The War on Climate Change: Hubris to Realism

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On the face of it, global efforts to tackle climate change look truly impressive. Nearly forty countries[1] that together account for almost 75 percent of the world's CO_2 emissions either already have a carbon pricing regime in place or are considering one. In a joint statement last year the two largest among them went further. China expressed intentions to increase the use of non-fossil fuels to 20 percent by 2030 (from 10 percent in 2013),[2] while the United States offered to reduce emissions 26 to 28 percent below 2005 levels by 2025.[3] Additionally, the private sector in India, the third largest CO_2 emitting country, recently committed to building about 266 gigawatts (GW) of new renewable generating capacity—a huge figure given India's current total installed capacity of 259 GW—in the next five years.[4]

Look closely, however, and the picture is rather grim. It is doubtful whether these efforts will actually achieve reductions anywhere near the level required to restrict global temperatures from rising to two degrees Celsius above average pre-industrial temperatures—a widely accepted goal set to avoid more serious climate-related challenges.[5] The carbon pricing regimes in the aforementioned forty countries apply to just over 10 percent of total global emissions due to exemptions and special cases. China has

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only agreed to a peaking of its emissions in 2030, while India wants to double coal production.[6] The world's CO_2 emissions are on an upward trajectory, having risen 55 percent since 1990 and 20 percent since 2005.[7] This trend appears set to continue under every current scenario.

It need not, but only if we are clear-eyed enough to grasp the magnitude of the task. There is broad consensus that the road to a less-than-two-degree Celsius warmer world leads through China and India, meaning that both countries must dramatically reduce their reliance on coal. But there is far less agreement on what specifically needs to happen to pave the way for such a transformation that is also supportive of their development goals. Existing electric systems are the main consumers of coal in both countries. But because they are products of local political economies, no two systems are identical and there is no one-size-fits-all approach. Power systems are also marked by inertia and take years to transform.

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In this article, I outline some of the key structural reforms that need to be made to put the Chinese and Indian electric sectors on cleaner trajectories and maintain realistic hopes of defeating the climate threat.

LOTS OF ZERO-CARBON ELECTRICITY NEEDED, URGENTLY

For the first time, in its most recent assessment report, the Intergovernmental Panel on Climate Change provides estimates of a 1 trillion metric ton cumulative carbon emissions budget, which anthropogenic activities must not exceed in order to have a better-than-even chance of limiting average global temperature rise to two degrees Celsius.[8] The bad news is that since the late nineteenth century we have already consumed approximately half of this allowance.[9] That leaves us about 500 billion metric tons to work with from here on out.

On current trends, the global electric sector alone would eat up over 40 percent of the remaining budget by 2050.[10] Fully half of that will be accounted for by China and India's electric sectors.[11] By contrast, electricity generation in the Organization for Economic Cooperation and Development (OECD), a group of thirty-four mostly rich countries that includes the United States and European Union, would consume only about a quarter of this budget.[12]

This is ominous news for the fight to stabilize the global climate. China and India are projected to take up such a large share of the remaining budget for two main reasons: heavy reliance on coal for electricity, and their large, fast-growing economies. Currently, both countries get about three-quarters of their electricity from burning coal, the most carbon intensive source of energy.[13] This is because coal is a bargain compared with the price of natural gas in both countries. It is also relatively abundant domestically and provides a reliable and quickly scalable source of electricity that is prized by growing economies with rapidly rising electricity demands. Indeed, the International Energy Agency projects that electricity consumption in China and India will triple by 2040.[14] Even then, per capita consumption of electricity in China and India will be just 75 and 20 percent respectively of current U.S. consumption levels.

To achieve the world's climate goals, therefore, China and India need massive amounts of electricity from low-carbon sources. In order for alternative sources to displace coal easily, however, they must be just as economical, reliable, and easily scalable as coal. This will be no easy task.

COAL HAS ITS PROBLEMS…

To be sure, coal faces multiple challenges in both countries. Plagued by inefficiency and corruption, domestic production of coal in India has more or less plateaued in recent years. Coal India, the state-owned coal monopoly, has failed to boost output to keep up with demand. Indian coal is also high in ash and packs relatively little heat.[15] High ash content tends to create problems in the newer supercritical plants. Imported coal, on the other hand, raises new geopolitical insecurities and pushes up the total import bill, something India, with a stubborn current account deficit, wants to avoid.

In China, severe air pollution is prompting a serious rethink on coal. The choking smog that now semi-permanently shrouds Beijing and other Chinese urban centers has become so oppressive that in March 2015 Chinese president Xi Jinping promised to "punish, with an iron hand, any [environmental] violators."[16] There are signs that the public mood may also be turning. "Under the Dome," a documentary by a Chinese investigative journalist about the country's pollution, has generated a passionate national debate and was viewed online by over 200 million people within days of its release.[17]

Chen Jining, the current environment minister of China, even compared it to "Silent Spring," the book in which Rachel Carson exposed the dangers of DDT and, according to many, started the environmental movement in the United States[18] Chinese policymakers have, as a result, been goaded into taking steps to reduce coal's share in China's electricity mix. Starting this year, China will no longer allow importation of coal that is high in ash and sulfur content, a particularly polluting sort.[19] And it has already banned all new coal plants around Beijing, Shanghai, and Guangzhou, the three main metropolises of China.[20]

Coal plants also consume large volumes of water, which is increasingly becoming difficult to procure in both India and China. According to some estimates, a majority of all existing and planned coal plants in both China and India may be in areas of high or extreme water stress.[21]

…BUT HUMAN DEVELOPMENT IS THE HERE AND NOW

Coal's future may appear to be on the wane, but only up to a point. In countries like China and India, the need to provide a basic standard of living to their people usually trumps long-term considerations like their carbon footprint.

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About a quarter of India's population has no access to electricity and an even larger share suffers from frequent load-shedding (rolling blackouts).[22] The average per capita consumption of electricity in India and China is just over 700 and 3,500 kilowatt-hours (KWh) per year respectively.[23] The average OECD consumption rate, by contrast, is over 8,300 KWh per year, while the comparative figure in the United States is more than 13,000 KWh per year.[24]

Since human development is closely linked to consumption of electricity,[25] when faced with a choice between switching to costlier alternatives with uncertain outcomes and keeping a reliable but dirty source of electricity available (after some cleanups to curb smog causing particulate matter emissions), the Chinese and Indian governments are likely to choose the latter. Seen in this larger context, coal's current problems look eminently surmountable.

Indeed, there are signs that both countries are moving in this direction. As part of China's national strategy, development is moving to the poorer western provinces, where most of the proposed coal plants will be built. Air quality is much less of an issue out west. In the five-year period ending in 2015, more than 800 million metric tons of new coal production capacity (about 90 percent of what the United States produced in 2013)[26] and 300 GW of new coal-fired power plants will be brought online in China.[27]

Unlike in the past, these will be in provinces like Inner Mongolia and Shaanxi, which are located away from the richer eastern coast where most of China's emerging middle class lives and where air quality concerns are most pronounced. Power will then be delivered to the eastern population centers via the grid.[28] And since most coal plants in China were built after 2000, several already have advanced pollution control equipment installed.[29] These controls can simply be switched on to reduce particulate matter emissions, the main cause of air pollution, without any reduction in CO_2 emissions.

India too appears to be gradually chipping away at some of the barriers holding back the development of coal-fired power plants. A landmark tariff case that is currently making its way through the courts in India could allow power companies to pass on the higher cost of imported coal to consumers and remove a major sticking point in the building of large new supercritical coal plants, known in India as "ultra mega power projects (UMPP)."[30]

The Central Electricity Regulatory Commission (CERC), the federal regulator, has already sided with Tata Power, a major private-sector developer of power plants in India that is seeking to raise rates to reflect a higher coal import bill.[31] Although the courts have not made a final ruling yet, it is unlikely that they will reverse CERC's decision. This is significant for the relatively young Indian government, which swept to power with big promises of economic development. Its first annual budget includes plans to build five new coal-fired UMPPs (20 GW) including the revival of several previously stalled ones.[32]

NEED FOR SYSTEM TRANSFORMATION

Both China and India, however, recognize that for the world's sake, and eventually their own, they need to change the way electricity is generated.[33] For now though, in their view,[34] such a change appears incompatible with a high growth rate. The trick will be to figure out an equally vibrant development pathway that does not include coal. If low-carbon sources are to make meaningful inroads in China and India, the electric systems of both countries must be drastically transformed.

Such a transformation will have three key elements. The first concerns market reforms, which are needed to undo the confluence of advantages that currently give coal a leg-up in the competition with low-carbon sources of energy. The second requires the implementation of structural changes to reshape the political economy of electricity. Vested interests in both countries that benefit from the status quo are likely to resist any change. And the third addresses any technical barriers to low-carbon resource development.

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Instituting Market Reforms

Nowhere in the world are electricity markets perfect, but in China and India, for the most part, they are absent altogether. China is a particularly egregious case. Its electric sector is not based on the principle of least-cost (i.e., power plants are called to generate electricity in order of their marginal cost of production), a basic concept of market organization just about everywhere in the world, including India. In China, each plant is allocated a fixed number of hours of operation, with those running on coal receiving between 4,000-5,100 hours.[35] Coal plants are thus guaranteed a utilization rate of between 46 and 60 percent, regardless of their efficiency or production costs. This prevents renewable resources from effectively competing with coal plants and displacing them as they would in a least-cost based economic dispatch system.

India's key market deficiency is a lack of "open access," which allows trade of electricity between parties that do not own the underlying transmission network. The Electricity Act of 2003 introduced the concept by requiring the unbundling of vertically integrated state electricity boards into generation, transmission, and distribution companies, but few Indian states have implemented this fully.[36] Open access brings independent power producers to the mix, introduces competition, and makes efficiency improvement a priority for existing plants. It enables wind-farms and other renewable sources of power, which typically do not own transmission assets, to get their output to market. State electricity distribution companies continue to resist full implementation of open access because the competition it brings often leads to the loss of their largest source of revenues: industrial customers (who currently pay significantly higher rates than other users). Open access would allow industries to procure electricity from cheaper sources or generate their own.

In general, robust electricity markets offer increased depth and liquidity, which allow renewable project developers to hedge risks and improve the profile of their investments. Deep and liquid markets attract an increased number of buyers and sellers that aggressively bid to drive prices down. This usually leads to a wider range of services and products being offered, including capacity markets and ancillary services (i.e., voltage support, frequency regulation, reserve generation, etc.) that are crucial to the integration of renewables into the grid.[37]

Another gap in the market is the lack of a price discovery mechanism for natural gas. Neither China nor India has functioning nationwide spot markets or effective alternative price benchmarks. Although China has launched two pilot natural gas-based spot markets in Shanghai, they remain small and illiquid.[38] Controlled pricing regimes hamper domestic production of natural gas and suppress demand at the same time. The inability of power producers to easily pass on fuel costs to consumers exacerbates this problem. Not surprisingly, natural gas, which emits half as much CO_2 as coal, is the source of less than 10 percent of total electricity in both countries.[39]

Reshaping Political Economy

Successful market reforms require a supportive political economy to give them teeth. In both China and India, there are significant forces of resistance to any energy sector market reforms. Take the case of state-level distribution companies in India, also known as "discoms." Most discoms are financially bankrupt, kept alive by federal subsidies. In the fiscal year that ended in March 2012, state-level distribution companies lost USD 14 billion.[40] These losses are largely due to a system of political patronage that keeps electricity prices below the cost of production. The financial health of Indian discoms is important because bankrupt ones are loath to invest in newer distribution equipment and are often hostile to higher levels of renewable energy integration since this increases their costs.[41]

The gross inefficiency of India's electricity transmission system is another example. India delivers (and collects payments for) only about 65 percent of the electricity it generates, losing the rest in transmission and theft.[42] The comparative figure in both the United States and China is around 94 percent.[43] Given the size of India's electric sector, these losses are not trivial. Reducing them to about 15 percent would be the equivalent of adding the output of almost seventy new coal-fired plants with no increase in CO_2 emissions.[44] Although substandard practices, dilapidated equipment, and faulty metering play their part, a major reason for such high losses in India is subsidized electricity for agriculture. Historically, the government has provided power to the agricultural sector at a low flat rate or even at no charge. One result of this is that electricity usage in the agricultural sector for the most part is not metered. Local politicians often take advantage of the unmetered agricultural account to dole out electricity to their voters. Tellingly, losses tend to increase just before state-level elections.[45]

China's problem, on the other hand, is well captured by the proverb *"tian gao, huangdi yuan,"* which translates into "heaven is high, the emperor is far away." If local officials do not like a particular reform, they often quietly ignore it. In China's provinces, administrators are driven overwhelmingly by stimulating local GDP growth and getting ahead within the central party structure, i.e., getting promoted. Even though on January 25, 2015, Shanghai became the first local government in China to adopt qualitative goals and dispense with a specific GDP target,[46] it was not clear whether any goals related to the environment would be among this list. Because the environmental performances of the provinces matter little during year-end evaluations, Beijing's diktats to clean up the environment are frequently paid the short shrift.

It is not difficult to see why. Environmental investments at the city or provincial level, unlike infrastructure spending on transportation, power plants, etc., do not generally result in higher land prices in the short term. This, in turn, reduces revenues from land sales and leases, which lowers the spending capacity of local governments.[47] Environmental efforts, in short, do not foster short-term local GDP growth and, therefore, do not lead to the promotion of local officials.

In certain situations, the central government's environmental policies can even be in direct conflict with the economic interests of provinces. The much discussed "coal cap" proposal, which sought to limit China's total energy use to 4.8 billion metric tons of coal equivalent by 2020,[48] is a good example. In China, state-owned enterprises (SOEs) can be centrally or provincially administered, with their tax revenues flowing accordingly. With the exception of the power sector, where centrally administered SOEs dominate, most coal mining companies and their largest customers are provincially administered SOEs. A coal or energy cap, therefore, would disproportionately affect the tax take of local governments, who can be expected to oppose any such move.

Even if these conflicts are resolved, the national security establishments of both countries will still view any increased reliance on foreign energy sources unfavorably. Because both China and India produce most of the coal they consume, any move away from coal would be seen as a strategic risk in these circles unless viable domestic replacements can be found. Nuclear power and renewable energy sources will likely pass muster of the local requirement. Not so for natural gas, the only viable replacement for coal on a large scale in the short term. For China, a switch to natural gas will almost certainly mean more imports from less than friendly regimes like Russia, and, in India's case, it will lead to an even higher current account deficit. In the long term, however, these worries could disappear depending on either country's ability to develop domestic sources of natural gas, particularly shale gas, of which China has reserves aplenty.[49]

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Surmounting Technical Hurdles

This issue reflects the third element of system transformation: the need to overcome technical barriers to low-carbon resource development. According to some estimates, China has the world's largest reserves of technically recoverable shale gas.[50] Despite this fact, it faces two major challenges in exploiting them. First, the geology of shale basins in China is complex. Shale deposits in China tend to contain relatively higher amounts of ductile clay, which does not fracture as easily as the brittle quartz found in most U.S. shale deposits. This makes drilling much trickier. Second, hydraulic fracturing is a water intensive operation, often requiring millions of gallons just to frack a single well. This could pose problems for China where the northern half of the country only has access to approximately 52,000 gallons of water per person per year.[51] The United Nations definition of water stress condition is anything less than 450,000 gallons.[52]

In India the picture is murkier. India produces relatively small amounts of natural gas and domestic production is declining.[53] A big question mark also hangs over the extent of India's reserves, particularly of shale gas. Estimates of total natural gas reserves, including unconventional sources like shale and tight gas, vary widely and with a high degree of uncertainty.[54] Even assuming reasonably sized reserves, India will struggle to develop them as it faces the same set of problems as China.

A more general problem in both countries is the lack of reliable data and timely information in the energy sector. This affects all manner of resources, but it boosts coal's survival in two important ways. Without good data, markets are unable to accurately price the risk of renewable projects, thus undermining these projects' access to investment. Renewable projects that do get funded end up paying higher rates, reducing their competitiveness. Unreliable data, compounded by a lack of technical capacity in both countries, also impede the preparation of detailed environmental impact assessments. This ultimately results in the incorrect pricing of negative externalities of coal consumption, potentially making electricity from coal less expensive than it would be otherwise.

The other more fundamental challenge that makes renewable resources even less competitive is that they impose additional integration costs on the electricity grid. Nearly 20 percent of all installed wind capacity in China remains cut off from the grid, partly as a result of troubles with integration.[55] Even those that are connected manage to achieve utilization rates of just 22 percent, one of the lowest in the world, because of frequent curtailment.[56] By comparison, U.S. wind farms achieved an average utilization rate of 34 percent in 2014.[57] Integration issues can be managed carefully and mitigated somewhat, but only if sophisticated technical and management expertise is applied. For example, Indian law stipulates that wind-farm operators face significant penalties for supplying electricity to the grid in amounts that vary by more than 30 percent from predictions.[58] Since exceedances are common, Indian wind-farms end up paying hefty fines that increase the overall cost of wind generation. Adopting international forecasting methods could reduce average variation of Indian wind generators to about 12 percent, enough to avoid all penalties.[59]

To get an idea of just how big nuclear power's CO_2 abatement potential is, consider the amount of carbon it currently prevents from being dumped into the atmosphere: together, nuclear power plants in China and India keep about 140 million metric tons of CO_2 from being emitted each year.

Then there is nuclear energy. It has the capability to provide large quantities of baseload electricity that is vastly cleaner than coal, more reliable than wind, and less reliant on supply infrastructure than gas. Although nuclear power currently plays a tiny role in both China and India's electricity mix—2 and 4 percent respectively—it is hard to see how global temperature rise can be restricted to 2 degrees or less without it playing a more significant role in the future.[60] To get an idea of just how big nuclear power's CO_2 abatement potential is, consider the amount of carbon it currently prevents from being dumped into the atmosphere: together, nuclear power plants in China and India keep about 140 million metric tons of CO_2 from being emitted each year.[61] Assuming all planned new capacity is built, about 50 billion cumulative metric tons of CO_2 would be prevented from reaching the atmosphere by 2050.[62] Even then, nuclear power will provide just over 10 percent of either country's total electricity.

There is thus plenty of room for nuclear power's share to grow and for it to make the task of remaining within the 500 billion metric ton budget of cumulative carbon emissions easier. But three interconnected issues scare the public and muddy the cost-benefit calculus of nuclear: the possibility of another Fukushima-like incident, the threat of proliferation, and the growing stock of spent nuclear fuel or waste. Design improvements in the latest generation of reactors address some of these issues.

But the real game-changer would be reactors that use thorium as fuel, if they can be successfully commercialized. Liquid fluoride thorium reactors (LTFR), unlike current uranium-based ones, are capable of operating at atmospheric pressure.[63] This absence of high pressure means that a blow-up is almost impossible. Thorium reactors also produce very little waste; whatever waste is produced loses radioactivity much faster compared with waste from today's reactors, making waste storage easier. Turning thorium into weapons grade material is relatively difficult, thus reducing the risk of proliferation significantly. With so much at stake, it is no wonder that both China and India are racing to build commercial reactors that run on thorium. Successful deployment of LFTRs, however, continues to prove elusive. This is largely due to the gap that exists between research and commercial reactors. In the words of Hyman Rickover, a U.S. Navy Admiral who oversaw the development of the world's first nuclear powered submarine (and thereby cleared the path for commercial nuclear reactors to be used for power generation): [64]

> An academic reactor … has the following basic characteristics: (1) It is simple. (2) It is small. (3) It is cheap. (4) It is light. (5) It can be built very quickly. (6) It is very flexible in purpose. … (7) Very little development is required. It will use mostly "off-the-shelf" components. (8) The reactor is in the study phase. It is not being built now.
>
> On the other hand, a practical reactor plant can be distinguished by the following characteristics: (1) It is being built now. (2) It is behind schedule. (3) It is requiring an immense amount of development on apparently trivial items. … (4) It is very expensive. (5) It takes a long time to build because of the engineering development problems. (6) It is large. (7) It is heavy. (8) It is complicated.

LESS THAN TWO DEGREES REMAINS POSSIBLE; BUT BARELY

Transforming the electric systems of China and India is a monumental task and there is no silver bullet at hand. Only a structural transformation can produce the kind of vastly cleaner electric sectors vital to stabilizing the climate. This article has outlined what the critical steps are: institute market reforms to establish robust energy markets and to provide a level playing field so that low-carbon sources of electricity are able to compete effectively; reshape the political economy of electricity to neutralize vested interests that find the current status quo lucrative and will therefore oppose any market reforms; and address technical barriers to speed up low-carbon resource development. Each provides a piece of the solution to the system transformation puzzle. Implemented together, they have the potential to put electric sector development in China and India on a path that is consistent with both global climate goals and the countries' developmental aspirations. ***f***

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