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Systematic Review Protocol

Title
What is the charging infrastructure demand range for different types of vehicles and user needs? (correction to PROCEED-23-00087)

In the previously published version (PROCEED-23-00087, https://doi.org/10.57808/proceed.2023.5), the order of authors was incorrect.
This has been amended in this version, and the protocol should be cited as follows: Biljana Macura, Maria Xylia, Bjorn Nykvist. What is the charging infrastructure demand range for different types of vehicles and user needs? A systematic review protocol: PROCEED-23-00104

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Keywords
Electrification, transport sector, policy target, infrastructure modelling

Background
Electric vehicle (EV) sales have doubled globally and represented about 8% of total vehicle sales in 2021 [1], with electrification rates increasing for commercial and heavy-duty vehicles. The EU is implementing measures to decrease CO2 emissions and aims for new cars and vans to produce zero emissions by 2035, with intermediate reduction targets set for 2030 [2]. Access to effective charging infrastructure is critical for EV attractiveness and achieving these targets. Sweden, which is a frontrunner in EV deployment, aims to reduce GHG emissions from domestic transport by 70% by 2030 [3], with road transport having the largest share, but the transport sector's emissions have been stagnant in 2021 [4], highlighting the need for electrification accompanied by necessary charging infrastructure deployment. There are two ways of interpreting charging infrastructure needs: by discussing deployment targets driven by policy ambition or by estimating the expected charging infrastructure demand based on transport flow data, user needs, and geographical coverage. However, data completeness and transparency issues make it difficult to understand how EV chargers should be optimally deployed, and there is more data available on public than private charging. Home charging availability levels vary depending on urban typologies, housing ownership structures, and electricity prices, and securing adequate access to home charging becomes a challenge due to a lack of data on private charging deployment and monitoring practices [5]. Previous studies have focused on methodological taxonomies of charging demand modelling [6] and

charging infrastructure deployment for cities around the world [7], but there is a lack of systematic reviews of existing evidence on charging infrastructure demand for different types of vehicles and users.

Theory of change or causal model
N/A

Stakeholder engagement
Stakeholder engagement will be continuous throughout the review process to assure the relevance of the review findings for stakeholders and better evidence uptake into policy and practice [8]. We conducted a stakeholder mapping as a part of the proposal drafting for this project. Stakeholders were identified via snowballing, systematic online searching and using existing contacts of the review team. The stakeholders identified for this review are representatives of Swedish municipal and regional authorities and public agencies, academia, EV trade organisations and other private sectors. The protocol was drafted with stakeholder input via a consultation process using a survey form. Stakeholders provided input on the review scope, the eligibility criteria, search terms and sources of grey literature. Appendix 1 includes a summary of stakeholders' input. At a later stage in the review process, we will present preliminary findings to the stakeholders for their comments on the clarity and usability of insights.

Objectives and review question
This review aims to synthesise the best available evidence on varying charging infrastructure demand for diverse types of vehicles and user needs.The primary review question is: What evidence exists on the charging infrastructure needs across different types of vehicles and users? The secondary questions are: What are the set targets and/or identified demand for charging infrastructure in the global literature? Are the charging infrastructure targets and/or demand for different transport sector segments and use cases adequately covered in the literature? What are the key knowledge gaps and clusters for charging infrastructure demand estimation? What are the methodological and data needs?

Definitions of the question components
Populations: Any urban and rural transport electrification context globally, including passenger cars, light and heavy-duty vehicles, buses, e-bikes, and e-scooters. Interventions: Road transport charging infrastructure such as home chargers, semi-public chargers at parking locations and offices, and public chargers. Different charging strategies, such as slow, fast, and smart charging. Different charger types, including conductive, inductive, and electric road systems. Outcomes: Estimation of charging infrastructure needs for different vehicle types and user groups, quantified and expressed either top-down (targets) or bottom-up (demand).

Search strategy
We will use a multipronged search strategy including bibliographic sources, search engines, specialist websites (see details below) and additional searches. Additional searches will rely on the input of the project’s stakeholder group which will be contacted for suggestions for relevant published research (see Stakeholder engagement section). We will issue calls for evidence via Twitter (at minimum). We will search bibliographies of relevant reviews identified during the search for relevant literature. See Appendix 2 for a detailed search strategy (including changes to the search string made in response to the stakeholder input).

Bibliographic databases
We will conduct bibliographic searches in Scopus and Web of Science Core Collections (WoSCC) (consisting of the following indexes: SCI-EXPANDED, SSCI, AHCI, CPCI-S, CPCI-SSH, and ESCI)

using English language search terms via the Stockholm University library. Searches will be conducted on title, abstract and keywords. WoSCC string is as follows: TS=((charg* NEAR/2 (station* OR demand OR demands OR infrastructure* OR strategy OR strategies OR management OR evaluation* OR facility OR facilities OR point* OR network* OR plan* OR policy)) AND ("electric* vehicle*" OR "electric road*" OR PHEV OR BEV OR "plug-in hybrid*" OR "plugin hybrid*" OR "plug in hybrid*" OR "plug-in-hybrid*" OR "vehicle to" OR V2G OR V2H OR V2L OR "vehicle-to-*" OR ((*mobility OR transport*) NEAR/2 electrification) OR (electri* AND (car OR cars OR bus OR busses OR truck* OR bike* OR scooter* OR bicycle* OR van OR vans)))) AND PY=(2017-2023) The search string was refined with the stakeholders' input. See Appendix 2 for a detailed search strategy.

Web-based search engines
Searches in Google Scholar will be performed in English and Swedish and on the title. We will use simplified sets of search strings such as: allintitle: mobility OR transportation "charging stations. The first 1000 search results will be extracted as citations using Publish or Perish software [9] and introduced into the deduplication and screening workflow with other records. See Appendix 2 for a detailed search strategy.

Organisational websites
Searches in specialist/organizational websites will be done to comprehensively capture more grey literature (complementing Google Scholar searches). The list of relevant websites was compiled with inputs from stakeholders and includes research institutes, public authorities, and organizations specializing in charging and transport electrification. Each website will be hand-searched for relevant publications using a simplified set of search terms such as "charging station", "charging demand", "electric vehicles", and "electrification". We will use English and Swedish search terms. See Appendix 2 for a list of search terms and organizational websites.

Comprehensiveness of the search
During the scoping phase, search results were screened against a benchmark list of 12 articles relevant to the review. In cases where relevant articles from the benchmark list were not found with the present search strategy, the search strings were examined to identify why articles were missed and were amended accordingly. This process was iterative. The final search string captures all articles from the benchmark list. Appendix 2 includes the list of benchmark articles.

Search update
Search update will not be conducted.

Screening strategy
The screening will be done by at least two reviewers and at two levels: at title and abstract (screened concurrently for efficiency) and at full text. Full texts of records with relevant abstracts will be retrieved, tracking those that cannot be located or accessed and reporting these in the final review. Retrieved records will be screened at the full text, with each record being assessed by one experienced reviewer. The final report will include a list of articles excluded at the title and abstract, and at the full text, with reasons for exclusion.

Eligibility criteria
Eligible populations: Any urban and rural transport electrification context globally, including passenger cars, light and heavy-duty vehicles, buses, e-bikes, and e-scooters. National and international/continental coverage studies are included. Eligible interventions: Road transport charging infrastructure such as home chargers, semi-public chargers at parking locations and offices, and public chargers. Different charging strategies, such as slow, fast, and smart charging. Different charger types, including conductive, inductive, and electric road systems. Eligible

outcomes: charging infrastructure need estimations for different vehicle types and user groups (see above), quantified and expressed either top-down (targets) or bottom-up (demand). Studies that do not specifically quantify the charging infrastructure demand for a given area or context, or do not explicitly state the type of charging they focus on will be excluded. Eligible types of study design: primary (including modelling or empirical studies) or secondary research (reviews). Time limitations: Studies published before 2017 will not be considered. Language: English and Swedish

Consistency checking
Before commencing screening, consistency checking will be performed on a subset of records at both title and abstract and full-text levels. Specifically, all reviewers will independently screen up to 200 titles and abstracts and 20 full-text records. The results of the consistency checking will then be compared among reviewers and all disagreements will be discussed in detail. Where the level of agreement among reviewers is low (below 80%), further consistency checking will be performed on an additional set of articles. This will be repeated until the agreement level reaches at least 80%.

Reporting screening outcomes
Screening outcomes will be reported using the ROSES flow diagram. The final report will also include a list of eligible articles and a list of excluded full-text articles with reasons for exclusion.

Study validity assessment
Study validity assessment for the primary studies will include an assessment of the robustness and source of data used for the demand estimate, missing data, measurement error, bias in reporting and funding source. Reviews will be appraised based on CEESAT criteria [10] relevant to the conduct. As a result of the appraisal process, we might categorise relevant studies as, for example, having a high and low validity. This information will be used in a sensitivity analysis during the synthesis stage of the review. The cut-off points for each validity category will be decided during the appraisal process and based on the overall state of the evidence base. Studies will not be excluded based on reporting of the outcome data to avoid selective outcome reporting bias. However, studies without sufficient methodological details will be categorised as unclear.

Consistency checking
To assure the repeatability of this stage and to test the appraisal tool, consistency checking will be performed on a subset of records (5) independently assessed by all reviewers. All disagreements will be discussed among the team, and assessment criteria will be clarified if needed. All the studies will be appraised by at least two reviewers.

Data extraction strategy
Apart from bibliographic information, study context and design, we will code charging targets: targets from policy and research, at what level they are set (e.g. local, regional, national), how they are expressed (e.g. concerning electric vehicles served, geographic coverage (km2), charging power (kW)), which transport sector segment they cover (e.g. passenger vehicles, light-duty commercial vehicles, heavy-duty vehicles, buses, micro-mobility), and which type of charging they address (e.g. private, public, smart, slow, fast). Appendix 3 includes a detailed overview of the coding schema. For missing or incomplete data related to the outcome, we will aim to contact study authors directly if necessary. Our extracted data records will be made available as additional files.

Meta-data extraction and coding strategy
See the previous section.

Consistency checking
The repeatability of the extraction process will be tested on a subset of studies (5) independently

assessed by all reviewers. All disagreements will be discussed among the team, and the extraction sheet criteria will be clarified if needed. The rest of the data will be extracted by a single reviewer.

Potential effect modifiers/reasons for heterogeneity
Potential effect modifiers to be coded and considered in the review are listed below. The list is compiled in consultation with stakeholders. - Study design and methodology for estimating demand and/or targets - Existing relevant policy targets - Transport segment - Socio-economic context: country, income level, urbanization level, services provided - Share of electric vehicles, number of chargers in the country - Type of users (individuals, companies, fleets)

Type of synthesis
Narrative and quantitative.

Narrative synthesis methods
We will apply narrative synthesis and the review findings will be presented with descriptive statistics and in a tabular form with an overview of study designs, charging types and targets.

Quantitative synthesis methods
We will use extracted quantitative data to analyse the targets across different types of charging infrastructure and users (sub-group analysis). Depending on the available data, we will also analyse (future) demands as the full range of road vehicles electrify. Finally, we will identify the advantages and disadvantages of different methodological approaches for estimating demands, as well as research needs for more effective target settings linked to infrastructure localization. We will use visualization tools (infographics, evidence atlas, and similar) to ensure effective knowledge dissemination.

Qualitative synthesis methods
N/A

Other synthesis methods
N/A

Assessment of risk of publication bias
The risk of publication bias will not be possible to assess due to the type of data collected in this review. To minimise the effect of publication bias we include searches for grey literature.

Knowledge gap identification strategy
The knowledge gaps will be identified through cross-tabulation of different variables (e.g. intervention vs outcome and similar).

Demonstrating procedural independence
Reviewers who have also authored articles to be considered within the review will be excluded from decisions regarding the inclusion of their work.

Competing interests
The authors declare no competing interests.

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Author’s contributions

BM and MX wrote the manuscript. BN reviewed the manuscript. All authors approved the manuscript.

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