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P R O C E E D I N G S

MR. EBINGER: Good morning ladies and gentlemen. I'm Charlie Ebinger, a Senior Fellow in the Energy, Security and Climate Initiative here at Brookings and it's my great pleasure today to introduce one of our colleagues from our office in New Delhi, Rahul Tongia, who is one of the leading experts on many aspects of Indian energy but particularly the challenges that are confronting India, trying to modernize its grid, introduce Smart Grid, integrate renewables in large profusion into the grid, not to mention the other broad challenges that the Indian energy sector has in almost every fuel type imaginable. Raul is, for many years, was on the faculty of Carnegie-Mellon University and he recently became an adjunct professor at Carnegie-Mellon. He has been active in the domain of Smart Grids and helped found the Smart Grid Task Force, part of the Indian government, as well as the India Smart Grid forum, a multi-stakeholder body chaired by the ministry of power in India and he is a critical advisor to both institutions. He was formerly a founding member of the Founding Member of the Technology and Advisory Board of Smart Connect, Southern California Edison's 1.2 billion dollar Smart Metering and Smart Grid project, and he was also a co-founder and program director and principle research scientist at the Center for the Study of Science, Technology and Policy, a Bangalore based not for profit think tank. You have his full resume, but I think you'll see that his intellectual interests are indeed Catholic, ranging not only from energy but information technology and modern technologies involving communications, and he has a prodigious publication record that truly covers a number of critical intellectual areas. He holds a B.S. in Science, Magna Cum Laude, in electrical engineering from Brown University, and a Ph.D. in engineering and public policy from Carnegie-Mellon University. Our forum today where Rahul will speak for 20, 25 minutes, and then I will join him on the stage and we will have a brief conversation with him and then we want to

open it to the floor as rapidly as possible to get to address the critical questions that you may have on your mind. So Rahul, it's a pleasure to welcome you. (applause)

MR. TONGIA: Good evening. Well that's what my body thinks since I just got here a day and a half ago, but very happy to be here, and wanted to share some personal views based on facts and experiences and hopefully insights on to India's energy and especially electricity space. I don't want to bore you with facts and numbers because now thanks to the internet, those are out there and you can look them up. And just on an aside, yesterday was the 20th anniversary of the internet as we know it. That's when it moved out of the government's hands, with private sector taking over some aspects of it. And if we now think about the future of the electricity grid, people talk about lots of buzz words. Are you Smart? Well, which utility wants to be dumb? Are you green? Are you clean? And the other buzzword out there is internet of things. That's the future of the electricity grid, that it will be a smart grid. Everything's connected and people will be able -- your fridge and toaster will be online. I don't know exactly why. There are some plausible use cases for such things, especially for peaking power or repairs or things like that, but that's a future that's a little bit out there. And so, one of things I keep telling people -- so, in India, one of the things they're very very proud of is mobiles. In India, there are 850, 900 million mobile users. It's the cheapest ARPU in the world -- Average Revenue Per User, only about two and a half, three dollars a month. So next time you look at your cell bill you can get jealous.

But you don't have Moore's Law in the energy space, which is really what's helped chips. Unfortunately you've got costs that are going up because of carbon scarcity and energy security and things like that. So energy is really much much harder than the telecom space.

Talking about India is both easy and hard to do because there are a lot

of commonalities across India, but it's also very heterogeneous. India is, at last count, 29 states. They are breaking up some of the larger states for administrative if not political reasons, but certainly administrative. And it's like the United States, very federal in structure. And electricity is explicitly federal in the constitution. It's so called concurrent, which means it's both center and state. What has happened is, any transactions of electricity that cross state borders goes to central jurisdiction from a regulatory pricing and transmission perspective. But distribution, which is really where the challenges lie, is entirely at the state levels.

The majority of state distribution is by public companies now, so what happened with the history of India, just a few minutes on this, and it's relevant. Before independence, you had the private sector running the show. After independence, the majority of these were nationalized, except in a few cities which remained under private hands, so Mumbai, Calcutta, Ahmadabad and a few others have private distribution companies, but the rest were public and they were state departments, or state electricity boards or what were called SEBs.

In the 1990's there was liberalization or restructuring of the electricity market and most of these unbundled. And so you had separation of generation transmission and distribution. And in two states, they privatized the distribution, which was Orissa and Delhi. After that, in the 1990's, by early 2000 for Delhi's case, no more states privatized and there was a bunch of reasons why it didn't really happen. And so now what you have is distribution companies in charge of procurement and retail of electricity, and these are government owned companies. So we can call them companies, but they're very much public sector enterprises, or state owned enterprises. And state level, literally in this case, state being not the government, but state.

These are challenged. I'm trying to search for the right euphemism, but

you can figure it out. Per unit of power, per kilowatt hour, they lose about one rupee. So a cent and a half, almost two cents, per kilowatt hours, the average loss is, per unit that you sell. So other than airlines, I don't know too many other businesses that sort of survive in this mode. In addition to losses at a fiscal level, you also have enormous physical losses so this is leakage or theft, especially and it's very high. After transmission, which is reasonably well known, the losses at the distribution level, which are both theft as well as technical losses, are in the order of 26, 27 percent across the country, which is very high. The total losses in the U.S. system, which is transmission and distribution, are about nine percent. So just to give you some scale. It's almost three times -- it's more than three times, because you have to add transmission which is about five percent, six percent in India. And so very very high losses in the total system.

How much is theft? How much is technical? It's hard to know, because one of the major problems in India is agricultural consumption, which is for the most part unmetered. So if you think about electricity entering a substation, it's coming from the grid, once it reaches the substation, it's well measured. After that it's going on a feeder out to the consumers, medium voltage and then you've got technical losses, you've got leakage, and you've got unknown consumption because you don't have metering for all the consumer, the agricultural, so three unknowns, one equation, so the engineers would say, have fun. Or, what actually happens is, make assumptions.

So that's one of the big problems with Indian energy, is data. There is a lack of granular data. And there are a lot of assumptions which may or may not be true at a granular level. And these are very very important when we come to renewables in a minute, and I'll explain why.

The other challenge, you know, we talked about losing one and a half plus rupees a kilowatt hour that you sell. Part of that is because agriculture is virtually

free if not free, depending on the state. And so, you've got about 20, 25 percent of your consumption, no one knows for sure, giving you only seven, eight percent of revenues at best. And then you've got residential consumers, where you have tiered consumption, or slabs as they call it. So it you're very low consumer, you pay very little. It starts typically in most states at about a rupee or rupee and a half, so two cents a kilowatt hour. Clearly, it's not recovering costs. But if you're a so-called paying customer, the commercial and industrial, C&I, you will be paying more than your fair share of costs. You will be paying eight, ten, fifteen, up to 18, 20 cents a kilowatt hour. And you're cross subsidizing the other consumers, so that itself is also very bad for economic growth. And ultimately you have shortfalls of power.

This is a very different world. We take electricity for granted here. And in part, much of the world. But in India, large segments lose power every day for a couple of hours. And they call it load shedding. So that's when the feeder shuts off for X period of time periodically. And that's a very very big social cost. Because if you're middle class or higher, you go for batteries and backup inverters or diesel, and if you're poor, you end up going to kerosene and candles, which is actually a very non-trivial cost to these consumers. So for those of you who know what the term, demand response is, that's in Smart Grids where consumers can switch off their load in response to a signal. I like to joke that India has the most effective demand response program in the world. Too bad it's not voluntary.

And so these are some of the challenges that are out there. In response, what is the government doing? They have a couple of programs underway. One is electrification. So about 300 million people, aren't connected to the grid. That's a very large, it's 25 percent-ish, at a household level. Now the first thing with all these numbers is, you have to understand what they do or don't cover, so the old definition of

electrification in India was, if a wire comes to the village and there's one light bulb, that village is electrified. About 10 years ago, they upgraded that definition to say, 10 percent of households need to be electrified, plus public area schools, clinics or things like that. Then the village is electrified. Using this definition, we now have about 95 percent of the villages electrified, so only about 30,000 villages or very small ones at that, or remote mountainous ones, are not electrified. And so for these, the government has programs to use distributed renewables to actually give electricity to those areas, because they're saying the grid's going to take too long to get there.

Now for the rest of them, they're trying to strengthen the grid, and they're moving towards larger percentages of households having electricity. So that's that 300 million or 25 percent that they want to up. The problem with that, and this is something we at Brookings have written about is, there's no service component. A wire to the home isn't good enough if there's no juice on that wire, especially when people need it. And so a number of us have proposed upgraded definitions for electrification. And these are being mulled over by the state. But the problem is, we just don't have enough electricity to go around. And that's why utilities load shed.

And so there's this very fascinating study we've done and it's published, on the Brookings website, which quantifies this load shedding -- who's getting hit -- rural versus urban. And it turns out for most of India, rural areas are shut off more. Utilities tend to do that because they're not the paying customer so much. But the amount of load shedding in rural areas is so much higher, that it's effectively a cross subsidy from the rural poor to urban areas, which is mind boggling if you think about it from a policy perspective. So there are attempts to improve electrification.

Now how do we actually provide the electricity? So as a thought experiment, if you take all the homes in India that don't have a connection, and you give

them a lifeline amount of supply, 50 watts or up to 100 watts, so enough for a couple of CFL's or LED's, charging your cell phone, yes, killer app, and TV, another killer app. It would only take on the order of about 15,000 megawatts or 15 Gigawatts of new capacity from a centralized traditional grid, including losses to actually deliver that power, which is not that much. They add more than that in one year. The problem is execution and how do you stop a consumer from actually just using 50 watts? because A, if it's very cheap, if not free, but subsidized, there's no controls, then people will use inefficient, high wattage appliances. In poorer areas, there were studies in Orissa, hundreds of thousands or millions of people started using electric coil heaters, very cheap, couple of dollars to buy, and they can use dozens or hundreds of dollars of electricity very quickly. So what you would actually need is a current limiting Smart meter, which we'll get to in a little bit -- Smart Grid and renewables.

So in addition to improving just raw electrification, governments are trying to reduce the losses. There are big programs to do that. They are also of course trying to up capacity. One of the big achievements the government's touting is, they've redone coal auctions in India, so the shortages of coal, the logistics, coordination with the railways -- these are all things that are being done. So as much as we're going to talk about renewables in a second, we can't get away from the fact that the majority of electricity in India, about, almost 70 percent, comes from coal today, and even though renewables have a higher growth rate, you're still going to find coal will be the mainstay for the foreseeable future in India.

So of the total generation in India, almost 70 percent comes from coal. The capacity is slightly lower because the output from coal is high. Hydro is about 22, 25 percent, nuclear is about three percent. Gas at a capacity basis is much higher, it's about eight, nine percent. But the generation from gas, because gas is expensive, is

much, much lower. And renewables today are now officially about 13 percent of capacity, plus or minus, and they're projected to grow to 18 percent of capacity. But obviously the capacity utilization factor, or what in India is called plant load factor, is very low. Renewables are only about 20 percent. And so the share of generation, kilowatt hours by renewables today, is six percent. Now India, a lot of people say, we are only six percent. Go look at Germany. They are 25 percent, they can handle it, ergo, no problem. So this is the other sort of pillar that India's chasing, which is renewable energy.

So from a 34,000-ish capacity of renewable power, megawatts, the majority is wind, somewhere in the order of 23, 24. Biomass is also several thousand. Solar is a little over 3000 megawatts, three and a half thousand, and then you've got micro-hydro and a few others. Here we're removing traditional hydro from the renewable mix. It's under so-called conventional energy. So micro-hydro comes under renewables. And there's a separate ministry for new and renewable energy -- MNRE.

So this is something that a lot of people say -- six percent, twenty-five percent in Germany, no problem. But there are a couple of things people don't understand and this is why renewables are very important for India, but also tough, and that is, actually, the focus of this briefing book that we put out at Brookings India, "Blowing Hard or Shining Bright: Making Renewable Power Sustainable in India". And so, yes, as my wife said, and I told my wife, it's a shameless plug, but it's a free download, so it's not so shameless. You can get the full book on line on the Brookings India website.

And so we're really digging deeper than these grand targets. So what are the targets that the government as put out? They had, a few years back, 20,000 megawatts of target for solar power in five years, or seven years. And after the Modi

government came on, they said we're upping this to 100,000 megawatts of solar in five years, which is ambitious, to say the least.

There was a very large global investor summit called RE Invest in February. And they solicited firm commitments from power generators -- Indian and global. How much renewable energy are you going to put in, and they actually received 266,000 megawatts of commitments for renewable energy from companies, which is mind-boggling, because that's the same size as your grid today. And in five years, they want that much RE, so the cynical answer would be yeah, right. How much of that would actually materialize? But these are said to be commitments by companies who have signed letters and handed them at this event to the Prime Minister, and there are global players in there, and there's a lot of JV's, as well as pure Indian entities that have made these commitments.

And so, there's certainly a lot of interest. How and why is there a lot of interest? Well, solar has been the majority of it, because prices have been falling, and there were support mechanisms like the Jawaharlal Nehru National Solar Mission -- JNNSM. And he's really gave up front some capital subsidies or feed in tariffs or other mechanisms for making solar viable. So from a supplier perspective, even though the prices come down from 17 rupees a kilowatt hour, which is 20 something cents a kilowatt hour, it's about 62 rupee, now you're down to weighted average for the next, most recent round, about 13 cents, 12 cents a kilowatt hour, so seven rupees and change, was the most recent. So that's very impressive for renewable energy. But the cost of capital is very very high in India. Interest rates are very very high, and that's been identified as the fundamental problem for making renewables more cost effective. But cost effective is only one side of the equation. What do you do about it in your grid, and that's really been one of the big challenges. So if we step back and say, renewable is great, what does it

mean?

Globally, you have three challenges that everyone talks about. One is, what does it cost? They say that for all energy, but for renewables, especially people worry about it, because they're saying, one's camp sort of says, these are subsidy driven, support driven. May or may not be true, but that's a policy choice.

Second problem is location specific-ness. Often, like in the U.S., Dakota's, you get wind, not where the people live, so now you've got transmission congestion, transmission bottlenecks.

The third challenge is variability, because obviously the sun has a reasonably well predictable shape. That variability is double hard in India. First, wind is seasonal. It's very very seasonal based on the monsoon. You get half your generation in the equivalent of a couple of months in the year, of normal, most wind farms. In addition to seasonal variability, and that monsoon period is actually when the demand gets lower, because things cool down, and agricultural demand is also lower when it rains.

Second problem with the sun -- the Indian grid is rather different from the rest of the grid, because the peak is at roughly 7 P.M. It's an evening peak for the most part. There is a morning peak, which is absolute in the winter in north India, because of heating needs, residential, and it's a bi-modal. So there's a mini morning peak, then it sort of stabilizes or even comes down, and then a super peak in the evening, mainly because of lighting as well as commercial loads, some air conditioning. So if you happen to be in New Delhi, more affluent area, the evening peak in the summer is 10 P.M. -- air conditioners, when people are going to sleep. So it's a very different beast. And now you've got this problem that the sun isn't shining. Not very bright from last I checked, at 10 P.M. So then people say, well what about a battery? Well that doubles your cost, at

least with today's technology, or the near term sorts of technology.

So this also leads to this other problem with renewables. If you're attempting to use it for the last, for the poorest of the poor, the rural areas that don't have good supply, saying, hey look, your grid is very bad, ergo, let's go for something else, the problem is again, this time dependency. With solar, you would need a battery, and solar is the only technology that scales well for a household level. The rest, wind is megawatt class. Even mini-hydro or biomass, are typically tens of kilowatts, so they're village level. So you still have the same last mile problem. So the renewables have those challenges.

Stepping back, renewables have the broader challenge that your grid in India is very very weak. You have the balancing mechanism called load shedding, the worst possible one. And you have frequency and voltage and other things that swing around very very wildly. And so it's an unstable grid. There are no ancillary service markets in India. So these are services that keep the grid stable. They're not traditional kilowatt hour, but they could be frequency regulation, ramp up, ramp down, so you have different types of generators that can be called to do a certain type of service and they have to be paid for that opportunity, because they're not generating kilowatt hours like other generators are. So these are well defined systems, either bilateral or mostly markets in most of the world. India doesn't have these. So that's one reason the grid is much more unstable. They are in the process of starting up ancillary services, but obviously that will take some time.

And then of course you've got the last challenge which is something we're digging into. And this has implications also for climate change, which is the heterogeneity of India, the state to state variances; whether its consumption amounts, mix of fuel sources. Renewables in India are concentrated in five states as of now -- 85, 88 percent or something in that range, comes in five states, which are Gujarat,

Rajasthan, and Maharashtra, Karnataka and Tamil Nadu. Tamil Nadu is the leader. They have by capacity, 40 plus percent, somewhere around 42 percent wind, so that's remarkably high at a state level. The problem is, they don't have much to balance with. They've got a lot of coal. They have virtually very little hydro, which is an ideal balancer, because you can turn it on and off very quickly. But now what do they do? So when the wind dies, they load shed more. And that's a very unfortunate happening.

And so one of the questions is, as renewables increase, how are you going to deal with it from an operational balancing mechanism? What are the incentives, the pricing, the market mechanisms that you would need to actually make that happen?

So renewables are happening, and they're happening because of several reasons. One is, prices are getting better and better. There are support mechanisms. And then you've also got, at some level, an inevitable, now, the only question is, how long of, you know, when -- utility death spiral. So that's the famous description seen in the west where they say, consumers will go for self-generation, batteries, storage, Smart Grids, demand response, and reduce or disconnect from the grid. And so therefore the utility has to still be their battery, so provide them emergency service or maybe peak service, but not otherwise. And that hurts the rest of the grid. You lose your best customers. If the grid becomes more expensive, then more and more people want to leave, and it's a spiral.

In India, you don't have that yet, but the spiral is exaggerated because you've got tariff distortions, where some people are way overpaying. So a commercial user, a mall, will say, you know what, I'm paying 12 cents a kilowatt hours for erratic power -- 13 cents. I could do my own solar. And the government is making it easier to do solar by giving them open access to the grid or preferential treatment and some other things, which are good from a policy support mechanism, but you can't ignore the

elephant in the room, which is the sort of system level economics, would it become one of the straws that could break the camel's back.

Another area where there's a lot of potential and hope that India's embarking on, is Smart Grids. Full disclaimer -- I'm pro-Smart Grids, but I'm also a realist. You don't need a Smart Grid to cut down theft. You need political will. But a Smart Grid makes it a lot easier to figure out where the electricity and energy is going. So that's one of the killer apps of a Smart Grid. But if I step back, the theft that you have in India, that you could realistically cut down from a Smart Grid is only going to be in the order of 15 percent, plus or minus. On the other hand, your growth and demand is going to be several hundred percent in the coming 15, 20 years. So managing that growth and that peak, I think, is going to be one of the key areas where smarter consumption, Smart Grids, demand response and all of these will become very very important. I mean the lesson I always take away is, for some years in between, China was adding a hundred thousand megawatts of capacity a year, and they face -- two more minutes? We have to adapt. That's a Smart Grid, to be adaptive.

They added 100 thousand megawatts a year and still had specific shortfalls. India has only added in the order of 20, 22 thousand in a single year. So yes, India has to add a lot more, or every type of supply. So when people ask, are renewables the answer? Is nuclear the answer? Is coal the answer? Yes. It's such a vast space. Your per capita consumption today is only in the order of seven, eight hundred kilowatt hours a person. World average is a couple of thousand. Europe, Western Europe, is about 6000-ish. U.S. is 13 or 14 thousand. Not saying that India wants to get to the U.S. level or should or even could, but certainly multiple times higher, with a population that is still growing. That's another major challenge ahead of India, unlike China. And so, managing that is, to me, one of the killer apps of the Smart Grid. I

won't go into what is or isn't a Smart Grid, because there's no one definition. Different people have different functionalities, designs, and all that. But certainly, leakage detection and managing flows, and managing the peak and demand are going to be very very critical for India.

I think Smart Grids have an excellent future in India, in part because they're very aggressive on price points. So in technology, one of the statements we always make is, if you can make it work in India or Africa, it will work in the U.S. because your price points are so much lower. Your conditions are so much harder. And so that's one reason I'm very optimistic. It's harder, but when it will work, it will work.

Second, engaging with the grid -- so in the U.S., just how many of you have a smart meter at home, I'm curious? A couple of folks raising their hand. How many of you know that you do not? Okay. And how many of you don't know? Yeah, so about 30, 40, 30. So how engaged are you is really the fundamental question of a Smart Grid. And this is where I talk about what I call the slice of pizza syndrome. In the U.S. you modify your lifestyle. Maybe you look at time of day. Maybe you get smarter appliances. You may save a couple of dollars a month. I don't think anyone's promising you more than that. Maybe you are if you're a very high consumer, but percentage wise, you're going to save maybe five percent, maybe. Ballpark it. For a slice or two of pizza, people aren't going to modify their lifestyle necessarily.

Now look at India. Three hours a day you're not getting electricity. They're already engaged with the grid. They're already planning their lifestyle around availability of electricity, and now you tell that if you shift your loads a little bit, you can avoid the brown out. People will say, sounds like a good idea. Or you would avoid diesel, which is 25 cents a kilowatt hour, or some very large amount of money. People go yes sir, that sounds like, I'll do what it takes. So people are willing to change, and that

I think is sort of the fundamental take away I have which is, you look at India's energy aspirations -- economic growth needs energy. And business as usual just will not work, whether you're talking about what fuel mix do you have, carbon implications, whether you're talking about prices, whether you're talking about just how long it will take to deliver that. People don't want to wait decades for that to happen. And that's why we are going to see transformations of the grid in India, faster than people would have imagined. It's not going to be easy, because any time you get change, you're going to have winners and losers. But I think it will happen. Carbon obviously is one of the reasons people do care about what's happening with renewables in India, but it's also an opportunity. It's a huge huge market. If you were going to grow 5X in a couple of decades in your electricity consumption, that's a huge opportunity for innovation as well as even traditional energy suppliers and players, even with quote unquote dirty fuels -- coal, oil, these things. But if you actually have a killer battery, it would do wonderfully in India. Because the need for a battery is far higher than it is, from a grid perspective. I'm ignoring automotive, which is probably the killer app in the United States.

So it's a very different space, but it's also similar because it's electricity and it's relatively similar around the world. The issues of policy, political economy, consumer behavior and preferences are absolutely very different from India, but this is where, if we put it together as a large system, I'm very confident that in about 10 or 15 years, it will be a very very different India, one that's smarter, greener and hopefully more viable and sustainable. Thank you. (applause)

MR. EBINGER: Well thank you Rahul for a very fascinating presentation. Several points and then we'll move rapidly to the floor. Given the prodigious nature of what India needs, as you say, across fuel types, what do you honestly in your heart of hearts think this means in terms of what India can feasibly do to

address climate change at the same time that you're not only having a very fast middle class rising up demanding more electricity oriented goods, but of course also the access of bringing the remaining people who have no access into the system?

MR. TONGIA: So the point, working a little backwards, those who have very little, I don't think they're going to impact the macro picture, because you get someone who has never had electricity, you give them a connection, for the most part, they're not going to use that much, especially if prices rationalize even more, or there's some other restrictions on how much they can use. So the total KwH from the lower strata is not going to be so much as opposed to the middle class, which is absolutely skyrocketing in terms of demand, because appliances and consumerism are definitely increasing. What India will need to do to manage the climate question I think, obviously changing fuel mix is good, but gas is limited. India does not have very much gas, so imports would be the option. They have not yet gotten to shale gas or some of the other options which may have enormous value, but India is far behind in terms of exploration and drilling and the wells dug in general are an order or two of magnitude lower than they might be otherwise.

Carbon, sorry -- coal, improving the efficiency is I think something that India's going to push very aggressively for. So most plants today are sub-critical and luckily the coal in India is low sulphur so you don't have the same environmental penalty from the sulfur perspective, the energy perspective. But it's also poor quality in terms of ash. It's about 25, 30, maybe higher percentage ash in the coal, so that's the domestic mainstay. But taking the efficiencies of those coat plants up by another five, seven, eight, to ten percent, by going super critical, ultra-super critical, I think is going to be one of the main technological directions India's going to take.

The other big thing that I think India needs to do much much more is the

consumption side. India never had the same amount of incandescence vis a vis some of the other world, CFLs are very very popular in India, and now they're moving to LED. And it's the hidden things that really make a lot of difference. There was a state program to give compact florescent lights to everyone at a subsidized rate, or make it available. And people tried them and they started failing. So people said, look, if I'm going to spend money for a payback of one or two years, and it breaks, it's useless. And so what this one state did, Karnataka, they said, you will have a no questions asked warranty on a light bulb. The guy selling it is going to write the date and sign it. If it stops working, you bring it back to him, he'll just hand you a new one. No receipt required. Which for India, is a revolution. Because in India, usually customer service warranties are very very tough and tight and limited. So that was an absolute amazing way to really get mind set and people buying in. So improving these efficiencies on a consumption side is to me going to be the heart of what India needs to do. So Bangalore for example, has mandated all houses have to have a rooftop solar panel, thermal. So hot water comes from the sun. And without that, you don't get an electricity connection. So very soft or hard paternalism, whatever you want to call it, but what it has done, is it has lowered the morning peak by about 350 megawatts on a base of 2000. That's pretty substantial.

MR. EBINGER: One issue you haven't said much about is of course, with the ongoing problems of power theft and technical, non-technical losses and bills either sometimes not being paid, even if they get delivered, do you feel that at both the state level and at the central government level that the regulatory process is strong enough, or do we need to -- does India need to put a lot more emphasis on getting strong regulatory bodies to be able to cut somebody off -- let the utility cut someone off if they don't pay their bill, rather than have some powerful political figure intervene and say don't cut off that power?

MR. TONGIA: Strong regulators are absolutely a weak link in the system. So the central regulator has central jurisdiction, which is usually much better staff, they're self-funded. States are really where the problem is. You have state electricity regulatory commission. So they have problems less on who can you connect or disconnect. So they have authorized the states, the distribution companies, the utilities, to disconnect those who don't pay. So the enablement is there. Actually doing it is a purely distribution company problem. The regulator isn't involved with, disconnect them or not and so forth.

Where they are more lacking is really on rational tariffs, enforcing rational tariffs, incentivizing, so for example, the 2003 Electricity Act enabled open access for large consumers. So instead of overpaying for your commercial industrial user, you could go get power from the market. Sounds great. It would help. The problem was the distribution companies put road blocks along the way saying, wait a minute, you're my best customer. If you leave, okay, I maybe can't stop you, but I'll declare emergency conditions to stop you. So they cited all these emergency conditions clauses to prevent across the state transfers of power. They also then told these bigger consumers, you leave, and you come back to us for emergency needs, we'll charge you triple tariffs as a temporary consumer. So there were all these sorts of desire intentions of policy that we got stuck in enforcement. So that's another area where regulators as well as policy makers really need to enforce the good intention.

I think, now this is just an opinion, things are so bad, that people realize that okay, we can't limp along. You can't just tweak it and deploy what you have better. We'll have to change our systems. So there is a recognition that we need to get real about policies and enforcement, but obviously these are easier said than done.

MR. EBINGER: Why don't we go to the floor now and we'll take as many

questions as we can. We have a mike if you'll wait. Please identify yourself and also, please ask any question.

SPEAKER: Thank you very much Professor Tongia. I'm Sasha Riser-Kositsky from Eurasia Group. I think we've corresponded before. A new question about the pending amendment to the Electricity Act in Parliament and I was wondering in your opinion, how effective do you think those regulatory reforms might be in reducing state control over distribution companies and state electricity regulatory commissions an whether or not states might actually then implement the provisions of the act given that they haven't implemented many of the 2003 Act provisions. Thanks.

MR. TONGIA: Yeah, I think you hit the nail on the head. So there are two aspects. One is what's in the Act. So these acts have -- so the 2003 Electricity Act which accelerated the separation of generation, transmission, distribution, made generation unlicensed. Anyone could become a generator, and they opened up for example, the Open Access Clause for large consumers over one megawatt. The main tenet of these amendments is, all electricity supply would become unbundled between retail and wire. So the distribution company would get split into a wires company, which would be the incumbent for now, and supply licensee, so there would be one incumbent licensee plus anybody else who wants to be a licensee retailer, the supply licensee. So that's great. So I think in the U.S., 19 states have that. That's competition available for retail. That's the intent. So in theory, these guys are A, not only meant to be efficient, they will also procure sufficient power to meet the needs of their consumers. If it works, it's wonderful. Patch, there are several. Zero divided by two is still zero, meaning, do you have enough power to actually physically meet that demand?

Second, how do you apportion flows and inefficiency and losses? Do you have moral hazard risks? So states are also trying to fight it because jurisdictional

issues, but I think most of them are, in principle, okay with doing it, but there are two other steps that, you know, the devil is always in the details. In addition to the act, there si in the act, a mandatory national tariff policy, which says these are the guidelines or processes that states have to follow in setting tariffs. That wasn't always done well. And states are resisting that. So extending not just the act, but the tariff policy as mandatory, and second, there are something called transfer schemes. That's essentially how they'll say that, okay, we're going to cut you here. Access on this side, go to the wire company, this side goes to the service company. How you apportion the system, the flows, the existing power purchase contracts, because who is getting power at what rates? That's really the devil where a lot of this will happen or not happen.

My understanding is, and we've been engaging with the government on this, is it's not going to be an overnight. It's not going to be, okay, the act is there. It's going to be quote, unquote, progressive, so they're going to roll it out either by size of consumer or geography in a staggered sort of manner. So I think that's more realistic than just expecting a switch to turn on and just to materialize.

MR. EBINGER: (inaudible)

SPEAKER: Thanks. This is great Rahul, thank you. I'm Tim (inaudible) with the Brookings Institution. My question is about, you addressed a number of major challenges that India faces -- energy security but economic growth, in the case that you look at the coal sector, job security, air quality concerns. If you were to advise the Indian government, which actually we know you do, how would you prioritize some of those challenges, because they may not all go hand in hand, and should we anticipate that the Modi government will take your advice (inaudible)?

MR. TONGIA: The last one's very easy and it doesn't matter whether they do or don't. Our job is to attempt to have this public dialog and give options which

the decision makers may or may not choose. But we certainly wish to engage and continue that. But what we've sort of been saying is, we have to come back to the lens of political economy. Until we identify a win-win-win that balances the top down and bottom up, this isn't going to work. And so whether it's power sources, different coal and so forth, if you -- this is something where they've actually done well, where they're saying, these auctions for coal blocks, those extra revenues are going to go to the states. The center's not going to keep it. So that cuts down a lot of the resistance that was there, which was not moral or philosophical, it was economic ultimately. Someone once put it, you know, theology, if you follow it, there's money somewhere back there.

The Smart Grids is another classic example. If you keep it top down and say thou shalt do X Y Z, they may even do it in a haphazard manner, but will it work, will it have your desired outputs, your effect? That's really where the rubber hits the road. So one of the things we've been attempting to do is say that we actually don't know the answer. I'm using Smart Grids more as an example. Let's iterate. Let's learn. Fail fast, fail early. And move on. So I think you're going to have a lot more variability in what gets done. I think this government is trying to move away from one size fits all. They're giving much more latitude to experimentation. And that's worked so, for example, Gujarat has done very well in electricity compared to other states. They're trying to bring up the bottom with minimums, but they're also now I think going to encourage states to stick their neck out, transform quicker, revamp quicker, restructure, structural changes as well, quicker. I think that's going to be the way forward for India.

MR. EBINGER: And we have a lady over here in the middle. Yes. We'll try to get to everybody if time allows.

SPEAKER: I appreciate this. Hi, I'm (inaudible) from International Food Policy Research Institute and I work on the link between energy and food security. I was

wondering, can you elaborate further on the link between renewable energy and the agricultural sector, especially in terms of production levels or production costs, any more thoughts on that? You touched a little bit, but I was hoping you can talk more?

MR. TONGIA: Sure. I mean, so, energy and electricity, they are two different sectors. So from a pure electricity aspect, we know that water and energy have a very big nexus as they call it. And so part of the problem is, cheap power to the farmers means they buy inefficient pump sets. They are a third of the efficiency of what they should be because electricity is very cheap and so therefore, they're overusing electricity. They also overuse water in some cases, which has salinity and ground water implications. And then you've got the second twin of this, which is PDS, the Public Distribution System on the food prices, which then means cheap power, cheap rice to the end consumer, and we'll support the price from the government to the farmer in between. So what's that done is distorted cropping patterns, in a big way. I don't get, I mean I know why, but dry areas of India, with 800 feet deep water tables or 1000 feet deep are growing rice. That wasn't the case two decades ago. It's these sorts of policies that have led to it. So one is, we need to break this nexus. Solar pumps are now gaining favor. They are a no brainer vis a vis diesel. So just to do a ballpark back of the envelope estimate, if we assume traditional solar at utility scale, it's about seven rupees a kilowatt hour or 12 cents. Solar pump sets are about 10, 12 rupees a kilowatt hour. A, they're smaller scale, and B, you have some efficiency losses because pump sets are always made not for the peak, because the sun sort of has a bell curve of output. You don't size your pump right at that tip, otherwise it would only operate for an hour a day. So it moves about 20, 30 percent from your panel vis a vis your motor, for a pump set. So putting that together, it's cheaper than diesel. Is it viable? Well, when you have nothing or it's not supplied, it's competitive. But the bottleneck is, from a capital cost perspective, the

farmer is used to paying very little, so you have to get the systems approach really right to making people move towards solar polar.

MR. EBINGER: Phil?

SPEAKER: Phil (inaudible), consultant. Question to just kind of bridge the gap between the regulatory, the technical and renewables specifically. I'm interested, when particularly on whether there's any experimentation going on with micro-grids and whether the micro-grids, you know, even below a state level, and how that fits with the sort of government's philosophy and the policy environment, and you know, the technology's driving us there, especially on renewables. And I just want to know a little bit more about how the regulatory environment's treating that.

MR. TONGIA: So in the amendments to the Electricity Act, they are explicitly making it easier to do micro-grid. I don't think the ultimate bottleneck will be the regulatory per se in terms of enabling, but it's pricing and policy. So if I look at a village today, they are heavily cost subsidized. And they're being cost subsidized across a very large base. Utilities are typically a third of the state if not the whole state, depending on the utility.

If I make a micro-grid, who am I going to subsidize it off, that's one fundamental problem. Second problem is of course the last mile still remains, that's one of your bigger bottlenecks. And the third is, reliability. I don't think the traditional micro-grid that some people thought of which is isolate from the grid is going to be the answer. To me it's going to be a more opportunistic hybrid micro-grid, which will use local resources with an energy arbitrage as opposed to a capacity arbitrage. And you will still have the grid as and when, where available, because the reliability factor is a very big deal. Biomass, which people say is locally available, is very seasonal. You have all these other problems of reliability; you need an N plus one module if it's entirely local.

That raises your costs. Now again, the bar is pretty low for reliability, but I don't think we should be designing systems towards lower reliability.

MR. EBINGER: Lady right here.

MR. TONGIA: Again I'm not pessimistic on micro-grids, but I think they're not the only answer and they'll play into a larger grid.

SPEAKER: Thanks Rahul, I'm Suzanne Goldenberg from the Guardian. I wanted to ask you a little bit more specifically about how this all fits in with climate change and the pledge that India will need to offer in the coming weeks or months. And whether you see India, how does India get to, or whether you see India as in a position to actually commit to a peak date and to peaking and to go beyond the offer to reduce energy, actually peak emissions and after to transmission.

MR. TONGIA: These are the million or billion dollar questions. So this is where I have to open my hat and pull out the disclaimers, these are personal opinions only, et cetera. I think the intensity one is a lot easier to do because they are dealing with trajectory. So just to step back a second, China made a commitment that was probably a lot easier because their population growth rate over this time horizon is expected to be only about two percent. With India, using the same data source of population, the projection is 38 percent growth. So A, you've got the population growth, B, you've got this very low base, quarter that don't have any. So to say if people want to, they are already starving; you can't put them much on a diet. So that's where I'm more cautious, I think India should come up with a number and a time frame. It's premature because I've looked at the data a little and I don't have enough confidence in the granularity of data. India being heterogeneous, you have big shifts in the economy, it's very agricultural centric. We know that that can't continue, 60 percent of people, or 15 percent of GDP, it's not going to continue. The U.S., it's about two percent population for three percent of

GDP, so that can't go on. Now the big question is how much will go towards manufacturing, how much will go to food services?

Just depending on where that coin falls, will completely change what is feasible or not feasible for India. So I don't want to try and put a number to it or put a thing, but the way I would think India could or should be doing that is really do a state level deep dives, because it's really the states that have to come up with their plan. Renewables is only part of it, efficiency, which type of industry do you want. India wants manufacturing, there's a very big Make in India program that Prime Minister Modi is talking about because they recognize there is opportunity and need for manufacturing. But which manufacturing of which vintage with which technologies, which efficiencies -- that's really going to determine what is or isn't feasible.

MR. EBINGER: If I could just add to that, if you look -- projections obviously can be grossly wrong, but if you just look at the projections of the IEA and British Petroleum, a number of people have recently put out about the volumetric increase in coal imports into India, it's very very difficult to see how they're going to be able to make a major commitment anytime soon, which of course is not very good for any of us, but it's probably closer to reality. Right here in front.

SPEAKER: Thanks Charlie, I'm Robad Archerry also with Brookings Global. I just wanted to build on what you said. I think the main implication of what you said is that business as usual trajectory for India is much more complicated than for any other country. And that particularly as India becomes the fastest growing large economy in the world; its impact on the global footprint comes hugely significant. So I think a lot of people, which would say that India is not contributing are wrong, but it has determining that contribution for India, I think you're implying would be much more difficult, I think.

MR. EBINGER: Back in the back.

SPEAKER: Hi. I'm Ruhit, I'm from Navigant Consulting. I have a question about the wind energy sector. I worked over there in that sector for two and a half years in India, and there are a lot more hurdles that I felt in for companies to come in and make turbines and set them up, set up wind farms. I want to see what center for wind energy technology --

MR. TONGIA: Now called National Institute for Wind Energy.

SPEAKER: Okay, yeah, it's been sometime so, I feel that they have a lot of hurdles in the process. You have to certify your wind, your assembly plant and all those things. I feel those create a lot of problems, especially when you have technology coming from outside the country and manufacturing in India. And the second is, I notice that a lot of wind turbines that were set up in the past, are now, they are dying and that land which may have a larger PLF should be replaced with higher capacity wind turbines. I don't know what the government is doing on this, if you have any idea about that.

MR. TONGIA: Oh absolutely, the book actually goes into it, the briefing book, so regarding the first one. Not all regulation is just regulation for regulation's sake. The intent was to insure minimum quality, one to protect the utilities, because the states didn't have certain capacity to handle it or to understand. And second, there were quality issues with grid integration, especially for wind inverters and there are no, as of now even, LVRT, Low Voltage Ride Through is not a requirement and things like that. So there were reasons they wanted to control it. Regarding -- so your second point was on the -- oh, the older ones, yeah. So yeah, so older stuff that came first was lower hub height and lower size, and so, the problem is, how do you allow them business-wise, can you accelerate their depreciation or do something else that will make it worthwhile to throw away a good enough asset to put in a newer one. Because if they just want to amortize it, they've still got a loan on it -- the equity and that for that, how those play out,

until that's squared, they're not going to be able to get rid of it limping along, vis a vis, what a newer, faster, shinier, brighter, turbine could really do. So there are proposals that have been thrown out there for the government on how you could actually allow them to revamp. Or people are saying, can actually mix hub heights, can actually stagger them if they're far enough away, I will take a small hit in terms of the turbulence flow because you're too close than optimal. But you're still better off and it's only that delta that I want to fund. These are some of the things that people are talking about.

MR. EBINGER: Right there, next to --

SPEAKER: Tom Timberg, consultant. I wonder, with the importance of electricity prices for different industries and so forth, has anybody done some studies about how the state to state difference in cost play out in terms of the investment decisions that are made in those states.

MR. TONGIA: I'm sure people have done good studies on it, but it's not at the tip of my fingers. But if I look at investment decisions, again in certain industries, energy is a much bigger deal, yes it would play much more, but if I look at generically manufacturing supply chain, ease of doing business, and land acquisition, trump the energy dimension for a lot more of the industries. So the ease of doing business from a political economy, navigating the system, how are your ports or transports set up which is also a very big deal. And just getting your hands on land, my understanding and again, this is not my domain, I think they trump -- the differences in energy costs -- so it's more that there's a threshold above which the industry doesn't want to go, so the very very high electricity states, they don't get to, but it's not as if one that is slightly cheaper is where they're running to, because the other things matter equally if not more.

MR. ENBINGER: There has -- I am familiar probably a year and a half old now, there was a study by the Asian development bank that looked at exactly that

question, but I unfortunately don't remember its conclusions. Up here in the front.

SPEAKER: Edward Ebings, so I wanted to have your opinion about the nuclear energy program in India, so I read a lot about difference agreements recently signed to India, Canada, and the U.S.; I also heard there are strong like political agreements to build new nuclear plants. There are also some constraints like even operations support for nuclear energy, and nuclear energy is expensive so what's your opinion, how it evolve? You know, this nuclear program.

MR. TONGIA: I think the last one is probably the -- is the fundamental, which the price has to be right, otherwise it won't grow as much. You can support a technology up to a point, but it's base load, so there is a certain amount of value to nuclear power, especially in the south, so southern India has a much greater deficit of base load power than the rest of India. And so that's one of the reasons two big Russian nuclear plants, a thousand megawatts each, have come up in Tamil Nadu, because that's the state which had a lot of wind as well.

So political support varies. It's classical nimbi, that Indians in general as an urban population aren't against nuclear nearly as much as they were in the United States post TMI, or Chernobyl and so forth. The agreements have been signed for two or three different levels. With Canada of course you've got your traditional, oh sorry, traditional by Indian standards, the CANDU reactors, the natural uranium deuterium reactors. But with other countries, India has been discussing light water reactor technology for which you need enriched fuel, lightly enriched uranium, which India doesn't have. It never went down that route. And so even the fuel would have to be imported and then maybe taken back depending on the agreement, and so all of these are on the table. India's ambitions towards nuclear are very very high, they want to grow that three percent number to five and seven and then ten percent over time, and on a

much larger base. And so the answer is just like, you know, is it coal, is it this, is it Canadian, is it French, is it Japanese? Yes.

MR. EBINGER: Are you familiar, I'm following up on that point, I know for many years India was at least toying with trying to develop a thorium fuel cycle, because India obviously has very large thorium reserves. Are you aware of any ongoing research in that area?

MR. TONGIA: They are, and so this is where the history of India's nuclear program was the so called three phase plan, Bhabha, the founder of India's atomic energy program, said that we're going to start with traditional nuclear power plants and in this case, CANDU design. Then that will have spent fuel with some plutonium in it, then we're going to run fast breeder reactors which are going to grow the facile base beyond the limited uranium of the country. And then, once you've grown the base, we will shift over to a thorium mode in a steady state. So thorium doesn't breed as much as plutonium cycles do, so that's why you grow the base through a fast breeder reactor in that second stage. And then you go to a thorium cycle, or you can accelerate the shift to thorium which would reduce your ultimate base, but then let you get to it faster. So there are reactors that can burn thorium instead of breeding it that are being proposed. There is the advanced heavy water reactor which is like a heavy water reactor, but it's more optimized to allow thorium to be used in the blankets mixed with natural uranium.

So there are attempts being made towards doing that. Absolutely. There is a lot of thorium, ultimately it will depend. But the flip side became heavy water turned out to be more expensive over the decades than people had imagined, and the second thing is, what are prices for uranium? It's not really a traditional market, but even otherwise, LEU is not a major bottleneck if you're in the supplier regime so therefore especially if a foreign nuclear supplier equals capital, then the light water reactor may

make more sense than some of these other routes, because it's not just about the technology but about the capital as well.

MR. EBINGER: Thank you, gentleman in the middle.

SPEAKER: Josh Halpern, Howard University. I have a question about which direction one should throw the smart grid in for optimal results. Should one start at the village level with mini-grids and many different possibilities, or should one try and do this from the national level?

MR. TONGIA: So I think you will have different experiments. There a bunch of pilots being talked about in India. Some will be more rural centric, some will be urban. If I have to step back and just look at the numbers, because it's always about the numbers. In the U.S., Smart Grid deployments end up being 150 to 200 dollars a consumer, ballpark sort of range. So you need commensurate benefits and paybacks and things like that. Europe has seen a little lower because their pricing for the hardware has been a little lower than the U.S., NL is the classic case, 35 million consumers are on smart meters for the last eight plus years, and they're talking of a four year payback, but there's nuances as to why that happened. They were due for an upgrade anyways of their meters.

In India, if you're dealing with areas of high diesel consumption, so I think urban areas with higher bills and bad quality are your prime case where the business case makes a lot of sense because you're avoiding diesel -- that's a no brainer. I can give you a one year payback in pockets like that. So I think where you have a blend of paying customers, high growth, and bad quality, and maybe theft as well, is going to be where your payback is very very rapid.

In rural areas, I think the killer app is there, because you can avoid kerosene, but that's a whole separate ministry that's subsidizing or dealing with that. So

if we can really get these together, we have some papers on the Brookings website that look into this issue in more depth. I don't think there's one answer because even in communications, you've got different technologies that may or may not work in different areas. This is why in the U.S. you've got Smart Grids, mostly with wireless, but in places you've got WIMAX, you've got optical fibers being used in Texas because the utility happens to have a bunch of fiber. So there's no one architectural solution.

Killer apps though, certainly peak management and theft production are going to be the key load management. Which loads and how, is it direct control, or is it just pricing that then the consumers are supposed to do it on their own? These are all things that we have to figure out along the way. I'm not even sure the U.S. has the answer.

MR. EBINGER: Lady all the way in the back in the red.

SPEAKER: Thank you for your presentation. I'm Laura Small with ESI. So earlier when you were talking about rural areas, how they're about 25, 26 percent of consumption but they only pay six percent so the urban areas --

MR. TONGIA: Agricultural, not rural, this is specifically agriculture, yeah.

SPEAKER: No, agricultural, ah, okay.

MR. TONGIA: Not the households which are rural, which are different.

SPEAKER: Ah, okay. Because then you mentioned later that rural areas are the fastest to be shed in load shedding. And so they subsidize urban. So can you clarify, kind of which way, yeah.

MR. TONGIA: Sure, so agriculture -- so how utilities manage shortfalls is by switching off feeders when they are short, instead of buying more peak power which is expensive. Now one of the things they do before load shedding is called roistering. In most states, what they do is, three phase supply is meant for pump sets, because most

pumps are efficient as three phase. And so they give three phase supply only X hours a day. Now do they actually give X as a big challenge? They sometimes give it in the middle of the night, which farmers aren't happy with. But in the evening peak, six to ten P.M., which is when lighting is your killer app, most states don't give agricultural supply. They only give one or two phases of supply which are spread amongst households. So in this setting we said, in six to ten P.M., how much load shedding are you doing? So we removed the fraction that would be for agriculture because A, it's not meant to be supplied, and we could estimate looking at the data. We actually got our hands on minute resolution data off every feeder in a state, so that was a very large amount of data studied.

And we could actually quantify who's being load shed how much. So in one particular state, with the metro, the metropolitan city was load shed released. Then you have tier two cities, towns and things that are load shed quite a bit, and then rural areas that are also shed even more. And so the kilowatt hours saved from the rural households turned out to be higher than from urban households. And that's -- we quantify that as a social welfare transfer, because by not buying peak power, the utility has lowered the tariff for everyone. Well that's not true, they've passed on a hidden cost to consumers, either as opportunity costs, or as diesel and some backup and things like that, or candles and kerosene for the household in rural areas. So excluding those costs, opportunity and avoided alternatives, just the quantum of savings of peak power turned out to be a very very large sum of money, going from rural to urban, that's what the paper goes into.

MR. EBINGER: Gentleman there in the back since you're right there.

SPEAKER: I'm Alex Boyce; I'm here with the Mahinder Group. I spent two years over in Mumbai working the solar space and one of the things that really

peaked my interest was the make -- was Indian made panels versus imports and I'm just wondering if in any of these amendments there's any sort of visibility on ongoing support for Indian made renewables, and manufacturing domestically and whether or not any sort of import tariffs are going to come off, or how that's going to be supported.

MR. TONGIA: So it's not at the amendments level, it's more at the regulations that come out or the specific, for example the JNNSM Jawaharlal Nehru National Solar Mission, in phase two round one that just went down. They have two separate bidding categories, one is open category, and one is domestic content category. So the prices are different, where they're saying the global stuff will turn out to be cheaper but we want certain quantum to come with domestic content. So be it if the prices are a little bit higher. So that's one of the ways they're explicitly and reasonably transparently trying to grow the domestic market instead of creating a separate tariff barrier against the imported. I don't know if that's right or wrong, I have not thought that portion through. But there is a clear recognition that they want to make more. Now you said assembled in India panels?

SPEAKER: Yeah, yeah.

MR. TONGIA: Because they're not made -- the cells are not made in India -- yet.

SPEAKER: Sure. (inaudible) forward.

MR. TONGIA: Yeah, I think there will be a small delta continuing, but both are going down. So one of those things is, instead of the gap coming down, they're both sort of doing this. So then that's okay. The other thing that they are pushing for is to actually get FABS in India. This is both a semiconductor side-FABS as well as solar cell-FABS. They want more first principals manufacturing being done in India. I think that should help lower the prices somewhat.

SPEAKER: So from Brookings, just I'm a little bit struck that air pollution has never been mentioned in this whole conversation and I'm wondering sort of how the changing politics of air pollution play into all these questions in the years going forward.

MR. TONGIA: It only didn't because there were so many things including consumer choice and equity and all of these, but air pollution is absolutely a very very big deal in India, but this next question then becomes how much is attributable to power plants? And in Delhi versus certain other cities, you've got many other point sources and non-point sources that contribute a lot more. Another point about pollution is not -- is this technology bad, but are people adulterating it, are they pilfering it, are they mixing it, or just bad engines, bad maintenance, bad -- people are throwing in kerosene into diesel. That's a huge problem because kerosene is heavily subsidized. So there's a whole diesel mafia that deals in that space. We're talking hundreds of millions, or billions, of dollars that are sort of flowing -- no pun intended, in that sort of a thing. So those have an enormous impact. You still have two cycle motor vehicles, motorcycles or rickshaws or other things. Two stroke, sorry, instead of four stroke. And so things like that actually have a very very big impact.

Local air pollution is absolutely a big deal, Delhi especially, one of the things Delhi did in the mid to early two thousands, the supreme court in fact mandated the use of compressed natural gas for all public transport. So all the rickshaws, taxis, and buses moved towards compressed natural gas, and that actually made a measurable difference to Delhi's air quality. The only problem is one, many other cities don't have the gas, Delhi is near the pipelines, the Trump pipeline, so they actually had gas. Second, it's helped but now other stuff has caught up and so in the last two or three years, air pollution has gotten much much worse in Delhi again. I think it's a great conversation. This is coming back to that point about systems approach of different ministries. If you

do an electric vehicle calculation, carbon is a wash. India being as of now, so coal heavy, it's within a couple of percent if you went to an electric vehicle. Not that much different. But if you actually valued air pollution, and even a hybrid electric vehicle, like a Prius cuts down your particulate SOX NOX by 90 percent. I think that's a very positive possibility. But the problem is, no one is calculating it or internalizing it into processes or decision making. That's something that several of us are attempting to do.

SPEAKER: I'm Malcolm Lovel from (inaudible), Brookings. I spent six months in India too, and on the watt info (inaudible).

MR. TONGIA: Sorry, governed by? Sorry I missed that, India benefitted being governed by?

SPEAKER: (OFF MIC)

MR. TONGIA: Ah, yeah, the colonial legacy. Yeah, so the British left behind rules of law and railroads as probably their two most tangible benefits of the colonial. And certainly India's railways are remarkable in terms of the volume they carry and rule of law and of course this is one thing global companies cite as doing business with India. Yes it's slow, yes it's painful, yes it's bureaucratic. But it's much more transparent than in many other countries, at least from a legal perspective. So I think those are two of the very strong beneficial ones. The flip side is of course, more than this -- whatever the British had was very centralized. The state bottom up was subdued for a very long time and that continued to narrow, it wasn't just the British, but the central government was very strong until the 1970s, 1980s. It's only after that you've had coalition governments, you've had regional parties and alliances and things. That's really changed the dynamics. So I think in terms of how policies play out, this organic bottom up, is going to be what I think drive India a lot over the next few years. Plus some state support, I think I pointed out -- I'm sorry, center support. The center can really give the

purse strings; it can really push a lot of states along, but ultimately, the enactment, enforcement -- until people want a certain change, they're going to resist it or muddle along for a while.

SPEAKER: I'm (inaudible), George Washington University. I have a question about RPO, so the states have their renewable purchase obligations. The problem with that is that some of the targets are set up too high for some states that do not have so much potential and this stays true to not comply to the obligations. And state electricity regulatory commissions do not have too much power to enforce them to comply to that. Part of the reason that they are nominated by the states and also this RPO non-compliance makes the REC, renewable energy certificate market not efficient. So I want to hear about your opinion about how to make this effective. Thank you.

MR. TONGIA: So that's absolutely a great point, that they want to have RPOs, they have a market mechanism called RECs, Renewable Energy Certificates which are meant to have a green price. And RECs essentially turned out to not be a very liquid or high price market. So they are very low prices. In the new amendments to the act, they are trying to put teeth into both enforcement and RPOs across states. And so now that, if your target is higher than what you can achieve in house which is obviously going to happen for certain states that are already poor, then they will have to go to the REC markets and that will in turn strengthen them. So the attempt is to push them along within the current framework. This is not to say that other frameworks cannot be done, including, people have talked about maybe bilateral contacts between states, that you can do bilateral mechanisms potentially. Again none of these are codified, but there is clear recognition of that problem, that the RECs didn't do what they were meant to do.

So I mean the way I look at whether its carbon or REC or any of these targets, targets should be achievable but with effort. So figuring out what that is, is really

the hard work. If they're too easy they don't push you along; if they're too hard then you make excuses.

MR. EBINGER: We have a lady there in the back.

SPEAKER: Thank you for your presentation, my name is Diana (inaudible) from Georgetown University. I also come from a country where we experience scheduled power outages, that's why I'm interested in the nexus between energy and conflict. So I was wondering, with the vast income disparities in India, does asking for a change in behavior from the customer, when the more well off probably will not change their behavior, so more of the burden is going to fall on the poor. Or other measures like the one in Bangalore where you said they had to put them on the roof to be able to get electricity, so can that lead to conflict later on? Thank you.

MR. TONGIA: It's a great question and I think my first answer, before I answer it is we actually don't know enough. Too much of these statistics are average numbers and it's really that granularity, like by decile of income is how you need to look at deployment consumption numbers and so forth. So the first request, we and a bunch of people have made to the government is, granular transparent data. So how much is being load shed where? Nobody really knows. The load dispatch center in states says we're short by 300 megawatts for two hours, cut some lines, quick. So then the distribution company flips open some theaters. How and which ones aren't automatically noted, they're not digitized, these data in most states, they're not aggregated for sure. They are put into some ledger officially, but if that's honest, if that's real, accurate and if that's compiled. So one of the recommendations we've really made is, figure out who's paying the burden for example shortfalls and all of these other things. Then you can come to better policies. So for me it's slightly premature to say this is what your framework should look like, but we recognize that there are absolute differences, not just

rural urban but within rural you've got the sugarcane area of the state versus the other state and part of the state. And those are very different in terms of income so that is absolutely important and explosive, people don't want that public.

MR. EBINGER: If I could just add another issue is the absolute non-availability of electricity. I did work in Nepal during the Maoist insurgency and it was absolutely staggering to look at a map where the Maoists were strongest and where they were weakest. And surprise, they were strongest where there was no electricity, so the absence deprivation apart from whether one is subsidizing another.

MR. TONGIA: Well not just electricity, but all services.

MR. EBINGER: All services in the states.

MR. TONGIA: You know, that these citizens take for granted or that are beneficiaries of a state machinery that they are lacking.

MR. EBINGER: We have time for maybe another question. If not I will exercise the power of the Chair to ask one final question on what I think has been a great session. A number of the donor agencies, for a long time, the ADB and the World Bank and US Aid have from time to time pushed that India ought to look more at getting some of its future electricity supplies from its neighbors. So wondering what your view of that and what you see as the obstacles to that happening?

MR. TONGIA: I think a regional grid makes -- a stronger regional grid makes a lot of sense. So India currently has interconnections with, especially Nepal and Bhutan for getting hydropower, and there's gas discussions with Bangladesh, and there's one electricity connection out of Pakistan as well. The catch is, one, especially Bhutan, is remote. It's the northeast part of India where you actually have reasonable capacity or hydro potential in that area. So you still have the transmission congestion issue. The other issue is, people in those countries have to want to give power to India and there's a

longer term political question so when Bangladesh says we have gas and we could give it to India people there said wait, that's our resource, why are you giving it to them. So it's more than just a market mechanism. I think the value of these interconnections will not just be the pure flow of energy but also a stability and a larger base and some other benefits. Plus India really needs in my opinion, to interconnect the northeast which goes around Bangladesh, so roads, electricity, if you have transmission lines that have to do this, versus they could cut through Bangladesh, that's a no brainer from an Indian perspective. And for that they also need to have something in return for Bangladesh of course.

MR. ENBINGER: Well I want you to join me in thanking Rahul for an excellent presentation, and thank you for your wonderful questions. Great job.

(Applause)

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