The Wrap-Up Presentation

end of 2nd day

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Vehicle-Grid Integration Summit
A Movement of Worldwide V2G Demonstrations
DTU Risø Campus, Roskilde, Denmark
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Summary:

That was impressive

(Thanks for creativity and all this great work)

What are our goals?

- Making electric vehicles more cost-effective.
- Creating low-cost distributed storage.
  - Really helpful in transitioning to a low-carbon, low pollution electricity system.
- Creating cool technology.
- Making better products, giving our EVs a competitive advantage, and other business goals.

The idea has percolated

- The basic arguments for Grid Integrated Vehicles supporting large scale renewables, those arguments we heard—and, stated correctly!— from:
  - DTU University Director
  - Spokesman on Energy and Climate, Social Democratic Party
  - CEO of the Danish TSO

A sample of findings

- Everoze found 50+ V2G demonstrators in 15+ countries; their summary was “it’s here, it’s happening, it’s amazing”, e.g., among many others…
    - Nuvve Denmark is on commercial market, good earnings per EV
    - PSA has serious scaling plan for full national rollout
- Many types of grid services, vary widely in revenue, from €10 to €1,800 per year
- Improvements in charger power, or charger efficiency, substantially increase profit
- Regulators and power sector are not adjusting rules because they don’t understand the value of V2G
- Standards are not the final word, standards are revised every 3 years
- Drivers accept V2G operations, no problem with sufficient charge
- For frequency control, it is possible to replace one island 4.5 MW diesel with 450 EVs (per model).

Finding on User Scheduling

- From Martin Messer Thomsen (Nuvve Denmark), not reported from podium; based on ~40 EVs doing V2G in Denmark

- Just three schedule types set in Nuvve's GIVe aggregator meet most/all driver needs:

  - Planned trip (at a time and distance), can repeat

  - "On call" - a minimum range maintained time1 to time2

  - "Emergency charge" - immediate charging to ___ km, controlled by app

Nuvve Sampler of Projects

- Nuvve is growing rapidly
- Many projects worldwide
- Only a fraction of those projects were described here in previous talks
  - The following is a sample of the breadth of Nuvve projects
  - (Thanks to Marc Trahand and Nuvve colleagues for the following slides)

United States

NUVVE

INVENT

Project Goal: Demonstrate the real-world benefits of advanced Vehicle-Grid Integration (VGI) applications for electric vehicles (EV) by demonstrating that EV owners can share their batteries when not needed (i.e., when parked and sufficiently charged) and as compensation, receive valuable benefits in return.

- **$4 million in funding from the California Energy Commission**
- **50 + EVS over three years across the state**
- **Executing both bi-directional and uni-directional services**

Partners

NISSAN
MITSUBISHI MOTORS
BMW
HITACHI Inspire the Next
NREL NATIONAL RENEWABLE ENERGY LABORATORY
PG&E
SDGE
SUNSPEC ALLIANCE

EVSA

Project Goal: Demonstrate that vehicle-to-grid (V2G) is a viable and low cost energy storage resource that can provide services to the grid.

- Work with Nissan and Honda to test the bi-directional capabilities of their vehicles
  - **2** 2014 Honda Accord PHEVs with on-board inverter ($V2G_{AC}$ charging)
  - **6** 2016 Nissan LEAFs ($V2G_{DC}$ Charging)

Test vehicles in the context of four "Use Cases":

Interconnection

Emergency Power Back-Up

Transformer Upgrade Deferral

Value of V2G

NUVVE UCSD

EVSA and INVENT Projects using NUVVE's PowerPort bidirectional AC charger

www.nuvve.com

Electric School Bus w/ V2G & V2B

Cost-optimized eBus

- charger in motor drive

- 3-phase

Revenue opportunity:

- Frequency response
- Other grid wide services

Cost optimization:

- Demand charge management
- Time of Use optimization

Cost mitigation:

- Local generation
- Stationary storage

Rialto Electric School Bus

- **Project Scope**:
  - 8 Bluebird electric school buses deployed at the Rialto Unified School District in San Bernardino, California in 2020
    - 200 kWh battery
    - 150 kW bidirectional charger (AC)
    - proof of SEA J3068 standard
  - Charged by Nuvve PowerPort 3-phase AC bi-directional charging stations
- **Services:**
  - Ancillary Services (regulation up/regulation down)
  - Vehicle-to-Building (demand charge management/peak shaving/solar integration)

NYSERDA

- **NYSERDA PON 3578** - *Plug-In Electric Vehicle (EV)-Enabling Technology Development and Demonstration Program*
  - Awarded July 2018
- **Scope**
  - 6 Nissan LEAF vehicles used to provide bi-directional grid services on the CUNY Queens College campus:
    - Demand Charge Management
    - Emergency Back-up Power
    - Simulated Frequency Regulation

CUNY The City University of New York

nyserda Energy. Innovation. Solutions.

UD Stationary Battery plus EVs

8 EVs @16 kW, UD eBox + eVan, plus..

220 kW storage performing frequency regulation for PJM (Largest ISO in the USA)

EVGrid Product based on second life automotive battery systems

Planned in service date Dec 2018

pjm

EVGRID

Customized Energy Solutions

Europe

United Kingdom

- eFlex
- NIA Project

France

- Grid Motion

Denmark

- Parker
- Aces

NUVE

eFlex – Innovate UK

E-Flex is a scaled demonstration of 200 V2G charging stations in the greater London area combining variable duty cycles and vehicle types to expand understanding of how whole-system benefits in a larger metropolitan city.

Consortium Partners

Cisco (Lead)
Nuvve
Greater London Authority
Transport for London
E-Car Club LTD
Imperial College London
Cenex

Key Goals:

- Examine the system value of V2G in a high density city
- Understand whole-system benefits of V2G
- Identify business models that provide end-to-end value for all participants - realizable market with multiple demand/supply participants.
- Install and operate 200 stations in greater London area

NIA Project – Northern Powergrid

<u>This 3 year project aims to:</u>

- Determine the connections required for bi-directional chargers. Inform connection standards – recommendations to Energy Networks Association
- Explore vehicle to grid as a potential solution to constraints that would otherwise be caused by EV clusters
- Understand any impact on power quality resulting from the use of V2G

19 Chargers will be located at 4 NPg owned sites.

NORTHERN POWERGRID

Newcastle University

Grid Motion - PSA

- 50 “smart” unidirectional chargers (Nuvve PowerPorts) - Residential customers around France who own a Peugeot or Citroën.
- 15 V2G fleet stations near Paris.

Key Goals:

Vehicles will provide grid balancing both bidirectionally and unidirectionally (combined V1G and V2G).

Charging is expected to be carried out when there is surplus electricity supply on the grid, while discharging is expected to be carried out when there is surplus electricity demand on the grid.

Project Partners

direct energie

PSA GROUPE

DTU

Proxiserve

Parker Project

The aim of the Parker project is to validate that EVs can support the power grid by becoming a vertically integrated resource, providing seamless support to the power grid both locally and system-wide. Ensure that barriers regarding market, technology and users are dealt with to pave the way for further commercialization and to provide an evaluation on the capability of EVs to meet the needs of the grid.

Consortium Partners

Mitsubishi Corporation
Mitsubishi Motors Corporation
PSA
Nissan
INSERO
Frederiksberg Forsyning
Enel
DTU

Project Goals

- Identify technical, economic and regulatory barriers for grid applications and viable business cases.
- Specify technical parameters for EVs to provide power and energy services to the grid – Produce a Grid Integrated Vehicles (GIV) certification that demonstrates the ability of an EV to support grid services.
- Promote replicability across other geographies, technologies and user groups.

Project Duration: August 2016 to July 2018 — completed

ACES Project

The ACES project intends to holistically investigate technical and economic system benefits and impacts by large scale electric vehicles integration in Bornholm, augmented by real usage patterns, grid data and field testing for across continents replicability.

Key Goals

- Assess the values of EV services in DK, UK and Japan, by using real EV driving data.
- Disseminate V2G applications and best practices in Europe and in Japan.
- Build up on the experience on Bornholm test case and contribute to enrich it.
- Derive guidelines for coordinating system wide services provided locally: Distribution System Operator (DSO) vs Transmission System Operator (TSO).
- Test whether EVs can help supporting Bornholm power system (balancing mainly).

Project Partners

BORNHOLMS ENERGI & FORSYNING

DTU

NISSAN

50 V2G Stations

April 2017 – March 2020

Asia Pacific

Japan

- METI Project

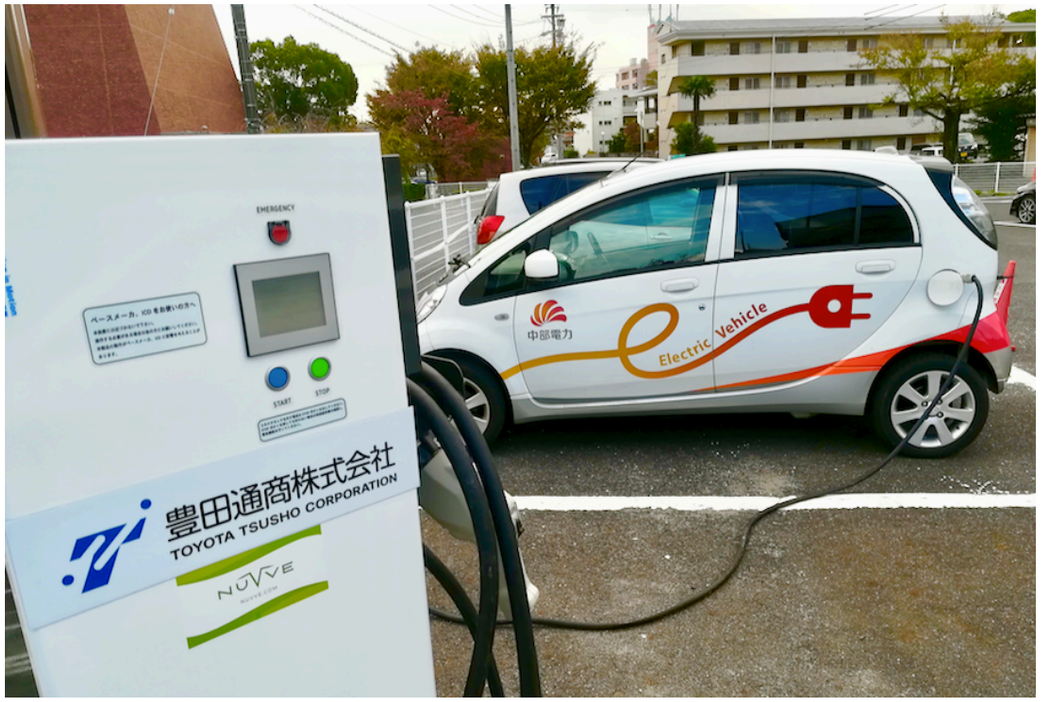
NUVE

JIVE – Japan Integrated Electric Vehicles

A METI VGI Project

- Phase 1 - One year project in Toyota City Japan
- Start August 2018
- 2 X MMC i-MiEV
- 2 X V2G charging stations from Tsubakimoto Chain Co.
- Nuvve aggregator
- Services

  - Frequency Regulation
  - Energy arbitrage



METI – Toyota Tsusho Corp

Project Goals

- Accelerate the introduction of PHVs/EVs, which only have low negative environmental impacts by providing new value streams of PHVs/EVs with bi-directional chargers.

- Reduce the cost of demand and supply adjustment of electricity by acquiring new types of Distributed Energy Resources which results in further diversification.

CHUBU Electric Power

TOYOTA TSUSHO

The Conclusions

- V2G Works, cars and chargers are available
- Existing comm standards work: IEC 62196, SAEJ3068, CHAdeMO (all more valuable with Nuvve additions)
- Drivers are accepting
- If Bidirectional, proven revenue up to €1,800 / year
- Would be helpful to have more OEMs; lower TCO and marketing distinction
- Lowest cost is on-board AC chargers, simple EVSE with some GIV intelligence

The Provocative Slide

- Now OEMs have 10-20 kWh hybrids, and 20 - 80 kWh EVs
- Typical AC charging is 3-7 kW for hybrids, 7 - 22 kW for EVs; driver flexibility and V2G favor home charging >10kW
- Bus and truck using SEA J3068, integrated low-cost 100 kW charger
- Battery costs dropping 17%/year, with step changes likely
- To user, larger battery is more convenient than fast charge, needed for high duty-cycle or long distance travel
- Large battery may be useful for drivers without home charging (e.g. workplace charging only)
- Above leads to the following “Kempton future” prediction of bimodal specifications on charge rate vs. battery size…

EV Evolution (sedan)

	2014	2018	Kempton future (two models, bimodal split)
Battery (kWh)	20	50	50/200
Efficiency (km/kWh)	5	7	8/7
Autonomy (km)	100	350	400/1400
Charge rate (kW)	7/50	7/80	12/50/120
Cost premium	++	+	-/+
GIV connector	J1772	CHAdeMO	IEC 62196, J3068

“Kempton future” bimodal data first published in Kempton, Nature Energy, 15 Aug 2016, DOI: 10.1038/NENERGY.2016.131

End

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Nuvve web: http://nuvve.com
UD V2G research: http://www.udel.edu/V2G/