DECODE: Cloud-connected Labs of Future for Energy Materials

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1. Introduction

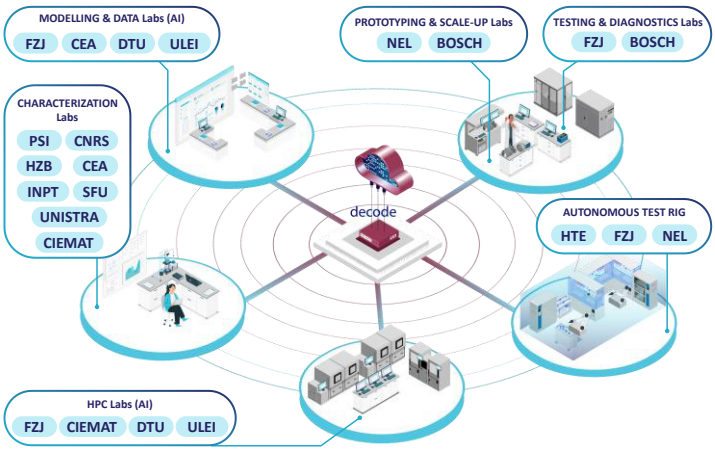

***Figure 1**: Representation of DECODE's Future Labs concept.*

The clean energy technology sector faces a major challenge with the pace of development trailing behind commercialization targets. The root cause hampering progress towards cleaner materials and technologies is that laboratories with complementary capabilities still largely operate in separation, with a lack of coordination among their efforts. The EU-funded DECODE project (**DE**-centralised **C**l**O**ud Labs for in**D**ustrialisation of **E**nergy Materials) aims to break down these barriers by creating a decentralised and adaptive cloud-connect labs concept. DECODE aims at transforming the development and innovation process for clean energy materials and technologies. The project envisions the creation of a decentralized platform that connects multiple labs to enhance the effectiveness and accelerate the progress of research and development in the field of clean energy technology. The core elements of the platform consist of the DECODE FABRIC, a matrix-like structure that facilitates collaboration, and a scoring system to assess integration readiness of methods and tools. An AI-enabled CPU orchestrates contributions from partner labs.

Initially focusing on hydrogen technologies, DECODE's vision may be expanded to other technologies including energy harvesting, storage, clean water and more. The platform strives for an unprecedented level of flexibility and adaptability, accommodating diverse strategies and technologies. In summary, DECODE accelerates clean energy innovation through interconnected labs, fostering a sustainable and cleaner future.

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The overall objective of DECODE is to digitally connect multiple labs, boost the effectiveness, and accelerate the development and integration of materials for sustainable hydrogen technologies.

Europe's transitioning to a sustainable and green future calls upon strategies for the accelerated development and scale-up of materials to respond to geopolitical threats to Europe's **technological sovereignty** and to the **supply chain security** of key raw materials.

The DECODE Consortium is a partnership of leading European research centres (RTOs) as well as industrial companies and academic partners representing various sectors of the industry such as electronic engineering, materials processing, algorithm development, software, and hardware design and development as well as integration and packaging technologies.

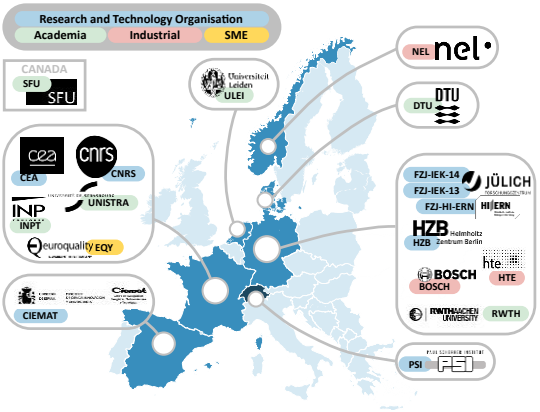

***Figure 2**: Consortium Overview*

2. General Methodology

The agnostic DECODE platform in comparison with the conventional approach is illustrated in Figure 5. At its core, DECODE strives to develop and deploy three innovative modules: 1) the **DECODE Foundry**, a semantic search engine for assembling methods and tools into practical workflows, 2) the **DECODE FABRIC**, a matrix structure that connects modelling and characterisation suites, and 3) the **DECODE CPU** for end-to-end orchestration of a given materials development to integration pipeline. The platform, designed for unprecedented flexibility and interoperability, harnesses AI-driven data management and ontological mapping to enable the seamless collaboration among partner labs. DECODE heralds a new era in collaborative and transferable clean energy research, with water electrolysis and hydrogen fuel cells as test cases.The DECODE platform will be built with a modular architecture, harnessing existing AI-cloud and data management infrastructure at Forschungszentrum JÜLICH - IEK-13 (Virtual Mind Labs).

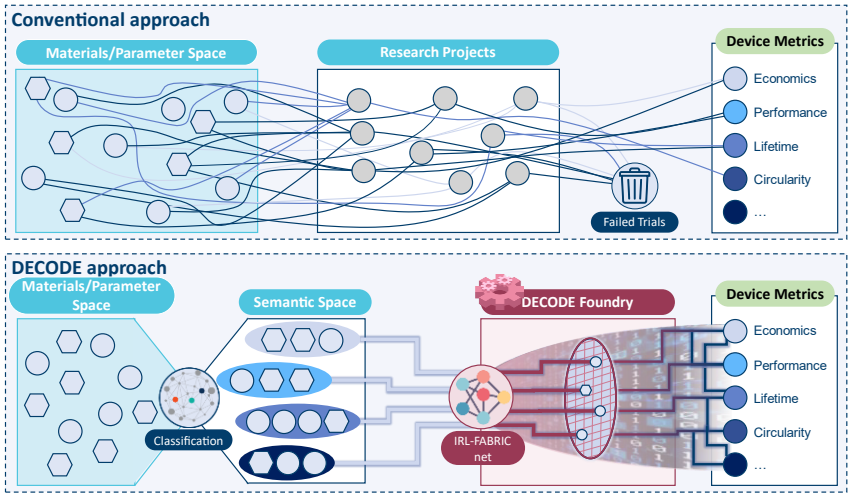

***Figure 3**: Conventional process vs. DECODE process. Modelling concepts (blue circles), characterisation tools (blue hexagons), methodologies (grey circles).*

3. Conclusion

The DECODE project[3] has been designed to achieve an integrated European materials platform, allowing a systemic use of tools and capabilities including materials modelling, characterisation, robotics, data documentation, ontologies, artificial intelligence, and machine learning, which are orchestrated to accelerate the design, development and application of chemicals, materials and related processes and manufacturing.

[3] This project has received funding from the European Union's Horizon Europe Research and Innovation Program under Grant Agreement No 101135537.