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Towards Green Industrialization in India: Challenges and Opportunities

This policy brief is based on a Policy Roundtable on "Green Industrialisation in India: Potential, Challenges and Policies," organised by ISID on April 5, 2022. Prof **Kelly S Gallagher**, Director, Climate Policy Lab, The Fletcher School, Tufts University, and **Dr Easwaran J Narassimhan**, Postdoctoral Fellow, Harvard Kennedy School, presented their work, followed by a discussion by panellists, Dr **Arunabha Ghosh**, CEO, Council on Energy, Environment and Water, Delhi; Dr **Tilman Altenburg**, German Development Institute, Bonn; Prof **Ambuj Sagar**, Head, School of Public Policy, Indian Institute of Technology (IIT) Delhi; and, Mr **René Van Berkel**, Director, Regional Office in India, United Nations Industrial Development Organization (UNIDO). The roundtable was moderated by Prof **Nagesh Kumar**, Director, ISID. The policy roundtable can be viewed at https://youtu.be/BYns1FmiR2Q

There is growing recognition of the fact that India, in its structural transformation, has missed the opportunity to industrialize and has transitioned from agriculture to services in its growth trajectory. This has delivered growth without adequate provisioning of decent job opportunities for the 12 million people who join the workforce every year. Meanwhile, the challenges to industrialization have grown. "Produce now and clean up later" is not an option available to India in an increasingly carbon-constraint world. The flip side of this scenario could be opportunities that beg exploration. Can India industrialize in a manner that also decarbonizes the economy, and not repeat the way industrialization happened in other parts of the world?

Scenarios of Decarbonisation Pathways

To achieve the global target of net zero emissions as called for in the Paris Agreement, considerable resources and investments are required. Estimates of a decarbonisation pathway for India in a business-as-usual scenario show 7.3 gigatons (gt) of CO_2 equivalent (7.3gtCO_2e) in 2050. Reducing these emissions under a raising ambition scenario to 2.2gtCO_2e in the same time frame would mean a reduction of emissions generated from the industrial, electricity, and transport sectors to 2.6gtCO_2e, 1.1gtCO_2e, and 0.7gtCO_2e, respectively. Each of these sectoral wedges creates opportunities that India could potentially invest in to reap economic gains from the transition.

The electricity sector, even in the business-as-usual scenario, is likely to deploy a significant amount of renewables. In the raising-ambition-scenario, the sector will have to add a significant amount of solar PV (1450gw from the current 50gw capacity), wind (900gw from the current 40gw capacity), offshore-wind (500gw), and 450gw of storage capacity.

Similarly, for the industrial sector, switching from fuel use to electricity as an input creates a significant wedge from 1588 to 9200 PJ/year, as does investment in hydrogen production that can go up from zero to 4500 PJ/year. This translates to about 150gw of electrolysis capacity.

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In the transport sector, India will need to move to an electric vehicle (EV) eco-system with more than four million cars, 52 million two-wheelers and three-wheelers, and a million plus buses and freight vehicles per year alongside a minimal addition of hydrogen vehicles (0.5 million cars and 1.2 million trucks per year.

These estimates indicate a significant opportunity to make technological investments in renewables and clean technologies, particularly in this decade, to scale up beyond 2030 to a low-carbon economy.

Can India industrialize in a manner that also decarbonizes the economy, and not repeat the way industrialization happened in other parts of the world?

Some Lessons from China

China, in many ways, is to green industrial policy as the Silicon Valley is to innovation. While emulating its journey might have limited possibilities for other aspiring countries, there are some insights that the country can offer.

In the late 1990s, China entered into a green transition through innovation and technological upgradation in automobiles. China deployed significantly higher amounts of renewables and generated a significant amount of renewable energy jobs per megawatt in the process. More than 50% of China's renewable energy jobs came from manufacturing. China's clean energy research, development, and demonstration (RD&D) investments increased over time, particularly from 2004 onwards, as it invested in manufacturing and sequentially scaled deployment in the country. China was able to combine supply-side policies and sequence it by understanding global market demand as well as creating domestic markets in response to industrial capacity in terms of manufacturing solar or wind components.

With respect to energy innovation systems, China's focus on green industrial policy reflects a techno-industrial policy approach, where it considered green technologies as economic opportunities with emissions reduction as a co-benefit. Admittedly, the country did so in a favourable time frame vis-à-vis the rest of the world with respect to climate action. Green industrial policy in China was mostly focused at the national level on the indigenization of technology and industrial development, with renewable energy manufacturers investing in technological upgrading and renewable energy developers focusing mostly on asset maximization, seeing renewable investments as an opportunity rather than a short-term revenue generation mechanism. Subnational provinces in China were competing with each other fiercely to create employment and increase their local GDP.

China made extensive use of short, medium, and long-term plans, sector by sector, taking a systemic approach to policy, pushing investments in green technology pathways through state-owned enterprise reform, and pulling bad industries. China instituted a financing catalogue of industries by red (prohibited), yellow (restricted), and green (encouraged) industries that were updated constantly and published annually in industrial catalogues to show the countries priorities. Productive allocation of financial resources and consistent interventions, negotiations between centre and provinces, a top-down steering approach through five-year plans, and the horizontal coordination across ministries on strategic emerging industries made it possible for China to reap gains with an early movers' advantage. To state an example, China understood that air pollution in big cities is an emerging crisis and anticipated and invested early in electric bus technologies. Today, the country has captured 95% of the world market in electric buses, an advantage that Europe, despite having a significant number of companies like Volvo, Daimler, and Scania, could not provide market incentives for developing electric buses.

Importantly, China's clean energy investments have a long history and have been built on a strategic and successful industrial policy with a base of significant investments in industrial technology, starting from 1986 through their state-led development plans, the 863 and 973 research programs funded and administered by the government to develop technologies across various fields. The Chinese story shows that

successful industrial policy depends on a fairly deep set of investments that take some time to yield results.

Strategizing for a Green Industrialization: Challenges and Opportunities

In India, the focus has so far been on domestic market formation to capitalize on the global decrease in renewable energy costs. Industrial policy was primarily limited to the localization of components. Clean energy RD&D investments have been negligible, with green industrial policy focusing primarily on a market-led and politics-centered approach. The national and sub-national objectives focussed on the cost-effectiveness of the policy, constrained by the political economy of primarily the electricity sector, with subnational policies focusing on electricity prices. Consequently, developers focussed on cost minimisation, and manufacturers on short-term profit maximisation rather than long-term technological upgrading.

Since then, some changes in the right direction have emerged. These include the PLI schemes to promote renewable energy equipment manufacturing and technology-focussed national missions, including the latest hydrogen mission and energy storage mission. What is, however, still missing is a broader green industrialisation strategy for India. The upcoming decade is a crucial decade for India to make investments to develop local capabilities in emerging decarbonisation technologies.

A comparison with other countries reveals that India made sizable public investments in energy RD&D in terms of purchasing power parity (ppp). However, investments in clean energy RD&D are negligible and concentrated in nuclear and fossil fuels. India's energy RD&D investments are mismatched with deployment trends and future technological needs for decarbonisation (such as battery and hydrogen). There is an urgent need for reorientation of India's RD&D investments towards technologies needed for the transition to a less-emission economy.

In terms of manufacturing, in order to peak and flatten the emissions curve, India needs to add 50gw of solar every year till 2050; the existing manufacturing capacity is about 3gw for cells and 15gw for modules per annum. Similarly, India has to add 50gw of wind capacity till 2050; currently, the wind capacity is one-fifth of the yearly potential demand. In terms of battery storage 15 gw needs to be added until 2050, while existing manufacturing is negligible. The production-linked incentive (PLI) scheme announcements recently to manufacture 12 gw of four-hour battery storage by 2027 is a sign in the right direction.

There is also negligible lithium-ion battery manufacturing for electric vehicles. Most electric two-wheelers and car manufacturers assemble imported EV components. For hydrogen, India needs deployment of 5gw of electrolyzers by 2050; so far, there is no manufacturing of electrolyzers. These estimates indicate a huge opportunity for India to invest significantly in the manufacturing of decarbonisation technologies.

Green industrial policy is an extension or complex form of traditional industrial policy. The process is more challenging for India as it has not demonstrated using its industrial policy in a time-bound, competitive, target-oriented manner. However, the scope for greening is immense. Sustainability is at the heart of successful industrialisation. Therefore there is a greater need to strategize and use resources efficiently to gain from the future of industries by optimising the strengths of existing and emerging industries.

Sequencing and Financing the Transition

Green industrial policy differs in many ways from traditional industrial policy that supports new technologies at the precompetitive stage through research and development (R&D). The basic aim of green industrial policy is to phase out fossil fuels and phase in renewables, phase out combustion engines, and phase in electric vehicles. This has clear policy implications because it requires proactively phasing in new things by investing much more in innovation

How do we sequence and finance the transition for a country like India?

and deployment. Importantly, it also requires phasing out technologies by disincentivizing polluted technologies and incentivising cleaner technologies.

How do we sequence and finance the transition for a country like India?

First, the widespread adoption of transitional technologies, for example, green buildings, bioenergy or biomass, shifts to alternative greener fuel, and so on, that have a less than five-year horizon. These can be rapidly adapted to an Indian business context.

Second, investing in foundational technologies that have a five to ten-year horizon, where a decade of investing in green technologies is required, for example, in energy storage and battery, next generation of efficient solar-based technologies, as well as gasification technologies, for moving from solid to gaseous fuels. This will require an innovative approach for joint research with the private sector, academics, and entities abroad.

Third, developing breakthrough technologies, for example, green hydrogen or green-house gas removal, where risk guarantees to investments are required to trigger large-scale investments from innovators as well as industries.

In these deliberations, particularly for the longer-term plans, international collaborations will be vital and need to be focussed on cooperation rather than competition. So far, an international finance agreement for climate transition has not been forthcoming. The technology mechanism of the United Nations Framework Convention on Climate Change (UNFCCC) is not adequate. The international community can help resource-constrained economies like India by revamping approaches towards improving innovation cooperation and collaborative R&D in a more systematic manner.

Fundamental to the transition process of greening is the need to adopt a politically acceptable transition to combat political opposition from both consumers and industry

Need to assess the level of financial support needed across different industries

There needs to be a demand assessment of the industrial sector to quantify the share of emissions in each industry

is essential and possible by co-designing the environmental and industrial policies. For example, internalising environmental costs through pricing, cap and trade systems, will be important to help the economy adopt the path of green growth; however, this has to be in balance with the ability to compete internationally, which could be compromised in the existing tradeables products during this transition. Another example relevant in India's context is the emerging middle class that might aspire for car ownership, which will get more expensive over time, and gradually give way to electric vehicles.

Green policies also require timely planning for future technologies. For example, green hydrogen is an under-researched area and will be cost-competitive in one or two decades. These require investments in technologies now. From an industrial development perspective, investment in hydrogen is promising for the following reasons. First, it provides a push for investment in renewables, so global investments will be attracted to it. Second, it requires investments in electrolyzers industry and can hold significant comparative advantages. For example, if part of the automotive industry wants to be certified as zero carbon, it can transfer its production sites to green hydrogen sites, and this can shift locational advantages to benefit countries richly endowed in solar and wind energy, in case of solar, for example, that could be India.

The country needs to develop a systematic approach to clean energy entrepreneurship by encouraging public-private consortia through incentivizing start-ups and MSMEs. Further, commercialisation should be encouraged, for instance, by increasing the capacity of patent office or encouraging joint ownership of patents rather than looking for acquisition alone.

Given the plethora of environmental issues and concerns in the transition to green

industrialization, what do we prioritise? The UN Environment programme has outlined the triple planetary crisis: climate change, nature and biodiversity loss, and pollution and waste. Each of these have significant impact in undermining the environment. Applied material efficiencies in homes for China and India can achieve a 60% reduction of life cycle emissions of housing, and the same in cars would reduce by around 30–35% by 2050. This can be a fast way to achieve emissions reduction.

Importantly, India needs to harness complimentary research capabilities across public research institutions and higher educational institutions to reorient its energy RD&D and analyse sector by sector, the mis-alignments in push and pull policies. There needs to be a demand assessment of the industrial sector to quantify the share of emissions in each industry (cement, iron and steel, chemicals, and so on) that could be replaced with green hydrogen and carbon capture and storage (CCS). To materialise this transition, one would need to assess the level of financial support needed across different industries and also to understand the short-term competitiveness impact of greening industrial inputs and processes.

Need to understand the short-term competitiveness impact of greening industrial inputs and processes

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