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Basic materials in the low-carbon society transition

Short abstract

A deep decarbonization of basic materials production fundamentally requires new process technologies. The current climate policy framework tends to preserve industrial structures and reward incremental improvements rather than prepare for a low-carbon transition. G8 countries should develop policies that shift the focus from compensating carbon cost and incremental change to developing technologies and policy strategies for zero carbon emissions by 2050.

Long abstract

For the production of basic materials a deep decarbonization fundamentally requires the development of new process technologies. However, the climate policies currently adopted in G8 countries mainly reward incremental improvements and preserve industrial structures rather than induce innovation and preparations for a low-carbon transition. The current policy approach is motivated by fear of carbon leakage and loss of competitiveness but will not be very effective in the longer term as carbon costs increase. There are several reasons why maintaining production capacity of basic materials in developed economies is a necessary strategy. These include technology development, keeping integrated value chains intact, protecting employment, and taking a responsibility from a consumption perspective. We argue that G8 countries should take the initiative to get a global policy response that shifts the current focus beyond short-term problems to a long-term innovation focus for developing zero-carbon process technologies.

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Introduction

Industry is responsible for roughly 30% of global GHG emissions. The main share of these emissions originates from the energy- and carbon-intensive production of basic materials such as steel, cement, basic chemicals, paper and pulp and aluminum. Several studies have been analyzing the potential and consequences of reduction strategies in the short and medium term up to 2020 and 2030, focusing on increasing energy efficiency and other best available technology options. But 2050 and beyond targets require a nearly complete decarbonization. This changes the perception of what is needed and what is possible, and extends to solutions beyond the marginal reduction within the current industrial structures. As regards electricity, housing, and transport sectors, visions and ideas for decarbonization have existed for several years. However, for the production of basic materials this is new, and the work on elaborating vision and ideas for a long-term decarbonization has just begun. The call from the EU commission for business association to develop "industry road maps" started a first and necessary push and development of ideas in identifying opportunities, as well as threats and challenges for a decarbonized industrial sector in the EU [1].

Basic materials are essential to the economy, and global demand is projected to grow even in a low-carbon society (LCS). For building the LCS we need several low-carbon building blocks such as electricity and heat, liquid fuels, agricultural products, but also access to sustainable and decarbonized steel, plastics, aluminum, paper and pulp, and fertilizers.

The production of basic materials – challenges for decarbonization

From the work done so far, three main technical strategies for decarbonising the production processes can be identified, see e.g. [2]:

- **Biomass as fuel or as feedstock:** Biofuels can replace fossil fuels in most processes and be used as feedstock for producing bio-based chemicals and materials, e.g. polymers. Biomass is readily available in the pulp and paper industry and has already replaced much oil use. If used in cement production, emissions can be reduced by about 50 per cent but the process emissions from calcium carbonate conversion remain. In principle, bio-coke can replace coal-based coke for reducing iron oxide to pig iron. But biomass and land is a limited resource and there are competing uses (for food, feed, fibre, chemicals, etc.) as well as conflicts with other environmental objectives such as biodiversity and recreation. Bioenergy accounts for about 50 Exajoule (EJ), or ten per cent of current global primary energy use. The potential 2050 deployment levels have been estimated at 100 to 300 EJ [3] so the contribution compared to future global energy demand is limited.

- **Carbon Capture and Storage**: CCS for industrial application can reduce a large share of industrial emissions including process emissions. But applying CCS to industrial facilities, especially the existing ones, is more complicated than applying CCS in the power sector. Typically, an industrial plant has several different source emissions with differing concentrations, and the physical space for post-process capture CO_2-scrubbers may be limited. The technologies currently proposed do not capture all the CO_2 in the flue gases, and they increase the consumption of heat and electricity. To capture more than about 80 per cent of all emissions from an industrial plant with CCS will require deeper integration into the core production processes. However, there are also some "low hanging fruits" in terms of relatively pure CO_2-streams in some industrial processes. Many issues remain, concerning

CCS, including the technical challenges, costs, large-scale infrastructure needs, legal aspects, and lack of public acceptance.

- **Electrification*:*** Electrifying the process completely, or using hydrogen, is a radical solution that could eliminate the industrial contribution of fossil-fuel-related emissions. A number of electro-thermal processes for industrial heating in different temperature ranges are possible (using, e.g., microwaves, infrared radiation or plasma). Hydrogen from electrolysis can be used for reducing iron oxide or replacing hydrogen from natural gas in fertiliser production. Through co-electrolysis of water and carbon dioxide, or by making hydrogen react with carbon dioxide, a synthesis gas (mainly CO and H_2), or methane, can be produced, from which a range of hydrocarbons and platform chemicals can be generated. Such "power-to-gas", "electro-fuels" or "electro-plastics" processes are technically possible but relatively expensive. Industrial emission reductions from electrification rest on the assumption that electric power supplies are fully decarbonised.

As can be seen, all major routes for decarbonisation have their limitations and barriers. CCS, by many regarded as a back-stop technology for electricity, is more complicated and costly when introduced to the large and complex integrated process industries [4]. Biomass is, by definition, a limited resource. Competition and thus prices of biomass will increase in a low-carbon scenario. Electrification and other routes for a complete decarbonization of the process (including, e.g., using magnesium-based instead of Portland cement) are still uncertain and require major research and development efforts before being technically proven.

A complementary and equally important strategy is to use more recycled and, thus, less virgin materials. In some cases this will enable greater electrification (e.g., for steel) or require greater integration between sectors, e.g. cascading biomass from chemicals to fuels, to heat and eventually, via electrification and CCU (Carbon Capture and Usage), back to chemicals again.

A different transition challenge

Decarbonizing the basic materials industry poses a different transition challenge compared to decarbonizing the power, housing and transport sectors.

The scale of individual facilities and each investment decision are huge. For any major investment that includes changing the core process steps (necessary for a complete decarbonization), a single investment decision could easily be more than 1 billion USD. Linked to this, the investment cycles for core process steps in energy intensive industry is typically 20 to 40 years or more. 2050 targets may seem distant, but for energy-intensive industry 2050 is only 1 or 2 major investment decisions away.

Decarbonized basic materials offer few if any co-benefits, and will be substantially more costly to produce compared to ordinary produced carbon-intensive materials [1]. It will thus be difficult to find any "niches" prepared to carry the initial high costs for development (compared to, for example, Solar PV), especially since goods are traded globally with countries that may have no or lower carbon constraints.

Another transition challenge compared to other sectors is that this transition will most likely need to involve the incumbent companies and actors. Energy-intensive industry has co-evolved with both energy systems, infrastructures and society, creating a lock-in into current systems. Changing this capital-intensive industry within the given timeframe requires the engagement of incumbents. Energy-intensive industry has gone through major technical changes before (e.g., from hearth to blast furnace) but this time the transition is purpose- and policy-driven.

The combination of large scale, long investment cycles, and the need to develop new core process technologies makes this transition extra challenging. Apart from major R&D, investments in decarbonized production routes for basic materials also requires a market environment with demand pull, including specific policy support, that can ameliorate the inherent risks and provide reasonable investment security.

The global climate policy response and industry

The global climate policy framework is deeply rooted in the principle of ”common but differentiated responsibilities” (art. 3 in UNFCCC) that so far has divided parties into two groups, one with clearly defined emission reduction targets (developed countries in Annex 1 of UNFCCC) and another group with no emission reduction targets (developing countries, so called Non-Annex 1).

This principle is understandable from an equity perspective but problematic in the context of basic materials with high exposure to carbon cost and globally traded. Since the early 1990s, several Non-Annex 1 countries such as China, Brazil, and India have gone through a remarkable transition and increased their industrial output several times (and so did their emissions). This transition has been fuelled by substantial subsidies to both fossil energy and investments in process industries [5]. Due to fear of carbon leakage and loss of competitiveness, Annex 1 countries have also refrained from imposing strict mitigation polices directed towards industry. Policy interventions in the G8-countries have been directed toward promoting energy efficiency and compensating increased carbon or energy costs. Unfortunately, this policy response tends to preserve industry rather than prepare it for a long-term transformation (Åhman and Nilsson *forthcoming*).

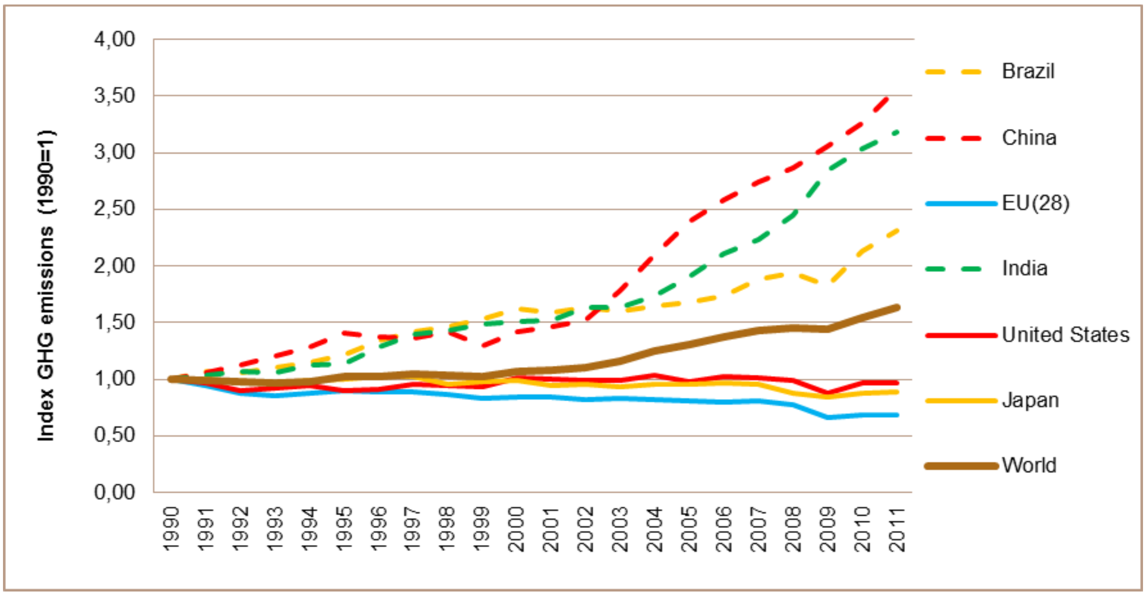

Figure 1. Global industrial direct emissions. Source: Adapted from WRI, CAIT 2.0. 2014. Climate Analysis Indicators Tool: WRI's Climate Data Explorer. Washington, DC: World Resources Institute. Available at: http://cait2.wri.org

As a result, the global response to climate change has had a relatively modest impact on global industrial emissions. Industrial emissions on a global scale keep rising due to unabated growth in several non-Annex 1 countries, whereas emissions in Annex 1 countries have stabilized, see Figure 1.

It is obvious that more ambitious emission reduction targets will put trade and industrial policies on a collision course with the current global climate policy framework.

Options for future development of the global carbon regime

If the global climate policy framework is to be effective and to induce long-term transformational change in the industrial sector, the emerging conflicts between trade, Annex 1 mitigation ambitions and non-Annex 1 views on equity have to be resolved. This could include a revised and longer-term interpretation of the right to development in Art. 3. Hopefully, a new global climate policy framework will emerge from COP 21 in Paris 2015 but the differentiation between countries, based on their technical and economic capabilities, will remain in some form or another within the UNFCCC, and this has implications for industry. Based on the challenges facing the basic materials industry, we argue that an effective G8 climate policy response needs to consider three different and interlinked strategies for inducing transformational change in energy-intensive industry: trade-related policies, consumption-based policies, and technology development policies.

- *Trade-related policies* include, but are not limited to, carbon border tax adjustments(CBA). Few governments in G8 countries are interested in introducing more trade barriers but a similar trade-related response could be sought in, e.g., policies for reducing unfair subsidies to energy or capital, or in a wider discussion on the suitable use of industrial policies.

- *Consumption-based climate polices* shift the burden of "carbon cost" from producer to consumer, ideally putting imported and domestically produced goods on an equal footing. Examples of potential consumption-based policies for basic materials are taxes, public procurement rules and feed-in-tariffs for basic materials. Policies encouraging reuse and recycling can also be included in this category.

- *Technology development policies* are the key long-term response. After 2030, all major investment decisions in energy-intensive industry need to involve a shift to low-carbon technologies. This gives G8 countries roughly 15 to 20 years to develop, demonstrate, and pilot new process technologies for decarbonizing the production of basic materials.

Decarbonising and keeping industry in G8 can be seen as part of the right of these countries to sustainable development. The alternatives are clearly unsustainable. G8 investments made in developing low-carbon process technologies will later benefit other countries, analogous to the development of renewable energy technologies, and thus be seen as major contribution to the overall objectives of the climate convention (UNFCCC).

An immediate concerted effort to increase the investments in R&D for energy-intensive industry with a focus on radical decarbonization is a first and necessary policy response. In the medium term, it is important for global climate policy to create an enabling market environment to ensure the demand for low-carbon materials. A balance needs to be struck between technology push and demand-oriented policies which also includes that the problem of long-term equity and carbon leakage need to be adequately considered in the global climate policy framework after Paris in 2015.

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