

Fear and loathing of electric vehicles: the reactionary rhetoric of range anxiety

Article (Accepted Version)

Noel, Lance, Zarazua de Rubens, Gerardo, Sovacool, Benjamin K and Kester, Johannes (2019) Fear and loathing of electric vehicles: the reactionary rhetoric of range anxiety. *Energy Research and Social Science*, 48. pp. 96-107. ISSN 2214-6296

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/id/eprint/79180/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

Copyright and reuse:

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

Fear and Loathing of Electric Vehicles: The Reactionary Rhetoric of Range Anxiety

Abstract: “Range anxiety,” defined as the psychological anxiety a consumer experiences in response to the limited range of an electric vehicle, continues to be labelled and presented as one of the most pressing barriers to their mainstream diffusion. As a result, academia, policymakers and even industry have focused on addressing the range anxiety barrier in order to accelerate adoption. Much literature recognizes that range anxiety is increasingly psychological, rather than technical, in its nature. However, we argue in this paper that even psychological and technical explanations are incomplete. We examine range anxiety through Hirschman’s Rhetoric of Reaction, which supposes that conservative forces may oppose change by propagating theses related to jeopardy, perversity, and futility. To do so, we use three qualitative methods to understand the role of range anxiety triangulated via a variety of perspectives: 227 semi-structured interviews with experts at 201 institutions, a survey with nearly 5,000 respondents, and 8 focus groups, all across 17 cities in the five Nordic countries. We find evidence where consumers and experts use and perpetuate the rhetoric of reaction, particularly the jeopardy thesis. We conclude with a reexamination of the policies geared to assuage range-based barriers, which a construction of range anxiety as a rhetorical excuse would render as ineffective or inefficient, as well as future implications for diffusion theory.

Keywords: electric vehicles; range anxiety; reactionary rhetoric; diffusion of innovation

1. Introduction

It has been well established that electric vehicles (EVs) have potentially substantial societal and individual benefits when compared to internal combustion engine vehicles (ICEVs). For example, EVs have several environmental benefits, namely climate change mitigation (1) and the improvement of public health (2). In addition, EVs can help integrate intermittent renewable energy sources and provide grid storage (3,4). Finally, EVs can provide several benefits to individual consumers, such as fuel savings, better performance and noise reduction (5–7). Nonetheless, despite the potential benefits, global EV deployment remains distressingly low, representing less than 1% of the global fleet (8).

Recent literature has investigated the variety of barriers that EVs face, and generally found that typical barriers include price, range, charging infrastructure, and consumer perceptions. For example Sovacool & Hirsch, implementing a qualitative literature review, found that EVs faced a variety of barriers, including price, conflicting social and cultural values, and institutional inertia (6). Secondly many transport economists have attempted to quantify the barriers in choice experiments, typically finding that price, range, and charging infrastructure/time are the most costly barriers (9–12). Other more recent literature have also consistently found similar yet varied barriers. For example, Graham-Rowe et al., utilizing test drives and interviews, found that price, range, aesthetics and symbolic value were the primary barriers to EV adoption (13). Finally, Rezvani et al. conducted a comprehensive literature review, found that price, range, and consumer perceptions and knowledge to be central and consistent barriers, among various others (14).

Thus, range and range anxiety is a prominent fixture in the literature as one of the more substantial barriers to EV adoption. A litany of studies articulate how range poses a barrier to EV adoption, firstly by investigating the technical requirements of an EV (e.g., (15)), or based on the psychology and inexperience of the consumer (e.g., (16)). Curiously, however, the understanding of range anxiety is still nebulous, especially as it continues to persist as a barrier despite the increasing range of EVs, the development of public charging infrastructure, and more consumer education and experience.

Reviewing the literature, we are left with several questions about the nature of range anxiety. Is range anxiety a true barrier to EV adoption? If so, is range anxiety technical or mental, or both? Does range anxiety decrease with experience or not? We argue that these questions cannot be resolved with the current understanding of range anxiety, but instead introduce a rhetorical construction of range anxiety, based on the rhetoric of reaction, which holds that conservative forces and actors will often resist new innovations, social changes, or threats through rhetoric centering on jeopardy, perversity, and futility (17).

In doing so, we apply Hirschman's rhetoric of reaction to individuals in the context of diffusion of innovation (18), specifically, as part of the adoption decision process. We argue that range anxiety mirrors the reaction Hirschman describes in his book (17) and can, at times, be construed as a knee-jerk, polemic reaction, which makes range anxiety more difficult to understand scientifically, as the current literature has attempted. Therefore, this paper aims to explore the use of reactionary rhetoric in terms of individuals invoking range anxiety, utilizing a variety of qualitative and quantitative methods, including expert interviews, focus groups and surveys.

Compared to the current literature, the paper aims to make three contributions. First and foremost, the introduction of reactionary rhetoric to range anxiety gives a better and more comprehensive

understanding of range anxiety, and it offers a novel addition to EV barriers literature. Secondly, rhetorical range anxiety brings a new context to the EV policy debate, since rhetorical performances and narratives about range anxiety may impact the efficacy of policy solutions to the technical and psychological aspects of range anxiety, such as public charging infrastructure investments or education and experience campaigns. Thirdly, we translate the theory of reactionary rhetoric, typically used for reactions to a societal or policy reform, to individual's reaction to an innovation, improving the understanding of consumer motivations to reject or adopt an innovation and provide a better understanding of anti-innovation reaction in the diffusion process.

The remaining paper is constructed as such: first, we review the current understanding of range anxiety, followed by introducing the theory of rhetoric of reaction, and then deducing the rhetoric of reaction to individuals, via diffusion of innovation theory. We then explain our methods before moving onto the results, showing the three theses of reaction in use by consumers and experts in the Nordic region. The paper concludes with a discussion of the future of range anxiety and rhetoric in EVs, and possibilities for future research.

2. Literature review and conceptual approach

In this section, we more comprehensively summarize recent literature on range anxiety, introduce our conceptual approach of the rhetoric of reaction, and lastly adapt its use for the purposes of this study.

2.1 Range anxiety in the academic literature

Range anxiety—the idea that consumers are psychologically sensitive to the limited range of an EV—is fairly well-studied, but as a concept, poorly understood. In our review of the literature, we came across various definitions and uses of the concept of range anxiety. For example, in Franke & Krems (16), range anxiety means a psychological response to the stressful situation of the battery running low (i.e. mostly focusing on the “anxiety” aspect), whereas King et al. (19) use it as a term for when a driver needs to drive a longer distance than the EV is usually capable of going in a single charge like 100 kilometers (i.e. focusing on the “range” aspect), or sometimes a combination of both (20). Thus, in this section, we aim to develop a more complete definition of range anxiety.

On its face, the range of an EV is an obvious disadvantage when compared to a conventional ICEV. Certainly, there is a technical limitation of EVs that restricts its overall utility as compared to an ICEV. Thus, there is clearly a technical component to range anxiety – the simple fact that the range of an EV may be insufficient to complete a trip that a consumer wants to take.

To understand the extent of this issue, a variety of researchers have investigated the capability of EVs to complete consumer trips, as compared to consumer travel surveys. Using an outdated EV range of 100 miles, Pearre et al. found that an EV could fit 95% of consumer's driving needs if people were willing to alter their behavior no more than 10 days a year (15). Even after substantial degradation of the EV's battery, such as 20% capacity loss, EVs can still meet the daily travel needs of over 85% of all U.S. drivers, leading Saxena et al. to conclude that “range anxiety may be an over-stated concern” ((5) at 275).

Moreover, if one were to assume a reasonable amount of public charging infrastructure, then range anxiety is even less of a concern. For example, Zhang et al. found that only 290 charging locations could enable

EVs to cover 98% of all driving in California (and 88% of long distance driving) (22). Similarly, Neubauer & Wood found that even lower speed charging (i.e., level 2 charging) could help EVs come close to a 100% utilization rate, for all intents and purposes, completely obviating range anxiety (20). While there is certainly a technical aspect of range anxiety, with a few exceptions, technical range demand is unlikely to pose a serious barrier to EV acceptance. Thus, we have to conclude that range anxiety is more than just a technical construction, and moreover, that discussions of range in general should keep in mind the overall technical sufficiency of EVs. That is, discussions of range anxiety and valuation of range should be viewed in the larger context where range is technically sufficient.

Of course, such a conclusion is not necessarily novel. With some growing recognition that range anxiety is not based on purely technical travel demand, some researchers have investigated the rationalization behind consumer's insistence on range anxiety as a primary barrier to their adoption. To distinguish between technical and the psychological aspects of range anxiety, Franke & Krems proposed three reference values for range utilization: competent, performant, and comfortable range (16), where competent and performant range focus more on EV's technical capacity of range and actual range in use, respectively, but comfortable range is more psychological, based on consumer's comfort with limited range resources. Additionally, comfortable range underscores a fear that occurs *while* driving, but psychological range anxiety can, and often more typically, will occur before consumers drive EVs, as they *expect* to experience range anxiety.

Either way, if range anxiety culminates as a psychological fear, but not a technical barrier, then it follows that experience with EVs would educate consumers that they could comfortably reach the vast majority of their trips without feeling anxious about the range left in their battery. In support of this thesis, Franke et al. found that after 12 weeks of EV use, the average consumer reduced their range safety buffer from 13.8 kms to 6.9 kms, implying that consumers became more comfortable with the range of their EV and experienced less anxiety (16). Similarly, another study found that experienced drivers in Norway rarely considered range anxiety to be a significant problem (23). Finally, Rauh et al. showed that experience allows EV drivers to be less psychologically stressed by situations when the remaining range of the EV is low, and urged further education and experience of consumers (24).

On the other hand, there is also evidence that experience does not decrease range anxiety or demand for additional range, implicating both the technical and psychological constructions of range anxiety. For example, in another study, Franke et al. found that after 3 months of experience, range was actually mentioned *more* often as a barrier to EV deployment (25). Similarly, Jensens et al. found that experience with EVs *doubled* the valuation of EV driving range, making it the most critical factor for EVs, both before and after experience (26). Buhler et al. also found that limited range was the most discussed barrier by consumers both before and after experiencing an EV, despite the fact that the average trip taken by the participants in their study was only 17 km (27), which conflicts with current understandings of psychological and technical aspects of range anxiety. These consumers may be demanding an increased range for a limited number of long distance trips or for the purposes of reducing daily charging inconvenience, both which are far from irrational, but also cannot be explained by the current construction of psychological range anxiety. Thus, if range anxiety were entirely psychological (or predictable), one would expect the importance of range and range anxiety to decrease in all these situations as consumers became more educated on the technically sufficient range to complete the vast majority of their trips.

Consequently, we conclude that a technical and/or psychological definition of range anxiety is insufficient to explain persistence of range anxiety as a primary barrier to EV deployment. Even when accounting for a psychological construction of range anxiety, Neubauer & Wood found the resulting decrease of an EV’s utility was a relatively meager 6%, resulting in an overall utility of about 80-88% of trips (20), showing that a psychological range anxiety should not be *that* limiting for consumers. And finally, Noel & Sovacool found that Better Place, a business model specifically aimed at conquering the technical and psychological aspects of range anxiety by conspicuously constructing battery-swapping stations and a network of chargers, catastrophically failed in EV deployment in Israel and Denmark, leading the authors to conclude that “range anxiety may continue to be a post-hoc excuse for consumers to reject electric vehicles in order to avoid changing their behavior or desires” ((28) at 384).

In this paper, we elaborate on this argument to demonstrate that range anxiety is, at least partially, rhetorical in nature. We argue that range anxiety is also a rhetorical argument that consumers use when discussing issues not covered by a technical or psychological construction of range anxiety. That is, when the issue is not about the technical sufficiency of the range of the car or the psychological anxiety one feels or imagines when driving an EV, but when range continues to be demanded by experienced users, or as a shortcut to reject EVs.

This rhetorical aspect of range anxiety can culminate in a variety of ways, and we do not mean to argue that any rhetorical use of range anxiety is necessarily bad or wrong. For example, a consumer may argue that an EV *should* be able to drive any and all trips across one or several days (without the perceived inconvenience of daily charging), including even long-distance trips that consumer knows are exceedingly rare, because otherwise the EV is limiting their perceived freedom, as compared with an ICEV, and thus conflicting with the symbolic nature of a car. While an understandable concern, a policy response rooted in either the technical or psychological construction of range anxiety (e.g. an expansive charging network covering 100% of *potential* trips or further experience and education, respectively) is unlikely to be effective.

On the other hand, other consumers may use range anxiety as a reactionary rhetorical device – an often unthinking reaction to oppose EVs without having to give them further consideration. Either way, we believe that investigating the rhetorical aspects of range anxiety may help fill a literature gap in the EV literature, specifically about emotional responses of consumers to EVs (14), the understanding of which is important to developing policies to overcome EV deployment barriers.

In sum, we propose an additional rhetorical construction of range anxiety. However, we do not mean to say that range anxiety is *exclusively* rhetorical, as Table 1 offers a fuller construction of range anxiety. Indeed, there are certainly real technical and psychological aspects of range anxiety, but we only mean to add that there is a rhetorical aspect that is currently overlooked, and likely has an important impact on the policy response to range anxiety. Below we aim to show how reactionary rhetoric can help explain range anxiety as a concept and how it manifests in arguments made by experts and consumers.

Table 1. Three academic perspectives on range anxiety

Range Anxiety Construction	Proposed Definition	Example	Policy Response
----------------------------	---------------------	---------	-----------------

Technical	When range demand is substantially higher than the EV's existing range	Traveling salesman who travels >300 km's each day, or consumers who regularly go on road trips and only own one car	Increase investment in public charging infrastructure, increase range in batteries
Psychological	Range demand below or around EV's existing range, but consumers irrationally worried about going below certain battery percentage or unwilling to adapt behavior (i.e., stop and charge)	A typical driver becoming nervous as battery continues to get lower (despite trips well within an EVs existing range)	Education and experience, possibly investing in public charging infrastructure (for safety net, not for actual use)
Rhetorical	Range anxiety is a rhetoric reaction that "masks" a deeper identity issues related to EVs in general	No direct connection to range, disinterested consumers use range anxiety as excuse to rationalize lack of consideration of EVs (can't purchase an EV due to fear of being stuck in mountains)	Response should be counterintuitively not focused on range, instead focus on other issues (like price or other benefits such as free parking)

2.2 The Rhetoric of Reaction

In order to illuminate the rhetorical aspects of range anxiety, we rely on Hirschman's Rhetoric of Reaction as our theoretical frame (17). To summarize briefly, Hirschman proposed that the reactionary rhetoric of three historical time periods of social reform (the French revolution, universal suffrage and the welfare state) fell within three categories: the perversity thesis, the futility thesis, and the jeopardy thesis (17). The perversity thesis suggests that any action taken to remedy an issue will only exacerbate the problem, similar to unintended consequences or the cobra effect. Or, as Hirschman succinctly summarized it: everything backfires. Secondly, the futility thesis argues that any action taken to remedy an issue will simply fail to effect any change at all, and any change is superficial. Thirdly, the jeopardy thesis contends that attempting to take an action to remedy an issue will pose great danger to some other previous accomplishment (17).

Essentially, Hirschman argued that much of the reaction against the three aforementioned time periods tended to fall within one of these three theses. Also, he argued that typically such reactions were unlikely to be supported by systematic evidence (at least to the extent that reactionaries claimed). As a result, Hirschman believed that if one could identify reactionary rhetoric, one could avoid addressing arguments based on knee-jerk reflexes, and instead move into deeper more evidential issues of the debate.

Hirschman argued that these three theses had a temporal or sequential order in terms of when they are argued in response to the introduction of a societal reform. First, the expected jeopardy would be argued initially, partially because there was a lack of experience on which to base the perversity thesis on. Second, he

then expected the perversity thesis to be invoked, once there are any experiences to lament. Finally, Hirschman argued that the futility thesis would come long after the period of social reform was over, to show that, in the end, the reform had little to no effect in the larger picture after all (17). Likewise, Hirschman argued that these three arguments have distinct appeals.

Generally, reactionary rhetoric is more likely to be used when conservatives are outnumbered – instead of an “all-out attack”, they are forced to rely on reactionary, more nuanced argumentation, a last-ditch effort to appeal emotionally against new reforms. More specifically, Hirschman finds that the jeopardy thesis draws its strength from stereotypes and various myths, which create easy and often subliminal connections with strongly rooted mental images of fear, despite fairly flimsy arguments ((17) at 123). Next, the perversity thesis relies on a perceived arrogance or incompetence of the individual enacting the social reform, drawing on the Greek mythological idea of hubris followed by nemesis, to show how lack of foresight will cause catastrophic unintended consequences. Finally, the futility thesis is founded on a much more cynical perspective, as it contends that any reform is pointless and will fail to change the deeper structure of society.

To summarize, the three theses proposed by Hirschman may be utilized differently depending on both the chronological progress of a proposed reform, and the current context of that debate. For example, the particular thesis used might depend on whether stereotypes, perceived arrogance or cynicism are found within the current context of the debate.

2.3 Conceptualizing the Reactionary Rhetoric of Range Anxiety

As Hirschman originally developed the Rhetoric of Reaction in respect to how conservatives respond to broader and even revolutionary social reforms, much of the literature employing his theory has since focused on the use of reactionary rhetoric in the context of policy implementation and the debates that surround it, such as the use of rhetoric in the Iraqi war or South African economic restructuring (29–31). While these studies find that Hirschman’s theory can explain and exemplify the underlying issues of society and governmental action, here we apply the tenets of reactionary rhetoric to individual consumers (or, at least, perspectives on consumers via interviews, focus groups, and a survey), in response to a particular innovation. As we will demonstrate, reactionary rhetoric can be constructive in unveiling consumer emotions particularly during the knowledge, persuasion, and decision stages of the diffusion of innovation process (18).

In line with previous literature calling for further research into how consumer’s emotional reaction to EVs need to be further explored (14), reactionary rhetoric can explain consumer reaction to innovations. For both EVs in particular and diffusion theory in general, reactionary rhetoric can clarify how and why consumers rationalize their decision to *not* adopt an innovation. For example, incorporating reactionary rhetoric can help diffusion theory overcome pro-innovation bias by taking into account people’s holistic perception of an innovation (positive, negative, or ambiguous), as well increase the understanding of motivations to adopt or reject an innovation ((18) at 109, 115).

Thus, reactionary rhetoric can give insight into the anti-diffusions of innovations, whether it is a reaction to positive innovation such as EVs, or a negative innovation, such as cigarettes. Moreover, given the temporal aspect of reactionary rhetoric, different theses may be used more frequently by different consumer categories based on the progress of the diffusion. That is, the jeopardy thesis is a reaction of the early majority (where the technology is seen as novel and can threaten older innovations), the perversity thesis a reaction of

the late majority (once there is any negative experiences to use as examples), and the futility thesis a reaction of the laggards (once the diffusion nears its end, as the thesis argues that the diffusion would not have changed anything), though it need not be exclusively within these categories.

In doing so, it is necessary to reexamine the three theses from an individual perspective, as we summarize in Table 2. For example, in Hirschman, the jeopardy thesis warned that a new social reform would greatly endanger a previous, hard-won reform. However, from an individual perspective, this is less intuitive. We instead adapt the jeopardy thesis to entail that an innovation, or a policy encouraging an innovation, will pose danger to the individual’s previous lifestyle, or perhaps to the individual themselves. On the other hand, the perversity thesis is more intuitive in its translation to individuals: an innovation, or policy to encouraging it, will make the individual less likely to adopting the innovation or change their behavior, thus making the problem of which the innovation was attempting to resolve worse. Finally, the futility thesis, as translated from a social reform to individual reaction, suggests that an innovation or innovation-related policy will fail to make any difference to the individual’s decision process (despite presumed heavy costs), leading to no change.

Table 2. Synthesizing Reactionary Rhetoric with Perspectives on Innovation

Hirschman’s Theses	Contextual Foundation	Original Social Reform Perspective	Translation into Diffusion of Innovations (and EVs)
<i>Jeopardy</i>	Stereotypes and myths	A new reform will endanger a previous, more precious achievement (e.g. Democracy threatens Liberty)	An innovation or policy encouraging an innovation will pose danger to the individual or their lifestyle
<i>Perversity</i>	Perceived arrogance or incompetence	A new reform, due to unintended consequences unforeseen by incompetent policymakers, will actually make the problem worse (e.g., welfare state incentivizes poverty)	An innovation or policy encouraging an innovation will make the individual <i>less</i> likely to adopt, or make the problem worse
<i>Futility</i>	Profound cynicism	A new reform will expensively fail to make any difference (e.g. French Revolution failed to make a difference in French governance)	An innovation or policy encouraging an innovation will expensively fail to change decision by individuals, failed to “make a dent”

Essentially, we aim to use Hirschman’s reactionary rhetoric to supplement the understanding of how consumers use range anxiety as a negative reaction to the diffusion of EVs. This offers a more nuanced framework to assessing the current barriers to EVs, can help improve policy responses, and provide a deeper understanding of consumer emotions in diffusion theory. In order to do so, we use data from a variety of original methods.

3. Research methods: Interviews, focus groups, and a survey

In order to better understand range anxiety through the conceptual lens of reactionary rhetoric, we investigate electric vehicle adoption in the Nordic region. We present original data collected from multiple methods to ensure a greater degree of rigor, validity, and triangulation, including expert interviews, consumer focus groups, and a survey. Given our focus on rhetoric as well as user (and stakeholder) perceptions, we elected to rely on such a qualitative research design rather than a more quantitative or econometric one. In research methodology terms, our study is exploratory (rather than confirmatory), and it is hypothesis generating rather than hypothesis testing (32), and results should be considered with this in mind. Data collection for all three methods took place from September 2016 to October 2017, and centered on sociotechnical benefits and barriers of electric vehicles and vehicle-to-grid technology, but both the experts and focus group participants discussed topics specific to range anxiety.

First, the authors conducted 227 semi-structured expert interviews with 257 participants from over 200 institutions in the five Nordic countries. A brief summary of the interview participants is presented in Table 3.

Classifications	Interviews (n=227)	Respondents (n=257)	% of Respondents
Country = Iceland (Sept-Oct 2016)	29	36	14.0%
Country = Sweden (Nov-Dec 2016)	42	44	17.1%
Country = Denmark (Jan-Mar 2017)	45	53	20.6%
Country = Finland (Mar 2017)	50	57	22.2%
Country = Norway (Apr-May 2017)	61	67	26.1%
Gender = Male	160	207	80,5%
Gender = Female	40	50	19.5%
Gender = Group	27		
Focus = Transport or Logistics	73	81	31.5%
Focus = Energy or Electricity System	63	75	29.2%
Focus = Funding or Investment	10	12	4.7%
Focus = Environment or Climate Change	12	16	6.2%
Focus = Fuel Consumption and Technology	22	23	8.9%
Focus = Other	13	14	5.4%
Focus = EVs and Charging Technology	34	36	14.0%
Sector = Commercial	68	70	27.2%
Sector = Public	37	46	17.9%
Sector = Semi-Public	40	51	19.8%
Sector = Research	37	39	15.2%
Sector = Non-Profit and Media	12	13	5.1%
Sector = Lobby	23	25	9.7%
Sector = Consultancy	10	10	3.9%

Table 3. Overview of Interviews. Source: Authors. Focus represents the primary focus area of the organization or person in question, sector represents the sector the company was working in (semi-public referring to commercial companies owned by public authorities, like DSOs).

As shown in Table 3, the experts represent a diverse array of stakeholders involved in transportation, energy and the environment. These interviews generally lasted between thirty and ninety minutes, and

participants were asked several questions about the benefits and barriers of both electric vehicles and vehicle-to-grid. Due to the open-ended nature of the semi-structured interview, many of the experts began to discuss a variety of issues related to EVs, including range anxiety. After collection of the interview data, each interview was subsequently fully transcribed, and then inductively coded in NVIVO.

Next, while expert interviews provided in-depth discussion of electric vehicles, focus groups were concomitantly organized in order to complement expert perspectives with the consumer’s public perspectives. In total 8 focus groups were conducted, with a total of 61 participants across six Nordic cities, as shown in Table 4. In addition, two of these focus groups were exclusively a single gender (one all-male, one all-female) and asked additional questions about how gender affects EVs. Each focus group was asked similar questions that were asked the experts, namely about their perceptions of electric vehicles and vehicle-to-grid benefits and barriers to adoption. However, the free-flowing nature of focus groups also allowed the discussion to cover various other topics relevant to range anxiety. Similarly, after data collection was complete, each focus group was fully transcribed and coded.

Classifications	Participants (n=61)	% of Participants
F1: Iceland (Oct 2016)	5	8%
F2: Sweden (Nov 2016)	6	10%
F3: Denmark [Mixed Gender] (Feb 2017)	10	16%
F4: Finland 1 (Mar 2017)	9	15%
F5: Finland 2 (Mar 2017)	7	11%
F6: Denmark [Male] (Jun 2017)	7	11%
F7: Denmark [Female] (Jun 2017)	8	13%
F8: Norway (Sept 2017)	9	15%
Gender = Male	29	48%
Gender = Female	32	52%
Have driver’s license	50	82%
Currently own or have access to a car	29	48%
Experienced an EV	8	13%
Own an EV	0	0%

Table 4. Overview of Focus Groups

Finally, a survey complemented the in-depth qualitative data from the expert interviews and consumer focus groups with more quantitative data. Responses were collected via both a random sample (distributed by Qualtrics) and a non-random convenience sample to target specific populations such as Icelanders or current EV owners. A total of 5,894 responses were collected, however, after filtering incomplete surveys, the final responses totaled to 5,067, nearly evenly distributed across the five Nordic countries. The survey consisted of 44 total questions, and split into 4 sections: including: i) Vehicle History & Background, ii) Vehicle Preferences, iii) Electric Vehicle Choice Experiment, and iv) Demographics. We only present results relevant to range anxiety, and other portions of the survey (such as the choice experiment) are reported elsewhere. Likewise, to provide further context, we also supplement our methods with a literature review of papers related to electric vehicle deployment specifically within the Nordic region.

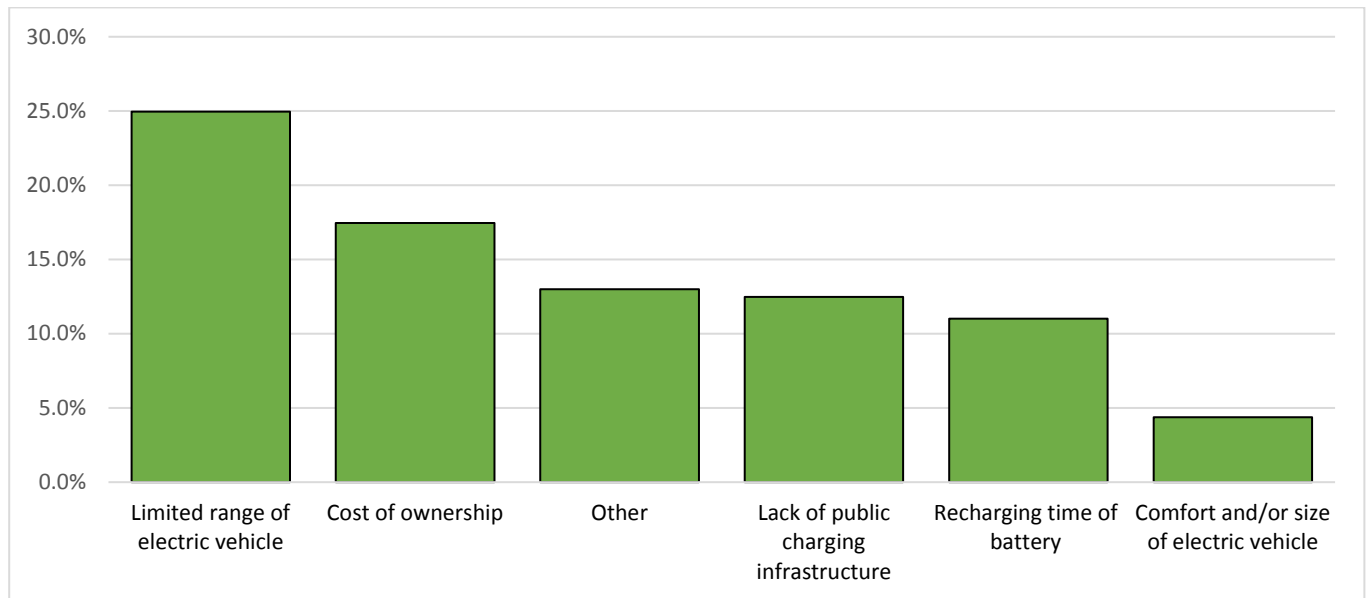
4. Results: Jeopardy, perversity, and futility in EV rhetoric

Given the relatively new emergence of this current generation of EVs in the Nordic region, we would expect the jeopardy thesis to be the most prominent among our sample of respondents. It was, although perhaps surprisingly we also see the perversity and futility themes at play.

4.1 Jeopardy

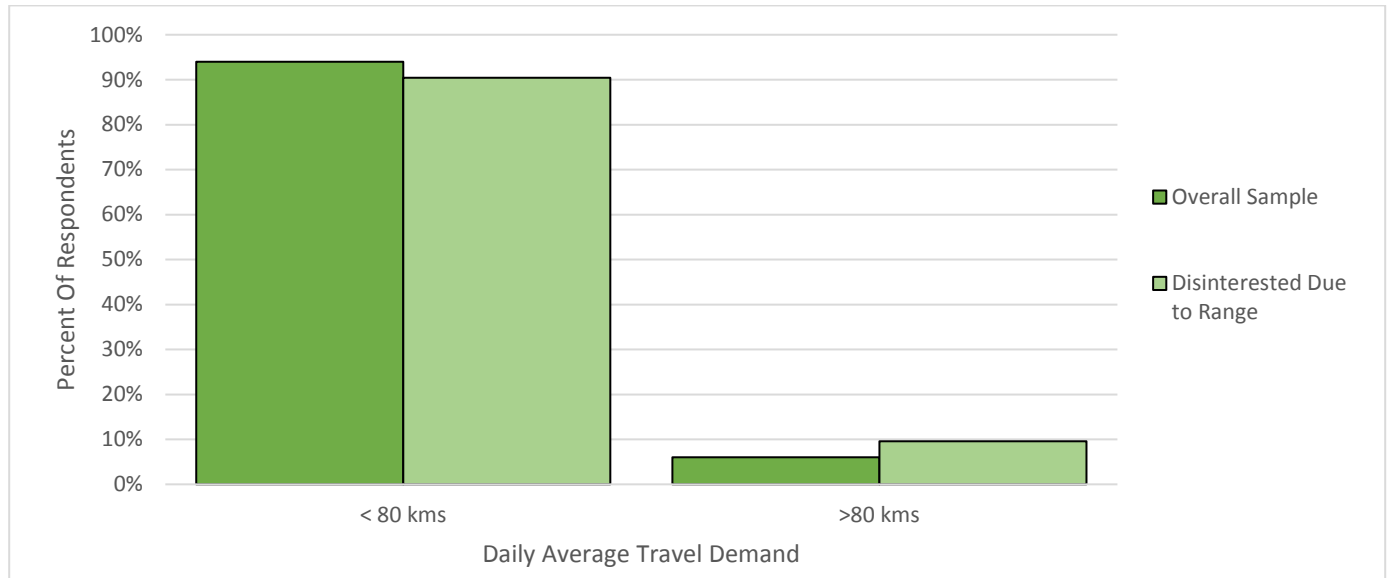
We find substantial evidence that despite considerable developments of battery technology and public charging infrastructure, range concerns continue to be the foremost reason for why consumers are disinterested in EVs, or at least state that they are disinterested. For example, in our survey we found that limited range was the primary barrier for those survey-takers who stated they were not interested in EVs, well more than the cost of ownership or lack of public charging infrastructure, see Figure 1.

Figure 1. Stated Reasons for EV Disinterest (Source: Author's survey). n=963. The "Prefer not to say" option is excluded in the figure.



Though the limited range of electric vehicles was the most prominent reason given for those disinterested in EVs, there was limited statistical difference in their stated travel patterns. As shown in Figure 2, the overwhelming majority of both the overall sample and also those who said they were disinterested in EVs because of limited range drive less than 80 kilometers a day. As one can tell there is a very minimal difference between the two groups, as 94% of the overall sample drove less than 80 km per day (and 6% more than 80 km), while 93% of those disinterested due to range drove less than 80 km per day (and 7% more than 80 km). Since only one additional percentage point of this subsample drive more than 80 kms, we believe that increased daily range demand is not the reason behind why these respondents said they were disinterested in EVs due to range limitations. Moreover, both groups of respondents had an average daily travel demand well below the range of existing EVs (e.g., a Nissan Leaf from 2016 had a nameplate range of 135 to 170 km), even when accounting for a range anxiety "range buffer" of 15 km (16).

Figure 2. Stated Average Daily Travel Demand for Various Subgroups of Survey Respondents. Note: “Overall Sample” refers to the total sample with “Disinterested Due to Range” removed.



While the survey data shows that range continues to be a substantial issue for a variety of groups, despite the literature supposing that experience should resolve both the technical and psychological constructions of range anxiety, the use of rhetorical range anxiety becomes evident in the expert interviews and focus groups. First, however, experts primarily casted range and range anxiety as a psychological barrier, thus moving beyond a technical construction but also not recognizing it as a rhetorical construction. For example, R38 said the main barrier to EVs and range anxiety was the mentality of the consumer, rejecting range as a technical barrier:

“So, I think the important thing is people's mentality, because 95% of all the driving distances, any electrical car that existed from 2009 and forward can make that.”

Likewise, R170 added that the so-called technical barrier of range anxiety was purely psychological that existed primarily within people’s minds:

“It is a major psychological issue, I think. And it doesn’t have to be. That is kind of the point. We made a crude estimate of how much transportation of these could be covered with electric cars, with just overnight charging, and it was about 90%, so it is not really an issue, but in people’s minds it is a major issue.”

Consequently, and in tune with the current literature, many of these experts argued that range anxiety is psychological barrier with an easy solution—experience and education. For example, R48 argued that experience should alleviate range anxiety, based on their own personal experience:

“I remember the first year I was driving it, I had a lot of anxiety. But it is about changing behavior and getting used to it. A lot could also be done for people to try and have an EV for a couple of weeks or a month would also help them overcome those barriers”

Similarly, R69 also drew on their own experiences with driving an EV and believed that range anxiety was purely psychological and due to inexperience, and thus recommended that the solution is simply give consumers the keys to an EV for a few days, or even a month:

“Range anxiety could be a problem, but for us who actually have driven an EV, I mean I’ve driven something like a hundred thousand kilometers for the last four years, and it’s a non-problem. It’s a non-problem. It’s only because they don’t know enough. So, if you give them the key and lend them a vehicle for a weekend, or for a week, or for a month, I would say that they would be convinced it is a non-problem.”

As previously discussed above, however, the literature has found that the importance of range remains very high and range anxiety does not always decrease after experience, despite the technical sufficiency of the range of existing and recently introduced EVs. While it is likely true that the psychological “anxiety” portion of range anxiety would be reduced with experience, rhetorical range anxiety could 1) partially explain why preferences for range remains unchanged after experience, and 2) prevent many consumers from even *trying* EVs and thus preventing the benefits that experience and education would have had.

Instead of range anxiety being a simple misconception that can be easily solved with education and experience we argue that range anxiety exists in a spectrum, with individuals often having a mixture of technical, psychological and rhetorical aspects to their range anxiety. For example, R202 argued that his stepfather opposed adopting an EV because of range, even though he would not even be able to use it:

“The biggest setback for EVs has been the lack of range. But, my take on it is that it’s a matter of perception. My stepfather, he is turning sixty in a couple of years and he always argues that well I can’t have an EV because I need to be able to drive five hundred kilometers, but then I’ll say well you’re pushing sixty, there’s no way going you’re going to be able to drive five hundred kilometers without stopping to pee or have a sausage somewhere, and then you’ll charge your car. So it’s, basically a matter of perception.”

R202’s stepfather poses a mixture of psychological and rhetorical range anxiety—the necessity of 500 km’s range is rooted in the consumer’s “ignorance” that, as R202 perceives, they would never be able to drive 500 km’s without stopping at least once. However, it is likely that the consumer in this example already knows the suitability for daily driving of an EVs, as he is informed by his stepson, or even the superfluousness of requiring 500 km range for most driving, but rather is rhetorically reacting to his son’s pro-EV insistence by requiring an EV to do the exactly same as an ICEV. If so, experience and education of R202’s stepfather is unlikely to convince him of adopting an EV.

Moreover, there already existed two EV with the requisite range, the Tesla Model S and the Opel Ampera-E (both with stated ranges over 500 km), but R202’s stepfather was not interested in these, but later stated that he was interested in purchasing a Jaguar I-Pace (an EV with approximately range of 480 km), reinforcing the argument that it is not range that is the barrier, but some other characteristic, such as brand or conspicuousness, which rhetorical range anxiety is masking. Similarly, even pro-EV consumers may have a rhetorical construction of range anxiety—for example, they may know that an EV can satisfy every day driving, but want more (which we often found in the literature discussed above), in spite of regular evidence it is not necessary, in order to fit their and society’s ideals of what a car *should* be able to do.

Moving onto what the consumers themselves said, we found that the focus group participants also emphasized themes consistent with reactionary rhetoric. First and foremost, since EVs are near the beginning of their diffusion and also because there exist significant stereotypes about EVs (especially as related to range), the jeopardy thesis was most commonly invoked. So, in place of concern regarding the suitability of an EV for average driving, focus group participants argued that it was the hypothetical distant trip that posed danger to them. For example, one participant in F6 plainly states that the potential danger range anxiety poses prevents any further consideration of EVs:

“The thought of an electric car always scares me to think that I’ll be stuck somewhere in the middle of nowhere, with nowhere to charge my car. So, that idea has kept me from considering buying an electric car.”

This concern for public charging infrastructure in mountainous areas conflicts with Figure 1, where charging infrastructure was the 4th most pressing concern. In addition, while it is likely that there are both psychological and rhetorical roots to this concern, this quote, along with ones subsequently presented, show that these consumers are employing the jeopardy thesis reinforcing, at least partially, underlying rhetorical constructions of range anxiety. In parallel, a participant in F8 argued that EVs posed a danger to them in Norway if they got “caught” out in the middle of the Norwegian mountains without any other resources:

“Running out of gas is almost impossible. And running out of electricity is actual possible. And what do you do then? Because when you run out of gas, then you might get someone to buy some gas and give you a can of gas and you can fill it up and you can drive to a gas station, but what do you do with an electrical car? Because you have to charge it. You can’t just bring an extra battery.”

The idea of being stranded was common throughout the all the focus groups. One participant in F4 also worried that they would be stranded outside of the city, which becomes very isolated very quickly:

“Especially if you’re in a part of the country that’s more sparsely populated and you might not have enough battery, you don’t want to be stranded.”

Additionally, some of the experts also recognized similar arguments, focusing on perceived EV inefficiency to safely reach their cabin. For example, experts noted how consumers believed that EVs would not be able to reach the vacation cabin and often invoked the jeopardy thesis of being stuck either on the way to their cabin or at a cabin with no electricity, such as R223:

“Yeah the people that don’t own an electric vehicle, they say I can’t drive it, I don’t have enough electricity, I can’t go to my cabin in the mountain with the car. It will not work because the distance is too long or I cannot charge when I’m in my cabin.”

In response, however, most of these experts, like R240, viewed these claims of not being able to safely reach the cabin as an outdated argument from a technical perspective:

“You know, a few years ago people asked ‘oh with an electric car I can’t go to the cabin or the cottage, I can’t go there and I cannot do this and cannot do that. But now, people know that longer range models are coming, so it is not an obstacle to buy an electric car.”

On the other hand, some other experts also argued that personal experience as evidence that the fear of being stuck in the mountains was overstated. R232 put it this way:

“One of our colleagues was driving to the mountains, and she was testing [her EV], and she, I think she had two kilometers left. And she’s like “okay come on”, but she knew what she was doing, so it wasn’t really a challenge to reach the cabin.”

However, it is not shocking that personal experience finds that there is a potentially easy solution to those invoking the jeopardy thesis, as the invokers are not carefully considering technical parameters, but rather utilizing reactionary rhetoric. Indeed, though there exists a variety of solutions to deftly avoid such a concern, whether the existing range is sufficient, or that consumers could use a second car, purchase a plug-in hybrid, or even rent a car, the argument is utilized frequently without too much additional consideration. Similar to Hirschman’s original contention, we do not mean to argue that the jeopardy does not actually exist, but rather it is being “invoked for reasons that have little to do with its intrinsic truth value, [and doubt] its occurring with the frequency that it is claimed” ((17) at 38).

Though there is little harm in experts being pleasantly surprised that they have so easily crafted a solution to consumers invoking the jeopardy thesis, the worse harm is when experts made policy recommendations in response to this construction of range anxiety. For example, many experts believed that government should heavily invest in public infrastructure, in order to calm consumer’s irrational fear of being stuck, such as R12:

“So, the government needs to start building up the infrastructure, so that people can have peace of mind that wherever they go, they won’t get stuck, their battery won’t get drained and then they are just stuck somewhere.”

If the consumers to whom R12 was responding were using range anxiety as a reactionary rhetorical device, then a policy response based on simplistic technological or psychological constructions of range anxiety would have no impact on those consumers. Indeed, the consumers may continue to invoke the jeopardy thesis regardless, or they may move onto other types of reactionary rhetoric.

4.2 Perversity

Even though EVs are still in the relative beginning of their mass diffusion (entering the so-called acceleration phase depicted by innovation scholars) (33,34), this is not to say that jeopardy is the only thesis that was invoked in relation to EVs and range, though certainly the most pertinent. Moving sequentially through Hirschman’s implied order, the next most logical thesis would be the perversity thesis. Historically, an unintended consequences argument (of which the perversity thesis is a radical version of) has already been made regarding electric vehicles and range: that electric vehicles would increase range and travel demand due to decreasing marginal costs of travel, known as the rebound effect (35). However, given a presumed lack of perceived arrogance or incompetence in terms of range anxiety, we expected that the perversity thesis would not be as widely invoked. Surprisingly, however, several experts made the argument that improving battery technology or increasing experience would actually *increase* range anxiety and subsequent demand for range. Likewise, it is also perhaps surprising that these arguments did not make the logical connection to the rebound effect.

Instead the experts expected that range anxiety may never be solved, because there would never be enough range for consumers, and any improvement to range or consumers knowledge would actually make the need for *more* range clearer. For example, as R211 expects, increasing range of EVs, though already technically enough for the majority of consumers, would not be sufficient:

“One barrier of course is our relationship to the range of the cars. We always opt for “ah we need longer range, we need long range”, and now we have a range up to three hundred kilometers, which is basically enough for lots of customers. But the discussion for the future is do you need five, six hundred kilometers in the future. But if you’re going eight hundred kilometers that’s still not enough.”

Indeed, from a technical perspective, increasing the range from 300 to 500 kilometers captures only a small portion of additional trips that can be made, and may not even convince some consumers that an EV range is sufficient. More explicitly R53 found that experience with EVs also increased demand for range, even though

“In our experiment, even when people see range as a limit, they manage with the range they get. We gave them an e-Golf, which practically got around a hundred and thirty kilometers, even if it’s stated as more. They never had any problem, they managed all the trips, but they still wanted more range.”

This insatiability, we argue, is a type of perversity thesis—that improving the range of the EV, either by battery capacity or public charging infrastructure, or by changing the perception thereof by increasing experience, would actually *worsen* consumer’s demand for range. Though speculative, this version of the perversity thesis may also elucidate the literature finding that range and range anxiety increases after experience.

Experts themselves experienced this version of perverse range anxiety. For example, one expert (R218) told that even their colleague’s Tesla (which often is construed as an expensive solution to range anxiety) was insufficient for their travel demands, disagreeing with their colleague that *“there is no such thing as range anxiety”*. Similarly, R109 described their experience with an EV, noting that despite meeting the overwhelming majority of his trips, the range anxiety became more pronounced:

“You charge mostly in the evening and then you’ve got full battery. And then you can drive around 200 kilometers. And I know it from myself, it’s around 8 times in a year that I drive more than that. But still I have this range anxiety, that ohh, do I have sufficient range? It is a limitation.”

However, given the assumption that the perversity thesis is invoked later in the diffusion process (perhaps most by the late majority), we believe that only first users (like some of the experts we interviewed) would invoke anything resembling the perversity thesis in terms of range anxiety. Hence, one can expect that the more radical versions of the perversity thesis discussed here may be invoked more in the near future once additional resistant consumers gain further experience with EVs.

4.3 Futility

Finally, and most prospectively, there were a few examples of the futility thesis being applied to range anxiety. Because the futility thesis is associated with a reaction at the end of the diffusion process, and also due to the perceived lack of profound cynicism, it is not expected to be widely invoked in the near future. Nonetheless, there are some early examples of the futility thesis as it related to range anxiety.

Arguments that rely on the futility thesis in relation to range anxiety focused mainly on the efficacy of existing public charging infrastructure, which some term as “charger anxiety”—the idea that public chargers have satiated range anxiety but EV drivers are now concerned that the chargers themselves will be too busy. For example, R199 noted that this fear already exists in Norway, based on EV congestion on the way to cabins (seemingly avoiding the warnings of those invoking the jeopardy thesis), which they had heard from word of mouth:

“Norwegians are a nature loving country, and our country side is among, we have the mountain range in the middle. So, in general people enjoy going to a cabin in holidays. That’s when the real challenge are showing up with electric mobility. A colleague of mine told me that 5 EVs were waiting in line for one charger at some point, a few hours up in the mountain. So, if you are the 5th or 6th car coming there and each car is going to use, 30 min, you’re stuck there for 2-3 hours, and they could observe that people were frustrating waiting. There’s a lot of advocates pursuing that developing the charging network is going to be so successful that waiting time is not an issue.”

Similarly, R105 found that although they did not experience range anxiety, they anticipated that charger anxiety may be the next pressing challenge for EVs, partially based on their own experiences:

“I didn’t have range anxiety. There are lots of fast-chargers so I could have stopped for 5 minutes, but I didn’t need to do that. So, the range anxiety disappears. Instead, we have charge anxiety now, that the charger is taken by one or two other vehicles. That’s the biggest issue. But since there are lots of chargers, it’s very seldom a problem. But we are afraid that, when suddenly EV picks up, it’s impossible to know when you will arrive, if you have a meeting or need to visit family. Because you can easily calculate how long time it takes to drive and charge, but you don’t know if the charger is taken. So that’s a big problem right now. Charge anxiety.

Finally, R14 also noted that even when public charging infrastructure was sufficient and EVs can make longer trips, the concern was whether other EV owners would already occupy the charger:

“Now I can drive on a battery a long distance, and then if there is one plug, but if you are already there before I come there, then I have to come half an hour before I can get electricity. And if someone else is also there then I have wait an hour before I can get the electricity. If I can reserve the plug then that’s of course an advantage but then a lot of people will start reserving, so you need to build a lot of plugs wherever you build them so you get definitely people using it.”

The futility thesis can be seen more clearly in the converse of this logic: that even heavy investments in public charging infrastructure does not matter, as some consumers may argue that charge anxiety is just the same as range anxiety and prevents them from purchasing an EV.

While the quotes above describe actual or perceived challenges that need to be addressed (and presumably can be done relatively easily, by building a second charger or having a reservation system), at the same time, one might expect reactionary consumers to coopt this argument saying that despite the expensive costs of developing a network of public charging infrastructure, infrastructure has failed to make an impact due to charger anxiety. While the futility thesis is assumed to be used mostly by the laggards during the end of a diffusion process, policymakers should consider the future claims of charger anxiety on their merits, especially

to avoid a wild goose chase of building the next public charger. Indeed, consumer may continually and simply lament that there is another hypothetical trip that can't be made by either range or charger anxiety.

4.4 Synthesis

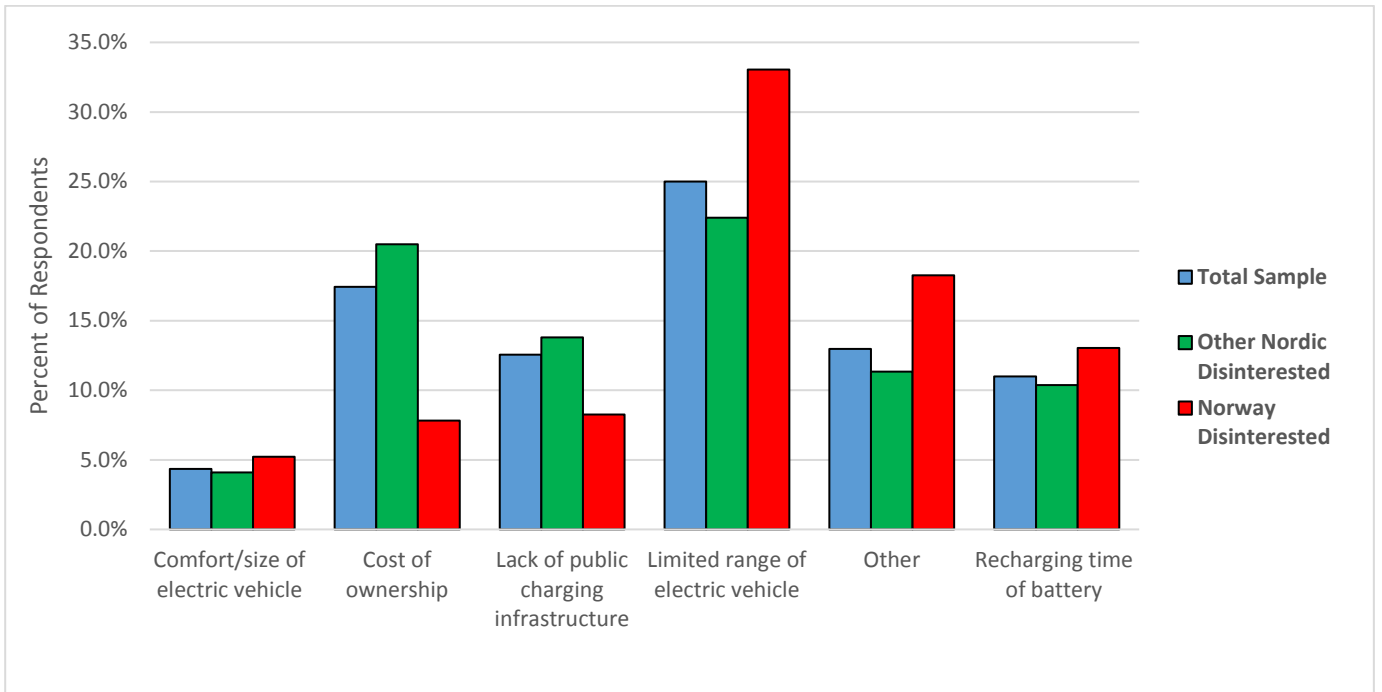
In sum, we have shown that range anxiety currently is, and in the future perhaps will be, used as a reactionary rhetorical device, as summarized in Table 5. We believe that these three theses help categorize current uses of rhetorical range anxiety, as well as prescribe future potential uses. However, beyond recognizing when one of Hirschman's three theses are being invoked, we believe identification of rhetorical range anxiety will lead to better policy making.

Table 5. The Three Rhetorical Examples of Range Anxiety

Hirschman's Theses	Example Applied to Range Anxiety
<i>Jeopardy</i>	EVs lack the range to make safe trips, people fear being stuck frozen in the mountains
<i>Perversity</i>	Range only becomes more important with experience or increased battery technology or charging infrastructure
<i>Futility</i>	Charger anxiety, increased charging infrastructure fails to meet a hypothetical trip, policies are "never enough", will not convince a consumer to adopt EVs

For example, one can use Norway as a case study for ways to address rhetorical range anxiety. Of course, Norway has been lauded as a success story for EV diffusion, based on a variety of policies incentivizing EV adoption (8), but most of which don't directly address range anxiety and instead focus on making the EV more affordable and more convenient. More so, even though Norway tends to drive among the least on an average day as compared to the rest of the Nordics (36), and despite presumably the population have the most experience and knowledge of EVs, we find that Norway has somewhat statistically significantly *more* consumers disinterested in EVs due to range than all other Nordic countries ($t=1.719$, $p=0.0859$), as seen in Figure 3. More tellingly, while Norway has a moderate significance with regards to range as a reason for disinterest, Norway has also substantially *less* consumers saying cost is the reason for disinterest ($t=-3.074$, $p=0.002$).

Figure 3. Reasons for Disinterest, Comparing Norway to Overall Sample and other Nordic countries



An increase in range anxiety in Norway seemingly can not be explained by neither a technical nor a psychological construction of range anxiety, given that the overall average demands of a driver in Norway tends to be the least of the five countries (and our survey found that 90% of all drivers drove less than 80 kms a day), and the fact that Norwegian consumers have had the continued exposure of EVs (presumably increasing EV knowledge). Instead, we theorize that Norway’s policies have instead addressed the actual “valid” sociotechnical concerns, particularly cost of ownership, leaving a higher concentration of those using range anxiety rhetorically.

Thus, if other Nordic countries wish to increase EV adoption, they may find better success ignoring those claiming range anxiety and instead focus on other barriers, like cost of ownership. Concomitantly, Norway’s “secondary” incentives, such as free tolls, free ferries, free parking, could be seen as rhetorical means to “convince” reactionary consumers to adopt the EVs, bypassing an argument over range. As a counterexample, systems that aim to assuage range anxiety exclusively, such as Estonia’s national charging infrastructure (37) or Better Place, result in very limited EV adoption. That is, Better Place sold 400 EVs in Denmark (28), and 26 EVs were sold in Estonia in 2017 (38). To put it strongly, the success of EV adoption may rely on governments ignoring rhetorical range anxiety and instead focusing on other sociotechnical barriers.

In addition, it is worth noting that the rhetorical construction of range anxiety can be connected to a political goal, that is, hampering the diffusion of EVs in general. While many of the consumers may be invoking rhetorical range anxiety to avoid personal changes (i.e., to avoid the idea that EVs damage their identity), other consumers may be using rhetorical reaction as a primarily political means to resist adopting EVs, as it can be seen as a politicized technology. In addition, other other political actors who wish to prevent the diffusion of EVs, such as oil companies, may politicize the rhetorical aspects of range to reinforce consumer resistance and stoke anti-EV notions within the public.

5. Discussion: Beyond Range Anxiety

As EVs continue their diffusion across the population, it is expected the reactionary rhetoric used by resistant consumers will likewise evolve. Not only did Hirschman contend that reactionary rhetoric evolves as a policy is implemented, it is also expected that consumer reactions to an innovation change over time during the diffusion process (17,18). With this in mind, we explore two additional topics here; first, that reactionary rhetoric can and may be used in other arguments against EVs outside of range anxiety, and second, how the use of rhetorical range anxiety influences future uses of reactionary EV rhetoric.

Obviously, range anxiety is not the only potential argument a consumer may pose against EVs (though arguably the most common). Indeed, we found several other examples of reactionary rhetoric being utilized in other aspects of EVs, though they were far less consistently utilized. For example, another common argument was that EVs pose a danger because of the possibility of starting fires while charging, plainly mirroring the jeopardy thesis. For example, R217 noted that the danger of EVs was already causing fear in some consumers:

“And there’s actually been a little bit of fear that people are afraid to have electric cars in the garage, because it would be possible to have a fire, because they have read something about that if you don’t charge correctly the charging cable can overheat and so on.”

Like many uses of reactionary rhetoric, the invoker tends to ignore key facts, such as the greater danger of fire that an ICEV poses, as R42 notes:

“There have been all kinds of newspaper articles about electric vehicles catching fire, and consumers are afraid of fire issues. Even though statistically, petrol cars burn just as much, or even more. But there’s too little information right now, and they don’t really believe it if you tell them, that that’s just a couple of EVs in the whole wide world.”

Another pertinent example of reactionary rhetoric is the use of the futility thesis in terms of the perceived environmental benefit of EVs as compared to ICEVs. That is, some argue that EVs are actually just as polluting (if not more polluting than ICEVs), so there is no point in adopting them. For example, many of the survey respondents who chose the “other” category for reasons of being disinterested in EVs (see Figures 1 and 3) wrote that their reason was due to the worse environmental damages of an EV, the second highest reason behind those who preferred gasoline engines (and excluding those who did not want to buy any car).

Multiple survey-takers wrote that EVs are “*eco-unfriendly*” or that “*electrical cars are very environmental UNFRIENDLY*”. There is a thread of perversity and futility theses, that EVs actually don’t improve environmental performance, or worse yet, worsen the environmental damages from personal transport (despite the fact that the Nordics have perhaps *the* greenest electricity sources for EVs (39)). That is, they invoke the perversity and futility theses by suggesting that EVs, an innovation that seeks to help the environment, fail to do so or worse, actively damage the environment, despite the evidence to the contrary, as Hirschman predicted. We expect that these types of arguments, as well as other reactionary rhetoric, will continued to be used as EVs continue their diffusion process.

Secondly, understanding the ways in which various reactionary rhetoric is deployed across the diffusion categories may play an influential role in understanding the diffusion of EVs (or any innovation). Future research should especially focus on how the use of various theses of reactionary rhetoric may undercut each

other, as Hirschman proposed the simultaneous invoking of the jeopardy and futility theses may impede arguments against the welfare state ((17) at 147).

Similarly, the ways in which rhetorical range anxiety may impede one another may be useful to policymakers or industry to understand the most effective ways to counter reactions against EVs. Additionally, future research should also investigate how other reactions to EVs beside range anxiety may reinforce or impede rhetorical range anxiety. For example, the jeopardy thesis of fires may reinforce the jeopardy thesis of range anxiety, stoking even greater fear that consumers would be stuck in the mountains, only to have their EVs catch on fire. Thus, policymakers should consider both at once to prevent even stronger anti-EV reactions.

Finally, Hirschman also described the rhetoric of progressives, again finding three central theses: mutual support (an additional reform will strengthen previous reforms, the opposite of jeopardy thesis), imminent danger (without an additional reform society is imperiled, also an opposite of the jeopardy thesis), and “history is on our side” (the additional reform is inevitable consequence of societal progress, the opposite of the futility thesis) (17). Though Hirschman does not find an opposite thesis for the perversity thesis, we propose a “spillover” thesis. Essentially, the opposite of the perversity thesis is that a reform would cause substantial secondary benefits in other unintended forms, widely benefiting society in ways unforeseen.

Just as policymakers should be careful to recognize when reactionary rhetoric is being utilized, they should likewise be careful not to fall into tropes when arguing for an innovation, especially if one of the progressive theses in turn provokes a reactionary thesis, as Hirschman implied could happen (17). Certainly, policymaking could use less rhetorical posturing of either kind and a more clearheaded fact-based process of implementing reforms and innovations. Lastly, we call for future research to investigate how progressive theses may be utilized during the diffusion process, for example by change agents, and whether that is effective or causes further reactionary rhetoric on the part of anti-innovation consumers (18).

6. Conclusion

We have aimed to construct a better understanding of range anxiety by drawing from and extending the Rhetoric of Reaction, complementing the current technical and psychological frames existing in the literature. To be sure, we do not mean to impugn those who invoke rhetorical aspects of range anxiety, nor to invalidate any of the concerns they have related to a rhetorical construction of range anxiety. However, we argue that, similar to Hirschman’s characterization of the underlying concerns of the three theses, range anxiety operates as a rhetorical construction that is neither purely technical nor psychological. This yields compelling policy and theoretical insights.

In terms of policy, for example, instruments and incentives based on technical or psychological components of range anxiety (e.g., further investment in public charging infrastructure or education and experience programs) may fail to address the actual concerns of the consumers invoking reactionary rhetoric. As a result, an expensive public charging infrastructure program may have limited benefits of EV diffusion, and consumers may even feel more alienated by the policy, and thus use a different reactionary rhetoric, such as charger anxiety.

Instead, policymakers should consider putting less effort into public charging infrastructure networks and educating consumers (though of course not completely), while also devising progressive rhetorical policy

responses to anti-EV consumers. For example, the Norwegian EV policies may have been successful because they focus on sociotechnical barriers that aren't as rhetorical as range anxiety. As such, they have resolved more primary barriers, arguably the low-hanging fruit, as well as rhetorically "sweetened the deal" for those rhetorically opposed to EVs.

Also, a rhetorical construction of range anxiety especially explains why Norway's non-monetary policies (e.g. free tolls, parking, etc.) may have been successful despite not really addressing range anxiety. In turn, diagnosing rhetorical range anxiety may be vital for other countries to cost-effectively implement EV policies, avoiding over-investment into mid and high level public charging infrastructure (which might not completely obviate range anxiety anyway (20)). Even worse, this over-investment in public charging infrastructure may fuel the futility thesis, as consumers can cite a hypothetical road trip that either the current charging infrastructure does not cover or would not be able to due to charger anxiety. Instead, if range anxiety is comprised of technical, psychological, and rhetorical aspects, then the policy solutions should likewise respond using a *combination* of technical, psychological, and rhetorical methods.

Theoretically, we have merged reactionary rhetoric with diffusion of innovation theory. This combination can help fill the current gaps of diffusion theory, particularly how consumers view innovations and provide novel understanding of consumer's motivations to resist adoption. Also, moving beyond EVs, understanding when and how consumers invoke reactionary rhetoric in a diffusion process may be key to effectively implement certain innovations. As such, researchers should further investigate how rhetoric is utilized in innovation diffusion in order to react appropriately across a variety of different technologies, products, services, or socio-technical systems. The use of the three rhetorical theses likely depends on the progress of the diffusion (i.e., near the beginning or near the end), as well as the context in which the innovation is being introduced (i.e., whether there are rampant stereotypes or perceived arrogance of the diffusor). As such, future research should look historically at an innovation that has completed its diffusion in order to better parse out the distinction between rhetorical and non-rhetoric aspects of resistance, including identification of elements that allow researchers and policymakers to more clearly recognize when rhetoric of reaction is being utilized.

In addition, we believe that reactionary rhetoric need not only be applied to diffusion of innovation and can also be employed in other theories focusing on individuals in a diffusion or transition process. For example, the rhetoric of reaction and the social construction of technology (SCOT), have ready connections, particularly the role of reactionary rhetoric in interpretive flexibility and embedding anti-technology scripts (40,41). Alternatively, reactionary rhetoric can also help explain how users react to innovations during niche development in the multi-level perspective (42,43). It can further offer greater nuance to other innovation study approaches looking at the functions of innovation systems (44,45), or the sociology of expectation (46–48), as it emphasizes either the psychological dimensions of emerging niches, which are only rarely investigated, or rhetorical elements beyond only ideographs or "promises and requirements." As such, we call for future research to apply reactionary rhetoric to other theories examining the role of users in technology diffusion and transitions.

Finally, reactionary rhetoric does far more than merely frame narratives or describe barriers. It can—even unintentionally—undermine and impede transitions to a more desirable future. We are often accustomed to viewing rhetoric as an ornament of speech—sometimes even pretentious, superficial, or unnecessary. This view, however, ignores that rhetoric can reveal fundamental patterns of human reasoning,

and how humans communicate their thinking to others. Berkhout compellingly notes that rhetoric itself can map possibilities and spaces, mobilize capital, and tie stakeholders together (46). We show, particularly when applied to EVs and range anxiety, that it can also impede the adoption of socially desirable innovations. Because the technological landscape is always changing, rhetoric—especially when reactionary—can deeply alter public perceptions of new technologies and how we envision a collective low-carbon future (49).

As such, and critically, deconstructing range anxiety and the reactionary discursive tactics at play can both offer a diagnostic tool (learning from previous visions) and also reveal the vested and even hegemonic interests and power relations underlying them. Doing so will be an elemental part of grappling with future visions and transitions well beyond the domain of passenger transport.

Bibliography

1. Jacobson MZ, Delucchi MA. Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials. *Energy Policy*. 2011 Mar;39(3):1154–69.
2. von Stackelberg K, Buonocore J, Bhave PV, Schwartz JA. Public health impacts of secondary particulate formation from aromatic hydrocarbons in gasoline. *Env Health*. 2013;12:13.
3. Noel L, Brodie JF, Kempton W, Archer CL, Budischak C. Cost minimization of generation, storage, and new loads, comparing costs with and without externalities. *Appl Energy*. 2017 Mar;189:110–21.
4. Kempton W, Tomić J. Vehicle-to-grid power fundamentals: Calculating capacity and net revenue. *J Power Sources*. 2005 Jun;144(1):268–79.
5. Carlsson F, Johansson-Stenman O. Carlsson & Johansson-Stenmen (2003) Costs and Benefits of Electric Vehicles).pdf. *J Transp Econ Policy*. 2003 Jan;37(1):1–28.
6. Sovacool BK, Hirsh RF. Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. *Energy Policy*. 2009 Mar;37(3):1095–103.
7. Sovacool BK, Kester J, Noel L, de Rubens GZ. The demographics of decarbonizing transport: The influence of gender, education, occupation, age, and household size on electric mobility preferences in the Nordic region. *Glob Environ Change*. 2018 Sep;52:86–100.
8. IEA. Global EV Outlook 2017 [Internet]. Paris, France: OECD/IEA; 2017 p. 66. Available from: <https://www.iea.org/publications/freepublications/publication/GlobalEVO Outlook2017.pdf>
9. Hidrue MK, Parsons GR, Kempton W, Gardner MP. Willingness to pay for electric vehicles and their attributes. *Resour Energy Econ*. 2011 Sep;33(3):686–705.
10. Axsen J, Kurani KS. Interpersonal influence in the early plug-in hybrid market: Observing social interactions with an exploratory multi-method approach. *Transp Res Part Transp Environ*. 2011 Mar;16(2):150–9.
11. Egbue O, Long S. Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*. 2012 Sep;48:717–29.
12. Schuitema G, Anable J, Skippon S, Kinnear N. The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transp Res Part Policy Pract*. 2013 Feb;48:39–49.
13. Graham-Rowe E, Gardner B, Abraham C, Skippon S, Dittmar H, Hutchins R, et al. Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transp Res Part Policy Pract*. 2012 Jan;46(1):140–53.

14. Rezvani Z, Jansson J, Bodin J. Advances in consumer electric vehicle adoption research: A review and research agenda. *Transp Res Part Transp Environ*. 2015 Jan;34:122–36.
15. Pearre NS, Kempton W, Guensler RL, Elango VV. Electric vehicles: How much range is required for a day's driving? *Transp Res Part C Emerg Technol*. 2011 Dec;19(6):1171–84.
16. Franke T, Krems JF. Interacting with limited mobility resources: Psychological range levels in electric vehicle use. *Transp Res Part Policy Pract*. 2013 Feb;48:109–22.
17. Hirschman AO. *The rhetoric of reaction: perversity, futility, jeopardy*. Cambridge, Mass: Belknap Press; 1991. 197 p.
18. Rogers EM. *Diffusion of innovations*. 5th ed. New York: Free Press; 2003. 551 p.
19. King C, Griggs W, Wirth F, Quinn K, Shorten R. Alleviating a form of electric vehicle range anxiety through on-demand vehicle access. *Int J Control*. 2015 Apr 3;88(4):717–28.
20. Neubauer J, Wood E. The impact of range anxiety and home, workplace, and public charging infrastructure on simulated battery electric vehicle lifetime utility. *J Power Sources*. 2014 Jul;257:12–20.
21. Saxena S, Le Floch C, MacDonald J, Moura S. Quantifying EV battery end-of-life through analysis of travel needs with vehicle powertrain models. *J Power Sources*. 2015 May;282:265–76.
22. Zhang L, Shaffer B, Brown T, Scott Samuelsen G. The optimization of DC fast charging deployment in California. *Appl Energy*. 2015 Nov;157:111–22.
23. Ryghaug M, Toftaker M. A Transformative Practice? Meaning, Competence, and Material Aspects of Driving Electric Cars in Norway. *Nat Cult*. 2014 Jun 1;9(2):146–63.
24. Rauh N, Franke T, Krems JF. Understanding the Impact of Electric Vehicle Driving Experience on Range Anxiety. *Hum Factors J Hum Factors Ergon Soc*. 2015 Feb;57(1):177–87.
25. Franke T, Cocron P, Bühler F, Neumann I, Krems JF. Adapting to the range of an electric vehicle—the relation of experience to subjectively available mobility resources. In: *Proceedings of the european conference on human centred design for intelligent transport systems, valencia, spain [Internet]*. 2012 [cited 2016 Feb 11]. p. 95–103. Available from: https://www.researchgate.net/profile/Thomas_Franke/publication/257401389_ADAPTING_TO_THE_RANGE_OF_AN_ELECTRIC_VEHICLE__THE_RELATION_OF_EXPERIENCE_TO_SUBJECTIVELY_AVAILABLE_MOBILITY_RESOURCES/links/00b4952530c399ee58000000.pdf
26. Jensen AF, Cherchi E, Mabit SL. On the stability of preferences and attitudes before and after experiencing an electric vehicle. *Transp Res Part Transp Environ*. 2013 Dec;25:24–32.
27. Buhler F, Cocron P, Neumann I, Franke T, Krems JF. Is EV experience related to EV acceptance? Results from a German field study. *Transp Res Part F Traffic Psychol Behav*. 2014 Jul;25:34–49.

28. Noel L, Sovacool BK. Why Did Better Place Fail?: Range anxiety, interpretive flexibility, and electric vehicle promotion in Denmark and Israel. *Energy Policy*. 2016 Jul;94:377–86.
29. Aune JA. The Argument from Evil in the Rhetoric of Reaction. *Rhetor Amp Public Aff*. 2003;6(3):518–22.
30. John Sender. Economic Restructuring in South Africa: Reactionary Rhetoric Prevails. *J South Afr Stud*. 1994;20(4):539–43.
31. Dollery B, Crase L. Rhetorical patterns in the Australian debate over war with Iraq. *Prometheus*. 2003 Sep;21(3):355–63.
32. Sovacool B, Aksen J, Sorrell S. Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy Res Soc Sci*. 2018;In press.
33. Schot J, Kanger L, Verbong G. The roles of users in shaping transitions to new energy systems. *Nat Energy*. 2016 May 6;1(5):16054.
34. Kanger L, Schot J. User-made immobilities: a transitions perspective. *Mobilities*. 2016 Aug 7;11(4):598–613.
35. Greening LA, Greene DL, Di C. Energy efficiency and consumption * the rebound effect * a survey. *Energy Policy*. 2000;13.
36. Liu Z, Wu Q, Christensen L, Rautiainen A, Xue Y. Driving pattern analysis of Nordic region based on National Travel Surveys for electric vehicle integration. *J Mod Power Syst Clean Energy*. 2015 Jun;3(2):180–9.
37. IEA. Estonia 2013 [Internet]. OECD/IEA; 2013 [cited 2018 Apr 16] p. 146. Available from: https://www.iea.org/publications/freepublications/publication/Estonia2013_free.pdf
38. EAFO. Vehicle Stats [Internet]. European Alternative Fuels Observatory Home. 2017. Available from: <http://www.eafo.eu/vehicle-statistics/m1>
39. IEA. Nordic Energy Technology Perspectives 2016: Cities, flexibility and pathways to carbon-neutrality. IEA; 2016 p. 269.
40. Kline R, Pinch T. Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States. *Technol Cult*. 1996 Oct;37(4):763.
41. Oudshoorn N, Pinch T, editors. How users matter: the co-construction of users and technology. 1. MIT Press paperback ed. Cambridge, Mass. London: MIT Press; 2005. 340 p. (Inside technology).
42. Geels FW, Schwanen T, Sorrell S, Jenkins K, Sovacool BK. Reducing energy demand through low carbon innovation: A sociotechnical transitions perspective and thirteen research debates. *Energy Res Soc Sci*. 2018 Jun;40:23–35.

43. Geels FW. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *J Transp Geogr.* 2012 Sep;24:471–82.
44. Hekkert MP, Suurs RAA, Negro SO, Kuhlmann S, Smits REHM. Functions of innovation systems: A new approach for analysing technological change. *Technol Forecast Soc Change.* 2007 May;74(4):413–32.
45. Bergek A, Jacobsson S, Carlsson B, Lindmark S, Rickne A. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Res Policy.* 2008 Apr;37(3):407–29.
46. Berkhout F. Normative expectations in systems innovation. *Technol Anal Strateg Manag.* 2006 Jul;18(3–4):299–311.
47. Borup M, Brown N, Konrad K, Van Lente H. The sociology of expectations in science and technology. *Technol Anal Strateg Manag.* 2006 Jul;18(3–4):285–98.
48. van Lente H. Navigating foresight in a sea of expectations: lessons from the sociology of expectations. *Technol Anal Strateg Manag.* 2012 Sep;24(8):769–82.
49. Brown N, Rappert B, Webster A, editors. *Contested futures: a sociology of prospective techno-science.* Aldershot, England ; Burlington, VT: Ashgate; 2000. 277 p.