EVS35
OSL2022

JUNE 11–15, 2022

Realize efficient charging of electric cars (EVs) with user-centred smart technology - A Swedish test pilot

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Robert Eriksson; Volvo Cars
Thomas Lindgren; Volvo Cars and Halmstad Högskola

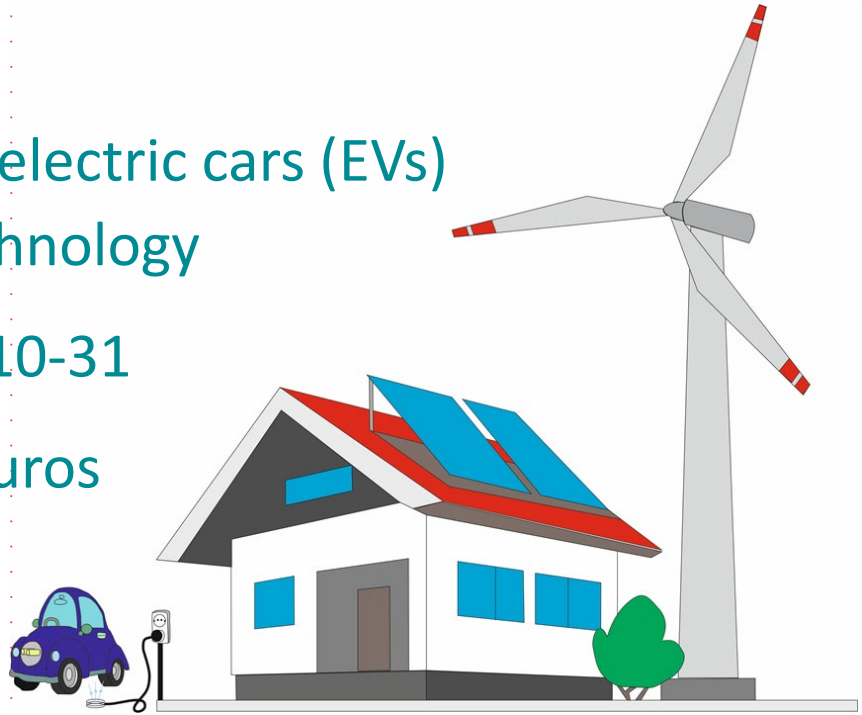
RI.SE

RELEVANT

Realize efficient charging of electric cars (EVs) with user-centred smart technology

Project 2019-11-01 -- 2022-10-31

Budget around 1.8 million Euros



FFI Fordonsstrategisk Forskning och Innovation

VINNOVA Energimyndigheten TRAFIKVERKET FKG SCANIA VOLVO

What is a prosument?

- A **prosumer** is a person who both *produces* and *consumes* a product.

  Refers to individuals who are more than just regular consumers and who also may have a professional interest in a company or its products and services.

- The product in focus is related production and consumption of *electrical energy*.
- Diminish the role of a corporate producer – an effect of automation and globalisation.
- Companies that open up their processes to the end-user, integrating them as prosumers for shared benefits.

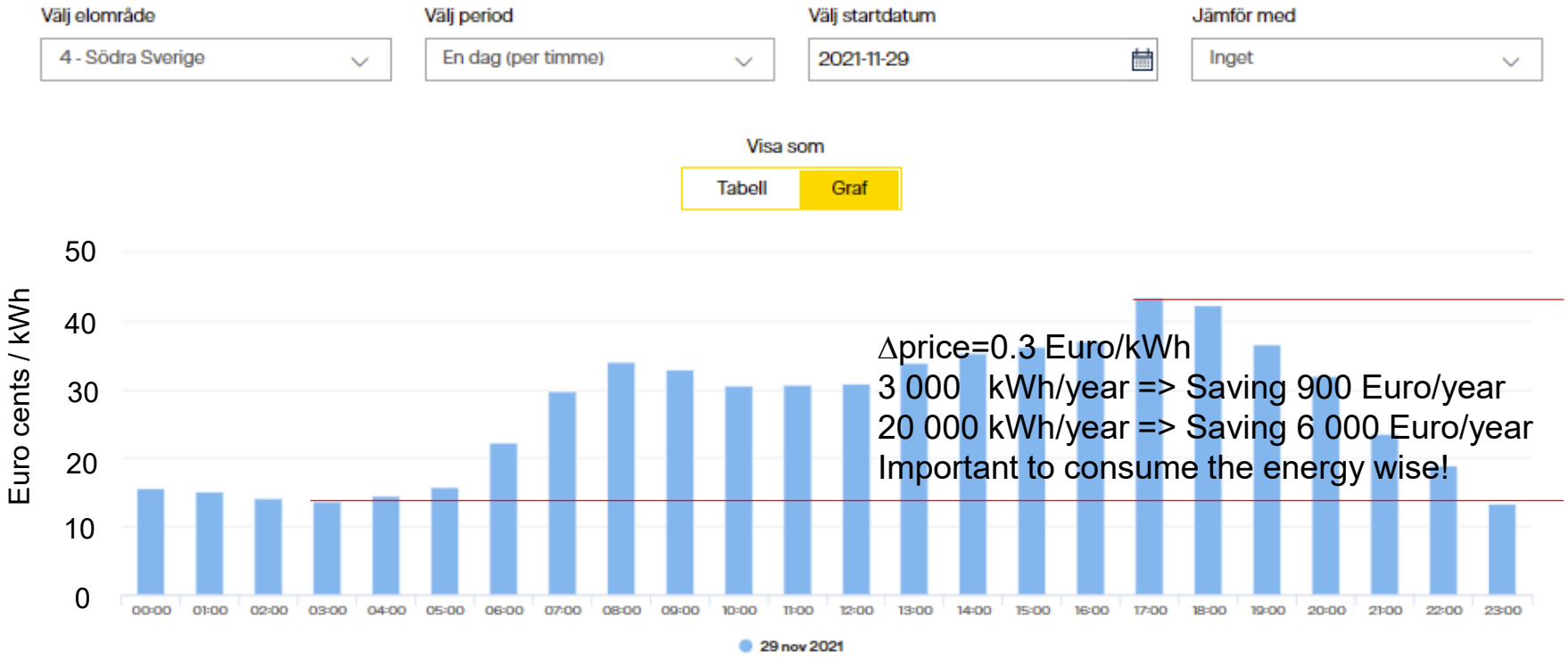
Potential values for the prosumers

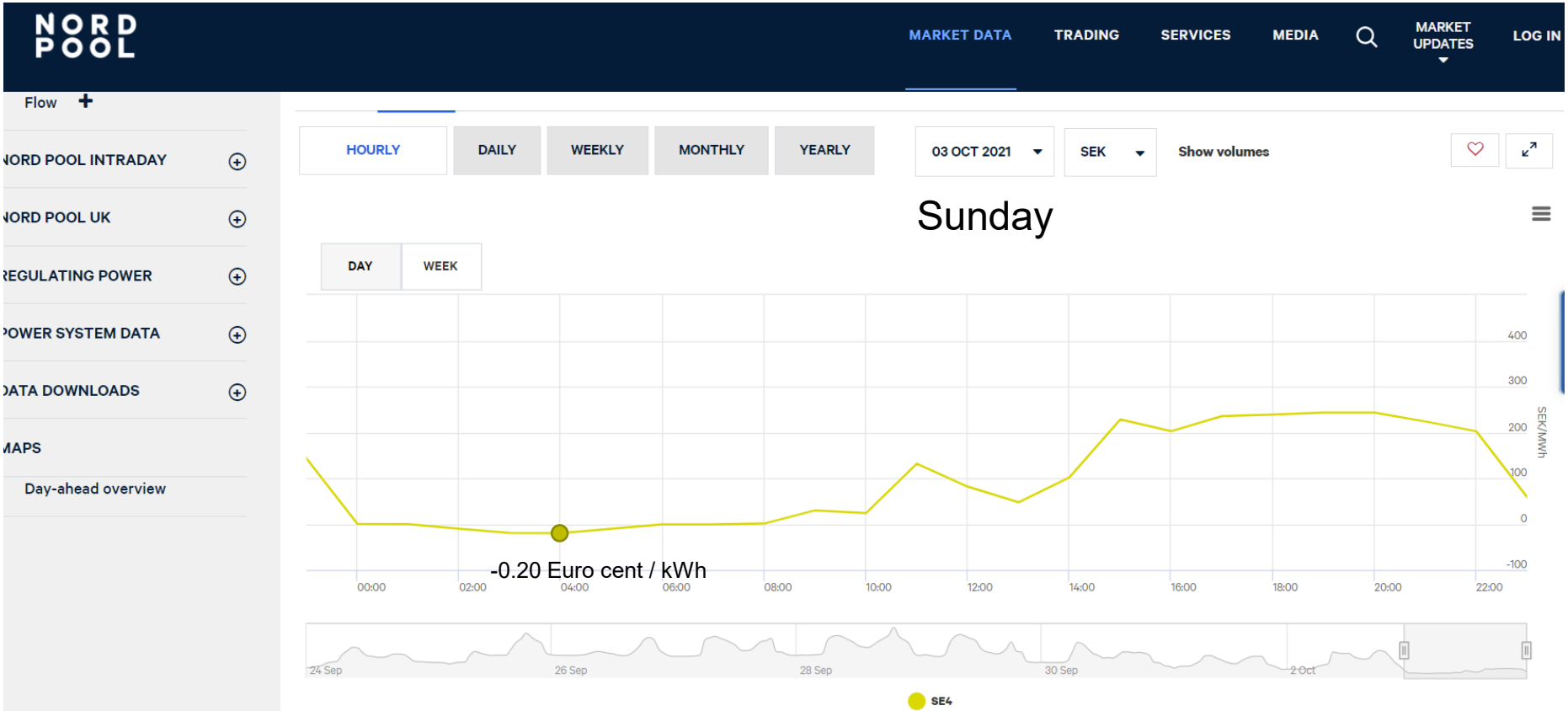
- Economy
  - Using energy when cheap electricity prices, and not if high ones
  - Peak shaving -> lower cost due to down-sized main meter fuses in the houses
  - Peak shaving -> lower cost when power tariffs
  - Less energy from the net -> cheaper in the long run
  - Paid for excessive electricity generated back to the grid from the house
- Convenience and better life
  - Comfortable feeling of being self-sufficient with electricity insensitive to price variations of electricity
  - Convenient solution with respect to maintenance and usability (inductive charging even more convenient)
- Energy security
  - Backup power – Vehicle-to-grid (V2G)
- Environment
  - Lower emissions

Spot price at the Nord Pool market (leading power market in Europe):

- Belgium, Denmark, Estonia, Finland, France, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, the United Kingdom, Sweden, Germany and Austria.

Does not include costs for the electricity certificate, additional costs, energy tax, VAT and grid costs.




NORD POOL
MARKET DATA
TRADING
SERVICES
MEDIA
MARKET UPDATES
LOG IN
Flow
NORD POOL INTRADAY
NORD POOL UK
REGULATING POWER
POWER SYSTEM DATA
DATA DOWNLOADS
MAPS
Day-ahead overview
HOURLY
DAILY
WEEKLY
MONTHLY
YEARLY
03 OCT 2021
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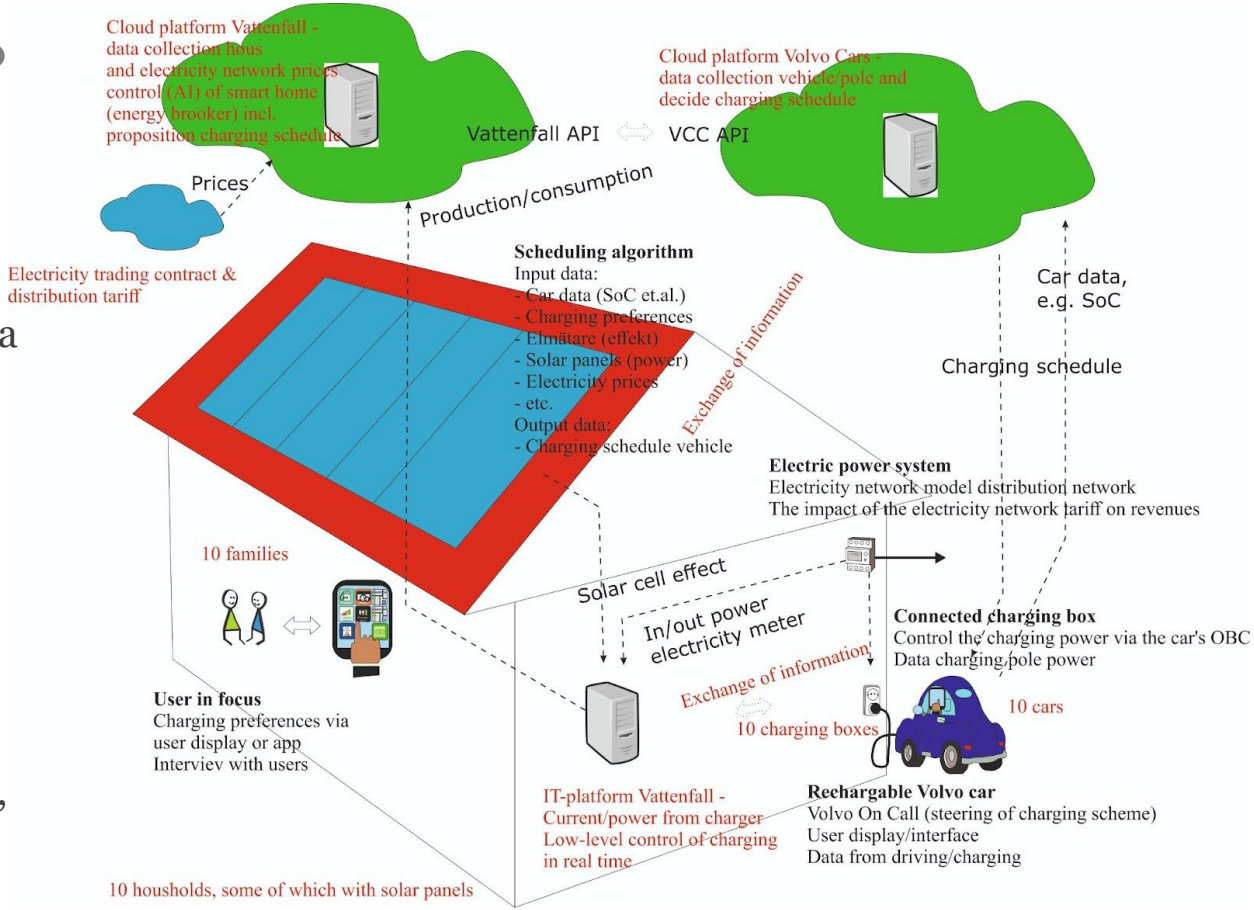
24 Sep
26 Sep
28 Sep
30 Sep
2 Oct
SE4

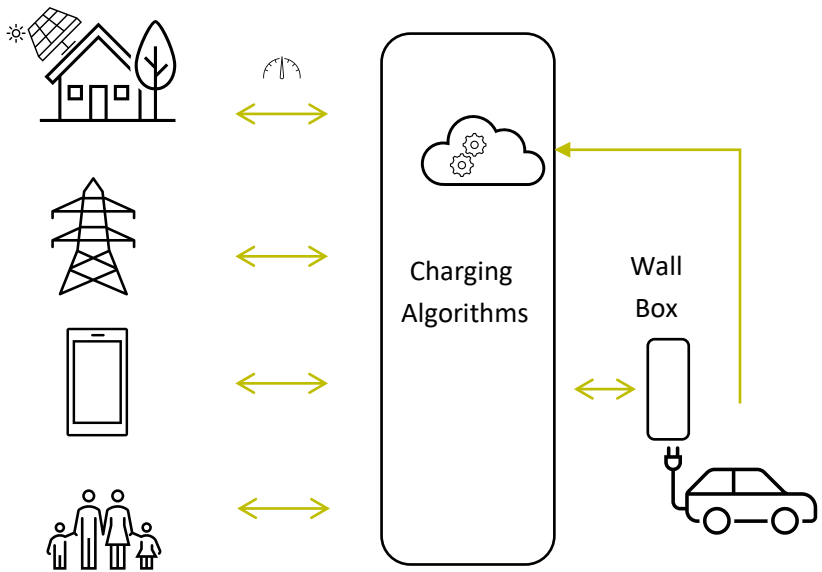
What are we doing?

- Provide about 10 households with rechargeable cars and equipment for controlling the home for a period of just over a year; some of the houses have their own generation of electricity
- Evaluate how the interaction between the home and the rechargeable car with the help of AI-based controller can be improved regarding energy consumption, network impact, costs and user attractiveness.



Research questions

- Users' preferences and expectations of smart charging of electric and charging hybrids
  - What charging preferences, real needs and routines do users have and why?
  - What possible charging preferences and routines can be created in a smart home?
  - What future expectations do users have of *smart charging* of their vehicle?
  - How do preferences and expectations change over time?
- HMI
  - How to design a user interface for a smart charging function iteratively to increase understanding, provide an opportunity to influence the function and encourage behavioral changes over time?
- System effect
  - What effect (regarding behavioral changes, energy management, etc.) will it be when electric vehicles are connected to the smart home?
  - What opportunities to even out the power need provide smart charging in the home about only information on power consumption and any solar panel generated power is available for the car?
  - How should the energy scheduling algorithm be designed to achieve the cost reduction? What information is needed and how much impact does it have?
  - What additional information from consumers and self-generated electricity in the house can reduce costs further and how is it taken care of by the controller functionality?


Charging
Algorithms
Wall
Box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kW.last
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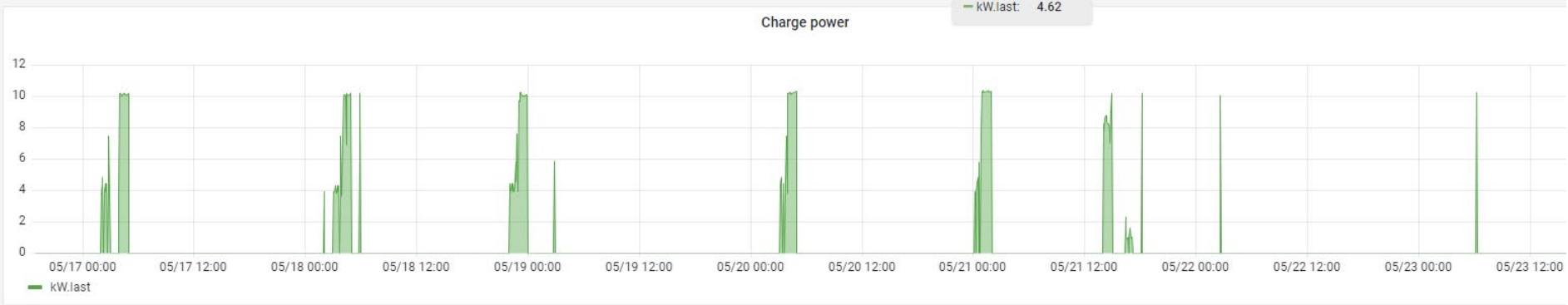
kW.last: 4.62


Charge power
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2
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kW.last


Energy Spot Price SE3 [SEK]
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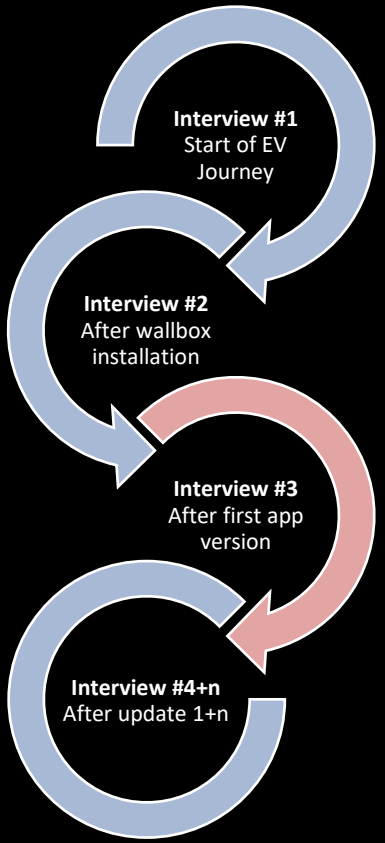
VOLVO

HALMSTAD UNIVERSITY

Design Ethnographic approach in RELEVANT



VOLVO

What does “Smart” mean to people regarding technology?

VOLVO

“Smart” means:
Technology that “support” me…

…to do smart things, such as:

- save cost
- save time
- simplify complexity
- remove “boring or unconvenient” routines
- to have a more sustainable lifestyle
- to make me learn something new
- make me feel smarter than others

Design Implications

- **People see different value in smart charging;**
  - **Technology need to “show” value in different ways for different users and through different stages (also within a household)**

“There can be a charging calendar”

“It would be interesting to export this info as excel sheets like driver log in VOC”

“..It’s about to confirm that it is working to get trust, not so much about seeing exactly how much is saved.”

“Good to see charging history to build the trust, but overtime it won’t be necessary.”

“What’s the price charging at Volvo, is it flexible too?”

“get notification of not charging inform me that it will not be fully charged by tomorrow” -M

“Tell me if I’m doing a good job in terms of sustainability.” -J

“Expect some tips…to help me start”

“ Smartness to tell me about when something has gone wrong, like if the heat pump is broken and energy consumption has changed”

Expert → Casual

VOLVO

“Smart” means:
I learn how to do things in a better way

- Understanding of EV’s and smart charging insuffcient
- Energy is abstract, Energy pricing, EV batteries work differently than fossil cars, or how to live more sustainable are tricky to figure out.
- People want to learn and learns along the way…

Forecast

“Want to have information where I can make choices for less cost and become more sustainable”
-J

“Interesting with spotprice forecast , I have seen when colleagues showing the Tibber app.”
-J

Process

“Before the app (Relevant) is working, I used to set an alarm on the iPhone”
-A

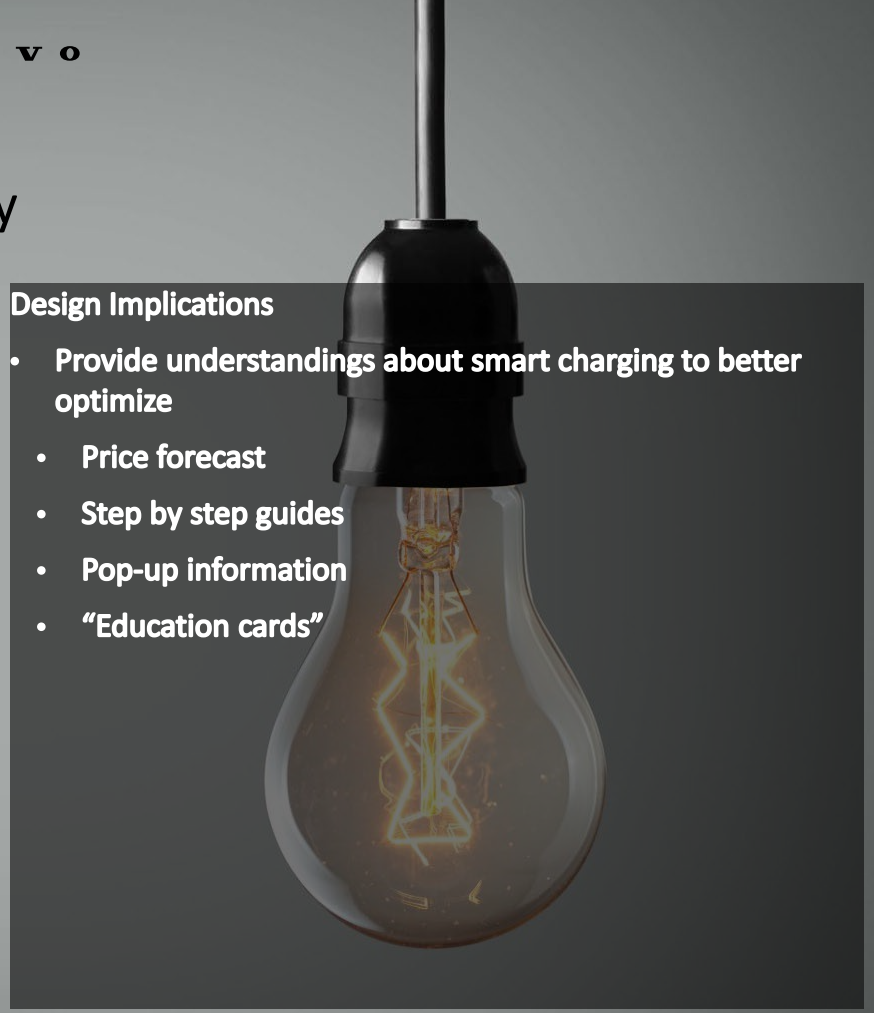
“I check energy price in Elen.se(?)and set a timer on VOC app”
-G

“Smart technology is not about the money, it's more about optimisation”
-N

Learning

“It’s interesting to know the wind speed or temperature.. if it is connected to the regional prices, not local weather. “

“After getting an EV, you need to train to continue to make good choices. Maybe taking ideas from training apps”
-J



Design Implications

- **Provide understandings about smart charging to better optimize**
  - **Price forecast**
  - **Step by step guides**
  - **Pop-up information**
  - **“Education cards”**

VOLVO

“Smart” means: More or less info…

- “smart” could mean both be reducing information and options as well as providing more information and options to make even ”smarter” decisions

“Want confirmation on actions: “Good that you made a good choices!” -J

Simplify

“I want to see average energy price of charging VS average energy price of home consumption.”

Compare

“I want to have the amount in krona to compare with petrol price.”

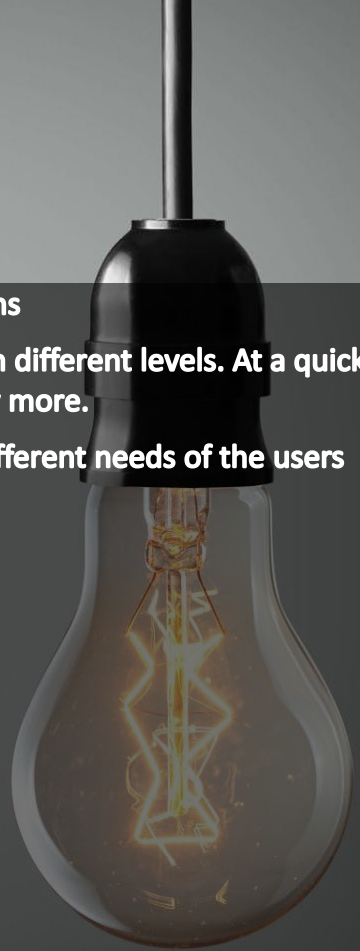
“Might be good with predicting charging window and costs to understand if it's worth charging for next trip or even go on that trip”

“Spot price info would be helpful to optimize dishwasher and washing machine.”

Details

“Difficult to find app that tracks spot price. Why doesn’t Vattenfall have an app showing that.”

“Really good to have this info, maybe just the next 8 hours is enough”



Design Implications

- **Information on different levels. At a quick glance or a step into it to know more.**
- **Adapting to different needs of the users**

VOLVO

“Smart” means:
Technology have to proove itself

- Smart technologies have to explain itself before it could be seen as smart
- And provide possibility for cooperation

Input

“I think it would be nice to see when the charging is planned next + see what actually happened, probably what happen next is secondary”

“I think it’s impossible to know how the energy price is set, there’re so many factors! probably nobody knows.”

Status

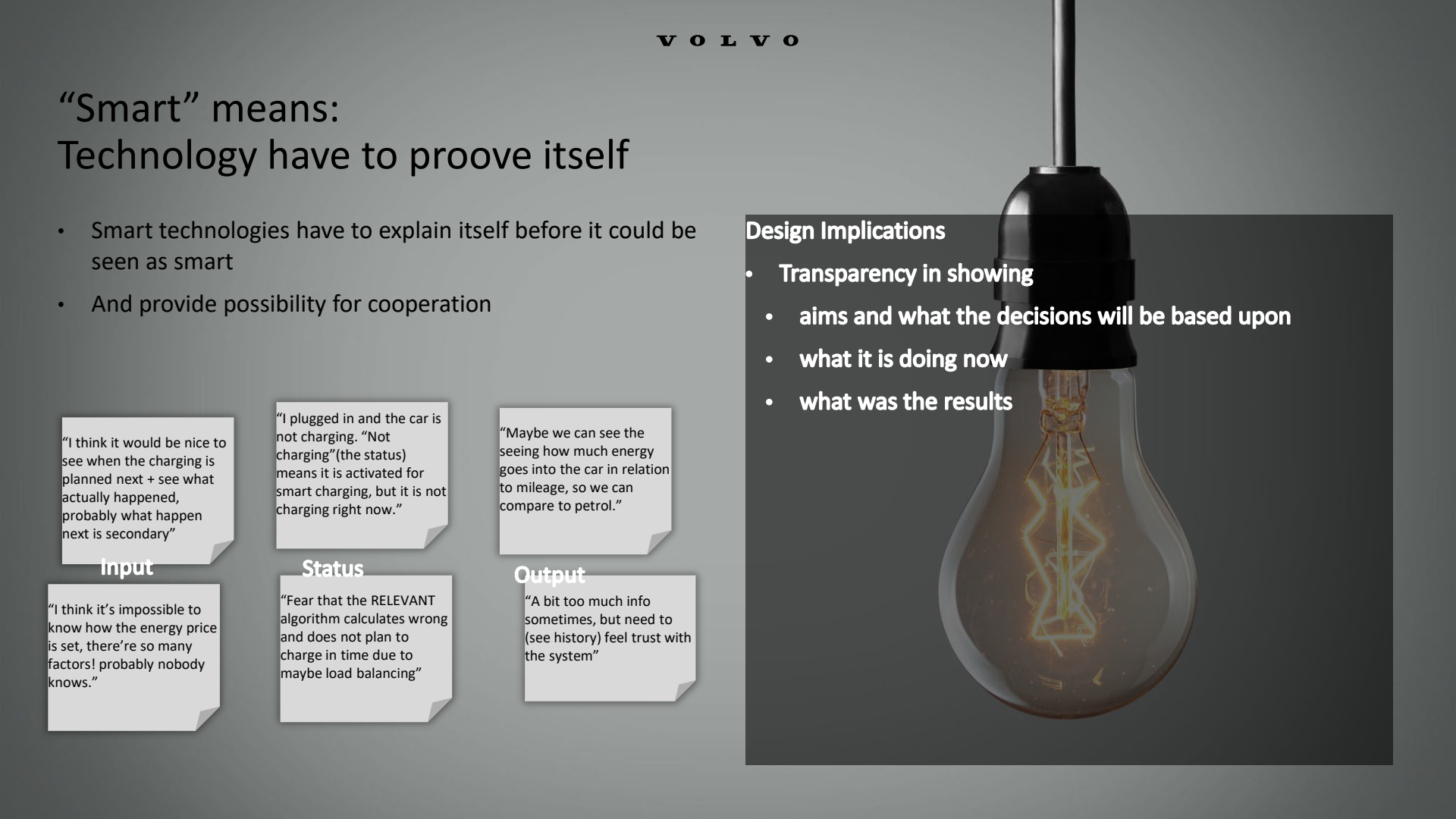
“I plugged in and the car is not charging. “Not charging”(the status) means it is activated for smart charging, but it is not charging right now.”

“Fear that the RELEVANT algorithm calculates wrong and does not plan to charge in time due to maybe load balancing”

Output

“Maybe we can see the seeing how much energy goes into the car in relation to mileage, so we can compare to petrol.”

“A bit too much info sometimes, but need to (see history) feel trust with the system”



Design Implications

- **Transparency in showing**
  - **aims and what the decisions will be based upon**
  - **what it is doing now**
  - **what was the results**

VOLVO

“Smart” means:
telling me about something is wrong…

- … extreme or broken, not only optimising

“I want to get notification only when it’s not charging instead of when it is charging.” -M

Unusual

“December 2021 is a good reminder that charge is not something we will do everyday going forward. and price is not always cheap during night.”

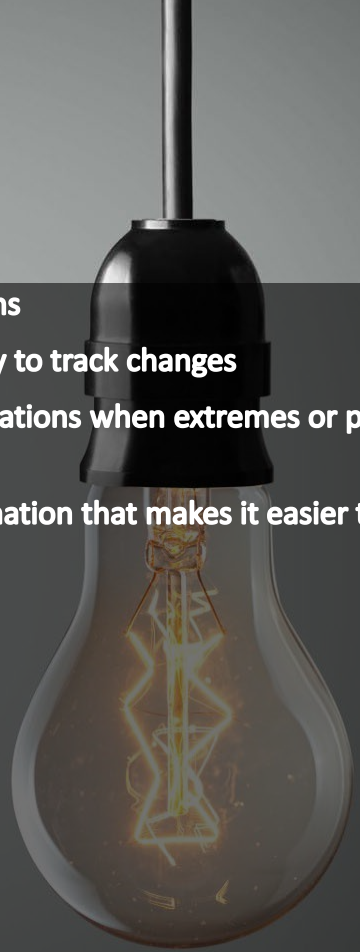
Extremes

“What happens when the lowest price at night is 300 öre and I plug in my car? Does it charge then?

Cuz 300 is in no way cheap.” -G

“ Smartness to tell me about when something has gone wrong, like if the heat pump is broken and energy consumption has changed”

Failures



Design Implications

- **Provide history to track changes**
- **Provide notifications when extremes or problems are detected**
- **Provide information that makes it easier to detect where the problem is**

VOLVO

“Smart” means:
technology have to evolve with me

- Technology have to evolve and adapt to other things in life.

Updates

“When I need to use the car, please make energy available through the wallbox for preconditioning. I could set 80% as a limit but get 78% in the morning.

“It’s Wednesday, I just need to work to and from work for two more days and spot price is extremely, then I don’t want to think about it(charging). So even if I plug in, it will not charge”
-M

Learn behaviour

“Normally same needs and behaviours, it should learn.
I want to tell it the deviations”
-M

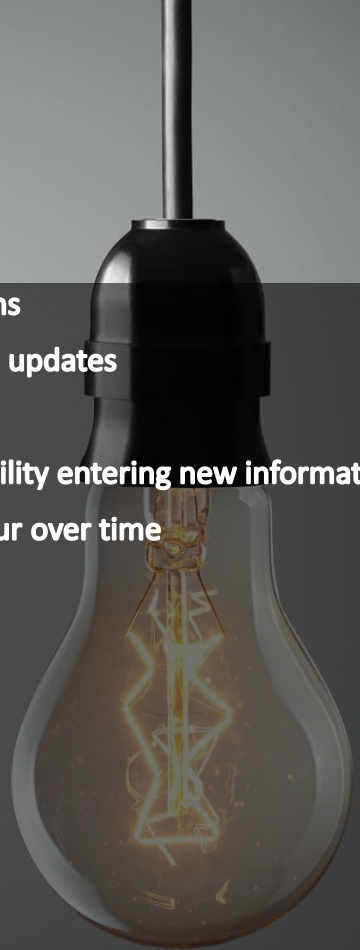
“There can be a weekday setting and a weekend setting”
-M

Changes

“..I thought about energy storage solution, but tricky to calculate the optimal size as winter needs a huge and summer only a small one.”
-F

“It was both for cost and environmental reason, but we had the option of renewable energy before (installation of solar panels) too.”

“ Possibility to add more cars into an app to separate costs and energy”
-N



Design Implications

- **Continious SW updates**
- **Flexible API**
- **Provide possibility entering new information**
- **Learn behaviour over time**

VOLVO

“Smart” means:

- **Smart is acknowledging the diversity of anticipations and fears in a household, and enabling the collaboration and merging of interests, values and routines.**

“when I come home on Friday, maybe I don’t need to use the car for the whole weekend, but Monday at 6am. and then I have a lot of room to play with optimization.... I guess it opens up for possibilities but can also create complexity.”
-F

“A weekly calendar for charge finishing time. Weekends and weekdays are different.”
-N

Household Routines

“If price is high, good to check weather if you can wait a couple of days. Optimization doesn’t have to happen the same day.”

“..Yes we avoid shower on peak hours, and we program our dishwasher.”

“..Unplanned charging with short notice when son needs the car.. simply override”
-J

Multiple users

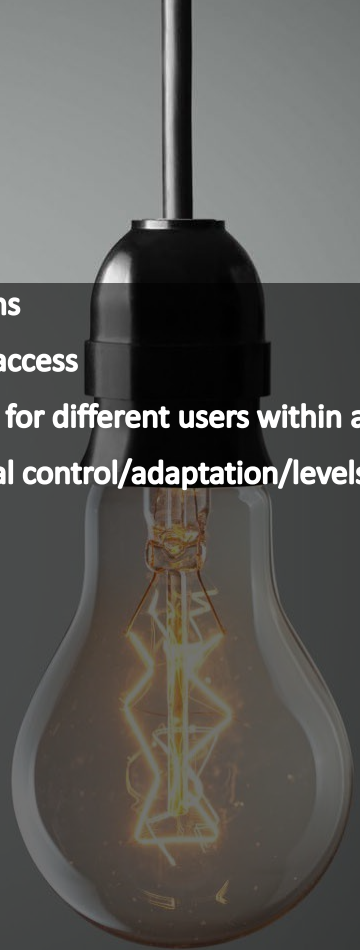
“I want to know which car is charged/being charged, switch in between, and be able to name them.”
-M

“I understand what to do, but I don't want to screw up my routine setting with overrides”

Access

“I change max limit to 100% when I go on long trips. I want to quickly override maximum.”
-F

“I don't understand why we are so afraid of letting people making their own decisions. That's frustrating. Volvo feels like a phone for elderly people (Doro)”
-N



Design Implications

- **Multiple user access**
- **Showing value for different users within a household**
- **Provide manual control/adaptation/levels**

VOLVO

Summary user needs:

Value

- For different users within a household
  (cost savings, simplification, load balancing, sustainability, data, learnings etc.)
- Split charging and household costs/energy consumption

Trust

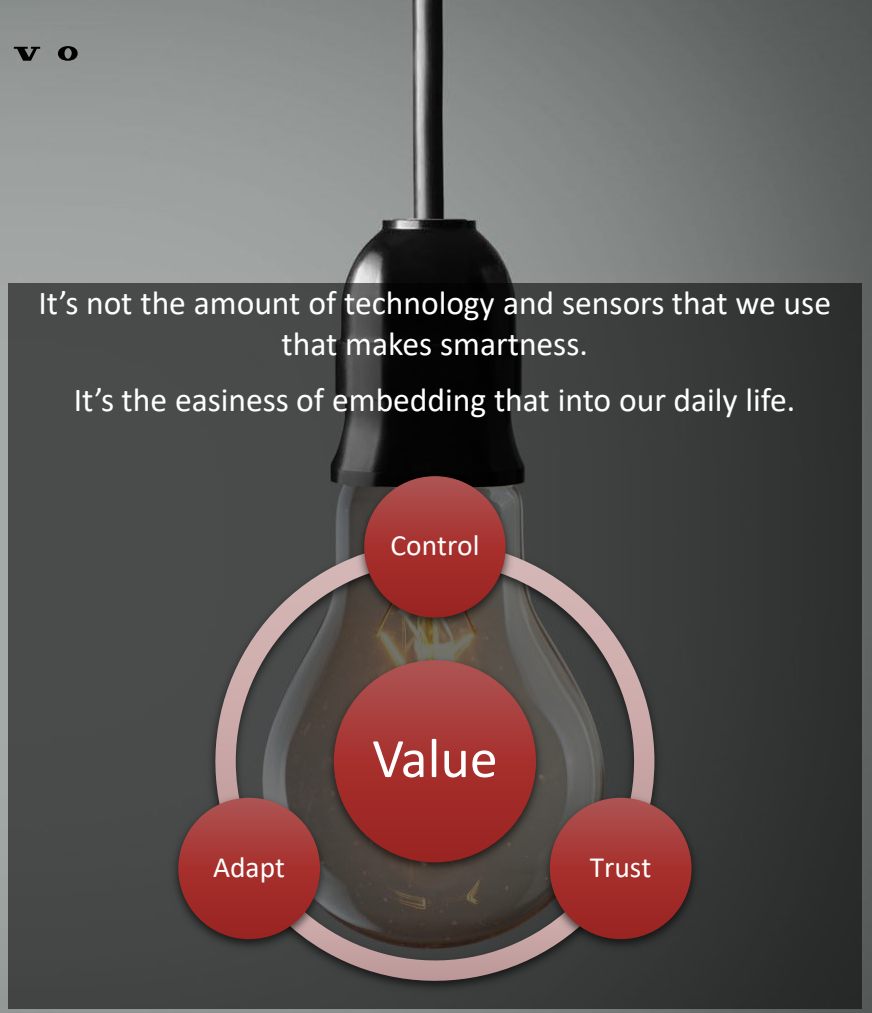
- How does it work? Forecast
- Does it work? History, Errors
- Range vs. SOC

Control

- Deciding when pause smart charging
- Same SOC settings in car and smart charging app

Adaptation

- Longer time planning, weekdays vs. weekends
- Preheating from wallbox
- Different users of the car
- Easy updates, enter data
- Two cars sharing wallbox/ two wallboxes

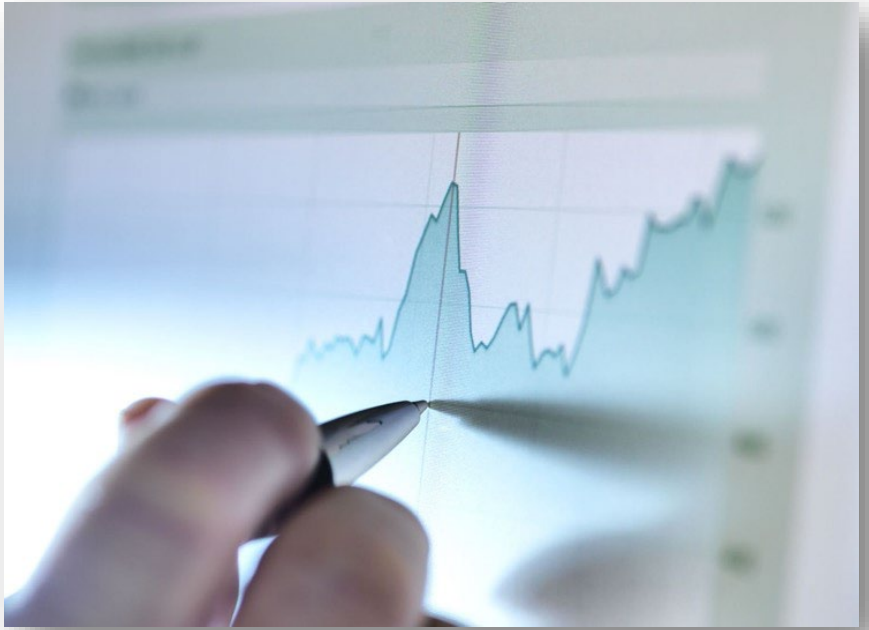


Insights - **It’s not all about money…**

Of course, everyone hope to save cost….BUT

- It’s not the amount of money that matters, it’s the feeling of making a smarter choice
- Very tricky to really calculate savings, you could easily calculate it’s a win or loose depending on your preconceptions
- The feeling of becoming more independent are strong. (avoid peak costs, provide their own fuel/energy, avoid grid limitations or power outage etc…)

… its also about the **feeling of making smart choices** and to **become more independent**



Insights – **Smart automation when it makes sense…**

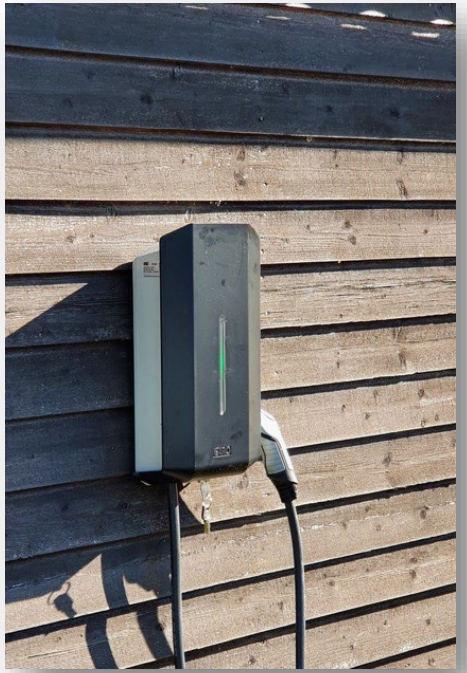
Make it effortless to manage energy as it is complex and confusing…BUT

- Enable me to have control to make decisions
- Make me understand why and guide me when needed
- Avoid the “maintenance” when automation has become the everyday
- “Does the smartness have to be that complex. Why don’t just charge at night?”

…as people know their everyday best and…

.. their understanding of smart charging **benefit is insufficient** and **trust in its reliability is low**

Therefore, a well performed **user-technology collaboration is needed for building trust**



SCALE

SCALE - Smart Charging ALignment Europe

Research and Innovation Action
CL5-2021-D5-01-03: System approach to achieve optimised Smart EV Charging and V2G flexibility in mass-deployment conditions (2ZERO)

SCALE-what will be done?

SCALE advances the smart charging and Vehicle-2 Grid (V2G) ecosystem capitalizing on the mass-deployment of electric vehicles

SCALE is a new Horizon Europe project that kicked off in June 2022. Leading European cities, universities and knowledge partners, networks, and energy and electric vehicle (EV) industry pioneers joined forces to explore and test smart EV charging and Vehicle-2-Everything (V2X) solutions. This will shape a new energy eco-system wherein the flexibility that EV batteries offer, will be harnessed for the first time at Scale.

SCALE's strategic objective is to create an open system solution, deploying a user-centric approach, thus reducing the need for power grid reinforcement investments through smart charging and V2X solutions.

SCALE paves the way to achieving the Fitfor55 goals. The project will test and validate a variety of smart charging and V2X solutions and services in 13 use cases in real-life demonstrations in 7 European contexts: Oslo (NO), Rotterdam/Utrecht (NL), Eindhoven (NL), Toulouse (FR), Greater Munich Area (GER), Budapest/Debrecen (HU) and Gothenburg (SE). The project involves Distribution System Operators (DSOs), public authorities, and e-mobility service providers.

In addition, SCALE has identified four Innovation Clusters where smart charging and V2X is either already playing a significant role or will become a necessity in the next years:

WE DRIVE SOLAR Elaadnl

Proposal Evaluation Form

EUROPEAN COMMISSION

Horizon Europe (HORIZON)

Evaluation Summary Report - Research and innovation actions

Call:	HORIZON-CL5-2021-D5-01
Type of action:	HORIZON-RIA
Proposal number:	101056874
Proposal acronym:	SCALE
Duration (months):	36
Proposal title:	SCALE - Smart Charging ALignment for Europe
Activity:	HORIZON-CL5-2021-D5-01-03

N.	Proposer name	Country	Total Cost	%	Grant Requested	%
1	STICHTING ELAADNL	NL	869,000	8.70%	869,000	8.70%
2	POLIS - PROMOTION OF OPERATIONAL LINKS WITH INTEGRATED SERVICES, ASSOCIATION INTERNATIONALE	BE	497,750	4.98%	497,750	4.98%
3	GoodMoovs	NL	308,187	3.08%	308,187	3.08%
4	RUPPRECHT CONSULT-FORSCHUNG & BERATUNG GMBH	DE	562,000	5.62%	562,000	5.62%
5	TRIALOG	FR	517,375	5.18%	517,375	5.18%
6	WE DRIVE SOLAR NL BV	NL	357,000	3.57%	357,000	3.57%
7	UNIVERSITEIT UTRECHT	NL	260,125	2.60%	260,125	2.60%
8	LEW Verteilnetz GmbH	DE	119,953	1.20%	119,953	1.20%
9	BAYERN INNOVATIV - BAYERISCHE GESELLSCHAFT FUR INNOVATION UND WISSENSTRANSFER MBH	DE	116,875	1.17%	116,875	1.17%
10	ABB BV	NL	550,295	5.51%	550,295	5.51%
11	ENERVALIS	BE	550,625	5.51%	550,625	5.51%
12	GEMEENTE UTRECHT	NL	334,500	3.35%	334,500	3.35%
13	Equigy B.V.	NL	312,875	3.13%	312,875	3.13%
14	SONO MOTORS GMBH	DE	625,875	6.26%	625,875	6.26%
15	Meshcrafts As	NO	383,750	3.84%	383,750	3.84%
16	RISE RESEARCH INSTITUTES OF SWEDEN AB	SE	419,450	4.20%	419,450	4.20%
17	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS	EL	564,875	5.65%	564,875	5.65%
18	FIER BV	NL	471,062	4.71%	471,062	4.71%
19	Emobility Solutions Kft.	HU	263,875	2.64%	263,875	2.64%
20	Serviced Office Belbuda Kft.	HU	97,635	0.98%	97,635	0.98%
21	ENEDIS	FR	394,187	3.95%	394,187	3.95%
22	L'ASSOCIATION EUROPEENNE DE LA MOBILITE ELECTRIQUE	BE	161,000	1.61%	161,000	1.61%
23	Norsk elbilforening	NO	116,750	1.17%	116,750	1.17%
24	VDL ENABLING TRANSPORT SOLUTIONS BV	NL	195,750	1.96%	195,750	1.96%
25	URBAN ELECTRIC MOBILITY INITIATIVE (UEMI) GGMBH	DE	100,687	1.01%	100,687	1.01%
26	RENAULT SAS	FR	449,125	4.50%	449,125	4.50%
27	CHALMERS TEKNISKA HOEGSKOLA AB	SE	109,000	1.09%	109,000	1.09%
28	Polestar Performance AB	SE	92,968	0.93%	92,968	0.93%
29	Hyundai Motor Netherlands b.v.	NL	189,062	1.89%	189,062	1.89%
	Total:		9,991,611		9,991,611	

Evaluation Summary Report

Evaluation Result

Total score: 15.00 (Threshold: 10)

Gemeente Utrecht FIER Automotive RUPPRECHT CONSULT Forschung & Beratung GmbH

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