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

Michael Saidani, Bernard Yannou, Yann Leroy, François Cluzel

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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

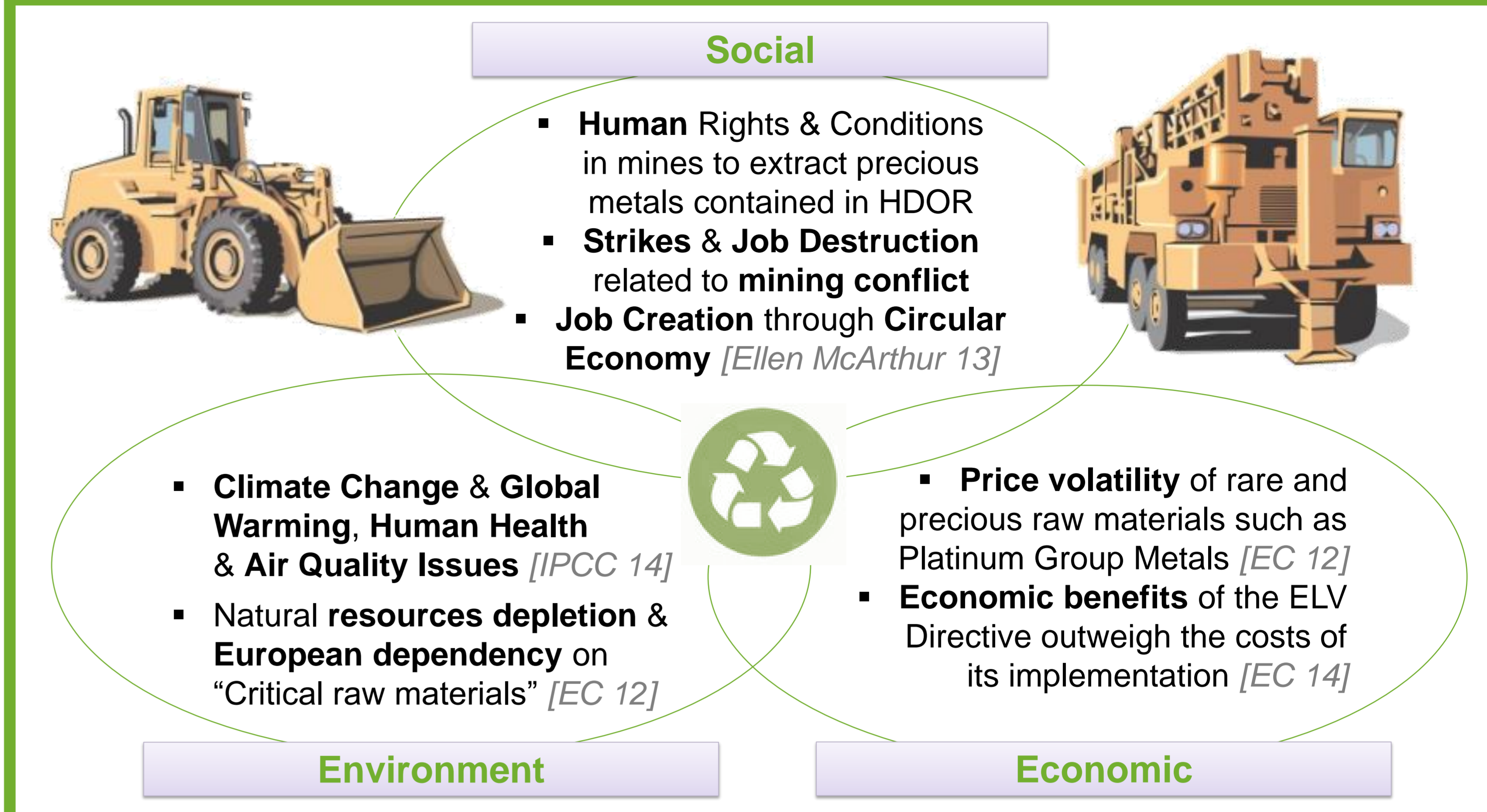
### Regulations

- **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



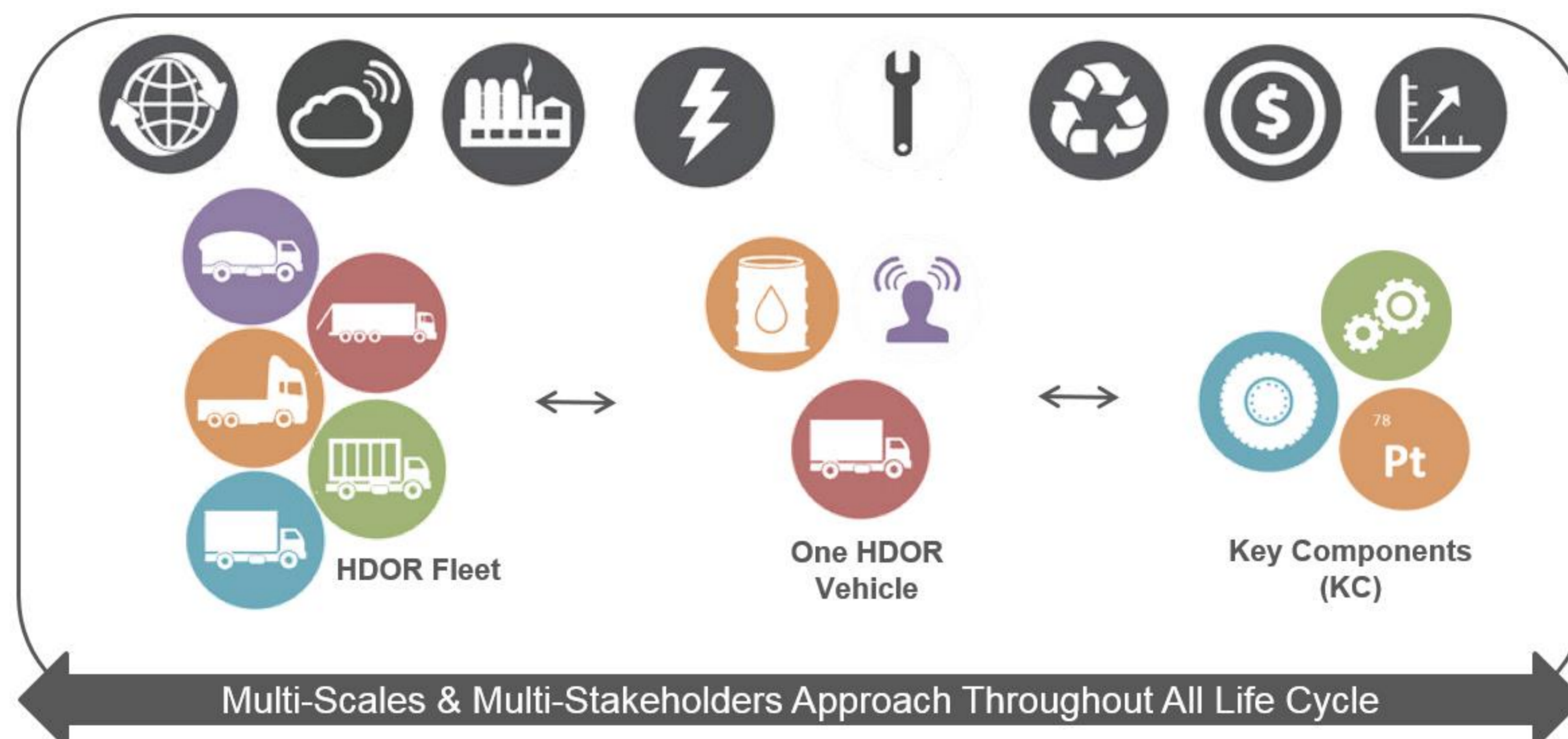
## Research Question, Multimethodology & Objectives

### 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

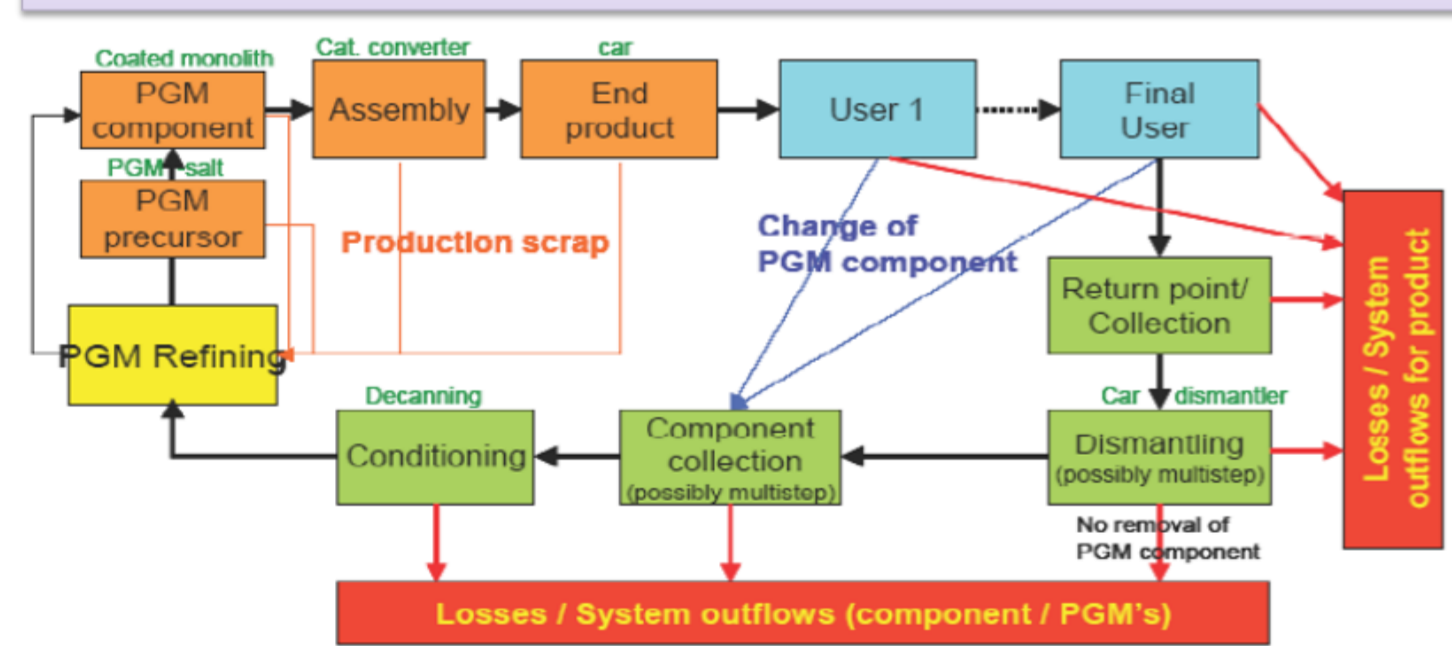
- For **Academics** = To develop relevant frameworks to handle the 3 sustainability pillars within socio-technical complex systems
- For **Industrial Sector** = To foster and help companies in a more sustainable management of their HDOR fleet all along life cycle
- For **Policy-Makers** = To support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

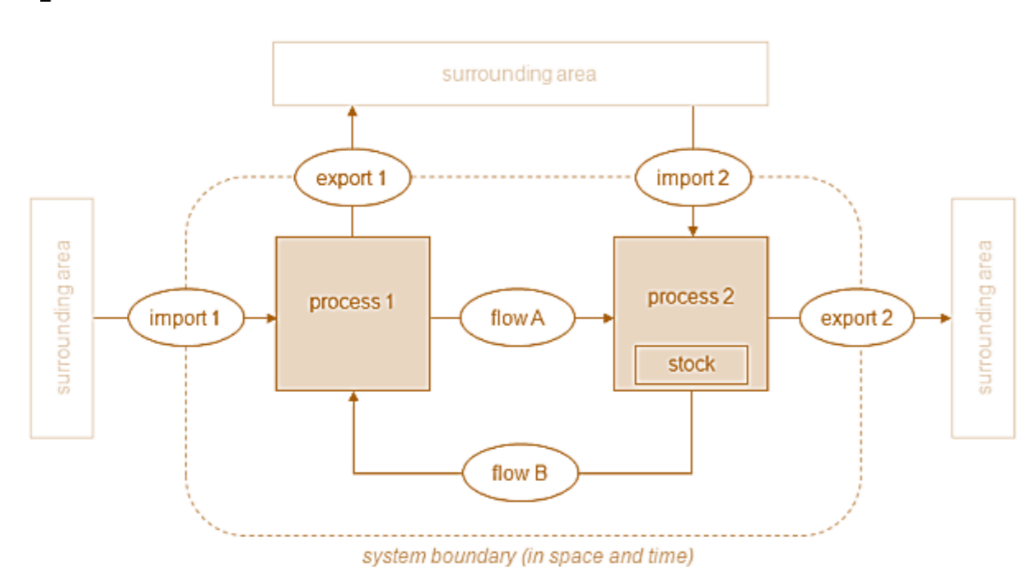
### 1. Cognitive Mapping



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

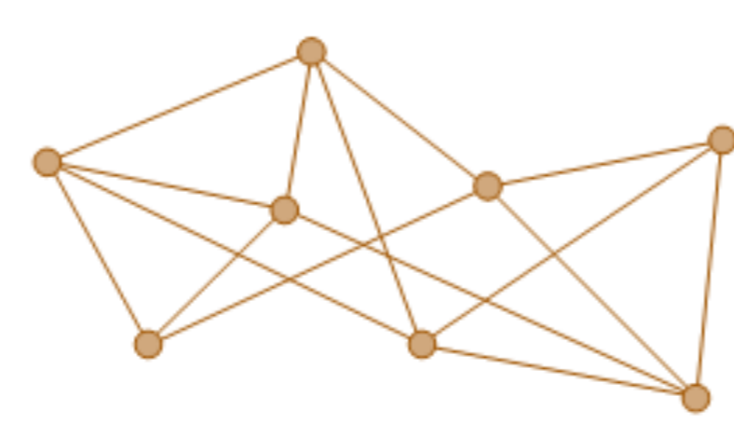
### Modelling Stages

#### 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]

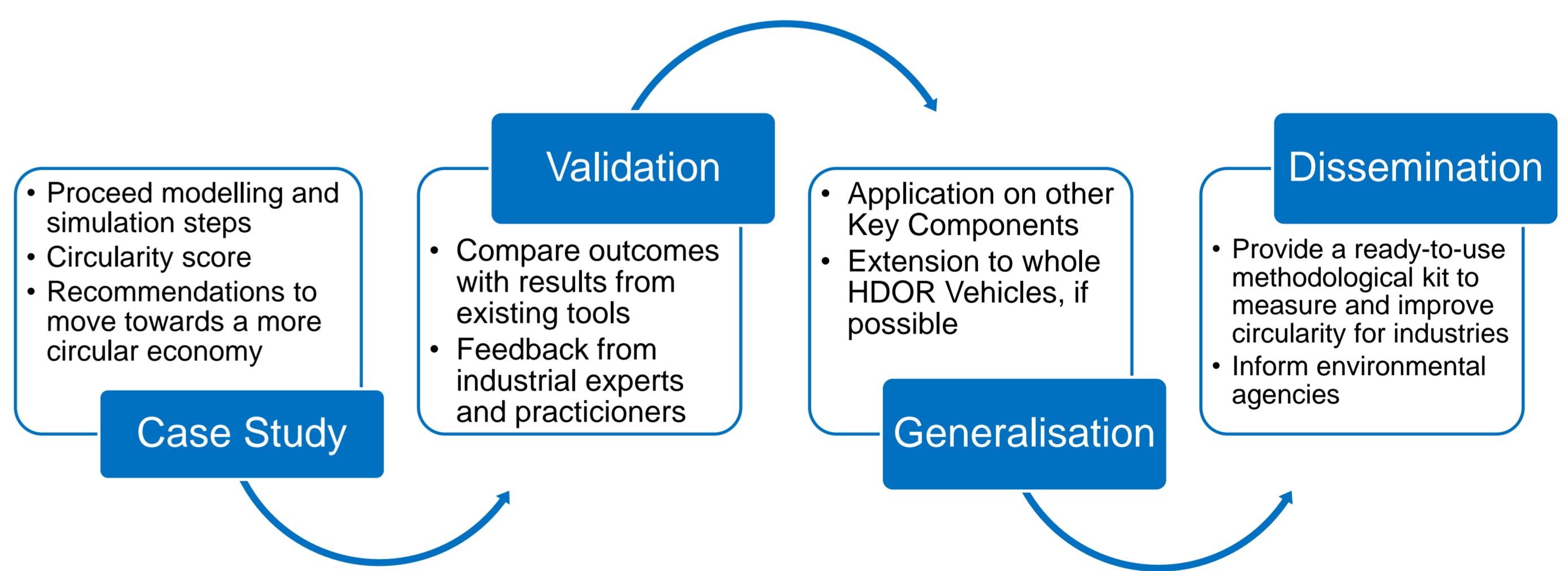
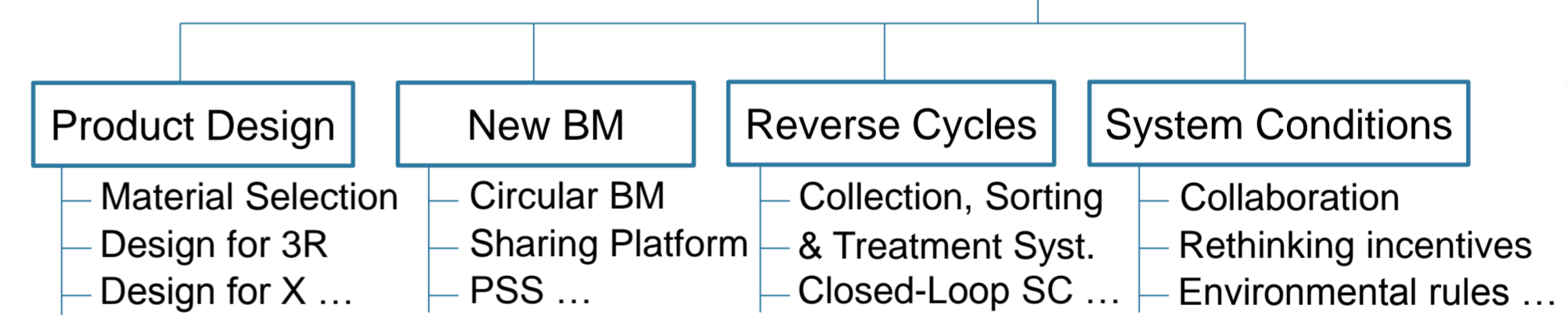
### How to close the loop of Platinum from Catalytic Converters of HDOR Vehicles?

- **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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