Gökçe Günel
Columbia University

What Is Carbon Dioxide? When Is Carbon Dioxide?

In this article, I focus on carbon capture and storage (CCS), a controversial climate change mitigation technology that operates by collecting carbon dioxide from point sources and depositing it in underground locations, such as depleting oil reservoirs. Specifically, I investigate the ways in which certain CCS professionals imagine and demand a reconceptualization of carbon dioxide: not as waste or as dangerous material that should be taxed and exchanged in carbon markets, but as a neutral gas that can be bought and sold as a commodity, and perhaps used as a drilling additive for the oil and gas industry. CCS professionals suggest that carbon dioxide has multiple legal, political, and chemical meanings and existences across different points on a CCS network, and they acknowledge how this condition makes it difficult to produce the molecule as a commodity characterized by exchange and commensurability. In studying the commodification of carbon dioxide, I show how these professionals do not intend to create "sameness" across the market, but instead wish to commodify the molecule through "linking" various versions of carbon dioxide together. By tracking carbon dioxide as it moves within a CCS network, I explore the moral logics of CCS technologies, which obscure how energy-intensive models of life triggered climate change in the first place.

The *Oxford English Dictionary* defines carbon dioxide as "a colorless, odorless gas produced by the burning of organic compounds and fossil fuels, by the processes of respiration and decomposition, and by volcanic activity, and absorbed by plants during photosynthesis." The entry explains how "carbon dioxide is naturally present in air (about 0.03 per cent) and is slightly soluble in water to form a weakly acidic solution (carbonic acid). It can be solidified by cooling, the solid (dry ice) subliming into gas at −78.5°C." In smaller type, the *OED* concludes, "The increasing quantity of atmospheric carbon dioxide produced by the burning of fossil fuels is widely believed to augment the greenhouse effect and lead to global warming."[1]

Carbon capture and storage is one of the many technological solutions that have been advanced in battling an "increasing quantity of atmospheric carbon dioxide." It is a controversial technology that operates by procuring carbon dioxide from localized sources of pollution, such as power plants; carrying it in solid, liquid, or gas form to storage sites such as oil reservoirs; and injecting it underground. Critics of the technology argue that carbon capture and storage projects may bring about the leakage and seepage of concentrated amounts of carbon dioxide from storage sites. Furthermore, issues such as selection of storage sites, monitoring plans for leakage and seepage of carbon dioxide, or transboundary effects of carbon dioxide injection have to be actively addressed when negotiating for carbon capture and storage projects. As such, since its conception as a possible carbon dioxide emission reduction strategy for climate change mitigation, debates over site feasibility, high operational costs, future safety, and legal liability make carbon capture and storage projects challenging to initiate, execute, and operate.

Accepted August 2014

PoLAR: Political and Legal Anthropology Review, Vol. 39, Number 1, pps. 33–45. ISSN 1081-6976, electronic ISSN 1555-2934. DOI: 10.1111/plar.12129.

With the advent of carbon capture and storage (CCS) technologies as a means to mitigate climate change, the transportation of carbon dioxide has become an increasingly prevalent concern. In transporting captured carbon dioxide from emission points to onshore or offshore storage locations, advocates of CCS stress that the challenges are not technical, but rather political and legal. They underscore that such logistics networks will entail the production of new regulations that will eclipse the various technical uncertainties from which current CCS technologies suffer.

In this article I analyze the ways in which certain CCS professionals, mostly working in Rotterdam, imagine and articulate the emergent legal and political infrastructures for regulating the movement of carbon dioxide. I investigate how carbon capture and storage professionals demand a reconceptualization of carbon dioxide neither as waste nor as dangerous material that should be taxed and exchanged in carbon markets, but rather as a neutral gas that can be bought and sold freely as a commodity, and perhaps used as a drilling additive for the oil industry. Accordingly, I seek to shed light on the complex relationships between the hard logistical infrastructure and the soft legal and political infrastructure that CCS professionals simultaneously rely upon and reproduce. In this article I show how these sets of infrastructures—power plants, pipelines, oil reservoirs, and offshore platforms, on the one hand, and carbon markets, liability protocols, contractual obligations, and political frameworks, on the other hand—cannot be thought of separately, but must be examined by taking into account their interlaced and interdependent natures.

My key argument in this article is that not all carbon dioxide is the same. Current legal and political regulations differentiate carbon dioxide based on its multiple functions: carbon dioxide as emitted, in the pipeline, or injected into an underground storage location. As such, the meaning of carbon dioxide is shaped in social practice and through its multiple relationships with hard and soft logistics infrastructures (Mol 2002). Carbon capture and storage professionals acknowledge how the multiplicity of the molecule makes it difficult for them to produce carbon dioxide as a commodity, characterized by exchange and commensurability. Yet CCS professionals do not intend to create "sameness" across the market. In formulating carbon dioxide as a commodity, they seek to create "links" between the different existences of the molecule. In this context, the process of making carbon dioxide into a commodity is not a practice of flattening but rather "linking" its various versions.

This article speaks to a long lineage of scholarship on commodification (Appadurai 1986; Kopytoff 1986; Marx 1978; Mauss 1967), as well as recent studies in materiality and ontology (Bennett 2010; Meskell 2005; Miller 2005). By concentrating on the process of "linking," the article highlights the material trajectories of captured carbon dioxide. This may recall Arjun Appadurai's (1986) conception of "the social life of a commodity," where commodities transform in meaning through time and space and acquire specific biographies. However, this article extends the emphasis on the materiality of the commodity and shows how captured carbon dioxide resists commensuration by appearing in different forms in different parts of the logistics network. It becomes, as one of my interlocutors stated, "hard to grasp." In this way, this article recognizes carbon dioxide as an "actant" (Latour 2004) that reformulates the supply chain.

This article also contributes to the scholarship on climate change governance (Jasanoff and Martello 2004; Miller and Edwards 2001; O'Reilly et al. 2012), as exemplified by this themed issue. It demonstrates that the multiple trajectories of carbon dioxide do not always coincide with the process of commensuration, requiring CCS professionals to initiate practices of "linking" rather than flattening. In sum, this article suggests that carbon dioxide, as well as its political and legal depictions, inform and modify professional perspectives on carbon capture and storage. Combined, this has a decisive impact on the wider landscape of climate change mitigation and global governance.

Some of my goals are to investigate the different existences of carbon dioxide, the conceptual logics of carbon capture, and storage technologies. First, by following carbon dioxide as it flows within a logistics network, this article shows that carbon capture and storage technologies ensconce carbon dioxide within closed loops of reproduction, which deny the environmentally destructive qualities of carbon dioxide and attempt to capitalize on the gas for enhanced oil recovery. Closed loops not only transform carbon dioxide into a commodity, but they also use it to produce more fossil fuels. This article argues that carbon capture and storage conceals the destructive qualities of carbon dioxide, which in turn obscures how the production and use of fossil fuels—or the energy-intensive models of life enabled through fossil fuels—triggered climate change in the first place. Second, this article demonstrates that CCS professionals are pragmatic planners that seek to bridge the energy future by instituting CCS as a temporary solution. In this perspective, CCS is offered as a provisional fix to be utilized until the end of the fossil fuel era, when renewable energy and clean technology become fully operational.

Straightforward Logistics

"Soon," Jan,[2] an executive at a large logistics company based in Rotterdam, told me, "we will be able to collect carbon dioxide from industrial facilities in the Cologne area, the most industrialized region of Europe, and carry it in barges through the Rhine to the port of Rotterdam." Jan and I had been introduced to each other through a project manager who worked on CCS projects in Rotterdam, after I expressed my interest to learn more about the carbon capture and storage systems that were planned for the North Sea. In our first meeting, we sat in a meeting room inside the headquarters of the logistics company where Jan worked, which was within eyesight of the port itself. The liquid carbon dioxide the company intended to gather from neighboring regions, such as the Cologne area, would be stored in new storage tanks at the port, transported by sea vessels or pipelines to depleting oil and gas reservoirs in the North Sea, and then unloaded to sub-seabed storage sites using the same technologies currently used in the offshore oil and gas industry.[3] "It is straightforward logistics," Jan said.

However, "logistics" have not been "straightforward" for all that long. Etymologically, logistics is rooted in the Greek word *logostikos*, which implies an expertise in enumeration. The contemporary meaning of the word became widespread only during World War II. In 1949 the US military's *Field Service Regulations* defined logistics as "that branch of administration which embraces the management and provision of supplies, evacuation and hospitalization, transportation, and services. It envisages getting the right people and the appropriate supplies to the right place at the right time and in the proper condition" (as cited in Huston 1991, 9). So, when did logistics become a matter of corporate concern?

In her article, "Geography of Logistics," Deborah Cowen (2010) attempts to answer this question. In the 1960s, she suggests, the logistics revolution began to be perceived as the solution to the economic depression of the 1950s, facilitating the efficient transportation of material and people. This emphasis on logistics, Cowen denotes, pointed to a "rationalization and deliberate management of spatial organization within the firm, as well as the opening up of a new space of action—the geographic and calculative space of operations between the end of the production line and the point of commodity consumption" (15). Slowly, logistics became, Cowen buttresses, "a technology of supranational firms operating in a relational geo-economic space" (17). As a result, logistics "opened up a crucial new field of value in distribution and reorganized production at multiple scales through systems approaches to supply" (17). Eventually, logistics grew to be synonymous with supply chain management.

Jan's "straightforward logistics" aimed to include liquid carbon dioxide in this global network of supply chains. But what did it mean for carbon dioxide—one of the primary greenhouse gases emitted through human activities—to be added to the global supply chain? Trained as a chemical engineer, Jan had long been employed as an executive at this Rotterdam-based large corporation, which concentrates on the storage and shipment of bulk liquids. He also had thirty years of experience with the agriculture business, specializing in fertilizers. This project, through which the company hoped to produce perhaps the largest carbon dioxide logistics network in the world, had been under his control since he started holding his particular position in 2009. Jan explained:

> "When you think about it, there are a lot of steps here. You have to build pipelines to carry the carbon dioxide; you have to liquefy it so that it is cleansed; you have to build storage tanks to keep the liquid carbon dioxide at minus 50 degrees Celsius temperature; you have to operate ships to carry it to offshore facilities; and once you reach offshore facilities, you have to inject it into depleting reservoirs, even during stormy winter seasons."

Even with this description, Jan insisted that the project was not technically challenging.

For Jan, the logistical infrastructure of carbon dioxide was technically clear. However, there was a different order of things that Jan struggled with: how to organize the legal and political understandings of carbon dioxide. Accordingly, he underlined how the logistics of carbon dioxide required not technical innovation but rather a new legal and political infrastructure that, nonetheless, proved difficult to bring together. In emphasizing the significance of emergent legal and political infrastructures, Jan echoed the many professionals who have been working on CCS projects around the world.

Oil-producing countries have the availability to use depleting oil fields as storage locations for the carbon dioxide that they obtain when implementing CCS projects, because these oil fields are considered naturally sealed reserves. Injecting gas into oil reservoirs has an added benefit: it leads to increased oil production in a process commonly known in the industry as enhanced oil recovery. By injecting carbon dioxide into ageing fields and pumping oil out, oil producers may increase the lifetime of the fields by up to 30 percent, while freeing up the natural gas more commonly used in such processes. The acknowledgment of CCS as an eligible technology for decreasing carbon emissions thus becomes an incentive for further oil production.

The implementation of CCS technologies also allows for the extended use of coal-based power plants around the world, such as the brown coal plants in the Cologne area. As an emergent "clean coal" technology, carbon capture and storage is portrayed as a mechanism that will facilitate economic growth in so-called developing countries, such as China or India, while cutting carbon emissions. Coal-based power plants may install carbon capture facilities, which will enable them to further rely on coal as a source of cheap energy while cutting carbon emissions. This rather oxymoronic emphasis on "clean coal" creates a crowding-out effect (Benson and Kirsch 2010), and it reduces incentives for investing in renewable energy power stations.

Jan's project, however, attempted to set aside the various debates over capture and storage of carbon dioxide, and focused on everything in between when carbon dioxide is in transit. "In order to make this work," Jan said, "you have to know how to get the full chain covered, find the right partners, oversee how they are cooperating, who has to pay for what, who is liable for what." In this sense, Jan's project was a large-scale management operation. All in all, Jan insisted that CCS logistics required a major shift in how carbon dioxide is regulated. Namely, as an object of regulation, carbon dioxide needed to be understood as not only a cost exchanged in carbon markets, but also as a profitable commodity on its own. If money were to be made through carbon dioxide, then the logistics of carbon dioxide would be more necessary than ever.

Not Waste, But Commodity

It was important to Jan that carbon dioxide becomes redefined; he said, not as "waste, but as a commodity." In this way, he indicated that carbon dioxide should no longer be exchanged in the form of carbon credits within emissions trading platforms, but should instead enter the global supply chain as the very material that it is.

By suggesting that carbon dioxide should no longer be conceptualized as a waste but rather as a commodity, Jan seemingly proposed that carbon dioxide's environmentally destructive qualities should be repressed so as to spotlight its uses for expanding the fossil fuel economy. In this way, Jan, along with many other CCS professionals, obscured how the crisis of climate change is actually a consequence of the energy-intensive models of society brought to life by industrial capitalism. Rather than interrogating the ways in which fossil fuels have exacerbated climate change, CCS professionals have searched for ways to extend such energy-intensive models further into the future. "We need every bit of energy we can get, and therefore carbon capture and storage is vital," a leading Shell executive told me during a short interview at the Durban (South Africa) climate summit in December 2011. "It allows us to consume coal or oil, without worrying about the carbon emissions they produce. I imagine that if I came back to the world in one hundred years, maybe then I could see a place which is fuelled by renewable energy sources, but not before then," he emphasized. In this context, carbon capture and storage served as a temporary environmental fix, not as a complete mitigation strategy. At the same time, however, CCS was the necessary bridge to renewable alternatives. As the Shell executive said, more drastic changes would take perhaps another one hundred years. In the meantime, CCS could serve as a pragmatic alternative, enabling fossil fuel-based growth while decreasing emissions.

Carbon capture and storage technologies build on the relentless growth drive that characterized industrial production in the twentieth century, clinging to the vision that the fossil-fuel-driven economy is infinitely expandable (Mitchell 2011). Carbon capture and storage would help development continue in countries such as China and India, which still relied upon coal plants. During another meeting at the Durban climate summit, a representative from a German nongovernmental organization (NGO) explained how and why civil society organizations in Germany were resisting the implementation of carbon capture and storage within the country's boundaries, and proposed that the capital invested in CCS should actually be used to improve renewable energy infrastructures. In response, a delegate from a West African country adamantly stated, "We can't improve our industry on solar power. We need to uplift our people, and we will need coal for that. Germany has educated its people and now it's time for it to clean up." According to this delegate, it was time for developed countries to give up their coal plants, but developing countries would need them for longer in order to create industrial infrastructures that matched developed countries such as Germany. "Perhaps CCS could be helpful in such cases," the West African delegate said, demonstrating how CCS could be perceived as a desirable means of development to expand industrial capitalism at a time of climate change. Again, the West African delegate understood CCS as a temporal bridge to another energy future, endowing it with a dazzling moral valence.

By facilitating the efficient transportation of carbon dioxide in a logistics network, Jan's company would carry carbon dioxide from places where it was unwanted to places where it could perhaps be utilized as a drilling additive. Operating from a city that hosts the largest port in the Western hemisphere, this logistics operation would push for, as Deborah Cowen notes, "rationalization and deliberate management of spatial organization . . . as well as the opening up of a new space of action," thereby facilitating a reorganization of "the geographic and calculative space of operations between the end of the production line and the point of commodity consumption" (Cowen 2010, 15). Through logistical adjustments, carbon dioxide emissions would be relocated and eventually dismissed from their sources. As noted above, this carbon dioxide would prolong fossil fuel consumption and production, possibly triggering further industrial growth in developing countries.

As our conversation progressed, Jan explained that building this new logistics network would not be technically challenging, especially because the molecule behaved very much like liquefied natural gas. "Carbon dioxide is the same type of material as liquefied natural gas (LNG)," he said. To illustrate how the project would not be difficult to handle, he added, "It is the same technical know-how and the commercial approach and type of contracts." In this context, the destructive qualities of carbon dioxide were replaced with the pragmatics of the desired operation. Jan's company already knew how to handle LNG, and thus it would be able to work with carbon dioxide easily.

The European Union Emissions Trading Scheme

In attempts to reconceptualize carbon dioxide as a commodity, Jan, along with other professionals focusing on CCS, visited policymakers at the European Parliament and the European Commission, and also spoke with ministers in the Netherlands. They wanted to discuss how the European Union Emissions Trading Scheme (ETS) had become increasingly unstable and unreliable. Jan told me that he was pessimistic regarding the future of ETS.

The ETS system was launched in 2005 as the first carbon dioxide emissions trading system in the world. Currently it operates in thirty countries (the twenty-seven European Union Member States, in addition to Iceland, Liechtenstein, and Norway), and remains the largest existing carbon market, which, as one of my interlocutors clarified, is roughly the size of the flat-screen television market. Its operations rely on a "cap and trade" principle, wherein every large emitter of greenhouse gases, such as carbon dioxide, is assigned a particular emissions allowance. If a company reduces its emissions, and has extra credits left at the end of a particular trading period, it can save the leftover credits or sell them to another company that has met its limit. The fact that the number of allowances is limited generates a specific value for each unit of emissions. As the number of allowances decreases over time, carbon prices will increase, thus providing an incentive for companies to reduce emissions.

The ETS system conceptualizes carbon dioxide as waste, which can be exchanged in terms of carbon credits. Its production costs companies money. But Jan, like many oil and gas professionals who invest in CCS schemes, thought that there was a possible solution to this problem, whereby carbon dioxide could be redefined as an exchangeable good in itself. "In the United States, there is another driving force," he said. "You can use carbon dioxide for enhanced oil recovery (EOR), so oil companies consider buying carbon dioxide so they can produce more oil in existing wells." By injecting carbon dioxide into depleting reservoirs, oil companies are able to increase the amount of crude oil that they extract from a field. Carbon dioxide is an especially effective gas for maximizing the output from the fields because it reduces the viscosity of oil. In other words, when US oil companies buy carbon dioxide emissions from other polluters, they do so to produce more fossil fuels, which in turn leads to the production of more carbon emissions.

And yet, Jan argued that EOR actually contributes to solving various climate change-related problems by specifically redefining carbon dioxide as a valuable product: a drilling additive for the production of oil. In this way, Jan suggested, EOR enables the reconceptualization of carbon dioxide not as a waste product that is only exchanged in the form of carbon credits, but as an emergent commodity. By this logic, EOR facilitated the exchange of unwanted carbon dioxide for an increased output of fossil fuels and bridged the temporal gap toward a drastically different energy future. Rather than paying taxes on emitted carbon dioxide, Jan conjectured, power plants could collect these emissions and sell them to oil and gas companies, which would, in turn, use them for enhanced oil recovery. If carbon dioxide became a commodity, power plants would have more incentive to accumulate their emissions and transport them to depleting oil reservoirs. In other words, power plants would potentially make money emitting and collecting carbon dioxide.

However, European carbon market regulations were started with a different concept. Jan summarized this conceptual drive as "the polluter pays." In this framework, carbon dioxide remained a waste, and could not exist in the market as a commodity that enables the production of further profits from fossil fuels. "So, in Europe, oil companies are laughing, they're just waiting for the carbon dioxide to be given to them, and they can use it for EOR," he explained. While inhibiting the redefinition of carbon dioxide as a commodity, "the polluter pays" system does not necessarily discourage enhanced oil recovery operations. Given the estimated depletion of the North Sea fuels some time between 2018 and 2028, enhanced oil recovery is becoming increasingly significant for European energy networks.

"The oil industry can handle a lot of carbon dioxide," Jan reminded me, "and once you create infrastructure and know-how using that, then you can deal with the larger flows in the future, and typically larger flows are easier because of economies of scale." Enhanced oil recovery would enable such preparation. All in all, for him, and for the company he represented, it was crucial to understand carbon dioxide as an exchangeable good, not as a waste product that should be taxed. He and his company believed that the polluter pays model was an outdated method to mitigate carbon dioxide emissions, and thus they wanted to redefine carbon dioxide as a commodity.

In imagining and articulating the future of carbon dioxide, carbon capture and storage professionals could not afford to think about hard and soft infrastructures separately. As explained above, these two sets of infrastructures—one comprising power plants, pipelines, oil reservoirs, and offshore platforms, and the other comprising carbon markets, contractual obligations, and political and legal frameworks—consistently transform one another. In building a logistics network, Jan and his colleagues sought to change carbon dioxide in meaning, turning it into a commodity. In doing so, they consistently criticized the ETS model, but in ways that were very different from the scholarly analyses of carbon markets.

Critiques of the Polluter Pays Model

The European Union Emission Trading Scheme, which functions on the model in which the polluter must pay, has attracted a wide variety of scholarly attention. Donald MacKenzie argues, for example, that carbon markets have enabled "a technopolitical shift" (2009b, 143) in the European political landscape, allowing for climate change mitigation to seep into public debate. Michel Callon, however, perceives carbon markets as "experimental objects" (2009, 538) whose detailed study will provide a vivid perspective on market devices. Larry Lohmann, a vehement critic of the marketization of carbon dioxide, suggests that carbon markets are "a constitutive part of the process through which neoliberalism finds itself," and perceives a detailed study of the carbon markets to be rather "superfluous" (2012, 84). As one of my interlocutors, who worked at the United Nations Framework Convention on Climate Change for more than five years, added, critiques of this model have mostly emerged from the left.

The type of criticism that I found in my conversations with Jan—and with many oil and gas professionals in Houston, Texas—however, was rather different from these scholarly analyses. For many of my interlocutors, carbon markets were not optimal because they were "not capitalistic enough." Mary, who spent approximately thirty years working on developing EOR technologies within a major oil and gas company in Houston, and who self-identified as a conservative, called carbon markets "socialistic" mechanisms. She asserted, "We should just let the private sector handle the transition to renewable energies and clean technologies. Regulation is by definition top-down, but the transition should be bottom up." According to Mary, carbon markets were top-down mechanisms that conceptualized carbon dioxide as waste. But markets—such as the oil and gas sector—were bottom-up mechanisms that could handle the climate change problem. The bottom-up market mechanisms would define carbon dioxide as a commodity and would regulate it more freely than the "socialistic" polluter pays model, adopted and promoted by the ETS. Mary believed that more capitalistic mechanisms would be better equipped for mitigating serious environmental challenges, and strongly advocated for the conceptual transformation of carbon dioxide from waste to commodity.

Mary's complaint has strong historical and local precedent, according to Martin V. Melosi and Joseph Pratt's (2007) study of the growth of the petroleum industry in Houston. They suggest:

> Oilmen had a strong aversion to government regulation of any kind . . . As a well-organized interest group with clear goals, long-term time horizons, control of data about their critical industry, and good lawyers and lobbyists, the oil industry proved quite successful in defining the terms of the political debate about oil-related pollution throughout the mid-twentieth century. (Melosi and Pratt 2007, 31–33).

Accordingly, Melosi and Pratt's study underlines how such self-regulation prevented the oil industry from taking the necessary measures to adopt health and safety standards, especially within the initial decades of the industry's establishment in the city. Short-term and profit-oriented approaches, they argue, dominated possible long-term and health-oriented solutions to emergent environmental problems. Later, as Melosi and Pratt show, energy companies situated their allies within government institutions, so government regulation stopped being a problem all together. This is one of the reasons the oil and gas industry has not transformed much since the beginning of twentieth century.

Lev, a Houston-based scientist, who has experience with policymaking on environmental issues, explained to me that he understands the oil and gas industry to be very cynical—and for good reason. "How could they say that their product is actually poison," Lev asked, "and how could they demand taxes on their own product? It only makes sense that they support a redefinition of carbon dioxide as a commodity."

During a lunchtime conversation, Mary laid out the framework within which these perspectives grow: "The oil and gas companies know that the climate is changing," she said, "but they just don't see it as human induced. They will have commercials saying that they believe in climate change, and are working on mitigating it, just because it's politically correct." The redefinition of carbon dioxide as a commodity would not only short-circuit the implementation of a system that would tax carbon emissions, but it would also allow oil and gas companies to generate new means of profitmaking through the production of extra oil from dying reservoirs.

It is important to note, then, that a redefinition of carbon dioxide, happening mostly through carbon capture and storage practices, reshuffles the whole climate change mitigation landscape. It also brings forth a reconceptualization of carbon markets as entities that are not capitalistic enough and that work against the business interests of oil and gas companies. In this sense, the criticism from within the field of climate change policy proves to be drastically different from the more common criticism that the carbon market has attracted from scholars and NGOs in the past decade. While criticism from scholars has drawn attention to how carbon markets are "the most recent expression of ongoing trends of ecological commodification and expropriation, driving familiar processes of uneven and crisis-prone development" (Böhm, Misoczky, and Moog 2012, 1617), the CCS professionals that I interviewed argued exactly the opposite, suggesting that carbon markets are "socialistic" mechanisms that prevent the commodification of carbon dioxide.

What kind of political transformation did CCS then call for? And would proponents of CCS ever achieve this aspired terrain? It is important to keep in mind that political transformation was not the only adjustment that Jan and his colleagues needed in order to implement their carbon dioxide logistics network.

"When Is Something Carbon Dioxide?"

In November 2012 I participated in an International Energy Agency (IEA) webinar, titled "Project Experience with CCS Permitting Processes," in which practitioners working on CCS projects around the world shared their experiences with legal and political infrastructures that regulate carbon dioxide. A representative from Rotterdam expressed that one of the major problems is how to qualify carbon dioxide. He asked, "Is it a dangerous material, or something else?"

After the webinar was over, I e-mailed the representative from Rotterdam to ask what he meant. In response, he clarified that his question was not about the chemical composition of carbon dioxide: "This qualification is merely the result of legal/political interpretation and not of chemical definition." Through the emergence of carbon dioxide logistics networks within the Netherlands, carbon dioxide had become an unstable object, changing legal and political definitions despite seemingly retaining its chemistry.

Some days later, I received a follow up e-mail from a legal expert working on CCS technologies in Rotterdam, who suggested that we discuss the legal, political, and chemical qualities of carbon dioxide over the phone. According to him, it was important to specify the localized point in which one attempted to define carbon dioxide. He explained:

> Carbon dioxide is qualified differently in different parts of the CCS chain. When it is emitted, it is not qualified at all; and then when it is in the pipeline, it is waste; when it is being stored, it is a dangerous gas. So if you're asking what carbon dioxide is, you also have to say what the context is.

By holding it accountable within a particular role and function, and assigning it a different meaning at every station, the legal regulations seemed to preclude the commensuration of carbon dioxide.

The being of carbon dioxide, while standardized in global exchange practices, was transformed based on the complex legal and political contexts in which it appeared, and it was rearticulated according to specific spatial and temporal conditions. In this case, carbon dioxide—a nonhuman agent floating within a logistics network and transforming the ways in which climate change mitigation is understood—has become reconstituted on its path. Stabilized within technical legal documents, the multiple definitions of carbon dioxide nevertheless remained too complex for the legal expert to fully understand or recite. Through emergent technologies, CCS professionals try to reconfigure carbon dioxide into measurable, transferable, and equivalent commodity units.

"But more importantly," the legal expert expressed, "when is something carbon dioxide?" I confessed that I had never thought about this question before. "What we call carbon dioxide is a gas that constitutes 90 percent pure carbon dioxide," he said. He then asked, "What is the exact composition that carbon dioxide should have?" The legal expert suggested that carbon dioxide has different types of impact when it is mixed with 5 or 10 percent water. Every power plant produces a different carbon dioxide, he specified, and it depends on the type of coal that is used within the power plant. In his account, it was not only the legal and political meanings, but also the chemical combinations that were categorized as carbon dioxide, that were endemic to the local context in which carbon dioxide was produced.

The emergence of a new commodity, however, requires different levels of "commensuration," whereby standardized metrics are produced, circulated, and implemented. In emissions markets, commensuration happens in one of three ways: technical, value, or cognitive (Levin and Espeland 2002). Technical commensuration entails using techno-scientific means to measure emissions from a multiplicity of sources and aggregating such findings at the nation-state level. Technical commensuration is the first, and perhaps the most essential, step toward generating credibility for the emissions market, especially because it reveals an emitter's capacity to comply with predetermined goals. Once authorities know how much carbon dioxide is being emitted in every nation-state, they have to generate a price tag for carbon dioxide that can be used in different settings. Value commensuration is the formulation of a price for allowances and credits. Government regulation is pervasive in this dimension, as public authorities have the task of setting the rules for the operation of carbon markets, thus creating scarcity and regulating liquidity. Cognitive commensuration, which is perhaps one of the main challenges that the CCS specialists in Rotterdam deal with, emphasizes the urgency of constructing a category of "abstract polluters." Such commensuration seeks to erase the differences between sources of emissions, making carbon dioxide the same across space and time. Each of these three ways of commensuration—technical, value, or cognitive—then enables the production of a new flattened commodity to be exchanged in new financial markets. Thus, they are essential to emissions trading.

The formation of carbon dioxide as a commodity, not in the form of an emissions allowance or credit but as a potential drilling additive, also required commensuration within legal and political regulations. It is important to remember that existing legal and political regulations differentiate carbon dioxide as emitted, in the pipeline, or injected into a well. Carbon dioxide is thus transient, both in matter and in meaning. It moves from the power plant to a pipeline to an oil reservoir, and its meaning moves with it. Accordingly, within the carbon dioxide logistics networks in the Netherlands, carbon dioxide acquires a different qualification at every station. The recognition of carbon dioxide as multiply constituted, or the absence of "cognitive commensuration" (Levin and Espeland 2002), made it difficult for Jan and other CCS professionals to transform this "fluid" molecule into an exchangeable good. "I know it is ridiculous," the legal expert that I spoke with said. "It changes too much; I find it hard to grasp." Carbon dioxide is too elusive.

These discussions showed that not all carbon dioxide is the same. In his article, "Making Things the Same," Donald MacKenzie (2009a) examines the ways in which the entities traded in carbon markets are made "the same." However, in the context that I studied, the intention was not to create sameness across the market but to produce a common denominator that could "link" the various appearances of carbon dioxide. How carbon dioxide was integrated into emergent systems of carbon dioxide governance depended on where it was located in the logistics chain, when it was produced, and how it was constituted. Every molecule of carbon dioxide carried a particular spatiality—a temporal as well as a chemical composition—that had to be identified and differentiated at every point within legal and political carbon dioxide infrastructures. Gavin Bridge suggests that carbon dioxide has emerged as "a common denominator for thinking about the organization of social life in relation to the environment" (2013, 2).

> From fossil-fuel addiction and peak oil to blood barrels and climate change, carbon's emergence as a dominant optic for thinking and writing about the world and human relations within it is tied to the various emergencies with which it is associated. (Bridge 2013, 2)

It is important to keep in mind that while serving as such a common denominator, carbon dioxide resisted becoming "the same." As the legal expert said, carbon dioxide was, in fact, hard to grasp.

Future Transitions

In order to transport carbon dioxide from the Cologne area over the Rhine to the port of Rotterdam, Jan's company needed one six-thousand-ton barge—the biggest barge allowed on the Rhine. By transporting one million tons of carbon dioxide, this barge would eliminate half the emissions from the brown coal plants in the Cologne area. The plants rely on a low-rank coal that does not burn very well because of the high ratio of organic materials in it, but this coal is widely available in the region. Thus, these brown coal plants operate much less efficiently than high-quality coal plants. If captured carbon dioxide were to constitute a commodity, then these plants could sell it to oil and gas companies operating in the North Sea, enabling them to increase the output from depleting reserves. In this way, Jan believed, the brown coal plants would have more incentives to capture the carbon dioxide in the first place.

Carbon capture and storage is a provisional fix, extending the fossil fuel economy until a time when the world may perhaps switch to renewable energy sources. In order to make this provisional fix work, CCS professionals proposed a reconceptualization of carbon dioxide, not as waste that should be taxed, but as commodity. But because carbon dioxide had a different legal and political standing at every point in the logistics network, it became difficult for these professionals to commensurate carbon dioxide. The process of commodification, therefore, occured through practices of "linking" rather than flattening, recognizing the various legal, political, and material appearances of carbon dioxide. At the end, the multiple existences of carbon dioxide refashioned the ways in which CCS professionals thought about this chemical compound and how to transform climate change mitigation and governance.

Jan admitted that it would perhaps make more sense for Europe to switch to another energy, such as solar or wind systems. For him, such sustainable energy systems would not merely constitute climate change mitigation strategies. He understood how energy infrastructures influence social and political life, and imagined that a clean, energy-driven Europe might be more independent, and perhaps more peaceful. He said:

> Oil supply is very much about politics. If you develop your own sustainable energy systems, you can get out, all of that is no longer your concern. It would stabilize the world a lot, if we had to not fight for oil anymore. If we ran our

own solar and wind panels, and everybody can use it, it would help a lot. But I guess not that many people agree with me.

He hoped such a transition would take place soon.

The transitions that Jan dreamed of will probably only occur long after his carbon dioxide logistics network is fully instituted. This network will manage the material, movement, and maintenance of carbon dioxide. It will also be bound by awareness, foresight, and preparedness, thereby having the capacity to overcome supply chain challenges in a most effective manner. It will qualify, transport, and service carbon dioxide; in the process, the network will redefine and reproduce carbon dioxide's meaning at every station, and eventually facilitate its burial in an underground reservoir, never to be exhumed.

Notes

Many thanks to Dominic Boyer, Elizabeth Povinelli, Anne Rademacher, Chika Watanabe, Jerome Whitington, and three anonymous reviewers for reading earlier drafts of this article and making helpful comments. The Wenner Gren Foundation, Cornell University, Rice University, and the ACLS Foundation provided funding for research and writing. I also thank my interlocutors for taking the time to share their perspectives on carbon dioxide.

1. *Oxford English Dictionary*, Third Edition, December 2008, s.v. "carbon dioxide."
2. For anonymity, all first names have been changed.
3. Liquefaction is one of the methods for purifying and transporting carbon dioxide. The process of purification eliminates the other materials that may be emitted from power plants, along with carbon dioxide, most prominently nitrogen. Following purification, carbon dioxide may be used in various sectors, such as the food industry or the fossil fuel industry.

References Cited

Appadurai, Arjun. 1986. *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge: Cambridge University Press.

Bennett, Jane. 2010. *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press.

Benson, Peter, and Stuart Kirsch. 2010. "Corporate Oxymorons." *Dialectical Anthropology* 35:45–48.

Böhm Steffen, Maria Ceci Misoczky, and Sandra Moog. 2012. "Greening Capitalism? A Marxist Critique of Carbon Markets." *Organization Studies* 33 (11): 1617–38.

Bridge, Gavin. 2013. "Resource Geographies 1: Making Carbon Economies, Old and New." *Progress in Human Geography* 35 (6): 820–834.

Callon, Michel. 2009. "Civilizing Markets: Carbon Trading between In Vitro and In Vivo Experiments." *Accounting, Organizations and Society* 34 (3): 535–48.

Cowen, Deborah. 2010. "A Geography of Logistics: Market Authority and the Security of Supply Chains." *Annals of the Association of American Geographers* 100 (3): 600–20.

Huston, James A. 1991. *Logistics of Liberty: American Services of Supply in the Revolutionary War and After*. Newark: University of Delaware Press.

Jasanoff, Sheila, and Marybeth Long Martello. 2004. *Earthly Politics: Local and Global in Environmental Governance*. Cambridge, MA: MIT Press.

Kopytoff, Igor. 1986. "The Cultural Biography of Things: Commodification as Process." In *The Social Life of Things: Commodities in Cultural Perspective*, edited by Arjun Appadurai, 64–91. London: Cambridge University Press.

Latour, Bruno. 2004. *Politics of Nature: How to Bring the Sciences into Democracy*. Cambridge, MA: Harvard University Press.

Levin, Peter, and Wendy Espeland. 2002. "Pollution Futures: Commensuration, Commodification and the Market for Air." In *Organizations, Policy, and the Natural Environment*, edited by Andrew Hoffman and Marc Ventresca, 119–147. Stanford, CA: Stanford University Press.

Lohmann Larry, and Steffen Böhm. 2012. "Critiquing Carbon Markets: A Conversation." *Ephemera* 12 (1/2): 81–96.

MacKenzie, Donald. 2009a. "Making Things the Same: Gases, Emission Rights and the Politics of Carbon Markets." *Accounting, Organizations and Society* 34 (3–4): 440–55.

———. 2009b. "Constructing Carbon Markets." In *Disaster and the Politics of Intervention* edited by Andrew Lakoff, 130–51. New York, NY: Columbia University Press.

Marx, Karl. 1978. "The Fetishism of Commodities and the Secret Thereof." In *The Marx-Engels Reader*, edited by R. Tucker, 319–29. New York: Norton.

Mauss, Marcel. 1967. *The Gift: Forms and Functions of Exchange in Archaic Societies*. New York: Norton.

Melosi, Martin V., and Joseph A. Pratt. 2007. *Energy Metropolis: An Environmental History of Houston and the Gulf Coast*. Pittsburgh, PA: University of Pittsburgh Press.

Mitchell, Timothy. 2011. *Carbon Democracy: Political Power in the Age of Oil*. New York: Verso.

Miller, Daniel. 2005. *Materiality*. Durham, NC: Duke University Press.

Meskell, Lynn. 2005. *Archaeologies of Materiality*. Malden, MA: Blackwell Publishing.

Miller, Clark. A., and Paul N. Edwards. 2001. *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. Cambridge, MA: MIT Press.

Mol, Annemarie. 2002. *The Body Multiple: Ontology in Medical Practice*. Durham, NC: Duke University Press.

O'Reilly, Jessica, Naomi Oreskes, and Michael Oppenheimer. 2012. "The Rapid Disintegration of Projections: The West Antarctic Ice Sheet and the Intergovernmental Panel on Climate Change." *Social Studies of Science* 42:709–31.