Hydrogen Derivates Analysis

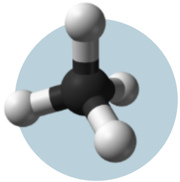
Zooming in on Synthetic Methane (SNG)
EXECUTIVE SUMMARY

July 2024, EMBARGOED

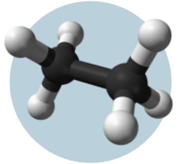
Future Cleantech Architects

Regardless of the Production Pathway, Both Fuels Have a Significant Climate Impact Due to the High Global Warming Potential (GWP) of Methane

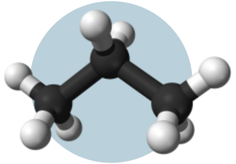
Natural Gas



Methane



Ethane



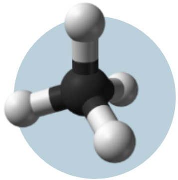
Propane

Composition: Mostly methane (CH_4), and light hydrocarbons, such as ethane and propane.

Production: Fossil fuel extracted from underground reservoirs.

Climate impact: Fossil carbon released on combustion, plus methane is a potent greenhouse gas
(GWP 80 over a 20-year period).

Synthetic Methane (SNG)



Methane

Composition: Methane (CH_4), natural gas drop-in fuel option.

Production: Synthetized from hydrogen and carbon dioxide (methanation).

Climate impact: Depends on source of carbon and hydrogen, plus methane is a potent greenhouse gas
(GWP 80 over a 20-year period).

Source: CATF, US EPA.

#1: SNG in the big picture of solutions

The SNG pathway is **an inefficient and energy-intensive option** when compared to other decarbonization options.

Moreover, it comes with **significant risks in climate integrity** and its presumed **cost advantage strongly depends on subsidy schemes**.

#2: Risks of investing in SNG

Two key risks come with betting on an SNG pathway, in particular for European economies:

1) An **increase in energy import dependence**
2) Binding valuable taxpayer **resources to a non-transformational pathway**

#3: SNG's potential future role

While there could be future, niche applications for SNG, in our view, these would follow comprehensive electrification.

We expect those applications in fields like high-temperature heat (e.g., steel), should biomethane supply be insufficient.

Derivative #1:
Zooming in on Synthetic Methane (SNG)

Carbon Sourcing and Accounting | Climate Merits and Risks

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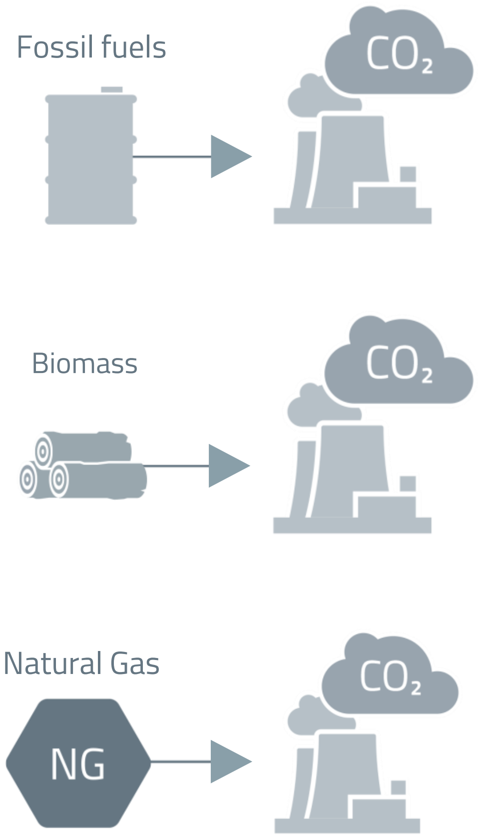
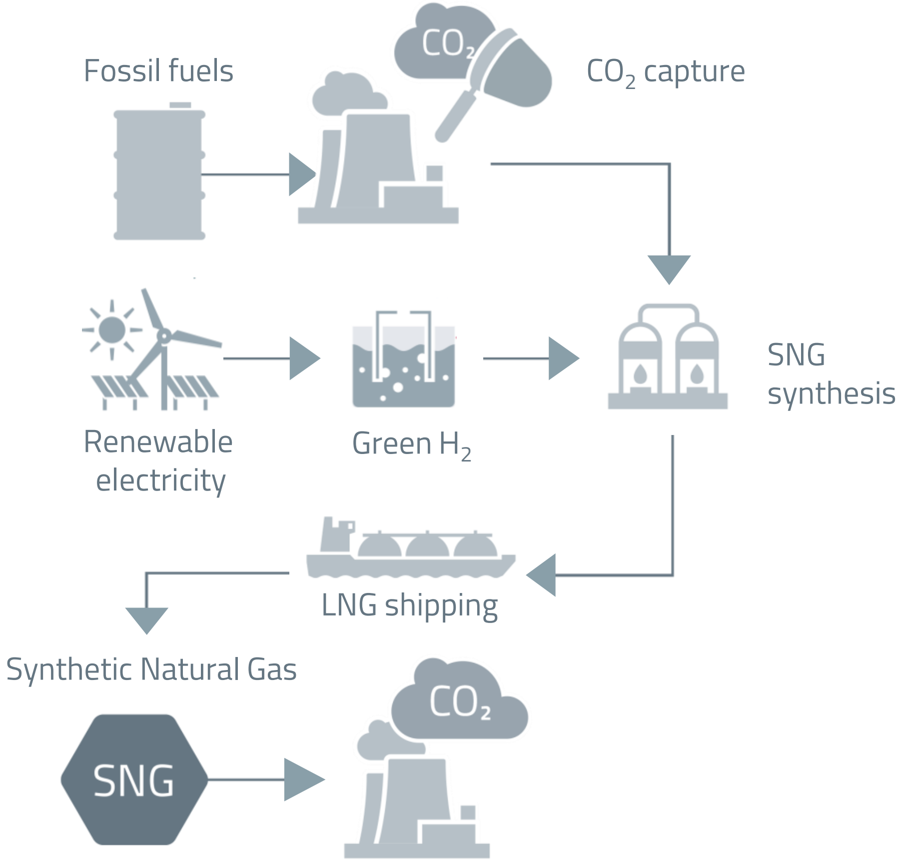
Conventional Economy



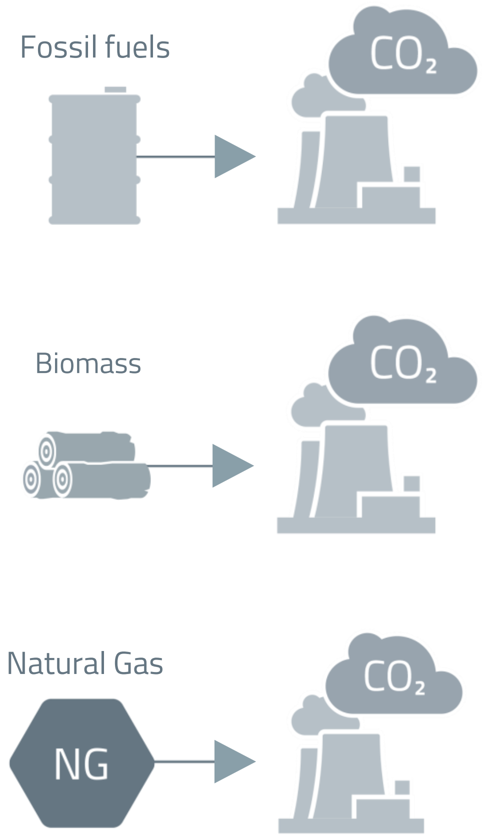
CO_2 emissions from all plants

1. Fossil Carbon Capture and Utilization



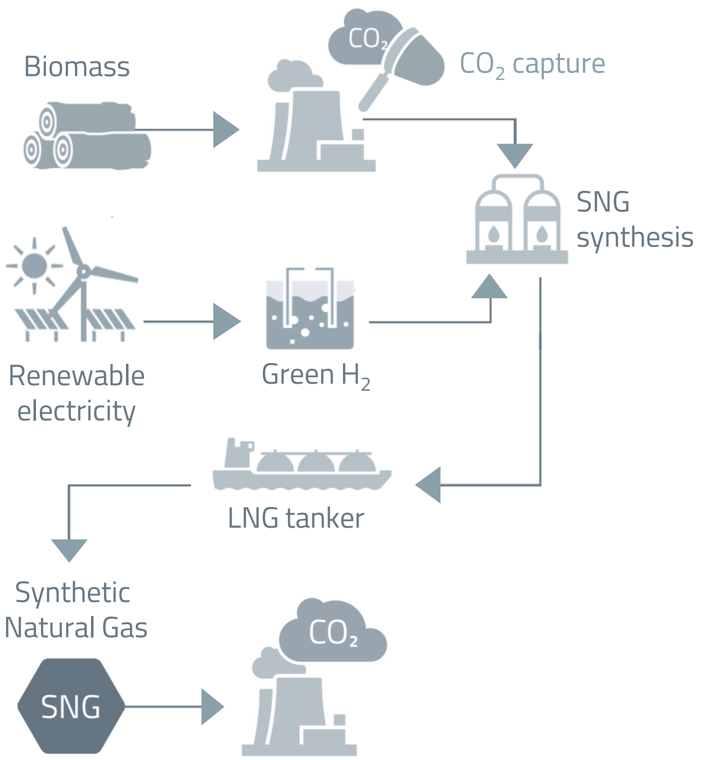
CO_2 shared between two plants
But who gets the credits?

Conventional Economy



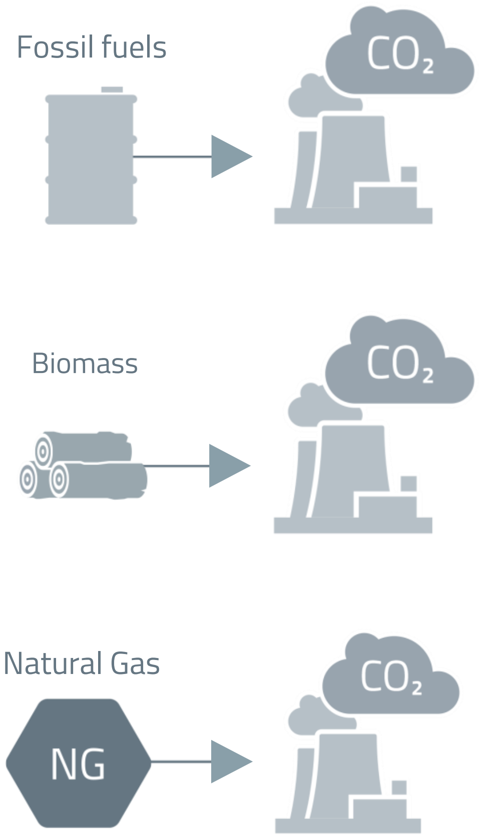
CO_2 emissions from all plants

2. Biogenic Carbon Capture and Utilization



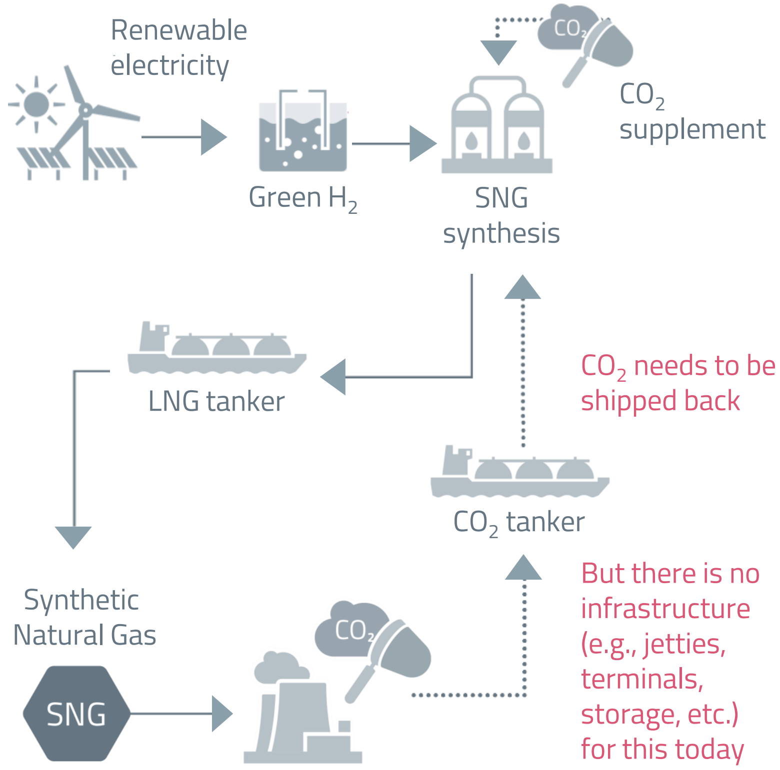
Carbon neutral in theory but methane leakage remains an issue (see also following slides)

Conventional Economy



CO_2 emissions from all plants

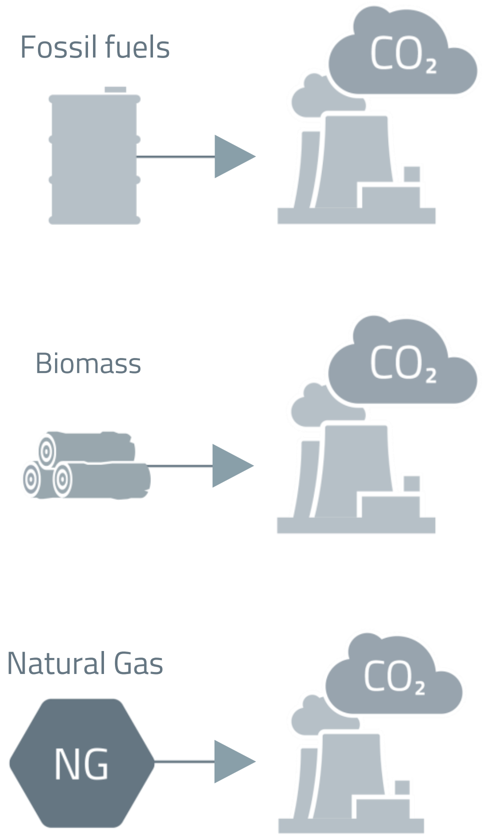
3. Carbon Capture and Utilization – Quasi-Closed Loop



Carbon-neutral in name only:

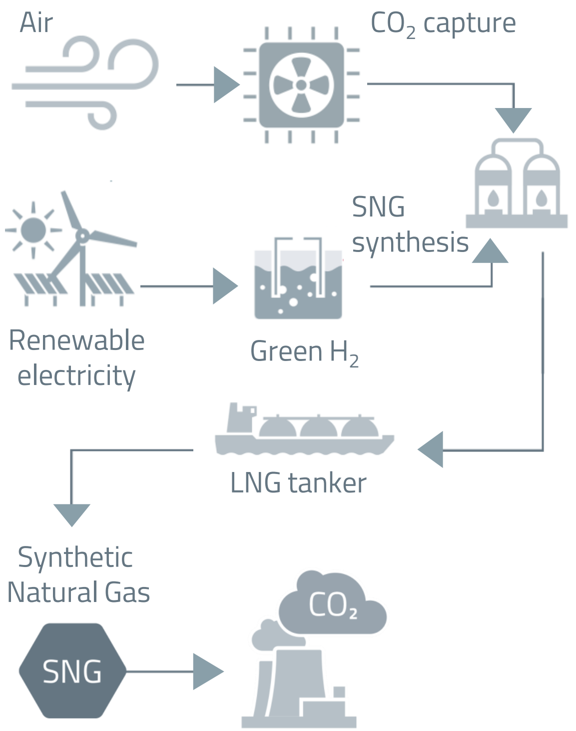
- Capture rates are never 100%
- Would need to be supplemented by CO_2 captured elsewhere (biogenic, fossil, DAC)

Conventional Economy

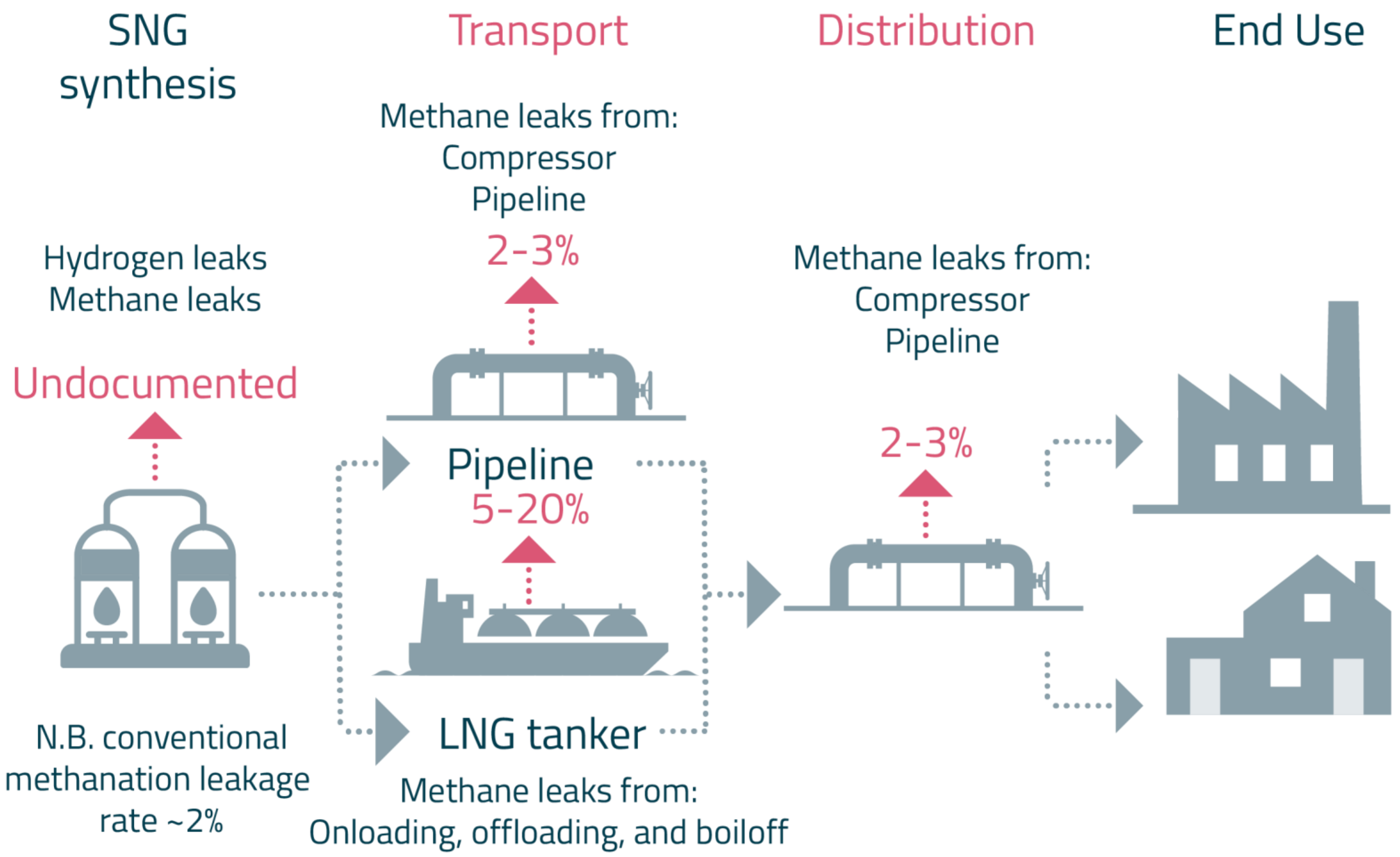


CO_2 emissions from all plants

4. Direct Air Capture



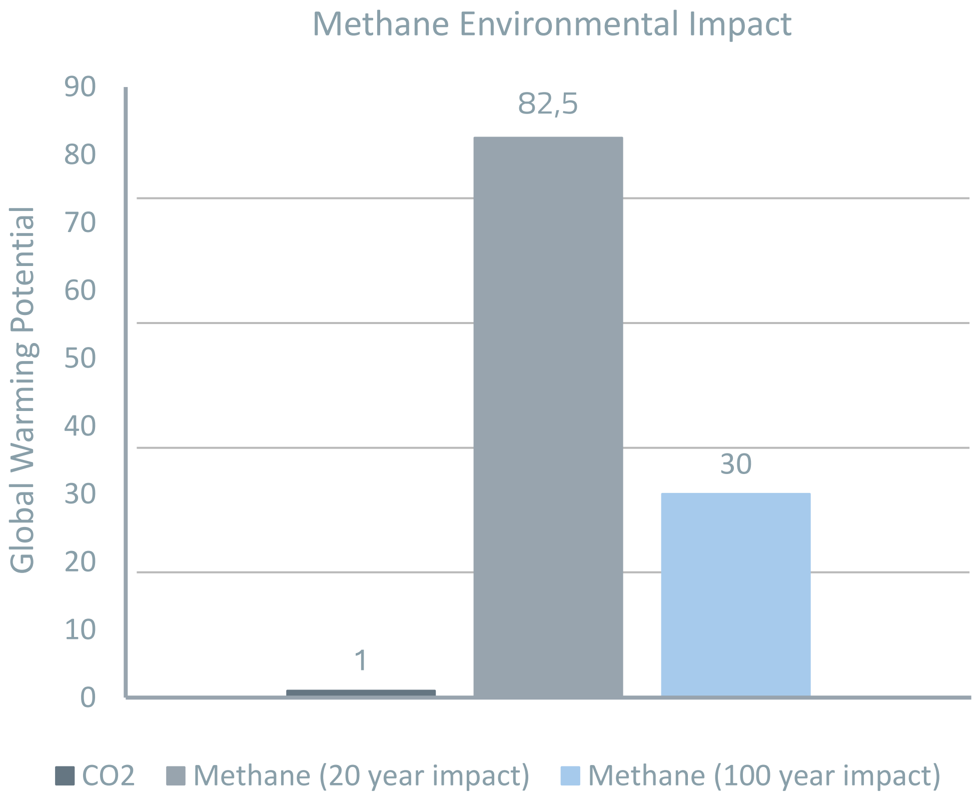
Net-zero CO_2 emissions (on paper), yet the **most expensive and energy-intensive option**



Transport and distribution leakages are based on reported rates across the US and Europe.
Leakage data is poor. Rates change based on location, distance, and regulation.

Source: CATF, US EPA, McKain et al., Ladage et al.

- The global warming potential **(GWP) of methane is 30 over 100 years** and 82.5 over 20 years.
- **Leakages of merely 2%** (the current average across the US pipeline network) **lead to 70 gCO_{2eq}/kWh_{el}**,which is 2-6 times higher than solar or wind or nuclear.
- Therefore, **SNG cannot be considered carbon-neutral**.
- There is scientific consensus that official estimates of leakage rates are poorly measured and probably too low, further adding to the climate risk.
- Methane is responsible for 0.5°C of global warming.



Source: data from IPCC, CATF, Ladage et al, Alvarez et al; analysis by FCA

The SNG Process and Its Efficiency: What Do We Need to Produce SNG and How Does the Process Compare?

SNG vs. Electrification Efficiency in Downstream Sectors

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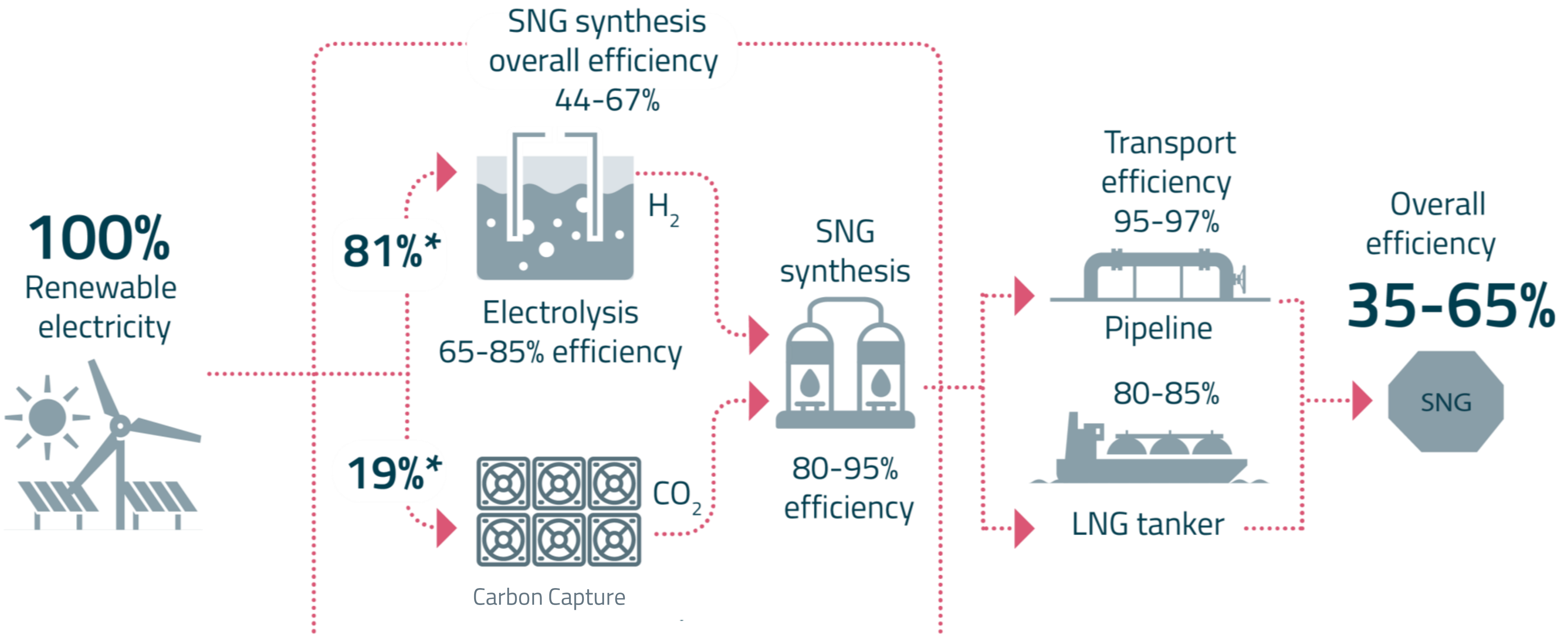
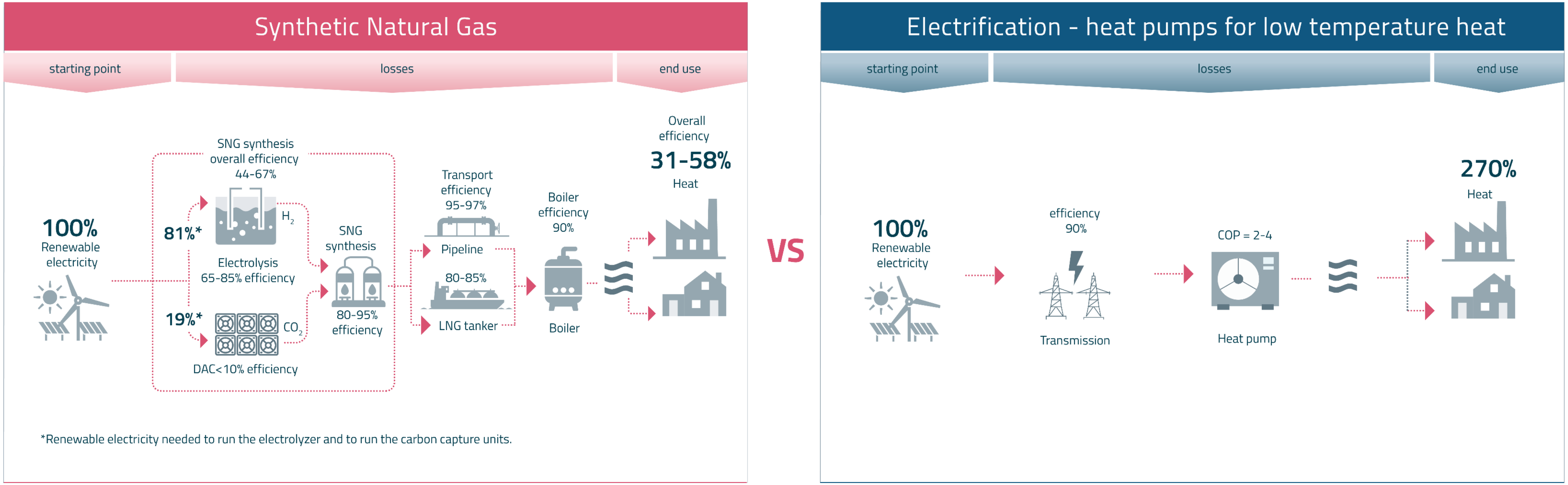


*Renewable electricity needed to run the electrolyzer and to run the carbon capture units.

For every five units of renewable energy used in the SNG production process, more than three units are not recovered due to the process efficiency. Losses stem mostly from generating green hydrogen.

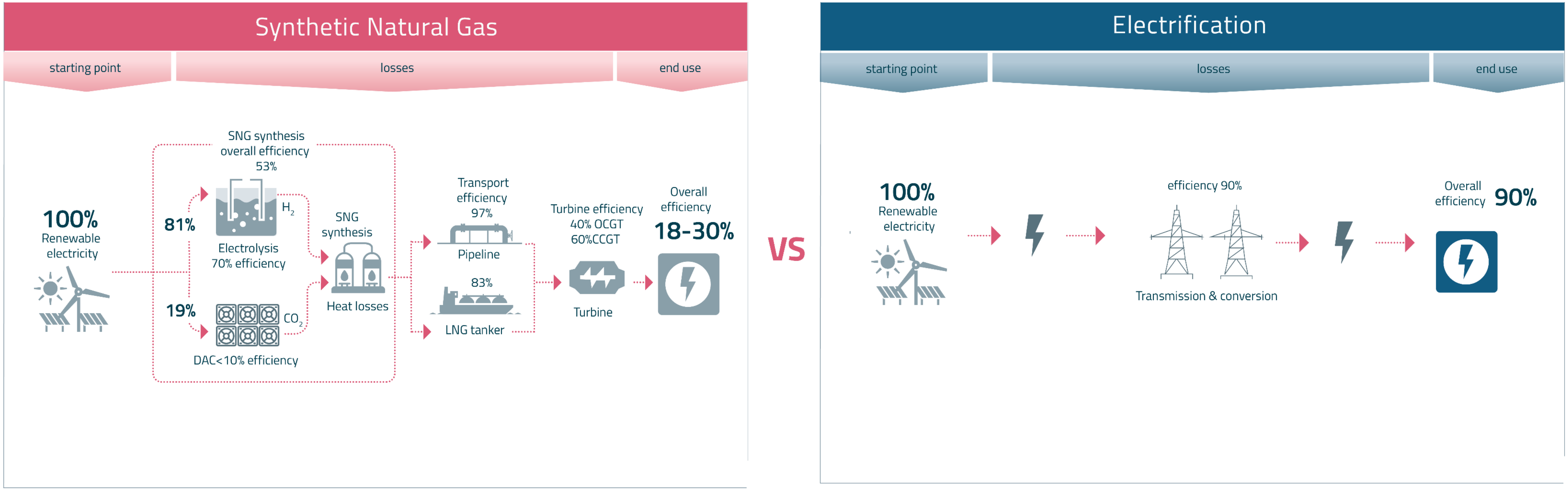
Source: CATF, US EPA, Tabkhi et al 2010 , FCA

Electricity Generation vs. SNG: An Efficiency Comparison to Generate Heat



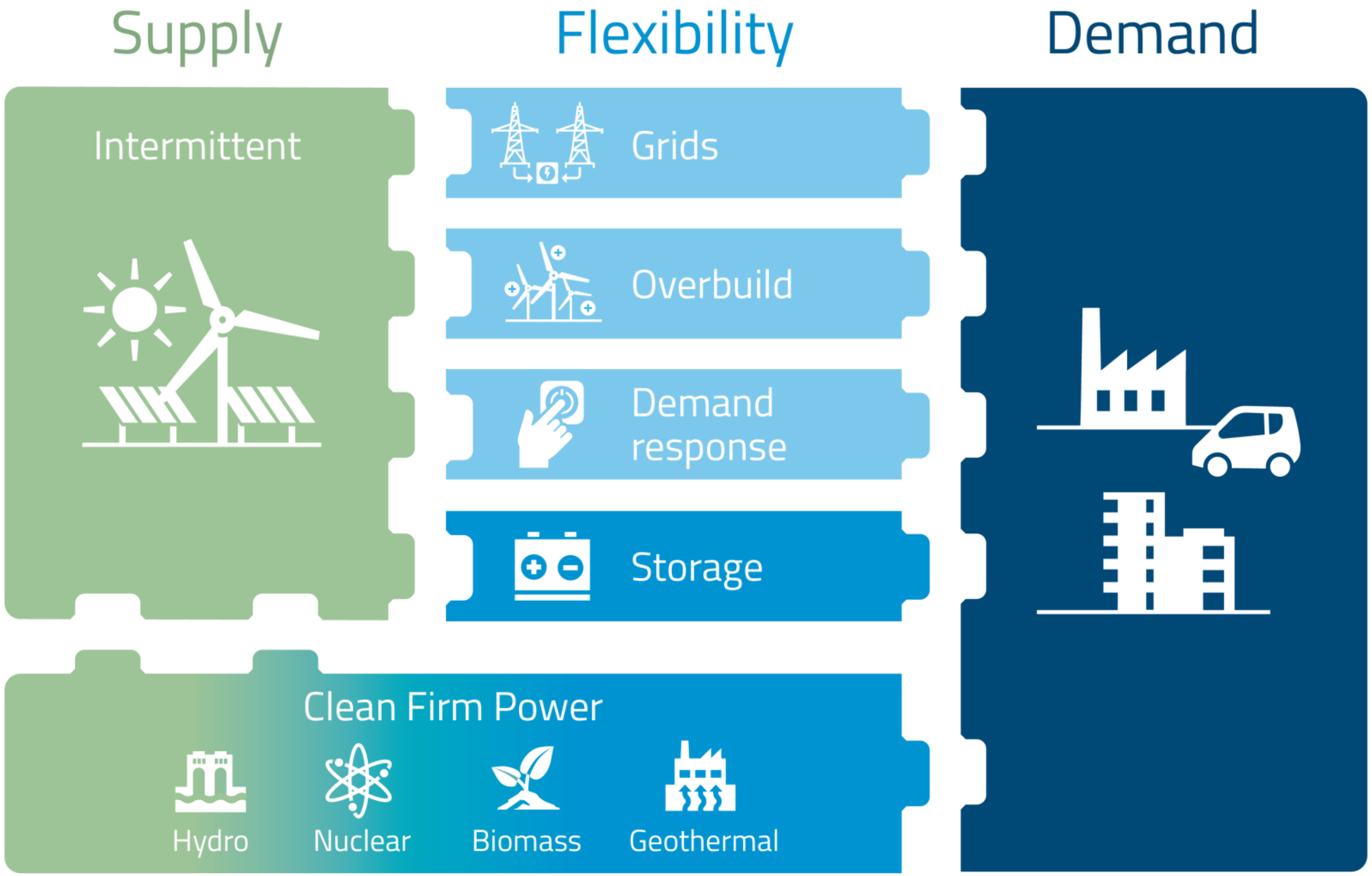
Direct electrification is always several times more efficient, with substantial positive implications for energy security, CAPEX, and OPEX of the system overall.

Source: CATF, US EPA, Tabkhi et al, Climeworks, FCA



Converting electricity to SNG only to then convert back to electricity can never be as efficient and economical as direct grid electrification – even considering cost for thermal and electricity storage for most applications.

Source: CATF, US EPA, Tabkhi et al, Climeworks, FCA



Minding the potential of flexibility options (and clean firm, power in particular), investment efforts should be focused on any of these options before exploring SNG and other derivative pathways.