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Argus Hydrogen and Future Fuels

Market news, analysis and prices

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Netherlands earmarks €7.8bn for hydrogen

Two thirds of the funds will support onshore renewable hydrogen facilities with electrolyser capacity of 500-1,000MW, in a bid to scale up output, writes Stefan Krumpelmann

The Netherlands has earmarked €7.8bn for renewable hydrogen production, as well as hydrogen transport and storage infrastructure, as part of a €28.1bn package to help the country achieve its 2030 climate goals. The bulk of the funding is supposed to be spend on renewable hydrogen production projects with electrolysis capacity of at least 500MW, demonstrating the industry's expected — and necessary — scale up in the coming years.

The funding for hydrogen-related support will be split across nine categories (*see table*), which are part of the larger package of 120 measures intended to reduce emissions by a further 22mn t of CO_2 equivalent by 2030. Such additional reductions would put the Netherlands on track to meet its target of cutting emissions by 55-60pc from 1990 levels.

Dutch support for H2	€mn
Onshore electrolysis 500-1,000MW	4,900
Offshore electrolysis up to 500MW	1,780
Offshore electrolysis up to 100MW	380
Imports via German H2Global scheme	300
Onshore electrolysis 50MW	250
De-risking large-scale storage	250
Use for road transport and inland shipping	178
Offshore hydrogen network	50
Offshore hydrogen knowledge centre	2

— *Dutch government*

Nearly two thirds of the hydrogen-specific funds have been reserved as support for onshore renewable hydrogen facilities with an electrolyser capacity of 500-1,000MW, in a bid to significantly scale up production projects. These schemes would be much larger than the biggest in Europe for which a final investment decision (FID) has been taken — Shell's 200MW Hydrogen Holland 1 complex in Rotterdam. The Netherlands is officially targeting 3-4GW electrolyser capacity by 2030, but energy minister Rob Jetten has indicated that the country might double its targets which would likely require a number of larger-scale projects to materialise over the remainder of this decade.

The Hague did not specify the mechanisms that will support these projects. But it indicated that a few preconditions would have to be met for the developments to get off the ground, including EU approval for state support, a revised estimate of possible CO2 reductions through the support and progress on the path to introducing purchase obligations for consumers to guarantee offtake.

Another €1.78bn has been earmarked for offshore hydrogen production — a technology that is still in its infancy and is yet to be proven at any significant scale. Some €380mn of this will be used for a demonstration project with an electrolyser capacity of up to 100MW, while €1.4bn will be used to support capital and operating expenditure of a 500MW project. The area for the larger project will be allocated at a tender announced in March — the government says this will be the largest offshore hydrogen production area in the world.

While the climate package funding promises to boost production projects, the comparatively small amounts earmarked for transport and storage infrastructure might raise concerns among those that view support for these areas as crucial.

Several industry observers, including the International Energy Agency, have recently voiced concerns that development of hydrogen infrastructure is not proceeding quickly enough and could prove a bottleneck in the build-out of a hydrogen economy. And the €50mn earmarked by The Hague for development of an offshore transport network and the €250mn set aside for de-risking large-scale hydrogen storage projects pale in comparison with the funds allocated for production facilities. A lack of storage, in particular, could pose a challenge for Europe as it might prevent hydrogen from helping to balance swings in demand.

That said, the Netherlands has progressed much further and quicker with plans to develop a national hydrogen transport grid — including some storage sites — than other European countries.

Subscriber notice

The next issue of *Argus Hydrogen and Future Fuels* will be published on Wednesday 10 May because of a UK public holiday on Monday 8 May.

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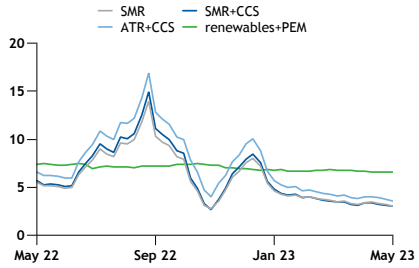
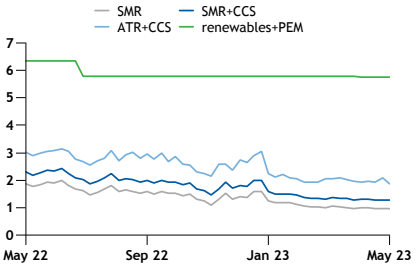
HYDROGEN PRICES

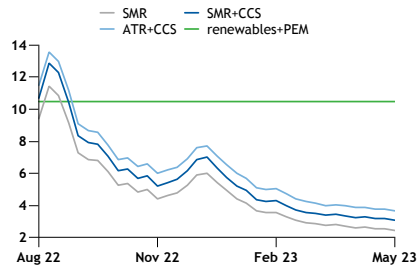
Northwest Europe average cost €/kg



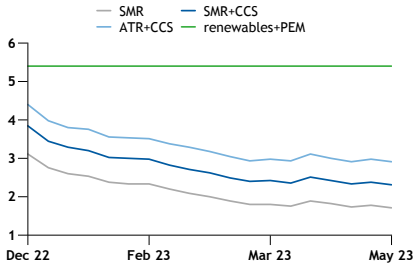
North America average cost $/kg



Northeast Asia average cost $/kg



Exporter average cost $/kg



Regional hydrogen cost markers — 2 May

	Process	Unit	Incl. capex Cost	Incl. capex ± 25 Apr	Excl. capex Cost	Excl. capex ± 25 Apr
Baseline						
Northwest Europe	SMR	€/kg	3.04	-0.16	2.77	-0.15
Northwest Europe	SMR	$/kg	3.35	-0.16	3.05	-0.15
North America	SMR	$/kg	0.98	nc	0.67	nc
Northeast Asia	SMR	$/kg	2.41	-0.10	2.10	-0.10
Middle East	SMR	$/kg	2.15	-0.08	1.83	-0.09
BAT+						
Northwest Europe	SMR+CCS	€/kg	2.99	-0.12	2.49	-0.12
Northwest Europe	SMR+CCS	$/kg	3.29	-0.12	2.74	-0.12
North America	SMR+CCS	$/kg	1.29	nc	0.75	nc
Northeast Asia	SMR+CCS	$/kg	3.05	-0.10	2.49	-0.11
Middle East	SMR+CCS	$/kg	2.80	-0.09	2.24	-0.09
Low-C						
Northwest Europe	ATR+CCS	€/kg	3.60	-0.14	2.92	-0.13
Northwest Europe	ATR+CCS	$/kg	3.96	-0.14	3.22	-0.13
North America	ATR+CCS	$/kg	1.86	-0.21	1.11	-0.21
Northeast Asia	ATR+CCS	$/kg	3.65	-0.10	2.89	-0.10
Middle East	ATR+CCS	$/kg	3.38	-0.09	2.62	-0.09
No-C						
Northwest Europe	Island renewable+PEM	€/kg	6.55	-0.02	4.83	-0.02
Northwest Europe	Island renewable+PEM	$/kg	7.21	nc	5.32	nc
North America	Island renewable+PEM	$/kg	5.76	nc	3.90	nc
Northeast Asia	Island renewable+PEM	$/kg	10.46	nc	8.57	nc
Middle East	Island renewable+PEM	$/kg	5.53	nc	3.69	nc
Exporter						
Exporter baseline	SMR	$/kg	1.71	-0.06	1.40	-0.06
Exporter BAT+	SMR+CCS	$/kg	2.32	-0.06	1.77	-0.06
Exporter low-C	ATR+CCS	$/kg	2.91	-0.06	2.15	-0.07
Exporter no-C	Island renewable+PEM	$/kg	5.39	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 — 4 Apr

	Unit	Price	± 3 Mar
Japan			
Eneos	¥/kg	1,650.00	nc
Iwatani	¥/kg	1,210.00	nc
Germany			
H2Mobility	€/kg	12.85	nc

MARKET DEVELOPMENTS

Electrolyser firms gear up for mass manufacturing

Previous examples suggest scaling up is seldom a straightforward process, writes Aidan Lea

Electrolyser makers have promised for some years that factory automation and expansion will cut equipment costs and unlock economically viable hydrogen production, but so far only a handful of participants have reached capacity for hundreds of megawatts of electrolysers. Recent announcements suggest more companies are preparing to take the step up, but questions remain over whether ambitious deadlines can be met, given the track record of electrolyser makers that have so far targeted expansions.

Several manufacturers outlined their scale-up plans at the Hydrogen and Fuel Cells conference in Hanover last month. Among them was US-headquartered Cummins which, through its new brand Accelera, plans to reach 2 GW/yr of capacity across North America, China and Europe by next year, Accelera's global business development leader Denis Thomas said. Cummins made tangible progress this week, with Chinese subsidiary Cummins Enze commissioning its proton exchange membrane (PEM) electrolyser factory in Guangdong province that is to reach 500 MW/yr in a first phase. Meanwhile, Germany's Sunfire said at the Hanover conference that it aims to reach 750 MW/yr of alkaline capacity by the end of 2023.

Other manufacturers are also making progress. Last month, Germany's H-Tec broke ground on a Hamburg factory that is to produce 'multiple hundred megawatts' of PEM electrolysis cells from early 2024, saying that it aims to reach 5 GW/yr eventually. Danish peer Topsoe this week broke ground on its SOEC factory at Herning, which is expected to produce 500 MW/yr from 2025. US firm Plug Power announced plans to invest nearly $750mn in a South Korean factory with domestic SK E&S. Plug said earlier this year that it expects to reach production of 100 MW/month at its existing facilities this quarter, equivalent to 1.2 GW/yr.

Deadline doubts

But while these announcements suggest potential for a sharp rise in manufacturing capacity in the coming year, this depends on companies meeting their deadlines — and there is reason for scepticism.

US-headquartered Ohmium, which manufactures electrolysers in India, announced last month that it had raised $250mn to help increase its global capacity to 2 GW/yr — an expansion that the firm had initially set for the end of 2022. The company says it decided to "further optimise and automate internal manufacturing processes", before scaling up. Other firms — such as Denmark's Green Hydrogen Systems and UK-based Clean Power Hydrogen — have also faced difficulties translating their product designs for large-scale production.

High inflation, supply chain disruptions and overall economic uncertainty have not made the task any easier for manufacturers. UK-based ITM cited these factors, among others, for sharply scaling back expansion plans for 2024 to 1.5 GW/yr from 5 GW/yr, but the firm also "underestimated the competencies and capabilities required to transition from a research and development company to a volume manufacturer", chief executive Dennis Schulz has said.

The chasing pack must avoid any missteps over the next few years to keep pace with rivals, some of which already have more than 1 GW/yr of capacity. While demand for electrolysers is poised to soar, competition for orders will probably be stiff. Companies that achieve scale first will be able to offer competitive prices, while latecomers might find themselves shut out of the market — unless they can offer a technological edge. Manufacturers still have time to get organised before the largest hydrogen projects start placing orders, Schulz said earlier this year. But the window of opportunity to stake a claim is starting to narrow and actions in the next year or two could be decisive.

Electrolyser manufacturing capacity data and download

For an overview of electrolyser manufacturing capacity and company targets, access the *Argus* data and download file 'Global electrolyser manufacturing capacity' here

For any queries, please contact hydrogen@argusmedia.com

MARKET DEVELOPMENTS

North Sea CCS plans constrained by lack of policy

European energy firms call for clarity on government support for carbon capture and storage, writes Georgia Gratton

Government representatives from nine countries met in Ostend, Belgium, last week for the North Sea Summit, with the aim of turning the North Sea into "the biggest green power plant in the world", according to Belgian prime minister Alexander De Croo. But while carbon capture and storage (CCS) was high on the agenda, given the geological advantages offered by the North Sea, no concrete agreement or new policy emerged from the summit.

The UK, Ireland, France, Germany, Belgium, Luxembourg, the Netherlands, Denmark and Norway committed to new offshore wind targets, while the UK and the Netherlands signed a 1.8GW interconnector project. But progress on CCS development was comparatively vague, despite Norway's presence. The country leads in Europe's CCS development and has large potential CO_2 stores. The 80pc state-funded Northern Lights CO_2 storage project is due to start up next year.

The EU and Norway signed a green alliance at the summit on clean energy, hydrogen and CCS, but the agreement contained no financial commitments or new policy. Belgium and Norway began formal talks on cross-border CO_2 transport, but the most solid pledge was to "formalise a bilateral agreement… as soon as possible", according to De Croo. Countries are currently not legally able to transport carbon cross-border for storage unless there is a bilateral agreement between the exporting and importing countries in place.

Another potential curb on development is the need for a full value chain to be up and running, comprising CO_2 capture, transport and storage projects. "We urgently need this new strategy, we are missing the regulatory framework," German upstream independent Wintershall's chief technology officer Hugo Dijkgraaf said last week. Germany is currently working on its carbon management strategy. "If Germany… wants to keep pace, our politicians must now clear a path," Dijkgraaf said. Wintershall aims to abate 20mn-30mn t/yr of CO_2 by 2040.

Hanging in the balance

The UK has 78bn t of storage potential and CCS is a "colossal opportunity waiting for us in the North Sea", UK energy minister Grant Shapps said last week. But while two storage clusters have been approved for mid-decade deployment, the government has advanced just eight capture projects — from a shortlist of 20 — to the next stage of negotiations, and it is not clear when they will receive support. Just three of these were based in the northeast, in the Teesside region, while none were chosen from the UK's industry-heavy Humber region, including UK utility Drax's bioenergy with CCS (Beccs) project.

Several Teesside CO_2 capture projects "hang in the balance", an industry representative said last week. Shell and the UK's National Grid Ventures last week pulled out of the planned Northern Endurance Partnership CCS project, which would transport and store carbon from both the Humber and Teesside capture projects. Shell plans to focus on the planned Acorn CCS cluster in Scotland, of which it is technical director. BP, Norway's Equinor and TotalEnergies remain partners in the Northern Endurance project.

The UK government has suggested that projects that were not selected this time will have another shot later this year and has begun formal talks directly with Drax. The company told an *Argus* conference in April that it would use the sale of voluntary carbon credits to partly fund its planned Beccs projects in the US and the UK. But elsewhere in Europe, emissions trading system prices will "play a determining role", Dijkgraaf said. Funding CCS through voluntary carbon credits is "not part of our strategy or plans", Wintershall chief executive Mario Mehren said.

NEWS

EU agrees mandates for hydrogen in aviation

EU institutions have reached an agreement on sub-targets for use of hydrogen and derivatives in the aviation sector, as part of a deal obliging fuel suppliers to blend sustainable aviation fuels (SAFs) with conventional jet fuel.

The European Parliament and the European Council, which represents member states, agreed last week that synthetic aviation fuels, such as hydrogen and e-kerosine, must reach a total share of aviation fuels of 1.2pc in 2030, 2pc in 2032, 5pc in 2035, and 35pc in 2050.

While these sub-targets for synthetic fuels only take effect from 2025, the agreement envisages an initial quote for SAFs in general already applying from 2025 — starting at 2pc, but rising as high as 70pc by 2050 (*see table*).

SAFs also include non-food and non-feed biofuels, notably from agricultural or forestry residues, algae, bio-waste, used cooking oil and some animal fats. Jet fuel produced from waste gases and waste plastic is also included.

The regulation must still be formally approved by parliament's plenary session — something likely to happen later this year — and then by EU ministers. It will be directly applicable in all 27 member states and does not allow countries to set other individual national mandates.

Industry body Hydrogen Europe says it welcomes the compromise reached between the institutions, but it noted that "not setting a first target as early as 2025 might be a missed opportunity".

Non-governmental organisation Transport & Environment was also satisfied with the outcome of the negotiations on the hydrogen-related sub-targets. Synthetic fuels "are the only type of SAFs that can sustainably be scaled up to meet the fuel demands of the sector", it said. And the agreed mandates are a "stark increase" from the European Commission proposal of 0.7pc from 2030 until 2035, signalling "a major win" for parliament.

The deal on aviation is the latest in a series of agreements on targets for hydrogen use in various sectors across the bloc. EU institutions in late March agreed on mandates for the maritime sector, on use of renewable hydrogen in industry and on goals for the development of a network of hydrogen refuelling stations.

By Dafydd ab Iago and Stefan Krumpelmann

EU SAF targets	%
Year	Share of overall aviation fuels
2025	2
2030	6
2035	20
2040	34
2045	42
2050	70

— European Parliament

India's Avaada raises $1bn for green H2 projects

Mumbai-based renewable power developer Avaada says it has raised $1.07bn to fund renewable hydrogen and ammonia projects.

The bulk of the funding has come from the renewables arm of Canadian asset management company Brookfield, which plans to invest up to $1bn, while Thai power utility Global Power Synergy Company (GPSC) — backed by state-owned PTT — will invest $68mn, Avaada says. GPSC bought 41.6pc of Avaada for 14.8bn baht ($434mn) in 2021. Avaada is in advanced discussions with potential investors to raise another $200mn, it says.

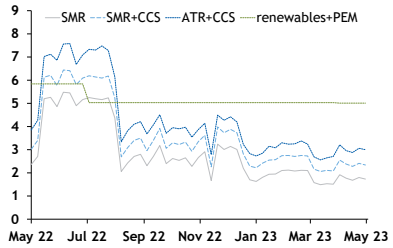
The funds could support the firm's green ammonia projects, including a 1mn t/yr plant in Rajasthan, facilities of the same size in Karnataka and Andhra Pradesh, and a hydrogen plant in Maharashtra. Avaada estimates that the plant in Rajasthan would cost around $5bn, while officials from Maharasthra indicated that the plant in their state could require investment of $5.6bn. This suggests that the four planned sites could cost over $20bn to build.

Avaada currently operates a 4GW renewable power portfolio, which it plans to increase to 11GW by 2026.

By Aidan Lea

NEWS

Australian H2 costs $/kg



Australia's Woodside, Keppel eye Singapore liquid H2

Australian independent Woodside Energy has signed a non-binding preliminary agreement with Singapore's Keppel Data Centres (KDC) in a push to deliver liquid hydrogen (LH2) shipments to the city-state by 2030.

Woodside says the preliminary agreement provides a pathway for the parties to develop further commercial principles for an LH2 supply chain between Singapore and any of Woodside's four proposed facilities across Australia, New Zealand and the US. The announcement follows a recently concluded study into the feasibility of hydrogen deliveries from Western Australia to Singapore.

The agreement envisages potential KDC purchases of some 1,000 t/d of LH2 by as early as 2030, by which time the parties expect production technology and shipping systems to have reached maturity. KDC's planned Datapark+ is envisaged as an energy-efficient facility, in line with Singaporean government directives that new data centres use more sustainable energy sources to cool IT equipment. Singapore has a 60pc share of southeast Asia's data centre market.

"Access to a stable supply of hydrogen to power our data centres in Singapore will accelerate our decarbonisation efforts as we transition towards net-zero emissions," KDC chief executive Wong Wai Meng says. "We look forward to deepening our collaboration with Woodside to explore ways to reduce emissions and make a positive environmental impact."

Another subsidiary of the Singaporean conglomerate, Keppel Energy, plans to build the nation's first hydrogen-ready power plant to begin commercial operations by 2026, designed to run on 30pc hydrogen-blended fuels or entirely on hydrogen. Keppel Energy recently agreed to a joint feasibility study to explore developing green hydrogen and green ammonia projects in Indonesia using geothermal energy. Singapore is also exploring options to import hydrogen from Malaysia and Japan.

By Tom Major

New JV eyes 5GW electrolyser capacity by 2030

A new joint venture between renewable energy developer Pash Global and investment firm Erih Holdings aims to develop 5GW of electrolyser capacity globally by 2030, with a view to producing renewable hydrogen and ammonia.

Pash says the projects will be powered by 10GW of renewable energy generated from solar, wind and geothermal sources.

The first of the projects will be in Turkey and Italy. The companies are also looking at the possibility of building plants in Spain, Greece, Serbia and Colombia. Erih will be in charge of co-ordinating the projects and will liaise with customers and transport operators.

Erih's chief executive, Akin Gunduz, says his company is focused on investing in "opportunities that are likely to find their way to market in the next 5-10 years and are not as dependent on substantial, co-ordinated long-term government subsidies that have yet to be designated or allocated".

"There is still some way to go in terms of approvals, design, construction and commissioning," Gunduz adds.

The two companies last month announced a partnership to develop 100MW of solar energy in Paraguay from 2024. Pash's current portfolio features renewable energy generation and storage projects in Botswana, Mali, Ghana, Puerto Rico and the island of Saint Helena, a British overseas territory located in the southern Atlantic Ocean.

By Pamela Machado

NEWS

Norway's Scatec pulls out of Oman green NH3 project

Norwegian renewables developer Scatec has pulled out of a $5bn-6bn project to jointly develop a 1.2mn t/yr green ammonia project in Oman, but its co-developer, Indian renewables company Acme, says the project remains on track.

The companies were due to take a final investment decision (FID) this month on the $650mn and 100,000 t/yr first stage of the project, but Scatec tells *Argus* it wants to "focus on our current project development activities in Egypt".

The Oman project remains on track for commercial start-up in 2025, Acme president and director for green hydrogen and ammonia Ashwani Dudeja says, without commenting further. Acme and Scatec previously set an industry first with pre-certification of the green credentials of its ammonia, and also agreed one of the first large offtake deals — 100,000 t/yr for Norway's Yara.

Scatec is developing a 100MW electrolysis plant in Egypt with Abu Dhabi-based Fertiglobe, which could be the first green hydrogen plant in Africa, Scatec says. Once complete, the project will produce 15,000 t/yr of green hydrogen for Fertiglobe's existing ammonia plants.

By Aidan Lea

US policy threatens Canada ammonia exports: Trigon

Hydrogen production tax credits set out in the US' Inflation Reduction Act (IRA) have threatened Canada's status as a potential clean ammonia exporter as its own investment tax credits might not be enough to compete, according to Canadian terminal operator Trigon.

Canada's planned tax credit incentive

Carbon intensity kg of CO_2e/kg of hydrogen	Tax credit rate
up to 0.75	40pc
0.76-2.00	25pc
2.01-4.00	15pc

— Canadian government

Trigon and its Asian partners had identified the Middle East, Australia and Canada as the best candidates for low-carbon ammonia production, with the Middle East the frontrunner, Trigon chief executive Robert Booker said at last week's Canadian Hydrogen Convention in Edmonton. "The US was not in the conversation," Booker said. "It was not considered a source, it did not make the top 10."

But the IRA knocked Canada from its place. Canadian clean ammonia proponents had all but lost hope until the country previewed its own clean energy incentives last autumn — but even recently announced investment tax credits for low-carbon hydrogen and ammonia might not be enough, according to Booker.

"It's the power of production credits versus carbon taxes and investment credits," he said. There is a way to produce cost-competitive ammonia in Canada, but it is more difficult and riskier without a production credit, he added.

Under the IRA, projects could receive up to $3 for each 1kg of hydrogen they produce, depending on lifecycle carbon emissions. Canada's support will also depend on lifecycle emissions, but instead of providing subsidies for operating costs, the country will provide investment tax credits of up to 40pc.

Some Canadian producers are betting on exporting hydrogen as ammonia to future demand centres, such as northwest Europe and northeast Asia — the region where interest first emerged, according to Booker.

Only a few years ago, most groups were unwilling to even discuss trading hydrogen as ammonia, with the exception of a few Japanese partners, Booker said. Japan was "walking the walk" in 2021 when it said its strategy to achieve net-zero emissions by 2050 entails deriving 15pc of its energy mix from hydrogen, in the form of ammonia — which worked out at about 30mn t/yr, he said.

"That was the conservative estimate they provided at that time," Booker said. "Today, they're not as public... as that first announcement, but there is a lot of conversation in Japan about that number being 30pc or higher.|

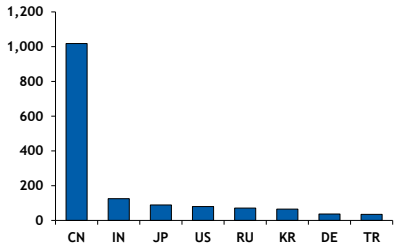
By Emmeline Willey

ANALYSIS

Steel reinforces Asia's hydrogen outlook

Limits on scrap availability could pave for way for hydrogen to play a key role in decarbonising the sector, writes Yongli Tng

Crude steel output in 2022 *mn t*



Decarbonising steel promises to provide a major market for clean hydrogen, and perhaps nowhere more than in Asia, home to four of the world's six biggest steel producers. Steel producers have other means of going green that do not involve hydrogen, most obviously by using ferrous scrap in electric-arc furnaces (EAFs). But limits on scrap availability present an obstacle on that path to decarbonisation, which could open the door for hydrogen.

Cleaning up the steel sector is key to tackling climate change. The industry accounts for 2.8 gigatonnes of CO_2/yr, equivalent to 8pc of total energy system emissions, or 10pc if including indirect emissions from power generation, according to a recent report by the International Energy Agency (IEA). The sector is also the biggest industrial user of coal, which represents 74pc of its energy inputs.

To hit climate goals, the industry will have to sharply cut its emissions, and Asia will have a key role to play. China, India and Japan are the three biggest steel manufacturers, and South Korea the sixth biggest, according to World Steel Association (WSA) data — together the four accounted for almost 70pc of global steel production in 2022. China alone accounted for over 50pc.

Steel manufacturers have looked to ferrous scrap to decarbonise. But utilising scrap to produce steel is limited by a structural shortage of the feedstock, as well as rising demand as decarbonisation gathers pace. Japan is already contending with the possibility of a scrap shortage by 2030.

So where could hydrogen fit into these countries' efforts to decarbonise steel manufacturing? Steelmakers can use low-carbon hydrogen instead of other reducing agents like natural gas to produce direct reduce iron (DRI), which is then fed into an EAF to produce steel. This would allow producers to circumvent potential scrap shortages by using iron ore as feedstock instead, while also achieving their carbon-reduction goals by switching away from more polluting reducing agents.

All of Asia's key steel-producing countries already have hydrogen strategies in place and a large-scale shift to hydrogen as a reducing agent could boost demand. Approximately 72kg of hydrogen would be required for 1t of steel, *Argus Consulting* data show. This means that even making just 10pc of the four countries' steel production using hydrogen would require over 9mn t/yr of supply.

Seoul plan

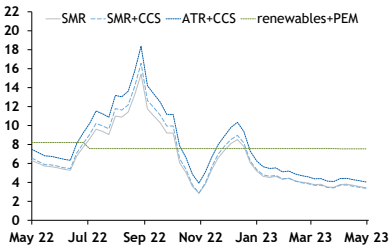
Of the four countries, South Korea has arguably outlined the most detailed plans to use hydrogen in steelmaking. Seoul's steel strategy from February this year earmarks 150bn won ($110mn) to support low-carbon steel production and envisages 11 blast furnaces being replaced with 14 hydrogen direct reduction plants by 2050. Japan in 2021 also proposed a plan to utilise hydrogen-based steelmaking and DRI technologies to cut CO2 emissions.

While hydrogen-based steel would likely require South Korea and Japan to rely heavily on expensive imports, India and China's abundant renewable power generation could provide them with ample scope for domestic hydrogen production — of which some could eventually be channelled into steelmaking.

India's steel ministry has identified green hydrogen as a key focus for decarbonising the sector in 2030-47. And the country's green hydrogen mission from January, which sets aside 197.44bn rupees ($2.4bn) for the sector, included plans for initial pilot projects for hydrogen-based steel making. China has not outlined such plans, but firms are nonetheless pushing ahead with a shift towards hydrogen. Steelmaker HBIS has emerged as a frontrunner and is building a 1.2mn t/yr hydrogen metallurgy DRI demonstration project that will use green and blue hydrogen, according to the WSA.

IN BRIEF

German H2 costs $/kg



H2 Green Steel signs €1.8bn offtake deal

Swedish low-carbon steel producer H2 Green Steel has signed a €1.79bn ($1.96bn) offtake deal with Italy's Marcegaglia. Under the seven-year agreement, H2 Green Steel will deliver steel from its site in Boden, Sweden, to Marcegaglia's plants in southern Europe, Poland and the UK. Marcegaglia is an investor in H2 Green Steel. H2 Green Steel's plant is to use an 800MW electrolyser to produce 2.5mn t/yr of green steel in its first phase starting in 2025, ramping up to 5mn t/yr at full capacity by 2030. The firm last month signed a seven-year deal worth over €250mn to supply steel to German processor Bilstein, and a five-year €125m supply contract with UK-based Steel Processing Midlands.

Alliance pools hydrogen plans in northwest Germany

Seven energy and infrastructure companies have set up an alliance to pool their hydrogen project plans in northwest Germany, with a view to developing a production and import hub at the port of Wilhelmshaven and transporting supply inland. The initiative — jointly developed by BP, utility Uniper, gas system operators Gasunie, Nowega, and Thyssengas, oil pipeline operator NWO and steel producer Salzgitter — involves creating a corridor for transporting hydrogen between Wilhelmshaven and industrial complexes in the states of North Rhine-Westphalia and Lower Saxony. BP and Uniper plan to import low-carbon ammonia at Wilhelmshaven and set up facilities for cracking it back into hydrogen, while Uniper's plans also include construction of a 1GW electrolysis plant.

Bulgaria eyes €860mn hydrogen connection to Greece

Bulgaria is considering investing €860mn ($951mn) to build a 250km hydrogen-dedicated pipeline from the capital Sofia running south to the Greek region of Sidirokastro. The link could form part of a future southeast European hydrogen corridor, natural gas system operator (TSO) Bulgartransgaz says. The cross-border pipeline would allow two-way hydrogen trade with Greece by connecting to similar infrastructure being developed by Greek TSO Desfa, according to Bulgartransgaz's 10-year development plan. The pipeline could be ready in 2029 and may later be extended north to Romania and east to the Maritza coal basin.

HIF gets environmental approval for Texas e-fuels site

US-headquartered HIF Global has received environmental approval to build a Texas plant that would produce 2mn gallons/yr of e-fuels using 300,000 t/yr of renewable hydrogen. The company says it received the go-ahead from the Texas Commission on Environmental Quality, which means the process of reviewing the facility's design and proposed operations has been completed. It plans to start building the plant next year, after concluding engineering, commercial contracting and financing arrangements. Production could begin in 2027, the firm says.

Linde to supply blue hydrogen to Dow in Canada

Industrial gas firm Linde will supply US chemicals giant Dow with blue hydrogen from a new plant that it plans to build in the Canadian province of Alberta. The hydrogen produced in Fort Saskatchewan will be used at Dow's planned low-carbon ethylene cracker. Linde's plant will convert cracker offgas into hydrogen, with the carbon captured on site and then "transported and stored by adjacent third-party carbon storage infrastructure partners", Dow says. The "world-scale air separation and autothermal reformer complex" will be part of Linde's existing complex, Dow says. Dow expects final investment decisions on its cracker and Linde's plant in the fourth quarter of 2023. The sites could start up by 2027.

COMPLETE HYDROGEN PRODUCTION COSTS

No-C Hydrogen									2 May
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 25 Apr	Price	Price in $/kg	± 25 Apr
Netherlands	Wind + PEM	Green	€/kg	5.75	6.33	nc	4.05	4.46	nc
Netherlands	Grid + GOO + ALK	Green	€/kg	8.41	9.26	-0.40	7.38	8.13	-0.40
UK	Wind + PEM	Green	£/kg	4.81	6.02	nc	3.35	4.19	nc
UK	Grid + GOO + ALK	Green	£/kg	8.86	11.09	-0.52	7.97	9.98	-0.52
Germany	Wind + PEM	Green	€/kg	6.85	7.54	nc	5.13	5.65	nc
Germany	Grid + GOO + ALK	Green	€/kg	9.04	9.96	-0.48	8.00	8.81	-0.49
France	Wind + PEM	Green	€/kg	7.04	7.75	nc	5.32	5.86	nc
France	Grid + GOO + ALK	Green	€/kg	9.90	10.90	-0.85	8.85	9.75	-0.85
Spain	Diurnal + PEM	Green	€/kg	4.57	5.03	nc	2.86	3.15	nc
Spain	Grid + GOO + ALK	Green	€/kg	8.64	9.52	-0.78	7.57	8.34	-0.78
US west coast	Diurnal + PEM	Green	$/kg	5.10	5.10	nc	3.29	3.29	nc
Canada	Wind + PEM	Green	C$/kg	8.70	6.41	nc	6.12	4.51	nc
Oman	Diurnal + PEM	Green	$/kg	5.43	5.43	nc	3.53	3.53	nc
Saudi Arabia	Diurnal + PEM	Green	$/kg	5.51	5.51	nc	3.61	3.61	nc
UAE	Diurnal + PEM	Green	$/kg	5.59	5.59	nc	3.83	3.83	nc
Qatar	Diurnal + PEM	Green	$/kg	5.57	5.57	nc	3.77	3.77	nc
Namibia	Diurnal + PEM	Green	$/kg	5.92	5.92	nc	3.61	3.61	nc
South Africa	Diurnal + PEM	Green	$/kg	5.88	5.88	nc	3.72	3.72	nc
Japan	Wind + PEM	Green	¥/kg	1,863	13.77	nc	1,605	11.86	nc
China	Diurnal + PEM	Green	Yn/kg	32.58	4.71	nc	19.72	2.85	nc
India	Diurnal + PEM	Green	Rs/kg	402.43	4.92	nc	240.48	2.94	nc
South Korea	Wind + PEM	Green	W/kg	17,272	12.90	nc	14,715	10.99	nc
Vietnam	Wind + PEM	Green	$/kg	7.84	7.84	nc	5.75	5.75	nc
Australia	Diurnal + PEM	Green	A$/kg	7.57	5.01	nc	4.80	3.18	nc
Brazil	Diurnal + PEM	Green	$/kg	5.39	5.39	nc	3.23	3.23	nc
Chile	Diurnal + PEM	Green	$/kg	5.38	5.38	nc	3.48	3.48	nc

Low-C hydrogen									2 May
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 25 Apr	Price	Price in $/kg	± 25 Apr
Netherlands	ATR + CCS	Blue	€/kg	3.59	3.95	-0.12	2.92	3.22	-0.11
UK	ATR + CCS	Blue	£/kg	3.04	3.80	-0.14	2.46	3.08	-0.14
Germany	ATR + CCS	Blue	€/kg	3.68	4.05	-0.12	3.00	3.30	-0.12
Spain	ATR + CCS	Blue	€/kg	3.41	3.75	-0.11	2.69	2.96	-0.11
France	ATR + CCS	Blue	€/kg	3.52	3.88	-0.18	2.84	3.13	-0.18
US Gulf Coast	ATR + CCS	Blue	$/kg	1.87	1.87	-0.01	1.13	1.13	-0.01
Canada	ATR + CCS	Blue	C$/kg	2.50	1.84	-0.41	1.48	1.09	-0.41
Japan	ATR + CCS	Blue	¥/kg	503	3.72	-0.11	400	2.96	-0.11
South Korea	ATR + CCS	Blue	W/kg	4,780	3.57	-0.10	3,762	2.81	-0.10
Australia	ATR + CCS	Blue	A$/kg	4.53	3.00	-0.06	3.38	2.24	-0.07
Trinidad	ATR + CCS	Blue	$/kg	3.51	3.51	-0.12	2.40	2.40	-0.12
Qatar	ATR + CCS	Blue	$/kg	3.30	3.30	-0.09	2.54	2.54	-0.09
UAE	ATR + CCS	Blue	$/kg	3.45	3.45	-0.09	2.69	2.69	-0.10
Russia west	ATR + CCS	Blue	$/kg	1.86	1.86	+0.01	1.00	1.00	+0.01
Russia east	ATR + CCS	Blue	$/kg	1.75	1.75	nc	0.89	0.89	nc

COMPLETE HYDROGEN PRODUCTION COSTS

BAT+ hydrogen									2 May
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 25 Apr	Price	Price in $/kg	± 25 Apr
Netherlands	SMR + CCS	Blue	€/kg	3.01	3.31	-0.11	2.52	2.77	-0.11
UK	SMR + CCS	Blue	£/kg	2.45	3.07	-0.13	2.03	2.54	-0.13
Germany	SMR + CCS	Blue	€/kg	3.07	3.38	-0.10	2.57	2.83	-0.10
Spain	SMR + CCS	Blue	€/kg	2.80	3.08	-0.09	2.27	2.50	-0.09
France	SMR + CCS	Blue	€/kg	2.88	3.17	-0.15	2.38	2.62	-0.16
US Gulf Coast	SMR + CCS	Blue	$/kg	1.34	1.34	nc	0.80	0.80	nc
Canada	SMR + CCS	Blue	C$/kg	1.68	1.24	nc	0.94	0.69	nc
Japan	SMR + CCS	Blue	¥/kg	415	3.07	-0.10	340	2.51	-0.11
South Korea	SMR + CCS	Blue	W/kg	4,057	3.03	-0.10	3,307	2.47	-0.10
Australia	SMR + CCS	Blue	A$/kg	3.53	2.34	-0.07	2.69	1.78	-0.08
Trinidad	SMR + CCS	Blue	$/kg	2.95	2.95	-0.12	2.13	2.13	-0.12
Qatar	SMR + CCS	Blue	$/kg	2.80	2.80	-0.09	2.24	2.24	-0.09
UAE	SMR + CCS	Blue	$/kg	2.79	2.79	-0.09	2.24	2.24	-0.09
Russia west	SMR + CCS	Blue	$/kg	1.31	1.31	nc	0.68	0.68	nc
Russia east	SMR + CCS	Blue	$/kg	1.22	1.22	+0.01	0.58	0.58	nc

BAT+ hydrogen							2 May
				Excl. capex			
	Process	Legacy colour	Unit	Price	Price in $/kg	± 25 Apr	
Netherlands	SMR + CCS retrofit	Blue	€/kg	2.66	2.93	-0.11	
UK	SMR + CCS retrofit	Blue	£/kg	2.11	2.64	-0.14	
Germany	SMR + CCS retrofit	Blue	€/kg	2.71	2.98	-0.12	
Spain	SMR + CCS retrofit	Blue	€/kg	2.41	2.65	-0.10	
France	SMR + CCS retrofit	Blue	€/kg	2.52	2.78	-0.16	
US Gulf Coast	SMR + CCS retrofit	Blue	$/kg	0.78	0.78	nc	
Canada	SMR + CCS retrofit	Blue	C$/kg	1.02	0.75	-0.01	
Japan	SMR + CCS retrofit	Blue	¥/kg	337	2.49	-0.10	
South Korea	SMR + CCS retrofit	Blue	W/kg	3,294	2.46	-0.11	
Australia	SMR + CCS retrofit	Blue	A$/kg	2.66	1.76	-0.08	
Trinidad	SMR + CCS retrofit	Blue	$/kg	2.11	2.11	-0.12	
Qatar	SMR + CCS retrofit	Blue	$/kg	2.22	2.22	-0.09	
UAE	SMR + CCS retrofit	Blue	$/kg	2.22	2.22	-0.09	
Russia west	SMR + CCS retrofit	Blue	$/kg	0.66	0.66	nc	
Russia east	SMR + CCS retrofit	Blue	$/kg	0.56	0.56	nc	

BAT+ hydrogen										*2 May*
					Incl. capex			Excl. capex		
	Process	kcal/kg NAR	Legacy colour	Unit	Price	Price in $/kg	± 25 Apr	Price	Price in $/kg	± 25 Apr
Australia	Coal gasification + CCS	5,500	Blue	A$/kg	5.32	3.52	+0.01	3.58	2.37	+0.01
Australia	Coal gasification + CCS	6,000	Blue	A$/kg	6.24	4.13	nc	4.51	2.99	nc
China	Coal gasification + CCS	3,800	Blue	Yn/kg	26.43	3.82	-0.01	18.40	2.66	-0.01
China	Coal gasification + CCS	5,500	Blue	Yn/kg	25.73	3.72	-0.02	17.71	2.56	-0.02
Indonesia	Coal gasification + CCS	5,500	Blue	$/kg	3.54	3.54	nc	2.31	2.31	nc
Indonesia	Coal gasification + CCS	3,800	Blue	$/kg	3.40	3.40	+0.01	2.16	2.16	nc
South Africa	Coal gasification + CCS	4,800	Blue	$/kg	3.61	3.61	+0.01	2.18	2.18	+0.01
South Africa	Coal gasification + CCS	6,000	Blue	$/kg	3.75	3.75	-0.03	2.32	2.32	-0.03
Russia West	Coal gasification + CCS	6,000	Blue	$/kg	3.12	3.12	nc	1.85	1.85	-0.01
US east coast	Coal gasification + CCS	6,000	Blue	$/kg	3.39	3.39	nc	2.26	2.26	nc

COMPLETE HYDROGEN PRODUCTION COSTS

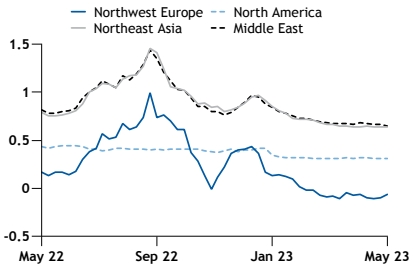
Baseline hydrogen									2 May
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 25 Apr	Price	Price in $/kg	± 25 Apr
Netherlands	SMR	Grey	€/kg	3.06	3.37	-0.15	2.79	3.07	-0.14
UK	SMR	Grey	£/kg	2.35	2.94	-0.14	2.11	2.64	-0.14
Germany	SMR	Grey	€/kg	3.11	3.43	-0.14	2.84	3.13	-0.13
Spain	SMR	Grey	€/kg	2.86	3.15	-0.12	2.56	2.82	-0.13
France	SMR	Grey	€/kg	2.94	3.24	-0.19	2.67	2.94	-0.18
US Gulf coast	SMR	Grey	$/kg	0.83	0.83	nc	0.53	0.53	+0.01
Canada	SMR	Grey	C$/kg	1.52	1.12	nc	1.10	0.81	nc
Japan	SMR	Grey	¥/kg	323	2.39	-0.10	281	2.08	-0.10
South Korea	SMR	Grey	W/kg	3,254	2.43	-0.10	2,839	2.12	-0.10
Australia	SMR	Grey	A$/kg	2.61	1.73	-0.07	2.14	1.42	-0.07
Trinidad	SMR	Grey	$/kg	2.19	2.19	-0.11	1.74	1.74	-0.11
Qatar	SMR	Grey	$/kg	2.15	2.15	-0.08	1.83	1.83	-0.09
UAE	SMR	Grey	$/kg	2.14	2.14	-0.09	1.83	1.83	-0.09
Russia west	SMR	Grey	$/kg	0.77	0.77	nc	0.42	0.42	nc
Russia east	SMR	Grey	$/kg	0.68	0.68	nc	0.33	0.33	nc

Baseline hydrogen									2 May
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/kg	± 25 Apr	Price	Price in $/kg	± 25 Apr
Netherlands	Grid + ALK	Yellow	€/kg	7.98	8.79	-0.39	6.96	7.66	-0.38
Netherlands	Grid + PEM	Yellow	€/kg	8.52	9.38	-0.36	6.88	7.58	-0.36
UK	Grid + ALK	Yellow	£/kg	8.63	10.80	-0.47	7.74	9.69	-0.47
UK	Grid + PEM	Yellow	£/kg	8.98	11.24	-0.43	7.57	9.47	-0.43
Germany	Grid + ALK	Yellow	€/kg	8.62	9.49	-0.47	7.57	8.34	-0.47
Germany	Grid + PEM	Yellow	€/kg	9.12	10.04	-0.44	7.45	8.21	-0.44
France	Grid + ALK	Yellow	€/kg	9.46	10.42	-0.84	8.43	9.28	-0.83
France	Grid + PEM	Yellow	€/kg	9.91	10.91	-0.78	8.25	9.09	-0.77
Spain	Grid + ALK	Yellow	€/kg	8.21	9.04	-0.77	7.14	7.86	-0.77
Spain	Grid + PEM	Yellow	€/kg	8.76	9.65	-0.71	7.06	7.77	-0.71
US west coast	Grid + ALK	Yellow	$/kg	6.61	6.61	+0.13	5.47	5.47	+0.13
US west coast	Grid + PEM	Yellow	$/kg	7.35	7.35	+0.12	5.54	5.54	+0.12
US Midwest	Grid + ALK	Yellow	$/kg	4.50	4.50	+0.31	3.36	3.36	+0.31
US Midwest	Grid + PEM	Yellow	$/kg	5.39	5.39	+0.29	3.57	3.57	+0.28
US east coast	Grid + ALK	Yellow	$/kg	4.70	4.70	+0.02	3.56	3.56	+0.02
US east coast	Grid + PEM	Yellow	$/kg	5.57	5.57	+0.01	3.76	3.76	+0.02
Japan	Grid + ALK	Yellow	¥/kg	1,085	8.02	-0.09	928	6.86	-0.09
Japan	Grid + PEM	Yellow	¥/kg	1,174	8.68	-0.08	925	6.84	-0.08

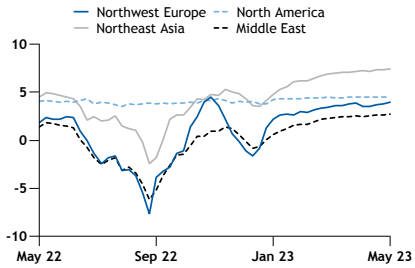
COMPLETE HYDROGEN PRODUCTION COSTS

Hydrogen decarbonisation spreads				*2 May*
	Incl. capex		Excl. capex	
	$/kg	± 25 Apr	$/kg	± 25 Apr
Northwest Europe				
No-C to BAT+	3.92	+0.12	2.58	+0.12
Low-C to BAT+	0.67	-0.02	0.48	-0.01
BAT+ to baseline	-0.06	+0.04	-0.31	+0.03
North America				
No-C to BAT+	4.47	nc	3.15	nc
Low-C to BAT+	0.57	-0.21	0.36	-0.21
BAT+ to baseline	0.31	nc	0.08	nc
Northeast Asia				
No-C to BAT+	7.41	+0.10	6.08	+0.11
Low-C to BAT+	0.60	nc	0.40	+0.01
BAT+ to baseline	0.64	nc	0.39	-0.01
Middle East				
No-C to BAT+	2.73	+0.09	1.45	+0.09
Low-C to BAT+	0.58	nc	0.38	nc
BAT+ to baseline	0.65	-0.01	0.41	nc
Net exporter				
No-C to BAT+	3.07	+0.06	1.68	+0.06
Low-C to BAT+	0.59	nc	0.38	-0.01
BAT+ to baseline	0.61	nc	0.37	nc

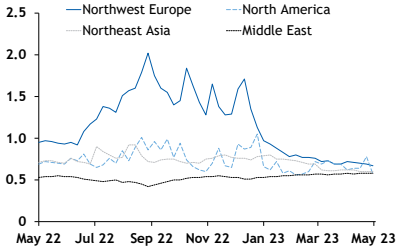
Decarb spread BAT+ to baseline *$/kg*



Decarb spread No-C to BAT+ *$/kg*



Decarb spread Low-C to BAT+ *$/kg*



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
- Global planned ammonia cracking facilities
- Global hydrogen production and electrolyser capacity targets

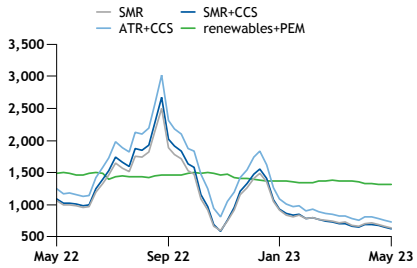
COMPLETE AMMONIA PRODUCTION COSTS

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

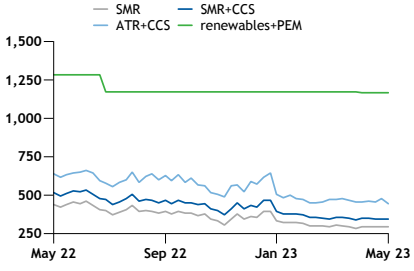
CO2e emissions on a gate-to-gate basis; purity >99.5pc; temperature -33°C

Regional ammonia cost markers						*2 May*
			Incl. capex		Excl. capex	
	Process	Unit	Cost	± 25 Apr	Cost	± 25 Apr
Baseline						
Northwest Europe	SMR	€/t	634	-26	523	-25
Northwest Europe	SMR	$/t	698	-27	576	-25
North America	SMR	$/t	293	nc	171	+1
Northeast Asia	SMR	$/t	525	-18	400	-17
Middle East	SMR	$/t	460	-14	339	-16
BAT+						
Northwest Europe	SMR+CCS	€/t	625	-20	476	-20
Northwest Europe	SMR+CCS	$/t	688	-20	524	-21
North America	SMR+CCS	$/t	347	nc	183	nc
Northeast Asia	SMR+CCS	$/t	635	-17	466	-19
Middle East	SMR+CCS	$/t	571	-15	410	-15
Low-C						
Northwest Europe	ATR+CCS	€/t	729	-24	549	-24
Northwest Europe	ATR+CCS	$/t	803	-24	605	-24
North America	ATR+CCS	$/t	444	-36	246	-36
Northeast Asia	ATR+CCS	$/t	736	-19	534	-18
Middle East	ATR+CCS	$/t	670	-16	473	-17
No-C						
Northwest Europe	Island renewable+PEM	€/t	1,315	-4	959	-3
Northwest Europe	Island renewable+PEM	$/t	1,448	nc	1,056	nc
North America	Island renewable+PEM	$/t	1,165	nc	782	nc
Northeast Asia	Island renewable+PEM	$/t	2,041	nc	1,648	nc
Middle East	Island renewable+PEM	$/t	1,087	nc	705	nc
Exporter						
Exporter baseline	SMR	$/t	405	-10	283	-10
Exporter BAT+	SMR+CCS	$/t	508	-11	345	-11
Exporter low-C	ATR+CCS	$/t	608	-11	410	-12
Exporter no-C	Island renewable+PEM	$/t	1,073	nc	671	nc

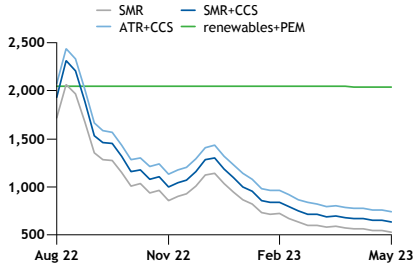
NW Europe ammonia average €/t



North America ammonia average $/t



Northeast Asia ammonia average $/t



COMPLETE AMMONIA PRODUCTION COSTS

No-C ammonia									*2 May*
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/t	± 25 Apr	Price	Price in $/t	± 25 Apr
Netherlands	Wind + PEM	Green	€/t	1,170	1,289	nc	817	900	nc
UK	Wind + PEM	Green	£/t	967	1,210	nc	662	828	nc
Germany	Wind + PEM	Green	€/t	1,365	1,503	nc	1,008	1,110	nc
France	Wind + PEM	Green	€/t	1,410	1,553	nc	1,052	1,159	nc
Spain	Diurnal + PEM	Green	€/t	917	1,010	nc	566	623	nc
US west coast	Diurnal + PEM	Green	$/t	1,033	1,033	nc	663	663	nc
Canada	Wind + PEM	Green	C$/t	1,761	1,297	nc	1,224	901	nc
Oman	Diurnal + PEM	Green	$/t	1,069	1,069	nc	674	674	nc
Saudi Arabia	Diurnal + PEM	Green	$/t	1,082	1,082	nc	688	688	nc
UAE	Diurnal + PEM	Green	$/t	1,100	1,100	nc	734	734	nc
Qatar	Diurnal + PEM	Green	$/t	1,096	1,096	nc	725	725	nc
Namibia	Diurnal + PEM	Green	$/t	1,179	1,179	nc	687	687	nc
South Africa	Diurnal + PEM	Green	$/t	1,162	1,162	nc	706	706	nc
Japan	Wind + PEM	Green	¥/t	361,903	2,675	nc	308,058	2,277	nc
China	Diurnal + PEM	Green	Yn/t	6,406	926	nc	3,770	545	nc
India	Diurnal + PEM	Green	Rs/t	79,014	966	nc	45,478	556	nc
South Korea	Wind + PEM	Green	W/t	3,376,766	2,522	nc	2,842,536	2,123	nc
Vietnam	Wind + PEM	Green	$/t	1,538	1,538	nc	1,093	1,093	nc
Australia	Diurnal + PEM	Green	A$/t	1,542	1,021	nc	977	647	nc
Brazil	Diurnal + PEM	Green	$/t	1,067	1,067	nc	614	614	nc
Chile	Diurnal + PEM	Green	$/t	1,055	1,055	nc	664	664	nc

Low-C ammonia									*2 May*
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/t	± 25 Apr	Price	Price in $/t	± 25 Apr
Netherlands	ATR + CCS	Blue	€/t	732	806	-21	556	612	-19
UK	ATR + CCS	Blue	£/t	608	761	-24	456	571	-24
Germany	ATR + CCS	Blue	€/t	737	812	-21	556	612	-21
Spain	ATR + CCS	Blue	€/t	689	759	-19	498	549	-19
France	ATR + CCS	Blue	€/t	717	790	-31	537	591	-31
US Gulf Coast	ATR + CCS	Blue	$/t	447	447	-2	250	250	-2
Canada	ATR + CCS	Blue	C$/t	598	440	-70	327	241	-70
Japan	ATR + CCS	Blue	¥/t	100,792	745	-19	73,328	542	-18
South Korea	ATR + CCS	Blue	W/t	973,398	727	-18	704,274	526	-17
Australia	ATR + CCS	Blue	A$/t	977	647	-10	670	444	-12
Trinidad	ATR + CCS	Blue	$/t	735	735	-21	436	436	-21
Qatar	ATR + CCS	Blue	$/t	659	659	-16	461	461	-16
UAE	ATR + CCS	Blue	$/t	680	680	-16	485	485	-18
Russia west	ATR + CCS	Blue	$/t	421	421	+1	194	194	+2
Russia east	ATR + CCS	Blue	$/t	402	402	nc	175	175	nc

COMPLETE AMMONIA PRODUCTION COSTS

BAT+ ammonia										2 May
				Incl. capex			Excl. capex			
	Process	Legacy colour	Unit	Price	Price in $/t	± 25 Apr	Price	Price in $/t	± 25 Apr	
Netherlands	SMR + CCS	Blue	€/t	633	697	-19	486	535	-19	
UK	SMR + CCS	Blue	£/t	508	636	-22	383	479	-22	
Germany	SMR + CCS	Blue	€/t	634	698	-17	483	532	-17	
Spain	SMR + CCS	Blue	€/t	586	645	-15	428	471	-15	
France	SMR + CCS	Blue	€/t	607	669	-25	458	504	-27	
US Gulf Coast	SMR + CCS	Blue	$/t	356	356	nc	194	194	nc	
Canada	SMR + CCS	Blue	C$/t	459	338	nc	234	172	nc	
Japan	SMR + CCS	Blue	¥/t	85,774	634	-17	62,910	465	-19	
South Korea	SMR + CCS	Blue	W/t	850,217	635	-17	625,278	467	-18	
Australia	SMR + CCS	Blue	A$/t	806	534	-12	553	366	-14	
Trinidad	SMR + CCS	Blue	$/t	640	640	-20	390	390	-21	
Qatar	SMR + CCS	Blue	$/t	574	574	-15	410	410	-16	
UAE	SMR + CCS	Blue	$/t	567	567	-16	409	409	-15	
Russia west	SMR + CCS	Blue	$/t	327	327	nc	139	139	nc	
Russia east	SMR + CCS	Blue	$/t	312	312	+2	122	122	nc	

BAT+ ammonia											2 May
					Incl. capex			Excl. capex			
	Process	kcal/kg NAR	Legacy colour	Unit	Price	Price in $/t	± 25 Apr	Price	Price in $/t	± 25 Apr	
Australia	Coal gasification + CCS	5,500	Blue	A$/t	1,046	693	+2	652	432	+2	
Australia	Coal gasification + CCS	6,000	Blue	A$/t	1,203	797	nc	812	538	nc	
China	Coal gasification + CCS	3,800	Blue	Yn/t	5,050	730	-2	3,231	467	-2	
China	Coal gasification + CCS	5,500	Blue	Yn/t	4,933	713	-4	3,113	450	-4	
Indonesia	Coal gasification + CCS	5,500	Blue	$/t	685	685	nc	406	406	nc	
Indonesia	Coal gasification + CCS	3,800	Blue	$/t	661	661	+2	380	380	nc	
South Africa	Coal gasification + CCS	4,800	Blue	$/t	710	710	+1	384	384	+2	
South Africa	Coal gasification + CCS	6,000	Blue	$/t	734	734	-5	408	408	-5	
Russia West	Coal gasification + CCS	6,000	Blue	$/t	617	617	nc	329	329	-2	
US east coast	Coal gasification + CCS	6,000	Blue	$/t	668	668	nc	412	412	nc	

Baseline ammonia									2 May
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Price	Price in $/t	± 25 Apr	Price	Price in $/t	± 25 Apr
Netherlands	SMR	Grey	€/t	642	707	-26	532	586	-24
UK	SMR	Grey	£/t	491	614	-24	396	496	-24
Germany	SMR	Grey	€/t	641	706	-24	529	583	-22
Spain	SMR	Grey	€/t	597	657	-20	477	525	-22
France	SMR	Grey	€/t	618	681	-32	507	558	-31
US Gulf coast	SMR	Grey	$/t	269	269	nc	148	148	+2
Canada	SMR	Grey	C$/t	430	317	nc	262	193	nc
Japan	SMR	Grey	¥/t	69,945	517	-18	52,899	391	-17
South Korea	SMR	Grey	W/t	713,646	533	-17	546,281	408	-17
Australia	SMR	Grey	A$/t	649	430	-12	459	304	-12
Trinidad	SMR	Grey	$/t	510	510	-18	323	323	-19
Qatar	SMR	Grey	$/t	463	463	-13	340	340	-16
UAE	SMR	Grey	$/t	456	456	-16	338	338	-16
Russia west	SMR	Grey	$/t	235	235	nc	94	94	nc
Russia east	SMR	Grey	$/t	220	220	nc	79	79	nc

COMPLETE AMMONIA PRODUCTION COSTS

Ammonia decarbonisation spreads				*2 May*
	Incl. capex		Excl. capex	
	$/t	± 25 Apr	$/t	± 25 Apr
Northwest Europe				
No-C to BAT+	760	+20	532	+21
Low-C to BAT+	115	-4	81	-3
BAT+ to baseline	-10	+7	-52	+4
North America				
No-C to BAT+	818	nc	599	nc
Low-C to BAT+	97	-36	63	-36
BAT+ to baseline	54	nc	12	-1
Northeast Asia				
No-C to BAT+	1,406	+17	1,182	+19
Low-C to BAT+	101	-2	68	+1
BAT+ to baseline	110	+1	66	-2
Middle East				
No-C to BAT+	516	+15	295	+15
Low-C to BAT+	99	-1	63	-2
BAT+ to baseline	111	-1	71	+1
Net exporter				
No-C to BAT+	565	+11	326	+11
Low-C to BAT+	100	nc	65	-1
BAT+ to baseline	103	-1	62	-1

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