Electric vehicles and the grid: Intermittent storage balancing intermittent generation.

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EESA 27/11/2018
OVERVIEW

• Electric vehicles – the future
  ➢ Drivers and predictions re uptake

• Electric vehicles – opportunities for the grid
  ➢ What if all cars electric?
    - All charged at once, no management (opposite problem to PV)
    + VPPS and DERMs, coordinated/managed (services to grid)

• Electric vehicles – three use cases
  1) Parking lots
     • Suburban shopping centre occupancy analysis
  2) Commuter vehicles
     • Commuter travel survey analysis
  3) Fleet service vehicles
     • Commercial V2G trial data – Parker Project, Denmark
EV TRENDS & FORECASTS
- The Drivers

https://www.youtube.com/channel/UCELrWeVLazR49umE5qSF3VQ
EV Trends & Forecasts - International

Asghar (BNEF), Evidence to Senate Select Committee on Electric Vehicles, Aug. 2018.

### EV Trends & Forecasts - International

Policies to phase out ICE’s, reduce GHG emissions

<table>
<thead>
<tr>
<th>Country</th>
<th>ICE end</th>
<th>CO2 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>2025</td>
<td>-45%</td>
</tr>
<tr>
<td>Denmark</td>
<td>2030</td>
<td>-45%</td>
</tr>
<tr>
<td>India</td>
<td>2030</td>
<td>?</td>
</tr>
<tr>
<td>Germany</td>
<td>2030</td>
<td>-45%</td>
</tr>
<tr>
<td>China</td>
<td>2040</td>
<td>75%</td>
</tr>
<tr>
<td>Britain</td>
<td>2040</td>
<td>-61%</td>
</tr>
<tr>
<td>USA</td>
<td>-</td>
<td>-38%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-</td>
<td>-30%</td>
</tr>
<tr>
<td>Australia</td>
<td>-</td>
<td>-27%</td>
</tr>
</tbody>
</table>


IPCC target: At least 27% share of renewable energy by 2030

Source: Bloomberg New Energy Finance

Asghar (BNEF), Evidence to Senate Select Committee on Electric Vehicles, Aug. 2018.
EV Trends & Forecasts - Domestic

Asghar (BNEF), Evidence to Senate Select Committee on Electric Vehicles, Aug. 2018.

Source: Bloomberg New Energy Finance

10/20/2018

Power bills will soar unless government prepares for electric vehicles, top adviser warns

By Nicole Hasham
18 October 2018 — 6:00pm

A top national infrastructure adviser has warned Australia risks being “caught flat-footed” by the electric vehicle revolution, leaving consumers to pay more for electricity if governments and industry fail to act.
The Future is Electric - Range of scales, distributions

Proposed solar plant to store power in shipping sized batteries

By Nicola Gage
Updated Sat 23 Jul 2016, 1:28pm


http://electriccarsreport.com/2015/12/nissan-and-enel-team-up-on-v2g-technology/

The first new project is planned for South Australia, with a 100MW solar PV plant to be combined with a battery storage array of up to 40MW. Green says the plant could be in operation near Roxby Downs by early 2016, and there are plans for other similar projects around the country.
EVs AND THE GRID
- What If All Cars Were Electric?
Electrification of transport
- Potential impacts of EVs on the grid

• Transport – can’t be ignored
  - transport consumes ~1/3rd of energy (currently mostly petroleum)
  - electrification inevitable (efficiency, compatibility, cost, etc.)
  - by 2025, 25% of new vehicles sold will be electric [ENERGIEA 2018]

• Typical EV energy capacity, range
  - Domestic battery storage (e.g. Tesla Powerwall) 6.4 - 10 [kW.h]
  - Hybrid EV (Toyota Prius) ~ 15 km range 1.3 [kW.h]
  - Full EV (Nissan LEAF) ~ 115/140 km (EPA) 24 - 30 - 40 [kW.h]
  - Full EV (Tesla S) ~ 430km (EPA) 85 - 100 [kW.h]

50 km round trip ~ 10 [kW.h]
c.f. average domestic household electricity consumption: 17 [kW.h/day]

• EV load/source on grid (overall)
  - e.g. major capital city with 1,000,000 EVs
    - 10 GW.h /day (currently 14.7 GW.h /day)
    - potentially 900 to 1,700 MW peak demand

⇒ More mobile storage (on wheels) than fixed (in households)
Battery storage
- Applications, costs, benefits, opportunities

Energy Storage

- Demand management - peak shaving *(utility)*
- Demand response *(customer)*
- Ancillary services *(market)*
- Renewable generation stabilisation *(intermittency)*
- Integrate distributed LV generation *(voltage/export)*
- Load balancing *(LV networks)*
- Emergency supplies
- Off-grid supply
- Micro-grids
- Retailer supply/demand contracts
- Energy arbitrage *(optimise response to tariffs)*
- Reduce grid supplied energy *(solar PV + storage)*
- Demand charge reduction *(C & T)*
- Electric mobility
- Community energy “bank”

The power of aggregation - VPPs and DERM

Interest in storage aggregation is gaining momentum

Timeline of selected virtual power plant (VPP) announcements

- **Reposit GridCredits**: ~1,100 households
- **SonnenFlat**: Commercially deployed
- **Simply Energy VPP**: 1,200 households
- **Powershop Grid Impact**: Commercially deployed
- **South Australia Government VPP**: 1,100 households (target 50,000)

Source: BloombergNEF. Note: Not a comprehensive list.
## Connected vehicles
### - Energy and information flows

<table>
<thead>
<tr>
<th>Electrical Energy Flow</th>
<th>Information Flow</th>
<th>1-way (from vehicle)</th>
<th>1-way (to vehicle)</th>
<th>2-way</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>-</td>
<td>e.g. Traffic monitoring</td>
<td>e.g. Dynamic routing, etc.</td>
</tr>
<tr>
<td>1-way (to vehicle)</td>
<td>-</td>
<td>Smart metering</td>
<td>Demand management</td>
<td>Transactional energy</td>
</tr>
<tr>
<td>1-way (from vehicle)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>V2H</td>
</tr>
<tr>
<td>2-way</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>V2G,X</td>
</tr>
</tbody>
</table>
EVs in a Smart Grid
- V2G opportunities and challenges

Positive impacts of EVs on grid
- G2V storage for excess renewable energy
- V2G services to grid (frequency, voltage, etc)
- V2H (e.g. peak shaving)
- V2V

Opportunities and challenges with batteries, EVs
- Source or sink of power
- Fast reaction time
- Finite energy – “rebound” effect
- Distributed resources (storage elements move)
- Intermittent / stochastic availability (depends on SOC, xport usage, location, etc.)

Five Categories of Energy Storage Application

<table>
<thead>
<tr>
<th>Category 1 — Electric Supply</th>
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</thead>
<tbody>
<tr>
<td>1. Electric Energy Time-shift</td>
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<tr>
<td>2. Electric Supply Capacity</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 2 — Ancillary Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Load Following</td>
</tr>
<tr>
<td>4. Area Regulation</td>
</tr>
<tr>
<td>5. Electric Supply Reserve Capacity</td>
</tr>
<tr>
<td>6. Voltage Support</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Category 3 — Grid System</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Transmission Support</td>
</tr>
<tr>
<td>8. Transmission Congestion Relief</td>
</tr>
<tr>
<td>9. Transmission &amp; Distribution (T&amp;D) Upgrade Deferral</td>
</tr>
<tr>
<td>10. Substation On-site Power</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 4 — End User/Utility Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Demand Charge Management</td>
</tr>
<tr>
<td>13. Electric Service Reliability</td>
</tr>
<tr>
<td>14. Electric Service Power Quality</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category 5 — Renewables Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. Renewables Energy Time-shift</td>
</tr>
<tr>
<td>16. Renewables Capacity Firming</td>
</tr>
<tr>
<td>17. Wind Generation Grid Integration</td>
</tr>
</tbody>
</table>

EVs IN A SMART GRID - USE CASES

Parking lots

Commuting

Service fleets

The Parker Project is applying grid-balancing services to a fleet of electric vehicles to demonstrate their potential to support the electricity grid as power resources.
1) If all cars were electric...
- Supermarket parking lot

Parked vehicles, suburban shopping centre in Sydney

→ 4500 parked EVs ~ 180 MWh peak storage (@ 40 kWh/vehicle)
2) If all cars were electric…
- Commuting

Travel survey data analysed
- 2014-15 Household Travel Survey (HTS)
  Transport Performance and Analytics
  Transport for NSW
- 50 LGA’s (Greater Sydney)
  19 million trips
  1 million weekday commutes
  82% < 35km (70km round trip)
  88% serviceable by EV (LEAF)

- Results: EV SOC by time and location
  (Assumption: charged to full o/night)

- Energy available in EV batteries always
  3 to 5 times larger (anywhere/time) than
  Energy required by EVs for transport
  → V2V, V2X
  → V2G (distribution network services)
2) Commuting - UK V2G projects


https://www.autocar.co.uk/car-news/industry/nissan-expand-bi-directional-charging-scheme-uk-project
Oct. 2017

Partnership between Nissan and Ovo Energy to enable EV owners to participate in providing energy supply services to grid - Nissan says the system could generate around £350 (AUD$640) per year for LEAF owners.

https://www.autocar.co.uk/car-news/industry/nissan-and-uk-government-lead-uk%E2%80%99s-biggest-vehicle-grid-project
Jan. 2018

AUD$18m Innovate UK project: installation of 1,000 V2G charge points across UK over next 3 years.

Head of Nissan’s energy division, Francisco Carranza, added that plugging EVs into the grid will make the UK grid "more sustainable and more stable".
3) If all cars were electric... - Fleet service vehicles

Demonstrate that contemporary electrical vehicles can participate in advanced smart grid services.

**Partners:** Nissan, Mitsubishi Corporation, Mitsubishi Motors Corporation, PSA ID, NUVVE, Frederiksberg Forsyning A/S, Insero A/S, Enel and DTU.

**Duration:** 8/2016 to 7/2018.

**Budget:** Two million Euros, funding by ForskEl

http://parker-project.com/
3) Fleet service vehicles - Parker Project

http://parker-project.com/

Parameters:
- Energy Deadline
- Energy Target
- Minimum Energy
- (Return Time)

Calculated FCR-N availability payment with 10kW V2G units (FCR-N, ~14 h/day)

120 Euro / Month / Vehicle

Figures c/o Lea Berthou and Peter Bach Anderson (DTU).
CONCLUSIONS

• Aggregated EV battery capacity = substantial storage resource
  - availability during day largely complementary to PV generation
  - from EV side: individual EV use patterns → improved V2G scheduling
  - from grid side: scale of “intermittent storage” outweighs limited availability

• EVs can/are having valuable positive impacts on the grid
  - capturing excess renewable energy generation
  - significant existing and future opportunities for provision of services to grid

• Next steps (looking for partners):
  - V2G trial in Australia
  - extension of V2G to distribution and other services

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