Assessment of Resource Efficiency and Innovation in Circular Economy through Remanufacturing, Reuse, Repair, and Refurbishment

International Resource Panel

G7 Value Retention Policies Workshop
Advancing Remanufacturing, Refurbishment, Repair and Direct Reuse (RRRDR)
Panoramic Hall, Montreal Science Centre
Montreal, 21-22 June 2018

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Context of the IRP study

Circular Economy (CE)

- CE seeks to maximize system efficiency through both resource utilization and value retention.

Value-Retention Processes (VRPs)

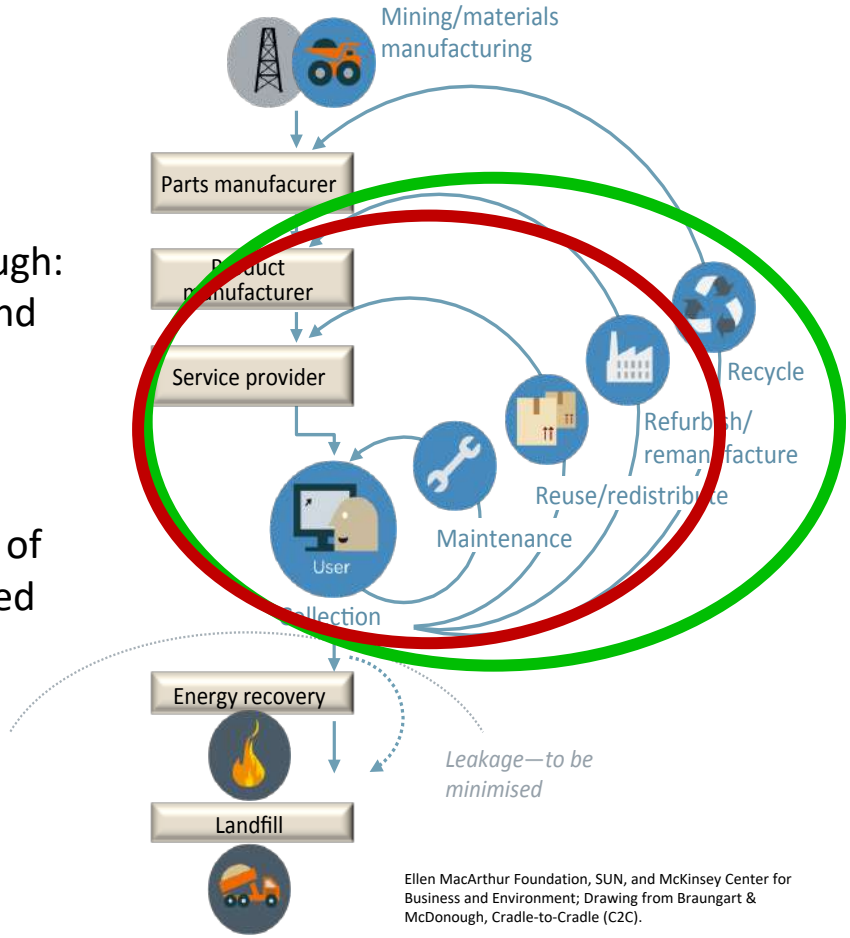
- Formerly *"Circular Processes"* or *"VRPs"*
- Processes that retain value within a system through: **arranging direct reuse**, **repair**, **refurbishment**, and **remanufacturing**.

Potential Benefits

- Offer substantial and verifiable benefits in terms of resource efficiency, circular economy, and reduced negative environmental impact.

Broader Impact

- Inform policy and guide private sector



Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle-to-Cradle (C2C).

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Research questions

1) What are the product- and process-level environmental and economic implications of circular VRP-based production, relative to traditional linear OEM New production?
2) What are the economy-level environmental and economic implications of circular VRP-based production, relative to traditional linear OEM New production?
3) What are the impacts of regulatory, market-based, technological, and collection infrastructure barriers to VRPs, and how do they affect transition to circular economy?
4) What behavioral-economic conditions influence the adoption and diffusion of VRP innovations within markets, and what interventions are possible to alleviate these kinds of market-based barriers?
5) What actions can be taken by industry and policy-markets to support and enable VRP market transformation for circular economy through VRPs?

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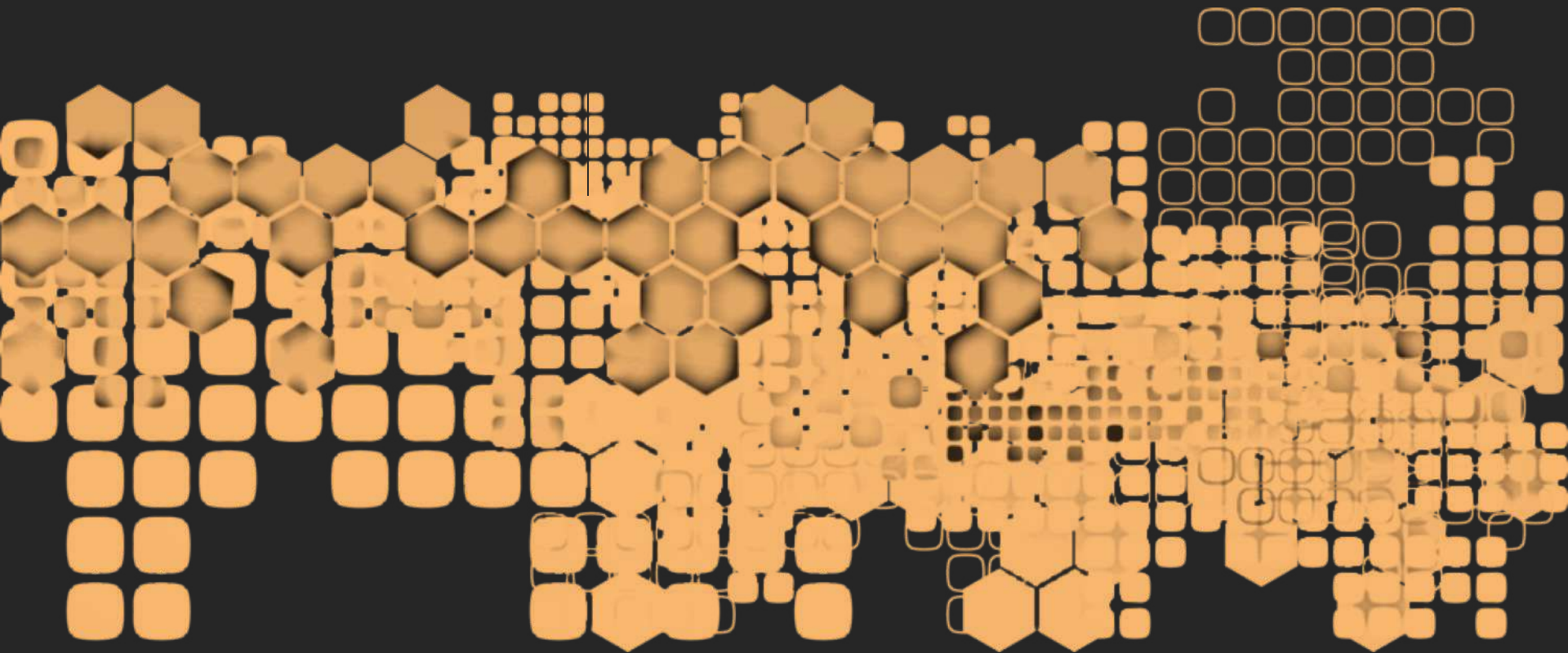
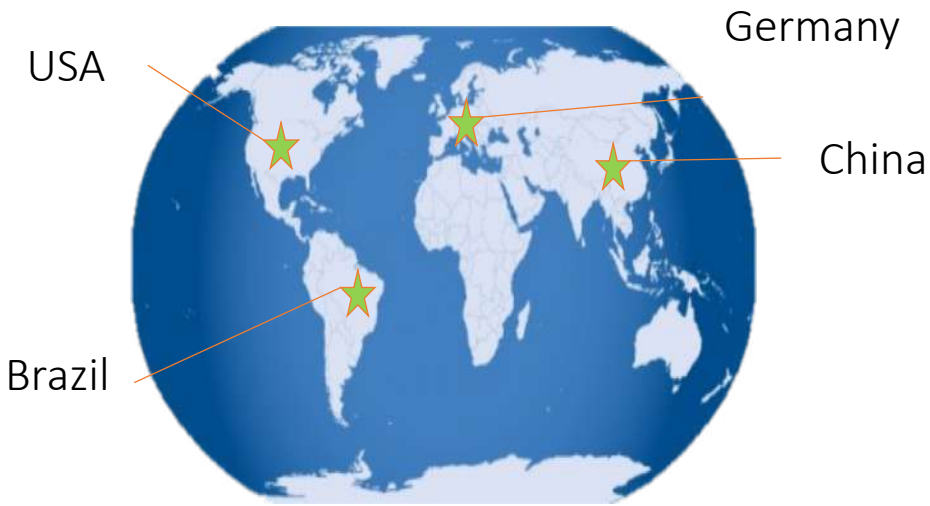
Methods & approach



Framework & modeling approach:

Top-down:

Macro-circular dynamic system modeling of 3 sectors across 4 economies



Bottom-up:

Material, product-, and process-level analysis of 3 representative products from 3 sectors

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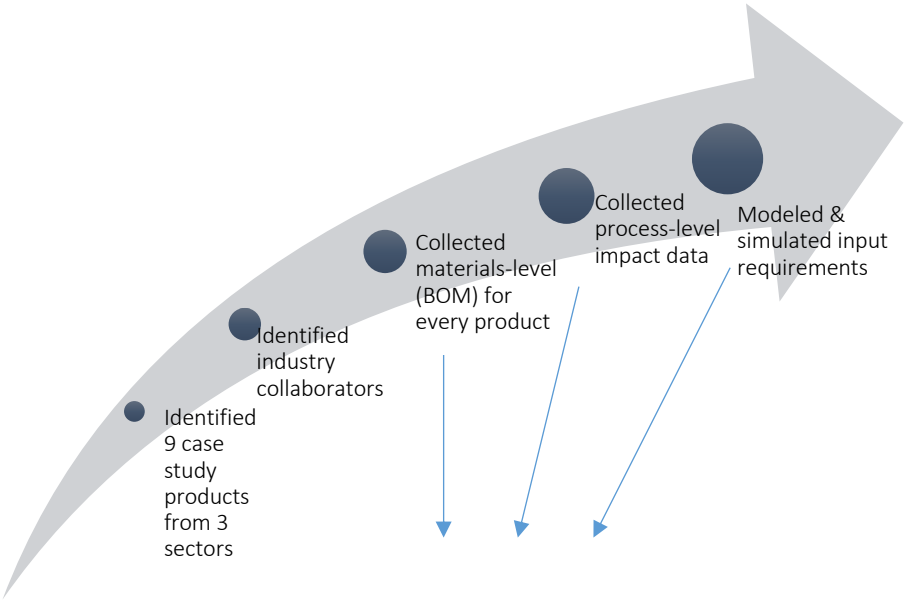
Data collection & impacts assessment



Data collected for primary input variables (33)

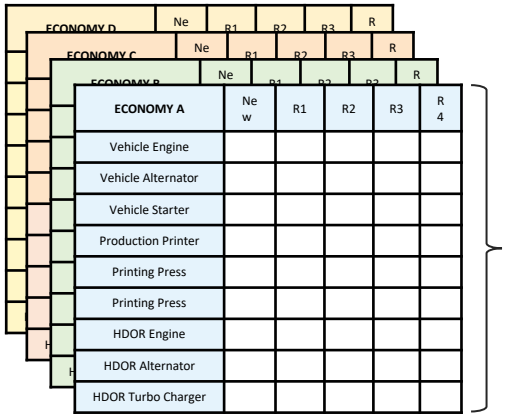
- Literature;
- Surveys;
- Industry data collection & interviews;
- UNEP Workshops; and
- Empirical research conducted by C. Kreiss on relative material efficiency of VRP processes.

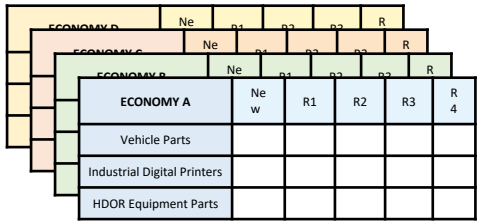
Aggregation of results:

- Cumulative by Sector:
  - Vehicle Parts;
  - Industrial Digital Printers;
  - HDOR Equipment Parts.
- Cumulative by Process:
  - Total VRPs;
  - OEM New.

Estimated/documented each product & process:

- Material requirement (kg) & waste (kg)
- Embodied materials energy (MJ)
- Embodied materials emissions (kg CO2-eq.)
- Process energy (MJ)
- Process emissions (kg CO2-eq.)
- Cost advantage ($ USD)
- Employment opportunity (FTE)





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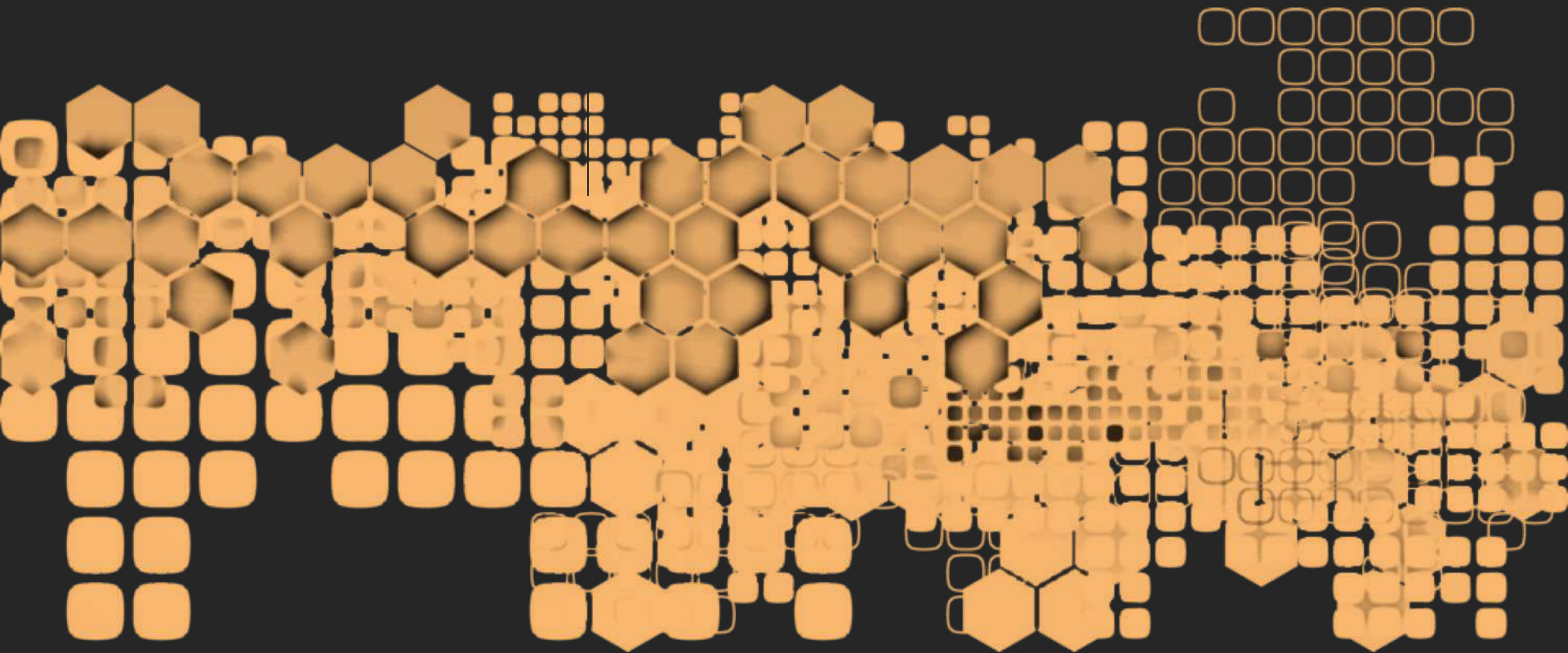
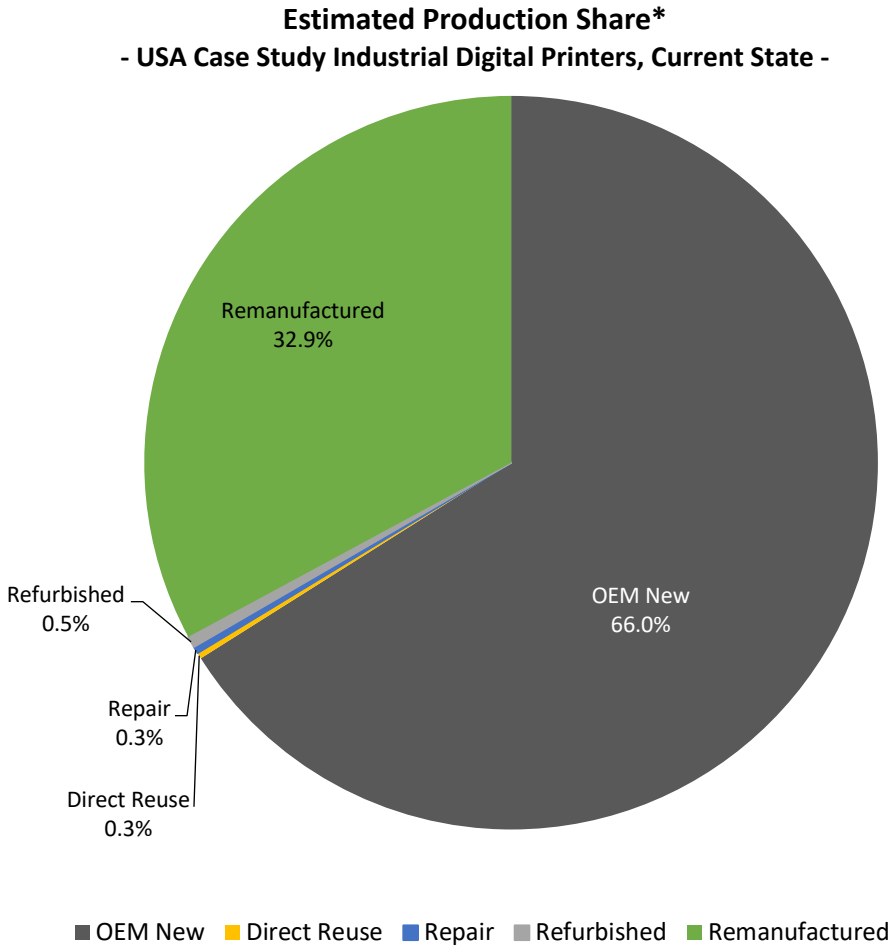
Sample Results



Estimated Current State of Production

- Direct reuse, repair, and refurbishment have marginal share compared to remanufacturing
- Only a few producers of Industrial Digital Printers engage in VRPs
- Remanufacturing has significant share with potential for growth if market access is not restricted



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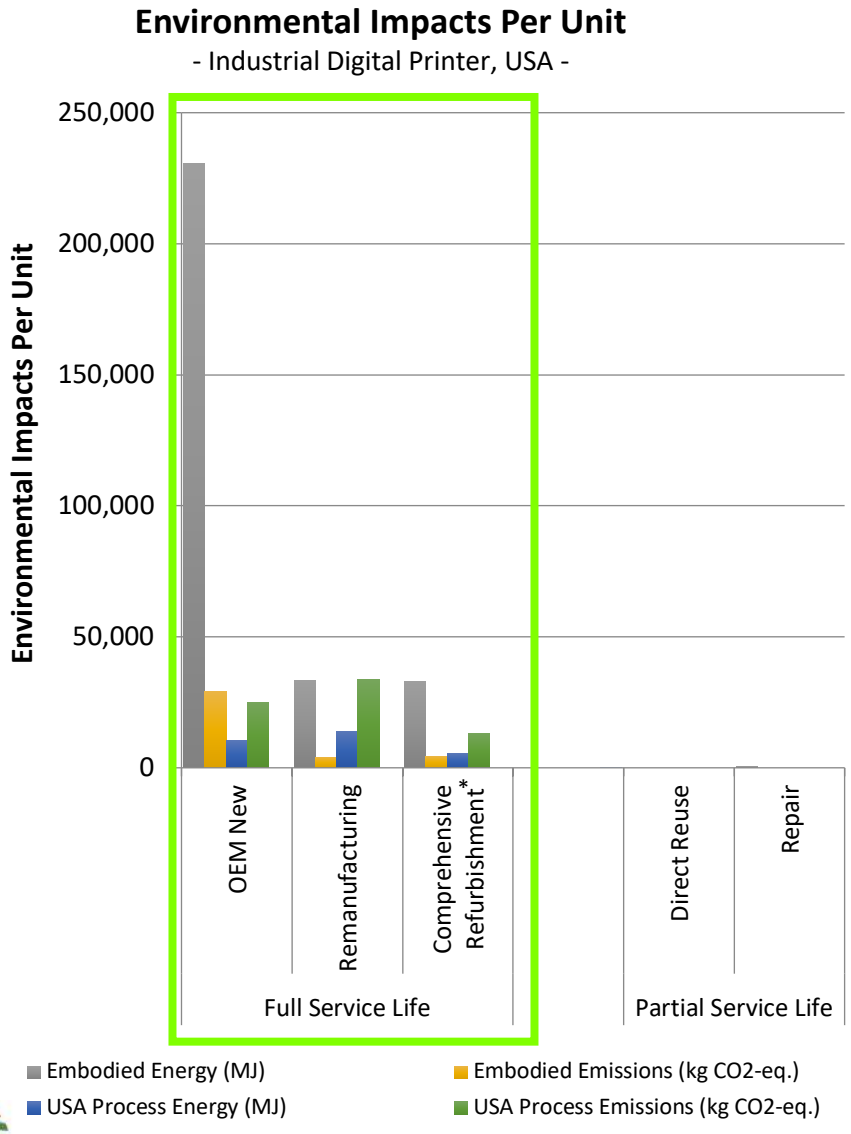
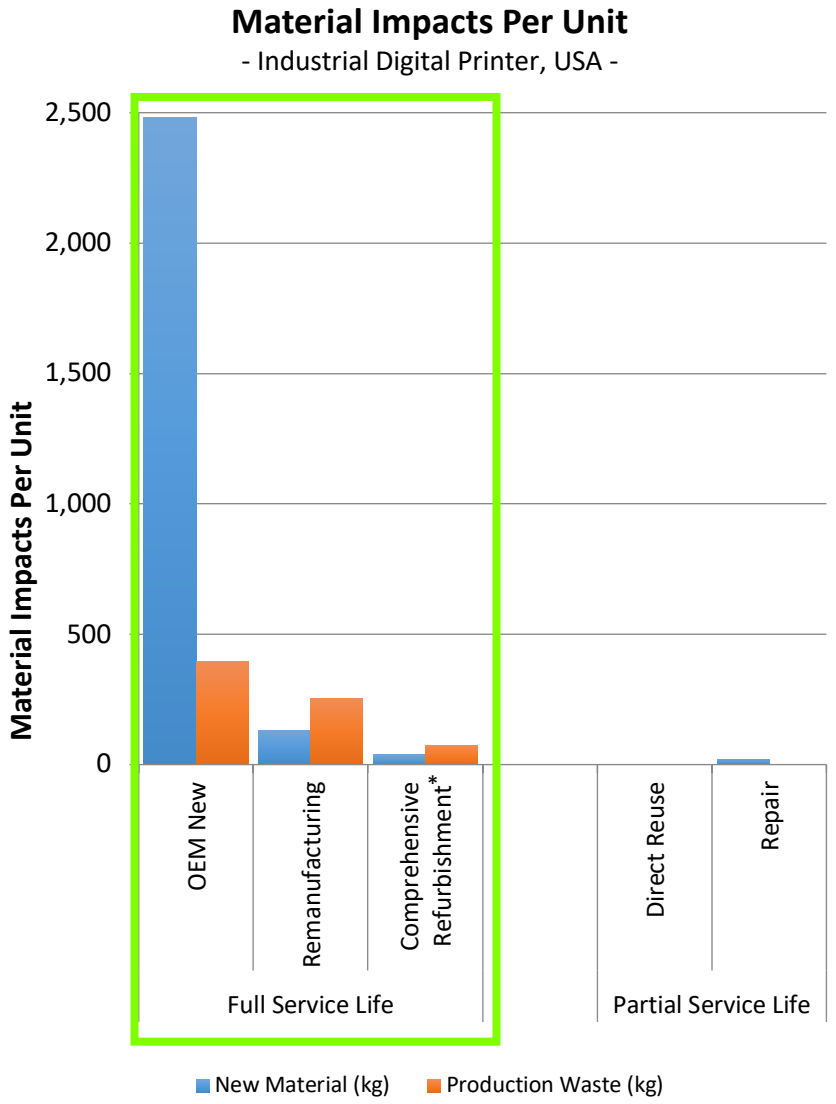
*Produced in USA for sale internationally

Product-Level Results: Digital Industrial Printer, USA





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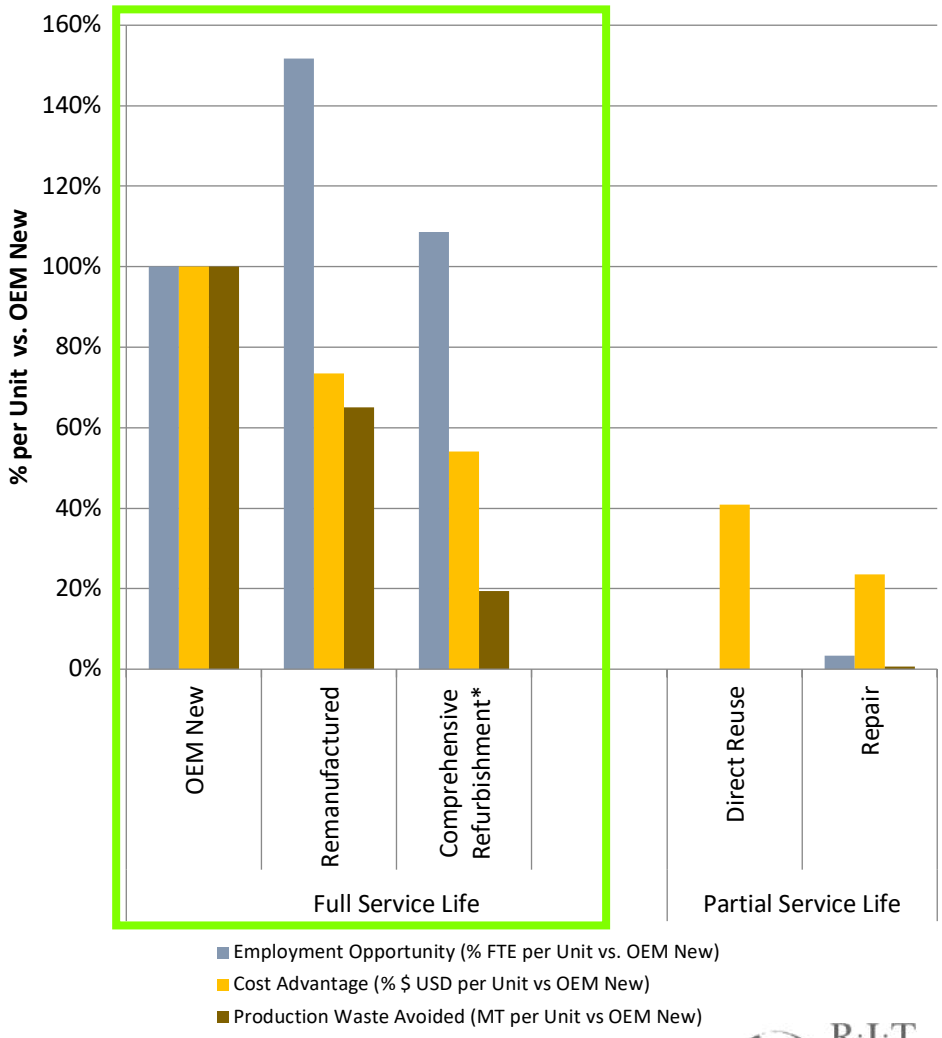
** Does not enable full new service life*

Product-Level Results: Digital Industrial Printer, USA

- Employment opportunity
  - Group 1/ Full Service Life VRPs have relatively greater skilled labor requirements;
- Cost advantage
  - All VRPs offer a cost advantage;
  - Advantage stems from offset inputs and requirements;
  - Magnitude of advantage inversely relates to value and utility-retained:
    - Higher cost-advantage: lower value and utility retention
- Production waste
  - Production waste avoidance suggests efficiency;
  - Production waste avoidance leads to operating cost avoidance.

Economic Opportunities Created via VRPs

- Case Study Industrial Digital Printing Press, USA -



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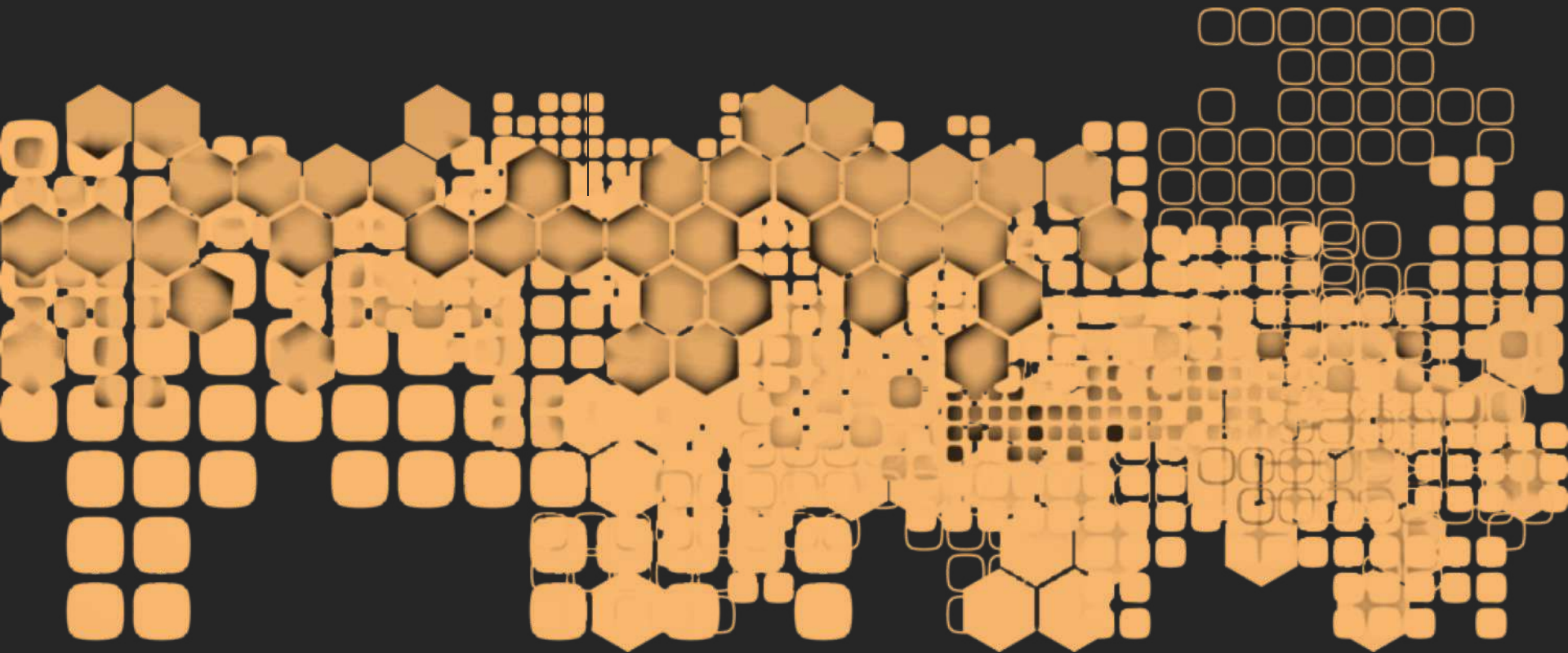
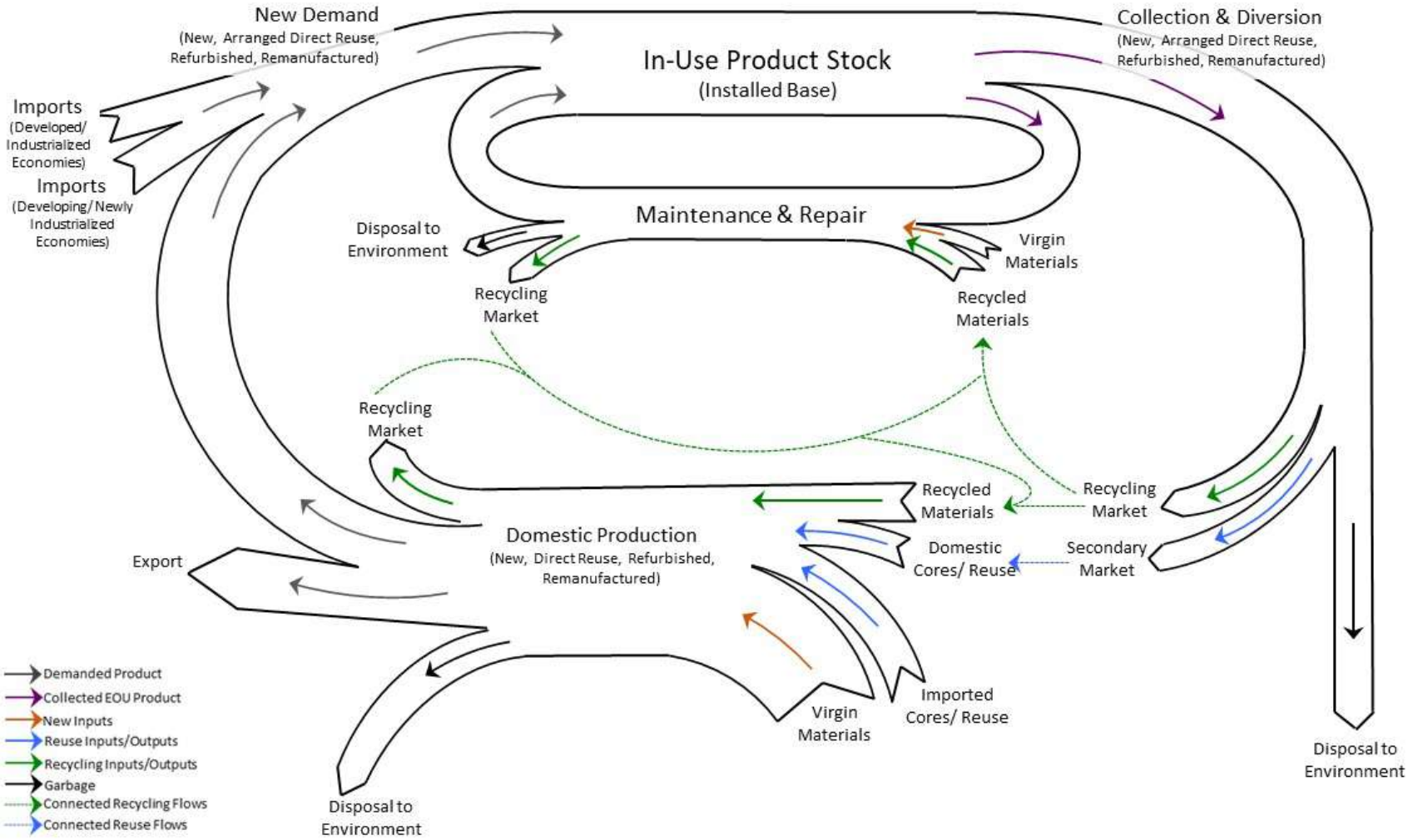
** Does not enable full new service life*

Key Insights from IRP Assessment Study



2) Production-level: A broad system perspective is essential



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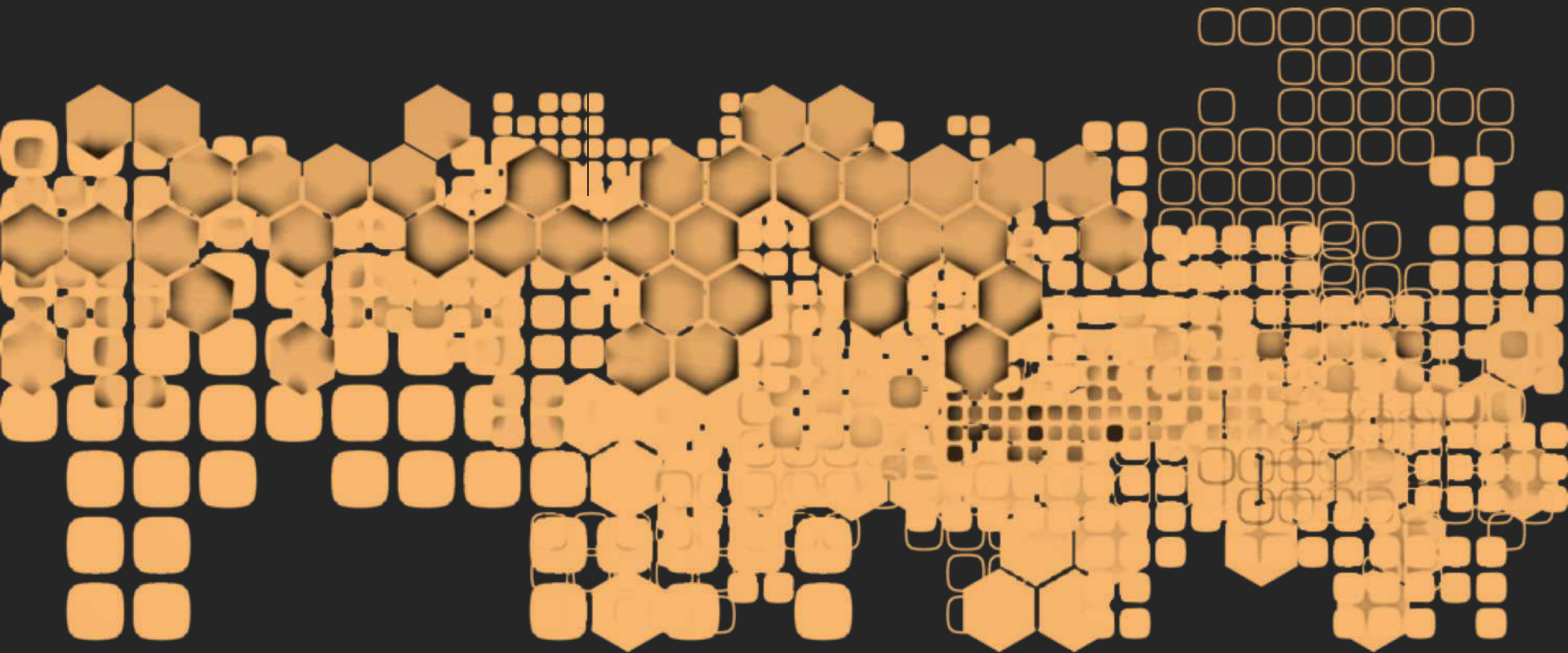
Summary of Policy Insights



Benefits of VRPs

- Increased VRPs within economy's production mix can create environmental benefits:
  - Reduced average new material demand;
  - Increased utilization rate of existing goods;
  - Avoided embodied new material energy and emissions;
  - Reduced production waste generation;
  - Gateway to recycling.
- Reduced new material and energy requirements for VRP production can create economic opportunities:
  - Lower operating costs reduce barriers to entry into marketplace;
  - Lower operating costs enable VRP producers to pass the cost advantage along to their customers.

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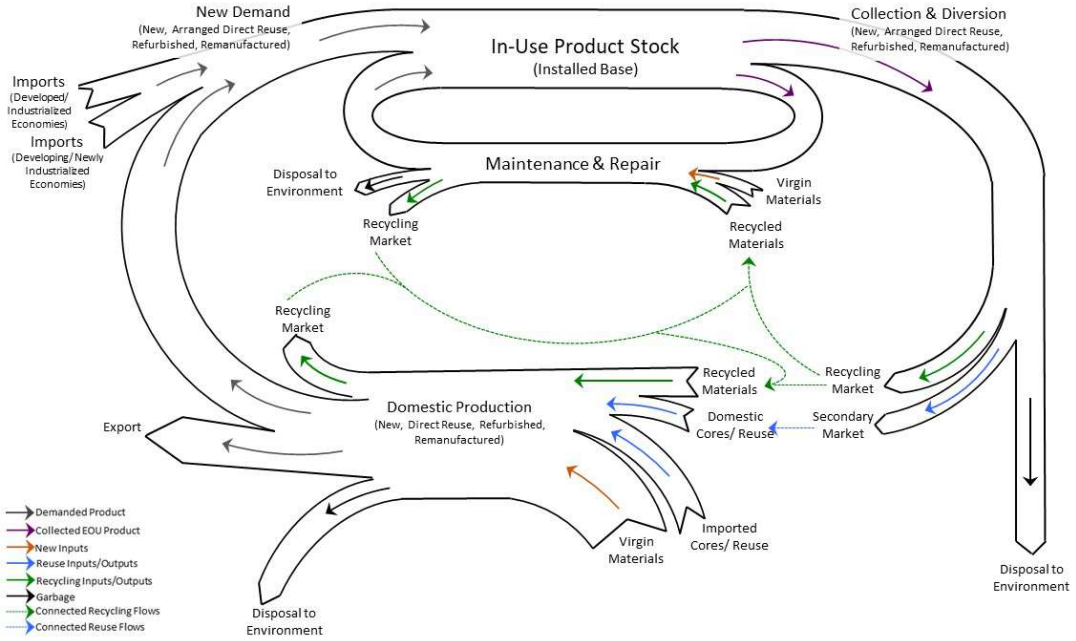
Need for expanded systems-perspective

- It is the presence and nature of barriers to VRPs that determine potential achievable benefits;
  - Not an issue of 'newly-industrialized' or 'non-industrialized' economic standing.
- Implicit requirement to consider the entire life-cycle of the product;
  - Must occur early in product development process;
  - Must extend beyond warranty and recycling.



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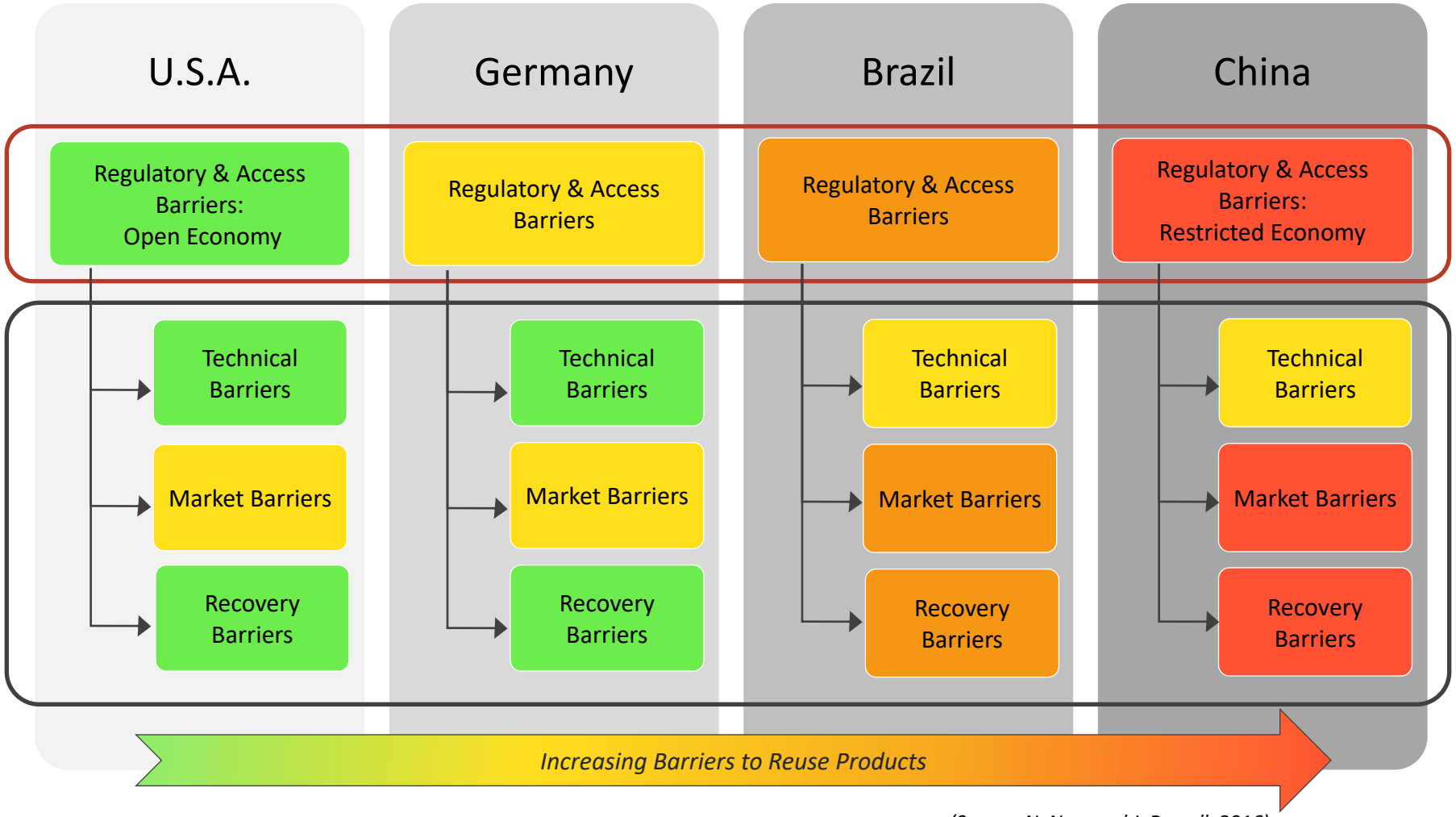
Economic Production Activity & Barriers



(Source: N. Nasr and J. Russell, 2016)

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Barriers to VRPs

Types of Barriers	Examples	Description of Barrier Impact
Regulatory & access barriers	• Complicated regulatory definitions for VRPs that affect import, export, and domestic production-consumption activities; • Lack of clear understanding and differentiation between VRPs; • Inputs to VRPs (product cores) often reflected as 'waste' under regulatory definitions.	Affects flows of finished VRP products from producers to customers in domestic and/or international markets (forward-logistics).
Collection infrastructure barriers	• Lack of policy requiring diversion of EOU/EOL products from waste; • Lack of efficient and/or effective diversion and collection infrastructure; • Cost-burden of reverse-logistics if left to individual organizations.	Affects flows of EOU products and components from the customer/user back into the secondary markets and/or to the OEM to be used as inputs to VRPs (reverse-logistics)
Customer market barriers	• Lack of standards/certifications for VRPs and VRP products; • Perceived low-price = low-quality of VRP products; • High customer risk-aversion.	Creates adoption and capacity constraints for the domestic VRP customer market.
Technological barriers	• Increased production complexity with reverse-logistics and supply-chain considerations; • Specialized labor and equipment requirements; • Cost-burden of investment and R&D on individual organizations.	Creates adoption and capacity constraints for domestic VRP producers.

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Need for integrated environmental and technology policy

- Policy interventions to support VRPs must target both radical (*system-level*) and incremental (*process-level*) innovation;
- Integrated technology and environmental policy approaches:
  - **Open market access to VRP products**, recognizing that market access barriers can have be the largest barrier;
  - **Technology-focus**, supporting technological innovation and training programs;
  - **Environment-focus**, emphasizing continuous improvement and customer engagement;
  - **Strategic Niche Management**, supporting development of technological networks and R&D;
  - **Public procurement**, leading by example via government procurement policies to establish new markets for early-stage VRP innovations.

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Nature of barriers must guide CE and VRP strategy

- Recognizing the nature of barriers to VRPs is key to overcoming them:
  - Barriers that inhibit the generation of demand are problematic for creating the business case that industry members require to engage in VRP production;
  - Barriers that restrict VRP producer's access to technological capacity, VRP inputs, and skilled labor, restrict domestic production capacity and efficiency opportunity.
- Policy-makers have a central and pivotal role in alleviating regulatory, access, and collection infrastructure barriers;
- Industry member collaboration is needed to alleviate customer market and technological capacity barriers.

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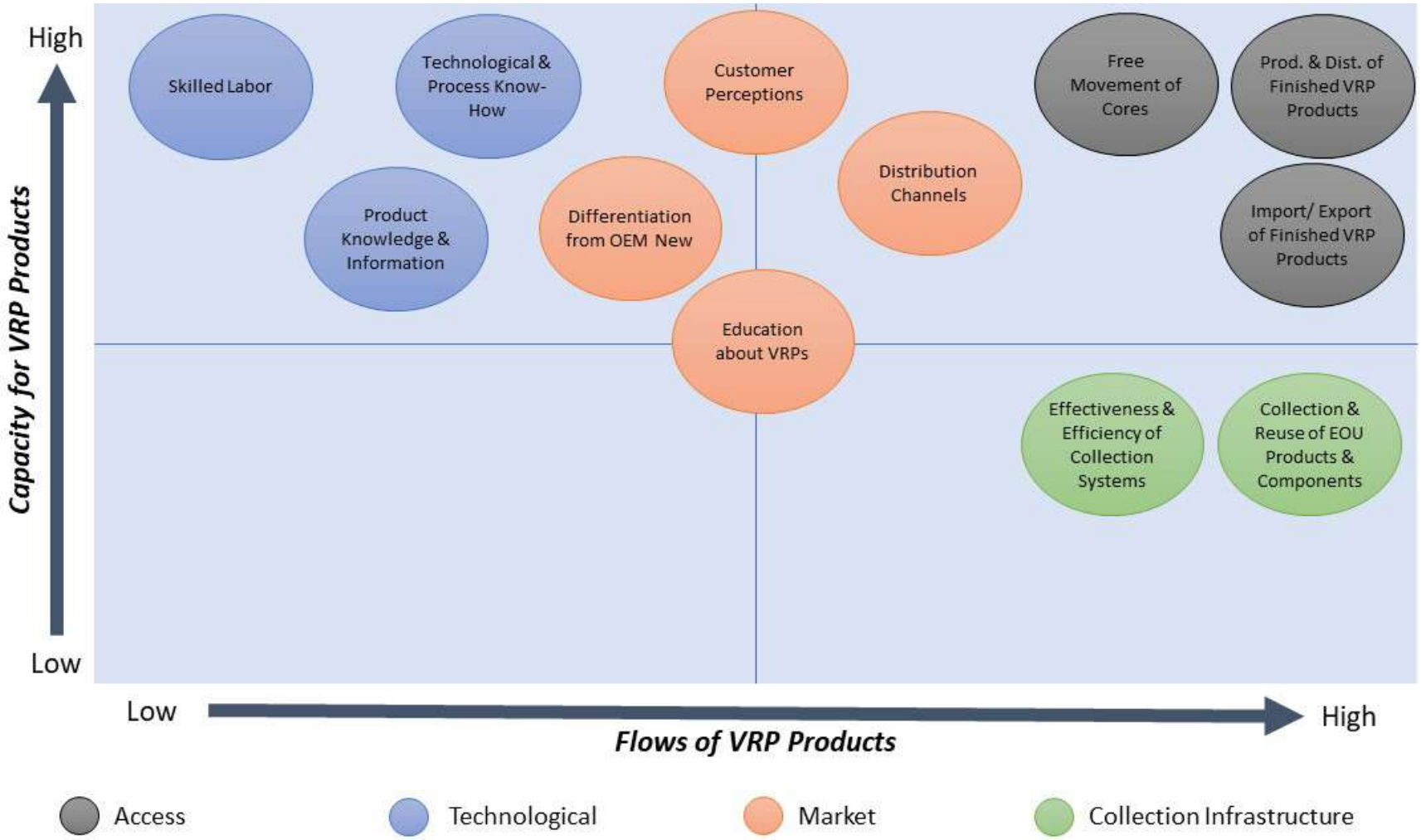
Different VRP strategies for different VRP barriers



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Thank you

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