Lessons Learnt - A cross-case analysis of six, real-time Smart Charging and V2X Operational Pilots in the North Sea Region

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Summary

The SEEV4-City project, funded by the EU Interreg NSR Programme, aims to demonstrate electric mobility solutions, integrate renewable energy and encourage uptake in cities. Six Operational Pilots in four countries implement different levels of Smart Charging and V2X technology. The variation and complexity of the different OPs provide a number of valuable Lessons Learnt. Through a questionnaire and interviews, OP inputs and experiences were documented, and analysed. Key conclusions: V2X setups need to be tailor-made by unifying existing, yet not readily compatible components; it pays to know the V2X market; and there is no single, generic, universally-applicable V2X business model.

Keywords: EV (Electric Vehicle); Smart Charging; V2G (Vehicle-To-Grid); Demonstration; Energy Storage

1 Introduction

Enabling clean and green transportation by increasing the number of Electric Vehicles (EVs) powered by renewable energy (RE) is a top priority in Europe [1]. However, this can create challenges as the RE supply does not always match the electricity demand of the EVs. Incorporating Smart Charging (SC) and Vehicle-to-Infrastructure (V2X - transmission of electricity from an on-board battery to infrastructure [2]) or Vehicle-to-Grid (V2G - using the EV battery to provide storage for the electricity grid [3]) technologies can lead to a better exploitation of RE, balancing of the grid (Figure 1 and 2) and avoiding the grid reinforcement.

Figure 1. Without Smart Charging and V2G.

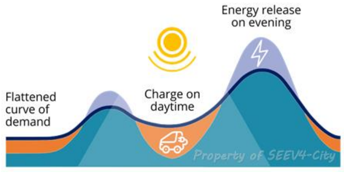

Figure 2. With Smart Charging and V2G.

The SEEV4-City project (Smart, clean Energy and Electric Vehicle 4 the City) demonstrates how Electric Vehicles can support the energy transition in cities by (i) increase in zero emission kilometres driven, (ii) increase in Energy Autonomy a (iii) potentially avoided grid related investments due to grid optimisation. The Operational Pilots (OPs) aim at demonstrating SC and Vehicle-to-X (V2X) (at different scales, namely: Vehicle2Home (V2H), Vehicle2Business (V2B) and Vehicle2Street/Neighbourhood (V2N). The process and experiences of making the pilots operational has taught us a number of valuable lessons. This paper focuses on Lessons Learnt from the initial phase, including the procurement of SC and V2X. We have explored previous or ongoing work of other V2X projects [4] to identify any important lessons for those embarking on their own initiative. Below are the key findings, derived from the projects; Itheca, City-zen, EFES, CleanMobilEnergy, Lombok V2G, as well as the Cenex V2G Market Study 2018 [5]:

- The high price of commercially available V2X units in combination to competition with managed charging capable of demand load balancing (sometimes referred to as V1G) and different Feed-in-Tariff energy taxation.
- Not many V2X hardware providers and limited choice of EV models enabled for V2X in the market.
- A longer-than-usual lead time for procurement and implementation can be expected.
- Limited suitable locations for the installation of V2X units.
- Lessons Learnt directed at the market:
    - For Distribution Network Operators (DNOs): adapt to existing/uniform interconnection standards & processes; clarify the value of Distribution System Operator (DSO) services; design service specifications with V2X in mind.
    - For industry: Improve the hardware; Need for V2X targeted services; Segment user behaviour. [6]

These outcomes can be used within the project and provide guidelines and recommendations for other cities or organisations considering developing a V2X or SC project in the future.

2 Methodology

This study aims to collect and present information that reflects both the positive (enablers) and negative (barriers) experience of the SEEV4-City project through a Lessons Learnt cross-case analysis. A template with a questionnaire was created, and questions in this have been answered by OP representatives and related stakeholders. It was observed that there was a large discrepancy in how the questionnaire was filled in by each participating OP. Some provided us with elaborate answers while others limited. Thereafter, meticulous, tailor-made interviewed were carried out with each OP through conference calls in order to fill in the gaps. Four areas were documented i. Project/Process Management, ii. Technical Management, iii. Human Factors and iv. Other aspects. Under each area, a list of enablers/barriers has been specified (i.e. Technology, Economics/Fiscal, Legal & Regulatory, Social, Environmental, Supply Chain, Information & Data and Resources & Coordination).

3 SEEV4-City Operational Pilots

The SEEV4-City project consists of six OPs in five different cities in the Interreg North-Sea region: Loughborough (United Kingdom), Kortrijk (Belgium), Leicester City (United Kingdom), Oslo (Norway) and Amsterdam, (The Netherlands). In this section, the OPs are briefly introduced, based on their size/scale.

3.1 Loughborough OP

The first and smallest pilot was installed in the city of Loughborough, United Kingdom. The Vehicle2Home OP aims to identify the (possible) added value of Smart Charging and Vehicle-to-Grid, using additional storage for optimised energy generation and consumption in households [7]. This Vehicle2Home OP includes a single household with a PV system, a static energy storage system and one EV. The PV system has an installation size of 4 kWp and the static storage system has a capacity of 2 kWh, which was operated by Moixa [8]. The Electric Vehicle is a Nissan Leaf with a 24 kWh Lithium-ion battery. The EV charger has bi-directional charging capabilities and was provided by Potenza Technology [8]. The complete energy system was inherited from a previous energy project called the Ebbs and Flows of Energy Systems (EFES) [9].

3.2 The city depot of Kortrijk OP

In Kortrijk (Belgium), an OP is running at the city's technical services depot, adjacent to a sport centre operated by the city. This Vehicle2Business pilot consists of a smart energy system that includes PV., a battery storage and a SC station. The PV system currently covers about 50% of the total energy consumption of the site with a maximum output of 78.75 kWp [10], and was installed prior to the SEEV4-City pilot's starting point. One EV charging point is operational and the energy storage system will be provided by the KU Leuven (KUL). The main goals of the Kortrijk pilot are to increase the energy autonomy, ultra-low emission kilometres and reduce the energy exchange with the grid [10]. This OP is a well-known innovation playground for the Flemish region. Kortrijk strives to be the first city of Flanders to become energy neutral.

3.3 Leicester City Hall OP

The City of Leicester joined the UK 100 group of cities and towns in pledging a transition to clean energy sources by 2050. Leicester's pilot is based at the City Hall headquarters of Leicester City Council. The existing components of the Vehicle2Building pilot are 90 solar panels and four Nissan Leaf electric vehicles. The solar panels provide 2.5% of the office building's energy consumption and were installed prior to the SEEV4-City project. The four EVs are used by the City Council's staff to support a range of council services. The pilot will replace the four existing uni-directional chargers with smart, bi-directional versions. An Energy Management System (EMS) will be provided to co-ordinate the workings of both the existing and the new elements of the pilot. The V2B charger's handshake with the EMS, which links to the City Hall building management system in order to provide a Mains supply to the EVs when there is no solar.

3.4 Amsterdam (Energy) ArenA OP - Johan Cruijff ArenA

The ArenA is a sports stadium in Amsterdam, The Netherlands, with a capacity of 68,000 seats, and is ranked as one of the most sustainable stadiums in the world. The Vehicle2Business OP currently consists of a PV system and a static battery system. The PV system on the roof of the venue has a maximum output of 1.128 MWp and produces around 12% of the total energy consumption [11]. The battery is supplied by Nissan, consisting of Nissan Leaf battery packs with a capacity of 2.8 MWh (equivalent to 140 battery packs) [12]. Stakeholders in this OP are the Amsterdam Energy ArenA, Eaton, Nissan as well as Liander as network operator [12]. The Amsterdam ArenA employs the battery to support the stadium's energy system during events, as backup functionality for the Frequency Containment Reserve (FCR) market of TenneT [13].

3.5 Oslo Vulkan Real Estate OP

The Vulkan real estate site in Oslo is owned by Aspelin Ramm Eiendom AS and includes one of the largest and most advanced EV charging garages of Europe. This Vehicle2Neighbourhood pilot has 100 AC chargers and two DC chargers in operation. A stationary battery supports the DC chargers for fast-charging of EVs. All EV chargers have a SC functionality and charge at 3.7 kW by default. The stationary battery installed has a capacity of 50 kWh. The complete energy system is installed (custom-built) and managed/monitored by Fortum (Charge & Drive). Fortum is the innovation partner of both Aspelin Ramm and the Oslo City Council.

3.6 Flexpower Amsterdam OP

Another operational pilot in Amsterdam is called the Flexpower Amsterdam project. This Vehicle2Street pilot anticipates the growing number of EVs and the existing issues with the electricity grid. Since the local grid is not built for the anticipated demand, SC is introduced first to understand the potential to relieve the net capacity using flexible charging speeds. Therefore, 450 SC stations, with two sockets each, are currently installed across the city. Charging speeds during non-peak hours are capped at a maximum of 24.2 kW, while the speeds of charging during peak hours capped at to 5.5 kW [14]. There are six Static Smart Charging (SSC) profiles for morning, evening and weekend. In this manner, the municipality of Amsterdam is trying to balance the supply-demand dynamics with the use of RE produces locally. The network operator is Liander and the charge points are operated by NUON and Heijmans.

4 Cross-case analysis

The analysis is broken down into four phases; (i) preparation, (ii) procurement, (iii) installation and (iv) operation phase, followed by the outlook of the pilots. Common enablers and barriers are discussed, as well as specific highlights of OPs that could contribute to the Lessons Learnt.

4.1 Preparation phase

In order to make well-educated decisions on procuring the required equipment for enabling V2X, the pilots each went through their own preparation phase. In this phase, pilots gather the technical specifications and requirements. The approach adopted for gathering the technical information differed in each OP. Kortrijk is cooperating with the KU Leuven in developing the energy system. The university hired researchers to investigate the possibilities of using an off-the-shelf battery, or even a salt water flow battery from Aquion, since developing and installing their own custom static battery pack brings too much risks in terms of responsibility. The cooperation with the university creates opportunities from a scientific viewpoint. Moreover, there is no commercial interest from the university side. This contrasts with the Oslo Vulkan car park site, whose innovation partner is Fortum Charge & Drive, and a real estate company as the commercial building owner. Fortum is responsible for the whole energy system. The installation company solely needed the technical information from the building. Leicester City Council follows a similar route and anticipates procuring a dedicated EMS rather than reprogramming the existing City Hall building management system with new connections and priorities. This would be expensive and pose unnecessary risks to the building management system operation, should problems arise with the V2X equipment in the pilot. As part of the procurement documents, the Council has prepared an electrical factsheet on City Hall to help suppliers get a good understanding of the electrical architecture their systems will become part of. To fill in the existing knowledge gaps in this phase, attending workshops and visiting of running pilots are deemed to be valuable.

4.2 Procurement phase

Every OP setting is unique and needs a tailor-made energy system. Some OPs are required to follow a certain procurement method, whereas private owned pilots simply look for the best deal. In some cases, funding was a necessity in order to finance the project, yet banks deem this kind of project as a high-risk investment and were not ready to invest. Funds for the Amsterdam Arena were raised at the Amsterdam Klimaat en Energie Fonds with a low interest rate. A ten-year Return on Investment (RoI) for the battery storage is calculated, based on the average FCR prices and a set fee for the backup functionality. The Amsterdam ArenA strived to build a battery bank consisting only of second-life batteries, but due to the low availability, now just 40% of the batteries are second life. This is an issue that may be resolved over time when more EV batteries flow into the static battery market for second life usage. The ArenA aimed to accept second-life battery cells with a State of Health (SoH) of <82%. The Oslo OP uses a brand-new Li-ion stationary storage battery but wants to consider second life batteries to expand the 50 kWh static battery capacity, or replace it in the future. Their battery costs €80,000 and the calculated RoI is nine years. Fortum built the entire energy system and invested (human) resources in the development phase to penetrate this new market. Leicester considered a 24 kWh of static battery storage to boost the pilot's energy autonomy. However, the evening discharge from EV batteries is expected to have a bigger impact on energy autonomy. When considering the extra costs and complexity from adding storage as well as the energy losses from PV to storage to EV, this element was not considered to be value for money. Some organisations may find a barrier in procuring V2X units at this stage given that some V2X units do not carry the CE mark yet, and the number of V2X unit manufacturers is limited. For example, ICT procurement in the Leicester OP will need assurance from suppliers that the models they are proposing will get CE certification. Failure to get this guarantee creates the risk that the Leicester City Council will have to remove the chargers, once certified ones are on the market. The current prices of the V2X units are very high compared to regular chargers, which may form a barrier for procurement (e.g. Amsterdam ArenA reports prices of a factor 10 compared to regular chargers). For regular (smart) charging units, the Flexpower OP by the Municipality of Amsterdam needs to pay connection costs of €700 per connection a year to the DNO, a large sum for its 450 smart charger stations and a possible barrier to expansion. Although the DNO benefits from the use of SC, the Dutch Autoriteit Consument & Markt (ACM) regulates the connection costs prices and states that this price must be equal for everyone in The Netherlands [15]. This differs from Germany, where capacity and pricing flexibility was used to incentivise the instalment SC units to avoid grid reinforcement investments [16]. In 2022 this pricing table is to be reviewed in The Netherlands and the experiences of the SEEV4-City and related projects need to be taken into account. This is essential for the development of the right incentives to boost the uptake of innovative charging solutions and anticipate the challenges the electric grid will face when scaling up further. In the Loughborough OP the equipment was inherited from the EFES project, thus no additional procurement of equipment was necessary.

4.3 Installation phase

Although V2G stands for Vehicle-to-Grid, most pilots do not produce enough energy to export regularly into the electricity grid. Additionally, to export to the grid, one must comply with DNO requirements that are more stringent than keeping the installation 'behind the meter'. Moreover, in Norway, the quality of the produced energy must exceed the quality of energy bought from the grid while the price one receives for the exported energy is sometimes very low, which may also be a barrier in other countries. Therefore, most of the OPs seek to improve their own Energy Autonomy (defined as a higher utilisation of local RES by using EVs for energy storage to even out the peaks and valleys of the highly variable supply, which is possible with Smart Charging and V2X [17]), as the priority using RES, static batteries and EV batteries for bi-directional charging. Bi-directional charging requires the use of V2X units. Moreover, DSOs have a monopoly, which makes transferring energy between buildings impossible. Therefore, increasing the Energy Autonomy is only possible on a building level. In the Loughborough pilot, one V2X unit was installed. Apart from commissioning issues, the units performed as expected. The Amsterdam ArenA pilot procured MagnumCap V2X units provided by Enel, however, during testing by The Mobility House the units did not perform as specified. The units stopped reacting to commands from the controller, and MagnumCap was not able to fix the issue (for as yet unknown reasons). Now the ArenA is replacing these by EV-tech V2X units. One of these MagnumCap units is being studied by KUL to determine why performance as not as expected. KU Leuven is programming another unit to integrate into their own system, though, this unit is not installed yet. In Oslo, the cooperation with Fortum faced no problems or delays. However, Oslo City Council would like to have a higher resolution of data in terms of different user groups (residents, professional users, and open city users).

4.4 Operation phase

Most projects have multiple development or procurement phases but are partially operational in the meantime (see Table 1 for OPs' current charging capabilities). For instance, the municipality of Amsterdam divided

Flexpower in four phases (see outlook) of which the first phase of which was finished recently (after successfully implement 52 charging poles equipped with the SSC, the OP was ready to scale up without having to reinventing the wheel). For now, the Flexpower project is mainly focused on SC. Kortrijk has one operational-unidirectional charging unit, which is used by their electric delivery van (a Nissan E-NV200) following the same delivery route daily. Most of the developments are currently being conducted in the laboratory of KUL, with a remote data access to the depot (though with some data reliability issues). The KUL developed algorithms (currently being tested and simulated) to optimise the system, which run on flexible energy tariffs that is bought by the hour from the Belgian Power Exchange Belpex. In 2017, using Belpex was calculated to be 15% more cheaply on average, however, due to changes in the energy mix (less power generated by the nuclear power plants [18]), the approach may turn out more expensive. The Loughborough pilot ran for just less than a year, until the energy system was disconnected due to building works at the property. A fault occurred at recommissioning the energy system. In addition, Moixa stopped their activities for the project, while Potenza Technology's business interest moved away from V2X technology and discontinued support. This OP is not operational and seeks for a new location to continue its operation in a new setting due to likely sale of the house. Leicester's V2X system is a behind the meter operation. The EVs on charge at the end of the working day will initially be available to provide a controlled discharge to City Hall of the residual energy in their batteries. This will help City Hall to meet its 35-40% baseload energy requirement during the expensive evening electricity peak demand period. Overnight recharging can be scheduled, utilising cheaper electricity rates. In Oslo, the Vulkan estate car park has 100 AC chargers, two DC chargers and a 50 kWh battery. The V2X units require a software modification in order interact with V2X-enabled EVs. Initially, users were able to choose what speed to charge with via a mobile application. Besides the default speed, the user could charge at 7.4 kW, 11 kW and 22 kW. It turned out to be too complex for users to deal with this model. Flexible charging is new for many EV drivers making it hard to develop a successful business model for EV drivers. The ArenA has a 2.8 MWh battery in operation to support the stadium's energy system during events and as backup functionality for the PCR market. The Mobility House gathers all the data (building consumption, PV energy generation, PCR market) and manages the energy flow from the energy storage system to or from the grid. Once the V2X units have been installed, the ArenA OP considers free parking for V2X users during events, so people can charge their car at home for about €8 and not be billed €20 for parking.

Table 1 Overview of the OP's current charging capabilities (March 2019)

PILOT	SMART CHARGING	V2G	V2B	PLANNING V2G
Amsterdam	Yes	No	No	In a later phase
Kortrijk	No	No	Is the objective	Not a priority
Loughborough	-	No	Yes	Not a priority
Leicester	-	No	Yes	Not a priority
Oslo	Yes	No	In a few years	Not a priority
Amsterdam Arena	No	No	Yes	Yes

4.5 Overcoming difficulties

Facing and overcoming difficulties is inherent to implementing innovative solutions, especially when the project has varied configurations and different stakeholders. Commissioning of the system appeared to be sensitive to delays for the Loughborough pilot (or rather the EFES forerunner); the delay took about a month until the issues were solved (the exact details are unknown). Another process sensitive to delays, turned out to be the case for building customised stationary battery packs for the Amsterdam ArenA and Kortrijk OPs. The Amsterdam ArenA experienced compatibility issues using a mix of new and second-life batteries. Balancing the second-life batteries with the new batteries proved far more difficult than expected, which led to a delay in development of the Battery Management System (BMS). Also, communication between various system components and safety installations took longer to set up. A problem for the qualification profiles for the FCR market was that charging speed could not be guaranteed as it is reduced once it reaches a certain State of Charge (SoC). These qualification profiles were changed by TenneT right before the launch in June 2018, therefore, the system required a redesign, causing an overall delay of five months. In terms of safety, the fire department is open to making new regulations. KUL were initially considering a second life stationary storage made of Volkswagen (VW) batteries for the Kortrijk pilot. Unfortunately, VW could not yet provide sufficient guarantees to the performance of the battery pack at this point. A 7 kWh battery with customised BMS was built instead, but the battery suffered a short-circuit. A commercial market solution will be implemented instead. In Oslo the OP data is gathered by Fortum. However, this is mainly recorded data from the charging point - such as charging sessions and amount of kWh charged. There is no hard data available regarding the characteristics of the cars, (such as EV battery capacity, SoC, etc) or soft data (such as the type of cars or state of ownership). Retrieving the soft data is not interesting for Fortum from a business case perspective. It would be of interest from a scientific and contextual perspective (and may well be of commercial strategic interest by the real estate company) but it requires additional human resources to analyse the data, which is expensive. Oslo, as well as other OPs, struggles with getting guarantees by the OEMs to enable V2X for bidirectional charging. Shortcomings in V2X standards charging units, infrastructure and vehicle-grid-integration caused challenges, but are expected to be resolved in the coming years (>2025) [19]. It resulted in additional time spent to find compatible solutions and required additional provider support for all OPs. Another barrier is the current price of the V2X units, and the procurement lead-times are also longer compared to regular EV charging units. For Leicester, Hitachi have indicated a four-month lead time, which is a challenge given the project timescale. The Leicester pilot is already delayed due to issues related to the impact of council-wide resource constraints. Leicester's ICT Procurement launched a Pre-Engagement advert to the market. Most suppliers of V2X chargers are based outside the UK, and this may complicate and the lengthen the process of responding to an Invitation to Tender. Having prior notification of an upcoming procurement window of opportunity is expected to help suppliers provide robust tender responses.

4.6 Outlook

In general, most of the OPs have the objective to make V2X units operational, but this depends on multiple factors such as (i) the amount of RE produced, (ii) unknowns in battery pack degradation, (iii) availability of V2X-enabled cars, (iv) high prices of V2X charging units, (v) connection costs, (vi) the business use case (is it profitable or rewarding to feed electricity back into the grid), (vii) energy autonomy, self-sufficiency & self-consumption preferences and (viii) trade-offs. The priority is to increase the OPs' energy autonomy. The ArenA and Kortrijk pilots are in the process of scaling up their V2X units to 3 and 20, respectively. The ArenA will also install 15 regular charging stations. The Leicester pilot has been hampered by resource constraints. Steady progress is now being made, but the likely long lead-time for the V2X chargers remains a concern. The continuation of the Loughborough OP is being investigated, the OP would require a similar setting on a new location. The Flexpower project development is divided into four phases: (i) controlled SC for grid optimisation (completed), (ii) include the calculation and prediction of RES (due summer of 2019), (iii) include real-time monitoring and switching of SC intensity depending on RES generation and EV demand (requires extensive simulation to build effective business models, e.g. in winter times, when PV-installations generate less RE), (iv) and lastly, implementing V2X(B/N). Predictive modelling will become more challenging and complex with a burgeoning EV car fleet and the implementation of RES prediction (solar energy forecasting).

5 Discussion

The Smart Charging and V2X technology are, at present, largely applied in demonstrator pilots. In order to accelerate the uptake of this technology for similar projects, the barriers and enablers of the six SEEV4-City OPs were identified using qualitative data gathered by questionnaires, structured in-depth interviews. These Lessons Learnt will be a valuable guide for others involved in similar projects in the future. The results found in the analysis share similar results with respect to the technical level and policy. However, differences are found due to the unique nature of each pilot and the regional variations. A few points of this study were found to be in common with previous studies, such as; (i) the significantly higher prices of the V2X units, which result in a poor competitive position compared to unidirectional charging units; (ii) a limited market for the V2X charging units as well as for V2X capable EVs; (iii) long lead-times for purchase of bi-directional chargers; and (iv) issues regarding hardware compatibility between V2X components. On the other hand, this study provided a few new insights, such as; (i) risks of differences in data synchronisation, (ii) definition of measuring points/schematics and interpretation of the data collected when using existing data collection systems; (iii) it is difficult to evaluate deferral of grid investment costs due to network & location-specifics and variations in the way DSOs calculate the grid reinforcement and losses; (iv) V2X standards for grid communication and V2X enabled vehicles are in the pipeline, but it will still take several years before implementation; (v) and legislation for Feed in Tariff taxation and capacity flexibility may change in the coming years in several regions/ countries. Suggestions for future research are: a) Identify a strategy for (wider) V2X roll-out opportunities in cities considering (i) grid infrastructure, (ii) energy demand trends, (iii)

EV usage patterns, (iv) RE generation (existing or planned), (v) area planning and (vi) (public) transport infrastructure; and b) Identify successful business models of such demonstration pilots that involve EV user participation in applying flexible charging in combination with V2X.

6 Conclusion - Lessons Learnt

It is common for any new innovative technology to face hiccups in the initial stages of execution. Proper anticipation, identification of problems faced, and their timely rectification is paramount. Therefore, sharing one's experiences and insights will help others to learn and avoid the same mistakes. In this direction, we present the Lessons Learnt from the SEEV4-City OPs, which will be an invaluable guide for others embarking on similar initiatives. The following four main Lessons Learnt have been identified:

1. The V2X market is not fully mature – one must be prepared to adapt and adjust according to the constantly changing landscape – this calls for close cooperation between relevant stakeholders.

- It is likely that no single supplier can provide a 'total system solution' - this will probably result in the formation of consortia and beneficial partnerships with other stakeholders.
- eMobility, specifically SC and V2X, is an area where a lot of innovation is ongoing. The scope, procurement, implementation and monitoring methodology which is adopted at the outset may change throughout the development stage as new opportunities are identified (which were not initially anticipated).
- Each V2X project is different in size, scope and complexity; therefore, it is practically not possible to have one-size solution that fits all.

2. V2X setups need to be tailor-made by unifying existing, yet not readily compatible components to achieve the desired outcome:

- Installing different components by multiple companies may cause problems since all components may not be able to communicate with each other. Contracting one technical installation company to be responsible for all energy system components may help overcoming technical issues.
- There is no existing, off-the-shelf EMS platform available yet that is compatible with all (hardware) solutions. A mix of prototype custom-built, and early market solutions should be considered.
- Mindfulness of data security and privacy must be taken into account: partners in consortia may require a Non-Disclosure Agreement (NDA) with third parties, and/or make specific agreements for access to the data, complying with General Data Protection Regulation (GDPR) legislation.
- In existing locations, you may come across different data collection systems. Pay special attention to avoid differences in data synchronisation, definition of measuring points/schematics and interpretation of the data collected. Interoperability, compatibility and data security/privacy need to be taken into account. Consider a joint effort to create a customised EMS platform designed as per the specific requirements of the local V2X setup.

3. It pays to (get to) know the V2X market - due diligence in market research and supply chain is essential.

- Procurement of components can take longer than anticipated. Allow for extra time during the planning stage. Currently a minimum of 4 to 12 months is average.
- Investment in human capital: Identify and impart skills and knowledge training to capable individuals within your organisation in the areas of procurement, supply-chain management and market research, related to e-mobility. Alternatively outsource this task/ invest in bringing external expertise on board with knowledge of energy systems, electric mobility and experience in supporting innovation tenders.
- It is necessary to know your suppliers and their offerings (basic product only, additional required components and perhaps added services, their lead-times, etc.)

4. There is no single, generic, universally-applicable V2X business model.

- Tariffs in each OP region/country are different and vary by the type of consumer (household / commercial / municipal / industrial) - thus it can be difficult to get detailed information about the breakdown of the energy costs.
- It is difficult to evaluate deferral of grid investment costs, since this is (i) both network and location specific, (ii) DSOs account for the grid reinforcement and losses in different ways.
- In current scenario, the business model for SC is better than V2X for the following reasons: (i) SC units are less expensive, (ii) availability of wide range of SC compatible EVs and (iii) current electricity grids can accommodate SC technology.
- Nevertheless, V2X does have a high research and innovation value in anticipation of future developments.
- Rewards for providing V2X services or feeding electricity back to the grid may change, if the Feed in Tariffs or electricity tariffs are altered.

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