IESR - Webinar Hidrogen Road to GHES 2025

IFHE
Indonesia Fuel Cell Hydrogen Energy

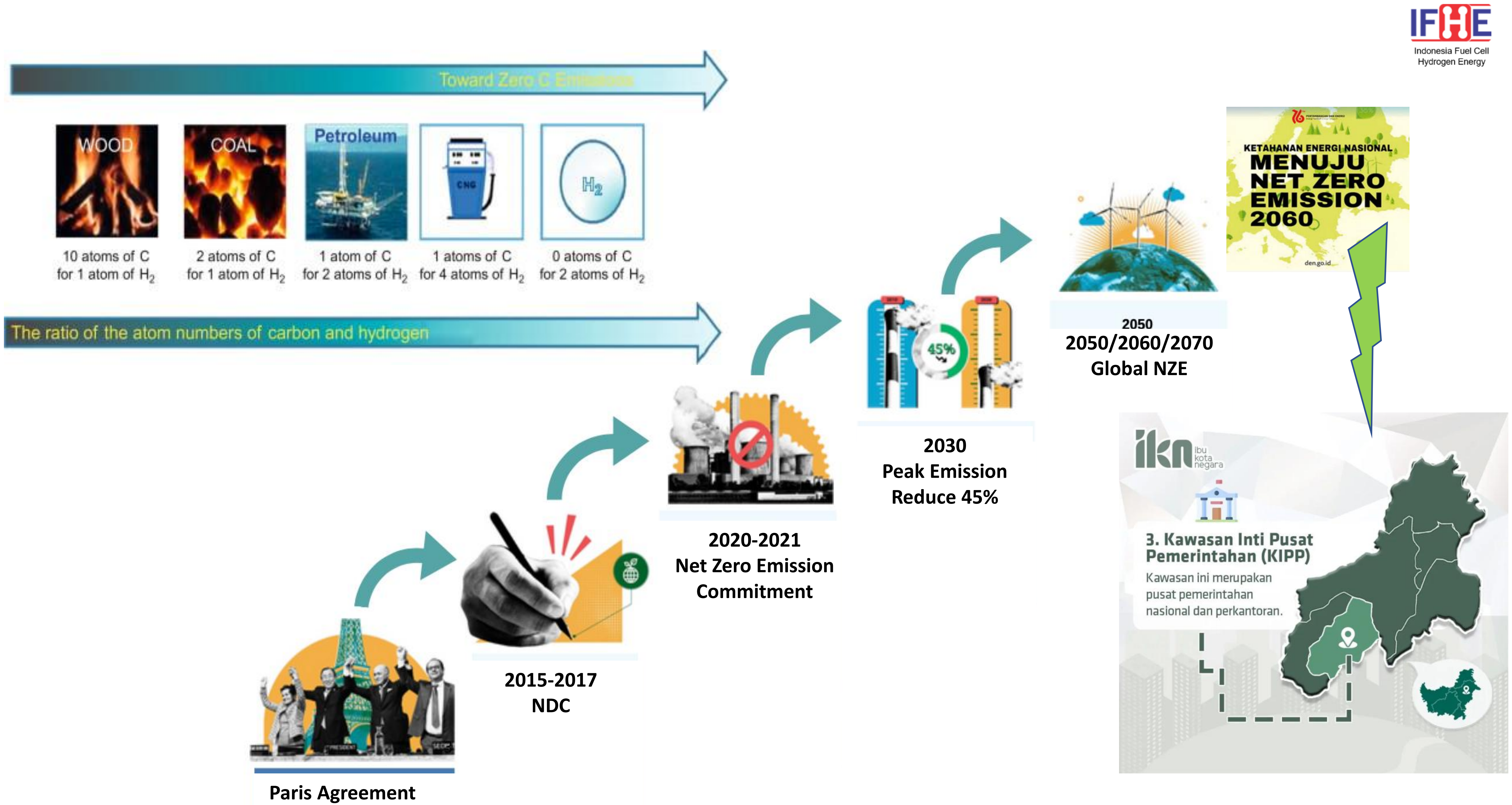
Teknologi Produksi dan Pemanfaatan Hidrogen Hijau di Indonesia

Dr. Eng. Deni Shidqi Khaerudini
Deputy II - Industrial Research Collaboration
Indonesia Fuel Cell and Hydrogen Energy (IFHE)

Research Professor
Research Group of Fuel Cell and Hydrogen Materials
National Research and Innovation Agency (BRIN)

Focal Point
Sub-Committee on Materials Science and Technology (SCMST)
Association of Southeast Asian Nations (ASEAN)

Online, 18 Maret 2024


Indonesia Fuel Cell Hydrogen Energy
Toward Zero C Emissions
WOOD
COAL
Petroleum
CNG
H_2
10 atoms of C for 1 atom of H_2
2 atoms of C for 1 atom of H_2
1 atom of C for 2 atoms of H_2
1 atoms of C for 4 atoms of H_2
0 atoms of C for 2 atoms of H_2
The ratio of the atom numbers of carbon and hydrogen
KETAHANAN ENERGI NASIONAL
MENUJU NET ZERO EMISSION 2060
den.go.id
2050
2050/2060/2070
Global NZE
45%
2030
Peak Emission
Reduce 45%
2020-2021
Net Zero Emission Commitment
2015-2017
NDC
Paris Agreement
ikn ibu kota negara
3. Kawasan Inti Pusat Pemerintahan (KIPP)
Kawasan ini merupakan pusat pemerintahan nasional dan perkantoran.

Physical Properties of Hydrogen

Property	Hydrogen	Comparison
Density (gaseous)	0.089 kg/m³ (0°C, 1 bar)	1/10 of natural gas
Density (liquid)	70.79 kg/m³ (-253°C, 1 bar)	1/6 of natural gas
Boiling point	-252.76°C, 1 bar)	90°C below LNG
Energy per unit of mass (LHV)	120.1 MJ/kg	3x that of gasoline
Energy density (ambient cond., LHV)	0.01 MJ/L	1/3 of natural gas
Specific energy (liquefied, LHV)	8.5 MJ/L	1/3 of LNG
Flame velocity	346 cm/s	8x methane
Ignition range	4-77% in air by volume	6x wider than methane
Autoignition temperature	585°C	220°C for gasoline
Ignition energy	0.02 MJ	1/10 of methane

Notes: cm/s=centimetre per second; kg/m³ =kilograms per cubic metre; LHV=lower heating value; MJ=megajoule; MJ/kg=megajoules per kilogram; MJ/L megajoules per litre.

Source: International Energy Agency 2019

Hydrogen Great Potential

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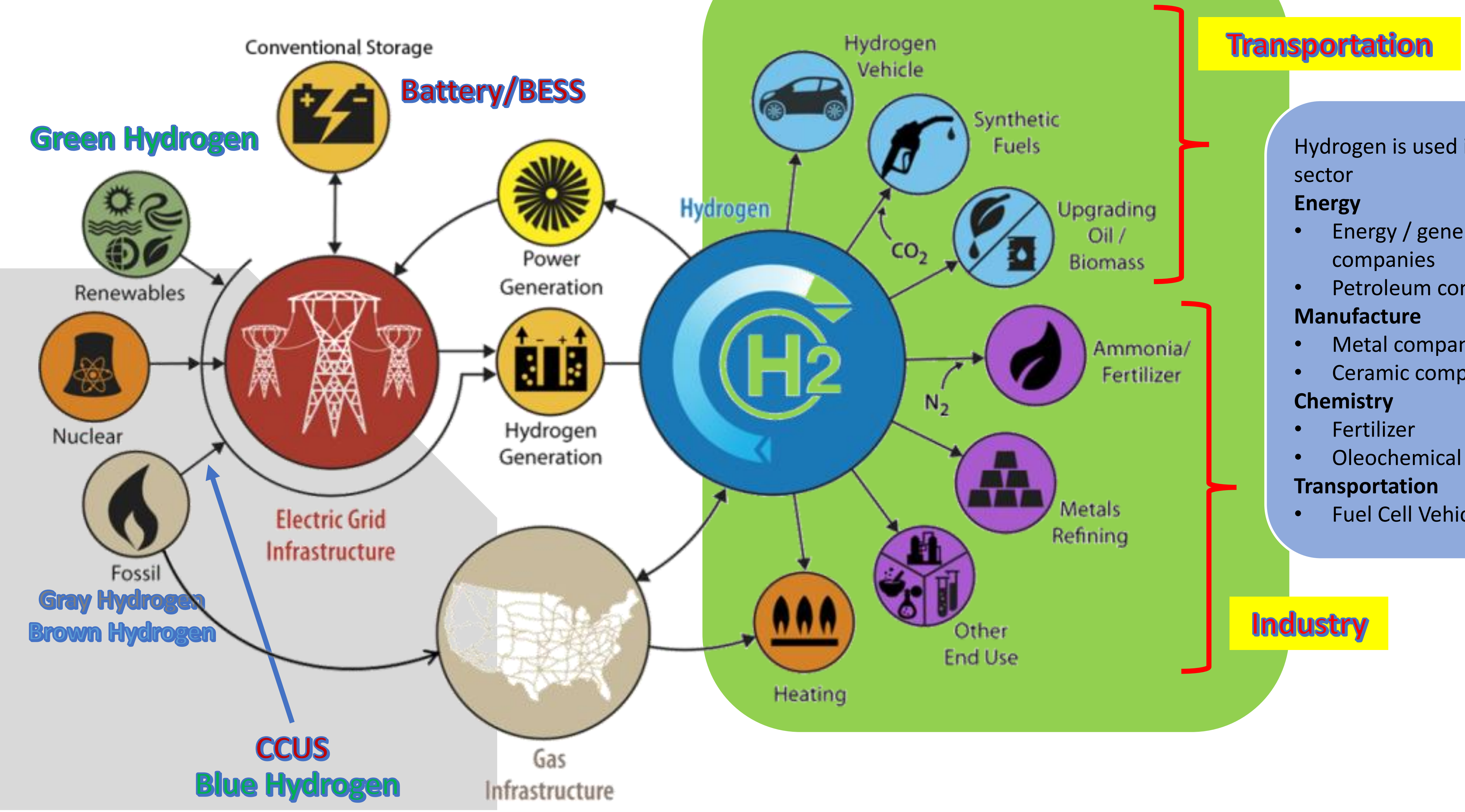
Standards Affecting H_2 Applications are Industry

Decarbonization Area



Hydrogen is used in many sector

Energy

- Energy / generating companies
- Petroleum company

Manufacture

- Metal company
- Ceramic company

Chemistry

- Fertilizer
- Oleochemical

Transportation

- Fuel Cell Vehicle (FCV)

Hydrogen Great Potential

Power generation and storage	H2 as fuel for transportation	H2 as feedstock for industry	H2 as energy source for industry	Gas for heating buildings
Power generation	Public refueling station	Ammonia production	Gas burning	Gas for heating and buildings
Power storage (backup power)	Industrial refueling station	DRI[1] production	Heating and drying	
Power trading		Oil refining		

[1] Direct reduction in iron (DRI)

Hydrogen Great Potential

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Refineries use hydrogen to remove impurities and upgrade heavy oil fractions into lighter products.

Coal can be replaced by clean hydrogen in the production of steel in a process that is almost emissions-free in a 'direct reduced ironmaking' (DRI) process

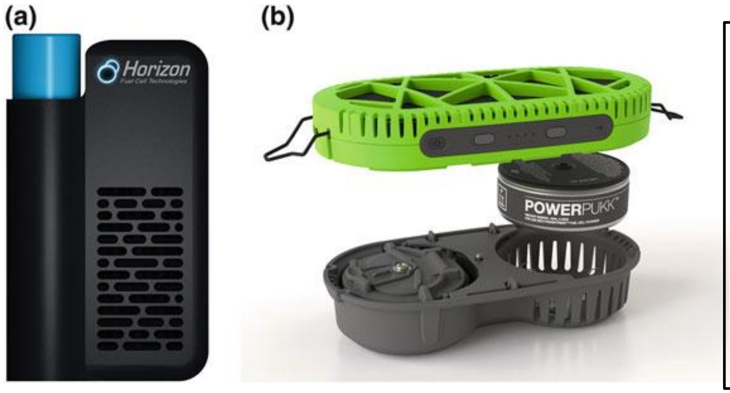
In the chemical industry, hydrogen is currently used as feedstock to produce ammonia, which is used mainly in fertiliser production.

Hydrogen-powered fuel cells are attractive options for long-haul road freight transport.

Hydrogen and hydrogen-derived fuels are also expected to play a key role in decarbonising the hard-to-abate maritime and aviation sectors.

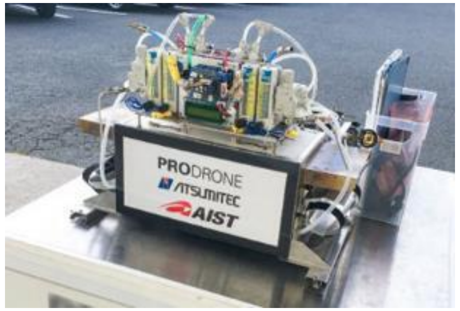
August 2022 saw the deployment of the first hydrogen fuel cell-powered train fleet in Lower Saxony in Germany.

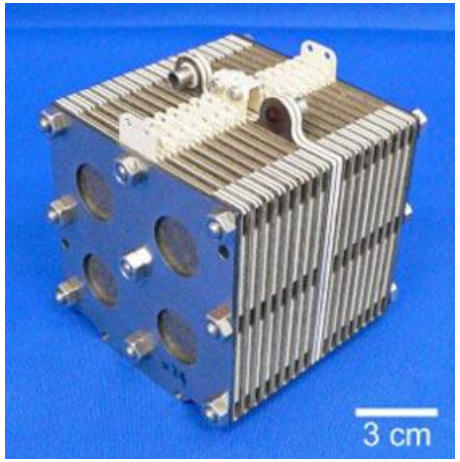
Hydrogen Great Potential



Battery chargers using fuel-cell technology.

a. Minipukk, from Horizon, 2W/14 Wh, 214 cm^3, 120/210 g without/with cartridge, http://www.horizonfuelcell.com, 4 Jan 2013.
b. Powertrekk from MyFC, 5W/4 Wh, 380 cm^3, 244 g, http://www.powertrekk.com, 4 Jan 2013





Hydrogen Great Potential

Fuel Cell Vehicle

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Drone Hydrogen

BRIN
BADAN RISET DAN INOVASI NASIONAL

UAV atau drone berteknologi fuel cell

Fuel Cell 800W

•Pada tahun 2016, drone bertenaga Hidrogen pertama di dunia keluar dan diproduksi oleh MMC, sebuah perusahaan pengembang drone.
•Bisa diaplikasi di berbagai bidang seperti pertanian, militer, broadcast TV, pengiriman jarak jauh, pemetaan
•Beberapa keunggulan yang bisa ditawarkan
(1) Waktu terbang menjadi lebih lama
(2) Ramah lingkungan
(3) Jangkauan yang luas
(4) Pengisian bahan bakar yang cepat

Penerbangan Berbahan Bakar H2

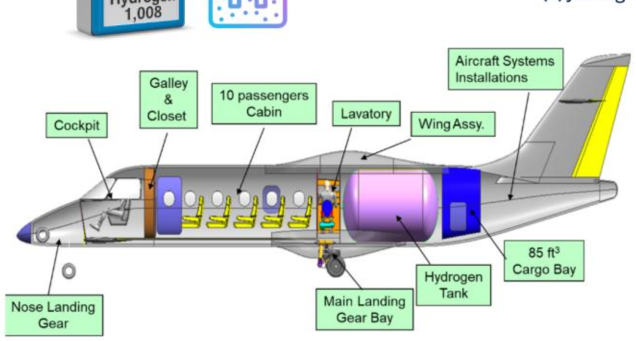
Penerbangan berbasis fuel cell

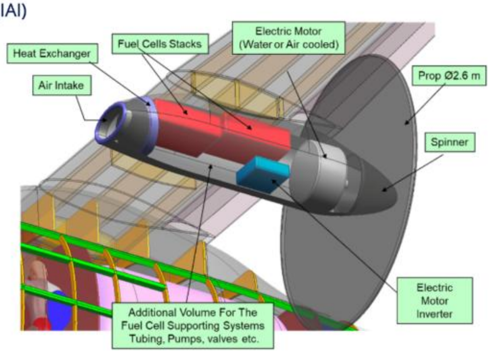
Pesawat Hydrogen

•Industri penerbangan Israel (IAI) terlibat bersama dengan R&D Eropa dalam proyek penelitian pesawat berbahan bakar H2 atau disebut konsorsium ENFICA-FC. Saat ni masih tahap pengembangan

Konsorsium

•Tiga tipologi pesawat H2 yang berbeda yang telah diinvestigasidi antaranya:
(1) Taksi Udara (EVEKTOR-Industri penerbangan di Ceko)
(2) Komuter Kecil (EVEKTOR)
(3) Jet Regional (IAI)





TAXI AIR HYDROGEN

·Awal 2022, penumpang dapat naik taksi air Rotterdam yang menggunakan hidrogen (Fuel Cell).
·Ini akan menjadi pertama kalinya di dunia dalam skala ini bahwa kapal komersial beroperasi sepenuhnya dengan bahan bakar zero-emisi.
·Taksi hidrogen-air ini sedang dikembangkan oleh konsorsium SWIM.

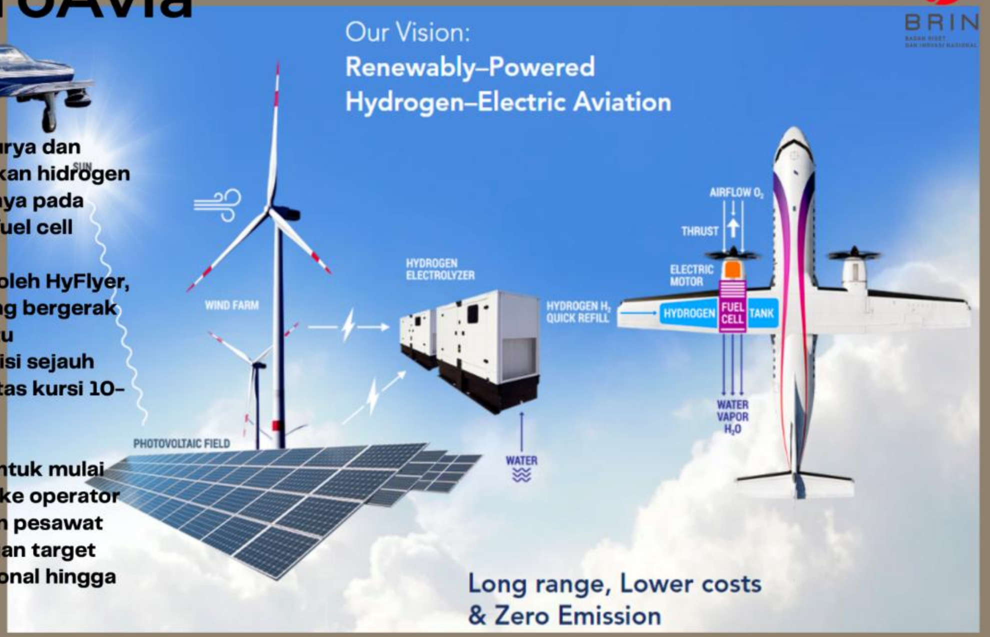
ZeroAvia

Penerbangan berbasis energi terbarukan

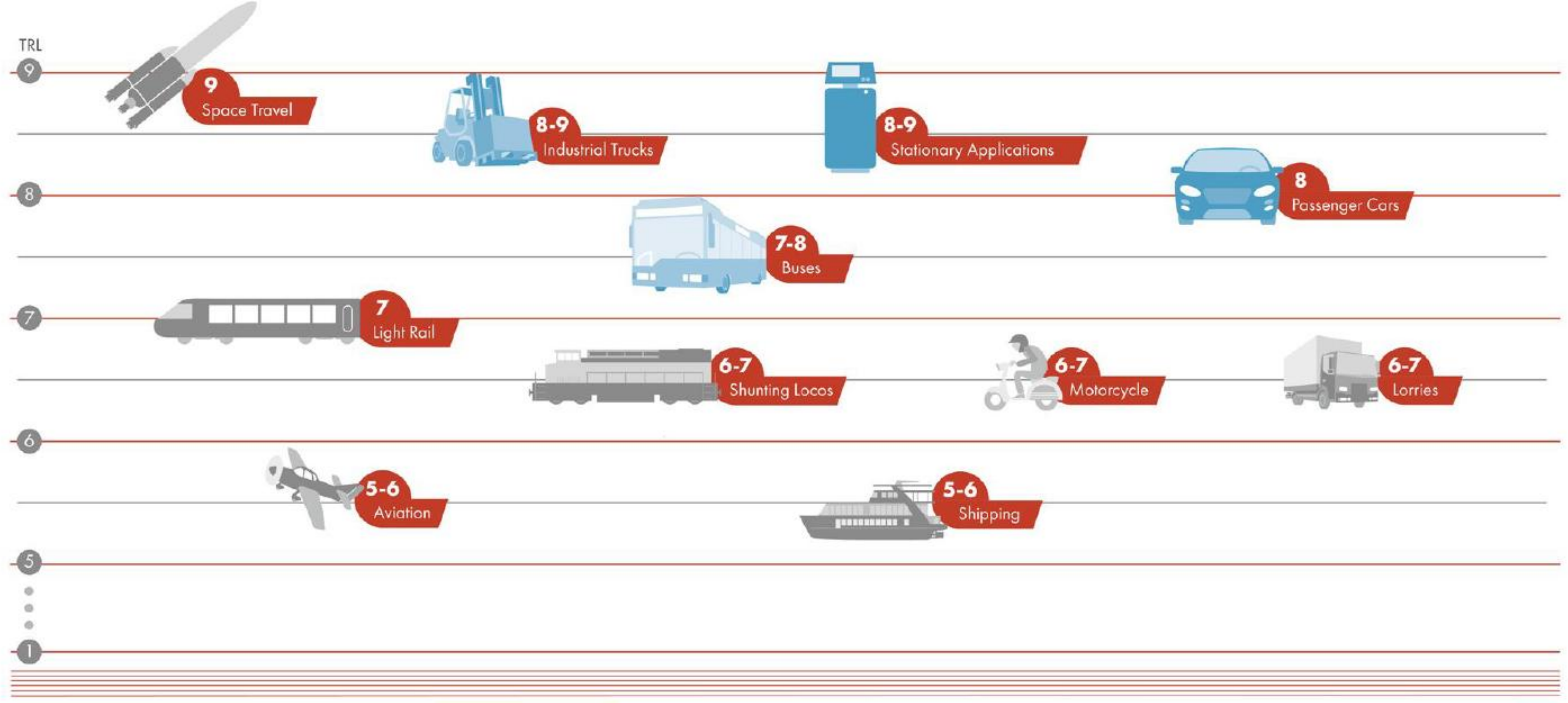
·Penggunaan tenaga surya dan angin untuk menghasilkan hidrogen hijau untuk memberi daya pada pesawat berteknologi fuel cell

·Demo telah dilakukan oleh HyFlyer, sebuah perusahaan yang bergerak di bidang hidrogen, yaitu penerbangan tanpa emisi sejauh 300 mil dengan kapasitas kursi 10-20 penumpang

·ZeroAvia berencana untuk mulai memasok platformnya ke operator komersial dan produsen pesawat pada tahun 2022, dengan target awal penerbangan regional hingga 500 mil.



Technology Readiness Levels of Hydrogen Applications



Industrial linkages of the green hydrogen economy

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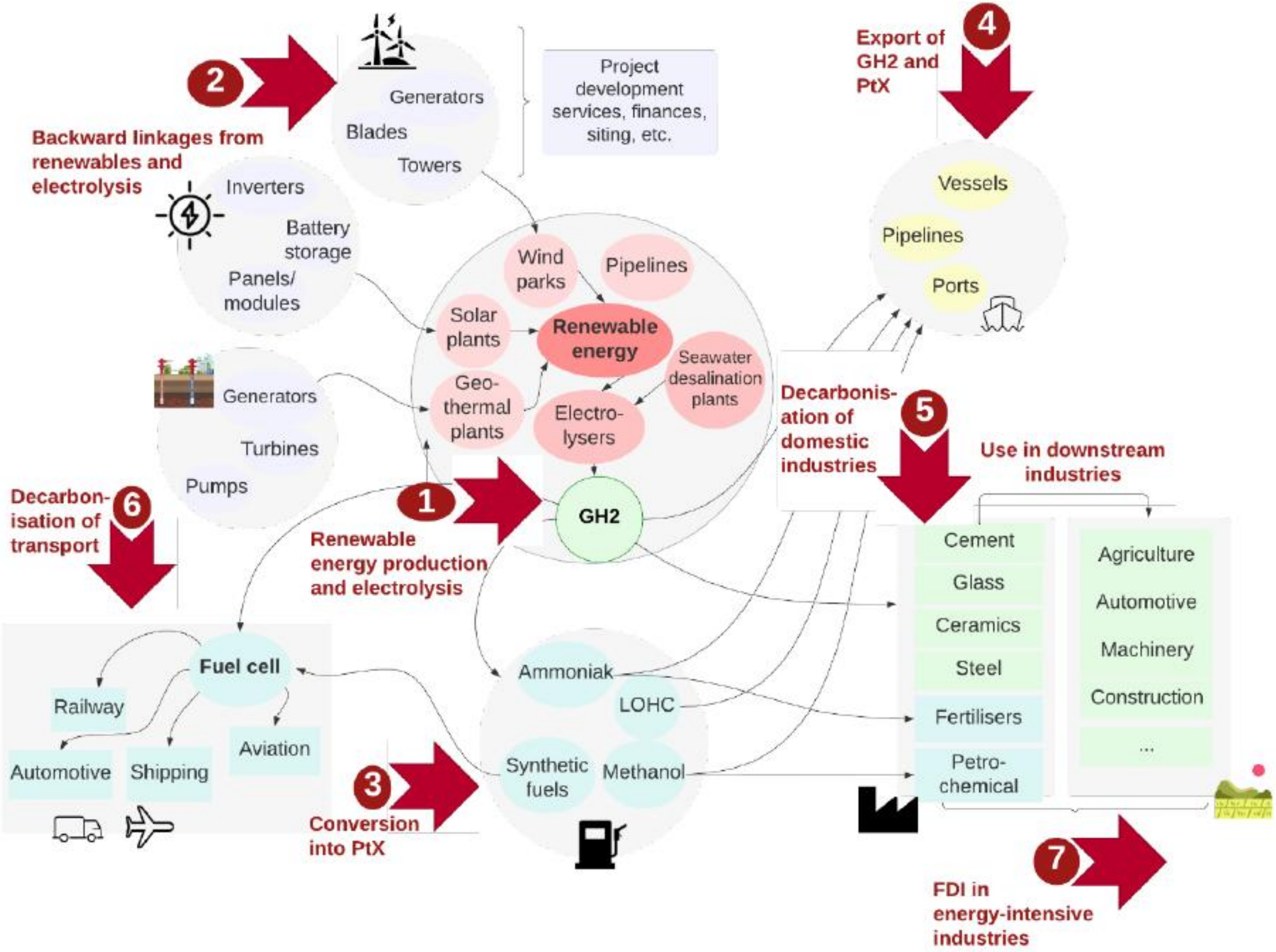
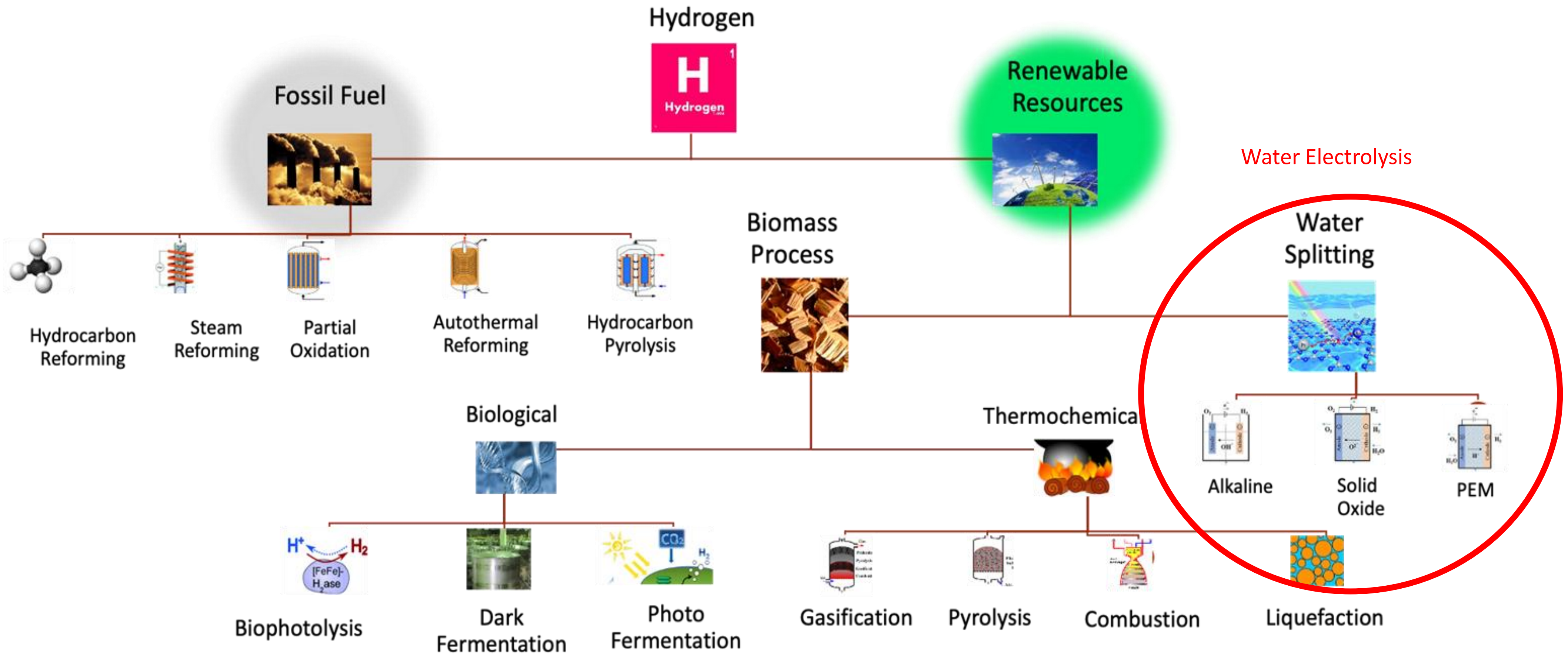


Hydrogen Production Category



The difference between green hydrogen and blue hydrogen [WWW Document], n.d. . Petrofac. URL https://www.petrofac.com/media/storiesand-opinion/the-difference-between-green-hydrogen-and-blue-hydrogen/ (accessed 12.6.22).

Hydrogen production by technology in 2022

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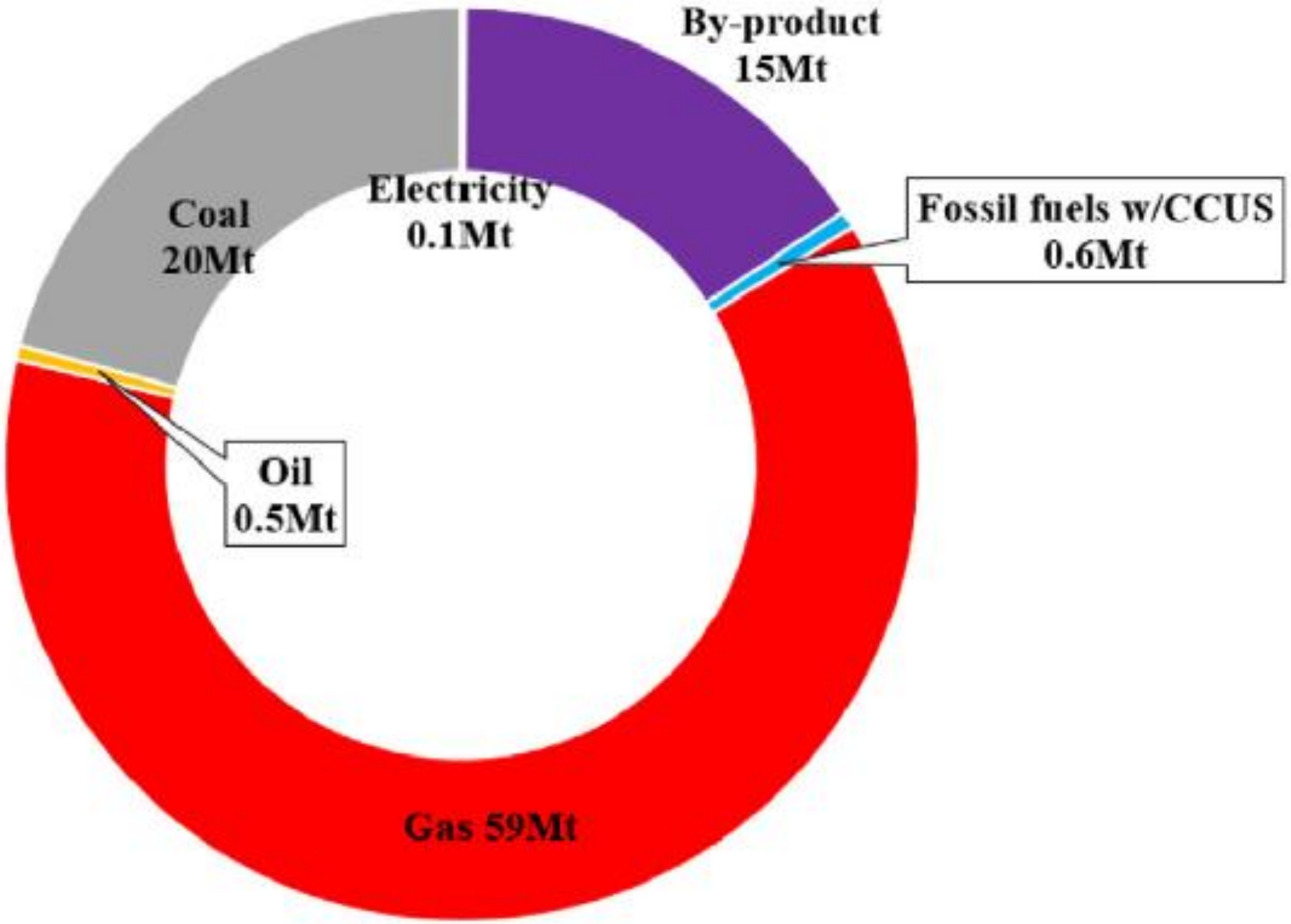
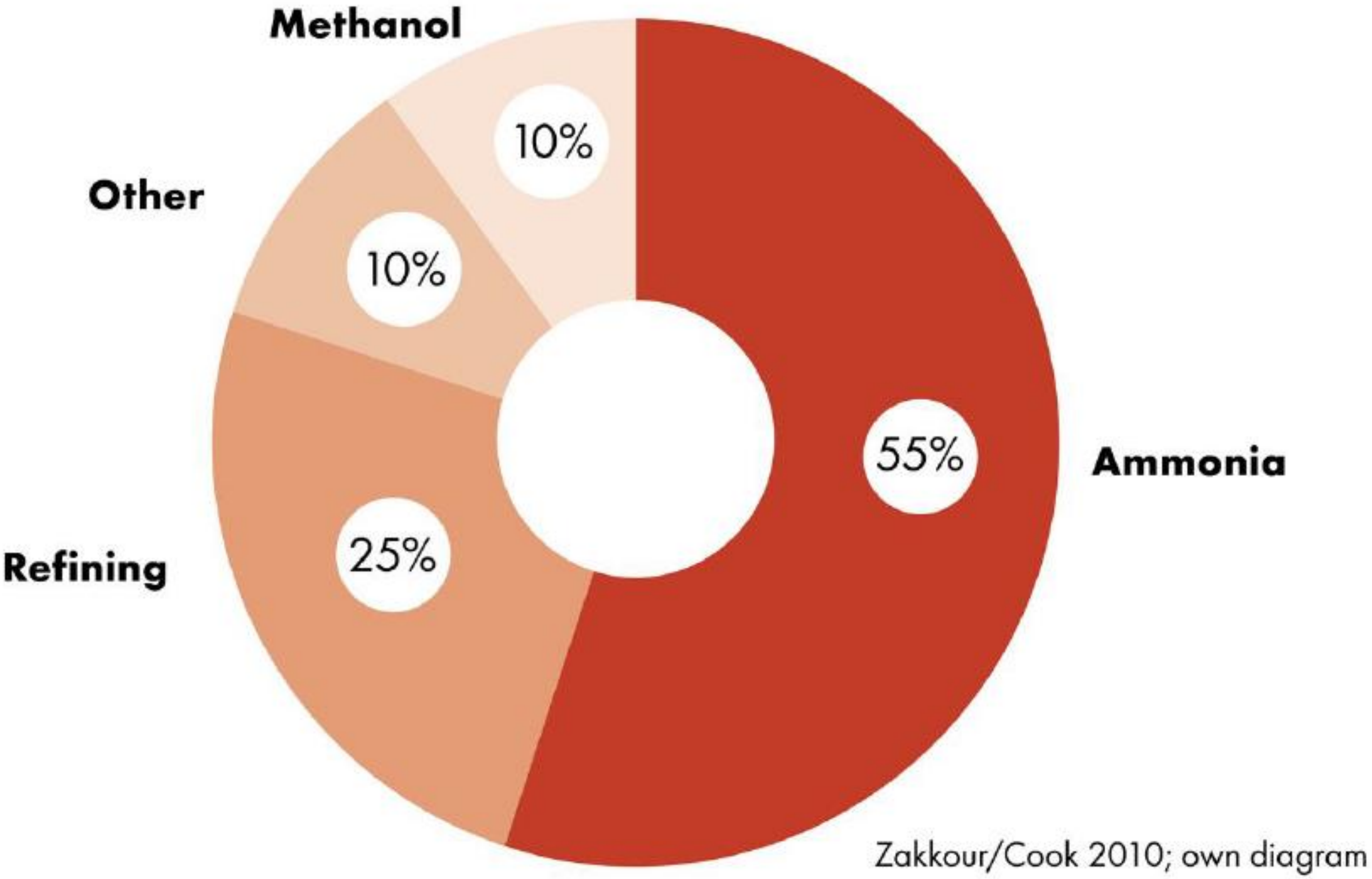
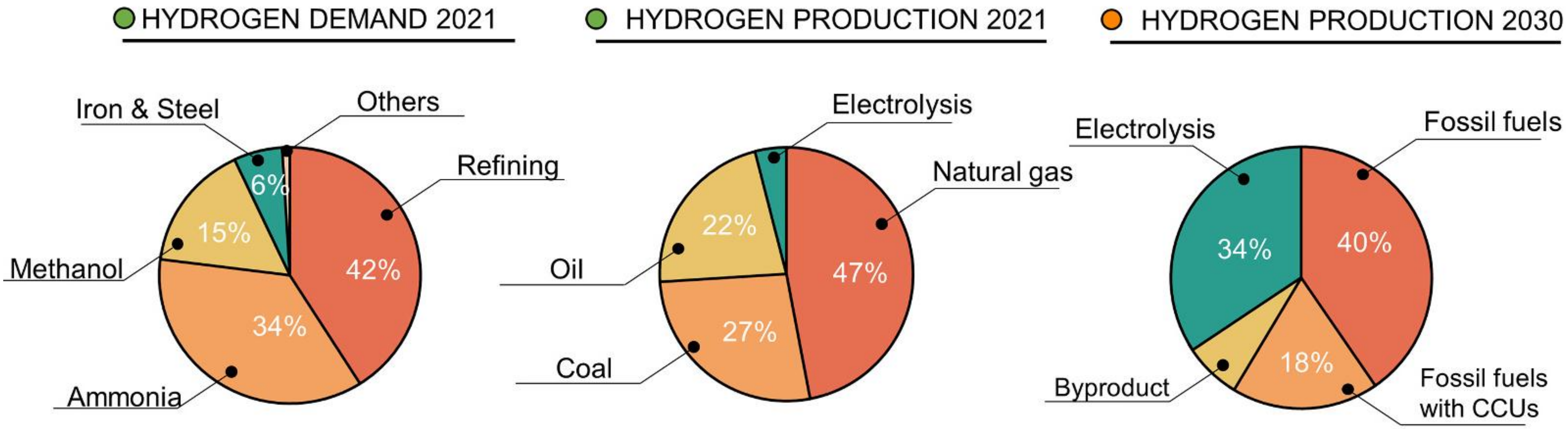


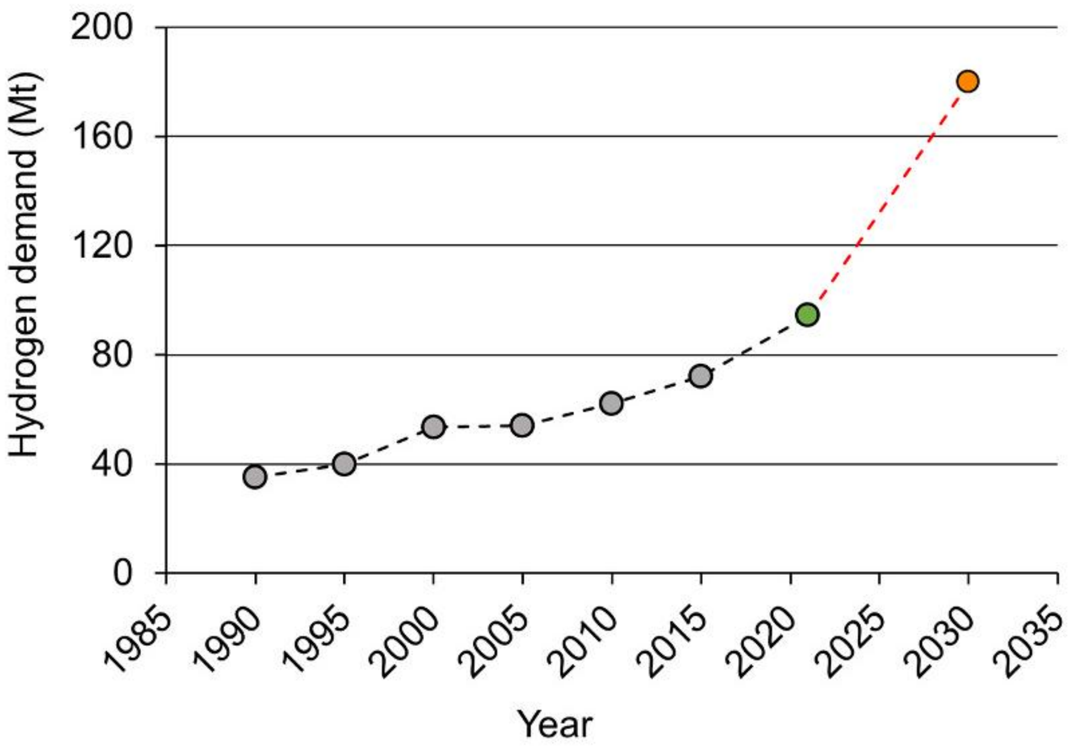
Global Usage of Hydrogen

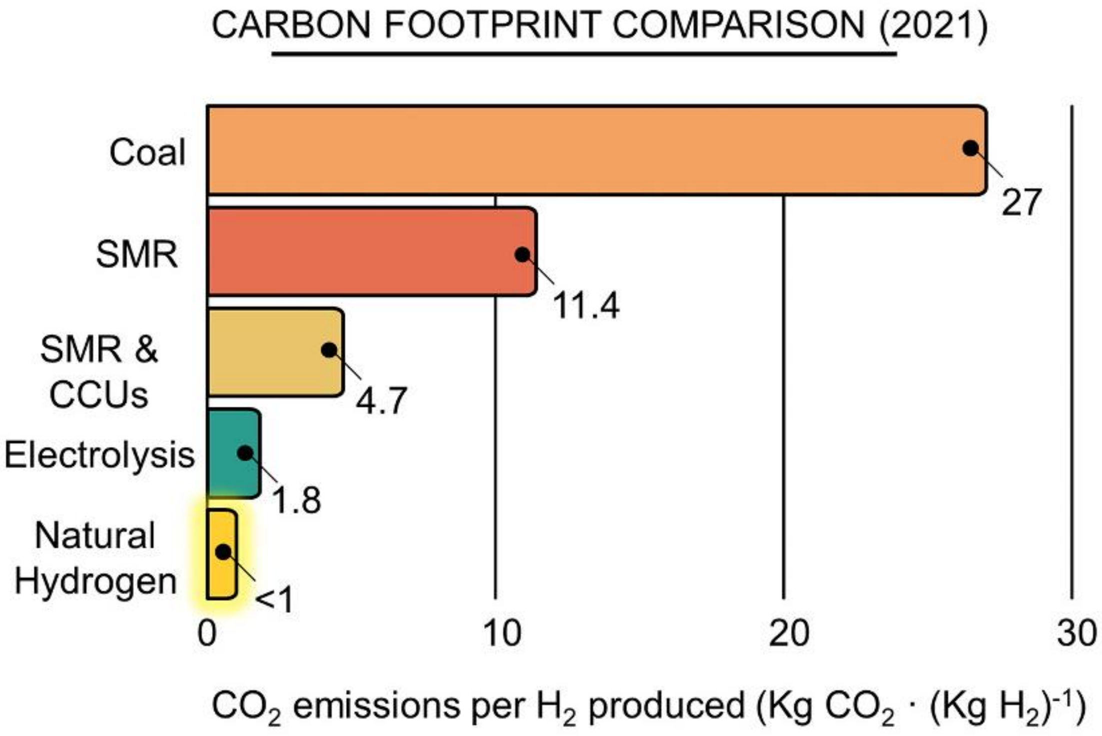


Hydrogen demand and production in 2021 and 2030



Source: Renewable and Sustainable Energy Reviews 189 (2024) 113888





Evolution of hydrogen demand from 1990 to 2030. Grey, green, and red colors represent past, current, and future estimates, respectively.

Carbon footprint for H_2 production processes (2021)

Source: Renewable and Sustainable Energy Reviews 189 (2024) 113888

Energy Structure in Nusantara

Energy Infrastructure

The energy supply strategy is designed to meet the net-zero emission target in the KPI.

ELECTRICITY

- Gas-insulated substation (GIS) with underground cable (UGC) transmission.
- Substations will be distributed to all KIKN and KPIKN, close to locations where there is a load demand for electricity.
- Implement the smart-grid system.

GAS

- City-scale gas is planned to be able to support the fulfillment of energy needs for households, offices, commercial, services, and other facilities.
- From the results of the study conducted, the options for the city gas supply system to be considered are hydrogen gas and natural gas.
- Solar farms are needed to support hydrogen production for the city's gas needs by 2045.

Relevant KPIs

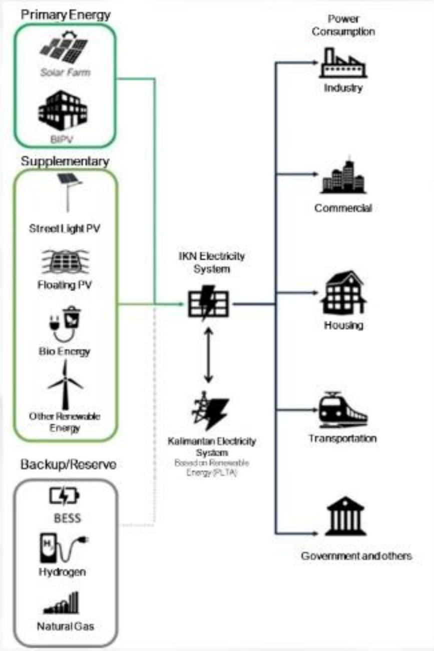
4. Low Carbon Emissions

4.1 The installation of renewable energy capacity will meet 100% of IKN's energy needs

4.2 **60%** energy savings for energy conservation in buildings

4.3 ***Net zero-emission** for IKN (when operating) in 2045 in the area of 256K Ha*

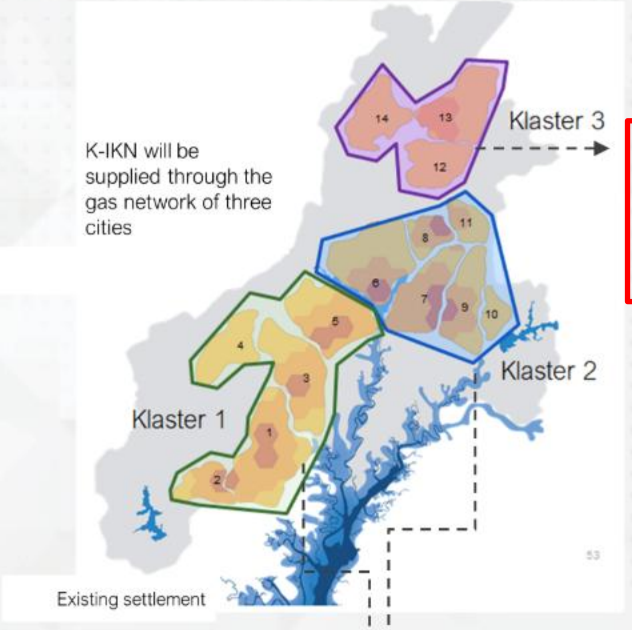
100% of IKN's annual electricity needs are supplied by renewable power plants such as solar farms and rooftop solar panels. IKN will be connected to the Kalimantan Electricity System based on renewable energy. IKN will take the required supply from the Kalimantan Electricity System.



Energy for the IKN transport system

& H Net Zero Emission

The city-scale gas energy supply at K-IKN will be supplied through the three-city gas network. Gas will be distributed through underground gas pipelines



2038-2045

80% Hydrogen

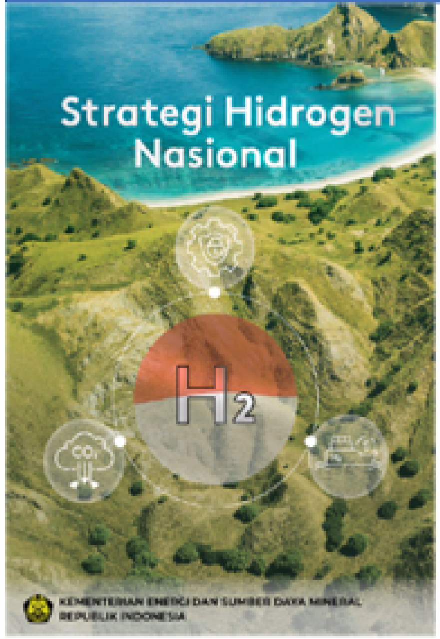
2020-2038

20% Hydrogen | 80% Natural Gas

Source: Bappenas

Done

1 National Hydrogen Strategy



This document described conditions, foresight and purpose of hydrogen development in Indonesia. **Soon to be launched** by Ministry of Energy and Mineral Resources.

On Progress

1 National Roadmap of Hydrogen and Ammonia

Penjelasan mengenai **rencana aksi terperinci**, serta target pengembangan hidrogen hingga tahun 2060.

2 Feasibility Study of Green Hydrogen Supply Chain (Upstream and Downstream)

- **Kajian detail dan panduan pemanfaatan hidrogen** di sektor transportasi secara lebih rinci untuk persiapan *pilot project* hidrogen di DKI Jakarta.
- Pemilihan kendaraan untuk uji coba hidrogen di wilayah DKI Jakarta saat ini masih dalam evaluasi. Target pilot project adalah Transjakarta, kendaraan perusahaan ekspedisi, kendaraan Pertamina, atau kendaraan pribadi.

3 National Standard and Technical Committee

3 SNI akan dikembangkan di tahun 2024:

- Spesifikasi bahan bakar
- *Safety*
- Persyaratan umum untuk HRS

Komite Teknis telah diusulkan kepada Badan Standardisasi Nasional (**BSN**) untuk dibentuk.

4 Trading Regulation

- Kementerian ESDM saat ini sedang mempersiapkan revisi Peraturan Pemerintah No. 14/2012 dengan penambahan pasal-pasal yang terkait dengan pembelian listrik dari energi baru untuk mengakomodasi pembelian listrik dari Pembangkit Listrik Tenaga Hidrogen.
- Izin dan Lisensi Bisnis Hidrogen sedang dalam tahap pembahasan (tahap awal identifikasi awal untuk izin yang diperlukan dan kode Klasifikasi Baku Lapangan Usaha Indonesia/KBLI)

INDONESIA HYDROGEN ROADMAP

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Indonesia Fuel Cell
Hydrogen Energy

ISBN 987-623-09-4851-0

01 The Current Energy Landscape in Indonesia

02 Hydrogen Potential in Indonesia

03 Policy and Regulatory Framework

04 Research and Innovation

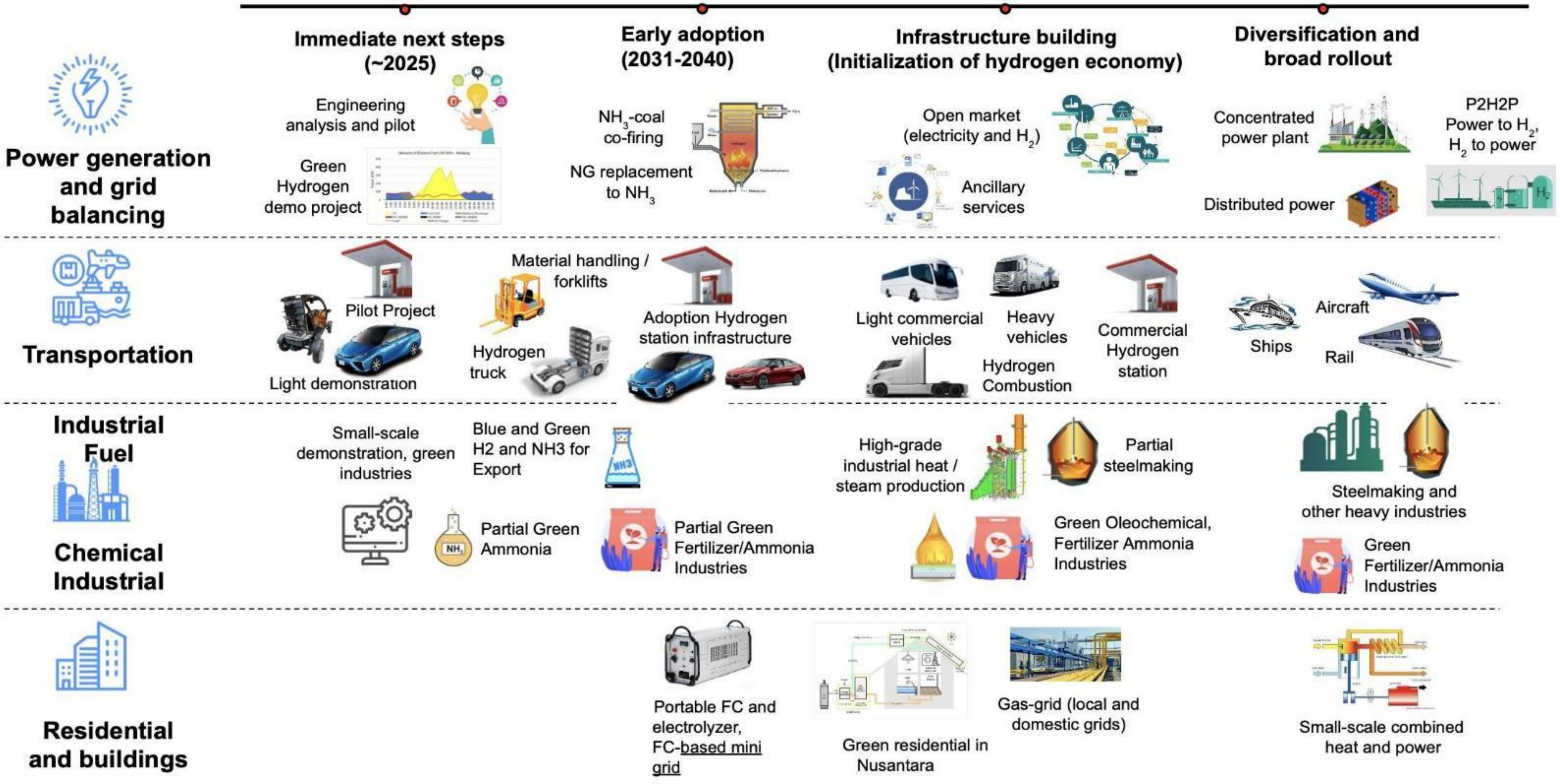
05 Hydrogen Adoption Scenario

06 Infrastructure Development

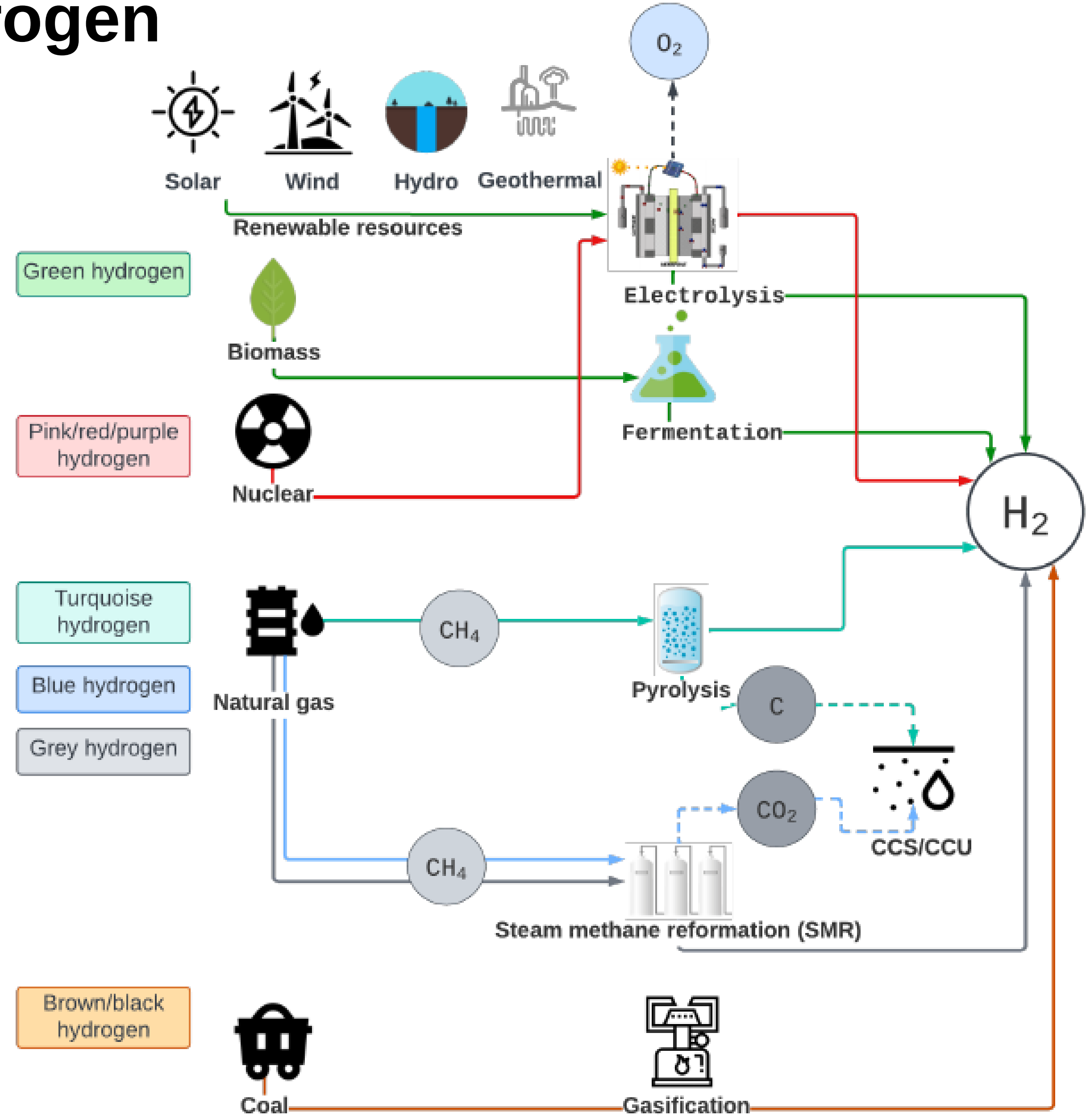
07 International Collaboration
& Hydrogen Supply Chain Development

08 Hydrogen Implementation and Utilization Plan

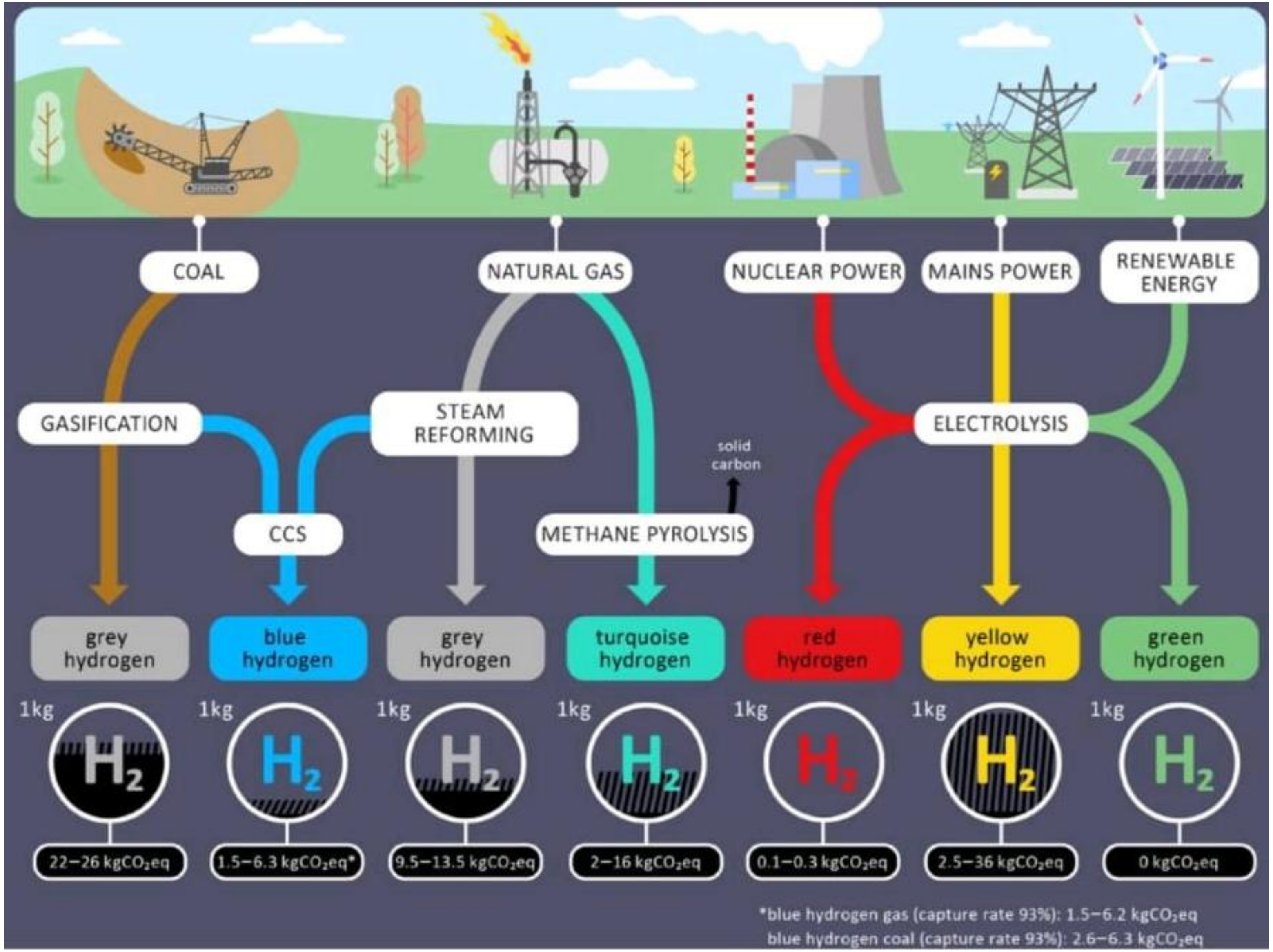
Possible H_2 Application Roadmap in Indonesia



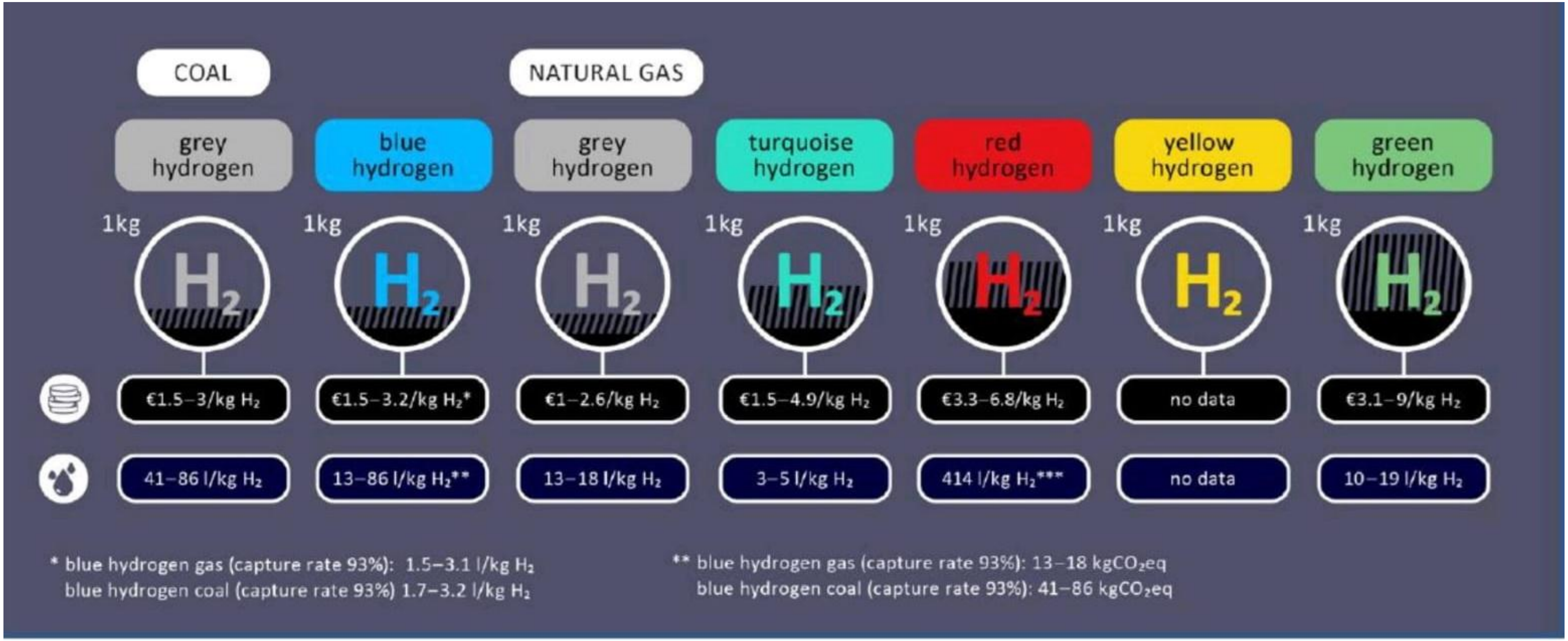
The Color of Hydrogen



How Much CO_2 is emitted when Producing 1 kg Hydrogen?

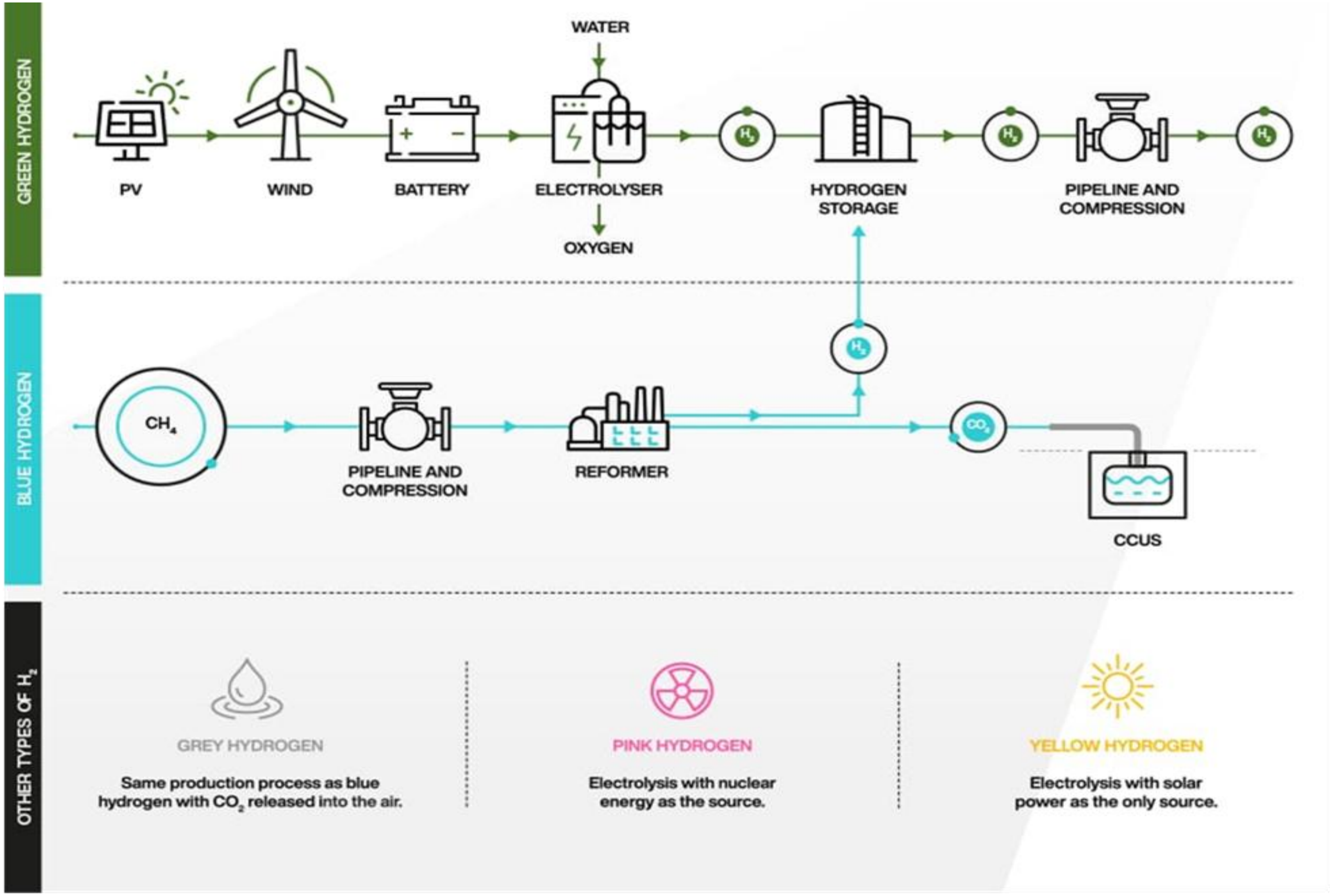


Production Cost and Water Usage for 1 kg hydrogen



Wurbs, Sven/ Stöcker, Philipp/ Gierds, Jörn/ Stemmler, Christoph/ Fischedick, Manfred/ Henning, Hans-Martin/ Matthies, Ellen/ Pittel, Karen/Renn, Jürgen/ Sauer, Dirk Uwe/ Spiecker genannt Döhmann, Indra: "How Important Will Hydrogen be in the Energy System of the Future?" (In a Nutshell!), Series on "Energy Systems of the Future" (ESYS), 2024, DOI: https://doi. org/10.48669/esys_2024-7.

Hydrogen Production Category



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Electrolysis Technology Comparison

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Keuntungan dan Kerugian dari Beberapa Teknologi Elektrolisis

Electrolysis technology	Advantages	Disadvantages
Alkaline water electrolysis	• Well established Technology • Commercialized for industrial applications • Noble metal-free electrocatalysts • Relatively low cost • Long-term stability	• Limited current densities • Crossover of the gasses • High concentrated (5M KOH) liquid electrolyte
AEM water electrolysis	• Noble metal-free electrocatalysts • Low concentrated (1M KOH) liquid electrolyte.	• Limited stability • Under development
PEM water electrolysis	• Commercialized technology • Operates higher current densities • High purity of the gases • Compact system design • Quick response	• Cost of the cell components • Noble metal electrocatalysts • Acidic electrolyte
Solid oxide water electrolysis	• High working temperature • High efficiency	• Limited stability • Under development

García, L. (2015). Hydrogen production by steam reforming of natural gas and other nonrenewable feedstocks. Compendium of Hydrogen Energy, 87

Saat ini, perkembangan teknologi elektrolisis terfokus kepada bagaimana mengatasi beberapa tantangan seperti sebagai berikut:

- Memenuhi target biaya hidrogen bersih sebesar $1/kg H_2 pada tahun 2030 (dan target sementara $2/kg H_2 pada tahun 2025) melalui pemahaman yang lebih baik tentang pertukaran kinerja, biaya, dan daya tahan sistem *electrolyzer* di bawah prediksi mode operasi dinamis masa depan menggunakan listrik bebas CO_2;
- Mengurangi biaya modal unit electrolyzer dan keseimbangan sistem;
- Meningkatkan efisiensi energi untuk mengubah listrik menjadi hidrogen pada berbagai kondisi pengoperasian;
- Meningkatkan pemahaman tentang sel electrolyzer dan proses degradasi tumpukan dan mengembangkan strategi mitigasi untuk meningkatkan umur operasional.

Electrolysis Technology Comparison

	Proton Exchange Membrane water electrolysis (PEM)	Alkaline Water Electrolysis (AEL)	Anion-Exchange membrane water electrolysis (AEM)	Solid Oxide Electrolysis Cell (SOEC)
Electrolyte	Solid (membrane PFSA)	Liquid (20-30% KOH solution)	Solid (Membrane)	Solid (solid oxide, YZS)
Electrode (Catalyst)	Platinum Group Metal Catalysts (e.g. Platinum, Iridium)	Non noble catalysts, Nickel coated perforated steel	Nickel and Ni-alloys	Nickel on solid oxide, rare earth compounds
Operational Temperature	50-80°C	70-90°C	40-60°C	500-850°C
CAPEX General	Cell stacks expensive Cheaper installation due to compact stack design	Cell stacks cheaper installation cost higher due to larger footprint		Cell stacks very expensive demanding steam treatment system
Typical Stack Efficiency	47-66 kWh/kg Hydrogen	47-66 kWh/kg Hydrogen	47-66 kWh/kg Hydrogen	35-50 kWh/kg Hydrogen
Technology status	Mature for small scale	Most mature technology	Demonstration for small scale	Demonstration
Advantages	Compact Design, ideal for containerized solutions, high dynamic operation	Low-cost materials, large stacks available for plant scale up	Low-cost materials, Potential high dynamic operation capability	High efficiency with thermal integration
Challenges/ Disadvantages	High costs of stacks Larger PEM stacks not yet available	Larger footprint Corrosive liquid electrolyte (lye handling)	Lifetime and scale-up need to be improved	Lifetimes need to be improved. High quality steam required

EIGA Doc 251, JA LI POST 13/10/2024

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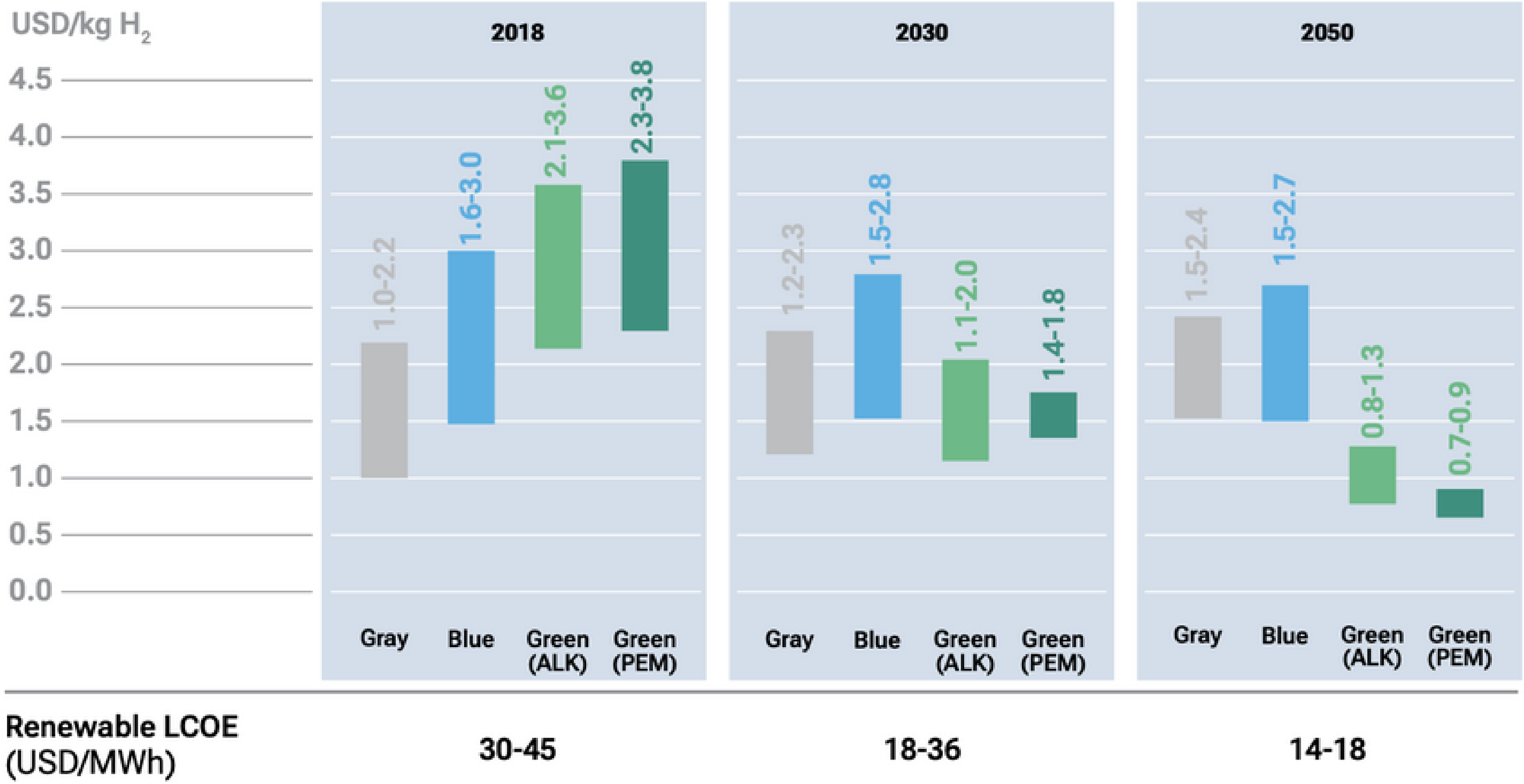
Main electrolyser characteristics

	Current | 2030 [A]	Alkaline	Pressurized Alkaline	PEM	SOE	AEM
Efficiency	kWh/Nm^3	4.7 | 4.3	4.7 | 4.3	4.8 | 4.5	3.6 | 3.3 [B]	4.8 (stack only)
Stack lifetime	hours	80,000 | 100,000	80,000 | 100,000	50,000 | >80,000	20,000 | >20,000	5,000
Flexibility	Time to reach nominal capacity	Minutes	<10s	<1s	<1s [C]	<1s
Pressure	bar	Atm.	<40 | <70	<40 | <70	atm. | <20	<35
Commercial status		Available	Available	Available	Available 2022-2024	Under development

[A] Predictions based on manufacturer indications, literature or FCH JU targets.
[B] Efficiency of SOE assumes external heat is provided.
[C] Hot system in laboratory, unknown for commercial systems. Cold systems require start up times of hours if not more.

Levelized Cost of Energy (LCOE)

Proyeksi biaya penerapan teknologi hidrogen tipe grey, blue, dan green (alkaline dan PEM)



Y. Anouti, S. Elborai, R. Kombargi, and R. Hage, "The dawn of green hydrogen," Strategy&, 16 (2020). https://www.iea.org/reports/the-future-of-hydrogen.

Turkey Containerized Products from Electrolyzer Manufacturers

(A) Nel's 1.25–2.5 MW PEM, (B) Cummins 1-MW Alkaline, C) A Rendering of Enapter's AEM 1-MW Multicore, and (D) Sunfire's 720 kW SOEC

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Technology	Alkaline	PEM	AEM	SOEC
Development stage	>1 GW deployed	>100 MW deployed	<10 MW deployed	>1 GW deployed (fuel cell) <10 MW deployed (electrolyser)
Electrolyte	Liquid: 25 – 40% KOH	Solid: proton exchange membrane (Nafion)	Liquid-solid hybrid: 1% KOH/anion exchange membrane	Solid: ceramic – zirconia or ceria based
Operating temperature (°C)	70 – 90	50 – 80	40 – 80	500 – 900
Operating pressure (bar)	Conventional: atmospheric Modern: up to 30 bar (50 among startups)	Up to 80 (350 among startups)	Up to 35 with potential for much higher in the future	0 – 2 bar
Typical current densities today (A/cm2)	0.4 – 1.0	0.2 – 4.0	0.2 – 2.0	0.5 – 1.5
System energy consumption (kWh/kg H_2)	50 – 78	50 – 83	57 – 69	38 (with steam import) 48 (without steam import)
Stack cost (2020 $/kW)	270 – 450	400 – 870	200	250 – 2,000

Electrolyzer system cost with BoP (2020 $/kW)	800 – 1,500	1,400 – 2,100	3,333	917 – 4,000
Stack lifetime (full load hours)	60,000 – 100,000	50,000 – 90,000	5,000 – 40,000	20,000 – 50,000
Degradation (% / 1000 hours)	0.13	0.25	0.4	0.55 – 1%
Ramp up time hot idle to nominal power	60s	10s	30 minutes	10 minutes
Cold ramp up time	30 – 60 minutes	5 minutes	20 minutes	>600 minutes
Minimum load	10 – 40%	5 – 10%	10 – 20	>3%

Steelmaking
TRL: 7

The benefits of coupling SOEC with a steel plant are similar to those of coupling SOEC with a nuclear plant, in that industrial process heat can be reused in the SOEC to increase the overall electrical efficiency of hydrogen production. In this configuration, a SOEC system will require less low-carbon electricity than PEM or alkaline electrolyzers to produce the same quantity of hydrogen.

In the first large-scale project to test this concept, called GrinHy 1.0, the German company Salzgitter AG installed a 140-kW Sunfire SOEC system at one of its steelmaking plants. The project proved that heat from a steel plant could be used with a solid oxide electrolyzer to produce hydrogen at the purity required for low-carbon steelmaking. In the first phase of the GrinHy project, however, hydrogen was turned back to electricity using the reversibility of solid oxide technology, rather than being used in steelmaking.[46]

GrinHy 1.0 was succeeded by GrinHy 2.0, which involves a substantially larger, 720-kW SOEC system. This prototype also recycles process heat from steelmaking

Figure 23: The GrinHy 2.0 720-kW Sunfire Electrolyzer at Salzgitter's Site[47]

but has been further integrated into Salzgitter's steelmaking operations in that it supplies hydrogen for the annealing process. By the end of 2022, stack performance had been proved for 20,000 hours of operation, producing a total of around 100 tons of high purity 'green' hydrogen at an electrical efficiency of minimum 84% (measured at the lower heating value (LHV) of hydrogen), and proving the technology at TRL level 7. In the next phase, the electrolyzer will supply hydrogen for the reduction of iron ore, which will reduce CO_2 emissions from this step of the steelmaking process by 95% and prove the technology at TRL 8.

SUNFIRE-HYLINK HL40	
Rated electrical power$_{AC}$	150 kW
Load variation (H_2 output)	0 % ... 125 %
Electric efficiency$_{AC}$ based on LHV	82 %
Specific electric energy$_{AC}$	3.7 kWh/Nm^3
H_2 production	40 Nm^3/h
H_2 pressure (after compression)	10 bar (g)
H_2 purity (after gas cleaning)	99.999 Vol.-% Atm. dew point temperature: - 60 °C
Steam input	Saturated steam: 150 °C; 3 bar (g); Mass Flow: 40 kg/h
Electrical interface	3 phase, 380/400/480 V$_{AC}$, 50 Hz/60 Hz
Noise	< 60 dB @ 3m distance
Ambient temperature	- 20 °C ... + 40 °C
Communication	Communication for remote monitoring and control

SCALABLE ELECTROLYSER FOR INDUSTRIAL USERS

SUNFIRE-HYLINK HL200

+ Electrolyser module:
  - Electricity input: up to 150 kW$_{AC}$
  - Hydrogen output: up to 40 Nm^3/h
+ Standard container:
  - Electricity input: up to 750 kW$_{AC}$
  - Hydrogen output: up to 200 Nm^3/h
  - Low footprint of 6,7 Nm^3H_2/m^2
+ Hydrogen drying unit
+ Hydrogen compression

Synthetic Fuels
TRL: 5 – 6

Because a solid oxide electrolyte can conduct oxygen ions, SOEC technology can be used to electrolyze molecules such as CO_2. The resulting product in this case would be carbon monoxide (CO).

When carbonated water is fed to a solid oxide electrolyzer, both water and CO_2 can be electrolyzed simultaneously – this process is called co-electrolysis. Co-electrolysis produces a mixture of carbon monoxide and hydrogen, also known as synthetic gas or 'syngas', alongside steam and CO_2. Syngas can be used to produce a range of synthetic hydrocarbons, including fuels and materials.

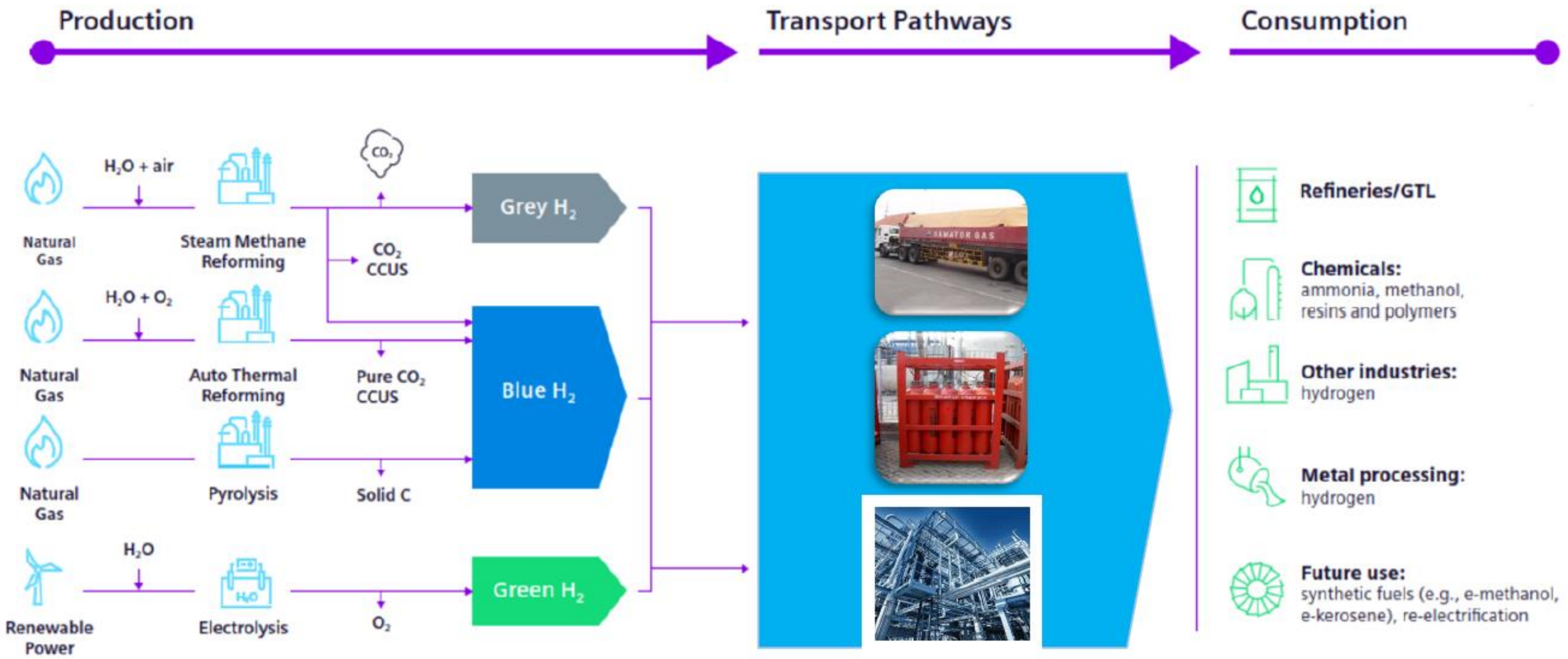
Sunfire has demonstrated a 150-kW co-electrolyzer for methanol production through its SynLink project, putting the technology at TLR 6.[48] In parallel, Sunfire has also validated a 10-kW module to produce synthetic fuels through its Kopernikus PtX project.

Another solid oxide cell manufacturer, Estonia-based Elcogen, has partnered with French energy company Engie SA on a pilot project to produce dimethyl ether (DME), a synthetic alternative to diesel fuel for transport applications. The project, called C2 Fuels is deploying a small solid oxide system, with electrical capacity in the single-digit kWs, in Dunkirk, France.[49]

Figure 24: Sunfire Co-Electrolyzer Module as Part of the Kopernikus PtX Project

The next challenge for co-electrolysis technology is demonstration on a MW scale. To that end, the European Union is co-funding an ongoing project, called MegaSyn, to demonstrate syngas production by co-electrolysis in an industrial environment. The aim is to lift the solid oxide co-electrolysis technology to TRL 7 by 2025.[50]

Current Hydrogen Market in Indonesia



Industri Hidrogen di Indonesia

IFHE
Indonesia Fuel Cell Hydrogen Energy

Hidrogen Plants di Indonesia

6 Samator
Hydrogen Plants

8 Air Products
Hydrogen Plants

1 Linde
Hydrogen Plants

3 Air Liquide
Hydrogen Plants

Metode Distribusi Hidrogen

Piping

Tube trailer

Cylinder

Fuel Cell in Indonesia

MCFC 300 kW

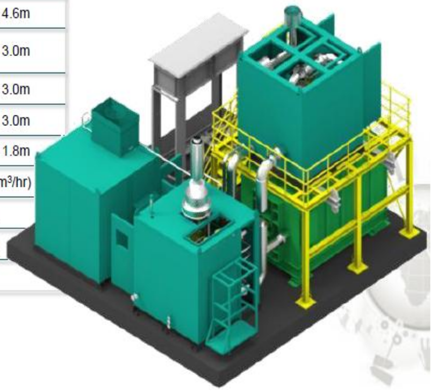
GAS → PGN
ELECTRICITY → BUMD → JAKARTA
HOT WATER → MERCURE HOTEL
ANCOL → MARINA BAY

MCFC INSTALLED IN ANCOL

Specification *2012 Stop, due to gas price*

❑ Plant overview

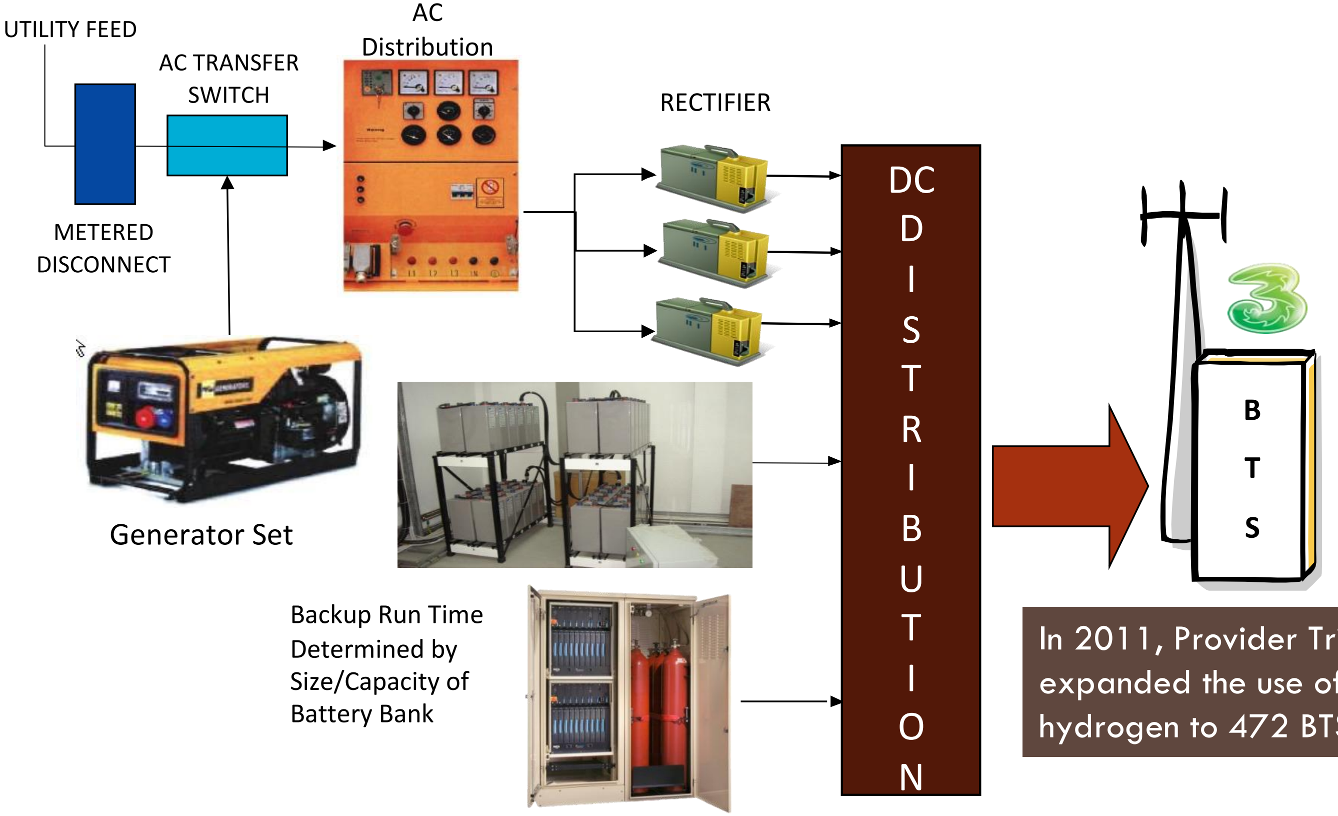
Item		Remarks
Output	Power	Net AC 300kW
	Exhaust Gas	1,270kg/h x 127mmAq x 343℃
Efficiency		47%(Except Cogeneration)
Size (H x W x L)	Block1(STACK)	2.9m x 5.3m x 4.6m
	Block2(Air Supply System)	2.6m x 3.0m x 3.0m
	Block3(Fuel Processor)	4.3m x 3.0m x 3.0m
	Block4(WTS System)	3.9m x 3.0m x 3.0m
	Block5(EBOP)	3.7m x 3.3m x 1.8m
Input	LNG / Water	68(N㎥/hr) / 0.5(m³/hr)
Emission	NO_X	0.2 ppm ↓
	SO_X	0.01 ppm ↓
	CO	10 ppm ↓



KOICA POSCO ENERGY

PEMFC 5 kW powered by Hydrogen gas and Methanol-Water

POWER GENERATION FUEL CELL AS BTS STANDARD BACKUP POWER SYSTEM



In 2011, Provider Tri expanded the use of hydrogen to 472 BTS

In Cooperation with PT. Cascadiant Indonesia

CASCADIANT
The Power Behind Your Network

Managed Services Fuel Cell

Type: Methanol PEM Fuel Cell
Capacity: 5 kW
For cooling buildings in the Baron Tekno Park area
Currently incorporated with a 5 kW Photovoltaic System

@Yogyakarta

Since 2014

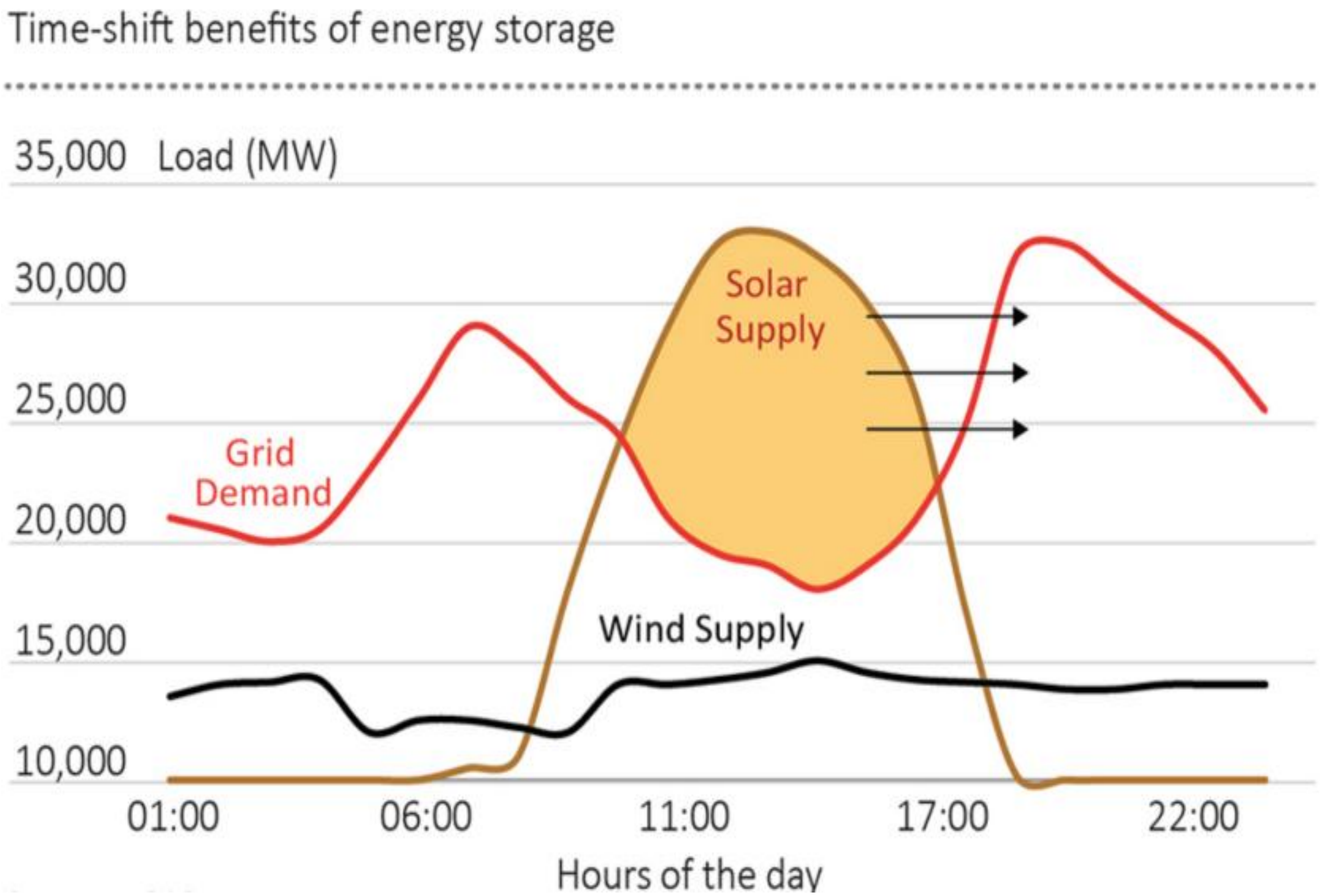
Type: Hydrogen PEM Fuel Cell
Capacity: 5 kW
As a back up for servers in Gedung Tekno 3, Puspiptek Area, Serpong

@Jakarta

Fuel cell fuel comparison (PT Cascadiant Indonesia, 2022)

Parameter	Methanol & Reformer	Hydrogen Canisters
Initial cost	Up to 50% lower than hydrogen cylinders, depending on runtime	Competitive at runtimes of 8 hours or less
Operation cost	Tends to be flat, depending on fuel usage	Tube rental, high refill cost, frequent, for low outage applications
Logistics	Liquid, easy to store, refill, distribute and widely available	100 lb canisters, difficult to store, refill and distribute, specialty chemicals with limited availability
Licensing	Not required for <60 gallons	Required (regulations differ by area)
Runtime	Duration (40 hours of operation on a 5 kW system = 59 gallons of HydroPlus^{TM} liquid fuel)	Short (40 hours of operation on a 5 kW system = 24 hydrogen cylinders stored on-site)

Renewable Energy Intermittency



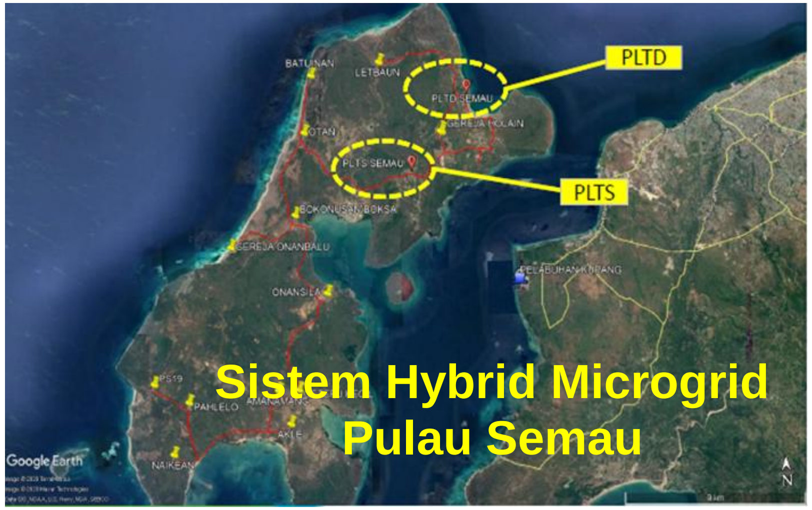
- Stability of electricity to deliver to the grid
- Use the excess power to run **Electrolyser**
- Combine renewable resources for stable grid

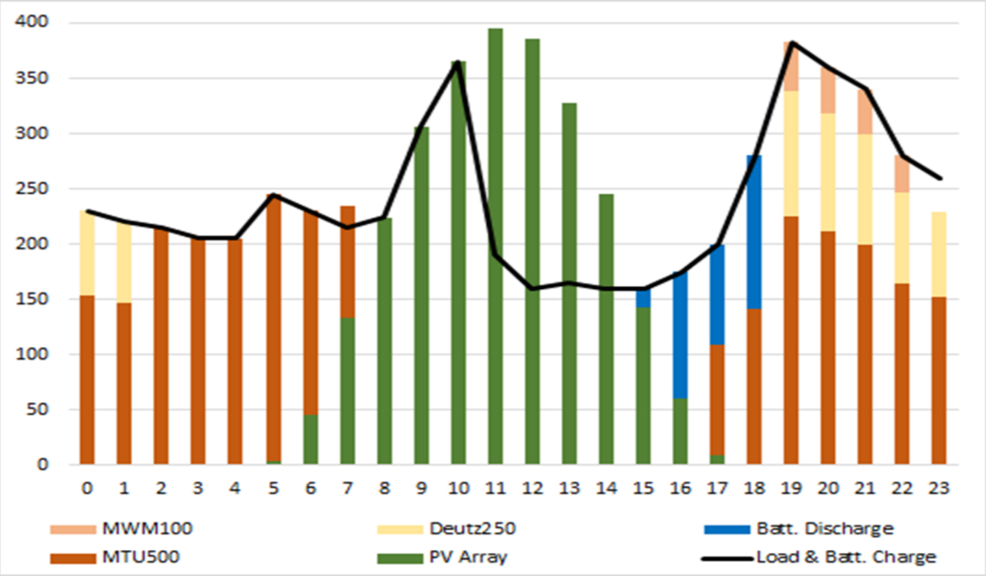
RESEARCH Collaboration

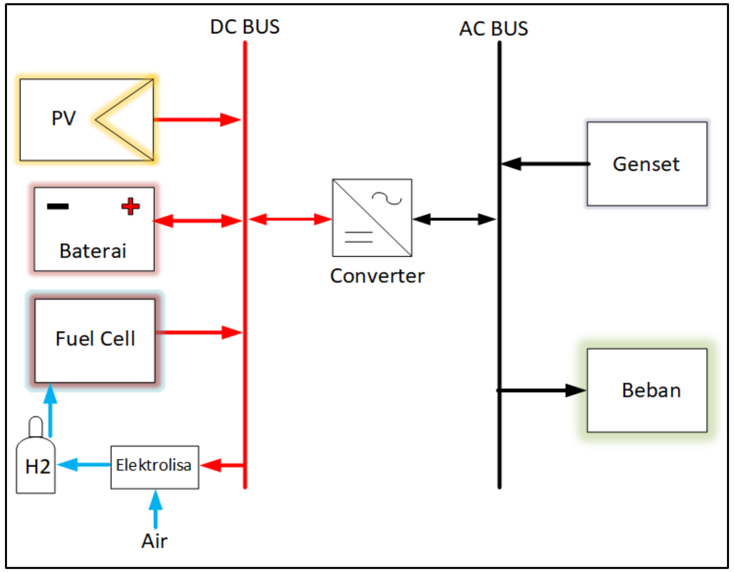
PLN HONDA The Power of Dreams BRIN IFHE Indonesia Fuel Cell Hydrogen Energy

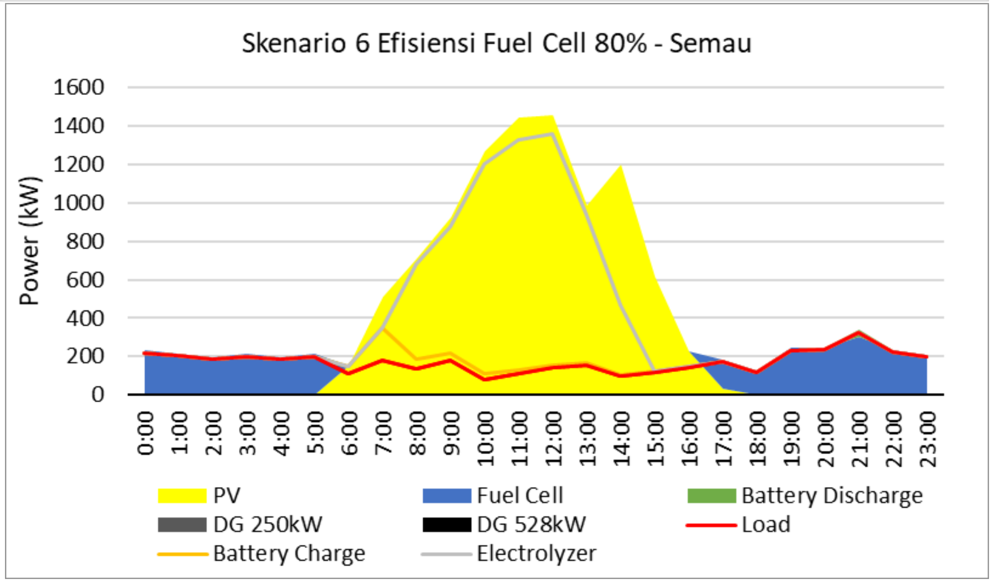
De-dieselization Program; Hydrogen

80 kW PEMFC Honda



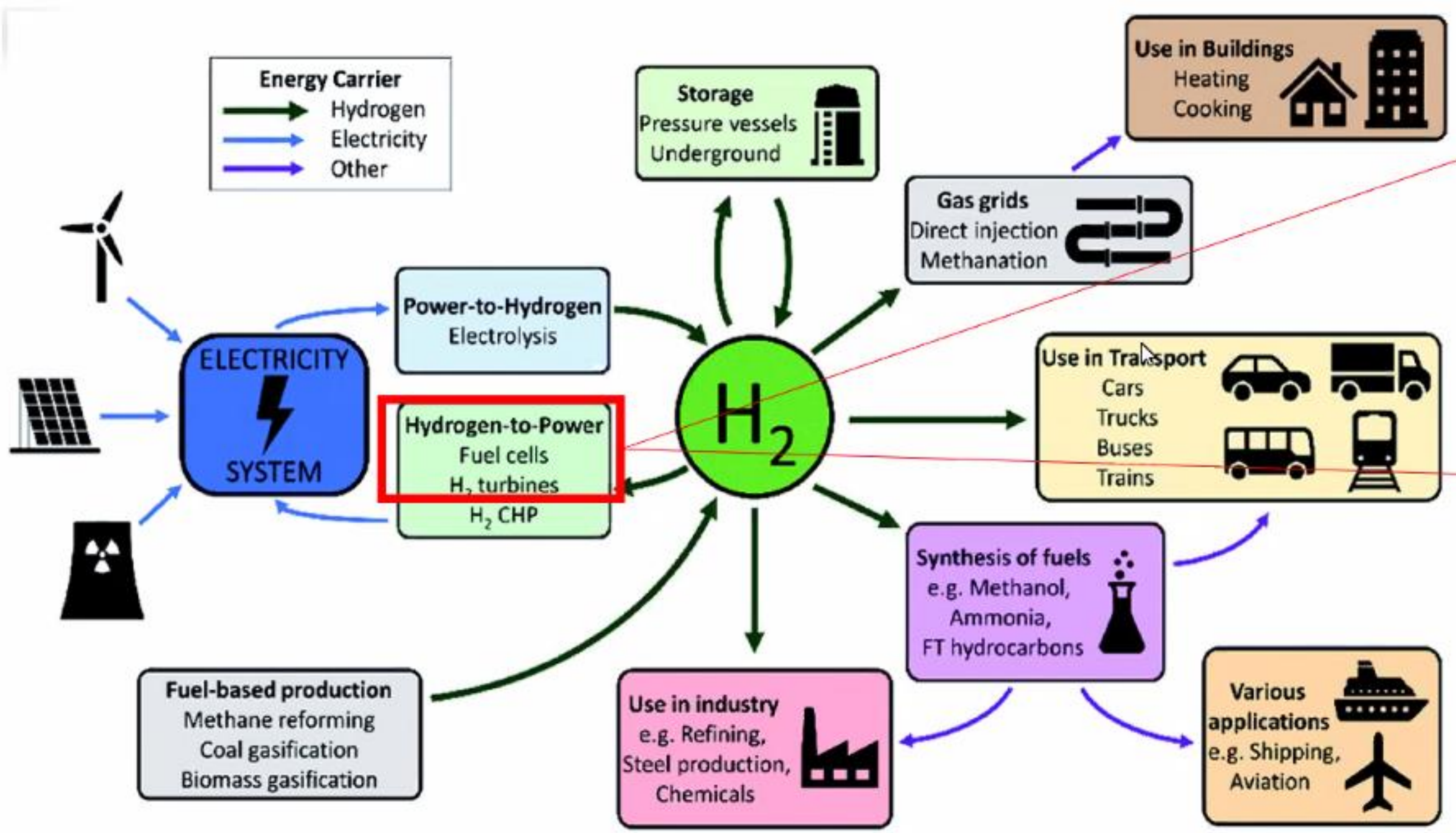






RESEARCH Collaboration

Diesel and Gas-fired power plants in Indonesia



Diesel: 5,261 units (2,068 MW)

	Units	MW
GT Simple	66	2,404
GT CC	79	10,168
Gas Engine	177	1,866
Total		14,338

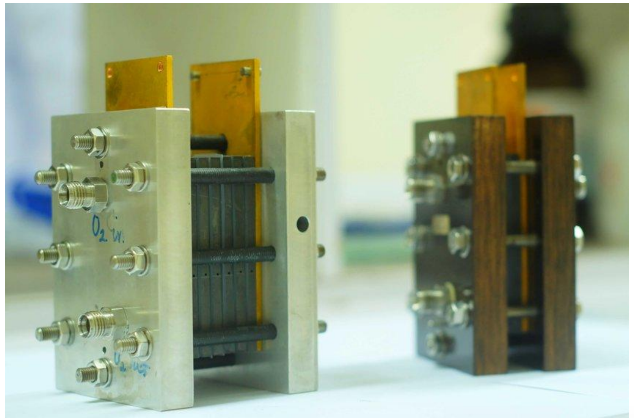
Source: Indarwan (2021), PLN (2021)

PLN BRIN IFHE Indonesia Fuel Cell Hydrogen Energy

H_2 based fuel cell

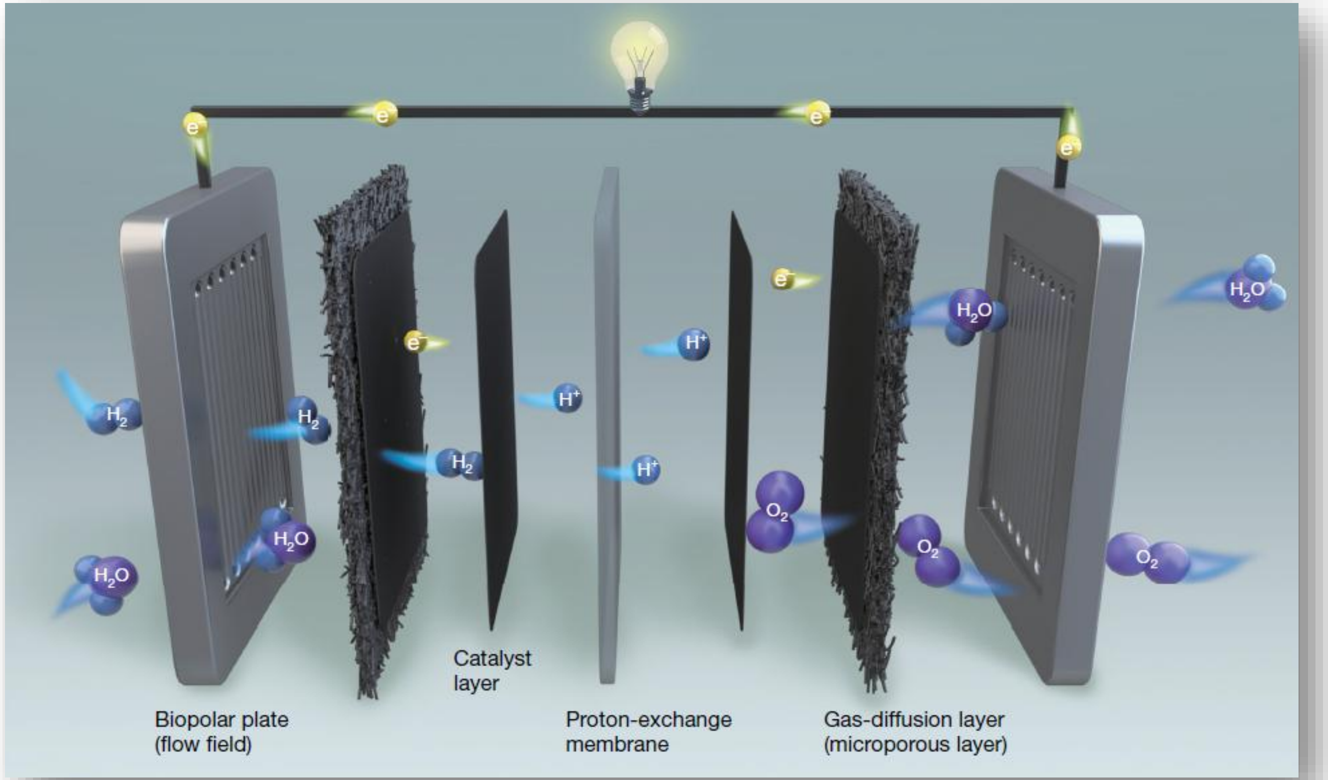
- Single-cell dan multi-cell
- Operation temperature (40-80°C)

$$2\,H2 + O2 \rightleftharpoons 2\,H2O + 572\text{ kJ of energy}$$

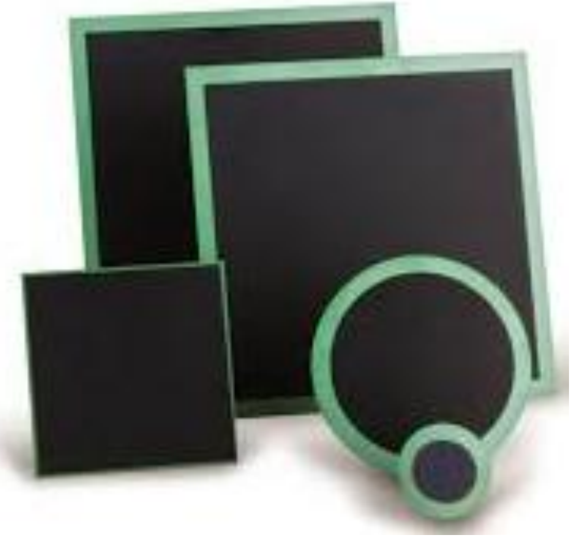


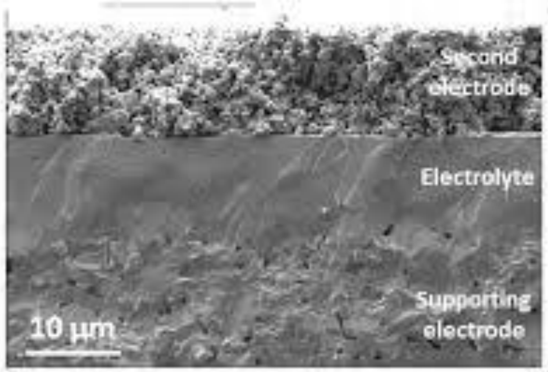
Fuel Cell Stack AMRC BRIN

Cell number: 7 cells
Cell active area: 25 cm^2
Power output: 5 - 20 Watt
GDL, Stacking, holder and BPP made by **AMRC BRIN**



SOEC - Manufaktur





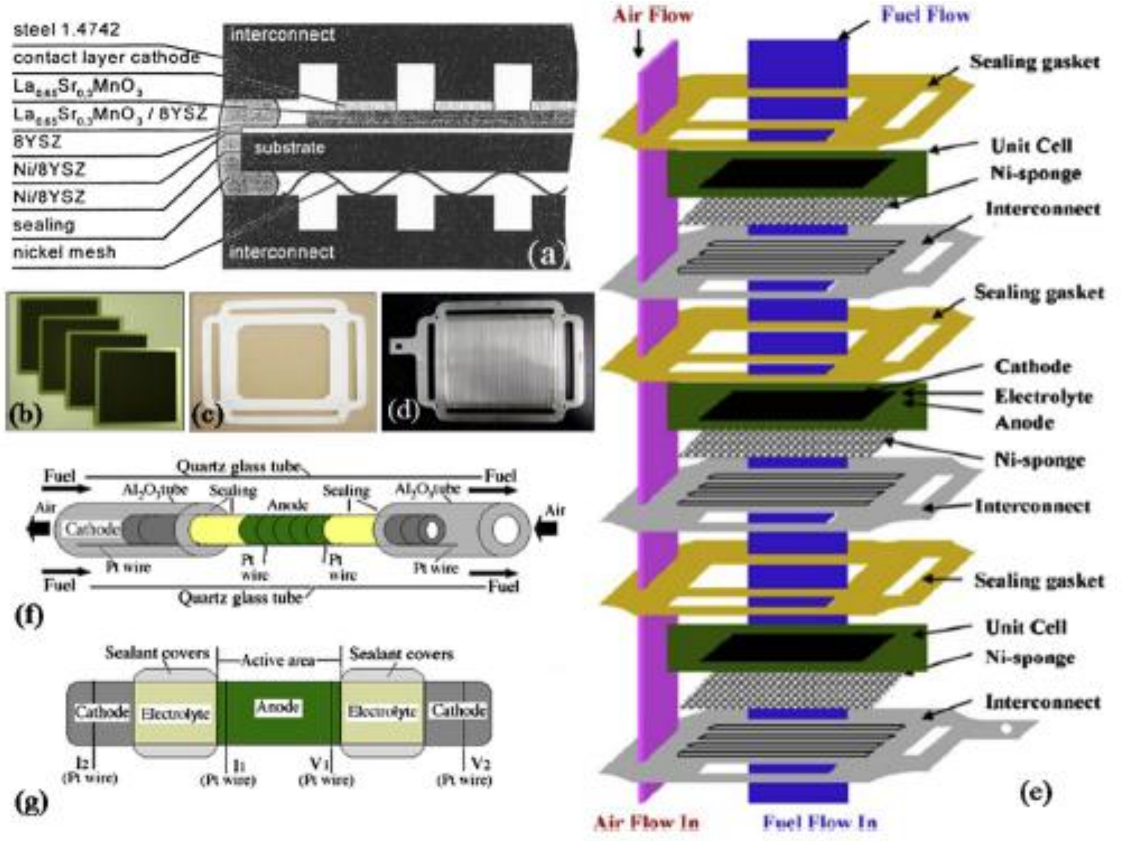


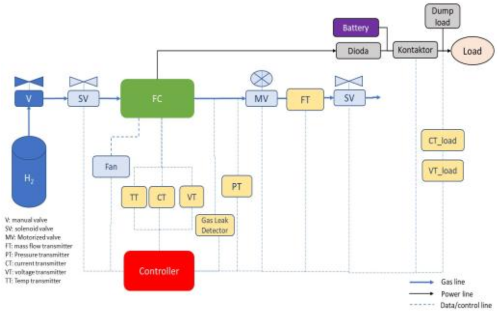
Fig. 76. (a) Schematic diagram of the cross section of a SOFC unit showing positioning of sealant material in a planer stack. Photographs of (b) anode-supported 10 × 10 cm unit cells (anode electrolyte and cathode), (c) sealing gasket, (d) interconnector. Schematic diagram of (e) an experimental apparatus for the single micro-tubular cathode-supported cell measurement, (f) the enlarged cross sectional view of the sealant cover and current collection through the cell, I_1, I_2: current collect terminals, and V_1, V_2: voltage detect terminals, and (g) planar SOFC stack based on anode-supported 10 × 10 cm unit cells shown in (b–d). ((a) Reprinted with permission from Ref. [454], Springer, 1999), (b–e) Reprinted with permission from Ref. [1037], Elsevier, 2006, (f and g) Reprinted with permission from Ref. [1042], Elsevier, 2007).

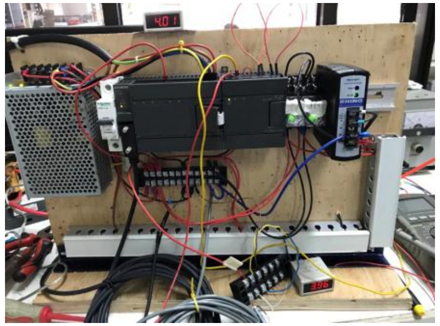
PEMFC, Hydrogen Production, and HRS System Research at BRIN

1 kW PEMFC Fuel Cell Vehicle

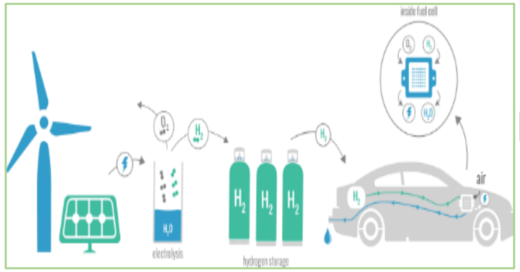
2.5 kW PEMFC Fuel Cell Vehicle plus 200 WP Photovoltaic

Fuel cell system will be developed for forklifts and other 4-wheeled vehicles.





Hydrogen Feeding Control on PEMFC



Electrolysis-based Green Hydrogen Production

Hydrogen Filling Station Prototype

Riset Kendaraan Berbasis Hidrogen di BRIN

BRIN
BADAN RISET DAN INOVASI NASIONAL

IFHE
Indonesia Fuel Cell Hydrogen Energy

HYDROGEN MOTORCYCLE

Use 500 W of PEMFC, NiMH tank 740 L at 150 psi, 48 VDC to 12 VDC controller

The concept of using fuel cells in electric motorcycle, using integrated electronic components. It has been made since 2009. It is still in operation until today (12 years old).

FUEL CELL VEHICLE

Use 1 kW of PEMFC, 30V-33.5A, 36VDC/1kW motor, H2-tank 295L/150 bar Compress Cylinder

Four-wheeled light electric vehicles with 2 passengers are converted into hydrogen gas-fueled vehicles.

HYBRID CAR BATTERY-PV-FC

Use 2.5 kW of PEMFC, 48VDC/3,7kW Motor, PV 200Wp, Lithium Battery 48V/80Ah

Installation of photo-voltaic on the roof of the golf-car and combination of PEM fuel cells on the back to create a combined system of electricity supply from renewable energy.

Hydrogen for free carbon society

IFHE
Indonesia Fuel Cell Hydrogen Energy

Join Us
www.bit.ly/ifhe-membership

THANK YOU

+62 822 1052 0510

info@ifhe.or.id