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HOW DO WE END ENERGY POVERTY?
DEBATING SOLUTIONS FOR INCREASING GLOBAL ELECTRICITY ACCESS

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P R O C E E D I N G S

MR. BOERSMA: Good afternoon, ladies and gentlemen. My name is Tim Boersma, I'm a fellow with the Energy Security and Climate Initiative at Brookings.

Intuitively I was going to say, welcome to Brookings, but we are at SAIS, and I want express my gratitude to our colleagues at SAIS for having us host this event here today. We are going to talk about energy poverty, and how to end energy poverty. I think the basic, sort of, data are well known to you. An estimated 1.2 billion people that lack any access to electricity today worldwide, and another estimated 2.7 billion that rely on traditional use of biomass for cooking, heating, and so on. And so, a massive challenge ahead, surely in the light of climate change, and that's a topic we are going to be addressing today.

And we have two excellent speakers who are going to help us navigate this discussion. In arbitrary sequence; Professor Dan Kammen of the University of Berkeley, and Ted Nordhaus from the Breakthrough Institute, both accidentally, maybe not, from California, who are here with today with us to share their insights. And we have excellent moderator, Lisa Friedman, editor of ClimateWire, who is going to guide us through this discussion, lead this discussion. So both speakers, I'd like to welcome them up here on the stage, they are going to make brief opening remarks, and then Lisa is going take from there.

So, welcome, and thank you for joining us. For those of you using Twitter, I should add, and I almost forget because I tend to forget that; please use hashtag EnergyAccess, if you want to use Twitter, and I would encourage you to do so. Thanks again for joining us, and I hope you have a good debate. Thank you.

(Discussion off the record)

MS. FRIEDMAN: Thank you. My name is Lisa Friedman, I'm editor of ClimateWire, we are an energy policy magazine here in D.C., for those of you who aren't familiar with us. And I'm so honored to moderate this debate. I was just telling Ted earlier that I sometimes moderate debates where we have people kind of preaching to the choir from just slightly -- the same choir from slightly different angles.

And today, we have two people who I feel they could come at this topic from more

different angles, which is really refreshing and terrific. We have two people who have given a lot of thought to how to best develop energy access for 1.2, 1.3 people who lack it around the world, and have come to very different conclusions.

I'm going to open this up with Ted. Maybe, whether you want to sit here, or to the podium, whatever you are comfortable with. But tell us a little bit about your latest research, the work you've been doing. You've said that -- in your latest paper you talk about relying on off-grid energies as confusing charity with development. Tell us a little bit about what that means.

MR. NORDHAUS: Okay. Well, I think I'm going up here a second.

MS. FRIEDMAN: Please.

MR. NORDHAUS: To figure out what I'm saying. But thanks, thanks to the Brookings Energy and Climate Team for organizing this event, and thanks to Lisa for moderating it, and Dan for joining me. I know I'm a Californian speaking in Washington where there is more people wearing ties in the audience than on stage.

MR. KAMMEN: We are from the same city, right?

MR. NORDHAUS: Yeah. Exactly, Berkeley, which I had to tell Dan he couldn't wear a Berkley tie. They send out, that's in the memo, right?

MR. KAMMEN: Yes. We get those at Berkeley.

MR. NORDHAUS: Yeah. So, where to start? Well, let me start here. I think obviously part of the reason we are all here is the growing recognition of their connection between energy consumption and human wellbeing. We look at societies that consume more energy, and they will score much better on practically every human development metric that you can think of. Life expectancy, educational attainment, health outcomes, economic security, you name it, the trend holds pretty well, or the relationship holds pretty well.

And as a result of that, in recent years, efforts to alleviate poverty increasingly have focused on improving access to electricity and modern fuels. In 2010 the United Nations declared 2012 the Year of Sustainable Energy for All, with the goal of ensuring universal access to modern energy services by 2030 I believe. In 2013 the Obama Administration launched Power Africa with the goal of doubling access to power in Sub-Saharan Africa.

And I think this is all very promising, it has all been very promising in the recognition of this really critical relationship between energy and human development, but there have also been some problems, I think, conceptually in how we are thinking about that relationship. And the first is that there's been a tendency to conflate energy access with energy consumption. And they are not the same thing, and we should be really clear that it is the latter, energy consumption, that is strongly correlated with human development, not the former.

The IEA defines energy access as, basically consuming 100 kilowatt hours per year. That's not enough to power a single light bulb, and I guarantee you nobody in this room would recognize that as modern energy access. The United Nations Sustainable Energy for All Initiative, a little harder to pin down on what the actual sort of standard or definition is, but when you look at the key technological pathways that they emphasize, clean cook stoves, biomass base, mini and micro grids, decentralized solar generation technologies and energy efficient solar lanterns. In lighting it's pretty clear what the scale of the ambition here is.

And I think, you know, the question that we've sort of have been asking the last couple of years and looking at in our own research is, what is a sort of -- what is a reasonable expectation for energy access and energy development efforts. And you know, I think a couple of questions, the first and most important of these is: Is what we are after here charity or is it economic development?

Are we trying to make deep, agrarian poverty more bearable for people who are trapped in it, or are we trying to move large populations out of agrarian poverty? And from that question I think follow a number of other key questions. One is: can development and economic growth proceed without dramatically raising the amount of energy that people consume? And certainly if you look at what sort of modern energy consumption actually looks like around the world, we are talking an order of magnitude in terms of the level of energy consumption above what IEA for one defines as constituting access.

The second question: Can higher energy consumption be achieved without moving most of the nation's population out of the agriculture sector, and out of rural, social, and economic arrangements? Third, can small scale interventions at the household level, things like cook stoves, micro grids, solar lanterns, support economic enterprises at the scales necessary for large populations to consume energy or modern energy services, if you will, at levels that are recognizably modern? And can

you actually achieve those things without (a) significantly expanding off-farm economic activity; and (b) significantly raising incomes?

Well, you know, there's lots of arguments about, sort of, how we do those things in the future, but one place to look to sort of answer some of those questions, is to look to the past, and look at where we have succeeded in raising -- moving large populations, achieving universal access to modern levels of energy consumption around the world. And we've spent the last couple of years doing that and, you know, can make some general observations. There's lots of differences in contacts, national endowments, other things, but there are some fairly common patterns or things that we can identify.

So one, and first, is that there's no large-scale precedent for what is being proposed at the U.N. and elsewhere. And I don't say that to pick on the United Nations, because I think it's sort of more a broader gestalt, but at the very least, sort of these really, really low-level, small-scale household interventions that have been a lot of the focus, or at best sort of ahistorical in terms of what actually has driven successful efforts to move people out of energy poverty.

And really, you know, beyond energy, just a track record on these kinds of micro interventions, just has not been good. And whether that's micro credit, and the work of folks like Mohammed Yunus and the Grameen Bank, whether it's Jeff Sachs' Millennium Villages, whether it's large-scale efforts to distribute clean cook stoves, and solar lanterns; those efforts have been proven and can help individuals and families improve their lives in very specific places.

But there's really not much evidence to date, and I stress, to date, that those kinds of interventions had succeeded in moving large populations out of poverty. And which is really, when we talk about these broad human and economic development objectives, that's really what we are after, but we started to argue, argue we should be after.

So then what has worked? Well, I'll observe a couple of things. The first is that no nation has exceeded in achieving universal access to electricity, modern transportation fuels, you name it, without moving most of the population out of agriculture, and into cities. Subsistence farmers can't pay for electricity, and they can't afford appliances for usefully converting electricity into energy services. Modern energy consumption requires growth in off-farm employment and income so that people can afford the services that it provides.

Second, historically household electrification has been a side benefit of energy development. So even in the United States, we hear a lot about Pearl Street, and the rich clients who were the first people to get lighting in their homes, but the main event in terms of early electrification in the United States wasn't household or residential use, it was trolleys in factories, which were the first large-scale applications of electricity in the U.S., or really anywhere in the world, which drove increasingly large loads which made it economical to build out generation in transition, infrastructure initially for productive economic enterprises, and public uses, but also lowered, very dramatically, the cost of extending connections and access to households.

Third, most people historically have gotten access to electricity by moving to the city. So the people go to the power, or the power mostly doesn't come to the people. And finally, there is just no substitute for functioning public institutions, that doesn't mean that you can't have some level of corruption or inefficiency. All over the world we've seen successful efforts where, you know, transparency was not complete; but there's no basic -- no shortcut really for basic infrastructure development and governance.

And so finally, let me wrap up by suggesting, you know, what I think those lessons really mean for contemporary efforts, and really, four things. The first is, prioritize energy development for productive economic enterprise. Industry, mining, agriculture and manufacturing, things that create jobs, incomes, economic mobility and employment outside of the farms -- of the agricultural sector.

Second, extend grid access in cities. We are in the midst of the largest migration and process of urbanization in human history right now. More people coming to places where at least some infrastructure is already in place. Huge populations, we know that already live in close proximity to electrical grids and centralized generation capacity. And we need to be working with those trends, and not against them.

Third, when we are focused on rural communities, and particularly off-grid applications, we need to really to target applications that raise agricultural productivity in on-farm incomes. Things like pops, threshers, mills, and again going back to the U.S. and other experiences with rural electrification, rural electrification has generally proven sustainable when those efforts have actually raised agricultural productivity, raised outcomes so that people could afford electricity, could afford appliances, and could afford the uses of electricity, if they don't have any (inaudible), can't.

And finally, we need to plan for the future as well as the present, you know, particularly in the developing world, just economics, social arrangements; living patterns are evolving really rapidly. Energy technology, investments, particularly those that are focused on off-grid technologies need to anticipate continuing energy development infrastructure, and integration so that we are planning for the ways in which those investments are going to get integrated into much more, larger and more complex infrastructure and energy systems.

So, I'm looking forward to a good conversation. And thank you all for having me.

(Applause)

MS. FRIEDMAN: Thank you. Yes. Dan, as you, well, take the stage. You've done a lot of work both at The World Bank, where I first met you when you were working, and now State Department, at Berkeley, making the case for off-grid and decentralized energy. You've worked on the ground in a number of countries. So, please, tell us what you've been working on lately, and then we'll get to the discussion.

MR. KAMMEN: Okay. Well, thanks so much for all being here. And Lisa, thanks for hosting. And Ted, thanks for giving me the chance to do it; and for Brookings, and Johns Hopkins for hosting this.

And I guess I should start out by really saying that my laboratory at Berkeley is focused on energy solutions across scales. And so we have partnerships and we built models of large central grid systems, models of West and North America, the Chinese grid, the grid in Southeast Europe, in Nicaragua, Mexico, Chile and East Africa. So we do a lot of work on the large-scale utility-connected systems, but we also, as you said, do a lot of work on the products that evolved in a very chaotic and haphazard pathway from efforts to look at things like cook stoves, to solar home systems, to now the exciting, really much more dynamic world where, pay-as-you-go off-grid products, mini grids, the whole continuum of grids is part of the dialogue.

And I think that's really a critical part of the story because one of the features that is critical to this area, is that data has often been quite lacking, and there have been fads of investment in different areas over time, and so my lab has worked now for many decades in East Africa, focused largely out of Kenya, but extensively also in South Sudan and Uganda and Ethiopia, also in Central America,

mainly focused the RAAS, the Autonomous Atlantic Zone, and in Malaysia, Malaysian Borneo, on access at the very small level all the way up to utility systems.

And the real unfortunate story is that we have balanced back and forth between different trendy areas, in terms of different technologies and different practices that were exciting at different points of time. One of those that is now much more than an exciting drop in the bucket, is this dramatic technology system, economic and behavioral integration that we are just seeing around off-grid decentralized solutions.

And that's critical because we have less than a decade of experience in doing these types of projects in a serious way. There are still major data gaps, we have stops and starts, funding has been incredibly problematic in these areas, but the lessons are dramatic. What started out, and I was in the room, when people in many of the big development agencies literally said, oh, just look at solar lanterns, this is just false energy, this is a glorified flashlight, and maybe the first generation was literally that, a flashlight, solar-powered, small lithium-ion battery, compact fluorescent light.

And then it added AM/FM radio, and then it added multiple lights, some were mobile, some were fixed, and now we have systems that do a very large range by a very large number of different employment agencies. You can now get color televisions, low-power, high performance color televisions, refrigerators, freezers, mills, a whole variety of technologies that are strung together in this plug and play, new, evolving world of decentralized small systems.

Many solar-powered but far from exclusive; there are small windmill developments, there are biomass gasifiers, micro-hydro systems, heat pumps, a whole range of technologies that we are only beginning to be able to tie together. And so instead of seeing this as an either or, one either keeps investing in the development process that we see in the past, or jumps to large-scale central systems, or get to in the end, what we really have is an opportunity to understand that what's going on in energy access is a continuum.

And some of the big successes have been around energy access and equity, equity between men and women, between disadvantaged minority groups, between advantaged groups, and this ability to democratize the energy process is one of the critical features of this decentralized -- I don't want to say off-grid -- but this continuum from the smallest individual solar lights, to now we have

companies that have gone from zero to close to half-a-million customers in East Africa, selling pay-as-you-go kits that began as these systems but are now expanding.

Now we are seeing mini-grid companies entering the story, and these are not mini grids to provide household services, these are mini grids to provide the kind commercial services, the power that you need. Innovation on batteries has become a critical part of story as well. So that it's not just lots more green kilowatts, but it's energy to do productive tasks; and from Central America, to East Africa, to Southeast Asia, we see strong economic performance, not just little bits of cottage industries emerging from this field.

The other part that we can't leave out of the story is that energy access is critical to economic development and social equality, but also to dealing with climate change, and one of the hallmarks of the biggest projects is that they take a very long time. We've seen major studies coming out of The World Bank, Oxford University, our laboratory at Berkeley, many places, highlighting the incredible overrun in cost.

The underperformance of large-scale centralized systems, be they fossil, be they large hydro, and that is not just unfortunate because it means they cost more, it often means that what we see is access for some large companies, but not access for propel overall. In fact, many of the highest profile projects funded by my former employer, The World Bank, but many other groups have raised prices for the poor, decreased access while providing marginally more energy for a few large industries.

And in fact what we have as an opportunity in a decentralized process is not to pick an either or, we need to extend grids, we need mini grids that are useful assets not discarded when the larger grids does come to those areas, but the opportunity cost of not building a much more broad, decentralized portfolio, is actually to bet on the past, not bet on the future. And when you look at a person's first access to energy, and they say getting this 100 watt panel, as we heard, is life-changing. That’s great.

But then we see local industries, and we see the ability to manage the local environment, not to destroy it, as part of a local good, that’s not climate change for the North, and then climate destruction for the South. That's the ability to build these systems as local assets. Kenya, Bangladesh are leaders in sustainable, off-grid energy systems, batteries, recycling of batteries, the whole ecosystem.

I think that's the last feature because the audience is, thankfully, young, in this room, is that one thing we've seen is that the last 10 years, the only dataset we have so far on these decentralized technologies, has demonstrated more innovation per dollar spent per unit time, more teams of students, young practitioners from universities, from think tanks, from private sector groups, changing the technology base, and demonstrating that this power for all, this ability to bring these services, is in fact much more closely coupled with what we think about as economic development, than waiting for large-scale systems; some of which we critically need, but many of which have done more harm to the poor, than good to the poor. Thank you very much. (Applause)

MS. FRIEDMAN: Those were two tight 10-minute presentations. Thank you.

MR. KAMMEN: I saw you looking with that little --

MS. FRIEDMAN: I'd like to open up our discussion by going back to one of the questions that you raised in your paper, Ted, and asking both of you talk about how we are defining energy access. And if I could step back for a moment and sort of distill what I feel like I hear from both sides in this debate is that, you know, one side accuses the other of being willing to leave poor people in developing countries at an unacceptable level of poverty, with a couple light bulbs for access, but not real economic growth.

And the other accuses folks who are, you know, promoting more centralized grid access, entirely, that people are going -- of ignoring people who are not reaching the grid, and might not reach the grid, in our lifetimes, and preventing them possibly from being able to access cheap, reliable energy in the form of decentralized energy.

That's maybe an inelegant way of blaming it down, but I'd appreciate you, both of you kind of speaking to that argument, what feels right and wrong to you, and tell us, when you talk about energy access, what is it that you mean. Do people deserve everywhere in the world, what we have right in this room? A well-air-conditioned, big auditorium filled with lights. Is energy access, does it begin with something much smaller and is that acceptable, at least, in the beginning? Let's start, maybe, with Dan.

MR. KAMMEN: Okay. So I think we actually agree on sort of the definition. I mean, energy services is really the critical part of the story. And that's services for household use, services for commercial activities, services for industry. And I think I heard versions of that in kind of what we've all

said, that's very different than many traditional pictures, metrics that have been used by many of the international groups that rally counted raw kilowatt hours often at a plant, often totally disconnected from end users.

And that is something that I'd like to think that the process at Sustainable Energy For All, at this real fluorescence of groups that are now working on this topic are looking to fill in. It's a story that's pretty similar to what's happened in water, where access to water as defined in very crude terms, total amount of available water per area, per population, as opposed to actual access to water that's usable in the right form. Potable water for drinking, for even the poorest citizens, water for industry, grey water recycling, et cetera.

Energy has many of the same features; it's taken longer, because energy is not storable in many of the simplest systems. The rise at energy storage as an opportunity changes that quite dramatically, low-cost batteries, and actually the evolution path for batteries to this day, is in fact ahead of where solar was for the comparable investments. And that's a bit complicated because battery research has gone on for a long time, but largely for lead-acid batteries, not really a part of this equation; that Bangladesh started with that but moved on.

But recognizing that energy services is what we are after, and those services need to actually be provided, not theoretically provided, is one of the challenges. And so when we look, and many groups, that look at the legacy of large-scale energy projects, there are some good ones, but the legacy of bad ones is extreme. That doesn't mean there aren't failures on the more decentralized power side, but the opportunity to essentially build a smarter more democratized energy system, is one of the elements that we are seeing in the best of the small-scale projects.

I would argue we are seeing in the large central ones too, but in terms of the time to reach people, and to meaningfully change lives, both on the time scale of providing better urban energy solutions -- and I would encourage everyone to look at last week's special issue of Science, that was all about urban sustainability, that highlighted energy, water, information technology, education, as a place where those messages are being pulled together.

But also to make this something that development groups, local governments have a direct ability to influence. And that's really the training and the capacity building that I think we probably

also share, is really the critical feature. Infrastructure can be done well or poorly, it needs to be done for either large-scale or small scale, and what I see is this continuum, is a far better match to the speed that we need to deliver energy, and the evolving technologies, so we don't try to repeat which has worked very inequitably in the countries that are, so-called, electrified today.

MS. FRIEDMAN: Ted, how do you define energy access?

MR. NORDHAUS: I mean, I guess I would -- A couple of things, but first I'd want to -- you know, I think you got at something, Lisa, and it's important, I think it's an important intervention that we'd be well-served to make. But I think in these various debates, there's been a lot of casting about of, you know, I care about the poor, and you don't care about poor, that kind of thing.

You just want to leave people in poverty, I wanted to -- You know, and each -- You know, the varying size in these debates have their own version of that. And I don't think it's very hopefully, I think, everyone is sort of involved in this -- is involved in it because, you know, they really understand that these issues are really important. I think we are having what I think is a healthy debate about the best way to meet --

MS. FRIEDMAN: To answer that?

MR. NORDHAUS: Yeah, both what the need is and the best way to meet the need. So that would be the first thing I would say, just right from the start is, you know, I think we should kind of cool it a little bit, in some of the, kind of, charges and countercharges and claims that are made.

The second thing, just on this, you know, I think I would disagree with Dan a little bit in that, on this question of sort of, well, it's just raw kilowatt hours, it's just a useful metric. And it reminds me a little bit of like the GDP debates, where, you know, you can critique GDP as a measure of true wellbeing or whatever, and everyone keeps trying to come up with these alternative metrics. And then, you know, you get the people to put all the metrics together, and so GDP is still sort of -- seem to actually predict the alternative metrics better than anything else.

And I think, sort of, energy consumption at a societal level is kind of like that, because I don't think you can just isolate household consumption, I think you are really looking at I think the -- You know, and obviously there's big differences among developed economies, lots of places that do quite well that use a lot less than U.S., but when you look at the differences between those places, and places that

are really poor, the order of magnitude is just huge.

So I think you need to consider that when we are talking about sort of energy for development, which I think is a better term than energy access, because it gets at why we care about it. You have to actually look at energy consumption on a societal, and a per capita level, and yes you can use it more efficiently, less efficiently, you can produce services more effectively. There's going to be differences depending on what the economy actually looks like, but I do think that it's sort of a useful, very rough metric for kind of talking about what the relationship between energy consumption and the societal outcomes that we care about is.

And I guess the last thing, you know, I think Dan and I agree, I would say -- I would not say no decentralized, no small scale, no nothing, and it sounds like Dan says -- you know, would agree that there is a need for still a need for large energy infrastructure in many parts of the world.

MS. FRIEDMAN: So, is that accurate?

MR. KAMMEN: That is absolutely -- I try to say over and over again, there's a clear continuum, but I worry --

MS. FRIEDMAN: So you are both on the continuum?

MR. KAMMEN: We are still on the continuum.

MS. FRIEDMAN: Are you?

MR. NORDHAUS: Yeah. Yeah. Absolutely. You know, and I think of it as the past versus the future, and of course these debates about the future sound really exciting and amazing, and it's weightless, and there are no tradeoffs, and that's because it's in the future, and then the past has consequences, that we can actually look at, and we can talk about. You know, sometimes intended, sometimes unintended. So we kind of look at the past and we go: You know, what has worked? Well, you can kind of throw all that out and go, forget it. But I think there are some pretty important lessons there about how societies have achieved broad prosperity and wellbeing, and the relationship that energy has had to that process.

And we can get better at it, the technological underpinnings may change to varying degrees, but I think -- I would beware, narratives that contrast sort of the bright, weightless, trade off with future, with the past that Messi and Hurd, and I don't think that Dan was necessarily doing that, but I think

we get lot of that sort of, we are always talking about the future as opposed to the present, were necessarily looking to what we can we can learn from the historical record on a bunch of these.

MS. FRIEDMAN: Well, certainly in covering this for a long time, I think you tend to find there's a lot of -- a lack of nuance until you start digging deep with folks like yourselves, or have been giving this issue a lot of thought. Dan, if industrialization and urbanization has been a precursor to broader energy access, is that the way it has to be? Are you seeing anything on the ground in the countries you are working with that speaks to a new way of industrialization?

MR. KAMMEN: well, I certainly don't think that the emerging feature is weightless and that it has all the promise but none of the bad stories. We all have, hopefully, seen the really poorly-managed, small, decentralized projects. There is a litany of efforts that, you know, we are sort of in the do-gooder category not in the do-well category. And that's a huge challenge. So I think there's a lot of evidence that one can look at, and one has to look at for the types of projects that haven't worked.

The challenge for me is that a narrative that we need to move people to the cities more quickly than we are already doing, we need to presumably make agriculture more intensive with less people, and allows us to think about large, centralized projects that's really the cornerstones of economic development, I think misses the facts. And the challenge isn't that, as Ted was saying, isn't compelling for a number of urban areas.

We have areas of massively rapid urbanization, not only in East Asia that often gets highlighted, but we are seeing similar stories in Central America, parts of Latin America, but the challenge is that large-scale systems, as we know how to deploy them, will largely be deployed in ways that we know how to deal with. So, the weight of history isn't the weight of history in a negative way, it's a weight of experience and how we'll do the projects.

And what we've seen is that that does generate more kilowatt hours where people live, but inequality has gotten very far apart, and the opportunity to make that process smarter and more democratic, and more servicing needs, and again, I don't just mean household lighting needs, I really do mean industrial opportunities. We have examples of mini grids in Malaysian Borneo that started off with very small systems, often an individual store or a welding shop that then became the hub of an issue.

Nepal did a very interesting effort to basically utilize the tracking routes, and to utilize

those two hotels, and micro-hydro as a way to build out significant energy. We are seeing an effort in East Africa which is perhaps my favorite right now, where Kenya, which was about 24, 25 percent on grid, until they start an effort to dramatically scale up the centralized grid, they are now heading over 30 percent and they want to get quite a bit higher, but at the same time, the decentralized energy opportunities, are not being sideline by the government. As many of the efforts in this area, do a dichotomy between what you can do large scale and small scale.

MS. FRIEDMAN: Can I ask you about that?

MR. KAMMEN: Sure.

MS. FRIEDMAN: I mean, are you also seeing -- Is there evidence that off-grid has raised incomes in communities? Are there studies?

MR. KAMMEN: So, let's be clear. So off-grid is not the term --

MS. FRIEDMAN: Okay. I'm sorry. I'm sorry. I knew it as I said it.

MR. KAMMEN: -- and I would choose, you know, what I'm saying it's decentralized; right?

MS. FRIEDMAN: Yes. Right.

MR. KAMMEN: And it's a big different, right? So, yeah, we have very clear evidence from the places that have invested in it. This is part of Central America, notably in Costa Rica --

MS. FRIEDMAN: That those are things that boost economies.

MR. KAMMEN: -- Nicaragua, Kenya, Tanzania, places where there's been an investment in decentralized energy, but enough to do economically productive tasks, and not just, you know, you have lights at your basket weaving shop, but to actually do light in medium industry in the space, which is less than a decade old. And this ramp up is dramatic. And so, you are right, it is fraught with lots of, well, we might mess it up as we've done to many things in the past, but its opportunity is one that are already seeing realized, it's not just -- it's not vaporware, it is storage systems, it is solar, micro-hydro, mixed in doing residential energy supply and commercial and light industrial.

And again, this is not an either or, I mean, as Ted and I both said, the large-scale systems are critical, the challenge for me is to make sure that a push for one doesn’t crowd out the other, and we clearly, in my view, and I think based on the data, need to make energy services available as

widely as possible, and with the least environmental impact as possible going forward.

MS. FRIEDMAN: Ted, one of the things we talked about the other day when we chatted, was the grid as it exists in many parts of the world, which is terrible, and Dan alluded to this. I mean, there's places all over the world where people -- where there is grid access, it's just lousy. What is the answer there?

MR. NORDHAUS: Yeah. I mean, I think -- As I said in my remarks, there's no substitute for decent institutions, and I think the important lesson, is that I don't think you get the sort of end run that with a different technology. You know, a failing state or failing states, places that are just really plagued with corruption, poor governance, poor institutions, have huge problems that often sort of transcend the provision of energy services, and --

MS. FRIEDMAN: But wouldn't providing decentralized energy let people avoid dealing with the failed states?

MR. NORDHAUS: I don't know. You know, when the militia comes to your village, you are dealing with a failed state, whether you've got a LED light bulb or not.

MS. FRIEDMAN: But how about some place like Islamabad, where, I mean everybody has got a backup diesel generator. That's distributed energy; it's just dirty, right?

MR. NORDHAUS: Right. And, you know, again I think a larger point is that there is a pretty well established, sort of development paradigm, and yeah, when you have failing systems, you know, very little economic opportunity, very large scale -- very little large-scale industry and, you know, and cottage industry is nice, but at the end of the day you look at like every -- practically every place that has sort of achieved, broadly achieve, something that looks like modern living standards, and you don't have to say to the U.S., that's wasteful or whatever.

Take Japan, take Germany, take -- you know, you start clicking down the list. And they've done it with industrial policy, really, and energy is always a part of industrial policy, you know, from the very earliest sort of manifestations of it, so there are no shortcuts to that, and when we imagine shortcuts, what we are actually doing is charity, it's not development. And it might be okay for us to do that, but we should be honest that that's what we are doing.

Now, I think that -- You know, I don't think that's what Dan -- the argument that Dan is

making. I think Dan is making an argument that these kinds of bottom-up efforts actually do aggregate in a particular kind of way, or at least have the potential to aggregate in ways that actually get you onto a similar. And, again, it's going to look in different place at different times, but sort of something that looks like that process of, you know, industrializing, urbanizing most people out of agriculture.

You know, you can kind of go down the sort of basic features of it so, you know, again, I think there's an argument, and I'm totally open to evidence so, you know, I think there are sort of some promising cases. I am wary of the tendency to just sort of take a set of relatively small-scale isolated things and say, if everything worked like this.

MS. FRIEDMAN: Sure.

MR. NORDHAUS: But those things are usually, almost always contingent, and you have to -- there are a lot of sort of scenario at work, will kind of take real micro things and blow them up macro in ways that don't really work in the real world. But as I've said, you know, I think that -- I think that there's a role for it, and exactly what the right mix is, I don't know if we know yet and, you know, I'm certainly, at least I can say, you know, to the degree to which there is strong evidence, that you can kind of bootstrap, or otherwise kind of aggregate the stuff to a level where you really start -- it really starts, and you can see it at a macro economic development level. You know, I'd certainly support it.

MR. KAMMEN: I'm not sure though, I was saying though, its bootstrap. That's I guess the bootstrap sort of implies distributed things whether they are planned or not, kind of grows organic. Let me do two super-short examples, just to get right into the fill --

MS. FRIEDMAN: Okay. Let me just pause. Then I'm going to open it up to questions, so if people have questions start thinking of them now and I will look out --

MR. KAMMEN: Okay. I'll do them really quickly, just because they are -- I mean, to the failed state one is a great place because no one has good solutions there. So, we have a team working in Sought Sudan, working the last several years, and people who have moved in and out of relief camps, whose towns have been overrun and attacked, one of the constants on both sides, whether you are on the opposition, the vice president and the president's side has been the inability to provide the basic services, whether it's for clinics, whether it's lighting, whatever else.

Well, one of the areas where the decentralized mini, micro-grid, whatever you want to call

it approach, has been really productive is actually to take those concentrations of few resources in a destroyed landscape, and within their fence line, build out solar with storage, and as people move back to the communities maintain that place as a new base-load, renewable part of a system. And you've seen this in (inaudible), in Wau, and a whole variety of places where this is an alternative.

Now, Ted has told me, right, all of these anecdotes have 50 caveats, and so you can't generalize. Sarawak, Malaysia, other extreme, large, forested, but also heavily impacted due to mining in other states, just cancelled its ironically-named SCORE, Sarawak Corridor of Renewable Energy; 12 mega-dams to flood forest, displaced a huge number, and they canceled the permit for the next dam, because the experience they are having with decentralized energy and commercially useful energy is positive.

And of course there's a footnote, they are using solar, a little bit of wind, biomass. But where did they get the biomass? It's the waste from palm oil, which is a huge destroyer of the forest. So that is a story that's incomplete, it doesn't speak to a perfect success, but to cancel a multi-billion-dollar internationally-funded dam, the first of 12, because of the opportunity to not destroy the landscape, to invest in community-by-community industry, is admittedly one act though, but it kind of highlights that this is not based on what we'd like to see happen when the price of batteries falls another 12 percent. It is an evolving story about decentralized smarter systems.

MS. FRIEDMAN: Super. We have a question in the front. Is there a microphone that's going -- Yes, there's a microphone this way. I'd ask folks to give us your name and affiliation, and try to keep things to a question. Thank you.

MR. VON SCHIRACH: Thank you very much. My name is Paolo von Schirach, I am the president of the Global Policy Institute here in Washington, D.C., and for about 25 years I worked in development in many countries. So, many of the things you gentlemen have expressed have a very strong echo. If I may, just a couple of observations, and then a question?

MS. FRIEDMAN: Oh. The first one is defying me; one observation.

MR. VON SCHIRACH: One observation. The one observation is this, contrary to what may be the impression, you know, listening to your remarks, is that somehow energy access has surged to a level of high priority in development. That is absolutely not the case. In other words, I have been

working for 25 years in Africa with people who are talking about, oh, health access, gender this, insurance for that, agriculture, with no energy. Energy was not part of the equation at all, which is I find extremely remarkable.

The other thing is that most -- that energy is contingent on funding. Most African countries and countries in Asia don't have, don't have the funds, don't have the ability to develop the bankable projects that would allow them to go and get the funding for energy infrastructure and for energy generation. Third, they lack completely any knowledge of how to organize and execute PPPs. In other words, they just don't how, they don't even know where to start, there's no, even legislation, and I can give you plenty of example. In Africa there are only two countries that have PPP legislation --

MS. FRIEDMAN: Let's -- the question?

MR. VON SCHIRACH: -- and that is South Africa and Egypt. And here it comes to my question, you referenced very briefly the Obama Administration Power Africa Initiative, and that's it. You didn't comment, you didn't say anything. This is on the table -- This is policy. Several billions of dollars that supposedly were going to transform entirely the delivery of U.S. foreign aid to Africa, by transforming entirely energy generation and distribution having a few pilot countries, but you now all of that, I imagine.

Anyway, you haven't said anything about it, and yet this is U.S. policy. Is it succeeding? Is it going well? Has it failed? I find it remarkable that in an entire conversation, and we don't mention even what's been mainstream U.S. policy for the last two or three years; nothing at all.

MS. FRIEDMAN: Thank you. Let's have quick report card on Power Africa from two differ perspectives.

MR. KAMMEN: So, I would argue Power Africa, with a slow start, is a huge evolving success. Power Africa is a significant amount of money, and in the last two years Power Africa has added a very significant program called Beyond the Grid. And so the design and the engagement with a number of countries around public private partnerships, around mapping the best corridors for large-scale power, but also finally investing in off-grid, in the mini-grid world, the White House had a summit on it, where hundreds of participants on the entrepreneurial side, many of them based in Africa, are part of the story.

But I see similar efforts funded by others, sometimes the host country is in parts Central

America, and so I don't think that actually I would agree that right now the critical feature is lack of money. I actually think we need to build infrastructure, training, some of the things that Ted as well, that the capacity is not something which is uniquely lacking there. When I go to U.S. utilities their ability to design public-private partnerships, their ability to meet their energy access low-income goals is also poor.

Not as poor as some of the countries we are talking about here, but the amount of global learning needed to support the capacity, to basically build smarter, more responsive systems is a global challenge. So I work most of my time in Africa, but I am --

MR. VON SCHIRACH: You worked within the (inaudible), it's not the same.

MR. KAMMEN: Maybe we have.

MS. FRIEDMAN: Ted have you -- Is this an initiative that you've focused on?

MR. NORDHAUS: I mean, I guess I'm sympathetic to some of the criticisms, which is that, you know, again there is a -- and some of this is just -- Again, we have to be clear about what our expectations are. I mean, the real history of development and energy, you know, sort of the transition to modern energy. I mean, it's really all been developmental states, through pretty much the entire history.

So if you don't have, you know, functioning developmental states with industrial policy and a clear vision for what they are -- how they are building out their economies, the international development money is -- I don't want to say it's insignificant, but I think we sometimes place too much -- we imagine it can do more than it really can do, and I think in the right context it can help.

And even where we haven't seen successful, you know, large-scale development, look, there's a lot of metrics around improving global health, improving global education attainment, improving life expectancies, numbers of people living in poverty. Though I think that like the millennium development goals had much to do with most of that, probably not, I think there's just more sort of macro-level things driving most of that. But, yeah, I think that one of the questions from the sort of international development perspective is just, what kinds of interventions that actually, matter, and in what context.

You know, where you don't have either institutions or the ability to, you know, or really much potential for industrialization, I think it's very, very hard. And so, without taking a lot of time, I don't want to -- you know, sort of something I've thought about, but I think thinking about what the sort the right models are, especially in places like sub-Saharan Africa, that really kind of gets you onto that virtuous

cycle of development, is maybe discussion for a different panel.

MS. FRIEDMAN: Let's take a couple more. We started about 5 minutes late. I don't know if we can get those 5 minutes back at the end, but I will see if they'll let us. The woman in the second row, over here, let's -- I think we could still do one at a time; and then, after that, the gentleman in the fourth row.

MS. DE NEVERS: Hi. My name is Michele de Nevers, I work at the Center for Global Development. I agree with you, Ted, about the fact 100 megawatts is not modern energy access, I know you were a member of a recent working group that said it should be between 300 and 1,500. The question I have is, I work on climate and development, and in this context we frequently hear this, it's either climate-friendly, small-grid off-grid, decentralized, or its fossil fuel, large-scale grid based. And even Oxfam recently came out with a paper saying we should allocate the remaining potential fossil fuel emissions in the atmosphere to least developed countries so they can build coal fire power plants.

Is that the case? Is it the case that centralized large-scale means fossil fuels, and if you want to have it renewable, you have to go the small grid, whatever? Or can you achieve appropriate levels of energy access with renewable energy maybe in the same frame, maybe at the same cost? But we can forget about cost for a minute.

MS. FRIEDMAN: That's a great question. Thank you very much. Maybe, Dan, can you kick that off? Does centralized energy mean we adjust the carbon budget?

MR. KAMMEN: No. It certainly doesn't. I mean, we have examples in Europe and North America, but in this context, maybe even more relevant. We have examples of large-scale wind farms, Lake Turkana Wind Farm in Kenya, large scale urban solar in Rwanda, that is powering the local city. So I don't think it's -- I don't think that's the case at all. The challenge, in fact just to pick up one of the elements that you said, we actually have really good data now, that the large-scale renewable projects also have the ability to be done more quickly.

That's not always the case. The first of anything is always a very painful birth. And so I don't want to generalize about that, but the ability to establish wind farms, often wind farms that are backed up by hydro, or wind farms that are backed up by biomass, there are opportunities to install renewable energy far more rapidly. But that doesn't mean it will happen necessarily.

I think Ted's comment is right on, that if you think we'll do this without first focusing on institutions, and having the right kind of capacity, we don't get there. So a project which I love, it's a joint effort in The World Bank, and the IFC, it's called InfoDev, and it's an effort to build clean energy training centers around the world based on donations from governments, in South Africa, in Rwanda and Vietnam and Kenya, these have been phenomenally successful at assisting entrepreneurs who wanted to do this.

These are not for large-scale grid projects. These are for these mini grids for taking a brewery and having them do industrial scale energy, and they are an example of doing it, but I think that the promise that you are offering, can we provide that significantly more energy more cleanly, is true, but the if/then statement is a programmer's nightmare. The number of pitfalls, especially for new projects, untested and unsupported by big banks, and many cases looked at skeptically because they might displace a funding stream that already goes to large-scale projects.

There's a lot of hurdles that this different path is going to have to get over, and we've seen that in South Africa -- we've seen that in Southern Africa, we've certainly seen that in Southeast Asia, we've seen that in Balkans where those projects never got to start, even when laws were on the books. Kosovo, debating coal plants, and yet it has a very well laid out laid out (inaudible) from the books, not one project has been built, because none of the financiers would make the switch.

MS. FRIEDMAN: Ted, what do you think?

MR. NORDHAUS: Well, I'll make a couple of observations. I mean, I just think the first is that the idea that we are going to sort of achieve our climate objectives the backs of the poorest people on earth is just a little absurd, and nonsensical. I mean, most of the emissions, most of the consumption, all of it coming from much more developed parts of the world, and much wealthier populations.

The second thing that I'll say is that even without addressing energy poverty at all, we are going past our climate targets. You know, I'm sorry if it upsets anyone, but the prospects of stabilizing emissions at 450 DPM are slim to nil at this point. And while it would be better to stabilize them at 450 or even below 450, I think that we've gotten ourselves in this kind of target game where it's sort of, like the world is safe at 449, and it's apocalypse at 451, and it doesn't actually work that way. I think the reality is that lower is better than higher, we should try to stabilize as low as we can while recognizing that there are other needs, there are other realities, there are other sort of human development priorities that have

to be accounted for.

And obviously, energy poverty is a big one. So, you know, again we are going to navigate those tradeoffs, and frankly if anyone is going to burn fossil fuels over the next 30 or 40 years, I would say the people who should have the priority for it are the poorest people in the world. In the meantime, I think we do have choices, and the choice isn't, you know, energy poverty or blow our climate budget, I think the choice is pragmatically, how do you balance the sort of economic development needs and human development needs with climate and other environmental considerations.

But I think there's lots of opportunities that don't put us into a zero carbon renewable versus coal, and that's all there is. You know, Africa has huge hydro resources, it's got a lot of natural gas and, you know, as opposed to East Asia and most of the rest of the world, might actually leapfrog a lot of coal burning in the process of its development, even if it doesn't go to off-grid 100 percent renewable, you know, right away.

You know, India, doing a lot of solar, doing a lot of nuclear, China doing a lot of everything, so I think that that -- some of this talk of carbon budgets and things like that, I think just sort of obscures the real practical choices that we have, and we'd better served to focus on those real specific local tradeoffs and decisions that we have.

MS. FRIEDMAN: Dan, do you want to solve climate change on the backs of the poor?

MR. KAMMEN: No. I think I said the opposite. In fact, Michele's question, I think that's a mischaracterization, because Michele said, you know, saving the carbon budget that we are going to spend, whether we hit a give target or not, that the ideal would be to utilize as much of that as we are going to use for meeting the needs of the poor. That doesn't just mean the poorest countries; that means the poor worldwide.

And so I think that's how I heard your question, but I think the real issue is that clean energy not as the only solution. I worry that we often hear this, and we are kind of hearing disagreement about the nuances here, but I can easily see headlines that just kind of blow it in directions which is not what we are saying. And I think that one of the features is that we have an opportunity and we've demonstrated it with clean energy, to more rapidly provide access with clean energy than with dirty energy.

The litany of over-budget projects that took decades longer to build in some cases, did not reach the poor, in fact the prices of energy for the poor sort of went up. Those are not a trivial number, in fact, if you add up all of the projects in that category, that's a really bad history, that doesn't mean I'm condemning fossil projects.

What I'm saying is that if we can take advantage of the ability to distribute cleaner energy to take advantage of the smarter meters, the storage, the generation, we have an ability to make access happen earlier and better than if we simply wait for the financing pipeline to, quite frankly, poop out a couple big projects, that is not a recipe to do access for getting the carbon budget, and that blows the carbon budget too.

MS. FRIEDMAN: A question over here, in the fourth row.

MR. CAMPBELL: Hi. Richard Campbell, Congressional Research Service. With the current distribution of Power Africa Funds going mostly to the Exim Bank, a lot of folks are saying what we are looking at is U.S. economic development rather than developing the developing countries. Shouldn't it make more sense to ship fully-packaged distributed generation and micro grid systems to these countries that could be slotted into a planned build out of grid systems in these countries?

MS. FRIEDMAN: Would you like to --

MR. KAMMEN: So, I agree with the first part. I do think that like many development projects, there is a worry and it's written into the law that a fraction of that money, a certain fraction has to go for U.S. type, and that's a concern because we want to make this as democratic a marketplace as possible. But the second part, I sort of run in fear from, because we've heard for decades now, kind of ideal technologies dropped in, and we know that's a recipe for failure.

Whether it's large centralized projects, dirty or clean or small projects, the capacity building part of the story is sort of critical and that's why I mentioned just one example, this InfoDev effort, which is really designed to build the human capacity, and ultimately I actually think that the climate story is not difficult. Let me repeat that. I don't think that meeting the climate targets, even though I also agree, 450 is almost a faint rearview mirror, but I don't think that the climate story is anywhere near as hard as our unwillingness to invest in human capacity, and to take advantage of things like, the much quicker routes to innovation and the more excitement about solving these problems, that I would say we are

seeing by building up the clean economy.

Now that is one of these kind of vapor wares that Ted was worrying about, that's something that's largely in the future, but when I look at teams of people working on these topics, more patents, more innovation, more products. The IBMs just did a global assessment of all of its research labs. The Nairobi Lab, with has a large focus on energy access came out on several of their metrics as the best facility they have right now in terms of ideas, teams built, dollars spent.

That doesn't mean that solves the whole story, but there is much more excitement at what I would say the innovative frontier right now in this area than ever before. It doesn't mean we don't need large and small, but I think that's the real challenge. Maybe we drop in these systems but we drop them in with a level of capacity that in the past we've been unwilling to invest in.

MS. FRIEDMAN: Do you want to share thoughts, or I'll move onto -- Okay. A question in the front from Mr. Ebinger.

MR. EBINGER: Hi. Charlie Ebinger from Brookings. I was wondering if the panelists would agree with me that probably the greatest thing holding back energy access are subsidies which the IMF has estimated are now at $1.2 trillion worldwide, the nonpayment of bills and usually by government agencies. In India, for example, the Ministry of Finance hasn't paid its electricity for years; the army never pays its bill in countries, power theft, power losses. I mean honestly, until these kinds of institutional problems are solved there is no incentive for private entrepreneurs to provide electricity when they can't recover the cost of providing service, and on through the energy economy.

MS. FRIEDMAN: Let's take on fossil fuel?

MR. NORDHAUS: I'm not sure I agree, actually. I do think institutions matter a lot, I think corruption is a problem, but I think you can look at a lot of those same problems in a lot of places, and they actually manage to still provide pretty significant. You know, you look at Brazil, a lot of other places had explicit intentions that the electricity would get stolen. And it works in a kind of informal way on the backs of the formal sort of development process or commitments.

So, you know, yeah, I think we kind of go with private entrepreneurs, but really like much of the energy infrastructure, globally, over the last century has not been built by private entrepreneurs, it's been built by governments. And at various points it gets privatized, you know, or whether -- it's not built

directly by governments often, but by sort of state-owned enterprises and things like that.

So there are things that we kind of keep pointing to and going, well, this is the price -- I mean, often those are the things that actually have, you know, a lot of context that actually worked and proven reasonably successful. Not the only way to do it. So, and sometimes actually, yeah, I think you need to deal with those problems, you need to deal with, you know -- And I just think we need to understand that fossil fuel subsidies is just energy subsidies, and often subsidies that are going to people who would otherwise, couldn't afford energy

So, you know, it's sort of, well, oh, my, god, if we had just gotten rid of all the energy subsidies, we'd stop using the fossil fuels, and it's not true, but we would probably reduce access to -- reduce energy consumption and access to energy for a whole lot of people, who gets something, if not enough now. So, yeah, I think I'm a little skeptical of some of those ideas.

MR. KAMMEN: Yes. And I think I will agree, for most of what Ted said, and I do think that we build a lot of our energy infrastructure in the public sphere, and so those wastes are serious. I mean, I don't make light of any of the numbers he just highlighted, but I think that is symptomatic of something, and I guess I would phrase it a little differently. I would say that the biggest barrier holding us back is knowledge and investment, and that's related to this.

You don't get some of the private sector actors investing; you don't get some of the public agencies investing where they can't recover. We have agencies in governments charging each other, and they can't get repaid. So, it's related, but I do think that the bigger part of it is that we are basically used to paying for hardware, that in the past was cheap upfront, and you paid off most of it over time. Gas plants, you often pay 70 percent of the price of its budget is fuel, so a very small upfront.

All of the energy efficiency in renewables projects are up-front weighted. So new ideas, finding ways to amortize it, whether it's PACE financing in the United States, or whether it's bonds or public-private partnerships, or all kinds of debt servicing deals, or even kind of the more radical ideas, the kind of Ken Arrow ideas, we should have declining discount rates. Those are mechanisms that we are going to have to build out, and the problem is that we have a lot of good ideas, but these have to get through a number of financial filters, and the amount that get through it are very small, and that just means that we are cutting off, we are choking off the financial stream.

The one point I think I would disagree with Ted a little bit, is that there's been a number of studies of the fossil fuel subsidies, and they don't make a lot, I mean, they are awful in a lot of ways, but the poor are not benefiting from them. Most of those subsidies actually go to more affluent. I think that's important, but I think it's really a second or a third order effective, so on almost everything Ted said I think agree, in terms of those labs.

And we tend to highlight. There is a book out front that I think there's not enough copies for everyone here, there is some, but it highlights a number of the stories about how to try to shift the investment into renewables, what have been the experiences, and these are generally real-world projects, Africa and Southeast Asia, compiled by Cambridge University, it's out front. It's called Smart Villages, if you want to download it, it's a free book online.

MS. FRIEDMAN: Okay. We have one more on this side of the room, in the middle. You had a question, right? The woman in the blueish sweater, yes.

MS. ALEXANDER: Hi. Caroline Alexander, of the American Nuclear Society. You've talked a lot about renewables, and you've talked a lot about fossil fuels. What role can nuclear play in energy development?

MS. FRIEDMAN: Did you plant this question, Ted?

MR. NORDHAUS: I did not. I did not. I was actually hoping I could get through the whole day without talking about nuclear, because I spend so much of my life talking about it. I think it depends on where, and it depends on the technology so, you know, obviously, most of the sort of continuing nuclear build out around the world is happening in developing world context. It's China, it's South Korea, the United Arab Emirates, you know, a bunch of stuff happening and actually, you know, we kind of sometimes forget here in the developed world, where we are not building a lot of nuclear, and we sort of imagine that it's a dead technology but it's actually alive and well in a lot of other parts of the world.

You know, that said, I mean, look, I've been a big skeptic of sort of exactly how far we are going to get on renewables, and at least given the current technologies, and also a bit of skeptic on how far we are going to get with existing nuclear. I think in the developed world, you know, you have mature energy, market slow demand, growth, not a lot of people wanting to make 1 gigawatt, 60- or 80-year bets on future electricity demand.

And, you know, in the developing world I think there's a potential for a fair amount of conventional nuclear, but I think until you have technologies that are sort of better, cheaper, sort of safer, more plug and play. So, you know, that's why we focus a lot of our work on advanced nuclear and getting to sort of better nuclear technologies that both have better economic characteristics and better scaling characteristics.

So I think there's an important role, and I certainly think that if we are getting anywhere close to these climate targets we all keep talking about, we are going to need a lot more nuclear, but I don't think we are going to do a lot or nuclear in, like, the Congo anytime soon. And I think we need to be sort clear about that.

MR. KAMMEN: So, I'm not a professor of nuclear engineering, and so I would like to be optimistic. And I think that in the long-term that the potential is, right, quite promising. You know, we have an industry experiment going on right now with a small modular, there's some very exciting solid and liquid metal. There is a whole variety of things that are really interesting in the long term, they need a lot of capital, and if there's one place where I don't think there's any real debate about, and that is that the nuclear energy access climate story doesn't work.

That's an equation that does not hunt, and by that I mean, we have over 400 nuclear reactors in the world today. If you are super optimistic about the number that are under construction and are under design, maybe you can stretch it to 70, 80, I mean 60 is the economical number but that does not even replace the fleet that must be entirely retired in the next three to four decades.

So, for nuclear to ramp up on any of these technologies, or all of them, to play a meaningful role in this conversation, energy access and this roughly Mid-Century, and I mean, I used to be an astronomer so I'm happy to say Mid-Century, plus or minus several decades. I'm not real precise about that, but for nuclear to play a role, you know, it's one of those cartoons, blah-blah-blah, do-dot-dot, then the miracle occurs. Not that I'm against miracles, but that I don't bet on them, and I just don't see it fitting into this dialogue.

I do see the long term as a whole different story, but if we think it's going to save us from this joint issue of energy access and climate change, nuclear is going to be incredibly fortunate to maintain market share, defining that in some really, really generous ways, just based on the cost, time,

and that's forgetting all of the other complexities.

So I'd like it to play, to figure in, I think for this conversation, we are not talking 2040, 2050, we are talking no significant nuclear, meaning doubling the world's fleet, that's what we started to talk about when you want to say, play a big a role. That's a way to solve it.

MR. NORDHAUS: Do you think no significant nuclear by 2015.

MR. KAMMEN: No, no, no. I said not to -- if nuclear can replace all the plants that must be retired between now and 2050, that's going to be already impressive. I'm going to be delighted if nuclear can, say, build back a 400 you know -- To have 400 working plants by Mid-Century --

MS. FRIEDMAN: Much less double.

MR. KAMMEN: That's right, but I think to play the big role we are talking about, we need to think about double that capacity over time and, you know, I don't want to get this conversation back in empty science fiction land, but I actually think that, at that timetable, then the discussion about vision versus fusion becomes a real conversation, not one that's 10, 50 years away -- for 50 years. So, I'd like, because nuclear solves all of my models for global clean energy, so if you plug it in, this wonderfully happens but the reality of those costs build out times, you know, just the capacity to do not just current containment vessels, but the things we might need even for the small module and new growth with -- this is a long road.

MS. FRIEDMAN: The nuclear conversation just brings up from me, something that I talk a lot and I ask a lot about which is data. And you and I talked about this the other day, when I first started covering issues of energy access in 2008,and was trying to do stories looking at what -- you know, what universal energy access would mean for climate change. There wasn't even good data about where energy access existed, and that didn't come for another year or two.

MR. KAMMEN: More than that.

MS. FRIEDMAN: Right. And so -- Well, yes, and more later. And so I'm wondering, you know, as you look, as the two of you look around at the energy access landscape, and you are trying to assess what is the best way to serve 1.2 billion people, what are the things you don't know yet that we need to know? What are some of the data the biggest data holds?

MR. NORDHAUS: I mean, I think there's a bunch of them. I think from a climate

perspective, I think the truth is that we don't know how to serve another -- You know, we don't how to serve the world today that is consuming modern levels, much less a couple billion more people, while sort of limiting global CO2 emissions to anything that anyone thinks would constitute significant mitigation.

So, you know, I think thinking about what pragmatic sort of bottom-up pathways I think we tended to do a lot of this stuff top-down where we decide what the target and the destination is, and then we kind of force the model or resolve by -- usually by, you can -- there's two things that they call nuclear, in all of those models, and one is nuclear, those are the honest ones, and the ones that aren't quite so honest are called backstop technology.

You just plug in a Magic technology, but basically I don't think -- or I think very difficult to get there without it. But the truth is, we don't really know how to do it, and nuclear faces few challenges as do all the other zero carbon technologies that really have any shattered scaling.

Second, you know, for me, and it's less than the energy climate question and it's just a basic development question, I mean, I think there are, you know, especially when you look at places like sub-Saharan Africa, I think there are just big questions about what the development pathway looks like. Big questions about at what rate really, practically, those places are going to be able to industrialize without industrializing, without jobs in manufacturing, there are at least, for the powerful argument, that the sort of pathway that we've historically seen to, you know, both modern living standards, and modern levels of energy consumption is not feasible where at least it's going to take a lot longer.

Not a lot of evidence, or a lot of places going from subsistence agrarian to sort of modern service economies without some form of industrialization in between. So, I think that's another huge question in my mind, is just, you know, what does, for late developing countries especially, what does development look like in sort of middle of 21st Century? And I think there are big questions there.

MS. FRIEDMAN: Daniel?

MR. KAMMEN: I think you are being charitable, saying that, you know, 2000, '07, '08' '09, we ramped up, I mean I do think this is one of the areas where you have to give the U.N. a lot of credit, because the discussion about standard of energy for all --

MS. FRIEDMAN: And certainly that sentence in --

MR. KAMMEN: -- was a bellwether for a lot of people who thought that development off

grid, squishy little stuff wasn't, you know, kind of where the action was in terms of projects financing et cetera, and we have huge data holds. I mean, Ted highlighted some. I could list forever. We have a whole institute based around --

MS. FRIEDMAN: Just a few of the big ones.

MR. KAMMEN: -- around the gaps in the data. But I do think that there has been a sea change. Almost every university I know, around the world, not just the U.S., has ramped up programs in inequality, energy access, that science, technology, economics, behavioral economics of this -- and we are discovering those holes are everywhere.

Even energy services, which sounds great, is not a defined term, there's no units on that, that there's common agreement around the discussion that Ted highlighted it before, around the millennium development goals, and the standard development goals are wonderful at a figurehead, you know, in nice, clean rooms like this, but they are really messy when you get to East Juba, and we are trying to figure out what that means in terms of generators of power like this was.

So, we don't understand the connection very well between generation and services, and an entire field that nobody models. We have people who look at large-scale power models; we have people who look at the end of the grid, individual devices. No one wants to model the distribution systems. No one wants to really partner up with utilities, partially because utilities have been, you know, fill in the expletive, unhelpful in sharing data because they've given no incentive to partner on these things.

MS. FRIEDMAN: That's right.

MR. KAMMEN: And to get utilities in the U.S., in sub-Saharan Africa and Central America to say, we actually want you to sell more product, but we want it more reliable and cleaner, and if we as a society have to pay more, that's part of the story. And so we are not investing in the partnerships that would make those data sites available. The number of utilities in sub-Saharan Africa that were semi-privatized, that were sold off to South African or other investors, has destroyed the few data linkages in many places that existed.

I won't mention any names, Tanzania, but we have examples of places where that process has just gone away, and it was never good in the first place. And it was never 21st Century, it

was never based around digitally capturing the information, now finally, we have people doing things where they drive around rural areas, and they download the data from large-scale power plants, from the use of cook stoves for mini grids, but that is just in the last year or two. And so we are starting to build the dataset that would have loved to have done five years back, but really none of that supply chain to what energy services mean in terms of units, regularity, and all of the huge gender and social mismatches between who gets energy and who doesn't even within a home, between tribes, we are not where we should be, and we'd only have excuse, because we've known, we've talked about these issues for a long time, but we haven't dug in on the data side.

MS. FRIEDMAN: Oh, that's fascinating. It's fascinating. We have time for a couple more questions, one over here towards the back, the gentleman with the tie.

MR. BEAVERS: Thank you. My name is Oliver Beavers, and I'm an independent consultant. My question is about the decentralized generation. I mean, comparing that to traditionally-financed projects, you know, one of those, the decentralized site seems to be much newer and much less mature of the business model. I wonder if you could comment on insurance and financing, just at a general level, in terms of risk appetite and, you know, whether if you think the same amount of money would go into decentralized generation that would be a bit more comparable.

MR. KAMMEN: So, on the one hand, I'm actually pretty excited, we are starting to see different kind of insurance mechanisms. We are starting to see a little bit of discussion about public-private partnerships to invest in these things, because often you are investing in capacity and communities. So I do think that there is the potential, and I mean, Bloomberg New Energy charts the number of traditional lenders that are now getting interested in the space. But at the same time, the story that has afflicted districted projects and has made some of the projects, that Ted described, as aid not development, is the future here.

And that is, you know, most of the big lending institutions no matter what they want to say on paper, do not fundamentally believe that a billion dollars made a dollar at a time is the same as single-billion-dollar project. And the incentives in terms of careers, and lending and prestige, and aggregation to lend at large amounts and to lend easily meaning, don't aggregate 1,000 small projects, find one big one.

The incentives for that in terms of individual's careers, careers of banks, ability to manage

that in central governments means that there is a huge human and information capacity hurdle, that is going to hurt not just decentralized clean or dirty energy, but projects that are fundamentally different than ones that look just like what we've done before with one or two, you know, kind of serial numbers changed a little bit. And that's not the only problem, but to underestimate that simple career billion-dollar pathway, I think really hurts what we've seen as the challenges.

And, you know, there's a lot of discussions just around the Grameen process that got a lot of criticism for this, but the decentralized energy one, is really vulnerable to not being aggregated even though we've seen a few cases where groups really have gone out, and they've been quite successful at it. So I think it's one of the biggest challenges out there.

MS. FRIEDMAN: And last questions over here.

MR. KAMMEN: Oh, Ted might want to --

MS. FRIEDMAN: Oh.

MR. NORDHAUS: Well, yeah, I would just say that -- I would be a bit more charitable maybe than Dan, towards why it's really difficult to finance those projects, which is just that in any context, where you are trying to move a lot of money, because it's a lot easier to move big chunks at a time than little chunks at a time. It's a lot harder to do due diligence on, you know, a million 1-dollar loans, versus a one million-dollar loan. Just huge opportunity costs to the institutions that are tasked with implementing those kinds of projects.

And, you know, we see this in lots and lots of context, and there's ways to kind of get around it, but it's not, it's not sort of stupidity or stubbornness, or careerism, it's often just sort of a practical kind of, you know -- sort of parameter or limits to what institutions can do. And when we ask institutions, you know, look when -- What was the financial crisis? Well, there was way more money that wanted to get into the mortgage market than there good loans to be made, or even people, people who, with some accountability could evaluate the investments on the properties were being invested in, and the result is that you had a lot of money just going through kind of a sort of flight-by-night operations into the mortgage market that really hadn't been properly vetted.

So, I think you have a lot problems in moving -- there are challenges with these distributed models beyond simply the sort of technical and engineering level, there are just problems with

instituting and implementing them that I think we sometimes don't. You know, so putting aside some of Dan's characterization I think I -- I think we would probably agree with some of the challenges, about some of the challenges there.

MS. FRIEDMAN: Well, unfortunately we've hit our 3:30 mark. And I actually think that ending on the money is a great place to end on and how we spend it and where. I'm sure that Dan and Ted might be around for a few, minutes, if you want to catch them and try and try talk afterwards, or ask some off-line questions.

But in the meantime, please join me in giving them a big round of applause. (Applause)

MR. KAMMEN: And thank you, Lisa. Thank you.

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