

### Co-Creation with Industry: Facilitating Vehicle-to-Grid (V2G) Uptake in Singapore

This deck is a living document and EMA will continue to iterate and update its content as we receive more feedback. Given the nascency of V2G in our market, the frameworks detailed within are to be taken without prejudice and subject to change.

### Overview

There is increasing industry interest to deploy Electric Vehicles (EVs). This **paves the way for the uptake of V2G** services such as selling energy back to the grid, and participating in services such as frequency regulation and demand response.

To achieve our goals of a progressive and sustainable energy landscape, **EMA is ready to support** new business models for the energy system. We also recognize the need to provide regulatory clarity for V2G to facilitate its uptake.

> EMA intends to **co-create with industry** and adopt an open-ended approach to seek feedback, to develop the policy and regulatory considerations on V2G participation in Singapore. These may include areas such as:

Proposed regulatory treatment, such as licensing and market participation

Technical considerations and national V2G standards that could be contextualized for Singapore Potential V2G business models that can be applied in Singapore

"Globally, over the five-year period (2014 to 2019), the number of Electric Vehicles (EV) saw an annual average increase of 60%, reaching 7.2 millions units in 2019"

– IEA Global EV Outlook 2020

### What is Vehicle-to-Grid?

- V2G technology allows energy transfer between the batteries within an EV and the power grid. This is more sophisticated than uni-directional charging of EVs.
- V2G enables a gamut of options and services that could serve to balance and support our energy grid.
- Renewables such as solar power is intermittent and managing this intermittency is important to ensure a stable power supply to consumers. Mitigating intermittency has traditionally been performed by power plants.
- With V2G technology, consumers are able to contribute as well. When solar generation drops due to rain or cloud cover, the EVs plugged into the system can balance out the fall in supply or if we have a period of significant solar generation, the EVs can store the excess energy.
- With a well functioning V2G landscape, consumers would be empowered to play a more active role and our energy system would be able to accommodate larger capacities of renewable energy.





### EV fleet is poised to grow as Singapore phases out ICE vehicles by 2040.

- To support a growing EV fleet, the Government is taking the lead to deploy 28,000 chargers island-wide.
  - To build-up a network of public charging infrastructure across carparks, authorities will be offering carpark lots to deploy charging points across existing public carparks. These infrastructure are targeted for operations in the coming years.
- Private-led expansions are also indicating a growing interest for EV adoption
  - SP Group has expanded its network of EV charging points to 200 island wide and plans to scale this up to 1000 charging points by 2021.
  - Shell has started deploying rapid charging (i.e. 50kW) across 10 Shell stations starting from 2019.
- As EV adoption increases, demand for vehicular charging would grow. To cope with the increased demand from EVs, our power system would have to be enhanced over the next 2 decades.
- The government is currently studying the impact of EV charging on the electrical distribution network and the potential grid infrastructure upgrades required. V2G is one avenue to manage this energy demand growth and enhance system stability.

### V2G has the potential to participate in multiple grid applications that could benefit the energy system.

- EVs have the capability to provide dispatchable power to the grid through the charging and discharging of the batteries housed within.
- This capability translates to a variety of applications including:

Domain	Service Examples	Description	
Transmission Grid	Frequency Regulation	Maintain frequency within a required interval	l
	Spinning Reserve	Provision of reserve during contingency events	
	Peak Shaving	Injection of power from EVs to reduce demand from traditional generation sources	Transmission Distribution End system system consumers
Distribution Network	Reinforcement deferral	Mitigate overloading of transformers and cables in the low tension network	
	Managing Voltage Issues	Mitigate overvoltage and voltage drop in distribution systems	■ * & -> & -> +
Consumer (Behind the Meter)	Energy arbitrage	EVs charged during off peak and discharged during peak periods	
	Demand response	Curtail consumption in response to price changes	

For Singapore, V2G provides greater optionality to tap onto energy storage resources to further stabilize the grid and support our longer-term solar ambitions of 2GWp by 2030.

Version 1.1 (15 September 2020)

# This was demonstrated in the Parker Project in Denmark with the first commercial V2G project in the world.

 Project aimed to demonstrate that contemporary EVs could participate in advanced smart grid services and V2G grid applications.



#### Aggregator:

- Reads the frequency signals from the grid, and uses an optimization routine to dispatch a combination of EVs, at differing power rates.
- Receives dynamic capacity information from the EVs, and uses that capacity, plus operator experience, to bid into the market
- Communication Architecture:
  - EV charger communicates with the Charge Point Operator (CPO) which in turn receives instruction from the Aggregator via a Open Smart Charging Protocol (OSCP).

#### Project was able to demonstrate:

- 1. <u>Scalability</u> 10 EVs were able to coordinate their individual responses in providing frequency regulation.
- 2. <u>Services Stacking</u>– Frequency regulation, energy services, DSOrelated services.
- 3. <u>Interoperability</u> Different OEMS for cars and batteries were used.

#### Key takeaways:

- 1. V2G is possible with existing hardware.
- 2. Precise control of the power electronics (i.e. EV or EV charger) in small power steps every second is important.
- 3. Relevant regulations and standards across the value chain need

to be properly implemented.

Version 1.1 (15 September

# However, many issues require resolution before widespread deployment of V2G could be realized.

- The majority of V2G projects around the world are still in testing or demonstration phases.
- The various projects also revealed many barriers that need to be addressed to facilitate commercial deployment.
   A non-exhaustive list is described below, which are also relevant for Singapore.



# Given the synergies with Energy Storage System (ESS), we are building on the ESS framework for V2G.

- ESS technology is a great enabler for solar adoption with its ability to capture energy produced at a particular time for later use. This can unlock various opportunities for the energy market and system, such as integrating higher levels of solar, and deferring costly grid investments to meet short term peak electricity demand.
- Given its benefits, we published a policy paper on ESS to provide greater regulatory clarity to industry and consumers to facilitate deployment. We believe this is one approach for organic growth.
- Given the similarities between V2G and ESS technologies, we intend to use the <u>ESS framework</u> <u>as the foundation</u> for the development of our V2G framework.
  - A specific V2G framework is still in development as V2G is nascent in Singapore and we yet to have V2G providers participating in the market today.

## While we yet to have V2G in our market, we developed an initial high level model\* of how a provider might participate.

- Building on the ESS framework, we have developed a high level model of how a V2G provider might participate in the market today.
- Broadly, in order to participate in our electricity market, companies would need to:
  - Obtain licenses from EMA and fulfil our Power System Operator (PSO)'s technical requirements.
  - Register with the Energy Market Company (EMC) to participate in the Singapore Wholesale Electricity Market (SWEM) to provide market services (e.g. energy or ancillary services).
  - Comply with EMC's dispatch instructions (e.g. to provide energy to the grid when called upon).
     Various monitoring systems in place would ensure compliance.
- These principals would apply to a V2G provider as well.
  - For example, a V2G provider aggregating the energy stored in a group of EVs to provide reserves is considered a market participant.

## While we yet to have V2G in our market, we developed an initial high level model\* of how a provider might participate.



# EMA continues to monitor global V2G developments and study its potential grid implications.



- EMA continues to monitor developments of International Electrotechnical Commission (IEC) V2G standards which would help guide and enhance development of technical frameworks.
  - The standards for V2G charging is currently under preliminary development, and it is not expected to be ready until later.



- EMA is working with other government agencies (coordinated through S&T PPO<sup>1</sup>) and industry to analyze the impact of EV charging on distribution grid network.
  - This includes a Proof-of-Concept (POC) testbed to identify potential grid constraints and optimization of EV charging locations.



## EMA seeks to co-create with industry to facilitate V2G into our market

- EMA would like to work with industry to support integration of V2G services in our market. We welcome comments and feedback on the information covered in the slides.
- Some areas of particular focus include:
  - Feedback and comments on participation model outlined in slide 10 (i.e. viability, commercial issues).
    - Potential hurdles taking into consideration existing regulations.
- Feedback on proposed regulatory treatment of V2G in Singapore.
  - Licensing treatment outlined in proposed model.
  - Potential market participation models that facilitate aggregation of EVs and Distributed Generation Resources (DER).



#### Technical considerations and national V2G standards that could be contextualized for Singapore.

 Technical standards that have been adopted for EV chargers that are capable of interfacing with the grid.

#### Sharing of V2G business models adopted in other jurisdictions that could be applied in Singapore.

 Details of participation models and any enabling regulations that facilitated them



## Please share your feedback via forms.sg



https://go.gov.sg/co-creatingv2g

EMA will review the feedback received and refine our considerations on an-ongoing basis.

Smart Energy, Sustainable Future

### **APPENDIX**

#### Illustration of V2G Participation Model

• Open-air EV carpark where the intermediary ESS is used to interface with EVs and participate in the market



#### Illustration of V2G Participation Model

Physical setup and ownership	<ul> <li>V2G provider would require an intermediary ESS or smart coordination unit to aggregate EV capacity and provide market services.</li> <li>Currently there is no aggregation model for generation sources in the Market Clearing Engine (MCE).</li> <li>Individual EVs cannot meet 0.1MW minimum offer requirement.</li> <li>Individual EV unlikely to meet PSO's technical requirements for reserve/regulation provision.</li> </ul>
	<ul> <li>V2G provider owns the intermediary ESS.</li> <li>Intermediary ESS deployed Behind-the-Meter (BTM)         <ul> <li>EV carpark's vehicle gantry, lights etc. will contribute to the Load.</li> </ul> </li> <li>EV carpark and intermediary ESS to adhere to existing Transmission and Metering Code requirements.</li> </ul>
Registration and Licensing	<ul> <li>Owner of the generating unit i.e. intermediary ESS, to obtain relevant generation licenses from EMA.         <ul> <li>(A) Electrical Installation license &amp; Generation license if generating unit is above 10MW,-or Wholesaler license-if generating unit is above 1MW and less than 10MW</li> </ul> </li> <li>V2G provider to register with Energy Market Company (EMC), the market operator as Market Participant (MF)</li> </ul>

#### Illustration of V2G Participation Model

Market Participation	<ul> <li>Intermediary ESS to be registered as a Generation Registered Facility (GRF) with EMC (Market Operator).         <ul> <li>Market Rules classify ESS as GRFs.</li> </ul> </li> <li>Intermediary ESS technically able to provide energy, reserve and regulation services .</li> </ul>
Compliance monitoring	<ul> <li>Intermediary ESS to adhere to telemetry and communication standards set out in the Transmission Code for GRFs.         <ul> <li>To ensure compliance with technical requirements (e.g. communication with PSO) and complete commissioning tests</li> <li>Required to keep a record of their battery units' output and provide 2-second data, at least at the aggregate level.</li> </ul> </li> </ul>
Dispatch and Settlement	<ul> <li>Intermediary ESS to adhere to dispatch instructions from MCE.</li> <li>V2G provider (as MP) will receive the same half-hourly payments for providing energy, reserve and regulation as ESS and conventional CCGTs.</li> <li>Penalties apply if intermediary ESS fails to adhere to dispatch instructions.</li> </ul>