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EDITORIAL

Introduction to topical collection: social science and sustainability technology

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1 Introduction

The world faces the grand challenge of providing sustainable prosperity: how do we continue to improve standards of living worldwide while reducing environmental footprints and eliminating greenhouse gas (GHG) emissions? Technology is a crucial component of meeting this challenge. Nuclear energy, hydropower, and wind and solar technologies can reduce GHG associated with energy production and consumption, replacing carbon-intensive energy sources with less carbon-intensive or carbon–neutral sources (International Energy Agency (IEA), 2023). New technologies in drought-resistant crops, seawalls, efficient building practices, and forecasting systems can facilitate societal adaptation to new challenges from climate change and other environmental stresses (Pörtner et al. 2022). Technologies in carbon removal, such as direct air carbon capture and soil sequestration, can supplement mitigation efforts to reduce carbon emissions (Skea et al. 2022). Emerging and innovative technologies such as solar geoengineering have been proposed to protect against the worst impacts of extreme climate change (National Academies of Science, Engineering and Medicine (NASEM), 2021). And "soft technologies" that encourage widespread behavior change can also reduce GHG and friction often associated with new technologies (e.g., Cook et al. 2023; Burgess et al. 2024).

Of course, sustainability technologies must not only be developed but they must also be widely adopted. The rates of development and adoption of sustainability technologies in a society both depend on society's social, political, economic, institutional, and cultural contexts. These contexts can bolster or undermine the potential of sustainability technology.

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Social science has important insights to offer the project of advancing sustainability technology (Burgess et al. 2024). For example, consumer and economic sciences can measure public response to incentives and how institutional designs facilitate or hinder technological innovations and deployment (e.g., Damar et al. 2024, in this collection). Behavioral sciences can measure how personal decision contexts affect consumers' uptake of sustainability technologies and their responses to incentives to adopt them (e.g., Dietz et al. 2009; DellaValle 2019). Political and behavioral sciences can measure the drivers of public support for the development and deployment of sustainability technologies and public support for policies that affect sustainability technology development or adoption. Public perceptions of nuclear energy risks, for example, posed a substantial barrier to widespread adoption of an important low-carbon energy source (Slovic et al. 1991), and, as Gonzalez Coffin and colleagues (2024) report in this collection, public perceptions of unnaturalness and risk may impede support for widespread adoption and development of low-carbon alternative meats.

Social sciences can also illuminate the actors and their interrelations within political, social, and economic systems that promote or inhibit sustainability technologies (Fig. 1). The interactions among policymakers, the private sector, and consumers are interconnected, with each actor influencing, anticipating, and responding to the others (Sherman and Van Boven 2024). Policymakers design policies that incentivize or require the creation of sustainable technologies, directly influencing the private sector and consumer behavior. Policymakers communicate intentions, values, and priorities to consumers and the private sector that can bolster or undermine the development of and support for sustainability technologies (Constantino et al. 2021; Syropoulos et al. 2024). The private sector, in response, can shape these policies through lobbying, innovation, and engaging with consumers. Consumers exert their influence on the private sector through consumer demand. Consumers impact policymakers through civic actions such as voting and lobbying and by shaping market demand in response to engagement from the private sector. Consumer acceptance or resistance to new technologies can significantly impact market trends and policy decisions. Responding to consumer patterns, policymakers adjust legislation accordingly, setting incentives, mandates, and social norms. These interrelations define prevailing forces in which sustainable technologies are developed and the extent of their adoption.

2 Overview of papers and themes

This topical collection includes instructive examples of social, political, and economic factors affecting the development and deployment of sustainability technologies. These papers illustrate how social science can provide important insights to support sustainability technologies, contributing to virtuous cycles that support scalable, sustainable solutions. The papers highlight four themes.

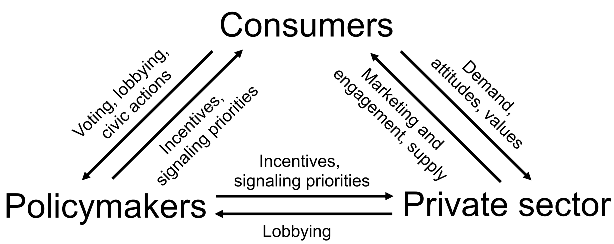

Fig. 1 The development and widespread adoption of sustainability technologies rests on a social-economic-political tripod of actors

One theme emphasizes the interactions between public attitudes, emotions, and behaviors regarding sustainability technologies and policies (starting at the top of the tripod in Fig. 1). Neale et al. (2023) explore how awareness of sustainability technology innovations ("eco-innovations") can combat climate despair. They find that exposure to novel climate-response options can foster a more hopeful outlook, demonstrating the power of technological innovation in shaping public perception and emotional responses to climate change. Garfin et al. (2024) investigate the relationship between sustainability behaviors and positive and negative emotions. They find that residents in regions vulnerable to climate-related extreme weather who experienced hope and response efficacy were more apt to pursue sustainable behaviors and technologies, even after repeated exposure to climate hazards such as hurricanes and heat waves. The two papers underscore the significance of psychological factors, like hope and worry, to shape individuals' engagement in sustainability actions, providing insights into how emotional responses can drive or hinder environmental behaviors. Gonzalez Coffin et al. (2024) examine how public perceptions of the naturalness of food technologies affect the support for developing and consuming sustainable protein technologies. They find that food technologies perceived as more natural were more supported, partly because seemingly natural technologies are considered safer and more beneficial. The study illustrates how culturally constructed ideas about naturalness affect societal values and priorities.

A second theme is the interplay between policy and technology development (the horizontal connection between policymakers and the private sector in Fig. 1). Kroeger and Burgess (2024) evaluate how electric utility sustainability plans align with Renewable Portfolio Standards and Clean Energy Standards in the U.S. They find that utilities' decarbonization targets are closely aligned with state policy targets, and the utilities are sometimes more ambitious. This study demonstrates the interplay between regulatory frameworks and private sector plans and the influences each has on the other. Boykoff (2024) studies a countervailing advocacy effort that aims to undermine sustainability technologies and public support for climate policy. More generally, this case study illustrates how grassroots ideological movements shape public opinion and policy discourse on climate change and sustainability technologies, affecting the legislative environment in which the private sector operates (the connection on the left of Fig. 1). The paper serves as a useful reminder that grassroots organizations not only advocate in favor of addressing climate change, but those organizations can also impede efforts to address the challenges of climate change.

A third theme explores the socioeconomic impacts of the policy environment and climate finance regulation, focusing on poverty rates and consumer behavior among households at the lower end of socioeconomic distributions. Moyer et al. (2023) project the impact of climate change on future global poverty levels, highlighting how climate change will increase global poverty, offsetting potential economic gains of not taking action to mitigate climate change for vulnerable segments of the global population. Their findings emphasize the need for policies addressing climate change and socioeconomic disparities. Complementarily, Damar et al. (2024) study how banking deregulation affects the consumption of home appliances in the U.S., finding that the increased access to credit following deregulation led to increased appliance purchases. They provide insight into how changing regulatory environments—including non-environmental regulations—can provide incentives to adopt sustainability technologies.

A fourth theme considers the public and policymakers' response to highly innovative and potentially risky sustainability technologies, especially geoengineering. One ethical concern about geoengineering is that it might "crowd out" efforts to reduce GHG emissions, creating a moral hazard (e.g., Wagner 2021). Cherry et al. (2023) use a laboratory experiment to examine how the option of risky geoengineering affects participants' willingness to invest in reducing GHG emissions. They find that contributions to GHG mitigation sometimes increase, contrary to the moral hazard hypothesis. Similarly, Merk and Wagner (2024) investigate the impact of presenting information about geoengineering and its effect on public engagement in climate mitigation. They find that communication about geoengineering neither undermines nor bolsters public support for policies to reduce GHG emissions while also highlighting the complexities of communicating about risky technological solutions. This result runs counter to the moral hazard hypothesis about geoengineering, too. The four themes in this topical collection represent the diverse approaches to understanding the relationship between social science and sustainability technology in the context of climate change, highlighting behavioral, technological, socioeconomic, and perceptual dimensions.

3 Virtuous cycles promote sustainability technology development and adoption

The papers in this topical collection explore the dynamics between policymakers, the private sector, and the public (consumers) in sustainability technologies (Fig. 1). The papers highlight the interdependence of the economic, social, and psychological behaviors among these key stakeholders. These interdependencies can either facilitate or hinder the broad-scale development and adoption of new technologies, creating either virtuous or vicious cycles (Burgess et al. 2024; Sherman and Van Boven 2024). Optimistically, early successes in sustainability policies and technology development can trigger a cascade of reinforcing effects. This leads to more widespread technology adoption, further innovations, and escalating positive behavioral changes. Such positive feedback loops generate a self-perpetuating momentum that can significantly speed up adopting and advancing sustainability technologies.

The rising adoption rate of electric vehicles (E.V.s) in the United States is illustrative. Over recent years, significant advancements in E.V. technology have yielded functional and reliable vehicles, which are starting to become cost-competitive for consumers (e.g., Woody et al. 2024). Corporate marketing and public advocacy have increased public acceptance and positioned some E.V.s as luxury status symbols in the U.S. (Buhmann and Criado 2023). Shifting consumer attitudes have been further supported by recent federal policies. For example, the Inflation Reduction Act (IRA) offers incentives that boost consumer demand (Caballero et al. 2024). And the Infrastructure Investment and Jobs Act allocated $7.5 billion for building E.V. charging stations to alleviate "range anxiety" (Pevec et al. 2020), alongside investments in battery manufacturing and other essential E.V. infrastructure (117$^{\text{th}}$ U.S. Congress 2021). Such legislative measures affect consumer behavior directly by creating financial incentives and indirectly by establishing social norms (Constantino et al. 2021; Syropoulos et al. 2024). Awareness of these policies and technological advancements can foster optimism and alleviate climate anxiety, offering a sense of collective action, as suggested by the papers in this topical collection (Garfin et al. (2024); Neale et al. 2023). As E.V. adoption becomes more commonplace, perceptions of E.V.s as familiar, natural, and safe will likely increase (c.f. Gonzalez Coffin et al. 2024). These evolving social norms, in turn, drive market forces to innovate further, achieve economies of scale, enhance supply chains, and lower costs. Increasing consumer and business confidence in E.V.s may lay the foundation for more pro-EV policies.

Self-reinforcing virtuous cycles in sustainability are characterized by the interplay between consumer attitudes, policies, and technologies, each of which can initiate the cycle. By the same token, these elements' interconnected and mutually reinforcing nature also means that any resistance in one area can hinder the entire interrelated cycle, thereby slowing the development and adoption of sustainable technologies. As Boykoff (2024) highlighted, coordinated opposition movements can decelerate policy progress and public opinion shifts (see also Oreskes and Conway 2011). Virtuous cycles can turn vicious. A crucial area of future research at the nexus of social science and sustainability technology involves identifying and understanding these areas of resistance. This is particularly important for technologies with moral implications, such as solar geoengineering.

Virtuous cycles illustrate how social science, policy, market dynamics, and innovation can collectively build a self-reinforcing loop that propels society toward a more sustainable future. The papers in this topical collection help lay the foundation to understand and harness the power of virtuous cycles to promote sustainable prosperity.

4 Conclusion

Technology is the application of scientific knowledge to achieve practical aims. It involves the use of devices, tools, and systems that result from scientific knowledge. This broad definition encompasses "social technology," the application of *social scientific* knowledge to achieve practical aims of promoting prosperity and social welfare (Derksen and Wierenga 2013). The topical collection on social science and sustainability technology summarizes research by social scientists considering the interrelations between consumers, policymakers, and private industry that shape the development and adoption of sustainably technologies. The social science of social technology can play a significant role in guiding the world toward sustainable prosperity.

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