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Abstract

The trend towards energy decentralization and innovations in data-driven e-mobility have given way to a new type of electric vehicle charging; namely, smart charging and vehicle-to-grid technologies. In order to unlock the full potential of electric mobility's flexibility, an exploratory ecosystem approach is first warranted in order to uncover stakeholder requirements, activities and (inter-)dependencies. The purpose of this research is to lay the foundation for future resilient business models in the grid-aware mobility ecosystem, which require novel multi-stakeholder collaborations. Through rigorous exploratory ecosystem modeling, flexibility recipient taxonomies, and a co-creation workshop, we have sought to uncover stakeholder intricacies in order to improve the overall innovation ecosystem value proposition. The results suggest many novel perspectives which were not considered (such as the issue of double taxation) and several prospective cross-sector business opportunities for fleet operators, vehicle OEMs, aggregators, and even public parking spaces. Additionally, stakeholders vary considerably in terms of needs, value-adding activities, (inter-)dependencies, risk, and flexibility services provided/requested, which need to be weighed and overcome on an (inter-)sectoral level.

Keywords

Digital transformation, ecosystem modeling, renewable energy, resilient energy grid, sustainable energy management.

The Context of Sustainable Mobility

Presently, two primary CO2 emittors are the energy and mobility sector (Christensen et al., 2012). As it stands, the prospect of global warming has hastened societies to lessen greenhouse gas emissions and decarbonize, with an insistence to move beyond the internal combustion engine (Adner, 2013). In response, individual mobility has become increasingly electrified, which has had spillover effects by transforming other economic sectors (Beaume and Midler, 2009). Furthermore, the share of worldwide electricity consumption due to electric vehicle (EV) charging is forecast to rise eleven-fold in the next ten years under the Sustainable Development Scenario (IEA, 2020).

Traditionally, the energy sector is made up of large centralized power plants which exploit economies of scale, generating and transmitting vast amounts of energy to the end user (de São José et al., 2021). Although this integrated supply chain is efficient, the sector has recently experienced a reconfiguration towards liberalization. Due to the urgency of mitigating climate change, securing energy reserves, and reducing dependence on centralized energy operators, there has been a shift towards local decentralized forms of energy; of which are often based on renewable energies and involve a stronger interlinkage of the energy production and consumption process (Bouffard and Kirschen, 2008).

Energy prosumption has become possible by improvements in ICT, transitions towards a smart grid, and the prosumption of big data (Li et al., 2017). In this vein, the Internet of Things (IoT) has extended itself into corresponding data-driven innovations, namely the Internet-of-Vehicles and the Internet-of-Energy (Wang et al., 2018). Amidst the 'electrification of everything' and the transition towards of cleaner forms of energy which are by nature intermittent, close coordination is needed of local energy supply and demand (Koirala et al., 2016). Such coordination mechanisms, referred to as demand response, require real-time data on energy generation and consumption. In this way, data-driven analysis tools can identify and control the available flexibility. Hence, the roll out of smart meters, meters which possess comprehensive two-way communication abilities, as part of an advanced metering infrastructure (AMI) is a key requirement to enable novel business models in this field, reducing transaction costs and lowering entry barriers for new market players (Pressmair et al., 2021).

The Introduction of Decentralized Energy-Mobility Sector Coupling

New technologies by nature create linkages between sectors which were previously detached (Gomes-Casseres, 1994); EVs are not an exception, as many of its corresponding business models capitalize on linkages in the mobility and energy sector (Engelken et al., 2016). Due to the proliferation of EVs on the road, electricity demand will be higher; yet electric vehicles can serve as decentralized sources of energy flexibility and a critical aid to overcome mismatches of energy production intermittencies and consumption (Koirala et al., 2016). Vehicle-grid integration (VGI) captures the mutual synergies of both grid-to-vehicle (G2V) and vehicle-to-grid (V2G) exchanges. Uni-V2G/V1G, also known as smart charging, involves a controlled stream of electricity from the grid or microgrid to the EV; while bi-V2G involves bidirectional charging in both directions, where the EVs can supply electricity back when needed (Ravi and Aziz, 2022). This does not only concern the main grid, but also on the local level, as the micro-grid and energy community concept has gained traction amidst the trend towards the energy resource decentralization. In both cases, the EV serves as a flexible load within an energy management system (Perez-DeLaMora et al., 2021). Essentially, coupling of the energy and the mobility sector can be considered both a chance and an imperative. The widespread usage of EVs means a roll out of mobile batteries that could be dispatched in a grid-aware manner and have an added value for keeping the energy system reliable. However, the expected increase of energy demand caused by EVs would overstrain current distribution grids, making smart sector coupling mechanisms purely a necessity.

Exploiting ecosystem alliances

When introducing new innovations, the use of old business strategies often fails to gain market traction. Instead, new products are best complemented alongside new corresponding business models (Adner, 2013). To understand the barriers of technical and structural innovation, business models warrant a more encompassing outlook away from the traditional framework of 'value creation, value capture' to properly grasp the models' overarching societal aim (Christensen et al., 2012). Going beyond mere product innovation, deploying new business models also addresses paradigm shifts in societal preferences, resource constraints and policy developments (Hall et al., 2017). Considering renewable energy business models, achieving individual stakeholder objectives is best done through collective cooperation. This also serves to overcome the intricacies of the sustainable mobility ecosystem, which comprises many diverse stakeholder types and sector types (Engelken et al., 2016; Sovacool et al., 2020).

In the last three decades, a coinciding shift is taking place in the realm of business, with a moving away from the idea of large integrated firms that defend market share in favor of simultaneous cooperation and competition with other firms (Adner, 2013; Cheong et al., 2016). Termed *co-opetition*, firms individually contribute to an ecosystem to achieve a shared value proposition, and as a result, yield greater benefits than what they could have accomplished by themselves (Cheong et al., 2016). These ecosystem alliances are especially advantageous in sectors whose technology is rapidly developing or require high investment costs (Gomes-Casseres, 1994), which is applicable to the mobility or energy sector. Not only that, but such partnerships allow involved firms to create a quality product and generate income in an early market (Zayer et al., 2022).

Market-leading firms often simultaneously balance varying tactics and objectives within different ecosystems (Augenstein and Palzkill, 2016). However, a key hurdle to be overcome is the fact that utility companies are historically shown to be resistant to business model innovation, possessing a minimal appetite for risk even amidst a changing landscape. In this case, incumbent utilities have been insufficient to develop a market model that incorporates local-scale renewable energy systems (Richter, 2013). This is not only limited to the energy sector, as even amidst societal urgencies, vehicle manufacturers have also demonstrated an opposition to change (Wells and Nieuwenhuis, 2012). As it stands, in order to properly reap the advantages of electrified mobility, business model innovation is a necessary condition, as its technological innovations are currently much more developed than the energy sector's capacity to adjust (Hall et al., 2017).

Value networks in EVs & energy flexibility services

Concerning electrified mobility, the 'ecosystem problem' of EVs has already been cited, as their success is reliant on the synergy of complementary products and actors, with previous attempts of EVs to become widespread failing due to a flawed compositon of partners in its ecosystem (Adner, 2013). As stated, "EVs cannot simply replace conventional cars without major changes in industrial production structures, business models, use patterns and political regulations. Thus, their success depends on the degree to which the sociotechnical system around it can be characterised as adaptable" (Augenstein, 2015:p.11). However, there remains a gap when extrapolating such an ecosystem approach to e-mobility's inherent linkage with the energy sector. Studies, such as those by Richards, Walker & Jones (2019) have delineated primary business models of EV V2G technology, among one of which is "load orchestrator: leverage EVs as batteries on wheels to balance load or provide ancillary services" (p. 5). Additionally, Goncearuc et al. (2023) have attempted to elaborate grid-aware EV charging business models, however, the study only focused on V2G-enabled Frequency Containment Reserve (FCR) services, only focused on public and semi-public EVSE infrastructure, and did not extrapolate this model to multiple V2G ecosystem actors. Generally, there is a lack of both real-life application and literature concerning V2G-enabled energy flexibility services from an ecosystem perspective. However, these flexibility services indeed account for most of the new value propositions brought on by V2G technology (Goncearuc et al., 2023), and such services would not only benefit grid operators, but also other network stakeholders, such as Balancing Responsible Parties (BRPs), EV charging businesses, industry, neighborhood managers and prosumers (Ilieva & Bremdal, 2020).

When mapping smart energy business models, the predominant method remains the business model canvas by Osterwalder & Pigneur (2010) (Paukstadt & Becker, 2021), although a systematic literature review demonstrated that one-third of businesses in the smart energy domain are a part of value networks (Paukstadt & Becker, 2021). Combining both the smart energy and sustainable mobility realms, these value networks and synergies amongst complementary products and stakeholders is a success factor to building strong business models around the flexibility services provided by vehicle-grid integration (Venegas, Petit & Perez, 2021).

Research Design for business model innovation in grid-aware mobility and energy sharing

In place of traditional analyses of a value chain on the firm level, such as the business model canvas or the value proposition canvas, reaping the benefits of electrified mobility warrants a value network approach in order to uncover its associated multi-sector linkages of cooperation and competition (Lang et al., 2021; Sovacool et al., 2020). As such, the focal aim of this research is to contribute a novel ecosystem approach to grid-aware mobility specifically. The success of grid-aware mobility lies in each stakeholder's individual contribution to the ecosystem, delivering complementary outputs to serve the collective value proposition of its ecosystem: *Energy-aware sustainable mobility*. In order to fulfill this, an initial comprehensive analysis is necessitated of each stakeholder's key resources and value-adding activities, along with uncovering stakeholder requirements, barriers and opportunities to take part in the ecosystem. The purpose of this is to lay the foundation for future business models in this area. Thus, we utilized an ecosystem pie model, created a taxonomy of relevant flexibility services and conducted a stakeholder expert co-creation workshop in order to uncover diverse stakeholder perspectives.

Ecosystem pie model

The ecosystem pie model, developed by Talmar et al. (2020b), is a scientific research method that designs and evaluates an innovation ecosystem by providing an overview of an innovation ecosystem's complementary actors, which range from *firms*, *organizations*, *communities*, but also *individuals* and *user segments*. This strategic tool delineates every stakeholders' key *resources*, *activities*, *value addition*, *value capture*, *level of risk or unwillingness to contribute*, and *level of dependence on the success of the ecosystem.* In this vein, the ecosystem pie model envisages to achieve a collective ecosystem value proposition. The ecosystem pie additionally functions as a boundary object, which by design enables network exploration and collaboration among diverse groups and bridges theory, practice and different social worlds (Star, 2010; Talmar et al., 2020a). By conveying a synthesized overview of the space (i.e., the ecosystem), the knowledge community can convey value to entities in return for gathering data, resulting in a mutually beneficial exchange (Talmar et al., 2020). To date, the ecosystem pie framework has been altered to model more than 260 innovation ecosystems spanning across numerous domains (Talmar et al., 2020a). Thus, the ecosystem pie model was adapted to the context of the grid-aware mobility ecosystem. The aim of this study was to contribute to the prior ecosystem explorations with the first grid-aware mobility ecosystem map to our knowledge.

Taxonomy of flexibility services

Business models making use of novel opportunities in energy-mobility sector coupling require a thorough understanding of the needs of all stakeholders who request energy flexibility. Hence, also a closer analysis of flexibility services is conducted, which could be provided by EVs to various flexibility recipients. To this end, a taxonomy of flexibility services has been developed, following a stakeholder-centric logic with the focus on the actual flexibility needs of market actors in the energy system.

Co-creation workshop

Co-creation is a deliberate method of creating value, with new technologies presenting a co-creation opportunity (Frow et al., 2007). A virtual workshop consisting of experts in the mobility and energy industry was conducted in January 2023 (N = 8). With the view of the manager as a *reflexive practitioner* who is an ethical actor and a critical agent of change (Cunliffe, 2004), we sought to recruit managers from a diversity of sectors who were drawn to the idea of innovations in the mobility and energy sector and eager to benefit from co-creation.

First, the all participants were briefed on the grid aware mobility and energy sharing project, the ecosystem logic, market potential, and possible use cases of EV charging innovations. Thereafter, we inquired to the panel which stakeholders' needs and obstacles would have to be overcome in order to accomplish these synergies. The participants were presented the following questions:

- What are your barriers and challenges to integrate smart charging or vehicle-to-grid?
- If you integrate smart charging or vehicle-to-grid methods, which benefits could it bring for you?

- Which possible business model(s) could be suitable for smart charging or vehicle-to-grid?

Their ideas were tabulated on (virtual) post-its using a collaborative software, and thereafter the post-its were discussed, organised, and ranked according to certain parameters. In this discussion, the interactive post-it notes served the role as *boundary* objects to bridge the experts' different experiences and realities.

Findings

Ecosystem pie model

The ecosystem value proposition is *energy-aware sustainable mobility*, i.e., the principal solution this ecosystem brings together, with a total of 16 relevant stakeholders: one as the end user's target group, *the EV driver* (such as the target segment "the retired professional", but not exclusively – as this segment was perceived to be the most valuable V2G customer archetype from the V2G Project Sciurus due their low vehicle use, predictable charing patterns, and high plug-in availability) (Cenex, 2021); six stakeholders in the energy sector; eight in the mobility sector; and lastly, one in the public sector (state and municipal government). Three stakeholders exhibited a low dependency on the dependence of the ecosystem (*renewable energy generators, battery manufacturers, and car dealers*), five exhibited a medium dependency (*corporate/carsharing fleets, public transport fleets, vehicle manufacturers (OEMs), end-of-life recycling providers*, and *energy retailers*), and seven stakeholders exhibited high dependency: *network operators* (i.e., TSOs/DSOs, who are responsible for electricity transmission and distribution, respectively), *aggregators* (who group together the flexibility of several EVs), *government, eMSPs* (e-mobility service providers, who provide the user interface and billing for EV charging), *CPOs* (charge point operators, who manage the charging infrastructure), *charging technology providers* (who manufacture the charging infrastructure), and *energy communities*. Considering risk of not delivering to the ecosystem, one stakeholder (*end user: EV driver*) was considered high risk; five were classified as medium risk (*corporate/carsharing fleets, public transport fleets, battery manufacturers, end-of-life recycling providers,* and *CPOs*); and ten were considered low risk (*energy generators, TSOs/DSOs, aggregators, government, battery manufacturers, eMSPs, charging technology providers, car dealers, energy retailers* and *energy communities*). Additionally, the stakeholders *energy communities* and *energy retailers* are the closest to the targeted market segment: *the EV driver*. Lastly, stakeholders carried out diverse value-adding activities to the ecosystem, displayed below (in order from least to most close to the end user):

Table 1 Stakeholders' Ecosystem Value-Adding Activities
(Source: own illustration)

Stakeholder	**Ecosystem value-adding activities**
(Renewable) energy generators	• Increase share of renewables • Provide supplemental energy when needed

Network operators (TSOs/DSOs)	• Ensure grid stability
Aggregators	• Represent groups of EVs as an intermediary • Serve as large-scale energy flexibility/stability
Corporate/carsharing fleets	• Replace old fleet/chargers with V1G/V2G capabilities • Provide V1G/V2G services when EVs are idle
Public transport fleets	• Complement V1G/V2G with other intermodal transport • Replace fleet with new V1G/V2G capable EVs
Government (state & municipal)	• Encourage V1G/V2G uptake via various policy mechanisms
Vehicle manufacturers (OEMs)	• Develop and produce high-tech, sustainable V1G/V2G-capable EVs
Battery manufacturers	• Develop and produce high-capacity, long-lasting V1G/V2G-capable EV batteries
End-of-life recycling providers	• Repurpose and utilize used EV batteries as secondary storage systems
E-mobility service providers (eMSPs)	• Create advanced billing to enable V1G/V2G • Ensure a positive user experience with V1G/V2G
Charge point operators (CPOs)	• Implement V1G/V2G energy management technology, charging technology, and protocols
Charging technology providers	• Replace existing chargers with V1G/V2G capabilities • Sell software knowhow to other charging providers
Car dealers	• Inform customers about V1G/V2G • Sell V1G/V2G-capable EVs and equipment
Energy retailers (Utilities)	• Provide smart meters • Install V1G/V2G charging points • Provide optimized energy
Energy communities	• Produce and consume self-sufficient energy from distributed energy resources • Lessen the dependence on (increasingly intermittent) grid energy • Provides a large source of flexibility resources

End user: EV driver	• Provide capital for V1G/V2G • Serve as critical exposure for V1G/V2G • Trial V1G/V2G for feasibility and improvements

A comprehensive elaboration of the grid-aware mobility ecosystem can be consulted below:

Figure 1 Ecosystem Pie Model of Grid-Aware Mobility (Source: own illustration)

Taxonomy of flexibility services

An overview of flexibility use cases, specifically for EVs, has been drafted in a position paper by ENTSO-E, an association for European transmission system operators (2021). Together with general classifications of the Universal Smart Energy Framework (Klaassen and van der Laan, 2019; de Heer et al., 2021) and in accordance with the EBIX (2022), this taxonomy provides an overview of existing flexibility services and a first estimation of relevance for EV fleets as flexible assets. In the remainder of this section, for each relevant flexibility-requesting stakeholder, such a taxonomy is provided in tabular form.

Transmission System Operators (TSOs) are responsible for operating the high voltage (HV) grid, usually in one country or in a large region of a country. In most liberalized countries, they run a balancing market for procuring flexible reserves to maintain system frequency within specific tolerances. They also engage in (more or less market-based) contracts with providers of other ancillary services, which are required to ensure grid stability.

Table 2 Flexibility Services for Transmission System Operators
(Source: own illustration)

Service	**Description**	**Relevance for EV fleets**
Balancing services	• Help to maintain system frequency within 50 Hz • Organized marketplace with weekly two-step auctions (availability auction and dispatch auction)	- Strict prequalification criteria - Difficult to ensure full availability with EVs + High market prices, i.e. promising revenues + Increasingly small bid size (from 1 MW) + Short trading horizons
Congestion management	• Also known as redispatch • Helps to avoid overstraining the power flow limits at physical grid nodes in the high-voltage grid • Static long-term contracts with a limited number of providers	- Usually no organized market; market-based procurement is emerging in some countries - Long-term contracts not suitable for EV fleets
Voltage control	• Avoids exceeding any voltage limits of the high-voltage grid; flexibility services can reduce the need for grid investment and prevent generation curtailment • No organized marketplaces	• No organized markets
Capacity mechanisms	• Aim to increase security of supply by procuring sufficient flexibility in long-term • Organized markets in some countries	• Long-term contracts not suitable for EV fleets • Demand side flexibilities usually not eligible

Distribution System Operators (DSOs) are responsible for operating the medium (MV) and low voltage (LV) grid, usually in a specific region. Flexibility could be used as a means to avoid local congestion and voltage control.

Table 3 Flexibility Services for Distribution System Operators
(Source: own illustration)

Service	**Description**	**Relevance for EV fleets**
Congestion management	• Helps to avoid overstraining the power flow limits at physical grid nodes in the low-voltage grid • Usually rule-based mechanisms in emergency situations, some first trials for so-called local flexibility markets	- Usually no organized market - Value of flexibility heavily depends on the physical situation in each LV area - Only a few prosumers can offer flexibility at a specific LV node + Local flexibility markets emerging in some countries + EVs as decentralized resources can offer flexibility at certain congested nodes
Voltage control	• Avoids exceeding any voltage limits of the low-voltage grid • No flexibility mechanisms in place	- No (market-based) mechanisms
Peak shaving	• Reducing the peak load at the point of common coupling between DSO and TSO; hence reducing the costs of the DSO paid to the TSO for peak power load	- Usually no demand side flexibility programs in place + Immediate cost savings achievable for the DSO + All prosumers in the DSO's area can offer this flexibility + Can be incentivized through a peak power tariff by the DSO

Balance Responsible Parties (BRPs) are responsible for ensuring a balanced portfolio of supply and consumption at all times among their associated energy suppliers. They can trade on the wholesale market (energy exchange or over the counter). They are independent from grid operations.

Table 4 Flexibility Services for Balance Responsible Parties
(Source: own illustration)

Service	**Description**	**Relevance for EV fleets**

Portfolio optimization	• Imbalance costs result from deviations between planned schedule and actual generation (i.e. intermittent renewables) or consumption patterns (which are not fully predictable). To reduce imbalance costs, flexible assets could be dispatched to balance the portfolio of an energy supplier (its BRP) in real time.	+ No need for additional trading mechanism + Strong incentive for a BRP to optimize + Energy supplier often is the e-mobility service provider or chare point operator, operating the charging back-end system - Uncertainty, if cost savings are sufficient to allow meaningful remuneration for end-user
Arbitrage trading	• BRP can buy energy at times of low market prices to charge the EVs and stop charging (or feed back in) during times of high prices	+ No need for additional trading mechanism - Low margin between high and low prices in the flexibility horizon of an EV (e.g. one day) - Uncertainty, if cost savings are sufficient to allow meaningful remuneration for end-user

Individual prosumers can use their flexibility to reduce costs in their electricity tariff scheme. This can be in terms the energy contract with the supplier or also the grid tariff.

Table 5 Flexibility Services for Individual Prosumers
(Source: own illustration)

Service	Description	Relevance for EV fleets
Tariff optimization	• In case a prosumer is subscribed to a dynamic or time-of-use contract, load shifting behind the meter can reduce its energy costs	+ No additional market arrangement required + Immediate cost reduction - Only relevant for individual EV owners, not for fleets

Self-consumption optimization	• Maximizing self-consumption is preferable for prosumers, as prices for feed in are lower than prices for buying energy from the grid	+ No additional market arrangement required + Immediate cost reduction - EVs are often not plugged in at home during photovoltaic peak generation time (at noon) - Only relevant for individual EV owners, not for fleets
Peak shaving	• In some grid tariff schemes, an extra monthly fee is incurred for the maximum power peak of a prosumer; reducing this peak behind the meter leads to cost savings.	+ No additional market arrangement required - Value depends on the DSO’s tariff scheme - Only relevant for individual EV owners, not for fleets

Energy Communities are a novel concept established through EU directives. They are entitled to collectively consume and share locally generated energy without an energy supplier as an intermediary. They do not operate a micro grid, but are connected to the grid through the local DSO.

Table 6 Flexibility Services for Energy Communities
(Source: own illustration)

Service	**Description**	**Relevance for EV fleets**
Energy sharing	• A consumer can directly buy surplus electricity from another prosumer	• Pure energy sharing is an energy service rather than a flexibility service
Collective self-consumption optimization	• As an addition to energy sharing • Shifting loads behind the meter in order to balance the community’s demand and supply profiles and thus maximise self-consumption within the community.	+ No additional market arrangement required + Relevant for shared community fleets (e.g. local car sharing) + Immediate cost reduction for community members

Concluding from this taxonomy of flexibility services, it becomes evident that out of the whole range of services, only a few can be considered reasonable for the deployment of EV fleets. According to this analysis, the most promising services are the following:

- Balancing services for the TSO: Although strict prequalification criteria apply, an advantage of this service is that already well-established organized markets exist for trading balancing products. Also, the settlement prices per kWh are on average the highest of all markets in this analysis;
- Peak shaving for the DSO: DSOs have a strong incentive to reduce peak power costs. The main advantage is that DSOs can procure a uniform flexibility product among all grid users within their area;
- Portfolio optimization for BRPs: Already nowadays, BRPs try to optimize their portfolio in order to reduce imbalance costs. Using EVs as a flexible resource is very promising, as energy suppliers often act as CPOs or eMSPs;
- Collective self-consumption optimization for energy communities: energy communities are currently adopted all over Europe. Communities with a high share of PV generation are also likely to couple their surplus with (shared) EV fleets in the near future.

Co-creation workshop

The feedback gathered from managerial experts in the energy and mobility sector conveyed their specific barriers, opportunities and proposed business models for implementing V1G/V2G charging in their operations. There was a diversity in the number of different sectors and industries represented, ranging from automotive manufacturers to software developers to grid operators. Their perspective provided novel insights which were not considered (such as the issue of double taxation) and meaningful cross-sector business opportunities for fleet operators, vehicle OEMs, aggregators, and even public parking spaces. The stakeholders' stated barriers and benefits of adopting grid-aware charging and prospective business models are summarized in the table below:

Table 7 Stakeholder Expert Workshop Input
(Source: own illustration)

Barriers	**Benefits**	**Business models**

- *Regulation* (double taxation, lack of regulation to support, enforce or delineate roles) - *Chargers* (cost of capable chargers, lack of uniformity of charging protocols) - *Battery degradation* - *User acceptance* (lack of practical pilot projects, too complex for consumers,too many user requirements) - *Grid infrastructure* (lack of smart meters, the grid isn't adapted for vehicle-grid integration)	- *For TSOs & DSOs* (peak shaving/valley filling/other load management, save money on grid upgrades) - *For users & energy communities* (increase local self-consumption of renewable energies, reduce grid dependence, reduce energy cost, reduce the EV's total cost of ownership) *For all stakeholders* - open up new markets, new market segments and new value streams	- *For fleet operators with predictable (dis-)charging patterns* (revenue while idle) - *For vehicle OEMS with V1G/V2G by default* (manufacturing competitive advantage) - *For small/local energy aggregators* - *For private users* (revenue while idle, exploit time-of-use tariffs, energy arbitrage)

Practical Implications

Researchers, firms and legislative bodies stand to benefit from a comprehensive ecosystem analysis. Firstly, as our analysis fills a clear research gap, our findings can meaningfully contribute to the scientific community and this field's existing body of literature. Secondly, firms stand to gain in order to optimally position themselves within the ecosystem, to get a grasp of their partners' (and sometimes competitors') own activities, and to innovate their own business models. Lastly, policy-makers stand to benefit, as knowledge of this ecosystem can help them uncover where and how it is deficient, alleviate these flaws via policy support, and in turn better accomplish public goals (Talmar et al., 2020a).

Research Limitations

Concerning the ecosystem pie model, it ideally forecasts the ecosystem on a two to ten year basis, which means that in order to make projections, stakeholder's future activities must be anticipated ahead of time – even in an ever-changing ecosystem. Thus, a complete model of stakeholder collaboration is not accomplished in this model, as certain stakeholder activities are not jointly deliberated upon (Talmar et al., 2020a). However, in this case, full deliberation is seldom conceivable and the model can offer a valuable insight into the grid-aware mobility ecosystem. Additionally, the workshop we hosted involved co-creation with managers and experts, and not end users. However, we assume the perspective that the managers are generally well-aware of their customers' needs and channeled them throughout the workshop as well, and that joint collaboration among experts also offers critical and new perspectives to the discussion.

Value

By using innovative and targeted methods to assess this grid-aware mobility ecosystem, this study aims to bring an explorative perspective to create additional value for participating stakeholders and this system's corresponding organizational impact. The underpinning of this research is to lay the foundation for resilient business models in data-driven sustainable mobility, by means of employing novel multi-stakeholder collaborations.

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