Case Simulation and Users Q&A: Algae and Aviation Fuels

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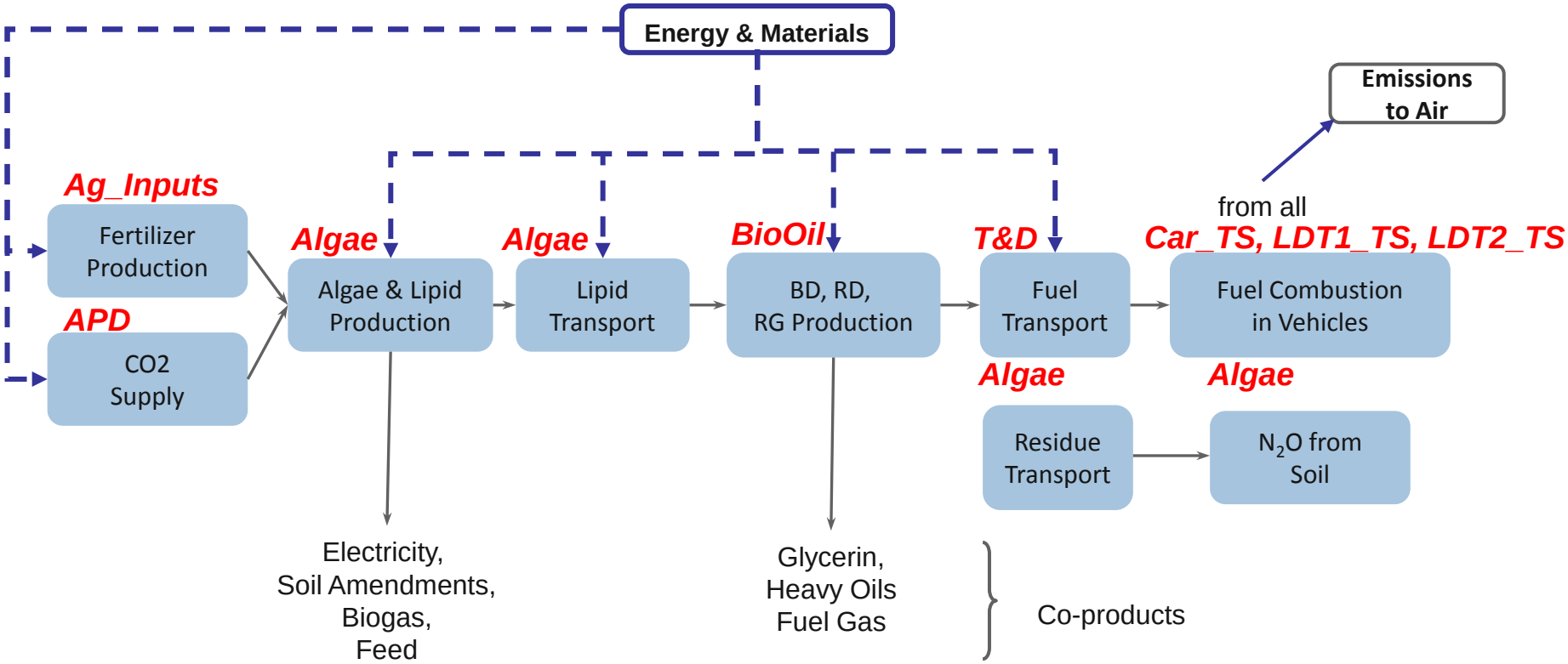
Outline

- **Algae**
- Aviation Fuels (Well-to-Pump)
- Aviation Fuels (Pump-to-Wake)

Algae LCA and System Boundary

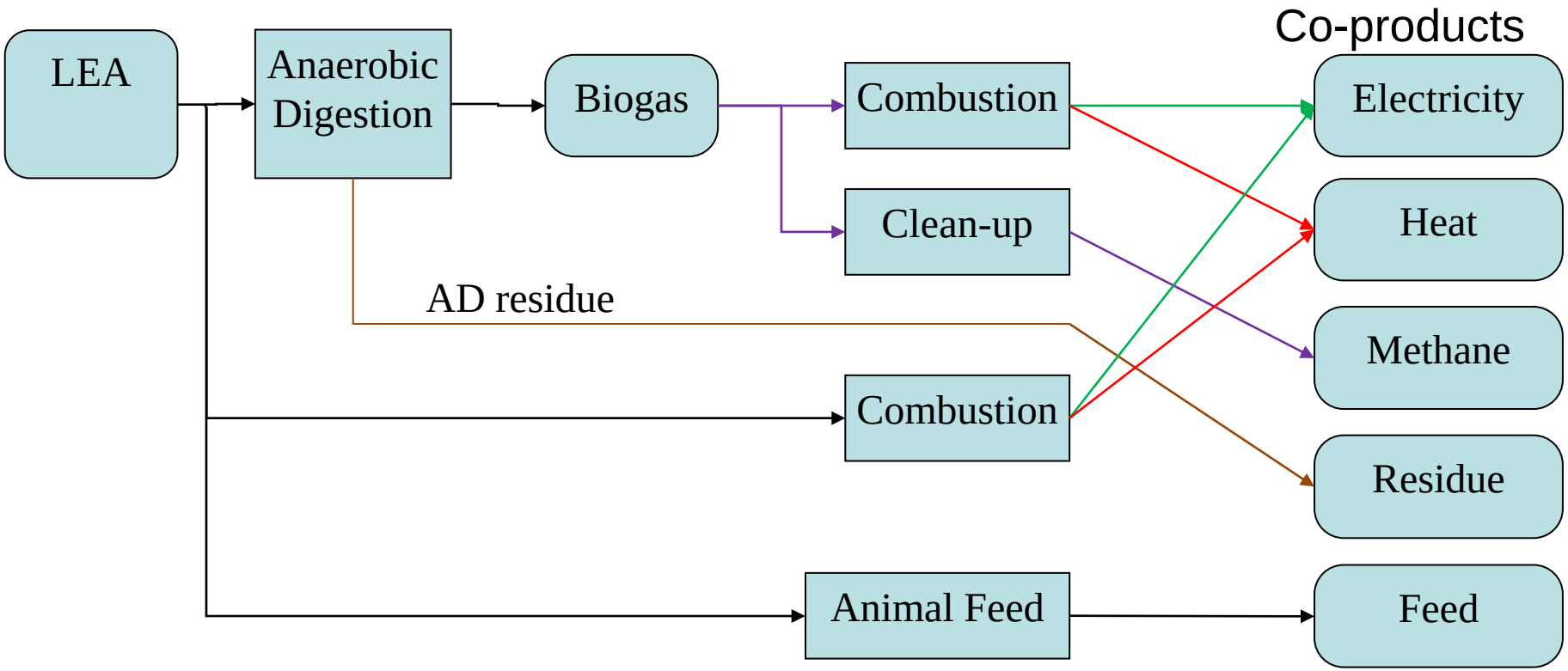


- Scenario Control

	A	B	C	D	E	F
1						
2	**Algae**					
3	**Scenario Control and Key Input Parameters**					
4	Scenario Control	Set with APD	Algae Process Description (APD) is located in the folder that GREET is installed.			

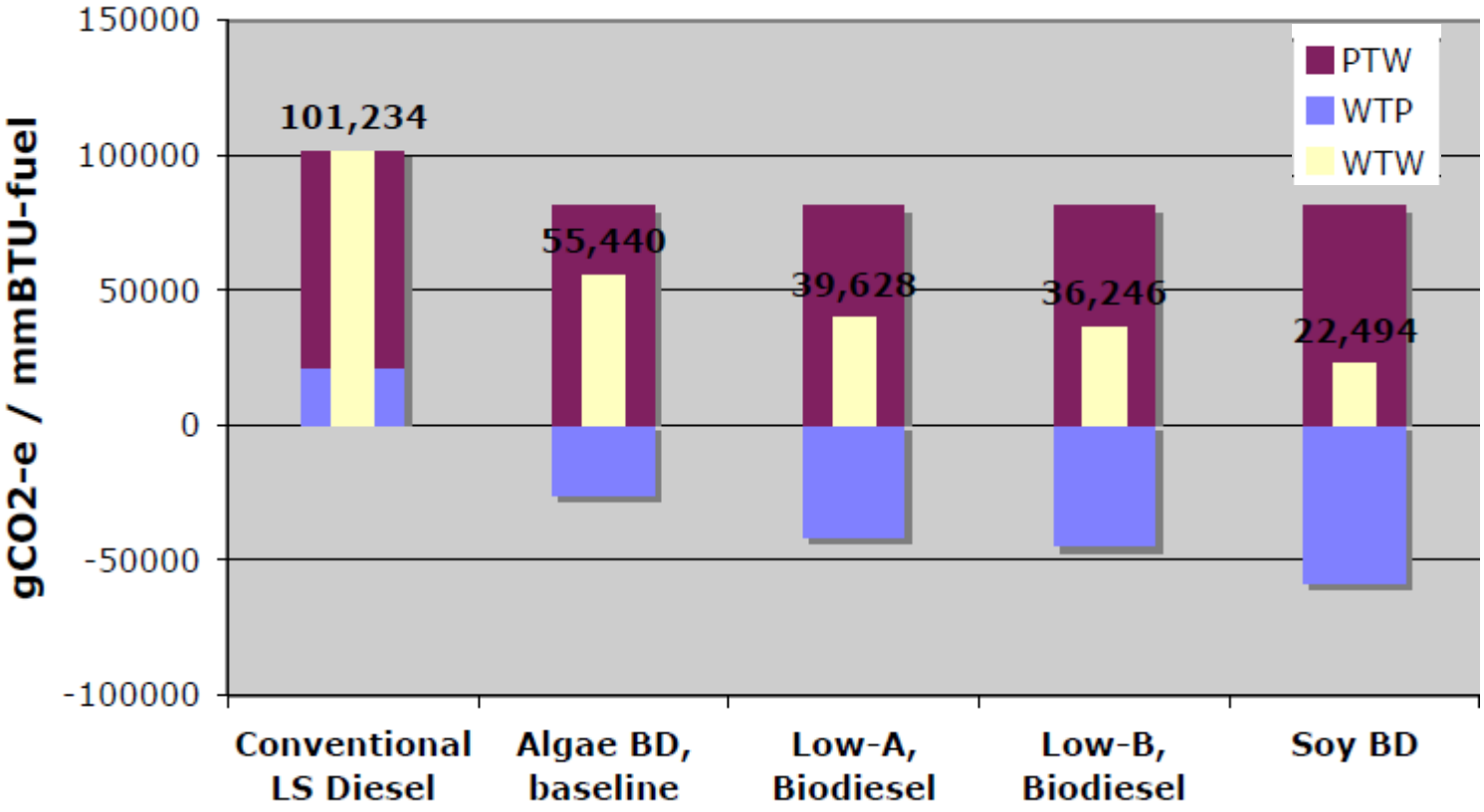
  - **Set with APD**: Key assumptions are obtained from APD through cells O2:W54
  - Three pre-configured scenarios: Baseline, Low-A, Low-B

Co-product Handling is a Key Issue



- Co-product handling method for the algal oil production stage can be selected in the ***Algae*** tab (Section 2)
- Co-product handling method for the BD, RD and RG production stages can be selected in the ***Inputs*** tab (Section 8)

Algal fuels have higher GHG emissions than soybean-based BD



Demo

- Scenario Control

- Recovery Options
  - Options for LEA use to produce different co-products
  - CHP Type: Boiler, **Turbine**, ICE engine
  - AD Residue Handling Description
    - AD Residue Transport: Solid content, Distance, Vehicles
    - Direct Emissions from AD Residue: Carbon Sequestration, NO/N2O Emissions

- Feedstock for bio oil-based fuels in the **Inputs** tab should be **Algae**

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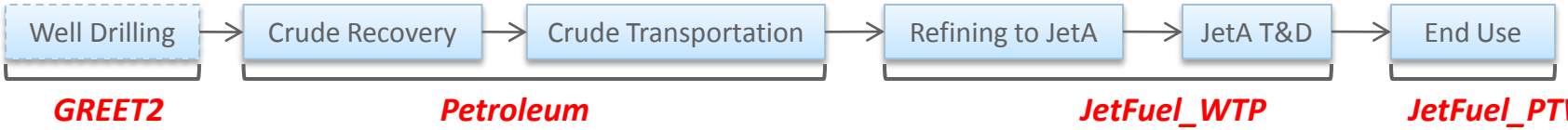
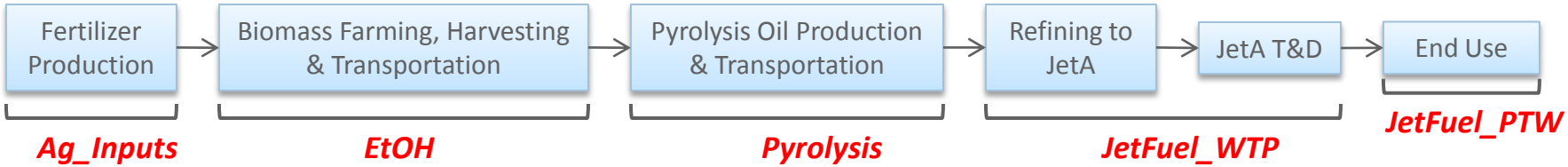
Aviation Fuels System Boundary

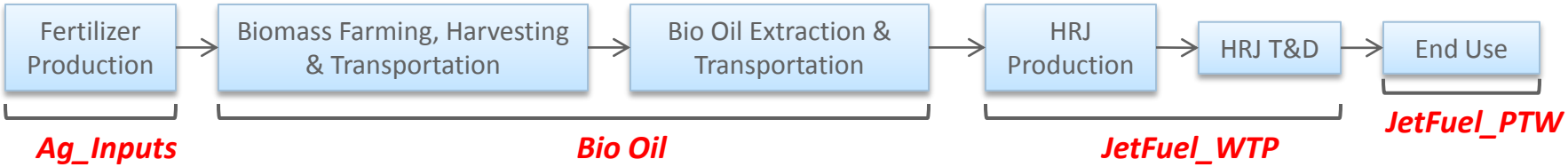
- Petroleum-based Jet A



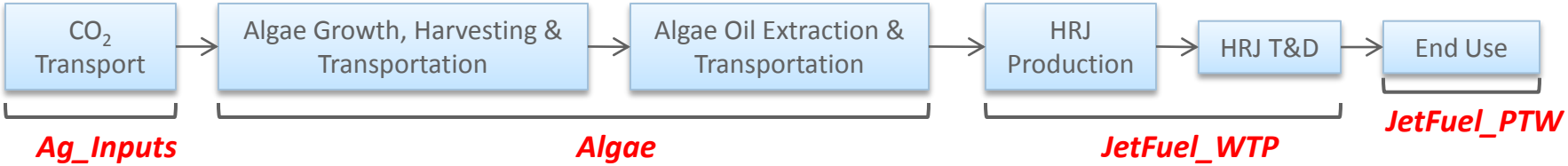
- Pyrolysis-based Jet A



- Six Bio-Oil-based Hydrotreated Renewable Jet (HRJ)
  - Soybean, Palm, Rapeseed, Jatropha, Camelina

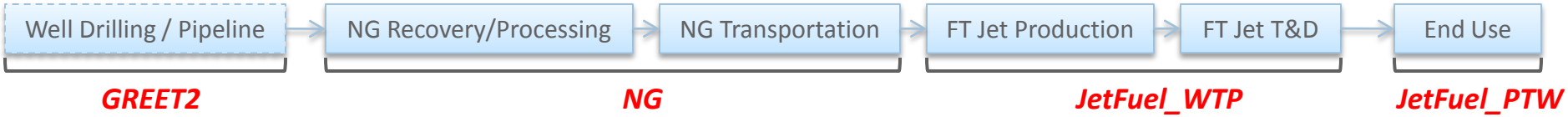


  - Algae

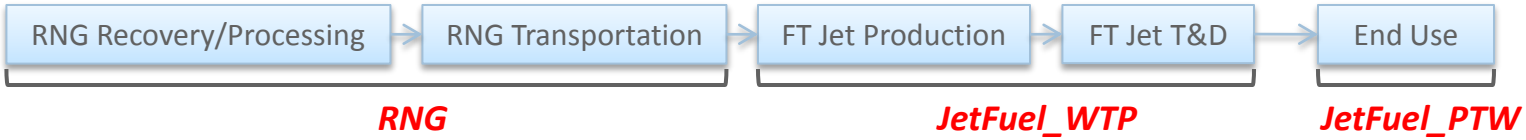


Aviation Fuel System Boundary (Cont'd)

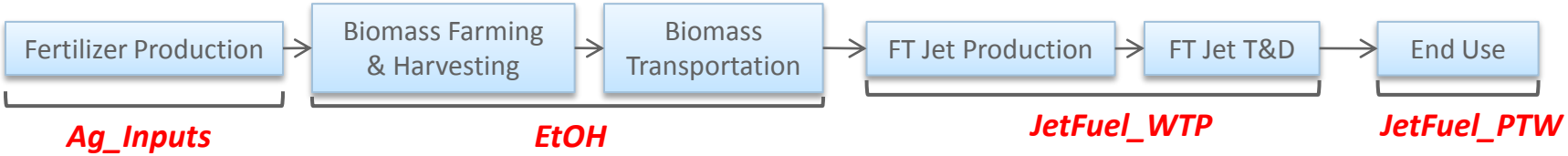
- Seven Fischer-Tropsch Jets
  - NG-based Fischer-Tropsch Jet
    - North American Natural Gas, Non-North American Natural Gas, Non-North American Flare Gas



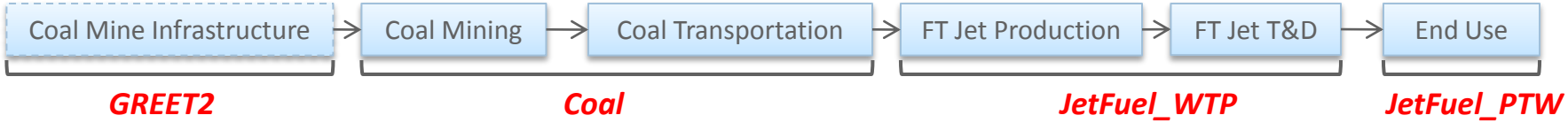
    - Renewable Natural Gas



  - Biomass-based Fischer-Tropsch Jet



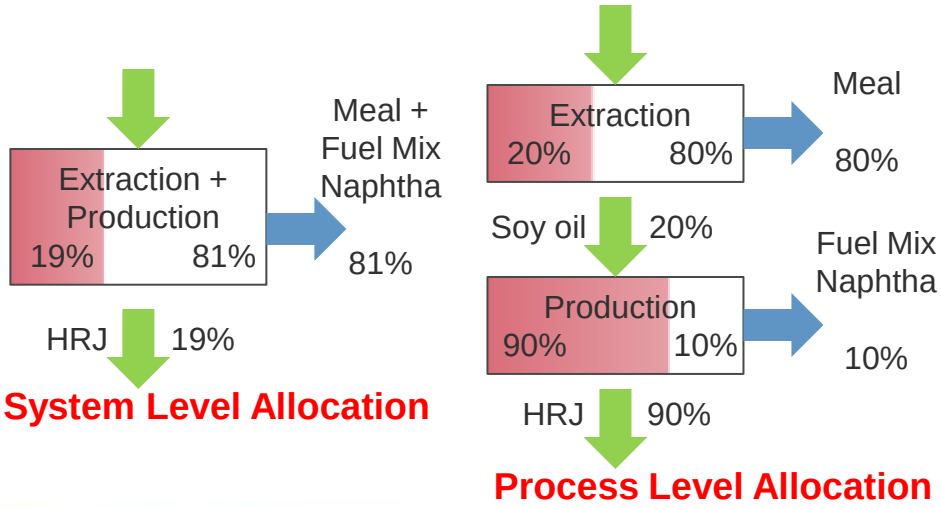
  - Coal-based Fischer-Tropsch Jet



  - Coal/Biomass-based Fischer-Tropsch Jet

Demo

- Petroleum-based and Pyrolysis-based Jet A Production: Section 1.1
  - Type of Jet A
  - Jet A Feedstock
  - Jet A refining process
- FT Jet Production: Section 1.2
  - The same assumptions and process models as in the FT diesel production are used
  - Types of biomass for biomass-based and coal/biomass-based FT jet and the share of coal and biomass for coal/biomass-based FT jet can be defined
- HRJ Production: Section 1.3
  - Feedstock Source
  - Process Scenario
  - Process Assumptions
  - Allocation methods
    - System Level Allocation
    - Process Level Allocation



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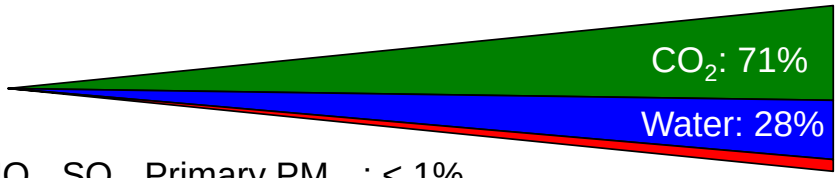
- **Aviation Fuels (Pump-to-Wake)**

Environmental Impacts of Aviation



CO, HC, NO_x, SO_x, Primary $PM_{2.5}$: < 1%

Aircraft Noise

Atmospheric Chemistry and Physics

Primary PM_{10}*

SO_x

NO_x

CO

VOC

UHC

Aldehydes

Secondary PM_{10}

Ozone

Population Exposure and Health Impacts

Combustion Emissions

soot

SO_x

NO_x

O_3

CH_4

H_2O

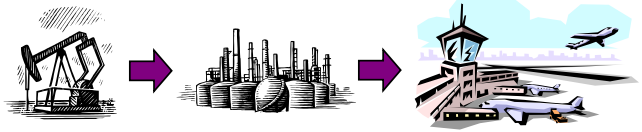
CH_4, N_2O, CO_2

Global Climate Change

Cooling Effects

Warming Effects

Emissions from Fuel Production



CH_4, N_2O, CO_2

Land and Water Usage

Items included in GREET PTW tool

Items included in GREET WTP tool

*Primary PM_{10} assumed to be same specie as soot/black carbon

Aircraft Types and Classes in GREET

- **Passenger Aircraft**
  - Single Aisle
  - Small Twin Aisle
  - Large Twin Aisle
  - Large Quad
  - Regional Jet
  - Business Jet

- **Freight Aircraft**
  - Single Aisle
  - Small Twin Aisle
  - Large Twin Aisle
  - Large Quad

PTW Results Are Determined by These Key Factors

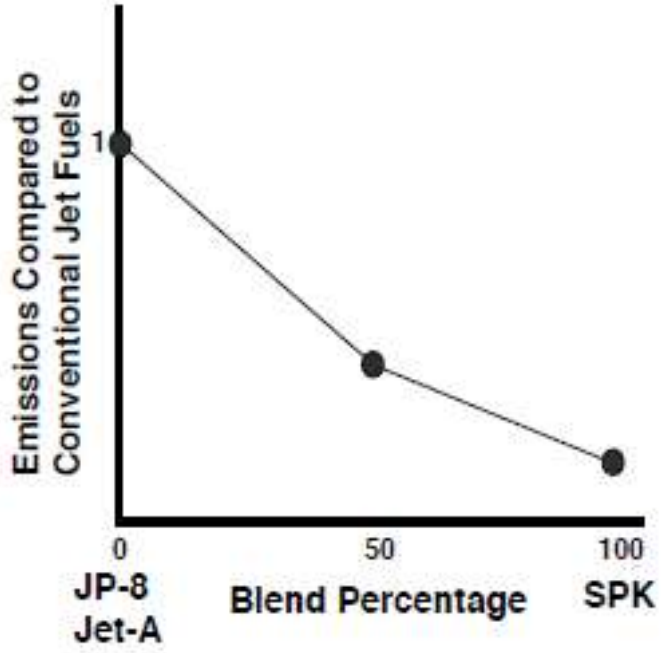
- Aircraft operation (Pump-To-Wake)
  - Total flight payload fuel energy intensity by aircraft type
  - Cruise and LTO emissions
  - Payload and great circle distance
- Three functional units in GREET
  - Per MJ of Fuel
  - Per kg-km
  - Per passenger-km

Jet Fuel Parameters in GREET

- Fuel properties for petroleum jet fuel and synthetic paraffinic kerosene (SPK)
  - Options for heat of combustion: LHV and HHV
  - Density, C ratio, S ratio (ppm & wt.%)
  - Fuel carbon and sulfur intensity (g/MJ)
- Share of SPK in blend (vol.%)
- Averaged information for each aircraft class (operational performance data from Volpe)
  - Average payload (kg)
  - Average trip great circle distance (km)
  - Total flight payload fuel energy intensity ($kJ/kg_{payload}\text{-}km_{great\ circle\ distance}$)
  - Fuel consumption (kg/LTO_{cycle})
  - CH_4, N_2O, CO_2, VOC, CO, NO_X, BC, and SO_X LTO and cruise emissions
  - Neat SPK LTO and Cruise emissions normalized to petroleum jet fuel

Share of SPK in Blend

- Data provided by MIT for 100% SPK, and for 50/50 blend of SPK with Conventional Jet
- GREET uses two-way interpolation between 0%-50% SPK and between 50%-100% SPK for other blending options



Aircraft Characterization

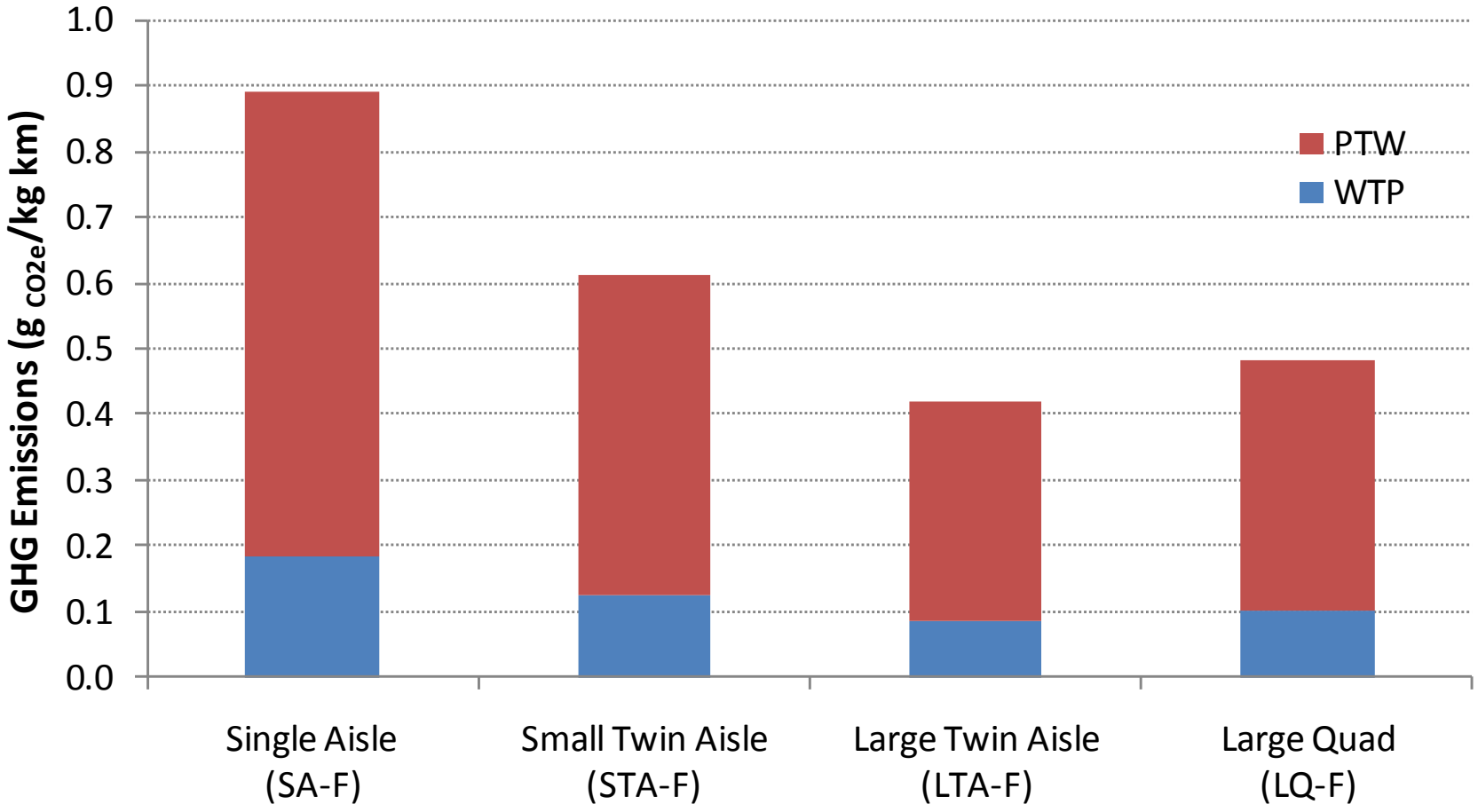
- Averaged aircraft operation data for specific aircraft classes

2010 US origin only AEDT aircraft types and operational performance data from Volpe

Aircraft Type	Aircraft Class	Aircraft Operations	Average Payload (kg/operation)	Average Trip Great Circle Distance (km/operation)	As-Operated Aircraft Average Trip Petroleum Jet Fuel Consumption (kg/operation)	Aircraft LTO Cycle Average Petroleum Jet Fuel Consumption (kg/operation)
Passenger Aircraft	Single Aisle (SA)	3,838,461	18,230	1,366	4,986	565
	Small Twin Aisle (STA)	131481	30,389	2,804	14,590	982
	Large Twin Aisle (LTA)	120,266	57,999	7,132	59,468	1,731
	Large Quad (LQ)	46,721	82,210	7,520	91,642	2,484
	Regional Jet (RJ)	3,382,535	7,017	755	1,728	257
	Business Jet (BJ)	95,238	1,581	1,177	1,730	273
Freight Aircraft	Single Aisle (SA-F)	22,074	21,036	723	3,389	598
	Small Twin Aisle (STA-F)	220,272	44,848	1,415	9,769	949
	Large Twin Aisle (LTA-F)	41,782	89,596	3,317	31,414	1,496
	Large Quad (LQ-F)	31,067	99,663	5,019	60,771	2,271

WTW GHG Emissions of Petroleum Jet Fuels

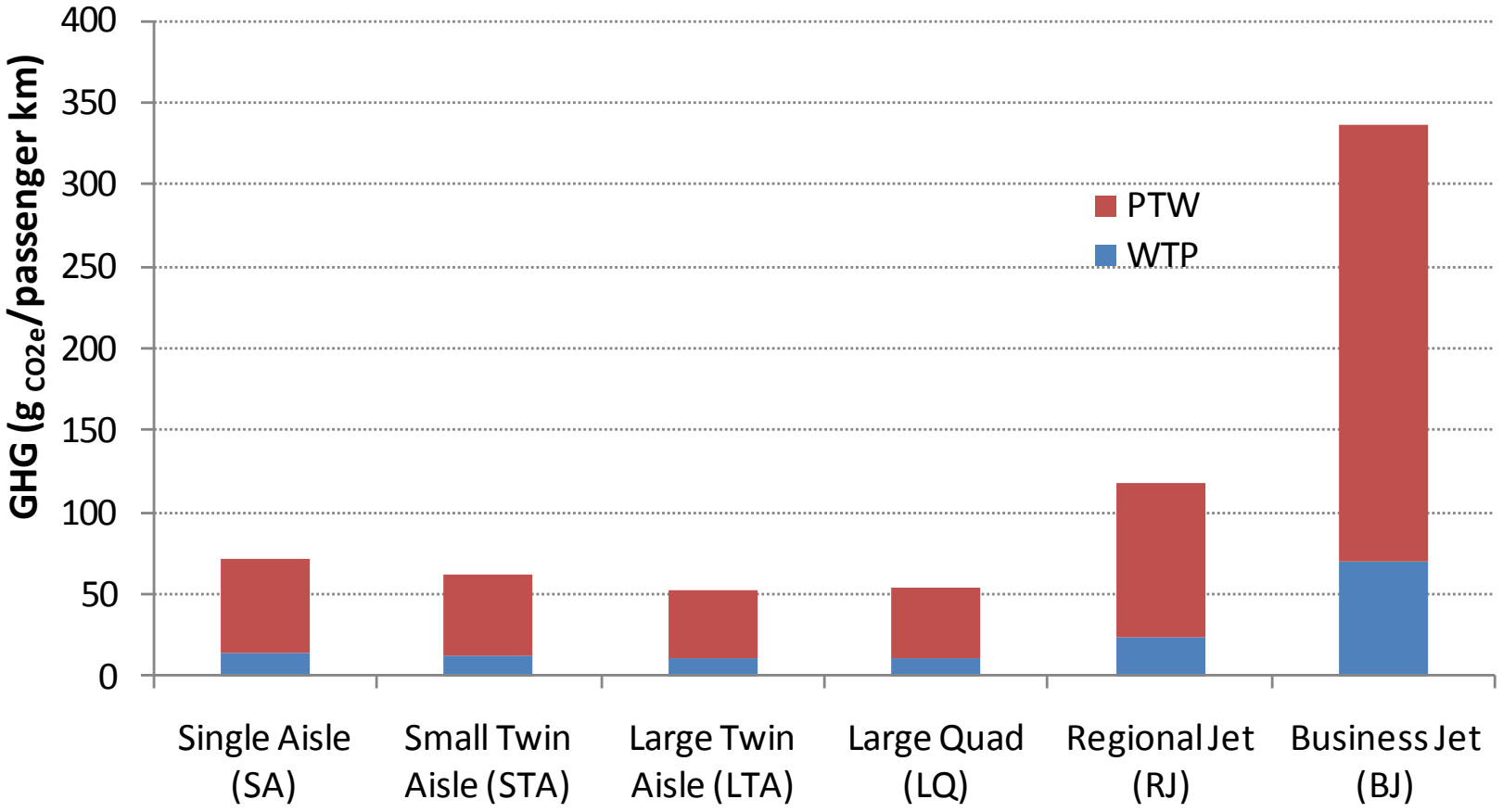
- LCA Functional Unit: per kg-km (Freight Aircraft)



WTW GHG Emissions of Petroleum Jet Fuels

- LCA Functional Unit: per passenger-km

(assume average passenger + luggage weight of 90 kg or 200 lbs)



WTW GHG Emissions of Alternative Jet Fuels

- LCA Functional Unit: per MJ of Fuel Consumption