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Legitimating the governance of embodied emissions as a building block for sustainable energy transitions

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1. Introduction

At present the study of sustainable energy transitions is largely focused on the supply side, whereas the carbon embodied in products remains mostly overlooked. 'Embodied' emissions are those resulting from the production and distribution of goods and services rather than those occurring during use or disposal. Without elaborate systems that keep track of the emissions embodied in products and services, these remain hidden and the use of sustainable energy does not get rewarded in the competition between different products or services.

Strengthening the role of embodied carbon promises to both diffuse and entrench shifts towards sustainable energy use. Taking embodied carbon into consideration can help to project incentives for the adoption of sustainable energy transnationally along supply chains, thereby contributing to the diffusion of sustainable energy technology and practices. It can also help to entrench sustainable energy use by shielding it from carbon intensive competition.

The standardised assessment of embodied carbon provides an important building block for the governance of emissions embodied in trade. Quantifying the carbon embodied in products can help to reward the use of low carbon or renewable energy and thereby accelerate sustainable energy transitions. For example, the Buy Clean California Act specifies maximum carbon intensities for the government procurement of a range of building materials [1,2].

How does one calculate the carbon embodied in a product? Life cycle assessments (LCAs) aggregate the environmental impacts associated with the various stages of a product's life cycle. For example, an LCA that seeks to depict the stages from a product's 'craddle' to its consumer would include the environmental impacts arising from the extraction and transport of all raw materials, the production and transport of any intermediate goods and those of the final good until it reaches the consumer. More and more producers offer Environmental Product Declarations (EPDs) [3,4]; see e.g. Ref. [5]. These are standardised and verified documents presenting the results of LCAs. Partial LCAs, solely focussing on greenhouse gas emissions and their global warming potential (GWP), are released in the form of Product Carbon Footprints (PCFs) (see e.g. Ref. [6]).

So far social scientists seem to have found PCFs to be a more compelling research topic than EPDs.[1] A recent study by Ref. [7] examines the case of PCFs in detail but does not establish any links to EPDs. In contrast, this paper draws consequences from the fact that EPDs comprise PCFs. We therefore explicitly address EPDs on the same plane as PCFs.

PCFs, either alone or as part of more holistic EPDs, are a medium that has the potential to extend the legitimation of renewable or

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[1] According to Web of Science data from 12.11.2017 only 11 of the 191 publications on the topics of "environmental product declaration*" or "type III environmental declaration*" or "product environmental footprint*" were in social science journals (we leave out the 'other topics'). None of these was in Politics or Environmental Studies journals. Instead, publications were in the Business, Economics and Urban Studies fields. In contrast, according to Web of Science data of the same date, 64 of the 402 publications on the topics of"product carbon footprint*" or "carbon label*" were in social science fields. These were Business, Economics, Management Science, Public Administration, and Social Science.

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low carbon energy from the domain of production to that of consumption. In doing so, producers subject themselves to an environmental accountancy regime, which permits them to endow their products with the virtue of being relatively low carbon products. Potentially, procurement requirements, downstream standards and border carbon adjustment measures could all draw on the information on embodied carbon as a decision-making criterion.

PCFs can help to increase the accountability of supply chains for carbon emissions. This holds the potential to accelerate the transition towards sustainable energy systems. Where the carbon emissions caused by production abroad and the importation of goods can be assessed in valid, reliable and legitimate ways, the reach of climate policy can expand from the mere regulation of domestically produced greenhouse gas emissions to also encompass those which domestic demand induces abroad. Domestic producers have been able to hold ambitious climate policy at bay by pointing to the threat of competitive disadvantages from the purely domestic regulation of emissions. As national climate policy begins to address foreign emissions, the threat of competitive losses from the purely domestic targeting of emissions would loosen its sway over policy-makers.

What are the major factors shaping whether embodied emissions policies and the informational devices enabling them are perceived as legitimate by the various actors that could advance or block their adoption? What is perceived as legitimate will vary depending on the context *in* which and the perspective *from* which one assesses the legitimacy of an object, practice, idea, person or organisation. The object of such an assessment will be accepted as legitimate when it qualifies as fulfilling the requirements of, variously, being *good*, *proper* or *fitting* within the internal logic of an intersubjectively - yet unevenly - shared convention as to what constitutes specific desirable qualities [8,9]. Which qualities are deemed desirable, and which trade-offs between them acceptable, varies between situations and among people. Therefore, processes of legitimation are most fruitfully analysed with reference to the plurality of different 'orders of worth' [10].

The paper draws on concrete examples from the building industry, on the basis of which we develop a critical discussion of the dynamic legitimation of product carbon footprinting as a policy tool for improving the accountability of energy transitions. Buildings are responsible for an important share of global carbon emissions, with overall global annual buildings-related carbon emissions amounting to 9.0 GtCO2 in 2016. Those from buildings construction contributed to more than a third of those. They had grown steadily from 3.1 $GtCO_2$ in 2010 to 3.7 GtCO2 in 2016, demonstrating the increasingly relevant role of embodied emissions [11].

In the next two sections we present theory and methodology. Section 4 provides more information on PCFs and EPDs. Section 5 describes the actual and potential use of PCFs and EPDs in the transition towards a sustainable energy regime. Section 6 describes important dimensions of legitimation in which PCFs and EPDs need to prove themselves in order to become incorporated by the climate policy regime and analyses the interactions between different legitimation dimensions. Section 7 provides a conclusion and policy recommendations.

2. A plurality of (de-)legitimation logics

EPDs/PCFs are standardised formats for governing the transmission of environmental information along value or supply chains [89].

As a niche innovation [12] their successful incorporations by the climate policy regime requires legitimation processes along several dimensions. Different policies and initiatives can advance such legitimation in successive steps, each of which can offer novel opportunities for the adoption of further policies and initiatives.

Sareen [13] inductively identifies four 'registers' upon which practices of legitimation draw in the field of sustainable energy transitions: discursive, bureaucratic, technocratic and financial. This typology has the advantage of being intuitively plausible and therefore well-communicable. However, it suffers from the separation of the realm of the relatively free form of the discursive from other, more restricted, systemic logics. This mirrors the Habermasian [14] juxtaposition of the 'life world' in which communicative subjects engage in enlightening and emancipatory dialogues to that of systemic logics, which have acquired their own expansive and self-perpetuating dynamics, functioning more akin to the systems theory of Luhmann [15] (see also [16]). The differentiation between 'discourse' and its others only too easily raises the question of whether statements that refer affirmatively back to systemic logics ought to be categorised as belonging to the register of the discursive or not. The fact that these registers are not mutually exclusive [17] limits their utility for analysing and communicating tensions and conflicts between different rationales.

An alternative to the separation between discursive and non-discursive symbolic patterns of interaction consists in understanding all societal domains as subject to legitimation processes based on procedures of evaluation and justification. Convention theory, also — variously and depending on disciplinary positioning — referred to as the *economics of convention* [90] or *pragmatic sociology* [18], adopts such an approach. It has become a flourishing field of inquiry which seeks to understand how plural forms of evaluation contribute to the (de-)legitimation of objects and practices [10,19–21]. It addresses issues of valuation that span the disciplinary boundaries of economics and sociology [9].

Convention theory scholars emphasise the tensions and compromises between different (de-)legitimation logics, such as those in accordance with market, industrial, green, civic and domestic norms. Table 1 shows a schematic summary of the different orders of worth relevant for this analysis. Legitimation here does not refer exclusively to moral considerations in the narrow sense but to various conception of the good in accordance with different orders of worth [91].

This typology of order of worth provides a finely-grained grammar of evaluation. Two of Sareen's [13] non-discursive registers can be identified as subsets of some of these orders of worth: financial ∈ market, and technocratic ∈ industrial. The bureaucratic register, however, is already a compromise between the civic and the domestic orders of worth: e.g., a government bureaucracy orients itself towards the civic order of worth by acting in the name of collective welfare, requires formal and official proofs, and takes as its qualified objects rules and regulations. Yet, its hierarchical structure renders those endowed with formal authority as qualified human beings, which reflects the domestic order of worth.

Several analysts of struggles over sustainability transitions in the field of agriculture have drawn on convention theory [23,24]. Lindberg et al. [25] applied convention theory to conflicts over the role of sustainability in the tourism sector. Nyberg and Wright [26] use convention theory to investigate discursive compromises between the environmental and market logics in corporations and find that these ultimately serve to legitimise the market logic. Pitanga [27] applied convention theory to the factors influencing the social acceptance of wind energy.

Ponte and Gibbon [89] have applied convention theory to the analysis of global value chains (GVCs). This is imminently relevant for the analysis of EPDs and PCFs, which are standardised formats for transmitting information on environmental impacts of production along value chains. For one of the major concerns of GVC

Table 1
Schematic summary of orders of worth (adapted for brevity from Ref. [22].

	Market	Industrial	Civic	Domestic	Green
Mode of evaluation (worth)	Price, cost	Technical efficiency	Collective welfare	Esteem, reputation	Environmental friendliness
Test	Market competitiveness	Competence, reliability, planning	Equality and solidarity	Trustworthiness	Sustainability, renewability
Relevant proof	Monetary	Measurable: criteria, statistics	Formal, official	Oral, exemplary, personally warranted	Ecological, ecosystematic
Qualified objects	Freely circulating market good or service	Infrastructure, project, technical object, method, plan	Rules and regulations, fundamental rights, welfare policies	Patrimony, locale, heritage	Pristine wilderness, healthy environment, natural habitat
Qualified human beings	Customer, consumer, merchant, seller	Engineer, professional, expert	Equal citizens, solidarity unions	Authority	Environ-mentalist

analysis is the flow of information between buyers and suppliers. From the perspective of convention theory the legitimation of such a transmission of product quality information depends on its performance with regard to criteria that may be established, or subjected to contestation, in accordance with relevant conventions [89].

3. Materials and methods

We first provide more contextual information on the current use and the promises of EPDs/PCFs. This provides us with the basis for applying the orders of worth schema to analyse the legitimation dynamics of EPDs/PCFs. In doing so we draw on empirical material in the form of document analyses and interviews.

4. Product carbon footprints as quality markers for low carbon products

EPDs/PCFs are a medium that permits extending the legitimation of renewable or low carbon energy from the domain of production to that of consumption. In doing so, producers subject themselves to an environmental accountancy regime, which permits them to endow their products with the virtue of being relatively low carbon products.

Establishing accountability for the carbon embodied in products has severe implications for the underlying supply chains. It would require a complex transformation of global commodity chains, probably with the same elements as those brought forward by Dauvergne and Lister [28] when discussing how to advance global timber sustainability: “chain of custody eco-certification, carbon accounting, and life-cycle assessments”.

PCFs address all of these aspects. Many producers of carbon intensive products already offer EPDs that comprise such a carbon footprint [29]. The pioneering UK-based Carbon Trust alone created about 28,000 PCFs [7,30]. In 2015 ([4]; p. 1201) reported that, globally, there were more than 3600 EPDs. Between 2013 and 2016 the number of EPDs released by European programme operators increased by 150% to a total of 4888 [31]. From 2017 to 2019 the number of EPDs that were verified in accordance to the specific standard EN 15804 for construction products nearly doubled from 3600 to over 6000. While the overwhelming majority came from Europe, nearly a 1000 came from the USA and about 500 from other countries, including Turkey, Latin America, Australasia and Brazil [32,33].

Green building rating schemes have started to address the environmental impacts embodied in building materials and to provide incentives for manufacturers to disclose the environmental life cycle data of their products. Major building material producers and trade association have released PCFs and EPDs for their products.

In 2010 CEMEX UK, with assistance from the Carbon Trust, launched their carbon label for cement [34]. CEMEX [35], one of the world’s biggest cement producers, prides itself on having been the “first company in the sector to voluntarily calculate the carbon footprint of all of its cement, concrete, and aggregate products, and [communicating] this information to [their] clients”. In 2018, CEMEX UK announced that more than 150 of their UK sites will run on renewable energy by 2019, as documented by Renewable Energy Guarantees of Origin (REGOs) [36]. By drawing on its carbon label, CEMEX will be able to communicate the carbon performance improvements of its products to customers.

Wienerberger, the world’s largest brick manufacturer, offers EPDs for its products [37]. In 2017, the company announced that it would start to procure renewable energy for all its UK sites, certified by REGOs [38,39]. Via EPDs, Wienerberger will be able to communicate the improved carbon efficiency of its products down the supply chain.

Where building material suppliers can document improvements in their carbon efficiency, those downstream users who wish to perform building LCAs will be able to claim reduced global warming potential (GWP) impacts for certified building materials.

5. Actual and potential use in governance and policy

So far, product carbon footprints have mainly had impacts in terms of consumer and business behaviour [7]. Green building certification schemes provide incentives for the use of products with EPDs in building projects by rewarding their use with ‘points’ or ‘credits’, which can translate into higher ratings [4,40,41]. This has been the major driver for the proliferation of EPDs in the building sector.[2]

In the European building sector, EPDs have become an established instrument for accounting for the embodied impacts of construction materials [42]. The European Construction Products Regulation [43] stipulates that

> “For the assessment of the sustainable use of resources and of the impact of construction works on the environment [EPDs] should be used when available.”

In October 2017 the governor of California approved the Buy Clean California Act (BCCA), a measure against carbon leakage,

[2] Interviews with representatives of the German Council for Sustainable Buildings (DGNB), IBU and the US Sustainable Building Council.

which foresees that from 2019 the state should only procure a range of building materials if it can be shown by means of EPDs that they are within the levels of a maximum acceptable global warming potential. The bill affects procurements of carbon steel rebar, flat glass, mineral wool board insulation, and structural steel [1,44]. The BCCA is unique in that it marks the first time a US State sought to reduce the emissions embodied in some of the goods it imports [45].

When a country or region introduces ambitious carbon and energy policies to mitigate global warming, there is the risk that its own products may become more expensive and those from other countries or regions, without or less ambitious policies, more competitive. The risk of such 'carbon leakage' is a major stumbling block on the way towards effective global warming mitigation. Border carbon adjustments (BCAs) could alleviate the risks of carbon leakage. PCFs and EPDs may not only inform public procurement and building standards but they also have the potential for providing important information for the possible adoption of BCAs. BCAs could, for example, take the form of border tax adjustments (BTAs), the requirement that importers need to purchase emissions allowances, or carbon-related charges at the point of consumption [46,48]. This could help to account for the carbon embodied in products and thus to provide incentives for the use of renewable energy across borders.

Nordhaus [49] considers a BTA approach so overly complex that he suggests it may be preferable to erect a uniform tariff wall for countries who refuse to join the carbon pricing club. Tirole [50], while observing that the "theoretical rationale for BTAs is impeccable", points to drawbacks in their implementation, listing *inter alia* the difficulty to assess the carbon contents of goods produced in transnational supply chains. According to a European Union Emissions Trading System (ETS) expert from the European Commission's Directorate-General for Climate Action the inclusion of consumption in the ETS or a BTA seems too complex and the administrative burden seems disproportionate to the limited value added.[3] Helm et al. [47] also suggest "that the calculation of appropriate BCAs will be devilishly difficult", yet they propose that one could start with a small number of key sectors, for which one could calculate carbon intensities relatively easily. One could also rely on standardised benchmarks for setting the BCA while giving producers the right to prove that their goods are less carbon intensive and thus outperform the benchmark [47]. PCFs and EPDs are ideally positioned to provide such evidence.

EPDs/PCFs radically differ from other instances of global governance through certification standards. Certification standards aimed at sourcing specific products, such as coffee, fish, soy, timber or palm oil in a more 'sustainable' way do not rely on the production of law but on the elaboration of soft law regulations legitimised by multi-stakeholder roundtables [9]. In contrast, EPDs/PCFs do not set any standards for the products themselves but enable governments to draw on the assembled data to enact policies.

6. How actors draw upon the orders of worth to (de-) legitimise the governance of embodied emissions

In the politics of energy transitions, a variety of interest groups or communities of interest advocate for their preferred outcomes with references to the different orders of worth. Non-Governmental organisations, business lobbies and experts all propose courses of action and present justifications.

In the practice of business lobbying, the market order effectively penetrates the political order [9]. The particularist and self-interested aspects of lobbying live in an uneasy tension with the universalist aspirations of jointly shared orders of worth. Where the market order simply imposes itself in such a way on the political order, without any furnishings of valid reasons by the actors involved, there is no legitimation to speak of but only the corruption of the civic order to observe — "sometimes the powerful are simply too powerful to be held to account by the standards that might appease a moral philosopher" [13]. In contrast, resonance with orders of worth will increase a policy's legitimacy. Lobbyism thus needs to be not only understood in the limited way of garnering bribes or donations, which tends more towards the corruption of civic norms by the market order, but also as a way for policy-makers to gain information on how to come up with and legitimise policies with the glow of orders of worth, such as the market, industrial or green orders.

In the following we address aspects relevant to the legitimation of EPDs and PCFs in accordance with the different orders or worth. The different legitimation dimensions have interacted in important ways, a close examination of which can be instructive for efforts at promoting the renewable energy transition. We identify major tensions between

- the civic and market orders with regard to the appropriate approach for furthering the green order,
- domestic and market orders in areas of trade and procurement policy, and
- the market and industrial orders with regard to the integrity of the lifecycle assessments that form the basis of EPDs and PCFs.

6.1. Green order

Environmental labels like EPDs and PCFs are ways to endow merchandise with the reified qualities of the green order — a non-market order of worth [9]. The green order of worth espouses the appreciation of interconnected, complex *ecological* relations in a holistic way [22]. It therefore legitimates comprehensive environmental labelling and policies governing embodied environmental impacts (see Fig. 1).

This holistic tendency helps to explain why the more

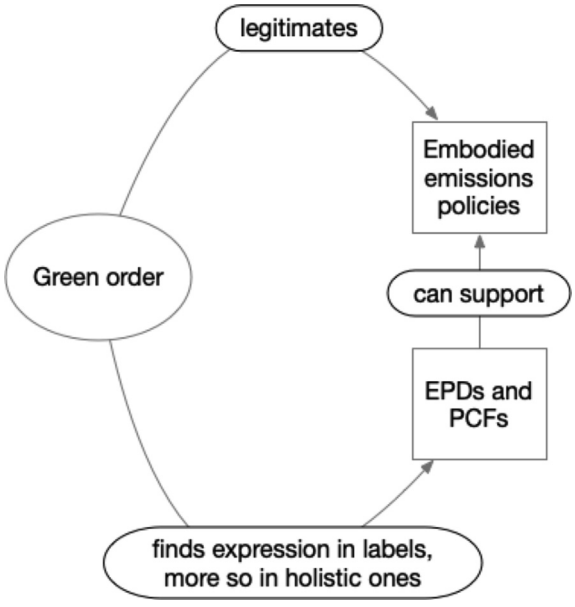

Fig. 1. The green order and environmental lifecycle assessment labels.

[3] Interview with EU ETS expert from DG CLIMA in August 2016; see also [76].

encompassing EPDs have seen more acceptance and institutional endorsement than the single indicator PCFs. EPDs are likely to be more resilient in the face of delegitimising critique, which, for example, could accuse PCFs of being overly restricted to one environmental impact category and therefore prone to contribute towards problem-shifting between environmental mediums. The disembedding and re-embedding of climate politics in wider environmental politics can be usefully conceptualised as a form of rescaling *across issue areas* ([92], p. 258).

The publication of the British PAS 2050 product carbon footprinting methodology in 2008 was perhaps the most significant institutionalisation of a formal methodology dedicated to product carbon footprinting ([17], pp. 13f). In the same year the ([51]; p. 10) published its conclusions on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, in which it invited "the Commission, taking into account Member States' experience, to start working as soon as possible on common voluntary methodologies facilitating the future establishment of carbon audits for organisations and the calculation of the carbon footprint of products". In consequence, the Commission conducted a study on PCF methods.

In 2009 the European Commission let Gallup survey citizens from 27 EU Member States and Croatia and obtained the result that 72% of them were in favour of making it mandatory for products to carry a label indicating its carbon footprint ([52]; p. 27f.). Yet, official enthusiasm for a label focussing exclusively on carbon soon vanished: the [53] reports the outcome of the study on PCFs as the realisation that "it is important to take into consideration all environmental impacts of products in a balanced way". As a follow-up, the Commission initiated a project on a Product Environmental Footprint (PEF), largely resembling an EPD ([53]).

According to a representative of the German Institut Bauen und Umwelt (IBU), the globally leading EPD programme for building products [54], one of their core principles is that they do not focus on individual environmental impacts. It could be that some products perform better when it comes to carbon emissions but that they perform worse when other environmental indicators are taken into account, too. IBU presents itself as founded by a diverse group from all areas of the construction products industry and it has the ambition to not only represent specific sectors but to cover the entire building products industry.[4] Arguably, a strict focus on greenhouse gas emissions would involve less ambiguity about relative environmental impacts and would have thus made it less attractive for heterogenous group of producers to convene. Here the ecological perspective's holistic logic overlaps with the dynamics of collective action among producers of heterogenous goods.

From epistemic and governance perspectives concerned with integrating complex interactions across human and natural systems — for example the resource nexus [55], environmental footprints or telecoupling [56] — EPDs are also a more promising way of communicating environmental impacts along supply chains. Indeed, the LCAs constitutive of EPDs are a core approach of integrated sustainability studies and market demand for LCA practitioners is likely to implicitly subsidise the expansion of academic sustainability studies. In this sense, an analysis of coupled systems interactions may well be extend to the interactions of private environmental governance, state policy and the development and reproduction of academic fields.[5]

6.2. Industrial order

The information provided by EPDs and PCFs needs to be accurately measured, calculated and brought into a comparable format. These are the hallmarks of the industrial order.

The higher immunity of EPDs against charges of reductionist singling out of one environmental impacts category, which can easily be levied against PCFs, has worked in favour of their adoption by green building schemes and producer associations. However, as EPDs cover many more environmental impact categories, the measurement and calculation of accurate estimates is more challenging.

Creators of EPDs in accordance with the international ISO 14025 standard for EPDs, which was initially released in 2006, enjoy considerable leeway when it comes to the provision of data. In practice, they can largely rely on secondary data, which may represent best available technologies rather than their own efficiency levels. The European standard for building product EPDs EN 15804, initially released in 2012, is more exigent and requires primary data from the producer that releases the EPD, yet it still allows for secondary data from LCA databases for supply chain data. In products with long and complex supply chains, solely relying on primary data by the producers of the final good could exclude a big chunk of emissions. In simpler products with short supply chains, this problems is less present.

In the USA industry association create their own idiosyncratic Product Category Rules (PCR), thereby limiting comparability.[6] In this way, the market order may undermine the industrial order (Fig. 2). In contrast, the German IBU coordinates the elaboration of PCRs across industries, thereby being able to guarantee a higher degree of comparability [57].

6.3. Market order

The market demand for PCFs and EPDs, may it be stimulated by private environmental considerations or by government policy, is a decisive criterium for legitimation in accordance with the market logic. So far, green building certification schemes have been important drivers for the proliferation of EPDs (see above). In the field of building materials, individual companies as well as sectoral trade associations and global business associations such as the World Business Council for Sustainable Development have come forward with PCFs and EPDs. By linking the business-driven accounting initiatives with new policies, such activity can be further incentivized.

As embodied carbon policies would confer competitive

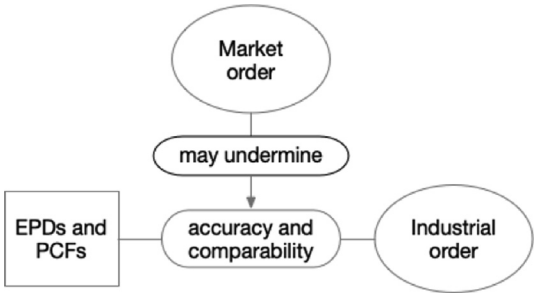

Fig. 2. Lifecycle assessment labels, the industrial order and conflicts with the market order.

[4] Interview with senior IBU representative in 2017.

[5] The cross-legitimation of epistemes and practices in this domain deserves more sustained reflection but also poses the temptation of succumbing to navel-gazing.

[6] Interview with Joep Meijer, President of *The Right Environment*, 2017.

advantages to relatively low carbon producers, they have incentives to support such measures, which could be beneficial for positively discriminating products that are produced with less or cleaner energy. However, given the prevailing norms of the entrenched liberal trade regime there is a strong risk that such measures would be seen as protectionist, thus risking to undermine their legitimacy and running the danger of furthering political polarisation around climate action.

Under the right conditions, carbon intensive sectors such as steel can be mobilised in favour of border carbon adjustments. After the failure of the Copenhagen climate summit in 2009, the French government was floating the idea of a 'carbon inclusion' mechanism, as a last resort in order to have a lever to revive international climate change negotiations. The carbon inclusion mechanism would have required importers into the European market to purchase EU ETS emission permits. In 2010 the European steel industry association Eurofer supported the French proposal for a carbon inclusion mechanism, as a potential complement to free allocation, to further shield it from competitive disadvantages. While Italy supported the French advance, Germany and the European Commission were more wary and highlighted the risk of triggering a trade war with China [58]. Again, in February 2017, in the run-up to the European Parliament's vote on the EU ETS reform, including carbon border adjustment measures, steel giant ArcelorMittal intervened in favour of a carbon border tax [59]. Yet, again, the market order prevailed over an amalgam of domestic and green concerns.

The liaison of the WTO with ISO's technical committee on environmental labelling indicates the relevancy of this standardisation activity for international trade. While direct actions targeted at changing production standards violate WTO rules, ([60]; p. 565) presents the EC's eco-labeling scheme as an instance where "some production standards can readily be turned into product standards, thus making them WTO consistent". The widespread adoption of PCFs and EPDs by businesses may well help to legitimate them as part and parcel of routine market activity, which may eventually help in any WTO decisions on the conformance of EPD or PCF-based policies with its statutes (see also [2,61]).

Potentially, procurement requirements, downstream standards and border carbon adjustment measures could all draw on the information on embodied carbon as a decision-making criterion for positively discriminating products that are produced with less or cleaner energy. The promise of competitive advantages is an important motivation for low carbon producers to support such measures as it may enable them to acquire a 'lead firm' position (cf. [89], p. 6). Once adopted, embodied carbon policies based on EPDs/PCFs would generate further market demand for them and thus contribute to that legitimating dimension (for a summary see Fig. 3).

6.4. Domestic order

The information provided by PCFs needs to be credible and trustworthy as any weak link in the reporting chain comes with reputational risks for the main producer and may undermine the legitimacy of the regulatory regime drawing on such information. For the governance of embodied emissions to be considered legitimate, the underlying information also needs to be legitimate. This aligns the legitimation of EPDs and PCFs with the domestic order, where the trusted provenience of goods and information plays an important role [89].

Another aspects of the domestic order is its preferential treatment of proximate entities, which can find its expression in localism, regionalism, nationalism, etc (see e.g. Ref. [62]; p. 391). As

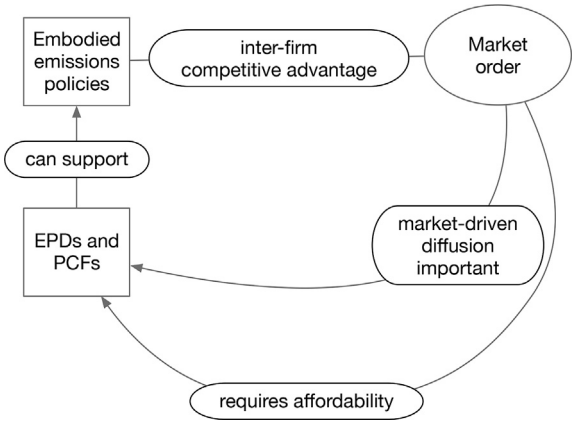

Fig. 3. The market order, lifecycle assessment labels and embodied emissions policies.

the successful mitigation of global heating requires international cooperation, there is an ever-present tension with the domestic order.

The Buy Clean *California* act manages to mobilise through the differential between a 'clean' inside and a 'dirty' outside. Here, different materials are not pitched against each other but more or less carbon efficient products within the same material class. The BCCA had both proponents and adherents among cement and concrete producers. Low carbon concrete company *U.S. Concrete*, a founding member of the Carbon Leadership Forum (represented via its subsidiary *Central Concrete*), was a major backer of the bill [63–65]. While the National Ready Mixed Concrete Association (NRCMA) had been an earlier promotor of EPD adoption and was involved in the initial formulation of the bill, it remained neutral on the inclusion of concrete in the Buy Clean California Act [65] and later came out in open opposition against the attempt to replicate the BCCA in form of a Buy Clean Washington Act [66].

The case of steel is particularly interesting, as here both businesses and trade unions came out in support for the BCCA. After investing millions into switching to renewable energy, Gerdau Steel, whose Vice President Mark Olson explicitly points out competitive disadvantages vis-a-vis less regulated competitors outside of California, helped craft the bill [64]. The [67] — a metals industry trade association — and the United Steelworkers trade union also supported the Buy Clean California Act [63]. The United Steelworkers are also a founding member of the [68] and supporters of U.S. President Trump's steel tariffs [69–71]. Here we can see how the domestic, green and market orders align to shape a green economic protectionism.

Downstream standards, which also pitch different materials and design against each other, while still privileging products with relatively high carbon performance, rely far less on the outsider/insider distinction. Downstream standards can also generate greater support by providers of alternative materials and service providers than intermediate product benchmarks.

Third-party verifiers are often in a direct market relationship with companies releasing EPDs. Verifiers can thus have incentives to adopt lenient verification procedures. Therefore, the market order may undermine the domestic order. In rich and stable countries there are already potential accountability problems arising from PCFs and EPDs as third party verifiers are likely to be structurally biased in favour of those who pay for their verification activity. These problems may become aggravated in more corruption-prone contexts, especially once different carbon intensity values affect revenues. One potential approach for tackling this misalignment of incentives consists in allocating the responsibility for the payment

and overseeing of third party verifiers with an organisation that is more vested in the continuation and expansion of the PCF/EPD system itself rather than in its alignment with any particular producer, such as in the case of the German IBU. Similar to the contestation processes around credit rating agencies' legitimacy [9], it might be precisely the continuing disputes addressing the fallout from the uneasy tension between green, industrial and market orders which, in a circular self-perpetuating motion, may help to stabilise the legitimacy of PCF and EPD creation and verification processes.

For a summary see Fig. 4.

6.5. Civic order

The proponents of norms in accordance with the civic order emphasise the equal rights of citizens, or people as political subjects, and exercise their critical capacity "to unmask the all-powerful selfish interests that lurk behind fine, altruistic discourse" ([10]; p. 114).

By rendering the carbon emissions associated with production visible, product carbon footprinting is supposed to exercise a disciplining effect throughout supply chains. Such disciplining can have various problematic effects. Producers in countries at the economic periphery may be labelled as 'dirty', thus provoking marginalisation and a rejection of the underlying rationale, which may be said to conflict with the principle of common but differentiated responsibilities ([86], pp. 131f.). The virtuous production might be reserved for those who request it, and a dirty production for the rest.

The adoption of EPDs/PCFs may initially arise in the fashion of a symbolic or simulative politics, either deliberately seeking the conspicuous consumption of goods endowed with an environmental 'glow' as a contribution to corporate social responsibility targets or to articulate ecological commitment in the face of the inability to revise lifestyles and societal structures in more profound ways [72]. As the set of the most conscientious consumers is likely to overlap with that of the most highly consumptive, in particular in wealthy Western countries, this runs the danger of replicating the global material divide in the domain of 'clean', 'pure' and 'ethical' consumption.

There are tensions between civic and market orders with respect to how the green order is to be supported. Certification in the form of EPDs and PCFs leads merchandise to absorb elements from the green order of worth into its exchange value. It thereby stabilises the dominant position of market exchange. This even more so, as the configuration of products as more or less environmentally friendly displaces action in accordance with the green order from the realm of (environmentally motivated) political action in accordance with the civic order to that of the market order [9].

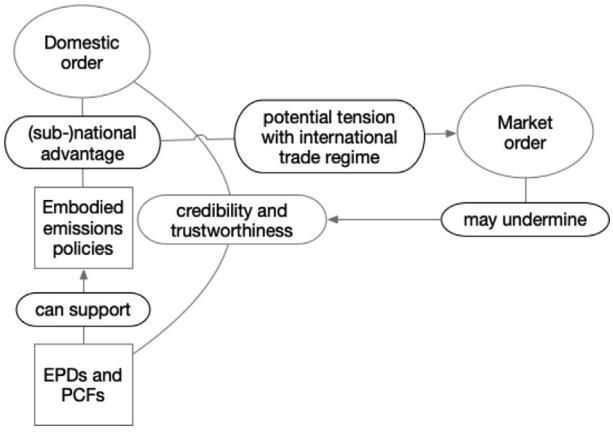

Fig. 4. The domestic order and tensions with the market order.

[6], p. 129a suggest that ".. product carbon footprinting raises important questions as to whether the carbon reduction strategies these numbers support are the most effective both in terms of cost or carbon reduction …" They criticise the assumptions behind tackling climate change via supply chain management and consumer choice, and suggest that

> "With the ideology of measurement linked to the ideology of action and this new-found emphasis on those quantifiable and disclosed emissions and reductions within a supply chain, we are seemingly sidestepping a more confrontational engagement with the unsustainable consumption practices at the heart of climate change." ([6]; p. 129a).

This is symptomatic for an understanding of product carbon footprinting as being solely located in the domain of consumer and business decisions and thus being made the object of a critique of neoliberal practices and imaginaries.[7] Here, the civic order is called upon to resist a marketised approach.

Problematic as the adoption of EPDs/PCF as a form of symbolic or simulative politics may be, these consumption acts, both by individual and corporate actors, can help to support product carbon footprinting at early stages, where it is not yet backed up by government policies. Their desire to legitimate consumption beyond pure functional cost-benefit rationality and endow it with green credentials can help to provide a niche for developing the institutional and organisational foundations for EPDs/PCF. Where it helps to establish both a consciousness of transnational flows of embodied emissions and an infrastructure that provides actionable information, it may eventually offer a basis for more systemic approaches going beyond purely symbolic or simulative politics. Where the introduction of green standards into the presentation of goods enables political decision-making in the form of policies which draw upon such distinctions, the possibility space for political demands also expands, which, in turn, can offer novel sites of political contestation. In this way, 'governing through standards' can relocate power from economics to politics [9].

The adoption of EPDs by green building schemes has provided them with a niche in which their financial viability (market order), scientific-technical accuracy (industrial order) and a history of practice among certifiers and auditors with the potential for the generation of trust (domestic order) could develop. Only once viability and validity are sufficiently established does political support for embodied carbon policies based on EPDs/PCFs have a good chance of leading to policy adoption. In this sense, the market success of EPDs/PCFs has helped to unlock novel policy opportunities, thereby empowering the sphere of politics to take action in accordance with the civic order.

PCFs and EPDs will only be seen as viable when they are deemed as legitimate both with regard to market concerns in terms of affordability and industrial concerns in terms of achievability. If they are not seen as viable for wider market segments, in particular SMEs and companies from developing countries, this can also affect

[7] ([77]; pp. 557f.), while striking a more positive note towards PCFs, also imagine them primarily as vehicles for consumer choice. When they discuss leakage, they solely discuss the problem that the introduction of mandatory carbon labelling in some regions may lead to production being relocated to other regions in order to avoid labelling requirements. Their discussion of the compatibility of PCFs with WTO rules also does not address any measures aimed at directly restricting carbon imports, such as tariffs ([77], pp. 559ff.).

equity concerns in accordance with the norms espoused within the civic order. Embodied emission policies rely on transparency requirements and differentiate products in accordance with their carbon content. This runs the danger of exerting asymmetric and detrimental effects on developing countries and smaller firms (on the asymmetric effects of information requirements see Ref. [73]. With regard to the effects of requirements for the creation of EPDs there is already an example of a trade association claiming that this would hurt small companies: When the National Ready Mixed Concrete Association (NRCMA) eventually came out in open opposition against the attempt to replicate the BCCA in form of a Buy Clean Washington Act [66], it argued that "EPDs are complex and costly for small business" ([74]; p. 15).[8] Here, both the industrial ('complex') as well as market ('costly') challenges are explicated. Similar arguments could be brought forward by other companies, and in other countries. Whether such arguments are deliberate attempts by carbon intensive industries to block reform or genuinely reflect asymmetrically distributed costs for gathering and providing information on embodied emissions is part and parcel of the debate itself.

For a summary see Fig. 5.

7. Conclusions and policy relevance

Product carbon footprinting can increase the accountability of the value chain culminating in products and thus offers great opportunities for supporting sustainable energy transitions. In order to fulfil their potential as devices for the governance of embodied emissions EPDs and PCFs require legitimation (Fig. 6 visualises the distinct requirements the different orders of worth impose on the legitimacy of EPDs and PCFs). The relevant legitimating dimensions interact in dynamic and path-dependent ways. Closer attention to these dynamics can inform attempts to accelerate the building of capacities for the governance of embodied emissions, which should

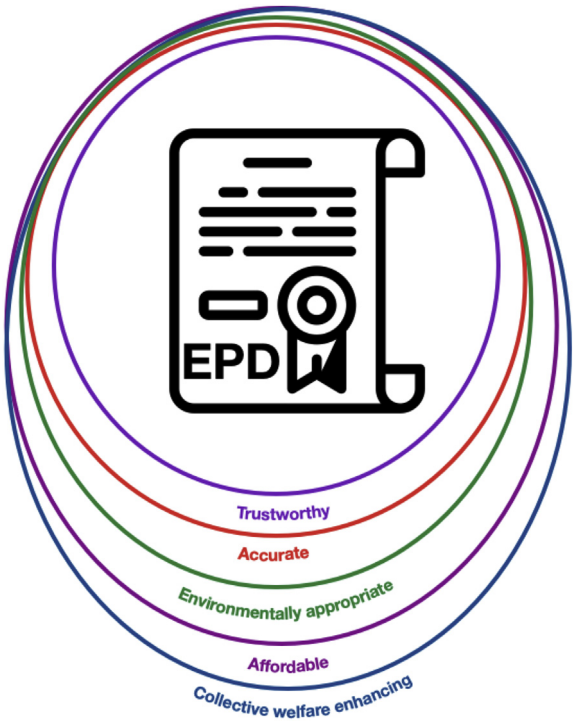

Fig. 6. Visualisation of legitimation requirements of EPDs and PCFs in accordance with Orders of Worth.

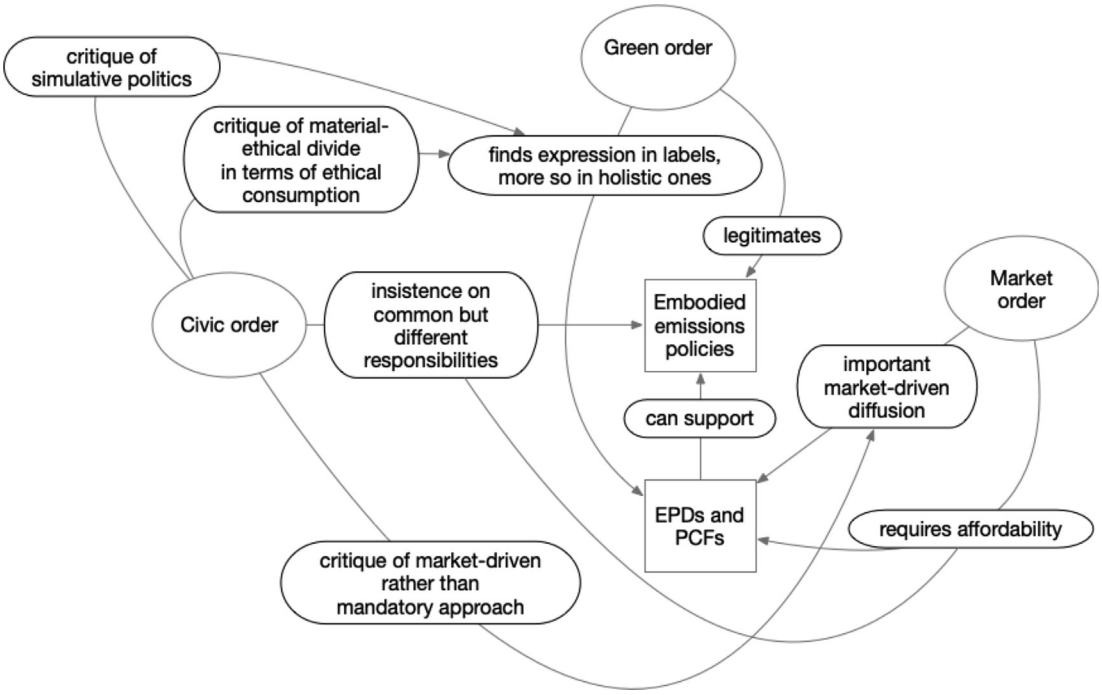

Fig. 5. The civic order's relation to green and market order rationales.

[8] Note that this would apply, too, in a scenario where whole building life cycle assessments were conducted on the basis of EPDs.

ultimately help to bolster the conditions for sustainable energy transitions.

Within the context of its embedding within the wider EPD framework carbon footprinting has improved prospects of passing the tests with regard to the green order. Critiques towards product carbon footprinting from the perspective of the civic order are likely to become less pronounced once their actual potential as a basis for regulation, and therefore their contribution to the mitigation of global heating, become more apparent. For the further legitimation and rise of product carbon footprinting it needs to be perceived as accurate and ready for scaling up (industrial order), affordable (market order) and trustworthy (domestic order). Beyond public legitimation in accordance with moral registers, support by interest groups who hope to benefit economically from embodied emissions policies is an important driver for the adoption of the latter. These interest groups may then advocate for embodied emissions policies not only with reference to the qualities of product carbon footprinting, which is merely an enabler, but also with regard to the environmental gains achievable by embodied emissions policies (green order), and the economic gains for certain sectors (market order), as well as (sub-)national units (domestic order).

While benefits for domestic businesses can be important to generate support for action on embodied emissions, in the mid to long term it seems important to reduce the perception that carbon policies are driven by protectionism. From early on, there should already be incentives to generate buy-in by producers of carbon efficient or carbon light products and services from other regions. In this way, one trade bloc or nation can help to legitimise concrete steps towards an improved governance of embodied emissions in the eyes of another trading partner's domestic interest groups.[9] Changes desirable from the perspective of the green order of worth may thereby find resonance with the market and industrial orders in transnational ways, helping to nourish low carbon constituencies.

Immediate requirements to fully account for the entire supply chain with primary data could make the process unwieldy and thus act as a deterrent to the adoption of EPDs. This makes it advisable to initially focus carbon footprinting efforts on products with shorter supply chains, e.g. prioritising the building industry over vehicles.

The policy sequencing should take advantage of business self-interest contributing to the dissemination of PCFs and EPDs. Polycentrically distributed policy-makers and advocates should increase the number of different policies that provide incentives for business to provide more and better information, which then enables even more ambitious and demanding policies, which may also serve to strengthen and stabilise such efforts.

While from a technical perspective EPDs are more demanding than PCFs, their greater potential for political support and alignment with the 'green order' speaks in favour of linking the efforts. Integrating the quest for the establishment of PCFs more strongly with overall environmental governance via its integration with EPDs can help to substantially enlarge the policy arena. EPDs are an important instrument for integrating the global heating mitigation and energy transitions agendas with key policies of the broader agenda of sustainable consumption and production (SCP), such as eco-design and a circular economy [75]. In this sense, a rescaling of informational governance from a primary concern with greenhouse gases to wider environmental media could help to entrench environmental accounting more deeply within industry and market structures. Such an entrenchment should ultimately provide more leverage for action in accordance with the green and civic logics.

[9] For example, European carbon tariffs on steel could muster the support of the relatively carbon efficient US steel industry.

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