Economics of Vehicle-to-Grid

Scenario-based calculation of profits using the Vehicle-to-Grid Profit Agent

Presentation in the context of the
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Vehicle-to-Grid (V2G)

- V2G: Demand-oriented back-feeding of energy stored in battery packs of EVs into the power grid
- Not yet established business model
- No grid-inherent energy storage possibility
- Fine-tuning of energy demand and supply necessary

Figure 1: Energy production out of renewable energy capacities in Germany until 2020. Source: [1].

Vehicle-to-Grid (V2G)

- Idea:
  - Charge (G2V) in times of low energy demand (cheap)
  - Discharge (V2G) in times of high energy demand (expensive)

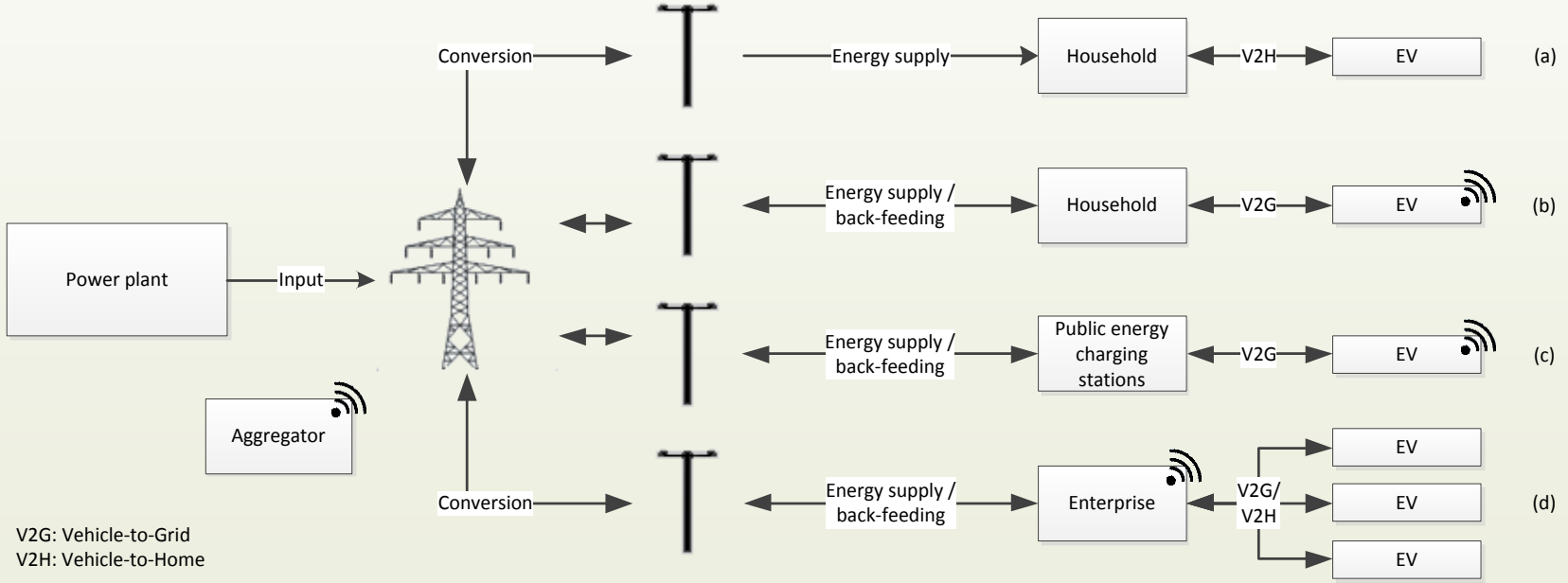

Figure 1: The V2G concept.

Energy markets

- Different energy markets 582 TWh
  - Base load (Ø 4 Ct/kWh) 437 TWh
  - Central and peak load (Ø 4,68 Ct/kWh) 136 TWh
  - Ancillary services („Regelleistung“) (Ø 15 – 44 Ct/kWh + CP) 9 TWh

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Capacity and energy payment

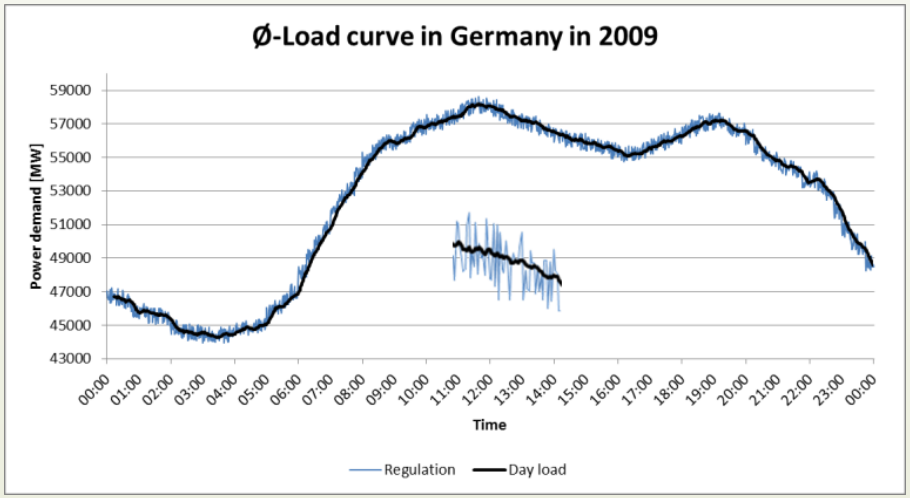

Figure 2: Average load curve in Germany in 2009.

Source: [2]

Cost model – Sales, Costs and Profit

U_{Ges} Sales

$$U_{Ges} = (P_L \cdot E_L) + (P_A \cdot E_A) \quad (1)$$

P_L	Capacity payment
E_L	Power capacity
P_A	Energy payment
E_A	Amount of energy

K_{Ges} Costs

$$K_{Ges} = (k_{var} \cdot E_A) + K_{fix} \quad (2)$$

k_{var}	Variable costs (battery wear)
E_A	Amount of energy
K_{fix}	Fixed costs (equipment)

G_{Ges} Profit

$$G_{Ges} = U_{Ges} - K_{Ges} \quad (3)$$

Vehicle-to-Grid Profit Agent (V2GPA)

- V2GPA: Microsoft Excel-based software tool for evaluating different scenarios
- Worst-, Best-, Average-, and eE-Tour-Case-Scenario outlined
- Energy and power offered all over the year
- Energy market data from Germany from 2009 used

V2G Profit Agent

Results

Type of load	Profit in the area of… [€]							
	…negative types of load (V2G)				…positive types of load (G2V)			
	Best	Average	Worst	eE-Tour	Best	Average	Worst	eE-Tour
Primary	4,556	-11,437	-48,078	-6,320	20,240	3,327	1,065	3,327
Secondary	0	-32,507	-58,455	-20,227	22,932	**4,275**	765	4,275
Tertiary	23,627	-2,614	-7,264	**-406**	12,622	**1,621**	189	**2,220**
Central and peak load	0	-50,319	-161,313	-66,425	---	---	---	---

Table 1: Achievable profits with V2G in Germany in 2009.

- V2G unprofitable, G2V profitable
- Combined profit of 1,814 €/year in the eE-Tour-Average-Case for tertiary reserve
- Achivable profits in the US scenario: 2,595 $/year

Conclusion and future work

- While V2G is a technically feasible solution of balancing demand and supply, its economic application fails in most examined scenarios
  - Break-even for tertiary reserve:

    352 €/kWh instead of 1000 €/kWh battery costs (- 65 %)

    Cyclic lifetime of 5576 instead of 2000 (+ 179 %)

    0.053 €/kWh instead of 0.031 €/kWh capacity payment (+ 71 %)

    0.392 €/kWh instead of 0.032 €/kWh energy payment (+ 1125 %)
- US study even better assumptions than Best-Case
- Future: Dynamic V2G Profit Agent using stochastic distributions instead of average values

References

1. http://www.eurosolar.de/de/images/stories/illustrationen/400/strom_ee_2020.jpg
2. Kempton, W.; Tomic, J.: Vehicle-to-grid power fundamentals. Calculating capacity and net revenue. In: Journal of Power Sources 144, S. 268-279, 2005.