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# Towards a Circular Economy of Heavy-Duty & Off-Road Vehicles and Associated Key Components

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## Contextual Framework

### HDOR Features & Issues

- Mass of EoL HDOR = Mass of ELV in France [ADEME 06]
- Poor traceability after sales & Recycling channels are marginal
- Shipment of HDOR by illegal operators is still a flourishing business [EC & Bio by Deloitte 14]

### Emerging Technologies

- Intelligent Transportation System
- More & more devices connected to the OBD (On Board Diagnosis)
- GPS + RFID + IoT + Telematics + Big Data Analytics applied to transportation and construction industries

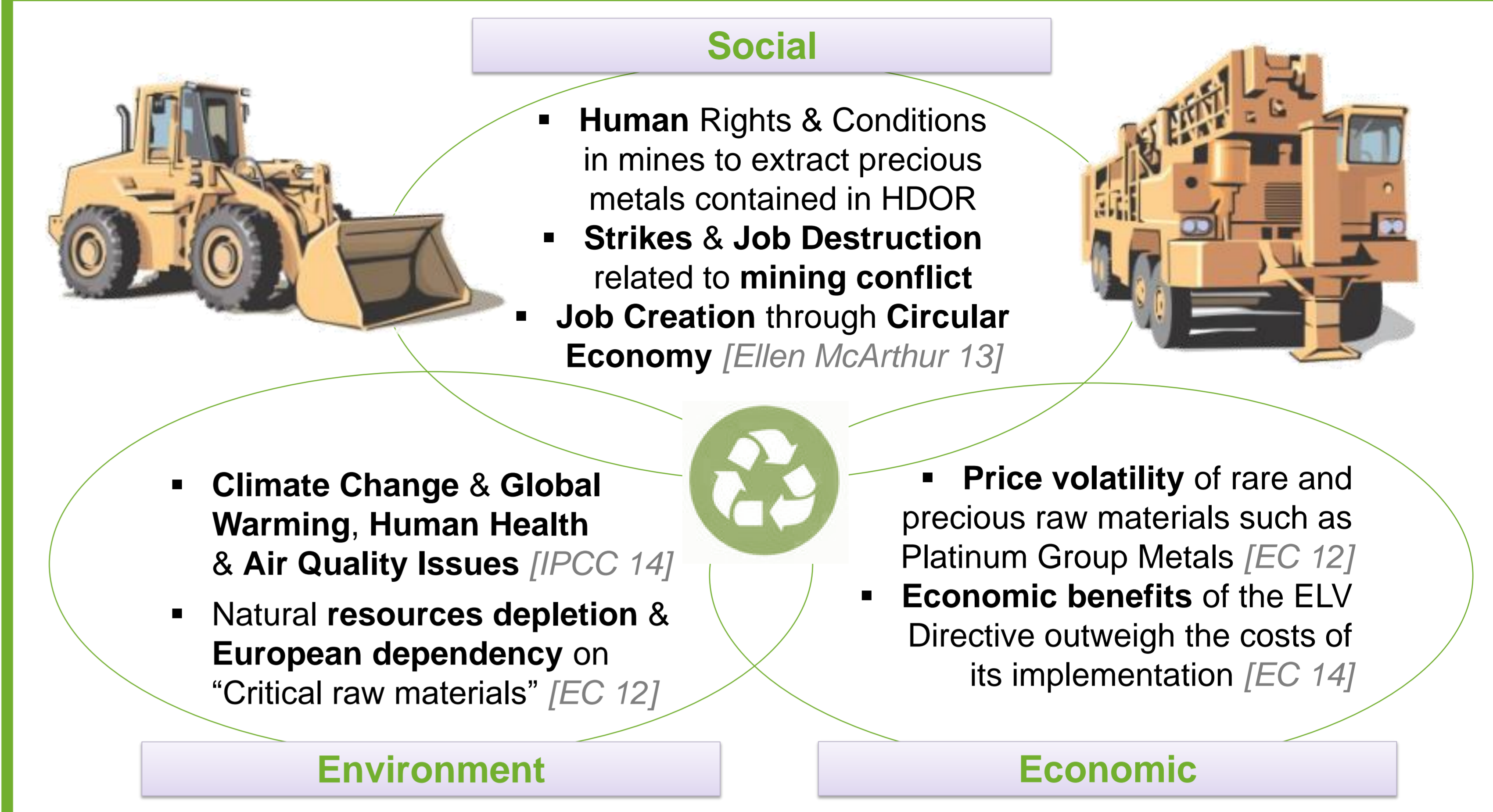
### Regulations

- Absence of a regulatory framework for EoL & CO<sub>2</sub> emissions of HDOR, contrary to ELV (2000/53/EC)
- Extended Producer Responsibility for some spare parts
- Beware: Geographical disparity of EoL & Emissions Regulations
- REACH; WEEE; RoHS

### Industrial Needs

- Anticipate upcoming regulations
- Develop new Business Model (e.g. PSS, Telematics Offers)
- Eco-management in real-time (e.g. eco-drive, preventive maintenance)
- Reduce dependency on oils & precious raw materials
- Waste Management & Treatment

## HDOR Vehicles & Sustainability Issues



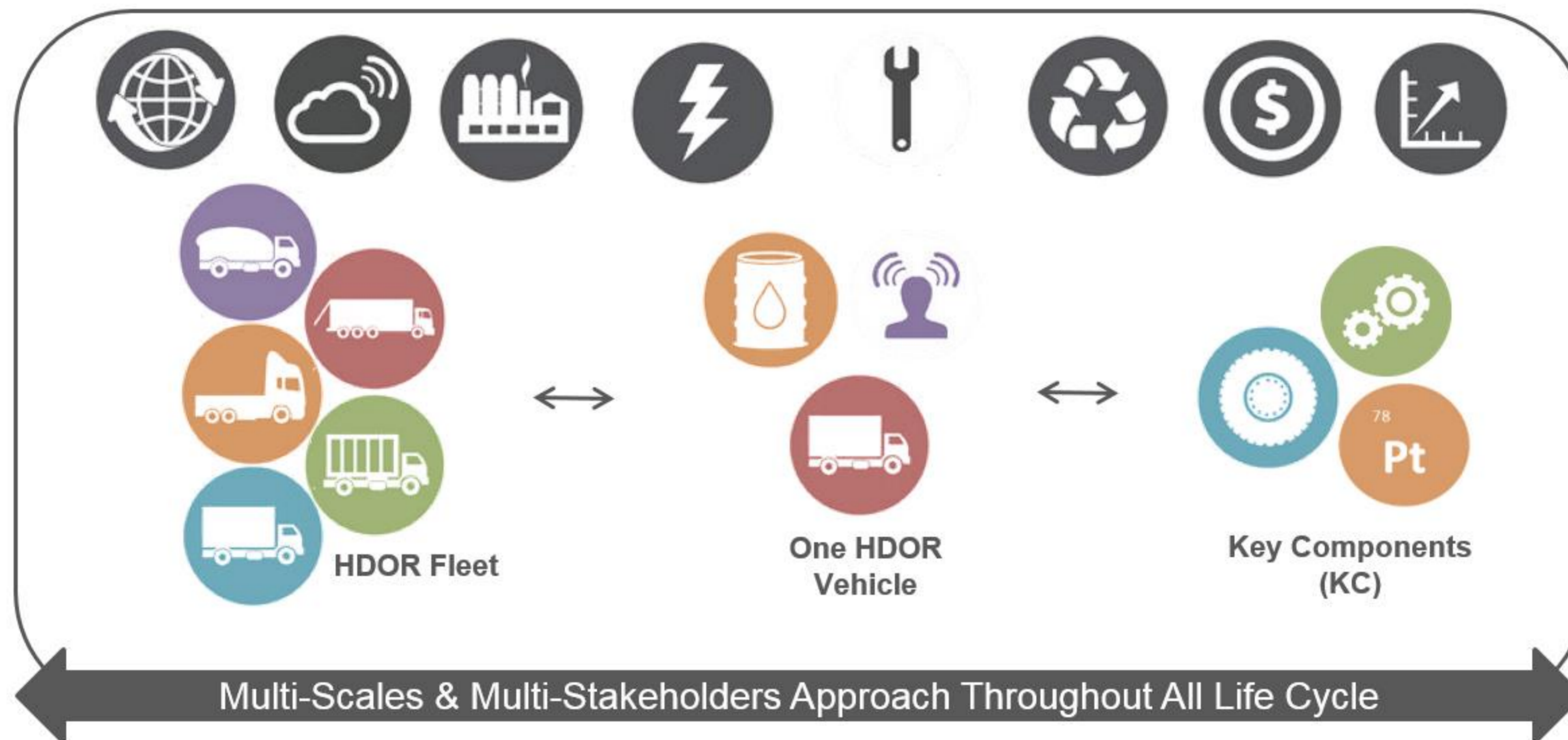
## Research Question, Multimethodology & Objectives

### Research Question

- How to enhance the sustainable management of HDOR Vehicles all along their life cycle, at different scales and for all stakeholders thanks to the help of new and emerging technologies, in the context of Circular Economy?

### Multimethodology

- Holistic & integrated framework that combined the strengths of complementary methods & tools



### Objectives

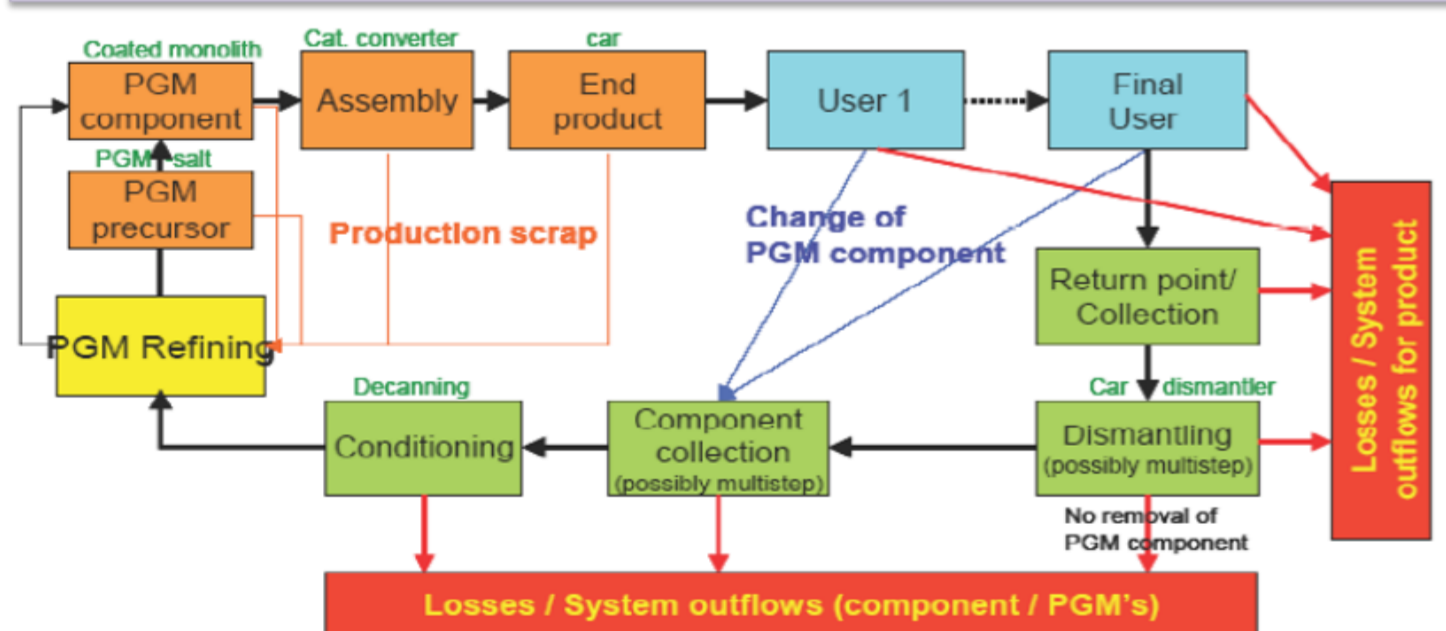
- For **Academics** = To develop relevant frameworks to handle the 3 sustainability pillars within socio-technical complex systems
- For **Industrial Sector** = To foster and help companies in a more sustainable management of their HDOR fleet all along life cycle
- For **Policy-Makers** = To support strategic policy decisions on the End-of-Life of HDOR Vehicles

## Case Study on 1 KC - The Catalytic Converter

### Why is it a Key Component ?

- Emission regulations are increasingly strict
- Essential control device to make the air cleaner
- Contains Precious Group Metals (e.g. Platinum)
- Tremendous cost and environmental impacts

### Previous Work & Current Situation



- Open loop recycling for catalytic converters → Overall platinum recycling rate below 50% [Hagelüken et al. 16]

### Data Construction

- Life cycle thinking approach
- Mix of data from mining operators, equipments manufacturers, users, market trends, recycling centers, environmental agencies reports, ...

→ Consolidation of all the data in one standardized Excel data sheet

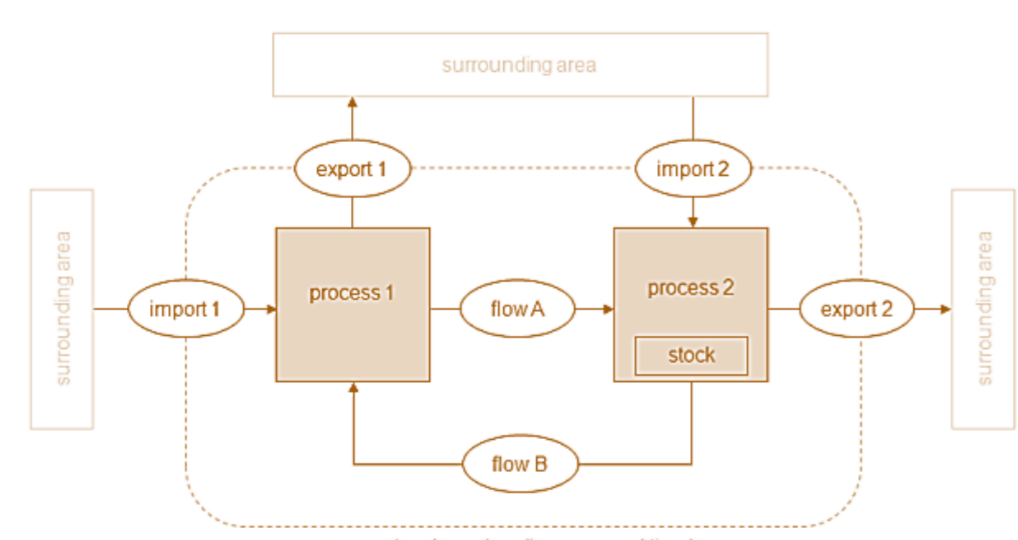
### 1. Cognitive Mapping



- To list and link all influencing parameters
- Comprehensive overview of the system

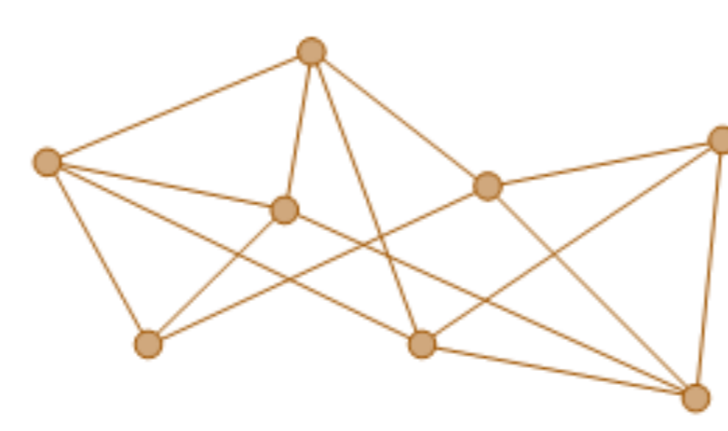
### Modelling Stages

#### 2. Up-to-date MFA of the value chain



- Quantitative information about the existing channel, stock and losses

### 3. Refined Graphical Model



- System Dynamics model
- Feedback loops that fit to the circular economy paradigm

### SD Simulations

### Simulations & Forecasts

[Farel & Yannou 13]

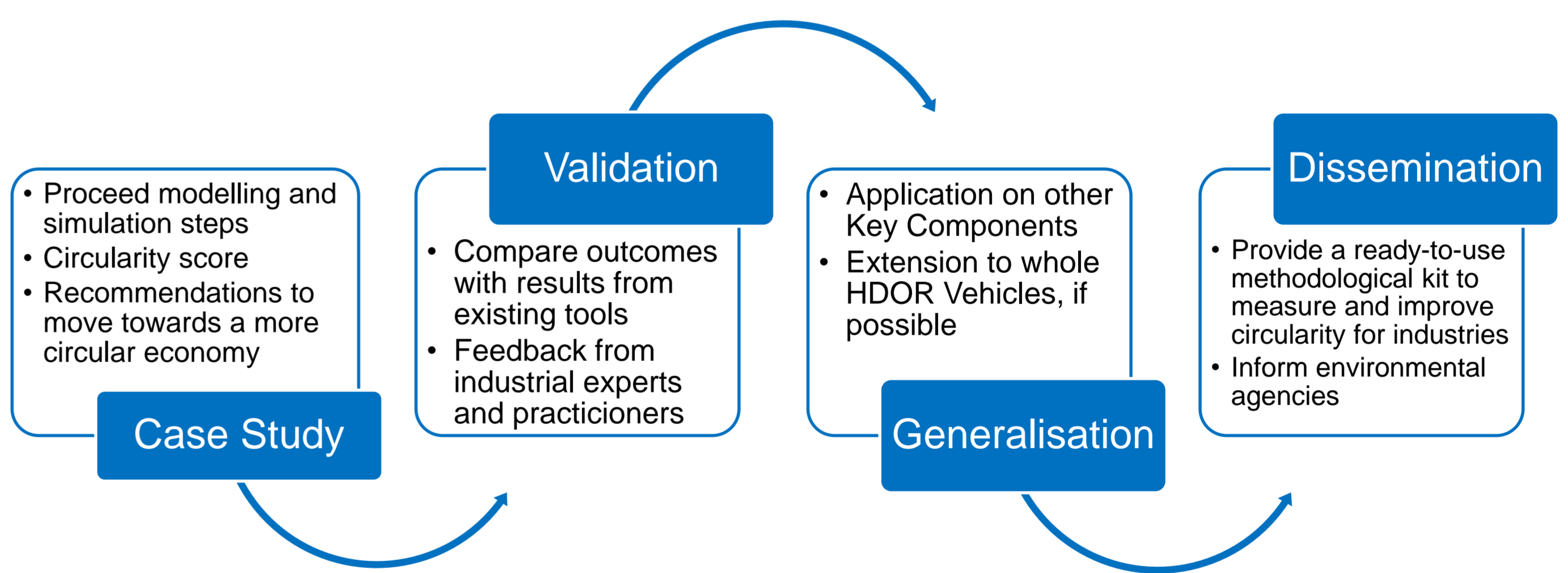
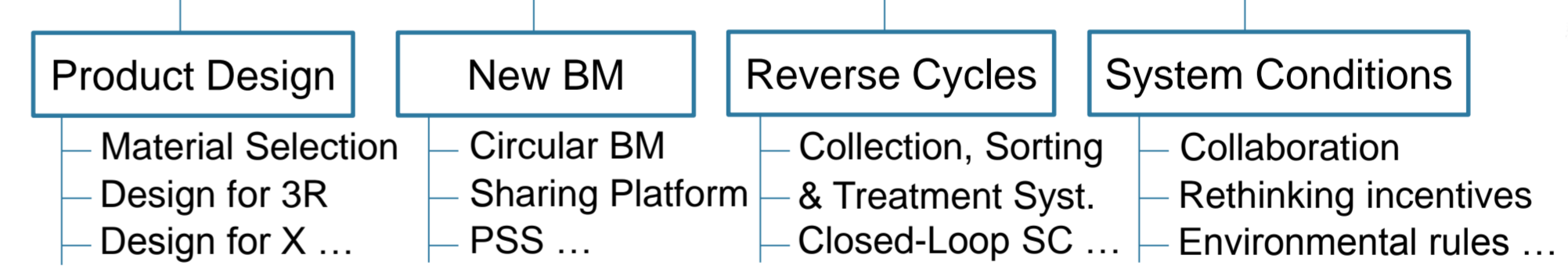
### How to close the loop of Platinum from Catalytic Converters of HDOR Vehicles?

- Prospective scenarios construction to evaluate potential environmental & economic impacts
- What will happen if a minimum mandatory recycling rate of HDOR Vehicles is implemented?
- What if collection rate is improved by 10% or if design is modified for easy disassembly? ...

## Progress & Next Steps

### 4 Building Blocks of a Circular Economy [EMF 15]

### Circularity Measurement



### Exchanges with Main Stakeholders all along Value Chain Insights from Best Industrial Practitioners



### References

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- [EC 14] Ex-post evaluation of certain waste stream Directives, European Commission, 2014.
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