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Green energy at home: Potentials and Challenges of user integration through design thinking

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Abstract: **In the face of advancing climate change, the use of renewable energy in private households is becoming increasingly relevant. Households act as both energy consumers and potential energy producers. Their integration requires innovative approaches to overcome technical, economic and social barriers. In this context, the design thinking approach offers a user-centered methodology for developing sustainable energy concepts. This article examines the role of design thinking in promoting renewable energy in households. Based on a comprehensive literature review and the analysis of existing case studies, it is shown that design thinking produces creative and practical solutions through iterative processes. The approach addresses technological uncertainties, economic challenges and social acceptance problems by systematically integrating technical requirements and real user needs.**

The results make it clear that prosumer households in particular, which both consume and produce energy, can be specifically supported through design thinking in order to increase self-sufficiency and grid stability. It also shows that participatory and transparent design processes are key success factors for the social acceptance of renewable energy. Overall, it can be seen that design thinking can make a decisive contribution to the practical, user-oriented development of sustainable energy concepts. Through the structured implementation of the six phases of design thinking, innovative solutions are created that take into account both technical feasibility and social and economic viability. The consistent application of this approach can make a significant contribution to accelerating the decarbonization of energy in the private sector and establishing sustainable transformation processes at household level.

Keywords: **green energy, design thinking, renewable energy, decarbonization of energy.**

I. INTRODUCTION

The use of renewable energy in private households is becoming increasingly important in view of climate change (cf. Federal Environment Agency 2025). Households act as both energy consumers and potential energy producers. Their integration requires innovative approaches to overcome technical, economic and social barriers (cf. Windkraftjournal 2025). The design thinking approach offers a promising framework for this, as it focuses on creative, user-centered solutions. This article examines the potentials and challenges of renewable energy in households using design thinking, with the aim of developing practical strategies to promote the acceptance and dissemination of sustainable technologies (cf. O'Brian 2025).

Despite technological progress, obstacles remain. Uncertainties regarding implementation, high information requirements, complex regulations and financing hurdles are making the transition more difficult (cf. Agora Energiewende 2025). Technical challenges such as the integration of decentralized generation and a lack of control systems exacerbate the problem (cf. Bundesministerium für Wirtschaft und Energie 2023). Social acceptance barriers, for example in rental and multi-party buildings, as well as ecological conflicts of interest, for example due to rebound effects, also have a negative impact on the implementation of renewable energy solutions (cf. Fraunhofer ISE 2025).

The switch to renewable energy in the private sector offers great potential, but requires a holistic view of technical, economic, social and environmental aspects (cf. Deloitte 2025). The design thinking approach makes it possible to develop user-centered and sustainable solutions iteratively. The main objective of this article is to analyze the potentials and challenges of the decarbonization of energy in the household sector and to evaluate the contribution of design thinking in the development of innovative energy concepts (cf. ScienceDirect 2025). The focus is particularly on prosumer households that contribute to grid stability through active energy generation (cf. Frontierd 2025). In addition, concrete recommendations for action are to be formulated for politicians and the private sector in order to accelerate a sustainable, renewable energy supply.

Based on these considerations, the following research question arises: What role does the design thinking approach play in the development of sustainable energy concepts?

II. RELEVANCE OF THE CHOSEN TOPIC

The transition to a sustainable energy system is one of the central societal challenges of our time. In light of climate change, rising energy costs, and the need for energy security, private households are increasingly becoming active participants in energy generation and management. However, the implementation of renewable energy technologies at the household level is often hindered by a complex interplay of technological, economic, and social factors. Against this backdrop, the research question addresses a critical issue: how can we develop energy concepts that are not only technically feasible and economically viable, but also socially accepted and tailored to the actual needs of users? This is where Design Thinking comes in, as a method that systematically integrates user perspectives into innovation processes.

Design Thinking provides a structured yet adaptable methodological framework that places particular emphasis on empathy, creativity, and iterative development. Within the context of sustainable energy, this approach gains special relevance as it enables the systematic integration of user perspectives into complex innovation processes. It facilitates the development of user-friendly technologies, such as intuitive smart energy management systems, that meet the practical needs and expectations of end users. Furthermore, Design Thinking supports the creation of participatory solution models, including energy-sharing systems and citizen cooperatives, which promote social acceptance and engagement. By applying iterative prototyping and real-world testing, Design Thinking also helps to identify and address barriers to acceptance and implementation at an early stage. This approach thereby contributes significantly to the development of energy solutions that are not only technically feasible and economically viable, but also socially embedded and user-centered.

Thus, the research question is highly relevant as it explores whether and how Design Thinking can close the gap between technological innovation and practical application in everyday life. The answer to this question may provide valuable insights for policymakers, developers, and researchers working at the intersection of sustainability, innovation, and user engagement.

III. ANALYSE OF RECENT RESEARCH

Renewable energies include resources that are naturally regenerative and play a central role in a sustainable energy supply (cf. Agora Energiewende 2025). These include solar energy, wind energy, hydropower, bioenergy and geothermal energy (cf. BEE 2025). Solar energy uses the sun's radiation to generate electricity (photovoltaics) and heat (solar thermal energy), whereby technological advances have led to significant increases in efficiency and cost reductions (cf. Irena 2025). Wind energy converts the kinetic energy of the wind into electricity using turbines and offers great potential, particularly in windy regions. Hydropower uses the kinetic energy of water to generate electricity and is an established technology (cf. Bundesverband Windenergie 2025). Bioenergy uses organic materials to generate energy and makes a significant contribution to CO_2 reduction (cf. Bio-CO_2 Use and Removal 2025). Geothermal energy taps heat from the earth's interior, particularly in geologically active regions (cf. GeoTHERM expo & congress 2025).

A. Advantages during implementation

Essentially, there are five significant advantages that can be summarized in relation to the research question outlined above.

- **Economic Advantages:** Self-consumption systems such as photovoltaic (PV) installations offer substantial long-term cost savings by reducing the need to purchase electricity from the grid (cf. Fraunhofer Institute for Solar Energy Systems ISE, 2025). Even though government subsidies for renewable energy are gradually declining, the economic feasibility of these systems remains strong. This is largely due to steadily increasing electricity prices and decreasing technology costs, particularly for PV modules and batteries (cf. Finanztip, 2025). Additionally, hybrid energy systems—such as

combinations of solar power, battery storage, and district heating networks—can further enhance energy efficiency and overall profitability by optimizing energy use across multiple applications (cf. Reneva, 2025).

- **Promoting Innovation through Creative Problem-Solving**: Design Thinking provides a user-centered, iterative approach to innovation that enables the development of tailored solutions in the energy sector. By focusing on actual user needs and real-world challenges, this methodology fosters the creation of intuitive user interfaces for energy management systems, making complex technologies more accessible. Furthermore, it opens up new possibilities for innovative business models, such as peer-to-peer energy sharing within local communities, which support the decentralization of energy systems (cf. Michelon, Zhou, & Morstyn, 2025).
- **Environmental Friendliness and Sustainability:** The use of renewable energy sources significantly lowers greenhouse gas emissions and helps combat climate change by replacing fossil fuels with clean alternatives. Beyond CO_2 reduction, renewable systems also minimize air and water pollution, which contributes to improved public health and environmental quality (cf. Energas, 2025). Moreover, decentralized energy production—such as rooftop solar installations—reduces the need for large-scale infrastructure, thereby lessening the ecological footprint and preserving natural landscapes (cf. Federal Environment Agency, 2025).
- **Self-Sufficiency:** Design Thinking can play a crucial role in empowering users to become more energy-independent. By developing user-friendly systems and tools that facilitate the production, storage, and management of self-generated energy, individuals can gain greater control over their energy usage. This not only reduces reliance on central grid operators but also protects users from volatile energy prices, leading to long-term financial and operational benefits (cf. ESB Network, 2025).
- **Grid Stability:** As users become more integrated into the overall energy system—through technologies such as smart meters, load-shifting appliances, and automated demand response—they can actively contribute to balancing supply and demand on the grid. By adapting their energy consumption to align with periods of high renewable generation, such as sunny or windy conditions, they help to ease stress on the grid and improve overall system stability (cf. Reuters, 2025). This dynamic participation is especially important in energy systems with high shares of variable renewables.
- **Sustainable Behavior and Awareness-Building:** Actively involving users in the design and implementation of energy systems fosters a deeper understanding of energy flows and environmental impacts. This participatory process enhances ecological awareness and encourages behavioral changes that support sustainability in everyday life. As users develop a sense of ownership and responsibility for the energy they consume and produce, they are more likely to adopt energy-saving habits and advocate for broader ecological practices (cf. Bremer, 2025).

B. Challenges during implementation

However, renewable energies are not only associated with advantages; there are also a few disadvantages and challenges that need to be considered.

- **Technological barriers:** The volatile feed-in of renewable energy requires efficient storage and management solutions. In addition, the integration of decentralized generators into existing grid structures is a key challenge (cf. VDE 2025).
- **Costs and investments:** High initial investments remain a barrier to entry, although there are long-term operating cost benefits. Government funding programmes and alternative financing models such as citizen participation can mitigate the economic burden (cf. Agora Energiewende 2025).
- **Social acceptance and legal framework:** Acceptance problems often arise due to a lack of participation and insufficient information. Fair distribution of the cost-benefit effects and participation models such as energy cooperatives increase acceptance. In addition, flexible legal frameworks are necessary to enable innovative approaches (cf. Fachagentur Windenergie 2025).

Based on this knowledge, the research question posed above can be answered as follows: The design thinking approach plays a central role in the development of sustainable energy concepts by enabling user-centered, creative and iterative solutions to the complex challenges of the decarbonization of energy in private households. Given the technological, economic and social barriers to the integration of renewable energy, design thinking offers a methodical approach that takes into account both technical requirements and user needs. The structured application of the six phases allows innovative energy concepts to be systematically developed and continuously adapted to real-life conditions.

The Figure illustrates the main contents in a systematically structured overview of key points. The integration of renewable energy in private households holds considerable potential, but requires technological, financial and social hurdles to be overcome (cf. Depta 2024). The design thinking approach offers a promising tool for developing sustainable and accepted solutions.

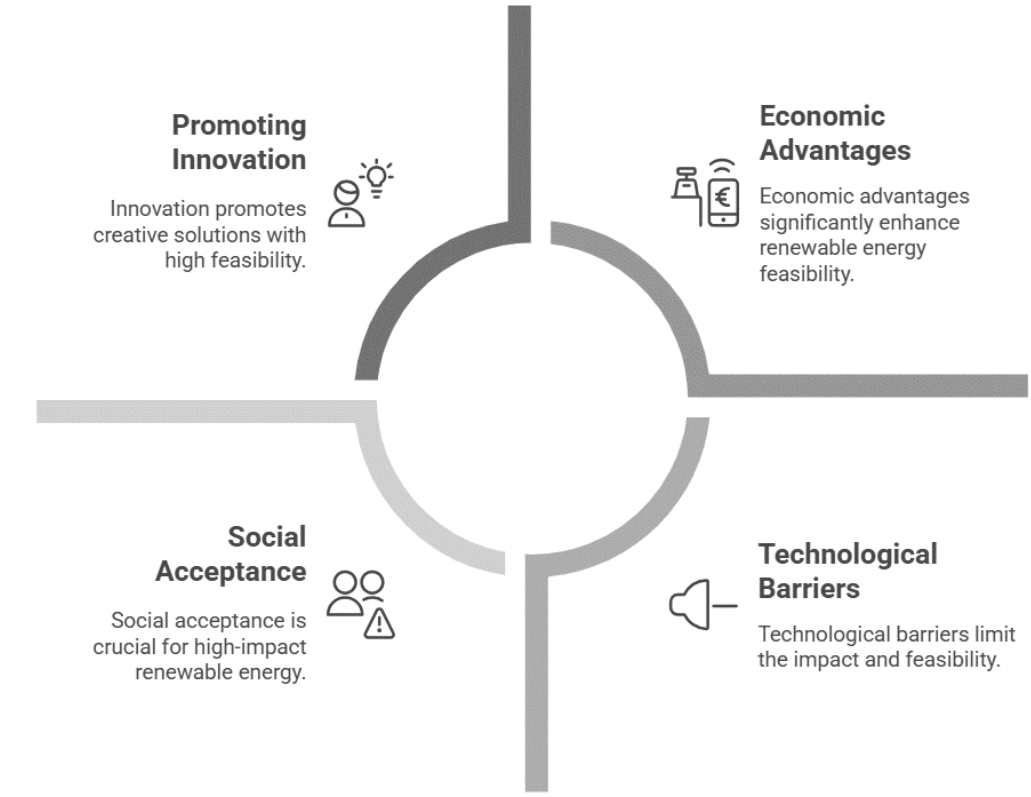

Figure 1: Renewable Energies - Advantages and Challenges

Source: Own representation

The expansion of renewable energy is essential in order to reduce dependence on fossil fuels and meet rising energy demand in a sustainable manner. This requires technological innovation, political support and social acceptance (cf. World Economic Forum 2025).

Relevance for private households: Renewable energy technologies such as photovoltaic systems and heat pumps enable households to reduce their ecological footprint and cut energy costs in the long term (cf. Fraunhofer ISE for Solar Energy 2025). Studies show that the electricity production costs of photovoltaic systems are now lower than end customer prices, which significantly increases their economic viability (cf. KfW 2025). Support programs and innovation processes are crucial to lowering investment barriers and strengthening social acceptance (cf. BEG 2025).

Developments and trends: Technologies such as solar and wind energy are constantly evolving and are becoming increasingly cost-efficient (cf. BloombergNEF 2025). The increased use of decentralized generation and storage technologies contributes to security of supply and system resilience (cf. S&P Global 2025). The sector coupling of electricity, heat and mobility as well as political measures such as research funding and market launch programs are accelerating the expansion of renewable energies (cf. Matidor 2025). Furthermore, these technologies not only make environmental contributions, but also promote local value creation and employment (cf. Vox 2025).

Design thinking as an innovation approach: Design thinking is a user-centered, interdisciplinary innovation approach that generates creative and practical solutions through iterative processes (cf. nuvio 2025). The process is divided into six phases (cf. Emeritus 2025): Understanding, observing, defining perspectives, finding ideas, developing prototypes and testing. Key characteristics are empathy with user needs, collaborative teamwork and rapid prototyping (cf. Charles Amith 2025). Studies show that design thinking can significantly improve innovation processes in the public and private sectors and also support social and political transformation processes (cf. EY Design Studio 2025).

Application of design thinking to renewable energy in households: Design thinking can be used to develop customized solutions for the integration of renewable energy in households (cf. Pedersen & van der Kaaij 2025). In the understanding phase, ecological, economic and social framework conditions are analyzed. In the observation phase, the needs and behavior of users are examined in detail. The definition of perspectives structures these findings and enables the targeted development of ideas (cf. Kumar 2025). In the idea generation phase, a variety of solution approaches are generated, which are transformed into initial feasible concepts and tested in the prototype development phase (cf. Laghari 2025). Finally, the test phase enables the concepts to be validated under real conditions and ensures their user-centric optimization (cf. Shreeram 2025).

The iterative nature of the design thinking process makes it possible to identify and address technical, economic and social challenges at an early stage (cf. Emeritus 2025). Design thinking is therefore an effective tool for sustainably promoting the acceptance and implementation of renewable energy in the private sector (cf. Triangility 2025).

IV. PURPOSE OF THE ARTICLE

The primary purpose of this article is to explore the relevance and applicability of the design thinking approach in the development of sustainable energy concepts, particularly within the private household sector. In light of pressing challenges such as climate change, rising energy costs, and the growing need for decentralized solutions, the integration of renewable energy at the household level is both necessary and complex. This complexity stems from a combination of technological, economic, and social barriers that hinder widespread adoption. Against this backdrop, the article examines how design thinking; as a user-centered, iterative innovation methodology can contribute to overcoming these barriers. Through the systematic analysis of recent research, publications, and case-based literature, the article aims to assess the extent to which design thinking can be employed to create practical, socially accepted, and technically viable energy solutions. The focus lies particularly on prosumer households, which play a dual role as both energy consumers and producers.

The article seeks to generate strategic insights and actionable recommendations for policymakers, energy providers, and technology developers by demonstrating how design thinking can foster user engagement, support innovation, and promote the acceptance of renewable energy technologies. In doing so, it contributes to the ongoing discourse on how interdisciplinary and participatory approaches can support the decarbonization of the energy system in a socially inclusive and economically sustainable manner.

V. METHODOLOGY

The objective of this article is to systematically analyze and evaluate the contribution of the design thinking approach to the development of sustainable energy concepts in the context of private households. In light of the growing importance of renewable energy and the existing technical, economic, and social barriers to implementation, the article examines the extent to which design thinking, as a user-centered and iterative innovation approach, is suitable for developing practical, widely accepted, and holistic solutions for the decarbonization of the household energy sector.

At the core of the analysis is the question of what potentials and limitations design thinking offers in the integration of renewable energy, and how this approach can be aligned with existing technical and political frameworks. Using a qualitative document analysis, relevant studies, practical examples, and publications are evaluated to derive actionable recommendations for policymakers, industry, and society. This article is based exclusively on the method of document analysis. Relevant specialist literature, scientific studies and relevant publications are systematically selected and evaluated for data collection. The aim is to enable a well-founded and differentiated discussion of the potential and challenges of using renewable energy in private households.

It begins with a terminological clarification of key terms. Building on this, the sources analyzed are used to classify and critically discuss the topic in its technical, social, economic and ecological context. It concludes with a critical reflection on the results and an outlook on future fields of research and application. The analysis is based on a comprehensive literature review and the evaluation of existing case studies. In addition, the interactions between space and technology in the context of the decarbonization of energy are examined. The aim is to develop a differentiated, holistic understanding of the challenges and opportunities in the implementation of renewable energy using the design thinking approach.

The use of renewable energy in private households offers significant ecological and economic benefits, but also poses challenges that require innovative approaches such as design thinking (cf. Agora Energiewende 2025). By reducing greenhouse gas emissions, renewable energies make an important contribution to climate protection and enable households

to make long-term cost savings (cf. KfW 2025), for example through the use of photovoltaic systems or heat pumps (cf. Fraunhofer ISE 2025).

Despite this potential, there are obstacles such as high initial investments, technological uncertainties and social acceptance problems (cf. Obuseh et al. 2025). Aesthetic concerns and a lack of information also have a negative impact on dissemination. Design thinking offers a systematic framework for iteratively integrating technical, economic and social aspects into user-centered solutions (cf. Alcook 2025). Successful implementation of renewable energy in households therefore requires an integrative, multifactorial approach (cf. Obuseh et al. 2025).

By focusing strongly on user perspectives, solutions can be identified that effectively address technical uncertainties, high initial investments and acceptance problems. Particularly in the area of prosumer households, which both consume and generate energy, design thinking helps to increase self-sufficiency and promote grid stability (cf. Sovacool & Dworkin 2025). The approach also helps to overcome social and legal barriers by developing participatory, understandable and visible value-added solutions that enable broader social acceptance of renewable energy (cf. PwC 2024). This is essential in order to overcome existing information deficits, aesthetic reservations and participation gaps.

Overall, it can be seen that design thinking can make a decisive contribution to the practical development of sustainable energy concepts (cf. Pedersen & van der Kaaij 2024). It creates a methodological foundation that addresses technical feasibility, economic viability and social acceptance in equal measure and thus enables the successful implementation of the decarbonization of energy at the household level (cf, Hasso Plattner Institute 2024).

The outlook for the use of renewable energy in private households using design thinking shows a promising picture, but also significant challenges (cf. Pedersen & van der Kaaij 2024). Comprehensive European cooperation could bring significant cost savings in the expansion of renewable energy. This includes in particular the optimization of locations and the use of economies of scale (cf. European Commission 2025).

Empathize: This stage involves understanding the user's needs, motivations, and pain points. This can be achieved through various research methods, such as interviews, surveys, observations, and user testing. The goal is to develop a deep understanding of the user's perspective. Define: In this stage, the problem is clearly defined based on the insights gathered during the empathize stage. This involves synthesizing the research data and identifying the core problem that needs to be solved. The problem statement should be human-centered and focus on the user's needs. Ideate: This stage is about generating a wide range of potential solutions to the defined problem. It encourages brainstorming, sketching, and other creative techniques to explore different possibilities. The goal is to generate as many ideas as possible, without judgment. Prototype: In this stage, the most promising ideas are turned into tangible prototypes. These prototypes can be simple sketches, paper models, or more sophisticated digital prototypes. The goal is to create something that can be tested and evaluated. Test: This stage involves testing the prototypes with users to gather feedback and identify areas for improvement. The feedback is then used to refine the prototypes and iterate on the design. This process is repeated until a satisfactory solution is achieved.

The illustration below makes it clear that Design Thinking is to be understood as a system of stages. Furthermore is possible from each step to jump back to the process before or complete to start at the beginning.

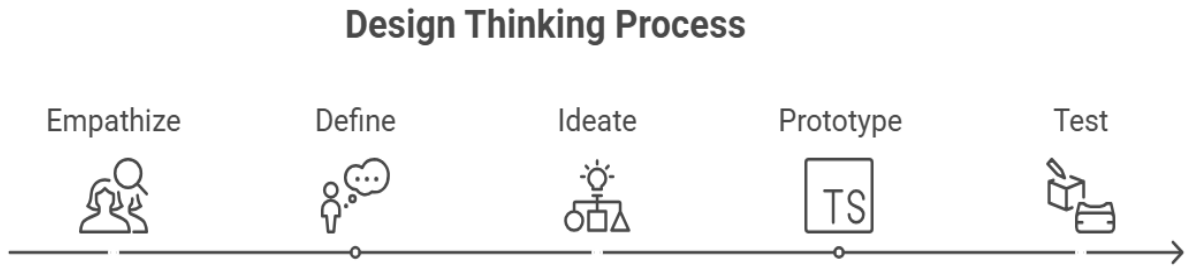

Figure 2: Design Thinking Process

Source: Own presentation

Design thinking offers a potentially valuable methodological approach to promoting innovation by enabling user-centered solutions to be developed and technological barriers to be overcome. In the long term, the technological integration and acceptance of renewable energy will be crucial (cf. Axpo Holding company 2025). The transformation also requires

considerable investment in infrastructure. For example, the expansion of grid capacities will be necessary in order to adequately handle the fluctuating feed-in of renewable energies (cf. German Federal Network Agency 2025). Another important employee survey topic area is social acceptance, which must be promoted through participatory planning processes and transparent communication strategies. Overall, it is clear that the consistent and coordinated implementation of the use of renewable energy, supported by innovative methods such as design thinking, is a promising way to shape the energy future of private households in a sustainable and economical way (cf. Bundesverband der Energie- und Wasserwirtschaft 2025).

VI. CONCLUSION

While design thinking offers promising perspectives for energy decarbonization, its actual relevance for transforming private households remains questionable. The approach is presented as a near-universal solution but without addressing methodological limits or practical challenges. Its focus on user needs neglects systemic, regulatory, and infrastructural constraints, as well as issues like grid integration, storage, and scalability.

The article relies mainly on theory, lacking empirical evidence for effectiveness. It centers on privileged prosumer households, overlooking socio-economic inequalities that may limit access to renewable technologies. Without targeted support and inclusive participation models, design thinking could reinforce existing disparities.

Cultural and psychological resistance to change also receives little attention. Effective solutions require combining user-centered innovation with technological, political, and social system analysis. Pilot projects and case studies should test its applicability, while interdisciplinary cooperation should integrate technical, economic, and cultural perspectives.

In sum, the potential of design thinking is overstated, and complementary systemic approaches are needed to address the complex challenges of energy decarbonization.

REFERENCES

[1] Agora Energiewende. (2025). Status of the decarbonization of energy 2025: Progress and obstacles to the expansion of renewable energy. Berlin: Agora decarbonization of energy. Retrieved from https://www.agora-energiewende.de

[2] Alcock, P. (2025). Design Thinking: Navigating Complexity in 2025. LinkedIn. https://www.linkedin.com/pulse/ design-thinking-navigating-complexity-2025-phillip-alcock-cgtkc

[3] Axpo Holding AG. (2025). Think inside the box: How design thinking reduces energy waste. https://www.axpo. com/ch/de/wissen/magazin/innovationsmanagement/ think-inside-the-box.html

[4] Bioenergia. (2025). Bioenergie und CO_2 Reduction. Bio-CO_2 Use and Removal 2025.Bioenergy Association of Finland. Retrieved from https://www.bioenergia.fi/en/2025/02/14/join-bio-co2-use-and-removal-2025-in-helsinki-on-may-6/

[5] Bremer, A.-K. (2025). Nachhaltigkeitsbewusstsein, nachhaltiges Konsumverhalten und Lebensqualität: Die Sicht junger Menschen zwischen 14 und 25 Jahren [Dissertation, Universität Bielefeld]. Budrich Academic Press. Retrieved from https://www.pedocs.de/volltexte/2025/32302/pdf/Bremer_2025_Nachhaltigkeitsbewusstsein.pdf.

[6] Bundesministerium für Wirtschaft und Energie. (2023). Renewable energies in Germany: Report 2023. Berlin: Retrieved from https://www.bundeswirtschaftsministerium.de/Redaktion/DE/Publikationen/Energie/20241129-erneuerbare-energien-in-zahlen-2023.pdf?__blob=publicationFile&v=12

[7] Bundesnetzagentur (2025). Network development plans 2025. https://www.netzentwick lungsplan.de/archiv/ netzentwicklungsplaene-2025

[8] Bundesverband der Energie- und Wasserwirtschaft (BEE). (2025). 47 Arguments in favor of renewable energy. Retrieved from https://www.bee-ev.de/service/publikationen-medien/ argumentarium

[9] Bundesverband Erneuerbare Energie. (2025). Climate balance of the traffic light system: stabilizing important progress through the expansion of renewables. Retrieved from https://www.bee-ev.de/service/pressemitteilungen/ beitrag/klimabilanz-der-ampel-wichtige-fortschritte-durch-den-ausbau-der-erneuerbaren-nun-verstetigen

[10] Bundesverband WindEnergie. (2025). Facts about wind energy. Retrieved April 27, 2025, from https://www.wind-energie.de/fileadmin/redaktion/dokumente/ publikationen-oeffentlich/themen/01-mensch-und-umwelt/01-windkraft-vor-ort/bwe_abisz_3-2015_72dpi_final.pdf

[11] CharlesAmith. (2025). The 6 Phases of the Design-Thinking Framework. Retrieved from https://charlesamith.com/blog/ux-design/design-thinking

[12] Deloitte Insights. (2025). 2025 Renewable Energy Industry Outlook. https://www2.deloitte.com/us/en/insights/industry/renewable-energy/renewable-energy-industry-outlook.html

[13] Depta, M. (2024). Decarbonization of energy 2024: What the green electricity record really means. https://energiefahrer.de/energiewende-2024-was-der-gruenstromrekord-wirklich-bedeutet/

[14] Emeritus. (2025). The 6 Stages of the Design Thinking Process and Why They are Important. Retrieved from https://emeritus.org/blog/product-design-innovation-design-thinking-process/

[15] Energás Ltd. (2025). The advantages and disadvantages of decentralized energy generation. Retrieved from https://energas-gmbh.de/dezentrale-energieerzeugung/

[16] Erneuerbare Energien Hamburg Cluster Agency. (2024). Design Thinking - Solving problems and shaping innovation. Hamburg: EEHH. Retrieved from https://www.erneuerbare-energien-hamburg.de/de/blog/details/design-thinking-probleme-l%C3%B6sen-und-innovation-gestalten.html

[17] ESB Networks. (2025). Innovation 2025: Innovation to Deliver Networks for Net Zero. ESB Networks.

[18] Europäische Kommission. (2025). New action plan: save EUR 260 billion in energy costs per year by 2040. https://commission.europa.eu/news/new-action-plan-save-eu260-billion-annually-energy-2040-2025-02-26_de

[19] European Environment Agency (EEA). (2025). Financing the energy transition: Barriers and opportunities for private households. Copenhagen: EEA. Retrieved from https://www.eea.europa.eu

[20] EY Design Studio. (2025). What is the design thinking process? Retrieved from https://studio.ca.ey.com/insights/six-key-stages-of-effective-design-thinking

[21] Fachagentur Windenergie an Land. (2025). New regulations on financial participation increase acceptance. Retrieved from https://www.fachagentur-windenergie.de/fileadmin/files/Veroeffentlichungen/Beteiligung/FA_Wind_Solar_Kompaktpapier_Kommunalbefragung_Paragraph_6_eeg.pdf

[22] Finanztip. (2025). Photovoltaics 2025: Is a solar system worthwhile? Retrieved from https://www.finanztip.de/photovoltaik

[23] Fraunhofer Institut for Solar Energy Systems ISE. (2025). Current facts on photovoltaics in Germany. Retrieved from https://www.ise.fraunhofer.de/content/ dam/ise/en/documents/publications/studies/aktuelle-fakten-zur-photovoltaik-in-deutschland.pdf

[24] Fraunhofer Institute for Solare Energiesysteme ISE. (2025). Study: LCOE of renewable energies. Retrieved April 27, 2025, from https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/studie-stromgestehungskosten-erneuerbare-energien.html

[25] Frontiers. (2025). Green transition for vulnerable households? Insights from behavioral science. Retrieved from

[26] Geothermie in geologisch aktiven Regionen: GeoTHERM expo & congress 2025. (2025). European Geothermal Energy Council. Retrieved from https://www.egec.org/events /geotherm-expo-congress-2025/

[27] German Association of Energy and Water Industries. (2025). Power lines: Fast lane for renewable energies. https://www.bdew.de/online-magazin-zweitausend50/neustart/stromtrassen-ueberholspur-fuer-erneuerbare/

[28] Hasso Plattner Institute. (2024). Design Thinking - innovative ideas for sustainability. https://hpi.de/en/d-school/article/design-thinking-innovative-ideas-sustainability/

[29] International Renewable Energy Agency (IRENA). (2025). Tripling renewable power and doubling energy efficiency by 2030. https://www.irena.org/Digital-Report/Tripling-renewable-power-and-doubling-energy-efficiency-by-2030

[30] Internationale Agentur für Erneuerbare Energien (IRENA). (2025). Record-breaking annual growth in renewable energy. Retrieved from https://www.irena.org/ News/pressreleases/2025/Mar/Record-Breaking-Annual-Growth-in-Renewable-Power-Capacity-DE

[31] KfW. (2025). The heat pump is establishing itself in Europe - the electricity price as a factor. Retrieved April 27, 2025, from https://www.kfw.de/PDF/Download-Center/ Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-2025/Fokus-Nr.-487-Februar-2025-Waermepumpen.pdf

[32] KPMG. (2025). The human side of https://assets.kpmg.com/ content/dam/kpmg/au/pdf/2025/human-side-of-energy-transition-2025.pdfthe energy transition.

[33] Kumar, A. (2025). Design Thinking: A Human-Centered Approach to Innovation. LinkedIn. Retrieved from https://www.linkedin.com/pulse/design-thinking-human-centered-approach-innovation-amit-kumar-oa7xc

[34] Laghari, R. (2025). Design Thinking: A Framework for Innovation. Medium. Retrieved from https://medium.com/@riazleghari/design-thinking-a-framework-for-innovation-2065aff32a98

[35] Landesverband Erneuerbare Energien Niedersachsen/Bremen (2025). Wind energy. Retrieved from https://lee-nds-hb.de/erneuerbare/windenergie/

[36] Matidor. (2025). New Trends in the Renewable Energy Space for 2025. https://matidor.com/blog/new-trends-in-the-renewable-energy-space-for-2025

[37] McKinsey & Company. (2025). Future path of electricity demand. Düsseldorf: McKinsey & Company. Retrieved from https://www.mckinsey.de/~/media/mckinsey/ locations/europe%20and%20middle%20east/germany/news/press/2025/2025-01-20%20future-path%20electricity-demand/mckinsey_future-path%20electricity-demand_january%202025.pdf

[38] Michelon, F., Zhou, Y., & Morstyn, T. (2025). Large Language Model Interface for Home Energy Management Systems. arXiv preprint arXiv:2501.07919.

[39] NetBramha. (2025). Designing a Greener Future: How Design Thinking is Tackling Climate Change in 2025. LinkedIn Pulse. https://www.linkedin.com/pulse/designing-greener-future-how-design-thinking-tackling-xjpfc

[40] nuvio. (2025). Design Thinking - Method. Retrieved April 27, 2025, from https://nuvio.health/design-thinking-als-innovationsansatz/

[41] O'Brien, C. (2025). 2025 Communities, Energy & Infrastructure Trends. Guidehouse. Retrieved from https://guidehouse.com/insights/communities-energy-infrastructure/ 2025/2025-cei-trends Advisory, Technology & Managed Services

[42] Obuseh, E., Eyenubo, J., Alele, J., Okpare, A., & Oghogho, I. (2025). A systematic review of barriers to renewable energy integration and adoption. Journal of Asian Energy Studies, 9, 26-45. Retrieved from https://www.researchgate.net/publication/388372445-_A_Systematic_Review_of_Barriers_to_Renewable_Energy_Integration_and_Adoptio

[43] Ozsoy, C. M., & Mengüç, M. P. (2024). A Transdisciplinary Approach and Design Thinking Methodology: For Applications to Complex Problems and Energy Transition. World, 5(1), 119-135. https://doi.org/10.3390/world 5010007

[44] Pedersen, M. B., & van der Kaaij, J. (2024). From pledge to performance: Using design thinking to achieve sustainability goals. I by IMD. https://www.imd.org/ibyimd/sustainability/from-pledge-to-performance-using-design-thinking-to-achieve-sustainability-goals/

[45] Pedersen, M. B., & van der Kaaij, J. (2025). From pledge to performance: Using design thinking to achieve sustainability goals. I by IMD

[46] PwC Legal & eueco. (2024). German Study on Citizen Financial Participation (DSFB). https://legal.pwc.de/fachartikel/Allgemein/pwc-dsfb-deutsche-studie-finanzielle-buergerbeteiligung-eueco-2024.pdf

[47] Renewa. (2025). Photovoltaic system: Costs & profitability 2025. Retrieved from https://renewa.de/wissen/photovoltaik/pv-kosten

[48] Reuters. (2025, March 18). US grids must harness electric vehicle growth to tackle load risks. Reuters. https://www.reuters.com/business/energy/us-grids-must-harness-electric-vehicle-growth-tackle-load-risks-2025-03-18/.

[49] Rusch, Magdalena: Sustainable innovations by design thinking. GAIA: Ecological Per-spectives for Science & Society, 32(3), 2023

[50] S&P Global. (2025). Top Cleantech Trends for 2025. https://www.spglobal.com/ content/dam/spglobal/ci/en/ documents/news-research/special-reports/top-cleantech-trends-for-2025.pdf

[51] ScienceDirect. (2025). Co-designing the urban energy transition: A resident-based approach. Retrieved from https://www.sciencedirect.com/science/article/pii/ S0264275124007200

[52] Shreeram, V. T. (2025). The Design Thinking Process: A Step-by-Step Guide to Innovation. LinkedIn. Retrieved from https://www.linkedin.com/pulse/design-thinking-process-step-by-step-guide-innovation-vt-shreeram-sijhc

[53] Sovacool, B. K., & Dworkin, M. H. (2025). Participation as a pathway to procedural justice: A review of energy initiatives. Energy Research & Social Science, 96, 102345. https://www.sciencedirect.com/science/article/ pii/S2214629625000635

[54] Triangility. (2025). Design thinking process: 6 phases to ideas and solutions. Retrieved from https://triangility. com/design-thinking-process/

[55] Umweltbundesamt. (2025). Emissions balance of renewable energy sources - Determination of avoided emissions in 2023. Retrieved from https://www.umweltbundes amt.de/sites/default/files/medien/11850/publikationen/03_ 2025_cc_emissionsbilanz_erneuerbarer_energien_2023.pdf

[56] Umweltbundesamt. (2025). Renewable energies in figures. Retrieved from https://www.umweltbundesamt.de/ themen/klima-energie/erneuerbare-energien/erneuerbare-energien-in-zahlen

[57] VDE. (2025). Energy storage for the decarbonization of energy: Storage requirements and effects on the transmission grid for scenarios up to 2050. Retrieved from https://www.vde.com/energiespeicher

[58] Vox. (2025). 10 charts prove that clean energy is winning - even in the Trump era. https://www.vox.com/ climate/377072/data-energy-trends-renewables-transition-escape-velocity

[59] Windkraft Journal. (2025, March 27). Consumers underestimate CO_2 emissions of private households. Retrieved April 27, 2025, from https://www.windkraft-journal.de/2025/03/27/verbraucher-unterschaetzen-co2-emissionen-privater-haushalte/209857

[60] World Economic Forum. (2025). Financing the Energy Transition: Meeting a Rapidly Evolving Landscape. World Economic Forum. https://reports.weforum.org/ docs/WEF_Financing_the_Energy_Transition_2025.pdf