Beyond Recycling: The Case for the Circular Economy in Indiana

2019 IRC Conference
Beyond Recycling: The Case for Embracing Circular Economic in Indiana

- **Background**
  - Linear and Circular Economies
  - Re-Triad / CE 1.0
  - Challenge of a Plastics CE
  - Essential Re’s for CE 2.0
  - CE and Indiana
My Journey into Sustainability and Circular Economy

27 Year
GE Plastics

8 Years
SABIC

*SABIC Sustainability Reports 2013. **ICEhouse, Davos, McDonough Innovation
Incredible Prosperity Achieved Over One Lifetime

- Mobility
- Longevity
- Convenience
- Information
- Novel Products
- Entertainment
Reshaping the Planet in One Lifetime

Global Plastic Volume

Success Driven by:
- Diverse Functionality
- Design speed
- Low cost

Source: Geyer et al. (2017)

https://ourworldindata.org/plastic-pollution
Accelerating Degradation Over the Same One Lifetime

**GHG**
+30% increase since 1960

- 414 ppm

**Oceanic Plastic**
+8MMT/y

**Deforestation**
50% of tropical forest gone

**Bio diversity**
1M species at risk

**Geochemical (P,N) Flow**
3x Pre-Industrial Levels

**Raw Material Use**
+300%
Sustainability Are Not Simply Environmental

17 UN Sustainability Development Goals

Clean Water (6)
Clean Energy (7)
Climate (13)
Ocean Life (14)
Land Life (15)

Poverty (1)
Hunger (2)
Health (3)
Education (4)
Gender Equality (5)
Inequality (10)
Sustainable Cities (11)
Peace/Justice (16)

Jobs/Economic Growth (8)
Infrastructure/Innovation (9)
Responsible Consumption (12)
Partnerships for Change (17)
A Transformative Economic Model Needed

Circular Economy

Social stability and more inclusive quality of life

New relationship with materials, energy and planetary boundaries
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Addicted to increasing consumption

Value embedded in products is lost and environment is degraded
Economic Issues with Linear(Consumption) Economy

MGI Commodity Price Index (years 1999–2001 = 100)

- World War I
- World War II
- Postwar depression
- Great Depression
- 1970s oil shock

Years:
- 1900
- 1910
- 1920
- 1930
- 1940
- 1950
- 1960
- 1970
- 1980
- 1990
- 2000
- 2011
Economic Issues with Linear(Consumption) Economy

Consumption

Scarcity

Cost/inflation

Economic downturn/instability

Loss of employment/quality of life

Environmental degradation

Social insecurity sets in

Unrest, migration, conflict....
Regenerate — Take — Remake — Make — Reuse — Consume — Recover — Waste

Moving Beyond a Linear Economy
Circular Economy (CE)

Inspired by natural metabolism/regeneration

- Continuous material reuse
- 100% renewable energy
- No persistent toxins
- Complex but totally interconnected
“Economic framework that is restorative and regenerative by design”

- Design out waste and pollution
- Keep products/materials in use
- Regenerate natural systems

Economic Implications

- Prioritizes long term stability over growth
- Retain and build value
- Secure the availability of raw materials
- Job creation, quality of life
Basic Elements of EMF Butterfly Chart

Renewable

Finite

Loops

Loops

Consume

Use

Leakage
Technical Nutrient Loops

Priority/Impact
1) Share, maintain/prolong
2) Reuse/redistribute
3) Remanufacture
4) Recycle
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Recycling

• #1 sustainability action understood by society
• Responsibility lies with the consumer or public
• Works reasonably well for metals, paper, glass

But

• Plastics at ~9% after 40 years of promotion
### Quiz Question  Raw Material Extraction vs Recycle

<table>
<thead>
<tr>
<th></th>
<th>Take Volume of materials (kg) extracted per day per person (1)</th>
<th>Recycle Volume of materials (kg) recycled per day per person (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>56</td>
<td>0.8</td>
</tr>
<tr>
<td>Indiana</td>
<td>56</td>
<td>0.6</td>
</tr>
</tbody>
</table>

(2) Recycled+Composted; 2015 EPA Recycle report, 2017 IDEM Indiana recycle report
## Plastic Markets and Application Lifetime

<table>
<thead>
<tr>
<th>Industry** Segment</th>
<th>% of Production</th>
<th>Mean Lifetime (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>44.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Building and Construction</td>
<td>18.8</td>
<td>35</td>
</tr>
<tr>
<td>Textiles</td>
<td>17*</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>13.2</td>
<td>5</td>
</tr>
<tr>
<td>Consumer and Industrial</td>
<td>11.9</td>
<td>3</td>
</tr>
<tr>
<td>Transportation</td>
<td>6.7</td>
<td>13</td>
</tr>
<tr>
<td>Electrical/Electronics</td>
<td>3.9</td>
<td>8</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.8</td>
<td>20</td>
</tr>
</tbody>
</table>

*Textiles was not included in % analysis, but on a production volume basis would represent ~17%.

Shortest lifetime is largest volume, 97% becomes waste within 1 year.

**[https://advances.sciencemag.org/content/advances/suppl/2017/07/17/3.7.e1700782.DC1/1700782_SM.pdf](https://advances.sciencemag.org/content/advances/suppl/2017/07/17/3.7.e1700782.DC1/1700782_SM.pdf)**

### Since 1950
- **10B Tons** Made
- **7B Tons** Waste
- **3B tons** In Use
Reduce and Reuse

Reduce
- Personal behavior
- Policy (bans, taxation)
- Durability/longer lifetimes
- Sharing...

Reuse
- Repair
- Refill
- Rebuild
- Maintain
- Upgrade...

Value durability, performance, conservation over cheap, convenient, fast fashion
Elimination of Single Use Packaging-Loop

300 products from Procter & Gamble, Unilever, Nestlé, PepsiCo, Danone........

Packages designed for 100 uses

Customers must pay a one time, fully refundable deposit for each package


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➤ Challenge of a Plastics CE
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Why is Plastic Recycling Limited? How Can a CE be Achieved?

Need regenerative processes that get back to virgin properties and concentrated flow
Plastic Recycling Processes Beyond Mechanical

Resources Feedstocks → Resin Operations → Application Operations → Consumer Use → End-of-Use

- Reuse, Repair
- Remanufacture
- Mechanical Recycle
- Chemical Recycle (Monomer)
- Chemical Recycle (Pyrolysis-Naphtha)
- Chemical Recycle (Gasification-CO, H₂)

GHG

Value Retention

Complexity Tolerance
## Chemistry of Chemical Recycling

### Monomer Recycling (PET)

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>De-polymerize</td>
<td>TPA-EG-TPA-EG--</td>
</tr>
<tr>
<td>Purify</td>
<td>TPA + EG</td>
</tr>
<tr>
<td>Re-polymerize</td>
<td>--TPA-EG-TPA-EG--</td>
</tr>
</tbody>
</table>

### Pyrolysis (Polyethylene)

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>De-polymerize</td>
<td>--E-E-E-E-E-E-E--</td>
</tr>
<tr>
<td>Process Oil</td>
<td>Naphtha → E</td>
</tr>
<tr>
<td>Re-polymerize</td>
<td>--E-E-E-E-E-E-E--</td>
</tr>
</tbody>
</table>

### Gasification (Polyethylene)

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Burning</td>
<td>--E-E-E-E-E-E--</td>
</tr>
<tr>
<td>Purify/Chemistry</td>
<td>Syngas → Naphtha</td>
</tr>
<tr>
<td>CO/H₂</td>
<td>Re-polymerize</td>
</tr>
</tbody>
</table>

![Chemical Structures](image1.png)
<table>
<thead>
<tr>
<th>Process</th>
<th>Waste Inputs</th>
<th>Outputs</th>
<th>Practitioners</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monomer Recycling</strong></td>
<td>PET, Nylon 6, Polyesters, Polycarbonate</td>
<td>PTA, EG, Caprolactam, Diacids &amp; Diols, BPA</td>
<td>Eastman, LOOP, Aquafil, Teijin</td>
</tr>
<tr>
<td><strong>Pyrolysis</strong></td>
<td>PE, LLPE, PP, PS, Polyolefins, Rubbers</td>
<td>Oil (fuel), Naphtha, Monomers, Carbon Black</td>
<td>Agilyx, Plastic Energy, RESPolyflow, IGES.....</td>
</tr>
<tr>
<td><strong>Gasification</strong></td>
<td>Refuge derived fuel, Biogenic waste, Non-biogenic waste</td>
<td>Syngas(CO, H₂), Naphtha, Oil (fuel), Chemicals</td>
<td>Enerkem, Fulcrum Bioenergy (LanzaTech)</td>
</tr>
</tbody>
</table>
Circular Economy Examples of Plastic Chemical Recycling

**Aquafil Econyl/Interface**
- Depolymerize nylon 6 recycle
- Reclaimed fishing nets, fibers
- Upcycle to carpet and fashion

**Teijin/Patagonia/Burlington**
- Depolymerize PET products
- Eliminates additives/colorants..
- Upcycle clothing, sporting gear

**Plastic Energy/SABIC**
- **TACOIL** from waste plastic
- SABIC reconverts to plastic
- True closed loop plastic
A Plastic Circular Economy Model

CO₂ → Renewable Energy

Feedstock → Energy

Pyrolysis, Gasification, Incineration

Monomer Recycle

Mechanical Recycle

Repair

Reuse

User

Application Mfg.

Resin Mfg.

Monomer Mfg.
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“Put the “re” back into resources”

William McDonough
“Design is the first expression of human intent”
William McDonough

How often has disposability been a design objective?
How often is reuse or recycle a design objective?

Design Objectives for a Circular Economy

Durability, reparability, refillability, disassembly, free of toxins
Standardization and simplicity of composition and format...
Value retention vs minimum initial cost
“Stop the bleeding”

Coalitions and collaborations

Alliance to End Plastic Waste, 2019

New Plastic Economy, EMF

International policies the discourage reckless disposal

Recovery, recapture efforts where feasible

Incentivized collection, sequestration, cleanup

Enable the restorative power of nature with time

DDT(50y), Ozone(100y)

Micro plastic, CO₂
Renewable Energy Considerations
Annual sunshine is 100,000x human consumption and 100x fossil fuel resources.

Cost of renewable electricity falling.

Bio renewable considerations
Annual terrestrial bio mass is sufficient to replace plastic hydrocarbon usage.

Investment in renewables could drive circular processes and eliminate leakage. (materials and $\text{CO}_2$)
No major environmental progress happens without public policies (Ozone/CFC’s, Acid rain/ SOx & NOx, Clean Water Act, Bottle laws....)

Nationalism and deregulation undermining governance

EU parliament ratified Circular Economic Package June 2018
- Improve **EU competitiveness, sustainable economic growth, jobs**
- MSW recycling rate targets: 55%(2025), 60%(2030), 65%(2035)
- No recyclable or recoverable materials to landfill (2030)
- Eliminate unnecessary single use/disposable applications
- Recycle usage requirements
- Implement extended producer responsibility

May not like it, but human nature requires it!
Responsibility: Extended Producer Responsibility

Reverses the flow of product ownership at end-of-use

- Value recovery at end-of-use is best done by who made them
- Encourages design for durability, disassembly, material recovery
- Builds stronger supplier-customer relationship

Consumers focus expectations on performance and service vs ownership of stuff

- Kilometers or Tires?
- Fashion or closet full of old clothes?
- Connectivity or half the Periodic table?
Put the “Re’s” in practice in personal/professional life
Communicate and socialize actions

You are responsible for tomorrow’s child

Glenn C Thomas, 1996
The Case for a Circular Economy (CE) in Indiana

- Background
  - Urgency for change

- Linear and Circular Economies
  - CE is an opportunity

- Recycling (CE 1.0)
  - Recycling is start

- Challenge of a Plastics CE
  - Even plastics can be circular

- Essential Re’s for CE 2.0
  - Many actions needed

- CE and Indiana
  - What about Indiana?
CE and Indiana is Inevitable

CE will need:
• Many Innovations/redesigns
• Lots of SME to service loops
• Renewable resources
• Education and Skills
• Artificial Intelligence
• Forward looking leadership

CE will result in:
• Economic potential
• Jobs
• Access to resources
• Healthier environment
• Thriving reputation
• Community resilience

CE initiatives commonly includes:
• A vision, innovation/start up hub, public/private collaborations, leadership

Indiana and Circular Economy are a path to a future thriving economy

https://www.envisioncharlotte.com/circular-charlotte/