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Argus *Hydrogen and Future Fuels*

Market news, analysis and prices

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Australia picks Hydrogen Headstart winner

The MGH project is expected to receive more than $500mn and will produce green ammonia for export, write Tom Major and Stefan Krumpelmann

Australia's Labor government has selected a first winner under its Hydrogen Headstart scheme, with the planned Murchison Green Hydrogen (MGH) renewable ammonia scheme in the state of Western Australia (WA) due to receive A$814mn ($511mn) over 10 years.

The project, led by Danish fund manager Copenhagen Infrastructure Partners (CIP), is expected to produce 900,000 t/yr of renewable ammonia using 1.5GW of electrolyser capacity in the first stage, which will be supported with the Hydrogen Headstart funds. CIP says the plant could eventually produce 1.8mn t/yr of ammonia with 3GW of electrolysis capacity once fully developed.

In the first stage, the project will use dedicated renewable assets providing 1.2GW of solar photovoltaic capacity and 1.7GW of onshore wind capacity, alongside a 600MW/1.2GW battery energy storage system, according to the Australian Renewable Energy Agency (Arena).

MGH was announced by Hydrogen Renewables Australia in 2019, before CIP took control in 2022. The plant will be built in WA's Mid West region, 20km north of the coastal town of Kalbarri. Environmental applications will be lodged with the WA government for assessment this year, the MGH developers say, before a final investment decision can be taken. Construction is then expected to start by 2027 and take about five years, implying a 2032 start date. CIP is targeting exports, primarily to Asian markets.

The Hydrogen Headstart funding would be released in the 10 years after the start of production. The $511mn in funding — based on prevailing exchange rates — would then amount to an effective subsidy of about $57/t of ammonia, or roughly $0.32/kg of hydrogen, over the support period.

The requested funding per MW of electrolysis capacity or kg of hydrogen produced was one of the criteria taken into account for the project assessments and CIP's submission for MGH might have been much lower than what the government had expected on average. When MGH launched the process in 2023, Canberra said the A$2bn budget for the first round could support about 1GW of electrolysis capacity, implying subsidies of close to A$2/kg, or well over $1/kg.

The $0.32/kg would be lower than the support secured by EU projects under the European Hydrogen Bank's pilot auction last year. But MGH could also receive an additional A$2/kg under Australia's production tax credit scheme. Provided it starts operations by 2032, it could avail the tax credits for about eight years, given the 2040 cut-off for the support.

Canberra has suggested that at least some of the remaining A$1.186bn from the first Hydrogen Headstart round could still be allocated. "Further information on other successful projects and round two will be made available in the coming months," energy minister Chris Bowen said.

A shortlist of six projects was announced for the first round in late 2023, but several projects on that list have since run into major obstacles and some have been put on hold, limiting Arena's options for allocating funding. Any unused funds might be used to top up the A$2bn second round.

That said, Hydrogen Headstart as a whole faces an uncertain future. The programme has become a political issue in recent months, with the conservative opposition promising to cut spending on renewable hydrogen if it is elected in May.

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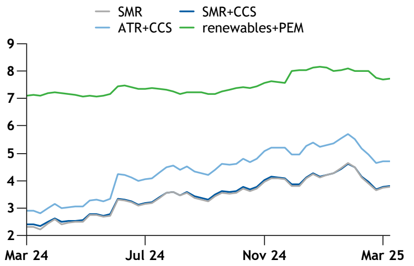
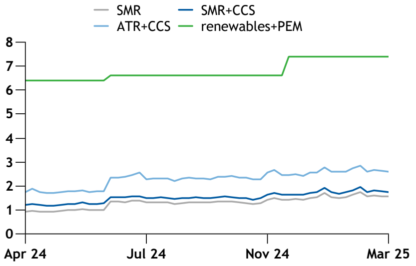
HYDROGEN COSTS

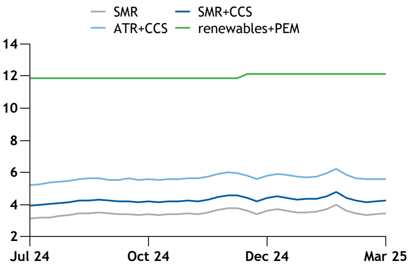
Northwest Europe average cost €/kg



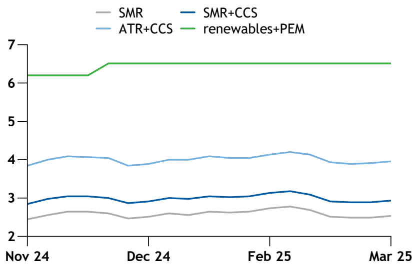
North America average cost $/kg



Northeast Asia average cost $/kg



Exporter average cost $/kg



Regional hydrogen cost markers							25 Mar
			Incl. capex		Excl. capex		
	Process	Unit	Cost	± 18 Mar	Cost	± 18 Mar	
Baseline							
Northwest Europe	SMR	€/kg	3.77	+0.03	3.24	+0.04	
Northwest Europe	SMR	$/kg	4.09	+0.02	3.51	+0.02	
North America	SMR	$/kg	1.57	nc	1.00	nc	
Northeast Asia	SMR	$/kg	3.42	+0.03	2.80	+0.04	
Middle East	SMR	$/kg	3.07	+0.03	2.51	+0.03	
BAT+							
Northwest Europe	SMR+CCS	€/kg	3.79	+0.02	3.15	+0.01	
Northwest Europe	SMR+CCS	$/kg	4.11	nc	3.42	nc	
North America	SMR+CCS	$/kg	1.76	-0.01	1.09	-0.01	
Northeast Asia	SMR+CCS	$/kg	4.23	+0.03	3.49	+0.03	
Middle East	SMR+CCS	$/kg	3.45	+0.03	2.78	+0.03	
Low-C							
Northwest Europe	ATR+CCS	€/kg	4.72	+0.02	3.57	+0.02	
Northwest Europe	ATR+CCS	$/kg	5.12	nc	3.87	nc	
North America	ATR+CCS	$/kg	2.60	-0.03	1.38	-0.04	
Northeast Asia	ATR+CCS	$/kg	5.60	+0.02	4.26	+0.02	
Middle East	ATR+CCS	$/kg	4.47	+0.03	3.26	+0.03	
No-C							
Northwest Europe	Island renewable+PEM	€/kg	7.73	+0.04	4.84	+0.02	
Northwest Europe	Island renewable+PEM	$/kg	8.38	nc	5.25	nc	
North America	Island renewable+PEM	$/kg	7.38	nc	4.55	nc	
Northeast Asia	Island renewable+PEM	$/kg	12.12	nc	9.34	nc	
Middle East	Island renewable+PEM	$/kg	6.02	nc	3.36	nc	
Exporter							
Exporter baseline	SMR	$/kg	2.53	+0.04	1.96	+0.03	
Exporter BAT+	SMR+CCS	$/kg	2.93	+0.03	2.26	+0.03	
Exporter low-C	ATR+CCS	$/kg	3.96	+0.04	2.74	+0.03	
Exporter no-C	Island renewable+PEM	$/kg	6.52	nc	3.64	nc	

Argus hydrogen taxonomy			
	Purity	Pressure	tCO_2e/tH_2
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

CO_2e emissions on a gate-to-gate basis

Pump prices, 70MPa			3 Mar
	Unit	Price	± 4 Feb
Japan			
Eneos	¥/kg	2,200.00	nc
Iwatani	¥/kg	1,650.00	nc
Germany			
H2Mobility (stations with “green” H2 supply)	€/kg	13.00	nc
H2Mobility (stations with conventional H2 supply)	€/kg	15.05-19.25	nc

MARKET DEVELOPMENTS

Astronomers take aim at Chilean H2 plans

Dust contamination, and ground vibrations and turbulence caused by wind turbines could spoil the view, writes Pamela Machado

Chile's northern province of Antofagasta offers some of the world's highest solar irradiation, drawing several hydrogen project developers to the area. But the clear skies are also precious to star gazers, and scientists are concerned that the development of a hydrogen industry will hurt astronomical research.

US-headquartered utility AES' plans for a $10bn renewable hydrogen and ammonia project in Antofagasta's southern Taltal region have come under fire after the firm submitted environmental studies to Chilean authorities in December.

Infrastructure for the Inna project would be spread over 3,000 hectares, between 10km and 20km from astronomical research sites, in an area that offers "the most pristine skies of the planet", according to the European Southern Observatory (ESO), an intergovernmental research organisation composed of 16 countries in Europe with observatories in northern Chile.

Taltal and Mejillones, Chile

ESO studied the potential impact from Inna and found "alarming" results. The project would severely hamper observation activities because of light pollution, dust contamination, and ground vibrations and atmospheric turbulence caused by wind turbines, the body says. "As all mitigating actions have already been taken", the Inna project should move "at least 50 to 100km away", ESO says.

Chilean authorities have voiced similar concerns. Regional environmental secretariat Seremi says the project would be located in an area "with unique observation conditions at the national and international level" and has asked for more details on artificial light emissions and brightness.

Seremi further notes that some assets for the Inna project would be located outside the limits of the area designated by the state for large-scale renewable generation under Chile's long-term energy plan. These are areas determined by the government that allow for "economically efficient" renewable power generation while "maximising the sustainability of the territory".

Seremi suggested that AES should "re-evaluate the project location" and indicate the alternative locations considered, while also requesting more information about how the Inna project will impact local flora and fauna.

But moving the project would arguably require AES to start much of the planning from scratch after the years of work and ample resources already invested.

AES declined to comment on its Inna plans following an *Argus* request. But in a presentation to Chile's senate last week, the company stressed that it has been engaging with ESO since 2019. The Inna project would be "outside the exclusion zone reserved for the protection of astronomical observation", AES argued. The plans would "fully comply" with lighting standards that came into force in October and "in whose development ESO played a leading role", it said.

Taltal signs

AES' plan anticipates that Inna would "contribute to the consolidation" of a hydrogen valley in the Taltal area, but the pushback might make other developers more inclined to look elsewhere.

Another large-scale renewable ammonia venture in Antofagasta is also undergoing environmental permitting, but developer MAE's Volta project is in Mejillones — about 300km north of Taltal — and would therefore not impact ESO's activities. Other developers — including Verano Energy, FRV-X and Alkeymia — have announced plans for Antofagasta, but have yet to disclose the exact locations.

Chilean authorities will have to strike a balance between stakeholders' interests. The Antofagasta government recently launched a tender for development of a hydrogen roadmap "in a sustainable manner" as a "strategic instrument" drawn up by the public and private sector along with academia and civil society.

MARKET DEVELOPMENTS

Green H2 assumptions too ambitious: Thyssenkrupp

Thyssenkrupp has sounded the alarm about its planned DRI plant, saying H2 is too scarce and costly for the operation to be viable, writes Stefan Krumpelmann

Initial assumptions about renewable hydrogen supply for German steelmaker Thyssenkrupp's planned direct reduced iron (DRI) plant in Duisburg were "too ambitious" and the firm might not be able to operate the facility in an "economically viable" manner for the foreseeable future, chief executive Miguel Lopez says.

With the DRI plant, Thyssenkrupp is "currently not just pushing the boundaries of what is technologically feasible", Lopez told the parliament of Germany's North-Rhine Westphalia (NRW) state on 19 March. "We are also pushing the boundaries of economic feasibility. Or as it stands today — beyond it."

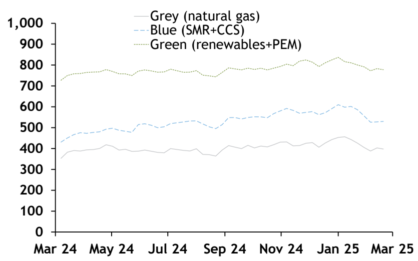
When the decision to build the plant was taken, Thyssenkrupp and other stakeholders expected that there would be "sufficient hydrogen available at competitive prices" upon completion or following a transitional period of natural gas use at the latest, Lopez said. But the buildout of hydrogen infrastructure is not progressing as expected and renewable hydrogen is not competitive, regardless of whether it is produced domestically or imported, he said.

Thyssenkrupp decided to build the plant in September 2022, and in 2023 secured €2bn in funding from the federal and state governments. The bulk of this was to support renewable hydrogen purchases. Thyssenkrupp reported strong participation in a tender for supply, but says it has for now put the procurement process on hold, partly because bid prices were much higher than anticipated. It will have to discuss the situation with Germany's next government and the EU, as the procurement would have been made with public funds, Thyssenkrupp says.

The DRI plant was initially envisaged as starting in 2026, and to start switching away from natural gas to clean hydrogen in subsequent years into the 2030s.

Lopez told the NRW parliament that Thyssenkrupp still intends to build the plant. But while the facility could run on natural gas for longer, this does not serve the purpose of maximising emissions cuts and reducing dependence on fossil fuels, Lopez said. The new government will have to ensure speedy construction of hydrogen pipelines in Germany and Europe to facilitate transport, he said.

Northwest European DRI costs $/t



Guarantees to satisfy

Lopez's comments came shortly after German hydrogen industry body DWV and steel association WV Stahl called for government guarantees to provide security around hydrogen offtake deals and stimulate investment. Berlin should provide special loan guarantees to back up offtake agreements for hydrogen, the groups said on 17 March. They also urged the government to provide long-term financing and guarantee instruments not only for the country's core pipeline network, but also for storage, import terminals and ammonia cracking facilities.

Steelmaker Salzgitter said earlier this month that during a tender last year it had received offers for over 1mn t/yr of renewable hydrogen supply from more than 100 projects, with over a quarter of these located outside of the EU. But the firm's head of energy strategy, Alfred Hoffmann, also noted that seaborne imports would hinge on the availability of ammonia cracking facilities and other port infrastructure. And like Lopez, Hoffmann had also pointed to the high cost of renewable hydrogen compared with natural gas.

Lopez last week drew some optimism from the EU's steel and metals action plan that was published shortly before his speech. The plan "goes in the right direction" but must now be put into practice "rapidly and decisively", he said.

Hydrogen features heavily in the plan as a key decarbonisation route. The European Commission in the document reiterated its intention from the Clean Industrial Deal published last month to finalise a definition of low-carbon hydrogen this quarter and to launch another European hydrogen bank auction later this year.

NEWS

Japan's Iwatani exits Queensland on CQ-H2 pause

Japanese hydrogen supplier Iwatani has closed its office in Queensland, Australia, after the 2.9GW Central Queensland Hydrogen (CQ-H2) project was put on hold because the state government decided not to provide further funding.

Iwatani closed the office in early March after the CQ-H2 project was put on hold, the company tells *Argus*.

But it has not decided whether to follow its former partner, Japanese utility Kansai Electric Power, and fully withdraw from the project. Kansai Electric Power exited the venture last year. Iwatani says it is reviewing the next steps with its partner companies, including Australia's state-owned Stanwell, and it is unclear when the firm will make a decision. But it will be challenging to continue the project as its feasibility was based on the subsidy, as well as power, water and land offered by the state of Queensland, Iwatani says.

The Queensland state government said last month that it would not provide equity and grant funding of more than A$1bn ($632mn) to the project, casting doubt on its future. For Stanwell and its partners to progress, "it would have required significantly more than A$1bn in state government funding, including infrastructure for water, port, transmission and hydrogen production", Queensland treasurer and energy minister David Janetzki said at the time. The decision followed a change in government last year, with the Liberal National party (LNP) taking over in October. CQ-H2 does "not align" with expectations to provide "affordable, reliable and sustainable power to Queenslanders", the LNP said.

CQ-H2 was one of the projects shortlisted for the first round of the Hydrogen Headstart subsidy scheme.

Iwatani says it will keep exploring opportunities for hydrogen production overseas, including in Australia. Iwatani and two partners, engineering company Kawasaki Heavy Industries (KHI) and refiner Eneos, last year decided to modify their procurement plan for a liquefied hydrogen shipping demonstration and switch the source to domestic production instead of output from an Australian coal-to-hydrogen project.

By Nanami Oki

India reallocates subsidies for 1,000 t/yr of green H2

India has adjusted the renewable subsidies from its second renewable hydrogen support tender after one bidder failed to meet financial requirements, a government source tells *Argus*.

Initially, 10 out of 13 bidders secured subsidies for a cumulative 450,000 t/yr over the first three years of their planned projects.

But Indian firm Nishal Enterprises' bid under the biomass-based hydrogen category was cancelled as the company failed to submit a performance bank guarantee (PBG), the government source says. Bidders have to submit PBGs backed by a bank or financial institution to assure that their projects would be completed according to the terms of the contract.

With Nishal Enterprises out, engineering firm Matrix Gas and Renewables was the only successful bidder in the biomass category.

To maintain the total allocated capacity at 450,000 t/yr, state-owned Solar Energy Corporation of India (SECI) awarded subsidies for an additional 1,000 t/yr to conglomerate Reliance.

SECI also published the maximum subsidy amounts allocated to successful participants last week (*see table*).

By Akansha Victor

Second green H2 tender winners

Bidder	Allocated capacity t/yr	Average incentive Rs/kg	Maximum allocated incentives Rs
Bucket I — technology agnostic pathway			
Oriana Power	10,000	0	300,000
Suryadeep KA1 Project	19,000	8	456mn
L&T Energy Green Tech	90,000	11	2.9bn
GH2 Solar	10,500	15	471mn
Green Infra Renewable Energy	90,000	16	4.37bn
Waree Clean Energy	90,000	19	5.1bn
AM Green	90,000	19	5.13bn
Reliance	49,000	25	3.67bn
Bucket II — biomass-based pathway			
Matrix Gas & Renewables	1,500	40	179mn
Total	**450,000**		

— *SECI*

NEWS

India picks Adani to enhance power grid for green H2

India has selected domestic conglomerate Adani's subsidiary, Adani Energy Solutions (AESL), to enhance electricity infrastructure for renewable hydrogen and ammonia production in the western state of Gujarat.

State-owned infrastructure financier Power Finance Corporation (PFC) picked AESL on the back of a tariff-based competitive bidding process launched in October for development of 3GW power transmission capacity from the Navinal substation to Mundra.

The transmission project is expected to cost about 28bn rupees ($290mn) and will be "delivered" in 36 months, Adani said in an exchange filing.

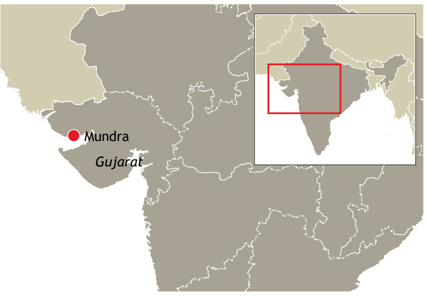
PFC has transferred a special purpose vehicle — Mundra I Transmission — from its consulting arm to AESL for the project's development. Electricity demand from renewable hydrogen and ammonia projects in Mundra is expected to reach 22GW by 2029-30, according to the ministry of new and renewable energy.

Adani's own hydrogen plans could be one of the beneficiaries from the new power transmission capacity. The conglomerate sees Mundra port as a key hydrogen hub, and is developing a renewable ammonia project with 1mn t/yr in the initial phase. The company has also secured 85,000 hectares in Rapar, Kutch, under Gujarat's wasteland policy for renewable hydrogen projects.

The award and potential progress on the power transmission plans will be good news to industry participants that are worried about potential electricity transfer bottlenecks. Slow expansion of electricity transmission networks is a major challenge for India's renewable hydrogen ambitions, renewables firm Avaada's chairman, Vineet Mittal, told *Argus* this month.

By Akansha Victor

Mundra, India



Egypt eyes $5bn-6bn dedicated power grid for H2

Egypt's government is in talks with Indian power infrastructure company Sterlite Power about a proposal to build a separate electricity network in Egypt for renewable hydrogen projects, the ministry of investment and foreign trade says.

The government says Sterlite Power's proposed project would cost $5bn-6bn, but the plans appear to be at an early stage because Cairo gave few details — notably the location in Egypt or when the developers might be able to build it. Sterlite Power was not immediately available for comment.

Sterlite sees a "promising market in Egypt" thanks to the government's support for renewable hydrogen projects, according to the ministry statement.

Egypt has set out hydrogen incentives for project developers and has attracted the most proposals in the Middle East, which could justify Sterlite's proposal.

A dedicated grid for electrolysis developers could trim overall system costs and might simplify compliance with rules for hydrogen production in export markets such as the EU. Countries including Oman have stressed that common user infrastructure makes a country more attractive by easing the burden on individual firms to build infrastructure.

Egypt's investment minister, Hassan El Khatib, also met with Indian developer ReNew Power to discuss the firm's $8bn renewable ammonia proposal in Egypt, the government says, without giving a firmer update. The project is at least six months behind schedule. It is more than two years since ReNew Power said it was 12-18 months from an investment decision. But ReNew Power's project is not alone in this, as delays have been a feature in Egypt, as indeed they have in the wider Middle East region and global market.

By Aidan Lea

NEWS

TotalEnergies to wrap up green H2 supply deals by 2026

TotalEnergies aims to sign deals to buy an additional 300,000 t/yr of renewable hydrogen by the end of 2026, its refining and chemicals division hydrogen director, Sebastien Bruna, says.

The company has secured about 200,000 t/yr of renewable hydrogen since it launched a tender for 500,000 t/yr in September 2023 to decarbonise its European refineries, and it aims to secure the rest before the end of 2026, Bruna says.

TotalEnergies' tender received more than 50 supply proposals totalling over 5mn t/yr of renewable hydrogen, its refining and petrochemicals director, Jean-Marc Durand, says. About 30pc came from EU-based bids and 70pc from elsewhere, he says.

Based on the bids, production in Europe and imports "come out at roughly the same price, that is three times the price of traditional European" fossil-based hydrogen, Durand says.

TotalEnergies recently entered a 30,000 t/yr offtake deal with German utility RWE for 15 years starting in 2030, and a 45,000 t/yr agreement with compatriot industrial gas firm Air Liquide.

It agreed its largest deal last year with US industrial gas company Air Products, under which TotalEnergies will take 70,000 t/yr of hydrogen from 2030. The supply will be delivered as ammonia and be cracked back into hydrogen in Europe.

TotalEnergies is also developing its own production projects, specifically at the La Mede and Grandpuits biorefineries in France.

By Pamela Machado

TotalEnergies' European refineries	
Belgium	Antwerp (oil)
France	Normandy (oil)
France	Donges (oil)
France	Feyzin (oil)
France	La Mede (bio)
France	Grandpuits* (bio)
Germany	Leuna (oil)
Netherlands	Zeeland (oil)

**under development*

Chile invests $26mn in electrolyser factories

Chile's economic development agency Corfo has awarded a combined $25.6mn to three consortiums that stood out among 10 bids to build electrolyser manufacturing and assembly in the country. Two of the winning bids involve Chinese firms.

Chinese consortium Beijing SinoHy Energy, led by electrolyser maker Hygreen Energy, plans to assemble alkaline electrolyser units of 2.5MW and 5MW capacity in the central-southern Biobio region. The group aims to build the Hygreen BioBio H2V site in multiple phases over five years, with first operations expected to begin in 2026. Hygreen will combine its electrolyser knowledge with "market expertise" of local companies in Chile, it says. The site can supply the Chilean and "the broader Latin American" hydrogen sectors, the firm says.

Chilean firm Fastpack has tied up with the Brazilian arm of China's Guofu to build a manufacturing base in the capital of Santiago. The firms will assemble alkaline electrolyser units with a capacity of 100kW-1MW and proton exchange membrane electrolysers of 50kW-1MW. The $10mn project has $6mn in funding from the Chilean government and $4mn from the consortium partners, Guofu says. The plans include one electrolyser stack assembly line and three assembly lines for balance of plant kit. It will start in mid-2026, Guofu says.

Spanish-led consortium Joltech Solutions will build an "automatic manufacturing line for alkaline electrodes" in Biobio, working alongside the University of Concepcion and Enertex engineering. This will support assembly of electrolysers of 100kW-1MW. Operations at the site are to start in 2026. Joltech and Guofu say they received $10mn and $6mn grants, respectively, which suggests Hygreen's grant is probably $10mn, but Corfo did not provide a breakdown of its funding.

The three projects could bring over $50mn investment and qualified personnel to Chile, aiding its hopes to become a major renewable hydrogen producer.

By Emily Russell

ANALYSIS

EU database plans leave global e-methane in limbo

EU certification troubles might stall prospective e-methane imports and divert some supply to Japan instead, writes Aidan Lea

Companies planning to make e-methane for export to the EU are struggling to progress plans as they do not know whether they will be able to log their products on the bloc's mandatory digital database.

E-methane involves combining hydrogen — typically from renewable power, with CO_2 – to make what is effectively synthetic natural gas. Proponents tout the possibility of using existing natural gas infrastructure — such as pipelines and LNG terminals — to transport and use the product.

But the EU's plans to demand extra layers of evidence from producers inadvertently rules out e-methane projects if they are connected to natural gas grids outside the bloc, according to companies and lobby groups. This could frustrate multiple project proposals that *Argus* is tracking in North America, Australia and elsewhere. Several developers have told *Argus* that their projects are affected.

The EU has set up the Union Database (UDB) to track fuels as they move through the supply chain — to prevent fraud and 'double counting' of emissions-saving benefits. This should help stop the kinds of abuse that have damaged the credibility of biofuels and carbon offsets in the past.

Brussels wants companies that claim certificates for using e-methane to prove that other firms have not already counted it for themselves, and that it is not counted towards national CO_2 reduction goals in the country where it is produced. This should be manageable for e-methane trading inside the EU because the Europe-wide database should be able to verify claims.

But the EU's demand poses a problem for e-methane projects that are connected to a gas grid outside the bloc — which might have their own tracking systems or none at all — because the EU cannot rule out double counting. Some e-methane projects eyeing deliveries to the EU would need to use gas pipelines to send their output to export terminals, for example.

Coalition of the concerned

E-methane producers could pivot to other markets. Japan is an attractive prospect because of mandates for blending e-methane with city gas from 2030

Lobbying on this has been a priority of the 21-company-strong E-NG Coalition, policy director Rafik Ammar says. The group is co-ordinating with the biomethane industry, which is also concerned. It has urged the EU to clarify when it might harmonise UDB rules with non-EU countries, and wants an interim measure so e-methane projects do not stall, but has yet to receive a clear answer, Ammar says. The European Commission tells *Argus* it is "open to establishing co-operation frameworks" with countries outside the bloc, but has not given a time frame.

The EU's priority appears to be full UDB deployment among members, followed by alignment with neighbours that are physically connected by pipelines. The commission says it is in "technical talks" with Ukraine and the UK, but E-NG says those talks are at a very early stage. Arranging access to the UDB for external countries is implicitly a lower priority for the EU, much to the frustration of affected companies and governments. Concerned government officials from more than a dozen external countries — including the US, Canada, the UK and Japan — have started meeting to co-ordinate on best practices and positions, Ammar says.

E-methane producers could pivot to other markets. Japan is an attractive prospect because of mandates for blending e-methane with city gas from 2030. Some projects targeting e-methane exports to Japan are advancing, and developers have not flagged concerns over compliance with Japanese rules, Ammar says.

But missing out on EU customers would be a blow to producers and the impasse will curb, or at least delay, biomethane and e-methane production and probably make it trickier for companies operating in the EU to comply with the bloc's fuel switching policies, such as FuelEU Maritime, Ammar says.

ANALYSIS

45V survival key for US low-carbon H2 demand growth

US green hydrogen's troubled infancy could see stunted growth as a result of Trump's disdain for climate-friendly policies, writes Jasmina Kelemen

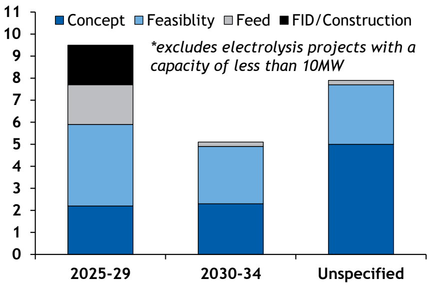
US demand for low-carbon hydrogen could rise more than tenfold between 2030 and 2050 as long as the 45V tax credit survives the current administration's review of clean energy initiatives, based on projections from *Argus Consulting*.

Domestic demand for low-carbon hydrogen, made from renewable power or from natural gas with carbon capture and storage (CCS), reaches 850,000 t/yr by 2030 in the base-case scenario set out in *Argus Consulting*'s *Low-Carbon Hydrogen Strategy Report* for the Americas, published this month. Demand then rises sharply to 4.5mn t/yr by 2030 and 9.5mn t/yr by 2050. Much of the increase is driven by maritime applications, with the sector expected to account for more than half of the demand by 2030 on the assumption of substantial emissions reduction targets for international shipping.

For its base-case scenario, *Argus Consulting* uses goals laid out in the Department of Energy's Blueprint for Transportation Decarbonisation and Industrial Decarbonisation Roadmap. It also assumes that 45V remains in place as a key tool for reducing low-carbon hydrogen production costs and stimulating uptake, especially in sectors such as fertiliser production.

Still, the base case represents a "moderate" scenario, given the lack of firm mandates for low-carbon hydrogen use in the US and "political headwinds". President Donald Trump has paused federal disbursements for clean-energy projects and pledged to boost oil and gas drilling, sparking concerns that measures stemming from the previous administration's Inflation Reduction Act is vulnerable to repeal. Trump's embrace of fossil fuels has meant some incentives could be on the chopping block to pay for Republican-led tax cuts, and until the fate of 45V is settled, hydrogen projects are likely to remain in a holding pattern.

US low-carbon H2 capacity* *t/yr*



— *Argus Consulting*

Stuttering start

The US hydrogen sector is no stranger to regulatory uncertainty and has progressed in fits and starts since the Joe Biden administration announced the 45V tax credits in 2022. A long wait for the final 45V rules, set out just weeks before Trump returned to office, had already made developers hesitant about advancing projects. Of the 14.6mn t/yr of low-carbon hydrogen capacity announced in the US with a specific start date, only about 12pc has reached the final investment decision (FID) or construction stage, based on *Argus Consulting* data.

Oil and gas firms have thrown their support behind 45V and have stressed that low-carbon hydrogen will have a key role to play in the future. "We base our actions around our beliefs — which doesn't change anywhere around the world or with any particular political position — and that is [that] the future of energy is low carbon," Chevron's vice president of hydrogen, Austin Knight, told *Argus* in a recent interview. "When you take the view of continuing to drive down carbon intensity, these are the types of products that you need to bring to market."

The most lucrative $3/kg tax credit could already drive the cost of CCS-based hydrogen well below that of conventional supply with unabated emissions. But it remains to be seen whether producers can bring their lifecycle emissions down sufficiently to qualify. With the 45V incentives, renewable hydrogen costs could slip below those of conventional supply by the end of this decade, at least in some locations, based on *Argus Consulting*'s projections.

In any event, subsidies from abroad could also help to get projects off the ground. *Argus Consulting* estimates that nearly 5mn t/yr of low-carbon hydrogen capacity in the US, especially from CCS-based projects, is targeted at exports to northeast Asia, and developers will be looking to secure support through subsidy mechanisms in Japan and South Korea.

45V hydrogen tax credit		$/kg
Emissions *kg of CO_2e/kg of H2**	Base	Multiplier†
2.5-4	0.12	0.60
1.5 to <2.5	0.15	0.75
0.45 to <1.5	0.20	1.00
<0.45	0.60	3.00

**based on lifecycle emissions; †applies if prevailing wage and apprenticeship requirements are met*

— *US government*

IN BRIEF

EU approves funding for next German CCfD round

The EU has approved €5bn ($5.4bn) in German state aid for companies under the bloc's emissions trading system (ETS) via carbon contracts for difference (CCfDs). Germany's scheme will decarbonise production processes through electrification, hydrogen, carbon capture or energy efficiency. Projects must cut greenhouse gas emissions by 60pc within three years and 90pc by the end of the 15-year CCfD timeframe compared with ETS benchmarks. Potential projects include fuel switching in the cement and lime sectors, chemical sector electrification and replacing traditional steel production with hydrogen-based direct reduction. Germany's first CCfD tender last year attracted 20 bids, exceeding its €4bn budget.

Japan's Osaka Gas exits ReaCH4 e-methane project in US

Japanese gas distributor Osaka Gas is to exit the ReaCH4 e-methane project in the US state of Louisiana, citing rising costs. The ReaCH4 project, which will continue to be developed by Tokyo Gas, Toho Gas, Mitsubishi and Sempra Infrastructure, aims to export 130,000 t/yr of synthetic methane to Japan by 2030 using the 15mn t/yr Cameron LNG facility. The developers aim to take a final investment decision in the 2025-26 fiscal year, Tokyo Gas tells *Argus*. Osaka Gas will focus on the e-methane project in the US Midwest it is developing with US firms Tallgrass Energy and Green Plains. That would export up to 200,000 t/yr by 2030 from the 15mn t/yr Freeport LNG terminal to Japan. Osaka Gas plans to blend e-methane into a future 622.6MW combined-cycle gas turbine unit by 2031, having won Japan's first auction for long-term zero emissions power capacity last year.

Canada awards HTEC $34mn for H2 liquefaction in British Columbia

Canada has awarded C$49mn ($34.2mn) to Vancouver-based HTEC for a hydrogen liquefaction facility in British Columbia that could start by 2026. The C$427mn project will capture by-product hydrogen vented from an Erco Worldwide sodium chlorate plant and liquefy it to supply HTEC's hydrogen refuelling stations in British Columbia and Alberta. The plant will make 15 t/d of what Canada's government called "low-carbon" hydrogen, enough for more than 100,000 truck refills annually, according to an HTEC project fact sheet. HTEC says this will offer the lowest carbon-intensity hydrogen in British Columbia and avoid up to 141,000t of CO_2/yr. HTEC's H2 Gateway programme envisages up to 20 refuelling stations, three hydrogen production plants and a fleet of 100 fuel cell electric trucks.

Hy2Gen lines up mining offtaker for Canadian green NH3

German developer Hy2Gen has struck a preliminary deal to sell renewable ammonia from its project in Quebec, Canada, to an explosives producer. It would allow the buyer to end its reliance on imported ammonium nitrate, Hy2Gen chief executive Cyril Dufau-Sansot says. Hy2Gen will use 307MW of hydropower from Hydro-Quebec to make about 230,000 t/yr of ammonia. The project is at the front-end engineering design stage, with environmental studies under way. Hy2Gen targets a final investment decision by 2026 and the start of operations in 2029-30. Hydropower cuts production costs compared with using wind farms and energy storage, Dufau-Sansot says.

EU approves €960mn Czech transition funding

The EU has approved €960mn state aid in the Czech Republic to provide grants to firms making "strategic" equipment for a net zero economy — including batteries, solar panels, wind turbines, heat pumps, electrolysers and carbon capture. Firms of any size can apply for the funds, which will be awarded by the end of this year.

COMPLETE HYDROGEN PRODUCTION COSTS

No-C Hydrogen									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands	Wind + PEM	Green	€/kg	7.59	8.23	nc	4.78	5.18	nc
Netherlands	Grid + PPA + ALK	Green	€/kg	8.10	8.78	+0.03	5.50	5.96	+0.02
UK	Wind + PEM	Green	£/kg	6.25	8.09	nc	3.80	4.91	nc
UK	Grid + PPA + ALK	Green	£/kg	7.46	9.65	+0.04	5.19	6.72	+0.04
Germany	Wind + PEM	Green	€/kg	7.62	8.27	nc	4.76	5.16	nc
Germany	Grid + PPA + ALK	Green	€/kg	7.74	8.40	+0.02	5.10	5.53	+0.02
France	Wind + PEM	Green	€/kg	7.96	8.63	nc	4.98	5.40	nc
France	Grid + PPA + ALK	Green	€/kg	7.98	8.66	-0.01	5.23	5.67	-0.02
Spain	Diurnal + PEM	Green	€/kg	5.97	6.47	nc	3.29	3.57	nc
Spain	Grid + PPA + ALK	Green	€/kg	6.41	6.95	nc	3.61	3.92	nc
Italy	Grid + PPA + ALK	Green	€/kg	8.73	9.47	+0.01	5.50	5.97	+0.01
Portugal	Grid + PPA + ALK	Green	€/kg	6.22	6.75	nc	3.57	3.87	nc
US west coast	Diurnal + PEM	Green	$/kg	6.62	6.62	nc	4.03	4.03	nc
Canada	Wind + PEM	Green	C$/kg	11.65	8.13	nc	7.25	5.06	nc
Oman	Diurnal + PEM	Green	$/kg	6.30	6.30	nc	3.33	3.33	nc
Saudi Arabia	Diurnal + PEM	Green	$/kg	6.05	6.05	nc	3.38	3.38	nc
UAE	Diurnal + PEM	Green	$/kg	5.65	5.65	nc	3.22	3.22	nc
Qatar	Diurnal + PEM	Green	$/kg	6.07	6.07	nc	3.52	3.52	nc
Namibia	Diurnal + PEM	Green	$/kg	7.35	7.35	nc	3.70	3.70	nc
South Africa	Diurnal + PEM	Green	$/kg	7.04	7.04	nc	3.79	3.79	nc
Japan	Wind + PEM	Green	¥/kg	2,450	16.39	nc	1,948	13.03	nc
China	Diurnal + PEM	Green	Yn/kg	32.60	4.50	nc	19.70	2.72	nc
India	Diurnal + PEM	Green	Rs/kg	569.19	6.61	nc	303.11	3.52	nc
South Korea	Wind + PEM	Green	W/kg	22,646	15.48	nc	17,936	12.26	nc
Vietnam	Wind + PEM	Green	$/kg	9.72	9.72	nc	5.68	5.68	nc
Australia	Diurnal + PEM	Green	A$/kg	10.00	6.30	nc	5.84	3.68	nc
Brazil	Diurnal + PEM	Green	$/kg	6.85	6.85	nc	3.53	3.53	nc
Chile	Diurnal + PEM	Green	$/kg	6.48	6.48	nc	3.71	3.71	nc

Low-C hydrogen									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands	ATR + CCS	Blue	€/kg	4.73	5.13	-0.01	3.61	3.92	-0.01
UK	ATR + CCS	Blue	£/kg	4.07	5.27	-0.04	3.08	3.98	-0.04
Germany	ATR + CCS	Blue	€/kg	4.79	5.19	-0.01	3.65	3.96	-0.01
Spain	ATR + CCS	Blue	€/kg	4.71	5.11	-0.01	3.31	3.59	-0.01
France	ATR + CCS	Blue	€/kg	4.65	5.04	+0.02	3.44	3.73	+0.02
US Gulf coast	ATR + CCS	Blue	$/kg	2.90	2.90	-0.01	1.68	1.68	-0.02
Canada	ATR + CCS	Blue	C$/kg	3.28	2.29	-0.06	1.53	1.07	-0.07
Japan	ATR + CCS	Blue	¥/kg	851	5.69	+0.01	644	4.31	nc
South Korea	ATR + CCS	Blue	W/kg	8,046	5.50	+0.03	6,144	4.20	+0.04
Australia	ATR + CCS	Blue	A$/kg	6.35	4.00	+0.09	4.40	2.77	+0.09
Trinidad	ATR + CCS	Blue	$/kg	5.08	5.08	+0.01	3.23	3.23	+0.01
Qatar	ATR + CCS	Blue	$/kg	4.38	4.38	+0.03	3.14	3.14	+0.03
UAE	ATR + CCS	Blue	$/kg	4.56	4.56	+0.04	3.38	3.38	+0.03
Russia west	ATR + CCS	Blue	$/kg	3.18	3.18	+0.01	1.10	1.10	+0.01
Russia east	ATR + CCS	Blue	$/kg	3.11	3.11	+0.01	1.04	1.04	+0.02

COMPLETE HYDROGEN PRODUCTION COSTS

BAT+ hydrogen									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands	SMR + CCS	Blue	€/kg	3.77	4.09	-0.01	3.15	3.42	-0.02
UK	SMR + CCS	Blue	£/kg	3.12	4.04	-0.04	2.57	3.32	-0.04
Germany	SMR + CCS	Blue	€/kg	3.84	4.16	-0.01	3.21	3.48	-0.01
Spain	SMR + CCS	Blue	€/kg	3.82	4.14	+0.01	3.04	3.30	+0.01
France	SMR + CCS	Blue	€/kg	3.75	4.07	+0.01	3.09	3.35	+0.02
US Gulf coast	SMR + CCS	Blue	$/kg	1.94	1.94	-0.01	1.27	1.27	nc
Canada	SMR + CCS	Blue	C$/kg	2.26	1.58	-0.01	1.30	0.91	-0.01
Japan	SMR + CCS	Blue	¥/kg	637	4.26	+0.03	523	3.50	+0.03
South Korea	SMR + CCS	Blue	W/kg	6,130	4.19	+0.03	5,076	3.47	+0.03
Australia	SMR + CCS	Blue	A$/kg	4.61	2.90	+0.08	3.53	2.22	+0.08
Trinidad	SMR + CCS	Blue	$/kg	3.85	3.85	+0.01	2.82	2.82	+0.01
Qatar	SMR + CCS	Blue	$/kg	3.44	3.44	+0.03	2.75	2.75	+0.03
UAE	SMR + CCS	Blue	$/kg	3.45	3.45	+0.03	2.80	2.80	+0.03
Russia west	SMR + CCS	Blue	$/kg	1.92	1.92	+0.01	0.77	0.77	+0.01
Russia east	SMR + CCS	Blue	$/kg	1.87	1.87	+0.01	0.72	0.72	+0.01

BAT+ hydrogen						25 Mar
				Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar
Netherlands	SMR + CCS retrofit	Blue	€/kg	3.48	3.77	-0.02
UK	SMR + CCS retrofit	Blue	£/kg	2.78	3.60	-0.04
Germany	SMR + CCS retrofit	Blue	€/kg	3.51	3.81	-0.01
Spain	SMR + CCS retrofit	Blue	€/kg	3.34	3.62	+0.01
France	SMR + CCS retrofit	Blue	€/kg	3.40	3.69	+0.01
US Gulf coast	SMR + CCS retrofit	Blue	$/kg	1.53	1.53	nc
Canada	SMR + CCS retrofit	Blue	C$/kg	1.79	1.25	-0.01
Japan	SMR + CCS retrofit	Blue	¥/kg	540	3.61	+0.03
South Korea	SMR + CCS retrofit	Blue	W/kg	5,281	3.61	+0.04
Australia	SMR + CCS retrofit	Blue	A$/kg	3.91	2.46	+0.08
Trinidad	SMR + CCS retrofit	Blue	$/kg	2.99	2.99	+0.01
Qatar	SMR + CCS retrofit	Blue	$/kg	2.96	2.96	+0.03
UAE	SMR + CCS retrofit	Blue	$/kg	3.00	3.00	+0.03
Russia west	SMR + CCS retrofit	Blue	$/kg	0.97	0.97	+0.02
Russia east	SMR + CCS retrofit	Blue	$/kg	0.92	0.92	+0.01

BAT+ hydrogen										25 Mar
					Incl. capex			Excl. capex		
	Process	kcal/kg NAR	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Australia	Coal gasification + CCS	5,500	Blue	A$/kg	5.99	3.77	nc	4.03	2.54	+0.01
Australia	Coal gasification + CCS	6,000	Blue	A$/kg	6.32	3.98	nc	4.35	2.74	-0.01
China	Coal gasification + CCS	3,800	Blue	Yn/kg	30.57	4.22	-0.01	21.01	2.90	-0.01
China	Coal gasification + CCS	5,500	Blue	Yn/kg	29.48	4.07	-0.01	19.92	2.75	nc
Indonesia	Coal gasification + CCS	5,500	Blue	$/kg	4.11	4.11	nc	2.62	2.62	nc
Indonesia	Coal gasification + CCS	3,800	Blue	$/kg	3.95	3.95	nc	2.46	2.46	nc
South Africa	Coal gasification + CCS	4,800	Blue	$/kg	4.18	4.18	nc	2.47	2.47	nc
South Africa	Coal gasification + CCS	6,000	Blue	$/kg	4.31	4.31	-0.01	2.59	2.59	-0.02
Russia west	Coal gasification + CCS	6,000	Blue	$/kg	3.95	3.95	+0.01	2.06	2.06	nc
US east coast	Coal gasification + CCS	6,000	Blue	$/kg	3.66	3.66	nc	2.43	2.43	-0.01

COMPLETE HYDROGEN PRODUCTION COSTS

Baseline hydrogen									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands	SMR	Grey	€/kg	3.75	4.07	nc	3.24	3.51	nc
UK	SMR	Grey	£/kg	2.96	3.83	-0.02	2.50	3.23	-0.02
Germany	SMR	Grey	€/kg	3.82	4.14	+0.01	3.29	3.57	+0.01
Spain	SMR	Grey	€/kg	3.77	4.09	+0.01	3.13	3.39	+0.02
France	SMR	Grey	€/kg	3.73	4.05	+0.03	3.17	3.44	+0.03
US Gulf coast	SMR	Grey	$/kg	1.57	1.57	nc	1.00	1.00	nc
Canada	SMR	Grey	C$/kg	2.24	1.56	nc	1.42	0.99	-0.01
Japan	SMR	Grey	¥/kg	513	3.43	+0.03	417	2.79	+0.03
South Korea	SMR	Grey	W/kg	4,974	3.40	+0.03	4,096	2.80	+0.04
Australia	SMR	Grey	A$/kg	3.81	2.40	+0.08	2.91	1.83	+0.08
Trinidad	SMR	Grey	$/kg	3.29	3.29	+0.01	2.42	2.42	nc
Qatar	SMR	Grey	$/kg	3.06	3.06	+0.03	2.48	2.48	+0.03
UAE	SMR	Grey	$/kg	3.08	3.08	+0.03	2.53	2.53	+0.03
Russia west	SMR	Grey	$/kg	1.47	1.47	+0.01	0.50	0.50	+0.01
Russia east	SMR	Grey	$/kg	1.42	1.42	+0.01	0.45	0.45	+0.01

Baseline hydrogen									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands	Grid + ALK	Yellow	€/kg	10.10	10.95	+0.25	7.80	8.46	+0.25
Netherlands	Grid + PEM	Yellow	€/kg	9.89	10.73	+0.24	7.42	8.05	+0.24
UK	Grid + ALK	Yellow	£/kg	9.79	12.67	+0.27	7.82	10.11	+0.27
UK	Grid + PEM	Yellow	£/kg	9.52	12.32	+0.25	7.39	9.56	+0.25
Germany	Grid + ALK	Yellow	€/kg	9.64	10.46	+0.21	7.30	7.92	+0.20
Germany	Grid + PEM	Yellow	€/kg	9.46	10.26	+0.19	6.94	7.53	+0.19
France	Grid + ALK	Yellow	€/kg	7.90	8.57	+0.09	5.50	5.96	+0.09
France	Grid + PEM	Yellow	€/kg	7.86	8.52	+0.08	5.26	5.71	+0.09
Spain	Grid + ALK	Yellow	€/kg	6.45	7.00	-0.11	3.84	4.17	-0.11
Spain	Grid + PEM	Yellow	€/kg	6.54	7.09	-0.10	3.72	4.03	-0.10
US west coast	Grid + ALK	Yellow	$/kg	7.43	7.43	nc	4.93	4.93	nc
US west coast	Grid + PEM	Yellow	$/kg	7.45	7.45	nc	4.75	4.75	nc
US Midwest	Grid + ALK	Yellow	$/kg	6.97	6.97	-0.24	4.47	4.47	-0.24
US Midwest	Grid + PEM	Yellow	$/kg	7.02	7.02	-0.22	4.32	4.32	-0.22
US east coast	Grid + ALK	Yellow	$/kg	8.25	8.25	+0.03	5.75	5.75	+0.04
US east coast	Grid + PEM	Yellow	$/kg	8.21	8.21	+0.03	5.51	5.51	+0.03
Japan	Grid + ALK	Yellow	¥/kg	1,526	10.21	-0.50	1,124	7.52	-0.50
Japan	Grid + PEM	Yellow	¥/kg	1,502	10.05	-0.46	1,067	7.14	-0.47

COMPLETE HYDROGEN PRODUCTION COSTS

Hydrogen decarbonisation spreads				25 Mar
	Incl. capex		Excl. capex	
	$/kg	± 18 Mar	$/kg	± 18 Mar
Northwest Europe				
No-C to BAT+	4.27	nc	1.83	nc
Low-C to BAT+	1.01	nc	0.45	nc
BAT+ to baseline	0.02	-0.02	-0.09	-0.02
North America				
No-C to BAT+	5.62	+0.01	3.46	+0.01
Low-C to BAT+	0.84	-0.02	0.29	-0.03
BAT+ to baseline	0.19	-0.01	0.09	-0.01
Northeast Asia				
No-C to BAT+	7.89	-0.03	5.85	-0.03
Low-C to BAT+	1.37	-0.01	0.77	-0.01
BAT+ to baseline	0.81	nc	0.69	-0.01
Middle East				
No-C to BAT+	2.57	-0.03	0.58	-0.03
Low-C to BAT+	1.02	nc	0.48	nc
BAT+ to baseline	0.38	nc	0.27	nc
Net exporter				
No-C to BAT+	3.59	-0.03	1.38	-0.03
Low-C to BAT+	1.03	+0.01	0.48	nc
BAT+ to baseline	0.40	-0.01	0.30	nc

Decarbonisation spreads relevant for subsidy mechanisms							25 Mar
		Incl. capex			Excl. capex		
	Unit	Spread	Spread in $/kg	± 18 Mar	Spread	Spread in $/kg	± 18 Mar
France							
No-C to Baseline[1]	€/kg	4.22	4.58	-0.03	1.81	1.96	-0.03
Germany							
No-C to BAT+[2]	€/kg	3.79	4.11	+0.01	1.55	1.68	+0.01
Netherlands							
No-C to baseline[3]	€/kg	3.84	4.16	nc	1.54	1.67	nc

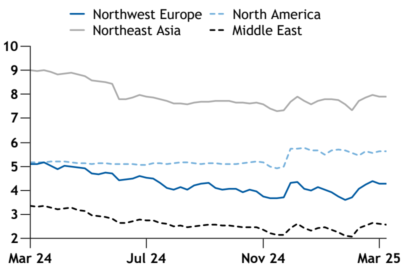
Differentials between the costs of renewable and natural gas-based hydrogen are used in subsidy mechanisms to establish the cost of switching to supply with a lower emissions intensity. The spreads above are relevant for the following:

1 France's planned operational support scheme for renewable hydrogen plants

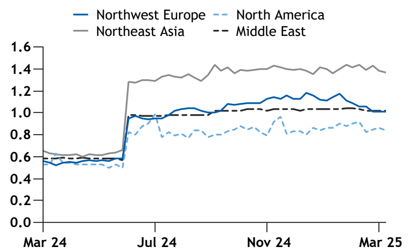
2 Future supply to Thyssenkrupp's direct reduced iron plant in Duisburg

3 Operational support granted to selected projects in Dutch subsidy scheme

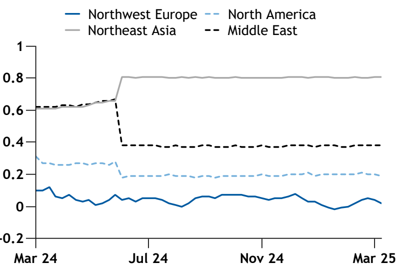
Decarb spread No-C to BAT+ *$/kg*



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



Decarb spread BAT+ to baseline *$/kg*

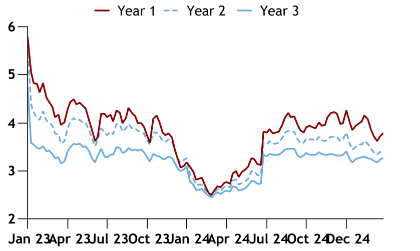


COMPLETE HYDROGEN PRODUCTION COSTS

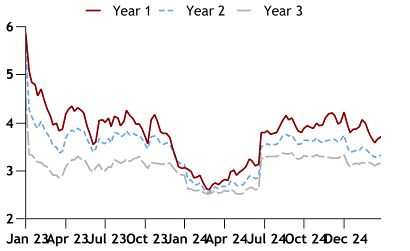
Low-C hydrogen forward									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands									
2026	ATR + CCS	Blue	€/kg	4.37	4.74	+0.05	3.25	3.53	+0.05
2027	ATR + CCS	Blue	€/kg	3.97	4.31	nc	2.86	3.10	nc
2028	ATR + CCS	Blue	€/kg	3.78	4.10	nc	2.66	2.89	nc
UK									
2026	ATR + CCS	Blue	£/kg	3.76	4.87	+0.05	2.77	3.58	+0.05
2027	ATR + CCS	Blue	£/kg	3.48	4.50	+0.01	2.48	3.21	+0.01
Germany									
2026	ATR + CCS	Blue	€/kg	4.43	4.81	+0.05	2.86	3.58	+0.05
2027	ATR + CCS	Blue	€/kg	4.05	4.39	+0.01	3.30	3.16	+0.01
2028	ATR + CCS	Blue	€/kg	3.85	4.18	nc	2.91	2.95	+0.01
France									
2026	ATR + CCS	Blue	€/kg	4.30	4.66	+0.04	3.09	3.35	+0.04
Spain									
2026	ATR + CCS	Blue	€/kg	4.46	4.84	+0.05	3.06	3.32	+0.04

BAT+ hydrogen forward									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands									
2026	SMR + CCS	Blue	€/kg	3.41	3.70	+0.04	2.79	3.03	+0.04
2027	SMR + CCS	Blue	€/kg	3.06	3.32	nc	2.44	2.65	nc
2028	SMR + CCS	Blue	€/kg	2.90	3.15	+0.01	2.29	2.48	+0.01
UK									
2026	SMR + CCS	Blue	£/kg	2.88	3.72	+0.05	2.33	3.01	+0.05
2027	SMR + CCS	Blue	£/kg	2.64	3.41	+0.02	2.08	2.69	+0.02
Germany									
2026	SMR + CCS	Blue	€/kg	3.49	3.78	+0.05	2.86	3.10	+0.05
2027	SMR + CCS	Blue	€/kg	3.13	3.40	nc	2.51	2.72	nc
2028	SMR + CCS	Blue	€/kg	2.98	3.23	+0.01	2.35	2.55	+0.01
France									
2026	SMR + CCS	Blue	€/kg	3.39	3.68	+0.04	2.73	2.96	+0.04
Spain									
2026	SMR + CCS	Blue	€/kg	3.48	3.77	+0.04	2.70	2.93	+0.04

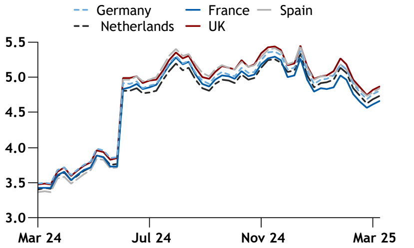
German SMR costs *$/kg*



Dutch SMR+CCS costs *$/kg*



European year 1 ATR+CCS costs *$/kg*



COMPLETE HYDROGEN PRODUCTION COSTS

Baseline hydrogen forward									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 18 Mar	Cost	Cost in $/kg	± 18 Mar
Netherlands									
2026	SMR	Grey	€/kg	3.40	3.69	+0.06	2.89	3.13	+0.06
2027	SMR	Grey	€/kg	3.07	3.33	+0.02	2.55	2.77	+0.02
2028	SMR	Grey	€/kg	2.92	3.17	+0.02	2.41	2.61	+0.02
UK									
2026	SMR	Grey	£/kg	2.78	3.59	+0.08	2.31	2.99	+0.08
2027	SMR	Grey	£/kg	2.54	3.29	+0.05	2.08	2.69	+0.05
Germany									
2026	SMR	Grey	€/kg	3.48	3.77	+0.06	2.95	3.20	+0.06
2027	SMR	Grey	€/kg	3.14	3.41	+0.02	2.62	2.84	+0.02
2028	SMR	Grey	€/kg	3.01	3.26	+0.03	2.47	2.68	+0.02
France									
2026	SMR	Grey	€/kg	3.38	3.67	+0.06	2.82	3.06	+0.06
Spain									
2026	SMR	Grey	€/kg	3.45	3.74	+0.06	2.79	3.03	+0.06

Direct reduction iron costs (21 Mar)		$/t
Specification	**Cost**	**±**
Natural gas DRI, ex-works NW Europe	397.72	-5.10
DRI spread No-C hydrogen (renewables+PEM) vs natural gas NW Europe	379.99	-0.12
DRI spread BAT+ hydrogen (SMR+CCS) vs natural gas NW Europe	132.33	+7.42

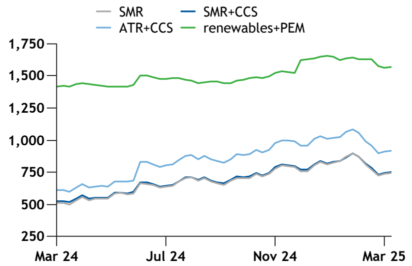
COMPLETE AMMONIA PRODUCTION COSTS

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

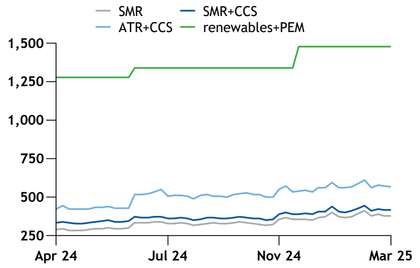
CO2e emissions on a gate-to-gate basis; purity >99.5pc; temperature -33°C

Regional ammonia cost markers						25 Mar
			Incl. capex		Excl. capex	
	Process	Unit	Cost	± 18 Mar	Cost	± 18 Mar
Baseline						
Northwest Europe	SMR	€/t	745	+5	580	+4
Northwest Europe	SMR	$/t	808	+2	629	+2
North America	SMR	$/t	379	-1	205	-1
Northeast Asia	SMR	$/t	693	+5	501	+6
Middle East	SMR	$/t	609	+5	449	+5
BAT+						
Northwest Europe	SMR+CCS	€/t	748	+3	566	+2
Northwest Europe	SMR+CCS	$/t	811	-1	614	nc
North America	SMR+CCS	$/t	414	-1	222	-1
Northeast Asia	SMR+CCS	$/t	837	+6	625	+6
Middle East	SMR+CCS	$/t	675	+6	497	+5
Low-C						
Northwest Europe	ATR+CCS	€/t	914	+4	632	+2
Northwest Europe	ATR+CCS	$/t	991	nc	686	nc
North America	ATR+CCS	$/t	564	-7	268	-8
Northeast Asia	ATR+CCS	$/t	1,077	+3	750	+3
Middle East	ATR+CCS	$/t	851	+5	578	+6
No-C						
Northwest Europe	Island renewable+PEM	€/t	1,568	+6	964	+4
Northwest Europe	Island renewable+PEM	$/t	1,701	nc	1,046	nc
North America	Island renewable+PEM	$/t	1,480	nc	902	nc
Northeast Asia	Island renewable+PEM	$/t	2,390	nc	1,799	nc
Middle East	Island renewable+PEM	$/t	1,179	nc	641	nc
Exporter						
Exporter baseline	SMR	$/t	526	+6	358	+5
Exporter BAT+	SMR+CCS	$/t	598	+6	412	+6
Exporter low-C	ATR+CCS	$/t	778	+6	492	+6
Exporter no-C	Island renewable+PEM	$/t	1,287	nc	701	nc

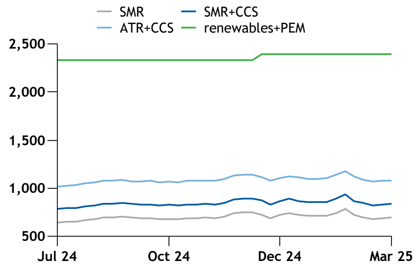
NW Europe ammonia average €/t



North America ammonia average $/t



Northeast Asia ammonia average $/t



COMPLETE AMMONIA PRODUCTION COSTS

No-C ammonia — 25 Mar

	Process	Legacy colour	Unit	Incl. capex			Excl. capex		
				Cost	Cost in $/t	± 18 Mar	Cost	Cost in $/t	± 18 Mar
Netherlands	Wind + PEM	Green	€/t	1,548	1,679	nc	961	1,042	nc
UK	Wind + PEM	Green	£/t	1,268	1,640	nc	749	969	nc
Germany	Wind + PEM	Green	€/t	1,540	1,670	nc	941	1,021	nc
France	Wind + PEM	Green	€/t	1,618	1,755	nc	992	1,076	nc
Spain	Diurnal + PEM	Green	€/t	1,185	1,285	nc	641	695	nc
US west coast	Diurnal + PEM	Green	$/t	1,309	1,309	nc	793	793	nc
Canada	Wind + PEM	Green	C$/t	2,366	1,651	nc	1,447	1,010	nc
Oman	Diurnal + PEM	Green	$/t	1,246	1,246	nc	633	633	nc
Saudi Arabia	Diurnal + PEM	Green	$/t	1,179	1,179	nc	642	642	nc
UAE	Diurnal + PEM	Green	$/t	1,103	1,103	nc	615	615	nc
Qatar	Diurnal + PEM	Green	$/t	1,186	1,186	nc	673	673	nc
Namibia	Diurnal + PEM	Green	$/t	1,474	1,474	nc	702	702	nc
South Africa	Diurnal + PEM	Green	$/t	1,392	1,392	nc	717	717	nc
Japan	Wind + PEM	Green	¥/t	480,165	3,212	nc	374,325	2,504	nc
China	Diurnal + PEM	Green	Yn/t	6,607	912	nc	3,789	523	nc
India	Diurnal + PEM	Green	Rs/t	111,857	1,299	nc	57,263	665	nc
South Korea	Wind + PEM	Green	W/t	4,456,127	3,046	nc	3,465,714	2,369	nc
Vietnam	Wind + PEM	Green	$/t	1,957	1,957	nc	1,083	1,083	nc
Australia	Diurnal + PEM	Green	A$/t	1,987	1,251	nc	1,159	730	nc
Brazil	Diurnal + PEM	Green	$/t	1,358	1,358	nc	669	669	nc
Chile	Diurnal + PEM	Green	$/t	1,263	1,263	nc	705	705	nc

Low-C ammonia — 25 Mar

	Process	Legacy colour	Unit	Incl. capex			Excl. capex		
				Cost	Cost in $/t	± 18 Mar	Cost	Cost in $/t	± 18 Mar
Netherlands	ATR + CCS	Blue	€/t	911	988	-2	642	696	-2
UK	ATR + CCS	Blue	£/t	782	1,011	-7	544	704	-6
Germany	ATR + CCS	Blue	€/t	925	1,003	-1	645	700	-1
Spain	ATR + CCS	Blue	€/t	931	1,010	-1	587	637	-1
France	ATR + CCS	Blue	€/t	904	981	+2	610	662	+2
US Gulf coast	ATR + CCS	Blue	$/t	608	608	-3	312	312	-3
Canada	ATR + CCS	Blue	C$/t	745	520	-11	321	224	-12
Japan	ATR + CCS	Blue	¥/t	164,141	1,098	+1	113,464	759	+1
South Korea	ATR + CCS	Blue	W/t	1,544,869	1,056	+6	1,084,042	741	+6
Australia	ATR + CCS	Blue	A$/t	1,274	802	+16	794	500	+16
Trinidad	ATR + CCS	Blue	$/t	1,042	1,042	+2	571	571	+1
Qatar	ATR + CCS	Blue	$/t	844	844	+5	557	557	+6
UAE	ATR + CCS	Blue	$/t	858	858	+6	598	598	+5
Russia west	ATR + CCS	Blue	$/t	734	734	+3	204	204	+2
Russia east	ATR + CCS	Blue	$/t	729	729	+2	200	200	+2

Low-carbon ammonia benchmarks — 25 Mar

	Unit	Cost	± 18 Mar
JKLAB CFR Ulsan, South Korea, incl. US 45Q tax credit	$/t	607.99	-2.95
JKLAB CFR Ulsan, South Korea, excl. US 45Q tax credit	$/t	743.99	-2.95
JKLAB CFR Niihama, Japan, differential	$/t	+0.30	+0.09
EULAB CFR ARA, incl. 45Q US tax credit	$/t	535.14	-3.32
EULAB CFR ARA, excl. 45Q US tax credit	$/t	671.14	-3.32

The low-carbon ammonia benchmarks include the US Gulf coast Low-C ATR+CCS ammonia production cost (with and without the US' 45Q tax credit for carbon sequestration) and freight costs. Freight costs are for delivery to Ulsan, South Korea, for JKLAB and to Amsterdam-Rotterdam-Antwerp (ARA) for EULAB. For JKLAB, the Niihama differential reflects the cost difference for delivery to Niihama in Japan, rather than to Ulsan.

COMPLETE AMMONIA PRODUCTION COSTS

BAT+ ammonia									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/t	± 18 Mar	Cost	Cost in $/t	± 18 Mar
Netherlands	SMR + CCS	Blue	€/t	742	805	-3	567	615	-3
UK	SMR + CCS	Blue	£/t	615	795	-7	461	596	-6
Germany	SMR + CCS	Blue	€/t	755	819	-2	575	624	-1
Spain	SMR + CCS	Blue	€/t	769	834	+1	546	592	+1
France	SMR + CCS	Blue	€/t	747	810	+3	556	603	+3
US Gulf coast	SMR + CCS	Blue	$/t	436	436	-1	244	244	-1
Canada	SMR + CCS	Blue	C$/t	560	391	-2	287	200	-1
Japan	SMR + CCS	Blue	¥/t	126,469	846	+5	93,731	627	+6
South Korea	SMR + CCS	Blue	W/t	1,209,855	827	+6	911,414	623	+6
Australia	SMR + CCS	Blue	A$/t	961	605	+14	649	409	+14
Trinidad	SMR + CCS	Blue	$/t	811	811	+2	506	506	+2
Qatar	SMR + CCS	Blue	$/t	679	679	+5	493	493	+5
UAE	SMR + CCS	Blue	$/t	670	670	+6	501	501	+5
Russia west	SMR + CCS	Blue	$/t	496	496	+2	153	153	+2
Russia east	SMR + CCS	Blue	$/t	489	489	+2	146	146	+2

BAT+ ammonia										25 Mar
					Incl. capex			Excl. capex		
	Process	kcal/kg NAR	Legacy colour	Unit	Cost	Cost in $/t	± 18 Mar	Cost	Cost in $/t	± 18 Mar
Australia	Coal gasification + CCS	5,500	Blue	A$/t	1,186	747	nc	735	463	+1
Australia	Coal gasification + CCS	6,000	Blue	A$/t	1,243	783	nc	791	498	-1
China	Coal gasification + CCS	3,800	Blue	Yn/t	5,904	815	-1	3,702	511	-1
China	Coal gasification + CCS	5,500	Blue	Yn/t	5,716	789	-2	3,513	485	nc
Indonesia	Coal gasification + CCS	5,500	Blue	$/t	805	805	nc	461	461	nc
Indonesia	Coal gasification + CCS	3,800	Blue	$/t	777	777	nc	433	433	nc
South Africa	Coal gasification + CCS	4,800	Blue	$/t	834	834	nc	435	435	nc
South Africa	Coal gasification + CCS	6,000	Blue	$/t	856	856	-2	456	456	-3
Russia west	Coal gasification + CCS	6,000	Blue	$/t	809	809	+2	367	367	nc
US east coast	Coal gasification + CCS	6,000	Blue	$/t	725	725	nc	443	443	-2

Baseline ammonia									25 Mar
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/t	± 18 Mar	Cost	Cost in $/t	± 18 Mar
Netherlands	SMR	Grey	€/t	739	802	nc	581	630	-1
UK	SMR	Grey	£/t	587	759	-3	448	579	-2
Germany	SMR	Grey	€/t	752	816	+1	589	639	+1
Spain	SMR	Grey	€/t	762	826	+3	560	607	+3
France	SMR	Grey	€/t	742	805	+5	570	618	+5
US Gulf coast	SMR	Grey	$/t	370	370	-1	196	196	-1
Canada	SMR	Grey	C$/t	555	387	-1	307	214	-1
Japan	SMR	Grey	¥/t	104,345	698	+5	74,596	499	+5
South Korea	SMR	Grey	W/t	1,005,043	687	+5	734,398	502	+6
Australia	SMR	Grey	A$/t	818	515	+13	537	338	+13
Trinidad	SMR	Grey	$/t	711	711	+2	435	435	+1
Qatar	SMR	Grey	$/t	613	613	+5	445	445	+5
UAE	SMR	Grey	$/t	605	605	+5	453	453	+5
Russia west	SMR	Grey	$/t	415	415	+2	104	104	+1
Russia east	SMR	Grey	$/t	408	408	+2	97	97	+1

COMPLETE AMMONIA PRODUCTION COSTS

Ammonia decarbonisation spreads				25 Mar
	Incl. capex		Excl. capex	
	$/t	± 18 Mar	$/t	± 18 Mar
Northwest Europe				
No-C to BAT+	890	+1	432	nc
Low-C to BAT+	180	+1	72	nc
BAT+ to baseline	3	-3	-15	-2
North America				
No-C to BAT+	1,066	+1	680	+1
Low-C to BAT+	150	-6	46	-7
BAT+ to baseline	35	nc	17	nc
Northeast Asia				
No-C to BAT+	1,553	-6	1,174	-6
Low-C to BAT+	240	-3	125	-3
BAT+ to baseline	144	+1	124	nc
Middle East				
No-C to BAT+	504	-6	144	-5
Low-C to BAT+	176	-1	81	+1
BAT+ to baseline	66	+1	48	nc
Net exporter				
No-C to BAT+	689	-6	289	-6
Low-C to BAT+	180	nc	80	nc
BAT+ to baseline	72	nc	54	+1

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