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Responsible Research & Innovation Pathway For The Future Of Sustainability Of E-Mobility

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Abstract - Due to various internal and external push and pulls, e-mobility is set to made inroads in the overall mobility sector of the country. Rising environmental pollution related public awareness, along with India's commitment to achieve the Sustainable Development Goals, has created pressure on the government for the concrete policy actions to promote the e-mobility. Technology comes and operate in a social context and in turn influences the society. From the past experiences of the introduction of new technologies without insufficient thought and consideration for the future consequences has resulted into new problems. Instead of black boxing of the technology, it is essential to focus on the co-creation. Responsible Research and Innovation is one of the single most important way of innovating responsibly in the field of the new technologies. It is in this context that it is critical to analyze the e-mobility at the yardstick of the responsibility and sustainability. To achieve this goal this research paper has been divided into four main parts. Part one, introduces the main research problem along with discussing various nuances associated with it. Second part has brought forward the RRI framework, which is also the theoretical framework for the study. Part three has discussed about the methods adopted for data collection as both primary and secondary data has been collected for this research work. Part four, brings forward the insights from the field study and future scope of the research in this direction.

INTRODUCTION

In the past few years, e-mobility has been the consistent feature of the almost every discussion pertaining to thecontribution of vehicular pollution to overall environmental pollution, particularly in the cities.There has also been considerable rise in the public consciousness regarding the harmful effect of the environmental pollutants on human health. This has also highlighted by the advocacy groups as well as the international organizations such as WHO.At the same time India has commitments to full fill on the Sustainable Development Goal (SDG) by 2030. As agreed by India in 2015 with other countries, SDG's include 17 goals and 183 targets to be achieved(Osborn et al., 2015). Though SDG'S regime has been criticized for being too many goals, at the same time 'technology interventions' affecting more than one goal or clubbing of goals under technological innovations has been identified as an important strategy(Sachs et al., 2019). Goal 3 on 'Good Health and Wellbeing', Goal 11 on 'Sustainable Cities and Communities' and Goal 13 on 'Climate Action', has direct forbearance with e-mobility(Holden et al., 2019). Apart from this, many targets such as, actions on poverty and empowerment of weaker sections of the society, would also be indirectly influenced positively by the e-mobility(Mills, 2015). It is in this background that government has been pushing for the e-mobility in the big way. This has been evident from the current budget of the union government presented in June 2019 in parliament. Though the government launched the mission on e-mobility in 2013 it picked up it way in start-ups and policy domain after the launch of the FAME scheme in 2015-16(Delhi, 2015). In the union budget 2019("Union Budget 2019-20: Steps

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taken to boost production of electric vehicles," n.d.), government has announced following steps to promote e-mobility: GST on electric vehicles is down from 12% to 5%, tax rebate of Rs. 1.5 lakh on interest paid on loans, Rs. 10000 cr. For the FAME-II scheme, custom duty waiver on the components (Lithium ion battery) so that more companies will motivated to import the components and assemble the vehicles in India. Further, focus is on narrow down the cost between internal combustion engine (ICE) and electric vehicle along with phase out of ICE scooters and three wheelers by 2025.

On the first look, the e-mobility looks like the panacea for all the wrongs with the fossil fuel based technology. But, in the past also, adoption of the technology without foresight for the future consequences has created many problems. The 'green revolution' is one of the very good example for such a technology adoption scenario. There are sure advantages of the e-mobility as compared to fossil fuel based technology currently used(Ghosh et al., 2016; Hopkins and Higham, 2016; Khan et al., 2017; Mohanty and Kotak, 2017). But at the same time, there are challenges and serious concerns related to the adoption and sustainable future of the transportation. For instance, e- vehicles need the charging of the battery which in turn requires an entirely alternative infrastructure. Such large-scale project has two prominent dimensions. One is, creation of new infrastructure catering to the needs of e-vehiclesand the second is, how the current fossil fuel based infrastructure would be phased out without further degrading the environment(Khan et al., 2017; Khanna et al., 2018). Further, there are legitimate concerns over the disposal of the batteries after once functional life of batteries gets over. Similarly, there are issues regarding the regulations and safety. Apart from this, there are important technological challenges such as speed, durability, design etc. which have an undisputed impact on the consumer choices, as a result over all adoption of the e-mobility by the people(Van den Hoven, 2013). Over optimism with the pure technological solutions to the problems which definitely have social, cultural, legal and policy dimensions, is a sure way to technological fixations than being sustainable in the true sense. Therefore, it is essential to go for a sustainability analysis of the e-mobility and RRI framework provides much needed pathway for the same.

RESPONSIBLE RESEARCH AND INNOVATION: A WAY TO SUSTAINABILITY

A suitable theoretical framework is critical for the successful completion of the research. The process of the selection of the theoretical framework is very important in itself. After literature review gaps are identified based upon which research problem is formulated, but it is the theoretical framework that offers the guidance for achievement of the research objectives in systematic manner. Since, the research problem is centering around the sustainability of the e-mobility, 'Innovation Studies' frameworks offered opportunity to study the changes. Within Innovation Studies, various frameworks were analyzed for the suitability. The 'Systems Perspective' including 'Sectoral Innovation' were carefully considered(Bergek et al., 2015; Breschi and Malerba, 1997; Carlsson et al., 2002). One of the key limitation among these frameworks was, lack of the focus on the innovation 'process' itself, which is central to the core 'idea of co-creation' to minimizethe e-mobility related future liabilities. At the same time, this work is dealing with the 'wicked problem' where the clarity over the problem itself would require the inputs from the field (Head, 2018; Termeer et al., 2019). For instance, threat and potential threat to the future of women safety in e-mobility PTS is not identified from the women's perspective, without which any conception of women's safety largely remains superficial. However, the responsible innovation framework, specially amended to suit the needs of developing

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countries (Setiawan and Singh, 2015) has provided a way forward to address such 'action oriented research'.

In the developing countries, primary objective of the innovations is largely constituting the eradication of poverty and underdevelopment. As a result, a theoretical framework with features responsive to such needs of society is needed. Therefore in the context of the developing countries a Responsive Innovation framework essentially includes key dimensions such as- Anticipation, Reflexivity, Deliberation, Responsiveness and Participation (Singh and Kroesen, 2012). These five dimensions enables the sustainability analysis of the new technologies. Here it must be noted that sustainability to be effective and practical includes social, economic and environmental sustainability (Koops, n.d.).

The responsible innovation (Armstrong et al., 2012; Blaskó et al., 2014; Burget et al., 2017; de Jong et al., 2015; Macnaghten et al., 2014; Muniesa and Lacoste, 2012; Owen et al., 2013a, 2013b, 2012; Ravesteijn et al., 2014; Setiawan and Singh, 2015; Singh and Kroesen, 2012; Van den Hoven, 2013; Von Schomberg, 2013; Zahinos et al., 2013) and design thinking (Chou, 2018; Plattner et al., 2012; Stickdorn et al., 2011; Warnecke, 2016) framework is capable of offering ground level evidences for meaningful policy on the desired future scenario. For this research work, responsible innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (Von Schomberg, 2007). A collective commitment of care for the future through responsive stewardship of science and innovation in the present (Owen, Still, Macnaghten, Gorman, Fisher, and Guston 2013) is essential. Being caring or ensuring care for certain values (such as women's safety) for social, economic and environmental sustainability by engaging in anticipation, reflexivity, deliberation, responsiveness and participation for bringing up any change in the existing public transport systems to bring them in specific market or use in specific society (Indian)(Setiawan and Singh, 2015; Singh and Kroesen, 2012) is the framework for this study. The responsible innovation framework, focuses on the Certain Values, which include Universal and Culture Specific Values, along with five dimensions. The responsible innovation framework through its interactive transparent process help in navigating through these socio-cultural varieties by engaging in- i) Anticipation- an act of forward looking, plausibility or foresight and helps in decisions about usage and adoption, funding, regulation and policy issues. ii) Reflexivity Creating and shaping innovations at different stages. iii) Deliberation- exploring and carefully considering various aspects and discussions. iv) Participation- involvement of stakeholders in the innovation process. v) Responsiveness- the reaction and response of the process towards different needs, views, issues and values. All these dimensions of responsible innovation framework provided the suitable analytical framework to make innovation process inclusive and providing inputs from the field level for effective, inclusive, evidence based policy on e-mobility based public transportation system in Delhi and India. The framework also constitutes goals of sustainability (Voegtlin and Scherer, 2017) for the innovation process which includes Social sustainability, Environmental sustainability as well as Economic Sustainability.

METHODOLOGY

This research study has used the both primary and secondary data. For secondry data, articles in journals, government policy documents and reports etc. has been studied. After the careful literature review questionnaire was prepared for the field study. Delhi NCR has been selected for the field study. The peripheral areas of Delhi NCR, provided the unique

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opportunity to study the technological transitions happening in the PTS. The universe of the study included the major stakeholders such as, owners of the e-vehicles, e-rickshaw drivers, commuters,manufacturers and experts working in the field of the e-mobility. For the collection of primary data semi-structured in-depth face to face interviews were conducted among the stakeholders. Stratified purposive sampling technique was used for the selection of the sample. In each stake holder category 20 interviews were conducted.The questions asked in interviews were grouped under three main heads as, Economic Sustainability, Environmental Sustainability and Social Sustainability. Further, for the robustness of the study, a Focused Group Discussion (FGD) was conducted at the Centre for Studies in Science Policy (at Jawaharlal Nehru University, New Delhi), in which five research scholars from the diverse fields including domains of policy, regulation, technology and environment, participated. The responses of the interviews were transcribed and tabulated for the analysis.

REFLECTIONS FROM THE FIELD STUDY

For the purpose this study, the term e-mobility has been considered in larger sense including the battery operated and hybrid vehicles. The responses to the administer interviews and FGD has been analyzed under three sustainability heads as discussed earlier.

Economic Sustainability: it is well established that in the adoption and spread of new technology, economy plays most significant part. When asked about the e-mobility from the commuters, most of them referred to the e-rickshaws, only expert and e-vehicle owners were familiar with the e-cars, e-scooters etc. Although a visible pattern has been noticed about the increasing information regarding e-vehicles. However, the single most uniform concern across the various stakeholders was regarding the near absence of the 'charging infrastructure' for e-vehicles. Particularly the e-car owners who has been interviewed, were dismayed with their return on the investment. As one of respondent categorically stated that "the e-car I purchased has become more or less a white elephant, most of the time I am compelled to use my other car. Apart from feel good it is not much of use specially when there are no adequate charging facilities". Another issue raised by the vehicle owners was the 'speed' of the e-vehicle. As compared to fossil fuel based engines e-vehicles are slow. The comparative models in terms of the speed are not produced in the country and importing them is far more expansive than purchasing petrol or diesel based vehicles in the country. Form the commuter's perspective e-vehicle are preferred for short distance travel and last mile connectivity. The women respondents who are usually do the 'care mobility'(Kamargianni et al., 2016), particularly appreciated the e-rickshaw's who charge lesser than the auto-rickshaw over a short distance such as visit to market etc. However, a technical analysis shows that per kilometer basis e-vehicles are more expansive than the fossil fuel vehicles. For example, the public buses fare starts at as low as two to five rupees, whereas the minimum starting fair in the e-rickshaw's is Rs.10.

On the issue of the creation of the new charging infrastructure, the FGD came up with a road map. The best possible way as agreed was to start with the hybrid engine which can utilize both fossil fuel and batteries. The second stage possible could be 'battery swapping stations'. In the third stage 'smart energy networks' should be established. There is also need of providing financial support to innovation in the field of improving e-vehicle engines efficiencies and design. Technological innovations are incapable of make real take off until and unless they make an economic sense to producer as well as the consumers.

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Environmental Sustainability: Most of the persons interviewed considered the e-vehicles 'clean' as compared to the fossil fuel based vehicles. Further, it was interesting to note that, many of respondents made references to the harmful effects of the PM2.5 and PM10 generated due to burning of the fossil fuels. Every year, dreadful experience of the smog (in Delhi NCR) and coverage about it in the media has generated awareness about the air pollution among the common people(Bhalla et al., 2019).E-rickshaws are particularly having popular perception of being environment friendly. However, some of the auto-rickshaw owners who has been interviewed though admitted that their business got affected but only over the shorter distance. One of the auto-rickshaw driver also expressed that number of the auto-rickshaws has not reduced with the arrival of e-rickshaw. It came into the light that e-rickshaws mostly replaced the manual operated rickshaws which were almost had negligible ecological foot print as compared to the e-rickshaws.In fact, government policies including use of state fund by elected representatives, focused on distribution of e-rickshaws among the rickshaw pullers.

One of the important issue raised in the FGD was the handling of the waste from the e-rickshaws. The batteries need to be discarded once their functional life is over. These batteries contain the metals such as lithium, lead etc. dumping in the open spaces may lead to the leaching of these harmful metals into the water bodies ground water etc. there is always danger of inclusion of heavy metals into the food-chain. The harmful effect of these are well established(Heacock et al., 2015). One of the possible solution as came up in FGD, is amendment of the e-waste handling rules and their strict implementation by making the registered owner responsible for sustainable disposal of the e-waste.

Social Sustainability: The term 'social sustainability' does not have a concrete definition, yet, inclusion, empowerment and improvement in the quality of life are considered important features(Axelsson et al., 2013; Larsen and Jensen, 2019; Mehan and Soflaei, 2017; Missimer, 2015). It has been well established by the previous works in the field of science technology and society studies that 'technology is not value free'(Van den Hoven, 2013; Voegtlin and Scherer, 2017). The embedded values in the e-mobility will determine the social sustainability of it in the future. As FGD rightly highlighted that, this is an opportune moment to embed the desired values in the e-mobility as government is providing big push for the same. One of the issue is pertaining to the rules and regulations for e-vehicles. In case of the e-rickshaws there was lot of hue and cry after an accident resulted into the death of a child in the Delhi. In fact, some of the respondents complained about the nuisance created by the increasing number of e-rickshaws. Onther aspect is related to the identification of values and defining them in the observable and objective parameters. One of such value is the 'women safety' in the public transportation, but these values are not defined in the clear terms. Further, to be socially inclusive fruits of e-mobility must reach to everybody. However, it has been observed during field study that like public buses there are no female e-rickshaw drivers. As a result, there is unequal distribution of employment opportunity which is antithetical to the social sustainability.

This study provides for the initiation of the sustainability analysis of the e-mobility. The main limitation of the study is the relatively small sample size in the stakeholder category of e-car owners and manufactures. Further, the scope of research could be expended by including technical expert on each component of e-vehicles. There is future scope of identification of every possible value associated with the e-mobility along with providing ways to measure these values.

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