

# Bridging the Gap Between 6G Technologies and Societal Values: A Comprehensive Analysis of Key Value Indicators (KVI) and Business Models

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**Abstract** — The evolution towards 6G technologies has introduced a paradigm shift in the telecommunications sector, emphasizing the need to assess not only technical Key Performance Indicators (KPIs) but also Key Value Indicators (KVIs). The uses of wireless connectivity are growing, with different user groups placing their emphasis on particular technical KPI improvements to align with the outcomes that they value most. This paper explores the significance of independent, objective KVIs in evaluating the societal impact of 6G, incorporating dimensions such as Sustainable Development Goals (SDGs) and societal requirements. The identification of KVIs involves a thorough examination of various societal values, with an emphasis on sustainability, digital inclusion, and trustworthiness. Several projects have contributed to the definition and analysis of KVIs. This paper begins with a brief literature review on KVs and KVIs, providing insights from projects, industry reports, and white papers. The second part of the paper delves into the intricate relationship between technology, business, and value. It explores the multi-faceted influence of technology on business growth, value creation, and societal development. Finally, the paper categorizes values into economic, environmental, and societal, providing a framework for prioritizing KVIs based on the direction of business and funding models. The TrialsNet project's methodology for assessing KVIs across use cases is outlined, showcasing the project's commitment to analyzing the positive impact of technology on society, the environment, and the economy. The European Commission's aims encompass the pursuit of sustainable development and social progress, along with the commitment to enhance environmental quality.

**Keywords**—KVs, KVIs, TMOG framework, sustainability, digital inclusion, trustworthiness, business model

## I. INTRODUCTION AND LITERATURE REVIEW

The terms Key Values (KVs) and Key Value Indicators (KVIs) were recently introduced in the telecoms sector as part of 5G-advanced/6G visions. Evaluating various Key Performance Indicators (KPIs) to measure progress towards “valued” objectives, such as Sustainable Development Goals (SDGs) or societal requirements, results in the identification of KVIs. These KVIs are pivotal in gauging the societal impact that 6G will have, going beyond KPIs associated with purely the technical performance of communications networks and more

towards the outcomes enabled by such networks. This approach is also applicable to addressing sustainability considerations within the realm of 6G. The process involves examining which KPIs serve as useful indicators for estimating the related KVIs. The incorporation of the KV concept integrates critical elements such as trustworthiness, digital inclusion, and sustainability. This concept underscores the influence of key enabling technologies in generating value for products, services, and society at large.

In recent years several projects, reports, and white papers have analysed the aspect of KVs and KVIs in the 6G context. We now briefly summarise and review these.

A 6G-IA paper [1] introduces societal values and discusses why they are important. It outlines a societal value-driven approach to technology development, which builds upon the concept of KVIs and complements the existing performance-based approach that employs KPIs. KVIs serve as indicators of pertinent societal values that can be enabled or influenced by future technology, particularly the novel services offered by 6G. According to the paper, the utilization of KVIs in the development of 6G serves two main purposes: first, to demonstrate and validate that 6G can effectively address societal needs, and second, to steer technology development towards directions that yield value-driven benefits. The paper recommends that KVIs should represent a measurable quantity or requirement that, in some manner, provides an estimation of the affected societal value. This enables the formulation of targets using KVIs, such as reporting the number of service users meeting certain conditions. According to a white paper published by Nokia [2], 6G development has been demonstrably different from previous generations by recognizing the need for defining KVs such as sustainability, trustworthiness, and digital inclusion to drive key challenges of research, as well as to enable various use case families of the 2030s.

Hexa-X [3] is an EU-funded project where several aspects of KVs and KVIs are analysed. To comprehensively evaluate the impact of 6G, it is essential to consider KVIs that encompass a broader range of dimensions beyond traditional deterministic performance measures. These dimensions include sustainability, digital inclusion, and trustworthiness. To effectively quantify and compare the contributions of technical enablers to each

relevant key value target, novel KVIs are derived. The link between KVIs, KPIs and new capabilities is also analysed in the project. While some KVIs may be evaluated directly, in most cases, they are associated with a set of KPIs that serve as proxies for the respective KVIs. These KPIs represent the characteristics or capabilities necessary for realizing specific use cases and their associated values. The establishment and consideration of KVIs, as also described in [4], contributes to economic growth and value expansion. The authors emphasize the shift in the fundamental network design paradigm pursued by initiatives like Hexa-X, which aims to transform the focus from purely performance-oriented network design to a holistic approach that incorporates both performance and value considerations.

An approach to KVIs and KPIs mapping was introduced in DEDICAT 6G project [5], and it is summarized in six steps. This includes the identification of KVIs and mapping of technical enablers for H2020 and SDGs societal challenges, the approach also includes the mapping of KPIs to SDGs challenges. Beyond the terrestrial network, [6] claims that contributions to KVIs' could also be provided by Non-Terrestrial Networks (NTN) since satellite communication is considered part of 6G technology. With the features of satellite communications that enable KVs such as ubiquity, continuity, scalability and resilience, NTNs stand to play a central role in 6G. In [7], the KVIs are associated with several verticals and given a priority score, i.e., high, nominal, and low, against each of the verticals.

Understanding value is important not only for recognizing the impact of 6G on societal goals but also for understanding willingness to pay for services and hence potential business and funding models. In [8], the revenues from Vehicle to Infrastructure (V2I) services and smart city services were evaluated and the socio-economic value across both of these service types was analysed. Conclusions were drawn on actions needed to realize social values, including public-private partnerships.

In [9], the operational and economic benefits of port services, e.g., port of Hamburg, were quantified. The net benefits from a range of wireless-enabled services, including container terminal automation, environmental monitoring, Augmented Reality (AR) in supporting construction sites and tourism and V2I services, were assessed. The social benefits of applying an intelligent transport system (ITS) in the city of Hamburg was forecast to grow up to Euro 2 million per year due to reduced travel time, lower CO2 emissions and lower traffic accidents. Part of the report in [10] analysed the commercial and socio-economic benefits and value across an airport, museum, and hospital setting; one of the key findings concluded that some use cases have a high socio-economic value but a low commercial value and vice versa.

Across the existing literature reviewed here, it is clear that the traditional approach of targeting improvements in technical KPIs alone is no longer appropriate for 6G networks. These KPI improvements need to be considered and prioritized in terms of the value that they deliver, with an increased focus on sustainability, trustworthiness, and digital inclusion. We also note the important link between understanding the value delivered by 6G technologies and potential funding and business

models for the deployment of such technologies. This is explored further in the next section.

## II. VALUE DRIVEN BUSINESS MODELS

The relationship between technology advancement, business growth, and value is multi-faceted, each of which influences the development of society in a dynamic and interdependent manner. As technology advances, it opens new avenues for businesses to innovate, streamline processes, and reach new and wider markets. This growth in turn creates economic opportunities that shape societal values and expectations. Concurrently, the values held by businesses and societies influence the direction of technological development and in an ideal world, they would both drive demand for ethically aligned solutions and sustainable practices. In addition, willingness to pay by the end user can be considered in some cases as an assessment of the KVs considered.

In this section, the link between business, value, and technology is presented, and an overview of business models and innovation frameworks is also shown.

### A. Relationship between Technology, Business, and Value

The relationship between technology, business, and value is intricate and mutually influential. Technology has become a critical enabler and driver of growth in the business world. In the case of wireless technology, this may be via enabling operational efficiencies in existing or new business processes and/or providing the ability to deliver new services and experiences. It has transformed the way businesses operate, communicate, and deliver products and services. By leveraging technological advancements, businesses can streamline operations, enhance productivity, and tap into new market opportunities. At the same time, technology itself is shaped and driven by the needs and demands of society, driven largely by the business world, as companies drive innovation through research and development investment and market differentiation. One of the ways technology adds value to businesses is through increased efficiency and productivity as shown in Figure 1.

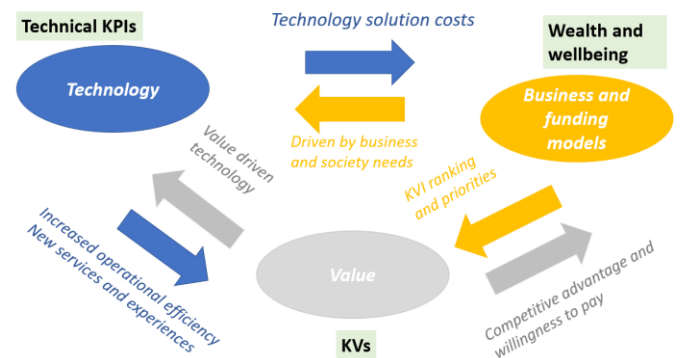


Figure 1 - Links between technology innovation, value generation, and business and funding models

The relationship between technology and value is significant. Technology plays a crucial role in creating, enhancing, and capturing value across various domains,

including economies, societies, environments, and individuals. In the case of wireless technologies, innovation contributes to operational value creation by underpinning improved efficiency and productivity. Automation and process optimization can potentially reduce operational costs and improve network performance. This enhanced efficiency translates into greater customer satisfaction and a higher probability of willingness to pay as shown in Figure 1. By leveraging technology, businesses can achieve higher levels of productivity and ultimately deliver more value to their customers and stakeholders which in return will translate into viable revenue streams and funding models both in the wireless sector and in the related verticals. In addition, there is a cost associated with new technology solutions.

In addition to business-related operational values, technology also has a broader societal impact. It has the potential to address social challenges, improve quality of life, and create positive change. Wireless technologies in areas such as healthcare, education, energy, and transportation have the power to save lives, increase access to services, and promote environmental sustainability. By leveraging these technologies for social good, organizations can generate value that extends beyond financial metrics, contributing to better communities and societies.

Technology, while often hailed for its many positive contributions to society, can also be harmful, either maliciously or unintentionally. This underscores the importance of responsible innovation, ethical considerations, and robust regulatory measures to safeguard against the dark side of technology.

In conclusion, technology plays a pivotal role in value creation across multiple dimensions. It enhances efficiency, drives innovation, facilitates collaboration, and addresses societal needs. Value can help in leveraging technology effectively in the telecoms sector, and drives innovative businesses and investment models. In return, this translates into unlocking new opportunities, driving growth, and achieving sustainable development. However, realizing the full potential of technology requires a thoughtful and strategic approach that aligns technological advancements with broader business goals and values. Private and public investors in technology need to be mindful of the wider impacts and the need to create wider pools of value. Hence in the following section business models and Technology, Market, Organization and Governance (TMOG) frameworks are explored.

#### B. TMOG – A framework towards value-driven business models

A business model is a comprehensive framework that outlines how a company creates, delivers, and captures value. It encompasses various elements, including the company's target customers, the value it provides to those customers, their willingness to pay, the way it generates revenue, its relationships with suppliers & partners, and the strategies it employs to sustain its operations and growth. In essence, a business model serves as a blueprint that defines the fundamental structure and approach a business takes to operate profitably and successfully in its chosen industry or market. There are numerous business models that an organization in the technology sector could

employ. As detailed in [11] the chosen business model describes how a vertical-related organization creates, delivers, and captures value, in economic, social, cultural and other contexts. In particular, the business model (value capture) will establish which use cases have the potential to realise the greatest value. A literature review of business models was presented in 5G-TOURS [11], these frameworks include:

- Business Model Canvas
- Value Chain
- V4 Business Model

The role of business models in encouraging sustainable innovation is vital in today's rapidly changing world. As technological advancements continue to shape industries and societies, businesses must adapt their models to ensure responsible and sustainable practices. Commercial value is important for business prosperity, however by recognising and targeting wider value it is possible to achieve long-term sustainability and positive societal impact. The TMOG framework is shown in Figure 2 and aims to include consideration of wider value towards responsible and sustainable practices when developing technology related to business and funding models. The TMOG framework is proposed in [12] for innovation assessment. Originally, an earlier iteration of this framework was introduced by Oxford University as TMO (Technologies, Markets & Organisations) as part of the content for its Strategy & Innovation courses [13]. The "G" part, i.e. governance, was developed under the 5G-TOURS project in recognition of the role that the political and regulatory environment can have in prioritizing value generation from technology to align with wider societal value. This extension of the framework to include governance also connects with the three key pillars of value creation, also highlighted in a precursor project 5G NORMA [8], of government (political benefits), private companies (private benefits), and consumers (common or social benefits).

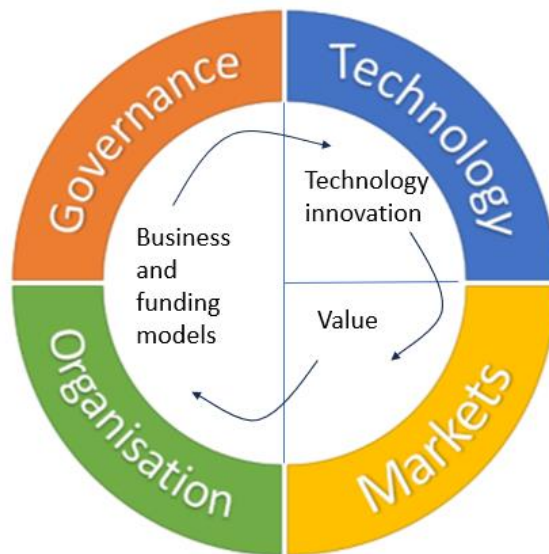


Figure 2 - TMOG framework

The TMOG framework recognises the huge variety of scale and scope that exists within the innovation space and in particular across these several dimensions. This empowers managers to develop robust strategies that support successful innovation and deliver greater value for their organisations, their partners, and their stakeholders.

The European Commission's stated aims include achieving sustainable development and social progress and protecting and improving the quality of the environment. TMOG allows for innovations to be evaluated based on their impact on the environment and society. Additionally, it is designed to mirror the values, ethics, and incentives of the organizations and individuals engaged in implementing and leveraging innovations. This aspect has grown in significance within the realm of investment decision-making. For more information about the framework, readers may refer to deliverable D8.5 of 5G TOURS [8]. The TMOG framework is revisited in the TrialsNet project [14] as part of the KVs assessment methodology across the UCs of the project.

### III. ASSESSING VALUE - KVs AND KVIs

Value is a fundamental concept in various fields including mathematics, philosophy, economics, and more. In a general sense, a value represents a principle, belief, quantity, or quality that is considered important or desirable. As shown in Figure 3 there are a few contexts in which the term value could be used. Hence, the meaning of value can vary based on the context in which it is used. It generally relates to the significance, worth, or importance assigned to something, whether it is a number, a belief, an object, or a concept.

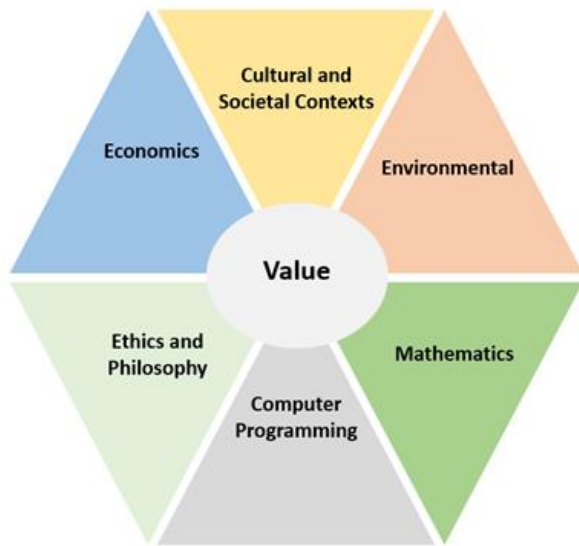


Figure 3 – Contexts of value

In essence, there are numerous values, and their nature evolves depending on the context. In Figure 4, over 130 values are shown [15] and these are divided into 4 categories:

- People: Social
- Planet: Environmental

- Profit: Economic viability
- Progress: Technological feasibility

Some of the values shown in Figure 4 may be relevant to 6G use cases, but it depends on the considered vertical and the related use case.

The use cases identified and described in the project have socio-economic and environmental effects. TrialsNet aims to establish a strong connection between technology and its positive impact on society, environment and economy, hence the project analyzes the values according to these three categories. There is list of KVs investigated for each UC, the aim is to analyse the benefits of the technology on the KVs which eventually will lead to the enhancement of these values. The project focuses on developing assessment frameworks that enable the evaluation of use case dynamics for societal and environmental acceptance, specifically in the context of 6G solutions.

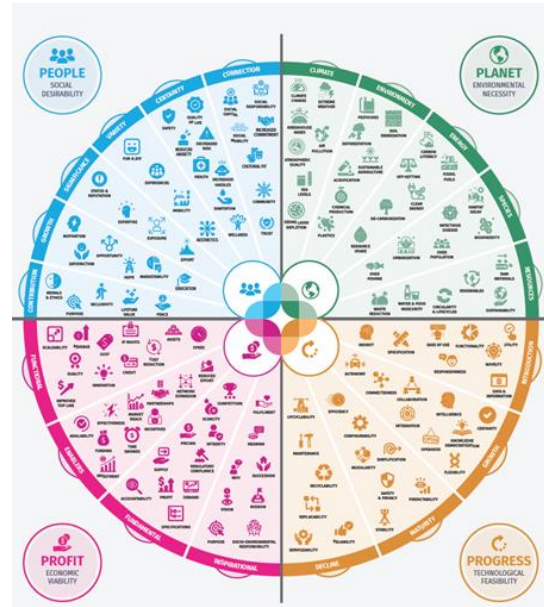


Figure 4 - Value types wheel [15]

The concept of KV will be analyzed across the UCs in the project, this increased visibility not only benefits the wireless industry but also aids non-technical adopters, such as users in the public, commercial, or environmental sectors, to understand the advantages. As explained in the literature review section of this paper, the concept of KV and KVI were recently investigated by several research groups. Figure 5 shows the steps and the questions to properly define the link between KVs and KPIs [1].

As shown in Figure 5, the adopted methodology starts by defining the KVs that are relevant to the project UCs, and then provides an assessment of those values, i.e., KVIs. It is also worth analyzing the enablers of these KVs and the technical impacts of the values, i.e., KPIs. For example, in the case of environmental sustainability being considered as a KV, KVI could be assessed by measuring the CO<sub>2</sub> emissions of a mobile network associated with delivering the UC.



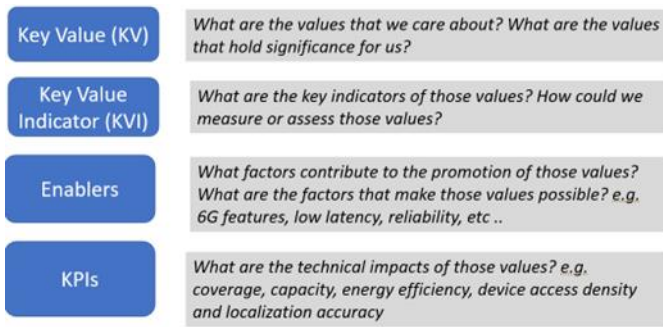


Figure 5 - Steps and questions to define KPIs from KVs

Some of these values can be translated into willingness to pay and revenues that feed into commercial business models and make new technological innovations commercially available and sustainable. Others can be used to show organizational, societal and governance targets being met, according to the way new technology is being used. Depending on the business and investment model being used to drive the realization of new technologies, there will be a natural ranking and prioritization across the identified KVs.

The framework proposed in TrialsNet categorizes the values as illustrated in Figure 6, with the resulting categories of:

- Economical
- Environmental
- Societal

This categorization will ideally help with the prioritization of KVs for each use case depending on the direction of the business and investment model.

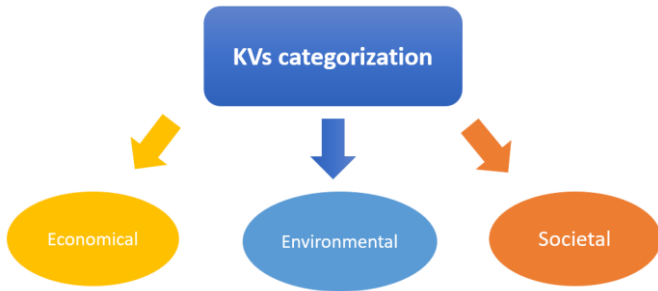


Figure 6 - Categories of KVs

Some values may belong to one category, two categories or even three categories. Some KVs have an economical value by generating business benefits and at the same time have societal value by contributing to the well-being of the society. For example, the KV “business effectiveness” belongs principally to the economic category, as businesses are more efficient and productive, hence eventually higher growth and profit occurs. However, this KV can also have a positive effect on the well-

being and development of society: a lower unemployment rate is a possible outcome when businesses grow.

#### IV. CONCLUSION

This paper has provided a comprehensive exploration of the evolving value and business model landscape in the telecommunications sector with the advent of 6G technologies. By introducing and emphasizing the significance of KVIs alongside traditional KPIs, this paper addresses the importance of evaluating the societal and environmental impacts of 6G beyond technical benchmarks. This paper underscores the industry's commitment to demonstrating the wider benefits of 6G and steering technological development toward value-driven outcomes. As we advance into the era of 6G, this holistic approach, grounded in the principles of sustainability, inclusiveness, and trustworthiness, will play a pivotal role in shaping a technologically advanced future that aligns with the broader values and aspirations of society.

#### ACKNOWLEDGMENT

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