

The Future of Green India: Energy and Climate Change: The Mittal Institute, Harvard University

Speakers

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Chaired by Henry Lee

Henry Lee: Welcome. My name is Henry Lee and I'm on the faculty of the Harvard Kennedy School. Welcome to The Future of Green India: the Energy and Climate Challenge. Let me quickly review the sponsors because I know in the end we're probably going to have so many questions and be compressed for time. This event is sponsored by the Laxmi Mittal Institute which is part of the South Asian institute at Harvard, the Harvard University Center for the Environment, the Harvard project on Climate Agreement and the Environment Natural Resource Program at the Belfer Center and I would also like to thank the sponsors at the Harvard Global Institute.

I think we have a very interesting program today. Let me try to begin with a few words on putting this whole issue in context. India is the third largest energy consuming country in the world, it's consumption has more than doubled in 20 years, yet 80% of it's demand is met by coal, oil and biomass. The International Energy Agency in Paris claims 'to meet its future projected growth, India will need to add an electric power system the size of the EU's every 20 years. India has had some very impressive successes in the last few years. It's now hooked up to the national grid, all the villages in India. A task that many people doubted when it was announced several years ago and its solar PV deployment program is one of the world's most ambitious. Yet many challenges remain. Energy poverty remains a major problem in India; water especially in the eastern states has become a big problem particularly with the droughts that those states experienced in the last few years. Energy demand for road transportation is forecasted to double by 2040 which means among that forecast is twenty five million more diesel trucks and the temperatures of the summer together with the migration to cities of over two hundred fifty million more people will dramatically increase the demand for air conditioning.

Now we've got three excellent panelists here and to talk about these issues. Let me introduce each of them and then turn the program over to them for their opening statements. Narasimha Rao is the associate professor at the Yale School of the Environment. He received his doctorate degree from Stanford, his researches examines the relationship between the energy systems and human development and climate change. Dr. Rao is a senior research scholar at the IIASA in Vienna and an adjunct at the Ashoka Trust for Research in Ecology and Environment in Bangalore.

Our next speaker is Mahua Acharya, who leads the Convergence Energy Systems which is part of the Energy Efficiency Service which is part of the Indian Ministry of Power. She works on topics at the

intersection of renewables, electric mobility and climate change and prior to this job she was the assistant director-general at Global Green Growth Institute, in Seoul, Korea.

Finally Abhishek Malhotra is an Assistant Professor at the School of Public Policy at the India Institute of Technology, New Delhi. He received his doctorate from ETH in Zurich and his research focuses on policy design for low-carbon development and innovation in clean energy technologies and hopefully he will be part of the Belfare center here as a fellow here with us on our program, working on India and energy; with this let me send the program over to Dr.Rao.

Narasimha Rao: Good Morning and Good Evening everyone. Thank you for the invitation to be here. This is a very crucial time, I think in human history actually with the run up to the next climate negotiation and also the expectations that countries are going to be expected to ram up their commitments to the Paris agreement and you've seen a lot of hype around that with the country governments making promises but there is also this view of treating all countries alike despite vast difference in capabilities and internal development challenges so its important to pay attention to the facts on the ground. So I have two themes that I would like to cover in these few minutes before we open up to a broader discussion the first is I want to put into context the successes that we've had in India and the challenges ahead for reducing emissions. The second is to discuss some of the points of intersection of climate mitigation with what I think are extremely important and lacking equitable development efforts within the country as well.

I want to start and lay the context out using this very useful figure given by the International Energy Agency in their recent report, it shows you the energy demand in India by sector along these columns and showing you the fuels that are used in each of these sectors. Keep in mind that electricity is a fuel as an input at the end use level so the coal used to produce electricity is not shown here. These are end uses. If we look at the overall big picture, the Indian energy sector contributes two-thirds of India's greenhouse gases so about two and a half billion tons, just under two tons per capita but also keep in mind that there's another billion tons also of carbon dioxide equivalents methane and nitrous oxide that are primarily from agriculture so the total of about 2 and a half to 2.7 tons per capita is a little more than half the world average compares to 16 tons per capita in the US. Most people are familiar with the electric sector and the remarkable growth that has taken place in renewables as we see over here, especially with solar and wind and its interesting that about a quarter of the installed capacity in India right now excluding hydro is from renewables. This compares to in the US about less than a quarter of the installed base including a large share from hydro is from renewables. So there's a pretty remarkable growth. However, at the same time you notice this black line showing the share of renewables have stayed fairly constant for a while and that's partly because coal capacity growth has match renewables growth until very recently but there has been a turnaround in the last few years where you have seen more renewables installed than coal. I would say regards to the future the jury is still out because we are seeing in the policy agenda; we see policy support for renewables as well for making coal mining potentially easier so it's a little bit unclear in the future. Taking into account also the political economy of the coal sector, how will the carbon intensity of electricity production end up but certainly the growth targets that have been set in the end of season appears to be on track to be met. Lets look at the rest of the economy so we have cement and steel which are independently dependent on coal aside from

electricity, steel for cooking and cement just for heat production. These are kind of the bedrock of development and we have them growing at a very high growth rate. The fertilizer industry is heavily dependent on natural gases, in India but half the calories are met by grains, rice and wheat are ready fertilizers heavy. We also have growths in consumer products which are basically petrochemicals not only in plastics but even clothing is increasingly polyester and nylons and these are all sectors where we don't have ready decarbonization solutions. This is the challenge anywhere in the world actually and particularly important in a developing economy.

We are going to be talking a lot about transport, a lot of talk about electrification. We have to keep in mind that more than two thirds of the country right now use public transit and the growth in automobiles however exceeds the growth of other sectors and in the transport sectors and keep in mind we have a lot of people who don't have access to motorized transport. We have also high urbanization expecting that half the population in 2050 will be living in cities and how we meet their travel needs will be absolutely critical for our emissions as we talk about little bit later and finally with air conditioning it's a large rate product but the growth rate is tremendous, we expect millions to be sold in the next decade but at the same time we expect hundreds of millions to be exposed to heat stress and not be able to afford air conditioning and we have to think about that as well, finally we have an upwards of eight million people who still use solid fuels for cooking which kills about one millions women and children in a year and some research we've done has shown that even moving all of them to Liquid Petroleum Gas LPG actually would be good for climate, it will reduce overall warming. This is extremely important from a health perspective as well. So this is a the big picture and I think we are going to talk about different challenges for reducing emissions growth but it is also important to understand that we need to think about what are the key development priorities in India to eradicate poverty and so I just want to talk about that and throw that into the conversation. We have done some research to look at what are the gaps in living standards in India and you see that the ranging across household amenities, access to water and sanitation, nutrition in terms of iron intake, having safe shelter with the potential need for air conditioning as well as having access to social wellbeing and to the internet and devices to access the internet. All of these are lacking far in excess to what we see as acute poverty in the World Bank's development measure so we wanted to ask if we wanted to eradicate poverty what would be the energy needs and where would be the most intensive areas we need to focus on and this is a global study but this is for South Asia and you see the large blocks in the middle are India and its clearly that seeing that mobility dominates the energy needs just for providing basic living standards to everyone in India. Given that public transit has a much lower energy intensity than automobiles and even two-wheelers, it's really important that we think about ramping up public transit not only buses but even rail which is already electric to a large extent but it could be even more so we need to focus on public transit especially in cities there's significant co-benefits for air pollution, for congestion and other benefits. So we really have to keep an eye on public transit. I have already mentioned clean cook stoves, in healthcare we need to provide access to hospitals to everybody, basic amenities in the home like refrigerators. I don't see any clear solutions there for significant efficiency improvements other than just higher standards for appliances but some of the other big areas that are important are construction materials and we have seen that there is a potential to use local materials, things like stabilized earth blocks to replace cement that can reduce energy use, they are cheaper and they provide the same

stability and service to people. So we have to think about new construction practices scaling up across the country we have about fifty million units today that need to be upgraded or need to be made into quality that are resilient that can protect against disease.

Finally I wanted to mention food security currently people depend on grains as I have mentioned and from our research we have shown the methane emissions from white rice are quite a significant contributor. We can increase nutrition things like iron by moving to coarse grains and reduce methane emissions as well and from our research we have shown that we can shift about 20% of production to coarse grains without reducing overall production, sorry, 20% of land use to coarse grains without reducing overall production. Of course people have to be willing to change over to these different dials. That of course is a big challenge so I'm gonna, those are the overall areas I wanted to bring up we can discuss later. Overall I'm quite optimistic I think there are many opportunities here for dove tailing , climate policy, goals of climate mitigation with the most fundamental needs of people in society and I want to stress that transport, public transit, housing, efficient construction and diets are areas we need to focus on in addition to what people talk about more generally with regards to decarbonization.

So I'll pass it on to my other panelists and look forward to discussion later. Thank you very much.

Henry Lee: Thank you. Mahua you wanna go next.

Mahua Acharya: Sure sure. Thank you Henry and again thank you to Rob and his colleagues for having me on this panel. I don't have slides and I deliberately chose not to use slides because I wanted to try to explain a little bit of a story to the lay person.

Renewables in India and in a lot of places has now become so technical that I find that unless you tell the story only the very technical people relate to it when in fact it is a reality of injecting more renewables into the grids in India is now a difficult challenge. It was anyway a challenge and now it has become more difficult. Let me put a little bit background to this.

India has a target of a hundred and seventy five gigawatts by 2022 and this target was up to four hundred gigawatts sometime after September 2019 if my memory serves me right and by all measures India is on track to reach these targets. It will reach the 2022 target soon and probably surpass the target so in climate balance this nationally determined contribution, India will probably be long on this on the nationally determined on the climate plan that was presented at Paris.

What is happening in the country is adding more renewables to the grid is becoming a challenge. You will hear in the media that solar has hit an all-time low, record low prices. Indians rupee terms less than two rupees a unit and it has, solar generation is at an all-time low as far as prices are concerned for various reasons not all of which are technical many of it are increasingly financial and certain level of market sentiment but lets also remember that coal is becoming just difficult to defend. Not only that it is proving you a baseload power meaning firm power, its just also becoming very difficult to finance and very difficult to defend and there on the other side you have the solar thats the cheapest source of power by the time it enters the grid in a lot of grids in the country, its about three times that price so you are selling , you are producing the price at two, you produce the solar at two by the time you are

selling it to the grid and by the time the grid ends up having to pay for it is three times that, it makes no sense at the point.

A lot of utilities in the country do not want day time power because for this one reason that suddenly when about 6 o'clock in the evening when the sun goes down there are load drops and then what are you going to do as a grid operator. You got to switch something else at 6 in the evening which is peak time, everybody is going home and the load goes up. So many states in the country right now are switching on old coal plants so normally does it negate the whole climate issue but then suddenly as it is you were buying expensive power and now you end up buying old coal power which is also very expensive so the answer to this lies in this technicality and the large body of technical issues where grids have to increase their capacity, they have to augment their transformers. India perhaps will need a new market to optimize these resources, we need a market for what's called ancillary power like how do I, what do I use at 6pm when the sun goes down and the wind is not blowing, not everywhere there's a wind blowing in the evening, in some states it does and when it does its nice and smooth it is fine, in others it is not so what do you do? You put on the switch you put on coal, it doesn't really sound so great. It is technically cost feasible, we use hydro power, we use what is called the pump tracker, we use the gradient of water falling from high up to down there and you use that and say ok I am going to quickly produce some power supply in the evening. Alternatively you put in batteries that is technologically more superior solutions. The problem is battery prices are not yet at a point where they will compete with the price at which the grids are paying for day time power or for what's called infer / variable power, there's green power that is coming in. Now we have two choices as a country either one can sit tight and say I'm going to wait until the battery prices are going to come down and at some time it is going to be competitive. On the other hand, I could perhaps make some interventions and what will those interventions be, now this is the power sector which is 60% of the climate problem comes from the energy sector and then there's transportation. For once and after so many years in my career there for once there seems to be an answer, the climate answer, the transport problem. When we had the carbon trading business out there, it was so difficult to go car by car by car. You couldn't do it, not even when it was so difficult it is impossible.

So there was no alternative to switch fuel, ethanol only works in Brazil so what are the options? Today there's for once there is a technology and it's a promising technology and for once after a long time especially in India, I live in Delhi. The pollution is becoming, of course there was a problem but now it is a stated governmental problem and the government is saying I'm going to do something about it so electric mobility is becoming an answer. Now lets say there are very ambitious electric mobility targets in India even if 30% of those targets were met, just a third, the amount of stress that would be put on the grid is again, you switch on your car at 6 in the evening when you go back home from work otherwise the same battery that is using, that is charging your vehicle could also be used to service the grid. Now suddenly that battery has more than one revenue stream to it, in feasibility studies that I have been involved in the most recent last two three months we find that without any subsidy with normal cost of capital on market terms that if a battery were to service your car and service the grid, it would still produce power that is cheaper than what the grid, in that particular grid because all of it is customized in that particular grid is cheaper than what the grid currently pays for buying/ turbine

power. So in other words if we just expand the way our policy formation works we would be able to make battery storage competitive, commercially competitive. No subsidy except that today our, India's regulators and I think its not just India's regulators in a number of other places there is no regulation to capture these two different value streams. With a single batter I've got charge going on and with the same battery I could perhaps be doing two different things for the grid that could stabilize a piece of the grid, I could differ a certain capital investment. Two three things I could do and the value delivered to the grid can certainly fetch a different price for different values. We don't have that regulation or that regulatory framework today so in the absence of that if I were to say ok on a kilowatt basis I could still come in cheaper. So what's the, of course India will meet its target but really the issue is now that solar is so cheap now that we are finding ways to find, to do decentralized renewables because land is a very difficult thing to find, large tracts of land in a very densely populated country is very difficult. Suddenly there's a possibility to expand the things, the way these policies work and suddenly there could well be a possibility where the real challenge in front of us is the grid is no longer a technology push, a political push. It's just a very serious issue the grid is no longer able to absorb the renewables coming in so I think our climate problem has reached a point where I started by saying its technical some the terminologies in these power sector discussions are very easily go straight over and I mean this would go over my head so can you imagine the disconnect with the climate policy person and the disconnect with somebody who does not necessarily have to get into the business of how many volts, you know what's ancillary and what's not ancillary that's really not the deal so as far as the climate policy is concerned this is really the big challenge I think this is the biggest impediment in front and unless India addresses this which it is but it is addressing this in batches unless it addresses it head on this will be the single largest limiting factor.

Henry Lee: Thank you very much, that was both excellent and provocative and will have questions for you to later in the discussion. Abhishek.

Abhishek Malhotra: Thank you Henry. I will share my screen and in the meantime I would just like to thank you again for giving me this opportunity to present here today. I am going to talk about something slightly different. We do talk a lot as a country about deployment, about cost reductions and the barriers to cost reduction and deployment but something that often gets missed out and as anybody would say about their research topic does not get enough attention is innovation in industrial policy so just to frame the issue innovation in low carbon technologies has enable a shift in how we see climate action so as Narsimha and Mahua have already mentioned there has been a tremendous cost reduction in several low carbon technologies Solo PV being the cost reminder of that but also lithium-ion batteries, LEDs so there are several technologies because of which the entire conversation around climate change mitigation has changed where the narrative has changed away from thinking of it as a burden and how it has to be shared globally but rather now as opportunities so there is a shift towards aligning climate with economic development so exploiting the co-benefits as Narsimha highlighted, benefiting from the low cost of these technologies but also the opportunity to create industries and jobs around these new and emerging technologies. Particularly in India, it hasn't only been since Paris, it always has been on its bandwagon for quite a while since before that so some of these examples that we've already talked about India came up with the National Solar Mission in 2010 which has been a big success in a lot of

terms, in terms of deployment, in terms of meeting targets related to cost reductions but one policy goal that often gets left out but is now receiving some prominence is that the national solar mission also aimed at setting up low quality, low cost high quality solar manufacturing in the country something that has not happened so far. Similarly for LEDs, it is a major success in terms of the scale and brevity in which this technology has diffused in the country but again innovation and manufacturing of this technology is something that we still lag behind in and right now the next big focus for the government seems to be lithium-ion batteries and electric vehicles which is again a tremendous opportunity and that is something that we seem to be getting left behind on when it comes to manufacturing in technological innovations there are some big questions that need to be addressed to avoid that so what does this mean for India's low carbon development strategy so I put together these graphs just for fun and also to place the issue more in context so these key technologies that I just talked about I just want to highlight few things from this slide are one the scale of deploying these, at which these technologies need to be deployed are enormous so Solar PV still represents only 4% of the generation skip in India's power mix having said that I don't want to diminish the achievements where prices for Solar PV have come down to around 15 to 17 rupees in 2011 and around 2 rupees now and annually we are deploying around 7-8 gigawatts but the local manufacturing capacity is still just 3 gigawatts. The import bill of importing solar cells in 2018 was around two hundred and sixty seven million dollars so similarly for LEDs we've seen a tremendous increase in its market share and the price has reduced from 310 rupees in 2014 to 38 rupees in 2016 but still the semi-conductor wafers and chips are largely imported and similarly for lithium-ion batteries and electric vehicles the grey part is two-wheelers for internal combustion commercial engines and the blue part is four-wheelers with internal combustion engines and this is just in terms of numbers and I promise I did put in electric vehicles in so there a tiny share of the commercial annual sales which is not even a percent yet but this is a huge opportunity particularly in two and three wheelers but right now the global manufacturing capacity is around 600 gigawatt hours for lithium-ion batteries whereas India has none at the moment domestically so how can nations not only India but other nations looking to benefit not only from cost reduction and climate change and mitigations and other co-benefits such as improved health due to improved air quality, how can they capture other co-benefits posed? The opportunities are posed by these new and emerging industries localizing industries, creating jobs around them so these are the questions and I apologize for that because there are no clear answers here but these are questions that need to be addressed I believe

So how does one build institution to organize for emissions in the energy sector? How does one go beyond the short term political cycle that the executive and the legislation in the country usually is and plan for on a decadal scale in terms how to rule out these technologies and how to invest in knowledge and R&D and commercialize innovative technologies in a longer term? How do we integrate different actors in the system that are required innovation all the way from R&D institutes, testing labs, building up human resources through training, having different sectoral ministries. What does this mean? Does it require an integrated framework for energy innovation policy in the country which sets up mechanisms to set up technology roadmaps and bring actors together and priorities technologies and invest in them in the longer term, that is the question that still to be addressed.

Another big question mark is over technological capabilities so right now there is not a systematic effort towards mapping technological capabilities that already exist in the country and how they fit with emerging technologies as well as where the gaps are so in the longer term do we want to focus more on specific technologies or do we want to focus on building up capabilities in related sectors for example the chemical sector for bleaching manufacturers, it's a broader question related to where capabilities related to advanced cell chemistries and materials science and how do we pick winners how do we identify this fit between the local capabilities and emerging technologies and how do we invest scarce public resources in a smart way that is something that is still we are quite early in terms thinking and having the answers to and question such as what is the role of startups and incubation what is the role of large state-owned enterprises where the largest 10 maharatnas, the big state owned enterprises in India where eight of them are in the oil and gas sectors so what is their future how do we diversify away from these technologies and how do we have to manage phase-out of this technologies , are they complementary technologies and sectors where they can already diversify their technology and investment portfolios and finally how does India place itself in the larger context of innovation that is happening internationally in other countries and in global valuations? Are there opportunities for collaborating in RD&D and often these collaboration are limited to pre-commercial stages because as soon as there is a potential for commercialization, countries tend to look at their own interest but are there complementary capabilities in global value chains

For example as in the case of Solar PV, China scaled up manufacturing of Solar PV cells but a lot of production equipment came from Germany so similarly if India plans to build battery packs which are adapted for India climatic conditions for electric two and three meters as well as passenger people's, is there a potential to work with cell manufactures that might be based in Japan or South Korea or increasingly now China and have effective industrial partnerships to adapt and localize some of these technologies so these are some of the big questions that keep me occupied and some of the questions that urgently need to be addressed that we can effectively answer them in the coming decades to make sure that besides preventing the negatives of climate change and mitigation we also do not miss out on the positives and I will leave it at that.

Thank you so much.

Henry Lee: Thank you for 3 terrific presentations. You have done a terrific job, we are still on time which would not have happened if we had 3 Harvard faculty members and you raised a lot of questions. I have a number of questions on the whole area of the electric grid before I get into that I want to just ask a broad question.

All the countries in the world have been admired in the worst pandemics in a couple of hundred years and this has hit India, where do we stand now a year and a month into the Covid'19 pandemic in terms of India's goal on energy and India's goal in reducing poverty and India's development goals. What is the state of India today? Narasimha you want to start with that?

Narasimha Rao: Yeah. I mean this has been a devastating challenge and I think we don't even know the extent of the challenge today that is in India. Just understanding the situation and how it differs in

different places in itself is a challenge. I think on the one hand it deepens the social crisis that we have in some of the important poverty alleviation challenges, I think we have significant employment issues. The agriculture sector has been hit really hard and addressing those is now of primary importance, of course in India. We have seen significant reduction in the overall growth in the economy and that may look like it's a good thing for emissions but it's obviously just temporary and I don't expect that it's going to put a dent in any significant way on the future growth, in fact we hope that it's going to restore to previous growth. I think there also because of the changes in employment growth its put a slight dampened the extent of the growth that has taken place in the renewables. So it's been a bit of a setback in both fronts. I don't think any of the overall goals have changed, I don't think there is any new, particularly any new opportunities, it's just, yeah, it has made all of the challenges both for climate change and mitigation or poverty alleviation a little more stark. I must say for now it's not a very optimistic story from my front but maybe my other panelists have some more specific views on the ground.

Henry Lee: Before I turn to them, let me say to the audience. You will see yout the bottom of your screen a Q&A icon, if you have a question just click on that and ask your question.

Does anybody else on the panel want to reply or add to what Narasimha has said, Mahua?

Mahua Acharya: Yeah, I could go. Yeah sure.

So the pandemic as far as the energy sector is concerned, let me try to limit it to the energy sector for now. You will see in a lot of announcements or even if you were to look at the data. The energy demand has recovered, pre-energy demand, energy demand pre covid is now back to today's energy demand is back to pre-covid levels but if you were to split that data which a lot of people don't necessarily do and is sometimes a little deceptive to say energy demand is come back up and so things are fine . In fact if you were to look at that you will find that in some states that have high agricultural load and high domestic load have gone up hugely and states that have high commercial load and high industrial load have not gone up as much and a lot of this has to do with the fact that in the coming year, I think in the coming 2 years agriculture productivity is expected to go up, 3.5% is the national number, maybe around 3.4-3.5 whereas industrial and services is expected to contract between 8-9% that's what's going on, that's the dichotomy. The single line does not reflect is not enough of the story and all India power demand there's a lot of announcement all India power demand touched an all-time high, it is correct. It is absolutely correct all India power demand is back up again but there's a decline in the labor force for sure because the service industry has been hit very badly. This means that there is an increasing gap between the rich and the poor, which is really the sad outcome, one of the biggest sad outcomes of the pandemic. So underneath the energy numbers it tells you a very different story and I think one has to look underneath that to understand the socio-economic story that is still very much brewing in the country.

Henry Lee: Abhishek, do you like to add anything?

Abhishek: Yeah, I would just like to add to what Mahua said particularly in the power sector on top of these disparities between different types of inconsumption, another effect of the pandemic has been to

expose and not that it was not common knowledge before but further expose the weakest chain, link in the chain when it comes to the power sector which is power distribution so India's power distribution utilities have perennially been a lot of them have been making losses primarily because of two reasons, one tariffs for agricultural and rural customers mostly are set below cost recovery levels and that is because electricity is seen as a renewable and has to be divided at an affordable price but the challenge is when the distribution utilities are not adequately subsidized to pay for these below cost recoveries tariffs which is often the case because states either do not release the subsidies or delay in doing so because these distribution utilities are perennially, financially stressed that has effects on not only on power generation but on the economy as a whole so vast quantity of non-performing assets for banks are actually in the power sector and because of lower demand for at least a few months even though demand has recovered now a lot of -- are in pretty bad financial shape to the extent that after only five years I believe last in 2015 was when it was when Denise Lee Package was announced for distribution utilities, another one is in the pipe line so that is a bottleneck and a roadblock that is likely to impede deployment of renewables in the coming years if it is not addressed because the lack of credit worthiness of the distribution utilities can be a big impediment for investment and the power generation in the coming years and does need to be addressed relatively soon and because of the pandemic that's become amply more clear now.

Henry Lee: Thank you. Let me turn to what I think is sort of the guerilla in this room which is the coal industry. All of you have painted a picture of a world in which, of India where the air pollution is getting worse in the cities that demand for solar, I think Mahua has pointed has plateaued a bit. You've got a situation in which the potential future demand for electricity is not only going to rise because of increase of urbanization, increase in demand for air conditioning but also if you move to electric vehicles or you move to electricity as a substitute for oil and the steel industry or other industry even more has been projected .

Mahua you have pointed out that renewables don't work as well at 6 o'clock in the evening and so I am looking at all of this and I am look at the goals and I am now going to plagiarize one of the questions that was asked here but you know if you look at India's thermal power generation sector, emission control technology has been consistently delayed in that sector. Time and again over the last seven years and according to CSE report 70% of India's coal fire power plants won't make the 2022 deadline. How are we going to a) reduce the pollution from these facilities and b) phase them out over time given the enormous increase in demand and the intermittency problem that is pervades solar energy. I come away saying you've done a terrific job on describing the challenges now I want you to help me find what the solutions is so I am going to start with Mahua then I'm going to go through all three of you to address this.

Mahua Acharya: Sure, sure. Yes, Henry this is coal it is a problem. In fact it is the guerilla in the room, yes you are absolutely right there are about 22 coal plants that have not reached the goals for desulphurization. Yes, you are absolutely right that those goals have been a bit of a moving goal post and there has been a moving goal post story for a while. The second point is which is a problem is not of old coal plants that are still working, there are a lot of old coal plants that have been switched off but not decommissioned they have not been switched on again after the pandemic or since the pandemic.

So they are sort of sitting idle. There are a number of other coal plants that are on the decommissioning board but that decommissioning takes a bit of time so all of this needs to be packaged together and something has to happen to them, the ones that need to be decommissioned which is the economic theory of decommissioning would be if the cost of keeping the plant alive which is the cost of what's called fixed power plus variable power is less than the cost of, is more than the cost of round the clock power then really the economic theory says you should really stop that plant because it's causing, it's unnecessarily bleeding the distributing company dry that is the problem. There's a number of those plants the last discovered tariff for round the clock power was X, there's quite a few plants whose tariffs are, who are in long term agreements and their tariff is higher than what it would cost to buy round the clock power. Should the distribution company simply decide to buy long term power from someone who is able to synchronize wind and solar with the battery for example. That's one, there is some discussion that is still ongoing on how to expedite this decommissioning and very recently I think as recent as last week there is a new order and there are very small small reforms that are taking place on a daily basis. Nothing massive because doing something largely massive with the coal sector runs into employment issues. It runs into the issues of just transition, it's not really the people working in the coal plant but it's also of the people working in the mine that services the coal plant and there's no answer to it. The largest coal mining company in the country gets 20% of their mines generates 80% of their revenues and I think about the majority of their underground mines are lost making. So there's this, to transition a portfolio as big as that takes time and there are a number of issues that are not necessarily just social, what do we do with money? What do we do with the unions? What do we do with these long term power contracts so the answer to this long term power contracts has been revealed last week where the utilities now are allowed to get away from situated contracts that are simply feeding these old coal plants whose plant load factors means their efficiency has come down below the technical minimum that you have to keep these at so it's really a bunch of questionable, there's a lot of questionable aspects which I think, I'm fairly sure the government is aware of and there has been discussions such as coal for solar kind of swaps, coal for renewables something that works like a cash flow clunkers, you will have to do a lot of work to synchronize the renewables and make sure that you were actually really able to bring on board renewables, etc., etc. but these are very large endeavors. Switching off coal plants is also not an option now, technically not an option simply because of the 6pm problem that I raised. It just is such a large capacity there's a number of measures that need to be done over a period of time but I'll say everybody is aware of this issue.

Henry Lee: One of the reasons I asked the question also that I look at China which has made a number of statements about phasing down coal but at the same time has 200 coal plants now in planting the construction level so it's getting wealth of coal simply not just closing down what you have but not building any more of them seems to be a challenge there and I would say the same challenge, the same conditions that creates the problems are also going to manifest themselves in India.

Abhishek do you want to address this?

Abhishek Malhotra: I'm am by no means an expert on this but I would to give credit to some excellent colleagues who have done great work on coal and thought about these questions for decades. Rohit Chandra who is an assistant professor at School of Public Policy was at Harvard Kennedy School has

been looking at coal and my thinking has been formed a lot by his work so which seems to point towards the fact that although coal does not have a very positive future it is not going anywhere, anytime soon so already investments in coal plants have been declining and are stagnating at the moment, which is partly to do with India's stagnation in power demand but in the near future a big question is because India's coal sector is largely insulated from global pressure on investment because a lot of coal mines and coal infrastructure is financed by state owned banks and not by private investors which have their own pressures related to ESG requirements. You see this public good rationale being played out with this job creation rationale when it comes to decisions related to either investment or phase out of any kind of coal infrastructure so the big question is how do we transition or get away from in a way that is a) politically feasible and b) socially just. We have seen from the farmers protest that recently how any shocks to the system will not be taken well, where if there is a threat to the livelihood of millions of people particularly in Indian states that are the core belt holds the primary form of economic activity and not much else going on, there have to be ways to get out of that, we have to think of economic diversification, we have to think about compensation, we have to think about reskilling, redwelling and reemploying those people in other sectors of the economy.

So it by no means is going to be easy but thankfully or not its going to be a slow process which gives us time to think about it which is also not great if you want to do it fast enough by latter half of the century.

Henry Lee: Narasimha?

Narasimha: Yeah, you have heard already. I will just add a couple more points I think we should also pay attention to the importance of the coal industry for the government's finances so you know I think a quarter of the tax revenue is for the federal government, central government comes from coal, from energy, from taxing coal as well as petroleum and other products and if you include indirect so things like dividends from the coal from the companies that are the public sector companies. The overall revenue of the government is also about 20% also so this is a fiscal issue as well even at the state level and the central level. It is a geographically concentrated issue as well as Abhishek pointed out the states where we have greater dominance of employment we have financial dependence on the coal industry. Yeah, it's not going anywhere. I agree completely with that being said, you did ask about solutions so I might venture into talking about that a little bit. We have tremendous amount of demand growth so how can you meet that with renewables so one has to think about skill and the government of course is trying. The grid issues are paramount, the ability to provide some kind of soothing if not the supply through the demand with the storage are incredibly critical and the extent to which technology transfer arrangements to make those more to accelerate the deployment in India I think its possible. I think I have seen model runs these are of course idealistic showing that one can manage with storage with pretty high percentage of solar and wind if they are managed and sited appropriately but it's a lot of technical issues but one has to think of skill so more of roof top solar which is more expensive, harder to deploy, low density if we can find a way to scale you know high capacity solar and wind with grid integration, I think the transmission grid is up for that. It would be the direction to go but the would be slow.

Henry Lee: Abhishek, I think you talked a lot about leverage the growth in the industrial manufacturing in the new technology. Let me focus specifically on one technology which is batteries and you said that you have a 15 year plan and that India would become a producer of lithium-ion batteries. Two part question one right now the dominant battery companies are in Japan, Korea and possibly China, they have got a 5-6 year lead on India. One might argue why doesn't one just buy batteries from those 3 countries because they are going to be cheaper and better quality at least the next possibly decade also there is a concern that the lithium-ion technology phase out to a new technology cause there are a lot of work going on right now and there's a lot of different alternatives to lithium, I don't know if anyone of them will work but you're in a very dynamic technology changing every two years rather substantially so what makes you think lithium batteries is a good investment strategy for the energy development area going forward.

Abhishek Malhotra: I would like to clarify that I do not think that India should be specifically aiming at lithium-ion batteries and positioning itself to catch up in existing chemistries because as you very rightly pointed out it is a highly dynamic environment and lithium-ion batteries today are very different from what they looked 15 years ago and who knows how they will look like 15 years from now in terms of their chemistries, home tractors you will see probably a lot of evolution in this space. Regarding the question of whether it will make sense to buy them from abroad. Yes, I totally agree, particularly where you see that more with Solar PV where you see a lot of efforts to set up custom duties to have protection for domestic manufacturers where often not only India and several other countries, the effect that it has is Solar PV just more expensive locally and does nothing for local manufacturing, innovation or cost reduction or job creation. So the broader question rather than focusing solely on specific technologies and trying to have local production and going along with this narrative that seems to be quite popular globally of self-reliance or in India 'Atma nirbharta' on not relying on external inputs looking inward and having narrow view of domestic industrial policy. The question that needs to be addressed is how does India organize itself in the longer run to be ready for the next opportunity that comes up when it comes to energy technologies. So I totally agree with you that India has totally missed the boat on the current generation of lithium-ion cells but even Japan and Korea which has had a 30 year start because that's where the cells for laptop and phones came from even before they were deployed for electric vehicles. China and US including Europe are ahead because they have been thinking about this for more than a decade. Investing in R&D, investing in Human Resources, infrastructure to set up an ecosystem for innovation and manufacturing but the key question for now is how does India orient itself for the future and not for the technologies that are here right now?

Henry Lee: Ok, Narasimha you want to add to that at all?

Narasimha Rao: I totally agree, I just wanted to point out the international dimension here. We see the story of solar a lot of the demand was created in Europe including Germany's million reuse program and India wanted to be the global sole manufacturing leader, China won that race and we ended up being benefitting from the spillover of that and we just have to recognize where we have to be a market leader and where we have to be a market follower and certainly batteries is where we have to be, I think a follower and there has to be a lead take in other countries to develop scale and some of the essential technologies that are needed everywhere and I think we have to write on that, the key

requirement that may require a lot of local innovation and development are on the smart grid and the specific conditions in India of the grid, of the resources, of how to best integrate them requires a lot of context, specific knowledge and R&D I think that's an area we need to focus domestically.

Henry Lee: Let me ask Mahua a different question I have got about four questions that I have come across from the Q&A here all focusing on distribution of energy on a decentralized scale from roof top solars to distributed solar systems and to say that could be an alternative in many areas to the heavy focus to the centralized systems. How would you respond to those questions?

Mahua Acharya: 100% absolutely agree Henry. I would go one step further and says the current understanding of decentralized energy is that you are completely away from the grade and you cut your little mini grade going on there that is not necessarily the only option, certainly not for India. There is happy medium in between where you're basically putting up solar panels right! Close to that point of use except that you are generating that power to the grid and by doing so having what the grid pays for would've otherwise paid for that feeder or having what the grid would otherwise would pay for even agriculture power by the time you get down to the last feeder it's usually in a remote village in states where the feeder is separated for agriculture versus non-agriculture given them power is free the load on the distribution companies is massive so even at that level I would be able to set up a decentralized system except that we only servicing to the grid now if there was some other another feeder that was not separated I would still come in with a solar power and still half the cost of supply and still have localize generation with minimum losses and if we were able to be creative even putting energy and green future demand because I would be able to be close to demand center so decentralize suddenly takes on a whole new meaning I'm still using the grid except that the panels and the point of usage are right there so decentralize in that sense absolutely I like that question is fantastic just that we should spend the efforts to articulate that the only model for decentralization solar is not completely off the grid because from the investment point of view or even from operate point of view is very difficult to scale those things it's very difficult to expand mini grid into many mini grids. Its very difficult to have isolated solar home systems and scale them its very difficult to have lithium-ion and produce them at an affordable price for individual solarized home system although it's still been done the cost per capita makes it quite challenge to scale that the cost of overheads becomes very high its almost 25% today so yes decentralize but slightly different model.

Henry Lee: How important is finance to all this cause you know we've talked about all these technologies. We've talked about people buying PVs we've talked about in you just mentioned that stepping down power you gotta move power to the other direction which means you gonna have to replace a lot of transformers in the grid system so there is a lot of money that gonna have to come up here where is the money is gonna come from for all of these emerging new energy to technologies and for moving or transitioning to less fossil fuels intensive energy system, who pays for this. Narasimha?

Narasimha Rao: Yeah, I mean this is the other elephant in the room ehre, you know the affordability you know the average income of Indian is 1/10th of that of the US but the most people barely consume any electricity I can imagine them affording any electric vehicle for two wheelers anytime soon so yeah like I said these technologies have to have a global market and have scale achieve to become more

affordable that's one thing. I think utility finances are also important here in the decentralization as well we have to keep in mind the last twenty years in India the electricity sector we had this situation where revenue generating customers leave the grid because the grid is in such a poor shape and such as high cost and losses and we have people moving to the captive power and there is a risk that you have potentially wealthier customers who will leave the grid to have their own PV production, who can afford it and the utility will be saddled with serving poor customers with poor system and not having the capacity to serve them very well so there is a little bit of that issue so it has to be an exclusive process and I do think the government can provide financing I mean of course they can but this is a broader issue of making this technology a lot more affordable than they are today for the consumer.

Henry Lee: Abhishek? You want to add to either of those last two comments?

Abhishek Malhotra:

The other is early stage financing for if not into the world innovations at least for in the context innovation for new untested technologies batteries for example there is not a lot of maturity in the financial sector to provide financing for these first few projects which can catalyze further investments for the sector so those are the two questions that need to be addressed.

Henry: Ok, one more question before I ask everybody to sum up and I'm gonna ask Narasimha The Glasgow conference which cops sort of the pending over now over a year a lot of people are pushing India to accept the pledge to net zero carbon mission by 2060 or a date similar to china. Do you think India should do that?

Narasimha: Given all that you have said I don't think there's any value if there's any value of these pledges is a brilliant diplomacy in the international negotiation space what happens in back rooms there's pressure that's put in the development countries government and I know all of this is aspirational they don't have that much value except in diplomacy. I think in the ground it's mind boggling to me to think about net zero in 2058, it really depends a lot what is happening in the rest of the world. Yeah, I think it can be talked about but it has to be really in tandem with conversations about depends what happening in market place conditional technology in achieving scale batteries becoming conditionally viable under these conditions certainly the condition pledge or aspiration could potentially meet the diplomatic interest but also make clear that those is ambitious required a lot of support internationally but the political economy around some of these we've be talked about the employment the call sectors those have transaction issues are extremely critical and need to be sorted out for those any kind of serious transitions to net zero

Or you have to develop carbon to make it commercially viable to me today it seems a bit fictitious already but that would need to happen if we continue to film independence as we see is very likely to be the case I have looked at scenarios, global scenarios and most of them have continued cold deployment in South Asia. It's just a reality and you just need to have a CCS or some other way of extracting a direct captcha of some kind which brings up again affordability and technology co-operation issues

Henry Lee: Ok, thank you all we have approximately 5 minutes. So that means one and a half minute for each of you if you were to sum up all of the conversations we've had this morning or this evening depending where you are and look at India's future energy destiny where is it going to go in the next 25 years? Let me start with Abhishek.

Abhishek:

That's a difficult question hopefully it is moving in the right direction but just based in the discussion the way is not going that easy a lot of short term issues needs to be resolved .

Issues related to finance, issues related reform in the power sector in the medium terms some of the things we need to think about how to be ensure that transition does not leave behind some of the poorest and most vulnerable parts of the society and how do we leverage these technologies benefit the rural agricultural consumers for example as mahua mentions and how do we transition people whose livelihood is dependent upon the kind of technology is there is in the power sector. A key issue is still as you rightly mentioned Henry about flexibility. We do not have a clear idea about what flexibility endeavours may enable high penetration of renewables in the future. We do not have a lot of gas, storage might be an option but that remains to be seen other options that remain available to other countries are hydro or gas do not seem to be viable now or in the near future so that remains a big question mark in the longer term.

Henry Lee: Mahua you've got 90 seconds.

Mahua Acharya

Oh great I'm very bullish Henry you've given me 25 years you've given me 25 years, absolutely completely. It's gonna be renewable, we will have overcome all of this problems we will have dealt with all this noise. I think 25 years is enough I think you have given a very long run way I'm not half this generation I talked to my government colleagues, I tell them I want all of this done before I retire and I will be retiring before 25 years.

So very very bullish Yea i think so India will have sorted out all their issues of course there will be other issues but I think a majority of these integrated problems will be solved.

Henry Lee: Ok, Narasimha?

Narasimha: Yea I am going to be optimistic as well not withstanding. I just do think there is significant potential that is not being tapped that I think is because of the political economy but I have been pleasantly surprised by the extant changes in the power sector in the last decade and I think that can really accelerate a lot but I do want to emphasis I touched upon a little bit in my talk but I think the real opportunities lies and I found in my reasearch to that on focusing more equivalent equipment can have actually significant disciplining effect on demand growth and missions growth but also really serve the needs of the people. You've seen that the public transport is so much more energy intensive and really focuses on low income people if we focus our efforts on really ramping up public transport rather than electric SUVs and if we focus on grains and sustainable food production and housing these are some of

the key areas where it doesn't really cost much of carbon emissions. If we put in efforts in areas we really need and fix housing, transport and food. I think at the same time if we keep with the grid decarbonization the way we are, I think we can go pretty far.

Henry Lee: Thank you, its on a good note that we have all come to. I want to thank all of the panelists, terrific 75 minutes and I want to thank again the sponsors The Mittal Institute, Harvard Center for the Environment, The Harvard Projects for climate agreements and NRP for a terrific presentation on the I have learned a lot and again I want to thank every bodyfor participating. Thank you all, have a good day.