Power-to-Gas

U.S. Department of Energy Electricity Advisory Committee

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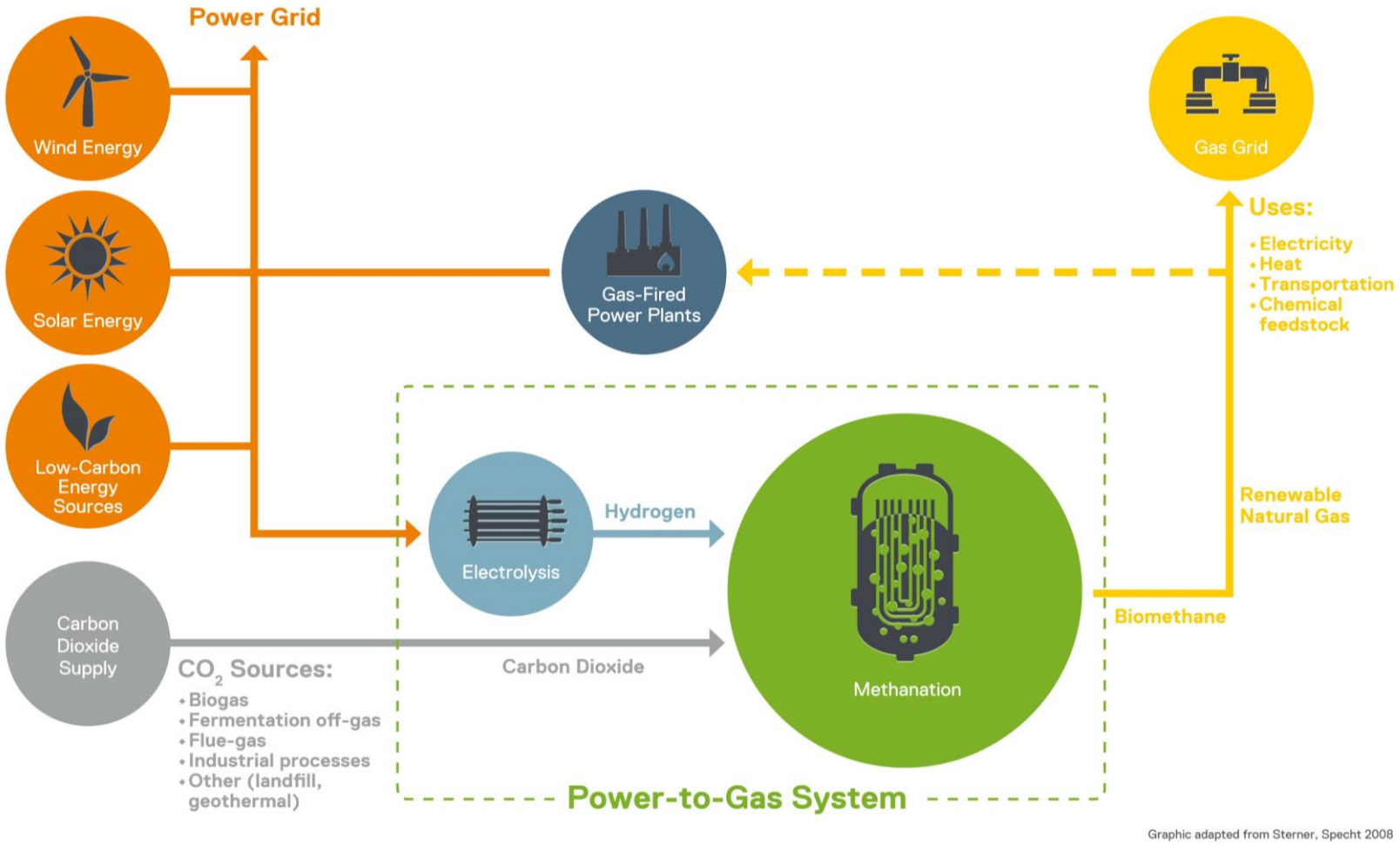
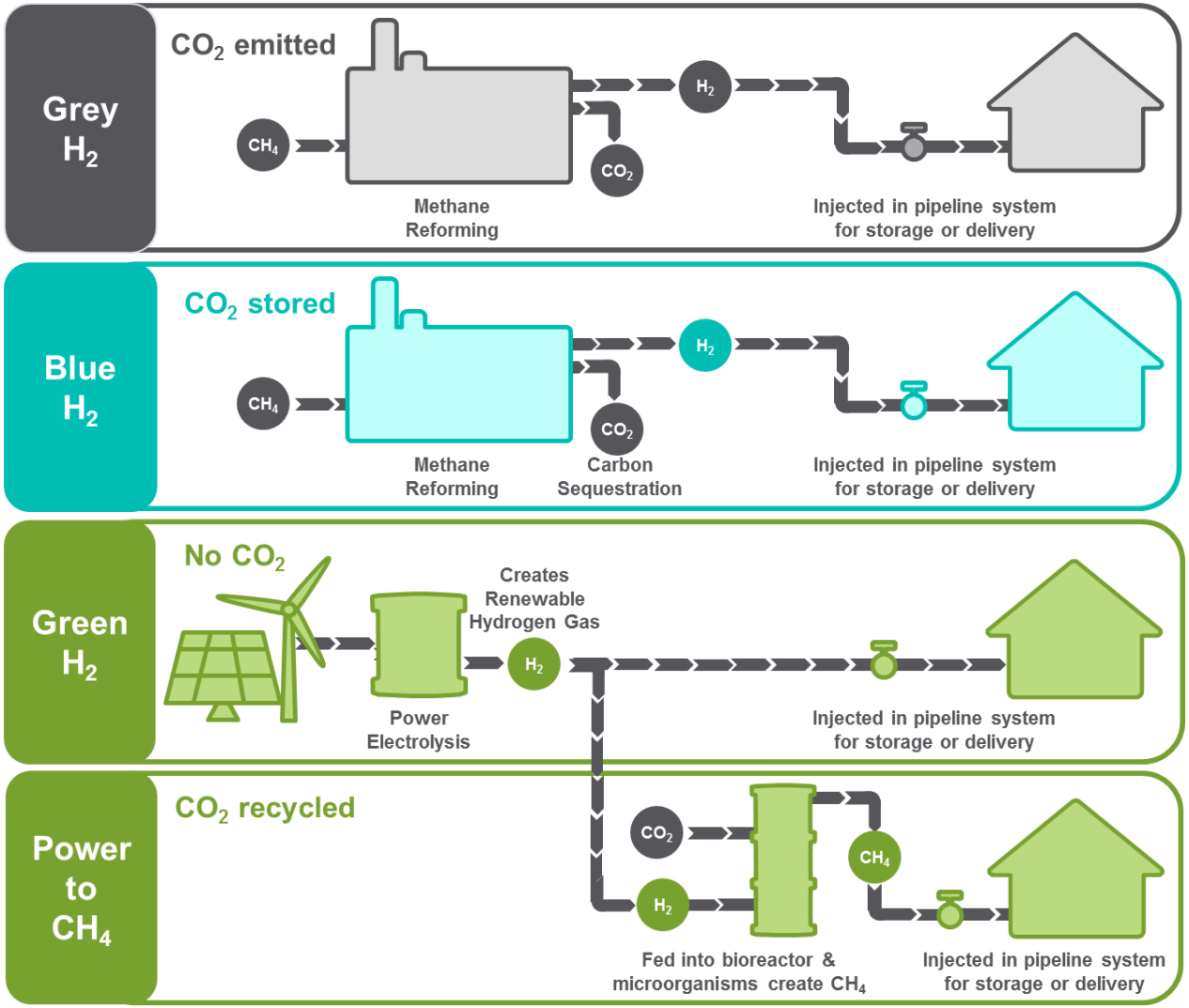
What is Power-to-Gas?

- **The conversion of renewable electricity into a gas fuel through electrolysis produces H_2 and can be methanated to produce CH_4**



Graphic adapted from Sterner, Specht 2008

Hydrogen sources and pathways



Efficiency, % Energy Conversion	Carbon Intensity, gCO_2e/MJ
75-90%	110
75-90%	< 20
57-73%	~ 0
50-64%	~ 0

Rough Estimates

CI based on NREL 2013 H2 Pathways Paper
Green H2 and P2M conversions from SoCalGas 2015

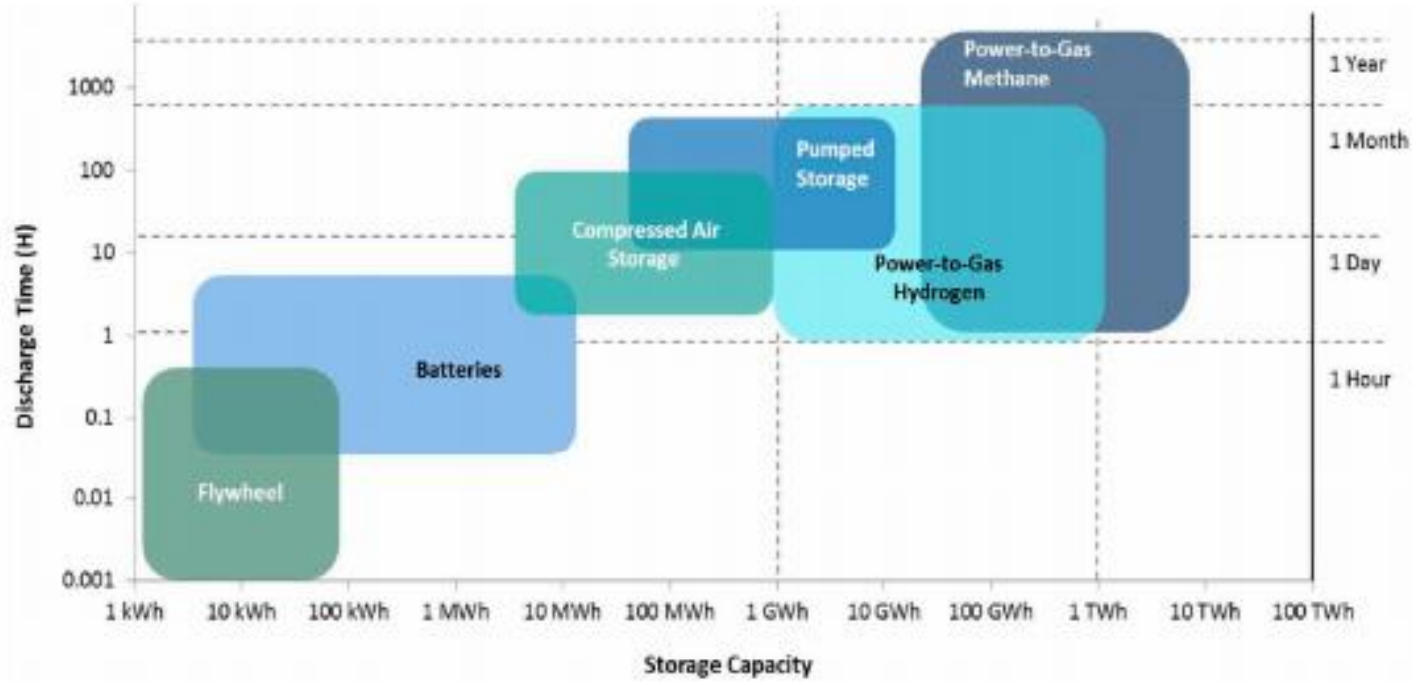
Green hydrogen via power-to-gas can provide long-term seasonal energy storage

Benefits of Green H2 / P2G

- Enables higher penetration of renewables like offshore wind by providing long-term, seasonal storage

Additional Benefits of Methanation

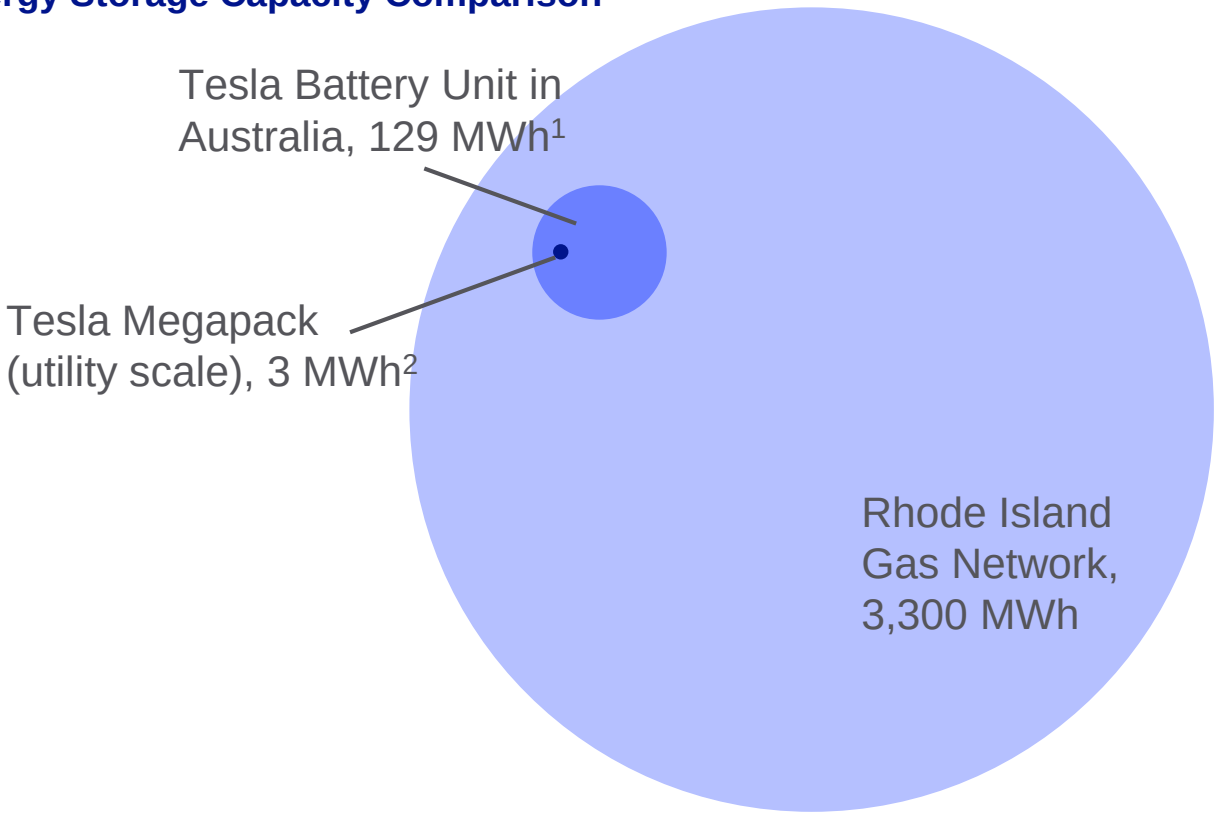
- Recycles CO_2
- Requires no modifications to standards, procedures, or equipment



Source: Moore and Shabani, energies 2016

The gas network is a high capacity battery, serving variable demand and providing potential outlet for excess renewables

Energy Storage Capacity Comparison

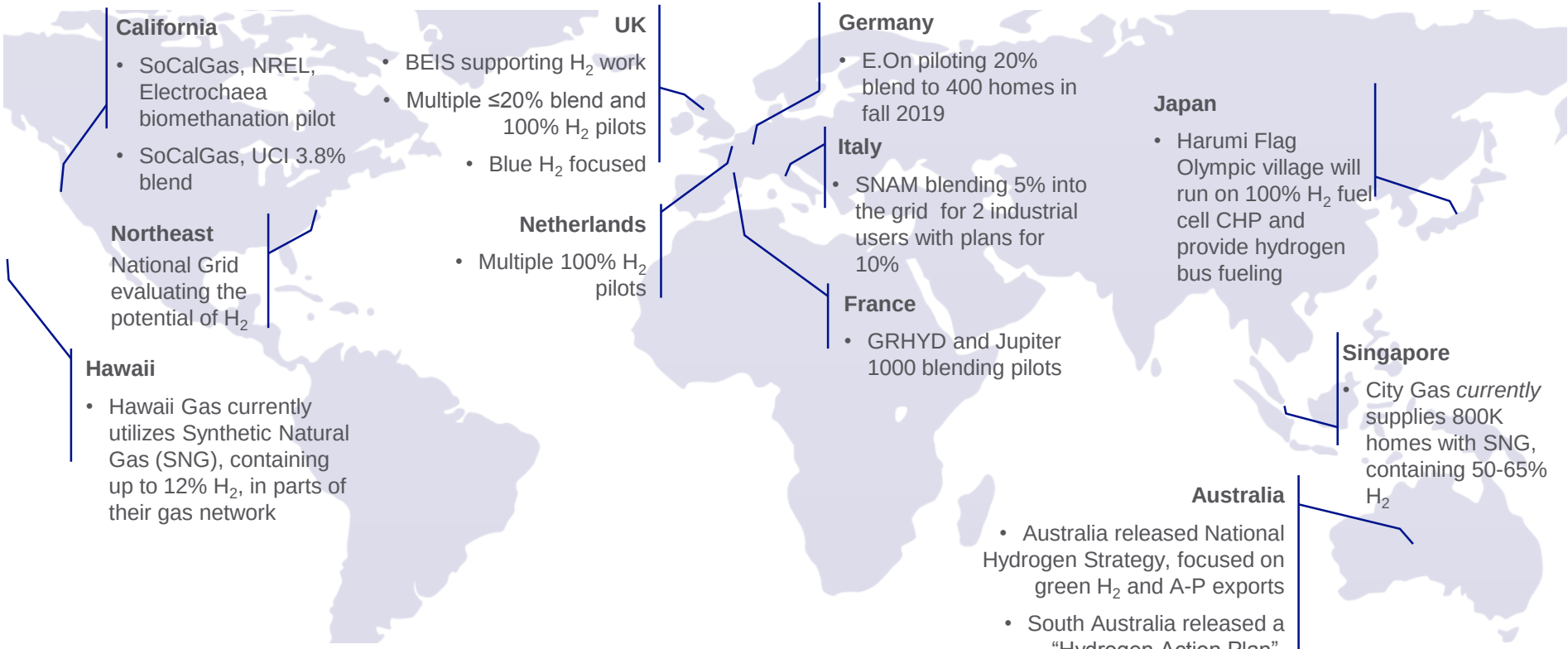


For example, Rhode Island's gas network can store ~25x the energy as Tesla's groundbreaking lithium ion unit in Australia

[1] *"The Verge, July 2019.*
[2] *Tesla, July 2019.*

Hydrogen for heat investments are increasing; these case studies will provide insight into the characteristics of successful deployment

Hydrogen for Heat Snapshot, Across the Globe



California

- SoCalGas, NREL, Electrochaea biomethanation pilot
- SoCalGas, UCI 3.8% blend

Northeast

National Grid evaluating the potential of H_2

Hawaii

- Hawaii Gas currently utilizes Synthetic Natural Gas (SNG), containing up to 12% H_2, in parts of their gas network

UK

- BEIS supporting H_2 work
- Multiple ≤20% blend and 100% H_2 pilots
- Blue H_2 focused

Netherlands

- Multiple 100% H_2 pilots

Germany

- E.On piloting 20% blend to 400 homes in fall 2019

Italy

- SNAM blending 5% into the grid for 2 industrial users with plans for 10%

France

- GRHYD and Jupiter 1000 blending pilots

Japan

- Harumi Flag Olympic village will run on 100% H_2 fuel cell CHP and provide hydrogen bus fueling

Singapore

- City Gas *currently* supplies 800K homes with SNG, containing 50-65% H_2

Australia

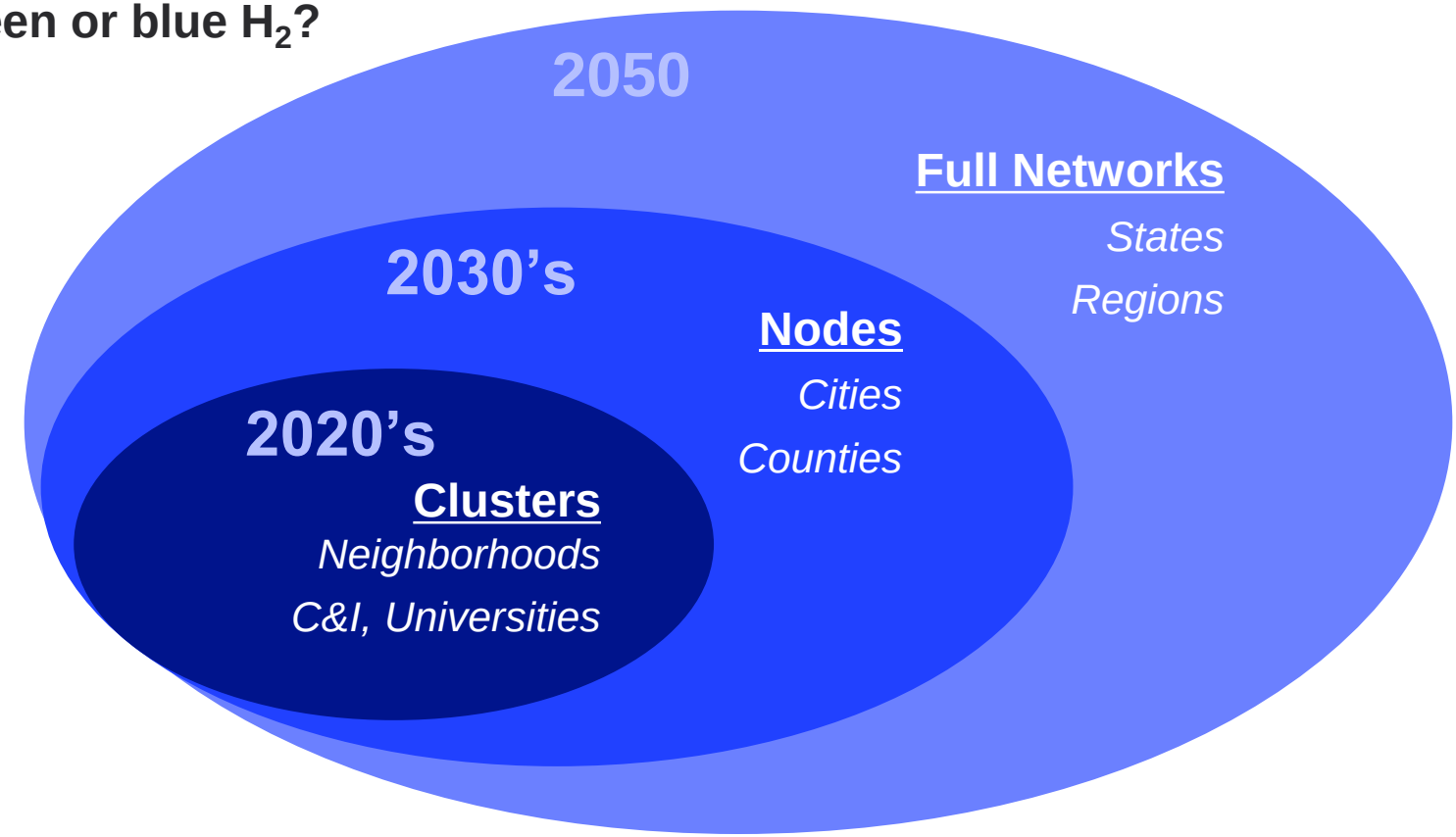
- Australia released National Hydrogen Strategy, focused on green H_2 and A-P exports
- South Australia released a "Hydrogen Action Plan", including 5% network blend demo

Map image from Icon Library: https://icon-library.net/icon/global-map-icon-11.html

Our current thinking of integrating hydrogen in the gas network

Staged Roll-out of Hydrogen into the Network, *Illustrative Example*

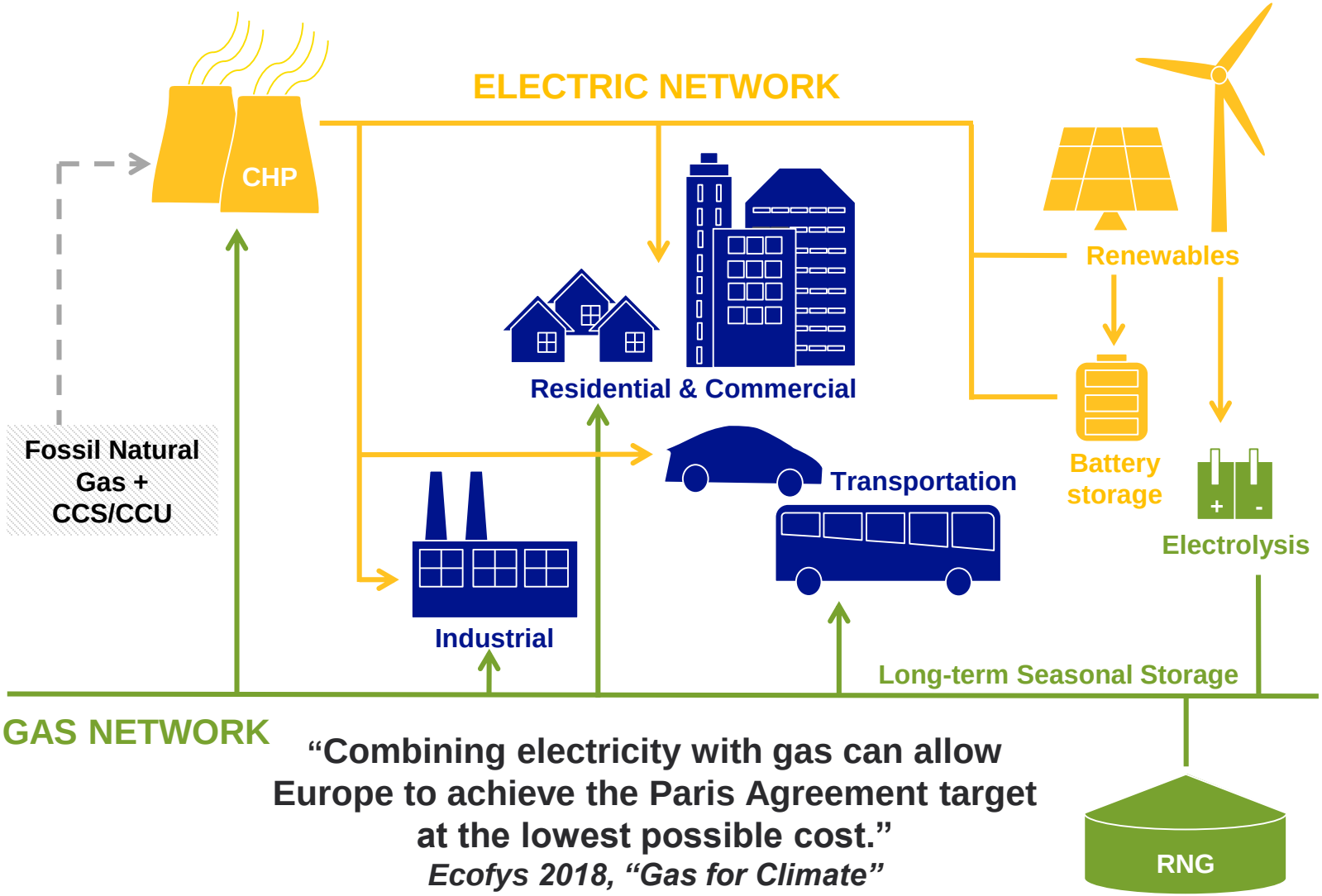
Green or blue H_2?



Blended H_2 & biomethane/RNG or 100% H_2?

Our vision – a holistic energy system

A deeply decarbonized gas & electric system is integrated & complementary



"Combining electricity with gas can allow Europe to achieve the Paris Agreement target at the lowest possible cost."

Ecofys 2018, "Gas for Climate"

Three significant hurdles to achieve the vision

1. Supportive policy and regulatory framework

- Policy has focused on transportation and generation sector, needs to include heat.

2. System integration

- Interconnection and other technical engineering issues

3. Education

- Lack of awareness

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