Hydrogen production, storage, and consumption – Data collection in APEC

21st APEC workshop on energy statistics: Data collection on new energy products and technologies

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Definition of terms

❑What is **Hydrogen?**

- Hydrogen is the simplest element on earth—it consists of only one proton and one electron—and **it is an energy carrier**, not an energy source. Hydrogen can store and deliver usable energy, but it **doesn't typically exist by itself in nature** and **must be produced from compounds that contain it**.
- **Ammonia (NH_3)-** Ammonia is a colourless, reactive gas that is lighter than air (approximately half as heavy) which dissolves readily in water. It represents one of the most promising potential solutions as energy vector and hydrogen carrier, having a higher potential to transport energy than hydrogen itself in a pressurized form.

Definition of terms

❑ e-fuels

- **Electrofuels**, also known as **e-fuels** or **synthetic fuels**, are a type of replacement fuel. They are manufactured using captured carbon dioxide or carbon monoxide and hydrogen obtained from sustainable electricity sources such as wind, solar and nuclear power.
- After processing in refineries, **e-fuels** can replace gasoline, diesel, heating oil, kerosene, gas and can completely replace conventional fuels.

Source: e-Fuel alliance. https://www.efuel-alliance.eu/efuels/what-are-efuels

Hydrogen production (1)

- **Thermal processes**
  - Involve steam reforming, a high-temperature process in which steam reacts with a hydrocarbon fuel to produce hydrogen
    - Natural gas reforming
    - Petroleum products reforming
    - Coal gasification
    - Biomass gasification
    - Biofuels reforming

Source: USDOE, https://www.energy.gov/eere/fuelcells/hydrogen-fuel-basics.

Hydrogen production (2)

- **Electrolytic processes**
  - Electrolysis is the process of using electricity to split water into hydrogen and oxygen.
- **Other processes**
  - **Solar driven processes** – use sunlight as the agent for hydrogen production including photobiological, photoelectromechanical and solar thermochemical.
  - **Biological processes** - use microbes such as bacteria and microalgae and can produce hydrogen through biological reactions.
  - **Others**

Source: USDOE, https://www.energy.gov/eere/fuelcells/hydrogen-fuel-basics.

Hydrogen transformation

- **Hydrogen liquefaction** is the process of liquefying Hydrogen to reduce the volume by cooling it to below -253°C.
- **Liquefied hydrogen regasification** is the process of regasifying liquefied hydrogen.
- **Hydrogen compound production** is the process of combining hydrogen with other elements to produce compound like ammonia, e-fuels and other products to facilitate safe transportation.
- **Hydrogen reconversion** is the process of separating hydrogen from compounds such as ammonia, e-fuels and other compounds.

Source: USDOE, https://www.energy.gov/eere/fuelcells/hydrogen-fuel-basics.

Proposed data collection format

APEC format for annual Hydrogen data

Table 1a. Production and supply

Unit: Terajoules (Gross calorific values)

		Energy input		Energy Output			
		Product	Quantity	Hydrogen	Ammonia	e-fuels	Total
		A	B	C	D	E	F
PRODUCTION	1		0	0	0	0	0
Thermal process	2		0	0	0	0	0
Natural gas reforming	3	Natural gas					
With CCS							
Without CCS							
Petroleum products reforming	4	Petroleum products					
With CCS							
Without CCS							
Coal gasification	5	Coal					
With CCS							
Without CCS							
Biomass gasification	6	Biomass					
With CCS							
Without CCS							
Biofuels reforming	7	Biofuels					
With CCS							
Without CCS							

- For simplification, we use “with CCS” and “without CCS”, instead of “CCS<30% (low) ”,“with CCS 60-90% (medium)” and “with CCS 90%+(high).

Proposed data collection format

		Energy input		Energy Output			
		Product	Quantity	Hydrogen	Ammonia	e-fuels	Total
		A	B	C	D	E	F
Electrolytic processes	8		0	0	0	0	0
Electricity exclusively from renewables	9	Electricity					
Geothermal	10	Electricity					
Solar (Thermal)	11	Electricity					
Solar (PV)	12	Electricity					
Wind	13	Electricity					
Hydro	14	Electricity					
Biomass	15	Electricity					
Others	16	Electricity					
Electricity exclusively from nuclear energy	17	Electricity					
Electricity exclusively from fossil fuels	18	Electricity					
Electricity from grid	19	Electricity					
Other processes	20			0	0	0	0
Solar-driven processes	21	Solar energy					
Biological processes	22	Other energy (specify)					
Others	23	Other energy (specify)					
Imports	24						
Exports	25						
International marine bunkers	26						
International aviation bunkers	27						
Stock change (opening-closing)	28			0	0	0	0
Gross inland deliveries (calculated)	29			0	0	0	0
Statistical difference (+ or -) (11 minus 13)	30			0	0	0	0
Gross inland deliveries (observed)	31			0	0	0	0
Stocks							
Total stocks in national territory- opening	32						
Total stocks in national territory- closing	33						

Proposed data collection format

APEC format for annual Hydrogen data

Table 2. Consumption in the transformation and energy sectors

Unit: Terajoules

		Hydrogen	Ammonia	e-fuels	Total
		A	B	D	E
TOTAL TRANSFORMATION SECTOR	1	0	0	0	0
Main activity producer	2	0	0	0	0
Electricity plants	3				
CHP	4				
Heat plants	5				
District cooling plants	6				
Autoproducer	7	0	0	0	0
Electricity plants	8				
CHP	9				
Heat plants	10				
District cooling plants	11				
Natural gas blending plants	12				
Gas works plants	13				
Coke ovens	14				
Blast furnaces	15				
Natural gas liquefaction	16				
LNG regasification	17				
Gas-to-liquid plants	18				
Oil refineries	19				
Petrochemical industry	20				
Hydrogen compound production (hydrogen to ammonia)	21				
Hydrogen reconversion (ammonia to hydrogen)	22				
e-fuels production (hydrogen to e-fuels)	23				
Other transformation	24				

		Hydrogen	Ammonia	e-fuels	Total
		A	B	D	E
TOTAL ENERGY SECTOR	25	0	0	0	0
Coal mines	26				
Oil and gas extraction	27				
Oil refineries	28				
Coke ovens	29				
Gas works	30				
Electricity, CHP and heat plants	31				
Natural gas liquefaction plants	32				
LNG regasification	33				
Natural gas blending plants	34				
Gas-to-liquid plants	35				
Oil refineries	36				
Hydrogen production	37				
Hydrogen compound production (hydrogen to ammonia)	38				
Hydrogen reconversion (ammonia to hydrogen)	39				
Hydrogen liquefaction	40				
Liquefied hydrogen regasification	41				
e-fuels production (hydrogen to e-fuels)	42				
Other energy sector	43				
Losses	44	0	0	0	0
Distribution	45				
Transmission	46				

Proposed data collection format

APEC format for annual Hydrogen data

Table 3. Final Energy Consumption

Unit: Terajoules

		Hydrogen	Ammonia	e-fuels	Total
		A	B	D	E
FINAL ENERGY CONSUMPTION	1	0	0	0	0
TOTAL INDUSTRY SECTOR	2	0	0	0	0
Iron and steel	3				
Chemical and petrochemical	4				
Non-ferrous metals	5				
Non-metallic minerals	6				
Transport equipment	7				
Machinery	8				
Mining and quarrying	9				
Food, beverages and tobacco	10				
Pulp, paper and print	11				
Wood and wood products	12				
Construction	13				
Textile and leather	14				
Not elsewhere specified	15				
TOTAL TRANSPORT SECTOR	16	0	0	0	0
Domestic air transport	18				
Road	19				
Rail	20				
Inland waterways	21				
Pipeline transport	22				
Not elsewhere specified	23				
TOTAL OTHER SECTOR	24	0	0	0	0
Commercial and public services	25				
Residential	26				
Agriculture	27				
Fishing	28				
Not elsewhere specified	29				

Proposed data collection format

Table 4. Non-energy consumption

		Hydrogen	Ammonia	e-fuels	Total
		A	B	D	E
TOTAL NON-ENERGY CONSUMPTION	1	0	0	0	0
Fertilizer production	2				
Manufacture of vegetable oil	3				
Manufacture of organic compounds	4				
Manufacture of hydrogen chloride	5				
Mettalurgy	6				
Other non-energy uses	7				

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APEC format for annual Hydrogen data

Table 4. Production Capacity

Unit: Terajoules/year

		Hydrogen	Ammonia	e-fuels	Total	Electricity generation capacity (MW)	Electricity consumption (MWh)
		A	B	D	E	F	F
PRODUCTION	1	0	0	0	0	0	0
Thermal process	2	0	0	0	0		
Natural gas reforming	3						
With CCS							
Without CCS							
Petroleum products reforming	4						
With CCS							
Without CCS							
Coal gasification	5						
With CCS							
Without CCS							
Biomass gasification	6						
With CCS							
Without CCS							
Biofuels reforming	7						
With CCS							
Without CCS							
Electrolytic processes	8	0	0	0	0	0	0
Electricity exclusively from renewables	9						
Geothermal	10						
Solar (Thermal)	11						
Solar (PV)	12						
Wind	13						
Hydro	14						
Biomass	15						
Others	16						
Electricity exclusively from nuclear energy	17						
Electricity exclusively from fossil fuels	18						
Electricity from grid	19						
Other processes	20	0	0	0	0		
Solar-driven processes	21						
Biological processes	22						
Others	23						

Proposed data collection format

APEC format for Hydrogen data
Imports by source

		Hydrogen	Ammonia	e-fuels	Total
		A	B	D	E
APEC Economies	1	0	0	0	0
Australia	2				0
Brunei Darussalam	3				0
Canada	4				0
Chile	5				0
China	6				0
Hong Kong, China	7				0
Indonesia	8				0
Japan	9				0
Republic of Korea	10				0
Malaysia	11				0
Mexico	12				0
New Zealand	13				0
Papua New Guinea	14				0
Peru	15				0
Philippines	16				0
Russian Federation	17				0
Singapore	18				0
Chinese Taipei	19				0
Thailand	20				0
United States of America	21				0
Viet Nam	22				0
ASEAN (non-APEC) economies	23	0	0	0	0
Myanmar	24				0
Lao P.D.R	25				0
Cambodia	26				0
Rest of the World	27	0	0	0	0

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APEC format for Hydrogen data
Exports by destination

		Hydrogen	Ammonia	e-fuels	Total
		A	B	D	E
APEC Economies	1	0	0	0	0
Australia	2				0
Brunei Darussalam	3				0
Canada	4				0
Chile	5				0
China	6				0
Hong Kong, China	7				0
Indonesia	8				0
Japan	9				0
Republic of Korea	10				0
Malaysia	11				0
Mexico	12				0
New Zealand	13				0
Papua New Guinea	14				0
Peru	15				0
Philippines	16				0
Russian Federation	17				0
Singapore	18				0
Chinese Taipei	19				0
Thailand	20				0
United States of America	21				0
Viet Nam	22				0
ASEAN (non-APEC) economies	23	0	0	0	0
Myanmar	24				0
Lao P.D.R	25				0
Cambodia	26				0
Rest of the World	27	0	0	0	0

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Proposed trial data collection format

Definition of products

1. Hydrogen (H_2)

Hydrogen is the simplest element on earth—it consists of only one proton and one electron—and it is an energy carrier, not an energy source. Hydrogen can store and deliver usable energy, but it doesn't typically exist by itself in nature and must be produced from compounds that contain it.

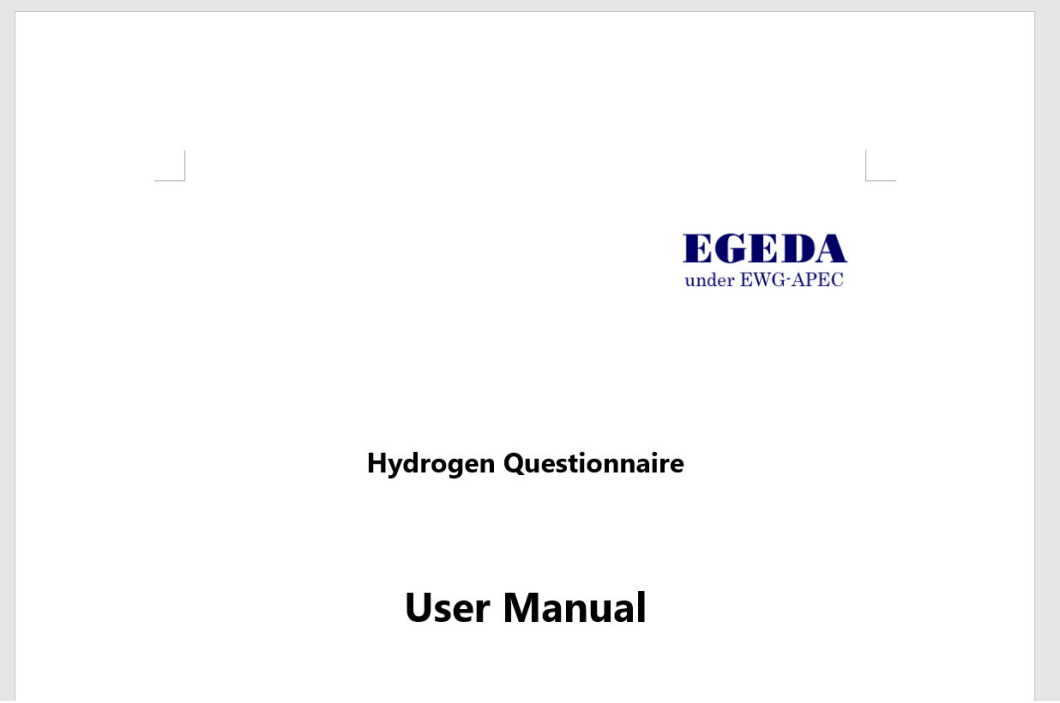
2. Ammonia (NH_3)

Ammonia is a colourless, reactive gas that is lighter than air (approximately half as heavy) which dissolves readily in water. It represents one of the most promising potential solutions as energy vector and hydrogen carrier, having a higher potential to transport energy than hydrogen itself in a pressurized form.

3. e-fuels

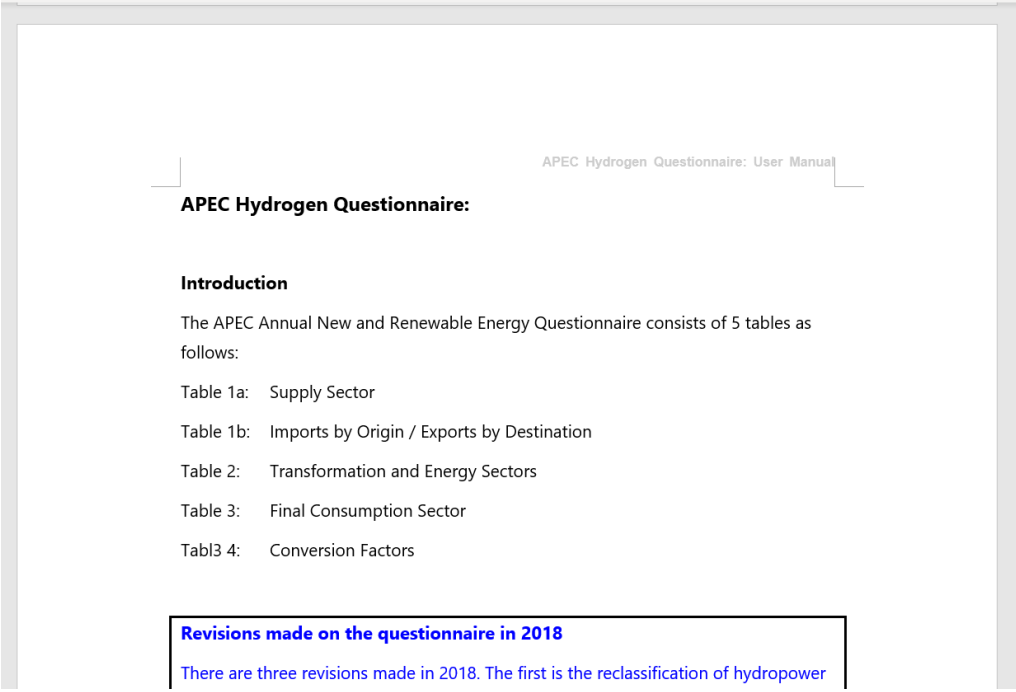
Electrofuels, also known as e-fuels or synthetic fuels, are a type of drop-in replacement fuel. They are manufactured using captured carbon dioxide or carbon monoxide, together with hydrogen obtained from sustainable electricity sources such as wind, solar and nuclear power. Examples of e-fuels are replacements for traditional jet fuel and diesel.

Hydrogen Questionnaire (User Manual)


EGEDA
under EWG·APEC

Hydrogen Questionnaire

User Manual



APEC Hydrogen Questionnaire:

Introduction

The APEC Annual New and Renewable Energy Questionnaire consists of 5 tables as follows:

Table 1a: Supply Sector

Table 1b: Imports by Origin / Exports by Destination

Table 2: Transformation and Energy Sectors

Table 3: Final Consumption Sector

Tabl3 4: Conversion Factors

Revisions made on the questionnaire in 2018

There are three revisions made in 2018. The first is the reclassification of hydropower

We are beginning to make the “APEC Annual New and Renewable Energy Questionnaire (User Manual: Hydrogen)”.

Status of hydrogen production and consumption based on the EGEDA33 meeting (the Philippines, 26-28 October 2022)

Economy	Status
Australia	Currently conducting surveys to get information on consumption data.
Brunei Darussalam	1-year demonstration project on hydrogen production and transportation.
Hong Kong, China	No hydrogen production and consumption data available at present.
Indonesia	Conducting Pre-Feasibility study on possible use of Hydrogen.
Korea	Trying to collect data but still needs to improve collection system.
Malaysia	Pilot project on ammonia co-firing in coal power plants.

Economy	Status
Papua New Guinea	Looking into studying renewable-hydrogen in the future.
The Philippines	Conducting further study on possible inclusion of Hydrogen in the energy mix.
Chinese Taipei	Conducting pilot project on green hydrogen and co-firing with hydrogen and ammonia.
Thailand	Conducting a study on the possibilities of hydrogen use in power generation, industry, transportation and others.
United Sates	Collects data on hydrogen disposition.
Viet Nam	Conducting the pilot study on Hydrogen production.

Status of hydrogen production and consumption based on the last EGEDA34 meeting (Joint Meeting with EGNRET 58, Hawaii, 4-5 April 2023)

・EGEDA Secretariat provided a report on EGEDA's efforts in collecting Hydrogen data, showing the proposed template introduced at the international meetings.

Q&A: EGNRET suggested that EGEDA should review the template presented well to ensure consistency of the tables and questionnaires. It also raised concerns on how to collect new technologies such as e-fuels and battery storage.
→EGEDA Secretariat welcomed the suggestion and mentioned at the international meetings there are also ongoing discussions on the definition and methodology of these new technologies and it ensured members will be updated on these.

Q&A: EGEDA reiterated its suggestion the secretariat extend its pilot testing of the hydrogen data collection to give enough time for revision of questionnaires if needed. As there are OECD members in APEC that submit data to IEA or other international organisations, it is important to unify the forms that are used in the collection of data.
→ EGEDA secretariat welcomed the suggestions and assured the members that APEC's questionnaire and tables are aligned with IEA and other international statistics agencies.

Status of hydrogen production and consumption based on the last EGEDA34 meeting (Joint Meeting with EGNRET 58, Hawaii, 4-5 April 2023)

Economy	Update
Hong Kong, China	Studies are in place for the collection of hydrogen. Is formulating plans for the use of Hydrogen and Ammonia. Mentioned that town-gas could be the source of hydrogen that can be used for transport, especially large buses and raised concerns as well on the need for capability enhancement in the collection. Has the potential to have a large hydrogen supply chain in Asia.
Japan	Has several pilot studies in place. Described its strategic energy plan to change its power generation mix, including hydrogen and ammonia targets for 2030.

Economy	Update
Singapore	Shared that hydrogen data collection strategy is in place in anticipation of large amount of hydrogen in the future.
Thailand	Shared difficulty in collecting data, the economy is developing a methodology in the collection of hydrogen data. Is currently conducting study/demonstration projects on the use of Hydrogen for transport.
USA	Energy Earthshots including hydrogen shot is a U.S. initiative that will accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade.
Viet Nam	Currently studying how to collect hydrogen data.

Conclusions

- If necessary, EGEDA Secretariat talks with APEC member economies, IEA and other organisations to further improve its data collection format in the future.

- EGEDA Secretariat will send data format by the end of 2023.

- Data collected will be 2022 data.

- IEA will be collecting the same data by using their own format. OECD-APEC members can use IEA format for submitting data to EGEDA Secretariat.

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Thank you for your kind attention.

https://aperc.or.jp