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Solar for Peat's Sake

Exploring Challenges and Opportunities with Ground Mounted Photovoltaics on Former Peat Extraction Sites in Sweden

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Abstract

Renewable energy expansion and carbon sink enhancement are central to developing sustainable climate pathways, yet the rapid deployment of renewable energy technologies is intensifying land-use competition and increasing the need for more resource-efficient siting strategies. Solar development on former peat extraction sites represents one such approach, as it enables the use of degraded land while avoiding conflicts with higher-value land uses. When combined with peatland rewetting, this approach may also provide dual climate benefits by integrating renewable energy generation with carbon sink preservation. Despite this potential, empirical research on the feasibility and current development of such projects remains limited. This thesis addresses this gap by examining the experiences and perspectives of 6 key stakeholder groups in Sweden. Guided by the PESTLE framework and the land–energy–climate nexus, the study assesses the opportunities and constraints associated with solar deployment on cut peatlands. The findings indicate a generally positive perception of the suitability of cut peatlands for solar development, particularly when combined with rewetting due to the potential of combined climate benefits. The viability of such projects is currently constrained by profitability concerns related to low electricity prices, limited grid capacity, and the use of novel technologies adapted to these land conditions. In addition, regulatory complexity and the absence of clear guidelines contribute to uncertainty among both developers and authorities, while the lack of financial incentives for integrating rewetting with solar development risks limiting the realization of the full climate benefits associated with these projects.

Keywords: *Solar development, after-use treatment of cut peatlands, land-use competition, multifunctional solar*

Executive Summary

To curb the trend of increased greenhouse gas emissions there is a need to decarbonize the energy sector and preserve existing carbon sinks. While renewable energy deployment offers low emitting electricity production, land-use conflicts of where to install them are becoming of increasing concern (Capellán-Pérez et al., 2017; Lamhamedi & Vries, 2022). This trend is also observable in Sweden where most large-scale ground mounted solar parks are being developed on arable land which is being questioned by regulating bodies and scholars as it risks hindering food security (Belzons Berthelemot et al., 2026). There is therefore a need for resource-efficient siting for solar development where the literature points towards degraded land, or alternatively integrated solar development with additional ecological, agricultural or social functions, often called multifunctional solar (Milbrandt et al., 2014; Oudes et al., 2022).

In light of these challenges, former peat extraction sites, also called cut peatlands, offer a promising land category with the potential of dual climate benefits when combined with rewetting. Active and inactive peat extraction sites in Sweden amount to around 24 000 hectares which emit around 10 ton CO_2 per hectare yearly, however, these emissions can be substantially reduced if the land is rewetted (Kasimir & Lindgren, 2024; SCB, 2023). Cut peatlands as a land type for solar development is gaining attention internationally mainly in Finland and Germany, with multiple permits awarded for solar development in Sweden. While these developments point towards emerging interest, significant knowledge gaps remain in terms of challenges and opportunities with this new land type as well as the enablers and barriers that would allow for combined solar development and rewetting initiatives.

Research Aim and Questions

From this background the aim of this thesis was to study the former peat extraction sites as a new land area for solar development and to decrease land-use competition from ground mounted solar power installations. The thesis also investigates the synergies and trade-offs that may exist with combined solar development and rewetting initiatives. The research questions studied were therefore:

RQ1: What is the current state of knowledge and development of solar power on former peat extraction sites in Sweden?

RQ2: Are former peat extraction sites a viable land area for solar power development?

RQ3: What are the opportunities and challenges for multipurpose land-use strategies that combine solar on former peat extraction sites with rewetting initiatives?

Research Design

This research takes a qualitative approach as its design where expert interviews were performed as the primary method for data collection. In total 16 interviews with 17 participants were conducted from six stakeholder groups, Technology Developers, Solar Developers, County Administration Boards, Interest Organizations, Researchers and one large Consultancy. This thesis used the PESTLE[1] framework and nexus approach as analytical frameworks which provides a soft structure to the background and literature review, stakeholder categorization, interviewee selection as well as the results and discussion. The collected materials were coded

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[1] Acronym for Political (P), Economic (E), Social (S), Technological (T), Legal (L), Environmental (E)

using NVivo software, applying both deductive and inductive codes which allowed for both a top-down and bottom-up approach.

Results

The current state of knowledge and development of solar on cut peatlands in Sweden (RQ1)

Development of solar projects on cut peatlands are concentrated to the permitting phase of development where no large-scale parks have been built. The findings identify large interest in the topic from all stakeholder groups, although knowledge gaps and uncertainties are present at all levels. Solar developers had a preference for dryer land conditions and were cautious towards new technologies that allow for wetter land conditions but result in higher investment costs. County Administration Boards are hesitant towards the potential impact of shading and leaching from the panels while also not in agreement on whether solar development can be considered an after-use treatment option for cut peatland sites. There also appears to be a discrepancy between peatland researchers and the rewetting strategy in Sweden, where the strategy has a strong focus on thick, organic, drained peat soils for rewetting while some researchers instead highlight the benefits of rewetting nutrient poor cut peatlands. However, many knowledge gaps and uncertainties are driven by the lack of projects that can provide quantitative insights into environmental and economic impacts from this land use strategy.

Viability of former peat extraction sites for solar power development (RQ2)

The thesis found former peat extraction sites to be suitable land areas for solar development, especially when combined with rewetting. However, the viability of these types of projects are currently limited by economic constraints. These constraints were identified to mainly be driven by the external market environment for solar development in Sweden where volatile and low electricity prices during the hours of solar production as well as grid constraints create a challenging business environment for solar developers. Technological challenges for cut peatlands were mainly identified for piled solutions in wetter and acidic environments whereas semi-floating or sitting peat buckets were considered to provide suitable technological characteristics for wetter peat soils. However these newer technological solutions are restrained by their higher cost.

Beyond economic constraints, multiple aspects of former peatland sites make them suitable for solar development. The low ecological value and remoteness of the sites were identified as the two main benefits contributing to higher regulatory and social acceptance while simultaneously decreasing the pressure on more valuable land such as croplands and forests. In addition, the findings highlight the size, flatness and lack of vegetation as beneficial for solar development.

Challenges and opportunities for solar development as a multipurpose land-use strategy (RQ3)

Combining solar development on cut peatlands with rewetting was considered a positive land use strategy, albeit not without challenges. Besides higher costs, which were perceived as a challenge for both solar development with and without rewetting initiatives. The results identify insufficient incentives for rewetting, a lack of proven environmental and climate benefits as well as the novelty of this approach as key barriers to its development.

On the other hand, the findings point towards dual climate benefits from carbon sink preservation and renewable energy generation, increased solar efficiency from panel cooling and reflectivity from rewetted surfaces as well as reduced panel soiling caused by dust from cut peatlands. Moreover, solar development was viewed as a land-use strategy that could facilitate the expansion of rewetted peatlands, which has historically been challenging because of landowners reluctance to rewet land that supports income-generating activities. For regulatory bodies, this combined approach may therefore provide a pathway to achieving compliance with the forthcoming Nature Restoration Law.

Conclusions and Recommendations

The study concludes that cut peatlands without rewetting initiatives can be considered a marginalized land area while cut peatlands with rewetting initiatives can be considered a multifunctional land-use strategy where both cases can be suitable for solar development. However, for full climate and environmental benefit, solar development should be conducted together with rewetting initiatives. Barriers to these land-use combinations are characterized by limited research and praxis creating large uncertainties in how the development should be conducted. There is therefore a need for guidelines and directions to ensure that environmental synergies are maximized while minimizing trade-offs.

Future research would benefit from comparing the climate benefit from solar development on cut peatlands with and without rewetting initiatives as well as study the impact from panel shading on peatland vegetation. Furthermore, the potential benefit from reflectivity and panel cooling on energy production, often highlighted as a benefit for electricity generation, remains insufficiently quantified in the context of rewetting or moist peatland environments. As a result, the magnitude of these technical and ecological benefits remains uncertain, limiting the ability to draw robust conclusions about their long-term implications.

The thesis further highlights the need for enhanced collaboration and knowledge exchange among stakeholders, as knowledge gaps were identified across stakeholder groups. Integrating multidisciplinary experience and expertise could support the further development of this land-use approach. Beyond its relevance for industry and regulatory actors, the findings may also support decision-making regarding after-use management strategies for cut peatlands among landowners and peat extraction companies. The findings also underscore the need for stronger policy support for projects that combine rewetting and solar development to derisk projects and create an environment that allows for first movers.

Table of Contents

List of Figures

List of Tables

Abbreviations

BESS = Battery Energy Storage System

CAB = County Administration Board

CO_2 = Carbon Dioxide

ETS = Emission Trading System

EU = European Union

GIS =Geographical Information System

GPV = Ground-mounted photovoltaics

GW = Gigawatt

Ha = Hectare (100 x 100m, 10 000m^2)

IPP = Independent Power Producer

LCOE = Levelized Cost of Energy

LULUCF = land use, land use change and forestry

MCDA = Multi-criteria decision analysis

MW = Megawatt

PPA = Power Purchase Agreement

PV = Photovoltaics

1 Introduction

Two major changes are creating large problems for the inhabitants of the planet, land use change and climate change. The past years have seen global temperature levels rising above historical baselines, calling for an urgent need to decrease greenhouse gas (GHG) emissions (UNEP, 2025). To mitigate rising GHG emissions it is critical to preserve existing carbon sinks as well as decarbonize the energy sector. From this background Sweden presents an interesting case with significant carbon sinks coupled with the ambition to be considered a forerunner in decarbonization.

Sweden targets net zero GHG emissions by 2045 at the latest compared to the 1990 baseline (Naturvårdsverket, 2025b). The country aims to meet these targets by adherence to EU's Emission Trading System (ETS), electrification as well as decarbonization of the transport sector and industry (Climate Policy Council, 2025). Fossil-free electrification is key to achieving these decarbonization targets, increasing the demand for fossil-free energy. To fulfill this transition the Swedish Energy Agency (2023) expects electricity demand to double by 2050 compared to the levels in the early 2020s.

A challenge for the energy transition is siting of locations for renewable energy deployment. Renewable energy solutions require larger land areas for installment to compensate for a lower energy density compared to fossil sources (Lamhamedi & Vries, 2022). As a result, there is a growing concern that the renewable energy transition may cause increased land-use competition. In Sweden this is particularly relevant for ground mounted photovoltaics (GPV), since the most preferable locations for solar development are in the south which is both the most urbanized area as well as where most agricultural production occurs (Belzons Berthelemot et al., 2026). To avoid competition with valuable land areas suitable for i.e agriculture or nature conservation, scholars and governance bodies call for new resource efficient land management strategies (Oudes et al., 2022).

Besides electrification, increased carbon sequestration and preservation of existing carbon sinks are necessary for Sweden to reach its decarbonization goals (Regeringskansliet, 2020). The land use, land-use change and forestry (LULUCF) sector contributes to a net removal of CO_2eq through carbon sequestration while being an important area for carbon storage. Pristine peatlands are a significant carbon sink storing more carbon than what is found in the worlds combined vegetation (Kasimir & Lindgren, 2024). However, a category of emissions often hidden in the LULUCF category are emissions from drained peatlands. These land areas account for around 20% of total Swedish GHG emissions which is roughly equivalent to the combined car-feet (Kasimir & Lindgren, 2024; Vasander et al., 2003).

Around 17% of the total land area in Sweden consists of peatlands of which 38% have been drained for forestry, agriculture, peat extraction, infrastructure or other land related reasons (Barthelmes et al., 2015). The majority of peatlands have been drained for forestry which account for 35% of the drained peatlands. 0.3% of peatlands have been drained for peat extraction which is a form of mining that has been conducted in Sweden for the past 200 years. Initially it was conducted for domestic litter and fuel, but during the 20th century it became an importance source of energy nationally (Barthelmes et al., 2015; Lundin et al., 2017). In recent decades, peat extraction in Sweden is mainly conducted for horticultural purposes which in 2024 accounted for 92% of total peat extraction (SCB, n.d.). In 2020 around 24 000 hectares (ha), or 0.1 %, of Sweden's total land area was classified as peat extraction areas which include both active and inactive extraction sites (SCB, 2023). Active peat extraction sites for energy and horticulture were in 2024 conducted on around 132 sites totaling 12 000 ha (Froster, 2024; SCB, n.d.). Southern Sweden has the highest concentration of peat extraction sites, also called cut peatlands, as presented by Figure 1-1 (SCB, 2023).

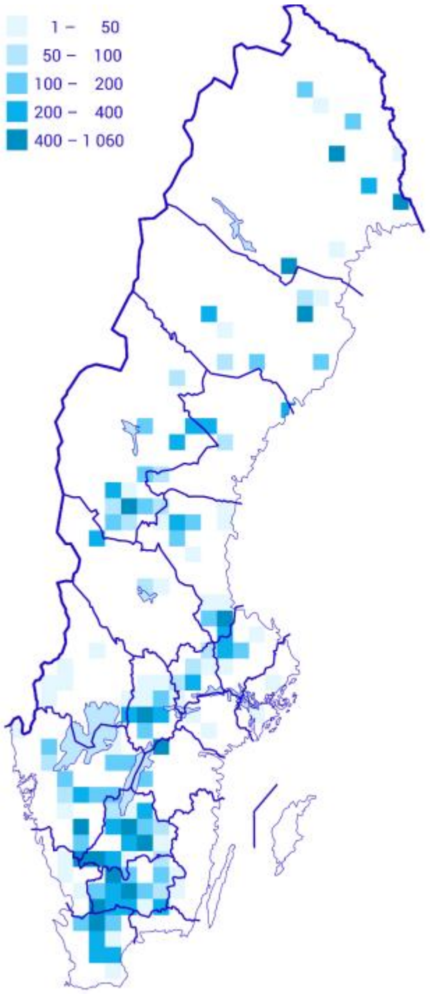

Figure 1-1. Regional distribution of peat extraction sites 2020, hectare per 25 x 25 km grid of Sweden

Source: SCB, Markanvändningen i Sverige 2020 MI03 Markanvändningen i Sverige 2023:1

Figure 1-1 presents the regional distribution of peat extraction areas in hectares through a 25x25 km square grid of Sweden. The daker colors correspond to higher concentration (more areas in terms of ha) of peat extraction areas. Largest concentration of such areas is found in the regions of Jämtland, Kronoberg and Jönköping.

1.1 Problem Definition

The transition to renewable energy systems is a central component of climate change mitigation strategies. At the same time, increasing competition for land, driven by agriculture, forestry, biodiversity protection and urbanization, has intensified the need for resource-efficient siting of renewable energy infrastructure. In this context, the use of degraded or marginal land for solar power development has gained increasing attention to reduce land-use conflicts while supporting decarbonization goals.

One such land category is former peat extraction sites. Drained peatlands are significant sources of GHG emissions due to ongoing peat oxidation, and rewetting is widely recognized as an effective measure to reduce these emissions (Jordan, 2016). Consequently, the potential to combine solar power development with peatland rewetting has emerged as a multifunctional land-use strategy, offering the possibility of both renewable energy generation and climate mitigation (Seidel et al., 2024; van Noord et al., 2024). Despite this potential, the deployment of solar power on peatlands remains limited. To the best of the researcher's knowledge, no solar parks have been constructed on former peat extraction sites in Sweden as of May 2026. However, several projects involving solar development on peat extraction sites are currently in the planning and permitting stages.

Internationally, examples of solar development on peatlands do exist, although they remain relatively limited. In Finland, the energy company EPV Energy has constructed a large-scale solar park with the capacity of 86 megawatts (MW) on a former peat extraction site, were activities ceased in 2022 (EPV, n.d). However, this project does not incorporate rewetting measures. In Germany, GPV had been developed on approximately 500 ha of drained peatlands as of 2022 (MoorPower, n.d). Since 2023, German policy has further supported solar development on rewetted peatlands by making the parks eligible for feed-in tariffs, thereby incentivizing landowners and solar developers to engage in peatland restoration (Schwill et al., 2025). The German project MoorPower aims to explore the technical and environmental feasibility of combining solar development with peatland rewetting. In Ireland, renewable energy development is being pursued on former peat extraction sites. However, there is a stronger emphasis on wind power rather than solar energy (Döringer, 2021).

In light of this international development coupled with an emerging interest in the literature this study seeks to explore the potential for solar development on former peat extraction sites in Sweden. The interest in this specific land area is largely driven by their preferential land conditions, where the literature identifies their size, remote location and degraded ecological status as potential opportunities for successful combination with solar development (Avonius, 2025; Raisanen, et al., 2022; Serenius, 2025). Additionally, technological developments in solar power are enabling the possibility of this combined form of land use.

While these developments demonstrate emerging interest, significant knowledge gaps remain. Challenges and opportunities of combining solar development with rewetting are not well understood, particularly in terms of implications this form of land use may have on the economic feasibility of the solar project, technological impact, environmental trade-offs as well as regulatory and permitting constrains. This lack of integrated knowledge creates uncertainty for key stakeholders, including solar developers, policymakers, and landowners, potentially hindering the adoption of this land-use strategy. The problem addressed in this research is thus both practical in terms of studying the experience of actors present in the space while also contributing to advancing academic knowledge on multifunctional land use strategies at the intersection of land, energy and climate systems.

1.2 Aim and Research Questions

To achieve a successful energy transition, resource efficient strategies are needed to enable decarbonization of industry and the transport sector without compromising food security, ecosystems or carbon sinks. This research is therefore concentrated on alternative strategies to decrease land-use competition from GPV installation. More specifically, the aim of the research is to explore former peat extraction sites as a new land area for solar power installation. Additionally, this research investigates potential synergies and trade-offs when combining solar power installations with rewetting initiatives. Finally, the research aims to map the current state of knowledge regarding solar diffusion on extracted peatlands in terms of challenges and opportunities experienced by multiple actors in the field. The research questions posed by the study are thus as follows:

RQ1: What is the current state of knowledge and development of solar power on former peat extraction sites in Sweden?

RQ2: Are former peat extraction sites a viable land area for solar power development?

Viability in the research is defined as the ability of these types of projects to function successfully where success is considered primarily from an economic, technological, legal and ecological perspective.

RQ3: What are the opportunities and challenges for multipurpose land-use strategies that combine solar on former peat extraction sites with rewetting initiatives?

RQ3 aims to study how these projects can be managed together with rewetting initiatives while also considering the desirability of such activities from a stakeholder perspective.

This thesis contributes to the existing literature by advancing the understanding of the land–energy–climate nexus, specifically through the lens of peatland rewetting and renewable energy development. It provides empirical insights into how different stakeholder groups perceive and engage with multifunctional land-use strategies, thereby complementing predominantly technical or theoretical studies in this field. By identifying key challenges and opportunities associated with solar development on former peat extraction sites, the study contributes to a more integrated understanding of how climate mitigation and energy production objectives can be aligned in practice. Furthermore, the results offer a structured overview of the current state of this emerging field, which can serve as a foundation for future research, including more detailed case studies and quantitative assessments.

1.3 Scope and delimitation

This study examines the potential for developing large-scale ground-mounted solar parks on former peat extraction sites also referred to as *cut peatlands*. Large-scale solar parks are defined as installations exceeding 1 megawatt (MW) of capacity (Lindberg et al., 2021). The study is geographically limited to Sweden. This delimitation is motivated by the need to account for country-specific regulatory frameworks, energy market conditions, and peatland management practices, all of which strongly influence project viability. Within Sweden, there is a natural scoping towards the southern regions (electricity bidding areas SE3 and SE4), where solar irradiance and electricity prices are relatively higher, and where most solar development currently occurs. While the primary focus is national, selected examples from other European countries are included to provide contextual insights and comparative learning.

Additionally, the study focuses specifically on former peat extraction sites which amount to around 24 000 ha and does not include other categories of drained or degraded peatlands. This delimitation is based on the distinct characteristics of extraction sites, where peat removal has been the primary land-use activity, resulting in different physical, ecological, and regulatory conditions compared to other peatland types. Furthermore, the study focuses on solar energy development as a post-extraction land-use option. Other after-use treatment options, such as afforestation or agricultural conversion, are not explored in depth, as they involve different land-use requirements and decision-making processes. However, these alternatives are acknowledged where relevant for comparative purposes. Finally, this research takes a general approach rather than studying the feasibility of a specific site which limits the results to a high-level understanding of the challenges and opportunities rather than revealing the exact measures that would make development on a specific site possible. As with most land areas there can be large differences between former cut pealands sites where site specific conditions need to be taken into account before development of a solar park.

1.4 Ethical considerations

This thesis was conducted in collaboration with the renewable energy team at Uniper, an independent power producer, who provided financial support for the project. The research topic was developed jointly between the researcher and Uniper; however, the formulation of the research questions, selection of interviewees, and development of the interview guide were carried out by the researcher. Uniper was also included as one of the interviewees in the study, and as such, its perspectives are reflected in the results and discussion sections alongside those of other participants. Furthermore, in line with the snowball sampling approach applied in this study, Uniper was invited to suggest additional relevant contacts for interviews. However, to ensure the independence and integrity of the study, all data analysis and interpretation of findings were conducted solely by the researcher. Moreover, the supervisors at Uniper also provided feedback on a draft version of the thesis.

Beyond the role of the partner company, important ethical considerations for this research regards the management of consent and confidentiality, both pre and post the interview stage. All participants were informed prior to the interview on how their responses would be used in the thesis and consent was received in written form via email and orally during the interviews. Where accepted, the interviews were recorded and the participants were informed that the recordings would not be saved after project completion. The recordings and transcribed interviews were stored on the researchers personal laptop and protected by the Lund University cloud system. All interviewees have had the opportunity to review how they have been presented as well as how quotes were used ahead of the publication of the thesis.

1.5 Audience

Findings from this research will be relevant for stakeholders interested in renewable energy development as well as multifunctional solar installations. The value of the research may differ between stakeholder groups and thus be used differently. Landowners of cut peatland sites may use the findings of the thesis as part of the decision making when choosing the after-use management strategy of their site. Knowledge of the techno-economical and environmental conditions under which cut peatland sites can be suitable for renewable energy diffusion may add to the knowledge base in site selection for solar developers. Furthermore, the findings may influence the views on this form of land use and contribute to the public opinion as well as point towards policy enhancements in the space which can be of interest for local, regional and national policymakers. Due to the multiple stakeholder groups included in the study, insights into the challenges and opportunities experienced within the different groups may also contribute to the discussion between actors.

1.6 Disposition

This thesis is structured into seven sections, each contributing to an understanding of solar development on cut peatlands. Following the introduction, Section 2 describes the research design, methodology, and analytical frameworks applied in the study. Section 3 outlines the background context for solar development in Sweden and distinguishes between pristine and cut peatlands while also providing an overview of the regulatory landscape. Section 4 reviews the literature on multifunctional solar development and the current state of research in the field. Section 5 presents the main findings through the PESTLE framework. In Section 6, these findings are discussed in relation to existing literature and the land–energy–climate nexus. Finally, Section 7 concludes the thesis by summarizing the main findings and contributions of the research.

2 Research design, materials and methods

2.1 Research design

The research design of this thesis includes relevant methods and frameworks to create a structure that assists in answering the research questions. A qualitative method for data collection supported by analysis using the PESTLE-framework and the Nexus approach, provides an overview of the current state of solar power development on former peat extraction sites.

This thesis takes an exploratory qualitative approach as its methods. According to Morse (1991), and in agreement with Cresswell & Cresswell (2018) a topic with unknown variables and theory base is suited for a qualitative research approach. Morse (1991) defines the characteristics if a qualitative research problem as "(a) the concept is "immature" due to a conspicuous lack of theory and previous research; (b) a notion that the lack of available theory may be inaccurate, inappropriate, incorrect or biased; (c) a need exists to explore and describe the phenomena and to develop theory; or (d) the nature of the phenomenon may not be suited to quantitative measures" (Morse, 1991, p. 120). The intersection of the form of land use and energy development that this research studies is a novel phenomenon that has not been conducted prior. On a higher level, land use and renewable energy trade-offs are a relatively new area of study without clear theoretical direction or established best practices.

A key characteristic of qualitative research is taking a holistic account. According to Creswell and Creswell (2018) "qualitative researchers try to develop a complex picture of the problem or issue under study. This involves reporting multiple perspectives, identifying the many factors involved in the study and generally sketching the larger picture that emerges" (p. 182). This study maps and includes relevant actors' different views with the goal to understand the viability of cut peatland sites as a new land area for solar development. This contributes to the larger understanding of land use synergies and trade-offs that exist within the transition to renewable energy.

Due to the limited amount of previous research in the area, exploratory research is suitable as it is a form of descriptive research that aims to create baselines to our understanding of a phenomena (Bogner et al., 2009). This study takes an exploratory activity-based approach where solar power development on cut peatlands is explored from two angles, with or without rewetting initiatives. The research is time bound to the current understanding of this emergent form of land use and collects data primarily from interviews but is also supported by legislation and literature.

2.2 Analytical frameworks

To address the research questions, two complementary analytical frameworks were applied throughout the thesis. The PESTLE framework was used as the primary analytical structure, guiding the categorization of findings across the literature review, interviewee selection, interview design, and the presentation of results and analysis. In parallel, the nexus approach provided a conceptual lens for examining the interlinkages across the PESTLE dimensions. While the PESTLE enabled a structured identification of opportunities and challenges, the nexus approach facilitated a more integrated analysis by highlighting synergies and trade-offs between these dimensions. The nexus framework also informed the structure of the discussion, where interactions between land use, energy, and climate objectives were explored in greater depth. Together, these frameworks strengthen the analytical coherence of the study and support a more comprehensive understanding of the research problem.

2.2.1 PESTLE

The PESTLE framework is an acronym for political (P), economic (E), social (S), technological (T), legal (L) and environmental (E) factors that influence firms and industry. It originates from business management and studies macro-environmental challenges and opportunities to aid adaptation and strategy development (Munter, 2026). The framework is typically applied in strategic planning, innovation and market research but also on a higher level to study country and regional attractiveness (Johnson et al., 2017). While it is not rooted in a specific scientific theory, it is rather a practical tool that provides structure in determining how external factors can impact the business environment of a firm or industry.

The political and legal dimension often considers government stability, sector specific rules and regulations, taxation as well as policy trends that influence the business area. The economic dimension considers broader macroeconomic factors and trends such as interest and exchange rates as well as microeconomic factors relating to costs such as the price of materials, labor and capital. Social factors deal with societal and demographic trends and may include cultural norms, attitudes, lifestyles and behaviors. The technological component looks at aspects such as technological advancements, research and development as well as broader technological changes. Finally, the environmental dimension assesses the dual influence of ecological and environmental issues on the firm while also encompassing the impact of the firm on ecological and environmental issues.

The PESTLE framework has been used in the literature to study renewable energy development, often to present challenges and opportunities with certain technologies (Nisha et al., 2025; Seidel et al., 2024) or within an energy system (Amega et al., 2024; Nica et al., 2024; Zalengera et al., 2014). In the literature the political and legal factors tend to relate to energy policy; economic factors tend to be concentrated to investment in the power sector, energy prices or technology costs; the social dimension usually includes public acceptance of renewable electricity; technological readiness may consider specific technology or the energy systems capability to transition to renewables; and climate change is the most frequent environmental criteria studied in the literature (Amega et al., 2024; Nica et al., 2024; Nisha et al., 2025; Seidel et al., 2024; Zalengera et al., 2014).

Benefits with the PESTLE framework include a holistic assessment of what challenges and opportunities external factors pose to a project, firm or industry, while simultaneously assisting with risk identification. Moreover, the framework creates a structural approach to mapping dynamic and complex environments (Munter, 2026). Outcomes of the analysis can help allocate resources and provide strategic direction for firms and organizations and is especially relevant for scenario planning and analysis (Johnson et al., 2017). Identified limitations with the framework are often liked to the ambiguity and volatility that may exist within the dimensions of the framework which can lead to uncertainties in the findings. This has given rise to critique relating to the predictability of the framework as it rarely identifies robust predictions or concrete solutions. Therefore the PESTLE is often complemented with other theoretical frameworks and modelling to assist in the development of proactive strategies (Munter, 2026).

A PESTLE analysis can be performed on both a high level as well as a more granular level of detail. Aspects of the analysis can be more vague or fuzzy in their nature, especially when relating to trends and opinions which usually require qualitative data in their assessments. The criteria considered in the analysis are usually scored using a scale to identify the most and least impactful factors. Consideration to the level of uncertainty as well as the interconnectedness of the factors is often recommended.

In this thesis, the PESTLE framework was be used to provide structure and guidance when considering the viability of solar development on cut peatlands. The different factors were studied in the literature review, and used to categorize the questions asked to the interviewees. The primary use of the PESTLE was to act as an analytical framework when organizing the results. Here the framework was used to address challenges and opportunities within the different categories identified by the interviewees. To summarize, the PESTLE framework acts as an overarching soft structure of the thesis assisting with data collection and analysis to help provide an understanding of the current landscape for these types of projects.

2.2.2 Nexus approach

A nexus approach is commonly applied within sustainability research and governance as a conceptual basis for understanding complex interdependencies between environmental resources, socio-economic systems and governance processes. In the sustainability field the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) defines *nexus* approach as "understanding the interlinkages and interdependencies between sectors and systems in a holistic manner to develop integrated and adaptive decisions that aim to maximize synergies and minimize trade-offs" (p. 9). Benefits of a nexus approach includes the potential to reduce risks while integrating planning, management and governance, to enhance sustainable development (Liu et al., 2018).

A nexus consists of two or more components, often called nodes, which can be either a resource, a system or an issue with the aim of maximizing synergies and minimizing trade-offs. Nexus terminology has historically been applied to the interlinkages between water, food and energy, but has also been used to study a range of other issues such as economic growth, trade, CO_2 emissions and poverty as well as resources or systems such as land and various materials (Estoque, 2023). Development pathways are assessed by examining how management strategies generate synergies or trade-offs across these components, thereby supporting more efficient and coherent policy design compared to isolated interventions. This perspective is particularly relevant for climate mitigation strategies, where energy and land-use policies may otherwise create maladaptive outcomes if implemented independently.

Lamhamedi and Vries (2022) studied how renewable energy technologies are developing and interacting in the Global South through the land-energy (renewable) nexus (IPBES et al., 2024). They discuss the dual tension that exists with renewable energy development, where some support rapid expansion to mitigate climate impacts, while others are concerned with land pressure and social impacts that may arise from renewable energy projects. The scholars find a need to integrate socio-environmental considerations in renewable energy development and call for land management to be multifunctional and multidimensional to reduce negative impact on climate change, ecosystems and societies.

In this thesis, the nexus approach provides an analytical lens for analyzing solar development on cut peatlands as an intersection between energy transition, land management and emission reduction thereby taking a land-energy-climate nexus approach. The study conceptualizes cut peatlands as a nexus space where renewable energy development, land management and climate mitigation interact, using the insights from multiple stakeholder groups. Applying a nexus perspective allows the thesis to assess whether land-use strategies can generate synergies, such as renewable energy generation and carbon sink enhancement, while identifying potential ecological, economic and governance trade-offs. Combined with the PESTLE framework, which studies macro-environmental factors influencing project viability, the nexus approach supports an integrated analysis of how technological, environmental and institutional dimensions jointly shape opportunities and constraints for solar development on former peat extraction sites.

2.3 Data collection

The primary method for data collection was through exploratory semi-structured interviews which were also complemented by a background and literature review that includes legal texts, reports and government investigations. Using multiple sources of data allows for triangulation which contributes to the internal validity of the study. Document data and the literature review were used to identify interview subjects, validate interview data and connect themes in the analytical portion of the study.

2.3.1 Interview data

The interviews followed a semi-structured explorative approach combining practitioners in the space, researchers and industry representatives. Semi-structured expert interviews were deemed the most suitable as they allow flexibility while staying within the topical boundary.

Semi-structured expert interviews

Expert interviews are a method of qualitative research that "(…) aims at exploring or collecting data about a specific field of interest" (Döringer, 2021 p. 265). Experts are typically defined as individuals who are responsible for planning, developing or implementing solutions to a problem, or have access to decision making processes (Döringer, 2021; Pfadenhauer, 2009). Exploratory expert interviews are commonly used to provide orientation and to generate knowledge and understanding of a relatively unknown fields, with the aim of creating baselines and conceptual structure (Bogner et al., 2009). These types of interviews are characterized by their focus on technical or highly specialized knowledge within a given domain (Döringer, 2021). In the context of this thesis, the selected interviewees possess technical expertise across several fields relevant to the research topic.

To develop a holistic understanding of the emerging field of large-scale solar power installations on cut peatlands, a diverse range of stakeholder groups was included to capture multiple perspectives. The PESTLE framework together with the land-energy-climate nexus, were used to identify relevant stakeholder groups. Using the selected groups, potential interviewees were then identified from the document and literature review, as well as during participation at a solar power conference. Recruitment was primarily conducted through emailing, where prospective participants were provided with information about the scope of the study. This initial recruitment was complemented by the snowballing method, whereby interviewees were asked to suggest additional relevant participants at the end of each interview.

Stakeholders identified through these processes were invited to participate in semi-structured interviews where the final sample included: solar developers/independent power producers (IPPs) with ongoing projects on cut peatland sites as well as the partner company for this thesis; CABs with the highest number of peat extraction permits issued over the past ten years (excluding the northernmost region) (SCB, 2020); technology developers of solar panel systems specifically adapted to peatlands, a researcher on rewetting of cut peatlands sites as well as a researcher on solar power with expertise in solar power on rewetted peatlands; the Swedish industry organization for peat extraction; and an innovation platform piloting solar power on a rewetted cut peatland site. This selection ensured a diversity of perspectives, combining both specialized expertise and practical experience.

Following the identification of relevant stakeholder groups to interview, an interview protocol was developed. This protocol included a set of overarching questions to ensure consistency across interviews, as well as tailored questions for specific stakeholder groups. Almost all interviews were conducted online, primarily through zoom, and were recorded with the participants' consent. To ensure informed consent all interviewees received a written statement outlining how their data would be used, the role of the partner company, and the conditions of participation, including recording (See Appendix 1). Each interview began with a review of these ethical considerations, after which participants were given the opportunity to ask questions.

A total of 16 interviews were conducted between 5th of March and 31st of March 2026, lasting roughly 50 min on average. In one interview two participants from the same organization participated and in one case two separate interviews were conducted with same CAB, but with different departments, otherwise all interviews were conducted with one representative from the organization.

Table 2-1. List of interviewees in ascending order based on interview date (05/03/2026-31/03/2025)

Reference[2]	**Position**	**Classification**	**Relation to peatlands**
TD1	Sales specialist	Technology provider	Develops solar modules specific for peatlands
CAB1	Wetland Coordinator	County Administration Board	Coordinating wetland related projects – grants, strategies, communication
SD1	Renewable energy development	Solar developer/IPP	No current projects, exploring possibilities of developing solar on peat
IO1	Secretary General	The Swedish Peat Association	Membership organization for peat producers and refiners in Sweden
SD2	Project manager	Solar developer/IPP	Developing a project on a former peat extraction site
TD2	CEO	Technology provider	Develops solar modules specific for peatlands
SD3	Swedish CEO	Solar developer/IPP	Develops projects on former peat extraction sites
CAB2	Environmental Protection Officer	County Administration Board	Compliance and permitting for environmental hazardous activities
R1	Researcher	Swedish University of Agricultural Sciences	Researcher on restoration and rewetting of peat extraction sites
SD4	Head of Permitting, Sweden	Solar developer/IPP	Previously engaged with developing solar parks on peat extraction sites
IO2	Program Manager	Innovation platform	Developing a demo solar site on a rewetted former peat extraction site
SD5	Project Developer	Solar developer	Developing solar projects on peatlands
R2	Project Manager	Swedish Research Institute	Projects relating to sustainable applications of Solar PV, among them combined solar development and rewetting
CAB3	Environmental Protection Officer	County Administration Board	Compliance and permitting of renewable energy, peat extraction and infrastructure
SD6	Senior Permit Advisor	Solar developer	Developing a solar project on former peat extraction site
C1	Environmental Engineer	Large Consultancy Company	Works with permit applications for industries and solar power project

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[2] Where TD refers to Technology Developer, CAB refers to County Administration Board, SD refers to Solar Developer, IO refers to Interest Organization, R refers to Researcher and C refers to Consultant.

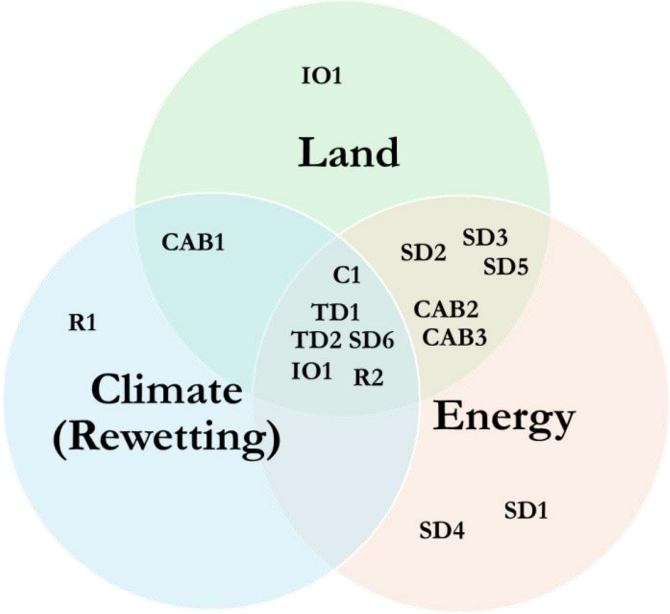


Figure 2-1. Visualisation of interviewees in relation to the land-energy-climate nexus

2.3.2 Limitations to expert interviews

There are multiple stages in the methodology where bias can be introduced. In qualitative research this can occur for example in the selection and sampling of interviewees, as the researcher chooses whom to include in the study and from interviewees who may tweak their answers to please the researcher, often referred to as social-desirability bias (Creswell & Creswell, 2018). In expert interviews managing the bias of experts is also a limitation that should be reflected upon when conducting these interviews (Von Soest, 2023). To mitigate potential bias results should be compared and triangulated using multiple perspectives and sources. Expert interviews are also dependent on the level of knowledge of the researcher asking the questions where experts may adapt their answers based on their perceived knowledge level of the researcher (Bogner et al., 2009).

2.4 Data Analysis

The interview data was analyzed through quantitative coding based on the framework of Creswell & Creswell (2018). A combination of deductive and inductive coding was applied using the coding software NVivo. Deductive codes were derived from the PESTLE framework, while inductive coding allowed for the identification of emergent themes beyond the predefined analytical structure.

All interviews were audio-recorded and transcribed using the transcription function in Microsoft Word. The transcripts were subsequently reviewed and manually edited to correct inaccuracies with regards to wording and spelling introduced during the automated transcription. Following this, the finalized transcripts were imported into NVivo for coding. An initial round of coding categorized the data to the six PESTLE dimensions, while simultaneously developing high-level inductive themes beyond the PESTLE dimensions. In the second stage of analysis, the sub-codes *challenges* and *opportunities* were developed deductively within the primary codes to capture more specific themes and perspectives expressed by the interviewees. While *challenges* and *opportunities* were the primary overarching subthemes, additional inductive sub-codes were introduced to account for neutral or descriptive insights that did not fit clearly within either category. This iterative coding process enabled both a structured comparison across PESTLE dimensions and the identification of nuanced insights emerging from the empirical data.

A total of 11 main codes were generated which beyond the PESTLE categories included, *Landowner, Peat, Solar and peat, Cases from other countries* as well as *Swedish solar market* under which a total of 33 sub-codes were created. Within all main codes, except, *Swedish solar market,* the deductive subthemes *challenges* and *opportunities* were applied. These categories were then further refined through the creation of additional sub-sub codes capturing more specific aspects of each theme. In some cases, additional levels of coding through sub-sub-sub codes were introduced to distinguish between nuanced perspectives and variations within the data. This top-down and bottom-up coding structure enabled a detailed and systematic organization of the material, while maintaining consistency across the different analytical categories (See Appendix 2 for examples).

The interview transcripts were not translated prior to coding to preserve linguistic nuance and avoid potential loss of meaning. Translation was only applied to selected quotations included in the thesis. These quotations were translated using DeepL and subsequently reviewed and, where necessary, refined by the researcher to correct inaccuracies and improve readability. This included the removal of stuttering and repetitions, as well as adjustments to ensure that the intended meaning of the statements was accurately conveyed. Despite these measures, the translation process entails an inherent risk of losing subtle nuances, undertones, and contextual meanings embedded in the original language. This limitation is acknowledged as part of the interpretive nature of qualitative research

3 Background

This section provides relevant background on the current state of solar development in Sweden, an introduction to peatlands and peat extraction as well as the regulatory landscape for energy development and peat extraction. The purpose of this section is also to distinguish between peatlands and peat extraction sites while also clarifying interactions between regulations.

3.1 Solar Development in Sweden

Electricity production from solar power has been developing rapidly during the past ten years in Sweden. The rapid installation has been driven by increased interest, subsidies on rooftop panels and cost reductions of the technology (Energimyndigheten, 2025a). Solar power presents a simpler and cost-efficient option that also complements other forms of renewable energy sources such as wind power, since solar generation tends to peak when wind availability is low (Lindberg et al., 2021). However, buildout of solar has been decreasing in recent years due to lower electricity prices, grid constraints and removal of certain support mechanisms (Swedish Energy Agency 2025).

Demand and supply for electricity is divided in Sweden where more electricity is consumed in the south while production is higher in the north. Since 2011 the electricity market has been divided into four bidding areas to better signal where increased electricity production is required to balance out the demand (Oller Westerberg & Lindahl, 2023). Higher solar irradiance and electricity prices have made southern Sweden the preferable location for solar power installment. However, as large land areas are required for GPV energy, the expansion competes on finite land resources with other land uses such as agriculture and natural habitats.

The preferred location for GPVs are croplands due to flat and open land areas coupled with their proximity to existing infrastructure such as the electricity grid, areas of electricity demand and the road network (Adeh et al., 2019; Lindberg et al., 2021). Conversely, the favored location for GPV development is also the most cultivated, giving rise to land-use conflicts. As autonomous food supply becomes of increasing importance, agricultural land becomes less suitable for energy generation (Klimatpolitiska rådets rapport, 2025). To reduce the pressure on arable land the concept of multifunctional PVs has gained attention as a method to combine renewable electricity with other functions such as agriculture or nature benefits (Biró-Varga & Stremke, 2026).

3.2 Peatland Characteristics

Peatlands are a form of wetland characterized by high water tables. The wet circumstances lead to slow decomposition of organic matter which accumulates and form layers of peat soils. Due to the organic matter decomposing at a very slow rate, the sequestered carbon in the vegetation is not released. Instead, the peatland becomes a carbon sink over time. On the other hand, once the peat is exposed to oxygen the carbon sink instead becomes a carbon emitter as centuries of stored carbon is released when the organic matter begins decomposing. Besides acting as a carbon sink, healthy peatlands also provide other valuable ecosystem services such as water filtration, flood preservation and biodiversity conservation (Ó Brolcháin et al., 2023).

Two of the main forms of peatlands include bogs and fens. Bogs are ombrotrophic systems receiving water exclusively from precipitation and are therefore nutrient-poor and acidic, whereas fens are minerotrophic systems influenced by groundwater inputs, resulting in higher nutrient availability (Joosten & Clarke, 2002). Differences in peatland conditions between bogs and fens also influence the decomposition rates where fens decompose organic matter faster due to the presence of lignin-rich vegetation and higher microbial activity compared to bogs who are more acidic and are dominated by *Sphagnum* mosses (Krumins & Klavins, 2022). As a consequence, bogs are typically more carbon-rich compared to fens.

3.3 Peat extraction

In Sweden, peat extraction today is dominated by horticultural use, although peat has historically played an important role in the national energy system. Around 2015, peat extraction for horticulture surpassed that for energy production, a trend that has continued in recent years. By 2024, horticultural peat accounted for approximately 92% of total peat extraction Sweden (SCB, n.d.), with extraction activities primarily located in southern Sweden (Barthelmes et al., 2015). In 2020 approximately 24 000 ha, or 0,1 %, of Sweden's total land area consisted of active or inactive peat extraction areas, of which roughly half remain in active use (SCB, 2023). Peat extracted for horticulture is mainly extracted from bogs and the emissions associated with the activity account for around 1% of Swedens total GHG emissions (Hirschler & Osterburg, 2022; Regeringskansliet, 2026). See Appendix 3 for more information on peat extraction practices.

Peat harvesting is typically conducted over long timeframes, often spanning 20-30 years, and finalizes when the majority of the peat resource has been removed (Lundin et al., 2017). The depth of remaining peat varies depending on extraction intensity, method and site characteristics, but generally only a thin peat layer remains above the mineral soil (Nilsson & Nilsson, 2005). Once the peat extraction has finalized on the site the ecological value of the land has been substantially degraded. Sites where only the uppermost peat layer has been removed are referred to as cutover peatlands, whereas sites extracted down to deeper peat layers are termed cutaway peatlands (Avonius, 2025; Price & Ketcheson, 2013). In this study the term *cut peatlands* is used as an umbrella concept encompassing both these post-extraction conditions. The after-use of cut peatlands in Sweden commonly include afforestation, or ecological restoration, although the feasibility and outcomes of restoration depend heavily on the degree of degradation and remaining peat depth (Avonius, 2025; Nilsson & Nilsson, 2005). The after-use strategy is a critical decision point for land use, where emerging alternatives such as renewable energy development, may compete with or complement traditional restoration pathways.

3.4 Restoration of Peatlands

Restoration of peatlands requires two main steps. The first being rewetting which means raising the water table, usually through backfilling drainage ditches (Convention on Wetlands, 2021). Besides rewetting, re-establishing the vegetation cover is critical for ecosystem improvement while at the same time mitigating the risk of wildfires. Bare peat dries out quickly and becomes susceptible to high temperatures making them vulnerable to fires (Convention on Wetlands, 2021). Vegetation may develop spontaneously after hydrologic conditions have been restored or need to be re-introduced depending on the local conditions of the restoration site. Upon successful restoration of the hydrological balance and vegetation, the carbon cycle of the ecosystem has the potential to begin functioning again (Vasander et al., 2003). Peatlands extracted for peat are considered the "most" and "maximal" forms of degradation and cannot be restored within a human lifetime, instead restoration could be aimed at re-creating the hydrological conditions to enable ecosystem recovery (Convention on Wetlands, 2021).

3.5 Swedish legislation for peat extraction

Peat extraction in Sweden is today primarily regulated under the Environmental Code, 1998:808 and the Environmental Assessment Ordinance (2013:251), although the Peat Act (1985:620) formally remains in force for sites initiated before January 1st 2017 (Naturvårdsverket, 2023a). Peat extraction is generally classified as both an environmentally hazardous activity and a water operation, meaning that permits may be required under Chapters 9 and 11 of the Environmental Code.

To obtain a peat extraction permit under Chapter 9 of the Environmental Code, the operator must provide financial security covering the costs of remediation and restoration measures required after the cessation of operations (Chapter 9, section 6e). In practice, this entails the submission of a preliminary after-use management plan as part of the permit application. The plan is typically finalized three years prior to the termination of extraction and implemented within one year after operations have ceased. The after-use management plan is developed in consultation with, and approved by, the County Administrative Board (CAB) (Regeringskansliet, 2026). The Swedish Environmental Protection Agency, one of the supervisory guidance authorities under the Environmental Code, recommends rewetting as the primary after-use strategy for peat extraction sites, with alternative ecological restoration measures considered where rewetting is not feasible (Naturvårdsverket, 2025a).

3.6 EU policy frameworks affecting peatlands and solar development

3.6.1 Climate mitigation framework

EU Climate law

EU climate law (Regulation (EU) 2021/1119) targets climate neutrality in the union by 2050 to be in line with the Paris Agreement. The law established a binding requirement for all Member states to reduce national GHG emissions by 2030. Furthermore, the regulation states that when fulfilling the reduction target the member states shall prioritize rapid and predictable emission reductions while at the same time enhancing removals through natural sinks (Regulation 2021/1119, art. 4, para.1). Additional regulations part of the policy package include Directive 2003/87/EC which established the EU ETS where emissions from fossil power production is included, among them emissions from energy peat, Regulation (EU) 2018/842 which introduced national targets for GHG emissions and regulation (EU) 2018/841 which requires Member States to balance GHG emissions and removals from LULUCF, also known as the LULUCF regulation stated in the preamble (Regulation 2021/1119, pmbl., para 12).

LULUCF Regulation

The revised LULUCF Regulation (EU 2023/839) establishes binding targets and accounting rules for GHG emissions and removals from land use, land-use change and forestry, aiming to increase EU carbon sinks to 310 Mt CO_2e by 2030 as part of the Fit for 55 climate framework. The responsibility of implementation is divided amongst the member states where Sweden shall increase its yearly carbon sequestration by 4 billion ton CO_2e between 2026-2030 compared to the average in 2016-2018 (Naturvårdsverket, 2023b). Peatlands and wetlands are among the land categories suitable for restoration to allow for biodiversity protection, soil erosion prevention and carbon sink enhancement set out in paragraph 2 and 34 of the preamble of the amendment (European Parliament & Council of the European Union, 2023).

Renewable Energy Directive

The Renewable Energy Directive (EU) 2023/2413 revised earlier renewable energy legislation and sets out a binding target of at least 42.5% of the EU's gross final energy consumption to come from renewable energy sources by 2030 (art. 1., para. 3). Besides setting targets for renewable energy diffusion, the directive also includes sectoral obligations such as faster permitting procedures and designation of "renewable acceleration areas" on specified land (art. 1., para. 24 & 26).

3.6.2 Land-use and restoration framework

Nature Restoration Law

The Nature Restoration Law (EU) 2024/1991 establishes rules intended to contribute to the achievement of the Union's overarching objectives related to climate change mitigation and adaptation, land degradation neutrality, and the fulfilment of the EU's international commitments. The Regulation creates a framework requiring Member States to implement effective, area-based ecosystem restoration measures. The objective is to collectively restore at least 20 percent of the land area and 20 percent of the marine area covered by the Regulation by 2030, and to restore all ecosystems in need of restoration by 2050.

The obligations established under the Regulation include, among other provisions, Article 11, which requires the implementation of restoration measures in agricultural ecosystems. This includes the restoration of a specified area of organic soils used for agriculture that consist of drained peatlands, primarily through at least partial rewetting. These measures shall be in place on at least (a) 30% of such areas by 2030, of which at least a quarter shall be rewetted; (b) 40% of such areas by 2040, of which at least a third shall be rewetted, (c) 50% of such areas by 2050, of which at least a third shall be rewetted. Restoration measures, including rewetting, carried out in areas affected by peat extraction can be counted towards achieving the targets (a), (b) and (c) set out in Article 11 paragraph 4. Member States' obligation to achieve rewetting targets does not impose a direct obligation on farmers or private landowners to rewet their land. Rewetting of agricultural land remains voluntary for them, without prejudice to obligations arising under national law.

3.7 Swedish Policy Context

3.7.1 National Environmental objectives

Sweden has 16 environmental objectives that among other areas cover wetlands, biodiversity and climate. Two main areas influence the trajectory for solar power and peatlands, *Reduced climate impact (*Begränsad klimatpåverkan) and *Thriving Wetlands* (Myllrande våtmarker) (Regeringskansliet, 2026). Reduced climate impact aims to limit emissions of GHG emissions in a way that protects biodiversity and food production while not limiting the success of other sustainability targets. One of the sub-targets includes net-zero commitment by 2045. Thriving wetlands aim to protect wetlands ecological and hydrological functions by, among other things, restoring wetlands and species habitats.

3.7.2 Rewetting policy and incentives

Sweden does not currently have any binding national targets for rewetting or restoration of damaged peatlands. However, the Swedish Climate Policy Pathways Inquiry (Regeringskansliet, 2020) found that 100 000 ha of forest and 10 000 ha of agricultural land would have to be permanently rewetted for Sweden to reach its carbon neutrality target by 2045. In addition, to fulfill the requirements set out by the Nature Restoration Law (EU) 2024/1991 Sweden must submit a national restoration plan by September 1st 2026 the latest, which will include rewetting.

Although Sweden does not have any strict targets for rewetting, there are around ten different grants for restoration of wetlands. These funds mainly target the forestry sector and municipal projects for rewetting and are governed by the Swedish Environmental Protection Agency (Naturvårdsverket, 2023c). Rewetting of former peat extraction sites does not fall under these grant categories as the restoration activities are included as part of the permitting process in accordance with the Environmental Code (see Section 3.5).

3.7.3 Renewable energy policy

Sweden's National Energy and Climate Plan (2021–2030) outlines the country's climate and energy ambitions. Key targets include a 63% reduction in GHG emissions by 2030 compared to 1990 levels and the achievement of a fully fossil-free electricity system by 2040, based on a combination of nuclear and renewable energy sources (Regeringskansliet, 2024). In 2023, renewable energy accounted for approximately 66% of Sweden's total final energy consumption, exceeding the EU's binding target under the Renewable Energy Directive (EU) 2023/2413 (European Environment Agency, 2025). The installed solar capacity in Sweden 2023 was 4.8 GW, delivering around 3 TWh yearly (Lindahl & Öhgren, 2025). Although Sweden does not have established specific national targets for solar energy deployment, scenario modeling by the Swedish Energy Agency expects solar power to increase to around 11-18 TWh by 2050 to meet the expected growth in energy demand, increasing from a 2% share in 2023 to a 5% share in 2050 in terms of national electricity generation (Energimyndigheten, 2025b).

3.7.4 Funding and governance gaps

Taken together, EU and Swedish policies simultaneously encourage renewable energy expansion and peatland restoration. However, the exact means as to which this shall be achieved is still not fully clear. In 2023 the Swedish Environmental Protection Agency issued a report on behalf of the Swedish government regarding rewetting of drained wetlands (Naturvårdsverket, 2023d). In the report the agency discusses, among other things, trade-offs and barriers to rewetting. They identified productivity loss for agricultural and forest producers, challenges in new infrastructure buildout and incentives for landowners as significant barriers to rewetting. According to the report, landowners may struggle to see the benefits from rewetting from a financial point of view as it can be unclear how the rewetted land can be used for income generating activities. Besides weighing loss of income against economic compensation for rewetting, the report identifies the administrative process as a burden for landowners. They state that the administrative burden is driven by long timeframes as well as complicated examinations and requirements to receive a permit or get the activity granted by the deciding body.

Another key policy document concerning peatlands and climate is the government investigation on horticultural peat and climate (Regeringskansliet, 2026). The investigation studied measures required to reduce the climate impact associated with the use of horticultural peat, and concluded that additional policy instruments are needed to support Sweden's objective of achieving climate neutrality by 2045. The report found that compensation schemes for rewetting are unlikely to constitute an effective standalone measure for reducing greenhouse gas (GHG) emissions. Instead, it proposed the introduction of an excise duty on horticultural peat as a more appropriate policy instrument, while noting that the practical and political feasibility of implementing such a tax may be limited.

Finally, while EU's and Sweden's climate legislation promotes renewable energy deployment, land-use and restoration policies increasingly prioritize rewetting of drained peatlands to enhance carbon sinks. This could be viewed both as a potential synergy or tradeoff in terms of solar power development on cut peatlands. Synergies could potentially be found in combining rewetting with solar installations, while trade-offs may exist for previously drained peatlands that are suitable both for solar energy development and ecological restoration.

4 Literature review

This section builds on the background section by adding perspectives on the economic, social, technical and environmental aspects of the PESTLE framework, while also reviewing previous research in the areas of solar development, peatland restoration as well as solar development on degraded peatlands.

4.1 Solar power

4.1.1 Viable solar locations

Where to place large solar parks is important to ensure the future viability of the project. In Sweden, development in solar installations has mainly been concentrated to residential and commercial applications as policies and financial incentives have been targeted towards this sector (Bankel & Mignon, 2022). On the other hand, development of utility scale parks is conducted by fewer actors as it has been proven difficult to develop economically viable projects (Lindberg et al., 2021). Between 2010-2020 the cost of solar panels decreased by 80% making larger projects more feasible (Fakharizadehshirazi & Rösch, 2024). However, geographical location remains a key element to ensure successful development of PV parks. In the site selection process multiple aspects must be considered to ensure viability and attractiveness of the project. This is commonly done in the literature through multi criteria decision analysis (MCDA) using geographical information system (GIS) and assigning various criteria different wights (En-Nouaary et al., 2024; Lindberg et al., 2021; Spyridonidou & Vagiona, 2023). By mapping the identified characteristics that are important for site selection, the opportunities and barriers of cut peatlands as a potential land-type for solar development can be evaluated.

Rediske et al. (2018) performed a systemic literature review of 27 case studies in an international context with the aim of determining the most important criteria for site selection. They identity six main points of view to consider: socioenvironmental, location, economic, political, climate and orography from which six most frequent criteria found in the literature are highlighted: (1) solar radiation, (2) proximity to power lines, (3) ground topography, (4) proximity to main roads, (5) proximity to residential areas and (6) land use.

Solar radiation: implies the amount of solar energy that a land surface receives during a certain period. It is considered among the most important indicators when identifying potential areas for solar power installation (Rediske et al., 2019). Spyridonidou and Vagiona (2023) performed a systematic review of 152 scientific studies from 73 countries covering the existing site election procedures and found that 83 % of the PV siting studies had conducted a solar radiation data analysis.

Proximity to power lines: Distance to transmission lines is important in solar projects as greater proximity implies lower transmission costs and power losses. Building powerlines is usually associated with high costs, amounting to around 0.3-1 MSEK/ha or 0.5-1 MSEK/MW(DC) (van Noord et al. 2024) while also impacting the nature and landscape (Fakharizadehshirazi & Rösch, 2024; Rediske et al., 2019). Spyridonidou and Vagiona (2023) identified the mean exclusion criteria regarding distance from the electricity grid for PV siting to be around 115 m, in their lower limit scenario, and Belzons Berthelemot et al. (2026) identify 5 km to be the longest distance for developers in project applications. These estimates are also in line with the 1-5 km selection van Noord et al. (2024) use in their scenario analysis.

While agreeing that grid proximity is relevant and important, a Swedish study by Belzons Berthelemot et al. (2026) point out that large solar parks are frequently contested, especially on agricultural land. They argue that increasing the length of powerlines could allow for access to lower cost land and avoiding legal barriers.

Ground topography: The topography and slope influences the ability of the PV system to receive solar radiation. Flatter grounds are preferred in solar installations as it reduces costs associated with preparation and planning of the terrain. Spyridonidou and Vagiona (2023) find the mean optimal value in their study to be less than 5% for piled solutions.

Proximity to main roads: Shorter distance to main roads enables transportation to the site. This is especially relevant during the construction period as roads are needed to transport the equipment to the location (Rediske et al. 2019). Spyridonidou and Vagiona (2023) found that the most restrictive upper limit for distance to the road network was 500 m.

Proximity to urban areas: Locating the solar park close to urban areas is favorable as demand for electricity is higher. Shorter distances between supply and demand reduce both congestion in the transmission network and energy losses while also minimizing the need for transmission line buildout (Rediske et al. 2019). Lindberg et al. 2021 further underlines the importance of proximity to grid connection, which they identify to be stronger closer to urban areas. However, this gives rise to a dilemma as suitable sites for larger parks near urbanized areas tend to be limited. A challenge that is heightened by higher land leases and lower public acceptance in these locations (Belzons Berthelemot et al., 2026; Lindberg et al., 2021).

Land use: Land use relates to the activity that is conducted in the selected area. Sites with high nature value are considered less suitable as they conflict with environmental interests and land available in heavily urbanized areas might be more appropriate for other forms of land use (Rediske et al. 2019; Lindberg et al. 2021). In addition there has been conflict associated with placing solar parks on agricultural land as it risks hindering local food production (Krasner et al., 2025). This is the case for Sweden where solar parks on agricultural lands have been contested and settled in court (Belzons Berthelemot et al. 2026)

To conclude, while several studies emphasize techno-economic optimization (Lindberg et al., 2021; Rediske et al., 2019; Spyridonidou & Vagiona, 2023), other scholars question this logic. Belzons Berthelemot et al. (2026) argue that MCDA-based approaches risk marginalizing local knowledge and reinforcing developer-centered priorities. Instead, they emphasize regulatory approval and public acceptance as equally decisive factors for project viability. Other scholars promote the inclusion of environmental impact criteria such as soil degradation and biodiversity conservation and promote the development of multifunctional solar parks (Fakharizadehshirazi & Rösch, 2024; Krasner et al., 2025; Tölgyesi et al., 2023). Thus, the literature reflects a broader tension between techno-economic optimization and socio-political legitimacy. While MCDA-based approaches aim to minimize cost and maximize technical performance, critics argue that long-term project viability depends equally on regulatory approval, land-use compatibility, and public acceptance.

4.1.2 Business models for solar development

This thesis focuses on large-scale solar park installation which according to Bankel & Mignon (2022) is defined as projects >1MW. Due to the size of the projects they often function under a third-party business model where the electricity is sold to the wholesale market or to industrial customers under PPA agreements (Burger & Luke, 2017). Key activities in solar diffusion are project development which includes the initial phases such as siting, pre-studies, applying for permits and solar park layout, technology sales meaning acquiring and selling solar components as well as construction and installation where project management is also included (Bankel & Mignon, 2022). In large scale solar projects the different phases can be conducted by a single actor or by separate firms, for example one company can be engaged in project development which is purchased by an independent power producer (IPP) who continues to develop and manage the solar park.

4.1.3 Land conflict and renewable energy

Land use competition is a rising theme in the literature for solar power development. Renewable energy is less energy dense compared to fossil counterparts and requires larger land areas (Lamhamedi & Vries, 2022). This special demand has raised concerns about potential land-use conflicts, especially in regions where land is already subject to competing pressures.

Scholars are concerned that renewable energy development will hinder preservation of natural ecosystems while also competing with land use to cover human needs such as food production and infrastructure development (Capellán-Pérez et al., 2017). The tension is particularly pronounced in agricultural landscapes. Croplands provide favorable conditions for solar PV installations due to their flat terrain, high solar exposure and existing grid connections. Consequently, they have been ranked as the most suitable sites for solar development, followed by grasslands and wetlands (Adeh et al., 2019). Also Sweden reflects that trend where the majority of solar parks, 64 %, located on arable land in 2021 (Björnsson et al., 2022). However, growing geopolitical unrest has given rise to stronger sentiments regarding resilience, questioning the suitability of solar development on agricultural land (Climate Policy Council, 2025).

A further point of contention concerns the temporality of solar installations. Energy developers frequently frame solar parks as reversible and temporary land uses, emphasizing their relatively low structural permanence. In contrast, scholars question this assumption, highlighting uncertainties regarding long-term ecological impacts. Emerging research suggests that solar parks can alter microclimatic conditions, potentially affecting soil stability, and ecosystem processes (Belzons Berthelemot et al., 2026; Spangler et al., 2024). These potential long-term changes complicate claims of full land restoration after decommissioning.

As an alternative to siting solar parks on agricultural land, several scholars suggest that solar parks should be located on marginalized land, defined by Milbrandt et al. (2014) as land with "inherent disadvantages or lands marginalized by natural or artificial forces" (p. 474) which could include abandoned or degraded land from human activity such as mining. However, scholars also underscore the risk of these land areas becoming scarce over time meaning other land use strategies will be needed as well (Milbrandt et al., 2014; Oudes et al., 2022; Tölgyesi et al., 2023). Out of the existing renewable energy technologies Milbrandt et al. (2014) find solar power to be the technology with the greatest potential to be installed on these types of land.

Where neither agricultural nor marginalized land offers an unproblematic solution, the literature increasingly points toward multifunctional land-use approaches. Multifunctional solar parks seek to integrate energy production with ecological, social or economic functions, thereby mitigating land-use conflict (Belzons Berthelemot et al., 2026; Biró-Varga & Stremke, 2026; Oudes et al., 2022; Semeraro et al., 2020). The most frequently mentioned multifunctionality of combining solar and land-use are agrivoltaics, the co-location of agriculture and solar energy. However, more recently ecovoltaics meaning combining ecological restoration with solar energy is gaining scholarly attention as a strategy to reconcile renewable energy expansion with biodiversity and climate goals (Krasner et al., 2025; Tölgyesi et al., 2023).

4.1.4 Challenges and opportunities with multifunctional solar power

Interest for multifunctionality in solar development has gained great attention in the literature as well as in policy development. Agrivoltaics is the most commonly discussed multifunctional solar usage found in the literature, although the concept of multifunctionality has also been applied to nature conservation, often referred to as ecovoltaics or nature-inclusive solar, as well as in combination with recreation, referred to as landscape-inclusive solar (Oudes et al., 2022; Semeraro et al., 2020; Tölgyesi et al., 2023). In this thesis, multifunctional solar is understood as solar energy systems intentionally designed to deliver simultaneous energy production and additional ecological, agricultural, or social functions.

Multifunctional solar is often portrayed in the literature as a resource-efficient solution that can alleviate challenges with land-use competition while offering economic, social and ecological benefits to both energy developers and landowners (Biró-Varga et al., 2024). Krasner et al. (2025) study the benefits of an ecovoltaic park in light of ecological restoration and find that besides reducing land-use competition, the solar panels can assist in reducing soil degradation and increase soil moisture content which can be especially beneficial in land areas susceptible to drought. McDonell (2025) elaborates on the secondary benefits of improved soil health and claims that these may result in increased abundance and diversity of flora and fauna which in turn creates a positive spiral and improves the soil health additionally.

Oudes et al. (2022) studied agrovoltaics, ecovoltaics and landscape inclusive solar through the perspective of societal considerations and found that multifunctional solar can have additional benefits beyond energy generation that include positive biodiversity impacts while also contributing to social acceptance by mitigating visual impacts and preserving cultural heritage. Similar to Oudes et al. (2022), Semeraro et al. (2020) highlight social benefits of multifunctional land use in terms of community contributions such as biodiversity conservation, socioeconomic activities in rural areas and improved flood mitigation. In addition, they also underline biodiversity improvements from the new microenvironmental conditions the solar panels may create.

Moreover, Semeraro et al. (2020) also discuss benefits that these projects may provide the energy producer. They reason that since the project is offering social and ecological services, producers could potentially benefit financially from avoiding paying fees to the municipality for the realization of the project. McDonell (2025) highlights benefits on solar productivity in ecovoltaic parks coming from panel cooling and decrease in panel soiling such as dust and debris.

Despite these promising outcomes, the literature simultaneously highlights significant technical, economic, and governance challenges that limit large-scale implementation. Shading from the panels and light availability remains an area of concern with significant impacts for agrivoltaics (Livera et al., 2025). Other challenges found in the literature for multifunctional solar parks include high investment costs due to greater land complexity and increased need for specialized infrastructure (Livera et al., 2025; Schindele et al., 2020). Oudes et al. (2022) also bring up challenges relating to lower energy density in production compared to conventional solar power production which in turn impacts the financial performance of the solar park.

Significant knowledge gaps on long term impact from multifunctional solar parks is another challenge emphasized in the literature. This gaps concern both how these solar parks influence the land conditions as well as surrounding ecosystems in the long term (Livera et al., 2025). What happens to the land area after the solar installation is decommissioned remains a concern especially for nature-integrated multifunctional solar parks. However, the long lifetime of a solar park, 20-30 years, is also viewed as an opportunity for the land to recover during the solar installation period (Randle-Boggis et al., 2020). Lack of knowledge regarding how to include and manage multifunctional solar in regulatory frameworks has also been identified as a barrier in the literature (McDonell, 2025).

While multifunctional solar parks theoretically contribute to enhancing multiple forms of sustainable development, they are currently not widespread in practice. Some agrivoltaics have been introduced in Europe while ecovoltaic parks are concentrated to piloting sites (McDonnell, 2025). An additional challenge when mapping the development of multifunctional solar parks is the lack of widespread definitions. Both evovoltics and agrivoltaics lack formal definitions, which creates uncertainty around what can be considered as multifunctional solar.

4.2 Peatlands

4.2.1 After-use treatment options for cut peatlands

Following the completion of peat extraction, planning for after-use management becomes a central stage in the peatland life cycle. The selection of after-use treatment depends on both the intended future land function and site-specific conditions, including residual peat thickness, chemical characteristics, soil properties, and hydrological conditions, all of which influence the suitability of different management strategies (Räsänen et al., 2023). Broadly, three main after-use pathways are identified in the literature: ecological restoration through soil enhancement and revegetation, conversion to alternative productive land uses, and, less commonly today, unmanaged abandonment (Tuittila et al., 1999; Räsänen et al., 2023). In Sweden, after-use treatment is legally required under the Environmental Code and the Peat Act (see Section 3.5) reflecting a focus on landscape transitions following extraction.

Conversion to alternative land uses has often been considered attractive from a landowner perspective, as it may generate new economic value (Vasander et al., 2003). Afforestation has historically been a common after-use strategy in Sweden, based on the assumption that drained peatlands provide favorable conditions for tree growth and may increase land value. However, empirical studies suggest that productivity outcomes are frequently limited due to the low nutrient status of the land. Karofeld et al. (2017) show that forests established on former peat extraction sites are rarely highly productive, resulting in modest economic returns. Successful afforestation appears to depend on specific site conditions, including thin residual peat layers, maintained drainage systems, and can require fertilization inputs. Agricultural conversion represents another applied after-use strategy. A synthesis review by Räsänen et al. (2023) finds that cultivation on former peatlands typically involves grass production or berry cultivation, reflecting adaptations to soil and hydrological constraints. While these land uses may provide economic opportunities the scholars highlight the need for studies relating to the socio-ecological impact and geographic context of such activities.

Restoration strategies, including the creation of shallow lakes or wetland-like environments, have also gained attention as after-use options due to their potential to enhance biodiversity and restore ecosystem functions. However, such approaches may require continuous management to prevent vegetation succession and infilling processes (Regeringskansliet, 2002). Furthermore, responsibilities for long-term maintenance and associated financial costs often remain unclear, creating governance challenges that may hinder implementation.

The environmental implications of different after-use strategies vary considerably, particularly regarding greenhouse gas (GHG) emissions. Nilsson and Nilsson (2005) demonstrate that afforestation may produce short-term emission benefits, whereas rewetting and wetland restoration tend to generate more favorable GHG balances over longer time horizons. These findings highlight trade-offs between economic objectives, ecological restoration goals, and climate mitigation outcomes when selecting after-use pathways.

4.2.2 Environmental impacts from rewetting cut peatlands

Emissions from cut peatlands are estimated to amount to around 10ton carbon dioxide (CO_2) per hectare and year (Kasimir & Lindgren, 2024). In general rewetting of drained peatlands decrease emissions of CO_2 and nitrous oxide (N_2O) while methane (CH_4) emissions may increase (Jordan, 2016). Depending on the peatland, restoration may also lead to increased phosphorus runoff in recipient watercourses (Vasander et al., 2003). Rewetting of peatlands also provides benefits to the surrounding ecosystem as ecosystem services are enhanced, through for example restored hydrological balance and nutrient cycles, leading to increased biodiversity (Lundin et al., 2017).

The timeline for re-establishing a carbon sink on cut peatlands differs in the literature as CO_2 fluctuations can vary with local conditions. A study by Tuittila et al. (1999) conducted over a period of three years found that the system began accumulating carbon two years. They also identified an increase in CH_4 emissions in the first two years after rewetting. However, the increase of CH_4 emissions was also influenced by the assumption that CH_4 emissions are close to zero prior to rewetting. While the study by Tuittila et al. (1999) was significant at the time of publication, it has been critiqued for its short study period of three years (Nilsson & Nilsson, 2005)

Lundin et al. (2017) studied emissions from rewetting a former peat extraction site over a period of 15 years and found that CO_2 emissions increased initially after rewetting due to CO_2-supersaturated groundwater. Jordan (2016) points out that re-establishing the peatlands carbon sequestration may take decades, while pointing out construction of shallow lakes as a mean to lower GHG emissions. The amount of emitted GHG emissions varies with the nutrient content of the peatland where drained nutrient rich peatlands emit more than nutrient poor peatlands (Drott & Eriksson, 2021; Jordan, 2016).

The potential of sequestering carbon and acting as a carbon sink is also dependent on the re-establishment of vegetation. Lindsay et al. (2014) highlights the importance of re-establishment of peat forming vegetation such as *Spahgnum* moss in restoration activities to develop a functional peatland ecosystem. The type of vegetation has an impact on the amount of carbon that could potentially be stored in the future (van Noord et al., 2024). Bare peat soils have been found to account for the highest CO_2 emissions in the peatland area according to the study by Jordan (2016).

Besides GHG emissions and phosphorus runoff, rewetting can also influence the pH level of the peatland. The two sites included in Lundin et al. (2017) study consisted of one nutrient rich and one nutrient poor site. They found that the pH level of the nutrient poor site decreased slightly after rewetting while the opposite was found at the nutrient rich site. However, they concluded that as vegetation develops and the rewetted ecosystem stabilizes it is likely that a lower pH will persist at both sites.

Additional environmental impacts from rewetting include hydrological change and benefits to biodiversity. Räsänen et al. (2023) identified recovering peatland hydrology as a key enabler for ecosystem restoration in their systemic review of after-use treatment strategies. They found fluctuations to the water table level to be a challenge where larger fluctuations were associated with higher nutrient and carbon leaching. In terms of biodiversity, common plant species such as *Sphagnum* and invertebrates were found to recover faster after restoration compared to the overall ecological community composition and soil organisms. Although they conclude that these metrics vary depending on the studied timeframe after the restoration activity had commenced.

Despite the risk of increased methane emissions and potential nutrient leaching, scholars are in agreement that rewetting is the most beneficial for the climate as well as biodiversity, with the ambition to strive for a re-establishment of the carbon sink (Convention on Wetlands, 2021; Jordan, 2016; Kasimir & Lindgren, 2024; Tuittila et al., 1999; Vasander et al., 2003). However, transitioning a damaged peatland to a carbon source from drainage appears to be simpler than transitioning it back into a carbon sink through rewetting.

4.3 Solar power and peatlands

Solar power installation as an after-use management option for peat extraction sites is gaining interest, which can be noted from the increase of land awarded for solar power development. While this development can be observed from energy developers websites and permit applications for solar development, there is a clear gap in the literature. There are only very few studies looking at the possibility of using former peat extraction sites for solar installations and none looking into the circumstances that would make it possible to combine with rewetting. Furthermore, studies considering the viability of establishing solar parks on cut peatlands from the perspective of solar developers is also non-existent in the case of Sweden. Instead, much of the research focuses on solar power development on other forms of degraded peatlands, often previously drained agricultural lands. However, this research field is also emerging rather than established. Due to the limited availability of peer reviewed research, gray literature such as reports from research institutes and government agencies as well as two master theses have been included in this section of the literature review to study the current knowledge in the field.

Solar power on rewetted peatlands is viewed in the literature as a multifunctional energy solution when combined with rewetting initiatives. While there is limited research conducted in the area in Sweden, Germany introduced a subsidy on solar power installation on rewetted peatlands used for agriculture which has given rise to recent studies concentrated to the German context (Seidel et al., 2024). However, multiple scholars and experts call for the need to establish more pilot or demonstration sites to verify expected improvement in hydrology and carbon storage, as well as monitor flora and fauna, while gaining knowledge on technical implementation (McDonnell, 2025; Seidel et al., 2024)

The following section reviews environmental, technical, economic and social impact of solar power on other forms of drained peatlands or wetlands, meaning the studies do not necessarily include cut peatlands specifically. While drained peatlands and cut peatlands share some similarities, one main difference can be the depth of the peat layer as well as the nutrient availability since peat has been extracted from a cut peatland.

4.3.1 Environmental impact

Combining solar power installment with rewetting of drained peatlands is not only framed as an energy solution but as a climate beneficial land-use strategy (Fakharizadehshirazi & Rösch, 2024; Seidel et al., 2024; van Noord et al., 2024). Seidel et al. (2024) emphasizes soil carbon conservation together with enhanced water retention and biodiversity function as key environmental benefits of combining solar PV installation with rewetting initiatives. Similarly, Fakharizadehshirazi and Rösch (2024) identify a "double climate benefits" of PV installation on rewetted peatlands as rewetting reduces the risk of soil erosion while promoting soil carbon conservation, thereby positioning drained peatlands as a favorable location of PV installation.

With regards to GHG emissions Schwill et al. (2025) found that avoided emissions resulting from peatland rewetting exceeded those associated with electricity displacement by the solar panels. Additionally, some studies highlight the shading effect of solar panels as a mechanism for reducing water loss through evaporation and potentially limiting soil respiration (CO_2

emissions) (Avonius, 2025; Seidel et al., 2024; van Noord et al., 2024). However, other scholars caution that increased shading may inhibit the development of native vegetation, potentially leading to reduced biodiversity (Serenius, 2025).

In a report by Kahal & Duke (2023) regarding GPV development on wetlands in the US they find shading from the panels to be a common concern identified in the literature. Nevertheless, they reason that results vary and point towards a study that concluded that while vegetation cover was lower in areas under the panels, there was comparable species diversity to areas not shaded by panels. Although the authors caution that this may depend on solar infrastructure design, site management practices, location and climate. To minimize impacts from shading, the scholars propose wider panel spacing, taller panel posts and/or smaller panel sizes to allow for more sunlight.

There is a debate on whether solar panels should be installed on drained peatlands without rewetting initiatives. Schwill et al. (2025) found in their study that solar parks in Germany on drained peatlands that were not rewetted emitted more CO_2 than it avoided when accounting for the life cycle emissions from solar panels. Considering this, scholars propose that solar parks on drained peatlands without rewetting should not be permitted (Schwill et al., 2025; Seidel et al., 2024; Tanneberger et al., 2021). On the other hand, Avonius 2025, who studies cut peatlands in her master thesis, states that cutaway peatlands exhibit the lowest potential for restoration, where the master thesis by Serenius (2025), who also studied cut peatlands, highlights that local conditions should be taken into account where efforts might be more justified on thick peat areas where rewetting has the potential to be more successful.

4.3.2 Technical feasibility

Soil characteristics change once the peatland is rewetted. The acidic and wet environment of rewetted peatlands provide challenges for installing solar panels (Schwill et al., 2025; Seidel et al., 2024; van Noord et al., 2024). The mounting structures of solar panels often consist of steel or aluminum which are sensitive to the low pH of the rewetted environment. In addition, the water content of the peatland varies over the seasons which can cause uneven settlements of the mounting foundations.

Different technological solutions with individual challenges and opportunities are proposed to manage the rewetted environment which include different anchoring techniques, higher mounting structures, semi-floating solar panels, bifacial panels or elevated tube panels (Schwill et al., 2025; Seidel et al., 2024; van Noord et al., 2024). Seidel et al. (2024) performed a qualitative study where an interviewed geotechnical engineer believed that a foundation with small piles in the mineral subsoil exhibits the highest potential. van Noord et al. (2024) studied three main types of technological solutions, anchoring the foundations in the mineral soil, anchoring the foundations in peat and semi-floating solar panels. They found semi-floating solar panels to be the most promising technological solution for wetter peat as more geological risks could be avoided. However, semi-floating solar panels on rewetted peat soils may pose challenges regarding vegetation management since site accessibility can become more challenging while in addition to being an untested approach. Both Schwill et al. (2025) and Seidel et al. (2024) point out that while semi-floating solar might be technically feasible they are dependent on evenly structured sites.

To summarize, the understanding of the technical viability of solar structures on peat soils, more specifically rewetted peat soils, is limited by the lack of existing projects in the field. Most researchers call for pilot projects to test how the technology functions in a wet landscape over time. However, the broader question appears to regard whether to promote semi-floating or piled solar installations to which the research is divided.

4.3.3 Economic feasibility

Economic modelling for solar parks on rewetted peatlands is next to nonexistent in the literature. However, scholars are in agreement that costs associated with technical hurdles may risk profitability for these types of projects (Seidel et al., 2024; van Noord et al., 2024). One PV expert interviewed in Seidel et al.'s (2024) study estimated additional costs for the overall installation to be 10-20% while another stated 50-100% increase due to new equipment requirements, higher material costs and a more challenging operational environment. These estimates regarded piled solutions. A Swedish report by van Noord et al. (2024) estimates that the investment costs for these types of projects using semi-floating systems may approximately be 10-20% higher than for conventional solar parks.

van Noord et al. (2024) conducted a profitability analysis in their report and found that profitability could potentially be achieved for parks of 5 MW or larger under the conditions of close proximity to grid connection (around 5 km), topographically even and well drained sites with low maintenance costs. However, the scholars reason that the electricity price would have to be around 5.5 cents/kWh, which is higher than current levels, to achieve a discounted payback time of 25 years given a levelized cost of energy (LCOE) of around 4 cents/kWh. The type of technology installed at the site also influences the cost of construction where piled fundaments, in the mineral or peat soils, are considered more expensive compared to semi-floating structures. Yet, cost estimates for semi-floating structures are challenging as no real cases of this type of technology exist on rewetted peatlands.

The profitability case is slightly different in Germany, where the projects receive more public support. Since 2023 solar parks on rewetted peatlands have been eligible for feed-in tariffs in Germany under the Renewable Energies Act (EEG) with a bonus of roughly 0.25 cents/kWh to strengthen the business case (Schwill et al., 2025). However, in the Strengths, Weaknesses, Opportunities and Threat (SWOT) analysis performed by Seidel et al. (2024), profitability was still considered a challenge due to the many technical uncertainties and difficult management conditions that the wet sites provide.

A few scholars discuss the potential for carbon credits for these types of projects which could generate an additional income stream for landowners (Seidel et al., 2024; Tanneberger et al., 2021; van Noord et al., 2024). Carbon credits have been issued for peatland rewetting initiatives, although they have not been tested in the case of combined rewetting and solar power installation.

4.3.4 Social acceptance

While much of the literature is exploratory and focuses on technical and economic feasibility of solar panels on damaged peatlands, fewer studies address landowners and energy developers desirability of this form of land-use. Laasasenaho et al. (2023) studied the preferences of landowners for after-use management of cutover peatlands in Finland. They identify solar and wind energy development as the third preferred after-use option among landowners after forestry and agriculture, based on a nationwide survey of all peat extraction site owners. Finland provides a relevant comparative context for Sweden, as both countries have historically relied on peat for energy production, although peat extraction has been more extensive in Finland (Räsänen et al., 2023). Ongoing decarbonization efforts in Finland have led to rapid decline in peat energy use, resulting in expanding areas of cut peatlands entering the after-use phase. As solar power has recently gained momentum as an after-use treatment option, Laasasenaho et al. (2023) also identify the need for more research on solar power development on cut peatlands. Especially considering that around 6000 ha of cut peatlands were allocated to solar power in Finland during 2023.

Biró-Varga & Stremke (2026) studied the social acceptance of multifunctional solar projects in the form of agrivoltaics on peat reclamation landscapes in the Netherlands. They reason that social acceptance is negatively influenced by landscape change and declining landscape quality from solar park installations. Moreover, their results point towards the importance of managing the visual appearance and shielding of the agrivoltaics as well as incorporating measures for biodiversity and habitats.

4.4 Summary of literature review and background

The current body of research highlights growing concerns regarding land-use conflicts driven by the expansion of solar energy. In response, scholars increasingly emphasize resource-efficient siting strategies, such as deploying solar on marginal land or developing multifunctional solar systems, to reduce pressure on high-value land uses like agriculture and forestry. However, the literature also identifies several barriers to the implementation of multifunctional solar, including technical, economic, and governance challenges, as well as persistent knowledge gaps. In addition, the limited number of realized projects means that much of the existing research remains largely theoretical.

Regarding after-use management of cut peatlands, the literature points to inherent trade-offs between ecological restoration objectives and landowners' economic interests. Within this context, solar development on degraded peatlands is often framed as a promising land-use option since drained peatlands can be considered marginal land, and when combined with rewetting, solar installations may represent a multifunctional strategy that integrates renewable energy generation with ecological restoration. However, the literature also reflects an ongoing debate over whether solar installations should be implemented with or without prior rewetting.

At the same time, the regulatory landscape for solar development and peatland restoration remains fragmented, with these domains largely governed in isolation and lacking clear frameworks for their integration. Taken together, both the literature and current policy context point to a need for further research into how, and under what conditions, solar development on cut peatlands can align the interests of policymakers, landowners, and developers, while contributing to Sweden's climate goals. From this background, this thesis seeks to uncover the experiences from actors in the field to enhance the development of solar power on former peat extraction sites.

5 Results and analysis

5.1 General findings

5.1.1 Current status of solar development on cut peatlands

The status of solar power development on cut peatlands in Sweden is emerging where no utility scale projects have been built on this land type. However, several developers had obtained permits for development on this land type, most commonly under Chapter 9 of the Environmental Code (SD3, SD6). Some had applied for combined Chapter 9 and 11 permits, while others had submitted notifications under Chapter 12, Section 6, and were awaiting investment decisions or grid connections before starting construction (SD2, SD5, SD6). Demonstration sites testing new technologies have also been initiated and are in the process of establishment (IO2, TD2). The size of the permitted parks varied between 45-176 ha, around 108 ha on average, with a production capacity ranging between 45-80 MW, around 66 MW on average. While these numbers remain estimates before investment decisions have been made it can be determined that the parks exceeding the >1 MW classification of large parks found in the literature (Bankel & Mignon, 2022). Larger parks have the benefits of economies of scale which decreases costs in the installation and maintenance of the park of interest for solar developers (SD1, SD3, SD4, SD5).

5.1.2 Views on solar development on cut peatlands

The interviewees views on solar development on cut peatlands were in general positive, although perceptions were divided where some interviewees viewed other land types as more suitable. The main benefit was viewed as the land having a low ecological value while simultaneously avoiding land with higher values such as forestry and agricultural land (IO1, IO2, CAM2, CAM3, SD1, SD3-SD6, TD1, TD2, R2). One interviewee did not prefer developing solar on cut peatlands while not being necessarily negative towards the land type (SD2). Only one solar developer was strongly against solar on cut peatlands due to the challenges they had experienced when trying to develop on the land area (SD4). Another interviewee (R1) stated that although solar development on cut peatlands is feasible, the interviewee questioned buildout on natural land and instead preferred technical grounds such as roofs, asphalt or brick. Finally, one interviewee (CAM1) stated that it might not be an optimal combination due to the impact on *Spaghnum* moss, hydrology and potential leaching of zinc while also stating that on the other hand there are very few incentives for the landowner to choose to rewet their land without an additional revenue stream.

5.1.3 Drivers and barriers for actors involved in the land-energy-climate nexus

This section explores the key drivers and barriers influencing different actors involved in the land–energy–climate nexus, based on interviewees' perspectives and experiences.

Landowners

Although landowners were not directly included in the study, their perspectives were captured indirectly through interest organizations and interviewees' experiences working with them. The two main drivers for landowner interest identified by the interviewees were potential for a new income stream (IO1, IO2, SD1, SD2, SD5, SD6, R2), and a personal interest in either energy production or nature restoration (IO1, IO2, SD2, SD5, SD6, TD2, CAB1). One interviewee (SD5) emphasized that solar parks are perceived as relatively low-maintenance investments, which is particularly attractive for older landowners who may not wish to rely on future generations to manage the land. In some cases, landowners were also motivated by noneconomic factors. One interviewee (IO2), developing a demonstration site for solar on a rewetted cut peatland, identified that landowners, particularly those engaged in agriculture, viewed solar development as a means to increase energy resilience of their establishment. The main barrier identified by interviewees relates to rewetting. Interviewees noted that the lack of economic incentives for rewetting discourages landowners, particularly when it may negatively impact existing income-generating land uses such as forestry (CAB1, CAB2).

Peat extraction companies

Peat extraction companies were not directly interviewed but were represented through their industry organization and indirectly through interviewees' experiences working with the sector, including one respondent with prior industry experience. A key driver identified was the potential for reputational improvement, as several interviewees suggested that engagement in solar development could help mitigate the negative public perception often associated with the peat industry (SD4, CAB3, R1). Another driver related to after-use land management, where solar development was viewed as a potentially cost-efficient after-use treatment option (CAB3). However, a significant barrier concerns the timing of site closure and after-use treatment, as peat companies are under regulatory and economic pressure to finalize operations quickly after extraction ends (SD6). This can conflict with solar developers' preferences, particularly regarding water management. For instance, one interviewee described how the cessation of drainage systems would lead to flooding of the site, where the developer would prefer controlled rewetting (e.g., maintaining water levels at approximately 10 cm below the surface) to optimize both GHG mitigation and solar installation conditions. This challenge is closely linked to regulatory conditions, further discussed in Section 5.2.5.

County Administration Boards

CABs play a central role as regulatory authorities, with the responsibility to ensure compliance with environmental legislation (CAB1, CAB2, CAB3). One interviewee (CAB2) highlighted Chapter 3 of the Environmental Code, which emphasizes the need for resource-efficient land and water use. Within the Environmental Code, the utilization of cut peatlands for solar development may be considered appropriate, particularly given their relatively low ecological value. However, a barrier identified by one developer (SD4) relates to the governance structure of CABs, which are guided by governmental directives and policy letters. This may limit their ability to support innovative or unconventional land-use solutions, particularly in cases where regulatory guidance is unclear.

Solar developers

All solar developers underscored the need to be profit driving, with economic viability representing a fundamental condition for project development. At the same time, interviewees emphasized that profitability considerations can act both as a driver and a constraint for innovation. Developers highlighted the importance of balancing economic objectives with environmental and social sustainability, particularly in the context of emerging land-use practices such as solar development on peatlands. While innovation is necessary to overcome technical and environmental challenges, it is often constrained as a financial risk driven by uncertain regulatory conditions and investor expectations, further elaborated in Section 5.2.2.

5.2 PESTLE analysis

5.2.1 Political factors

The political landscape influences the viability for solar power development in general, as well as solar power development on cut peatland sites specifically. Thus, challenges and opportunities identified by the interviewees were multidimensional, ranging from the international energy landscape to national policy and governance.

Challenges

Challenges in the political landscape were mainly concentrated on barriers that hinder solar energy buildout. Some interviewees discussed how instability in the geopolitical landscape has resulted in a slower shift from fossil fuels which in turn negatively impacts the demand for renewable buildout (TD2, SD4, SD5, SD6). Similarly, interviewees (T2, SD1, SD2, IO2) also mentioned changes in government and a lack of clarity in Swedish energy policy as challenges hindering long term planning. As one developer (SD2) explained:

> *"We need to generate more electricity in Sweden. According to all available forecasts, we need to generate more electricity in Sweden, but how exactly we should go about it isn't entirely clear, and right now, since no clear stance is being taken, there may not be a clear path forward for any particular energy source. So, clarity is really the most important thing for developers like us to be able to make good decisions and yes, to be able to take some initiative, create some strategies, or think more long-term, rather than just reacting to what's happening in the markets."*

In terms of subsidies or financial support for solar diffusion, in general and on peatlands, interviewees state that the challenge mainly concerns unequal treatment where some energy sources such as nuclear receive financial support while others, like renewables, do not (SD4, SD6). However, the interviewees do not necessarily promote subsidies for renewable energy, rather point towards how differences in treatment influence the appetite for renewable energy buildout. Similarly, one interviewee (SD1) also points towards an imbalance in innovative sustainable development of solar power projects where developers drive advancements in technology design, combined land use and permitting:

> *"I think the balance of who is driving development is too skewed given our shared goals, because the industry is driving development to a great extent. But we all need to work together. That's my position."*

One interviewee (R1) questioned the current rewetting priorities in Swedens rewetting strategy on the basis that the focus on rewetting nutrient rich, organic, soils is incorrect. Instead, the interviewee (R1) highlights the benefits of rewetting former peat extraction sites due to their potential of having a low nutrient status:

> *"Yes, exactly [CABs rewetting strategies focusing on nutrient rich agricultural land], because they do not know and they do not understand [developers of the strategies], and we have been trying all along to point out that it is wrong to focus on nutrient-rich peatlands in southern Sweden—where "nutrient-rich" means rich in phosphorus, nitrogen, and other nutrients. It doesn't mean they are particularly rich in carbon. Because if you look at the nitrogen-to-carbon ratio, you'll see that in the nutrient-rich ones it's pretty low, and that means the carbon has been mineralized, and that process releases a lot of nitrogen. On the other hand, the nutrient-poor peatlands that are drained—they do not contain much nutrition, but perhaps still a lot of carbon, and so it is more important to keep the carbon in the soil rather than worrying about nutrients that are not there—yes, unfortunately, that is how it is."*

While there are strategies and guidelines for rewetting, both industry and government actors request guidelines for the case of solar power development on peatlands. One actor (R1) highlighted that there could potentially be large risks to the environment if there are no rules to guide this emerging land use strategy. The interviewees also request guidelines to enable sustainable development of solar parks and avoid uncertainties in the permitting process (SD1, SD3, SD5, IO2, CAB2).

Opportunities

General EU policy aimed at phasing out fossil fuels was identified as a key enabler for solar energy development (IO2), while the Nature Restoration Law was highlighted by some interviewees as a driver for peatland rewetting initiatives (CAB2, R2). Although cut peatlands are not explicitly prioritized within the regulation, they may still be included within broader rewetting targets (CAB1).

However, considerable uncertainty remains regarding how combined solar and rewetting projects will be treated under the Nature Restoration Law. One interviewee (R2) noted that they are currently involved in a project exploring whether the requirements of the regulation can be fulfilled through integrated approaches combining solar energy production with peatland rewetting. In addition to assessing compliance, the project aims to investigate how multifunctional land use can be facilitated in practice. The interviewee further suggested that such initiatives could contribute to future policy development, potentially including revisions to permitting procedures, adjustments to existing government support schemes, and the introduction of new mechanisms to better support rewetting of peatlands in combination with renewable energy development.

While there are no current grants for solar development on rewetted cut peatlands, some interviewees viewed it as potentially possible to receive some compensation for rewetting in certain cases given that rewetting targets will be driven by the Nature Restoration Law (CAB1, CAB3, R2). However, two interviewees (R2, TD2) pointed out that it is likely that demonstration or pilot projects showcasing the climate impact from combined rewetting and solar installation would be needed to enable financial support. One interviewee (SD4) found it unlikely for combined rewetting and solar installation to be viable without financial insurance guarantees from the government as a measure to derisk the project. Another enabler identified by one interviewee was the need for collaboration, perhaps through an industry association for solar developers on peatlands (SD1).

5.2.2 Economic factors

Uncertainty regarding whether the projects can become economically viable or not appears as the most critical challenge facing solar development on cut peatlands. A greater economic concern could also be identified if the projects would be combined with rewetting. Based on the interviews two main themes of economic challenges arose, external economic challenges and economic challenges specific to cut peatlands. From the interviews it also became clear that there are different land-use strategies conducted by the solar developers on this type of land use which influenced the challenges and opportunities they identified.

Differences in business strategies

Two main strategies could be identified from the interviews. The first was integrating the solar park as part of the after-use management plan for peat extraction. With this strategy, the peat extraction company and the solar developer overlap slightly in their activities (SD3, SD4, SD6). The second strategy was developing solar projects on historic peatland extraction sites. On these land areas after-use treatment had been carried out meaning that there could be production forest or rewetted areas (SD2, SD4, IO2). However, as the peat extraction had ceased, there was no overlap in the activity by the peat extraction company and the solar developer. In both cases there was also contact with the landowner who is part of the decision-making process on how the land area should be managed. One interviewee was developing a project on a large land area which contained both areas with pristine wetlands, historic cut peatlands as well as forests (SD5).

While similar in many ways, the status of the land area, active or historic peat extraction site, could influence the economic viability of the project. Historic extraction sites have typically undergone after-use treatment, most commonly through the establishment of production forests (SD2, IO1). Furthermore, depending on how the drainage ditches have been managed in the after-use treatment, historic sites could have accumulated water which can introduce additional considerations in the permitting process, see Section 5.2.5 (SD1, SD6). On the other hand, active extraction sites present a different set of opportunities and uncertainties. While some interviewees viewed solar energy production as a potential after-use solution, it remains debated whether solar deployment can formally qualify as an after-use treatment for peat extraction.

Finally, one developer (SD4), who had previously pursued projects on both historic and active peat extraction sites, ultimately chose to liquidate their peat portfolio. This decision was attributed to economic challenges associated with developing solar projects on cut peatland sites, highlighting the financial risks perceived within this development context.

Challenges

External

The interviewees identified two primary external challenges influencing the development of solar power projects: grid connection constraints (TD1, TD2, SD2-SD6) and current electricity market prices (TD1, TD2, SD1, SD4, SD6, R2).

Challenges related to grid connection were described as twofold. First, grid availability was highlighted as a major constraint. Before a project can be connected, grid operators must conduct a capacity assessment to determine whether sufficient transmission capacity exists at the relevant connection point. While Swedish grid operators are legally obligated to provide connection for the requested capacity, interviewees noted that the timelines associated with grid expansion can be lengthy. As a result, project commissioning may be significantly delayed, postponing the start of electricity delivery and revenue generation (TD1, TD2, SD5, SD6). Second, interviewees emphasized the cost of grid connection, particularly expenses related to required grid reinforcements or upgrades. Developers are often responsible for financing these enhancements, and several respondents described these costs as a decisive factor in project feasibility. In multiple cases, grid connection expenses were characterized as a "make-or-break" component determining whether projects could proceed (TD2, SD3- SD6). Interviewees also highlighted low and fluctuating electricity prices as a barrier to solar deployment which cause investment uncertainty thereby constraining the pace of solar power expansion.

Economic challenges with cut peatlands

Some interviewees identified economic challenges associated with the remote location of cut peatland sites (SD3, SD4, IO1). These locations were described as having limited existing infrastructure beyond what was originally developed to support the peat extraction activities. According to the interviewees, the remoteness of these areas is typically associated with low local electricity demand, requiring generated electricity to be transmitted over longer distances within the grid. This increases transmission-related rates and fees borne by the electricity producer, thereby negatively affecting project profitability (SD3, IO1). In addition, one interviewee noted that grid operators may have limited incentives to expand or reinforce grid infrastructure in remote areas due to the absence of significant local demand. As a result, project timelines may be substantially delayed, and developers may face considerably higher costs if they choose to finance grid reinforcements themselves (SD4).

Beyond electricity network constraints, one interviewee also highlighted that solar irradiation conditions at some peatland sites can be comparatively unfavorable due to the locations of the sites. Consequently, projects may need to compensate for lower solar irradiance through alternative measures, such as increasing project scale or reducing installation costs for the project to remain economically viable (SD3).

If combined with rewetting another large theme influencing profitability is the novelty of cut peatlands as a land category for solar development which is closely related to new technology and economies of scale (TD2, SD1). The interviewees highlight additional challenges relating to construction and maintenance that appear when these types of projects are combined with rewetting, causing some project developers to refrain from such activities (SD2, SD3, SD5). Here interviewees identify both investors' risk aversion for projects as well as competition with established technology as challenges (SD4, TD2). One interviewee (SD4) summarized the challenges with combined rewetting and solar development as follows:

> *"In that case [combining development with rewetting], we have a low pH, which means we have to use special steel. We have issues with ground settlement, so to speak. We either need to drive it very, very deep into the ground or build custom solutions to accommodate the cells. Now, there are certain sleds available that can support semi-floating installations. But even those are very expensive. So that results in a completely different construction cost, which also makes it not particularly appealing. We end up with a more expensive permitting process, a more expensive facility, and higher and more difficult maintenance costs, making the whole process much more complicated and expensive. Consequently, it's not economically viable, which means investors aren't interested in participating in such projects, purchasing them, or building them. Then we'll have to build them ourselves, which means low profitability, and our owner isn't really interested in that."*

Taking both external and internal economic challenges together, the current economic viability for these types of projects is low. Although interviewees are more positive towards the economic viability of such projects when avoiding the combination with rewetting. Additionally, interviewees also highlight that while this is the case in general, there will always be specific sites that contradict the general profitability concerns with cut peatlands (SD4).

Opportunities

External

To manage the challenges that arise with fluctuating electricity prices, multiple interviewees promote the inclusion of battery energy storage systems (BESS) which can allow the electricity producer to charge the battery when electricity prices are low and sell the electricity when the prices are more favorable (SD4, IO2). Designing the solar park by positioning the solar panels in a different location, east-west instead of south facing, is also a method taken by developers to avoid producing electricity when the prices are low (TD1, TD2).

Economic opportunities with cut peatlands

Some physical characteristics of cut peatlands were highlighted by interviewees as favorable for solar power development. These included the absence of rocks (SD2), relatively flat terrain (TD2, IO1), and shallow peat depth (SD2, SD3, SD4). However, perceptions of favorable site conditions varied depending on the development strategy and the type of mounting technology considered. In particular, shallow peat depth and limited rock presence were viewed as especially advantageous for piled mounting solutions, where ground penetration is required for structural stability (SD2, SD3).

Regarding capital expenditure, most interviewees agreed that semi-floating solar panel systems currently involve higher upfront costs compared to conventional piled installations (TD1, TD2, IO2, SD1, SD4, SD6). Despite this, respondents expressed optimism about ongoing technological development and emphasized that semi-floating solutions may represent the most suitable option for wetter peatland areas where ground-based anchoring is technically challenging.

Technology developers further stressed the importance of valuing operational expenditures into overall cost assessments. According to both technology developers (TD1, TD2), semi-floating or surface-sitting systems may generate economic advantages during the operational phase. These solutions do not require ground penetration, meaning they may reduce costs associated with permitting and installation, as extensive geotechnical investigations are not required to the same extent as for piled systems. One developer (TD2) additionally noted that the full structure remains accessible for inspection throughout its lifetime, potentially improving system durability. This was contrasted with piled solutions, which may face increased risks of corrosion in wet peatland environments characterized by low pH conditions.

One technology developer (TD1) described their proprietary solution, referred to as peat buckets, as a lower-cost alternative to traditional piled systems when deployed on cut peatlands. The same developer also presented a vertically mounted panel design (see Section 5.2.4), which was estimated to reduce costs by approximately 40 % compared to peat bucket installations, positioning it as a potentially highly cost-efficient solution for this land type. Furthermore, due to the lower structural height of semi-floating and sitting solutions that hinders panels from shading each other, parks can be designed with tighter panel spacing allowing for increased production density per hectare (TD1, TD2).

In areas characterized by higher soil moisture or in scenarios involving combined rewetting, several interviewees identified potential economic advantages related to electricity production. Interviewees noted that solar panels installed on moist or rewetted surfaces may benefit from a cooling effect, which can improve panel efficiency and thereby increase electricity generation (SD1, SD2, SD6, TD1, TD2). In addition, some respondents highlighted that water surfaces beneath installations may enhance light reflection when using bifacial solar panels, potentially contributing to higher energy yields (SD1). Interviewees also emphasized operational benefits associated with wetter peatland conditions such as reduced vegetation growth in rewetted or waterlogged areas lowering the need for vegetation management and resulting in decreased maintenance requirements over the project lifetime (TD1, TD2, R1, R2).

In development scenarios where full rewetting was not implemented, some interviewees described alternative forms of combined land use, including berry or grass cultivation beneath solar panels (SD3, IO1). Grass cultivation was suggested to provide additional surface reflectivity, which could further enhance the performance of bifacial solar panels and increase electricity yield (SD3).

5.2.3 Social factors

The social perspective of the PESTLE was explored through the lens of public acceptance that the interviewees had experienced, mainly through the development of projects. Overall, interviewees reported relatively limited public opposition to solar development on cut peatlands. In several cases, such developments were instead perceived as socially acceptable or even favorable land-use alternatives compared to solar installations on previously undisturbed landscapes. One interviewee highlighted concerns regarding workers’ safety when developing projects in wet areas.

Challenges

Public acceptance of solar power in general was described as closely linked to perceptions of visual impact and landscape transformation (TD1, SD4–SD6, CAB1, CAB2, IO1, C1). One interviewee emphasized that, unlike wind power, solar parks are not governed by equally strict national guidelines regarding minimum distance to nearby residents, meaning that decisions on buffer zones are often left to developers, which can create uncertainty in addressing social concerns during project planning (CAB2). Acceptance was also noted to depend on land-use history, as solar development on formerly extracted peatlands that have transitioned into recreational or naturalized areas may face stronger resistance if redeveloped, particularly where sites hold cultural or industrial heritage value requiring careful consideration in permitting processes (C1). Interviewees further reported mixed public attitudes toward peatland rewetting, with resistance in some cases toward solar projects without rewetting measures, while in other contexts rewetting itself generated conflicting stakeholder views (CAB1, IO1). Beyond public perception, occupational safety concerns were also highlighted, as unstable, water-saturated peatland conditions were described as posing risks during construction and installation activities involving heavy machinery and work at height, especially in the case of piled solutions (SD3).

Opportunities

While many social challenges associated with solar development are general rather than specific to peatlands, interviewees more frequently emphasized social opportunities linked to siting solar parks on cut peatlands (SD1–SD4, SD6, TD1). For active peat extraction sites, prior industrial use was perceived as enhancing public acceptance, as local communities are accustomed to extraction activities may view solar development as a relatively minor landscape change compared to development on pristine land (SD3, SD6). In addition, the typically remote location of cut peatlands was seen as reducing potential social conflicts due to limited proximity to residential areas (SD2). Technological design was also identified as an important factor, with semi-floating or surface-sitting solar systems noted to have lower structural height than conventional piled installations, thereby reducing visual impact (TD1). More broadly, interviewees suggested that acceptance could be strengthened through communication strategies that highlight broader land-use benefits, particularly the avoidance of competition with agricultural or forested land, which was viewed as a potentially persuasive argument for increasing societal support (SD1, SD3, SD4).

5.2.4 Technological factors

Three main types of technologies were explored in the interviews: traditional piled mounting, semi-floating solar mounting and peat buckets. While all technologies serve the same primary function of supporting photovoltaic panels, their key differences lie in how they are stabilized within or on the peat substrate. A piled mounting structure requires piles to be driven into the ground and anchored in the soil. Variations of this approach include the use of ground screws, which require less penetration depth (SD2-SD6). Semi-floating solar systems consist of a plastic pontoon on which the solar panels are mounted and attached to each other in the sides into larger modules. The modules are then anchored though a ballast system, see Figure 5-1 (TD2). Finally, the peat buckets are constructed using two trapezoid shaped, magnelis coated, buckets per panel. These systems are assembled into larger modules and stabilized through ballast, with only minimal ground penetration (approximately 3 cm), see Figure 5-2 (TD1). The same developer is also exploring vertical mounting systems, where panels are attached to track-like structures designed to sit on the peat surface, also seen in Figure 5-2 (TD1).

Preferences for technological solutions varied among developers. Two developers expressed a clear preference for piled solutions (SD2, SD3), while two others favored piled solutions but remained open to alternatives (SD5, SD6). One developer emphasized that technology choice should be site-specific and dependent on ground conditions (SD1), whereas another expressed skepticism toward existing solutions and instead highlighted the potential of further developing semi-floating technologies (SD4).

Challenges

Cut peatlands present a range of technological challenges due to their unique physical and environmental characteristics. Interviewees described these sites as having soft and unstable soils, low vegetation cover, low pH, and elevated flood risk, all of which may vary over time as hydrological conditions change (TD1, TD2, SD1- SD3, R2). Peat depth was reported to vary between approximately 30 cm and 1 m following extraction, further influencing technology suitability. Additionally, climatic conditions in Sweden impose requirements for structures to withstand snow loads during winter (SD2).

Apart from the economic challenges mentioned in Section 5.2.2 interviewees identified how these land conditions and technological solutions influence the development of solar on cut peatlands. Across the interviews, uncertainties in installation and maintenance were driven by knowledge gaps regarding emerging technologies as well as uncertainties in risk management of the land areas, especially when the technology would be located in wetter areas.

Installation and maintenance

Installation of solar panels on cut peatlands can be challenging due to peat conditions of the site and the remote location (SD3) where additional challenges were identified in wetter areas. The feasibility and complexity of installation differed across technologies. Maintenance challenges were viewed as larger for wetter or rewetted areas where site accessibility and management of critical infrastructure were questioned by some interviewees (R1, R2, SD2-SD4).

Piled solutions require heavy machinery to drive steel piles into the ground. Due to the softness of peat soils, longer piles are often necessary to ensure structural stability (SD3). Additional reinforcement measures, such as cross-bracing or steel collars, may be required to reduce the risk of uneven settlement. To mitigate corrosion risks associated with low pH conditions, piles are typically coated; however, one developer reported higher-than-expected corrosion rates at a demonstration site, leading them to abandon this approach (SD4). Furthermore, concerns were raised that piled installations could potentially disrupt the hydrological balance of the site (TD1, R1, SD2). Due to the technological challenges with piled solutions in wetter environments, most interviewees who supported this solution did not consider a combined rewetting and solar approach (SD2, SD3).

Maintenance of piled solutions was generally perceived as more straight forward compared to alternative solutions, primarily due to the typically drier ground conditions required for their installation. These conditions were considered to facilitate access for maintenance activities, although some adaptations in machinery, such as the use of vehicles suited for soft terrain, may still be necessary (SD2). Interviewees noted that maintenance operations could often be conducted via established internal road networks, allowing relatively easy access to panel rows and associated infrastructure (SD2, SD3, SD5). In cases where ground conditions were wetter, strategic park design, such as the placement of access routes and critical infrastructure, was highlighted as an important measure to ensure maintainability throughout the projects lifecycle (SD3, SD5).

Semi-floating solutions (Figure 5-1) are installed by positioning modular pontoons onto the surface, either by winching them into place or deploying them during colder periods when the ground is sufficiently stable (TD2). Because these systems do not penetrate the soil, corrosion risks associated with acidic peat conditions and ground stability are reduced. Interviewees generally did not express major concerns regarding the structural robustness of these systems; instead, their primary limitation was identified as high capital cost (TD1, TD2, IO2, SD1-SD6).

Multiple interviewees raised concerns regarding site accessibility under wet conditions, as well as the management and routing of electrical cables in environments characterized by high moisture levels (R1, SD2, SD3). Depending on site wetness, maintenance of semi-floating systems may require adapted access solutions. One approach highlighted by an interviewee is the installation of walkway bridges between panel modules, enabling safe movement for inspection and servicing activities (TD2). Furthermore, the technology developer emphasized the importance of strategic park design, suggesting that critical infrastructure, such as inverters and connection points, should be located on drier peripheral areas or alternatively installed on elevated platforms to ensure functionality and ease of access (TD2).

Figure 5-1. Semi-floating solar modules on peatlands

Source: Interviewee

Sitting peat bucket solutions (Figure 5-2) are assembled off-site or on more stable peripheral ground, after which modules are transported, either by ground vehicles or potentially by drones, to their final location (TD1). Installation may also be optimized by conducting work during winter when the ground is frozen. These systems typically involve lighter structures with a lower profile, which may simplify installation. However, awareness of this technology among industry actors was limited, and several interviewees indicated that they lacked sufficient experience to assess its performance (IO2, SD4, TD2).

The same concerns regarding accessibility and management of critical infrastructure applies for the peat bucket solutions as they are developed for wetter ground conditions. The technology developer highlighted strategic park design where the critical infrastructure would be clustered in areas with more stable ground conditions to facilitate access and ensure reliable operation (TD1).

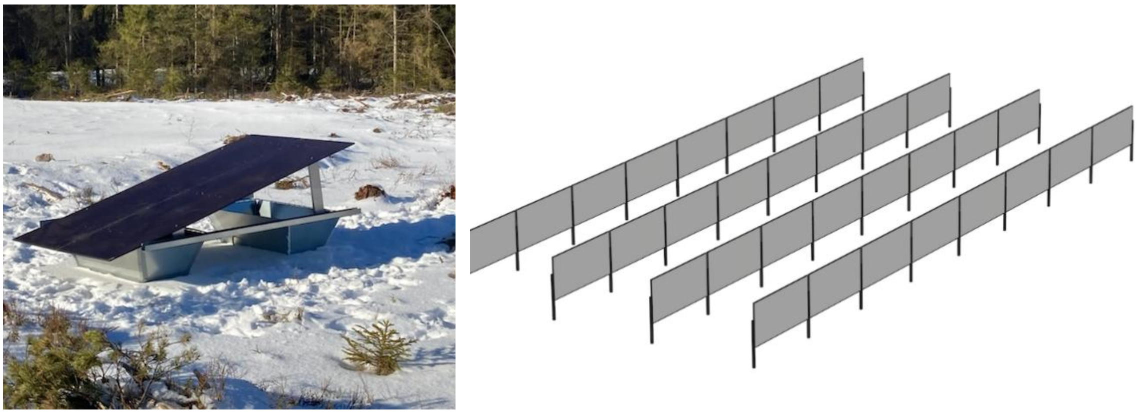


Figure 5-2. Sitting peat bucket solution on peat (left) and model of vertical solutions (right)

Source: Interviewee

Additional challenges

Additional challenges identified by the interviewees mainly related to the new technologies (IO2, SD2, SD4, R1, TD1, TD2, CAM2). The main area of concern among the interviewees regarded the untested status of the newer solutions for larger scale projects where multiple actors requested more demonstration sites (IO2, TD1, TD2, SD1, SD5, R2). Although one technology developer (TD2) stated that it can be difficult to transition from smaller piloting scale to larger projects, as no one necessarily wants to be the first mover, especially with the economic challenges the solar industry is facing. The interviewee presented this challenge as a catch-22.

Another challenge identified by one developer relates to the limited track record of these emerging technological solutions, which can complicate access to long-term guarantees and insurance coverage (SD4). The perceived uncertainty associated with deploying relatively untested technologies in novel land conditions was viewed as a significant barrier to project development. As a result, the feasibility of such projects depends on the willingness of risk-tolerant investors to support early-stage implementation despite these uncertainties (SD4).

Opportunities

Technological opportunities identified in the interviews were closely linked to positive environmental interactions as well as the potential for flexible and multifunctional land use.

Several interviewees highlighted that cut peatlands are often large, flat, and relatively uniform, which facilitates installation processes and enables large-scale solar park development (SD3, SD6). In cases where project areas span multiple land types, one interviewee suggested that a combination of different technological solutions could be applied within the same park to optimize performance across varying ground conditions, although this is not currently a preferred solution (SD5, R2).

Several interviews also identified risks that can arise if cut peatlands are maintained in a dry state, these were increased GHG emission, higher fire risk, and dust formation (R1, SD4, SD6). Where fire risk and dust formation were considered the larger risks for solar power production. In this context, rewetting was identified as a complementary strategy that may reduce these risks and improve overall site conditions. Some interviewees also noted that installing solar panels on dry peatlands could contribute to elevated ground temperatures due to a "black body heat effect", potentially increasing fire risk under certain conditions (R1, SD4). However, it was also emphasized that solar panels themselves are not inherently fire-prone, although external ignition sources may still pose a risk (SD3, SD4, SD6).

In wetter environments, several technological advantages were identified. Interviewees suggested that solar panels may contribute to water retention by reducing evaporation, which can have positive implications for both electricity generation, through a cooling effect on panel efficiency, and peatland hydrology (IO2, SD1, TD2). Under such conditions, non-piled solutions, including semi-floating and surface-sitting systems, were highlighted as particularly advantageous. These technologies avoid ground penetration and are therefore less dependent on peat depth and soil stability, reducing certain technical risks associated with anchoring (R2, SD5). Semi-floating systems were also noted for their ability to accommodate periodic flooding, increasing their suitability for dynamic hydrological environments (TD2). Interviewees also stated that these newer technological solutions, due to their lower height, also allow for closer panel spacing which has the potential to increase the density from circa 1 MW per ha to around 2 MW per ha (SD1, TD1, TD2).

Additionally, the low invasiveness and modularity of surface-based solutions, were identified as key advantages. These systems can be more easily relocated, adjusted, or removed, providing flexibility in response to changing site conditions or technological developments during the lifetime of the project (IO2, TD1). This adaptability was further highlighted as a means of reducing long-term project risk, as installations are not permanently fixed to a single configuration or location (TD1).

5.2.5 Legal factors

The legal dimension was explored through challenges and opportunities associated with the permitting process for solar development on cut peatlands.

Under the Swedish Environmental Code, solar developers are required to notify their activities in accordance with Chapter 12, Section 6. However, interviewees noted an increasing tendency among developers to instead apply for environmental permits under Chapter 9, environmentally hazardous activities (CAB2). This shift was attributed both to increasing project scale and to a desire to reduce risk exposure, as permits provide stronger legal certainty compared to notification procedures (C1, SD1-SD6). A key legal issue specific to peatland-based solar development concerns the potential classification of projects as water operations under Chapter 11 of the Environmental Code. If classified as such, projects require a more extensive permitting process through the Land and Environment Court, rather than the CAB, which some interviewees view as significantly increasing procedural complexity, especially when compared to notification procedures in accordance with Chapter 12 paragraph 6 as well as a permit under Chapter 9 of the Environmental Code (SD3-SD6).

Challenges

Legal challenges were primarily associated with the novelty of combining solar development with peatland environments, resulting in substantial regulatory uncertainty. A majority of interviewees highlighted the lack of clear guidelines and legal praxis as a central barrier to project development (IO2, R1, R2, CAM1–CAM3, SD1–SD6).

Classification as water operations

A major source of uncertainty concerns whether or how solar installations on peatlands should be classified as water operations (C1, IO2, SD1, SD3–SD6, R2, TD2, CAB3). This classification differs significantly from conventional solar permitting and introduces several challenges such as limited experience among developers and authorities, increased permitting complexity, higher administrative and financial costs as well as requirement for court-based approval.

A specific legal ambiguity relates to how the extent of the water operation is defined. Interviewees described ongoing debates regarding whether the relevant area refers to the footprint of the piles, or the total shaded or covered area of the solar installation (C1, SD5). Interviewees often interpreted the shaded area the distinguishing factor for a water operation (C1, SD1, SD5). This distinction is critical, as it determines whether the project exceeds the 3,000 m^2 threshold, thereby triggering full permitting requirements under Chapter 11 (C1, SD5). Permitting under Chapter 11 was described as significantly more costly and time-consuming than other permitting pathways. Interviewees noted that large-scale projects may incur a separate application cost of approximately 400,000 SEK, in addition to expenses for legal advice and technical investigations (C1, SD4, SD5, SD6). Rewetting activities themselves are also classified as water operations, further compounding costs in projects combining solar development with peatland restoration (CAB2).

Lack of consistency and regional interpretation

Another key challenge relates to inconsistent interpretation of regulations across regions, particularly regarding whether solar development can be considered part of the after-use management plan of peat extraction. Interviewees reported divergent positions among CABs where some rejected solar as an after-use option (CAB2, R1) and others considered solar appropriate where ecological values are already degraded (CAB3). In the absence of formal guidelines and established case law, these differences create regulatory uncertainty and unpredictability, despite ongoing efforts by authorities to share experiences (CAB1–CAB3, SD1, SD3, SD5, SD6, IO2, TD1). This challenge was summarized by SD6:

> *"Another drawback is that water is usually involved, and in that case there's a high risk that it will be classified as a water operating activity, which means the case isn't adjudicated under Chapter 9, but under Chapter 11. And it's the courts that serve as the adjudicating authorities. Yes, it's probably more complicated, and above all, there aren't many such cases, so there isn't much praxis or anything like that."*

Competing land use priorities

Legal challenges were also linked to conflicting land use objectives, particularly between ecological restoration (e.g., rewetting), and solar energy development. Authorities may prioritize restoration measures, while developers often prefer drier conditions for technical and economic reasons (SD4, SD5). Additionally, the implementation of the Nature Restoration Law may further increase pressure to rewet cut peatlands, potentially limiting opportunities for solar development (CAB1). However, it remains unknown whether the two activities can be combined under the Nature Restoration Law (R2).

Limited legal recognition of co-benefits

Although some interviewees highlighted the potential for combined climate benefits, through both renewable energy generation and reduced emissions from rewetting, these synergies are not formally recognized within the current legal framework (SD6, C1). This limits the extent to which such benefits can influence permitting decisions.

Opportunities

A key legal and strategic opportunity identified by interviewees is the potential to develop solar parks on cut peatlands instead of more contested land types, such as agricultural or forested areas (IO1, IO2, SD1, SD3, SD5, SD6, CAM2, CAM3, TD2, R2). This land-use approach was widely perceived as advantageous, as it avoids competition with food production and high ecological value landscapes, which are often subject to stricter regulatory scrutiny. Several interviewees noted that this positioning may lead to higher regulatory acceptance, particularly CABs, which are typically more restrictive toward solar development on agricultural and forest land. As a result, solar development on cut peatlands can be framed as a mutually beneficial land-use strategy, aligning the interests of developers, regulators, and environmental objectives.

While the classification of solar projects as water operations under Chapter 11 was primarily perceived as a challenge, some interviewees also identified potential advantages associated with this permitting pathway. In particular, the more comprehensive permitting process was viewed as providing stronger legal protection and clarity for projects once approved and could potentially be conducted in a shorter timeframe (C1, SD5). Additionally, one interviewee suggested that the difference in cost between permitting pathways may not be so significant (SD6). Finally, one technology developer emphasized the potential for alignment between regulatory and technological development, particularly in scenarios combining rewetting with non-intrusive solar technologies (TD1).

5.2.6 Environmental factors

Environmental benefits were identified as one of the most significant dimensions of solar development on cut peatlands, both in scenarios with and without rewetting. Interviewees highlighted both potential climate and biodiversity benefits, as well as key environmental risks. Two primary environmental concerns were consistently raised across interviews, the shading effect of solar panels on vegetation growth (C1, TD1, R2, TD2, CAB1, CAB3) and the potential leaching of metals from panel structures (C1, IO2, CAB1, CAB2). However, one researcher (R1) stated that *Sphagnum,* a key peat-forming species, can grow under diffused light conditions, including beneath snow cover, suggesting that shading effects may not necessarily inhibit peatland vegetation (R1, TD2). Technological adaptations, such as vertical panel configurations, may further reduce shading impacts in rewetted environments (TD1).

Challenges

Without rewetting there is continued oxidation of the peat soil, leading to sustained CO_2 emissions (R1, SD6). R1 stated that solar development without rewetting is undesirable as it does not benefit the climate, biodiversity or the hydrology. Additional environmental concerns identified mainly related to the loss of benefits rewetting the land such as enhanced fire risk on dry peatlands (SD3, SD4, SD6, R1). Two interviewees also emphasized the need for further research comparing climate impacts between rewetted and non-rewetted solar projects (SD6, R2).

With rewetting environmental challenges were primarily linked to the implementation and management of rewetting processes. The key challenges identified were high costs and technical complexity of rewetting (SD2, SD5, CAM1), methane emissions risk if rewetting is improperly managed, particularly if water levels are too high (CAM1) and the need for precise hydrological control, typically requiring water tables to be maintained around 10 cm below the surface (CAM1, R1, SD6). In addition, rewetting requires landowners' approval, as many peatlands remain privately owned (IO1). IO1 further underscores the necessity to recognize that rewetting does not fully restore original ecosystem conditions, meaning historical ecological values cannot be fully restored. Rewetting may also introduce project-related constraints, such as increased difficulty in project financing or resale (SD5).

Opportunities

Environmental opportunities were identified across both scenarios, though they differed in magnitude and type depending on whether rewetting was included. A major environmental advantage highlighted by interviewees in both scenarios is that cut peatlands typically have low ecological value, making them suitable for solar development without competing with high-biodiversity or productive land uses (C1, IO1, IO2, SD1, SD3–SD6, CAB2, CAB3, TD2). This supports the framing of solar on peatlands as an efficient land-use strategy, particularly as there is increased pressure to preserve agricultural and forest land.

Even without rewetting several environmental benefits were identified. Interviewees identified the potential for microclimate creation, supporting certain species such as birds and insects through reduced evaporation and sharing effects which may moderately improve local conditions (SD2, SD3, SD5, SD6). However, interviewees emphasized that these benefits are uncertain and require further research, particularly regarding biodiversity and long-term ecosystem impacts (SD1, TD2, SD5).

Projects with rewetting were considered to have the largest environmental benefits, particularly in terms of climate impact. Interviewees identify key opportunities such as reduction in GHG emissions through avoided peat oxidation (CAB2, R1, R2, SD6) as well as restoration of wetland hydrology and associated ecosystem function over time (R1, SD6). One interviewee highlighted that cut peatlands are highly suitable for rewetting due to their low nutrient status, reducing risks of nutrient leaching as well as methane emissions (R1). Some interviewees stated that the peat depth may influence the suitability of rewetting (SD3, SD4, R2, CAB1). However, another interviewee stated that rewetting can be conducted in shallow peat soils (~30cm), provided that the peat soils are not hydrophobic (SD3, R1). One interviewee, SD6, summarized the benefits of combined rewetting and solar development as follows:

> *"I think this is such a smart idea—you can combine carbon sequestration in the ground with energy production in the same area, and on top of that, it's good for biodiversity without disturbing people. It sounds absolutely perfect. The idea is really great. Then it's just a matter of figuring it all out and putting it all together, and that's it. It's really just the electrical connection that's the most crucial part, that's for sure."*

5.3 Summary of the PESTLE

The PESTLE analysis highlighted various challenges and opportunities with solar development on cut peatlands, both with and without rewetting initiatives. Table 5-1 presents the researchers perception of the magnitude of barriers interpreted from the interviews where major refers to the most cited and determining barriers and minor the least for project viability.

Table 5-1. Classification of barrier levels according to the findings of the PESTLE analysis

Barrier classification	Major	Significant	Minor
Political		X	
Economic	X		
Social			X
Technological			X
Legal		X	
Environmental			X

6 Discussion

This section presents an interpretation of the findings through a nexus approach and relates them to the existing literature. The section also accounts for limitations in the research and points towards future areas of research based on knowledge gaps identified in the thesis.

6.1 Findings in relation to the literature

Comparing the results from the PESTLE analysis to the findings from the literature, there are both areas of alignment as well as new themes of challenges and opportunities that arise.

6.1.1 Overview of key findings

The findings highlight that while such projects present significant environmental and land-use opportunities, their implementation is constrained by regulatory uncertainty, economic risks, and knowledge gaps. However, if realized, solar power on cut peatlands can contribute substantially to the electricity mix. As referenced in the interviews, solar energy can produce around 1 MW electricity per ha. In a hypothetical scenario, removing the economic dimension and disregarding current land activity, solar generation on cut peatlands then has the potential of generating 12 GW of electricity, given that all 12 000 ha of inactive cut peatlands sites are used for solar energy. Considering a capacity factor for Swedish solar electricity to be 9-13% (Lewan, 2024), this corresponds to a hypothetical annual generation of roughly 10-14 TWh, calculated as:

$$Annual\ generation = \ Capacity\ \times 8760\ h\ \times capacity\ factor$$

Keeping in mind that these calculations are merely a high-level demonstration that does not reflect an actual scenario, they suggest that solar deployment on cut peatlands could make a substantial contribution to the projected increase in electricity demand of 8-15 TWh solar power by 2050 as modeled by the Swedish Energy Agency (2025b), even if only a portion of these sites were developed. According to the interviewees, semi-floating installations have the potential to increase production to around 2 MW per hectare, further enhancing the potential contribution to the Swedish electricity mix.

Although cut peatlands have the possibility to generate large amounts of solar electricity, it is highly unlikely that all sites would be suitable for solar development. Table 6-1 seeks to compare the findings from the interviews with the literature on key characteristics for viable solar locations. From the table it is evident that the remote location of former peat extraction sites can act as both an enabler in terms of social acceptance, land use considerations and regulatory approval, while also acting as a barrier due to the distance from existing infrastructure. Overall, sites with good access to existing infrastructure presents favorable conditions for solar development in terms of the siting enablers identified in Section 4.1.1.

Table 6-1. Siting enablers and barriers identified by interviewees based on the key conditions found in the literature Section 4.1.1 (nr of interviewees in parenthesis)

Siting	Enabler	Neutral	Barrier
Solar radiation			X (1)
Proximity to power lines		X (5)	X (3)
Ground topography	X (7)		
Proximity to main roads			X (1)
Proximity to urban areas			X (4)
Land use	X (10)		

Social acceptance	X (7)		
Regulatory approval	X (8)		

Source: Results from interviews presented in section 4 compared to the findings by Belzons Berthelemot et al., (2026), Lindberg et al. (2021) Rediske et al. (2019) and Spyridonidou & Vagiona (2023)

6.1.2 The land-energy-climate nexus

Analyzing the findings through a nexus perspective reveals a set of interrelated synergies and trade-offs between climate objectives (rewetting), energy production (solar development) and land management (cut peatlands). These interactions highlight both the potential and the complexity of combining renewable energy generation on a new land type. Interestingly, the climate benefit from hindering peat oxidation is not captured anywhere, presenting a major barrier to incentivize this combined form of land use.

Trade-offs and synergies between climate (rewetting) and energy development

Rewetting of cut peatlands was consistently identified, both in the literature and in the interviews, as the most environmentally beneficial after-use management strategy (Nilsson & Nilsson, 2005). Interviewees emphasized that rewetting contributes to reduced GHG emissions through avoided peat oxidation, while also enhancing hydrological function and biodiversity. These findings align with existing literature, which widely recognizes rewetting as a key strategy for climate mitigation and ecosystem restoration (Convention on Wetlands, 2021; Jordan, 2016; Kasimir & Lindgren, 2024; Tuittila et al., 1999; Vasander et al., 2003).

Synergies

The findings indicate several potential synergies between rewetting and solar energy development. Interviewees highlighted benefits for both the land such as improved moisture retention from panel shading as well as for electricity generation such as panel cooling, and reduced soiling due to lower dust levels. These observations are supported by previous studies demonstrating how multifunctional solar installations can create beneficial microclimatic conditions (Krasner et al., 2025; McDonnell, 2025; Semeraro et al., 2020; Tölgyesi et al., 2023). In particular, McDonell (2025) emphasizes the role of cooling and reduced soiling for improving panel performance. Contrary to the findings of Oudes et al. (2022), interviewees identify the possibility of higher energy production compared to conventional solar parks from newer technological solutions available for rewetted peatlands.

An additional synergy identified in the interviews relates to the emergence of modular and less invasive solar technologies, which may enable greater compatibility with rewetted conditions. One interviewee emphasized the value of flexible systems that are not permanently fixed, allowing for adaptation over the project lifetime. While this perspective is not explicitly reflected in the existing literature, it complements broader discussions on the long-term land-use implications of solar parks, where the extended lifespan of installations has been framed as an opportunity for ecological recovery (Randle-Boggis et al., 2020).

Another synergy identified for multifunctional land use by Oudes et al. (2022) is social acceptance, where they argue that multifunctional land use could contribute positively to social acceptance by mitigating visual impact and preserving cultural heritage. This benefit was reflected by the interviewees who identified stronger social acceptance for cut peatlands due to lower visual impact as a key enabler for this land-use form.

Finally, solar power development and rewetting could be a strategic combination that allows CABs to comply with regulations. These could include rewetting and energy targets from the

Nature Restoration Law and Sweden's net-zero target, while also conforming to the requirements of Environmental Code regarding resource conservation. However, this angle needs to be explored as there are no studies on combined rewetting and solar generation with regards to the Nature Restoration Law, although an interviewee pointed out that a project has been initiated.

Trade-offs

Despite these synergies, significant trade-offs were identified, particularly in relation to rewetting as a condition for solar development on cut peatlands. Interviewees consistently viewed rewetting as an economic barrier due to increased costs for construction, maintenance, and technological adaptation in wet conditions, although the magnitude of these cost increases remains uncertain given the early stage of this combined land-use approach. Additionally, rewetting in itself is a costly procedure. While no concrete estimates were provided in the interviews, existing literature suggests that multifunctional systems may increase investment costs by approximately 10–100% (Seidel et al., 2024; van Noord et al., 2024). These findings are consistent with broader research indicating that multifunctional solar parks tend to create greater land complexity resulting in a need for specialized infrastructure which can significantly increase investment costs (Livera et al., 2025; Schindele et al., 2020). Beyond economic considerations, the findings also highlight less explored trade-offs, particularly potential work safety risks associated with construction and maintenance in wet peatland environments, an aspect largely absent from the current literature and indicating a clear research gap.

Trade-offs and synergies between land-use and energy development

Solar installation without rewetting initiatives was perhaps the most common solution identified in the interviews. However, there is very limited research on this approach in the literature. Multiple interviewees, the Swedish rewetting strategy and Serenius (2025) all propose that rewetting should be focused on drained forests and agricultural land with thicker peat layers which makes cut peatlands without rewetting a suitable land area. However, one of the interviewees, a peatland researcher, challenges this strategy stating that the focus of rewetting should also be on cut peatland areas due to their low nutrient status and potentially higher carbon content.

Synergies

Numerous synergies were identified in relation to solar development on cut peatlands without rewetting. A key finding across the interviews is that these land areas are widely perceived as appropriate for solar development due to their low ecological value and the opportunity to avoid the use of more sensitive land types, such as agricultural land and forests. This aligns with previous research, which highlights marginal or degraded land as particularly suitable for renewable energy deployment (Milbrandt et al., 2014; Oudes et al., 2022; Tölgyesi et al., 2023). Given the spatial extent of cut peatlands in Sweden, estimated at approximately 24,000 ha of active and inactive extraction areas (SCB, 2023), these lands may therefore represent a significant alternative resource base for solar development, potentially reducing pressure on more productive or ecologically valuable land.

An additional synergy, not explicitly identified by interviewees but observable through spatial analysis (See Figure 1-1), relates to the geographical distribution of cut peatlands. Many of these areas are located in bidding areas SE3 and SE4, where electricity demand exceeds local production and prices are generally higher (Westerberg & Lindahl, 2023). This suggests that solar development on cut peatlands could be strategically aligned with areas of greater electricity demand, potentially enhancing project profitability and contributing to regional energy balance.

However, interviewees also noted that the remote location of these areas may hinder grid buildout, even though the regional location is producing electricity at a deficit.

Further synergies relate to incentives, particularly among landowners and peat extraction companies. Interviewees emphasized that solar development could provide new revenue streams from otherwise unproductive land, making it an attractive option for landowners. In addition, peat extraction companies were described as motivated to engage in solar development as a means of improving their public image. While this perspective is not widely reflected in the literature, it suggests that reputational considerations may play a role in enabling this form of land-use transition and justifies further investigation.

Finally, a practical synergy relates to the relative ease of installation and maintenance in non-rewetted conditions. Without rewetting, conventional piled mounting systems can be used, allowing for established construction practices and lower costs compared to alternative solutions such as semi-floating systems. This reduces both technical complexity and investment requirements, further strengthening the economic attractiveness of solar development on dry cut peatlands.

Trade-off

The main trade-off with this form of land use is the loss climate benefits from rewetting highlighted in Section 4.2.2. Schwill et al. (2025) found in their study that solar parks in Germany built on drained, non-rewetted, peatlands emitted more CO_2 than it avoided when accounting for the life cycle emissions from solar panels and displacement of fossil sources in the electricity mix. However, this study was conducted on drained agricultural land rather than cut peatlands, hindering the transferability of the results. On the other hand, Kasimir & Lindgren (2024) estimate the emissions from cut peatlands to around 10ton CO_2 per ha and year. These claims are also supported by Jordan (2016) who found that bare peat soils account for the largest CO_2 emissions of the peatland area. Furthermore, if the 12 000 hectares of active sites are rewetted, this could roughly prevent the emissions of 120 000 ton CO_2 per year, using the emission factor of Kasimir and Lindgren (2024). Although, it is important to keep in mind that not all carbon emissions are prevented with rewetting and that this is purely a rough hypothetical estimate to demonstrate the climate benefits of multifunctional land use strategies. However, it points to the importance of including climate impact in the assessment of this form of land use, which is traditionally disregarded in solar development.

A potential future tradeoff could be that there is land conflict over previously cut peatlands as rewetting targets become stricter. The Swedish Climate Policy Pathways Inquiry found that around 100 000 ha of forest and 10 000 ha of agricultural land need to be permanently rewetted for Swedens to reach its net zero target by 2045. This could potentially lead to solar development and rewetting coming into conflict as active and former peat extraction sites might seem more beneficial to rewet as opposed to rewetting drained peatlands used as productive forests or agricultural croplands.

An additional trade-off could be that the peat extraction company prepares the land for solar development thereby finalizing its requirements under the Environmental Code. However, since they are not responsible for erecting the solar park and solar developers need long lead times to determine grid availability and make investment decisions, in cases where the location is deemed unsuitable there is a risk that the peat extraction site will be left without a solar park and with the drainage intact.

Trade-offs and synergies between land-use and climate (rewetting)

Rewetting of cut peatlands is a somewhat contested land-use strategy, both in the literature and among interviewees, reflecting broader tensions within the land–energy–climate nexus.

Synergies

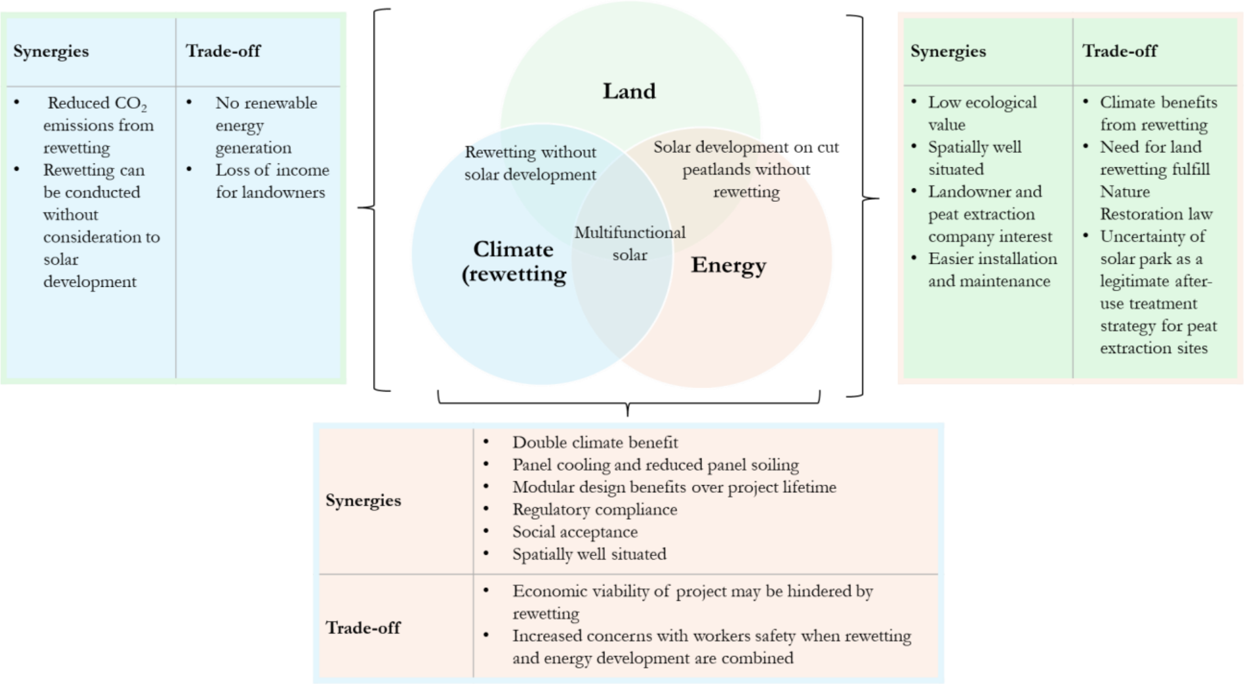
Rewetting is widely recognized as a climate mitigation strategy due to its potential to reduce GHG emissions by preventing peat oxidation. However, both the literature and interview findings indicate that these benefits are context dependent. A key concern is the risk of methane emissions and nutrient leaching following rewetting. While these risks are highlighted in the literature (Vasander et al., 2003), one interviewee emphasized the importance of distinguishing between nutrient-rich and nutrient-poor peatlands. In nutrient-poor peatlands, which are common for peat extraction, the risk of nutrient leaching is significantly lower. This suggests that cut peatlands may be particularly suitable candidates for rewetting, provided that site-specific conditions are carefully assessed. In addition, while the low nutrient status is beneficial for rewetting, it creates problems for afforestation, further underlining the suitability of rewetting as an after-use treatment strategy (Karofeld et al., 2017). At the same time, the findings point to a misalignment between scientific knowledge and policy implementation. While research increasingly emphasizes rewetting of nutrient poor peatlands, national strategies and regional guidelines, including Sweden's rewetting strategy and CAB practices, tend to focus on tick peat soils with high nutrient content. This discrepancy may result in suboptimal prioritization of rewetting efforts and underscores the need for more differentiated, evidence-based policy frameworks.

Trade-offs

Despite its environmental benefits, rewetting introduces important land use trade-offs, particularly from the perspective of landowners. Rewetting of historic cut peatlands, now used for forestry or agriculture, can restrict or eliminate existing income-generating activities, thereby reducing the economic utility of the land. In the absence of sufficient financial incentives or compensation mechanisms, this creates a significant barrier to implementation. In addition, broader questions were raised regarding the strategic use of land for energy production. Some interviewees preferred other land types such as agricultural land and forests while others suggested technical surfaces such as rooftops or asphalt may be more suitable for solar deployment as they have no natural value. Furthermore, the overall economic viability of utility-scale solar power in Sweden has been questioned by interviewees and scholars (Lindberg et al., 2021). If solar development is not considered competitive within the national energy system, the rationale for utilizing cut peatlands for this purpose becomes less compelling.

Trade-offs and synergies in the land-energy-climate nexus

Combining solar development with rewetting initiatives can provide a multifunctional land use strategy that allows for carbon sink enhancement and renewable energy production which scholars and interviewees identify as beneficial. However, regulatory and technological uncertainty, increased economic costs and need for collaboration create barriers to its development. Figure 6-1 summarizes the different approaches presented in Section 6.1.2.



Synergies	Trade-off
• Reduced CO_2 emissions from rewetting • Rewetting can be conducted without consideration to solar development	• No renewable energy generation • Loss of income for landowners

Synergies	Trade-off
• Low ecological value • Spatially well situated • Landowner and peat extraction company interest • Easier installation and maintenance	• Climate benefits from rewetting • Need for land rewetting fulfill Nature Restoration law • Uncertainty of solar park as a legitimate after-use treatment strategy for peat extraction sites

Synergies	• Double climate benefit • Panel cooling and reduced panel soiling • Modular design benefits over project lifetime • Regulatory compliance • Social acceptance • Spatially well situated
Trade-off	• Economic viability of project may be hindered by rewetting • Increased concerns with workers safety when rewetting and energy development are combined

Figure 6-1. Synergies and trade-offs between the different nodes in the land-energy-climate nexus

6.1.3 Uncertainty as a barrier

A key finding across all PESTLE dimensions is the role of uncertainty as a systemic barrier, largely driven by the novelty of combining solar development with peatland restoration. This “novelty problem” manifests across political, legal, economic, environmental and technological domains, limiting the ability of actors to engage in long-term planning and investment.

From a policy and governance perspective, interviewees emphasized the lack of clear strategies for both rewetting and renewable energy development as a major constraint. While there are no studies specifically addressing the permitting of solar development on cut peatlands in Sweden, similar challenges are documented in the literature on peatland rewetting. The Swedish Environmental Protection Agency (2023c) highlights administrative burden, long permitting timeframes, and complex assessment procedures as key barriers for landowners, findings that closely align with the experiences described by interviewees. However, the absence of legal praxis and clear guidelines for this specific land-use combination further exacerbates uncertainty for both developers and regulatory authorities.

Uncertainty is also evident in the technological and environmental domains. Both interviewees and existing literature (e.g., McDonnell, 2025; Seidel et al., 2024) highlight significant knowledge gaps related to technological performance, impacts on flora, fauna, and climate. Installation and maintenance concerns with new technology appeared more frequently in interviews compared to the literature. In response, multiple actors emphasized the need for pilot and demonstration projects as a means to reduce uncertainty and build empirical evidence. These pilot projects are not only important for validating technological solutions but also for establishing best practices and informing regulatory development.

From an economic perspective, uncertainty directly affects investment decisions. The lack of proven large-scale projects limits the ability to demonstrate economic viability, contributing to investor hesitation and difficulties in securing financing and insurance. As highlighted by interviewees, early-stage projects therefore depend on risk-tolerant investors and first movers willing to operate under high uncertainty.

The findings also suggest that uncertainty is particularly pronounced in the case of multifunctional land use, where solar energy production is combined with rewetting. Existing literature points to challenges in integrating such approaches into regulatory frameworks (McDonnell, 2025). In the context of rewetted peatlands, additional uncertainties arise regarding the magnitude of climate benefits, which are not currently quantified nor incorporated into policy instruments or financial incentives. As a result, developers bear the costs of rewetting without being compensated for the associated climate benefits, reducing the attractiveness of this combined land-use strategy.

Finally, the interviews reveal that uncertainty is not limited to institutional or economic factors but also extends to fundamental knowledge gaps regarding peatland conditions and system behavior. This includes limited understanding of long-term site dynamics, hydrological changes, and operational challenges in wet environments. Together, these uncertainties reinforce one another slowing down the development and scaling of solar projects on cut peatlands.

6.2 Reflecting on the results of the study

This section reflects upon the findings as well as how the choice of analytical frameworks has influenced the findings. It also includes interesting paths for futures studies to enhance the understanding of the field.

6.2.1 Contextualizing the findings

The findings of this research do not point clearly towards how viable cut peatlands are for solar development. While it can be determined that this land area has low ecological value and that there are technological solutions that can make projects viable, viability remains restricted in the short term by the economic dimension of the PESTLE. Low electricity prices during hours of solar electricity generation limits the margin for solar projects, making it challenging for solar developers to be innovative. However, in a scenario with more stable electricity prices or stronger support for renewable energy buildout, contributions from solar on peatlands can significantly meet increased demand for solar power as mentioned in Section 6.1.1 while potentially hindering around 120 000 ton CO_2 from being emitted per year if also developed together with rewetting (Kasimir & Lindgren, 2024).

The results also raise important questions regarding which actors have the capacity to enhance the viability of this land-use approach, particularly in the case of combined rewetting and solar development. Multifunctional land use has the potential to decrease the governance challenges of rewetting identified by Regeringskansliet (2002) by aligning the interests of multiple stakeholders: landowners are motivated by opportunities to lease land for solar development, while CABs seek to promote rewetting in line with environmental objectives. Integrating solar development with rewetting can enable landowners to retain an income stream, addressing one of the key barriers to peatland restoration identified in the literature. At the same time, solar developers are interested in utilizing land with low ecological value in a manner consistent with sustainability goals. While these findings point to the potential viability of such combined land-use strategies, they also indicate that political and policy support may be necessary to reduce economic risks and enable large-scale implementation. Perhaps studying the use of feed-in tariffs in Germany could provide an interesting starting point for Swedish policy developers. Without coordination between actors, there is a risk of stagnation in the field resulting in lost opportunities in terms of renewable energy buildout with additional climate benefits.

6.2.2 Limitations to frameworks and methods

The results of this thesis are shaped by the selection of the PESTLE and nexus approach its analytical frameworks. While slightly different in their approach, the two frameworks are both used to provide a high level and broad understanding of challenges and opportunities related to the topic. The selection of these frameworks to analyze a novel land use approach has allowed for inductive findings in the interviews, which have contributed to new insights in the results. At the same time, the categories of the PESTLE, as well as the nodes of the nexus have provided a soft structure to the study that has assisted with the selection of interviewees, themes for the interview guide as well as in structuring the results and discussion. The frameworks have also allowed easier comparison of otherwise quite broad results and findings.

On the other hand, the high-level usage of the frameworks has also led to high-level results. The results from this study would have to be complemented by a feasibility study prior to determining the suitability of a specific cut peatland site. The lack of quantitative data also makes the results slightly ambiguous. As the economic aspect of the study appeared highly significant, a cost analysis and comparison between the different technologies could have been motivated.

Further limitations also relate to the choice of expert interviews. While this thesis aims to represent expert views and experiences of multiple actors and from the different PESTLE levels, there is an overrepresentation of solar developers compared to the other categories of actors. This is partly intentional as solar developers are the actors driving the establishment of solar installations. However, a larger sample size including more developers inactive in the space would contribute to additional insights and potentially decrease bias in the results. The study also lacks the perspective of significant actors such as landowners of peatland sites as well as peat extraction companies, who declined to participate in the study. These perspectives were instead complemented by the interviewees experiences working with these stakeholder groups. Finally, due to the critique against Swedens rewetting strategy posed by one of the interviewed researchers, it would have been interesting to complement the claims with additional Swedish scholars and stakeholders in this area.

Since there are no solar parks conducted on this landform, quantitative data on economic and environmental impact could not be obtained, making the results dependent on the perception of the interviewees. Future studies would therefore benefit from introducing quantitative data alongside the views of interviewees to strengthen the internal and external validity of the results. In both cases, installing solar power with rewetting initiatives as well as without, local conditions of the site are likely to influence project viability more than the conclusions that can be drawn from this high-level study.

6.2.3 Future studies

The findings of this study highlight several areas where future research is needed to support the development of solar power on cut peatlands as a multifunctional land-use strategy.

First, additional research is required to better understand the environmental impacts of combining solar development with peatland conditions, particularly with regard to vegetation and biodiversity. Both the literature and the interviews indicate that the shading effect from solar panels may have both positive and negative implications for biodiversity. While some studies suggest that shading can create favorable microclimatic conditions, the extent of these remains highly context-dependent and unquantified. Similarly, the potential benefit from reflectivity and panel cooling on energy production, often highlighted as a benefit for electricity generation, remains insufficiently quantified in the context of rewetting or moist peatland environments. As a result, the magnitude of these technical and ecological benefits remains uncertain, limiting the ability to draw robust conclusions about their long-term implications. This has further impacts on the desirability of this form of combined land use for solar developers who are interested in the economic suitability of these projects.

Second, there is a need for comprehensive assessments of the climate impacts associated with different after-use strategies for cut peatlands. In particular, the emissions associated with maintaining peatlands in a drained state remain insufficiently examined in the context of solar development. While some studies, such as the master theses by Serenius (2025) and Avonius (2025) as well as some interviewees emphasize the low ecological value and shallow peat depth of cut peatlands as arguments against rewetting, contrary arguments can also be found in the literature as well as from the interviews. Since permits for solar development do not require climate considerations to be included, the size of emissions from these lands are not reviewed thoroughly before establishing a solar park. Future research should therefore aim to quantify and compare the emissions associated with including solar development with or without rewetting.

Third, the potential role of carbon credit mechanisms as an economic incentive for peatlands restoration warrants further investigation. Some scholars discuss the potential of carbon credits as an additional income source for landowners if rewetting or restoration activities are initiated (Seidel et al., 2024; Tanneberger et al., 2021; van Noord et al., 2024). While this perspective was not raised by interviewees, recent EU policy developments such as the LULUCF Regulation 2023/839 and the Nature Restoration Law 2024/1191 indicate an increasing focus on carbon accounting in land-use systems. However, since rewetting primarily prevents emissions rather than generating additional carbon sequestration, its eligibility within carbon credit frameworks remains uncertain. Further research is therefore motivated to explore how avoided emissions from peatland rewetting could be quantified, certified and potentially monetized within emerging carbon markets.

7 Conclusion

Peatlands are fantastic in many ways. They provide ecosystem services such as water filtration, flood prevention, unique habitats for flora and fauna, while at the same time acting as one of the largest carbon sinks globally. Cut peatlands on the other hand have been significantly degraded and offer minimal ecological values. As the need for land areas grows to enable the renewable transition, actors are looking for marginalized land for solar development. Using cut peatlands for solar development can be suitable by avoiding land competition with more valuable land such as agricultural fields, forests or pristine wetlands, while also allowing for the possibility of nature restoration. However, this land use combination is characterized by limited research creating large uncertainties in how the development should be conducted. This thesis studied this emerging field of solar development through a multi-stakeholder approach interviewing solar developers, CABs, interest organizations, a consultant, researchers and technology developers to map the current knowledge base and answer the following research questions:

RQ1: What is the current state of knowledge and development of solar power on former peat extraction sites in Sweden?

There is large interest in developing solar power on former peat extraction sites although knowledge gaps appear in relation to the permitting phase, the function of new technological solutions and the impact on ecosystems which creates some hesitancy among the different stakeholder groups. From the interviews, the state of development appears to be limited to permitted projects as none of the actors had erected any parks nor knew of any utility sized parks that had been built on cut peatlands. However, solar energy projects have been built on drained peatlands in Germany, and on cut peatlands in Finland which can provide relevant new insights for the Swedish context.

RQ2: Are former peat extraction sites a viable land area for solar power development?

Viability in the research is defined as the ability of these types of projects to function successfully where success is considered with regards to the PESTLE categories. In many ways, cut peatland sites can be suitable for solar development. They are characteristically large, flat, unvegetated and severely degraded with low ecological value. Solar development on this landform also alleviates the burden on more valuable land such as agricultural land and forests which is also viewed as a benefit.

In terms of the PESTLE categories, the technological, social, legal, environmental and political categories offer possibilities, albeit not without challenges to the viability of the project.

Technological challenges arise as these land areas tend to be located remotely, far from urbanized areas with the additional challenge of acidic and softer soils due to the remaining peat layer which can make conventional piled solutions difficult. New technological solutions that do not require ground penetration such as semi-floating or sitting panel systems manage many of the specific land challenges and may therefore be preferable, although they are yet to be tested for utility sized parks.

In terms of the **social** dimension, public acceptance is considered higher for this form of land use as the neighboring communities are used to existing industrial activities in the land area while newer technologies also offer less visual disturbance.

From a **legal** perspective, the permitting process can offer new challenges not experienced on arable land due to the possibility of the project being classified as a water operation where a higher instance of court approval may be needed that can induce higher costs. However, regulatory approval was perceived as higher where CABs were generally positive to this form of land development.

Environmental benefits mainly relate to the low ecological value of this landform as well as the avoidance of land with higher ecological values. The environmental impact was not viewed as a significant challenge to the projects, however, the environmental benefits are considered larger if the projects are combined with rewetting where scholars have found that the climate benefits of rewetting may exceed the benefits of renewable energy generation, although the exact contributions on this combined land use remains unquantified in the Swedish context.

While there is not much **political** support for renewable energy in general, and solar development on cut peatlands specifically in Sweden, it is mainly viewed as a barrier due to the lack of guidelines. Furthermore, solar developers experience carrying the full cost of innovation due to the lack of support from government actors. On the other hand, EU regulations such as the EU climate law (2021/1119) and Swedens net zero target for 2045 can be viewed as enablers for project viability.

The main barrier influencing the viability of projects on cut peatlands relates to the **economic** dimension. Where current electricity prices and costs associated grid connection hinders the profitability of solar projects in general in Sweden. Uncertainties regarding costs for installation and management as well as higher capital costs for technological solutions make the current business case for solar development on this type of land challenging. That being said, interviewees highlight that profitability may be achieved on certain cut peatlands with favorable land conditions and good grid connection. In addition, taking a long-term perspective, if electricity prices stabilize or there is larger interest for renewable energy buildout, cut peatlands can be a viable and even desirable land use area for solar development, especially when combined with rewetting.

RQ3: What are the opportunities and challenges for multipurpose land-use strategies that combine solar on cut peatlands with rewetting initiatives?

There are many opportunities associated with combining solar development on rewetted cut peatlands. The double climate benefit from soil carbon preservation as well as renewable energy generation is identified as the largest benefit. This form of land use is also directly in line Article 4 paragraph 1 of the EU Climate Law (2021/1119) which states that Member States should fulfill the carbon reduction targets by prioritizing rapid and predictable emission reductions while at the same time enhancing removals through natural sinks (art. 4, para. 1).

However, there are also significant challenges relating to the novelty and economic dimensions of this form of ecovoltaic park. The combination needs to prove its functionality through demonstration projects to enable investments as well as to prove the environmental and climate benefits that are identified in theory. Benefits to solar production such as panel cooling and reflection also need to be proven to motivate solar developers to engage in this form of multifunctional land use. The cost of rewetting is also considered a barrier to combined land use.

7.1 Practical implications and recommendations

This thesis contributes to emerging discussions on multifunctional renewable energy landscapes by illustrating how degraded land transitions require coordination across sectors that are traditionally governed separately, including energy, restoration, land-use planning, and climate policy. Without coordination it is likely that the opportunity of dual climate benefits will stagnate in its realization driven by economic barriers and unresolved research gaps.

For **public authorities,** including CABs, the results underscore the need for clearer guidelines and more consistent regulatory practices. The current lack of legal praxis and standardized approaches contributes to uncertainty for both developers and authorities. Developing guidance frameworks and best practices could facilitate more efficient permitting processes while ensuring that environmental objectives are upheld. To enhance solar development with rewetting initiatives, a decision on whether solar development without rewetting can be considered a legitimate after use-strategy will also be needed. Based on the findings of this research, it is advisable that rewetting is considered the favored after-use treatment, although, in cases where solar development shall be erected after the termination of peat extraction, rewetting conditions should consider the needs of the solar park. In addition, it is likely that public support would be needed to derisk multifunctional projects where it is recommended that regulating bodies assist with the funding of rewetting historic cut peatland sites, or on active sites where rewetting is not covered by the after-use treatment plan. Furthermore, public authorities can assist project developers by implementing securities that can act as insurance for first movers willing to combine solar development on rewetted peatlands.

For **technology developers,** the study identifies several concerns raised by solar developers, researchers, and public authorities regarding the performance, cost and maturity of different technological solutions. These insights can inform further technology development, guide research priorities and support more effective communication of technological benefits and limitations to potential users and regulators. For multifunctional solar projects to become successful, technology providers should prioritize studies that demonstrate panel efficiency from wet peatland environments and showcase cost savings relating to lower vegetation management, decreased panel soiling as well as maintenance benefits from surface sitting structures compared to conventional piled solutions.

For **solar developers,** the findings contribute to a better understanding of key risks and uncertainties associated with this land-use strategy. In particular, the study highlights regulatory complexities in terms of the permitting process under Chapter 11 of the Environmental code, as well as environmental and technical considerations linked to rewetting and site conditions. This knowledge can support more informed project planning, including early-stage assessment and stakeholder engagement. Additionally, the thesis found different strategies taken by solar developers when developing projects on cut peatlands which may offer new insights to decision makers in the field. What is needed from solar developers to enhance the development of this combined land use form is a first mover willing to trial this new solution where support from research institutes or the government would be advisable to decrease risks and costs.

For **landowners and peat extraction companies,** these findings offer information on solar energy development as an after-use treatment option for cut peatland sites which can contribute to the decision-making process of how to manage the land after peat extraction has ceased.

Across all stakeholder groups, the study points to the value of enhanced collaboration and knowledge exchange. The establishment of an industry platform or interest organization focused on solar development on peatlands could provide a forum for sharing experiences, disseminating research findings, and aligning expectations between actors. Such a platform could also support the development of guidelines by serving as a knowledge base for policymakers and regulatory bodies. Finally, the findings highlight the importance of integrating scientific expertise into project development, particularly in relation to peatland ecology and hydrology. Involving researchers can help ensure that potential environmental synergies, such as reduced emissions through rewetting, are realized, while minimizing unintended trade-offs.

While the findings are context-specific and shaped by the Swedish regulatory, climatic, and governance context, several insights from this study may be transferable to other regions exploring multifunctional use of degraded lands for renewable energy deployment. In particular new technological development and environmental considerations raised in this thesis are likely to be of relevance for countries exploring solar on cut peatlands as well as management of challenges related to institutional coordination, permitting complexity, competing land-use priorities. However, the transferability of the findings should be approached with caution, as factors such as national policy frameworks, ownership structures, restoration objectives, and energy market conditions may significantly influence implementation processes and stakeholder perspectives.

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Appendix

Appendix 1: Example of consent consideration in email (translated using DeepL)

Below is some information about the thesis; if you have any questions, please feel free to reach out. I was also wondering if it would be okay for me to record the interview so I can transcribe it and refer back to your answers?

My thesis is an independent research project but is being written in collaboration with Uniper. The thesis explores the opportunities and challenges of establishing solar parks on peatlands and whether this should be done in conjunction with rewetting initiatives. The purpose of the work is to examine the topic objectively without taking a position on the issue.

The interview is voluntary, and you may choose not to answer any questions or stop at any time. The thesis will be published publicly. You will have the opportunity to approve any quotes and review the thesis before publication if you wish. I will not save the recordings, and personal information will be handled in accordance with GDPR.

Appendix 2: Example of coding structure applied in NVivo

Example of code
Main codes (11) – Deductive and inductive **Deductive:** Political, Economic, Social, Technological, Legal, Environmental **Inductive:** Peat, landowners, solar market in Sweden, solar & peat, other countries
Sub-codes (33) – Deductive and inductive For example, sub-codes of Economic **Deductive:** Challenges and opportunities **Inductive:** Business models
Sub-sub codes (56) - inductive For example, sub-sub-codes of Economic challenges *Development costs, External, peatland specific, profitability*
Sub-sub-sub codes (8) - inductive For example, sub-codes of peatland specific *Investment risk, location, management phase*

Appendix 3: Summary of types of peat extraction methods conducted in Sweden

Type	**Practice**	**Application**
Milled peat	Removing thin surface layers of peat typically 1.5-2 cm at a time. Processes is repeated 5-10 cycles per year	Horticulture, animal bedding, to a lesser extent energy production
Block peat	Involves cutting and drying larger peat sections	Soil enhancement
Sod peat	Mechanically processing moist peat into compressed units	Energy production

Appendix 4: Declaration of Use of Generative AI (GAI) Tools

1) Permitted Uses in This Course

Students may use GAI tools for:

- Brainstorming and idea generation
- Planning and outlining
- Language support (grammar, clarity, tone)
- Translation of non-personal, non-sensitive content
- Drafting outlines (not full assignments)

Requirements:

- You must critically review, fact-check, and edit all AI outputs.
- Do not submit unedited AI-generated work.
- Do not input personal, sensitive, or confidential data into GAI tools.

2) Student Declaration (to be completed)

Project/Assignment title: _Master Thesis_______

Did you use GAI tools for this work? ☒ Yes ☐ No

If Yes, complete the items below.

a) Tools used

List the tools and versions (e.g., “ChatGPT, Claude, DeepL”):

ChatGPT, DeepL, Scopus AI

b) What you used them for (check all that apply)

☒ Brainstorming / idea generation

☐ Planning / structuring

☒Language editing (grammar/clarity)

☒ Translation (non-sensitive content)

☐ Outline drafting

☐ Other (specify): ________________________________

c) How you used the tools (be specific)

Describe prompts, steps taken, and how you revised the outputs:

I used Scopus AI to map and find literature as well as to compare the references with those from my own literature search. If the Scopus AI references sounded interesting, I read the paper to determine the relevance.

I used DeepL to translate the quotes that I chose to include in my thesis from Swedish to English as well as some additional words mainly relating to the permitting process. Prior to including the quotes in the thesis I reviewed the translation and sometimes edited it to remove stuttering or to enhance the cohesiveness of the quote.

I used ChatGPT to learn more about my topic generally by asking questions such as "what is the difference between mire, wetland and peatland" and "what are the differences between sod peat and block peat". I did not necessarily revise the outputs but I also did not base my knowledge of the topic from outputs from ChatGPT. The purpose was to clarify new terminology in order to better navigate the literature.

I also used ChatGPT for brainstorming different theories. In the end I did not use a theory.

I used ChatGPT for grammatical aid asking questions about how it would improve the sentence och part. Using prompts like "how would you enhance this paragraph", depending on the answer I sometimes revised the text based on some of the suggestions.

d) Your own contributions

What parts are entirely your original work?

All parts are my original work. Sometimes there are words included from translations by DeepL or phrases assisted by ChatGPT, but I wrote all the text myself and conducted the analysis without assistance from AI.

e) Verification and editing

How did you verify accuracy and edit AI output?

I mainly used AI for text editing. In order to verify the accuracy of the translation I used an online dictionary and/or my own language skills to determine the correct term or phrasing.

In cases where I used ChatGPT to learn more about the topic I prompted it to provide me with sources for all its claims. Then I read the sources and if I found the source to be trustworthy and interesting, I sometimes included it in the study. In cases where I wished to clarify a term I also compared the explanation from AI with other sources.

Student signature: ____________________ Date: __15/05/2026____