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climate policy

Global climate policy and deep decarbonization of energy-intensive industries

MAX ÅHMAN*, LARS J. NILSSON, BENGT JOHANSSON

Department of Environmental and Energy Systems Studies, Lund University, Box 118, 221 00 Lund, Sweden

If we are to limit global warming to 2 °C, all sectors in all countries must reduce their emissions of GHGs to zero not later than 2060–2080. Zero-emission options have been less explored and are less developed in the energy-intensive basic materials industries than in other sectors. Current climate policies have not yet motivated major efforts to decarbonize this sector, and it has been largely protected from climate policy due to the perceived risks of carbon leakage and a focus on short-term reduction targets to 2020. We argue that the future global climate policy regime must develop along three interlinked and strategic lines to facilitate a deep decarbonization of energy-intensive industries. First, the principle of common but differentiated responsibility must be reinterpreted to allow for a dialogue on fairness and the right to development in relation to industry. Second, a greater focus on the development, deployment and transfer of technology in this sector is called for. Third, the potential conflicts between current free trade regimes and motivated industrial policies for deep decarbonization must be resolved. One way forward is to revisit the idea of sectoral approaches with a broader scope, including not only emission reductions, but recognizing the full complexity of low-carbon transitions in energy-intensive industries. A new approach could engage industrial stakeholders, support technology research, development and demonstration and facilitate deployment through reducing the risk for investors. The Paris Agreement allows the idea of sectoral approaches to be revisited in the interests of reaching our common climate goals.

Policy relevance

Deep decarbonization of energy-intensive industries will be necessary to meet the 2 °C target. This requires major innovation efforts over a long period. Energy-intensive industries face unique challenges from both innovation and technical perspectives due to the large scale of facilities, the character of their global markets and the potentially high mitigation costs. This article addresses these challenges and discusses ways in which the global climate policy framework should be developed after the Paris Agreement to better support transformative change in the energy-intensive industries.

Keywords: Climate change policies; decarbonization; energy-intensive industry; innovation policy

1. Introduction

Global emissions of GHGs must follow a reduction path that reaches zero from 2060 to 2080 in order to limit global warming to less than 2 °C (IPCC, 2014). The timing and speed of emission reductions will differ between countries, as a consequence of the principle of 'common but differentiated responsibilities' (CBDR) under the United Nations Framework Convention on Climate Change (UNFCCC) and

■ *Corresponding author. *E-mail*: max.ahman@miljo.lth.se

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between sectors due to the differing availability and cost of technologies. However, it is clear that all sectors in all countries must aim for deep decarbonization with the goal of reaching zero emissions.

The prospects for decarbonizing the transport, building and energy sectors have significantly improved in the past 10 to 20 years. The development and market growth of potential zero-emission technologies such as wind and solar power, electric transport systems, zero-energy buildings and advanced biofuels have been impressive and the co-benefits of mitigation are widely recognized (IPCC, 2014). Today, investments in zero-emission technologies are rapidly catching up with investments in fossil energy (REN 21, 2015). In contrast to these advances, the energy-intensive industries (EIIs) are facing greater challenges. EIIs produce basic materials such as steel, cement, aluminium, fertilizers and plastics, and account for a large share of global GHG emissions. The best available technologies (BATs) can only reduce emissions by 15–30% in these industries, even if they are applied on a large scale (Fischedick et al., 2014). Reductions beyond this require investments and fundamental changes in the core processes used based on new 'breakthrough technologies' that need further development to become both technically and commercially viable.

Studies on the potential for mitigation in EIIs have mostly dealt with short- to medium-term means of increasing energy efficiency by adopting best available technologies (BATs) and closing the 'efficiency gap'(Worrell, Bernstein, Roy, Price, & Harnish, 2009). Studies exploring the long-term options for deep decarbonization[1] have only recently begun to emerge (Åhman, Nikoleris, & Nilsson, 2012; Lechtenböhmer, Nilsson, Åhman, & Schneider, 2015; Napp, Gambhir, Hills, Florin, & Fennell, 2014).

As EIIs operate in international commodity markets, albeit to varying extents, and compete on price, they are greatly affected if differences in carbon costs arise as a result of different national emission reduction targets. Various studies have analysed the effects of climate policy on industry by assessing the potential loss of competitiveness and the risk of relocation of industries, so called carbon leakage (Dröge, 2009; Reinaud, 2008). Trade measures as complements to domestic climate policy instruments, as analysed by Helm, Hepburn, and Ruta (2012), or various 'sectoral approaches' dealing with EIIs separately from other sectors as investigated by Schmidt, Helme, Lee, and Houdashelt (2008), Cook and Ponssard (2011), and Åhman, von Malmborg, and Magdalinski (2009) have been suggested as ways of overcoming the risk of carbon leakage in the timeframe from now to 2020.

However, reducing the emissions from EIIs to zero by 2050 and beyond poses quite different challenges compared with improving energy efficiency and managing the risk of carbon leakage in the short to medium term. The implications for the future climate policy regime of such a transition are still relatively unexplored.

The CBDR principle highlights the potential conflict in policy between efficiency from an economic point of view and concepts such as equity and fairness. The analysis in this article starts from the premise that, in order to be successful, carbon policy will have to strike a balance between economic efficiency and equity or fairness.

The aim of this study is to analyse how the global climate framework can be developed in order to support the transition to zero emissions in EIIs. For this purpose, we start with a description of EIIs, followed by a brief assessment of the mitigation options and technology developments required for deep decarbonization and the major barriers to technical change. On the basis of submitted national communications (NCs) from major emitters and literature sources we present an overview of the effects that the global climate regime has had on national policy responses to reduce EII emissions. We then discuss the global climate policy framework and the attempts made so far in the negotiations to address the problems relevant to EIIs. We conclude by analysing how the future global framework should be developed after the Paris Agreement in order to facilitate a transition to zero emissions in EIIs.

2. The energy-intensive production of basic materials – emissions and mitigation options

The industrial sector accounts for about 30% of global GHG emissions and an equivalent share of global energy use. Most industrial emissions – typically between 60–80% depending on definitions – originate from the energy-intensive production of basic materials in EIIs (Fischedick et al., 2014).

As shown in Figure 1, global industrial emissions have continued to grow since 1990 despite the global climate policy framework. The growth in emissions is not evenly distributed, but has mainly occurred in rapidly developing countries whereas emissions in developed countries have decreased slightly. Chinese industries emitted approximately 3.7 $GtCO_2e\ yr^{-1}$ in 2011 compared with industries in the EU, the US and Japan, which together emitted 2 $GtCO_2e\ yr^{-1}$.

In general, the development of industrial emissions mirrors the changes in the production of basic materials by EIIs. The growth in emissions from increased production has been partly offset by the improvements in energy efficiency that have occurred the past 20 years. The global consumption of basic materials has increased steadily over this period alongside the growing global economy (Krausman et al., 2009). The growth in production has occurred mainly in rapidly industrializing countries

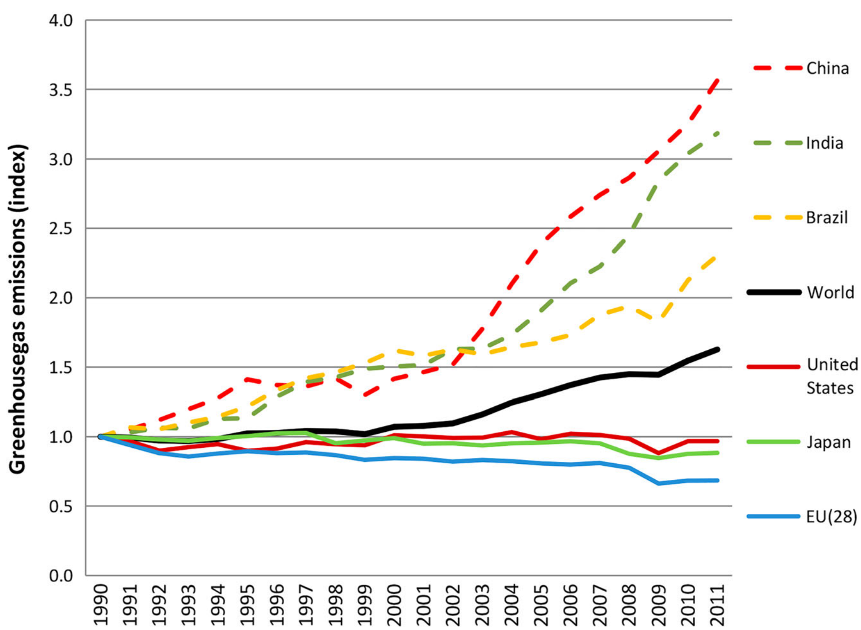

Figure 1. Index of global industrial direct GHG emissions. The data are normalized to 1990, when UNFCCC accounting started. *Source*: Data are from (WRI, 2015).

such as China and Brazil, whereas production volumes in the Organisation for Economic Co-operation and Development (OECD) countries have remained stable or even decreased slightly (Schaffartzik et al. (2014).

International trade in basic materials has increased steadily over the past 20 years as a consequence of continued globalization and the liberalization of trade. Most materials are traded in the commodity markets, based on standard products, large volumes and price competition. There are also some market segments with specialized and differentiated products that have a higher economic value (e.g. specialty steels). The trade intensity differs considerably between EIIs. For steel and aluminium, between 25% and 35% of globally consumed materials are internationally traded. Cement, paper and pulp are mostly sold in national and regional markets due to high transport costs, although marginal volumes are sold in international spot markets, which also makes these sectors susceptible to increasing global price competition.

EIIs do not typically sell their products directly to end consumers, but mainly to other manufacturing industries downstream in the industrial value chain. Along these chains, materials are traded in global markets several times in the form of feedstock, basic materials and intermediate semi-finished products, before reaching the end consumer. More than 50% of all goods traded are semi-finished products (Backer & Miroudot, 2013). The production of basic materials accounts for only a small share of the added value (about 1–6%) of most end-user products (Allwood & Cullen, 2012) but it accounts for 60–80% of energy use and emissions in industry.

Despite the low added value, basic materials are essential to the economy. Climate policy will increase the carbon and energy costs for EIIs and could lead to relocation (carbon leakage). However, there are many factors other than energy and carbon costs that influence the location of EIIs, including macro-economic conditions, political stability, transport infrastructure, labour legislation, access to markets and feedstock, industrial policy, etc. EIIs are often regarded as strategically important, which has been a motivation for supporting industrial policies. Energy and capital subsidies have been used extensively in rapidly industrializing countries such as China (Haley & Haley, 2013), but the use of tax exemptions, investment grants and other mechanisms that shield EIIs against global competition is also common in the OECD countries (Åhman & Nilsson, 2015; OECD, 2013). A strategy for transitioning to zero emissions should therefore consider EIIs in a broader industrial development context, rather than merely as the source of a specific pollution problem.

2.1. Decarbonizing EIIs – technical options

Emissions from EIIs arise from the combustion of fuels for energy, and from the production processes through, e.g. the calcination of limestone to clinker, the reduction of iron ore to iron and the depletion of carbon cathodes in aluminium production. Industries also cause indirect emissions in the electricity sector (from the combustion of fuels) and in the waste sector, e.g. when plastic waste is incinerated.

Improvements in material, energy and end-use efficiencies can lead to considerable reductions in demand for a material and thus the emissions (Allwood & Cullen, 2012). Nevertheless, decarbonizing the processing of virgin or recycled feedstocks such as biomass, iron ore, bauxite, limestone, ethylene, scrap metal or recycled paper and plastics into basic materials poses considerable technical challenges. There are three basic types of technical options: replacing fossil feedstock with biomass, electrification of the process and the use of carbon capture and storage (CCS) (Lechtenböhmer et al., 2015; Åhman et al., 2012). All of these entail fundamental technical changes and innovation, including the development and introduction of new core production processes and new associated infrastructures. These technologies are still relatively unexplored, and they exist only in small demonstration and pilot projects, on the lab scale, or as more or less proven ideas (IEA, 2015). In the case of petrochemicals the main option is to replace the fossil feedstock with biomass and/or hydrocarbons produced in processes based on renewable electricity (e.g. methane from power-to-gas conversion). For steel production, the options for producing virgin steel without process-related emissions implies either the introduction of new concepts such as process-integrated CCS and electrification (electrowinning) or bio-methane/hydrogen direct reduction (DRI). Each sub-sector within the EIIs has its own specific technical challenges to producing basic materials with zero emissions. However, all of the zero-emission solutions for EIIs have in common that they can be regarded as systemic and will result in substantially higher production costs, but no fundamental co-benefits or advantages.

2.2. Decarbonizing the EIIs – innovation challenges

Major technology shifts in the core processes for EIIs have occurred historically, but they have been driven by either improved economic performance (as with the change from open-hearth to the basic oxygen furnace for steel; Oster, 1982), better feedstock (as with the change from coal- to petro-based chemicals; Bennett & Pearson, 2009) or by large changes in consumer demand driven partly by regulations (such as the change to chlorine-free paper production (Bergquist & Söderholm, 2015) and to mercury-free processes in the chlor-alkali industry; Yarime, 2009). However, deep decarbonization of EIIs and the associated technical changes will not be driven by improved economic performance, but will have to be motivated by long-term climate policies.

In comparison, successful development and market growth of zero-emitting solutions have occurred in the transport, building and energy sectors. This development has been policy driven and can be attributed to a range of government policies across the innovation chain, ranging from the funding of basic and applied research, pilot and demonstration projects, to market-creating polices such as feed-in tariffs, carbon pricing, regulations and standards (Grubb, Hourcade, & Neuhoff, 2014). These policies span 30 years with a varying focus on 'push' and 'pull' to eventually bridge the 'valley of death' between technical readiness to market competitiveness for emerging technologies (Wilson & Grubler, 2011). Such combinations of technology-push and demand-pull policy packages are still essentially absent in EIIs and consequently very few companies have attempted to develop new technologies aimed at zero emissions.

A barrier for decarbonizing the EIIs compared with the successful development of relatively small-scale and modular renewable electricity (e.g. solar cells and wind turbines) is the large scale of individual plants. Investment in an industrial plant that includes changes to the core process could easily involve more than US$ 1 billion, and as investment cycles are typically 20–40 years or longer (Lempert, Popper, Resetar, & Hart, 2002) the risks associated with investing in a new technology are high.

There is also a lack of credible long-term policies that ensure a market in which there is a willingness to pay for decarbonized materials. This is critical, especially as technologies for zero emissions in basic materials production offer few, if any, co-benefits, whereas production costs may increase considerably. CCS is a case in point as it adds both cost and energy demand to the existing processes – a hypothetical carbon price of $ 100 per tCO_2 would roughly double the price of cement, and increase the price of construction steel by 20–30% (Rootzen, 2015). With no or few co-benefits and a high cost of decarbonization it will be difficult to find any niche markets that are prepared to carry the initial high costs for development.

Governing transitions to low-carbon emissions in EIIs will thus require comprehensive and long-term dynamic policy strategies that include the whole innovation chain: from basic research via demonstration programmes, to enabling niche markets for growth and eventually long-term market-pull policies to create a sustainable demand for zero-emission materials. In the transport, building and energy sectors, such ambitious transformative strategies have been managed mainly within national/regional borders. For EIIs, operating on a global and price-competitive market, this approach is more problematic and requires international agreements and/or complementary policies to avoid relocation and carbon leakage or trade conflicts.

3. National industrial climate policy responses triggered by the UNFCCC

The aim here is to give a brief overview of the domestic policy responses targeting EIIs that have been instigated as a result of the UNFCCC and the Kyoto Protocol. The Kyoto Protocol was agreed on in 1997 as the first step towards fulfilling the long-term aim of the UNFCCC. It included, among other things, emission reduction targets for the period 2008–2012. The division of responsibilities between developed countries (Annex 1) and developing countries (non-Annex 1) was a contentious issue in the Kyoto Protocol as only Annex 1 countries had binding targets for emission reductions. To soften this divide, a clean development mechanism (CDM) was introduced in order to reduce the cost for Annex 1 countries while at the same time inducing mitigation actions in non-Annex 1 countries.

The responses to the UNFCCC and the Kyoto Protocol in domestic climate policy-making are presented in the NCs (the reporting requirement for the UNFCCC). Reported policies and measures for mitigation include general emission reduction targets at the national or sectoral levels, technology-oriented policies aimed at reducing emissions with a specific technology, such as energy efficiency or fuel shifts, and also policies intended to have long-term and enabling effects on emissions, such as increased funding for research and information campaigns.

In Table 1 we have listed the reported policies and measures of relevance to EIIs in the six countries with the highest GHG emissions (three from Annex 1 and three from non-Annex 1). The policies and measures are characterized according to whether they are intended to have a direct effect on emission reductions (e.g. carbon pricing, standards or regulations) or are intended to enable long-term reductions (e.g. research and development; R&D). The UNFCCC reporting format offers considerable flexibility regarding which policies should be reported. Therefore, the detail and scope of the NCs differ between countries, but the quality of the information has generally improved in the latest reports. Furthermore, the effects of similar policies will not be the same between countries due to differing policy styles and context (Wallace, 1995), so it is difficult to perform a fair comparison of both ambitions and outcomes.

The types of policy responses implemented for EIIs are similar in both Annex 1 and in non-Annex1 countries. Policy responses have focused on various support schemes for energy efficiency with some efforts to induce a fuel shift from coal/oil to less CO_2-intensive fuels such as natural gas and/or biomass

Table 1. Reported policy responses for EIIs.

	Mitigation policies and measures with an intended direct effect	Mitigation policies and measures with intended long-term effects
EU	Regulated target for industry together with the power sector via the EU ETS Regulations reducing emissions of industrial gases Energy efficiency directive that forces member states to enforce energy efficiency in industry	Funding for demonstration of CCS and bioenergy project with some relevance for industry (the New Entrants Reserve programme (NER 300))
Japan	Implementation by Voluntary Action Plans by industry (Keidaren) for promoting energy efficiency Subsidies for increasing the adoption of BATs	Published a 'low carbon technology roadmap' relevant to steel. Includes research efforts on CCS and 'electrification of industry' including 'Course 50' for steel
US	Energy Star Program for industry for adopting energy efficient technologies Several programs for non-CO_2 industrial gases Voluntary program for the aluminium industry BAT regulation and tax credits for CCS	The ARPA-E program focusing on energy with relevance to EIIs Several initiatives to boost manufacturing in the US are mentioned, but with no targets for decarbonization
China	Major programs on energy efficiency in industry (1000 enterprises) Mandated phase-out of 'outdated backward' industries Pricing policies favouring energy efficiency including several new carbon trading systems Major host of CDM project for non-CO_2 gases	Discussions on future industrial restructuring and circular economy towards a more service-oriented economy in the tertiary sector Research programmes for CCS in steel production
India	'Mission on Energy Efficiency' including the PAT scheme for industrial efficiency and a charter for efficiency in industry Policy for finding CDM-financing for efficiency	Research mainly on bio economy, e.g. bio-refineries, bio-waste in industry and biofuels
Brazil	Sectoral plan for industry including energy conservation programmes Policies promoting shift to natural gas in industry and to charcoal in the iron & steel industry	Extensive research on bio-economy Policies for increasing charcoal use in steel industry Encouraging use of charcoal from plantations instead of native forests

Based on latest National Communications (6 for Annex 1 and 2 for non-Annex 1) available at www.unfccc.int where possible. Industrial gases (hydrofluorocarbons, HFCs) have been reduced substantially at a relatively low cost by regulation or voluntary agreements in Annex 1 countries, and by the incentives given in the CDM in non-Annex 1 countries. Supporting industrial energy efficiency has been a win–win strategy for the EIIs in both Annex 1 and non-Annex 1 countries, as it increases industrial competitiveness and at the same time reduces emissions. Industrial energy intensity has decreased by 10% since 2000, and this is attributed to both a structural change in the economy and to technical efficiency (IEA, 2015). The difference in industrial energy efficiency between Annex 1 and non-Annex 1 countries is decreasing rapidly as most new industrial investments today are made in fast-growing developing economies using the BATs (Fischedick et al., 2014)

Avoiding carbon leakage and the loss of competitiveness has been an important policy issue. Annex 1 countries have refrained from imposing policies that result in high carbon costs for EIIs, and have met their Kyoto commitments mostly by mitigation in other sectors[2]. In the EU, the only region where an emission cap has been applied to industry via the EU Emissions Trading Scheme (EU ETS), carbon leakage was avoided by compensating industry directly with free emission allowances and indirectly through, e.g. exemptions from taxes and quota obligations, or by supporting energy efficiency policies (Åhman & Nilsson, 2015). This strategy seems to have worked well so far, as there has been no evidence of carbon leakage (Bolsher et al. 2013).

Investing in R&D is an important policy response that does not result in direct emission reductions today, but enables future action. The formal adoption of the 2 °C target by the UNFCCC in 2010, and the growing awareness of the need for deep decarbonization, prompted some Annex 1 countries to begin exploring options for attaining zero emissions in industry – the European Commission challenged industries to come up with their own ideas for achieving zero emissions, which has resulted in several industrial road maps. The EU and its member states also have several long-term research programmes that focus on decarbonization in industry (including the Ultra Low Carbon Steel (ULCOS) programme for steel in which CCS and other options are investigated). In Japan, various research programmes, such as the CO_2 Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50 programme for steel making, are aimed at long-term emission reductions, and in the US, the research initiative Advanced Research Projects Agency – Energy (ARPA-E) has industrial relevance but no specific focus on long-term decarbonization. In China, India and Brazil new investments in EIIs are typically done using the BATs and these countries have also started investing in the R&D of advanced technologies as part of a 'green industrial policy' or 'restructuring of the economy', including the use of biomass in industry in Brazil and CCS in China.

In conclusion, there are a number of initiatives directed towards EIIs but the focus has so far not been on deep decarbonization. There are R&D efforts, but they are rather new and greater efforts will be necessary. So far, there are only few demonstration programmes and no instruments for building niche markets or creating demand-pull for low/zero-emission materials. Also, there are no strong carbon price signals that encourage mitigation. Where carbon prices exist they are too low and are combined with allocation rules that blur the price signals. The uncertainty in future global climate policy for EIIs and the different conditions for various nations in previous agreements that resulted from the CBDR principle have not been helpful in avoiding these deficiencies.

4. Negotiating issues relevant to EIIs

The negotiations for agreeing on new commitments to replace the Kyoto Protocol started in 2005 and were supposed to have ended at COP 15 in Copenhagen in 2009. However, this failed and in Doha in 2012 the Kyoto-Protocol was amended and prolonged until 2020. The negotiations continued and finally, in December 2015 in Paris, a new agreement for how to operationalize the UNFCCC after 2020 was agreed upon (the Paris Agreement). In the post-Kyoto negotiations, the discussions relevant for EIIs have focused mainly on 'levelling the playing field' by either narrowing the Annex 1/non-Annex 1 divide in terms of emission reduction commitments and/or solutions that could reduce the risk of carbon leakage. The approaches discussed include sectoral approaches, technology agreements and/or trade measures.

Several Annex 1 countries have suggested a range of 'sectoral approaches' to reduce the divide between Annex 1 and non-Annex 1 countries for the post-Kyoto negotiations, see Baron, 2006 or Åhman et al., 2009 for an overview of proposals. The most radical proposal was the Japanese 'carve-out model' that gave EIIs separate (from the rest of the economy) emission reduction targets, with little or no differentiation between industries whether located in Annex 1 or in non-Annex 1 countries. The EU suggested a 'sectoral crediting mechanism' in which non-Annex 1 countries would accept either a formally binding or informal non-binding target (no-lose target) and thus take on some responsibility for mitigation, typically suggesting a 15–30% deviation from a business-as-usual trajectory. Non-Annex 1 countries preferred even softer policy mechanisms such as the sustainable development policies and measures (SD-PAMs) suggested by South Africa (Winkler, Spalding-Fletcher, Mwakason, & Davidsson, 2002), where mitigation actions are seen as part of bottom-up derived development policies with no targets and no issuing of carbon credits but with eligibility for direct financial support. Several variations of these proposals have been discussed, merged with other proposals or discarded; see Table 2 for a selection.

Table 2. Summary of proposals and initiative with a sectoral focus.

Sectoral Approaches linked to:	Proposals	Interpretation of CBDR principle	Status
Carbon trading	EU sectoral crediting	15 to 30% from BAU	Failed
	New market mechanisms (NMM)	Undefined, varying and voluntary	Developing bilaterally within the INDC concept
	Sectoral CDM	Kyoto (all responsibility on Annex 1)	Failed
Technology	Japanese proposal ('carve out')	No differentiation between Annex I and non-Annex I	Failed
	Asia-Pacific Partnership (APP)	No differentiation as no targets (only information sharing)	Abandoned, never part of the UNFCCC process
Policies and programmes	SD-PAMs	Kyoto (all responsibility on Annex 1)	Failed, but resembles INDCs
	National appropriate mitigation actions (NAMAs)	Undefined, varying and voluntary	A part of the INDC concept

Neither the Japanese nor the EU proposals had any success in the negotiations, as non-Annex 1 countries would not accept any type of emission reduction targets, with reference to the CBDR principle. On the other hand, Annex 1 countries could not support the SD-PAMs as these had no targets for rapidly developing countries such as China and India. The SD-PAM proposal bears resemblance to the negotiation principles where nations determine their own efforts as in the Intended Nationally Determined Contributions (INDCs) that now form the basis of the Paris Agreement.

Focusing on technology-oriented agreements with direct public support to R&D and demonstration, instead of strict mitigation commitments, can offer a means of reaching reduction targets without harming competitiveness. Specific targets for technology development are only briefly mentioned in the UNFCCC (Article 4c), and have not been included in negotiations – apart from discussions on technology transfer, which is one of the objectives of the CDM. In 2010, a technology mechanism was established within the UNFCCC to further accelerate the transfer of BATs from Annex 1 to non-Annex 1 countries. Technology transfer is both motivated and important, but it is not aimed at the innovation and development of the new zero-emission technologies that are needed in EIIs in the long term. Although technology development is a key element of climate policies in most countries, it is seen mainly as a national responsibility. It has been suggested that the UNFCCC should take a greater role in a global technology development effort for sustainable energy (Brook, Edney, Hillerbrand, Karlsson, , & Symons, 2015). Technology development (by information sharing and reporting only) was also at the core when the US initiated the now defunct Asia-Pacific Partnership, which was developed as an alternative to the UNFCCC process (Karlsson-Vinkhuyzen & van Asselt, 2009). Technology development also played a prominent role in the earlier Japanese proposals for sectoral approaches. Technology development as a focused strategy was again highlighted during the negotiations in Paris with the launch of Mission Innovation. This initiative is supported by a number of countries and private companies and calls for a doubling of clean energy R&D efforts.

Trade measures that are intended to compensate the higher carbon cost for industries in Annex 1 countries by introducing border carbon adjustments (BCAs) could be a means of levelling the playing field. Explicit BCAs have not yet been put forward at any point of the UNFCCC process nor have BCAs been implemented by any party, but the question lingers in the climate policy debate and BCAs have been discussed both in the US and the EU[3]. Trade measures and BCAs have also been suggested by academics as a key ingredient in incentivizing countries to join the club of 'climate-ambitious' countries (Helm et al., 2012; Victor, 2011). There is a major concern that BCAs may be used for unfair protectionism, and not only to level the playing field, potentially spawning a new wave of protectionism and trade conflicts. The legality of BCAs has not yet been tested, but studies indicate that it would be possible to introduce them from a World Trade Organisation (WTO) perspective if properly designed and implemented (Horn & Mavroidis, 2011). However, the UNFCCC states that climate policy responses 'should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade' (UNFCCC 1992, Article 3 Paragraph 5). What 'unjustifiable' means in this context is not clearly defined, and whether BCAs would be acceptable from a UNFCCC perspective is unclear (Hertel, 2011) and will eventually have to be negotiated. One example of the interactions between trade and climate policy was the unilateral attempt by the EU to level the playing field in terms of the carbon cost for aviation by forcing all airlines landing in or taking off from EU airports to buy emission allowances within the EU ETS, making no distinction between Annex 1 and non-Annex 1 destinations or airlines. The EU had to withdraw this proposal as neither the US (citing the Chicago Convention) nor the Chinese (citing the UNFCCC) could accept this initiative (Gehring & Robb, 2013).

Trade disputes relating to climate policy have instead been concerned with shielding infant climate industries, as illustrated by the EU versus China Solar PV dispute where China was accused of dumping low-cost solar panels on the market (Voituriez & Wang, 2015).

5. Opportunities for a global climate regime to drive transformative change in EIIs

The post-Kyoto negotiations first focused on prolonging the top-down, prescriptive Kyoto-style architecture with binding emission reduction targets distributed fairly among as many parties as possible. At the time, the strategy seemed rational, given the global character of the climate change problem. The top-down approach was, however, confronted by the full complexity of mitigating climate change – including fairness, strategic interests, geo-politics and inadequate institutional capacity – and it proved too difficult to find common ground on which to agree. This approach did not result in any new binding commitments in Copenhagen in 2009.

Since the Cancun meeting in 2010, the emerging global climate framework has been more geared towards bottom-up initiatives through pledges, reporting and the facilitating role of the UNFCCC (Bodansky & Diringer, 2014). This trend was manifested in the Paris Agreement, which rests on bottom-up INDCs with a common goal. The aggregate effects of the INDCs will be reviewed every five years (UNFCCC, 2015). It is still too early to draw any conclusion on how the Paris agreement will affect the prospects for deep decarbonization in EIIs. In this context, the agreement can be seen as a framework for continued work that has to be built upon.

Based on our account of both the technical and political challenges for a low-carbon transition in the EIIs, we argue that post-Paris climate negotiations need to develop along three interlinked and strategic lines to facilitate a transition to zero emissions. First, the CBDR principle needs to reinterpret what afair construction that recognizes the right to development for all parties, while at the same time supporting the necessary industrial transition, would be. Second, greater efforts are needed in technology development, deployment and transfer strategies in this sector. Third, potential conflicts between free trade regimes and industrial policies, motivated by the need to combine decarbonization and a regime with differentiated responsibilities, must be dealt with and resolved.

Article 3 (including CBDR) of the UNFCCC is written in such a way that it allows interpretations to be dynamic and change with time as countries develop. The Paris Agreement replaces the strict Kyoto-distinction between Annex 1 and non-Annex 1 countries with the less-defined 'developed', 'developing' and 'less developed' countries. The Paris Agreement may allow for a more varied and flexible interpretation of what differentiated responsibilities means, e.g. through placing greater emphasis on differentiating the financing of innovation for facilitating long-term targets, rather than the differentiation of national emission reduction targets. The interpretation of Article 3 could thus be directly linked to who has the capacity and finances (and thereby the responsibility) to develop zero-emission technologies for EIIs. Investments made in low-carbon process technologies in developed countries will later benefit developing countries, analogous to the development of renewable energy technologies, and could thus be seen as a major Annex-1 contribution to the overall and common objectives of the climate convention.

Technology development policies are key to decarbonizing EIIs, not least since the demand for basic materials is expected to continue to grow (IEA, 2015). Unfortunately, investment in R&D is traditionally lower in EIIs than in other industrial sectors. Furthermore, innovation is targeted mainly at product innovation and marginal process improvements, rather than fundamental changes in the processes and feedstocks. Establishing better and more serious reporting requirements on technology development for EIIs within the UNFCCC could facilitate comparisons between countries and motivate countries to take action. Dai (2010) demonstrates how even soft agreements, based mainly on reporting, can have major effects on domestic policy-making by strengthening domestic actors. The total resources spent on R&D are not the only important factor – the balance between basic research and applied research and demonstration in order to avoid the valley of death is also crucial (Beard, Ford, Koutsky, & Spiwak, 2009). For a clearer direction of research and innovation efforts towards zero-emission solutions, we also need a vision of the types of technologies/systems we should strive for and how transition pathways may unfold. Establishing common goals for decarbonized basic materials is necessary, and would be a first but important step in initiating global discussions among industrial leaders and for building capacity. This discussion has already started in the EU and, to some extent, in Japan.

Trade issues related to carbon leakage and industrial policies will probably play an important role in climate policy in a world that is likely to see unequal carbon prices and climate ambitions for at least another 30–40 years. Trade-related policies include, but are not limited to, BCAs. Domestic policy responses for dealing with carbon leakage can reduce, at least partly, future conflicts with trade policy. A national climate policy based on carbon pricing could combine this with domestic compensations schemes; ideally putting imported and domestically produced goods on an equal footing. As an example, the EU ETS offers free allocation of emissions rights and support for indirect power cost increases as compensation but cannot compensate fully in order to keep the trading system effective. A more regulative approach to national climate policy would be consumption-based policies, such as public procurement regulations requiring a certain level of zero-emission materials, feed-in tariffs similar to those for electricity, or consumption taxes on materials, thus avoiding differing carbon costs between domestic production and imports. However, consumption-based policies could have difficulty in incentivizing up-stream innovation in the industrial value chain. Neuhoff et al. (2015) proposes that consumption-based incentives should be combined with up-stream carbon pricing in the EU ETS, with free allocation of emission rights and a carbon-indexed tax on materials consumption. This proposal could solve some of the issues with carbon leakage but would still need complementary policy support for driving high-risk investment in deep decarbonization.

Trade-related responses in the EIIs are also related to domestic energy subsidies. Proposals for reducing the subsidies for fossil fuels, which are estimated to between $ 400 to 500 billion per year by the IEA[4], have recently featured prominently in the climate policy debate, and fossil fuel subsidy reform programmes are included in several INDCs. Reducing subsidies for fossil fuels would have a major impact on EIIs in many countries. However, subsidies for EIIs should be seen in the wider context of industrial policies that also include prioritized access to markets, regulated prices, subsidies on capital and state ownership (Haley & Haley, 2013). Industrial policy and subsidies are today discussed as being of strategic interest for fostering new high-growth industrial clusters, but also in developing countries as 'industries of national interest' for promoting industrialization, job opportunities and export incomes. Industrial policy has gained increasing acceptance in the policy debate following the financial crisis (Warwick 2013). The emerging narrative of green industrial policies and the appropriate levels and forms of domestic support to ensure effective niche markets are equally important and should be discussed when negotiating climate-related trade issues. Annex 1 countries also act to protect their EIIs by offering minimum energy taxes and paying for dedicated infrastructure, among other mechanisms for supporting these industries. Clearly, both Annex 1 and non-Annex 1 countries see a need to ensure a certain level of industrial capacity within their borders for a number of reasons beyond climate policy.

6. Concluding discussion: time to revisit sectoral approaches?

The global climate policy regime has not been able to bring about the long-term and transformative policy responses needed for decarbonization in EIIs. Implemented policies have mainly supported energy efficiency and marginal emission reductions, while at the same time shielding EIIs from increased energy and carbon costs through exemptions and compensation schemes. These policy responses can be explained by the global market situation of many EIIs and the divide between developed and developing countries in the UNFCCC. This divide generates fundamental conflicts between climate, industrial, competition and free trade policies.

The deep decarbonization of EIIs requires an internationally coordinated response in order to mobilize sufficient resources and to avoid unfair competition and carbon leakage. For that purpose there is a need to revisit sectoral approaches. International sectoral approaches are important as EIIs differ significantly from other sectors through their high carbon- and trade intensity, the technical challenges to deep decarbonization and the fact that many nations see EIIs as strategically important for their economic development.

The idea of sectoral approaches is not new, but under the Kyoto architecture such proposals were blocked by the prevailing interpretation of CBDR. The Paris Agreement provides a new context with both long-term targets and broader participation. This motivates renewed efforts. New approaches still need to be sensitive to legitimate concerns regarding differentiated responsibilities and fairness. However, the new climate regime appears to be open to a greater diversity in approaches and it could be that these contentious issues may be managed more easily in this new context.

In contrast to earlier proposals, a new approach should have a more long-term focus on technology development for deep decarbonization, consistent with the ambitions of the Paris Agreement. It must also have a broader scope and deal with the associated industrial, competition and free trade policy conflicts.

A globally coordinated R&D effort would be a desirable first step, e.g. through an industrial innovation mission aimed at decarbonization in EIIs. This could be based on low-carbon visions and roadmaps developed collaboratively between key countries and stakeholders. The CBDR principle could initially be manifested through differentiated financial contributions between countries.

In addition to research efforts, a new approach must seek agreement on what may constitute fair and acceptable industrial, competition and trade policies in a decarbonization scenario. In the absence of stringent and universal climate policies it will be necessary to allow for national and regional instruments for niche market creation (demand-pull) and investment support schemes (supply-push). International coordination is desirable for trade-intensive goods but BCAs may be motivated and acceptable at different stages to facilitate the transition.

Developed countries should invest in and take the main responsibility for the development of decarbonization technologies for EIIs. This is necessary for meeting the objectives of the Paris Agreement. It is analogous to how developed countries have invested in and developed renewable energy technologies. Compared with other sectors, decarbonizing the EIIs requires much closer international cooperation and consequently agreement on sectoral approaches. However, the details of such approaches cannot be prescribed, but must be negotiated.

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Notes

1. Deep decarbonization here denotes emission reductions down to, or close to, zero emissions.
2. The US never ratified the Kyoto Protocol.
3. In the 2008 EU ETS directive (Article 10b), the European Council and Parliament required the European Commission to consider measures targeted at importers as a way to stave off carbon leakage. It was also considered in the US Waxman Markey proposal.
4. The IEA provides an online database for fossil fuel subsidies.

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