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# Timely transitions? How time-bound targets shape visions for the future of emerging energy storage technologies

Anieke Kranenburg<sup>a</sup>, Eva Wolf<sup>a</sup> and Martijn Groenleer<sup>a,b</sup>

<sup>a</sup>Tilburg Center for Regional Law and Governance, Department of Public Law and Governance, Tilburg Law School, Tilburg University, Tilburg, The Netherlands; <sup>b</sup>TNO, Netherlands Organization for Applied Scientific Research, The Hague, The Netherlands

## ABSTRACT

Cutting-edge energy storage technologies can play a promising role in attaining climate targets. However, due to their emergent nature, these technologies' future partly depends on stakeholders' visions. These visions arise within the context of climate targets. While such time-bound targets are often championed as a means to accelerate change toward a goal, existing studies also indicate that they may limit stakeholders' ability to envision alternative futures. Despite the growing use of time-bound targets in policy and planning, little is known about how they shape visions for emerging technologies. This article addresses this gap by examining how climate targets shape stakeholders' visions for the future of emerging energy storage technologies. Drawing on 31 in-depth interviews with stakeholders in the Netherlands, we identify three distinct visions: (1) Removing barriers: 2030 as a call for targeted interventions; (2) Rallying the nation: 2030 as a deadline for coordinated state action; (3) Local answers to a looming deadline: 2030 as a push for decentralized solutions. Our analysis reveals that time-bound targets shaped these visions in three ways: by narrowing the envisioning process; by compartmentalizing the process into manageable steps; and by prioritizing urgent change. These dynamics both enable and constrain the scope of envisioned change.

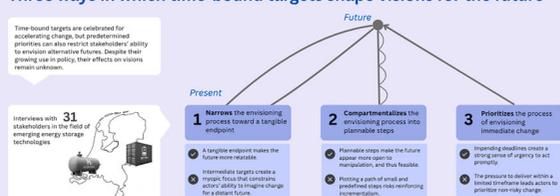
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### Three ways in which time-bound targets shape visions for the future



## 1. Introduction

The European Union (EU) has set ambitious climate targets, aiming for at least a 55% reduction in greenhouse gas (GHG) emissions by 2030 and achieving net-zero emissions by 2050. Meeting these

**CONTACT** Anieke Kranenburg  a.kranenburg@tilburguniversity.edu  Department of Public Law and Governance, Tilburg Center for Regional Law and Governance, Tilburg Law School, Tilburg University, Warandelaan 2, Tilburg, 5037 AB, The Netherlands

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objectives requires transforming a fossil-fuel-dependent energy system into one based on renewable sources, a transition demanding large-scale deployment and the integration of innovative technologies. Among the most promising solutions are electrochemical energy storage systems, which have the potential to address the intermittency of renewable energy, thereby facilitating the shift toward low-carbon energy systems (Ravestein et al., 2018; Schmidt et al., 2019). However, despite their promise, these electrochemical storage technologies remain at an early stage of development: they are still characterized by high uncertainty and have only been tested in laboratory settings or validated in pilot projects (Macnaghten et al., 2019; Meijer & Hekkert, 2007; Rotolo et al., 2015). Whether they can fulfill their promise and be implemented at scale to support climate targets remains unclear.

Given this high uncertainty, visions of their future play a critical role in shaping the path that these technologies will take. Visions for the future can affect the present by mobilizing people, resources, decisions, and actions toward a shared endpoint (see e.g. Bakker et al., 2011; Dignum, 2013; Gupta et al., 2020; Johnson et al., 2022; Konrad, 2006; Rosvall et al., 2023). Scholars have found that when it comes to emerging technologies, divergent visions compete to garner support for a specific technological solution (Bakker et al., 2011; Engels et al., 2017; Hess & Sovacool, 2020; van Lente & Rip, 1998). These visions are emerging in the context of climate targets, notably the EU's GHG reduction goals for 2030 and 2050. Such time-bound targets may influence how stakeholders envision the future of these technologies.

Previous research has demonstrated the positive effects of numerical targets in steering sustainability transitions and accelerating change toward achieving these goals. Time-bound targets, such as specific GHG emissions reductions by a target year, provide direction for actions by establishing measurable objectives, facilitating effective communication, and mobilizing actors toward coordinated efforts (Haarstad, 2020; Jørgensen & Sørensen, 2022; Mazzucato, 2018; Mazzucato et al., 2020; Morsetto, 2020; Morsetto et al., 2017). While time-bound targets may enable transitions, scholars studying the role of time and timing in policy processes have also demonstrated that rigid planning may constrain change by narrowing down the space for experimentation or adaptation (Eshuis & Van Buuren, 2014; Pot et al., 2023; Wolf & van Dooren, 2018). For instance, the perception that time is 'running out' (Wolf & van Dooren, 2018) can hamper new policy options from being seriously considered in existing policy processes. Moreover, studies on future envisioning suggest that predetermined priorities may limit stakeholders' ability to envision alternative futures that diverge from predefined objectives (Hajer & Pelzer, 2018; Hajer & Versteeg, 2019; Mangnus et al., 2022).

Despite their growing prominence in policy practice, the effect of time-bound targets on visions of change remains insufficiently understood. This article examines how time-bound targets shape the envisioning process for emerging energy storage technologies. It asks the following question: *What are stakeholders' visions for the future of emerging energy storage technologies, and how are these shaped by time-bound targets?*

To answer this question, we conducted in-depth interviews with 31 stakeholders active in the energy storage field in the Netherlands. We focused on the Netherlands, where emerging energy storage technologies are seen as promising solutions for achieving Dutch climate targets. These technologies can support the integration of intermittent renewable energy sources, such as solar and wind, into the Dutch energy system, which is currently not equipped to manage the fluctuating energy supply. Through interviews with representatives of diverse stakeholder groups, we identify visions for the future of emerging energy storage technologies and assess how time-bound targets shaped these visions.

The article is structured as follows. Section 2 explains the role of visions in driving the progress of emerging technologies and explores the relationship between visions and time-bound targets. Section 3 discusses the research setting and the methodological design. Section 4 identifies and analyzes the current visions for the future of energy storage. These insights provide the necessary basis to subsequently examine, in Section 5, how climate targets affect these visions. Finally, Section 6 concludes the paper by elaborating on the study's contributions, discussing limitations, and outlining directions for future research.

## 2. Theory

### 2.1. *How visions shape the present and the future*

Scholars have long emphasized the role of images of the future in guiding technology development and sustainability transitions in the fields of Technology Assessment (see e.g. Grin & Grunwald, 2000; Grunwald, 2004), Science and Technology Studies (see e.g. Groves et al., 2021; Jasanoff & Kim, 2009; Smith et al., 2005; Sovacool et al., 2020), and Sociology of Expectation (see e.g. Berkhout, 2006; Borup et al., 2006; Dignum et al., 2018; Konrad, 2006; van Lente & Rip, 1998). Although a variety of terms are employed to describe these images of the future (as noted by e.g. Hess & Sovacool, 2020; van der Helm, 2009), they share a common concern with the ways in which these images establish relationships between imagined futures and present-day developments.

Within this body of work, guiding visions refer to a particular type of vision that steer the development and implementation of emerging technologies. Guiding visions were originally defined as shared images of the future held by a group of scientists and engineers which provide orientation for current decisions and actions by articulating a desirable future state (see e.g. Grin & Grunwald, 2000; Grunwald, 2004; Roelofsen et al., 2008). In this definition, the emphasis was on how such visions guide technological development by offering direction and coherence within scientific and engineering communities. Over time, the definition of guiding visions has been broadened (see e.g. Arentshorst, 2017; van der Meij et al., 2023) to include images of the future held by a wider set of actors, such as policymakers, researchers, industry representatives, and infrastructure providers. Throughout this article, we adopt the broadened definition of guiding visions but refer to them simply as visions.

Visions are social constructs: they help actors make sense of new technological developments by linking them to broader societal goals and offering direction in situations of uncertainty. As interpretive frameworks, such visions offer direction on where technologies might lead, who might be affected, and how these technologies should be embedded in society (see e.g. Arentshorst, 2017; Borup et al., 2006; Groves et al., 2021; van der Meij et al., 2023). Importantly, visions are not merely individual perceptions but are collectively constructed, contested, and negotiated among actors. For example, technological innovators from start-ups and scale-ups in the smart mobility and transport sector around Amsterdam developed a shared vision of a 'clean, frictionless city' within the broader Amsterdam Smart City network, which connects companies, public organizations, and the municipality (van der Meij et al., 2023). In this context, shared visions took shape through interactions among actors working toward common goals, illustrating how visions emerge from collective sense-making.

Crucially, visions do not merely describe possible futures; they also shape the present by mobilizing actors, aligning resources, and legitimizing choices (e.g. Borup et al., 2006; Dignum, 2013; Dignum et al., 2018; Johnson et al., 2022; Konrad, 2006; Rosvall et al., 2023; van Lente & Rip, 1998). As such, visions shape the conditions under which change processes unfold, rather than

prescribing the steps themselves; they are not a blueprint for action. The long-standing vision of hydrogen energy technologies in the United States, which promoted hydrogen as a means to reduce energy dependence, illustrates this dynamic. By providing direction and reducing uncertainty, the vision coordinated actors and legitimized large-scale investment (Dignum, 2013). Policy and funding initiatives, such as the FreedomCAR Partnership, later translated this vision into practice, giving it lasting material consequences by embedding it in federal programs and research agendas (Dignum, 2013).

While visions provide direction by setting preferred directions, they may also constrain alternatives. Because technological promises are inherently uncertain, visions are not neutral descriptions of the future, but are shaped by competing interests and strategic use (Eames et al., 2006; Hielscher & Sovacool, 2018). By prioritizing particular futures, they can foreclose others and reinforce lock-in, where one pathway gains dominance through early advantage, even if it is not the most desirable. Visions are also shaped by existing lock-ins, which make some futures appear more feasible or desirable than others. This is especially evident in the energy sector, which is vulnerable to infrastructural, technological, and institutional lock-ins (Janipour et al., 2020; Seto et al., 2016; Unruh, 2002). For example, in the Dutch chemical industry, carbon lock-ins persist because costly, long-lived installations discourage early phase-out, even though they are incompatible with emerging hydrogen technologies needed for emission reductions (Janipour et al., 2020). Because visions can both create and reinforce such lock-ins, it is important to understand the nature of the envisioned change and how factors, such as time-bound climate targets, may influence the emergence of visions.

Following prior research on guiding visions (see e.g. Arentshorst, 2017; Grin & Grunwald, 2000; Roelofsen et al., 2008; van der Meij et al., 2023), we identify visions through the ways in which stakeholders (1) define the perceived problem in the current state of affairs and (2) formulate a more or less explicit claim about a desired future, including its relation to the wider societal context. These elements capture how visions articulate a call for change, driven by dissatisfaction with present practices and the belief that a better future is attainable, without necessarily detailing the steps needed to achieve the envisioned future. In this study, we draw on this understanding of visions to understand how current visions contribute to either enabling or constraining sociotechnical change.

## **2.2. The role of climate targets in shaping visions**

To drive change toward specific goals, public authorities such as the European Commission and national governments often institute targets, including the EU's GHG emissions reduction targets for 2030 and 2050. Climate targets have been shown to guide transformative processes by providing direction and motivation through a clear benchmark for measuring progress (Haarstad, 2020; Jørgensen & Sørensen, 2022; Mazzucato, 2018; Mazzucato et al., 2020; Morsetto, 2020; Morsetto et al., 2017). Their numerical precision enhances their communicability across actors, while their temporal nature clarifies the timeframe for action. This clear timeline and numerical focus support practical implementation, as exemplified by the EU's target of attaining 100 climate-neutral and smart cities by 2030, which has guided funding allocation and strategic partnerships (European Commission, 2024).

A number of policy and planning studies have drawn attention to how time-bound targets shape the structuring of time within governance processes. For example, Berker and Throndsen (2017), in their study of smart grid roadmaps, demonstrate how such instruments that include time-bound targets coordinate actors by organizing expectations into sequential phases, embedding assumptions about when and how change should occur. Similarly, Lennon and Tubridy (2023) argue

that time is not a neutral backdrop in planning processes, but a political force that shapes how people interpret what is happening and what should be done. They therefore stress that ‘omitting time as a concern for planning research is problematic’ (p. 301). Gillard and Lock (2017) further show that climate targets actively shape policy timelines and, as such, can become focal points for political negotiation. Together, these studies demonstrate that time-bound targets are not purely technical and neutral instruments but also structure how time is ordered, interpreted, and planned for.

While the benefits of time-bound targets are well documented, their potential downsides remain underexplored, particularly in relation to how they structure time and change. Jørgensen and Sørensen (2022), for instance, call for further research into both the opportunities and limitations of using quantitative targets in sustainability transitions. Scholars from the field of planning and public governance have already foregrounded some of these limitations, particularly regarding how time and timing shape policy processes.

For instance, Eshuis and Van Buuren (2014), in their study of water governance, demonstrate how fixed deadlines can constrain the capacity for experimentation. Rather than enabling innovation, rigid timelines may force alignment with dominant planning cycles, marginalizing slower or more uncertain developments that require deliberation. Building on this, Wolf and van Dooren (2018) highlight how tight policy deadlines can reduce policymakers’ receptivity to new insights during implementation, reinforcing a logic of ‘sticking to the plan’ even in the face of new information. This kind of rigidity is particularly problematic in complex and uncertain contexts, where adaptability is crucial. Pot et al. (2023) further argue that narrowly framed or overly rigid time-bound targets can lock actors into fixed trajectories, limiting their capacity to respond to unforeseen developments. In addition, Ruwet (2023) notes that political declarations driven by ‘deadlineism rhetoric’ can shape policy response in ways that reinforce an illusion of controllability, obscuring the complexity of environmental change.

If time-bound targets can limit responsiveness during policy implementation, they may also shape how visions for emerging technologies are imagined and articulated. Faced with pressure to deliver on fixed deadlines, stakeholders – such as policymakers, industry actors, and researchers – may find their visions constrained by the urgency to act. The literature on future studies highlights a dual effect of predetermined priorities: while they can enable the mobilization of change toward specific goals, they may also limit actors’ ability to imagine alternative futures beyond predefined objectives (Hajer & Pelzer, 2018; Hajer & Versteeg, 2019; Mangnus et al., 2022). In this sense, time-bound targets can narrow imagined possibilities, confining visions to particular understandings of progress rather than opening up space for radically different futures.

In summary, while visions can guide the development of emerging technologies toward desirable futures, time-bound targets may shape how such futures are imagined. As this theory section has shown, deadlines and predetermined priorities may have possible constraining effects on the ability to envision alternative futures. Although policy practice increasingly relies on time-bound targets to accelerate sustainability transitions, their effects on how futures are envisioned remain insufficiently understood. This study therefore examines the effect of time-bound targets on visions for the future.

### 3. Methods

#### 3.1. Case selection

This study examines energy storage technologies in the Netherlands as a case of an emerging technology developed in a context shaped by time-bound climate targets. The technologies considered

include electrochemical storage solutions<sup>1</sup> such as hydrogen-bromine redox flow batteries, iron-based flow batteries, and acid–base flow batteries that use table salt and water for energy storage (Hugo et al., 2020; Jumare, 2020; Pärnamäe et al., 2020), as well as power-to-hydrogen systems. Power-to-hydrogen systems convert surplus renewable electricity into hydrogen, which can subsequently be stored in pressurized tanks or underground formations, such as empty salt caverns (Blanco & Faaij, 2018; Mayyas et al., 2020; Pan et al., 2024).

These technologies are considered emerging due to their radical novelty, rapid technological advancements, and ongoing testing in pilot projects (Macnaghten et al., 2019; Meijer & Hekkert, 2007; Rotolo et al., 2015). Despite high uncertainty regarding their scalability, cost-effectiveness, and integration into existing energy infrastructure, they are viewed as promising solutions with the potential to accelerate the Dutch energy transition.

Beyond their technological promise, these energy storage technologies are directly tied to national and European climate targets. In accordance with EU goals, the Netherlands has committed to reducing its GHG emissions by 55% compared to 1990 levels by 2030 and to reaching near-zero emissions by 2050. At the same time, the rapid expansion of renewable energy is placing increasing strain on the Dutch electricity grid (Netbeheer Nederland, 2023), which delays the roll-out of new large-scale solar and wind projects. It is estimated that projects currently stalled due to insufficient grid capacity could power more than six million households (Actieteam Netcapaciteit, 2022). In this context, emerging energy storage technologies can play a role in balancing energy supply and demand, thereby facilitating the integration of these delayed renewable energy projects (Eid et al., 2019; Shan et al., 2022). As such, emerging energy storage technologies are perceived as a promising means of achieving climate targets.

### **3.2. Data collection**

To analyze how time-bound targets shape visions for the future of emerging energy storage technologies, we conducted interviews with stakeholders involved in the development, implementation, and/or governance of these technologies. Interviews are a commonly used method to explore visions (see e.g. Groves et al., 2021; Sovacool et al., 2020; van der Meij et al., 2023), particularly when such visions have not yet been formalized in written documents. This was also the case in our study: at the time of data collection, visions for these technologies had not yet been documented, reflecting the nascent stage of these technologies' development.

To ensure a diverse range of perspectives, we selected stakeholders with varying backgrounds who are involved in the early development and societal embedment of emerging energy storage technologies. Stakeholders were first identified through a mapping exercise based on desktop research, with a few participants added through recommendations during the interviews. The final sample included 31 representatives from different stakeholder groups. Each interviewee was assigned an anonymized alphanumeric identifier combining the stakeholder group and a serial number (e.g. GOV3, MAN2). These identifiers are used consistently throughout the text and in Appendix A. [Table 1](#) provides an overview of the stakeholder groups and the number of interviewees in each category.

Interviews were conducted with representatives in senior positions – including chief executive officers, chief technology officers, and senior managers – as they are more likely to have developed a vision for the future, even amid the high uncertainty associated with emerging energy storage technologies. The interviews took place between the summer and fall of 2021, lasting between 45 and 70 min, averaging 60 min. Most interviews were conducted online (with video enabled) due to the COVID-19 pandemic, with one held in person and another via e-mail.

**Table 1.** Stakeholder composition of the interview sample.

Stakeholder group	Code	N	Stakeholder group	Code	N
Academic researcher	ACD	1	Manufacturer of emerging energy storage technologies	MAN	3
Advisory board member for the Dutch government	ADB	1	Pilot project testing emerging energy storage technologies	PIL	3
Energy service provider	ESP	1	Power generation company	PGC	2
Grid operator	GO	1	Regional development agency	RDA	2
Industry interest group	IIG	5	Independent research or advisory organization	RES	3
Local, regional, or national government	GOV	7	State-owned energy infrastructure or supply company	SOE	2

Note: The numbering within each category (e.g. GOV1 – GOV7) does not correspond to any particular sequence of interviews.

We used a semi-structured interview format to capture visions in a systematic yet flexible manner. The relatively open setting encouraged interviewees to articulate their desired future for energy storage in their own terms because visions are often personal, implicit, and shaped by broader experiences and values. This approach yielded rich qualitative data while ensuring comparability across interviews. Our aim was to uncover stakeholders' current visions for the future, rather than trace their development over time. To this end, the interview questions covered three main themes: (1) current developments in the energy storage field, (2) perceived barriers and drivers in the context of these developments, and (3) the interviewees' envisioned futures for energy storage, particularly for emerging energy storage technologies. Follow-up questions were used to deepen understanding of the scope and nature of the envisioned change. For example, interviewees were asked to what extent their vision for the future differed from current practices, how they imagined an ideal future for emerging energy storage technologies, and what role they foresaw for these technologies in society. All interviews were conducted in Dutch, then transcribed and coded using NVivo software. Quotations presented in this study were translated by the researchers.

### 3.3. Data analysis

During coding, special attention was given to symbolic language as a medium for constructing images of the future (Jasanoff & Kim, 2009). In particular, metaphors were coded, as interviewees frequently used these rhetorical devices to articulate their envisioned future. By linking abstract visions of uncertain technologies to familiar concepts, metaphors made these ideas more tangible and comprehensible, creating a mental picture of envisioned futures. Interviewees used metaphors to convey defining aspects of their visions and highlight resemblances between phenomena. Metaphors were used to describe the current state of affairs, such as 'let a thousand flowers bloom' to express frustration with fragmented initiatives, and the 'invisible hand of the market' to question market-driven solutions. Others, like '2030 is basically tomorrow,' emphasized the urgency to act. Metaphors such as 'it feels close to home' convey envisioned futures in which energy storage is portrayed as psychologically proximate and embedded in everyday life. Identifying and coding metaphors thus provided deeper insights into how interviewees imagine energy storage futures and contributed to the differentiation of distinct visions.

In addition to coding metaphors, broader themes were identified through thematic coding. This process resulted in various codes reflecting interviewees' dissatisfaction with the current situation (e.g. the netting scheme),<sup>2</sup> their desires for the future (e.g. a call for state-led coordination), and recurring topics (e.g. opportunities presented by electric vehicles as mobile storage units).

These coding processes were embedded in an abductive coding strategy (Timmermans & Tavory, 2012; van Hulst & Visser, 2024), which involved moving back and forth between empirical data

and theory during the coding process. During this process, we initially focused on identifying how interviewees envisioned the future of emerging energy storage technologies. As the analysis progressed, a recurring pattern became apparent: interviewees repeatedly and unprompted referred to climate targets when articulating their visions. This observation led us to revisit literature on temporal dynamics in sustainability transitions and to refine our analytical focus on how time-bound targets shape envisioning processes.

In the final stage of analysis, codes were grouped according to the two elements of a vision: (1) the perceived problem in the current state of affairs and (2) a more or less explicit claim of a desired future, including its relation to the wider societal context (see Section 2.1). Based on these grouped codes, we identified three visions for the future of energy storage in the Netherlands, each shaped in different ways by references to climate targets. These visions are not mutually exclusive but analytical constructs distilled from recurring themes across the interviews. In practice, interviewees articulated elements of more than one vision when describing their vision for the future. The three visions are discussed in the following section and further analyzed in section 5.

## 4. Visions for the future of emerging energy storage technologies

### 4.1. Three visions for the future

Based on stakeholder interviews, we identified three visions for the future of emerging energy storage technologies: (1) Removing barriers: 2030 as a call for targeted interventions; (2) Rallying the nation: 2030 as a deadline for coordinated state action; and (3) Local answers to a looming deadline: 2030 as a push for decentralized solutions. None of the visions was strongly aligned with or exclusively supported by any particular stakeholder group. In this section, we present the three visions and examine the role of time-bound targets within each. For representative quotes illustrating each vision, see Appendix A. Based on these results, Section 5 will analyze how time-bound targets shaped the articulation of these visions.

#### 4.1.1. Vision 1. Removing barriers: 2030 as a call for targeted interventions

**4.1.1.1. Perceived problem in the present.** According to the first vision, the problem with emerging storage technologies currently stems from too many regulatory and policy barriers that prevent these technologies from addressing the suboptimal performance of the current energy system. These inefficiencies are seen as too great an impediment to renewable energy deployment, as underscored by a senior manager at a technology manufacturer: ‘Curtailed is happening too easily.’<sup>3</sup> Renewable energy sources are simply switched off. We have to adjust policies to optimize usage through storage rather than waste renewable energy’ (MAN1). Commonly mentioned barriers include the netting scheme (*salderingsregeling*); the absence of uniform national guidelines for permitting small-scale hydrogen storage projects; and the lack of subsidies for high-risk, innovative technologies. A representative from an industry interest group noted: ‘Infrastructure permitting and regulations [for small-scale hydrogen storage] significantly slow down innovation processes. An effort from the government is needed to remove these barriers and speed up crucial projects’ (IIG2).

**4.1.1.2. Envisioned future.** To cope with this problem, stakeholders envision a series of small-scale targeted interventions aimed at removing practical obstacles, which are seen as the most effective approach to unlocking the potential of these technologies. These interventions include streamlining

permitting procedures, clarifying market conditions, and abolishing the netting scheme. In this envisioned future, national, regional, and local governments are expected to adjust existing regulatory and policy frameworks to remove barriers, playing a facilitating role within a broader field of stakeholders. Through these targeted interventions, interviewees anticipate that these technologies will enhance overall energy efficiency by alleviating grid congestion and supporting renewable energy integration into the current system.

In terms of the proposed pathway, the 2030 climate target is seen as a catalyst for optimizing existing regulatory and policy frameworks. Postponing action is considered increasingly risky. As a senior manager from the Dutch natural gas infrastructure and transportation company stated: ‘To achieve our energy goals by 2030, storage needs to become part of a sustainable business model. Storage will not be adopted unless we solve the regulatory and financial hurdles we currently face’ (SOE1). After these adjustments, interviewees foresee a relatively seamless integration of emerging energy storage technologies into the current system, comparing them to well-known technologies such as everyday batteries. A research institute representative explained: ‘People are very familiar with batteries, in mobile phones and otherwise. In that sense, it [emerging flow batteries] is not a new technology; it feels close to home’ (RES2).

#### **4.1.2. Vision 2. Rallying the nation: 2030 as a deadline for coordinated state action**

**4.1.2.1. Perceived problem in the present.** According to the second vision, fragmented efforts and a lack of national leadership are the main barriers to energy storage deployment. Multiple interviewees described the current landscape as a patchwork of disconnected initiatives. A representative of a regional development agency captured this sentiment: ‘Let a thousand flowers bloom, a bit here, a bit there, but not too much. That sparks a lot of ideas, but it always falls short when it’s time to really follow through together’ (RDA1). Interviewees problematize the absence of national governmental leadership, arguing that this absence prevents these technologies from scaling and contributing meaningfully to the achievement of climate targets. A senior representative of a technology industry association underscores this concern: ‘The Netherlands aims to achieve its climate targets, but we really need the political commitment to invest in our own industrial sectors [related to energy storage] to play a role in this. If we don’t do this now, we’re done’ (IIG4). An academic researcher working on emerging energy storage technologies echoed this concern: ‘There is too little direction and strategic action from the national government. That is simply because we assess the end goal [climate targets], but not the path to get there’ (ACD1).

**4.1.2.2. Envisioned future.** To address the problems noted above, this vision calls for coordinated state action: setting explicit goals for storage capacity, mobilizing public funding, and directing infrastructure investments through integrated planning. Government leadership is seen as essential for developing a roadmap that enables private actors to align their efforts and investments. In this envisioned future, the government takes charge as a central actor, providing strategic direction through top-down planning across all sectors of the energy system.

The 2030 climate target is frequently cited as justification for this state-led approach. A senior manager from a knowledge organization (RES3) stressed the urgency: ‘We have climate targets for 2030, but for industry, 2030 is tomorrow! You must have technology ready right now, and you need a clear and shared vision, a roadmap to realistically reach these targets’ (RES3). Several interviewees compared the required effort to the Dutch Delta Programme, a centrally coordinated flood protection initiative that reflects a familiar Dutch governance tradition in nationwide infrastructure planning. A chief technology officer articulated this comparison: ‘What’s really needed is

a clear, central vision: this is how we're going to do it. Think of the Delta Works. Do you really believe the invisible hand of the market would have made that happen? Of course not. It was concentrated action, directed from the top' (MAN2).

#### **4.1.3. Vision 3. Local answers to a looming deadline: 2030 as a push for decentralized solutions**

**4.1.3.1. Perceived problem in the present.** In the third vision, the current centralized energy system is seen as incompatible with the decentralized potential of emerging storage technologies. Interviewees argue that centralized grid structures obstruct innovation in solutions such as neighborhood batteries, which could help alleviate local grid congestion and support more flexible forms of energy management. A national government official explained: 'We have more and more heat pumps, electric vehicles, more solar and wind. But our top-down energy system is actually not developed for that or equipped. We need decentralized solutions to achieve the 2030 target' (GOV7). Many interviewees voiced frustration with the legal prohibition on distribution system operators (DSOs) owning storage assets.<sup>4</sup> A few also mentioned DSOs' reluctance to embrace innovations. A regional policy official observed: 'I see many people who want to explore the option of a neighborhood battery. However, the DSO in our region says: Energy storage is nonsense; we have a fantastic [centralized] energy grid' (GOV1). This quote reflects frustration with the continued belief in a centrally organized grid that leaves little room for decentralized storage solutions.

**4.1.3.2. Envisioned future.** In response, interviewees envision a future with a new system in which energy storage becomes a cornerstone of a decentralized energy system. Emerging technologies, such as flow batteries that can be used at a neighborhood level, are seen as solutions to alleviate grid constraints and support decentralized energy management, benefiting residential users and local industries. Interviewees also highlight the opportunities presented by electric vehicles for decentralized storage through bidirectional charging. In this vision, DSOs are expected to evolve into collaborative partners that help enable local storage integration, particularly as the pressure of the 2030 climate deadline intensifies the need for practical alternatives. While this vision promotes substantial changes to the current system by advocating disruptive innovations in ownership schemes and business models, it still builds on existing practices in the Netherlands, such as community-owned wind turbines and technologies already gaining traction.

In terms of timing, decentralized solutions are portrayed as faster to implement than traditional grid reinforcements.<sup>5</sup> As a regional policy official (GOV1) noted: 'We have the choice to invest in reinforcing the grid, which takes at least 10 years, or to install a neighborhood battery, which can be done much more quickly.' An industry representative commented on the timeframe: 'We need to try it [local energy storage] together, as there is an urgency because of the 2030 climate target' (IIG1). The 2030 deadline is thus framed as a driver of decentralized innovation and local ownership.

#### **4.2. Three visions toward one deadline**

The three visions differ in their diagnosis of the present problem and the desired futures they propose (see [Table 2](#) for an overview). They also diverge in governance preferences: Vision 1 emphasizes regulatory and policy reforms, Vision 2 calls for centralized coordination, and Vision 3 promotes decentralized solutions. Despite these differences, all three visions share a relatively modest scope of envisioned change. Vision 1 relies on incremental adjustments to current regulatory

**Table 2.** Overview of the three visions for the future of emerging energy storage technologies.

Vision	Perceived present	Envisioned future	Envisioned change
<i>Vision 1. Removing barriers: 2030 as a call for targeted interventions</i>	Emerging energy storage technologies face regulatory and policy barriers within an underperforming energy system	Emerging energy storage technologies serve as an optimizer of the current system after targeted adjustments	Optimizing the current system
<i>Vision 2. Rallying the nation: 2030 as a deadline for coordinated state action</i>	Emerging energy storage technologies cannot thrive within the current energy system as efforts are too fragmented to accelerate change	Emerging energy storage technologies become part of a nationally coordinated project of urgent importance.	Reinforcing familiar patterns of centralized state-led infrastructure planning
<i>Vision 3. Local answers to a looming deadline: 2030 as a push for decentralized solutions</i>	Emerging energy storage technologies cannot flourish in a centrally organized energy system that hinders decentralized innovation	Emerging energy storage technologies form a key building block of a new decentralized energy system	Facilitating current advancements at a decentralized level

and policy frameworks; Vision 2 calls for renewed centralized coordination rooted in familiar Dutch governance traditions; and Vision 3 proposes systemic change through decentralized solutions though it builds on existing grassroots initiatives. This similarity is notable given the early-stage and open-ended nature of the technologies involved, which might otherwise invite more varied visions.

One explanation for this convergence lies in a common thread running through all three visions: the way stakeholders referenced climate targets, particularly the 2030 deadline, when articulating their desired futures. The 2030 target was consistently invoked as a central reference point. While the 2050 target is formally in place, it was rarely mentioned.

Stakeholders often interpreted the 2030 target as a hard deadline, one that created a sense of time pressure. They frequently used temporal language – emphasizing urgency, acceleration, or deadlines – to frame their preferred visions for the future. A senior manager stressed: ‘We have climate targets for 2030, but for industry, 2030 is tomorrow!’ (Vision 2). Others argued that removing policy barriers ‘can speed up crucial projects’ (Vision 1), warned that ‘if we don’t do this now, we’re done’ (Vision 2), or pointed out that neighborhood batteries ‘can be done much more quickly’ (Vision 3).

Beyond generating urgency, the 2030 climate target also served to legitimize particular courses of action. It was invoked to justify a push for regulatory and policy reforms (Vision 1), to demand stronger state intervention (Vision 2), and to accelerate decentralized innovation (Vision 3). Almost all interviewees envisioned their preferred pathway not only as desirable, but as necessary to meet climate goals. The target functioned as a narrative anchor, aligning future visions with what was perceived to be a non-negotiable deadline.

Taken together, these findings suggest that time-bound climate targets played an integral role in shaping how stakeholders envisioned the future of energy storage. The next section explores this dynamic in more detail.

## 5. How time-bound targets shape envisioned change

As the previous section has shown, stakeholders articulated distinct visions for the future of emerging energy storage technologies. These visions differed in their diagnoses of present problems and their envisioned futures, but shared a notable commonality: each was anchored in the 2030 climate target. This target served not only as a policy milestone but also as a central structuring device for imagining the future. The three visions clustered around short-term, actionable pathways toward

that deadline. This convergence raises important questions about how time-bound climate targets shape the envisioning process itself. The present section turns its attention to this dynamic, examining the ways in which time-bound targets shaped the futures stakeholders could imagine.

### 5.1. How time-bound targets enabled and constrained change in the envisioning process

Based on our empirical analysis, we identify three distinct ways in which time-bound targets shaped the envisioning process for emerging energy storage technologies, including various types of flow batteries and power-to-hydrogen storage systems. These dynamics had both enabling and constraining effects on how change was imagined, as elaborated in the sections below. Table 3 provides more insights into their effects across the three visions.

#### 5.1.1. Narrowing change toward a tangible, but myopic, endpoint

First, time-bound targets narrowed the envisioning process toward a tangible endpoint. Climate targets offered a clear temporal horizon that helped interviewees anchor their visions in a specific future moment. This anchoring occurred unprompted during the interviews, with respondents consistently explaining their visions as pathways toward the 2030 target. In Vision 1, 2030 marked the year by which existing regulatory and policy barriers must be overcome; Vision 2 cast it as the

**Table 3.** How time-bound targets enable and constrain envisioned change.

Identified visions	Time-bound targets narrow the envisioning process toward a tangible endpoint	Time-bound targets compartmentalize the envisioning process into plannable steps	Time-bound targets prioritize the process of envisioning immediate change
<i>Vision 1. Removing barriers: 2030 as a call for targeted interventions</i>	<p><b>Enabling effect:</b> Focuses on immediate regulatory and policy reforms achievable up to 2030.</p> <p><b>Constraining effect:</b> Limits the scope on actionable adjustments up to 2030, leaving the post-2030 future undefined.</p>	<p><b>Enabling effect:</b> Outlines stepwise improvements to regulation and policy frameworks, structuring change as a checklist of actionable items.</p> <p><b>Constraining effect:</b> Reinforces a backward-mapped sequence of policy and regulatory reforms, restricting exploration of alternative pathways.</p>	<p><b>Enabling effect:</b> Justifies swift regulatory and policy action within a constrained timeframe.</p> <p><b>Constraining effect:</b> Discourages more radical systemic overhaul by prioritizing feasible regulatory and policy adjustments.</p>
<i>Vision 2. Rallying the nation: 2030 as a deadline for coordinated state action</i>	<p><b>Enabling effect:</b> Advocates state-led intervention to meet the 2030 climate target.</p> <p><b>Constraining effect:</b> Focuses action on a state-led roadmap up to 2030, with no outlook beyond that point.</p>	<p><b>Enabling effect:</b> Calls for phased implementation through state coordination, prioritizing planned interventions and actions.</p> <p><b>Constraining effect:</b> Avoids less manageable changes by favoring step-by-step rollout of state-led interventions.</p>	<p><b>Enabling effect:</b> Supports rapid deployment via a top-down, centrally coordinated action program.</p> <p><b>Constraining effect:</b> Prioritizes familiar forms of centralized state action for urgent interventions, limiting exploration of alternative governance models.</p>
<i>Vision 3. Local answers to a looming deadline: 2030 as a push for decentralized solutions</i>	<p><b>Enabling effect:</b> Grounds change in decentralized solutions achievable within the 2030 timeframe.</p> <p><b>Constraining effect:</b> Leaves the structure of a post-2030 decentralized system undefined.</p>	<p><b>Enabling effect:</b> Advocates feasible and planned opportunities that emerge for decentralized solutions.</p> <p><b>Constraining effect:</b> Limits more radical and yet-to-be-invented decentralization models by relying on expanding proven local practices</p>	<p><b>Enabling effect:</b> Highlights the speed and visibility of decentralized solutions.</p> <p><b>Constraining effect:</b> De-emphasizes long-term alternatives in favor of rapidly deployable decentralized solutions seen as more attainable within a short timeframe.</p>

point of convergence for coordinated national action; and Vision 3 treated it as deadline demanding decentralized solutions.

This temporal anchor had a dual effect. On the one hand, it enhanced the relatability of the future by linking it directly to the present, bringing the future within reach by presenting it as being just around the corner. On the other hand, this same focus constrained actors' ability to imagine a more distant or open-ended future. The prominence of 2030 fostered what might be described as a myopic orientation toward an intermediate goal, restricting reflection on longer-term trajectories. This was evident in all three visions, which treated 2030 as a definitive horizon for action, with minimal attention to developments beyond that point.

### ***5.1.2. Compartmentalizing change into plannable, but moderate, steps***

Secondly, time-bound targets helped structure the envisioning process into discrete, plannable steps. The presence of sequential milestones encouraged interviewees to break down long-term transformation into shorter, manageable phases, each tied with concrete interventions. These included measures such as abolishing the netting scheme, setting explicit national goals for storage deployment, or investing in neighborhood batteries. Each action was presented as a necessary and pragmatic step toward meeting the climate target.

Like the temporal anchor discussed before, this compartmentalization had a dual effect. On the one hand, this compartmentalization made the future appear more open to manipulation and control. Intermediate targets functioned as scaffolding that lent structure to an ambitious transition, thereby enhancing its perceived feasibility. On the other hand, this form of backward mapping also risked reinforcing incrementalism. By plotting a path of small and predefined steps, actors primarily focused on adjusting existing systems rather than exploring more radical or transformative alternatives. The long-term pathway beyond 2030 remained vague, and emerging technologies were imagined primarily through already-familiar mechanisms, leaving little room for yet-to-be-invented, disruptive, and unmapped futures.

### ***5.1.3. Prioritizing immediate, but non-risky, change***

Third, time-bound targets shaped the envisioning process by prioritizing immediate action through the creation of a strong sense of urgency. Imminent deadlines created an experience of time pressure that shaped how actors ranked possible actions. In doing so, the targets served as a filter through which options were assessed, elevating those options most likely to deliver visible results within the given timeframe.

Like the dynamics discussed in the previous paragraphs, this urgency both enabled and constrained envisioned change. On the one hand, it fostered a readiness to act, as interviewees expressed a clear preference for interventions with immediate impact. Interviewees were motivated to act promptly within the given timeframe, as exemplified by how they prioritized choices such as installing a neighborhood battery, favored for its immediacy, over actions that they perceived as more time-intensive, such as investing in expanding the grid. On the other hand, the immediacy of the deadlines also led to a prioritization of immediate change, which was considered most likely to contribute to meeting deadlines, thereby limiting enthusiasm for riskier actions. The pressure to deliver within a limited timeframe led many actors to focus on what was realistically achievable in the short term, rather than what might be desirable or necessary in the long run.

Taken together, time-bound targets shaped the envisioning process by temporally anchoring stakeholders' visions; by compartmentalizing change into manageable steps; and by prioritizing immediate action. These dynamics both enabled and constrained the kinds of futures stakeholders

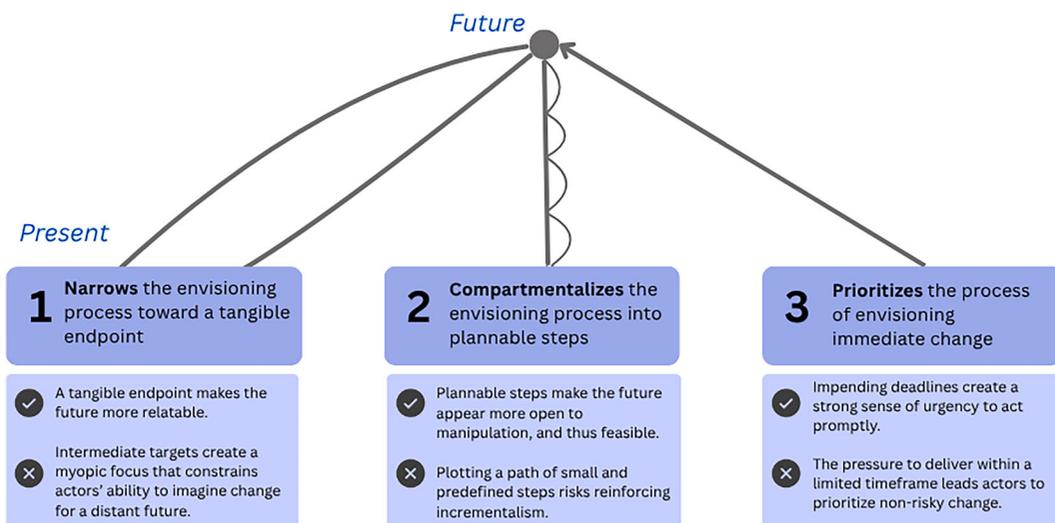
could imagine by shaping not only what the future should look like (by narrowing visions to a tangible endpoint), but also how to get there (by compartmentalizing change into sequential, planable steps), and which actions were considered worthwhile (by prioritizing those that could deliver visible results quickly). [Figure 1](#) provides a visual representation of these dynamics.

## 5.2. The dominance of the intermediate target

While these three dynamics – narrowing, compartmentalizing, and prioritizing – capture the mechanisms through which time-bound targets shape how futures are imagined, they also raise a broader question: which target comes to dominate this process? Although both the 2030 and 2050 targets formally coexist as deadlines in the case we studied, our analysis suggests that interviewees consistently gravitated toward the intermediate rather than the long-term goal. This may not be surprising, given its temporal proximity, but it reveals an important pattern: rather than functioning as a stepping stone toward a long-term transformation, the 2030 target functioned as the primary reference point around which visions were constructed.

Although intermediate targets are typically framed in policy practice as milestones along a longer pathway, our findings suggest that they can become the primary focus of action, effectively replacing the original endpoint. Despite the significant time gap between the 2030 and 2050 climate targets, the 2030 deadline consistently emerged in all three visions as the dominant point of orientation. As [Section 4.2](#) demonstrates, the 2030 target was repeatedly used to describe and to justify envisioned futures. [Section 5.1.1](#), including [Table 3](#), further demonstrates a myopic orientation toward 2030, leaving the post-2030 future undefined. As such, the 2030 target was not imagined as part of a continuum, but rather as a destination around which action needed to be organized.

In the analysis of visions for emerging energy storage technologies, then, the 2030 target emerged as the dominant temporal reference point, effectively displacing the longer-term 2050 horizon. It was this intermediate target that guided how actors narrowed their visions, structured change into manageable steps, and prioritized immediate actions. As a result, visions were not only focused on meeting the 2030 goal but also bound by it. This effect may be particularly



**Figure 1.** How time-bound targets shape envisioned change.

consequential in the context of emerging technologies, such as those examined in our case study, where early stages of development provide a critical window for defining purpose, direction, and societal role.

## 6. Conclusion and discussion

This article has explored how time-bound climate targets shape the visions formulated for emerging energy storage technologies. Drawing on interviews with 31 stakeholders in the Netherlands, we identified three distinct visions, each offering a different interpretation of the present and a preferred pathway toward the future. Despite their differences, these visions were consistently structured around the 2030 climate target, which functioned as the dominant horizon for imagining change. By narrowing the envisioned futures to a tangible endpoint, compartmentalizing change into manageable steps, and prioritizing immediate, non-risky actions, the 2030 target both enabled and constrained how stakeholders imagined the role of energy storage in the transition to a low-carbon energy system.

Our research contributes to existing literature in at least three ways. First, we add a temporal dimension to studies on guiding visions for emerging technologies (see e.g. Arentshorst, 2017; Grin & Grunwald, 2000; Grunwald, 2004; Roelofsen et al., 2008; van der Meij et al., 2023). We show that time-bound climate targets, particularly the 2030 goal, play a central role in shaping the kinds of futures that are envisioned. In doing so, we demonstrate that guiding visions are not only driven by actors' values or technological expectations but are also conditioned by policy timelines. Moreover, by identifying the effects of time-bound targets on envisioning change, we also add empirical detail to discussions on the role of predetermined priorities in structuring the future (see e.g. Hajer & Pelzer, 2018; Hajer & Versteeg, 2019; Mangnus et al., 2022).

Second, our study contributes to planning and policy studies by advancing understanding of how planning instruments like climate targets shape the structuring of time in governance processes (Berker & Throndsen, 2017). By identifying their effects on envisioned change, our findings affirm and further strengthen calls to take time seriously as a structuring force in planning (see e.g. Berker & Throndsen, 2017; Gillard & Lock, 2017; Lennon & Tubridy, 2023). This call becomes even more important in light of the constraining effects we observed, including a myopic focus, the backward mapping of incremental steps, and the prioritization of non-risky change. In addition, our findings speak directly to concerns raised about the risks of rigid deadlines in policy processes. While previous studies have demonstrated how rigid deadlines suppress deliberation and adaptability (see e.g. Eshuis & Van Buuren, 2014; Pot et al., 2023; Wolf & van Dooren, 2018), our study sheds light on how time-bound targets shape the scope of envisioned change by identifying three dimensions along which they can have both enabling and constraining effects.

Third, we offer a more nuanced perspective on time-bound targets, which are widely regarded in sustainable transitions literature as an effective method for mobilizing change toward a specific endpoint (see e.g. Haarstad, 2020; Jørgensen & Sørensen, 2022; Mazzucato, 2018; Mazzucato et al., 2020; Morseletto, 2020; Morseletto et al., 2017). While our findings confirm that time-bound targets can facilitate the development of visions aimed at feasible and rapid change in the near future, we also demonstrate that these targets can hinder actors' ability to envision radical changes in a more distant future. Moreover, we revealed that intermediate targets take precedence as the primary focal point for envisioning the future even when long-term targets are in place. This short-term orientation constitutes another related risk of using time-bound targets to govern change toward an end goal.

Our research also has limitations, which offer avenues for future exploration. First, this study examined the influence of time-bound targets on visions for emerging technologies at one moment in time. Such visions, however, demand continuous reflection as they are likely to evolve when technologies mature (see e.g. Bakker et al., 2011; Grin & Grunwald, 2000). Some visions may already have been adapted or institutionalized in Dutch policy documents since our interviews. For example, the national energy storage roadmap published in 2023 does place emphasis on the 2030 horizon (Ministry of Economic Affairs and Climate Policy, 2023), suggesting that time-bound targets remain a notable structuring element in ongoing policy discussions on energy storage. Future research could explore whether the effects we identified persist as these technologies become more embedded in planning processes. As the deadline to achieve climate targets draws nearer, the pressure may amplify a short-term and incremental focus in envisioning change.

In a similar vein, future research could also build on our findings by examining the role time-bound targets play in the formation of coalitions, such as discourse coalitions (Hajer & Versteeg, 2005), as the field matures. In early-stage technological fields, discursive alignments are often only beginning to take shape and circulate primarily within expert communities, largely dominated by industry representatives (Ulnicane et al., 2021). As those who hold visions coalesce, the form and function of these visions may shift, for instance as they become vehicles for coordination or negotiation in the wider policy debate. It would be valuable to understand whether actors mobilize particular (elements of) visions, such as time-bound targets, to strengthen their position and build coalitions and how this shapes which visions ultimately gain traction.

Second, some visions for the future of emerging energy storage technologies in the Netherlands may not have been captured by our stakeholder selection. While their insights are valuable due to their involvement in the field, they may have been, by the nature of their involvement, more inclined to take the current system as a starting point when envisioning the future. As a result, our study offers limited insight into whether more radical or latent visions circulate outside the group currently involved in the development and implementation of these technologies. Future research could include actors not yet involved to explore whether, and how, such visions are able to gain traction. It could examine how time-bound targets may influence these dynamics, for example, by creating a sense of urgency that sidelines actors perceived as too time-intensive to involve.

Third, this study was conducted in the Netherlands, where visions of energy storage are formulated within a consensus-oriented governance tradition that combines state coordination with market involvement. This institutional setting may have led climate targets to inspire both visions of urgent, coordinated state action and visions of locally embedded, collaborative solutions that share similar temporal horizons. In contexts with stronger traditions of central planning, by contrast, climate targets might more readily reinforce state-led visions emphasizing rapid, centrally coordinated change. Conversely, in more adversarial governance settings, such targets could stimulate more fragmented, competitive pathways where multiple actors may pursue their own time-bound projects in parallel, resulting in a patchwork of competing initiatives that lack overarching coordination. Future research could therefore examine how different governance traditions mediate the relationship between time-bound climate targets and the kinds of visions that emerge.

Finally, the findings hold broader relevance for policy and planning practice beyond this specific case, as time-bound targets are increasingly central to how governments seek to accelerate sustainability transitions. Our study demonstrates that these targets do more than set implementation deadlines; they also shape how people think about the future and what kinds of futures they consider possible.

## Notes

1. Electrochemical energy storage refers to the process of converting electrical energy into chemical energy and vice versa. Flow batteries store energy in liquids kept in tanks and releases it through a chemical reaction that turns the stored energy into electricity. Power-to-hydrogens uses electricity to create hydrogen that can be stored in tanks or underground spaces and turned back into electricity when needed.
2. The Dutch netting scheme (*salderingsregeling*) provides a financial benefit by allowing small users to offset the solar power they feed into the grid from the electricity they purchase, making home solar panels more attractive but reducing the incentive to invest in storage.
3. Curtailment means temporarily shutting down wind and solar power to prevent grid overload when supply exceeds demand. This can avoid costs or even generate revenue, especially when energy prices turn negative.
4. In the Dutch energy system, DSOs are legally responsible for managing the local electricity grid. They are currently largely prohibited by law from owning energy storage assets to ensure that they remain neutral market facilitators. Energy storage can be considered a commercial activity because it often involves buying and selling electricity in the electricity markets, which conflicts with the DSOs' role as a neutral market facilitator.
5. Interviewees contrast two approaches to reducing grid congestion: upgrading the existing grid to increase its capacity to transport and distribute electricity or installing decentralized storage systems to better balance local energy supply and demand.

## Ethical clearance

Ethics approval was obtained from the Tilburg Law School Ethics Review Board under the authority of the Board of Tilburg Law School, Tilburg University. Identification code: TLS-ERB # 2021/21, dated 25 October 2021.

## CRedit authorship contribution statement

Anieke Kranenburg: Conceptualization, Formal analysis, Methodology, Investigation, Project administration, Writing – Original draft, Writing – Review & Editing. Eva Wolf: Conceptualization, Supervision, Writing – Review & Editing. Martijn Groenleer: Conceptualization, Supervision, Writing – Review & Editing, Funding acquisition.

## Disclosure statement

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