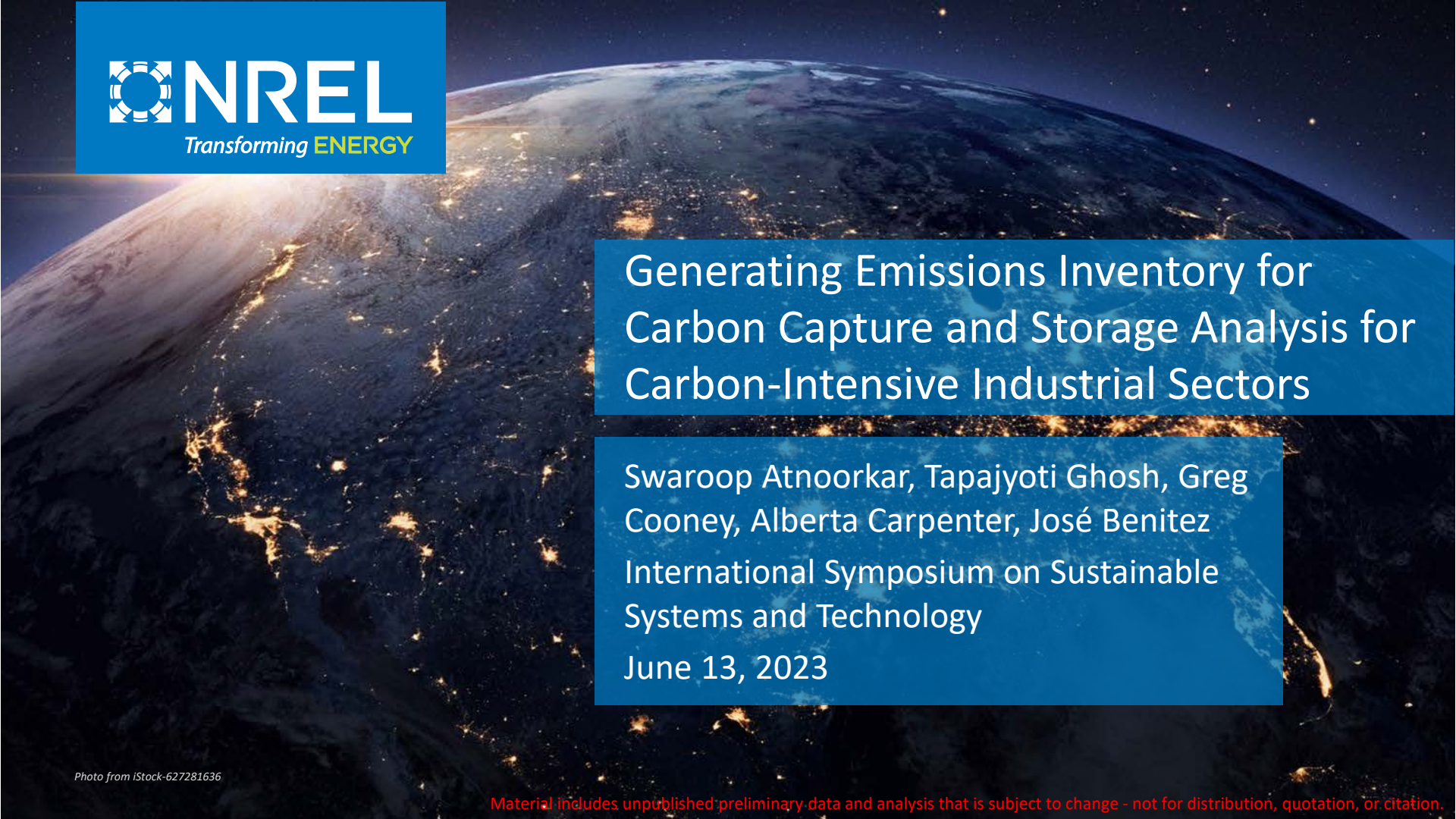

Generating Emissions Inventory for Carbon Capture and Storage Analysis for Carbon-Intensive Industrial Sectors

Swaroop Atnoorkar, Tapajyoti Ghosh, Greg Cooney, Alberta Carpenter, José Benitez

International Symposium on Sustainable Systems and Technology

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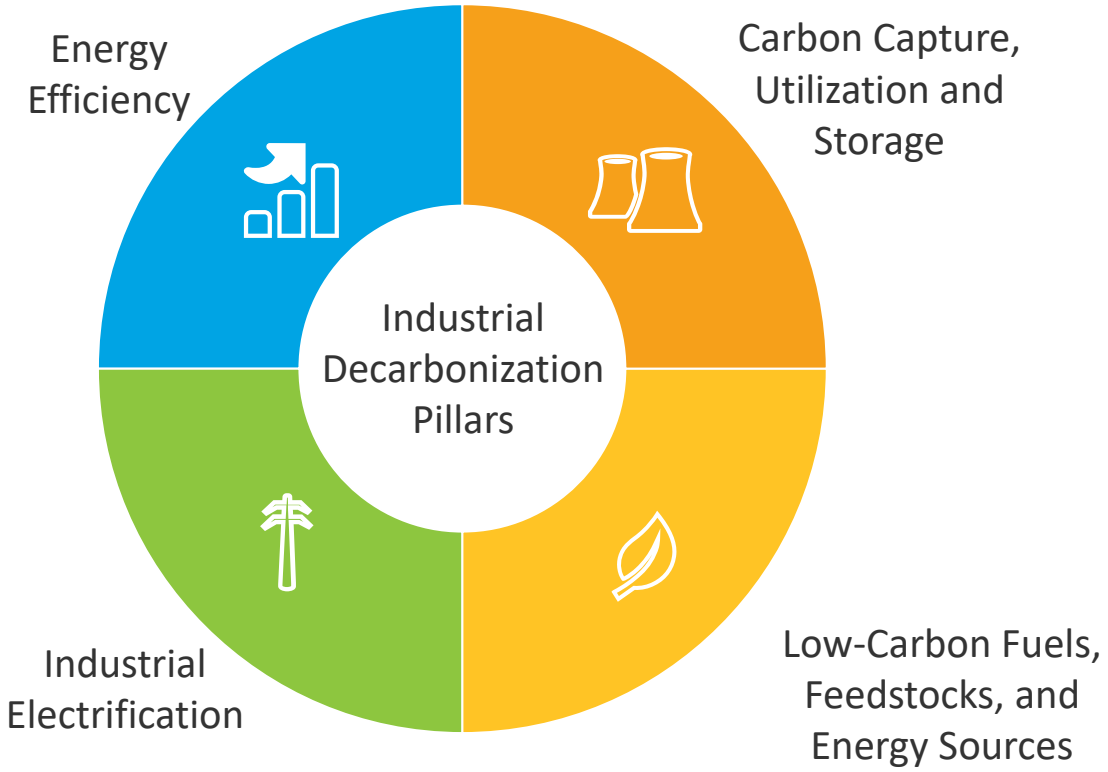
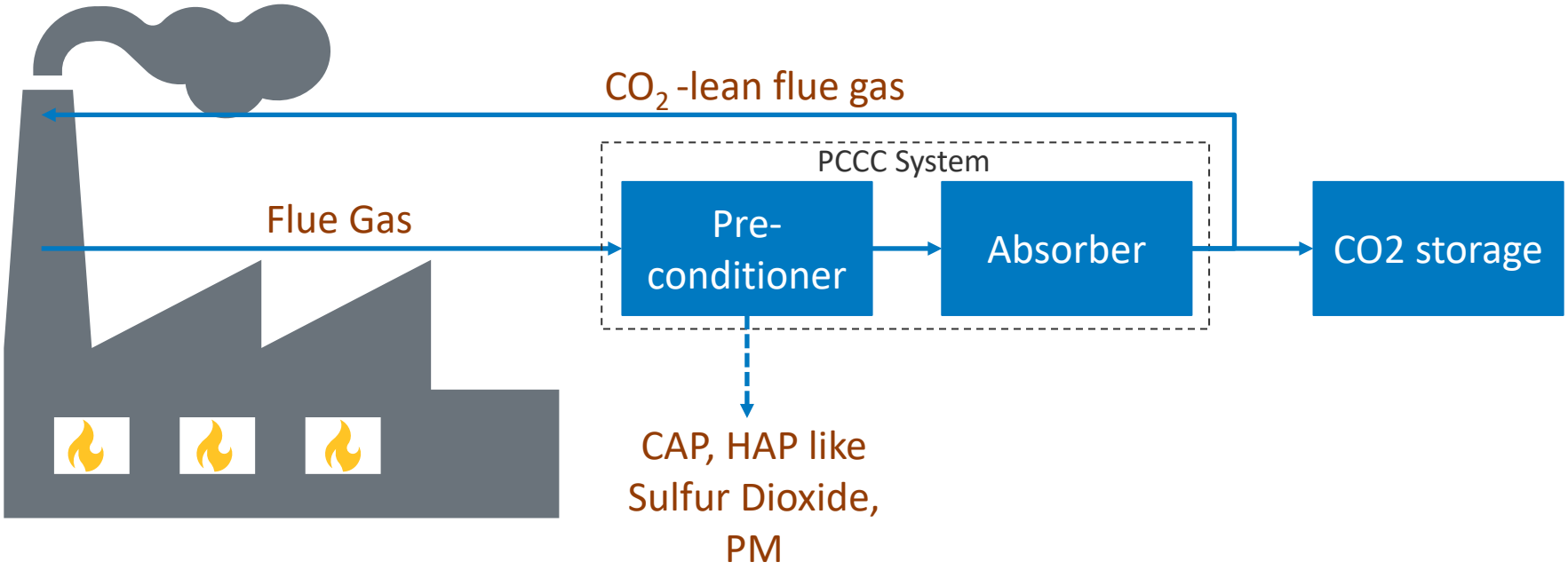
Carbon Capture, Storage and Utilization (CCUS) is crucial to reaching net-zero emissions by 2050



Source: U.S. Department of Energy (2022)

Post Combustion Carbon Capture (PCCC) can result in capture of pollutants other than CO_2



CAP = Criteria Air Pollutants; HAP = Hazardous Air Pollutants; PM = Particulate Matter

The type and amount of CAP/HAP which can be captured is not well understood

Co-benefits of carbon capture depend on the characteristics of the industrial process:

- Concentration and type of pollutants
- Physical properties of the flue gas

However, there is a lack of data about flue gas pollutant concentrations at the national level

Air Emissions Grouped by Industrial Sectors (AEGIS)

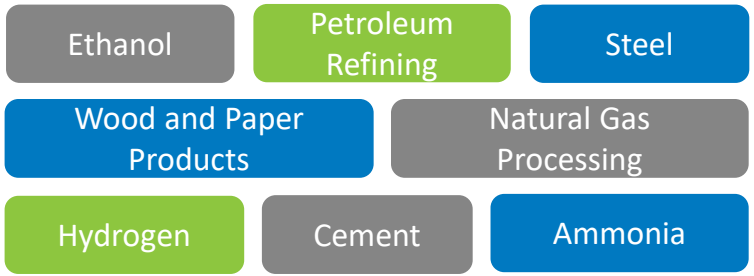
SIGNIFICANCE: Facilitate the estimation of co-benefits of post-combustion carbon capture in industrial facilities for emissions reductions of regulated pollutants.

OBJECTIVE: Develop a high-resolution inventory of air pollutant flows from carbon-intensive industrial point emissions sources in 8 industrial sectors.

CALCULATED PARAMETERS:

- Types and amounts of pollutants in flue streams
- Concentration of pollutants
- Temperature of the flue gas
- Height of the flue stack

Sectors Covered



Methods: The inventory was developed in 3 steps

Compile AEGIS database of industrial facilities and pollutant flows from EPA databases

Calculate total amount and concentration of pollutants in the flue gas

Statistical analysis

Methods: Data Sources

Compile AEGIS database of industrial facilities and pollutant flows from EPA databases

Calculate total amount and concentration of pollutants in the flue gas

Statistical analysis

GHGRP

The Greenhouse Gas Reporting Program (GHGRP) estimates the **total greenhouse gas emissions** across all sectors using national-level data. Approximately 8,000 facilities are required to report their emissions annually. (U.S. Environmental Protection Agency [a])

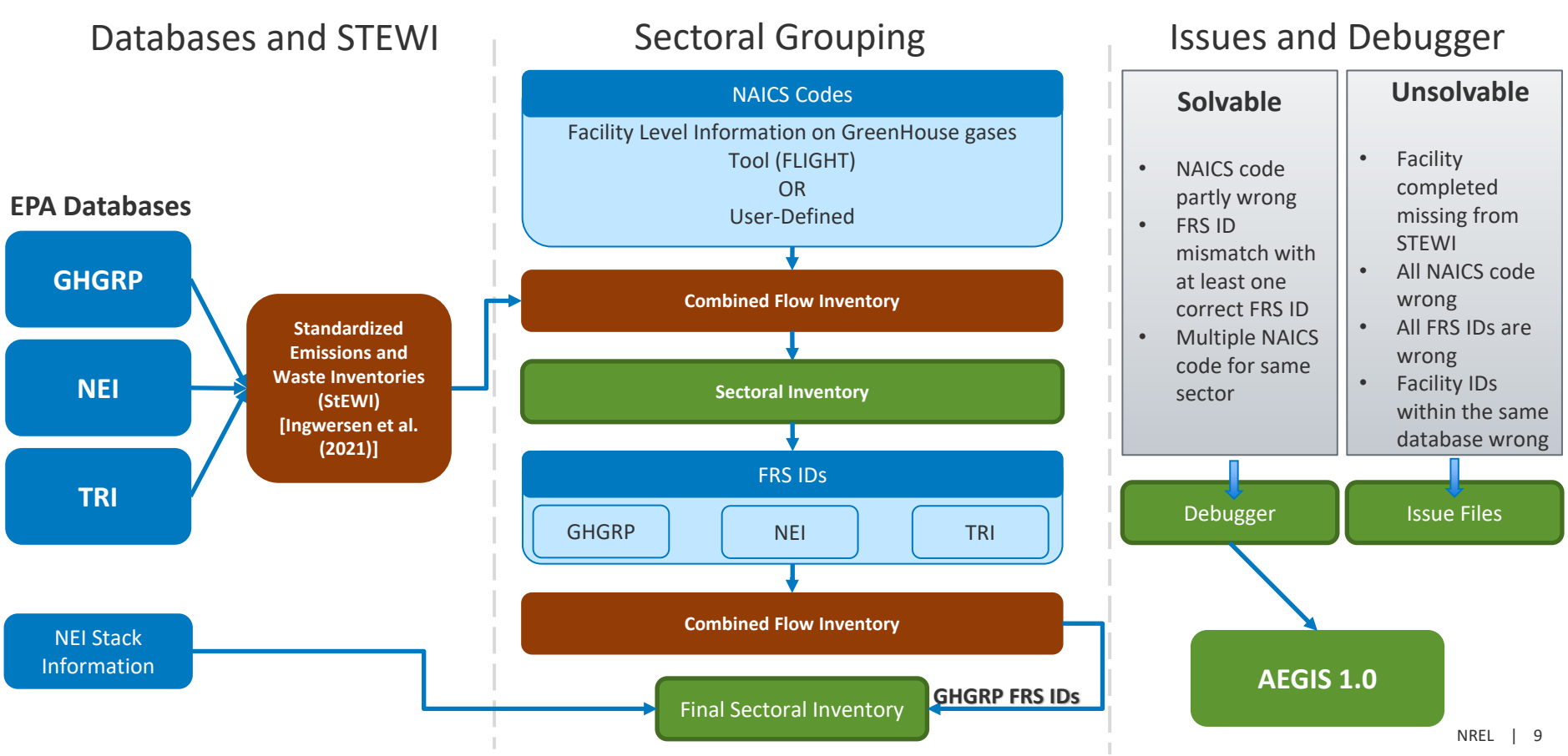
NEI

The National Emissions Inventory (NEI) provides detailed estimates of **air emissions of criteria pollutants, criteria precursors, and hazardous air pollutants from air emissions sources** reported every 3 years. NEI point sources include emissions estimates for larger sources that are located at a fixed location. (U.S. Environmental Protection Agency [b])

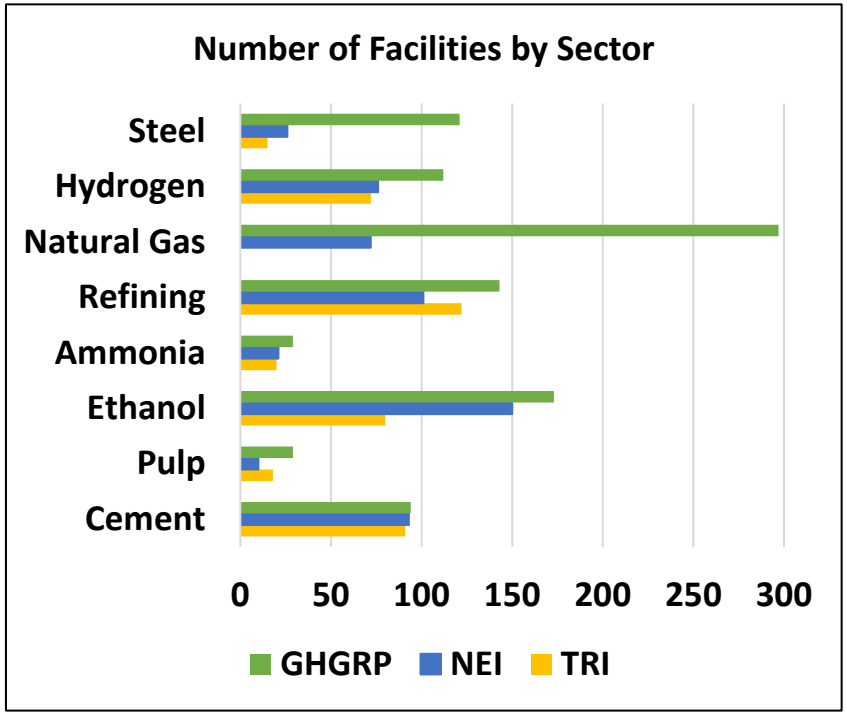
TRI

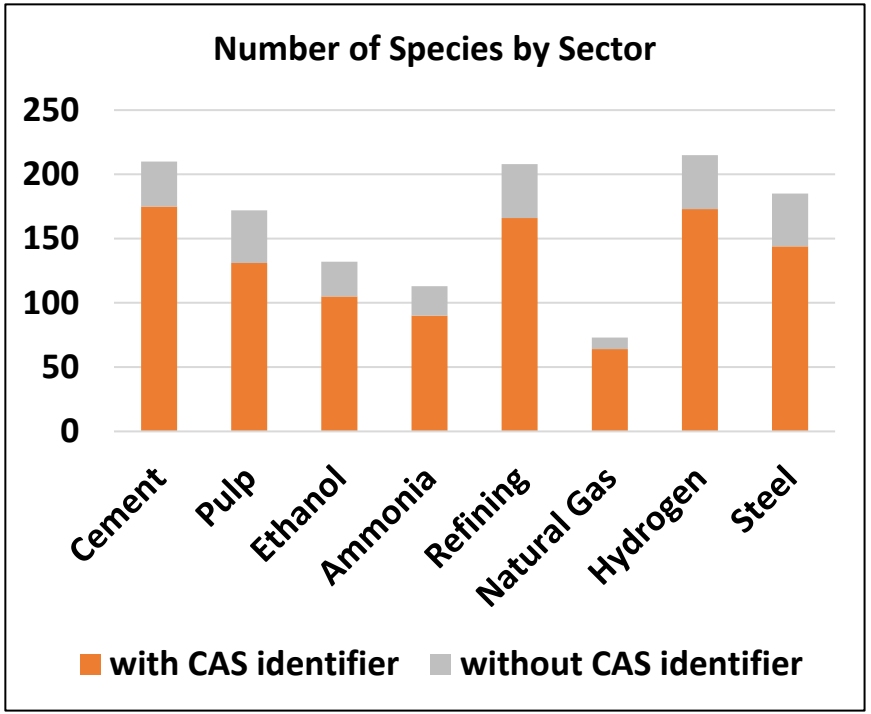
The Toxics Release Inventory (TRI) is a resource for learning about **toxic chemical releases** and pollution prevention activities reported by industrial and federal facilities. (U.S. Environmental Protection Agency [c])

Methods: Facility Level AEGIS Compilation



Results – Industrial Sectors Overview



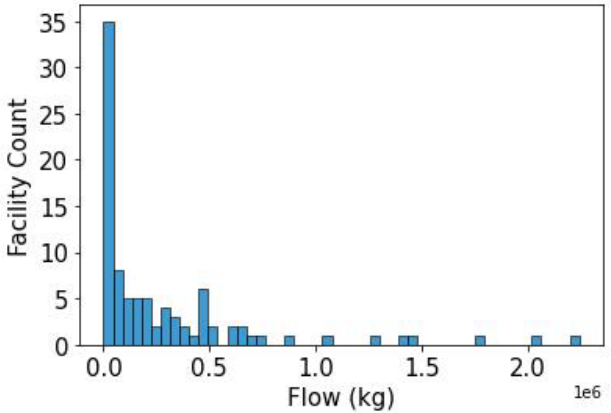


CAS = Chemical Abstract Services: Enables connections to other databases

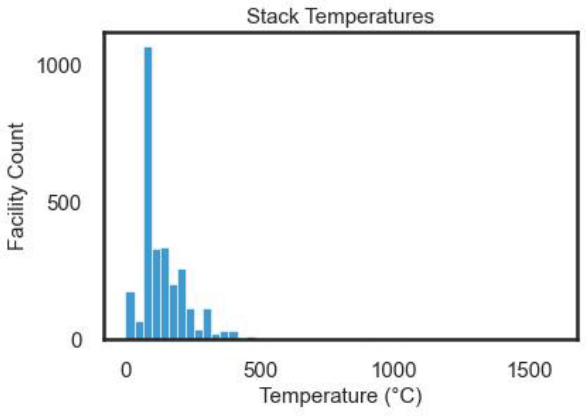
Cement Sector Exploration

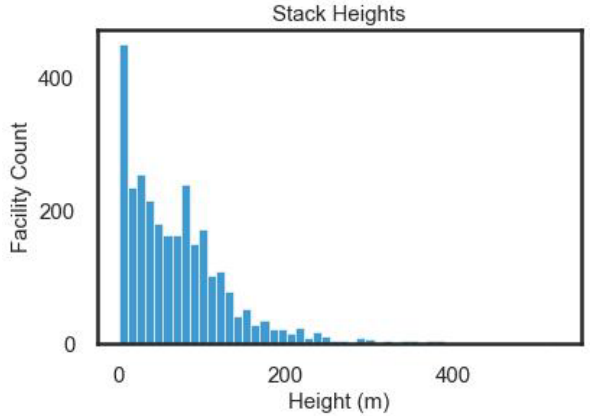
Emissions	Total (million metric ton)	% of US emissions
CO_2	67	1.3
SO_2	0.027	1.13
VOC	0.005	
$PM_{2.5-10}$	0.008	

Distribution of SO2 flow from cement facility stacks



Distribution of stack parameters across 93 facilities with 2960 stacks





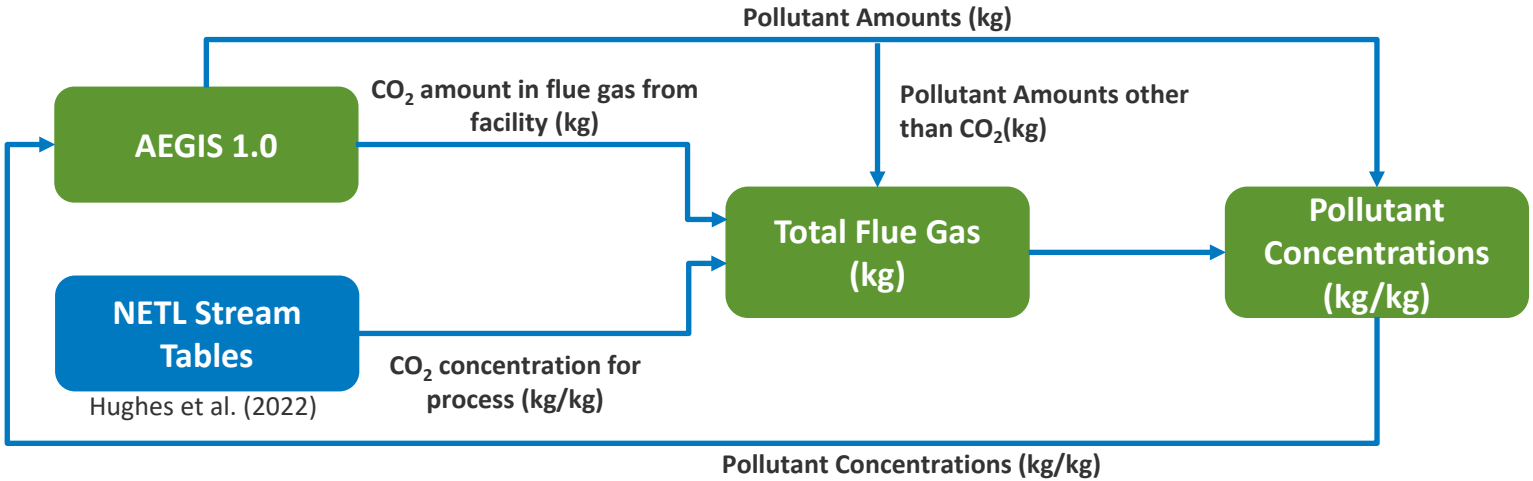
Stack Data	Temp Range	Height Range
68% of all fac	60-200 C	1 – 100m

Methods: Concentration

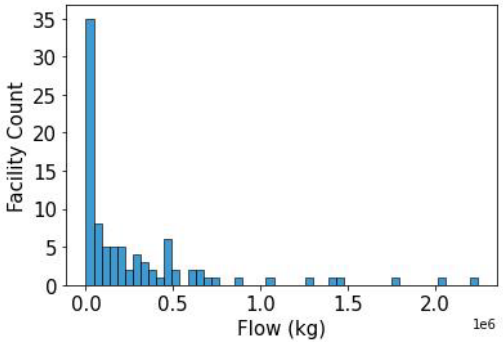
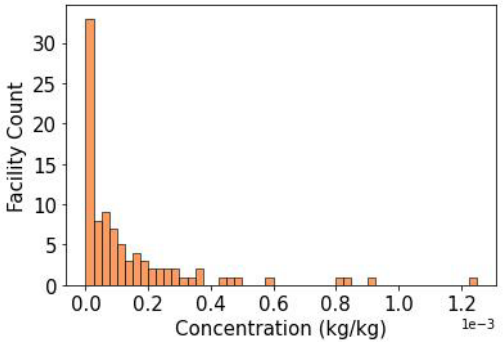
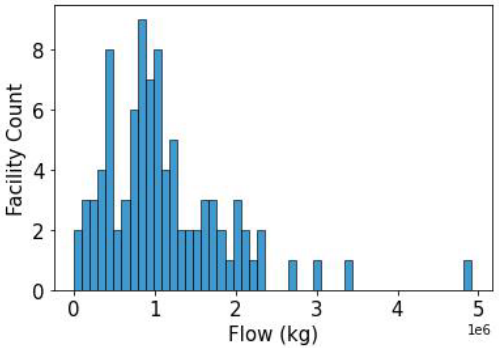
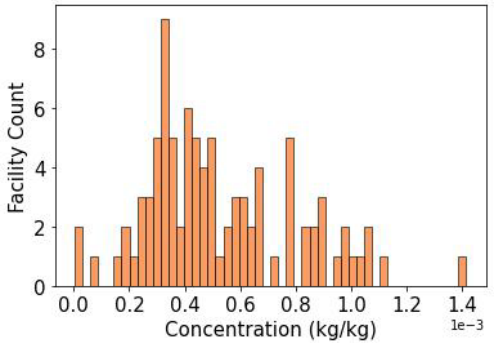
Compile AEGIS database of industrial facilities and pollutant flows from EPA databases

Calculate total amount and concentration of pollutants in the flue gas

Statistical analysis



Cement Sector: Emissions Distribution

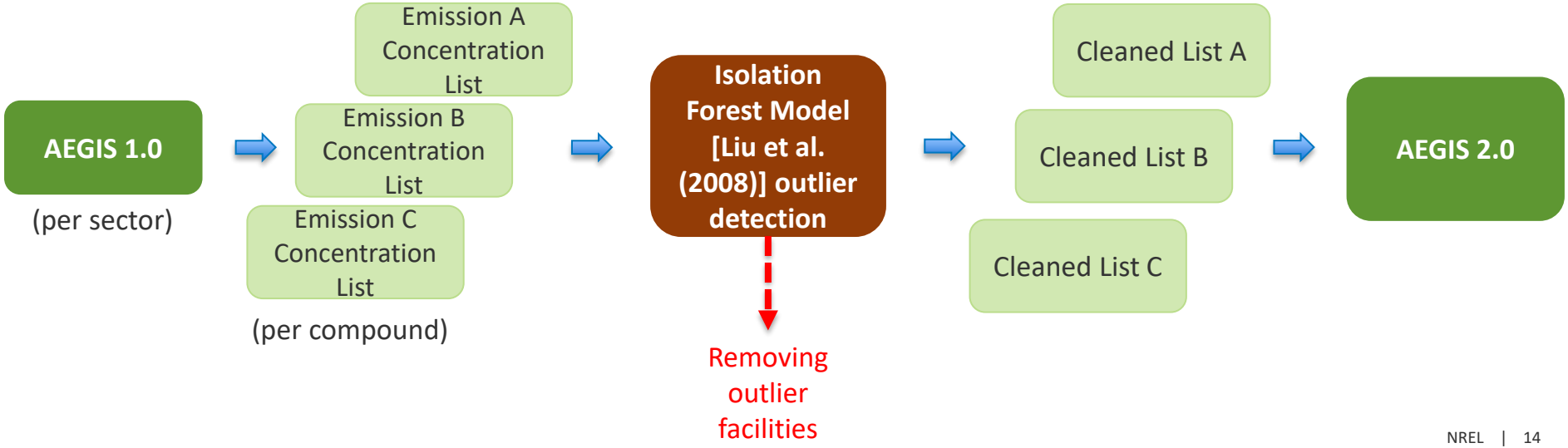
	Distribution of Pollutants in Cement Facility Stacks	
	Total Flow Amount	Concentration
Sulfur Dioxide (SO_2)		
Nitrogen Oxide (NOx)		

Methods: Removing Outliers

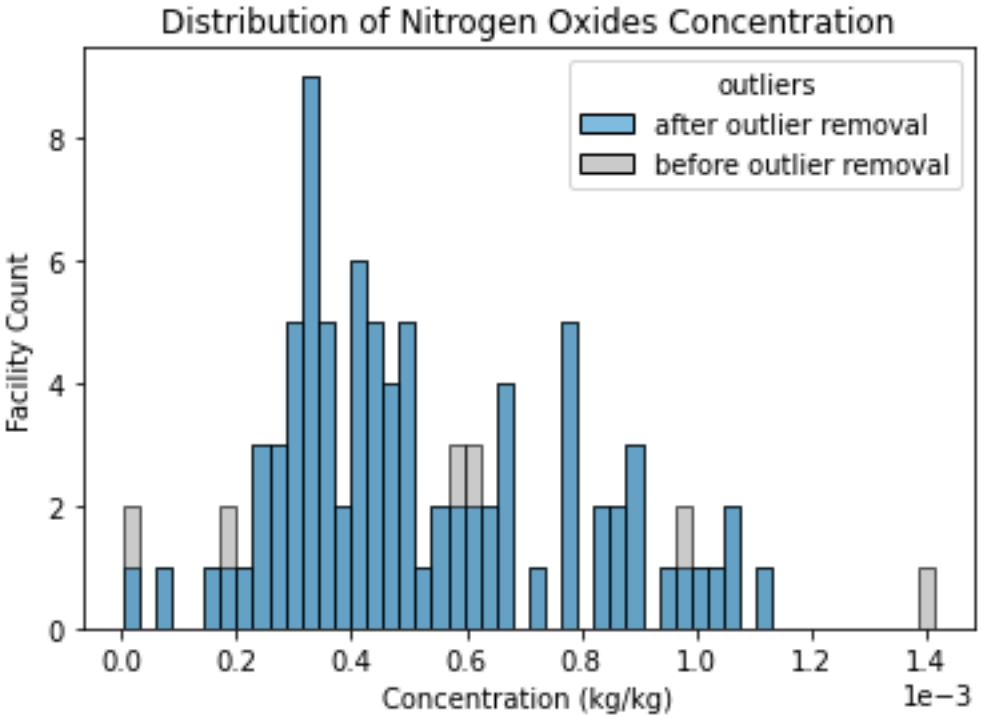
Compile AEGIS database of industrial facilities and pollutant flows from EPA databases

Calculate total amount and concentration of pollutants in the flue gas

Statistical analysis



Cement Sector Exploration



Outlier Removal Status	1st-2nd-3rd Quartile Values
Before	**0.33-0.46-0.67**
After	**0.33-0.45-0.66**

Methods: Process Level

Databases and StEWI

EPA Databases

GHGRP

Fuel

Unit

NEI

StEWI [Ingwersen et al (2021)]

Source Classification Code

Sectoral Grouping

NAICS Codes

Facility Level Information on GreenHouse gases Tool (FLIGHT)
OR
User-Defined

Improving the NAICS Code Grouping (Future)

GHGRP Process inventory → GHGRP process sectoral

NEI process inventory → NEI process sectoral

Current results

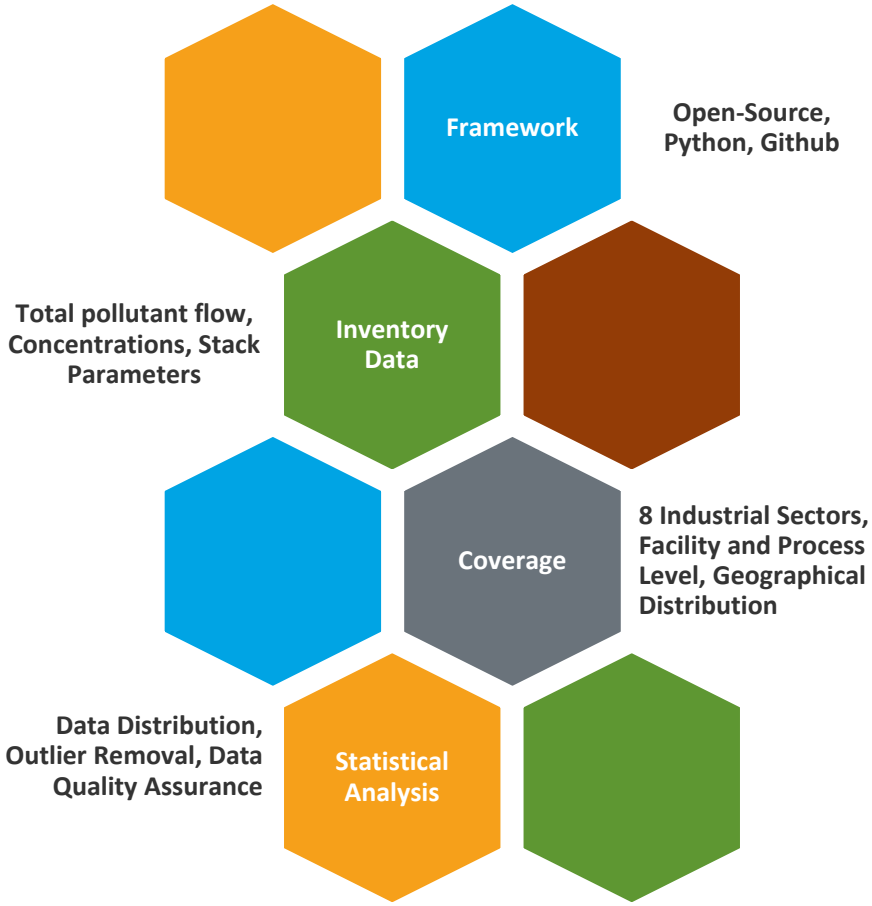
GHGRP

- Methane
- CO_2
- Nitrogen Oxide
- Biogenic CO_2
- Unit models
- Unit types
- Fuel used

NEI

- 139 pollutants
- Unit types
- Unit description

Conclusion


Framework
Open-Source, Python, Github
Total pollutant flow, Concentrations, Stack Parameters
Inventory Data
Coverage
8 Industrial Sectors, Facility and Process Level, Geographical Distribution
Data Distribution, Outlier Removal, Data Quality Assurance
Statistical Analysis

Future plans for AEGIS

EPA

Providing feedback to the StEWI development group regarding the issues concerning the harmonization of databases, errors in the original data sources etc.

Process Level Resolution

Detailed inventory development at the process level within each facility to explore flue gas concentration within individual unit operations of the facility.

Life Cycle Inventory Development

Creating a robust life cycle inventory from collected emissions data, informing the U.S. Life Cycle Inventory (National Renewable Energy Laboratory, 2012) repository development etc.

AEGIS - Air Emissions Grouped By Industrial Sectors

OBJECTIVE: Develop a high-resolution inventory of pollutant flows from carbon-intensive industrial point emissions sources.

Compile database of industrial facilities and pollutant flows from EPA databases

Calculate concentration of pollutants in the flue gas

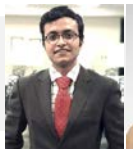
Statistical analysis

SIGNIFICANCE: Facilitate the estimation of co-benefits of post-combustion carbon capture (PCCC) in industrial facilities for emissions reductions of regulated pollutants.

Sectors Covered

- Ethanol
- Petroleum Refining
- Steel
- Wood and Paper Products
- Natural Gas Processing
- Hydrogen
- Cement
- Ammonia

TEAM:

swaroop.atnoorkar@nrel.gov gregory.cooney@doe.gov

Thank you! Questions?

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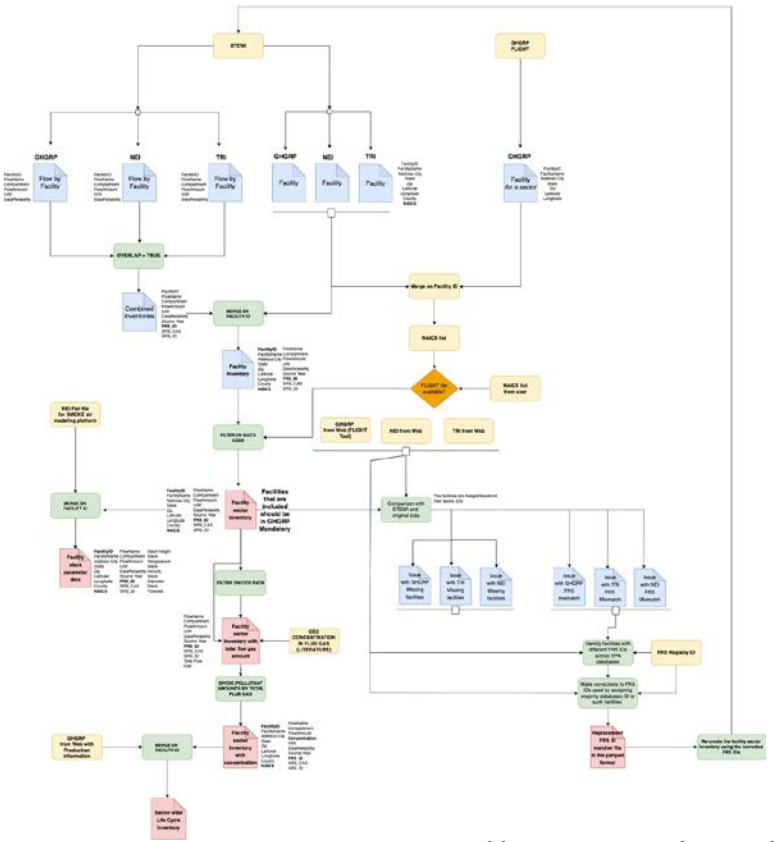
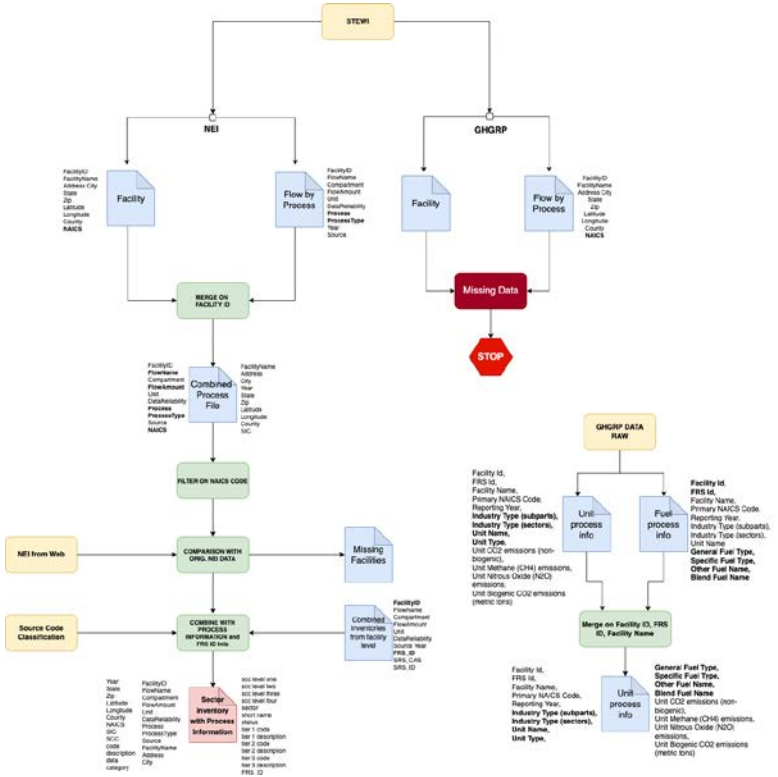
Complete Automated Python Framework





https://github.com/NREL/Industrial-Emissions-Inventory