Summary Report of High-Level Roundtable Stakeholder Discussion on Horizon Energy Technologies, Technology Partnerships and National Energy Policy

Jointly Organised by the Council on Energy, Environment and Water (CEEW), India and National Institute for Transforming India (NITI Aayog), Government of India

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1. Background

Energy is an important pillar in any nation's growth and development story. With expectations of a rapid economic growth, energy sector has been time and again highlighted as a key sector for realising India's growth ambitions. However, at this stage, India has numerous energy challenges. Foremost is the issue of energy access, as millions of people in India live without reliable access to affordable energy. Energy security has been another concern. India imports more than 70% of its oil requirements, and imports of coal and gas are increasing year on year. Carbon dioxide emissions and local pollutant emissions are increasing with increasing energy use, and limiting these negative externalities is another challenge facing Indian energy policy makers. To address the multiple challenges, there is a critical need to have a well thought out and visionary energy policy which can address these concerns simultaneously.

For giving a direction to the country's response to impending energy challenges, the Government of India is in the process of drafting a National Energy Policy. The NITI Aayog has been tasked with spearheading this effort. Traditionally, India's national energy policy has addressed the important concerns around energy access, energy security and energy affordability. Making India a leader in energy technology development and commercialisation needs to be recognised as another important objective, which till now has not been viewed in a strategic way. The Council on Energy, Environment, and Water (CEEW) has been highlighting the strategic importance of including horizon technologies and technology partnerships within the framework of national energy policy. By horizon technologies, we mean energy technologies that are at early stages of ideation or development within India and abroad. CEEW has been tasked with contributing to the issue of 'horizon energy technologies and technology partnerships' within the framework of India's national energy policy being formulated by the NITI Aayog. A high-level stakeholder roundtable discussion was organised on 20th October by CEEW and NITI Aayog in this regard for informing the national energy policy.

2. Structure of the roundtable discussion

The speed with which the technology is changing and revolutionising the world is phenomenal. It is clear that effectively integrated technology, can become a strong tool for developing countries to boost their economic growth. The aim of the 'High-Level Round-Table Stakeholder Discussion' was to bring together experts and key stakeholders on a common platform to initiate discussion on strategic advancement in future technologies and address the key policy issues to accelerate technology transfer and technology partnerships. The roundtable saw participation from senior experts from the government, academia, industry, and civil society. The detailed list of participants is given in Appendix 1.

The discussion started with opening remarks by Dr. Arunabha Ghosh (CEEW) who highlighted the importance of including horizon energy technologies and technology partnerships within the framework of India's national energy policy and the objective of this roundtable discussion. This was followed by welcome remarks by Mr. Rajnath Ram (NITI Aayog). Mr. Ram informed the participants about the process of formulation of India's national energy policy and the importance of expert stakeholder discussions for providing inputs to the national energy policy. Following this, Dr. Vaibhav Chaturvedi (CEEW) delivered a briefing presentation highlighting the key issues that need to be discussed by the participants. Dr. Arunabha Ghosh then presented his views on technology partnerships based on his recent research on energy and climate technology partnerships. The floor was made open for discussions on both the issues of horizon energy technologies and technology partnerships. The half a day roundtable workshop was concluded by summary comments by Dr. Vaibhav Chaturvedi who highlighted the key themes emerging from the discussion. Dr. Chaturvedi also highlighted that for beginning the process of institutionalizing policy and planning on the strategically important issue of horizon energy technologies, there is a need to constitute an independent and autonomous expert committee with a clear mandate and set of objectives. Details about this committee are given in the section on recommendation. The summary remarks were followed by a vote of thanks by Mr. Ram to the participants who had devoted their valuable time and effort and contributing to the discussions on this critical issue.

3. Key messages and discussion outcome

3.1 Role of energy policy in shaping horizon energy technologies is critical, and an autonomous national body is required to spearhead this process

There are many programmes and policies in India that aim to foster technology development. However, these initiatives are not specific to energy technologies. It is important to have a focus on horizon energy technologies separately as well, and India's national energy policy can play a key role in institutionalising this process. Following are the key takeaways from the stakeholder discussion on this issue:

- Horizon energy technologies are by definition technologies that are far from commercialisation. Hence, the role of policies in discovering and supporting both horizon technologies as well as beyond-horizon technologies is critical.
- Role of government policy is to support such technologies till a market for these is created. Another important role of policy is to give long -term direction and signal to private investors and markets so that they can start investing in the direction.
- The policy document should include goals and timelines.
- Policies should be framed with a longer term vision, not for addressing the issues we face today but for addressing future challenges. The issue of horizon energy technologies hence is an issue which is strategic in nature given the longer term vision behind it.
- Along with the longer term vision, the policy should have near-term, mid-term and long-term targets against which the progress can be measured.
- The policy should be customised in terms of Indian context, and should avoid incentivising a particular technology. Development of an ecosystem for investment in R & D for high impact horizon energy technologies should be the priority for the national energy policy.
- The policy on horizon energy technologies should not be prescriptive in nature.
- It is important to observe that missions like 'Make in India' cannot be supported with renewables only which have been a focus of most discussions in India, and the objective of the energy policy should be to look at the larger picture and to a wide variety of horizon technologies across sectors.
- India's Intended Nationally Determined Contributions (INDCs) envisage high share of solar and wind, which will be dependent on storage solutions as well as grid management solutions. These solutions are currently not there yet, and bringing these in the purview of national energy policy for a strategic push becomes important.
- India has a low cost procurement environment which should help commercialisation of future energy technologies, giving India a cost advantage.
- Policy should enable the 'Ministry of Finance' and 'Department of Science and Technology' to undertake technology transfer smoothly.

- It is important to work across energy sectors and to develop a micro-level understanding of each sector so as to initiate collaboration across sectors for horizon energy technology development.
- It will be important to focus on identifying areas and sectors that require horizon technologies and a framework to deal with future challenges.
- Benchmarking of technologies will be important for competing with the cutting edge technology development process happening across different countries in the world. The role of the government and bureaucracy in the benchmarking process is also important.
- Horizon energy technologies and technology partnerships need to be a part of India's National Energy Policy. Ideally, this should be a separate focus (potentially a separate chapter) along with the focus on energy access, energy security and energy affordability.
- Ultimately, a permanent national body needs to be created with a specific focus on horizon energy technologies and technology partnerships, e.g. 'Cell on Strategic Horizon Technologies (C-SHoT)'. The process of creation of such a permanent body can be initiated through constituting an expert committee on horizon energy technologies and technology partnerships. Whether this body is an autonomous body, or is governed completely by a government ministry or department, this should be determined by the expert committee. It is important that this committee is led by non-government experts to ensure autonomy, but it should have representation from all key ministries and departments. A detailed suggested role and form of the expert committee is given in the last section on policy recommendation. The committee should not just identify technologies but should also lay guidelines about the processes that should be undertaken to implement them.

3.2 Which are some potential horizon energy technologies?

The objective of this expert stakeholder discussion was not to identify horizon technologies. The identification and prioritisation process should be based on a set of criteria developed through in-depth stakeholder discussions. However, it is important to highlight some such technologies that could be critical for India in the future:

SUPPLY SIDE TECHNOLOGIES:

Energy storage solutions: Energy storage is one of the most critical areas of research, given that India has huge ambitions of scaling up intermittent and variable renewable energy technologies. A lot of research has been happening on lithium-ion batteries, but there are new technologies like solid state batteries also emerging. Energy storage technology development should encourage processes that are more environmental friendly. There are many new

configurations of energy technologies that are being tested around the world and any breakthrough would be important for India.

Advance nuclear energy technologies: Some experts believe that nuclear energy will play a big role in long term policy in order to have low carbon energy technologies and reduce carbon imprints. However, there are many advance nuclear technologies that are being researched around the world. Most of these are also passively safe technologies. It is important to have a strategic view on which of these 'advance' nuclear technologies could be developed as one of the potential horizon technologies.

Shale gas extraction technologies: India is supposed to have significant reserves of shale gas and oil, however, these are not explored to the extent required for estimating their potential. In the future, shale oil and gas could be an important resource. Extraction technologies have already been developed by US companies. Partnership with those companies could be one potential way of getting access to this technology. Irrespective of the arrangement, this category of technology would be very important for India as a horizon technology.

Geothermal / Wave energy: Geothermal energy is not supposed to be a big contributor to India's power production even in the long future. However, it is an energy form which could be critical to meeting the energy demand for remote areas, especially the hilly region. Similarly, wave energy is a horizon technology that could be used to harness the power of waves across India's long coastline. Both of these are renewable forms of energy and can be very useful for niche applications where it is difficult to supply grid power.

DEMAND SIDE TECHNOLOGIES:

Hydrogen fuel cell vehicles: Recently, car maker Toyota announced its plans to focus on hydrogen powered vehicles. Such vehicles are also on road in some countries as a part of some research and pilot testing programs. Replacing oil in our transportation system is critical for a cleaner environment. Electric vehicle technologies are being discussed and the world has seen rapid development on that front especially with car companies like Tesla. Hydrogen powered vehicles could be another technology for potentially changing the transportation sector significantly.

Space cooling technologies: Research has shown the demand for space cooling and air-conditioning systems in both residential and commercial operations will increase significantly in the near and long term future. Market trends also suggest this. Air-conditioners, even after significant efficiency increases, are huge guzzlers of electricity. With India rapidly

developing new cities, there is a potential for cooling technologies like district cooling that can reduce the demand for electricity from air-conditioners separately. Thinking about space cooling in novel ways is important and will have significant impact on electricity demand from India's building sector.

High speed rail: India has a huge rail network. There are many long distance routes and trains. Very recently, expert institutions from Japan studied the feasibility of developing a high speed passenger rail corridor in India. With increasing incomes, passenger demand for travel services is bound to grow. This is being witnessed in the growing air traffic year on year within India. Bullet trains are well poised to meet demands for long distance high speed travel. This technology is already functioning in other parts of the world and could be important for India in the future.

3.3 Need to collate and synthesize programmes on horizon energy technologies running across departments and ministries

The stakeholders highlighted that there are programs and research already happening within the country, but at the same time these are all viewed as individual researches. It will be useful to give these efforts a coherent shape and direction so that the whole becomes larger than the sum of individual parts:

- There are various programmes running across ministries and departments on technology development.
- Most of the bilateral programmes are project specific and limited in terms of scope.
- There is however no programme that strategically addresses the issue of horizon energy technology as a group, though there are initiatives around individual technologies.
- Indian organisations are involved in many partnerships with international institutions on variety of energy technologies.
- If developing horizon energy technologies is accepted as a strategic issue by the government, then the government has to create a separate and dedicated mechanism to pursue these technologies.
- There is clearly a need to synthesize information from the existing set of programmes and activities and brain-storm on a future course of strategic planning for the development of horizon energy technologies.
- The national energy policy is the best suited policy document for giving a strategic direction to horizon energy technologies by bringing all the related programmes and policies under one umbrella.

3.4 The time is ripe for planning and investing in strategic research and development for horizon energy technologies

India's policy makers have time and again highlighted the importance of innovation and research and development. In developed countries, a lot of innovation happens outside the government structure, though significant support and incentive is provided by the governments also. With energy demand set to increase significantly, and with the global energy systems in the beginning of a significant transition towards cleaner energy sources, the time is ripe for strategic investment in horizon energy technologies. Following are the key discussion outcomes for this issue:

- Indian energy policy must focus on research and development (R&D). Currently there are very few government labs and India is lagging behind its peers internationally. This calls for a technology jump. However, government labs should not be the only platforms for horizon energy technology development. There is tremendous expertise in India's private sector. The role of national energy policy is critical in channelling this expertise into a strategic direction.
- Policy should include education on energy and energy research. Demonstration centres where technology products are exhibited should be a part of a communication plan that needs to be integral to the policy. Thus, policy should not be just about R & D, it should also be including a strong public communication component.
- R&D labs and research institutes should be encouraged to collaborate and cooperate through symposiums, consortiums etc.
- Academics need to be nurtured to take-up R&D projects.
- Involvement of state governments is very important to ultimately meeting the aspirations, and developing the required infrastructure for research.
- With the industries best interest and know-how of the market place, it is important to deploy technologies in the industry.
- Research needs should be identified by the industry experts along with experts from research and academic institutes. We should ideally try to build a consortium with representatives from industry and research institutions.
- Research institute/academia should bring solutions to the problems.
- Government laboratories should be incentivised to perform on the number of engagements they have and not just on the number of publications they do.

3.5 Private sector participation and private-public collaboration in this discussion needs to be ensured

Fostering the technical, financial and managerial expertise of the private sector should be an important aspect for delivering on the ambition of becoming a leader in horizon energy technology development and commercialisation. There are two channels through which the private sector can participate. One is through collaborations with the government agencies. Other is through its own research and development efforts, which are driven by market developments rather than any collaboration with the government. The NEP should mobilise private sector participation through both these channels, and these would require different kind of incentives. Following are the key messages from the stakeholder discussion on this aspect:

- Partnership of government and private research institute is required for achieving the goal of horizon energy technology development. Collaborations of govt. sector with industries, research and academia is important. Collaboration between private companies and research lab can be instrumental in delivering on cutting edge research and development (e.g GE and National Chemical Laboratory).
- There is a need to review and learn from collaborative transnational/ public-private R&D frameworks.
- Joint Ventures of the government companies and private sectors with those companies which are experts in horizon technologies should be encouraged.
- The government needs to set market signals through fiscal incentives for innovation and deployment of technology on the ground.
- Policy needs to have a support for trials/risk taking in the process of innovation which will incentivise private companies and entrepreneurs to invest in the development of horizon energy technologies.
- Incentives for Indian industries is an important aspect and the creation of an innovation ecosystem is critical, irrespective of the collaborative opportunities between the public and private sector.
- Address intellectual property rights (IPR) issue, as this would be instrumental in deciding whether the private sector will invest or not: while the government would be interested in bringing low cost easily available technology for the benefit of the country - private sector might not be interested in sharing the technology that they possess. The policy should aim at enabling the private sector companies to achieve adequate returns for the risk they undertake in the process.
- Support or needs of the academia should be served by the industries, e.g. in terms of funding for high impact research.
- Corporate Social Responsibility obligations can be used to invest in technology innovation, skill development and R&D.

- CSR law dictates that R&D investment that has indirect benefit to the investor company cannot be considered as CSR spending. This aspect is an impediment to R&D in the energy sector.
- Though private sector participation is most important, often the promotion of technology development by private sector may not necessarily contribute to strengthening the energy sector. Rather it could end up contributing only to their individual market interests and end up monopolising energy technologies which eventually make it costlier for the general public to access. The energy policy should highlight this aspect and call for arrangements to address this concern.
- Financial and business models are critical at each stage of energy technology development and commercialisation. In terms of technology applicability, the pace at which change in energy technology is taking place is much faster now than ever before.
- With the help of business and financial models, there has been an increase in the absorption, adaptation and application of technologies. Finance from both private and public sector is an important enabling condition for the success of any R & D policy.

3.6 Learning from the international experiences and initiatives will be beneficial

There are many countries around the world, especially in the developed world, that have deep experience in strategic initiatives around energy technologies. It is important for Indian energy policy to recognise this and learn from these experiences.

- It will be useful to assess learning from the examples of Chile and California that plan to have large-scale energy storage technology penetration, to help reduce variability, control frequency and manage peak loads. This will help India in harnessing its vast potential of renewable energy.
- Germany has been a global leader in policies and programs for incentivising solar energy. These efforts have also aimed to bridge the gap between innovation and practice. Development of required skills and capacities has been an important area for consideration for becoming a global leader on energy technology development. The role of finance is critical and government and private sector funding are in place to encourage R&D in newer energy technologies.
- The Advanced Research Project Agency- Energy (ARPA-E) programme of the US government is a flagship programme to identify high potential high impact energy technologies. The support of this programme has already led to significant drop in the cost of storage technologies. There are substantial learning for India from this programmatic approach towards horizon energy technologies.

3.7 Technology partnerships are going to be critical

Technology partnerships can take various forms. These could be between public and private sector within India, could be between Indian company and foreign company, or could be bi-lateral or multi-lateral partnerships between Indian government and foreign government(s). Along with different forms, there will also be different functions and objectives of each such technology partnership arrangement. For example some partnerships can be focused on innovation, while others can focus on commercialisation of technologies. The form and function will depend on the horizon energy technology under focus. Following are the key points on technology partnerships from the stakeholder discussion:

- India has experience in running large consortiums, and collaboration of government, industry and private sectors (e.g. clean energy symposiums). It can clearly build upon its experience and expertise to build technology partnerships with a strategic focus on horizon energy technologies. Technology partnerships should hence be an important element in India's energy policies. Such partnerships need not be exclusively for horizon energy technologies, these can also be for acquiring existing technologies that can potentially play a critical role in addressing India's energy challenges.
- Effective technology partnerships could be the bridge between the challenges of need for investment in energy technology and the current scenario of low investment in R&D in energy.
- An institution and governing body to do a mapping focused on India specific needs for technology partnership with descriptive recommendations will be instrumental in moving ahead strategically on technology partnerships
- There is need to channelize funding to thrust energy technologies from the lab to an applicable form through technology partnerships.
- For fostering intergovernmental partnerships, identification of the right stakeholders is a key issue. India's national energy policy needs to evaluate the strategic advantages of partnering with different countries.
- One of the possible option is to explore the transfer and development of energy technologies in India through existing technology transfer mechanisms (such as Climate Technology Centre and Network (CTCN)) under the global climate mitigation regime or under the bilateral technology transfer initiatives (such as 'Joint Crediting Mechanism' that Japan has been proposing).
- Generally technology partnerships are only sought after from developed nations where in the technical and financial capacities are present. However, there lies tremendous opportunity for India for forging strategic horizon technology partnerships with less developed nations. The capacity of technologically less advanced countries should be appreciated and acknowledged. Their capacity, knowledge and input should be included in the R&D for energy technologies and

appropriate partnerships should be fostered. Intellectual property should be protected as well as be used to co-develop and co-own new knowledge.

3.8 Funding is critical and a high impact funding pool needs to be created for supporting investments in horizon technology research and partnerships

Funding is required across the value chain, from research to commercialisation, for harnessing the strategic potential of horizon technologies in India. The kind of funding, and type of incentive structure varies depending on for which stage of value chain is the funding required. For the current discussion on horizon energy technologies as undertaken in this stakeholder discussion, the focus was mainly on the research and innovation front. Funding and incentives are already extended by the Indian government for many different initiatives across various stages of the value chain. What is required however is a strategic funding pool focusing solely on horizon energy technologies. This section summarises such efforts in the USA along with the associated financial commitment, as well as examples from Australia and Germany.

USA

- **ARPA- E:** The Advance Research Projects Agency - Energy (ARPA-E) is a US government agency with an objective of promoting and funding research and development of advanced energy technologies. ARPA-E started with an initial funding of $400 Mn in 2009. The budget for subsequent years was $180 Mn in fiscal year 2011 (FY2011), $275 Mn in FY 2012, $251 Mn in FY 2013, and $280 Mn in both FY 2014 and 2015. Since 2009, ARPA-E has funded over 400 transformative projects across a wide range of research ranging from batteries to bio-fuels to electricity network integration and has impressive achievements.
- **Lithium-Ion Batteries:** Through the Recovery Act, the United States made a significant investment to build domestic manufacturing capacity and secure position as a global leader in advanced lithium-ion battery technology. This investment includes:
    - $2.4 billion in loans to three of the world's first electric vehicle factories in Tennessee, Delaware, and California.
    - $2 billion in grants to support 30 factories that produce batteries, motors, and other EV components. Companies are matching the funding dollar for dollar, doubling the impact of taxpayer investments. These grants are enabling companies to build the capacity to produce 50,000 EV batteries annually by the end of 2011 and 500,000 EV batteries annually by December 2014.
    - Rewarding communities that invest in electric vehicle infrastructure through competitive grants is an innovative approach being considered. To provide an incentive for communities to invest in EV infrastructure and remove

regulatory barriers, the President is proposing a new initiative that will provide grants to up to 30 communities that are prioritizing advanced technology vehicle deployment.

- **Solar fuel technology:** In April 2015, the US DOE announced up to $75 Million in Funding to renew the Joint Center for Artificial Photosynthesis (JCAP), a part of DOE 'Fuels from Sunlight' Energy Hub, which was established in FY 2010 and is led by the California Institute of Technology in major partnership with Lawrence Berkeley National Laboratory and with SLAC National Accelerator Laboratory, the University of California, Irvine, and the University of California, San Diego, as additional partners. The mission of JCAP is to demonstrate a scalable, manufacturable solar-fuels generator using Earth-abundant elements that robustly produces fuel from the sun ten times more efficiently than (current) crops. The Joint Center for Artificial Photosynthesis (JCAP) will receive up to $75 million for an additional five years (subject to congressional appropriations) to continue its foundational research aimed at harnessing solar energy for the production of liquid fuels.
- **Batteries and Energy Storage:** In 2012, the US Secretary of Energy Steven Chu with Senator Dick Durbin, Illinois Governor Pat Quinn, and Chicago Mayor Rahm announced a $120 million funding for over five years to establish a new 'Batteries and Energy Storage' Hub. The Hub's aim is to combine the R&D capabilities of five DOE national laboratories, five universities, and four private firms in an effort aimed at achieving huge advances in battery performance. Argonne National Lab has been chosen to lead the team. Governor Quinn of Illinois allocated a $5 million funding for a capital construction plan to help build the state-of-the-art JCESR facility at the Argonne National Laboratory campus in suburban Chicago. An additional $30 million was being considered in future capital funding for the building, which will serve as a nationwide center for energy storage research and is a key part of the governor's plan to create jobs and grow Illinois' economy through cutting-edge innovation.
- **Smart Grid:** Since 2010, large public and private investments totalling over $9 billion made under the American Recovery and Reinvestment Act of 2009 (ARRA) have fostered smart grid technology deployments, providing real-world data on technology costs and benefits as well as best practices. The electricity industry spent an estimated total $18 billion for smart grid technology deployed in the United States during the 4-year period of 2010 through 2013. Smart grid investments under the ARRA accounted for nearly half—approximately $8 billion—during the same time frame (DOE 2014a). As of March 2013, joint federal and private expenditures under ARRA totaled $6.3 billion from the 99 Smart Grid Investment Grants (SGIG), which represent the largest portion of ARRA investments.

Australia

- The Australian government initiated the $1.9 Billion CCS Flagships Program administered by Australia's Department of Resources, Energy and Tourism for supporting construction of two to four commercial scale CCS projects with combined capacity of 1000 GW by 2020. The programme has emerged from the National Low Emissions Coal Initiative, which has been undertaking research, demonstration, mapping and infrastructure work, and also includes the Global Carbon Capture and Storage Institute – set up by the government to fast-track the development of commercial-scale CCS projects world-wide. The programme aims to fund projects that demonstrate the large-scale use of integrated CCS in Australia and support widespread national and international use of CCS technology from 2020. Four CCS projects were shortlisted for CCS Flagship Program funding at the end of 2009 – Wandoan and ZeroGen in Queensland, Collie South West Hub in Western Australia and CarbonNet in Victoria. Progress however on actual implementation of these projects has been delayed.

Germany

- Energy research has been a strategic element of Germany's energy policy. The responsibility of energy policy are now within the purview of a single ministry, the Federal Ministry for Economic Affairs and Energy. Project funding for basic energy research and bioenergy however lies with other ministries. The strategic research domains supported through the 'Federal Ministry for Economic Affairs and Energy' are energy efficiency, renewable energy, new grid technologies and energy storage. The 6th Energy Research Programme of the German government, which entered into force in 2011, has been the vehicle for promoting research through companies and research establishments to develop innovative energy technologies for tomorrow. Between 2013 and 2016, the German government is committed to provide EUR 3.5 Billion in energy research funding to foster research and development of modern energy technologies.
- Hydrogen and fuel cell research has been a critical area of research for the German government. The German government set up the National Organization for Hydrogen and Fuel Cell Technology (NOW) in 2008 to promote the development and commercialization of internationally competitive hydrogen and fuel cell technology products. A total budget of EUR 1 Billion was committed for hydrogen and fuel cell technology research, development and demonstration projects over a ten-year period. Of this, EUR 200 Million was available as R & D funding, and EUR 500 Million was available for demonstration of hydrogen and fuel cell technologies in traffic and transport.

4. Policy recommendation: Expert Committee on Horizon Energy Technologies and Technology Partnerships (EC-HETTP)

Horizon energy technologies and technology partnerships are central to the discussion of providing 24 X 7 energy access to Indian households through low carbon technologies, and simultaneously making India a dominant player in the world energy market. The role of India's national energy policy is critical in this regard. The policy should lay the foundation for a process that should be institutionalised with the objective of making India a global leader on horizon energy technologies through domestic efforts as well as international technology partnerships.

Based on the expert stakeholder discussion coordinated by the Council on Energy, Environment and Water (CEEW), we recommend the creation of an expert committee through government mandate. The ultimate goal, post the term of this expert committee, would be to create a specialised body to address the issue of horizon energy technologies and technology partnerships on a regular basis so that this process is institutionalised. The expert committee (EC-HETTP) recommended by the stakeholders could be a first step in this direction. Ideally this expert committee should be an independent entity having a broad representation and should be outside the government's formal structure, though it should have significant government representation. Being outside the government structure will give the committee ability to leverage the network of its members as well as give flexibility in its function and approach as more and more information is gathered and more avenues need to be explored for achieving the committee's objective. However, coordinating with the government ministries, departments and other agencies is critical to the success of the committee in leveraging expertise within the government, as well as ensuring that the committee's recommendations have a broad acceptance within the government set up.

4.1 The objectives of the EC-HETTP should be the following:

- Collate and synthesise the existing state of research on horizon energy technologies and technology partnerships within India and abroad.
- Develop criteria for identification of horizon energy technologies with a cross-sectoral view including on-grid technologies, off-grid technologies, and other supply and demand side technologies.
- Develop criteria for effective technology partnerships.
- Identify and prioritise a list of horizon energy technologies which are of strategic importance to India based on the identified criteria.

- Review the role, performance and success of Council of Scientific and Industrial Research (CSIR) in fostering energy technology development and highlight learning from efforts of CSIR
- Suggest policies and programmes through which India can move on the path towards development and commercialisation of horizon energy technologies in an expeditious manner.
- Suggest policies and programme to enable high impact energy technology partnerships at various levels within the country as well as with international organisations and other governments. This could be on the lines of US Dept. Of Energy's (DOE) Vehicle Technologies Program[1], as well as a new Energy Innovation Hub[2] devoted to developing better batteries and energy storage capacity to support electric vehicles and other technologies.
- Suggest plan of action to develop enabling conditions like human-resource capacity, finance, networking, etc. for successful delivery of the objectives of horizon energy technology development policy.
- Articulate the role of Indian states in this process and how government institutions from states can participate in the process of horizon technology development.
- Suggest dedicated annual public funding requirement for the purpose.

The committee should not be prescriptive in terms of its recommendations. Based on all the detailed analysis, ultimately this expert committee should recommend the form and function of a permanent body for institutionalising the process of identifying, prioritising and investing in strategic horizon energy technologies and technology partnerships. **E.g. 'Cell on Strategic Horizon Technologies (C-SHoT)'**. Whether this body is an autonomous body, or is governed completely by a government ministry or department, this should be determined by EC-HETTP.

4.2 Process: Within India, there is deep expertise on both the issues of horizon energy technologies as well as technology partnerships. The expert committee should be viewed as a coordinating agency, which synthesises and presents this deep expertise from across the broad spectrum of stakeholders. Thus, it is recommended that for addressing each objective the committee should be engaging deeply with the stakeholders across all the relevant fields. Stakeholder engagement process should form the backbone of the work undertaken by the expert committee.

[1] http://energy.gov/eere/vehicles/vehicle-technologies-office

[2] http://science.energy.gov/bes/research/doe-energy-innovation-hubs/

4.3 The Expert Energy Technology Committee should have representation from the following bodies:

- Representative from Ministry of Power
- Representative from Ministry of Coal
- Representative from Ministry of Oil and Gas
- Representative from Ministry of New and Renewable Energy
- Representative from Ministry of Environment, Forest and Climate Change
- Representative from NITI Aayog
- Representative from the Department of Science and Technology (DST), preferably Technology Information, Forecasting, and Assessment Council (TIFAC)
- Representative from the Bureau of Energy Efficiency
- Energy and climate policy research expert from Indian think tank with understanding of policies for promoting horizon technologies
- Academic from top management institute with expertise on energy and climate policy
- Academic from top technical institute with expertise on technology development
- Expert from private sector with expertise on business models related to new technologies, preferably energy technologies
- Technology partnership expert from think tank/ academia

The responsibility of coordination and management of this committee should ideally be with a non-government agency.

4.4 A dedicated funding pool and mechanism is required

Path breaking and transformative research in horizon energy technologies, as well as technology partnerships, can happen only if there is a sustainable pool of public funding available to support it. The experience of other countries, as detailed in section 3.8, shows that countries have earmarked dedicated funds year-on-year for research on innovative energy technologies and their applications. One of the important objectives of the recommended committee should be to suggest the amount of funds that India should start investing in regularly for supporting research and development through providing competitive grants to Indian universities and research institutions. Looking at what the developed countries have been doing, India should be thinking about a dedicated fund to the tune of US$ 250 Mn per year (approximately 1500-1600 Crores INR) only for research and development. For the demonstration and deployment of technologies, as the CCS experience in Australia and smart grid experience in the USA shows, funding support to the tune of Billions of US$ would be required.

Appendix I: List of Participants

LIST OF PARTICIPANTS - STAKEHOLDER ROUNDTABLE DISCUSSION (20.10.2015)		
'Horizon Energy Technologies, Technology Partnerships and the National Energy Policy of India'		
Sr. no.	**Names**	**Organisation**
1	A. K. Tripathi	Ministry of New and Renewable Energy, Govt. of India
2	A. Mohamed Hussain	National Institute of Wind Energy (NIWE)
3	Amitabh Shrivastava	CSIR-Tech Private Limited
4	Ankita Sah	Council on Energy, Environment and Water
5	Arumugasamy, Gurunathan	GAMESA-India
6	Arunabha Ghosh	Council on Energy, Environment and Water
7	Biswanath Bishoi	NITI Aayog, Govt. of India
8	Enrico Robertus	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
9	Harendra Kumar	NITI Aayog, Govt. of India
10	Janardhanan Nanda Kumar	Institute of Global Environmental Strategy (IGES)- South Asia Desk
11	Kalyan Bhaskar	Indian Institute of Management-Lucknow
12	Kamanio Chattopadhyay	Interdisciplinary Centre for Energy Research , IISC
13	Kankanika Neog	Council on Energy, Environment and Water
14	Koyel Mandal	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
15	Manoj Kumar Upadhyay	NITI Aayog, Govt. of India
16	Manoj Singh	NITI Aayog, Govt. of India
17	Mridula Dixit	Centre for Study of Science, Technology and Policy (CSTEP)
18	O. P. Wali	Centre for International Trade in Technology (CITT), Indian Institute of Foreign Trade (IIFT)
19	O. S. Sastry	National Institute of Solar Energy, MNRE
20	Poonam Kapur	NITI Aayog, Govt. of India
21	Probal Ghosh	Integrated Research and Action for Development (IRADe)
22	R. K. Kaul	NITI Aayog, Govt. of India
23	Rahul Tongia	Brookings India
24	Rajnath Ram	NITI Aayog, Govt. of India
25	Raman Mehta	Vasudha Foundation
26	Sanjai Bajpai	Technology Mission Cell- Water & Clean Energy , Department of Science & Technology,

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27	Saon Ray	Council for Research on International Economic Relations (ICRIER)
28	Satish Kumar	International Energy Studies Group Lawrence Berkeley National Laboratory
29	Shubha Pandey	Technology Watch & Foresighting Division Department of Science & Technology, Ministry of Science & Technology, Govt. of India
30	Sirish Garud	Energy-Environment Technology Development (EETD),TERI
31	Srinivas V Veeravalli	Dept. of Applied Mechanics, Indian Institute of Tehnology, Delhi
32	Srinivas Rao	AES India Pvt. Ltd.
33	Surendra Singh Sur	NITI Aayog, Govt. of India
34	Tanikella Chandrasekhar	Technology Information, Forecasting and Assessment Council (TIFAC), Department of Science and Technology (DST), Ministry of Science & Technology, Govt. of India
35	Tribhuvan Kumar Roy	NITI Aayog, Govt. of India
36	Vinod. K. Agarwal	Regen Power Tech
37	Vaibhav Chaturvedi	Council on Energy, Environment and Water
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Appendix II: General comments for India's National Energy Policy

The stakeholder discussion focused on the issue of horizon energy technologies and technology partnerships. There were many comments by the experts on general issues related to National Energy Policy. The key comments which will be useful for the national energy policy have been summarised here:

- The policy must include key technologies like hybrid technologies into its framework in order to layout structure and regulations for the development. It should also scope out the potential of hybrid technology transfer and on regions where solar and wind can be co-located.
- We need to have a structured policy with a bottom-up approach and should be focused on the relevance of need in accordance to India context.
- Technology management system from use to disposal is important before bringing/introducing any technology in India.
- Building sector consumption of 30-40 % of the total energy consumption and to cater to this need if we develop renewable energy like rooftop solar to support energy demand, what is important to note is that we do not have a strong infrastructure, there is leakage in envelope and little R&D. Therefore we need to focus on : What India needs? What are the technologies available? What India can develop? What do we need in terms of tech-transfer?
- Role of private sector and how it can bring digitisation in analytics of the system will be important.
- The country should have a strategic vision for energy development. Investment is required in infrastructure development for new technologies.
- Address how are India's technology and policy needs different from those of other countries?
- Focus on how to create a balanced grid as in future grid when the supply is more variable and storage notwithstanding, there will be problems in planning and incentivising.
- Electricity pricing should be clear, government should make pricing mechanism transparent.

- Government should work on drafting a mechanism to pass the energy savings due to taxing oil or through lower import bills on energy, to the public through tax breaks and to the sectors responsible for the implementation of the technologies.
- Fossil fuel industries need to be involved to avoid their loss of interest as stakeholders in the development of the new market.
- Government buildings should be converted to low carbon and energy efficient buildings. Government officials should be incentivised to adopt electric vehicles.
- There is a requirement of new roadmaps which are holistic and integrated over existing ones, we also require a well-defined sectorial break down of the road map.
- Storage systems for housing sector and for electric vehicles serve differently, same is with the manufacturing sector of different technologies, where one energy storage system roadmap is not aligned with the other sector and thus we require new and well-defined road maps.
- The new national energy policy must include thermal energy technologies as they are going to be the main stay of India's electricity systems for some time to come. Transport energy is highly dependent on fossil fuel. The interface between transport and energy is important. CNG driven locomotives, biofuels in railways are some programmes by the govt. The policy should focus on clean energy for the transportation sector and on the modal shift of energy. Transport energy is highly dependent on fossil fuel.
- The interface between transport and energy is important. CNG driven locomotives, biofuels in railways are some programmes by the govt. The policy should focus on clean energy for the transportation sector and on the modal shift of energy.
- Both the previous and present governments have shown immense interest in the manufacturing and industrial development in the country. The initiatives that the present government has undertaken shows the emphasis on manufacturing have important implications for India's future energy pathway, technological development, innovation, and India's National Energy Policy.
- The rules in terms of General Financial rules and income tax law etc. which discourage joint ventures should be reviewed and revised if required.
- Manufacturing of electric vehicles is essential for bringing low carbon technologies in the transport sector. For strengthening the policy that promotes electric vehicles in India, push is required from both the government and industries. As charging infrastructure will be available only when there are enough electrically operated vehicles on the road and the sale of electric vehicles on the road will only boost with facility to charge the vehicles readily available in the market.

- In relation to the 'National Electric Mobility Mission' the challenge is with electric vehicle charging infrastructure, with 67 million electric vehicles target by 2030 (mainly electric scooters). This would require at least 2 GW additional power for meeting the charging demand of the Electric vehicles sector.
- Installation of charging station is a low cost infrastructure, does not require high R&D, and can be supported by urban local bodies. Example of Beijing, with 10,000 charging station installed to enhance the technology uptake in the market with ready infrastructure.
- Issues like time of charging, dispatch strategy and role of smart grid will be important in a long term scenario beyond 2030.
- The government (Department of Heavy Industry, Ministry of Heavy Industries & Public Enterprises) in consortium with industry and academia, , has identified four different areas to work on the R&D to support electric mobility – vehicle system integration, chargeable energy storage system, power electronics and charging infrastructure. The government has also worked on developing specifications and standards in all the areas and recommended addressing the challenges through forming consortiums.