Circular Economy of Materials and Global Supply Chains

Fazleena Badurdeen, PhD
Professor of Mechanical Engineering
Director of Graduate Studies for Manufacturing Systems Engineering,
Institute for Sustainable Manufacturing,
University of Kentucky
Circular Material Flow: The 6R Approach

- **Manufacturing**
- **Use**
- **Pre-Manufacturing**
- **Product/Process Design**
- **Material Processing**
- **Recover**
- **Reuse**
- **Remanufacture**
- **Redesign**
- **Extraction**
- **Post-Use**

Reduce resource consumption and waste generation throughout lifecycle...

(Source: Jawahir and Bradley, 2015)
For a Circular Economy, sustainable manufacturing requires emphasis across different domains.
Exponential Increase in Value for all Stakeholders by Managing Embodied Energy and Material Flow in Closed-Loop Lifecycles

6R-based approach enables operationalizing the ‘Circular Economy’

Sustainable manufacturing at *product, process and systems* levels must:

- demonstrate reduced *negative environmental impact*,
- offer improved *energy and resource efficiency*,
- generate *minimum quantity of wastes*,
- provide *operational safety*, and
- offer improved *personnel health*;

- All while maintaining and/or improving the *product and process quality* with overall *lifecycle cost benefits*.

Operationalizing the Circular Economy through the Supply Chain

(Badurdeen et al., 2009, “Extending total lifecycle thinking to sustainable supply chain design”, IJPLM, Vol. 4, Nos 1/2/3, 2009)
Circular Economy Business Model Impacts

Laser Toner Cartridges

Emphasis on all lifecycle stages

Circular Economy Business Model Impacts

Laser Toner Cartridges

Benefits Multi-lifecycle Products for Circular Economy*

- Value recovery potential varies: Reuse > Remanufacturing > Recycling
- Success depends on ability to enable end-of-life takeback from customer
- Supply chain partnerships essential
- Business case for Circular Economy is very clear; challenges will vary from one industry to another

*Compared to baseline design without 6R application