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Understanding Carbon Offset Technologies

HEATHER LOVELL & DIANA LIVERMAN

In this article we unpack the 'black box' of carbon offsetting through a critical examination of the technologies and techniques that create carbon credits. Drawing on empirical research of compliance (Clean Development Mechanism) and voluntary carbon offset markets, we highlight the diversity of technologies, techniques and devices involved in carbon offsetting, ranging from refrigerant plants to systems of calculation and audit. We suggest that polarised debates for and against offsetting do not adequately reflect the considerable variations between types of offset project and governance practices in the compliance and voluntary offset markets. Using conceptual insights from governmentality theory and science and technology studies we assess the tensions in making standard, fungible carbon credits. In conclusion, we suggest attention to the technologies and materiality of carbon offsetting allows a fresh perspective on somewhat entrenched debates about the advantages and disadvantages of offsetting.

Keywords: carbon offsetting, Clean Development Mechanism (CDM), offset technologies, climate change, governmentality, science and technology studies (STS)

Introduction

Carbon offsetting allows carbon to be reduced in the global atmosphere by compensating for excess emissions in one location through carbon reductions in another (Bumpus and Liverman 2008). There is a growing literature on carbon offsetting, in particular on the Clean Development Mechanism (CDM), but much of it is polarised, either for or against offsetting, often on principles and values rather than detailed empirical investigation or a careful assessment of different types of offsets (for exceptions see Boyd et al. 2007a,b; Bumpus and Liverman 2008). This polarised abstract debate misses many of the subtleties and nuances of the operation of the CDM and other variants of carbon offsetting, and we suggest it is this detail that ultimately determines the ability of carbon offsets to effectively

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mitigate climate change and encourage sustainable development. We therefore focus in this article on how carbon offsets are produced: how the complex mix of offset technologies, techniques, practices and rules come together and with what results. We concentrate in particular on differences between the voluntary and compliance offset markets, suggesting that these two markets have distinct conceptions about how best to achieve 'the conduct of conduct' (Dean 1999: 11). We examine these differences through the theoretical lenses of governmentality and science and technology studies, concentrating our analysis on the tensions in producing identical, standardised units of carbon from a wide diversity of offset projects.

We aim to address the call by Okereke et al. (2009) for detailed empirical studies about new types of climate governance, and to provide a 'theoretically sensitive, empirical investigation that can articulate implications of current and possibly future initiatives for the authority of the state and the series of actors on which the state now seems to rely in order to dispense its traditional functions in governance' (Okereke et al. 2009: 16).[1] We suggest, however, that understanding climate governance involves considering not just the social world of policy makers, offset organisations and project developers but also the material world: the technological substance of climate mitigation. Carbon offsetting is a rich empirical site to investigate the hybrid networks of material things and people that constitute contemporary climate governance. We critically examine the role of low carbon technologies and devices in framing the governance and politics of carbon offsetting using ideas from governmentality theory and science and technology studies (STS), with the objective of unpacking the 'black box' of carbon offsetting. The advantage of drawing on ideas from both literatures is that we have a set of conceptual tools that covers the spectrum of activities that offsetting entails: that is, the extensive audit and calculation activities that comprise the governance system for offsetting (the CDM in particular) – the 'techniques' with which governmentality is particularly concerned – through to the engineered, material technologies on the ground that comprise offset projects.

We note that governmentality and STS scholars use the term 'technology' in different ways and before proceeding it is important to clarify this area of semantic confusion. The governmentality definition of technology denotes practices and 'techniques and devices' (e.g. audits, systems of measurement) rather than engineered material technologies (i.e. the more conventional definition – wind turbines, cookstoves and such like). Examples of governmental technologies range from policy instruments to new tools of management and institutional devices (Dean 1999; Oels 2005). In other words, technologies are defined in an unusual way, including 'softer' policy techniques and partnerships. STS scholars attend as one might expect to more conventional technologies – power stations, pipes and wires (Hughes 1983; Moss 2001) – the type of technologies that are used within carbon offset projects to produce carbon credits. We return to this definitional overlap below, as it hints at a more substantial issue. To avoid confusion the term 'techniques' will be used henceforth to describe the governmentality conception of technologies, and 'technologies' to describe material engineered things – the STS definition.

The article is structured as follows. First, we introduce carbon offsetting, explaining the differences between compliance and voluntary carbon offsets and considering the diversity of technologies involved in producing carbon credits. Second, we compare and contrast the voluntary and compliance approaches to governing carbon offsets, particularly focusing on how technologies and techniques are variously used to control and standardise the production of carbon credits and to ensure 'the conduct of conduct'. In conclusion, we reflect on the implications of considering the role of technologies within theories of governance, and how tensions in governing carbon offsets might be resolved.

Before proceeding we briefly outline our empirical research and methodology. Because of the shortage of primary research on carbon offsetting in political science we consider this to be important. The specialist knowledge, technologies and discourses associated with offsetting mean that offset organisations are key players in understanding how carbon offsets are produced and consumed, and it is therefore mainly with offset organisations that we concentrated our research. During 2007 and early 2008 we conducted 25 interviews with offset organisations, mostly with managers and directors of two particular international organisations (one operating in the compliance and one in the voluntary offset market). The research was funded by the UK Tyndall Centre and forms part of a project examining the role of non-nation-state actors in shaping the current and future international climate regime (see Tyndall Centre 2008). Since early 2007 we have conducted ongoing analysis of the grey literature on offsetting, including company reports and websites, news reports, evaluations by non-governmental organisations (NGOs) and others. We were also able to observe some of the interactions that offset organisations had with other actors at the Bali 2007 and Poznan 2008 United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties, as well as at several public workshops on offsetting during 2007 and 2008.

An introduction to carbon offsetting

There are two broad types of carbon offset project: compliance (primarily the Clean Development Mechanism under the Kyoto Protocol) and voluntary. The CDM is one of the Kyoto 'flexible mechanisms', which allows countries to comply with their target emission reductions through carbon trading and purchasing emission reductions made internationally rather than through domestic reductions. The demand for carbon reductions is driven by the commitments made by industrialised countries that have ratified the Kyoto Protocol and thereby agreed to reduce emissions from a 1990 baseline by an average of 5.2 per cent by 2012. But many companies and individuals also wish to offset their emissions in the parallel voluntary offset market to directly compensate for their greenhouse gas emissions. The voluntary offset market has developed independently of the international climate regulatory regime and anybody – NGOs, businesses, individuals – can produce and consume voluntary offsets however they choose: there are, as yet, no widely used international standards or regulations. In contrast the compliance offset market is regulated by a complex array of rules at the international level, administered by the CDM Executive

Board of the UNFCCC. The CDM has mechanisms to define credits strictly and establish standards of quality for projects' design and methodologies (including those for additionality and baselines). All CDM projects must be registered through the UNFCCC, and carbon finance is typically channelled through private sector or World Bank carbon funds, which then finance offset projects in the developing world (Bumpus and Liverman 2008).

In contrast to the hierarchical and highly regulated structures controlling offset projects within the CDM, the voluntary offset market is much more informal than the compliance market, with no standard definition for credits, varying carbon calculators, and several competing voluntary standards. Often described as a 'parallel market', voluntary offset projects tend to be smaller, have a greater sustainable development focus (often described as social or community 'side-benefits'), lower transaction costs, involve a wider range of methods or techniques, and are typically located in countries not active in the CDM (e.g. the non-Kyoto signatory the USA and African countries) (HoC Environmental Audit Committee 2007). Unlike offset organisations working within the structure imposed by the UNFCCC and the CDM, voluntary offset organisations can use flexible practices through more informal networks with NGOs or companies active in the Global South to source projects and ultimately generate credits (Taiyab 2006).

One common source of misunderstanding about carbon offsets (a way that offsets are typically 'black boxed') is a lack of appreciation of the diversity of technologies that can be used to produce carbon credits. Critics have often overgeneralised from failures of forest projects in the voluntary market (FERN 2005; Sinks Watch 2007) or from the use of the CDM to fund greenhouse gas reductions at a few industrial facilities in China (Warra 2007). Table 1 shows the carbon offset projects approved by the CDM Executive Board to date and the number of credits issued per technology type. Note that these are approved technologies for compliance projects only; there is little comparable data on voluntary offset technologies. In order for a technology to be approved for credit generation under the CDM it must go through a lengthy process of review and assessment which can take up to a year or more (IETA 2008). As the data in Table 1 demonstrates, the most common types of offset project under the CDM are hydropower, biomass and wind: these three technologies comprise nearly half of all registered CDM projects. If considering the number of carbon credits actually issued, however, then industrial gas projects (nitrous oxide and hydrofluorocarbons – HFCs) are most significant – representing approximately three-quarters of credits.

Table 2 shows a further breakdown of project sub-types under a selection of the main technology categories listed in Table 1 in order to illustrate further the complex diversity of technologies that comprise compliance offset projects. Thus, for example, the CDM category of 'biomass' comprises 15 possible sub-types of project, ranging from processing palm oil to forest residues and 'black liquor'.[2] Each of these biomass technologies falls under a separate CDM methodology which varies in terms of the technology used, the production process and the typical volumes of carbon credits produced. They also vary in terms of their impacts on local communities and associated sustainable development and environmental side benefits. Nonetheless these CDM projects all generate identical carbon credits – Certified Emission Reductions (CERs) – that

TABLE 1. Technologies used to produce carbon offsets in the Clean Development Mechanism

Type of low carbon technology	Projects		Credits issued	
	No.	%	No. (000s)	%
Hydro	1,098	26	7,436	4
Biomass energy	632	15	10,835	5
Wind	568	14	7,026	3
Energy efficiency (own generation)	375	9	8,414	4
Landfill gas	302	7	5,249	3
Biogas	267	6	1,041	1
Agriculture	226	5	3,504	2
Energy efficiency (industry)	172	4	642	0.3
Fossil fuel switch	135	3	1,385	1
Industrial gas (N_2O)	65	2	41,781	20
Coal bed/mine methane	61	1	638	0.3
Energy efficiency (supply side)	46	1	161	0.1
Cement	38	1	1,003	0.5
Fugitive	29	1	5,153	3
Afforestation and reforestation	34	1	–	0
Solar	24	1	–	0
Industrial gas (HFCs)	22	1	109,595	54
Geothermal	13	0.3	318	0.2
Energy efficiency (households)	12	0.3	–	0
Energy efficiency (service)	10	0.2	–	0
Industrial gas (PFCs)	8	0.2	–	0
Transport	8	0.2	129	0.1
Energy distribution	4	0.1	–	0
Tidal	1	0.0	–	0
CO_2 capture	1	0.0	–	0
Total	4,151	100	204,310	100

Source: UNEP-Risoe 2009, http://uneprisoe.org/ (last updated November 2008).

are fully fungible and interchangeable. Indeed, the system of compliance offsetting hinges on the crucial dissociation between the offset production process and the resulting carbon credit. In other words, it is essential to the successful functioning of the compliance offset market that the technical diversity of offsetting – the project-to-project variation in how the offset is produced – is disregarded. Although there are some proposals for credits produced by particular technologies reaching a lower market value (e.g. credits from industrial gas projects and forests – Carbon Finance 2007), or for weighting those with development benefits (Boyd et al. 2007b), in broad terms the aim of credit fungibility has been achieved: a CER (a CDM offset) has a uniform price and can be freely traded on a like-for-like basis without reference to its origins. In order to achieve this ambitious policy goal a substantial amount of work has been put into devising a system of calculation, measurement and audit aimed at 'making things the same' (MacKenzie 2009), and it is to this crucial point that we return below in discussion of the techniques and technologies used to achieve the 'conduct of conduct' in offsetting.

TABLE 2. Further breakdown of selected Clean Development Mechanism project technologies by sub-type

Type	Sub-types of project in each CDM technology category
Biomass energy (635 projects)	Bagasse power (173), Palm oil solid waste (48), Agricultural residues: other kinds (166), Agricultural residues: rice husk (135), Agricultural residues: mustard crop (5), Agricultural residues: poultry litter (3), Black liquor (10), Irrigation (1), Forest residues: sawmill waste (27), Forest residues: other (29), Forest biomass (15), Industrial waste (4), Gasification of biomass (12), Biodiesel (7), Ethanol (0).
Landfill gas (301 projects)	Landfill flaring (91), Landfill power (102), Combustion of MSW (15), Gasification of MSW (3), Composting (90)
Biogas (491 projects)	Biogas flaring (226), Biogas power (265)
Hydro (1097 projects)	Run of river (740), Existing dam (60), New dam (297)
N2O (65 projects)	Adipic acid (4), Nitric acid (60), Caprolactam (1)
Solar (24 projects)	Solar PV (14), Solar thermal electric (2), Solar water heating (2), Solar cooking (6)
Energy efficiency (industry) (173 projects)	Chemicals (43), Petrochemicals (34), Paper (14), Cement (13), Iron & steel (13), Machinery (9), Textiles (10), Electronics (6), Food (7), Building materials (12), Glass (5), Non-ferrous metals (3), Coke oven (2), Mining (1), Metal products (1)

Source: UNEP-Risoe 2009, http://uneprisoe.org/ (last updated November 2008).

In contrast, within the voluntary offset market carbon credits are not fully fungible; there is a much less extensive governance system to measure, verify and audit voluntary carbon credits, termed ‘VERs’ (verified or voluntary emission reductions) (Bumpus and Liverman 2008; Kollmuss et al. 2008; Lovell et al. 2009). The focus is on the offset project and hence offset technologies are much more visible and subject to scrutiny by potential purchasers of the credits and the media. As we argue elsewhere (Lovell et al. 2009), the discourse about carbon offset projects is particularly important in the voluntary offset market: certain carbon credits are attractive because they have a story associated with them and can be sold at a premium as ‘gourmet’ or ‘boutique’ carbon with an emphasis on their poverty-alleviation ‘side benefits’. In other words, information and knowledge about how the offset is produced – where and using what technology – is crucial within the voluntary offset market, in stark contrast to the compliance market where this type of information is actively dissociated from the credit.

A key distinction between the voluntary and compliance offset markets is therefore the amount of bureaucracy involved in producing and selling a carbon credit: from sourcing greenhouse gas reduction projects and managing their assessment and verification, to issuing the resulting credits for sale. Figure 1 provides a graphical illustration of the project origination, development and credit issuance stages in the voluntary and compliance markets. What Figure 1 does not show, however – and it is quite misleading in this respect – is the amount of work (and time) involved at each stage. For CDM projects the effort includes writing

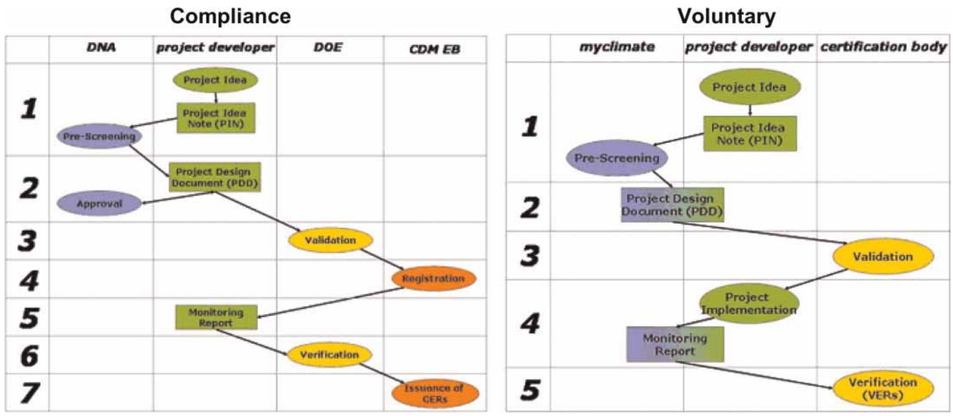

FIGURE 1. Procedures of compliance and voluntary offset projects
Abbreviations: DNA = Designated National Authority, DOE = Designated Operational Entity, CDM EB = CDM Executive Board, CER = Certified Emission Reduction. VERs = Verified Emission Reductions.
Source: http://www.myclimate.org/index.php?lang=en&m=project&um=action&uum=cer.

project development documents and submitting them for approval, and often involves a number of different organisations in approval, verification and monitoring with considerable transaction costs. For voluntary projects there may be both paid and unpaid labour in project development and growing transaction costs to meet demands for monitoring, transparency or certification. While there are economies of scale in some large CDM projects which are complex and time-consuming to develop, the voluntary sector may need to work equally hard to produce a number of small projects for equivalent carbon savings. It raises an important question about how central technologies (as opposed to the techniques that underpin carbon markets – the calculations, audits, etc.) actually are in compliance offset markets in particular. For within the CDM the 'technologies' in the material and commonsense use of the term (those that are producing greenhouse gas emission reductions within a project, e.g. a hydropower plant or industrial gas scrubber) are only really central at certain stages (stages 1 and 2 in Figure 1); elsewhere the primary focus is on audits, calculation, measurement and other techniques used to create a standard carbon credit. It is to these different conceptions and applications of technologies and techniques in offsetting that we now turn.

Theorising the role of technology in offsetting

In this section we examine in more depth ideas from governmentality and STS about the agency of technology and its important role in shaping social relations, politics and policy processes, responding in part to a call by Okereke et al. (2009: 3) to look more closely at 'what the content of social structures might be'. So whilst we agree with a governmentality conceptualisation of power as relational – i.e. that it depends on an organisation's position within the particular networks in which they are operating – we wish to elaborate here on the central proposition of STS scholars that it is not just social networks that are important, but material ones too. We demonstrate how the technologies and techniques of carbon offsetting are multiple, complex and diverse. A focus on these technologies and techniques – and the agency they have – provides a novel and useful lens through which to analyse carbon offsetting.

In the introduction to the article we clarified a semantic issue – the different way in which the term 'technology' is used by governmentality and STS scholars – and we revisit it here because it overlies a more substantive issue, namely that the role of 'material' technologies in policy is typically not included in governmentality analyses. With exceptions (Merriman 2005; Backstrand and Lovbrand 2006), little attention has been paid to how the deployment and use of technologies also reflects and constitutes rationalities of governing. Governmentality is of course centred on issues of governance and government: how policies and programmes are enacted, managed, governed, etc., and by whom, and in this way it has tended to focus on people and ideas rather than things. In contrast within STS theories (particularly actor-network theory), policy and governance issues have tended to be overlooked (see for example Akrich 1992; Latour 1992). The empirical focus of actor-network theory has typically been on technology–people relations in particular places (Callon 1986; Rohracher 2001; Rutland and Aylett 2008).

Extensive reviews of governmentality and STS literatures (including actor-network theory) have been provided elsewhere (see Dean 1999; Rutland and Aylett 2008) and we do not intend to duplicate this work. Instead we concentrate on exploring the different lenses on technology held by governmentality and STS through considering how governance has been conceived and operationalised in carbon offsetting, whether it is via techniques (audits, verification, etc.) or technologies (industrial gas scrubbers, treadle pumps, etc.). We do this principally through comparing the compliance (CDM) and voluntary offset markets. As discussed, carbon offsetting tends to be lumped together in one category, but in reality there are two distinct markets or spheres of offsetting – compliance (CDM) and voluntary – which usefully provide us with contrasting governance styles.

Achieving 'the conduct of conduct'

We identify two spheres of activity central to achieving governance in carbon offsetting: calculation and measurement, and control-at-a-distance (or translation); objectives that are prioritised by actors within the compliance and voluntary markets respectively.

Compliance offsetting. Starting our analysis with the compliance offset market, governmentality provides a framework for understanding the complex audit process of the CDM and its obsession with calculation – in project design, verification, through the CDM Executive Board decision-making process, etc. The CDM represents an elaborate attempt to control and order the process of offset production. Indeed, in compliance offsetting, building and maintaining a credible system of governance has arguably become the main focus of policy and professional effort – for measurement processes and techniques are critical to the overall goal of producing standardised (fungible) uniform credits that are dissociated from their origin. In a sense the policy goal has shifted to become one of making the audit and verification system work, and away from the fundamental objective of taking carbon out of the atmosphere. For instance, the CDM governance process has been heavily criticised for becoming too cumbersome because of the obsession with accuracy (Lohmann 2009), as one offset company director with 15 years' experience in carbon markets explains:

> the CDM Executive Board is very, very concerned with getting things exactly right, as opposed to being conservative and recognising that you don't know every piece of data on every single project. That has been a key concern . . . the current CDM insists on extreme exactitude around every single project and every single asset . . . It is realising the absurdity of that . . . there has to be an adaptation of the approach. (Interview, Director of a carbon offset organisation, January 2008)

Conceptual insights from governmentality help us understand the strong focus of the CDM on calculation and standardisation. For instance, Murray Li, in her excellent analysis of development projects in Indonesia, views calculation and defining objects of government in a technical way as vital to modern practices of governmentality. As she explains:

> Calculation is central, because government requires that the 'right manner' be defined, distinct 'finalities' prioritized, and tactics finely tuned to achieve optimal results. Calculation requires, in turn, that the processes to be governed be characterized in technical terms. Only then can specific interventions be devised. (Murray Li 2007: 6)

These ideas can very readily be applied to the CDM, through which the problem of climate mitigation has been progressively more narrowly framed in ways that can be addressed by and managed by international systems of CDM audit and calculation. As other commentators have noted, there is significant and constant behind-the-scenes effort in carbon markets to 'make things the same' (Lohmann 2005; MacKenzie, 2009), i.e. in maintaining the fungibility of carbon credits despite their production involving a large diversity of offset technologies in many different places. Adam Bumpus (2009), for example, highlights this tension in his in-depth analysis of the practices and materiality of carbon offset projects in Honduras. In a comparison of two contrasting types of offset project (the CDM La Esperanza micro-hydropower project and the voluntary offset improved cookstove project in Tegucigalpa), Bumpus provides several examples of how carbon is an unusual and 'slippery' commodity, in part because of the uncooperative nature of carbon offset technologies. Thus, for instance, cookstoves in the Tegucigalpa project unexpectedly become much more expensive because of an increase in the world price of metal. Further, because cookstoves were dispersed across multiple sites and used by 'non-standard' families, it was difficult to measure and monitor emission reductions. Similar issues complicating standardisation and measurement of emission reductions arose with the La Esperanza hydro project, where for instance the generator blew up because of unexpectedly heavy rainfall (Bumpus 2009). These types of complication at a project level help us understand how over time the focus on calculation in the CDM has led to the prioritisation of low carbon technologies that produce greenhouse gas emission reductions which can be relatively easily measured and controlled (Lohmann 2009). A manager at an offset organisation describes for example their efforts to bring less easily quantifiable greenhouse gas reduction technologies into the CDM framework:

> What we are struggling with right now is how can we innovate in some sectors … the cool, co-benefits kind of projects that buyers are constantly wanting to add to our portfolio, but that are very difficult to implement from a CDM or traditional method of doing carbon credits. You just cannot do entire PDDs [Project Design Documents] and come up with huge baseline analyses and do the very complicated monitoring up to the tenth decimal point for a project that is going to do small scale biodigesters in Nepal … In order to really make it work in a sensible way you need to have new protocols and new ways of thinking that are outside of the box. (Interview, Voluntary Market Manager at an offset organisation, April 2008)

In a similar vein the director at a voluntary carbon offset organisation discusses the difficulties of measuring carbon savings in a charcoal cookstove project in South Africa:

> the science of making the charcoal … actually capturing the amount of greenhouse gases that go from chopping down the trees to cooking the food in a house in Kampala … the science of that process needs to be got right in order for us to be able to count the savings from that project … so there is very specific stuff that we need to get right. (Interview, Director of an offset organisation, July 2007)

In this way those working in carbon offsetting appear quite limited and constrained in terms of the type of low carbon technologies they can use. Again Murray Li provides a good summary of this type of technical constraint in her description of how experts and programmers operate in the field of development studies:

> A central feature of programming is the requirement to frame problems in terms amenable to technical solutions. Programmers must screen out refractory processes to circumscribe and arena of intervention in which calculations can be applied. (Murray Li 2007: 2)

In effect the thing that is being measured (in this instance 'carbon' or greenhouse gas emission reductions) over time adapts to suit the measurement techniques

(Lohmann 2009). Michael Power describes this effect in his research on audits, arguing even though the audit is meant to be scientific and objective, in practice the institutions being audited change their practices to fit the audit (Power 1994). Moreover, techniques such as audits are often borrowed or adapted from other areas and applications. An explicit programme of policy intervention is a rare thing, more often than not it is a 'heterogeneous assemblage' (Murray Li 2007: 6) cobbled together using a blend of past practices and ideas. A prime example of this is the transfer of financial sector techniques in carbon markets, as an offset organisation director explains:

> The bank traders want something that will fit into their existing systems. They have been learning to trade electronically for the last 18 years and the trader sits there with two lines and the price goes up, or it goes over the top of that line, they sell it. When it goes under the bottom of that line they buy ... all they have got to do is watch the screen. So from the point of view of a three dimensional instrument [like a carbon offset] whereby actually there's all these other things, it's not just those two factors [price and volume], they actually don't have the mechanisms. So it depends on their appetite for change. (Interview, CEO of an offset organisation, October 2007)

Some of the challenges of monitoring and aggregating certain small scale technologies have resulted in proposals to streamline and expand the CDM for certain technologies, regions and clusters of projects. For example, there are proposals to scale up the CDM to target carbon finance at transforming whole economic sectors or policies, such as cement, transport or electrical utilities, in key developing countries; to add controversial but low carbon technologies such as nuclear power and carbon capture and storage; and to ensure a more equitable distribution of projects, especially to Africa (see Olsen and Fenhann 2008). Many of the proposed reforms include ideas for more effective techniques of approval and audit, and for clustering and expanding the range of technologies covered, and different groups favor certain reforms depending on their underlying interests in equity, transparency or technology innovation.

Voluntary offsetting. The voluntary market has in contrast to the compliance market concentrated much less on the regulatory system, and more on individual offset projects and the human–technology relations within them. In essence the focus has been more 'bottom-up' than 'top-down': on specific greenhouse gas reduction technologies – how they work and how socially integrated they are in specific localities – rather than the techniques and practices of government. For example, a manager at an offset organisation contrasts the voluntary sector focus on the project technology with the compliance market as follows:

> Obviously, the compliance market doesn't care where it [the offset] comes from. The compliance market just wants to get that thing,

> you know, make sure it's verified and signed off and, boom, off you go. Whereas in the voluntary market it's very, very dependent on what the technology is – very dependent. Our pricing structure reflects that. (Interview, Voluntary Market Manager at an offset organisation, April 2008)

So the objective of the voluntary market can be seen to focus on achieving stability through developing embedded stable networks of people and technologies, i.e. ensuring the low carbon technologies are integrated into everyday lives in particular places (a process termed 'translation' by STS scholars – see Callon 1986, 1991; Murdoch 1997), rather than via calculation and measurement. For instance, as a manager at a voluntary offset organisation explains:

> carbon is so abstract . . . these [voluntary offset] projects are colourful and personable and involve real people and things that people can engage with. So you don't have to talk about hydrofluorocarbon and such and such process being more efficient, you can talk about cooking your evening meal without having to have a smoke-filled kitchen. But it also brings along with it a range of complications . . . because they are sustainable, so the project might involve partly financing the organisation that is doing the work so they can buy a new office, partly financing their educational work so that people actually know about the technology maybe sometimes a direct subsidy of whatever piece of kit. (Interview, Marketing manager at an offset organisation, October 2007)

Thus in the voluntary market the governance of offset production has been achieved more through efforts at translation and 'action-at-a-distance' – developing stable (strong, durable) socio-technical connections, not just within a project, but also across the supply chain between producers and consumers:

> there are lots of reasons . . . why voluntary offset providers focus on smaller scale projects but one of them is demand for customers and what they are like . . . people want to feel a connection where the money is being spent and that is much, much easier for people if we talk about communities and families and school and day-to-day [things] and not big fat technical processes . . . I think it will be harder to sell the idea of parting with some of your cash for carbon reductions if you don't have those sort of stories. (Interview, Marketing manager at an offset organisation, October 2007)

In other words, voluntary offset production and consumption involves establishing a direct connection between consumers of offsets and a particular offset project (see Lovell et al. 2009) and this is how credibility is obtained, rather than through complex abstract processes of calculation audit and measurement, in direct contrast to the compliance market. However, criticisms of some CDM projects' lack of sustainable development benefits and negative impacts on communities means that even the CDM must now consider the 'human face' of compliance credits in order to gain the support of key non-state actors such as environment and development NGOs, or major corporations concerned with reputational risk (Olsen and Fenhann 2008).

The material technology (the greenhouse gas reduction technology) and its social connections have been central to achieving the 'the conduct of conduct' in voluntary offsetting. This observation lends itself well to STS ideas about socio-technical relations which ascribe an integral role to materials or technologies (the non-human elements of policy) in processes of change. The key argument is that technologies are a vital component of social networks – the 'missing masses' of society (Latour 1992). So from an STS perspective it is not just society that constructs problems and proposes solutions, materials and technologies themselves play an important role – they decay, they break down, they act in unforeseen ways, but they also provide stability to human relations. By translating an idea into a material form – whether it be constructing a new type of power plant or demonstrating a new renewable energy technology – the idea is given some permanence. Material objects thereby play an important role in adding stability to emerging human–technology relations, as Law (1992: 5) explains: 'some materials are more durable than others and so maintain their relational patterns for longer . . . Consequently, a relatively stable network is one embodied in and performed by a range of durable materials.'

Indeed, because carbon markets are still 'hot' or unsettled (Lohmann 2005) – and the institutions and practices of carbon offsetting are only relatively weakly embedded – technologies arguably play a vital role in providing stability and connecting diverse social actors. Carbon offsets are a complex commodity with hybrid origins (part technical, part social), and it is evident that relationships between technologies and humans at a project level can be fragile, as the director of a voluntary offset company explains:

> Two years ago there were two of us in this market and now there are 120. The rate of growth, the rate of journalistic misunderstanding, the intervention of clumsy government, the uncertainty about whether some things are going to get subsumed like stoves into the Kyoto protocol or not means that it's just going be turbulent. It's not like selling widgets that have been sold for the last 35 years . . . we're on a river, the river's going down, eventually we know it's going to reach the sea but there's going be some waterfalls on the way. (Interview, Director of an offset organisation, October 2007)

The agency of offset technologies. Ascribing agency to a technology alerts us to the possibility that carbon offset technologies can behave in unpredictable ways and that they cannot necessarily be relied on to behave as expected (as discussed by Bumpus 2009). For example, we see this clearly in the case of the offset company AgCert whose predictions for the yield of carbon credits from its agricultural projects had to be substantially downgraded because the complex methane capture technology did not work as effectively as planned in reducing greenhouse gases, resulting in it going into administration (ATTRA 2008; Macalister 2007). Debates about the uncertainty and unpredictability of technologies are also taking place with regard to creating carbon credits from forests (and how to account for risks of fire, disease, etc.) (Nelson and de Jong 2003; Boyd et al. 2007a; HoC Environmental Audit Committee 2007); and likewise with energy efficiency projects, where there are concerns about how to standardise measurement and verification of emission reductions from multiple, dispersed technologies (Olsen and Fenhann 2008).

STS approaches are also instructive in drawing our attention to the 'path dependency' or 'lock-in' of particular technologies and socio-technical systems, acknowledging that technologies themselves have a history: that they have been used in different places and for different purposes in the past, and that this can affect their contemporary influence, role and social meaning (Arthur 1989; Schot et al. 1994; Unruh 2002). To take cookstoves as an example, the technology has been used for decades prior to emergence of carbon offsetting and has been funded under previous programmes of development and poverty alleviation. The technologies have now been actively 'reframed' as about carbon rather than development, and it is this reframing that is the innovation – i.e. they are new as offsets, but not new as technologies. Attention to the path dependency of technologies can further our understanding and appreciation of why technologies reframed as carbon offsets might be resisted or embraced in particular locales, depending on their history of use. Technologies and materials can act as a 'script' (Akrich 1992), placing boundaries on the acceptable limits of policy initiatives.

Although STS approaches describe and explain complex socio-material relations, little attention is paid to governance as such, for example the ways in which technology is translated into policy through techniques and devices, and how technology is shaped by discourse and politics. Here ideas from governmentality are instructive for they add a broader critical perspective on why and how things might be 'rendered technical' (Murray Li 2007) in policy through close attention to the discourse or rationalities of government. Governmentality approaches consider, first, how objects of government are defined and how problems are framed ('rationalities'), and second, how they are governed through techniques and devices (Dean 1999). Objects of government are 'rendered technical' through a set of practices

> concerned with representing 'the domain to be governed as an intelligible field with specifiable limits and particular characteristics . . . defining boundaries, rendering that within them visible, assembling information about that which is included and devising techniques to mobilize the forces and entities thus revealed'. (Rose 1999, quoted in Murray Li 2007: 7)

Neoliberalism and offsetting. The governmentality emphasis on the close connection between the rationalities and technologies of government suggests that carbon offset technologies and techniques should be understood in the context of the dominant neoliberal discourse or 'rationality' that permeates contemporary climate governance (Bryant 2002; Oels 2005; Backstrand and Lovbrand 2006; Rutland and Aylett 2008). Neoliberalism or 'advanced liberal government' is defined as a belief in the efficiency of markets to solve policy problems combined with minimal state intervention (Dean 1999; Oels 2005; Raco and Imrie 2000). As Oels elaborates in her governmentality analysis of international climate politics and policy:

> Advanced liberal government ... renders climate change governable as an issue of state failure requiring market-based solutions or the creation of markets. The extent to which action is to be taken on *climate change is not a moral issue but instead a matter of cost-benefit analysis*. (Oels 2005: 201, emphasis added)

The influence of neoliberalism is evident in many ways in the compliance offset market in particular, where greenhouse gas reductions have been narrowly defined on the basis of being calculable and measurable and therefore able to be commoditised and traded (Bumpus and Liverman 2008; Bumpus 2009). The massive amount of auditing and verification follows from, and feeds back into the neoliberal rationale guiding offsetting – it is about trying to make markets work, about creating the framework for a carbon market to function efficiently. But whilst a neoliberal rationality is central to CDM offsetting, in the voluntary market the situation is more mixed. The discourse and rationality of key players in the voluntary offset market is more holistically about sustainable development and not just carbon, as one offset manager describes:

> there are lots of reason why voluntary offset providers focus on smaller scale projects ... people want to feel a connection where the money is being spent and that is much, much easier if we talk about communities and families and school and [the] day-to-day, and not big fat technical processes. (Interview, Marketing manager of an offset organisation, October 2007)

Another manager at the same voluntary offset organisation describes the pressures they face in maintaining the sustainable development elements of voluntary offsets:

> We can see the way the market is going – do we try and really try and influence it and try and bang the drum for VERs [voluntary offsets] in order to keep the sustainable development elements or do we just say right ok well let's become a commercial player in the market? (Interview, CEO of an offset organisation, October 2007)

So the attention given in the voluntary market to socio-technical relations at project level stems from a rationale of sustainable development and also appeals to moral bargains made by firms and individuals who wish to compensate for their emissions by investing in the developing world. Most of the pioneering voluntary offset organisations for instance commenced their operations initially through community agro-forestry and cookstove projects (see Nelson and de Jong 2003; Climate Care 2006; Couton 2007) – the substance of international development programmes. Although in the CDM sustainable development is in theory meant to be considered within offset projects, in many cases the approval is made by host governments who rarely stop projects because of the desire for carbon finance investments in their economies (Olsen and Fenhann 2008). Sustainable development is difficult to measure, and therefore not prioritised: the problem is much more narrowly framed as being about climate change and therefore carbon.

Summary and conclusions

There remains confusion amongst those working outside of carbon offset markets about exactly what offsetting is. Carbon offsetting has indeed become tremendously complex: there is an obsession with calculation and with the accuracy of methods used to measure the production of carbon credits from individual projects using a vast array of different greenhouse reduction technologies. In the media, and academia too to some extent, the debate about offsetting has become polarised and overgeneralised, with much of the subtleties of the diversity of technologies and techniques of offsetting being misinterpreted or overlooked. Carbon offsetting tends to be lumped together in one category, but in reality there are two distinct markets or spheres of operation – compliance and voluntary – comprising many different types of offset technology. The compliance and voluntary offset markets provide contrasting examples of styles of government or 'governmentality'. The compliance market is heavily regulated, with a strong focus on audit, verification, measurement: building a credible system of governance has been the focus of policy and professional effort because measurement processes and techniques are central to the CDM goal of producing standardised (fungible) uniform credits that are dissociated from their origin. The compliance offset market thereby lends itself to a governmentality analysis: the emphasis is on the governance techniques, rather than the offsetting technologies at an individual project level. The voluntary market in contrast has concentrated less on the governance of credits and more on individual projects and the human–technology relations within them, so the focus has been on the greenhouse gas reduction technologies themselves – the mechanics of them, how they are integrated in specific localities, and how their stories are communicated.

There are a number of policy and conceptual implications that stem from our analysis. In terms of policy implications, the limitations of the CDM taking calculation and measurement so seriously are increasingly being recognised: the governance process is widely perceived as too cumbersome because it is overly obsessed with accuracy (HoC Environmental Audit Committee 2007; World Bank 2007; IETA 2008; Lohmann 2009). Further, expert knowledge (about finance, project origination, law, auditing, accounting, etc.) has become central to the operation of the CDM and to a lesser extent other offsetting schemes in the voluntary market, and this is acting to exclude certain voices from the debate. The focus of CDM on techniques of government has also led to a lack of attention to the operation of low carbon technologies at a project level and in some of the regions of the world with less capacity and fewer opportunities. But the voluntary market is having credibility problems too at the other end of the spectrum because of too little monitoring and regulation of offsetting activities. Several new industry-led voluntary standards were launched in 2007 and 2008 in response to criticisms (Kollmuss et al. 2008). We suggest there must be greater recognition of a middle ground between the voluntary and compliance market, with acknowledgement of the case against perfectionism in calculating greenhouse gas emission reductions.

The conceptual implications of our analysis stem initially from the overlapping terminology in governmentality and STS, with both literatures referring to 'technologies' but meaning different things (the governmentality definition refers to techniques, devices and practices; and the STS definition to working engineered, material objects). The semantic confusion hints at a more substantial issue, however, regarding the near absence in governmentality of ideas about the conduct of technologies being managed (it is largely about control of people). STS theories in contrast do ascribe agency to technologies, and are centred on human–technology interactions at a micro-level, but miss the broader governance and policy focus, and in this way the two literatures are complementary. Carbon offset technologies and techniques are a vital part of the dynamic networks that comprise contemporary climate governance, and yet governance networks are typically seen as populated by social actors and institutions as explained by Sending and Neuman (2006: 668):

> It is thus not the functional role of the state which has changed as such, but the intermeshing of the networks which has become so much denser that it qualitatively changes how the state goes about minding that function – how it recruits its personnel, organises its work and shapes in different ways the plethora of actors central to governmental functions.

We suggest that in the case of carbon offsetting it is crucial to pay close attention to the material world and role of technologies, which form a vital part of this 'plethora of actors'. Moreover, attention to the technologies and materiality of carbon offsetting brings a fresh perspective to somewhat entrenched debates about the advantages and disadvantages of offsetting.

Notes

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1. It is important to note that we are working with a larger group of researchers and postgraduate students who are currently undertaking exactly these kind of investigations through detailed studies of the CDM and voluntary offsets, including Emily Boyd, Adam Bumpus, John Cole, Christian Ellerman, and Deborah Ley at Oxford and Esteve Corbera in Tyndall. Adam Bumpus has a parallel article in preparation focusing on the materialities of offsets using examples from his fieldwork in Honduras (see Bumpus 2009).
2. 'Black liquor' is the term used for waste from pulp and paper processing, which is burnt to produce electricity and/or heat.

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