



The socio-political context of energy storage transition: Insights from a media analysis of Chinese newspapers

Yixin Chen^{a,*}, Ian H. Rowlands^{b,2}

^a Department of Geography and Environmental Management (GEM), University of Waterloo, University of Waterloo, 200 University Ave W, Waterloo, ON N2L 3G1, Canada

^b School of Environment, Resources and Sustainability (SERS), University of Waterloo, 200 University Ave W, Waterloo, ON N2L 3G1, Canada

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ABSTRACT

The development of energy storage (ES) technology is essential for a sustainable energy transition; however, the socio-political context of ES tends to make its large-scale development challenging, which requires more attention. Given the role of media discourse in both reflecting and influencing such socio-technical processes, we initially analysed the national media representation of ES in China based on the Socio-Political Evaluation of Energy Deployment (SPEED) framework. We did this by analysing 156 ES-related articles from two Chinese mainstream newspapers, *People's Daily* and *China Daily*. Through investigating the framing and frequency of articles, the particular ES technology mentioned, and the stakeholders involved, we identify (1) a generally promising pathway of ES development due to its transformative role in China's low-carbon energy transition and its alignments with other national priorities and interests; (2) some uncertainties about ES development regarding local institutional inertia and how people interact with ES technologies, which could hinder an ES transition; and (3) domestic complexity and dynamics underpinning ES technologies, reflecting a supportive attitude of the Chinese government and a top-down governance system. Our findings help to uncover the unique socio-political environment around ES in China, how audiences are informed, and the support provided to stakeholders' strategies.

1. Introduction

The transition toward a decarbonized energy future is underway, being catalysed, in large part, by concerns about global climate change. Many believe that energy storage (ES) will play a critical role in the transition process. ES supports grid reliability, intermittent renewable energy integration, and electricity balancing between supply and demand; it can also be used for grid services, behind-the-meter applications, off-grid applications, and transportation (e.g., electric vehicles) [1,2]. ES, which refers to various energy technologies, including pumped hydro, compressed air, and batteries, is experiencing dramatic cost reductions and increased levels of research and development (R&D) investments [3]. However, despite rapid technological advancements, widespread ES deployment is still uncertain, geographically uneven, and generally at an early stage. The global market for various types of ES reached 183 GW in 2019, with roughly 3 GW capacity being added

annually [4]. South Korea, the United States, and China accounted for nearly one-half of 2019's newly-installed capacity, whereas most other regions of the world still have very limited ES markets [5].

China, as the world's largest greenhouse gas emitter and energy consumer, has made great efforts towards green development and has set targets of reaching its carbon emissions peak by 2030 and achieving carbon neutrality by 2060. Its actions relevant to the energy transition will be highly influential as to whether worldwide environmental protection and global climate change mitigation goals will be effectively achieved. The development of ES as part of the energy transition has significantly contributed to technological progress and increased installed capacity, but even China's ES industry is still emerging and lacks widespread deployment due to still emerging set of technical standards, evaluation systems, and policy frameworks [6]. These issues highlight the tendency of socio-political circumstances to lag behind technological progress. From one perspective, the green energy

* Corresponding author.

E-mail addresses: yixin.chen@uwaterloo.ca (Y. Chen), irowlands@uwaterloo.ca (I.H. Rowlands).

¹ ORCID iD: 0000-0002-5626-0448.

² ORCID iD: 0000-0001-7060-3403.

transition that is underway can be regarded as a socio-technical change that requires not only technological shifts but also progress across multiple dimensions, including social acceptance, business support, and multi-governance strategies [7]. This framing emphasizes the significant role of the social environment in interacting with or influencing technological change [8–11], a role that has not been given as much attention as technical and economic feasibility in energy studies [12]. Some existing studies focus on the socio-political dimensions of smart grid technologies [13,14], unconventional fossil fuels [15,16], and carbon capture and storage (CCS) [17–19] mainly in Europe and North America. However, few studies regarding broader socio-technical transitions have focused on China [20,21], particularly for ES technology, and existing ES studies in China have mostly emphasized technology or industry [22,23]. This study thus aims to fill this gap by investigating the socio-political context of ES technology in China.

Media³, as a communication practice, play a crucial role in understanding the social-political dimension of low-carbon energy transition and technological development processes. On the one hand, energy transition involves the interactions among multiple actors such as policy makers, industrial stakeholders, and consumers, and their debates, perceptions, and engagement significantly affect the ‘domestication’ of emerging technologies. The media can reflect and represent those debates and perceptions of energy policies, investments, or prospects, as well as the way in which various actors engage [15,24–27]. On the other hand, media can inform public understanding of reality and shape public perceptions, further influencing policy agendas and legitimizing policy making [19,28–30]. Media’s dual role enables them to be vehicles through which socio-political complexity and dynamics in specific jurisdictions worldwide can be understood.

The media in China play a different role compared to that of the United Kingdom, Canada, and other Western countries due to the different socio-political landscapes; accordingly, the media provide different insights. The press in the West has fought for and advocated its freedom, with increasing attention to its responsibility [31]. Media in the democratic context are mainly regarded as watchdogs of private and government actions and drivers for citizen engagement and participation in political processes [32]. By contrast, China has more political leadership of all kinds of media and their discourse via the supervision and regulation by the government and the Chinese Communist Party. Today, in the pluralistic Chinese media environment – notwithstanding the increasing number of commercial media organizations – the mainstream media are still working as mouthpieces and publicity vehicles of the government and the Party [33,34]. Therefore, ES media discourse and representation in Chinese media mainly reflect information on ES that aligns with the position of the Chinese government, which in turn further shapes public perceptions.

This study adds to our understanding of the global landscape of ES (c. f. [35–36]) by focusing on the national socio-political environment of ES technology in China through an exploration of national media discourse. We conduct content analysis based on the Socio-Political Evaluation of Energy Deployment (SPEED) framework to examine the framing and frequencies of national ES media coverage between 2017 and 2019 in the Chinese-language *People’s Daily* and English-language *China Daily*, both of which are widely circulated mainstream Chinese newspapers. In doing so, this study sheds light on how political, economic, and other influences interact to facilitate or hinder ES development in China from an integrated perspective. Further, it illuminates the political goals and policy responses of ES that the Chinese government has delivered to date. It also serves as an initial study applying the SPEED framework in

the Chinese energy context. Thus, this study advances our understanding of the socio-political catalysts and barriers to ES development faced by those interested in developing low-carbon technology strategies and achieving a sustainable energy transition.

2. Background

2.1. An overview of energy storage in China

ES plays a relatively niche role and the development of different ES technologies has not yet achieved advanced commercialization or widespread popularization in spite of the fact that China’s ES installed capacity was amongst the world’s top three countries in 2019 [5]. Still, the cumulative installed capacity of ES projects in China has steadily increased from 24.3 GW by the end of 2016 to 32.4 GW by the end of 2019 [37,38]. The cumulative capacity in China in 2019 accounted for 17.6% of the global installed capacity of ES [38]. Pumped hydro ES contributed the largest share (93.4%) of accumulated installed ES capacity in China in 2019, followed by electrochemical ES and molten salt (thermal) ES [38]. Electrochemical ES, which is mainly based on lithium-ion batteries, is relatively mature among ES technologies in China and developed rapidly between 2015 and 2019, with the highest annual growth rate of 175.2% in 2018 [38] (Fig. 1). The country’s main electrochemical ES projects are largely located in the northwest regions (e.g., Qinghai province and Xinjiang Uygur Autonomous Region), where the projects help to integrate renewable energy projects, and in the east-central regions (e.g., Jiangsu, Guangdong, and Zhejiang provinces), where the projects are deployed in microgrids [37,39].

China’s central government officials have promulgated numerous policies for energy transition with the strategic emphasis on ensuring energy security, prioritizing energy conservation, advancing green and low-carbon goals, and promoting technology innovations [40]. The release of the *Thirteenth Five-Year Plan for Energy Development* in December 2016 pointed to a new period for Chinese energy development between 2017 and 2020, serving to accelerate the transition from coal to clean energy and to set the broader framework for other energy-related policies in the period [41,42]. The *Plan* catalysed the transition in many ways, including diversifying and decarbonizing energy supply, advancing energy system optimization and modernization, promoting low-carbon and high-efficient energy consumption, emphasizing fair and efficient market mechanisms, and encouraging international energy cooperation.

The development of ES technology and industry has been a part of the transition pathway in China since 2005, when ES technology development was mentioned in the official national document, *Renewable Energy Law* [43]. Related policies, some of them listed in Table 1, mainly focus on (1) technical support with demonstration project implementation, R&D, and standard formulation; (2) market development, such as new business pattern exploration and compensation mechanisms for ancillary services; and (3) environmental protection with battery second-life management. The strategic priorities for ES development in China include its development with distributed energy

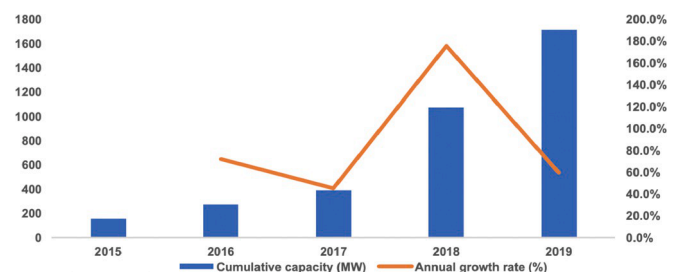


Fig. 1. Cumulative capacity (left) and annual growth rate (right) of electrochemical energy storage in China (2015–2019) [37,38].

³ The term media can refer to various types, including print media, broadcast media, and social media. There are burgeoning studies paying attention to social media (e.g., Facebook, and Twitter) for understanding energy and environmental issues. Our study here focuses on a traditional media source – namely, newspapers.

Table 1
Central government's official policies related to energy storage in China.

Date of publication (year/month)	Title	Main objectives	Reference
2016/06	Notice on Promoting ES to Participate in the Compensation (Market) Mechanism for Electricity Ancillary Services in Northeast China, North China, and Northwest China	(1) Promote ES application in ancillary services; (2) Explore ES business patterns	[47]
2016/12	Thirteenth Five-Year Plan for Energy Development	(1) Carry out ES demonstration projects; (2) Optimize the operation and coordination between ES systems, renewable energy systems, and grid systems	[41]
2016/12	Thirteenth Five-Year Plan for Renewable Energy Development	(1) Promote ES demonstration projects within the development pattern of renewable energy field; (2) Explore ES business patterns; (3) Improve technical standards, certification processes, and grid connection specifications	[42]
2016/12	Energy Production and Consumption Revolution Strategy (2016–2030)	Develop ES in the context of distributed energy systems and energy internet and other smart energy technologies	[40]
2017/09	Guiding Opinions on Promoting the Development of ES Technology and Industry	The first national ES industry policy with official guidance about the development of large-scale ES technology and application	[48]
2018/01	The Interim Measures for the Administration of Recycling Traction Batteries of New Energy Vehicles	Provide instructions for vehicle batteries' recycling and demolishing	[49]
2019/06	2019–2020 Action Plan of the "Guiding Opinions on Promoting the Development of Energy Storage Technology and Industry"	Complement the implementation of "Guiding opinions" and clarify the lead department for each specific policy measure	[50]
2019/06	Notice on Measures for Supervision and Examination of Transmission and Distribution Pricing and Costs	The costs of pumped storage power plants and electrical ES facilities cannot be incorporated within the costs of power transmission and distribution for power grid enterprises	[51]
2019/06	The Abolishment of "The Requirements of the Industry Standards for the Power Storage Batteries of New Energy Vehicles" issued in 2015	Abolish the white list of battery manufacturers who meet the criteria (e.g., technologies, production conditions, and products) of battery manufacturing and can receive policy support	[52]

technologies, its integration with energy internet or other smart energy technologies so as to improve the level of informatization and control, and its role in demonstration projects that incorporate research, development, and demonstration goals [44–46]. Thus, ES-related policies are not isolated; instead, they complement other policies related to renewable energies, smart energy, and new energy vehicles, paving the way for electricity market reform, clean energy transition, and low-carbon development in China.

2.2. Media discourse and energy transition

2.2.1. Media discourse and socio-political dynamics in an energy transition context

In recent years, increasing numbers of scholars have realized the significance of the politics and policies of energy transition and their change processes, giving greater attention to the involvement of political contestation/power struggles/policy uncertainty over decision making in socio-technical energy transitions [8,53]. The understanding of social acceptance of energy innovations and related matters (e.g., infrastructure and applications) in three dimensions – socio-political acceptance, community acceptance, and public acceptance – has also evolved, particularly with respect to how social acceptance is conceptualized [54–57] and how it becomes critical in supporting or hindering socio-technical change [58–60]. The unveiling of these socio-political contexts and processes of socio-technical change has been facilitated and enriched via discursive approaches using stakeholder interviews, policy documents, and media analysis [61–63]. The various types of discourse do not merely demonstrate the relationships between socio-political contexts and the physical reality of technologies, but they also structure these relationships via narratives and visions [64].

Media discourse, as one of the lenses, reflects public opinions and reactions to energy technologies and related policy issues and the underlying political contexts. Energy choices and issues are inherently constructed in political processes regarding state orientation, political ideology, and how different stakeholders with varied power interests engage [65]. The media also use various framings via emphasizing or highlighting specific aspects of messages over others to mobilise the public by increasing awareness and shaping perceptions/attitudes towards energy innovations [65]. These processes influence decision making in such a way that the public and policy agenda is set and energy policies are further legitimised or delegitimised. Therefore, media discourse analysis can inform policy intervention and practices to avoid resistance to energy technical solutions.

In view of the few existing studies in analysing energy transitions in China from the lens of media discourse, especially the lack of studies on ES deployment, we draw upon existing studies regarding media analysis of energy and environmental issues in Western countries (Sections 2.2.2 and 2.2.3) and media analysis in China (Section 2.3) to develop our hypotheses.

2.2.2. Media analysis with the SPEED framework

The SPEED framework, which was initially proposed by Stephens et al. [66], has proved to be a practical and effective conceptual framework for undertaking a media analysis on energy technology innovations in Western settings. It provides a holistic understanding of energy technology adoption and diffusion across six aspects – technical, economic, political, regulatory and legal, environmental, and cultural – and through benefit or risk framing [66,67]. The technical frame category includes engineering and technical details and the economic category includes issues related to costs and benefits, industries and markets, and broadly, economy. In addition, the political frame category comprises factors influencing political and strategic goals as well as power relationships among stakeholders; the regulatory and legal category includes specific policies as well as regulatory and legal structures and frameworks; the environmental aspect includes issues associated with environmental impacts; and the cultural category

includes social dimensions such as community engagement, behaviour change, and public perceptions. Further detailed information can be found in [Appendix A](#).

By drawing upon “transition management, technology diffusion, regulatory analysis, and risk perception” as its theoretical foundations, the framework also has advantages in capturing both technical and non-technical risks on energy transition pathways [68,69]. It has also been widely applied with diverse approaches. As a media analysis, for instance, it has been used to investigate how media representation of emerging energy technologies reflects and informs general acceptance of them and how these associations evolve over time [13,14] and across space [35,36,70]. For instance, the application of the SPEED framework on smart grid technologies has demonstrated the prominence of risk and economic framing in newspaper articles in British Columbia, Canada, which was aligned with opposition and negative perceptions among local citizens [14]. This result was further supported by a study which also found more negative framing in the media with people more exposed to related smart grid deployment programs [13]. The SPEED frames of a certain technology in its media profiling also suggest the development stage and trend of the technology. A previous study of the SPEED framework application in analysing ES-related newspaper articles in Canada and the UK, for instance, has identified the salience of technical frames (e.g., the increase of grid flexibility and the lack of technical planning and analysis for commercialization) and economic frames (e.g., new job creation and vague market regulations) compared to other SPEED frames; this points to specific national priorities as well as the early-stage development and niche market of ES in these two countries [35,36].

The general applicability of the SPEED framework has concentrated on Western societies, and only very limited literature applies the SPEED framework in the Chinese context. The exceptions have used the framework to construct a risk evaluation index in China’s shale gas and oil refining investment abroad [71,72]. Other studies of the political and institutional context of low-carbon energy technologies in China exist, but they did not utilize the SPEED framework. They examined wind energy development via the process of legislation and policy enactment and administration [73] and large-scale CCS deployment via drawing upon the concept of the ‘Technology Innovation System’ and associated strategic, tactical, and operational activities [74]. Therefore, we went beyond the current geographical scope of SPEED framework studies and proposed Hypothesis one with the aim of analysing the development trend and socio-political environment of ES in China.

Hypothesis one: Technical frames and economic frames within ES media coverage in China are more salient than other SPEED frames.

2.2.3. Media analysis using the ‘technology hype cycle’

Building upon Down’s ‘issue-attention cycle’, which focuses on social issues [75], Gartner Group’s ‘technology hype cycle’ provides insights into the interactions between cyclical patterns of public interests and expectations towards technology innovations and innovations’ uptake and development in society. It is argued that the general development path a technology takes can be characterized as having five stages: ‘innovation trigger’, ‘peak of inflated expectations’, ‘trough of disillusionment’, ‘slope of enlightenment’, and ‘plateau of productivity’ [76]. An emerging technology is introduced into the society with a growing number of success stories, resulting in rising expectations among the public regarding the technology. Expectations will then fall and attitudes towards the technology will become more mixed when the technology’s corresponding costs or failures of implementation appear. Expectations, however, will rise again once the benefits and broader applicability of the technology are more widely understood. The ‘hype cycle’ has been used in recent discursive analysis studies, including media analysis, to help analyse social technological expectations and expectation dynamics of various emerging energy technologies [77]. For example, the media coverage between 1992 and 2015 illustrated that solar-photovoltaic technology in Germany and Spain both experienced a

hype and disillusionment phase, whereas the two societies have divergent negative expectations in the stage of disillusionment: the Spanish doubted the profitability of the technology while German society was concerned with its negative impact on the overall economy [78].

Existing research using the ‘hype cycle’ in examining media coverage is predominantly confined to Western countries with limited attention to media coverage in China, particularly energy technologies and environmental issues. Based on existing literature, media attention to emerging energy technologies [79] and environmental issues, such as climate change [80,81], air pollution [82,83], and sustainable development [84], can be largely characterized as the cycle of rise-peak-decrease-rise. These ups and downs are associated with ‘trigger events’ (e.g., policy formulation and the occurrence of accidents). More importantly, these ups and downs also correspond with the shifts of media framing. The stage of ‘peak of inflated expectations’ is associated with over-enthusiastic claims or more benefit framing than risk framing, whereas risk framing in media presages a ‘trough of disillusionment’. Therefore, we presented Hypothesis two in order to investigate the socio-political dynamics of ES in China.

Hypothesis two: The trend of national ES media coverage frequencies in China conforms to the general technology hype cycle of rise-peak-decrease-rise.

2.3. Media framing in China

Media analysis of a certain technology or an issue can reveal variations across different media channels and national contexts underlined by different politics. The media in democratic regimes have adopted the role of being the people’s representative, demanding governments’ accountability via monitoring the mood of the nation and contributing to decision-making and agenda setting, in addition to information provision [85]. Western media are mainly run for profit, leading to a priority in attracting audiences’ attention via various framings. In contrast, the mainstream media in China are mainly seen to be the voices of Chinese central government and the Party regarding official policies and political ideology, which then guides the tone of local newspapers [86–88]. For example, China has strong commitment to nuclear energy production with pro-nuclear policies and strategies; accordingly, national media profile nuclear energy as valuable [89,90]. Therefore, we put forward Hypothesis three, following not least of all the Chinese government’s supportive roles towards ES development, as reported in [Section 2.1](#).

Hypothesis three: The positive framing of ES is much more prominent than negative framing in mainstream newspapers in China, and ES is regarded as a beneficial technology rather than a risky one.

The framing process that media present to affect the representation and social construction of issues or technologies thus shapes public perceptions. As ES refers to various technologies with different profiles, we would expect diverse impressions of ES among audiences. In view of media’s role in China, we thus assume that ES technologies and projects that have received much socio-political attention (i.e., increased foci within the policy development agenda) are given more attention in national media coverage (Hypothesis four).

Hypothesis four: Battery technology and remarkable ES-related projects are the most frequently-mentioned ES technologies in mainstream newspapers in China.

The selection of specific stakeholders involved – i.e., whose voices are the news sources – is also part of the framing process, which provides insights into who plays important roles and who has credibility in specific fields. The Chinese mainstream media coverage of nuclear energy mainly involved industrial actors, central government agencies, and experts [90]. Moreover, regarding haze coverage, authorities (government agencies and experts) were more salient than other stakeholders in Chinese mainstream media coverage [82]. Such practices may infer that these particular stakeholders are closely related to the specific energy innovation or environmental issue and are perceived to be the most

credible. However, Chinese media coverage of health issues (e.g., autism [29]) quoted family members and health professionals frequently, which implies that health issues inherently require medicalization and significant involvement of families. Based on the media analysis study of energy technology in China [90], we thus put forward Hypothesis five.

Hypothesis five: The voices of central governments, industrial actors, and experts and academia are more quoted in the two mainstream newspapers in China regarding national ES media coverage than other stakeholders.

3. Methods

This study investigated ES-related news articles using content analysis in two national mainstream newspapers in China – *People's Daily* and *China Daily* – both of which are influential and top circulating newspapers and represent national-level discourse. The introduction of Chinese Economic Form in 1978 brought the market economy into the media sector, resulting in more media agencies with greater financial autonomy and less political involvement, particularly local/regional media agencies. However, state-owned/mainstream media regulated by the government and the Party continue to hold substantial market shares and continue to be widely accepted as reliable sources. *People's Daily* was selected because it is the “most influential and authoritative newspaper in China” and sets the tone for other Chinese newspapers at both national and local levels in terms of the publication of major or controversial issues in China [91]. Its primary goal is to provide policy information and decisions of the Chinese government. In addition to its primary Chinese-language edition, it has editions in other languages such as English and French. *China Daily*, the only state-owned newspaper in China in English, was launched as “a voice of China on the global stage”, and two-thirds of its circulation is distributed overseas [92]. Its main aim is to attract domestic and international high-end (educated, affluent, influential) readers from various fields. Comparisons between these two newspapers are offered in Table 2.

We used the Factiva database, which is a global news database providing a wide range of articles such as newspapers and industrial reports, to retrieve ES-related news articles within the timeframe of 1 January 2017 to 31 December 2019 (three years). The timeframe was chosen due to the release of the *Thirteenth Five-Year Plan for Energy Development* in December 2016 and the *Guiding Opinions on Promoting the Development of ES Technology and Industry* in 2017, which is regarded as the first official ES industrial guidance. Thus, we expect more public

Table 2
Comparisons between *People's Daily* and *China Daily* [91,92].

	<i>People's Daily</i>	<i>China Daily</i>
Global circulation	3 million	0.9 million (0.6 million distributed overseas)
Launch date	June 1948	June 1981
Ownership	The Chinese Communist Party	The Chinese Communist Party; The State Council Information Office
Aim	“To provide policy information and resolutions of the Chinese government and major domestic news and international news releases from China”	“To attract high-end readers from diversified fields, including diplomats, representatives of international organizations and transnational corporations, international media reporters and editors, as well as foreign tourists”
Reputation	“The most influential and authoritative newspaper in China”	“A voice of China on the global stage”
Headquarters and principal editorial office	Beijing, China	Beijing, China
Primary language	Chinese	English

debates over ES technology after 2017 in mainstream newspapers. Note that, within the Factiva database, the ‘Region’ filter was set to ‘China’ and ‘Sources’ was set to ‘China Daily’ mainland edition and ‘People's Daily’ respectively.

Since our study focuses on a wide concept of ES in the context of energy transition, including energy-related and transport-related applications, various terms can be used to describe these applications. We searched for the following terms in the full articles of the two newspapers, thus taking into account previous studies – those ES studies from other countries that used similar methods [35,36] and those ES studies from China [38]:

“energy storage” or “electricity storage” or “power storage” or “pumped hydro” or “thermal storage” or “lithium-ion battery” or “NaS battery” or “lead-acid battery” or “flow battery” or “supercapacitors” (Search terms for *China Daily*)

“储能”或“抽水蓄能”或“熔融盐储能”或“锂离子电池”或“钠硫电池”或“铅蓄电池”或“液流电池”或“超级电容” (Search terms for *People's Daily*)

(“energy storage” or “pumped hydro” or “molten salt heat storage” or “lithium-ion battery” or “NaS battery” or “lead-acid battery” or “flow battery” or “supercapacitors” in Chinese)

The search terms thus included both conceptual terms (e.g., ES, power storage, and electricity storage) and focused terms (e.g., pumped hydro), which represent, respectively, general ES and specific ES technologies/applications. All retrieved articles were reviewed, and duplicates and non-related articles (i.e., ES is mentioned, but not within the context of energy transition – for instance when ES was mentioned in the context of a new robot creation that became a recipient of high-value patents [31 October 2019, *China Daily*]) were removed. All samples were reviewed, coded, and analysed twice by the same researcher to make sure the criteria were consistently applied throughout.

To test our Hypotheses (Sections 2.2 and 2.3), our analysis was based on the following: (1) the types and frequencies of six frames under the SPEED framework mentioning ES benefits and risks (results are summarized in Appendix A). Each sample was coded for both SPEED frames and risk or/and benefit frames, and each can also be categorized by various frames if they are mentioned, e.g., technical benefit, technical risk, and environmental risk framing; (2) the total number of ES-related articles and the number of articles by frame in China over time between 2017 and 2019; (3) the types and frequency of ES technologies/projects involved; and (4) the specific stakeholders involved.

4. Results

A total of 423 articles (*People's Daily* $n = 322$, *China Daily* $n = 101$) were retrieved for the three years and the final sample size for analysis is 156 (*People's Daily* $n = 105$, *China Daily* $n = 51$) after removal based on requirements mentioned above.⁴

4.1. Benefit versus risk framing analysis under the SPEED framework

Overall, technical frames and economic frames, for both benefits and risks, dominated in the full data set, accounting for roughly 84% and 55%, respectively. Fig. 2 provides a breakout for the two newspapers, showing that the technical and economic frames dominated in both cases, which supports Hypothesis one. Moreover, the positive framing of ES was more noticeable than negative framing across the six SPEED frames in the two newspapers, and thus Hypothesis three was also supported.

The technical benefit framing of ES was most frequently mentioned, with roughly 74% of all articles referring to its positive developments,

⁴ The total number of articles published between 2017 and 2019 in *People's Daily* is 78,701 and in *China Daily* is 51,596.

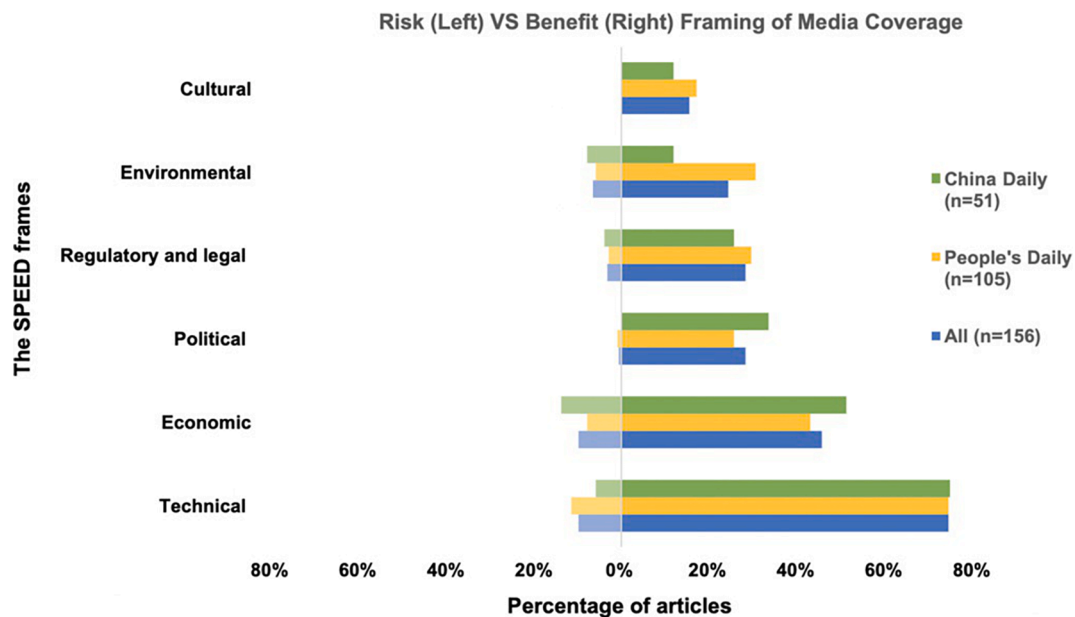


Fig. 2. The SPEED frames of ES media coverage in *People's Daily* and *China Daily* (2017–2019). The percentage of articles including SPEED risk and benefit framing.

such as rapid technological advancements of ES technologies, increasing R&D collaboration, and its supportive role in the energy transition, including grid modernization and renewable energy integration. Nearly one-half of all articles also mentioned the economic benefits of ES, emphasizing its cost savings for different stakeholders across power systems and its beneficial effect on energy and transport industries and economic developments in societies. By contrast, negative statements associated with technical and economic framing were also prevalent, with coverage mentioning the bottlenecks of technological development and potential financial and economic risks. For example, the cost of processing disused vehicle batteries was regarded to be higher than the value of the recyclable materials [17 July 2019, *China Daily*], which thus raises questions about the technological breakthrough status of battery recycling or reusing and challenges the careful cost-benefit analysis of battery second-life management. *People's Daily* recognized more technical risks than economic risks, whereas *China Daily* contained more economic risks than technical risks.

Political, regulatory and legal, and environmental aspects were mentioned with similar frequencies. However, *People's Daily* contained more environmental frames (36% of 105 samples) and *China Daily* covered more political frames (33% of 51 samples). The discussion of ES's political benefits focused on the alignment between ES development and political goals, and stakeholders' cooperation. For example, the State Grid Corporation of China constructed five pumped storage power plants to support national goals to limit coal power for better air quality [9 January 2019, *China Daily*]. Regulatory and legal frames of ES largely contained debates over whether or not there were favourable national policies and regulations related to ES development. As for the environmental frames of ES, roughly one-quarter of all articles recognized ES's beneficial impacts, including its ability to reduce emissions of smoke dust, SO₂, and NO [27 November 2018, *People's Daily*]. Environmental risk framing was more prevalent in the two newspapers, at least compared to three of the other SPEED categories (6% of 156 articles): significant concerns about the impact of disused vehicle batteries in terms of potential resource waste and environmental pollution were mentioned [17 May 2017, *People's Daily*].

There was very limited cultural framing of ES, but there were examples of articles that discussed how ES technologies allowed for positive consumer behaviour changes (e.g., the shift of vehicle purchases from internal combustion engine vehicles to electric vehicles [28 June 2018, *China Daily*]), increasing public engagement, and public service

guarantees (e.g., the provision of energy solutions for households, factories, communities, and industrial areas [16 March 2018, *People's Daily*]). By contrast, our samples did not contain any cultural risk frames of ES, for instance, social inequality issues and public reluctance to accept ES projects.

4.2. Frequency analysis of ES media coverage in China between 2017 and 2019

The total ES coverage is more prominent in *People's Daily* than in *China Daily* (105 articles vs 51 articles). Fig. 3 summarizes the frequency of ES articles by half year between 2017 and 2019, where the number of ES-related articles largely followed a rise-peak-decline-rise trend. Therefore, Hypothesis two was supported. The two newspapers have similar patterns of ups and downs during the three years except for the second half of 2018 when *People's Daily* covered more aspects related to ES than *China Daily*, including ES development as the avenue for local or provincial industrial transformation and upgrading [4 December 2018, *People's Daily*], provincial or local pumped hydro projects [27 November 2018, *People's Daily*], and stakeholder cooperation [7 September 2018, *People's Daily*]. By comparison, articles in *China Daily* mainly focused on battery technology via technical benefit framing, including technological breakthroughs in increasing battery energy density [28 December 2018, *China Daily*] and new battery plant construction [11 December 2018, *China Daily*], and economic benefit framing, such as new business partnerships [20 August 2018, *China Daily*] and the improvement of battery market competitiveness [11 December 2018, *China Daily*]. These differences shed light on the different ES technology emphases between these two newspapers, which will be discussed further in Section 4.3, below.

Trigger events also coincided with the surge of media coverage in 2018, the decline of coverage during the first half of 2019, and the rise again in the second half of 2019. Various ES-related regulations, which were introduced beginning in the middle of 2017 and throughout 2018 (and which were related to the improvement of ES market mechanisms and the administration of disused battery recycling and reuse), were contributors to the surge of public attention. The unprecedented increase of new installed battery projects in 2018, which was shown in Fig. 1, also contributed to the rise of ES coverage. However, the cancellation or stagnation of new ES projects in the first half of 2019 led to the decline of ES coverage at that time. The regulation about



Fig. 3. The frequency of ES articles published in the two newspapers (2017–2019).

transmission and distribution pricing and costs in 2019 (see Table 1) stipulated that power companies cannot incorporate the costs of ES facilities into their expenses of power transmission and distribution, which thus discourages investment in ES projects.

The ES coverage recovered slightly in the second half of 2019, which was mainly attributed to increasing numbers of ES-related articles in *China Daily* at that time. The abolishment of the white list of battery makers in June (see Table 1) enabled a more competitive market with more companies participating in battery manufacturing. Therefore, related business partnerships (Daimler’s truck and bus division and Contemporary Amperex Technology Co Ltd) [20 September 2019, *China Daily*], new research center formation (UL LLC’s first global battery laboratory) [12 August 2019, *China Daily*], and disused battery processing (Manufacturers’ repurposing of disused batteries for storage) [12 August 2019, *China Daily*] received considerable coverage. These shifts of ES coverage suggest that socio-political dynamics and changes have led to the fluctuation of media attention on ES.

We further examined the media framing of ES by SPEED category

over time to unpack the trend of ES coverage frequencies from 2017 to 2019. According to Fig. 4, the percentage of risk framing dramatically falls from the second half of 2017 to that of 2018, whereas it increases during the first half of 2019. The increase was predominantly driven by the increase in the environmental risk framing of ES, which emphasized the pollution risk caused by inappropriate management of retired EV batteries [17 January 2019, *People’s Daily*; 6 May 2019, *China Daily*]. In sum, ES coverage between 2017 and 2019 experienced a general pattern of rise-peak-decline-rise which is associated with trigger events such as policy releases and project construction activities. We also saw a correlation whereby the decrease/increase of the proportion of risk framing occurred alongside an increasing/declining number of articles, although media representation of ES in our study included more positive claims than negative claims across all SPEED categories (Fig. 2) and across time (Fig. 4).

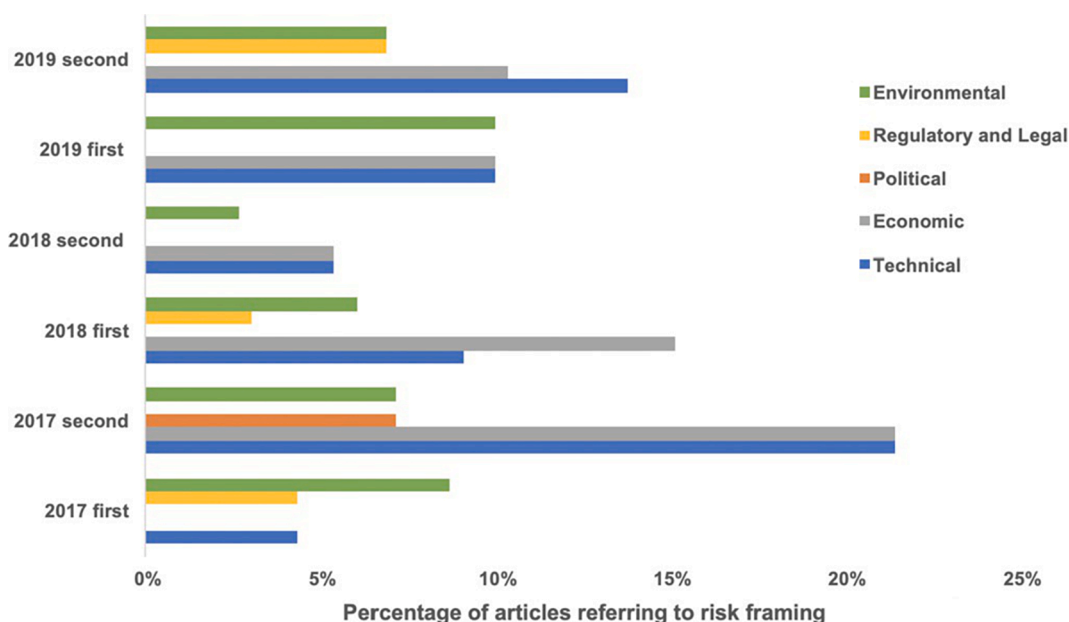


Fig. 4. The percentage of all sampled articles referring to different SPEED risk frames by every half year (2017–2019).

4.3. ES technology mentioned

Various ES technologies were mentioned in the two newspapers between 2017 and 2019 (Table 3): battery technologies were the most frequently mentioned (56% of all articles), followed by general ES (40%). The two newspapers exhibit differences in their respective foci. More articles (43%) in *People's Daily* mentioned ES in a general way with reference to specific ES demonstration projects or ES technology as a whole without mentioning individual technologies, while *China Daily* focused more on battery technologies. The ES projects mentioned in *People's Daily* are mainly located in Qinghai (n = 10), Jiangsu (n = 6), Hebei (n = 5), and Guangdong (n = 4) provinces. However, *China Daily* predominately mentioned battery technology in Jiangsu province (n = 4) with reference to the construction of new vehicle battery factories in the cities of Changzhou [12 August 2019, *China Daily*] and Wuxi [11 September 2018, *China Daily*]. Pumped hydro, despite its predominant position in terms of installed capacity in China's ES market, was not frequently mentioned in Chinese mainstream media.

Additionally, the ES projects mentioned highlight the geographic focus of ES within the policy agenda in China. For example, Qinghai province, with its rich wind and solar resource endowments, has nevertheless experienced critical power curtailment issues. This has thus attracted significant socio-political attention and has encouraged the development of a number of ES pilot projects. The Luneng Haixi ES power station was one example; it was the first ES station in China to apply shared ES auxiliary service technology and market transaction. The project integrated isolated and scattered ES stations and built up market-oriented transactions between ES stations and renewable generation companies. This not only supported the integration of renewable energy to advance grid flexibility/reliability, but it also reduced the cost of the power system and lessened the project's payback period [5 May 2019; 17 April 2019; 9 August 2019, *People's Daily*]. This pilot project also enabled Qinghai province to realize its goal of '15-day green electricity' – the provincial power supply from 9 June 2019 to 24 June 2019 was from clean energy [18 June 2019; 2 July 2019, *People's Daily*]. The Zhangbei landscape storage demonstration project in Hebei province [15 October 2018; 31 October 2018, *People's Daily*], regarded as the world's largest and most comprehensive ES project with wind, solar, ES, and smart transmission integration, was another project that received attention in media coverage. Consequently, Hypothesis four was confirmed.

4.4. Stakeholders involved

The stakeholders that were most often mentioned in ES coverage in the two newspapers – both individually and overall – were industrial actors, including state-owned corporations and private companies (Table 4). By contrast, local/provincial governments were the least mentioned. Central government agencies and experts were ranked the second and the third most frequently mentioned in total samples, which confirms Hypothesis five. Aside from industrial actors, *China Daily* mostly cited expert/academia/association as news sources (n = 22, 43%

Table 3

The frequency and percentage of ES technologies in all articles. Note: ES general includes articles mentioning ES projects/facilities/systems/industry/technology as a whole without specific technologies mentioned.

	Battery	ES general	Pumped hydro	Supercapacitor	Thermal storage
<i>China Daily</i> (n = 51)	34 (67%)	17 (33%)	3(6%)	4(8%)	1(2%)
<i>People's Daily</i> (n = 105)	53 (51%)	45 (43%)	15(14%)	5(5%)	5(5%)
All articles (n = 156)	87 (56%)	62 (40%)	18(12%)	9(6%)	6(4%)

Table 4

The frequency and percentage of news sources (whose words were used/quoted) in all articles.

	Central government	Local government	Expert/Academia/Association	Industry	The public
<i>China Daily</i> (n = 51)	14(28%)	1(2%)	22(43%)	32 (63%)	4(8%)
<i>People's Daily</i> (n = 105)	30(29%)	13(12%)	19(18%)	48 (46%)	15 (14%)
All articles (n = 156)	44(28%)	14(9%)	41(26%)	80 (51%)	19 (12%)

of all articles in *China Daily*) and local governments received the least attention (n = 1, 2% of all articles). Alternatively, *People's Daily* mostly cited – again, apart from industry – governments, both the national level and local level, as news sources (n = 43, 41% of total articles in *People's Daily*).

This analysis further validated the framing analysis – discussed in Section 4.1 – regarding salient ES media discourse in technical and economic frames. The prominent role of industrial voices in ES coverage illustrated that technological development and market/industrial mechanisms of ES may be considered to be the mainstream topics of current ES coverage. The less frequent involvement of public voices in the two newspapers was also consistent with the previously-uncovered minimal coverage of ES cultural framing, which means that public awareness and perception of ES technologies, their engagement with the technologies, and ES's implication on the public have not received as much attention.

5. Discussion

Based on the results presented above, the predominantly positive framing of ES in both of China's main newspapers mirrors ES's perceived beneficial role in sustainable energy transition and provides an optimistic perspective, which further reflects a favourable attitude that the Chinese government holds towards ES development. The techno-economic emphasis on ES implies that economic and technical debates are prevalent within the energy transition dialogue and that central government officials prioritize ES development justified from technical and economic perspectives (e.g., grid modernization, renewable integration, and cost reduction). Additionally, ES media coverage largely exhibits the classic technology hype cycle with varying public interests/attention, which were associated with socio-political changes including policy development and regulatory shifts. The greater media focus on battery technologies and high-profile ES demonstration projects, as well as attention given the voices of industrial actors, central government agencies, and experts, further confirmed the ES framing patterns we found and the particular political orientation that underpins Chinese news media. These results reveal the socio-political complexity and dynamics in which ES is contextualized, which are critical in achieving the goal of a sustainable energy transition in China.

5.1. ES development in China

The media representation of ES in China reflects ES's critical and disruptive roles in sustainable energy development – namely, that public discourse over ES is primarily around technical and economic feasibility, even while other aspects are sometimes considered. This techno-economic emphasis aligns with national energy priorities (e.g., renewable deployment and integration, grid modernization, and smart grids) and other national economic development priorities (e.g., industrial transformation and upgrading). It also underlines the transformative

potential of ES in challenging incumbent energy and transport regimes, including fossil fuel-dominated grid systems [15 October 2018, *People's Daily*] and traditional automotive makers in manufacturing internal combustion engine vehicles [4 January 2018, *People's Daily*]. The positive political framing of ES also connects with national interests in energy security. This finding, however, is inconsistent with CCS deployment in China, which has been found to be misaligned with national development priorities. (CCS at coal-fired power plants, for instance, tends to be costly and serves to increase coal reliance in China [74].) The match of various priorities in ES seems to drive transformation from ES pilot projects towards commercialization or large-scale popularization, enabling public legitimacy and suggesting a promising socio-technical development perspective of ES.

The media discourse also reflects some policy responses that may eventually become barriers in ES adoption and transition in China. The limited reflection on cultural framing and limited participation of public voices give rise to potential uncertainties about the implications of large-scale ES deployment – that is, how the processes in which people interact with ES technologies affect people's perceptions and opinions towards ES, which may in turn facilitate or hinder ES diffusion. Given that, in Canada for instance, media representation of smart grid technologies shifted from more positive to negative as more specific policy programs were implemented [13], there may be lessons for China. Indeed, the acceptance level of local residents to wind power projects in Shandong province in China dramatically fell when challenges became salient (e.g., high electricity costs and the lack of awareness of wind power information) [93]. Thus, given that the role of public- and community-level empowerment and capacity building has been seen as critical in promoting a decarbonized energy transition [94] and, more broadly, in advancing sustainable development [95], all should consider the issue, regardless of their sector or their location.

Additionally, the minimal incorporation of local/provincial governments' voices in ES media discourse raises questions. More specifically, given that the environmental governance system in China largely follows a top-down approach – the national level makes overarching strategies and assigns targets to the sub-levels, with provincial governments implementing the policies and fulfilling the targets – our finding begs the question as to whether there is the risk of local institutional inertia (e.g., inadequate administrative actions), which could hamper ES transition in local areas and thus undermine national ambition. Some studies on the solar energy program for poverty alleviation [96] and wind energy planning and permitting procedures [73] in China have already identified the lack of incentive mechanisms for local stakeholders and standards for planning implementation, thus suggesting the need for a more careful consideration of contested local aspects and more context-specific or flexible standards and regulations. Nonetheless, we also acknowledge that the marginal involvement of local governments could be contributed to the national roles, rather than provincial roles, of the *People's Daily* and *China Daily*.

Differences in emphasis across different SPEED frames further reflects ES's emerging role in the energy system and early-stage development in China. The prevalence of technical and economic framings that was found in our study was also found in studies of other emerging energy technologies, including smart grids [13,14,97]. However, technologies that are relatively well-established (e.g., wind turbines [69] and nuclear power [90]) were found to involve more cultural or environmental concerns, including safety and health issues and pollution. Our study reveals a similar trend – that is, the environmental risk framing of ES is mainly attributed to battery technologies, which are relatively more mature among the various ES technologies.

Additionally, as energy innovations have been introduced, media

attention on ES has followed a general technology hype cycle in China with a distinct peak in the second half of 2018, which is supported by socio-political dynamics and shifts. The national media coverage of ES aligns with related energy policy and regulatory developments, project planning and construction activities, business partnerships, and R&D collaboration, all of which are possible contributors to heightened public interests or expectations on ES. More importantly, the cyclical trend of media reporting also coincides with its framing. Our finding indicates that the decrease of ES media coverage in the first half of 2019 is associated with the increasing proportion of environmental risk framing in batteries, further implying that electric vehicles' deployment in China has already reached a stage for battery retiring and requiring careful consideration of battery management.

We acknowledge that the timeframe of our study is relatively short. However, our observation is based on national media coverage, which generally prioritizes a "bigger picture" with long-term expectations, instead of regional or local media coverage, which primarily focuses on specific events in a short-term context [35,90]. Consequently, our findings could still provide insights on the general trend of ES technology development in China so as to help policy makers make interventions at appropriate times in order to reduce ES development barriers for further low-carbon transition (e.g., the standard setting and policy formulation of battery management to reduce environmental risks).

5.2. Implications for the SPEED framework and media analysis

Given the SPEED framework's integrated perspectives for describing the socio-political environment of energy technologies in Western countries, our study applied it in order to understand ES development in a Chinese setting. The SPEED framework serves as a useful conceptual framework to investigate both technical and non-technical benefits and risks of ES transition in China. It not only generates an overview of the ES issue in China, but it also provides insights into how audiences are informed or primed on this issue, which we considered in Section 5.1, above. Moreover, we suggest that public discourse in media coverage of various energy technologies generally follows particular patterns: technical and economic frames dominate in the media discourse of emerging energy technologies, while cultural and environmental frames are more prevalent in the media discourse of relatively mature energy technologies.

However, we also encountered some challenges in the application of the SPEED framework which could be worthy of further investigation. For one, political framing and regulatory and legal framing are closely related in the Chinese context. Consider, for instance, the following: the State Grid Corporation of China constructs pumped storage power plants to support the national ambition to move away from coal power in order to combat air pollution [9 January 2019, *China Daily*]. While this was identified as political framing following our protocol, this example could also conceivably be regarded as regulatory and legal framing, because the political goal of coal consumption reduction in China is often accompanied by regulations and policies.

Similar to what previous studies have established [87,89], our study also identifies the government's noteworthy influence on mainstream media framing, providing a useful lens through which Chinese media analysis can be better understood. The hypotheses we propose, following media analysis studies either in Western countries or in China, collectively serve as a comprehensive and integrated way of investigating and understanding the media discourse of emerging energy technologies within the context of energy system change in China. Future research can be conducted in order to test further these

hypotheses in the energy transition – not only within China, but indeed within any jurisdiction that has similar centrally-led energy markets and governance systems.

5.3. The comparison between countries and newspapers

Through the comparison of SPEED frames in our ES study and other ES studies in Canada and the UK, our findings further shed light on the socio-political forces of ES development in China. The overall benefit-to-risk framing ratio considering all frames is 7.3 in China and is much higher than that in Canada and the UK, i.e., benefit framed articles are roughly seven times higher than risk framed ones (see Table 5). Specifically, ES media coverage in China has significantly higher benefit-to-risk ratios in political and regulatory perspectives and moderately higher ratios in technical and economic aspects than those in Canada and in the UK. Nevertheless, the ratio in the environmental perspective is similar to that in Canada but is much lower than that in the UK. The notably higher ratios in political and regulatory and legal perspectives further highlight that ES development in China is largely facilitated by its integration with political strategies/goals and relevant favourable regulations and policies. It is not surprising since China has a relatively unified governance system and Canada and UK have fragmented governance with more emphasis on market-based policy instruments. Understanding the similarities and disparities of ES media discourse in China and other countries would help illuminate the unique socio-political contexts of ES in different jurisdictions.

Moreover, we note additional key findings about the comparison of the two mainstream newspapers in our study. The different emphases of the two newspapers represent their specific purposes and characteristics. *People’s Daily’s* goal of disseminating policies and resolutions of Chinese governments explains the abundant use of national or local governments’ voices and the focus on wide-ranging and general topics. *China Daily’s* aim of attracting high-end readers from diverse fields and global audiences justifies its reliance on the claims of experts, academia, and associations with issue-specific knowledge. The positioning of certain voices as dominant is also closely associated with the desired tone of the presentation; journalists or the press emphasize particular voices in order to create desired narratives and to influence the ways in which media consumers conceptualize or evaluate issues [98,99]. The dominant role of government officials in *People’s Daily* and of experts’ voice in *China Daily* is consistent with their focus on the benefit framing of ES, playing vital roles in enhancing public understanding and perceived credibility.

Table 5
SPEED frame benefit-to-risk ratios in studies from China, Canada, and the UK. Note: Cultural risk framing is none, so the value is NA.

The SPEED frames	Benefit/Risk-China (2017–2019) ^a	Benefit/Risk-Canada (2016–2017) [36]	Benefit/Risk-UK (2016–2017) [36]
Technical	7.7:1	3.0:1	6.0:1
Economic	4.7:1	2.3:1	4.0:1
Political	44.0:1	1.4:1	2.0:1
Regulatory and legal	8.8:1	0.0:1	0.9:1
Environmental	3.8:1	3.0:1	25.0:1
Cultural	NA	5.0:1	20.0:1
Total	7.3:1	3.0:1	4.0:1

^a The data in this column are derived from Fig. 2 in Section 4.1 where the benefit-to-risk ratio for each SPEED frame equals the percentage of articles including benefit framing divided by the percentage of articles including risk framing.

6. Conclusion

ES has become a vital technology for advancing an energy transition to a low-carbon future and for securing reliable energy systems globally. In China, despite its great technological advancements, the development of ES is still in the domain of ‘niches’ (i.e., early-stage development) and far away from the domain of ‘regimes’ (i.e., large-scale popularisation with established market and institutional contexts). This gap highlights the unique social-political context for ES development in China, which has not received much academic attention. We thus analyse the media discourse of two mainstream newspapers on ES technology in China based on an integrated approach to identify socio-political opportunities and barriers for ES deployment. We found that (1) Chinese ES systems are supported by socio-political complexity with the involvement of different aspects (SPEED frames), evolving public expectations, and varied technologies and stakeholders; (2) the prevailing benefit framing of ES across SPEED frames represents the alignments between ES development and other fundamental national interests, suggesting an optimistic perspective of ES development in a low-carbon energy transition; (3) the comparison of benefit-to-risk ratios across SPEED frames in China, Canada, and the UK further highlights the significant role of political and regulatory and legal aspects in facilitating ES diffusion; and (4) less media coverage of lay public’s and local governments’ voices also suggests some uncertainties surrounding how people contextualize and perceive ES and the impact of the implementation of national strategies on local communities.

Our findings also present pathways for future research areas and provide useful policy directions. On the one hand, our study can be seen as one of the first studies to use the SPEED framework in China. Like previous energy studies carried out in Western settings, our study also confirms its effectiveness for understanding how different socio-political drivers interact with one another in influencing an energy transition. Nonetheless, the unique domestic environment in China (e.g., the interrelation between political and regulatory contexts) requires a nuanced application of the SPEED framework. On the other hand, ES representation is related to the broader socio-political context, which itself varies from jurisdiction to jurisdiction. Future comparative studies on media analysis of ES technology – whether within or outside China – could continue to shed important light on our understanding of ES deployment in societies. We also acknowledge that there are other perspectives in investigating ES deployment including the perspectives of market/community/the public, and our study can thus be complemented with other perspectives in future studies for fuller understanding. Our study provides useful directions for both industrial actors and governments in their efforts to better understand energy innovations’ core socio-political dynamics and trends. By using media analyses and understanding media discourse, these stakeholders can better participate in society-wide conversations and thus advance social acceptance and public support of energy innovations in future developments.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

The SPEED framework applied to ES newspaper coverage in China (2017–2019) with examples.

The SPEED frames	Benefit	Risk
Technical	<ol style="list-style-type: none"> 1. Applicable to other areas. e.g., The company built an ES station of 45 kWh power capacity with disused vehicle batteries in Nanjing Jiangbei New District. [30 December 2019, <i>People's Daily</i>] 2. Support renewable energy integration (a solution for wind or solar curtailment and balance intermittence). e.g., The project enables 24-hour constant electricity supply and can be seen as a solution for wind and solar curtailment. [23 December 2019, <i>People's Daily</i>] 3. Improve grid flexibility and reliability (frequency response and peak shaving). e.g., The pumped hydro storage project in Hainan is mainly responsible for grid frequency response and emergency back-up. [1 August 2018, <i>People's Daily</i>] 4. As a crucial element of energy system modernization (smart grid and energy internet). e.g., The project directly links wind power, solar power, and pumped hydro storage with power consumption centers in the formation of energy internet. [28 February 2018, <i>People's Daily</i>] 5. Technological advancements and breakthroughs. e.g., There are many technology breakthroughs in vehicle batteries; related battery property indicators have steadily improved in China. [21 July 2018, <i>People's Daily</i>] 6. R&D collaboration. e.g., The Ningbo Institute of Materials Technology and Engineering, together with leading enterprises in the domestic graphene industry and other companies, founded an innovation center in 2017. [28 December 2018, <i>China Daily</i>] 	<ol style="list-style-type: none"> 1. Concern about technological performance. e.g., Current vehicle batteries cannot meet long-distance driving need in terms of safety and energy density. [4 January 2018, <i>People's Daily</i>] 2. Technical bottlenecks or constraints. e.g., Large-scale ES technologies have bottlenecks. [28 November 2019, <i>People's Daily</i>]
Economic	<ol style="list-style-type: none"> 1. Strengthen economy and foster industrial growth. e.g., A sufficient ES and supply ability is critical to ensure energy demand security and support economic development. [14 October 2019, <i>China Daily</i>] 2. Cost savings at end-user levels (electricity bills, vehicle purchase prices, etc.). e.g., The State Grid Jiangsu Electric Power Co., Ltd reused retired vehicle batteries as power storage, complemented with time-of-use rates. In this way, the company can help consumers save massive electricity costs [30 December 2019, <i>People's Daily</i>] 3. Cost savings across the grid system (utilities, manufacturers, etc.). e.g., Pumped hydro storage projects can improve overall system economy. [27 November 2018, <i>People's Daily</i>] 4. Help the formation of a new industry or supply chain (industrial transformation and upgrading). e.g., Qinghai has constructed a new clean energy industry with the dominance of "solar + storage". It has formed complete solar PV, solar thermal, and ES industrial chains and has built a crucial national renewable industrial base. [23 December 2019, <i>People's Daily</i>] 5. Create market opportunities or economic benefits to companies (business transformation, increase market competitiveness, profit growth, etc.). e.g., GCL is currently experiencing business transition from electricity suppliers to utilities with more business services related to batteries including battery manufacturing, hierarchical-recycling, and application. [9 March 2017, <i>People's Daily</i>]. 6. Attract new business partnerships and investment opportunities (between local, national, international stakeholders). e.g., Tianneng Battery Group Co Ltd has invested 3 billion RMB to set up a new industrial park for EV battery recycling. [6 May 2019, <i>China Daily</i>] 	<ol style="list-style-type: none"> 1. High costs outweigh benefits (cost ineffectiveness). e.g., The costs of processing some types of battery are higher than the value of the recycled materials. Therefore, extraction technologies sometimes are cost inefficient. [17 July 2019, <i>China Daily</i>] 2. Create new costs or risks to actors within and beyond energy systems (fossil fuel enterprises, disruption to automotive industry, or ES supply chains). e.g., The high dependence on imported battery raw materials and their rising prices have led to surging production costs for domestic manufacturers in recent years. [8 January 2019, <i>China Daily</i>] 3. Increase economic and financial risks. e.g., Over 70 lithium-ion battery manufacturers and ancillary businesses had gone bankrupt between 2015 and 2018 in Sichuan, Shandong, Guangdong, and Henan provinces. [12 March 2018, <i>China Daily</i>] 4. The lack of market mechanisms (cooperation mechanism between businesses, commercialized recycling and reusing mechanism, etc.). e.g., Effective cooperation mechanisms are inadequate between vehicle manufacturers, battery manufacturers, and battery comprehensive utilization companies. [29 June 2018, <i>People's Daily</i>]
Political	<ol style="list-style-type: none"> 1. Positive political ramifications (strengthen energy security, energy independence, regional or national identity/reputation). e.g., A sufficient ES and supply are regarded important to guarantee energy demand security and support economic development. [31 July 2019, <i>China Daily</i>] 2. Align with provincial or national strategic or political goals (energy production and consumption reform, the development of new energy vehicle industry, innovative development, and "Belt and Road Initiatives"). e.g., The State Grid Corporation of China's construction of five pumped storage power plants came amid the national determination to move away from coal power to combat air pollution. [9 January 2019, <i>China Daily</i>] 3. Coalition formation and cooperation between different stakeholders. e.g., Jiangsu province formally established a vehicle battery recycling industrial alliance. [30 December 2019, <i>People's Daily</i>] 	<p>Misalign with/fail to achieve national strategic or political goals. e.g., The current development level of fuel cell vehicles is inconsistent with the Chinese new energy vehicle strategy, namely, fuel cell vehicles play similarly crucial roles in new energy vehicles with EVs and hybrid vehicles. [26 July 2017, <i>People's Daily</i>]</p>
Regulatory and Legal	<ol style="list-style-type: none"> 1. Favourable or supporting national policies and regulations (guidelines, standards, plans, requirements, etc.). e.g., Experts argued that the outlook for lithium battery firms in China would be turning positive due to tariff cuts on raw materials in the announcement by the Ministry of Finance in 2018. [8 January 2019, <i>China Daily</i>] 2. Complement existing regulatory frameworks. e.g., Boosting the construction of pumped hydro stations and ES projects is one of the plans in the report of the 19th National Congress of the Communist Party of China for a clean, low-carbon, safe, and efficient energy system. [1 April 2018, <i>People's Daily</i>] 	<p>Inadequate or lacking favourable/supportive policies, regulations, or standards. e.g., Financial/tax incentive policies of reusing and recycling disused vehicle batteries are inadequate. [29 June 2018, <i>People's Daily</i>]</p>

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The SPEED frames	Benefit	Risk
Environmental	<ol style="list-style-type: none"> 1. Support climate change adaptation and mitigation (reduce GHG emissions and energy consumption and encourage fossil fuel phase-out). e.g., The demonstration project in Zhangjiakou has already been in operation since December 2011. The total electricity supply during the process is equivalent to nearly 2.43 million tons of standard coal saving and CO₂ emission reduction of nearly 5.93 million tons. [4 December 2019, <i>People's Daily</i>] 2. Reduce solid waste (sustainable life cycle with recycling and reusing) and air/water pollution. e.g., It is estimated that Jurong pumped hydro storage power project can reduce emissions of smoke dust by 134,000 tons, SO₂ by 500 tons, and NO by 5,000 tons. [27 November 2018, <i>People's Daily</i>] 	<p>Shift risks to new environmental areas (environmental pollution and resource waste)</p> <p>e.g., Disused vehicle batteries will cause severe environmental pollution if these batteries go to illegal channels or are not appropriately managed. [17 January 2019, <i>People's Daily</i>]</p>
Cultural	<ol style="list-style-type: none"> 1. Allow for positive energy consumer behaviour change (vehicle purchase shift, from consumers to prosumers, demand management, etc.). e.g., Tesla and BYD don't just sell cars, but also sell additional storage units and solar panels, which enables motorists to become "prosumers" of their own fuels. [15 February 2017, <i>China Daily</i>] 2. Strengthen public engagement and pride (participate in ES projects and become global leading projects). e.g., The success of Jurong pumped hydro storage power station is inseparable from the spirit of model workers and craftsmen. [27 November 2018, <i>People's Daily</i>] 3. Guarantee affordable electricity access, reliable electricity supply, or meet the demand of daily commute (remote communities, islands, households, factories, industrial areas). e.g., The involvement of BYD in solar-photovoltaic ES projects in the Middle East will help the region achieve affordable solar power generation, efficient ES, and electric public transportation. [18 January 2017, <i>China Daily</i>] 	None

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