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Article

News Media Analysis of Carbon Capture and Storage and Biomass: Perceptions and Possibilities

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Abstract: In the US, carbon capture and storage (CCS) has received most of its attention when coupled with the fossil fuel industry as a mitigation strategy for climate change. CCS, which is constituted as a broad suite of capture and sequestration technologies and techniques, does not preclude coupling with other energy industries such as bioenergy (bioenergy and CCS or BECCS). In this paper, we examined news media coverage of CCS and biomass individually in locations throughout the US where these technologies are being explored to determine how they are perceived and what possibilities lay in their coupling for climate change mitigation. From our analyses, we 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. Combined references do, however, speak to their value for climate change mitigation and as an alternative to fossil fuels.

Keywords: carbon capture and storage (CCS); bioenergy; energy technologies; newspapers; communication

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1. Introduction

Achieving global climate change mitigation goals will require a transition towards a sustainable energy system based on a reliable supply of low carbon fuel sources. To meet the most stringent mitigation scenarios, low carbon and renewable energy sources will need to be coupled with novel technologies to further reduce CO_2 emissions and atmospheric concentrations. Recent scholarly work and policy reports suggest deployment of the combination of bioenergy and carbon capture and storage (BECCS) as a means for keeping atmospheric CO_2 concentrations below 450 ppm will be necessary [1]. In the United States, bioenergy development has expanded rapidly over the last decade, driven by federal policies designed in part to mitigate climate change such as the U.S. Renewable Fuel Standard. While using biomass for energy production has a long history (e.g., wood stoves), recent emphasis has been placed on the development of liquid and other drop-in biofuels that can be placed into existing distribution and conversion infrastructure, including replacing gasoline, co-firing biomass with coal in power plants, and coupled heat and power in small industrial buildings using efficient biomass boilers. Thus far, much of the biomass output for bioenergy has been corn production for ethanol in the U.S. Midwest [2]. However, significant research and national and sub-national policies have been directed at developing perennial energy crops (often termed second generation) such as shrub willow, hybrid poplar, and switch grass as a viable replacement for fossil fuels [3]. The U.S. Billion Ton Update estimates that by 2030 perennial energy crops could supply as much as 61% percent of biomass output in the United States and could possibly replace up to 30% of petroleum feedstocks.

Bioenergy advocates suggest that in addition to the GHG mitigation potential of bioenergy, its production and use have multiple social and environmental co-benefits. These co-benefits include jobs creation and rural economic development, energy independence through decreased reliance on foreign fossil fuels, increased national security, enhanced biodiversity, and the protection of soil and water resources [3–5]. However, not all researchers are so sanguine about the impacts of bioenergy development. For example, critics have pointed out that bioenergy development can increase competition for land that is currently used for food production, leading to food insecurity and rising land, timber, and food costs, or may sacrifice their ability to store carbon and maintain biodiversity [6,7]. Further, it has been argued that the potential for biomass used for energy purposes to reduce GHG emissions has been overstated as proponents fail to account for the CO_2 released when the biomass is burned, instead considering it to be offset by the biomass feedstock [6]. Critics also maintain that bioenergy is an inefficient energy producer compared to other forms of alternative energy that could use the same land more efficiently, such as solar photovoltaics.

Carbon capture and storage (CCS) technologies allow carbon emissions from industrial processes and fuel combustion to be captured and stored underground (known as geologic sequestration) or be reused in other industrial processes such as enhanced oil recovery. In the United States, CCS is currently in the latter stages of research and development (from here on referred to as R&D). Proponents laud CCS for its ability to offset carbon emissions on a major scale, but public opposition to CCS demonstration projects has been documented in Europe and the United States. For example, opposition to a CCS demonstration project in Ohio arose because of concern about the project's negative impact on property values, concerns about leakage, and citizen objections to being the object of an experimental process [8].

Other noted concerns include distrust of industry and government entities involved with CCS projects, fairness of implementation procedures, and lack of citizen empowerment in local decision-making [9].

While CCS has received most of its attention as a means for the fossil fuel industry to reduce their carbon footprint [10], its coupling with bioenergy holds promise because it can mitigate climate change through negative emissions, offsetting residual emissions from other sectors in the latter part of the 21st century [1]. Currently, BECCS is still in the R&D stage in the United States, with two ethanol fuel plants capturing their carbon emissions and piping it for use in enhanced oil recovery [11]. A larger project in Illinois—the Illinois Basin Decatur Project—funded in part by the U.S. Department of Energy's Industrial Carbon Capture and Sequestration Program, is projected to capture up to one million tons of carbon per year from an Archer Daniels Midland ethanol plant in Decatur, Illinois, which will then be stored in the Mount Simon Sandstone formation [12].

Because BECCS research and development is still in the early stages and its deployment is expensive, it will require robust financial incentives to make it competitive with other technologies [1]. As such, public support for and understanding of BECCS and the role it can play in the transition away from fossil fuels towards renewable energy and climate change mitigation will be important for gaining policy support for BECCS deployment. Given the proliferation of bioenergy crops in the United States and the nascent BECCS industry's potential for climate change mitigation, it is important to understand perceptions of the two suites of technologies, bioenergy (*i.e.*, liquid fuels) and CCS, independently before considering perceptions of their coupling in the form of BECCS. Media analyses serve as a useful method for examining public discourse about new technologies by examining their benefits as well as risks [13]. Relatively little research has examined media representations of either bioenergy or CCS [14–16]. Because BECCS is in its infancy, no research has done so. The goal of this study is to contribute to the nascent literature examining media representations of these technologies by exploring media representations of CCS and second generation bioenergy, as well as cross utilization of CCS technologies for bioenergy production in states pursuing these energy technologies. These representations inform public opinion, knowledge, and acceptance of technologies such as BECCS because of media's role as a source of information on science and technological findings [17]. We focus on the state-level for this analysis in order to capture state and federal-level context impacting technology R&D and commercialization. We use media as a means for exploring a generalized public discourse on energy systems in a carbon constrained world and to gain a better understanding of how energy technologies related to climate mitigation are framed for a public readership by mass media outlets. Using newspaper data collected from previous analyses on CCS and woody/warm season biomass respectively, we will examine: (1) social systems emphasized in media coverage of the two technologies individually including their positive and negative framing; and (2) the presence and context of cross references of the technologies in the two data samples.

1.1. Media Framing of Science and Technology

The mass media in modern society serves as an intermediary between scientists, policy makers, industry, and the public by translating scientific information for general consumption [18,19]. According to Corbett and Durfee, "For most citizens, knowledge about science comes largely through mass media, not through scientific publications or direct involvement in science" [20] (p. 130). Journalistic norms in

reporting by the mass media also help determine what is novel and relevant to its readership. These norms include personalization and dramatization of information, reliance on authority figures as information sources, and giving equal weight to both sides of the story (see [18] for further description of journalistic norms). These journalistic norms also lend to the presentation of scientific and technological information as factual or, for the sake of balance, as a binary between benefits and risks. Along this benefit-risk vein, Skjølsvold argues that newspaper coverage provides its readership with an evaluation of the technologies addressed in their text, thus "taking part in the technology diffusion process" [14] (p. 513). He goes on to state that newspapers assist with the construction of meaning of artifacts such as biomass energy, and that in order to construct this meaning, the media draws from multiple actors within society such as scientists, policy makers and publics to produce a collective meaning of that technology. These presentations of science and technology therefore have the ability to shape and reflect public perceptions and debates [14], thus making media analyses a useful tool for gauging public perceptions about technologies such as CCS and biomass.

1.2. SPEED Framework

The Socio-Political Evaluation of Energy Deployment (SPEED) framework is an empirical tool for assessment of emerging energy technologies within a state-level context [21]. This framework draws on Luhmann's theory of social function systems [22], which posits that society responds to environmental issues through a series of related, yet distinct social systems that communicate with each other through a process of resonance. Each system, while distinct in its emergence, structure, operation, maintenance, and language [23], can have an impact on other systems such as science influencing the economy or politics influencing the legal system. Thus when one system is perturbed by an event or issue, it can cause reverberations within the other systems. According to Luhmann, these modern day social systems include, but are not limited to economy, law, science, politics, religion and education. To better adapt to an energy deployment context at a more micro scale, the SPEED framework includes a re-categorizing of systems into the following: technical, political/legal, health/safety, environmental, economic and aesthetic (Table 1). The SPEED framework uses these systems to examine technological development, but at three levels of exploration: (1) strategic, which includes long-term visioning and context for an issue; (2) tactical, which includes institutional agenda setting, negotiation and coalition-building; and (3) organizational, which encompasses project building and implementation [13]. The benefit of this approach is its ability to deconstruct complex, multi-scalar issues in a way that is informative to both academics and practitioners. It is also tailored to a specific type of dilemma, energy policy development, making its structure context specific. The framework can be used in conjunction with various forms of data, most notably interviews, focus groups, policy analyses and media analyses. This study uses the media analysis approach which, according to Stephens, Wilson, and Peterson [21], allows for the examination of policy goals and their rationale as portrayed by the media as well as public perceptions of these goals. The empirical structure of SPEED allows for the measurement of media coverage of these social systems to determine emphasis placed on these systems during various stages of energy technology deployment. To date, this framework has been used to conduct media analyses on emergent and establishing energy technologies such as wind [24,25] and CCS [26]. In later writings, Luhmann

even includes the mass media as a social system unto itself because of its impact on the construction of reality [27].

Media analyses using the SPEED framework provide insight into progress made in the deployment of energy technologies as well as help identify systems requiring further deliberation and problem-solving. Unlike other methods that capture data during a particular point in time, media analyses can be used to track progression over time, making the ebbs and flows of energy discourse more apparent in addition to bringing to light the impact of specific events on this discourse (e.g., passage of new legislation or impacts to energy infrastructure due to a natural or human-caused disaster). For these reasons and the reasons noted above, examination of news media has predictive power in understanding general public acceptance of energy development.

Table 1. SPEED framework system categories.

Category	Description
Technical	Includes advancements and limitations of the technology and its development and makes comparisons against other energy technologies with the same purpose.
Political & Legal	Includes (1) political support and opposition to the technology by political figures, coalitions and the general public; (2) benefits and drawbacks of the technology to a state or nation's national or global standing or goal achievement; and (3) issues related to permitting, liability and technology siting.
Health & Safety	Consists of benefits and drawbacks of the technology on human health and safety and includes comparisons against other energy technologies with the same purpose.
Environmental	Consists of benefits and drawbacks of the technology on the environment and includes comparisons against other energy technologies with the same purpose.
Economic	Includes (1) economic incentives, savings and costs associated with technology deployment at the R&D and commercial scales; and (2) marketability of the technology.
Aesthetic	Consists of (1) positive and negative impacts to viewsheds as well as cultural, historical, or recreational sites; and (2) educational impacts.

2. Methods

The data and analysis for this paper stem from two independent studies focused on CCS and biomass individually using similar analyses. Locations for the data sets were chosen because of R&D occurring in those states (*i.e.*, Massachusetts, Minnesota, Montana and Texas for CCS and New York for biomass). For the purposes of this analysis the data have been cross analyzed, though it should be noted that the biomass data are focused specifically on perennial crops (*i.e.*, warm-season grasses and willow) R&D for energy production and not ethanol production from crops such as corn. Similar to corn ethanol, woody/warm season biomass can be used for the production of drop-in biofuels (*i.e.*, biomass derived hydrocarbon fuels similar to gasoline, diesel or jet fuels) as well as heating. This leads to some constraints within the biomass data: (1) data sets were collected during different years and for different durations of time; and (2) the types of newspapers selected differed slightly because of their stage in development and goals of the individual research project. Though these constraints are not ideal for a complete cross analysis of CCS and biomass, the data does present some compelling results for future coupling of the energy technologies.

2.1. CCS Data Collection and Coding

CCS media data stemmed from a previously published study by Feldpausch-Parker *et al.* [26]. In this study news media coverage of CCS technologies was analyzed at the state level in four states spanning the U.S. (Massachusetts, Minnesota, Montana and Texas) to examine media perceptions of the technologies in states with different energy histories and efforts toward CCS development. For each state, three types of newspapers were selected to provide a comprehensive view of state-level media coverage. These included the (1) highest circulated newspaper in the state (*Boston Globe*, *Minneapolis Star Tribune*, *Billings Gazette*, and *Houston Chronicle*); (2) the newspaper situated within the state capitol or a similar newspaper with strong coverage of policy (*Springfield Republican*, *St. Paul Pioneer*, *Missoulian*, and *Austin American-Statesmen*), and a regional newspaper in close proximity to energy R&D activity (*Cape Cod Times*, *Duluth News Tribune*, *Bozeman Daily Chronicle*, and *Midland Reporter Telegram*). LexisNexis Academic database and individual newspaper archives were used to access articles. Search terms for the study included CCS, carbon sequestration, carbon capture, carbon storage, and/or clean coal. These terms needed to be present in the title and/or lead paragraph of an article to be considered for analysis. The analysis timeframe was from 1 January 1990 to 15 June 2009; with the start date coinciding with publication of the 1990 Intergovernmental Panel on Climate Change Assessment Report. All article types were included in order to account for all forms of media coverage. A codebook developed using the SPEED framework was used to code articles at the sentence level. Four coders were used for the original coding process and inter-coder reliability was obtained through a coder consensus process resulting in 100% inter-coder agreement. However, for the purposes of the current analysis, the coding unit was changed to the article level for a more accurate comparison with the warm-season/woody biomass data, also coded at the article level. We found no significant change to the data trends due to this change in coding level.

2.2. Warm-Season/Woody Biomass Data Collection and Coding

The goal of the original warm-season/woody biomass analysis (unpublished) was to capture topics addressed by news media in communities directly or indirectly involved in or impacted by biomass operations in New York State. This determined the choice of news media sources, which included the highest circulated newspapers in the four counties of the state with the most warm-season/woody biomass R&D projects underway: *Watertown Daily Times* in Jefferson county, *Observer-Dispatch* in Oneida county, *Journal and Republican* in Lewis county, and *Post-Standard* in Onondaga county. Access World News database was used to access the selected newspapers. Search terms included general biomass terms as well as specific species under investigation and companies involved in biomass activities. These terms included the following: biomass, biofuel, bioenergy, switchgrass, miscanthus, willow, BCAP, cellulosic, Mascoma, Catalyst Renewables, Double A Willow, and Celtic Energy. The search criteria were whether articles included the aforementioned terms in the title and/or lead paragraph of an article and/or first 200 words of the article if there was no obvious lead paragraph based on formatting offered by the database. The analysis timeframe was from 1 January, 2008 to 31 December, 2013, with the start date coinciding with the introduction of the Biomass Crop Assistance Program (BCAP) in the state. This particular program was designed by the Food, Conservation, and Energy Act of 2008 [28]

and aims at facilitating development of advanced biofuels derived from non-food/feed crops. Similar to the CCS analysis, all article types were included.

The articles that met the search requirements were retrieved and coded at the article level. A codebook was developed to guide coders in identifying function systems in action based on the SPEED framework written specifically for bioenergy development and implementation. The coding structure for this codebook was adapted from the CCS media project. Two coders were involved in the analysis. Inter-coder reliability for the two coders was tested on 10% samples of the data until the required 85% of inter-coder agreement and the minimum 0.7 of the Krippendorff's Alpha were achieved for each coding category [29]. Once accepted levels of inter-coder reliability were obtained, the coders analyzed the remaining articles individually.

2.3. CCS and Warm-Season/Woody Biomass Analyses

For both sets of data, we used the qualitative data management software NVivo Version 10 for the coding process. Function system coding at the article level allowed for the creation of a searchable, text-based database. Using this database, we ran queries to determine the frequency of the various function systems by state for each technology. We then looked for cross references of the two technologies in each set of technology-based articles, using the search terms specific to each respective technology (*i.e.*, biomass search terms used to search the CCS articles and vice versa). All cross references found were then examined by coding category.

3. Results

3.1. CCS Coverage

Nine of the 12 newspapers under consideration reported on CCS technologies during the 19-year time period, resulting in 216 total articles. The highest numbers of articles were contained in the three Texas newspapers, with the *Austin American Statesman*, *Houston Chronicle*, and *Midland Reporter Telegram* containing 11, 17, and 91 articles, respectively. Montana had the second highest coverage with the regional newspaper having the highest frequency of CCS articles in the state: *Billings Gazette* (5), *Bozeman Daily Chronicle* (62), and the *Missoulian* (1). The fewest number of articles reporting on CCS were in Massachusetts, where the *Boston Globe* contained 19 articles, and in Minnesota, where the *Minnesota Star Tribune* had four articles and the *St. Paul Pioneer Press* had six. Similar to New York, a higher number of stories were contained in regional newspapers distributed near places where CCS research is being pursued or that have active commercial energy production. For example, the high number of articles on CCS in the *Bozeman Chronicle* is likely explained by the presence of the Big Sky Carbon Sequestration Partnership in Bozeman, which is a partnership made up of university, private sector, and government representatives dedicated to researching and developing CCS in the Northwestern United States.

3.2. CCS Function Systems Reporting

The political/legal function system received the most coverage in all four states. Newspapers in Montana and Massachusetts reported on political/legal matters most frequently (34% of articles), with Texas (31%) and Minnesota (27%) exhibiting slightly less coverage. Articles that mentioned the political/legal function system gave more attention to benefits than they did to risks and focused on one of two issues: state-level attempts to avoid national legislation regulating carbon through the development of state-level standards, and the challenges that attend CCS siting and permitting processes ([26]; Figure 1). In general, political/legal statements described the importance of diversifying state level energy portfolios and transitioning to renewable energy futures that were based on long-term goals. The next most covered function system was the economic system. Coverage was similar across all four states. In Minnesota and Massachusetts economic benefits and risks were given equal coverage, while in Texas and Montana references to the statements about the economic function system more frequently focused on benefits than they did risks. Statements about the economic benefits described the job creation potential of CCS, with claims such as "It will pave the path to clean development of our vast coal reserves—an industry that will bring new jobs and positive growth to Montana" [30] being commonplace. When economic risks were mentioned, the statements focused on the financial risks that CCS development posed to industry or U.S tax payers should the projects fail [26]. Notably, the economic function system was mentioned less often in CCS articles than it was in the biomass articles, despite both having similar economic development benefits and potential. Coverage given to the environmental function system was consistent across states and primarily highlighted the environmental benefits of CCS. In particular, newspapers lauded the ability of CCS to reduce greenhouse gas emissions and its potential to mitigate the problems caused by "old" and "dirty" coal-fired power plants. For example, one newspaper quoted an industry representative: "oil pumped out using the stored carbon dioxide should be called 'green oil' because more carbon dioxide is stuffed underground than is generated by the oil when it burns" [31].

The technical function system received a similar amount of coverage as the environmental system, though the level of reporting on risks and benefits was more even. When technical benefits were mentioned, the articles described how well established CCS technologies are. This was especially true in Texas. When risks were mentioned, CCS technologies were portrayed as still being experimental and the articles expressed doubt as to whether the CCS technology is ready for commercial-scale deployment. One Letter to the Editor went so far as to express doubts that CCS would be an effective way to mitigate carbon emissions: "If these researchers are correct, it is way beyond the capacity of natural carbon sinks, and extremely unlikely for any technological carbon sinks, to ever effectively sequester even half the atmospheric carbon that must be released from the burning of fossil fuels" [32]. Finally, the health/safety and aesthetic function systems received little to no media coverage in any of the four states. When health/safety was mentioned in an article, the focus was on either the potential for CCS to improve air quality or concerns about the possibility of toxic chemical releases from plant failures and related impacts on property rights [26].

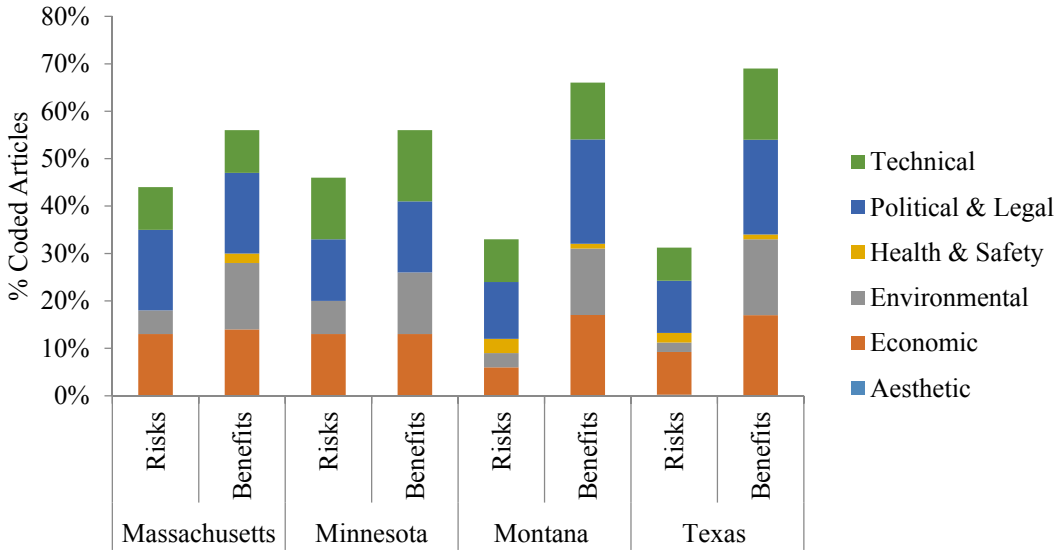

Figure 1. Media coverage of CCS function systems and their related risks and benefits.

3.3. Warm-Season/Woody Biomass Coverage

Each of the four selected newspapers in New York State reported on biomass over the five year period under investigation, resulting in a total of 114 articles. The *Watertown Daily Times* in Jefferson County (74) and the *Post-Standard* in Onondaga County (24) contained the highest number of articles on biomass and or bioenergy, while the *Observer-Dispatch* in Oneida County (8) and the *Journal and Republic* in Lewis County (8) reported on biomass/bioenergy less frequently. The high number of articles on biomass in the *Watertown Daily Times* is likely the result of Jefferson County being an active site under the United States Department of Agriculture funded BCAP, which provides subsidies to landowners who grow biomass crops on their land, as well as its proximity to ReEnergy Black River, a 60 MW power plant that relies on locally-sourced biomass as its primary fuel source. Finally, we found that reporting across the five year time period on biomass peaked every other year, with 23 articles in 2008, 14 articles in 2009, 19 articles in 2010, 14 articles in 2011, 29 articles in 2012, and 15 articles in 2013.

3.4. Warm-Season/Woody Biomass Function Systems Reporting

In this section we report which of the function systems the coded articles reported on, as well as whether the article discussed biomass as providing a benefit or posing a risk to the system under consideration. The economic function system was the most reported on in the coverage in all four counties, with 28% of coded articles discussing biomass as an economic issue. The coded articles were far more likely to discuss the economic benefits of biomass (24%) *versus* the economic risks (6%). Statements of the economic benefits of biomass described its economic development potential, both through the creation of local jobs and the monetary savings that could be gained through a switch from fossil fuel generated electricity and heat to biomass powered systems (Figure 2). For example, the *Watertown Daily Times* reported that, "A growing biomass industry will not only help our region meet goals for energy self-sufficiency but it will be a stimulus to our local economy by keeping our land in production, diversifying our farming operations and creating jobs in agriculture, forestry and

manufacturing" [33]. When potential economic risks were presented, the discussion centered on circumstances that may impinge on the economic development potential of biomass, such as a lack of available markets and concerns about the viability of biomass to thrive without heavy government subsidies. A quoted farmer provided a representative quote of this position: "I probably won't put in any more until I get a market for it (biomass crops). It takes a while to develop" [34].

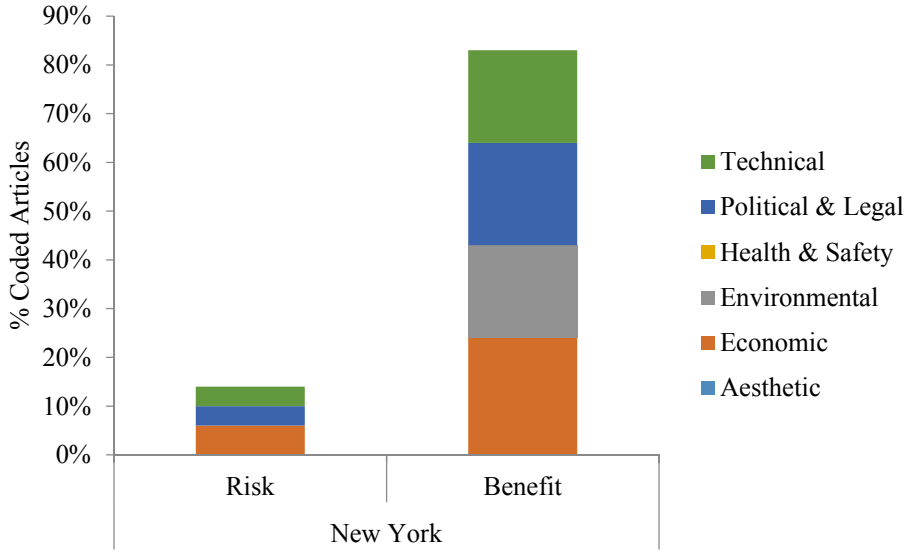

Figure 2. Media coverage of biomass function systems and their related risks and benefits.

The next two most covered function systems were the technical function system and the political legal system. Articles that mentioned the technical functions of biomass only described its benefits, and the discussion primarily focused on the ability of biomass crops to grow on marginal land not suitable for food crops. For example, the *Post-Standard* reported that, "On many farms, there is a field that is too wet or too far away and not used to its fullest potential. We can give them a way to make good use of that land and keep it from growing up into brush" [35]. Twenty-one percent of coded material referred to the political and legal benefits of biomass, while only 4% noted risks. Political/legal statements highlighted that biomass development may help New York gain a competitive advantage over other states in the emerging renewable energy industry. As the *Post-Standard* reported, the "concept (of biomass crops) has been well received in Madison County, which has been on the forefront of green energy issues for the past decade" [35]. A similar level of attention was given to the contributions biomass could make to national energy independence. No legal or political risks were mentioned other than two discussions about a New York State Supreme Court Case that dealt with reassessing the value of a biomass co-generation facility, which could have a negative impact on the local tax base.

The environment function system received slightly less media coverage than the political legal function system, and was present in 20% of coded articles. This coverage only focused on the benefits of biomass to the environment, and described the technology as green and sustainable, noting its carbon benefits and its soil nutrient recycling capabilities, and explaining that growing biomass would have a favorable impact as it would allow "the soil (to) remain fertile" [36]. Newspaper coverage in all four counties gave no coverage to the aesthetic as well as health and safety functions of biomass. Finally, the results show that in contrast to the coded CCS articles which had a more balanced presentation of the

risks and benefits associated with CCS, the biomass articles focused far more on the benefits associated with biomass production than the risks. This difference is likely the result of CCS being farther along in the R&D process, while biomass production for bioenergy, at least in New York, is still in its infancy.

3.5. Cross References of Biomass and CCS

Table 2 shows the number of times that the CCS newspaper articles in our study made explicit reference to biomass as an energy source that could be coupled with CCS to reduce CO_2 emissions and concentrations in the atmosphere. It also shows the number of times the biomass focused articles mentioned CCS as a possible way to improve the carbon benefits of biomass. There was little discussion of biomass or bioenergy in CCS articles and no mention of CCS in the New York biomass articles. When biomass was mentioned in the CCS articles, the focus tended to be on the benefits of ethanol production for achieving climate change mitigation goals and as a replacement for fossil fuels. Interestingly, in Minnesota and Massachusetts, both states where CO_2 storage projects will likely not be implemented because of their distance from geologic formations suitable for CO_2 storage, biomass is mentioned in relation to CCS more frequently than it is in Texas and Montana, where CCS has capture and storage capacities. This may be because neither Minnesota or Massachusetts has fossil fuel extraction present, while both Montana and Texas do, causing the states with rich fossil fuel resources to focus more heavily on CCS in relation to fossil fuels than they do bioenergy.

Table 2. Presence of cross references between CCS and biomass.

Type of cross reference	State	# of articles w/cross reference	% of articles w/cross reference out of total articles examined
CCS articles mentioning biomass	Massachusetts	2	11%
	Minnesota	2	20%
	Montana	2	3%
	Texas	4	3%
Biomass articles mentioning CCS	New York	0	0%

4. Discussion

The CCS and biomass news media data used in this study came from pre-existing data from two independent studies. Though in many respects, this type of meta-analysis comes with some limitations (e.g., different research goals and different data collection strategies), there are some valuable takeaway points from their combined analysis. The following sections address some of these key points and their utility to better understanding the potential for combining CCS technologies with biofuel production.

4.1. Media Coverage

The CCS data used in this study covered nearly 20 years of newspaper articles in four states (Massachusetts, Minnesota, Montana, and Texas), resulting in 216 articles. The warm-season/woody biomass data only covered a quarter of that time and resulted in 114 articles in one state: New York. This demonstrated higher coverage of warm-season/woody biomass by the mass media; something of note considering that warm-season/woody biomass is not as far along in its commercialization and not

as popularized by the media as its annual crop counterparts (e.g., corn ethanol). Feldpausch-Parker *et al.* [25] attributed this low coverage of CCS to a lack of public concern about climate change during a large portion of the study's time span. With the exception of efforts in Bozeman, Montana, CCS R&D activities were also not as well publicized as they were in the warm-season/woody biomass data. In many articles, CCS was also tied directly to climate change mitigation or emissions reduction. This same linkage has been made in other countries such as Norway where CCS is seen as a way to create consensus on climate policy while still taking advantage of fossil fuels [37]. Warm-season/woody biomass was not as closely tied to climate change mitigation, but more so described as "sustainable" or "green". By not having such a close tie to climate change mitigation, biomass had a broader appeal, which was bolstered further by the fact that it was taking advantage of a regional resource in a state not known for being a big producer of fossil fuels. Further, the disparity between the level of coverage for biomass and CCS is likely attributable to the fact that bioenergy development in New York is led by the State University of New York College of Environmental Science and Forestry, which issued a significant number of press releases about the topic that have been picked up by the media.

Another interesting finding from these combined studies was the sheer amount of media coverage on either CCS or warm-season/woody biomass coming from the regional newspapers compared to the larger newspapers with higher circulation. The CCS data, with the greater diversity of newspapers represented in their study data, made this point, with the regional newspapers sometimes containing five to 10 times the number of articles than the largest state papers. This particular finding was the reason for the regional newspaper focus in the warm-season/woody biomass study, which again showed greater media coverage from newspapers closest to the energy operations than their more distant counterparts. Our combined study findings informs our argument that media analyses of regional newspapers closest to sites of interest provide the greatest amount of detailed discussion on a particular energy source. Focusing on regional newspapers also provides a different perspective of the issue than the commonly analyzed national newspapers [38]. There is an issue of scale that is not often discussed in media analyses, but can be very informative when trying to determine progress made in the deployment of energy technologies. For instance, what makes "sense" at the national level in respect to energy systems may or may not translate to the local level and *vice versa*. This type of scale discrepancy in energy dialogue has been made obvious in coverage of high volume hydraulic fracturing in Pennsylvania and New York, where one state, New York, put a moratorium, later changing to a ban, on natural gas development in due part because of experiences from the other state, Pennsylvania. Evensen *et al.* [39] stated that "The journalists have given us reason to believe that regional newspaper coverage of Marcellus Shale issues is heavily reflective of local discourse, particularly information, ideas, and opinions shared at public meetings, which, in turn, are shaped by history and culture" (p. 74). Sengers Raven and Van Venrooij also point out in their study of biofuels in the Netherlands that "Resistance to a technology is often more clustered and confined to small, but organized groups, which often strategically use media" [40] (p. 5014). Signs of such resistance would be more obvious close to production sites and thus picked up by the regional media. These findings demonstrate a need for more attention given to local or regional dialogue when determining barriers and opportunities for energy development of CCS and biomass.

Finally, though our study showed more media attention focused on warm-season/woody biomass than CCS, it by no means compared to media coverage given to much more controversial sources of energy such as natural gas from hydraulic fracturing. In a five year study of hydraulic fracturing media coverage

in the states of New York, Pennsylvania, Michigan and Texas, Batill and Feldpausch-Parker [41] found substantially greater coverage of the issue (more than 1,800 articles from the four states) than what we found in either the CCS or warm-season/woody biomass data. Mazur [42] explains these findings with his Quantity of Coverage Theory, which states that the amount of media coverage of a particular technology is in direct relation to that technology's level of public opposition. In the case of hydraulic fracturing, the opposition is high [41], but this does not seem to be the case for either CCS or warm-season/woody biomass. This discussion of energy technology promotion or opposition leads into our next section addressing social function systems.

4.2. Function Systems

From a mass media perspective, both CCS and warm-season/woody biomass are more often viewed in a beneficial light than as a risk because of their perceived economic benefits to a region through job development as well as their demonstration of technological innovation and value for climate change mitigation, or in the case of biofuels, replacement for fossil fuels. News coverage of warm-season/woody biomass focused most heavily on economics because of its development possibilities in economically depressed regions of New York. The economic function system was also a hot topic for CCS in the four study states, but like most technologies that have received coverage for an extended period of time, doubt about their benefits start to filter into the media dialogue. For both suites of technologies, the political/legal function systems received a high degree of coverage by state level newspapers. Reasons for the heavy focus on these combined function systems have to do with the importance of these systems during certain periods of time within the greater energy conversation (*i.e.*, generally after R&D is well underway). Luhmann explains this importance, stating that "whatever the economy does not bring about on its own has to be accomplished by politics with the help of its legal instrument" [22] (p. 63). He also mentions how politics "claims a special place in society…Even today we still expect politics to provide social integration and the solution of otherwise insoluble problems" (p. 84). This is obvious from the references to incentive programs, which often serve as the backbone to emerging energy technologies until a solid enough market comes into place. Heavy reliance upon incentives was noted specifically in relation to warm-season/woody biomass, but was also part of the conversation for CCS, placing a level of doubt about their development without strong political support.

The environmental and technical function systems, as noted above, was a noticeable topic of conversation by the media for both CCS and biomass. Though they were often a distance behind the topics of policy, law, and economics, these function systems were of key importance in the media discourse and often served as justifications for moving away from "dirtier" forms of energy production.

Wright and Reid [5] found similar framings in their media analysis of biofuels in the United States. In their study, they examined the *New York Times* as one of the highest circulated US newspapers. They used broad search terms such as ethanol, biofuels and renewable fuels, but they found that most of the content focused on corn ethanol. Similar to our study, economic development, the environment, and national security were the main themes. Their three year study differed, however, in that over time, environmentally positive framings of biofuels changed to more negative framing.

> Claims were made that biofuels were actually culpable in advancing deforestation, carbon sequestration, global warming, and other environmental disasters. Over time, many frames

> did offer room for congruence by distinguishing "good biofuels" from "bad biofuels". For example, frames commonly differentiated corn ethanol (bad) from cellulosic ethanol (good) [5] (p. 1394).

This distinction made between "good" and "bad" biofuels may explain why our warm-season/woody biomass results remained almost entirely positive during the five year duration of the study. Media coverage of warm-season/woody biomass has not suffered the same concerns as annual crop-derived biomass such as corn or soy beans because it is not perceived as being in direct competition with food production as noted in the Netherlands biomass media study [40]. Wright and Reid's [5] U.S. findings showed that economic development and national security framings, which were initially high were also starting to balance out over time in the media. This eventual balancing of the media-reported pros and cons of renewable and/or low carbon energy technologies is a trend pointing to a more well-rounded public dialogue of U.S. energy considerations while at the same time showing promise that continued development is desired even at the regional scale, assuming proper public input into its implementation is given. CCS media coverage across the four research states was moving toward a more balanced, yet positive, reporting as time went by, whereas warm-season/woody biomass news coverage in New York showed that it was still very much in the early stages of public discourse with its overly positive and less detailed coverage.

4.3. Cross References

Our final area of analysis with the CCS and biomass data was to examine the two technology data sets for cross references with the other technology of interest (*i.e.*, mentions of biofuels in the CCS articles and vice versa). We found very few cross references between the two technologies (10 articles out of 330), and when they were present, they were limited to the benefits of ethanol production and CCS for achieving climate change mitigation goals and as a replacement for fossil fuels. These results indicate that the technologies are still treated by the media as separate opportunities for changing our energy system, even though there are operations currently underway that are combining these technologies such as the Illinois Industrial Carbon Capture and Storage Project in Decatur, Illinois that is taking CO_2 produced from an ethanol plant and storing it in a geologic formation [43]. This lack of media coverage of these coupled technologies would therefore indicate a potential lack of knowledge on the part of the public of such opportunities. However, considering the generally positive coverage of the CCS and bioenergy independently, a positive public perception of their coupling as BECCS would be assumed.

5. Conclusions

This paper was a meta-analysis of CCS and warm-season/woody biomass media coverage by state-level newspapers in the states of Massachusetts, Minnesota, Montana and Texas for the CCS analysis, and New York for the biomass analysis. Based on our findings, we were able to determine that individually, the two types of technologies were generally positively received and would in all likelihood be accepted in their coupled state. This analysis also shows that combined references to bioenergy and CCS speak to their value for climate change mitigation and as an alternative to fossil fuels.

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Author Contributions

Andrea M. Feldpausch-Parker and Theresa Selfa conceived and designed the experiments; Maryna Melnik and Meaghan L. Callaghan performed the experiments; Morey Burnham analyzed the data; Andrea M. Feldpausch-Parker and Theresa Selfa contributed analysis tools; Andrea M. Feldpausch-Parker and Morey Burnham wrote the paper; Theresa Selfa reviewed the paper prior to submission.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Creutzig, F.; Ravindranath, N.H.; Berndes, G.; Bolwig, S.; Bright, R.; Cherubini, F.; Chum, H.; Corbera, E.; Delucchi, M.; Masera, O.; *et al*. Bioenergy and climate change mitigation: An assessment. *Glob. Change Biol. Bioenergy* **2014**, doi:10.1111/gcbb.12205.
2. Gillon, S. United states biofuel production as climate policy: Tensions between greenhouse gas reduction, agricultural economies, and agro-ecological practice. *Norteamérica* **2012**, *7*, 129–164.
3. Volk, T.A.; Abrahamson, L.P.; Bucholz, T.; Caputo, J.; Eisenbies, M. Development and deployment of willow biomass crops. In *Cellulosic Energy Cropping Systems*; Karlen, D.L., Ed.; John Wiley and Sons, Ltd.: West Sussex, UK, 2014; pp. 201–218.
4. Bain, C.; Selfa, T. Framing and reframing the environmental risks and economic benefits of ethanol production in Iowa. *Agric. Hum. Values* **2013**, *30*, 351–364.
5. Wright, W.; Reid, T. Green dreams or pipe dreams? Media framing of the U.S. biofuels movement. *Biomass Bioenergy* **2011**, *35*, 1390–1399.
6. Searchinger, T.; Heimlich, R. Avoiding bioenergy competition for food crops and land. In *Working Paper, Installment 9 of Creating a Sustainable Food Future*; World Resources Institute: Washington, DC, USA, 2015. Available online: http://www.wri.org/sites/default/files/avoiding_bioenergy_competition_for_food_crops_and_land_final.pdf (accessed on 16 February 2015).
7. Holleman, H. Energy policy and environmental possibilities: Biofuels and key protagonists of ecological change. *Rural Sociol.* **2012**, *77*, 280–307.
8. Van Noorden, R. Buried trouble. *Nature* **2010**, *463*, 871–873.
9. Bradbury, J.; Ray, I.; Peterson, T.; Wade, S.; Wong-Parodi, G.; Feldpausch, A. The role of social factors in shaping public perceptions of CCS: Results of multi-state focus group interviews in the U.S. *Energy Procedia* **2009**, *1*, 4665–4672.
10. International Energy Agency (IEA). Combining Bioenergy with CCS. 2011. Available online: http://www.iea.org/publications/freepublications/publication/combining-bioenergy-with-ccs.html (accessed on 15 October 2014).

11. DiPietro, P.; Balash, P.; Wallace, M. A note on sources of CO_2 supply for enhanced-oil-recovery operations. *SPE Econ. Manag.* **2012**, *12*, 16752–1654.
12. Gollakota, S.; McDonald, S. CO_2 capture from ethanol production and storage into the Mt Simon Sandstone. *Greenh. Gases Sci. Technol.* **2012**, *2*, 346–351.
13. Friedman, S.M.; Egolf, B.P. Nanotechnology: Risks and the media. *IEEE Technol. Soc. Mag.* **2005**, *24*, 5–11.
14. Skjølsvold, T.M. Curb your enthusiasm: On media communication of bioenergy and the role of the news media in technology diffusion. *Environ. Commun.* **2012**, *6*, 512–531.
15. Nerlich, N.; Jaspal, R. UK media representations of carbon capture and storage: Actors, frames, and metaphors. *Metaphor Soc. World* **2013**, *3*, 35–53.
16. Boyd, A.D.; Paveglio, T.B. Front page or buried beneath the fold? Media coverage of carbon capture and storage. *Public Underst. Sci.* **2014**, *23*, 411–427.
17. Carvalho, A. Ideological cultures and media discourses on scientific knowledge: Re-reading news on climate change. *Public Underst. Sci.* **2007**, *16*, 223–243.
18. Boykoff, M.T.; Boykoff, J.M. Climate change and journalistic norms: A case-study of U.S. mass-media coverage. *Geoforum* **2007**, *38*, 1190–1204.
19. Buhr, K.; Hansson, A. Capturing the stories of corporations: A comparison of media debates on carbon capture and storage in Norway and Sweden. *Glob. Environ. Change* **2011**, *21*, 336–345.
20. Corbett, J.B.; Durfee, J.L. Testing public (un)certainty of science: Media representations of global warming. *Sci. Commun.* **2004**, *26*, 129–151.
21. Stephens, J.C.; Wilson, E.J.; Peterson, T.R. Socio-political evaluation of energy deployment (SPEED): An integrated research framework analyzing energy technology deployment. *Technol. Forecast. Soc. Change* **2008**, *75*, 1224–1246.
22. Luhmann, N. *Ecological Communication*; The University of Chicago Press: Chicago, IL, USA, 1989.
23. Luhmann, N. *Introduction to Systems Theory*; Polity Press: Malden, MA, USA, 2013.
24. Stephens, J.C.; Rand, G.M.; Melnick, L.L. Wind energy in U.S. media: A comparative state-level analysis of a critical climate change mitigation technology. *Environ. Commun.* **2009**, *3*, 168–190.
25. Fischlein, M.; Feldpausch-Parker, A.M.; Peterson, T.R.; Stephens, J.C.; Wilson, E.J. Which way does the wind blow? Analyzing the state context for renewable energy deployment in the United States. *Environ. Policy Gov.* **2014**, *33*, 169–187.
26. Feldpausch-Parker, A.M.; Ragland, C.J.; Melnick, L.L.; Chaudhry, R.; Hall, D.M.; Peterson, T.R.; Stephens, J.C.; Wilson, E.J. Spreading the news on carbon capture and storage: A state-level comparison of US media. *Environ. Commun.* **2013**, *7*, 336–354.
27. Luhmann, N. *The Reality of the Mass Media*; Stanford University Press: Stanford, CA, USA, 2000.
28. United States Department of Agriculture. Food, conservation, and energy act of 2008. Available online: http://beta.congress.gov/110/bills/hr6124/BILLS-110hr6124enr.pdf (accessed on 2 August 2013).
29. Krippendorff, K. *Content Analysis: An Introduction to its Methodology*; Sage Publications: Thousand Oaks, CA, USA, 2004.
30. Fed legislation revives carbon sequestration study at MSU. *Bozeman Daily Chronicle*, 2007.
31. Schneider, M. Orlando utilities gets $235 million to build clean coal plant. Available online: http://jacksonville.com/apnews/stories/102104/D85S4B081.shtml (accessed 28 February 2010).

32. Rose, D. Getting to clean coal (Letter to the Editor). *Boston Herald*, 2007.
33. Lawrence, J. Benefits of biomass fuels overlooked (Letter to the editor). *Watertown Daily Times*, 2010. Available online: http://libezproxy.syr.edu/login?url=http://infoweb.newsbank.com/?db=AWNB (accessed on 17 September 2013).
34. Ellen, M. Lawmakers to visit St. Lawrence farms third annual ag tour: Switchgrass project, organic dairy farm, tile drainage facility on itinerary for state, county officials. *Watertown Daily Times*, 2011. Available online: http://libezproxy.syr.edu/login?url=http://infoweb.newsbank.com/?db=AWNB (accessed on 17 September 2013).
35. Potrikus, A. Study: Biomass crops viable for CNY. *Post-Standard*, 2010. Available online: http://libezproxy.syr.edu/login?url=http://infoweb.newsbank.com/?db=AWNB (accessed on 18 September 2013).
36. Potrikus, A. Serious about biomass crops-1000 potential growers contacted about plans. *Post-Standard*, 2009. Available online: http://libezproxy.syr.edu/login?url=http://infoweb.newsbank.com/?db=AWNB (accessed on 18 September 2013).
37. Sørensen, K.H. Beyond innovation: Towards an extended framework for analyzing technology policy. *Nordic J. Sci. Technol. Stud.* **2013**, *1*, 12–23.
38. Antilla, L. Climate of scepticism: US newspaper coverage of the science of climate change. *Glob. Environ. Change* **2005**, *15*, 338–352.
39. Evensen, D.T.; Clarke, C.E.; Stedman, R.C. A New York or Pennsylvania state of mind: Social representations in newspaper coverage of gas development in the Marcellus Shale. *J. Environ. Stud. Sci.* **2014**, *4*, 65–77.
40. Sengers, F.; Raven, R.P.J.M.; van Venrooij, A. From riches to rags: Biofuels, media discourses and resistance to sustainable energy technologies. *Energy Policy* **2010**, *38*, 5013–5027.
41. Batill, K.M.; Feldpausch-Parker, A. Hydrofracking in the news: How does media's coverage of hydraulic fracturing shape public discourse about emerging energy technologies. In *The U.S. Environmental Communication as a Nexus*, Proceedings of the 12th Biennial Conference on Communication and the Environment, Uppsala, Sweden, 6–10 June 2013.
42. Mazur, A. Nuclear power, chemical hazards, and the quantity of reporting. *Minerva* **1990**, *28*, 294–323.
43. Midwest Geological Sequestration Consortium. Available online: http://www.sequestration.org/ (accessed on 14 December 2014).