

## Accelerating Clean Energy Innovation in India

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### Webinar Panelists

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<b>Sanjay Bajpai</b>	Department of Science and Technology), Government of India
<b>Renu Swarup</b>	Ministry of Science and Technology, Government of India
<b>Varsha Joshia</b>	Ministry of New and Renewable Energy, Government of India

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**Eric Lockhart** Hello, everyone. I'm Eric Lockhart with the National Renewable Energy Laboratory, and welcome to today's webinar, which is hosted by the Clean Energy Solutions Center and partnership with Mission Innovation and the India Ministry of Science and Technology.

Today's webinar is focused on the Accelerating Clean Energy Innovation in India.

One important note to mention before we begin our presentation is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center resource library as one of many best practices resources reviewed and selected by technical experts.

Before we begin, I'll quickly go over some of the webinar features. For audio, you have two options: you may either listen through your computer, or over your telephone. If you choose to listen through your computer, please select the mic and speakers option in the audio pane. Doing so will eliminate the possibility of feedback and echo. If you choose to dial in by phone, please select the telephone option and a box on the right side will display the telephone number and audio pin you should use to dial in. If anyone is having technical difficulties with the webinar, you may contact the Go To Webinar's helpdesk at 888-259-3826 for assistance.

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viewing the materials through the webinar portal, you will find the PDF copies of the presentations at <https://cleanenergysolutions.org/training/>, and you may follow along as our speakers present. Also, an audio recording of the presentations will be posted to the Solutions Center training page within a few weeks and will be added to the [Solutions Center YouTube channel](#), where you will find other informative webinars, as well as video interviews with thought leaders on clean energy policy topics.

Today's webinar agenda is centered around the presentations from our guest panelists, Dr. Renu Swarup, Dr. Sanjay, Bajpai, Varsha Joshia, and Prakash Hirani. These panelists have been kind enough to join us to discuss Mission Innovation and key policies and programs aimed at accelerating clean energy innovation in India. Before our speakers begin their presentations, I'll provide a short informative overview of the Clean Energy Solutions Center initiative. Then following the presentations we'll have a question and answer session, where the panelists will address questions submitted by the audience, followed by closing remarks and a brief survey.

This slide provides a bit of background in terms of how the Solutions Center came to be. The Solutions Center is one of 13 initiatives of the Clean Energy Ministerial that was launched in April of 2011 and is primarily led by Australia, the United States, and other CEM partners. Outcomes of this unique initiative include support of developing countries and emerging economies, through enhancement of resources on policies relating to energy access, no-cost expert policy assistance, and peer-to-peer learning and training tools, such as the webinar you are attending today.

The Solutions Center has four primary goals. It serves as a clearinghouse on clean energy policy resources. It also serves to share policy best practices, data and analysis tools specific to clean energy policies and programs. The Solutions Center delivers dynamic services that enable expert assistance, learning, and peer-to-peer sharing of experiences. And lastly, the center fosters dialogue and policy issues and innovation around the globe. Our primary audience is energy policymakers and analysts from governments and technical organizations in all countries, but we also strive to engage with the private sector, NGOs, and civil society.

A marquee feature that the Solutions Center provides is the no-cost expert policy assistance known as Ask-an-Expert. The Ask-an-Expert program has established a broad team of over 30 experts from around the globe who are available to provide remote policy advice and analysis to all countries at no cost. For example, in the area of demand and policy evaluation, we're very pleased to have Paul Komor from the Renewable and Sustainable Energy Institute serving as one of our experts. If you have a need for policy assistance in renewable energy policy or any other clean energy sector, we encourage you to use this valuable service. Again, the assistance is provided free of charge. If you have a question for our experts please submit it through our simple online form at <https://cleanenergysolutions.org/expert>. We also invite you to spread the word about the service to those in your networks and organizations.

Now I'd like to provide a brief introduction for today's panelists. First up today is Dr. Renu Swarup, who is currently a Senior Advisor to the Department of Biotechnology; Managing Director for the Biotechnology Industry Research Assistance Council, which is an initiative to foster and nurture innovation and entrepreneurship ecosystem in the biotech system.

Following Dr. Swarup, we will hear from Dr. Bajpai is Associate Head of Technology Mission Division at the Department of Science and Technology with the charge of coordinating the department's initiatives for clean energy. He is responsible for monitoring the DST's national initiative in clean energy and shaping major bilateral programs with the U.S. and U.K. in the areas of solar energy, building energy efficiency, energy storage, smart grids, and clean energy systems.

Following Dr. Bajpai, we will hear from Varsha Joshia, who is the Joint Secretary under the Ministry of New and Renewable Energy, where she is involved in the policy regulation and facilitation for onshore/offshore wind, bioenergy, geothermal, tidal and hybrid energy, human resource development, training and skills augmentation for the renewable sector.

Now our final speaker today is Prakash Hirani, who has been with NTPC and R&D, now NETRA, since 1991, working in the areas of water/boiler chemistry, ambient air and stack flue gas monitoring and analysis, development of value added products from waste and fly ash, environmental science and alternative energy resources.

And with those introductions, I'd like to welcome Dr. Swarup to the webinar.

**Renu Swarup**

Thank you very much for this introduction. I would like to start-

**Eric Lockhart**

Dr. Swarup, if you could —sorry to interrupt; if you could just full-screen your slides.

**Renu Swarup**

Yes, let me just make that —sure. Is that all fine? Can you see the-

**Eric Lockhart**

That's perfect. We see them very well, thank you.

**Renu Swarup**

Thank you. And I would like to first of all take this opportunity on behalf of Government of India to thank all the participants, to thank Clean Energy Solutions for hosting this, and just to let everyone know how excited we are to be a part of the Mission Innovation Program.

What I will do is the first couple of slides I would just like to share on the Mission Innovation and a brief about it, just for those who are coming in first time to hear about the Mission Innovation from us. Now in this —I'll just get my slides going. And you already have been given the introduction about the panel and the Mission Innovation, as also you would know on November 30, 2015. And we have now in fact the leaders of 20 countries have now stood, with each one making a commitment to double their investments in clean energy R&D. And this is the initiative which has been led by various

countries, and the private sector initiative is led by the Breakthrough Energy Coalition.

This is really what the global scope is. And if you see that all the countries who have been involved in this Mission Innovation will pledge to be partners to this are those who are very concerned about the fact that we do need to look at clean energy solutions, looking at R&D as solutions for this.

And this really is the status so far that we have in which we have said that we are looking at doubling our plans and we've got priorities which have been identified, which I will share with you in the next couple of slides. We already have EU, which joined us as the 21st member, and we are now looking at Netherlands and Finland joining in as members. They're hoping that all countries who are part of it would be closely committed to take this initiative forward.

The Mission Innovation enabling framework for how we will proceed has been formalized. We have different subgroups, which are looking at the R&D sharing of information, looking at the innovation roadmapping, and also looking at how we could bring in the private sector engagement. Details about this area are all available on our website, Mission Innovation, and as has been said, the webinar today would also be posted on [YouTube](#) and we would have information on this available for all others who may not have been able to join us today.

Just to let you know that how we are looking at the clean energy R&D investments, this is a chart from Mission Innovation. The countries together have pledged a baseline amount and said that how by 2021 we would be able to double this to the figures which have been shown onto your screen. This is a collective figure which has come from all countries. Each one has their own strategy, and in the next couple of slides I will share with you the strategy from India in the sector of biofuels specifically, and then going on to my colleagues from the other municipalities, who will be able to share with you the policies in other sectors.

India's participation —India, as I said, has been a key participant. We've been attending all the meetings. We had a preparatory meeting in Beijing in March and then we had ministerial the 1st and 2nd of June, which all the head delegations from all the countries participated with the enabling framework and the baseline figures for the countries were released to the public and the data was also brought out as to what our doubling plans would be. India is also formally a member of the Joint Research Group and the Business and Investor Engagement Subgroups for private sector.

The part of presentation today will tell you what our areas are, what the policy is, where we stand on our current initiatives, what really are our various achievements in terms of these teams, and most importantly, how we collaborate with the industry, because that's a very important component, not only to look at private sector investment, but also to look at how industry, especially the startups and other young innovators can be part of our entire research group as we move on. The large number of international

collaborations, both bilateral and multilateral, which we will talk about, and then lastly, what are the new initiatives and what could be the investment opportunities to take this forward. These are priority areas which have been identified for India and which are, again, keeping with the parity ideas, which are a part of the Mission Innovation as we move on.

For those of you who are familiar with the Indian government system, there are a large number of ministries who are dealing with research in clean energy. The Ministry of Science and Technology, which has three departments; we have the Ministry of Power, the Ministry of New and Renewable Energy, the Ministry of Environment, Ministry of Defense, Earth Sciences, Petroleum, and our whole effort for international is coordinated by our External Affairs Ministry.

This is really the baseline data which was released on 1st and 2nd of June in San Francisco by the heads of the various delegations. And you see the highlighted figure tells you what India's baseline currency is, and this we have pledged to double in the next five years. This is the total baseline which you saw in the chart earlier, and we hope each country has given its commitment to double this in the next five years.

This is the country-wise priority, and if you'll see that India has also identified each of the areas as priority. The carbon capture utilization was initially not identified as a priority by India, but we have now looked at it and seen that we would look at components of research related to carbon dioxide capture and utilization as a part of our priority, so soon we would have a green dot on that as well.

Coming now specifically to the energy biosciences and biofuel sector, the national biofuel policy that we have, we have what really is our strategies is what I would share with you in my next slide. This is the bioenergy road map and from MNRE I'm sure Varsha Joshia will share with you the larger policy, but there is a policy to try and see how we could have 20-percent blending of fuels by 2020. Our whole policy [Inaudible] the roadmap that we have created brings out components of how we could have research, development, demonstration, and capacity building to be able to take this towards commercialization so that we have sufficient quantities of fossil fuel for the ethanol for blending with our fossil fuels by 2020. We're looking at a large number of next generation biofuels as well from different feedstocks.

These are figures that we have in terms of what is business opportunity for the growth of this sector in the next five years. By 2022, you'll see we are ready to reach up to a business of \$7.5 billion, a huge amount of business pending for both bioethanol and biodiesel as we move into the stream fuel for the transport sector.

The current research in India is focusing right from the first generation to the second generation to next generation biofuels. We have various technologies which we've already commercialized, both for bioethanol and biodiesel from jatropha. We have many pilot plants which have been set up, and for the lignocellulosic ethanol plant, we set up our first plant at ten tons, the capacity

which is ready now for commercialization. There are a large number of laboratories across universities, research institutes, private sector and public sector, looking at cutting edge R&D technologies for new generation fuels.

This is really an overview of the schemes that we have been supporting, as I said, right from research programs to creating centers of excellence. We have a whole special focus on algal biofuel, which is an area of special interest as we move through this Mission Innovation, clean energy programs being one. Capacity building, again, is a main area that we are trying to see how we cleared capacity, and that is a priority in our Mission Innovation joint research programs as we move ahead.

This tells you exactly what our budget allocation is for nationals teams and what are the various programs that we are trying to support in terms of our centers, our R&D projects, our international cooperation and the capacity-building exercises.

We have four bioenergy centers that have been set up by the Department of Biotechnology, each one of them targeting the main objective of looking at new generation biofuel, and each one complements what we have been able to do in terms of the technology development. The main center that we have, the first one that was set up, was the DBT-ICT Centre, which is established at Mumbai, while it does cutting edge research, as I said, the first national level demonstration plant has been set up at ten tons biomass per day. This technology is now ready for commercialization. We are having a detailed technical due diligence by a large number of oil marketing companies to see how we can move on.

We have our second center that we have set up with one of our major oil companies, the Indian Oil Corporation, where again they're looking at we have capacities for pilot level scale-up of developed technologies, looking at different lignocellulosic based biofuels, biotechnological methods for carbon dioxide mitigation, and also starting the detailed life cycle analysis. And interesting part of the center is that we are also working on developing new novel enzymes which can then help the commercialization of these technologies to these novel enzymes, which would be critical for the scale-up of these technologies.

As I said, our major focus now as we move on into the next phase and which we are also been discussing with the Mission Innovation member countries is if we could establish a major network programs on algal biofuels. Opportunities in this exist for both bilateral and multilateral cooperation. India has a lot of strength in this area. We have three repositories where we have a large number of culture collections which have been set up. We have more than 2,000 cultures which have positive collected from different parts of the country, and these are potential cultures which can then be available for our algal biofuel program.

This is really the mission that we are talking about and we have already established leads into this. We have a large group of centers across the country who are working on this, so a potential area for collaboration. We

have a large number of industries who are now showing interest in this. This could be a potential area not only for collaboration amongst within our country, but for, as I said, multilateral cooperation and also be an area which could be of immense opportunities.

Biobutanol and biohydrogen, again, we have advanced technologies and this is today at a pilot state. We would be ready to take this towards demonstration state, which would then be scaled up for different groups. And industrial collaboration is available in both these technologies. We've been working along with the industry to take it to where it's commercialization.

These are our various opportunities which exist from agricultural biomass and to our programs, worked with the public and the private sector. Each one of these is being tackled by various groups. So the ultimate main is that how could we look at the agricultural biomass being able to give us solutions, clean energy solutions, and also look at value-added products which help the bioeconomy to grow? And that is of primary importance to us.

For all these programs that we do it's very important for us to create the necessary capacity, and we have specific programs in which we've done both national and international various programs for our researchers, for exchange of scientists, and also for bringing in distinguished professors from different laboratories. This is, again, a potential area for collaboration with different countries.

Coming towards the end of my presentation, there are new initiatives which we are initiating. Many of you would know that India is looking specifically at a clean India mission, and therefore that converting solid waste to energy is one of our primary areas of importance. We have emissions that we are currently targeting on that; next generation fuel and cutting-edge technology for synthetic biology, which is the potential technology for the future.

And this is really what we are trying to achieve. We have centers, in this we are looking at collaborations with different countries as we move ahead.

Our international collaboration programs, we have a number of them. Our most important program that we've taken up for collaboration in clean energy is our Indo-U.S. Joint Clean Energy Research Center, which has three consortiums: solar energy, energy efficiency of building, and second-generation biofuels. We also have a very fruitful collaboration with India-U.K. and then one which we are looking at sustainable bioenergy and biofuels.

This is a little bit about the Indo-U.S. JCERDC program, in which we are looking at different components of the clean energy.

Again, we are looking at new initiatives with Germany and with many other countries; many of them were partners of the MI program, and we hope that under this we'll be able to build [Inaudible] collaborations.

Coming lastly to our investment opportunities with the private sector. The government of India has set up a separate organization, BIRAC, which promotes the industry investments and also helps focus the startup ecosystem. Through this, we have been able to bring onboard a large number of startups. We have over 500 startups and SMEs who are part of our program for [Inaudible] [Inaudible] we have different funding schemes through which we fund them. There are grant challenge competitions that we have. We also have competitions similar to the X prize, where we take an idea to a protocol right up to a product development.

This is really the various teams that we have available and details of this would be available in the presentation later for you to go through.

These are the partners with whom we operate to take our program on public/private partnership ahead. And you'll see in addition to national partners we have a large number of international partners, including organizations like the Bill and Melinda Gates Foundation, Wellcome Trust, WHO, Bpifrance, and many others work with us to make the program think forward in terms of the private partnership.

These are the kind of industries within the country that we'll be collaborating to take forward some of our technologies for commercialization.

And this of course is some of the key areas that we've been working with the industry both in biofuels and waste-to-energy projects, which again, look at meeting our objectives of public-private partnership.

Lastly, I would like to say that India is very well represented. We did a Startup India program in Saint Francis School last year when our prime minister was there, and many of these startups that you see, 25-percent of these were those who were responding to clean energy solutions, and these were based on the details that we have already presented to you.

So lastly, I would just like to say that we feel bioenergy is a major contributor. Partnered centers and PPP is the way that we would like to move ahead. We are looking towards international collaboration, specifically not only the biofuel sector, but for the entire Mission Innovation partnership that we know, and private sector not only the investment, but partnership to take our programs and do very important work.

Thank you very much for your patient hearing of this.

Eric Lockhart Great. Thank you very much, Dr. Swarup. With that, we'll turn to Dr. Bajpai. That was a fantastic introduction to mission innovation and bioenergy in India. Great, I see your slides, Dr. Bajpai; if you could just full-screen them, you're ready to go.

**Sanjay Bajpai**

Yeah. Hello, everyone. It's my pleasure to present research, development, demonstrations and commercialization activities of the Department of Science and Technology. The Department of Science and Technology is an organization which primarily funds research in all the domains. It is also the

[Inaudible] department for all [Inaudible] formulation on science, technology, and innovation. We do believe that [Inaudible] quality framework is essential for promoting innovation. This policy charters the path for it to accelerate the scientific development in select high priority areas, including energy. The policy very explicitly recognizes and emphasizes critical importance of enhanced global corporation and public-private partnerships.

DST mandate emanates from this policy and it is basically to enhance capacity and capability of Indian science, technology, and innovation systems through partnerships, programs, and targeted emissions.

The mission activities on clean activity promote large number of ideas and they foster promising ones through the part of translational research and nurture successful startups and industries. The government definition of clean energy technologies as we recognize include not only emissions, but also implications on environment and natural resources, especially water. It's our endeavor that every successive step of research advances the technology readiness level of these technologies.

There are several programs in the Department of Science and Technology which address the entire spectrum of research and development, right from the basic and applied research, capacity building, pre-competitive research, and [Inaudible] [Inaudible] solution delivery to the market.

Clean energy research program in Department of Science and Technology had a very modest start in 2009. And after initial growth that almost flattened between 2013 and '14. But due to countries' increasing commitment to — renewed commitments to INDC goals, COP21 and MI, this has again shown the spark in our bi-study expenditure. We expect to develop our expenditure in the current year from the baseline and it is —our plan is to triple it in the next financial year.

Our portfolio of clean energy research is quite vast; it includes energy efficiency, renewable energy, [Inaudible], cleaner fossilized energy renewal edition and basic science is also a component. As we can see from this chart, that there has been a substantial increase in all these activities.

One thing which I would like to mention here is that investment figures which we have quoted here may exclude very fundamental research, which cannot be related to energy directly, and also the deployment of solutions, which they're not [Inaudible] them in the Department of Science and Technology. Also the budget figures [Inaudible] [Inaudible] here does not take into account the manners that have been working by scientists and companies working in public funding institutions, which can also be estimated or included as government investment.

Sustained funding to national research programs serve the green purpose of capacity building and advancing research capacity. The Mission Program on Clean Energy has supported more than 175 projects at the cost of around 2000 million rupees, do not valued and included in the mission innovation. Our mission on water availability, quality, and recycling has supported 300

projects at 1500 million rupees. Even tied to MI we're having a provision of international partnership in nationally funded defense programs and fellowships with totally funded by us, having provisions for international exposure to Indian scientists.

There are two programs which are started recently; one is Techno Platform for Electric Mobility. This aims at joint testing facilities, joint product development in partnerships with the Department of Heavy Industry. And this program is totally in a more of a public-private partnership. And program which is a little older, this is National Programme on Carbon Sequestration Research. We have spent around at least 500 million rupees and supported more than 110 projects. That focus here is on investing in the process of sequestration and understanding the process steps. This program is currently being reworked with new initiatives.

Also, Mission Innovation, we have taken several steps: our new Promote Habitat Energy Efficiency, energy storage, and smart grids. And also, we have launched a national mission on advanced super critical technologies for cleaner coal technologies. Keeping in view the country's goals towards cleaner environment, we are embarking upon a national mission on methanol and di-methyl ether as cleaner fuels.

The Department of Science and Technology has a dedicated organization, National Innovation Foundation, which supports grassroots innovations, and not just innovations to [Inaudible] programs. Technology Development Board is another program which is responsible for commercialization for technologies. Here I would like to mention that Technology Development Board has also invested in a special venture, which is promoted by the DST-supported incubator, but promoting early stage clean technology companies.

Our New Initiative for Developing and Harnessing Innovation system to transform the startup ecosystem has been launched with the commitment of 5000 million rupees, and this program delivers more than 100 technology business incubators, which have been set up in public and public-private partnerships.

I would also like to mention [*musical tone*] universal lighting —provided universal lighting access and has the application in more than 10 million slums and households to meet their lighting needs. Startups and industries, they are welcome to join this movement.

Substation investment has been made by Department of Science and Technology on clean energy centers on different teams. Besides these centers, there are knowledge networks which focus on solar thermal power electronics, solar hydrogen, and these are fairly large networks comprising of a large number of faculties and industries. There are two DST laboratories which have a specific energy focus: International Advanced Research Centre for Newer Materials focuses on fuel cells, solar energy, and also [Inaudible] batteries. Indian Association for Cultivation of Science is primarily engaged materials for advanced solar sense. Subsequent to the launch of Mission Innovation, we are planning to set up all material research centers on

advanced ultra-supercritical technologies, and then investment of 500 million rupees has been committed for these centers. These centers are also supported by Technical Research Centers on Energy and Water.

DST has very vibrant international agreements and we have I think international agreements with more than 44 countries. DST is able to enhance SMP competitiveness and [Inaudible] deliveries using international collaboration as a tool based on [Inaudible] and reciprocity. The investment which we have made jointly with Australia is one of perhaps one of the largest investments which Australia has made in the clean energy sector jointly with India. Our collaboration with other countries, both bilaterally and multilaterally cover a large spectrum of clean energy research and almost touch every aspect of clean energy.

With some of the countries where we have successful collaboration and there was a commitment to invest at a substantially high scale. We have been able to set up joint clean energy research and development centers, Solar Energy Research Institute for India and the U.S., and CBERD have been mentioned by my previous speaker. Indo-U.S. Joint Clean Energy Research Center on Smart Grid and Energy Storage Technology is coming up shortly. We are also setting up a clean energy center for integration of intermittent renewables with suitable energy storage in on grid or off grid situations.

The clean energy research program of the Department of Science and Technology has the unique distinction of being one of the programs where industry was funding for developing and demonstrating clean energy systems. Our recent mission bilateral and multilateral solicitations also welcome investor participation, both in [Inaudible] as such, as well as for development of devices, systems, and subsystems. As can be seen from the screen, there are several national and bilateral arrangements available with —funding can be made available to startups and industries in these bilateral organizations or the bilateral [Inaudible], the government of India provides matching funding to the industries for commercial addition of clean energy activities.

Our successful industry collaboration is depicted in this slide, this thermal desalination system, and this solar biomass hybrid power system, they have very important social elements and they are actually set up in the field with partnerships for upscaling.

These are some of our industrial partners who have contributed in our endeavors and where we have full collaboration with all of them.

Coming to my last slide, I would like to spend some time on plans, priorities, and investment opportunities which DST has in the context of Mission Innovation. The scaling up plan which we have formulated for clean energy innovations and [Inaudible] is scaled up funding for R&D, setting up our national bilateral and multilateral capacity building programs. We have also plans to set up demand-oriented mission programs on clean coal technologies, building energy efficiency, cleaner fuels and of course solar energy, in which we already have a research program. Of course, we will be guided by joint research and capacity-building subgroup, which will be coming up with

several innovative models for collaboration both bilaterally as well as multilaterally.

In terms of our research strategies, we have clean coal technologies and several others, which I would not read here. But all of these priorities are not in the on and off preference and we are open to what [Inaudible] on these areas. Energy-water nexus is the latest addition in this list and we are considering mounting a meter program in this area.

The enhanced scale of activities offer a plethora for opportunities for investment by private sectors. The technology business incubators with DST setup and DST will be setting up much more in the future and researches public-private partnerships. Investors are welcome to match the contribution of government in these technological investing incubators. We will also welcome industrial partnership in upcoming research centers to benefit sharing and sharing of risk and research. A clean energy fellowship on investor-defined problems where the costs are matched by the government and industry equally, can be developed on the clean energy.

For the problems it can be addressed in the shorter duration and say around up to three years, technology platforms led by industry with participation of academic and R&D institution can also be considered. And lastly, upscaling of universal lighting access through micro solar dome, for which we have set up a very ambitious target to be fulfilled in another one year is also an opportunity for startups and industries.

I will conclude with this verse and would like to thank all of you for joining the webinar. Thank you.

Eric Lockhart All right. Thank you very much, Dr. Bajpai. I'd like to remind the attendees to submit questions in the question pane at any time during these presentations.

With that, we'll turn to Varsha Joshia.

**Varsha Joshia**

Good afternoon. My presentation will be about the role of the Ministry of New and Renewable Energy in the space of accelerating clean energy innovation in India.

The MNRE has a vision to promote research, design, development, manufacture and deployment of new and renewable energy systems and devices for various applications like transportation; portable and stationary applications in rural, urban, industrial, and commercial sectors; technology mapping and benchmarking; and to lay down standards, specifications and performance parameters at par with international levels and facilitate industry in attaining the same. So as to be seen, we are not fully and purely an R&D ministry, we are also a larger mandate of having to assist in the large-scale deployment of renewable energy in various sectors.

We have five major institutions already functioning for several years under the ministry. The first three, that is the National Institute of Solar Energy at

Gurgaon; the National Institute of Wind Energy (NIWE) at Chennai; and the National Institute of Renewable Energy, which mainly works with bioenergy, at Kapurthala in Punjab, our centers of academic work as well as testing standards and facilitation for industry. The Indian Renewable Energy Development Agency (IREDA) is among [Inaudible] financial institution, which has for the last 20-odd years been supporting the new energy deployment through commercial loans and self loans.

The Solar Energy Corporation of India (SECI) has been started a few years back with a mandate of large-scale [Inaudible] deployment of solar energy. And this has already turned out something like 4,500 megawatts. But now from this year onwards it is also picking up other kinds of renewable energy deployment adoptees. These are the basic five categories of five tasks that the ministry does: research and development; piloting and demonstration of technologies which have been proven to work in research; assisting in deploying them on a larger scale; we support a framework of policy and regulations; and testing, standards, facilitation and capacity building.

The ministry has an active research and development assistance program right from the inception and has supported work in all manners, all kinds of clean energy in academy institutions and research institutions, as well as an industry across the country. Some of the major highlights of research which have come in through MNRE support, we have identified the major climatic zones within the country and assessed degradation levels for solar PV in each of these zones. This is what has been done by the National Institute of Solar Energy along with IIT Bombay.

IIT Bombay has achieved an efficiency of over 12-percent in perovskites in solar technology. At Banaras Hindu University the hydrogen lab has been developing solid state materials such as metal hydrides for hydrogen storage for various applications, including thermal, like in cooking; transport; power generation, and so on. IIT Delhi along with the beverage company Mahindra & Mahindra have developed and demonstrated hydrogen fuelled three wheelers. As you know, three wheelers are a very major source of transportation across India. And at the Indian Institute of Science Bangalore, the center for biomass gasification has developed gasifiers of various sizes for decentralized power generation and for hydrogen production.

The major research and development initiative that the ministry is embarking on from this year onwards is a hydrogen roadmap. And a report by Professor Sveeterman and the National Senior Expo Center here have put together the roadmap in which all aspects of hydrogen, including production of hydrogen, development of fuel sense for transportation for stationary users, for small maintenance, large maintenance. And they augment the fuel cells with other kinds of fuel such as methanol, [Inaudible] and so on. There's a whole roadmap, including research as well as —and deployment goals and the total package is about \$50 million USD. And certainly, this is one area in which MNRE would invite navigation from all other agencies across the globe.

The other kind of work we do in the ministry is the piloting and demonstration of technologies which has already been shown to work on the

ground. And this is always something innovative —slightly innovative approach is required, because if something is already commercially viable then the government doesn't need to do too much. And if it's R&D, then we all know how to support R&D institutions. So in this in-between stage of piloting and demonstration we have been attempting some innovative ways of making sure the technologies get off the ground.

And one example is our present proposed lignocellulosic ethanol viability gap funding bidding scheme. And this we are proposing to give out that viability gap funding of up to 40-percent for projects up to 150 million liters per annum production capacity. We have designed the scheme in such a way that non-sizes, which are already operating across the [Inaudible], if they're commercially successful already they can bid up to a higher level. If they have demonstration plans or pilot plans, they can bid up to a smaller level that is 40 x the size of their existing demonstration pilot plant.

The idea of having a scheme like this is to ensure that technologies across the world who are confident of coming in at whatever level of —size of funding that they are confident at, they can come in and they are agnostic to the specific kinds of technology; we would like to see which one works better, which one is more efficient, which one can give us a lower price. And we want that anyone across the globe who can produce ethanol could come here and set up their plants. And so this year also we're proposing a supporting policy framework in which several ministries have promised to help us in ensuring that these projects take off, including the Ministry of Petroleum, the Agriculture Ministry, the Forest Ministry, and so on.

On similar lines we have the energy storage bidding scheme in which we have put together already by inviting an expression of interest, we've put together several projects in the private sector and the public sector. There the agency would like to try out storage and see how it can help them provide better power or to save fuel. And we would then bid for it so that the technology that comes in is that which is cost efficient, which is confident in being able to work, and will eventually lead to a roadmap in which the costs, which are actually really high, will come down.

So this is the way we are experimenting with bringing something which is perhaps not yet fully commercially viable in India to a level where it becomes more commercially viable and we would like to hedge our bets by making sure that every kind of technology which can work will come in.

The third thing, which Dr. Bajpai already mentioned, about infused ventures. We have also contributed and the Center for Innovation, Incubation, and Entrepreneurship (CIIE) at IIM Ahmadabad, has already supported over 20 new business ideas which have been converted into functioning companies. So this is one of the most successful incubators in renewable energy. And the beauty of the CIIE is that with the help of the government funds it has received it has been able to leverage a lot of private funds also. And this is another space that they will invite funding from across the globe to come, because the incubator has worked and the businesses that it has funded have [Inaudible].

This aspect of deployment assistance from the ministry is a false [Inaudible], but I would still like to mention it, because it's a very important part of our work. And any kind of new policy which will help with the deployment is something the ministries are open to try. So, we had the viability gap funding, in which the subsidy has been passed on through a bidding process and eventually we have been able to successfully stop giving any subsidy in water heaters because the prices came down, there was enough bulk deployment in the market and we did not further [Inaudible]. And has been known, we are reaching the same stage in solar PV already.

In wind power, we have gone with the generation-based incentive so that the better technology, which gives more firm power, is going to be encouraged over a larger period of time. In solar rooftops, where the capex high and in the retail market people are a little bit doubtful about spending so much money upfront. Concessional loans are being facilitated through multilateral lending situations, including the World Bank. And these would be funding the entrepreneurs so that the markets can take off.

And the process of going through large tenders, consolidating demand from across the country, creating an aggregated tender has gotten a very —it's been a very successful model in energy balance by the Bureau of Energy Efficiency. And similarly, we have achieved a similar situation in solar PV by aggregated tenders from the Solar Energy Corporation of India. And we've already tendered 4,500 megawatts of solar PV, and this year the SECI is going to tender 5,000 megawatts of solar PV, rooftop, and wind.

We have been trying different kinds of policy and regulatory interventions such as those, so have a deployment and safe investments. We have gone through already feed in tariffs for several years, and originally by solar, which was replaced by bidding; invent, which is now being replaced by bidding; and in other technologies, such as [Inaudible] energy, where the technology is commissioned, as it still needs some support, because a feed in tariff gave us the project.

The renewable energy purchase obligations under the Electricity Act have been simply improvised outputs so that our 175-gigawatt target is achieved and all the energy that's produced from, new capacity is purchased and used.

We have recently floated a draft wind solar hybrid policy. And as far as we know across the globe is the first time that a country is looking at a full-fledged policy, because we have seen that this position of wind and solar data across the country, which was a huge potential for developing both cell solar and when in the same regions and often at the same location. And this is another field in which we would love to develop more innovation and it would invite technologies from across the world to come in and help us feed an environment in which hybrids can become [Inaudible] viable very soon.

Another core activity of the ministry is testing standards, facilitation, and capacity building. And this is where our three national institutions come into play. The National Institute of Solar Energy has been the center for research. As stated, there are distinct facilities for modules, bumps and inverters and

batteries. Has been assisting industry in various kinds of product development from its inception and presently is leading the solar training initiative called Suryamitra, this friend of the sun, which is for entrepreneurs and workers in solar energy, in the industry. And within barely one year, we've already trained 3,000 people across the country and have a target of reaching 50,000 trainees in the next five years, and we are well on track for doing this.

The National Institute of Bio Energy in Germany has been the mean agency which has acted as a hub for [Inaudible] [Inaudible] in India. We wanted to reach nearly 27 gigawatts of [Inaudible] in India and the National Institute of Bio Energy has been essential to this whole process. Solar and wind potential assessment in the country has been done through them; they have ground equipment and they analyze satellite data. And they have [Inaudible] some collaboration with National Renewable Energy Laboratory of the [Inaudible].

They're also doing solar and wind forecasting. They are doing quality assessment and they are very popular within the street called the expense concentrations. Similarly, we had the National Institute of Bio Energy at the [Inaudible], where there are testing facilities for cook stoves and other biomass based technology and an extensive R&D Program.

In 2015, we held the Global Renewable Energy Summit for the first time in New Delhi. The focus at that time was to attract investment because of our target 175 gigawatts, and it was a huge success because we got investment commitments of over 275 gigawatts right there on the spot from industry. Now we are well on the way of the deployment of 175 gigawatts and now we are looking forward into the future. The next edition of RE-Invest should be held from the 15th to the 17th of February 2017 at Mahatma Mandir, Ahmedab. And the focus of the new edition of RE-Invest is going to be innovation and technology. And we invite anyone in the field of clean energy innovation and technology across the world to participate at RE-Invest and tell us how they would like to collaborate with us. Thank you.

Eric Lockhart Great. Thank you very much for that presentation. We'll turn to Prakash Hirani. Just a moment, Prakash. I just want to let you know about time. It would be great if you could keep your presentation to 10 or 15 minute so we save time for questions at the end.

**Prakash Hirani** Okay, I'll do my best.

**Eric Lockhart** Thank you. And to the attendees at well, if you would like to ask questions at any time, just a reminder to submit questions in the questions bin. Thank you, Prakash, over to you.

**Prakash Hirani** Okay, everyone. Welcome on behalf of Ministry of Power. [Inaudible] beyond the data energy [Inaudible] is increasing. Fossil fuels energies pollute the environment and causes a climate change, but environmental regulation and climate change are not actually the traits, but there are challenges to the mankind, which in turn demands technology innovations.

For Ministry of Power, there's a key ministry of ensuring the electricity situation in the country. It is also uncertain to be a prospect of planning policy formulations and also for the concentration and distribution of electricity.

Now it applies —NTPC is one of the major public sectors of the [Inaudible] power and it's connecting a number of research programs for the clean and affordable power. My presentation is going to be a little technical, unlike the other presenters, so one has to bear with me.

The focus area for the R&D central [Inaudible] NTPC are the climate change and environmental protection, clean coal technologies, renewable energies, energy efficiencies, and then we also offer scientific support to the existing power stations. As you can see, most of these initiatives are mainly for, first of all, to clean and affordable power.

Now one of the key areas is the carbon capture and utilization. As we all know, the greenhouse gases are going to be a threat for the humankind. Keeping that in mind, we are trying to help some research initiatives for the carbon gets captured to development of modified amines for carbon capture. The process is very long, but we are trying to increase the efficiency of that process through modified amines. Similarly, we are also working on researching adoption of the CO<sub>2</sub> [Inaudible], be able to leave it on by scale. We have also four big tanks in this particular technology and we are trying to set up a pilot scale at one of our NTBC stations.

For the CO<sub>2</sub> utilization, this is the one key factor which government of India policy supports very, very strongly and we are also trying to use the fuel gas for the algae generation by replacing of the CO<sub>2</sub> by the algal moss.

Similarly, as we all know that all the power stations, especially the coal ones, they have the —ash is one of the key factors, because as we all know that in India coal carries —has about 40-percent of ash, so a lot of ash is related to the coal power stations. Keeping that in mind, we have, again, the three major initiatives. One is the setting up of the lightweight aggregate plant, which can help us in conserving our precious natural resources. Similarly, we are also trying to make a green cement through the fly ash using the geo-polymeration route, about which we are trying to cooperate with the University of Melbourne and its [Inaudible] [Inaudible]. We are also trying to use the bottom ash for the converting this into a sand, which is a really essential part of the concrete.

Similarly, we all know that water is one of the major inputs for the power stations. Keeping that in mind, we are trying to use the wastewater to the recycling. And this particular initiative is being also developed by one of these stations which will become [Inaudible] very soon. So water conservation is also one of the key factors which we are keeping in our [Inaudible] [Inaudible] portfolio.

The other [Inaudible] which we are keeping are the advanced [Inaudible] [Inaudible] technologies; NTPC as a [Inaudible] [Inaudible] public sector is one of the key members in this particular initiative, in which we are trying to

have the [Inaudible] pictures of about 720° C, but [Inaudible] around 300 [Inaudible] apart. And this will help in reducing these [Inaudible] emissions by almost a 20-percent [Inaudible] for each power operation unit. Similarly, we also have some more initiatives, especially for the ESP efficiency improvement, and then also composition of Flue dynamics for Flue gas for ESP efficiencies. And similarly, we also have some other initiatives which will help us engage energy efficiency.

In the renewable area, we have tracking of the floaters, solar PV floaters. As we all learned, it's going to be a key factor for the solar generation. So we have —we are trying to work on the water bodies, availability of our [Inaudible]. And that's why we are trying to develop some solar PV floaters indigenously. Similarly, we are also trying to have the setting of the PV and solar laboratories in collaboration with [Inaudible] and Germany, which will help us in the setting up the concentrated PV and solar PV level —or the concentrated thermal and concentrated PV. These two things would be then associated with them. We are also working on the studies of one that [Inaudible] [Inaudible] tracking system for increasing diesel efficiencies.

Again, on the solar efficiencies, we have [Inaudible] [Inaudible] forecasting system. And as we all know that water is one of the major factors of cleaning the PVs, and India has a lot of dust in its atmosphere, so we are trying to develop the local [Inaudible] system, which will not require any water.

Similarly, we also have the state of art solar thermal laboratories which we are developing, which I've shown in the presentation. We also plan to work on the low energy nuclear reaction. This will generate a lot of power, a lot of energy through the working in the atomic level, like working on the low atomic elemental or higher atomic level. Of course, this is being carried out by a number of entities in there and then also taking initiative for this particular technology now.

Similarly, we are also trying to work on the flow batteries. Flow batteries are more efficient, they have good energy storage, and we are trying to work with the —and [Inaudible] with the engineers who are [Inaudible] [Inaudible] trying to develop [Inaudible] conditions.

Nano technology is one of the areas which is coming up very fast. Keeping that in mind, we are trying to intervene in our high-energy demanding power plant equipment, wherein we are trying to use the nano-lubricants for the coal mill gearbox and we are seeing, you know, increasing efficiencies in [Inaudible] [Inaudible] 30-percent. And we are also finding that coal mill gearbox oil is having a higher life. Simulating the [Inaudible] to [Inaudible] work on the nano-coolant for heat exchanger, which will help us in increasing the efficiencies of heat exchangers by almost 30 to 40-percent.

We are also trying to work on the low temperature heat recovery. We have installed the 100-ton air conditioning using the flue gas of the power plant for the air conditioning. We are trying to initialize this technology and we have seen it [Inaudible] and we're trying to repeat it before [Inaudible] other stations now.

Similarly, we are also trying to work on the flexible coal unit operations and then the installation of phase matching units. These all initiatives are taking for the energy efficiency automation.

We also have the [Inaudible] keeping all these research in focus and to keep all these research initiatives in a light position and need the support of the labs, so we have a number of labs, as you can see on this slide. And these labs are helping us in formulating our certain initiatives and fulfilling them.

Keeping the collaboration is one of the key factors for us. We are always looking for new collaborations. As you can see that we have collaborations with Germany, U.S. and Australia; Germany for the solar thermal lab and Germany again for the CFD modeling. We are also trying to have the collaboration with CSIRO Australia for advanced combustion and gasification technologies. MIT USA is one of renowned institutes of the world; we are trying to have collaborations for the [Inaudible] [Inaudible] utilization and also in renewables. Similarly, we are trying to have these collaborations with some Australian universities for different initiatives. We are also open to all the other partners, all the international partners the way that we have this energy between us, and we must —Mission Innovation has one of these [Inaudible] find is the innovation, collaboration through innovations. So we are keeping that open for all the information partners.

Similarly, we have the collaborations within India with almost 30 institutes on the different sides, for the IGCAR Kalpakkam for the Advanced [Inaudible] [Inaudible], for CIPET Chennai for floating solar. So you can see the more of —we have the more of initiatives and we are still looking for more. These are some more institutes, TERI for the water footprint, IISc for [Inaudible] process simulation. We are also in domestically as well as internationally for collaboration for making these [Inaudible] clean and affordable energy.

Thank you, Eric.

Eric Lockhart Wonderful. Thank you very much. Thank you to all of the panelists for those fantastic presentations. We've had some great questions coming in and we'll use the remaining time to answer them and discuss.

The first question is about the integration of wastewater treatment and algal biomass production. The participant knows that the Ganga restoration program adopts [Inaudible] treatment technology and could produce huge amounts of biomass, and asks if the panelists could speak to that, integrating wastewater treatment and biomass production. That's open to all four of you, of course. And please let me know if you'd like me to repeat any part of that question.

**Renu Swarup**

Would you like to take that from NETRA NTPC, [Inaudible]? Or do you want me to respond to that? Would you like to take it from NTPC first?

**Prakash Hirani**

I think, madam, you can start, then I can support on that. [Inaudible] [Inaudible] [Inaudible], so I can support you on that.

## Renu Swarup

So I think the main, as you would have heard in the three presentations from the Department of Biotechnology and we also heard about it from the NTPC power presentation and also a bit of it was talked about from the esteemed MNRE. The focus that is currently there is to try and see how the wastewater can be used as a potential source for looking at the biomass growth, mainly the algal growth. We are looking at, as I said, various algal cultures which are available which have been tested, and trying to see how this could be used not only for increasing the biomass for algae, which is important as a feedstock, both for the animal feed mainly, but also looking at it from the carbon dioxide sequestration program, as was informed by NTPC.

There is an effort that has been made to see how we enhance the production capacities and try and in addition to in looking at increasing the biomass growth of the algae in wastewater. Algae is also being used as a source for the purification of the water itself so that you can actually then convert the wastewater in terms of its quality into usable water. There is a lot of work that is being done which is now —this is currently at the lab stage in our projects. We are trying to look at bringing in the cost reductions and also making it a viable technology which could then be used in decentralized manners in households and societies and also within the industry for larger use.

From NTPC, if you would like to add on.

## Prakash Hirani

We are following a different approach for the wastewater. As one of the slides I showed, that we are trying to recycle that water, again, for the power plant use. That's one of the initiatives and it's to be commissioned very soon and we'll see the [Inaudible] with that. As far as use of wastewater for the biomass is concerned, we have done some [Inaudible] on that, but as Dr. Swarup was telling, that people are trying to work with the cleaning of the wastewater to be algal. That is a full thing we have demonstrated some places. Right now, we are trying to work with the water which is groundwater, but at a later stage, we are definitely going in the wastewater for the algae [Inaudible] also. Thank you.

Eric Lockhart Great. Thank you very much for those responses.

Our next question is about mission innovation. The participant asks if there are plans through the mission innovation budget increases to set up new centers of excellence that are dedicated to technology in addition to the centers already existing for solar, wind, and bioenergy.

## Renu Swarup

I will give an initial response to that before I ask Varsha and Sanjay Bajpai to add on to it.

The mission innovation, as you've said, is a platform in which countries have come together and each country identifies its own priorities how to move ahead. The modalities of how this is implemented could vary from country to country. For India, as we have said, the doubling plans that we have indicated would include all components, right from research project to setting up and creating centers of excellence, to also creating demonstration sites where these programs could be demonstrated so that they are ready for deployment.

And within our country, in the biofuel sector and I know that in the solar and other sectors there are plans for creating centers of excellence. The specific details of that would be available within our programs as we move on.

Varsha, would you like to say something? And then followed by Sanjay Bajpai.

**Varsha Joshia**

Yes, please. The three institutions we already have are solar, wind, and bioenergy. There is a plan within the ministry to make them centers of global excellence and there is a consideration of funding of around USD \$50 million per institution. And proposals for upgrading these institutions have already been sent into the new development bank. And we're also looking independently within our own budgets for taking up some of these proposals in a fast track mode. And more extensive testing and sanitization laboratories within business institutions and perhaps in other places where they are required are also under consideration.

Apart from that, the ministry is looking to create a center for new energy, which would likely be set up either at Kaharti or at Mogadishu; it's going to be one of those two places. And Andhra Pradesh national renewal energy university is being set up by the Andhra government, which the Ministry of New Development and Energy is going to be supporting. Thank you.

**Sanjay Bajpai**

To add to that, we at Department of Science and Technology are following a two-pronged approach. First thing is we are starting our own laboratories to setting up technical research centers. As I mentioned, that we actually have [Inaudible] and [Inaudible] are being strengthened with going in technical research centers on energy. In addition to that, we are also encouraging academics and R&D institutions to join hands on virtual network and then set up the facilities at a central place and get it to the larger area.

We have also set up one —we also have plans to set up a center on the material research, energy material research at Indian Institute of Science and also at the RCA [Inaudible]. So there are several initiatives which have been taken up these centers. And [Inaudible] centers, which we have —we are planning to extend them further. Thank you.

**Renu Swarup**

I would just like to supplement this by saying that we have presented to you our collaborations, international collaborations, in which the Indo-U.S. collaboration on the joint team energy research center, which is a collaboration of the public-private sector, both the U.S. government and Indian government together. We would like to see more of these models so that these centers of excellence are not limited just to our Indian public sector, bringing in the private sector, bringing in other countries, both in bilateral and multilateral cooperation is what we would like to take forward through the mission innovation.

**Eric Lockhart**

Fantastic. Thank you very much.

Our next question, so I lean more general and ask how can eco-friendliness and fuel efficiency be balanced? That's to say what are the trade-offs between eco-friendly fuels and good fuel efficiency, if there are any?

**Renu Swarup**

That is a very general question. I would have actually loved to have the clean energy solutions respond to that. But from the Government of India point of view I think that's a general question where we are trying to look at bringing in a balance of the two so that we not only make the clean energy solutions available, but then this is also something which while it looks like at the environment, is also something which is accessible. And in a country like India we could not—it's not possible for us to bring out solutions which are only important to address climatic needs; we have to look at socioeconomic and cultural requirements for a particular technology or a solution to be adapted and to be accepted by the community at large. So I think each program that is being done within the country the details of it are worked out, keeping this in mind, looking at the acceptability in the long term.

Anybody else would like to add on anything else, it would be-

**Varsha Joshia**

Yeah, I'd like to just—one of the major things which we're doing, like I mentioned in my presentation, is working on a solar wind hybrid policy so that we can make most of every piece of land we have which can be used for harvesting an energy farm and the kind of transmission that can be utilized best by putting both wind and solar together on the same piece of land. So that is one way of looking at reducing the cost and still getting better efficiency.

And on the bioenergy side, you know, most of the bioenergy that we're talking about is energy from what is essentially waste. So if you're talking about wastewater has already been just discussed. Then we have agricultural biomass waste, which can be turned into biofuels. And we have municipal solid waste, which can be turned into CNG. So converting waste into energy is, I think, all in the positive side; so it's a balancing which is beneficial on both sides. Thank you.

**Sanjay Bajpai**

I'd like to just start by saying that the fuel switch we are looking at, they are very cleaner in combination in the fields, which are cleaner in combination. They are [Inaudible] [Inaudible] and generally they are very fuel efficient also, like CNZ, biofuels, all of these are very environmentally benign and the emissions are also very less compared to the conventional fuels.

**Eric Lockhart**

Good. Thank you very much for those responses. We've spoken a good amount about commercialization in partnership with industry, and one of our participants is asking about biofuel startups and how successful they've been, and if there are any success stories, how many you've worked with.

**Renu Swarup**

The biofuel work that we have done with the industry so far, we've had the technology, which has reached the stage of commercialization, is not with a startup, but with an industry, and that is because it was a capital-intensive setting up a plant that was required. The startups that we have supported, and we have a number of them who have been supported, as I had mentioned, we

have programs in which we are working with students from the IITs. Those are our premier education institutions, and helping them create their enterprises. We have funding opportunities in which we have given them grants to be able to take their research forward. In our list that I have shown you of projects that we have supported in the biofuel, we have, I think, out of that about 20-percent of those were startups who have just been able to take their idea through a proof of concept stage.

The enthusiasm is great. The numbers may not be very huge right now; we'll just be having about 10 to 15 such startups were coming forward in the biofuel sector. But the enthusiasm being great, we have also now looked at partnering with some of the private investment funds. You heard about Infuse, which was talked about by my colleagues, which is a fund which is act, the IIM Ahmadabad, there is a private fund which is being created, again, to help clean energy team tech startup companies and the Government of India through bio [Inaudible] and DPT has pledged an amount to be put into that as the government deputy states to promote startups.

Lastly, I would like to say that they are also trying to promote startups in the clean tech sector by now working with our intuition centers. And currently these are sector-agnostic, where they look at all areas. But as we have done for the medical devices sector, which has proven very, very effective, we are now talking to draw some of our centers of excellence, who can then set up incubation centers, which would be focused on helping our startups to then take their technologies out into their [Inaudible] technologies ready for commercialization. So our plans are there and in the next like two years we would be having these incubation centers and special funds for clean tech startups, so that the number that we see, which are not very large now, we hope that we will be able to steal that down.

Eric Lockhart Great. Thank you very much. I'd like to mention there are a lot of great questions coming in, many of which we unfortunately will not have time to get to. So we will —Clean Energy Solutions Center will be working with the panelists to get responses by e-mail to those questions that we can't get to live on the webinar. I'd like to also point out that the slides will be posted on the Clean Energy Solutions Center website.

The last question before turning to closing comments is if you could elaborate more on how these various government institutions work with each other, since they are supporting overlapping research and development interests in renewable energy.

## **Renu Swarup**

I'll begin this and then I'll request my colleagues from other ministries to come in. As you've seen that in the Government of India we have the Science and Technology Ministry, which is primarily mandated to support research and development. And this ministry has a number of institutes which are directly under its control, very similar to the laboratories as in the U.S. Department of Energy and other federal governments. But in addition to that, the Ministry of Science and Technology supports extramural research across laboratories within the university and research institute systems across the country.

There is a level of competition that is brought in, so this is all competitive research, and most of the funding that goes in for the initial research, the discovery research, and the innovation is all under the competitive grants teams that we operate, because most of it is in the re-competitive area, where any new IP, et cetera, that gets generated would help to move forward. And we have to support more than one so that many times they are all working for the same objective; and two, the funding agencies they are then brought together in sort of networks and teams so that the results are shared with each other. So while it may seem that they're working on competing aspects, many times these are complementary to each other.

As we move up and closer to the product development chain, those organizations which then become responsible for delivering specific outputs which are closer to the objective come together in network mode and each one of them has a responsibility, as I said, that is synergy in their working to be able to respond to it. There is a lot of coordination between all centers. Most of the centers that you see, which are listed on all our ministry sites, are working through these expert groups in collaboration with each other.

There is also an effort to bring together the private sector and the startups in this whole system. Our committees, our taskforces, our expert groups as they work, have representatives not only from the ministries, but from various organizations, who then represent or are the key representatives of the sector in which they are.

Maybe I would request Dr. Bajpai and Varsha if there's anything else you would like to respond from your ministry's perspective.

**Sanjay Bajpai**

I think from a Ministry of Science and Technology perspective you're going most [Inaudible]. One to [Inaudible], which we have in the nine ministries is that we have a certain amount of [Inaudible], but there is a synergy in terms of the participation in each of those committees and then there is a certain distinction in terms of the technology readiness level that we are addressing. So far an example in the solar energy research, DST will be working in the very, very [Inaudible] of research to bring it to a technology readiness level of 2 to 4 and then [Inaudible] demonstration and that things can be taken up at a larger scale by a [Inaudible].

And one more thing which has been cautiously done is that the evolution of the programs is in most of the case by expert panels, which has overlapping members. So there is no outlet per say. In fact, there is a synergy in those parts.

I will request to Ms. Varsha Joshia to supplement on this.

Varsha Joshia Yes. In fact, I would recall what ma'am and Dr. Bajpai have just said; it is a synergy which works because our mandates are slightly different. More fundamental research is done mainly through the DBT and the DST and the MNRE comes in when it's a question of piloting, administrating, and making something more commercially acceptable. And I'd like to give a small example of how collaboration works. I had mentioned

the presentation about hydrogen solid-state storage being developed at the Banarus University Hydrogen Lab and the three wheelers, which Mahindra & Mahindra and IIT Delhi have together developed. So we had the storage device, which has been developed at BHU, which has been used in the making of the three wheelers, and the three wheelers are themselves being operated on the BHU campus and if you go there you can ride on them. So you have a private industry, you have two very different academic institutions, and you have MNRI threading the whole work together. So that's how collaboration works quite successfully in all R&D work across the government and across other institutions.

**Eric Lockhart** Great. Thank you very much.

**Prakash Hirani** [Inaudible Crosstalk] Sorry.

**Eric Lockhart** No, go ahead.

**Prakash Hirani** [Inaudible] [Inaudible] power it's —yeah. Your power is also very low carbon [Inaudible] [Inaudible] of [Inaudible] through collaborations on the generation front. I think more efficient, so particular [Inaudible] will be [Inaudible] for particular technologies for coal dust power plants, maximizing the induction of hydro power plants on the conservation side by increasing the [Inaudible] level of concentration to the [Inaudible] [Inaudible] [Inaudible] without [Inaudible] transmissions and by simply reducing the [Inaudible] and [Inaudible] losses through IPDS and smart grids. These are all [Inaudible] [Inaudible] to collaborations with various industries, various research institute partners. Thank you.

**Eric Lockhart** Impressive. Thank you very much. Thank you all for those great presentations and that very informative question and answer session.

I have just the last couple of minutes here left. I just want to invite the panelists to make any brief closing remarks you'd like to make and then we'll turn to a survey.

**Renu Swarup** I would just like to say thank you very much from our side for all the participants who have come in, and would like to reiterate that through our presentations I think that the message has come out clear that the Government of India is fully committed to take this Mission Innovation objective forward. While we are making all effort to see that, we use this as an opportunity to really enhance our own clean energy research efforts within the country, we would be very happy to take this forward to bilateral and multilateral corporations.

As I mentioned, the Mission Innovation itself is looking at identifying two or three major missions which would be taken up by a majority of the Mission Innovation member countries. By the end of September we should have identified through a consensus these missions. We would also look at private sector participation definitely from the investment viewpoint; you've heard of various opportunities where private sector can come in, but also encouraging

the private sector in the country to be partners with the public sector to take this Mission Innovation form.

Thank you very much. We'll be happy to respond to any other questions that come through which we could not respond to today.

Eric Lockhart Wonderful. Thank you very much. Thank you again to all of our panelists. We'd now like to ask the audience to take a few minutes to answer a quick survey on the webinar you viewed today. We have five short questions for you to answer. Your feedback is very important to us, and it allows us to know what we're doing well and where we can improve.

The first question is "The webinar content provided me with useful information and insight."

The next question, "The webinar's presenters were effective."

"Overall, the webinar met my expectations."

"Do you anticipate using the information presented in this webinar directly in your work and/or your organization?"

And finally, "Do you anticipate applying the information presented to develop or revise policies or programs in your country of focus?"

Great. Thank you very much. Thank you for answering our survey.

On behalf of the Clean Energy Solutions Center, I'd like to extend a thank you to all of our expert panelists and to our attendees for participating in today's webinar. We had a terrific audience, and we very much appreciate your time. I invite our attendees to check the Solutions Center website if you would like to view the slides and listen to a recording of today's presentations as well as previously held webinars. Additionally, you'll find information on upcoming webinars and other training events. We are now posting webinar recordings to the [Clean Energy Solutions Center YouTube channel](#) as well. Please allow for about one week for the audio recording to be posted.

We also invite you to inform your colleagues and those in your networks about resources and services, including no-cost policy support. Have a great rest of your day, and we hope to see you again at future Clean Energy Solutions Center events. This concludes our webinar.