Energy Transition in Southeast Asia

From Biogas and Biomethane to clean and green H2

Carsten Dommermuth
Dipl-Ing. MBA, Vice President

Vice President & Managing Director APAC
INNIO's Jenbacher brand

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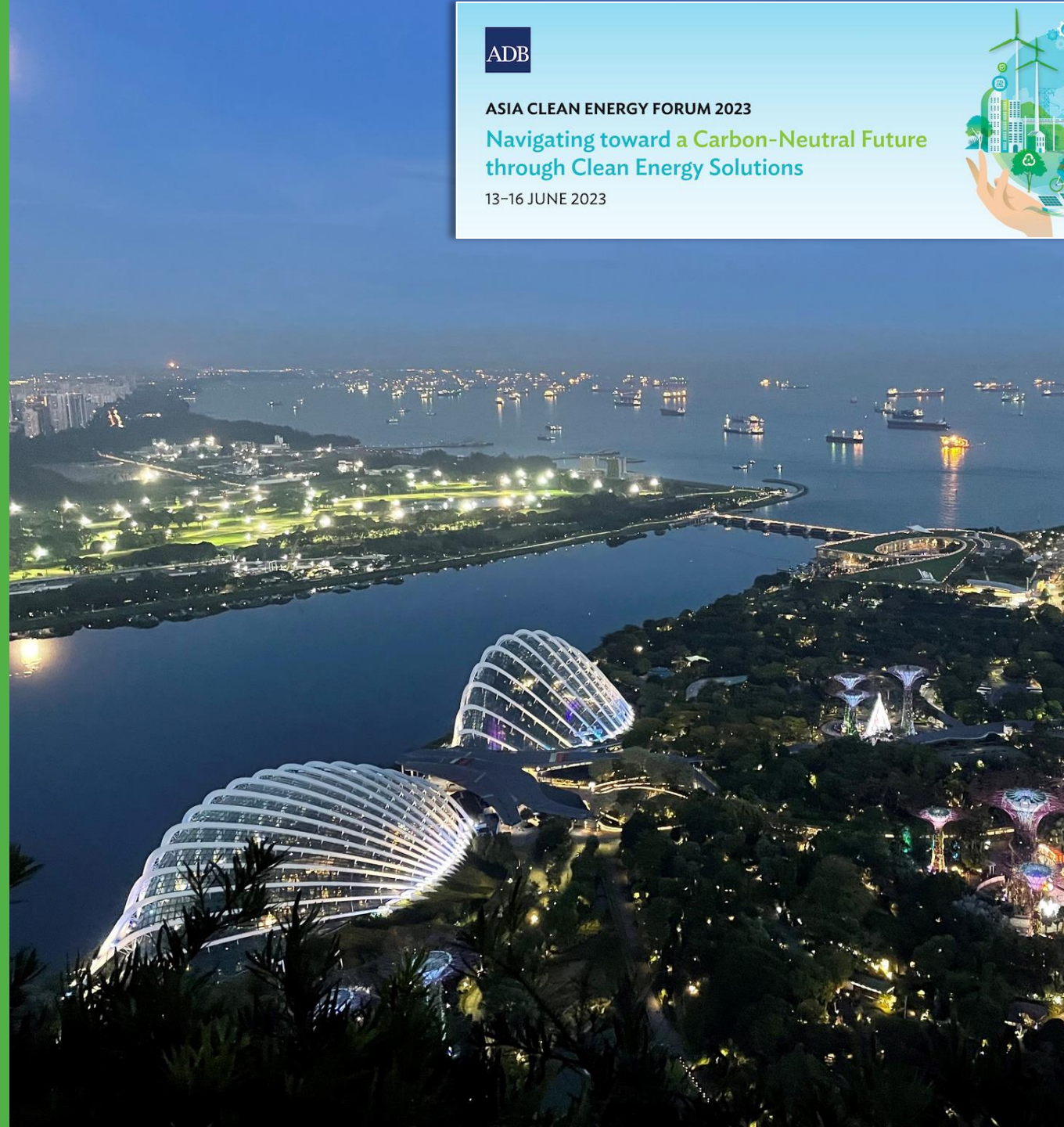

Green hydrogen can be a tool to enhance energy security and accelerate decarbonization not only in Southeast Asia.

At INNIO, we integrate green H2 into our Jenbacher solution development

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March 28, 2023 To convert green electricity to green hydrogen (H2) for its power-to-hydrogen-to-power project, INNIO has ordered two electrolyzers with a total capacity of 2 megawatts (MW) from H-TEC SYSTEMS

March 8, 2023 The largest gas engine power plant in Germany with 190 MW, powered with 20 Jenbacher engines will be converted to green Hydrogen up to 2023.

Link, Video

CONTACT DETAILS

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Carsten Dommermuth is the Vice President and Managing Director for the APAC region for INNIO's Jenbacher product brand. He is based in Singapore.

For more than 20 years, Carsten has held leadership positions at various major international energy companies in sales, after sales service, sales support, business, and product development.

His responsibilities have included the development of the EPC and IPP business covering gas-to-power and LNG solutions as well as liquid and gaseous biofuels and hydrogen.

Carsten has a degree in mechanical engineering and an MBA in corporate management. He also received project finance training at Boston University.

Richard Richard

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Richard is the Senior Sales Manager for Indonesia & the Philippines for INNIO's Jenbacher brand and based in Jakarta.

Richard has 18 years professional background in the power industry working on both thermal and renewable power plants with different roles such as project management, project tendering, sales and after sales services, and business development at major multi-national companies.
He has gained experience for the development of EPC and IPP projects covering gas-to-power and small-scale LNG solutions as well as liquid and gaseous biofuels, and hybrid power plant.

Richard holds a degree in nuclear engineering and a master's degree in management.

WHO WE ARE

1957
1st Jenbacher genset

65,000 m²
Brilliant manufacturing production space

~25,000
Jenbacher engines delivered

1,700
Employees
100 apprentices

Generating reliable and efficient power at or near the point of use

Jenbacher fleet at a glance

37 GW
delivered globally

25,000
delivered engines

60 million
households*

1.5 x Germany*

12,000
digitally-connected engines **(myPlant)**

60%
of Jenbacher engines in operation are connected with myPlant*

250 kW → 10.6 MW

- **Pipeline gas and renewable gases**
- **Special gas applications**
- **Power generation**
- **Combined Heat and Power**
- **Combined Cooling, Heat and Power**

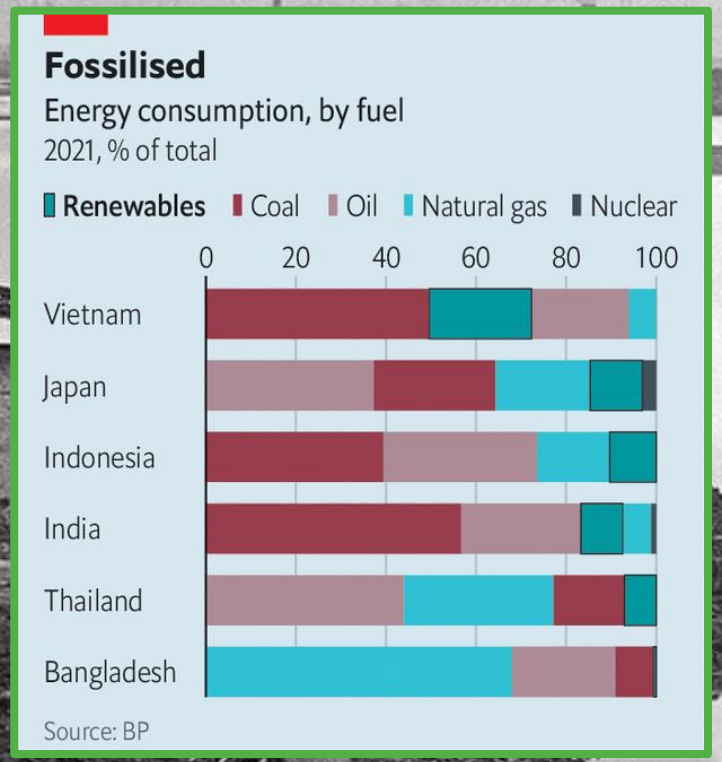
Advantages

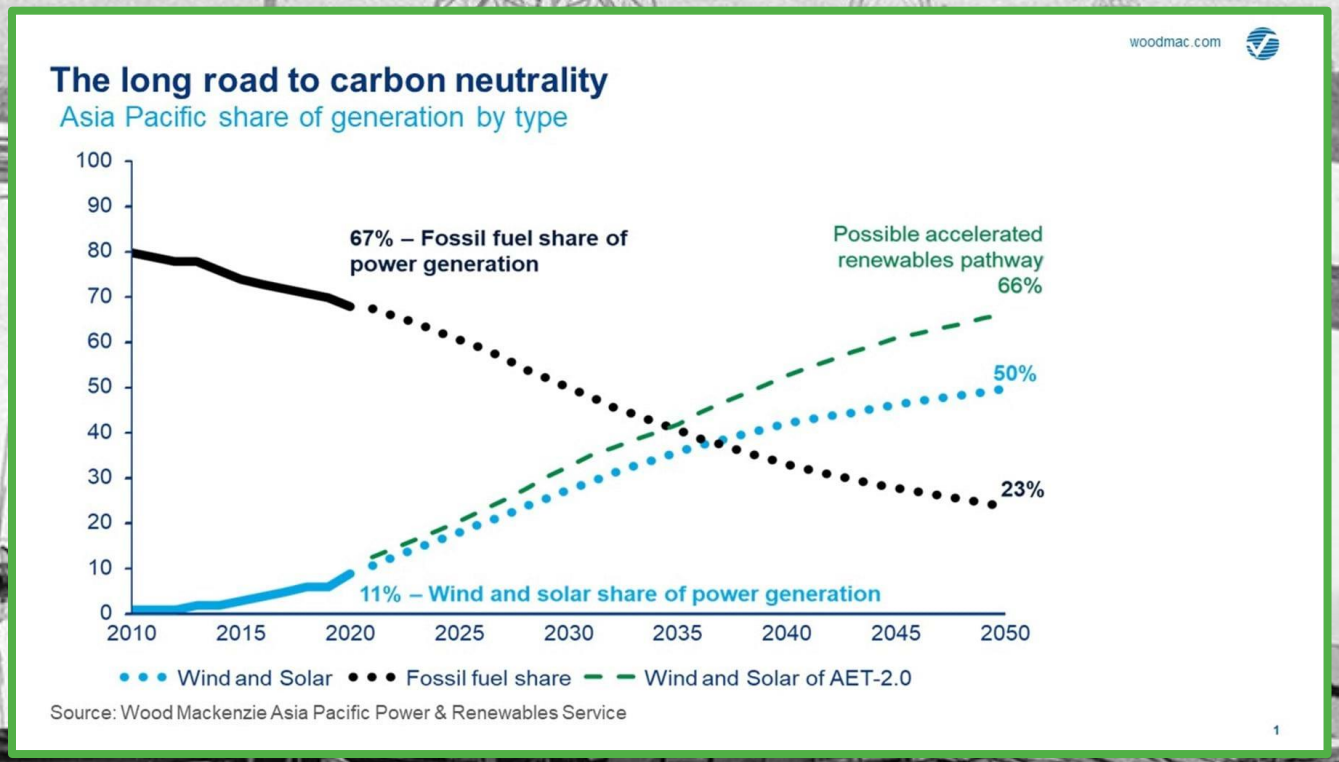
- Overall efficiency of 90% or more
- Durability
- 65 years experience
- Fast-start capability
- Fuel flexibility
- Life-cycle services

*Sources: Electricity consumption of private households by household size, 2020, https://www.destatis.de/EN/Themes/Society-Environment/Environment/Material-Energy-Flows/Tables/electricity-consumption-households.html;
DE electricity consumption per dwelling, 2018, https://www.odyssee-mure.eu/publications/efficiency-by-sector/households/electricity-consumption-dwelling.html ; Number of households in Germany, 2019, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfst_hhnhtych&lang=en

How to get Asia to net zero

Coal is still king – 60-70% still out of fossil power generation





CARBON-INTENSITY ENERGY MIX IN APAC

Coal-fired power plants	Efficiency	CO_2 emissions per kWh
Supercritical hard coal	45%	757 g/kWh
Subcritical hard coal	38%	896 g/kWh

Oil-fired power plants (heavy fuel oil)	Efficiency	CO_2 emissions per kWh
Diesel engine cogenerating	70%	398 g/kWh
Diesel engine single cycle	45%	619 g/kWh

Gas-fired power plants	Efficiency	CO_2 emissions per kWh
Gas engine cogenerating	90%	224 g/kWh
Gas turbine combined cycle	55%	367 g/kWh

Hydrogen	Efficiency	CO_2 emissions per kWh
Gas engine cogenerating	90%	0 g/kWh
Gas turbine combined cycle	55%	0 g/kWh

Notes: Calculation based on IEA emission factor

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Source: Company Information and IEA 2022

Southeast Asia is going green!

TRANSITIONING TO 100% RENEWABLE FUELS

INNIO's Jenbacher fleet in APAC

Today: 3,000 MW

75% ⬅ APAC ➡ 25%

Traditional gas CHP/Power

More than 500 Biogas engines

Tomorrow: Dispatchable & fast power to support the fluctuating new baseload of PV & wind

Biomethane or Synthetic Methane CHP

Biomethane & CO_2 Usage

Hydrogen CHP/CCHP

Biogas (Flex-Biogas)

INNIO's mix of fossil traditional gases & renewable gases in APAC—today

Carbon-neutral fuels & green hydrogen

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Source: Company Information

ENERGY TRANSITION OPPORTUNITIES & SOLUTIONS

Energy transition in APAC is a marathon, not a sprint! And INNIO has the solutions

	1 “Coal is still king in APAC”	2 Volatility vs. grid stability	3 Infrastructure
CHALLENGES			
SOLUTIONS	Expand renewables, biogas and clean fuels, using gas as a bridge technology	Flexible, fast-starting, dispatchable power and tri-generating solutions	Flexibility at point of use for fluctuating hydrogen mixes in the gas network

TROUBLED WATERS AND A NEW ORDER FOR THE GLOBAL GAS BUSINESS

Independence on supply is key for countries

Time for local fuel sources like biogas, biomethane, and virtual pipeline solutions to support independence

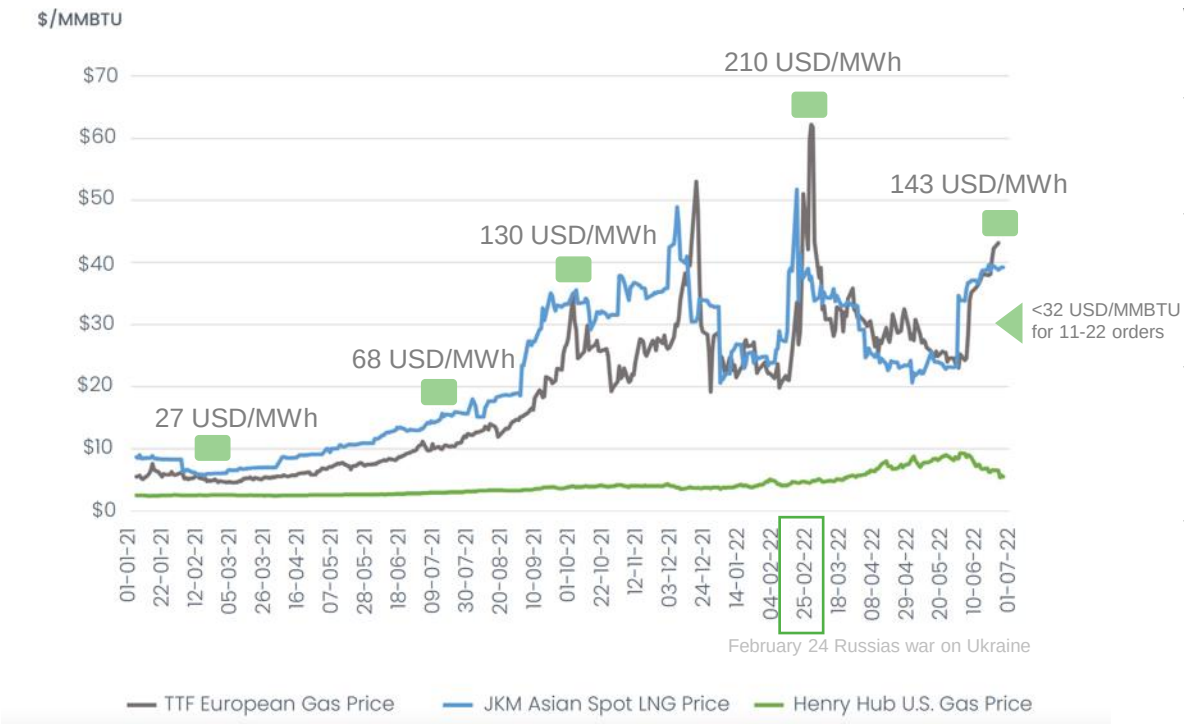

Figure: Henry Hub, TTF and Asian Spot LNG price developments as of July 03, 2022; source: Bloomberg NEF (EURO/USD 1,04 / Sept19 -2022; 1/1)

What this development means in numbers

- Base line over the last 15 years was a cheap, stable, and predictable gas and LNG market.
- Spot and futures at the leading gas markets up to March 2020 were in a range of 8 USD/MMBTU (27 USD/MWh)
- This development was the main driver for the huge investments in the LNG infrastructure for liquefication and regasification.
- It had the momentum for the change from coal to gas in APAC

Lessons learned

- Countries with gas pipeline connections, e.g., Germany and parts of the EU, will actively work on alternative supply opportunities.
- Alternatives in (new) nuclear and new coal will be selective but need time to come online
- One main strong promoted feature will be LNG and the virtual pipeline business to unlock the risk of a single source of supply.
- Local fuel sources like biogas will stronger promoted for a more diversified local energy mix.
- Acceleration of alternative new fuels like Hydrogen

End-user power prices in APAC increased for dominant gas markets like Japan with +42%, South Korea +37% and Singapore with +31%*

New business models supporting Virtual pipelines with multi-supplier options & future-ready for the supply of liquified biogas and H_2

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*Wood Mackenzie's Global Power Market Update, July 2022

MCKINSEY Quaterly 2022 | TRANSITION TO NET ZERO

TRANSITION TO NET ZERO

By 2030, the expected value from sustainable fuels, upstream and downstream electrification, and hydrogen could exceed $1 trillion. During this decade, capital spending (an average of some $400 billion a year over five years) is likely to shift from fossil fuels to sustainable forms of energy, such as bio and synthetic fuels.

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https://www.mckinsey.com/capabilities/sustainability/our-insights/spotting-green-business-opportunities-in-a-surging-net-zero-world/transition-to-net-zero/fossil-fuels

Southeast Asia is going green!

In **1874**, science fiction author Jules Verne set out a vision that has inspired entrepreneurs ever since.

“Water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable”.

Jules Verne,
The Mysterious Island

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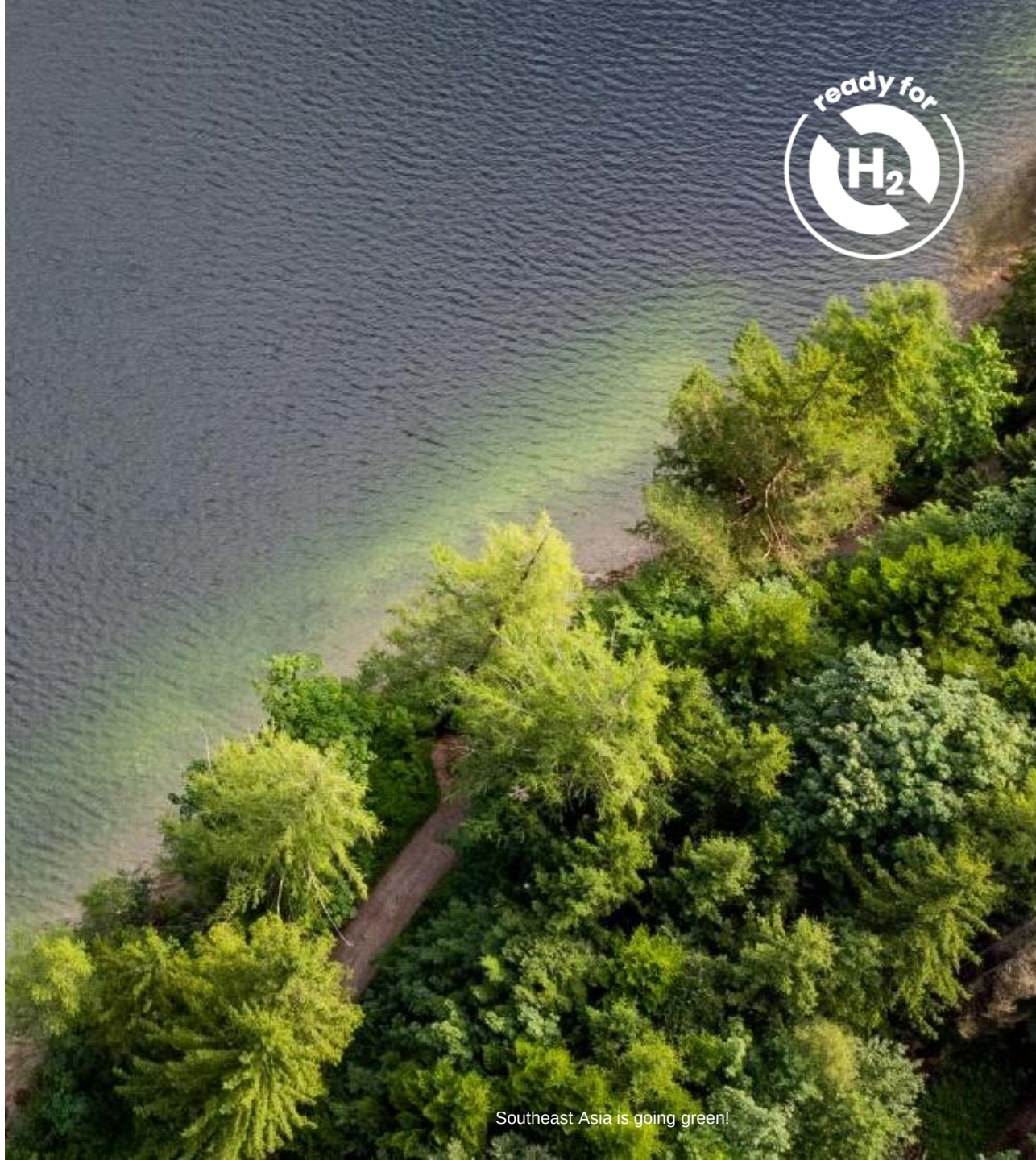


The rise of hydrogen pilot cities in South Korea

As part of its effort to achieve carbon neutrality by 2050, the government of South Korea is working to transition hydrogen to be a vital engine of economic growth and job creation.
To accomplish this, the government implemented a strategy focused on laying legal foundations to promote hydrogen. Enter the Hydrogen Economy Promotion and Hydrogen Safety Management Act (“Hydrogen Act”), an act passed into law by the Korean National Assembly that became the world’s first hydrogen law that took effect in early 2021.

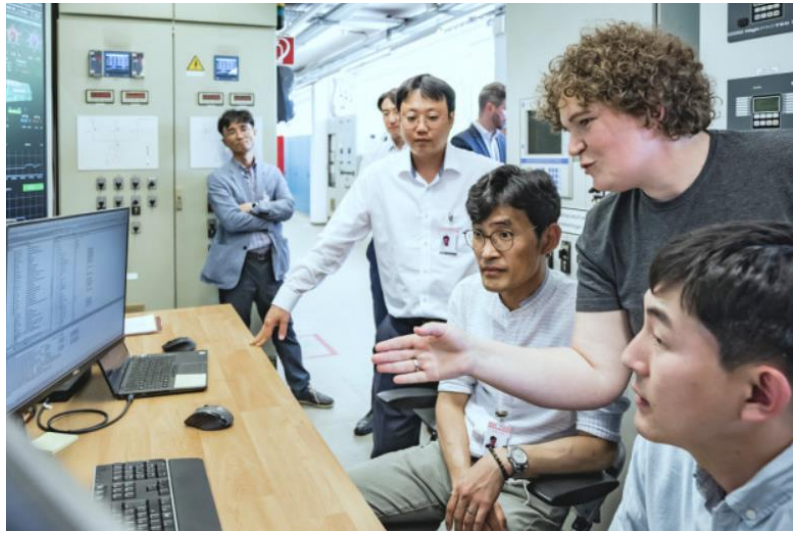
The power couple: Hyosung hydrogen and Jenbacher engine

Source:
https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf

TRANSITIONING TO 100% RENEWABLE FUELS in APAC

November 19th, 2021 – Our Hydrogen Journey started

November 19, 2021
First order for a 100% Hydrogen MW scale Jenbacher engine in APAC



May 11, 2022
Factory Acceptance Test (FAT) of the Hydrogen engine taking place at our H_2 test facility in Jenbach.

The Hydrogen Revolution in APAC*

"Hydrogen is already having, and will continue to have, a significant impact in the Asia-Pacific (APAC)
region – the opportunity is already being embraced by **Australia, Japan and the Republic of Korea** in particular. Hydrogen offers the APAC region a practical option to reduce carbon emissions and fossil fuel dependency."

*https://www.dlapiper.com/~/media/files/insights/publications/2021/10/hydrogen-report-apac.pdf

Green Growth: Capturing Asia's $5 trillion green business opportunity**

The addressable market size for green businesses in Asia is expected to reach between $4 trillion and $5 trillion by 2030. Entering the green space will come with risks, but also potential rewards for businesses that move early.

** https://www.mckinsey.com/featured-insights/future-of-asia/green-growth-capturing-asias-5-trillion-green-business-opportunity

Transitioning to green with INNIO's Jenbacher H_2 solutions

READY FOR H_2

All new Jenbacher engines are "Ready for H2".

In general, „Ready for H2" Jenbacher units can be converted to operate on up to 100% hydrogen in the future. Details on the cost and timeline for a future conversion may vary and need to be clarified individually.

Furthermore, models can be offered with the option to operate with up to 25% (vol) H2 in the pipeline gas.

Type 4 engines are offered for 100% H2 operation.

From 2025 onwards INNIO's entire Jenbacher product line is expected to be rolled out for 100% hydrogen operation.

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Key takeaways from Singapore's ´22 Energy Week

Deputy Prime Minister Lawrence Wong

Deputy Prime Minister Lawrence Wong at the Singapore International Energy Week on Tuesday (Oct 25)

Singapore will commit to the goal of achieving net-zero emissions by 2050, as well as aim to reduce emissions to 60 MtCO2e by 2030 after peaking emissions earlier.

- **Singapore aims to supply up to 50 per cent of its power needs with hydrogen by 2050**

For a start, it will launch an expression of interest for commercial projects using ammonia - a derivative of hydrogen for power generation

Singapore will also scale up supply chains for low-carbon hydrogen, among other steps, to ensure it reaches its hydrogen goal

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- **Carbon Tax – first real incentive for change**

5 SGD Singapore dollars per ton of CO_2 equivalent in 2022 to about 50-80 dollars by 2030.

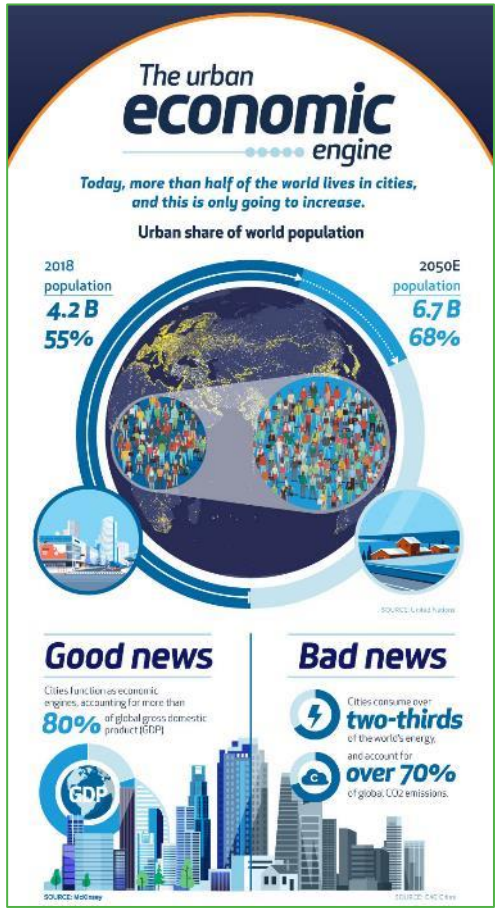
- **International cooperating (with Australia at Oct 18)**

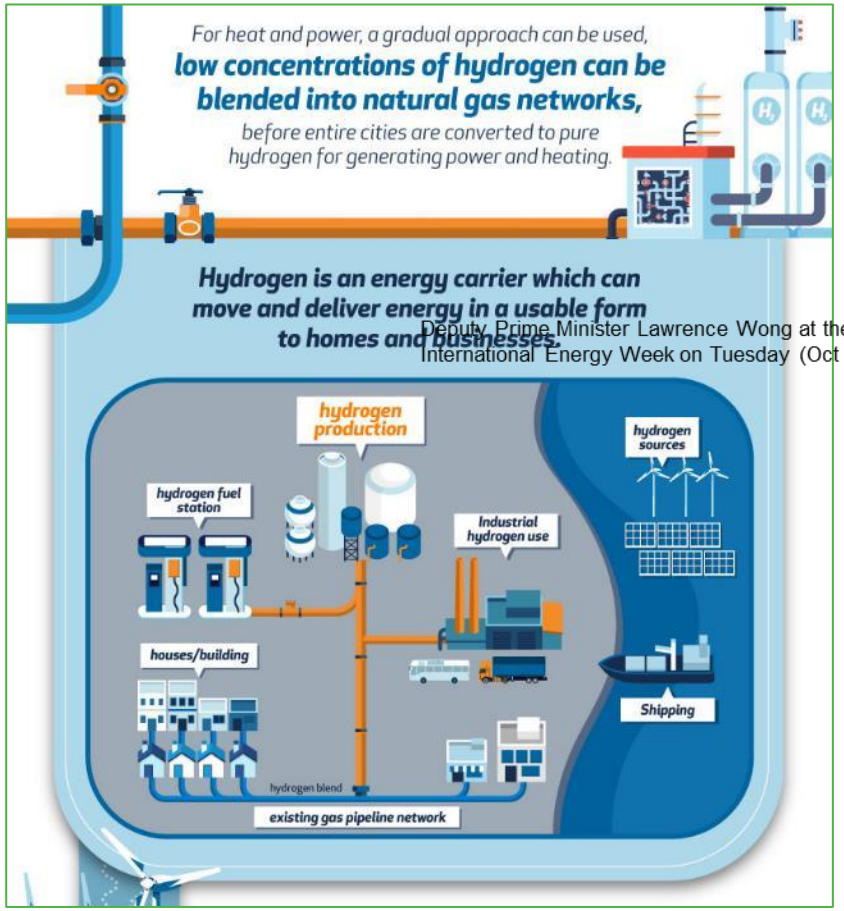
Singapore, Australia sign Green Economy Agreement with 17 initial projects

FUTURE OF A SUSTAINABLE DISTRIBUTED POWER SUPPLY

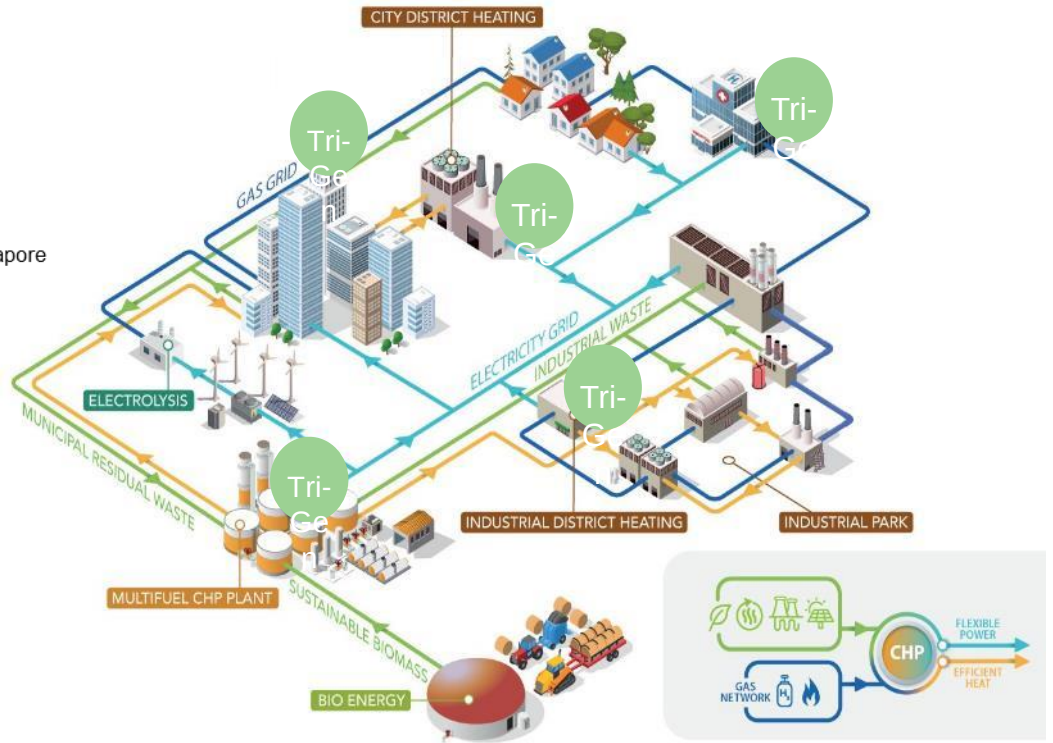
CHP/trigeneration ideal solution for providing dispatchable residual load

Integrated energy system with flexible H_2 injection into the existing gas grid





Deputy Prime Minister Lawrence Wong at the Singapore International Energy Week on Tuesday (Oct 25)

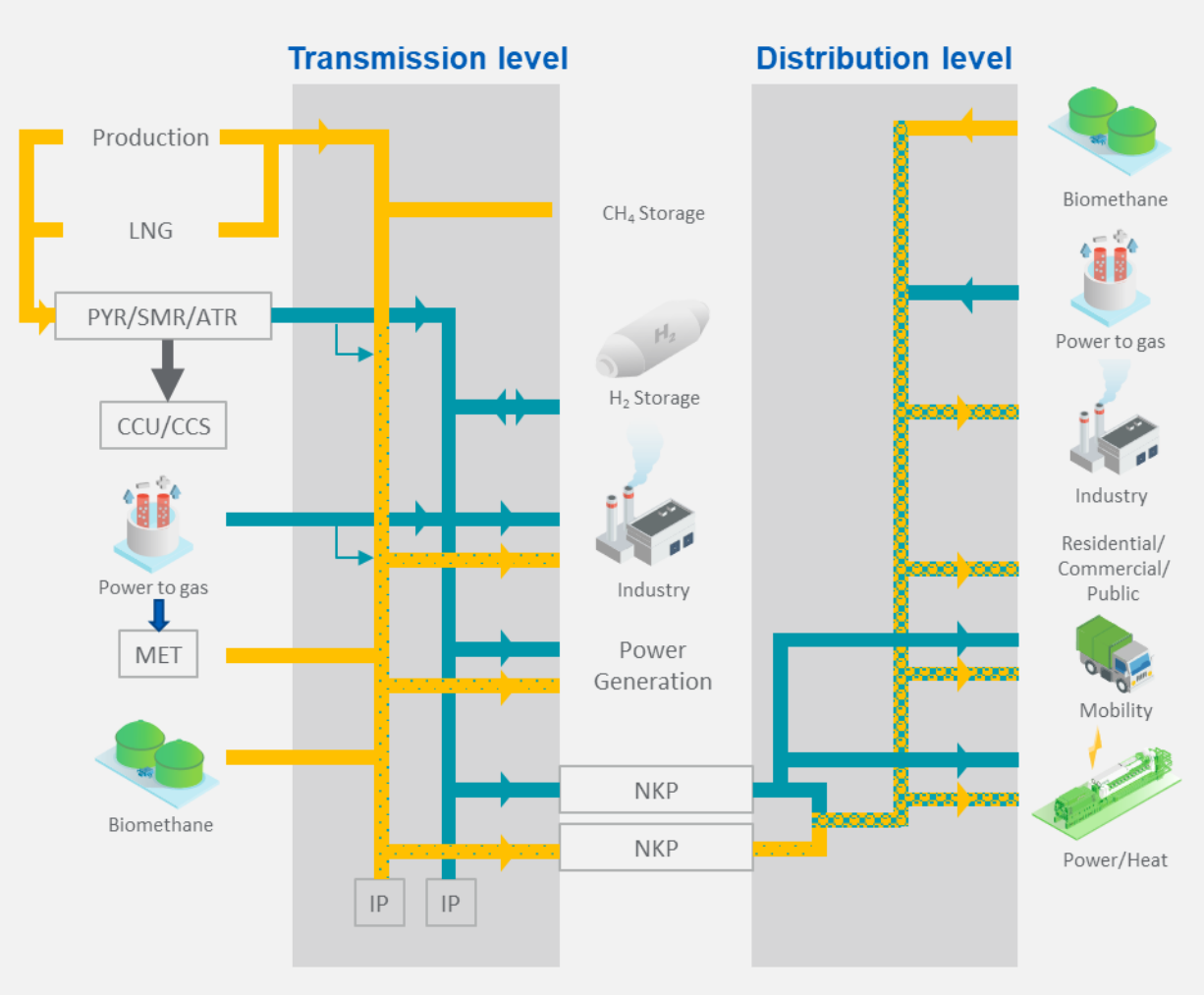


Source: https://www.visualcapitalist.com/

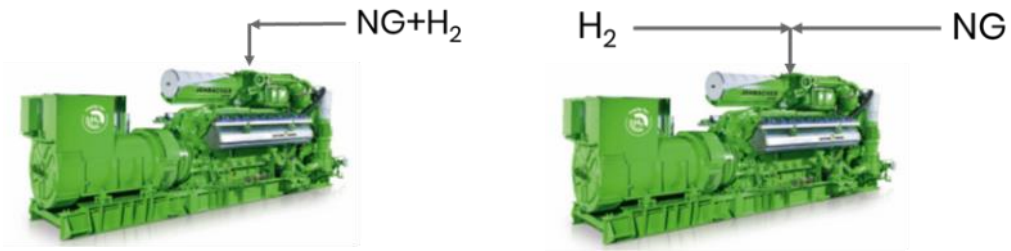
Southeast Asia is going green!

READY FOR HYDROGEN — BACKGROUND

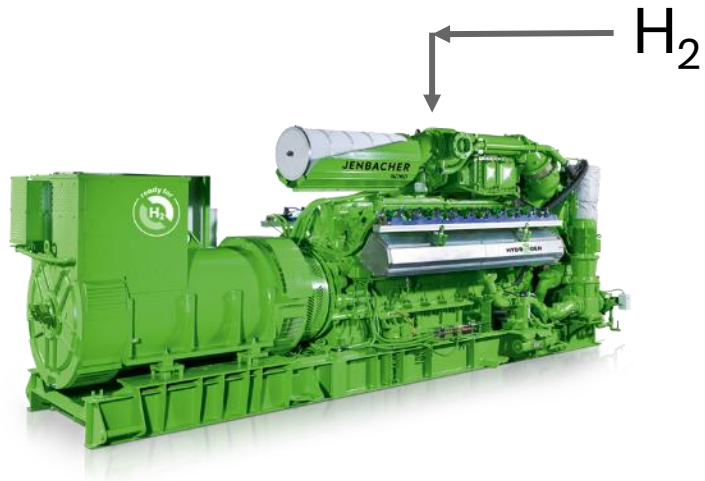
Hydrogen mixed with pipeline gas or provided through a dedicated hydrogen network



Short term



Longer term



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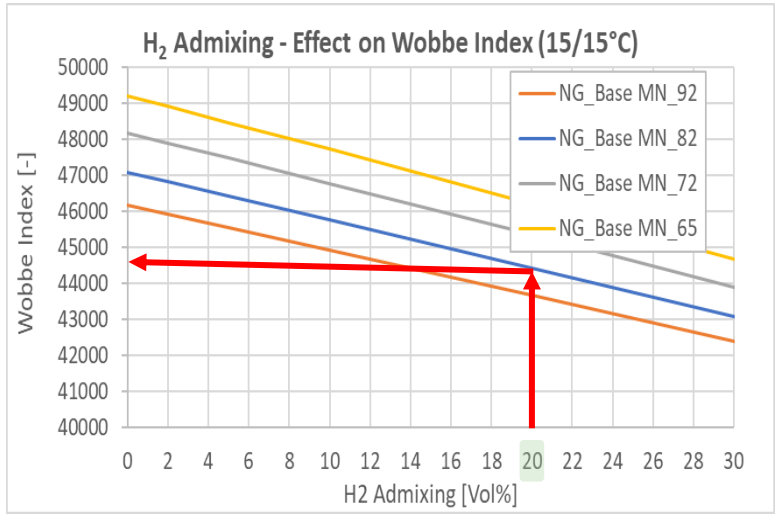
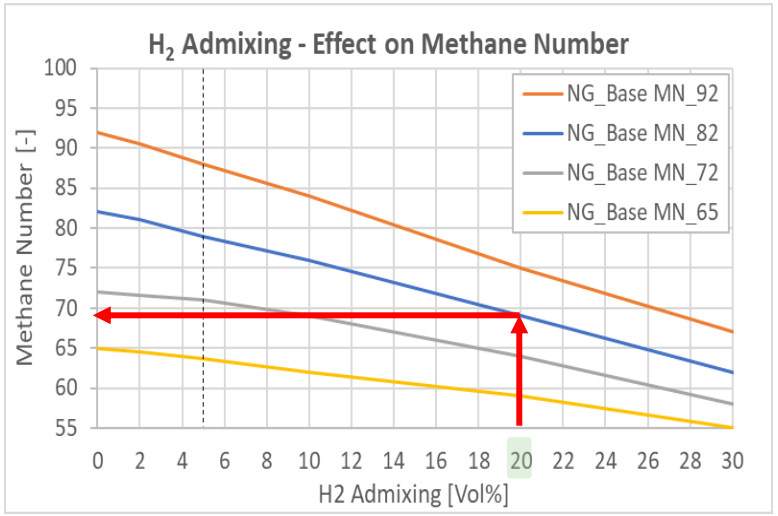
READY FOR HYDROGEN — BACKGROUND

Hydrogen mixed with pipeline gas or provided through a dedicated hydrogen network

H_2 Admixing-Effect on Wobbe Index

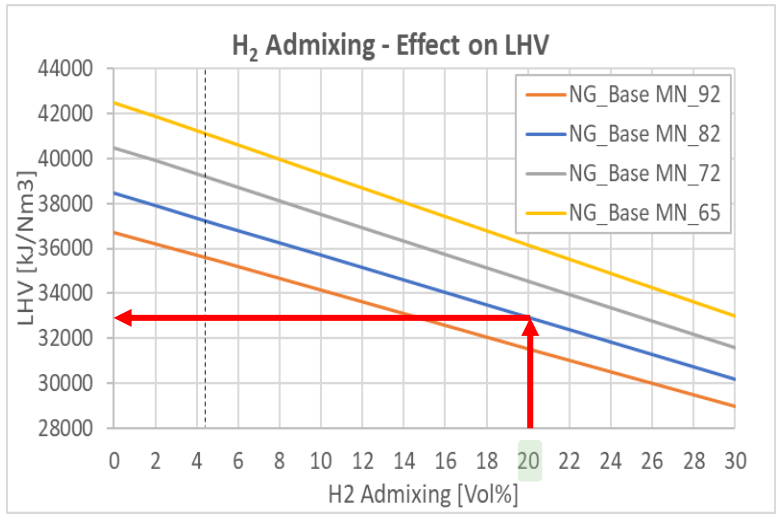


H_2 Admixing-Effect on Methane Number (MN)



20 Vol% H_2 -> **10-15 MN reduction**

H_2 Admixing-Effect on LHV



20 Vol% H_2 -> **~15% heating value**

INNIO: PROVEN EXPERIENCE WITH HYDROGEN MIXTURES & 100% H_2

Process gas (Krems)
COD 1996
>95% H_2 as fuel 4 x 200,000 oh

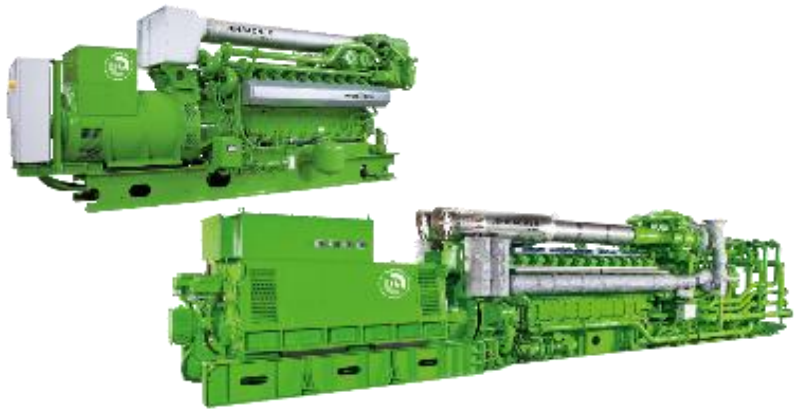
H_2: ~15-17% (vol)
CH_4: ~1.5% (vol)
LHV: ~0.5 kWh/m^3

Syngas (Mutsu)
COD 2003
CO_2 neutral

H_2: ~30-40% (vol)
CO: ~25-30% (vol)
LHV: ~2.5 kWh/m^3

Pipeline gas (Hychico)
COD 2008
Pipeline gas/H_2 mixture

H_2: ~0-42% (vol)
CH_4: ~100-58% (vol)
LHV: ~10-7 kWh/m^3



Pure hydrogen
2021+

H_2: <u>100% (vol)</u>
Pipeline gas or inserts
LHV: ~3 kWh/m^3

Commercial operation
(Challenges: gas quality variations)

Future

250+ MW installed with syngas/process gases, 90 projects, 28 countries

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H_2 ADMIXING DEMO PROJECTS

30% H_2

Bozen — Italy

J612, main fuel NG

30% H_2

Austria, 2008 Demo

J312, main fuel NG

42% H_2

Hychico — Argentina
Operating since 2008

J420, main fuel NG

60% H_2

Stuttgart, Germany

Shipped Q2/2020

J312, main fuel NG

up to 100% H_2

HanseWerk Natur — Hamburg
2020/2021 Demo

J416, main fuel NG

up to 100% H_2

Hyosung — Korea
Shipped Q3/2022

J420, main fuel H_2

60% H_2

Minato, Japan
01/2020 Demo

J312, main fuel NG

HYCHICO

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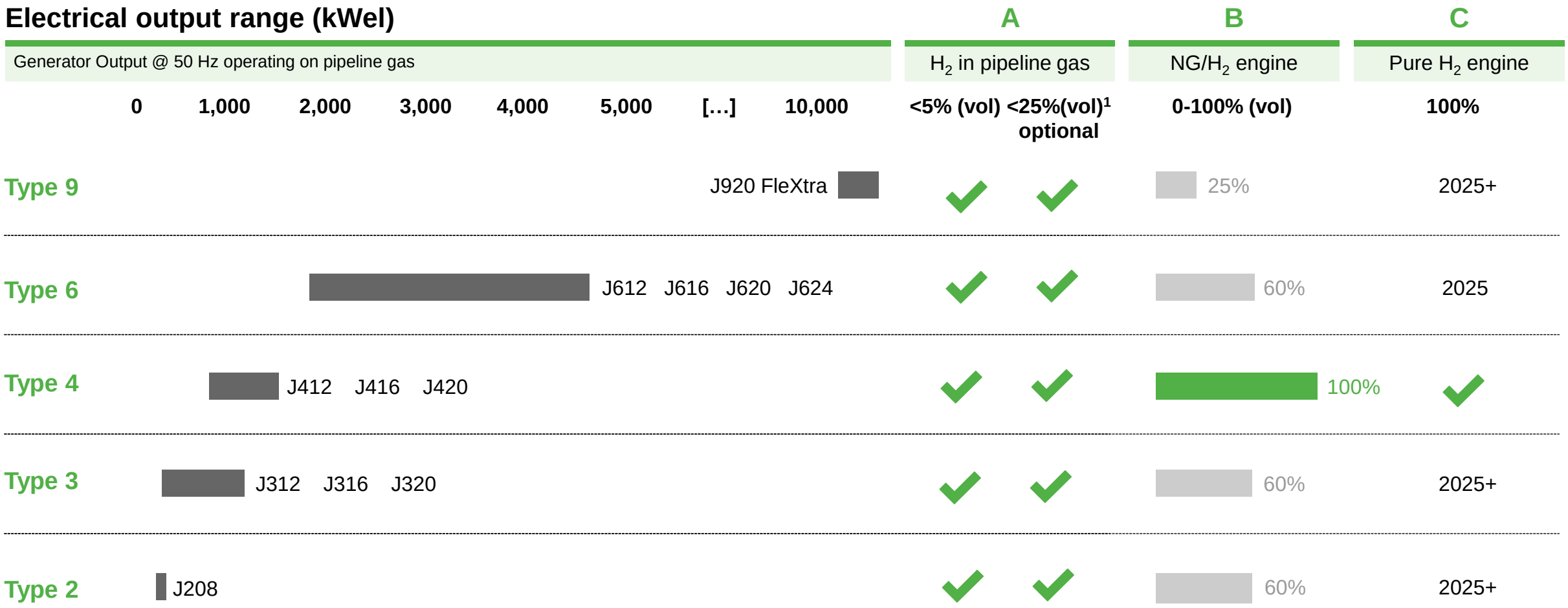
‘READY FOR HYDROGEN’

INNIO’s alternative H_2 Jenbacher product portfolio — available for today & the future (for 50 & 60 Hz)

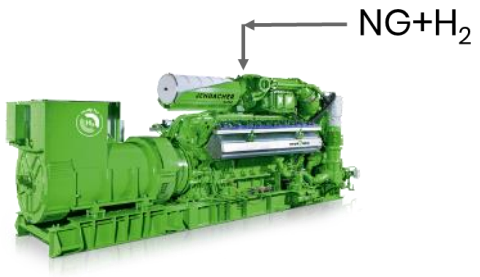


1) Subject to required modifications for the certification of the fuel gas components — a modification of the maintenance schedule for such components may be required

‘READY FOR H_2’ — JENBACHER CATEGORIZATION

A

H_2 in natural gas pipeline

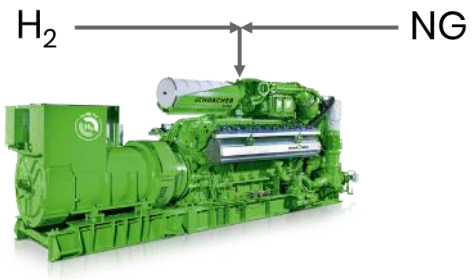


A-1: Low H_2 blending
no upgrade required
<5% (vol) H_2

A-2: Medium H_2 blending
minor upgrades required
5–25% (vol) H_2

B

H_2 local admixing

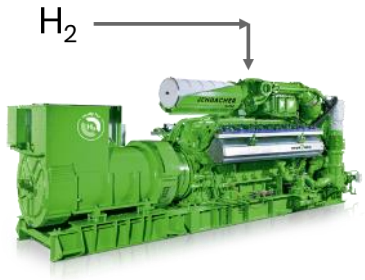


B-1: Special gas engine
dedicated product design
up to ~60% (vol) H_2

B-2: pipeline gas / H_2 engine
upgrades required
100% NG / 100% H_2

C

Pure H_2



C: H_2 engine
upgrades required
100% (vol) H_2

Traditional gas + H_2 fuel mixture boosted system

H_2 fuel injection system

no modifications required	existing versions available	existing versions available	special released engines	special released engines

H_2 ADMIXING IN TRADITIONAL GAS — VALIDATION AT INNIO'S HEADQUARTERS IN JENBACH

H_2 trailer station for supply to test beds

Validation purpose

Simulation of hydrogen content in traditional gas

H_2 trailer station for hydrogen supply

Investments in H_2 infrastructure in Jenbach for product development

H_2 VALIDATION AT INNIO'S HEADQUARTERS IN JENBACH

H_2 own production for supply to test beds

Jenbach, Austria – March 28, 2023

To convert green electricity to green hydrogen (H2) for its power-to-hydrogen-to-power project, INNIO has ordered two electrolyzers with a total capacity of 2 megawatts (MW) from H-TEC SYSTEMS. This represents a critical step in realizing the company's sustainable hydrogen product strategy as part of which all new Jenbacher plants are already "Ready for H2"** today. The entire Jenbacher engine product line is expected to be rolled out for 100% hydrogen operation as of 2025. At the same time, the supply of green hydrogen at the Jenbach site represents a milestone on the way to net zero operations on site.

Simulation of hydrogen content in traditional gas

- **Nominal load:** 1 MW
- **Hydrogen production:** 450 kg/d
- In the space of just one standard 40-foot container

https://www.h-tec.com/en/products/detail/h-tec-pem-electrolyser-me450/me450/

INNIO orders 2 electrolyzers for its hydrogen production

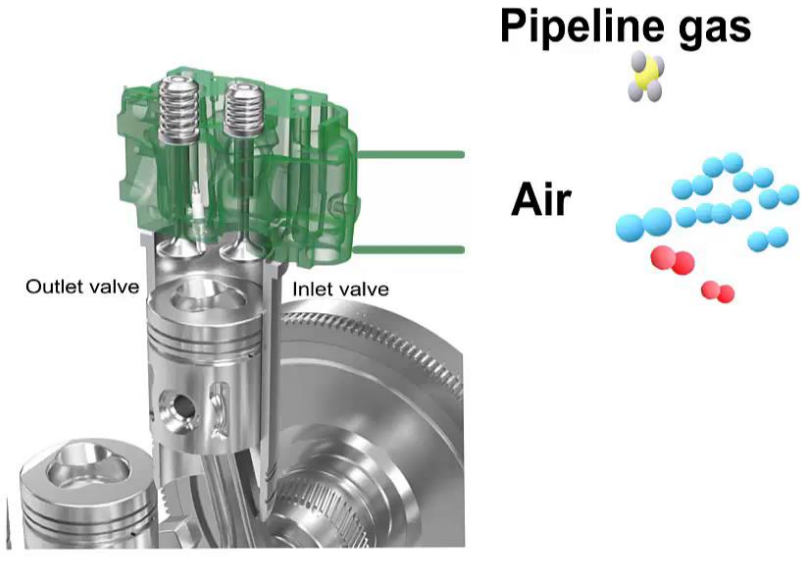
https://www.innio.com/en/news-media/press-releases/rapid-progress-on-installation-of-innio-s-hydrogen-production

Green Hydrogen out of Hydro Power Investments in H_2 infrastructure in Jenbach for product development

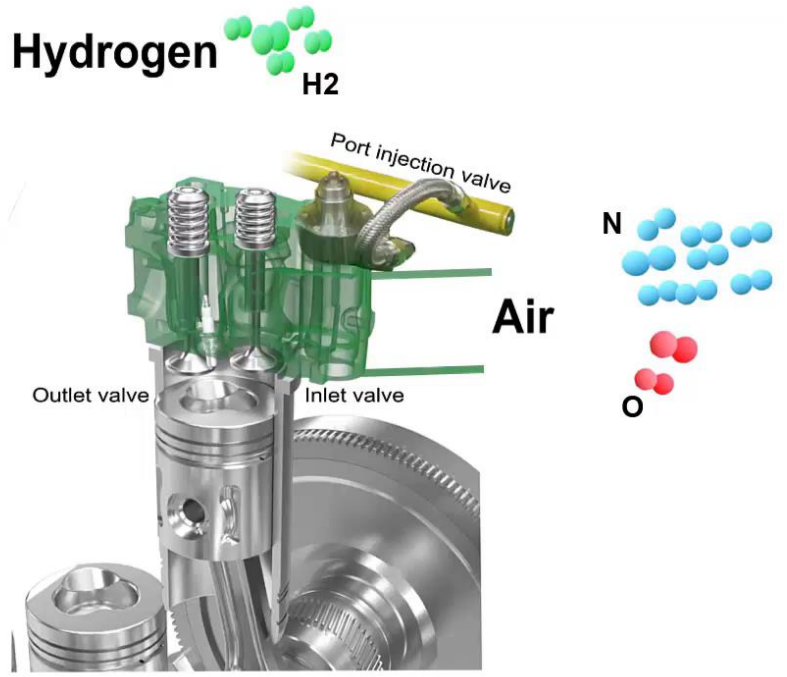
TRADITIONAL GAS VERSUS H_2 ENGINE TECHNOLOGY

What's the difference?

PIPELINE GAS ENGINE



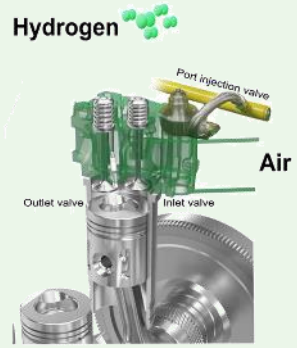
HYDROGEN ENGINE



HYOSUNG HEAVY INDUSTRIES: H2-ENGINE CHP

Ulsan, South Korea

J420	Pipeline gas	100% H_2
Electrical output	1,060 kW	1,060 kW**
Electrical efficiency	38.4%	~38.4%
Total efficiency	~89%	~85%
NOx emissions	<250 mg/Nm^3 @ 5% O_2	<100 mg/Nm^3 @ 5% O_2
CO_2 emissions	226 g/kWh$_{el}$	0 g/kWh$_{el}$
H_2 consumption		~83 kg/h



Largest 60 Hz H2-Engine CHP plant in Asia

Hydrogen as a byproduct from polypropylene production from Hyosung chemical

Hyosung heavy industry demonstrating the use of hydrogen for an IPP plant as an industrial CHP (with steam boiler)

H2-Engine installation and service provided by RNP, INNIO's authorized distributor for our Jenbacher brand

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INNIO360 Energy Lab

Ready for H_2

Hydrogen-ready projects

HYOSUNG HEAVY INDUSTRIES

100% hydrogen plant to be completed by Q4 2023

100% H_2

H_2 CHP plant

First H_2 reference in Korea

Hanse Werk Natur

100% hydrogen & natural gas dual fuel capability

100% H_2/natural gas dual fuel capabilities via retrofitting

Existing natural gas CHP plant converted

24/7 STADTWERKE KIEL

“Hydrogen commitment”

Committed to operate all 20 Jenbacher 10 MW engines on H_2

Plans to produce electricity & district heating carbon-neutral before 2040

Source: Company information

Potential admixing in the Philippines

Biogas sources

Capas, Tarlac
3x 1.0 MW JGS320, Biogas

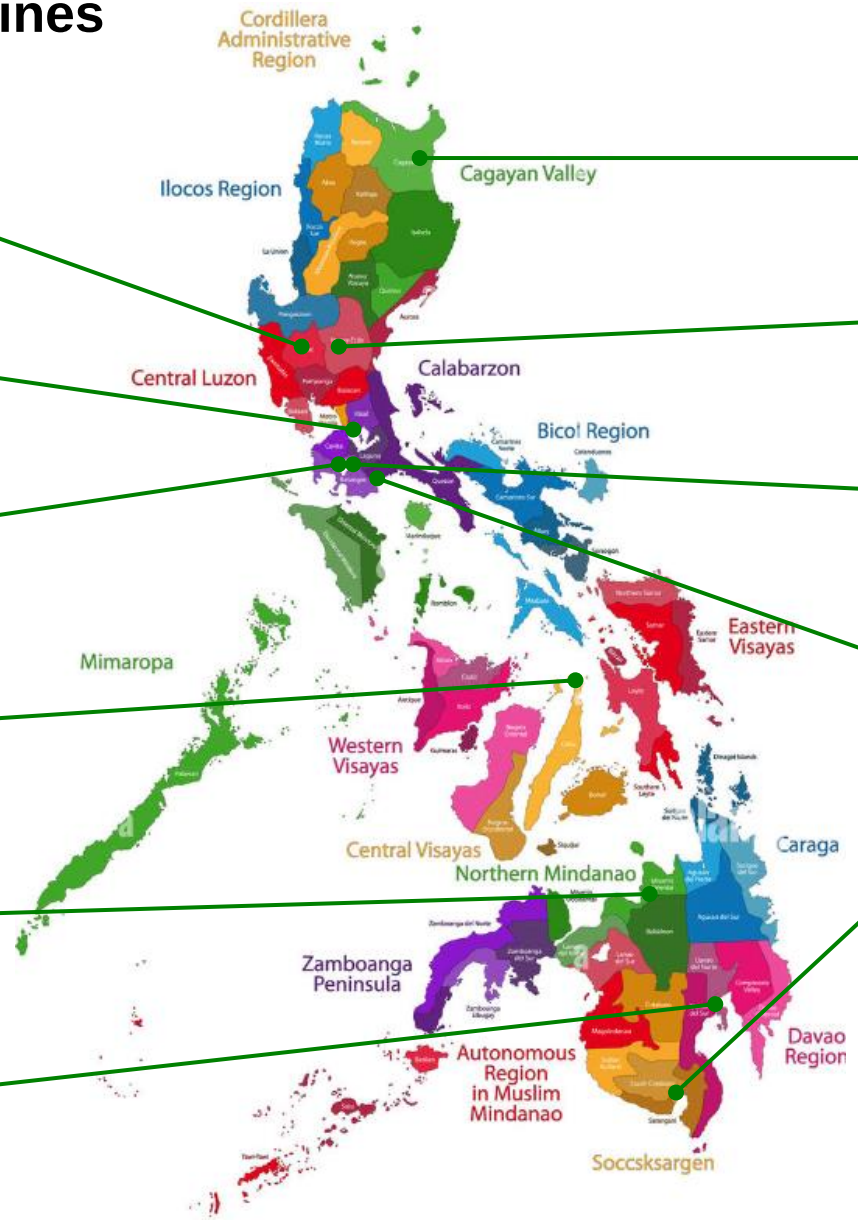
San Pedro, Laguna
4x 1.0 MW JGC320, Landfill Gas

Lian, Batangas
4x 1.4 MW JGS420 and
3x 1.0 MW JGS320, Biogas

Bantayan Island
1x 0.6 MW JMC312 CHP, Biogas

Cagayan de Oro
2x 1.4 MW JMC 420 CHP, Biogas
1x 1.0 MW JGC 320, Biogas

Davao
1x 0.6 MW JMC312, CHP, Biogas



Isabela
3x 1.0 MW JMS320 CHP, Biogas

Bulacan
2x 0.5 MW JGS312, Biogas

Batangas
1x 0.6 MW JMC312, CHP, Biogas

Quezon
1x 1.4 MW JGC420, CHP, Biogas

South Cotabato
2x 1.0 MW JMC320, CHP, Biogas
6x 1.4 MW JMS420, CHP, Biogas

Total: 34 units (38.4 MW)

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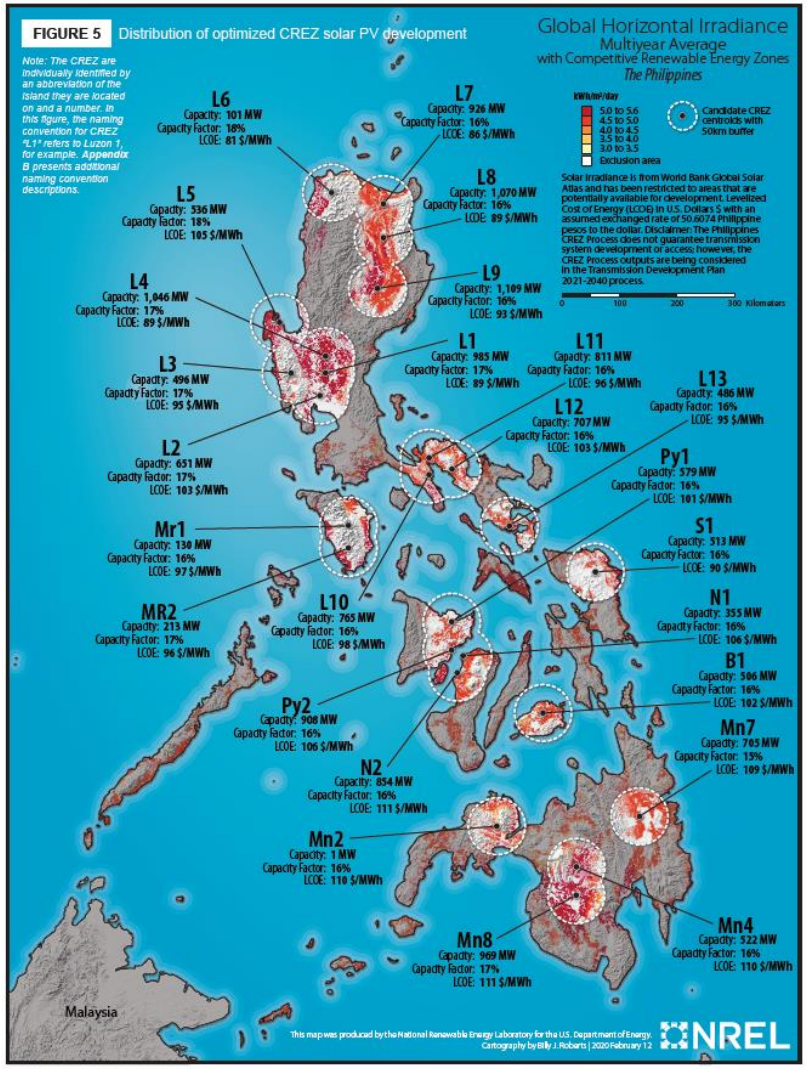
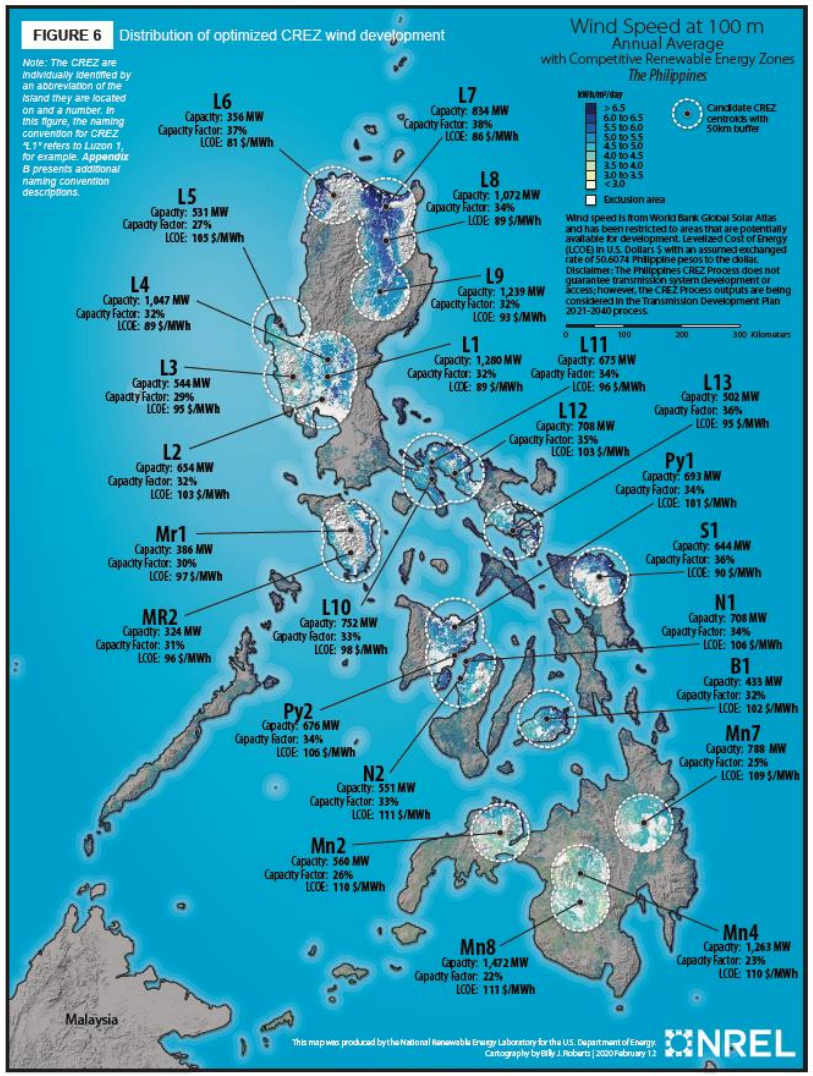
Source: Company Information

Potential H2 sources from Renewables in the Philippines

Solar PV



Wind Farm



Source: Ready for Renewables – Grid Planning and Competitive Renewable Energy Zones (CREZ) in the Philippines, NREL 2020.

SUMMARY
Energy Transition in APAC

Energy Transition is a Marathon, not a Sprint

The transition from hydrocarbons to clean fuels becomes viable only with explicit business incentives.

Necessary clean fuel support can be ensured through strategic energy policies, tax reforms, and incentives, enabling decarbonization within the industry and power sectors.

Rapid installation of electrolysis capacities in regions abundant in wind, photovoltaic, hydro, and geothermal power is imperative.

Source: www.techwireasia.com/2022/04/singapore-data-centres/

THANK YOU VERY MUCH!

INNIO is ready to develop powerful energy solutions for your application

Reach out today by completing the form online: innio.com/contact

Our Sales contact will follow up with you.

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INNIO is a leading energy solution and service provider that empowers industries and communities to make sustainable energy work today. With our product brands Jenbacher and Waukesha and our digital platform myPlant, we offer innovative solutions for the power generation and compression segments that help industries and communities generate and manage energy sustainably while navigating the fast-changing landscape of traditional and green energy sources. INNIO is individual in scope, but global in scale. With our flexible, scalable, and resilient energy solutions and services, we enable our customers to manage the energy transition along the energy value chain wherever they are in their transition journey.

INNIO is headquartered in Jenbach (Austria), with other primary operations in Waukesha (Wisconsin, U.S.) and Welland (Ontario, Canada). A team of more than 4,000 experts provides life-cycle support to the more than 55,000 delivered engines globally through a service network in more than 100 countries.

INNIO's improved ESG Risk Rating again secures the number one position across more than 500 companies globally in the machinery industry assessed by Sustainalytics.

For more information, visit INNIO's website at **www.innio.com**

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In general, "Ready for H2" Jenbacher units can be converted to operate on up to 100% hydrogen in the future. Details on the cost and timeline for a future conversion may vary and need to be clarified individually.

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