CHAPTER 8

Increase Social Acceptability of Nuclear Fusion, Agrivoltaics, and Offshore Wind Through National Support Programmes

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Policy Highlights To achieve the recommendation stated in the chapter title, we propose the following:

- Facilitate the establishment of observatories to monitor social acceptability of low-carbon energy technologies at the EU and national levels.

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- Offer technical assistance to help Member States incorporate social acceptability factors into their energy transition strategies.
- Develop training programmes to integrate social acceptability factors into the design of low-carbon energy projects from the start.
- Assist countries in managing and resolving disputes and interactions regarding different low-carbon energy technologies.
- Social Sciences and Humanities (SSH) Science, Technology, Engineering and Mathematics (STEM) collaborative recommendations can ensure policies are informed by a nuanced understanding of technical and social structures, making them more practical and widely accepted.

Keywords Low-carbon energy · Topic modelling · Community engagement · Public perception · France

8.1 Introduction

The REPowerEU Plan involves accelerating Europe's clean energy transition (European Commission, 2022). This means speeding up renewables deployment, including issuing permits for project implementation and reducing the time for project roll-out. For instance, it takes up to 9 years to obtain a permit for onshore or offshore wind energy projects and up to 4.5 years for solar photovoltaics (PVs) (European Commission, 2022). To expedite this process, the European Commission (EC) suggests more participatory approaches that involve local and regional authorities, setting up special 'go-to' geographical areas for renewable energy as a top priority, and creating special zones ('regulatory sandboxes') to generate new ideas. These suggestions call for swift and strong actions, but often ignore the local and national opposition to projects, rarely treating social acceptability as crucial in the early design stages.

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In this chapter, we investigate the social acceptability of three low-carbon energy technologies, focusing on the case of France: offshore wind turbines (using huge fans in the sea to generate electricity from the wind), agrivoltaics (integrating photovoltaic [PV] modules into agricultural land without reducing its productivity), and nuclear fusion (joining small atoms to make a larger one and release energy). Social acceptability means "the consent of the population in a project or decision resulting from collective judgment that the project or decision is superior to known alternatives, including the status quo" (Gendron, 2014, p. 118). Social acceptability of low-carbon energy projects involves multiple stakeholders at different levels, leading to legitimate arrangements and rules that align with each territory's vision and the stakeholders' preferred development model (Fournis & Fortin, 2015).

In 2015, France committed to the Paris Agreement to address climate change, aiming to keep global temperature increases under 2 °C, and ideally below 1.5 °C. This goal requires shifting from fossil fuels (comprising 60% of France's energy production-40% oil, 20% natural gas and < 1% coal) (RTE, 2022) to cleaner energy sources, and cutting energy use in France by 40% by 2050, back to the 1960s' levels. By 2035, renewable energy's share in electricity production in the French energy mix must reach at least 40% (excluding nuclear energy). However, efforts to increase renewable energy have faced problems, such as difficulties in finding suitable land and struggles in balancing energy needs, environmental restoration, and community concerns (CESE, 2022). Scenarios show that France must boost its renewable energy capacity, regardless of nuclear power's role. Moving to renewable energy also means shifting to decentralised power, leading to more energy projects and potential conflicts with a progressively sensitive civil society (Sebi & Bally, 2023). These problems reveal social acceptability concerns that should be considered in renewable and low-carbon energy projects.

Offshore wind turbines and agrivoltaics are mature technologies in France. In 2022, Europe had around 30 GW of offshore wind farms in operation. France has 16 offshore wind farms installed or planned, totalling 8 GW by 2032, but only one farm is currently operational. Agrivoltaics systems are now expanding significantly. In 2022, ADEME (French Agency for the Environment and Energy Management) recorded 167 agrivoltaics projects in France, with a capacity of 1.3 GW. France's Multiannual Energy Programme (PPE) stipulates that solar energy production in 2028 must reach 44 GW, including agrivoltaics (Ministère de la Transition Écologique et Solidaire, 2020). Conversely, nuclear fusion is perceived as a future technology, facing substantial scientific and technical hurdles that need resolution before the technology reaches the market. The interest in these three approaches stems from their dual role in energy production and carbon–neutral technologies, their frequent social controversy, and their intricate governance challenges.

Our policy recommendation is based on the following assumptions: (1) Various factors spread through public discussions and shape the social acceptability of low-carbon energy technologies over time, (2) How social acceptability appears and varies between the local and the national levels, and (3) Sources of social acceptability and unacceptability exist among the three low-carbon energy technologies, challenging the energy mix acceptability.

We, the authors, come from interdisciplinary backgrounds, including four Science, Technology, Engineering and Mathematics (STEM) researchers, with these specialisations: (1) thermal energy storage and wind power, familiar with French energy regulations; (2) complex system modelling, focusing on agrivoltaics in France and its social acceptance; (3) plasma Physics for nuclear fusion; and (4) Computer Science, handling data collection and analysis. Two Social Sciences and Humanities (SSH)/ Management Science researchers contributed their expertise in innovation adoption and social acceptability at individual and institutional levels. The STEM and SSH contributors' synergy is crucial for this project, due to the topic's intrinsic nature. For example, STEM researchers explained the complex technologies behind low-carbon energies, while the SSH researchers identified aspects of these technologies that could cause community apprehension.

We used topic modelling and sentiment analysis of the keywords in press documents (published in 2013–2023, extracted from the Europresse[1] database (Clain et al., 2024)). We first reviewed prior research on the social acceptability of the three low-carbon energy technologies—offshore wind, agrivoltaics and nuclear fusion—in specific European countries, including France. This review helped us to recognise the social, political, technological, and institutional determinants of social acceptability. It is also laid the foundation for the three assumptions underpinning the recommendation (see Sect. 8.1). We then analysed the French national and local daily newspapers using the Europresse database, searching for articles containing predetermined keywords—we obtained a total of 27,422 articles (from January 1, 2013, to December 31, 2023).

Offshore wind accounted for the highest number of articles (27,781), followed by agrivoltaics (4324) and nuclear fusion (1317) (Clain et al., 2024).

8.2 Unpacking the Social Acceptability of Low-Carbon Energy Technologies

8.2.1 Social Acceptability of Low-Carbon Energy Technologies

Social acceptability addresses the key question about implementing energy projects ('what for?') and is considered ahead of the project's decision. In the low-carbon energy technology context, social acceptability goes beyond the Not-In-My-Backyard (NIMBY) effect. It is not limited to characterising opposers and supporters, but strives to reveal how power relations shape these technologies, their deployment, and people's responses (Batel, 2020).

Social acceptability values citizen intelligence, integrating it into the projects. The exchanges among the stakeholders aim to build common learning in order to reach social consensus (Batellier, 2012). Social acceptability is thus a question of shared values and beliefs, referring to a collective evaluation rather than to individual positions. Nevertheless, perceiving community benefits merely as tools to enhance social acceptability overlooks the complexity of acceptability. In fact, social acceptability from communities is an essential condition before planning permission can be granted (Cowell et al., 2011). Low-carbon energy projects need to consider the macro-economic level (making major social agreements that influence development plans and project structures), the meso-political level (making fair rules and decisions to help different strategies work together and solve major disagreements through planned arrangements), and the microsocial level (coordinating among people or groups to make sense of low-carbon energy projects and work together) (Fournis & Fortin, 2015). Overall, social acceptability not only considers the stakeholders' immediate reaction (agree, tolerate or reject) to low-carbon energy projects, but also deals with their values, attitudes, and beliefs regarding technologies, infrastructures, society, and the environment.

We reviewed 21 studies (period: 2013–2023) about 9 EU countries (Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Poland and Spain) and the UK, focusing on the social acceptance and acceptability of the three mentioned low-carbon energy technologies. Our analysis of the key findings reveals three critical areas: (1) *Public perception and attitude* vary widely due to cultural, socio-economic and political contexts, affecting how technologies are accepted, (2) *Policy and governance* are crucial for adopting and effectively implementing these technologies, significantly influencing public reception, and (3) Success and acceptability rely on more than technical aspects; *contextual factors*—local conditions, economic factors, and project visibility—are also pivotal.

Social acceptability differs across European nations shaped by each country's unique circumstances. For example, in Germany and the UK, offshore wind turbines' acceptability is affected by geographical, environmental, and community impacts. Conversely, agrivoltaics in Germany, Belgium, and Denmark is influenced by how well agricultural and energy policies align. Similarly, the reception of nuclear energy and nuclear fusion in countries such as Austria, Finland, Spain, Belgium, and Hungary hinges on a blend of historical, cultural, and political influences, as well as public awareness and education.

8.2.2 Focus on the Social Acceptability of Offshore Wind Turbines, Agrivoltaics, and Nuclear Fusion in France

Social Acceptability Has Gained Significant Attention in Discussions About Large-Scale Energy Projects in France

French people support wind energy but often oppose local wind farms. The Harris Interactive poll showed that 73% of French people positively viewed wind energy (Lévy et al., 2018). The Institut Français d'Opinion Publique (IFOP) survey in 2021 found 77% of the respondents expressed a positive view of wind power (Chasles-Parot & Chatelet, 2021). Additional surveys indicated a generally favourable perception, with figures ranging between 76% (Lévy et al., 2021) and 71% (Bracq & Sliman, 2021). Nevertheless, two-thirds of wind farm projects encounter resistance and administrative hurdles from local groups opposed to nearby installations, often delaying, or halting these projects. Social acceptability is a delicate and time-consuming process to cultivate and, once formed, is difficult to overturn.

Agrivoltaics Social Acceptance Was Taken for Granted by the French Government

The law passed on 10 March 2023 (République Française, 2023) aimed to accelerate agrivoltaics technology roll-out, emphasising its benefits to farmers and anticipating its social acceptance. Recent studies addressed the social acceptability of agrivoltaics due to institutional and governance concerns (Torma & Aschemann-Witzel, 2023). In France, the decree (République Française, 2024) endorsing the law of March 2023 sets a default maximum PV module coverage of 40% on plots for solar farms over 10 MW. Conversely, France's National Research Institute for Agriculture, Food, and Environment (INRAE) has warned that coverage beyond 20% significantly reduces agricultural output, questioning the economic viability of the agrivoltaics installation (Mongenier, 2023). Agrivoltaics deployment often leads to land-use conflicts and uncertainty among local stakeholders (Carrausse & de Sartre, 2023).

Public Opinion on Nuclear Fusion Is Influenced by the Existing Nuclear Fission Landscape

France's nuclear fission infrastructure is significantly larger than the European average. Germany have been reducing their reliance on nuclear energy, initiating a phase-out in 2010 and have already closed six nuclear fission reactors. Italy completely ceased its national nuclear fission production following a 1987 referendum. France's extensive use of centralised nuclear fission, with 46% of its citizens supporting nuclear energy (ASN, 2023), might lead to more positive public attitudes towards nuclear fusion compared to Germany (Jones et al., 2019). In France, public discussions about nuclear fusion are primarily held in Provence, where the International Thermonuclear Experimental Reactor (ITER, 2024)—a global effort involving members such as the EU, Japan, Russia, the USA, China, South Korea, and India—is under construction. Viewed as a path to clean energy, this international commitment has garnered support from a segment of the public that believes in the potential of nuclear energy.

The Focus on Nuclear in Social and Political Systems Slows Non-Nuclear Low-Carbon Energy Adoption in France

Social acceptability poses a key challenge to France's achievement of a 100% renewable energy mix, including offshore wind power—in France, this scenario is even harder to accept than the one where nuclear power makes up 50% of the energy mix (RTE, 2022). The nuclear influence dominates the discourse on energy decarbonisation in France. A key argument against offshore wind turbines is that this technology is not essential to France's energy strategy. The growth of other renewables struggles with inconsistent government support, highlighting the French Government's preference for nuclear energy (Desvallées & de Sartre, 2023).

8.2.3 Results and Analysis

The rising number of articles on offshore wind in the 2020s coincided with the enactment of laws accelerating public action (République Française, 2020). By 2022 and 2023, 4000 articles were published annually, 80% by regional newspapers. These laws enabled the wind power industry to launch multiple projects along the same coastline, and paved the way for broadening public debate for the 2024 decision-making on maritime and offshore wind energy.

Agrivoltaics coverage grew in the 2020s, peaking in June 2023 due to the law of March 2023. Concerns over crop shading, waste, and chemicals from agrivoltaics emerged. Debates about the coverage rate for agrivoltaics plants (over 10 MW; 40% versus 20%) questioned the economic viability threshold. Other articles focused on cohabiting between energy production and agriculture.

Nuclear fusion witnessed increased media attention, spiking with significant events, including the Germany-Wendelstein 7-X experiment in 2016[2] and US fusion records in 2021. From 2021 to 2023, there was a notable increase in nuclear fusion discussions, likely driven by more private investments in the technology and the impact of Russia's invasion of Ukraine on talks about Europe's energy self-sufficiency.

The next step of the analysis entailed grouping similar words, selecting keywords, and identifying the main topics in the news. We used topic modelling algorithms to explore technology themes (Clain et al., 2024). Finally, the sentiment analysis revealed public feelings about these technologies over time (Clain et al., 2024).

Factors Shaping Social Acceptability of Low-Carbon Energy Technologies Over Time

The initial topic modelling analysis identified the key factors and stakeholders influencing the social acceptability of the analysed low-carbon energy technologies in France (Clain et al., 2024). Offshore wind is challenged both technologically and socio-politically as diverse stakeholders—including industry experts, policymakers, and local communities—engage in debates about the technology, with this highlighting the need to consider and balance their different perspectives. Agrivoltaics, which combines energy production with agriculture, involves farmers, technology companies, and local communities, focusing on creating economic–environmental synergies and emphasising the need for effective communication. Nuclear fusion concentrates on innovation and international research collaboration, involving global research bodies and governments, particularly in reactor development and funding. The analysis highlights convergences, including innovation, investment, international cooperation, and technological synergies, alongside distinctions such as technological maturity and local impacts, among the social acceptability factors regarding the three low-carbon energy technologies. Overall, there is a need to gauge and enhance public acceptance and adoption of these technologies.

Social acceptability varies significantly across different levels—locally, offshore wind and agrivoltaics occasionally encounter resistance due to environmental and aesthetic concerns, but are broadly supported as renewable sources. Nuclear fusion faces mistrust, largely due to historical nuclear fission accidents and ongoing concerns over nuclear waste management, despite it promising significant long-term environmental benefits with minimal waste. However, the real environmental impact of nuclear fusion has yet to be assessed. Overall, there is a need to ensure that low-carbon energy technologies are designed with community support and understanding in mind.

Sources of Social Acceptability and Unacceptability of the Three Low-Carbon Energy Technologies

Finally, the sentiment analysis sorted the 10 most positive and the 10 most negative articles associated with each low-carbon energy technology (Clain et al., 2024). The analysis shows that social opposition to low-carbon energy projects emerges most strongly during public inquiries, marking a significant difference from more tempered public debates and opinion polls. During these inquiries, local communities become aware of the projects' real and immediate impacts, sparking more intense reactions. The diverse arguments from opponents cover ecological, landscape, economic, and governance issues, as well as challenges related to French energy policy, local job creation, and financial impacts. Although these ideas are intertwined and complex to untangle, the emerging hierarchy of concerns indicates the priorities and sensitivities unique to each community facing different energy projects. Overall, there is a need to equip individuals with the skills to promote and implement low-carbon energy technologies effectively, and to ensure smooth integration and conflict resolution in the energy sector.

8.3 Achieving Our Recommendation

As the EU accelerates its energy transition, the importance of low-carbon energy technologies' social acceptability cannot be overstated. Our analysis highlights the multifaceted nature of social acceptability, influenced by cultural, socio-economic, and political contexts that vary significantly across countries. In France, technologies, such as offshore wind, agrivoltaics, and nuclear fusion, are received differently, based on local perceptions, institutional contexts, and interactions among various stakeholders. This variance underscores the need for policies that are both technically sound, and culturally and socially informed. Thus, we formulated our policy recommendation—*increase social acceptability of nuclear fusion, agrivoltaics, and offshore wind through national support programmes*—which can be achieved through the following actions addressed to the European Commission.

Observatories should be established for low-carbon energy technologies, to allow the systematic analysis and monitoring of social acceptability factors regarding various low-carbon energy technologies across the EU and at the national level. This initiative would involve collecting data, conducting research, and disseminating findings to inform and guide policy and project implementation. These observatories would help diffuse transparent communication campaigns that clearly outline the energy projects' benefits and potential impacts, addressing concerns proactively to foster trust and acceptability.

Dedicated technical assistance should be provided to EU member states to help them integrate social acceptability factors into their energy transition strategies. This support could include offering advisory services, sharing best practices, and facilitating workshops and seminars to build capacity at national and local levels.

Comprehensive training programmes for facilitators and project managers should be developed and implemented. Dealing with low-carbon energy technologies, these programmes should focus on the integration of social acceptability factors from the early stages of project design, ensuring that facilitators are well-equipped to handle community engagement and conflict resolution.

Countries should be assisted in understanding, and effectively managing, the interactions and disputes arising from various low-carbon energy technologies. This support could involve conflict resolution services, mediation between stakeholders, as well as the development of guidelines for managing technological and sectoral overlaps.

These recommendations aim to address the critical elements of social acceptability identified through our research. By focusing on enhancing community engagement, fostering cross-sectoral collaboration, and educating stakeholders, the EU can ensure a smoother transition to a sustainable energy future. These strategies will help mitigate the risk of social resistance and maximise the societal benefits of transitioning to low-carbon energy sources.

Notes

1. https://www.europresse.com/.
2. The world's largest fusion device of the stellarator type.

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