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Argus Hydrogen and Future Fuels

Market news, analysis and prices

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More momentum for subsurface H2 plans

Claims that geological H2 production costs could be much lower than for other pathways underpin the surge of interest, writes Pamela Machado

Interest in naturally occurring subsurface hydrogen is growing rapidly, with a big rise in the number of exploration projects and new partnerships showing potential pathways to commercialisation.

Argus is now tracking more than 70 publicly announced exploration projects globally, up from just over 50 in November. North America has the largest number of announced projects, with 29 initiatives, followed by Oceania and Europe. While most ventures remain at the exploration or resource appraisal stage, the increasing number of permitting decisions, drilling campaigns and commercial partnerships suggests the sector may now be moving beyond its nascent phases.

Europe has seen some of the most significant recent advances. French exploration company Mantle8 has secured authorisations from the French and Spanish governments to investigate subsurface hydrogen and helium resources in the Pyrenees, while France's FDE is targeting first geological hydrogen production from its Lorraine project in late 2028 or early 2029.

Activity is also gathering pace in North America. Canadian company Max Power recently expanded its Saskatchewan position, increasing its permitted landholdings to around 2mn acres from roughly 1.3mn previously. The company now controls 12 subsurface hydrogen projects in the province, reflecting growing confidence in the region's geological potential. Several other companies, including Koloma, HyTerra and Vema, are advancing projects in the US and Canada.

Would-be developers claim that production costs could be significantly lower than for other low-carbon hydrogen pathways — claims that have caught the attention of downstream companies.

US company Vema Hydrogen recently signed a preliminary agreement to supply around 4,000 t/yr of subsurface hydrogen to Canadian developer SAF+ International for the production of synthetic sustainable aviation fuel in Quebec. And in South Australia, Japan's Mitsubishi Gas Chemical and explorer Gold Hydrogen are assessing the feasibility of producing methanol using subsurface hydrogen from the latter's project.

But major uncertainties remain and challenges will need to be addressed.

Scientists from organisations including the US Geological Survey and the American Association of Petroleum Geologists caution that the presence of naturally occurring hydrogen does not necessarily translate into a commercially recoverable resource because hydrogen behaves differently from conventional hydrocarbons — hydrogen is a smaller, lighter molecule that can migrate more easily through geological formations and react with its surroundings.

A recent report by France's senate and parliamentary office for scientific and technological assessment highlighted these uncertainties, saying that no large-scale economically viable subsurface hydrogen deposit has yet been demonstrated. The report notes that the commercial viability of projects will ultimately depend on several factors — production rates, hydrogen purity, reservoir size, depth and proximity to potential customers.

Helium could also play an important role in project economics because it can provide developers with an additional revenue stream. Some exploration firms — Gold Hydrogen, being one — say they might even prioritise helium production in the short term, especially in light of the global shortage.

Geological hydrogen projects, by region

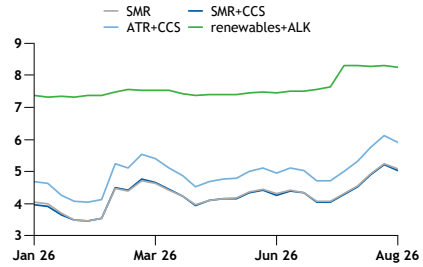
Region	Number
North America	29
Oceania	13
Europe	12
Africa	6
Middle East	5
Latin America	4
Asia-Pacific	3
Total	**72**

— Argus

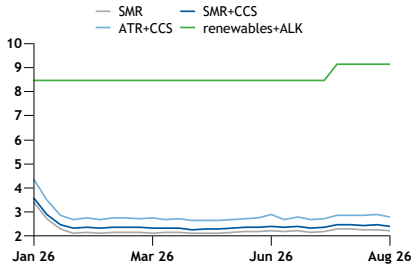
CONTENTS

HYDROGEN COSTS

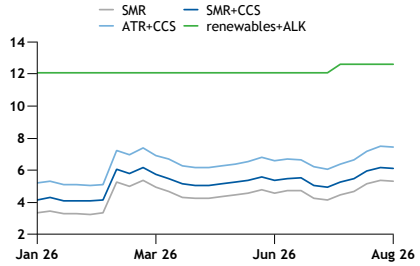
Northwest Europe average cost €/kg



North America average cost $/kg



Northeast Asia average cost $/kg



New production project tracker

Argus is now publishing a project tracker table that provides a monthly overview of updates to operational and planned projects for production of renewable or low-carbon hydrogen and derivatives. The tracker will be published in the first issue of *Argus Hydrogen and Future Fuels* of each month, covering updates from the previous month. It will be included in the data section ahead of the complete production cost data (pp13-15 in this issue). The information is also available in a downloadable dataset.

Regional hydrogen cost markers — 4 Aug

			Incl. capex		Excl. capex	
	Process	Unit	Cost	± 28 Jul	Cost	± 28 Jul
Baseline						
Northwest Europe	SMR	€/kg	5.07	-0.18	4.15	-0.17
Northwest Europe	SMR	$/kg	5.82	-0.16	4.76	-0.16
North America	SMR	$/kg	2.22	-0.04	1.07	-0.04
Northeast Asia	SMR	$/kg	5.30	-0.08	4.22	-0.08
BAT+						
Northwest Europe	SMR+CCS	€/kg	5.03	-0.18	4.00	-0.16
Northwest Europe	SMR+CCS	$/kg	5.78	-0.15	4.59	-0.15
North America	SMR+CCS	$/kg	2.40	-0.05	1.11	-0.04
Northeast Asia	SMR+CCS	$/kg	6.10	-0.08	4.88	-0.09
Low-C						
Northwest Europe	ATR+CCS	€/kg	5.92	-0.20	4.76	-0.17
Northwest Europe	ATR+CCS	$/kg	6.80	-0.17	5.46	-0.16
North America	ATR+CCS	$/kg	2.80	-0.10	1.34	-0.11
Northeast Asia	ATR+CCS	$/kg	7.42	-0.10	6.05	-0.10
No-C						
Northwest Europe	Island renewable+PEM	€/kg	8.26	-0.06	6.17	-0.05
Northwest Europe	Island renewable+PEM	$/kg	9.48	nc	7.08	nc
North America	Island renewable+PEM	$/kg	9.16	nc	6.49	nc
Northeast Asia	Island renewable+PEM	$/kg	12.59	nc	10.18	nc
Exporter						
Exporter baseline	SMR	$/kg	2.19	+0.01	1.32	+0.02
Exporter BAT+	SMR+CCS	$/kg	2.65	+0.01	1.66	+0.01
Exporter low-C	ATR+CCS	$/kg	3.24	+0.02	2.14	+0.03
Exporter no-C	Island renewable+PEM	$/kg	6.08	nc	3.44	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 — 1 Jul

	Unit	Price		± 1 Jun
Japan				
Iwatani	¥/kg	1,650.00		nc
		Low	High	
Eneos	¥/kg	2,200.0	2,750.0	nc
Germany				
		Low	High	
H2Mobility (stations with conventional H2 supply)	€/kg	13.50	19.25	nc
H2Mobility (stations with "green" H2 supply)	€/kg	13.50	17.75	nc

MARKET DEVELOPMENTS

China H2 investment more than doubles in 1H — NEA

Beijing wants renewables-rich regions to do more with green energy than just electrification, writes Chingis Idrissov

Investment in China's hydrogen sector more than doubled on the year in the first half of 2026, the National Energy Administration (NEA) says, as Beijing prepares to allow renewable hydrogen, ammonia and methanol count towards renewable energy consumption targets from 1 August.

Without giving an outright figure, the NEA says hydrogen investment grew by 160pc in January-June. This is much faster growth than seen in any other area of energy investment it lists, far outstripping increases elsewhere (*see table*).

Rules jointly issued by the NEA and the National Development and Reform Commission (NDRC), effective on 1 August, permit renewable hydrogen, ammonia and methanol to count towards renewables consumption targets.

The aim is to give surplus wind and solar power another outlet in hydrogen and derivatives. This will ease pressure on the grid in regions rich in renewable resources where local absorption capacity is limited and long-distance transmission faces constraints, NEA new energy department deputy head Pan Huimin says.

China had built more than half of global renewable hydrogen and derivatives production capacity by the end of 2025, Pan says. But using renewable power for purposes other than electrification is still not cost-competitive and the market does not properly reward the green attributes, so policy is needed to build steady demand, she says.

Firms can meet the power part of the targets by generating renewable power on site, taking supply through a dedicated direct line, sourcing green power from the grid or purchasing green electricity certificates (GECs), the NEA says. In June, the NEA and other government bodies integrated GECs into China's carbon accounting framework. Beijing also extended GEC issuance to renewable plants that are not connected to the public grid, which Pan calls the "last gap" in the system. Such plants, which include most off-grid renewable hydrogen projects, previously had to prove their green credentials by metering the power directly.

China's renewable capacity was 2.46TW at the end of June, up by 14pc on the year and accounting for 61pc of total generating capacity, with wind and solar at a combined 1.95TW. Renewables accounted for 41pc of Chinese power output in the first half of 2026, while coal's share fell to 50pc. China also leads in global energy storage installations.

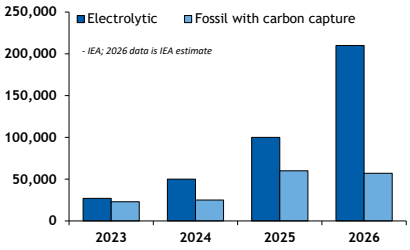
The NEA recently listed renewable hydrogen, ammonia and methanol among its innovation priorities for the country's 2026-30 Five-Year Plan. It has started work on 48 technical standards for hydrogen and derivatives infrastructure, to be completed in 2028, the body said on 27 July.

1H26 y-o-y investment growth

Sector	Growth %
Hydrogen	160
Energy storage	74
Vehicle charging infrastructure	21
Power grid build-out	14

— *NEA*

China's low-emission H2 output *t*



High Five

The industry and information technology ministry published its industrial green and low-carbon development blueprint under the Five-Year Plan on 31 July. This sees industrial CO_2 emissions peaking by 2030, in line with other government bodies.

The ministry wants renewable energy-rich regions to take on aluminium smelting, steel, petrochemicals, solar and battery production. It urges regions to use renewable hydrogen, ammonia and methanol in industrial sectors to step up use of renewable energy for purposes other than electrification. It wants 500 zero-carbon factories built by 2030, using more renewable power and hydrogen or derivatives.

Hydrogen is also listed as a component of "industrial green micro-grids", alongside solar, wind, heat pumps, storage and waste heat-recovery systems. The plan backs direct connection of renewables to industrial users and integrated generation, grid, demand and storage projects. This suggests the ministry wants more electrolysers at off-grid renewable sites.

MARKET DEVELOPMENTS

Europe lags China on e-fuel plants for shipping: T&E

China is leaving Europe in its wake, with bigger plants and plans, and clearer government support, writes Chingis Idrissov

Europe has 69 renewable hydrogen-based e-fuel projects that could supply the shipping sector, but only six of these are producing and their combined output is just one-tenth of the three operating plants in China, according to Brussels-based climate group Transport and Environment (T&E).

The European projects in T&E's shipping e-fuels database could deliver 4.09mn t/yr of oil equivalent (toe/yr) by 2033 if all are realised as planned. This would equate to about 14pc of European shipping fuel demand, but for many the final offtake markets remain uncertain. Only 13 of the 69 projects target the maritime sector as their primary market. These account for a combined capacity of 320,000 toe/yr. If realised by 2031, this could suffice to meet that year's FuelEU Maritime 1pc renewable fuels of non-biological origin (RFNBO) target, which T&E calculates at around 280,000toe. By 2034, around 580,000 toe/yr could be needed to meet FuelEU Maritime's 2pc target, T&E says.

Of the total 4.52mn toe/yr of planned capacity that could go towards the shipping sector, renewable ammonia and e-methanol account for the largest shares (*see table*). Spain leads across all products with 1.58mn toe/yr of announced capacity, ahead of Finland, Denmark and France.

But more than 80pc of the European projects are yet to reach a final investment decision (FID), with only seven initiatives having passed this stage. The largest of these is Spanish firm Moeve's Andalusian Green Hydrogen Valley, which is expected to make around 474,000 toe/yr of renewable ammonia and e-methanol combined. Construction is due to start in September, Moeve said last week.

Six projects are operational and make around 30,000 toe/yr between them. Danish renewables developer European Energy's Kasso plant is by far the largest of these, accounting for over two-thirds of the total with its 42,000 t/yr of e-methanol output, although not all of this is for maritime use.

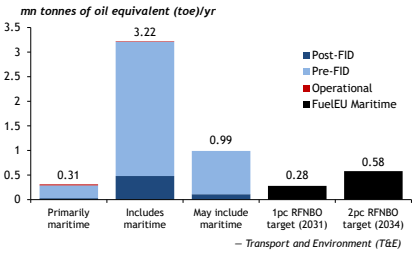
Announced capacity in Europe by 2033

Product type	*mn toe/yr*	*mn t/yr product*
Total	**4.52**	**7.64**
Renewable NH3	1.63	3.67
E-methanol	1.57	3.30
Renewable H2	0.89	0.31
E-methane	0.43	0.36

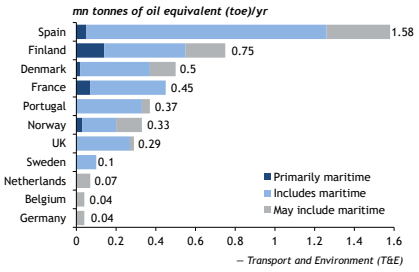
Figs include 0.43mn toe/yr of capacity without start-up target

— T&E shipping e-fuels observatory, Argus

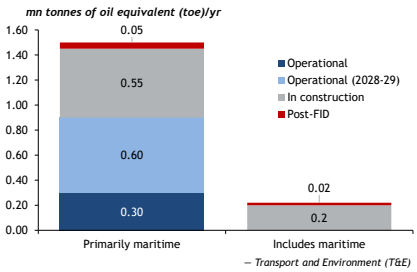
Announced European e-fuel capacity, by status



Announced European e-fuel capacity for 2026-33, by country



Tracked Chinese e-fuel capacity, by status



Size does matter

Chinese projects far outstrip European initiatives by size.

T&E counts 15 Chinese projects above 10,000 toe/yr, with 1.72mn toe/yr of combined capacity by 2029. Of these, 11 primarily target shipping with 1.5mn toe/yr. Three are operating at partial capacity, making around 300,000 toe/yr — exceeding Europe's operational capacity 10 times over. The plants are expected to reach full capacity by 2028-29. A further 10 are under construction.

T&E also tracks 22 Chinese biomethanol and mixed bio and e-methanol projects pointed at shipping, with 2.78mn toe/yr combined by 2029. Chinese firms have had some success in signing offtake deals for output from these hybrid plants, with Goldwind set to supply shipping firm Maersk with 500,000 t/yr of mixed bio and e-methanol and shipper Hapag-Lloyd with 250,000 t/yr.

Offtake deals for pure e-fuels remain rare, T&E says, citing thin vessel demand. Only 47 ammonia-fuelled ships are on order, against 284 methanol-fuelled vessels and 1,108 LNG-fuelled vessels, according to June data from shipbroker Clarksons. Most methanol-powered vessels are likely to use biomethanol or a mix of bio and e-methanol, T&E data show.

T&E says EU financial support to close the price gap with fossil bunkers, alongside clean fuel targets, is needed to keep European production competitive and prevent Chinese supply from flooding the market.

All 14 Australian projects in T&E's database are pre-FID and none targets shipping as its main market. Eleven plan to make 7.71mn toe/yr between them, with 6.28mn toe/yr announced for 2031. The Australian Renewable Energy Hub alone accounts for 68pc of the total.

NEWS

Yara, Air Products finalise Saudi green ammonia deal

US industrial gas firm Air Products has finalised a deal with Norway's Yara on renewable ammonia sales from the planned 1.2mn t/yr Neom plant in Saudi Arabia.

Yara will market renewable ammonia that Air Products does not sell as hydrogen, according to Air Products' second-quarter results, published on 30 July. The firms said in December that they were in discussions regarding a "marketing and distribution agreement" for Neom output.

Air Products is Neom's sole offtaker under a 30-year contract. It plans to crack ammonia back into hydrogen for sale in Europe, including under a deal with TotalEnergies. The agreement with Yara allows some of the Neom supply to be sold directly as ammonia instead of being cracked into hydrogen. The volumes will be "sold and delivered to Yara's existing global supply chain", Air Products chief executive Eduardo Menezes says. Yara will be "compensated on a commission basis" for the sales, Air Products says.

The US firm says the agreement reduces its "need for green hydrogen downstream investment", potentially lowering its requirement for ammonia cracking capacity. Air Products previously announced plans for ammonia cracking plants at several locations in northwest Europe, but it has yet to take a final investment decision on any of them. The arrangement could help Air Products to market early Neom volumes before any ammonia cracking facility starts operating.

Neom could produce first ammonia in 2027, the project developers said in March. But Air Products expects "a long commissioning process" and that "it will take some time for the facility to get to full production", Menezes says. Air Products expects "no gain or loss" related to the Neom project in 2027, he says.

The company recently called off plans to continue developing the Louisiana Clean Energy Complex, which was to produce around 600,000 t/yr of hydrogen from natural gas with carbon capture and storage. Air Products is now looking to deploy assets purchased for the facility in other projects or sell them to other companies, Menezes says.

By Stefan Krumpelmann

India sees H2-based road transport viable at $2.50/kg

India expects hydrogen-powered road transport to become commercially viable at hydrogen prices of around $2.50/kg — and these levels could be achievable in the next two to three years, according to Abhay Bakre, director of the country's National Green Hydrogen Mission.

Hydrogen-fuelled road transport could become competitive with conventional transport options if hydrogen prices were around $2.50/kg, compared with roughly $2/kg for shipping and $1.20-1.50/kg for green steel production, Bakre said on the sidelines of the Hydrogen Mobility conference in New Delhi on 29 July.

The assessment suggests transport could emerge as an earlier source of hydrogen demand than sectors such as steel and shipping, which are also often viewed as potential end-use markets.

The government is targeting delivered hydrogen costs of 250-260 rupees/kg ($2.61-2.72/kg) at refuelling stations within the next two to three years, Bakre said, adding that costs could fall below Rs300/kg sooner.

Reaching those levels would require further substantial further cost reductions from current market benchmarks. Contracts for renewable hydrogen supply to refineries through tenders have been awarded at delivered costs of $3.50-4/kg, including goods and services tax.

By Anmol Choubey

Refinery-linked green H2 tender winners

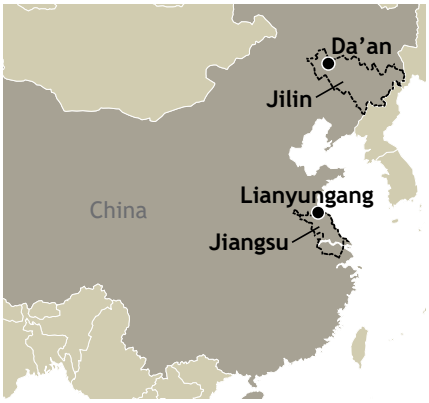
Refiner	Tender winner	Winning bid *Rs/kg**	Winning bid *$/kg†*
NRL	NeuEN	329	3.62
HPCL	Ocior	387	4.26
BPCL	Ocior	387	4.26
IOC	L&T	397	4.37

**including 18pc goods and services tax; †currency conversion rate as of 4 Aug*

— company announcements

NEWS

Da'an and Lianyungang, China



China's SPIC ships 3,750t green ammonia to S Korea

Chinese state-owned utility State Power Investment Corporation (SPIC) has exported 3,750t of renewable ammonia to South Korea in what it says is the largest delivery of its kind so far.

The cargo left Lianyungang port in Jiangsu province on 28 July aboard a South Korean vessel, SPIC's Green Energy subsidiary says. SPIC Green Energy was formerly known as Jilin Electric Power.

The firm has not named the buyer or said for what the ammonia will be used. The ammonia comes from SPIC's Da'an plant in Jilin province, which came on stream in July 2025. The site is backed by 800MW of wind and solar capacity and can make 32,000 t/yr of renewable hydrogen and 180,000 t/yr of ammonia.

The plant has been certified by ISCC to be compliant with the EU's renewable fuels of non-biological origin (RFNBO) definition. But SPIC has not said whether the cargo shipped to South Korea meets RFNBO requirements. SPIC says the ammonia was sold based on its lifecycle emissions savings. It calculated that the cargo avoids more than 10,000t of CO_2 compared with Chinese coal-based ammonia.

SPIC is not the first Chinese firm to send renewable ammonia to South Korea. Envision Energy shipped a cargo to Lotte Fine Chemical in February.

But while Chinese developers have added renewable ammonia capacity quickly, export opportunities remain rare. South Korea has pulled back from burning imported ammonia in power plants and says it would favour domestic hydrogen output. Near-term demand for imported cargoes is more likely to come from industrial users and, potentially, from shipping on routes covered by FuelEU Maritime rules or the International Maritime Organisation's net zero framework, although much uncertainty hangs over the latter, with a vote still pending.

By Chingis Idrissov

China's Envision sells green NH3 certificates to PepsiCo

China's Envision Energy has delivered environmental attribute certificates (EACs) linked to 1,000t of renewable ammonia to food and beverage firm PepsiCo.

The certificates represent emissions reductions equivalent to around 5,000t of CO_2, Envision says. The transaction is part of a wider agreement under which Envision will supply PepsiCo with EACs associated with renewable ammonia produced at its 320,000 t/yr plant in Chifeng, Inner Mongolia, in 2026-30. The certificates are intended to support reductions in PepsiCo's Scope 3 emissions — those across its supply chain. They are issued and managed through environmental attribute registry operator S3 Markets.

Under a book-and-claim approach, buyers can claim the emissions reductions associated with renewable ammonia without taking physical delivery of the product. This can lower logistical costs and related emissions while allowing environmental attributes to be sold separately from the physical product.

Industry participants have previously said renewable ammonia produced in China is mainly sold to domestic customers at grey ammonia prices. A book-and-claim scheme allows Envision to sell its renewable ammonia to Chinese companies while receiving the premium from other offtakers looking to reduce emissions.

The agreement allows PepsiCo to reduce emissions linked to fertiliser use "without changing our existing procurement or production arrangements", PepsiCo Asia-Pacific and Greater China supply chain senior vice-president Fred Li says.

PepsiCo is also working with S3 Markets as part of a separate agreement that includes agricultural technology firm TalusAg.

By Pamela Machado

NEWS

Hynego eyes new partner for 100MW Sicily H2 plant

Priolo, Italy

Italian developer Hynego is in talks with a new investor for its planned 100MW renewable hydrogen plant on Sicily, after Swiss firm Axpo withdrew.

Axpo joined the project in 2024 to co-fund a feasibility study that is now complete, Hynego chief executive Alfonso Morriello says. Hynego is in talks with a partner "who will not be limited to a minority stake" to take the project towards financial close, he says. French investment firm Enego, which started the project in 2021 and holds a majority stake in Hynego, recently refinanced the developer through a subsidiary, Morriello said.

The plant would be built at Priolo and would make 10,000-15,000 t/yr of hydrogen. Most of that would go to the neighbouring 320,000 b/d refinery through a dedicated pipeline, Morriello said. Hynego has initial offtake deals with other buyers at the Priolo petrochemical complex and is seeking more buyers for a second phase that would lift capacity to 300MW. Expansion depends on demand and on connecting to future pipeline networks, Morriello says.

The firm now puts total investment at €240mn-250mn ($277mn-289mn), up from the €200mn cited when Axpo and Enego lined up the refinery as the anchor offtaker in April 2025. Hynego has had no public funding, but is counting on contracts for difference under Italy's new tariff decree, which the European Commission approved in March. The support is essential to supply offtakers at competitive prices, Morriello says.

Hynego plans to use mainly alkaline electrolysers, but has not ruled out other technologies. It is in talks with several suppliers and expects to order equipment by the end of 2027. Construction would finish in 2029 and commercial output would start in the first half of 2030, Morriello says.

By Chingis Idrissov

H2, gases demand for electronics is rising: Air Liquide

French industrial gas supplier Air Liquide expects the electronics sector to account for around half of the contracts it signs over the next 12 months, driven by chipmakers buying more hydrogen and other carrier gases for plants making components for data centres.

Air Liquide investment decisions on carrier gas supply for electronics passed €1bn ($1.14bn) in the first half of 2026, up by 46pc on the whole of 2025. Component demand tied to artificial intelligence (AI) accounted for almost all the rise, chief executive Francois Jackow said during an earnings call on 28 July.

Air Liquide secured three US electronics projects in the first half, worth more than $480mn combined, for makers of semiconductor nodes and memory chips.

New plants in Indiana and Arizona will produce hydrogen, among other gases. The Arizona plant, due on stream in 2028, will make low-carbon hydrogen using on-site carbon capture, with the CO_2 liquefied for the customer. Jackow says the firm favours such smaller to mid-sized projects sited next to customers, but that he expects some larger electronics contracts to close within 6-12 months.

Hydrogen demand from US refiners is also rising — although for fossil-based rather than low-carbon supply. Large-industries sales in the Americas rose by 7pc in the first half, and hydrogen and air-derived gas volumes on US Gulf coast pipelines hit record levels in the second quarter as refining and chemical customers raised output because of the Middle East conflict, chief financial officer Jerome Pelletan says. Hydrogen sales to refineries in France and on the Iberian peninsula also grew, offsetting declines in Germany and Saudi Arabia.

By Chingis Idrissov

Gas and Services unit revenue, 1H26

Type	Americas	EMEA	Asia-Pacific
Revenue €bn	5.23	5.41	2.77
Share of regional revenue %			
Large industries	15	37	33
Industrial merchant	70	32	28
Electronics	4	2	36
Healthcare	11	29	3

Excludes €420mn of revenue for Engineering and Technologies division for 1H26

— Air Liquide

ANALYSIS

E-methane offers fastest route to market: Arctic Sisu

E-methane was the pragmatic choice for Arctic Sisu's Kotka project, which could launch in 2030, writes Pamela Machado

Finland's Arctic Sisu has chosen e-methane as the first product in its Power-to-X strategy, arguing that it offers a faster and lower-risk route to market than other hydrogen derivatives. In contrast to many other developers, the firm has switched from a phased-development approach for its first plant to advancing full-scale plans from the get-go and has been able to revise down cost estimates.

Arctic Sisu is advancing plans for a large e-methane project in Kotka, in south-east Finland, and sees the fuel as the most commercially viable entry point for hydrogen derivatives, chief engineer Antti Pohjoranta tells *Argus*.

The project is designed to produce 56,100 t/yr of renewable hydrogen and convert it into 113,100 t/yr of e-methane using biogenic CO_2 captured from neighbouring paper producer MM Kotkamills. Arctic Sisu plans to source renewable electricity from Finnish assets through power purchase agreements.

Kotka, Finland

The company recently decided to develop the project in a single phase rather than in stages — a move intended to improve economics and reduce execution risk. "There is enough demand to justify building the plant in one go," Pohjoranta says. The project requires substantial electricity infrastructure, including a major grid connection, and much of that infrastructure would need to be built at full scale even under a phased approach. The company already has an offtaker for the project, although the details are confidential.

Power-to-X, as the hydrogen derivatives sector is often known, is a "really diverse and broad" market that presents opportunities to decarbonise activities ranging from shipping and steelmaking to chemicals production, Pohjoranta says.

But Arctic Sisu deliberately focused on the application with what it views as the clearest near-term commercial case. E-methane can already be deployed in existing gas infrastructure and end-use applications, avoiding many of the challenges facing newer-fuel value chains. "We find it the most cost-effective and pragmatic approach at this point in time," Pohjoranta says.

Stepping stone

Arctic Sisu acknowledges criticism that methane remains a greenhouse gas and could eventually lose market share to electrification or alternative fuels in the future. But the firm believes the market opportunity for renewable methane will persist long enough to justify investment in Kotka. The company also sees e-methane as a stepping stone towards broader PtX opportunities and an opportunity to learn about new technologies and supply chains.

The Kotka project is currently progressing through Finland's permitting process following completion of its environmental impact assessment. Arctic Sisu is targeting a final investment decision by mid-2027, subject to successful permitting and project development, with commercial production expected in 2030.

Capital expenditure is now expected to be in the €500mn-600mn range, suggesting it could stay below earlier estimates of around €600mn for the full plant. Pohjoranta says equipment suppliers, technology licensors and engineering firms have become more experienced in hydrogen and Power-to-X developments, helping to reduce project costs and improve confidence among investors.

Arctic Sisu's upbeat view comes as signs of increased interest from offtakers begin to emerge. Finnish developer Ren-Gas recently announced an agreement to supply e-methane to fuel companies in Germany for distribution to heavy-duty trucks, driven by quotas for use of renewable hydrogen derivatives in transport.

Even so, most e-methane plans remain at an early stage. Most announced projects have yet to reach a final investment decision, and even firmer demand signals will be needed on the path to wider adoption.

INTERVIEW

Off-grid power is driving UK green H2 use: Protium

UK developer Protium is expanding its renewable hydrogen production and distribution network, aiming to supply customers across the UK within four hours. The firm has acquired developer Storegga's UK hydrogen portfolio — including the 15MW Cromarty project in Scotland, which it aims to bring to financial close by the end of this year. Argus spoke to chief executive Chris Jackson about Protium's plans, its business model, industry challenges and UK policy. Edited highlights follow:

Where does Protium stand today and what is your business model?
Protium operates three green hydrogen plants in the south and has supply arrangements from three production sites across the UK. We provide green hydrogen as a service, which includes production, storage and delivery to customers. We can deliver fuel cell-grade hydrogen to 80-90pc of our customers in Wales, the south and England's Midlands in under four hours. We also offer other services such as engineering support, project management and equipment construction on customers' sites. We work across three verticals — industrial customers using hydrogen as a process gas or for heat and power, diesel displacement in off-grid power and transport, and the e-fuel market. The latter is where we are the green molecule layer for developers like OXCCU and ET Fuels. Hydrogen for off-grid power use is moving faster for us than other sectors.

Cromarty is in the UK's best area for green hydrogen production, with the highest availability of onshore and offshore wind in northwest Europe and the highest curtailment rates in the UK

What was the rationale for buying Storegga's portfolio?
As a UK green hydrogen player we want to see projects succeed and the UK government has committed significant resources to this. Cromarty was the last remaining Scottish project selected under the government's first hydrogen allocation round (HAR1). It is in the UK's best area for green hydrogen production, with the highest availability of onshore and offshore wind in northwest Europe and the highest curtailment rates in the UK. Many industrial customers in northern Scotland are off the gas grid and have limited power grid access, so they burn fossil fuels. Many sites up there even burn kerosine in their industrial processes. Power there is expensive and transmission lines are vulnerable to high winds and snow, so supply resilience matters. The local councils, the Scottish and UK governments are also supportive. Our focus is on Cromarty, but we are reviewing options for advancing the 70MW Speyside project too.

Can you discuss your collaboration with H-Power?
We supply H-Power with green hydrogen for the fuel cell generators that they run in partnership with Speedy Hire. By procuring hydrogen from their ammonia cracker at Dunsfold in Surrey, which runs on biogenic ammonia from Europe, we wanted to show that there are customers willing to buy that product. It also adds supply resilience for our customers in the south of England and gives us access to the site for storage and distribution. Distribution is one of the costliest parts of moving any fuel, so another node close to customers is helpful.

We've been led to believe Andy Burnham's administration remains committed to net zero. If they are serious, hydrogen will be a key part of it

What do you expect from the HAR rounds and UK hydrogen policy?
Our Magor and South Tees projects were shortlisted for HAR2. Many firms have lost money betting on what government will do with HAR, but we are not trying to. So far, we've been led to believe that [new prime minister Andy Burnham's] administration remains committed to net zero. If they are serious, hydrogen will be a key part of it. HAR lets government target specific clusters and sectors and it feeds into fuel security concerns. What we don't know is what the new government plans for Clean Power 2030 (CP2030). We are the first UK company

INTERVIEW

with a demand response contract with Ofgem and we expect a lot of interest in electrolyser deployment providing flexible demand while making hydrogen that could decarbonise gas peakers. What is missing is a cohesive strategy linking HAR, the transport and storage business model and CP2030. The government may do something on HAR2 by the end of this year. We may get loose details on HAR3 this year, but I expect most announcements next year.

How cost-competitive is your green hydrogen?

It depends on how you assess cost competitiveness. We would argue that we're already cost competitive with grey hydrogen in the UK on a delivered basis without subsidies. The fossil fuel industry is also not paying the true cost because of its 'dirty discount', so the question is how far above that you need subsidy for a level playing field. Using unsubsidised hydrogen with a fuel cell generator is already cheaper than diesel on a fuel basis, especially when customers factor in air quality or noise-reduction benefits. If the government wants hydrogen at the price of natural gas, or e-fuels at the price of fossil fuels with no other mechanism, subsidies have to stay high. Cost parity with gas is the best long-term policy focus, as electrification is emerging as the new benchmark. The government does not see an extended role for the gas grid and keeps advocating for electrification, so I would encourage it to look at demand-side mechanisms. Why would an industrial user spend money to adapt its site, just for hydrogen to end up at parity with natural gas and not generate a green premium? You need mechanisms to encourage conversion and ways to monetise the green premiums.

Using unsubsidised hydrogen with a fuel cell generator is already cheaper than diesel on a fuel basis, especially when customers factor in air quality or noise reduction benefits

Which sectors are willing to pay and how are contracts structured?

There are many firms looking for off-grid power that are willing to pay. Firms in construction, television, events and other sectors are trialling hydrogen. Every major construction company in the UK has trialled hydrogen, because embedded CO_2 in construction is seen as problematic. We work with organisations that work in city centres where loud, polluting diesel generators are undesirable. We work with firms with contracts near waterways because the Environment Agency has very strict rules around diesel there. Our customers include Panasonic for power generation and Wales & West Utilities for mobility. As showcased by Kimberly-Clark, industrial users are willing to spend resources and sign 15-year offtake contracts, when they could just keep buying gas on a spot or quasi-spot basis. On offtake contracts, it is a simple equation. Long-term commitment gets you a better price because it makes life easier. If you want flexibility, you should be comfortable paying more.

We work with organisations that work in city centres where loud, polluting diesel generators are undesirable. We work with firms with contracts near waterways because the Environment Agency has very strict rules around diesel there

What is the biggest challenge to developing production sites?

Offtake, financing, permitting, securing power and grid connections all have a major influence, but the mindset is perhaps the biggest issue. Every company looking at decarbonisation faces the same problem. Replacing fossil fuels will cause challenges and disruption, and firms have to be willing to pay green premiums. Even when companies are aware of climate change, they are still unwilling to pay for the transition. Energy is a small part of total product cost for many industries. Large electronics and consumer goods companies can afford to go fully renewable, they just have to be incentivised. That is where policy has to step in, but the government is terrified of firms passing on costs to consumers and raising inflation. The government's biggest challenge is balancing the cost of living with decarbonisation and resilience. If they introduced carbon taxes and fossil fuel bans by certain dates, you would not need subsidies. So it is a political-economic decision, not a technology question.

IN BRIEF

US start-up Lydian raises $43mn for modular e-SAF tech

US technology start-up Lydian Labs has raised $43mn to commercialise its modular synthetic aviation fuel (e-SAF) production system. The series A round was led by Bill Gates-founded Breakthrough Energy Ventures. Climate-focused AP Ventures and Builders Vision also took part, alongside existing backers. The money will fund the launch of Lydian's 70,000 t/yr e-fuel production platform. Lydian's technology converts hydrogen and captured CO_2 into jet fuel-range hydrocarbons in an electrically heated reverse water-gas shift reactor, paired with a modified Fischer-Tropsch system. Lydian has been running a 30 t/yr e-fuel pilot plant in Boston since 2024. It plans to bring a 7,000 t/yr commercial demonstration plant on stream in 2028 and deploy the 70,000 t/yr design in 2030.

USTDA backs study for Western Sahara renewable ammonia plant

The US Trade and Development Agency (USTDA) has signed a $5.7mn grant agreement to fund a pre-front end engineering and design (pre-Feed) study for a renewable ammonia project developed by the ORNX consortium in Laayoune, in the disputed Western Sahara territory. ORNX — which comprises US-based Ortos, Spain's Acciona and Germany's Nordex — has selected a group of US companies to carry out the study, USTDA says. ORNX in February signed a preliminary land reservation agreement under the 'Moroccan Offer' — the Moroccan government's support framework for hydrogen and derivatives projects. The aid marks the first US state support for an overseas renewable hydrogen or ammonia project.

Companies carrying out feasibility study

Company	Sector
KBR	Engineering
GE Vernova	Power solutions
Electric Hydrogen	Electrolyser manufacturing
Terabase	Solar technology

— USTDA

EU greenlights €290mn Dutch subsidies for SAF, e-SAF

The EU has approved Dutch plans to subsidise two sustainable aviation fuel (SAF) schemes with a combined €290mn. The funding will help support SAF production of around 285,000 t/yr, the EU says. Announced in April, the schemes will support advanced bio-SAF and hydrogen-based synthetic aviation fuel (e-SAF), but not hydrotreated esters and fatty acids. The budget could be split into €210mn for e-SAF and €90mn for advanced bio-SAF, the Netherlands signalled recently. The funding runs from 2027 to 2031 at the latest. Up to five rounds will take place during this period, depending on how much money is available.

Shell to sell European renewable assets to TotalEnergies

Shell has agreed to sell its European onshore renewable energy portfolio to TotalEnergies. The transaction covers assets in Italy, the Netherlands, Spain and the UK, and is expected to close by the end of 2026, subject to regulatory approvals. Shell and TotalEnergies did not disclose the value of the deal. TotalEnergies says the acquisition includes 500MW of solar and wind capacity already in operation or under construction — mainly in Italy and the Netherlands. The sale also includes a 3.5GW solar, wind and battery project pipeline covering Italy, the UK and Spain. TotalEnergies has separately agreed to sell a 50pc stake in a 1.2GW European onshore solar and wind portfolio to an insurance account managed by KKR.

HyFive signs second preliminary e-methanol offtake deal

Spanish developer HyFive has signed a preliminary offtake agreement to supply up to 10,000 t/yr of e-methanol from its Musel project in Gijon, on Spain's north coast, to an unnamed buyer based in the Amsterdam-Rotterdam-Antwerp region. The agreement represents a second potential customer for the Musel project, which is expected to produce 100,000 t/yr of e-methanol from 2029. HyFive signed a preliminary offtake agreement in March, covering 50,000 t/yr of e-methanol output from the facility for the maritime sector.

IN BRIEF

Germany's RWE delivers first H2 from Lingen project

German utility RWE has delivered the first volumes of renewable hydrogen from its Lingen electrolysis facility to Evonik's chemicals production plant in Marl through around 120km of hydrogen pipeline. The delivery took place during the commissioning of the GET H2 Nukleus project. RWE took a final investment decision on the broader 300MW project in September 2024. UK-headquartered ITM Power is providing two 100MW proton exchange membrane electrolysis systems for the project, while German manufacturer Sunfire is due to supply 100MW of alkaline electrolysis capacity. The plant will supply different industrial consumers in western Germany.

Japan's Nedo selects 12 hydrogen projects for funding

State-owned research institute Nedo has selected 12 Japanese hydrogen supply-chain development projects for financial support between 2026 and March 2029. The projects are categorised as either a feasibility study or a demonstration, and seven of them will focus on developing production. Supported ventures include an initiative by H2 Hokkaido to assess magnesium as a hydrogen carrier, a project by Air Water Hokkaido to study the feasibility of generating hydrogen from coal and biomass, engineering firm Takafuji's plans to study renewable hydrogen and ammonia production using surplus waste-fuelled electricity, and a hydrogen refuelling station project put forward by auto component maker Aisin.

Hydrogen transportation pilots

Consortium members	State	Funding *rupees mn*
Phase 1		
NTPC, AL	Multiple	390.5
Tata Motors, IOCL	Multiple	700.2
ANERT, BPCL	Kerala	348.4
RIL, AL	Gujarat	468.7
HPCL, Volvo	Andhra Pradesh	171.3
Total		**2,079.1**
Phase 2		
NTPC - GEL	Gujarat	266.1
NHPC	Himachal Pradesh	17.7
ANERT, KSRTC, TML	Kerala	515.4
VECV, BPCL	Madhya Pradesh	59.1
Waaree, Indify Horizon Fuel Cell Technologies	Gujarat	287.7
Eka Mobility, KPIT Technologies, BPCL, Super Spares & Services	Madhya Pradesh	448.4
KPI Gel, TML, AB Process Technologies	Multiple	434.2
Total		**2,028.6**

— Ministry of New and Renewable Energy

India awards 12 hydrogen transportation pilot projects

India has allocated 4.12bn rupees ($43.1mn) in viability gap funding for 12 mobility pilot projects that aim to deploy hydrogen-powered vehicles and 16 hydrogen refuelling stations along 21 routes, according to minister of state for new and renewable energy Shripad Yesso Naik. The projects involve 27 buses and 43 trucks powered by fuel cells and hydrogen internal combustion engines. Awarded project consortia include NTPC, Indian Oil, Bharat Petroleum, Hindustan Petroleum, Tata Motors and Reliance Industries. Gujarat state accounts for the largest number of routes selected for the pilot.

India's MahaGenco seeks offtake interest for green H2

India's MahaGenco Renewable Energy has invited expressions of interest in renewable hydrogen and ammonia offtake from its planned project in Uran, Maharashtra state. The project will be developed in phases, with initial production of around 2,000 t/yr and scope to expand to 50,000 t/yr, MahaGenco REL says. Expressions of interest can be submitted until 31 August. The offering includes by-product oxygen. Minimum hydrogen offtake is 200 t/yr.

China's 195km green H2 pipeline nears completion

China Huadian's 195km hydrogen pipeline in Baotou, Inner Mongolia, is close to completion and being prepared for operations, according to engineering contractor CPECC, a subsidiary of state-owned oil and gas firm CNPC. The line runs south from the Barun industrial park to the Kundulun district. It is designed to carry 100,000 t/yr of hydrogen and includes four stations, according to the developer, Inner Mongolia Huadian Huameng Pipeline, a subsidiary of state-owned utility China Huadian, which estimates total project costs at 1.13bn yuan ($166mn). The pipeline is a branch of Inner Mongolia's planned renewable hydrogen network and is one of the first hydrogen pilots to be backed by the National Energy Administration. It will link wind and solar-powered hydrogen production plants with industrial users in Baotou, including steel and rare earth-processing sites.

JULY HYDROGEN PROJECT TRACKER

Hydrogen and derivatives production project tracker

Country	Site location	Project	Developer	Size/capacity	(Planned) commissioning	Project update
Americas						
Canada	Montreal, Quebec		SAF+ International		2028	Signed **preliminary offtake agreement** with Vema for supply of geological H2 to make SAF
Canada	Come By Chance, Newfoundland and Labrador	Wind-to-Hydrogen phase 1	North Atlantic	30,000 t/yr electrolytic H2		Entered **front-end engineering design** phase
Canada	Come By Chance, Newfoundland and Labrador	Wind-to-Hydrogen phase 2	North Atlantic	30,000 t/yr electrolytic H2		Began **environmental assesment** process
Chile	San Gregorio, Magallanes		Consorcio Austral	40,000 t/yr electrolytic H2		Submitted **environmental impact statement**
USA	Cadiz, California		Cadiz	50 t/d electrolytic H2		Signed **preliminary agreement** with RIC Energy for on-site **solar generation**
USA	Phoenix, Arizona		Air Liquide	Undisclosed amount of CCS-enabled H2	2028	**New $160mn projec**t announced for deliveries to semiconductor manufacturer
USA	Matagorada, Texas	Matagorada e-Methanol	HIF Global	300,000 t/yr electrolytic H2	2026	**Sold project land** to data centre firm Mara Holdings
USA	Gothenburg, Nebraska	Meadowlark	J Westling	500 t/d CCS-based NH3	2029	Signed **technology agreement** with Topsoe
USA	Graham, Texas	Plug Power		45 t/d electrolytic H2		**Sold project land** to data centre firm Stream US
Asia-Pacific						
Australia	Portland, Victoria		HAMR Energy	220MWel		Received A$32mn in **conditional funding** from the Australian Renewable Energy Agency to support development work
Australia	Newcastle, New South Wales	Hunter Valley Hydrogen Hub	Orica	50MWel; 4,700 t/yr electrolytic H2	2029	Reached **FID.** Selected Plug as **electrolyser supplier**
Australia	Arrowsmith, Western Australia	Mid West Clean Energy	Pilot Energy	175,000 t/yr low-carbon hydrogen		Developer entered **administration**
Australia	Brisbane, Queensland	Port of Brisbane Hydrogen	Lion Energy	2MWel; 300 t/yr electrolytic H2		Developer ended its lease obligations and completed the **sale of its hydrogen production and refuelling equipment**
Australia	Moree, New South Wales	Good Earth Green Hydrogen and Ammonia	Hiringa Energy, Sundown Pastoral Company	4,500 t/yr electrolytic NH3	2027	Placed **order for solar modules** from Trina Solar
China	China Coal Energy			25MWel		Selected Verde as **electrolyser supplier**
China	Shenyang, Liaoning		China Energy Engineering Corporation	100,000 t/yr combined bio and e-methanol	2028	Began **construction**
China	Da'an, Jilin	Da'an renewable ammonia	SPIC Green Energy (Formerly known as Jilin Electric Power)	32,000 t/yr electrolytic H2 and 180,000 t/yr electrolytic NH3	2025	**Exported 3,750t** of ammonia to South Korea
China	Inner Mongolia, Northern China		Junrui Green Hydrogen	420MWel; 30,000 t/yr electrolytic H2		**New project** announced
China	Liaoyuan, Jilin	Liaoyuan e-methanol	China Tianying	170,000 t/yr e-methanol	2026	Installed **e-methanol reactor**
China	Linxi, Inner Mongolia		Ming Yang Smart Energy	50,000 t/yr combined bio- and e-methanol	2028	Entered **front-end engineering design** phase
China	Chifeng, Inner Mongolia		Envision Energy	320,000 t/yr electrolytic NH3	2025	Delivered **Environmental Attribute Certificates** to PepsiCo
India	Gopalpur, Odisha		Acme	405,000 t/yr electrolytic NH3	2030	Signed **offtake agreement** with Japan's IHI to supply 177,000 t/yr electrolytic NH3
India	Kendrapada,Odisha		Acme	200,000 t/yr e-methanol		Signed **offtake agreement** with Japan's Mitsubishi Gas Chemical to supply 100,000 t/yr e-methanol
India	Paradip, Odisha		Acme	800,000 t/yr electrolytic NH3	2029	Signed **offtake agreement** with Japan's IHI to supply 83,000 t/yr electrolytic NH3
India	Gopalpur, Odisha		Jakson Green	200,000 t/yr electrolytic NH3		Received RFNBO CertifHy **precertification**
India	Uran, Maharashtra		MahaGenco Renewable Energy	2,000 t/yr electrolytic H2 in first phase		Launched **expression of interest** for offtake

JULY HYDROGEN PROJECT TRACKER

Hydrogen and derivatives production project tracker

Country	Site location	Project	Developer	Size/capacity	(Planned) commissioning	Project update
Uzbekistan	Tuproqqal'a , Khorezm		Allied Biofuels	2.4GWel	2030	Signed **logistics service agreement** with Pro Logistic
Europe						
Austria	Bruck an der Leitha, Lower Austria		OMV	140 MWel; 23,000 t/yr electrolytic H2		Was granted a **€450mn loan** from the European Investment Bank (project is already under construction)
Austria	Gampern, Upper Austria	RAG Valley Gampern	Andritz, RAG Austria	12.5MWel; 1,500 t/yr electrolytic H2	2026	Started **construction**
Belgium	Ghent, East Flanders	H2BE	Engie, Equinor	210,000 t/yr CCS-enabled H2	2030	Signed **preliminary offtake agreement** with Ineos
Croatia	Rijeka, Primorje-Gorski Kotar		Ina	10MWel; 1500 t/yr electrloytic H2	2027	Installed **solar panels** for H2 production
Finland	Kotka, Kymenlaakso		Artic Sisu	56,100 t/yr electrolytic H2	2030	Entered **public consultation** phase.
Finland	Tampere, Pirkanmaa		Nordic Ren-Gas	50MWel	2029	Signed **offtake agreement** with Avanca/Alter-noil for distribution in Germany
France	Seine-Maritime, Normandy	DeZir	Verso Energy	81,000 t/yr e-SAF	2030	Announced plans for **biogenic CO2 supply pipeline** with Trapil
France	Somme, Hauts-de-France	FertHySomme	Fertighy	200MWel (subsidies only for 95MWel)		Selected for an undisclosed share of €778mn in **subsidies** under France's first electrolytic H2 tender. Subsidies will be for 95MWel
France	Fos-sur-Mer, Alpes-Cote d'Azur	H4 Marseille Fos	Hy2Gen	390MWel; 75,000 t/yr e-SAF		Signed **nuclear power supply deal** signed with EDF. Secured 50pc of biogenic CO2 supply from Rhone Decarbonisation project
France	Saint-Chely-d'Apcher, Occitanie	Hydrozere	Engie	5MWel		Selected for an undisclosed share of €778mn in **subsidies** under France's first electrolytic H2 tender
France	Fos-sur-Mer, Bouches-du-Rhone		GravitHy	720 MWel; 120,000 t/yr electrolytic H2 for 2mn t/yr HBI	2029	Submitted **permit applications**
France	Dunkerque, Hauts-de-France	SHYMED	Hynamics	1.25MWel; 540 kg/d electrolytic H2	2025	Received RFNBO CertifHy **certification**
France	Isere, Auvergne-Rhône-Alpes	eM-Rhone	Elyse Energy	210MWel (subsidies only for 61MWel)		Selected for an undisclosed share of €778mn in **subsidies** under France's first electrolytic H2 tender. Subsidies will be for 61MWel
Germany	Steyerberg, Lower Saxony		German eFuel One	75mn l/yr e-gasoline	2028	Secured Eneos as **first offtake partner** in Asia
Germany	Duren, North Rhine-Westphalia		HyDN	10MWel		Recieved RFNBO CertifHy **certification**
Italy	Marghera, Venice		Sapio	5MWel; 750 t/yr electrolytic H2	2026	Signed **power purchase agreement** with Edison
Netherlands	Nieuw-Buinen, Drenthe	H2Hollandia	Novar Energy	5MWel; 300 t/yr electrolytic H2		Recieved RFNBO ISCC **certification**
Netherlands	Rotterdam, South Holland		Power2X	250,000 t/yr e-SAF	2032	Appointed **project management consultant**
Netherlands	Vlissingen-Oost, Zeeland	ScheldeH2	RWE	220MWel	2032	Submitted **environmental permit** application
Netherlands	Rotterdam, South Holland	Smart Hydrogen Hub	Platform Zero, Adsensys, Port of Rotterdam and Innovation-Quarter.	2.5MWel	2029	Placed **electrolyser order** placed with Enapter
Netherlands	Oude-Tonge, South Holland		Van Kessel	1MWel; 160 t/yr electrolytic H2	2026	Received RFNBO ISCC **certification**
Netherlands	Vlissingen, Zeeland		VoltH2	25MWel; 2,000 t/yr electrolytic H2	2029	Secured undisclosed amount of **funding** under the 2025 SDE++ subsidy round
Portugal	Sines, Setubal		Beyond Green	10MWel	2027	Reached **FID**. Placed **electrolyser order** with RCT
Spain	A Coruna, Galicia	Atlas	Repsol	50MWel; 6,060 t/yr electrolytic H2		Was invited for **grant agreement negotiations** under Spanish fund allocations for the third European Hydrogen Bank. Funding could reach €133.4mn

JULY HYDROGEN PROJECT TRACKER

Hydrogen and derivatives production project tracker

Country	Site location	Project	Developer	Size/capacity	(Planned) commissioning	Project update
Spain	Toledo, Castilla-La Mancha	Eco2Fly	Holcim,Ignis P2X,Exolum	100,000 t/yr e-SAF	2032	Signed **preliminary offtake agreement** with Volotea
Spain	Gijón, Asturias	HyMet Musel	HyFive	100,000 t/yr e-methanol	2029	Signed **logistics agreement** with Evos for supply to Rotterdam. Signed 10,000 t/yr preliminary offtake agreement with undisclosed shipping company
Spain	Navarra, Basque		Mantle8			Received **permits** to explore geological hydrogen in Navarra and Basque regions
Spain	Huelva, Andalusia	Noon II	Iberdrola	80MWel; 11,100 t/yr electrolytic H2		**Withdrew from grant agreement negotiations** under Spanish funding allocations for the third European Hydrogen Bank
Spain	Huelva, Andalusia	Odin	Iberdrola	140 Mwel; 19,500 t/yr electrolytic H2		**Withdrew from grant agreement negotiations** under Spanish funding allocations for the third European Hydrogen Bank
Spain	Huelva, Andalusia	Onuba	Moeve	45,000 t/yr electrolytic H2		Placed final tranches of **electrolyser order** with De Nora
Spain	Puertollano, Castilla-La Mancha	P-Hynet	Repsol	12MWel; 2,200 t/yr electrolytic H2		Was invited for **grant agreement negotiations** under Spanish fund allocations for the third European Hydrogen Bank. Funding could reach €49.8mn
Spain	Villadangos del Paramo, Castilla y León		Reolum	200MWel; 140,000 t/yr e-methanol		Received **environmental approval**
Spain	Murcia, Cartagena		Repsol	100MWel; 15,000 t/yr electrolytic H2	2029	Received **environmental approval**
Sweden	Hovgarden, Uppsala		Metacon	1,480 t/yr electrolytic hydrogen		Received 111mn kroner in **funding** from the Swedish Environmental Protection Agency
UK	Barrow-in-Furness, Cumbria	Barrow Green Hydrogen	Carlton Power, Schroders Greencoat	30MWel	2028	Received **environmental approval**. Appointed engineering consultant
UK	Stockton-on-Tees, Teesside	Pioneer 3	Protium	2.5MWel		Received **environmental approval**
UK	Immingham complex, Lincolnshire	Kings Road Humber	ET Fuels	35,000 t/yr e-SAF	2030	Renamed from Project SkyFuel. Decided **project site** at Immingham
UK	Port of Workington, Cumberland	Starling Synthetic Aviation Fuel	Carbon Neutral Fuels	120MWel; 31,000 t/yr e-SAF	2031	Entered pre-planning phase. Finalised **project site** at port of Workington. **Raised planned output** by around 24pc
Middle East & Africa						
Saudi Arabia	TBC, between Jeddah and Jazan		HEIC, CNCEC	1mn t/yr electrolytic NH3		**New $3bn project** announced
Saudi Arabia	Neom, Tabuk	Neom	Neom Green Hydrogen Company	1.2mn t/yr electrolytic NH3	2027	Finalised **sales agreement** for Yara to market renewable ammonia that Air Products does not sell as hydrogen

— company announcements; Argus research

COMPLETE HYDROGEN PRODUCTION COSTS

No-C Hydrogen									4 Aug
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul
Netherlands Terneuzen	Wind + ALK	Green	€/kg	7.88	9.05	nc	5.89	6.76	nc
Netherlands	Grid + PPA + ALK	Green	€/kg	8.97	10.30	+0.04	5.89	6.76	+0.04
UK Harwich	Wind + ALK	Green	£/kg	5.74	7.70	nc	3.99	5.35	nc
UK	Grid + PPA + ALK	Green	£/kg	7.85	10.52	nc	5.11	6.86	nc
Germany Bremen	Wind + ALK	Green	€/kg	8.26	9.48	nc	6.17	7.08	nc
Germany	Grid + PPA + ALK	Green	€/kg	7.51	8.62	nc	4.42	5.08	nc
France Sete	Wind + ALK	Green	€/kg	8.63	9.91	nc	6.45	7.40	nc
France	Grid + PPA + ALK	Green	€/kg	7.13	8.19	+0.04	3.81	4.38	+0.04
Spain Teruel	Diurnal + ALK	Green	€/kg	5.72	6.57	nc	3.07	3.52	nc
Spain	Grid + PPA + ALK	Green	€/kg	5.85	6.71	-0.02	3.28	3.76	-0.02
Italy	Grid + PPA + ALK	Green	€/kg	9.38	10.77	+0.06	6.03	6.93	+0.06
Portugal	Grid + PPA + ALK	Green	€/kg	6.01	6.90	-0.02	3.46	3.97	-0.02
Sweden	Grid + PPA + ALK	Green	$/kg	6.65	6.65	+0.02	3.83	3.83	+0.03
US Wilbarger	Diurnal + ALK	Green	$/kg	7.48	7.48	nc	4.49	4.49	nc
Canada Newfoundland	Wind + ALK	Green	C$/kg	15.22	10.83	nc	11.94	8.50	nc
Oman Duqm	Diurnal + ALK	Green	$/kg	4.40	4.40	nc	2.67	2.67	nc
Saudi Arabia Tabuk	Diurnal + ALK	Green	$/kg	4.02	4.02	nc	2.08	2.08	nc
UAE Abu Dhabi	Diurnal + ALK	Green	$/kg	5.69	5.69	nc	3.32	3.32	nc
Qatar Mesaieed	Diurnal + ALK	Green	$/kg	6.51	6.51	nc	4.13	4.13	nc
Namibia Walvis Bay	Diurnal + ALK	Green	$/kg	7.77	7.77	nc	3.90	3.90	nc
South Africa Coega	Diurnal + ALK	Green	$/kg	7.47	7.47	nc	4.72	4.72	nc
Japan Fukushima	Wind + ALK	Green	¥/kg	2,087	13.02	nc	1,580	9.86	nc
China Jilin	Diurnal + ALK	Green	Yn/kg	24.38	3.61	nc	16.85	2.49	nc
India Kutch	Diurnal + ALK	Green	Rs/kg	370.87	3.88	nc	257.82	2.70	nc
South Korea Ulsan	Wind + ALK	Green	W/kg	30,430	21.13	nc	26,185	18.18	nc
Vietnam Phu Yen	Wind + ALK	Green	$/kg	9.81	9.81	nc	7.86	7.86	nc
Australia Burrup	Diurnal + ALK	Green	A$/kg	10.94	7.66	nc	6.46	4.52	nc
Brazil Piaui	Diurnal + ALK	Green	$/kg	5.20	5.20	nc	2.81	2.81	nc
Chile Mejillones	Diurnal + ALK	Green	$/kg	5.16	5.16	nc	2.98	2.98	nc

Low-C hydrogen									4 Aug
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul
Netherlands	ATR + CCS	Blue	€/kg	6.01	6.90	-0.17	4.84	5.56	-0.17
UK	ATR + CCS	Blue	£/kg	5.03	6.74	-0.16	4.03	5.41	-0.16
Germany	ATR + CCS	Blue	€/kg	5.78	6.64	-0.15	4.77	5.47	-0.16
Spain	ATR + CCS	Blue	€/kg	5.98	6.87	-0.17	4.76	5.47	-0.16
France	ATR + CCS	Blue	€/kg	5.98	6.86	-0.17	4.66	5.35	-0.17
US Gulf coast	ATR + CCS	Blue	$/kg	3.01	3.01	-0.06	1.52	1.52	-0.06
Canada	ATR + CCS	Blue	C$/kg	3.62	2.58	-0.16	1.62	1.15	-0.16
Japan	ATR + CCS	Blue	¥/kg	1,224	7.63	-0.12	1,004	6.26	-0.12
South Korea	ATR + CCS	Blue	W/kg	10,373	7.20	-0.09	8,403	5.83	-0.09
Australia	ATR + CCS	Blue	A$/kg	5.95	4.16	+0.12	3.93	2.75	+0.12
Trinidad	ATR + CCS	Blue	$/kg	6.33	6.33	-0.13	4.40	4.40	-0.14
Russia west	ATR + CCS	Blue	$/kg	2.76	2.76	-0.01	1.26	1.26	-0.01
Russia east	ATR + CCS	Blue	$/kg	2.68	2.68	-0.01	1.18	1.18	-0.01
Saudi Arabia	ATR + CCS	Blue	$/kg	2.54	2.54	nc	1.29	1.29	nc

COMPLETE HYDROGEN PRODUCTION COSTS

BAT+ hydrogen									4 Aug
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul
Netherlands	SMR + CCS	Blue	€/kg	5.06	5.81	-0.15	4.02	4.61	-0.15
UK	SMR + CCS	Blue	£/kg	4.16	5.57	-0.13	3.27	4.39	-0.13
Germany	SMR + CCS	Blue	€/kg	4.89	5.61	-0.14	3.98	4.57	-0.15
Spain	SMR + CCS	Blue	€/kg	5.09	5.84	-0.15	4.00	4.59	-0.16
France	SMR + CCS	Blue	€/kg	5.16	5.92	-0.15	3.99	4.58	-0.15
US Gulf coast	SMR + CCS	Blue	$/kg	2.46	2.46	-0.04	1.14	1.14	-0.04
Canada	SMR + CCS	Blue	C$/kg	3.30	2.35	-0.04	1.52	1.08	-0.05
Japan	SMR + CCS	Blue	¥/kg	982	6.13	-0.09	787	4.91	-0.09
South Korea	SMR + CCS	Blue	W/kg	8,739	6.07	-0.08	6,990	4.85	-0.08
Australia	SMR + CCS	Blue	A$/kg	4.92	3.44	+0.07	3.13	2.19	+0.07
Trinidad	SMR + CCS	Blue	$/kg	5.49	5.49	-0.12	3.78	3.78	-0.12
Russia west	SMR + CCS	Blue	$/kg	2.28	2.28	-0.01	0.95	0.95	-0.01
Russia east	SMR + CCS	Blue	$/kg	2.22	2.22	-0.01	0.89	0.89	-0.01
Saudi Arabia	SMR + CCS	Blue	$/kg	2.05	2.05	nc	212	212	nc

BAT+ hydrogen							4 Aug
				Excl. capex			
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	
Netherlands	SMR + CCS retrofit	Blue	€/kg	4.06	4.66	-0.16	
UK	SMR + CCS retrofit	Blue	£/kg	3.28	4.40	-0.13	
Germany	SMR + CCS retrofit	Blue	€/kg	4.03	4.63	-0.14	
Spain	SMR + CCS retrofit	Blue	€/kg	4.05	4.65	-0.15	
France	SMR + CCS retrofit	Blue	€/kg	4.03	4.63	-0.16	
US Gulf coast	SMR + CCS retrofit	Blue	$/kg	1.08	1.08	-0.04	
Canada	SMR + CCS retrofit	Blue	C$/kg	1.61	1.14	-0.05	
Japan	SMR + CCS retrofit	Blue	¥/kg	760	4.74	-0.09	
South Korea	SMR + CCS retrofit	Blue	W/kg	6,784	4.71	-0.08	
Australia	SMR + CCS retrofit	Blue	A$/kg	2.99	2.10	+0.08	
Trinidad	SMR + CCS retrofit	Blue	$/kg	3.68	3.68	-0.13	
Russia west	SMR + CCS retrofit	Blue	$/kg	0.89	0.89	nc	
Russia east	SMR + CCS retrofit	Blue	$/kg	0.83	0.83	-0.01	

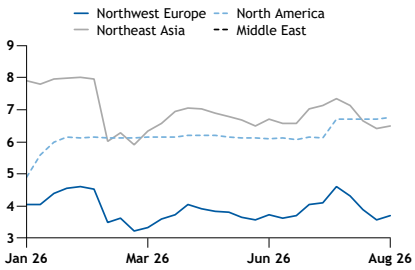
BAT+ hydrogen											4 Aug
					Incl. capex			Excl. capex			
	Process	kcal/kg NAR	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul	
Australia	Coal gasification + CCS	5,500	Blue	A$/kg	6.33	4.43	+0.01	3.86	2.70	+0.01	
Australia	Coal gasification + CCS	6,000	Blue	A$/kg	6.81	4.76	+0.03	4.33	3.03	+0.04	
China	Coal gasification + CCS	3,800	Blue	Yn/kg	27.61	4.08	-0.01	19.07	2.82	-0.01	
China	Coal gasification + CCS	5,500	Blue	Yn/kg	26.67	3.95	-0.01	18.14	2.68	-0.01	
Indonesia	Coal gasification + CCS	5,500	Blue	$/kg	4.00	4.00	nc	2.61	2.61	nc	
Indonesia	Coal gasification + CCS	3,800	Blue	$/kg	3.87	3.87	nc	2.48	2.48	nc	
South Africa	Coal gasification + CCS	4,800	Blue	$/kg	5.16	5.16	nc	2.64	2.64	nc	
South Africa	Coal gasification + CCS	6,000	Blue	$/kg	5.33	5.33	-0.02	2.81	2.81	-0.02	
Russia west	Coal gasification + CCS	6,000	Blue	$/kg	3.77	3.77	+0.02	1.94	1.94	+0.03	
US east coast	Coal gasification + CCS	6,000	Blue	$/kg	4.36	4.36	-0.02	2.53	2.53	-0.02	

COMPLETE HYDROGEN PRODUCTION COSTS

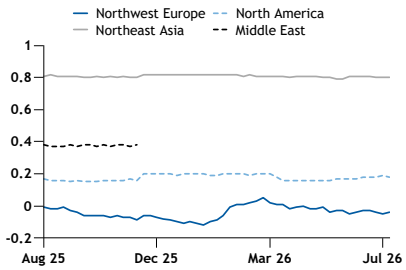
Baseline hydrogen									4 Aug
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul
Netherlands	SMR	Grey	€/kg	5.09	5.85	-0.16	4.17	4.79	-0.16
UK	SMR	Grey	£/kg	4.07	5.45	-0.14	3.28	4.40	-0.14
Germany	SMR	Grey	€/kg	4.94	5.67	-0.16	4.14	4.75	-0.16
Spain	SMR	Grey	€/kg	5.12	5.87	-0.17	4.15	4.77	-0.16
France	SMR	Grey	€/kg	5.18	5.94	-0.17	4.14	4.75	-0.17
US Gulf coast	SMR	Grey	$/kg	2.03	2.03	-0.04	0.86	0.86	-0.04
Canada	SMR	Grey	C$/kg	3.39	2.41	-0.05	1.81	1.29	-0.04
Japan	SMR	Grey	¥/kg	844	5.27	-0.09	671	4.19	-0.09
South Korea	SMR	Grey	W/kg	7,664	5.32	-0.08	6,111	4.24	-0.08
Australia	SMR	Grey	A$/kg	4.13	2.89	+0.07	2.54	1.78	+0.07
Trinidad	SMR	Grey	$/kg	4.89	4.89	-0.12	3.37	3.37	-0.12
Russia west	SMR	Grey	$/kg	1.86	1.86	nc	0.68	0.68	nc
Russia east	SMR	Grey	$/kg	1.80	1.80	nc	0.62	0.62	nc
Saudi Arabia	SMR	Grey	$/kg	1.65	1.65	nc	0.67	0.67	nc

Hydrogen decarbonisation spreads					4 Aug
	Incl. capex		Excl. capex		
	$/kg	± 28 Jul	$/kg	± 28 Jul	
Northwest Europe					
No-C to BAT+	3.70	+0.15	2.49	+0.15	
Low-C to BAT+	1.02	-0.02	0.87	-0.01	
BAT+ to baseline	-0.04	+0.01	-0.17	+0.01	
North America					
No-C to BAT+	6.76	+0.05	5.38	+0.04	
Low-C to BAT+	0.40	-0.05	0.23	-0.07	
BAT+ to baseline	0.18	-0.01	0.04	nc	
Northeast Asia					
No-C to BAT+	6.49	+0.08	5.30	+0.09	
Low-C to BAT+	1.32	-0.02	1.17	-0.01	
BAT+ to baseline	0.80	nc	0.66	-0.01	
Net exporter					
No-C to BAT+	3.43	-0.01	1.78	-0.01	
Low-C to BAT+	0.59	+0.01	0.48	+0.02	
BAT+ to baseline	0.46	nc	0.34	-0.01	

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



Decarb spread BAT+ to baseline *$/kg*



COMPLETE HYDROGEN PRODUCTION COSTS

Decarbonisation spreads relevant for subsidy mechanisms								4 Aug
		Incl. capex			Excl. capex			
	Unit	Spread	Spread in $/kg	± 28 Jul	Spread	Spread in $/kg	± 28 Jul	
France								
No-C to Baseline[1]	€/kg	3.45	3.96	+0.16	2.31	2.65	+0.16	
Germany								
No-C to BAT+[2]	€/kg	3.37	3.87	+0.14	2.18	2.51	+0.14	
Netherlands								
No-C to baseline[3]	€/kg	2.79	3.20	+0.17	1.72	1.97	+0.16	

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

Low-C hydrogen forward										4 Aug
				Incl. capex			Excl. capex			
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul	
Netherlands										
2027	ATR + CCS	Blue	€/kg	4.95	5.69	-0.15	3.78	4.34	-0.15	
2028	ATR + CCS	Blue	€/kg	4.18	4.80	-0.04	3.01	3.45	-0.05	
2029	ATR + CCS	Blue	€/kg	3.91	4.49	nc	2.74	3.15	+0.01	
UK										
2027	ATR + CCS	Blue	£/kg	4.20	5.63	-0.14	3.20	4.29	-0.14	
2028	ATR + CCS	Blue	£/kg	3.54	4.74	-0.04	2.54	3.40	-0.05	
Germany										
2027	ATR + CCS	Blue	€/kg	4.82	5.53	-0.14	3.19	4.36	-0.15	
2028	ATR + CCS	Blue	€/kg	4.04	4.64	-0.04	3.80	3.47	-0.05	
2029	ATR + CCS	Blue	€/kg	3.77	4.33	+0.01	3.03	3.16	nc	
France										
2027	ATR + CCS	Blue	€/kg	4.84	5.55	-0.15	3.52	4.04	-0.15	
Spain										
2027	ATR + CCS	Blue	€/kg	4.74	5.45	-0.14	3.52	4.04	-0.15	

BAT+ hydrogen forward										4 Aug
				Incl. capex			Excl. capex			
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul	
Netherlands										
2027	SMR + CCS	Blue	€/kg	4.19	4.81	-0.12	3.15	3.62	-0.12	
2028	SMR + CCS	Blue	€/kg	3.56	4.08	-0.04	2.51	2.89	-0.04	
2029	SMR + CCS	Blue	€/kg	3.35	3.84	nc	2.31	2.65	nc	
UK										
2027	SMR + CCS	Blue	£/kg	3.52	4.71	-0.12	2.63	3.53	-0.12	
2028	SMR + CCS	Blue	£/kg	3.00	4.02	-0.04	2.11	2.83	-0.04	
Germany										
2027	SMR + CCS	Blue	€/kg	4.09	4.70	-0.12	3.19	3.66	-0.12	
2028	SMR + CCS	Blue	€/kg	3.45	3.96	-0.04	2.55	2.93	-0.04	
2029	SMR + CCS	Blue	€/kg	3.24	3.72	nc	2.34	2.69	nc	
France										
2027	SMR + CCS	Blue	€/kg	4.23	4.86	-0.12	3.06	3.51	-0.13	
Spain										
2027	SMR + CCS	Blue	€/kg	4.13	4.75	-0.12	3.05	3.50	-0.13	

COMPLETE HYDROGEN PRODUCTION COSTS

Baseline hydrogen forward									4 Aug
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/kg	± 28 Jul	Cost	Cost in $/kg	± 28 Jul
Netherlands									
2027	SMR	Grey	€/kg	4.23	4.86	-0.13	3.31	3.79	-0.14
2028	SMR	Grey	€/kg	3.61	4.15	-0.05	2.69	3.09	-0.05
2029	SMR	Grey	€/kg	3.43	3.93	-0.01	2.50	2.87	-0.01
UK									
2027	SMR	Grey	£/kg	3.49	4.67	-0.14	2.70	3.62	-0.14
2028	SMR	Grey	£/kg	2.99	4.00	-0.06	2.20	2.95	-0.06
Germany									
2027	SMR	Grey	€/kg	4.15	4.76	-0.14	3.35	3.85	-0.13
2028	SMR	Grey	€/kg	3.53	4.05	-0.05	2.73	3.14	-0.05
2029	SMR	Grey	€/kg	3.34	3.83	-0.02	2.54	2.92	-0.01
France									
2027	SMR	Grey	€/kg	4.25	4.88	-0.14	3.22	3.69	-0.14
Spain									
2027	SMR	Grey	€/kg	4.17	4.79	-0.13	3.21	3.68	-0.14

Direct reduction iron costs (31 Jul)		*$/t*
Specification	**Cost**	**± 28 Jul**
Natural gas DRI, ex-works NW Europe	474.29	-21.25
DRI spread No-C hydrogen (renewables+ALK) vs natural gas NW Europe	419.18	+13.77
DRI spread BAT+ hydrogen (SMR+CCS) vs natural gas NW Europe	213.28	+32.91

Renewable hydrogen certificate revenue (RH2CR)				*4 Aug*
	€/kg	**± 28 Jul**	**$/kg**	**± 28 Jul**
Germany RH2CR from GHG reduction obligations	9.76	+0.04	11.21	+0.14

In Germany, companies can generate tradeable certificated by delivering renewable hydrogen or derivatives to road fuel markets. They can then sell these certificates to parties that are obliged to meet certain greenhouse gas (GHG) emission reduction targets. The RH2CRs represent the revenue suppliers can generate from selling the certificates for each kg of hydrogen they produce. Calculations are based on hydrogen's lower heating value of 120 MJ/kg and assume a 70pc reduction in GHG emissions compared with the fossil fuel comparator of 94.1 of CO2 equivalent/MJ.

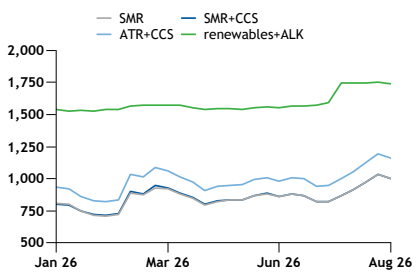
COMPLETE AMMONIA PRODUCTION COSTS

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

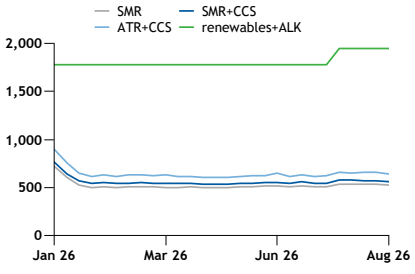
CO2e emissions on a gate-to-gate basis; purity >99.5pc; temperature -33°C

Regional ammonia cost markers						4 Aug
			Incl. capex		Excl. capex	
	Process	Unit	Cost	± 28 Jul	Cost	± 28 Jul
Baseline						
Northwest Europe	SMR	€/t	1,001	-32	769	-31
Northwest Europe	SMR	$/t	1,149	-28	883	-28
North America	SMR	$/t	525	-7	237	-7
Northeast Asia	SMR	$/t	1,054	-14	783	-14
BAT+						
Northwest Europe	SMR+CCS	€/t	1,000	-31	744	-30
Northwest Europe	SMR+CCS	$/t	1,148	-26	854	-27
North America	SMR+CCS	$/t	564	-8	246	-7
Northeast Asia	SMR+CCS	$/t	1,202	-15	903	-14
Low-C						
Northwest Europe	ATR+CCS	€/t	1,160	-35	874	-33
Northwest Europe	ATR+CCS	$/t	1,332	-29	1,004	-29
North America	ATR+CCS	$/t	643	-18	287	-18
Northeast Asia	ATR+CCS	$/t	1,441	-17	1,106	-18
No-C						
Northwest Europe	Island renewable+PEM	€/t	1,740	-14	1,254	-10
Northwest Europe	Island renewable+PEM	$/t	1,998	nc	1,440	nc
North America	Island renewable+PEM	$/t	1,948	nc	1,331	nc
Northeast Asia	Island renewable+PEM	$/t	2,547	nc	2,009	nc
Exporter						
Exporter baseline	SMR	$/t	514	+2	241	+2
Exporter BAT+	SMR+CCS	$/t	602	+2	300	+2
Exporter low-C	ATR+CCS	$/t	714	+4	376	+4
Exporter no-C	Island renewable+PEM	$/t	1,293	nc	702	nc

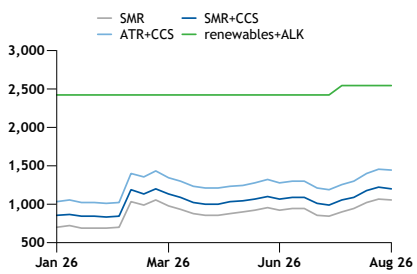
NW Europe ammonia average €/t



North America ammonia average $/t



Northeast Asia ammonia average $/t



COMPLETE AMMONIA PRODUCTION COSTS

No-C ammonia									4 Aug
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/t	± 28 Jul	Cost	Cost in $/t	± 28 Jul
Netherlands Terneuzen	Wind + ALK	Green	€/t	1,677	1,926	nc	1,207	1,386	nc
UK Harwich	Wind + ALK	Green	£/t	1,216	1,630	nc	807	1,082	nc
Germany Bremen	Wind + ALK	Green	€/t	1,723	1,978	nc	1,252	1,437	nc
France Sete	Wind + ALK	Green	€/t	1,821	2,091	nc	1,303	1,496	nc
Spain Teruel	Diurnal + ALK	Green	€/t	1,228	1,410	nc	637	731	nc
US Wilbarger	Diurnal + ALK	Green	$/t	1,631	1,631	nc	952	952	nc
Canada Newfoundland	Wind + ALK	Green	C$/t	3,183	2,265	nc	2,402	1,710	nc
Oman Duqm	Diurnal + ALK	Green	$/t	904	904	nc	540	540	nc
Saudi Arabia Tabuk	Diurnal + ALK	Green	$/t	833	833	nc	420	420	nc
UAE Abu Dhabi	Diurnal + ALK	Green	$/t	1,153	1,153	nc	663	663	nc
Qatar Mesaieed	Diurnal + ALK	Green	$/t	1,307	1,307	nc	819	819	nc
Namibia Walvis Bay	Diurnal + ALK	Green	$/t	1,723	1,723	nc	790	790	nc
South Africa Coega	Diurnal + ALK	Green	$/t	1,640	1,640	nc	949	949	nc
Japan Fukushima	Wind + ALK	Green	¥/t	424,236	2,647	nc	312,441	1,950	nc
China Jilin	Diurnal + ALK	Green	Yn/t	5,116	757	nc	3,389	501	nc
India Kutch	Diurnal + ALK	Green	Rs/t	76,434	800	nc	51,367	538	nc
South Korea Ulsan	Wind + ALK	Green	W/t	6,100,090	4,236	nc	5,151,389	3,577	nc
Vietnam Phu Yen	Wind + ALK	Green	$/t	2,030	2,030	nc	1,553	1,553	nc
Australia Burrup	Diurnal + ALK	Green	A$/t	2,191	1,533	nc	1,285	899	nc
Brazil Piaui	Diurnal + ALK	Green	$/t	1,162	1,162	nc	575	575	nc
Chile Mejillones	Diurnal + ALK	Green	$/t	1,131	1,131	nc	611	611	nc

Low-C ammonia									4 Aug
				Incl. capex			Excl. capex		
	Process	Legacy colour	Unit	Cost	Cost in $/t	± 28 Jul	Cost	Cost in $/t	± 28 Jul
Netherlands	ATR + CCS	Blue	€/t	1,177	1,352	-30	890	1,022	-30
UK	ATR + CCS	Blue	£/t	981	1,315	-28	737	988	-28
Germany	ATR + CCS	Blue	€/t	1,121	1,288	-27	873	1,003	-27
Spain	ATR + CCS	Blue	€/t	1,172	1,346	-29	873	1,003	-29
France	ATR + CCS	Blue	€/t	1,182	1,357	-30	860	988	-29
US Gulf coast	ATR + CCS	Blue	$/t	684	684	-9	320	320	-9
Canada	ATR + CCS	Blue	C$/t	845	602	-26	356	253	-27
Japan	ATR + CCS	Blue	¥/t	236,368	1,475	-21	182,648	1,140	-20
South Korea	ATR + CCS	Blue	W/t	2,025,079	1,406	-15	1,543,133	1,072	-15
Australia	ATR + CCS	Blue	A$/t	1,257	880	+21	763	534	+20
Trinidad	ATR + CCS	Blue	$/t	1,289	1,289	-25	818	818	-24
Russia west	ATR + CCS	Blue	$/t	625	625	-1	258	258	-2
Russia east	ATR + CCS	Blue	$/t	610	610	-3	243	243	-3
Saudi Arabia	ATR + CCS	Blue	$/t	578	578	nc	273	273	nc

Low-Carbon Ammonia benchmarks			4 Aug
	Unit	Cost	± 28 Jul
JKLAB CFR Ulsan, South Korea, incl. US 45Q tax credit	$/t	719.51	-10.12
JKLAB CFR Ulsan, South Korea, excl. US 45Q tax credit	$/t	855.51	-10.12
JKLAB CFR Niihama, Japan, differential	$/t	-0.31	-0.02
EULAB CFR ARA, incl. 45Q US tax credit	$/t	632.07	-9.74
EULAB CFR ARA, excl. 45Q US tax credit	$/t	768.07	-9.74

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										4 Aug
				Incl. capex			Excl. capex			
	Process	Legacy colour	Unit	Cost	Cost in $/t	± 28 Jul	Cost	Cost in $/t	± 28 Jul	
Netherlands	SMR + CCS	Blue	€/t	1,007	1,156	-27	750	861	-27	
UK	SMR + CCS	Blue	£/t	826	1,107	-23	608	815	-22	
Germany	SMR + CCS	Blue	€/t	961	1,104	-25	739	849	-25	
Spain	SMR + CCS	Blue	€/t	1,010	1,160	-27	743	853	-27	
France	SMR + CCS	Blue	€/t	1,032	1,184	-27	744	854	-26	
US Gulf coast	SMR + CCS	Blue	$/t	578	578	-7	252	252	-7	
Canada	SMR + CCS	Blue	C$/t	774	551	-8	336	239	-8	
Japan	SMR + CCS	Blue	¥/t	193,347	1,206	-16	145,291	907	-15	
South Korea	SMR + CCS	Blue	W/t	1,725,078	1,198	-14	1,293,947	898	-15	
Australia	SMR + CCS	Blue	A$/t	1,063	744	+13	621	435	+13	
Trinidad	SMR + CCS	Blue	$/t	1,127	1,127	-22	706	706	-21	
Russia west	SMR + CCS	Blue	$/t	530	530	-1	202	202	-1	
Russia east	SMR + CCS	Blue	$/t	520	520	-1	192	192	-1	
Saudi Arabia	SMR + CCS	Blue	$/t	485	485	nc	212	212	nc	

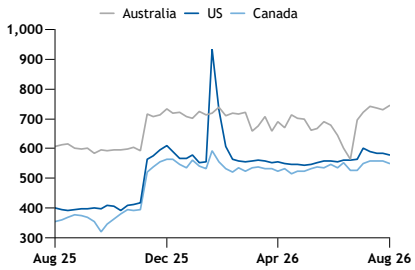
BAT+ ammonia											4 Aug
					Incl. capex			Excl. capex			
	Process	kcal/kg NAR	Legacy colour	Unit	Cost	Cost in $/t	± 28 Jul	Cost	Cost in $/t	± 28 Jul	
Australia	Coal gasification + CCS	5,500	Blue	A$/t	1,391	973	+2	752	526	+2	
Australia	Coal gasification + CCS	6,000	Blue	A$/t	1,474	1,032	+7	835	584	+6	
China	Coal gasification + CCS	3,800	Blue	Yn/t	5,753	851	-1	3,550	525	-1	
China	Coal gasification + CCS	5,500	Blue	Yn/t	5,589	827	-2	3,386	501	-2	
Indonesia	Coal gasification + CCS	5,500	Blue	$/t	844	844	-1	486	486	nc	
Indonesia	Coal gasification + CCS	3,800	Blue	$/t	821	821	nc	462	462	-1	
South Africa	Coal gasification + CCS	4,800	Blue	$/t	1,152	1,152	-1	500	500	-1	
South Africa	Coal gasification + CCS	6,000	Blue	$/t	1,183	1,183	-3	531	531	-3	
Russia west	Coal gasification + CCS	6,000	Blue	$/t	846	846	+4	372	372	+4	
US east coast	Coal gasification + CCS	6,000	Blue	$/t	971	971	-3	500	500	-3	

Baseline ammonia										4 Aug
				Incl. capex			Excl. capex			
	Process	Legacy colour	Unit	Cost	Cost in $/t	± 28 Jul	Cost	Cost in $/t	± 28 Jul	
Netherlands	SMR	Grey	€/t	1,007	1,156	-29	775	889	-29	
UK	SMR	Grey	£/t	805	1,080	-24	608	815	-25	
Germany	SMR	Grey	€/t	966	1,109	-27	765	878	-27	
Spain	SMR	Grey	€/t	1,010	1,159	-30	768	881	-30	
France	SMR	Grey	€/t	1,029	1,181	-29	768	882	-29	
US Gulf coast	SMR	Grey	$/t	495	495	-6	200	200	-7	
Canada	SMR	Grey	C$/t	781	556	-7	385	274	-7	
Japan	SMR	Grey	¥/t	167,993	1,048	-16	124,479	777	-15	
South Korea	SMR	Grey	W/t	1,526,104	1,060	-13	1,135,728	789	-13	
Australia	SMR	Grey	A$/t	914	640	+13	515	360	+13	
Trinidad	SMR	Grey	$/t	1,013	1,013	-22	632	632	-21	
Russia west	SMR	Grey	$/t	449	449	-1	152	152	-1	
Russia east	SMR	Grey	$/t	439	439	-1	142	142	-1	
Saudi Arabia	SMR	Grey	$/t	409	409	nc	162	162	nc	

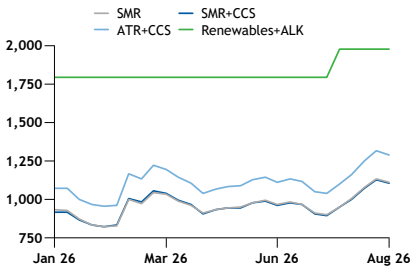
COMPLETE AMMONIA PRODUCTION COSTS

Ammonia decarbonisation spreads	Incl. capex		Excl. capex	4 Aug
	$/t	± 28 Jul	$/t	± 28 Jul
Northwest Europe				
No-C to BAT+	850	+26	586	+27
Low-C to BAT+	184	-3	150	-2
BAT+ to baseline	-1	+2	-29	+1
North America				
No-C to BAT+	1,384	+8	1,085	+7
Low-C to BAT+	79	-10	41	-11
BAT+ to baseline	39	-1	9	nc
Northeast Asia				
No-C to BAT+	1,345	+15	1,106	+14
Low-C to BAT+	239	-2	203	-4
BAT+ to baseline	148	-1	120	nc
Net exporter				
No-C to BAT+	691	-2	402	-2
Low-C to BAT+	112	+2	76	+2
BAT+ to baseline	88	nc	59	nc

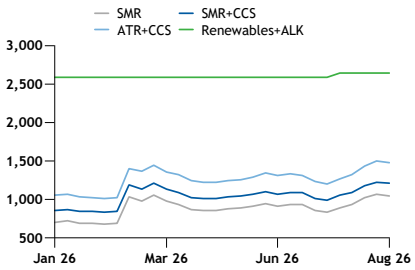
SMR+CCS ammonia costs $/t



German ammonia costs $/t



Japanese ammonia costs $/t



COMPLETE E-METHANOL PRODUCTION COSTS

No-C e-methanol			Incl. capex			Excl. capex		4 Aug
	Process	Unit	Cost	Cost in $/t	± 28 Jul	Cost	Cost in $/t	± 28 Jul
Netherlands	PPA+ALK	€/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Spain	PPA+ALK	€/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UK	PPA+ALK	£/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sweden	PPA+ALK	$/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Australia Burrup	Diurnal+ALK	A$/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
China Jilin	Diurnal+ALK	Yn/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
India	Diurnal+ALK	Rs/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Brazil Piaui	Diurnal+ALK	$/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
US Wilbarger	Diurnal+ALK	$/t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COMPLETE E-SAF PRODUCTION COSTS

No-C e-SAF								4 Aug
			Incl. capex			Excl. capex		
	Process	Unit	Cost	Cost in $/t	± 28 Jul	Cost	Cost in $/t	± 28 Jul
Netherlands	PPA+ALK FT	€/t						
Netherlands	PPA+ALK MtJ	€/t						
Spain	PPA+ALK FT	€/t						
Spain	PPA+ALK MtJ	€/t						
UK	PPA+ALK FT	£/t						
UK	PPA+ALK MtJ	£/t						
Sweden	PPA+ALK FT	$/t						
Sweden	PPA+ALK MtJ	$/t						
Australia Burrup	Diurnal+ALK FT	A$/t						
Australia Burrup	Diurnal+ALK MtJ	A$/t						
China Jilin	Diurnal+ALK FT	Yn/t						
China Jilin	Diurnal+ALK MtJ	Yn/t						
India	Diurnal+ALK FT	Rs/t						
India	Diurnal+ALK MtJ	Rs/t						
Brazil Piaui	Diurnal+ALK FT	$/t						
Brazil Piaui	Diurnal+ALK MtJ	$/t						
US Wilbarger	Diurnal+ALK FT	$/t						
US Wilbarger	Diurnal+ALK MtJ	$/t						

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