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Resource Efficient EV Charging Infrastructure in Real Estate Environment

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Summary

Real estate market, in particular buildings with large parking areas, is quite challenging environment for EV charging. The limitations include availability of energy and power in the building, strict cost efficiency requirements, and scattered location of vehicles which need electricity. Parking Energy provides a complete system as an all-inclusive service. The article presents a solution which has been built to demanding real estate environment, and presents experiences in deployment and operation of such system. The case includes EV charging capability installed to all parking spaces cost-efficiently and resource-efficiently. Analysis of costs, experiences, and effects on property is presented.

Keywords: charging, optimization, smart, business model, infrastructure

1 The Challenges of EV charging in real estate

The main challenges in real estate environment in existing buildings is limited availability of electrical power and cost of installation and operation. Adding more capacity may increase cost of EV charging substantially, and property owners, in particular when controlled by multiple owners in an apartment building, are cautious of investments in upgrades for future needs of electric cars while number of electric cars is still low. The risks considered are investment in quickly evolving technology, maintenance cost and future upgrade needs. For EV drivers, high costs of charging would negate economic benefits of EVs.

1.1 Resistance of building owner or investor

Many building owners hesitate investing in EV charging. This can be contradictory, as a single parking space typically costs tens of thousands of Euros to build. While regulation can force things, there will be resistance, and suboptimal lowest-cost-possible installations are often done. To reduce this resistance, costs must be low enough to make it commercially attractive to install EV charging to the parking area.

1.2 Process cost

Installing single charging unit or small group of charging units is expensive, as the project includes electrical planning, possible expansion of main distribution board, installing conduits and cables, updating electrical drawings and certification or final inspection of the installation. If this is done every time the system is expanded, the cost per charging point becomes very high, sometimes reaching 5000 €+/charging point.

1.3 Cost of EV charging

The cost of EV charging in real estate is a major factor in real estate owner's value proposition. If the building has cost-efficient EV charging available, it will increase property's value and make the building more attractive to tenants. If the building has unpractical or expensive EV charging, or none at all, most of larger companies will simply not rent space in such buildings, as they already have environmentally friendly company car policies in place.

1.4 Maintenance of charging points

In addition to installation, maintenance of charging points requires resources and expertise. Unlike simple lighting fixtures or similar, a charging point can be a complex intelligent device, involving metering, regular checks, and contacts and cables which need regular maintenance or replacement. Typical building maintenance companies do not have these skills readily available.

1.5 Ease of use

EV chargers in apartment buildings and offices are used by ordinary people. This will require easy to understand and use product, with plug-and-play design.

1.6 Amount of power and energy available

In most real estate cases, such as office and apartment buildings, transport parking and airports, amount of energy needed on average is quite low. As typical energy need of average vehicle is approximately 10 kWh, the average charging power needed for a car is quite low when the car is charged overnight or during workday. This makes EV charging easier and more cost-efficient to do at home or office, as lower average power levels can be used, and smart Load Management can accommodate varying needs of different vehicles.

While average vehicle needs approximately 10 kWh of energy daily, a taxi may consume more than 100 kWh per day. Installing system to cover 100 kWh daily energy consumption to all parking spaces would be prohibitively expensive.

This makes Load Management and shared cabling layout important factor in cutting the costs while still providing service which covers needs to all car owners. For example, if cabling is built as a star, cost and amount of copper / aluminium used can quadruple.

Building's electrical connection is a limiting factor, and upgrading it can be very expensive, often tens of thousands for a typical apartment building. This can, in some cases, be more than installation of everything else related to EV charging. An EV uses approximately same amount of electrical energy as one bedroom flat, so energy requirements of most buildings can grow substantially when EV market share grows.

If EV charging is not controlled intelligently, the electrical load would concentrate to specific times, in office buildings, at 9 am when people come to work, and in apartment buildings, at 5 pm when people come back from work. This would force oversizing the electrical connection by a large factor if Load Management would not be available.

1.7 Multi-stakeholder issues

In apartment buildings which are legally organized as co-ops, decision making can be challenging, requiring majority, qualified majority of ⅔, or even consensus decisions. Getting EV charging system installed, upgrading electrical connection, and other similar work is often blocked by resistance from apartment owner who do not have an EV or any kind of vehicle. This is usually aggravated by the fact that traditionally costs of installing EV charging systems has been very expensive.

Charging users for the charging service and consumed electricity is usually required for equality or taxation reasons.

Parking spaces can be dedicated or non-dedicated and both cases present consequences on the economics and administration of acquiring EV charging. With dedicated parking spaces, installing a designated charging unit for a single user less complex, although there is still the question of building electrical supply upgrade

cost and distribution of it. Yet the particular parking space can be located in any place within the garage, thus the cabling costs can vary wildly. If the utilization of the dedicated parking space is due to ownership, changing the parking space nearer to electrical distribution cabinet will mean selling one and buying other parking space, which may involve a significant asset transfer tax.

If on the other hand, parking spaces are non-dedicated, the case is opposite. Charging points can be installed in a compact set near to electrical distribution cabinet, needing less cabling and more generally, all infrastructure specifications can be considered in a cost-efficient way. While with non-dedicated parking spaces, the technical aspects can be optimized, the availability of the chargers becomes problematic. The ICE-car owners may fill the parking spaces equipped with chargers. If the EV-driver cannot be 100 % sure that a charger is available to use at any time, the willingness to pay for a charger, whether by investing or by buying it as a service will drop dramatically, especially if the parking garage happens to be the EV-driver's home garage. This failure of service can be avoided if the parking spaces equipped with chargers are set aside. This effectively means splitting the garage into two sections, which leads to lower occupancy meaning lower economic productivity. The other option is to add the costs of the chargers to the general parking space rent, but the still majority ICE-car drivers may resist the idea that they should pay for the EV-drivers' needs.

1.8 Technology and future proofing

Electric car charging is still a developing area of technology. Building owners are hesitant to invest in technology which may become obsolete or insufficient for future needs. The standards are still evolving, and new technologies such as inductive charging is likely to become popular when adopted by car industry.

1.9 Scaling number of EVs

EV market share is still quite low, even in early adopter countries such as Norway. However, the growth can be quick in city areas, new buildings and offices, where EV market share can be substantially higher than average. While in Finland market share of plug-in cars was just 0,2 % at end of 2016, we already see 10 % of people asking for EV charging in newly built above-average cost apartment buildings. Similarly, office property owners see EV charging becoming a commercial requirement.

1.10 Sharing EV chargers

Due to cost, many buildings install just few charging points, sharing them between multiple users. This is very inconvenient, and forces people to move their cars to allow others to charge.

1.11 Smart grid requirement

When electric cars become ubiquitous, controlling their charging process becomes important part of smart grid.

1.12 Regulatory requirements

The proposal aiming to revise the EU Directive on the Energy Performance of Buildings (EC, 2016a) proposes EV charging infrastructure such as cabling, conduits, and for commercial properties, 10 % of parking spaces to be installed with EV chargers, when building new or renovating existing buildings.

2 Solution

2.1 Design goals

The key goal for system design has been bringing the electricity to the cars, instead of bringing cars to the electricity.

Parking Energy system was designed for large parking areas in real estate. The requirements have been

- Cost efficient cabling and quick connector system which covers all parking places in a parking area

- Use of existing infrastructure whenever possible
- Charging units are installed by demand
- Building maintenance personnel should be able to take care of routine installations and replacements of charging units
- Software is provided as a cloud service and a mobile app, and intelligent charging units can be updated over-the-air.
- Use of the system must be easy enough for ordinary people
- The system must be capable of Dynamic Load Management to avoid or delay upgrades to other electrical infrastructure
- The system should be able to participate to grid balancing
- The system should be able to optimize EV charging to lower cost of energy
- The system should be able to maximize use of renewable energy
- The system needs to be future-proof
- The system should scale up to the point where all vehicles are electric

These requirements needed development in all areas of the business and technology used. At the time of founding of Parking Energy in 2014, there was nothing on the market which fulfilled all these requirements.

The system components include

- Cloud based system which combines inputs from number of sources such as energy cost, weather information, grid balancing requirements, electricity price, user requirements, car battery status and building and local distribution loads, and optimizes the energy use in large scale.
- Mobile app which acts as user interface to the system
- Smart charging units, which are by themselves capable of in-building load management, identifying users, and metering energy
- Cabling system

The business model work included processes, legal agreement frameworks and service model development.

2.2 Separation of Cabling system and Smart charging units

In Parking Energy system Cabling is installed to all or majority of parking spaces as a one-time investment, and Smart charging units are provided for a monthly fee as a service. Cabling is typically very long term investment, with recommended lifetime of 30 to 40 years, while charging unit design lifetime can be less than 10 years. This separation helps keeping costs down and gives building owners and tenants more flexibility than traditional fixed installation.

The cabling system is built with quick connectors, allowing installation of Charging points to be a simple plug-in operation, which can be executed by building maintenance person rather than electrician. This will save in costs and allow building maintenance to take care of replacements and servicing.

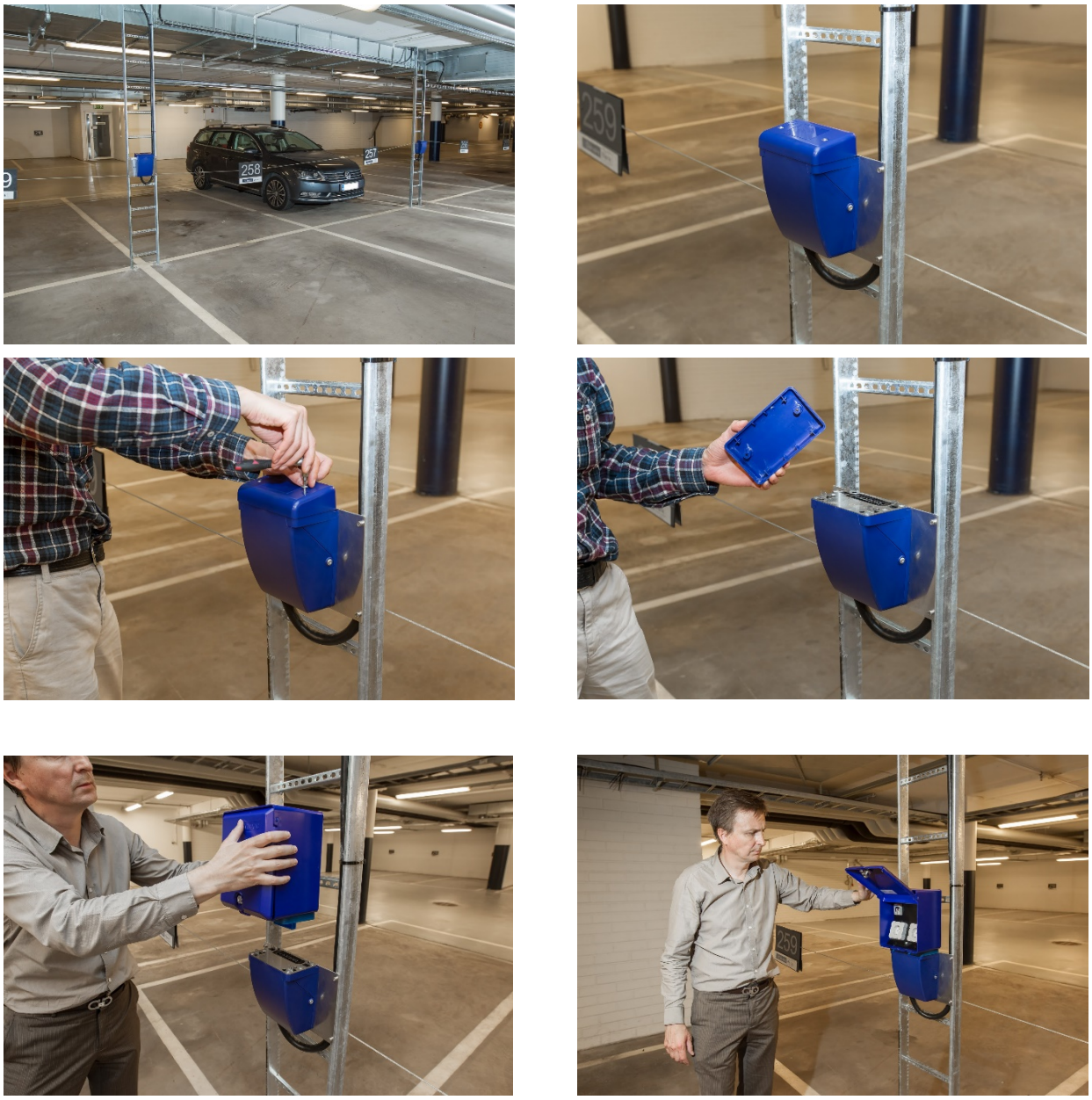

Figure 1: Installation of Charging unit to a quick connector

2.3 Electrical system topology

Parking Energy system is typically installed with star/bus topology. The motivation for this is lower cost and easier installation. The system is based on star cabling to distribution boards in the parking area, from which bus cabling is daisy-chained to quick connectors between parking places. Typically, one quick connector is shared by two parking spaces.

The cost difference between star and bus topologies can be further shown by comparison. The following table compares the cost of materials for a 100 parking space garage with two different configurations. A star topology has all parking spaces connected to the distribution board, while bus topology connects 6 electrical cables in bus fashion to the distribution board.

Table 1: Cost comparison for electrical topologies

Installation topology	Copper used	Cost of installation, materials and work
Star	Average length of 55 m of 5x10 mm2 cable, 100 cables, 2300 kg of copper	31 000 €
Star + bus topology	Average length of 92 m of 5x16 mm2 cable, 6 cables, 500 kg of copper.	10 000 €

The calculation is based on real parking garage case. While the bus topology has lower maximum theoretical capacity, the above bus setup provides approximately 150 km of daily driving range, or 2-3 times more than average, to everyone. The cost more than triples in star topology, as cable capacity cannot be shared.

Additionally, star shaped topology may have higher cable losses than bus-based topologies, as bus-based topologies are usually run at very low load factors compared to capacity of the cable, in particular when EV market share is low.

Table 2: Number of parking spaces per bus varies for different types of buildings

Building or use type	Parking spaces per 3x63 A group
Apartment building, overnight parking	18 or fewer spaces, 2,5 kW of average power, 120-140 km/night
Office building, normal workplace parking	12 or fewer spaces, 3,7 kW of average power, 140-200 km/working day
Guest parking, hotel overnight parking. Short visit times or large battery sizes are assumed	4-6 or fewer spaces, 7,2 to 11 kW of average power, 70 - 100 km/hour

The maximum power currently available is 22 kW, if 3-phase Type2 charging is used. High-power charging units can be installed to any quick connector. The quick connector has been designed for 44 kW power, to either be shared by two 22 kW charging units, or for one 44 kW charging unit.

2.3 Charging units

Smart charging units are available for different power levels, from HLP (High Load Profile) Schuko plug to 22 kW Type 2 unit. This will allow users to choose a charging unit for their own need - if car owner has a plug-in hybrid with 3,7 kW charger, installing costly 22 kW Type2 unit does not make any sense - even HLP Schuko provides 100-200 km of daily range, which is sufficient for great majority of car owners. A 1x32 A Type1/Type2 charging unit will provide 200-300 km of daily range and is often selected on comfort provided by tethered cable rather than additional charging power. A taxi driver parking in the same parking area can select 22 kW Type2 unit to get his Tesla with a 100 kWh battery charged in 4-5 hours at night.

Upgrades and servicing is done by replacement rather than on-site. Any failed charging unit is replaced with a new one, and failed one is returned to local service center.

The system allows easy scaling. Instead of guessing how many EV drivers there will be during next few years, and installing charging points based on that estimate, charging units can be added by demand. As the service provides real time visibility to usage of the charging points, the building owner can get alerts on increase of use and have more charging units installed at any time.

In buildings where fixed parking spaces are allocated to car owners or companies, the system allows charging points to be brought to where the cars are, instead of changing parking spaces for those who buy an EV.

2.4 Service model

Typical building management does not have resources, expertise, and ability to do metering, smart grid connectivity, authentication of users and other EV charging related matters. To solve this, Parking Energy model is service based rather than traditional buy-and-maintain. Parking Energy runs the back-office, provides the apps, does invoicing and provides the large-scale control of the system. Parking Energy partners provide the physical maintenance and sales of the systems. The building owner signs with Parking Energy partner, and partner then coordinates the installation and maintenance.

The electricity consumption is invoiced directly from car owner by Parking Energy, and thus, the building owner does not need to process invoicing of the energy. The users are authenticated, and can park in any parking space and plug in, and the invoice follows the user rather than is based on specific charging point.

2.5 Cost efficiency

Parking Energy system installation cost is approximately 1 % of building cost of parking space in a garage. It is likely that rent increase for a parking space in a building with EV charging availability can be substantially higher than required investment. If the installation cost is paid by the parking space user, the payback time through cost savings when switching from gasoline car to electric or plug-in hybrid is just few months.

3 Case study of 250 parking spaces with EV charging

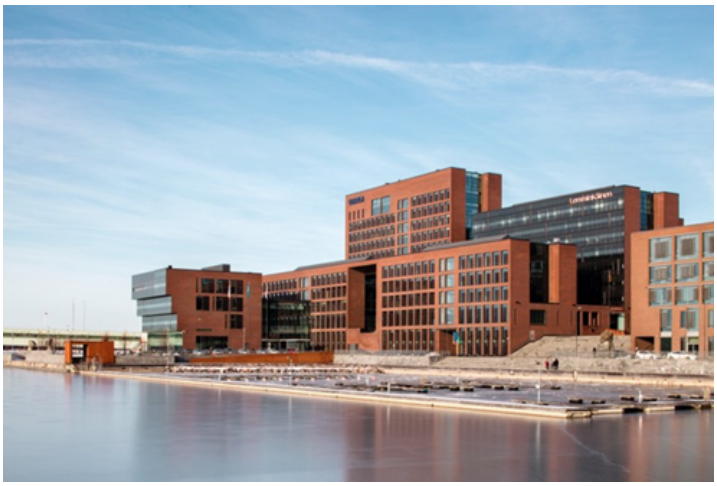

Figure 2: 250 parking spaces with EV charging option in a single office building.

Parking Energy provides the EV charging system to the headquarters of one of the largest Nordic real estate owners. Unlike traditional EV charging installations, Parking Energy system covers almost all parking spaces in the building with total of 250 spaces equipped with EV charging possibility. The system is one of the largest in the world.

The service allows parking users to select from charging units ranging from 3,7 to 22 kW, right to their own dedicated parking areas. All common charging connector standards are available. The charging units are provided to the tenants directly from Parking Energy, and Parking Energy installs and maintains the units.

3.1 Schedule of installation and effects on building infrastructure and use

The project started in April 2017 by electrical planning, and installation commenced in May, with system installed throughout the garage by early August. The drivers have been able to charge their cars in August. Most of the electrical installation work was scheduled for July when most Finns have their summer vacation.

The building electrical feed and main distribution board turned out to be sufficient and there was no need to upgrade either. The approximate amount of electrical power needed is less than 2 kW on average per parking space.

Some new cable ways were installed, however, most of this work was minor. When parking space was not next to a wall for quick connector installation, vertical cable trays were used for installation.

Figure 3: Seven new distribution boards were installed

3.2 Cost

The total cost of the system in the garage come to approximately 90 000 €. The cost to cover 250 parking spaces with Parking Energy system was similar to installation of 20 traditional charging points. The cost of installation of a single parking space is less than 400 €. Due to large capacity of the building electrical connection, there was no need to upgrade.

For comparison, installing a similar system to a new building, when included during planning and construction phase, the cost would be substantially lower. The cost variations in different buildings are usually attributed to possible need of installing conduits and cable ways, and possible work in main distribution board or building electrical connection.

Table 3: The distribution of system installation costs

Item	Budget	Actual Cost
Electrical planning	10 500 €	7 500 €
Electrical installation including materials	75 000 €	81 000 €

3.3 Service cost to tenants

The charging units cost from 15 to 40 €/month, depending on power level, and the monthly fees are paid by tenants directly. The electricity is charged from drivers or tenants depending on whether the car is a company vehicle or private vehicle, at 0,12 €/kWh.

3.4 Driving distance provided by the system

The cabling was built with charging capacity providing approximately 200 km of range per working day, even in case everyone arrives with their battery empty. This is about 4 times the average distance driven by drivers in Finland per day. As the capacity is distributed intelligently, it should be plentiful even for 100 % EV market share. Load management will take care of limiting the capacity to available level to avoid peak loads which could occur at start of working day.

3.5 Experiences

The building owner considered one of the important factors for decision to install the system to be increase in building value through provision of better service for the tenants. In particular, the owner considered low cost of charging EVs important.

Some areas in the garage turned out to be complex to install, for example, due to air conditioning ducting complicating installation of cabling. The effect on total installation cost was minor.

The electrical planning was done by original designer of the electrical system of the building, and this allowed electrical planning work to be completed under budget. During the project, some details of the plan were changed when easier cable routing or similar improvements were found during review phase.

At the time of writing user experiences were not yet available.

4 Conclusions

Parking Energy cabling system and service provides a cost-effective and flexible system to install EV charging to large buildings and parking areas. The cost savings are result of multiple factors, and include savings in both installation phase and operation.

The solution proved to be straightforward to install, there were no material cost overruns, and apart for few weeks of delays due to long delivery time of distribution cabinets the installation schedule was within estimates.

It turned out that there was no need for major electrical upgrades to the building electrical supply.

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