

Read all about it! Comparing media discourse on energy storage in Canada and the United Kingdom in a transition era

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0 Abstract

Energy storage (ES), both grid-scale and behind-the-meter, will depend largely upon domestic acceptance of the technology in the public sphere. Recognizing the role that media play in this socio-technical process, we compare national news discourse on ES in Canada and the United Kingdom in an energy transition context. We combine the Socio-Political Evaluation of Energy Deployment (SPEED) framework with content analysis methods to evaluate 494 ES articles drawn from top-circulating national newspapers between 2008 and 2017. Comparing benefit/risk framing, narrative use, valence, and other reporting patterns, we consider how cross-national variations in media discourse reflect unique domestic contexts and priorities for ES adoption. We then examine how these discursive trends may drive or hinder ES adoption in the two countries and assess the broader role of news media in energy system change. We find that the case of ES demonstrates: (1) how energy innovations associated with socio-technical sustainability transitions are receiving increasing attention in national media outlets; (2) that techno-optimism is important for energy system change; and (3) that domestic contexts are critical for understanding media coverage of such novel technologies. These findings help to inform our understanding of public perceptions and adoption of ES in both countries, and thus support future research and public communication around ES as an energy transition technology.

1 Introduction

Growing global climate and energy security pressures call for more ambitious deployment of low-carbon energy technologies worldwide. By supporting decarbonization and energy security mandates, energy storage (ES) technology can support the transition to cleaner, more reliable, and cost-effective energy systems [1,2].

In Canada and the United Kingdom (UK), both grid-scale and behind-the-meter ES technologies are increasingly used to provide grid optimization and power reliability benefits, support end-use sector electrification, and reduce reliance on fossil fuel generation [3,4,5,6]. Through both their domestic and joint collaborative initiatives such as *the Canada-UK Partnership on Clean Growth and Climate Change* and *Power Forward Challenge* [7,8], the two countries are investing in a global ES market that is expected to grow from 12 gigawatt-hour (GWh) in 2018 to 158 GWh by 2024 [8,9,10]. However, despite progress to date, technical advancements in ES within these countries appear to be outpacing the socio-political conditions required to support system-level integration of storage applications [7,11]. From a socio-technical transitions perspective [12,13], this lag between technological innovation and technology diffusion can be a result of various interrelated yet underestimated social factors that inform energy system change [14].

Like most major energy innovations, ES adoption will be driven largely by domestic support at varying structural, institutional, and socio-political levels that currently uphold incumbent, carbon ‘locked-in’ energy regimes [15,16]. Stakeholder acceptance of ES will hinge upon how well the technology is perceived to align with domestic priorities, socio-political contexts, and social values related to energy system change [16,17]. As society’s agenda-setters and indicators of societal change, news media play a key role in this socio-technical process [18,19]. The influence of media reporting on new technologies is now well-documented [20,21,22,23]. Still, little is currently known about how these dynamics are unfolding in the case of ES technology at a national level [7,11]. The observed lack of attention to ES in energy social science is problematic, particularly given the technology’s ‘transformative potential’ [1,6] and the influence that publics, through their engagement with unfamiliar technologies, can have on the fate of energy innovation and transformation [24,25,26,27,28]. Media analysis can help to address this gap by revealing how unique socio-political factors, articulated in public discourse [29], may both reflect and influence ES uptake in two evolving national energy systems.

In this paper, we compare national-level media discourse on ES in Canada and the UK, in order to better understand emerging socio-political perceptions of the technology in two jurisdictions that are currently undergoing energy system change. The guiding research question is: *How does national media reporting on ES compare between Canada and the UK in an energy transition context?* To answer this question, we pair the Socio-Political Evaluation of Energy Deployment (SPEED) framework [21,28] with various content analysis methods, to compare media reporting on ES in

top-circulating national newspapers between 2008 and 2017. In doing so, we contribute a new comparative case study on ES in efforts to inform public communication and implementation strategies, while unveiling the often-overlooked social influences affecting energy system change.

2 Background

2.1 Energy innovation, media discourse, and energy transitions

We use ‘energy storage’ broadly to refer to the suite of both grid-scale (e.g., compressed-air, pumped hydro storage) and on-site customer-facing (behind-the-meter) applications (e.g., home batteries), which can be used for storing and recovering energy for later use [1,2]. By providing power system benefits (e.g., voltage support, load management) [1], such technologies can optimize and stabilize power grids fed by intermittent energy sources, in turn supporting the penetration of renewable and distributed energy resources while meeting customer needs in an evolving energy era [9,10]. However, current research, development and demonstration (RD&D) activities are advancing the technology faster than existing policy landscapes and actors can ‘contain it’ [6,30]. As a result, ES is often referred to as a ‘disruptive’ energy technology that inherently contradicts existing centralized, fossil fuel-based energy systems, even in market-leading countries like Canada and the UK [7]. Addressing this misalignment to advance ES at a national level thus requires closer attention to the non-technical foundations of energy transition processes [31,32,33].

In response to Devine-Wright et al.’s [11] research agenda for ES and calls for more comparative social analyses on energy technology deployment [31,33,34,35], we draw upon socio-technical transitions [12,13,16,31,32], social acceptance [27,33], and social representation literatures [36,37,38] using comparative media content analysis. As venues for public knowledge and meaning making [39], media can help shape energy transitions by: (1) creating awareness of landscape-level energy system trends (e.g., prosumerism, grid optimization); (2) influencing and representing public and policy agendas for technologies at the regime level (e.g., support for energy policies); and (3) motivating or discouraging key actors to adopt niche-innovations (e.g., at the bulk or end-user levels) [40,41,42]. These effects have been well observed for energy technologies around the world, including carbon capture and storage (CCS) in the Netherlands [44], geothermal technology in Australia [45], biofuels in the United States [46,47], and smart grid in Canada [22]. In recent years, a growing focus on renewables in media research has examined stakeholder perceptions of energy innovation and associated matters (e.g., financing, siting, market trends), the level of importance that

actors assign to such innovations, and their perceived feasibility for large-scale deployment [22,26,48]. Such efforts have enriched our understanding of the complex and often underestimated social contexts surrounding energy innovation and change.

Applied with perspectives from sociology and social psychology, media studies provide insight on how system actors and socio-political processes are interacting with energy innovations to affect socio-technical change [11,40,49]. Levidow & Upham [49] link the foundational 'Multi-Level Perspective' (MLP) transitions framework [50] for instance with 'social representations theory' [37] to demonstrate how socio-political agents 'anchor' novel technologies by making them familiar through cognitive framings which either accommodate or challenge energy regime rules. Here, 'social representations theory' is concerned with 'how people collectively make sense of socially relevant issues' [51]. The framework is thus suitable for examining media reporting trends and public discourses which shape broader debates around new energy topics [52,53,54]. While 'discourse' is similarly understood as 'a shared way of apprehending the world' [55; p.2], 'social representations' such as 'frames' and 'narratives' represent the units of interpretation that guide individuals 'to locate, perceive, identify and label' specific issues and events [38, p.21]. 'Narratives' can be further understood as 'storylines' for constructing meaning [56] and have been more recently adopted in science and technology studies to crystallize arguments concerning energy transformations [52]. Another lens used in more policy-focused energy research is 'valence' analysis, which examines the emotional appeal (i.e., positive, negative, neutral) of a topic that makes it attractive or palpable for implementation [57].

These various discursive approaches have advanced debates in energy transitions literature by demonstrating how socio-political contexts and processes can both support and hinder socio-technical change [58]. Large oil and gas players, for example, have been known to exploit CCS technology by leveraging climate change frames in efforts to sustain fossil fuel-based economies [59,60]. Others have applied discourse analysis to explore how innovations are 'domesticated' (i.e., contextualised) in public domains, reinforcing that media can inform transition processes, such as consumer adoption and policy change, by generating nationally appealing storylines for new technologies [61,62,63]. More recent attention on technology 'hypes' [64] examines ways in which news media perpetuate cyclical patterns of public interest around innovations that can influence their uptake in society [64,65]. A Dutch study recently observed how blockchain was shaped by media discourse into an

overextending, mutable 'hyperobject' that ultimately drove the innovation beyond the 'reach of intellectual and practical grasp' after its hype in 2016 [67].

Yet, much of this literature remains limited to sub-national and single-case studies that rely on one or few methodologies. The globalization of clean energy innovation, media's role in setting this agenda [18,19], and cross-national differences in journalistic practices [68] present a strong case for more comparative media research in energy social science [40]. Here, we offer a new cross-national case study that applies various discursive approaches and mixed methods to assess social representations of ES in two countries with energy transition agendas. ES is fitting for this integrated approach, given its potential to alleviate national energy challenges in an era of rising electricity costs, aging infrastructure, and growing climate imperatives [1,2,69] Still, apart from some emerging efforts [29, 69,70,71], little social scientific attention has been given to ES, particularly in energy media studies [72]. We initially set out to address this gap in an earlier contribution by comparing provincial-level ES media representations in Canada. Our pilot study found regional-level variations that unveiled competing energy development priorities in the country between 2007-2017 [29]. Here, we intend to build upon our early work and similar research on media framing of smart grid innovation [22,73] for more international comparative insights on the potential of ES in two public spheres (i.e., where public discourse and social learning takes place) [75]. While we understand that news discourse is not a direct proxy for public perception, we argue for its capacity to inform technology and policy change for next-generation energy systems [74]. Further, as ES technologies mature beyond their current niche spaces, a greater understanding of this interplay in public discourse will help to support public communication and development strategies for ES in Canada, the UK, and similar emerging markets.

2.2 The *SPEED* framework

We apply Stephen et al.'s [21] *SPEED* framework as it is a well-established tool for comprehensive media analysis on emerging energy technologies. Based on Luhmann's [76] theory of ecological communication, the framework helps to systematically capture and compare varying interrelated factors associated with energy technology deployment across six dimensions: cultural, economic, environmental, political, regulatory and legal, and technical, using an intuitive benefit-vs-risk matrix [21,28]. The *SPEED* approach has become a preferred framework for media framing research as it moves beyond typical techno-economic analyses in energy policy

research [72,77] to illustrate the role that socio-political factors (e.g., political will, social values) play in shaping public acceptance and technology adoption. The framework is most often applied in content analysis [22,78,79] to assess stakeholder benefit and risk perceptions of new technologies, as well as the unique contexts into and by which innovations are being deployed and informed. For example, SPEED studies on large-scale wind energy deployments have effectively demonstrated how perceived risks of human health and safety, aesthetics, and community impact (i.e., articulated through cultural risk framing) have influenced policy and siting decisions in the United States [78,80].

SPEED is often preferred over other agency-based frameworks, as those emphasizing individual behaviour often focus too much on individualistic efforts (e.g., NIMBYism) [54] and fail to acknowledge the systemic complexity that the SPEED approach uncovers. There are now over a dozen published SPEED assessments that showcase the complex, interrelated factors informing benefit/risk perceptions of emerging technologies [21,28, 78,79]. Few, however, have applied SPEED to early 'disruptive' niche-innovations, and even fewer (i.e., with the exception of Mallett et al.'s [73] Canada-US smart grid comparison) have done so at the international scale. This has invited critique that existing energy social acceptance literature still overlooks collective public engagement with new technologies across 'multi-level perspectives' and jurisdictions. We thus join SPEED researchers in encouraging more comparative energy technology analyses to support appropriate policy solutions that proactively consider public concerns and understanding of energy system change.

Here, we use SPEED as both a conceptual and a methodological model to compare ES media representations in Canada and the UK. We build upon our original qualitative media study on ES [29] with statistical measures and best practices for cross-national comparative content analysis [81]. We also take an integrated approach by combining SPEED with issue salience, narrative, and valence analyses to deliver a more comprehensive discourse assessment. In doing so, we hope to: (1) strengthen our understanding of socio-political processes underlying energy system change; (2) help advance the ES social-scientific research agenda with a comparative international focus; and (3) encourage more transparent and effective public communication around ES as part of national energy sustainability agendas.

3 Methodology

3.1 Research design and case study profiles

This study compares Canada and the UK given their similar energy transition priorities (e.g., grid decarbonization, decentralization, modernization), yet unique barriers (e.g., influence of Canada’s oil economy and the UK’s public distrust in energy developers), as well as their cross-national partnerships (e.g., \$20 million Canada-UK transatlantic smart energy challenge) that have advanced ES activities [8, 29]. We also leverage their different geographic and energy contexts, such as population size and energy profiles, as well as their unique drivers and opportunities for ES, in order to contribute new comparative insights to SPEED literature. **Table 1**¹ below further summarizes the context and rationale for our assessment.

	Canada	UK
General		
Population (2017)	37 million	66 million
Surface area	9,984,670 km ²	243,610 km ²
Energy context		
Electricity generation profile by source (2016)	59% hydro; 15% nuclear; 10% gas/oil/others; 9% coal; 7% non-hydro renewables	42% gas; 24% renewables; 21% nuclear; 9% coal; 3% oil and others
World renewable energy production ranking (2017)	Ranked 4 th (418,679 GWh)	Ranked 14 th (87,083 GWh)
CO _{2e} tonnes per capita (2016)	18.62	5.59
Electricity market structure	Under provincial jurisdiction; monopoly (e.g., Quebec), semi-liberalized (e.g., Ontario) and liberalized markets (e.g., Alberta)	Liberalized market operated by Office of Gas and Electricity Markets (Ofgem); market dominated by “The Big Six” energy companies
Price of residential electricity (2018) (USD per kWh)	0.06-0.11 (varies by province)	Approximately 0.22
ES context		
Drivers and opportunities	Grid optimization, distributed generation, and system planning; regulation and policy changes; government funding; declining costs; technology improvements; new revenue	Grid modernization and energy flexibility; energy security and national independence priorities; timely electricity market reforms; investment in diverse and distributed energy resources;

¹ Table information reflects contexts and data available during the qualitative study period (2016-2017).

	streams; decarbonization; renewable energy and electric vehicle opportunities	push for customer BTM applications; energy innovation programs
Risks and challenges	Regulatory and financing challenges; stakeholder acceptance; technical and geological constraints; political and economic influence of oil industry; uncertain commitment to climate change mitigation; pushback from traditional utility stakeholders	Historical reliance and commitment to gas plants; unclear market rules and policy signals; asset classification and financing uncertainties; supply chain risks; political contention regarding energy development and uncertainty in EU (e.g., Brexit); lacking public trust in energy developers
Media context		
General	Liberal media-political model; newspaper market (98 publications in 2016) primarily owned by one company; few 'national' newspapers; challenges with declining revenue streams, market convergence, foreign control of press, and declines in print media	Generally liberal media-political model with one of the most right-leaning media orientations in EU; significant marker of UK culture and history; diverse newspaper market (over 1,000 newspapers with 15 national dailies divided into broadsheet quality press and tabloids)

Table 1. Comparing Canada and UK energy and media contexts [83,84,85,86,87,88,89,90,91]

3.3 Methods

We examined ES news articles published from 2008 to 2017 in each country's top nationally circulating newspapers (print and online). Sample sizes and time frames were compared to similar studies [29,92,93,94] and selected based on their suitability for the chosen analytical methods. As Canada only has two nationals (*The Globe and Mail* and *The National Post*), three regional newspapers (*The Toronto Star*, *The Vancouver Sun*, and *The Montreal Gazette*) were selected based on circulation and geographic diversity [97]. In the UK, editorial stances and newspaper ownership are more diverse, and were thus selected on the account of circulation and 'quality of press.' Sampled UK newspapers were *The Daily Telegraph*, *The Times*, *The Independent*,² *The Financial Times*, and *The Guardian*. These sources were selected as they represent quality ('elite') national-level discourse, commonly report on energy issues, possess large readerships, and are known for their high agenda-setting impact [98,99]. We aimed for a diverse mix of editorial stances and political leanings in the full sample. Circulation data for both newspaper sets are comparable given each country's

² The Independent transitioned to digital-only format after 2016.

population size. Information on each publication is summarized in **Table 2.**³

We recognize that media messages widely vary by source and in turn reach and influence different audiences in ways that may have broader implications for social perceptions of covered topics like ES. It is possible that reproducing our analysis using non-traditional (i.e., social) media sources or different publications could elicit different results from what we describe here. We also recognize that our efforts to select more nationally representative sources may have excluded underrepresented and extremist perspectives (i.e., in ‘far left’ and ‘far right’ publications) – a trade-off outweighed by our focus on media perceptions of the general populous. Overall, we do not view these factors to be major limitations to the study, as national newspapers continue to be critical sites for engagement among both laypersons and decision-makers, and serve as key information sources for other sources, such as social platforms (e.g., Facebook, Twitter) reporting on scientific developments [41]. In an era of ‘fake news,’ newspapers still represent one of the most trusted news sources, which influence democratic processes, particularly on environmental issues [94,95].

Publication	Average daily newspaper circulation (digital and print combined)	Notes	Ownership	Editorial stance
Canada				
<i>The Globe and Mail</i>	336,487	Daily national broadsheet newspaper; Canada’s most widely read newspaper on weekdays and Saturdays	Globe and Mail Inc.	Right-centre
<i>The National Post</i>	186,108	Daily national broadsheet newspaper	Post Media Network/Sun Media	Right-centre
<i>The Toronto Star</i>	318,763	Daily regional broadsheet newspaper; Canada’s highest-circulated newspaper in overall weekly circulation; based in Toronto, Ontario	Torstar Corp	Left-centre
<i>The Vancouver Sun</i>	136,787	Daily regional broadsheet newspaper based in Vancouver, British Columbia	Post Media Network/Sun Media	Left-centre

³ Circulation numbers reflect 2015 data provided by News Media Canada. News focus and editorial stances based on newspaper website information and *Media Bias/Fact Check* <https://mediabiasfactcheck.com> as of August 2017.

<i>The Montreal Gazette</i> ⁴	116,446	Daily regional broadsheet newspaper based in Montreal, Quebec	Post Media Network/Sun Media	Left-centre
United Kingdom				
<i>The Daily Telegraph</i>	477,900	Daily national broadsheet newspaper	The Barclay Brothers' Press Holdings	Right-centre
<i>The Times</i>	430,000	Daily national broadsheet newspaper based in London, UK	News UK (News Corp)	Right-centre
<i>The Independent (i)</i>	267,900	Daily national broadsheet newspaper	Johnston Press	Left-centre
<i>The Financial Times</i>	186,300	Daily international broadsheet newspaper based in London, UK; known for reporting on national UK issues	Nikkei Inc.	Right-centre
<i>The Guardian</i>	149,400	Daily national broadsheet newspaper	Scott Trust Limited's Guardian Media Group.	Left-centre

Table 2. Newspaper sample. Circulation, ownership, political leanings, and other notes.⁵

To search for ES articles, we used the Factiva Global News Database, which provided access to all types of articles (e.g., news, business, editorials) in all 10 newspapers published between January 1, 2008 and December 31, 2017. The search was limited to articles with the following terms appearing anywhere in the full article:

(energy storage or power storage or electricity storage or battery storage or thermal storage) AND (project or research or facility or system or policy or technology)

Search terms were chosen following several scoping searches and review of similar methods employed by Langheim et al. [78], Stephen et al. [80], and Ganowski et al. [29]. While some have used more specific and technical search algorithms, we

⁴ Due to language and resource limitations, Canadian francophone newspapers were excluded. The Montreal Gazette (an English regional newspaper based in the country's French-speaking province) was selected to increase the geographic and cultural representation.

⁵ Based on available data: circulation numbers reflect 2015 News Media Canada data (Canada) and 2017 Statista data (UK). Editorial stances were retrieved from *Media Bias/Fact Check* <https://mediabiasfactcheck.com> as of June 2018. Ownership information reflects 2017 News Media Canada data (Canada) and 2015 Media Reform Coalition data (UK); UK circulation numbers were rounded based on available data.

found that a broader algorithm returned more relevant coverage on ES. We also examine ES technologies in aggregate due to limited public experience with specific applications to date [84,86,96]. However, we maintained ‘battery’ and ‘thermal’ technologies in the search as these applications are still general enough to describe ES. As in similar media studies [22,28], we focused on articles that discussed ES both in concrete (e.g., projects, user-experience) and conceptual (e.g., ES as part of an energy transition) terms. We recognize that the use of ES as an ‘umbrella term’ has some limitations, as different applications may have unique socio-technical characteristics and acceptance profiles. As the technology matures and media reports focus on specific applications, future research on this topic will need to consider these nuances. Non-relevant articles (e.g., ES in biological contexts) and duplicates were removed from the sample. With a focus on grid-scale and behind-the-meter ES, electric vehicle stories were excluded unless they covered integrated grid or local ES use-cases (e.g., vehicle-to-grid).

To answer the research question, we used NVivo 11.4™ content analysis software to code and analyze, by country: (1) the frequency and salience of ES articles published in each newspaper, over time (2008-2017); (2) the types and frequency of SPEED frames describing ES benefits and risks (2016-2017); (3) the types and frequency of narratives in which ES was discussed (2016-2017); and (4) the valence (i.e., tone/orientation) used to describe ES (2016-2017). Qualitative coding was facilitated using a detailed codebook for analyzing components (1) through (4). Additional methods were used to catalogue (5) other themes, buzzwords, and technology mentions in the full sample (2008-2017).

To assess issue salience (i.e., the level of attention attributed to ES), we adapted best practices [22, 78] for organizing filtered articles into ‘focus’ categories based on the extent to which stories exclusively focused on the topic. ES-Focused (ES-F) articles were those that focused entirely on ES (e.g. articles discussing new battery projects), ES-Subsection (ES-S) articles did not focus on ES exclusively, but mentioned ES within an article subsection, and ES-Irrelevant (ES-IR) articles mentioned a key search term without sufficient context for coding (e.g., briefly mentioning the technology alongside others). We then used the SPEED framework [28] to analyze the framing of ES benefits and risks in all ES-F and ES-S articles published in 2016 and 2017. This sub-sample was chosen as it was suitably sized for in-depth qualitative analysis [100,101] and represented then-current media discourse. All articles were thoroughly read and coded by the lead researcher. SPEED analysis was

carried out by assessing the frequency of the six benefit-risk frames appearing in the sample (the results of which are summarized in **Table 5**). Articles were also coded for narratives describing ES. Narratives were adapted from our Canadian pilot study on provincial ES media representations [29] and derived from early scoping searches in both countries. Valence analysis (i.e., assessing positive, negative, or neutral emotional appeal of ES) was similarly conducted. An article coded as having 'negative' valence typically contained more SPEED risk frames than benefit frames and depicted ES with negative emotional appeal using discursive tactics such as dramatized language. Other mixed-methods were applied to capture emerging ES representations that were not coded deductively (i.e., text-search queries).

To satisfy inter-coder reliability, two researchers coded the same reliability subsample ($n = 50$) using a detailed codebook and reliability features in NVivo to determine agreement on coding issue salience, frames, narratives, and valence. Both Holsti's [101] percentage agreement method and Landis & Koch's [102] scale for Cappa (κ) were used to evaluate inter-coder reliability. Final percentage agreement ranged from 72%–98% and 0.38–0.83 (κ), respectively. Thus, reliability was satisfactory, with highest results found for salience and SPEED framing and lower results achieved for narrative and valence. Examination of reasons behind coding disputes were used to refine coding schemes and then applied to the remaining qualitative sample ($n = 216$). SPEED frame categories with lower reliability scores were maintained in the dataset, as they contained important insights, such as political and technical frames (see Appendix). Further, while most SPEED studies rely on frame analysis, and often without statistical reliability measures, we combined our SPEED assessment with salience, narrative, and valence analyses to further support our inferences. For instance, valence findings (i.e., whether an article was positively or negatively oriented toward ES) supported SPEED coding (i.e., negative valence articles typically contained many SPEED risk frames).

4 Results

4.1 Frequency analysis: ES coverage and article focus – 2008-2017

The Factiva search returned a total of 669 articles (Canada: $n = 366$, 54%; UK: $n = 303$, 46%) reporting on ES between January 1, 2008 and December 31, 2017 (52 duplicates were automatically removed from the search). Upon removing 175 non-relevant articles, 494 articles were retained for analysis (Canada: $n = 240$, 49%; UK: n

= 254, 51%). **Figure 1** depicts annual frequencies of published ES articles in each country across all sampled newspapers.

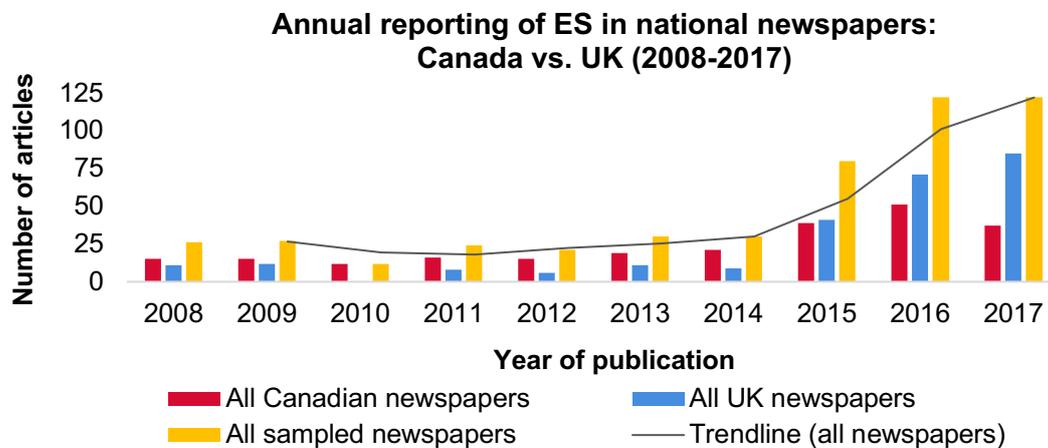


Figure 1. Annual frequencies of ES articles published in Canadian and UK newspapers, (2008-2017; $n = 494$); **Note:** trendline = 2 per mov. avg. (# of articles published over 10-year period)

Overall, ES reporting in both countries increased over the 10-year period, particularly between 2012 and 2017. ES coverage in Canadian newspapers increased steadily from 2012 ($n = 15$), peaked in 2016 ($n = 56$), and decreased again in 2017 ($n = 37$). Sampled UK newspapers had relatively less coverage until 2015, at which point the UK began to surpass Canada in annual article frequency. No ES UK articles were returned by the search for 2010. Chi-square⁶ results confirmed differences between the countries with respect to frequency of ES reporting over time, $\chi^2 (9, n = 494) = 48.26, p < .001$. Despite the overall increase in ES reporting over time, article frequency data suggested that ES is more salient in UK newspapers than in Canadian newspapers between 2016 and 2017; 64% of this sub-sample ($n = 216$) were UK articles, while only 36% were Canadian. **Table 3** provides a summary.

Newspaper	Distribution Frequency / % of total sample
Canada ($n = 240$)	
<i>The Globe and Mail</i>	98 (20%)
<i>The Toronto Star</i>	71 (14%)
<i>National Post</i>	33 (7%)
<i>Vancouver Sun</i>	26 (5%)
<i>The Montreal Gazette</i>	12 (2%)
UK ($n = 254$)	
<i>The Guardian</i>	98 (20%)

⁶ Chi-square tests of independence were performed to determine whether national differences between dependent media variables (i.e., number of ES articles published per year) and independent variables (i.e., country of publication) were statistically significant.

<i>The Times</i>	55 (11%)
<i>Financial Times</i>	48 (10%)
<i>The Daily Telegraph</i>	39 (8%)
<i>The Independent</i>	14 (3%)
Total	494 (100%)

Table 3. *Distribution of ES articles in Canadian and UK newspapers, (2008-2017; n = 494)*

Of the entire sample ($n = 494$), 244 articles were published in 2016 and 2017 (qualitative sub-sample), including 59 (24%) ES-F, 157 (64%) ES-S, and 28 (11%) ES-IR articles. Upon removing ES-IR (irrelevant) articles, a total of 216 articles (Canada: $n = 78$, UK: $n = 138$) was retained for qualitative coding. The distribution of articles coded at specific 'focus' cases in NVivo was similar between the countries; no significant associations were found between the two variables, $\chi^2(2, n = 244^7) = .005, p = .98$. Thus, while quantitative findings (i.e., the annual frequency of published ES articles) suggested greater (and perhaps growing) issue salience in UK newspapers (2008-2017), the distribution of articles with varying ES 'focus' codes suggested nationally similar levels of attention to ES during this more-restricted period (2016-2017).

However, when ES 'focus' findings were broken down by publication 'year,' results again suggested, to some extent, a growing ES issue salience in the UK (from 2016 to 2017), and declining salience in Canadian newspapers during this time. The percentage of ES-F articles (i.e., those focusing exclusively on ES) in the UK sample increased from 21% (2016) to 26% (2017), while the respective Canadian percentage declined from 25% (2016) to 24% (2017). A greater percentage increase in ES-IR articles (i.e., those with insufficient focus on ES) was also found in Canadian coverage between these years as compared to the UK: 8% (2016) to 16% (2017) vs. 11% (2016) and 12% (2017), respectively.

4.2 Frame analysis: ES SPEED benefits vs. risks – 2016-2017

Overall, newspapers contained more positive framing (benefit statements) of ES than negative framing (risk statements) across all SPEED categories. **Figure 2** provides a comparative breakdown of SPEED framing in the two national samples.

⁷ Reflects total number of articles in 2016-2017 coverage, including ES-F, ES-S, and ES-IR articles; once ES-IR articles were removed, the final sub-sample contained 216 articles.

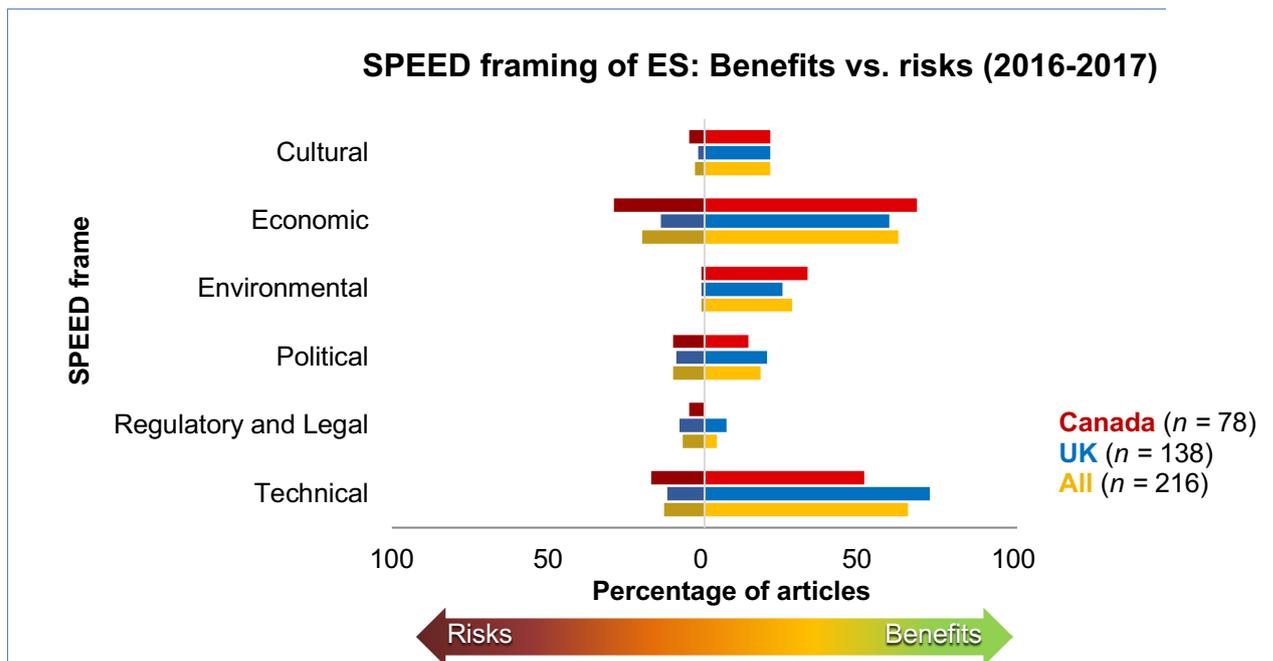


Figure 2. Comparative breakdown of ES SPEED framing in Canadian and UK newspapers, (2016-2017; n = 216)

Of the six SPEED categories, economic (benefit and risk) frames (contained in 82% of all articles) and technical frames (78%) dominated across all newspapers. Regulatory and legal framing was least common (11%). Environmental framing of ES (contained in 29% of all articles) was also prevalent, particularly in Canadian newspapers (35%). The technical benefit framing of ES dominated overall, with 65% of articles mentioning benefits such as improved power quality and grid flexibility [e.g., *The Guardian*, October 9, 2017]. The economic benefit frame was the second most common (contained in 62% of all articles), often linking ES to cost savings for end-users, new market opportunities, and job creation [e.g., *The Globe and Mail*, March 24, 2017]. Environmental benefit frames (28% of all 2016-2017 articles) argued for the sustainability benefits of ES, such as its potential to enable a “clean energy future” by reducing reliance on fossil fuel generation [e.g., *The Globe and Mail*, March 24, 2017].

The overall benefit-to-risk framing ratios (all categories considered) were 3:1 for Canada and 4:1 for the UK, indicating a more favourable benefit-to-risk framing of ES in the UK than in Canada (i.e., we found four times as many benefit framed articles in the UK sample than risk framed articles). The regulatory and legal frame was the only category that contained more risk than benefit statements (1.75:1). Regulatory and legal framing, which was especially contentious in the UK sample, generally focused on inadequate and unresponsive regulatory environments for ES. In this context, ES as part of broader energy transition processes was often described as posing challenges

for energy regulators (e.g., asset classification and definition). A comparative breakdown of benefit-to-risk ratios is depicted in **Table 4** to demonstrate how ES is profiled in each country using the SPEED matrix.

SPEED frame	National SPEED frame ratio (benefit:risk)		
	Canada (n = 78)	UK (n = 138)	All (n = 216)
Cultural	5:1	20:1	7:1
Economic	2.3:1*	4:1	3:1
Environmental	3:1	25:1	8:1
Political	1.4:1*	2:1	1.8:1*
Regulatory and Legal	0:1	0.9:1*	0.6:1*
Technical	3:1	6:1	5:1
Overall ratio	3:1	4:1	3.7:1

Table 4. SPEED frame benefit-to-risk ratios. Canadian vs. UK newspapers; **Note:** Presented in lowest terms with all risk values standardized to 1; * = lowest ratios left as decimals for easier comparison

Both national samples also discussed risks associated with ES deployment. The economic risk frame (appearing in 20% of all articles) contained concerns about unclear market rules, financing challenges, and the threat that ES could pose to the fossil fuel industries, upon which both countries still rely on heavily to meet energy needs [e.g., *The Globe and Mail*, December 6, 2017]. The technical risk frame (13% of all 2016-2017 articles) contained concerns about scalability and technical limitations (e.g., charge capacity, space requirements) [e.g., *Vancouver Sun*, July 11, 2017].

Table 5 provides a summary of perceived benefits and risks of ES in both countries (including the full collection of frames found in the 2016-2017 articles).⁸

SPEED frame	Risk	Benefit
Cultural	Invites public skepticism and community opposition (e.g., concerns over loss of control, impact on way of life, siting); cultural reluctance to electricity system changes; may prove difficult to influence consumer adoption and behavior change; potentially leading to social divisions, vulnerabilities, and frustrations.	Encourages public support and adoption of renewable power / lower-carbon energy systems (e.g., less NIMBYism than other energy technologies); strengthens community sustainability, engagement, and pride (e.g., participation in ES projects, services remote communities); allows for positive energy consumer behaviour change (e.g., consumer empowerment, agency, energy management)

⁸ Each article coded for a SPEED frame was further coded into the above sub-frames (risks/benefits); most articles contained multiple frames (e.g., economic benefit, economic risk, environmental benefit).

Economic	High costs outweigh benefits (e.g., technology still cost ineffective); creates new costs or risks to actors within and outside energy system (e.g., transmission, disruption to other industry supply chains, fossil fuel industries); increases economic and financial risks (e.g., inadequate funding, investment difficulties, unclear or lacking market rules, cost analysis difficulties)	Strengthens economy and fosters growth (e.g., job creation, training); opportunities for legacy and new system actors (e.g., increases competitiveness); cost savings at system level (e.g., infrastructure upgrade deferral); cost savings at end-user level (e.g., consumers); optimization of existing assets (e.g., renewable and others); attracts new business partnerships and investment opportunities (e.g., between local, national, international stakeholders)
Environmental	Potential threats to ecological health (e.g. land use, resource extraction, habitat destruction, waste disposal); shifting risk to new environmental areas; contributes to carbon emissions and embedded carbon	Supports climate change mitigation and adaptation (e.g., reduces emissions, facilitates conservation and efficiency, supports fossil fuel phase-out); creates no or little harmful waste (e.g. manufacturing processes, sustainable life cycle); improved environmental or public health
Political	Negative political ramifications (e.g., opposition to new policies, political contention); challenges associated with lacking government support; undermines existing energy plans or strategies; does not align with other national policy frameworks or goals	Positive political ramifications (e.g., fosters stakeholder collaboration and public satisfaction, improves national/regional identity); supports existing energy plans and strategies; aligns with other national policy frameworks and goals
Regulatory and Legal	Not suitable for existing regulatory framework; lacking or unfavourable policies and laws (e.g., building code restrictions, permitting issues); lacking, underdeveloped, difficult, or deadlocked regulatory processes stalling/derailing system change	Complements existing regulatory frameworks; encourages new clean energy regulations and policies; supports necessary regulatory changes to energy system
Technical	Could cause negative technical consequences; interaction of technologies creates new system risks, needs, or vulnerabilities; requires unavailable resources and/or specialized skills and expertise; unsuitable for existing grid or other energy infrastructure; other technical or logistical constraints; concerns or uncertainties regarding current technological performance (e.g., further testing required)	Improves grid flexibility; supports renewable energy integration; increases energy capacity and reliability (e.g., addresses intermittency issues); integrable into existing infrastructure and other sectors (e.g., transportation); technology easily scalable; relatively short project development timelines; part of energy system modernization

Table 5. *SPEED framework applied to ES coverage in Canadian and UK newspapers, (2016-2017; n = 216)*

Chi-square tests of independence revealed some national differences in SPEED framing for the economic risk frame, $\chi^2(1, n = 216) = 7.03, p < .001$; the regulatory and legal benefit frame, $\chi^2(1, n = 216) = 5.31, p < .05$; and the technical

benefit frame, $\chi^2(1, n = 216) = 9.80, p < .001$. Overall, Canadian articles contained more economic framing of ES, often describing the value of ES to system actors (e.g., grid operators, utilities) and to Canada's transitioning energy economy. For instance, one *The Globe and Mail* article, entitled 'In a low-price environment, storage becomes a money maker,' articulated this economic focus on ES:

...there is now little doubt that we are on the cusp of big changes in the energy market. The business of digging stuff out of the ground will be with us for a long time but not as a growth industry. Instead, it will be the business of storing and managing power distribution that attracts investment and creates jobs. – *The Globe and Mail*, March 31, 2016.

At the same time, Canadian articles contained significantly more economic risk-framing of ES than did UK articles. These articles discussed financial risks (e.g., to taxpayers, developers), investment uncertainties, and other market barriers (e.g., securing capital). More broadly, economic risk articles also linked ES market growth paired with renewable investments to potential economic losses in Canada's nuclear, oil, and gas industries, particularly in the country's oil capital, Alberta. Within these discussions, the 'disruptive' nature of ES was often associated with an uncertain and turbulent future for utilities and generators that have traditionally relied on fossil fuel sources (e.g., coal, gas):

More capital flowing to energy storage and renewables means less investment in new thermal-power plants, a trend that's already starting to hit big equipment suppliers such as Siemens and General Electric. Siemens, for example, recently announced plans to cut nearly 7,000 jobs in its power and gas division, which sells turbines and other equipment for thermal-power plants. One board member went so far as to describe the market as 'burning to the ground' – *The Globe and Mail*, December 5, 2017.

Similarly, UK articles argued that ES 'could help to cut the costs of the green transition' (by up to £8 billion a year) and provide new economic opportunities [e.g., *The Times*, April 17, 2017], while others linked ES to economic risks associated with a more distributed energy system (e.g., stranded oil and gas assets) [e.g., *The Daily Telegraph*, April 18, 2017]. In general, in the UK, a high-risk/high-reward perspective seemed to outweigh economic ES concerns, with Canadian articles containing greater economic emphasis on ES overall.

UK newspapers articulated technical functions of ES positively, focusing on its potential to enable renewable energy integration (i.e., reducing intermittent generation issues), improve energy security, and provide greater grid flexibility. Within this frame, UK articles also portrayed ES with a strong national focus, emphasizing the technology's potential to address various domestic energy challenges:

As Britain builds more wind farms and solar panels, which produce electricity only when the wind blows or the sun shines, keeping supply and demand in balance is becoming more challenging. To keep the lights on, the system needs flexible power sources that can respond quickly to short-term fluctuations to keep the grid frequency at safe levels, such as the service provided by the [UK Power Network] battery [...] Batteries that can help to overcome renewables' intermittency by storing power for when it is needed have long been the holy grail of the energy system. Now, thanks to rapid technological advances and cost reductions led by the electric vehicle market, they appear to be within reach. – *The Times*, April 17, 2017.

Some articles expressed doubts about the commercial readiness of large-scale ES, calling for further technical planning and analysis of more experimental innovations. Others criticized the unprecedented hype around ES and pointed to emerging consequences of techno-optimism:

The [energy storage] field is littered with the remnants of grandiose hype and unfulfilled promises. “There’s a battery innovation announced at least every month, usually every couple of weeks [...] The result is massive pressure on inventors, developers and financial backers to proclaim the Next Big Thing without it having passed critical tests such as commercial viability,” Mr. Chamberlain [scientist at Argonne] says. “A number of battery discovery claims ended up being big letdowns,” he adds. “The VCs [venture capital firms] are impatient, but the science itself is slow.” – *The Globe and Mail*, February 5, 2016

Technical risk framing in UK articles also contained concerns about the technology’s ‘early stages of development’ [*The Daily Telegraph*, June 25, 2016]. Even anti-nuclear discussions presumed that technical limitations of ES mean fossil fuels will continue to play a key role in the UK’s energy future:

“Hinkley [nuclear plant] is a project from a dying era,” said Friends of the Earth, the environmental group. Renewables, smart grids and energy storage are the fleet-footed mammals racing past this stumbling, inflexible nuclear dinosaur [...] Yet, the battery technology needed to deliver the green vision – by filling gaps when wind and solar power is unavailable – remains years from maturity. Gas and nuclear will be needed in the meantime to maintain UK energy security as coal-fired power is phased out. – *Financial Times*, July 22, 2017

UK newspapers appeared to focus more on ES success stories than failures – particularly at the residential level with positive responses to home batteries. Regulatory and legal framing was also more prevalent in UK newspapers. Many regulatory and legal benefit articles identified ES as a catalyst for addressing outdated regulatory models that are stalling the UK’s energy transition. In others, regulatory and legal risk articles viewed ES as creating new regulatory and policy uncertainties. Canadian articles also discussed lagging regulatory frameworks and attempts for legislated incentives for ES implementation. One article effectively illustrated regulatory

risks and barriers in the province of Ontario, where ES development has been particularly active⁹:

...There are generally no structures for the offering of bundles of services as energy suppliers, managing and co-ordinating cumulative output of distributed generation and storage when more electricity is needed, conservation and demand management resources, reducing grid demand by relying on distributed generating and storage capacity and ancillary services such as grid-frequency regulation. – *The Globe and Mail*, May 16, 2017.

4.3 Narrative analysis: Narratives used to describe ES – 2016-2017

Our narrative analysis provided richer context for SPEED framing of ES. Overall, the 'economic development' narrative (described in 56% of all 2016-2017 articles) and the 'energy security' narrative (55%) dominated. The 'climate change' narrative was the least common overall, although still mentioned in 25% of the sub-sample. **Figure 3** provides a comparison of national ES narrative distributions. The proportions of articles describing the 'economic development' and 'technological innovation' narratives were comparable. However, chi-square tests again confirmed significant national differences in respect to the 'climate change' narrative, $\chi^2(1, n = 216) = 10.87, p < .001$, and the 'energy security' narrative, $\chi^2(1, n = 216) = 23.36, p < .001$. Overall, the 'climate change' narrative was more prominent in Canadian newspapers, while the 'energy security' narrative was most prevalent in UK newspapers.

⁹ While some regulatory benefits were identified in earlier articles (published before 2016) during frequency analyses, none were identified in the 2016-2017 Canadian media sample (resulting in a benefit-to-risk ratio of 0:1).

ES narratives in Canadian and UK news articles (2016-2017)

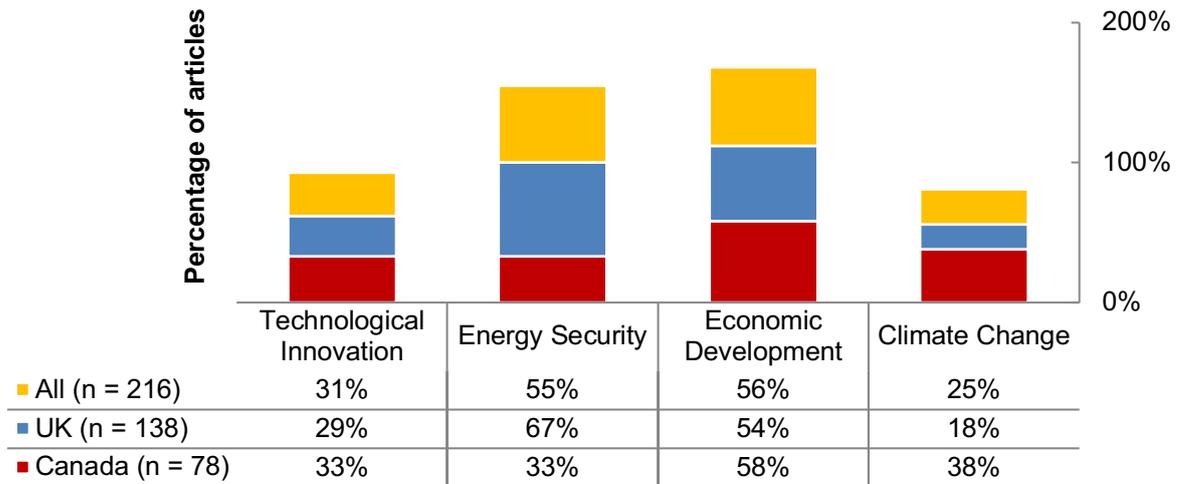


Figure 3. Percentages of articles containing four ES narratives: Canada vs. UK (2016-2017; n = 216); **Note:** Articles typically contained more than one narrative.

All four narratives were generally positive. The ‘technological innovation’ and ‘economic development’ narratives promised major economic rewards behind the anticipated breakthrough in cost-effective ES. Canadian articles used pithy buzzwords to construct the ‘technological innovation’ narrative, while UK articles more commonly assessed specific technical benefits. Both narratives were more common in Canadian coverage, which generally portrayed ES as a key innovation that ‘will support the transition to a cleaner, smarter electricity network in Canada’ [*National Post*, March 24, 2017]. The ‘climate change’ narrative was also more common in the Canadian sample. Overall, 38% of Canadian ES articles described climate change as an urgent national issue, with imminent environmental, economic, and cultural implications for Canadian citizens – an issue which innovations like ES could help address. UK articles also linked ES to climate change mitigation but focused on perceived immediate benefits of the technology, such as improved local air quality, which in 2016, was still largely compromised by gas and coal generation [*The Guardian*, June 9, 2016].

UK news coverage (2016-2017) on ES was dominated by the ‘energy security’ narrative, which was significantly less prominent (as the shown by χ^2 results above) in Canadian newspapers. Indeed, 67% of UK ES articles discussed national energy security and affordability challenges amongst unprecedented technological and political change. This narrative often appeared in national energy independence discussions (e.g., around then-timely Brexit negotiations), wherein ES was said to help reduce the UK’s reliance on foreign energy supply during a time of increasing price volatility and political uncertainty in Europe [*The Guardian*, August 8, 2016]. The ‘energy security’

narrative also appeared to be linked to an additional narrative, particularly in the UK, which was captured inductively during qualitative analysis and thus excluded from the four deductively coded narratives above. The ‘political contention’ narrative, which demonstrated the country’s diverging political agendas and views on clean energy development, examined ES amidst broader energy policy debates such as poor government leadership in an evolving sector. The following excerpt illustrates how this narrative was constructed:

The UK government has been criticized for recently awarding £175m of subsidy to highly polluting diesel generator farms [...] “Amber Rudd is talking a lot about energy storage, but we need a clear regulatory steer,” says [Jill] Caine [UK Electricity Storage Network]. “The planes are circling, but there is no runway to land on.” [...] Prof Ian Arbon, at the Institute of Mechanical Engineers, which in 2014 called energy storage the “missing link” in the UK’s energy plans, is even more direct: “As a nation we are nowhere near where we should be on energy storage. There is a clear need for massive and urgent attention. Energy storage is one of the obvious solutions to the [decarbonisation] problems we face.” [...] The government is keen to build new gas-fired power stations and develop fracking, but Arbon said: “The UK is the only country in the world who thinks it is going to hit its renewable targets by doing more fossil fuels.” – *The Guardian*, February 4, 2016.

4.4 Valence analysis: Emotional appeal of ES media coverage – 2016-2017

ES reporting in Canadian and UK newspapers (2016-2017; $n = 216$) was similar in respect to ‘valence’ – i.e., general emotional appeal toward ES; 152 (70%) were found to be ‘positive’ toward ES; 52 (24%) were neutral, and 12 (6%) were negative (see **Figure 4**). Valence analysis was used to validate SPEED findings (i.e., a positive valence trend in the samples aligned with predominant benefit SPEED framing). No significant differences were found between ‘country’ and ‘valence’ variables, $\chi^2 (2, n = 216) = 1.11, p = .57$. The following excerpt demonstrates how ES was often discussed with positive valence. Such articles contained mostly benefit frames and often weaved together various narratives to paint ‘win-win’ scenarios for ES:

Improving Britain's energy storage and managing electricity demand could save consumers up to £8bn a year by 2030, according to a report by Lord Adonis commissioned by the Treasury. It could also enable the UK to meet its 2050 carbon emissions targets and secure the country's energy supply for generations, the report says. – *Financial Times*, March 4, 2016

**Valence of ES news articles in Canadian and UK newspapers
(2016-2017)**

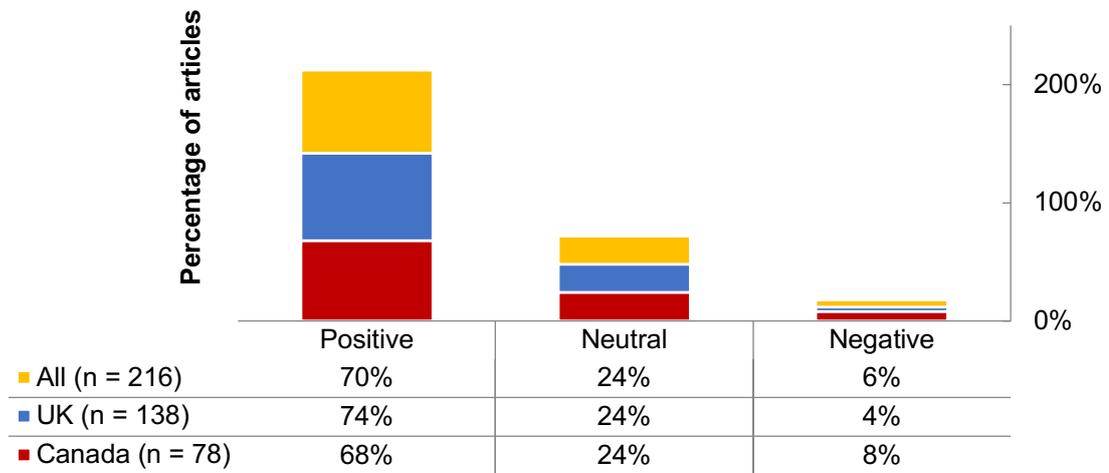


Figure 4. Percentages of ES news articles with varying valence: Canada vs. UK (2016-2017; n = 216)

In sum, the above analyses revealed interesting similarities and differences between Canadian and UK news coverage on ES: (1) a potentially increasing issue salience over time (more strikingly in the UK) in both countries; (2) generally positive SPEED framing of ES (with national differences in economic, regulatory and legal, and technical framing); (3) a prevalence of ‘economic development’ and ‘energy security’ narratives (with differences in use of ‘climate change’ and ‘energy security’ narratives); and (4) a predominantly positive valence around ES in media reporting overall. We elaborate on these findings in the later discussion.

4.5 Other themes, buzzwords, and technology mentions – 2008-2017

A series of text-search queries in NVivo were also conducted to determine the frequency of articles within the ten-year period (2008-2017) that mentioned certain themes, buzzwords, and technologies. Terms were selected based on common words and themes identified during the qualitative analyses and then validated using NVivo’s frequency word query features. All articles returned by the queries were manually reviewed to confirm whether search term references were explicitly related to discussions about ES – those that did not were removed from query sub-samples. Results are depicted in **Table 6** and **Table 7**.

Theme/narrative	Text-search terms	Frequency / percentage of articles		
		Canada (n = 240)	UK (n = 254)	Combined (n = 494)

Climate change	<i>climate change, climate, global warming, emissions, carbon</i>	131 (55%)	130 (51%)	261 (53%)
Economic development	<i>economic development, economic growth/opportunity, economy, investment, jobs</i>	127 (53%)	125 (49%)	252 (51%)
Political context (contention)	<i>politics, policy, political, government, public</i>	97 (40%)	132 (52%)	229 (46%)
Technological innovation	<i>Innovation/innovative, R&D/research and development, breakthrough</i>	88 (37%)	77 (30%)	165 (33%)
Energy transition	<i>energiewende, energy transition, energy transformation, energy revolution, phase-out</i>	74 (31%)	79 (31%)	153 (31%)
Energy security	<i>energy security, energy access, secure supply/energy supply, reliability, energy needs/demand</i>	32 (13%)	70 (28%)	102 (21%)
Industry buzzwords	<i>holy grail, game-changer/changing, missing link, disruptive technology/innovation, cutting-edge, ground-breaking</i>	40 (17%)	29 (11%)	69 (14%)

Table 6. *ES representations in Canadian and UK newspapers (2008-2017): Text-search query results*

The most common themes in all sampled newspapers were ‘climate change,’ ‘economic development,’ and ‘political contention.’ Search queries captured two additional themes (‘energy transition’ and ‘political contention’) which emerged (often together) during qualitative coding. For example, 31% of articles in both samples contained an ‘energy transition’ theme as they discussed ES in respect to ‘the shift to a low-carbon economy’ [e.g., *The Guardian*, September 4, 2017]. The queries also confirmed that ES was more frequently linked to coverage on ‘energy security’ issues in UK newspapers (28%) than in Canadian newspapers (13%). Many of these articles expressed concerns over Britain’s increasing energy dependence and debates on government priorities regarding energy supply:

There is an incredible opportunity for the UK to become a world leader in these disruptive technologies [referring to ES and renewables], yet our current energy security subsidies favour dirty diesel generation over smart new clean tech solutions. – *The Guardian*, October 15, 2016.

A similar pattern was observed for the proportion of articles discussing ES in contentious political contexts; 52% of UK articles (vs. 40% of Canadian articles) mentioned at least one of the ‘political contention’ terms. Politically contentious discourse in an ES context contained hostile issue framing that made political attacks

and arguments on government action – or rather, lack there of. This narrative positioned ES amidst broader political debates, arguing for instance, that ‘Britain’s energy policy needs a reboot’ for technologies such as ES to commercialize [*The Daily Telegraph*, October 24, 2017]. A greater prominence of the ‘political contention’ narrative in the UK sample also appeared to articulate the uncertain state of energy security and political climate in the European Union between 2016 and 2017 [103].

Various ‘buzzwords’ describing ES were also identified. Of the 494 articles, 14% included at least one of the buzzwords listed in **Table 6**. Phrases such as ‘game-changer’ and the ‘holy grail’ often appeared within ‘climate change’ and ‘energy transition’ narratives, wherein ES was positioned as the ‘missing link’ to solving national energy security and sustainability challenges [e.g., *The Guardian*, February 4, 2016]. Overall, buzzwords appeared more often in Canadian articles (17%) than in UK articles (11%):

As the world looks for alternatives to the internal combustion engine, light, safe, powerful batteries to drive electric cars, buses, forklifts and other machinery, as well as store wind and solar power are the holy grails of a low-carbon world. – *The Vancouver Sun*, July 11, 2016.

Various ES technologies were mentioned between 2008 and 2017, with ‘batteries’ most frequently mentioned (i.e., in 61% of the entire sample, although likely due to the initial search terms containing ‘battery’). Overall, more Canadian articles (73%) mentioned specific technologies than UK articles (69%) and often in reference to specific experimental ES projects while UK articles focused less on novel large-scale technologies, and more on affordable and improved battery ES. ‘Home batteries’ (e.g., Tesla’s residential battery packs), for example, were often discussed as gaining customer interest and adoption in the UK [e.g., *Financial Times*, December 27, 2017]. Grid-scale batteries were also frequently debated as alternatives to controversial projects, such as hydro-electricity dam expansions (e.g., Site-C in British Columbia, Canada) and nuclear plants (e.g., Hinkley Point C in Somerset, UK) [e.g., *Vancouver Sun*, November 5, 2017; *The Daily Telegraph*, September 16, 2016].

Technology	Frequency / percentage of articles		
	Canada (n = 240)	UK (n = 254)	All (n = 494)
Batteries	142 (59%)	161 (63%)	303 (61%)
Fuel cells	28 (12%)	15 (6%)	43 (9%)
Pumped hydro	20 (8%)	16 (6%)	36 (7%)
Hydrogen storage	30 (13%)	3 (1%)	33 (7%)
Compressed-air	23 (10%)	6 (2%)	29 (6%)
Flywheels	23 (10%)	5 (2%)	28 (6%)

Thermal storage	14 (6%)	7 (3%)	21 (4%)
Ultra/Super-capacitors	7 (3%)	2 (1%)	9 (2%)

Table 7. *Frequencies and percentages of ES technology mentions: Canadian vs. UK newspapers (2008-2017; n = 494)*

These text-search analyses provided additional insight on ES salience and representation in Canadian and UK newspapers in the full 10-year sample. First, while ‘climate change’ and ‘economic development’ themes were most common overall, ES was linked to ‘energy security’ and ‘political contention’ discourse more often in the UK than in the Canadian sample. Second, Canadian articles typically contained more mentions of specific ES technologies and buzzwords than did UK articles.

5 Discussion

The aim of this research was to compare news media discourse on ES in Canada and the UK in a socio-political energy transition context. We identify several key findings from this assessment. First, ES is receiving national news media attention in both countries, which speaks to its significance as an emerging energy technology. We discovered an upward trend in ES coverage between 2008 and 2017, which aligned with heightened ES market and policy activities in both countries, and yet with cross-national differences in salience and framing profiles. Second, techno-optimism for ES, especially in Canadian newspapers, suggests some evidence of its progress and fate along the classic technology hype cycle [64]. Third, despite similar national interests in ES, the technology is contextualized differently in the two public spheres, reflecting unique domestic socio-political drivers and opportunities for the technology which offer new avenues for future research. We elaborate on these and other key findings from our results below.

5.1 Issue salience and hype dynamics of ES

By bringing issues into public focus, news media can both reflect and set national agendas for energy system change [17,19,65]. As such, issue salience of ES – i.e., the level of attention and extent to which media report on storage – may have a steering influence on public and policy support for its large-scale deployment. In examining longitudinal reporting and the focus (i.e., ES-F) attributed to ES, we found that reporting on storage aligns with generally increasing media coverage on energy innovation [22, 28, 63, 79, 92] and with hype trends observed for other ‘disruptive’ technologies. As with smart grid and blockchain hypes (which too peaked around 2016) [22,61], increased reporting on ES in the two countries may be due to the

technology's uniquely 'stackable' value propositions for improving current unsustainable and problematic electricity grids [72]. However, the steadier climb in ES interest in our UK sample differed from the pronounced interest 'peak' in Canadian coverage in 2016 – a milestone year for ES due to legislative changes and procurements in the country (e.g., 50 megawatts of battery capacity coming on-line in Ontario) [6,7], perhaps also amplified by the unveiling of Tesla Motors' 'cutting-edge' Powerwall home battery that year.

Similar to our Canadian ES media analysis [29] findings, national ES reporting in the two countries coincided with: (1) related energy policy and regulatory developments (e.g., UK's 2017 Smart Systems and Flexibility Plan); (2) emerging RD&D and market activities (e.g., Ontario's 2012-2015 ES procurements); (3) and 'newsworthy' projects (e.g., Hydrostor's underwater compressed-air ES project) within the last decade [84,86, 103]. This supports the argument that emerging political and technological developments, paralleled with growing climate attention, are contributing to heightened reporting on 'sustainable' energy technologies [21,28,29,42]; although, further causal research would help to determine exact driving factors for increased reporting on ES.

Notably, our observed Canadian ES hype differed from the string of shorter 'bursts of enthusiasm and concern' [105] that our pilot study [29] found in provincial-level ES media discourse in Canada within the same timeframe. However, upon comparing longitudinal trends of regional vs. national coverage, we indeed found issue salience in our regional Canadian newspapers to similarly wax and wane, while national coverage represented a prominent hype peak in 2016. This supports documented differences between national and regional news reporting practices, whereby nationals are known to report on 'the bigger picture' and develop stories as on-going trends (i.e., creating long-term generalized expectations), while local newspapers prioritize time-bound and event-oriented reports (often resulting in peak-and-trough patterns) [106,107]. The known trend could also explain the 'still-rising' interest in ES observed in UK newspapers during this time (all of which were national newspapers). A sharp increase in UK coverage since 2014 may also indicate a sudden interest (seemingly prompted by energy market reform and security concerns at the time [103,108]) which may eventually level off and rise again as ES developments unfold. Understanding the reporting practices of various news media sources could help market analysts and policymakers more accurately assess technology trends and 'windows' of opportunities [29]. Further longitudinal and correlational analyses would

help to support reasons for these observed patterns their potential effects on public audiences (e.g., by assessing ‘aftereffects’ of news, comparing coverage to real-world implementations).

5.2 Social representations and domestication of ES

Media ‘frames’ and ‘narratives’ are also well known to shape public understanding and responses to new energy developments [39,56,67,68]. Our analysis revealed that ES media representations in Canada and the UK are similar, yet fundamentally different. The national samples align in their overall positive (benefit) framing and narrative use around ES, which appeared to contribute to storage hype during this time. Yet, the countries differed in their overall benefit-to-risk frame ratios, suggesting a more favourable media perception of ES in the UK than in Canada overall. Like the case of smart grid in Canada and the U.S [73], the media samples also varied in SPEED framing, supporting that national socio-political contexts (i.e., of the political economy) [108,109] underpin the social representation of energy technologies in media discourse. Interestingly, while more-established and debated energy innovations (e.g., CCS, wind turbines) are typically subject to cultural and environmental risk framing [79,80,81], a technical and economic emphasis on ES seems to be linked to its perceived potential for improving electricity distribution systems [72,86] while creating new ‘green’ economic opportunities. On the surface, this may imply a promising socio-technical trajectory for ES in the two countries compared to other innovations that were initially profiled with socio-cultural frames before meeting policy and institutional pushback.

We note two additional key findings here: (1) individually, all four ES narratives were in favour of the technology, carrying a discursive affinity for heightened techno-optimism; and (2) while each storyline contained unique sets of conflicts, solutions, and actors, the four narratives co-existed harmoniously to reinforce ES advocacy. In some cases, decoupling narratives during coding was challenging, particularly when storylines were woven together to construct ‘win-win-win’ scenarios for national climate action, energy generation and use, and technological innovation. We offer this additional excerpt as an example:

Improving Britain's energy storage and managing electricity demand could save consumers up to £8bn a year by 2030, according to a report by Lord Adonis commissioned by the Treasury. It could also enable the UK to meet its 2050 carbon

emissions targets and secure the country's energy supply for generations – *The Financial Times*, March 4, 2016

As also observed in the case of biofuels [47], smart meters [107], and CCS [110], this discursive tactic demonstrates how media often string together narratives concerning complex and unfamiliar phenomena to appeal to the culturally-lived experiences and values of public audiences (e.g., energy security, environmental protection). However, in effort to gain public legitimacy through ‘unifying strategic narratives,’ media tend to exaggerate opportunities and overlook risks pertaining to new technologies (e.g., see also Jönsson [114]). This in turn can further perpetuate inflated optimism around energy innovations like ES, the implications of which are discussed below.

Positive techno-economic representations of ES align with media profiling of other alternative technologies that challenge the ‘status-quo’ of incumbent, centralized energy regimes [115,116]. However, not all new ‘alternative’ energy innovations share this profile. Public discourse on biogas, for example, has been known to be less challenging of dominant discourse on conventional energy systems [47]. In Canada and the UK, ES media discussions appear to be upholding the perceived ‘transformative potential’ [6] of ES (i.e., to spur fundamental industry change) in the public sphere. This inflated techno-optimism, however, may well manifest into a ‘hype-disappointment’ effect on stakeholder acceptance [116,117]. The US biofuel movement, for example, saw strong initial support for the technology, which quickly turned into scrutiny as costs and risks of the technology were fully realized [47]. Studies on blockchain and hydrogen fuel cells further suggest that such hypes can in fact spur public resistance to change, stall innovation processes, and slow implementation [23,67]. From a transitions standpoint, techno-optimism can adversely affect the perceived legitimacy of the sector, and thus the potential for ES to emerge beyond its current niche space [7]. From a sustainability transformations perspective, exaggerations of ES as a ‘techno-fix’ may also lead to public reliance on technological innovation for solving climate issues [109]. Developers and policymakers thus ought to pay close attention to how ES is positioned in this context, as heightened expectations and associations of ES with transition processes (e.g., policy and infrastructure change) could influence public responses to new deployments.

Variations in framing suggest that national energy and socio-political contexts (i.e., of the political economy) [110] serve to ‘domesticate’ energy innovation in media [62,63,118]. We also observed this finding in our Canadian media analysis [29],

wherein ES framing varied by Canadian province in reflection of local socio-political contexts such as the province of Alberta's position as the country's fossil fuel capital and comparatively greater reluctance to investing in renewable ES solutions. Supporting Ejderyan et al.'s [61] argument on the 'role of context' here, the domestication of ES in news media may influence the way in which publics perceive and adopt emerging applications, such as a newly proposed battery project or compressed-air facility in their communities or daily activities [46,97].

Overall, the techno-economic focus on ES reflects both unique and similar national priorities for ES (i.e., grid modernization, energy security), while pointing to the usual economic priorities and arguments that underpin energy system change debates [62,63,119]. Other media representations (e.g., narratives, buzzwords) also contributed to these effects to support that a combination of domestic structural (e.g., energy resources and production), institutional (e.g., politics and industry), and cultural (e.g., social values and priorities) factors influence the ways in which technologies are framed in the public sphere [118]. For example, a greater focus on ES and climate change in the Canadian sample may emerge from the country's historically poor climate performance [120] and growing public advocacy for robust climate action following recent extreme weather events (e.g., 2016 Fort McMurray forest fires, 2017 Ottawa floods) [121]. Overall, this narrative functioned to convince readers that ES deployment will support the mandate to tackle the national climate crises and preserve the quality of life which Canadians cherish.

By linking ES to national energy trends (e.g., energy decarbonization in Canada) and priorities (e.g., energy security in the UK), as well as national values (e.g., electricity affordability in Canada) and socio-political conflicts (e.g., Brexit uncertainties in the UK at the time), news articles seemed to deliberately construct ES storylines that resonate with domestic audiences. Overall, these findings reaffirm that social constructs play a key role in systems of energy innovation and technology diffusion [122], as they stand to inform the ways in which publics identify with and accept technologies in relation to their domestic circumstances and lived experiences.

5.3 Practical implications of hype and techno-optimism

Instinctively, positive news coverage on ES spells good news for its future in Canada and the UK. However, as inflated expectations and unrealistic timelines begin to meet socio-technical inertia, such as the 'nebula of regulations and investment

procedures' that stalled Hydrostor's underwater compressed-air project in Canada's Lake Ontario [*The National Post*, January 31, 2015], the ES sector may become 'littered with the remnants of grandiose hype and unfulfilled promises' [*The Globe and Mail*, February 5, 2016]. This may in turn compromise the required support for announced projects, public trust in developers, and continued investment in ES [23].

Valence analysis also pointed to a potentially looming hype-disappointment reality for ES, a product of what Bakker & Budde [122] term 'expectations and innovation races.' Positive valence around ES between 2016 and 2017 may reflect a hype that is attracting and mobilizing system actors, funding, investments, policy, and institutional change that would otherwise not have progressed (or at least not as quickly) [72]. Our results suggest that ES hype may have instigated an 'innovation race' in which both new and incumbent regime actors are rushing to deliver a cost-effective solution so as not to be 'left behind' as the world shifts to smarter, more sustainable energy infrastructure [e.g., *The Globe and Mail*, March 28, 2016]. However, this is also very much an 'expectations race' in which public discourse may be as important for driving change as innovation itself – i.e., by holding innovators and governments accountable for delivering their promises to public stakeholders. This 'race' dynamic has been widely observed with electric and autonomous vehicles [122,123,124], resulting in a range of outcomes, from institutionalized innovation activities to public distrust in energy developers [23,71]. Further research on how our results compare to actual ES deployments and utilization in the two countries would provide further insight on this observation.

There are other risks to consider should techno-optimism continue to fuel political debates around ES. In both media samples, debates on governments' handle on ES point to some niche-regime misalignment between 2016 and 2017, particularly at the policy and regulatory levels [7]. From a social acceptance standpoint, this inconclusive discourse sends unclear messages to key stakeholders, which may adversely affect public trust in domestic ES implementation strategies, as well as stakeholder adoption of the technology itself. For example, one ES article noted that 'continued uncertainty around the [UK] Government's energy policy has created a confusing picture for investors seeking a low-risk return,' which allegedly contributed to an 'all time low' ranking for investments in the country's clean energy sector in 2016, following early Brexit debates [*The Independent*, October 28, 2016]. Such discourse echoes the politicization of energy transition activities in the media (as one *Daily Telegraph* article explicitly noted) and reaffirms the complex relationship between

energy and politics in industrial societies [31,110,125] [e.g., *The Daily Telegraph*, May 2, 2017].

Considerations of public distrust in ES actors could be particularly important in the UK, where public ‘trust deficit’ toward energy companies and governments has grown due to perceived profit-driven political motivations behind poorly received energy system reforms [17,71]. Proactively addressing these dynamics with more diverse and transparent coverage on ES development may help to balance technology uncertainties and optimism, thus protecting against hype-disappointment outcomes [122]. We elaborate on this point in our concluding remarks.

5.4 Limitations and future research directions

Given its exploratory nature, our research has some limitations. First, we acknowledge that public discourse is not an exact prism for public opinion, and media research only provides the potential to discover possible social acceptance and system change implications for new innovations. Researchers interested in examining public acceptance of ES explicitly would benefit from qualitative approaches such as national public surveys [70] or in-depth stakeholder interviews [25] to uncover more complete knowledge on perceptions beyond those articulated in media discourse. Second, in recognition of the common methodological shortfalls of media framing research, we used best practices for media content analysis [126,127] by applying an integrated methodology to validate conclusions, developing a detailed codebook, and reporting on several inter-coder reliability statistics [101,102] for additional transparency. Finally, we acknowledge the valuable inquiries that could emerge from using alternative non-traditional media sources, such as popular social media platforms (e.g., Facebook and Twitter). Nevertheless, we found national newspapers to be a suitable dataset for investigating our research questions given their continued influence in thought leadership and agenda-setting [18,19]. There is, however, opportunity to extend our scope here to also capture populist and other underrepresented perspectives that stand to challenge sustainable energy transitions more directly [125].

Further, as the technology matures, researchers should distinguish among the many applications that make up ‘energy storage’ as they will individually possess unique socio-technical characteristics, public acceptance profiles, and social representations – such as benefit/risk frames and narratives [82]. We also encourage researchers to continue: (1) comparing lessons from ES (issues and perceptions at the abstract level) with those of other energy technologies (e.g., wind turbines) that have

attracted controversy (perceived risks/costs vs. benefits, threat to locked-in systems); (2) exploring (as technology and economics improve) how other important socio-technical elements (e.g., financial incentives, payback periods, electricity prices) are shaping social perceptions at various levels (i.e., local, national); and (3) considering, more closely, not only the cross-national differences in energy technology and transition discourse, but also what similarities in these contexts may mean for macro-level energy system change (e.g., global 'shifts').

6 Conclusion

Large-scale adoption of ES could advance more secure, lower-carbon energy systems in Canada and the UK. Given the agenda-setting influence of the media, and the role that public stakeholders play in energy transition processes, the social representation of ES in these jurisdictions and beyond warrants careful consideration. Using an integrated approach, we analyze a rich dataset spanning ten years of ES news coverage in the two countries. Our findings reinforce three observations: (1) that novel energy innovations (in this case, ES) are receiving increasing national media attention [73,81,115]; (2) that techno-optimism may be just as important for, if not more important for, system change than the innovation itself [23, 67,117,122]; and (3) that domestic socio-political factors and national contexts are central to media profiling of this emerging energy innovation (namely, ES) [118]. As one of the first cross-national comparative analyses on ES, our work has helped to unveil national-level variations in ES discourse which provide new benchmarks for researchers and practitioners advancing the technology in Canada and the UK, and perhaps other markets.

We argue that decision-makers and proponents ought to be cognizant of their contributions to the social construction and learning of high-potential technologies like ES. Proponents can leverage public communication tactics to their advantage but should remain conscious of growing public trust deficits in energy stakeholders [17,71] due to inflated promises and unrealistic goal setting for new energy solutions. Governments also ought to focus on enabling compelling yet transparent energy discourse that allows for inclusive policy change in order to restore civic trust and encourage engagement in clean energy development. This will be challenging given conflicting political interests and competing roles of governments in ensuring impartial assessments and building public support for key initiatives. Nevertheless, in an era of 'fake news' and increasing political tensions surrounding energy issues [87,109], we end with a call-to-action to science communication scholars and practitioners to introduce new strategies and greater efforts to:

- construct and circulate productive social representations of energy innovations that resonate with and encourage domestic public participation;
- acknowledge and present the scientific evidence upon which such representations, consensus, and advocacy amongst experts have been established;
- ensure that both the descriptions of energy innovations like ES as well as the motivations and goals for pursuing them are clear and realistic to laypersons; and
- recruit credible and experienced spokespersons (e.g., technologists and industry experts) and leverage trusted media platforms, particularly for high-impact news with wide-ranging implications for diverse audiences.

Given the critical role of media in socio-technical change and the fluid complexity of energy transitions, we believe that both energy scholars and decision-makers have much to gain (and still to learn) from tapping into public discourse on emerging technologies and trends.

7 Appendix [SUBMITTED AS DATA IN BRIEF]

7.1 Codebook

[to be inserted]

7.2 Intercoder reliability results

[to be inserted]

8 References

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