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SOLAR ENERGY STORAGE SOLUTIONS: A COMPARATIVE ANALYSIS OF LITHIUM-ION BATTERY AND HYDROGEN STORAGE SYSTEMS FOR CASA NOVA BAU GMBH

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Abstract

This work project investigates the strategic integration of solar energy storage technologies at Casa Nova Bau GmbH, a German startup in photovoltaic systems. Utilizing frameworks like the Business Model Canvas and Innovation Lifecycle, the study evaluates Lithium-Ion Batteries and Hydrogen Storage Systems, incorporating insights from expert interviews and a comprehensive literature review. The analysis underscores Lithium-Ion Batteries as an effective immediate solution and Hydrogen Storage as a long-term strategic option. The findings offer directional insights for aligning Casa Nova Bau GmbH's operations with its sustainability goals in the evolving renewable energy landscape.

Keywords: Solar Energy Storage, Lithium-Ion Batteries, Hydrogen Storage Systems, Business Model Canvas, Innovation Lifecycle

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1. Introduction

The global energy landscape is undergoing a transformative shift towards renewable energy, driven by the urgency to combat climate change and reduce reliance on finite fossil fuels. Solar photovoltaic (PV) systems, experiencing a significant rise in adoption with a 20% annual increase in global solar PV capacity, are at the forefront of this transition. This growth is attributed to declining costs, advancements in solar technology, and a heightened environmental consciousness, as reported by the International Energy Agency and corroborated by research from Auer et al. (2022). However, the variable nature of solar energy introduces challenges in terms of effective storage and management.

Focusing on Casa Nova Bau GmbH, a German startup founded in 2022 and specializing in photovoltaic system construction, this work project investigates the company's exploration into diversifying with solar energy storage solutions. Notably, the study concentrates on Lithium-Ion Batteries and Hydrogen Storage Systems for their efficiency and high-density energy storage capabilities, in response to the evolving market and growing demand for comprehensive, integrated energy solutions. This work project poses a fundamental question: *Given the strategic and operational goals of Casa Nova Bau GmbH, which solar energy storage technology should be integrated into its product line-up to maximize effectiveness and alignment with the company's vision?* The work project combines expert insights with an extensive literature review, leveraging the Business Model Canvas and Innovation Lifecycle Framework for a comprehensive evaluation of these technologies. The objective is to formulate a diversification strategy for Casa Nova Bau GmbH that bolsters feasibility, profitability, and sustainability, equipping the firm with the insights needed for informed decision-making in a rapidly evolving energy sector.

The work project begins by laying a theoretical foundation of underlying key concepts, focusing on the application of frameworks pertinent to Lithium-Ion Batteries and Hydrogen Storage Systems. It then moves into a detailed methodology, leading to a comparative analysis and

discussion of findings, while acknowledging the study's limitations. The conclusion draws on these insights to offer strategic recommendations for Casa Nova Bau GmbH aimed at effectively navigating the renewable energy landscape.

2. Casa Nova Bau GmbH – Context and Significance of Research

Founded in Hamburg, Casa Nova Bau GmbH specializes in PV system installations in Germany, serving both private households, which account for 75% of its annual revenue, and businesses seeking to reduce their environmental impact. The company's success is mainly driven by a skilled team, including technicians and project managers, who handle every phase of PV system projects, from design to installation. Additionally, the company's commitment to innovation and customer satisfaction has positioned it as a rising player in the German solar PV market. This sector demonstrated consistent growth over the past decade. Between 2011 and 2021, the Compound Annual Growth Rate of cumulative PV installations was 30%, according to Frauenhofer-ISE (2023). This growth is attributed to several factors including government incentives, rising consumer awareness regarding climate change, and decreasing installation costs, leading to solar energy becoming a preferred choice for numerous households and businesses (Bhandari et al., 2018; Tervo et al., 2018). Hamburg, representing a prominent urban hub, mirrors this broader progression, with a growing adoption of solar solutions in buildings. This uptrend is motivated not only by sustainability objectives but also by noticeable economic advantages, such as savings and potential revenue generated from surplus energy feed-in (EEHH-Cluster, 2023).

Yet, as more players enter the solar PV market, competition intensifies, margins tighten, and businesses, particularly startups like Casa Nova Bau GmbH, face increased pressures. For Casa Nova Bau GmbH, challenges are manifold. The rising competition from both local and international providers in the Hamburg region means that differentiation becomes vital. Furthermore, with the technology evolving, customers are now looking for integrated solutions – systems that not only generate energy but also store and manage it efficiently. These emerging

challenges and market dynamics have prompted Casa Nova Bau GmbH to introspect and strategize. In light of the prevailing context, considering the expansion of Casa Nova Bau GmbH's product portfolio is not only a path for growth but potentially a crucial step towards ensuring future resilience. Analyzing the integration of energy storage solutions with their existing PV system offerings may enable the company to propose a more comprehensive, end-to-end solution to its clients. Considering the company's predominant client base of private households and examining the extensive spectrum of energy storage technologies, Casa Nova Bau GmbH has identified Lithium-Ion Batteries and Hydrogen Storage Systems as the two most promising candidates for in-depth examination. Lithium-Ion Batteries, having earned their reputation over decades, present undeniable efficiency and practicality (Mauger & Julien, 2017; Reddy et al., 2020). On the opposite spectrum, Hydrogen Storage Systems, though younger in their technological lineage, exhibit vast potential. Their clean energy output, combined with the capability to provide high-density energy storage, make them an exciting prospect for the future of sustainable energy (Ekpotu et al., 2023).

3. Literature Review

This chapter discusses the theoretical concepts of the Business Model Canvas and the Innovation Lifecycle Framework, shedding light on how companies can adapt to technological changes. The chapter then assesses Lithium-Ion Batteries and Hydrogen Storage Systems, evaluating their applications, advantages, and disadvantages in the residential sector, crucial for Casa Nova Bau GmbH's potential diversification and technology integration.

3.1 Business Model Canvas

In the realm of strategic business planning and innovation, understanding and applying the right frameworks is crucial for an organization's success. The Business Model Canvas (BMC) is a strategic management tool that offers a structured way to visualize and analyze the connections between innovation and a business's overarching strategy (Mulyadi, 2020). Particularly relevant to Casa Nova Bau GmbH, the BMC allows for an in-depth examination of various business

components, especially within the context of technological innovation. Developed by Osterwalder (2013) the BMC has become a fundamental tool in contemporary business strategy development. It provides organizations with a clear, concise template to describe, design, challenge, and pivot their business model. The canvas's nine building blocks create a comprehensive view of a business's operational and financial architecture (Fritscher & Pigneur, 2014; Mulyadi, 2020). For a detailed view of these components, see the Business Model Canvas in Appendix [F]. This framework is particularly effective for businesses operating in technology-intensive sectors, such as solar energy, where rapid innovation and market shifts are common.

For Casa Nova Bau GmbH, applying the BMC is instrumental in aligning its operational, financial, and sustainability goals with market trends and emerging opportunities in the solar energy storage industry. As discussed by Teece (2018), the dynamic capabilities of firms to integrate, build, and reconfigure internal and external competencies are critical in rapidly changing environments. The BMC assists in this process by providing a structured approach to understanding how each aspect of the business model can adapt and respond to these changes. Chapter 5.1, *"Contextualizing through the Business Model Canvas",* will delve into how Casa Nova Bau GmbH's current business model aligns with the evolving landscape of the photovoltaic and solar energy storage sectors. This will include a thorough examination of each BMC component in the context of Casa Nova Bau GmbH, identifying key areas for integrating solar energy storage solutions. This analysis is crucial for ensuring strategic fit and for positioning the company to capitalize on its market potential.

3.2 Innovation Lifecycle Framework

In light of the previously discussed Business Model Canvas, the Innovation Lifecycle Framework (ILF) proves to be an essential element of this work project, as it complements the BMC by offering a structured approach to the evolution and maturation of solar energy storage technologies. The ILF provides Casa Nova Bau GmbH with insights for aligning technologies

with its strategic and operational goals, ensuring effective integration and viability within the business model as depicted by the BMC. The ILF was chosen for its comprehensive outline of the innovation journey, structured into five distinct stages (Figure 1). The journey begins with *Idea Inception*. This first phase marks the genesis of potential breakthroughs, driven by market needs, technological advancements, or shifts in consumer expectations (Bassiti, 2013). Subsequent to this is the *Development Phase*, where ideas evolve into prototypes, supported by extensive research and development, and market analysis (Waychal et al., 2011). After Development, the *Pilot Phase* introduces these innovations to selected market segments to test their acceptance and pinpoint improvements (Bassiti, 2013). If the *Pilot Phase* is successful, the innovation moves into the *Scaling Phase*, where it begins to reach a broader market (Borglund & Rönnberg, 2021). The final stage is *Maturity* or *Integration*, where successful innovations become a standard part of business operations or start to phase out if newer innovations take over (Waychal et al., 2011).

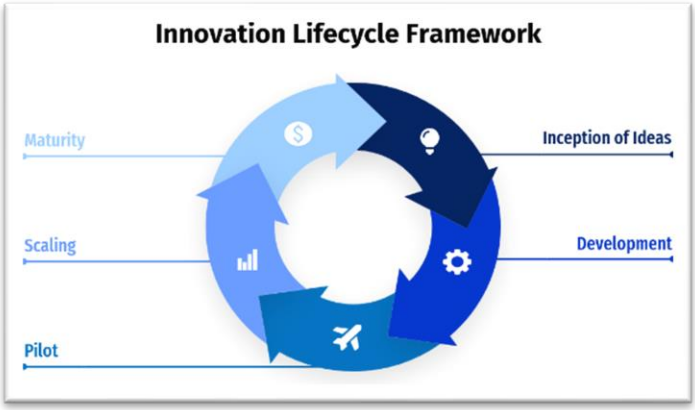

Figure 1- *Innovation Lifecycle Framework*
(created by author, adapted by Waychal, 2011)

Referring to Casa Nova Bau GmbH, understanding where Lithium-Ion Batteries and Hydrogen Storage Systems reside within the Innovation Lifecycle Framework isn't merely academic—it's strategic. By understanding their positions, the company can anticipate challenges, strategize resource allocation, and frame decisions that resonate with its operational, profitability, and sustainability tenets. While the BMC offers a structured way to visualize and analyze the business model, focusing on operational viability and market positioning, the ILF complements this by tracing the technological evolution from inception to market maturity. The ILF highlights stages where technological advancements align with strategic needs, revealing opportunities and challenges that the BMC might not explicitly address. Conversely, the BMC

can identify potential business model constraints or opportunities that the ILF's technological focus overlooks. This interplay allows for a more nuanced understanding of how technological innovation and business strategy can cohesively drive Casa Nova Bau GmbH towards its strategic and operational goals. Chapter 5.3, *"Positioning Technologies in the Innovation Lifecycle",* will further explore the alignment of these technologies within the ILF and the resultant implications for Casa Nova Bau GmbH.

3.3 Introduction to Photovoltaic and Energy Storage Technologies

Photovoltaic systems, once primarily seen in large-scale commercial settings, have increasingly become a common sight in residential areas (Auer & Duic, 2022). This trend is partly driven by a growing desire among homeowners for energy independence, a sentiment intensified by recent energy crises, and the potential for cost savings during periods of high electricity prices (Bórawski et al., 2023). Reflecting a shift in homeowner priorities towards sustainability and autonomy, PV systems offer the ability to transform the sun's energy directly into electrical power (Behura et al., 2021). Despite their potential, residential PV systems face significant challenges, particularly with the mismatch between peak solar energy production and household energy demand, which typically occurs in the early morning and evening (Kairies et al., 2019). This leads to a surplus of electricity when the sun is brightest, which homeowners often return to the grid. However, grid feed-in policies can be complex and vary widely, sometimes offering low compensation rates or not being available at all (Tervo et al., 2018). In Germany, private individuals and farmers own the majority of PV systems, directing approximately 80% of the generated energy to low-voltage grids. These grids can struggle with the inflow of decentralized power, particularly during periods of high solar generation and low consumption, potentially causing overloads and equipment damage (Kairies et al., 2019; Schwarz et al., 2019).

The challenges outlined above have spurred the advancement of solar energy storage systems, essential in reconciling the mismatch between solar energy production and residential demand. These systems capture surplus energy to be used when demand peaks, ensuring a steady power

supply and promoting grid stability. The significance of solar energy storage is underscored by rapid technological advancements and their broadening scope of applications, ranging from home backups to industrial-scale grid support (Mauger & Julien, 2017). Given the significance of solar energy storage in addressing the mentioned challenges, two promising technologies are Lithium-Ion Batteries and Hydrogen Storage Systems.

In the pursuit of efficient energy storage solutions for photovoltaic systems, Lithium-Ion Batteries stand out due to their high energy density, longevity, and decreasing costs, enhancing solar system viability and reliability (Mauger & Julien, 2017; Reddy et al., 2020). Lithium-Ion Batteries, having displaced Lead-Acid Batteries in many applications, present a more favorable energy-to-weight ratio and avoid the environmental detriments associated with lead (Kebede et al., 2021). Their operation is built on the mobility of lithium ions between anode and cathode components, enabling efficient charge and discharge cycles (El Haj Assad & Rosen, 2021).

Safety concerns, primarily regarding overheating risks, have been a focal point of research and have led to significant advancements in battery management systems to mitigate these risks (Da Deng, 2015). Furthermore, the environmental and socio-economic impacts of lithium extraction highlight the need for sustainable and ethical sourcing practices, an area that continues to be addressed through improved regulatory frameworks and industry standards (Institute For Energy Research, 2020; Petavratzi et al., 2022; Díaz Paz et al., 2023). Regulations governing Lithium-Ion Battery recycling and disposal are instrumental in minimizing their environmental footprint, contributing to the overarching aim of sustainability within the energy sector (Marconi et al., 2022). Economically, the decreasing cost trajectory of Lithium-Ion Batteries enhances their attractiveness for residential energy storage, although market fluctuations remain a variable to consider (Bajolle et al., 2022).

The emergence of Hydrogen Storage Systems as a green energy solution is relatively recent, especially concerning their integration with PV systems. In the broader landscape of renewable energy, Hydrogen Storage Systems have gained traction, offering a potential for high energy

density and zero emissions (Abe et al., 2019; Ekpotu et al., 2023). The increasing viability of PV systems has amplified interest in Hydrogen Storage Systems, presenting a solution to the intermittent nature of solar power. Such a synergy enables a steadier electricity supply, despite fluctuating sunlight conditions, ensuring optimal use of harvested solar energy (Usman, 2022; Fedkin & Dutton, 2023).

Environmentally, producing hydrogen through electrolysis, ideally using PV systems, creates a carbon-free cycle, contrasting with traditional methods (Turner, 2004). Advancements promise economic growth and require strategic workforce development (McCoy & Rubin, 2008). Regulatory scrutiny is heightened around Hydrogen Storage Systems due to the flammable nature of hydrogen, prompting strict guidelines for its handling and incentivizing safe technology adoption (Zhang et al., 2020). Economically, despite the decreasing costs driven by technological progress, Hydrogen Storage Systems still confront a dynamic financial landscape influenced by raw materials and market forces (Satyapal et al., 2017). Hydrogen's role within the renewable energy sector is foundational yet nascent, especially in pairing with PV systems. The distinct benefits and inherent challenges associated with Lithium-Ion Batteries and Hydrogen Storage Systems significantly underscore the intricate decision-making process Casa Nova Bau GmbH must navigate in integrating either technology into their product line-up.

4. Research Methodology

4.1 Research Design

To determine whether Lithium-Ion Batteries or Hydrogen Storage Systems align best with Casa Nova Bau GmbH's goals, this work project employs an interpretive and inductive research design, utilizing qualitative methods as suggested by Gephart (2004), Eriksson and Kovalainen (2016), and Anas and Ishaq (2022). These methods highlight the richness of understanding that can be gained from the subjective experiences and observations of individuals with specific expertise in their contexts. In initiating this research, a thorough literature review was conducted to lay the theoretical groundwork and define the scope of the study. This foundational review

was crucial in identifying relevant frameworks and tools that could effectively guide the investigation into Casa Nova Bau GmbH's exploration of solar energy storage systems. Consequently, the Business Model Canvas and the Innovation Lifecycle Framework were chosen for their applicability in assessing the company's strategic expansion in this area. While these frameworks provide a structured approach to analyzing potential business models and situating the technologies within the broader industry context, the core of this research is driven by a methodological focus on expert interviews. The inclusion of expert interviews as a primary research method reflects the study's emphasis on obtaining current and relevant perspectives from those actively engaged in the field. This approach ensures that the research is not only anchored in academic theories but is also deeply informed by practical, real-world experiences. Guided by established evaluation criteria, such as operational feasibility, profitability prospects, and sustainability objectives, these insights contribute to a nuanced comparative analysis of the technologies. This alignment of expert insights with the objectives and considerations of Casa Nova Bau GmbH enhances the applicability and relevance of the work project's findings, providing well-rounded analysis that is both theoretically informed and pragmatically grounded.

4.2 Sampling Process and Data Collection

For this study, given its focus on the strategic alignment of solar energy storage systems with the business objectives of Casa Nova Bau GmbH, a purposive sampling strategy was employed. This approach is advocated for its efficacy in selecting information-rich cases that can provide deep insights pertinent to the research question (Pattern, 2003; Mayring, 2016). The sampling process commenced with the identification of criteria that potential participants should meet. These criteria included having expertise in solar energy storage technologies, possessing an understanding of the business strategies associated with these technologies, and having professional experience with technological implementation in real-world settings (Appendix A). This ensured that the chosen participants had a wealth of knowledge and experience relevant

to the research domain. Considering the specific circumstances of Casa Nova Bau GmbH, the study focused exclusively on interviews with external experts in the field of solar energy storage systems, encompassing both Lithium-Ion Battery and Hydrogen Storage domains, to gain a comprehensive understanding by capturing the diverse perspectives and expertise from outside the organization.

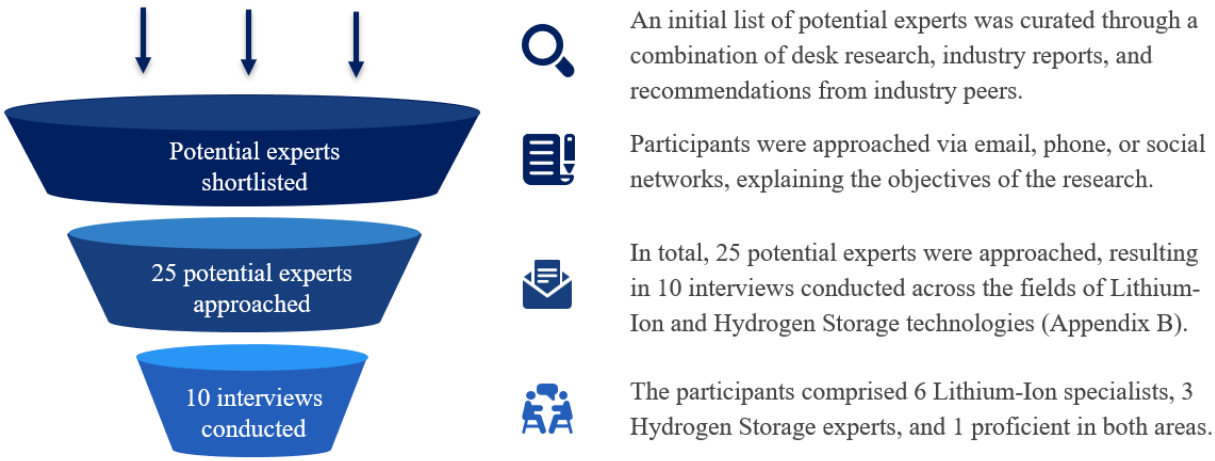

Figure 2 *– Sampling Process*
(created by author)

Figure 2 illustrates the sampling process of the experts. It represents the market distribution of the two technologies, indicating a scarcity of Hydrogen experts. The initial interview with a Lithium-Ion expert (Candidate 4) served as a pilot to assess the interview protocol's efficacy. To ensure confidentiality and prevent potential conflicts of interest, all interviews were anonymized. Furthermore, an interview was conducted in German with Candidate 10 to garner deeper insights from a non-English fluent expert.

The primary tool for data collection in this study was semi-structured expert interviews. The decision to employ this method was rooted in its ability to provide detailed insights while offering flexibility to adapt the line of questioning based on the expert's responses, ensuring richness and depth (Mayring, 2016). Each interview was structured around a guide that comprised a series of open-ended questions designed to delve into the participant's expertise regarding solar energy storage technologies (Appendix C). These questions, formulated based

on the literature review and the objectives of the study, were crafted to evoke discussions on the potential business strategies, challenges, and opportunities associated with each technology. The interviews, exclusively conducted via conference call or video conferencing platforms to accommodate participants' preferences and schedules, lasted between 15 to 25 minutes. They were audio-recorded with the explicit consent of the interviewees to ensure accuracy in transcription and subsequent analysis. Field notes were also taken during the interviews to capture the interviewer's observations, which offered additional context during the data analysis phase. Prior to each interview, participants were informed about the objectives and scope of the study, ensuring they had a clear understanding of the research's aims.

4.3 Data Analysis

This qualitative analysis adheres to a thematic analysis framework as proposed by Mayring (2016), which allows for identifying, analyzing, and reporting patterns within the data. Initially, the data derived from interviews were transcribed verbatim, ensuring that the nuances and emphasis of expert opinions were preserved. Following transcription, the data were meticulously read through several iterations to gain a sense of depth and context, which helped in the preliminary identification of patterns and themes relevant to the research objectives. The next stage involved a rigorous coding process, where chunks of data were categorized into meaningful groups. This coding was both inductive, driven by the content of the data itself, and deductive, guided by the research objectives and the established frameworks and theories outlined in the literature review (Appendix D). Codes were then classified into potential themes and sub-themes, which were reviewed and refined to ensure they formed a coherent pattern that accurately reflected the collected data. This involved a recursive process of going back and forth between the dataset, coded extracts, and the developed themes to verify their authenticity and relevance to the research questions. For triangulation and to enhance the credibility of the findings, the themes derived from the expert interviews were compared with insights gained from secondary data sources. This approach ensured that all aspects of the research were

coherently incorporated into the comparative analyses, providing a holistic view of the strategic implications for Casa Nova Bau GmbH.

5. Evaluating Solar Energy Storage Integration for Casa Nova Bau GmbH

This chapter provides an in-depth evaluation of solar energy storage technologies for Casa Nova Bau GmbH, focusing on their strategic alignment and feasibility. It assesses these technologies against specific criteria within Casa Nova Bau GmbH's business framework, using the Business Model Canvas for integration analysis and the Innovation Lifecycle for technology maturity. Expert interviews add practical insights, leading to a focused comparative analysis that will inform Casa Nova Bau GmbH's decision-making regarding solar energy storage solutions.

5.1 Establishing Evaluation Criteria

The following evaluation criteria have been carefully developed to provide an objective platform for assessing Lithium-Ion Battery and Hydrogen Storage technologies, ensuring they meet Casa Nova Bau GmbH’s operational, financial, and sustainability objectives. The multi-criteria decision analysis (MCDA) methodology, a robust approach in scientific research (Zlaugotne, 2020), was employed for its proficiency in handling the complexity of evaluating competing criteria. These criteria are assorted and prioritized to resonate with Casa Nova Bau GmbH’s strategic imperatives.

With a focus on the company's success, the criteria for technology comparison were selected based on their relevance to the industry and the strategic aims of Casa Nova Bau GmbH. This selection was refined through a comprehensive methodological process that included stakeholder engagement and extensive literature review. A balance between quantitative and qualitative factors enables a complete evaluation, while adherence to market and regulatory frameworks ensures the company’s edge in a competitive landscape. The justification for the selection of these criteria is detailed in Appendix [E]. To operationalize these criteria, a scoring system is implemented, where each criterion is rated on a scale of 1 to 10, with 1 being the lowest and 10 the highest. The scoring reflects the degree to which each technology meets the

specific criterion. Additionally, to emphasize the areas of paramount importance to Casa Nova Bau GmbH, weights are assigned to each evaluation dimension. Operational Feasibility, Profitability Prospects, and Sustainability Objectives are given higher weights (40% and 30% respectively), reflecting their criticality in the company's decision-making process. This weighted scoring system ensures that the most significant aspects have a greater influence on the overall assessment. Table 1 presents these dimensions, criteria, their weights, and the scoring scale, forming the foundation for a detailed comparative analysis.

***Table 1** – Evaluation Criteria and Scoring*

Evaluation Dimension	Criteria	Weight	Scoring Scale	Description
1. Operational Feasibility	System compatibility, Integration ease, Maintenance, Reliability, Scalability	40%	1 (Low) - 10 (High)	Assessing how well the storage technologies fit within Casa Nova Bau GmbH's current and future operational framework.
2. Profitability Prospects	Initial investment, Operational costs, Subsidies, Lifespan, ROI	30%	1 (Low) - 10 (High)	Evaluating the financial impact and potential returns on investment for each technology.
3. Sustainability Objectives	Carbon footprint, Resource efficiency, Recyclability, Contribution to sustainability targets	30%	1 (Low) - 10 (High)	Measuring the environmental impact and how each technology aligns with sustainability goals.
4. Compatibility with Renewable Energy Sources	Energy conversion efficiency, Supply-demand support, Performance in various climates	15%	1 (Low) - 10 (High)	Determining the effectiveness of the storage systems in conjunction with renewable energy sources under varying conditions.
5. Market and Regulatory Considerations	Market acceptance, Consumer demand, Regulatory compliance	15%	1 (Low) - 10 (High)	Considering the market dynamics, consumer preferences, and regulatory environment affecting each technology.
6. Future Outlook	Technological Advancements, Market Trends, Policy Developments, Industry Adaptability, Integration Potential	10%	1 (Low) - 10 (High)	Assessing the potential future trajectory of each technology in terms of advancements, market trends, and policy landscape.

5.2 Contextualising through the Business Model Canvas

In order to fully contextualize the integration of solar energy storage technologies within the strategic framework of Casa Nova Bau GmbH, the Business Model Canvas (BMC), presented

in Appendix [F], is employed as an analytical tool. The following conceptual analysis explores how the integration of Lithium-Ion Battery and Hydrogen Storage technologies might align with, enhance, or challenge Casa Nova Bau GmbH's business model, with specific consideration given to the evaluation criteria.

Key Partnerships at Casa Nova Bau GmbH, evaluated under 'Operational Feasibility', will be critical for adopting these technologies. Lithium-Ion Battery Systems will necessitate new supplier partnerships for component procurement, while Hydrogen Storage Solutions could establish alliances with technological innovators and hydrogen fuel producers, indicating a shift towards a diverse partnership network. The **Key Activities**, which are essential to the company's operations and also fall under 'Operational Feasibility', would expand to include the installation of photovoltaic systems and the incorporation of storage systems, with Lithium-Ion Battery Systems involving routine maintenance and Hydrogen Storage Systems requiring additional complex handling. Casa Nova Bau GmbH's workforce, a component of **Key Resources**, would need to acquire specialized skills or invest in infrastructure to handle these technologies, marking a decisive turn in the company's resource allocation and skill development programs.

Value Propositions are significantly impacted by 'Operational Feasibility' and 'Compatibility with Renewable Energy Sources'. Lithium-Ion Batteries would provide reliable and rapid energy storage deployment, while Hydrogen Storage Systems offers long-term solutions and potentially lower maintenance. In strengthening **Customer Relationships**, an emphasis on 'Sustainability Objectives' is evident as the company educates customers on the efficiency and lifecycle or sustainability aspects of each storage option. The educational initiative could enhance customer trust and loyalty. Regarding **Channels**, and viewed through 'Market and Regulatory Considerations', the company would leverage existing marketing channels for Lithium-Ion Battery Storage benefits while potentially initiating workshops to highlight the innovative nature of Hydrogen Storage Systems. The **Customer Segments** impacted,

particularly concerning 'Market and Regulatory Considerations', might see Lithium-Ion Batteries attracting environmentally conscious clients, while Hydrogen Storage Systems appeal also to early adopters.

Financial aspects, categorized under 'Profitability Prospects', suggest that the **Cost Structure** of Casa Nova would evolve with the variable costs of Lithium-Ion Battery technology advancements or the higher initial investments in the nascent market of Hydrogen Storage Systems. Finally, **Revenue Streams** would diversify to include Lithium-Ion Battery System sales and after-sales services or Hydrogen Supply contracts, reflecting a strategic adaptation to the novel value each technology offers. The 'Future Outlook' criterion adds an essential perspective, anticipating how technological advancements, market trends, policy developments, industry adaptability, and integration potential will shape Casa Nova Bau GmbH's business model in the long term. For a comprehensive overview, Appendix [G], succinctly compares the effects of Lithium-Ion Battery and Hydrogen Storage technologies on each BMC segment and aligns them with the corresponding evaluation criteria.

5.3 Positioning Technologies in the Innovation Lifecycle

Using the Innovation Lifecycle Framework (ILF), this analysis positions each technology in its respective lifecycle phase, revealing market status and impact on Casa Nova Bau GmbH's goals. This evaluation, detailed in Appendix [H], combines theoretical and practical aspects, aiding in strategic decision-making. Lithium-Ion Batteries, a technology with a more established market presence, currently sits in the *Maturity phase* of the ILF. Its adoption into Casa Nova Bau GmbH's product portfolio capitalizes on a proven demand, aligning with the operational feasibility and market acceptance criteria from Chapter 5.1. The integration of such a mature technology could streamline the procurement process and installation services, offering Casa Nova Bau GmbH a competitive edge in operational efficiency and customer satisfaction. The extensive experience and existing infrastructure for Lithium-Ion Batteries could also yield a more predictable cost structure and a stable revenue stream through installation and

maintenance services, reflecting positively on Casa Nova Bau GmbH's profitability prospects. Conversely, Hydrogen Storage technologies are emerging into the *Pilot phase*, marked by higher market uncertainty but also significant growth potential. Casa Nova Bau GmbH's engagement with this innovative technology could position the company as a forward-thinking leader in the sustainability space, appealing to early adopters and environmentally conscious customer segments. Adopting Hydrogen Storage Systems would align with Casa Nova Bau GmbH's sustainability objectives and commitment to renewable energy sources. However, it would also necessitate a readiness to navigate the complexities of an emerging technology, including higher initial investments in infrastructure and training, as well as thorough market and regulatory considerations. As depicted in Table 2, the placement of each technology within the ILF carries specific implications for Casa Nova Bau GmbH:

***Table 2** – Implications of the Innovation Lifecycle Framework*

Criteria	Lithium-Ion Batteries (Maturity)	Hydrogen Storage (Pilot)
Operational Feasibility	Higher scores in system compatibility, integration, scalability	Challenges in integration and scalability
Profitability Prospects	Clearer profitability, predictable ROI and costs	Higher initial costs, uncertain ROI
Sustainability Objectives	Evolves to meet sustainability targets	Aligns with long-term sustainability, lower carbon footprint
Compatibility with Renewable Energy Sources	Proven performance and efficiency with renewable sources	Promising, but needs more evidence for renewable source compatibility
Market and Regulatory Considerations	Established market, clear regulatory compliance	Uncertain market dynamics, evolving regulatory compliance
Future Outlook	Stable, predictable future outlook	Potential for significant advancements, market trends

5.4 Findings of Expert Interviews

In exploring the integration of solar energy storage technologies, the research revealed diverse and insightful perspectives from industry experts on Lithium-Ion Batteries and Hydrogen Storage Systems. These interviews provided a rich array of viewpoints, highlighting various

stages of technological advancement and market readiness for these systems. Participants shared their experiences and observations, offering depth in understanding the practical, economic, and sustainability aspects of each technology (Appendix I). To illustrate the insights from the expert interviews in a concise and comparative format, the following Table 3 summarizes the key findings for both Lithium-Ion Batteries and Hydrogen Storage Systems across the predefined criteria. Detailed discussions on each criterion, including direct quotes and further elaborations from the interviews, follow in the subsequent section of this subchapter.

Table 3 - *Comparative Summary of Expert Insights on Lithium-Ion and Hydrogen Storage*

Criteria	Lithium-Ion Batteries	Hydrogen Storage Systems
Operational Feasibility	Efficient, adaptable, easy integration, easier installation, minimal maintenance	Complex operations, evolving, requires specialized setup and knowledge
Profitability Prospects	Affordable, decreasing costs, good ROI	Higher initial costs, potential long-term benefits
Sustainability	Reducing non-renewable reliance, environmental concerns in production	Zero-emission potential, sustainability depends on production methods
Compatibility with Renewable Energy Sources	Seamless integration with PV systems, reliable across climates	Effective in large-scale applications, adaptable to various climates
Market Readiness and Policy and Regulation	High market acceptance, supportive regulatory environment	Developing market, evolving regulations
Future Perspectives	Stable and predictable outlook, facing competition from emerging technologies	Promising future role, significant opportunities for advancements

Operational Feasibility: Lithium-Ion Batteries are recognized for their efficiency and adaptability in residential solar systems. Candidate 1 mentioned, *"Compact efficient... lifespan complements the solar panels' operational life"*, highlighting their harmonious integration with solar panels. They are also adaptable, with the ability to customize storage capacity to household energy profiles, maximizing efficiency and cost-effectiveness. Lithium-Ion Batteries are generally easier to install and maintain, making them a more straightforward option for residential applications. Hydrogen Storage Systems, on the other hand, present a more complex picture. Candidate 6 observed, *"...our goal... addressing the challenges of... adapting these*

systems for home use", pointing out the ongoing efforts to make these systems safe, efficient, and user-friendly. Although seen as technically complex, Hydrogen Storage Systems are evolving, with promising results observed in their adaptation for long-term storage. Hydrogen Storage Systems require more specialized knowledge and handling, making their operational integration more complex.

Profitability Prospects: Lithium-Ion Batteries have been noted for their increasingly favourable price point and reliable return on investment. As technology advances, the costs are trending downward, making them more accessible to a wider range of consumers. Candidate 1 stated, *"The price point... trending downward as technology advances… Operational costs are another selling point... very little maintenance and predictable life cycle",* emphasizing their economic appeal. In contrast, Hydrogen Storage Systems typically involve higher initial investments, posing a barrier to immediate adoption. However, their long-term economic benefits are recognized, especially as the technology matures and becomes more integrated into residential solar systems.

Sustainability Objectives: Lithium-Ion Batteries are lauded for efficiently storing solar energy, which helps reduce reliance on non-renewable energy sources. However, concerns exist regarding their production, particularly the mining of lithium and its environmental impact. As one expert put it, *"…their ability to store solar energy efficiently helps reduce reliance on non-renewable energy sources…"* (Candidate 2), but also pointed out the need for more sustainable practices in battery production. Hydrogen Storage Systems offer a promising outlook in terms of sustainability, especially when hydrogen is produced using renewable energy sources like solar. As an expert noted, *"If hydrogen is produced using renewable energy...almost emission-free…"* (Candidate 1), indicating its potential for a significantly lower carbon footprint and higher resource efficiency. However, the sustainability of these systems also hinges on the efficiency of the electrolysis and storage process.

Compatibility with Renewable Energy Sources: Lithium-Ion Batteries are highly compatible with renewable energy sources. Their established nature ensures proven performance in various climates and efficient energy conversion, making them a reliable choice for integration with photovoltaic setups. *"...easily adapted to different PV systems...perform reliably across a range of climatic conditions"*, as mentioned by Candidate 3, indicates their versatility and robustness. Hydrogen Storage Systems, while promising, may require more evidence to establish their compatibility with renewable energy sources. They are more complex to integrate than Lithium-Ion Batteries, but they can be an effective solution for large-scale storage needs, especially in scenarios where larger storage capacities are required.

Market Readiness, Policies and Regulation: Lithium-Ion Batteries enjoy a strong position in the market with established acceptance and clear pathways for regulatory compliance. Their current market dominance is a testament to their maturity and consumer trust, making them a safe choice for residential applications. In contrast, Hydrogen Storage Systems are navigating a less certain market landscape. They face challenges in market penetration and consumer acceptance, compounded by an evolving regulatory environment. This creates a scenario where Hydrogen Storage Systems must continually adapt and prove their viability to both consumers and regulators.

Future Perspectives: The future outlook for Lithium-Ion Batteries is generally stable and predictable. They are expected to maintain their position in the market in the short to medium term. However, as technologies evolve, Lithium-Ion Batteries might face competition from emerging technologies, especially in terms of sustainability and energy efficiency. Hydrogen Storage Systems, currently in their nascent stage, present significant opportunities for technological advancements and market growth. Their potential for large-scale and sustainable energy storage positions them as a key player in the future energy landscape, especially as the focus on renewable and clean energy sources intensifies.

Summarising, both Lithium-Ion and Hydrogen Storage Systems present unique advantages and challenges as revealed by these expert interviews. While Lithium-Ion Batteries currently lead in market readiness and operational feasibility, Hydrogen Storage systems show significant promise for future sustainability and large-scale applications. The next subchapter will delve into a detailed comparative analysis of these technologies, weighing their pros and cons in the context of Casa Nova Bau GmbH's strategic objectives.

5.5 Comparative Analysis of Storage Technologies

Building upon the insights gathered in the previous chapters, this section conducts a comparative analysis of Lithium-Ion Batteries and Hydrogen Storage technologies. It evaluates these technologies using data from the BMC, ILF, and expert interviews against the evaluation criteria. Table 4 provides a summary of their scores, facilitating direct comparison. For score generation methodology details, refer to Appendix [J]. Furthermore, each criterion is accompanied by a detailed explanation that ties the scores to insights and evaluations from the applied frameworks, ensuring a deep understanding of how each technology performs across these critical dimensions.

Operational Feasibility: Lithium-Ion Batteries offer Casa Nova Bau GmbH economic benefits like reduced costs and strong ROI, reflected in their BMC analysis and *Maturity* phase in the ILF. This results in a stable cost structure and dependable revenue from services, earning a weighted score of 3.2. Experts note their long-term viability, citing decreased costs and longer lifespan. Conversely, Hydrogen Storage Systems, in the ILF's *Pilot* phase, have higher initial and operational costs, leading to a lower score of 2.0. However, experts acknowledge their potential for long-term economic gains as the technology and market mature.

Profitability Prospects: Lithium-Ion Batteries offer economic benefits for Casa Nova Bau GmbH, with their affordability and lower operational costs leading to stable ROI. The BMC and *Maturity* phase in the ILF predict a steady revenue stream, reflected in a weighted score of 2.1. Experts agree, citing their cost-effectiveness. In contrast, Hydrogen Storage Systems have

higher initial and ongoing expenses, as shown in the BMC and their *Pilot* phase in the ILF, resulting in a score of 1.5. However, experts recognize their long-term economic promise, viewing them as a strategic future investment with significant economic potential.

Table 4 – *Summary Comparative Analysis*

Criteria Dimension	Lithium-Ion Batteries	Hydrogen Storage Systems
Operational Feasibility (40%)	High feasibility (BMC, ILF) - Easy integration, minimal maintenance (Expert Interviews) **Score: 8, Weighted Score: 3.2**	Lower feasibility (BMC, ILF) - Complex operations, specialized knowledge needed (Expert Interviews) **Score: 5, Weighted Score: 2.0**
Profitability Prospects (30%)	Economically viable: Affordable, decreasing costs (BMC, ILF, Expert Interviews) - Predictable ROI and stable revenue **Weighted Score: 2.1**	- Higher initial investment and operational costs (BMC, ILF) - Long-term economic potential recognized (Expert Interviews) **Weighted Score: 1.5**
Sustainability Objectives (30%)	Reduces non-renewable reliance but has production concerns (BMC, Expert Interviews) **Weighted Score: 1.8**	Strong alignment with sustainability, zero-emission potential (BMC, ILF, Expert Interviews) **Weighted Score: 2.4**
Compatibility with Renewable Energy Sources (15%)	Excellent compatibility, reliable performance (BMC, ILF, Expert Interviews) **Weighted Score: 1.2**	Potential effectiveness but needs more evidence (BMC, ILF, Expert Interviews) **Weighted Score: 0.9**
Market and Regulatory Considerations (15%)	High market acceptance, clear regulatory compliance (BMC, ILF, Expert Interviews) **Weighted Score: 1.2**	Developing market, evolving regulations (BMC, ILF, Expert Interviews) **Weighted Score: 0.75**
Future Outlook (10%)	Stable and predictable outlook, needs innovation (BMC, ILF, Expert Interviews) **Weighted Score: 0.7**	Promising growth and innovation potential (BMC, ILF, Expert Interviews) **Weighted Score: 0.8**

Sustainability Objectives: Lithium-Ion Batteries, while reducing reliance on non-renewable energy, face environmental issues in production and disposal, leading to a weighted score of 1.8. They require ongoing sustainability improvements. On the other hand, Hydrogen Storage Systems, aligning with long-term environmental goals due to their zero-emission potential, as shown in the BMC and ILF, receive a higher score of 2.4. Experts highlight Hydrogen Storage's ability to meet sustainability targets, particularly with eco-friendly production methods.

Compatibility with Renewable Energy Sources: Lithium-Ion Batteries are highly compatible with renewable energy, integrating well with photovoltaic systems and boosting efficiency, as shown in the BMC and in the ILF, leading to a weighted score of 1.2. Experts confirm their effectiveness in various renewable applications. In contrast, Hydrogen Storage Systems are still proving their compatibility, as indicated in the BMC and *Pilot* phase in the ILF, with a score of 0.9. They have potential for large-scale use and adaptability to diverse climates. Experts see them as a key player in the future solar energy sector, particularly for large energy storage needs.

Market and Regulatory Considerations: Lithium-Ion Batteries are favoured for Casa Nova Bau GmbH due to high market acceptance and regulatory compliance, as shown in the BMC and ILF, earning a weighted score of 1.2. Experts confirm their market maturity and wide acceptance, highlighting their strong presence and adherence to regulations, making them a reliable choice for immediate adoption. Conversely, Hydrogen Storage Systems face market readiness and regulatory challenges, with consumer acceptance uncertainties and evolving regulations, as indicated in the BMC and in the ILF, resulting in a score of 0.75. Experts note the importance of clear regulations for Hydrogen Storage's market growth.

Future Outlook: Lithium-Ion Batteries are expected to sustain a strong market presence, backed by their *Maturity* phase status in the ILF and BMC, achieving a weighted score of 0.7. They remain a reliable option despite competition, needing ongoing innovation to stay relevant. Experts emphasize the need for their technological evolution. In contrast, Hydrogen Storage Systems score 0.8, signifying a promising future. They are seen as vital in the upcoming energy landscape, particularly for their scalability and sustainability alignment. Their early market stage suggests rapid advancements and significant potential to shape future energy trends.

In conclusion, this comparative analysis equips Casa Nova Bau GmbH with critical insights for selecting the most suitable energy storage technology, aligning with its strategic and sustainability goals. The Business Model Canvas revealed that Lithium-Ion Batteries, scoring 10.2, present an immediate, practical option, excelling in market presence, operational

feasibility, profitability, and regulatory compliance. The Innovation Lifecycle Framework demonstrated that these batteries offer rapid market readiness, aligning well with Casa Nova Bau GmbH's focus on rapid integration and commercialization. Expert interviews corroborated these findings, highlighting Lithium-Ion Batteries' efficiency, integration ease, and compliance advantages. Conversely, Hydrogen Storage systems, scoring 8.35 in the Business Model Canvas, offer a strategic, long-term investment opportunity. The Innovation Lifecycle Framework indicated their significant growth and innovation potential, especially in terms of sustainability, while the experts pointed to their zero-emission capability and adaptability for large-scale renewable energy use, marking them as a key player in future energy solutions.

6. Discussion

In the context of this research, it is important to recognize certain limitations inherent in the study. Notably, the potential for expert bias stands out as a significant factor. The insights provided by industry professionals, while invaluable, might carry inherent biases, especially if they are closely affiliated with a particular technology. This could inadvertently lead to a skewed analysis favouring the technology they are more familiar with. It is critical to view these perspectives as subjective, acknowledging that they may not comprehensively represent the broader industry view. Moreover, the study did not distinctly differentiate between residential and commercial sectors concerning the expertise of the interviewees. This decision was made to ensure enough suitable experts were available, but it could impact the study's results, as the feasibility, cost structures, and sustainability goals differ markedly between these sectors. Future studies should aim to offer more detailed insights tailored to each specific sector. Integrating the Business Model Canvas and the Innovation Lifecycle Framework in this analysis offers theoretical implications by showcasing how combining these models can provide a more holistic view of technology assessment. This approach bridges the gap between operational practicality and innovation potential, highlighting how such frameworks can be synergistically used to inform strategic decisions in the renewable energy sector. This

methodological combination may inspire future research and strategy formulation in similar contexts.

The study's findings contribute significantly to the discourse in energy storage technologies. When comparing these results with those of Bajjolle et al. (2022) and Diouf and Pode (2020), similarities in Lithium-Ion Technology's efficiency metrics are evident. However, the rapid advancements in technology and shifting market dynamics pose limitations to the study, suggesting that its conclusions may have a limited period of validity. For Casa Nova Bau GmbH, it is imperative to remain agile and well-informed about the latest technological developments and market trends. The findings of this study also hold implications for other companies considering similar decisions. While the analysis is specific to Casa Nova Bau GmbH, the methodology and considerations can serve as a blueprint for other organizations. Companies can adapt this integrated framework approach to align technology choices with their unique operational needs and sustainability goals. However, it is crucial for each organization to consider its distinct market position and strategic objectives when applying these insights.

The work project also does not extensively explore potential future policy and regulatory changes, which could markedly impact the adoption and viability of energy storage technologies, a factor that could either facilitate or impede the implementation of these systems. The broader implications of adopting either technology, particularly in the context of global sustainability goals and the company's innovation agenda, are also crucial. While the work project aligns with current sustainability trends and innovation trajectories in the energy sector, a discussion on the wider impact of these technology choices on global sustainability initiatives and the company’s commitment to innovation would add depth to the analysis.

7. Conclusion

This study has undertaken a meticulous journey through the complex landscape of solar energy storage solutions, focusing on a comparative analysis between Lithium-Ion Batteries and Hydrogen Storage Systems, particularly for their application in Casa Nova Bau GmbH. The

comprehensive analysis, grounded in the Business Model Canvas, the Innovation Lifecycle Framework, and expert interviews, has illuminated the distinct characteristics, advantages, and limitations of both Lithium-Ion Batteries and Hydrogen Storage Systems. Lithium-Ion Batteries, with a total weighted score of 10.2, emerged as a more immediate and practical solution for Casa Nova Bau GmbH. Their established market presence, operational feasibility, and regulatory compliance align well with the company's current operational and financial goals. The adaptability, efficiency, and economic viability of Lithium-Ion Batteries make them a dependable choice for short-term implementation.

In contrast, Hydrogen Storage Systems, scoring a total weighted score of 8.35, have been identified as a forward-looking investment with significant potential for future innovation and growth. Despite current challenges in market readiness and operational feasibility, their strong alignment with long-term sustainability objectives and the potential for large-scale renewable energy applications position them as a strategic choice for future energy solutions. The zero-emission potential and adaptability of hydrogen storage systems are particularly compelling, highlighting their role in driving the future of sustainable energy.

For Casa Nova Bau GmbH, staying informed and adaptable to the latest technological developments and market trends is crucial. The findings from this study provide a foundation for informed decision-making, aligning the company's operational objectives with sustainable energy storage solutions. As the energy landscape continues to evolve, further research and continuous assessment of emerging technologies will be essential. Future explorations could focus on sector-specific studies, extended market analyses, and the impact of policy and regulatory changes on the adoption of energy storage technologies. This study concludes by affirming the vital role of strategic foresight and adaptability in the realm of renewable energy solutions. It is a step towards empowering Casa Nova Bau GmbH and similar entities to make decisions that resonate not only with their immediate operational needs but also with their long-term aspirations for sustainability and innovation in the renewable energy sector.

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Appendices

Appendix A – Sampling Criteria

Criteria	Description	Purpose
Expertise in Solar Energy Storage (Lithium-Ion or Hydrogen)	Participants should have specialized knowledge in solar energy storage technologies, particularly lithium-ion or hydrogen systems.	To ensure in-depth technical understanding of specific storage technologies and their applications.
Understanding of PV-Business and Market	Participants need comprehensive insights into the photovoltaic business and market dynamics.	To provide an understanding of the solar industry's commercial and economic environment.
Possessing an understanding of the Business Strategies associated with these Technologies	Participants should have a thorough understanding of business strategies associated with solar energy storage technologies.	To offer insights into how business strategies are shaped by and impact solar energy storage technologies.
Technological Innovation and Development Knowledge	Participants must be knowledgeable about recent technological innovations and development trends in solar energy storage.	To capture insights on emerging technologies and future trends in solar energy storage.
Practical Implementation Experience	Participants should have hands-on experience in implementing solar energy storage systems in real-world settings.	To provide practical viewpoints on the challenges and successes in deploying solar energy storage technologies.

Appendix B – Sampling Criteria

Candidate	Professional Role	Academic Qualification	Years of Experience
1	Founder and CEO (Lithium-Ion/Hydrogen Expert)	M. Sc.	5 Years
2	Senior Project Manager (Lithium-Ion Expert)	Master in Engineering	2 Years
3	Project Lead Electrotechnology (Hydrogen Expert)	Master in Engineering	12 Years
4	Senior Marketing Manager (Lithium-Ion Expert)	B. Sc.	2 Years
5	Competency-Center Engineer (Lithium-Ion Expert)	Master in Engineering	3 Years
6	Development Engineer (Hydrogen Expert)	Master in Engineering	4 Years
7	Head of Sustainability (Hydrogen Expert)	M. Sc.	10 Years
8	Business Innovation Manager (Lithium-Ion Expert)	M. Sc.	6 Years
9	Consultant (Lithium-Ion Expert)	B. Sc.	3 Years
10	Team Lead Quality Management (Lithium-Ion Expert)	B. Sc.	4 Years

Appendix C – Interview Protocol

Interview Protocol – Casa Nova Bau GmbH
Introduction

- Warmly greet the interviewee.
- Introduce the purpose of the research: to evaluate whether Casa Nova Bau GmbH should incorporate solar energy storage into their product offerings, specifically focusing on Lithium-Ion batteries and Hydrogen Storage Systems.
- Mention the evaluation criteria guiding the interview: operational feasibility, profitability, sustainability, compatibility with renewable sources, and market/regulatory considerations.
- Confirm the interview's duration (approximately 20-25 minutes).
- Obtain consent for audio recording to be used for research analysis.

Background & Experience
1. Could you describe your experience with lithium-ion batteries or hydrogen storage systems within residential solar energy applications?
Profitability Prospects
2. Considering initial investment and long-term operational costs, what are the key financial aspects that determine the viability of lithium-ion batteries and hydrogen storage systems in the residential market?
Operational Feasibility
3. Could you discuss the technical and logistical challenges and requirements, including skills and infrastructure, for the deployment and maintenance of lithium-ion batteries or hydrogen storage systems in residential settings?
Sustainability Objectives
4. How do the production and lifecycle of lithium-ion batteries or hydrogen storage systems align with sustainability targets, especially in terms of carbon footprint and resource efficiency?
Compatibility with Renewable Energy Sources
5. In your experience, how well do lithium-ion batteries or hydrogen storage systems integrate with existing PV setups, and how do they perform in various climate conditions?
Comparative Insights
6. If you have experience with both storage systems, could you compare them in terms of operational feasibility and sustainability? If not, what are the distinct advantages of the technology you specialize in?
Market and Regulatory Considerations
7. How do you see the market acceptance and regulatory environment evolving for these storage technologies, and what impact might this have on their adoption in residential solar energy systems?
Future Perspectives
8. What is your vision for the future development and market role of lithium-ion batteries or hydrogen storage systems in residential solar energy storage?
Closing
9. Do you recommend any other experts or sources that could contribute to our understanding of these technologies?

10. Are there any additional insights or suggestions you'd like to offer that might aid our research?

Thank You

- Express gratitude for the interviewee's time and insights.
- Explain how their input will contribute to the research findings.
- Offer contact information for any further inquiries or follow-up.

Appendix D – Coding Scheme

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion and hydrogen storage systems in residential solar systems.	Extracted from the transcripts	Inductive conclusion of statements
Economic Viability	Financial considerations of using lithium-ion and hydrogen storage systems in residential settings.	Extracted from the transcripts	Inductive conclusion of statements
Operational Challenges	Practical challenges in deploying and maintaining lithium-ion and hydrogen storage systems.	Extracted from the transcripts	Inductive conclusion of statements
Sustainability	Environmental impact and sustainability of lithium-ion and hydrogen storage systems.	Extracted from the transcripts	Inductive conclusion of statements
Compatibility with Renewable Energy Sources	Integration of lithium-ion and hydrogen storage systems with existing PV setups and their performance in various climates.	Extracted from the transcripts	Inductive conclusion of statements
Comparative Insights	Comparison of lithium-ion and hydrogen storage systems in terms of operational feasibility and sustainability.	Extracted from the transcripts	Inductive conclusion of statements
Market Readiness	Market acceptance and consumer perspectives on lithium-ion and hydrogen storage systems.	Extracted from the transcripts	Inductive conclusion of statements
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion and hydrogen battery adoption.	Extracted from the transcripts	Inductive conclusion of statements
Future Perspectives	Vision for the future development and market role of lithium-ion and hydrogen storage systems in residential solar energy storage.	Extracted from the transcripts	Inductive conclusion of statements

Appendix E – Evaluation Criteria Justification

Justification Aspect	Description
Relevance to the Renewable Energy Industry	Criteria reflect key standards and practices in the renewable energy sector, tailored to residential construction. Selection is based on current and emerging market trends for future applicability.
Strategic Alignment with Casa Nova's Goals	Criteria align with Casa Nova's mission for innovation and sustainability in residential construction.
Stakeholder and Expert Consultation	Criteria refined via consultations with internal stakeholders and external industry experts.
Literature Review and Best Practices	Review of scholarly and industry literature to ensure criteria are rooted in established evaluation practices.
Methodological Rigor	Employing MCDA and tools like Analytic Hierarchy Process to weight criteria appropriately.
Comparison with Competitors and Market Leaders	Analyzing and aligning with criteria used by market leaders to maintain or exceed industry standards.
Quantitative and Qualitative Balance	Incorporating both quantitative (e.g., ROI, costs) and qualitative (e.g., sustainability, compliance) factors.
Adherence to Market and Regulatory Frameworks	Ensuring compatibility with current and anticipated market and regulatory landscapes.

Appendix F – Business Model Canvas

Business Model Canvas

Designed for:	*Designed by:*	*Date:*	*Version:*
Casa Nova Bau GmbH	Alessandro Stefanelli	19.10.2023	1

Key Partners
- Local and national regulatory bodies
- Solar PV system component suppliers
- Renewable energy associations and networks
- Referral and Delegating Companies (selection criteria: Reputation & Track Record)

Key Activities
- Installation of photovoltaic (PV) systems
- Client consultation and personalized energy solutions
- Compliance with local and national energy regulations
- After-sales support and maintenance

Key Resources
- Skilled workforce: technicians, project managers, and support staff
- Technical infrastructure for PV system installations
- Strategic relationships with stakeholders
- Capital from bootstrapping

Value Propositions
- Expertise in tailored PV system installations for diverse clientele
- Strong commitment to sustainability and innovation
- High-quality installations with customer-centric approach

Customer Relationships
- Personalized renewable energy solutions for individual households and commercial clients
- Continuous support during transition to renewable energy
- After-sales maintenance and system checkups
- Feedback loops for product/service

Channels
- Direct client consultations in Hamburg
- Online presence and digital marketing campaigns
- Partnerships with local housing and renewable energy associations
- Workshops and seminars on renewable energy adoption for households

Customer Segments
- Private households (accounting for 75% of revenue)
- Businesses seeking to minimize environmental impact
- Green energy enthusiasts
- Early adopters of sustainable technologies
- Underserved markets seeking renewable solutions

Cost Structure
- Investment in PV system components
- Labor costs for skilled workforce
- Compliance and regulatory costs
- Marketing and outreach expenses

Revenue Streams
- Revenue from PV system installations
- Maintenance and support fees
- Sale of integrated energy storage solutions (once adopted)
- Consultation fees for custom renewable energy solutions

Figure 3: *Business Model Canvas for Casa Nova Bau GmbH.*

Source: Author's own creation, based on Osterwalder (2013)

Appendix G – Effect of Lithium-Ion and Hydrogen Storage Systems on BCM

BMC Segment	Impact of Lithium-Battery Storage	Impact of Hydrogen Storage	Evaluation Criteria
Key Partners	New supplier partnerships for battery procurement	Partnerships with tech innovators and hydrogen producers	Operational Feasibility
Key Activities	Installation and maintenance of battery systems	Installation, maintenance, plus hydrogen fuel handling	Operational Feasibility
Key Resources	Battery storage handling capabilities	Investment in hydrogen-safe infrastructure	Operational Feasibility
Value Propositions	Reliable energy storage, quick deployment	Long-term storage, reduced maintenance	Operational Feasibility, Compatibility with Renewable Energy Sources
Customer Relationships	Education on battery efficiency, lifecycle	Education on hydrogen safety, sustainability	Sustainability Objectives
Channels	Promotion in existing marketing channels	Workshops, seminars on hydrogen innovation	Market and Regulatory Considerations
Customer Segments	Environmentally conscious clients, proven tech preference	Early adopters, high-tech affinity	Market and Regulatory Considerations
Cost Structure	Variable costs with technology advancements	Higher initial costs, emerging market	Profitability Prospects
Revenue Streams	Battery system sales, after-sales services	Hydrogen supply contracts, system servicing	Profitability Prospects

Appendix H – Innovation Lifecycle Model

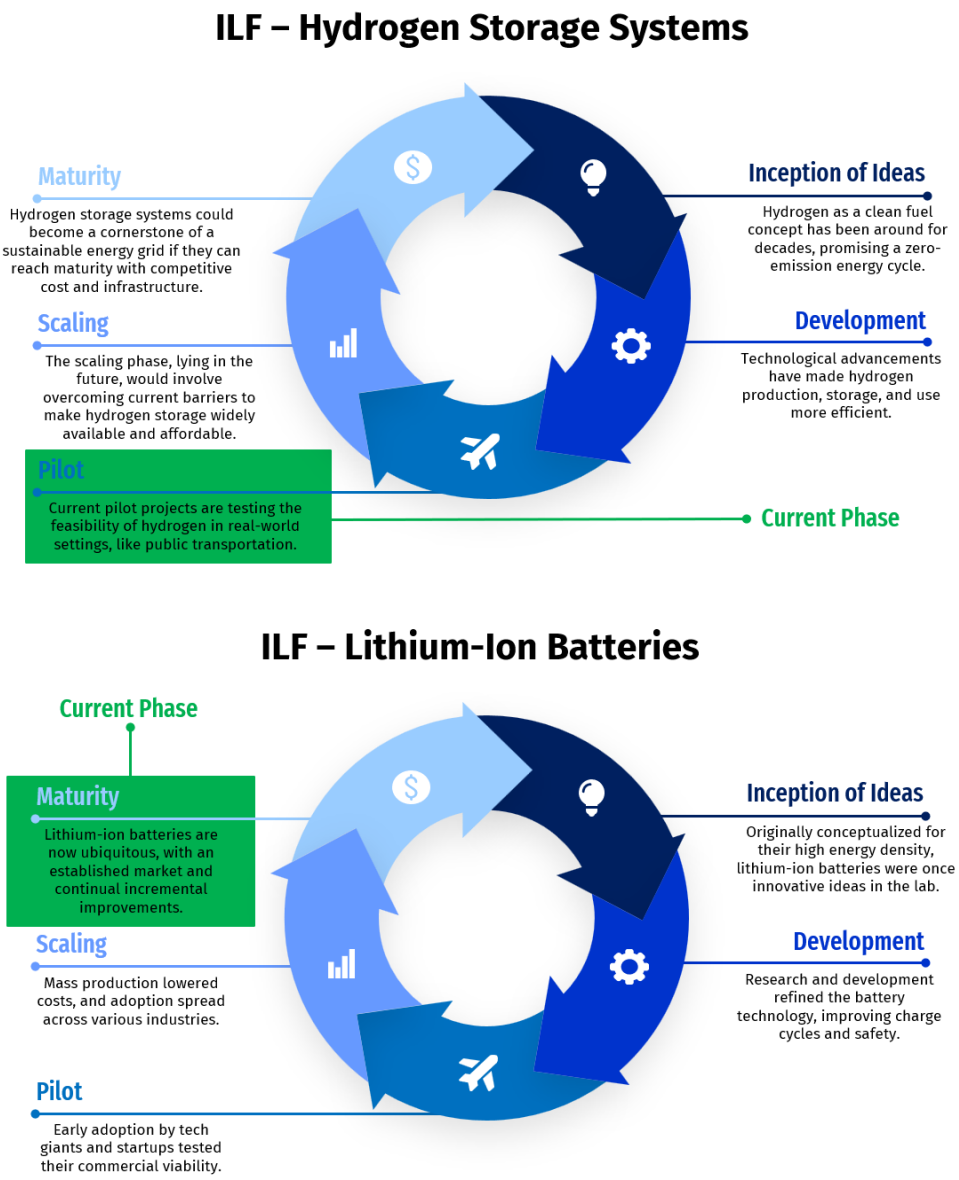

Figure 4: *Innovation Lifecycle Model*
Source: Author's own creation, adapted from Waychal (2011)

Hydrogen storage systems are considered to be in the *Pilot* or *Scaling phase*, as they are beyond initial development but have not yet reached full market maturity. They represent a growing field in the renewable energy sector, especially for applications that require high energy density and quick refueling, like transportation and grid storage. Lithium-ion batteries, due to their widespread adoption and technological maturity, would likely be placed in the *Maturity phase* of the ILF. They have become the standard for portable energy storage, with extensive use in everything from consumer electronics to electric vehicles.

Appendix I – Coding of Expert Interviews

: Highlighted parts are used in subchapter 5.4 Findings of Expert Interviews

Candidate 1 - Interview partner: KJ, Founder and CEO (Lithium-Ion/Hydrogen Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion and hydrogen storage systems in residential solar systems.	*"Integrating storage solutions has been a key part of our offerings"* (Line 16) *"Lithium-ion is more common in our installations due to its current market maturity"* (Line 26-27) *"Hydrogen storage...more niche...requires a bit more specialized setup*" (Line 29-34)	Lithium-ion batteries are more common and straightforward to integrate, while hydrogen storage, though niche, is growing in interest due to its unique applications.
Economic Viability	Financial considerations of using lithium-ion and hydrogen storage systems in residential settings.	*"Lithium-ion batteries have become more affordable...good return on investment"* (Line 39-41) *"Hydrogen storage tends to have higher initial costs...more of a long-term investment"* (Line 44-47)	Lithium-ion batteries are increasingly affordable and offer good ROI, whereas hydrogen storage is seen as a long-term investment with higher initial costs but significant potential
Operational Challenges	Practical challenges in deploying and maintaining lithium-ion and hydrogen storage systems.	*"Installing lithium-ion batteries...more straightforward"* (Line 55-56) *"…challenge lies in… sizing the system to the home's energy needs"* (Line 56-57) *"…integrates well…maintenance level is…minimal"* (Line 57-58) *"Hydrogen storage...more complexities...safe handling and conversion"* (Line 59-60) *"Hydrogen storage systems require specialized knowledge...more coordination"* (Line 68-69)	Lithium-ion batteries are easier to install and maintain, while hydrogen storage involves more complex and specialized operations.

Sustainability	Environmental impact and sustainability of lithium-ion and hydrogen storage systems.	*"...lithium-ion...helps reduce reliance on non-renewable energy sources"* (Line 74-76) *"...battery production, the mining of lithium...has environmental impacts"* (Line 77-78) *"...advances in recycling are improving the overall sustainability..."* (Line 78-79) *"If hydrogen is produced using renewable energy...almost emission-free..."* (Line 80-81) *"...depends on...how efficiently the electrolysis and store process are managed."* (Line 82-83) *"I expect it to become a more sustainable option..."* (Line 84)	Lithium-ion batteries aid in reducing reliance on non-renewable energy but have production concerns, while hydrogen offers almost emission-free potential if produced sustainably.
Compatibility with Renewable Energy Sources	Integration of lithium-ion and hydrogen storage systems with existing PV setups and their performance in various climates.	*"...lithium-ion batteries...easily adapted to different PV systems...perform reliably across a range of climatic conditions."* (Line 93-95) *"...extreme temperatures can affect efficiency to some extent..."* (Line 96) *"...hydrogen storage systems...more complex to integrate...effective solution...where large-scale storage is needed..."* (Line 97-100) *"...less sensitive to temperature variations...beneficial in more extreme climates."* (Line 101-102)	Lithium-ion batteries are versatile and adapt well to different PV systems, while hydrogen storage, though complex, is beneficial in extreme climates and in large-scale applications.
Comparative Insights	Comparison of lithium-ion and hydrogen storage systems in terms of	*"Lithium-ion...operationally feasible...ease of installation and maintenance"* (Line 105-106)	Lithium-ion batteries are operationally more feasible for homeowners, whereas hydrogen storage, though

	operational feasibility and sustainability.	*"…they're a mature technology with a robust support infrastructure"* (Line 106-107) *"Hydrogen storage...operationally more challenging...great potential in sustainability"* (Line 109-111)	challenging, shows great potential in sustainability.
Market Readiness	Market acceptance and consumer perspectives on lithium-ion and hydrogen storage systems.	*"Market acceptance for lithium-ion batteries is already high...continues to grow"* (Line 117-118) *"...hydrogen storage...market is still developing…but interest is definitely on the rise…"* (Line 120-121)	Lithium-ion batteries are well-received and growing in market acceptance, while hydrogen storage is emerging with increasing interest.
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion and hydrogen battery adoption.	*"...regulatory environment for lithium-ion is well-established...helps with consumer confidence…"* (Line 119-120) *"...hydrogen storage...regulatory environment is also catching up…"* (Line 120-122)	Lithium-ion benefits from an established regulatory environment, whereas regulations for hydrogen storage are evolving to become more supportive.
Future Perspectives	Vision for the future development and market role of lithium-ion and hydrogen storage systems in residential solar energy storage.	*"...lithium-ion will likely continue to lead… in the short to medium term.. I also.expect further advancements in their efficiency and capacity…"* (Line 129-131) *"...hydrogen...role will expand as the technology evolves...potential for large-scale storage…"* (Line 132-134) *"…I envision a future…technologies coexist and complement each other…"* (Line 135-136)	Lithium-ion is expected to maintain its lead due to reliability, while hydrogen storage is seen as a growing future option, especially for large-scale solutions, so that both technologies will coexist in the future.

Candidate 2 - Interview partner: RJ, Senior Project Manager (Lithium-Ion Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion batteries in residential solar systems.	*"Compact efficient... lifespan complements the solar panels' operational life"* (Line 19-20) *"Customize the storage capacity to the household's energy profile…which maximizes efficiency and cost-effectiveness… Especially…with AI…"* (Line 22-24)	Lithium-ion batteries are an efficient and adaptable energy storage solution for residential solar systems.
Economic Viability	Financial considerations of using lithium-ion batteries in residential settings.	*"The price point... trending downward as technology advances…"* (Line 27-28) *"Operational costs are another selling point... very little maintenance and predictable life cycle… reliable Return on Investment"* (Line 34-36) *"Incentives for solar-plus-storage systems…offset the upfront costs"* (Line 37-38)	The cost-effectiveness and maintenance ease of lithium-ion batteries make them an economically viable choice for homeowners, especially in the long-run.
Operational Challenges	Practical challenges in deploying and maintaining lithium-ion batteries.	*"Deployment...easy…"* (Line 44) *"…any qualified electrician can handle…easy to first integrate these batteries."* (Line 47-48) *"Minimal maintenance"* (Line 50) *"Right size system for the home requires detailed analysis"* (Line 54)	Implementing lithium-ion battery systems involves straightforward deployment and minimal maintenance but sizing them correctly for each home is crucial.
Sustainability	Environmental impact and sustainability of lithium-ion batteries.	*"Small carbon footprint"* (Line 62-63) *"Highly efficient... less energy wasted"* (Line 63-64) *"Improvements in recycling technologies"* (Line 65)	Lithium-ion batteries contribute to environmental sustainability with their efficiency and evolving recycling technologies.
Compatibility with Renewable Energy Sources	Integration of lithium-ion batteries with existing PV setups and	*"Integrate seamlessly with PV setups"* (Line 74)	Lithium-ion batteries offer seamless integration with photovoltaic setups and

	their performance in various climates	*"Consistent performance across a range of climates"* (Line 76)	reliable performance across diverse climates, enhancing their compatibility with renewable energy sources
Comparative Insights	Comparison of lithium-ion batteries with other storage systems in terms of operational feasibility and sustainability.	*"Operational feasibility... user-friendly"* (Line 102-103) *"Longevity matches well with the lifespan of solar panels"* (Line 104-105) *"Help reduce reliance on the grid… carbon footprint"* (Line 106-107)	Lithium-ion batteries stand out for their user-friendliness and sustainability, complementing the lifespan of solar panels and contributing to grid independence.
Market Readiness	Market acceptance and consumer perspectives on lithium-ion batteries.	*"Market acceptance for lithium-ion batteries is really strong"* (Line 86) *"People understand the technology, they trust it"* (Line 87)	Lithium-ion batteries are well-received in the market, with a growing trust and understanding among consumers.
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion battery adoption.	*"Regulatory environment – generally supportive"* (Line 88) *"…policies in place to encourage the adoption"* (Line 90) *"Outdated policies can slow things down"* (Line 94)	The adoption of lithium-ion batteries is influenced by a regulatory environment that is evolving to better support renewable energy technologies.
Future Perspectives	Vision for the future development and market role of lithium-ion batteries in residential solar energy storage.	*"Become more efficient and cost-effective"* (Line 115-116) *"Becoming the norm in residential solar systems"* (Line 116) *"Storage capacity and… smart systems adapting to energy needs"* (Line 119-120)	The future of lithium-ion batteries in residential solar energy storage is promising, with advancements leading to greater efficiency, cost-effectiveness, and integration with smart systems.

Candidate 3 - Interview partner: GL, Project Lead Electrotechnology (Hydrogen Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of hydrogen storage	*"...integrating these systems to…store solar energy efficiently"* (Line 22-23)	Hydrogen storage systems, while complex, have a technical adaptability that makes them suitable for

	systems in residential solar systems.	*"...technical expertise... highly transferable to smaller-scale residential systems..."* (Line 25)	residential solar energy storage.
Economic Viability	Financial considerations of using hydrogen storage systems in residential settings.	*"...initial costs are... on the higher side... when you compare them to... traditional batteries"* (Line 33-34) *"...operational costs for hydrogen ...can be lower in the long term... longer lifecycle..."* (Line 35-37) *"...as the tech advances, we expect costs to...come down...making hydrogen a more viable option..."* (Line 37-38)	Hydrogen storage systems present higher initial costs but offer potential long-term economic benefits due to lower operational costs and longer lifecycles.
Operational Challenges	Practical challenges in deploying and maintaining hydrogen storage systems.	*"...deploying hydrogen systems in a home...it's complex..."* (Line 46) *"...installing tanks, electrolyzers... needs to be done safely"* (Line 47-48) *"...infrastructure needs to be compact yet capable"* (Line 49) *"...logistic side...need for specialized delivery and installation processes..."* (Line 50) *"...technicians...need to be trained specifically for hydrogen systems..."* (Line 51-52) *"...maintenance isn't overly complicated..."* (Line 52) *"...finding appropriate professionals can be a future problem..."* (Line 57-58)	The deployment of hydrogen storage systems involves complex installation and the necessity for specialized technical expertise, emphasizing safety and compactness.
Sustainability	Environmental impact and sustainability of	*"...production through electrolysis... is essentially a clean process"* (Line 64-65)	Hydrogen storage aligns with sustainability goals through clean production

	hydrogen storage systems.	*"...manage the systems at the end of their life…recycle the components"* (Line 67-68) *"...improve the efficiency of the whole cycle, from production to storage…"* (Line 69) *"…we need to consider the source of the materials for the electrolyzers and storage tanks…" (Line 70-71)*	processes and the focus on recycling and efficiency throughout the lifecycle.
Compatibility with Renewable Energy Sources	Integration of hydrogen storage systems with existing PV setups and their performance in various climates.	*"...they work well with PV systems... store excess energy…"* (Line 78-79) *"...hydrogen storage is…quite robust… the efficiency of the storage remains consistent.* " (Line 82-83) *"…reliable source of energy…regardless of the climate or weather conditions outside."* (Line 85-87)	Hydrogen storage systems are robust and efficient in various climates, complementing PV systems by storing excess energy and providing consistent performance.
Comparative Insights	Comparison of hydrogen storage systems with other storage technologies in terms of operational feasibility and sustainability.	*"...more complex to set up... but they're catching up in terms of feasibility"* (Line 93-94) *"...hydrogen has a potential edge in sustainability in the long run"* (Line 96) *"…at the end…there is no cleaner option to store energy than in hydrogen…"* (Line 100-101)	Hydrogen storage, though operationally more complex, offers significant potential in sustainability compared to other storage technologies.
Market Readiness	Market acceptance and consumer perspectives on hydrogen storage systems.	*"...market for hydrogen, it's growing, but still emerging. Acceptance is increasing…"* (Line 104-105) *"…other solar energy storing technologies that are more popular… as they are already easily scalable"* (Line 106-108)	Hydrogen storage is gaining traction in the market, particularly in commercial applications, with increasing acceptance as awareness of its potential grows.

		"...in the commercial market... hydrogen storage is getting more popular" (Line 109-110)	
Policy and Regulation	Impact of government policies and legal frameworks on hydrogen storage adoption.	*"...regulatory environment is adapting and becoming more favorable."* (Line 111-112) *"As regulations evolve... we'll likely see an acceleration in its adoption"* (Line 112-114)	The evolving regulatory landscape is becoming increasingly supportive of hydrogen storage, likely accelerating its adoption in the energy sector.
Future Perspectives	Vision for the future development and market role of hydrogen storage systems in residential solar energy storage.	*" I expect to see...substantial advancements in the efficiency and cost-effectiveness..."* (Line 122-123) *"...shift towards a more decentralized energy system... where hydrogen...plays a key part..."* (Line 124-125) *"I believe hydrogen storage will become a more mainstream option... complementing traditional energy storage methods..."* (Line 129-130)	The future outlook for hydrogen storage is optimistic, with expected advancements in efficiency and a pivotal role in decentralized energy systems.

Candidate 4 - Interview partner: WM, Senior Marketing Manager (Lithium-Ion Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion batteries in residential solar systems.	*"...push the envelope on how these batteries can store more power... especially during winter months..."* (Line 19-20)	Lithium-ion batteries are being developed to store power more efficiently, adapting to varying seasonal energy inputs, especially in challenging climates like winter.
Economic Viability	Financial considerations of using lithium-ion batteries in residential settings.	*"...balancing the cost of materials...can be very volatile..."* (Line 30-31) *"...production scalability...prices fall as manufactures' processes became more...streamlined."* (Line 33-33)	Economic viability of lithium-ion batteries hinges on balancing material costs, scalable production, and navigating external factors like public perception and policy.

		"...can't overlook the role of public perception and policies...tax breaks, rebates, incentives..." (Line 33-34)	
Operational Challenges	Practical challenges in deploying and maintaining lithium-ion batteries.	*"...need skilled technicians...who understand electrical systems, battery chemistry, and even software..."* (Line 44-45) *"...logistically... manage transportation, safe handling and installation"* (Line 45-47) *"...after care...providing an ongoing service."* (Line 48-49)	Successful deployment and maintenance of lithium-ion batteries require skilled technicians and careful logistics, emphasizing safety and minimal homeowner disruption.
Sustainability	Environmental impact and sustainability of lithium-ion batteries.	*"...we take a look at the entire lifecycle...where materials are sourced, how...produced...how they are disposed or recycled..."* (Line 54-56) *"Mining for raw materials has its issues..."* (Line 57-58) *"...investing in finding greener alternatives...ethical sourcing... improving recyclability..."* (Line 58-59)	Sustainability efforts focus on the entire lifecycle of lithium-ion batteries, from ethical sourcing to recycling, despite challenges in mining and production processes.
Compatibility with Renewable Energy Sources	Integration of lithium-ion batteries with existing PV setups and their performance in various climates	No explicit mention	Not applicable for this interview.
Comparative Insights	Comparison of lithium-ion batteries with other storage systems in terms of operational feasibility and sustainability.	*"...lithium-ion...leading the residential storage market...efficiency and reliability are...unmatched for small-scale applications..."* (Line 68-69) *"...hydrogen storage...especially in larger grid operations..."* (Line 70-71)	Lithium-ion batteries are preferred for residential use due to their efficiency and reliability, whereas hydrogen storage is more suited to larger grid operations.
Market Readiness	Market acceptance and consumer perspectives on lithium-ion batteries.	*"...market adoption...isn't just about having a superior product... navigate these external*	Market adoption of lithium-ion batteries relies not only on product quality but also

		factors… align them with consumer demand" (Line 35-36)	on navigating external factors like consumer demand and policy incentives.
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion battery adoption.	*"…tax breaks, rebates, incentives …make a big difference in adoption rates."* (Line 34-35)	Government policies, including tax incentives and rebates, significantly influence the adoption rates of lithium-ion batteries.
Future Perspectives	Vision for the future development and market role of lithium-ion batteries in residential solar energy storage.	*"…batteries that can predict your energy usage patterns...integrate with your other smart devices...sell back energy to the grid…"* (Line 82-84)	Future lithium-ion batteries will be more interactive, integrating with smart home technologies and playing a dynamic role in energy usage and grid interaction.

Candidate 5 - Interview partner: BM, Competency-Center Engineer (Lithium-Ion Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion batteries in residential solar systems.	*"…highly efficient... over 99% efficiency in energy conversion…"* (Line 19-20) *"…batteries store it effectively with minimal loss…"* (Line 20-21) *"…help in managing energy use more intelligently…"* (Line 24)	Lithium-ion batteries demonstrate high efficiency in energy conversion, making them effective for storing solar energy with minimal loss.
Economic Viability	Financial considerations of using lithium-ion batteries in residential settings.	*"…higher upfront cost… significant long-term savings…"* (Line 40-41) *"…longer lifespan and maintain efficiency over time... reducing the need for replacements."* (Line 41-42) *"…provide lower electricity bills…"* (Line 47) *"…countries where energy costs can fluctuate…lead to substantial savings…"* (Line 48-49)	Lithium-ion batteries have higher initial costs but offer long-term economic benefits due to their longer lifespan and efficiency, reducing the need for replacements.

Operational Challenges	Practical challenges in deploying and maintaining lithium-ion batteries.	*"...correct sizing and integration of the battery with the solar system..."* (Line 57-58) *"...check if the systems match the infrastructure's requirements..."* (Line 62-63) *"...installation requires professional expertise...but every electro-technician should be able to install our systems..."* (Line 68-69)	The main technical challenges include ensuring the correct sizing and integration of batteries with solar systems, requiring professional expertise for installation.
Sustainability	Environmental impact and sustainability of lithium-ion batteries.	- *"...ongoing effort to make production more environmentally friendly...includes sourcing materials responsibly and improving manufacturing efficiency..."* (Line 82-83) *"...their long lifespan...reduce the need for frequent replacements...lowers the environmental impact..."* (Line 84-86) *"...recycling technologies that allow for the recovery and reuse of materials..."* (Line 87-88) *"...harming the environment when it comes to lithium mining or harming the health of their workers..."* (Line 96-97)	Efforts towards environmental sustainability include responsible sourcing, efficient manufacturing, and advancing recyclability of lithium-ion batteries, but lithium mining is still considered with some challenging aspects regarding social and environmental sustainability.
Compatibility with Renewable Energy Sources	Integration of lithium-ion batteries with existing PV setups and their performance in various climates	*"...seamless storage of energy generated by solar panels..."* (Line 108-109) *"...lithium batteries are quite resilient...operate effectively across a broad range of temperatures..."* (Line 111-112) *"...extreme conditions can impact their efficiency to some*	Lithium-ion batteries integrate well with PV systems, effectively storing energy and operating efficiently across various temperatures, but extreme conditions can have a marginal impact on performance.

		degree…constantly works on improving this aspect…" (Line 113-115)	
Comparative Insights	Comparison of lithium-ion batteries with other storage systems in terms of operational feasibility and sustainability.	*"…currently more operationally feasible than many alternatives…"* (Line 121-122) *"…easier to install, require less maintenance…more established market presence…"* (Line 122) *"…better balance of energy density, efficiency, and environmental impact…"* (Line 127-128)	Lithium-ion batteries are more operationally feasible and sustainable compared to many alternatives, offering a balance of efficiency and environmental impact.
Market Readiness	Market acceptance and consumer perspectives on lithium-ion batteries.	*"…market acceptance is continually increasing... driven by the growing demand for renewable energy and energy independence…"* (Line 132-133) *"… consumers are more aware or interested in sustainable energy storage options…"* (Line 134-135)	Lithium-ion batteries are increasingly accepted in the market, particularly due to growing consumer interest in sustainable energy storage.
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion battery adoption.	*"…evolving to support the increased adoption of these batteries…"* (Line 136) *"…policies and incentives that promote the use of renewable energy and energy storage…"* (Line 137-138)	The regulatory environment is evolving to support lithium-ion batteries, with policies and incentives fostering their adoption.
Future Perspectives	Vision for the future development and market role of lithium-ion batteries in residential solar energy storage.	*"…playing an increasingly crucial role in residential solar systems…*" (Line 146) *"…advancements in battery technology, leading to higher energy densities and longer lifespans…"* (Line 147-148) *"…to become more integrated…to smart home*	Lithium-ion batteries are expected to become more integral to residential solar systems, with advancements improving their efficiency and integration with smart homes.

		systems…demand…is bound to rise…" (Line 150-153)	

Candidate 6 - Interview partner: GM, Development Engineer (Hydrogen Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of hydrogen storage systems in residential solar systems.	*"…our goal is to harness excess solar energy…to produce hydrogen…"* (Line 15-16) *"…addressing the challenges of… adapting these systems for home use... ensuring they are safe, efficient, and also user-friendly…"* (Line 27-28) *"…technology is still emerging, but we've seen promising results…"* (Line 29)	Hydrogen storage systems show promise for residential solar integration, with ongoing improvements in safety, efficiency, and user-friendliness.
Economic Viability	Financial considerations of using hydrogen storage systems in residential settings.	*"…initial setup for hydrogen storage systems is…higher than…conventional batteries...due to the technology's complexity."* (Line 35-36) *"…long-term benefits... hydrogen has the potential for large energy storage... especially beneficial in areas with less consistent sunlight…"* (Line 38-39) *"…as technology improves…costs will naturally decrease... operational costs are comparatively low…"* (Line 44-45)	Hydrogen storage systems, while currently more expensive upfront, offer long-term and large-scale economic benefits through larger energy storage capacities and low operational costs.
Operational Challenges	Practical challenges in deploying and maintaining hydrogen storage systems.	*"…deploying hydrogen storage systems is indeed more complex than traditional batteries... requires a deep understanding of hydrogen's properties…"* (Line 50-52) *"Safety is also a very important keyword... proper containment and ventilation are critical…"* (Line 55-56) *"…infrastructure for hydrogen delivery and maintenance support, which is still developing…"* (Line 58-59)	Deploying and maintaining hydrogen storage systems requires overcoming complexities in safety, infrastructure, and technical expertise.
Sustainability	Environmental impact and sustainability of	*"…hydrogen…if produced via electrolysis by using solar energy, is as*	Hydrogen storage is highly sustainable, offering zero emissions

	hydrogen storage systems.	*green as it gets, zero emissions"* (Line 77-78) *"...it's a closed-loop system... converting hydrogen back to electricity without any carbon byproduct."* (Line 79-81) *"Hydrogen requires only water as a feedstock... developing methods to recycle and also repurpose the core components..."* (Line 82-85)	and a closed-loop system that relies on water and emphasizes recyclability.
Compatibility with Renewable Energy Sources	Integration of hydrogen storage systems with existing PV setups and their performance in various climates.	*"...hydrogen storage systems can be beautifully synergistic with PV systems... storage of excess energy that would otherwise be waste..."* (Line 91-93) *"...particularly useful in climates where sunlight is variable...maintain performance across a range of conditions..."* (Line 93-97) *"...the technology is adaptable...it can ensure that...energy needs are met all year-around..."* (Line 98-99)	Hydrogen storage systems complement PV systems well, especially in varying climates, by effectively storing excess energy.
Comparative Insights	Comparison of hydrogen storage systems with other storage technologies in terms of operational feasibility and sustainability.	*"...currently more complex than lithium-ion systems... technology is still maturing, higher barrier to entry in terms of the skill and knowledge required..."* (Line 109-111) *"...sustainability-wise hydrogen has the potential to outshine other technologies due to its cleaner lifecycle and the possibility for large-scale energy storage..."* (Line 112-114)	Hydrogen storage, while currently more complex, holds potential for superior sustainability and large-scale storage capabilities compared to other technologies.
Market Readiness	Market acceptance and consumer perspectives on hydrogen storage systems.	*"...market acceptance for hydrogen is growing...at a nascent stage compared to more established energy storage solutions..."* (Line 132-133)	Market acceptance for hydrogen storage is gradually increasing, though it still trails behind more established energy storage solutions.
Policy and Regulation	Impact of government policies	*"Currently, technology is developing faster than the*	The regulatory landscape for hydrogen storage is

	and legal frameworks on hydrogen storage adoption.	*corresponding…regulations…"* (Line 134-135) *"...regulations become…more defined and supportive, I expect to see a significant uptick in adoption, at least in the mid- and long-term…"* (Line 137-138)	evolving, with growing support that is expected to facilitate increased adoption.
Future Perspectives	Vision for the future development and market role of hydrogen storage systems in residential solar energy storage.	*"...hydrogen…complements existing technologies to create a more robust and reliable energy grid…"* (Line 149-150) *"...key player in the transition to a decentralized energy system... homes can not only produce and store their own energy but also contribute…"* (Line 150-152) *"...hydrogen storage costs will decrease…making it competitive with other storage options…"* (Line 153-154)	Hydrogen storage is poised to play a critical role in the future of energy storage, complementing existing technologies and aiding in the shift to decentralized energy systems.

Candidate 7 - Interview partner: BN, Head of Sustainability (Hydrogen Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of hydrogen storage systems in residential solar systems.	*"...integrating hydrogen storage with solar energy systems..."* (Line 17-18) *"...smart battery system...not much bigger than conventional batteries like lithium-ion batteries."* (Line 27-28) *"...can store more energy over a longer period than traditional batteries…"* (Line 31)	Hydrogen storage systems offer innovative solutions for residential solar applications, storing more energy for longer periods than traditional batteries, albeit with some technical complexities.
Economic Viability	Financial considerations of using hydrogen storage systems in residential settings.	*"...initial investment…can be higher than traditional storage solutions..."* (Line 40-41) *"...significantly longer lifespan… don't need to be replaced as often…leading to*	While the initial cost of hydrogen storage systems is higher, they offer long-term economic benefits due to their larger energy storage capacity and longer lifespan.

		considerable savings." (Line 42-44) *"...larger energy storage capacity... translates to more prolonged energy independence..."* (Line 46-47)	
Operational Challenges	Practical challenges in deploying and maintaining hydrogen storage systems.	*"...deployment...does come with... unique challenges...more complex than conventional..."* (Line 61-62) *"...requires specialized knowledge and handling..."* (Line 67-68) *"...installation must adhere to strict standards and regulations..."* (Line 68) *"...finding the right...expertise...and ensuring safe installation are key challenges..."* (Line 71-72)	Deploying hydrogen storage systems presents challenges due to their complexity and the need for specialized knowledge and strict adherence to safety standards.
Sustainability	Environmental impact and sustainability of hydrogen storage systems.	*"...production... through renewable sources like solar is incredibly clean..."* (Line 88-89) *"...lifecycle...last a long time, reducing the need for frequent replacements..."* (Line 90-91) *"...exploring environmentally friendly methods to handle any waste."* (Line 92)	Hydrogen storage aligns well with sustainability goals due to its clean production process, long lifespan, and focus on environmentally friendly disposal methods.
Compatibility with Renewable Energy Sources	Integration of hydrogen storage systems with existing PV setups and their performance in various climates.	*"...perfectly aligned with every common PV system..."* (Line 99-100) *"...hydrogen is less affected by climate variations compared to traditional batteries..."* (Line 99-100)	Hydrogen storage systems integrate well with PV systems, showing resilience to climate variations and enhancing energy storage efficiency.
Comparative Insights	Comparison of hydrogen storage systems with other storage technologies in	*"...more complex...operationally than traditional battery systems..."* (Line 109-110)	Hydrogen storage systems are operationally more complex but offer a significant sustainability advantage with

	terms of operational feasibility and sustainability.	*"…sustainable standpoint…hydrogen has the potential to outperform many traditional storage solutions…"* (Line 114-115) *"…ability to store large amounts of energy without harmful emissions..."* (Line 115-116)	their large energy storage capacity and clean energy conversion.
Market Readiness	Market acceptance and consumer perspectives on hydrogen storage systems.	*"...market acceptance for hydrogen storage in Australia is growing..."* (Line 121) *"…not many companies that provide hydrogen solutions at the moment…"* (Line 122) *"…interested homeowners…searching for alternatives…"* (Line 124) *"...increasing public awareness of the benefits of hydrogen..."* (Line 129)	Market acceptance for hydrogen storage is on the rise, supported by growing public awareness and interest in renewable energy alternatives.
Policy and Regulation	Impact of government policies and legal frameworks on hydrogen storage adoption.	*"...regulatory environment is evolving to support the shift..."* (Line 126) *"...policies and incentives encourage the adoption of renewable energy technologies, including hydrogen storage"* (Line 127-128) *"…not yet very common in the residential sector…these incentives are more for the commercial sector…"* (Line 128-129)	The regulatory landscape for hydrogen storage is becoming more supportive, with policies and incentives that promote renewable energy adoption, but they are currently more focused on the commercial sector.
Future Perspectives	Vision for the future development and market role of hydrogen storage systems in residential solar energy storage.	*"...will become more accessible and user-friendly..."* (Line 137) *"...offer a level of energy independence...creating a self-sustaining energy ecosystem..."* (Line 139-140)	The future of hydrogen storage systems is promising, with potential for increased accessibility and a significant role in creating self-sustaining residential energy ecosystems.

Candidate 8 - Interview partner: SP, Business Innovation Manager (Lithium-Ion Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion batteries in residential solar systems.	*"...integrating lithium-ion battery solutions in residential environments..."* (Line 16) *"...batteries are a core component of our smart energy systems..."* (Line 17) *"...transform a home's energy profile, providing reliability and efficiency..."* (Line 22-23)	Lithium-ion batteries are key in transforming residential energy systems, providing reliability and efficiency due to their technical superiority.
Economic Viability	Financial considerations of using lithium-ion batteries in residential settings.	*"...investment in a lithium-ion battery system can be significant..."* (Line 29-30) *"...long lifecycle... minimal maintenance and can offer substantial savings on energy bills..."* (Line 34-35)	Although the initial investment for lithium-ion batteries is high, their long lifecycle and minimal maintenance offer substantial long-term savings.
Operational Challenges	Practical challenges in deploying and maintaining lithium-ion batteries.	*"...maintenance...is usually minimal effort..."* (Line 14) *"...someone needs to set them up for the first time, a professional...durable and require little intervention once they're up..."* (Line 56-57) *"...most common maintenance task is a firmware update, which can often be done remotely..."* (Line 59)	Lithium-ion batteries require minimal maintenance effort, with most tasks, like firmware updates, being manageable remotely, but a professional needs to set them up once.
Sustainability	Environmental impact and sustainability of lithium-ion batteries.	*"...enable...homes to maximize the use of solar energy and reducing reliance on fossil fuels..."* (Line 73-74) *"...striving to make the process cleaner and more resource-efficient..."* (Line 75) *„...mining of some metals is crucial...some black sheeps...making fortunes by*	Lithium-ion batteries contribute significantly to sustainable energy solutions by enabling efficient use of solar energy and reducing reliance on fossil fuels, but transparency is key, as mining has to be clean.

		exploiting the earth and the people…" (Line 77-78)	
Compatibility with Renewable Energy Sources	Integration of lithium-ion batteries with existing PV setups and their performance in various climates.	*"…can be integrated with… virtually any PV setup…"* (Line 88) *"…they're quite plug-and-play in that regard…"* (Line 90) *"…robust across a range of climate conditions…"* (Line 95)	Lithium-ion batteries are adaptable, easily integrating with various PV systems and performing robustly across different climate conditions.
Comparative Insights	Comparison of lithium-ion batteries with other storage technologies in terms of operational feasibility and sustainability.	*"…batteries have become benchmark for residential energy storage…"* (Line 107-108) *"…easy to install…relatively compact…technology is…mature…"* (Line 109-111) *"…longer lifecycle and higher energy density…"* (Line 115) *"…doesn't require the same investment in new infrastructure…more feasible option in the short-term…"* (Line 118-119)	Lithium-ion batteries are preferred in residential settings for their operational feasibility, long lifecycle, and higher energy density compared to other technologies.
Market Readiness	Market acceptance and consumer perspectives on lithium-ion batteries.	*"…market acceptance of lithium-ion technology…is already quite high…continues to grow"* (Line 123) *"…consumers become more energy-conscious…"* (Line 124)	The market acceptance of lithium-ion batteries is strong and continues to grow as consumers become more energy-conscious.
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion battery adoption.	*"…regulatory bodies are generally supportive offering various incentives…"* (Line 124-125) *"…positive regulatory environment will likely increase adoption rate…reduces effective costs to the homeowner…"* (Line 126-127)	Supportive regulatory environments and incentives are fostering the adoption of lithium-ion batteries in residential settings.

Future Perspectives	Vision for the future development and market role of lithium-ion batteries in residential solar energy storage.	*"...continuing to evolve in both capacity and efficiency..."* (Line 136-137) *"...trend towards integrating batteries with smart home technology..."* (Line 140-141)	The future of lithium-ion batteries in residential solar energy storage is promising, with ongoing advancements in capacity, efficiency, and integration with smart home technologies.

Candidate 9 - Interview partner: KS, Consultant (Lithium-Ion Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion batteries in residential solar systems.	*"...lithium-ion batteries...that are a game-changer for residential solar storage..."* (Line 18-19) *"...providing a way to store excess energy generated during the day..."* (Line 19-20) *"...balancing technical capabilities with homeowner's energy usage patterns."* (Line 23-24)	Lithium-ion batteries are integral to home energy solutions, effectively storing excess solar energy and tailored to individual household needs.
Economic Viability	Financial considerations of using lithium-ion batteries in residential settings.	*"...initial investment in a lithium-ion system is still significant, but it's been decreasing..."* (Line 35-36) *"...long term savings on energy bills...long lifespan and low maintenance costs...."* (Line 41-43) *"...look at the ROI...lithium-ion batteries can be quite attractive for residential solar systems..."* (Line 44-45)	While the initial cost of lithium-ion batteries remains high, their long lifespan and low maintenance offer significant long-term savings.
Operational Challenges	Practical challenges in deploying and maintaining lithium-ion batteries.	*"...main challenge usually lies in the initial assessment...making sure that the system is sized correctly..."* (Line 51-52) *"...logistically...ensuring that we have the right infrastructure in place to manage the installation efficiently is key."* (Line 53-54)	Key challenges include correctly sizing systems for individual homes and ensuring efficient infrastructure for installation, but maintenance remains minimal.

		"...maintenance is pretty minimal…occasionally there might be a software update or a check-up…." (Line 56-60)	
Sustainability	Environmental impact and sustainability of lithium-ion batteries.	*"...environmental impact during production mainly, due to mining…"* (Line 70) *"...industry is working hard to mitigate this... challenging…talking about getting raw materials…"* (Line 71-72)	The main environmental impact of lithium-ion batteries arises from production, with ongoing industry efforts to improve sustainability in sourcing and manufacturing.
Compatibility with Renewable Energy Sources	Integration of lithium-ion batteries with existing PV setups and their performance in various climates.	*"...to integrate them with home storage systems…seamless process…"* (Line 90-91) *"...perform under a variety of climate conditions..."* (Line 95)	Lithium-ion batteries integrate seamlessly with PV setups and are versatile in performance across different climate conditions.
Comparative Insights	Comparison of lithium-ion batteries with other storage technologies in terms of operational feasibility and sustainability.	*"...ahead in terms of operational feasibility…established, with a clear track record."* (Line 104-105) *"…safer bet for homeowners and installers alike…"* (Line 107-108) *"...higher energy density and efficiency...better sustainability profile."* (Line 111-112)	Lithium-ion batteries are operationally more feasible and sustainable than many alternatives, with higher energy density and an established track record.
Market Readiness	Market acceptance and consumer perspectives on lithium-ion batteries.	*"...growing rapidly…people are becoming…more energy-conscious…looking for reliable ways to store solar energy."* (Line 115-116)	Market acceptance of lithium-ion batteries is rapidly growing, driven by consumer demand for reliable energy storage and supportive regulatory environments.
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion battery adoption.	*"...incentives encouraging the adoption of energy storage…"* (Line 117-118) *"...regulatory environment supportive with various incentives…helps to offset the*	Policies and incentives are crucial in encouraging the adoption of lithium-ion battery storage systems in residential settings.

		initial costs for homeowners…" (Line 117-119)	
Future Perspectives	Vision for the future development and market role of lithium-ion batteries in residential solar energy storage.	*"...expect we'll see major advancements in capacity and efficiency…"* (Line 126-127) *"...more integrated into home energy management systems…"* (Line 129-131)	The future of lithium-ion batteries in residential solar storage is promising, with expected advancements in technology and integration with smart home systems.

Candidate 10 - Interview partner: DM, Team Lead Quality Management (Lithium-Ion Expert)

Category	Description	Examples of Applications	Generalised Statements
Technical Feasibility	Evaluation of the technical aspects of lithium-ion batteries in residential solar systems.	Not explicit mentioned	Not applicable for this interview.
Economic Viability	Financial considerations of using lithium-ion batteries in residential settings.	*"… …that the initial costs are the main financial aspect."* (Line 27-28) *"...that about half has to be paid for the storage...battery capacity relatively expensive"* (Line 29-30) *"...running costs...negligible...virtually no maintenance costs..."* (Line 31-32) *"...profitability also depends on electricity costs."* (Line 38)	Although the initial costs of lithium-ion batteries are still high, their low operating costs and low maintenance requirements enable considerable savings in the long term.
Operational Challenges	Practical challenges in deploying and maintaining lithium-ion batteries.	*"...logistical challenges...storage units are delivered by a forwarding agent...few challenges..."* (Line 54-55) *"...technical challenges...space in homes...appropriate safety distances...but relatively small devices..."* (Line 57-58)	Key challenges include space and safety requirements and facilitating the installation. But these challenges are mitigated by their compact size and standardization.

		"...product...what many installers know, which is standardised...no major challenges..." (Line 60-61)	
Sustainability	Environmental impact and sustainability of lithium-ion batteries.	*"...lithium...partly negative effects during the degradation process..."* (Line 69-71) *"...about 18 times as much energy can be stored as is used in production or mining..." (Line 78-80)* *"...in connection with PV system...Co2 balance largely positive..."* (Line 83-86)	The main environmental impact of lithium-ion batteries arises from production, but compared to its capacity positive Co2 balance, especially in combination with PV-systems.
Compatibility with Renewable Energy Sources	Integration of lithium-ion batteries with existing PV setups and their performance in various climates.	*"...combined in one device...but also possible to upgrade a storage system in existing PV systems...both possible without any problems."* (Line 93-98) *"...lithium-ion batteries are robust...can be used in various...climatic environments."* (Line 101-102) *"...that it is suitable for various climatic conditions..."* (Line 108)	Lithium-ion batteries integrate seamlessly with PV setups, either in combined systems or as an upgrade, and are robust in performance across different climate conditions.
Comparative Insights	Comparison of lithium-ion batteries with other storage technologies in terms of operational feasibility and sustainability.	*"...safe and low-maintenance operation..."* (Line 114-115) *"Lithium-ion batteries have many charging cycles..."* (Line 117) *"...especially with regard to hydrogen...lithium-ion storage systems have a very high efficiency..."* (Line 119-120)	Lithium-ion batteries are very efficient, simple to install and easy to maintain. Also, their durability is an advantage, as they have many charging cycles.
Market Readiness	Market acceptance and consumer perspectives on lithium-ion batteries.	*"...the acceptance in the market is already completely there...both with*	Market acceptance of lithium-ion batteries is already strongly

		customers...but also with funding programmes" (Line 128-131)	established both with homeowners and funding programs.
Policy and Regulation	Impact of government policies and legal frameworks on lithium-ion battery adoption.	*"...but hurdles are also being removed...a product is already known..."* (Line 137-138)	Policies are supporting lithium-ion batteries through subsidies and reduction of bureaucracy.
Future Perspectives	Vision for the future development and market role of lithium-ion batteries in residential solar energy storage.	*"...already dominating...further research...prices continue to fall...lithium batteries without competition..."* (Line 148-151) *"...lithium batteries primarily as short-term storage...hydrogen...more as long-term storage..."* (Line 153-155)	Lithium batteries will continue to dominate the private sector, especially as short-term storage devices. However, hydrogen could still harbor a lot of potential in terms of long-term storage.

Appendix J – Score Generation Methodology Explanation

At the outset of the comparative analysis in subchapter 5.5, it's important to understand the methodology behind the score generation. The scores assigned to each technology across various criteria dimensions are derived using a combination of quantitative and qualitative assessments. This process involves three main sources of data: the Business Model Canvas (BMC), the Innovation Lifecycle Framework (ILF), and insights from expert interviews.

1. **Quantitative Assessment**: Wherever possible, quantifiable data from the BMC and ILF is used. This includes factors like cost structures, market growth phase, and other measurable indicators.
2. **Qualitative Assessment**: Expert interviews and qualitative insights from the BMC and ILF play a crucial role in areas where numerical data is not sufficient. This includes subjective aspects like market readiness, sustainability potential, and future outlook.
3. **Scoring System**: Each criterion is rated on a scale from 1 to 10, with 1 being the lowest and 10 the highest. The scores reflect the degree to which each technology aligns with the specific criterion.
4. **Weight Assignment**: To emphasize the criteria of paramount importance to Casa Nova Bau GmbH, weights are assigned to each evaluation dimension. These weights are reflective of the strategic imperatives of the company.
5. **Weighted Scores**: The final weighted scores are calculated by multiplying the score of each criterion by its respective weight. This weighted scoring system ensures that the most significant aspects have a greater influence on the overall assessment.

By integrating both quantitative and qualitative data and applying this scoring methodology, we aim to provide a holistic and nuanced view of each technology's performance against the key criteria. This approach ensures a balanced and comprehensive comparative analysis, aiding Casa Nova Bau GmbH in making well-informed strategic decisions.

Appendix K – Transcripts

Transcript Candidate 1 – Lithium-Ion/Hydrogen Expert

Interview partner: KJ, Founder and CEO

(**I**: Interviewer, **KJ**: Interviewee)

I: Good afternoon, KJ…Thanks for taking the time to join me today…I really appreciate that.

KJ: Hi! Sure, I'm always keen to... to discuss our work and share insights, especially on sustainable energy solutions, I mean this is my daily business, so, I am quite passionate about that…

I: Cool, that's great to hear, I mean turning your passion into your job sounds really…Like, this is also a goal that I have… Okay, so we're here on behalf of Casa Nova Bau GmbH, a small company that is specialized in solar installation, so photovoltaic systems… Right now, they're exploring whether to include solar energy storage systems in their offerings, focusing on either lithium-ion or hydrogen technologies… We'll be looking into aspects like operational feasibility, profitability, and… sustainability and the interview should last about 20-25 minutes.

KJ: Yes, sounds good… So, let's start.

I: Okay, so, KJ, could you start by sharing your experience with both lithium-ion batteries and hydrogen storage systems in residential solar energy applications?

KJ: Yes, of course. At Company 1, we've been focusing on solar PV systems for a while now, and integrating storage solutions has been a key part of our offerings... I mean, we founded this company 5 years ago and since then we are growing rapidly, as the whole market is growing very fast… And besides the photovoltaic systems, so, maybe I should mention before, that we're selling and installing photovoltaic systems for private homes and we're covering everything from transport to installing the panels and also maintenance of the systems, we're currently working in City 1 and its surroundings, but we're planning to operate nationwide in the next years… And, yeah, so besides the PV installation, we're working with partners to also provide storage systems to our clients… So, we're integrating storage systems with our PV panels… And we've worked with both lithium-ion batteries and hydrogen storage systems, though our primary focus is on the PV side, so we partner up with specialized companies for the storage component... So, Lithium-ion is... well, it's more common in our installations due to its current market maturity and it's been great for homeowners who want a reliable way to store and manage the energy their solar panels produce. But, like now, hydrogen storage, it's a bit more, niche at the moment, but we're seeing growing interest, especially from those looking

for larger-scale storage solutions or those keen on cutting-edge technology, there are always, like pioneers that want to try something new, so… And yes, the integration process for both is quite distinct, with lithium-ion being more straightforward and hydrogen requiring a bit more... let's say, specialized setup.

I: Cool, so that's very interesting to hear your perspective on both technologies as you are working hands-on with both technologies. And, in terms of financial viability, what do you see as the key considerations for homeowners when choosing between these two storage options?

KJ: So, financially, it's a bit of a balancing act, lithium-ion batteries, they've become more affordable over time, and they offer a pretty clear value proposition, lower maintenance, reliability, and also a good return on investment through energy savings, especially in the last years, because, yeah, as you know we've had the rising energy costs due to the crises, for homeowners, this makes them a safe and sensible choice, particularly with the incentives available in some regions... Speaking of hydrogen storage, on the other hand, tends to have higher initial costs, mainly due to the complexity of the… of the systems and the current state of the technology… So, we're more at the beginning here… But it's more of a long-term investment, both financially and environmentally. Like, homeowners who are keen on being at the forefront of sustainable energy technology are more inclined to consider hydrogen, despite the higher initial outlay, because, as I said before, the future cost benefits, especially as the technology matures, could be significant… But also, there are not many suppliers that produce hydrogen storage systems for residential use, at the moment this technology is more applied in the commercial sector…

I: Yes, that makes sense. So, with your extensive experience, can you discuss the technical and logistical challenges of deploying and maintaining these storage systems?

KJ: Sure. So, from a technical standpoint, installing lithium-ion batteries is generally more straightforward. I mean, the challenge lies in accurately sizing the system to the home's energy needs and ensuring that… that it integrates well with the solar setup and also very important is… that the maintenance level is minimal, which of course appeals to homeowners… Regarding hydrogen storage… I would say that it involves more complexities, it's not just about storing energy, but also about the safe handling and conversion of hydrogen… This can or this still is very challenging… So, the setup requires careful planning, especially around safety protocols. And logistically, hydrogen systems are more demanding, from installation to ongoing…

Break due to lost connection

I: Sorry, I think I lost the connection for a second… Could you please repeat your last sentence?

KJ: Sure, no problem. So, I said that hydrogen storage systems require specialized knowledge, which is why we partner with experts in this field, the logistics of hydrogen, from delivery to installation and maintenance, require more coordination, and the maintenance is more specialized compared to lithium-ion systems… That was it.

I: Okay, thank you very much for repeating. Now I got it so, KJ, let's talk about sustainability. How do lithium-ion batteries and hydrogen storage systems align with sustainability goals, especially in terms of their production and lifecycle?

KJ: Oh, that's a great point. So, for lithium-ion batteries, the sustainability aspect is... well, it's two-fold, on the one hand, their ability to store solar energy efficiently helps reduce reliance on non-renewable energy sources… But on the other hand, there's the issue of... of battery production, the mining of lithium and other metals, which has environmental impacts… However, the industry is moving towards more sustainable practices, and advances in recycling are improving the overall sustainability of lithium-ion technology, now, with hydrogen storage, the picture's a bit different… If hydrogen is produced using renewable energy, like solar for example, the entire cycle can be almost emission-free, which is very promising… But the sustainability of hydrogen systems also depends on... how efficiently the electrolysis and storage processes are managed, it's still a developing field, and as the technology evolves, I expect it to become a more sustainable option, particularly if we focus on green hydrogen production, but this is still… I mean this technology is still in its beginning, so let's see what will happen in the future.

I: Okay, so it's clear that both have their unique sustainability profiles, as far as I understood it right… Moving on, how well do these storage technologies integrate with existing PV setups, and how do they perform in different climates?

KJ: Yes, you're right and may I add that both storage methods are very important because, without them, we would have a lot more energy waste, because the energy generated is very volatile… So, either way it is a step in the right direction in terms of sustainability. So… back to your question like integration-wise, lithium-ion batteries are… they're quite versatile. So, they can be easily adapted to different PV systems, making them a popular choice for residential solar applications. And they perform reliably across a range of climatic conditions. I mean, sure, extreme temperatures can affect efficiency to some extent, but this effect is quite low. And in

terms of hydrogen storage systems... they're a bit more complex to integrate, mainly due to their larger size and the additional components required, like electrolyzers. But once properly set up, they can be an effective storage solution, especially in areas where large-scale storage is needed or where solar energy availability is … long-term inconsistent, like in Scandinavia… They're less sensitive to temperature variations, which is beneficial in more extreme climates also…

I: That makes sense. Now, can you compare these two technologies in terms of operational feasibility and sustainability?

KJ: Sure. So, lithium-ion batteries are currently more operationally feasible for most homeowners, primarily due to their… ease of installation and maintenance… And they're a mature technology with a robust support infrastructure. So, sustainability-wise, while there are concerns about raw material sourcing, advances in recycling are helping to mitigate this, like I said before… hydrogen storage is operationally more challenging due to its complexity and the need for specialized installation and maintenance… But, it has great potential in sustainability, because, like we discussed before it can provide larger-scale storage solutions and, if produced via green methods, has a very low environmental impact. So, while it's less common in residential settings now, its role is likely to grow, especially as we move towards more sustainable and large-scale energy solutions…

I: Cool, that sounds very interesting. Moving on, how do you see the market acceptance and regulatory environment evolving for these storage technologies?

KJ: Well, the market acceptance for lithium-ion batteries is already high and continues to grow, especially as people become more environmentally conscious and seek energy independence. And the regulatory environment for lithium-ion is well-established, which helps with consumer confidence… And for hydrogen storage… I would say that the market is still developing, but interest is definitely on the rise, due to the points we discussed before… The regulatory environment is also catching up here… Like, with more guidelines and standards being developed as the technology… yes, becomes more prevalent, I expect that as both the technology matures and regulations become more supportive, hydrogen storage will become a more… a more common option, complementing lithium-ion in the residential energy storage market.

I: Perfect so, as we look towards the future, KJ, what's your vision for the development and role of these storage technologies, particularly in the residential solar energy sector?

KJ: Looking ahead, I see both technologies playing crucial roles. Like, lithium-ion will likely continue to lead, I mean in the short to medium term due to its reliability and established market presence, I also expect further advancements in their efficiency and capacity, which will make them even more attractive for residential use… As for hydrogen, yeah, it's a bit more difficult to say… So its role will expand as the technology evolves and becomes more accessible. And it has the potential to offer large-scale storage solutions that lithium-ion can't match…. That's why I envision a future where both technologies coexist and complement each other… Like, in offering homeowners a range of options depending on their specific, like energy needs and sustainability goals… That's what I think…

I: Okay, I mean that's a future to look forward to, right. So, next, can you recommend any experts or resources that might offer additional insights into these technologies?

KJ: So, I think in interviewing experts in this field you do a really good job, like in terms of your research purposes, as I or we are more focused on the photovoltaic systems, I would maybe suggest you to speak with experts that, for example, build lithium-ion batteries or hydrogen storage systems, because they have a deeper understanding of how things are developing and what challenges or opportunities they see or expect…

I: Yes, that makes sense… So, to be honest, you're the first person who I am interviewing who has knowledge regarding both technologies, because, like you also suggested, I mainly speak to experts from one of the industries… So, it was very refreshing to hear your opinion on both technologies, thank

KJ: Ah, okay, I see… So

I: Yes, thank you very much… Finally, KJ, I would like to ask you, do you have any additional insights or suggestions that might aid our research into these storage solutions?

KJ: Well, I'd say… So, like I said before, it makes sense to talk to experts that also have a deeper understanding of the technical perspective of these technologies… But, yeah, I think that's what I would recommend you, to just talk to as many experts as you can find and based on that build your own… opinion.

I: Okay, thank you… So, your contribution today has been incredibly informative. I really appreciate your time and the knowledge you've shared.

KJ: It's been a pleasure to be a part of this, thank you very much for letting me talk that much… If you have any more questions or need more information, feel free to reach out. And yeah, otherwise I wish you best of luck with your research…

157 **I:** Thank you once again, KJ. Have a great day.

158 **KJ:** You too, goodbye.

Transcript Candidate 2 – Lithium-Ion Expert

Interview partner: RJ, Senior Project Manager

(**I**: Interviewer, **RJ**: Interviewee)

I: Good morning, RJ, thank you for agreeing to speak with me today.

RJ: Morning! No problem at all, it's nice to break up the daily routine with something like this... Helps me to reflect on the work too, you know? So… yeah…

I: Yes, that makes sense! It's great to get a fresh perspective… So, I'm conducting this interview to assist Casa Nova Bau GmbH in evaluating solar energy storage systems for their portfolio. As I told you before this interview, Casa Nova Bau GmbH is currently specialized in the installation of PV systems, but now considering including storage systems into their product portfolio, that's why I am examining the question whether it makes sense, like in a business context, to expand their product portfolio and if so, with what kind of technology and the focus here lies on lithium-ion batteries and hydrogen storage systems. So, the interview should be about 20 minutes, if you have any questions or notes, please just tell me.

RJ: Sure… I've got the time set aside… Okay, I am glad that I can provide some input, just make sure it's put to good use… haha.

I: I will try my best… Okay, so, could you start by telling us about yourself and your current role at Company 2 and your expertise regarding lithium batteries?

RJ: Sure, my work at Company 2 with lithium-ion batteries has been quite extensive, especially in the residential sector... For… some years now, these batteries have been very important for homeowners looking to maximize their solar investments, like for photovoltaic panels, they're compact, efficient, and… also have a life span that complements the solar panels' operational life, which makes them a perfect fit. So, we've tailored systems to match daily energy consumption patterns and, well, by that we´re ensuring that homeowners can rely on solar power even after sunset, the key has been to customize the storage capacity to the household's energy profile, which maximizes efficiency and cost-effectiveness… Especially, you know, now with AI and intelligent systems, this is getting more and more important…

I: That's insightful, thanks, when looking at the financial side, particularly initial investment and operational costs, what stands out for lithium-ion batteries in residential settings?

RJ: Well, that´s an important question… With lithium-ion batteries, the price point has been a moving target… It´s trending downward as technology advances and production scales up, this is what we experienced in the last years very extremely, the initial investment is now, or let´s

say since a couple of years… more accessible to a wider range of homeowners, making it a viable option… and not just for the environmentally conscious, but also for those people… that… yes, are looking to save on long-term energy costs, which is getting very important, especially now with the recent energy crises. And we saw that prices can increase in a very short term extremely… So, the operational costs are another selling point, these batteries require very little maintenance and have a predictable life cycle, which means… well, fewer surprises for the users and also, a reliable return on investment over time… Plus, many regions offer incentives for solar-plus-storage systems, which can significantly offset the upfront costs… Here in Germany it is, at least this is my latest understanding, we have the highest incentives for photovoltaic systems and also batteries for private households in all Europe!

I: Okay, that sounds very interesting for homeowners, like financially. Now, can you discuss the technical and logistical requirements for deploying and maintaining these batteries in residential environments?

RJ: Sure, the deployment of lithium-ion batteries is generally easy… The technology is mature, and we have standardized procedures for installation… Most of the time, like also the most important point regarding the deployment… it's about integrating the battery system with the existing electrical setup of the house, which is something any qualified electrician can handle… But we also have combined solutions, where the installation is even easier, because all the components are already harmonised in advance… So, it´s quite easy to first integrate these batteries… Also, the maintenance is minimal, which of course homeowners love, these batteries are pretty much set-and-forget… I mean, like occasionally, you might need to check the connections or update… the system software, but that's about it… And regarding logistics… I would say, the biggest logistical hurdle is probably ensuring that you have the right size system for the… systems or the home, which requires a detailed analysis of the homeowner's energy use patterns, like in case we install a storage system into an already existing set-up… But once that's done, the rest falls into place quite naturally, so maybe this also belongs more to the deployment of such systems.

I: Perfect, so RJ, you've given me a very nice understanding of lithium-ion batteries' role in residential, solar or photovoltaic applications. Let's move next to how they align with sustainability goals. Can you give me a brief description of the environmental aspects?

I: Oh, absolutely... Sustainability is a huge part of why we advocate for lithium-ion batteries… So, from an environmental standpoint, they have a relatively small carbon footprint and, especially when compared to traditional energy sources, they're highly efficient, which means,

well, less energy is wasted in the process of storing and also using electricity. Plus, we're seeing improvements in recycling technologies, like that is a huge development at the moment, which is crucial because, you know, it's not just about using green energy but also about ensuring we're not creating waste in the process... And... as for resource efficiency, we're always working to improve the materials used in the batteries to make them more... sustainable, more durable… So, there's still work to be done, but the trajectory we're on is quite promising.

I: Okay, that's a quite positive outlook for the future, I would say… Moving on, in terms of compatibility, how do lithium-ion batteries integrate with existing PV setups, and what's their performance like in various climate conditions?

RJ: Oh, like I said before, they integrate seamlessly… one of the biggest advantages of lithium-ion batteries is… their versatility… They can be easily adapted to... pretty much any PV setup, you know? And their performance is consistent across a range of climates, from, let's say, the sunny regions in Southern Germany to the more temperate zones... even with less sunlight. Like, they're reliable, and that's what you want in a battery system, you want to know that no matter where you are, your system will perform as needed…. no matter what the outer circumstances or conditions are. And with the advancements in energy management systems, we can optimize battery performance for efficiency, no matter the climate, which is very cool.

I: That's really cool, especially for homeowners. Now, if we consider market acceptance and the regulatory environment, how do you see these evolving for lithium-ion technology, and what impact might this have on adoption in residential solar systems?

RJ: Well, market acceptance for lithium-ion batteries is... well, it's really strong and only getting stronger… I mean, people understand the technology, they trust it. As for the regulatory environment, it's generally supportive, especially with governments pushing for more renewable energy solutions... Take Germany, for example, we've got some of the most proactive policies in place to encourage the adoption of solar energy and storage solutions, this is also a reason for the increasing number of photovoltaic systems and also storage systems like lithium batteries… But you know, regulations can also be a double-edged sword... they need to keep pace with technology, sometimes, for example, you've got these outdated policies that can slow things down, but luckily, we're seeing a lot of positive movements towards updating those… and making it better or easier for homeowners to invest in these systems. So, all in all, I'd say the regulatory environment… is becoming more conducive to adoption, which is great news for us and for homeowners looking to switch to solar or photovoltaic systems.

I: Okay, so it certainly seems like things are moving in the right direction. Thanks for sharing that, RJ. Next, what is or what are the distinct advantages of lithium-ion batteries that you've observed, particularly concerning operational feasibility and sustainability?

RJ: Sure, the distinct advantages... I'd say the biggest one is their operational feasibility, these systems are just so user-friendly… For example, Homeowners don't need to be tech-savvy to benefit from these systems, they're easy to use and… Plus, the longevity of lithium-ion batteries matches well with the lifespan of solar panels, which means you're not having to replace parts constantly... And as for sustainability, these batteries help reduce reliance on the grid, which in turn reduces the overall sustainable carbon footprint of a household, they make it feasible for homes to become nearly self-sufficient, which is a big step towards sustainable living... And you know, as the tech improves, we're looking at batteries with even longer lifespans and also better performance, which will only amplify these advantages.

I: Yes, that sounds… good, thank you. Now, looking ahead, RJ, what's your vision for the future development and market role of lithium-ion… batteries in residential solar energy storage?

RJ: My vision?... Well, I firmly believe lithium-ion batteries will continue to play a significant role… They… They're set to become even more efficient, more cost-effective, and… I also think we'll see them becoming the norm in residential solar systems, which they already are, to be honest… the technology is already here, and it's improving all the time and I see a future where virtually every home or every home with a PV system has… a lithium-ion battery setup, it's all about storage capacity and smart systems that can adapt to energy needs in real-time… I'd say, in the next decade I mean, we're going to see these batteries becoming smarter and more integrated with home energy systems, and, well, crucially, also more sustainable with advancements in recycling and resource management.

I: So, that's an exciting future to… consider, and as I continue my… research, could you point me toward any other experts or sources that could deepen my understanding of lithium-ion technology? Especially in the discussed context?

RJ: Sure… I'd recommend… So, IR… Dr. Recommendation 1… She's a leading researcher in battery technologies and has done extensive work on the lifecycle of lithium-ion batteries… I mean, her insights on sustainable practices in the industry could be valuable to you and I think it was one or two months ago, she was invited to a new product presentation from Company 2 and she had a, like a small introduction to her latest studies, which was very interesting, maybe also for your research. Also, the work being done at the Fraunhofer Institute for Solar Energy

Systems is really promising, they're always pushing the envelope on solar storage solutions and their publications could give you a solid foundation on the current state and future directions of the tech, especially from a research perspective.

I: Dr. Recommendation 1 and the Fraunhofer Institute, got it. Thank you so much… I'll definitely look into those… Before we wrap up, do you have any additional insights or suggestions that might aid this research?

RJ: Well, I'd just say, keep an eye on the emerging tech in the field… There's a lot happening around solid-state batteries and integration with home energy management systems… So, these developments could… change the game, in terms of efficiency and safety at least and, don't forget the human aspect – user experience is crucial in this topic… If we… For example, if we want widespread adoption, we need to ensure that these systems are user-friendly and that there's adequate safe support for homeowners to make the… transition. So, my suggestion would be to also focus on the customer education and support side of things. Yes.

I: That's very helpful advice, thank you and thank you so much for your time today and for sharing your expertise… Your insights will undoubtedly contribute significantly to Casa Nova Bau GmbH's research and decision-making process…

RJ: Sure, absolutely, I'm always happy to talk shop and share what I know, like especially on this topic, which is very exciting for me, just shoot me an email or give me a call, I mean, you have my contact information…

I: Perfect, I'll do that, again, thank you for your valuable time and the informative discussion.

RJ: No problem at all, it was my pleasure. And Good luck with the research, and I look forward to seeing what you come up with. Take care!

Transcript Candidate 3 – Hydrogen Expert

Interview partner: GL, Project Lead Electrotechnology

(**I**: Interviewer, **GL**: Interviewee)

I: Hi GL... Thanks for joining me today! So, I am very excited to have you here to talk about hydrogen storage.

GL: Good morning... Yeah, I'm pleased to be here… and before we start let me say that hydrogen is much more interesting than it sounds so, yeah…

I: Cool, that's great to hear, so I am even more excited now… Just so you know, we're conducting this interview to help Casa Nova Bau GmbH explore the possibility of adding, specifically, hydrogen storage systems to their product offerings… Like, as I told you in advance, Casa Nova Bau GmbH currently specializes in the installation of PV systems in the German market and they are considering expanding their product portfolio with storage systems… So, yes, I would really like to get some insights from you as an expert… That's why I will ask you some questions in the following about topics like deployment of storage systems, sustainability, regulations and some more… The interview should take around 20-25 minutes and, like I said, is recorded… So, should we start?

GL: Sure thing, like I said, I don't mind the recording. Let's get this started!

I: Cool! So, let's begin… GL, with your extensive experience, particularly in hydrogen storage systems, could you... maybe start by sharing your experience with these systems in relation to solar energy applications?

GL: Well, I've been in this field, the field of electrotechnology for... what is it, twelve years now? And at Company 3, we've really focused on commercial buildings, but the... the principles behind hydrogen storage, they don't change much when you... when you shift focus to residential, I suppose, and my role involves integrating these systems to, you know, store solar energy efficiently, it's about ensuring a reliable and... and sustainable power source for when solar input is, let's say, less optimal and even though my focus is more on the commercial side, the technical expertise is... it's highly transferable to smaller-scale residential systems, which is, as far as I understand the core of your research and core of Casa Nova's business activities, right?

I: Yes, that's right! They or we are focused on small-scale residential application, in terms of storage systems for solar energy… but yeah, that's a good point, so your expertise is also relevant in this area… Now, when we're looking at the financial side of things, what, in your

view, are the major financial factors influencing the adoption of hydrogen storage systems, particularly for home use?

GL: Financial aspects, right... They are essential for adoption, the initial costs are... well, they are on the higher side, especially when you compare them to, let's say, traditional batteries, but it's important to see the bigger picture, you know? For example, I mean the operational costs for hydrogen, they can be lower in the long term… The systems are efficient, and they... they have a potentially longer lifecycle, as other storage technologies and as the tech advances, we expect the costs to, you know, come down, making hydrogen a more viable option financially for homeowners in the future. As I said before, we're more focused on commercial buildings with our systems, but this is also due to the current state of technology… When… I would assume that in a couple of years these applications will also be much more relevant in the… residential context… As technology develops…

I: Yeah, so it seems like there's a lot of future potential there… So, could you perhaps discuss the... technical and logistical requirements that come with deploying hydrogen storage systems in a home setting?

GL: Oh, sure... So, technically, deploying hydrogen systems in a home... it's, it's complex, more complex than in commercial setups, we're talking about installing tanks, electrolyzers, and all that needs to be done safely, because you're dealing with hydrogen, which is highly flammable and the infrastructure needs to be, how should I say, compact yet capable and then on the logistics side, there's a need for specialized delivery and installation processes... which can be quite an undertaking… Like, skilled technicians are essential, they need to be trained specifically for hydrogen systems and while maintenance isn't overly complicated, it's... critical for ensuring the system's longevity and safety. But, this might also be a future problem when hydrogen systems will be more relevant in the residential sector, I mean, the installation and handling requires a lot of, like, special skills and good trained personnel… Even with PV systems we currently see that there's a shortage of technicians, and… the installation of these systems is much easier than dealing with hydrogen… So, finding appropriate professionals can be a future problem, which could slow down the distribution of such systems…

I: Right, safety and expertise are clearly crucial, I can imagine that… Alright, let's move on to sustainability, which is quite critical nowadays. How do you see hydrogen storage systems in terms of their production and lifecycle aligning with sustainability goals?

GL: Oh, sustainability… Yes, it's... it's at the core of our mission at Company 3. So, when we talk about hydrogen, its production through electrolysis, especially when powered by solar energy, is essentially a clean process, right? You're just using water and electricity to produce hydrogen, so there's no direct carbon emissions there… But, the sustainability of the whole lifecycle, that includes how we manage the systems at the end of their life, how we recycle the components… It's something we're actively working on, we're also looking at how to, let's say, improve the efficiency of the whole cycle, from production to storage, to make sure we're minimizing any environmental impact and on top of that, we need to consider the source of the materials for the electrolyzers and storage tanks to ensure they're, you know, being sourced responsibly… Of course, it's very difficult to have, like, no carbon footprint at all, especially as a company or a company that operates in the… energy sector… But, as you said, sustainability gets more and more important, so… we're trying our best to comply with the requirements… I mean, in the end, hydrogen is the most environmentally friendly energy storage that exists so far… So, we should align the rest of the business operations with this advantage we have.

I: Perfect, that's quite… comprehensive and… regarding integration, how well do hydrogen storage systems work with existing PV setups, particularly in different climate conditions?

GL: Right, so integration... it's a big part of what makes hydrogen storage appealing… They work well with PV systems because, they offer a way to store excess energy that might otherwise be, you know, lost… As the sun is not always shining in the same way, you sometimes have excess energy and with hydrogen you can easily store that energy and not waste it… And in terms of climate... Well, hydrogen storage is quite robust, it doesn't matter if it's hot or cold, the efficiency of the storage remains consistent, this means that in places with less sunlight during certain seasons, hydrogen can provide a steady, reliable source of energy… Now, this is crucial for making renewable energy more reliable year-round, no matter where you are... It's about creating a system that can provide energy security, regardless of the climate or the weather conditions outside.

I: Okay, perfect… And, from your experience, if you could compare hydrogen storage systems in terms of operational feasibility and sustainability, what stands out?

GL: Well, if we're comparing hydrogen to, say, acid batteries or lithium-ion batteries, there are some clear differences… Operationally, hydrogen systems are a bit more complex to set up because of the safety considerations, but they're catching up in terms of feasibility… The technology is evolving, and as it does, it's becoming more… accessible. And from a

sustainability perspective, hydrogen has a potential edge in the long run, I would say… The ability to store large amounts of energy and the cleanliness of the cycle, from solar to hydrogen and back to electricity, means we could see a very sustainable system… especially as we improve the efficiency of the electrolyzers and, the overall system design… So at the end, like I mentioned before, there is no cleaner option to store energy than in hydrogen…

I: Okay, that makes a lot of sense, and looking at the market acceptance and regulatory environment, how do you see these evolving for hydrogen storage technologies?

GL: So… the market for hydrogen is, it's growing, but it's still emerging… Like, acceptance is increasing as awareness grows about its potential, especially in the context of a clean energy future… But, we can see that at the moment there are other solar energy storing technologies that are more popular, especially in the residential market, as they are already easily scalable, for example lithium batteries, which currently is the standard… But in the commercial market, where we are operating, we can see that hydrogen storage is getting more and more popular due to its advantages… This is why we as a company are also growing quite fast and in terms of regulations… The regulatory environment is... it's adapting and it's becoming more favourable, as regulations evolve to address the… unique aspects of hydrogen, its production and storage and safety protocols, we'll likely see an acceleration in its adoption and with greater market acceptance, I expect more investment in the infrastructure needed to grow... I mean, to support hydrogen systems, which will in turn drive further adoption. So, this a cycle that feeds itself, and as the technology matures, I think we'll see hydrogen becoming a much more, significant player in the residential energy storage market too…

I: Cool, that's a very insightful perspective, GL. Thank you for sharing your expertise on these topics… Now, as we think about the future… what developments do you expect to see in the role and market for hydrogen storage systems, particularly for residential energy storage?

GL: Well, looking ahead, I'm really optimistic about hydrogen's role, I must say… I expect to see... substantial advancements in the efficiency and cost-effectiveness of hydrogen storage, I mean this is also what we are actively working on and we're likely to witness a shift towards a more decentralized energy system… where hydrogen plays a key part in ensuring homes have a reliable, renewable energy source. So, this will be particularly important for balancing the energy grid and providing… providing backup power during... let's say, peak demands or outages. And as for the market… So, as public awareness grows and the infrastructure expands, I believe hydrogen storage will become a... more mainstream option, complementing traditional energy storage methods, like PV systems…

I: That's an exciting prospect, cool. So, with such a future in mind, can you recommend any experts or resources that could further our understanding of hydrogen storage technologies?

GL: So, in general I would say… there are many interesting sources on how hydrogen technology is… advancing and what developments we can see there… You could also look for US experts regarding these storage systems, I mean, they have very innovative approaches and quite cool startups over there that are… handling hydrogen storage topics… There… I recently read an interesting article about a startup that… that developed a very small, hydrogen powered storage system… I… I can't remember the name of the startup, but this could be very interesting for you… Especially, because of… your focus on residential applications…

I: Cool, that sounds very interesting, I will

GL: If I remember the name, I will share it with you… Sorry.

I: Perfect, that sounds good! So, thanks for that and finally, GL, are there any additional insights you would like to share that might benefit our research into hydrogen storage solutions?

GL: Well, I'd emphasize the importance of considering the entire system when looking at hydrogen storage…. So, like, it's not just about the storage itself, but how it integrates with the solar panels and the home's energy system, and even the larger energy grid and… also policy developments, both locally and internationally… Because policy changes can have a significant impact on, especially on the adoption and development of technologies like hydrogen storage. And... think about the consumer education aspect as well, there are still a lot of myths and misconceptions about hydrogen that need to be addressed to increase acceptance and adoption rates…

I: Okay, that helps a lot, thank you! And thank you again for your valuable insights and the time you have taken…

GL: No problem at all, I'm glad I could help… and now I am even more proud to work in this field, as I again promoted it here…

I: Yeah, I can imagine that, I mean, it's a very interesting field with a lot of potential in it, as we're forced to develop new technologies also regarding, or especially regarding the storage of energy… So… Yeah… Thank you again, GL…

GL: Absolutely, have a nice day!

I: Thank you, you too. This recording is now over.

Transcript Candidate 4 – Lithium-Ion Expert (Pilot Interview)

Interview partner: WM, Senior Marketing Manager

(**I**: Interviewer, **WM**: Interviewee)

I: Hi WM, thank you very much for participating and giving me your time for this interview… This interview is to… The purpose of this interview is to assist the Casa Nova Bau GmbH in deciding whether to incorporate solar energy storage systems into their product portfolio. Right now, they are specialized in the installation of PV systems, and they are considering exactly this question. The interview will take approximately around 15 to 20 minutes…

WM: Okay, that sounds good to me!

I: Cool, perfect. So then let´s start. WM, it would be very nice at first if you introduce yourself shortly.

WM: Yes of course. Well, thanks Alessandro for inviting me… to this call… My Name is WM, I live and work in Germany for Company 4, it´s a German company and I am working as a Senior Marketing Manager… now it´s been around two years.

I: Okay, thank you very much, then let´s get to the topics. So, the first question regarding your background and experience would be, could you provide a brief overview of your experience with lithium-ion batteries, particularly in the context of solar energy storage applications?

WM: Yes, of course. My background is… to be honest really deeply rooted in lithium-ion battery systems and over the past two years with Company 4, I´ve had the opportunity to work on a variety of solar energy storage projects. So, what´s really exciting, for me, is trying to push the envelope on how lithium-Ion batteries, which form the core of our solar storage systems, can store more power and also for longer periods, especially, during winter months, when the solar input is… as you know, especially in Germany… less predictable. So, we´ve had some breakthroughs in improving the efficiency of charging cycles and even in the integration of home energy systems, so it has been quite a ride, tackling these engineering feeds and also having an eye on the user experience, but I would say that so far we performed quite well…

I: Yeah, I can imagine that, thank you for your answer. So, in terms of profitability prospects, what factors do you believe significantly impact the cost-effectiveness and the market penetration of lithium batteries, from your view, so, from a supplier´s perspective?

WM: Well, the profitability of lithium-ion batteries is a more or less multifaced issue. So, from a suppliers' perspective, we´re always balancing the cost of materials, which is, as you might expect, or can be very volatile. So, yes that is one perspective. And then there is production scalability, we´ve seen prices fall as manufacturers' processes became more, let´s say, streamlined, but you can´t overlook the role of public perception and policies. So, for example,

tax breaks, rebates, incentives, they all make a big difference in adoption rates and market adoption, in the end, it isn´t just about having a superior product, it´s also about how well you can navigate these external factors and align them with consumer demand and this is what we're trying at Company 4.

I: Okay, thank you very much for that extensive answer. Let´s get to the next question, the operational feasibility. So, what are the main obstacles and requirements, in terms of skills and logistics, that you encounter in the deployment and maintenance of lithium batteries for residential buildings?

WM: Well, when we talk about deployment and maintenance for residential applications, the first thing that comes in my mind is the experience required, it´s not like installing a simple appliance, you need skilled technicians, who understand electrical systems, battery chemistry and even software nowadays, for the smart tech involved, that´s a lot and logistically, these aren´t small components, so you´ve got to manage transportation, safe handling and installation.. and all this while ensuring minimal disruption to the homeowner. So, it´s kind of a lot to handle… Plus, there is the aftercare, the service aspect, I mean we´re not just selling one product, we´re also providing an ongoing service and so you need this, expertise…

I: Okay, that makes sense. Thank you very much, let´s move to the sustainability level, from an environmental perspective, how does the lifecycle of lithium batteries and the production fare in terms of sustainability? What would you say?

WM: I mean, living in the twenty first century, of course the environmental aspect is huge for us, it´s part of our brand´s promise and so we take a look at the entire lifecycle, where the materials are sourced, how the batteries are produced and eventually, how they are disposed or ideally recycled, so we´re trying to close the loop, in the end, and make the process as sustainable as possible, though I won´t pretend it is without challenges… Mining for raw materials has its issues and we´re heavily investing in finding greener alternatives, more ethical sourcing and also improving the recyclability of our batteries, but this is an ongoing process, we´re all confronted with this, change. So, yeah. That´s our… idea.

I: Okay, okay. That brings us to the comparative insights of our interview. The next question is optional. I mean, it may be that it´s not applicable to you, because you´re an expert of lithium batteries and … Nevermind, I will just go for it, so, the question would be, are you familiar with both, lithium batteries and hydrogen storage systems, and if so, could you provide a high level comparison in terms of their operational and sustainability aspects? If not, what would you say is the standout benefit of the technology you´re specialized in?

WM: Okay, well. Quite a long question… I can speak most confidently for certain about lithium-ion technology, which has been leading the residential storage market for years and their efficiency and reliability are, well, they're unmatched, for small scale applications at least and I am somewhat familiar with hydrogen storage too, it has its place of course, especially in larger grid operations or industries, no question, but for residential use… Lithium-ion batteries are compact, like compared to hydrogen storage systems at least… It´s scalable and the existing infrastructure, I mean, it´s just more conducive to that environment. So that´s not to say hydrogen doesn´t have potential, I mean, it´s just, yeah, the infrastructure, I mean, the ecosystem for residential use ins´t quite there yet… So, who knows what the future brings…

I: Okay, I mean, yes, this brings us to the next question of the future perspectives. Looking ahead, how do you envision the evolution and role of lithium batteries in the residential solar energy market?

WM: The way I see it, the future of solar energy storage will be a lot more interactive… We´re not just looking at lithium-ion as a passive receptible for excess energy anymore… with the rise of smart homes, we´re talking about batteries that can predict your energy usage patterns, that can seamlessly integrate with your other smart devices, and even sell back energy to the grid, it´s a dynamic field and with the advancements in AI and IoT the role of batteries in the home is, well, it´s set to be a game changer, I guess. Yeah.

I: Okay, so, thank you very much. Let´s get to the last question… Before we conclude now, are there any other professionals or resources on this topic that you can recommend? That we can consult? And do you have any parting insights or suggestions for our research?

WM: Well, so for a deeper technical dive, our R&D department is full of minds that are, yeah kind of shaping tomorrow's storage solutions, I would say… They´re the ones to talk to and on the market side of things, industry analysts could you provide a brief overview of your experience with lithium-ion batteries, particularly in the context of solar energy storage applications… It may give you the broader trend for the economic landscape or any in-depth research they´re invaluable, I´d say. And remember, my door is always open for further discussion, if you need any sounding board for any new ideas or for a brainstorming regarding this topic, I am always, yeah, I am always here. Don´t hesitate…

I: Perfect, that sounds very good. Thank you so much, that´s the end of our interview. Like I said, thank you a lot. That was very helpful to get these insights. The next steps for me would be to have several of these interviews in order to gather some information that I can use for my research and to answer my research question. I would like to get to know your R&D part, the

people, maybe you can introduce them after this interview, we can have a quick chat, that would be awesome.

WM: Of course. You´re

I: Thank you

WM: I wanted to thank you. I feel kind of honored that you asked me as an expert. So I wish you all the best for your research, for your studies, and as I understood it´s also for your master degree. So best luck and yes, don´t hesitate, I can give you all the contacts and introduce you to our R&D and yes, thanks a lot.

I: Thank you very much. This interview is over.

Transcript Candidate 5 – Lithium-Ion Expert

Interview partner: BM, Competency-Center Engineer

(**I**: Interviewer, **BM**: Interviewee)

I: Hello BM, I hope you're doing fine, thank you for taking the time to join me today, I am very excited about your input…

BM: Hey, no problem, I'm also looking forward to discussing our work at Company 5 and diving into our products, or… I think your, focus lies on battery storage for solar energy, right?

I: Yes, that's right, I mean, maybe it makes sense to start with a short introduction from me, so, yeah, I'm conducting this interview for Casa Nova Bau GmbH and I'm exploring the inclusion of solar energy storage systems, particularly focusing on lithium-ion technology and hydrogen systems and therefore I am discussing topics like operational feasibility, profitability, and sustainability with various experts from these fields… So, this interview should take about 20 minutes and if it's okay for you, I would like to record this session, in order to further analyze the data gathered during this interview.

BM: Sure, recording is totally fine... I'm ready to share what I know, or at least I try my best to do so…

I: Fantastic!... So, BM, could you start by sharing your experience with lithium-ion batteries in the context of solar energy applications?

BM: Absolutely. So, at Company 5, we've been integrating lithium-ion batteries with our solar inverters and energy storage systems, these batteries are crucial for optimizing solar energy utilization, because they're highly efficient and providing over 99% efficiency in energy conversion… So, this means when solar panels generate energy, lithium-ion batteries store it effectively with minimal loss and in terms of residential applications, we're seeing more homeowners interested in these systems, especially those looking for sustainable and long-term energy solutions. So, in the end the batteries not only store excess solar energy but also help in managing energy use more intelligently, aligning with our advanced liquid-cooled energy storage systems like Product 1 and Product 2, these are kind of our unique selling points, because we have one of the highest efficiency rates when it comes to storage power, seen on the market at the moment. Yes, and talking about me, I am with Company 5 for 2 years now, working as an engineer in the competency center, so I'm directly involved in most of our technological advancements regarding our products, which is, yeah quite cool I would say…

I: That really sounds cool… Okay, for Casa Nova Bau GmbH one crucial point, when it comes to storage technologies, is the financial prospects of the product… So what would you say, what are the key financial aspects homeowners should consider with lithium-ion storage systems? As they are the biggest clientele the company has or aims for with these kind of products…

BM: Well, from a financial perspective... homeowners should look at the initial investment versus long-term benefits… I mean, when we talk about our products, so the batterie systems, by the way, we only produce lithium-ion battery systems, hydrogen and other storage technologies are not included, because we think that lithium-ion technology is the future… And lithium-ion batteries, while having a higher upfront cost, offer significant long-term savings and they also have a longer lifespan and maintain efficiency over time, reducing the need for replacements.

I: Okay, so, BM, just to clarify, you mentioned the initial costs of lithium-battery systems, but we're also interested in the variable or running costs that occur during the usage of such systems, could you expand on that?

BM: Oh, sure, my apologies, so the financial considerations… the improved energy management that our storage systems provide means lower electricity bills, which is very important, like in countries where energy costs can fluctuate, this can lead to substantial savings, for example here in Germany or in whole Europe as we've seen recently… And, ah, just one more point to add to the initial costs is that there are often incentives for solar energy systems that include storage, making the investment more appealing, so homeowners can reduce their initial costs, which of course is quite beneficial for them and also for us, because this makes the products more attractive…So energy costs are a significant factor, and lithium-ion batteries offer a way to mitigate these costs in the long run, regardless of the region.

I: Perfect, thanks for clarifying. And from a technical standpoint, what challenges do homeowners face in deploying these systems?

BM: Well, technically, the biggest challenge is ensuring the correct sizing and integration of the battery with the solar system, like it's crucial that the battery capacity matches the energy output of the solar panels and the consumption pattern of the household, but this not only refers to storage systems, but also to photovoltaic panels, like if the voltage of the generated power is not matching the infrastructure this can lead to troubles, so homeowners should always, or the companies selling these systems, should always check if the systems match the infrastructure's

requirements, so this is also what we do at Company 5 before we sell one of our products… We have specialized technicians for this kind of work that will check everything…

I: That makes sense and what would you say, like logistically, can be challenging for you as a company or for a homeowner?

BM: So, logistically, the installation process does require professional expertise, but every electro-technician should be able to install our systems, of course, especially for our advanced systems like Product 1, these are high-tech solutions and proper installation is key to ensuring safety and optimal performance and our team at Company 5 works closely with installers to provide the necessary training and support, ensuring that these systems are deployed effectively and safely, but we don't do the installation ourselves, we have partners for that, that are specialized on this and also on the maintenance of these products or repair works. But, back to your question, otherwise there are no logistical implications with our storage systems, as they are not super big, so they fit in basically every basement…

I: Perfect, that's very insightful, thank you BM… Okay shifting focus a bit, how do lithium-ion batteries align with sustainability goals, especially considering their production and lifecycle?

BM: Good Point, so sustainability is a key factor in the development and use of lithium-ion batteries and at Company 5, we're deeply committed to sustainable practices, like in terms of production, there's an ongoing effort to make the process more… environmentally friendly, so this includes sourcing materials responsibly and improving manufacturing efficiency… And as for the lifecycle, lithium-ion batteries have a significant advantage due to their long lifespan and high efficiency, like I said before, and they reduce the need for frequent replacements, which in turn lowers the environmental impact over time… Another crucial aspect is the recyclability of these… batteries, so we're seeing advancements in recycling technologies that allow for the recovery and reuse of materials, further enhancing the sustainability aspect and like, overall, lithium-ion batteries, when integrated with solar energy systems, contribute significantly to reducing carbon emissions and promoting renewable energy use.

I: Yes, that's an important aspect for sure. But, in terms of sustainability you often hear about the implications of the lithium mining, for example in Africa or South America… How do you deal with that kind of sustainability as you are focusing on lithium-battery technology?

BM: So, well, that's a very good and important point, I mean, sure, are there a lot of, like, bad companies that are harming the environment when it comes to lithium mining or harming the

health of their workers? For sure, but I think you have these problems in every industry, so you have to deal with that and not just cancel or avoid a technology that obviously is more sustainable than current alternatives, you know? So, we at Company 5 try to face these issues in working with trustworthy partners and suppliers of the raw material that are, for example, based in Europe and oblige European law, so we try to create transparency here, so that our clients don't have to worry about these aspects when it comes to our products…

I: Okay, thank you for that answer. So, moving on, could you elaborate on how these batteries integrate with existing PV setups and their performance in different climates?

BM: Yes, so lithium-ion batteries are highly compatible with PV systems, I mean this is like the core of our business, but sure, I think the much bigger industry for lithium batteries are telecommunication and automobile sector… But, yeah, regarding the compatibility of our storage systems with PV systems, they can seamlessly store the energy generated by solar panels, making it available for use when needed, like during peak demand or at night, so this integration enhances the overall efficiency of solar energy systems. And also regarding performance in various climates, lithium-ion batteries are quite resilient, so they operate effectively across a broad range of temperatures, that's why their popularity is rising in, like basically every market in the world… However, extreme conditions can impact their efficiency to some degree, but at Company 5, our R&D team constantly works on improving this aspect, ensuring that our batteries perform optimally in diverse environmental conditions, which is particularly relevant given the varying climates in the regions we operate in, as you know we're an international company, so this is quite important for us, to provide the best solutions to our clients no matter where they are located.

I: Cool, that sounds good… Now, can you compare lithium-ion batteries to other storage technologies in terms of operational feasibility and sustainability?

BM: Yes, sure, so, lithium-ion batteries are currently more operationally feasible than many alternative storage technologies, particularly in the residential sector, because, like they're easier to install… require less maintenance, and have a more established market presence, so of course this makes them a reliable choice for homeowners and in terms of sustainability, while the manufacturing process does have an environmental impact, the long lifespan and recyclability of lithium-ion batteries contribute positively to their sustainability profile and, compared to other technologies, they often offer a better balance of energy density, efficiency, and environmental impact, making them a preferred choice for integrating with solar energy systems…

I: Okay, perfect, so, next question, how do you see market acceptance and the regulatory environment for lithium-ion batteries evolving?

BM: So, the market acceptance of lithium-ion batteries is continually increasing, like, driven by the growing demand for renewable energy solutions and… energy independence and also consumers, in general, are more aware or interested in sustainable energy storage options, which bodes well for lithium-ion technology and regarding the regulatory environment, I would say that it's evolving to support the increased adoption of these batteries, like we're seeing more policies and incentives that promote the use of renewable energy and… energy storage. So, of course, this supportive regulatory landscape helps in building consumer confidence and accelerating the adoption of lithium-ion batteries in residential solar energy systems and it's an exciting time in the industry, and at Company 5, we're thrilled to be at the forefront of these developments…

I: Thank you, BM, for such detailed and informative responses… Moving forward, BM, what's your vision for the future development and market role of lithium-ion batteries, especially in residential solar energy storage?

BM: So, my vision for the… future of lithium-ion batteries is quite optimistic, I would say, because I see them playing an increasingly crucial role in residential solar energy systems, but also in the non-residential niche and we're likely to witness advancements in battery technology, leading to higher energy densities and longer lifespans, so this will make them even more appealing for home use, I think. And in terms of market role, I expect… lithium-ion batteries to become more integrated into smart home systems and offer enhanced energy management and efficiency, as people become more conscious about their energy consumption and environmental impact and also the demand for these efficient storage solutions is bound to rise, because of that I think. So, Company 5 is continuously innovating to meet these evolving needs.

I: That sounds like a promising future, can you recommend any experts or resources for further insights into lithium-ion technology?

BM: Yes, sure, so for deeper technical insights, I'd recommend checking out the Journal for… … yes, the Journal for Renewable Energy, they publish everything like regarding to renewable energy and they also have a huge database for solar energy and also solar energy storage advancements… As they publish very regularly you can always stay up to date with their studies and papers…

I: Cool, that sounds very promising, thank you very much! So, finally, are there any additional insights or suggestions you'd like to offer for our research into lithium-ion storage solutions?

BM: Well, from a technical standpoint, I mean as an engineer, I suggest keeping an eye on advancements in battery materials and design, so the industry is currently experimenting with a variety of different semiconductors and materials that's why we have a lot of development in this technology and this is where significant improvements in efficiency and sustainability in the future will likely come from. Also, consider the impact of… regulatory changes and market dynamics on the adoption of these technologies, I mean if people are not convinced of a certain technology or product they won't buy it, so it has no chance to get popular in the market, so understanding these factors will provide a more comprehensive view of the future of lithium-ion batteries in solar energy storage, I would say.

I: Cool, so BM, your in-depth knowledge and insights have been incredibly helpful. Thank you for taking the time to speak with us today, this is the end of our interview…

BM: Sure, it's been my pleasure to share my thoughts and it was quite fun, so, yeah I hope I could give you some information that is interesting for your work and thank you very much for this nice conversation, Alessandro!

I: Yes, definitely, thank you once again, BM. Take care and yeah, I hope to see or hear you again!

BM: Okay, goodbye then.

Transcript Candidate 6 – Hydrogen Expert

Interview partner: GM, Development Engineer

(**I**: Interviewer, **GM**: Interviewee)

I: Hi GM, thank you very much for joining me today!

GM: Hey, thank you for the invitation…

I: So, I am quite thrilled to have your expertise here… Today's… discussion will help Casa Nova Bau GmbH explore the possibility of adding hydrogen storage systems to their solar energy solutions. So, we're particularly interested in operational feasibility, long-term profitability, sustainability, and market trends, like I briefly described in my mail… This conversation should last around 20 to 25 minutes… So, are you ready?

GM: Sure, I'm all for it, let's go!

I: Perfect, since you've been with Company 6 for over a year, could you tell us about your role and your experience with hydrogen storage systems in the context of residential solar energy applications?

GM: Sure, so I am working for Company 6 as a Development Engineer and we're specialized on solar storage systems… that are based on hydrogen… And we're currently providing small- and large-scale storage systems to our clients, like for private clients and also for industrial clients, but my team is focused on our residential product line and our or my goal here is to harness excess solar energy that is gathered through PV-systems to produce hydrogen, which can offer substantial storage capacity and can be used as a power source when solar isn't available. This is… like, a crucial and very important point when it comes to using solar energy, as you might know… Because, especially during periods with low sun appearance, solar or photovoltaic systems don´t generate enough electricity, which is why the demand is higher than the output. And If you, for example, on the other hand have a very high sun rate and you can store the excess energy, you can then use this excess in periods with a low sun rate… If you want me to get more into detail on how this works, just let me know, then I will dive deeper into the… technical parts of this!

I: Okay, thank you for that! But I think it's fine so far…

GM: Okay and yes, back to me. So, my role as a Development Engineer, particularly with my background in electrotechnology, involves addressing the challenges of adapting these systems for home use and ensuring they are safe, efficient and also user-friendly. And although the

technology is still emerging, we've seen promising results and I personally believe that it has a significant role to play in the future of residential energy too.

I: Okay, so that sounds like a very pioneering field… Considering the investment and operational costs, what are the key financial aspects that influence the viability of hydrogen storage systems for homeowners? What is your opinion on that?

GM: So, the financials are quite… you have to distinguish them for hydrogen systems… Like, the initial setup for hydrogen storage systems is admittedly higher than, for example, conventional batteries… due to the technology's complexity, if we're talking about the cost of electrolyzers, storage tanks, and other infrastructure. However, it's important to recognize the long-term benefits, for example, hydrogen has the potential for large energy storage, which can be critical in areas with less consistent sunlight, so also for example here in Germany it can play a crucial role, but also in countries like Norway and Sweden, where they have even longer periods during winter without sunlight...And on the other hand they have very long periods with a lot of sunlight during the summer months, so if you can store your solar energy long enough you can generate electricity during this period and also use it during the dark seasons. Yes. And the idea is that as technology improves and becomes more widespread, so costs will naturally decrease. Plus, the operational costs are comparatively low, especially if you consider the longevity and potential energy independence it offers.

I: Okay, so it seems that the focus here is on the long-term view… On the practical side of things, what can you tell us about the technical and logistical challenges of deploying hydrogen storage in residential homes?

GM: So, that is a very important point that we are focussing on at Company 6, deploying hydrogen storage systems is indeed more complex than traditional batteries, as the equipment is specialized and the installation requires a deep understanding of hydrogen's properties and as this technology is not that common, at least at the moment, this is a very crucial point when it comes to new developments in this field, as there are just a few experts that are specialized on the deployment of hydrogen, so safety is also a very important keyword, as hydrogen is a highly flammable gas and proper containment and ventilation are critical and the systems must adhere to stringent safety standards. So, from a logistical standpoint, the current challenge is the infrastructure for hydrogen delivery and maintenance support, which is still developing… Homeowners will need specialized support for system checks and potential repairs, this is nothing that they can do themselves with, for example, applications or instructions, as handling this kind of resource, you know, can be very… dangerous, if you are not a professional. And

even as a professional it's not like every electrician can do this, you need special skills and training. But still, as the market grows, I anticipate these services will become more streamlined and accessible… Also like, when you mirror the support networks that we see for more established home utilities even today.

I: Yes, so the safety and infrastructure aspects are clearly crucial, from your point of view. Thank

GM: Yes, absolutely!

I: Thank you for outlining these considerations, GM. We'll continue to explore how hydrogen storage aligns with sustainability goals in a moment. I just need to take a sip of water. Sorry.

GM: Sure, I mean at the end we are talking about water the whole time, so no wonder you are getting thirsty…Haha.

I: Haha. You're probably right. So, I am ready to continue. Now, let's turn our attention to sustainability. How do hydrogen storage systems align with sustainability targets, particularly in terms of carbon footprint and resource efficiency?

GM: So, sustainability is actually one of the strongest arguments for hydrogen storage… When we talk about the carbon footprint for example, hydrogen, I mean if produced via electrolysis by using solar energy, is as green as it gets, so zero emissions. So, there is no cleaner way to produce hydrogen. And it's a closed-loop system, what I mean by that is that solar energy powers the electrolysis of water, producing hydrogen… this can then be converted back to electricity without any carbon byproduct. As for resource efficiency, hydrogen requires only water as a feedstock, which is abundant and non-polluting, unlike the rare metals needed for some battery technologies, also for popular lithium-ion technology… And when it comes to the system's lifecycle, we're developing methods to recycle and also repurpose the core components, further reducing environmental impact. But we are already quite far in doing so… But, sure… you also have to first produce the different components of such storage systems, but this is something you have to do either way…

I: Okay, that sounds like a very sustainable future, I mean, that hydrogen could provide… With that in mind, how do hydrogen storage systems integrate with existing photovoltaic setups, and how do they perform under different climate conditions?

GM: That is also a very good question. So… How do I start… Hydrogen storage systems can be beautifully synergistic with PV systems, even today… They allow for the storage of excess energy that would otherwise be waste and this is particularly useful in climates where sunlight

is variable, during overcast days… or long nights, hydrogen can step in to provide a continuous energy supply… And referring to the conditions under which hydrogen systems can work properly, we're seeing that these systems can maintain performance across a range of conditions, which is vital for regions with less predictable weather patterns, this brings us back to Germany or Skandinavia, for example… The technology is adaptable, and with the right setup, it can ensure that a household's energy needs are met year-round, regardless of the climate. Again, this is why we at Company 6 are focused on the northern European market, as this is a big advantage of hydrogen storage, also compared to other storage technologies.

I: So, in other words, adaptability seems to be a key advantage here, right?

GM: Yes, that´s the right word for that.

I: Okay, so moving to a comparative perspective, based on your experience, how do hydrogen storage systems stand in terms of operational feasibility and sustainability when compared to other technologies?

GM: Well, hydrogen storage systems offer a unique proposition, because… Like, in terms of operational feasibility, they're currently more complex than lithium-ion systems and the technology is still maturing and there's also a higher barrier to entry in terms of the skill and knowledge required for installation and maintenance… However, this is rapidly changing as technology advances and as training and support infrastructures develop… Sustainability-wise, hydrogen has the potential to outshine other technologies due to its cleaner lifecycle and the possibility for large-scale energy storage, also if compared to lithium-ion batteries…While lithium-ion batteries are efficient and have a lower upfront cost, they face challenges with raw material sourcing and end-of-life disposal. I mean, you surely heard about all the problems that they have with environmental and social aspects when it comes to mining these resources… Hydrogen, produced from renewable sources, doesn't have such issues, it's a more scalable and… potentially more, sustainable solution in the long run, especially if we consider the growing global emphasis on cutting carbon emissions… But sure, I might be a little bit biased when it comes to this topic, as I am quite convinced of this technology, which, yeah, which is why in the end I am working for a company like Company 6.

I: Perfect, so that's an insightful comparison, GM. Thank you… This expertise you talk with really gives me a clear understanding of hydrogen's place in the energy storage landscape, that's very interesting… Do you

GM: I'm glad to hear that!

I: So, are you ready to move on?

GM: Sure, let's keep going!.. I mean, there are just a few questions left, right?

I: Right, so**,** as we consider the broader picture, how do you see market acceptance and the regulatory environment evolving for hydrogen storage technologies and what impact might this have on their adoption in residential solar energy systems?

GM: So, the market acceptance for hydrogen is growing, though it's at a nascent stage compared to more established energy storage solutions, because… like, the real pivot will surely come as the regulatory environment catches up with the technology, as currently, technology is developing faster than the corresponding… regulations… So, at the moment regulations are still being developed to fully support the implementation of hydrogen systems, I mean at a residential level, and as these regulations become… more defined and supportive, I expect to see a significant uptick in adoption, at least in the mid- and long-term… I think, this will be further bolstered by public education on the… benefits and also safety of hydrogen energy, which is crucial for homeowner buy-in… I would also say that the impact will be substantial, as favourable regulations could lead to… incentives and subsidies and also support programs that could make hydrogen systems as commonplace as solar panels are today, so this is also what, for example, fueled the current development and integration rate of lithium-ion batteries for private homeowners…

I: Okay, so that would indeed be a significant shift that could happen… Okay, so, looking forward, what is your vision for the future development and market role of hydrogen storage systems in residential solar energy storage?

GM: Yes, so my vision for hydrogen in residential energy storage is one where it complements existing technologies to create a more, like, robust and reliable energy and also a sustainable energy grid… I see hydrogen as a key player in the transition to a decentralized energy system, where homes can not only produce and store their own energy but also… contribute, because this is also the case for lithium batteries, so homeowners can contribute to the stability of the wider grid and I expect, as the technology matures, that hydrogen storage costs will decrease and thereby making it competitive with other forms of energy storage… I mean sure, this will likely be a gradual transition, but one that accelerates as renewable energy takes on a more dominant role in our overall energy supply, that's what I think.

I: Nice, so this is an exciting future you paint… Okay, before we conclude, are there other experts or sources you would recommend for further insights into hydrogen storage technologies?

GM: Well, I can recommend you a colleague of mine who's working on the integration of hydrogen systems with smart grids, that's maybe a bit more… hands-on and could give you more technical insights… Also, the International Hydrogen Energy Association publishes a lot of information that could be beneficial for your research, especially regarding current macro trends in this technology… I mean, as far as I remember they cover everything from technological advances to… like, market trends and also regulatory developments… And well, I would suggest to look at the developments in electrolyzer technology… It's a critical component of the hydrogen production process and advancements here could drastically change the cost dynamics, so this is why basically every big company in our industry is researching in this field… Also, consider the interplay between hydrogen storage and electric vehicles… This is also a very interesting research field, also for a lot of big businesses… There's potential for synergy here, which could drive forward both technologies… And also, don't underestimate the importance of policy changes… Shifts in energy policy could either accelerate or hinder the growth of hydrogen storage… so staying informed on this front is crucial to keep up with current developments…

I: Sure, that sounds awesome. Thank you, GM. It would be cool if you could help me with an introduction to your colleague… And I definitely will review the publications… Thank you again for that and yeah, I can't thank you enough for your time and the depth of information you've shared today, so your insights will be… important in, like, shaping Casa Nova Bau GmbH's approach to incorporating hydrogen storage into their product offerings.

GM: Perfect, It's been my pleasure. Thank you… I am glad that I could contribute and, as I said before, I think hydrogen will be very promising in the next years… So, yes, the earlier you get in touch with this technology, I mean if you're working in this industry, the better…

I: Yes, that sounds indeed promising… Again, thank you for your valuable time and insights. Have a great day, GM.

GM: You too, take care!

Transcript Candidate 7 – Hydrogen Expert

Interview partner: BN, Head of Sustainability

(**I**: Interviewer, **BN**: Interviewee)

I: Good afternoon, BN, and thanks for for joining us today. I Really appreciate it.

BN: I was just wondering why you're greeting me with good afternoon, as we have 9:00 am here in Sydney, but I totally forgot that you're sitting in in Portugal, right? Haha.

I: Haha. Yes, I am sitting in Lisbon, that's right. So, I mean, here it is 10 pm… That's quite a huge time difference we're having here… So, as background information for you, let me start with… Okay, so I am conducting this interview for Casa Nova Bau GmbH, a company exploring the inclusion of hydrogen storage systems in their solar energy offerings now. In this sense, we'll be discussing aspects like operational feasibility, profitability, and sustainability that these systems might offer and the interview should be around 20 minutes…

BN: Yes, I was really interested in your project when I first read your mail! So, I am glad that I can, hopefully, provide you some insights here…

I: Cool, that's great to hear and yeah, I am also glad that you want to provide me some information regarding your expertise… So, okay… Could you maybe start by sharing your experience with hydrogen storage systems, particularly in the context of residential solar energy applications?

BN: Absolutely, I can…. So, although my technical expertise isn't super distinctive, in my role at Company 7 I've had a broad overview of how to combine hydrogen storage with solar energy systems… So, our focus here at Company 7 is on leveraging the abundant solar energy we have and storing it efficiently. As you might know, photovoltaics plays a crucial role here in our country, not only for private households, but we also have huge solar farms across the country, like commercial solar farms and at Company 7 we're trying to optimize the process of generating solar energy, by storing excessive energy that is generated throughout the peak periods during the day, in order to use it when we have a energy shortage, for example during the night… So, what is really innovative referring to Company 7, is the fact, that we developed a Home Solution that stores energy in form of hydrogen… I mean, this technology itself is not completely new in the market, but we as a company… managed to develop a kind of smart battery system that is not much bigger than conventional batteries, like lithium-ion batteries, so in our product we combine lithium batteries with hydrogen storage technology… Also, this Home Solution is created for households, which don't have to be massive in order to integrate

our system into it and advantages of this solutions are that they can store more energy over a longer period than traditional batteries, making them ideal for the Australian climate and lifestyle. But, sure, there are many more places around the world where this technology is beneficial… And, we see growing interest from homeowners who want to maximize their solar investments and are looking towards more innovative, sustainable solutions like hydrogen… Just to give you a small overview on who we are…

I: Wow, that's already a quite comprehensive overview, thank you very much. So, moving on, what are the key financial aspects homeowners should consider when looking at hydrogen storage systems?

BN: Well, you're right, it's important to look at the whole financial picture… when considering hydrogen storage… Like, homeowners should first think about the initial investment, which, admittedly, can be higher than traditional storage solutions, at least with the current prices… But it's not just about the upfront cost, also the long-term benefits of hydrogen storage are quite substantial. So, for one, these systems have a significantly longer lifespan… also compared to conventional batteries. This means they don't need to be replaced as often, which, over time, can lead to considerable savings. Also, they have the… the potential for larger energy storage capacity, which is a big plus. And, this translates to more prolonged energy independence for the homeowner and the ability to store more energy… So, when it's plentiful, like during sunny days, to use when it's needed most. Well, in the Australian context, especially, this can be a game-changer. You know, energy costs here can be quite high, particularly in remote or rural areas where grid electricity is either too expensive or not reliable. So, in these cases, having a robust hydrogen storage system can mean a world of difference, offering not just energy security but also a more cost-effective solution in the long run. And then, there's the sustainability angle – as more Australians move towards renewable energy, investing in a hydrogen storage system aligns with this shift… Like, it's not only about saving money but also about contributing to a greener future. So, while the initial investment might be higher, the long-term benefits, both financial and environmental, make hydrogen storage a compelling option for many homeowners here.

I: Okay, that's an important consideration in the decision-making process, I guess. And from a technical and logistical standpoint, what are the challenges and requirements of deploying these systems in residential settings?

BN: So, the deployment of hydrogen storage systems does come with its unique set of… challenges. Technically the systems are more complex than traditional batteries. You know,

they involve components like electrolyzers for hydrogen production, I don't know if you've heard much about that, but it's basically the process of using electricity to split water into hydrogen and oxygen, it's a fascinating technology but not without its complexities. But then, logistically, installing these systems is quite a task, as it requires specialized knowledge and handling, particularly because hydrogen is a highly volatile substance. So, safety is absolutely paramount and the installation must adhere to strict standards and regulations, which can vary quite a bit from region to region and here in Australia, we're still adapting to these systems. I mean, the market is learning, and we're seeing more and more professionals skilled in this area, but it's a gradual process. So, I would say, that finding the right expertise and ensuring safe… installation are key challenges we are currently addressing, but it's not unique to Australia… I think this is what's happening in every market around the world, but like the good news is that, in the last few years, we've had a lot of advancements regarding the stability and safety of hydrogen. So, while it's a current issue, I'd say it's one that we're rapidly overcoming, as we're seeing more robust and secure systems come onto the market, and I think that in the next few years, these challenges will become significantly less daunting.

I: Alright, so

BN: And as this technology becomes more mainstream, I believe the logistical hurdles will start to diminish, especially with the … increased investment in research and development. So, it's a challenging area, but one that's moving in the right direction, and it's exciting to be part of this journey in making hydrogen a viable and safe energy storage solution… Sorry, I was interrupting you.

I: No problem, thank you for this extensive answer! So, sustainability is a key topic these days. How do hydrogen storage systems align with sustainability goals, particularly in their production and lifecycle?

BN: So, that's a critical question and at Company 7, we're very focused on the sustainability aspect of our hydrogen storage solutions, as the production of hydrogen, when done through renewable sources like solar, is incredibly clean, like it's basically water and energy, with no harmful emissions…. the lifecycle of these systems is also quite sustainable. They last a long time, reducing the need for frequent replacements and when it comes to disposal, we're exploring environmentally friendly methods to handle any waste. In Australia, where there's a strong push towards renewable energy, hydrogen storage aligns perfectly with national sustainability goals, that's why our customers also can apply for subsidies for our products…

I: Okay, so it sounds like hydrogen storage fits well within the sustainability framework… Next, how about integration with existing PV systems and performance in various climates?

BN: Well, the… integration with PV systems is an area where hydrogen storage really shines, I mean this is exactly our use-case… So, our product is perfectly aligned with every common PV system that households have… And hydrogen allows for excess solar energy to be stored efficiently and used when needed and in terms of performance, hydrogen storage is less affected by climate variations compared to traditional batteries, I mean, like traditional batteries are also just affected slightly in their performance in harsh climate conditions, but referring to hydrogen we basically have no effect on performance, which is quite unique… In Australia, where we have diverse climate zones, this is particularly beneficial, as it ensures that regardless of whether you're in a hot, dry area or a cooler, temperate region, your energy storage remains efficient and reliable, especially over long periods.

I: Well, it seems like hydrogen storage offers a lot of flexibility, if I understood that right… From your perspective, how do hydrogen storage systems compare in terms of operational feasibility and sustainability to other technologies?

BN: So, hydrogen storage systems are certainly more complex, like, operationally than traditional battery systems, but however, the technology is advancing rapidly and we're seeing improvements in ease of installation and maintenance. So, all in all I would say that, from a sustainability standpoint, hydrogen has the potential to outperform many traditional storage solutions, also the most popular ones like lithium-ion batteries. And its ability to store large amounts of energy without harmful emissions is a significant advantage, especially as we look towards a more sustainable future, with our focus on clean energy, hydrogen is gaining a lot of attention for its potential to support larger renewable energy systems…

I: Cool, so moving on, do you see the market acceptance and regulatory environment for hydrogen storage evolving?

BN: Well, market acceptance for hydrogen storage is growing… I mean, there are not many companies that provide hydrogen solutions at the moment, especially regarding private clients. But, we’re growing exponentially and we can tell that there are many inquiries of interested homeowners who are searching for alternatives to, for example, lithium-ion batteries… There's a lot of interest in adopting new technologies that can help reduce our carbon footprint. And the regulatory environment is evolving to support this shift. For example, we’re seeing more policies and incentives that encourage the adoption of renewable energy technologies, including

hydrogen storage, but as hydrogen storage is not yet very common in the residential sector, these incentives are more for the commercial sector, but sure, this supportive regulatory landscape, combined with increasing public awareness of the benefits of hydrogen, is setting the stage… yeah, for more widespread adoption in the… in the residential sector… But yeah, I think this still takes some time before incentives are really targeting the adoption of hydrogen storage in the residential sector…

I: Perfect! As we look towards the future, BN, what's your vision for the development and role of hydrogen storage systems, particularly in the residential solar energy sector?

BN: So… looking ahead, I see hydrogen storage playing an increasingly vital role… The technology is evolving rapidly and I believe it will become more accessible and user-friendly. And for the residential sector, especially in Australia, hydrogen storage can offer a level of energy independence that's really appealing… also in the future, I envision homes being equipped with solar panels and hydrogen storage, creating a self-sustaining energy ecosystem, so storage methods will be more relevant and this vision aligns well with the worldwide push towards renewable energy and reducing carbon emissions…

I: That sounds very interesting. Now, could you recommend any other experts or resources that might provide more insights into hydrogen storage technologies?

BN: We have a very informative newsletter at Company 7 that is… also publicly available… We're publishing it, I think… every two weeks with the latest advancements regarding hydrogen storage, so that could also be very interesting for you. Also, the reports and publications from the Clean Energy Council of Australia offer a wealth of information on the latest trends and developments in renewable energy, including hydrogen storage.

I: Perfect, those sound like valuable resources, thanks for sharing. Lastly, are there any additional insights or suggestions you'd like to offer that might aid our research into hydrogen storage solutions?

BN: I think it's crucial to keep an eye on the technological advancements in hydrogen storage. The field is evolving quickly, and new developments could significantly impact how we use and perceive this technology… also understanding the specific energy needs and climate conditions of different regions can help tailor hydrogen storage solutions more effectively, so maybe it would make sense, to look at different markets and countries here… And finally, public education and engagement are key, the more people understand the benefits and potential of hydrogen storage, the more likely they are to adopt it, I think…

I: That’s very helpful advice, BN, thank you so much for your time today and for the valuable insights you've provided, they’ll be very helpful for my research, thank you!

BN: Sure, it was a pleasure and I hope that everything goes well with your master thesis.... If you have any further questions or need more information, feel free to reach out. Good luck with your research, and have a great day, Alessandro!... Sorry, I forgot the time difference again, so, I should rather say sleep well…right?

I: Haha. Yes, you’re right, that would make more sense! Thank you again, BN, have a great day and let’s keep in touch.

Transcript Candidate 8 – Lithium-Ion Expert

Interview partner: SP, Business Innovation Manager

(**I**: Interviewer, **SP**: Interviewee)

I: So, good morning, SP and welcome… I really appreciate you taking the time to speak with me today and I am, yes, very excited to listen to your expertise.

SP: Hi! Sure, it's my pleasure… I am happy to provide you some information about our storage systems at Company 8…

I: Awesome! As part of my research for Casa Nova Bau GmbH, I'm looking into the integration of solar energy storage solutions, or particularly lithium-ion batteries and hydrogen storage systems, into their portfolio… In this interview, just to be on the same page, we'll therefore be discussing various aspects such as operational feasibility, profitability, and sustainability in this context. The interview should take around 20 to 25 minutes…

SP: That sounds interesting, so go right ahead... I'm curious about your research and glad to contribute, or at least I hope that I can contribute with some insights or knowledge.

I: Perfect, thank you...To begin, could you outline your experience with lithium-ion batteries? So especially in terms of residential solar energy applications and your position at Company 8?

SP: Sure, so, I've been with Company 8 for around six years, and I… so, my focus has been primarily on PV-systems and lithium-ion battery solutions… These batteries are a core component of our smart energy systems, which… yeah, are the heart of our business, they offer homeowners not just energy independence but also a way to actively manage their energy use and regarding my job, so, my role involves not only the business development side, but also ensuring that our products meet the high technical standards required for residential use, which are sometimes even more complex than the standards for industry systems, so I've seen firsthand how these batteries can transform a home's energy profile, providing reliability and efficiency… not only at my job here at Company 8, but also because I have a Company 8 system integrated at my home for two years now and I am more than happy with that, so I am an double expert, if you will…

I: Ah, so you have firsthand experiences with this kind of batteries, as a professional and also as a client, that's interesting. Now in terms of profitability, what are the key financial factors that homeowners should consider when it comes to lithium-ion battery storage?

SP: Well, the invest… the financial aspects are critical. Initially, the investment in a lithium-ion battery system can be significant, but it's important to look at the long-term operational

costs, which are quite low, it's like… I mean people or homeowners also struggle when they first see the prices for photovoltaic systems… But when they calculate their benefit in, like a cost-benefit calculation, they realise that they're more economic than conventional energy resources… And, these batteries, so lithium batteries, have a long lifecycle…they require minimal maintenance and can offer substantial savings on energy bills… by optimizing solar usage…. Also, there's the increasing value of self-consumption and energy autonomy, particularly, so we've recently seen what can happen to prices in a short term… Last year the energy prices were exploding… So the autonomy aspect is quite important when it comes to photovoltaic and also solar energy storage systems… Regarding the market, many countries offer incentives that can make the initial investment more affordable, like for example subsidies, which play a crucial role… at the moment they are even discussing if they will increase the subsidies for lithium-ion batteries for solar purposes, I mean in Germany at least. And at Company 8, we focus on creating systems that not only provide immediate returns but also continue to deliver value over the life of the product, so it's a long-term investment.

I: Okay, thank you. That was a very comprehensive view of the financial benefits of lithium storage systems… Now, could you delve into the technical and logistical challenges involved in deploying and maintaining lithium-ion battery systems in residential settings?

SP: Sure, I mean in terms of technical issues I can dive deep into very specific details, if you like, but… So, as far as I understood it, you are more focused on the business part of the storage systems, right?

I: Yes, so we don't have to discuss very technical challenges, or at least not that detailed, but still… If we can handle it on a more general level, it would be good… But, we can still dive deeper, if it's necessary….

SP: Okay, okay… so, I'll just start and then you can tell me whether you want more detail or not… So, the question regarding technical and logistical challenges… So, as for maintenance, it's usually minimal effort, our systems are designed to be durable and require little intervention once they're up and running… Sure, they, I mean someone needs to set them up for the first time, a professional, but afterwords these systems require just a little bit effort… The most common maintenance task is a firmware update, which can often be done remotely. So, Homeowners appreciate the resets and forget it's aspect of our batteries, which is something we've worked hard to achieve…

I: Okay and what would you say are the logistical challenges of lithium batteries?

SP: So, as the components are quite small it's no effort to transport our systems to our clients, that is easy… But, sure… As we are not producing each component of the batteries by ourselves, we are also kind of dependent on our suppliers… And, I mean, especially in times of high demand, there can be bottlenecks for some parts of our product, which then can lead to more waiting time for the clients… This could be a logistical issue, I would say…

I: Okay, so that sounds like a normal problem that many industries are facing when demand is increasing fast... with your deep involvement in lithium-ion technology, how do you see these systems aligning with sustainability goals? As sustainability gets more and more important, this is something that Casa Nova Bau GmbH is also trying to consider.

SP: Well, lithium-ion batteries have a significant role to play in sustainable energy solutions, as they enable people or… homes to maximize the use of solar energy and reducing reliance on fossil fuels and lowering carbon emissions in general. And in terms of production, we're constantly striving to make the process cleaner and more resource-efficient. Also, we're trying to make our supply chain as transparent as possible… Especially, as you might know the mining of some metals is a crucial point referring to sustainability… So, there are some black sheeps that are making fortunes by exploiting the earth and the people, often in Africa. That's why we try to screen all our suppliers, and, if possible, also their suppliers in order to yeah, have a clean supply chain… That is part of our mission…

I: Okay, so that sounds like sustainability plays an important role in

SP: Yes and also, at Company 8, we look beyond the battery's lifecycle to consider recycling and repurposing used batteries, which contributes to a circular economy and aligns with broader sustainability targets… This is also a very important part of our business…

I: Okay, thank you, SP… That was very insightful. So moving on to the next question… How do lithium-ion batteries integrate with existing photovoltaic setups, and how do they perform in different climate conditions?

SP: So, lithium-ion batteries are highly adaptable and can be integrated with virtually any PV setup, or at least any common PV system that is used for residential purposes… This is part of their appeal, they're quite plug-and-play in that regard. So you basically just need to connect these systems with the batteries, but sure, this sounds easier than it is… at the end this should be performed by a professional electrician who has the skill to work with lithium battery systems… There are also different requirements that vary between different PV systems, for example, in terms of density and capacity of the panels… As for performance, lithium-ion

batteries are robust across a range of climate conditions. So, they do well in both high and low temperatures, though extreme conditions can affect performance slightly… But, as for now, we're focussing on markets or countries where the weather conditions are usually not that extreme, but as I said, even if the conditions are extreme due to storm or rain, the implications on the performance are not that severe and we engineer our batteries to operate within a specific temperature range to ensure longevity and reliability and this is something we continually improve upon with each new generation of products… So they are very adaptable…

I: Perfect, that's good to know… So, moving on, how do lithium-ion batteries stand out in terms of operational feasibility and sustainability when compared to other technologies? Based on your experience.

SP: That's a good question… So, when we compare lithium-ion batteries to other energy storage technologies, a few key points stand out… For example, lithium-ion batteries have become the benchmark for residential energy storage largely due to their operational feasibility, as it, I mean we discussed this before, it's very easy to install them and they're also relatively compact, which is ideal for residential settings where space is often small, also the technology of lithium-ion batteries is mature, meaning that the supply chain, installation processes and maintenance procedures are all, like, known or well-established… which translates to a level of reliability and also user-friendliness that is crucial for users or homeowners… Compared to… compared to other technologies, such as lead-acid batteries, for example, lithium-ion offers a longer lifecycle and higher energy density… and also better efficiency, which contributes to a lower overall environmental impact... But also, when we're looking at emerging technologies, such like hydrogen storage… lithium-ion doesn't require the same investment in new infrastructure, as this technology isn't yet established very well, making it a more feasible option in the short term, I mean lithium-ion batteries.

I: That's an insightful comparison, thank you SP… So, considering market acceptance and the regulatory environment, how do you see these evolving for lithium-ion technology, and what impact might this have on adoption in residential solar systems?

SP: Well, the market acceptance of lithium-ion technology… is already quite high and it continues to grow… as consumers become more energy-conscious… Also, regulatory bodies are generally supportive, offering various incentives for solar and storage adoption... This positive regulatory environment will likely increase the adoption rate, as it reduces the effective cost to the homeowner, I mean the current trend continuous, the key impact, that's my personal opinion, will be an acceleration in the shift toward renewable energy, with lithium-ion batteries

serving as a critical bridge in this transition, as this is the only mature technology that is already established in the market, the residential market….

I: Okay, it's probable that lithium-ion batteries are set to remain a significant player in this market, this is what you say, I mean… Thank you for sharing such detailed insights, SP…Okay, let's keep going, we have a very good pace here… So, if we look to the future, what developments do you foresee for lithium-ion batteries in residential solar energy storage?

SP: Looking ahead, I see lithium-ion technology continuing to evolve in both capacity and efficiency, this is also what we're seeing considering our own products, we're on the best way of breakthroughs that could significantly increase energy density, which means smaller, more powerful batteries… that last even longer and this is not just us as a company, but this is also what you can see in the market… There's also a trend towards integrating batteries with smart home technology… as this is allowing real-time energy management that can adapt to both user behaviour and fluctuating energy costs… But, in the long run, I believe lithium-ion batteries will be at the heart of home energy systems... To be honest, I don't really know much about other, comparable, technologies, but I think I would have heard of technologies that could overtake lithium-ion batteries, if the, yes, if they would exist…

I: That's a promising vision, thank you so much, SP! In the realm of expertise, could you point us toward any other experts or sources that could… expand our understanding of lithium-ion technology?

SP: Certainly, I would recommend reaching out to different types of engineers that are… I mean, especially in the R&D departments of big companies, as they might have some expertise regarding advancements of different solar storage technologies… So, it would make sense to hear different perspectives, like, different parts of the supply chain of various technologies… or also start-ups, they sometimes can disrupt a complete market, before the competitors ever heard of them…

I: Thank you… thank you for the recommendations… So, lastly, before we end this interview, are there any further thoughts or insights you'd like to share that might benefit our research?

SP: Good question… I would suggest keeping an eye on the developments in solid-state battery technology… They are developing super-fast, at the moment and… Yes, this could be a game-changer for the energy storage industry… Because these batteries offer higher safety and energy density than conventional batteries, also conventional lithium batteries…

I: Awesome, thank you so much! I'll definitely take those points into consideration. SP, your expertise has been immensely helpful, and I am very grateful for the time you've spent with me today…

SP: Sure, I'm glad I could help and I'm looking forward to seeing the outcomes of your research or master thesis… Thank you.

I: I will and thank you again. Have a great day.

SP: You too, goodbye.

Transcript Candidate 9 – Lithium-Ion Expert

Interview partner: KS, Consultant

(**I**: Interviewer, **KS**: Interviewee)

I: Hi, KS. Thank you so much for joining me today! I am really excited for this interview, and I hope I will get some insights to your job or your daily business and… yeah…

KS: Hi, no problem at all, happy to share what I can about the work we're doing.

I: Great to hear... So, we're here to gather insights for Casa Nova Bau GmbH. As I told you before, Casa Nova Bau GmbH is a German company that is specialized on the installation of photovoltaic systems and, so now they're considering whether to expand their product offerings to include solar energy storage, focusing specifically on lithium-ion batteries and hydrogen storage systems. So we'll be discussing various topics like operational feasibility, profitability... sustainability, and market trends, regarding lithium-ion batteries, which is part of your expertise. This interview should take about 20, maybe 25 minutes is that okay?

KS: Oh, sure, that's fine. Go ahead with your questions.

I: Thanks, to get started, could you talk a bit about your experience with lithium-ion batteries in residential solar energy systems?

KS: Yeah, of course... So, I've been with Company 9 for, well, one and a half years, and my focus has been on comprehensive photovoltaic solutions that combine PV systems and lithium-ion batteries… At Company 9 we specialize on photovoltaic installations and solar storage systems for both, private and commercial clients and our solar energy storage systems, which are based on lithium-ion batteries, are…they really are a game-changer for residential solar, as… they're providing a way to store excess energy generated during the day for use at night or during peak demand times very efficiently, so without losing a lot of energy… I've consulted on numerous installations, ensuring that the batteries meet the specific needs of each household, which, of course, can differ a lot, as each installation has its own requirements… it's about balancing the technical capabilities with the homeowner's energy usage patterns, you know?

I: Yeah, that makes a lot of sense. But are you specialized in residential, I mean lithium batteries for residential applications? Or are you also consulting referring to commercial buildings?

KS: So, as I said at Company 9 we are doing both in terms of photovoltaic and energy storage systems… But for both, we have separate teams, as the requirements are very different, so lithium batteries meet very different criteria when it comes to small-scale private systems or

huge commercial systems. I am, for example, part of the residential team and we just consult private clients.

I: Okay, I got that. And in terms of costs, what are the financial considerations for homeowners when it comes to lithium-ion battery storage?

KS: So, financially speaking, the initial investment in a lithium-ion system is still significant, but it's been decreasing as the technology becomes more widespread, right now we are facing even stronger decreasing prices, as a lot of suppliers have stocked up their warehouses and… I mean we had a peak of demand in the last years for photovoltaic panels and solar storage systems, as there were many subsidies and people urged to be independent, when… yeah, when prices surprisingly increased during COVID and the energy crisis… But, generally speaking, homeowners should consider not just the upfront cost but also the long-term savings on their energy bills, this is what makes a big difference… These batteries have a long lifespan and low maintenance costs, and, depending on the region, there may still be subsidies or incentives available, so, when you look at the ROI, lithium-ion batteries can be quite attractive for residential solar systems, this is what also a lot of studies proof.

I: That’s an important aspect for homeowners to think about, I would agree… Moving on to the practical side, can you describe some of the challenges and requirements when it comes to deploying these batteries?

KS: Well, from a technical standpoint, lithium-ion batteries are fairly straightforward to install… In the end, there’s not much difference in installing PV panels or a lithium-ion battery system or both… Like, the main challenge usually lies in the initial assessment, so in making sure that the system is sized correctly for the home's energy needs… As I said before, each location has its own requirements and special features and logistically, ensuring that we have the right infrastructure in place to manage the installation efficiently is key. So, sure, before we can integrate a lithium battery storage, we need the photovoltaic system to be installed… As for maintenance, it's pretty minimal, which is a big selling point, so homeowners don't need to worry much once the system is up and running... Speaking from my own experience with my clients, this is often the biggest concern that homeowners have, I mean, besides the price of these systems… Basically everyone is very happy when they hear that they don’t have to do anything regarding maintenance of the system. But, even occasionally, there might be a software update or a check-up needed, but… but that's about it. And as these storage systems are smart nowadays, we even have notifications and reminders through applications on the

users' phone for example. So, you don't have to actively think about controlling your system, as the app will tell you when to check and when to call a technician…

I: Cool, that's really great to hear. It sounds like your systems are quite user-friendly… thanks for sharing your insights. So, sustainability is such a hot topic right now. How do lithium-ion batteries fare when it comes to sustainability targets, especially considering their production and lifecycle?

KS: Yeah, sustainability is a big part of our discussion with customers… Lithium-ion batteries, they do have an environmental impact during production, mainly due to mining... But the industry is working hard to mitigate this. So, at the end it is always very challenging when we're talking about getting raw materials… Also, like, gold mining is linked to several issues that should concern the world, but sure, we're trying to search for partners that are also interested in being sustainable… Also, when it comes to mining or the production of our components, at the moment we're looking into more sustainable material sourcing and improving the... the efficiency of the manufacturing process. In terms of lifecycle, these batteries last a long time, and when they reach the end of their life, we can recycle a lot of the components, so the good thing is that this applies to every sort of lithium-ion battery, not only to those that are applied in solar energy storage systems, that's why there is a lot of research happening right now, especially when looking into big industries like the automobile industry or computer or phone manufacturing and in the last years we've seen a lot of advancements regarding the recycling of batteries and I think there are a lot of innovations following, so that the whole lifecycle of batteries gets more and more sustainable… And the carbon footprint, if you look at the entire lifecycle, it's... well, it's lower than you might think and we're constantly finding new ways to reduce it further, like I just said.

I: Okay, I mean that's good to hear... And in terms of integrating with existing PV setups, how do lithium-ion batteries perform? What would you say?

KS: So, they integrate really well with PV setups, I mean, I already told you that there are a lot of requirements for lithium batteries in this context, but still, as long as you know what kind of PV setup you have and at which location, it's quite easy to integrate them with home storage systems… But we mainly provide our clients combined solutions, where PV-systems and lithium-battery storages are already combined into one product… Like, it's pretty much a seamless process and because they're so versatile, I mean the batteries, they can perform under a variety of climate conditions... which is great for reliability, what we've found is that with the right system design, lithium-ion batteries can maximize the effectiveness of a home's solar

array, storing energy when there's excess and providing it when needed, like during the night or on cloudy days… And this is also something that you can manage digital and automated nowadays, so, like we have smart and intelligent systems that can improve the efficiency of such home storage systems. This is also something that homeowners really love, that this is so easy, like, adapting, so the system is adapting to the respective circumstances.

I: Okay, so it sounds like they're quite adaptable. Now, if we look at the operational feasibility and sustainability, how do lithium-ion batteries compare to other technologies?

KS: So, that's a very good question, so lithium-ion batteries are... they're quite ahead in terms of operational feasibility, they're more established, with a clear track record… Sure, it's still something new and there is still a lot of potential for improvement, but, it's not, like, that it's something or some technology completely new… This makes them a, let's say, a safer bet for homeowners and installers alike and as for sustainability, while there's always room for improvement, they're a solid option for reducing reliance on the grid and using more renewable energy, because sure, you have way less energy waste, when you can store your energy excess… And compared to other battery technologies, lithium-ion offers higher energy density and efficiency, which translates to, yes, like I said, less waste and, over time, a better sustainability profile.

I: I see, that's a good comparison, thank you. And looking at market acceptance and regulatory considerations, what are your thoughts on how these factors are shaping the adoption of lithium-ion batteries in residential settings?

KS: Well, market acceptance for lithium-ion is... it's growing rapidly… People are becoming more and more energy-conscious and are looking for reliable ways to store solar energy and the regulatory environment is also supportive, with numerous incentives encouraging the adoption of energy storage, especially in Europe, this is crucial because it helps offset the initial investment cost for homeowners and as policies continue to favour renewable energy, I expect we'll see even more widespread adoption of lithium-ion battery systems in homes in the next years…

I: Okay, perfect… So, moving on, KS, looking into the future, what are your expectations for the development and market role of lithium-ion batteries in residential solar energy storage?

KS: Oh, the future looks... it looks bright for lithium-ion batteries, I would say… I expect we'll see major advancements in their capacity and efficiency, so the development will keep going… And, you know, with ongoing improvements in smart home technology, I think lithium-ion

batteries will become... well, more integrated into home energy management systems, allowing for smarter and more efficient use of stored solar power… Market-wise, I believe they'll continue to grow in popularity as more people look to renewable energy to power their homes, especially with rising energy costs and... increasing environmental awareness… And as lithium-ion batteries are still the go-to technology at the moment, I think they will surge in popularity in the same pace like PV systems will…

I: Okay, cool… That's an exciting prospect. Could you recommend any other experts or resources that we could consult to deepen our understanding of lithium-ion technology?

KS: Wow, that's a good question… So, I would recommend to just look into new studies that are published… I mean, as there are a lot of researchers working in this field, you'll find a lot of valuable studies, also in journals… But, yeah, in general I would advise you to just keep track of the most recent innovations in this field… You can find them, like I said, in journals or also in the news… For example, there is also a very cool podcast, in which the hosts talk about recent developments regarding PV systems, but they also talk about storage methods and stuff… Let me… So, it's called SOLAR-POWER Podcast… you can find that on Spotify…

I: Awesome, that sounds very helpful, thanks for that. Lastly, any additional insights or suggestions that might aid our research into lithium-ion batteries?

KS: Well, I'd say, consider the entire lifecycle of the battery, from production to disposal... In the SOLAR-POWER Podcast they also have like an episode where they talk about recycling methods and also prospects, which is very interesting, because they… are… They have an expert, so a reasearcher as guest speaker invited and he is talking about recent pilot projects, which is very exciting. And it's important to understand not just how they work but also their environmental impact. And keep an eye on the evolving regulations around battery storage, like they can significantly influence market dynamics, we have also seen in the PV industry… Lastly, don't underestimate the importance of consumers... The more homeowners understand about the benefits and workings of lithium-ion batteries, the more likely they are to adopt them and the more money is in the market the faster the development of new technologies or advancements will follow…

I: Yes, that makes sense… So, KS, I really appreciate you taking the time to speak with me and share your expertise… Your insights will be incredibly helpful for my research…. Thanks

SR: Sure, it was fun!... And it's been my pleasure…

I: Thank you once again, KS… Enjoy the rest of your day and yeah…

158 **KS:** You too, goodbye.

Transcript Candidate 10 – Lithium-Ion Expert

Interview partner: DM, Teamlead Quality Management

(**I**: Interviewer, **DM**: Interviewee)

: Highlighted parts are translated in the coding scheme (Appendix D).

I: Moin DM, vielen vielen Dank, dass du dir die Zeit nimmst, dass wir hier dieses Interview führen können, wie auch vorab kurz schon erwähnt, geht es hierbei um meine Masterarbeit, um genau zu sein, um eine kleine Recherche, in der es darum geht, dass ich für eine Firma, für die Casa Nova Bau GmbH, Solar Speicher miteinander vergleiche, da diese im Moment am abwiegen sind, ob sie Solarspeicherprodukte mit ins Sortiment aufnehmen wollen, wobei der Schwerpunkt hier auf Lithium-Ion Batterien und Wasserstoffspeichern liegt. Für die Bewertungskriterien dieses Vergleiches habe ich zum einen die betriebliche Machbarkeit rangezogen, zum Anderen die Rentabilität, Nachhaltigkeit, Kompabilität mit erneuerbaren Energiequellen und die Markt- und Regulierungsüberlegungen. Das siehst du auch gleich im Interviewprotokoll. Weil die Fragen, die ich dir gleich stellen werde, hangeln sich an diesen Bewertungskriterien entlang. Und ja, ich denke das Interview wird so zwischen 20 und 25 Minuten dauern und, um das Ganze eben auch entsprechend verwerten zu können, würde ich es gerne aufzeichnen.

DM: Ja, passt… Lass uns gerne loslegen!

I: Cool, super! Okay, dann würde ich sagen, fangen wir auch direkt an. Zum Thema Hintergrund und Erfahrungen, magst du dich und deine Erfahrungen einmal im Hinblick auf Lithium Batterien vorstellen, bevor wir tiefer ins Thema einsteigen?

DM: Ja, gerne… Also zu meiner Person, ich arbeite in nem Photovoltaik-Unternen, einem Mittelständler mit 150 Mitarbeitern und bin selbst in der Netzwerkkommunikation und im Qualitätsservice tätig. Und das Unternehmen, in dem ich arbeite, bietet Photovoltaik-Anlagen und Speicher für den Privatsektor an und wir verkaufen ausschließlich Lithium-Ion Speicher.

I: Okay, super! Das passt ja schon mal, dann würde ich sagen, steigen wir auch tiefer ins Thema ein und zwar, angefangen mit den Rentabilitätsaussichten, aus Perspektive eines Kunden, welches sind die wichtigsten finanziellen Aspekte, die die Rentabilität von Lithium-Ion Batterien auf dem Wohnungsmarkt bestimmen, insbesondere unter Berückstichtung der Anfangsinvestition und der langfristigen Betriebskosten?

DM: Gut. Ja, zur Rentabilität lässt sich sagen, dass die Anfangskosten den wesentlichen finanziellen Aspekt ausmachen. Die Kosten, zum Beispiel, wenn man ein Photovoltaik-System

mit Speicher kauft, kann man davon ausgehen, dass davon etwa die Hälfte für den Speicher bezahlt werden muss. Somit ist Batteriekapazität verhältnismäßig teuer in der Anfangsinvestition. Die laufenden Kosten sind dabei aber vernachlässigbar gering und gerade bei Lithium-Ion Batterien hat man quasi keine Wartungskosten. Das heißt, wenn das System einmal installiert ist, braucht man keine Wartung durchzuführen und die Rentabilität bzw. die Amortasisationszeit bei einem PV-System mit Speicher beträgt etwa so 12 – 15 Jahre und der Mehrwehrt im Betrieb ergibt sich dadurch, dass Strom eingespart wird bzw. das Strom gespeichert werden kann und dadurch eben zu einer späteren Stunde, also zum Beispiel Nachts verbraucht werden kann und somit wird dann Netbezug eingespart oder bzw. Strom aus dem Netz eingespart und demnach ist die Profitabilität auch Abhängig von den Stromkosten. Also wenn man jetzt mal eine Rechnung macht, wenn man von den aktuellen Strompreisen ausgeht, aber wenn die Strompreise weiter steigen, dann amortisiert sich eine Anlage auch entsprechend kürzer.

I: Okay, also insbesondere zu Krisenzeiten, kann sich solch eine Anlage eher lohnen?

DM: Ja, genau. Des Weiteren**,** ein Satz vielleicht dazu noch, die Kosten für Lithium-Ion Speicher sind auch drastisch gesunken in den letzten Jahren. Also Lithium-Ionen Speicher sind sowohl in Handys, Laptops, also in diversen alltagsgebräuchlichen Gegenständen und sind mittlerweile auch im Massenmarkt angekommen, also dementsprechend ist auch die Kostensenkung relativ stark und es ist davon auszugehen, dass die in den nächsten Jahren auch nochmal günstiger werden und dadurch auch nochmal profitabler werden.

I: Okay, super! Ja, dann danke schon mal für die Antwort zum Thema Aussichten kommen wir auch nochmal, aber ich würde mal sagen, wir kommen erstmal zur nächsten Frage, und zwar kommen wir zur betrieblichen Durchführbarkeit, welche technischen und logistischen Herausforderungen bzw. Anforderungen gibt es für den Einsatz und die Wartung von Lithium-Ion Speichern, insebesondere in Wohnhäusern?

DM: Angefangen mit den logistischen Herausforderungen. Also Speicher werden per Spedition zu Kunden geliefert und insofern sind da die Herausforderungen gering. Das ist ein alltäglich. Das passiert alltäglich bereits. Und die technischen Herausforderungen sind, gut zum einen natürlich der Platz in Wohnhäusern, der gegeben sein muss, mit entsprechenden Sicherheitsabständen. Das sind aber verhältnismäßig kleine Geräte und somit ist der Platz in einem normalen Wohnhaus gegeben. Ansonsten, Aspekte der Installation… sind auch. Also relativ einfach, dadurch, dass es bereits ein Produkt ist, was viele Installateure kennen, was

standardisiert ist und dadurch gibt's auch da keine großen Herausforderungen, also für normale Elektromonteure.

I: Okay, das hört sich dann ja machbar an. Dann würde ich sagen, gehen wir zur nächsten Frage über, zum Thema Nachhaltigkeit, was ja heutzutage immer relevanter wird. Und zwar, wie lassen sich die Produktion und der Lebenszyklus von Lithium Batterien mit dem Nachhaltigkeitsbegriff in Einklang bringen? Insbesondere im Hinblick auf den CO2 Fußabdruck und die Ressourceneffizient von eben solchen Speichergeräten?

DM: Zum Thema Nachhaltigkeit, also ein wesentlicher Bestandteil bei den Speichern ist, wie der Name schon sagt, Lithium und Lithium ist ein sehr häufiges Element… Es kommt allerdings nur in geringen Konzentrationen vor an den meisten Orten und die Abbaugebiete, in denen es vorrangig abgebaut wird, sind zum Beispiel, Chile, Bolivien und Argentinien. Dort gibt's beim Abbauprozess teilweise negative Auswirkungen auf den Grundwasserspiegel und, also das sind… Da gibt's einige Bedenken, wobei auch da gibt's mittlerweile schon Projekte Lithium zum Beispiel in Deutschland herzustellen oder zu Fördern, also insofern ist das verhältnismäßig ein kleiner Punkt, also das ist jetzt kein großes… kein großer…keine…

I: Große Herausforderung?

DM: Genau, keine große Herausforderung, also keine schlimme Auswirkungen auf die Natur und in Bezug auf den Co2 Fußabdruck lässt sich sagen, dass bei einem Lithium-Ion Speicher im Schnitt ungefähr 18 mal so viel Energie gespeichert werden kann, als bei der Produktion oder dem Abbau aufgewendet wird. Dafür gibt es auch einen Wert. Der nennt sich Energy Stored and Invested und wenn man das Ganze ins Verhältnis setzt und somit ist eben auch die Co2 Bilanz entsprechend positiv anzusehen. Und vorallem vor dem Hintergrund, dass ja vorallem grüner Strom in den Speicher, also in Verbindung mit einer PV-Anlage, in den Speicher eingespeichert wird, wird da auch entsprechend das Netz weniger belasted, man hat da keine Verluste durch den Transport im Netz und somit ist die Co2 Bilanz weitestgehend positiv.

I: Okay, super! Das hört sich ja gut an. Dann geht es nun zum Thema Kompatibilität mit Erneuerbaren Energiequellen, ich meine, du hattest es gerade angesprochen, in der Regel fließt dort grüner Strom rein, durch die PV-Anlagen, vor dem Hintergrund die Frage, wie gut lassen sich deiner Erfahrung nach Lithium-Ion Batterien in bestehende PV-Anlagen integrieren und wie verhalten sie sich, bei verschiedenen Klimabedingungen?

DM: Also grundsätzlich brauch man natürlich eine PV-Anlage und eben einen Speicher und oft ist das halt schon in einem Gerät kombiniert, sodass man quasi ein Kombigerät hat, was dann sowohl für die Umwandlung von der PV-Anlage genutzt wird, also von Gleich- zu Wechselstrom und gleichzeitg auch um die Batterie zu laden, also somit hat man dann gleichzeitig ein passendes Produkt zusammen, es ist aber auch möglich, in bestehende PV-Anlagen einen Speicher nachzurüsten. Das wäre dann, ein etwas anderer Typ, aber es ist beides problemlos möglich.

I: Und zum zweiten Teil der Frage, weißt du, ob es da Unterschiede gibt, wo meine PV-Anlage sich befindet, also in Bezug auf den Einfluss von Klima darauf und auf den Speicher?

DM: Also… allgemein lässt sich sagen, dass Lithium-Ion Speicher relativ robust sind und somit auch in verschiedenen klimatischen Umgebungen genutzt werden können. Bei den Speichern, die wir verbauen, ist in der Regel für die Garantie ein gewisser Rahmen gesetzt, der zum Beispiel von -5 bis 40 Grad geht. Das hängt aber auch dann von den Herstellern ab… Die Speicher, die wir nutzen, sind dann entsprechend für den deutschen Markt. Ich denke, da gibt es aber auch für diverse andere klimatischen Bedingungen, dann auch Speicher, die dafür entsprechend… robuster gemacht sind. Also insofern kann man schon sagen, dass es für diverse klimabedingungen tauglich ist, zumindest solange die sich im Rahmen halten und jetzt nicht unbedingt mitten in der Wüste sind, also ich denke da hätte man dann auch andere Probleme mit Staub…

I: Okay, alles klar! Weiter geht's mit nem kleinen vergleichenden Einblick und zwar, was sind deiner Meinung nach die eindeutigen Vorteile von Lithium-Ionen Speichern, gerade im Kontext von Speichermethoden für Solarstrom?

DM: Also wie anfangs schon erwähnt, zum einen ist es der sichere und wartungsarme Betrieb… Sicher im Sinne von, es ist ein Produkt, das im Massenmarkt angekommen ist und wartungsarm, gut, steckt schon im Wort, es fallen nicht viele Wartungen im Laufe der Lebenszeit an… Also Lithium-Ionen Speicher haben sehr viele Ladezyklen, also über 1000 Stück, das heißt, über 1000 Mal kann der Speicher voll be- und entladen werden. Das ist ein sehr großer Vorteil und zum Anderen, vorallem jetzt im Hinblick auf Wasserstoff, ist zu sagen, dass Lithium-Ionen Speicher einen sehr hohen Wirkungsgrad haben. Der liegt über 100%. Das heißt, wenn man etwas in die Batterie einspeichert und später wieder rausholt, dann hat man einen Wirkungsgrad von 100%. Die Kombination macht Lithium-Ion Batterien zu dem dominierenden Speichersystem im Heimsektor…

I: Super, danke dafür! Weiter geht es mit den markt- und regulatorischen Überlegungen. Und zwar hast du es ja schon ein paar Mal angeschnitten. Wie siehst du die aktuelle Entwicklung der Marktakzeptanz und des regulatorischen Umfeldes für Lithium-Ionen Batterien und welche Auswirkungen könnte dies auf deren Einsatz in privaten Solarenergiesystemen haben?

DM: Also die Akzeptanz im Markt die ist schon vollkommen da. Also sowohl bei den Kunden, die sich selbst oft vorab informiert haben und zum Anderen aber auch bei Förderprogrammen von Bundesländern, die dann den Zubau von Speichern zu PV-Anlagen dann auch noch fördert. Ja, da gibt's diverse Programme, zuletzt gab es auch von der KfW auch ein Programm, in dem die Kombination aus PV Speicher und Wallbox zum Beispiel mit bis zu 10.000 Euro gefördert wurde. Der Topf war dann aber auch sehr schnell ausgeschöpft, weil die Nachfrage so enorm war, aber das ist ein Beispiel dafür, wie es bereits angenommen wird, in der Gesellschaft. Zum regulatorischen Umfeld noch kurz, da ist es so, dass man beim jeweiligen Netzbetreiber den Speicher anmelden muss, genau so wie bei der PV-Anlage… Da werden die Hürden aber auch abgebaut, dadurch, dass es einfach ein Produkt ist, dass schon bekannt ist. Also auch in der Handhabung… Da gibt's bereits Verfahren, auch zur Onlineanmeldung und insofern sind da auch die Hürden relativ gering.

I: Okay, super! Dann kommen wir jetzt auch schon fast zu unserer letzten Frage und zwar Thema Zukunftsperspektiven, nochmal im Detail und zwar, wie siehst du die zukünftige Entwicklung und die Marktrolle von Lithium-Ionen bei der Speicherung von Solarenergie in Wohngebäuden? Du hattest ja gerade schon angeschnitten, dass aktuell Lithium Batterien die dominierende Solarspeichertechnologie darstellen. Meinst du das geht auch so weiter, also kurz und mittelfristig oder auch langfristig? Oder gibt es da andere Technologien, die da gerade Potenzial für die Ablösung von Lithium-Batterien haben?

DM: Also es gibt, soweit es mir bekannt ist, diverse Forschungsprojekte zu verschiedenen Stoffen, aber soweit es jetzt absehbar ist, dadurch das Lithium-Ion Batterien jetzt schon so dominierend sind und auch daran weitergeforscht wird und auch da die Preise weiter sinken, also, ist auf absehbarer Zeit, also meiner Meinung nach, sind Lithium-Batterien ohne… ohne Konkurrenz. Und insofern, also wie es dann in einigen, also mittelfristig, in den nächsten 10 Jahren dominieren Lithium-Ionen Batterien, meiner Meinung nach und wie es danach aussieht, wird sich dann in Zukunft zeigen. Vielleicht im Vergleich zu Wasserstoff, also Lithium Ionen Batterien sind vorallem als kurzzeitiger Speicher beliebt. Wasserstoff, da ist die Perspektive eher als Langzeitspeicher, wobei da noch weiter Forschung betrieben werden muss, also das ist

eher noch in den Kinderschuhen. Also sobald das im Markt ankommt, werden dann da bestimmt auch Preissenkungen und weiteres ankommen…

I: Ja, okay, super! Jetzt sind wir soweit durch mit den Fragen, also zum Schlusswort, wenn du noch irgendwie weitere Erkenntnise oder Vorschläge hast, die du mitteilen möchtest, oder Anmerkungen, gerne raus damit. Falls nicht, auch kein problem.

DM: Also, vielleicht noch ein letzter Satz. Also wie ich es eben schon erwähnte habe, ich bin auf jeden Fall ein Verfechter von Lithium-Ionen Batterien und denke auch, dass die die dominierende Rolle haben werden und das war's auch von meiner Seite!

I: Super, dann sind wir durch, vielen vielen Dank für die Zeit und die Einblicke, das hilft uns auf jeden Fall sehr weiter. Damit ist die Aufnahme zu Ende.