Carbon Capture & Utilization from a Waste-to-Energy Facility

Final Presentation - Group 2

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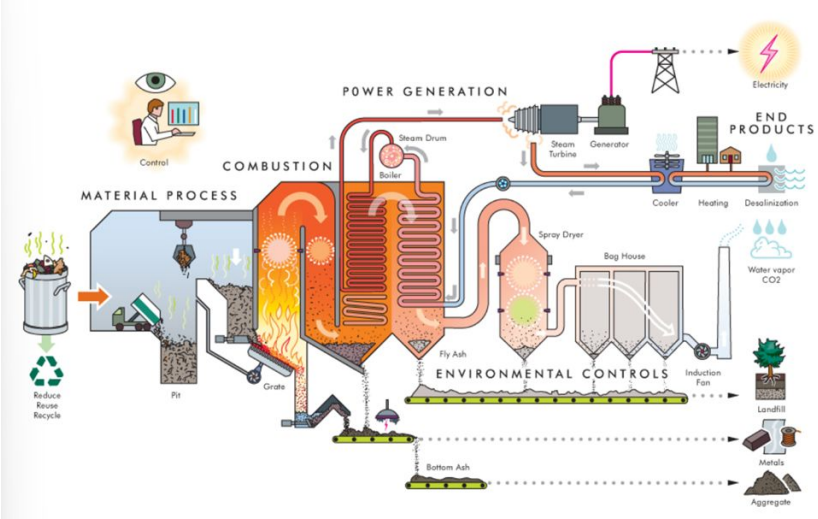
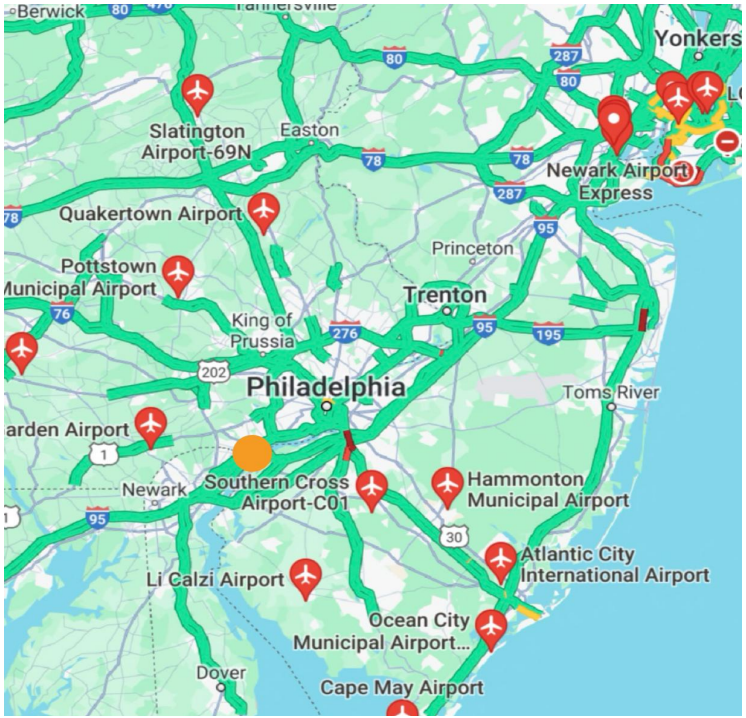
Project Overview

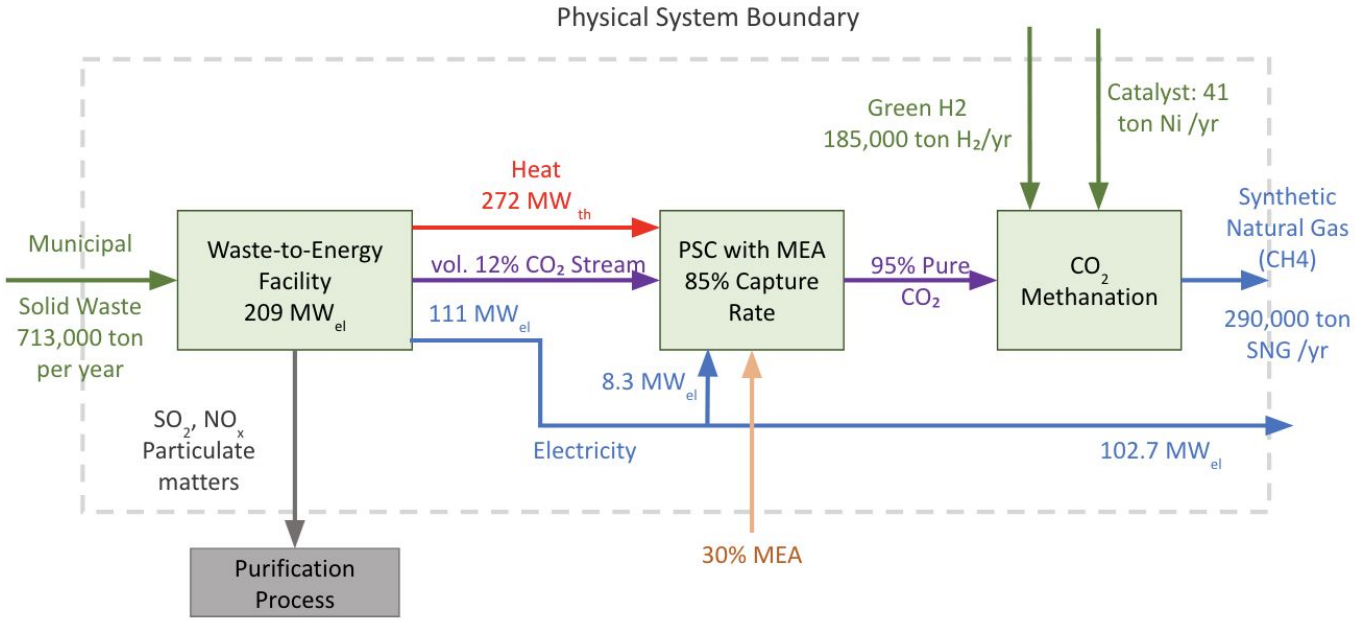
- Focus on Chester, PA - Covanta site
  - Add PSC
  - Scale up by 2.4 times reach goal
  - Sufficient waste
- Co-Benefits from this process
  - Already saving waste from landfill





- Utilization
  - Most sensible
  - Close proximity to many airports

Technical Analysis - Flow Diagram



Inputs:

Point Source Capture:

- Municipal solid waste
- CO_2 12% vol of emissions = 1.2 M ton CO2/yr
- Heat (steam)

Utilization:

- Green H_2 for conversion to aviation fuel

Outputs:

- Synthetic Natural Gas

$$CO_2 + 4\,H_2 \longrightarrow CH_4 + 2\,H_2O$$

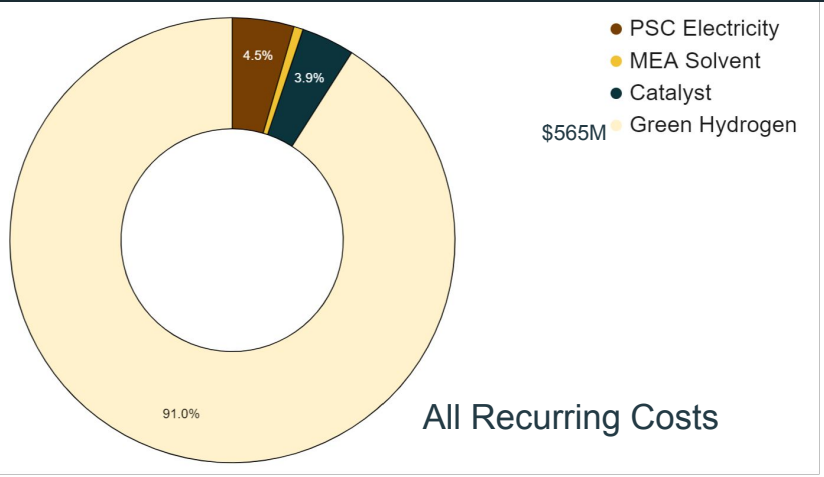
ΔH_r = -165 kJ/mol CO2

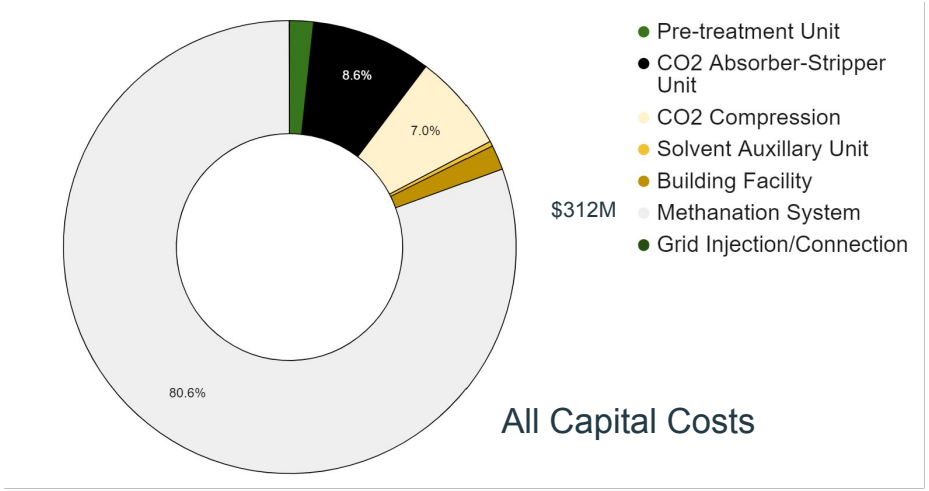
TEA Results - Costs & KPIs

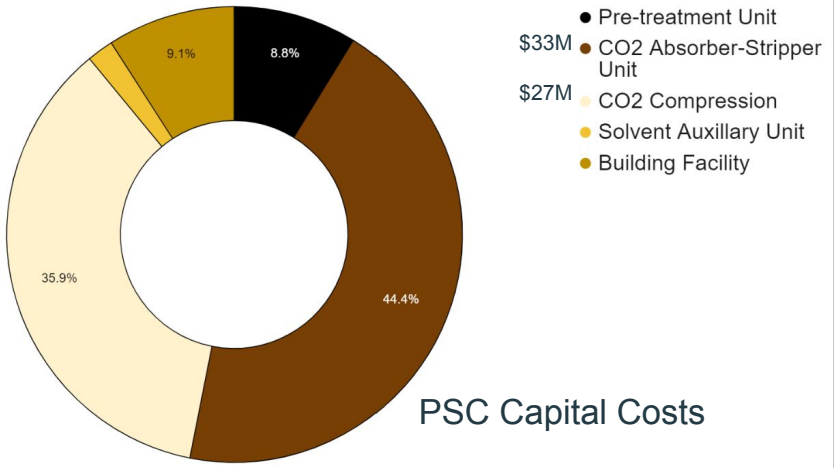
- Capital costs:
  - PSC design: $75M
  - Conversion: $312M
- Operating costs:
  - PSC design: $32M
  - Conversion: $590M
- Revenue:
  - Synthetic NG: $155M
- Key assumptions:
  - SNG sale price: $0.54/kg
  - MEA: $2.76/kg
  - Green H2: $3.04/kg
  - Electricity: $0.03/kWh

KPIs	Value
Net Present Value	$-30B
Carbon Capture	$627/ton CO2
SNG Production Cost	$2,212/ton SNG
SNG Revenue	$538/ton SNG
SNG Net Revenue	$-1,675/ton SNG

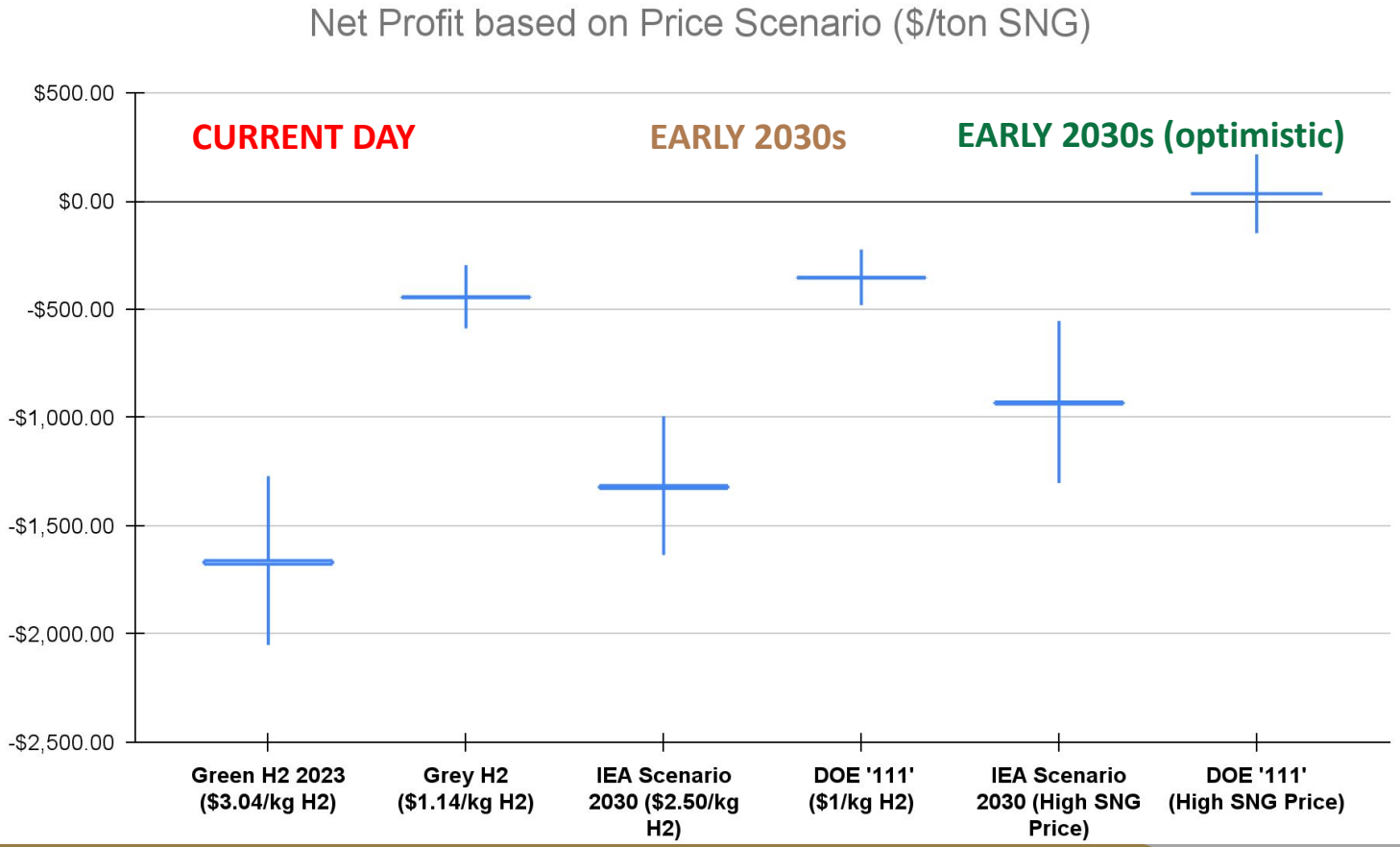
TEA Results - Major Contributors







TEA Results - Sensitivity & Scenario Analysis



Economic Profitability in 2030 Optimistic Scenario

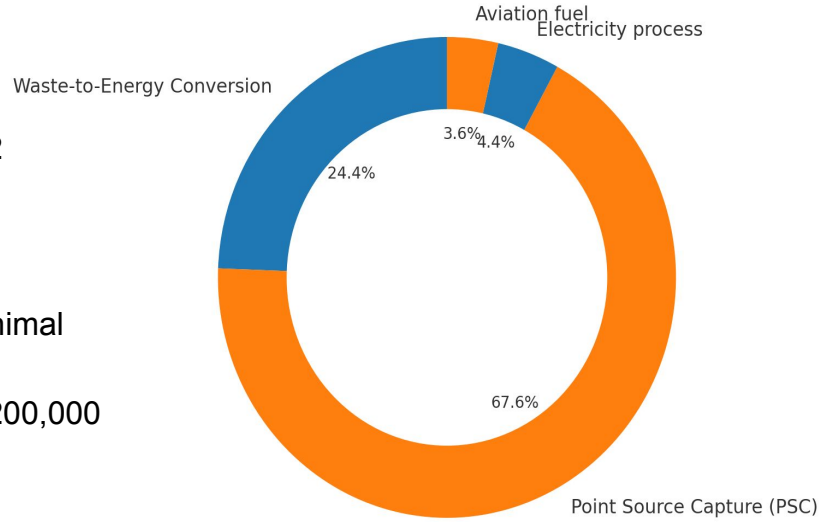
Key assumptions:

- SNG sale price: ~~$0.53/kg~~ → $0.87/kg
- Green H2 cost: ~~$3.04/kg~~ → $1/kg
- Methanation Unit ~~$312M~~ → $174M

KPIs	Value
Net Present Value	$ -312M
Carbon Capture	$ 235/ton CO2
SNG Production Cost	$ 829/ton SNG
SNG Revenue	$ 870/ton SNG
SNG Net Profit	$ 41/ton SNG

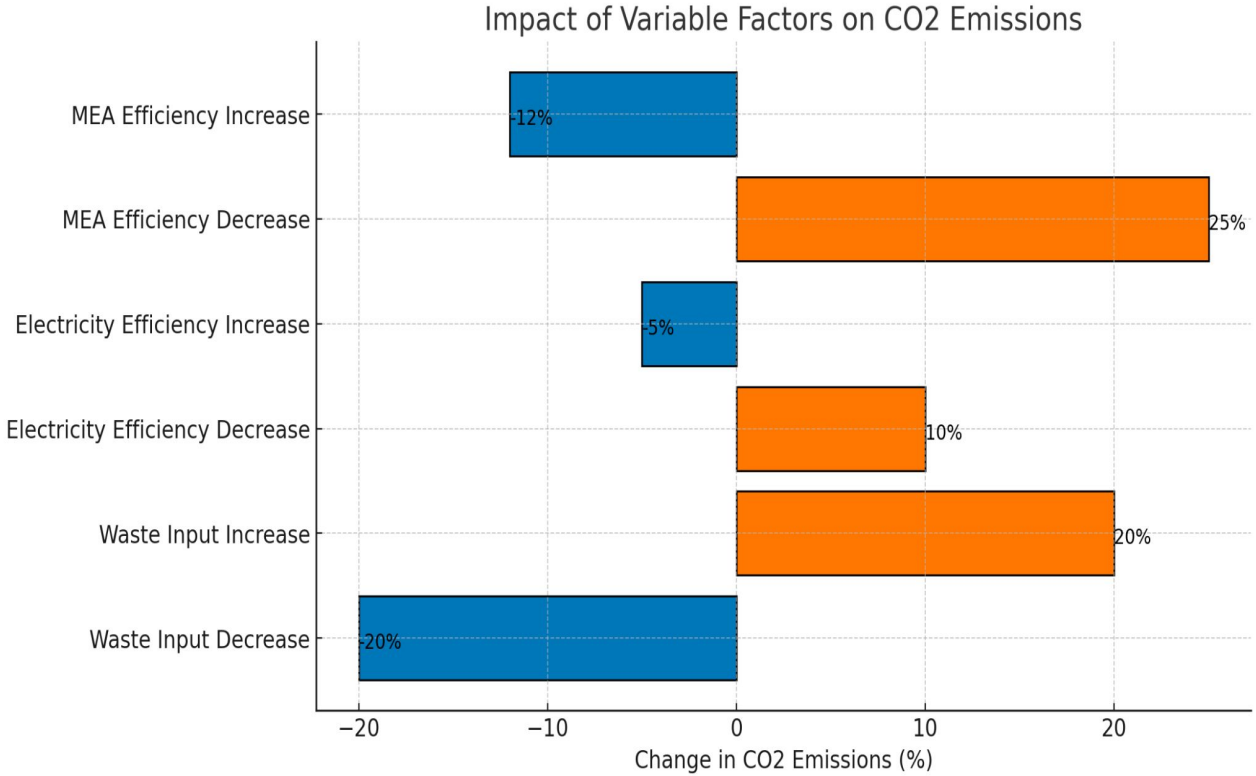
Current Process LCA & Contributors

- Waste-to-Energy contributes 24.4% to total CO2 emissions.
- PSC, mainly solvent regeneration, is the major contributor at 75.6%.
- Electricity process & Aviation fuel/SNG have minimal impact.
- Net CO2 Emissions from WTE Conversion = 1,200,000 - 887,000 = 313,000 tons CO2 per year.
- PSC CO2 Capture Efficiency ≈ 85%



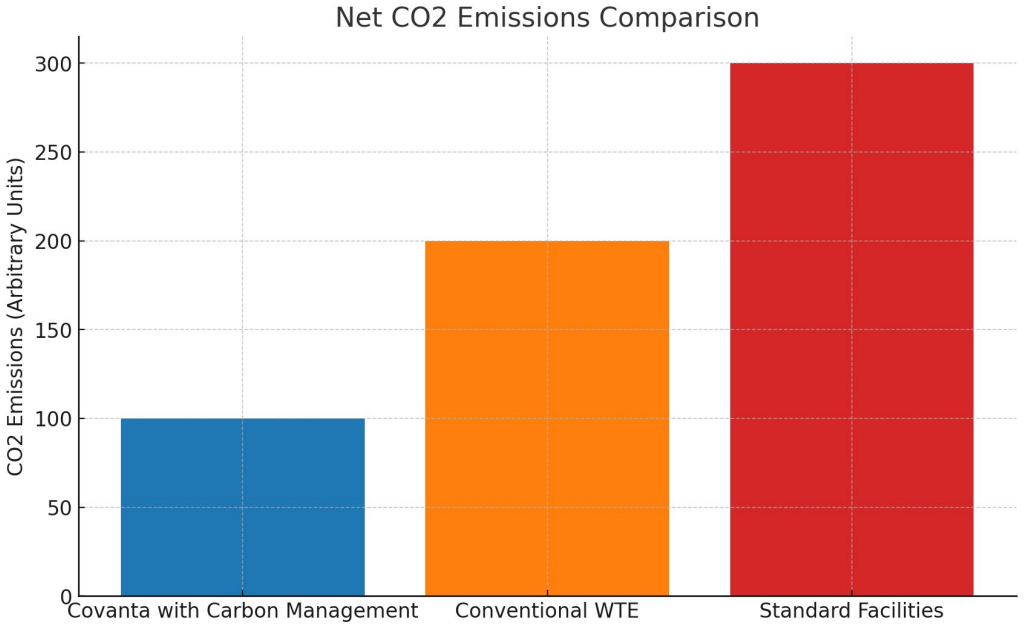
LCA Sensitivity Analysis

- MEA efficiency strongly affects CO2 capture.
- Electricity efficiency has a moderate impact.
- Waste input directly influences CO2 emissions.



LCA Comparison & Assumption

- Covanta's current process with carbon capture significantly reduces CO2 emissions compared to:
  - Conventional WTE without carbon management.
  - Standard power plants or industrial facilities emitting CO2 without capture.
- Assumptions and Deliberate Emissions
  - Emission Source Focus
  - Simplified Life Cycle Stages
  - CO2 Utilization Efficiency
  - No Secondary Effects



COVANTA

Location: Chester, Greater Philadelphia Region

Proximity to SAF Demand Centers: Philadelphia International Airport (13 miles); Wilmington Airport (17.9 miles); Brandywine Regional Airport (19 miles); New Castle Airport (21 miles); and Chester County Airport (36 miles)
Access to Colonial's Line 39 Pipeline: for SAF delivery (Airport fuel tank farm). Also connects with Colonial's 5500 mile system connecting major airports

Location of CO_2 Point Sources

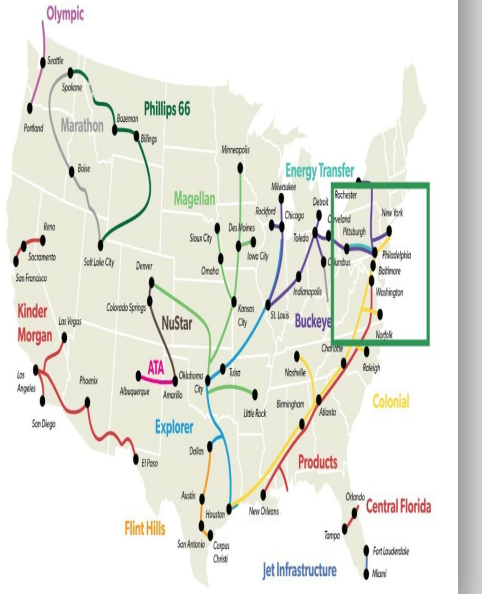
- In 2018, Philadelphia generated 2.2 MMT of MSW annually.
- Current MSW estimated between 3 to 3.5 MMT.

Clean Energy Availability

- Ample potential to leverage solar, wind, geothermal, and biomass sources.
- PA has committed to be 100% renewable powered by 2050 or sooner.

Land, Water, Biomass Availability

- Ample industrial land availability in urban, peri-urban areas. Approx. 20 million sq. ft. @ $6.3/sq. Ft.
- Industrial use accounts for 7% of ground & surface water withdrawals from Delaware River basin (6.4 bn gallons per day)
- PA forests produce ~ 6 to 9 MMT of wood and forest by products annually



COVANTA

Location: Chester, Greater Philadelphia Region

Socioeconomic & Community Impacts

Jobs

- Up to 36 direct and indirect jobs created per 10,000 tons of waste processed annually
- PA lost over 600 coal mining jobs from 2017 to 2020, highlighting the need for new employment in sustainable industries

Waste Reduction

- Philadelphia, fifth most populated city in the U.S.; population density @ 11,936.92/sq mi (2022)
- The WtE plant could reduce 2,000 lbs of garbage to 300-600 lbs of ash; thus potentially reducing waste volume by about 87%

Communities

- Increase awareness of sustainable waste management, through renewable energy workshops, educational partnerships, facility tours.

Others

- Effective waste management contributes to better air and water quality thereby enhancing overall quality of life
- Stimulate demand for local services and goods, enhancing economic resilience.

Conclusions

Process: 1 Mt CO2 Capture and Conversion to Natural Gas from a Waste-to-Energy Plant

- Technologically mature but large-scale implementation of methanation are few
- Aggressive cost reduction of H2 and methanation units is necessary
- PSC similar to that at standard fossil fuel or industrial facilities, can be carbon-negative like BECCS depending on biogenic waste fraction, and more effective than DAC
- Unlike carbon mineralization, CO2 is not permanently sequestered (planes emit CO2 back to atmosphere)
- Why converting valuable H_2 into CH_4 ?

  → Easy Long-term Storage → Existing Pipelines → Potential use as SNG

Recommendations

- We recommend further research in this process because of multiple benefits for a densely-populated area with growing waste and demands:
  - Divert waste from landfills which emit CH_4 (100x more potent than CO_2)
  - WTE facility powers itself, homes, and businesses
  - Produce synthetic natural gas to eventually use as fuel for nearby airports
- Investments in 2030 is economically viable
- Policies or incentives to improve prospects of implementation of the process at scale:
  - Certificates or tax credits for WTE negative emissions
  - Fund development and production of green hydrogen and SNG
  - Support research about new CCUS technologies
  - Streamline environmental review process and educate community

Thank you!

Questions?