Journal of Intelligence Studies in Business

Journal of Intelligence Studies in Business

Publication details, including instructions for authors and subscription information: https://ojs.hh.se/index.php/JISIB/index

Measuring public acceptance with opinion mining: The case of the energy industry with long-term coal R&D investment projects

Kalle Nuortimo[a]*

[a]Sumitomo SHI FW Energia Oy, P.O.Box 201, FIN-78201, Varkaus, Finland; *kalle.nuortimo@shi-g.com

To cite this article: Nuortimo, K. (2018) Measuring public acceptance with opinion mining: The case of the energy industry with long-term coal R&D investment projects. *Journal of Intelligence Studies in Business*. 8 (2) 6-22.

Article URL: https://ojs.hh.se/index.php/JISIB/article/view/307

PLEASE SCROLL DOWN FOR ARTICLE

Journal of Intelligence Studies in Business
Vol. 8, No. 2 (2018) pp. 6-22
Open Access: Freely available at: https://ojs.hh.se/

Measuring public acceptance with opinion mining: The case of the energy industry with long-term coal R&D investment projects

Kalle Nuortimo[a*]

[a] *Sumitomo SHI FW Energia Oy, P.O.Box 201, FIN-78201, Varkaus, Finland*

Corresponding author (*): kalle.nuortimo@shi-g.com

Received 18 June 2018 Accepted 21 August 2018

ABSTRACT New Web 2.0-based technologies have emerged in the field of competitor/market intelligence. This paper discusses the factors influencing long-term product development, namely coal combustion long-term R&D/Carbon Capture and Storage (CCS) technology, and presents a new method application for studying it via opinion mining. The technology market deployment has been challenged by public acceptance. The media images/opinions of coal power and CCS are studied through the opinion mining approach with a global machine learning based media analysis using M-Adaptive software. This is a big data-based learning machine media sentiment analysis focusing on both editorial and social media, including both structured data from payable sources and unstructured data from social media. If the public acceptance is ignored, it can at its worst cause delayed or abandoned market deployment of long-term energy production technologies, accompanied by techno-economic issues. The results are threefold: firstly, it is suggested that this type of methodology can be applied to this type of research problem. Secondly, from the case study, it is apparent that CCS is unknown also based on this type of approach. Finally, poor media exposure may have influenced technology market deployment in the case of CCS.

This paper is the extended version of a paper from the ICI 2018 international conference on Competitive & Market intelligence, June 5-8 Bad Neuheim, Germany.

KEYWORDS Carbon Capture and Storage, CCS, greenhouse gas control, market deployment, opinion mining, public acceptance, web-intelligence

1. INTRODUCTION: EMERGING WEB-INTELLIGENCE APPLICATIONS FOR COMPETITOR AND MARKET INTELLIGENCE

The aim of competitive intelligence (CI) is to analyse and exploit information about a company's competitors and sectors of activity to determine its competitive strategy and to develop new knowledge about its competitors in an increasingly complex and fast-moving economy to maintain levels of innovation and thus gain a competitive advantage (Amarouche et al. 2015). The most popular term used in the literature is competitive intelligence, followed by business intelligence (BI) and market intelligence (MI) (Dutoit 2015).

The lack of sufficient and reliable information sources about competitors can restrict the capability of CI (Xu et al. 2010). Traditionally, information about competitors has mainly been obtained from press releases, analyst reports, and trade journals, and recently also from competitors' websites and news sites. Unfortunately, such information is mostly generated by the company that produces the product; therefore the amount of information is limited and its objectivity is questionable (Xu, et al. 2010). Competitive intelligence is favoured at the expense of strategic management as a field and has evolved over the years as a result of the need for enterprises to scan the complex external environment (Dutoit 2015). Competitive intelligence provides the company with a clearer picture of its competitive environment, while the increasingly frequent use of information and communication technologies (ICT), including online shopping sites, blogs, social network sites, and forums, provides incentives for companies to promote their advantages over their competitors (Amarouche et al. 2015).

Due to the emergence of Web 2.0, including social media, CI now has a potentially wide field for developing new applications. The large numbers of customer-generated product reviews often contain information about competitors and have become an interesting source of competitive and market intelligence to mine (Xu, et al. 2010). Finding the weakness of products from customer feedback can help manufacturers improve their product quality and competitive strength. In recent years, more and more people have begun expressing their opinions about products online, and both the feedback of manufacturers' own products and their competitors' products could be easily collected (Chang et al. 2012).

Several applications have been developed for next generation CI/MI. The opportunities associated with data and analysis in different organizations have helped generate significant interest in business intelligence and analysis (BI&A). BI&A is often described as the techniques, technologies, systems, practices, methodologies, and applications for analysing critical business data to help an enterprise better understand its business and market, and to make timely business decisions (Chen et al. 2012). Opinion mining in product CI was discussed by Amarouche et al. (2015). A system to efficiently analyse patent data, a patent trend change mining (PTCM) approach that can identify changes in patent trends without the need for specialist knowledge, has been proposed by Shih et al. (2010). Market intelligence from microblogs, which have become great sources of consumer opinions, has been developed in the form of compact numeric summarization of opinions by Li et al. (2013), from which the proposed mechanism can effectively discover market intelligence (MI) to support decision-makers. In 2012, Chang et al. introduced Weakness Finder, which helps manufacturers find their product weakness by using aspect-based sentiment analysis on Chinese reviews. In computational linguistics, irony is one of the more challenging topics in sentiment classification, and tools to detect irony were described by Reyes and Rosso in research focusing on identifying key components for the task of irony detection (2012).

This paper describes an opinion mining approach to discover the public acceptance of carbon capture and storage (CCS) technology, in order to highlight influences on long-term R&D strategy. Compared to media images of solar and biomass power (Nuortimo 2017a&b), differences exist, and can be used to highlight the link and differences between existing theoretical base.

2. CASE CARBON CAPTURE AND STORAGE (CSS)

The need to reduce atmospheric CO_2 has resulted in several global agreements (e.g. Kyoto Protocol, 1997; Paris Agreement, 2015), all affecting environmental legislation, technology strategies, and decision-making of individual companies. The large-scale adoption of CCS in combination with increased energy efficiency is seen as one option to halt CO_2 emissions in the short run (Wennersten et al. 2015). Power plants with CCS in addition to large shares of low carbon generators such as renewables would be required to meet the global targets (Brouwer et al. 2015). Carbon capture and storage facilities coupled with energy efficient power plants would provide a strategy to permit the continued use of fossil fuels whilst reducing CO_2 emissions. The CCS process includes three stages of capture and compression of CO_2 from power stations, transport of CO_2, and storage away from the atmosphere for hundreds to thousands of years (Hammond et al. 2011).

However, regardless of the potential, the technology deployment has not been realised due to lack of economic incentives, regulations, and public acceptance (Nuortimo 2012). Technologies have been connected with societal controversies in the past; for example, nuclear power and gene technologies have been surrounded by dispute, potentially causing public rejection. Past rejection of technologies by the public emphasises the urgency to understand the psychological features of societal acceptance of technologies (Gupta *et al.* 2012). Public acceptance of technologies such as CCS is crucial for successful introduction into the society (Huijts et al. 2012). In this study, the media image of CCS, especially in social media (SoMe), was studied to find possible implications for public acceptance of CCS technology. This was done by reviewing the relevant CCS discussions and studying the media image of CCS from 2014 to 2016. The main research question is formulated as: what is the media image of CCS and its possible implications for public acceptance, and, furthermore, how does this relate to coal combustion technologies in general?

This paper is organised as follows. First the literature is analysed in terms of the important aspects of CI/MI tools and developments, case CCS and related public acceptance and market deployment, and subsequently with application of the new method, opinion mining with machine-based media analysis. A possible link from media image to product market deployment is suggested in the discussion section. Then follows the methodology section, including explaining the learning machine-based media analysis that was used to demonstrate the importance of visibility for technology acceptance. Finally, discussion, conclusions, and policy implications are presented. This methodology is rather new and experimental, but its main contribution is highlighting the paradigm shift from human-made media analysis to machine-made analysis with a multidisciplinary approach, and describe its possibilities in technology intelligence, especially in weak-signal detection related to long term R&D strategy decisions.

2.1 Public acceptance of CCS

The viability of CCS, or any other technology, is influenced by economic, regulatory, and technical aspects, but also by public acceptance. Public acceptance of CCS is seen to depend on people's sense of trust in stakeholders and not solely on the properties of the technology itself. (Terwel et al. 2011). The size of the project and local history as well as trust in stakeholders may influence local public acceptance of CCS (Dütschke 2011). Trust in organisations also affects people's perceptions of the magnitude of risk and the benefits as well, impacting their acceptance of CCS (Terwel et al. 2009). Similar logic has been presented, for example, for public acceptance of gene technology (Siegrist 2000) and also for nuclear waste where overwhelming political opposition has been fueled by the public's perception of risks (Slovic et al. 1991).

Education about CCS can also affect public acceptance by highlighting qualities of the technology that the public finds acceptable and thereby reducing fundamental opposition (Itaoka et al. 2004). Public acceptance of different CCS elements— namely plant type, transport, and storage—may, however, be different, as Wallquist et al. (2012) indicate. Pipelines, for example, may result in lower acceptance, whereas storage location can have the least influence (although environmental legislation practically prohibits land storage in Europe), and plant type some influence. Itaoka et al. (2009) indicate that different factors, including risks, effectiveness, responsibilities, and fuel use, have varying impacts on CCS acceptance.

Lay attitudes toward CCS are also seen as relevant, and the lack of public acceptance is seen to potentially reduce the viability of CCS severely (Terwel et al. 2009). In fact, people's acceptance is seen as critical for the widespread deployment of any low-carbon technologies to become viable options for reducing CO_2 emissions (Fleishman et al. 2010). The way CCS might contribute to reducing the impact of global warming is unclear, even to those who believe they have a good understanding (de Best-Waldhober et al. 2009). This is interesting, as many studies indicate that awareness of the necessity of preventing global warming can be crucial to the acceptance of CCS (Itaoka et al. 2009; Tokushige et al. 2007)

Past examples exist for lack of public acceptance being a major hindrance for developing new energy infrastructure cost-effectively, affecting many technologies, including nuclear (Grove-White et al. 2006), CCS (Bradbury et al. 2009), wind farms (Firestone and Kempton 2007), gene technology (Siegrist 2000), nanotechnology (Siegrist et al. 2007a), and many others. Public acceptance in these cases is typically affected by fears of radiation (Kim et al. 2013), CO_2 being released from the ground and causing suffocation (Wallquist et al. 2009), potential noise or threat to animals (Wolsink 2007), and unknown consequences (Zechendorf, 1994; Siegrist et al. 2017b).

Public acceptance is somewhat an unknown factor in developing public policy for CCS technology (Itaoka et al. 2004). Only educating in order to increase public awareness of need for mitigating CO_2 emission would not directly increase the acceptability of CCS (Itaoka et al. 2004), but information may increase support for some aspects of the technology, such as storage options. On the other hand, information on CCS may in some cases result in stronger opposition (Palmgren et al. 2004), particularly against geological storage under the ocean. It is noteworthy that public acceptance depends on information sourced from different actors, especially people's influence on each other, emphasizing trust (Huijts et al. 2007). International examples may also be required to enhance confidence and trust in CCS, as public acceptance is seen as a requirement for market deployment (de Coninck et al. 2009). In fact, high public acceptance is seen as one of the critical factors for widespread deployment of various CCS projects (Zhang and Huising 2017).

Public acceptance is seen as one of the important obstacles for CCS implementation, along with a lack of policy framework, costs, and international regulatory framework, a factor that is seen to potentially have the biggest effect on commercial success (Gough 2008). In some ways, however, public acceptance is viewed among other uncertainties surrounding CCS (Lohwasser and Madlener 2012). Benefit and risk perceptions are seen to influence on the progress of the technology (Wallquist et al. 2010).

Wüstenhagen et al. (2007) describes three types of public acceptance to highlight different aspects of market deployment, namely socio-political acceptance, market acceptance and community acceptance. Bell et al. (2007) note how public acceptance can have multiple dimensions by indicating that the acceptance of generic technology might be very different from that of local projects. Regardless of general acceptance of CCS, 'not in my backyard' (NIMBY) attitudes can appear when facilities are proposed close to one's own communities, yet attitudes about CCS are based on concepts and perceptions, not on actual past events, making the possibilities of comparing NIMBY attitudes to other energy industry developments somewhat limited (Krause et al. 2014).

Although there are many CO_2 storage sites available, the possibility of CO_2 leaking from the storage area has affected public opinion towards the technology. Wallquist et al. (2011) found the NIMBY attitudes to exist towards both CO_2 pipelines and storage sites. Such attitudes persist regardless of techno-economic aspects favouring the large technology market deployment of near-zero CO_2 power production in the medium term (10-20 years). Due to public fears, CCS market deployment in the form of building a commercial-size demonstration plant (for example oxyfuel technology) has been delayed (Santos 2015). The situation has been seen to have strong linkages to public acceptance and as well as to political decision-making.

CCS technologies have been increasingly communicated during their development, starting from the early 2000s (Ashworth et al. 2009). The topic has also attracted, to a lesser extent, attention on social media. Due to the fact that CCS technology is still under development, its commercialisation is dependent on public opinion and on related media communication.

Market deployment includes the actions towards managing organisational resources in the marketplace (Slotegraaf et al. 2003), and deployment is the next step after the R&D activities in the product cycle (Midttun and Gautesen 2007). Various factors (political, technological, financial, etc.) can promote market deployment.

CCS market deployment necessitates achieving effective emission reduction incentives alongside public-private funding for R&D (Gielen et al. 2014). From the technological perspective, the energy mix and ambitious CO_2 reduction targets impact market deployment, whereas should coal be part of the energy mix, CCS is seen as the only technological solution worth deploying (Folke et al. 2011).

Investment costs and CO_2 allowance prices strongly influence the market deployment of coal-fired CCS power plants (Lohwasser and Madlener 2012). Money is an important factor in the market deployment of new energy industry solutions that necessitate private finance (Mathews et al. 2010). Market deployment of new technologies such as CCS requires significant investments and entails some technological risks to demonstrate their viability (Burnham et al. 2013).

Attracting the attention of government and industrial sectors is important for CCS market deployment since incentives, financial support, the regulatory system, and venture capital require widespread participation of government and businesses (Dapeng and Weiwei 2009). Complementary policies and incentives are seen to impact market deployment (Grubler and Riahi 2010). Systemic policy strategy is necessary for market deployment to overcome any technology barriers and manage the risks (Åhman et al. 2013). Different types of policies are potentially needed for supporting low-carbon technologies along with the technology maturity to support the level of market deployment (IEA 2010).

Because it comprises the measures that aim at promoting energy technologies from early research to market deployment, an energy technology policy is needed (Ruester et al. 2014). Initiatives such as the Strategic Energy Technology Plan, the technology pillar of the EU's energy and climate policy adopted by the European Union in 2008, are the first steps toward establishing an energy technology policy for Europe. This type of initiative may eventually result in market deployment of key low-carbon technologies at the European level (Fütterer et al. 2014).

Market deployment is potentially hindered by the commonly understood fact that it typically takes some thirty years for a new technology to materialise and to build the necessary expertise, capacity, and knowledge (Kramer and Haigh 2009). Further, those R&D efforts that focus on technologies with modest potential for mitigating climate change result in market deployment initiatives for technologies to remain fragmented (Grubler and Riahi 2010). In the case of CCS, the time is now critical for the potential market deployment (Maddali et al. 2015). Market deployment takes its time as the extensive number of wells required for global scale deployment of CCS limits the possibilities of deploying CCS on a wide scale in a rapid manner (Maddali et al. 2015).

Public opinion and attitudes are reflected in political decision making, impacting policies, regulations, and even finance. Hence, the realities of CCS market deployment can be affected by the public accepting the technology.

2.2 Research methodology

This study is a first attempt to study media image, public acceptance, and product market deployment by first studying the literature and then comparing the results to findings from empirical analysis through opinion mining with learning machine-based media analysis of a vast number of editorial and social media sources. Therefore, this work is not directly related to one specific field of study; supporting literature is gathered from CI/MI and technology intelligence methods, as well as from corporate decision-making, and is used to describe a possible link from SoMe users to possible effects in company management. The basic research principles have been used in different fields, but are now applied to a single case; in the same way, public acceptance studies have been carried out on other topics using media analysis but with much smaller data sets. Bursher et al. (2015) applied a similar approach with editorial content media framing and sentiment analysis by software. In this study the application of media framing, cluster analysis and statistical methods were considered to be non-applicable. This is due to the comparison of editorial content with social media and to the fact that media frame comparability between two different types of communication is challenging with a large amount of data. Hence, the learning machine-based media analysis is applied in this study to demonstrate the importance of visibility, whether it would be a driver for technology acceptance, namely public acceptance and product market deployment, or not.

The main reasons for choosing the opinion mining approach along with the learning machine-based media analysis method was its applicability to large global data sets (both from editorial content and SoMe), fast data processing, and reduced risk of bias caused by human perceptions and interpretations (Matthes & Kohring 2008). The analysis period and data for this study covers one year, including a major international climate conference, the Paris COP21. Much narrower sentiment analyses have previously been carried out in the field of marketing, yet this study applies the existing elements in a new way. The users of the social web now have a new role as data providers, which seems to provide an excellent platform for analysing public attitudes (Penalver-Martinez et al. 2014). By adopting a media analysis approach and a particular tool, the quantity of media sources to be analysed is drastically increased compared to questionnaires and interviews or traditional media analyses. Merely relying on qualitative methods such as research interviews would entail challenges, compared to a global media coverage study. For example, responses can be difficult to code and answers may vary by participant, while respondents can provide socially acceptable responses, telling what is considered acceptable, to the researcher (Sovacool et al. 2012). The analysis in this study was conducted to clarify the social acceptance status of CCS technology in order to investigate the possible connection to recent challenges in technology market deployment. The analysis findings were synthesised to obtain a clear view of the effect of media image, resulting social acceptance on CCS technology development, and related market deployment. Hence, the research setting in this article is media analysis, where media sentiment is analysed to discover possible implications for public acceptance, political decision-making, and technology market deployment.

The methodology used in this study can be considered a fairly new method in media research, especially in a comparison of global editorial media and global social media. In the past, some attempts have been made to create an automated tool for analysing nuclear power acceptance (Reis et al. 2011), but media sentiment has not been clarified to this extent. This study relies on commercial software to mine the opinions relating to CCS, a similar method to that applied by Bursher et al. (2015). Opinion mining can be seen as a highly active research field consisting of natural language processing, computational linguistics, and text analysis technologies with an aim to get various added-value and informational elements from user opinions (Penalver-Martinez et al. 2014).

The analysis was conducted to clarify the CCS technology's media image. Also, the potential effects on social acceptance of technology and its commercialisation were highlighted by comparing literature to data analysis. Hence, the research setting used in this article is media analysis for one case, which is then compared to different, similar analyses (Nuortimo 2017 a&b)

M-Adaptive software is used as the main tool in the learning machine-based analysis of global editorial and social media (SoMe) sources. In this study, the M-adaptive sources cover 3 million social media platforms globally and 100,000 news outlets in 71 languages in 236 regions (M-Brain 2015). Sentiment analysis was carried out based on a combination of linguistic knowledge and human-aided machine learning, which means that the software suggested classifications to researchers who then provided feedback on correctness. By repeating this process a number of times the system learned to improve its classification of content into sentiment categories (M-Brain 2015). In practice, the sentiment-coding expressions in the text were first recognised and classified automatically. The software matched all relevant CCS-related documents after which the sentiment-focused types were assessed, while the overall compound judgement displayed four options: positive, negative, neutral, and mixed. Data analysis was conducted from 4 December 2014–28 February 2016, by searching 'Carbon Capture Storage' and 'CCS', which included a total of 4496 data points (3380 editorial/1116 SoMe).

According to M-Brain's internal tests, 80 percent of the sentiments are correct on average for a given document when using the M-Adaptive software. Hence, it is possible that the system may make a mistake with any given individual document, due to inherent ambiguity in natural language. Further, it is widely known that humans do not agree 100 percent in similar tests either, due to some individuals not being capable of identifying humour or sarcasm. As is the case for any artificial system, humour, sarcasm and irony are beyond the system's abilities to understand. However, catching the trends in the data becomes more accurate as the number of analysed documents increases, meaning that with large volumes, the overall model qualitatively matches human judgement on the same data.

3. RESULTS OF MACHINE-AIDED MEDIA ANALYSIS OF CCS TECHNOLOGY

The large number of data points enabled the analysis of media sentiment towards CCS. Figure 1 depicts overall sentiments towards CCS in both editorial publications and social media.

The number of hits for CCS (4496) was low compared, for example, to wind power during

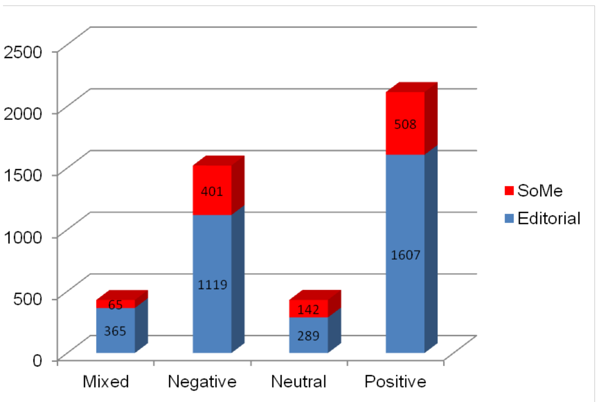

Figure 1 Sentiment analysis of social media and editorial publications.

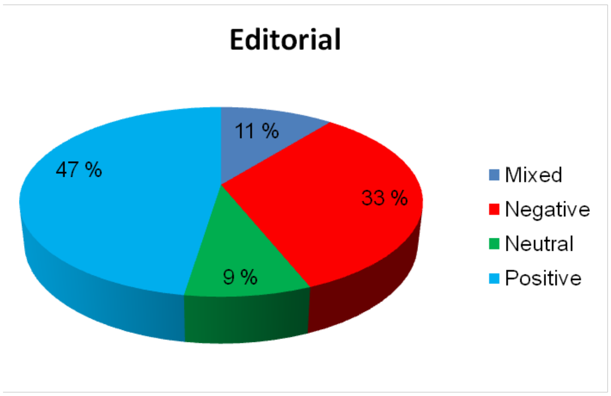

Figure 2 Sentiment analysis of editorial publications.

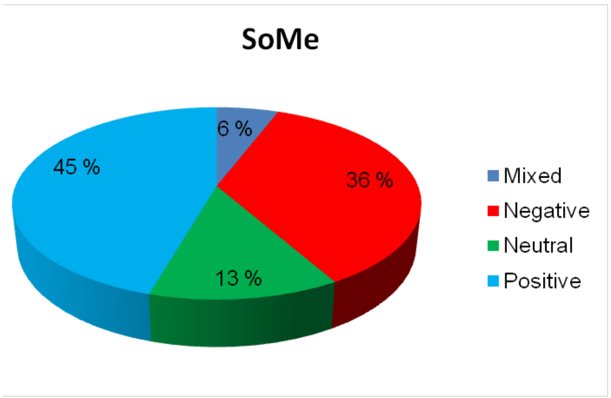

Figure 3 The media sentiment of CCS in social media.

the same period (76,819), indicating relatively low visibility of CCS in the media. The results show that CCS resulted in positive hits mostly in editorial publications but also in social media. Nevertheless, a larger proportion of negative hits in social media indicate lower levels of public technology acceptance. Additionally, the number of SoMe hits is smaller compared to editorial hits, which also indicates less exposure to the general public. Further analysis shows that 33% of hits in the editorial publications were negative and 47% positive, indicating relative technology acceptance among scientists, experts, and journalists. The number of mixed and neutral hits is relatively small, which seems to indicate a consensus towards CCS (Figure 2).

Attitudes in social media appeared somewhat different compared to editorial publications. Figure 3 indicates that public sentiment toward CCS in social media is also mostly positive (45%) with only a minor 2% difference compared to editorial publications. The amount of negative hits was 3% higher than in editorial publications, indicating a bit more negative attitude. In mixed hits the difference was 6-11%, which can be seen as an indication of stricter view expression in social media. However, the 4% more neutral hits seem to indicate that some groups have not yet firmly fixed their attitudes, which can be considered an indication of a need to increase communication efforts in SoMe.

Figure 4 illustrates the social media sentiment of CCS across different media. Dividing the social media sentiment by media type reveals that blog writing has attracted most of the social media attention with over six hundred hits, of which the largest share is positive towards CCS. Also Facebook has been active with over 250, mostly negative, hits. Due to a more visible number of negative hits, the social media effect can be considered quite large when public opinion towards technology is formed.

In Figure 5, media sentiment in selected countries is presented. In Germany, France, and Finland, the sentiment was more positive than in China or Australia, emphasising the need for further communication efforts.

Relevant international events may also influence the appearance of pertinent writings in the media and media sentiment at the time. For example, during the Paris COP negotiations from 30 November to 12 December 2015, a total of 279 hits appeared in the media. The media attention towards CCS was

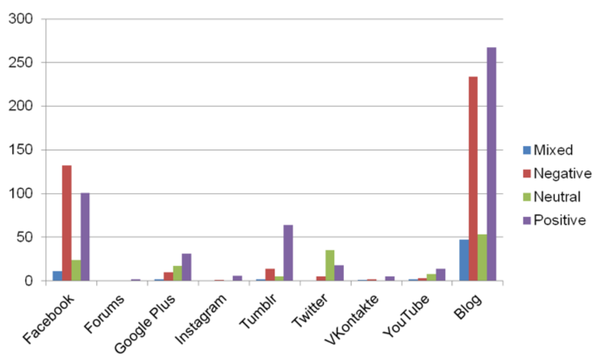

Figure 4 Social media sentiment of CCS across different media.

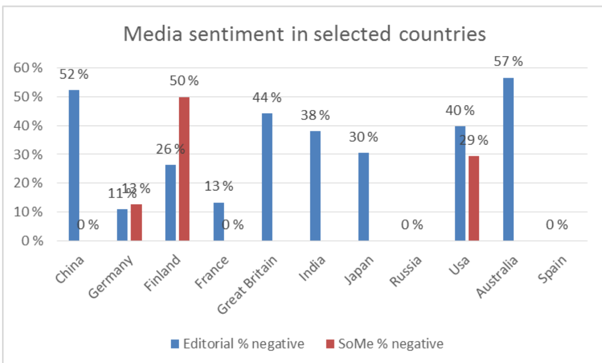

Figure 5 Negative sentiment percentage in selected countries.

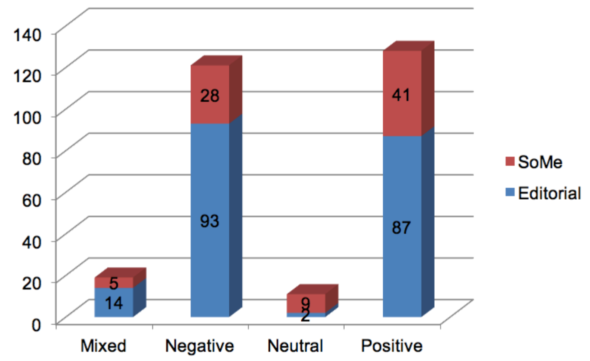

Figure 6 Media hits during Paris COP 30.11-12.12.2015.

approximately doubled during these two weeks compared to an average of 300 hits a month (Figure 6) (calculated as monthly average over 15 months).

Aside from the visibility of CCS being relatively low, it was evident that the editorial hits during the meeting were more negative than usual with 47% negative hits for CCS, while the same for SoMe was only 34%. The normal 15-month averages were 33% and 36%, respectively. The percentages of positive hits during the Paris COP negotiations were 44% and 49%, respectively, while the 15 month averages were 47% and 45%.

4. DISCUSSION

This paper describes the media image of CCS technology, with possible implications especially from SoMe for public acceptance and product market deployment, by synthesising a possible literature-based connection and demonstrating the role of visibility of CCS technology via advanced media analysis. When comparing the literature and empirical findings, the following can be observed. CCS has smaller media exposure with a more positive image. According to some communications theories, large media exposure can have some effect, whether positive or negative; small exposure maybe doesn't affect at all, and small attention is transferred to be negative—if something is unknown, it has more associated risks. Here, this is visible via the number of hits through various media-channels, especially in the editorial/SoMe ratio. When comparing CCS to the case of biomass, CCS also has a positive image with a small number of hits, making the impact smaller. In the case of CCS, one of the main findings is that it is rather unknown, which is the worst case, because people can be afraid of what they don't know. This is evident both from literature as well as from our analysis, therefore partly validating the method used.

In the case of CCS, both communication and corporate stakeholder literature prove beneficial for explaining the phenomenon. For example, traditional stakeholder salience theory does not fully take into account general public attitudes, which can influence corporate decisions both directly and indirectly. In the case of CCS, it is evident that: 1) Literature states that CCS is unknown (Wallquist et al. 2011), which is empirically true due to low numbers of media hits. 2) PR-communication theory implies that if technology is unknown, it can have poor acceptance (McCorkindale et al. 2013). This is evident via the opposition to end storage in different countries and single projects. Also, empirical country by country analysis indicates a high percentage of negative hits in countries with no deployment, such as Australia, and also a high percentage of negative hits in SoMe, such as in Finland. 3) Communication has been intra- and interspecialistic (Ashworth et al. 2009). This follows the funnel model by Bucci et al. (2008). This is empirically visible via the low number of hits, indicating the urgency to increase communication activities to the general public already in the beginning of the product development cycle. 4) Poor media image can possibly have an effect on technology market deployment in the case of CCS. This can be deducted from points 1–3. 5) Means to measure media image have previously been challenging to apply to large global data sets. This study incorporates a new method, opinion mining approach including machine learning, which is tested and found applicable for fast large data-set sentiment analysis.

The total media sentiment relating to CCS was found to be generally positive based on the analysis due to a relatively large number of positive editorial hits, among the rather low media visibility. In the social media, the sentiment seemed to be a bit more negative. For example, Facebook appeared as a platform with active discussions concerning CCS with over 250, mostly negative, hits. The appearance of CCS in various platforms used by the public highlights the role of social media in shaping opinions.

The sentiment also varies by country, as, for example, Germany and France had positive attitudes, whereas Australia had a negative media sentiment, with no deployment of the technology possibly twined with the sentiment. The sentiment can also vary among the type of media, as, for example, in Finland, the editorial content was seen to be more positive than in the social media. The general attitude towards the technology may differ from the local as for example in Germany, it seems that NIMBY is large, regardless of positive general attitudes in both editorial and SoMe content, and as projects have been cancelled due to challenges in finding end-storage sites. Such matters are not directly visible in media analysis and therefore this is a limitation of the utilised methodology. The analysis, however, indicates that general public opinion can be an important factor for public acceptance, and derived from that aspect, also for political decision making. Hence, from the perspective of market deployment, it seems that the more editorial and SoMe content CCS can obtain the better, to counteract the status of being unknown, whereas all possible scientific, technical, marketing and PR communication efforts are important for CCS market deployment, especially those targeted to the general public.

The media sentiment toward a technology can be affected temporarily by relevant international events, such as the global climate negotiations, Paris COP 21, during which the media sentiment seems to be influenced in one way or another. In this case the effect towards CCS by the editorial publications was mostly negative.

Although the needs of CO_2 reduction and the related agreements are of a global nature, technology commercialisation is influenced by regional politics and legislation. It is to be noted that local NIMBY attitudes are not necessarily clearly visible by using the approach in this study. Any discrepancies between media sentiment and the actual project implementation seem to be a clear indication of stronger NIMBY attitudes.

It would seem that one of the main benefits of the study lies in discovering global trends and technology development directions with a larger data set than previous studies, and also trying to establish new methodology for big-data-based media research. Also, this study highlights effectively the differences in channels of communication that may affect public acceptance and perhaps political decision making. The role of SoMe is continuously increasing and presents a challenge for technology developers. It seems that at some level, a speculative negative link from public acceptance, economics, and policies to technology market deployment might exist in the case of CCS.

Another contribution of this study lies in incorporating a method formerly utilised mainly for marketing purposes to study media image and, furthermore, trying to find correlations to public acceptance of CCS, therefore bringing a new angle to related media and social acceptance issues. This is a new approach compared to questionnaire- or interview-based studies with moderate data sets of some hundreds of data points that are used in similar studies (e.g. Heras-Saizarbitoria et al. 2011). When compared to regular qualitative studies, the method has its positives and negatives, but it can be considered an approach that might provide a basis for longitudinal data-series analysis in the future.

As highlighted by Sovacool (2013), quantitative tools can make it difficult to indicate nuances and variance, and they also seldom look for acceptance. However, by utilising this method and comparing editorial content and SoMe, some indication of acceptance appears to have been gained. Hence, it is straightforward that this type of approach would be best, if supplemented with qualitative methods, such as questionnaires. The software sets some limitations, although it still allows the analysis of extensive data sets. The important local media sentiments, such as the NIMBY syndrome (Wolsink 2000), have not been analysed.

In accordance with the results by Heras-Saizarbitoria, et al. (2011), it would seem to be a call for research combining qualitative and quantitative study on the public acceptance issue of CCS technologies. The type of approach involving vast data might be most useful to sight larger trends and could be complimented by qualitative methods, such as questionnaires and interviews. Also further text analysis methods could be applied, such as framing and discourse analysis, but as in this case, the comparability of two large data sets can be challenging. This is due to different types of communication in SoMe, such as hate speech. The changes that take place in the mass media coverage and framing can also affect public acceptance (Heras-Saizarbitoria, et al. 2011). However, this is not so visible when using this type of approach. Also, these types of issues are often emotionally charged, potentially influencing the appearance of the issue, particularly in social media. According to Stieglitz and Dang-Xua (2013), emotionally charged social media messages tend to be repeated more often and more quickly compared to neutral ones. Hence, there is a possibility that media sentiment is influenced by these types of factors.

The managerial implications of this study are related to MI/CI method utilization, and also public acceptance research method development issues. This study highlights the fact that in traditional stakeholder theories, a SoMe participant is not considered so much as a salient stakeholder. However, when combining SoMe users into larger groups, there are possible implications at the corporate level in cases needing both proper political decisions and regulatory environment and policies, as well as long-time R&D activities with also perceived technical and HSE risks. This study tries to find applications of a new method for power plant investment-related media analysis, a learning machine-based sentiment analysis that utilises a very large global data set. Managers working with relevant issues can potentially benefit from the results or the potential of the methodology. The method is applicable to analysing global attitudes, and also their changes, for example, during the time of relevant international events. Furthermore, managers planning power projects or long-term R&D development projects may benefit from understanding the needs for public engagement, and the urgency of social media participation. Figure 7 describes a possible chain from CCS media-image to product market deployment.

This chain starts from public image, which influences people's perceptions of technology. In addition to traditional news media, which can shape public opinion regarding any issue by emphasising certain elements of the broader controversy over others (Shah et al. 2002), social Media (SoMe) presents more direct opinions, often including emotional content (Stieglitz and Dang-Xua 2013). The application of social media is seen to support market intelligence and product development (Berendsen et al. 2015). Media framing in editorial content has the potential to influence public acceptance as attention is focused and placed on a field of meaning (Heras-Saizarbitoria, et al. 2011). Following this reasoning, in PR-communication literature, the rule of effects describes the chain from media exposure via attention, comprehension, motivation, and behavioural trial to sustained behavioural change (McCorkindale et al. 2013). According to the rule of effects, in the rule of halves describing the effect is halved in each step, leaving the percentage from media exposure to sustained behavioural change to 0.78 %, emphasising the need for extensive media exposure. For CCS, one main challenge when the public perception is considered is that in most countries, the public is rather unfamiliar with the technology (Wallquist et al. 2011). This also seems to indicate that communication activities so far have been mostly intra- and interspecialistic, following the funnel model by Bucci et al. (2008), which states that more popular communication is usually done in the commercialisation stage of the product development.

Media image influences public acceptance, and furthermore, public opposition can influence CCS projects directly in the form of local action groups, and indirectly via making the political climate unfavourable for CCS (Wallquist et al. 2011). Recent years have witnessed proliferation of studies on public perceptions of CCS, accompanied by the efforts to translate such knowledge into toolkits for public engagement and communication. At the same time, both literature and toolkits have paid little attention to the organisational dynamics and views of project implementers with regard to public engagement (Breukers et

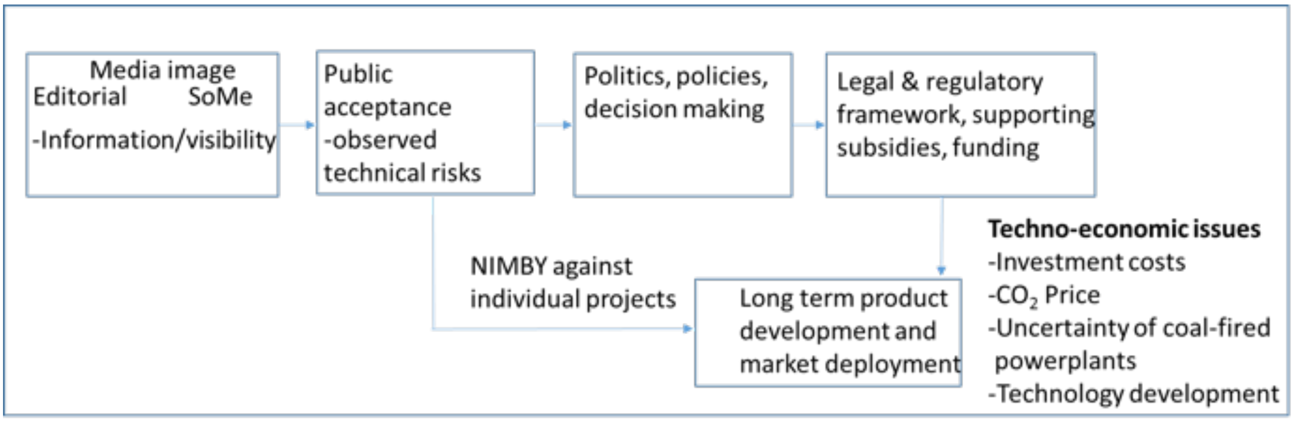

Figure 7 Possible chain from media image to product market deployment/case CCS.

al. 2015). Allowing for improved understanding of the global capacity and applicability of CCS is seen to potentially strengthen the global trust, awareness, and public confidence in CCS technology (de Coninck et al. 2009). For nuclear waste, it was observed that long-term, stable contacts with the local politicians and population are important, but also, as can be seen from the Finnish decision by Parliament, a good contact with the national politicians is necessary. However, there is not necessarily a link between national public acceptance (or lack of it) and political decisions. National decisions, however, require a local acceptance (Le Bars, Y., et al.).

A US-based study found that individually, both CCS and biomass are perceived generally as beneficial for energy development by the news media, though they are not often mentioned in combination, as Feldpausch-Parker et al. (2015) emphasise their value for climate change mitigation and as an alternative to fossil fuels. Earlier examples of failed technology commercialisation have indicated that social acceptance is a decisive factor for technologies, including CCS, while the early adoption of the general public may be essential for technology acceptance (Ashworth et al. 2009).

As a final step from public acceptability to managerial decision-making and technology deployment, a stakeholder salience model (Mitchell et al. 1997) can be considered. The stakeholder salience model introduces three key attributes for stakeholder classification: power, legitimacy, and urgency. The question is: how can one evaluate the groups communicating via SoMe? How can one measure someone's power, legitimacy, or urgency when posting opinions in various discussion forums or on Twitter? Considering

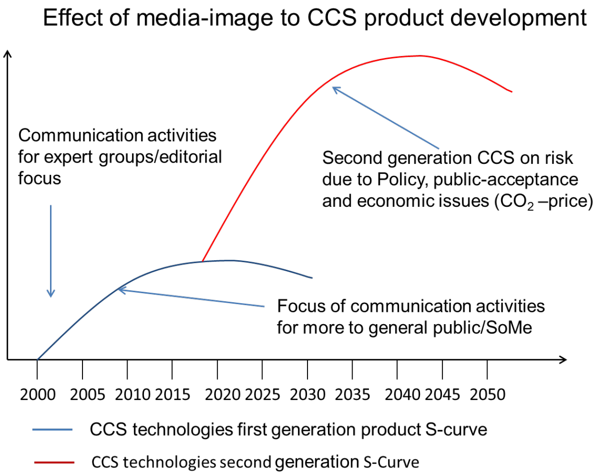

Figure 8 Stakeholder adoption in CCS product development.

development and technology deployment of a single company, these groups have seemingly no power, legitimacy, or urgency and could therefore be considered traditionally to be non-stakeholders in the decision making and would be perceived as having no salience by the firm's managers. However, reflecting on Figure 7, in the case of CCS product market deployment, one pathway for this is suggested.

Furthermore, Figure 8 is synthesised, suggesting that earlier stakeholder adoption would benefit from CCS market deployment. The findings from media study support this hypothesis via implicating negative attitudes toward the technology, especially in SoMe, and low levels of hits in general, implying unknown technology. The figure illustrates how CCS-technology development would have potentially benefited from the earlier stakeholder adaptation. Furthermore, due to lack of public acceptance, second generation CCS-technology, development is under risk.

Some of the managerial implications of this paper are also related to the R&D decision-making process and the social media influence. This study indicates that investments in CCS technology may not be favourable due to uncertainties in public acceptance. It was clearly visible that the amount of media attention was not large enough to fully support product commercialisation. The utilised artificial learning machine-based analysis tool may prove beneficial when evaluating social acceptance issues affecting long-term R&D investments. Hence, as a practical implication, this study emphasises the need for more versatile analysis of factors affecting long-term R&D investments with strong public involvement both directly and via political decision-making.

The limitations of this study include the analysed media sentiment being limited to those classifications possible with the used keywords and also to the English language. Using other keywords, or not including some topics, might provide slightly different results. In addition, framing, cluster analysis, and statistical methods were found difficult to apply as the comparability between editorial content and SoMe could have been lost. In addition, although statistical techniques are widely used among communications scholars to identify news frames, they are criticised for not being able to do so in a conceptually valid manner (Carragee & Roefs 2004). This also brings a challenge to further research.

The utilised method may entail some uncertainties that require further studies. Results correlate to literature, so that based on the analysis, CCS is unknown and also has more positive sentiment. Also, the methods that were used for CCS product life-cycle estimation are not based on calculated figures and are only directional. In addition to addressing the limitations of this study, relevant future research could relate to developing the machine/artificial intelligence-based methods further.

5. CONCLUSIONS AND POLICY IMPLICATIONS

New AI, computational linguistics and machine learning methods can be utilized for weak signal detection in CI/MI and strategic planning functions of a company. Public acceptance appears as a clearly essential part of the energy market products' market deployment, an issue that should be addressed during the early stages of a product life-cycle. The overall visibility of a technology is important, while if public acceptance is ignored, it can cause delayed or abandoned market deployment of long-term energy production technologies, accompanied by techno-economic issues. This paper has twofold implications. Firstly, it studies CCS media image with a new type of method, public acceptance, and product market deployment based on literature. Secondly, it highlights the importance of visibility and studies possibilities for closing the gap between the rhetoric and technical progress inherent to CCS, which is critically important to global climate mitigation efforts. Developing strong international cooperation to demonstrate CCS with global coordination, transparency, cost-sharing, and communication as guiding principles would facilitate efficient and cost-effective collaborative global learning about CCS. Founded on the learning machine-based media analysis, it appears that the popular type of communication might have been beneficial to start to a larger extent during the early stages of CCS product development.

As a policy implication, the media image of technologies, possibly affecting larger audience groups' public acceptance, can be studied by means of learning machine-based analysis. This type of analysis indicates the majority of attitudes in both editorial publication and social media. Learning machine-based analysis provides a fast way for policy makers to get information on the general public sentiment. The media image of CCS was found to be mainly positive—however, small and unknown, implying a need to push towards regulations to provide some common ground to commercialise CCS technologies. However, the visibility of CCS is currently lacking. Policies favouring CCS could be created as an implication of positive media image; however, not in my back yard (NIMBY) attitudes need to be assessed and addressed locally.

As a future field of study, the further evaluation of adoptability of this type of opinion mining approach to weak signal detection of BI/MI activities is one topic to consider. Additionally, opinion mining method development and the application itself would be an interesting field of study.

6. REFERENCES

Abrahams, A. S., Jiao, J., Fan, W., Wang, G. A., and Zhang, Z. (2013). What's buzzing in the blizzard of buzz? automotive component isolation in social media postings. *Decision Support Systems*, 55 (4): 871.

Åhman, M., Nikoleris, A., and Wyns, T. (2013). Decarbonizing industry: emerging roadmaps point to major need for financing radical innovation. *Carbon Management*, 4 (1): 5-7.

Alphen, K., Voorst tot Voorst, Q., Hekkert, M., and Smits, R. (2007). Societal acceptance of carbon capture and storage technologies. *Energy Policy*, 35 (8): 4368–4380.

Ashworth, P., Boughen, N., Mayhew, M., and Millar, F. (2009). An integrated roadmap of communication activities around carbon capture and storage in Australia and beyond. *Energy Procedia.* 1 (1): 4749-4756.

Le Bars, Y., Murray, C., Ormai, P., Seppälä, T., and Bøhmer, N. Summary of the Panel Discussion Concluding Session IV on Public Involvement and Acceptance Panel IV: '*Can NIMBY be overcome?'*

Bell, D., Gray, T., and Haggett, C. (2005). The 'Social Gap' in Wind Farm Siting Decisions: Explanations and Policy Responses. *Environmental Politics*, 14 (4): 460-477.

Berendsen, G., Middel, R., Pieters, I., Angard, F., and Hillerström, F. (2015). Social media within sustainable product development: an exploratory multiple case study on the perception of social media usability in the new product development process. *Int. J.*

Technology Intelligence and Planning, 10 (3/4): 273–293.

Bradbury, J., Ray, I., Peterson, T., Wade, S., Wong-Parodi, G., and Feldpausch, A. (2009). The role of social factors in shaping public perceptions of CCS: Results of multi-state focus group interviews in the U.S. *Energy Procedia*, 1 (1): 4665–4672.

Brouwer, A. S., van den Broek, M., Seebregts, A., and Faaij, A. (2015). Operational flexibility and economics of power plants in future low-carbon power systems. *Applied Energy*, (156): 107-128.

Bucchi, M. (2008). Of deficits, deviations and dialogues: Theories of public communication of science. Featured in: M. Bucchi and B. Trench (Ed.) *Handbook of public communication of science and technology,* New York: Routledge International Handbooks, 57-76.

Budd, J.M. (2007). Information, analysis, and ideology: A case study of science and the public interest. *Journal of the American Society for Information Science and Technology*, 58 (14): 2366-2371.

Budescu, D. V., Broomell, S., and Por, H.-H. (2009). Improving Communication of Uncertainty in the Reports of the Intergovernmental Panel on Climate Change. *Psychological Science 2*0 (3): 299-308.

Burnham, J., Debande, O., Jones, O., Mihai, C., Moore, J. and Temperton, I. (2013). Report on Innovative Financial Instruments for the Implementation of the SET Plan, First-of-a-kind project. *JRC Scientific and Policy Reports*, Ref: EUR 26058, OPOCE LD-NA-26058-EN-N, https://ec.europa.eu/jrc/sites/default/files/ldna26058enn_002.pdf, accessed 23 May 2017.

Burscher, B., Vliegenthart, R., and de Vreese, C. (2015). Frames Beyond Words: Applying Cluster and Sentiment Analysis to News Coverage of the Nuclear Power Issue. *Social Science Computer Review*, 1-16

Breukers, S. and Upham, P. (2015). Organisational aspects of public engagement in European energy infrastructure planning: the case of early-stage CCS projects. *Journal of Environmental Planning & Management*, 58 (2): 252-269.

Cambria, E., Schuller, B., Xia, Y., and Havasi, C. (2013). New avenues in opinion mining and sentiment analysis. *IEEE Intelligent Systems* 28 (2): 15-21.

Carragee, K. M. and Roefs, W. (2004). The neglect of power in recent framing research. *Journal of Communication*, 54: 214–233.

Chen, H. (2010). Business and market intelligence 2.0. IEEE Intelligent Systems 25(1): 68-71.

Chen, H., Chiang, R. H., and Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. *MIS Quarterly*, 1165-1188.

Dapeng, L. and Weiwei, W. (2009). Barriers and incentives of CCS deployment in China: Results from semi-structured interviews, *Energy Policy*, 37 (6): 2421–2432.

de Best-Waldhober, M., Daamen, D, and Faaij, A. (2009). Informed and uninformed public opinions on CO_2 capture and storage technologies in the Netherlands, *International Journal of Greenhouse Gas Control*, 3 (3): 322–332.

de Coninck, H., Stephens, J. C. , and Metz, B. (2009). Global learning on carbon capture and storage: A call for strong international cooperation on CCS demonstration. *Energy Policy*, 37 (6): 2161-2165.

Dessler, A. E. and Parson, E. A. (2006). *The Science and Politics of Global Climate Change: A Guide to the Debate.* Cambridge: Cambridge University Press

Dütschke, E. (2011). What drives local public acceptance – comparing two cases from Germany, *Energy Procedia*, 4: 6234–6240.

Du Toit, A. S. (2015). Competitive intelligence research: An investigation of trends in the literature. *Journal of Intelligence Studies in Business*, 5(2).

Druckman, J. (2004). Priming the vote: Campaign effects in a U.S. Senate Election. *Political Psychology* 25 (4): 577-594.

Feldpausch-Parker, A., Burnham, M., Melnik, M., Callaghan, M. L., and Selfa, T. (2015). News Media Analysis of Carbon Capture and Storage and Biomass: Perceptions and Possibilities. *Energies*, 8 (4): 3058-3074.

Firestone, J. and Kempton, W. (2007). Public opinion about large offshore wind power: Underlying factors, *Energy Policy*, 35 (3): 1584–1598.

Fleishman, L. A., De Bruin, W. B., and Morgan, M. G. (2010). Informed Public Preferences for Electricity Portfolios with CCS and Other

Low-Carbon Technologies, *Risk Analysis*, 30 (9): 1399–1410.

Folke, C., Radgen, P., Rode, H., Irons, R., Schaaf, H., Read, A., Möller, B. F., Schoenmakers, H., Imber, P., and Peter, K. (2011). E.ON's current CCS activities, *Energy Procedia*, 4: 6091-6098.

Fütterer, M. A., Carlsson, J., de Groot, S., Deffrennes, M., and Bredimas, A. (2014). European energy policy and the potential impact of HTR and nuclear cogeneration, *Nuclear Engineering and Design* 27: 73–78.

Gerbner, G. and Gross, L. (1976). Living with the television: The violence profile. *Journal of Communication* 26 (2): 172-194.

Gielen, D., Podkanski, J., and Unander, F. (2004). Prospects for CO_2 capture and storage Organization for Economic Co-operation and Economic Development, (OECD)/International Energy Agency (IEA), Paris, France, p.252.

Godbole, N., Srinivasaiah, M., and Skiena, S. (2007). Large-scale sentiment analysis for news and blogs. ICWSM, 7 (21): 219-222.

Gough, C. (2008). State of the art in carbon dioxide capture and storage in the UK: An experts' review. *International Journal of Greenhouse Gas Control* 2 (1): 155–168.

Greenberg, M. and Truelove, H. B. (2011). Energy choices and risk beliefs: Is it just global warming and fear of a nuclear power plant accident? *Risk Analysis*, 31 (5): 819-831.

Grove-White, R., Kearnes, M., Macnaghten, P., and Wynne, B. (2006). Nuclear futures: Assessing public attitudes to new nuclear power, *Political Quarterly*, 77 (2): 238–246.

Grubler, A. and Riahi, K. (2010). "Do governments have the right mix in their energy R&D portfolios?", *Carbon Management*, 1 (1): 79-87.

Gupta, N., Fischer, A. R. H., and Frewer, L. J. (2012). Socio-psychological determinants of public acceptance of technologies: A review. *Public Understanding of Science* 21 (7): 782-795.

Hammond, G. P., Akwe, S. S. O., and Williams, S. (2011). Techno-economic appraisal of fossil-fuelled power generation systems with carbon dioxide capture and storage. *Energy*. 36 (2): 975-984.

Heras-Saizarbitoria, I., Cilleruelo, E., and Zamanillo, I. (2011). Public acceptance of renewables and the media: An analysis of the spanish PV solar experience. *Renewable and Sustainable Energy Reviews*, 15 (9): 4685-4696.

Huijts, N. M. A., Midden, C. K. H., and Meijnders, A. L. (2007). Social acceptance of carbon dioxide storage, *Energy Policy*, 35 (5): pp.2780–2789.

Huijts, N. M. A., Molin, E. J. E., and Steg, L. (2012). Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renewable and Sustainable Energy Reviews,* 16 (1) 525– 531.

IEA. (2010). Energy technology perspectives: Scenarios & Strategies to 2050, International Energy Agency, Paris, <online> https://www.iea.org/publications/freepublications/publication/etp2010.pdf accessed 23 May 2017.

Itaoka, K., Saito, A., and Akai, M. (2004). Public acceptance of CO_2-capture and storage technology: a survey of public opinion to explore influential factors, the Seventh International Conference on Greenhouse Gas Technologies, Vancouver, 5 September 2004.

Kim, Y., Kim, M., and Kim, W. (2013). Effect of the Fukushima nuclear disaster on global public acceptance of nuclear energy. *Energy Policy*, 61: 822–828.

Kramer, G. J. and Haigh, M. (2009). No quick switch to low-carbon energy. *Nature,* 462: 568-569

Krause, R. M., Carley, S. R., Warren, D. C., Rupp, J. A., and Graham, J. D. (2014). 'Not in (or Under) My Backyard': Geographic Proximity and Public Acceptance of Carbon Capture and Storage Facilities. *Risk Analysis*, 34 (3): 529–540.

Lohwasser, R. and Madlener, R. (2012). Economics of CCS for coal plants: Impact of investment costs and efficiency on market diffusion in Europe. *Energy Economics*, 34 (3): 850–863.

Li, Y. and Li, T. (2013). Deriving market intelligence from microblogs doi:https://doi.org/10.1016/j.dss.2013.01.023

Liu, B. and Zhang, L. (2012). A survey of opinion mining and sentiment analysis. *Mining text data*. Springer. 415-463.

Mathews, J. A., Kidney, S., Mallon, K., and Hughes, M. (2010). Mobilizing private finance to drive an energy industrial revolution. *Energy Policy*, 38 (7): 3263-3265.

Maddali, V., Tularam, G. A., and Glynn, P. (2015). Economic and Time-Sensitive Issues Surrounding CCS: A Policy Analysis. *Environmental Science & Technology*, 49 (15): 8959-8968.

Midttun, A. and Gautesen, K. (2007). Feed in or certificates, competition or complementarity? Combining a static efficiency and a dynamic innovation perspective on the greening of the energy industry, *Energy Policy*. 35 (3): 1419-1422.

Mitchell, R. K., Agle, B. R., and Wood, D. J. (1997). Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of Management Review* 22 (4): 853-886.

McCorkindale, T., DiStaso, M. W., and Carroll, C. (2013). The power of social media and its influence on corporate reputation. The Handbook of Communication and Corporate Reputation, 497-512.

Matthes, J. and Kohring, M. (2008). The content analysis of media frames: Toward improving reliability and validity. *Journal of Communication*, (58): 258–279.

M-Brain. Corporate communications. Received 11/2015.

Miller, J. and Krosnick, J. (2000). News media impact on the ingredients of presidential evaluations: Politically knowledgeable citizens are guided by a trusted source. *American Journal of Political Science,* 44 (2): 295-309.

Nasukawa, T. and Yi, J. (2003). Sentiment analysis: Capturing favorability using natural language processing. Proceedings of the 2nd International Conference on Knowledge Capture, 70-77.

Nuortimo, K. (2012). Essays on exploring alternatives in CO_2-neutral power generation product development. Licentiate thesis. University of Oulu.

Nuortimo, Kalle & Harkonen, Janne & Karvonen, Erkki. (2017). Exploring the global media image of solar power. Renewable and Sustainable Energy Reviews. 81. 2806-2811. 10.1016/j.rser.2017.06.086.

Nuortimo, K., Härkönen, J., and Karvonen, E. (2017b). Exploring the social acceptance of biomass power, *Interdisciplinary Environmental Review*, 18 (1): 14–27.

Oltraa, C., Salaa, R., Solàa, R., Di Massob, M., and Rowec, G. (2010). Lay perceptions of carbon capture and storage technology. *International Journal of Greenhouse Gas Control*, 4 (4): 698–706.

Palmgren, C. R., Morgan, M. G., de Bruin, W. B., and Keith, D. W. (2004). Initial Public Perceptions of Deep Geological and Oceanic Disposal of Carbon Dioxide, *Environmental Science & Technology*, 38 (24): 6441–6450.

Peñalver-Martinez, I., Garcia-Sanchez, F., Valencia-Garcia, R., Rodríguez-García, M. Á., Moreno, V., Fraga, A., and Sánchez-Cervantes, J. L. (2014). Feature-based opinion mining through ontologies. *Expert Systems with Applications*, 41 (13): 5995-6008. doi:10.1016/j.eswa.2014.03.022

Pietilä, V. (1997). Joukkoviestintätutkimuksen valtateillä. Tampere: Vastapaino. In Finnish.

Rainer, D. (2008). *A Looming Rhetorical Gap: A Survey of Public Communications Activities for Carbon Dioxide Capture and Storage Technologies*. Judge Business School, University of Cambridge.

Reis, T., Barroso, A. C., and Imakuma, K. (2014). Monitoring and analysis of nuclear acceptance by information retrieval and opinion extraction on the internet. Available from Thiago Reis, retrieved on 21 June 2016.

Ruester, S., Schwenen, S., Finger, M., and Glachant, J.-M. (2014).A post-2020 EU energy technology policy: Revisiting the strategic energy technology plan, *Energy Policy*, 66: 209–217.

Santos, S. (2015). Oxy-CFB Combustion Technology, Its potential role in CO_2-mitigation; O_2GEN workshop, 18 June 2015, Turku, Finland.

Scheufele, D. (1999). Framing as a Theory of Media Effects. Journal of Communication, 49 (1): 103-122.

Shah, D. V., Watts, M. D., Domke, D., and Fan, D. P. (2002). News framing and cueing of issue regimes: Explaining Clinton's public approval in spite of scandal. *Public Opinion Quarterly*, (66): 339–370.

Slotegraaf, R. J., Moorman, C., and Inman, J. J. (2003).The Role of Firm Resources in Returns to Market Deployment, *Journal of Marketing Research*, 40 (3): 295-309.

Song, M. and Thieme, J. (2009). The role of suppliers in market intelligence gathering for radical and incremental innovation. *Journal of Product Innovation Management* 26(1), 43-57.

Sovacool, B. and Ratan, P. L. (2012). Conceptualizing the acceptance of wind and solar electricity. *Renewable and Sustainable Energy Reviews*, 16 (7): 5268–5279.

Siegrist, M. (2000).The influence of trust and perceptions of risks and benefits on the acceptance of gene technology, *Risk Analysis* 20 (2): 195–203.

Siegrist, M., Cousin, M.-E., Kastenholz, H., and Wiek, A. (2007a). Public acceptance of nanotechnology foods and food packaging: The influence of affect and trust, *Appetite*, 49 (2): 459–466.

Siegrist, M., Keller, C., Kastenholz, H., Frey, S., and Wiek, A. (2007b). Laypeople's and Experts' Perception of Nanotechnology Hazards, *Risk Analysis* 27 (1): 59–69.

Slovic, P., Flynn, J., and Layman, M. (1991). Perceived Risk, Trust, and the Politics of Nuclear Waste. *Science* 254: 1603–1608.

Stieglitz, S. and Linh D.-X. (2013). Emotions and Information Diffusion in Social Media—Sentiment of Microblogs and Sharing Behavior. *Journal of Management Information Systems* 29 (4): 217-248

Teo, T. S. and Choo, W. Y. (2001). Assessing the impact of using the internet for competitive intelligence. *Information & Management*, 39(1), 67-83.

Ter Mors, E., Weenig, M. W. H., Ellemers, N., and Daamen, D. D. L. (2010). Effective communication about complex environmental issues: Perceived quality of information about carbon dioxide capture and storage (CCS) depends on stakeholder collaboration. *Journal of Environmental Psychology*, 30 (4): 347-357.

Terwel, B. W., Harinck, F., Ellemers, N., and Daamen, D. D .L. (2009). Competence-Based and Integrity-Based Trust as Predictors of Acceptance of Carbon Dioxide Capture and Storage (CCS). *Risk Analysis* 29 (8), 1129–1140.

Terwel, B. W., Harinck, F., Ellemers, N., and Daamen, D. D. L. (2011). Going beyond the properties of CO_2 capture and storage (CCS) technology: How trust in stakeholders affects public acceptance of CCS. *International Journal of Greenhouse Gas Control*, 5 (2): 181–188.

Tokushige, K., Akimoto, K., and Tomoda, T. (2007). Public perceptions on the acceptance of geological storage of carbon dioxide and information influencing the acceptance, *International Journal of Greenhouse Gas Control*, 1 (1): 101–112.

Valkenburg, P. and Valkenburg, W. (2016). Media Effects: Theory and Research.. 67: 315–338.

Wallquist, L., Visschers, V. H. M., and Siegrist, M. (2009). Lay concepts on CCS deployment in Switzerland based on qualitative interviews. *International Journal of Greenhouse Gas Control*, 3 (5): 652–657.

Wallquist, L., Visschers, V. H. M., and Siegrist, M. (2010). Impact of Knowledge and Misconceptions on Benefit and Risk Perception of CCS. *Environmental Science & Technology*, 44 (17): 6557–6562.

Wallquist, L., Seigo, S. L., Visschers, V. H., and Siegrist, M. (2012). Public acceptance of CCS system elements: A conjoint measurement. *International Journal of Greenhouse Gas Control*, (6): 77-83.

Wennersten, R., Sun, Q., and Li, H. (2015). The future potential for Carbon Capture and Storage in climate change mitigation – an overview from perspectives of technology, economy and risk. *Journal of Cleaner Production*, 103 (15): 724-736.

Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy* 21 (1): 49-64.

Wolsink, M. (2007). Wind power implementation: The nature of public attitudes: Equity and fairness instead of 'backyard motives'. *Renewable and Sustainable Energy Reviews*, 11 (6): 1188–1207.

Wood, E. (2001). Marketing information systems in tourism and hospitality small- and medium-sized enterprises: A study of internet use for market intelligence. *International Journal of Tourism Research*, 3(4): 283-299.

Wüstenhagen, R., Wolsink, M., and Bürera, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, 35 (5): 2683–2691.

Xu, K., Liao, S. S., Li, J., and Song, Y. (2011). Mining comparative opinions from customer reviews for competitive intelligence. *Decision Support Systems*, 50(4): 743-754.

Zhang, Z. and Huising, D. (2017). Carbon dioxide storage schemes: Technology, assessment and deployment. *Journal of Cleaner Production*, 142, Part 2: 1055–1064.

Zechendorf, B. (1994). What the Public Thinks about Biotechnology. *Bio/Technology*, 12: 870–875.