METHODOLOGY AND SPECIFICATIONS GUIDE

argus

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ARGUS HYDROGEN AND FUTURE FUELS

Contents:

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The most up-to-date Argus Hydrogen and Future Fuels methodology is available on www.argusmedia.com

Argus Hydrogen and Future Fuels

Argus Hydrogen and Future fuels includes modelled costs for hydrogen produced at newly constructed facilities using several industry standard production paths.

For each technology a standard project is modelled using assumed capital and other costs, adjusted for each location based on risk and tax rates that vary by country.

Those costs, summarised below are reviewed periodically and are subject to change from time to time as national taxation and fiscal policies change. To those capital costs is added operating costs and the variable cost per kilogram of hydrogen. Assumptions used in determining fixed and variable costs are described below and are updated semi-annually, subject to market consultation.

Timing

Costs are calculated and published electronically each week, on Tuesday, and appear in the weekly print edition of Argus Hydrogen and Future fuels.

Where daily feedstock prices are used in calculations, they are the average of prices available since the last time hydrogen costs were calculated.

Currency and unit

Prices are published in US dollars per kilogram and in the local currencies for Australia, Canada, China, Europe, India, Japan and South Korea. Currency conversions are made using an average exchange rate during the week before publication. Hydrogen and ammonia prices can be converted to energy terms using the Argus Direct platform. Argus assumes a lower heating value of 33.33kWh/kg for hydrogen conversions and 5.17kWh/kg for ammonia.

Capex/no-capex hydrogen costs

For each location and technology, two sets of hydrogen costs are published, one including capex and another excluding capex, allowing for clear comparisons of fixed and variable costs between locations and technologies.

Hydrogen capex summary

	$/kW	$/kg H2, actual
Electrolysis (Chinese technology; diurnal)	655-1,131	0.76-3.78
Electrolysis (Chinese technology; offshore wind)	1,047	1.44
Electrolysis (OECD technology; diurnal)	1,259-1,919	1.34-2.10
Electrolysis (OECD technology; offshore wind)	1,916-2,300	1.47-2.00
Electrolysis (OECD technology; grid)	1,916	1.99-2.80
ATR+CCS		1.06-1.75
SMR		0.83-1.38
SMR+CCS		0.94-1.55
Coal gasification+CCS		0.99-2.25

Note: Argus publishes hydrogen prices including and excluding capex, allowing for specific capex assumptions on a $/kg of hydrogen basis to be calculated for each technology and location. Ranges of those figures are shown here and vary depending on country risk and tax rates

Green (No-C)

Green (or No-C) hydrogen is produced using renewable electricity, either generated as part of an integrated hydrogen and electricity project or purchased through a power purchase agreement (PPA).

Project assumptions

Cost are modelled based on alkaline electrolyser technology, supplied either by Chinese or western manufacturers, depending on location. Plant sizes and capital, operating and other costs vary by location.

Plants have an annual production of either 20,000 t/yr or 100,000 t/yr, depending on location, and a lifetime of 25 years. They are assumed to require 58MWh of electricity per tonne of hydrogen.

Off-grid diurnal installations are assumed to receive 25pc of their electricity from solar photovoltaic (PV) assets and 75pc from onshore wind assets. Electrolyser capacity factors of 50-75pc are assumed for off-grid diurnal projects and 65-85pc for offshore wind installations, depending on location. A 50pc capacity factor is assumed for PPA-supplied projects in Spain and Portugal and 40pc is assumed for PPA-supplied projects outside Iberia.

Green (No-C) hydrogen cost assumptions

Location	Electricity source	Capacity t/yr	Origin	Capacity MW
Europe				
Netherlands (Terneuzen)	Offshore wind	20,000	OECD	176
Netherlands	Grid+PPA+51.2pc fees	20,000	OECD	327
UK (Harwich)	Offshore wind	20,000	OECD	175
UK	Grid+PPA+30pc fees	20,000	OECD	327
Germany (Bremen)	Offshore wind	20,000	OECD	185
Germany	Grid+PPA+27.3pc fees	20,000	OECD	327
France (Sete)	Offshore wind	20,000	OECD	179
France	Grid+PPA+20.7pc fees	20,000	OECD	327
Spain (Teruel)	Onshore wind and solar	20,000	OECD	225
Spain	Grid+PPA+27.4pc fees	20,000	OECD	262
Italy	Grid+PPA+26pc fees	20,000	OECD	327
Portugal	Grid+PPA+34.8pc fees	20,000	OECD	327
Americas				
US (Wilbarger)	Onshore wind and solar	20,000	OECD	209
Canada (Newfoundland)	Offshore wind	20,000	OECD	170
Brazil (Piaui)	Onshore wind and solar	20,000	China	224
Chile (Mejillones)	Onshore wind and solar	20,000	China	249
Middle East and Africa				
Oman (Duqm)	Onshore wind and solar	100,000	China	1,367
Qatar (Mesaieed)	Onshore wind and solar	100,000	OECD	1,249
Saudi Arabia (Tabuk)	Onshore wind and solar	100,000	OECD	959
UAE (Abu Dhabi)	Onshore wind and solar	100,000	OECD	1,158
Namibia (Walvis Bay)	Onshore wind and solar	20,000	China	286
South Africa (Coega)	Onshore wind and solar	20,000	China	243
Asia				
Japan (Fukushima)	Offshore wind	20,000	OECD	193
South Korea (Ulsan)	Offshore wind	20,000	OECD	180
China (Jilin)	Onshore wind and solar	100,000	Chinese	1,146
Australia (Burrup)	Onshore wind and solar	100,000	OECD	1,197
Vietnam (Phu Yen)	Offshore wind	20,000	Chinese	221
India (Kutch)	Onshore wind and solar	100,000	Chinese	1,171

Electricity prices

Argus has modelled the levelised cost of electricity for off-grid installations, depending on location. Costs are updated semi-annually, along with other assumptions.

PPA prices are based on Pexapark's weekly averaged market-based pricing for blended pay-as-produced solar and wind electricity over a 10-year supply period for the named country. See https://go.pexapark.com/pexapark-price-assessments

Grid fees

Grid fees are added to the cost of electricity for projects connected to the power grid. Fees are expressed as a percent of the wholesale power price and are reviewed semi-annually.

Grey (baseline), Blue (Low-C and BAT+)

Argus publishes the cost of hydrogen produced using steam methane reforming (SMR) and autothermal reforming (ATR) processes, with or without carbon capture and storage (CCS) and with natural gas drawn from the local market, priced at regulated tariffs or bought at international market prices.

Two technologies are modelled — SMR and ATR — for which capital, operating and other costs vary by location. Argus also publishes costs excluding capex for existing SMR plants where a CCS system has been retrofitted. All assume 187,975t/yr plant design capacity except SMR plants with retrofit CCS, which assume 60,000 t/yr. All assume a capacity factor of 90pc.

Assumptions per tonne of hydrogen produced

SMR without CCS
- 9.49t of CO2 is released
- 174.5mn Btu of natural gas is required, including gas for fuel
- 8.59t of water is consumed
- 0.749MWh of electricity is consumed

SMR with CCS
- 3.18t of CO2 is released
- 6.31t of CO2 is captured and stored
- 174.5mn Btu of natural gas is required, including gas for fuel
- 8.59t of water is consumed
- 0.749MWh of electricity is consumed
- CO2 transport and storage costs vary by country, see below

SMR with CCS retrofit
- 4.75t of CO2 is released
- 4.75t of CO2 is captured and stored
- 174.5mn Btu of natural gas is required, including gas for fuel
- 8.59t of water is consumed
- 0.749MWh of electricity is consumed
- CO2 transport and storage costs vary by country, see below

ATR with CCS
- 0.69t of CO2 is released
- 9.35t of CO2 is captured and stored
- 193.17mn Btu of natural gas is required, including gas consumed as fuel
- 3.64MWh of electricity is consumed
- 15.36t of water is consumed
- CO2 transport and storage costs vary by country, see below

CO2 transport and storage costs

Per tonne of CO2
- Canada $40/t
- US Gulf coast $40/t
- Russia $40/t
- Saudi Arabia $40/t
- Australia $60/t
- China $60/t
- France $60/t
- Germany $60/t
- Indonesia $60/t
- Netherlands $60/t
- South Africa $60/t
- Spain $60/t
- UK $60/t
- Trinidad $60/t
- Japan $110/t
- South Korea $110/t

Natural gas prices

Natural gas prices are converted at a fixed 48.62mn Btu/t

Europe

Netherlands: TTF day-ahead
UK: NBP day-ahead
Germany: Germany VTP (Trading Hub Europe) day-ahead
Spain: PVB front-month
France: PEG day-ahead:

See the Argus European Natural Gas methodology

North America

US Gulf coast: Henry Hub day-ahead index
Canada: Alliance ATP day-ahead index

See the Argus Natural Gas Americas methodology

Asia

Japan: LNG des northeast Asia (ANEA) first half month forward
South Korea: LNG des northeast Asia (ANEA) first half month forward
Australia: AEMO Victoria, prompt
Saudi Arabia: the Saudi Aramco natural gas tariff for industrial consumers

See the Argus LNG Daily methodology

Russia
Gas prices are the regional maximums for industrial consumers as set by the Federal Tariff Service of the Russian Federation

Russia west: Orenburg region
Russia east: Yamal region

Trinidad and Tobago
LNG fob Trinidad and Tobago first half month forward.

See the Argus LNG Daily methodology

CO2
Hydrogen producers are assumed to purchase allowances or pay CO2 taxes for unabated CO2 emissions.

EU and UK: CO2 costs are the Argus assessments of EU ETS and UK ETS spot prices. See the Argus Carbon methodology.
Japan: the Tax for Climate Mitigation, imposed by the Ministry of the Environment is added to the gas price
South Korea: the price of credits in the Korea ETS (K-ETS) scheme
Canada: priced as per the Greenhouse Gas Pollution Pricing Act

Electricity prices

Europe
The Argus month-ahead base load price for the named country. See the Argus European Electricity methodology.

Russia
The weighted average day-ahead wholesale auction price from Russian state wholesale power market trading platform operator ATS.

Russia west: Orenburg region
Russia east: Tyumenskaya region

Japan
The day-ahead base load price on the Japan Electric Power Exchange (JEPX) for the Tokyo market area.

South Korea
The Kepco tariff for high-voltage electricity consumers.

Saudi Arabia
The Saudi Electricity Company tariff for industrial consumption

Australia
The average Australian Energy Market Operator (AEMO) Victoria spot price

Canada
The average Alberta Electric System Operator (AESO) daily pool price

Trinidad and Tobago
Trinidad and Tobago Electricity Commission (TTEC) tariff for very large industrial consumers

US
To produce a price of electricity for every day in the calendar month, Argus averages peak and off peak price assessments as described below.

Gulf coast: the Argus day-ahead off peak and peak price assessments for the Entergy market area. Peak is 07:00-23:00 on business days, off peak is all other hours. See the Argus US Electricity methodology.

Blue (coal gasification)

Argus publishes the cost of hydrogen produced using coal gasification with carbon capture and storage (CCS) and with coal purchased at international market prices.

Capital, operating and other costs vary by location. All assume 250,000 t/yr plant design capacity and a capacity factor of 90pc.

Assumptions per tonne of hydrogen produced

- 1.5t of CO2 is released
- 17.7t CO2 captured and stored
- 11.43t of 5,500 kcal/kg coal is consumed
- 1.36MWh/t of electricity is consumed
- 12.17t of water is consumed
- CO2 transport and storage costs vary by country, see above

Coal
Prices are the latest available

Australia
fob Newcastle 6,000kcal/kg NAR
fob Newcastle 5,500kcal/kg NAR

China
cfr south China 5,500 kcal/kg NAR
ddp Shanghai 3,800 kcal/kg NAR

South Africa
fob Richards Bay 6,000 kcal/kg NAR
fob Richards Bay 4,800 kcal/kg NAR

Indonesia
fob Indonesia 5,800 kcal/kg GAR (5,500 kcal/kg NAR)
fob Indonesia 4,200 kcal/kg GAR (3,800 kcal/kg NAR)

Russia
fob Black Sea 6,000 kcal/kg NAR

See the Argus Coal Daily International methodology

US
fob Hampton Roads terminals 6,000 kcal/kg NAR

See the Argus Coal Daily methodology

Electricity

Australia: the average Australian Energy Market Operator (AEMO) Victoria spot price

China: State Grid Corporation of China monthly tariff

South Africa: The tariff for Eskom direct customers

Indonesia: National Electricity Company PLN quarterly industrial tariff

Russia

The weighted-average day-ahead wholesale auction price from Russian state wholesale power market trading platform operator ATS.

Russia west: Orenburg region

US

To produce a price for every hour in the calendar month, Argus averages peak and off peak price assessments as described below.

East coast: the Argus month-ahead off peak and peak price assessments for the PJM West market area. Peak is 07:00-23:00 on business days, off peak is all other hours.

See the Argus US Electricity methodology

Regional technology averages - hydrogen

Argus also publishes regional average hydrogen costs grouped by production technology.

Each price is an average of the listed published costs, converted to US dollars per tonne.

Northwest Europe
- Baseline: Netherlands, UK and Germany SMR (no CCS)
- BAT +: Netherlands, UK and Germany SMR + CCS
- Low-C: Netherlands, UK and Germany ATR + CCS
- No-C: Netherlands, UK and Germany ALK (offshore wind)

North America
- Baseline: US Gulf coast and Canada SMR (no CCS)
- BAT +: US Gulf coast and Canada SMR + CCS
- Low-C: US Gulf coast and Canada ATR + CCS
- No-C: US ALK (wind and solar) and Canada ALK (offshore wind)

Northeast Asia
- Baseline: Japan and South Korea SMR (no CCS)
- BAT +: Japan and South Korea SMR + CCS
- Low-C: Japan and South Korea ATR + CCS
- No-C: Japan, South Korea ALK (offshore wind) and China ALK (wind and solar)

Middle East
- No-C: UAE, Qatar, Saudi Arabia and Oman ALK (wind and solar)

Exporter
- Baseline: Australia, Saudi Arabia, US Gulf coast SMR (no CCS)
- BAT+: Australia, Saudi Arabia and US Gulf coast SMR + CCS
- Low-C: Australia, Saudi Arabia and US Gulf coast ATR + CCS
- No-C: US, Chile, Namibia, Australia, Oman and Saudi Arabia ALK (wind and solar)

Hydrogen decarbonisation spreads

Argus also publishes the difference between lower- and higher-carbon intensity hydrogen production costs.

Regional

Deltas are published showing the $/kg difference between No-C and BAT + costs, between Low-C and BAT + costs, and between BAT + and baseline costs for each of the regions described above.

National

Deltas are published in $/kg and €/kg.

France: No-C to baseline
Germany: No-C to BAT+
Netherlands: No-C to baseline

Renewable hydrogen certificate revenue

The value, in €/kg of hydrogen, of certificates received for supply of hydrogen into the road fuel markets of Germany and the Netherlands.

In all calculations, hydrogen's lower heating value of 120.1MJ/kg is assumed.

Germany

The difference between the emissions created by the supply of hydrogen, assumed to be 70pc less than the 94.1kg CO2/GJ fossil fuel comparator as set in German law, and the emissions of standard fuels, assumed to be the 94.1kg CO2/GJ fossil fuel comparator less current greenhouse gas (GHG) emissions reduction quota required for all.

The resulting GHG savings is multiplied by three, per German law, and the €/t CO2 equivalent value of GHG reduction for "other" methods. See the Argus O.M.R. Fuels methodology for more information about German GHG savings quota assessments.

Netherlands

Calculated as 0.3 the current year HBE-O reduction obligation value price. See the Argus Biofuels methodology for more information about Dutch renewable fuel unit (HBE) assessments.

Complete list of hydrogen costs

Africa and Mideast Gulf

Namibia
no-C diurnal+ALK Walvis Bay

Oman
no-C diurnal+ALK Duqm

Qatar
no-C diurnal+ALK Mesaieed

Saudi Arabia
baseline SMR
BAT+ SMR+CCS
Low-C ATR+CCS
no-C diurnal+ALK Tabuk

South Africa
BAT+ coal gasification 4800 NAR
BAT+ coal gasification 6000 NAR
no-C diurnal+ALK Coega

UAE
no-C diurnal+ALK Abu Dhabi

Americas

Brazil
no-C diurnal+ALK Piaui

Canada
baseline SMR
BAT+ SMR+CCS
Low-C ATR+CCS
no-C offshore wind+ALK Newfoundland

Chile
no-C diurnal+ALK Mejillones

Trinidad
baseline SMR
BAT+ SMR+CCS
Low-C ATR+CCS

US
baseline SMR
BAT+ coal gasification east coast
BAT+ SMR+CCS Gulf coast
Low-C ATR+CCS Gulf coast
no-C diurnal+ALK Wilbarger, TX

Asia-Pacific

Australia
baseline SMR
BAT+ coal gasification 5500 NAR
BAT+ coal gasification 6000 NAR
BAT+ SMR+CCS
low-C ATR+CCS
no-C diurnal+ALK Burrup, WA

China
BAT+ coal gasification 3800 NAR
BAT+ coal gasification 5500 NAR
no-C diurnal+ALK Jilin

India
no-C diurnal+ALK Kutch

Indonesia
BAT+ coal gasification 3800 NAR
BAT+ coal gasification 5500 NAR

Japan
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Fukushima

South Korea
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Ulsan

Vietnam
no-C offshore wind+ALK Phu Yen

Europe

France
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Sete
no-C grid+PPA

Germany
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Bremen
no-C grid+PPA

Italy
no-C grid+PPA

Netherlands
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Terneuzen
no-C grid+PPA

Portugal
no-C grid+PPA

Spain
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C diurnal+ALK Teruel
no-C grid+PPA

UK
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Harwich
no-C grid+PPA

Russia
BAT+ coal gasification 6000 NAR

Russia east
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS

Russia west
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS

Forward costs

Argus Hydrogen and Future Fuels also includes forward cost calculations for hydrogen produced one, two or three years in the future. Costs for future hydrogen production are calculated in the same way as those for spot production and assume the same fixed costs but incorporate forward price assessments for gas, electricity and CO2 emissions allowances.

Forward hydrogen costs are published for:

Europe

Netherlands
baseline SMR years 1-3
BAT+ SMR+CCS years 1-3
low-C ATR+CCS years 1-3

Germany
baseline SMR year 1-3
BAT+ SMR+CCS year 1-3
low-C ATR+CCS year 1-3

UK
baseline SMR year 1-2
BAT+ SMR+CCS year 1-2
low-C ATR+CCS year 1-2

France
baseline SMR year 1
BAT+ SMR+CCS year 1
low-C ATR+CCS year 1

Spain
baseline SMR year 1
BAT+ SMR+CCS year 1
low-C ATR+CCS year 1

Ammonia

Argus Hydrogen and Future Fuels includes modelled costs for ammonia produced at newly constructed facilities using hydrogen as a feedstock. Modelled ammonia production costs are differentiated by location and by the cost of hydrogen production. Hydrogen costs are modelled as described above.

Timing

Costs are calculated and published electronically each week, on Tuesday, and appear in the weekly print edition of Argus Hydrogen and Future fuels.

Currency and unit

Prices are published in US dollars per tonne and in the local currencies for Australia, Canada, China, Europe, India, Japan and South Korea. Currency conversions are made using an average exchange rate during the week before publication.

Blue/grey ammonia assumptions

Blue and grey ammonia is produced using fossil fuels — blue ammonia involves the capture and storage of CO2 and grey ammonia does not.

- Ammonia:Hydrogen ratio 5.67:1
- Capacity:1.066mn t/yr of ammonia production (gas projects), 1.417mn t/yr of ammonia production (coal projects)
- Plant lifetime: 25 years
- Capacity factor: 90pc
- Water consumption: 3.5t/t of ammonia (gas projects) 0.6t/t of ammonia (coal projects)
- No off-site heat or power consumption is assumed

Green ammonia assumptions

- Ammonia:Hydrogen ratio 5.67:1
- Production: 113,400 t/yr of ammonia for locations with hydrogen production of 20,000 t/yr and 567,000 t/yr of ammonia for locations with hydrogen production of 100,000 t/yr
- Plant lifetime: 25 years
- Capacity factor: 90pc
- Water consumption: 1.6t/t of ammonia
- Electricity consumption: 1.05MWh/t of ammonia

Ammonia capex summary

	$/t NH3, actual
Electrolysis (Chinese technology; diurnal)	173-911
Electrolysis (Chinese technology; offshore wind)	355
Electrolysis (OECD technology; diurnal)	287-469
Electrolysis (OECD technology; offshore wind)	347-441
Electrolysis (OECD technology; grid)	446-596
ATR+CCS	259-429
SMR	210-347
SMR+CCS	231-384
Coal gasification+CCS	293-581

Note: Argus publishes ammonia prices including and excluding capex, allowing for specific capex assumptions on a $/t of ammonia basis to be calculated for each technology and location. Ranges of those figures are shown here and vary depending on country risk and tax rates

Regional technology averages - ammonia

Argus also publishes regional average ammonia costs grouped by production technology.

Each price is an average of the listed published costs, converted to US dollars per tonne.

Northwest Europe

- Baseline: Netherlands, UK and Germany SMR (no CCS)
- BAT +: Netherlands, UK and Germany SMR + CCS
- Low-C: Netherlands, UK and Germany ATR + CCS
- No-C: Netherlands, UK and Germany ALK (offshore wind)

North America

- Baseline: US Gulf coast and Canada SMR (no CCS)
- BAT +: US Gulf coast and Canada SMR + CCS
- Low-C: US Gulf coast and Canada ATR + CCS
- No-C: US ALK (wind and solar) and Canada ALK (offshore wind)

Northeast Asia

- Baseline: Japan and South Korea SMR (no CCS)
- BAT +: Japan and South Korea SMR + CCS
- Low-C: Japan and South Korea ATR + CCS
- No-C: Japan, South Korea ALK (offshore wind) and China ALK (wind and solar)

Middle East

- No-C: UAE, Qatar, Saudi Arabia and Oman ALK (wind and solar)

Exporter

- Baseline: Australia, Saudi Arabia, US Gulf coast SMR (no CCS)
- BAT+: Australia, Saudi Arabia and US Gulf coast SMR + CCS
- Low-C: Australia, Saudi Arabia and US Gulf coast ATR + CCS
- No-C: US, Chile, Namibia, Australia, Oman and Saudi Arabia ALK (wind and solar)

Ammonia decarbonisation spreads

Argus also publishes the difference between lower- and higher-carbon intensity ammonia production costs. Deltas are published showing the difference between No-C and BAT + costs, between Low-C and BAT + costs, and between BAT + and baseline costs for each of the regions described above.

Japan, Korea low-carbon ammonia benchmarks

Argus Hydrogen and Future Fuels includes calculated delivered prices for US ammonia delivered to Ulsan, South Korea and Niihama, Japan. Prices are calculated as the Low-C ATR+CCS US Gulf coast ammonia cost (including capex) plus the lower of the weekly average freight rates from Donaldsonville to the destination via the Panama Canal or the Cape of Good Hope. See the Argus Gas Freight meth-

odology. Two versions of the Ulsan price are published, including and excluding the value of a US 45Q tax credit for carbon sequestration. The Niihama price is published as a differential to the Ulsan price.

EU low-carbon ammonia benchmark

Argus Hydrogen and Future Fuels includes calculated delivered prices for US ammonia delivered to the Amsterdam-Rotterdam-Antwerp area (ARA). Prices are calculated as the Low-C ATR+CCS US Gulf coast ammonia cost (including capex) plus the weekly average freight rate from Donaldsonville to ARA. See the Argus Gas Freight methodology. Two versions of the ammonia price are published, including and excluding the value of a US 45Q tax credit for carbon sequestration.

Benchmark supplement

Argus publishes the Argus Hydrogen and Future Fuels Low-Carbon Ammonia Benchmark Supplement each Thursday containing month-to-date averages of the cfr Ulsan (JKLAB, with and without the US 45Q tax credit), the cfr Niihama differential and the cfr ARA (EULAB, with and without the US 45Q tax credit) prices. The supplement also includes 12-month low-high ranges of the cfr Ulsan (excluding the 45Q tax credit), cfr Niihama differential and cfr ARA (excluding the 45Q tax credit) prices.

Complete list of ammonia costs

Africa and Mideast Gulf

Namibia
No-C diurnal+ALK Walvis Bay

Oman
No-C diurnal+ALK Duqm

Qatar
No-C diurnal+ALK Mesaieed

Saudi Arabia
Baseline SMR
BAT+ SMR+CCS
Low-C ATR+CCS
No-C diurnal+ALK Tabuk

South Africa
BAT+ coal gasification 4800 NAR
BAT+ coal gasification 6000 NAR
no-C diurnal+ALK Coega

UAE
No-C diurnal+ALK Abu Dhabi

Americas

Brazil
No-C diurnal+ALK Piaui

Canada
Baseline SMR
BAT+ SMR+CCS
Low-C ATR+CCS
No-C offshore wind+ALK Newfoundland

Chile
No-C diurnal+ALK Mejillones

Trinidad
Baseline SMR
BAT+ SMR+CCS
Low-C ATR+CCS

US
Baseline SMR
BAT+ coal gasification east coast
BAT+ SMR+CCS Gulf coast
Low-C ATR+CCS Gulf coast
no-C diurnal+ALK Wilbarger

Asia-Pacific

Australia
baseline SMR
BAT+ coal gasification 5500 NAR
BAT+ coal gasification 6000 NAR
BAT+ SMR+CCS
low-C ATR+CCS
no-C diurnal+ALK Burrup

China
BAT+ coal gasification 3800 NAR
BAT+ coal gasification 5500 NAR
no-C diurnal+ALK Jilin

India
no-C diurnal+ALK Kutch

Indonesia
BAT+ coal gasification 3800 NAR
BAT+ coal gasification 5500 NAR

Japan
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Fukushima

South Korea
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Ulsan

Vietnam
no-C offshore wind+ALK Phu Yen

Europe

France
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Sete

Germany
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Bremen

Netherlands
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Terneuzen

Spain
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C diurnal+ALK Teruel

UK
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS
no-C offshore wind+ALK Harwich

Russia
BAT+ coal gasification 6000 NAR

Russia east
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS

Russia west
baseline SMR
BAT+ SMR+CCS
low-C ATR+CCS

Direct Reduced Iron

Argus Hydrogen and Future Fuels includes weekly averages of calculated production costs for Direct Reduced Iron (DRI). See the Argus Ferrous Markets methodology.

Prices are published for

- Natural Gas DRI
- DRI spread – No-C hydrogen (renewables+ALK) vs natural gas northwest Europe
- DRI spread – BAT+ hydrogen (SMR+CSS) vs natural gas northwest Europe

e-SAF

The cost of producing aviation fuel using the Fischer-Tropsch process. Costs are published in €/t and $/t, including and excluding capex.

Project assumptions

Costs are modelled for production of 15,095t/yr in the Netherlands, assuming $3,419/t of capex (including the electrolysis plant) and other inputs of:

- **Hydrogen:** 1.3t/t
- **Hydrogen cost:** Argus no-C PPA+ALK
- **CO2:** 5.3t
- **CO2 cost:** $85/t
- **Power requirement:** 3.6MWh
- **Power cost:** PPA+grid fee costs
- **Water:** 5.6t
- **Refrigerants and catalysts:** 0.32t

The production process also generates 0.35t of naphtha and 0.32t of diesel, the value of which is assumed to be the relevant average Argus fob ARA bionaphtha and HVO price assessments for the week of publication. Steam is also a by-product and is assumed to be sold to local users at $102.70/t for the 30.79t of low-pressure steam and $110.60/t for the 10.38t of high-pressure steam produced.