

International Benchmark Biointelligence: Analyzing an Emerging Technological Innovation System

AUTHORS

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I. INTRODUCTION AND PROBLEM STATEMENT

- A transformation towards a **sustainable bio-based, technology-oriented needs-based economy** requires, on the one hand, technological progress (especially in information technology and biotechnology), and on the other hand, fundamental changes of prevailing production and consumption patterns [1].
- The **biological transformation** of industrial manufacturing is a process of increasing the use of material, structures and principals of natural systems in technology towards biointelligent technologies and systems [2].
- The **international benchmark study "InBenBio"** aims to identify the latest developments in the field of biointelligence worldwide, comparing them with current activities and the framework conditions in Germany. The study is important for decision-makers from industry and research who are engaged in tomorrow's value creation, because in the future, companies will have to develop new technologies and business models to meet the growing demands of customers and society.

How can we systematically identify and analyze worldwide developments and innovation activities in the field of biointelligence?

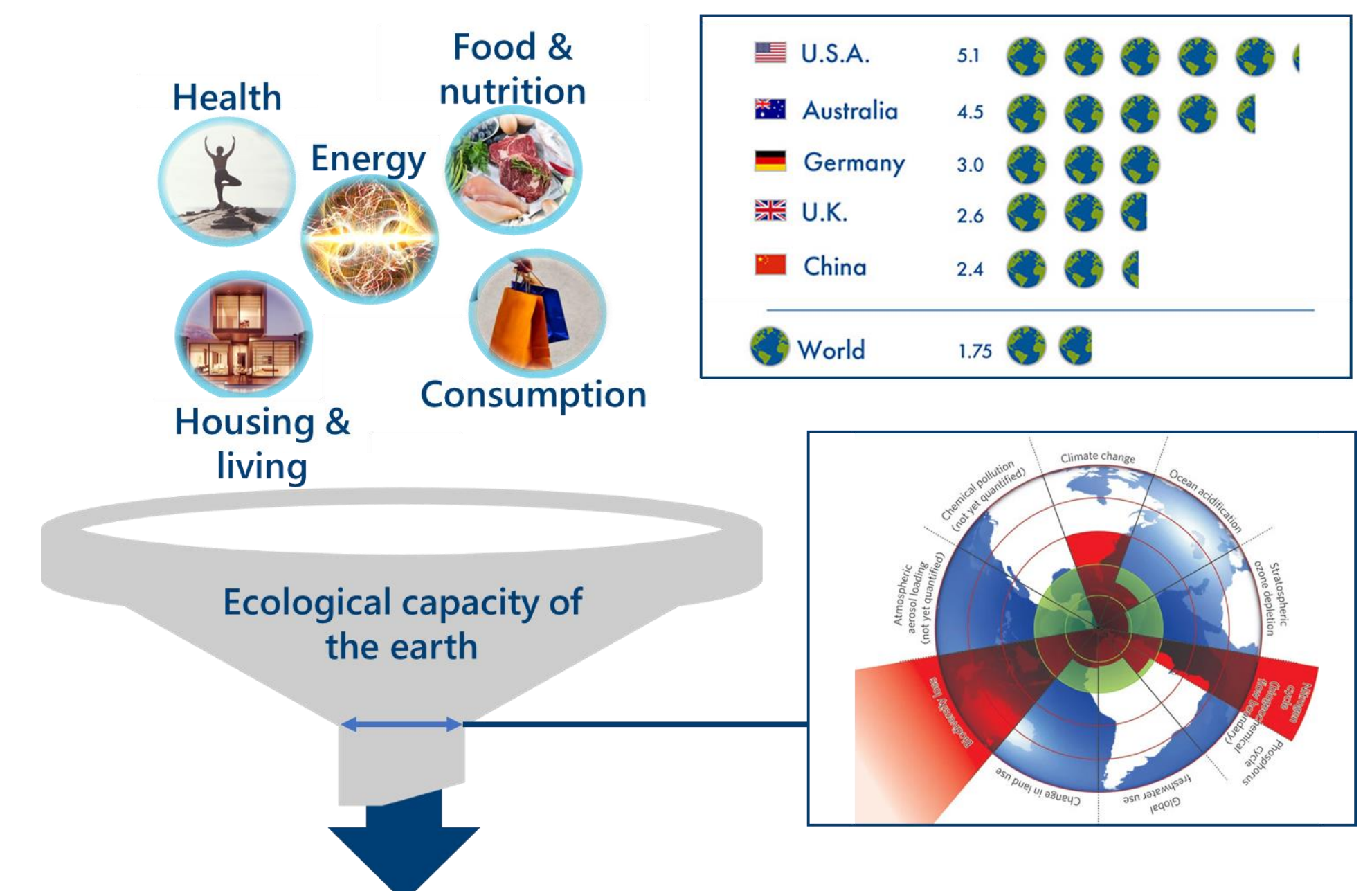


Figure 1. Addressing the human fields of needs in the ecological capacity of the earth. [3-5]

II. THEORETICAL BACKGROUND

Biointelligence

...is the result of the **convergence of bio-, hard- and software**. This cross-fertilization of knowledge between *life science, engineering and information science* has the potential to trigger the *emergence of a new technological paradigm* that unlocks innovative transformation paths and technological trajectories in a variety of domains.

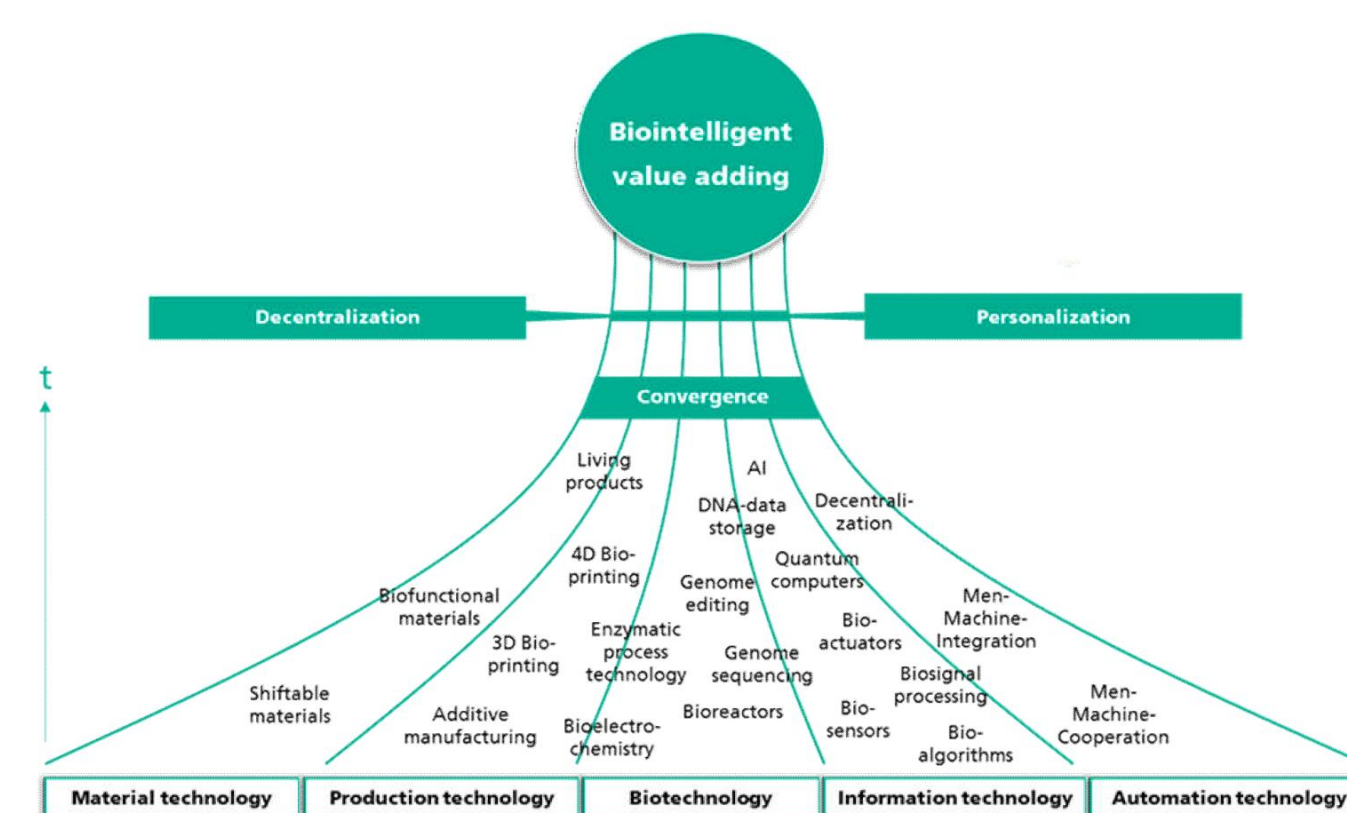


Figure 2. Convergence of formerly separate technological areas in the context of the biological transformation. [6]

Biointelligent systems

- contain a *technical* and a *biological* component as well as a feedback loop and exhibit generally accepted characteristics of (*artificial intelligence*) [2, 6-7].
- are intended to contribute to a sustainable design of products and production in various fields of human needs, including health, nutrition, energy, housing, and consumption [2, 7].
- utilize biological resources reasonably and strive to align itself with both its natural environment and the systems in its surroundings [2, 7].

Technological innovation systems (TIS)

- The innovation systems approach allows an analysis of all socio-economic components that contribute directly or indirectly, intentionally or not, to a transformation [8-10].
- A **technological (innovation) system** focuses on *generic technology with application in various industries* [11] and is defined as "[...] a network of agents inter-acting in the economic/industrial area under a particular institutional infrastructure (...) and involved in the generation, diffusion, and utilization of technology" [12].
- For successful diffusion of technological innovations, both the seven functions should be taken into account and the system components should be well developed and coordinated.

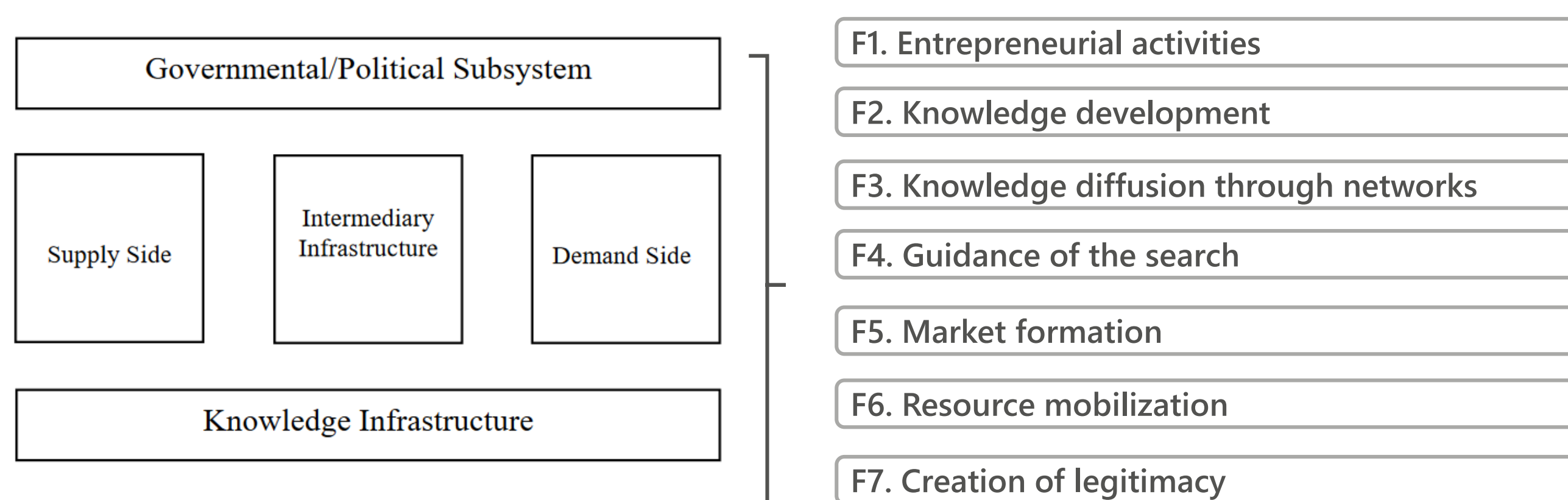


Figure 3. Components, structures, and functions of TIS according to [8, 13].

III. METHODOLOGICAL APPROACH



Figure 4. Four-stage methodological approach to identify relevant focus topic areas and indicators.

IV. CONCEPTUALIZATION OF AN ANALYSIS FRAMEWORK FOR THE BENCHMARK

The focus topic areas

- enable a *comprehensive country-specific comparison* and form the *basis for*
 - the identification of lead countries
 - the system boundaries of the research of technologies and actors
 - the formation of hypotheses for the expert interviews
 - the country-specific comparison (benchmark)
 - the calculation of market volumes
 - the derivation of scope for action
- The **information sheet** of each focus topic areas includes a *description* and a *quantitative and/or qualitative set of criteria*.

Technology perspective	Economic & political factors	Innovation capacity & pioneering spirit	Dimension	Innovation capacity and pioneering spirit
(bio)intelligent Technologies	Access to markets	R&D activities	Focus topic areas	Research and development activities
Business models	Access to financial capital	Networks	Key focus	R&D expenditures Patents R&D collaborations
Market potential of technologies	Political risk and regulations	Entrepreneurial activities	Short description	In the course of biointelligent value creation, R&D activities (e.g. for the development of technologies, products and/or business models) and/or venture response R&D activities often take place in collaboration and co-development R&D activities on the basis for innovation as well as the development of new markets, identification of users and new value creation networks The new technological knowledge is disseminated through research institutions and in the context of collaborations.
Impact on sustainability	Access to resources	Ethical considerations and acceptance in society	Indicators	Indicator
Structure of value creation networks		Education and qualifications		Source
				Evaluation
				Description

Figure 5. 14 focus topic areas in three dimensions and their information sheets.

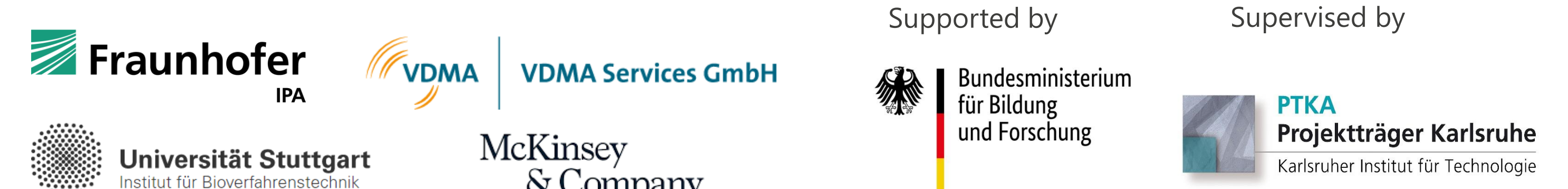
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