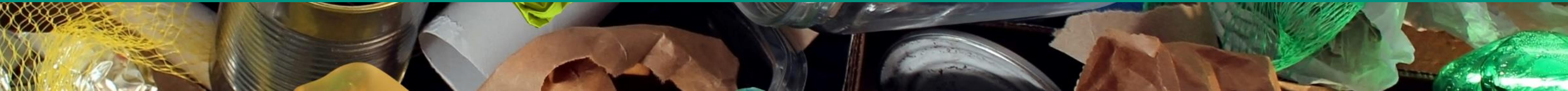
Oregon Recycling Modernization Act Technical Workgroup on Materials Lists

Meeting #3

May 31, 2022



Guests

- Nicholas Georges – Household & Commercial Products Association
- Matt Durbin – Cyclyx International / Agilyx
- Alison Keane and Sam Schlaich – Flexible Packaging Association
- Tonya Randell – Stina Inc.
- Nicole Janssen – Denton Plastics
- Martin Vogt – EFS Plastics

Comparative Life Cycle Assessment of Expanded Polystyrene Dispositions

Chemical Recycling (Pyrolysis) vs. Mechanical Recycling vs. Landfilling

Peter Canepa | Oregon Department of Environmental Quality

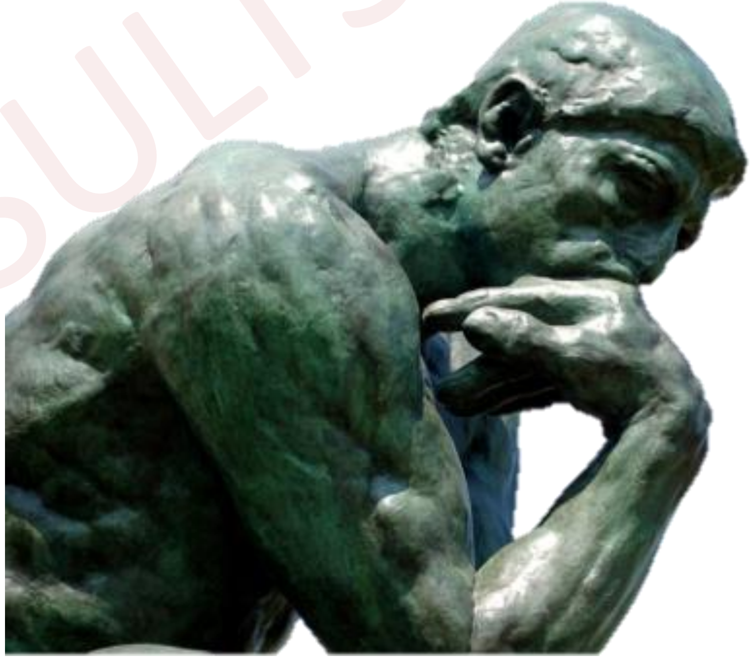
Agenda

- Goal and Scope
- Results
- Interpretation and Limitations
- Potential Next Steps

Goal and Scope

Project Goals/Objectives

- Using Comparative Life Cycle Assessment
  - Quantify the environmental impacts of different end of life management scenarios for Expanded Polystyrene (EPS) to identify trade-offs and key variables.



Scope – Functional (Declared) Unit

- **Function:** Disposition of EPS through different end of life pathways

- **Magnitude/unit:** 1 us ton (short ton)

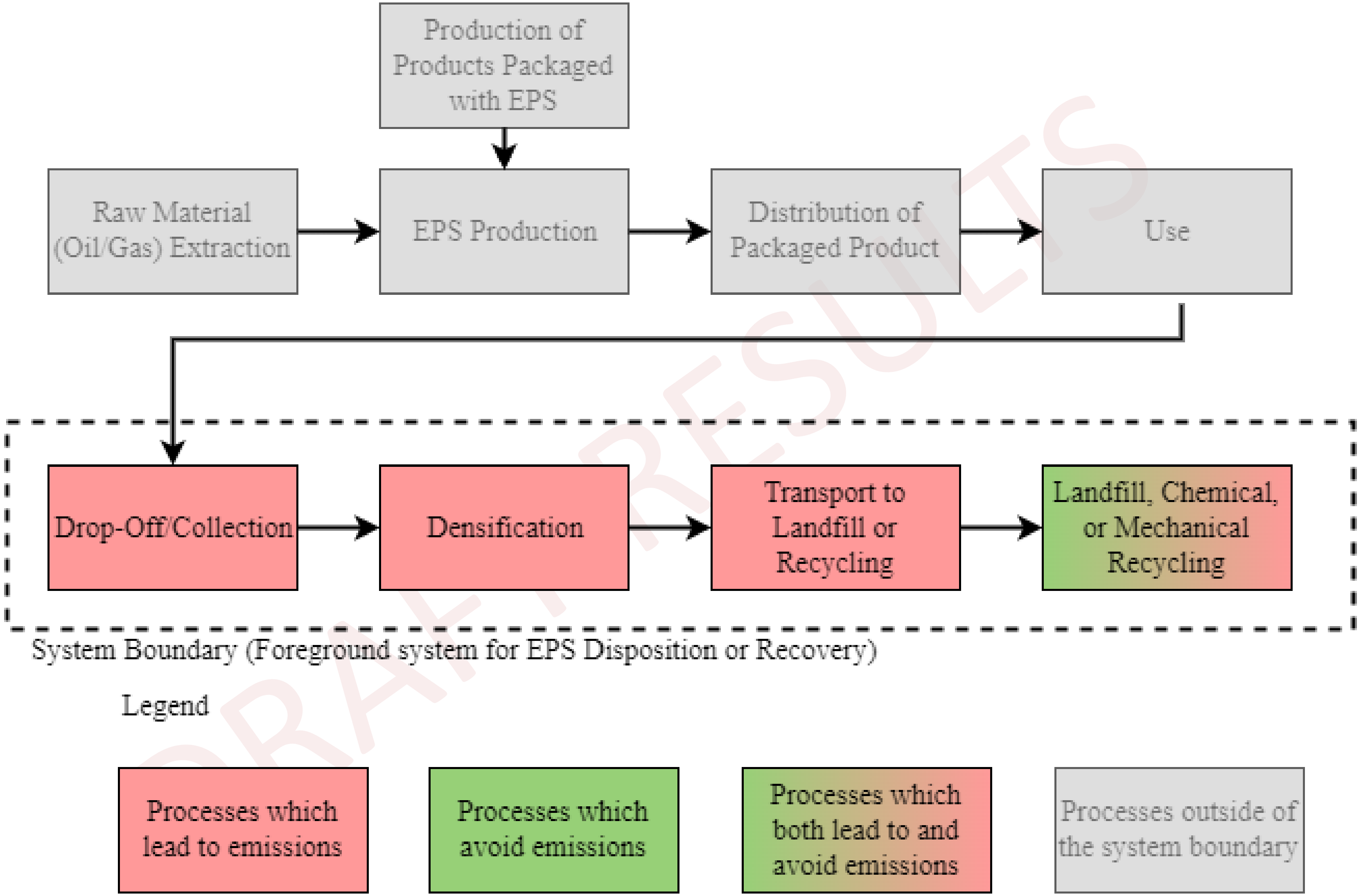
Scope – Key Variables Evaluated

- Collection - Marginal vs Additional Drop-Off vs On Route
- Densification – Onsite vs Offsite vs Undensified
  - Transport – Densified vs Undensified
- End of Life Dispositions - Chemical Recycling (Oregon) vs Mechanical Recycling (Asia) vs Distant Landfilling vs Local Landfilling

Scenarios Evaluated

Scenario Number	Collection	Densification	Disposition
S1	Drop-Off (Marginal)	On-site	Pyrolysis (in-state)
S2	Drop-Off (Additional)	On-site	Pyrolysis (in-state)
S3	Drop-Off (Marginal)	On-site	Mechanical Recycling (Asia)
S4	Drop-Off (Additional)	On-site	Mechanical Recycling (Asia)
S5	Drop-Off (Marginal)	Off-Site	Pyrolysis (in-state)
S6	Drop-Off (Additional)	Off-Site	Pyrolysis (in-state)
S7	Drop-Off (Marginal)	Off-Site	Mechanical Recycling (Asia)
S8	Drop-Off (Additional)	Off-Site	Mechanical Recycling (Asia)
S9	Drop-Off (Marginal)	None/Undensified	Pyrolysis (in-state)
S10	Drop-Off (Additional)	None/Undensified	Pyrolysis (in-state)
S11	Drop-Off (Marginal)	None/Undensified	Distant Landfill
S12	Drop-Off (Additional)	None/Undensified	Distant Landfill
S13	On Route to Transfer Station	None/Undensified	Distant Landfill
S14	Drop-Off (Marginal)	None/Undensified	Nearby Landfill
S15	Drop-Off (Additional)	None/Undensified	Nearby Landfill
S16	On Route Direct to Landfill	None/Undensified	Nearby Landfill

Scope – System Boundary



Scope – System Boundary

- **Temporal Coverage** – 2016-2022
- **Geographical Coverage** – Oregon
- **Technological Coverage** – This study is intended to represent materials management options for expanded polystyrene the foreground system covers technology and processes related to transportation of EPS to central locations or collection depots, mechanical densification, transport to end markets, chemical recycling, mechanical recycling, or landfilling. The background system includes electricity, thermal energy, and energy carriers (e.g. fuels).

Scope – Data Sources

- Primary Data Sources
  - Mechanical Densification – from Tillamook County
  - Pyrolysis – from Agilyx/Regenyx Air Contaminant Discharge Permit - 2020 Annual Report
- Secondary Data Sources
  - Truck Emissions – diesel combustion from USLCI (US DOE)
  - Truck Fuel Efficiency – US EPA Smartway
  - Passenger Vehicle Emissions – GaBi Database
  - Ship Emissions – GaBi Database
  - Mechanical Recycling – GaBi Database
  - Landfilling – GaBi Database
  - Fuels (Diesel or Gasoline) – GaBi Database
  - Production Emissions for Displaced Materials (Styrene and Polystyrene) – GaBi Database

Scope – Selected Impact Categories and Indicators

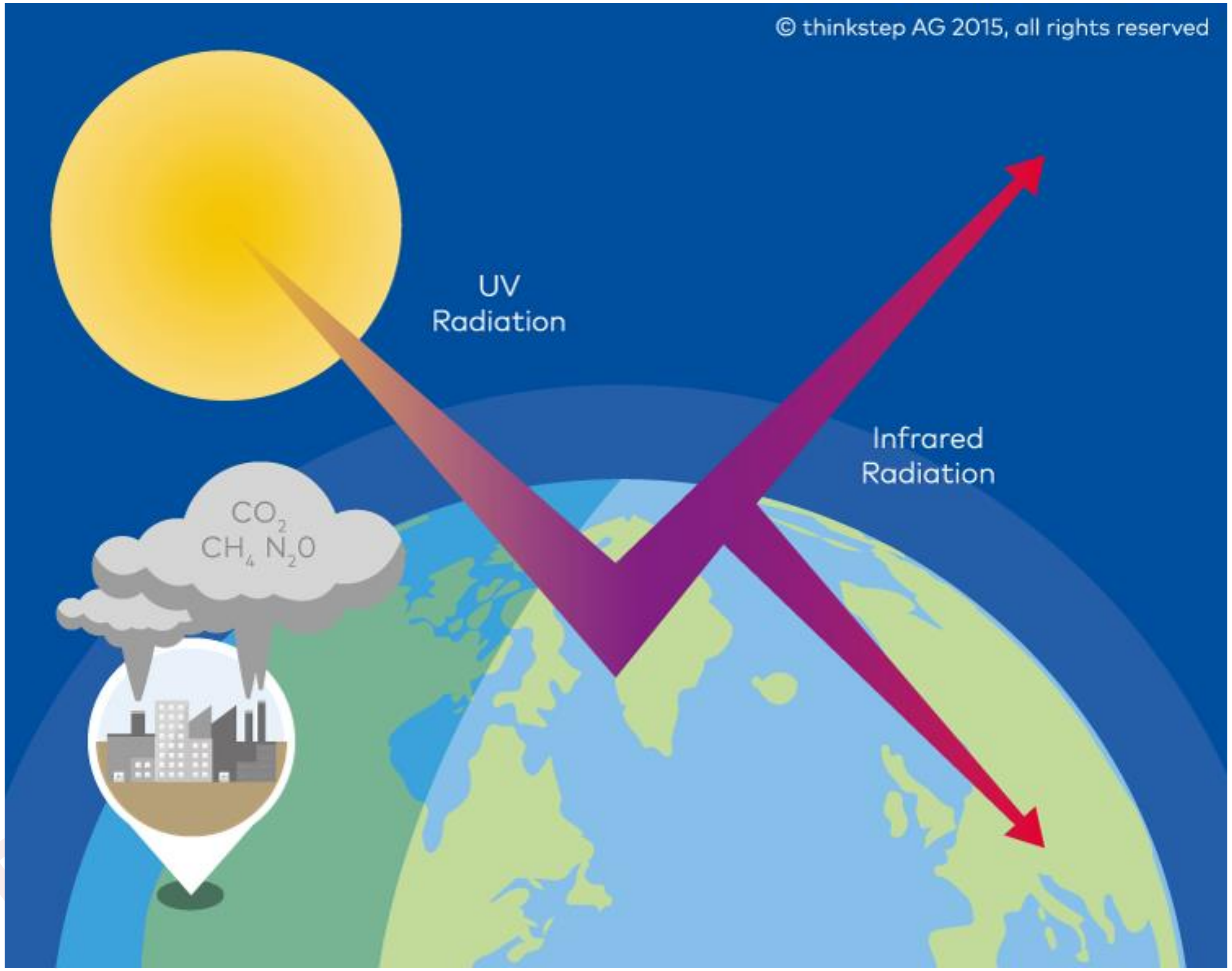
TRACI 2.1 LCIA Categories

- Acidification Potential (AP)
- Eutrophication Potential (EP)
- Ecotoxicity (ETP)
- Global Warming Potential (GWP100)
- Particulate Matter (PM2.5) Potential
- Human Toxicity Potential (HTP) – Cancer
- Human Toxicity Potential (HTP) – NonCancer
- Ozone Depletion Potential (ODP)
- Smog Formation Potential (SFP)

Environmental Indicators

- Fossil Resource use
- Water Consumption
- Primary Energy Demand

Global Warming Potential



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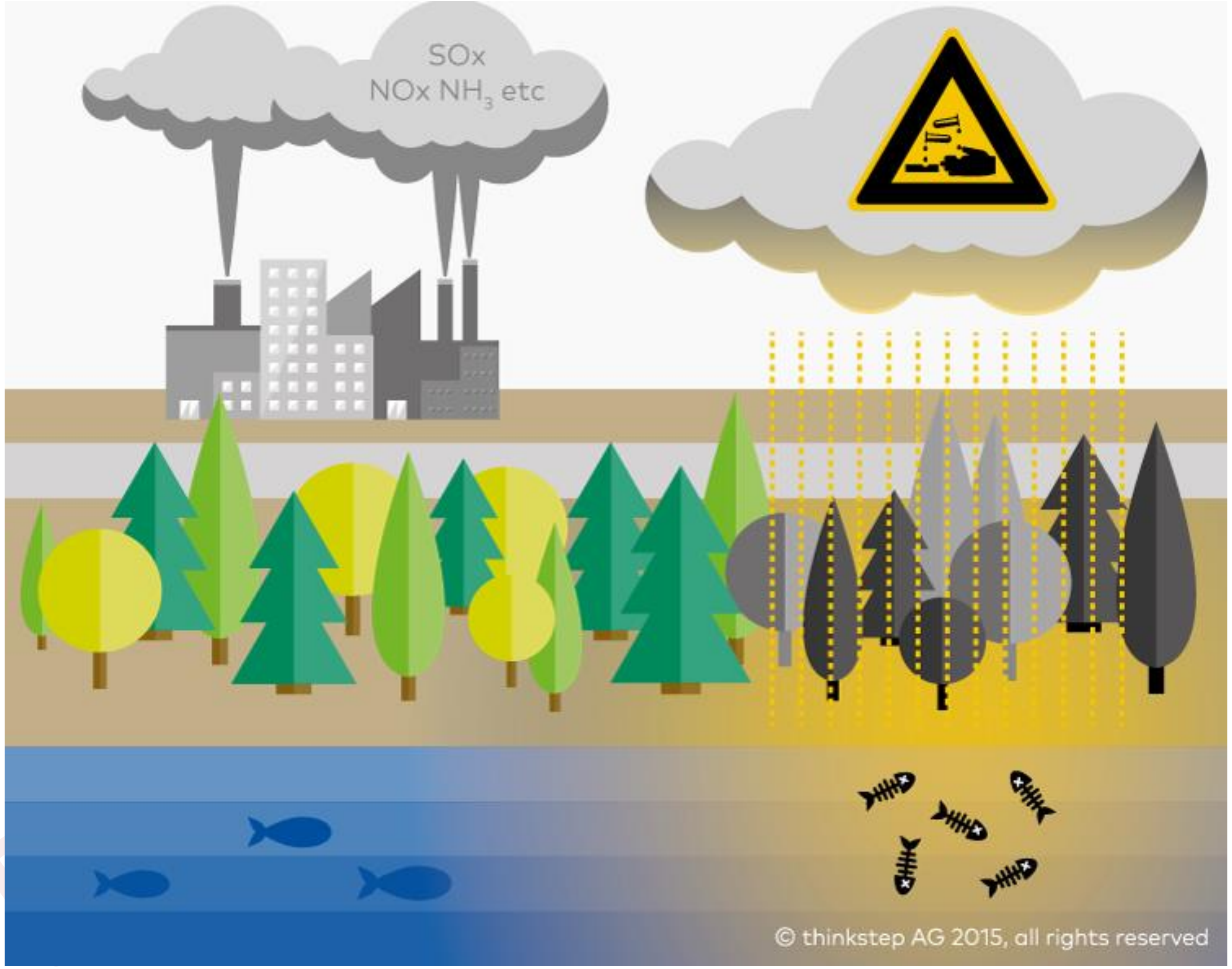
Acidification Potential



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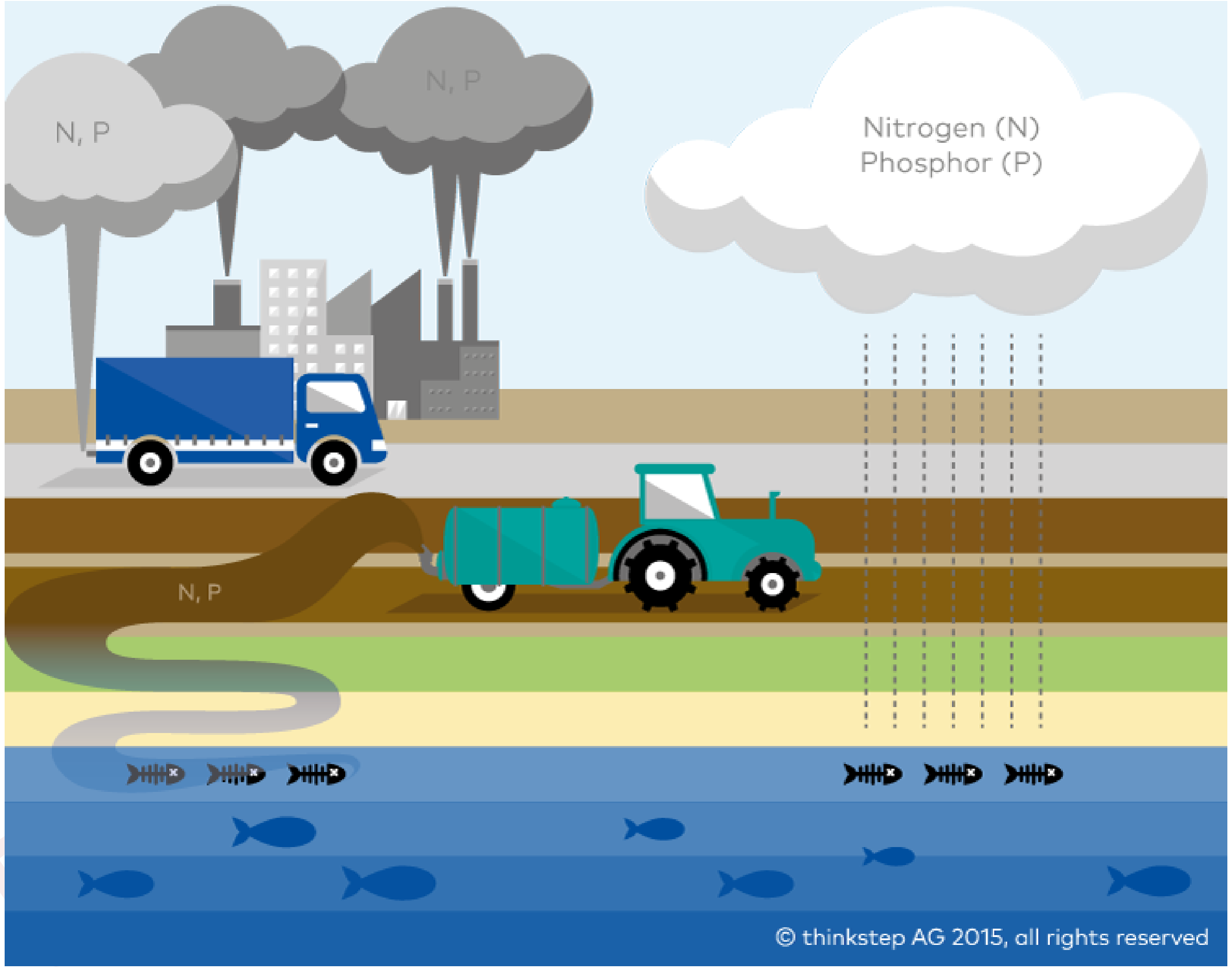
Eutrophication Potential



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Smog Formation Potential

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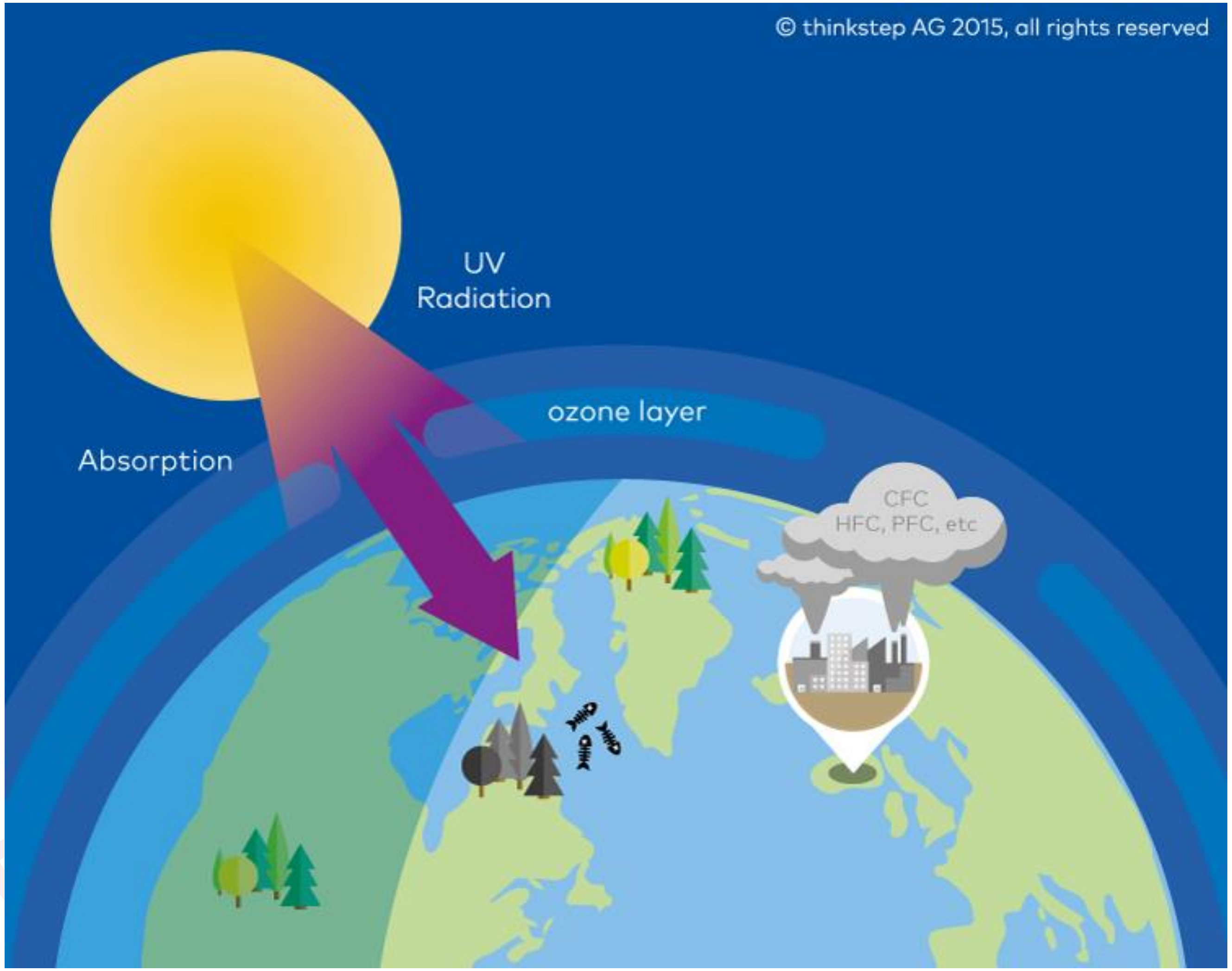
Ozone Depletion Potential



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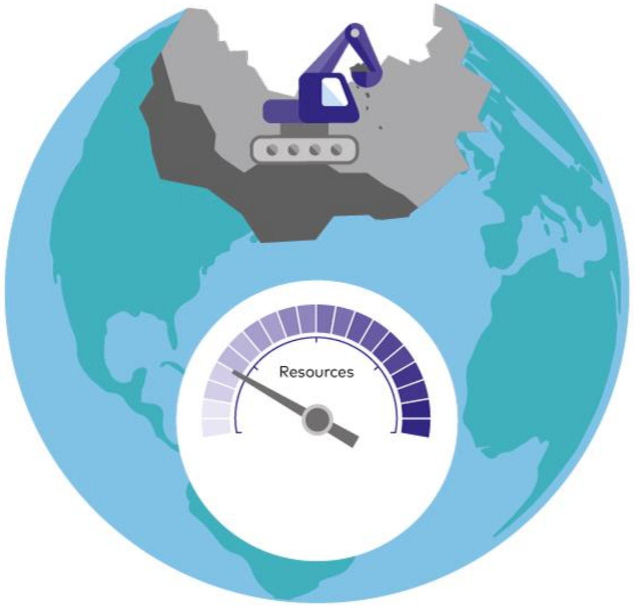
Primary Energy Demand



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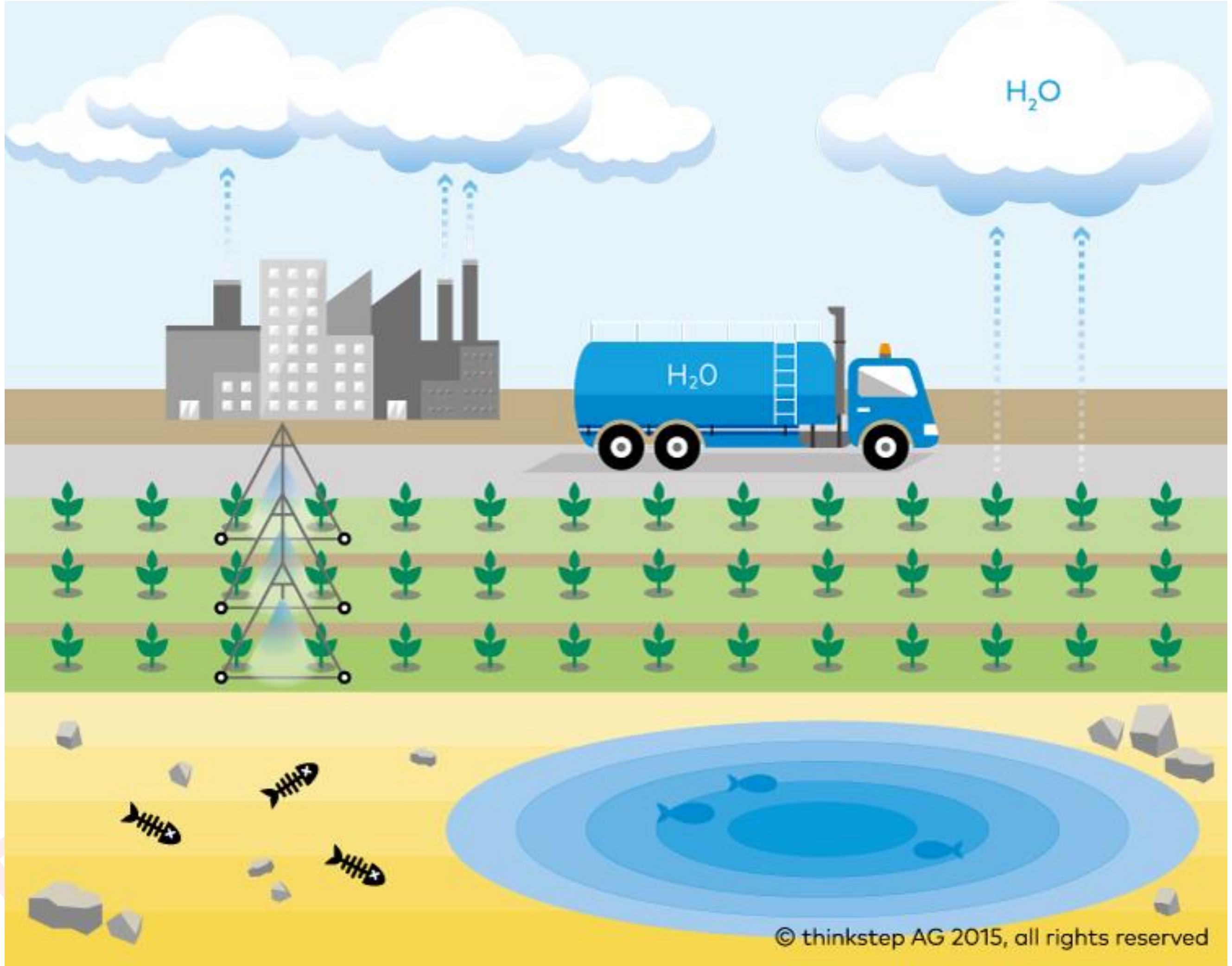
Freshwater Consumption



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Preliminary Results

Life Cycle Impact Assessment (LCIA) and Indicators

Scenarios Evaluated

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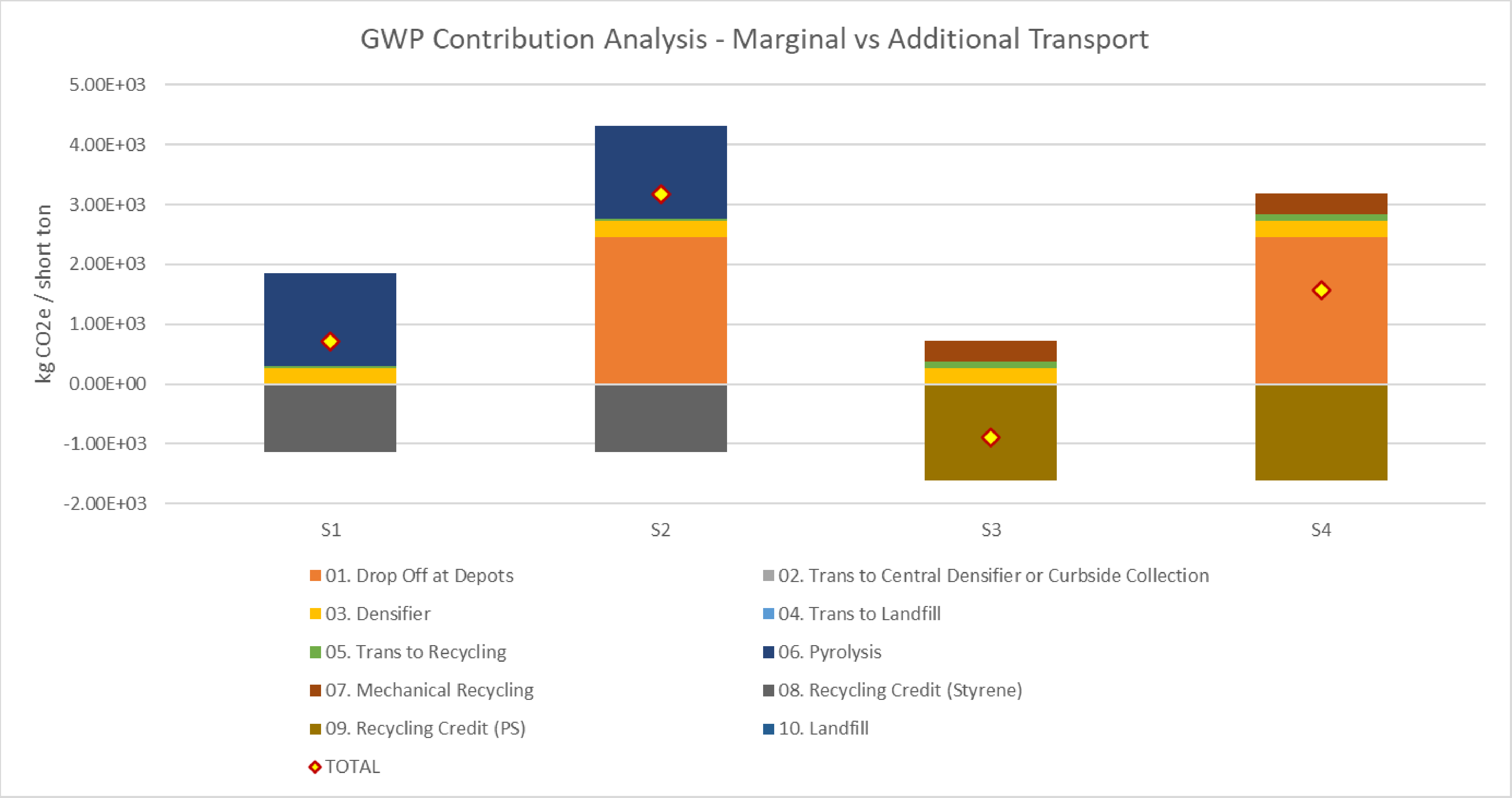
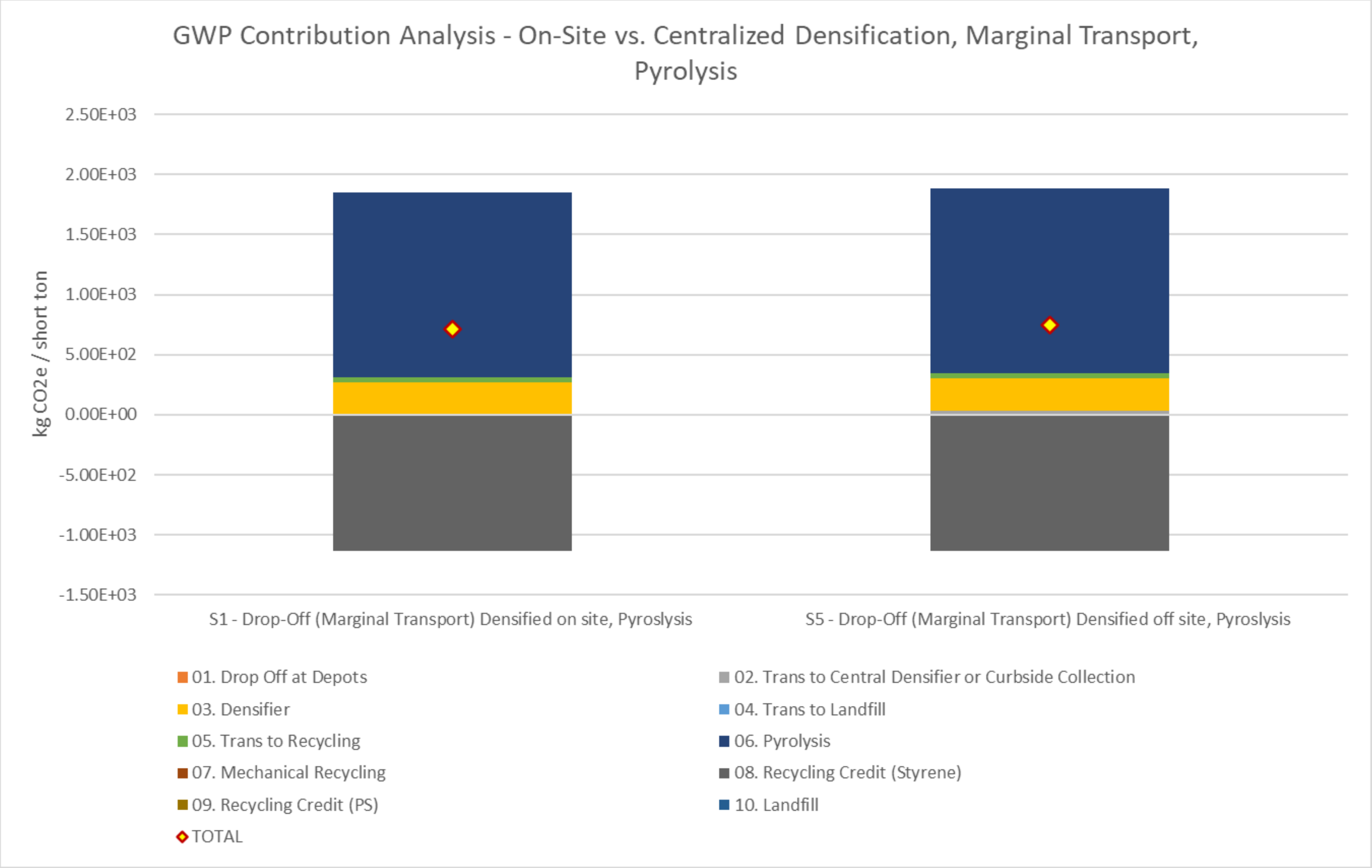
Draft LCIA Results – Global Warming Potential (GWP)



Draft LCIA Results – Global Warming Potential (GWP)



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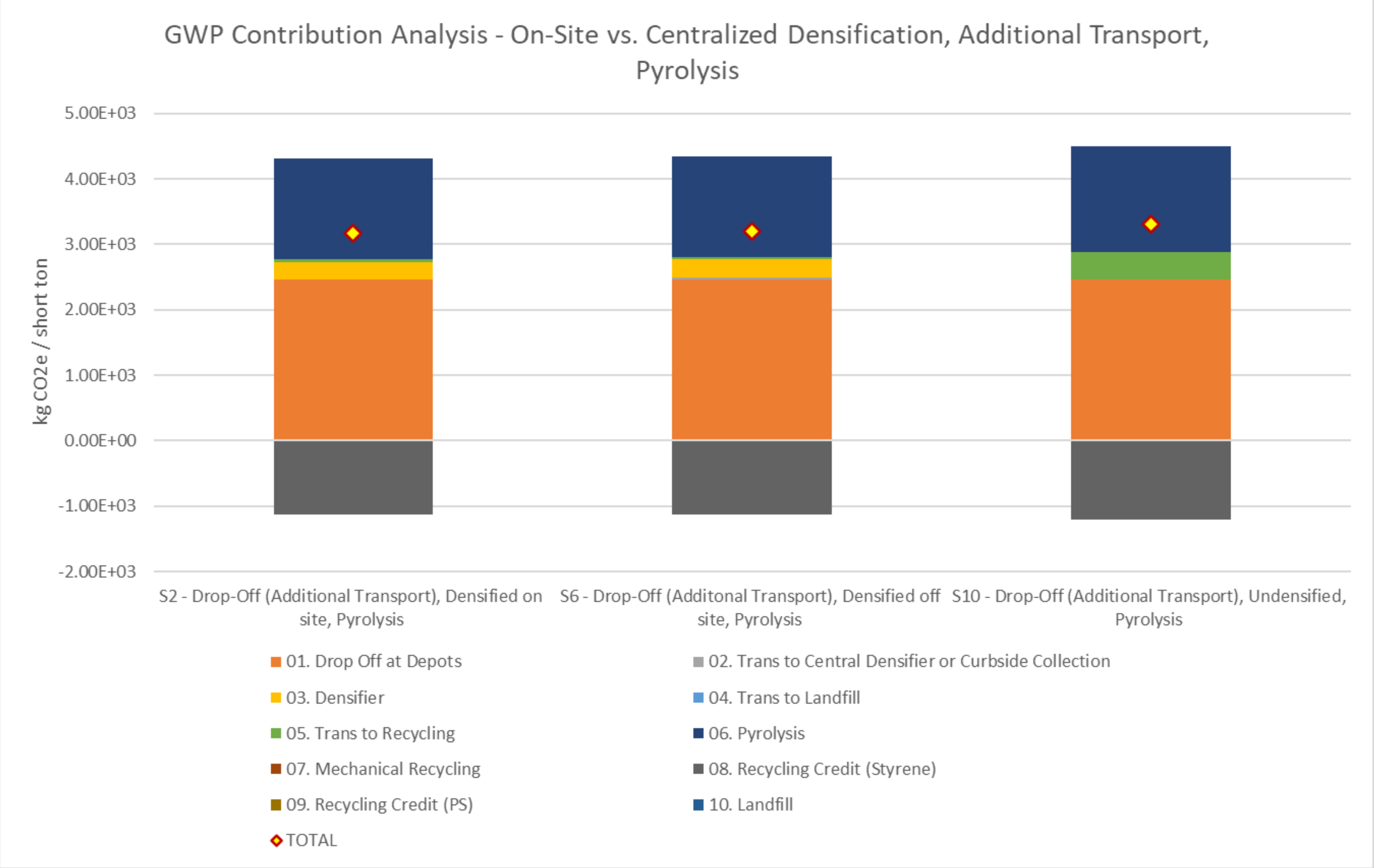

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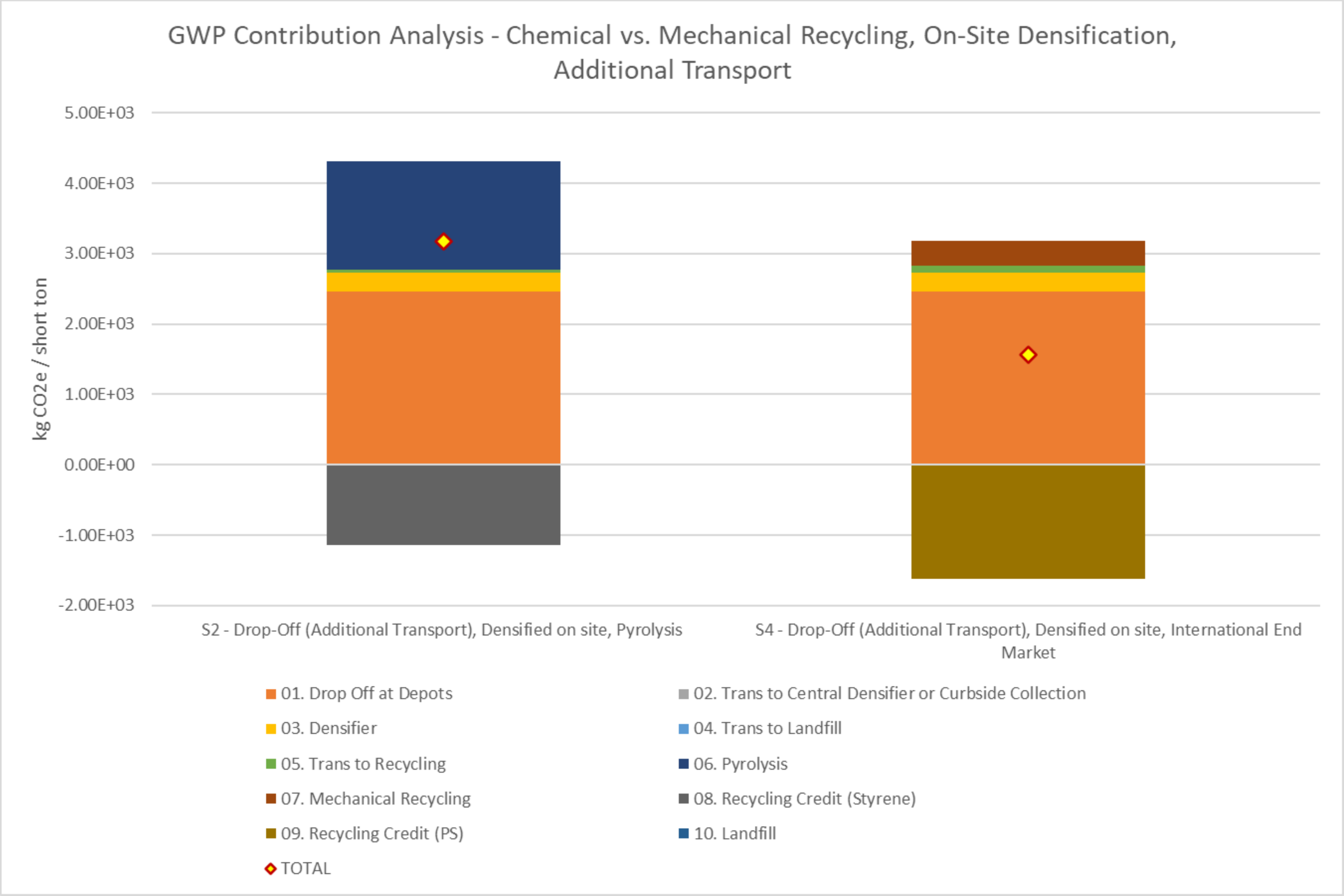

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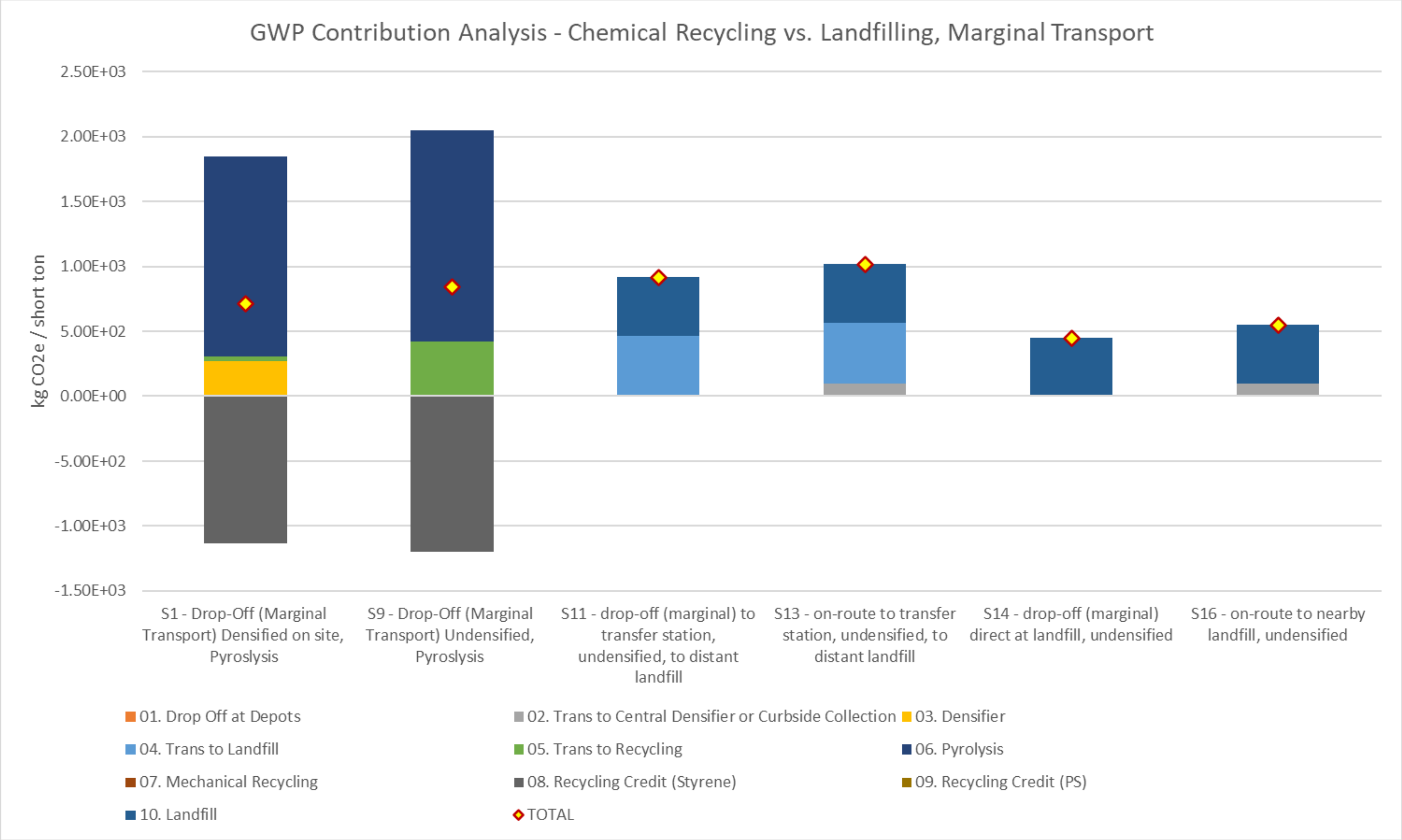

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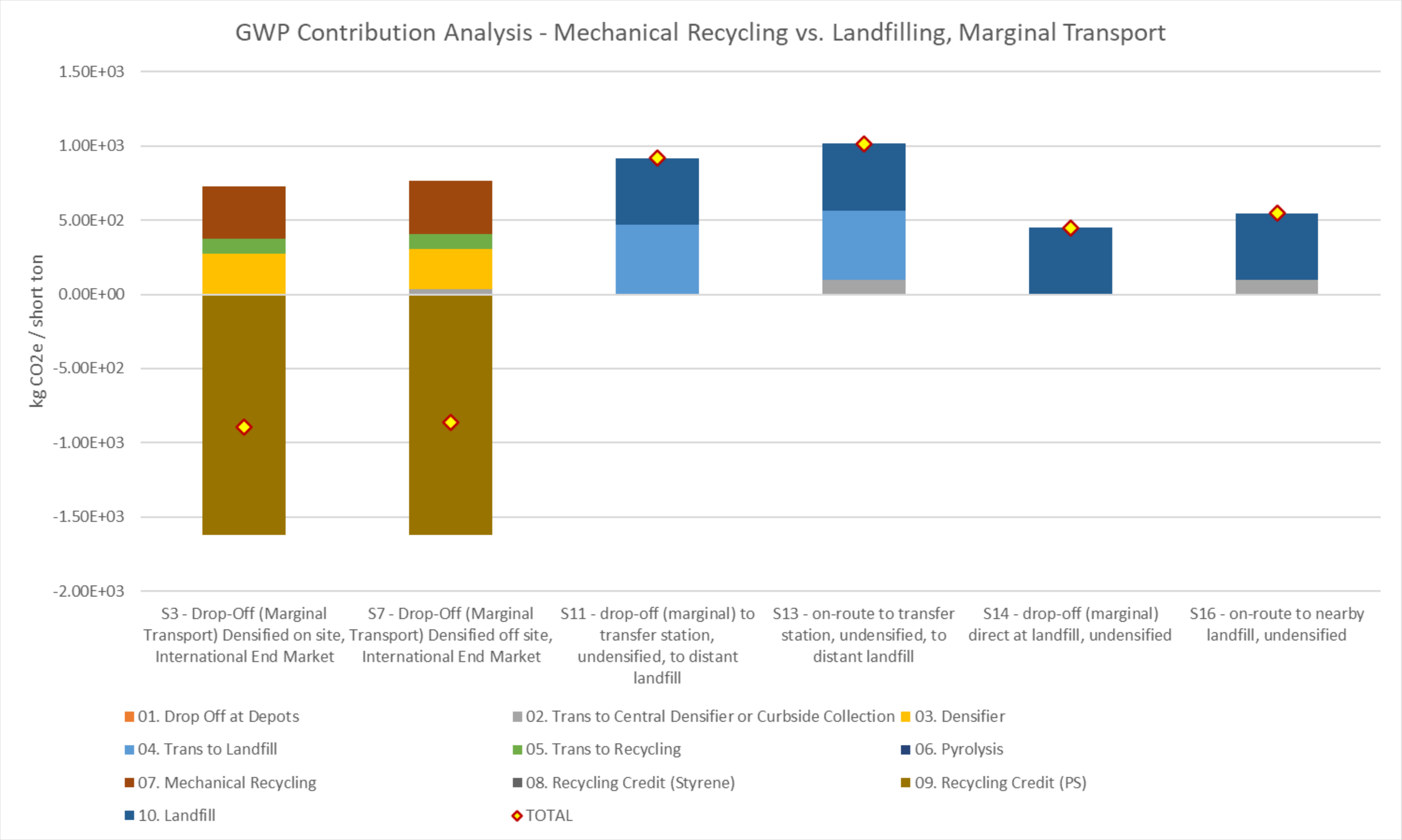

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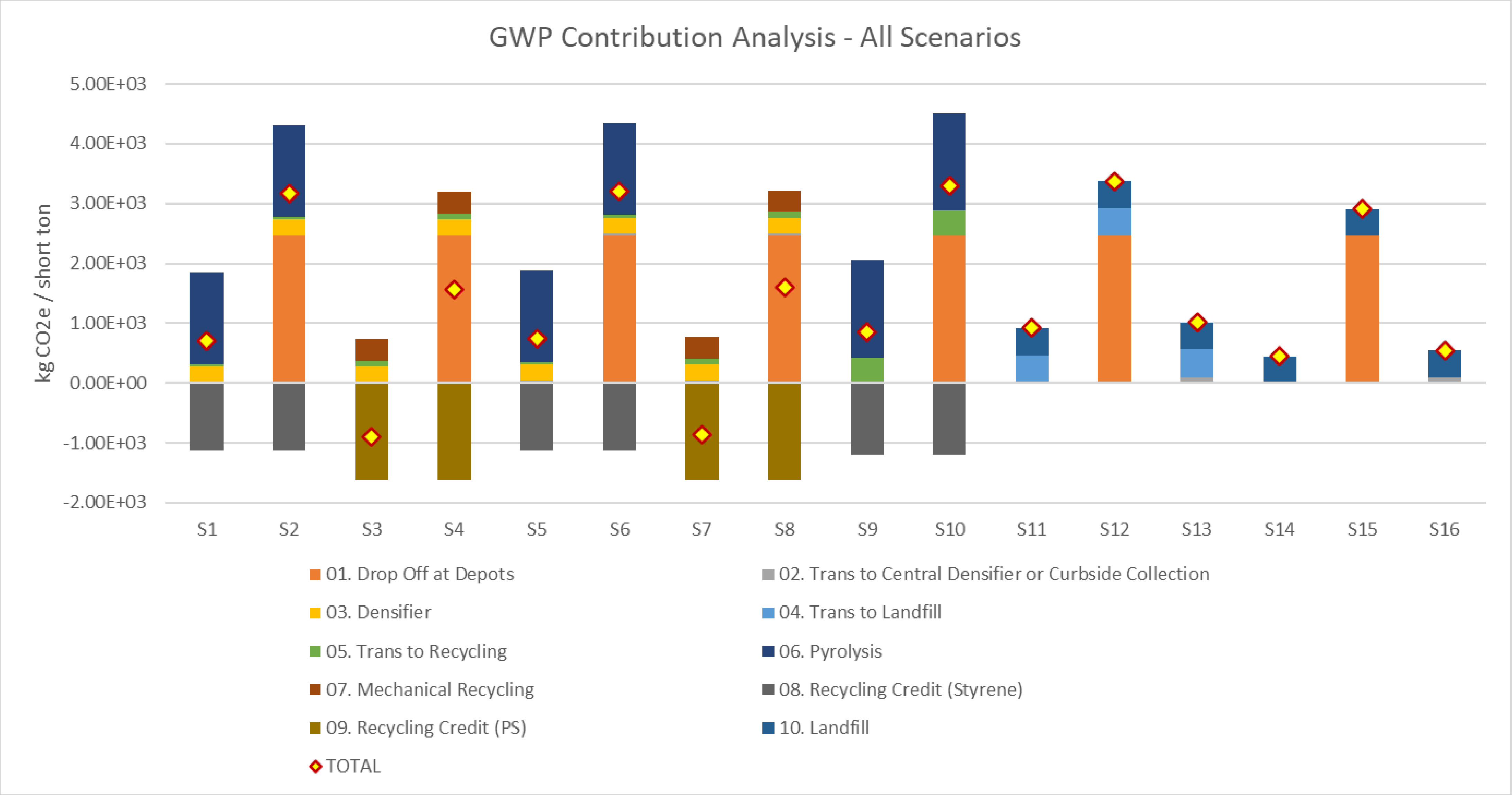
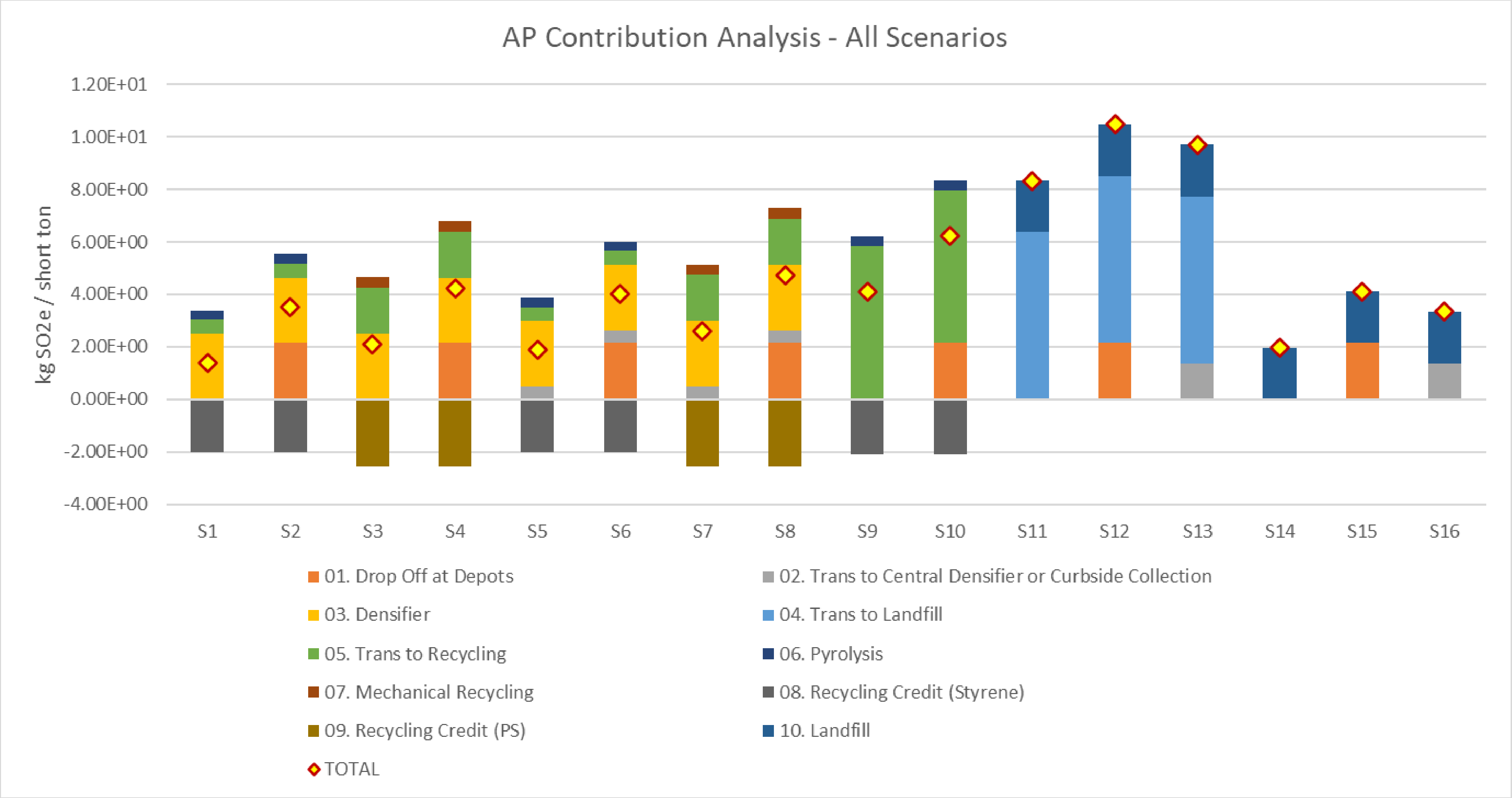
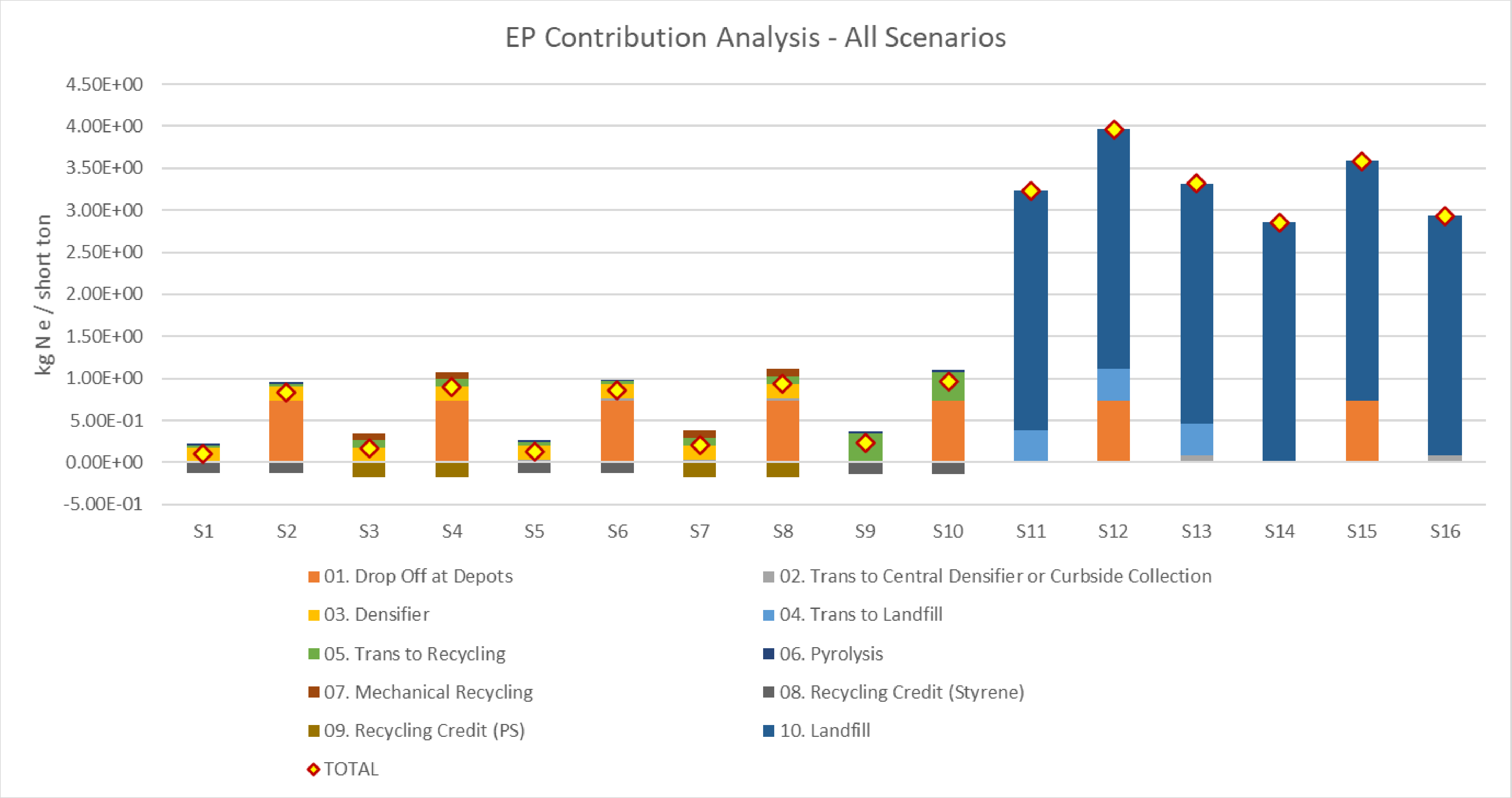


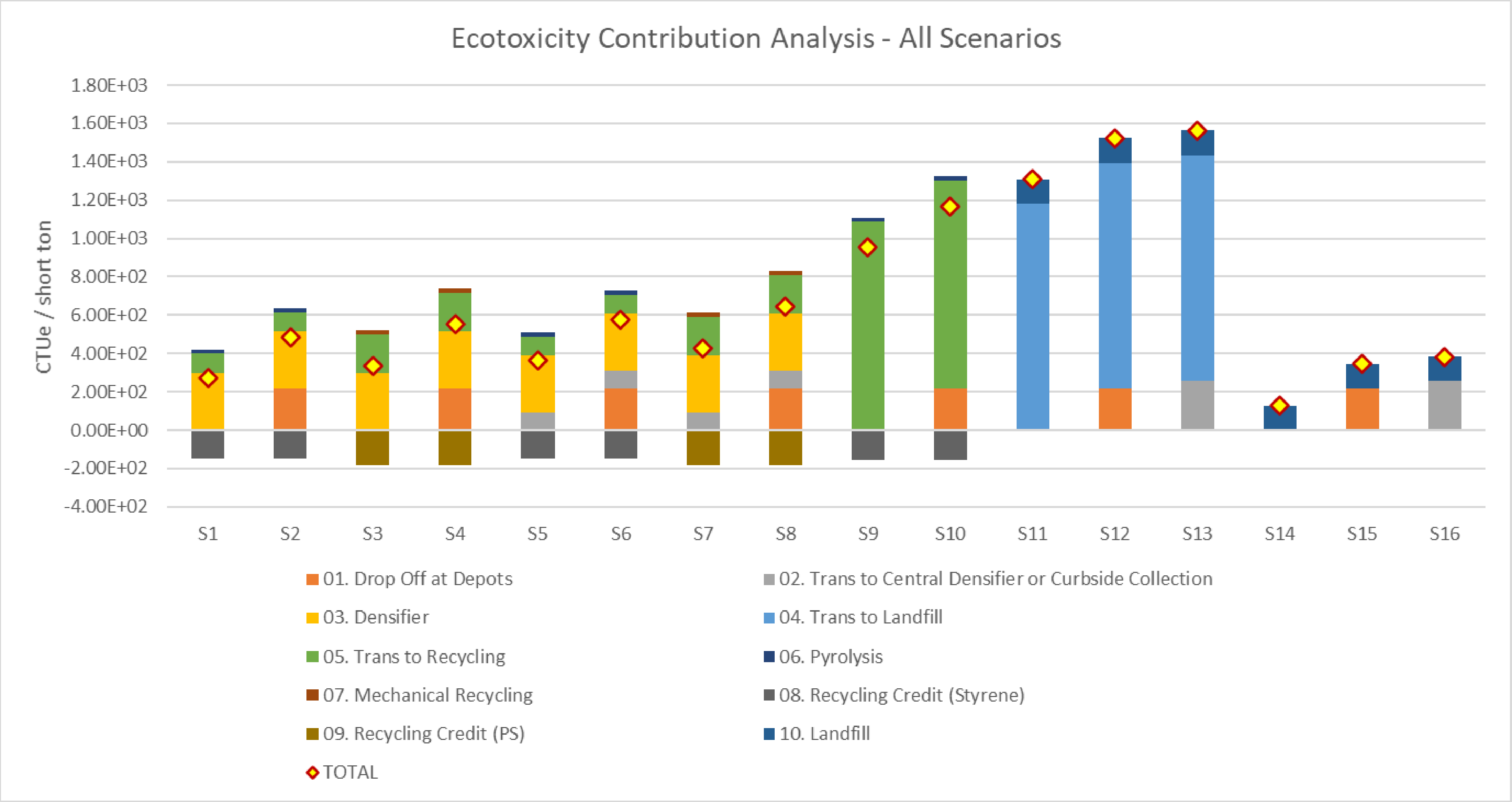
Draft LCIA Results – Acidification Potential (AP)



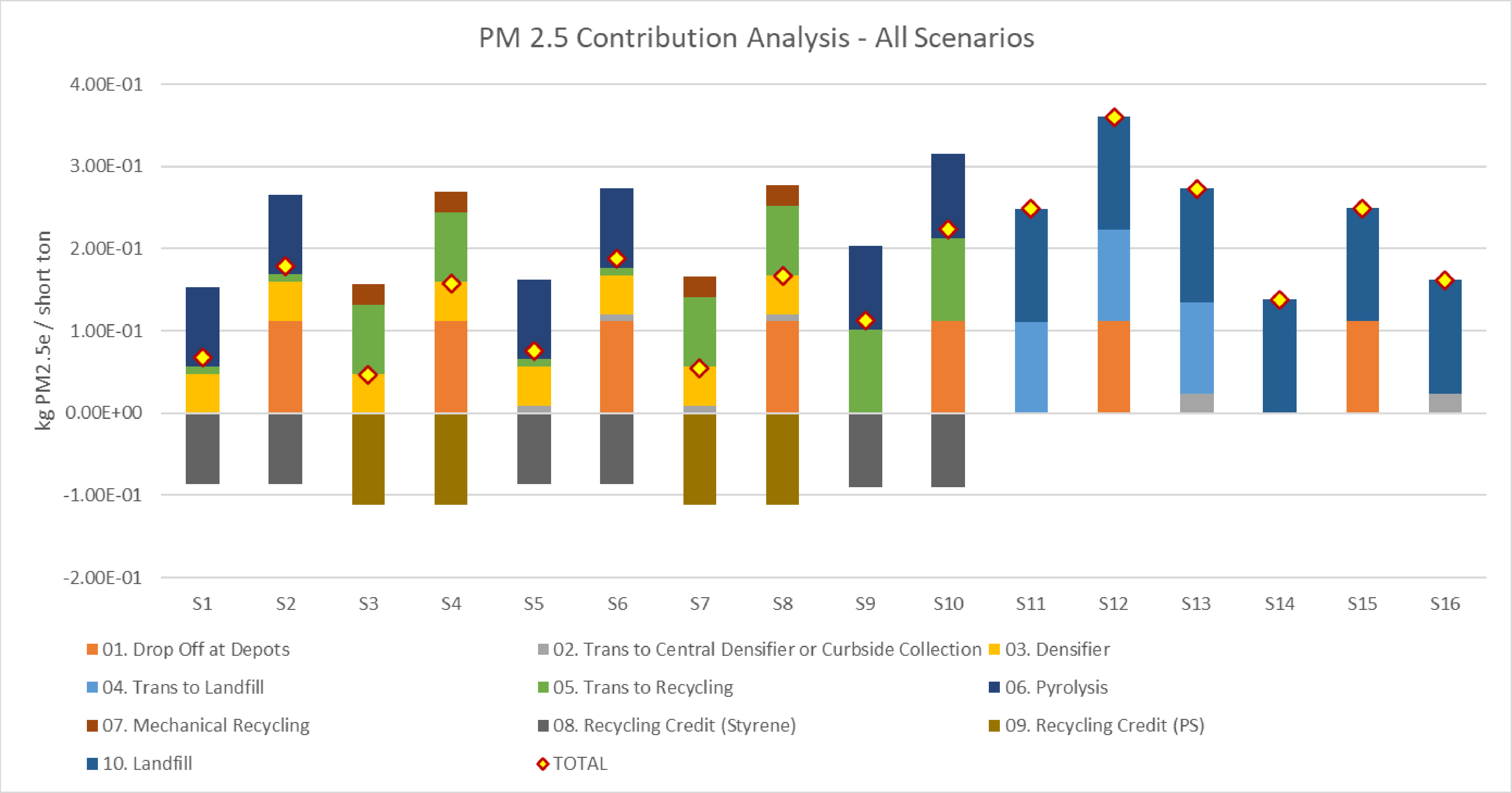
Draft LCIA Results – Eutrophication Potential (EP)



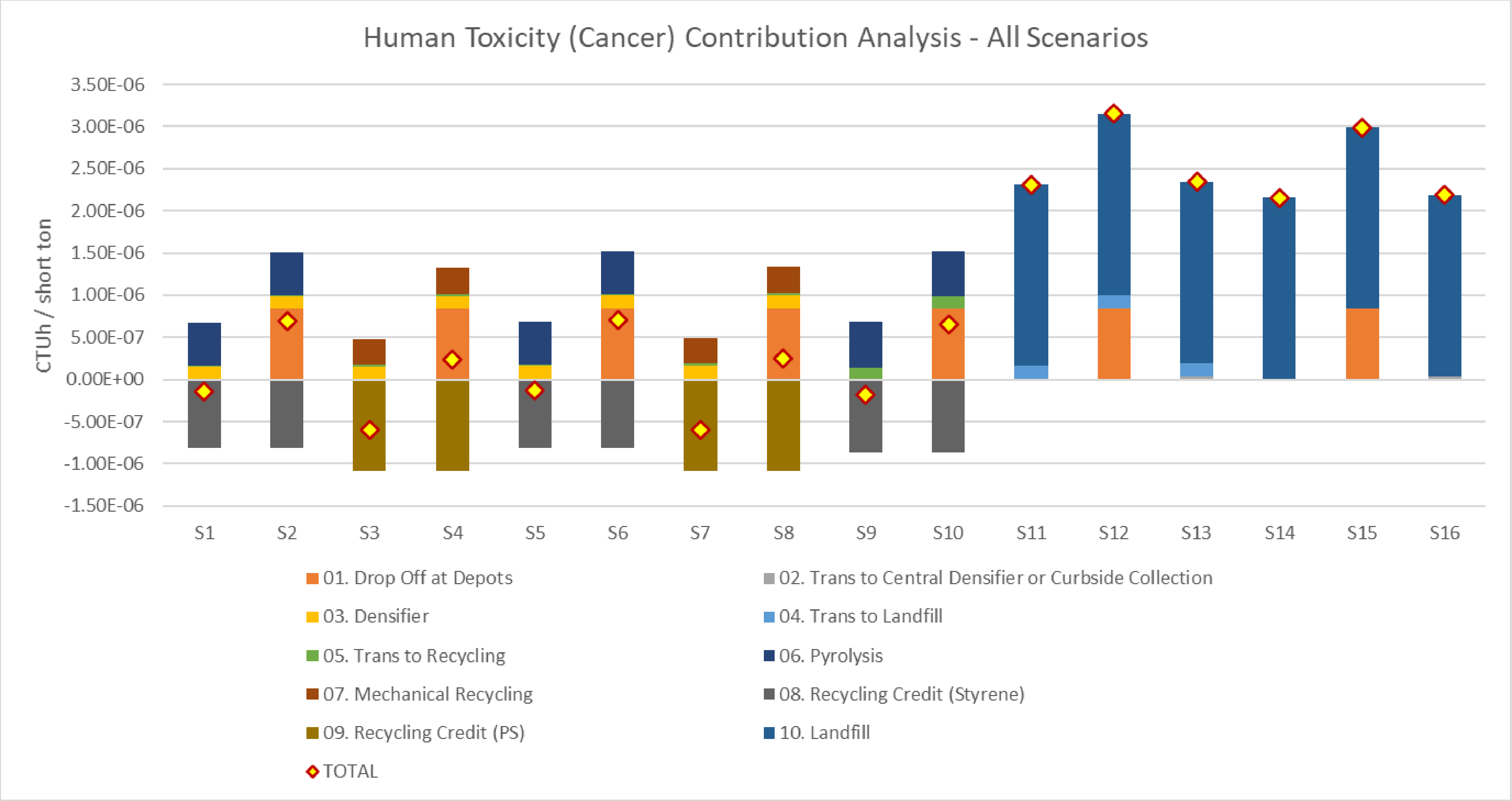
Draft LCIA Results – Ecotoxicity Potential (ETP)



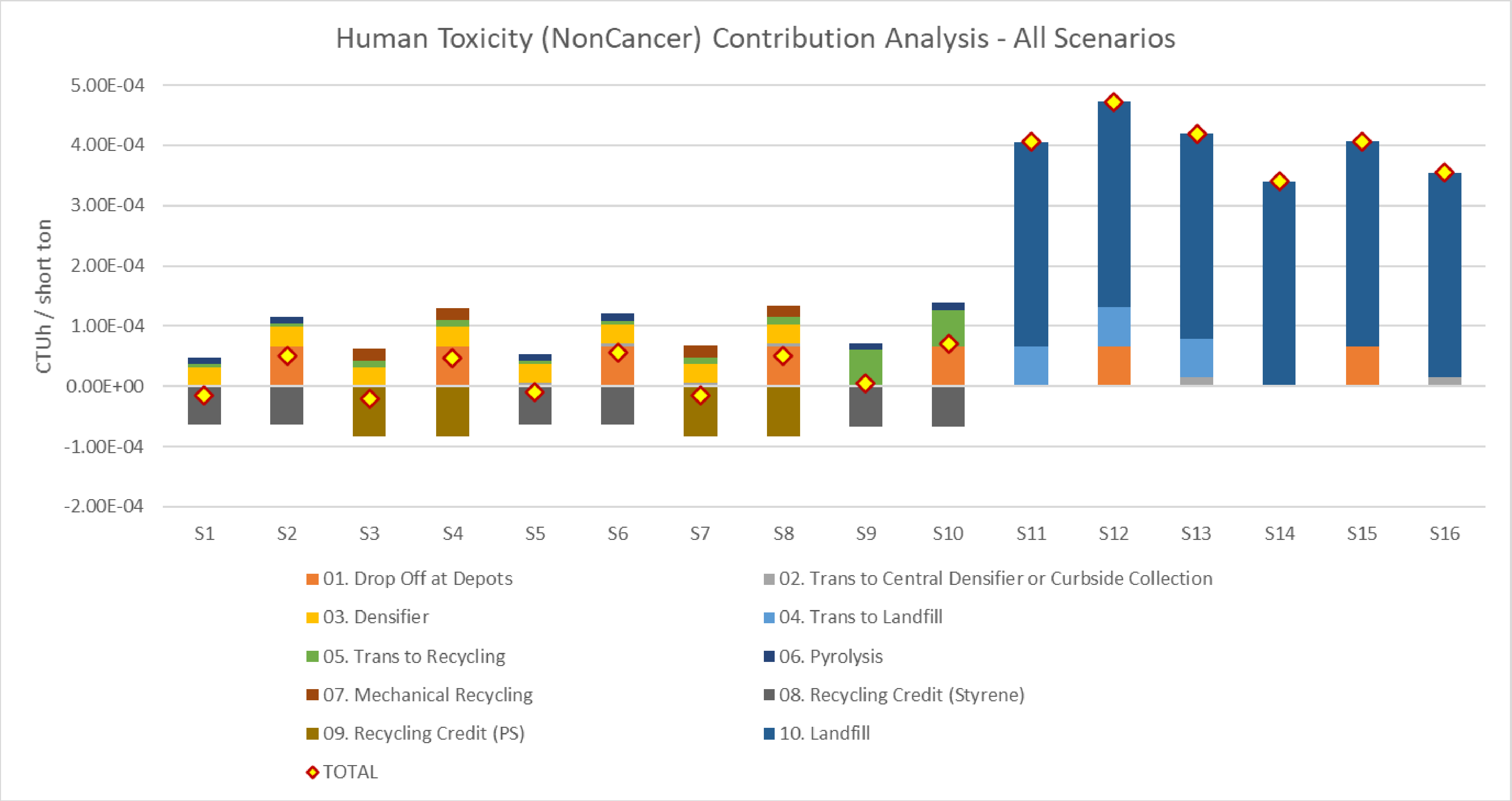
Draft LCIA Results – Particulate Matter (PM 2.5)



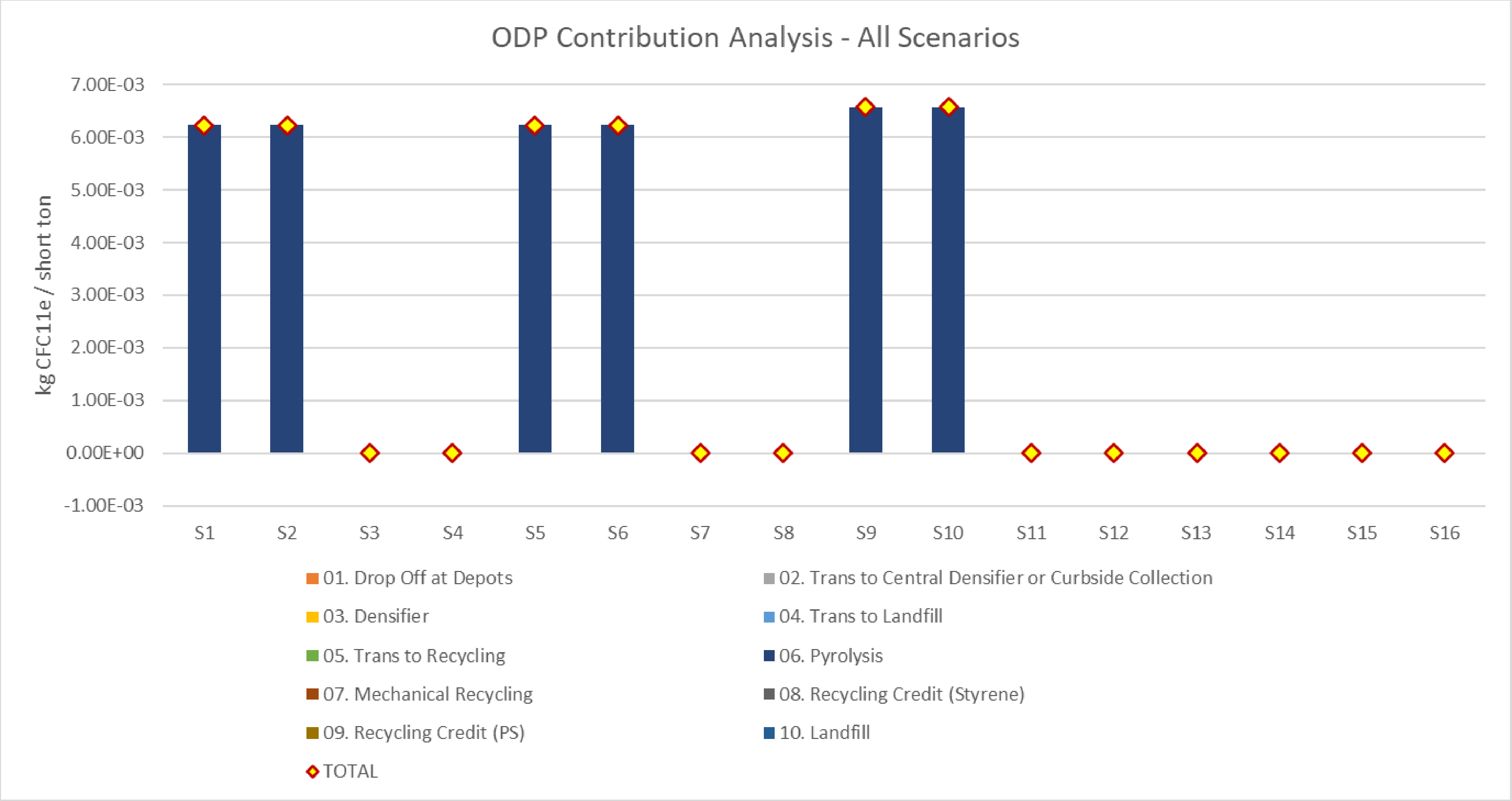
Draft LCIA Results – Human Toxicity Potential (Cancer)



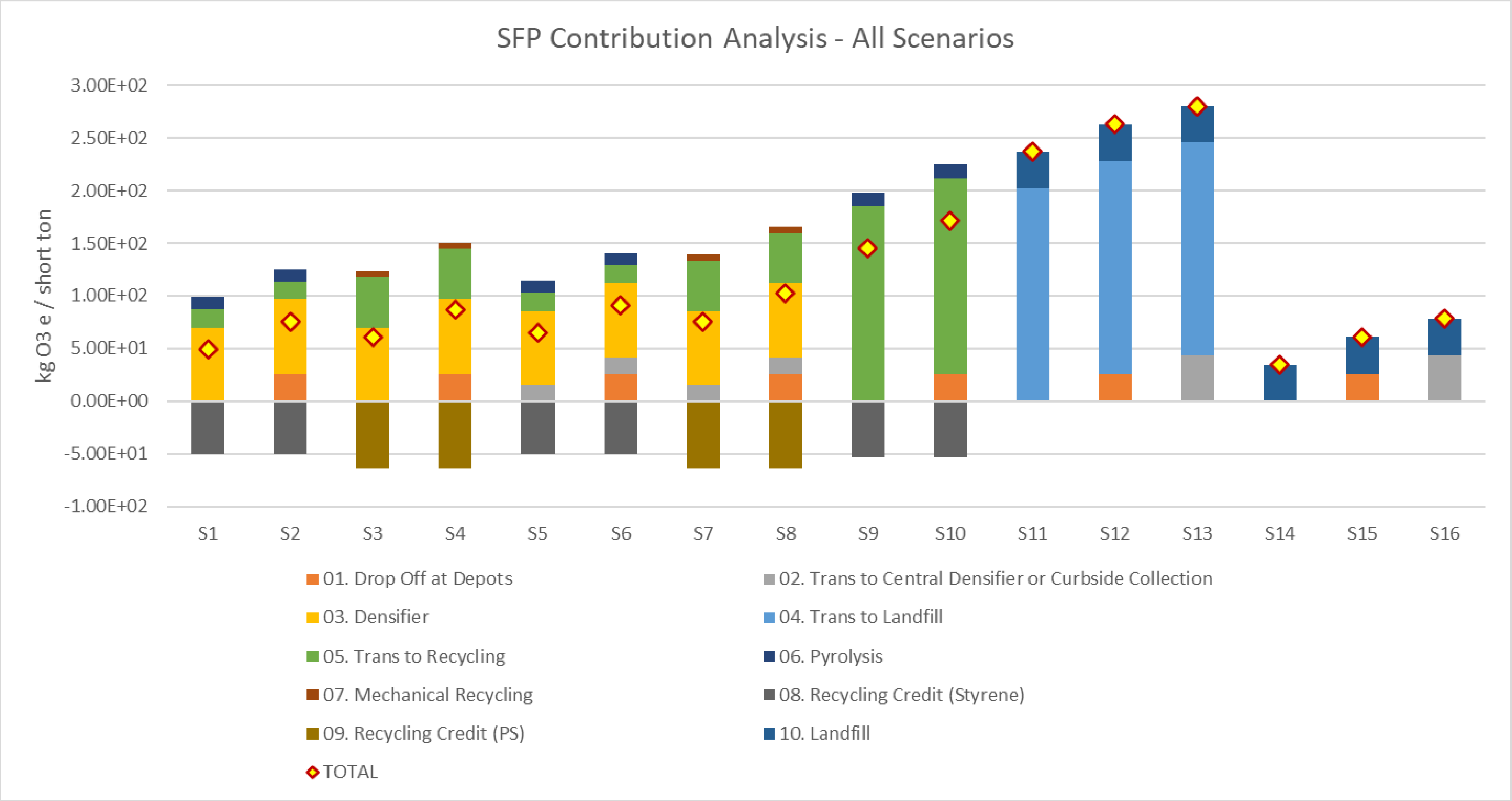
Draft LCIA Results - Human Toxicity Potential (NonCancer)



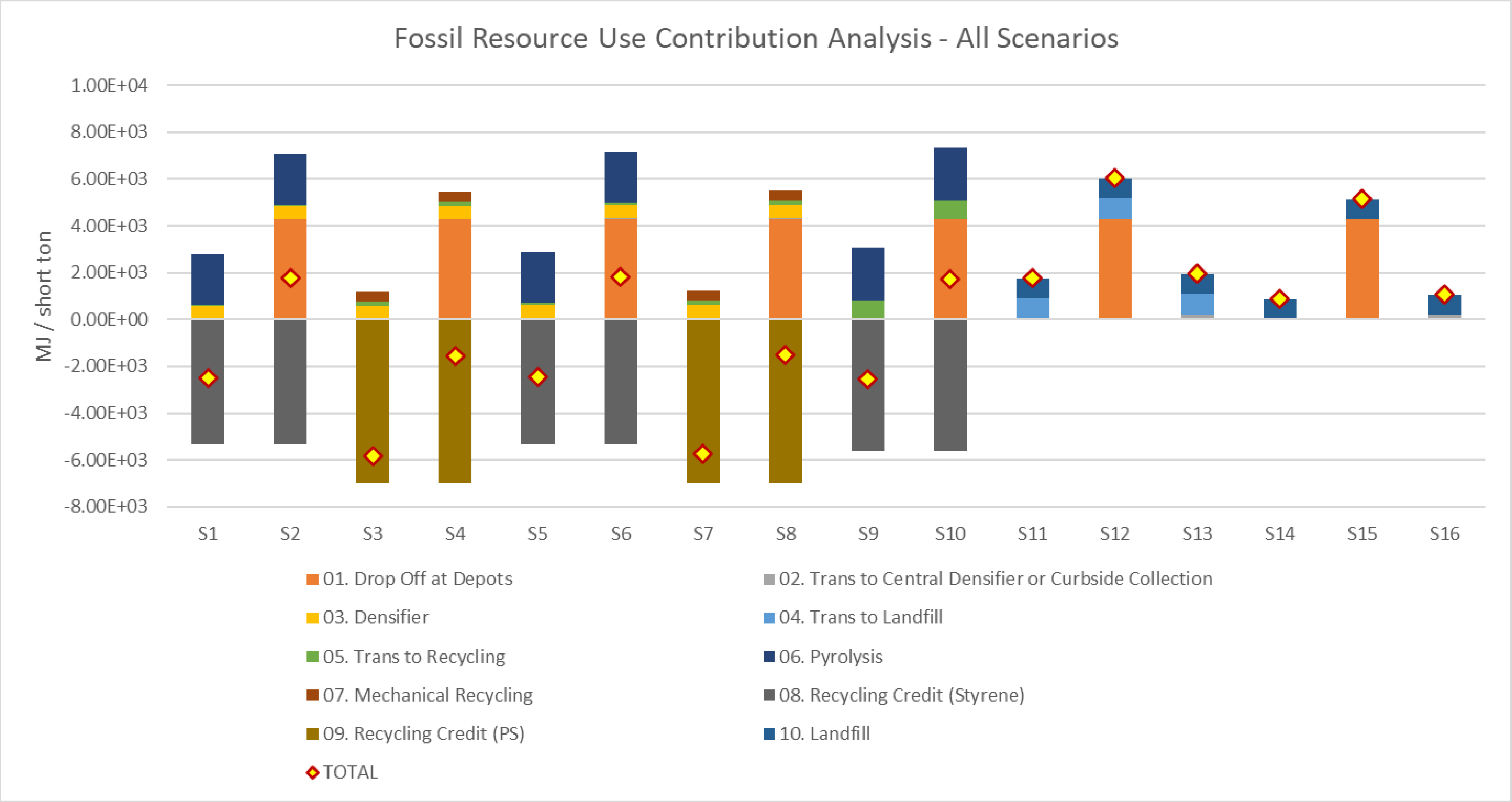
Draft LCIA Results – Ozone Depletion Potential (ODP)



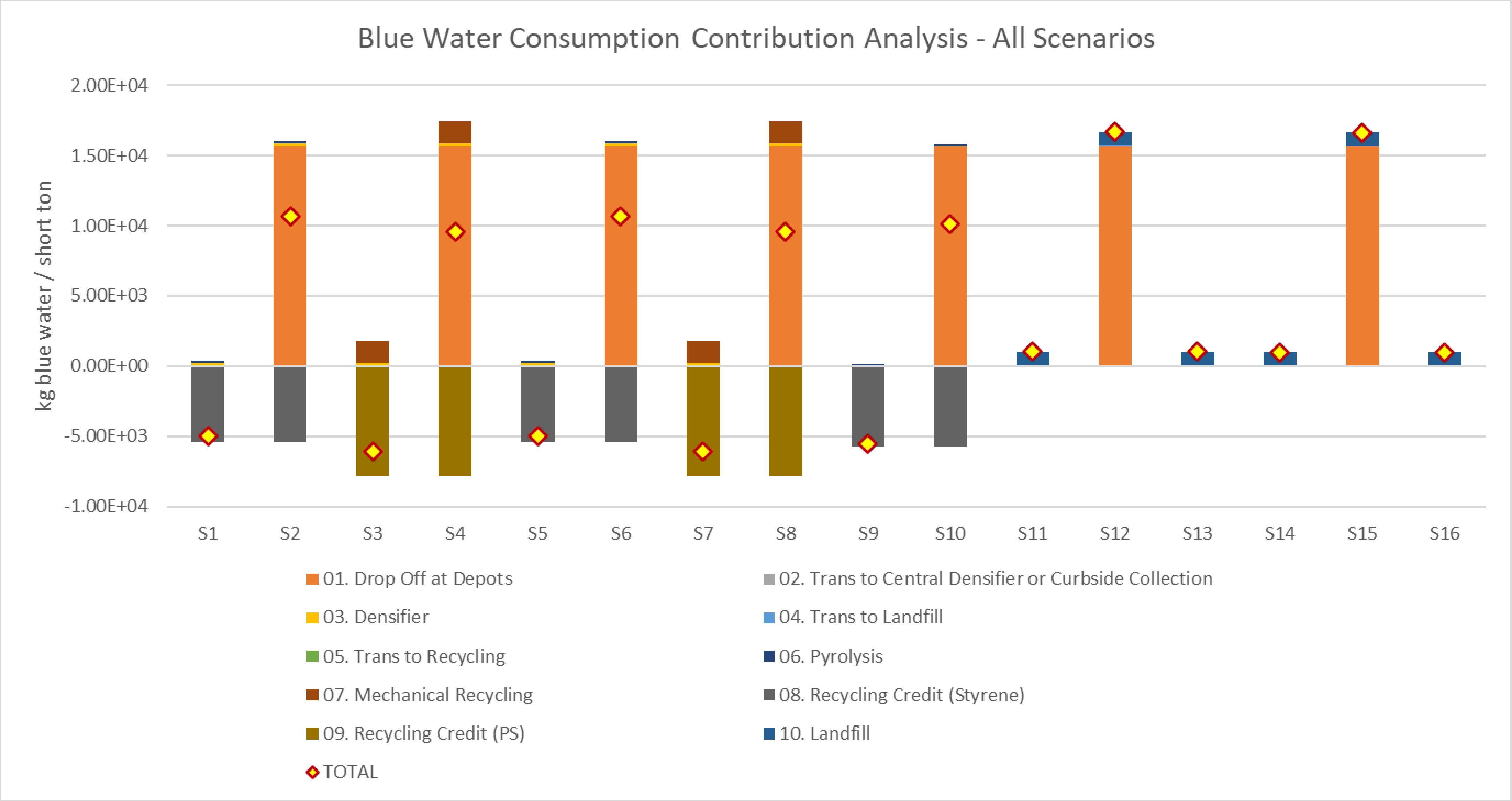
Draft LCIA Results – Smog Formation Potential (SFP)



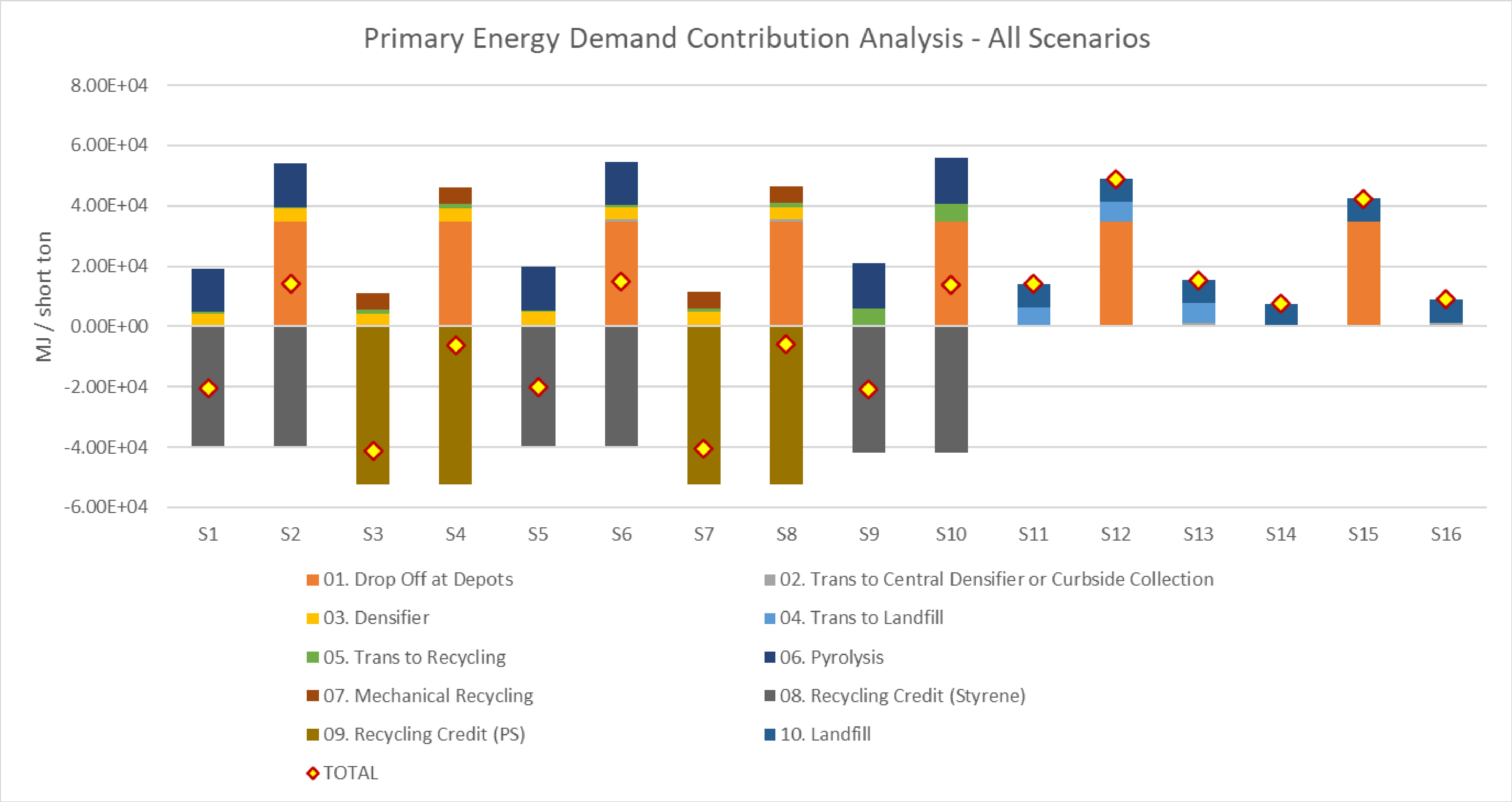
Draft Indicator Results – Fossil Resource Use



Draft Indicator Results – Bluewater Consumption

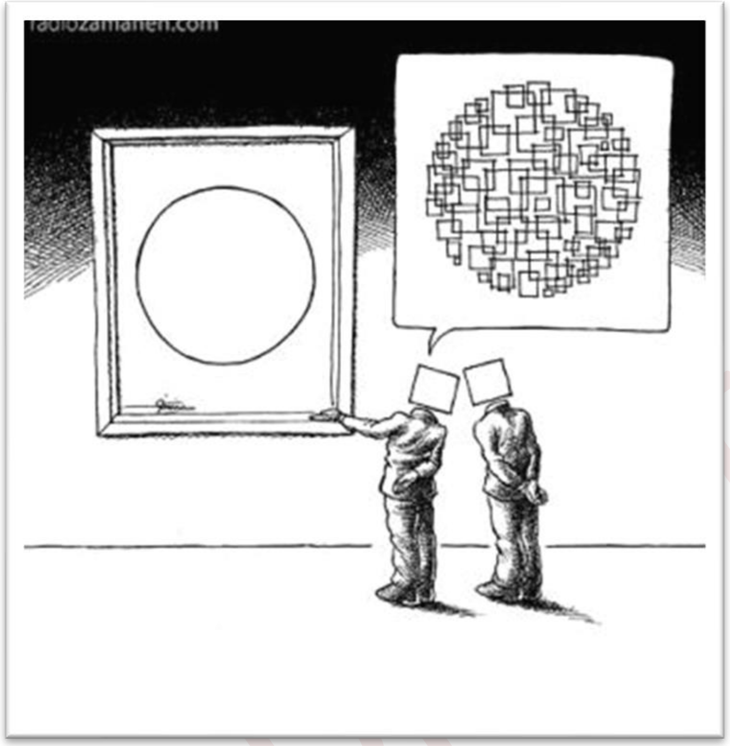


Draft Indicator Results – Primary Energy Demand (PED)



Interpretation

Key Findings



- **Convenience of drop-off sites matters -** idea of marginal vs additional transport was the single biggest variable influencing results.
- **Densification is justified** when transport distances are large
- **Densification** can be on-site or off-site
- **Disposition results are mixed**
  - The best disposition varies by impact category
  - Also depends on whether your landfill is nearby or distant

Assumptions and Limitations

Assumptions

- Average distance traveled for drop-off (additional) is 4 miles (so 8 miles round trip) all of these emissions are allocated to EPS recovery and so do count towards the impacts of this system.
- Average distance traveled for drop-off (marginal) is 4 miles (so 8 miles round trip) however the emissions are allocated to the primary purpose for the trip (e.g. grocery store) and so do not count towards the impacts of this system.
- Densification of EPS is based on mechanical densifier technology only (however thermo-mechanical densifiers are also used in practice)
- Transport for drop-off is by passenger vehicle
- Transport to landfill is by truck
- Transport to chemical recycling is by truck
- Transport to mechanical recycling is a combination of transport by truck and ocean ship
- Have scaled-up the impacts of landfilling (typically expressed on the basis of mass) by a factor of approximately 5. This reflects an assumption that landfill operations are a function of volume. For an undensified material (e.g. EPS), per-pound impacts will increase because of the volume of this material compared to municipal solid waste generically (based on the ratio of the density of EPS compared to the average density of MSW).
- Model assumes 1:1 substitution for primary material production as a recycling credit. In other words, for each unit of EPS recovered (after losses are accounted for) an equivalent unit of primary production is avoided (e.g. Styrene or Polystyrene).

Assumptions and Limitations (cont.)

Limitations

- No information on co-products (char, syngas, wax, etc.) of pyrolysis are included, so all emissions associated with pyrolysis are allocated exclusively to styrene monomer produced. Depending on the amount and quality of co-products, when included, a reduction in the process emissions for pyrolysis is expected (though it is predicted to be small if allocation is based on the economic value of these co-products)
- No direct human health exposures are accounted for by processors of this material (e.g. those handling EPS at the recycling facility)
- The effects of mismanagement of these materials (e.g. litter) are not accounted for in the model or impact results.

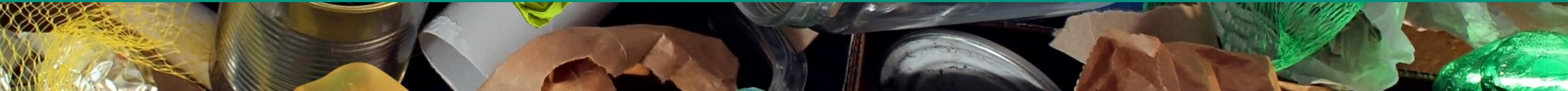
Feedback and/or Questions

Thank You!

Peter Canepa (peter.canepa@state.or.us)

Lunch Break

The meeting will resume at approximately noon PDT



Guests

- Gary Panknin – PakTech
- Ashley Elzinga – Foodservice Packaging Institute
- Resa Dimino – Signalfire Group / Resource Recycling Systems