

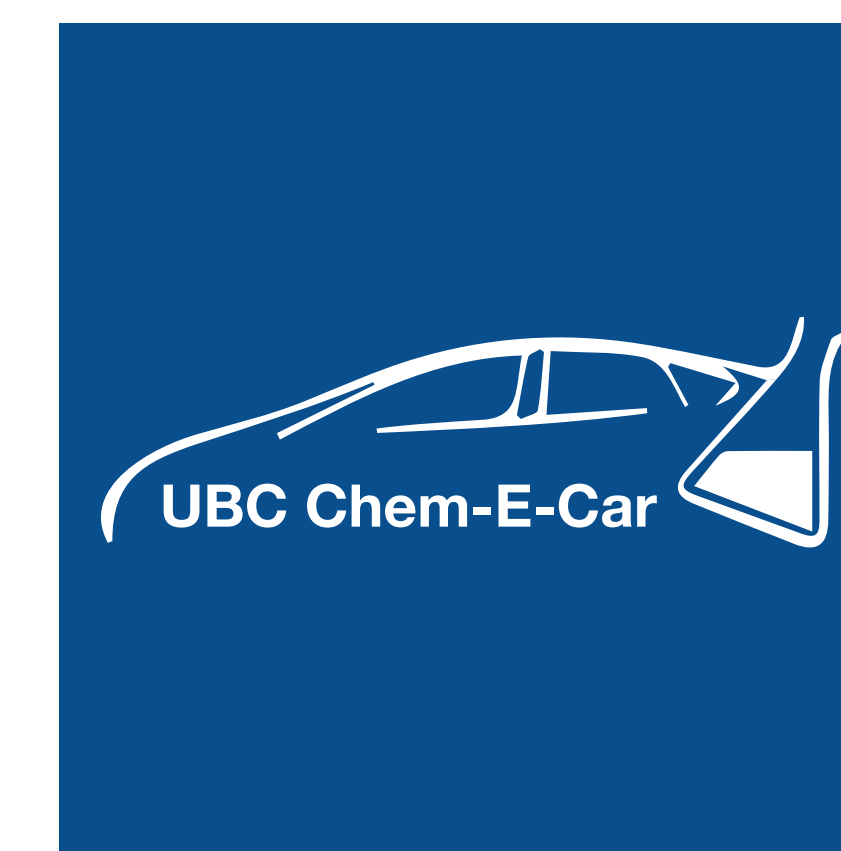


Carbon-Neutral Production and Transport of Hydrogen Using LNG Infrastructure

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Carbon Emission Challenges

- By mid-century fossil fuels will comprise 65% of the world's energy mix
- Alternative energy sources will mitigate the risk of irreversible environmental impact from melting Arctic methane hydrates

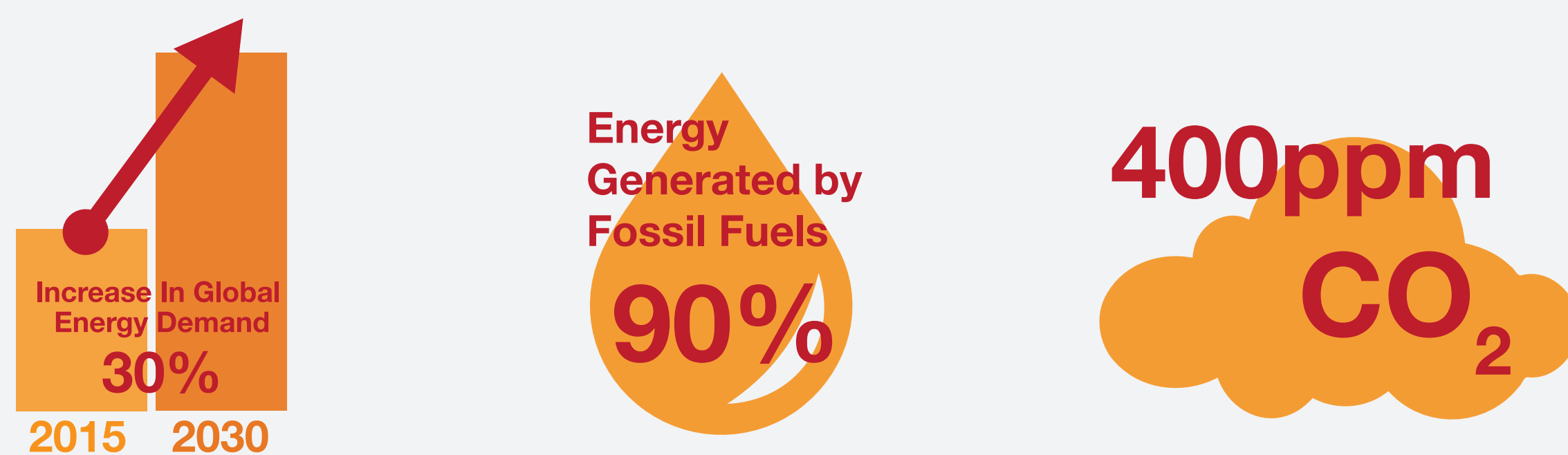


Figure 1. Current energy demand, energy mix and atmospheric CO2 concentrations



Figure 2. Effects of climate change leading to disruption in food production

Hydrogen Economy

- A hydrogen-supplemented fuel economy can reduce emissions
- Hydrogen is a clean and renewable fuel when produced from low-carbon sources such as wind, solar, and biomass



Figure 3. Hydrogen production from low-carbon sources: wind, solar and biomass

- The large-scale production of hydrogen using natural gas employs the steam shift process to recover hydrogen
- Hydrogen can provide on-site energy in midstream gas collection and processing
- The CO2 by-product of the steam shift can be captured and converted to syngas for feedstock
- The feedstock necessary for hydrogen production is at the natural gas field – water for fracking and natural gas

Integration of Hydrogen into the LNG Value Chain

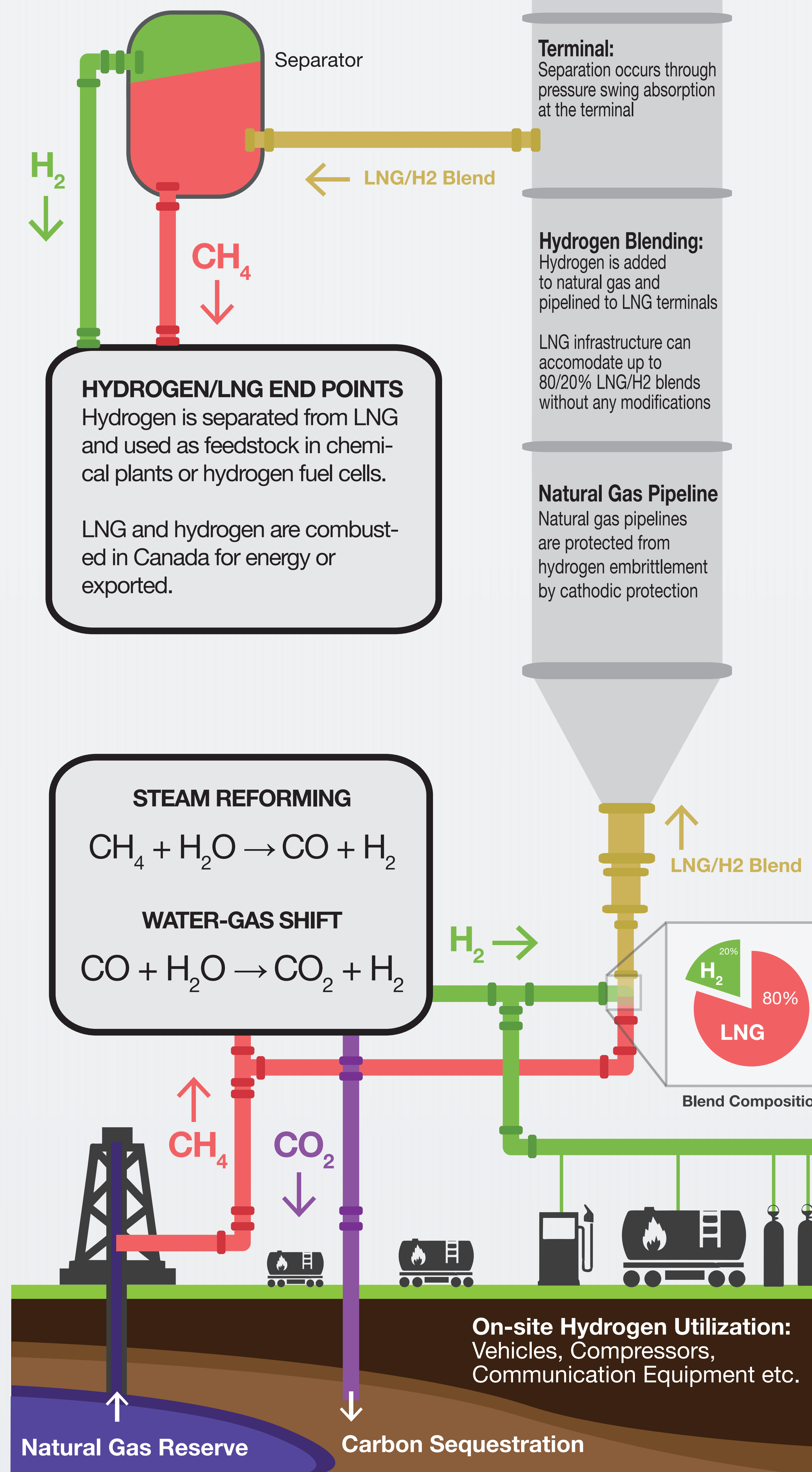


Figure 4. Conceptual schematic diagram of the overall LNG value chain

Benefits

Economy

- Adds value to the LNG production chain and contributes to the multiplier effect on the economy
- Provides incentive for carbon neutral hydrogen economy with inexpensive natural gas and hydrogen
- Supports growth in manufacturing of equipment needed for renewable energy
- Increases safety of hydrogen transportation by replacing compressed gas cylinders with blended gas pipelines

Environmental

- Minimizes emissions of nitrous oxide, sulfide, carbon dioxide, or particulate matter pollutants by hydrogen fuel cells
- Mitigates greenhouse gas (GHG) emissions from natural gas
- Reduces risks of spills because hydrogen and natural gas are non-toxic and evaporate when spilled

ASPEN Plus Simulation

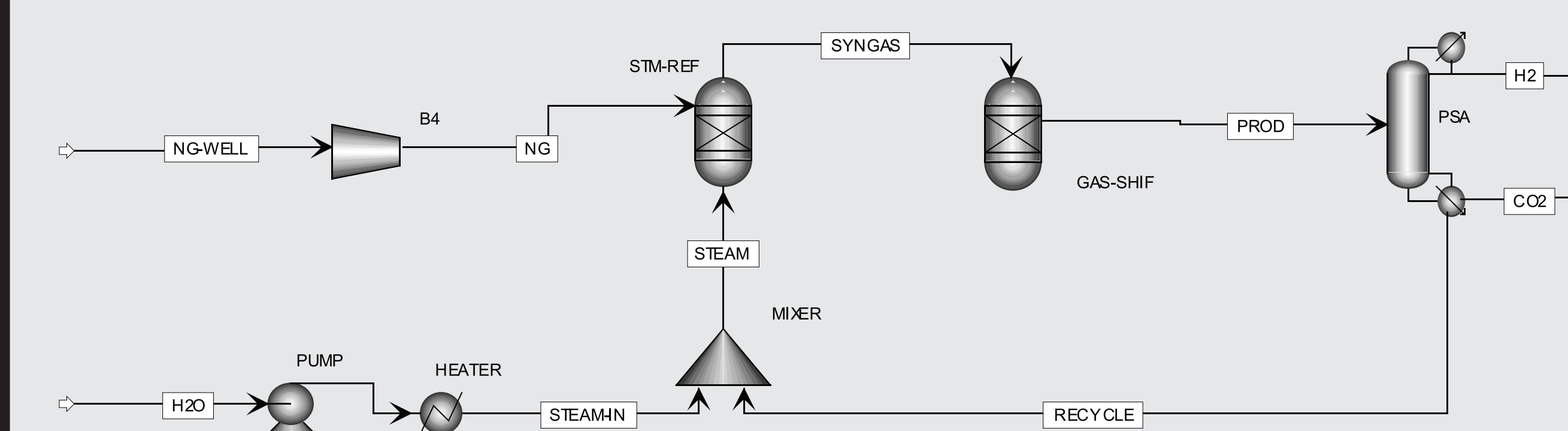


Figure 5. Methane and Steam are pumped into the first reactor where they react to form CO and H2. The CO is converted to CO2 and H2 in a second reactor using a lower-temperature gas-shift reaction. The H2 and CO2 are separated, and sent downstream; un-reacted CO and H2O are recycled into the process.

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References

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