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mySMARTLife

Deliverable due date: M36 – November 2019

D4.25 Report on Smart personal EV charger system in operation (WP4, Task 4.7, Subtask 4.7.3)

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**
Project Duration	1st December 2016 – 30th November 2021 (60 Months)
Deliverable	D4.16 Report on Smart personal EV charger system in operation
Diss. Level	PU
Status	Working Verified by other WPs Final version (selected)
Due date	30/11/2019
Work Package	WP4 Demonstration in Helsinki
Lead beneficiary	SAL
Contributing beneficiary(ies)	Forum Virium Helsinki Oy (FVH)
Task description	Subtask 4.7.3: eCar sharing definition and deployment. FVH and SAL will lead the eCar sharing concept will be defined and deployed, including the definition of smart personal EV charger system that will be put in operation.

Date	Version	Author	Comment
24/10/2017	0.1	Radovan Janoso (SAL)	Structure of the deliverable and work planning
30/10/2017	0.2	Radovan Janoso (SAL)	Added eCar sharing concept as provided by Timo Ruohomäki
02/11/2017	0.3	Radovan Janoso (SAL)	Ready for review
29/11/2017	0.4	Radovan Janoso (SAL)	Modifications based on comments from reviewers
19/11/2018	0.5	Radovan Janoso (SAL)	Update reflecting current status
31/5/2019	0.6	Henrik Jakobsson (SAL)	Hardware tests added
17/8/2019	0.7	Henrik Jakobsson (SAL)	SPOT Notification service added
4/9/2019	0.8	Henrik Jakobsson (SAL)	Pilot update, new hardware
15/10/2019	0.9	Henrik Jakobsson (SAL)	EV in operation
10/11/2019	1.0	Henrik Jakobsson (SAL)	Corrections made upon review feedback received

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Abbreviations and Acronyms

Acronym	Description
EV	Electric Vehicle
PEV	Personal Electric Vehicle
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy (the project)
OCPP	Open Charge Point Protocol
Charge Point	Device for charging a vehicle one at a time
UI	User Interface
UX	User experience design
AC	Alternating Current, in this context used to describe one of the charging options for EVs, mainly for home use, i.e. slow charging in this context
DC	Direct Current, in this context it describes the charging option for more commercial use and fast charging

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1. Executive Summary

This deliverable describes the design and implementation of a personal EV charging service that consider grid load balancing and variable price of electricity. eCar sharing concept and the urban data platform. Initial findings about standards and market readiness is presented. Plan to develop service is defined further in this document. In addition, impact of charging optimisation on city and country level from viewpoint of better grid utilization is indicated.

EV charging plan from concept to solution is presented as well as analysis of needs to build solution is included pointing out on readiness of various building blocks. User motivations to adopt such solution are provided.

EVs are going to be much more relevant for power systems than they have been in the past. With uncontrolled charging, EVs could drive incremental needs for peak power generation and transmission capacity. (Eickelmann, 2017)

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2. Introduction

2.1 Purpose and target group

Today, transport still relies on oil for 94% of its energy needs. Europe imports around 87% of its crude oil and oil products from abroad, with a crude oil import bill estimated at around €187 billion in 2015, and additional costs to the environment. Research and technological development have led to successful demonstrations of alternative fuel solutions for all transport modes. Countries and member states shall ensure that sufficient amount of charging stations are built both private and public ones.(infrastructure, 2014). Continues growth of EVs will require that integration to Smart infrastructure where charging points and meters shall help the stability of the grid. In practice it means that charging system and points will allow EVs to be charged during times when demand of electricity is low, i.e. there is extra capacity available. Electric mobility is expanding at a rapid pace. In 2018, the global electric car fleet exceeded 5.1 million, up 2 million from the previous year and almost doubling the number of new electric car sales. (The International Energy Agency, 2019)

This deliverable defines concept of personal EV charging process modification to optimize grid utilization, charging costs reduction and concept of eCar sharing. In case of PEV charging plan from concept to solution is presented as well as analysis of needs to build solution is included pointing out on readiness of various building blocks. User motivations to adopt such solution are provided.

By providing flexibility services, electric mobility can increase opportunities for integration of variable renewable energy resources into the generation mix, as well as reducing cost associated with the adaptation of power systems to increased EV uptake. Electricity markets should facilitate the provision of ancillary services such as grid balancing that are suitable for EV participation and allow for the participation of small loads through aggregators. (The International Energy Agency, 2019)

Identified target groups for personal EV charging solution are these:

- PEV owner that has Spot day ahead price electricity agreement with utility company.
- Housing association that aims at optimal utilization of available grid capacity for PEV charging.

2.2 Contributions of partners

The following Table 1 depicts the main contributions from participating partners in the development of this deliverable.

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Table 1: Contribution of partners

Participant short name	Contributions
FVH	Contributing partner
SAL	Main responsibility for delivery

2.3 Relation to other activities in the project

The following Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D4.1	This deliverable defines approaches to optimise usage of produced electric energy considering EV charging point of view
D4.11	This deliverable defines the methods to provide data on urban platform defined in D4.11

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3. Concepts

3.1 Personal EV charging concept

Personal EV charging approach typically follows two common patterns:

1. EV starts to be charged immediately when it is plugged into the charging point.
2. EV starts to be charged from defined time (if either EV software allows user to configure charging time or there is a control of charging point).

In both cases there is rather limited control over charging process. If there is no need to charge personal EV immediately modification of charging process allows to bring savings to end users as well as on higher scale it provides local load management and has positive effect on grid utilization. To achieve savings for end users precondition is that user has contract based on electricity spot market prices. Fluctuations in electric energy price on spot market can vary quite noticeably as it is demonstrated on snapshot of hourly prices from Nordpool spot market.

3.2 Energy Management

Energy Management has an important role in electromobility. The required amount of energy might be expensive at the time the EV is connected to the charger. There is a need to control the usage of energy and if possible rationed according to supply and demand. Tool to enable better energy management is charging and load management. This will help the reduce the load on the grid. Energy management will take into account different types of loads and energy consumers in the local grid. (Eickelmann, 2017)

As for this deliverable the focus has been set on adjusting the charging times to follow the Electricity market.

3.3 Electricity Market

As the below table show the price for electricity do fluctuate as much as 200% during a day.

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EUR/MWh

All hours are in CET/CEST. Last update: **Today 12:42 CET/CEST**.

	31-10-2017	30-10-2017	29-10-2017	28-10-2017	27-10-2017	26-10-2017	25-10-2017	24-10-2017
00 - 01	28,80	3,00	25,52	24,18	26,53	26,16	25,80	29,58
01 - 02	28,63	2,99	24,11	24,76	25,39	25,05	19,27	29,35
02 - 03	28,60	3,37	23,02	23,52	25,43	24,95	18,32	28,90
02 - 03	-	-	21,63	-	-	-	-	-
03 - 04	28,39	4,05	18,71	22,27	25,06	25,43	19,50	28,82
04 - 05	28,89	4,89	21,00	22,13	25,38	26,39	23,95	28,97
05 - 06	30,34	25,59	20,10	23,98	31,89	28,44	27,34	36,56
06 - 07	34,83	28,42	21,02	25,23	40,49	34,87	33,68	48,00
07 - 08	38,73	33,54	22,50	25,32	46,68	39,07	35,02	48,58
08 - 09	41,09	33,54	21,34	26,02	45,09	40,50	35,08	56,87
09 - 10	40,45	33,97	25,45	26,27	43,90	40,43	35,01	52,88
10 - 11	40,40	33,89	25,93	26,26	42,53	40,42	33,88	63,82
11 - 12	41,43	33,84	25,40	26,10	42,42	40,50	33,39	52,88
12 - 13	41,03	33,89	24,92	25,79	42,17	41,21	32,92	52,72
13 - 14	40,99	33,56	24,13	25,66	40,50	41,12	33,60	44,70
14 - 15	38,24	33,55	22,88	25,44	39,44	40,57	32,02	44,11
15 - 16	39,05	33,55	24,13	25,89	38,05	39,89	31,12	40,86
16 - 17	42,45	36,81	25,53	27,47	37,95	39,92	31,02	45,67
17 - 18	46,96	39,90	27,13	29,26	40,14	42,47	34,91	49,03
18 - 19	47,36	35,91	27,62	32,09	42,17	48,01	38,21	60,98
19 - 20	40,44	30,57	28,23	27,68	39,79	40,94	34,63	47,57
20 - 21	31,27	29,79	24,85	26,76	29,98	34,86	29,91	30,28
21 - 22	30,19	29,68	19,96	25,91	26,94	31,84	29,43	29,74
22 - 23	29,58	29,26	17,86	24,78	25,80	29,01	28,22	28,91
23 - 00	28,88	28,52	17,60	22,18	20,45	27,52	27,10	27,02

Figure 1: Nordpool spot market prices

The EV Service uses information about electricity hourly spot market prices, EV battery capacity, EV battery charge level, allowed / maximum charging point load and time available for charging process to calculate most cost-efficient way to charge EV. Considering all needed input variables there are certain requirements for charging point which shall provide necessary information about connected personal EV.

With increasing amounts of personal EVs there is benefit of charging optimization service in increase of produced electric energy utilization. As most of optimized personal EV charging will happen during times when cost of electricity is low which is clear indication from production side of need to use energy. That way we will lower demand for energy during “peak” (expensive) hours and therefore avoid need to produce more energy to satisfy demand. Such approach will have then direct impact on produced CO_2 emissions as well as on grid utilization (local level / area / national).

In addition, first energy utility companies in Finland started to introduce so called power charge concept where customer is additionally billed based on highest consumption. Optimization service shifts consumption and consequently lowers power charge fee.

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3.4 Load balancing with multiple PEV

Increasing amount of personal EVs and respective increase in amount of charging points presents challenge for existing grid infrastructure to deliver required power. Upgrade of infrastructure bears substantial cost therefore other means of managing charging process and related increase in demand of power shall be investigated. Load balancing of EV charging points (chargers) would provide answer to such demand.

Approach is to have means to define maximum permissible load with regards to infrastructure and maintain it below such value. Optimization process then continuously checks how many PEVs require charging and calculates distribution of available power amongst them. In addition, information received from PEV user about time available for charging was taken into optimization process.

Load balancing approach in an optional service that can be build for cases where there are multiple PEV charging points available in same location and therefore share same electricity distribution lines. Housing associations with many charging points would be one example of target user group that would benefit from such service.

3.5 eCar sharing concept

The planned eCar sharing concept aims to fill the gap between public and commercial car charging stations and private, personal car charging. The intended target market could as an example include housing cooperatives that purchased a car for shared use for their own shareholders.

The car would in such case be similar shared resource than Flexispaces or other rental spaces. The housing cooperative could use the same Flexispace booking system that they use for the house communal space or meeting room. The booking system would then not be involved with any financial transaction since the use of shared vehicle could be charged in similar fashion than any other shared commodity in the building such as water or cleaning of the communal areas.

In order to track the mileage, the car has been used by each shareholder, an API is required to collect the meter readings from the vehicle after every charging event. For this purpose, the OCPP - protocol and/or ISO/IEC 15118 vehicle-to-grid charging protocol should provide the information required. The same interface could also be used to collect pre-emptive maintenance information in order to ease and outsource the service of the communal car.

Charging unit that has communication with EV based on ISO/IEC 15118 protocol would provide the optimization service access to parameters to make the solution more user friendly. The protocol should provide needed information about EV, its battery and charging status.

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The API defined as part of this deliverable would have an endpoint on the Urban Platform (See Deliverable D4.11 for details). The urban platform shall have the capability to manage data streams from personal EV chargers as personal data according to the definitions of the General Data Protection Regulation (GDPR). The platform would then associate the data stream with the owner of the car, who only can give the consent to use the data in other services or research. The urban platform also provides the mechanisms to associate the data streams with various types of services that can be about data analysis, visualisation or integration to other services.

3.6 Salusfin Smart Home

To support dynamic grids and green thinking, New energy controls for demand-response was added during this deliverable. Energy controls can be used for both electricity and district heating optimization.

3.7 Personal EV charger solution description

Approach to control charging process shall be selected in accordance with EV charging unit capabilities. In our case we can recognize these options:

1. Charging unit that supports standardized protocols without direct local access.
2. Charging unit that supports standardized protocols with direct local access.
3. Charging unit that does not have communication capabilities.

Following diagrams describe solution options in more details.

Option 1. represents case where charging unit (EV charger) supports protocols that allow it to communicate with EV (ISO/IEC 15118) as well as towards external systems (OCPP). However from Salusfin’s point of view there is no direct connection to charging unit therefore integration with charging unit manufacturer’s cloud or service provider’s cloud needs to be performed.

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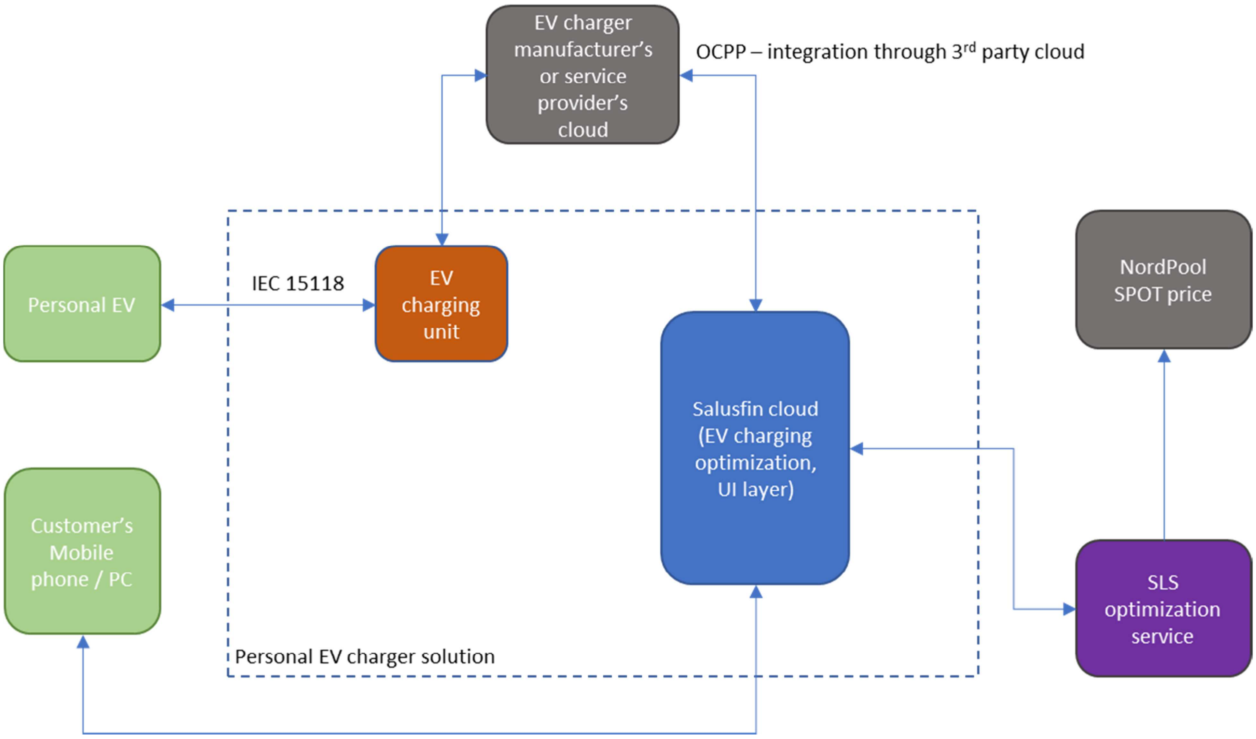

Figure 2: Personal EV charger solution Option 1

Option 2. presents case where Salusfin optimization solution has direct integration with charging unit using standardized protocols as show in following diagram.

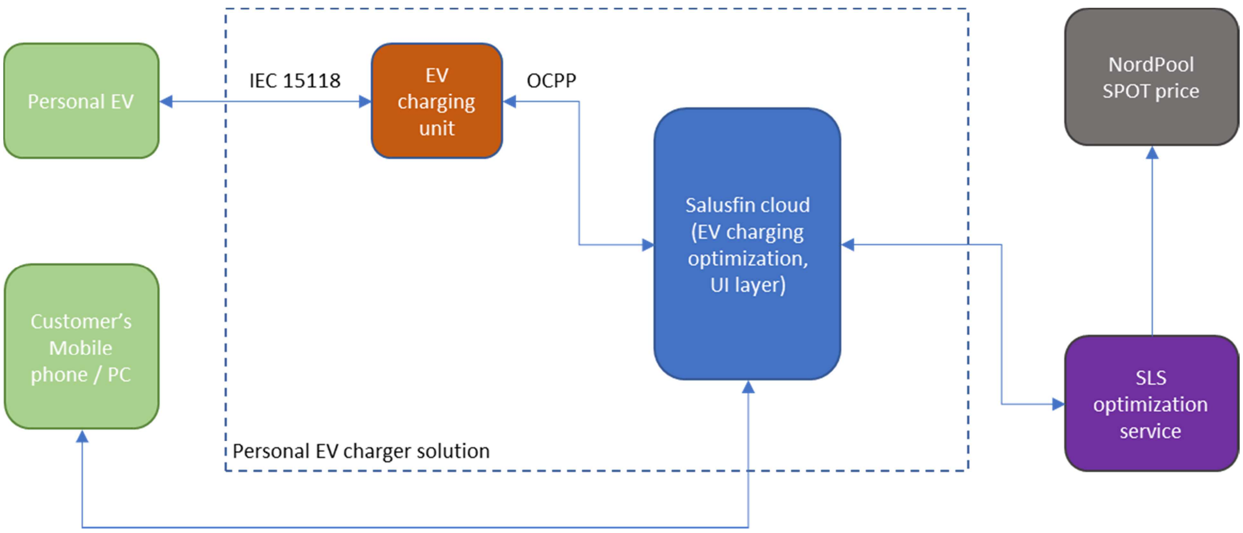

Figure 3: Personal EV charger solution Option 2

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Last option uses approach where charging unit does not have communication capabilities therefore only option to control charging process is to turn unit ON and OFF via additional compoment that Salusfin optimization solution can control.

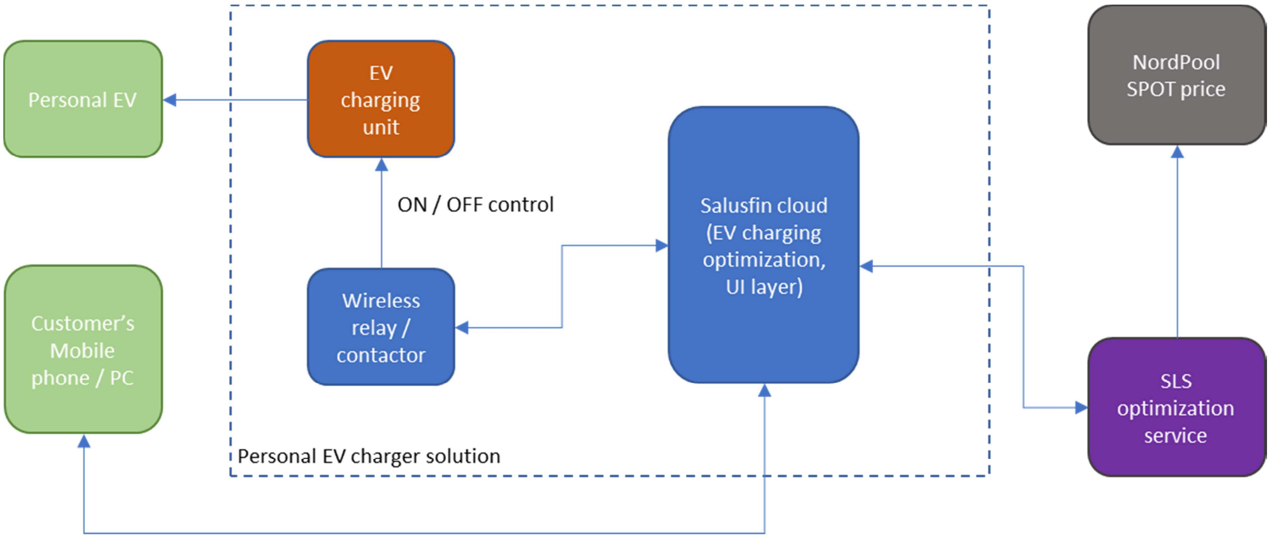

Figure 4: Personal EV charger solution Option 3

3.8 Technical solution description

The technical implementation is based on a three-layered architecture:

* Personal EV charger solution:

· Layer 1 contains wireless components, which communicate with a gateway wirelessly, in this implementation the personal EV charging unit.

· Layer 2 is the cloud solution. The Cloud is the integration layer and contains the data repository, optimization and machine learning features.

· Layer 3 is the user interface (UI) layer. The layer consists of native mobile clients on iOS and Android platforms as well as web interface.

* External entities:

- Personal EV
- Customer's mobile phone / tablet / computer (device through which personal EV charger is operated)
- SLS (Smart Load Solutions) machine learning optimization service
- NordPool market price information service
- EV charger

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- (optional, for future) Weather service to add additional optimization parameter for charging personal EV taking into account effect of cold / hot climate

Communication between EV charger and Salusfin cloud optimization is secure and wireless. The service is an extension of Salusfin Smart Living service which allows the users to take advantage of additional services such as security and safety. The optimized schedule returned from cloud to the EV charger solution is stored on the gateway, which is having the crucial role as bridge between the physical component and Salusfin Smart Living Service.

3.9 Optimization interface description

Personal EV optimisation solution uses machine learning optimization service provided by our partner SLS (Smart Load Solutions) platform that is capable of optimizing the charging cost and taking into account electricity SPOT price, PEV battery level and available charging power.

SLS machine learning service has access to SPOT price info from NordPool service and offers HTTP POST interface to get optimal charging schedule. Interface uses JSON format to exchange information. Salusfin service provides information to SLS on battery capacity, initial levels, times when battery shall be fully charged.

In the following section the API definitions and the message content will be further explained.

3.9.1 API definition:

- Request type: POST
- URL: http://slsoptimizationservice.cloudapp.net/json/reply/OptimizeConsumption
- Request parameters (JSON): {'producer': { 'storageChangeCharacteristic' : '<value>', 'maximumPower' : ['<value>', '<value>'], 'minimumPower' : '<value>' }, 'source':'{}','storage' : {'initialLevel':'<value>','finalLevel':'<value>','minimumLevel':'<value>','maximumLevel':'<value>','flow':'<value>'},'deviceID':'<value>'}

Whereas input parameters (message request) are:

- Storage – PEV battery parameters:
  - initialLevel – indicates initial charge level of PEV battery at the start of charging cycle [in our case we start at 20%]
  - finalLevel – defines target charge level of PEV battery at the end of one charging cycle [in our case we stop at 100%]
  - minimumLevel – defines minium possible level of PEV battery [minimum possible level of battery charge is 0%]
  - maximumLevel – defines maximum possible level of PEV battery [maximum possible level of battery charge is 100%]

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  - flow – indicates level of power flow from battery [in our case there is no flow from battery therefore parameter is 0]
- Producer – charging unit parameters:
  - maximumPower – is an array in which we indicate what is maximum power available for charging per hour from time when request is made.
  - storageChangeCharacteristic - indicates us how many units of raw material is produced per one unit of electrical consumption (e.g. t/MWh).
- deviceID – unique device ID that represents PEV of which battery charging shall be optimized.

Example of message request in JSON format for piloted Mitsubishi MiEV charging (deviceID is intentionally removed):

{'producer': { 'storageChangeCharacteristic' : '5200', 'maximumPower' : ['0.002', '0.002', '0.002', '0.002', '0.002', '0.002', '0.002', '0.002', '0.002', '0.002', '0.002','0.002', '0.002', '0.002', '0.002', '0.002', '0'], 'minimumPower' : '0' },'source':'{}','storage' : {'initialLevel':'20','finalLevel':'100','minimumLevel':'0','maximumLevel':'100','flow':'0'},'deviceID':''}

And respective response message example:

{"1542733200": "0", "1542736800": "0", "1542740400": "0", "1542744000": "0", "1542747600": "0", "1542751200": "0", "1542754800": "0.001384615384615384615384615 38", "1542758400": "0.002", "1542762000": "0.002", "1542765600": "0.002", "1542769200": "0.002", "1542772800": "0.002", "1542776400": "0.002", "1542780000": "0.002", "1542783600": "0", "1542787200": "0", "1542790800": "0", "1542794400": "0", "1542798000": "0", "1542801600": "0", "1542805200": "0", "1542808800": "0", "1542812400": "0", "1542816000": "0", "1542819600": "0", "1542823200": "0", "1542826800": "0", "1542830400": "0", "1542834000": "0", "1542837600": "0"}

Where we can see schedule that shall be followed to achieve most cost optimal charging.

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4. Implementation

4.1 Charger selection

The search for commercial EV charging units that have ISO/IEC 15118 communication standard implemented has proceeded. The recent ISO/IEC 15118 protocol provided more functionality to enable vehicle-to-grid (V2G) communication and was added to the CCS protocol, DC charging in 2018, whereas for AC charging the car manufacturer has to yet implement this from the vehicle perspective (OECD, 2019). As EVs with ISO/IEC communication is very limited and production of first EVs with this kind of support recently started. (Daimler, 2018). As of now there are no such EV and EV charging units commercially available that works for this business case that require AC charging facility.

4.2 AC charging vs DC

AC charging is the most used way of charging ones EV. AC charging. All commercially available EVs have an onboard charger and rectifier, which can handle 230 V and 400V AC. What this onboard system does is to convert the power to DC that is used to charge the batteries. Time it takes to charge the batteries is dependent on the current level set for the charging. Dynamic energy management / Demand-Response for optimized energy usage. The main difference between the AC model is that DC charging is having the rectifier unit outside the EV and it’s the charging station that will provide charging current directly in DC to the EV. DC chargers are mainly used for commercial and public infrastructure and charging times of the battery will be often much shorter than for EVs. As DC technology in chargers is more complex more expensive than the more affordable AC makes DC not desirable for this deliverable. The objective for this deliverable was to lower the TCO for the individual EV owner and to allow the charging to take place over a longer time period where indicators from the electricity market can bring savings.

4.3 Intial tests

Pilots and field tests with EVs using standard wall socket charger controlled via Salusfin smart plug continues. There is limited communication between EV and Salusfin cloud and therefore the need to transfer a lot of data is not a requirement however the charging process must follow agreed and preconfigured settings such as battery level and battery capacity based on vehicle that is being used. Optimization takes into account electricity spot price and analyses it to control the charging process. Data about charging process is being collected on Salusfin cloud.

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4.4 Field tests

Personal EV charging is in field test phase and the service is being promoted to distributors and preparation of additional field tests are being prepared. Salusfin has been expecting to have ISO/IEC15118 compatible EVs and charging stations available. The lack of standardized chargers for AC has led to adoption of more traditional chargers. The lack of EVs with support of IEC15118 for AC charging has also been a driving force to continue with chargers of Type IEC 62752 in Cable Box as described in next chapter.

4.5 Personal EV charger

In order to have a cost efficient, safe and reliable solution we have tested different approaches from different types of relays and chargers. The charger solution we have selected is controlled by Salusfin cloud, mobile APP and selected hardware modules.

- Smart IoT Power Relay (Power Relay)
- Travel charger of type: IEC 62752
-

4.5.1 Smart IoT Power Relay (Power Relay)

The hardware modules consist of a Smart IoT Power Relay (Power Relay) that provides secure and safe usage. The capable IoT device is connected to the local grid of the house or building and controlled by Salusfin cloud. The Power Relay has now been certified as device that can be installed and used by Salusfin services, including the optimization service. The Power Relay provides real time information of its status and power consumption to Salusfin cloud. The Power Relay supports one phase, 230 VAC and can handle up to 40 Ampere of current. The status of the Power Relay is visible for the user from mobile APP and portal on Salusfin cloud.

Figure 5: Personal EV charging modules, Power Relay

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4.5.2 Travel charger of type: IEC 62752

The Telewell AC charger Type 2 of model Travel Charger or similar that will allow charging current up to 16 A or 3.7 kWh. This setup is cost efficient and safe to use and it will allow the EV with a 20 kW battery to be fully charged in 6 hrs. The AC charger is capable to recover from being turned on or off by the Power Relay. The Travel charger is EV specific and needs to be having correct connector in order to allow the car to be charged.

Figure 6: Personal EV charging modules, Travel charger of Type 2

4.6 UX and UI

Mobile APP and cloud have been developed to support additional hardware modules that will allow safe and reliable control of charging the EV. New functionality in order to promote users behaviour is a so called Spot notification service that will be providing price indication to the user in advance during times when charging is not automated. If the user of the EV received the Spot notifications he/she will have the early indication on what the Spot price will be and notification will be informing too if íts high or low according to earlier preferences. The notification and the Mobile APP have been created to take into account the local languages in order to provide to increase its potential and also to make it easy to adopt to and use. User interface for EV charging is depicted in figure 6. The main user interface for times when the optimization is not active is the mobile APP. From the mobile APP the user can control the charging by manoeuvring the charger connected to the EV. In order to know when to charge the APP will provide early indication on when the Spot price is high or low.

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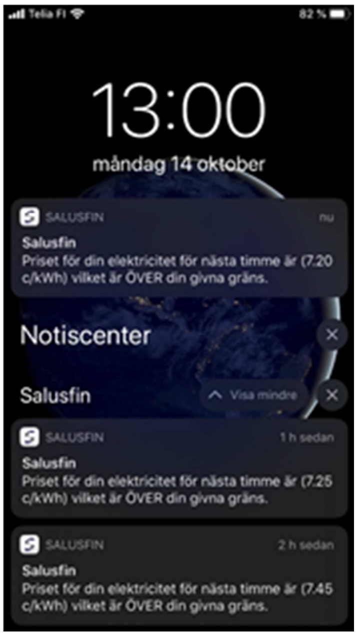

Figure 7: Personal EV charging optimisation – User interface

The needed user input for optimization process is minimized. Battery charge level (in the beginning of the charging process is predefined, Time when the battery should be fully loaded is set to early morning next day. Outside the optimized hours the user of the EV can start the charging from Salusfin mobile APP or cloud. The APP will provide current consumption of the charger and if the user of the EV desire an additional Power meter can be setup and controlled and viewed from the APP.

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5. In operation

The optimization is aimed at users that can utilize AC charging and can leave the EV for longer time.

To take full advantage of energy optimization from the users perspective a SPOT price agreement for electricy is needed. The price can fluctuate heavily during the day and by being able to catch the low - price / low demand hours the impact.

Use case: EV Owner returns home from work and connects his car to the EV charger unit. The process is automatic and by next morning the EV have been charged at lowest possible price. In case the user will need to charge the car during other hours he or she is in full control to do so and the make it easier for the user the system will send notifications when SPOT price reaches the limits set. The Notification works in both scenarios and user will informed 1h in advance of cheap or affordable price.

5.1 Charging session

Figure 8 contains an example of a single charging session where personal EV was connected to charger at 17:00 of local time and optimisation process selected best charging time according to electricity price. Capacity of personal EV battery, its initial charge level and time when battery shall be fully charged (08:00 local time) are preconfigured. During the charging session the internal temperature of the Power Relay used to control the charging process is carefully monitored.

5.2 Optimization

As Salusfin cloud is connected to Nordpool Energy market through its partner network the system have access to real-time energy price information. With such information the system is capable to control the charger unit by setting a schedule for it to follow. An EV with a 20 kWh onboard battery most often require 4.2 hours to be fully charged. (SLS, 2018)

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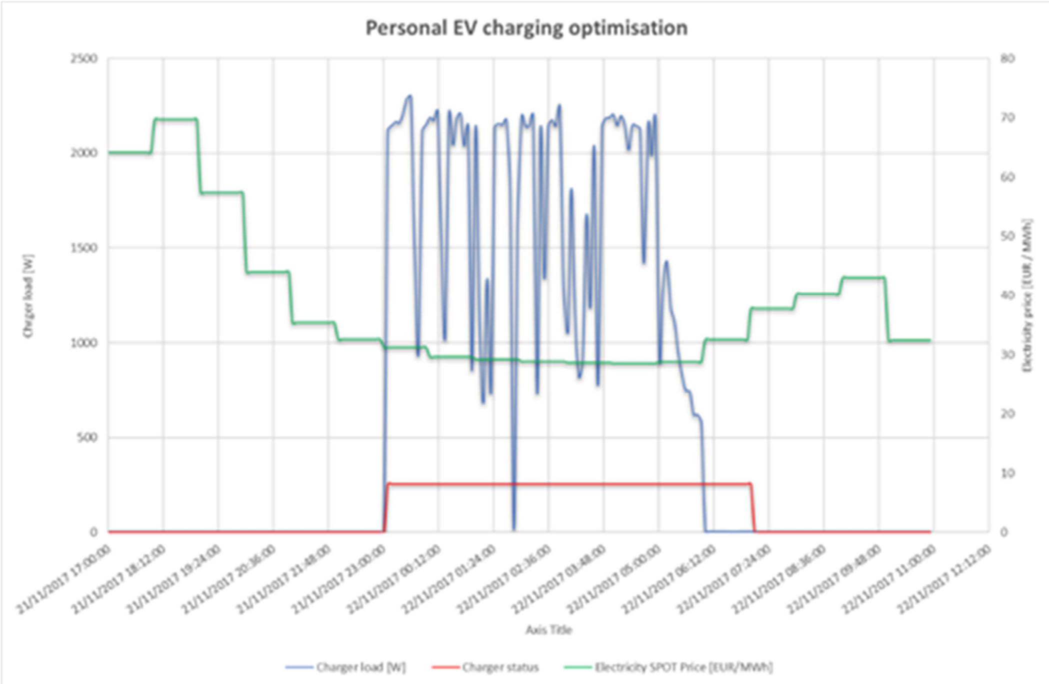

Figure 8: Personal EV charging optimisation – graph of collected data

Green line in graph represents electricity price that varied between 28,71 EUR/MWh at its lowest value and 69,72 EUR/MWh at maximum price. Optimisation process calculated needed time to charge personal EV battery and such information was used to control charger status (ON/OFF) as seen on red line. Measured charger actual power consumption is represented by blue line.

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6. Business models

With the service we try to lower the Total Cost of Ownership for the EV owner.

The basic business model is based on Hardware (HW) & Services sales.

In this case the HW would be gateway and charging station and possibly other components of energy management or security and safety areas.

Service fees are derived from services used and the fee covers the operation, maintenance and development. Service fee level varies depending on service type that customer subscribes to.

Salusfin can consider new types of business models like benefit-based approach with consumers or revenue sharing with B2B partners.

Additional elements can come from Demand-Response / sub-aggregator-aggregator-electricity market approach where controllable load is offered to the markets and revenue would be shared between participants. In Salusfin case the controllable load can consist of EV-charging and e.g. electric floor heating.

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7. Conclusions

Aim of activities under task 4.7.3 described in this document is to have impact on carbon footprint reduction and to support the European Parliament and the Council on the deployment of alternative fuels infrastructure with its Directive 2014/94/EU.

Concept of eCar sharing formulates ideas how to increase utilization of available resources (in this context personal EVs) as well as how to bring environmentally friendly means of transport to housing communities.

Personal EV charging optimization service on the other hand aims at consumption of electric energy for EV charging during low demand hours (when energy price is low). That way it would allow electricity producers to avoid of additional production capacity to be ramped up during peak hours (defined by high energy price). Primary benefit from end customer (consumer) point of view is lowered costs of EV charging. In case of load balancing with multiple personal EV additional benefit is in optimal utilization of available grid capacity at the location where multiple EVs are required to be charged.

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8. Recommendations

Data exchange of required parameters for optimization service between vehicle (EV) and EV charger is crucial for service to perform with minimal dependency on end user. Aim was to build a service that will be user friendly and cost efficient application that would require only necessary input from user. The protocol should provide needed information about EV, its battery and charging status which would have simplified the solution implementation and made it more user friendly. In an ideal case only information when charging shall be completed and if optimisation service is enabled should be requested. For this reason such EV and EV charger that has such capability was sought for to allow service to be widely deployable. Based on research of charging models it was decided to focus on units that support international standard ISO/IEC 15118. This protocol should have allowed the charging unit to communicate with the personal EV and provide all necessary data that are needed for optimization service. Due to commercial unavailability of ISO/IEC 15118 charging units and EVs supporting ISO/IEC on AC charging the option to build the EV charging solution based on ON/OFF control of charging unit was chosen. Salusfin will continue to develop and bring new additions to the existing implementation. Product backlog includes support for 3phase chargers and even a more initiative user interface.

For even further future EV development and when ISO/IEC 15118 will become a standard also on AC charging the concept and the use case will be much more user friendly. For future implementation it would also be to consider what kind of delta energy is available to be consumed. With Delta energy we refer to what is the load is put on the local grid, what other appliances consume and find out how much can be used for the EV charging process. This information could be added to the cloud intelligence and by knowing the current consumption and historical consumption need we could allow the charger to work more effectively and ensure the main switch circuit breakers limit is not reached.

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