# Improving strategic decision making with big data-based media analysis – The case of coal power

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**Abstract:** Big data-based methods are currently being developed to aid corporate decision making. This study utilises a big data-based global media analysis to clarify the role of a coal power-related media image in company decision making. Opinion mining is carried out by utilising a specific software tool designed for media analysis and monitoring. The analysis is based on the notion that the media image of company products – or of a specific technology – may have an impact on corporate investment and divestment decisions in the energy production sector. The assumption is that a coal power-related media image may cause corporate brand image-related pressures. The findings indicate that the general media sentiment towards coal power clearly appears to be negative, possibly influencing decisions at the corporate level. It appears that the large negative media sentiment towards coal power in general may override the potential benefits of developing more unknown, cleaner types of coal power and related technologies such as carbon capture and storage (CCS) and carbon capture and utilisation (CCU). Hence, the negative media sentiment towards coal power may mitigate the potentially more positive image of related less well-known technologies. Evidence is provided on the media impact of coal power-related divestment decisions and potential impacts on decision making.

**Keywords:** Media image, Coal power, Carbon capture and storage, CCS, Carbon capture and utilisation, CCU, Big data, Media analysis, Investment/divestment decisions, Brand image, Technology image, Global environmental issues.

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# 1 Introduction

Big data-based methods are currently being developed to aid corporate decision making in different sectors (Hagel, 2015; Monino, 2016). New approaches are offered for companies to speed up their operations, enhance the flexibility of their decision making, change their strategic position and improve their efficiency through technological means, including the internet-of-things, different interfaces, social media, 3D printing, cloud computing and networked mobile devices. All these have enabled the rise of new forms of organisational intelligence through big data collection and analysis (Bhimani, 2015). For example, social media is currently utilised to benefit product development and market intelligence (Berendsen et al., 2015).

Coal power seems to face public opposition due to CO2 emissions and incentives towards preventing global warming (Bertsch et al. 2016; Oei and Mendelevitch, 2016). However, according to the International Energy Agency (IEA, 2015) the use of coal has remained quite stable globally and new coal-fired power plants are still being built. Forecasts indicate that the share of coal as a primary global energy source will decline to 24% by 2040 while the global demand will increase by 15% (IEA, 2014). Hence, the utilisation of coal for power generation is viewed as remaining strong, but with significant regional differences (Nalbadian-Sugden, 2016). Nevertheless, despite commitments to reduce greenhouse gas emissions, coal capacity expansion is still being supported (Zhao and Alexandroff, 2019).

Simultaneously, the pressures to reduce atmospheric CO2 has resulted in several global agreements including the Kyoto Protocol (1997) and the Paris Agreement (2015). These agreements may increase the coal power related divestments and push towards developing, and using clean coal technologies with higher efficiency, multi-fuel capabilities and low emissions to slow down the global warming (Xu et al., 2017). Also, cleaner coal power technologies, such as the carbon capture and storage (CCS) are seen as options to mitigate climate change (Gründinger, 2017). CCS and carbon capture and utilisation (CCU) both have advantages in technical and environmental aspects but the potential disadvantage in the economic side revolving around carbon taxation (Man et al. 2014). Nevertheless, the previous literature is somewhat limited in considering the influence of general-public on the adoption of these technologies. The adoption of new cleaner coal technologies might require a positive response from the public.

The public can be considered as a less studied stakeholder group for technology- and energy-related decision making and might not be understood to have as much influence as in reality. The classification could be considered for example along the Mitchell's stakeholder salience model (Mitchell et al, 1997). The public acceptance can influence the technology adoption (Keating et al. 2011). Also, the media and technology related communication may influence the public acceptance (Ho and Kristiansen, 2019). There has been debate concerning mass media and its effect, and the influence of any media, since the technology introduction, and the assumption has been that the media does play a role (Scheufele, 1999). It might also be necessary to differentiate between the types of media communication and their specific influence as the nature of media, selectivity of media use by the public, or the properties of media may play a role in whether the media effect is indirect, conditional and transactional (Valkenburg et al. 2016). The public image of some renewable technologies, such as the solar power and biomass power have been attempted to clarify (Nuortimo et al. 2017; 2018a). However, the previous literature has not clearly clarified coal power related media-sentiment, or public acceptance, or their influence on the development of related technologies.

Opinion mining approach may have advantages in terms of analysing media content for decision-making (More and Ghotkar, 2016). The advantages include global reach, objectivity of algorithm-based sentiment classification, and comparability of datasets. Editorial publications can be seen to describe the consensus in a more filtered way, with a potential larger effect. On the other hand, social media sources may implicate the attitudes more directly. Both can be

considered as somewhat directional for general policy formation, and decision-making. (Shah et al., 2002; Stieglitz and Dang-Xua, 2013). A need exists for studies to better understand the dynamics of the media-sentiment, including the social media, to better plan for potential R&D and market deployment of technologies, and the investment/divestment decisions. Also, corporate brands, seen as long-term assets, and technology management may benefit of this type of analysis (Wood, 2000).

This study utilises big-data based media analysis to clarify the media-image of coal power. The overall media-image is compared to that of more developmental products of Carbon Capture and Storage, and Carbon Capture and Utilisation. Opinion mining approach is utilised by the means of a specific software tool designed for media analysis and monitoring. The idea is to assess the applicability of media analysis to support company decision-making and clarify the role of public acceptance and the potential influence on investment and divestment decisions in the energy production sector.

The above can be condensed to the following research questions:

*RQ1: How is the overall media-image of coal power, and how does the image of more developmental cleaner coal technology products compare to that?*

*RQ2: Can media analysis and the understanding over public acceptance support company decision-making in the energy production sector?*

The remaining paper is organised as follows. The literature is first reviewed to cover necessary coal power, CCS, CCU and the linked public acceptance discussion to form basis for the empirical analysis. Section three explains the research process and the methodological approach. Section four presents the results of big-data based global media analysis on coal power by covering the editorial publications and the social media. The media-image of coal power is compared to that of the newer CCS and CCU technologies. Case of German utilities is also presented to demonstrate some potential linkages between negative media-image, low levels of public acceptance and the coal power related investment/divestment decisions. Section five presents the discussion, illustrates a possible link between coal power media-image, product development and the market deployment. Scientific and managerial implications are also presented. Section six concludes the paper.

## 2 Coal power - brief review

The coal power is one of the few major energy technologies that has been in use for over a century and is still re-inventing itself (Yeh and Rubin, 2007). The total installed global coal-fired capacity was estimated to approach 2000 GW by 2030, which is nearly double of the capacity in 2000 (EIA, 2006). Nevertheless, the capacity exceeded 2000 GW already in 2016 (IEA, 2019), and new capacity is being built and planned (Carbon Brief, 2019). According to IEA the investments in coal-power dropped in 2017, but the capacity will remain significant (IEA, 2019). Nevertheless, there are big regional differences in the coal use for power generation.

The history of coal capacity development includes the recent phenomena of the German electricity sector witnessing "dash for coal" towards the end of 2010, where within a period of only a few years, new coal power investments amounted to around 15% of the total energy sector capacity. (Pahle, 2010). The main reasons behind the phenomena included the replacement requirements caused by the nuclear phase out, favourable long-term economic and technological prospects compared to natural gas, status-quo bias of investors with regards to future renewable deployment, and explicit political support for coal at the time (Pahle, 2010). However, the announcement of Vattenfall to sell its German lignite assets to Czech energy group EPH and citing commitment to sustainable energy completely changed situation (Vattenfall, 2016). The change continues in the form of coal technology divestments, now affecting also CCS technologies. The situation highlights the total change of direction in energy politics and indicates the possible effect of public image on energy policies and on investment/divestment decisions concerning coal and lignite plants. The current trend is that west-European utilities seem to divest their coal businesses, sometimes even with large risk premiums. The energy security might even be ignored to some extent and is visible via, for example gas conflicts with Russia. (Umbach, 2009).

The history provides indications how many technologies have been associated with societal controversies that may have led to public rejection of their use. Hence, it is important to understand also the psychological determinants of societal acceptance of technologies (Gupta et al., 2012). These days it is clearly visible, that media coverage influences the public acceptance of technologies (Heras-Saizarbitoria et al., 2011). Earlier examples of failed technology commercialisation exist, cases which have indicated that the social acceptance is a decisive factor for technologies, while the early adoption of public is seen to be relevant for technology acceptance (Ashworth et al., 2009). For coal, it has been studied that those people who trust authoritative institutions, such as government, are usually more supportive also for coal technologies, simultaneously it seems that renewable technologies are not so much liked as coal technologies are disliked (Sovacool and Ratan, 2012). The social acceptance may be critical also for the commercialisation cleaner coal related technologies such as the CCS (van Alphen et al. 2007). Carbon capture and storage technology, however, raises numerous environmental policy considerations. Currently, certain regulatory uncertainty seems to exist, which hinders entities undertaking, or wishing to undertake CCS. CCS technologies are subject to or affected by the Emission trade directive (2009/29/EC) and the CCS directive 2009/31/EC on the geological storage of carbon dioxide. The public understanding of CCS technology is presented as an essential factor for the technology adoption among law and policy, technology R&D, and funding, and is indicated to affect the laws and policies (Koh et al. 2019). An initial link from the public acceptance to the market deployment of energy production has been presented (Nuortimo and Harkonen, 2018). Necessary regulatory environment may even not exist everywhere for CCS, but the public outreach is seen as a vital element for implementation (Wildgust et al. 2019). The public acceptance of CCS is increasingly recognised as a vital precondition for the commercial-scale rollout of the technology (Whitmarsh et al. 2019). The same seems to apply to Carbon Capture and Utilisation (Arning et al. 2019).

The factors that influence the public acceptance of CCS at a local level include the size of the project and local history (Dütschke, 2011). Organisational trust also affects people's perceptions of the magnitude of risk compared to the received benefits, with an impact on CCS acceptance (Terwel et al., 2009). The determinants of public acceptance include benefit and risk perceptions, which is furthermore seen to affect the technological progress (Wallquist et al. 2010). As a new channel for this, social media provides a potential avenue for interaction, which supports the social process that is seen as necessary for public acceptance, whereas the traditional media has its role in providing objective information. International demonstration of CCS could also be required, due to the needs to enhance trust and confidence on CCS, potentially making the public acceptance vital for the widespread deployment (de Coninck et al., 2009). Consequently, a high level of public acceptance is seen as one of the most important factors for gaining wide-spread deployment of various CCS projects (Zhang and Huising, 2017). In fact, the public acceptance is seen to be a more challenging issue to address than the CCS related technical issues (Nuortimo et al. 2018b). The public acceptance of the elements in CCS chain may be different as Wallquist et al. (2012) indicate, including the plant type, and transport, and storage. In addition to general acceptance of CCS, "Not in my backyard (NIMBY)" attitudes exist, if a plant is planned to be located close to one's own communities. However, attitudes towards CCS are based on concepts and perceptions instead of actual past events, which makes the comparison of NIMBY attitudes against other energy industry developments rather challenging (Krause et al., 2014). Awareness is a key factor in people's behaviour, which impacts their opinions, and visibility in the media creates awareness and instigates knowledge. Visibility, awareness and knowledge all seem to impact the public trust. Hence, public acceptance may influence the possibilities of different technologies via indirectly impacting various matters, or directly via NIMBY against single projects (Saito et al. 2019). When mergers and acquisitions are considered at a company level, it has been studied that mergers would positively influence the R&D intensity and profitability of top companies (Fernandez et al., 2019), so that in case of coal portfolio divestment of Vattenfall (Vattenfall, 2016), the media effect of coal power and related R&D before the analysis could be considered as negative from this viewpoint.

The following proposition is distilled: *The media-image of coal power and the public acceptance are interlinked. The image of traditional coal power may affect the acceptance of newer cleaner coal technologies and further affect the related regulations and investment decisions.*

## 3 Research process and methodological approach

This study is carried out as a combination of literature review on coal power, CCS and CCU, public acceptance and media-image, and big-data based global media analysis to clarify the role of coal power related media-image in company decision-making. The big-data based media analysis consists of software-based opinion mining carried out on coal technologies via a learning machine-based media-analysis that includes the utilisation of big-data of editorial and social media sources. The basic research principles of media analysis have been formerly applied in different fields, as public acceptance studies have been previously carried out on other topics, however with much smaller datasets and manual data classification by the researchers. As an example of new type of software-based applications, a similar method was used by Bursher et al. (2015), including media framing from editorial content and automated sentiment analysis. The type of approach used in this paper has been also applied to clarify the public image of some renewable technologies (Nuortimo et al., 2017; 2018a). The main motivation for choosing opinion mining, based on learning machine media-analysis, was the ability to analyse large global datasets, and to analyse both editorial content and the social media. Also, the fast data

processing and reduced risk of bias caused by human perceptions and interpretations was among the motivations (Matthes & Kohring, 2008). The analysis period and data for this study covers one calendar year. The analysed also covers the time of a major international climate conference, the Paris COP21.

The utilised methodology can be seen to have a place in the media research. Similar applications are common in marketing research and brand follow-ups, mainly in the consumer-related manufacturing industry (Abrahams et al., 2013). There have been increasing needs to develop computational tools to analyse preferences and attitudes due to the increasing number of online sources, such as discussion forums, blogs and such (Neviaroyskaya et al., 2014). The users of social web now emerge as data providers, which seems to provide an excellent platform for analysing public attitudes (Peñalver-Martinez et al., 2014). In addition, individuals and organisations are increasingly taking advantage of public opinions in the media in their own decision-making (Liu and Zhang, 2012). Sentiment analysis and opinion mining include studies to analyse people's sentiments, opinions, evaluations, attitudes, and emotions from written language, and as one of the active research areas in natural language processing and is also widely studied in data mining (Liu, 2012). Sentiment analysis includes different levels, document level, sentence level, and aspect level (Feldman, 2013). The number of applications of sentiment analysis is growing along with the social media due to reviews, forum discussions, blogs, micro-blogs, Twitter, and social networks that are available. For the first time in history an enormous volume of opinionated data is recorded in digital form enabling its analysis (Liu, 2012). Sentiment analysis as the terminology already points out entails classification by predicting the polarity words and using a classification such as positive, negative and neutral (Kumar et al., 2017). Nevertheless, the main uncertainty issues in sentiment analysis include accuracy, data size, data sparsity, and sarcasm (Ye et al. 2014).

The analysis in this study attempts to clarify the media-image of coal power to investigate the connection to recent decisions at corporate level, namely the investment/divestment decisions of power companies. Hence, the big-data based media-analysis is utilised to discover possible implications from technology image to the corporate decisions. The coal technologies' social acceptance status was analysed to better understand the coal power markets. The findings were synthesised to obtain a view over the possible effect on technology development. The analysis utilises M-Adaptive software for media analysis. The sentiment classification method utilised by the software is based on academic know-how accumulated over tens of man-years of research experience in Helsinki and Aalto University both in computational linguistics and computer science. The found documents are judged based on local sentiments weighted by their relevance to the analysed topic.

The selected language for global analysis is English. The software has lexicons for different languages but does not automatically translate the search terms. The search being to English language is limitation for some local social media-sentiments. Global sentiment is hence somewhat more accurate due to large data set and the language selection. The utilised sources cover 3 million social media platforms, 100,000 news outlets in in 236 regions. The sentiment analysis applied in this study is based on a combination of linguistic knowledge and human aided machine learning, which means that the software makes suggestions of classifications to humans, and humans then provide feedback on correctness. By repeating this procedure, the system learns to improve its content classification into sentiment categories.

The analysis was carried out on keyword basis, using "coal power", "CCS", "CCU", "Carbon capture and Storage" and "Carbon Capture and Utilisation" as keywords. The analysis was made for time-period 2.7.2015-28.1.2016. A very large number of identified data points was included, for coal power only a total of 22,939 data points from both editorial publications (10,676) and Social Media (SoMe) sources (12,263). This was followed by time-line analysis of Vattenfall's negative media hits between 2.11.2015-20.1.2017. In practice, the sentiment-coding expressions are first recognised in

the text and classified automatically, for example positive terms, or quantifying the expressions. The amount and type of sentiments are then assessed, and the overall compound judgement displayed using five options: positive, negative, neutral, mixed and unknown. Naturally, it is possible for the system to make a mistake with respect to any given individual document due to inherent ambiguity in natural language, but the software providers tests have indicated eighty percent of the sentiments to be correct on average. To put this into context, human based analysis would not be more accurate as it is well-known that humans do not fully agree in similar tests either. A limitation, as for any artificial system, is that the system is not able to recognise sarcasm, humour or irony. However, once the amount of documents analysed by software is increased, the trends can be caught from the data more accurately and model will match human judgement.

## 4 Results - media analysis of coal power

Despite of some minor inaccuracies in machine-based analysis, the large amount of data points provided a good basis to analysing the media-image/sentiment. Figure 1 illustrates the overall sentiment towards coal power, depicted both in the context of editorial publications, and the social media.

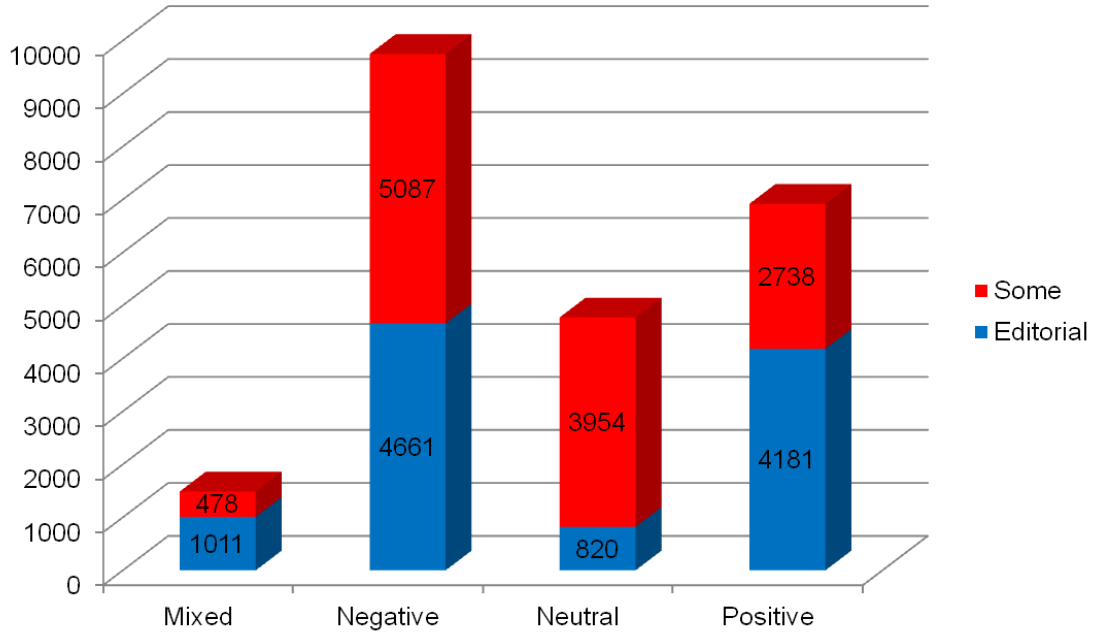


**Figure 1.** Sentiment analysis of social media (SoMe) vs. the editorial publications

The findings show how that the coal power resulted mostly in negative hits, both in editorial publications, and the social media. The amount of negative hits was almost the same in editorial content and in the social media, namely 4,661 hits compared to 5,087 respectively. The neutral hits were divided as a ratio of 820 in the editorial content, and 3,954 in the social media, indicating more neutral views in in the social media. Mixed hits, however, are concentrated to editorial content with 1,011 hits compared to 478 hits in social media. The positive hits were concentrated to editorial publications with the clear ratio of 4,181 against the 2,738 in the social media, indicating more clear influence of techno-economic aspects in the editorial content, and also smaller effect of pure opinion.

Figure 2 illustrates the media-sentiment towards coal power in editorial publications.

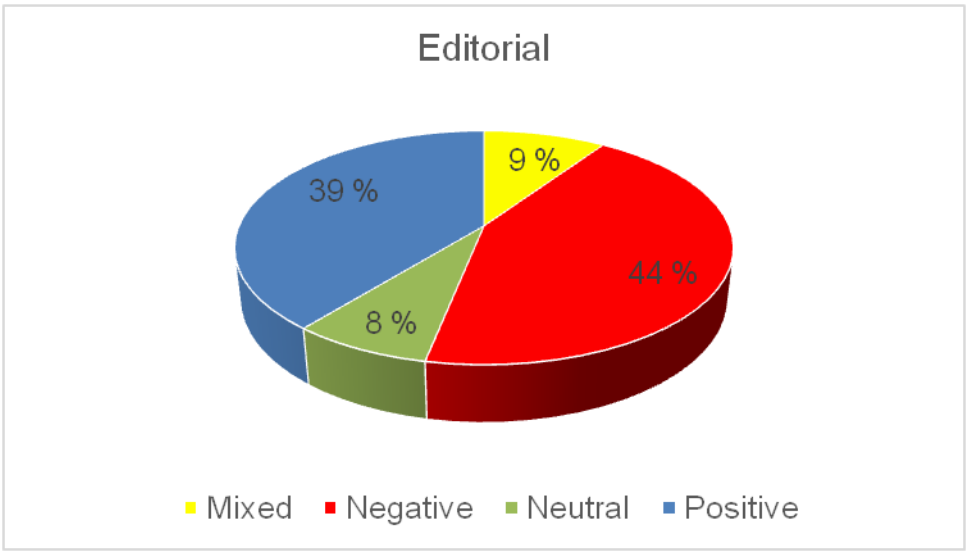


**Figure 2.** Coal power related media-sentiment in editorial publications

It is visible in Figure 2 how 44% of hits in editorial publications have been negative. Further analysis shows how 39% of hits in the editorial publications have been positive indicating a relative technology acceptance among scientists, experts, and by the journalists. The number of mixed (9%) and neutral (8%) hits is relatively small, indicating a level of consensus of views towards Coal Power.

Figure 3 further illustrates the media-sentiment towards coal power in social media.

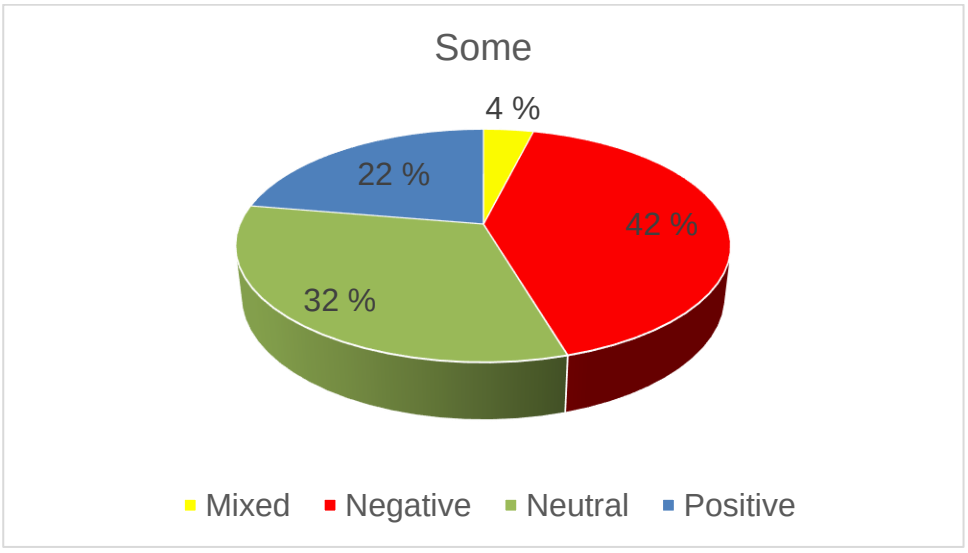


**Figure 3.** Coal power related media-sentiment in Social Media

It is visible in the figure 3 how the public sentiment toward coal power in the social media has been also mostly negative (42%). Sentiments in the social media seem, however, to be different when compared to the editorial publications. Figure 3 also implies the public sentiment toward coal power in social media being more neutral (32%), the difference being 24 % compared to the editorial publications. This can be seen as an indication, that some groups have not yet decided their attitudes, which might be a basis for increasing communication efforts in the social. On the other hand, the amount of positive hits was 17% smaller than in editorial publications, indicating less-positive attitudes and lower levels of public acceptance. In mixed hits this difference was only 5%.

Figure 4 shows the division of hits among different social media channels.

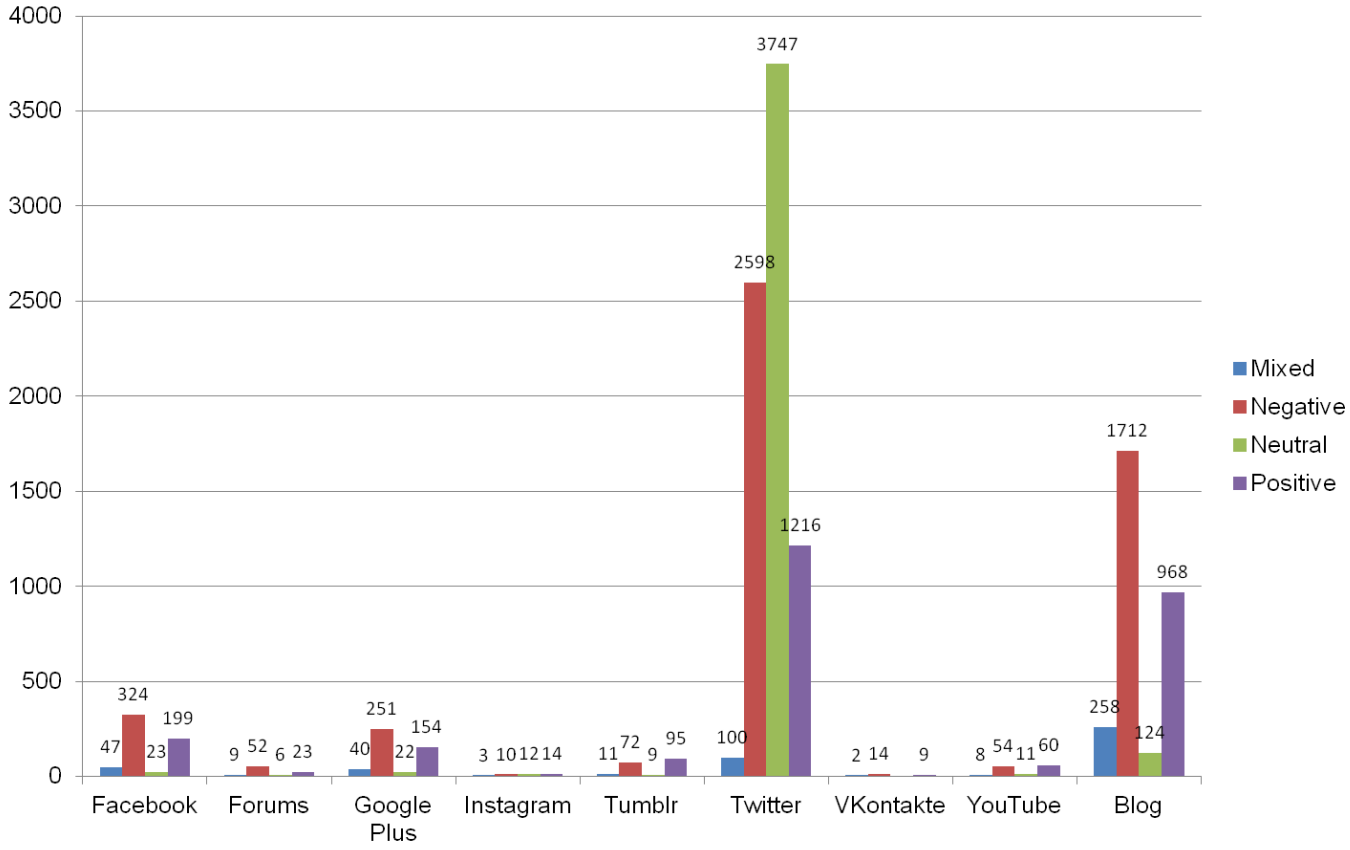


**Figure 4.** Social media-sentiment of coal power among different channels

Figure 4 illustrates how twitter has been in the main social media channel for coal power with over seven thousand hits, most of which have been neutral (3,747) or negative (2,598) towards coal power. Much less positive (1,216) and mixed (100) hits were found during the analysis period. This can be considered as an indication of clear negative data concentration, and thus, also general negative inclination of attitudes. Also, blog writing has been active in the social media with over 1,712 negative hits, and 968 positive, 258 mixed and 124 neutral during the analysis period. Comparing the total number of hits to Tumblr (187), Google Plus (467), Facebook (593) YouTube (133), VKontakte (25), Instagram (39) and Forums (96), the short communication via Twitter (7,661) can be seen as the most influential of social media source during the analysis period. Therefore, the social media effect can also be considered as a quite large when the public opinion towards technology is formed.

Figure 5 illustrates the gender deviations of coal power media-sentiment in the social media.

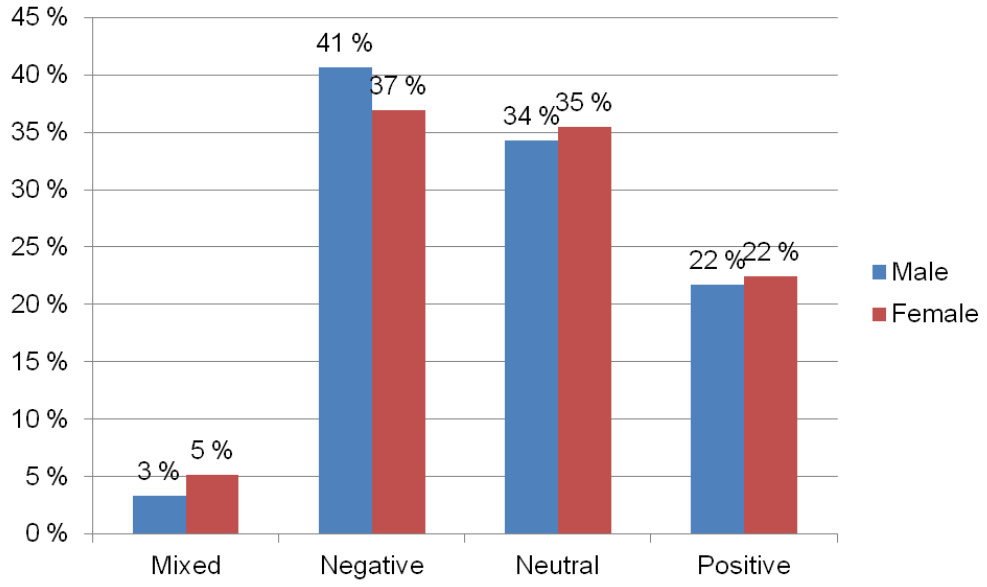


**Figure 5.** Gender sentiment deviations in social media

The data during the analysis period does not seem to indicate any significant gender differences in the attitudes towards coal power in the social media. As a summary, it is visible that public sentiment towards coal power in both the social media and editorial publications has been largely negative.

Nevertheless, one interesting addition to the media-sentiment analysis over the analysis period is the impact of relevant large international events. The 21st Conference of Parties of the United Nations Framework Convention on Climate Change took place during the analysis period. During the Paris COP21 negotiations between November 30th, 2015 and December 11th 2015 there were a total of 1,466 hits on coal power, hence the media attention for Coal Power remained at its regular levels compared to regular average month of 3,277 hits, calculated as a monthly average (Figure 6).

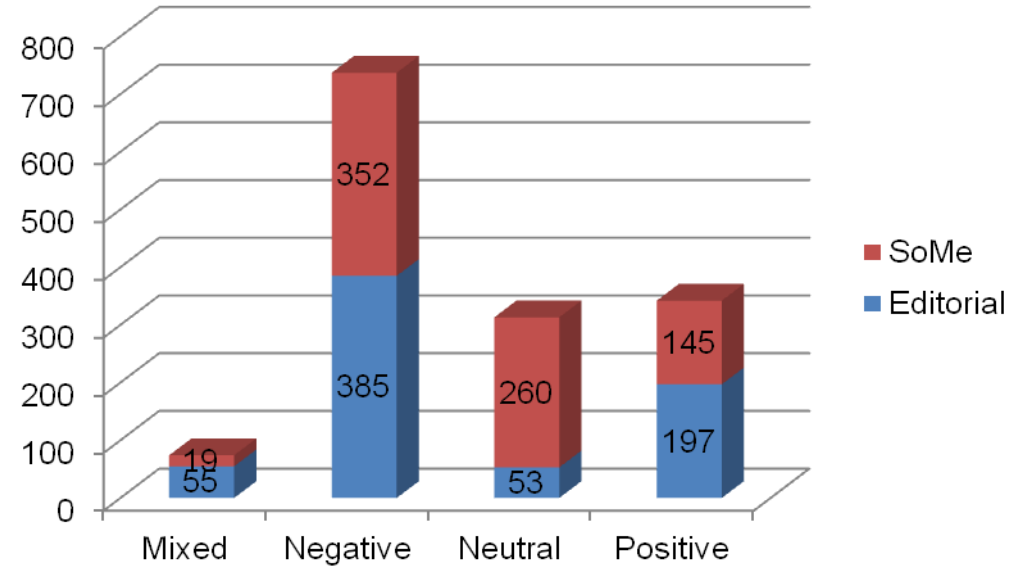


**Figure 6:** Media hits during Paris COP 30.11-12.12.2015

Nevertheless, it is clearly visible how editorial hits for coal power during the Paris COP21 meeting were 12% more negative with 56% negative hits, compared to an average month with 44% negative hits. In the social media the negative sentiment was only 3% higher (45%) during the same time, compared to an average 42%. This indicates the media presence having an impact on the sentiment during an international event, but no significant change in the social media behaviour of people. Figure 7 further illustrates the negative sentiment during the event.

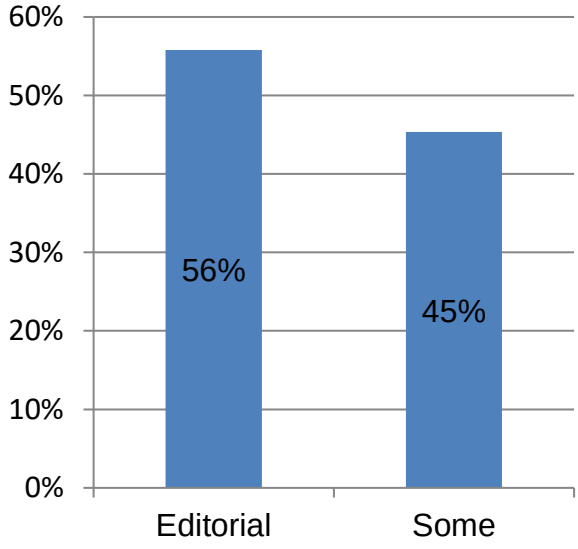


**Figure 7:** Negative sentiment during Paris COP21

The higher negative media-sentiment towards coal power during the global Paris COP climate negotiations in editorial publications compared to social media is evident. The preliminary conclusion that could be drawn without further analysis entails the coal technology not being considered as a solution to climate change, and thus the negative image of coal technologies is emphasised at the time of large media attention during an international event. One could be inclined to think in this manner as at the same time, the social media attitude was less negative compared to the editorial media the and remained almost at the monthly average level.

### *4.1 Media-image comparison of coal power, CCS and CCU*

The media-image and implied level of public acceptance of coal power and CCS technologies are compared in figures 8-9 as total numbers of hits during the analysis period and as percentages.

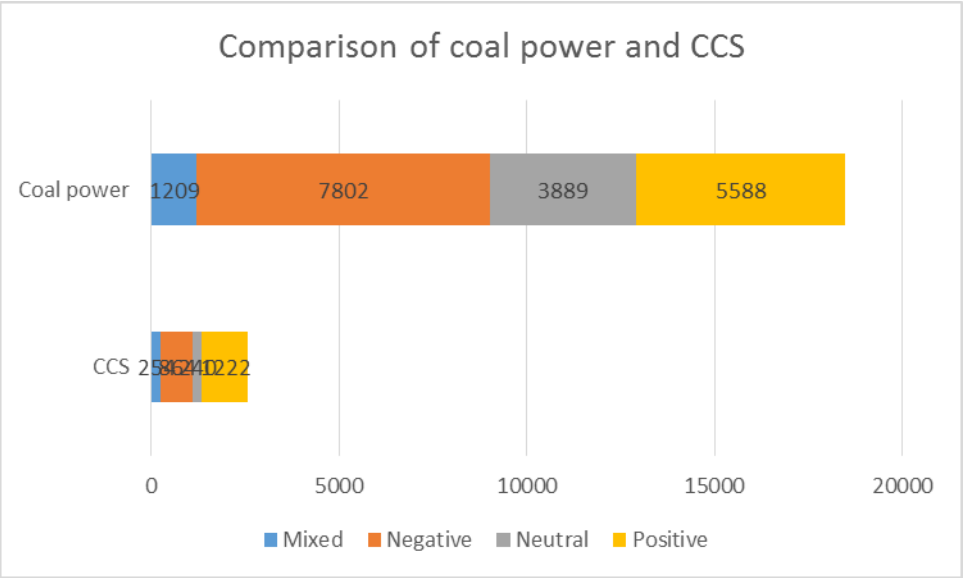


**Figure 8.** Comparison of media attention of coal power and CCS as media hits

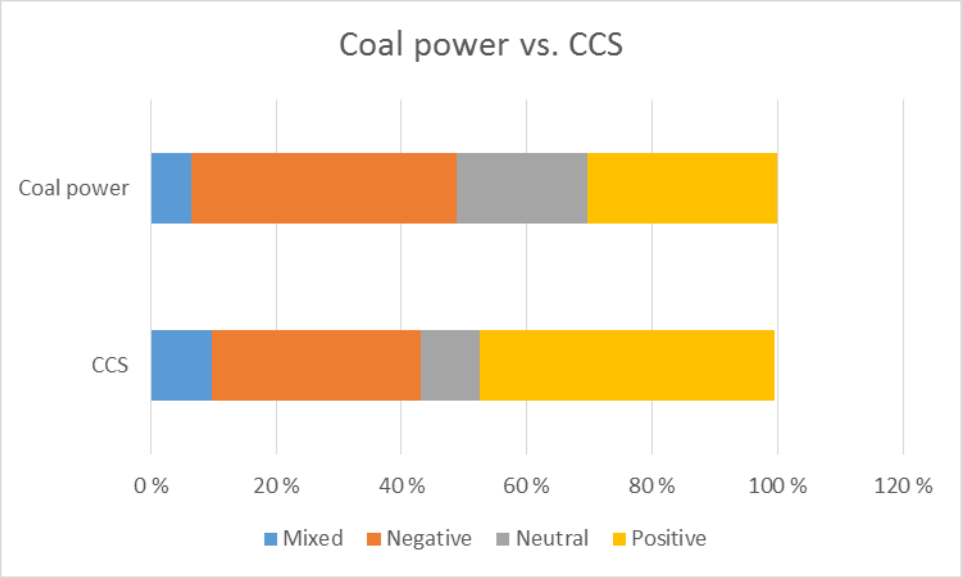


**Figure 9.** Sentiment of coal power and CCS as percentage

It is visible from Figures 8-9 that coal power has a large negative sentiment, which may override the slightly more positive sentiment of CCS. This can be based for example on the rule of effects (McCorkindale et al. 2013). Hence the main implication from media-image could be that the general-public does not want any coal power, even, if would be near CO2 emission neutral. This may hinder all R&D projects that relate to coal power.

Figures 10-11 describe the media attention for carbon capture and storage and carbon capture and utilisation, both as total number of hits during the analysis period and as percentages.

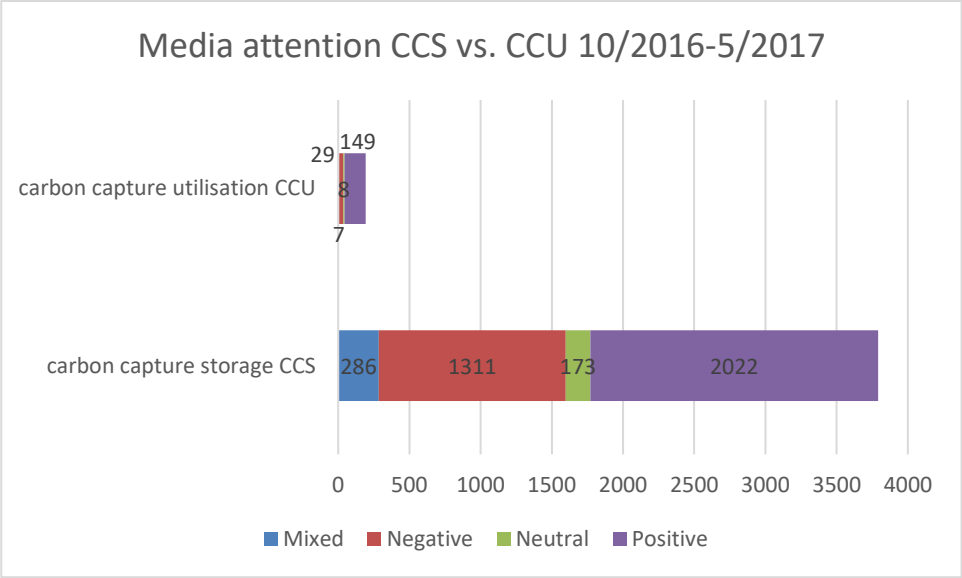


**Figure 10.** Media-attention of CCS and CCU as number of media hits

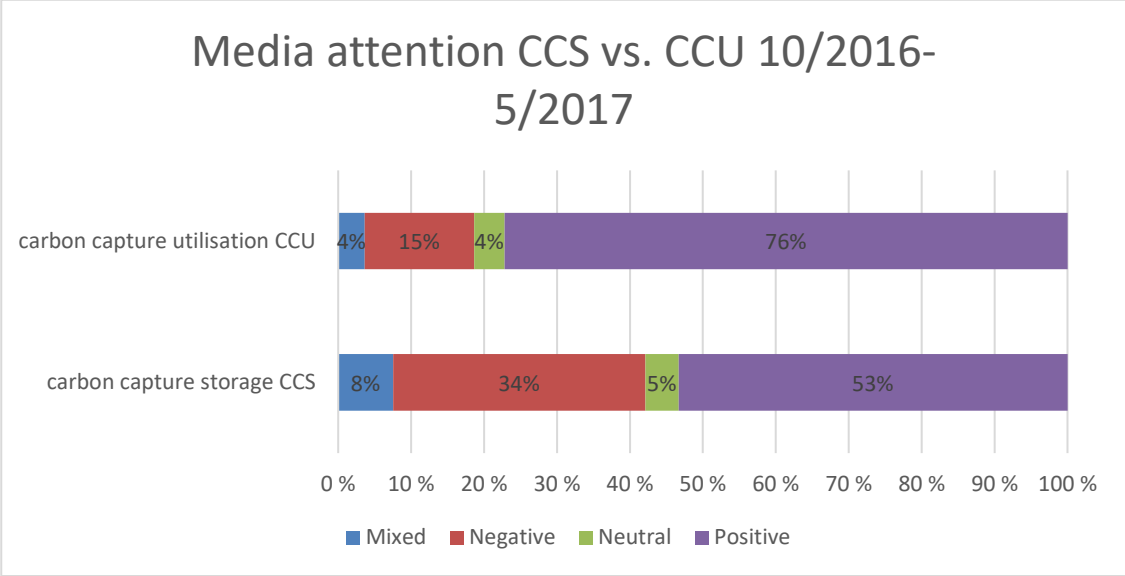


**Figure 11.** Sentiment of CCS and CCU as percentage

Similar ratio in media attention seems to apply but CCU seems to have a more positive media-sentiment. CCU is more unknown and is seen as more positive than CCS, however the number of hits is rather low for CCU, making the percentage value comparison less reliable. If it was possible to make further interpretations, the result could be seen so that the result is well in line with smaller NIMBY attitude for CCU as the CCU technology does not involve CO2 storage as is the case for CCS.

### *4.2 Case of German utilities*

The German power utilities, RWE, EOn and Vattenfall can be used as an example of possible influence of public acceptance/media-image effects at the company level. The public acceptance/media-image can be seen related to investment/divestment decisions for branding related reasons, and the existing coal fleet. RWE established Innogy for renewable power production to form separation to coal and nuclear plants, and EOn formed Uniper for fossil power production. Vattenfall is also particularly interesting as after investing in German coal plants during 1999-2002 (Vattenfall, 2017), and also in CCS technology, the company decided to end its CCS development in Janschwalde pilot plant due to the large-scale public opposition that was based on environmental fears, and also on the lack of the German Government delineating the CCS legal framework in December 2011 (MIT, 2017). The situation was followed by a decision in 2014, when Vattenfall decided to investigate the opportunities of divesting the lignite operations in Germany in order to reach the target of reducing the company's CO2 exposure to 65 million tonnes and transform to more renewable production. At the same time, Vattenfall continues its investments in wind power (Vattenfall, 2017). This was followed by a final decision to divest its German coal plants on March 18th, 2016 (Vattenfall, 2017).

Figure 12 illustrates the negative media attention during the time of Vattenfall's decisions.

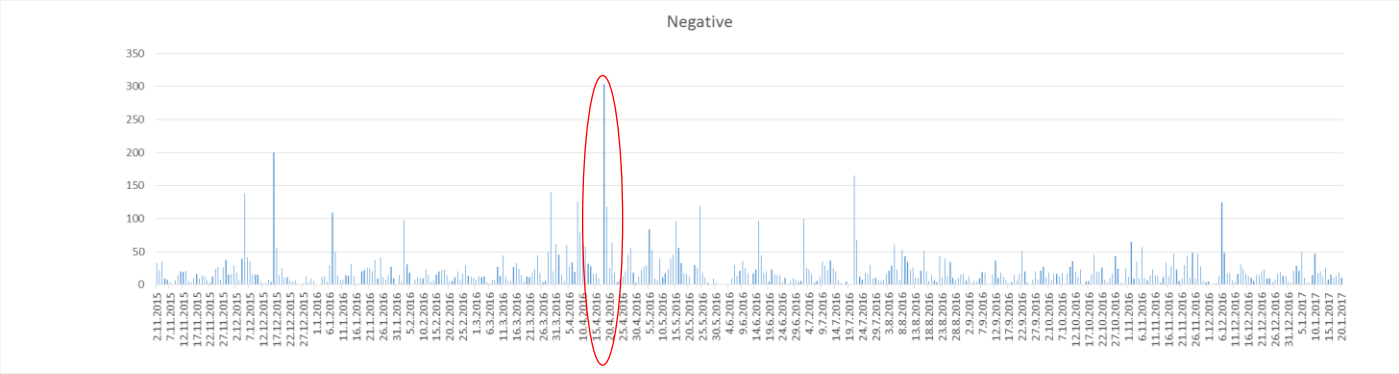


**Figure 12.** Negative media-attention concerning Vattenfall

The figure shows the negative media-attention, hits/day on Vattenfall globally in both editorial and Social Media. From the picture it is visible that negative hits are emphasised at time of the announcement of German coal plant divestment on March 18th, 2016 (Vattenfall, 2017), circulated as red in the figure.

Based on the case Vattenfall, it seems that some correlation between negative media-image and low levels of public acceptance of coal power and the related investment/divestment decision might exist. It seems that the divestment has generally been seen as avoiding the responsibilities related to coal power production fleets in terms of CO2-emissions. However, analysing merely the company's negative hit timeline, there seems to be an indication that only the coal divestment decision was considered as negative. The supporting story for negative image effect on coal power investment/divestment issues comes mainly from the company itself. This is derived from coal power's negative media-sentiment. However, the separation of correlation between techno-economic issues and the media-image is challenging, thus direct causality cannot be established.

## 5 Discussion

Corporate decision-making and power technology adoption are affected by the existing policies, legal framework, the progress of technology and R&D efforts, and available funding and incentives, but also the public acceptance of the technology. These factors that influence the decision-making may also affect each other by some mechanism. Hence, there is the possibility that the media-image of a specific technology, or company products, may have impact on corporate investment and divestment decisions in the energy production sector.

The analysis in this study points out that the media-image of a technology can be an important factor, possibly influencing coal power and related R&D project deployment. The large negative media-sentiment of coal power in general may even override the potential benefits of developing more unknown, cleaner coal power technologies such as Carbon Capture and Storage (CCS) and Carbon Capture and Utilisation (CCU). The big-data based global media analysis indicates that there may be a correlation between the negative media-sentiment for coal power in general, and that of the cleaner coal technologies. Inversely, the CCS and CCU technologies and the potential related technology market deployment might benefit of more positive editorial and social media discussion. Large international events may also play a role in the media-sentiment, at least at the time of the event. It is also to be noted that there may be regional differences in the media-sentiment. The regional differences are not analysed in detail in this study. Although the potential reasons for negative media-sentiment of coal power may relate to people linking coal power to global warming and the need to reduce atmospheric CO2, any agreements are of global nature, but coal technology deployment itself is subject to regional politics and legislation.

The results also indicate that aside understanding the media-sentiment of technologies, also the motivations or impacts of single company decisions might be possible to analyse via the media by using a large data set. The analysis indicates that some level of correlation between negative media-image and low level of public acceptance of coal power and investment/divestment decisions may exist. The corporate decisions may also cause the public to make certain interpretations over the decisions. This study however presents only snapshots of a single corporate decision. Nevertheless, some differences can be observed in channels of communication that may influence brand-image and corporate decisions. This study contributes by utilising big-data based method on a coal power to clarify the media-image of coal power and related cleaner technologies, hence providing a potential new angle to strategic corporate decisions.

Figure 13 synthesises the possible link from coal power media-image to R&D and market deployment.

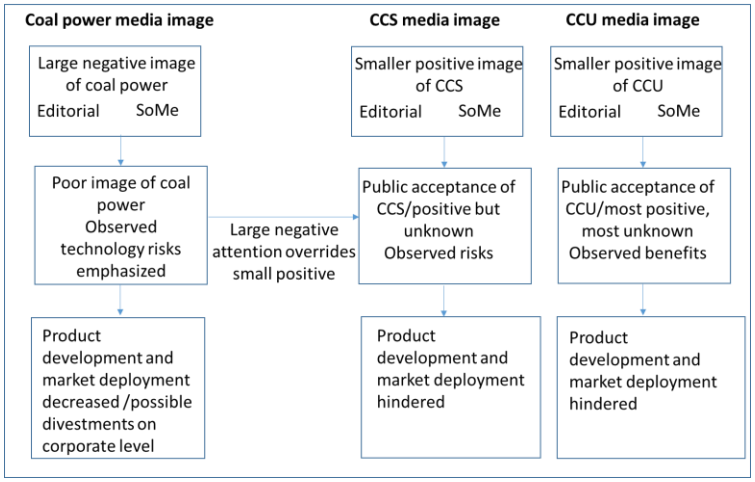


**Figure 13.** Descriptive link from media-image to product market deployment and investments/divestments - case coal power, CCS and CCU

The presented chain of reasoning starts from the public image of coal power, which is large, popular type and negative, thus possibly influencing people's perceptions of the technology, and finally also the R&D efforts intended towards near zero CO2 emissions. Following this reasoning, the concept of rule of effects, for example, can be used for further explanation to show the link from media exposure via attention, comprehension, motivation, behavioural trial to sustained behavioural change that would follow the rule of halves, meaning that where possible, the effect would be halved in each step, lowering the percentage from media exposure to sustained behavioural change. Hence it appears that large, popular communication with negative attitudes for coal power can possibly override the smaller positive attentions, mainly inter- and intra-specialist, for CCS and CCU. It is, however, to be noted, that this paper does not suppose direct causality, but highlights some possible correlations, and effects at a global level.

It seems that the media-image can influence the public acceptance, and furthermore, public opposition can influence technology projects. Conflict may appear in situations, where the public acceptance is lacking new policy directions, due to the fact, that public acceptance has been shown to be a major issue in government decision-making (Burstein, 2003). Major reason why public acceptance can be lacking for new policy directions is the perceived risk associated with an activity that does not match its actual risk (McGuire, 2015).

### *5.1 Scientific implications*

The scientific implications of this study include indicating that overall negative media-image of coal power may negatively influence also the possibilities of cleaner coal technologies. Further, the company decision-making in the energy production sector can potentially benefit over understanding the public acceptance. The findings are hence in line with (Bhimani, 2015; Hagel, 2015; Monino, 2016) in big-data analysis providing potential benefits for corporate decision-making. This study, however, provides new contribution by analysing the media-image of coal power and related cleaner coal technologies CCS and CCU. This is new as comparable previous analysis exists only for renewable technologies (Nuortimo et al. 2017; 2018a). The findings support and is in-line with the notion that opinion mining may have advantages in analysing media content for decision-making (More and Ghotkar, 2016). Understanding the media-image of coal power can provide support and indicate necessary directions for decision-making. This is in line with (Shah et al., 2002; Stieglitz and Dang-Xua, 2013). The findings indicate that the negative media-image may affect the development of coal technologies and influence the potential market deployment. This is in line with (Keating et al. 2011) in the public acceptance having the potential to influence the technology adoption. Nevertheless, the findings are also in-line with the reverse logic by supporting the notion that technology related communication may influence the public acceptance (Ho and Kristiansen, 2019). Hence, the findings support (Scheufele, 1999) in the media playing a role.

In case of coal power, the large negative communication seems to affect the development and deployment, also the cleaner CCS and CCU, and related investment/divestment decisions. The situation seems to have links to public acceptance and potentially also further also to political decision-making. This is in line with (Nuortimo and Harkonen, 2018) who have provided an initial link from the public acceptance to the market deployment of energy production. This is also in-line with (Koh et al. 2019) who presented the public understanding of CCS technology as an essential factor for technology adoption, R&D, funding, and even indicated the public understanding to affect the laws and policies. Hence, the understanding provided by the analysis is also in-line with (Wildgust et al. 2019) who understand that the public outreach might be necessary for CCS implementation. The findings revealing the media-image of coal power supports previous literature (Arning et al. 2019; van Alphen et al. 2007; Whitmarsh et al. 2019;) in the understanding that the public acceptance of CCS and CCU might be a vital precondition for the commercial-scale rollout of the technologies.

It is important to realise how the public acceptance can influence technologies and company decisions, but simultaneously it is vital to ensure the public also understands the bigger picture that relates to the energy industry. This as without truly understanding the energy mix of a society, regular people may show inconsistent preferences, such as support expanding wind and solar power, but may not be in favour of new transmission lines, or the public may support gas power plants to produce electricity but are against additional CO2 emissions. Hence, this study supports (Greenberg and Truelove, 2011) in understanding how it is important to emphasise the needs of nations when developing and communicating comprehensive energy strategies.

### *5.2 Managerial implications*

The managerial implications mainly relate to indicating the potential of big-data based methods as an aid for corporate decision-making. The managers can also benefit of understanding the media-image of coal power, and the related cleaner coal technologies, and the potential influence of negative media-image on other related technologies. The understanding over the potential effect of media-image at company level may also benefit the decision makers. Understanding how the negative coal power image may affect future R&D possibilities and the market deployment, may prove beneficial. Also understanding the possibilities to influence the media-image might prove beneficial. At the corporate level the importance of understanding the linkage and logic, and the potential influence of public acceptance on investment/ divestment decisions should not be ignored. Big-data based media analysis is also a possible tool for politicians, legislators and PR personnel for figuring out the public sentiment in a very large scale. The techno-economically motivated decisions at a time and the resulting direction of the energy sector may change along with public acceptance and changes in the political direction.

### *5.3 Limitations*

The limitations of this study include the analysed media-sentiment being limited to those classifications possible with the used keywords, and the English language. Hence, utilising other keywords might provide slightly different results. In addition, no detailed content analysis was possible due to a very large dataset, nor were any framing or other discourse analysis methods used. Also, the ability of the software and computational capabilities do set some limitations to the extent of possible time periods to be analysed, yet still allowing to analyse rather extensive data sets. The study focuses on finding some correlation between the analysed factors and does not attempt to establish direct causality.

## 6 Conclusions

This study utilises big-data based global media analysis to clarify the role of coal power related media-image in company decision-making. The findings provide some indications over the benefits of this type of method as a decision support for corporate decisions. The public acceptance of coal power has some linkages to R&D investments, company investments/divestments, and the market deployment. This study clarifies the media-image of coal power, and that of related CCS and CCU technologies. The findings indicate that the negative media-image of coal power has a negative impact also on the possibilities of CCS and CCU. Understanding the media-image of not only the editorial sources, but also the social media may prove beneficial by providing a view over the less filtered opinions.

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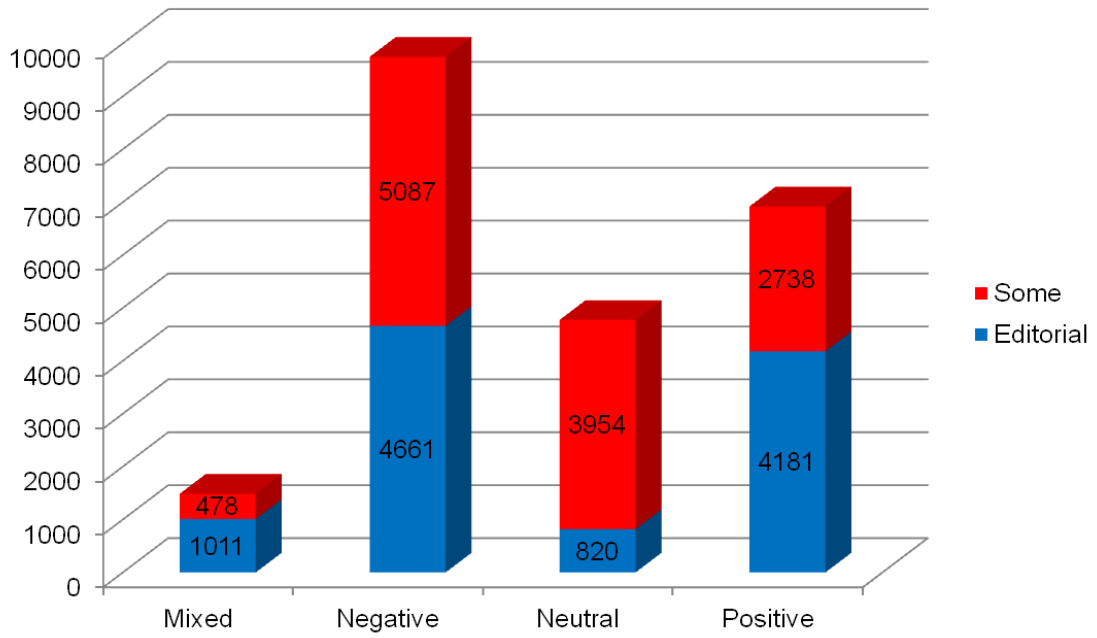


**Figure 1.** Sentiment analysis of social media (SoMe) vs. the editorial publications

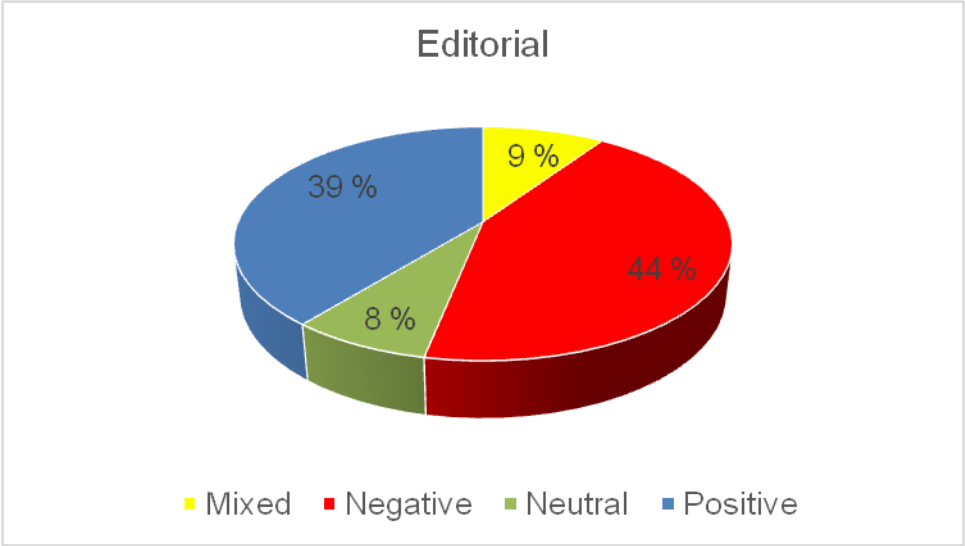


**Figure 2.** Coal power related media-sentiment in editorial publications

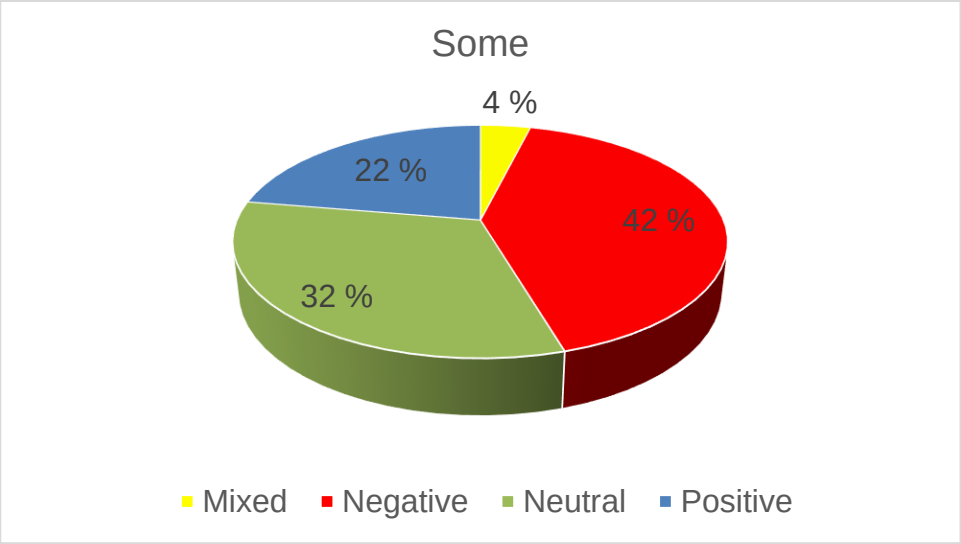


**Figure 3.** Coal power related media-sentiment in Social Media

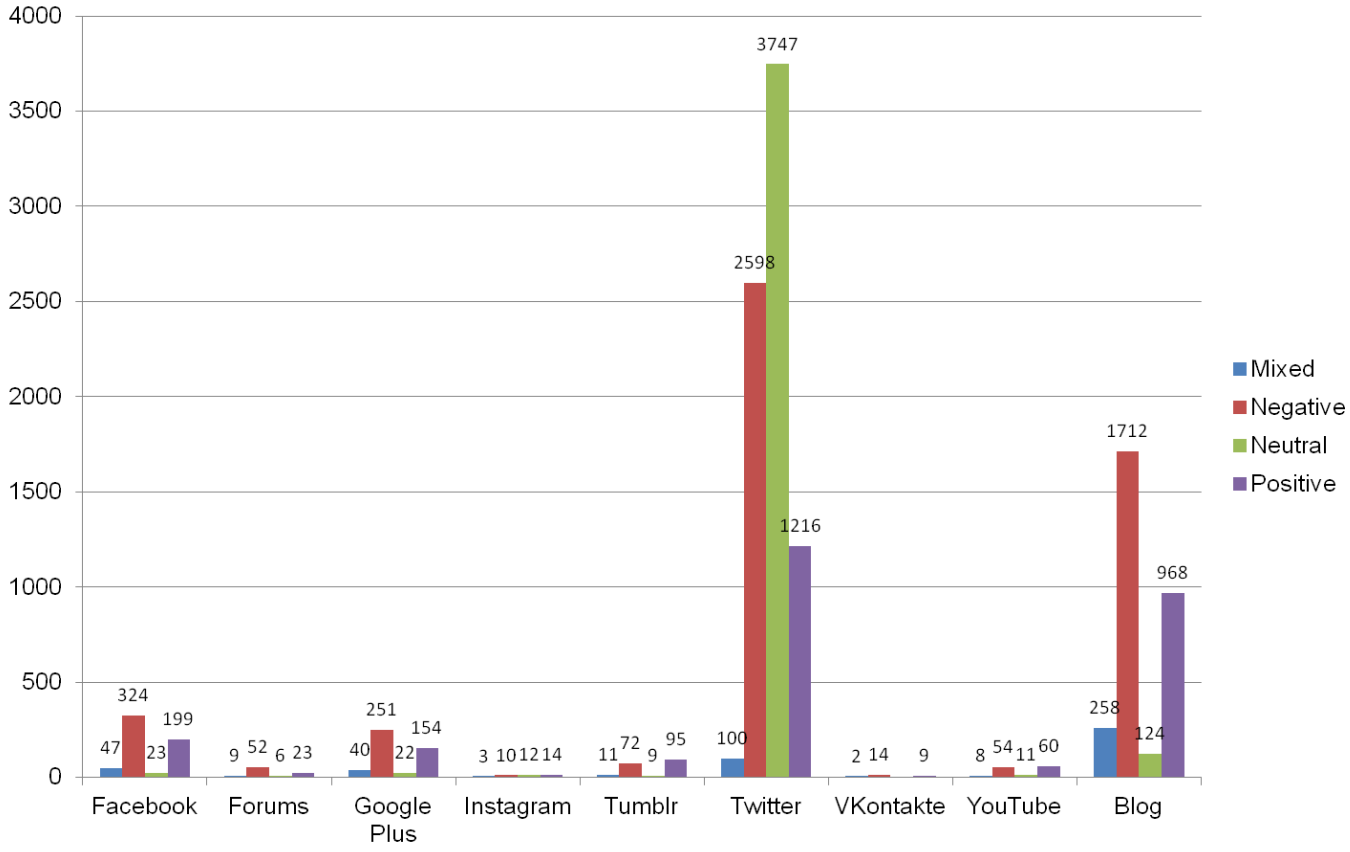


**Figure 4.** Social media-sentiment of coal power among different channels

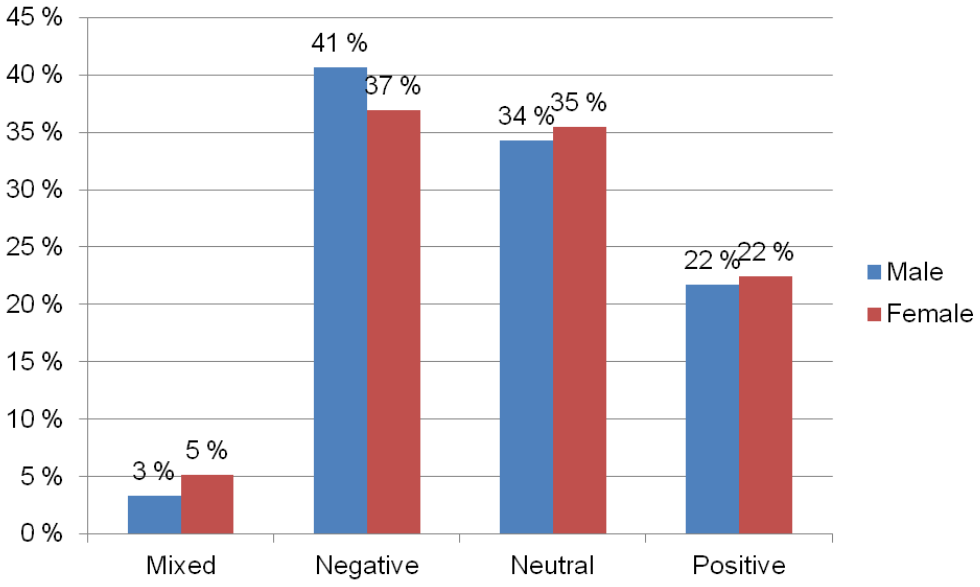


**Figure 5.** Gender sentiment deviations in social media

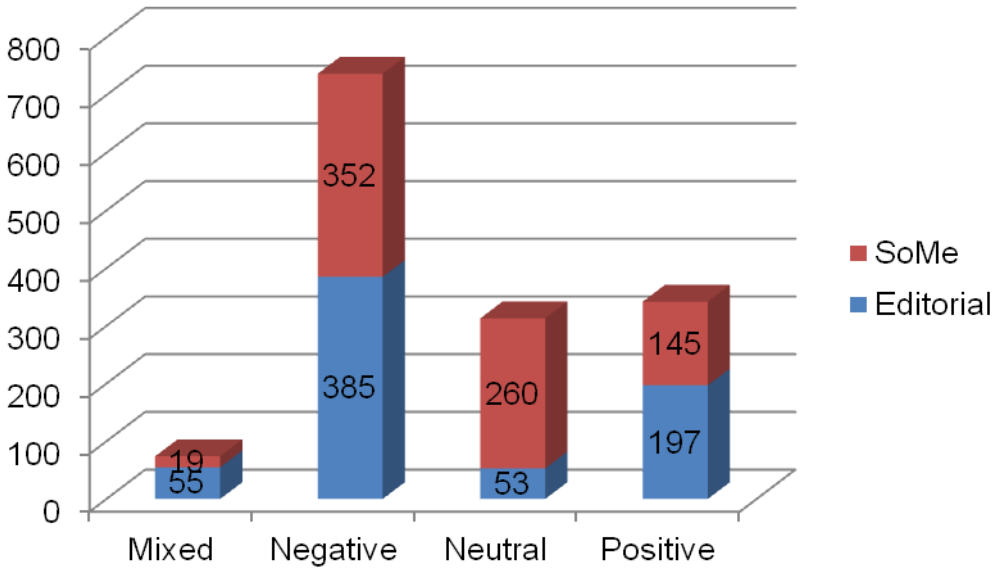


**Figure 6:** Media hits during Paris COP 30.11-12.12.2015

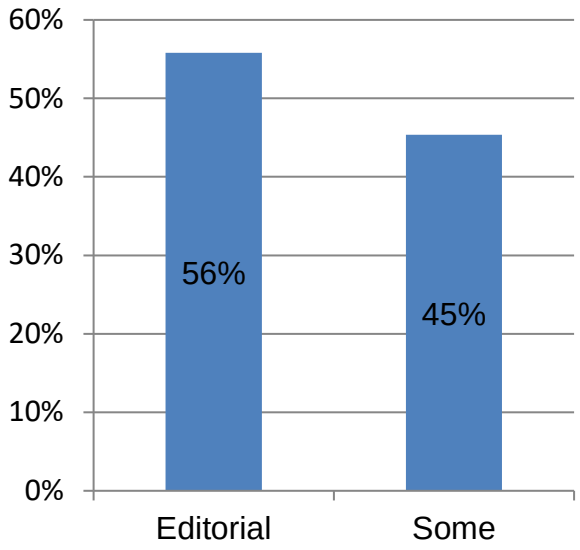


**Figure 7:** Negative sentiment during Paris COP21

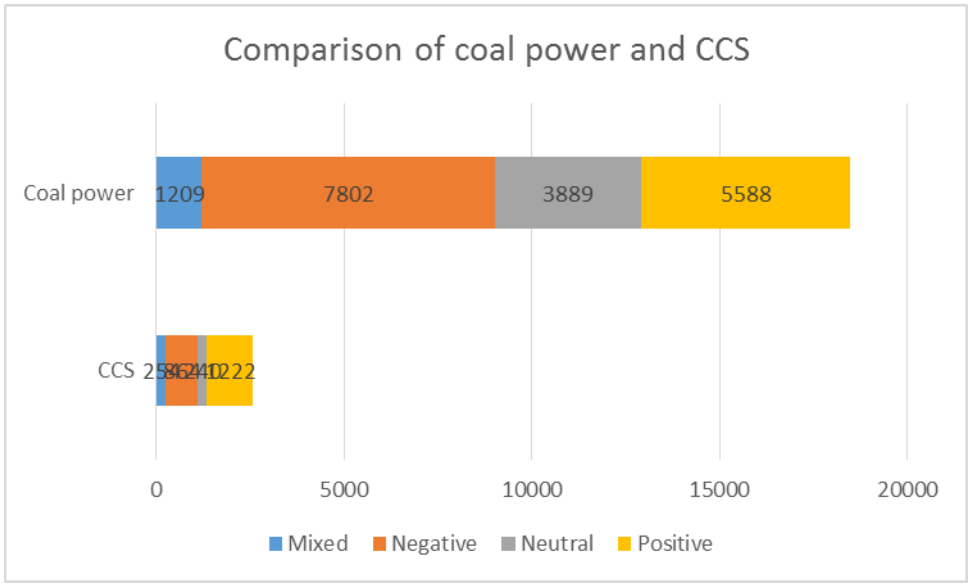


**Figure 8.** Comparison of media attention of coal power and CCS as media hits

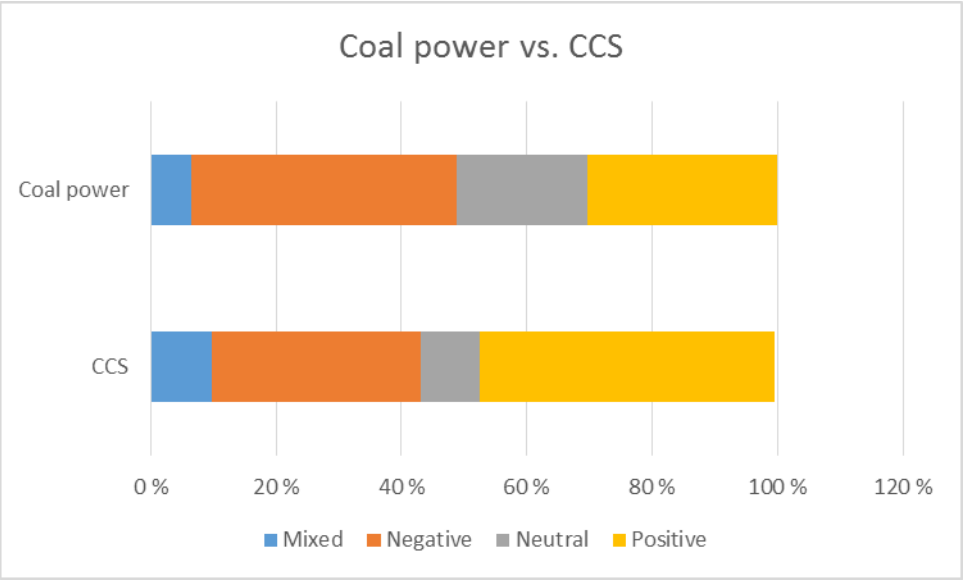


**Figure 9.** Sentiment of coal power and CCS as percentage

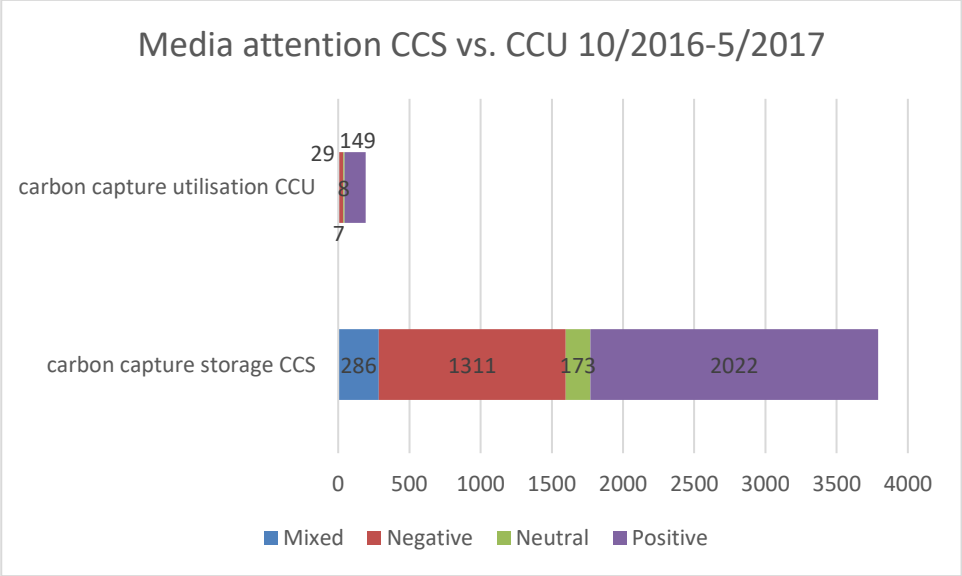


**Figure 10.** Media-attention of CCS and CCU as number of media hits

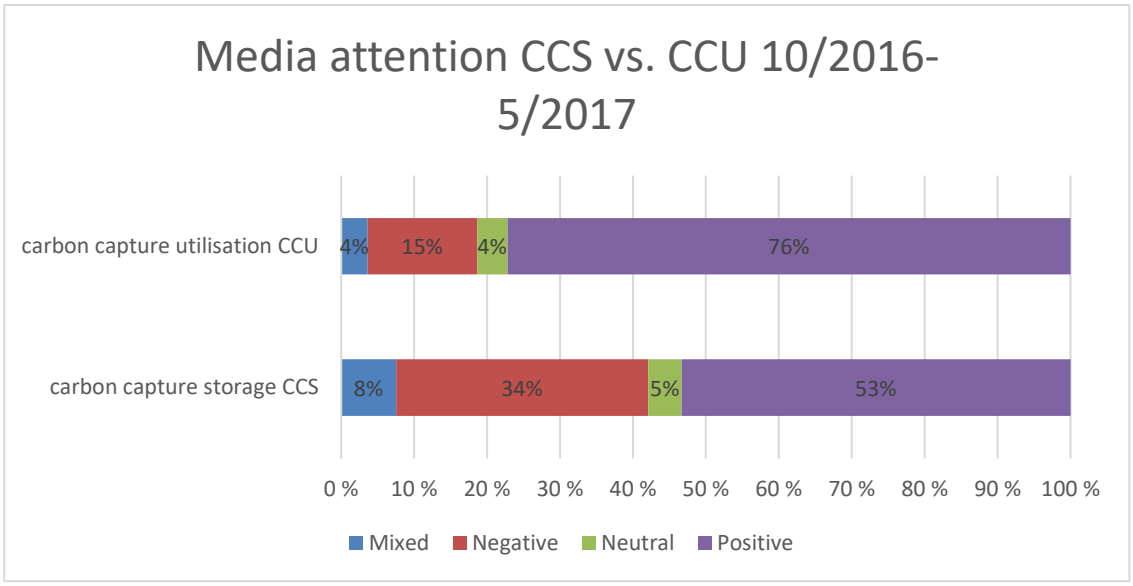


**Figure 11.** Sentiment of CCS and CCU as percentage

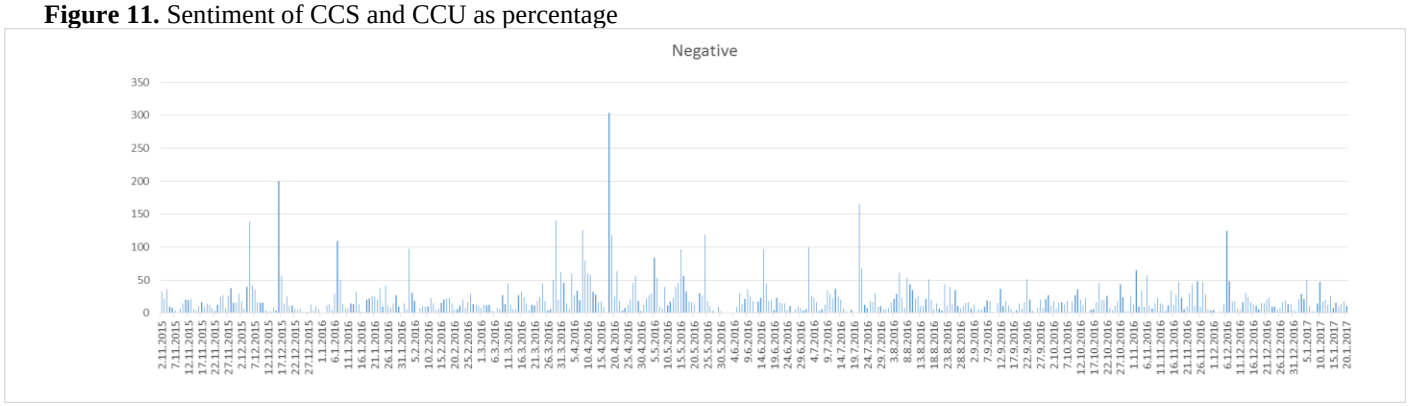


**Figure 12.** Negative media-attention concerning Vattenfall

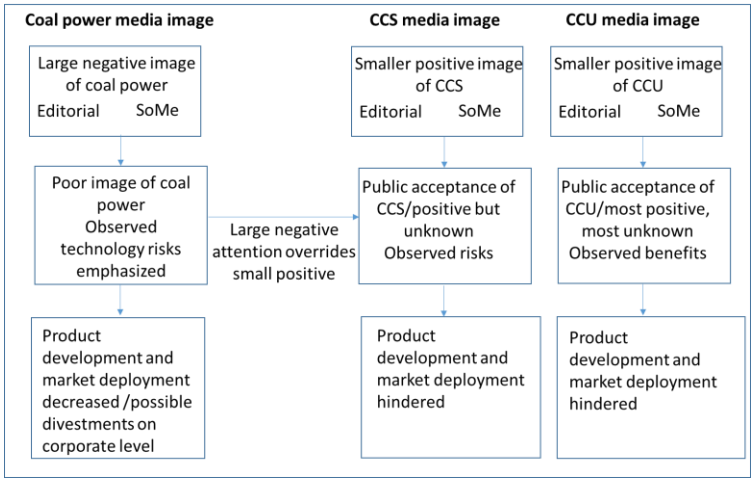


**Figure 13.** Descriptive link from media-image to product market deployment and investments/divestments - case coal power, CCS and CCU