

Perspective: Unlocking the “Hard to Abate” Sectors

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ENERGY-INTENSIVE INDUSTRY AND FOSSILS

Energy-intensive industries (EIIs) produce basic materials, such as steel, petrochemicals, aluminum, cement, and fertilizers, that are responsible for around 22 percent of global CO₂ emissions (Bataille 2019). The emissions keep increasing due to growing demand for basic materials as the world develops and effective global climate policy responses remain lacking. Reversing this trend and aligning the emissions trajectory with the goals of the Paris Agreement is an urgent and challenging task. EIIs are an integral part of the industrialized society and have coevolved over several decades with infrastructure, social institutions, knowledge, and technology. This has led to a highly efficient but fossil-fuel dependent production system resulting in a carbon lock-in. This path dependency can be traced to several mechanisms at play simultaneously. The dependency can be unlocked, but this will require concerted effort and long-term vision.

TECHNICAL AND ECONOMIC DEPENDENCIES

The most obvious mechanism creating a strong lock-in to fossil energy is the technical reality. The use of fossil energy and fossil feedstock is deeply embedded in the production process. Examples include the use of coke for reducing iron ore in blast furnaces, oil crude as the primary feedstock for petrochemicals, and natural gas as feedstock for ammonia. These industries emit CO₂ in ways additional to the combustion of fossil energy. For example, the so-called process emissions of CO₂—directly related to the physical process itself, such as when limestone is transformed to clinker or when the carbon anodes are depleted in aluminum production—can also be substantial. For a deep decarbonization of industry we cannot simply apply more energy efficiency and some fuel shifts to existing production processes. We

need to develop and shift to new breakthrough process technologies that use 100 percent renewable energy and feedstock.

It will not be easy for new production processes to compete with current production routes that over the years have developed into highly energy-efficient, complex, and integrated industrial sites where a lot of the heat energy from the current core processes is reused somewhere in the process. Several different industries are often also integrated at sites in industrial symbiosis configurations where energy or material flows are efficiently shared, making a transition more difficult. The most prominent example is the petrochemicals clusters, where refineries and chemical production are co-located, began developing in 1940. Industrial symbiosis and integration increases energy and material efficiency but also creates dependencies, locking us into current production processes based on fossil resources. The use of carbon capture and storage or usage technologies (CCS/CCU) as an end-of-pipe solution could prolong the current fossil path (especially for cement), but it does not have the potential to reduce emissions more than 60 to 70 percent without major redesign of and reinvestment in the core production process (Bataille et al. 2018).

Large industrial sites are highly dependent on infrastructure such as power grids, gas pipelines, harbors, and railways to supply both energy and feedstock. A shift in production processes will in most cases make current infrastructure abundant and require investment in new infrastructure. Good infrastructure is an enabler, but existing infrastructure is also a large sunk cost that adds to path dependency.

An economic dimension of path dependency is the capital intensity and the scale of process industries. Investments in core process technologies are “lumpy” and based on long-time planning. The production scale of EIIs has

steadily increased over the past 100 years, with huge sunk costs in current assets such as blast furnaces, kilns, crackers, and the associated infrastructure. EIIs operate continuously and for longer periods, with major reinvestment and refurbishment only done every 15 to 25 years (Wesseling et al. 2017). The windows of opportunity to make major technical changes and invest in new low-carbon process technologies present themselves infrequently. The main components of current production systems, such as blast furnaces, rotary kilns, or crackers, have even longer technical lifetimes and are normally only replaced when economics calls for a larger scale or more energy-efficient technology.

Changing to zero-emission production routes will come at a cost. Steel is expected to become 20 to 40 percent more expensive if produced from renewable hydrogen (Vogl et al. 2018), cement could cost 70 to 100 percent more with CCS (Rootzén and Johnsson 2016), and plastics could be 200 percent more expensive if based on renewable electricity and hydrogen instead of low-cost fossil feedstock (Palm et al. 2016). This might seem like a lot, but the increased production cost of these basic commodities represents an increase of less than 1 to 2 percent of the selling price at the end of the value chain for, say, a car or an apartment building block (Rootzén 2015). A barrier here is the current lack of awareness among end-consumers about the climate impacts of the everyday materials we use in our products. There is no or little information on the climate footprint from the material content in most of our products and thus no consumer demand for “green steel” or “green cement.” Reliable information and certification schemes for making the materials’ climate footprint visible is an important step in harnessing consumers’ willingness to pay for green materials.

INSTITUTIONAL PATH DEPENDENCY

In addition to the technical and economic mechanisms for path dependency, a strong lock-in also stems from the institutional frameworks governing these industries. Path dependency is common in policymaking, since policies, institutions, and industries coevolve over time. Policies and regulations, once implemented, define stakeholders and interest groups and create forums through which they organize and lobby. A specific “way of doing things”

or policy style comes to link bureaucracies, industries, and interest groups, one that includes not only *who* is represented but also *what* is important or not and *how* to regulate. Energy-intensive industries have developed over centuries, and the institutions around them are strong and well organized into labor unions, industry associations, and the government institutions that regulate them.

Governing climate emissions for EIIs needs to take into consideration the many other and sometimes conflicting social objectives relevant for these industries. For developed countries, EIIs have a historic legacy and are located in traditional industrial regions that need jobs. For developing countries, heavy industry is seen as crucial to lifting the country out of poverty and ensuring large numbers of decently paying blue-collar jobs. Industrial policy that aims to strengthen countries’ “industrial base” has resurfaced as a strategic area for policymakers in response to the financial crisis that began a decade ago. In an industrial policy context, environmental and climate concerns are just one part of that response. If long-term climate solutions are to win political acceptance, mechanisms for ensuring economic prosperity and a just transition also need to be part of these efforts.

GLOBAL MARKETS AND NATIONAL CLIMATE POLICY

Technical, economic, and institutional path dependencies can be found in almost every sector relevant to climate change. However, some specific attributes of the EIIs make fossil path dependency more difficult to break. A key feature is the global character of these industries versus the national focus of implementing climate policy. Industries often ask for “a level playing field,” but this is not in line with global climate policy and the call by the UN Framework Convention on Climate Change for differentiated responsibilities for nations, especially that industrial countries should do more than developing ones. Basic materials are typically globally traded under harsh price competition. Climate policy costs imposed unilaterally will affect industries’ competitiveness and in the longer term could lead to carbon leakage, that is, the moving of production to countries with less stringent climate policies. Concern for carbon leakage

has led to exempting energy-intensive industries from most of the costs imposed by climate policy in climate-ambitious regions such as the European Union. EIIs have thus been shielded from climate policy, with the result that emissions so far have declined little if at all. The “hard to abate” sectors have been left for later, with ambitious countries focusing more on decarbonizing the power, housing, and transport sectors that operate on domestic markets. How to solve this gridlock for industrial decarbonization—that is, concern about carbon leakage that inhibits leadership—has been debated for 20 years. Various policies have been proposed such as carbon border adjustments, sectoral approaches, or club approaches, all of which aim to make the playing field less uneven while still respecting developing countries’ right to development. Thus far no proposals have gained the acceptance and momentum necessary, so the policy challenges at the global level remain.

UNLOCKING INDUSTRY FROM FOSSIL DEPENDENCY

Historically, major technological shifts of the core industrial processes in heavy industry have always occurred as a consequence of major economic gains, such as the shift from the open heart furnace to the basic oxygen furnace in the steel sector or the shift from coal to naphtha as fuel for refineries in the chemicals sector. The difference this time is that this transition will depend on policymakers’ implementation of stringent climate policy in line with the Paris Agreement.

Can we unlock the production of basic materials from fossil energy or feedstock? Yes, there are signs that this is beginning to happen. Recent research suggests that it is technically and economically possible to decarbonize industry within the time frame specified by the Paris Agreement, that is, to go for zero emissions by 2050. Options for steel, cement, aluminum, ammonia, and plastics are technically available but not yet demonstrated at commercial scale at integrated production facilities (Material Economics 2019). Several initiatives are currently ongoing with R&D and pilot trials. Policy support is needed along the whole innovation chain from R&D, to demonstration projects, to early market support for ensuring that innovations are translated into real investment decisions for deep decarbonization of

industry. A difference compared to ongoing transitions in the transport and electricity sectors is that this transition will, to a large degree, have to come from “within” the sector, that is, from the incumbents themselves. In other transitions, new innovative entrants have had a key enabling and spearheading role. Given the economies of scale and the market for commodities logic, it is difficult (but not impossible) to imagine new entrants scaling at the pace needed to reach the goals of the Paris Agreement. The major risk of such a transition, from a private company perspective, is the uncertainty of climate policy and how it will be implemented. A tipping point will come when business leaders and policymakers view the risk of continuing the current fossil path to be greater than the risk of innovation and investing in a new fossil-free path.

For this to happen and for the institutional inertia to be unlocked, we need vision, long-term planning, and dialogue with the main stakeholders. A first step that has shown promise in frontrunner countries is the development of road maps. These road maps should not only present the technical issues but also start a dialogue with the business community and unions on what can and should be expected from policy and the framework conditions necessary to make such a transition. An industrial transition will necessitate a green industrial policy that focuses on transforming the incumbent industries. Such an industrial policy will include large investments in infrastructure and changes to regulations and the institutional framework. The aim of a well-developed dialogue and road map is to facilitate coordination between government and business initiatives and reduce the risk for businesses of investing in innovative low-carbon options. The normal critique of this kind of government planning is the risk of picking winners. However, in the case of industry decarbonization the options available are limited.

As I have noted above, efforts at the global level will also be needed for good ideas to spread and for the risk of trade conflicts to diminish. Innovation, as evidenced by the development of solar photovoltaics and wind, is taking place in a global innovation system. Cooperation and taking advantage of the unique advantages of each nation or region might be the best way to ensure a global transition of energy-intensive industry. Several

initiatives are ongoing in that direction, such as **Mission Possible by the Energy Transitions Commission and the UN Industrial Transition Leadership group launched in September 2019 (ETC 2018; UN Department of Global Communications 2019).**

REFERENCES

- Bataille, C.G.F. 2019. "Physical and Policy Pathways to Net-Zero Emissions Industry." *WIREs Climate Change*, December 22. <https://doi.org/10.1002/wcc.633>.
- Bataille, C., M. Åhman, K. Neuhoff, L.J. Nilsson, M. Fishedick, S. Lechtenböhmer, B. Solano-Rodriguez, et al. 2018. "A Review of Technology and Policy Deep Decarbonization Pathway Options for Making Energy-Intensive Industry Production Consistent with the Paris Agreement." *Journal of Cleaner Production* 187: 960–73.
- ETC (Energy Transitions Commission). 2018. *Mission Possible: Reaching Net-Zero Carbon Emissions from Harder-to-Abate Sectors by Mid-century*. November. London: ETC.
- Material Economics. 2019. *Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry*. Cambridge: University of Cambridge Institute for Sustainability Leadership. <https://materialeconomics.com/publications/industrial-transformation-2050>.
- Palm, E., M. Åhman, and L.J. Nilsson. 2016. "Electricity-Based Plastics and Their Potential Demand for Electricity and Carbon Dioxide." *Journal of Cleaner Production* 129: 548–55.
- Rootzén, J. 2015. "Pathways to Deep Decarbonisation of Carbon-Intensive Industry in the European Union Techno-economic Assessments of Key Technologies and Measures." PhD diss., Chalmers University.
- Rootzén, J., and F. Johnsson. 2016. "Managing the Costs of CO₂ Abatement in the Cement Industry." *Climate Policy*, 1–20. <http://dx.doi.org/10.1080/14693062.2016.1191007>.
- UN Department of Global Communications. 2019. "New Leadership Group Announced at Climate Action Summit to Drive Industry Transition to Low-Carbon Economy." Press release, September 23.
- Vogl, V., M. Åhman, and L.J. Nilsson. 2018. "Assessment of Hydrogen Direct Reduction for Fossil-Free Steelmaking." *Journal of Cleaner Production* 203: 736–45.
- Wesseling, J., S. Lechtenböhmer, M. Åhman, L.J. Nilsson, E. Worrell, and L. Coenen. 2017. "The Transition of Energy Intensive Processing Industries towards Deep Decarbonization: Characteristics and Implications for Future Research." *Renewable and Sustainable Energy Reviews* 79: 1303–13.