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How to Innovate E-vehicle Charging in Support of the Energy Transition

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Abstract: With electric vehicle penetration steadily increasing and therefore their respective energy requirements, coupled with more intermittent renewable energy comprising the energy mix, new charging innovations are warranted to better facilitate the energy sector's matching of supply and demand. To carry this out, this requires the cooperation of both sectors - the mobility and the energy sector. Within this study, we extrapolate an innovation ecosystem perspective to the e-mobility and energy space to better understand stakeholder needs and requirements for such mutually-beneficial exchanges. Here, we conducted a stakeholder ecosystem analysis and an expert co-creation workshop. Thus far, our method has provided a comprehensive view of this integrated system and its contributors. Such an analysis can be useful to better guide its implementation.

Keywords: Digital transformation; ecosystem modelling; renewable energy; energy resilience; sustainable energy management; electric vehicles; innovation ecosystem; vehicle-to-grid; e-mobility; co-creation.

1 Managing innovation amidst the e-mobility transition

Although electric vehicles help meet de-carbonization objectives, the share of worldwide electricity consumption due to electric vehicle (EV) charging is forecast to rise eleven-fold in the next ten years (IEA, 2020). Concurrently, the energy mix is becoming increasingly composed of renewables, which involve more variable production (Kempton & Tomić, 2005). Here, electric vehicle batteries can play a major role, which has given rise to new charging designs, such as smart charging (V1G) and vehicle-to-grid (V2G) EV charging, in order to better coordinate electricity supply and demand (Tan et al., 2016). In order to mitigate power grid fluctuations and energy bottlenecks, a closer alignment of the mobility and energy sector is warranted.

At the same time, in the last three decades, a coinciding shift is taking place in the realm of business, moving away from the idea of large integrated firms that defend market share. This trend has led to the emergence of innovation ecosystems, where multiple actors work together to create value and drive innovation (Bessant et al., 2014; Adner, 2013). To effectively participate in innovation ecosystems, firms need to have a deep understanding of the ecosystem's structure, dynamics, and key actors. They also need to be able to identify and assess potential partners and collaborations that align with their strategic goals and capabilities. This can present a significant challenge for innovation management, as these ecosystems can be complex and difficult to navigate, and many firms lack a comprehensive understanding of participating in or assessing the value proposition of innovation ecosystems (Han et al., 2022).

2 Extrapolating an innovation ecosystem lens to e-mobility

To date, several scholars have pointed to the innovation ecosystem characteristics of electrified mobility (e.g., Adner, 2013; Talmar et al., 2020). However, there remains a gap when extrapolating such an ecosystem approach to e-mobility's inherent linkage with the energy sector. Specifically, these new e-mobility charging innovations remain an enigma to the energy sector and involve numerous stakeholders with varying goals and limitations (Tan et al., 2016; Sovacool et al., 2020). Although these charging innovations have the potential to alleviate many complications related to e-mobility and increase the triple bottom line, it has remained merely a niche topic among specialized groups (Kester et al., 2018). Moreover, such an exploratory stakeholder analysis is especially helpful during the introduction of new technologies to uncover their accompanying interdependencies and to inform new business models tailored to the new technology (Talmar et al., 2020). Involved stakeholders – ranging from grid operators, to vehicle OEMs, to fleet operators, and more – stand to benefit from such a study, as the technology is still in the early diffusion phase, where numerous requirements have yet to be met and barriers to be overcome before managers can fully take advantage of these innovations (Tan et al., 2016).

The field of innovation management more broadly can take advantage of being aware of this vehicle-grid ecosystem construct in order to fully reap their full potential. Many market-leading firms face a challenge in balancing different strategies and objectives within different ecosystems (Augenstein & Palzkill, 2016). On the energy side, there is a general risk-aversion and resistance shown by utility companies to business model innovation, which puts a strain on the development of market models that connect local-scale renewable energy structures. This lack of willingness to take risks is hindering the energy sector's ability to adjust to changing circumstances (Richter, 2013). Similarly,

vehicle manufacturers have also demonstrated reluctance to change, despite the urgent need for electrified mobility (Wells & Nieuwenhuis, 2012).

With that being said, business model innovation is a necessary condition to properly reap the advantages of electrified mobility. While technological innovations are currently more advanced, the energy sector's capacity to adjust lags. Thus, firms need to overcome resistance to change and take calculated risks to develop innovative business models that incorporate renewable energy systems and electrified mobility (Hall, Shepherd & Wadud, 2017). In such a scenario, using firm-level business modelling alone, such as the business model canvas or value proposition canvas, may be too narrow-sided and insufficient to account for the wider ecosystem and processes at hand. Therefore, this research explores an innovation ecosystem approach in order to ascertain each stakeholder's requirements, barriers, and goals for contributing to a grid-vehicle innovation ecosystem. Subsequently, an ecosystem can be co-modelled that is mutually beneficial for all market actors to nurture its implementation.

3 Research Design

3.1 Stakeholder mapping

The research design employed is two-fold. First, in order to see which market actors have a stake in this vehicle-grid ecosystem, we developed a typology of involved stakeholders. Every stakeholder brings with themselves their own resources, activities, value capture, dependence and risk to the ecosystem (Talmar et al., 2020).

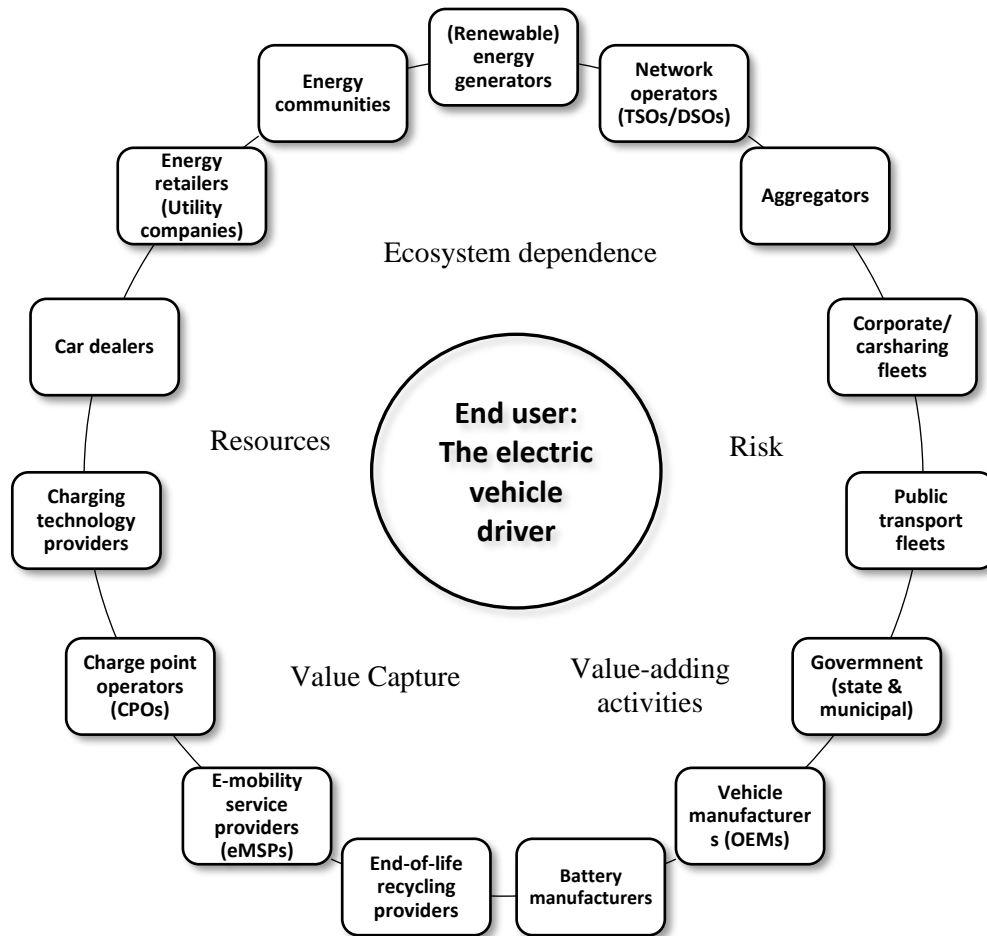


Figure 1 The grid-aware mobility ecosystem.

3.2 Expert stakeholder workshop

Thereafter, Austrian experts in the energy and mobility sector were consulted during an in-person stakeholder workshop ($N = 17$) in February 2023. Co-creation is a purposeful technique of generating value, with innovations presenting a co-creation opportunity (Frow et al., 2007). With the view of the executive as a *reflexive practitioner* who is a moral actor and can spearhead change (Cunliffe, 2004), we sought to gather managers from a diversity of relevant backgrounds and who were enthusiastic to benefit from such co-creation. During the workshop, the experts were presented with a synopsis of our ecosystem analysis, along with possible business models and use cases of grid-integrated e-vehicle charging. The participants were presented the following questions:

1. Which fleets are suitable to provide grid services?
2. Between smart charging and vehicle-to-grid, which charging technology is promising?

3. Which new stakeholders enter the smart charging or vehicle-to-grid market, and with which business model(s) and activities?
4. What kind of grid/ancillary services are electric vehicle fleets suitable for?

The respondents were requested to think the former notions over and to share their perspectives on grid-aware charging from the perspective of their individual experiences. Their ideas were tabulated on individual post-its and posted. Thereafter, the post-its were organized and discussed. Lastly, the participants had the chance to voice any last comments.

4 Interim findings

The results draw on the explorative, systematic ecosystem modeling with 16 meaningful stakeholders articulated, and the feedback gathered from the 17 managerial experts in the energy and mobility sector. We were astonished by the breadth of interim feedback received from the stakeholder experts, which provided us with novel perspectives that we have not yet considered, such as double taxation and regulatory issues, and envisaged cross-sector business opportunities for market players ranging from fleet operators, vehicle OEMs, aggregators, and even public parking spaces. Indeed, these expert stakeholder workshops delivered a meaningful articulation of this ecosystem's stakeholder archetypes. These joint analyses lay the foundation for future cross-segment cooperation opportunities and a possible business case in grid-optimized charging.

5 Practical implications

The aim of this research is to make a meaningful contribution to innovation management's understanding of vehicle-grid integration through the lens of an innovation ecosystem. The wider view of this system and its corresponding interdependencies provides those involved in innovation management with a complement to firm-level concepts, such as the business model canvas. Researchers, businesses and lawmakers stand to gain from such an analysis. Firstly, our findings can meaningfully contribute to the scientific community. Secondly, firms can to properly position themselves within the ecosystem increase their value proposition. Lastly, lawmakers can gain, as knowledge of the ecosystem can help them uncover where it lacks, relieve these flaws via policy measures, and in turn achieve societal targets (Talmar et al., 2020).

6 Limitations

A possible limitation of our approach is that we involved managers and not end-users. It's important to recognize that involving end-users in the co-creation process can offer valuable insights and perspectives that may not be apparent to managers or experts alone. With that being said, involving managers and experts in the co-creation process can also be valuable, as they have insights into the organization's goals and objective and/or bring specialized knowledge and skills to the table. This joint collaboration can lead to new and innovative ideas that may not have been possible with a narrower focus on end-users alone.

7 Areas for feedback and development

We are looking for feedback and recommendations for future development with a special focus on the following questions:

- How can we further improve our ecosystem analysis for the purpose of innovating EV charging in support of renewable energies? Which other scientific methods might best complement our ecosystem mapping and co-creation workshops?
- Is there something lacking within this study which should be included or kept in mind?
- How is the digital transformation affecting the energy and mobility sector?

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