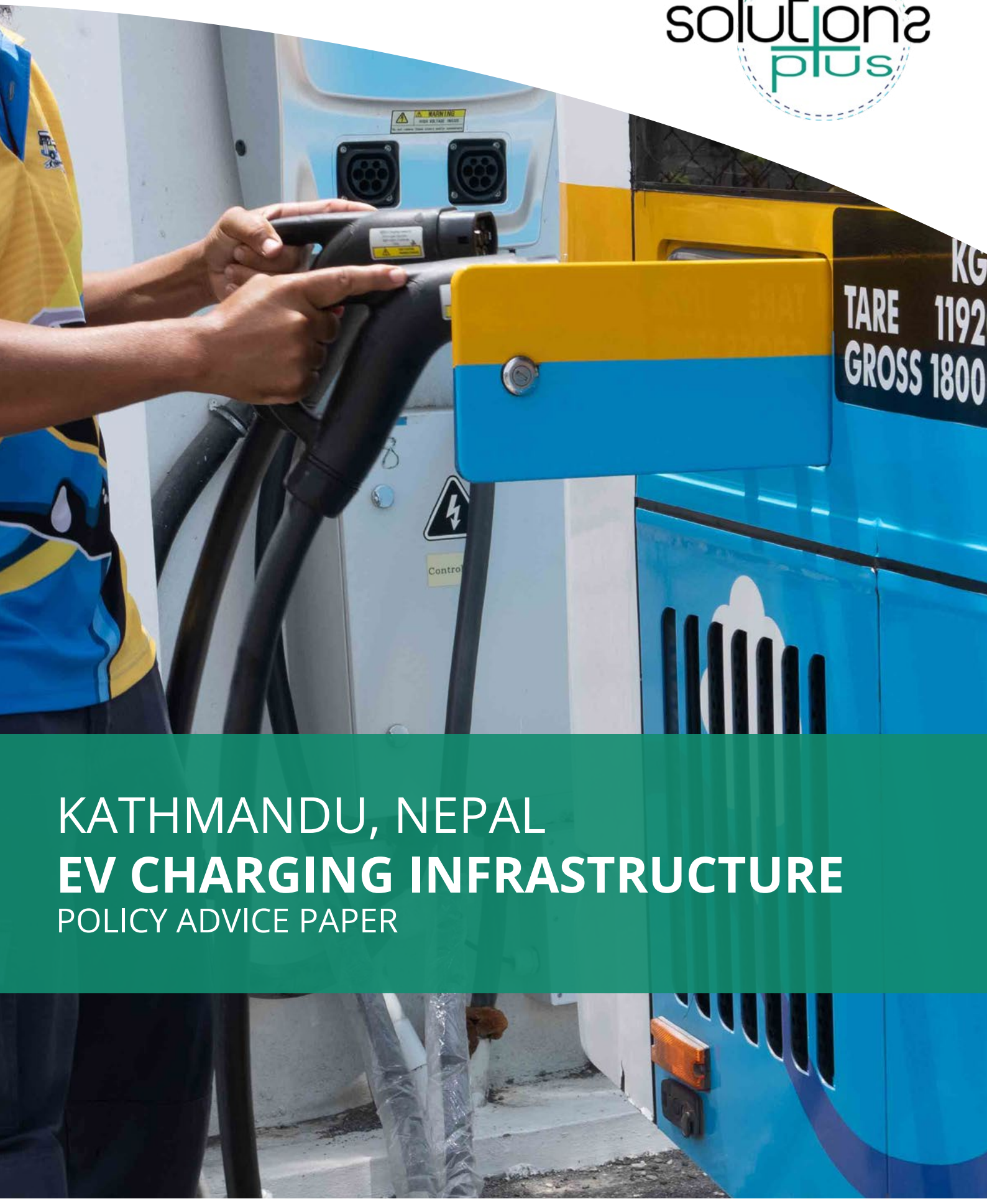

KATHMANDU, NEPAL
EV CHARGING INFRASTRUCTURE
POLICY ADVICE PAPER

This project has received funding from the European Union Horizon 2020 research and innovation Programme under grant agreement no. 875041

PROJECT PARTNERS

ABOUT

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TITLE

Kathmandu, Nepal: Ev Charging Infrastructure

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Purpose

This policy advice paper aims to provide practical guidance for developing an electric vehicle (EV) charging infrastructure in Nepal.

Coordination

Wuppertal Institute

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Some part of report draws from publications from SOLUTIONS+ partners, including the "STF Recommendations for public authorities for procuring, awarding concessions, licences and/or granting support for electric recharging infrastructure for passenger cars and vans", developed for the European Commission by TNO, POLIS and reviewed by FIER (Sustainable Transport Forum, 2021), "The impact of electric buses on urban life" (UITP, 2019) and "Large-scale bus electrification, the impact on business models" (UITP, 2021)..

Contents

1. Introduction

1.1. The SOLUTIONSplus project in Kathmandu

SOLUTIONSplus is launching a transformative project in Kathmandu that aims to revolutionize urban mobility, particularly through the promotion of electric vehicles (EVs). This aim aligns with Kathmandu's commitment to sustainable development and environmental stewardship. Integrating EVs into the city's transportation ecosystem can significantly reduce carbon emissions, alleviate traffic congestion, and improve air quality. This project brings together a coalition of stakeholders, including cities and industry leaders, research institutions, implementing organizations, and finance partners, who are highly committed to establishing a global platform for shared, public, and commercial e-mobility solutions.

The SOLUTIONSplus project ushers a new era of low-carbon urban transportation through city-level demonstrations and a wide range of training activities in Kathmandu. The city-level demonstrations seek to develop an ecosystem for electric mobility. They will serve as testbeds for innovative and integrated e-mobility solutions. The demonstrations will showcase locally produced components and various electric vehicle designs, including a converted diesel bus and mini truck to electric, a remodelled e- three-wheeler (Safa Tempo) for passenger and cargo use, a newly designed e3W for passenger and cargo use, an electric shuttle van, and an electric waste collection vehicle. Charging solutions for these vehicles are provided at dedicated depot charging stations. The exhibitions will highlight the viability of EVs in Kathmandu and provide valuable insights into their impact on urban mobility and environmental sustainability.

1.2. Objective

As a part of needs assessment within SOLUTIONSplus project, carried out via interviews and surveys with several stakeholders, indicate that Kathmandu's lack of charging infrastructure is one of the primary barriers for EV adoption. The project also facilitates various national and international training activities involving stakeholders from the government, utility companies, local industries, academia, and service providers to address barriers to EV adoption, including charging infrastructure. In addition to these activities under SOLUTIONSplus project, the paper gives an overview on charging infrastructure technology and advices on policy and planning taking into consideration on barrier.

2. Fundamentals of EV charging infrastructure

This section outlines the fundamental elements for establishing a charging infrastructure, including technical considerations (particularly charging standards) and planning aspects (including strategic factors to consider, grid management, open standards and interoperability).

(The content presented here draws primarily from SOLUTIONSplus Policy Advice paper on Electric Vehicles Charging Infrastructure: Kigali Demonstration Action[1], which incorporates the wealth of expert's insights from SOLUTIONSplus partners).

2.1. Charging standards

2.1.1. Chargers for various vehicle types

The charging systems are based on EV types, which have different infrastructure requirements, such as for Light electric vehicles (LEVs) and larger electric vehicles.

- **Light electric vehicles (LEVs)** include e-scooters, e-bicycles, small e-motorcycles, and small e-three- and four-wheelers. These vehicles are typically powered by a low-voltage powertrain (typically up to 48 V), and their batteries—usually removable—can be charged by plugging them into the ordinary grid, similar to any household appliance. In principle, there is no need for dedicated charging infrastructure if the user has a socket to charge the vehicle overnight, as well as reliable power supply that does not rely primarily on a local diesel generator.

  Yet, to incentivise the mass deployment of LEVs, safe, smartly distributed public charging points can be made available to support the deployment of an electrified shared or taxi LEV fleet, especially if the conditions above are not met. As charger types are limited and charging times are typically low, charging infrastructure for these vehicles is easy to deploy. LEVs are also ideal for centric urban areas in which available space is a constraint and where the users' turnover is high. These vehicles do not need to meet interoperability requirements.

  The overall impact of LEVs on the power grid is generally low and limited to potential peak loads, should the grid be weak. Generally speaking, the impact will depend on various factors, including the overall installed capacity, vehicles electrified and charging times (electricity availability), load duration curve etc.

- **Larger electric vehicles** include high-power motorcycles, passenger cars, commercial vehicles, trucks, and buses. Heavier weight and larger range requirements lead to powerful motors that need to be fed by higher capacity batteries. Voltage is significantly increased, and safety requirements are a major technical concern for the vehicle, charging infrastructure, and communication protocols between the vehicle and chargers. Interoperability measures are important for this group.

[1] Barris et al. (2021), Policy Advice paper Electric vehicles charging infrastructure Kigali Demonstration Action. Available at https://www.solutionsplus.eu/_files/ugd/6a0a2f_c56042fd24944a1a842da25649a5ecda.pdf

Table 1. Charging system typologies

Vehicle type	Charging system	Charging power	Suitable charging solution
Bicycles and light motorcycles	Direct grid and DC simple transformer	< 3kW	
High power motorcycles	Mode 3 and Mode 4	3 - 20kW	
Passenger utility vehicles	Mode 3 and Mode 4	3 - 100kW	
Passenger luxury vehicles	Mode 3 and Mode 4 HP	3 - 350kW	
Transport vehicles (vans)	Mode 3 and Mode 4	3 - 200kW	
Commercial vehicles (buses and trucks)	Mode 4 and high-power interfaces (e.g., pantographs)	50 - 600kW	

Source: IDIADA, 2024[2]

[2] IDIADA (2024). https://www.applusidiada.com/, Retrieved on 21st December, 2023

2.2. Charging types

2.2.1. AC and DC chargers

Electric vehicle types have varying power needs, which also determines the recharging speed, together with the specifications of the vehicle. Different technologies are being used with regards to different levels of power output; these are mainly divided into AC and DC recharging and are referred to as "modes". Most public-access AC recharging points provide between 3,7 and 43 kW, but the most common is 11 kW. AC recharging is usually referred to as "slow" recharging (up to 3,7 kW), "normal" (circa 11 kW), or "fast" (22 kW and higher). For power outputs above 43 kW, recharging point manufacturers provide DC recharging solutions, which are referred to as "high-power", or also "ultra-fast" recharging.

For these different "modes" of recharging, various standard connectors have been adopted, which differ slightly by continent. In Europe, the AC connector mandated by the EU is the Type-2 "Mennekes" connector, adopted for a variety of vehicles including passenger cars.

Choosing among different charging solutions (slow, fast, ultra-fast) not only has an impact on charging speed and the use of space, but also on costs of e-mobility systems and battery lifespans. All options must therefore be carefully assessed to identify solutions optimally adapted to local operational, financial, and technical conditions, especially for buses.

Table 2. Charger types

	AC-recharging Wall outlet	AC-recharging Wall outlet IC-CPD	AC-recharging Wallbox	AC-public recharging-station	DC - recharging
Mode	1	2	3		4
Standard		IEC 62752/UL 2231	IEC 61851-1/-21/-22		IEC 61851-23
Power class	max. 1ph 16A (3.7kW) max. 3ph 16A (11kW) max. 3ph 32A (22kW)		max. 1ph 16A (3.7kW) max. 3ph 63A (43kW)		25kW - 400kW

	N. America	Japan	EU and the rest of markets	China	All Markets except EU
AC	 J1772 (TYPE 1)	 J1772 (TYPE 1)	 Mennekes (TYPE 2)	 GB/T	Tesla 
DC	 CCS1	 CHAdeMO	 CCS2	 GB/T	

Source: European Alternative Fuels Observatory (EAFO), 2024[3]

[3] European Alternative Fuels Observatory (2024). https://alternative-fuels-observatory.ec.europa.eu/general-information/recharging-systems. Retrieved on 21st June, 2024

AC Charging Standards

Type 1 (SAE J1772)

Type 1 (SAE J1772) is developed by the Society of Automotive Engineers (SAE). This type of charging is widely used in North America and Japan. Its features include alternating current (AC) charging, two-level charging (i.e., Level 1 for slow charging at 120V and Level 2 for medium charging at 240V), and a rectangular-shaped plug with five pins. Type 1 charging is commonly found in residential settings and public charging stations.

Type 2 (IEC 62196-2)

Type 2, also known as IEC 62196-2, is prevalent in Europe. It supports both single-phase and three-phase AC charging. Mode 3 charging ensures communication between the vehicle and the charging station. The Type 2 connector features a circular plug with seven pins, and it is widely used in public charging infrastructure across Europe.

Fast Charging Standards

CHAdeMO

CHAdeMO, originating in Japan, provides high-power direct current (DC) fast charging. This standard created by a Japanese-only association is a simpler, closed charging protocol, now compatible through specific adapters with EVs from some European and American OEMs.

CCS (Combined Charging System)

The CCS standard combines AC and DC charging capabilities. It features a combo connector integrating Type 1 or Type 2 AC connectors with two additional DC pins. CCS supports fast charging up to 350 kW, and it is gaining popularity in Europe and North America. High-power CCS charging stations are strategically placed along highways.

GBT

China has developed another charging protocol that, even if using a pin layout similar to the IEC connector (used in Germany), is incompatible with the other existing protocols. It relies on CAN BUS signalling for control, instead of PLCs.

Tesla Supercharger

Tesla's proprietary supercharger network is exclusive to Tesla vehicles. Superchargers provide high-speed DC charging, allowing Tesla owners to recharge their EVs rapidly. The Tesla-specific plug is available only at Tesla supercharger stations worldwide

ChaoJi:

In June 2020, the China Electricity Council and the CHAdeMO association reported progress on a joint effort to develop a new standard, supposedly faster, safer and compatible to all other main existing protocols in the market. It aims at becoming the international reference standard and replacing existing standards by 2035.

2.2.2. EV Battery swapping

In addition to recharging, EV batteries can be swapped. Battery swapping involves exchanging a depleted battery for a fully charged one, either with batteries owned by the user or from commercial battery recharging stations. Battery swapping has numerous advantages. Depending on the battery size, it only takes a few minutes and can be done manually or mechanically. The use of swappable batteries, therefore, eliminates recharge time, which is a major hurdle for electric mobility uptake. Swapping schemes enable the use of smaller batteries. Further, multiple systems can co-exist as long as each system has a critical mass of clients. However, swapping is less widespread worldwide because of challenges related to investment costs, the required number of batteries, the lack of standardisation[4,5], and the disconnect between EV makers and swapping service providers. Swapping can be difficult unless they fall under a single company. Hence, the battery swapping landscape and corresponding standards are less defined than charging.

Nonetheless, battery swapping is gaining traction in contexts with intensive vehicle use, such as ride-hailing services (which use two- and three-wheelers) and bike-share systems. Business models where batteries are owned by energy operators and then rented out to drivers or vehicle owners are particularly successful in India despite the swapping fee. The separate ownership of the vehicle and the battery mitigates the high upfront cost of EVs, which is key to e-mobility adoption. At the same time, battery swapping ensures higher utilisation rates for swapping service providers since drivers owning or renting electric vehicles are tied to a particular provider.

2.3.Planning for a charging infrastructure

Establishing an EV charging infrastructure is not as simple as installing a few charging stations. It requires careful planning, grid management, open standards and interoperability. A suitable charging infrastructure is key to a successful electric vehicle transition.

2.3.1. Strategic planning for charging infrastructure planning

Choosing the adapted charging solutions

No "one-size-fits-all" charging solution: It is key to consider city characteristics

Setting up electric charging infrastructure requires analysis of city-specific characteristics, including travel patterns (mode split, distribution of origins and destinations, journey length); use and operations (e.g., typical driving ranges); housing stock; access to electricity; topography; and thermal variability. Those characteristics define the performance required for vehicles and the general energy and recharging requirements. The analysis should include identifying social objectives and corresponding technical requirements.

The following principles can guide the design of charging systems:

- **Prioritise regular charging instead of high-power, or opportunity charging** to smooth out the energy demand curve, maximise charging efficiency, and extend the lifetime of the EVs.

[4] Eccarius, T. and Lu, C (2020). Adoption intentions for micro-mobility – Insights from electric scooter sharing in Taiwan. *Transportation Research Part D Transport and Environment*. 84. DOI: 10.1016/j.trd.2020.102327

[5] UNEP (2020). Policy Guidelines for Electric 2- & 3-wheelers for Southeast Asia. https://cleanairsolutions.asia/wp-content/uploads/ASEAN-E2-E3Vs-Policy-Guidelines.pdf

- **Charging, in as much as possible, should not be carried out during operation** but when the vehicles are not in use: parked at their destination. That entails the deployment of a dense network of mid-power chargers in large commercial areas, work centres, and residential districts as well as promoting the installation of private chargers at residential locations.
- **High-power charging should be deployed only to meet specific needs:** opportunity charging for private users during longer journeys, and partial recharging of commercial and public transport vehicles whose daily operation exceeds the battery range and emergencies. Ideally, high power chargers should be deployed at the intersections of the main arteries in the city outskirts, and in destinations in which users spend little time: small shops, restaurants in industrial areas, supermarkets, etc.

Forecasting charging demand

An analysis of the recharging needs (i.e. the number of needed charging points) is required to prevent short-term investments in suboptimal and redundant infrastructure, since charging infrastructure typically has a lifetime of at least seven years. **Public long-term strategies for recharging infrastructure** require a clear vision on how the local mobility and electricity demand situation should develop. Main factors to consider include:

- **Transport data**: number of daily commuters coming to a given area, amount of transit (long-distance) traffic, changes in traffic densities and traffic flows,
- **Present and forecasted transport electrification**, expected ownership or use of EVs, and resulting charging needs of specialised/captive fleets such as taxis, (urban) logistics, etc.,
- A**mount of semi-public recharging infrastructure as well as private one** (private parking space, stores, etc.),
- **Urban planning changes**, e.g., changes in the intensity of commercial activities and residential uses in particular city areas.
- **Forecasted modal shift**, e.g., a shift from the user of personal motor vehicles to walking, cycling, and public transport.
- **Changes in vehicle fleets**, e.g., number of e-vehicles and drivetrain types,
- **Technological developments of EVs**, e.g., battery size, recharging capabilities, etc.
- **Policy developments**, especially Urban Vehicle Access Regulations (UVARs) and Low Emissions Zones and,
- **Local energy demand** and hosting capacity of the local electricity grid.

Methods to determine the location of public charging points

To the extent that city authorities are involved in planning the charging network, they should aim to balance ease of use and cost effectiveness, as described in the following table 3.

Table 3. Criteria for efficient charging infrastructure

1. Providing flexibility for electric vehicle users by:	a. defining the required number of recharging points, b. identifying appropriate locations, c. ensuring geographical dispersion, d. identifying appropriate power levels.
2. Reducing overall deployment costs and nuisance by:	a. making best use of existing infrastructures to limit installation costs e.g., shopping malls/schools etc. can be used during night for parking/charging of a commercial fleet, b. limiting the use of (public) space, c. preventing nuisance during installation and maintenance works, d. maximising the occupancy rate of recharging infrastructure (effective EV parking policy).

Selecting adequate locations for recharging infrastructure can be either made centrally by public authorities or (semi-)public undertakings (e.g., utilities, distribution system operator), or by market players utilising data extracted from existing recharging points or indirectly by responding to requests for a new recharging point from prospective EV owners.

Central planning of infrastructure may be useful in early stages of network development to establish a basic network, in order to convince the earliest-moving consumers to switch to electric vehicles (solving the "chicken-and-egg dilemma" of electric mobility), or if public authorities want to ensure a good geographical spread. When opting for this method, public authorities often delegate the decision to a specialised public undertaking or to the distribution system operator (DSO). Tables 4 and 9 provide further insights into aspects to consider in the modelling.

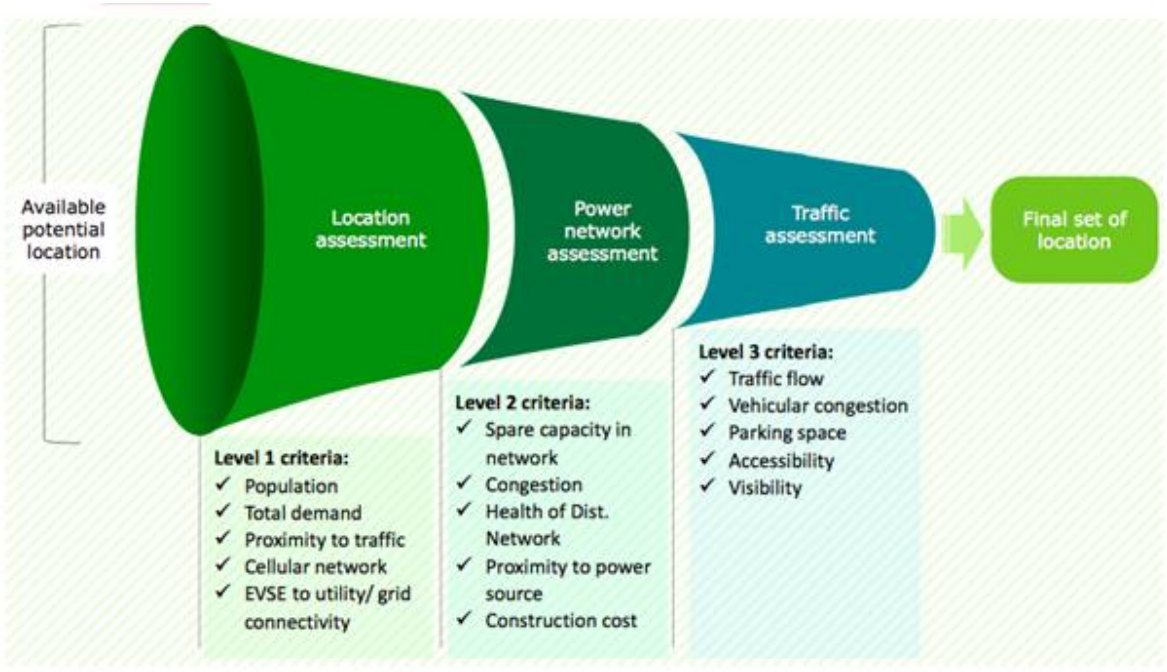
Table 4. Key factors to consider in multi-criteria decision-making to select the location for EV charging infrastructure [6]

Parameters	**Factors to consider**
Location profile	Location, Topography, Demography, etc.
Type of transportation	Roadways, railways, airways, etc.
Key statistics	Type of transport: 2 wheelers, 3 wheelers, 4 wheelers, Buses, Commercial vehicles, Personal Vehicles Key attributes viz. • Spacial distribution of registered motor vehicles • Share of Different Modes of Transport in overall transportation sector (LCV, MCV etc.) • Average annual growth by category
Key areas	Ring roads, Commercial and industrial hubs, Expressways, Highways, Intra-city roads, Bus terminals

[6] GIZ GmbH and Deloitte Touche Tohmatsu India LLP (2021). Status quo analysis of various segments of electric mobility and low carbon passenger road transport in India. https://www.changing-transport.org/ wp-content/uploads/1612416043_Status_quo_analysis_of_various_segments_of_electric_mobility.pdf

Forecasts for transportation sector	• Forecast for private and commercial vehicles • Forecast for freight transportation • Expected penetration of conventional vehicles and Electric vehicles in the future
Power infrastructure	• High level network overview with load growth forecasts • Overloaded/ under-loaded areas • Optimal locations for solar power

Table 5. Shortlisting criteria for selection of location of location for EV charging[6]



Combined charging infrastructure at strategic locations

In many cities, strategic locations for private vehicle charging infrastructure are also locations that are important for public transport and shared mobility. In many cases, the combination of dedicated charging infrastructure with an open charging infrastructure for public use, gives a better business case in strategically interesting locations. Such combined charging solutions may have:

- **Dedicated charging infrastructure for the operation of electric public transport buses or transport modes offered under a shared or taxi modality**. This infrastructure can be designed according to operators' specifications.
- **Additional public-access facilities for private vehicles** that should follow the standards for public-access charging stations set out by government authorities, and be interoperable.

2.3.2. Grid management

The electricity market will experience added demand due to vehicle electrification. Heavy-duty electric vehicles, especially buses, may affect the electric grid, especially in the absence of smart charging, energy storage, or other balancing technologies. The power sector also faces the challenge of developing a greener energy mix, while meeting demands of a stable energy supply and growing demand. Sustainable power sources such as solar and wind power are intermittent, thus influencing the stability of the energy supply and the grid balance.

The use of high-power chargers, combined with the growth of the electric fleets, will increase peak demand on grids. A grid that is unable to handle peak demand will slow down future growth of e-mobility. Therefore, load management (demand-side response) will be critical for realising peak shaving to prevent large investments in grid upgrades. Dynamic pricing to match renewable energy generation cycles can help in balancing of new energy sources and new energy mobility solutions. Furthermore, as battery prices reduce and as second life batteries become available, renewable energy projects need to include on site storage facilities so that the load and demand can be matched.

The location of the power delivery and power demand is also crucial. The energy demand from high power chargers at a site can be so high that new medium-voltage connections with new transformers are needed. To make the best use of investments, it would be advisable to combine supply and demand as new grid connections are established.

2.3.3. Interoperability and open standards

Charging interoperability refers to the ability of vehicles, chargers, networks, management systems and networks to interact and manage data to ensure safety, functionality, and system reliability. Interoperability and compatibility can reduce the risk of premature obsolescence of assets and of failure to meet users' and operators' expectations on performance and cost. This is crucial today, at the verge of widespread proliferation of heavy-duty electric vehicles.

Assessing interoperability measures reveals the need for the industry to speed up development and homogenisation: various immature standards are being developed and implemented in parallel by separate committees. Some charging protocols use non-standardised connectors, and the major standards are competing for market share. New entrants are challenging incumbents by introducing new vehicle and infrastructure solutions in the market, sometimes disregarding reliability in favour of minimising time to market. Skipping the planning phase and letting suppliers define charging system parameters can result in fragmentation and sub-optimal charging infrastructure. This creates a risk that charging solutions will not be accessible to everyone and will become sunk assets.

Open standards and communication protocols, **especially for the category of larger EVs** (passenger cars, buses, commercial vehicles), can help to 1) ensure charging safety, 2) avoid vendor lock-in monopolies, 3) protect digital security and access to data, 4) enable competition for standardised protocols and promote charging technology innovation. An example of an internationally accepted open communication protocol is the OCPP, which has become the standard for communication between the charge point and the electric vehicle. Adopting open standards can eliminate the need for different types of DC chargers, which has increased charging equipment expenses and impeded the deployment of public access units. Overall, using open standards can decrease costs, enhance user-friendliness, maximize utilization, and improve the accessibility, compatibility, and interoperability of charging stations. EV users can easily charge their vehicles without considering the network or vehicle model.

3. The current state of Nepal's charging infrastructure

This section overviews the current state of Nepal's charging infrastructure in a four-part discussion. The first part discusses the existing status of EV adoption and charging infrastructure development in the country. The second and third parts examine Nepal's electricity supply, demand, and charges and charging technology, respectively. These are important considerations for charging infrastructure development. The last part outlines key motivations for installing a charging network in Nepal.

3.1. Existing e-mobility and charging infrastructure

3.1.1 Status of electric vehicle adoption

In Kathmandu Valley, the electrification of public transport dates back to the 1970s, when trolleybuses were introduced. In the early 1990s, *Bikram Tempos* (diesel-run three-wheelers) were banned due to high air pollution concerns. However, most of them were successfully converted to electric power. Since then, the Valley has been using *Safa Tempos* (electric three-wheelers) as public transport. The unprecedented popularity of *Safa Tempos* in the early 2000s led to the establishment of seven manufacturing plants and nearly 40 charging stations, generating green jobs, especially for women drivers and owners. In recent years, Sajha Yatayat, a semi-government-owned transport operator, procured 40 e-buses with government grants. Sundar Yatayat, another private transport operator, currently operates four electric buses in the Kathmandu Valley.

Despite a promising start and the recent developments in e-bus adoption, the full electrification of Nepal's public transport remains incomplete. The operation of trolleybuses was shut down in 2001. Further, battery issues and associated costs thwarted the growth of the electric *tempo* industry. The ban on diesel-run *tempos* inadvertently led to the importation of petrol microbuses at reduced tariffs, resulting in many owners switching to fossil-based vehicles. On the other hand, infrastructure challenges hindered e-buses deployment. To address these challenges, projects like SOLUTIONSplus collaborate with local entrepreneurs to innovate *Safa Tempo* designs and test diesel bus to e-bus conversions. The Mitigation Action Facility, implemented by GIZ and supported by the Ministry of Physical Infrastructure and Transport, Ministry of Forests and Environment, and Ministry of Finance, aims to deploy over 3,000 electric minibuses and charging stations in Nepal, with a vision for 85% of newly purchased minibuses to be electric by 2030.

Although EV sales in the country are gradually increasing, given the rising fossil-fuel costs, EVs continue to have a low market share. The automobile growth in Nepal is 15% annually. However, the share of EVs is less than 1% (equivalent to around 50,000 EVs, including e-rickshaws)[7]. Nonetheless, various electric two- and three-wheeled vehicle models operate in Nepal. Some EVs are imported, while others are from local manufacturing start-ups. According to the Nepal Automobile Dealer's Association, around 11,000 EVs were imported between 2022 and 2023[8]. Imported electric cars and vans are mostly privately owned.

[7] Kathmandu Post (2023). Changing policy is hurting Nepal's plan to switch to electric vehicles, experts say. https://kathmandupost.com/money/2023/05/15/changing-policy-is-hurting-nepal-s-plan-to-switch-to-evs-experts-say. Retrieved on June 20, 2024

[8] The Kathmandu Post (2023). EV sales continue to soar despite the overall market slowdown. https://kathmandupost.com/money/2023/11/25/ev-sales-continue-to-soar-despite-the-overall-market-slowdown. Retrieved on June 20, 2024

3.1.2 Status of charging infrastructure development

The charging infrastructure is the backbone of e-mobility. Yet, the expansion of charging infrastructure in Nepal remains sluggish. According to EV dealers, just over 60 DC fast chargers and 300 AC chargers are available nationwide, primarily established by the private sector. This quantity significantly falls short of what is required to bolster the EV market effectively.[9] The inadequate number of chargers and slow charging speeds impede EV uptake in Nepal. Additionally, while the number of privately installed charging stations is increasing, their lack of interoperability poses a challenge to seamless EV charging.

Nonetheless, the Nepal Electricity Authority (NEA), the state-owned power utility, has taken significant strides to develop the country's charging infrastructure. NEA installed 51 electric vehicle charging stations nationwide. This initiative aims to establish one charging station approximately every 60 kilometres along the country's main highways, facilitating long-distance EV travel. Notably, six of these stations are operational within the Kathmandu Valley. This project was funded by NEA investment and concessional loans from the Asian Development Bank (ADB), while the Norwegian government provided technical support. Through further collaborative efforts with the private sector, NEA has facilitated the installation of 45 additional charging stations across the country, enhancing accessibility to EV charging infrastructure.

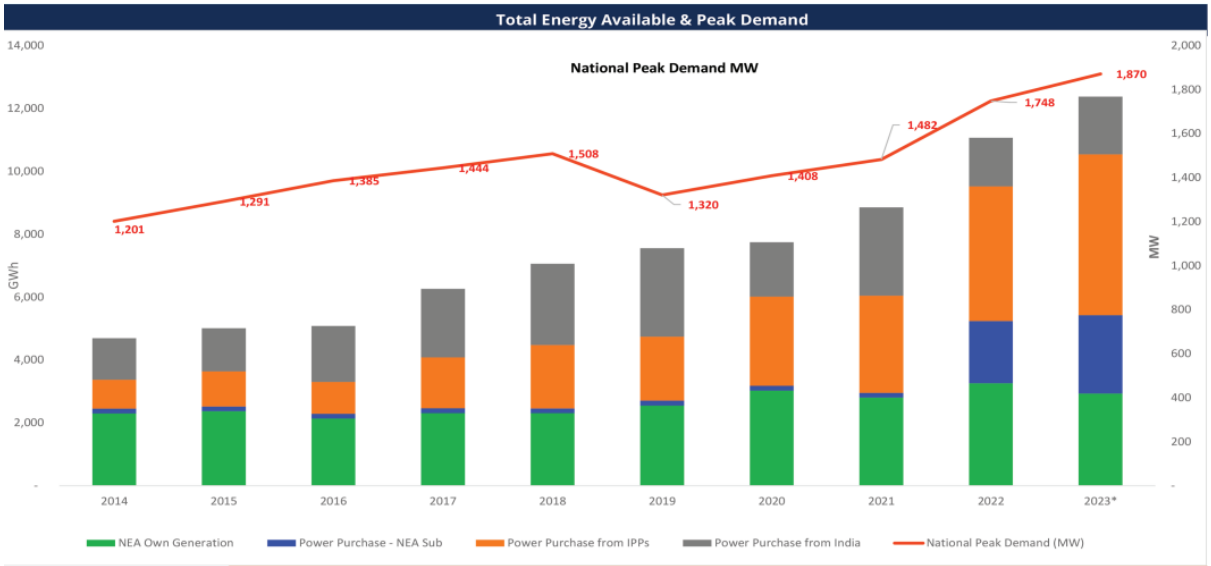
3.2. Electricity supply, demand, and charges

3.2.1. Electricity generation and demand

One of the biggest opportunities for electric vehicles in Nepal is the use of hydropower electricity generated within the country. Approximately 13% of the country's total energy supply is sourced from petroleum products imported from neighbouring countries. This dependency on petroleum can be reduced by enhancing domestic hydroelectricity production and utilizing it within the transport sector[10]. Such measures can help curb the nation's trade deficit and reduce electric vehicles' well-to-wheel emissions. Although Nepal has a substantial potential for hydropower generation, estimated at around 83 GW, the current installed capacity remains relatively low. According to the data provided by the Nepal Electricity Authority (June 2023), Nepal has an installed capacity exceeding 2800 MW of hydroelectricity, while the projected peak domestic power demand is 1870 MW in 2023 (see Figure 1). There is also a disparity in demand throughout the day as it peaks between 7:00 to 10:00 a.m. and 5:00 to 8:00 p.m., while the demand is lower at night-time, particularly from 10:00 p.m. to 5:00 p.m. These peak hours stress the grid, potentially leading to wasted energy during off-peak periods. Charging electric vehicles at night can effectively utilize surplus energy. Figure 2 shows the average number of EVs charging within a typical day in Nepal.

[9] The HRM (2023). The Nepali EV market. Retrieved from https://thehrmnepal.com/cover-story/the-nepaliev-market/

[10] Ghimire, L.P., Kim, Y., Dhakal, N.R. (2023). Which Policies and factors drive electric vehicle use in Nepal?. *Energies*. 16(21), 7428. Doi: 10.3390/en16217428



Particulars	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023*
Availability (GWh)										
NEA Own Generation	2,298	2,368	2,133	2,305	2,308	2,548	3,021	2,804	3,259	2,930
Power Purchase - NEA Sub	151	147	154	155	149	157	155	148	1,976	2,488
Power Purchase from IPPs	919	1,122	1,012	1,623	2,019	2,033	2,836	3,093	4,286	5,118
Power Purchase from India	1,319	1,370	1,778	2,175	2,582	2,813	1,729	2,806	1,543	1,833
Total Availability (GWh)	**4,687**	**5,007**	**5,077**	**6,258**	**7,058**	**7,551**	**7,741**	**8,851**	**11,064**	**12,369**
National Peak Demand (MW)	1,201	1,291	1,385	1,444	1,508	1,320	1,408	1,482	1,748	1,870
System Peak Demand Including Export (MW)									1,964	1,986

* Provisional Figures (Subject to audit)

Figure 1. Total energy available and national peak demand[11]

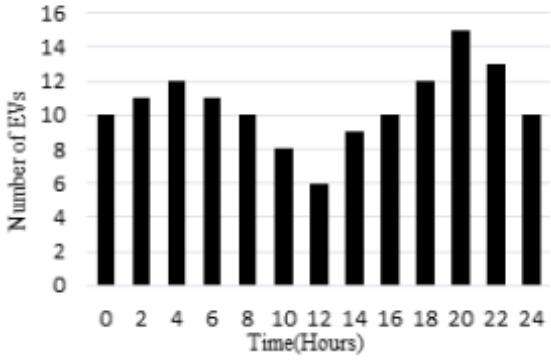


Figure 2. Average number of EVs plugged in a typical day in Nepal[12]

3.2.2. Electricity tariff

EV fast charging costs in Nepal vary depending on the time and charging station. During peak time (5 p.m. to 11 p.m.), off-peak time (11:00 p.m. to 5:00 a.m.), and normal time (5:00 a.m. to 5:00 p.m.), private electric vehicles are charged NRs 11.20 per kWh, NRs 4.45 per kWh, and NRs 10.10 per kWh,

[11] Nepal Electric Authority (2023). Nepal Electricity Authority A year in review-Fiscal year- 2022/2023

[12] Karki et. al (2019). Power Flow management among PV, BESS and Grid for EV Charging. *Nepal Engineers' Association, Gandaki Province Technical journal.* Vol 1, No.1. 102-112. ISSN : 2676-1416

respectively. On the other hand, electric public transport vehicles are charged less at NEA charging stations. The cost of charging electric public transport vehicles during peak, off-peak, and normal times are NRs 8.40 per kWh, NRs 4.45 per kWh, and NRs 6.60 per kWh, respectively (see Figure 3). For household charging, the rate remains the same as the domestic tariff rate per unit of energy as per the supply capacity. However, vehicle company-owned charging stations impose different electricity tariff rates.

For Public Transportation (Charging station)			
	Energy Charge Nrs./kWh		
Description	**Peak Time (17.00-23.00)**	**Off Peak Time (23.00-5.00)**	**Normal Time (5.00-17.00)**
Tariff Rate from Baisakh to Mangsir			
Medium Voltage (33 kV)	8.4	4.45	6.6
Medium Voltage (11 kV)	8.6	5.05	6.7
Low Voltage (230/400 V)	8.7	5.05	6.9
Tariff Rate from Paush to Chaitra			
Description	**Peak Time (17.00-23.00)**	**Normal Time (23.00-17.00)**	
Medium Voltage (33 kV)	8.4	6.6	
Medium Voltage (11 kV)	8.6	6.7	
Low Voltage (230/400 V)	8.7	6.9	
For other transportation			
Description	**Peak Time (17.00-23.00)**	**Off Peak Time (23.00-5.00)**	**Normal Time (5.00-17.00)**
Tariff Rate from Baisakh to Mangsir			
Medium Voltage (33 kV)	11.2	4.45	10.1
Medium Voltage (11 kV)	11.6	5.05	10.2
Low Voltage (230/400 V)	11.7	5.15	10.3
Tariff Rate from Paush to Chaitra			
Description	**Peak Time (17.00-23.00)**	**Normal Time (23.00-17.00)**	
Medium Voltage (33 kV)	11.2	10.1	
Medium Voltage (11 kV)	11.6	10.2	
Low Voltage (230/400 V)	11.7	10.2	

Figure 3. Energy charge for public and other transportation at charging stations[13]

[13] Nepal Electric Authority (2023). Nepal Electricity Authority (2022), A year in review-fiscal year 2021/22

3.3. Charging technology

Charging connector technology has evolved in different parts of the world. For example, fast charging connectors and standards vary in Europe, the United States, China and Japan. However, Nepal has not yet developed its fast-charging connector standard due to limited capacity and resources. However, standardizing charging connectors can reduce capital investment for charging stations since most, if not all, EV models can connect to the charging station. Table 7 shows the different types of connectors identified by IEC (International Electrotechnical Commission) 62196-1 for EV charging. In a study of current market conditions, it appears that Type 1, Type 2, Configuration AA, and Configuration FF are the most commonly used connector types in Nepal so far.

Table 6. Connector types

Configuration	Type of connector
Basic configurations	Type 1
	Type 2
Direct current (DC) configurations	Configuration AA (also known as CHAdeMO)
	Configuration BB (DC charging, Chinese Standard)
Combined direct current (DC) and alternating current (AC) configurations	Configuration EE (also known as CCS, used in North America)
	Configuration FF (also known as CCS, used in Europe)

3.4.Motivations for installing a charging network

The installation of a charging network for electric vehicles in Nepal is driven by a combination of factors, including environmental concerns, government policies, and global trends in sustainable transportation. Nepal, like many other countries, increasingly recognises the need to reduce its reliance on fossil fuels and curb air pollution, making the transition to electric vehicles an attractive prospect. In collaboration with various stakeholders, the government of Nepal has undertaken several initiatives to facilitate the installation of a charging network in the country, particularly in Kathmandu Valley. Some of their key initiatives include:

Policy Support: The government has formulated and implemented policies and regulations to promote electric mobility and support charging infrastructure development. For example, the National Electric Mobility Policy outlines the vision, targets, and strategies for adopting electric vehicles and establishing charging facilities.

Public-Private Partnerships: To expedite the deployment of a charging infrastructure, the government has encouraged public-private partnerships, enabling private entities to invest in and operate charging stations. This approach uses the private sector's expertise and resources to complement government efforts.

International Collaboration: Nepal has collaborated with international organizations and development partners to access technical expertise, financial assistance, and best practices for deploying a charging infrastructure. For example, the Asian Development Bank and the World Bank supported the development of a charging infrastructure along the national highway.

4. Barriers to EV charging infrastructure development in Nepal

This section identifies key barriers that impede EV charging infrastructure development in Nepal. These barriers are categorized into four: technical, regulatory and institutional, economic and finance, and knowledge barriers. The barriers were identified through the research and study of different technical articles and papers as well as conducting questionnaire survey with relevant identified EV experts and stakeholder from academia, industry, private sector, development sector and government.

4.1. Technical barriers

- **Lack of reliable power supply:** The country's unreliable power supply hinders the smooth operation of charging stations. Power cuts prevent EV users from charging their vehicles in a timely manner, putting EVs in a bad light. EVs could be viewed as less reliable than their ICE counterparts. Power cuts can also result in higher failure rates. Power distribution system disruption can cause serious technical challenges to the charger.
- **Limited charging network in rural areas:** The Nepal Electricity Authority (NEA) has developed 51 charging stations in Nepal's main cities and along its major highways. However, the charging network in rural and sub-urban areas is very limited, prompting hesitance among EV drivers to use their vehicles for long-distance travel.

4.2. Regulatory and institutional barriers

- **Lack of comprehensive regulatory standards:** The absence of a clear set of standards for charging stations hinders the development of a robust charging network. It undermines a charging infrastructure's interoperability, safety, and quality, negatively impacting the overall adoption and effectiveness of EVs in the country.
- **Inadequate national policy:** There is still a lack of a national plan for how and where to set up charging stations, although the private sector and the NEA have begun setting up charging stations nationwide. Poor long-term planning and goal setting on EV infrastructure are some barriers to EV use in Nepal.

4.3. Financial and economic barriers

- **Low investment in charging infrastructure:** The limited interest in investing in charging infrastructure as a primary business, primarily due to low returns, is a significant barrier to charging infrastructure development in Nepal. The limited number of charging stations remains a concern as electric vehicle purchases increase in the country.
- **Unavailability of subsidies for electricity tariffs and charging stations:** The lack of subsidies and incentives for electricity tariffs and the high initial cost of developing an EV charging infrastructure hinder the promotion of electric vehicles in Nepal. The construction and operation of EV charging stations require a large investment. The average Nepali businessperson cannot afford to run a charging station as a primary business.

4.4. Knowledge Barrier

- **Lack of trained human resources:** The scarcity of human resources trained for charging station maintenance is another significant barrier to EV charging infrastructure development in Nepal. According to a study conducted by the Automotive Research Association of India

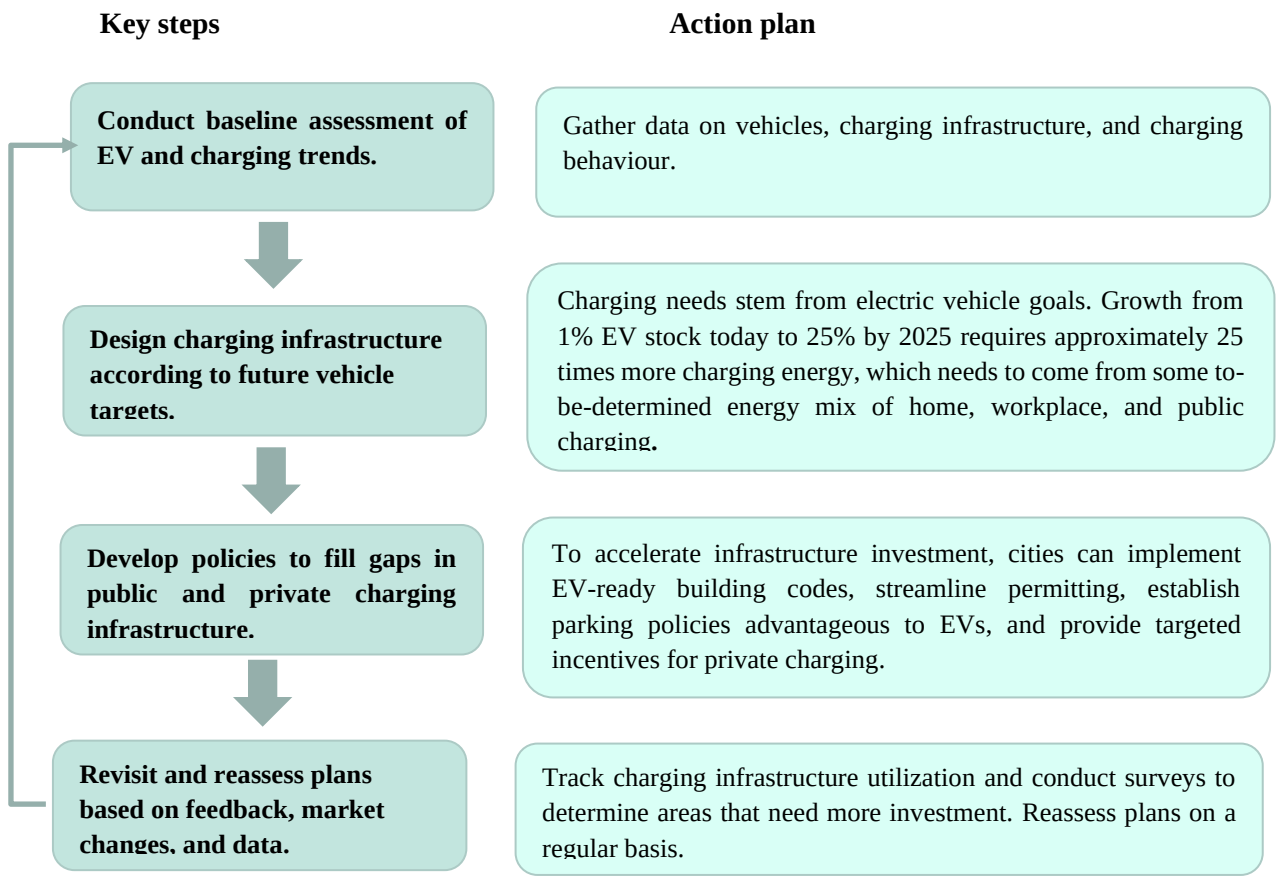
(ARAI), the availability of trained personnel is crucial to the healthy functioning of EVs and charging stations.

5. Recommendations

This section, constituting five parts, provides recommendations for charging infrastructure planning in Nepal. Part 1 shows a flowchart of the planning process. Parts 2 and 3 provide short to medium-term and long-term recommendations, respectively. Part 4 identifies specific action plans and strategies. Part 5 proposes sustainable business models for charging infrastructure in Nepal. The recommendations are based on the research and technical paper study, stakeholder consultation from the academia, industry and government sector. The survey questionnaire is mentioned in Annex 1.

5.1. Flowchart for charging infrastructure planning in Nepal

The diagram below shows an iterative process for charging infrastructure planning in Nepal.



5.2. Short to medium-term recommendations

The government of Nepal promoted the use of EVs by waiving about 90% of import duties on EVs, resulting in a quick uptake. However, the government eventually reversed its position. It raised import duties on EVs, significantly reducing EV adoption as they became an expensive option. Then, the high import duty was reduced to its earlier levels. Such frequent policy changes, though intended for good, negatively impact the uptake of EVs. The inability to rapidly roll out EVs and EV infrastructure limits the financial viability of charging stations, risking the entire undertaking. Therefore, it is critical to establish a comprehensive and coherent policy for EV promotion. As experience shows, a strong policy can catalyze the growth of the entire EV ecosystem. The following are the key areas that Nepal should prioritize in the near to medium term to ensure a successful transition to a fully functioning EV ecosystem:

- **Incentivize charging infrastructure investment:** Governments worldwide have implemented various initiatives to ensure that early momentum in EV roll-out is not lost. Policy mandates supporting charging infrastructure investments are necessary to ensure progress. Support for installing charging infrastructure can be provided through financial and non-financial incentives. Financial incentives include subsidies on the purchase of EV supply equipment (EVSE), tax rebates to entities operating charging infrastructure, exemptions from acquisition and excise taxes, and local incentives for private home charging arrangements. On the other hand, non-financial incentives could be provided to operators and developers. For example, they can be given access to land at nominal rates, electricity networks, and designated parking spaces for EVs in municipal areas.
- **Develop and implement clear regulatory standards for EV charging stations**: Nepal must develop basic standards for EVSE, the charging equipment that connects an electric vehicle to the main electric supply. Although various EV charging models are used worldwide, Nepal must standardize public charging infrastructure to enable interoperability between charging stations and EVs manufactured by different automobile companies.
- **Introduce subsidies in electricity tariffs:** Introducing subsidies in electricity tariffs can benefit EV charging infrastructure operators. A clear and transparent regulatory framework can help create a conducive business environment, boosting investor confidence. For instance, a sound tariff structure that balances consumer interests (EV users) and business interests (EV charging operators) can significantly and positively impact the overall EV ecosystem.
- **Awareness and education program on EV technologies:** Education plays a pivotal role in EV promotion. One of the key hurdles faced in the widespread adoption of EVs is the public's lack of knowledge and understanding about the technical aspects of this technology and the importance of a charging infrastructure. Range anxiety will remain a significant concern for prospective EV owners until an extensive charging station network is provided. Hence, it is important to formulate educational initiatives that emphasize the benefits of electric vehicles, the need for a robust charging infrastructure, and the significant impact of the whole electric vehicle ecosystem on the building and adoption of electric vehicles. Further, the Nepalese government should collaborate with local authorities, conduct awareness campaigns, and implement education programs to drive support and investments in this sector.

- **Training on charging infrastructure ecosystem:** Comprehensive training programs, such as the Electric Vehicle Infrastructure Training Program (EVITP), are required to ensure that the installation and maintenance of charging stations meet the industry's best practices and standards. Additionally, collaborations with charging station operators, industry partners, and government agencies can facilitate knowledge-sharing, helping them to stay updated on the latest market trends, challenges, and opportunities. Training programs that focus on developing a skilled workforce and establishing sustainable business models can facilitate the growth of the EV ecosystem in Nepal and ensure the industry's long-term success.

Aspect	Barrier	Recommendation	Action Plan	Solution
Technical	Lack of reliable power supply	- Improve reliability of power supply through infrastructure upgrades and maintenance.	- Conduct an assessment of the existing power infrastructure to identify areas for improvement. - Invest in upgrading the power grid to ensure a stable and reliable electricity supply to charging stations.	- Improved reliability of power supply will ensure uninterrupted charging services for EV users, enhancing their confidence in using EVs.
	Limited charging network in rural areas	- Expand the charging network to rural and suburban areas through public-private partnerships. - Incentivise private companies to set up charging stations in remote areas.	- Identify key locations in rural and suburban areas for new charging stations based on demand and accessibility. - Collaborate with local governments and private companies to establish new charging stations in these areas. - Offer financial incentives such as tax breaks or subsidies to attract private investment in charging infrastructure.	- Expanded charging network will increase accessibility and convenience for EV users across the country, promoting EV adoption in rural areas. - Public-private partnerships will leverage resources and expertise to establish charging infrastructure in remote locations where demand may be lower.
Regulatory & Institutional	Lack of comprehensive regulatory standards	- Develop and implement clear standards for charging stations to ensure interoperability, safety, and quality. - Establish a regulatory body to oversee the implementation and enforcement of these standards.	- Coordinate with industry stakeholders to formulate technical specifications and safety standards for EV charging equipment. - Establish a regulatory authority or task force to monitor compliance with standards and regulations. - Conduct regular inspections and audits of charging stations to ensure adherence to standards and safety guidelines.	- Clear standards will ensure that charging stations meet minimum requirements for safety and performance, building trust among EV users. - A regulatory body will provide oversight and enforcement, maintaining the quality and reliability of charging infrastructure.

Aspect	Barrier	Recommendation	Action Plan	Solution
	Inadequate national policy	- Formulate a comprehensive national policy for EV infrastructure development with input from stakeholders. - Set clear goals and timelines for the deployment of charging infrastructure.	- Engage stakeholders in policy development, including government agencies, the private sector, and civil society. - Define specific targets for deploying charging infrastructure, considering factors such as urbanization and vehicle electrification trends. - Establish a roadmap with actionable steps and timelines for achieving the policy objectives.	- A comprehensive national policy will provide a clear framework for EV infrastructure development, guiding investment and actions from stakeholders. - Clear goals and timelines will create a sense of urgency and direction, driving progress towards a robust charging network.
Financial & Economic	Low investment in charging infrastructure	- Provide financial incentives such as tax rebates and subsidies to attract investment in charging infrastructure. - Facilitate access to financing for charging infrastructure projects.	- Offer tax incentives or rebates to companies investing in charging infrastructure to reduce the financial burden and incentivize investment. - Collaborate with financial institutions to create specialized financing options for charging infrastructure projects. - Establish a fund or grant program to provide direct financial support for installing charging stations.	- Financial incentives will lower the barriers to entry for investors, stimulating investment in charging infrastructure. - Access to specialized financing will enable charging infrastructure projects to secure the necessary funding for implementation. - Direct financial support will accelerate the deployment of charging stations, especially in underserved areas or regions with low EV adoption.
	Unavailability of electricity tariff subsidies	- Introduce subsidies in electricity tariffs specifically for charging stations to reduce operational costs. - Create a transparent tariff structure that balances consumer and business interests.	- Design a tariff structure that offers discounted rates for electricity used at charging stations, making it more economically viable for operators.	- Subsidized electricity tariffs will lower the operating costs for charging stations, making them more financially viable. - A transparent tariff structure will ensure fairness and clarity, promoting stakeholder trust and cooperation.

Aspect	Barrier	Recommendation	Action Plan	Solution
			- Implement a transparent mechanism for tariff calculation that considers consumer affordability and business sustainability. - Communicate the benefits of the new tariff structure to stakeholders to encourage its adoption and implementation.	- Effective communication will help stakeholders understand the advantages of the new tariff structure, encouraging its widespread adoption and implementation.
Knowledge	Lack of trained human resources	- Establish training programs for personnel involved in installing and maintaining charging stations. - Collaborate with industry partners and educational institutions to develop relevant curricula.	- Develop training modules and materials tailored to the specific skills required for operating and maintaining charging infrastructure. - Partner with technical institutes and universities to integrate EV charging technology into their curriculum. - Offer certification programs to ensure that personnel meet industry standards for competence and proficiency.	- Training programs will ensure personnel have the necessary skills and knowledge to operate and maintain charging stations effectively. - Collaboration with educational institutions will ensure that future professionals have the skills needed for the evolving EV industry. - Certification programs will provide a benchmark for competence, ensuring a high-quality standard in charging infrastructure maintenance.

5.3. Long-term recommendations

In the long term, the policy landscape for the EV segment in Nepal should move away from initial stage support, which focuses on providing financial incentives and developing policies that promote sustainable business models in both usage-based and charging infrastructure segments. Key support areas for action in the long term are described below.

- **Upgrade charging infrastructure:** A large portion of the EV charging infrastructure is expected to be hosted in the real estate sector. Modifying building by-laws for new buildings and those undergoing major renovation is essential to ensure that EV penetration is scaled up. These modifications should either require the installation of charging stations or ensure the installation of ducting infrastructure in parking spaces. Existing building owners should also be required to prepare for conditions wherein electric cars and two-wheelers are plugged in. Amendments to existing legal frameworks and regulations should be made based on the most recent charging technologies. Further, they must be updated regularly to ensure applicable laws and regulations do not delay EV transition.

- **Improve reliability of electricity:** It is important to have a robust and reliable transmission and distribution network to enable the large-scale adoption of electric vehicles. Investment in Nepal's transmission and distribution systems should be targeted to meet necessary infrastructure upgrades. To assess the impact of EV penetration on the existing electricity network, NEA should conduct evidence-based studies in coordination with local municipal bodies and the transport department or ministry. Such analyses will help determine the electricity network elements or segments that need strengthening to meet EV load growth.

  Planning the expansion of the electricity network is essential. The network must be designed to provide electricity access to existing and future EV charging stations to maintain system reliability. Planning the implementation of electricity infrastructure also ensures the timely release of electricity network connections, particularly in terms of locational requirements and load adequacy. Suppose a new charging station is proposed in an area where the electricity network is already experiencing peak loading conditions. In that case, releasing an additional load to install a charging station may not be possible. Reinforcement of the electrical network by the utility to release load in such cases may lead to lags and delays. Therefore, upgrade plans for the transmission and distribution network must consider potential high EV penetration areas to create a robust electricity network.

- **Formulate a national EV infrastructure plan:** The plan should consider the growing demand for electric vehicles and the need for a robust charging infrastructure. It should prioritize establishing a network of charging stations nationwide to adequately support increasing EV use, such as by constructing fast charging stations on main highways and urban areas, ensuring a consistent and stable flow of electricity, and providing a user-friendly interface with compatible connectors.

Aspect	Long-Term Recommendation	Action Plan	Solution
Policy landscape for the EV segment	Shift focus from initial financial incentives to sustainable business models.	- Review existing policies and regulations related to EVs and charging infrastructure to identify areas for long-term policy development. - Engage stakeholders to gather input and feedback on potential policy changes. - Develop and implement long-term policies that support sustainable business models for EVs and charging infrastructure.	- Shifting focus to sustainable business models will ensure the long-term viability of the EV segment and charging infrastructure. - Involving stakeholders in policy development will lead to more comprehensive and effective policies. - Long-term policies will provide stability and direction for businesses in the EV sector, encouraging investment and growth.
Upgrading the charging infrastructure	Modify building by-laws to require the installation of charging stations or ducting infrastructure in parking spaces.	- Review and amend building by-laws to include requirements for EV charging infrastructure in new and renovated buildings. - Establish guidelines for existing building owners to retrofit parking spaces with EV charging infrastructure. - Collaborate with relevant authorities and stakeholders to ensure effective implementation and enforcement of the modified building by-laws.	- Modifying building by-laws will ensure that new and renovated buildings are equipped with EV charging infrastructure, supporting the growth of the EV market. - Retrofitting guidelines for existing buildings will accelerate the adoption of EV charging infrastructure, especially in urban areas. - Effective collaboration will ensure that the modified building by-laws are implemented and enforced consistently, creating a conducive environment for EV adoption.
Upgrading the transmission and distribution system	Invest in upgrading Nepal's transmission and distribution systems to support EV charging infrastructure.	- Conduct a comprehensive assessment of Nepal's transmission and distribution systems to identify upgrade requirements for EV charging infrastructure. - Develop a roadmap for targeted investments in the transmission and distribution network to support EV charging infrastructure. - Coordinate with NEA, local municipal bodies, and the transport department or ministry to align infrastructure upgrades with EV penetration projections.	- Investing in transmission and distribution systems will ensure that Nepal's infrastructure can support the increased demand from EV charging stations. - Developing a roadmap will provide a clear plan for infrastructure upgrades, optimizing resource allocation. - Coordination with relevant stakeholders will align infrastructure upgrades with EV adoption trends, ensuring the network can meet future demands.

Aspect	Long-Term Recommendation	Action Plan	Solution
Formulating a national EV infrastructure plan	Prioritize establishing a network of charging stations nationwide to support the increasing number of EVs.	- Conduct a comprehensive study to assess Nepal's current and future demand for EVs and charging infrastructure. - Develop a national EV infrastructure plan that outlines the deployment of charging stations in strategic locations. - Prioritize the construction of fast charging stations on main highways and urban areas to support long-distance travel and urban EV usage.	- A comprehensive study will provide data-driven insights into the demand for EV infrastructure, informing the development of the national plan. - The national plan will provide a roadmap for deploying charging stations, ensuring coverage across the country. - Prioritizing the construction of fast charging stations will address range anxiety, support the growth of long-distance EV travel, and enhance the accessibility and usability of charging stations, improving the overall EV charging experience.

5.4. Action plans and strategies

EV adoption is still in its beginning stages in Nepal. Hence, it is important to deploy invested resources efficiently. We therefore encourage policymakers to follow these five key strategies based on expert study and advices:

- **Coordination and cooperation:** Planning, installing, and operating a charging infrastructure for electric vehicles involves many stakeholders with diverse backgrounds. Cooperation between these various actors is crucial for a smooth network roll-out. Hence, it is necessary to facilitate active engagement and an exchange of views between institutions and ministries from different domains to identify and address challenges comprehensively. Given that the amount of currently available private charging directly impacts the need for public charging, planning new infrastructure should involve coordination with all relevant entities, including transport and energy departments, urban planning units, and utilities, to ensure an integrated approach.
- **One door policy**: The government should break down outdated organizational systems to facilitate cross-sectoral discussions on EV charging infrastructure. Creating cross-sectoral working groups can be a more feasible approach than wholesale institutional reform. Regular dialogue between different levels of public administration is also important to ensure coherent policies. Further, policymakers should create opportunities to share ideas and experiences with counterparts from other cities, countries, or regions to develop integrated EV deployment and charging infrastructure strategies.
- **Tailor strategies for deploying EV infrastructure in Nepal:** Every country, region, or city is unique and requires strategies tailored to its priorities and parameters. Gathering relevant data on vehicle stock, ownership rates, travel patterns, population density, and parking availability is essential to understand the local context. Considering the local context in planning allows the government to accurately identify areas or types of infrastructure that require new investment and those that may only need supportive mandates or regulations. Nonetheless, the overall strategy should consider sharing existing infrastructure to optimize the use of charge points and develop policies promoting modal shifts towards shared public transport to reduce the demand for charging infrastructure.
- **Make EVs a national priority to attract infrastructure investment**: Deploying public charging infrastructure requires significant investment, which does not necessarily have to be solely borne by the government. However, the government should set clear targets for EV and EVSE deployment, guarantee transparency in the tender process, and ensure efficient procedures for obtaining necessary licenses and permits to attract private investors.
- **Encourage standardization to enhance user experience and ensure efficient deployment:** The government should work with the industry to standardize charging stations and ensure interoperability to improve user experience and the efficiency of infrastructure deployment. Designing charging stations to cater to all types of plugs and plug-in positions guarantees accessibility for users. On the other hand, roaming capability for all charge points can simplify the user experience by allowing cooperation among charging service providers. Similarly, standardizing charging stations can reduce installation costs significantly. Setting performance targets with vendors and establishing mandatory maintenance schedules also ensures service quality.

5.5.Business models for charging infrastructure in Nepal

Comprehensive business models for developing a charging infrastructure in Nepal that incorporates smart features and revenue streams are outlined in the following table:

Business Model	Description	Revenue Model	Smart Features
Charging Point Set-up by EV Manufacturer (Importer)	EV manufacturers or importers set up charging points at strategic locations across Nepal.	- Installation fees - Subscription model - Energy sales	- Mobile app integration - Real-time monitoring - Payment gateway
Public-Private Partnership Model	Collaborate with government bodies, private companies, and NGOs to establish an extensive charging network.	- Government subsidies - Advertising and sponsorship - Usage fees	- Solar integration - Dynamic pricing (time-based) - Emergency services integration
Private Charging Stations for Residential Areas	Encourage homeowners to install private charging stations at their premises.	- Installation and maintenance fees - Subscription plans	- Home automation integration - Scheduled charging - Remote monitoring
Fast Charging Corridors on Highways	Establish fast-charging stations along major highways connecting cities.	- Pay-per-use - Partnerships with stopover restaurants and shops	- Predictive maintenance - Navigation integration

6. Conclusion and Way Forward

Developing a robust and accessible charging network is crucial for the widespread adoption of electric vehicles in Nepal. The barriers to developing an EV charging infrastructure in Nepal comprise technical, regulatory and institutional, economic and finance, and knowledge challenges. Specifically, technical barriers include the unreliability of power supply in the country and the limited charging network in rural areas. Regulatory and institutional barriers include the lack of comprehensive and coherent government policies and regulations that support and accelerate EV adoption, as well as inconsistent public sector commitment. On the other hand, some financial and economic barriers are insufficient investment in charging infrastructure, unavailability of electricity tariff subsidies, high upfront costs of EVs, and inequitable and unaffordable access to EV charging infrastructure. Knowledge barriers include the deficiency of trained personnel and the limited awareness and understanding of EV technology and benefits among the general public and stakeholders. Addressing these main barriers and fostering the development of a robust and accessible charging network are crucial for the widespread adoption of electric vehicles in Nepal, which is critical to reducing greenhouse gas emissions and achieving sustainable transportation.

The current efforts to address the limited charging infrastructure in Nepal include government and private sector collaboration, selecting a bidder to prepare the Master Plan for Public Charging, and infrastructure development. However, there remains a lack of a comprehensive plan for the mass installation of charging stations. The development of the EV industry has outpaced government policy. Hence, there is an urgent need to formulate a comprehensive national plan to install an extensive network of charging stations in Nepal, specifying a minimum number of charging stations in urban and rural areas. It is also important to incentivize private sector investment in charging infrastructure and EV adoption, particularly through subsidies and tax breaks for investors and individual EV buyers. Additionally, it is crucial to develop a charging network that is accessible and affordable for all users, specifically by setting up charging stations in public spaces and along major transportation routes. Similarly, a reliable power supply is essential for charging stations; hence, investing in renewable energy and energy storage solutions is necessary. Overall, it is critical to foster public awareness of the benefits of EV use and initiate collaborations between government agencies, private sector businesses, and civil society organizations to formulate a comprehensive and coordinated approach for EV promotion and charging infrastructure development in Nepal.

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8. Annex

8.1.End-User/Potential User Survey Questionnaire

Assessment of Charging Technologies, Infrastructure, and Charging Station Recommendations:

1. **Demographic Information**

    - Age:
    - Gender:
    - Education Level:
    - Occupation:
    - Annual Income:

2. **Electric Vehicle (EV) Usage**

    - Do you currently own an electric vehicle? (Yes/No)
    - If yes, what is the make and model of your electric vehicle?
    - If not, are you considering purchasing an electric vehicle in the next five years? (Yes/No)

3. **Charging Technologies**

    - Where do you often charge or plan to charge your electric vehicle? (Home, Office, Charging Station)
    - What type of charging technology do you currently use or plan to use for your electric vehicle? (Level 1, Level 2, DC Fast Charging)
    - Why did you choose such charging technology? (Speed of charging, Availability, Cost, Other)

4. **Charging Infrastructure**

    - How would you rate the availability of public charging stations in your area? (Poor, Fair, Good, Excellent)
    - What challenges have you experienced with the existing charging infrastructure? (Limited availability, Inconsistent performance, Affordability, Other)

5. **Charging Station Recommendations**

    - What policies or incentives do you believe would encourage the expansion of charging infrastructure? (Subsidies, Regulatory support, Other)
    - In your opinion, what financial models would be effective for sustaining the growth of charging stations? (Public-private partnerships, Utility investments, User fees, Other)

6. **Future Expectations**

    - What improvements or developments would you like to see in Nepal's electric vehicle charging infrastructure in the next five years?

7. **Additional Comments**

    - Please provide any additional comments or suggestions related to electric vehicle charging technologies and infrastructure.

8.2.Business Person/Investor Survey Questionnaire

Assessment of Charging Technologies, Infrastructure, and Charging Station Recommendations:

1. **Demographic Information**

    - Age:
    - Gender:
    - Education Level:
    - Occupation:
    - Annual Income:

2. **Electric Vehicle (EV) Charging Infrastructure**

    - What is your current role in EV charging infrastructure development in Nepal?
    - What are the main challenges you face in developing Nepal's charging infrastructure?
    - What policies or incentives do you believe would encourage the expansion of charging infrastructure?
    - In your opinion, what financial models would be effective for sustaining the growth of charging stations?

3. **Technical, financial and policy Aspects**

    - What technical barriers have you encountered in developing EV charging infrastructure in Nepal?
    - What regulatory and institutional barriers have you faced in developing EV charging infrastructure in Nepal?
    - What economic and financial barriers have you encountered in developing EV charging infrastructure in Nepal?
    - What knowledge and awareness barriers have you faced in developing EV charging infrastructure in Nepal?
    - How do you ensure the awareness and understanding of EV technology and its benefits among the general public and stakeholders?

4. **Future Expectations**

    - What improvements or developments would you like to see in Nepal's EV charging infrastructure in the next five years?

5. **Additional Comments**

    - Please provide any additional comments or suggestions related to the development of EV charging infrastructure in Nepal.

8.3.Policymaker/Regulatory Bodies Survey Questionnaire

Assessment of Charging Technologies, Infrastructure, and Recommendations:

1. **Demographic Information**

    - Age:
    - Gender:
    - Education Level:
    - Occupation:
    - Annual Income:

2. **Barriers to EV Charging Infrastructure**

    - What are the main barriers to EV charging infrastructure development in Nepal in terms of technical, regulatory and institutional, economic and finance, and knowledge aspects?
    - How do these barriers affect the widespread adoption of electric vehicles in Nepal?
    - What are the current efforts to address these barriers?

3. **Technical Aspects**

    - What technical barriers have you encountered in developing EV charging infrastructure in Nepal?
    - How do you ensure the reliability and performance of EV charging stations in Nepal?

4. **Regulatory and Institutional Aspects**

    - What regulatory and institutional barriers have you faced in developing EV charging infrastructure in Nepal?
    - What are the efforts to comply with Nepal's existing regulations and guidelines for EV charging infrastructure?

5. **Economic and Financial Aspects**

    - What economic and financial barriers have you encountered in developing EV charging infrastructure in Nepal?
    - How are you ensuring the affordability and accessibility of EV charging stations for the public?

6. **Knowledge and Awareness Aspects**

    - How do you ensure awareness and understanding of EV technology and its benefits among the public and stakeholders?

7. **Power Supply (NEA only)**

    - What challenges has NEA faced in ensuring a reliable power supply for EV charging stations in Nepal?
    - What is NEA’s plan for providing a reliable power supply for developing EV charging infrastructure in Nepal?

8. Current Efforts

- What are the current efforts to address Nepal's limited charging infrastructure?
- How effective have these efforts been in addressing the barriers to EV charging infrastructure?

9. Additional Comments

- Please provide any additional comments or suggestions related to EV charging infrastructure development in Nepal.


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