SoGE School of Geography and the Environment

UNIVERSITY OF OXFORD

Research Presentation

iDODDLE — Studying the Impacts of Digitalised Daily Life on Climate Change

April 7th, 2025 (in-person @EPFL)

Attended by: EPFL TRANS-OR Research Group
Delivered by: Marcel Seger

My educational background blends entrepreneurship w/ operations research

Study Background & PhD Research Group

Marcel Seger

DPhil Student (3rd year)

iDODDLE

Research Project

Environmental *Change* Institute

Educational Track

2022 - today

DPhil (PhD) in Geography & the Environment at the Environmental Change Institute (ECI), University of Oxford

2019 - 2022

Honours Degree in Technology Management at Center for Digital Technology & Management (CDTM)

2014 - 2022

B.Sc. & M.Sc. In Management & Technology (Industrial Engineering, Operations Research) at TU Munich

Key Information & Context

Research Objective

Studying the impacts of digitalised daily life on climate change across the domains food, home, energy, and mobility

Methods

Primary data collection with 'living lab' households for qualitatively rich insights on, i.a., technology adoption

Funding

Fully funded research scheme by European Research Council, Consolidator Grant ID #101003083

Agenda

01	**Introduction** Presenting my area of research by outlining the key research questions
02	**Deep Dive PhD Paper 1 (published)** Case study: empirical assessment of ‘value of smart charging’ in workplace setting, motivated by industry partner
03	**Deep Dive PhD Paper 2 (ongoing)** Qualitative and quantitative evaluation of an open-source web application using Design Science Research
04	**Deep Dive PhD Paper 3 (design phase)** Assessing EV users’ propensity to adopt smart charging strategies in the workplace context
05	**Discussion** incl Q&A

RQs

Specific RQs

RQ	**Leading the charge**: Leveraging digital technologies to unlock demand-side flexibility (DSF) of electric vehicles (EV)
RQ 1	What are the benefits of coordinated EV workplace charging for firms?
RQ 2	How to design a web application for predictive modelling of EV workplace charging loads that serves as decision support for business executives? What value does it deliver?
RQ 3	In how far are EV users willing to adopt different workplace charging strategies?

Roll-out of extensive EV charging infrastructure on employee car park

Case study: Context-relevant information

RQ1 What are the benefits of coordinated EV workplace charging for firms?

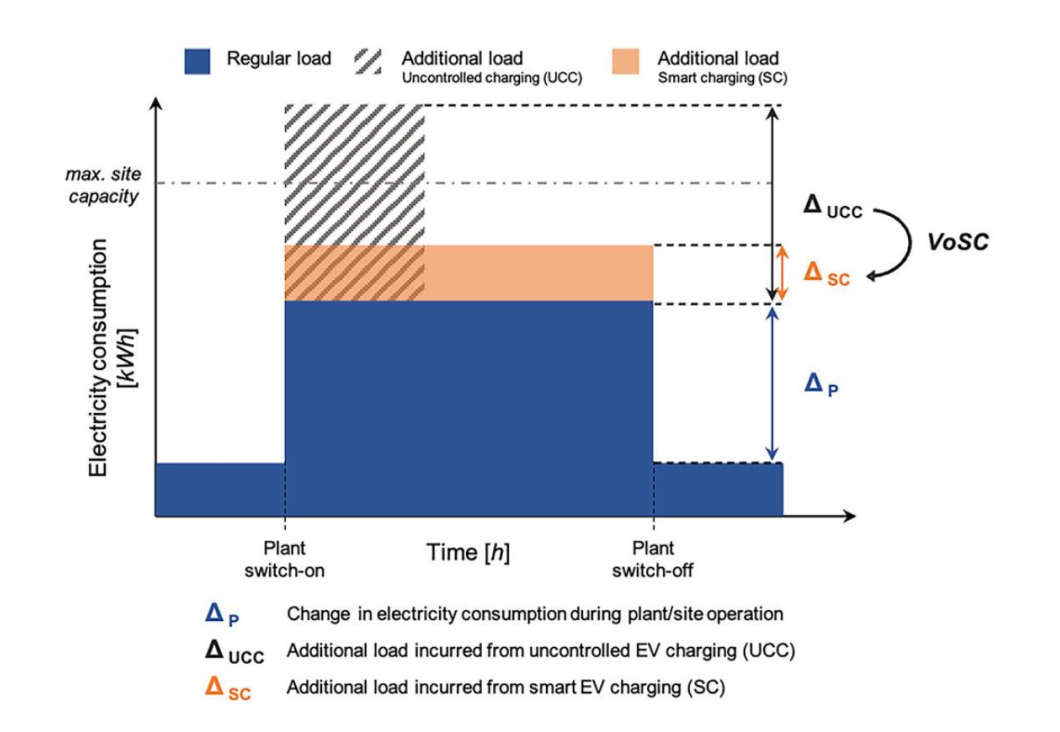


Fig. 1 | Schematic electricity consumption profile of industrial site.

Fig. 2 | Aerial image of employee car park.

We benchmarked each model type against uncontrolled charging (UCC) [%Δ]

Approach: Outlining four-step structure

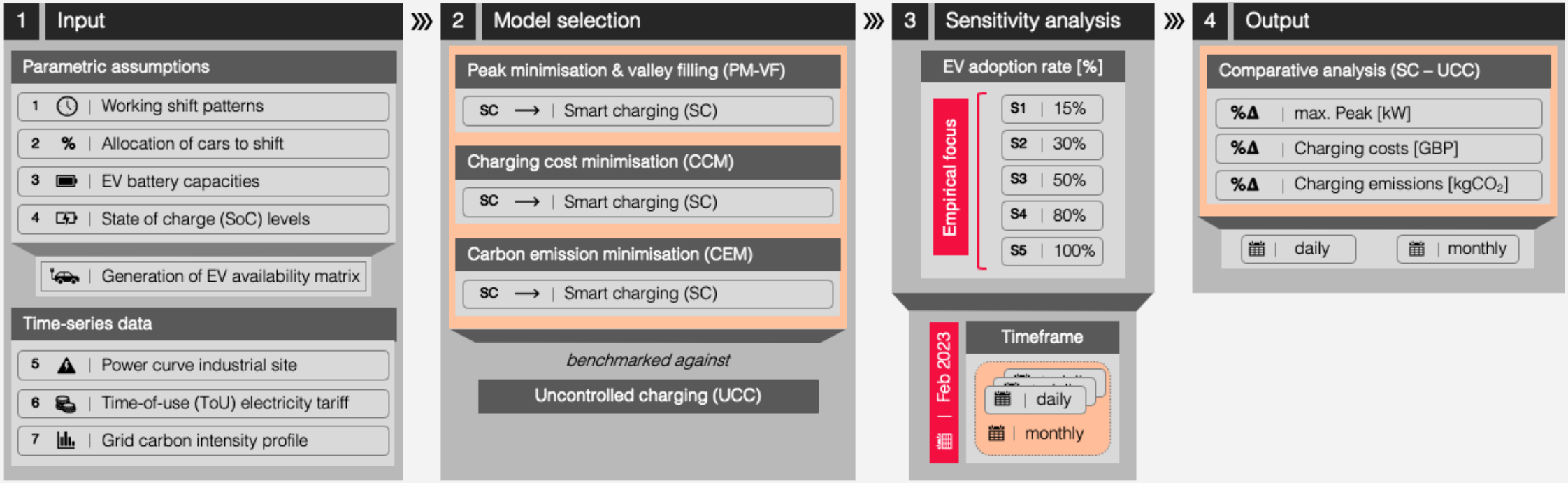


Fig. 3 | Schematic overview of our modelling framework. Step 1: Specification of input parameters. **Step 2:** Selection of model, assessing (i) peak minimisation & valley filling (PM-VF), (ii) charging cost minimisation (CCM), or carbon emission minimisation (CEM). **Step 3:** Sensitivity analysis with varying EV adoption rates [%] and temporal scale. **Step 4:** Computation of model results for each objective function in relative terms (%Δ).

Each model pursues a different optimisation goal, yet w/ identical constraints

Methods: Drawing from operations research (OR)

Peak min. & valley filling (PM-VF):

$$min \ \ z_{PM-VF} = \sum_{t \in T} (P_t + y_t - C)^2$$

Charging cost min. (CCM):

$$min \ \ z_{CCM} = \sum_{t \in T} y_t * \lambda_t$$

Carbon emission min. (CEM):

$$min \ \ z_{CEM} = \sum_{t \in T} y_t * \gamma_t$$

[1]	$s.t. \quad y_t = \sum_{m \in M} x_{mt} f_{mt}$	$\forall\, t \in T$	Total charging load
[2]	$-p_{max} \leq x_{mt} \leq p_{max}$	$\forall\, t \in T;\ m \in M$	Charging power restrictions
[3]	$0 \leq E_m^{ini} + \sum_{k \in T \mid k \leq t} x_{mt} f_{mt} \leq E_m^{cap}$	$\forall\, t \in T;\ m \in M$	Battery capacity restrictions
[4]	$E_m^{fin} = E_m^{ini} + \sum_{k \in T \mid k \leq t} x_{mt} f_{mt} \geq E_{T+1}$	$\forall\, t \in T;\ m \in M$	Minimum state-of-charge (SoC) requirement
[5]	$0 = x_{mt}(1 - f_{mt})$	$\forall\, t \in T;\ m \in M$	Logical operator ensuring car availability

$$C = \frac{max(P_t) + min(P_t)}{2}$$

Constant C

$$f_{mt} = \begin{cases} \mathbf{1}, if\ EV\ m \in M\ is\ parked\ at\ workplace\ at\ time\ t \in T, \\ \mathbf{0}, \qquad otherwise \end{cases}$$

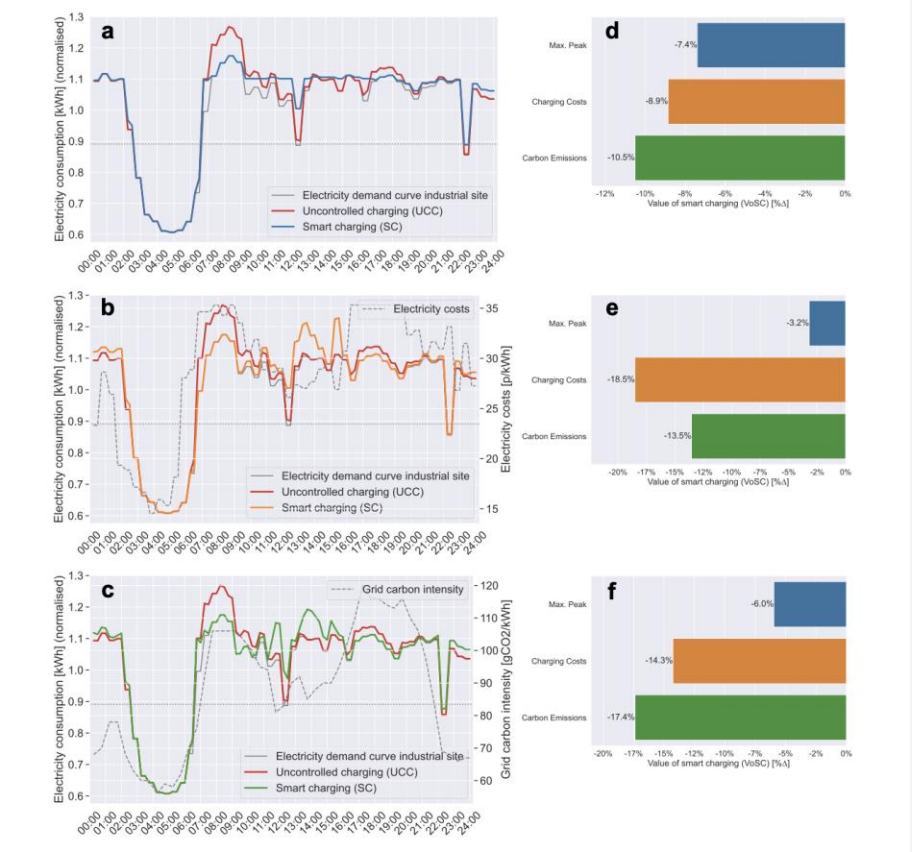
Definition of car availability matrix

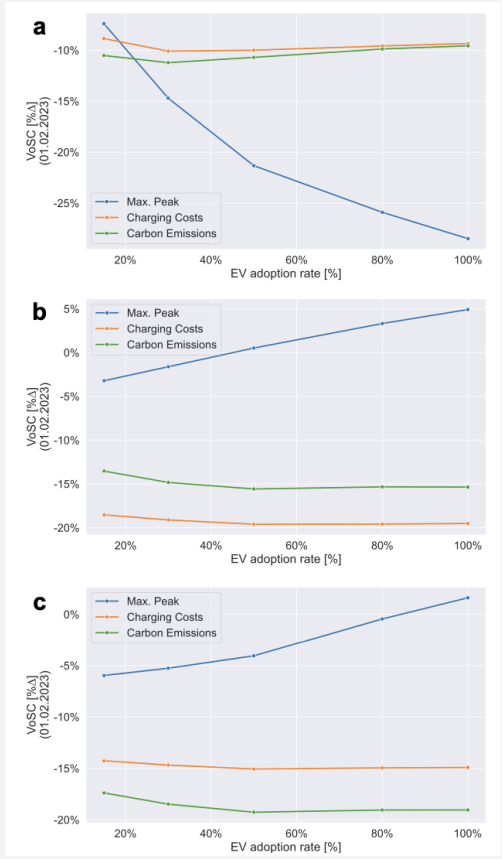
Table 2 | Nomenclature

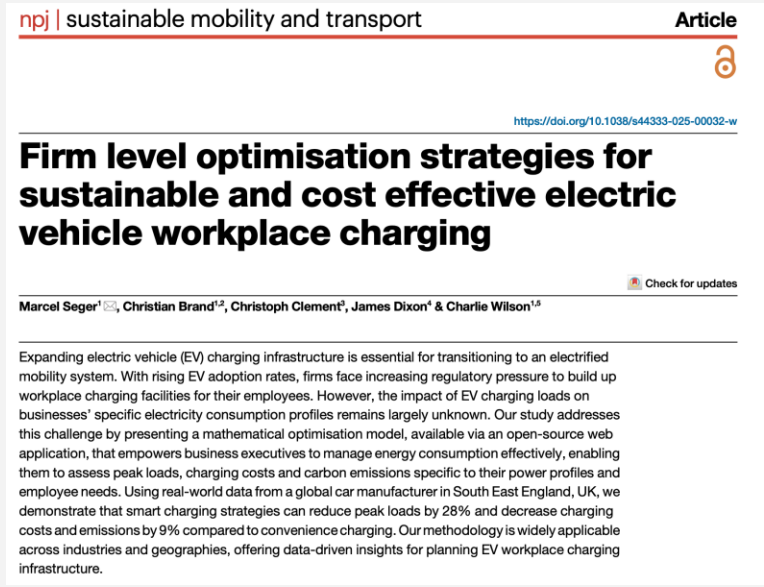
Sets	
$M = \{m\}$	Set of EVs, where m represents a single EV
$T = \{t\}$	Set of time slots, where the duration of a time slot t is fixed and given
Parameters	
P_t	Electricity demand curve of industrial site at time step t [kWh]
λ_t	Time-of-Use (ToU) electricity price tariff at time step t [p/kWh]
γ_t	Grid carbon intensity at time step t [gCO_2/kWh]
E_m^{cap}	Total battery capacity of EV m [kWh]
E_m^{ini}	Initial battery charge level of EV m upon arrival at workplace [kWh]
E_{T+1}	Minimum battery charge requirement after work shift (specified by EV user) [kWh]
p_{max}	Maximum charging power capacity of charge point [kW]
f_{mt}	Parking availability matrix (binary) of EV m indicating arrival and departure times
C	Average value of daily max. and min. P_t [kWh]
τ	Length of each time interval t [15 min]
Auxiliary variables (AVs)	
y_t	Total electricity demand from EV charging at time step t [kWh]
E_m^{fin}	Final battery charge level of EV m upon departure from workplace [kWh]
Decision variable (DV)	
x_{mt}	Charging electricity demand for EV m at time step t [kWh]

SC strategies yields 28% lower peak loads while reducing charging costs by 9%

Overview of key output graphs







npj | sustainable mobility and transport **Article**

https://doi.org/10.1038/s44333-025-00032-w

Firm level optimisation strategies for sustainable and cost effective electric vehicle workplace charging

Check for updates

Marcel Seger[1], Christian Brand[1,2], Christoph Clement[3], James Dixon[4] & Charlie Wilson[1,5]

Expanding electric vehicle (EV) charging infrastructure is essential for transitioning to an electrified mobility system. With rising EV adoption rates, firms face increasing regulatory pressure to build up workplace charging facilities for their employees. However, the impact of EV charging loads on businesses' specific electricity consumption profiles remains largely unknown. Our study addresses this challenge by presenting a mathematical optimisation model, available via an open-source web application, that empowers business executives to manage energy consumption effectively, enabling them to assess peak loads, charging costs and carbon emissions specific to their power profiles and employee needs. Using real-world data from a global car manufacturer in South East England, UK, we demonstrate that smart charging strategies can reduce peak loads by 28% and decrease charging costs and emissions by 9% compared to convenience charging. Our methodology is widely applicable across industries and geographies, offering data-driven insights for planning EV workplace charging infrastructure.

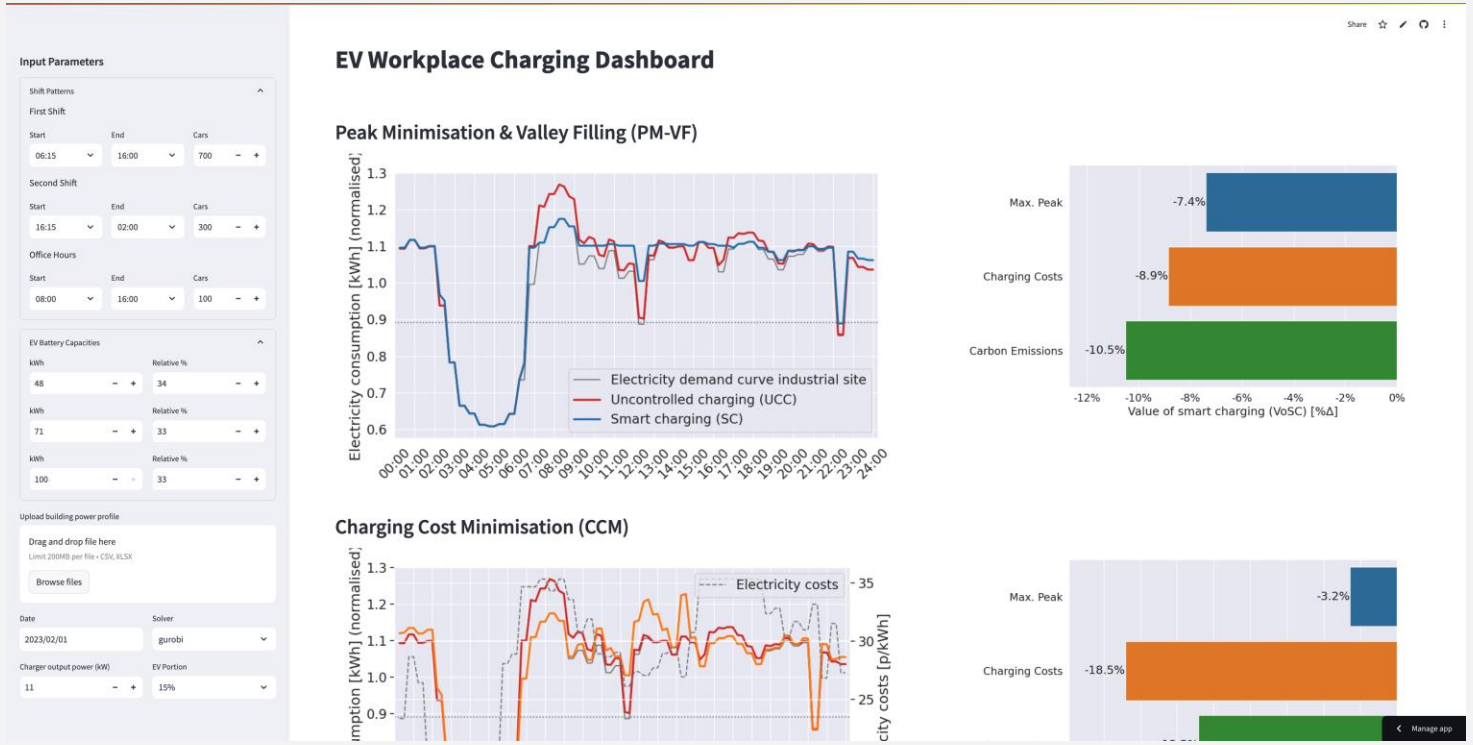
Full publication available here:
https://www.nature.com/articles/s44333-025-00032-w

Fig. 4 | Charging profiles differentiated by model type and different EV adoption rates

Evaluation of web application using qualitative interview approach

First version of web application

RQ2	How to design a web application for predictive modelling of EV workplace charging loads that serves as decision support for business executives? What value does it deliver?



Openly accessible here:
https://ev-workplace-charging.streamlit.app/

Fig. 5 | Screenshot of open-source web application

Testing and evaluation of digital artefact using DSR framework

Design Science Research Framework

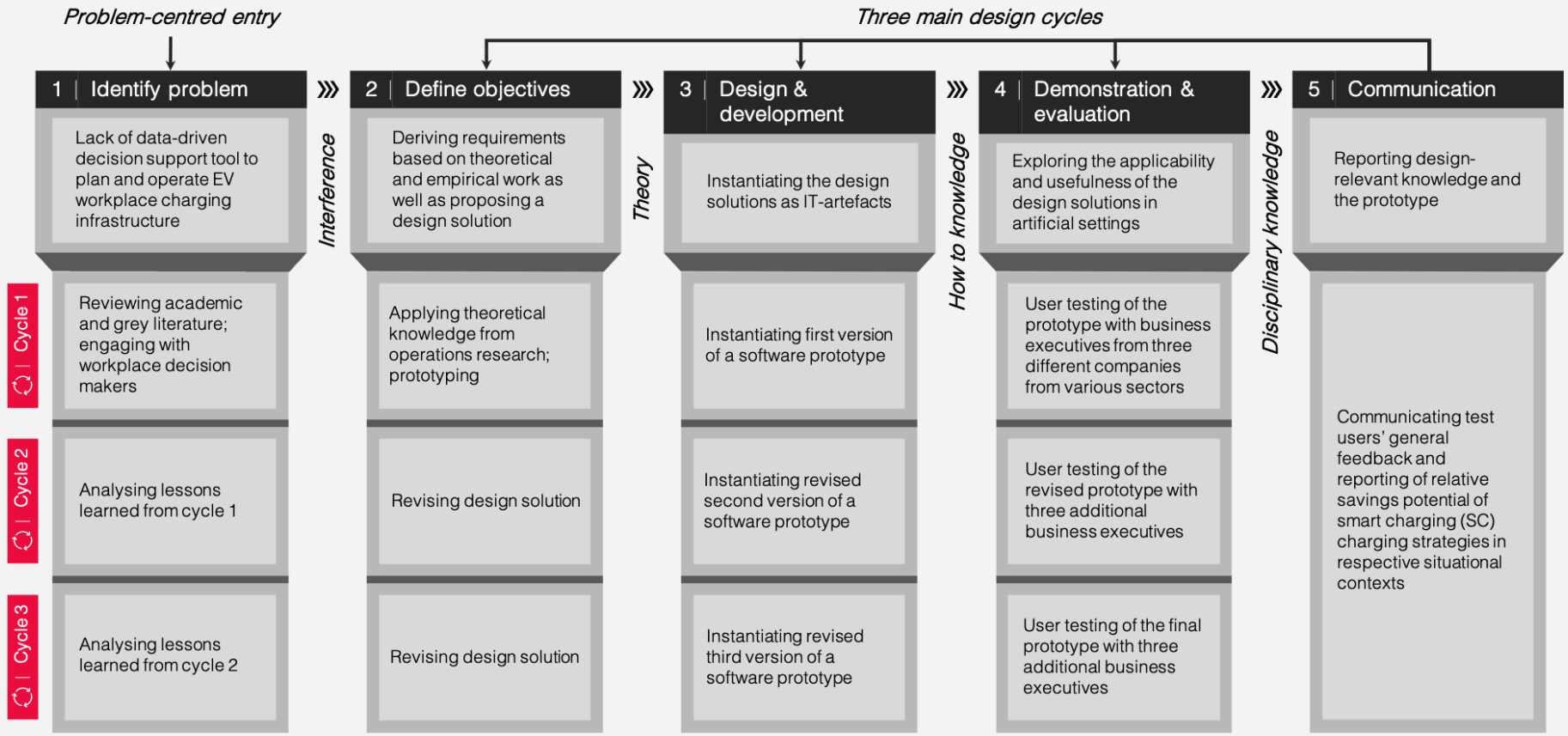


Fig. 6 | Design Science Research (DSR) Framework (Peffers et al., 2008)

Preliminary results serve as input for design of updated web application

Preliminary results

DC	ID	Quotes from interviews (round 2)	Qualitative code(s)	Prio.
1	1a	"Something I might even wish for more is this: You've now (...) taken the load profile of a single day at our site and analysed it. As a complement or extension, one could perhaps create some kind of average."	Aggregated analytics (multi-day)	High
1	2a	"What would actually be interesting for me personally as a user would be to have a document to understand what the system is doing with the value I'm currently changing. Just to have that sense of security. Because I don't like to blindly trust technical systems 100%, and even if they've proven themselves many times, I'd still like to know what exactly is being changed here."	User guide	High
1	3a	"What would of course also have been interesting: what is the absolute number [of savings]? To say: this is a fact, this is what we actually achieved."	Quantify absolute savings	Medium

Tab. 1 | Qualitative evaluation of the artefact based on user interviews

No.	System Usability Scale (SUS)	Response Distribution 'strongly disagree' (score: 1) to 'strongly agree' (score: 5)
1	I think that I would like to use this system frequently.	1 2 3 4 5
2	I found the system unnecessarily complex.	1 2 3 4 5
3	I thought the system was easy to use.	1 2 3 4 5
4	I think that I would need the support of a technical person to be able to use this system.	1 2 3 4 5
5	I found the various functions in this system were well integrated.	1 2 3 4 5
6	I thought there was too much inconsistency in this system.	1 2 3 4 5
7	I would imagine that most people would learn to use this system very quickly.	1 2 3 4 5
8	I found the system very cumbersome to use.	1 2 3 4 5
9	I felt very confident using the system.	1 2 3 4 5
10	I needed to learn a lot of things before I could get going with this system.	1 2 3 4 5

Tab. 2 | Quantitative evaluation of the artefact using SUS scale

Extensive prior research on EV characteristics and EV charging strategies

State of (academic) literature

RQ3 In how far are EV users willing to adopt different workplace charging strategies?

- Approach: Structured literature review across Scopus and Web of Science using search string:
  - **"TITLE-ABS-KEY** (("electric vehicle" *OR* "ev" OR "plug-in hybrid" *OR* "phev" *OR* "pev") *AND* ("charging" *OR* " smart charging" *OR* "vehicle-to-grid" *OR* "v2g") *AND* ("consumer preference" *OR* "charging choice" *OR* "willingness to accept" *OR* "willingness to pay" *OR* "demand side flexibility" *OR* "financial compensation"))
  - Yield: **475** unique publications; currently evaluating its fit based on title and abstract
- Extensive research on consumer preferences for EVs / alternative fuel vehicles in early 2010s using Discrete Choice Experiments (Hidrue et al., 2011; Jensen et al., 2013; Hackbarth and Madlener, 2013)
  - Common attributes:
    - **Car specific**: Driving range, fuel cost saving, pollution reduction, performance, purchase price, battery lifetime, acceleration (Jensen et al., 2013)
    - **Charging specific**: Charging time, CO2 emissions, charging cost / monthly electricity bill, availability of charging information, availability of charging service, station accessibility, % of green electricity, source of green electricity, guaranteed minimum charge, program type (Time-of-Use, smart charging, V2G), override functionality (Moon et al., 2018; Wen et al., 2025) ; for Vehicle-to-Grid (V2G) specifically: Guaranteed minimum driving range, average length of required plug in time per day (Parsons et al., 2014)
    - **Other**: EV user experience, policy incentives, contribution to local environmental ambitions (Hackbarth and Madlener, 2013; Noel et al., 2019; Wen et al., 2025)

Early research has focused mostly on EV specific attributes

Prior DCE examples

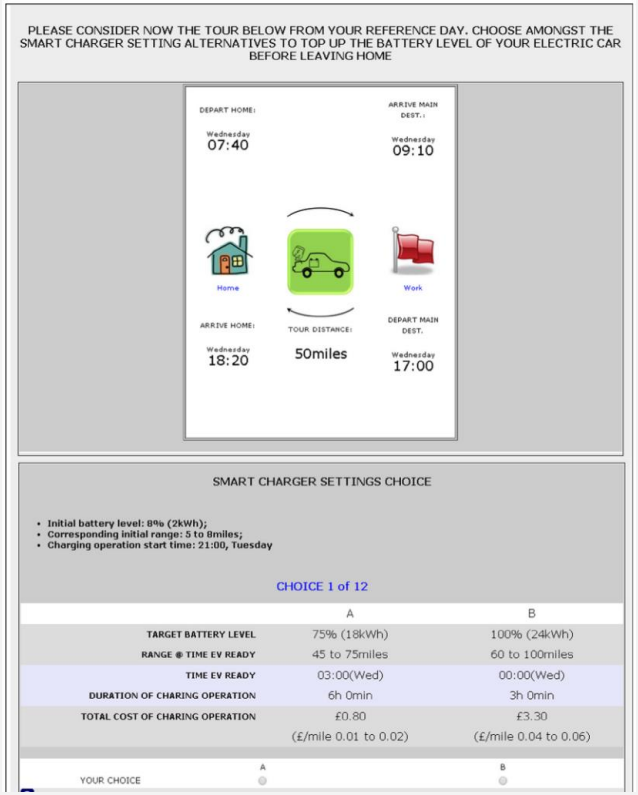


Fig. 7 | "Electric vehicle charging choices: Modelling and implications for smart charging services" (Daina, Sivakumar and Polak, 2017).

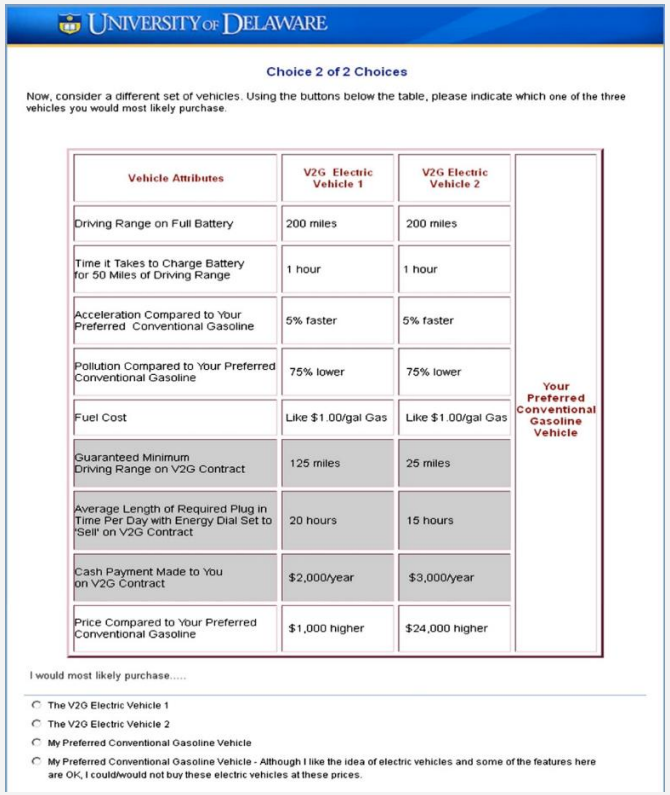


Fig. 8 | "Willingness to pay for vehicle-to-grid (V2G) electric vehicles and their contract terms" (Parsons, Hidrue, Kempton and Gardner, 2014).

A more recent study has used TAM-constructs to evaluate V2G WTA

Example of multi-equation econometric modelling

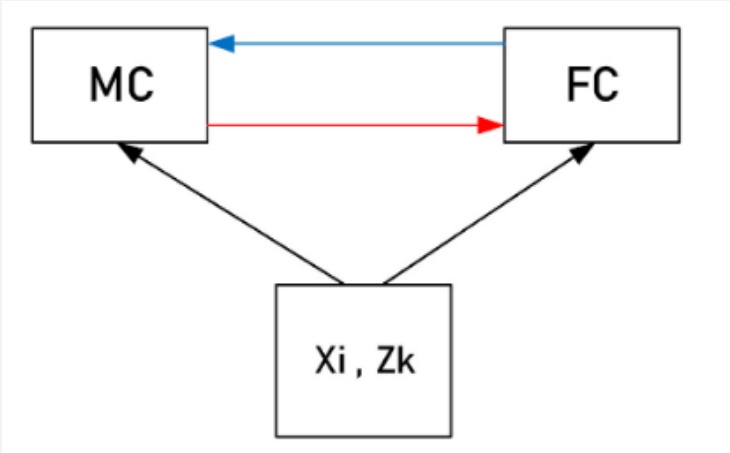


Fig. 9 | "Estimating financial compensation and minimum guaranteed charge for vehicle-to-grid technology"; MC = Minimum guaranteed charge; FC = Financial compensation (Mehdizadeh, Nordfjaern and Klöckner, 2023).

"We also hypothesise that **several psychological factors**, such as **perceived usefulness** and **perceived ease of use** of the V2G system, **trust** in the V2G service, **favourable attitudes and norms** towards the V2G system, and **vehicle battery concerns**, can be possible predictors of FC and MC.

It was decided to consider these **psychological factors** as predictors since they have been found relevant in the research literature on **technology diffusion** (van Heuveln et al., 2021). According to Davis (1989) **Technology Acceptance Model (TAM)**, **perceived usefulness (PU)**, and **perceived ease of use (PEU)** to some extent explain user acceptance and different behaviour regarding the use of technology.

As defined by the TAM model, **perceived ease of use** refers to "*the degree to which the prospective user expects the system to be trouble-free*" (Davis, 1989, p.319), whereas **perceived usefulness** refers to the extent to which *a technology is expected to improve a potential user's performance* (Davis, 1989).

For instance, we hypothesise that people with favourable perceptions about usefulness of V2G services are likely to demand less FC".

Focus on workplace charging to assesses EV users' willingness to accept

Preliminary research design ideas for my own study

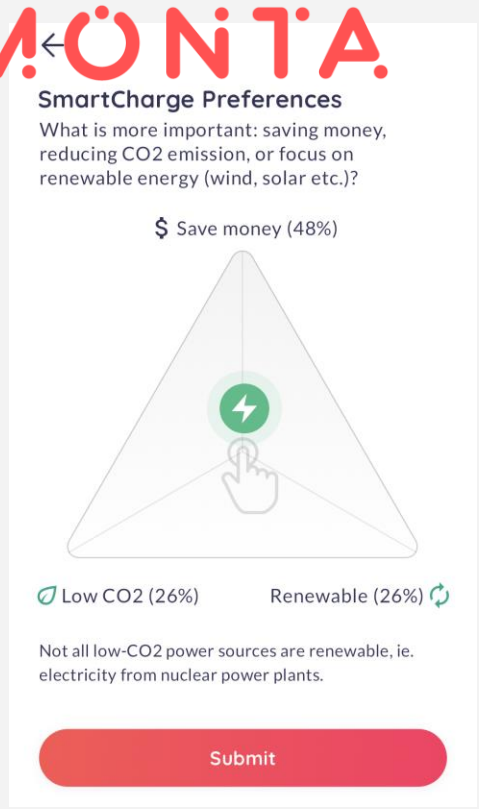


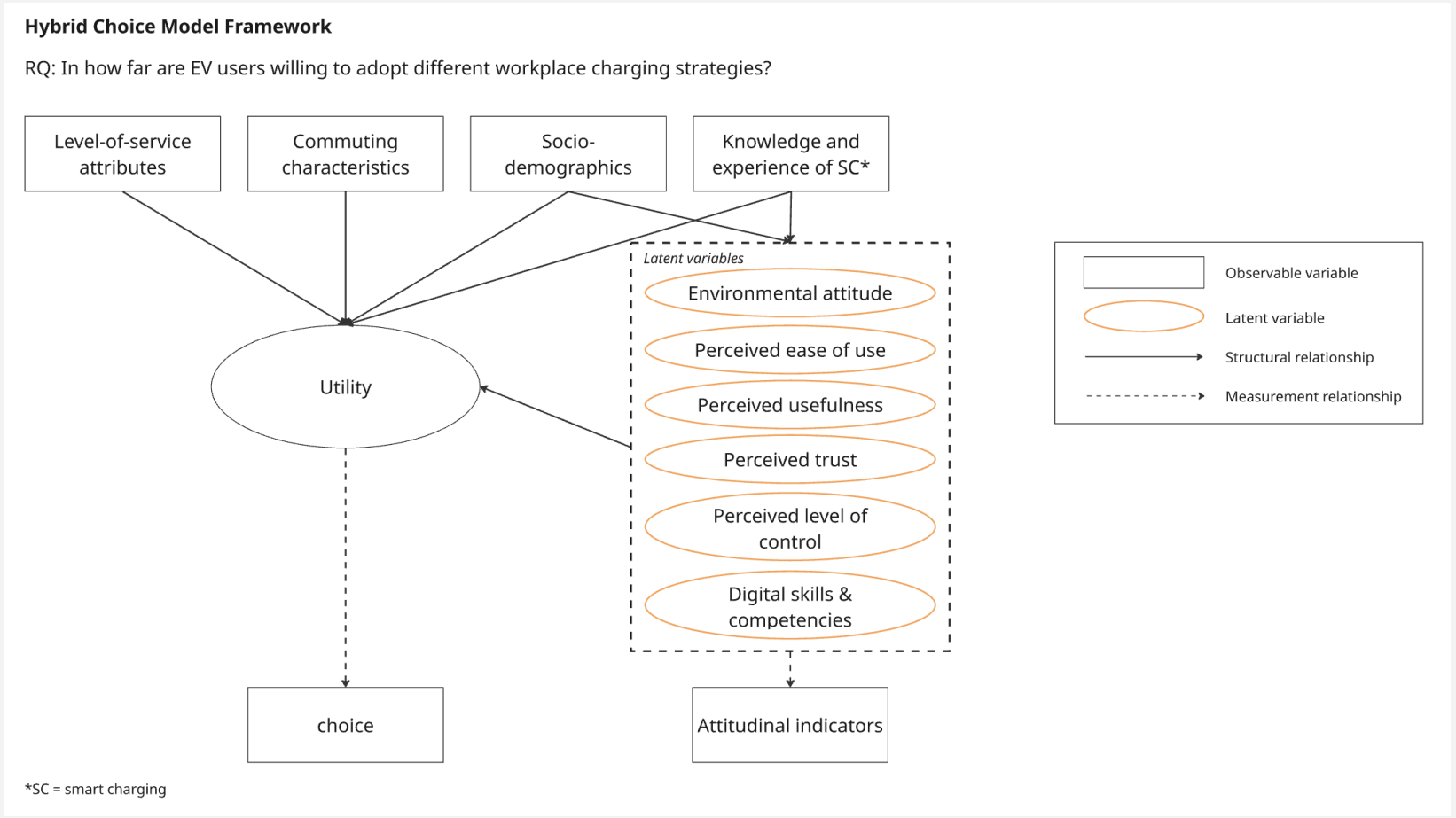
Fig. 10 | Screenshot of Monta's EV charging app (Monta, 2024)

Attributes / SC strategy (›)	Peak reduction	Cost optimal	CO2 minimal	Vehicle-to-Grid (tbd)
Flexibility (total charge time, charging window)				
Minimum charge (% SoC)				
Charging costs				
Carbon (CO2) emissions (electricity source)				
Control functionality (override, smartphone app)				
Contractual terms (plug-in requirements etc)				
'Strain' on the grid (peaks)				
SC operated by				
Contribution to firm's (local) Scope 3 reduction				

Tab. 3 | Preliminary design of choice task (attributes etc): Each survey respondent will be given the choice to select between two charging strategies

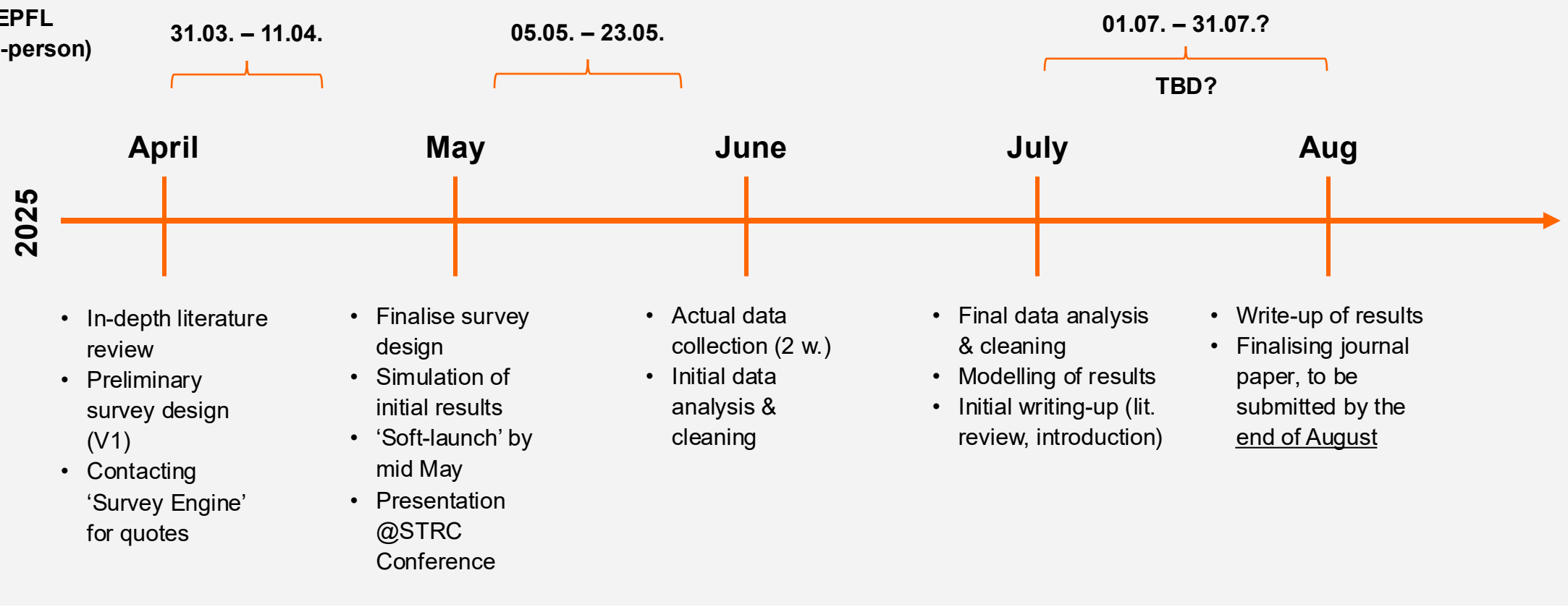
Augmenting TAM constructs by wider digital skills & competencies variables

Preliminary hybrid model framework (*work-in-progress*)



Aiming for actual data collection latest by early June

Anticipated timeline



Thank you!

Any Questions?

Environmental Change Institute

University of Oxford
3 S Parks Rd
Oxford, OX1 3QY, UK

Marcel Seger
DPhil in Geography and the Environment
marcel.seger@eci.ox.ac.uk

Eliciting users' preferences to adopt smart charging solutions in the workplace using a DCE

Reference study by Xue et al. (2024)

RQ 3 In how far are EV users willing to adopt different workplace charging strategies?

Components of hybrid choice model

- **Structural model**
  - Capturing relationship between sociodemographic and knowledge & experience of AVs and latent variable (LV) (see *Figure*)

$$LV_n^q = \alpha_n + \beta_n SK_q + \varphi_n^q,\ \varphi_n^q \sim N(0, \sigma_{\varphi_n})$$

- **Measurement model**
  - Capturing the observed values of the indicators using ordered probit model (attitudinal statements were rated on a 5-point Likert Scale)

$$IND_{n,r}^{q^*} = \delta_{n,r} + \theta_{n,r} LV_n^q + \zeta_{n,r}^q,\ \zeta_{n,r}^q \sim N(0, \sigma_{\zeta_{n,r}})$$

$$IND_{n,r}^q = \begin{cases} j_{n,r}^1,\ if\ \tau_{n,r}^0 < IND_{n,r}^{q^*} < \tau_{n,r}^1 \\ j_{n,r}^2,\ if\ \tau_{n,r}^1 \leqslant IND_{n,r}^{q^*} < \tau_{n,r}^2 \\ \vdots \\ j_{n,r}^k,\ if\ \tau_{n,r}^{k-1} \leqslant IND_{n,r}^{q^*} < \tau_{n,r}^k \\ \vdots \\ j_{n,r}^5,\ if\ \tau_{n,r}^4 \leqslant IND_{n,r}^{q^*} < \tau_{n,r}^5 \end{cases}$$

- **Discrete choice model**
  - Two-level nested logit (NL) model accounting for varying characteristics of respondents (e.g. ownership of car: yes/no)

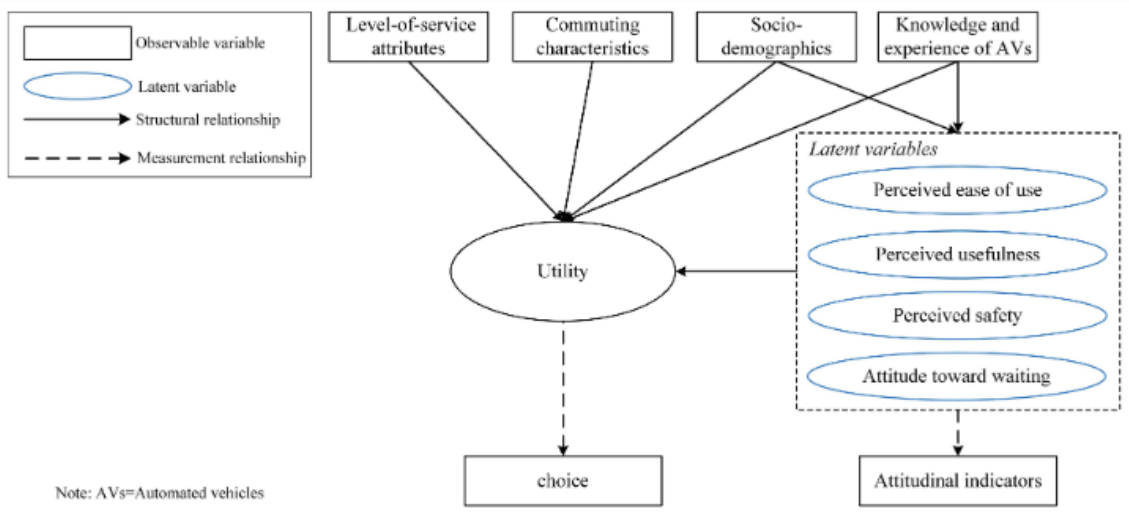


Fig. 4. Illustration of the hybrid choice model framework for this study.

Xue, F., Yao, E., Cherchi, E., Correia, G.H.D.A., 2024. Modeling the joint choice behavior of commuters' travel mode and parking options for private autonomous vehicles. *Transportation Research Part C: Emerging Technologies* 159, 104471. https://doi.org/10.1016/j.trc.2023.104471