Terms of Reference for SHURA's next study on
"Business Models, Regulatory Framework, and Implementation Roadmap for EV Smart Charging"
SHURA Energy Transition Center
İstanbul, Türkiye
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Background

The global energy transition from fossil fuels to zero-carbon technologies is currently underway and is fueled by a sense of urgency. Türkiye has also lit the fuse on its energy transition as the transformation of the Turkish power system has already been initiated. However, electricity demand still accounts for only 20% of Türkiye's total final energy consumption, while most of the remaining demand is met by direct fossil fuel use in buildings, industry and transport, where transport represents 26% of total final energy demand. Renewable electrification of the transport sector will be the key for reaching 2053 net zero emission targets for Türkiye. SHURA's Net Zero 2053 study[1] shows that the electrification of the transport sector will reach 58% in 2053, and emphasize that the decarbonization of transport can be achieved through a shift to electric vehicles and use of clean fuels.

Türkiye has a vision to deploy at least 1 million EVs and 100,000 public charging points by 2030. Charging this fleet of EVs is expected to create an additional 4 billion kWh of electricity demand, representing about 1-2% of total power demand. Integration of EVs into the power system is a major concern since their uncontrolled charging could negatively impact the operation of distribution grids. To limit these impacts and manage the additional electricity load of EVs, smart charging concepts and business models are emerging to enable cost-effective charging by EV users and more efficient grid use. Most notably along with transforming the transport sector, EVs present a viable opportunity to increase the share of renewables into the Turkish power generation mix.

SHURA's 2019 study on electric vehicles (EVs)[2] shows that 2.5 million EVs (representing 10% of the total vehicle stock in 2030) could be integrated to Türkiye's distribution grid by 2030 with almost no additional investments and with limited impact on grid operation. The study estimates the capacity factors of the charging infrastructure at residential and commercial buildings to be between 15%-20% and even more than 50% in some pilot regions, indicating that much of the charging capacity can be better utilized. However, significant capacity factor differences between individual regions are likely to occur and grid-specific planning would be needed to assess the number and locations of new charging infrastructure.

Finally, it will also be important to understand the complementary role that different charging points can interchangeably offer to each other in utilizing their capacities in the most optimized way. This will also be important for enabling smart charging to receive flexibility services from EVs since EV batteries are connected for longer hours at homes as opposed to the public places.

Within this framework, Shura is looking to improve understanding of the current trends and future opportunities of the EV ecosystem and charging infrastructure in Türkiye. To do so, Shura will investigate an implementation roadmap for EVs, including a critical review of business models and policies for EVs smart charging.

[1] https://shura.org.tr/en/net-zero-2053-a-roadmap-for-the-turkish-electricity-sector/
[2] https://shura.org.tr/en/transport-sector-transformation-integrating-electric-vehicles-into-turkeys-distribution- grids/

Objective and tasks

The study investigates the degree of complementarity between variable renewable energy sources and EVs, as well as the flexibility potential of smart EV charging [within the scope of this study, EVs include passenger vehicles and light duty vehicles (LDVs) such as urban buses. Heavy duty vehicles (HDVs) are excluded] and how this potential could benefit from the implementation of smart charging by 2035 and 2053. It will discuss how EVs' potential for grid flexibility could evolve in both medium (2035) and long (2053) terms. It will also assess the suitability of different types of charging infrastructure and their locational optimization with a quantitative modelling for smart charging, elaborating EV market value chain and business models. Finally, the project will investigate the challenges and best practices, as well as current trends and future opportunities for EVs & charging infrastructure for further grid integration. The report will give an implementation roadmap for EVs & charging points, offering policy recommendations to enable necessary action steps.

The project will build on SHURA's earlier studies on transport sector transformation:

- "Transport Sector Transformation: Integrating Electric Vehicles into Turkey's Distribution Grids[3]"
- "Net zero 2053: A Roadmap for the Turkish Electricity Sector[4]"

to model the potentials, costs, benefits, impact of EV charging on grid and optimization of the charging infrastructure. The study will end with a discussion on the policy framework, implementations, business models and strategies for smart charging of EVs including light duty vehicles.

The study will specifically focus on:

Task 1: Overview and stock take of existing targets, legislation and policies impacting the development of the Turkish EV ecosystem and associated charging infrastructure.

Task 2: Identifying the potential of EVs (including LDVs) in the Turkish transport sector and its electrification share within the power demand towards 2053, based on demand and growth projections via estimating technology costs that align with SHURA Net Zero study. Assessing the costs and benefits of the required technology and infrastructure investments (particularly for the charging technologies such as AC1, AC2, and DC) to reach the electrification potential in transport sector with a focus on 5-year time steps to 2053. Here, the focus will be on the passenger EVs including LDVs such as urban buses. Regarding the number of EVs which will be added to the Turkish transportation fleet, 2053 net zero emission targets for Türkiye provided in SHURA's Net Zero 2053 study will be considered as the main scenario. Under this scenario, two sub-scenarios entitled as "unmanaged charging" and "smart charging" will be addressed in the grid impact analysis (Task 4).

Task 3: Identifying the pilot regions, EV breakdown for each pilot region, and grid model for target years. 2-3 pilot regions will be selected for this task. For each pilot region, one feeder serving the metropolitan area and one feeder serving the rural area will be chosen. Furthermore, a pilot charging station located on a major highway, such as the Istanbul-İzmir highway, will be analyzed. Once the pilot feeders are determined, the total number of EVs determined in Task 2 will be distributed among the pilot regions. This allocation process will consider factors such as population, number of vehicles in the region, and electricity consumption data. The allocated EVs for each region will be assessed in two combinations: a) Home Charging Support (HCS), offering time flexibility and usage of AC1 and AC2

[3] https://shura.org.tr/turkiye-ulastirma-sektorunun-donusumu-elektrikli-araclarin-turkiye-dagitim-sebekesine- etkileri/

[4] https://shura.org.tr/net-sifir-2053-turkiye-elektrik-sektoru-icin-yol-haritasi/

charging technologies b) Public Charging Support (PCS) with a higher share of fast charging during the day which offers less time-based flexibility. For the selected regions, the demand growth by 2053 (focusing on the target year 2035) will be modeled and minimum grid investments to respond for the load growth will be modeled. This model will be used in Task 4 for EV uptake impact analysis.

Task 4: Assessing the EVs' potential impact on selected pilot regions to 2035 and by 2053. This task will be performed in two phases:

1. **Phase 1: Unmanaged charging pattern.** In this phase, a stochastic approach will be adopted, where several possible charging patterns pertaining to each type of EV technologies will be generated. Afterwards, the generated patterns will be reduced to representative patterns to reduce computational burden of the problem and thereby, making it tractable while keeping the stochastic information as intact as possible.
2. **Phase 2: Smart charging pattern.** In this phase, the patterns generated in phase 1 are considered as the base patterns and on top of them, the charging pattern of flexible charging technologies, such as charging infrastructures at residential level will be optimized. Here, an optimization model will be tailored for which the objective function and associated constraints will be determined based on the results of phase 1. The optimization process may include optimization of charging time, charging station locations and vehicle to grid processes.

The analysis under this task will be performed in weekly resolution for 4 representative weeks of the target years.

Task 5: Identifying a roll-out plan for EV charging infrastructure to meet mobility and grid demand consistent with Turkey's net-zero goal in 2053 and developing smart charging mechanisms for load management. Assessing two combinations (a) residential (home-based) charging, offering time flexibility to optimize for low-cost hours and make better use of the under-utilized network capacity via dynamic pricing and technology; and (b) commercial and public charging, with a higher share of fast charging during the day which offers less time-based flexibility, but can be optimized to absorb
e.g. noon-time solar energy, and **can also be optimized by location**, pointing out charging points in selected distribution grids. Developing region-specific measures to avoid overloading and voltage violations.

Task 6: Designing smart charging strategies and required policies for maximizing the benefits of EVs in Türkiye towards 2053, considering different power market actors, the most optimal locations for charging infrastructure needs and more renewable energy deployment. Deducing actions to be taken in terms of policy and regulation as well as recommendations to achieve EV growth and grid flexibility potential. This task will also include conducting a series of stakeholder meetings to discuss the findings of the study and receive their feedbacks in the report.

Task 7: A policy maker friendly report that derives a list of major policy recommendations for policy makers and other stakeholders that are necessary for the deployment of EV smart charging potential and its implementations for maximizing the synergy between the transport and power sectors.

General Notes

Multiple stakeholders from Türkiye's private sector are working on electrification, including the public administration, as part of Türkiye's energy agenda (e.g., electric vehicles, heat pumps, stakeholder engagement in data collection, methodology development, and policy aspects). This study will prioritize the options for electrifying transportation in a highly digitalized future over alternatives of improving energy efficiency and direct use of renewables. It will pay attention

to the need for vast expansion of renewables and smarter, much more flexible grids in a more electricity-intensive energy system.

Stakeholders that are associated with the EV ecosystem can provide inputs for a deeper analysis on the EV regulatory framework. TOGG (Turkish EVs manufacturer), DSOs, Ministry of Transport and Infrastructure, Ministry of Energy and Natural Resources (MENR), Energy Market Regulatory Authority (EMRA), and E-MOD can be potential partners. Policymakers and public sector actors including the Ministry of Environment, Urbanization and Climate Change, Ministry of Transport and Infrastructure, EMRA, energy companies, TOGG, E-MOD, sector associations, DSOs, energy service providers and end- use sectors could be the target audience.

The draft final report will be submitted to SHURA for concurrence and comments. The Consultant will prepare the final report considering SHURA's comments. The Consultant shall document the overall study results in a comprehensible manner in a final report that includes at least the following elements:

- A concise summary in English and Turkish at native level.
- A long version of the study results, with a focus on strong visual representation of the results, and a transparent description of the methodological approach;
- Appendices with descriptions of the models, data sets, and assumptions used;
- A PowerPoint presentation of the overall study results.

Deliverables and timeline

Deliverables	**Responsible**	**Timeline**
Contract starts	SHURA	June 2023
Task 1: **Assessing the existing outlook, targets, legislation and policies in Türkiye's EVs ecosystem and charging infrastructure.**	Consultant	June 2023
Task 2: **Identifying the EVs potential in the Turkish transport sector and its electrification share in the power demand towards 2053, based on demand and growth projections via estimating technology costs that align with SHURA net zero study.**	Consultant	June-July 2023
Task 3: Identifying the pilot regions, EV breakdown for each pilot region, and required charging points.	Consultant	July-August 2023
Task 4: **Assessing the EVs potential impact on selected pilot regions to 2035 and by 2053**	Consultant	September-October 2023
Task 5: Identifying a roll-out plan for EVs (including light duty vehicles) charging infrastructure to meet mobility and grid demand. Developing smart charging mechanisms for load management.	Consultant	October 2023
Task 6: Designing smart charging strategies and required policies for maximizing the benefits of EVs in Türkiye towards 2053 considering electricity market design, the most optimal locations for charging infrastructure needs and renewable energy deployment.	Consultant	November 2023
Task 7: A policy maker friendly report with a slide deck to present study results	Consultant	December 2023

- Some more details on the process:
    1) SHURA provides earlier SHURA studies to consultant/s
    2) Consultant/s, based on know-how and input received by SHURA, prepares key parameters for discussions and presents to SHURA. These will need to be agreed upon and approved by SHURA.
    3) The work will be carried out in consultation with SHURA's project management team: At least biweekly progress meetings will be organized and all task results will be discussed with SHURA. Task outputs will need to be agreed upon and approved by SHURA.
    4) At least one stakeholder workshop will be held by the Consultant with the support of SHURA. The results of the stakeholder meetings will be used by the consultant/s to adjust the model.
    5) The consultant should submit a detailed technical proposal specifying methodology/approach/expertise they will use for each task. The consultant/s should elaborate how they will handle complex interactions such as economic and sectoral dynamics in the proposal.

Qualifications

The consultant must be a firm with comprehensive knowledge on the Turkish energy and transport sectors, existing technologies in Türkiye's transport sector, electric vehicles ecosystem, distribution grid and energy market. The consultant must have cost-benefit analysis experience in the energy and transport sectors and have experience on writing policy-maker friendly reports that include policy/regulation recommendations.

The consultant needs to be a firm that has a team with experts having the following requirements:

- Team with proven record of analytical skills in the field of power system and transport sectors analysis, particularly on EVs
- Experienced team in applying a suitable method with a proven track record for a number of similar analyses.
- Advanced university degrees (masters or equivalent) in economics, engineering, environment or natural science, or other relevant field related to energy;
- A senior expert with a minimum of ten years of progressively responsible experience with regulatory/policy analysis of energy sector and an expert with skills on electrification analysis;
- Track record of publications in relevant field;
- Track record of establishing successful and effective engagement with policy makers, regulators and the utility is an asset;
- Excellent written and spoken Turkish and English

The proposal to be submitted as part of the tender offer should clearly state and elaborate the methodology and types of background data to be used in the study and include information regarding the qualifications stated above.