Analyzing Next-Generation Supply Chains Using the Materials Flows through Industry Tool

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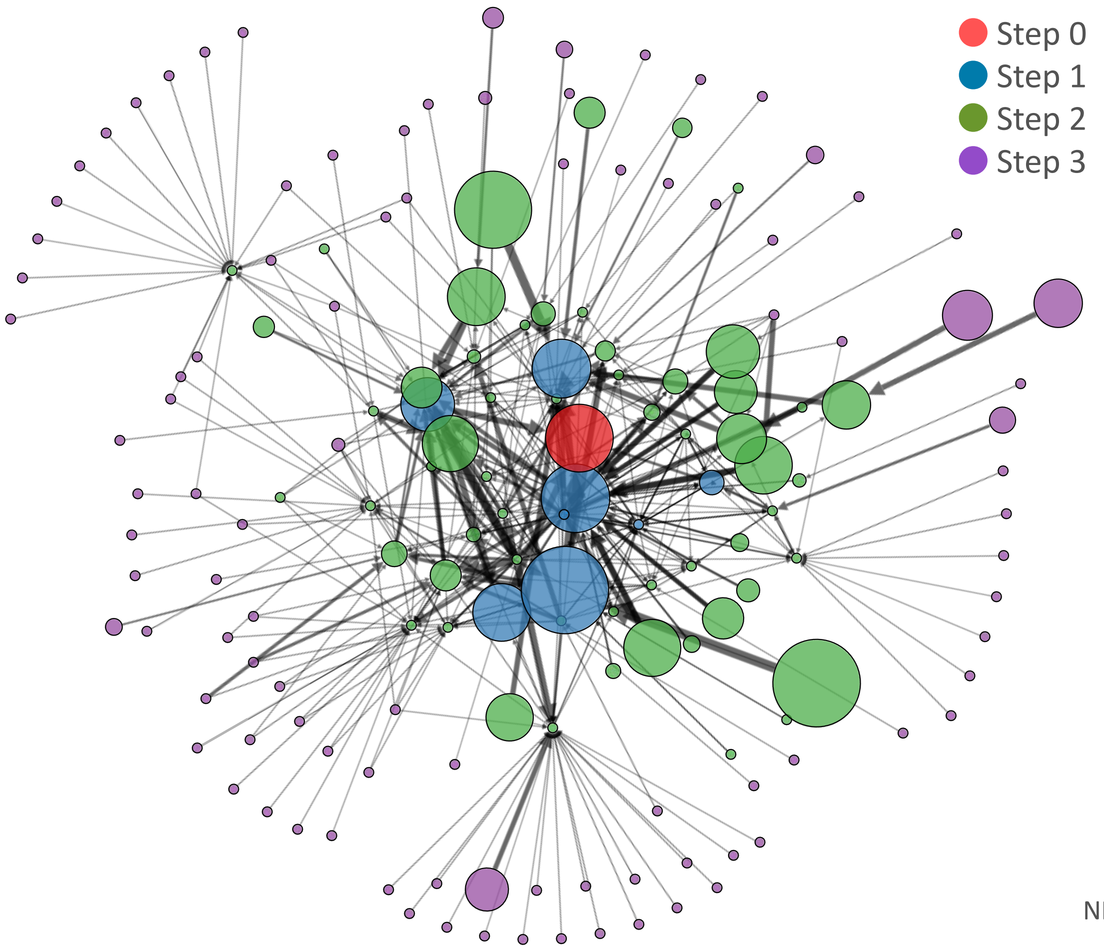
The Materials Flows though Industry (MFI) Tool

MFI is a supply chain modeling tool funded by the Advanced Manufacturing Office created to identify and analyze opportunities to reduce the energy and carbon intensities of the U.S. industrial sector.

- Linear network model
- U.S.-based supply chains
- ~750 industrial, bulk commodities
- ~1300 recipes (unit processes)
- Mine-to-materials; does not include use-phase or end-of-life by default
- Outputs: Energy consumption and GHG emissions
- Web application now publicly available to try out: mfitool.nrel.gov

Glass Fiber Reinforced Plastic Supply Chain Network



Comparison to Similar Analysis Models

	MFI	LCA (ecoinvent, US LCI)	EEIO (EIO-LCA, Eco-LCA)	Techno-Economic Analysis
System Boundary	Mine to materials *(user defined)*	Cradle to grave *(user defined)*	Entire economy	Gate to gate *(user defined)*
Model Type	Bottom up	Bottom up	Top down	Bottom up
Level of Detail	Individual production technologies	Regional average production technologies	Economic sectors	Individual process or facility
Units	All physical units	All physical units	Monetary and physical units	All physical units
User Options	Four sets of scenario parameters	Product demand, scope	Product demand	Many

Bottom Line	Very flexible	Slightly flexible	Inflexible	Most flexible
	Very detailed	Moderately detailed	Least detailed	Most detailed
	Moderate boundary	Large boundary	Largest boundary	Smallest boundary

How has MFI been used (so far)?

Vehicle Lightweighting

Photo by Dennis Schroeder, NREL 22832

Bulk Chemical Sector

Photo by Warren Gretz, NREL 282

Plastic Upcycling

Photo by Dennis Schroeder, NREL 47349

Photo by Dennis Schroeder, NREL 27204

Catalytic Fast Pyrolysis

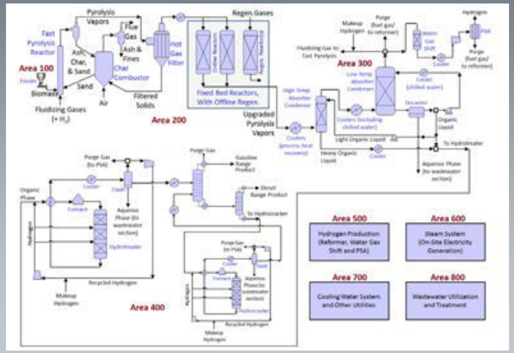


Figure from Dutta et al. 2018

PET Upcycling to Composites

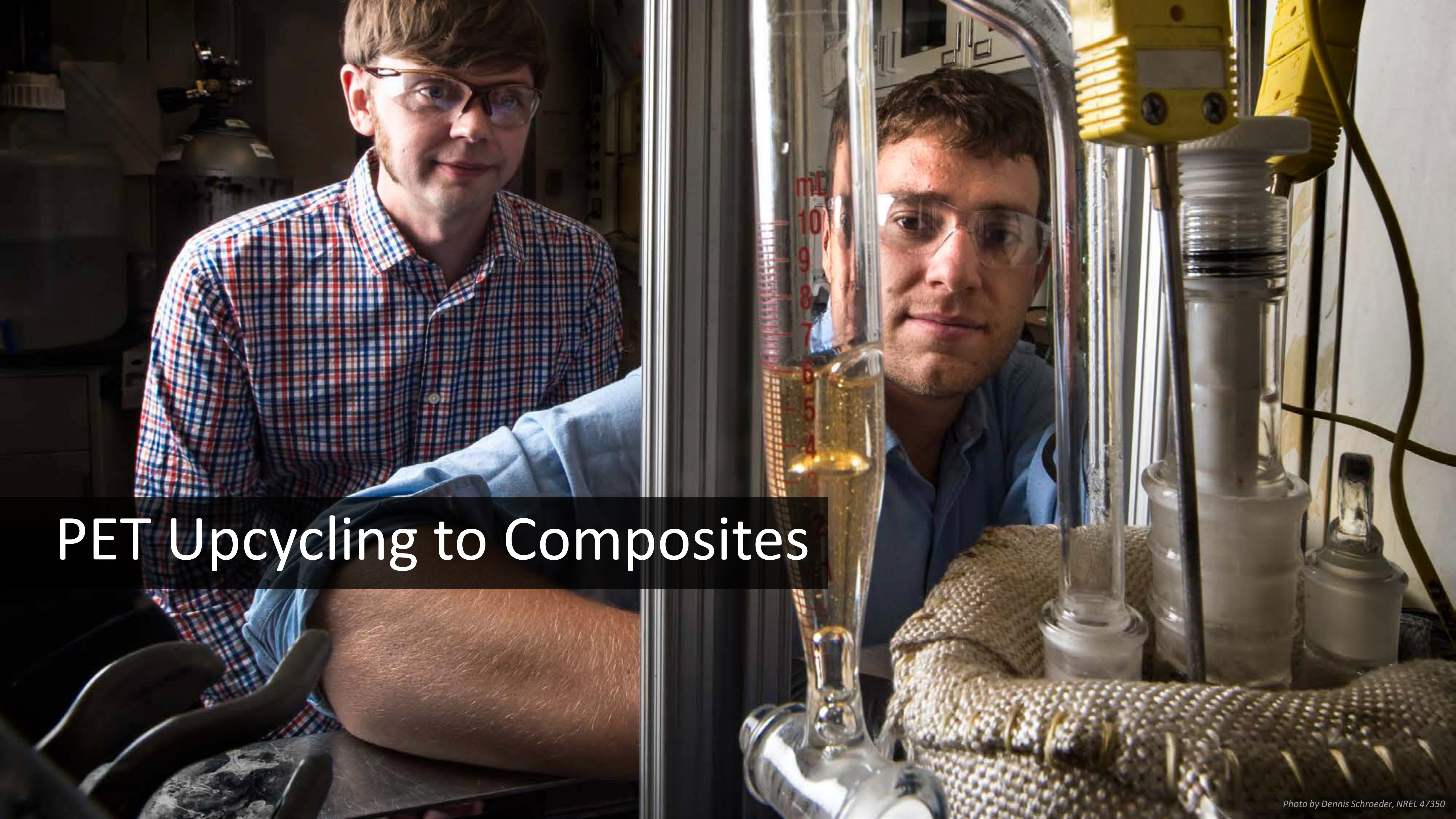


Photo by Dennis Schroeder, NREL 47350

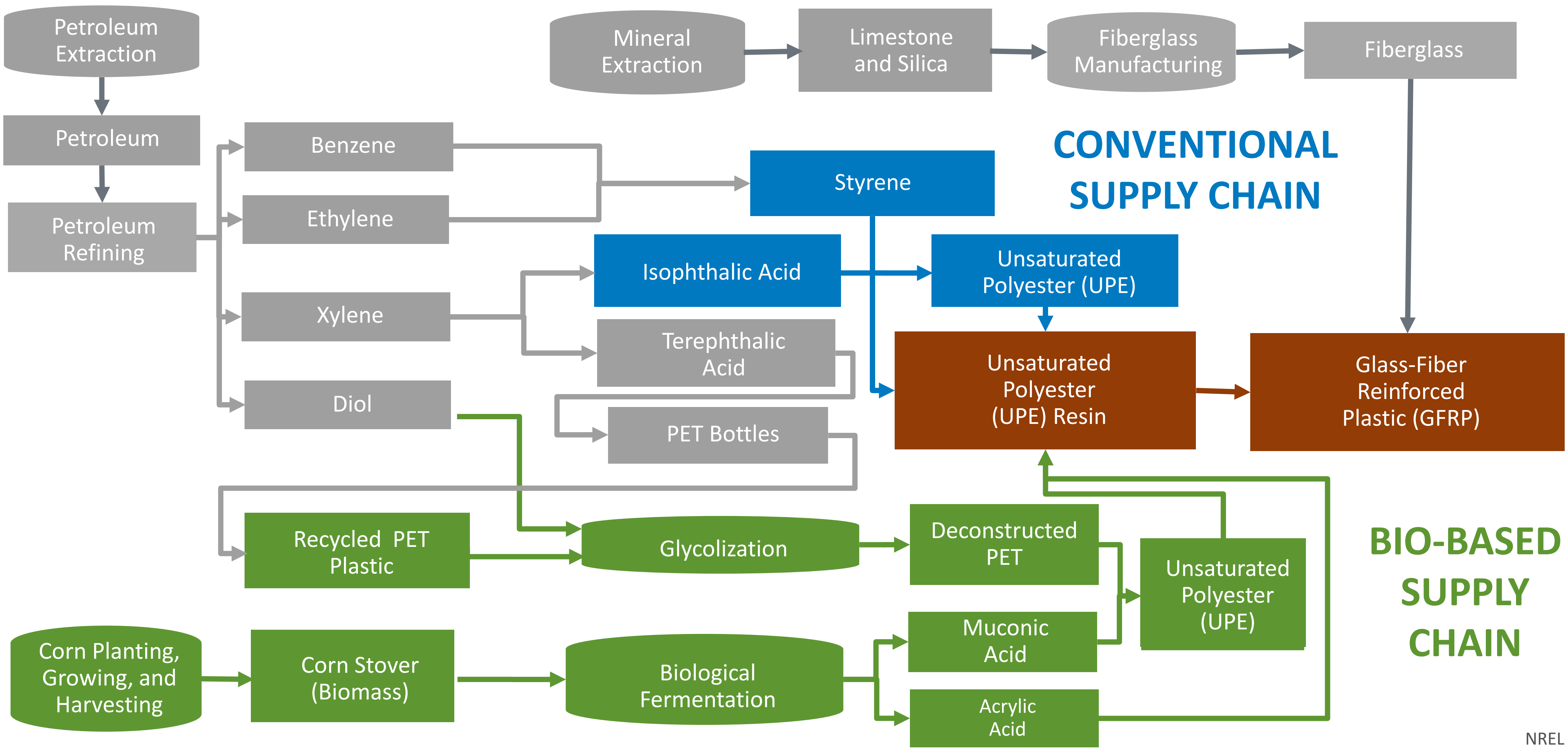
rPET Upcycling Background & Motivation

- Most commercial PET recycling is mechanical
- Mechanical recycling leads to lower-grade plastic with fewer applications (carpet fiber, etc.)
- Chemical recycling of PET bottles back to its monomers is expensive
- What if we could make higher value glass fiber reinforced plastic with recycled PET?

Photo from pxhere.com

Are there energy savings associated with rPET–based GFRP production?

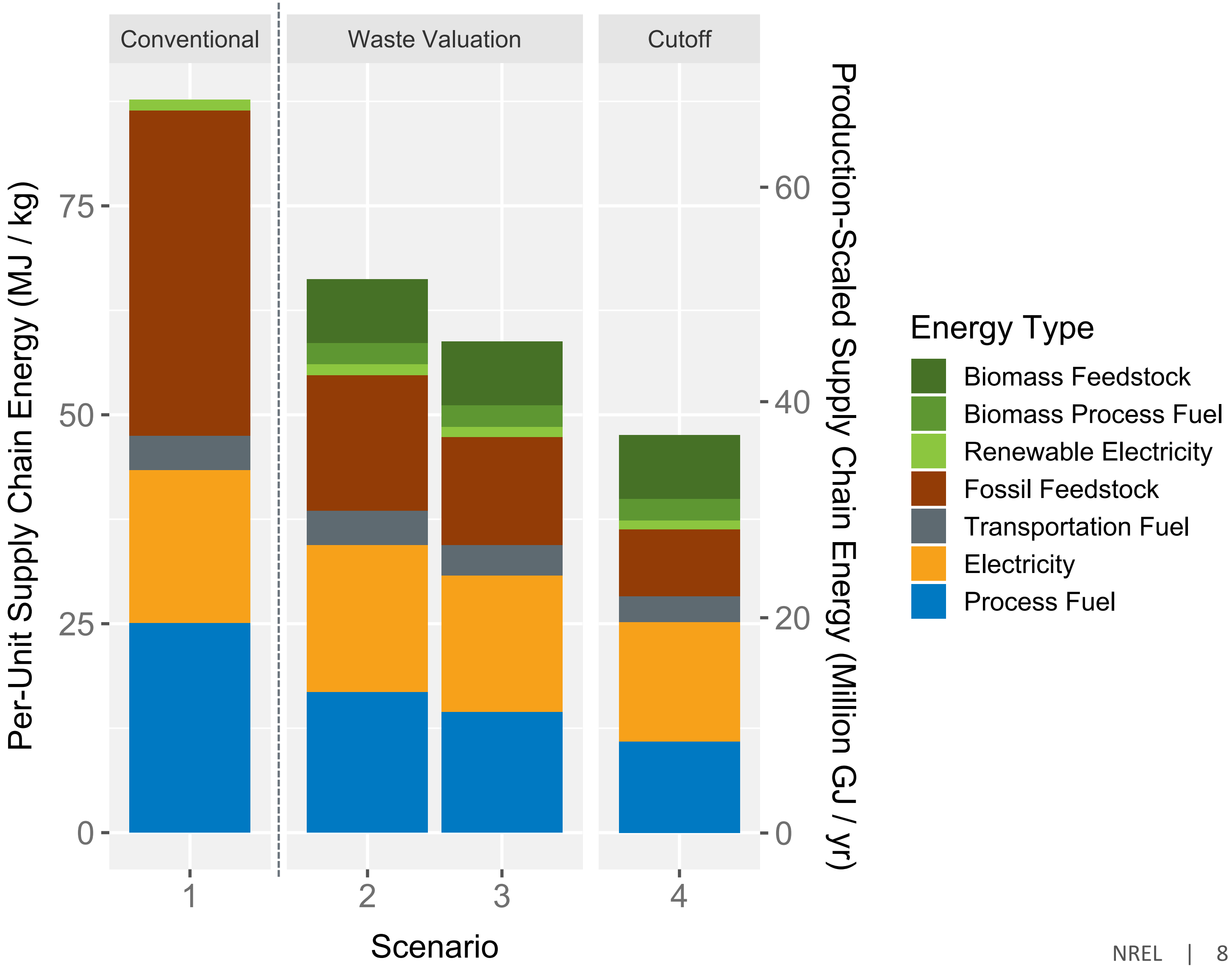
Conventional and Bio-Based GFRP Production



Comparison of Supply Chain Energy Requirements for GFRP from Conventional vs Upcycled rPET

Depending on the allocation method, supply chain fossil energy reductions range from **37% to 58%**.

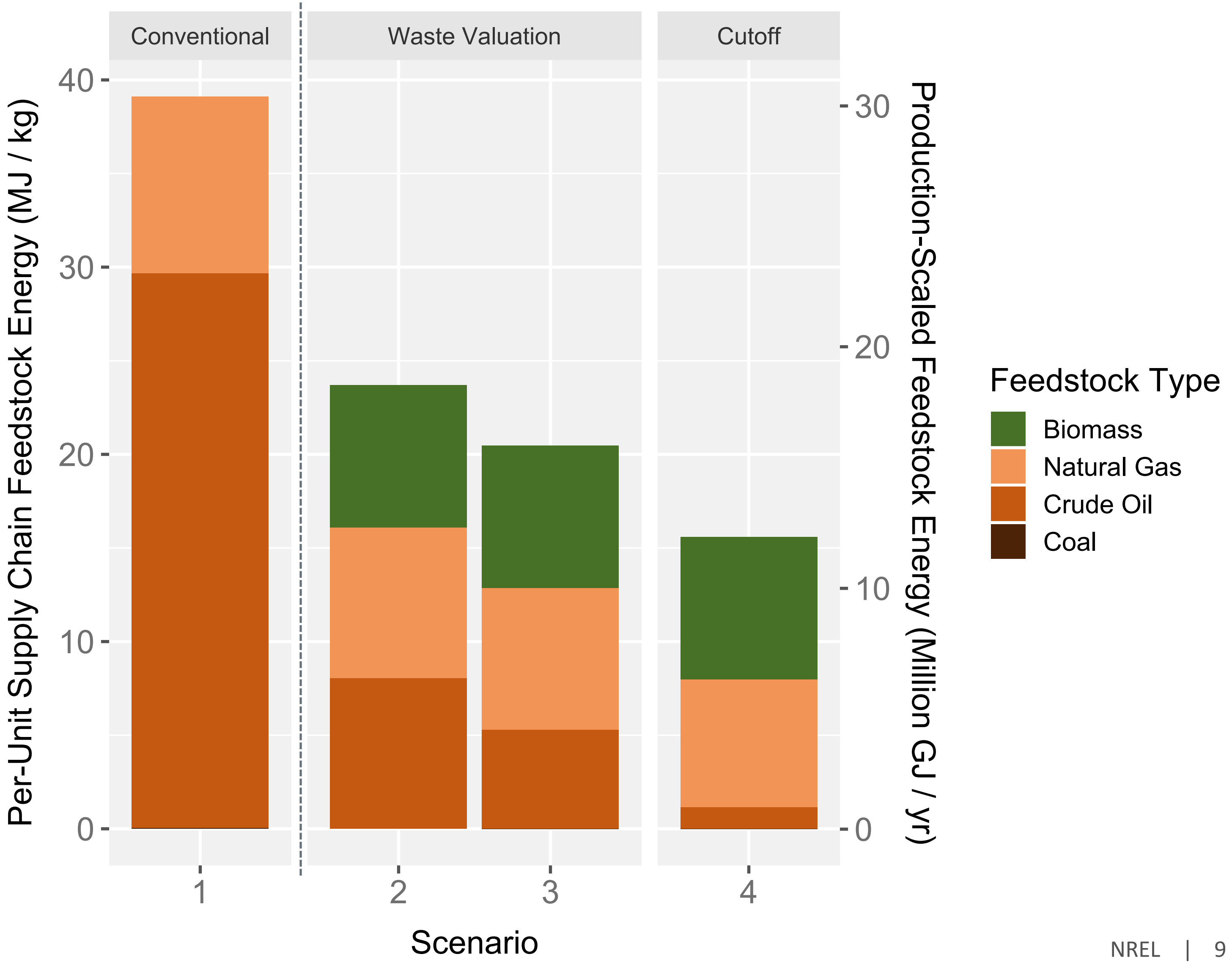
Scenario	Name	PET Bottle (First Life) Allocation
1	Conventional GFRP	N/A (No rPET Used)
2	Waste Valuation; Reclaimed Clear rPET 	≈54% (Economic)
3	Waste Valuation; Reclaimed Green rPET 	≈32% (Economic)
4	Reclaimed rPET - Cutoff	0%



Supply Chain Feedstock Energy Requirements for GFRP from Upcycled PET

Overall, supply chain fossil feedstock energy reductions range from **58% to 79%**

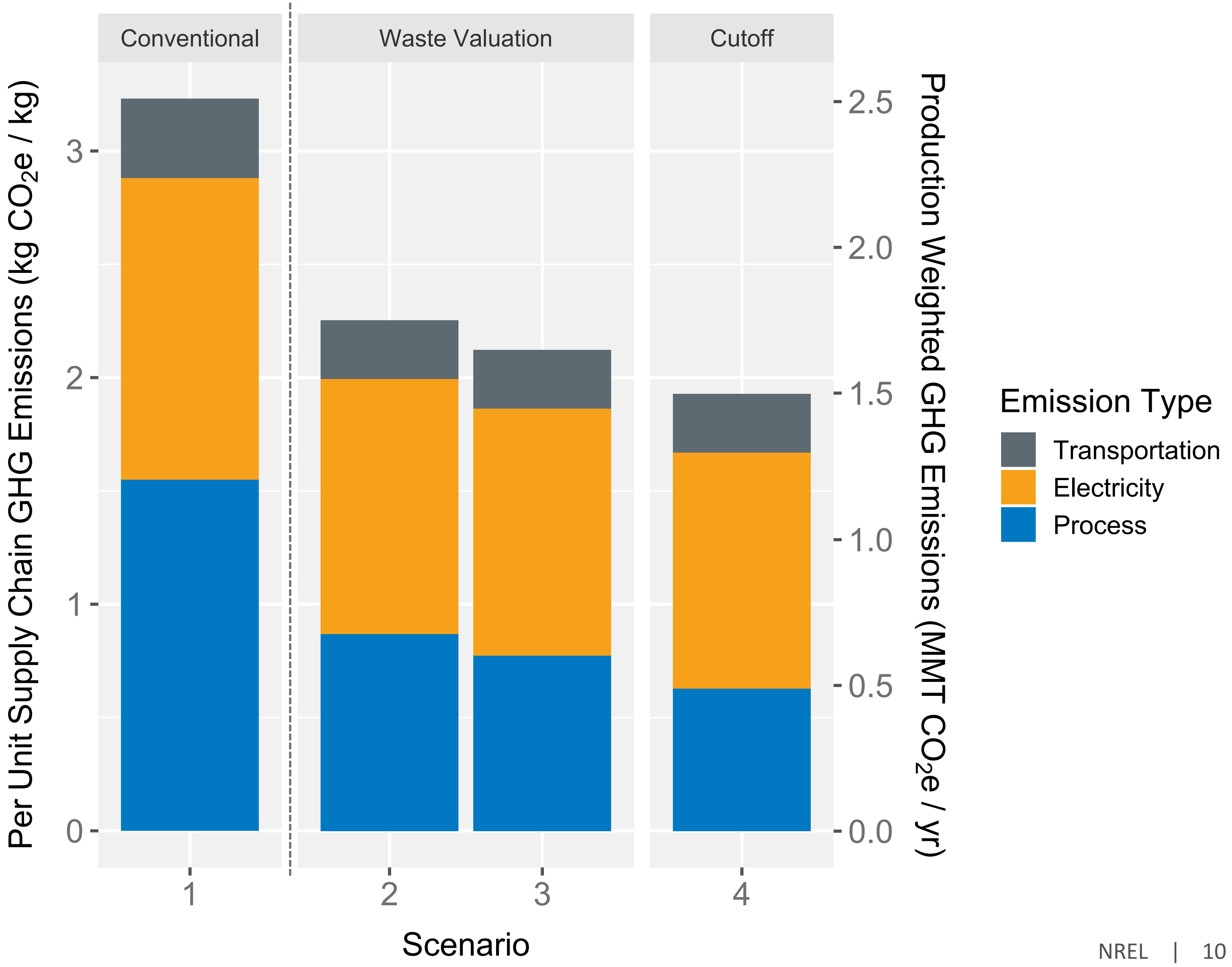
Scenario	Name	PET Bottle (First Life) Allocation
1	Conventional GFRP	N/A (No rPET Used)
2	Waste Valuation; Reclaimed Clear rPET 	≈54% (Economic)
3	Waste Valuation; Reclaimed Green rPET 	≈32% (Economic)
4	Reclaimed rPET - Cutoff	0%



Supply Chain Combustion GHG Emissions for GFRP from Upcycled PET

- Overall, supply chain GHG emissions reductions range from **30% to 40%**
- 0.7 – 1.0 MMT-CO_2e offsets; Equivalent to taking **150,000 - 200,000 cars** off the road

Scenario	Name	PET Bottle (First Life) Allocation
1	Conventional GFRP	N/A (No rPET Used)
2	Waste Valuation; Reclaimed Clear rPET	≈54% (Economic)
3	Waste Valuation; Reclaimed Green rPET	≈32% (Economic)
4	Reclaimed rPET - Cutoff	0%

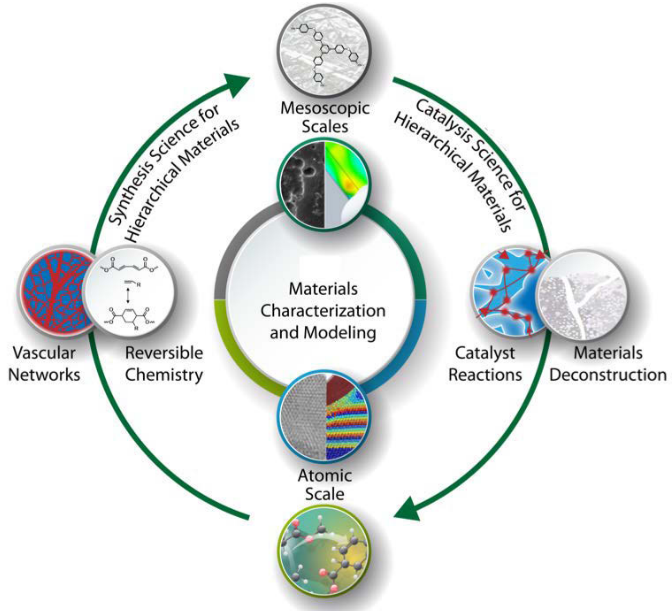


The Plastics Upcycling Consortium

Slides courtesy of Gregg T. Beckham
National Renewable Energy Laboratory

Vision and Mission

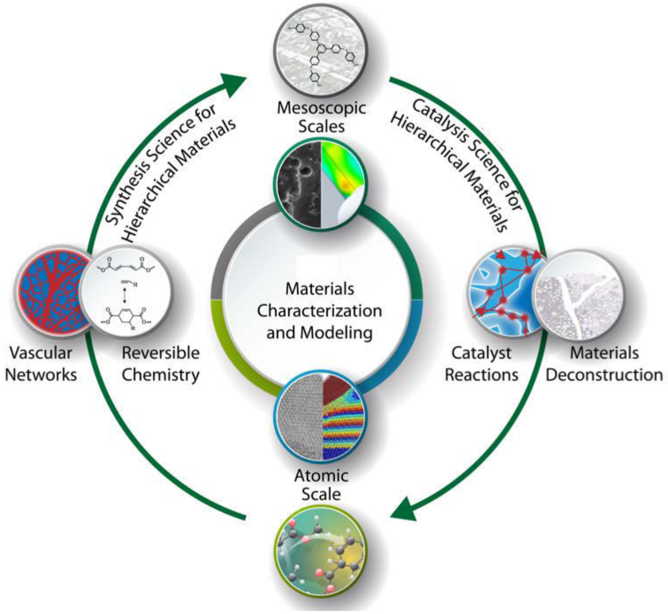
The **vision** for the **Plastics Upcycling Consortium** is to deliver technologies that will incentivize reclamation of waste plastics to enable a circular plastics economy



The **mission** of the **Plastics Upcycling Consortium** is to:
(1) develop robust processes to upcycle existing waste plastics, and
(2) develop new plastics and processes that are recyclable-by-design

Goals

- Develop **selective, scalable processes** to deconstruct and upcycle **commodity thermoplastics** that are discarded in large quantities today including PE, PP, PS, PET, nylons, and polyurethanes
- Work with industry to catalyze a new upcycling paradigm for plastics



- Design new chemistries and associated processes for direct chemical recycling of future plastics and composites that are recyclable-by-design
- Leverage AMO, BETO, and DOE investments in process development, biological and chemical catalysis, analysis-driven R&D

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MFI Web App Link:
mfitool.nrel.gov

Thank you

www.nrel.gov

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