

Orchestrating Innovation Network: Case of Sustainable Transportation Technology

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Abstract

Currently, the transportation sectors are heading into the advancement of sustainable transportation technology to tackle the issue of unsustainable transportation system which leads to various drawbacks in the future. One of the innovation in sustainable transportation technology is the development of electric vehicle (EV). However, there are noticeable difference between sustainable transportation system and conventional transportation system that requires a massive and synchronous network of related stakeholders to keep innovating and catch up with the progression. On the other side, transportation sector is one of the sector with the massive development that has the consequences of high risk and uncertainty, which leads to the tendency of innovation avoidance. Therefore, the innovation network of EV needs to be nurtured to ensure its sustainability. From the previous study on various sectors, the innovation strategy focuses on two matters: innovation target and actor integration. The latter purpose is required to be conducted in an inclusive manner by engaging people from inside or outside the organization. In the case of innovation in sustainable transportation, the vertical approach plays a significant role in terms of fostering technological advancement. The main solution to reach this objective is through the well-established research ecosystem, which significantly supported by R&D investment by the government. The government takes the role of the innovation strategy implementer to establish a strong research network. Besides as the R&D funder and the hub between researcher and industry, the government also take a role to keep the dynamics of an ecosystem through interaction stimulation, while also engage the innovation results to be relevant with the social, technological, environmental, and economic problems. Moreover, the research center also takes an important role in the ecosystem, such as to engage reiteratively with the industry, become the open-innovation enabler, have the dedicated research agenda, become the multidisciplinary innovation enabler, collaborate with multi-stakeholders, has core research infrastructure, and become the innovation cultural hub. While the country's industrialization demand keep rising, the research center could consistently become the intermediaries in conducting the research and build the relationship with other non-industry actor. This way, the high risk and uncertainty of innovation could be reduced.

Keywords

Electric vehicle; Sustainable innovation; Innovation network; Niche formation

1 Introduction

Transportation has been one of the strategic sectors in Indonesia, with the year-on-year investment growth of 58.6% in 2019, followed by telecommunication and logistic sectors [1]. This growth is caused by the success of infrastructure development, which already initiated since the beginning of a new cabinet. The next strategy of transportation sector advancement will be focused on the sustainable transportation system development. This solution is required to overcome the challenge of unsustainable signs of the transportation system in Indonesia, which marked by a high level of traffic congestion, dependence on non-renewable energy resources (fossil fuel), and a high level of pollution [2]. This strategy is marked by the enactment of a presidential decree on the

electric vehicle (EV) acceleration program [3]. Moreover, public transport stakeholder has already initiated the usage of EV, which makes the solution towards an unsustainable transportation system even more comprehensive. For example, Transjakarta, as one of the provincially-owned corporation (BUMD) which provided Bus Rapid Transit (BRT) in Jakarta, has committed to implement EV [4], and the publicly listed taxi company, Blue Bird Group also deployed the EV for their taxi fleets [5].

EV as one of the innovation in sustainable transportation, will construct a different system from the conventional transportation technology system which requires a massive and synchronous network of related stakeholders to keep innovating. However, transportation sector is one of the sector with the massive development that has the consequences high

uncertainty, which leads to the tendency of innovation avoidance [6]. The large and strategic sector faces the great innovation dilemma due to its reluctance to a high-risk project, while on the other side, required to keep innovating and conducting research to avoid sectoral collapse. Therefore, the innovation process has to be conducted by the whole actors in the network rather than individual actors. Although the development of EV in Indonesia seems heading to the better and progressive trajectory, EV needed to be implemented by orchestrating the innovation network to ensure its sustainability.

2 Innovation Network and Strategy for Various Sector

In order to establish a successful innovation on a massive scale, a strong innovation network has to be developed. However, the formation of an innovation network differs in each sector. For example, in the case of the biotechnology sector, the initial approach to form the network is the identification of worldwide market opportunities rather than working on fostering existing products of primary research facilities [7]. The importance of innovation networks also applied to industries. Samsung, ITRI, and Ericsson China proved that the technological collaboration between the private and public sectors could strengthen the innovation system by significantly develop cumulative innovation capacity [8].

The variation of innovation network formation and structure yields to the different innovation strategies. Practically, the strategy used for implementing innovation relies on the leadership expression to meet the objectives. Moreover, innovation strategy also targeted to develop the framework of plans, processes, and tools for supporting innovation. Among those practical outlines, the key principle of the innovation strategy is to engage both internal and external collaborative processes that foster the innovation process [9].

To achieve this objective, innovation strategy focuses on two matters: innovation target and actor integration. The latter purpose is required to be conducted in an inclusive manner by engaging people from inside or outside the organization [9]. These focuses on the innovation strategy are deployed in a dynamic process that involves organization and contractual complexity. In the case of the transportation sector, Crossrail International applied this innovation strategy in an iterative way to manage the evolving and adaptive innovation. The innovation strategy is fueled by the utilization

of the external environment, internal resources, and capabilities, which aims to drill the innovative capabilities in a rapidly changing environment [9].

3 On Sustainable Innovation Niche Formation

The difference between sustainable and non-sustainable innovation lies in its implementation challenge, mainly when this sustainable innovation product is relatively new and exists inside the niche of conventional product or technology. The first challenge is related to the technological gap between the technology proposed by sustainable innovation and the incumbent of conventional innovation. When the new technology is compared with the established technology, there will be a gap in terms of complementary technologies availability, which oftentimes expensive and inadequate. Moreover, in terms of technology reliability, early-stage technology will also become problematic due to its low-scale production and even small-scale testing. Secondly, the challenge will emerge from the government side with its unclear statement on the needs of a particular technology. This obscurity will make manufacturers reluctant to develop the technology and to invest in that fuzzy high-risk environment. Those two challenges will originate from other emerging challenges such as cultural factors (since the new technology will be unfamiliar to the majority of customers and leads to skepticism), supply and demand factors, also infrastructure adaptation [10].

From the aforementioned problems, it is critical to managing this new particular technology in the protected environment that ensures its development and growth by using the influence of government policy. This strategy is called Strategic Niche Management (SNM), which has the primary purpose of establishing an institutional connection as well as its adaptation to nurture technological transition with the focus on the learning process. This nurturing process can be undertaken by implementing financial assistance, and market security for this particular technology by incorporating various parties (government, manufacturers, university, research center).

The niche formation can be achieved by three main steps. The initial stage of niche formation is to shield the technology implementation at the particular protected space in the form of a dedicated R&D or demonstration project. This step will result in feedback for technology improvement until the specific level of technology acceptance is met. Secondly, this improved new technology shall be introduced to the

manufacturer to establish market formation. This step is highly correlated with the knowledge transfer process, adaptation, and to foster social acceptance. The third step aims to upscale the market by increasing the sales, production, and enact the standard of communication practices between manufacturers [11].

3.1 Role of government in sustainable transportation innovation

Figure 1 shows the framework of sustainable innovation that incorporates the Multi-Level Perspective (MLP) [12], with the added factors and mechanism. In this framework, it is concluded that sustainable innovation occurs in three layers: technological niches, socio-technical regimes, and

landscape or contextual consideration. Each of the layer thickness differs based on the role significance in establishing sustainable innovation. The upscaling to each layer is driven by the business innovation [13], policy [14] and social factors [15]. From the technological niches to socio-technical regimes, the added profitability is important concerning the absence of policy due to its ongoing transformation. Besides, the social transformation to adapt to the new technology also needed to be reckoned. The next transfer from the socio-technical regimes to the contextual landscape requires further adjustment of those three factors, while the business factors required a more established business model.

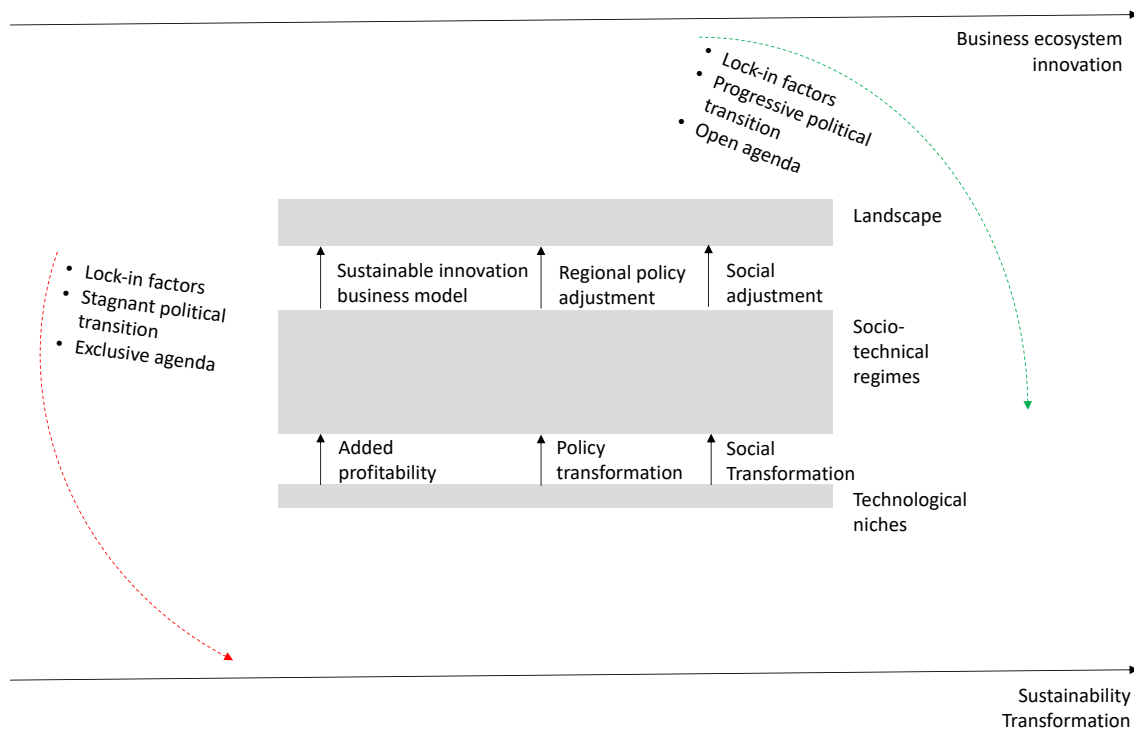


Figure 1 Sustainable Innovation Framework

The notable difference between sustainable innovation and the conventional one lies in the adoption motivation due to the relatively higher cost of sustainable innovation, lower availability, and lower perceived ease of use. Therefore, to make sustainable innovation widely adopted in a certain period, the extra forces are needed. It is found that the approach for consumers needed to be exerted in both vertical and horizontal ways. The vertical way is nurtured by the implementation of regional policy, thus, transforming the policy and ensure the interoperability of the policy is essential, especially in the context where social symbolic attribute influence is minor. Moreover, the horizontal way is fostered through ensure the market readiness. This is significant to keep both the innovation and

production on track. More thing to be considered is the transformation towards sustainability also co-evolve with the innovation of the business ecosystem. Therefore, business actors have to continuously re-evaluate and re-defined their business model to cope with the sustainability transformation, no matter how incremental the innovation is.

In the case of innovation in sustainable transportation, the vertical approach plays a significant role in terms of fostering technological advancement. The main solution to reach this objective is through the well-established research ecosystem, which significantly supported by R&D investment by the government. However, the high

degree of risk and uncertainty of this sector yields to the unpredictable investment warrant. On the other side, technological advancement has to be immediately accomplished, as it is one of the key drivers of the high adoption rate of sustainable transportation. In the case of an electric vehicle, the battery cost, range per charge, weight per watt, life cycle, and battery charging infrastructure is the most influencing factors of EV adoption rate in the US [16]. Catenacci, Verdolini, Bosetti, and Fiorese (2013) have found that the cost of an electric vehicle will reach USD 200 – USD 250 kWh⁻¹ by 2030. The US department of energy also determined that cost of an electric vehicle has to be cut from USD 400 – USD 650 kWh⁻¹ to USD 125 kWh⁻¹.

This indicates that R&D funding is needed to be boosted in order to develop high-technology batteries with high density, thus making electric vehicles adoption rate to grow.

Besides technological advancement, oil prices also considered as the factor that influences EV adoption. The low oil prices will vanish the eminence of EV and make the ICEs vehicle into lock-in alternatives. Even the environmental motivation of using EV could not overcome this consideration, as it is considerably low among customers. Therefore, [16] conclude the EV adoption scenario characteristics in Figure 2.

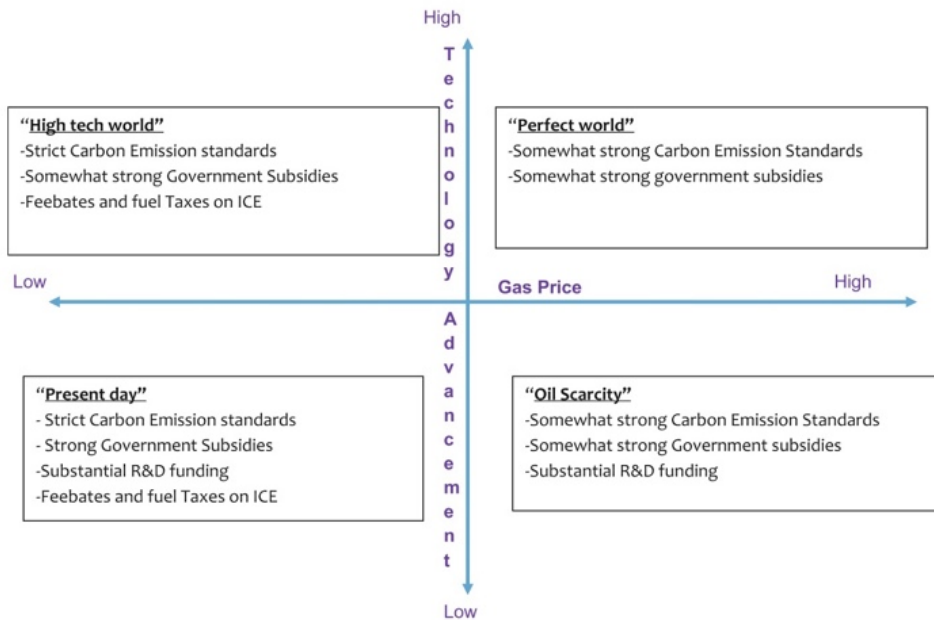


Figure 2 Alternative scenarios of EV adoption [16]

The key point is, the government plays an important role in every scenario as an R&D funder or subsidies provider. To conclude, the government takes the role of the innovation strategy implementer to establish a strong research network. Besides as the R&D funder and the hub between researcher and industry, the government also take a role to keep the dynamics of an ecosystem through interaction stimulation, while also engage the innovation results to be relevant with the social, technological, environmental, and economic problems [18].

3.2 Role of research center in sustainable transportation innovation

Research center, particularly at the university level has been known to plays an important role in the innovation ecosystem. While the country's industrialization demand keep rising, the research

center could consistently become the intermediaries in conducting the research and build the relationship with other non-industry actor. This way, the high risk and uncertainty of innovation could be reduced [19]. Moreover, in terms of this vast communication and technology era, the paradigm shift of innovation networks enable the research center to have these novel seven roles: 1) research center and industry engages in an reiterative way between applied research and prototype development, 2) research center takes part as the open-innovation enabler due to their relationship with the various non-industry actors, 3) research center has wide research and education agenda that allows technology, social and economic innovation aspect to be included in innovation, 4) research center enables the multidisciplinary innovation, 5) research center is dedicated to conduct the systematic approach on learning and

teaching reformation through the collaboration with multi-stakeholders, 6) research center has the designated core research infrastructures, and 7) the intermediary properties of research center enables them to become the innovation cultural hubs [20].

In the case of Indonesia, the university-based research on sustainable transportation is conducted in the designated national research center, namely National Center for Sustainable Transportation Technology (NCSTT). NCSTT is the research center that engages multidisciplinary researchers to support the technological advancement of the transportation system in Indonesia. The aim of NCSTT is “to develop technology for integrated and sustainable transportation systems that can support economic growth in Indonesia” [21]. In terms of a research network, NCSTT has globally recognized to establish collaborative research with national transportation stakeholders that consists of numerous national and international universities, industries, government, and other research institutions. NCSTT has been contributed to developing the sustainable transportation innovation product implemented in Indonesia, such as electric bus, electric trike, and the socio-economic study of sustainable transportation implementation. Besides expanding the network of sustainable transportation stakeholders and serve the actual demand from the government, NCSTT also plays the role of basic research, such as disseminating international academic publications and combining multidisciplinary knowledge [18].

4 Sustainable Innovation Framework: Emerging Factor Towards Successful Innovation

There are several theories that build the more comprehensive construct of sustainable innovation ecosystem. The main idea of ecosystem, which conceptualized by frameworks, have been studied from myriad of perspectives. In the case of sustainable innovation, the studies are stemmed in the institutional theory, resource-based view, stakeholders' theory, and evolutionary theories [22]. The earliest framework emphasizing the innovation related actor and mechanism is Technological Innovation System (TIS). This framework views that innovation system consists of the interacting stakeholders in the specific institutionalized economic area [23]. While this framework is deeply concerned in the rigid hierarchical entities rather than resource-based view with its social dynamics, another framework incorporating Socio-Technological Transition (STT) view is suggested. The perspective on social dynamics

embrace the uncertainty factors which also differs on each stage of innovation process [24]. Since these two fundamental frameworks are seem complementary to each other, the multi-level perspective (MLP) framework to integrate these views are developed [12]. This framework resulted in the layer of innovation system consisting technological niches (derived from TIS), sociotechnical regimes (derived from STT), and sociotechnical landscape. The latter level of MLP gives another insight on adding the factor of context to this discussion. In the MLP framework, the main influencing factor is a political transition to adapt sustainable innovation, supported by the open agenda, regimes, and spatial aspects [25]. On the other side, the factors that could either foster or inhibit (lock-in factors) this sustainable innovation transition are resources, technologies, and stakeholders [26]. The path-dependence properties of innovation transition also need to take into account. Therefore, the policy transition which is progressive in term of the lock-in factors is required to shape the well-established system of sustainable innovation.

While innovation are deemed successful when it is accepted by the market [27], thus, having the perspective on business ecosystem is deemed beneficial. The investigation in the case of sharing mobility companies in Shanghai shows that the transformation towards sustainable city has the strong correlation with the co-evolution of the innovation ecosystem. Therefore, the simultaneous co-evolution between policy transition and technical niches are important to foster the sustainable technology at the early stage [28].

4.1 Policy as prominent force of EV implementation: case of China

The study on early stages sustainable technology adoption is mainly conducted in the Asian and Nordic countries. In case of electric vehicle (EV) company in China, the sustainable innovation business is maintained by producing EV while keep serving the minority of niche market by producing the EV's most expensive part such as battery and infrastructure equipment. Moreover, this company also diversified their ecologically sustainable product into solar technology [29]. Besides the company's strategies, the implemented policy by government of China such as traffic controls, registration lottery, and subsidies also nurtured the adoption of sustainable technology. However, there still a limitation in the subsidies due to the conflict with the local protectionism [14]. This also confirms the policy as the lock-in factors that either foster or inhibit the sustainable innovation.

The stage of Chinese NEV development is classified into three phases (See Figure 3): industrial exploration

stages, fostering steps, and development stages. The first stages (2006-2009) of industrial exploration began with the research and development validation of EV products supported by national funding projects and demonstration projects in the 2008 Beijing Olympic

Games. This demonstration program also conducted in 2009 by the Ministry of Finance (MOF) and the Ministry of Science and Technology (MOST), which managed to deploy 585 NEVs.

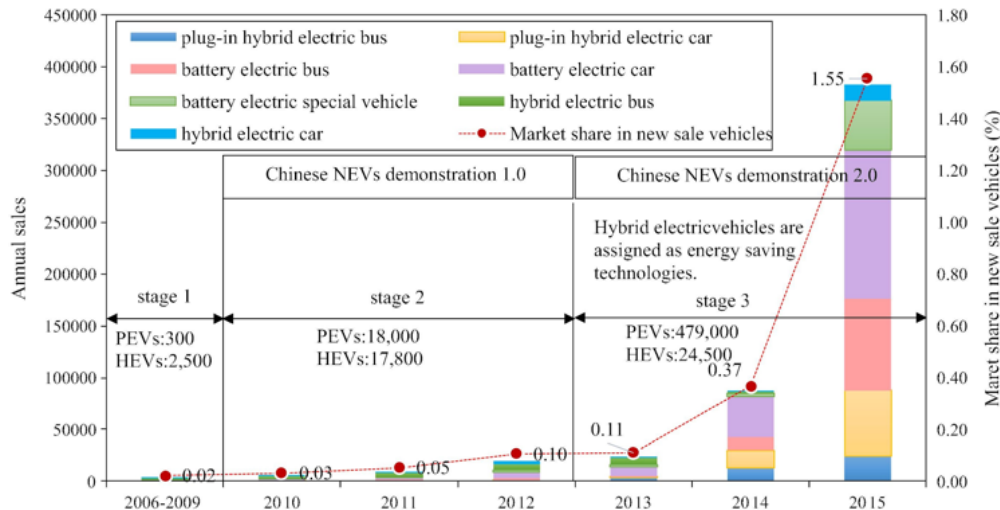


Figure 3 Progress of Chinese EV Industries [30]

The second stage (2010-2012) focuses on the industrialization preparation period in which the purchase subsidy of NEVs is officially issued. This subsidy system is called “national subsidy policy 1.0” and implemented in six cities in China. Besides, the funding of PEVs research and development also made as a priority. These policies have successfully influenced the penetration of NEVs into the public sector, with 12,765 hybrid electric buses and 3,392 battery-electric buses being put on the road.

The third stage (2013-2015), namely NEV industrialization development stage is started to implement national subsidy policy 2.0 in which the concept of subsidy phasing-out is introduced. In this policy, the subsidies are set to decrease by 5% in 2014 and 10% in 2015. Moreover, the demonstration also maintained by expanding its scope into 88 cities. This stage yields 470,900 NEVs that being put on the road.

While the implementation of those three stages seems fruitful, some challenges remain present: immature key technologies, incomplete industry chain, insufficient charging infrastructures, and imperfect policies and regulations. Chinese government attempts to solve this problem by investing more than 10 billion RMB to promote research and development on EV technology, as well as listing the joint venture EV to push the mass penetration and reduce the NEVs cost. The study by [8] have found that the disparity between R&D expenditure and employment in East Asia is significantly large. In the case of Indonesia, with the spending of around \$2 per capita annually on R&D, the advancement of technological collaboration is not

maturely fostered, which leads to low research capacity. Therefore, the diffusion-orientated partnership strategy is suggested to develop the base of national technology advancement.

5 Conclusion

This review highlights how innovation network should orchestrate in the field of sustainable transportation technology. The importance of sustaining innovation network is confirmed in various field besides transportation technology, moreover, in the case of sustainable transportation technology, there are several novel paradigm that requires further approach that differs from conventional transportation technology networks. Concerning the formation of innovation network niche, the government and university-based research center play an important role in orchestrating the innovation network. These two actors act as the enabler and intermediaries to allow the initial stage of niche formation, which is to shield the technology implementation at the protected space is conducted in the dedicated agenda. At the next step when the technology is introduced to form the market, these two actors also able to introduce the technology to their horizontal network that consists various stakeholders. While the network is constantly built from the previous step, the establishment of the network in upscaling the technology in the market could be conducted in a more convenient way by nurturing the existing niche and network.

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