Composites Sustainability: Circularity & Recycling

Bristol Composites Institute Composites Perspectives

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The Boeing Company

AGENDA

Sustainability & Aerospace

Composites & engineered materials

Call to action – sustainable aerospace together

BOEING'S SUSTAINABILITY GOALS

EMPLOYEE SAFETY & WELL-BEING

GLOBAL AEROSPACE SAFETY

EQUITY, DIVERSITY & INCLUSION

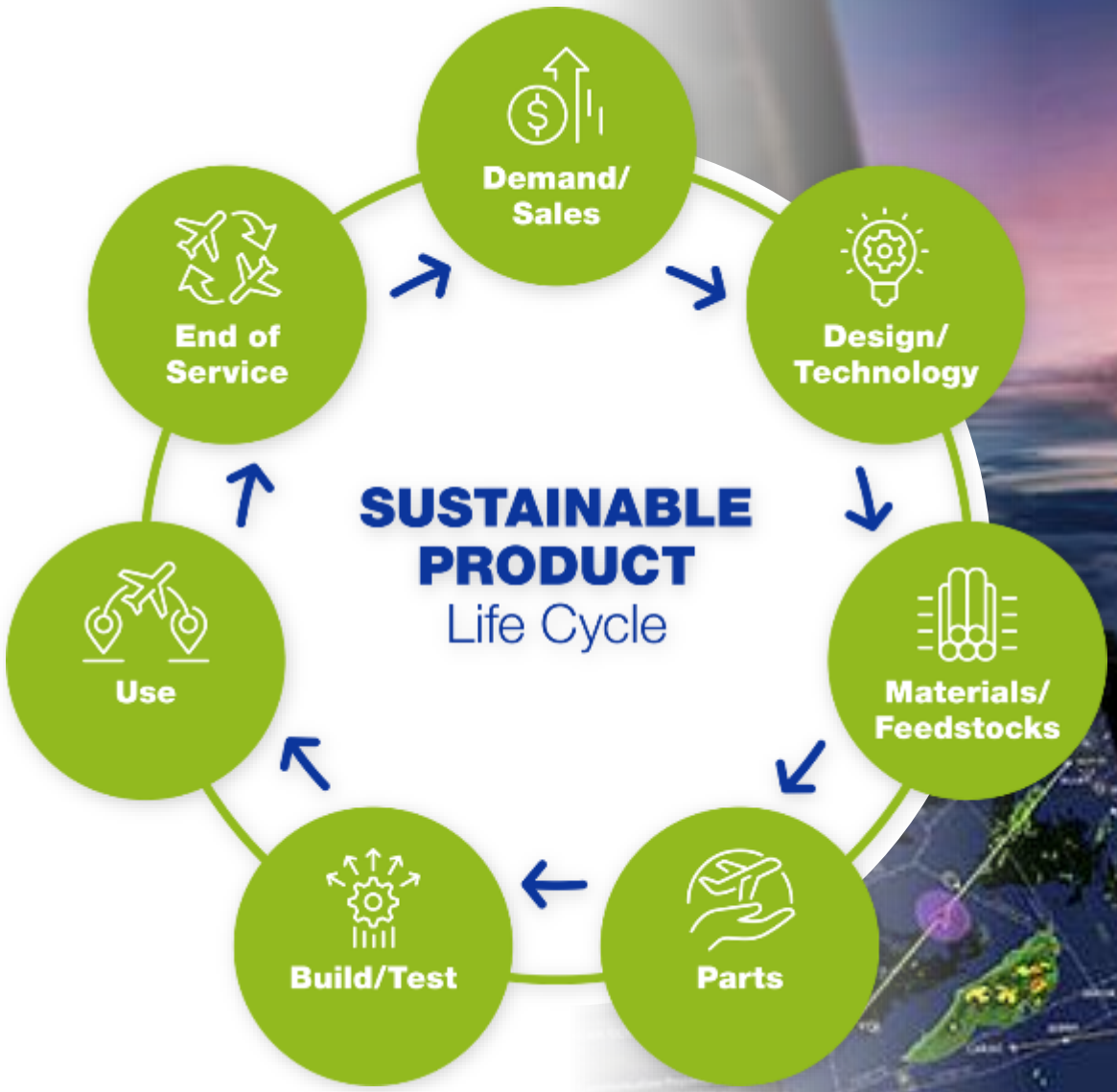
SUSTAINABLE OPERATIONS

INNOVATION & CLEAN TECHNOLOGY

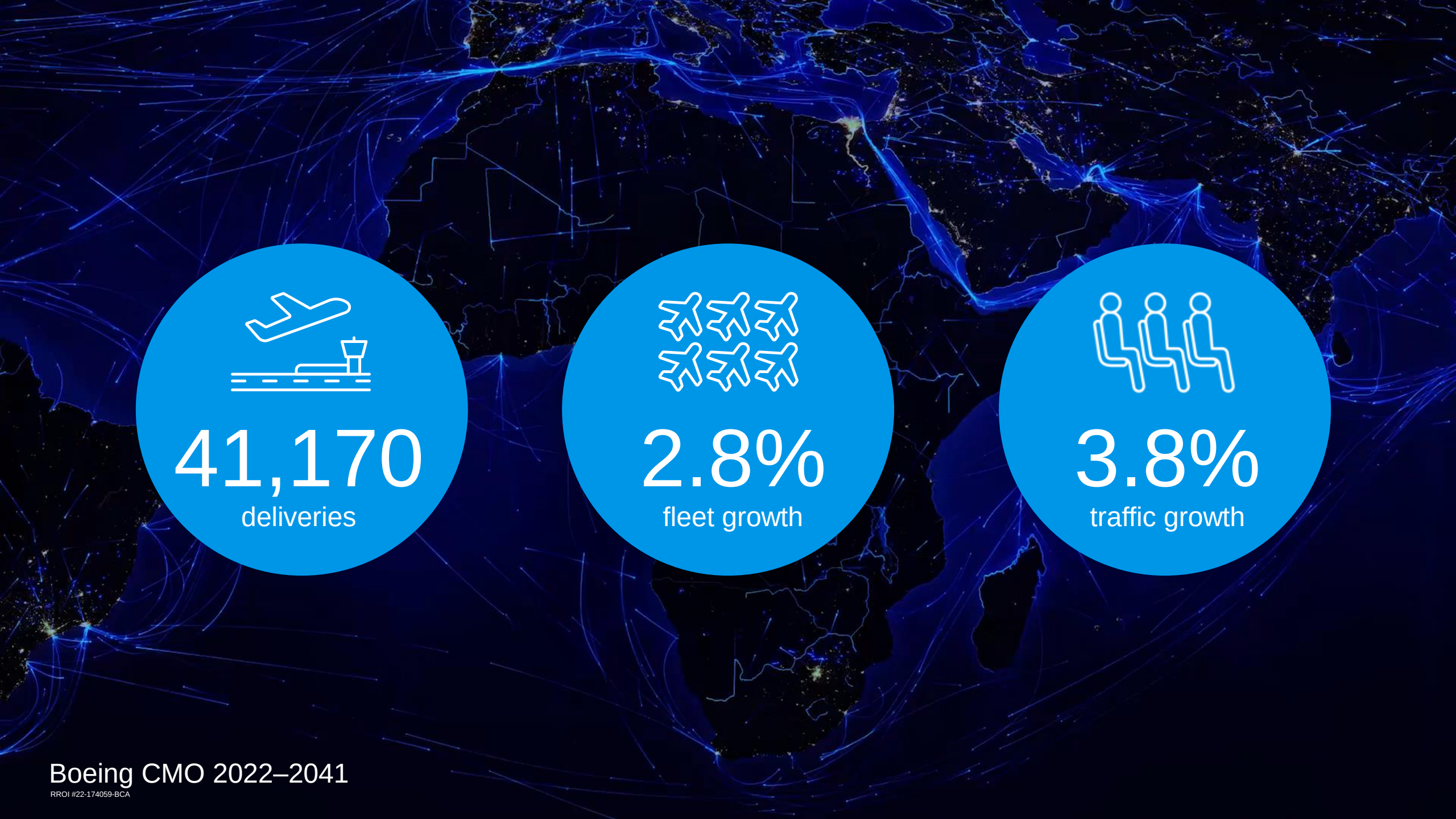
COMMUNITY ENGAGEMENT

SUSTAINABLE AEROSPACE TOGETHER

SUSTAINABILITY IS BUILT IN



[April 2021 IQ Magazine]

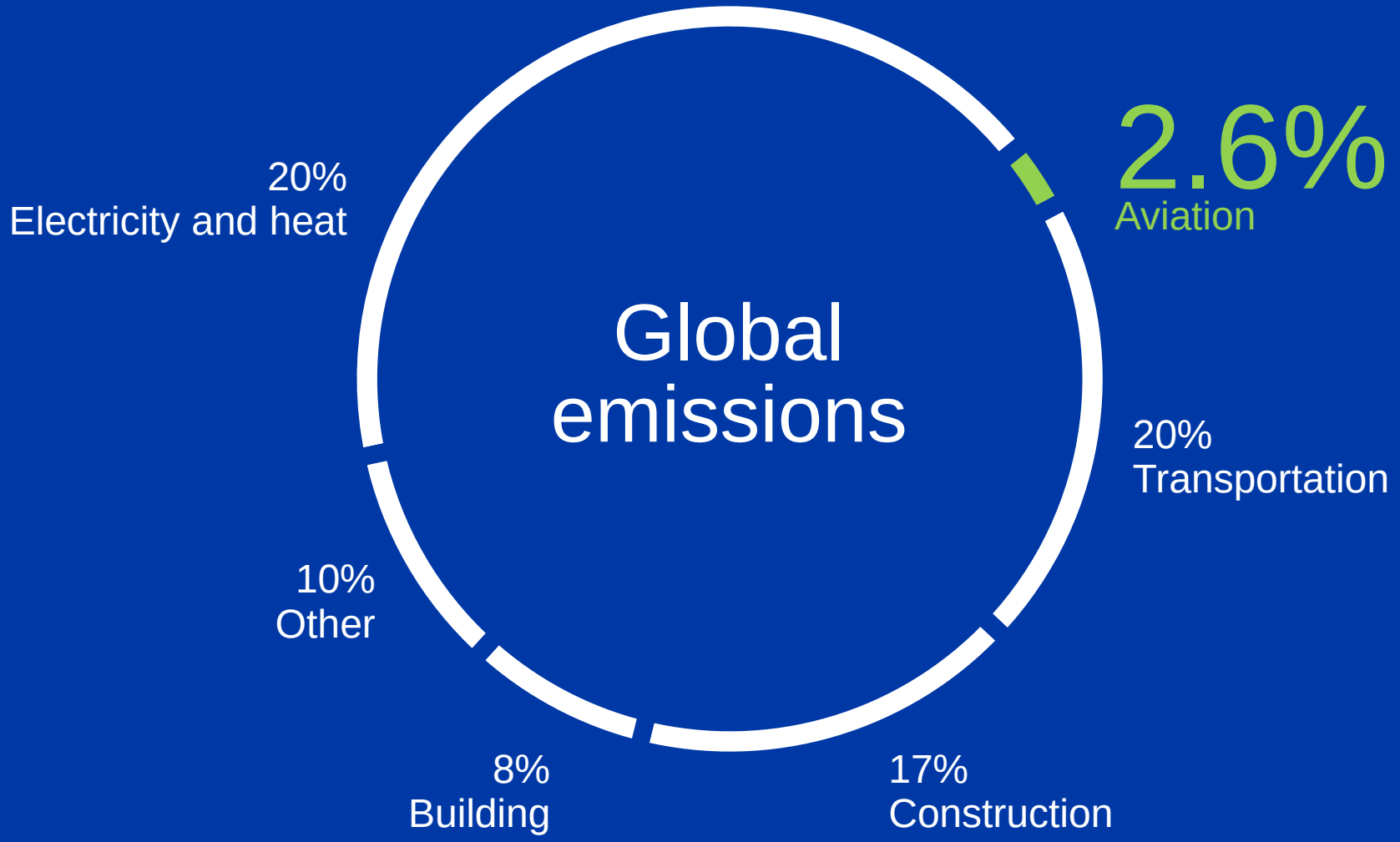


Boeing CMO 2022–2041

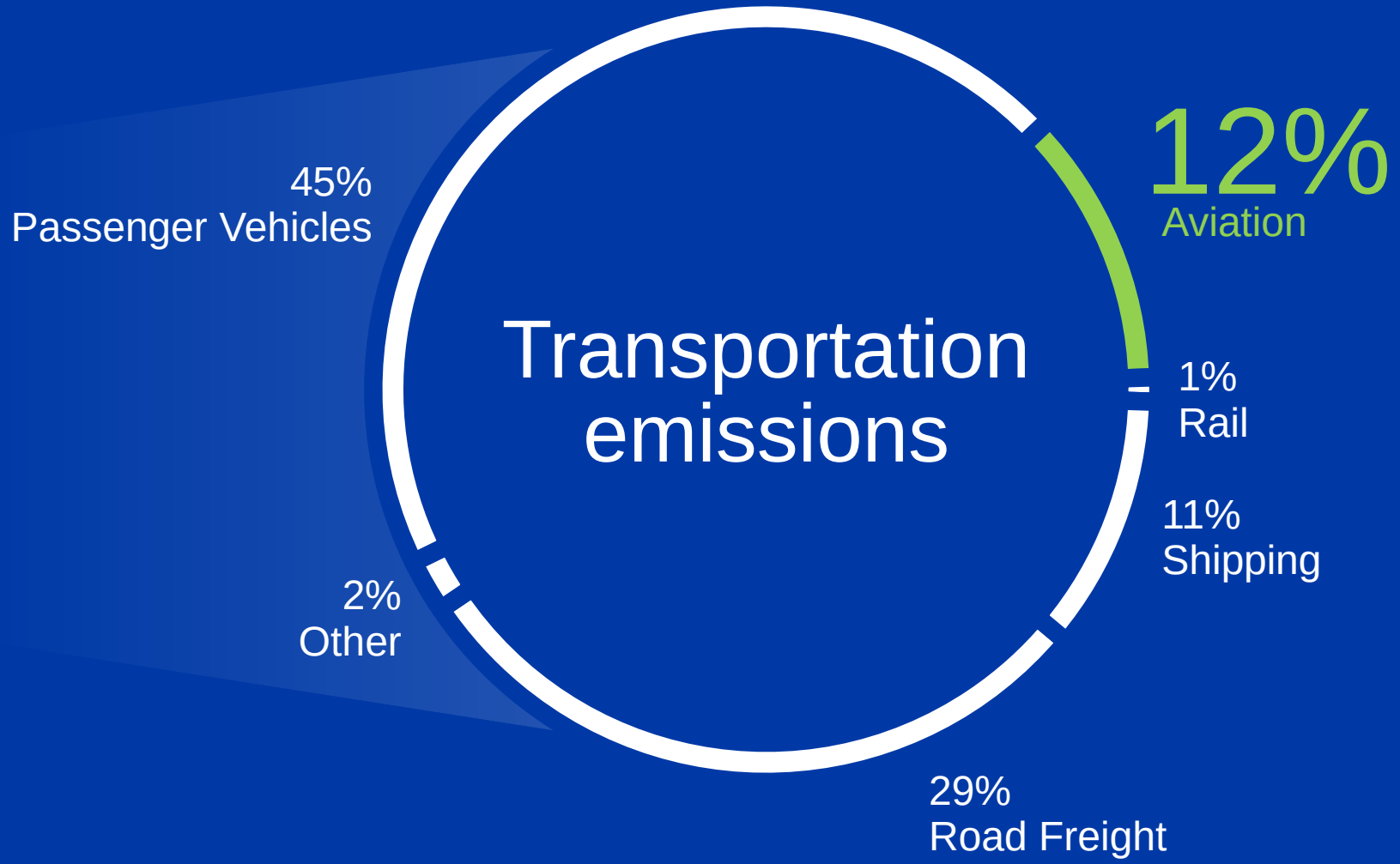
RROI #22-174059-BCA

Aviation contributes 2.6% of total global emissions

Source: 2018, World Resources Institute

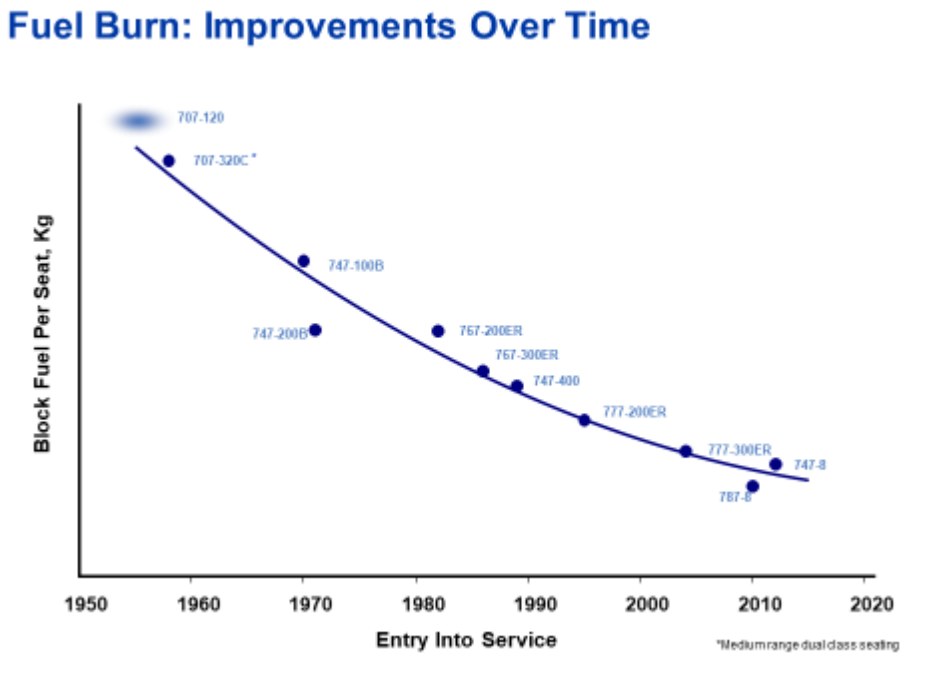


Source: 2018, World Resources Institute



Source: 2018, World Resources Institute

Composites Enable Aerospace Innovation & Performance



- ✓ Design
- ✓ Weight
- ✓ Durability

RROI #22-174059-BCA

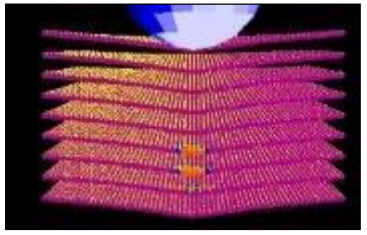
Demanding Airplane Specific Requirements

Crashworthiness

Bird strike

Tire impact

Large damage arrestment



Hail impact

150% design limit load

Structural tests

- ✓ Supportability
- ✓ Manufacturability
- ✓ Sustainability

RROI #22-174059-BCA

Recycling for Sustainable Factories

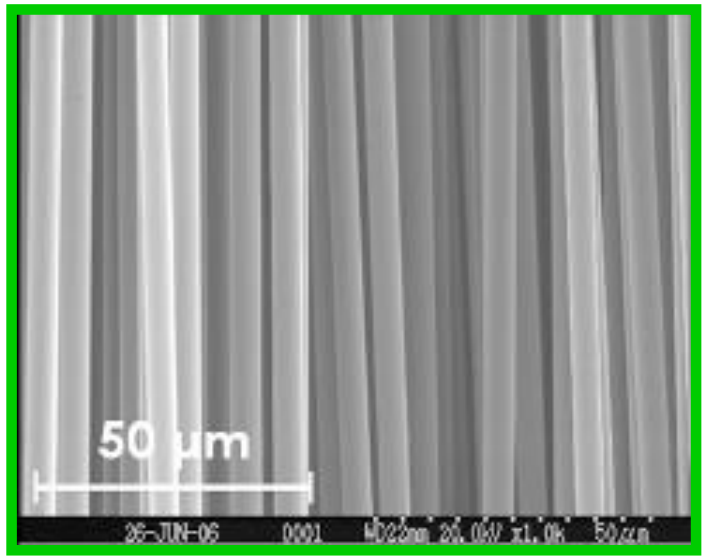
Mature a commercially viable recycling industry

Enabled Zero waste to landfill

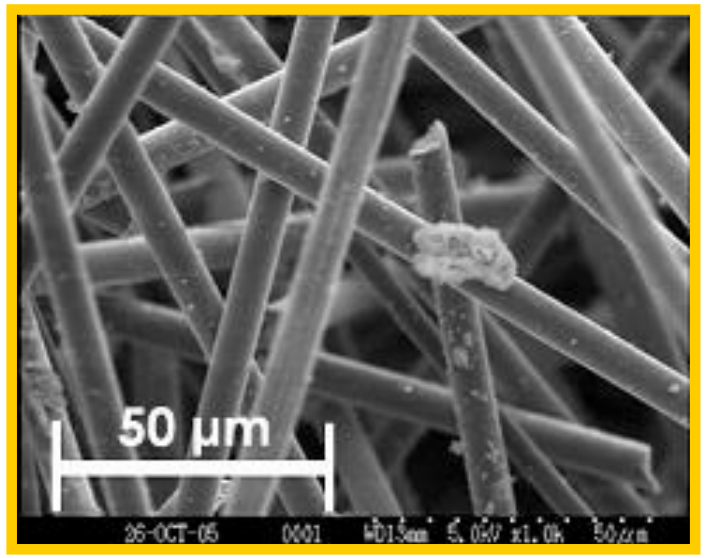
Create a path to second use value material

RROI #22-174059-BCA

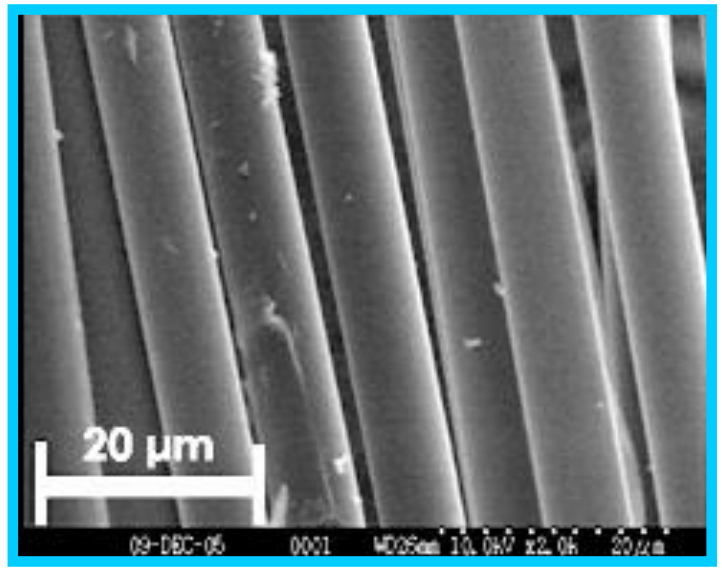
Partnered with Academia for Process Assessments



Electron Microscopy
Virgin Fiber



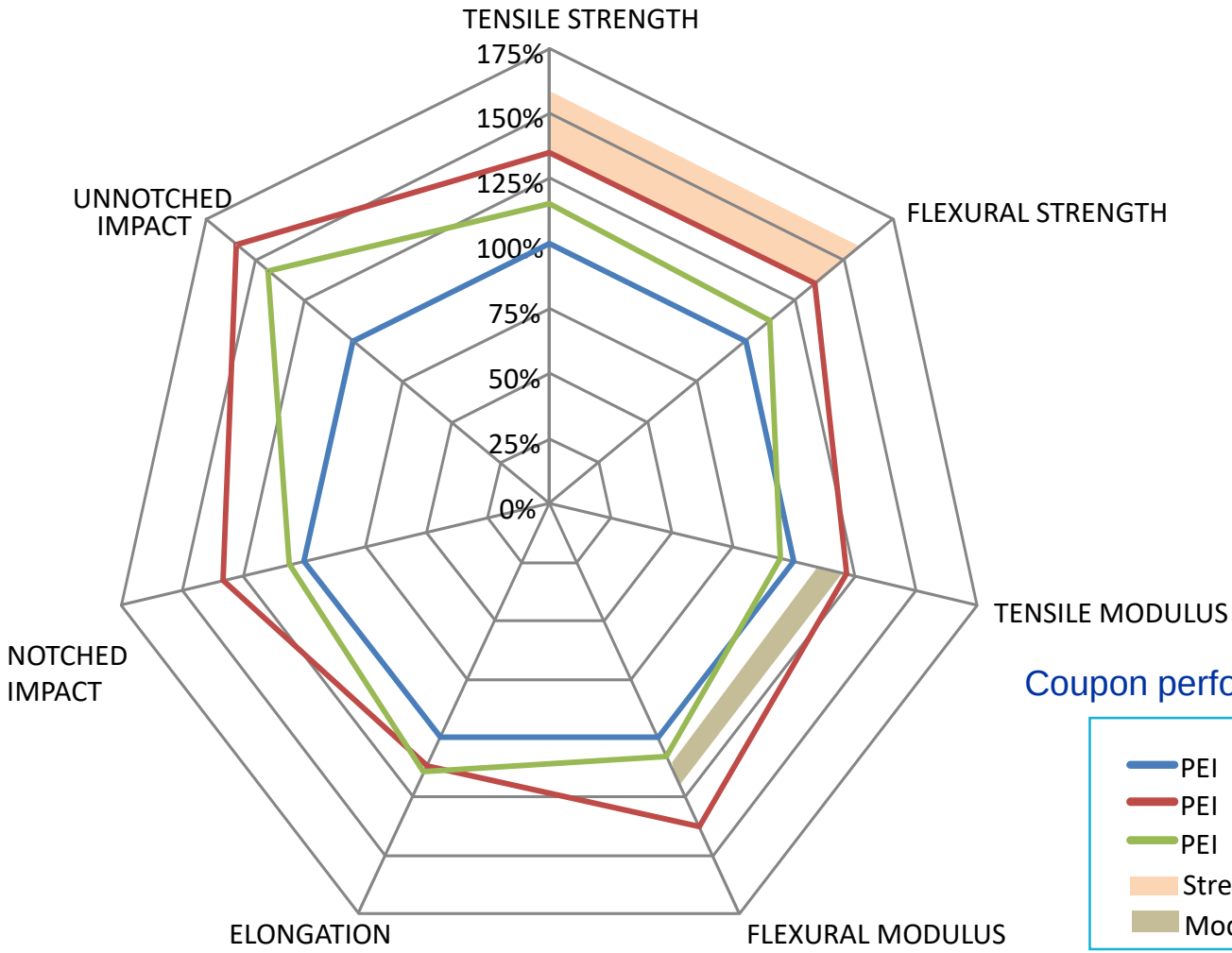
Electron Microscopy
Sovolysis

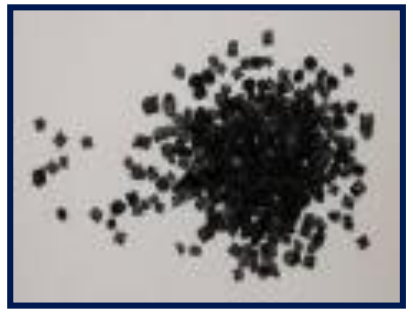


Electron Microscopy
Pyrolysis/Oxidation

Pete George et al., Society for the Advancement of Material & Process Engineering 2022

Recycled Carbon Fiber for Compounding Products





Recovered Dry Fiber and Pyrolysis Recovered Fiber Compounded with Polyetherimide (PEI)

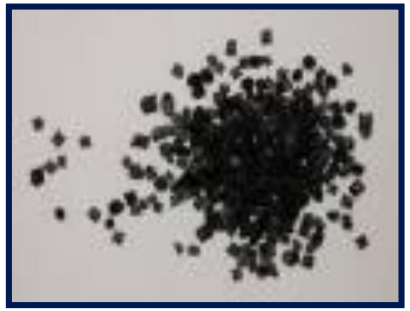
Coupon performance vs virgin fiber compound

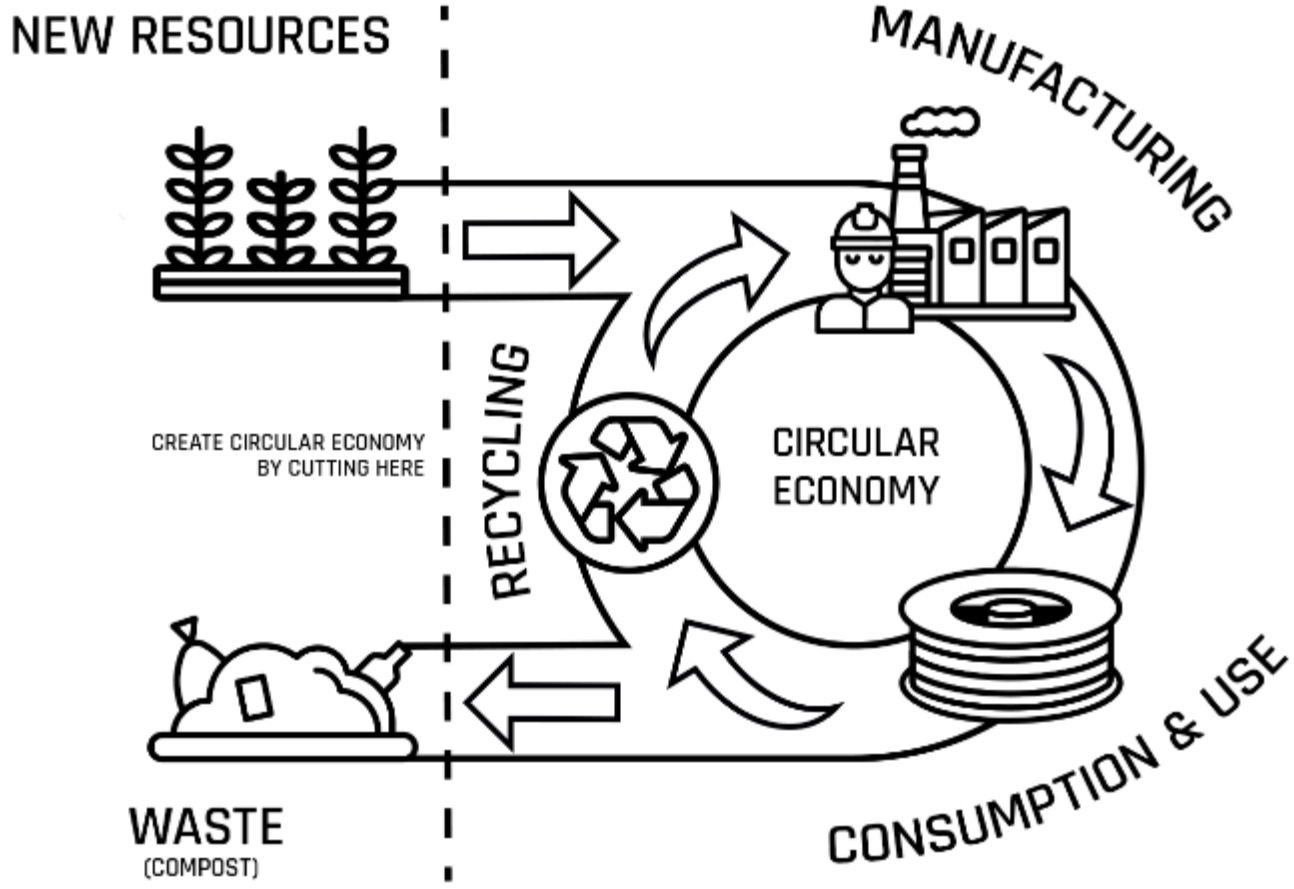
- PEI 30wt% Virgin CF
- PEI 30wt% Reclaimed textile IM7
- PEI 30 wt% Pyrolysis Reclaimed T800S
- Strength Comparison of IM to SM fibers
- Modulus Comparison of IM to SM fibers

Pete George et al., Society for the Advancement of Material & Process Engineering 2022

Circularity

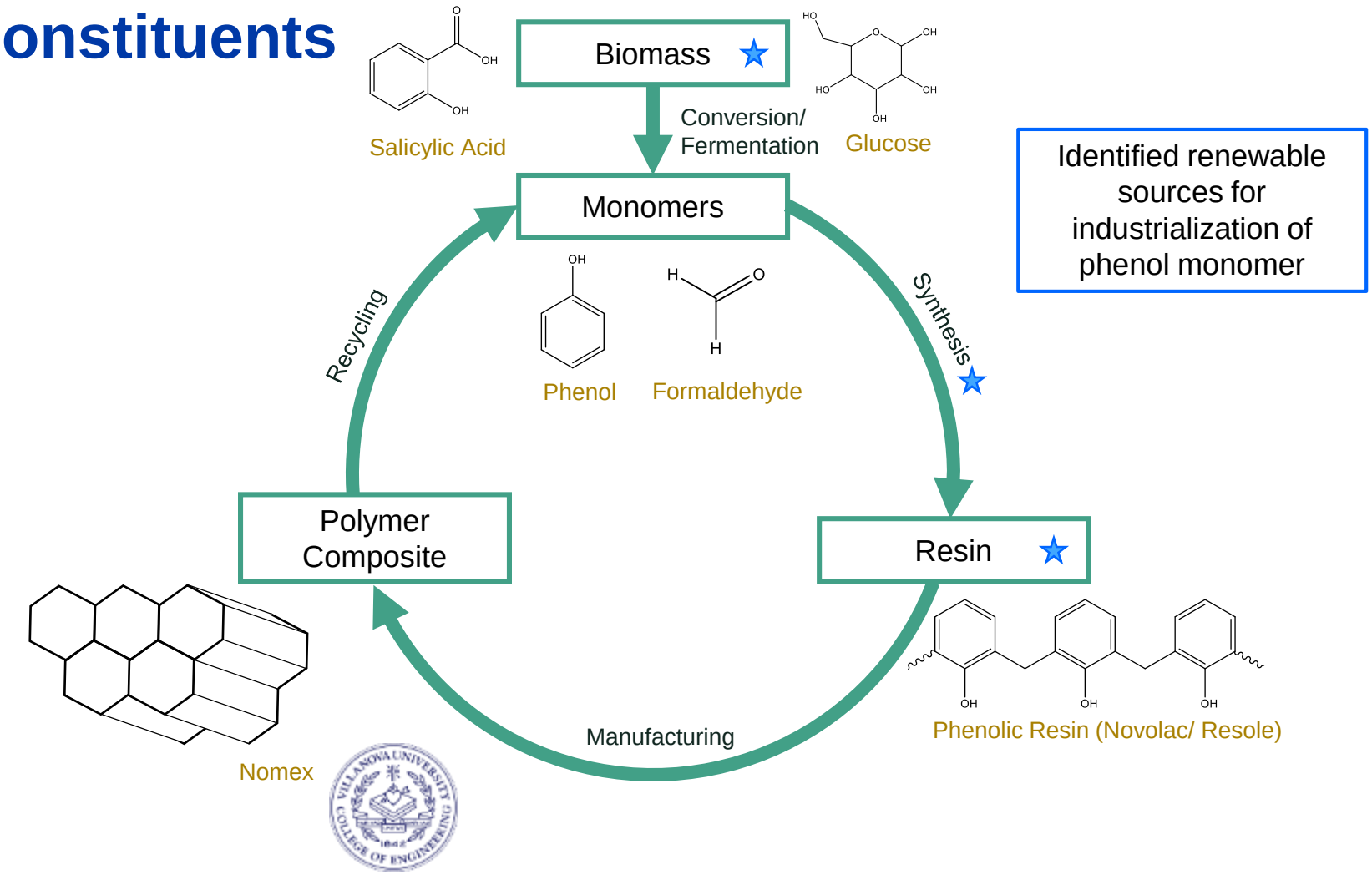
- **Optimum use of resources**
- **Avoid waste**
- **Value-add second use**





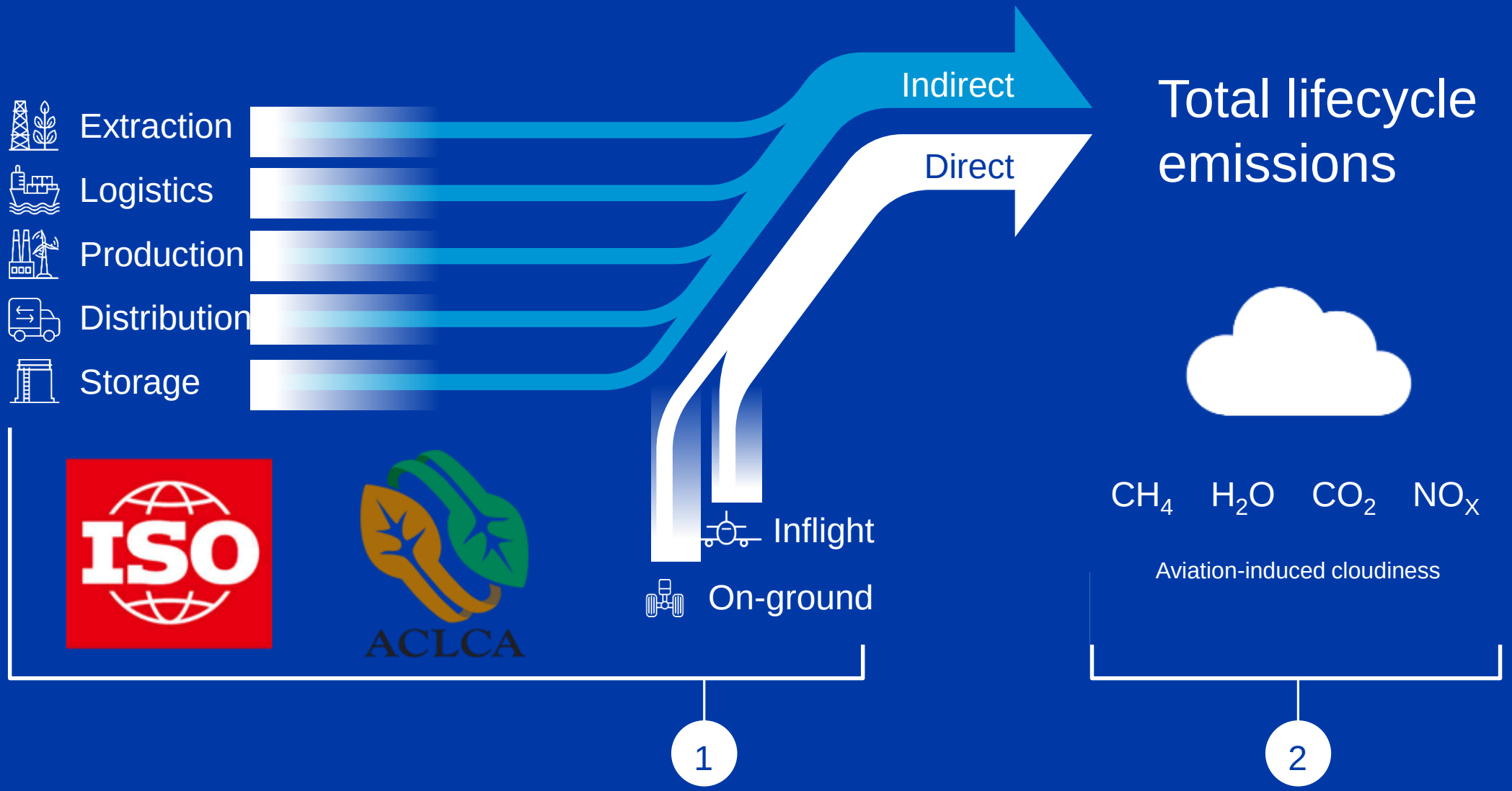
https://3dprintingindustry.com/news/circular-economy-3d-printing-opportunities-to-improve-sustainability-in-am-190425/

Innovation in Materials
Renewable Constituents



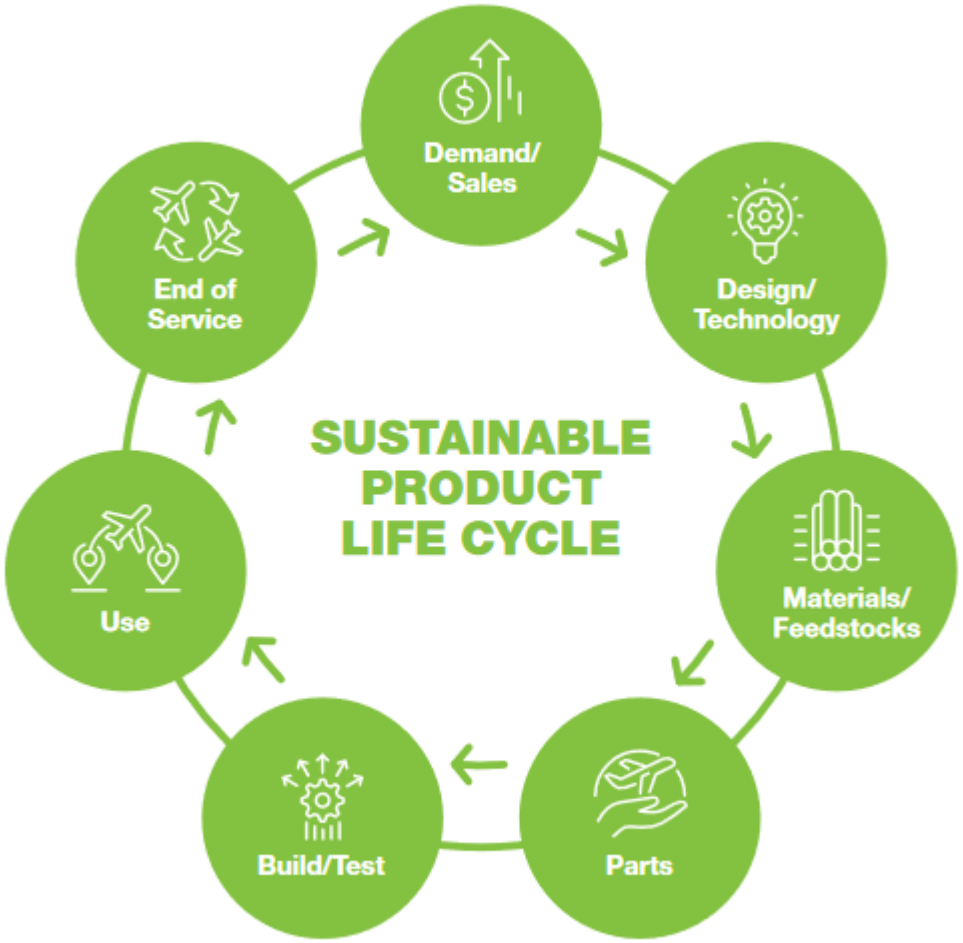
Identified renewable sources for industrialization of phenol monomer

Piscitelli, Alicia. *Decarbonization and Sustainability Assessment of the Aerospace Phenolic Resin Supply Chain*. 2021. Villanova University, PhD Dissertation.



Zero-impact: Full lifecycle accounting Total climate effects

Opportunities



- **Circularity mindset for engineered materials**
- **Full life cycle analysis**
- **New constituents and engineered materials**
- **Fabrication approaches – energy, water, waste**
- **Engagement and collaborations**