BROOKINGS INDIA

KAMALNAYAN BAJAJ CONFERENCE ROOM

Seminar | Electricity access and demand growth

New Delhi

Friday, October 27, 2017

Brookings India

Second Floor, No. 6, Dr Jose P Rizal Marg

Chanakyapuri, New Delhi – 110021

India

Ph: 011 2415 7600

PARTICIPANTS

Speakers:

Johannes Urpelainen (Professor, John Hopkins SAIS)
Rahul Tongia (Brookings India) – Moderator

*****

PROCEEDINGS

Rahul Tongia: Good afternoon everyone. We'll get started just a few minutes after and welcome to everyone who's online, I'm not sure which camera it is, so I'd say hi to both of them. My name is Rahul Tongia, I'm a fellow scholar at Brookings India interested in learning about energy and sustainability and sustainable development. And one of the best parts of this work is really the engagement in interaction with experts from both India and around the world. It's my distinct pleasure to have Professor Johannes Urpelainen – if I pronounced it correctly – joining us to give a talk on electrification, really talking about electricity access demand and growth, because now household electrification is upon us, it's just a matter of time for the most part, but what does that mean, how may it roll out, there's a lot of both questions, things that may evolve because is the future going to look just like the past or what may change, is one of the key questions that comes up. So, if I could request Johannes to join on the stage.

Johannes' bio is already with all of you but for many years he was a professor at Columbia University doing somewhat similar work, I would say, really looking at electrification and sustainable energy policy. And in fact, he's the founding director of ISEP (Initiative for Sustainable Energy Policy) at Johns Hopkins in DC and so this is a new effort, I would say,

but really bringing together multiple researchers doing different facets, and South Asia is one of your key focus areas, not just India but the entire region. So, before we hand over to Johannes, I wanted to have an intervention and invite a colleague at Brookings India, Sahil, to share a few results of an ongoing study. You may remember about two years ago, we were putting out 2020 and 2022 supply demand numbers that really emphasize how 1500 million tonnes of coal, 175 gigawatts RE and modest growth in demand, all three could not triangulate. We're now in the midst of a large exercise led by Sahil looking at 2030 demand and so, one component of that is households and residential, which is what Johannes will really share some thoughts on. But I thought we'll just take a few minutes with a teaser of some of the results and this paper is under review and it should be coming out within a few weeks, hopefully. Sahil.

Sahil Ali: Thanks Rahul. What I want to present here is only a small component of our larger study on coal, which is being led by another colleague, Anuraaga, which looks at optimizing the ecosystem for coal waste, I mean power generation, electricity use and overall what other scenario is going to be in terms of the supply side, how much demand can we expect and how can we make the value chain more efficient through linkages and so on so forth, and coal is going to stay and how we're going to make

it more sustainable and efficient is what the study is overall focusing on. This piece of work is a part of the bottom-up supply/demand analysis for electricity sector and electricity demand, and what I'm going to focus on is going to be residential buildings here. We have done similar work across other demand sectors – agriculture, commercial, industry, so on so forth – so, it's a bottom-up calculation where we try to look at different factors that may play a role in shaping service demand. So, for example, if I were to think of agriculture, then it looks at [net area] under agriculture and how that has changed from historically, how it's likely to grow in the future, what is the cropping pattern, what are the water requirements, water use efficiencies and area and canal irrigation, micro irrigation, how policies and all of that are going to change the demand for water for cropping in the future. It goes to that level of details and then topped up with other efficiency and other features.

So, just if you could focus on this slide on the blue parts, which talk about how the residential share on the total electricity consumption has changed over time, how residential consumption itself has grown. So, you would find that while overall demand since… so, the X-axis on the left-hand side graph represent years from 2001 onwards, so 1 – 15 is 2001 – 2015.

Overall, the demand is growing at a CAGR of 7%, whereas residential and commercial consumption in themselves have been growing at a much faster rate than the other sectors. So, currently, it's around 23–24% of the total end-use electricity consumption in India, the residential sector; this is including captive power, if you net out captive power, then it reaches somewhere around 27–28%. But the interesting feature which might also be useful to get your insights, Johannes, on today's talk is that our EPIs, which are basically a square footage consumption, kilowatt hours per square meter annually. For residential sector, if you look at the at the 2015 number at the bottom right-hand side graph, the blue line again, is 15.2, which is extremely extremely low compared to global standards. We know our per capita consumption is low, our consumption per unit of built-up area is also extremely low, to give a sense of what it's like in residential complexes – the places that you and I probably come from – it's around two and a half to five to six times higher than the national average, so it tends to give you a sense of the disparity in terms of consumption across the board, and the picture changes drastically with the inclusion of air conditioning and so on so forth.

Some of the key factors in terms of the macroeconomic picture, how that's going to change over time, over the past 15 years,

we've been growing at CAGR of 7.2% per annum at average CAGR, which is quite healthy. Of course, per capita income growth has been slightly lower because, of course, you're going to net out the population growth rate but the population growth rate has been declining over time and that's going to lead to an increase in per capita income growth rate higher than your GDP growth rates. For 2030, we have considered three scenarios of electricity demand; 6.5%, 7% and 7.5% based on a host of projections from government and other international banking institutions, development organization, so on and so forth, which will deflect not only built-up area buildings, but even appliance, ownership, growth usage and technology adoption. And finally, to one of the more interesting and important components, I'd love to hear the more disaggregated picture on that from your experience, especially in UP and other places, is how the urbanization is going to reach from currently around 32% - 40% in 2030 and we're projecting around 100 million additional households driven by smaller household sizes, a trend that has continued over census periods. Smaller household sizes, higher urbanization, this will result in 75% of the new households, actually coming in the urban areas. So, that will be a challenge in terms of affordable housing that the government has talked about, a 2022 target, we examine this in depth in this study,

I’m not gonna go over the details but if you could just move to the next slide please.

Yeah, so we kind of shifted the target to 2030. There are two components in our assessment for buildings; one is the organic element of intensification of households that are already within utilities plan or gonna come into the planning of utilities going forward, based on the number of households it currently sees but there is this element of affordable housing that families or households that are without houses (physical infrastructure), that have to be built up and we realize that 2022 targets are far too stringent compared to the rate of addition of housing order of magnitudes higher. So, we extended the target till 2030 and examined two scenarios where we have in a lower scenario, around a 1/3 achievement of the 100% housing access target and in the other one, we have a 100% achievement and that gives the kind of rate of growth of a million homes yearly, you would need to add in the first table, the fourth column, million homes yearly, you see the rate of addition in different years and also the EPI. So, we're kind of targeting an EPI, a consumption. This is something, again, that's hotly contested – what is the consumption of newly connected households? What is lifeline vs productive use and to what extent do each of these kind these forces play out in terms of

the kind and complexity of appliances at play? There's a separate component I am not included here, which is the growth rate and standard growth rate in different appliances be it refrigerators, air conditioning, lighting, so on so forth, fans and other internal loads, all these are predicated on per capita income, organization and a host of other factors.

So, based on that, these are, again, ranges I've kind of constricted the bounds, there are total nine scenarios, so I mean within a reasonable range, we can expect the demand to grow from anywhere between 5.7% – 6.9% CAGR, roughly, which translates to from around 217 terawatt-hours in 2015 to 500 to 600 terawatt-hours in 2013, the upper bound case and close to 500-496 terawatt-hours in the lower bound case. Why I give you 2015 numbers is also important because with consumption and use consumption, these numbers are prone to getting changed and recalibrated usually, it's good practice to use a couple of years back dated numbers when they come from the government side so that you know all those adjustments are accounted for.

Rahul: Just to clarify, what you call 'upper and lower bound' are plausible ranges as opposed to the extreme upper bound where everything goes in one direction, perfect storm sort of?

Sahil Ali: Yeah. So, the overall range for building sector within this study, is 5% – 7% and 7.9%. These are extreme

scenarios, which you're most likely not going to see because they're not compatible in an additive. Higher growth rates, for example, will most likely be not accompanied by a lower bottom of the scale efficiencies because you're going to have market transformation aspects, the ceiling and floor of efficiencies are going to be pushed up as is been the experience in numerous countries. And what we need to then understand is how the composition of electricity demand is changing; lighting which contributes almost 1/5 of loads today, is going to probably have less than 1% contribution in the electricity demand going forward, that's going to be the extent of change we are most likely to see, coupled with a spurt in air conditioning share of usage which grows from 7.26% in 2015 to around 45%, the big jump. And similarly, growth in refrigerated share, it's something that is getting really far adopted really fast but fans and all kind of retain or slightly reduce their shares.

And therefore, just few questions for the future; based on our study, we kind of understand that while urban demand will constitute the bulk of electricity demand going forward, rural electrification will continue to be a challenge. At present, 7% of the newly electrified villages have achieved 100% household level electrification. Then there is the aspect of change or in composition of demand that I talked about, you're most likely

going to see various studies are projecting a tenfold increase in AC's from where we are today, which then means a big change in terms of time of day; where are [good peeps] going to be, how's it gonna board for renewable energy integration and so on so forth. And then, the inorganic demand from affordable housing – the unseen and unplanned electricity demand – we figured from this study, is actually very trivial, it's 50 terawatt-hours, which is 0.5% and less than 0.5% of today's generation. So, that's not going to be a challenge, what is going to be a challenge is the quality of access. And one of the key questions we'd like your input on, is also what is the ladder of future energy consumption for these household in terms of productive use of energy? And then finally, how do we measure electrification, is it just physical infrastructure – poles, kind of just dug up and in one place – or is it more on the energization fronts – the quality and supply of access hours of used voltage and all of that, and the complexity sophistication of appliances that are connected?

So, the stage is all yours.

[Indistinct explanations].

Rahul Tongia: So, I'm not sure too many rural households will have these risk factors next to them, so if we could just hold off questions…

Question: When is this going to be in a position to be shared? Because I mean, I have lots of questions.

Sahil Ali: So, absolutely, I'll begin share for your comments and all of that, it's going to be up really soon, we're gonna also release the model for you to tinker with the levels and the assumptions but…

Rahul Tongia: Measured in weeks.

Sahil Ali: Yes.

[Indistinct exchanges]

Rahul Tongia: We will come back to that very shortly, I think these are key questions for discussion and debate. So, but this study has been through peer review, it has been through external reviewers and other things, so it's just being re-tweaked and should be out very shortly. And like Sahil mentioned, at Brookings India, we attempt to release a lot of our models because if you don't like the assumption on GDP, just change it, not the GDP but the assumption at least. Thank you, Sahil. So, Johannes, over to you. Would you like to use the lectern?

Johannes Urpelainen: All right. Thanks a lot for the kind invitation to give this presentation and thanks to all of you for coming. I feel, having seen the guest list, that I'm the least qualified person in this room to give these comments but

hopefully, I'll have at least something to say about how things work outside India and what that may have meant for the country now and in the future.

Okay. So, what I want to do first is I just want to relate India to the rest of the world in terms of progress in electrification to get a kind of a global sense of where things are and how India is doing. Then, I want to talk about really the key issue, which is the relationship between electrification and growth and already from the previous presentation, we saw that in many cases, the demand growth doesn't actually come from new electrification because these newly electrified households have low demands but we will need to look at that looking at different countries' experiences, how this might change depending on income levels and other relevant factors. And then finally, at the end, we'll talk a little bit about the implications of this analysis, especially for India.

So, in India, the story is reasonably straightforward. So, if we start with the 2001 census of India, we're at about 55% electrification, of course, much lower in the rural areas than in the urban areas. If we go to 2011, which is when we have the next census, which about 67% of people living in electrified households, again, lower levels in rural areas (about 55%) and higher levels in in urban areas, and today, the rate has grown

to about 80%. This is a very aggressive growth rate, it's one of the fastest in the world in electrification at this time. You will see, once I show some figures, that it's not historically unprecedented. So, if you look at, for example, China and Vietnam, they've grown even faster in the past but right now, if you look in the world, they're very few economies where rectification is growing as fast as in India, so India's really kind of leading the charge toward Universal electricity access. The epicentre of the problem right now, is two major states in the Hindi speaking areas in North India, which are Pradesh and Bihar, so if you were able to solve the electrification issue in these two states, you would basically solve it in all of India, there wouldn't be that many households left, there would be something in Eurasia, something in Rajasthan, maybe even a few households in the South, but generally speaking, these two states are really where the issue is, where the policy challenge lies.

And right now, the biggest thing that is happening in India, as you all must know very well, is this [Sub-Hagia] scheme which is Prime Minister Modi's new effort to increase household electrification. I won't spend a lot of time discussing it because it's probably familiar to many of you, but just very briefly speaking, the idea here is to facilitate access to

electricity connections. So, this scheme does not provide a support for paying your bills or anything like that, there are separate schemes that are related to that but the [Sub-Hagia] scheme allows households that are classified below the poverty line according to the socio-economic caste census to get a free connection, so the BPL classification expands. It's been for a long time the case that the BPL households will get a free connection but now that classification has been significantly expanded, there are many more households that now qualify for free. And then other households will be able to get a connection for 500 Rupees which you can pay in instalments of 50 rupees in 10 instalments. So, that's a decrease of about 60 - 70% compared to, for example, what the connection cost would have been in UP one year ago - so, a kilowatt connection would cost about 1500 rupees in most UP districts and for most Discomms back then.

Okay. So, here is the global picture and this is from the new International Energy Agency report on energy access, so this is the World Energy Access Outlook, they do these special reports every year, they had one on India two years ago and now this year, the energy access was their theme. So, here we look at population without access to electricity by region and a few key points that I want to make here is that the blue line is India, as you can see, it's very rapid decrease. We go from 600 million

in the year 2000 to somewhere between 200-240 million at the end of 2016. In other areas, so Southeast Asia and others like Latin America, you see the same trend of decrease but the trend is less fast and that's obviously because the baseline is much lower. So, South Asia has really been, besides sub-Saharan Africa, the area where most people in the world without electricity have lived. Now, Sub-Saharan Africa on the other hand, is a challenging case. So, if you look at that line, it has sort of decreased a little bit in the past three years but overall, the trend has actually been an increase in the number of non-electrified households, and the reason for this is fast population growth. So, even though electrification rates are improving, so the percentage of people who are electrified is growing in Sub-Saharan Africa, it's not enough to sort of offset the impact of the growing population. And sub-Saharan Africa in general, is a much more challenging place for electrification than India because the population densities are very low and the grid is very underdeveloped, so the kind of economics of grid extension in most Sub-Saharan African countries look very different from the economics of grid extension in India.

The other figure on the side just sort of shows the same picture in terms of shares, the only main point I would make here is that, as you can see, back in the year 2000, we had a situation

where the sort of electrification issue was kind of evenly distributed between India/Southeast Asia, Sub-Saharan Africa and everybody else. Today, we are at the point where Sub-Saharan Africa has more non-electrified people than all other areas of the world and as a result of that, if you're looking at this kind of very basic problem of creating connections, it's becoming kind of geographically concentrated, it is really only one region in the world left where this is a major issue on a large scale.

So, what I want to talk about next a little bit is about how we do electrification and this is important because it will have significant implications for the demand growth potential. So, historically, there's really been only one sort of major way of electrification which is grid extension, right? So, if you look at just 10 years ago, almost all electrification was through extending the centralized grid in different countries, which in most cases meant that it was a public effort. So, most countries had publicly owned often vertically integrated power sectors and then the government just expanded the grid as much as they could, based on the funding and resources they had and then that helped people gain access to electricity. Recently, there has been some interest in distributed generation. My very first project here in India was an impact evaluation of Off-grid solar

power in Otto Pradesh, this has emerged as an alternative because the cost of things like small solar home systems, micro grids, has decreased. It's still significantly more expensive than just connecting a household to a pole that is 20 meters away, that's kind of obvious because in both cases, you need the wire but in the other case, you also need the solar panels, the batteries and all of that. But nonetheless, if you again, look at areas that have low population densities and where the grid is nowhere at sight, hundreds of kilometres away possibly, that you could make a case for a micro grid or mini grid or even solar home systems. And so, the cost of electricity access then depends, first of all, most fundamentally on geography, it's a very important factor but on the other hand also, on the income of the people. Because it depends on how much you consume; so, if all I need is light, the cheapest solution is actually a solar lantern, it's about $20, 1300 Rupees, I can get high-quality solar lantern and that's my light, so that solves my lightning problem in a very minimal sense but the cost is actually not that high. On the other hand, if I want to consume a lot of power, I want to use a freezer, an air conditioner, which apparently is a kind of a major trend here in India right now, then trying to do that with a solar home system or distributed system would be extremely expensive because you don't have those economies of scale. So, this becomes an

important issue in electrification planning, is you need to have a good understanding of what are these sorts of main trends in the local economy. And Indian context, again, is overwhelmingly a grid, so even though these decentralized alternatives have grown, there are now different businesses that are setting up micro-grids, selling home systems, selling solar lanterns. The reality still is that, if you look at how many people have grid electricity and how many are being electrified every day, then most of that comes from a grid extension. The reality in Sub-Saharan Africa would be very different, there the grid does expand and it's making a significant contribution but if you look at some countries like Kenya, I think by now, there are more people using off-grid electricity than there are people using grid electricity, that's quite a remarkable change in those countries.

So, what does this really mean now for electricity demand, this is really the topic of the day that we are discussing is, what happens when you electrify these rural households, what happens to electricity demand. And what we want to take into account here is to what extent can this be predicted and how should we do it and there's a set of models that I used to do this and we've seen one of them today, there are many others also which sort of feed in things about GDP growth, urbanization, household

size, efficiency, things like these assumptions and then from that, they try to kind of back out what would be the electricity demand. And I'm not a modeller myself, so I'm not going to get into details of which model is the best or sort of how excellent those are, our colleague here can answer those questions, Rahul can maybe also comment on that. But what I want to point out is that there is some recent empirical research that kind of highlights the difficulty of currently predicting what happens to electricity demand, and this is some very interesting work that was done at the University of California, Berkeley by Kathryn Wolfram and her team and what they did was that they obtained some very detailed data on appliance ownership in Mexico. So, this is just one country, it might not work the same everywhere but there they found that there is this kind of tipping point in appliance ownership, where once a country reached a certain level of income, which is let's say 9000 US dollars in today's terms, so much higher than where India would be today, there happened to be a sort of massive increase in rural electricity demand. And the reason was that you had this sort of large group of people all reaching a certain point, kind of the income distribution at the same time, which allowed them to start buying basically fridges; Mexico is a very hot country so fridge is a very popular thing but they're expensive, they consume a lot of power. So, when a lot of farmers, because of

technological change and other improvements, reach the same point, they all go and buy those fridges and that means that the share of rural electricity demand very rapidly in the sort of space of, let's say, three to five years, increase very fast.

So, basically people went from one level of consumption to another, and this relates again to sort of just basics of electric appliances; you can start the ladder with mobile charging and lights, you need a few watts and in fact, you need less and less because of LEDs and technologies like that. Then you go to fans, televisions, you need a little more but it's still pretty minimal. But the next step from that up, if you want to have a fridge is a very significant increase and then if you want to have a freezer and or an air conditioner, then it really grows very fast. So, these decisions are discreet, there is no kind of, mathematically we will say a convex combination of a fridge and a fan, you cannot sort of reach those points. You have a family, once they get to the point where they get the fridge, their demand changes completely, their profile is very different from the past. So, unless you know exactly when this kind of transition happens, it's very hard to predict exactly. It will happen at some point, if those assumptions about GDP growth are even roughly correct, where there is five, six, seven and eight, that that's not so important, at some point, it will

happen because people will get wealthier and wealthier but your estimate of the timing might be off by a decade if you don't know when this tipping point happens with very significant implications for planning.

And certainly, if we look at now what's happening among the very poor people, one thing that's been very, I think, kind of exciting recently is that we've started to get much better micro data on what households actually consume. So, I've seen datasets come out, some from India, some from Haiti, Kenya, Uganda, some of this comes from this off-grid companies, others come from distribution companies and if you look at all of them, you really see that currently, the poor people who are getting electrified consume basically no electricity at all. Even if they get electrified, they put the lights on, that's about it, and that will not, with LEDs, result in much consumption. And I will show you some figures where we've done this ourselves in Ulnar district in Otto Pradesh, and you'll see how amazingly low the electricity demand is even among people who take these connections and start using it. So, this is very important because it means that the difference in electricity consumption among non- electrified and electrified households initially is actually very low and this is one of the reasons why, in many of these estimates of what happens when you electrify households,

you say it doesn't matter at all, is that this initial consumption is very low. And in India, this is this kind of thinking is very important because the grid is everywhere, most households are getting grid electrified, so in principle, they could consume fairly substantial amounts of electricity. They are not doing it right now because of wealth issues and other constraints but in the future, they might. So, unlike in a country where a solar home system is the standard mode of electrification, in India, there is this kind of upward uncertainty, where if people's wealth levels started to grow and they started to buy more energy intensive appliances, you might see rapid increases in electricity consumption.

So, this is from my project that we did with a company called Booned Engineering and Development, my good friend, Rustom Sengupta, used to be the CEO of this company, it’s a Delhi-based micro-grid provider and we show here the electricity demand in two different systems in their micro-grids over a year. So, the red dots are what we call ‘static pricing’, here the price of power for this off-grid systems is always the same, the dynamic pricing is one where it reacts to the condition of the battery. So, it's kind of a demand-side management approach and this is based on a randomized control trial we did, and I'm not gonna go into the details of that study, if somebody's interested, I'm

happy to share it. But if you look at the average weekly electricity use, we're looking at 100-watt hours, 200-watt hours, this is nothing, there are 168 hours in a week. So, at a typical time, a typical household will spend less than one watt of electricity in these systems, this is really not at all different from not using any electricity at all. And the reason for this is quite simply people are very frugal, they're very stingy, so they know exactly how expensive electricity is, even when we gave them three fans, they only put them on for like five to ten minutes, when it is 49 degrees Celsius in that area on that day. So, even at that point, they were not willing to spend the money that it would take to run a fan, so it's an incredible sort of aversion to spending money on electricity. And in fact, one of the sort of ironic things about this prepaid and pay-as-you-go systems is that, for this micro-grid companies, that might actually be the worst possible way to try to make money because people are so stingy that they will not spend any electricity at all, you might be better off just having a fixed monthly fee as you used to have in the old days.

So, now what I'll do is, in the second part of the talk, once we've gone through this sort theoretical basics, is I'll tell you about the experience of two countries, China and Vietnam. Both countries I think are quite interesting for India because,

obviously, we know that China started its kind of reform about 15 years before India did, it's a much wealthier country than India today and it's gone through this sort of quite remarkable economic transformation. Vietnam, on the other hand, if you look at most of the sort of economic indicators, is about at the same level as India. The key difference is that Vietnam is much more industrialized, it doesn't have the same sort of high-tech service economy but on the other hand, when it comes to basic industry, it seems to be doing better. So, Vietnam is also a very interesting country because it's kind of grappling with some of these same issues that India has.

So, China: We looked at China fairly carefully, because it's part of a book project that we have right now comparing kind of energy access experiences in different countries, including India, China, Vietnam, we have Kenya, Ghana, South Africa, it's quite a comprehensive range. I'm not going to go to all of them because the point is not to have this marathon six-hour session today, but I'll illustrate this with China and Vietnam, which I think are particularly relevant. So, when you start with China, a good starting point is 1949. This is the time of the communist revolution, when Chairman Mao comes into power and China is a desperately poor country back then. Back in those days, China was actually poorer than India, India started at its

independence with slightly higher level of socio-economic development and there was no rural electrification at all, and so literally, in China, the only places that were electrified where these major cities like Shanghai or Beijing, that's it, the 0.001% of the population was electrified. By 1978, China had actually achieved 68% electrification rate, that's an amazing rate. This was before the economic reform started, this was at the time when China was still an extremely poor country, but they had actually made a lot of progress in doing this, and one of the reasons for this is actually geography. So, China as a country has this interesting feature where they have these rivers and fairly kind of high altitudes almost everywhere, so anywhere you go in China, there's a hill or a mountain next door.

So, what the Chinese did was they built these micro hydro systems, tens of thousands of them and they were the origin of off-grid or distributed decentralized energy entrepreneurs, they did this almost everywhere in China. They had some very interesting business models for doing this, the communist country, Sewickley, Marxist, Leninist, no sort of private business but they had these arrangements where they sort of said that the central government will basically allow the local governments to do anything they want because the central

government had no money, nothing back then, and that meant that the local governments were actually quite entrepreneurial in doing this and they reached a very high rate already before the reforms. In the next 20 years, they basically electrified the entire countryside, except for a few very sort of remote and small villages; think of a village somewhere in Tibet, somewhere in the mountains, those are the kind of places that were not electrified back then. And China did this in a very interesting way, because they went from distributed to national grid, so they did not start with a National Grid and then the distributed came as an alternative, rather the distributed systems, so they are not the kind of systems you would see based on solar with 100 houses, I think about like 3000 - 5000 fairly large mini-grids but they recently combined those, so as they've sort of moved into a very heavily industrialized economy with lots of coal-fired power generation, they've kind of like combined all of these local grids into a larger system.

So, let's look now at what did that mean for demand? This is obviously a very hard thing to estimate and I recommend you take these numbers with a grain of salt, they come from the official Chinese statistics, so there is probably a little bit of overestimate and kind of tinkering here and there depending on whether it's the time of the season when you are promoted for

your next position and all that among the officials but nonetheless, the sort of big picture I think is quite clear. So, the perk up in the demand between 1993 and 2002 went from 168 kilowatt hours to 404 kilowatt hours. So, in 10 years, they increased by more than twofold, almost threefold, so it's quite a significant growth. These numbers, if you want to sort of relate them, India's current per capita is like 1,000 or less than that, and much of that comes really from agriculture and industry, so if you look at the residential, it would be much lower than that, and this is the rural China, this is the poor China, this was 15 years ago. So, you can see this is actually very fast growth, it's quite impressive and just to give you a sense of how this happened, I found this interesting statistic, this was from the edited volume, Rahul, I think you wrote the Andhra Pradesh piece for the Stanford project a long time ago. I found this very interesting statistic where between 1990 and 2004 among the rural families, washing machine ownership went from 9% to 37%, so this is the kind of transition that really changes the electricity demand; washing machines are not trivial appliances, they consume a lot of power, even though these are surely pretty basic, they don't have dryers or any of these fancy distinctions between different types of clothes, nonetheless, this is completely different from just having lights or mobile charging, I guess, wasn't a thing back then but

just compared to having lights, this is a completely different level of demand. And if you do the same exercise now, looking then that televisions, electric cookers, inductions or almost anything, you would see similar patterns. So, this is the key thing here is, that once these bigger appliances start to become popular, the rural electricity demand will really grow quite fast.

And so, the story in some sense is simple, the main driver of this demand is really economic growth in the rural areas. So, people are wealthier, they have more money, they spend more. Reliable service is important; I guess you might buy a washing machine, even if it were not entirely reliable but you just hope that you sort of do your laundry whenever the electricity is available. But for many of these things like air conditioners and so on, you probably wouldn't waste the money if you didn't have enough hours because when the temperature goes up, everybody switches it on at the same time and then the peak creates a situation of load shedding. So, basically, appliance ownership grows and as a result, there's consumption growth, so it's basically, you go from income to appliance ownership, from appliance ownership to demand growth, this is the pattern that we see in China. And, of course, if you compare this, still this is modest compared to China's overall electricity demand because

the industry is such a kind of major source, so the main reason why China is such a coal intensive and [convert] energy intensive economy is really the industry and not the households. So, even though this is significant growth in the big picture, it's still a small part of the total.

Okay. Let's move from China to Vietnam, that's the same trip I did in December, I was first in China then in Vietnam, so let's talk a bit about Vietnam. So, Vietnam, if anything, I think is an even more amazing story than China because when you start in 1975, they really had one of the most destructive wars ever. The North Vietnamese communist government wins the war, takes over the South Vietnamese military dictatorship that was supported by the United States but they're left with basically nothing. At that point, they've lost millions and millions of their population, all infrastructure is gone, there is nothing left of North Vietnam or South Vietnam, all the cities, everything. So, it's not really just that there's no rural electrification, it's there's no any kind of electrification or any kind of infrastructure for anything. Just 20 years later, they are at 50% national electrification rate. Now, Vietnam has some advantages that China did not have. One of them is that it's a very small country relative to its population density. In fact, one of the discussions I had in Vietnam when I was there

recently is that one of the big problems for their renewable energy market, which is badly lacking behind, is that there's no land, there's no place where you could actually build any new energy infrastructure unless it is extremely intensive, so a nuclear power plant or something like that.

But I think more importantly, also Vietnam had a very good electrification program. So, they started this so-called [Doy-moy] reforms in the mid-1980s, this was their sort of Vietnam's equivalent of what China did 10 years earlier, where they start kind of slowly opening the economy, allowing some market activity entrepreneurship very slowly and if anything, I think they've been less aggressive than China has been but as a part of this, they also make an infrastructure push because these kind of reforms make the World Bank, make all these donors get very excited, they're willing to give money and so Vietnam built what is known as 'the backbone' in Vietnam, which is this massive north to south transmission line and then they just start connecting all the communities around it. And they do it, again, in a model that resembles China to some extent, but with much more national central investment. So, the central government gives a lot of money to the local governments, the local governments make investments and one thing that's very interesting about Vietnam is that the demand for electrification

is very high, so whenever you went to a village and provided the infrastructure, the households immediately line up and start paying so that they can get the connections. So, you don't have the same issue where a lot of people choose not to have electricity connections that you would have, for example, in UP even though the infrastructure is there. So, this kind of resembles to some extent the Jota Graham kind of experiment that was done in Gujarat, where these feeders were segregated, you had a different system for households, different system for agriculture, households getting 24 hours, agriculture getting eight hours but households paying more. So, they used a similar thing, as soon as the scheme was introduced, all their villages households immediately sort of signed up to this, so Vietnam had a similar experience and they expanded their grid as a result very quickly, it's now a fully electrified country, there are very few remote places where you don't have electricity but, in the time of 35 years, they've gone from nothing to almost full electrification.

Okay. So, for Vietnam, one thing that's interesting that, there we have some pretty detailed data on appliance ownership, it's readily available from the World Bank's statistics and I took a look at them this morning to give you a kind of a sense of what's happening here. So, if you look at per capita demand in

rural areas, it went from basically nothing, 0.1 kilowatt hours per household to about 300 kilowatt hours in 2009. So, you see this is still much less than where China was in 2002, so Vietnam is still behind but it's not trivial, so this means that there is real electricity demand among these rural households. Maybe a more interesting statistic is, if you look at appliance ownership. So, the World Bank did this very interesting survey, where they surveyed a very large number of rural households in different provinces and they tried to understand, okay so what kind of appliances do people actually have. And it's a very nice study because it shows that Vietnam has kind of reach the point where these mid-level appliances are starting to become popular; so, colour TVs, for example, 83% of households had a colour TV, that might not sound for most of us sort of much but again, if you look at most poor countries, including for example, areas of India like Otto Pradesh, this is definitely not the case, most people wouldn't have a television and apparently, these colour TVs are actually replacing all the black-and-white TVs. It wasn't the case that people just bought their first TV but they replaced their decades-old Soviet black-and-white TV with a colour TV. 75% had a fan, again, quite a significant thing and 55% even had a rice cooker, which is a very significant sink of power, because when you cook you'll need to put a lot of heat into it. So, appliance ownership is actually quite significant

and again, here I'm maybe being a little bit cheeky, but I'll just, again, repeat the same story. These rural households are gaining wealth, they are doing better than in the past, the service is good enough, so a kind of a market for appliances forms and people start buying them.

One thing I want to emphasize that's interesting in Vietnam is, I don't know if this happened in China, but in Vietnam, apparently, the cost of these electric appliances has decreased very significantly over time. So, there's been a real kind of business response to the latent demand, where entrepreneurs have figured out that if we can offer an affordable colour TV instead of two million people in the big cities economy buying it, we could have 30 million people buying it in the rural area. So, there's been a real kind of a positive business reaction to this situation and as a result of that then, we've been able to see quite rapid growth in electricity demand in Vietnam. And Vietnam's electricity sort of challenges right now are really much more about kind of the sort of environment and sustainability aspects plus the usual issue of distribution company finances, which is a major issue in in Vietnam as well as India, rather than electrification, electrification is basically done.

So, this figure, I don't know if you can see it, I, again, copy-pasted from a World Bank report in the interest of time, but I'll just show you this very interesting kind of piece of that survey that they did, which shows basically households and contrasting how long ago were they electrified and what kind of appliances they had. So, those three data points that you see going from left to right are electrified less than three years – so, pretty recently electrified household – electrified three to six years and electrified for more than six years. It's a descriptive survey, so this is not kind of an effect of time on anything, there's no experiment, nothing here but it will give you some sense of how this happens kind of over time. So, if you look at these households that have electrified less than three years ago, you can see, for example, that among them, only about 60% have a colour TV; electrified three to six years, it climbs to over 80% to about 90% for electrified more than six years. Part of this could be just this kind of selection bias, where the wealthy people are electrified first. So, again, this is not an effect of time on anything but you could also imagine the situation where as long as the economy is doing well, households are growing wealthier, you would see this reaction where even if the first appliance you have is lights, the next one might be a TV and then at some point, you'll buy a fan and then over time, you might even get a fridge and then that would change your

electricity demand completely. Rice cooker, a very similar story if you start with electrified less than three years, you get below 40% penetration and then it grows to something like 60% three years or more.

One interesting thing in Vietnam you see is electric water pumps are actually very common, so people use these on their own water pumping for their irrigation but also then drinking water and things like that. And here, you can see this is a very striking number, is that for households electrified three or more years, we are looking at something like 30% penetration. If you go to UP, you will see two percent, three four five percent penetration max and these are electric pumps, not diesel pumps. So, this is quite an interesting thing, where if the rural economy gets to the point where households can make investments to water pumps, that is also a very significant change of things. And then you see, nonetheless, there is still scope for growth, this was done about 10 years ago, for example, fridges are still at about 15% even for households that have been electrified for long. So, Vietnam in some sense, they have reached a kind of a transition point where they are starting to use appliances but they have not reached the peak one yet, in the sense that things like flat irons, refrigerators and so on remain kind of out of reach for most of the households, so there

might be another transition, it might be happening right now, I don't have the latest statistics, unfortunately.

So, this is pretty much the story that I wanted to tell, so let's take…

Rahul Tongia: [indistinct question]

Johannes Urpelainen: These would be electric only, yeah that's right.

Rahul Tongia: [indistinct question]

Johannes Urpelainen: And then that would have very significant implications for this if people made a big transition from LPG to inductions, those would have a very significant implication for power demand. Okay. So, let's talk a bit about the conclusions. One of them is a kind of a boring one, you know. We all like to think that electrification is important, ideally it will drive the rural economy and all that but if you look at these other countries' experiences, it's really much more that sort of fundamental macro-economic changes and regulatory changes drive income growth, which will then drive quality of service, appliance markets and all that. So, there's really this sort of, if there's one thing that I think is going to be critical for understanding rural electricity demand, it's simply how well the economy is going to do. So, if this area [cycle-

two] Pradesh in the future able to grow faster than they are currently, then that will have very important implications for those numbers that we see in these models, that's just a very basic thing that I think is very important to remember because so far, what we've seen is kind of rural stagnation in these areas, it's a kind of an endless race between population growth and agricultural technology. Hopefully, in the future, we would see some more sort of proactive approaches in UP and that would then, over time, have very very important implications for how things change.

I want to mention urbanization, I didn't have it on my slides but since we had it in the previous presentation, I think that's also extremely important because urban areas tend to have higher wages even for very basic things. It's really hard to sort of, for most of us I guess, to understand how this works but it is really true that the rickshaw-wallah in Lucknow makes a lot more money than the subsistence farmer, that's just how it is. And if people moved to urban areas, almost all of them will get electricity and then they will start buying these appliances. So, if organisation is faster than predicted, that will have a significant implication for the growth as well. So, electricity demand will first and foremost, depend on the success in poverty alleviation and right now, India has, unfortunately, not done

very well with this, so poverty remains a chronic issue in area cycle-two Pradesh and Bihar. This kind of extreme poverty has decreased, so the good news in some sense is, if you look at any kind of socio-economic indicators or human development indices, you see that things like very very troubling things like infant mortality and so on are decreasing but what has not decreased is this sort of number of people who still remain at this basic level of at most having electric lights, and the income growth here is the main thing. So, I think if we now take all these lessons and sort of assume that some of these at least would apply to India, then I think the sort of implication here, first of all, is that my guess is the [Solberghia] scheme itself will not have a significant impact on electricity demand overall. It might have some actually unfortunate financial implications for the distribution companies because they are basically providing units to these households at a loss, they're doing very expensive collections for very small bills, all of these things they have to do under the government schemes. So, it might be that the financial implications are actually more significant than the fundamental, which is kilowatt hours transmitted and distributed.

On the other hand, it will also have the implication that, if we think of electrification as a way of economic development, I

think there's good reasons to be sceptical that, if all we can do is connect house households, even if we can provide better electricity quality for them, it's most likely not going to be enough. Because there are so many other constraints to economic growth that unless we can solve education, healthcare, roads, market access, all these different things, I think this electricity sector itself will not sort of pull itself out. Fundamentally, if you look at countries that have done well, whether it's China, Vietnam – which by the way both Still face serious issues on the financial side – if we look at, I don't know, Brazil, all of these countries, what often happens is that you need to have this critical mass of people who consume a lot of electricity and then that will improve your finances and then you can then use that money to subsidize the rest, whether you want to do it cross-subsidy or just through tax revenue is up to the government and I'm not going to comment on that right now. But nonetheless, fundamentally, India's problem is that there is a small number of people who consume a lot of electricity and a very large number of people who don't consume a lot of electricity and in a setting like that, it's really hard to make this sort of equation work in an economically sustainable way that contributes to the well-being of the society.

Thank you very much.

*****