Emergence of New Ecosystems for Innovative e-Mobility Services: Exploring Business Model Patterns for Vehicle-to-Grid Technology

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Emergence of New Ecosystems for Innovative e-Mobility Services: Exploring Business Model Patterns for Vehicle-to-Grid Technology

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Abstract

Globally, electric vehicle (EV) penetration is steadily on the rise. In order to overcome electricity bottlenecks caused by EVs' heightened electricity demand, new charging innovations are necessary to properly coordinate electricity procurement. Vehicle-to-grid charging innovations as an enabling technology have been introduced as a solution to fill this void; however, their specific corresponding business models remain uncertain due to its corresponding ecosystem complexities. This paper aims answer the question of how the use of business model patterns can be extended to vehicle-to-grid use cases to enable digital business model innovation in vehicle-grid integration. By identifying business model patterns from conceptional use cases of vehicle-to-grid services, the mechanisms behind such interactions can be uncovered. Our study results suggest that by leveraging digital business model patterns to the context of the vehicle-to-grid market, novel business model innovations have the potential to be deliberated upon and developed. Ultimately, this method can serve an exploratory purpose when investigating digitally enabled market models to overcome vehicle-to-grid ecosystem complexities, and thereby ensure its successful implementation.

Keywords

Digital transformation; business model innovation; enabling technologies; sustainable energy management; electric vehicles; vehicle-to-grid.

1. Vehicle-to-Grid as an Enabling Technology

Enabling technologies that aim to relieve the effects of climate change are heavily found in the energy sector (Nylund et al., 2022), which includes novel exchanges between EVs and (micro-)grids. The role of EVs providing grid services to aid power markets becomes even more prominent amidst the addition of more renewable energies in the energy mix, which are by nature intermittent (Kempton & Tomić, 2005). On a technical level, utilities are making the shift towards an information-based digital architecture, where major activities are digitalized and market flexibility is realized through technical enhancements (Schoklitsch, 2018). Thus, the Internet of Things (IoT) also extends itself into the Internet-of-Vehicles and the Internet-of-Energy (Wang et al., 2018). Due to advancements in information and communication technology, smart grids, and the use of big data, energy prosumption is made possible (Li et al., 2017). This requires real-time data on energy generation and consumption to coordinate local energy supply and demand (Pressmair et al., 2021). Demand response mechanisms rely on data-driven analysis tools to identify and control energy flexibility (Pressmair et al., 2021). Such exchanges are enabled by Open Charge Point Protocols (OCPPs) on the backend the uptake of modern international technical standards (ISOs) (Gschwendtner et al., 2021). For this to take place, the deployment of smart meters with two-way communication abilities as part of an advanced metering infrastructure (AMI) is essential to enable novel business models in the energy industry (Pressmair et al., 2021).

Specifically, new charging innovations have come to the fore: unidirectional vehicle-to-grid/smart charging (V1G) and bidirectional vehicle-to-grid charging (V2G). These charging methods involve the selective (dis-)charging of EVs to correspond to the needs of the grid, and further facilitate a circular economy by mitigating energy waste and ensuring the efficient utilization of resources (Ravi & Aziz, 2022). However, for the effective implementation of vehicle-to-grid technology, one must focus beyond batteries, grids and vehicles alone. The development of sustainable business models incorporating vehicle-to-grid is just as crucial as its technological development, and its future is contingent on its business and economic elements (Sovacool et al., 2020).

2. Exploring Digital Business Model Patterns in Vehicle-to-Grid Ecosystems

Vehicle-to-grid charging presents a hopeful prospect; however, not all such enabling technologies reach broad market penetration (Nylund et al., 2022). When attempting to bring a new technology to the market, its effective commercialization is essential (Chesbrough, 2010). Business model innovation, which is thought to yield higher returns than product or process innovation, greatly benefits new products that are specifically geared toward environmental sustainability (Gassmann et al., 2014; Geissdoerfer et al., 2018).

In addition, new technologies that shake up previously established industries significantly lead to value creation networks, and in turn open up new market segments (Amshoff et al., 2015). The flexibility services made possible by vehicle-to-grid technology create value for many involved stakeholders (Venegas et al., 2021), with the mechanisms behind these interactions being their participation in innovation ecosystems (Sovacool et al., 2020). The interactions among these allied firms are said to be structured as a simultaneous cooperation and competition, termed *co-opetition*, where the cooperation of typical competing firms is to the benefit to all involved (Brandenburger & Nalebuff, 1998). Such 'alliance networks' allow firms to individually contribute a part to its overall collective system, which enable all involved firms to reap a competitive advantage which no single firm could have accomplished by itself (Gomes-Casseres, 1994; Talmar et al., 2020). Ultimately, the desires and acceptance of the end user is a focal consideration in achieving a collective ecosystem value proposition (Talmar et al., 2020). According to Sovacool, business models concerning vehicle-to-grid should indeed acknowledge the role its surrounding innovation ecosystem and their varying interdependencies and exchanges between producers, collaborators and consumers; thus, not just a focus on value and returns alone (2020). Such market models must simultaneously encourage new charging and grid services products, integrate novel infrastructural configurations and reform routines and policies (Abdelkafi et al., 2013; Sovacool et al., 2020). Thus, a systems level approach is warranted.

In our analysis, we have delineated 16 stakeholders within this ecosystem, which are needed to achieve the value proposition for vehicle-to-grid:

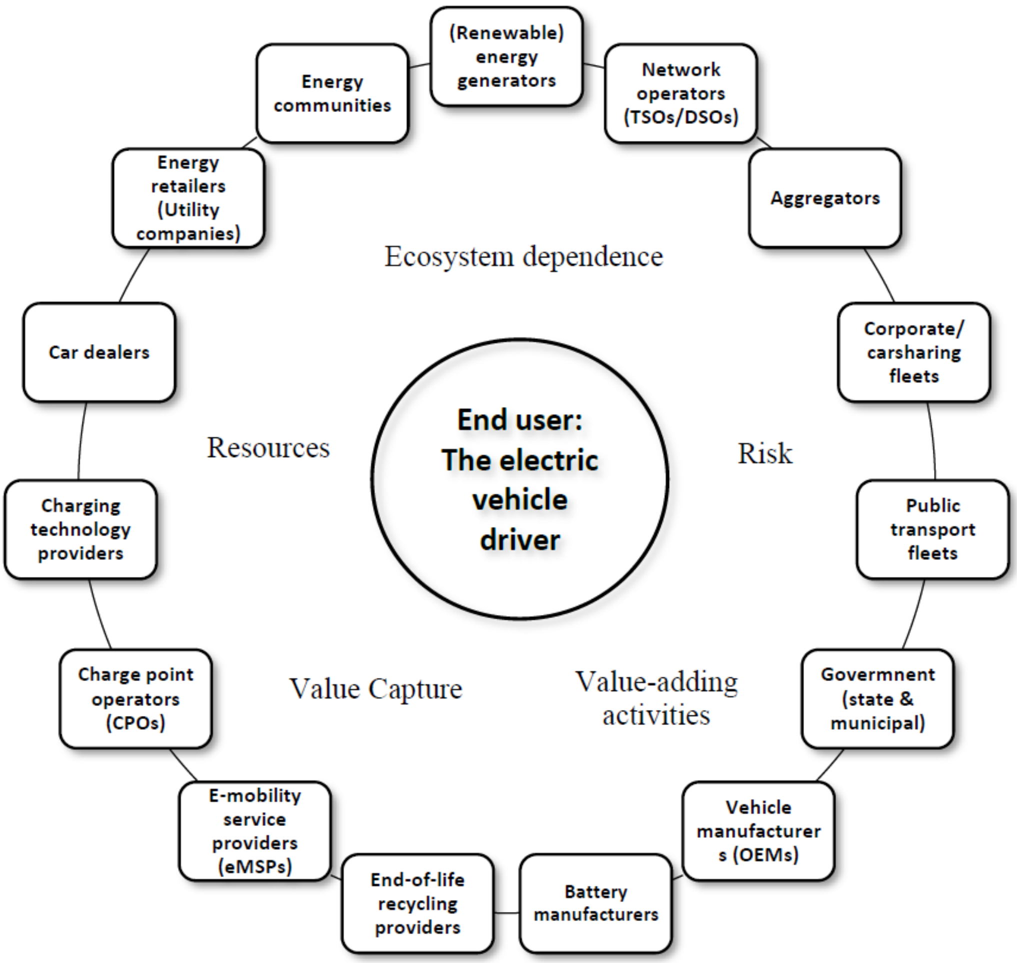

Figure 1 The vehicle-grid integration ecosystem (Thelen et al., 2023, p. 4)

However, a core challenge of value networks is foreseeing the business logic of the ecosystem's market segments and generating business models (Amshoff et al., 2015). Well known business model frameworks, such as the *Business Model Canvas* (Osterwalder & Pigneur, 2010), are typically only used to document and collaborate upon a firm's existing business models and are often criticized as not concrete enough and unable to provoke business model creativity (Amshoff et al., 2015; Eppler et al., 2011). A solution for business management's lack of foresight with regard to designing new business models has given rise to predictive toolkits like business model patterns, such as those by Weill et al. (2006) and Johnson (2010). A more recent set of business model patterns was produced from the University of St Gallen with their *55 Business Model Patterns* (Gassmann et al., 2014), which analysed the most innovative existing business models in recent times and compiled a catalogue of the most recurring patterns that took hold. Such rule-based predictive methodologies have been envisaged to fill business management's gap between business model theory and practical implementation of such models. This is achieved by not only documenting, but also exploring new business model patterns which can be implemented on their own or combined, that are also applicable to different business types and sectors (Gassmann et al., 2014). According to Gassmann, the building blocks for such business models revolve around four dimensions: (1) "*who*" are the target customers, (2) "*what*" is offered to customers, (3) *"how"* are the offerings produced, and (4) *"why"* does it generate profit? (Gassmann et al., 2014, pp. 6–7). Firms can generate business model innovations via patterns in three ways: (1) learning from their own industry's patterns and applying them, (2) exploring external industries' patterns and applying them, or (3) bringing together different patterns to suit their specific needs and objectives (Abdelkafi et al., 2013). Ultimately, even the most resilient business models are not everlasting and must constantly adapt to changing environments; nonetheless, the use of business model patterns was found to effectively mitigate Porter's five competitive forces, or the external threats a firm faces that threaten their competitiveness and profitability (Lüttgens & Diener, 2016; Porter, 2008).

Particularly, contemporary technologies, such as the internet and data-driven innovation, have enabled the revitalization of old business models and the creation of new patterns (Abdelkafi et al., 2013). Specifically, business model patterns have already been applied in the realm of e-vehicles by Abdelkafi et al. (2013), whereby the most prominent business logics borrowed from the auto industry were *bricks and clicks, disintermediation, long tail, product-to-service, leasing, subscription, pay-as-you-go, affinity club* and *freemium*. Business model patterns which were not utilized in the automotive industry but are nonetheless applicable to EVs were envisaged to be *razor & blade, no frills, fractionalization* and *leverage new influencers*. In another work, Laurischkat et al. (2016) has delineated "vehicle-to-grid" as its own business model pattern for EVs. Additionally, Johnson (2010) has attempted to explore the EV's inherent connection with the energy sector, where he extrapolated the *reverse auction* business model pattern regarding EV owners taking advantage of price fluctuations by participating in electricity markets (Johnson, 2010). Abdelkafi et al. (2013) has extended this notion further by formulating an *electronic bourse* pattern, where broker platforms can facilitate bidding and selling electricity. However, the integration of EVs with the energy sector encompasses more than just arbitrage on electricity markets, for which additional research on this topic could not be found. More broadly, the digitization of the mobility and energy sector has enabled many other novel digitally enabled services to take hold, affecting households, prosumers, distribution, transmission, generation and retail (Küfeoglu et al., 2019).

Thus, this research aims to tackle this topic further with the research question: *"To enable digital business model innovation in vehicle-grid integration, how can the use of business model patterns be extended to vehicle-to-grid use cases?"* We surmise that business model patterns that capitalize on optimizing digital data flows will be the most prominent.

3. Method

Within the scope of this paper, prospective business model patterns or combinations thereof from Gassman et al. (2014) that were found to be suitable for the vehicle-grid flexibility services were identified based on use cases found in the literature. Although many scholars have come up with different business model pattern typologies, Gassmann's are regarded as the most extensive to date (Amshoff et al., 2015). Each specific use case brings with it varying actors, objectives and ways of creating value. Additionally, the use cases presented differ by degree of technical complexity and time until market maturity. This paper brings to the fore real-life example of such proposed flexibility services, along with its corresponding business model pattern(s) and ascertaining the "*what, who, how, why?*" building blocks of its business model (Gassmann et al., 2014). Additionally, as these business model patterns are operating in innovation ecosystems, a preliminary contribution is also made to which market stakeholders serve as a *provider of energy flexibility* versus those who serve as a *recipient of energy flexibility.* Their pains and gains are specified, following the value proposition design methodology by Osterwalder et al. (2014).

Figure 2 Building Blocks of Business Model Innovation (Gassmann et al., 2014, p. 7)

The content of this paper was presented to stakeholder experts during co-creation workshops in January and February 2023 on behalf of the international project Grid Aware Mobility and Energy Sharing (GAMES) (https://games-innovation.net/), whose focal goal is to uncover stakeholder requirements and (inter-)dependencies within the context of vehicle-grid integration. These flexibility classifications and use cases serve as a complementor to other preliminary research within the project, e.g. citizen consultation and systematic ecosystem modeling (Talmar et al., 2020). By connecting business model theory with the state of the art of vehicle-grid integration, the principal aim is to lay the foundation for future resilient business models that leverage the EV's capability as a flexible energy asset for (micro-)grids.

4. Findings

Based on our analysis, we have observed the following interaction mechanisms among actors within this vehicle-to-grid ecosystem:

4.1 Flexibility actors

When delineating use cases within this sphere, it is worth establishing who plays the role as a flexibility provider and a flexibility recipient. An overview is below:

The *providers of energy flexibility* are the actors that possess the capabilities to provide flexibility services. In by doing so, providing electricity flexibility alleviates a pain.

Table 1 Providers of Energy Flexibility (own illustration)

	Pains (-)	**Gains (+)**
Properties with a parking lot	The building sometimes exceeds their energy consumption limits and purchasing surplus electricity is expensive	Have a back-up energy reserve and reduce electricity costs
EV fleet operators (corporate fleets, carsharing fleets, public transport fleets)	While the vehicles are idle, there is lost revenue potential	Generate additional supplementary revenue while the fleet is not in use
Energy communities	There is a surplus of unused energy within the community	Generate revenue from their surplus energy reserves

On the other hand, the *recipients of energy flexibility* are actors that obtain flexibility services. In by doing so, receiving electricity flexibility alleviates a pain (note that energy communities possess a dual role as a recipient and provider).

Table 2 Recipients of Energy Flexibility (own illustration)

	Pains (-)	**Gains (+)**
Energy retailers	Incur high fixed costs even during off-peak hours; experience high price volatility buying from wholesale markets	Generate income during off-peak hours; optimize resources; lower the overall cost of providing services by taking advantage of short-term price fluctuations
Distribution system operators (DSOs)	Handles high volumes of grid services which are not always stable; risk of bottlenecks	Improve grid management; optimize resources; avoid curtailment
Energy communities	Mismatches of energy production and consumption; a source of flexible energy storage is needed	Meet their community's demand for dynamic energy by integrating adjacent systems

4.2 Business model patterns

Our research is based on four selected business model patterns from Gassmann et al. (2014), namely:

Table 3 Business Model Patterns used (own illustration)

Integrator	"Has command of the majority of the steps in the value-adding process, including all resources and capabilities in terms of value creation. Efficiency gains, economies of scope and reduced dependency on suppliers result in a decrease in costs and may increase the stability of value creation" (p. 350).

Leverage customer data	"New value is created by collecting customer data and preparing it in beneficial ways for internal usage or interested third parties. Revenues are generated by either selling this data directly to others or leveraging them for the company's own purposes, i.e. to increase the effectiveness of advertising" (p. 350).
Layer player	"A specialized company limited to providing one value- adding step to different value chains. This step is typically offered within a variety of independent markets and industries. The company benefits from economies of scale and often leads to more efficient production. Furthermore, the established special expertise can result in a higher quality process" (p. 350).
Two-sided market	"Facilitates interactions between multiple interdependent groups of customers. The value of the platform increases as more groups or as more individual members of each group are using it. The two sides usually come from disparate groups, i.e. businesses and private interest groups" (p. 350).

These business model patterns were based off four use cases for vehicle-to-grid charging found in the literature, in order from lowest to highest degree of technical complexity and time period until market maturity (Nymoen et al., 2022):

Table 4 Locating Business Model Patterns with Use Cases of Vehicle-to-Grid Energy Flexibility Services (own illustration)

		Business Model Pattern			
		Integrator (23)	*Layer player (24)*	*Leverage customer data (25)*	*Two-sided market (52)*
Use Cases	*Increase in self-consumption*	X		X	
	Emergency power supply	X		X	
	Bidirectional load management		X	X	
	Local flexibility services		X	X	X

1. Business model patterns*: (23) integrator, (25) leverage customer data*

   a. Use case: *Increase in individual or energy community self-consumption (Low technical complexity, market maturity in the short-term)*

Description: Renewable energy sources (usually solar PV) should be used as extensively as possible directly within a local system without feeding it into the power grid (such as an autonomous microgrid/energy community). The excess energy in the EV's battery is supplied to adjacent systems when needed. Increasing self-consumption is ecological, because collective renewable energy resource consumption is optimized; it is also economical, as energy communities do not buy electricity from the grid (Nymoen et al., 2022). By integrating these complementary products together and making use of these different data points, the value proposition is independence from energy suppliers and autonomous energy management.

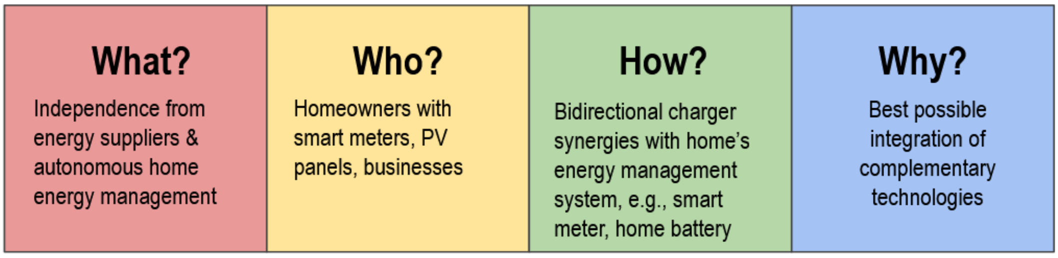

Figure 3 Increase in self-consumption business model (own illustration)

Practical example: The Belle-Ile-en-Mer microgrid at the entrance of the "VVF Club Intense" vacation villa in France, under the joint partnership of Mobilize (Renault Group) and Morbihan Energies (Mobilize, 2018). This microgrid focused on tourism integrates solar PVs, an intelligent energy management system (EMS), 10 second-life Renault Zoe batteries and one V2G retrofitted prototype of a Renault Zoe. The energy generated from the PV system is to be used in real time or stored in the EV battery or the 10 second-life batteries in order to use it at a later date when there is more energy demand within the microgrid. Interim results demonstrated that the integrated ancillary services of the EVs was particularly helpful for heating bungalows and keeping heating costs down. This has allowed the French island to extend their tourist season (Randall, 2018).

   b. Use case: *Emergency power supply* (*Low technical complexity, market maturity in the short-term)*

Description: By taking in surplus energy from renewable energy sources, the EVs act as on-demand reserves of decentralized energy storage when needed (Ravi & Aziz, 2022). The value proposition is reduced surplus purchasing during peak times and reduced electricity blackouts. Ultimately, grid congestion is mitigated. This requires the integration of electric vehicles, solar PV and stationary batteries to (partially) replace the grid in case of an energy shortage or outage. Constant communication flows between the integrated objects via real-time data facilitate this exchange.

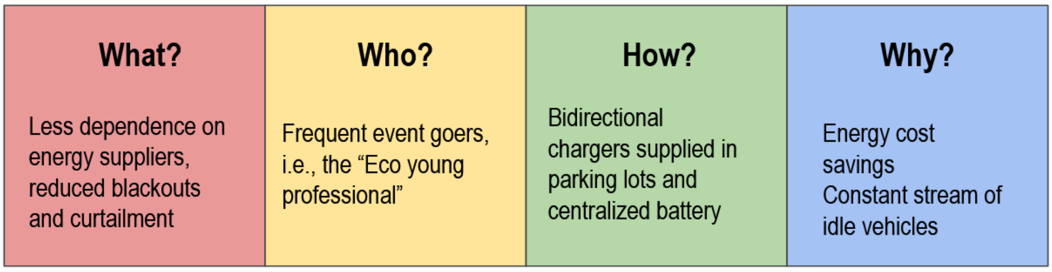

Figure 4 Emergency power supply business model (own illustration)

Practical example: The installation of vehicle-to-grid communications in the Johan Cruijff ArenA stadium in Amsterdam, which is the largest energy storage system in Europe using second-life and new EV batteries in a commercial building (Holsen, 2018). The stadium incorporates 15 EV vehicle-to-grid charging stations, 148 stationary Nissan Leaf batteries, and 4.200 solar panels on the roof of the stadium (The Mobility House, 2019). When the stadium's electricity load is very high, the stadium instead utilizes the energy stored from the electric vehicles connected in its parking lot or from the 148 stationary batteries, instead of drawing surplus electricity from the grid. As purchased surplus energy from the grid can be very costly, this mechanism also serves to provide cost savings. This large amount of electricity storage capacity (3 mW) also serves to provide power to the whole stadium in case of a power blackout (Holsen, 2018). To implement this solution, there is the integration of the Johann Cruijff ArenA's processes, the intelligent software provided by The Mobility House, solar PVs, stationary batteries and willing owners of electric vehicles parked at the stadium. Interim results point to a large reduction in the stadium's CO_2 emissions, to the order of 7.800 tons per year, and a smooth integration of this new energy management into the stadium's infrastructure. Due to its success, the stadium will now expand its 15 EV vehicle-to-grid charging stations to 200 stations to provide even more ancillary support (Holsen, 2018).

2. Business model patterns*: (24) layer player, (25) leverage customer data*

   a. Use case*: Bidirectional load management* (*Medium technical complexity, market maturity in medium-term)*

Description: Reduction of possible load peaks through controlled charging and discharging of EVs, where several EVs are charged at times of low load and discharged at times of peak load. EVs are also prioritized in terms of mobility requirements. When necessary, vehicles feed energy back to enable the charging of higher-priority vehicles without exceeding the maximum reference power. In addition to its applications in a commercial context, e.g. parking garages and other locations with high volumes of charging cars, this use case can also be applied in private homes (e.g. housing complexes, shopping centers with housing above). Here, the focus is on optimizing the load peaks within a defined system instead of optimizing several EVs among each other (Nymoen et al., 2022). Being the layer intermediary between charging stations, energy management systems, and possibly local energy production (e.g. solar PV), a market player here harnesses these data points for optimal local load management.

What?	Who?	How?	Why?
Charge your BEVs simultaneously without load surplus	Owners of private homes, apartment and commercial buildings with >1 BEV	Bidirectional chargers & smart charging platform	Low marginal cost of each additional connected customer

Figure 5 Bidirectional load management business model (own illustration)

Practical example: FLEXeCHARGE's smart charging platform in Denmark offers software to conduct load management for private homes, apartment buildings and commercial buildings (FLEXeCHARGE, n.d.). On the interface, the connected EV's load management can be monitored and load management preferences can be edited. Here, certain vehicles can be granted prioritized charging if needed, and the software is also capable of integrating solar PV production data within the building's overall energy production and consumption.

3. Business model patterns: *(24) layer player, (25) leverage customer data, (52) two-sided market*

    a. Use case: *Local flexibility services (High technical complexity, market maturity in the long-term)*

Description: Optimized EVs serve as local flexibility sources for grid operators (DSOs/TSOs) to resolve network bottlenecks via (dis-)charging based on a network signal or by calling on an aggregator that bundles the services of different vehicles. These signals can be based, for example, on a locally excessive load or consumption peak. EVs can be used specifically to provide regional flexibility with the aim of avoiding the curtailment of renewable energy sources (Nymoen et al., 2022). Additionally, using V2G in this context can also bypass the need to upgrade grid infrastructure (Ravi & Aziz, 2022). An aggregator here would function as an intermediary between aggregated EVs and the electricity grid, and their flexibility services would provide specialized know-how to harness multiple data points for optimal selective (dis-)charging. This intermediary would facilitate exchanges in this two-sided market, to the benefit of both EV owners and grid operators.

What?	Who?	How?	Why?
Data-driven value to benefit TSOs, DSOs and avoid curtailment	Charge point operators and fleet operators	Large-scale aggregation of EVs	Achieve grid stability (by means of aggregators, CPOs and fleet operators)

Figure 6 Local flexibility services business model (own illustration)

Practical example: The project *EVFlex* will develop flexibility aggregation services for DSOs and TSOs to achieve grid stability (HSLU, n.d.). This project develops the data management approach and algorithmic basis for the large-scale aggregation of electric vehicles. Although full local flexibility services are still premature, project *EVFlex* aims to make a meaningful contribution to the ideal. The interim results of *EVFlex* are yet to be made available; however, the project underlined an emphasis on the interactions between charge point operators, EV fleet owners and system operators (DSOs/TSOs).

5. Conclusion and Future Outlook

For the effective implementation of vehicle-to-grid technology, the development of sustainable business models is a crucial success factor (Sovacool et al., 2020). By attempting to make the shift from theory to practice by extending business model patterns to vehicle-to-grid use cases, this study aims to bring an explorative yet concrete perspective on the business logic of such corresponding business models. As the process of vehicle-grid integration process is still in its initial stages, robust business models are yet to be fully established, which warrant further exploration. As recognized by the use cases, such longstanding commercialization patterns have already taken hold by new enterprises that capitalize on vehicle-grid integration. We second other scholars' sentiments that the method of applying business model patterns is a generally helpful means to formulate the foundations of novel business models (Abdelkafi et al., 2013; Amshoff et al., 2015; Eppler et al., 2011; Johnson, 2010; Lüttgens & Diener, 2016; Weill et al., 2006), and is particularly valuable when applied in the e-mobility and e-energy sector (Abdelkafi et al., 2013; Johnson, 2010). As hypothesized, the most cited business model deduced from the vehicle-to-grid use cases were ones that leveraged data to create services for energy flexibility.

The process of identifying business model patterns was trying, as there were 55 patterns to be considered, and it was a complex procedure to select the business model patterns that were the most fitting to the descriptions of the services. Although the *leverage customer data* pattern was anticipated, other patterns (such as *layer player*) were less straightforward. This complexity is further demonstrated as all use cases exhibited not just one pattern, but rather a combination of business model patterns. These findings were presented to stakeholder experts during co-creation workshops in January and February 2023 on behalf of the international project Grid Aware Mobility and Energy Sharing (GAMES) (https://games-innovation.net/). Here, the use of business model pattern thinking was generally appreciated by the experts in the mobility and energy sector, who ranged from the fields of consulting to academia, original equipment manufacturers (OEMs), government agencies, digital service providers and grid operators (DSOs/TSOs). Many productive exchanges were had after the presentation of these business model patterns. Not only that, but within the scope of this project, business model pattern delineation was found to be a powerful complement to further preliminary research within the project, e.g. systematic ecosystem modeling (Talmar et al., 2020).

By recognizing time-tested patterns of business models in the nascent vehicle-to-grid market, both incumbent and enterprising firms in this area can gain an understanding into this sector's business logic. In doing so, firms can revitalize old business models or create new ones. In doing so, market players can establish a foothold in this new ecosystem and can further solidify the commercial success of their digitally enabled products/services. As 90 percent of business model innovations are repurposed or combined from previous ones (Gassmann et al., 2014), we anticipate that vehicle-to-grid business models are no exception and will similarly be transferred and reconfigured from previously successful business model innovations.

6. Limitations of Research

This study focused on the established business model patterns of Gassmann et al. (2014). Although these patterns are thought to be the most extensive collection of patterns to date (Amshoff et al., 2015), this study did not consider other older business model pattern typologies, such as that of Weill et al. (2006) or Johnson (2010). Additionally, the use cases discussed were the ones relevant within the scope of the GAMES project, although many additional pertinent use cases exist. For further reading on these use cases, consult Nymoen et al. (2022), Ravi & Aziz (2022) and Sovacool et al. (2020).

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