CCG WORKING PAPER SERIES: E-MOBILITY AND RENEWABLE ENERGY INTEGRATION

MAKING E-MOBILITY AND RENEWABLE ENERGY INTEGRATION WORK IN ASIA AND THE PACIFIC

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KEY MESSAGES

New electricity demand from e-mobility can incentivize investment in new clean generation and grid infrastructure, thus improving power system services. As electric vehicle charging is flexible, this demand can be shifted to follow supply from low-cost variable renewables, like wind and solar.

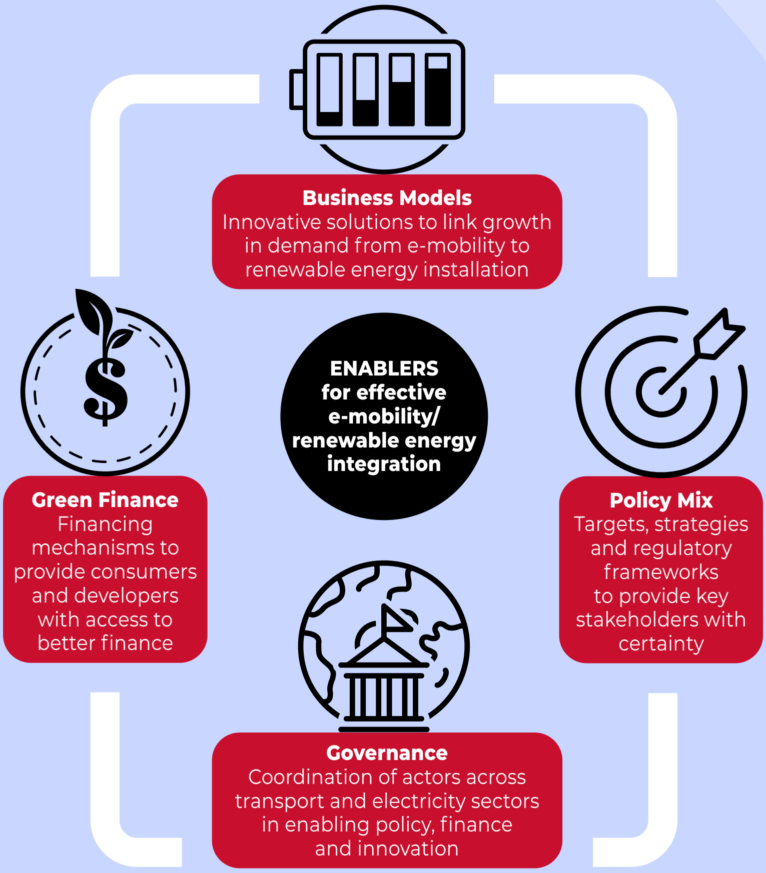

Figure 1 Framework of enablers for effective e-mobility and renewable energy integration

We identify nine key barriers to effective e-mobility/ renewable energy integration, which revolve around upfront cost, locked-in governance and technology uptake.

We present a framework of enablers for effective e-mobility and renewable energy integration. The framework divides enablers into four categories (as shown in **Figure 1**) and subdivides them into ten subcategories (as shown in **Figure 4**). We identify enablers according to this framework, which will be used as a base from which to develop practical solutions in the Asia-Pacific context.

Through presentation of a case study, we demonstrate how these enablers can make 'win-win' solutions in e-mobility and renewable energy integration a reality in making tangible contributions to Asia-Pacific countries' decarbonization pathways while increasing access to mobility and electricity.

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CONTENTS

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INTRODUCTION

This working paper explores the barriers to – and enablers for – the successful integration of e-mobility and renewable energy (RE) in Asia and the Pacific.

When the integration of e-mobility and RE is successful, it can provide a route from high-carbon, low-reliability electricity systems to low-carbon, high-reliability systems [1]. This is because:

- Electric vehicles (EVs), including 2- and 3-wheelers, passenger cars, mini-buses and buses, can act as an 'anchor load' for power systems [2], creating a new and consistent electrical demand that incentivizes the development of generation and grid infrastructure, thus improving the ability of the power system to provide a reliable supply. Payments can be 'ring-fenced' and 'secured', de-risking power system investment [3].
- The flexibility of charging demand, whether this be done via battery swap stations or EV charge points, naturally favours low-cost variable RE like wind and solar [4] as it can maximize the utilization of these sources when supply is high or other demands are low [5]. EV charging can respond in real time to the needs of a grid, providing an integrated system with improved stability and quality of supply [6, 7].

The potential for e-mobility and renewable energy integration to work for decarbonization and strengthening of supply is shown in **Figure 2**. However, there are gaps in the coordination of policies and financing to enable solutions in this space.

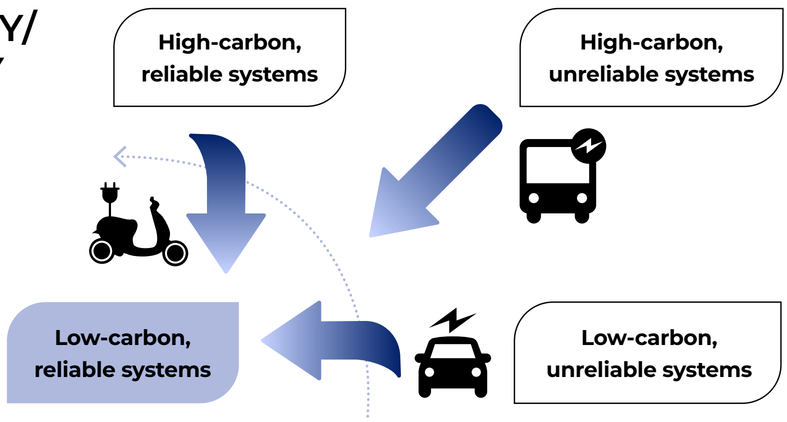
Furthermore, there are no one-size-fits-all solutions that will work across different transport–energy systems, due to the diversity between them. Key differences that will affect the suitability of particular enablers in making e-mobility and RE integration work include:

Figure 2
Effective e-mobility & renewable energy integration as a pathway from high-carbon, unreliable power systems to low-carbon, reliable power systems

EFFECTIVE E-MOBILITY/ RENEWABLE **ENERGY INTEGRATION**

CAN REDUCE CARBON EMISSIONS

- Flexible anchor load **incentivizes** installation of renewables
- Controlled charging can **maximize utilization** of variable renewables



CAN INCREASE RELIABILITY

- Increased electricity demand **incentivizes** grid development
- Electric vehicles used as **storage** when parked can provide backup power in unreliable systems and help smooth out peaks and troughs in renewable electricity supply

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- Whether the power system is a national grid or ‘off-grid’ – the latter corresponding to mini-grids and standalone charging systems.
- What the electricity generation mix in the power system is – crucially, how much of it is variable renewables (like wind and solar).
- How high the level of reliability offered by the power system to its customers is (typically quantified by the frequency and duration of outages).
- What the means of recovering system costs are, such as a liberalized energy market, a regulated monopoly or a state-owned utility.

This working paper is the first in the Climate Compatible Growth (CCG) Programme and Asian Development Bank (ADB) series on ‘e-mobility and renewable energy integration’. It is guided by the outputs of a workshop held amongst a diverse and cross-cutting range of experts of CCG and ADB in October 2021. The workshop’s 27 participants were assigned to four groups and conducted the following three tasks.

- Identification of barriers to effective e-mobility and RE integration
- Introduction to the concept and a broad framework of enablers
- Identification of enablers of effective e-mobility and RE integration

Further engagement with ADB is underway in developing the next paper in the series. The next paper will explore the applicability of practical solutions in different electricity system archetypes, dictated by the key differences above.

MIKE/PEXELS

BARRIERS TO SUCCESS

We identify nine key barriers to successful e-mobility and RE integration in Asia and the Pacific. These are grouped into three categories: upfront cost, locked-in governance and technology uptake (Figure 3).

BARRIERS TO EFFECTIVE E-MOBILITY & RENEWABLE ENERGY INTEGRATION

UPFRONT COST	LOCKED-IN GOVERNANCE	TECHNOLOGY UPTAKE
Upfront cost of EVs is too high for private individuals and public transport operators, who often struggle to secure finance.	**Government subsidies for fossil fuels** disadvantage e-mobility solutions as petroleum-fuelled mobility becomes artificially low-cost.	**Unreliable power systems** limit the appeal of e-mobility, particularly in SIDS.
A lack of economies of scale can prevent some countries, particularly Small Island & Developing States (SIDS), from being able to access solutions affordably.	**Governments have limited resources** and often can't afford to trial different solutions before implementation.	**Lack of standardization** of EV charging infrastructure, in terms of payment systems, communications and connector types, hinders widespread adoption and applicability of business models across regions.
	Monopolies of electricity and transport system authorities can be resistant to change and oppose integration of sectors.	**Lack of renewable generation flexibility** hinders ability of renewable energy to decarbonize transport.
	Silos of operation between transport, electricity and finance limit visibility of cross-sectoral benefits of e-mobility/RE integration.	

Figure 3
Barriers to effective e-mobility and renewable energy integration

BUSINESS MODEL ENABLERS

CREATING MARKETPLACES & VALUE STREAMS

Establish revenue streams from grid services provided by flexible charging and Vehicle-to-Grid (V2G) from charge point or battery swap station operators. In unreliable systems, V2G can replace diesel generators as a backup power supply.

Explore potential of using Vehicle-to-Building (V2B) and V2G from battery swap stations, establishing revenue streams to swap station owners.

Develop Peer-to-Peer (P2P) trading on local distribution systems to make revenue streams available to consumers and incentivize shared use of resources.

OPTIMIZING OPERATIONAL EFFICIENCY

Shift EV charging to times of high renewable output/ low demand to maximize decarbonization potential and utilization of renewable resources.

Develop business models around the falling cost of storage to enable use of RE outside times of availability.

INCREASING BUSINESS PARTNERSHIPS

Develop business models supporting installation and maintenance of e-mobility and renewable energy integration systems, e.g. mini-grids for off-grid solutions.

Develop business models that cut across transport, electricity and finance sectors to unlock co-benefits of e-mobility and renewable energy integration to different sectors.

GREEN FINANCE ENABLERS

ATTRACTING NEW FINANCE

Use concessional finance to encourage mini-grid developments in areas with low energy access.

Co-opt utilities to bring in procurement and grow the market for innovative solutions.

Use innovative partnerships to tap financing to incentivize charging infrastructure development.

Use minimum revenue guarantees to de-risk investment in development of business models.

Explore possibility of bringing in pension funds to invest in high risk/high reward climate investments.

RE-STRUCTURING FINANCE

Improve proportion of banked citizens to facilitate lending and consider innovative lending schemes for those who are un-banked to provide micro-financing and loans to low income groups.

Allocate costs of grid strengthening to beneficiaries of e-mobility to reduce mobility inequality between those who can afford EVs and those who are unable to.

Re-invest savings from elimination of fossil fuel subsidies into e-mobility/ renewables integration.

POLICY MIX ENABLERS

STRATEGIES FOR LONG TERM SECURITY

Set date for the phase out of petrol/diesel vehicles to provide businesses with more certainty and ability to plan.

Establish long term plans for improving electricity access and clean generation capacity.

Create enabling commercial environment to **promote sustainable local EV manufacturing.**

REGULATORY INSTRUMENTS

Standardize charging services – in terms of payment, communications and connector types – to extend viability of business models between areas.

Consider cross-border electricity trading arrangements to mitigate electricity generation curtailment and establish additional revenue streams to business model actors.

Support sustainable production of EVs to mitigate against unintended environmental consequences of e-mobility transition (e.g. through extended producer responsibility and design-for-recycling principles.)

Develop a flexible regulatory environment with streamlined standards to speed up uptake, particularly in off-grid contexts.

Promote competitive procurement to deliver best value for money for end-users.

ECONOMIC POLICY INSTRUMENTS

Remove fossil fuel subsidies to engender demand for e-mobility.

Employ carbon taxation and direct gains as incentives for purchase of EVs to accelerate uptake.

Offer targeted support for renewable energy to avoid reliance on fossil fuelled power stations and diesel generators in off-grid systems.

Offer subsidised loans to consumers for EVs to encourage uptake of e-mobility.

Offer targeted support to electrified public transport such as e-buses and e-minibuses.

Offer targeted support to e-mobility and RE integration solutions in areas with low energy access/low mobility access to provide low carbon electricity and e-mobility solutions to communities that need it most.

Mandate financial institutions to diversify into high risk/high reward climate investments (e.g. portfolio standards).

Explore the potential of reducing import tariffs on batteries and other EV components to accelerate uptake by lowering cost barriers.

GOVERNANCE ENABLERS

STRATEGIC GOVERNANCE

Employ 'best practice'/ lessons learnt across resource-scant regions (such as SIDS) to increase the chance of robust solutions being selected.

Utilize Public-Private Partnerships (PPP) to accelerate investment in RE, e-mobility charging infrastructure and electricity networks. Form cooperatives, at national or regional levels, to increase accessibility of finance and economies of scale.

Better understand the potential and constraints of integration with the private sector to promote optimal level of involvement.

CROSS-SECTORAL GOVERNANCE

Include mobility as part of electricity decarbonisation programs to promote joined-up thinking and reduce investment risk.

Create space for cross-sectoral discussions between electricity system planners, transport planners and financiers to break down silos between expert groups.

Coordinate stakeholders (transport operators, private sector finance, energy providers) in system planning.

Set shared electricity and mobility access targets to promote transport-energy nexus collaborative efforts.

Integrate transport and electricity revenue of projects to enhance attractiveness to financiers.

Figure 4 Enablers for effective e-mobility and renewable energy integration

ENABLERS FOR SUCCESS

To lay a foundation for the development of practical solutions to address the barriers in Figure 3, we present a framework of enablers for effective e-mobility and RE integration that can deliver the benefits shown in Figure 2.

The framework is based on four overarching categories, further divided into a total of ten sub-categories defined below. For a sustainable transition and holistic system change, these categories must be addressed in parallel, not in isolation.

The identified enablers are shown in **Figure 4.** Discussion is provided in the subsections that follow.

BUSINESS MODELS

Business model enablers enhance the value that can be captured from the integration of e-mobility and RE, and they can therefore incentivize improvement in affordable mobility and low-carbon energy access.

The business model enablers identified here are divided into three categories: **(i) creating marketplaces and value streams, (ii) optimizing operational efficiency and (iii) increasing business partnerships.**

Enablers that create new marketplaces and value streams are based on unlocking the co-benefits of effective e-mobility and RE integration. An example of this is the development of Vehicle-to-Grid (V2G)[1] to provide backup power supplies and grid services[2] in modulating power consumption and production in real time to smooth out fluctuations in supply and demand. Backup power supply from V2G is more relevant in weaker grids than stronger ones, though grid services are used in strong grids and are increasingly required as power systems increase their share of variable RE like wind and solar. In countries vulnerable to external shocks such as natural disasters brought about by extreme climate events, such technologies could enhance resilience and adaptive potential in responding in aftermath of disaster events [8]. In this instance, the provision of grid services creates a new value stream for the charge point operator, such that they can generate revenue from both selling energy to vehicles and selling grid services to the electricity system operator. From the electricity system operator's perspective, the market for the provision of grid services has grown to include the charge point operators, which can drive down the cost of procurement. From the electricity consumer's perspective, this should result in lower electricity prices for a given level of service. Furthermore, as V2G represents a low-carbon source of grid services, this arrangement can contribute to the decarbonization of power systems.

Vehicle-to-Building (V2B)[3] from battery swap stations was identified as another marketplace-creating business model enabler: this works in a similar way to V2G, but on a local scale. Peer-to-Peer (P2P)[4] trading was identified as a means of

[1] V2G refers to a controlled two-way flow of electricity from/to an EV to/from a power grid.

[2] Grid services are procured, usually by an electricity system operator, to help balance supply and demand in real time. Storage and flexible demand are common providers.

[3] V2B refers to a controlled two-way flow of electricity from/to an EV to/from a building.

[4] P2P refers to the buying or selling of energy between consumers without the intermediation by a third party (such as an energy supplier).

BRETT SAYLES/PEXELS

unlocking revenue streams to consumers at a local scale – for example, generating revenue from their EVs selling energy to buildings on the local network.

Enablers that optimize operational efficiency serve to increase the viability of these new value streams. These include shifting EV charging to times of high renewable output and/or low residual demand to maximize the utilization of renewable resources, and benefiting from the falling costs of electricity storage in the development of new business models.

Enablers that increase business partnerships are those that break down the silos between transport, electricity and finance in developing new business models. This also includes the development of business models that act to support, through installation and maintenance, the development of e-mobility and RE integration solutions.

POLICY MIX

Policy mix enablers are designed to offer guidance and more security to the actors in business model innovation. A policy mix can be separated into **(i) strategies for long-term business security,** stemming from policy plans that set out overarching goals, and **(ii)** concrete **regulatory** and **(iii) economic instruments** which instrumentalize these goals through both support and legal guidelines [9]. In this case, the policy mix includes phase-out dates for petrol/diesel vehicles, targeted support for renewables, the removal of fossil fuel subsidies (and the investment of the savings into subsidies for e-mobility or renewable energy generation), the reduction of import tariffs for clean technologies and the establishment of common standards.

Standardization of charging services – in terms of payment, communications protocols and connection types – was identified as a key policy enabler to allow business models to be viable across multiple contexts. However, as noted by McKinsey & Company [10], the wrong kind of standardization can stifle innovation. Therefore, the approach to standardization should be outcomes-based and solution-agnostic to de-risk development of solutions in this space, while providing innovators enough scope to develop new solutions. In particular circumstances, such as the development of mini-grids to serve communities with low energy access, it was identified that an informal regulatory environment, while bound to a set of minimum standards, can help speed up uptake.

In the event of governments supporting particular private companies, there is a danger that this could lead to the monopolization of the provision of mobility or energy services, which would limit the ability of these solutions to drive down costs to consumers. As a result, it was identified that mandating competition rules may be necessary to ensure that these solutions represent value for money.

Policies are also needed to ensure that the transition to e-mobility does not produce unintended environmental consequences. This includes supporting sustainable production of EVs. This could be achieved by regulating how raw materials are extracted, how EVs are manufactured and how they are recycled at the end of their working lives [11], perhaps by considering Extended Producer Responsibility policies [12]. This can go hand-in-hand with the creation of an enabling commercial environment to promote local EV production.

It is important to note that there is no one-size-fits-all policy mix that can be applied uniformly across countries. These reforms need to be developed, taking into consideration the specific needs of each country, to ensure they are fit-for-purpose and will enable a just transition[5] by developing member countries.

GREEN FINANCE

Finance enablers are intended to allow would-be EV consumers and generation/grid infrastructure developers access to better returns. This includes **(i) attracting new sources of finance** and **(ii) re-structuring existing sources of finance.**

Enablers for attracting new sources of finance at the level of businesses and individuals include concessional finance to encourage mini-grid development, innovative partnerships in different services across the public and private sectors, and minimum revenue guarantees to de-risk investment. There are further opportunities at the level of utilities and financial institutions, including co-opting utilities to bring in procurement and grow the market, and potentially influencing spending of pension funds to invest in climate investments.

There are significant opportunities in re-structuring existing sources of finance. At the level of individuals, this includes improving the proportion of banked citizens to facilitate lending and considering innovative lending schemes for the un-banked. At a higher level of governance, this includes allocating the costs of grid strengthening needed as a result of e-mobility growth to those who benefit from the growth in e-mobility, and the re-investment of savings from the elimination of fossil fuel subsidies into e-mobility and RE integration.

[5] *Just transition refers to a transition to a low-carbon society that does not entail the loss of peoples' livelihoods or reduction in their quality of life.*

GOVERNANCE

Governance enablers are tasked with allowing finance and policy to support innovation in integrating e-mobility and renewables. They can be divided into **(i) strategic governance** and (**ii) cross-sectoral governance.**

Strategic governance enablers include employing 'best practice'/lessons learnt across regions that were identified to not have sufficient resources to trial solutions before implementing them and utilizing Private–Public Partnership (PPP) funding[6] to encourage growth in the sector. However, it was identified that the potential and constraints of private sector involvement should be better understood to ensure the optimal level of integration.

Cross-sectoral governance enablers intend to break down silos between transport and electricity planners: in practice, this means including transport decarbonization targets as part of electricity decarbonization programmes, coordinating stakeholders and creating spaces for cross-sectoral discussion. Bridging across to the finance enablers, this includes the integration of transport and electricity revenues into one project, as to attract financiers. At a basic level, governments can proactively encourage the breaking down of these silos by creating spaces (such as working groups or committees) for cross-sectoral discussion.

[6] PPP refers to an arrangement between public and private sector organizations used to finance investments.

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CASE STUDY

Gogoro electric scooter battery swapping stations with Vehicle-to-Grid (V2G) to support power systems

Taipei-based electric two-wheeler (E2W) manufacturer Gogoro operates a network of battery swap stations to allow users to quickly replenish the driving range of their vehicles (Figure 5) [13]. This business model allows the vehicle to be sold without the battery, which helps remove a barrier by reducing the upfront cost of the E2W [14].

The network's rapid expansion of charging stations to over 2,000 as of December 2020 was made feasible with government support, providing a finance enabler: public subsidies covered some of the construction costs of around one third (675) of these stations [15].

Gogoro has strengthened its commercial viability by expanding into new marketplaces and value streams identified as enablers in this paper (Figure 4). Gogoro has partnered with electricity system operator Taipower [16] to provide grid services via Vehicle-to-Grid (V2G), supplying energy from the battery swap stations to the grid when those batteries are not being used in E2Ws. By smoothing out fluctuations in the supply and demand of electricity, this technology has been demonstrated to be a key enabler for increasing the grid's proportion of renewable energy while maintaining system resilience [17]. Therefore, this technology can assist with local decarbonization targets of a twenty-fold increase in the share of renewable electricity generation by 2025 versus a 2008 baseline[7].

Figure 5 Gogoro battery swapping charging station, Taipei

[7] In 2008, renewables made up 0.4% of total electricity generation in the region [22]. The 2025 target is that renewables will make up 8% of total electricity generation [23].

This collaboration of a mobility provider (Gogoro) and an electricity system operator (Taipower) is an example of what the cross-sectoral governance enablers identified in this paper are designed to promote: the mobility provider benefits from the additional value in e-mobility and power system integration; the electricity system operator benefits from a higher number of market participants from whom it can procure grid services to balance supply and demand. Not only is V2G a low-carbon provider of grid services (as opposed to diesel generators or part-loaded gas-fired power stations as is currently often the provider of these services) but ultimately, if the market performs properly, the consumer can expect lower prices for both mobility and electricity.

The pairing of a private company (Gogoro) and a state-owned utility (Taipower) represents a Private–Public Partnership (PPP), which was identified as an enabler for encouraging cross-sectoral growth in this area. However, a government-supported PPP for the provision of services across a network (in this case, of battery swap stations) may have adverse effects on competition and hence the ability for these solutions to drive down energy and mobility costs to consumers. As identified in this paper, governments should consider introducing competition rules as part of the regulatory environments they create to avoid the negative impacts of monopolization.

Since its initial expansion, Gogoro has partnered with Indian E2W manufacturer Hero to build a charging network for E2Ws in India [18], with Chinese manufacturers DCJ and Yadea to do the same in China [19] and with Indonesian on-demand mobility platform Gojek to electrify two wheel ride hailing services in Indonesia [20]. In all three of these countries, electricity mixes are dominated by burning fossil fuels, particularly coal, whose elimination in the power sector is vital in securing a global temperature rise of less than 1.5°C [21]. Therefore, promoting the cross-sector collaboration between e-mobility platforms and electricity system operators to provide services to the power system that can improve the viability of replacing fossil fuel power stations with renewables can make a tangible difference in these countries' decarbonization pathways.

This case study not only illustrates the potential for these solutions and the challenge ahead, but demonstrates that transport–electricity system integration as a route to decarbonization is not only possible but favourable.

GOGORO

NEXT STEPS: BEYOND COP26

This working paper has presented the barriers to, and enablers for, effective e-mobility and renewables integration in Asia and the Pacific.

There is enormous potential for 'win-win' solutions across transport electrification and renewable energy, which can lead to decarbonization of, and improved access to, both transport and electricity. We demonstrate through a case study that business model innovation can allow growth in affordable e-mobility to interact positively with the electricity system in a way that directly promotes growth in renewables. However, particularly in lower-income countries which tend to have lower reliability power systems and limited access to finance, these business models require sufficient policy mixes, financing mechanisms and governance frameworks to allow them to flourish.

The enablers for effective e-mobility and renewable energy integration, across the four categories of business models, policy mix, green finance and governance, can make these 'win-win' solutions a reality.

To seize the opportunities presented in this paper, the following next steps will be taken:

- The framework presented in this document and the collection of specific enablers will be used as a baseline from which to develop practical solutions for e-mobility and renewable integration in a variety of contexts in Asia and the Pacific.
- These practical solutions will be further assessed in terms of impact and effort (cost and time to implement).
- The potential benefits of e-mobility and renewable integration will be quantified for a selection of contexts within ADB member countries (e.g. the storage volume a fleet of vehicles can offer, and what the implications are for the grid).

These next steps will be carried out through further engagement with the ADB.


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