gasification + CCS	4,800	Blue	$/kg	3.25	3.25	-0.01	2.25	2.25	-0.01	
South Africa	Coal gasification + CCS	6,000	Blue	$/kg	3.40	3.40	-0.05	2.40	2.40	-0.05	
Russia west	Coal gasification + CCS	6,000	Blue	$/kg	2.72	2.72	nc	1.86	1.86	nc	
US east coast	Coal gasification + CCS	6,000	Blue	$/kg	3.14	3.14	-0.05	2.40	2.40	-0.05	

COMPLETE HYDROGEN PRODUCTION COSTS

Baseline hydrogen									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 14 Feb	Price	Price in $/kg	± 14 Feb
Netherlands	SMR	Grey	€/kg	3.74	4.00	-0.12	3.47	3.71	-0.13
UK	SMR	Grey	£/kg	3.10	3.73	-0.18	2.87	3.45	-0.18
Germany	SMR	Grey	€/kg	3.76	4.02	-0.13	3.49	3.73	-0.13
Spain	SMR	Grey	€/kg	3.63	3.88	-0.06	3.34	3.57	-0.06
France	SMR	Grey	€/kg	3.63	3.88	-0.08	3.36	3.59	-0.08
US Gulf coast	SMR	Grey	$/kg	0.84	0.84	nc	0.56	0.56	+0.01
Canada	SMR	Grey	C$/kg	1.63	1.21	-0.02	1.24	0.92	-0.01
Japan	SMR	Grey	¥/kg	405	3.02	-0.25	366	2.73	-0.24
South Korea	SMR	Grey	W/kg	3,963	3.07	-0.24	3,575	2.77	-0.25
Australia	SMR	Grey	A$/kg	3.06	2.11	+0.03	2.64	1.82	+0.03
Trinidad	SMR	Grey	$/kg	2.75	2.75	-0.11	2.31	2.31	-0.11
Qatar	SMR	Grey	$/kg	2.70	2.70	-0.22	2.40	2.40	-0.22
UAE	SMR	Grey	$/kg	2.70	2.70	-0.22	2.40	2.40	-0.22
Russia west	SMR	Grey	$/kg	0.78	0.78	-0.01	0.44	0.44	-0.01
Russia east	SMR	Grey	$/kg	0.68	0.68	-0.01	0.34	0.34	-0.01

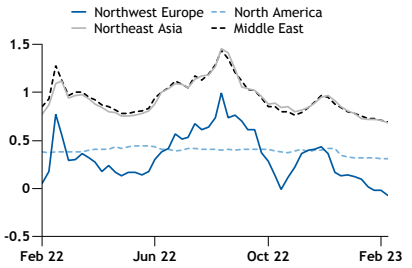
Baseline hydrogen									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 14 Feb	Price	Price in $/kg	± 14 Feb
Netherlands	Grid + ALK	Yellow	€/kg	10.72	11.45	-0.18	9.65	10.31	-0.18
Netherlands	Grid + PEM	Yellow	€/kg	11.11	11.87	-0.17	9.40	10.04	-0.17
UK	Grid + ALK	Yellow	£/kg	11.95	14.38	-0.22	11.02	13.26	-0.22
UK	Grid + PEM	Yellow	£/kg	12.12	14.58	-0.21	10.63	12.79	-0.21
Germany	Grid + ALK	Yellow	€/kg	11.21	11.98	-0.17	10.13	10.82	-0.17
Germany	Grid + PEM	Yellow	€/kg	11.58	12.37	-0.15	9.85	10.52	-0.16
France	Grid + ALK	Yellow	€/kg	13.73	14.67	nc	12.65	13.51	-0.01
France	Grid + PEM	Yellow	€/kg	13.92	14.87	nc	12.20	13.03	nc
Spain	Grid + ALK	Yellow	€/kg	9.71	10.37	-0.25	8.59	9.18	-0.25
Spain	Grid + PEM	Yellow	€/kg	10.20	10.90	-0.22	8.42	9.00	-0.22
US west coast	Grid + ALK	Yellow	$/kg	7.82	7.82	+0.75	6.67	6.67	+0.75
US west coast	Grid + PEM	Yellow	$/kg	8.49	8.49	+0.70	6.65	6.65	+0.69
US Midwest	Grid + ALK	Yellow	$/kg	4.68	4.68	+0.04	3.53	3.53	+0.04
US Midwest	Grid + PEM	Yellow	$/kg	5.57	5.57	+0.04	3.73	3.73	+0.03
US east coast	Grid + ALK	Yellow	$/kg	5.10	5.10	+0.08	3.95	3.95	+0.08
US east coast	Grid + PEM	Yellow	$/kg	5.96	5.96	+0.08	4.12	4.12	+0.07
Japan	Grid + ALK	Yellow	¥/kg	1,667	12.44	-1.22	1,511	11.27	-1.22
Japan	Grid + PEM	Yellow	¥/kg	1,717	12.81	-1.13	1,466	10.94	-1.14

COMPLETE HYDROGEN PRODUCTION COSTS

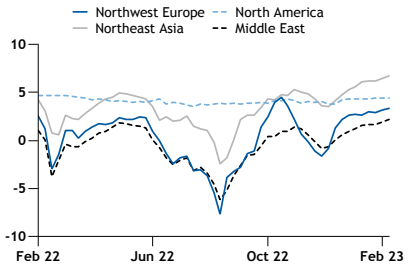
Decarbonisation spreads				21 Feb
	Incl. capex		Excl. capex	
	$/kg	± 14 Feb	$/kg	± 14 Feb
Northwest Europe				
No-C to BAT+	3.33	+0.16	1.93	+0.16
BAT+ to baseline	-0.07	-0.05	-0.29	-0.05
North America				
No-C to BAT+	4.44	+0.01	3.08	+0.01
BAT+ to baseline	0.31	nc	0.08	-0.01
Northeast Asia				
No-C to BAT+	6.75	+0.27	5.37	+0.27
BAT+ to baseline	0.68	-0.03	0.45	-0.02
Middle East				
No-C to BAT+	2.16	+0.24	0.83	+0.25
BAT+ to baseline	0.69	-0.02	0.46	-0.03
Net exporter				
No-C to BAT+	2.69	+0.11	1.25	+0.11
BAT+ to baseline	0.63	-0.01	0.40	-0.01

DATA

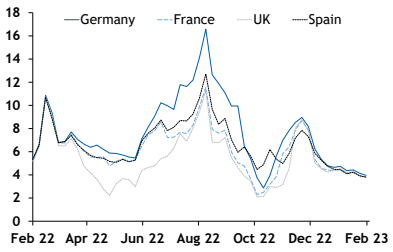
Decarb spread BAT+ to baseline $/t



Decarb spread No-C to BAT+ $/t



SMR+CCS H2 costs $/t



Argus Hydrogen and Future Fuels Data & Downloads

Argus Hydrogen and Future Fuels subscribers can access the full range of data available to the service through the Data & Downloads section of Argus Direct or by clicking on the links below.

- Global cross-border offtake agreements for low-carbon hydrogen and derivatives
- H2Global tenders for hydrogen and derivatives
- Global e-Methanol production facilities
- Global electrolyser orders
- Global electrolyser manufacturing capacity

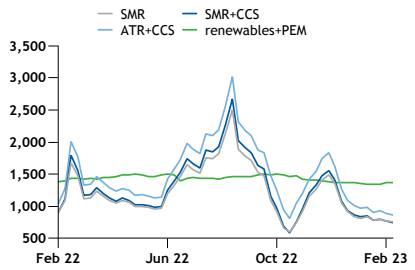
COMPLETE AMMONIA PRODUCTION COSTS

Argus liquid ammonia taxonomy (for calculated costs)	
	tCO2e/tNH3
Baseline	<1.93, >1.37
BAT+	<0.49, >0.17
Low-C	<0.17, >0.09
No-C	<0.01

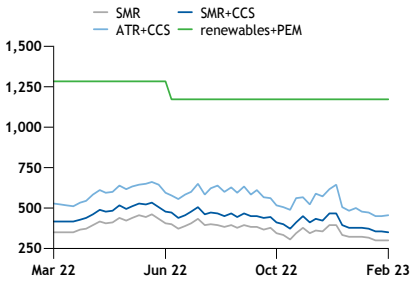
CO2e emissions on a gate-to-gate basis; purity >99.5pc; temperature -33°C

Regional ammonia cost markers						21 Feb
			Incl. capex		Excl. capex	
	Process	Unit	Cost	± 14 Feb	Cost	± 14 Feb
Baseline						
Northwest Europe	SMR	€/t	749	-15	640	-17
Northwest Europe	SMR	$/t	800	-18	684	-19
North America	SMR	$/t	298	-2	183	+1
Northeast Asia	SMR	$/t	630	-41	511	-42
Middle East	SMR	$/t	551	-37	437	-37
BAT+						
Northwest Europe	SMR+CCS	€/t	739	-22	593	-25
Northwest Europe	SMR+CCS	$/t	789	-26	634	-28
North America	SMR+CCS	$/t	351	-2	196	-1
Northeast Asia	SMR+CCS	$/t	747	-46	588	-46
Middle East	SMR+CCS	$/t	669	-41	516	-42
Low-C						
Northwest Europe	ATR+CCS	€/t	862	-23	687	-25
Northwest Europe	ATR+CCS	$/t	921	-27	734	-28
North America	ATR+CCS	$/t	453	+2	266	+2
Northeast Asia	ATR+CCS	$/t	863	-51	673	-50
Middle East	ATR+CCS	$/t	763	-42	579	-41
No-C						
Northwest Europe	Island renewable+PEM	€/t	1,365	+3	988	+2
Northwest Europe	Island renewable+PEM	$/t	1,458	nc	1,056	nc
North America	Island renewable+PEM	$/t	1,173	nc	782	nc
Northeast Asia	Island renewable+PEM	$/t	2,050	nc	1,648	nc
Middle East	Island renewable+PEM	$/t	1,095	nc	705	nc
Exporter						
Exporter baseline	SMR	$/t	465	-17	350	-17
Exporter BAT+	SMR+CCS	$/t	573	-19	418	-20
Exporter low-C	ATR+CCS	$/t	669	-14	482	-15
Exporter no-C	Island renewable+PEM	$/t	1,081	nc	671	nc

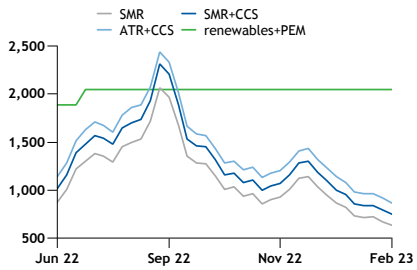
NW Europe ammonia average €/t



North America ammonia average $/t



Northeast Asia ammonia average $/t



COMPLETE AMMONIA PRODUCTION COSTS

No-C ammonia									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/t	± 14 Feb	Price	Price in $/t	± 14 Feb
Netherlands	Wind + PEM	Green	€/t	1,214	1,297	nc	842	900	nc
UK	Wind + PEM	Green	£/t	1,014	1,220	nc	688	828	nc
Germany	Wind + PEM	Green	€/t	1,416	1,513	nc	1,039	1,110	nc
France	Wind + PEM	Green	€/t	1,463	1,563	nc	1,085	1,159	nc
Spain	Diurnal + PEM	Green	€/t	952	1,017	nc	583	623	nc
US west coast	Diurnal + PEM	Green	$/t	1,040	1,040	nc	663	663	nc
Canada	Wind + PEM	Green	C$/t	1,755	1,305	nc	1,212	901	nc
Oman	Diurnal + PEM	Green	$/t	1,077	1,077	nc	674	674	nc
Saudi Arabia	Diurnal + PEM	Green	$/t	1,090	1,090	nc	688	688	nc
UAE	Diurnal + PEM	Green	$/t	1,108	1,108	nc	734	734	nc
Qatar	Diurnal + PEM	Green	$/t	1,104	1,104	nc	725	725	nc
Namibia	Diurnal + PEM	Green	$/t	1,189	1,189	nc	687	687	nc
South Africa	Diurnal + PEM	Green	$/t	1,171	1,171	nc	706	706	nc
Japan	Wind + PEM	Green	¥/t	359,889	2,685	nc	305,202	2,277	nc
China	Diurnal + PEM	Green	Yn/t	6,405	934	nc	3,738	545	nc
India	Diurnal + PEM	Green	Rs/t	80,643	974	nc	46,035	556	nc
South Korea	Wind + PEM	Green	W/t	3,266,848	2,531	nc	2,740,228	2,123	nc
Vietnam	Wind + PEM	Green	$/t	1,547	1,547	nc	1,093	1,093	nc
Australia	Diurnal + PEM	Green	A$/t	1,492	1,028	nc	939	647	nc
Brazil	Diurnal + PEM	Green	$/t	1,076	1,076	nc	614	614	nc
Chile	Diurnal + PEM	Green	$/t	1,063	1,063	nc	664	664	nc

Low-C ammonia									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/t	± 14 Feb	Price	Price in $/t	± 14 Feb
Netherlands	ATR + CCS	Blue	€/t	863	922	-30	691	738	-31
UK	ATR + CCS	Blue	£/t	743	894	-35	594	715	-36
Germany	ATR + CCS	Blue	€/t	862	921	-31	685	732	-32
Spain	ATR + CCS	Blue	€/t	828	885	-19	642	686	-19
France	ATR + CCS	Blue	€/t	860	919	-20	684	731	-22
US Gulf coast	ATR + CCS	Blue	$/t	441	441	+2	255	255	+1
Canada	ATR + CCS	Blue	C$/t	625	465	+3	373	277	+4
Japan	ATR + CCS	Blue	¥/t	118,221	882	-55	92,754	692	-53
South Korea	ATR + CCS	Blue	W/t	1,089,379	844	-47	844,140	654	-46
Australia	ATR + CCS	Blue	A$/t	1,026	707	+22	749	516	+20
Trinidad	ATR + CCS	Blue	$/t	829	829	-19	542	542	-21
Qatar	ATR + CCS	Blue	$/t	753	753	-41	566	566	-41
UAE	ATR + CCS	Blue	$/t	773	773	-42	591	591	-41
Russia west	ATR + CCS	Blue	$/t	413	413	-2	197	197	-2
Russia east	ATR + CCS	Blue	$/t	393	393	-1	177	177	-1

COMPLETE AMMONIA PRODUCTION COSTS

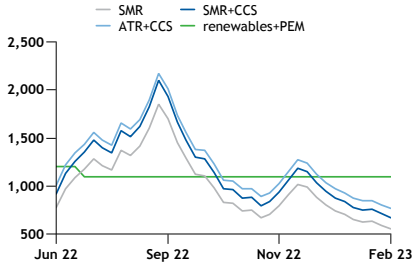
BAT+ ammonia									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/t	± 14 Feb	Price	Price in $/t	± 14 Feb
Netherlands	SMR + CCS	Blue	€/t	748	799	-30	605	646	-31
UK	SMR + CCS	Blue	£/t	623	750	-34	500	602	-34
Germany	SMR + CCS	Blue	€/t	742	793	-30	597	638	-31
Spain	SMR + CCS	Blue	€/t	716	765	-19	562	600	-19
France	SMR + CCS	Blue	€/t	724	774	-20	578	618	-21
US Gulf coast	SMR + CCS	Blue	$/t	354	354	nc	201	201	+2
Canada	SMR + CCS	Blue	C$/t	467	347	-4	257	191	-4
Japan	SMR + CCS	Blue	¥/t	99,992	746	-46	78,546	586	-46
South Korea	SMR + CCS	Blue	W/t	964,178	747	-46	760,242	589	-46
Australia	SMR + CCS	Blue	A$/t	871	600	+7	640	441	+5
Trinidad	SMR + CCS	Blue	$/t	735	735	-20	498	498	-20
Qatar	SMR + CCS	Blue	$/t	671	671	-41	516	516	-43
UAE	SMR + CCS	Blue	$/t	666	666	-41	515	515	-42
Russia west	SMR + CCS	Blue	$/t	323	323	-1	144	144	-2
Russia east	SMR + CCS	Blue	$/t	304	304	-1	125	125	-2

BAT+ ammonia										21 Feb
					Incl. capex			Excl. capex		
	Process	kcal/kg NAR	Legacy colour	Unit	Price	Price in $/t	± 14 Feb	Price	Price in $/t	± 14 Feb
Australia	Coal gasification + CCS	5,500	Blue	A$/t	888	612	nc	641	442	nc
Australia	Coal gasification + CCS	6,000	Blue	A$/t	1,088	750	-41	843	581	-43
China	Coal gasification + CCS	3,800	Blue	Yn/t	4,321	630	-19	3,134	457	-19
China	Coal gasification + CCS	5,500	Blue	Yn/t	4,321	630	-23	3,134	457	-22
Indonesia	Coal gasification + CCS	5,500	Blue	$/t	604	604	-17	418	418	-17
Indonesia	Coal gasification + CCS	3,800	Blue	$/t	563	563	-16	377	377	-15
South Africa	Coal gasification + CCS	4,800	Blue	$/t	622	622	-2	396	396	-1
South Africa	Coal gasification + CCS	6,000	Blue	$/t	648	648	-8	421	421	-9
Russia west	Coal gasification + CCS	6,000	Blue	$/t	524	524	nc	331	331	nc
US east coast	Coal gasification + CCS	6,000	Blue	$/t	602	602	-9	436	436	-8

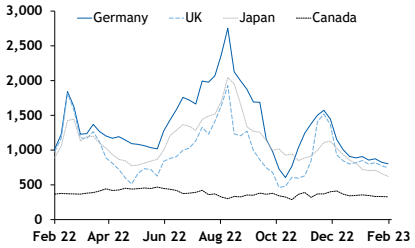
Baseline ammonia									21 Feb
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/t	± 14 Feb	Price	Price in $/t	± 14 Feb
Netherlands	SMR	Grey	€/t	759	811	-20	651	696	-22
UK	SMR	Grey	£/t	619	745	-31	528	635	-30
Germany	SMR	Grey	€/t	752	803	-22	642	686	-22
Spain	SMR	Grey	€/t	727	777	-10	611	653	-11
France	SMR	Grey	€/t	736	786	-13	626	669	-14
US Gulf coast	SMR	Grey	$/t	267	267	nc	153	153	+2
Canada	SMR	Grey	C$/t	441	328	-4	285	212	-1
Japan	SMR	Grey	¥/t	83,237	621	-42	67,287	502	-41
South Korea	SMR	Grey	W/t	823,488	638	-41	669,891	519	-43
Australia	SMR	Grey	A$/t	711	490	+5	541	373	+5
Trinidad	SMR	Grey	$/t	600	600	-18	421	421	-19
Qatar	SMR	Grey	$/t	553	553	-37	438	438	-37
UAE	SMR	Grey	$/t	548	548	-37	436	436	-37
Russia west	SMR	Grey	$/t	232	232	-2	98	98	-2
Russia east	SMR	Grey	$/t	215	215	-2	81	81	-2

COMPLETE AMMONIA PRODUCTION COSTS

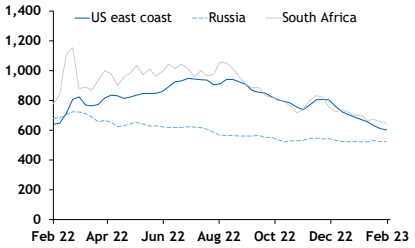
Middle East ammonia average $/t



SMR ammonia costs $/t



Coal ammonia NAR 6,000 $/t



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