Reaching Towards a More Sustainable Thermoset Composites Industry

Jonathan McKay, Ph.D.

INEOS Composites

07 September 2022

What motivates sustainability efforts?

- It's the "right thing to do"
- Customers require it
- Customers feel better about products/brands
- A helpful marketing tool
- Regulations mandate it
- "Competitors are viewed as 'more sustainable' than we are"
- Leadership's ESG goals demand it
- Company stock price depends on it
- Save the earth/prevent climate catastrophe
- Elevate responsible consumer consumption
- Maintain a viable industry

Motivation may change specific needs, but shouldn't change the general direction!

Some ways that composites been marketed as “sustainable”

- Extended part life – especially infrastructure, heavy truck, and “very-durable” goods
- Reduced part count/complexity and overall assembly simplification – streamlined operations making with fewer parts and fasteners
- Lightweighting – fuel efficiency for GHG savings
- Reduced emissions versus materials like concrete
- Can remove a paint/coating step and associated oven bake
- …but far less frequently, by raw material type
  - Recycled content
  - Bio-based/bio-attributed
  - Bio-circular

Some ways we talk about raw materials being “sustainable”

Term	Benefit	Example	Counter-example
Bio-based	Uses renewable resources, potentially conserves oil	Soy/corn oil and derivatives	Syngas (and syngas products) from wood
“True” Recycled	Potentially lowers energy inputs and saves landfill space	Aluminum cans	Recycled plastics #3-#7
Circular	Potentially lowers energy inputs and saves landfill space	Using post-industrial or post-consumer PET in a new UPR resin	Chopped windmill blade as concrete filler
Repurposed	Extends useful life of material, lowers energy inputs, saves landfill space	Windmill blade shelters	Burning windmill blade organics for fuel

Our Technology, Next Opportunities and Future Challenges

Existing Technology

- Soy and corn based UPR
- Recycled PET UPR
- Recycled PET LPA

Short to Mid Term Opportunities

- Increase bio content
- Increase recycle content
- Reduce cycle times
- Incorporate recycled styrene

Long Term Strategy

- Expanded technologies and practices for resin reclamation and recycling of thermoset composites.

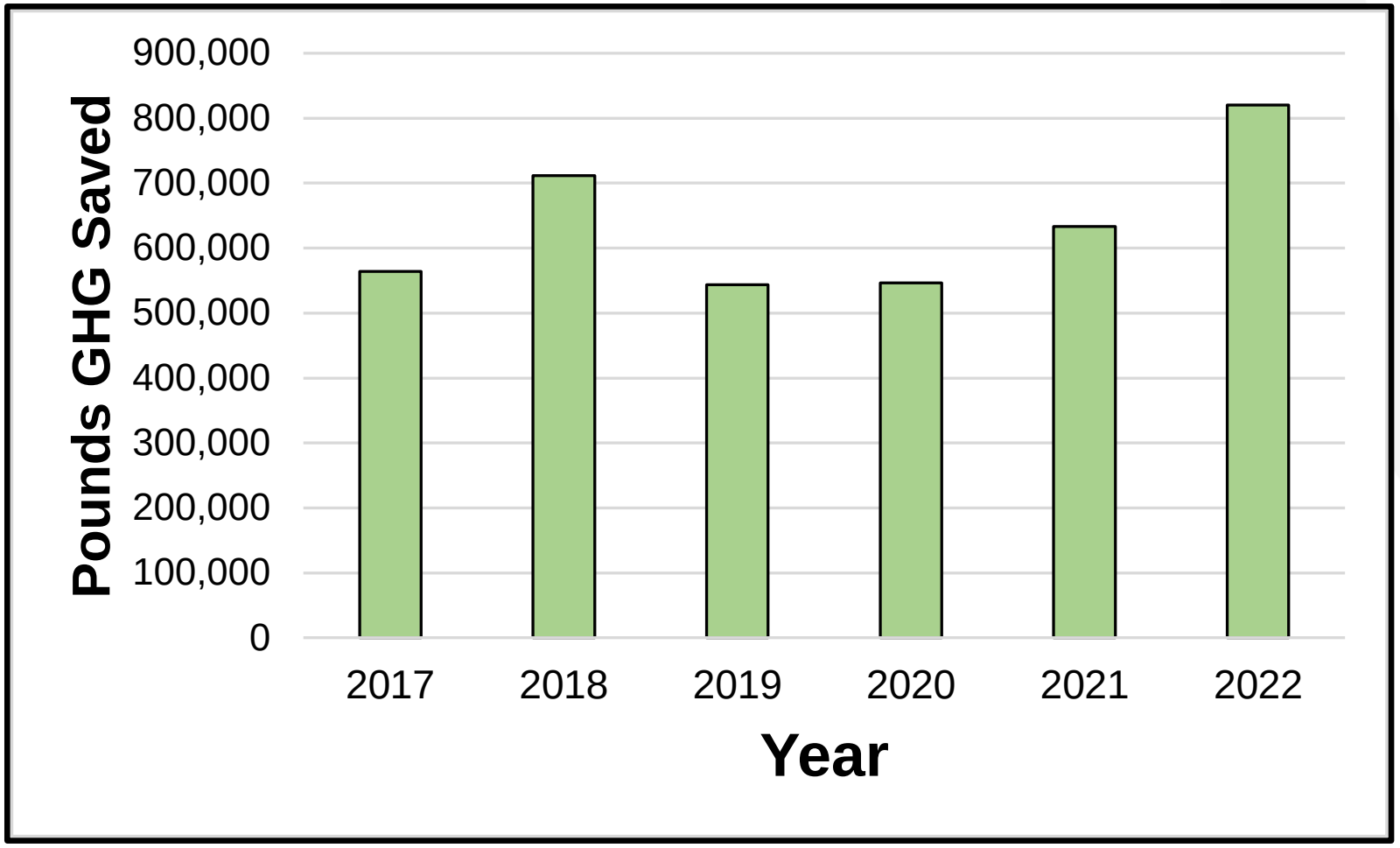
Bio-based Envirez Composite Resins

Sources: Teijin Automotive Technologies, Ashley Industrial Molding

- **INEOS Envirez 1807** introduced in 1999 – the first unsaturated polyester resin to use a significant amount of **soybean oil and corn-based ethanol** in its production.
- **18 wt%** of Envirez 1807 is from grain-derived organics.
- Each 17 MT batch of resin saves 10 barrels of crude petroleum and **removes 15 MT CO_2** from the environment.
- Current commercial applications include include large **SMC panels and covers** for John Deere and CNH agriculture equipment.

INEOS Composites

Bio-based Envirez Composite Resins GHG Savings



- Every 17 lb of Enrivez 1807 saves 15 lb of GHG (CO_2)
- 3.82 million lb cumulative GHG saved from 2017-2022 in NA
- 2022 data annualized from volumes as of 31 July

INEOS Composites

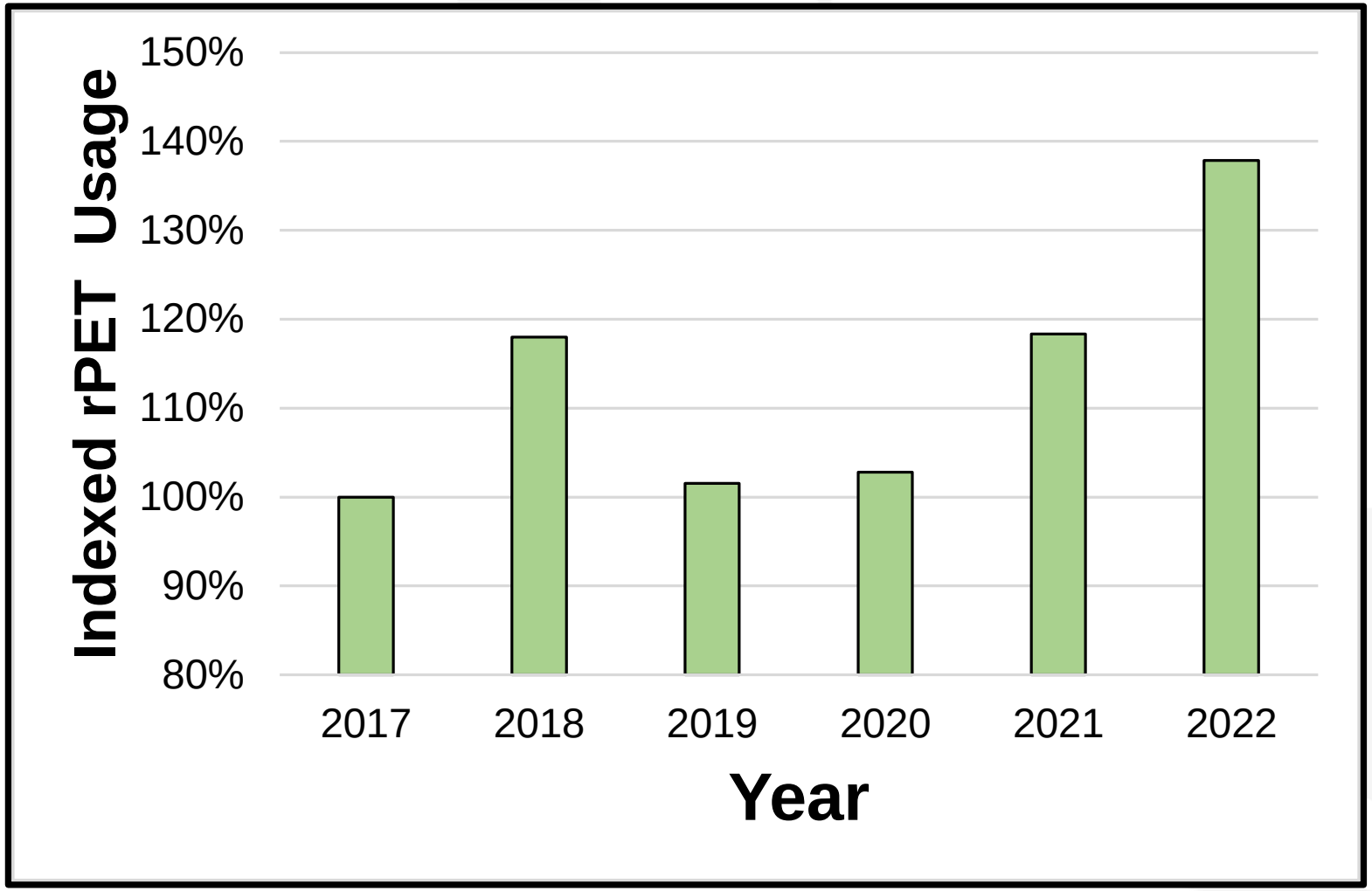
Recycled-PET-based Composite Resins & Additives

- rPET-based INEOS Composites products include:
  - **Aropol 3058 unsaturated polyester resin**
    - ➢ **Neulon 2431R low profile additive**
- Aropol 3058 contains ***more than 25 wt%*** **of post-industrial recycled PET**
- Current (and future) commercial applications include **LCM stowage assemblies, HLU saunas, pultruded ladder rails, and SMC body panels**

INEOS Composites

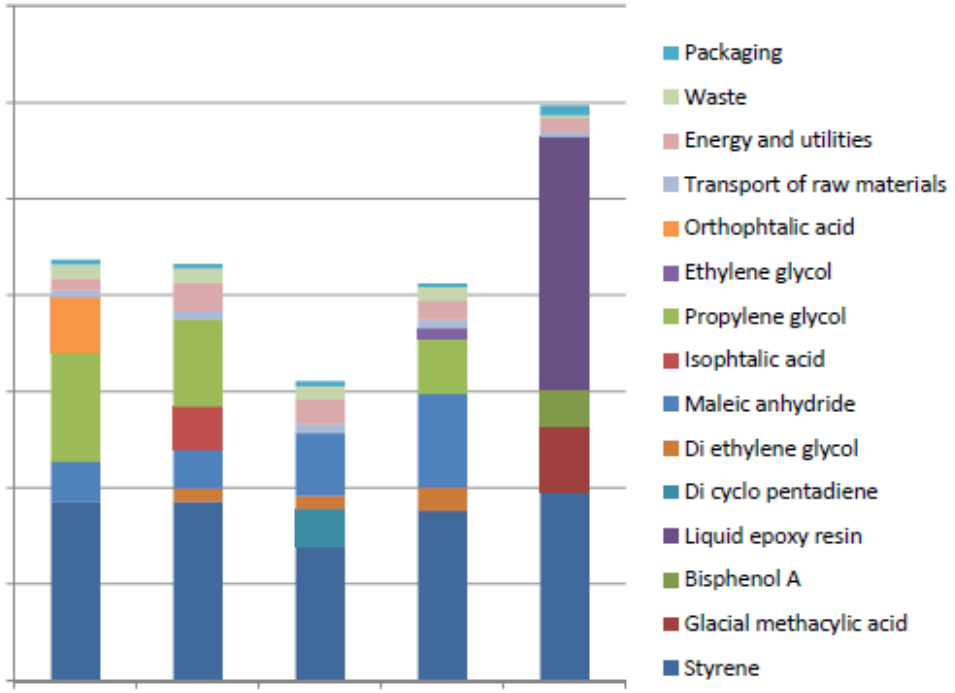
Recycled PET usage in INEOS Composite Resins (NA)

- Positive growth in resin volumes from 2017-2022 despite flat/declining PET recycling rates in US
- NA PET estimated recycling rate was 33.9% in 2020 (26.6% in US) on a volume of 8.52 billion lb
- 2022 data annualized from volumes as of 31 July



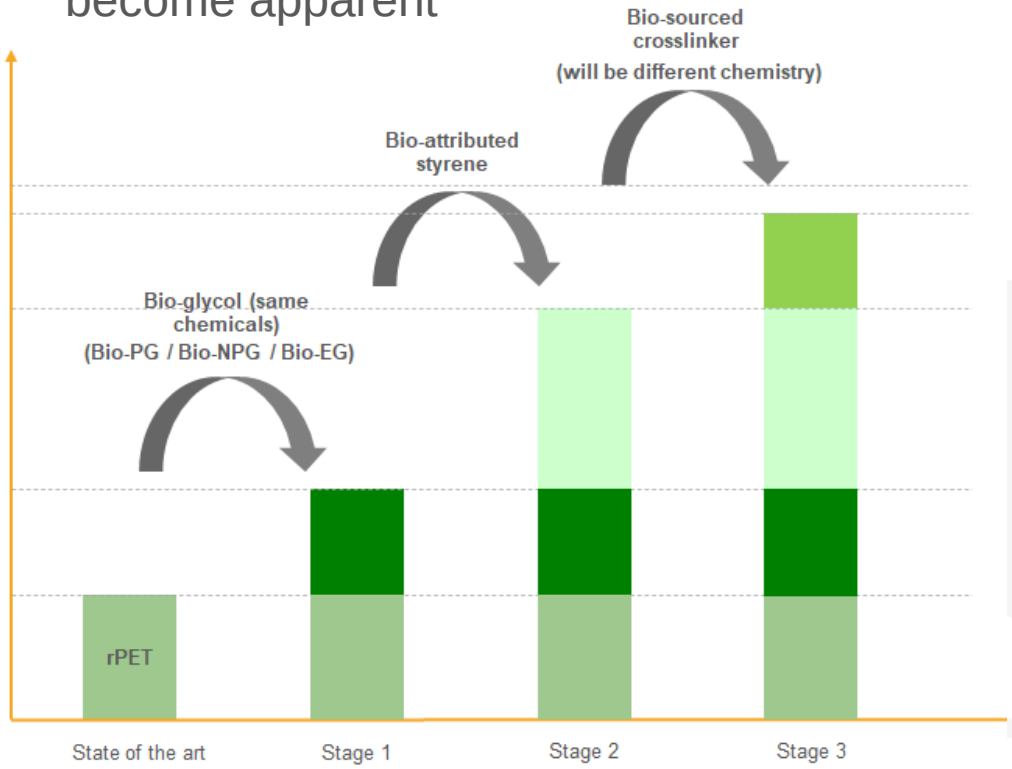
INEOS Composites

Life Cycle Analysis (LCA) can give sustainable insights



- LCA quantifies environmental impact of all aspects of a product
  - Raw materials, production, packaging etc.
- Combine with market positioning, product portfolio, etc.
- Largest impacts are the biggest opportunities

- With best opportunities identified, evaluate:
  - Technical feasibility
  - Market dynamics
- Potential strategic choices and timing can become apparent



INEOS Composites

Evolving opportunities

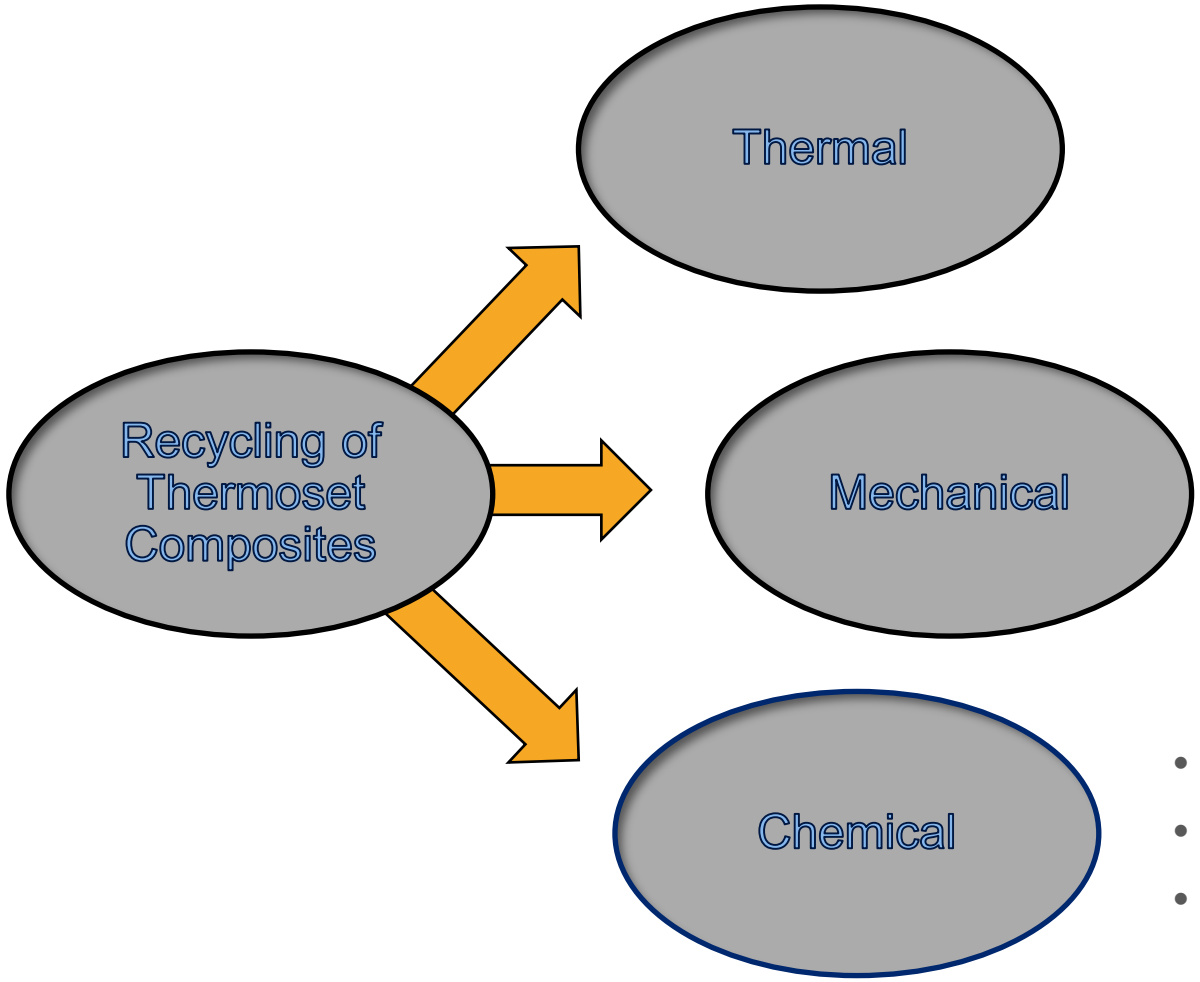
Immediate term opportunities

- Emphasize sustainable aspects of current products to customers
- Develop complete SMC systems/formulation “kits” focused on the sustainable resin portfolio for targeted popular automotive applications
  - Class-A fenders, body panels, heavy truck
  - Structural SMC, truckboxes
  - Battery covers, battery enclosures

Potential sustainable horizons

- Complete increased recycled content in rPET resins and verify performance in SMC
- Enhance use of bio-based raw materials (glycols) throughout resin line (identical performance)
- Focus system formulation on low-cycle time resins
- Integrate recycled styrene into raw material stream (varies by region)

Composite Recycling Roadmap



Making thermosets efficiently circular will require collaboration

- Raw material suppliers
- Tier 1 suppliers
- OEM's
- Industry organizations
- Academia

- Recycled fiber/resin compatibility optimization
- Recovery and reuse of solvolysis byproducts
- Polymer engineering solutions

INEOS Composites

Summary

- Sustainable thermoset resin options exist right now:
  - Thermoset technologies with bio- and recycled-content are being sold
  - Development efforts to increase that content are ongoing
- LCA can be used to understand the environmental impact of our products
- We are supporting the industry in sustainable directions
  - Perceived market needs are receiving more resources
  - Longer-term efforts are being considered
- Input from the industry can help shape the scope and timing of our sustainability efforts

Jonathan McKay, jonathan.mckay@ineos.com, +1.614.790.5512