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Life Cycle Assessment and Circularity Indicators to Design Future Circular and Sustainable Electric Outboards: Results from Workshops with Industrial Experts

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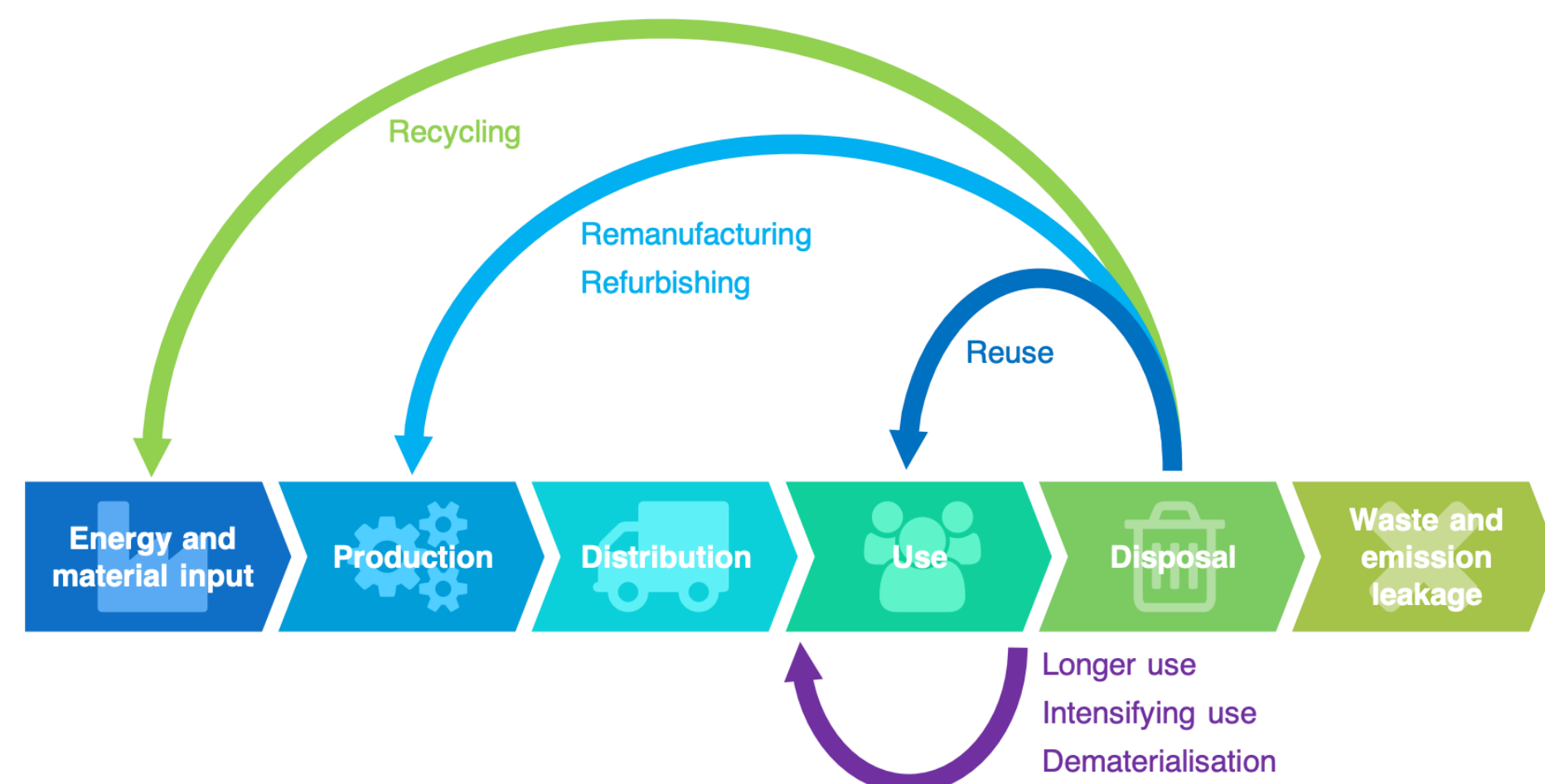
MOTIVATIONS

Energy transition:

- A pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. At its heart is the need to reduce energy-related CO₂ emissions to limit climate change.
- The benefits of switching diesel-powered machines for fossil-free, electric counterparts are numerous: green house gases (GHG) emissions reduction, lower noise level, energy efficiency, ease of maintenance.

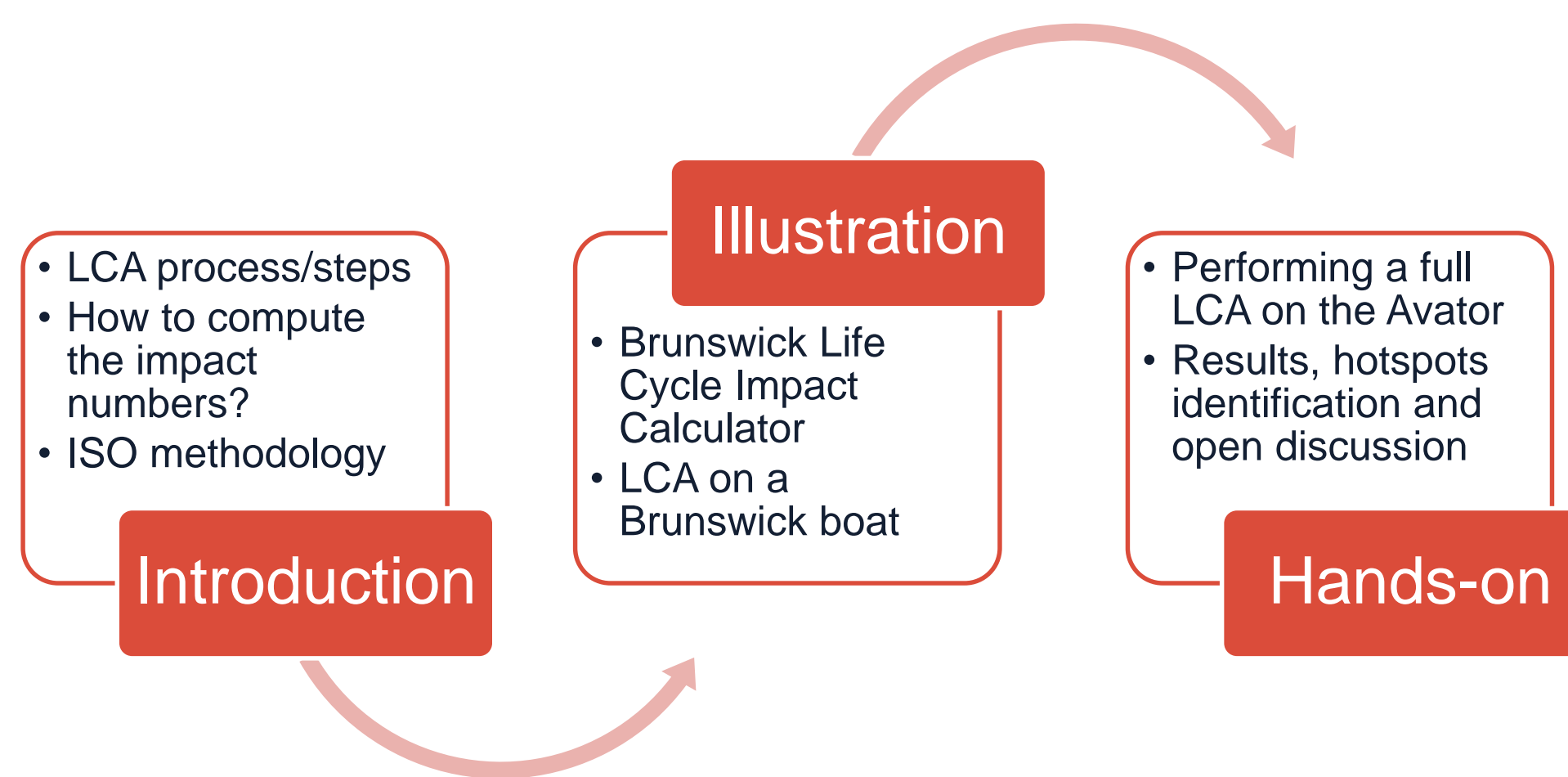
Circular economy (CE):

- Momentum to rethink, create and optimize a circular supply chain in the recreational boat industry.
- Need to identify and quantify opportunities to design for Re-X (reuse, remanufacturing, recycling).

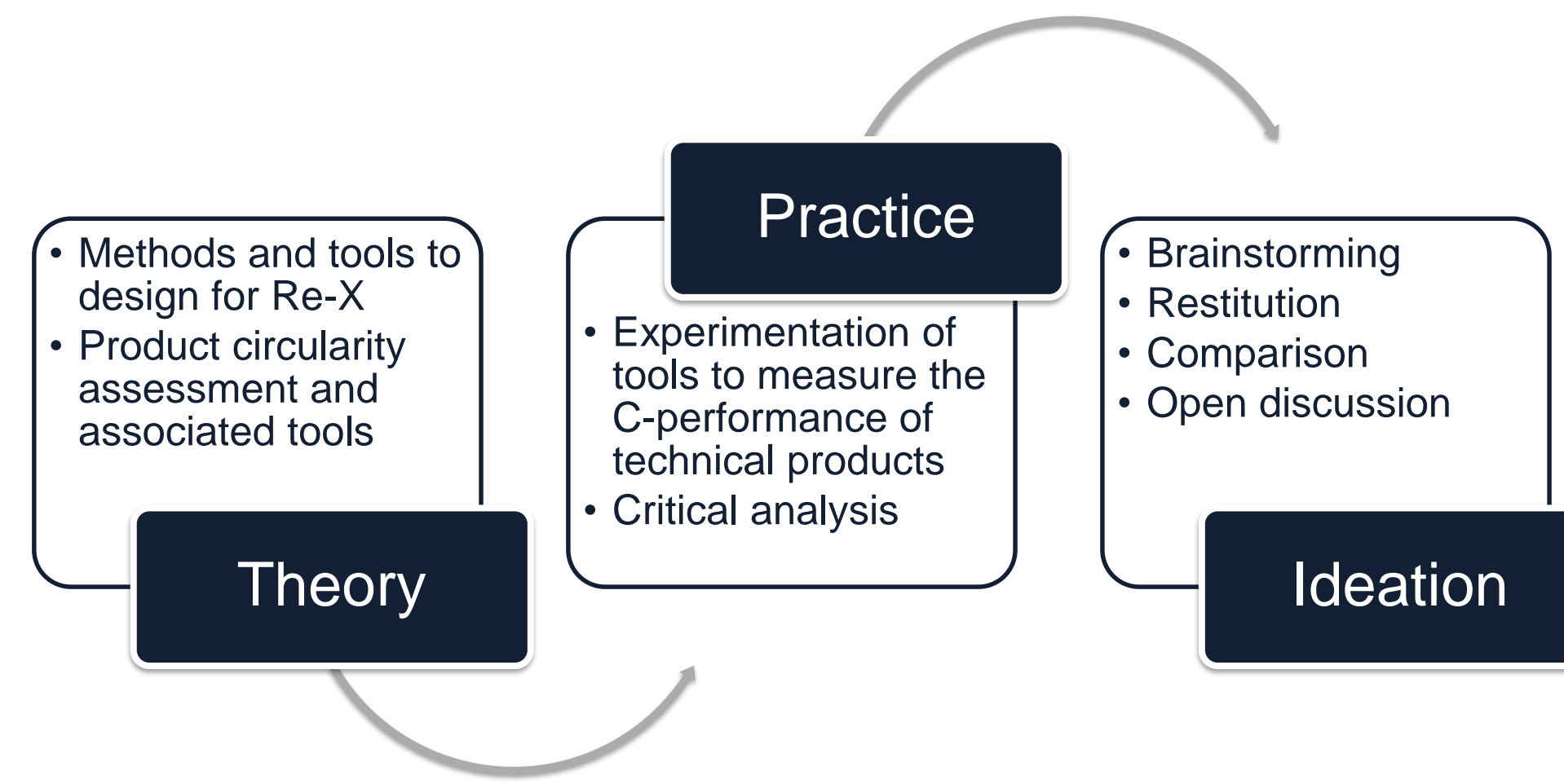


TWO HALF-A-DAY WORKSHOPS

Session #1 on life cycle analysis (LCA)



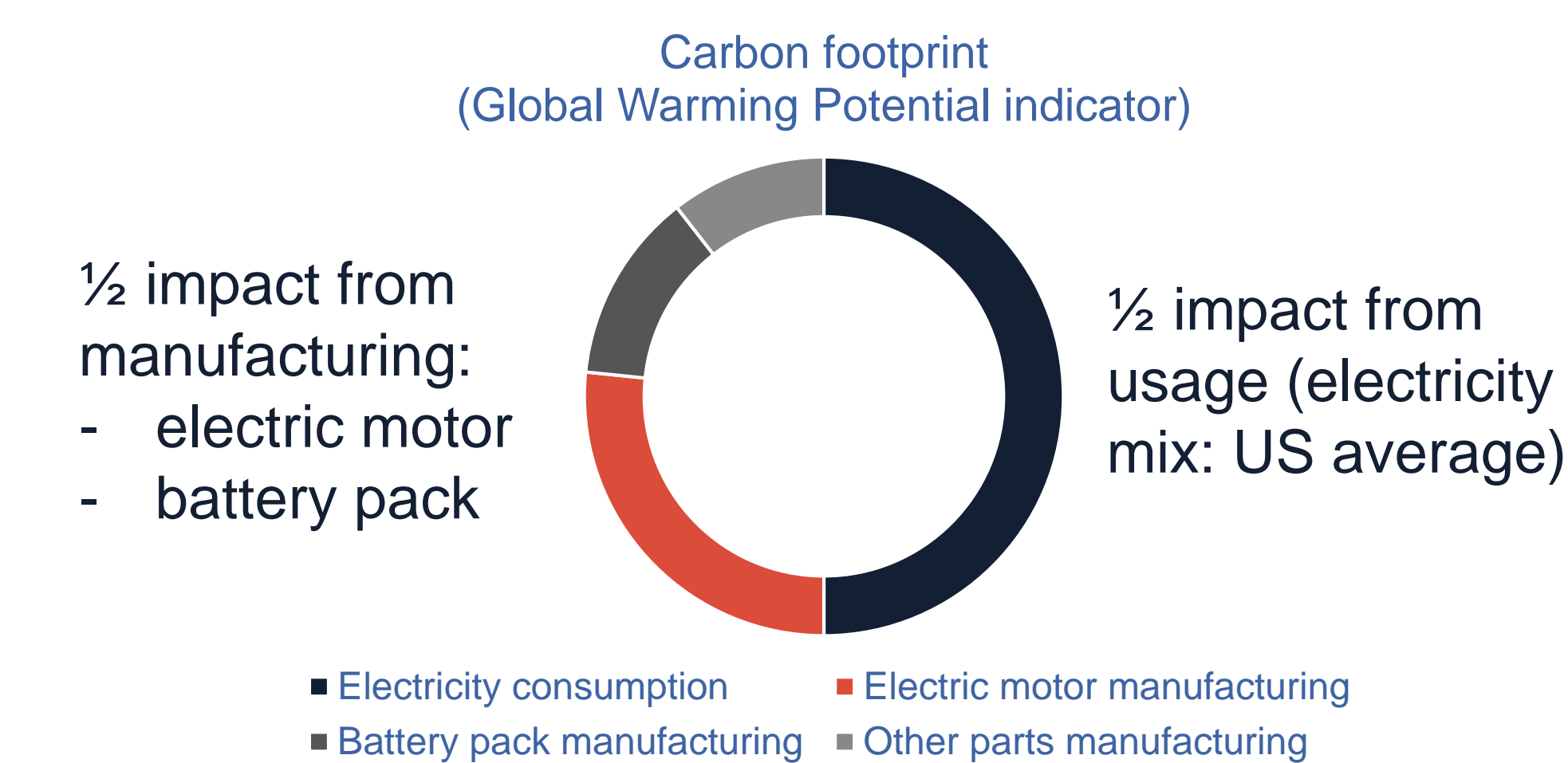
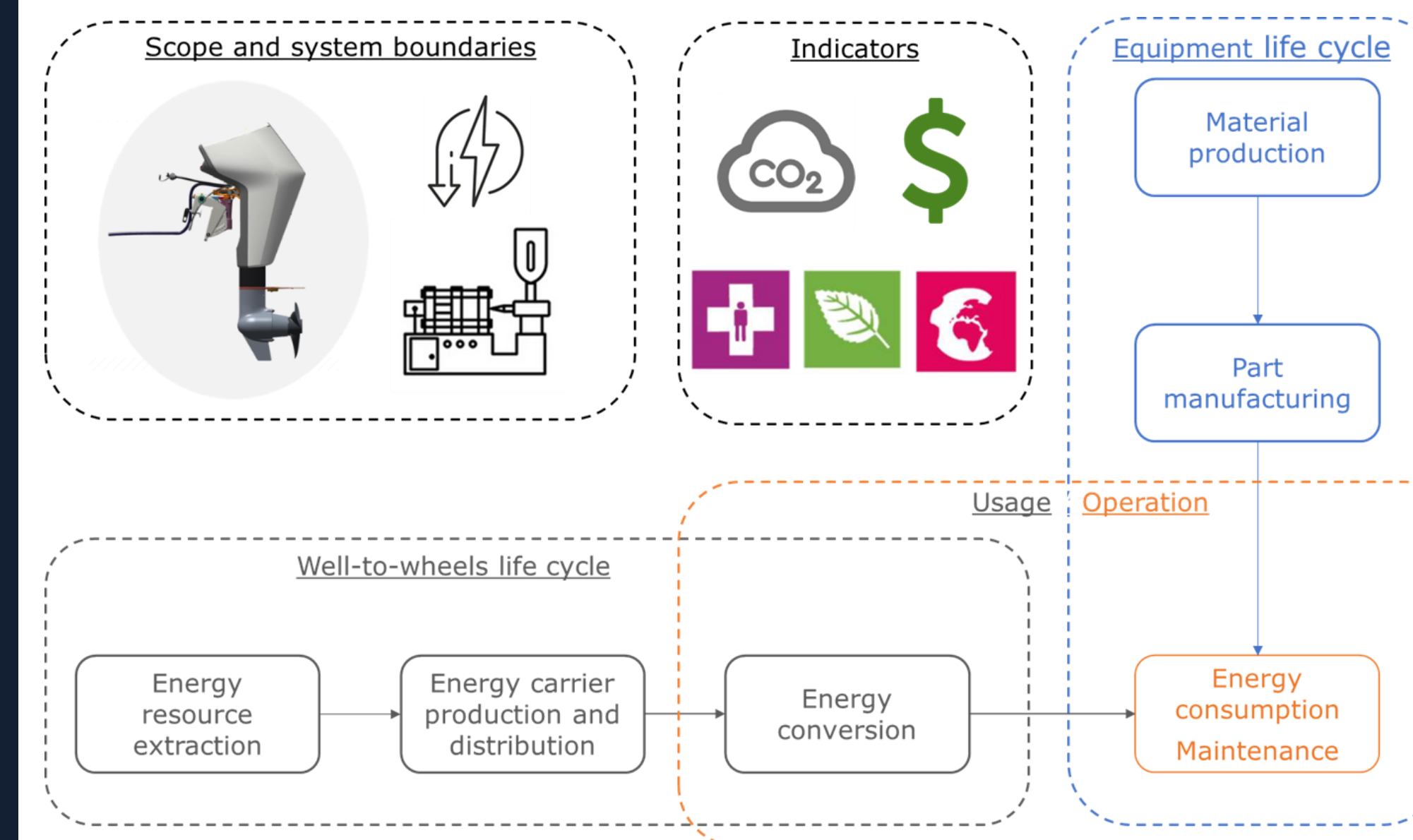
Session #2 on circularity indicators



RESULTS & INTERPRETATIONS

Life cycle impact assessment (LCIA):

Database: ecoinvent 3.7 ; Method: ReCiPe (H) 2016
Functional unit: Manufacture and operate one electric outboard of 1 hp (the Avator 15-inch) during one lifetime, i.e., 35 hours a year during 15 years.



DISCUSSION

- These workshops met the following key objectives:
 1. Learn how to calculate the environmental impact of a design, in alignment with ISO 14040-44
 2. Learn how to assess the circularity of a design
 3. Complete LCA and Re-X assessments and, leveraging the assessments, generate practical ideas
 4. Gather key experts/stakeholders to collaborate on sustainable and circular design, including the Director of Sustainability Engineering Programs, the Remanufacturing General Manager, the Product Technical Leads, Materials Engineers (x2), and Interns (x3)
- The participants found both frameworks (the Excel-based LCA Calculator and the two circularity indicators-based tools) simple of utilization and efficient: “very easy to use” ; “the workshop today was excellent, from my perspective” ; “the engagement was very high”.

OBJECTIVE

Three complementary research questions (RQ):

1. What is the ecological impact of Brunswick's new electric outboard and what are the critical components (environmental hotspots)?
2. How to assess the circularity performance of this electric outboard (Avator 1hp 15-inch)?
3. Which design for Re-X strategies and mechanisms to deploy to close-the-loop in a sustainable fashion?

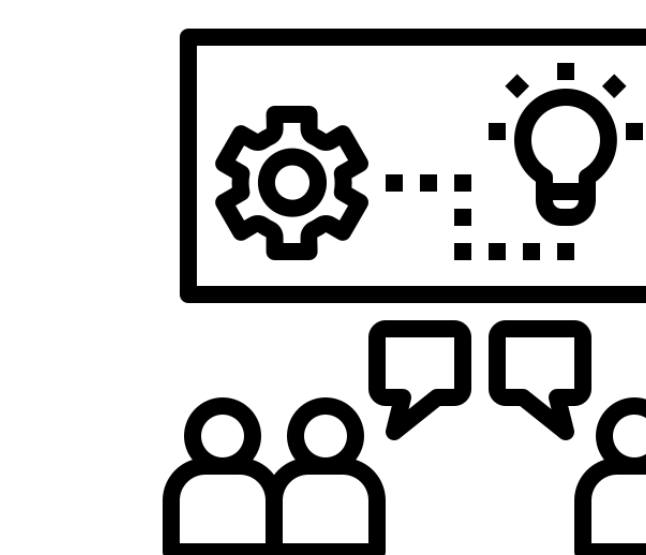
Circular Economy Indicator Prototype (CEIP) to assess the circularity potential of the electric outboard at a full product level

3 RESULTS					
Product Rating	Product Ranking	Points			
43%	Good	Scored	Available		
		65	152		
Lifecycle	# Questions	Scored	Available	Rating	Ranking
Design/Redesign	3	10	27	37%	Fair
Manufacturing	2	0	25	0%	Poor
Commercialisation	3	3	30	10%	Poor
In Use	4	17	35	49%	Good
End of Use	3	35	35	100%	Excellent
TOTAL	15	65	152	43%	Good

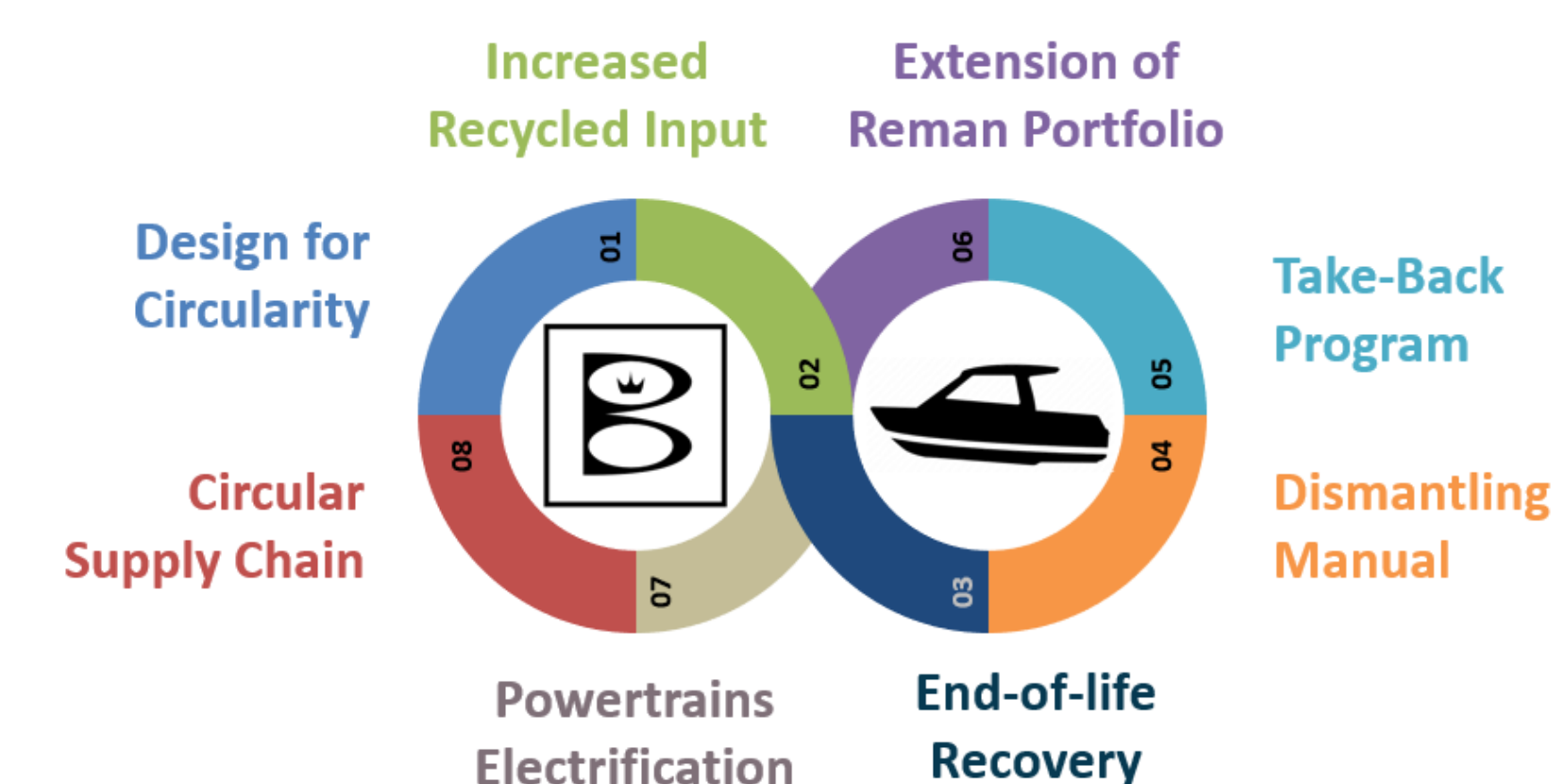
Circular Potential Indicator (CPI) to assess the circularity performance of the two key components: electric motor and li-ion battery

Circularity Performance Indicator	Circularity Score of the Motor = (out of 100)	Score
Unlock the Circularity Potential of your Product	47.23	
BB#1 - Circular Product Design		13.89
BB#2 - New Business Model		7.50
BB#3 - Reverse Cycles		8.75
BB#4 - Favourable System Conditions		17.09

Circularity Performance Indicator	Circularity Score of the Battery = (out of 100)	Score
Unlock the Circularity Potential of your Product	55.04	
BB#1 - Circular Product Design		11.43
BB#2 - New Business Model		5.00
BB#3 - Reverse Cycles		19.58
BB#4 - Favourable System Conditions		19.03



10+ CE-related ideas generated and associated projects to increase the circularity performance



PERSPECTIVES

Quantify the actual sustainable benefits from closing the loop:

1. At a material level: Assess the potential impact savings from recycled materials in manufacturing (by increasing the recycled content).
2. At a component/product level: Look further at the components and parts that can be reused and/or remanufactured.
3. At a system level: Analyze and experiment the opportunities discussed after the circularity assessment, such as circular business model, take-back scheme, etc.

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ISO-International Organization for Standardization. 2006. ISO 14040: 2006 Environmental management - Life cycle assessment - Principles and framework. In: ISO 14000 International Standards Compendium. Genève, Switzerland.

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