Assessing the Life Cycle Environmental Impacts of Liquid Hydrogen Production in La Guajira, Colombia

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Energy Context in Colombia

- Coal is a major Colombian export
  - Exports of coal briquettes were 14% of value of Colombian exports in 2019[1]
  - Comprises only 9% of electricity grid
- Largest open pit coal mine is in La Guajira
  - Mining industry contributes to 39% of La Guajira GDP[2]
  - Also has 18 GW of wind energy potential
- National goal to reduce CO2e emissions from energy sector by 35%

Figure 3. Coal mines, power generation units, and existing and proposed coal infrastructure in Colombia. Source: Own illustration based on UPME (2014) and USGS (2006).

Hydrogen to Support a Clean Energy Transition?

- Colombia has identified interest in national hydrogen production:
  - 2030 goal to produce 50 kt of H_2
    - Plentiful energy resources like coal, wind, and solar
  - Aim to support greenhouse gas emissions goals
    - (Complements intermittency of renewable resources like sun and wind through use as a long-duration energy storage tool
    - Use as a zero-emissions fuel in international shipping, heavy duty trucks, and aviation
  - Long-run goal to export H_2
    - Hydrogen exports have potential to account for some of the losses expected from contraction of coal markets

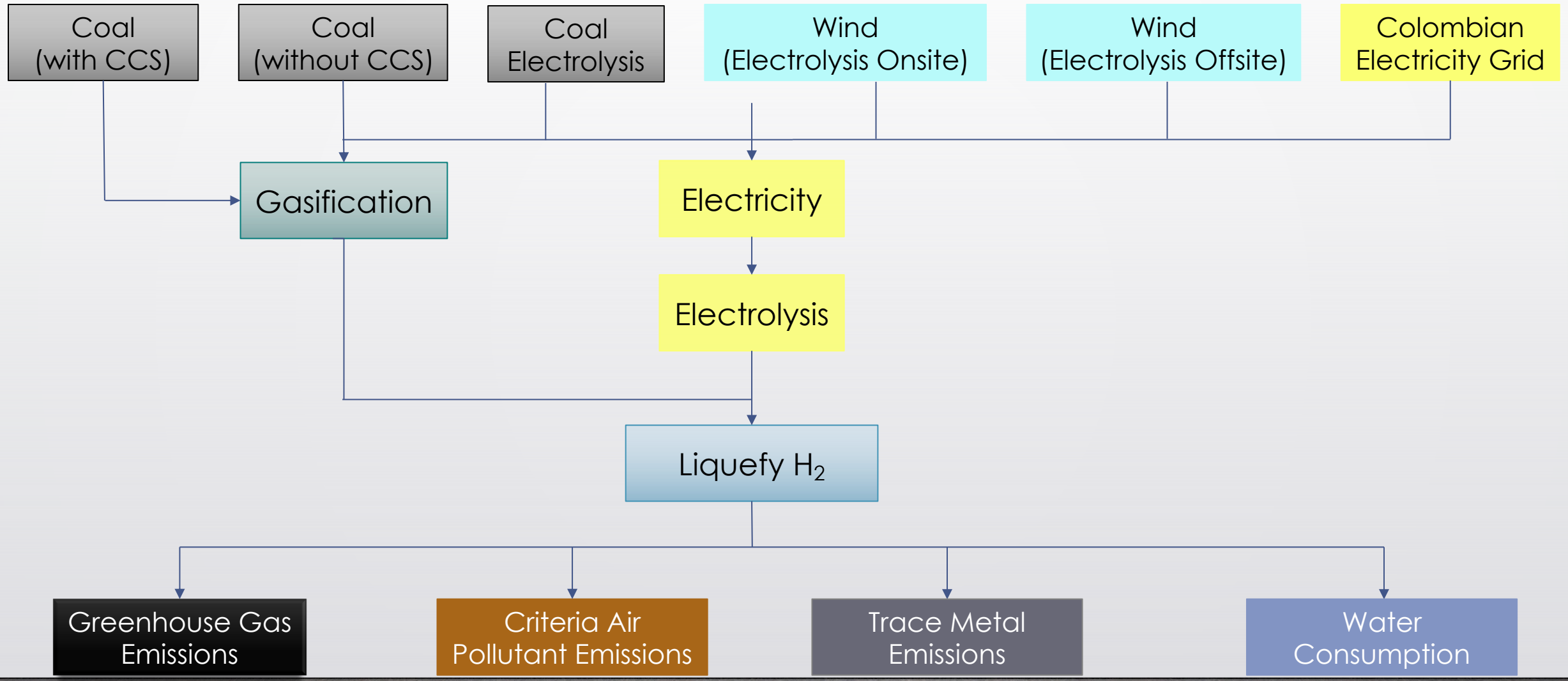
Research Question:

What are the life cycle environmental impacts of prospective liquid hydrogen production in La Guajira?

H_2 Production Considerations

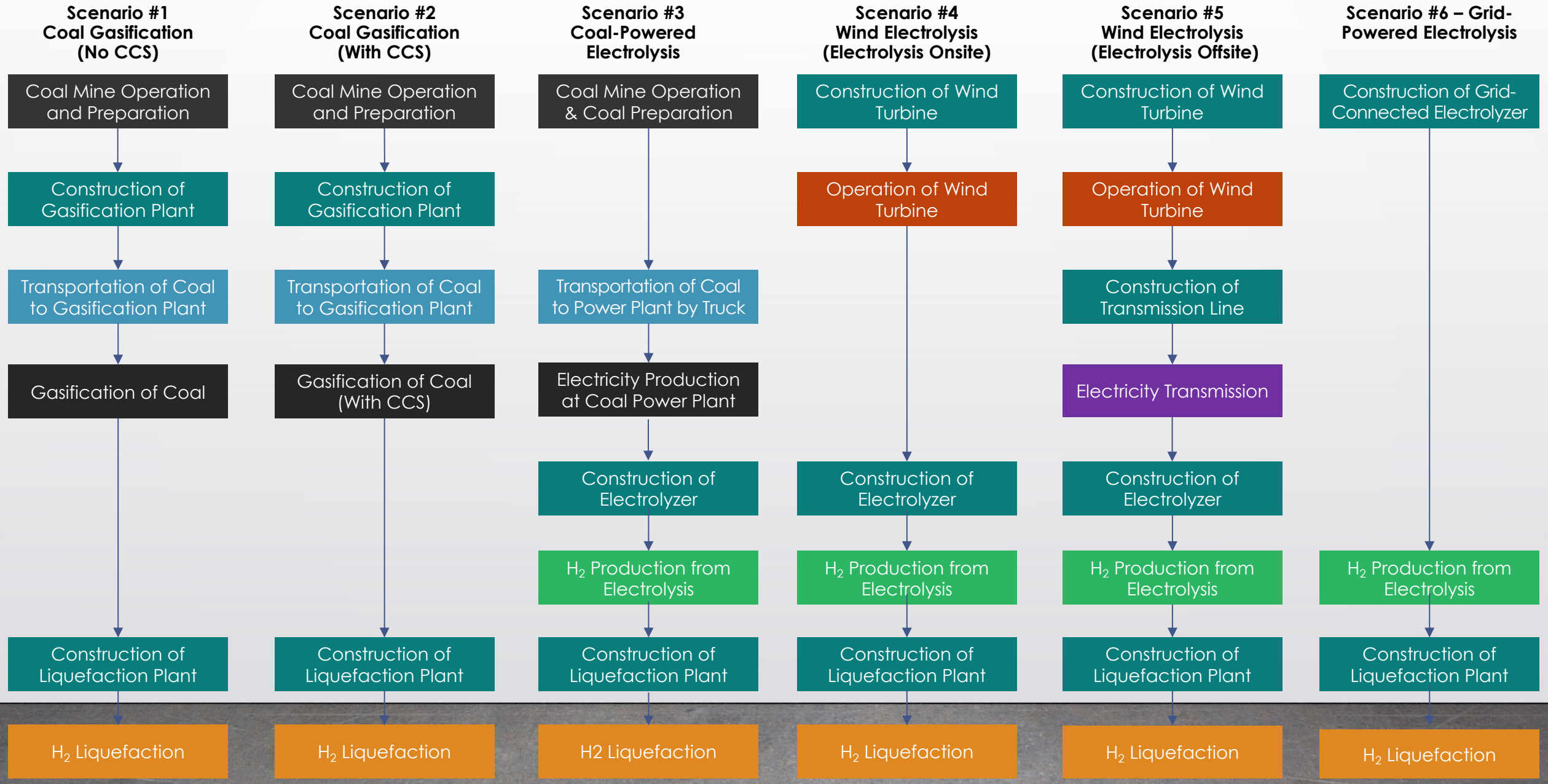
- 3 Types of H_2
  - Grey: Produced from fossil fuels
  - Blue: Produced from fossil fuels with carbon capture and storage (CCS)
  - Green: Produced from zero-emissions energy sources
- Intensity of H_2 impacts varies by production method
  - Greenhouse gas emissions
  - Air pollutant emissions
  - Trace metal emissions
  - Water consumption

Life Cycle Assessment Scope – Liquid H_2 Pathways



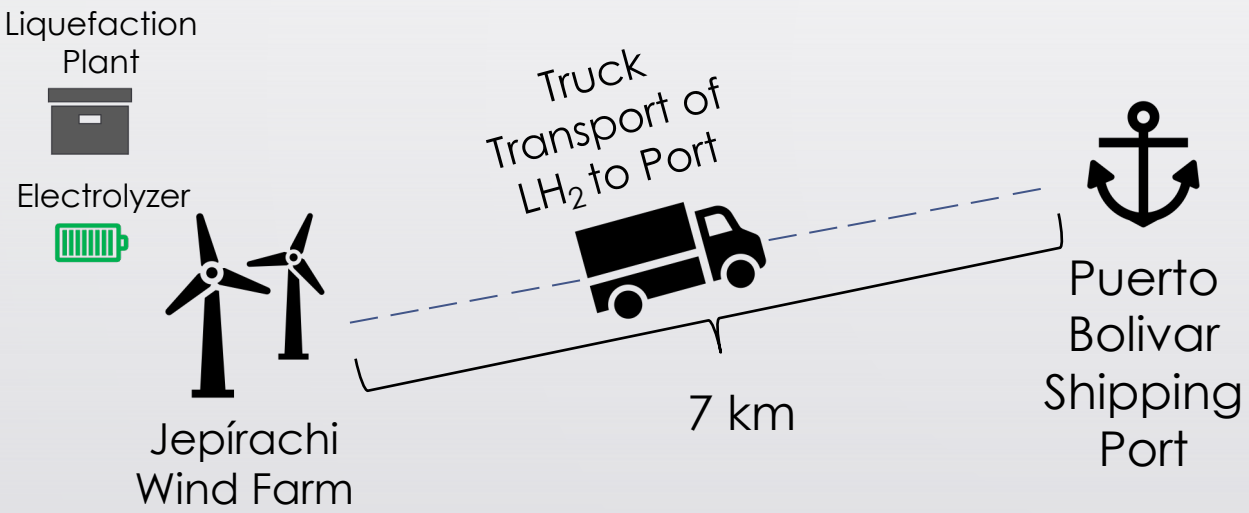
Functional Unit: 1 Tonne Liquid Hydrogen

LH_2 Production Pathway Breakdown

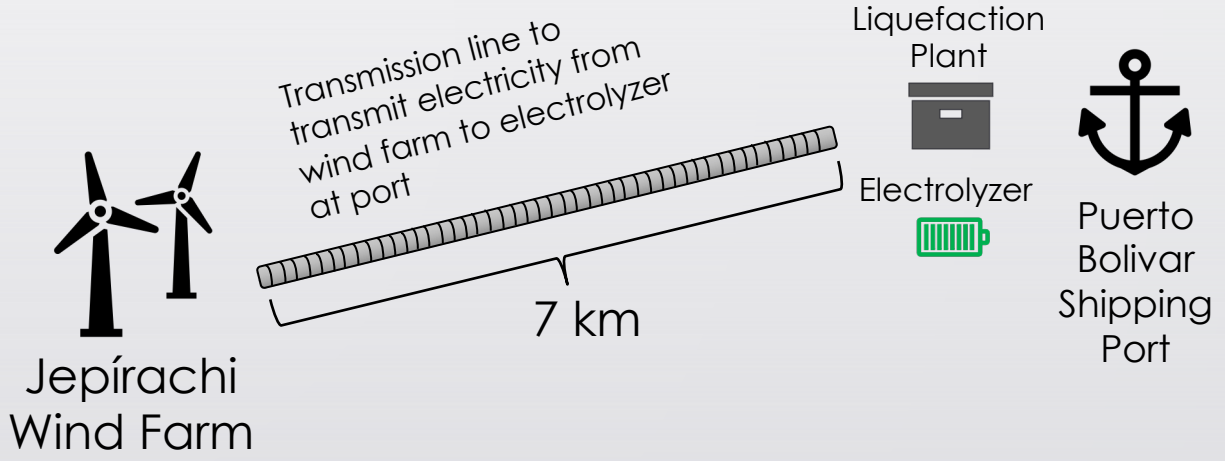


Wind Scenario Differences

Wind Scenario 1: Electrolysis Onsite



Wind Scenario 2: Electrolysis Offsite

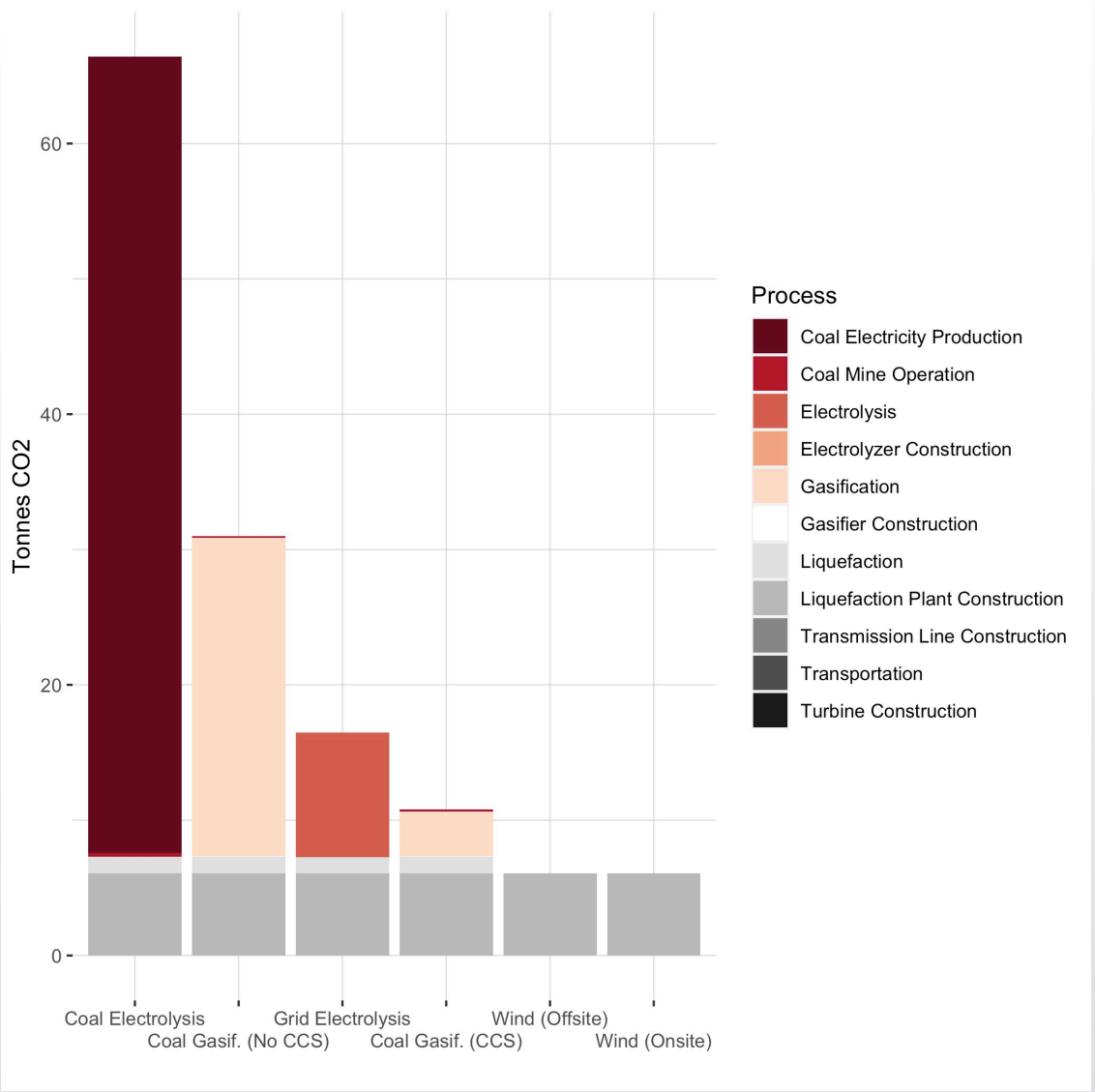


Impact Categories

INDICATOR	
Greenhouse Gases	CO_2, CH_4, Non-methane VOCs
Air pollutants	NO_x, PM < 2.5, PM 2.5 – 10, PM > 10, SO_2
Trace Metal Leeching	Aluminum, Arsenic, Cadmium, Copper, Dissolved Solids, Fluoride, Inorganic Solids, Iron, Lead, Manganese, Mercury, Nickel, Nitrate, Nitrite, Oils, Strontium, Sulfate, Zinc
Water Consumption	Cubic meters of water consumed

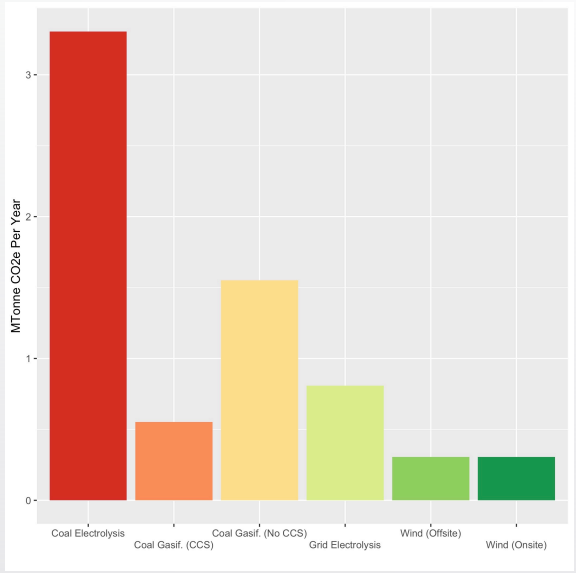
CO_2 Emissions by Process

- Majority of Wind CO_2 emissions from liquefaction plant construction
- Coal electrolysis emissions largely from electricity production
- Coal gasification emissions largely from gasification process

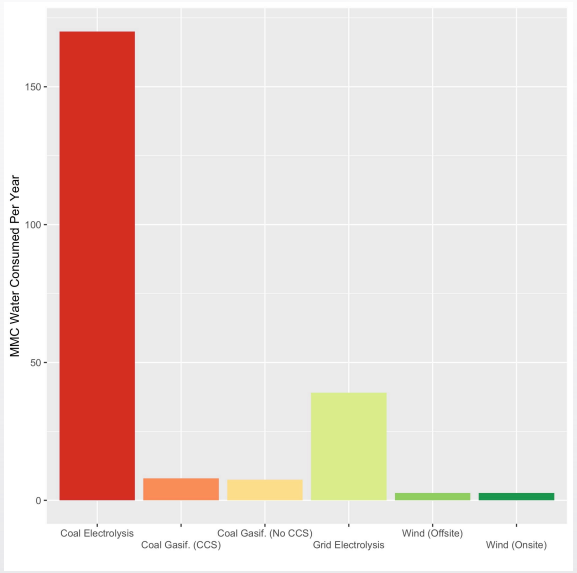


Per Year Impact Levels

CO2e



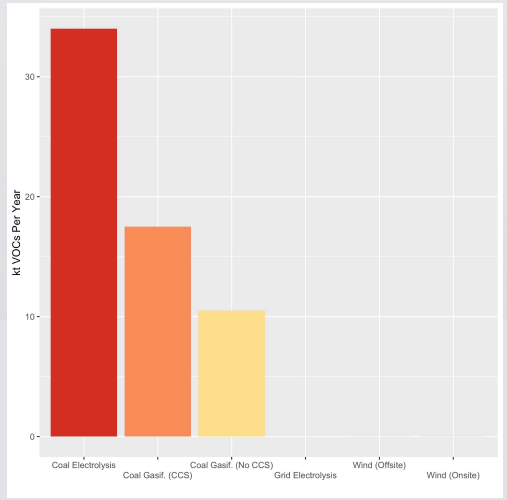
Water Consumption



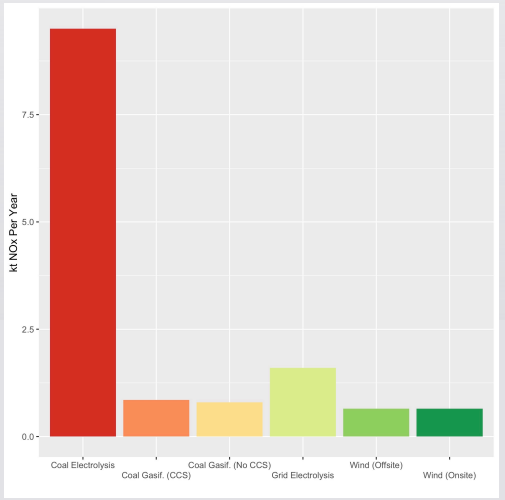
Legend

- Coal Electrolysis
- Coal Gasification with CCS
- Coal Gasification without CCS
- Grid Electrolysis
- Wind Electrolysis (Offsite)
- Wind Electrolysis (Onsite)

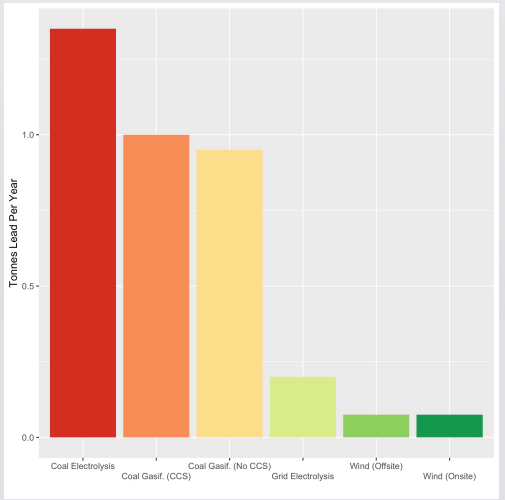
VOCs



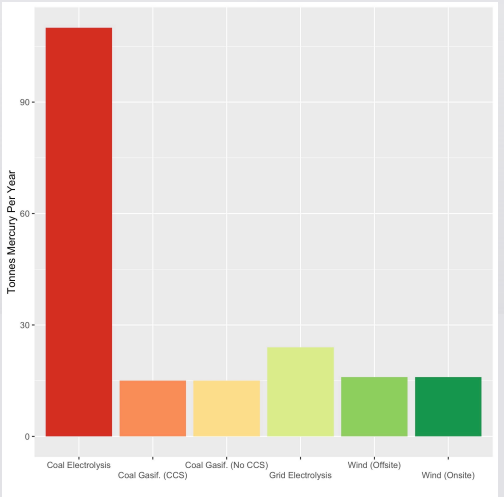
NOx



Lead



Mercury



National Hydrogen Strategy Considerations

- Siting of electrolyzer & liquefaction plant little impact on indicators, but should look to community in development decisions
- Manufacturing locations important for identifying localized impacts (air pollution, water consumption, trace metal emissions)
- Water consumption implications for drought in region & agricultural practices of communities
- CCS significantly reduces CO2 emissions, but increased inputs increase emissions of other pollutants
- Carbon lock-in concerns of developing coal-based hydrogen production systems

For questions, please contact:

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