Global Hydrogen Review: Assumptions annex

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Global Hydrogen Review 2024: Assumptions annex

This annex collects the various assumptions that underpin the analyses throughout the *Global Hydrogen Review 2024.* For technologies, global averages are presented. However, several analyses in the report present regional examples, for which costs will vary with material and labour inputs and differ from the global average. These input parameters reflect choices made by the IEA on the basis of different sources of information consulted.

Renewable electricity cost and full load hours

Solar PV

	LCOE (USD/MWh)		Full load hours (h)
Region	2023	NZE 2030	
Australia	32	24	2330
Chile	23	17	3060
China	22	16	2550
European Union	34	25	2170
India	25	18	2550
Japan	116	87	1340
Middle East	20	14	2810
North Africa	46	32	2680
United States	37	27	2490

Offshore wind

	LCOE (USD/MWh)		Full load hours (h)
Region	2023	NZE 2030	
Australia	63	45	4990
Chile	85	61	5890
China	67	48	4120
European Union	55	36	4790
India	90	64	4100
Japan	145	99	4530
Middle East	120	85	4050
North Africa	113	80	4180
United States	86	60	4940

Onshore wind

	LCOE (USD/MWh)		Full load hours (h)
Region	2023	NZE 2030	
Australia	39	36	3660
Chile	32	29	4220
China	33	31	3130
European Union	37	35	3690
India	45	39	3060
Japan	101	95	3290
Middle East	62	57	3280
North Africa	60	56	3240
United States	27	25	4420

Notes: LCOE = levelised cost of electricity; NZE = Net Zero Emissions by 2050 Scenario. Renewable electricity generation costs and full load hours for good resource conditions in a region or country.

CO_2 prices and costs

CO_2 prices

Region	CO_2 price (USD/tCO_2)	
	2023	NZE 2030
Advanced economies	0-90	140
Selected emerging market and developing economies*	0	90-130
Other emerging market and developing economies	0	15-25

* Includes Argentina, Brazil, China, India, Indonesia, Mexico and South Africa.

CO_2 transport and storage cost for CCUS

	(USD/tCO_2)	
Region	2023	NZE 2030
United States	14	12
Middle East	14	12
Europe	49	33
China	15	12
Rest of the world	24	20

Notes: CCUS = carbon capture, utilisation and storage; NZE = Net Zero Emissions by 2050 Scenario.

Production pathways

Hydrogen

Technology	Parameter	Units	2023	NZE 2030
Water electrolysis	CAPEX* (global average)	**USD/kW$_e$**	2160	960
	CAPEX* (China)	**USD/kW$_e$**	1100	620
	Efficiency (LHV)	**%**	66%	69%
	Annual OPEX	**% of CAPEX**	3%	3%
	Stack lifetime (operating hours)**	**hours**	50000	50000
Natural gas reforming	CAPEX	**USD/kW$_{H2}$**	720	720
	Efficiency (LHV)	**%**	76%	76%
	Annual OPEX	**% of CAPEX**	5%	5%
Natural gas reforming w/CCUS	CAPEX	**USD/kW$_{H2}$**	1420	1420
	Efficiency (LHV)	**%**	69%	69%
	Annual OPEX	**% of CAPEX**	4%	4%
	CO_2 capture rate	**%**	95%	95%
Coal gasification	CAPEX ***	**USD/kW$_{h2}$**	2640	2640
	Efficiency (LHV)	**%**	60%	60%
	Annual OPEX	**% of CAPEX**	5%	5%
Coal gasification w/CCUS	CAPEX ***	**USD/kW$_{H2}$**	2750	2750
	Efficiency (LHV)	**%**	58%	58%
	Annual OPEX	**% of CAPEX**	5%	5%
	CO_2 capture rate	**%**	95%	95%

* CAPEX includes the electrolyser system, electric equipment, gas treatment, plant balancing, and engineering, procurement and construction (EPC).

** Stack lifetime can reach up to 95 000 h. The selected value (50 000 h) comes from the IEA's analysis of the optimum economic lifetime, considering degradation issues.

*** For China, CAPEX is assumed to be 50% of the world average for coal gasification and 52% for coal gasification with CCUS.

Notes: LHV = Lower heating value; NZE = Net Zero Emissions by 2050 Scenario. All CAPEX refers to the installed cost of the technology. 25-year lifetime and a 95% availability factor assumed for hydrogen production from natural gas, 25-year lifetime and 90% availability factor are assumed for the production of hydrogen from coal. Availability factors for electrolysis are based on the full load hours of electricity shown in the previous section. For water electrolysis, water costs and possible revenues from oxygen sales have not been considered in the cost analysis.

Hydrogen-based fuels

Haber – Bosch (Ammonia)

Parameter	Units	2023	NZE 2030
CAPEX (including air separation unit)	**USD/(tNH_3/y)**	770	770
Annual OPEX	**% of CAPEX**	3%	3%
Electricity consumption	**GJ/t_{NH3}**	2.2	2.2

Fischer-Tropsch (synthetic liquid fuels)

Parameter	Units	2023	NZE 2030
CAPEX	**USD/kW_{liquid}**	2160	1770
Efficiency (LHV)	**%**	57%	57%
Annual OPEX	**% of CAPEX**	5%	5%
Variable O&M	**USD/MWh_{prod}**	5.5	4.7
Lifetime	**years**	30	30
Electricity consumption	**GJ/$GJ_{product}$**	0.018	0.018

Notes: The efficiency refers to the final transport fuels, from the energy content of hydrogen used in the FT synthesis.
Assumed cost of feedstock: biogenic CO_2 USD 30/tCO_2, DAC CO_2 USD 600-1 000/tCO_2 (today), USD 200-700/tCO_2 (2030)

Hydrogen transport

Hydrogen onshore pipelines

Parameter	Units	Small	Medium	Large
Lifetime - pipelines	**years**	42	42	42
Lifetime - compressor	**years**	24	24	24
Operation conditions	**% of design capacity**	75%	75%	75%
Diameter	**inch**	20	36	48
Design Capacity[1]	**GW H_2, LHV**	0.9	3.6	12.7
Inlet pressure	**bar**	30	30	40
Outlet pressure	**bar**	50	50	80
Utilisation	**%**	57%	57%	57%
Compression power	**MW_e/1 000 km**	6	40	183
CAPEX - new pipeline	**MUSD/km**	1.8	2.6	3.2
CAPEX - repurposed pipeline	**MUSD/km**	0.3	0.5	0.6
CAPEX - compressor	**MUSD/MW_e**	4.0	4.0	4.0

[1] With 75% of design capacity
Notes: MUSD = million USD

Seaborne transport

Tankers

Parameter	Units	Liquefied hydrogen	LOHC	Ammonia
Capacity	**$t_{carrier}$/tanker**	10 200	34 700	51 800
CAPEX	**MUSD/tanker**	410	45	70
Speed	**km/h**	30	28	32
Boil-off rate[1]	**%/day**	0.60%	0.00%	0.02%
Flash rate[2]	**%**	1.00%	0.00%	0.02%
Fuel consumption[3]	**MJ/km/tanker**	-	1 770	2 650

[1] The boil-off gas is the gas that spontaneously evaporates from liquefied gas due to the extremely low temperatures.
[2] The flash rate is the rate of loss that occurs upon each loading/unloading of liquefied gas.
[3] Ship carrying liquefied hydrogen uses carrier gas for propulsion, so the fuel for the ship would not incur an additional energy consumption.
Notes: MUSD = million USD.

Import and export terminals: storage tanks

Terminal	Parameter	Units	Liquefied hydrogen	LOHC	Ammonia
Import	Capacity	**$t_{carrier}$/tank**	12 800	3 300	36 700
	CAPEX	**MUSD/tank**	1 270	85	115
	OPEX	**USD/year as a % of CAPEX**	3%	3%	3%
	Electricity consumption	**kWh/kgH_2**	0.190	0.013	0.003
	Boil-off rate	**%/day**	0.07%	0.01%	0.01%
Export	Capacity	**$t_{carrier}$/tank**	12 300	3 300	36 700
	CAPEX	**MUSD/tank**	1 160	85	115
	OPEX	**USD/year as a % of CAPEX**	3%	3%	3%
	Electricity consumption	**kWh/kgH_2**	0.200	0.013	0.001
	Boil-off rate	**%/day**	0.07%	0.01%	0.01%

Notes: MUSD = million USD.

Liquefied hydrogen

Technology	Parameter	Units	Value
Liquefaction	CAPEX	**USD/t H_2/day**	NA
	OPEX	**USD/t H_2/day**	NA
	Electricity consumption	**kWh/kg H_2**	6
Regasification	CAPEX	**USD/t H_2/day**	20
	OPEX	**USD/t H_2/day**	1
	Electricity consumption	**kWh/kg H_2**	0.06

Notes: NA = not available due to confidentiality.

Liquid Organic Hydrogen Carrier (LOHC)

Technology	Parameter	Units	Value
Conversion[4] to LOHC	CAPEX	**USD/t H_2/year**	790
	OPEX	**USD/year as a % of CAPEX**	4%
	Electricity consumption	**kWh/kg H_2**	1.5
Reconversion[5] to H_2	CAPEX	**USD/t H_2/year**	2 950
	OPEX	**USD/year as a % of CAPEX**	4%
	Electricity consumption	**kWh/kg H_2**	1.50
	Fuel consumption	**kWh/kg H_2**	13.6
	Dehydrogenation rate	**%**	98%
	PSA hydrogen recovery rate	**%**	99%
	LOHC loss	**%/cycle**	1.50%

[4] Conversion: LOHC = Toluene +H_2 → Methylcyclohexane (MCH).

[5] Reconversion: LOHC = MCH → Toluene + H_2.

Notes: PSA = Pressure swing adsorption. System lifetime assumed to be 30 years, unless stated otherwise.

Ammonia cracking

Technology	Parameter	Units	Value
Ammonia cracking	CAPEX	**USD/t H_2/year**	3 050
	OPEX	**USD/year as a % of CAPEX**	4%
	Electricity consumption	**kWh/kg H_2**	1.50
	Fuel consumption	**kWh/kg H_2**	9.7
	Dehydrogenation rate	**%**	99%
	PSA hydrogen recovery rate	**%**	99%

Notes: PSA = Pressure swing adsorption. Data for ammonia conversion are included in the table on ammonia production above.

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