Transport electrification and V2G

A new purpose for vehicles: catalyzing the transition to sustainable energy

Caribbean countries MOVE webinar
September 2020
ONE SINGLE PLANET
Climate change: a call for smart energy solutions
Our team

Unique global expertise in the field of e-mobility

- Over 10 years of experience
- Largest independent EV Office worldwide
- Multidisciplinary backgrounds (e.g. technical, commercial, economic, legal)
- International experience with e-mobility strategy, project management and innovation
Our work

Accelerating EV in 400 projects in 20 countries
Our clients

Government

Energy & Utility

Automotive & Operators
Our home base

Amsterdam ambition: 100% electric cars in 2030
E-mobility is inevitable

- Purchase **price parity around 2025** – depending on sector & geographical context
- **Lower operation cost** for EV; maintenance down to 30% and energy cost 25-50%
- >400 km range is the new normal; enough for the average consumer
- It’s a mind shift: instead of fueling you will **charge where you park**; at home or at office
- European grid mix charged **EV results in 50% lower CO2 emissions** over whole lifetime
- Smart charging and Vehicle-to-grid will make EV **an asset for the grid**, instead of a threat
- **Million mile batteries**; long lifetime in the vehicle; and repurposed as second-life battery
- New battery chemistries allow for **75% reduction in cobalt**, nickel, etc.
Transport electrification and V2G

1. The future and the potential
2. The road to get there
Today

Transport electrification and V2G

1. The future and the potential

2. The road to get there
V2G: electric car as a grid asset

Energy transition requires flexibility and storage
> can be provided with electric vehicles
Proving that it works

The popular Mitsubishi OUTLANDER PHEV is the first car in the Netherlands to balance the Dutch energy network using V2G-technology. Every Mitsubishi OUTLANDER PHEV and its battery already having the capability to utilize a V2G charge point.

“The Mitsubishi Outlander PHEV, with its 12 kilowatt-hour battery, stores as much energy as the average family consumes in one day.”

Electric car supplies Amsterdam neighbourhood with green electricity

Een elektrische deelauto heeft in Amsterdam stroom terug geleverd aan het publieke elektriciteitsnet. De Nissan Leaf van Buurauto leverde tijdens de test elektriciteit aan woningen via een zogenaamde Vehicle-to-Grid-laadpaal van NewMotion.
Global review of V2G projects

THE V2G MAP OF THE WORLD

V2G IS HAPPENING NOW AND HAPPENING GLOBALLY!
My personal V2G hype cycle

- Peak of Inflated Expectations
- Plateau of Productivity
- Slope of Enlightenment
- Trough of Disillusionment
- Technology Trigger

TIME

VISIBILITY
V2G benefits

Value Propositions

Revenue-Generating Energy Trading
Resilience
Personal Net Zero / Self Sufficiency
Benefit to Society
Enhanced Battery Management

$+650\, \text{€/EV/year}$
Drive for Free with V2G

- Earn annual revenues equivalent to 8,000 EV costed miles a year

- £2,000 for 10kW V2G fast charger + standard installation (similar cost to a normal fast charger)

- Preferential leasing rates on V2G compatible Nissan models

- 5 year contract duration including supply

- Access to customer support

- Smart back office system that includes fleet management and charge scheduling apps

- Guaranteed charge for your vehicle’s daily needs
Mauritius

A 10 year Roadmap for the integration of electric cars
Mauritius

Total cost of ownership

Annual GHG emissions

- Total cost of ownership (MUR)
  - ICE
  - BEV (1)
  - BEV (2)
  - PHEV

- Annual GHG emissions per car [tonne CO2]
  - ICE
  - BEV
  - PHEV
  - 2020
  - 2025
  - 2030
Mauritius

Additional grid peak of EVs

<table>
<thead>
<tr>
<th>Year</th>
<th>LOW 10% EV</th>
<th>MEDIUM 15% EV</th>
<th>HIGH 30% EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2030</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

EV grid integration cost

Total grid upgrade costs

-60%

- with smart charging
- without smart charging
Aruba

- 100,000 inhabitants
- 50,000 personal cars
- 100 MW average demand
- 17% renewables
Aruba

FUTURE POWER SYSTEM:
= 70% RENEWABLES

TWO SCENARIOS:

• DOMINANT WIND
  Wind 160 MW
  Solar 60 MW

• DOMINANT SOLAR
  Wind 120 MW
  Solar 200 MW
Aruba

In daytime, at work locations
TOTAL SYSTEM LEVELISED COST
- DOMINANT SOLAR -

SYSTEM LEVELISED COST
[€/MWh]

140
130
120
110
100

HFO
Uncontrolled
Smart charging
V2G
Hawaii

Smart grid project with 80 bidirectional EVs for peak shaving & frequency support
“We delivered V2G at scale, from real world families we had no control over”
- Project representative, Hitachi

Peak after project start

Peak before project start
Today

Transport electrification and V2G

1. The future and the potential

2. The road to get there
V2G ecosystem
V2G ecosystem

- CAR OEMs
- USER
- UTILITIES
- CHARGE POINTS OPERATORS & AGGREGATORS
- OPERATORS
- AGGREGATORS
V2G cars

<table>
<thead>
<tr>
<th>2013</th>
<th>2019</th>
<th>2020</th>
<th>&lt;2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>NISSAN</td>
<td>THE LION ELECTRIC CO</td>
<td>HONDA</td>
<td>PSA GROUPE</td>
</tr>
<tr>
<td>MITSUBISHI MOTORS</td>
<td>BLUE BIRD</td>
<td>HYUNDAI</td>
<td>FIAT</td>
</tr>
<tr>
<td>RENAULT</td>
<td>BMW</td>
<td>VOLKSWAGEN</td>
<td></td>
</tr>
</tbody>
</table>
V2G standards

Level 1 - V1G
Cooperative Charging
- EV and EVSE are compliant with the technical requirements, guidelines, and regulations.
- This level only considers charging events from grid to EV.
- The charging power is below thresholds, requiring controllability / load management by the DSO.

Level 2 - V1G/H
Controlled Charging
- The charging event can be influenced regarding the charging power and can be shifted in time remotely by DSO (with highest priority).
- CPD, EV user, EV or home energy management (HEM).
- The EV is capable of waking up for defined start/stops.
- Reaction timings are defined.
- EV/EVSE, HEM consider variable power settings.

Level 3 - V2H
Bidirectional Charging
- EV and EVSE negotiate a charging profile based on various drivers (monetary incentives or grid constraints).
- Energy transfers are motivated by sustainability or economical reasons (storage and usage of power, generated by local PV panels or similar).
- Supports behind the meter (BTM) use cases.

Level 4 - V2G
Aggregated (bidirectional) charging
- The EV and the EVSE fulfill functions that go beyond the customer’s own energy system.
- Energy transfers between EVs battery and the home / customer system.
- Supports in front of the meter (FTM) use cases.
- Swarm qualification / aggregation across larger area (entire state or country).

Technical requirements:
- Various local regulations per country (e.g. grid codes, IEC61851-1, IEC 60364 series, ...)
- Local regulations: EV and EVSE:
  - PWM signal, IEC 61851
  - DIN SPEC 70121 (for DC)
  - EVSE and grid (utility, CPD, ...)
  - DCCP:1.6
  - Demand-response
  - Opt-out possibilities
- Local regulations: EV and EVSE:
  - ISO/IEC15118 Ed1
  - Telematics
  - EVSE and grid
  - OCPP:1.6
  - TSO level
  - ToU
- Local regulations: EV and EVSE:
  - See level 2
  - ISO/IEC15118 Ed2
  - EVSE and grid
  - See level 2
  - E-Bus
  - Many requirements still missing
- Local regulations: EV and EVSE:
  - See level 2
  - EVSE and grid
  - See level 3
  - Many requirements still missing

Grid connection:
EV = electric vehicle, EVSE = electric vehicle supply equipment, DSO = distributed system operator, CPD = charge point operator.
V2G chargers

World’s first compact bidirectional home charger
Costs include HW, aggregation and battery degradation costs.

Cycle life degradation assuming 4500kWh/year throughput.

High revenues estimated in high-congestion DSO areas.
V2G customer proposition

Self-sufficient solar home energy storage system

SOLAR PANELS

HOME BATTERY

BI-DIRECTIONAL CHARGER
V2G customer proposition

Entry price $100 per month

App for reservation and opening

Shared, smart, solar powered electric cars
From charging to V2G

Yesterday
- Charging infrastructure
- Services (CPO, MSP, Roaming)
- Installation services

Today
- Smart charging
- Optimized grid extension
- Reduce demand charges
- Increase utilization

Enable e-mobility
- Charging infrastructure
- Services (CPO, MSP, Roaming)
- Installation services

Realize value pools
- V2H
- V2G
- Grid and energy services
- Swarm management
- Battery Care

Minimize cost
- Smart charging
- Optimized grid extension
- Reduce demand charges
- Increase utilization

bidirectional charging

Grid and energy services
- V2H
- V2G
- Smart charging
- Optimized grid extension
- Reduce demand charges
- Increase utilization

Swarm management
- Grid and energy services
- V2H
- V2G
- Smart charging
- Optimized grid extension
- Reduce demand charges
- Increase utilization

Battery Care
- Grid and energy services
- V2H
- V2G
- Smart charging
- Optimized grid extension
- Reduce demand charges
- Increase utilization
“V2G-ready” smart charge hubs in 25 Dutch cities
Policy

5 main EV strategies for Mauritius:

1. **Clean power for EVs** from renewable sources; solar carports
2. **Start small and scale EV** by target groups: taxi, corporate & government
3. **Incentivise nationwide network** of fast chargers at hotels, malls, highways
4. **Build the EV Community** for raising awareness & knowledge sharing
5. **Staged smart charging** & vehicle-to-grid strategy
Implementation

Porto Santo: Island microgrid

- 15% renewables
- 20 unidirectional EVs
- 2 bidirectional EVs AC
- 2 2nd life stationary batteries (132 kWh capacity)
Implementation

HOW V2G TECHNOLOGY AND ELECTRIC SCHOOL BUSES CAN HELP CURB POWER BLACKOUTS

US School buses as grid support & stabilization
Amsterdam ArenA: Football stadium as energy & mobility hub
Implementation

World's largest bidirectional solar charging plaza
PAVING THE ROAD TO RENEWABLES

SMART INTEGRATION OF ELECTRIC VEHICLES TO INCREASE UTILISATION OF INTERMITTENT RENEWABLES INTO AN ISLAND ENERGY MIX
Sjoerd Moorman
EV Consultant  Expert V2X & Smart charging

What I work on:

EV strategy:
- Roadmaps - EV modelling - Fleet transition plans

Innovation:
- Charging hubs - Smart Charging - V2X

- World-first Global Review of Vehicle-to-Grid projects
- Smart Charging Strategy & Roadmap for DNO UK Power Networks
- Market sizing for V2B services in the UK
- Fast charging rollout business case for supermarket chain in France
- Fleet transition plan for City of Amsterdam
- World-first online EdX course on electric mobility (>140,000 learners worldwide)

Find me on LinkedIn, Twitter

+31 6 11903585
s.moorman@evconsult.nl
Sustainable Energy Technology
Delft University of Technology