A European industrial development policy for prosperity and zero emissions

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Keywords

decarbonisation, governance, industrial policy, energy intensive industry

Abstract

The objective of this paper is to outline and discuss the key elements of an EU industrial development policy consistent with the Paris Agreement. We also assess the current EU Industrial Strategy proposal against these elements. The "well below 2 °C" target sets a clear limit for future global greenhouse gas emissions and thus strict boundaries for the development of future material demand, industrial processes and the sourcing of feedstock; industry must evolve to zero emissions or pay for expensive negative emissions elsewhere. An industrial policy for transformation to net-zero emissions must include attention to directed technological and economic structural change, the demand for emissions intensive products and services, energy and material efficiency, circular economy, electrification and other net-zero fuel switching, and carbon capture and use or storage (CCUS). It may also entail geographical relocation of key basic materials industries to regions endowed with renewable energy. In this paper we review recent trends in green industrial policy. We find that it has generally focused on promoting new green technologies (e.g., PVs, batteries, fuel cells and biorefineries) rather than on decarbonizing the emissions intensive basic materials industries, or strategies for handling the phase-out or repurposing of sunset industries (e.g., replacing fossil fuel feedstocks for chemicals). Based on knowledge about industry and potential mitigation options, and insights from economics, governance and innovation studies, we propose a framework for the purpose of developing and evaluating industrial policy for net-zero emissions. This framework recognizes the need for: directionality; innovation; creating lead markets for green materials and reshaping existing markets; building capacity for governance and change; coherence with the international climate policy regime; and finally the need for a just transition. We find the announced EU Industrial Strategy to be strong on most elements, but weak on transition governance approaches, the need for capacity building, and creating lead markets.

Introduction

The Paris Agreement as a foundation for future European industrial development has very strong implications for the emissions intensive industries. So far, industrial policy has focused mainly on new technological opportunities and growth in new sectors, e.g. ICT and biotechnology. For heavy industries, such as the steel, cement and (petro)chemical industry, there has been a focus on safety, competitiveness, environmental protection (i.e., to reduce the local and regional effects air, soil and water) and energy efficiency (New Climate Initiative, 2015; ODYSSEE-MURE, 2014). However, none of these policies have been implemented along the rationale of the Paris Agreement. As a result, the emissions intensive industry sectors are far from the desired level of change or even the preparedness to change needed to meet the Paris climate objective.

According to a wide range of global modelling studies that have structurally contributed to the United Nations climate negotiation processes, an appropriate policy response from industry should at least entail a CO_2 emission reduction of 58 %–93 % by 2050 compared to 2010 levels for developed countries, using the 10th and 90th percentile of all 1.5 °C scenarios (Huppmann et al., 2018; IPCC, 2018). However, the overall focus on the industry sector as a whole in these modelling studies conflate the enormous challenges or opportunities for specific industries and often rely heavily on negative emissions in other sectors to compensate for remaining industrial emissions. Recent publications (EC, 2018; van Sluisveld et al., 2018) emphasise that policy responses by specific industries can vary substantially from the aggregated response, ranging from having only a limited decarbonisation potential to fully turning into a carbon sink by 2050.

Transforming industrial systems to the scale as indicated by global modelling studies entail changes across and between existing value chains, economic sectors and policy domains (Bataille, 2020). As systems of production and consumption of materials, products, and services are closely intertwined there is no single silver bullet strategy to decarbonize emissions intensive industries. Instead, several complementary options must be pursued in parallel along the entire value chains. Frequently mentioned key options include (i) energy efficiency, (ii) reduced demand, (iii) materials efficiency, (iv) circular material flows, (v) electrification and fuel switching, and (vi) CCUS. Whereas energy efficiency and circular economy have been prominent on the policy agenda for some time, less practical policy experiences have been gained on the other four options. For example, materials demand is only indirectly and not consciously managed, e.g. through city planning and building codes that have implications for the demand for construction materials such as steel and cement. Alternatively, electrification and CCUS are dependent on transformative developments in other sectors while also typically increasing production costs. Lastly, the tools at hand for governments to curb emissions in the emission intensive industries may also not be suitable to drive a just transition, such as the emission permit trading and carbon pricing mechanisms (Bataille et al., 2018b; Åhman and Nilsson, 2015).

Against this background, the present paper presents a framework for industrial policy, focused on the energy intensive industries, in which we outline and discuss key elements aimed at deep decarbonization, i.e. aiming for zero emissions in all sectors. We draw on previous literature about industrial policy and extensive research on key technologies, industry characteristics, economic implications, as well as policy and governance approaches. We also discuss the recently released EU Industrial Strategy in light of the proposed framework.

Industrial policy revisited

Industrial policy has been given many different definitions (Aiginger and Rodrik, 2020) but we define it here as the combination of instruments and measures that directly or indirectly influence industrial development in certain directions. An important aim for historical industrial policy has been to protect infant industries in periods of early industrialisation. In the post-war era and during the structural crises in the 1960s and 1970s, the aim was to shield and protect domestic incumbent industries due to strong national interests, e.g. the protection of steel plants and shipyards from international competition as well as support for defence related industries. This was mainly done directly through instruments such as state ownership, direct subsidies, or tax breaks but also through tariffs and other trade policy related instruments (Grabbas and Nutzenadel, 2014).

Following the globalization of many parts of the economy, industrial policy has shifted and although most countries today publicly embrace competition and free trade, they still take precautions to support and protect domestic industries in various ways. Policies are however more focused on promoting high-tech growth sectors as well as fostering small and medium sized enterprises (SMEs) for local job creation and economic development and growth. To support these policy aims, the instruments employed have shifted towards economic support for research, development and innovation (RDI) either through tax credits or direct payments, as well as support for start-ups and new firms through incubator programmes and provision of private equity. Innovation policy, which has hitherto mainly aimed to support any type of economic development (Schot and Steinmueller, 2018), is however insufficiently equipped to initiate and support fundamental changes towards greater sustainability in the economy. Given that the aim of policy is not merely to support the development of innovations, but rather to instigate specifically directed changes of the socio-technical systems that deliver key services in society such as transport, housing or food, there is a need for considering broad policy mixes rather than individual policy instruments. With increasing complexity, the strategic and procedural aspects of policy come to the forefront, in addition to an emphasis on portfolios of policy instruments (Rogge and Reichardt, 2016; Edmondson et al., 2019). Importantly, this is also the case for industrial development policies, in particular those aimed at the greening of industries (Binz et al., 2017; Grillitsch and Hansen, 2019).

A recent turn in industrial policy, aiming for transformative change of economies for sustainable development, has been championed by countries like South Korea and the European Union. The need for industrial policy and the turn towards green growth has also been advocated by scholars such as Rodrik (2014), Aiginger (2014) and Warwick (2013). They make a strong case for systemic industrial policies which instead of being mainly growth-oriented also support broader social and environmental goals such as job-creation and climate protection. Similar lines of thought, which tackle societal problems that are systemic in nature are found in OECD reports on green growth and system innovation (OECD, 2011; 2015). However, these approaches to industrial policy and innovation have not paid explicit attention to the necessity of zero emissions and the profound changes in production, use, and recycling of emissions intensive basic materials that this entails. This particular challenge, however, has gained increasing attention since the Paris Agreement, particularly in Europe, and in the past few years several policy briefs and recommendations on industrial decarbonisation have been published by NGOs, industrial actors, and academic scholars (CISL, 2019; HLG-EII; Material Economics, 2019; E3G, 2020). Most proposals acknowledge the need for industrial policy to set the direction and present pathways and roadmaps for long-term systemic changes. The proposals further elaborate on the importance of research and innovation as well as the need for bringing innovations to markets through supporting first-of-a-kind solutions and scaling up these solutions.

In addition to pointing to the need for innovation in primary production to reach zero emissions, recent proposals often emphasize the role that improved materials efficiency will play in reducing emissions, both in the use phase and circularity of materials after use. Although these are important parts of the puzzle, we argue that industrial policy for zero emissions must include aspects that go beyond this to account for the dynamics and complexities of the issue, including the need for new governance arrangements for institutional capacity as well the role of trade and coherence with international treaties and agreements in a net zero global economy. We therefore propose a framework for industrial policy that builds on six pillars: **directionality**, referring to the ways that the state can express and emphasize the direction of development accepted and needed; **knowledge creation and innovation**, referring to support for low-carbon innovation and learning throughout value chains; **creating and (re)shaping markets**, as markets are not natural but rather political outcomes, policy must both create new markets and reshape existing ones; **building capacity for governance and change,** which will be needed as the challenges for industrial climate solutions are different from the ones mainly addressed by agencies for energy and transportation that have thus far taken the lead; **international coherence**, referring to the growing need for international collaboration within and outside global agreements on climate, trade, and other issues; and the **need take responsibility for the socio-economic implications of the foreseen development**, which for some households and regions will be negative and significant.

A framework for industrial policy for zero emissions

DIRECTIONALITY

Change and development occurs not only at a certain rate but also in a particular direction. Public policies, directly or indirectly, play a key role in defining the direction of travel by creating specific incentive structures. Embracing directionality is to acknowledge that we need to generate innovations not just as efficiently as possible, but we also need to ensure that these contribute to moving society in the desired direction (Weber and Rohracher, 2012). Future industrial policy must shift focus from a narrow focus on economic efficiency to a broader policy combining efficiency with a sense of direction that contributes to society's environmental and socio-economic goals (Aiginger and Rodrik, 2020). An industrial policy with a strong sense of direction does not call for top-down state centred projects (Mowery et al., 2010). Instead, it requires bottom-up partnerships between private and state actors (Aiginger and Rodrik, 2020) to support the development not only of new technologies, but a new techno-economic paradigm (Perez, 2010; Mathews, 2013).

Overarching policy frameworks such as climate laws that define the policy ambition are important starting-points to set the direction of travel. However, it also requires that more detailed plans are developed, closer to the realities and specifics of different industries. Industrial associations and individual firms play an important role in developing roadmaps that map out possible development options that are available to achieve the desired direction of travel. Directionality can also be materialised through infrastructure investments, a domain in which governments have opportunities to make investments that allow for system-building and acceleration of the transformation (Cass et al., 2018). To achieve the direction of travel, a wide policy toolbox of direct and indirect policy measures is necessary (Andersson and Karpestam, 2012; Rogge and Reichardt, 2016).

Setting the direction of travel is not limited to tilting the playing field in the desired direction. It also limits the room for manoeuvre for competing, less sustainable solutions. Consequently, the policy mix should include both creation and destruction policies (Kivimaa and Kern, 2016; Rogge and Johnstone, 2017). The combination of creation and destruction creates winners and losers and may require various forms of compensation for the losers to accept the chosen direction of travel. Again, this illustrates the importance of situating the industrial policy not just in a narrow field of industrial development, but also in the wider context of societal development.

KNOWLEDGE CREATION AND INNOVATION

Studies of innovation processes have highlighted the importance of government interventions for ensuring sufficient – from a societal perspective – investments in research, development and innovation (RDI) and the possibilities for firms to profit from these investments by establishing intellectual property rights systems. Since the late 1980s, a systemic perspective on innovation processes has gained traction in research and policy practice (Freeman, 1987; Lundvall, 1992; Malerba, 2005; see also Godin, 2009). This perspective emphasizes the interactive nature of innovation processes encompassing not only the 'usual suspects' of firms, universities and research institutes for creating knowledge and innovating, but also the role of public sector actors and intermediary organizations as well as actors on the demand side. Further, it stresses the influence of formal and informal institutions connected to specific industries on innovation processes (Schot and Steinmueller, 2018; Grillitsch et al., 2021).

Most energy intensive industries are characterised by large dominant actors on the production side of the value chain with low investments in RDI, typically below 1 % of the annual turnover (Wesseling et al., 2017). The industries are shaped by high capital intensity and incremental technical development focused on processes and only limited opportunities for product innovation. New technologies typically need to fit into existing processes, and high capital utilisation is necessary for recovering investment costs. Many radical innovations that are necessary for industrial transformation are hence perceived as risky, hard to integrate and uncompetitive compared to established technologies. Thus, firms that attempt to commercialise emerging technologies will likely incur substantially higher production costs with few monetizable co-benefits.

Public RDI policies reduce the cost for firms to engage in innovation and are therefore needed in order to overcome this barrier (Nemet, 2009). This may include public funding of basic research, pilot and demonstration plants, as well as support for education and training. Such policies may also be justified by knowledge spill-overs where other firms capture part of the benefits of this new technology without paying for the development cost.

A systems perspective which recognises the interdependencies with other sectoral developments is necessary for the governance of industrial decarbonisation to be effective. The need for such an approach is particularly evident for two key decarbonisation pathways; electrification (directly or via hydrogen) of industrial processes and of CCUS (Lechtenböhmer et al., 2016). These pathways require access to low carbon electricity, electricity transmission and distribution networks, CO_2 and hydrogen grids, and storage. Investments in these infrastructures require long-term planning and a common vision between government, industry and civil society. Such a common vision could evolve via stakeholder-oriented pathway processes which are important tools for learning, communicating and coordinating transitions (Lechtenböhmer et al., 2015).

Industrial decarbonisation is more likely to succeed with collaboration along the value chain since this enables combining knowledge held by different actors and collective learning (Bataille et al., 2018a). Traditionally, technology providers have an important role in the technical development of the energy intensive industry since many industry companies outsource or collaborate intensively with them on process development (Wesseling et al., 2017). Furthermore, collaboration across sectors that complement each other's knowledge and capabilities is considered to be necessary in some cases such as the upscaling of forest biorefineries although it has proven to be difficult to engage a diverse group of actors in such collaborations (Karltorp and Sandén, 2012; Bauer et al., 2018b). The government can promote collaboration and knowledge exchange in their design of pilot and demonstration programs and by catalysing actor networks, which they may also participate in via public research centres and universities.

CREATING AND RE-SHAPING MARKETS

The creation of modern industrialism required a far-reaching transformation of economies through political interventions as described by Polanyi (1944/2001) to create and shape markets. Contemporary markets for industrial products are no naturally occurring phenomena but are co-created outcomes of decades of economic development and political processes, and shaped through (often state-owned) enabling infrastructures which provide states with a key role in deciding the rules of access to such markets. Consequently, introducing a new political goal – near zero emissions in the industrial sector – necessitates support for the development of new social practices, technologies, and products, but also their introduction to and the reshaping of existing markets – in evolutionary terms, changing the selection environment to allow for new growth (Nelson and Winter, 1975; Ayres, 1991; van den Berg et al., 2006). Creating and shaping niche markets – protective spaces in which new technologies can mature – for new, green technologies and products has been part of national environmental policy making for some time. However, the notion that existing markets also can and must be reshaped to conform with climate targets has received less attention (Mazzucato, 2016).

The scale-up of small-scale green niches is hampered by fossil energy subsidies and supportive market architectures, such as through codes and standards that hamper innovative solutions. Decarbonised production systems are often at a competitive disadvantage due to both higher risks associated with novel technologies and the high degree of lock-in of present systems (Seto et al., 2016). Higher production costs are a major barrier to deep decarbonisation in the energy intensive industries. Examples include steelmaking with hydrogen-based direct reduction, cement production with oxyfuels and CCS, or electrification and the methanol-to-olefins route in chemicals; resulting in cost increases ranging from 38 % to 277 % (Agora Energiewende & Wuppertal Institut, 2019). A plethora of policy instruments have been suggested for market creation and re-orientation (cf. Neuhoff et al., 2019; HLG-EII, 2019). The prior typically take the form of carrots, such as subsidies or quota obligations, while the latter are usually sticks, such as taxes or regulatory standards. Market shaping can target the supply side, such as production subsidies, or market demand through standards, quota obligations or public procurement.

Supply-side policies are effective measures to enable the commercialization of large first-of-a-kind industrial plants, such as the ones required to decarbonise steel or cement (Vogl et al., submitted). First-of-a-kind plants also rely on market demand for green industrial products, created and shaped by formation policy (Vogl and Åhman, 2019). Setting up such markets for industrial products relies on information instruments such as carbon footprint tracing or tradable certificates for green materials. In turn, this facilitates the introduction of product requirements and quota obligations, and allows private and public actors to procure green products (Vogl et al., submitted). Demand-side market creation policies are emerging around the world. Both the Buy Clean California Act (AB 262) and the Swedish Transport Administration set upper limits for allowed material climate impacts in public procurement (Toller and Larsson, 2017). In France, a new building code includes LCA metrics for encouraging the use of low-carbon building materials (Schwarz et al., 2019).

Tilting the playing field through market shaping requires a series of choices regarding the policy process and design (Mazzucato et al., 2019). Negotiating eligibility for support for both demand- and supply-side market policies bears a high risk of deepening existing, or creating new, carbon lock-in. Furthermore, information collection in globalized value chains is far from trivial and requires significant bureaucratic capacity. Finally, the creation of markets for green products will likely produce spill-overs outside the jurisdiction that has created the market. Although detrimental for cost-efficiency, these markets can serve as a source from which low-carbon industrial production can diffuse internationally.

BUILDING CAPACITY FOR GOVERNANCE AND CHANGE

The need for fully decarbonising industry is a new policy challenge that has not been high on the agenda until very recently. As long as total reduction targets were short term and less ambitious (in the range of 8 %, i.e., the EU Kyoto commitment 2008–2012, to 20 %, i.e., the EU 2020 target) industry could be left for later. The idea of near term and marginal solutions with low abatement costs is now being replaced with the idea of zero emissions and a transformational change of industry. This presents new challenges to governments, industry and other actors.

Climate policy has been a part of energy and transport policies for decades. As a result, there has been a build-up of institutional capacity in these fields including the creation of directionality, policy learning, government expertise in ministries and agencies, as well as academic research. In comparison, reducing industrial emissions to zero, is a new and underdeveloped field for policy and governance. Plastics is a case in point where initial policy efforts were quite piecemeal, through the Plastics Strategy (EC, 2018) and Single Use Directive (EP and EC, 2019), and not addressing the fossil feedstock and emissions. For the future, there is also a need to consider the broader structural decarbonisation challenges facing the integrated oil, gas, petrochemical, and plastic sectors (Bauer et al., 2018a). Building a new and broad institutional capacity is important for dealing with new and broad challenges.

The long-term perspective and the transformative aspects of a green industrial transition require changes in governance perspectives and frameworks. There is a need to combine stable conditions, reducing the risk for businesses to invest in new technologies, with an ability to adapt policies as there are changes in technologies, demand patterns, or external conditions on a geopolitical scale. This is a difficult task as there is a risk for both regulatory capture and that suggested policies generate unfair conditions among businesses, or excessive profits for some actors. Creating long-term stable investment conditions may also have democratic implications if this severely restricts options available to future policymakers (and voters) to adapt their policies according to new knowledge and priorities.

Policy coherence is often argued as important for efficient policies and something that might require institutional reforms (for discussions of the role of policy coherence see e.g., Bocquillon, 2018; Nilsson and Weitz, 2019). A coherent policy approach to industrial transformation will cut across many traditional policy domains if the future is much more material-efficient, circular, and electrified with new sectoral couplings. It may cut across building codes, waste handling, product standards, electricity market design, resource security, environmental permitting, trade, CCUS infrastructure and regulation, and much more, in addition to RDI and market creation as discussed above.

Systems for continuous monitoring and evaluation will be important parts of the institutional setting as they contribute to learning and political accountability (see e.g. Mickwitz, 2006). The learning effect can reduce the risk for the asymmetric knowledge that may exist between the regulator and industry. Monitoring and evaluation can be organized next to existing governmental structures, e.g., an external observatory function like the UK Climate Change Committee or the Swedish Climate Policy Council. It can also be organised as part of the existing government structure, e.g., in existing agencies and ministries. Objectives, mandate, resources, independence and organisation may vary between countries depending on political and institutional traditions.

INTERNATIONAL COHERENCE

Most energy intensive industries are both carbon and trade intensive, which makes them vulnerable to different national carbon pricing policies. The UNFCCC has as a core principle that the responsibility for mitigating GHG-emissions is "common but differentiated according to respective capabilities" between countries. This means that industrialized countries e.g., the EU, US and Japan, should implement stricter carbon policies compared to countries such as China, South Africa and India. This core principle of the UNFCCC creates an institutionalized "uneven playing field" for private global actors such as steel, cement and aluminium producers and has been criticized by industrial countries for leading to decreasing competitiveness and carbon leakage. Industrialized countries have responded by sheltering domestic industries from the costs that stems from climate policy (Åhman et al., 2017). The strategy has worked, at least for the EU and so far, as no real evidence of carbon leakage has yet been seen (Åhman and Nilsson, 2015).

The differentiation in climate ambitions between rich and poor countries is still relevant but has been played down in the new Paris Agreement. This is partly due to developments in the global economy over the past 20 years. Reality on the ground has changed with the rapidly industrialising BASIC countries now being major emitters. Industrializing countries need capacity for producing steel, cement and other materials for their development, but the narrative has shifted from these countries being allocated "extra" GHG-emissions to instead getting technical and financial help to decarbonize their heavy industry (Bataille, 2020). The issue of global fairness is still very present.

Carbon border adjustments (CBA) is an increasingly discussed policy response within the EU. Correcting for differences in carbon pricing at the border might seem like a quick fix, but it is anything but. Disadvantages for industries do not just come from higher carbon prices but also from domestic subsidies and other advantages (Haley and Haley, 2013). Such subsidies are all part of a broader industrial policy for development that especially China and other fast growing and industrialising countries have as a key political priority. A trade policy response to carbon leakage would thus need a broader approach, including agreements on fair levels of subsidies, competition and market access.

A future approach must take into account that industry needs to transform in a context where they compete internationally at the same time. Sectoral and cooperative approaches for the energy and trade intensive industries should be made more prominent in international climate policy, but it must also be integrated into trade policy (Åhman et al., 2017). This is possible within the Paris Agreement, Article 6, but the yet unfinished negotiations on "the rule book" gives few concrete indications of how countries could cooperate more effectively towards deep decarbonisation.

The Paris Agreement opens for and depends on initiatives that are taken outside, but supportive of, the UNFCCC. Several initiatives have been launched including the Mission Innovation and Energy Transition Commission that focus more on innovation and transformation, partly including the emission intensive industry. Several bilateral initiatives on developing cooperative approaches that have also been launched in the past 5 years (see, e.g., Greiner et al., 2019). Furthermore, in September 2019, the UN Secretary General launched the Industrial Leadership Group headed by Sweden and India with the aim of showcasing countries and sectors willing to take action and commit to long-term decarbonisation plans. If current emerging national initiatives on deep decarbonisation should spread and scale-up, it is imperative that the nexus of international trade and national interests for these industries is dealt with in a way that encourages innovation and development.

PHASE-OUTS AND SOCIO-ECONOMIC IMPLICATIONS

The Paris Agreement target implies the discontinuation and phase-out or repurposing of existing fossil fuel and feedstock infrastructures (e.g. coal power plants, gas pipelines, and blast furnaces). Lessons can be learnt from the ongoing phase-out of coal and nuclear, e.g. in Germany (Johnstone and Hielscher, 2017; Rogge and Johnstone, 2017; Stegmaier et al., 2014). Any major techno-economic transition in the industrial sector is likely to have far-reaching economic and political effects, and create winners and losers among firms, workers, regions as well as countries.

Firms will be affected in different ways depending on their position in the value chain. In the European Union, jobs in the extractive fossil fuel industries, i.e., coal, oil and gas extraction and processing, are most threatened. The effects on jobs in steel and chemicals may be small if these industries can eliminate emissions while retaining production. There may be fewer blast furnaces and steam crackers, but relatively few jobs may be affected and new ones will be created elsewhere e.g., with more circular material flows. For cement, smaller and older plants that are not suited for CCS may be phased-out and affect local economies. Radical technological change for energy-intensive industries will have limited effect on the downstream industries unless it causes a relative price change (Andersson, 2020a). Most studies point towards basic materials becoming costlier to produce when avoiding fossil fuels and feedstock or applying CCS. This may suggest that this cost increase will spread through the economy, reducing economic welfare. However, Rootzén et al. (2016) demonstrate that in the case of steel and cement, even substantial increases in the cost of primary materials will have negligible impacts on the price of final products. In addition, Andersson (2020a) finds that downstream industries that face high levels of competition are likely to absorb most of the cost increase through new products and new and more efficient production technologies. The effect on consumers and thus economic welfare is negligible.

New skills are needed to take up jobs in new or other sectors, which may hinder a transition of workers from old to new sectors. Technological change will lead to fewer jobs in some industries but it will be hard to attribute such effects to emission reductions in the larger context of continuous industrial restructuring, automation and digitalization. Criticism has been raised that the EU industrial policy to increase industrial competitiveness and cheapen exports could depreciate real wages (Wigger, 2019) and lead to higher income insecurity and precarity (Standing, 2012). Calls for an industrial policy that acknowledges the vulnerability of workers and communities have crystallised under the demand for a ”just transition for all” (International Labour Organization, 2015). It is a concept dating back to the 1970s, but it has since been mainstreamed beyond the confines of labour unions and broadened in its meaning (Stevis and Felli, 2015). An industrial transition will have a more concentrated impact on some regions than others. Workers are vulnerable in the process of industrial restructuring, such as the consolidation to fewer and larger plants or plant closures in “one-company-towns”. A consequence of low carbon development might be that, for example, the trend towards electrification (Lechtenböhmer et al., 2016) will put regions with limited access to inexpensive renewable energy at a disadvantage.

Governments can respond to this with transitional assistance policies that provide monetary assistance, public goods and services, or tailored local or regional assistance (Green and Gambhir, 2019). A commitment to both procedural and distributional justice of phase-outs and industrial development is key in order to earn public support for the transition (Newell and Mulvaney, 2013). Structural policies that promote flexible labour markets may contribute to easing the transition while preserving key objectives such as social balance and equity (Andersen et al., 2015). Labour market and welfare policies for well-functioning re-training and re-investment are needed in regions that will lose industries.

Discussion – The 2020 EU Industrial strategy and ways forward

The European Commission published its new *EU Industrial Strategy* shortly before the completion of this paper (EC, 2020). The strategy clearly marks a renewed interest in broad based industrial policies from the Commission. Here we analyse the strategy through the lens of our suggested framework. We also discuss the potential impact of the Covid-19 pandemic on industrial policy. The pandemic, and its economic consequences, offers both opportunities and threats to the new strategy.

The strategy builds on previously published policy documents and communications but is broader in scope. For example, it combines the twin ecological and digital transitions, and relates the industrial policy to the creation of jobs, skills and social fairness. The strategy clearly recognises the need for setting the *direction* and not just promoting any kind of industrial development. It stresses the importance of political leadership and calls on industrial sectors to define their own roadmaps for achieving climate neutrality and encourages the formation of industrial alliances.

In our view, the focus on *direction* with climate neutrality also for heavy industry is welcome, as it has been less explicit in the past. However, a focus on traditional industrial sectors in defining roadmaps run the risk of becoming too narrow (e.g., focused on intra-sectoral options) and too supply oriented (e.g., focused on production and recycling). Decarbonization, and digitalization, are likely to i) involve and create new intersectoral couplings, and ii) require a wide range of supply and demand-side mitigation policies, including demand management and materials efficiency. For example, a supply-oriented cement industry roadmap is likely to find a much narrower set of solutions to decarbonization than a multi-stakeholder roadmap that includes the demand side through e.g. the construction sector.

Innovation is strongly emphasised in the strategy, as in previous strategy documents. An important new element put forward is the idea of embracing both successes and failures. Radical change is rarely achieved without failures on the way. These provide important insights and lessons that help find the path forward. The strategy suggests the launch of a European Innovation Council. Its aim is to “identify next generation technologies, accelerate their commercial application and help them support the rapid scale up of start-ups”. The strategy also points at Industrial Projects of Common European Interest (IPCEIs), changes in state aid rules and notes that “the EU ETS Innovation Fund will help deploy large-scale innovative projects to support clean products in all energy-intensive sectors”.

Supporting innovations, during their early development phases, are important tasks for the government. Governments have an important role in setting the direction, supporting innovation and incentivising action, but supply and demand innovations will come mainly from the private sector. A problem for supply side innovations for decarbonising primary production is the lack of market demand. The strategy touches relatively lightly on the need for *creating and reshaping markets* and points mainly to public procurement as a mechanism for that. Regulations, guaranteed prices, quotas, contracts for different and other instruments should also be considered and developed in order to bridge the gap between innovation and broader scale commercial deployment.

Further, the strategy speaks about co-design and co-creation of solutions with industry and industrial alliances as appropriate approaches also for low-carbon industries. It states that "the Commission will systematically analyse the different ecosystems and assess the different risks and needs of industry" and in doing so work closely with "an inclusive and open Industrial Forum". This appears to place monitoring and evaluation mainly within existing EC structures rather than with an independent observatory function. The Industrial Forum does not yet have a clear composition or mandate, but we want to note the risk of cementing existing power-relations and protecting vested interests. We see a need for being inclusive but also for *building capacity* on industrial decarbonisation among many stakeholders, including public actors and academia.

The strategy emphasises the need for *international coherence* as well as the need for the EU to protect its economy. A Carbon Border Adjustment mechanism in 2021 is suggested if differences in ambition around the world persist. The ambition is to take a global lead, maintain leverage and mould international markets to reflect EU values through, for example, making the Paris Agreement an essential element of all future comprehensive trade agreements. In our view, such a policy is welcomed as long as it is used to accelerate a decarbonization of the EU economy, and not as a general barrier for foreign trade. Trade and climate policy integration and coherence is important.

Overall, the strategy is an important first step towards climate neutrality in European industry. For its implementation it is important to avoid supply-side focus and also include demand management and materials efficiency. In addition to promoting innovation, it must also create market demand for climate neutral solutions and consider other instruments along with public procurement. It must also be sensitive to new sectoral couplings within industry, as well between industry and the energy and waste sectors.

The economic consequences of the Covid-19 pandemic is a new context and puts the strategy at risk. A new industrial policy requires a change in the policy direction. Major economic crises have historically been turning points when such changes have occurred (Andersson, 2016). However, the present economic crises may not make the implementation of the strategy any easier. All economic crises highlight weaknesses in society and open a window of opportunity for new ideas to set the agenda. A decade of poor economic growth, increasing inequality and environmental unsustainability may highlight the need for a new industrial strategy not just to rebuild the European economy following the Covid-19 crisis but also to address the long-term structural weaknesses in society. On the other hand, rapidly growing public debt ratios reduce the fiscal scope to invest in a climate transition and to support radical innovations during their start-up phase. The crisis may also motivate a push for recovery and growth at any cost, to grow out of the debt burden. The ecological transition may come second to economic growth policies. A new EU-wide industrial policy requires closer political collaborations among the member states of the union. The Covid-19 crisis has further exposed the political dividing lines and conflicts among the member states (Andersson, 2020b). Globalization and international collaborations were under threat already before this crisis – regrettably the crisis has so far reinforced that tendency.

Conclusions

Industrial policy in the 21st century must meet several challenges, including the transformation of emissions intensive industries. Following the financial crisis in 2008, much emphasis has been put on the rate of industrial and economic development. Less emphasis has been put on the direction of development. We argue that it is a favourable time for industrial policy to take responsibility for a development towards zero emissions in 2050 – and that this is a necessity for such a development to occur. Achieving this goal requires greater attention to energy intensive industries, which have previously received scarce attention in industrial policy. While the EU Industrial Strategy is a significant step forward in this regard, there is a need for a continuing commitment to decarbonisation in industrial policy also when facing the Covid-19 pandemic. We have highlighted the importance of pursuing multiple decarbonisation options simultaneously and placing industrial policy in the context of wider societal development, beyond a narrow focus on industrial development.

Consequently, we suggest the need for a broader framework for industrial policy. Drawing on a wide range of literatures including economics, governance, and innovation studies, our framework for an industrial policy for energy intensive industries emphasizes six dimensions: the need for ensuring directionality in policy; supporting knowledge creation and technological development; creating and re-shaping markets; building capacity for governance and change; international coherence and; socio-economic implications of phase-outs.

Future research on these six dimensions is needed to allow for better industrial policies for energy intensive industries, specifically addressing the following topics. First, international coherence is important not only regarding carbon pricing policies but also in policies supporting knowledge creation and technological development. Given the significant costs associated with demonstrating technologies in energy intensive industries, questions around when to develop domestic facilities and knowledge base, and when to tap into international resources is a topic for future research (Hellsmark et al., 2016). Second, establishing markets for zero-carbon materials in the context of energy intensive industries requires greater insights into market segment and value chain characteristics. The value and feasibility of zero-carbon solutions vary significantly between market segments depending on institutions and task environments (Bergek et al., 2018), however, we know very little about such differences in energy intensive industries' market segments. Third, an industrial policy, which directly takes socio-economic implications of decarbonisation into consideration, requires a thorough understanding of synergies and trade-offs between different public policy goals for different transition pathways. While research on interactions between sustainable development goals has progressed in recent years (Nilsson et al., 2018), energy intensive industries are – also on this topic – an understudied empirical field.

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Acknowledgements

We thank the European Commission for support under contract No. 730053 for the H2020 REINVENT project and the Swedish Energy Agency for project Nr. 38271-1, Green transition and co-evolution of industry and the energy system (GIST).