Digitale Transformation im Forschungssektor Metallrecycling zur Unterstützung der Kreislaufwirtschaft von Metallen

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Research on Metal Recycling: Requirements for Metals

The circular economy is demanding **high performance** in recycling technology:

The **Products**

- From waste to products: quality and performance

The **Processes**

- Efficient processing: energy and materials usage optimization

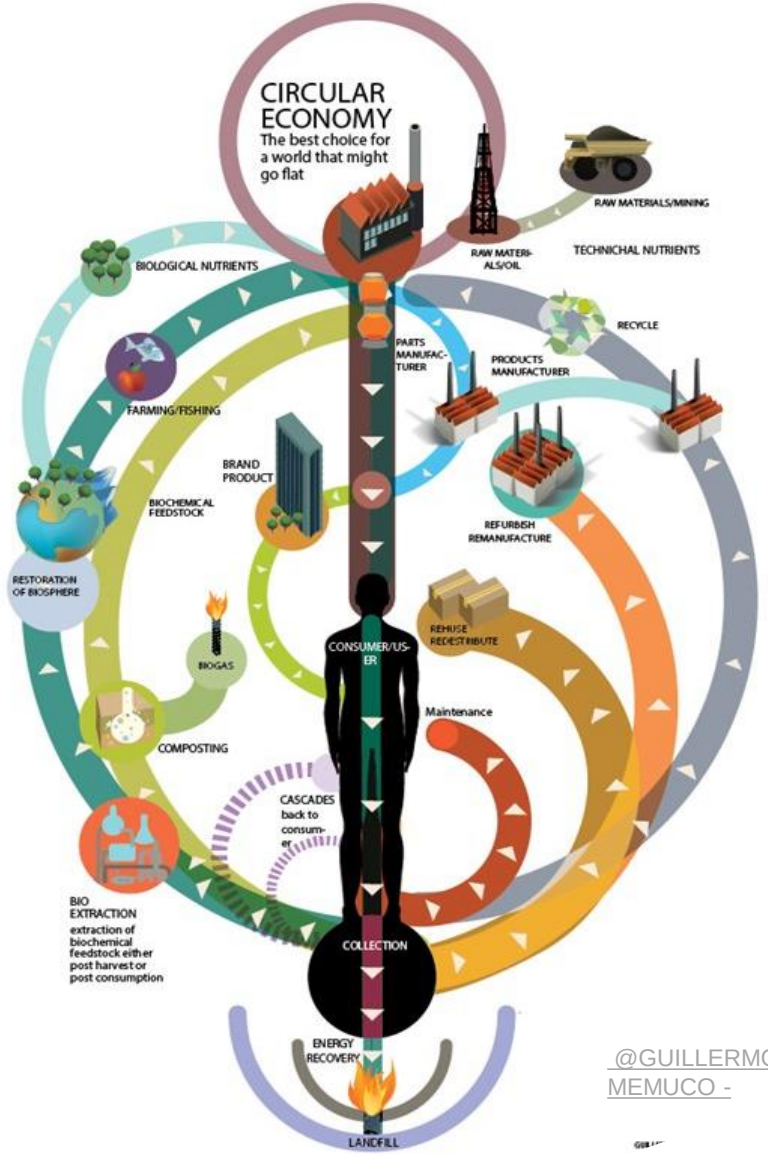
The **Socio-economics**

- Viable process: tracking the value chain and developing senseful incorporation of the recycling strategies

The **Environmental Footprint**

- Sustainable Processing: safeguarding the natural resources and protecting the environment from wastes and emissions

Current recycling technology demand predictive skills and rapid action in short period of time!



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Current Challenges in the Metallurgical Recycling Sector

Hydrometallurgy:

- Constant need of optimization of **kinetics** and process **parameters**
- Time-consuming **laboratory analysis**
- Relatively **sensitive** processing (impurities, temperatures, reagents, etc.)
- Parti… …ds to sam…

Pyrometallurgy:

- Difficult material **characterization**
- Extreme **environments** for sensors (High temperatures, reactive atmospheres)
- **Energy**-intensive processing → rapid decision making

Could digitalization address the technical challenges in metal recycling?

Pictures @Tom_shoots_people

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Digitalization in Metal Recycling Process

Current state in industry

- Digital tools
  - Enterprise Resource Planning (ERP) software for waste management and recycling
  - Index online tool for metal recycling machine
- Sorting process
  - laser object detection (LOD) system from TOMRA-Sorting
  - Redwave XRF/C for metal sorting
  - Hand-held LIBS-Analysis for light elements
  - AI-powered robotic sorting systems from ZenRobotics

ZenRobotics [4]

Current state in research

- Process simulation and system modelling
- Measurement and data infrastructure
- Data-driven solutions for concrete use cases

Digitalization in Metal Recycling Process

Why it is **necessary** for research institutes to accelerate the progress of digitalization?

- Better **know-how in the early stage** of the development
- Training for **experienced engineers** with digitalization skills and solid understanding of the metallurgical field

Why it is **difficult** for research institutes to implement digitalization?

- Limited attention and budget for digitalization topics
- **Communication** difficulties

Which **aspects** need to be located for digitalization in research institutes?

- **Digital tools** to support in experimental design
- Sensor technology and online monitoring for increased **process transparency**
- **Centralized** data- and information management system

IME Activities in Digitalization – Overview

Process Simulation and System Modeling

- Quantification of process indicators through **mathematical** modeling
- **Thermodynamic** simulation
  - with FactSage
  - with HSC Chemistry

SCADA System and Online Monitoring

- Siemens WinCC system
  - Furnace monitoring
  - Off-gas cleaning system monitoring
- LabVIEW Program
  - Hydrometallurgical recycling processes

Sensor Technology and Control System

- Temperature & Pressure measurements
- Gas & Water analytics
- Hydraulic control system
- Valve & Pump control systems

Data Management and Data Analysis

- Centralized experiment database
- Data-driven solutions
  - Online process evaluation
  - System identification modelling

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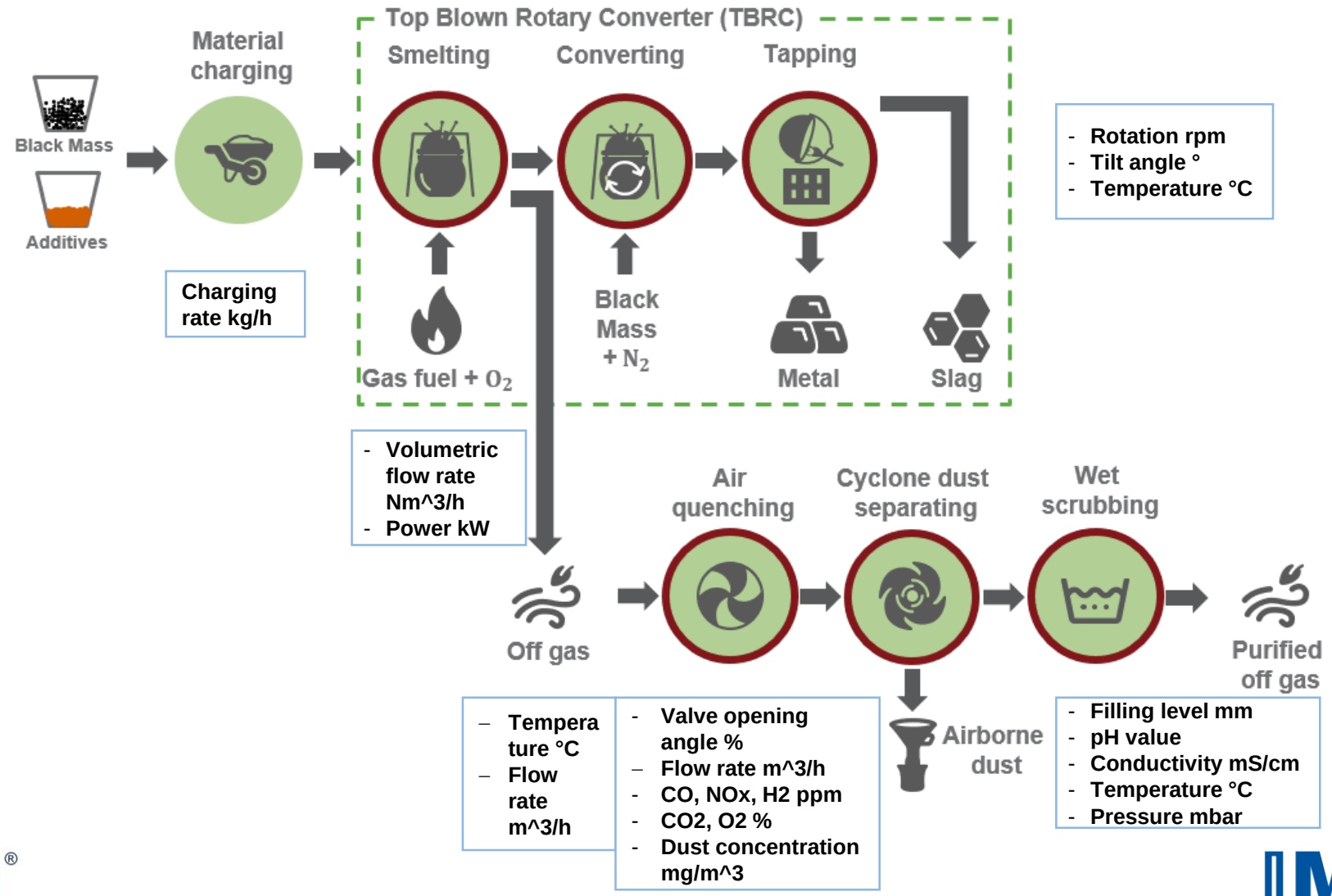
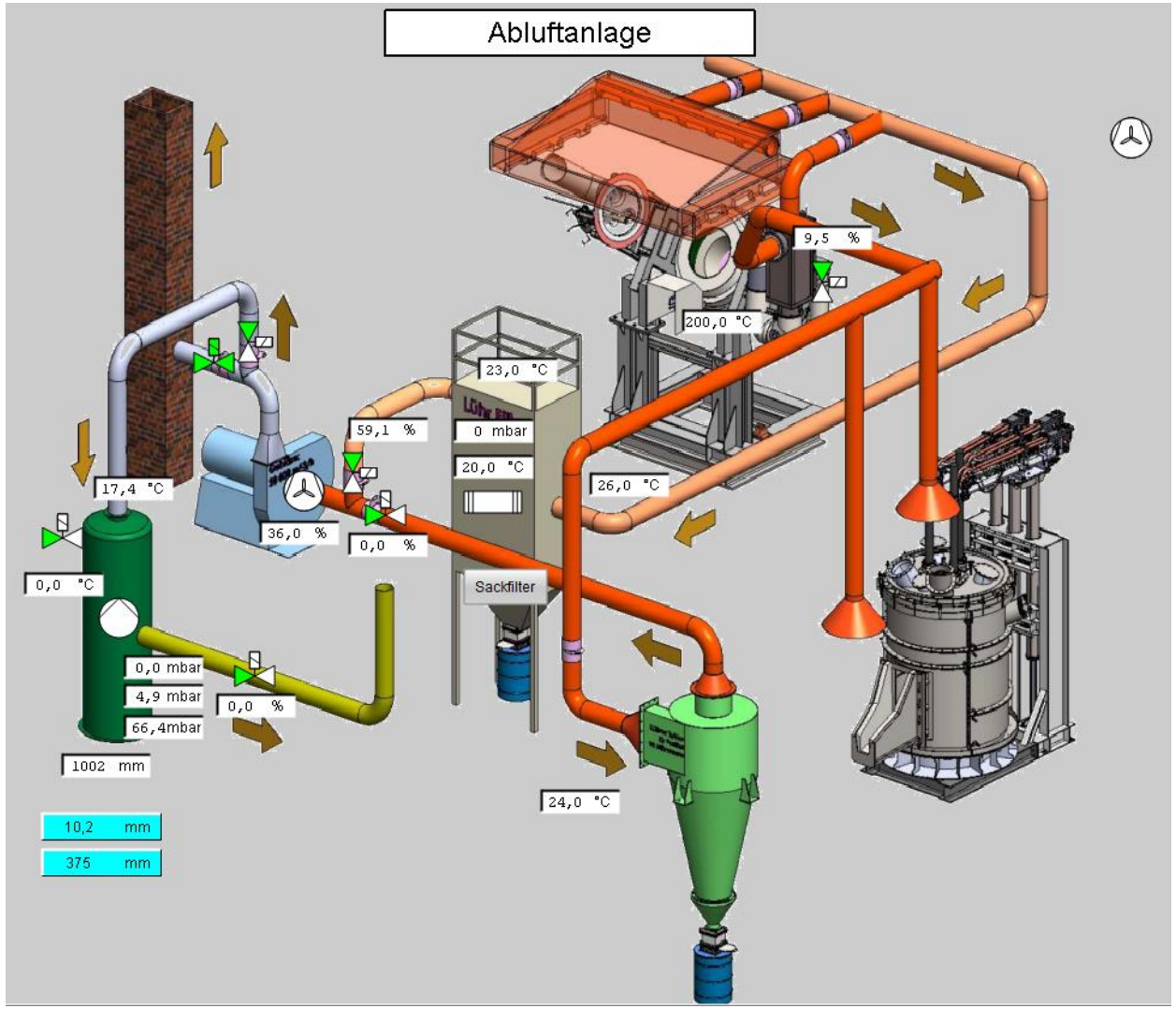
IME Activities in Digitalization – TBRC Recycling Process

Definition of the **influencing factors** along the process chain



IME Activities in Digitalization – TBRC Recycling Process



SCADA system and online monitoring

- Overview of all signals in off-gas cleaning system at one glance

Control elements

- Valves
- Pumps
- Fan

Measurements

- Thermocouples
- Pressure sensors
- Gas analytics
- Filling level meter
- Water analytics

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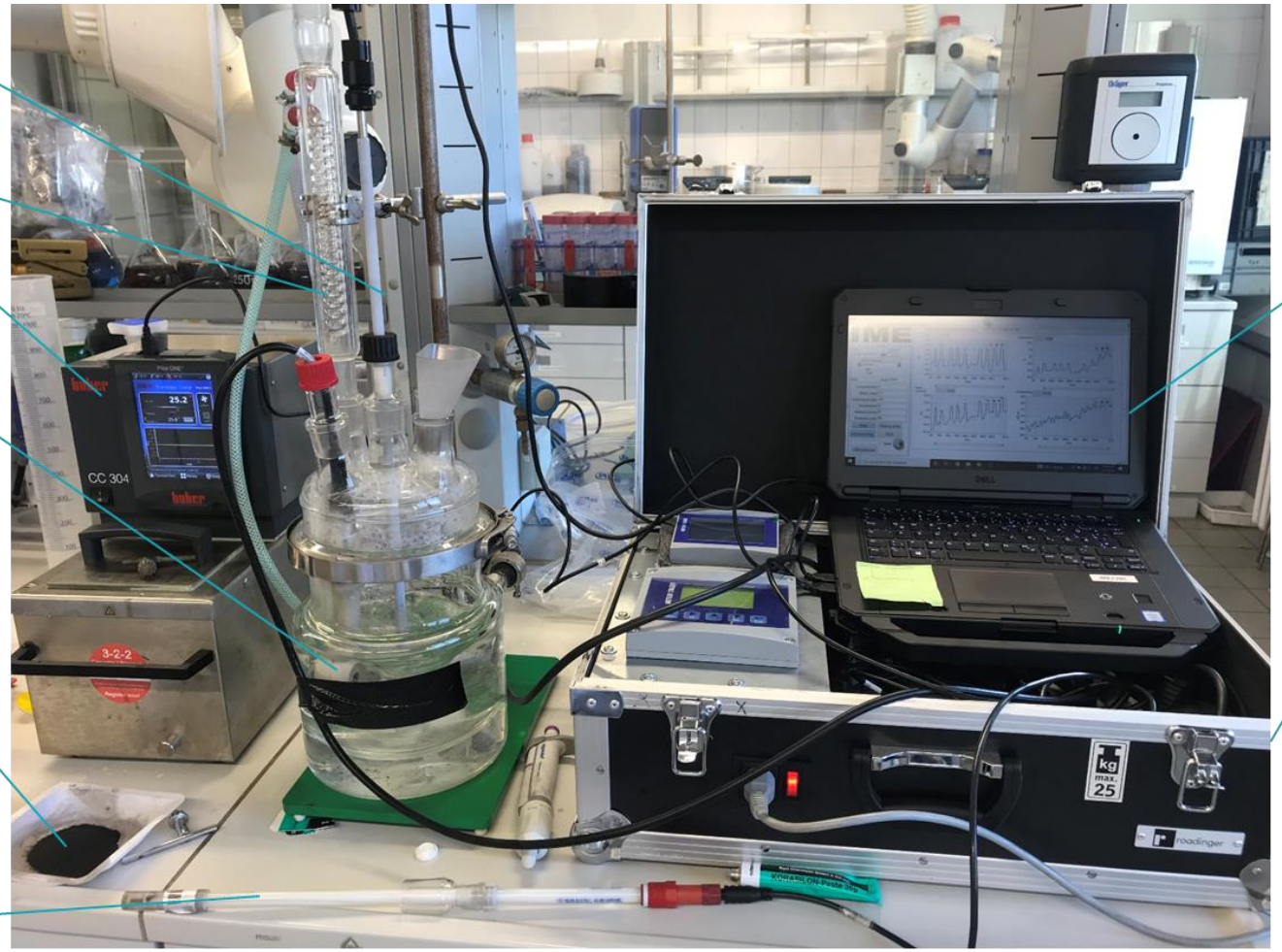
IME Activities in Digitalization – Hydrometallurgical Recycling Processes

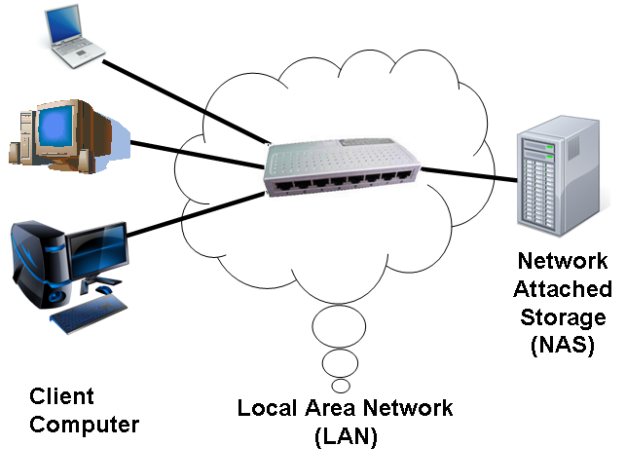
Online Data Acquisition System for Hydrometallurgical Recycling Process

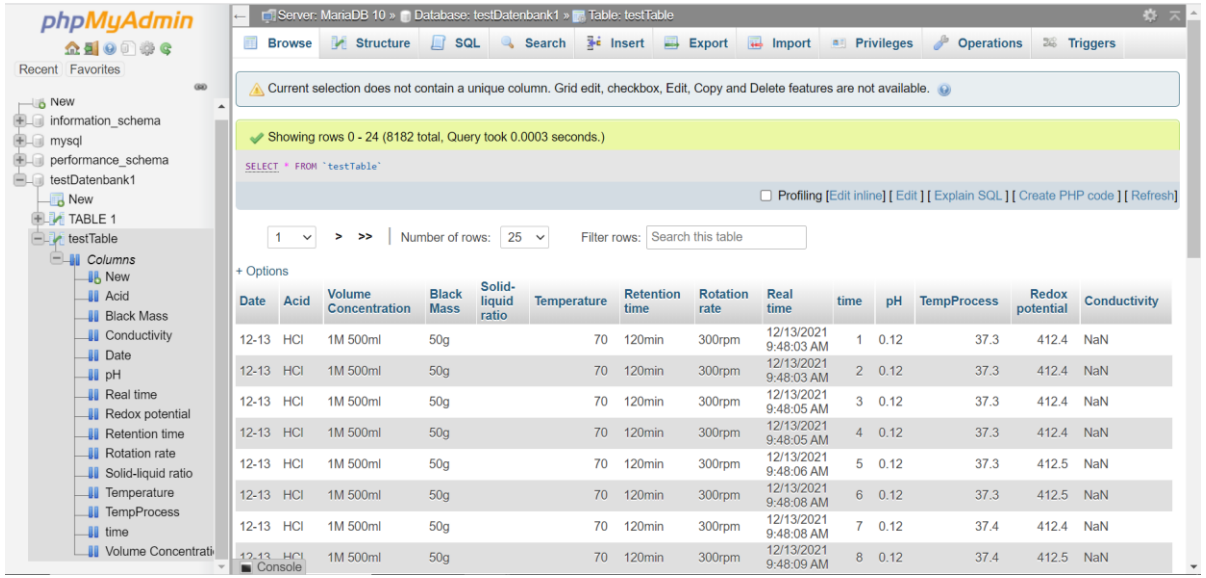


IME Activities in Digitalization – Experiment Database

IME experiment database

- Network Attached Storage (NAS)
- Relational Database Management System (RDBMS)
- Database server: MariaDB
- Data importation through an interface program (developed in python)





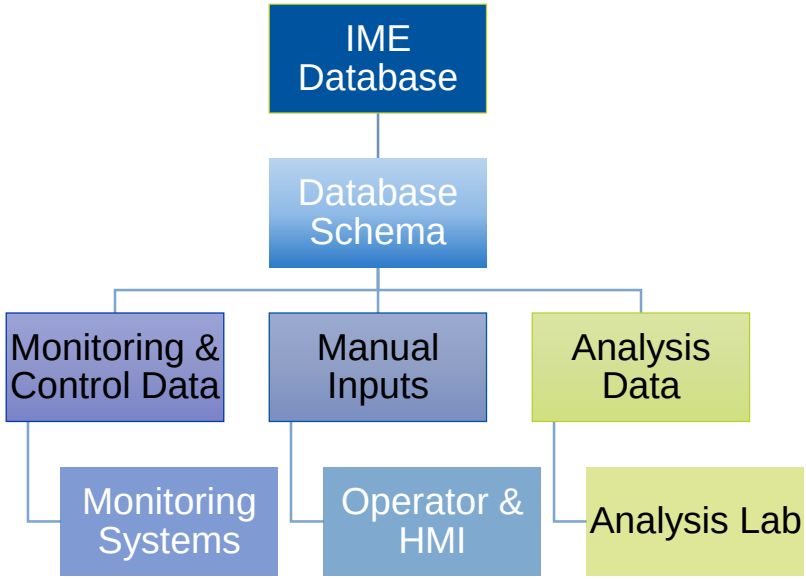


Foto: https://de.wikipedia.org/wiki/Datei:NAS.png

Conclusion and Outlook

Digitalization in metal recycling process

- Further development required for both industry and research institutes

Sensor technology and online monitoring system

- Improved process **transparency**
- Solutions for process **analysis** and further process **optimization**
- New sensor technologies are required for abrasive environments

Centralized data management system

- **Structured** and long-term data archiving
- Overview of all experimental work
- Information **exchange** and knowledge **sharing** platform

Photo: RWTH Center for Circular Economy

Thank you for your attention!

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