Super Smart Charging Hubs | Interreg North Sea | Co-funded by the European Union

Definition of SSCH Solution

August 2025

Summary sheet

Project Name	**Super Smart Charging Hubs**
Title of the document	**Definition of SSCH Solution**
Deliverable number	D 1.4
Programme	Interreg NSR
Coordinator	Province of Zeeland
Website	https://www.interregnorthsea.eu/super-smart-charging-hubs
Author	Marcus Finn Lamp, Gate21
Status	Final
Dissemination level	Public
Reviewed by	
Submission date	
Starting date	June 2024
Number of months	36

Project partners

Organisation	Abbreviation	Country
Province of Zeeland	PZ	Netherlands
City of Vlissingen (subpartner)	VLI	Netherlands
Gate 21	Gate 21	Denmark
ASTER cv	Aster	Belgium
GreenFlux Assets B.V.	GFX	Netherlands
VUB-MOBI Electromobility Research Centre	VUB-MOBI	Belgium
Flux50	Flux50	Belgium
Agrisnellaad	ASL	Netherlands
Autodelen.net – carshare Belgium	Autodelen	Belgium
Hub Park AB	HUB	Sweden
Free Hanseatic City of Bremen	BRE	Germany
Partenord Habitat	PH	France
Sustain	SUS	Denmark
Dutch Association of Electric Drivers	VER	Netherlands

Document history

Version	Date	Organisation	Main area of changes	Comments
0.1	11-08-2025	Gate 21	First draft	With comments from Sustain (Steen Gravenslund Olesen=SG)
0.2	29/08	ASTER		Some minor additions
0.3				

Table of Contents

1. Executive Summary

This paper presents a commercial solution for Super Smart Charging Hubs (SSCH)—multi-charger sites hosting at least six 11–22 kW bidirectional chargers, dedicated to Vehicle-to-Grid (V2G) enabled vehicles.

The SSCH integrates locally produced renewable energy, optional stationary batteries, an Energy Management System (EMS), and Virtual Power Plant (VPP) aggregation, targeting V2G enabled private and shared cars, vans, and light electric vehicles such as electric bicycles and mobility scooters across multiple Living Labs in the North Sea Region.

Strategic Purpose & Value Proposition

Electric vehicle energy demand in Europe is forecasted to rise sharply—from 9 TWh in 2021 to 165 TWh by 2030—bringing potential grid reinforcement costs approaching €69 billion unless managed effectively. SSCH's address this challenge by levelling peak loads, leveraging local renewables, and providing flexibility via aggregated V2G assets to optimize grid integration and reduce infrastructure strain.

Human Desirability Insights

Deployment in urban and shared settings (e.g. Copenhagen's Fælledby) has surfaced user emphasis on cost savings, environmental impact, and trust in charging systems. Transport users want assurance that charging schedules honor their departure needs without undue battery wear or inconvenience (based on early stakeholder engagement in Living Labs).

Regulatory & Legal Landscape

Under Germany's "Coalition of the Willing" framework, European working groups outline a roadmap targeting functional, interoperable V2G solutions by 2025 and mass-market readiness by 2030. Regulatory recommendations include tax and surcharge exemptions for energy discharged into grids during flexibility events, dualmeter arrangements for rebate transparency, and enabling capacity payment models for Distribution System Operators (DSO's) and aggregators. Across European regions, legal frameworks remain fragmented, which SSCH must navigate to achieve scale.

Business Viability

Revenue models for SSCH combine:

- Charging fees,
- Arbitrage across dynamic tariffs,
- Grid services such as frequency regulation, peak shaving, and VPP aggregation.

Pilot data suggest ancillary service revenue of ~€20/month per EV is commercially realistic (Greenflux). Success depends critically on electricity price spread dynamics, battery cycle costs, and supportive tariff design.

Technical Feasibility & Smart EMS

An SSCH integrates ISO1511820 compliant bidirectional charging units (e.g., XXX 11 kW or 22kW chargers), rooftop or ground-mounted RES (Renewable Energy Sources), optional stationary storage, and a central EMS and VPP platform. Advanced centralized control—validated in academic pilot studies—reduces transformer load variability, smooths grid demand, and maximizes local renewable utilization.

2. Introduction & Context

2.1 The Need for a Paradigm Shift in EV Charging

Electric vehicle (EV) adoption is accelerating across Europe, with forecasts suggesting that by 2030 more than 40 million EVs will be on European roads. This transition presents an urgent challenge: how to ensure that the power grid can support charging demand without costly reinforcement, and at the same time leverage EV batteries as a flexible energy asset. Traditional unidirectional charging models exacerbate local peaks in electricity demand, while Vehicle to Grid (V2G) and smart, bidirectional charging enable vehicles to act as distributed energy resources, smoothing demand and creating value for both the grid and EV owners.

2.2 Concept of the Super Smart Charging Hub (SSCH)

The **Super Smart Charging Hub (SSCH)** is conceived as a multi-functional charging ecosystem that combines:

- **Bidirectional chargers**

- **Energy Management System (EMS)** for load balancing, demand response and VPP interaction
- **Integration with local renewable sources** such as a field or roof based photovoltaic plant sized to deliver at least 35% self-sufficiency
- **Grid connected stationary energy storage that will fill out the gaps and reduce grid reinforcement requirements**
- **Grid-interactive VPP capability** to monetize flexibility and reduce grid strain

An SSCH is designed for a **diverse user base**: shared mobility fleets, private cars, vans, and in some cases light electric vehicles. Beyond just charging, these hubs also **support local energy communities** by allowing energy sharing with residential or office buildings – all in all – the SCCH is by default an active component to maximize RES uptake, reduce the investments required and hence accelerate the green transition.

2.3 Why Focus on 11–22 kW AC V1G and V2G Charging?

Unlike high-power DC fast charging, AC charging at 11–22 kW is more suited for controlled, predictable, and cost-efficient charging sessions – and not least they rely on the key components to be installed in the electric cars instead of the AC/DC converts to be installed in the charging stations.

These yet slower sessions allow for:

- **Higher renewable penetration** by scheduling charging when solar/wind are available
- **Bidirectional energy exchange** with minimal stress on the grid and EV-batteries
- **Lower connection capacity requirements** than fast chargers

This controlled environment maximizes the **grid services potential of V2G**, which becomes much harder in fast charging scenarios.

2.4 Living Labs as Testing Grounds

To validate the SSCH concept, real world Living Labs are being set up in Denmark, Belgium, the Netherlands, and Sweden. These pilots provide diverse operational contexts: urban residential zones, social housing districts, and mobility hubs. Each site tests user interaction, EMS algorithms, financial models, and integration with local energy production.

By studying actual user behavior and system dynamics, these pilots will define KPI's for replication across Europe.

2.5 Barriers to be Addressed

Several interdependent barriers justify a dedicated SSCH approach:

- **User acceptance**: Trust in leaving vehicles connected, concerns about battery wear, and guaranteed availability.
- **Legal/regulatory fragmentation**: Uneven frameworks for V2G compensation, grid access rules, and liability.
- **Business model uncertainty**: Lack of clear monetization pathways for flexibility services.
- **Technical complexity**: Integration of EMS, VPP, and distributed renewable energy sources at scale.

2.6 Opportunity for a Systems Solution

SSCH represents a system-of-systems approach that unites human desirability, business viability, and technical feasibility.

It positions V2G not as an add-on feature but as a core pillar of energy transition, where charging hubs act as critical nodes in future decentralized energy networks.

3. Defining SSCH

3.1 SSCH Definition

A Super Smart Charging Hub (SSCH) is:

- A charging hub with multiple bi-directional smart charging stations.
- A SSCH provides charging infrastructure for V2X enabled electric vehicles (these could be shared cars, private cars and vans and possibly also light electric vehicles).
- The SSCH is connected to the electricity grid and makes use of locally produced renewable energy sources. It consists of an energy management system for load balancing and optionally energy storage capabilities (next to the V2G EV's).
- The SSCH includes a 'virtual power plant' (VPP) that solves the business case as it aggregates energy within a portfolio.

- The SSCH interacts directly with the community and the grid operator, using a smart energy management system to optimize the energy flows in the SSCH (charging, discharging, utilization of locally produced electricity, etc.). This will reduce strain and have a positive impact on the grid, often allowing for a smaller connection to that grid.
- The SSCH will be able to provide energy for other energy users, for instance, public or private offices and residential buildings.

Through the project we hope that we will gain a better understanding of relevant KPI's that could show the benefits of a SSCH. Indicative KPI's could be some of the following:

- **Grid interaction** (≥ 20-30 % peak load variance reduction),
- **Flexibility revenue** (€/kW/month levels),
- **Renewable integration** (≥ 30 % local self-consumption),
- **User satisfaction** (≥ 95 % reliability on SoC/timing),
- **Battery impact** (< 5 % incremental degradation),
- **Operational efficiency** (≥ 85 % charger uptime),
- **Financial performance** (< ?year payback)
- **System responsiveness** (< 1 s EMS latency),
- **VPP aggregated capacity** (scalable by fleet size or with the overall setup with buldings and stationary batteries?)
- **Scalability** (≥ 10 simultaneous sessions).

4. Technical Architecture and Energy Management System (EMS)

4.1 Overview of SSCH Technical Architecture

The Super Smart Charging Hub (SSCH) is a complex, integrated system designed to optimize bi-directional energy flows between buildings (office, residential, or other), Electric Vehicles (EVs), stationary batteries, local renewable energy sources, and the local grid connection.
Its architecture integrates multiple components that work together to enable additional loads in both existing and newly built areas through efficient control and energy management.

The key elements include:

- **Bidirectional Charging Stations:** A minimum of 10 AC chargers (ISO 15118-20 and OCPP 2.1 compliant) rated between 11 kW to 22 kW. The chargers should live up to the local TSO- and DSO-requirements to handle both charging EVs and discharging energy back to the local micro grid or national DSO-grid.
- **Local Renewable Energy Sources:** Typically, photovoltaic (PV) panels or small wind turbines integrated to supply clean energy directly to the hub.
- **Optional Stationary Energy Storage:** Battery units that complement EV storage for increased flexibility and grid services.
- **Virtual Power Plant (VPP) Interface:** Aggregates multiple SSCH's and connected assets into a portfolio for participation in energy markets and ancillary services.
- **Communication Network:** Secure and standardized communication protocols (e.g., ISO 15118-20, OCPP 2.1) for data exchange among EVs, EMS, grid operators, and energy suppliers.
- **User-interface** allows end-users to interact with the system. E.g. to book a shared car with a minimum milage at the desired pickup time
- **Energy Management System (EMS):** The "brain" of the SSCH that orchestrates charging sessions, energy storage operation, and grid interaction based on real-time data and predictive algorithms.

4.2 Functional Blocks and Data Flows

At the core of the SSCH is the Energy Management System (EMS), responsible for real-time coordination of:

- **Load Balancing:** Scheduling charging and discharging to reduce demand peaks and avoid overloading of local DSO-transformers.
- **Renewable Energy Integration:** Prioritizing the use of locally generated solar or wind energy, minimizing grid dependency and emissions.
- **Battery State-of-Charge Management:** Ensuring EVs maintain the required charge level for user needs while enabling flexibility when possible.
- **Grid Interaction:** Responding to TSO-grid operator signals for demand response, frequency regulation, or voltage support, respecting the overall business case optimum.
- **Energy Storage Coordination:** Optimizing stationary battery use in tandem with EVs to maximize economic and technical benefits.

The EMS continuously collects data from:

- Buildings: Actual consumption and forecast
- RES: Renewable generation forecasts and real-time production
- Batteries: SoC, Forecast

- EVs: EV arrival/departure times and state-of-charge requirements
- Users: User preferences and contractual agreements
- DSO: Grid conditions (voltage, frequency, tariffs)
- TSO: Market prices for electricity and ancillary services

Using predictive algorithms and machine learning models, the EMS dynamically adapts to charging schedules and flexibility offers to maximize technical feasibility, economic return, and user satisfaction.

4.3 Energy Flow and Load Balancing Diagram

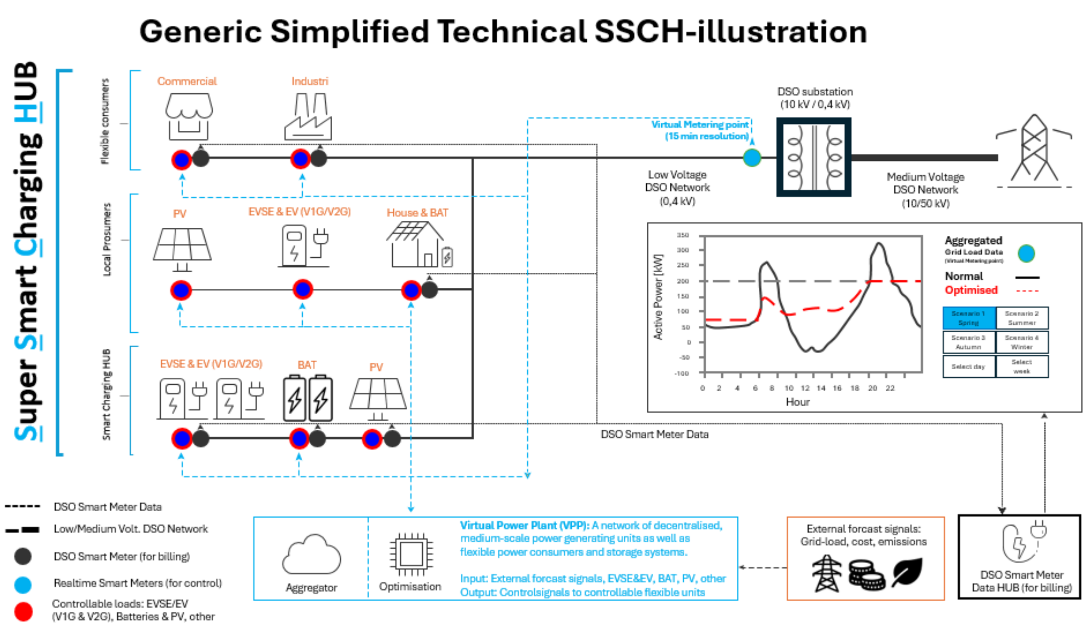

Diagram 1: A schematic illustrating bidirectional power flows between EVs, local renewable sources, stationary battery storage, the electricity grid, and local building loads, all coordinated via the EMS.

Diagram 1 visually represents the SSCH's capability to:

- **Charge EVs** using solar energy when available, or grid power during off-peak times.
- **Discharge EV batteries** to supply local building demand or feed power back to the grid during peak periods.
- **Operate stationary storage** to buffer renewable generation and reduce grid stress.
- **Participate in VPP services** by aggregating energy flexibility from multiple hubs such as **Flexible consumers, Local Prosumers and Smart Charging Hubs**

4.4 Communication and Control Protocols

The SSCH relies on open, standardized communication to ensure interoperability:

- **ISO 15118-20, 2nd amd1 (2025):** Provides a secure, standardized interface for smart charging and V2G communication between EVs and charging stations, supporting plug-and-charge and automatic authentication.
- **Open Charge Point Protocol (OCPP 2.1):** Enables communication between charging stations and central EMS or backend systems for remote control, monitoring, and diagnostics. OCPP 2.1 opens for the V2G
- **Grid Operator Interfaces:** Custom APIs or market protocols for demand response signals, price notifications, and grid status updates.

Cybersecurity is embedded in these protocols through encryption, authentication, and real-time intrusion detection to maintain system integrity.

4.5 Scalability and Modularity

The SSCH technical design is **modular and scalable** to accommodate:

- Varying numbers of charging stations and EVs
- Different renewable energy sources and storage configurations
- Integration with multiple VPPs or aggregators
- Adaptation to local grid constraints and regulatory requirements

This flexibility allows the SSCH to be deployed in diverse environments, from urban mobility hubs to residential communities.

4.6 Technical Challenges and Mitigation Strategies

Implementing the SSCH architecture involves overcoming challenges such as:

- **Managing battery degradation:** EMS algorithms incorporate battery health models to optimize charging cycles and limit deep discharges.

- **Balancing competing objectives:** Prioritizing user needs, grid requirements, and economic optimization requires advanced multi-objective optimization techniques.
- **Ensuring real-time responsiveness:** Fast communication and control loops ensure the SSCH reacts swiftly to grid signals without compromising user experience (depending on the setup this will include household consumption and mobility needs).
- **Interoperability:** Conformance testing and certification ensure all hardware and software components work seamlessly.

5.

SSCH Consortium

Living Lab Partners

Research partner

Network and knowledge partners

Replication partners

For further information please visit https://www.interregnorthsea.eu/super-smart-charging-hubs