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Renewable Energy Technologies for Smart Cities

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Abstract: Renewable energy is the energy which is derived from a limitless source. Proper utilization of energy resources is a hot debate going these days. Renewable energy resources will play an important role in the world's future. The energy resources have been split into three categories: fossil fuels, renewable resources and nuclear resources. The climate change equation India generated 2,505 MtCO2eq of GHGs in 20101 (Source: World Development Indicators, World Bank) through anthropogenic activities. A significant 43% (electricity/ heat – 37% and other fuel consumption – 6%) of this was contributed by the energy sector. Buildings in India accounted for 35% of the total energy consumption (Source: GBPN - Mitigation potential in India's buildings). Further, due to the nexus of the transport sector (direct emissions: 6%, 2010, World Bank), especially passenger transport and the industry sector (direct emissions: 17%, 2010, World Bank),with urban lifestyles in India.
Key Words: - Renewable energy, fossil fuels, greenhouse gases, HPE.

I. Introduction

Renewable energy is the energy which is derived from a limitless source. Proper utilization of energy resources is a hot debate going these days. It is very essential to choose which source of energy must be used and why. Majority of factors such as cleanliness, cost, stability, efficiency and environmental effects must be taken into account. It is a bitter fact that many industries around the world are still dependent on fossil fuels for electricity generation. No doubt, these fuels are very effective as far as power production quality is concerned, but in the long run they are not advantageous. Fossil fuels will deplete one day and the industries must turn to renewable sources as soon as possible. Moreover, these fossil fuels pose a huge threat to environmental balance and are a cause of many ecological hazards.

II. Renewable Energy Resources

Renewable energy resources will play an important role in the world's future. The energy resources have been split into three categories: fossil fuels, renewable resources and nuclear resources [1]. Renewable energy sources are those resources which can be used to produce energy again and again, e.g. solar energy, wind energy, biomass energy, geothermal energy, etc. and are also often called alternative sources of energy [2]. Renewable energy sources that meet domestic energy requirements have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Renewable energy system development will make it possible to resolve the presently most crucial tasks like improving energy supply reliability and organic fuel economy; solving problems of local energy and water supply; increasing the standard of living and level of employment of the local population; ensuring sustainable development of the remote regions in the desert and mountain zones; implementation of the obligations of the countries with regard to fulfilling the international agreements relating to environmental protection [3]. Development and implementations of renewable energy project in rural areas can create job opportunities and thus minimizing migration towards urban areas [4]. Harvesting the renewable energy in decentralized manner is one of the options to meet the rural and small scale energy needs in a reliable, affordable and environmentally sustainable way [5, 6].

III. Reasons to Act 'Smart

The climate change equation India generated 2,505 $MtCO_2eq$ of GHGs in 20101 (Source: World Development Indicators, World Bank) through anthropogenic activities.A significant 43% (electricity/ heat – 37% and other fuel consumption – 6%) of this was contributed by the energy sector. Buildings in India accounted for 35% of the total energy consumption (Source: GBPN - Mitigation potential in India's buildings). Further, due to the nexus of the transport sector (direct emissions: 6%, 2010, World Bank),especially passenger transport and the industry sector (direct emissions: 17%, 2010, World Bank),with urban lifestyles in India, it can be said that direct and indirect emissions attributed to urbanization in Indiapose a grave threat contributing to climate change. The Fifth Assessment Report (AR) of the Intergovernmental Panel on Climate Change (IPCC) observes that, in the global context, the impact of doing nothing is very likely to have a significantly adverse impact on the environment – 3.7 degree to 4.8 degree centigrade rise in temperature by 2100. Be that as it may, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) asserts that the baseline estimates of the "consumption loss" (not the same as GDP loss) of taking mitigation action in buildings, transport and the industrial sector combined would be negligible – 0.06% on an annualized basis till 2100 to meet the target of less than 2 degree centigrade temperature rise over pre-industrial levels or upto 450 ppm of CO_2eq of GHGs. However, the IPCC adds a caveat that if such preventive measures are not deployed immediately it might be very difficult to reverse the tide, particularly after 2030.

IV. Sustainable Energy Integration In Smart Cities

Let's take a look at the cards that nature has dealt India as far as energy reserves are concerned. India has the world's fifth largest reserves of coal at 267 billion tons. However, just 20 billiontons is extractable (Source:TERI). India's reserves of oil (894k barrels/day production vs. 3,727k barrels/day consumption, 2013) and natural gas (33.7 billion cubic meters production vs. 51.4 billion cubic meters consumption, 2013) are less than 1% of the world's proven reserves (All data sources: BP Statistical Review of World Energy Report 2014). This is surely not a very good advertisement for energy security, a very critical measure of economic and national security, and thus deserves urgent attention. Hence we must invest in installation, indigenization, research, development, and capacity building in renewable energy technologies, energy efficiency technologies, and energy storage technologies vigorously. However, fossil fuels are here to stay for a few decades if not longer. Therefore, it's important that a few technologies be considered for research, development and deployment (RD&D) through the transition phase from fossil fuels to renewable forms of energy. Fossil Energy with CO2 Capture and Storage (CCS) CCS prevents CO2 emissions from entering the atmosphere by grabbing point-of-source emissions and interring them into a storage site such as geological formations or in the form mineral carbonates. However, capturing, compressing and sometimes transportation to the storage site increases fuel requirement by 10-40%, thereby reducing the efficacy in proportion to the extra fuel required. As a result the financial feasibility of this technology is questionable. Shale (natural) gas: atransition fuel Natural gas produces about half the CO2 emissions than coal for the same quantum of energy generated. However, latest research points out that if natural gas leakage is even 3.2%, then natural gas is as bad as coal. In another research, it has been claimed that the leakage is more than 3.2% starting from extraction to consumption (Source: Cornell University). However, this claim has been contested by Lawrence Cathles who says that more careful studies by the Environmental Protection Agency put the leakage at below 1.5%. Additionally, given the differentials in the decay of methane gas on burning natural gas as opposed to CO2 in burning oil or coal, the former is still a better bet. The 5th AR of the IPCC also suggests, backed by robust evidence, that the replacement of "current world average coalfired power plants with modern, highly efficient natural gas combined-cycle power plants or combined heat and power plants, provided that natural gas is available and the fugitive emissions associated with extraction and supply are low or mitigated"is the way forward. Underground Coal Gasification (UCG) This seems to be a plausible case for India. UCG is applied in situations where coal reserves are not technically or commercially extractable. According to asurvey of National Resources, 2007, World Energy Council, UCG can help exploit 600 billion tons of unreachable coal coal reserves. According to Lawrence Livermore National Lab, the exploitable USA coal reserves can be enhanced by 300% by UCG. Considering most of India's coal reserves might be inextricable, UCG might just be the technology that is required at the moment. UCG has a positive social and environmental impact. It doesn't require mining and therefore it minimizes hazard to life and flora and fauna. Also, the environmental impact is minimal. There is no surface damage because there is no extraction process involved. As a result of minimal surface damage, noxious gases such as SO2 and NOx are not discharged into the atmosphere. There is a possibility that UCG can be used with CO2 Capture and Storage (CCS). On the flip side there are a number of operational concerns with the technology and so judgment needs to be tempered in the light of recent incidents, one of which was in Australia where the government filed charges of environmental damages against Linc Energy UCG plant in 2014. Further, in 2010, Bulletin of Atomic Sciences asserted that UCG could lead to a quadrupling of CO2 emissions if used without CCS. Renewable energy generation Considering the relatively nascent situation of the various mitigation options for fossil fuel energy, we can see that the scope for localizing these technologies is still limited. Hencea switch to renewable sources of energy is highly desirable with more investment in R&DD for renewables. Wind India has an installed capacity of 22.5 GW as of December 2014. The potential of wind energy in India has been measured at 100 GW by the Center for Wind Energy Technology and MNRE. Further India's offshore wind energy sector is said to have a potential ranging between 127 to 350 to 500 GW. Even as the best sites for wind in India are taken up, making incremental micro-sites more capital intensive, there is opportunity in the unexplored potential in offshore wind energy. Also, bigger wind turbines can replace smaller outdated wind turbines of lower capacity at older sites. Indigenizing technology and linking the development of renewables to the "Make in India" initiative would help reduce the capital cost and net operating cost to the country. Solar India has an installed capacity of 3.06 GW as of December 2014. India has a potential of 750 GW of solar energy, according to the National Institute of Solar Energy. As technology improves the capacity utilization factors, the use of rooftop solar would become ubiquitous and the penetration levels of solar should increase. Financial incentives for adopting this green power should be given in a more systematic institutionalized and targeted manner. Waste to energy India generates about 62 million tons of waste. This number is expected to reach 436 million tons in 2050. At present, India's municipalities lack an institutionalized functional mechanism to dispose waste appropriately. As a result 81% of the waste generated is dumped indiscriminately. It has been estimated that if mechanisms to handle this waste are not devised by 2050, a dump yard of the size of London with a height of 10 meters would be required to accommodate it. Today, India boasts of just 8 waste to energy (W2E) plants, 29 refuse derived fuel (RDF) plants, 172 biomethanation plants and 279 compost plants. Most of the W2E plants are defunct for various reasons such as lack of financial due diligence, non-supply of quality/ quantity waste contracted for, lack of know-how, inadequate market infrastructure and Not In My Back Yard (NIMBY) concerns. India's waste to energy potential as estimated by a government task force will be around 556 MW by 2050. This might be moderate but that should not be a reason to overlook the realizable potential. The W2E sector should not be looked merely as an energy generation sector but as complementary to sectors such as waste management, health, sanitation and water. The direct benefits and co-benefits of waste to energy far outweigh the efforts and cannot be merely captured in the shallow number of 556 MW of generation potential. Smart grids and meters India's sustainable energy challenge does not stop at generation but continues into the transmission and distribution (T&D) sector as well. As of 2012, T&D losses for electricity were 24% as reported by the Central Electricity Authority (CEA). This compares poorly to the world average of 9.8% in 2010. India's Southern Grid was only recently synchronized with the rest of India with the commissioning of the Raichur – Sholapur 765 KV line in December 2013. India has currently invested in the development of smart grids with some seriousness. 14 smart grid pilots have been approved. They will be evaluated as proof of concepts for techno commercial feasibilities and then scaled up. The purpose of the smart grids would be to essentially take care of the aggregate technical and commercial losses, renewable energy integration, peak load management, power quality improvement, creation of micro grids and distributed generation. Smart meters, though strictly speaking are essential for smart grid infrastructure, can also be viewed as a standalone area of intervention that needs to be addressed in parallel with reducing losses. Smart meters can allow power to be fed back into the grid from households that have a surplus (say through rooftop solar) while also helping households monitor their consumption and lower their energy bills. Energy Efficiency India's energy intensity (quantum of energy required for a unit of GDP) has lagged behind that of most nations. According to the Ministry Of Statistics and Programme Implementation (MOSPI), in 1970-71, India's energy intensity was 0.128 KWh. This has only risen marginally in 41 years to 0.148 KWh. The 5th AR of the IPCC clearly points to energy efficiency and behavioral changes as a key mitigation strategy in scenarios for reaching atmospheric CO2eq concentrations of about 450 ppm by 2100, without sacrificing growth. Adoption and implementation of green building codes that specify various parameters for applicable 'moving parts' of the building energy infrastructure is the most intuitive step. Again, the 5th AR of the IPCC strongly advocates such adoption and retrofitting existing buildings and goes on to say -"Building codes and appliance standards, if well designed and implemented, have been among the most environmentally and cost-effective instruments for emission reductions." Reproduced below are the main findings of the IPCC report, organized by major efficiency mitigation strategies:

Technology Efficiency High performance building envelope (HPE)

- Efficient appliances (EA)
- Efficient lighting (EL)
- Efficient Heating, Ventilation, and Air- Conditioning systems (EHVAC)
- Building automation and control systems (BACS)
- Use of LEDs instead of CFLs• Day lighting
- Heat pumps
- Indirect evaporative cooling to replace chillers in dry climates
- Advances in digital building automation and control systems
- Solar powered desiccant dehumidification
- System Efficiency Passive house standard (PHS)
- Nearly/net zero and energy plus energy buildings (NZEB)
- Integrated Design Process (IDP)
- Urban planning (UP)
- District heating/cooling (DH/C)
- Commissioning (C)
- Advanced building control systems

- High efficiency distributed energy systems
- Co-generation
- Tri-generation
- Load leveling
- Diurnal thermal storage
- Advanced management
- Utilization of waste heat
- Behavioral and Lifestyle Efficiency

Smart CitiesMechanism Design: pathway to regulatory policy implementation

There are a few definitions of Smart Cities available globally, as discussed below. However, what we need is one that fits the Indian context and does justice to the ambition of the scale of the Smart Cities Mission of the Government of India as envisioned by the Prime Minister Shri Narendra Modi. It should also fit into the matrix of similar policy initiatives planned and designed by the central government such as “Make In India”, “Digital India”, “Swachh Bharat Abhiyan” and “Skill India Mission”.

V. Conclusion

Smart Cities is a strong movement worldwide, but definitions are varying. Cities and regions are key players by transforming the energy system of a country, energy is a key aspect of Smart Cities .100 Smart Cities is an ambitious vision of the Indian Government with a very broad approach focusing on economy, employment, water, waste, sewage, energy, mobility, and ICT . Modeling tools help to identify the most cost-effective design of sustainable urban or regional energy systems.

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