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Leveraging Technology for Value Creation in the Context of Smart Cities:

Five Potential Approaches | Blockchain in the Energy Market

Louisa Kreis von Ratibor (46308)

Work project carried out under the supervision of:

Professor João Nuno Lopes de Castro

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Abstract

This master thesis report investigates the potential of five different innovations for value creation in the context of Smart Sustainable Cities by 2050, applying the research question "How to create value by entrepreneurially using innovations in Smart Sustainable Cities?". Primary (interviews with experts) and secondary research was conducted. In-depth analyses and assessments of value creation and sustainability; critical examinations of the five innovations' challenges, interconnections, and potential are performed, concluding that by applying disruptive technology that surpass the requirements of the Smart City Canvas, leverage environmental sustainability without sacrificing price, quality or other advantages, value creation is ensured.

Keywords: Digital Business, Technology Strategy, Smart Cities, Sustainability, Technology, Entrepreneurship, Innovation, Value Creation, Digital Transformation, Business Model, Technology Adoption, Technological Innovation, Sustainability Assessment, Sustainable Development Goals, Mobility, New Product Development, Smart Sustainable Mobility, Mobility-as-a-Service, Biophilic Design, Green Buildings, Sustainable Architecture, Renewable Energies, Energy Efficiency, Energy Management, Clean Energy, Energy Market, Peer to Peer Energy Trading, Blockchain, Financial Technology, Fintech

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Table of Abbreviations:

Agtech: Agriculture Technology

AI: Artificial Intelligence

AML: Lisbon Metropolitan Area (Área Metropolitana de Lisboa)

App: Appendix

BC: Blockchain

BD: Biophilic Design

CA: Conventional agriculture

CAPEX: Capital Expenditure

CE: Circular Economy

CF: Cash Flow

DIY: Do It Yourself

EGME: Eletric Mobility Network Regulator (Entidade Gestora da Rede de Mobilidade Elétrica)

EM: Energy Market

EV: Electric Vehicle

FF: Freight Farms

Fintech: Financial Technology

GHG: Greenhouse Gas

ICE: Internal Combustion Engine

IoT: Internet of Things

ML: Machine Learning

P2P: Peer-to-Peer

R&D: Research & Development

RE: Renewables or Renewable Energy

RQ: Research Question

SDG: Sustainable Development Goal

SG&A: Selling, General & Administrative

SME: Small- and medium-sized enterprises

SUMP: Sustainable Urban Mobility Plan

TML: Transports Authority for AML (Transportes Metropolitanos de Lisboa)

UN: United Nations

UNECE: United Nations Economic Commission for Europe

VC: Venture Capitalists

VIF: Vertical Indoor Farming

1. General Introduction

"If we could build an economy that would use things rather than use them up, we could build a future. There is a massive economic opportunity out there to be taken without waiting for government legislation. When you start, you're trying to achieve staying alive and getting home."

– Ellen MacArthur

How will we live in 30 years? The answers to this question can be very diverging, but one thing is certain - the world will change dramatically. In the context of digitalization, Smart Cities is a concept that is constantly being discussed. New urban projects offer their inhabitants a vast amount of possibilities, of which many are still undiscovered and there is much to understand still. The state of affairs regarding this topic is constantly shifting and incorporating innovations and concepts that until very recently would have been considered futuristic but now are a reality.

Added to this is the growing importance of sustainability since issues such as the climate change, increasing scarcity of raw materials, and lack of urban space will be decisive not only for the coming years but for the future generations that are yet to come. It is the responsibility of companies and innovators to entrepreneurially tackle problems that now urge to be solved, as the consequences of ignoring them can be disastrous.

Therefore, the question which needs to be answered is: How to create value by entrepreneurially using innovations in Smart Sustainable Cities?

1.1. Previous research

"Smart city concept enjoys different aspects and a variety of definitions" (Mohseni 2021), meaning there is no unambiguous way to describe them in a sizable pool of research.

According to Anand Prakash (2019), the concept of Smart Cities was invented by an information technology firm, the International Business Machines (IBM) Corporation. First, the words "smart" and "cities" were separated, and several definitions analysed. It is then concluded that a Smart City is a city in which many essential business problems – such as "organized power supply, provision of clean water, strong civic infrastructure, sewage, and waste treatment plant, rainwater harvesting and solar energy through advanced connectivity" – are tackled. Often a Smart City is also defined as a city "that monitors and integrates conditions of all of its critical infrastructures, […] can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens" (Hall, 2008).

Research about Smart Cities has suggested various components and features that also range between many different areas, such as infrastructures, buildings, transportation, energy, health care, financials, governance or education (Mohseni 2021). Other definitions include other "aspects of urban life, such as urban planning, sustainable development, environment, energy grid, economic development, (…), social participation and so on" (Prakash 2019).

While discussing these components that compromise Smart Cities, the concept of sustainability becomes increasingly relevant. According to Virtanen (Virtanen, Siragusa, and Guttorm 2020), "the Brundtland Commission initially provided the notion of 'sustainable development' with its three intersecting and ranked hierarchically pillars (social, economic, environmental)".

To achieve the functioning and building of Smart Cities with sustainable methods, a modern and technology-driven approach (Prakash 2019), meaning technological and digital innovation, needs to be involved. So, the concept of 'Smart City' is outlined by its technical core, which, in turn, is inspired by advances in computer science and engineering field (Prakash 2019).

1.2. Research Gap and Aim of the Work Project

This work project considers the existing research and focuses rather on the exploration of innovative methods to make cities smarter and more sustainable through technological or digital innovation. A preliminary analysis of several innovations will be performed, which allows a scoping of five approaches that were selected due to their high potential for value creation and contribution towards sustainability.

The objective is to get insight into different, individual dimensions within Smart Cities, that are backed up by an innovative technology or digital platform. Within these individual dimensions, it will be determined how value is created and its impact on the environment, economy and society. In this way, a better impression can be created of what our lives will look like in 30 years from now. To delimit the analyses, it will be geographically focused on Europe, and the timeframe will be set until 2050.

1.3. Research Question

The above-described gap and research objective lead to the following defined Research Question (RQ) that will be explored throughout this paper: How to create value by entrepreneurially using sustainable innovations in Smart Sustainable Cities?

This question is separated into three main topics: technological innovation, sustainability assessment, and value creation. The first topic, technological innovation, will be tackled by defining five key areas of focus of this research. The work project aims to analyse the value these innovations create in this setting of cities of the future. After analysing the current state of affairs for each specific case, the second and third topic will be tackled by performing a value creation and sustainability assessment must. Theses assessments will be conducted through several formats, resulting in a critical discussion on the connection between these two dimensions.

Therefore, value creation must be defined in a specific way to understand better the question at hand. This can give us insights into the structure and analysis of this work project. Value Creation is achieved when a company generates added benefits for its customers through its work and resources. It can be assessed through different approaches. One way to validate it is to understand if the solution generates benefits of any kind for all the stakeholders involved. At the same time, it is important to assess what is the extent of these benefits. Another methodology is to assess the financial viability of the company business model, thus proving that financial value is created. Throughout this work project, the five different innovations presented will assess value creation using different methods.

This work project aims to answer the RQ on the ground of these dimensions of value creation on each of the subtopics and through a comprehension at the end. As mentioned in Chapter 1.1., sustainability comprises a social, economic, and an environmental dimension and will be explained in the later chapters. Each one of these can be tested and validated in different ways, ranging from gathering of primary data to question how citizens and other stakeholders are impacted to thorough research of available data to validate whether all of the dimensions are met, or even through a quantitative analysis of potential environmentally sustainable impact that an innovation can bring.

To thoroughly answer the RQ, it is additionally essential that a future outlook is provided to give a clear understanding of the state-of-the-art, potential, and associated implications of the innovation at the moment and in the future.

1.4. Supporting Questions

To answer the RQ as precisely and accurately as possible, it is necessary to define supporting questions first, which lead to the overall RQ, to ensure a clear understanding of every individual aspects. These questions will be answered in the General Conclusion, functioning as a final

validation framework of the conclusions that were the product of each of the innovations analysed.

For what do sustainable innovations create value?

To analyse and explain how to create value by entrepreneurially using sustainable innovations in smart sustainable cities, the output that the sustainable innovations lead to must be defined. Additionally, the stakeholders or key areas affected must be defined.

Are current Smart Cities already applying/adopting these technologies/digital services?

The willingness to implement and adopt new technologies and digital services is fundamental for possible value creation. If this willingness does not exist, value creation is not even possible from the start. Therefore, the prerequisite for answering the RQ is to consider the readiness of Smart Cities to adopt and implement the technologies and digital services.

What are the key challenges of the innovation?

In addition to the state of affairs, the challenges that may arise are also considered. The extent to which each challenge can be posed as a barrier to entry can depend on micro and macroenvironmental factors. Still, an assessment of each challenge and understanding of the level of risk towards implementation that it poses is key to a critical analysis.

Are these innovations in these Smart Cities truly sustainable?

Another very important point, after analysing the possible value creation, implementation and risks, is to assess whether the listed innovations have a positive environmentally sustainable effect on Smart Cities.

After answering these supporting questions, based on the detailed analysis of the possible value creation of the different sustainable innovations in sustainable Smart Cities, the RQs of this

master thesis can be answered successfully.

1.5. Relevance of Research Question

Despite occupying only 2% of the world's surface, cities have a disproportionate climatic impact and energy footprint, according to C40, a network of megacities committed to tackling climate change. Cities consume more than two-thirds of the world's energy and produce over 70% of global emissions (‘Beyond Smart Cities: Why Smart and Sustainable Cities Are the Way Forward’ n.d.). Environmental externalities - primarily resulting from population growth, rapid urbanization, high private motor vehicle dependency, the deregulated market, mass livestock production, and excessive consumerism - have raised serious concerns about the future of natural ecosystems in which we are a part of. Global climate change, one of the most significant problems humanity has ever faced, directly influences people's well-being and, in the long term, on humanity's existence (‘Climate Effects on Health | CDC’ 2021). In the past two decades, the concept of Smart City, especially the sustainable development of Smart Cities, has increasingly become the focus of attention in the fields of technology, science, urban and environmental planning, development and management, as well as for urban decision makers and practitioners. This was caused by digital technologies being a key enabler in stimulating paradigmatic transformations in visions, strategies, execution, and learning connected to urban development.. The combination of technocentric and environmentalist views is a path to the ideal urban form of the 21st century (Ahad et al. 2020).

1.6. Organization of Work Project and Delineation of Field of Study

In the following section, the structure of this paper and the procedure for answering the RQ will be explained. First, the basic building blocks for answering the question are laid in Chapter 2. For this purpose, a precise definition and literature review of Smart Sustainable Cities, along with an historical context and the analysis of existing Smart City business models will be performed. Furthermore, sustainable innovations in the context of Smart Cities will be defined.

The potentials, challenges, trends, and developments of these are examined in more detail. Next, the delimitation strategy is described by breaking down the general overarching theme of Smart Sustainable Cites to the focus of sustainable innovations within Smart Cites. After the basic building blocks have been laid, the methodology used in the further work for the analysis and application of the RQ is discussed in Chapter 3. For this purpose, the used data sources are listed, and the methodology used to define the five key innovations chosen is explained. The analytical methods to assess entrepreneurial and sustainable value are outlined in each individual part. In the following chapters, five different sustainable innovation areas within Smart Sustainable Cities are discussed in detail, ranging from smart sustainable mobility, vertical farming, and biophilic design to Fintech and blockchain in the energy market. Thereby, an analysis will be carried out on how and to what extent these sustainable innovations create value in Smart Cities. In Chapter 3, a general discussion of the research project will be conducted. Finally, the limitations of the RQs are discussed, and a look into the future of sustainable innovations in Smart Cities is ventured.

The RQ will be elaborated in the field lab "Technology Strategy" focusing on sustainability. The question was derived by breaking down this defined topic area into various possible application areas. The choice fell on the application area Smart City since, within a Smart City, multiple stakeholders and dimensions are affected by the implementation of new technologies. To create a link to sustainability, it was decided to limit the topic to innovations , that make cities smarter and more sustainable, as this topic is of significant relevance today, as explained in Chapter 1.2.

2. General Literature review

2.1. Delimitation Strategy of the Literature Review

As previously demonstrated, Sustainable Smart Cities contain a wide range of cross-cutting

topics that can be evaluated within an in-depth analysis. Although this type of analysis would enrich the research in terms of content, this work project will limit the focus of the research to sustainable innovations.

The urgency of adapting the traditional business models to preserve the human species and environment to guarantee a future for the new generations has never been higher. In many societies, the government is responsible and leading the innovation policy. These innovation processes are, however, often hindered by extreme bureaucracy. Therefore, innovations are typically tackled and achieved by entrepreneurs, adapting and creating new business models, in a faster and more efficient manner.

2.2. Smart Sustainable Cities

2.2.1. Definition

As previously established, the concept of Smart Sustainable Cities is very innovative and can have several definitions. To establish which new technologies can entrepreneurially create value for smart sustainable cities, a definition of "smart" and "sustainable" needs to be set up first. The UN in 1987 defined sustainability the following way: "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Nations n.d.). United Nations Economic Commission For Europe (UNECE)'s definition distinguishes both parts of the concept of Smart Sustainable City very clearly, defining it as "an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" ('Sustainable Smart Cities | UNECE' n.d.).

Dr. Rudolf Giffinger and the European Smart Cities research group at the Centre of Regional Science of Vienna University defined six Smart City areas of action (Giffinger 2015), which were later popularized in Dr. Boyd Cohen's "Smart Cities Wheel" (Cohen 2018). Although

these areas only refer to the sustainability dimension of Smart Sustainable Cities, they will be applied in the further work project to categorize the innovations assessed and to assess their sustainability according to the parameters defined in UNECE's definition.

The first area of action is "Smart Government", which includes creating synergies between the government and all stakeholders through the creation of policies, fostering transparency, and taking a digitally innovative approach. The second area, "Smart Economy", comprises the use of an entrepreneurial spirit and technology to create economic efficiencies, such as making a city more attractive for new businesses, and leading to local and global interconnectedness. Thirdly, "Smart Environment" relates to urban planning and the management of all key city infrastructures, ranging from waste management to the energy sources that are used. "Smart Living" also focuses on quality of life, but from a social standpoint. It relates to the access to basic services such as healthcare, housing, and the internet, and how access to these key infrastructures is enabled. "Smart Mobility" concerns the maximization of the efficiency of urban transports, making it more economically and environmentally sustainable through innovative and technological solutions. Finally, the sixth dimension – "Smart People" – focuses on the interaction with each other and with the public and private sectors. A Smart City should provide accessible and inclusive measures that foster the participation of all stakeholders in the city's matters through the implementation of intelligent solutions.

2.2.2. Historical Evolution of the Concept

As the definition of Smart Sustainable Cities has been established, taking into consideration the status quo for being "smart", "sustainable" and a "city", it is important to stress that this concept has evolved and changed over time, due to the constant development of society. In fact, Höjer and Wangel stated five key areas that ultimately led to the origin of research of the Smart Sustainable Cities concept (Höjer and Wangel 2014) – globalization of environmental problems and sustainable development, urbanization, and urban growth, sustainable urban

development and sustainable cities, information and communication technologies and Smart Cities. By understanding the latest developments within these five key areas, it is possible to trace the historical development of the Smart Sustainable Cities concept.

For a long time, environmental problems were perceived as local issues. In 1972, the Stockholm Conference – the first United Nations conference that focused on international environmental issues – these matters started to be perceived as a global concern, and the foundation for global environmental governance was set (United Nations n.d.). Later, in 1987, the concept of sustainable development appeared through the Brundtland Report (also known as "Our Common Future"), released by the World Commission on Environment and Development. In this report, sustainability was defined, as previously mentioned, as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Additionally, among other results, the report set the grounds for the 1992 Rio Summit, in Rio de Janeiro, which ultimately led to the creation of the UN Commission on Sustainable Development in the same year. This commission was created with the purpose of tracking and implementing Agenda 21 – the output of the Rio Summit -, which was strongly reaffirmed at the World Summit on Sustainable Development held in 2002 in Johannesburg (United Nations n.d.). Other key events that were essential to international cooperation for environmental sustainability were the Kyoto Protocol in 1997, which consisted in a commitment to reduce GHG emissions through binding individual targets, requiring stronger efforts from developed nations (UNFCCC n.d.), and the Paris Agreement in 2015, which requires effort from all nations and introduces a higher level of flexibility and national ownership, allowing countries to set their own emission targets according to their development level (United Nations 2015). Even though the literal definition of "Smart Sustainable City" words has not been previously applied, the political, environmental, and economic factors that have been evolving over time lead to an update of past policies, adapting them to the current

state of affairs. Therefore, it is essential to mention the European Green Deal, which is a "new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" (European Comission 2019). It was proposed at the end of 2019, amidst a rise of global leaders that are considered to be hostile to the climate action cause, such as the former President of the USA, Donald Trump, and the current President of Brazil, Jair Bolsonaro. As so, it was not only a call for action for environmental purposes but also a political statement from the European Commission, presided by Ursula von der Leyen, as to what the priorities should be for the next decades, until at least 2050. It focuses on key areas of action, defining how to develop Smart City infrastructures and ultimately stating what factors need to be met to be considered as a sustainable city, and which policies and technologies should be developed to have a smarter path towards a more sustainable future.

It is expected that, as technology, policies, and cities evolve, the concept also shifts. To understand potential reasons for a transition and assess the value Smart Sustainable Cities can create, the City Model Canvas framework, introduced in the next chapter, will be used.

2.2.3. Key Concepts Related to Smart Sustainable Cities

The following concepts will be relevant for this work; Sustainable Development Goals (SDGs), the Three Principles of Sustainability, the ESGs, the Circular Economy, the Well-to-Wheel Analysis.

The Global Sustainable Development Goals (SDGs) ('THE 17 GOALS | Sustainable Development' n.d.). will be applied, which were created by the UN in 2016, as these can more distinctly describe the individual contributions of each innovation even though they might not be related. This helps to better frame and assess the innovations with regards to answering the RQ. In addition, the SDGs are very contemporary and are a global standard. Those define

sustainability goals in 17 areas, which bound every aspect together in one concept even though they do not seem related at first sight. This is the upside of applying the SDGs in the frame of this thesis as well. In the individual thesis report that tackles specific innovations, sustainability concepts are applied to assess and determine if the discussed innovation can be considered sustainable or not. For that, the definitions of sustainability (UN and SDGs) plus additional frameworks such as Circular Economy will be applied.

In connection to Smart Sustainable Cities, it is crucial to mention that sustainability can also be assessed by differentiating and analysing the technology at hand with the help of the three principles; environmental, social, and economic sustainability. Based on this dating definition, the concept of ESG emerged and became a standard in the financial world. Even though investing, transactions and loans might not be connected to sustainability, the history of sustainability concepts is linked. ESG stands for the pillars of sustainability: Environment, Social (Society), Governance (which stands for the governance of economic bodies). Nowadays, different standards of ESG are used to classify e.g. investment funds. For example, the higher the ESG standard, the more selective the screening process becomes for assets in one fund (eg. MCSI World (1601 Assets); MSCI World ESG Screened (1506 Assets); MSCI World ESG Enhanced Focus (1490 Assets); MSCI World SRI (386 Assets) (Zeiter 2021). Furthermore, banks, insurances, and other financial bodies express their contribution to sustainability in ESG terms.

Another concept that is more strictly bound to the concept of Smart Cities is Circular Economy (CE), which can be used to assess the environmental sustainability of an innovation. The advantage of the concept is that the Ellen MacArthur Foundation cooperates with firms that focus on Smart Cities. Often, it is required that autonomy in the food supply is needed for an urban population in a Smart City, which would mean that a working Circular Economy has to be applied. Looping back to the initial definition, a wasteless city is the goal also of the dating

definition from the UN, as waste necessarily harms future generations as even treated waste occupies space. If a working CE is applied, no waste is generated, all materials are resources, regardless of the state. This transformative approach has also the advantage as physical processes can be assessed based on their output of harmful material (e.g. CO_2) or waste created.

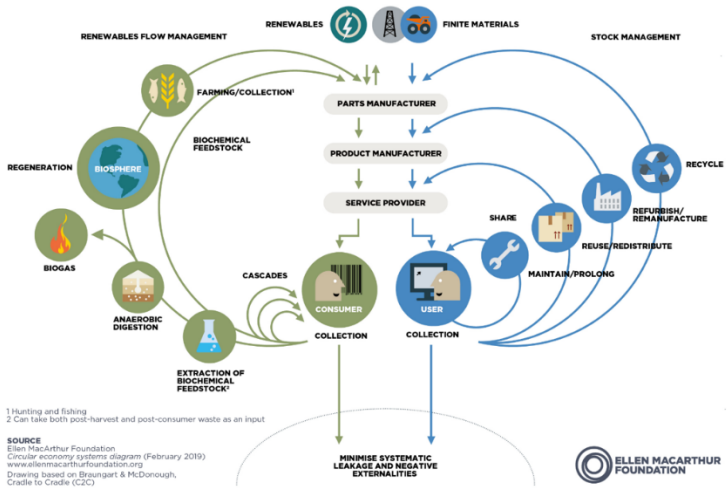

Figure 1: Circular Economy: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C) ('Intelligent Assets: Unlocking the Circular Economy Potential' n.d.)

Finally, a more quantitative concept is the Well-to-Wheel Analysis, which is a policy-neutral methodology that allows for the calculation of GHG emissions, energy efficiency, and industrial costs associated with several types of fuels, as well as respective technological implications. As shown in the figure below, this analysis focuses on the emissions exhausted from well to tank – meaning, from the moment these are produced to the moment these reach the fuel tank – and tank to wheel – meaning, the burning of the fuel. (Nieuweling 2016)

Those concepts are no definite answer to the question of what is and how to get to ultimate sustainability as there is no clear answer to it. Rather, those serve us as possible ways to assess the innovations presented in the context of Smart Cities, even though they seem unrelated. And the concepts show that those innovations are connected through the criteria posed.

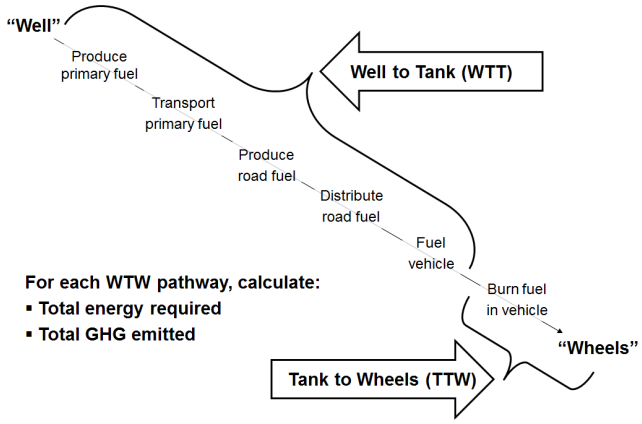

Figure 2: Graphic representation of the Well-to-Wheel Analysis

2.2.4. Smart Cities Business Model Canvas

To analyse sustainable value creation in depth the Business Model Canvas is applied. According to Alexander Osterwalder, creator of the Business Model Canvas "the Business Model describes the logic by which an organization creates, distributes and captures value" (Osterwalder, Pigneur, 2010). Essentially at the corporate level, the company creates value, markets it to the market, satisfying the desires of consumers, and obtains for itself a share of that generated value, i.e. profit. The Business Model is not a strategy, but a concrete and immediate tool, not based on the future but the action in the present (Magretta, 2002).

Humankind, who increasingly moving towards urban centers, representing a wide range of innovations and development to satisfy the daily needs, pushes the city apparatus to provide adequate services that can enhance the living experience within the social context. Thus, in recent years, cities have sought to accelerate the innovation process, using technologies that simplify citizens' lives such as the Internet of Things (IoT), Artificial Intelligence (AI), and Blockchain (BC). Population growth, largely due to the influx of people populating large urban centers for greater economic opportunities, has pushed cities to ensure an improved quality of life by focusing mainly on environmental impact, safety, mobility, and public and private health. Smart Cities are those that use new technologies to solve society's daily urgent tasks

such as housing, transport, and energy in urban planning and governance. To realize them, investments in Smart Cities are the result of complex relationships between the public sector and private leaders, who together contribute to the final result. Therefore, all these solutions need to be mapped correctly according to a business model that is fit for purpose. But how can we apply a Business Model to Smart Cities? As previously mentioned, the Business Model Canvas is one of the best tools to synthesize and analyse value creation through a business or technology. The canvas consists of nine building blocks divided into key partners, key activities, key resources, value proposition, customer relationships, channels, customer segmentation, cost structure and revenue streams (Timeus, Vinaixa & Pardo-Bosch, 2020).

It is a very useful tool to graphically represent all the fundamental components of a business model in a single image, while still being clear and useful to understand how the company works and how to create value or find new business opportunities. A more recent and extended version of the Business Model Canvas adapted to Smart Cities, proposed by Díaz-Díaz, Muñoz and Pérez-González called *City Model Canvas* (Timeus, Vinaixa & Pardo-Bosch, 2020). By adding an environmental dimension to the economic assessment of business models, it helps municipalities to deliver value sustainably, which will be used within the research.

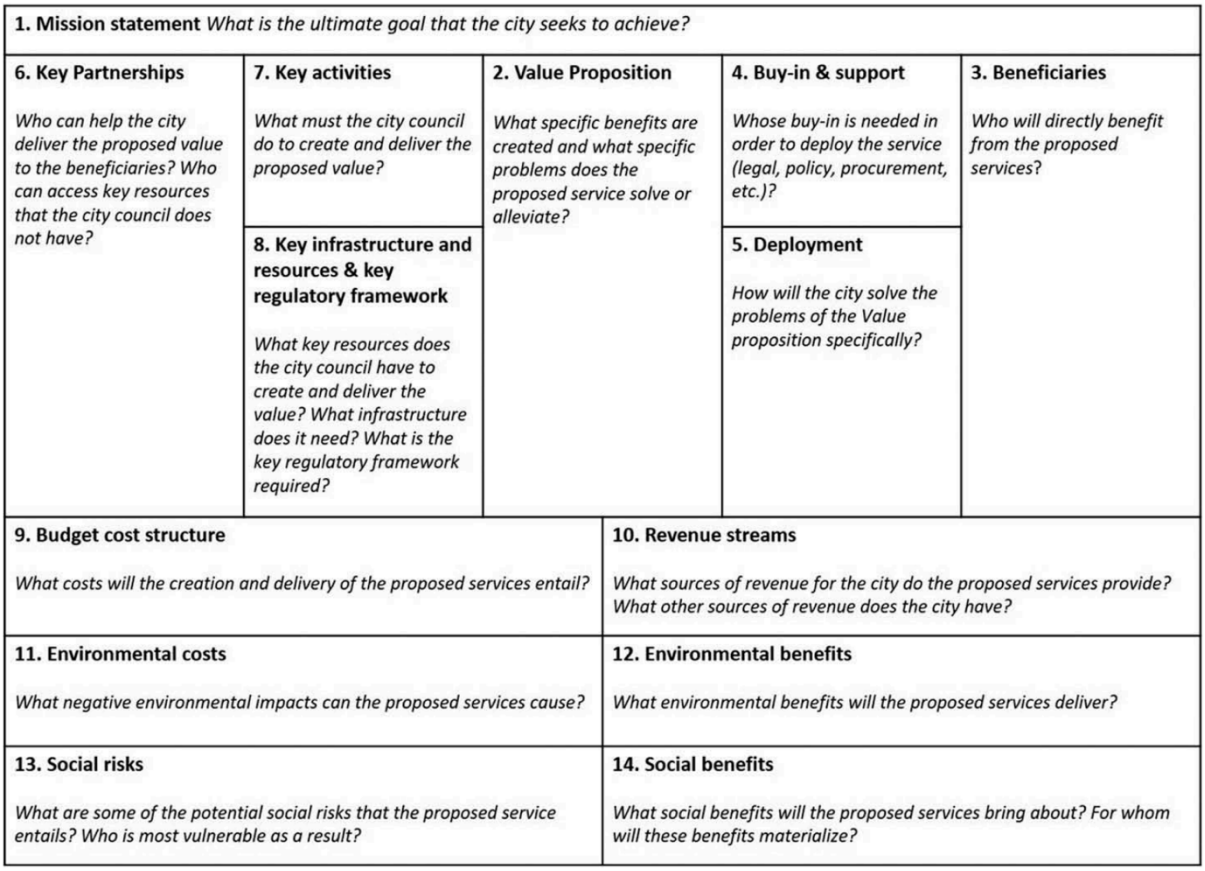

Figure 3: City Model Canvas

It consists of 14 blocks that are divided into four parts. The first part of the model concerns the presentation of the mission, i.e. the objective the city wants to achieve and the value proposition. The second part focuses on stakeholder action and the logistics of service delivery for citizens. The third part focuses on all aspects of value creation, in particular financial resources, infrastructure, and political resources. The fourth and final part consists of an assessment of the economic, social and environmental costs and benefits of the intelligent service to be proposed (Joyce and Paquin (2016). With this tool, not only the economic feasibility of the project is being assessed, but above all the sustainable impact it has on society and the environment.

2.3. Sustainable Innovations

2.3.1. Definition in the Context of Smart Cities

As previously established, sustainability is one of the requirements of Smart Cities, so innovations that benefit that pillar could already be regarded as sustainable innovations in the context of Smart Cities. However, sustainability in Smart Cities might have different definitions compared to e. g. sustainability in the context of Circular Economy or sustainable development. For this purpose, the definition of sustainability that was set in Chapter 2.2.1 - "meeting the needs of the present without compromising the ability of future generations to meet their own needs" – is relevant to define sustainable innovation.

To bring all relevant terms into context and provide consistency through the overall work project, a definition of innovation is necessary. As such, "Innovation is the creation and implementation of new processes, products, services, and methods of delivery which result in significant improvements in outcomes, efficiency, effectiveness or quality" (Eveleens 2010).

Finally, after defining the concepts of "sustainable" and "innovation", it is clear that the concept of sustainable innovation comprises the creation of a new tangible or intangible component that causes significant improvements in any area without harming others. This definition is in accordance with the definition given by Lee, who defines sustainable innovation as the creation of or adaption of existing products or services to achieve sustainable social, environmental, and ecological impact, while at the same time generating profits for the company. Through sustainable innovation, companies can create and deliver products or services that directly can contribute to sustainability (Lee n.d.).

In the context of this thesis, innovation has two major criteria: 1. It has to create value in the sense that it can be entrepreneurially harnessed and ultimately, profits can be achieved. 2. One aspect of sustainability has to be benefitted without harming another one. This is due to the complexity of sustainability (Tainter 2006), which implies potential downsides to every achieved progression. The most prominent example is that a more efficient technology (which could be beneficial e.g. carbon reduction due to more efficient usage) often leads to higher

consumption, which on the other hand has a negative influence on the absolute CO_2 emission balance. Therefore, this report aims at considering innovations that are not bound to this effect but are truly benefitting one area of sustainability (e.g. carbon reduction despite increased demand).

2.3.2. Potential for Sustainable Innovation

The biggest potential stems from the value created by sustainable innovations as a multitude of aspects are tackled at the same time. First, Smart Cities benefit from businesses that are successful and this can be the measured by the value generated for the inhabitants. Second, such an innovation would not only create value in terms of a service or product to the customers, but also leverage the sustainability of the service or product. For example, if the innovation creates a product that cuts 50% of the CO_2 emissions compared to its conventional counterpart and represents an integral part of a Smart City, then multiple desired outcomes for Smart Cities are pursued at the same time.

2.3.3. Challenges of Sustainable Innovation

The special context of Smart Cities, in which innovations should be integrated, poses a unique set of difficulties, that need to be overcome to foster value and succeed in such a market. A few findings are outlined:

1. The Articulation of technological innovation and change to the lifestyles of the individuals: Smart cities require a different lifestyle for the inhabitants compared to conventional cities. This inevitability becomes even more dominant when innovations are not only radical by the concept but also by implication. Therefore, if the implication of a disruptive technology offers or forces an adapting behaviour of a user, then resistance might be one of the reactions (Saujot & Erard 2021).
2. The complexity of intersectionality: Like the complexity of sustainability intersectionality can pose challenges to the interactivity of innovations and their users.

This is mainly an issue of infrastructure and data management and applies if the innovations are integrated in such a way that interdependency is the result (Saujot & Erard 2021).

3. The organisation of citizen participation: This point is highly business-model-specific and depends also on the innovation itself. For example, some business models require the users to be administers at the same time, which poses challenges in terms of communication misconduct questions and role issues. Furthermore, the business model identified (Saujot & Erard 2021)
4. The collaboration of public and private partners: What seems like a communication problem also is a funding problem and is, again, a specificity that arises from the applied business model (Saujot & Erard 2021)

3. General Methodology

3.1. Time Horizon and Geographical Delimitation

The time period and geographical area investigated are limited to answer the RQ in a more targeted and detailed manner. This paper examines only sustainable innovations in Smart Cities within Europe. Furthermore, the time horizon limitation is set to the year 2050. This determination was made based on the European Green Deal by the EU and following the EU's Paris Agreement commitment to global climate action. The key objective of the European Green Deal by the EU is to be climate-neutral by 2050, based on the fact that the targeted 1.5ºC to 2ºC increase in global warmth is the maximum that the planet can take without bearing uncontrollable consequences.

Furthermore, by 2050 the EU aims to become an economy with net-zero GHG emissions. To reach this goal, the EU aims to provide 100 climate-neutral and Smart Cities by 2030. Furthermore, according to the EU Commission, cities are a significant factor in achieving this mission of climate neutrality by 2050, as they account for only 4% of the EU's land area. Still,

the cities house 75% of EU citizens, using more than 65% of the world's energy, and produce more than 70% of CO_2 emissions ('EU Mission: Climate-Neutral and Smart Cities | European Commission' n.d.). Based on the EU's mission and the remarkable role of Smart Cities, the delimitation for this RQ was set.

3.2. Rationale of the Selection of the Innovations

Based on the previous chapter, recent trends were identified, which led to innovations commonly associated with Smart Cities in the context of sustainability. In addition, contemporary sources identify key technologies that were also considered in the frame of this report. For the selection of the five innovations further deepened in the subtopics a pool of 22 suitable and relevant innovations was selected and analysed through an Innovations Scorecard, presented in Appendix 1.1. The innovations are ranked based on the following criteria to assess their usefulness in this thesis and rated with a 3-point system.

The final score for each innovation results on the weighted average of the score attributed to the following variables:

Quality of life (15%). 3 points: An innovation has a significant positive impact on the quality of life throughout different areas of life; 1 point: No or negative effect on the quality of life through the innovation.

Efficiency of urban operation and services (15%). 3 points: A significant increase in efficiency in at least one of the mentioned areas (communication infrastructure, waste, energy and mobility); 1 point: No increase or a decrease in quality in urban operations and services.

Competitiveness (15%). 3 points: The innovation and its business model have a solid and differentiated value proposition compared to competitors; 1 point: Weak or common value proposition.

Economy (15%). 3 points: Long-term economic growth and profitability are expected for the innovations and its business model; 1 point: Long-term economic growth is not expected, or

decrease is expected.

Environment (15%). 3 points: The innovation (almost) causes no harm to the environment (e.g. air and material pollution/land usage/resource exploitation/biodiversity loss/biomass loss etc.) or even recovers prevalent environmental damage; 1 point: The innovation does not improve / not significantly improve environmental standards compared with the conventional counter technologies.

Society and Culture (15%). 3 points: A Life-changing positive impact in societal & cultural factors is expected through the implementation of the innovation; 1 point: No or a negative impact in societal & cultural factors is expected.

Own Interest/Experience (10%). This category is based on interest and experience. It is ranked from no (1 point) to strong interest (3 points).

The highest ranks are the innovations discussed in the individual chapters: Fintech (Ø 2,55), Blockchain in the Energy Market (Ø 2,55), Vertical Farming (Ø 2,4), Biophilic Design (Ø 2,4), Cooperation for Sustainable Mobility (Ø 2,7).

3.3. Resources and Data Sources

For the analysis of all sustainable innovations, both primary and secondary data were used for data collection. The primary data was generated using semi-structured interviews with experts and surveys. The secondary data was collected through in-depth analysis of contemporary sources, existing studies and academic papers, with a focus on the quality of these to ensure the highest academic quality of the work project. A detailed description of the resources used and the approach to data collection is provided in the individual sections of each innovation.

4. Motivation

The authors of this paper were driven by different motivations to contribute to the academic community with the analysis of each subtopic. The climate emergency is real. To achieve climate neutrality, a 90% reduction in transport emissions is needed until 2050 (European

Commission 2019). However, innovations and technology are the opportunities the world needs to exploit today to achieve sustainability goals. The cause of “technology for good” allowed to highlight the economic benefits of the sharing economy for cities in the branch of Smart Mobility. The reason for the focus on Biophilic Design, on the other hand, stems from the focus on a state of human well-being, a psycho-physical, mental, almost philosophical condition. The need for the human to live in a positive environment that can generate well-being and increase daily performance, using energy and hydraulic sustainability tools within the four walls. This fusion of art, design, and attention to future investments is the result of passion, academia, and the desire for a better quality of life. Vertical Farming represents an innovation that creates a value potentially recognized by every human being, since everyone has to eat, and this is an important driver for research. Furthermore, conventional agriculture needs to be revolutionized in terms of sustainability and indoor aquaponics represent a technology that leverages sustainability and has the potential to be economically scalable. VIF has the potential to become the new standard for growing leafy greens in urban areas in the next 10-30 years (Diaz, 2021), and can be used in a completely decentralized way, so with little initial capital an entrepreneur can grow the business from city to city, from a small scale to a larger one. Burning fossil fuels creates large amounts of carbon emissions and in addition in today's power grid due to long-distance transmission, there are significant energy losses. The idea of using Blockchain, a very recent technology with a large number of applications, to give the next generation a future with less inequality has motivated research to provide a timely and comprehensive review of possible solutions. Finally, coming back to everyday life, today Fintech has become an integral part of most people's daily lives. It facilitates human life every day, through the integration in various public services and easy usage through mobile devices. However, what needs to be considered about these opportunities are its sustainability and, above all, whether it can create long-term value.

5. Innovations

5.4. Blockchain in the Energy Market

1. Introduction

The modern world depends on electricity, and especially in urban areas, it is a crucial resource. Nevertheless, the grid and the systems in the background are often taken for granted, and people do not know or understand how they work due to high complexity. In recent years, there has been a general trend shifting the Energy Market (EM) to a more decentralized system than the traditional one. Negative consequences of the climate situation, economic bottlenecks, and social problems make innovative ideas and technologies indispensable (Yildizbasi 2021). There are already developments happening, which are needed to create a Smart Sustainable City. As claimed by a survey of the International Renewable Energy Agency Innovation and Technology Center (IITC), Renewable Energy (RE) is planned to cover up to 36% of the global grid by 2030 (Liu et al. 2020). However, this is not sufficient. Technologies like Blockchain (BC) can help provide solutions and drive the change even further in many areas of the industry by using an innumerable amount of distinct applications. Thus, this work focuses on answering the following Research Question (RQ): How to create value by entrepreneurially using BC technology in the EM in Smart Cities? It is necessary to comprehend the different concepts and look into real-life examples to understand the added value of this novel technology for future Smart Cities. Furthermore, public opinion has a critical view towards the EM, for example, regarding inefficiency, lack of transparency, and the dominance of big corporate players. Therefore, this work argues how those disadvantages of the status quo can be partly addressed. This is achieved by adressing for example BC based Peer to Peer (P2P) Energy Trading, looking at relevant stakeholders in the EM, and focusing on the issue of outdated regulations and their impact.

2. Literature Review

2.1. Energy Market – Electricity

The supply of electricity is partially provided by non-RE sources like burning coal, oil, and gas (Kumar et al. 2020) or by RE sources, like solar, wind, or waves (Shivakumar et al. 2019) (German main energy players and energy sources share in App. 5.1.). Both RE and non-RE enter a shared power grid to satisfy society's electricity demand (Energy n.d.). Compared to the conventional grid, there is also a so-called Smart Grid, which is bidirectional and decentralized (Kumar et al. 2020). This system is needed for the integration of Distributed Energy Resources, such as distributed RE, Energy Storage, or *EV* (Yang et al. 2021), often with the help of BC applications. This means that consumers can also become producers, so-called *prosumers*, producing their own energy and sharing excess electricity with society (Yildizbasi 2021) (see example of BC-based P2P Energy Trading steps in App. 5.2.).

Furthermore, Smart Grids focus rather on RE (Kumar et al. 2020), increased efficiency, and minimization of supply imbalances (Yildizbasi 2021). They might lead to increased flexibility, reduced transaction costs, and an improved understanding of power consumption in daily life (Christidis et al. 2021). This switch from a centralized to a more decentralized system, incorporating RE and more Distributed Energy Resources, is called Energy Transition and is also influenced and advanced by BC. Moreover, the Energy Transition is pushed ahead on EU level by promoting communication between relevant stakeholders (European Comission n.d.).

2.2. Blockchain

BC is a type of distributed ledger technology. Its main advantage is the decentralization (deeper explanation App. 5.3.) of processes by eliminating possible intermediaries (Yildizbasi 2021). Furthermore, the avoidance of the centralized structures, the involvement of several independent participants, and the increased transparency and traceability in combination with complex encryption lead to overall higher security (Andoni et al. 2019).

Nevertheless, to be applied extensively in all areas of people's lives, different challenges need

to be faced, like scalability and, in some cases, high involved costs (Andoni et al. 2019). Additionally, due to insufficient knowledge and too few contact points, the BC is still perceived as a black box from a significant share of society (Christidis et al. 2021). Besides, people currently believe that all BC applications use vast amounts of energy (McDonnell n.d.). This increases the controversiality of joining BC and EM. Therefore, many start-ups that use recently adjusted BC applications are trying to find solutions for the mentioned challenges. For instance, the application of BC-based P2P Energy Trading uses new mechanisms of validation that are less power consuming than the known ones used beforehand, for example, for Bitcoin ('Grid Singularity Technical Approach - Grid Singularity Wiki' n.d.). These are the promises start-ups and new developments are making. The BC-based P2P Energy Trading concept can be better understood through the already mentioned Appendix 5.2. and will be further explained in the use case analysis. Further information about BC can be found in Appendix 5.3.

3. Methodological Approach

The methodological framework of this work project is based on collected data using an analysis of academic papers and semi-structured interviews. The following table presents the crucial steps to understand the structure and aim of this work.

STEP 1	- RESEARCH ON THE TOPIC - **71 START-UPS/PROJECTS IN EUROPE**	Full list of start-ups with fields of activity (App. 5.4.)
STEP 2	- List led to 2 **INTERVIEWS** WITH STARTUPS: *1. Emanuele Rossi* 2. *Dr. Ana Trbovic* - Interviews led to **FOCUS on one field of activity**: BC BASED P2P ENERGY TRADING - **USE CASE** in that area was selected: GRID SINGULARITY	1. *E. Rossi:* Product and Innovation Manager at Flexidao (App. 5.5.) 2. *A. Trbovic:* co-founder + COO of Grid Singularity + Governing Board Member of both the European Institute for Innovation and Technology + the Energy Web Foundation (App. 5.6.)
STEP 3	- **USE CASE** ANALYSIS - **SMART CITY** ANALYSIS - **SUSTAINABILITY** ANALYSIS - **CHALLENGE** ANALYSIS **FOCUS on main threat**: REGULATIONS	→Social Business Model Canvas (App. 5.7.) →City Framework (App. 5.8.) →City Framework +SDG Ranking + SWOT Framework (App. 5.8.- 5.10.) →SWOT Framework (App. 5.10.)
STEP 4	- Interpretation of results based on the main threat - **DISCUSSION** OF 5 DIMENSIONS (D) - **IMPLICATIONS**/*OPORTUNITIES* OF D. - V**ALIDATION** OF D.: 1 **SURVEY** from an energy consumer prospective: 2 **INTERVIEWS**.: *1. Joscha Bröhrmann* *2. Christoph Dietrich*	Survey: 8 questions, 68 respondents (App. 5.11.) 1. J. Bröhrmann: Wind and Electrical Engineer - independent freelancer (at RWE) (App. 5.12.) 2. Christoph Dietrich: Research Scientist at Grid Singularity (App. 5.13.)
STEP 5	- Answering RESEARCH QUESTION + CONCLUSION - LIMITATIONS + FUTURE WORK	→Scenario Matrix (App. 5.14.)

Figure 4: Own representation of the key steps to understand the subtopics' structure and objective

4. Findings and Research Insights

4.2. Use Case Analysis: "Grid Singularity"

For a quick introduction to the use case and an overview of the vital information, the Social Business Model Canvas is applied partially (complete SBMC in App. 5.7.).

Grid Singularity was one of the first green energy BC ventures and, therefore, also named World Economic Forum Tech Pioneer in 2018 ('Ana Trbović' 2019). The firm is based in Berlin and was founded in 2016. They are working in partnership with leading BC technology developers, who are principal founders of the known open source not-for-profit organization, Ethereum ('Grid Singularity - Crunchbase Company Profile & Funding' n.d.). They are completely open-sourced, and they focus, among other topics, on BC-based P2P Energy Trading in local markets. The platform of *Grid Singularity* can not only be used by private individuals (e.g. prosumers) but also by other EM participants like grid operators, regulators, etc. (*Beneficiaries and Consumers*) (App. 5.6., Trbovic, interview). Different platforms and applications are provided, but the main one is the *Grid Singularity Exchange*, aiming to put the

individual in the centre of the energy system and on the same level with large energy suppliers. This is achieved by providing a simulation tool and operating interconnected grid-aware energy marketplaces. Users can simulate and implement P2P and community Energy Trading by generating local EM (*Core Intervention*) ('Grid Singularity' n.d.).

In comparison to competitors, they offer not only an exchange of energy certificates but also provide the actual trading facilities (App. 5.6., Trbovic, interview). The program is open-sourced (permissioned), internet-based, decentralized, and built on the most advanced BC technology, which is here used to incorporate the energy asset identity authentication and ensure transparency and automation (App. 5.6., Trbovic, interview). It provides a solution that could transform the current centralized energy model.

4.3. Blockchain in the EM in the context of Smart Sustainable Cities

This work aims to show the added value of the BC innovation for Smart Sustainable Cities in the future. As already stated in the general Chapter 1.5., 75%-80% of world energy consumption is attributed to cites, which also results in 70% of global GHG emissions ('Beyond Smart Cities: Why Smart and Sustainable Cities Are the Way Forward' n.d.). This makes energy a major topic of concern in cities and induces the need for innovative solutions, like BC applications, since it can help to increase life quality, the effectiveness in operations, and the competitiveness of the market (see how in the Smart City Framework App. 5.8.) (App. 5.5., Rossi, interview). All three points are also mentioned in the definition of Smart Sustainable Cities. Additionally, *Grid Singularity* facilitates the access and participation of individuals at local EMs. Citizens would therefore handle energy in smarter ways, as they would, for example, optimize their resources and reduce grid congestion (App. 5.6., Trbovic, interview). Thus, the BC seems to be a relevant aspect that should be considered for future cities. It will be needed to generate further advantages and a smooth flow of all activities and systems, which is described in the following sustainability analysis.

4.4. Sustainability Analysis

Within the context of sustainability, BC technology is generally known to positively impact four main sections: accountability, cybersecurity, traceability, and transparency (Fraga-Lamas and Fernández-Caramés 2020). To assess this sustainability, the Three Principles of Sustainability and the Social Development Goals (SDGs) offer an ideal framework for the analyses.

1st Principle: Environmental Sustainability - As analysed, the BC technology is partially environmentally sustainable. Research results show that it affects the following SDGs: 7. *Affordable and Clean Energy*, 11. *Sustainable Cities and Communities* and 13. *Climate Action.* This can be seen in the following results of the research. The innovation does improve environmental standards, for example, by integrating and encouraging the use of REs, and therefore lowering GHG emissions (App. 5.6., Trbovic, interview) (App. 5.5., Rossi, interview) (Yildizbasi 2021). This use of green energy supply is optimized by promoting self-consumption and improved investment in local RE production ('Grid Singularity Mission - Grid Singularity Wiki' n.d.). In this context, it is essential to mention that the network and the BC application used by *Grid Singularity* do not overuse electricity as they do not rely on a Proof of Work (PoW) mechanism of validation (App. 5.6., Trbovic, interview) ('Grid Singularity Technical Approach - Grid Singularity Wiki' n.d.). This presents a partial solution for high energy consumption by BC.

Nevertheless, it has to be considered that the environmental impact could be subsequently questioned. Even though the BC-based P2P Energy Trading is less harmful for specific environmental issues, it is still a technology based on energy consumption.

2nd Principle: Social and Cultural Sustainability - The use case analysis and research showed that this technology has a significant positive impact on culture and society. Thus, it could be stated that the following SDGs are positively influenced by this technology: 7. *Affordable and*

Clean Energy and 10. *Reduced Inequalities,* as demonstrated below. Furthermore, users can take information-oriented decisions because of transparent and accurate data (App. 5.5., Rossi, interview) (Christidis et al. 2021) (Yildizbasi 2021). It is essential to mention that, due to all the former discussed aspects, the costs for energy can be reduced and the affordability can be increased (App. 5.6., Trbovic, interview). Studies carried out by *Grid Singularity* together with German energy communities and prominent energy companies have revealed that the activation of local energy markets via *Grid Singularity Exchange* can increase community self-sufficiency and self-consumption by 7.7% and 5.7%, respectively. Furthermore, it can reduce energy bills by around 21%, which could be reinvested in additional storage or other distributed energy assets ('Grid Singularity Mission - Grid Singularity Wiki' n.d.). Therefore, this could lead to a minimization of financial and social inequality (Andoni et al. 2019).

Even though BC-based Energy Trading would lower energy prices in the long run for all participants, investments (e.g., in assets like buying EV, storage, PV) are expected to achieve more considerable benefits (App. 5.6., Trbovic, interview). Meaning other costs could emerge. From this point of view, social sustainability could be criticized.

3rd Principle: Economic Sustainability - As proven in the research and the use case, this technology will additionally lead to long-term economic growth and profitability, which would positively impact SDGs 8. *Decent Work and Economic Growth* and 9. *Industry, Innovation and Infrastructure.* As BC in the EM is growing at a fast pace, the economic impact is already established and will become even more prominent (Kumar et al. 2020) (Liew et al. 2021). Several sources are showing that the technology has high potential: From being described as a "game-changer in the energy industry" (Andoni et al. 2019) over assisting in establishing more competitive businesses (Christidis et al. 2021) to being forecasted to become one of the "leading tools in the energy sector" (Yildizbasi 2021). Apart from the direct supporting impact on economic sustainability, the platforms of *Grid Singularity* can promote further innovation

and create incentives (App. 5.6., Trbovic, interview). It additionally encourages prosumer-ship, local generation, and consumption, which is less costly than buying or selling energy directly from the grid while considering a more comprehensive range of individual preferences ('Grid Singularity Mission - Grid Singularity Wiki' n.d.).

There are some arguments against the positive effects of BC on economic sustainability because of the complexity of the topic. This negatively impacts the adoption and, therefore, scalability, as will be explained in the challenges section and the discussion.

The full framework with the Three Principles of Sustainability and the SDG ranking with other SDGs that are partially met are in Appendices 5.8. and 5.9.

4.5. Challenges of the Adoption for Large Scale Implementation

BC in the EM has many *strengths* (SWOT in App. 5.10.), many of which were shown in the previous chapter. Downsides and difficulties are mostly not displayed publicly and are therefore difficult to find. Nevertheless, some *threats and weaknesses* (SWOT in App. 5.10.) were identified using interviews. As mentioned previously in the possible negative impact on economic sustainability, one challenge for BC is the complexity of the topic due to insufficient knowledge and contact points, which leads to a lower implementation rate. *Grid Singularity*, for example, has technically mature products that cannot be absorbed by the markets mainly due to limited knowledge of the individual consumers. The main reason for the limited adoption is outdated regulations that do not enable this technology to be used on a large scale. Especially due to a particularly high degree of regulations in the EM (App. 5.6., Trbovic, interview), the resolution of this challenge is crucial for future success. It is clear that BC faces more challenges in the EM, such as inappropriate grid infrastructure and the fact that the knowledge available is currently mainly theoretical. Thus, there is little proof of practical functioning, which is hampering the path to making this innovation more tangible (App. 5.5., Rossi, interview) (see SWOT in App. 5.10. for further challenges). Due to the relevance of the

challenge and the need to focus on one key area, the discussion in the next chapter focuses on restricting regulations.

5. Interpretation of Findings and Results

After identifying the outdated regulations as one of the main challenges, this chapter will discuss potential dimensions/questions within the German EM. The standpoint of the following four key stakeholders will be considered (more details in App. 5.1.):

1. INDIVIDUALS	2. SMALL FIRMS/ START-UPS	3. BIG ENERGY COMPANIES	4. GOVERMENTS AND REGULATORS
COULD BE ENERGY CONSUMERS BUT ALSO PROSUMERS	THAT ARE FOSTERING THE ENERGY TRANSITION: E.G. GRID SINGUALRITY, FLEXIDAO, ETC.	UTILITIES: E.g. E.ON, RWE, Vattenfall and EnBW (Big Four) +TRANSMISION OPERATORS (TSO): E.g. TenneT, Amprion, 50 Hertz and TransnetBW. + ETC.	E.G. THE GERMAN Ministry for Economic Affairs and Energy (MEAE) + REGULATORY BODY: Federal Network Agency (FNA)

Figure 5: Own representation of an overview of the four main players in the EM observed in the discussion

5.1. Discussion, Validation and Implications

To assess the value creation based on the analysis, five key questions regarding regulations arose and are discussed in the following section. Each question addresses a separate dimension that contains implications and a final validation or rejection by two experts, Joscha Bröhrmann and Christopher Dietrich (interviews in App. 5.12. and 5.13.). The point of view of individual energy consumers is validated through the survey answers (survey details in App. 5.11.).

In a first step, it is important to analyse which players are mainly affected by the current regulatory framework.

Dimension 1: Discrimination due to outdated regulations

Based on the former analysis, it can be interpreted that both the individual prosumers and the small firms seem to be the victims of the outdated regulations. This means that especially the stakeholders who aim to drive Energy Transition forward are the ones suffering the most, regardless of their individual situations.

It is difficult for individuals to get access to the infrastructure due to heavy bureaucratic hurdles that cost both time and money. This is further complicated by the limited supply of information

in the market. Furthermore, the regulations still do not support private persons trading their excess energy with others.

Small firms that foster the Energy Transition are also at a disadvantage due to the impossibility of successfully placing their product or service in the market. Therefore, due to high regulations and market entry barriers, individuals are not motivated to participate in their platforms, which causes start-ups not to get a critical mass of users they need to persuade further.

In turn, the suffering of small firms is an advantage for big energy players. Lack of disruption ensures that incumbent entities remain in a strong position of power, with time to adapt to new arriving trends while at the same time profiting from the status quo. Thus, they do not see a benefit in fostering the energy transition.

On top of time and money spent to reshape regulations, complex governance structures could have other effects, for example, on the whole model of cities. This uncertainty makes changes, therefore, risky. Also, governments and regulators seem to have other priorities than changing the regulations.

Both experts confirmed this interpretation to be entirely correct regarding the validation of this point (App. 5.12., Bröhrmann, interview) (App. 5.13., Dietrich, interview). Additionally, in the survey, 75% of private energy users confirmed that they feel disadvantaged compared to big energy companies (App. 5.11.).

After this, it was logical to explore if the affected stakeholders are also the ones that are actively asking for change.

Dimension 2: Unilateral initiative to encourage BC development

The former analysis and the last discussion result indicate that individuals and small firms take the initiative to drive the change towards the energy transition.

Due to increasing electricity costs, individuals would benefit from the energy transition. Additionally, there is an overall demand for transparency which could also be satisfied by BC

used in the EM. Consequently, this would result in an improved and steady information flow that is not provided by the current EM and policies. The equality, the balancing of power, and the independence of big players are advantages for private users.

Small firms are also keen to advance the Energy Transition because it is almost impossible to grow consistently and compete against the big established players. But, similar to the first question, big players and governments are so far not pushing towards change.

However, this assumption could not be confirmed and validated in the experts' interviews. Both interviewees believe that private individual does not think about electricity and is consequently not interested in the energy transition (App. 5.12., Bröhrmann, interview) (App. 5.13., Dietrich, interview). This assumption was supported by approximately 50% of the survey respondents. Nevertheless, the other half stated that they were interested in the EM, supporting the dimension. Since the distribution is almost equal, the interest of the private individual in the Energy Transition is unclear (App. 5.11.).

After answering the last question, a further question arose: What are the changes needed?

Dimension 3: Positive correlation between the renewal of regulation and attractivity of trading business model

Based on the analysis, the current regulations are mainly responsible for the lack of success of the BC-based P2P trading business model and are therefore the showstopper for further evolvement. By implementing appropriate regulations, the attractiveness of the business model would be improved. In addition, new rules would increase consumer adoption, consequently leading to further innovations and, therefore, an equilibrated energy supply of individuals and current utilities. In the long run, it would also balance out the demand and supply of electricity, which would result in more stable prices. Furthermore, overall positive effects on the sustainability of cities could take place, which would create benefits for all stakeholders.

Apart from the reduced costs, all points were validated in the interviews (App. 5.12.,

Bröhrmann, interview) (App. 5.13., Dietrich, interview). Nevertheless, the expert, Joscha Bröhrmann, was unsure if costs for individuals would actually decrease if the Energy Transition happened. Anyway, the survey results showed that 81% of participants would be interested in such a business model as individual consumers, validating that the positive traits of the business model would be attractive if regulations allow it (App. 5.11.).

This calls for a rigorous change, but what and where are the hurdles?

Dimension 4: Lack of lobbying effort due to missing incentives

The analysis raised the question of why the big players do not push to change regulations. Due to their size and power, they could encourage actions. The reason why this lobbying effort is not made at the moment is the lack of incentives.

This statement was so far confirmed and validated by the interviewees (App. 5.12., Bröhrmann, interview) (App. 5.13., Dietrich, interview) and by 91% of survey respondents (App. 5.11.). One expert went even further and stated that the big players are the ones who in a way propose the regulations to the government because they are the ones presenting the electricity grid development plan every two years (App. 5.12., Bröhrmann, interview).

To make progress regarding the energy transition, this impact needs to be reduced with an independent regulating entity representing all market players, including small firms and individuals, accordingly. This would also imply a change in the direction of self-production and self-consumption.

If those are the key players, what is a possible future outlook? This question is discussed in the following dimension.

Dimension 5: Analogy of the regulation challenge with electromobility

This regulation challenge based on missing incentives allows the comparison with the enforcement of EVs in Germany during the last years. Analogous to the current standpoint of the energy transition, the initial market penetration of the EV was also limited even if the

technology existed already and the positive impact on climate change was proven. The main reasons for the difficulties were high costs and complicated applications for the individual, lack of interest from big players in the automotive sector, and missing incentives provided by the government. Furthermore, there is a substantial economic dependency between the government and the automotive industry. Both problems have certain similarities. In the meantime, the market penetration of EVs was increased significantly by imposing overarching regulations and providing incentives for the stakeholders. This observation would also enforce the results of the discussion. The renewal of rules and the creation of incentives are the main conditions for future success, consequently leading to value creation.

Regarding the validation of this point, the experts agreed with this statement (App. 5.12., Bröhrmann, interview) (App. 5.13., Dietrich, interview). Nevertheless, one expert raised the fact that electric mobility is much more tangible for the individual and still took a substantial time to be as successful as it is right now (App. 5.12., Bröhrmann, interview). Based on both points, it is possible that even incentives and regulations would not necessarily accelerate the Energy Transition in the short term.Nevertheless, the survey showed that most of the respondents (94%) confirm that they believe that the conditions talked about would make BC in the EM more accessible (App. 5.11.).

5.2. Answering the Research Question, Conclusion and Future Outlook

There are different steps to answer the RQ: “How to create value by entrepreneurially using BC in the EM in the context of Smart Sustainable Cities?”. It was analysed and proved that value can theoretically be created through the positive traits (SWOT *strengths* and Sustainability Framework App. 5.11. and 5.12.) of BC in the EM in general, particularly in the energy P2P trading. This value is specially created for future Smart Cities and in the area of sustainability. The added value is also potentiated when combining BC with other technologies, like Smart Contracts (explanation in App. 5.3.), AI, Big Data, other smart devices, or

Distributed Energy Resources. This means that the theoretical idea of this technology can create value. However, to understand if this innovation can genuinely lead to value creation in practice, possible challenges (SWOT *weaknesses* and *threats* App. 5.12.) need to be reviewed. The focus was on the primary and overarching threat, outdated regulations, to understand potential future *opportunities* (SWOT App. 5.12.).

Answering the RQ in the scenario with outdated regulations is not that straightforward and therefore needs to be split into two parts. On the one hand, there is a significant potential for value creation in case that regulations are adjusted appropriately. This means that the theoretical value can only be seen and applied if the regulatory framework is the right one, allowing the further development of Distributed Energy Resources and the Smart Grid that integrates BC in many solutions. Therefore, in the first step, an adequate environment for all players of the EM needs to be created by adding regulations that empower individuals and small firms and by providing incentives for big firms and governments. Additionally, important stakeholders should work together to exploit the maximum potential. Transparent and open communication would lead to further innovation in the energy sector. This development would equal an upwards spiral with a high value creation for the EM in the context of smart cities.

On the other hand, an unchanged condition framework with outdated regulations would probably harm the spread and the adoption of BC-based P2P Energy Trading in the EM. Consequently, the scalability is impaired, and the economic and long-term value creation is unclear. Therefore, the confirmation of value creation is extremely reliant on further developments within the city's environment.

Nevertheless, there still would remain a possibility that BC in EM and the application reviewed creates a value on another level. Value could be created on a knowledge and experience level. Even if the significant breakthrough of BC technology is not realized, the learnings can still be seen as a basis for future innovations and developments. P2P Energy Trading with the help of

BC is a recent innovation, meaning it is expected that its development and final value creation are still uncertain. It is key to keep up with changes, maintain a fresh and innovative mind, and entrepreneurially improve this technology.

It can be said that the interviews positively led to the conclusions stated in the previous chapters. According to the interviewees, there will be many changes in the following years until 2050 in Europe. That means that the situation can change quickly. All in all, how to create value for cities by using this innovation? Value can be created by closely reviewing the *strengths,* internal *weaknesses,* and external *threats*. Only like this it is possible to be prepared, act when needed, and find the right *opportunities* to create tangible value in the future.

6. Limitations

Energy Trading with the help of BC is only one of many BC applications in the EM that are available and at disposal today. For instance, a more known application of BC is validating and tracking CO_2 certificates or certificates of origin (certifying that your energy is generated through RE), e.g., to avoid greenwashing. Additionally, the technical and legal knowledge of the energy sector and the BC technology was limited. Therefore, deeper and more accurate conclusions could not be drawn. Furthermore, regarding the grid's infrastructure, many challenges limit this technology from functioning how it should, e.g., regarding additional key players like transmission operators (TSOs). TSOs manage all the transmission lines, affecting the functioning of Energy Trading on a technical level. They could not be considered on a deeper level because of limitation issues. Another limitation is the focus on just one challenge. This focus enabled a more detailed analysis but consequently led to a certain one-sidedness. Further limitations that apply to all the different subtopics will be shown at the end of the work.

7. Future Research

There is a wide range of possibilities for future research, mainly because of the inclinations towards business and the use of qualitative data from specialists in the area of BC in the energy

sector. Therefore, it would make sense to add a quantitative analysis. Comparing the current real-life and theoretical applications (start-ups) between each other, the exact differences and draw conclusions can be understood. Another critical point that could be analysed in more depth in the future is the application of different BC types on a technical level and their actual impact on the EM. This project discussed the development of regulations and their implications as one possible scenario. The other four scenarios were set up and are shown as a matrix in Appendix 5.18. but could not be further analysed due to page limitations. A complete scenario comparison would therefore be plausible for future research. Chapter 9 General Future Research will show further research that consistently accounts for all the subtopics.

6. General Discussion

While some conclusions in this report can be derived from the results of the research, another aspect might have multiple viewpoints to them.

In all the individual cases, presented sustainability can be leveraged compared to their conventional counterparts but often that cannot be stated with precision. Mobility, VIF or BC are examples of technology, which need some energy input to function. So, sustainability assessment results need to be taken cautiously as sustainability can only be levered if certain requirements apply. The energy source needs to be of renewable sources, otherwise, the lever to save e.g. CO_2 emissions is low. By presuming all of the technologies presented in this thesis report supplied with fossil energy, the innovation could not be considered sustainable.

However, if the energy sources would be 100% renewable, this thesis would be also pointless as one of the biggest problems would be solved, which is the global change of energy. Rather, the transition towards renewables and towards more impactful (in terms of sustainability) technical solutions that create value on multiple layers (e.g. the mobility case provides public transportation, CO_2 reduction and gamified user experience) is the true contribution despite the

uncertainty of the energy supply.

But energy is not the only aspect, which is source-dependent. E.g., the packaging of the plants sold from VIF or the system on which a BC is applied are uncertainties that might limit the impact of the innovations discussed. This limitation is also a disadvantage that needs to be considered along the way until 2050 in the sustainability assessment or the validation of value creation. However, this uncertainty might be a point that further leverages the impact of the innovation as uncertainty means that an entrepreneur can influence the development of the use of the sources. E.g., if the community of VIF-users agree to solely use paper wraps (or better no packaging at all) the impact would be increased.

Also, in all individual parts, the conclusion with regards to the sustainability assessment was positive and the innovation enhanced the status quo where applied. But that bettering the current state does not mean solving the problem entirely. In the introduction, the problem of climate change was addressed, and it is evident that this issue is among the most threatening problems we as humans face. Therefore, improving the status quo is not enough for the long run. The Paris Agreement states that CO_2 neutrality should be reached by 2050, which, in turn, mean for the innovations presented that CO_2 neutrality should be aspired. This does not necessarily mean that businesses that apply the innovations need to cut all the CO_2 polluters but to take the whole value chain into account and net around 0 (also after taking into account the biocapacity).

And here lies a big contrast: smart cities that use lots of technology to reach true interconnectivity, which supposedly should be sustainable might have worse CO_2 balances as the current best-performing country (and its cities) is Bhutan – an, according to western countries, poor country with less technology but committed efforts to reduce CO_2 emissions. This country is the only one to have reached CO_2 negativity (Munawar 2016) already and serves

as a role model in terms of environmental sustainability. Therefore, the approach of using technology to solve CO_2 emissions is not wrong but not the only solution possible.

In the context of smart cities, it is important that the value of innovations can be increased by the interconnection with other technologies. Synergies in the case of this report might be Fintech, BC and smart mobility but there come some downsides to it. Each innovation and each perspective of one technology or business can be embodied by stakeholders that all have interest, which consequently mean that the more perspectives on an innovation exist and the more interconnections are prevalent within smart cities, the more interests there are. This might sound positive as more perspectives enrich the diversity but also lead to an increase in the complexity and possibly conflicting interests. Therefore, it is important to agree on a consensus that supports an agenda that is suitable for all the entities of a network that decides to collaborate. Naturally, the more entities there are, the more difficult it becomes to set the specifics of a common agenda. This applies to business practices but also to technology, sustainability or social aspects. However, the complexity is not a problem that is not solvable as the network of Smart Sustainable Cities with its decentralized entities (VIF or mobility) and interconnections is part of the value created by such a system (Smart city canvas).

The scenario of a full Sustainable Smart City in 2050 serves as a canvas for the innovations to build beneficial use-case scenarios for the inhabitants of a potential city but also poses significant uncertainty as the scenario is 29 years in the future and the potential technical, social and regulatory developments are beyond grasp at the moment. So, the applicability of the innovations discussed might be as presented and would truly work in such a scenario, but they might also not. On the one hand, the individual parts deal with technologies that can be considered progressive, as they approach the challenge of sustainability (representing a future challenge), and transitioning as with them come new standards (at least technical or economically) – on the other hand, those might not be the technologies that will be adopted by

the markets. In the early 2000s, only a handful of people could imagine how we now (20 years later) would communicate: via WhatsApp. Therefore, predicting the future is almost impossible and perhaps BC is a technology that will get disposed by something more advanced.

However, one of the most influencing factors is the aspect of regulation. In all the five individual parts is concluded that regulation will influence the success of the innovation and represents one of the most relevant uncertainties. For example, the mobility case presumes that regulation will develop in favour of the idea (which is in the context of benefitting changes that promote sustainability to fight climate change, is rather likely in the next 10-30 years) meaning that subsidies benefit the shared use of EVs. The business model is based on the potential future development which poses some risks. In fact, the regulation might turn out to be sanctioning the business model (not likely but plausible) if priorities in a market are different than expected. The same happens for the application of BC to the EM. The key challenge that was tackled is outdated regulations, which prevent a tangible, city-scale, user-oriented application of this technology to this market. To base an enterprise on the hope of regulative improvements might not be the safest business idea but entails chances for future success, which, in contrast, is part of the purpose of this report. The business models of the other cases are not relying on the positive change of regulation but are susceptible to it. Especially the aspect of regionality in markets forces proper market analysis and negotiation with regulatory stakeholders to avoid too much uncertainty.

Some of the examples discussed revealed that regulation, in part, is behind the progression of the technology in terms of the benefits for positive change. In some cases, regulatory discrimination seems to slow down the development (Blockchain) and application of technology. This leads to the state where the market would be ready for adoption, but the incentives are missing. Therefore, it seems logical to invest in such technologies as an entrepreneur in the near future as it might turn out to benefit the business of the innovations.

The problem is, however, that regulation often is not steered by one chancellor or president in terms of market condition as regionality plays a big role. Therefore, stakeholders of the regions are the important ones, and this poses a disadvantage for businesses as also the governance and regulation of Smart Sustainable Cities are complex. That means that a business based on a technology, that has multiple entry points to a or multiple markets, might suffer from the bureaucracy of different regulatory entities such as different district laws, communities, communes, provinces, cities, etc. This might slow the process of market adoption and development down and decreases the attractiveness for entrepreneurs to launch their business.

Because the numbers of the business cases (except mobility) are based on the current prices and units, and because the regulation is not yet favouring the concepts, the prices might be higher (in some calculations - mainly VIF and Biophilic Design - it is questionable if the market would already positively respond to sustainability alternatives and pay more than the benchmark, but to provide the same value (in terms of quality, e.g. fresh VIF vegetables as good as conventional ones; biophilic buildings as good as conventional ones) – plus sustainability advantage, is a value proposition that stands out from the conventional counterparts. The problem, rather, is if the product or service would be below the quality of the competitors despite an environmental or social benefit. Then, adoption is less likely as clients would not adopt technology that is lower in value and cost more. But higher prices are in some cases inevitable (Biophilic Design) as it is the natural cycle of development and market adoption. The problem is that there are no alternatives to sustainable solutions as the threat of climate disasters poses too much danger to society (and all other beings). That means that some sustainable solutions will become the new benchmark with the openness to the kind of innovation.

6.1. Answering the Supporting Questions

As mentioned in the beginning of this report, to answer the Research Question as precisely and

as accurately as possible, it is necessary to answer supporting questions first. The objective of the supporting questions is to ensure a clear understanding of the individual aspects/concepts presented. This methodology aims at summarizing and verifying the conclusions from each chapter before objectively answering the research question.

For what do sustainable innovations create value?

As previously shown, each individual innovation leads to its own singular output, and the key areas of focus are mobility, biophilic design, vertical farming, blockchain in the energy market and the fintech industry. It is interesting to notice that although these topics have such different final products, the stakeholders that each one of it affects are fairly the same – citizens, the city and governments are not only extremely affected by each innovation, but also essential for their existence.

Are current Smart Cities already applying/adopting these technologies/digital services?

The extent to which Smart Cities are already adopting the analyzed technologies varies. The cases of mobility and fintech are the most proven, meaning that there are several applications of the models proposed. Even so, these are two areas that are constantly growing in number, complexity and impact of applications. On the other hand, for biophilic design and vertical farming, the scenario is different. The technology already exists and several business models are available, but only for higher-level fringes of society. As so, the focus is on applying the innovations to people in medium to low class and to small-scale markets, respectively. Finally, Blockchain in the energy market has been theoretically proven and tested in real life with several B2B applications, but regulations prevent it from being tested at the necessary scale to allow individuals to become prosumers.

What are the key challenges of the innovation?

General challenges that affect all innovations are the complex governance models of key

stakeholder entities that are required to be on board and regulations that prevent the innovations to be implemented with a higher level of flexibility. Even so, this paper assumes the necessary level of enablement of the innovations, as the focus is on the entrepreneurial and sustainable value rather than the legal ramifications. Depending on the implementation location or overall context, other specific barriers to entry exist.

Are these innovations in these Smart Cities truly sustainable?

Another very important point, after analyzing the possible value creation, implementation and risks, is to assess whether the listed innovations really have a positive environmentally sustainable effect on Smart Cities.

The frameworks utilized to perform individual sustainability assessment ensure a minimum level of positive environmental impact. Even so, since this paper considers a time delimitation based on the European Green Deal's (2050), caution must be kept with regards to the long-term impact and the appearance of other solutions (that do not necessarily require a sophisticated technological level) that better meet sustainability requirements.

After this final validation through supporting questions, it is time to provide a definite answer to the research question.

6.2. Answering the Research Question

To answer the RQ "How to create value by entrepreneurially using sustainable innovations in Smart Cities?" in one sentence: by applying disruptive technology that leverage environmental sustainability without sacrificing price, value or other advantages and, if they surpass the requirements of the Smart City Canvas and the rating, which was part of the report (this would not exclude the ones below 5 but these are the ones selected as part of the report), by integrating them to Smart Cities. This way, value for the common key stakeholder can be assured: the citizens of Smart Cities represent the clients of the applied technologies presented which also

benefits the entrepreneurs using the innovation to provide that value.

Because of the diversity of the innovations and the specificity and the multitude of the RQ the RQ will be answered in the sections Sustainability, Smart City and Value Creation.

Sustainability: Depending on the technology and its application a sustainability assessment (either based on CE, SDG or CO_2 emissions calculations) was performed to ensure a standard that significantly improves environmental or social concerns compared to the conventional counterparts that represent (for the majority of applications) the today's standard in 2021. The selection of the 5 innovations assessed is based on the (potential) environmental and social impact and the assessment for the innovation confirms that a significant value in terms of sustainability is guaranteed, given a correct integration of the technology. The methods led by the concepts of the innovations and its value propositions vary drastically. To exemplify: Fintechs can influence companies and policy makers to leverage financial inclusion and benefit the efficiency of economic operations, while the application of biophilic design leads to better mental health or passive heat regulation of buildings – the outcome, however remains the same. New standards are set and boundaries are relocated to a higher level (despite the acknowledgement that the innovations have different sustainability standards). Ultimately, this is a value created to the customer and to all the stakeholders, that suffer from the current climate disaster, which are all the organic entities in the biosphere.

Smart Cities: Also, in the category of Smart Cities it is important to note that a high standard to the preselection of the innovations (before the development of the thesis report), was set to guarantee that the technology fit the requirements of Smart Cities. As expected, different innovations have different focal areas, which, in the end leads to a portfolio of strengths when it comes to the integration of all the innovations. Still, common themes as decentralization, a benefit to the quality of life or interconnectivity are prevalent. To exemplify: the application of

BC in the EM has the highest impact on the categories quality of life, effectiveness of urban services, competitiveness and especially interconnectivity due to the potential for integration with IoT/industry 4.0 and for automation and decentralization. This has a similar fit to Smart Cities as Fintechs benefit social sustainability, improved quality of life, interconnectivity, automation and decentralization for autonomy, which, again, has a similar effect as vertical indoor farming.

Value creation: This aspect is the most uncertain of all researched areas as regulation until 2050 can drastically vary due to the time until 2050 but also due to regional effects and different markets. This has implications on the competitiveness and scalability of one innovation (e.g. BC, mobility, VIF). But as first regulators benefit more sustainable options, e.g. carbon tax, this uncertainty is expected to unveil to the favour of the innovations (besides that climate emergency and social movements e.g. Fridays for Future pressure policy makers and regulators into this direction).

As mentioned in the sustainability paragraph, the value is created by sustainability-related factors such as CO_2 emission reduction but also by the non-sustainability-related aspects (it remains questionable if the term is correct as every value that contributes to the thriving of humankind is somehow benefiting sustainability values.). The value provided are diverse, but through the interconnectivity of Smart Cities and through the frameworks used, related. To exemplify: Smart mobility concepts and Fintech could be improved by the application of BC. The same applies to potential synergies of VIF and biophilic design (e.g. potential to breed settlings at the same nursing station), which leads to the conclusion that in different values are lots of similarities.

7. Main General Conclusion

The initial goal of this research was to understand the potential that certain fields of innovation

can have on cities, to make them smarter and more sustainable. For that, a broad initial exploration was done, and parameters for a preliminary potential assessment were defined. The chosen innovations focused on the following areas: Mobility, Vertical Farming, Biophilic Design, BC, and Fintechs. These concepts may sound like jargon, but after in-depth study, it is clear that the benefit they bring to citizens can essentially change the way we live within cities in current and future days. After proving the entrepreneurial and environmentally sustainable value that these innovations generate and understanding the structural changes that would be required to implement these changes within a city, it is important to reflect upon the Sustainable Development Goals (SDGs) that will be affected by them, not only individually, but as a whole. In fact, out of the 17 SDGs, 15 of them are at least partly affected by at least one of the innovations, being Decent Work and Economic Growth (SDG 8) the one that is tackled by every analyzed innovation. This means that all of them contribute to promoting sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all (United Nations n.d.), which has been verified in the value creation analysis for each of the five innovations. By building a MaaS solution that fosters the use of the public and shared transport networks, it is not only the solution itself that is benefiting from growth, but also – and most importantly – the networks, which can then improve in qualitative and quantitative terms due to the success of this solution. Furthermore, enabling vertical farming for small-scale players means not only enabling every player to use more environmentally friendly solutions, but also giving the same opportunities for economic growth to all. The same happens with biophilic design architecture which, as previously explained, is a type of architecture from which only the most privileged fringes of society can benefit. But, at its core, the goal is to integrate nature and human beings and, through finding solutions on how to enable it for everyone, steps are being taken towards a more inclusive economic growth. On a more individual sense, Fintech solutions can increase financial inclusion through higher access to

financial services, boosting SMEs and entrepreneurs' success enabling mobilization of domestic savings, allowing long-term investments and ultimately increasing economic growth. Finally, applying BC to the energy market not only opens space for more players in the sector, fostering competitiveness and growth, but also creates new opportunities for several players in the city context, and even a potential new revenue source for citizens if they choose to become prosumers.

Although SDG 8 is touched upon by every subject approached in this research, it is not necessarily the key one for all of them. In fact, when talking about mobility, the main one is SDG 17 – Partnerships for the Goals, as enabling a MaaS solution in the city context requires a strong alignment between private and public players – not only in terms of transport modes but also, and mainly, with regards to technology, and a solid and flexible governance model. When talking about Vertical Farming, one of the main aspects is the fostering of Responsible Consumption and Production (SDG 2) – by enabling small business owners to use such technology in the sourcing of their products, production becomes sustainable (not only economically, but also environmentally), allowing a cycle of responsible consumption and production to be generated. For the application of biophilic architecture, the main focus is SDG 11 – Sustainable Cities and Communities, as it works towards making these types of buildings accessible to all, thereby aligning with "making cities and human settlements inclusive, safe, resilient and sustainable" (United Nations n.d.). Applying innovative Fintech solutions in the city context mainly contributes to SDG 1 – No Poverty as, as discussed during the in-depth analysis, reducing payment costs and enhancing access to capital and investments leads to higher financial inclusion and literacy. Finally, applying Blockchain technology to the energy sector mostly contributes to SDG 7 – Affordable and Clean Energy, as it leads to higher transparency of the energy infrastructure due to the decentralized nature and traceability of Blockchain.

Technology is constantly evolving. Ages ago, the fire appeared. Then, eventually, the Man invented the wheel. Later, the light bulb and the printer became part of our lives, and today we all live connected through the Internet. Things that we never thought could exist have much more than the direct application that can be initially assumed from it. As so, pursuing this kind of exploratory research and potential assessment is key to ensure not only the cities' improvement but the evolution of mankind.

8. General Limitations

The limitations concerning research find some points in common and others of difference between the various subtopics. A group work articulated in five different areas that converge in a single objective leads to clashes with difficulties that are mainly technical and research-related, and with others that are consequences of the former. Sustainability is one of the most discussed and researched objectives of the last century and will be what mankind will have to achieve to survive. Smart Cities, on the other hand, represent the future starting from the small steps that man and technology take today, trying to build around it a welcoming and stimulating environment that reacts to human stimuli and guarantees a high quality of life. From this we can deduce that the topics dealt with are extremely topical and in particular, subtopics such as the Blockchain in the energy context or Biophilic Design from the point of view of cost analysis or the use of new architectural technologies lack numerous relevant academic articles that can provide further information as they are fields that are sometimes still unexplored. However, it is the future that will provide answers to our proposed solutions. In the course of the research, different frameworks were used, and sometimes it was not possible to obtain the desired results from them. From the point of view of Vertical Farming, we were not able to obtain a business plan and a real market research with real identification of the latter. The reason for this is purely due to the scarcity of quantitative data obtained and the large amount of qualitative information, which led to conclusions that were not based on numerical/analytical evidence. A similar

problem was faced in the Fintech sub-topic where we have no information on the cost structure, in the Biophilic Design sub-topic where we have a qualitative analysis with some assumptions on the cost data due to the lack of architectural background and in the Smart Mobility sub-topic where we had to make assumptions on the public sector cooperation (even if its interest was quite validated) and on the costs/demand. The Smart Mobility area also encountered some limitations in using a survey: closed-ended questions limit the person's opinion to the options proposed by the research, with a risk of leading to distortions due also to a word-of-mouth sample. On the other hand, the number of interviews was not high enough to get a complete picture of the experts' opinions, however, also due to the lack of response and not to the lack of research and as previously mentioned, they are purely qualitative, therefore they mainly provide opinions, validated however by the experience of the interviewees. It would also have been useful to be able to elaborate on many other points relevant to the research, such as regulatory frameworks for Blockchain in the energy market, the wide range of applications that Fintech provides today or quantitative analyses regarding the funding of this type of innovation.

9. General Future Research

According to Statista, the projected revenue generated by companies in a Smart City, offering products and services based on data technologies to increase the value creation, will rise to 241.02 billion U.S. dollars in 2025 (‘Global Smart City Revenue 2020-2025’ n.d.). Simultaneously, regulations and societal demand are increasingly pushing companies to focus on sustainability in their actions. These two developments show that in the future the topic of value creation through sustainable innovation in a Smart City will gain constantly importance and needs to be explored more deeply. This shows that this subject area must continue to be investigated.

To gain more insight into the value creation through innovations in sustainable Smart Cities, there are several options and approaches for future research.

The first option is to build on the limitations just listed. In the analysis of each innovation, some limitations limited the validity of the answer to the RQ. Future research could focus on these limitations and try to address them by collecting primary data. For example, focusing on the missing information about the business cost structure and discovering it through data collection. Another limitation, which can be solved in future research, is the limitation of the validity due to the limited field of view. The present work focuses on the value creation of five innovations. To analyze the value added by innovations in a Smart Sustainable City in a more precise way, a wider range of innovations of different types must be considered. The second possibility for future research is to focus on the impact of the innovations on the three pillars of sustainability separately. In this way, the value creation through innovations in a Smart City can be divided into society, economy and environment. This helps to go into more detail about the impact of a single innovation on a specific target group and to better understand how value is created. The third possibility would be to support the existing findings with primary data by conducting a long-term experiment to truly analysze whether the innovations lead to sustainable value creation in reality. Since the results will be depending on the micro and macro-environmental circumstances, the experiment needs to be conducted in different cultural areas, to be able to deliver independent research results.

In conclusion, there is still a great deal of research potential in this area and, given its enormous relevance, the study should continue to be carried out from various perspectives and with different approaches.

10. Review of the collaboration and motivation of this work

The theme of sustainability, assigned at the beginning of this course, was not only a motive for academic research but above all a way of making everyone feel part of a group that wants to have objectives to change the world in its small way, improving it, looking towards the future. So, research after research, providing ideas to our teammates and working on what seemed to

be suitable with our profile, the structure of the project became increasingly clear. Collaboration was the main driver of the research. It led to a general knowledge of the drafting process in a homogeneous way, with each component being interested in all subtopics. The initial motivations were different for each of the team members. They reflected interests, passions, character and academic backgrounds related to the underlying topic. However, it was not easy to link interests to knowledge to keep the research business-oriented. Learning from areas completely outside the comfort zone has been challenging but at the same time interesting and educational. We achieved new knowledge, that have never before been explored in fields such as engineering, architecture, or agriculture. The greatest success is to see what in the beginning was just an idea born from a theme, that of sustainability, become a working project full of passion, creativity, and research. Through the choice of these solutions presented, it was a challenge to try to get to the heart of the matter: Can we create value? Can we in this way achieve sustainability goals linked to the SDGs that can one day give a better future to new generations, as the previous ones did not? This question was the driving force behind the research, which passionately tried to provide all the necessary points for as detailed an understanding as possible, albeit with significant limitations. All the subtopics could be explored in more detail. However, each of these innovations is more or less unexplored territory and this generated curiosity among the members throughout the drafting of the research. In the end, many points of initial prediction were mitigated by barriers that still drive society and governments. Personal motivations remain almost the same as at the beginning, albeit with much more awareness and knowledge of how processes work that are often taken for granted.

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Appendices

Appendix 1 General

Appendix 1.1. Innovations Scorecard

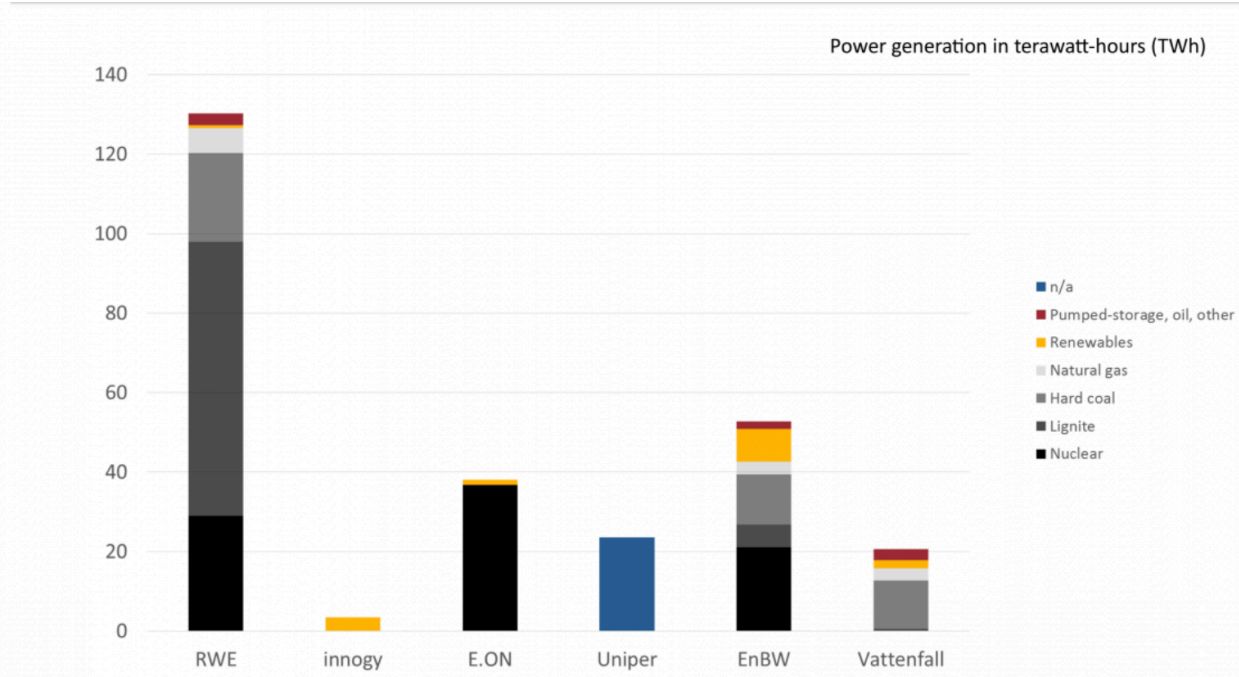
	Smart			Sustainable		Context		
	Quality of life (15%)	Efficiency of urban operation and services (15%)	Competitiveness (15%)	Economy (15%)	Environment (15%)	Society and Culture (15%)	Own Interest/Experience (10%)	Final Score
Cooperation for Smart Sustainable Mobility through MaaS solutions	3	3	3	3	2	2	3	2.7
Sustainable Fintechs	2	2	3	3	2	3	3	2.55
Blockchain for Renewable Energy Integration	2	3	3	3	2	2	3	2.55
Vertical Farming	2	3	2	3	3	1	3	2.4
Biophilic Design	3	2	1	2	3	3	3	2.4
Clean controllable onsite electricity for home or business through blockchain	2	3	2	3	2	2	1	2.2
IoT – oriented infrastructures	3	3	2	2	1	3	1	2.2
Pre-filled forms on central online portal for administrative services/ Data Usage for Administrational Things	2	3	2	1	2	3	1	2.05
3D printing for healthcare	2	3	1	2	2	2	1	1.9
Fully online medical advice	3	2	2	2	1	2	1	1.9
Technology to discover methane leaks quickly	1	2	3	2	3	1	1	1.9
App for tracking your carbon consumption	2	1	2	2	2	2	1	1.75
Plastics from carbon emissions	3	1	1	3	2	1	1	1.75
Solarpowerd railways	1	2	2	3	2	1	1	1.75
3D printing for food replacement	2	2	3	2	1	1	1	1.75
Wireless Sensors for autonomous driving	2	2	3	2	1	1	1	1.75
Circular economy solutions for food waste	2	1	2	1	2	2	1	1.6
Sustainable roof covering made from pyrolysis oil	1	2	2	2	2	1	1	1.6
Personalized travel experiences through advanced analytics	2	2	2	1	1	2	1	1.6
Special technique to dye clothing to reduce water consumption	2	1	1	2	2	1	1	1.45
Reusable packaging	1	1	2	1	2	1	1	1.3
Eco fibers to produce sport clotches and swimsuit as a replacement of neoprene	1	1	1	3	1	1	1	1.3

Appendix 5. Blockchain in the Energy Market

Appendix 5.1. Example Energy Market Germany

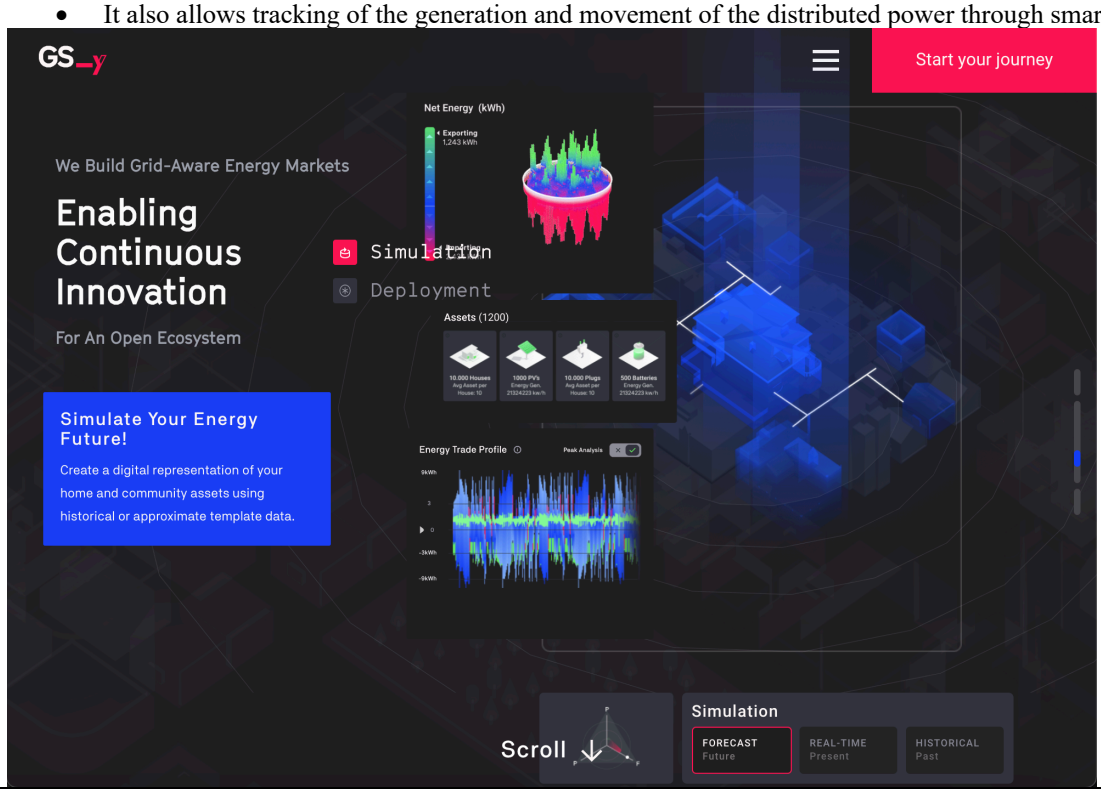
	Regulators	Transmission Operators (TSOs)	Big four Utilities	Distribution Operators (DSOs), other supply companies and others
German key energy players	**Regulating body:** Federal Network Agency (FNA) **Responsible ministry:** The German Ministry for Economic Affairs and Energy (MEAE)	**Only 4:** TenneT, 50 Hertz, Amprion, TransnetBW 	**The Big Four:** RWE/Innology, EnBW, E.ON, Vattenfall **Market share:** "67 % of the conventional power market in Germany and Austria in 2013"	**Other smaller companies and organisations:** "Distribution and the supply sectors are characterised by a large number of companies and – in supply – strong competition."
Key activities	**FNA:** Evaluate, approve and oversee Network Development Plan (NEP). At least every four years passes on the confirmed NEP and an environmental sustainability report to the government. **MEAE:** uses it in drafting the Federal Requirements Plan	**Mainly:** Operate high voltage transmission lines. Only they are allowed by government to manage the grid. **Every two years:** Propose the Network Development Plan (NEP) and submit to public consultation and let it sign off by the FNA	**Mainly:** Retail business, meaning selling/supply/ (facing the end customer) **Separate entities for:** - Energy distribution (low voltage transmission lines), - Energy generation - Energy trading	
Owner ship?	-	Private but are supported by government	Private	"Mostly owned by municipalities, some in private-public ownership"

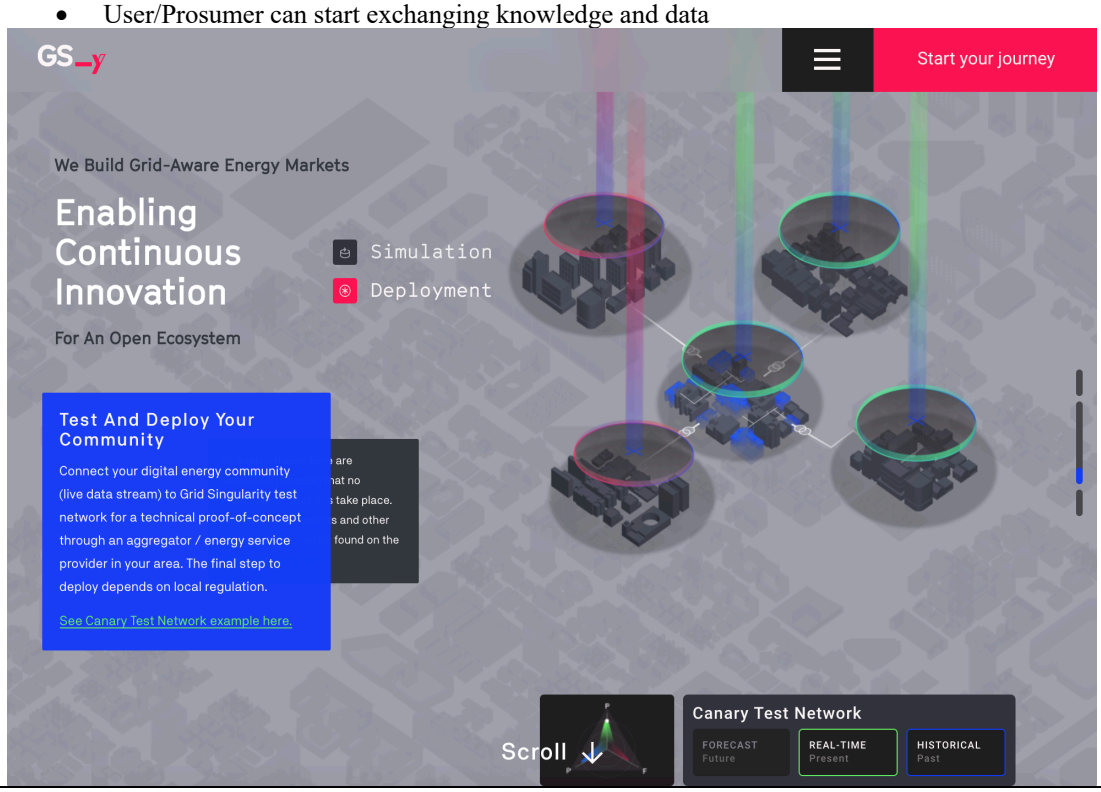
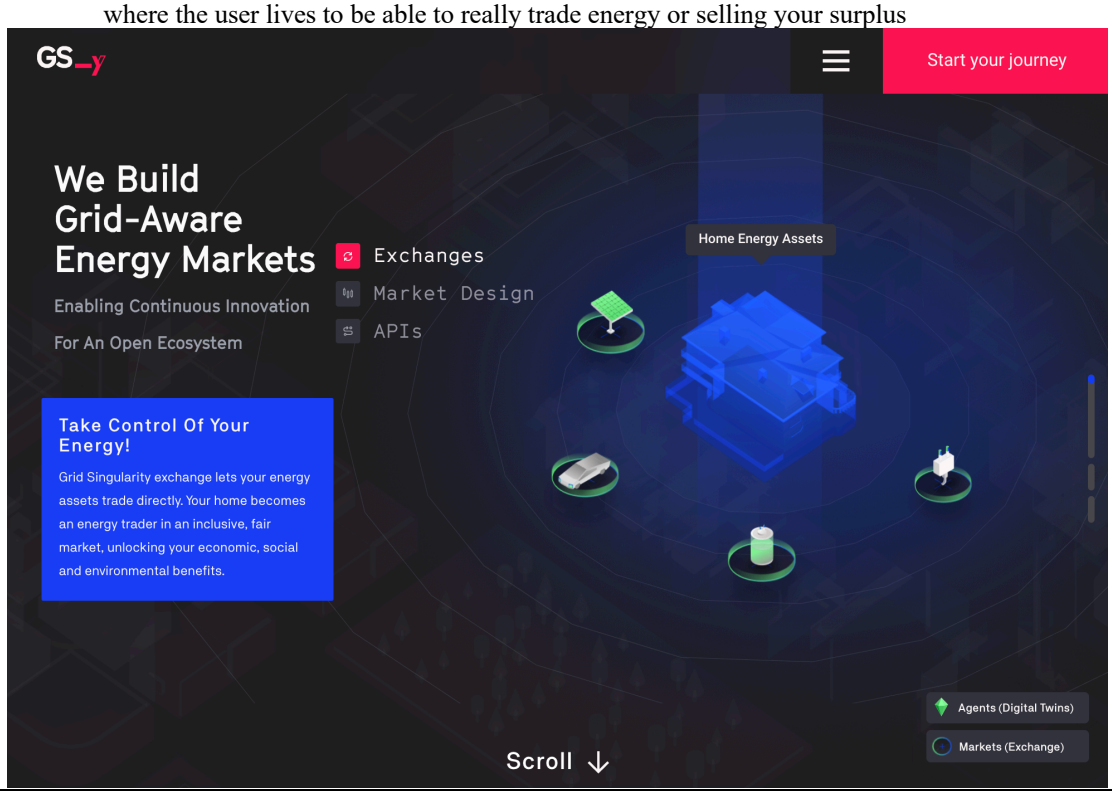
Sources: ('Set-up and Challenges of Germany's Power Grid' 2015), ('German Utilities and the Energiewende' 2015), ('Germany's Largest Utilities at a Glance' 2017), ('Electricity Law and Regulation in Germany | CMS Expert Guides' n.d.), ('Bundesnetzagentur - About Us' n.d.), ('Netzentwicklungsplan Strom 2035, Version 2021', n.d.)

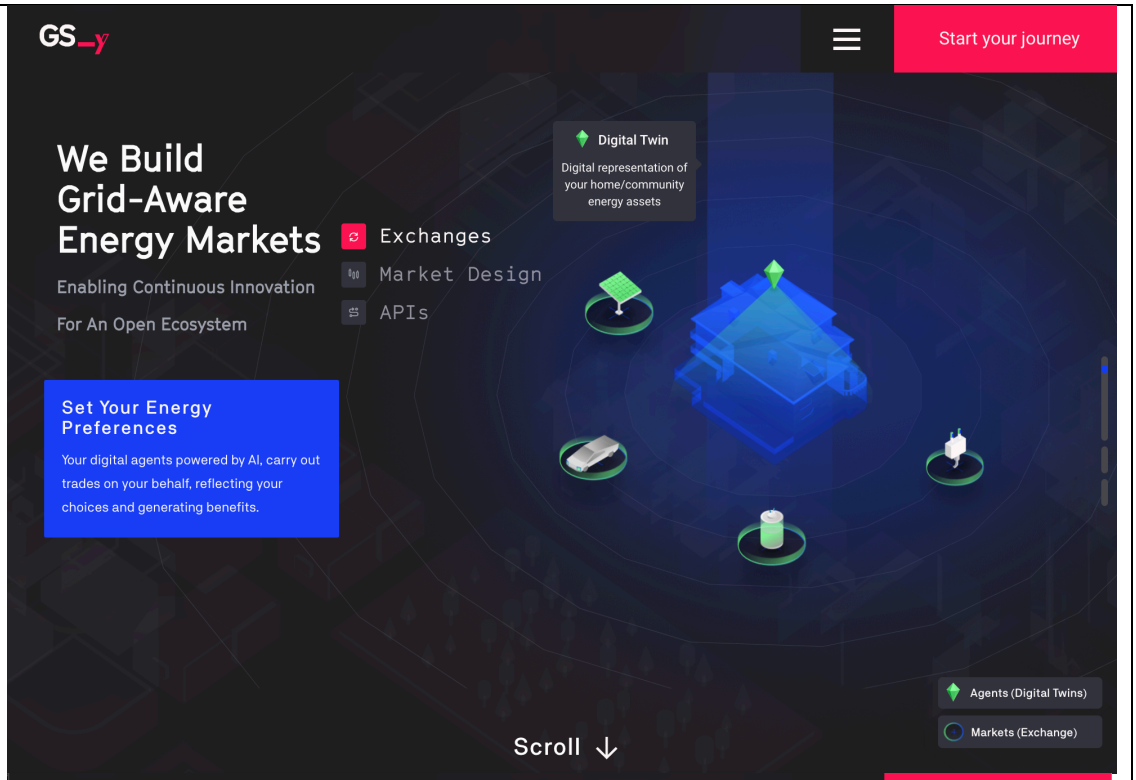


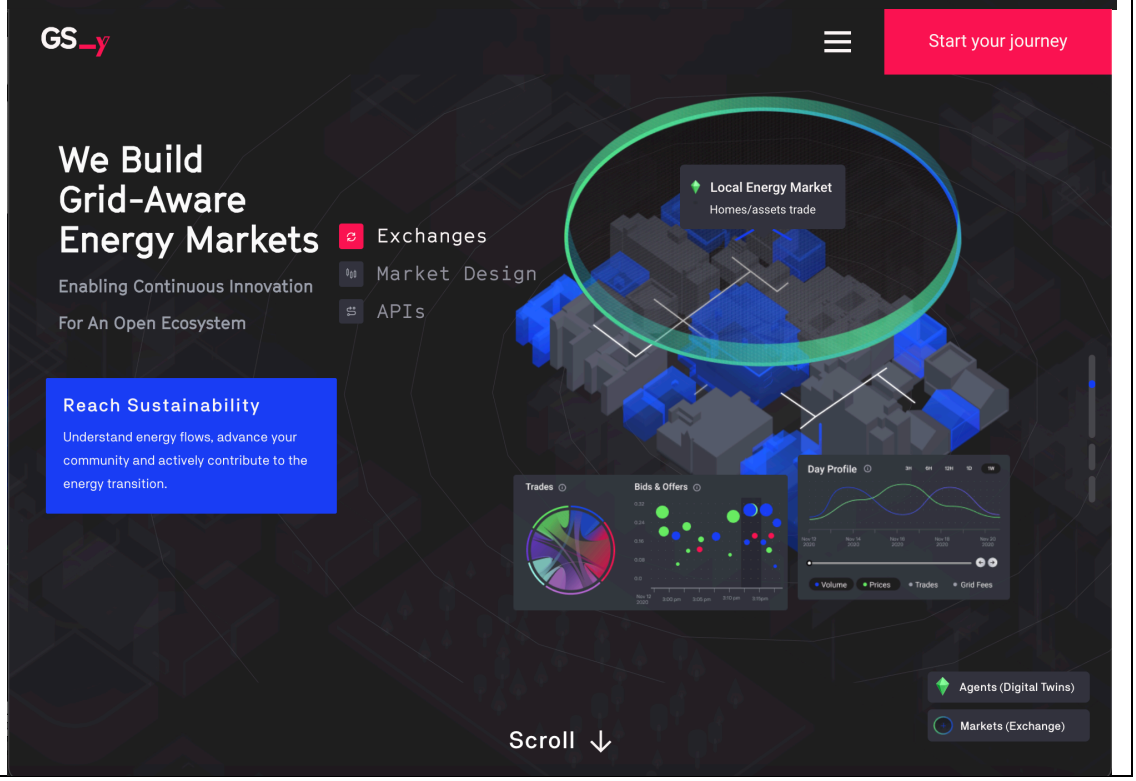
Power generation by energy source of the big four utilities in Germany in 2016. Innogy is part of RWE, and Uniper of. E.ON. Source: ('Germany's Largest Utilities at a Glance' 2017).

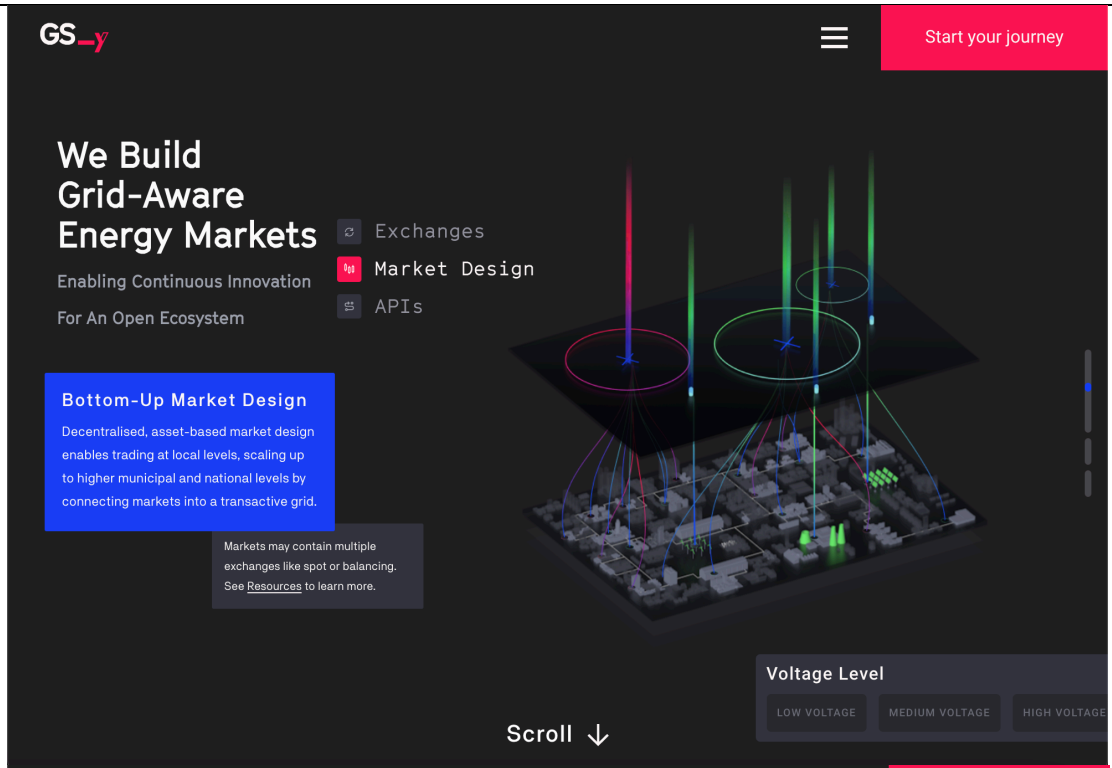
Appendix 5.2. Grid Singularity BC based P2P Energy Trading

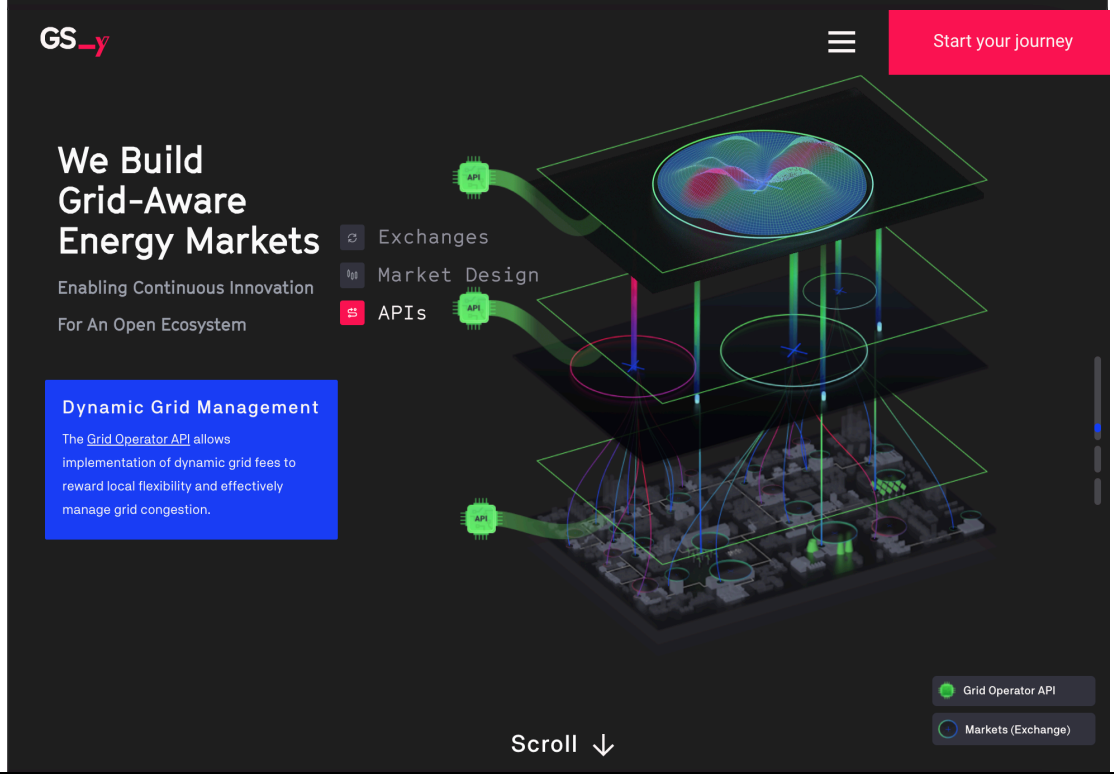
	User Grid Singularity
Step 1	• **Simulation** on the GS Energy Exchange Platform, which is a free business application for energy trading and simulation tool • Gives the user the opportunity to check the impact and optimal pricing of energy tariffs and assets one could own (like PVs or electric cars) • It also allows tracking of the generation and movement of the distributed power through smart devices 

Step 2	• **Testing** through virtual live collaborative energy trading through the Canary Test Network • User/Prosumer can start exchanging knowledge and data 
Step3	• User should now be able to install energy assets and ultimately really **start consuming own energy and selling/sharing excess energy** • Then it is very important to check the country's regulations to be aware of what is possible where the user lives to be able to really trade energy or selling your surplus 


GS_y
Start your journey
We Build Grid-Aware Energy Markets
Enabling Continuous Innovation
For An Open Ecosystem
Exchanges
Market Design
APIs
Digital Twin
Digital representation of your home/community energy assets
Set Your Energy Preferences
Your digital agents powered by AI, carry out trades on your behalf, reflecting your choices and generating benefits.
Agents (Digital Twins)
Markets (Exchange)
Scroll


GS_y
Start your journey
We Build Grid-Aware Energy Markets
Enabling Continuous Innovation
For An Open Ecosystem
Exchanges
Market Design
APIs
Local Energy Market
Homes/assets trade
Trades
Bids & Offers
Day Profile
Volume
Prices
Trades
Grid Fees
Reach Sustainability
Understand energy flows, advance your community and actively contribute to the energy transition.
Agents (Digital Twins)
Markets (Exchange)
Scroll


GS_y
Start your journey
We Build Grid-Aware Energy Markets
Enabling Continuous Innovation
For An Open Ecosystem
Exchanges
Market Design
APIs
Bottom-Up Market Design
Decentralised, asset-based market design enables trading at local levels, scaling up to higher municipal and national levels by connecting markets into a transactive grid.
Markets may contain multiple exchanges like spot or balancing. See Resources to learn more.
Voltage Level
LOW VOLTAGE
MEDIUM VOLTAGE
HIGH VOLTAGE
Scroll


GS_y
Start your journey
We Build Grid-Aware Energy Markets
Enabling Continuous Innovation
For An Open Ecosystem
Exchanges
Market Design
APIs
Dynamic Grid Management
The Grid Operator API allows implementation of dynamic grid fees to reward local flexibility and effectively manage grid congestion.
Grid Operator API
Markets (Exchange)
Scroll

Source: (Singularity 2021)

Benefits	Grid Operators (Utilities, TSOs, etc.) and other participants
Platform could enhance	• Smart grid management • Trade of green certificates/certificates of origin • But also ease investment

Based on references: (App. 5.6., Tribovic, interview), (Singularity 2021)

Appendix 5.3. Blockchain additional information

Hashes	• Blockchain consists of chronologically ordered chain of blocks consisting of cryptographic hashes • Timestamped • Specific mathematical algorithms • Difficult to be recreated (Andoni et al. 2019) (Fraga-Lamas and Fernández-Caramés 2020)
Distributed Ledger	• All participants have access to identical copy of information • Every transaction open to be reviewed by anyone of the platform (Yildizbasi 2021)
Smart Contracts	• User-selected applications that control the rules of writing in the ledger • Their implementation is often helpful for reaching the full potential of BC applications (Andoni et al. 2019)
Decentralized	• Information is not controlled by a centralized unit • Protects from fraud • Ensures that nobody can manipulate the stored information (Yildizbasi 2021)
Uniqueness	• There are many different BC systems and configurations • No overall BC solution • Unique configuration for each use case (Andoni et al. 2019)
Applications	Bitcoin: first real-life implementation by Nakamoto in 2008 with Bitcoin (Nakamoto 2008)

Appendix 5.4. List of European Start-ups/Real life applications of BC in the EM

After the theoretical approach, the practical testing of the technology and the real-life application becomes important. In Europe, 71 start-ups can be identified which are focusing on practical solutions of those theoretical research fields (Andoni et al. 2019). All these efforts demonstrate the strong interest and demand for the BC innovation in Europe's EM. From these firms, 28 focus on P2P Energy Trading/Decentralized Energy Trading. According to researchers the P2P Energy Trading based on BC is one crucial column of the future EM.

Company & Project	Field of activity	Platform	Consensus algorithm	Location
4New	Cryptocurrencies, tokens & investment	n/a	n/a	UK
BCDC (Blockchain Development Company)	Cryptocurrencies, tokens & investment	Ethereum	Proof of Work	UK
EcoCoin	Cryptocurrencies, tokens & investment	Hyperledger Fabric	Practical Byzantine Fault Tolerance	Netherlands
Energi Mine	Cryptocurrencies, tokens & investment	Ethereum	Proof of Work	UK
Enervalis (NRGCoin)	Cryptocurrencies, tokens & investment	n/a	n/a	Belgium
Envion	Cryptocurrencies, tokens & investment	Tendermint-based	Delegated Proof of Stake	Germany
Green Energy Wallet	Cryptocurrencies, tokens & investment	n/a	n/a	Germany
Grünstromjeton	Cryptocurrencies, tokens & investment	Ethereum	Proof of Work	Germany
HydroMiner	Cryptocurrencies, tokens & investment	n/a	n/a	Austria
Inuk	Cryptocurrencies, tokens & investment	Ethereum	Proof of Work	France
MyBit	Cryptocurrencies, tokens & investment	Ethereum	Proof of Work	Switzerland
PROSUME	Cryptocurrencies, tokens & investment	Proprietary	n/a	Switzerland
WePower	Cryptocurrencies, tokens & investment	Ethereum	Proof of Work	Gibraltar
Energy21 & Stedin	Decentralised energy trading	Quasar	n/a	Netherlands
OneUp	Decentralised energy trading	Ethereum	Proof of Work	Netherlands
Oursolargrid & ITP	Decentralised energy trading	Ethereum	Proof of Work	Germany
PONTON (EnerChain)	Decentralised energy trading	Tendermint	Practical Byzantine Fault Tolerance	Germany
PROSUME	Decentralised energy trading	Proprietary	n/a	Switzerland
Restart Energy	Decentralised energy trading	Pylon Coin CORE (LiteCoin & CREAtivecoin-based)	Proof of Capacity	Romania
SunContract	Decentralised energy trading	n/a	n/a	Slovenia
Wien Energie	Decentralised energy trading	Interbit		Austria
Alliander & Spectral Energy (Jouliette at De Ceuvel)	Decentralised energy trading	MultiChain	Proof of Work, Round Robin-based	Netherlands
Alliander (Alva)	Decentralised energy trading	Ethereum	Proof of Work	Netherlands
Bittwatt	Decentralised energy trading	Ethereum	n/a	Romania
BLOC (EnergyBlock & Community Power)	Decentralised energy trading	n/a	n/a	Denmark
Bouygues Immobilier & Stratumn	Decentralised energy trading	Proprietary	Proof of Process	France
BTL	Decentralised energy trading	Interbit	BFT-based	Canada & UK
Clearwatts	Decentralised energy trading	BigchainDB (Tendermint-based)	Practical Byzantine Fault Tolerance	Netherlands
Conjoule	Decentralised energy trading	Ethereum	Proof of Work	Germany
Green Running (Verv)	Decentralised energy trading	Energy Web (Ethereum-based)	Proof of Authority	UK
Grid Singularity	Decentralised energy trading	Energy Web (Ethereum-based)	Proof of Authority	Germany
Hive Power	Decentralised energy trading	Ethereum	Proof of Work	Switzerland
Power-ID	Decentralised energy trading	n/a	n/a	Switzerland
Pylon Network	Decentralised energy trading	n/a	n/a	Spain
Spectral Energy	Decentralised energy trading	MultiChain	Proof of Work, Round Robin-based	Netherlands
StromDAO	Decentralised energy trading	Fury Network	Proof of Authority	Germany
ToBlockChain	Decentralised energy trading	n/a	n/a	Netherlands
toomuch.energy	Decentralised energy trading	n/a	n/a	Belgium
VAKT & partners (including BP, Shell & Statoil)	Decentralised energy trading	n/a	n/a	UK
Vattenfall (Powerpeers)	Decentralised energy trading	n/a	n/a	Netherlands
Wuppertal Stadtwerke (Tal.Markt)	Decentralised energy trading	n/a	n/a	Germany
Alliander (Charge Ledger)	Electric e-mobility	Ethereum	Proof of Work	Netherlands
Car eWallet	Electric e-mobility	Hyperledger Fabric	Practical Byzantine Fault Tolerance	Germany
Innogy Motionwerk (Share&Charge)	Electric e-mobility	Ethereum, Energy Web (Ethereum-based)	Proof of Work, Proof of Authority	Germany
PROSUME	Electric e-mobility	Proprietary	n/a	Switzerland
Slock.it	Electric e-mobility	Ethereum, Energy Web (Ethereum-based)	Proof of Work, Proof of Authority	Germany
Alastria	General purpose initiatives & consortia	n/a	n/a	Spain
BlockLab	General purpose initiatives & consortia	n/a	n/a	Netherlands
Endesa Energia (Blockchain Lab)	General purpose initiatives & consortia	n/a	n/a	Spain
Energy Web Foundation	General purpose initiatives & consortia	Energy Web (Ethereum-based)	Proof of Authority	Switzerland
EU Blockchain Observatory and Forum	General purpose initiatives & consortia	n/a	n/a	EU
Eurelectric (Blockchain Discussion Platform)	General purpose initiatives & consortia	n/a	n/a	EU
Grid Singularity	Green certificates & carbon trading	Energy Web (Ethereum-based)	Proof of Authority	Germany
Poseidon	Green certificates & carbon trading	Stellar	Federated Byzantine Agreement	Switzerland
Electron	Grid management	Ethereum, Energy Web (Ethereum-based)	Proof of Work, Proof of Authority	UK
Grid Singularity	Grid management	Energy Web (Ethereum-based)	Proof of Authority	Germany
OurPower (CEDISON)	Grid management	n/a	n/a	UK
PONTON (EnerChain)	Grid management	Tendermint	Practical Byzantine Fault Tolerance	Germany
PROSUME	Grid management	Proprietary	n/a	Switzerland
Tennet & Sonnen	Grid management	Hyperledger Fabric	Practical Byzantine Fault Tolerance	Netherlands
Tennet & Vandenbron	Grid management	Hyperledger Fabric	Practical Byzantine Fault Tolerance	Netherlands
SP Energy Networks, SSEN, SP Distribution, SP Manweb & UK Power Networks	Grid management	n/a	n/a	UK
FlexiDAO	Grid management	n/a	n/a	Spain
DAISEE	IoT, smart devices, automation & asset management	Ethereum	Proof of Work	France
Dajie	IoT, smart devices, automation & asset management	n/a	n/a	UK
ElectriCChain (SolarCoin)	IoT, smart devices, automation & asset management	Bitseed, Chain of Things, Ethereum, Grid Singularity, IOTA and SolarCoin	n/a	Andorra
Fortum	IoT, smart devices, automation & asset management	n/a	n/a	Finland
Freeelio (AdptEVE)	IoT, smart devices, automation & asset management	Energy Web (Ethereum-based)	Proof of Authority	Germany
Green Running (Verv)	IoT, smart devices, automation & asset management	Energy Web (Ethereum-based)	Proof of Authority	UK
Oli	IoT, smart devices, automation & asset management	Ethereum	n/a	Germany
Slock.it	IoT, smart devices, automation & asset management	Ethereum, Energy Web (Ethereum-based)	Proof of Work, Proof of Authority	Germany
Wirepas	IoT, smart devices, automation & asset management	Energy Web (Ethereum-based)	Proof of Authority	Finland
Electron	Metering, billing & security	Ethereum, Energy Web (Ethereum-based)	Proof of Work, Proof of Authority	UK
Elegant	Metering, billing & security	n/a	n/a	Belgium
BAS Nederland	Metering, billing & security	n/a	n/a	Netherlands
CGI & Eneco	Metering, billing & security	Tendermint	Practical Byzantine Fault Tolerance	Netherlands
Enercity	Metering, billing & security	Tendermint	Practical Byzantine Fault Tolerance	Germany
Engie	Metering, billing & security	n/a	n/a	France
M-PAYG	Metering, billing & security	n/a	n/a	Denmark
PROSUME	Metering, billing & security	Proprietary	n/a	Switzerland
Pylon Network	Metering, billing & security	Pylon Coin CORE	Proof of Capacity	Spain
SunChain (TECSOL & Enedis)	Metering, billing & security	Hyperledger Fabric	Practical Byzantine Fault Tolerance	France

List based on reference: (Andoni et al. 2019).

Appendix 5.5. Interview with Emanuele Rossi, Product and Innovation Manager at FlexiDAO

Interview held online on November 9th, 2021.

Interviewer: Louisa Kreis von Ratibor	Interviewee: Emanuele Rossi from FlexiDAO
Very good thank you for your time. Maybe you can tell me a bit about your position at FlexiDAO. I think for for the beginning it's very interesting for me to know what you do as a as a product innovation manager. Are you like are you really developing? Or are you in contact with the customers or what is your exact position?	So, I joined more than three years ago now. And when I started here, we were five, the three co-founders. I started working on the product and right now, we're at 80 already. We are currently hiring product guys are at the moment. So, I joined three years ago we were only five and I started working on the product from day one. Right now, we are 80 in general, but at the moment I'm alone in this area. What I do is everything that starts from idea creation and customer meeting. So potential clients, existing clients and then all the product process, so design everything, and also management of IT workload.
And I don't know, if I understood correctly from what I read from the webpage that your customers are only companies and also energy retailers, but not individual people, right? *(what are the main challenges of your product or service/company?* *How would you rate the consumer adoption for your product or service? What is the reason, that still many people do not use this product or service? (And still choose the traditional way) Is there any resistance to change and adapting behaviour?)*	Yes, it is what we have seen in the market. So, just to give you a bit of the history of the company. The company started more on peer to peer NMT(Energy?) exchange model, so with a very tacky algorithm, to ensure the optimal transaction and flows of electricity and it was working, but the market wasn't ready, and the market is not ready yet. We have some competitors that are doing it, but they are just focusing on very small and rural areas, or microgrids, which is not really applicable to smart cities and to cities of today. So basically, we transition from there, to something that was applicable now and something that could create value, at least for part of the society. We've seen that in terms of sustainability issues and drivers, the companies are the ones that are driving all this stuff. So, it's a little bit of both, so the companies are driven by consumers, by their clients. The raising awareness of their clients related to sustainability issues, emissions and everything.
Are regulators adapting a bit? *(In regard to the "City Model Canvas" (see figure 1. on page 3.) what key infrastructure and resources and key regulatory framework is needed to apply your innovation on a high scale in a smart sustainable city?)*	Yeah, but it's still, let's say, under development. Regulations are not really in place yet to be so strict and enforcing a lot of sustainability actions for companies. So, we're seeing for example, now, in the last six months, Google and Microsoft are starting to go 24/7, meaning real time electricity matching. Which is exactly what we are doing at FlexiDAO, basically. But this is not enforced by regulations, and will not be enforced by regulation, most likely, not in the next couple of years, because companies are not ready, and neither are governments.
Has this also to do with the infrastructure? Or is it more the people and governments that are not ready for this energy transition? *(In regard to the "City Model Canvas" (see figure 1. on page 3.) what key infrastructure and resources and key regulatory framework is needed to apply your innovation on a high scale in a smart sustainable city?)*	No, definitely the infrastructure was not meant to ensure perfect allocation of electricity in real time. On a physical level, yes, because if you switch the light on, the light comes immediately, but not in terms of contractual relationships and agreements. Since sustainability reporting is only based on contractual agreements, it means that more or less, you need two or three times the amount of renewables to cover your consumption in order to be 24/7. We were doing some pilots and projects with companies. Microsoft, for example, is one of them. Overall, with all the clients we've seen that they need between 200% and 250% of renewable energy production, to cover between 70 and 90% of their loads, on real time basis. (…)
It's really interesting because as you said already like this peer to peer trading is something of course comes up when looking into this Blockchain topic in the energy market. But for me, for example, if I look at Grid Singularity, it's very difficult to understand what they're doing exactly. *(What is your opinion towards critics concerning your product* *position your product or service in sustainable smart cities?)*	Yes! So, there are besides Grid Singularity, three known energy startups. In the state's,…, Power Ledger in Australia. All of these companies basically started doing peer to peer and they're still doing peer to peer, but now, I think they are transitioning more and more into our vertical, because they have seen that what they're doing is not very scalable. I'm not really sure that it will be in the future, ever. So the concept of the microgrids can be applicable in rural areas, but the future is not going towards that. If you have a glopoly(?) or like a huge city, most likely it is not what is needed. It has to do with the way that the grid is structured that it should be a microgrid. Because then you make it very complicate, to exchange flows between one another.

	It is also very hard to restructure completely the electricity infrastructure in the city, that is growing and growing. I don't know, I just don't see it coming.
Through your software with the dashboards, it makes your work very visual. And I think that's very important for people that are not experts in this topic that they can understand what the metrics are, that you're looking at. What do you think and what would you say are the important metrics? *(What development and changes will occur until 2050 in this area in Europe? (he said the two sided ..)* *What are further application areas that can be based on your concept? (other sustainability metrics in reporting, not only electricity, is only a small piece))*	Yeah, considering that many companies also don't have very experienced individuals, focusing only on electricity. We're covering is just a small piece of the puzzle of sustainability reporting, for which there are three scopes. Electricity enters in scope 2 which is already part of the puzzle. Then in scope 2, electricity is just one question out of maybe 20 questions, so it's a very small piece. Usually companies have sustainability manager that cover everything, so all these flows that are part of sustainability reporting and it's not only about flows, so it's not only about water, heat, electricity, but it's also about for example, diversity in the workspace, so social sustainability. So, as you see, it's a very broad topic and usually the sustainability manager needs to cover a lot of different issues. So, they cannot be very focused on one specific one only. Usually they prefer to have one single sustainability tool, that collects all the data they need and that's why I'm saying that still also our market is very early stage. Because again, if regulations are not enforcing anything related to for example, 24/7, then it becomes less interesting for that. So, considering that at the moment the standards for sustainability, are only voluntary. So, as a sustainability manager, I make the claim, that I am renewable, and I have certificates to back it up. That's the only thing that I'm doing, I put 1 number of total electricity consumption and 1 number total certificates received.
They don't have the urge. Maybe some are doing it because customers are asking for it, but still it is in a transition phase. *(create value and for whom(benefits the most?)*	Exactly! So, what you're seeing is either a push from clients or a push from internal stakeholders that want the company to establish itself as a leader in the transition. In that case, we have seen Google and Microsoft, because they already were the leaders of the PPA(?) transition, and now they are the leader of this 24/7 transition. Also being the first movers mean that they can lobby, and they can try to force the methodologies on others. Which makes sense, because if you if you take a look at both methodologies, Google and Microsoft, they have very different scopes and very different criteria and requirements. For example, Google includes nuclear, and Microsoft doesn't. Both of them are trying to push for this for their specific case, because of course it is beneficial for them. If you imagine Google procurement strategy, they are already going in one direction, they don't want to shift the direction and change their procurement budgets, procurement contracts, and everything, just because they need to change their methodology. So, they're trying to push for their methodology, being the first movers, in order for them to have a lot of companies following their lead.
It is interesting to see it from that side. *Just a question, because you say that customers of you are also energy retailers, what can I understand under energy retailers?*	Okay, so basically, retailers, commercializadoras in Spanish are all the companies that are offering contracts to clients. Electricity companies that are offering contracts, energy tariffs to individuals or businesses. For the other kinds, or for the big players, there there is usually, there's one company name, so E.on is one, but they usually have E.on distribution, which is the distribution system operator. They have E.on generation, which is the generation company and then they have E.on retail, which is the one that is signing, actually the contract with the customer. So, you see them as one, but they're actually diversified. It's the same for NL, for example, or…
Okay, but then there are also small ones, like the ones only focusing on green energy. Are you also taking these into account or only the big firms? And you are only focusing on renewables? *(In regard to the "City Model Canvas" (see figure 1. on page 3.) what key infrastructure and resources and key regulatory framework is needed to apply your innovation on a high scale in a smart sustainable city?)*	No, then we don't really care about, we're focusing just on renewable energy. It is true that we are currently working with a lot of big guys, mainly because they have higher budgets. But also because smaller energy retailers, are often not guaranteed of origin generation, which is very important for us. Because if you and I want to start an energy retail company, we can easily do it, because in the end it's just buying electricity from the market and sell it, like a trader. So we can set up a company today, claiming that is 100% renewable and the only thing that we do is we buy electricity in the market, we sell the electricity to our clients and then the end of the year we buy the certificates, the guarantees of origin, which is a yearly statement that says that a certain quantity of electricity has been produced by renewable energy generation. In Europe it is called guarantees of origin abbreviated as GOs, or GOO's. So, these are usually referred to as energy attribute certificates (EACs). and there are different schemes of the word but guarantees of origin is one of them and is the monopoly in Europe, like how you call it, as official certificate. So,

	if I'm Google, for example, I cannot claim to be renewable if I don't have guarantees of origin to back this day.
So, we talked a bit about the concept of smart cities, where would position your firm, and your product in future smart cities, if we look in the timeframe Europe until 2050? *(Did you already work with the concept of smart cities? If yes, where exactly would you position your product or service in sustainable smart cities?* *What development and changes will occur until 2050 in this area in Europe?* *What are further application areas that can be based on your concept?* *main challenges of your product or service/company?* *How does your product or service create value?)*	We need to consider that two out of three founders studied in a master called Energy in smart cities and I studied the same master, so we come, well, at least the three of us, with a background of studying from a technical electricity point of view, smart cities and how cities should move in the future. It is clear that the electricity grid and the electricity sector is very traditional and old fashioned, especially because it was meant basically to be one way, so from generation to consumption. Now with renewables, we are starting to see a two-way electricity grid. Consumers are also prosumers, they can inject in the grid, then they can get electricity from the grid. It's going to become more and more complicated into the future with new technologies, with storage that is going to be crucial. But then also how do you deal with the waste of storage and all of that. And it is also clear that then there will be electric vehicles and the injection or the request of electricity from electric vehicle will also change the way that the consumption load is shaped and how in the end, the electricity grid needs to be controlled. So, at this stage, usually the majority of the responsibility was on the TSO, on the high voltage grid because the generation was usually and mainly connected to the high voltage grid. But now we are seeing a lot of TSOs that are worried because a lot of generation is being connected into low and medium voltage grids, that are decentralized, also with the distributed energy resources. Also, right now nobody's really caring about where the electricity generation is connected. So basically, they are like owning mushrooms, but they're not really careful about where they are connected, and the electricity grid is made out of nodes and if one node gets congested, because there's a lot of renewables, that means that potentially renewable energy generation is good. Yeah, so basically, the electricity just isn't also connected generation assets. So, if you imagine that the genetic capacity and, in that node, there is the injection of a lot of improper energy generation assets, let's say 180. Above, that means that only 100 of that 180 can be dispatched. So, you can you can continue investing on renewable energy assets. But on the one hand, it will lay down cables that are more electricity, or it gets curtailed, and basically your investment is, is useless. Nobody right now is also looking into that, which is a very technical issue. And mainly because there's this kind of information silos between TSOs, retailers, and DSOs. That they are not really speaking to each other. And that's a bit a bit the role we are trying to play there connecting the art a bit like connecting the energy players. Yeah, so at the moment, we're only focusing on action and 3d, because future that is moving. But we also have some clients that are TSOs. And so, we have a project, for example, in Spain, working with the TSOs track decentralized energy generation. recommendation So the TSO has no visibility over the PV installations in the country. So, what you're doing is just tracking where they are, and how much electricity they're producing in on a real time basis.
What advantages and potentials are offered to your environment and customers through your products or services? What are your sources of value?	Yeah. It's clear that it is for this man cities of the future that we need to be more communication between parties. And these most likely also where Blockchain could make any impact on because companies don't like to share information. Bobby, Bobby, usually have a very old-fashioned infrastructure, IT infrastructure. So that means for example, that if I need to give you access to data, I need to give you access to my database, and you can potentially retrieve all the data. So now parts and disease were blocked, Blockchain could actually encrypt the data and then being able to only parts, exactly behind private keys to be able to actually see only the data that you need to see. And it's it's tougher to hack and we're seeing that in the sector, a lot of companies that have been hacked. The basis we had in Spain, EDP, we had an actual now they've got hacked. And this means a lot of private information went public and data of consumption of companies.
On a source of you it said: no company	It's an added additional feature and it will be needed, but it gives.

really needs Blockchain. But it is an additional feature that gives you security, can help against hacking and others, is that right? *(What advantages and potentials are offered to your environment and customers through your products or services? What are your sources of value? the main challenges of your product or service/company?)*	So, for the moment, Blockchain is needed only as digital ledger. So, it's just it's just there's a new way to perform auditing. For example, to ensure traceability, the transparency of the data, before it was done inside the energy within the database. So, before Blockchain you were trusting the energy retailer with all the data that they were sharing with you. Right now, on top of the energy retailer, you have Blockchain, s which is something that also a lot of companies are not understanding. So, it's also a process that will have to be done. Yeah. And it's not from zero to 100. So, it's just the process.
What is really the value your product transmits and for whom, really the main value and the main beneficiaries of your product? *(What advantages and potentials are offered to your environment and customers through your products or services? What are your sources of value? How does your product or service create value and for whom (benefits the most? Who does really capture this value in the end?* *How does your product contribute positively to sustainability? Which area, stakeholders etc.)*	okay, so basically, the product that we're selling, can be of two types. Basically, on the back end are the same, but let's say on product side, it's exactly the same on commercial, we have just, let's say two different products. One, which is called Basic. The basic is just a collection of the time certificates. And then one really doesn't need Blockchain. So, we have it, but it's, it's not necessary. And so that is more for very beginning companies that are starting the renewable energy transition and join me, but they are not ready yet to be trained to track the electricity in real time. They don't have PPA contracts, they only have three days, or they just get certificates at the end of the year. So, these more or less the first product. And the value is, it is very difficult for a company, for example, to gather all the data in all the countries of consumption and have certificates. I mentioned to you before that the countries of origin have these energetical certificates mechanism that we have in Europe to ensure and to certify that it is one system, but then every country applies it in a different way. So, there's this one, let's say high level regulation. But then every country is applying characteristics, which means different ways to integrate in each country, and a lot of time-consuming procedures for consumers. So, this is let's say the first part so value creation for Consumers Energy collection, energy data collection, which is also not very accessible at the moment. And certificates from a retailer point of view, we say that some of our clients are retailer while the value creation is still for them consumers, clients, but retailers are willing to jump in and use our platform because they diversify from competition. So, they create a new service. We've advanced analytics, advanced visualization, to actually help them reducing the churn rate and increasing their customer retention. This is the Basic. Then instead we also have the Advanced 24/7. So we see for example, Google Making these claims and they are making claims but they do not have the tool to actually do what, they are not able to track production consumption data on real time basis, because they're focusing on something else to their business is focused on different things. And so, what we are doing basically is providing them the tools to back their statement. More or less the gist of it Then at the moment, there is a coalition. We call it organization called energy dog that is lobbying for these 24/7 Electricity matching. N TAG for example are not in the webpage energy tag. Yeah. So you can check the white paper, for example, and the websites and all these companies that are interested in that, you know, since either this provider and they're trying to lobby and create a framework to actually perform these granular matching, and creating these new, let's say certificates called grandma certificate. Future So that's what they should, like, the other one should go on, and there's one or one general one that could be made make it easier. Yeah, exactly, exactly, it will be a very high-level framework. So, there will still be different methodologies inside the energy framework. But still, it will lay more or less the rules, the basic rules that companies need to follow. And right now, nobody is actually working on making these rules only us and a few others.

Appendix 5.6. Interview with Dr. Ana Trbovic, Co-founder and COO at Grid Singularity

Interview held online on November 10th, 2021.

Interviewer: Louisa Kreis von Ratibor	**Interviewee: Dr. Ana Trbovic**
Why is your product or service and innovation? What do you understand under the concept of innovation?	So not 3da anymore it is called now Grid Singularity exchange platform, but it is the same. They exist in two formats. One is a simulation environment, which is free to use, and which is educational, because allows people to configure digital energy communities and to understand the benefits of energy trading. And then, you know, as we're getting closer, it will be also software that you can deploy to operate real local energy markets. The innovation is in that it's a bottom up approach rather than top down, and the exchange happens at the level, more reflective of the reality of the market. At the level of the house, then at the level of the street, and then going up, whereas at the moment, the exchange happens much higher and there are many inefficiencies. And the goal of what we do is to optimize the consumption of what is produced locally, right, so to consume as much as possible to share, and also for people to be more encouraged to invest in renewables and participate in generations. So that is the innovation, it is actually quite disruptive, because it changes the way the market works. And, and we have done studies to prove that that is a more efficient way of organizing the market. What we are doing also, you know, we're working in a highly regulated industry, which is energy industry. And therefore, currently, what we're proposing is not covered by regulation. And the regulation has to evolve to allow for this different type of market design. So yes, I hope that answers the first question.
How does your solution differ from other (innovative) solutions?	How do we Yeah, how do we differ? Right? We're local, we're not wholesale. Also, there are other solutions that say they do peer to peer trading, but they really only do an exchange of energy certificates, not the actual facilitation of trade. And also, we're the only project that goes that is completely open source. Everything you do is public.
Okay, so going to the next question of smart cities. Did you already work with the concept of smart cities? If yes, where exactly would you position your product or service in sustainable smart cities?	Yes, it's it's intertwined with smart cities in that in that you are promoting local energy markets participation of individuals and more equitable access of individuals to the energy market. They would be smarter in that they would optimize their resources and reduce grid congestion and keep other benefits, which you can all see on our Viki suggest you also review our wiki as a set. You can share your share that we're also actually working in one EU project called AI for cities where we are collaborating with another startup from Sweden. And they're developing smart trading algorithms for energy trading so that you can even be more optimal in local trading and then trade even more smartly. This is a project that we're doing with some cities in Europe as pilots and they will be sharing some data and you will be doing some testing. And at the moment, the entire software is really in testing stage to convince regulators over time to adapt regulation to allow it.
Sustainability are the principles, also your principles, I like them a lot, because they're going the three dimensions like of sustainability, like sustained, like environmental, social, but also economical, you want to bring that forward. *How does your product contribute positively to sustainability? Which area, stakeholders etc.*	Yes, absolutely. Because it increases the consumption and the self-sufficiency of different energy communities that participate in this local energy markets. Yes, yes, the 4 principles are really the values that we share. And that's why it's an open source development as well. It is sustainable. So even the Blockchain implementation that we use is not proof of work, so it doesn't overuse electricity. So definitely, all the aspects are, you know, our internal policies and everything we try to promote sustainability. Yes, so we actually contribute to multiple SDGs which you can, you know, easily cross reference. Like you said, economic, social and environmental, right, energy efficiency, and also more equity and equal better access for individuals to the market, which also leads to empowerment of different groups that are currently marginalized. So actually, we contribute to multiple SDGs.
Do you use any sustainability metrics to measure the sustainability? Which ones? How do you contribute positively to the SDGs?	So yeah, so we're small, you know, so we don't issue annual reports or anything, but we definitely abide by the principles. If you see our team as well, gender diversity is an important aspect. And diversity, you know, generally, you know, also promoting youth the interaction with education

	with research. So, yes, so in practice, this is what we do, but I agree with you and I could be interesting, maybe that's something you can contribute. Maybe you can maybe Give us an analysis of different SDG goals that we meet and actually do that. I will get me we can add the diagram. Yeah. To our wiki.
What advantages and potentials are offered to your environment and customers through your products or services? What are your sources of value? How does your product or service create value and for whom (benefits the most? Who does really capture this value in the end?	Oh, yes. We have a list of benefits on our wiki. I think that's easiest for you to use for your thesis. And who benefits the most, you know, the person and the individual? Yeah, because at the moment, it's really the way the market works is that only large players benefit from it. And this is levelling the playing field and allowing access to the individual.
What would you say is your impact mission?	In fact, we actually have one mission in the wiki as well. I think a lot of these are already there. You know, I think you used to you saw that page probably with our mission
How would you rate the consumer adoption for your product or service? What is the reason, that still many people do not use this product or service? (And still choose the traditional way) Is there any resistance to change and adapting behaviour?	So currently, like I said, our development is in two stages, the simulation person then deployment and the simulation, we are getting feedback from researchers from individuals who have no energy background. And, you know, we continually increase the functionality so that so that it's more useful to them. We also work with NGOs. You may have seen we did a study that with an NGO in Germany, BBN that promotes energy sustainability for citizens. And we did a study using our simulation to demonstrate how one such energy community could be benefit if they started trading peer to peer.
What is your opinion towards critics concerning your product or service and what are the main challenges of your product or service/company?	Our biggest challenge is regulatory. And I can't say there is a critic because even the regulators are supportive, it's more the pace of change, that is a challenge, right? We don't really have the only obstacle is pace of reform change. It's not the direction it's going in the right direction, it's more holistically we will get there. Um, and this is also preventing other startups from coming more strongly into this field is preventing development because it's a slow regulatory change. And we are a startup that already had one successful venture. And we're using that funding to develop this particular product, but not every startup has that luxury to take the time and be there when the regulator's survey these so it is, you know, the regulators should be increasing the pace not just for our product come to life, but also for everyone else to start businesses not building business models that benefit citizens in renewables.
Do you think that overall there is collaboration between public and private partners regarding this area?	yes, like I said, we have research projects, with different cities with communities with energy companies with research already as Asians overall that there is there is a drive to endorse local energy markets, but as noted it the pace is not I cannot say that satisfactory.
How will this (innovation/product) affect and shape the future? What are the main potentials and opportunities? What development and changes will occur until 2050 in this area in Europe?	So, we're hoping two to three years. Yes. And it's it's really dependent on regulatory pace. And it may happen faster in some markets than others. For example, Australia and California are more advanced in the regulatory change. Some EU member states are more advanced than others, for example, Austria, in developing the Energy Community legislation, so that really depends on regulations more than on our technology development, because, you know, we can already start the pilots as is and we are starting them in different research projects. But you know, the market is still not ready for us to deploy more mainstream going back to your campus. Yes. So, in our case, the regulation is at the country level, not the city level. What city can do is making it easier for people to invest in renewables. Because the more people have assets, the more they can benefit from local trading and local markets. So that is the role for the cities. It's more at that level. Even that is tied to national legislation, but there is also a role for cities.
But is it really ready, like the infrastructure also to begin with this kind of project on large scale? Because maybe it has to do that people need to invest and need to have?	So that's a good question, because people think that they need to have a lot of resources to benefit. But in fact, they have shown that even if you have zero resources, and you just have your load, meaning how you consume, even then you can participate because people have different patterns of consumption. A bakery and a person who goes to an office during the day will consume differently during that day, right? So yes, so even if you don't have many resources, you can benefit from local energy markets. And then add that if you have possibly an EV car, right. If you have an electric vehicle, that's also a resource and then imagine if you also have like a solar panel or heat pump

	storage. Yes, yes. So those are all possibilities. But the benefits are, of course greater, the more diverse and different you know that the size that you have, if you have storage. Obviously, the benefits are greater, but you already have benefits even if you just participate with your consumption pattern.
For normal people it is very difficult to understand quickly, what this new energy world is about. How can you increase awareness or plan to increase user numbers?	Did you see our latest medium article? It's to kind of simplify everything. Yeah, it's very hard to help people understand. But you know, there are also many NGOs that try to do that and educate people. So eventually, you know, for us to have more impact, we want to work with them and work with different energy partners. Right. So, we are the exchange. So, we're just the facilitators, so we always need partners in different markets to have a multiplier effect. And they are everybody's interested, the regulators are supportive, but you know, not all the pieces of the regulations are there yet to be able to fly. That's why we are we're working in an uncertainty. But, you know, we believe there is value even from educating people, and also, you know, having them understand the benefits of participating in this market.
There are so many stakeholders in the energy market, so many participants. Could you explain me what differentiates them?	There are some specifications. So, so TSOs, they manage the grid at the higher level, right voltage level, and then the distribution operators, they manage it at more local level, and the distribution operators are very interested in our products and local energy markets, because it allows them to manage congestion better, right. And to say, Now, I will procure from the city and for example, there is a project that California did now called the flex alert with the energy bath Foundation, which we helped co found that was our first venture, and with a flex alert, people can be alerted. And then they can say yes, I will participate, and I will give you my flexibility to maybe prevent the blackout, you know, in my streets. This, these projects are already happening. And so our tool goes in that direction and allows the grid operator, the sorry, the distribution operator, in this case, to send the price signal and say I will give you a better price because I it's less costly for me to give you a better price now. And then to get it from let's say, you know, you're in Munich and the wind farm is in Hamburg, it that's more expensive than buying from a local person help the congestion in Munich. And so that's why this distribution operators are very interested in local energy markets and they're very supportive. Utilities are basically energy suppliers, right? Utilities, the idea of our product is to put you as a person at the same level as the utility alright, and the energy trade traders that you mentioned are more at the different levels so they're not at the local level. And what we're proposing is that you as a person become an energy trader and utility if you have a resource, right, and that you have exactly the same rights as these big players, But this is what not what the system was designed for. The system doesn't say you can't trade. It doesn't say it's not legal, but the system says, it talks about much higher values, right, that we cannot meet these households. And of course, you know, because it's so regulated, there is a set of criteria you need to fulfil to be an energy trader. But if you're a household, you're not going to go and apply for an energy license. Right. This is why the system has to be adjusted to allow small players to come in and have the same conditions as the big players without the administrative hassle, which is too burdensome for small for household.

Appendix 5.7. Social Business Model Canvas Grid Singularity

SBMC Grid Singularity

Key Resources

- NETWORK OF PARTNERS, INSTITUTIONS
- KNOWHOW
- DEVELOPERS AND ENGENEERS
- GATHERED DATA
- SERVER
- CODEBASE
- CAPITAL

Key Partners and Stakeholders

Ownership Status Privately Held (backing)
PARTNERS:
- EWF (FOUNDATION)
- ROCKY MOUNTAIN INSTITUTE (JOINT VENTURE)
- ERA-NET MEMBERS
- SOCIAL ENTERPRISES
- ENERGY/TECH COMPANIES

STAKEHOLDERS:
- CONSUMERS/PROSUMERS
- INVESTORS/ FINANCIAL P.
- REGULATORS AND GOVERMENTS

Core Interventions

- OPEN (PERMISSIONED), INTERNET-BASED DECENTRALIZED E. DATA EXCHANGE PLTF. (VIA EWF)
- OWN GRID MGT PRODUCT (ON TOP OF EWF)

D3A.io/ GS E. Exchange Pltf: (BUSSINESS APPLICATION BY GS) - E. TRADING MODELLING + SIMULATION TOOL
CANARY TEST NETWORK: (BU. APP) TESTING TOOL VIRTUAL LIVE COLLABORATIVE E. TRADING (FOSTER COOPERATION AND KNOWLEDGE EXCHANGE)
LOCAL E. MARKET DEPLOY API/SW: (HIGH LEV. SERVICE) API/SW. CUSTOM LOCAL E. EXCH.
EWF DID REGISTRY: (SUPPO SW.)-BB DECEN. ASSET REGISTRY
INTEG. API W. HARDW. PART: (PHYSICAL) AGGREGATORS /SMART METERS/ OTHERS
- EVERYTHING COUNTS AS TOTAL SOFTWARE OPEN SOURCE GNU

Key Activities

- E. DATA EXCHANGE
- PROVIDE FREE SIMULATION PLATFORM (new interface is live July 2021)
- DOCUMENT TECHNICAL DVLP ON PUBLIC GITHUB AND WIKI PAGE
- TRACKING GENERATION, MOVEMENT, DIST. POWER THROUGH SMART DEVICES
- FORECASTING FOR GRID BALANCING (SMART G. MNGT)
- OPTIMIZE CURRENT OPERATIONS
- REINVENT E. GENERATION, TRADING AND DISTRIBUTION --> MORE SUSTAINABLE POWER MARKET (USE OF RE)
- MAKE CHANGE: ENCOURAGE AND REWARD MORE SMALLER AND ALTERNATIVE POWER R.
- ELIMINATE ROLE OF TRADITIONAL INTERMED.
- CREATE NEW /GREEN BM
- CREATING TRANSPARENCY AND INTEGRITY
- EWF: (CORE INFRAS. LAYER) NEURAL PLAYER- BRINGS TOGETHER STARTUPS, UTILITIES, GRID OPERATORS, ENVIRONMENTAL GROUPS

Beneficiaries / Customer

MAIN BENEFICIARIES/Cust:
- E. CONSUMERS (INDIVIDUALS)
- E. COMMUNITIES
- ENVIRONMENTAL GROUPS

OTHER BENEFICIARIES/CUST:
- UTILITIES (E.g. RWE, EON, ENBW)
- TRANSMISSION GRID OPERATORS: (E.g. TenneT)
- DISTRIBUTION GRID OPERATORS: (DE: REGIONAL AND MUNICIPAL APPROX. 880) (also some belong to large conglomerates eon,innogy, enbw)
- GRID REGULATORS: (E.g. Federal Network Agency)
- E. INVESTORS (Centrica, Elia, Engie, Shell, Sempra Energy, SP Group, Statoil, Stedin, TWL, and Tepco have joined, and also raised $2.5 million in funding)
- 4 investors: Blockchain Capital, i5invest, Team in Residence, The Blue Minds Group
- ETC.

Value Proposition for Beneficiaries / Customers

- 1. FOSTER EQUITY: overcome access barriers to facilitate equal market opportunities for diverse participants. + champion social entrepreneurship that puts ecosystem benefit before profit.
- 2. INNOVATE FOR ALL: open source development can create accountability, inclusivity and ecosystem engagement.
- 3. PRIORITIZE ENVIRONMENT AND SOCIETY: safeguard the environment by optimising renewables and enhancing efficiency, creating a negative footprint.
- 4.DEMOCRATISE: enable transparency and sovereignty with tools to implement free and informed choices in a fair market competition.

Impact Mission

- "Grid Singularity's mission is to build a sustainable, inclusive and democratic energy market that facilitates the ultimate degrees of freedom for the individual and the energy communities, allowing you to consume, trade or share energy based on your preferences of an energy type, location source, price or trading partner. You are energy."

Channels

ONLINE:
- WEBSITE
- SLACK
- PARTNER SITES

STATIONARY:
- AT SUMITS AND FAIRS
- WORD OF MOUTH

Revenue Streams

- ANNUAL SUBSCRIPTION FEE GS CANARY TEST NETWORK SERVICE (FOR GRID OPERATORS E.G ADDITIONAL FEATURES AND TOOLS)
- TRANSACTION FEE - SOFTWARE DEPLOYMENT MODEL (DETERMINED BASED ON PARTNERS)
- FUNDING? Financing Status: Venture Capital-Backed - LATEST DEAL TYPE: EARLY STAGE VC
- LICENSE PRICE: (GNU GENERAL PUBLIC L.) PROPIETARY COMMERCIALISATION

Cost Structure

- R&D costs and Staff costs
- Overhead costs (electricity, processing time)
- Capital costs: (physical resources)
- support costs (customers, users)
- Sales and Marketing costs

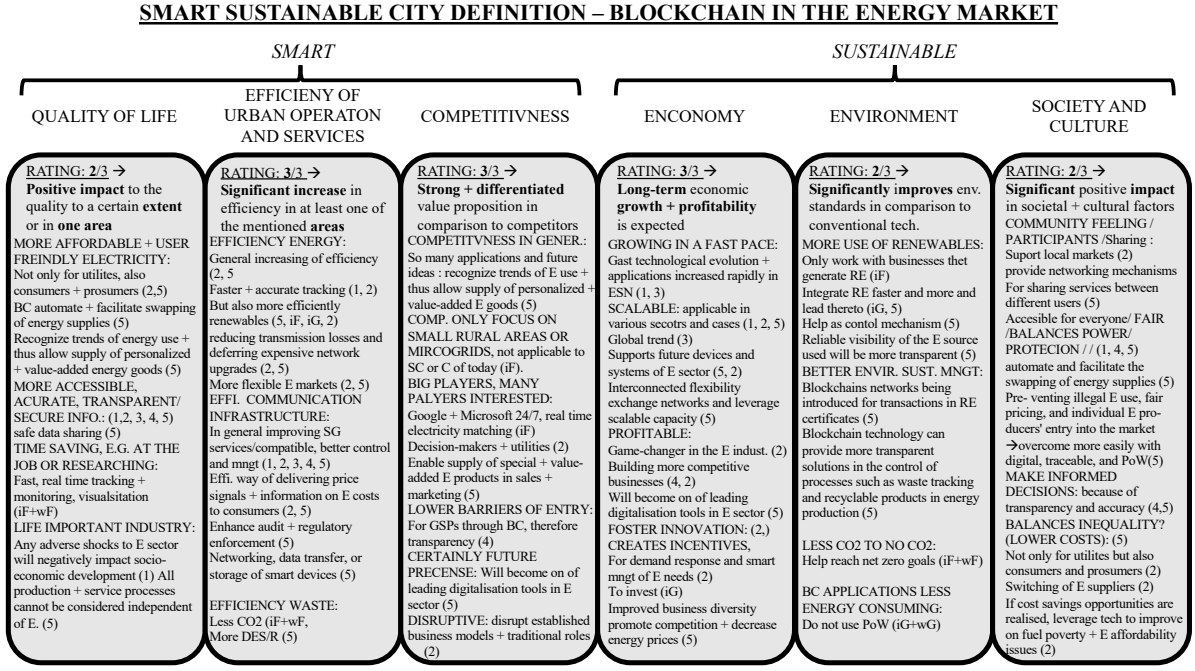
Surplus

- n/a

Own representation of the Social Business Model Canvas ('Using Business Model Canvas to Launch a Technology Startup or Improve Established Operating Model' n.d.).

Content based on the Interview with Trbovic (App. 5.6.) and sources: ('Eventhorizon Summit' 2017), ('Licensing and Open Source Ethos - Grid Singularity Wiki' n.d.), ('Grid Singularity Web' n.d.), (Grid Singularity Medium 2021), ('Grid Singularity - Crunchbase Company Profile & Funding' n.d.), ('Grid Singularity GmbH - Company Profile and News' n.d.), ('Grid Singularity GmbH, Berlin, Germany' n.d.), ('Grid Singularity Mission - Grid Singularity Wiki' n.d.), ('Grid Singularity Technical Approach - Grid Singularity Wiki' n.d.), ('Grid Singularity Vision - Grid Singularity Wiki' n.d.), ('Grid Singularity Slack' n.d.), (Singularity 2021)

Appendix 5.8. Framework Smart Sustainable City Definition



Own framework based on the definition of Smart Sustainable Cities, reference general Chapter 2.2.1.: (‘Sustainable Smart Cities | UNECE’ n.d.), (Nations n.d.).

A deeper explanation of the **“Smart” categories** is below and the **“Sustainable” categories** are intext under the BC Chapter 4.4.

Content based on interviews with Trbovic and Rossi (App. 5.5. and 5.6.), as well as sources: 1- (Kumar et al. 2020), 2- (Andoni et al. 2019), 3- (Liew et al. 2021), 4- (Christidis et al. 2021), 5- (Yildizbasi 2021), (‘Grid Singularity Web’ n.d.), (‘Grid Singularity Mission - Grid Singularity Wiki’ n.d.), (‘Grid Singularity Vision - Grid Singularity Wiki’ n.d.), (‘FlexiDAO | Renewable Energy Monitoring Software’ n.d.).

Categories under “Smart”

Quality of Life

Regarding the first criteria *Quality of Life* this crucial innovation was ranked with a 2 out of 3, meaning that it has a positive impact to the QOL to a certain extent. This technology is in general providing value by keeping the energy system constantly updated to new standards. An up-to-date technology in the EM can reduce the risk of suffering a crash or a shock in the energy distribution sector that would definitely impact socioeconomic development and therefore also everyone’s life (Kumar et al. 2020). BC can also facilitate the swapping of energy suppliers (Yildizbasi 2021) what also makes life easier from a consumer perspective. It is also seen as a technology that can detect trends of energy usage and therefore could lead to new forms of personalized and value-added energy products (Yildizbasi 2021) .

Efficiency of Operations and Services

The category *Efficiency of Operations and Services* in the energy sector is massively supported by value creation form BC. In general, it can be said that efficiency is one of the known benefits of BC and this can be seen in the EM in many ways and processes (Andoni et al. 2019) (Yildizbasi 2021). An example would be the way it helps reducing transmission losses and suspending costly network upgrades (Andoni et al. 2019) (Yildizbasi 2021). Efficient communication infrastructure is achieved because the regulatory and audit processes can be enhanced through BC (Yildizbasi 2021). Grid singularity also wants to create value for smart cities, by promoting local energy market participation for individual energy producer. This idea creates a smart benefit for every individual since the resource consumption is optimized and grid congestion is reduced.

Competitiveness

In the section of *Competitiveness*, there is also value created e.g. through its disruptiveness by establishing new business models and changing traditional roles (Christidis et al. 2021). This was also mentioned by Dr. Tribovic (App. 5.6.) in the interview who was confirming that this is one of their tasks. These are only some of the ways how this technology creates value in the context of smart cities, to find further arguments, see framework above.

Appendix 5.9. SDG analysis and Ranking

BC in EM field general		
SDG Ranking/ Rating	**Motivated by or focused to:**	**Really impacting:**
1	*7. Affordable and Clean Energy*	Partially, clean
2	*10. Reduced Inequalities*	Not yet
3	*11. Sustainable Cities and Communities*	Partially, clean
4	*13. Climate Action*	Yes
5	*9. Industry, Innovation and Infrastructure*	Yes
6	*12. Responsible Consumption and Production*	Yes
7	*1. No Poverty*	Not mainly, only alongside
Normally not really focusing on:		
8	*8. Decent Work and Economic Growth*	Yes
9	*16. Pace Justice and Strong Institutions*	Not yet
10	*17. Partnerships Dot the Goals*	Yes
11	*4. Quality Education*	Partially
Normally not focusing at all:		
12	*3. Good Health and Well Being*	No
13	*14. Life Below Water*	Only alongside maybe
14	*15. Life On Land*	Only alongside maybe
15	*2. Zero Hunger*	No
16	*5. Gender Equality*	Only alongside maybe
17	*6. Clean Water and Sanitation*	No

GS		
SDG Ranking/ Rating	**Motivated by or focused to:**	**Really impacting:**
1	*10. Reduced Inequalities*	Not yet
2	*7. Affordable and Clean Energy*	Partially, clean
3	*11. Sustainable Cities and Communities*	Partially, clean
4	*9. Industry, Innovation and Infrastructure*	Yes
5	*13. Climate Action*	Partially, clean
6	*12. Responsible Consumption and Production*	Partially, clean
7	*16. Pace Justice and Strong Institutions*	Not yet
8	*17. Partnerships Dot the Goals*	Yes
9	*4. Quality Education*	Partially, knowledge
Normally not really focusing on:		
10	*8. Decent Work and Economic Growth*	Not yet
11	*1. No Poverty*	Not mainly, only alongside
Normally not focusing at all:		
12	*3. Good Health and Well Being*	No
13	*14. Life Below Water*	Only alongside maybe
14	*15. Life On Land*	Only alongside maybe
15	*2. Zero Hunger*	No
16	*5. Gender Equality*	Only alongside maybe
17	*6. Clean Water and Sanitation*	No

Flexidao		
SDG Ranking/ Rating	**Motivated by or focused to:**	**Really impacting:**
1	*13. Climate Action*	Yes
2	*11. Sustainable Cities and Communities*	Yes
3	*8. Decent Work and Economic Growth*	Yes
4	*9. Industry, Innovation and Infrastructure*	Yes
5	*12. Responsible Consumption and Production*	Yes
6	*17. Partnerships Dot the Goals*	Yes
Normally not really focusing on:		
7	*10. Reduced Inequalities*	No
8	*7. Affordable and Clean Energy*	Partially, clean
9	*16. Pace Justice and Strong Institutions*	No
10	*4. Quality Education*	Partiall, only when pay
11	*1. No Poverty*	Not mainly, only alongside
Normally not focusing at all:		
12	*3. Good Health and Well Being*	No
13	*14. Life Below Water*	Only alongside maybe
14	*15. Life On Land*	Only alongside maybe
15	*2. Zero Hunger*	No
16	*5. Gender Equality*	Only alongside maybe
17	*6. Clean Water and Sanitation*	No

Own ranking based on the sustainability analysis.

It is interesting to see that the motivation and the focus on specific SDGs (as could be identified from the webpages or others) does not necessary reflect the real impact they have at the end.

Appendix 5.10. SWOT Analysis

SWOT Analysis– BLOCKCHAIN IN THE ENERGY MARKET

	HELPFUL	*HARMFUL*
INTERNAL ORIGIN	STRENGTHS GENERAL: • Future tool • Scalability, many areas and applications • Efficiency and effectiveness in energy system GRID SINGULARITY: • Open source database • Many Partnerships, knowledge exchange • For every participant of the energy market • Social: more affordability, integrating, transparency • Economic: Promotes development, innovation and investment • Environmental: integrating Res (lowering GHG emissions), optimization through self- consumption, does not overuse energy (no PoW)	WEAKNESSES GENERAL: • Complex, difficult to relate to energy sector and additionally BC, consumer adoption • Still uses energy, GRID SINGULARITY: • Website and appearance not clear, confusing if not from tech and energy • Working in uncertainty, knowing that market is not ready (Ansoff Matrix below) • More benefits for users that invest money in their assets (additional costs) • No own sustainability KPIs, showing inconsistency
EXTERNAL ORIGIN	OPPORTUNITIES GENERAL: • Governments: implement contemporary regulations + to create incentives for big firms + independent regulating entity representing al players • For players to communicate openly ant to work together GRID SINGULARITY: • Actively be part of the energy transition • Adapt webpage to lower complexity and attract more users, join the different webpages into one • Take clear position in regards to REs, since it only helps for integration of them but does not ask for the full usage of them • Establish sustainability KPIs like the SDGs to track their own performance not only ask for it from others	THREATS GENERAL AND FOR GRID SINGULARITY: • Outdated regulations • Infrastructural developments of the grid

Own representation of the SWOT framework ('What Is SWOT Analysis? - The British Library' n.d.).

Sources from interviews with Trbovic, Rossi, Bröhrmann and Dietrich and same sources as the Smart Sustainable City Framework App. 5.8. The mentioned threats, weaknesses and opportunities in the framework that are not explained deeper in the work are showed in detail below.

Further Challenges and Implications - Threats, Weaknesses (Ansoff Matrix) and Opportunities

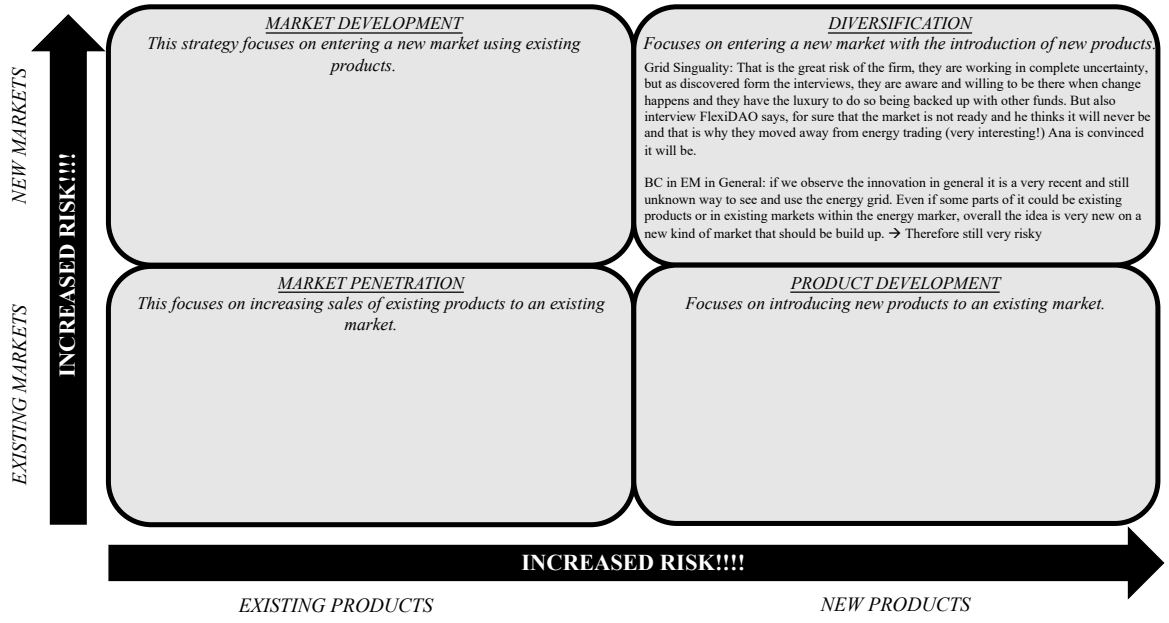
Further Threats:

Another thread is posed by the overall infrastructural conditions of the grid. So far, it is still not adequately developed for the BC application, which can still lead to congestions. Furthermore, there would be the need of a constant enhancement and maintenance. (App. 5.6., Trbovic, interview)

Further Weaknesses of Grid Singularity:

As could be understood from the interviews is that a weakness that Grid Singularity faces is the fact that the entire environment of BC is still not established and therefore uncertain (App. 5.6., Trbovic, Interview). According to Rossi (App. 5.5.), the market is still not prepared for the energy exchange business model from firms like Grid Singularity. In his point of view this business model can only work out for rural areas and microgrids (app. 5.5, Rossi, interview). Tribovic is convinced that the business model will perform but at a later stage (App. 5.6., Trbovic, Interview). The challenge can be explained by the **Ansoff matrix** (framework sown below, derived from "The Ansoff Matrix that was developed by H. Igor Ansoff and first published in the Harvard Business Review in 1957, in an article titled "Strategies for Diversification."('Ansoff Matrix' n.d.)). Placing a new product in a new market is the riskiest approach. All individuals are main target group for Grid Singularity. In a next step, the target group can be extended by all other firms, start-ups and energy players with the same goals. At this moment the main target group (individuals) does not really understand the value mainly due to difficulties of knowledge transfer. So far, this exchange only works out for the firms (second target group). Having the original business model with main focus on P2P trading in mind, it needs to be admitted that the product is still not successfully established on the market. This represents the present risk that the consumer is therefore more difficult.

ANSOFF MATRIX Strategies – BLOCKCHAIN IN THE ENERGY MARKET



Own representation of the Ansoff Matrix based on the source: ('Ansoff Matrix' n.d.)

Another weakness is the structure of the website and its comprehensibility. This is particularly challenging as the technology is very complex and therefore difficult to be adequately represented. The website of Grid Singularity is even more complex as it consists of five different websites/platforms. One for the simulating platform, one for the wiki, one for articles, one for the code on git hub and slack as cha t→ ('Grid Singularity Web' n.d.)('Grid Singularity Github' n.d.)('Grid Singularity Mission - Grid Singularity Wiki' n.d.)(Grid Singularity Medium 2021)('Grid Singularity Slack' n.d.). This structure does not necessarily help potential customers to understand the product or service.

A weakness presented by GS is that that participating in their platform would bring you more benefits when investing in an own asset which means that money needs to be spent. Saying that it is also the role of the citizens to generate a change, Tribovic (App. 5.6.) shows indirectly a weakness which can scare potential customer off.

Another weakness in the strategy of Grid Singularity is the misleading and contradictory approach to support on one hand the integration of REs through their platform, and on the other hand to operate on a market with fossil fuels.

A further weakness that shows a form of inconsistency to the customer is the fact that the own sustainability KPIs are not monitored at all (App. 5.6. Tribovic, App. 5.5., Rossi).

Further Opportunities for Grid Singularity:

In regard to the website complexity, in order to create an opportunity, the recommendation would be to clearly state on their webpage that the participation also has many benefits, not only individual energy consumer but for all participants. Also, to explain how BC works In their case with an simple framework.

As said above, they are supporting the integration of REs but not avoiding conventional sources all together. Especially as this is a moral question that can prevent potential customers from using Grid Singularity, the recommendation would be to take a clear position. This could also lead to gain more customer that focus on sustainable values.

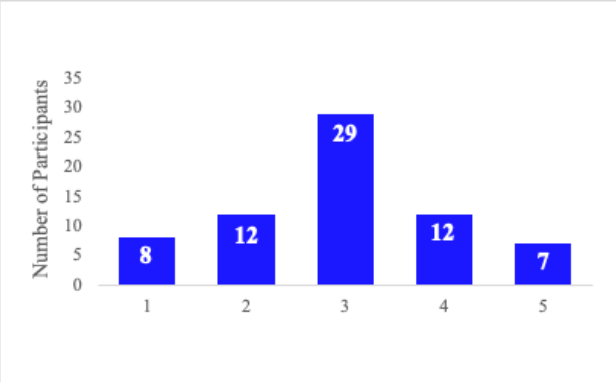
Even if it is only small start-ups with a limited impact on the sustainability, for communication reasons it important that they also do for themselves, what they also want from other. By introducing own sustainability metrics, they would show that they are not only just expecting this behaviour from others but also using them for themselves. This makes their company mission and appearance more believable and meaningful. They could start with the SDGs and as Tribovic (App. 5.6.) said, since they are already interested in it.

Appendix 5.11. Survey

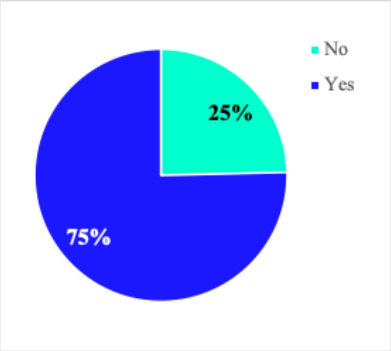
Survey about the Energy Market - Awareness & Knowledge: The survey had 8 questions that were based on scales and short yes or no answers. The respondents were asked on their opinion and experience as a private energy consumer.

The survey had a total of 68 responses. As can be seen in question 7. The majority of the respondents lives in Europe and can be considered for the geographical framework of Europe that was set.

1. In a scale from 1 to 5 how much do you think about - are you interested in the energy market?
   1 being - Not at all and 5 - Yes, very much.

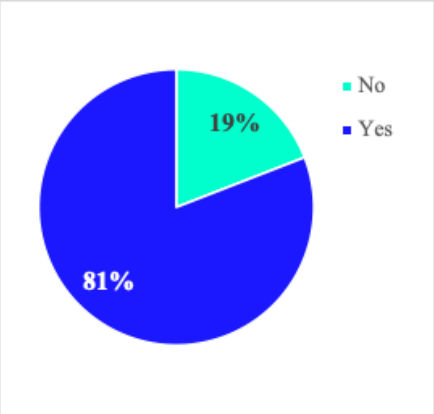


2. Do you think that you are at disadvantage in comparison to big energy companies because you do not have the knowledge about and power over the energy market like they do?

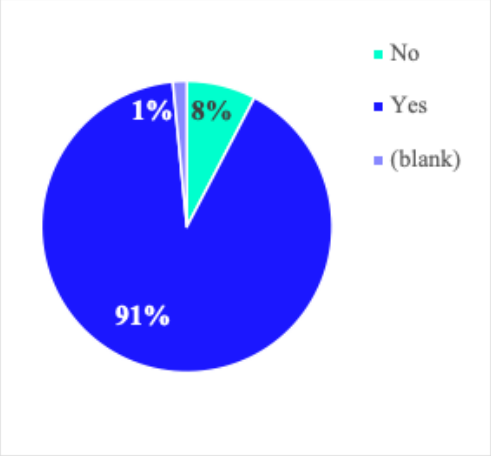


3. Imagine that you could produce the energy you need and, if you have excess, sell it to your neighbour. At the same time, if you have not produced sufficient energy for yourself, you could still buy energy from big energy companies or other users in the system.

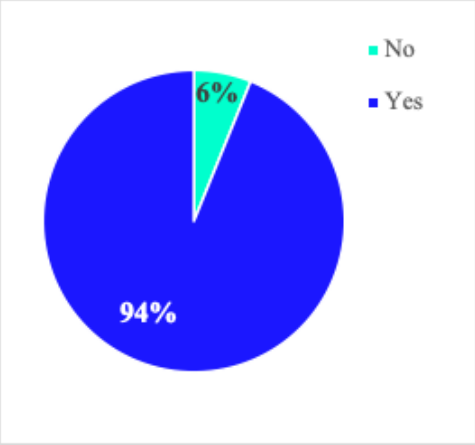
Would you be personally interested in such a business model where everyone can participate in the energy market (buying, selling energy and all having the same information)?



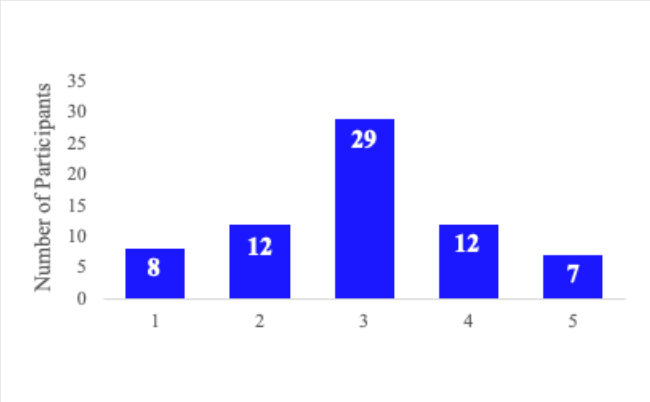
4. Do you think that to be able to implement a business model like this, regulations that at the moment make it very difficult need to be updated?



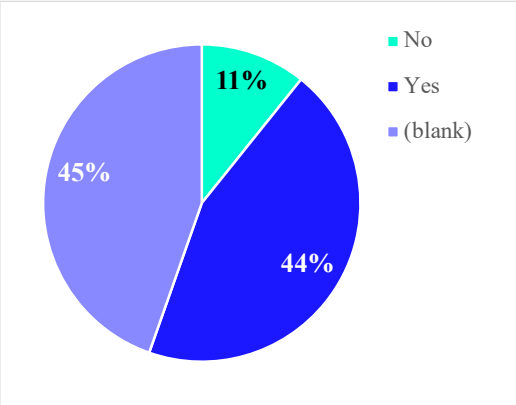
5. Do you think that the implementation of this model would be easier to achieve if governments create incentives for big energy firms that have influence, like in the automotive industry?



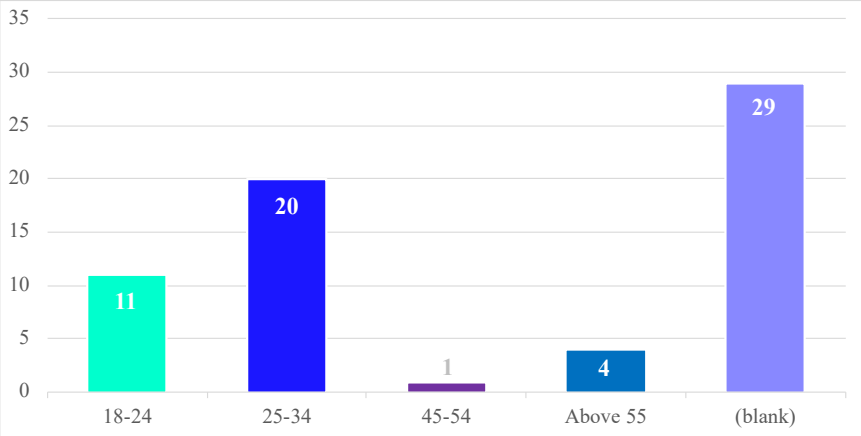
6. Do you know how blockchain technology works?
1 being - Not at all and 5 - Yes, I do.



7. Are you currently living in Europe?



8. How old are you?



Appendix 5.12. Interview Joscha Bröhrmann, Wind and Electrical Engineer (freelancer)

Interview held on the phone on December 2th 2021.

Interviewer: Louisa Kreis von Ratibor	**Interviewee: Joscha Bröhrmann**
1st Dimension: Discrimination due to outdated regulations?	I think you can't do more than guess in the social conditions. But I think the German government is also a bit backward in many areas. Here it's about creating a decentralised market, so to speak. But there is still so much beurocratic hurdles for everything in Germany. But in any case, we still have a lot of catching up to do here, which is first of all about digitalisation and then extremely. We have to take care somehow in the form of electricity or worry and think much further. Then they will think further. Then they just don't yet. Yes, eat or die. That's just the way it is, that strategy. So yes, for small companies it might make life much more difficult, yes, or probably even, because unfortunately big firms, they have no interest in it.
2nd Dimension: Unilateral initiative to encourage BC development?	I am really only aware of myself personally, we have green electricity. We have green electricity, which we buy, so to speak, from a green electricity provider. And I'm going to be reasonably happy with that now. And I mean, I actually find the idea totally sexy. If I could go there now and then, let's say, join in as a driver, I can say OK, I can now directly buy my shore power from my neighbour, then from neighbours anyway, and I can buy my shore power from them. And you also have to say, and that's where I would actually see this difficulty. And that is that in Germany we don't really know about the electricity grid.
3rd Dimension: Positive correlation between renewal of regulation and attractivity of trading business model?	Yes. Yes, that's why. I don't know yet if that will actually happen in the end, become more favourable. So yes. Yes, I, I don't want to say, I don't want to exclude that it is. That it can happen and that it might even lead in the end to the fact that we can produce more cheaply under electricity. I just think that a lot has to happen on the technical side first. It's not about building wind farms or solar plants, but about preparing the infrastructure for it, so to speak. Yes, in the sense of. I mean, I already have all these new electricity meters, which are all somehow connected to the internet. They are already, so to speak, the network effect. And then you can possibly say in the future, OK, someone has my solar cell on my solar cells on the roof and I can, so to speak. Of course, my infrastructure then says independently that we can market the electricity.
4th Dimension: Lack of lobbying effort due to missing incentives?	At the end, that's how it's sort of offset against each other. That's right. The reality is that these regulations are made by them, the big energy companies. You simply have to say that they have a strong lobby. That's just the thing. And in the end, they write the rules. I have a buddy who once worked in his lobbying office in Berlin for the energy sector. It was a different energy producer, but the principle was all the same. Well, you write there actively, yes, with all the regulations.
5th Dimension: Analogy of the regulation challenge with electromobility?	Yes, how long, how long that took in the German car companies have moved at all a bit in this power needed the halt with a Teslas quasi slowly, since that has snatched the market shares. That's just the way it is, that they've somehow managed to assert themselves. Mobility, that's something for everyone
Independent view?	I'm currently a project engineer at RWE for Wind parks.

	I am not employed; I am a freelancer and I am self-employed. I am self-employed project engineer and employed as a consultant at such companies that develop Wind parks. I see a lot of what they do but I am even quite unemotional towards the companies.

Full transcript or audio can be provided upon request.

Appendix 5.13. Interview Christopher Dietrich, Research Scientist at Grid Singularity

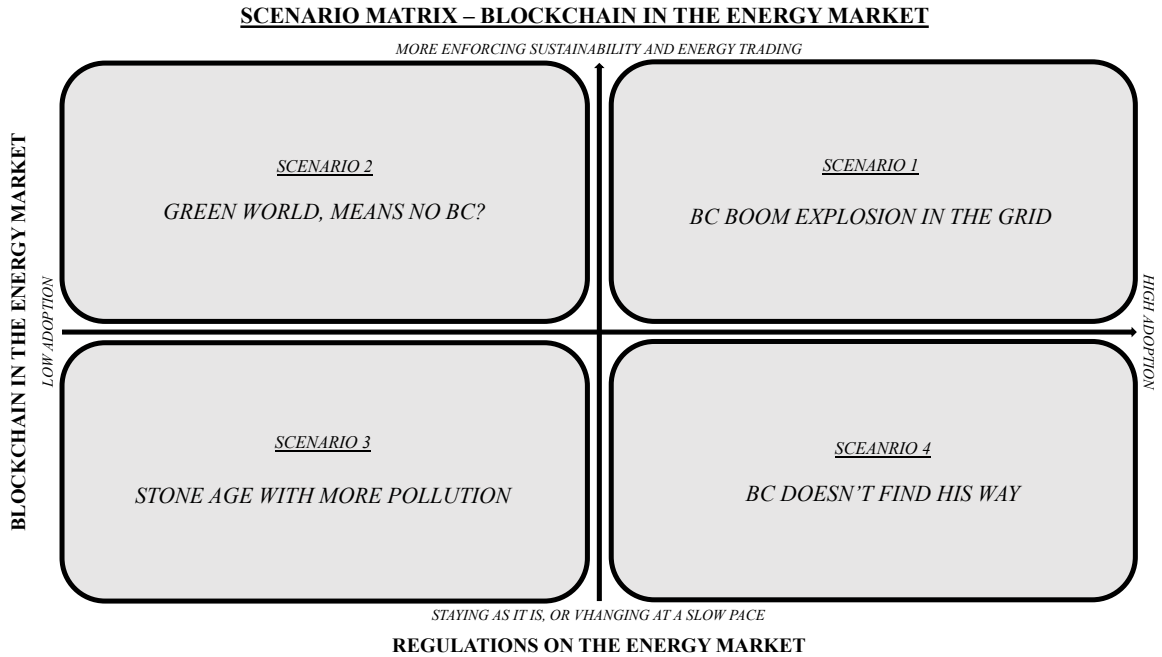
Interview held online on December 14th, 2021.

Interviewer: Louisa Kreis von Ratibor	**Interviewee: Christopher Dietrich**
1st Dimension: Discrimination due to outdated regulations?	Yeah, I agree that's individual discriminated by regulation at the moment. Yeah, small firms also kind of discriminated. Because the energy market is quite old in the end. And you have these big companies that are there for many, many years, and have a position of power and at the moment they don't have the incentive to change that. And like, for instance, Switzerland is even further back in terms of regulation than Germany. For instance, the in Switzerland the DSO and the utilities the same company. So that is distinction.
2nd Dimension: Unilateral initiative to encourage BC development?	Yeah, the individuals don't notice it's right because for now, energy is not something that every people know about, like you should talk to your friends or parents or anything like it's not something that that interest is necessarily interested to have more freedom right in the national market. But that's also one shame. I guess that is why they get discriminated by all data and litigation because they don't see the motivation to change that. At least for individuals. Yeah, I see at least the small firms are trying to push to regulation changes. And they're trying to make proof of concepts to try to show the policymaker that your point makes sense to have an actual trading to show what are the benefits on individual so all the energy companies guys to get, at least in my opinion, that is the last step that is needed to fully convince them. Yeah, one thing that could improve is the fibrillation sandbars. These are: if you have like an energy community that is isolated from the rest still connected to the grids, but different calculation applies to the you have small firms or big firms that are able to make experiments on that. And, for instance, you could say that on the sandbox of 20 houses, then you can deploy your energy trading for one year. And then we made a conclusion or yet what are the benefits? What went wrong and so on? indices? Yeah. Yeah, at least in Germany, because that's not sufficient to make the true our proof of concept or simulation. You need something that is close to reality, reality can work. And also, big missing piece in simulation is that you don't have the human behaviour. You don't know how people would react.
3rd Dimension: Positive correlation between renewal of regulation and attractivity of trading business model?	I think so. And at least I see a lot of benefit for the individuals, economical, sustainability and social as well. Still some benefit that needs I think, to be proven for big companies like utilities and DSOs. And this is also what we're trying to do. We don't want to avoid or disable those stakeholders, but we want to raise them and integrate them as well, in our product transparency tools.
4th Dimension: Lack of lobbying effort due to missing	Yeah, I think there is a lack of incentive for them to change or to make innovation, because they have this position of power and there is not a lot of competition. These companies are there for many years. You didn't have any competition. Like even when

incentives?	you see from some in France like there is this maybe three huge companies and apart from that you don't really have any company. They have like this innovation group, but it's still like it doesn't urge them to reinvent themselves.
5th Dimension: Analogy of the regulation challenge with electromobility?	I think so too. I think also like a process, because that for instance, for individuals back in Germany before they were highly incentivized to have more PVs, right. This e.g. that was very high before like a few years. But there's still something missing I think in the process because like if they want to have a PV, they have to fill out all these different forms that are taking a lot of energy from them. Like time and Exactly. And so, there is a high chance that they lose motivation during the process.
Solve complexity of energy market and adopt BC based energy trading on a large scale?	At the moment we don't offer buying assets on the platform. But this is what we want to enable, that we have this process that is very smooth to onboard people to be a prosumer or buy asset or start trading. For instance, if we want to have this flow to from the simulation to reality, there is also this regulation that comes in where each country in Europe have different regulation. That's the thing inside the same country you have also exceptions, right? Like if you are under the same transformer do the you know if you are 5500 metres away from each other? Yeah, all of these different things. It's also very difficult to educate them about BC because right now there is also this mass media that is talking about blockchain right on crypto currencies and the overuse of energy. People get confused. Like if you tell them no like you trade energy based on blockchain, but on the other side, they hear all this news that blockchain is bad for the environments that will get confused and that's understandable.

Full transcript or audio can be provided upon request.

Appendix 5.14. Scenario Matrix



Own representation of a scenario matrix and the possible scenarios for future research.