Economic Analysis of Fleet V2G Applications: Part II

Christine Holland, Bowen Huang, Jeremy Twitchell, Di Wu

Pacific Northwest NATIONAL LABORATORY

ABSTRACT

Results from the initial fleet V2G study showed that increased cycling which caused a reduction in battery life beyond its calendar life was cost prohibitive for fleet owners. In this follow-up study, we continue to study four different grid services: energy arbitrage, demand charge reduction, frequency regulation, and spinning reserve, but with battery cycling constrained to not exceed calendar life. Additionally, we expanded our study to include four price regions: BPA, CISO, MISO, and NISO. Results show that 23% of the applications have a benefit/cost ratio greater than one, with MISO having the most. Buses were the most successful due to having more down-time. Energy arbitrage and frequency regulation performed the best.

PROJECT OVERVIEW

This study helps answer:

- ❑ How can utilities use medium- and heavy-duty fleets of electric vehicles as a grid resource without impacting primary driving patterns?
- ❑ Which price streams are more conducive to fleet V2G dynamics?

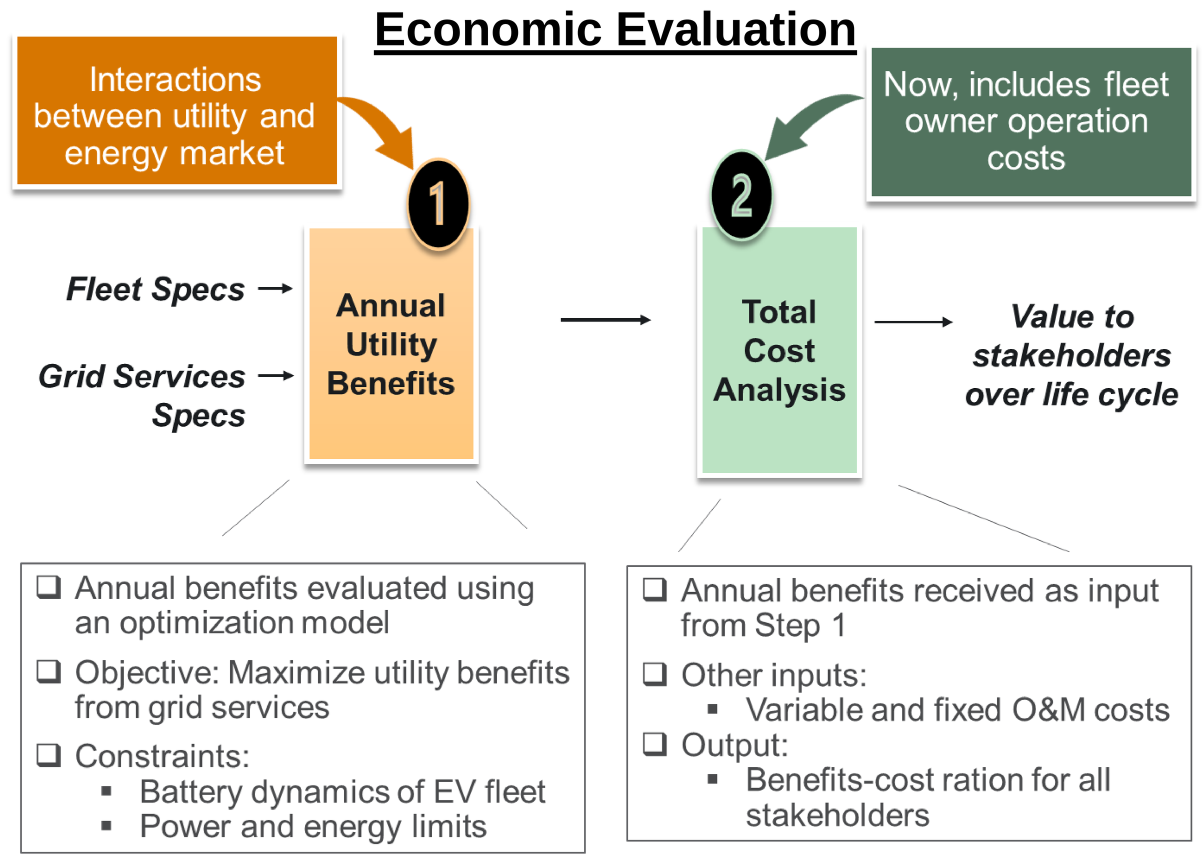
This study isn't:

- ❑ It is not a demand response program typical of retail programs; there are no 'calls' for demand reduction.
- ❑ Fleet owners do not alter their daily operations.

Fleet Assumptions (50 vehicles each)

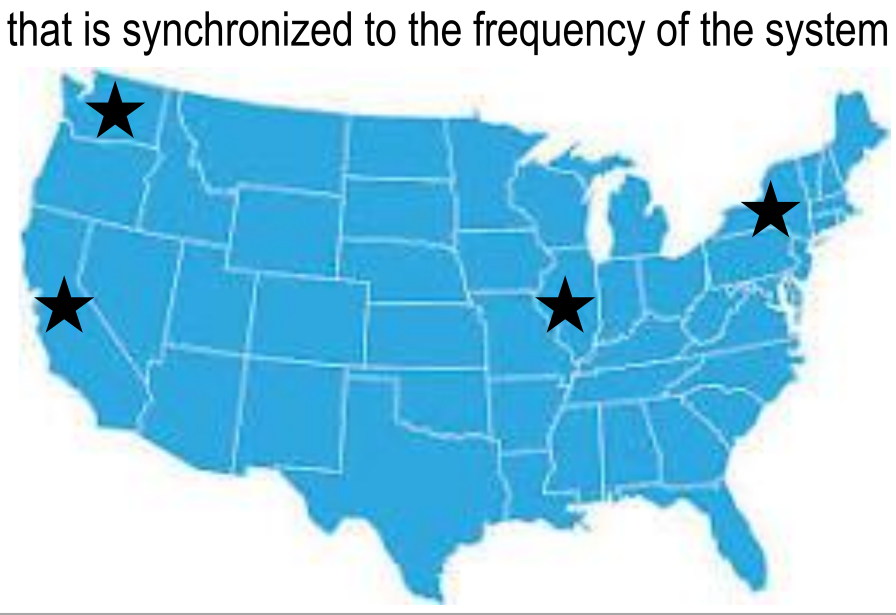
Fleet 1: School Bus (eLion C)	Battery size 210 kWh; Total fleet 10.5 MWh; Max power in/out: 19.2 kW
Fleet 2: Delivery Vans (Rivian)	Battery size 180 kWh; Total fleet 9 MWh; Max power in/out: 11 kW
Fleet 3: Truck (Ford F-150 Lightning)	Battery size 170 kWh; Total fleet 8.5 MWh; Max power in/out: 22.5 kW

Economic Evaluation



FOUR USE CASES & REGIONS

- ❑ **Energy arbitrage**: to discharge fleet electricity when electricity price or load is high and to charge fleets when the price or load is low
- ❑ **Demand charge reduction**: the use of fleet to reduce monthly peak
- ❑ **Frequency regulation**: to continuously balance generation and demand under normal conditions by following automatic generation control signals
- ❑ **Spinning reserve**: power that is synchronized to the frequency of the system in the event electricity is needed



RESULTS

Assumptions and Input Parameters:
- Federal and individual state taxes applied
- Project life: 15 years
- Nominal discount rate: 5%
- Inflation rate: 2.4%
- Round trip battery losses: 94.5%
- Fixed labor: $4800/yr
- Variable O&M: $0.52/MWh

Utility Benefits (Step 1)

Gross Annual Revenues

		BPA	CISO	NISO	MISO
Bus	Energy arbitrage	$322,262	$357,854	$120,456	$125,922
	Demand charge reduction	$23,534	$26,890	$8,155	$6,604
	Frequency regulation	$3,539	$4,076	$156,542	$307,043
	Spinning Reserve	$1,639	$2,237	$48,500	$26,806
Van	Energy arbitrage	$610,799	$658,064	$160,011	$103,047
	Demand charge reduction	$35,185	$46,167	$24,831	$5,232
	Frequency regulation	$4,481	$7,028	$328,054	$280,243
	Spinning Reserve	$1,406	$2,152	$100,957	$26,245
Truck	Energy arbitrage	$301,431	$358,147	$253,760	$7,756
	Demand charge reduction	$25,460	$28,152	$71,254	$5,644
	Frequency regulation	$3,131	$4,202	$1,062,630	$303,661
	Spinning Reserve	$1,620	$2,005	$312,917	$23,189

Annual Revenues Net of Charging

		BPA	CISO	NISO	MISO
Bus	Energy arbitrage	$21,033	$23,356	$16,233	$30,299
	Demand charge reduction	$1,536	$1,755	$1,099	$1,589
	Frequency regulation	$231	$266	$21,096	$73,880
	Spinning Reserve	$107	$146	$6,536	$6,450
Van	Energy arbitrage	$13,905	$14,981	$5,877	$15,894
	Demand charge reduction	$801	$1,051	$912	$807
	Frequency regulation	$102	$160	$12,049	$43,225
	Spinning Reserve	$32	$49	$3,708	$4,048
Truck	Energy arbitrage	$10,975	$13,040	$2,874	$1,098
	Demand charge reduction	$927	$1,025	$807	$799
	Frequency regulation	$114	$153	$12,035	$42,991
	Spinning Reserve	$59	$73	$3,544	$3,283

Total Cost Analysis (Step 2)

Benefit/Cost Ratio

		BPA	CISO	NISO	MISO
Bus	Energy arbitrage	0.42	1.28	1.01	1.11
	Demand charge reduction	0.25	1.17	0.62	0.56
	Frequency regulation	0.81	0.44	1.04	1.15
	Spinning Reserve	1.00	1.21	0.97	0.97
Van	Energy arbitrage	0.25	0.94	0.95	0.55
	Demand charge reduction	0.39	0.99	0.90	0.51
	Frequency regulation	0.81	0.70	0.89	1.06
	Spinning Reserve	0.98	0.97	0.96	0.88
Truck	Energy arbitrage	0.47	0.96	0.95	1.02
	Demand charge reduction	0.23	0.95	0.81	0.49
	Frequency regulation	0.86	0.81	0.98	1.07
	Spinning Reserve	0.98	0.96	0.95	0.91

CONCLUSIONS AND FUTURE WORK

- ❑ The financial success of a particular V2G application depends upon the price differentials in the market.
- ❑ In most cases, the revenues from V2G applications could not overcome the hurdle costs.
- ❑ Buses had the highest number of viable applications due to having more 'down time'.
- ❑ What are resilience applications?

Acknowledgements

This work is supported by the Washington State Department of Commerce and the U.S. Department of Energy (DOE) Office of Electricity. We are particularly grateful to Dr. Imre Gyuk for providing financial support and leadership on this and other related work at PNNL.

U.S. DEPARTMENT OF ENERGY

Contact: **Christine Holland**
Economist
Energy & Environmental Directorate
Pacific Northwest National Laboratory
Email: christine.holland@pnnl.gov