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

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Towards a Circular Economy of Heavy-Duty & Off-Road (HDOR) Vehicles and Associated Key Components (KC)

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]*

Regulations

- **Absence** of a regulatory framework for EoL & CO_2 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

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

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

Social

- **Human** Rights & Conditions in mines to extract precious metals contained in HDOR
- **Strikes** & **Job Destruction** related to **mining conflict**
- **Job Creation** through **Circular Economy** *[Ellen McArthur 13]*

Environment

- **Climate Change** & **Global Warming**, **Human Health** & **Air Quality Issues** *[IPCC 14]*
- Natural **resources depletion** & **European dependency** on "Critical raw materials" *[EC 12]*

Economic

- **Price volatility** of rare and precious raw materials such as Platinum Group Metals *[EC 12]*
- **Economic benefits** of the ELV Directive outweigh the costs of its implementation *[EC 14]*

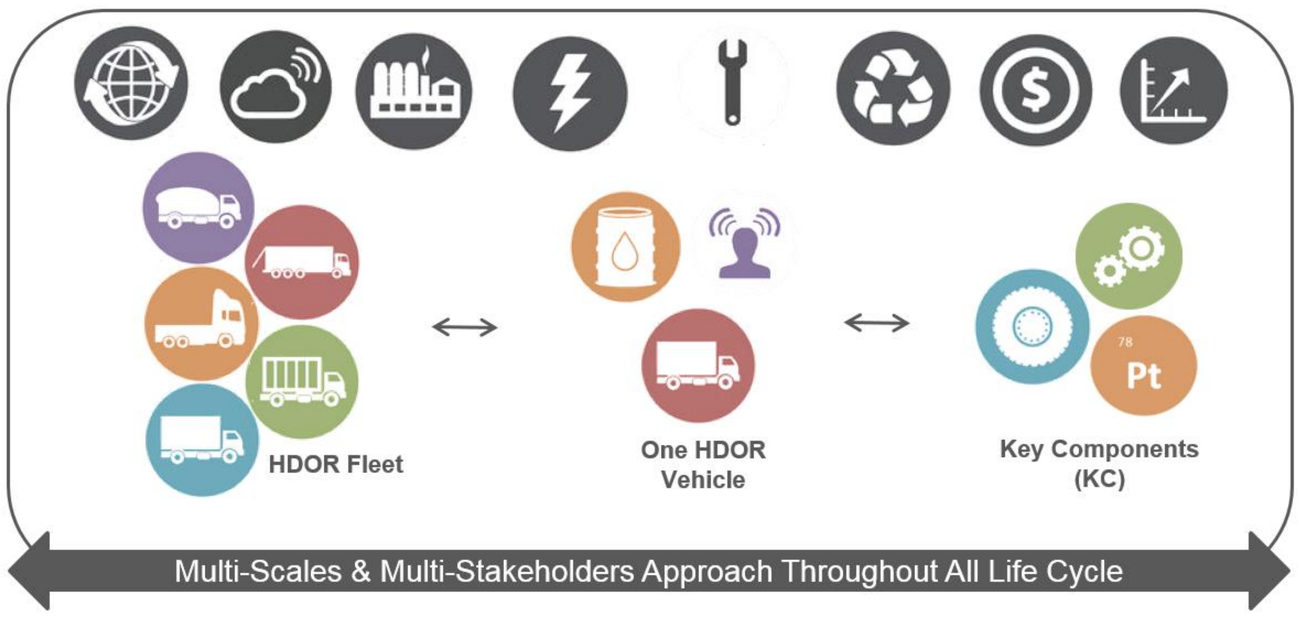
Research Question, Multimethodology & Objectives

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

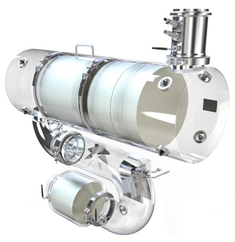
- **Holistic** & **integrated framework** that combined the **strengths** of **complementary methods & tools**



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

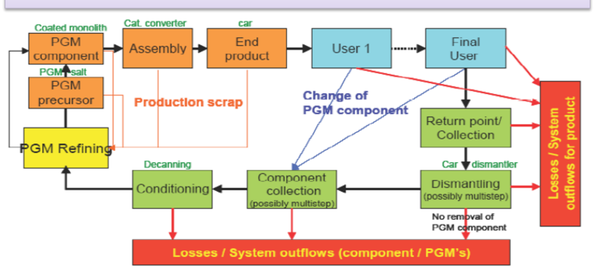
Case Study on 1 KC - The Catalytic Converter



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, …

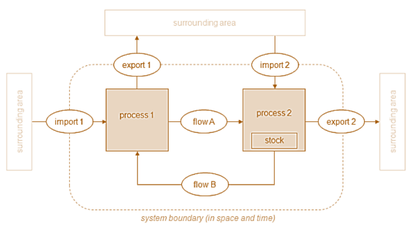
→ **Consolidation** of all the data in **one standardized Excel data sheet**

Modelling Stages

1. Cognitive Mapping

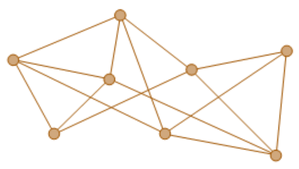
- To list and link all influencing parameters
- Comprehensive overview of the system

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

Simulations & Forecasts

SD Simulations

[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

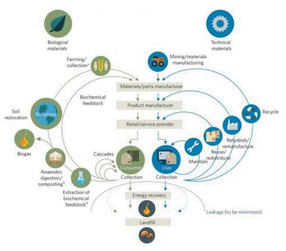
- What will happen if a minimum mandatory recycling rate of HDOR Vehicles is implemented?
- What if collection rate is improved by 10% or if design is modified for easy disassembly? …

Progress & Next Steps

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

Circularity Measurement

- **Product Design**: Material Selection; Design for 3R; Design for X …
- **New BM**: Circular BM; Sharing Platform; PSS …
- **Reverse Cycles**: Collection, Sorting & Treatment Syst.; Closed-Loop SC …
- **System Conditions**: Collaboration; Rethinking incentives; Environmental rules …



Case Study
- Proceed modelling and simulation steps
- Circularity score
- Recommendations to move towards a more circular economy

Validation
- Compare outcomes with results from existing tools
- Feedback from industrial experts and practicioners

Generalisation
- Application on other Key Components
- Extension to whole HDOR Vehicles, if possible

Dissemination
- Provide a ready-to-use methodological kit to measure and improve circularity for industries
- Inform environmental agencies

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

Johnson Matthey Precious Metals Management · MANITOU HANDLING YOUR WORLD · VOLVO TRUCKS · BOUYGUES CONSTRUCTION · ANGLO PLATINUM · CATERPILLAR · LIEBHERR · RENAULT TRUCKS · CIDER Engineering

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