UNPLUGGING THE ROSE-COLORED BIDIRECTIONAL CHARGER:

MISSING INPUTS IN V2G ECONOMIC MODELS

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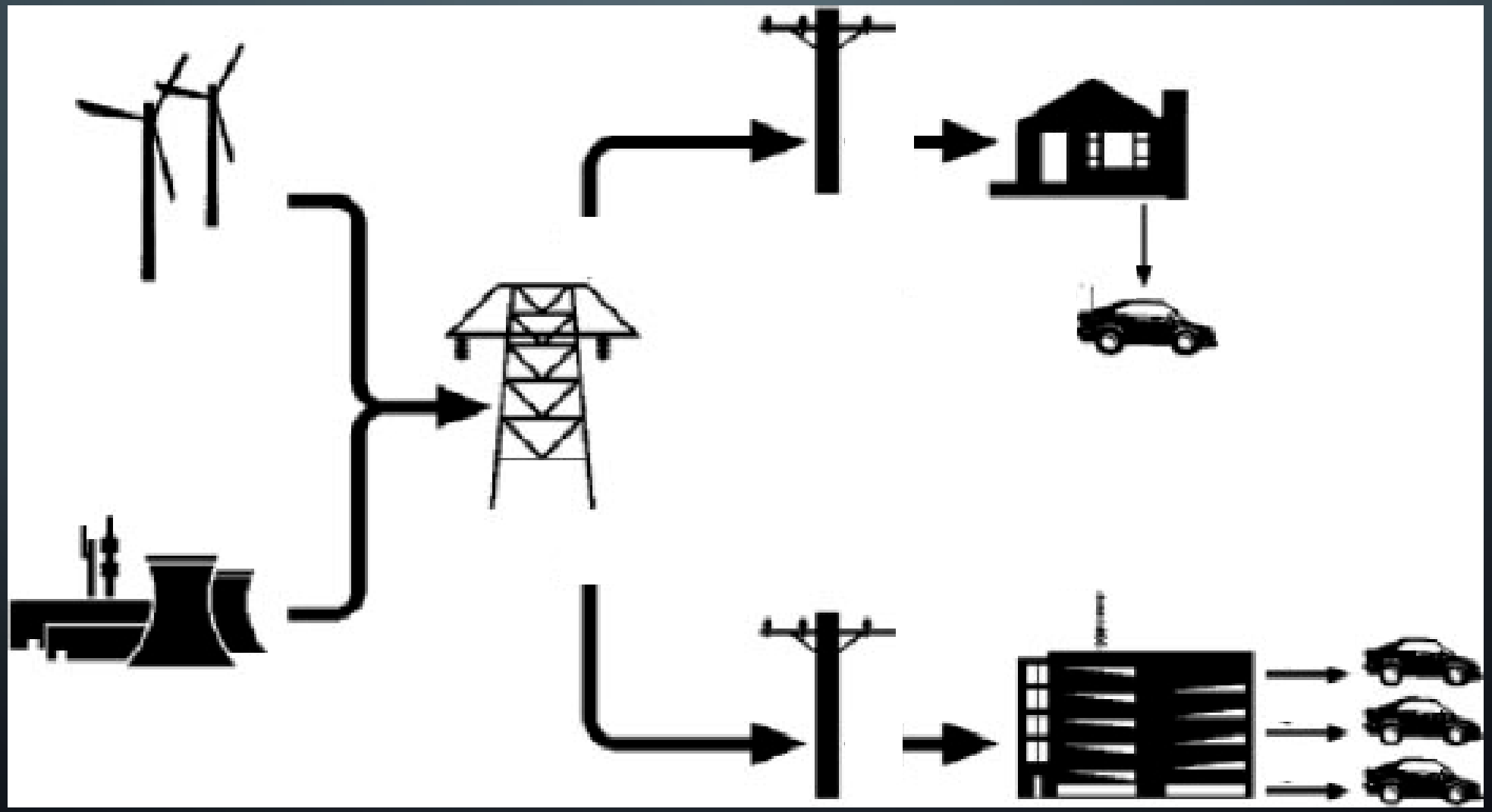
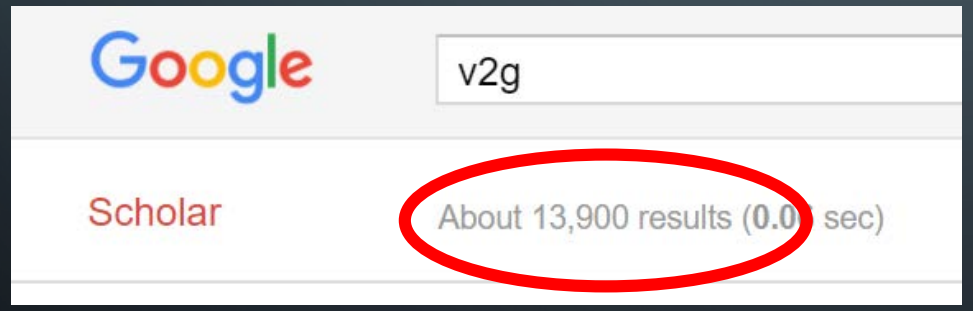
WHAT IS V2G?



VEHICLE TO GRID (V2G)

- Proposed in 1997
- Major funders
  - Multi-million $ programs
- Hugely popular in academic journals ….



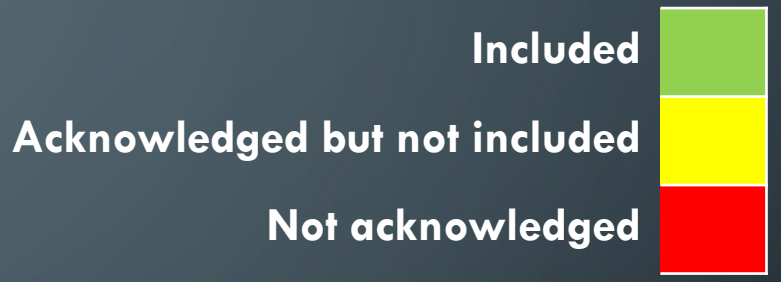
~14,000 results Google Scholar

EXISTING ECONOMIC ANALYSES

- Overwhelmingly find V2G economically viable
- Assumptions:
  - Historically high grid service prices
  - Huge maintenance savings
  - Diesel price ($4.20/gal and 8.5% escalation)
- But I'm not here to talk about mis-specified inputs…

OMITTED INPUTS

- Efficiency Loss
- Voided Warranty
- Aggregator Fees
- Temperature Limitations
- Convenience Loss
- Demand Charge
- Risk Premium
- Private-Public Consistency
- Competitive Pressures
- Marginal Emissions



EFFICIENCY

- V2G is ~60% efficient (Apostolaki et al., 2017)
  - Transformer → Breakers → EVSE → PEU → Parasitic → Battery
- Owner is paid for storing the energy, but responsible for any energy losses
- V2G is 'lossy'. Electricity losses are largest cost of business*

*Shirazi and Sachs (Under Review)

WARRANTY COVERAGE

- No vehicle sold in the US is V2G-enabled off the lot
- V2G immediately and irreversibly voids warranty policies*
  - Prohibit '*using the vehicle as a power source*'
  - Tesla, Nissan, Chevy, others
- Need to assess cost of voided warranty

*Hutton and Hutton (2012)

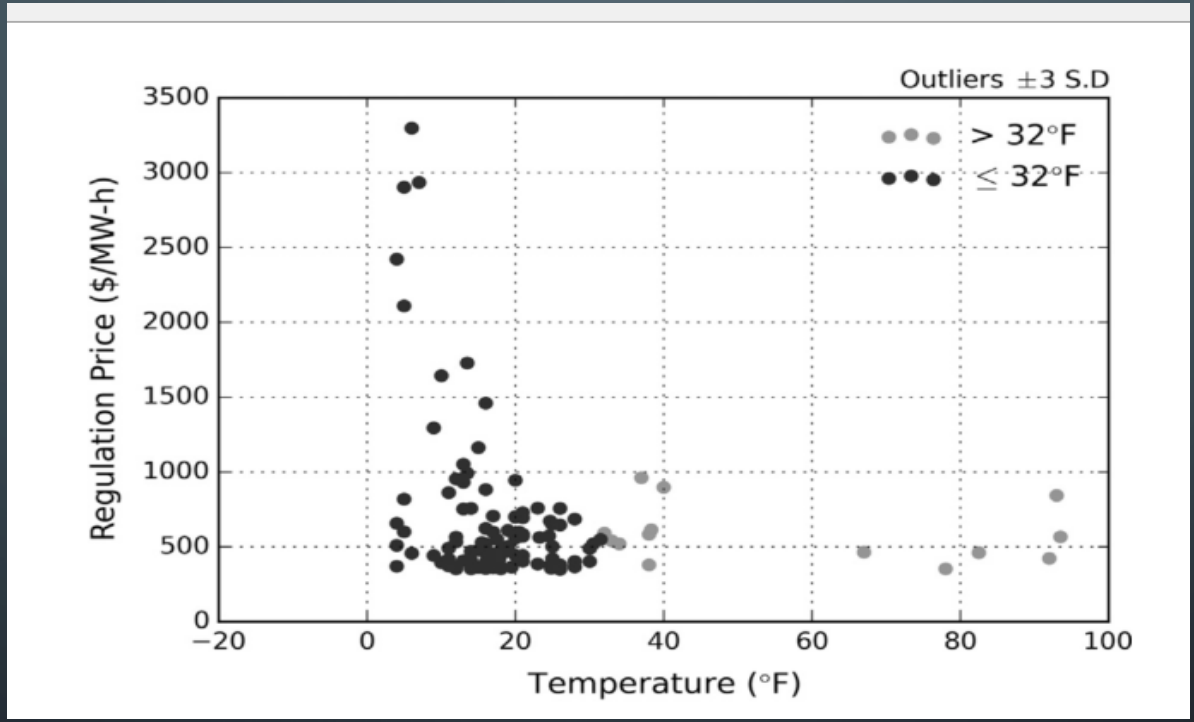
AGGREGATOR

- 'Selling tomatoes to Walmart'
- Provide Scale and Sophistication
- Minimum bidding increments of 100 kw -1,000 kw
  - Typical charger is 50 times smaller
- Fees estimated at 10% - 50% of revenues*
- Aggregators are necessary, costly middlemen in V2G operations

*Hill et al (2012)

ADVERSE TEMPERATURE

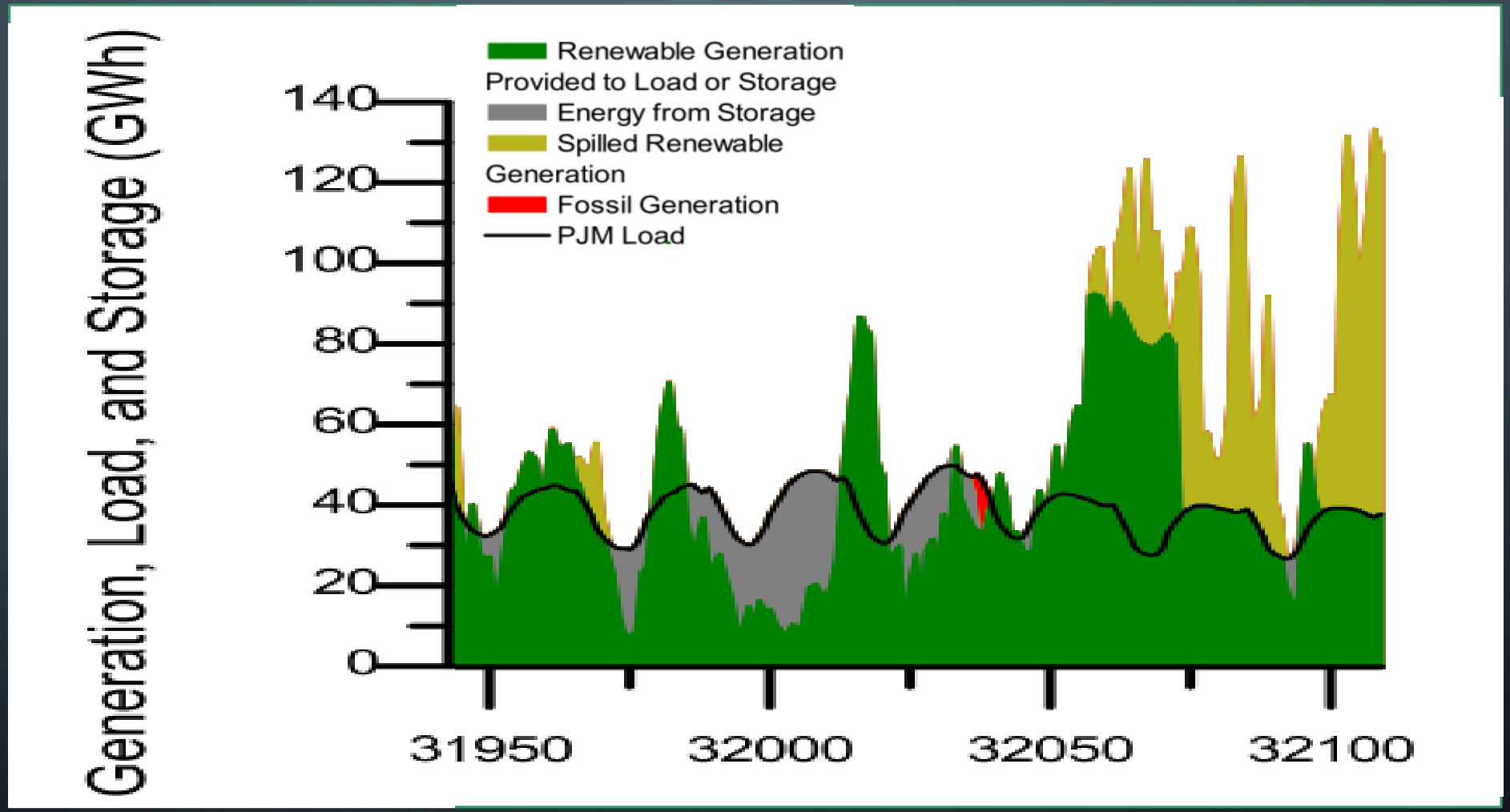
- "By 35F our vehicles are only able to provide 20% of typical power…" (Personal communication 2015).



- Temperatures constraints limit V2G revenue*.

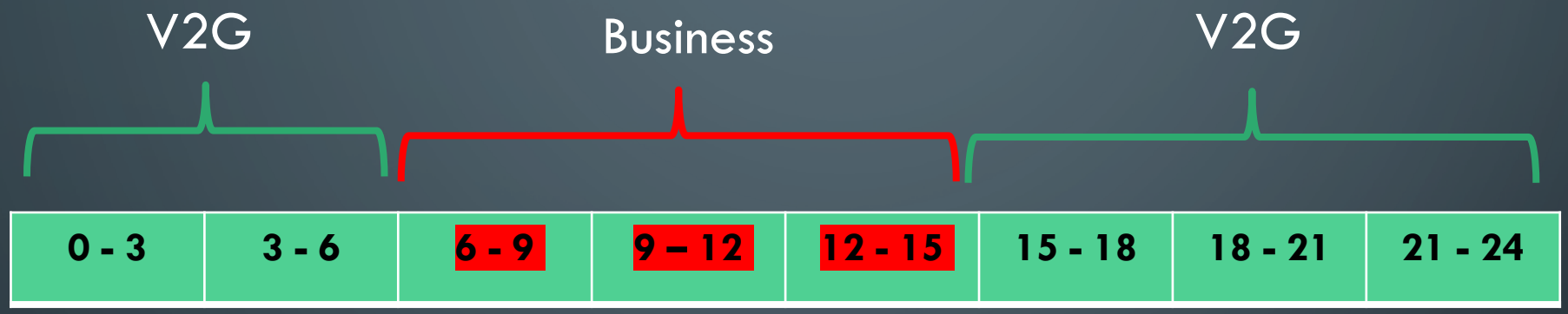
*Shirazi et al., 2015

CONVENIENCE/CAPACITY LOSS



Convenience losses create very large user costs

DEMAND CHARGE (FEE PER KW/MONTH)



- Charging quickly to maximize V2G hours
  - Leads to astronomical demand charges ($10/kW/mo)
- Cost to charge is dominated by demand charge (kW) not energy charge*

*Shirazi et al., (2015)

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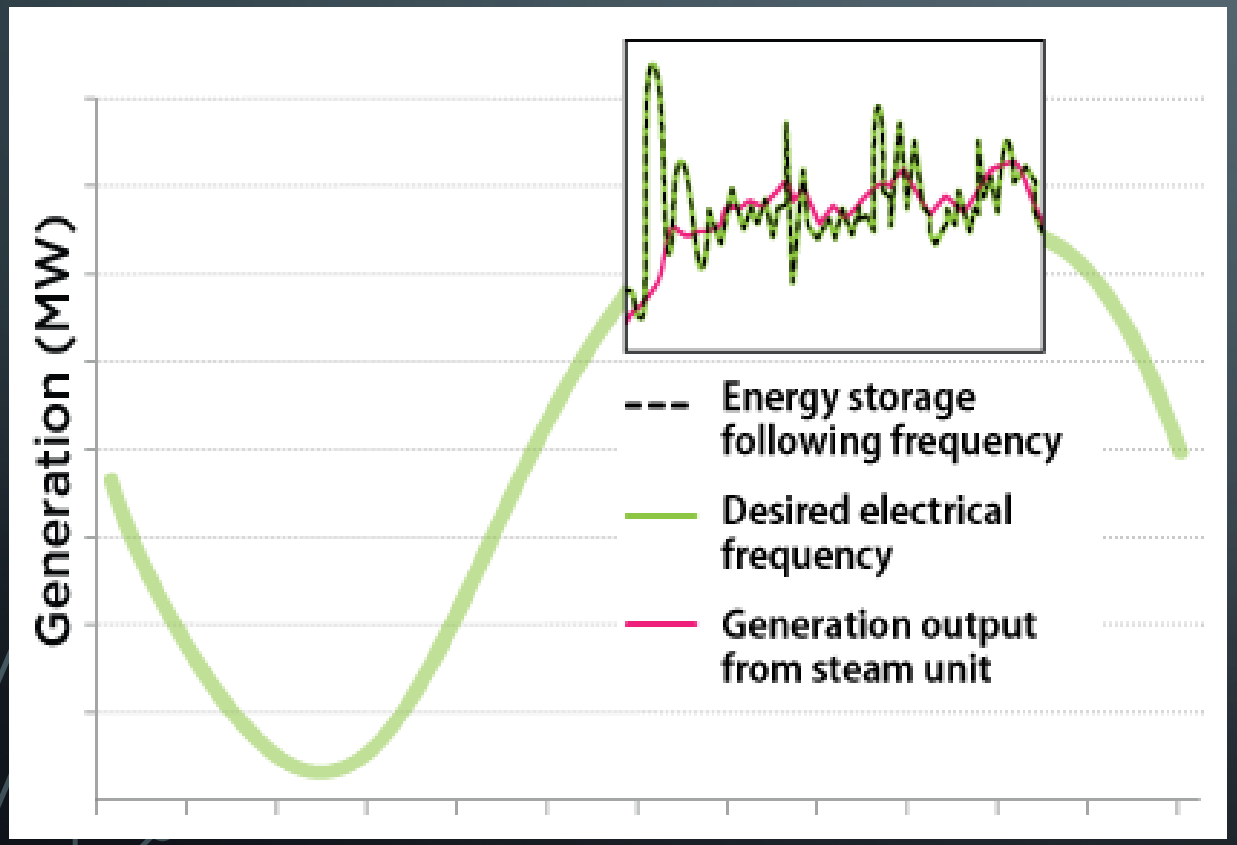
Table 7
Total GIV system percentage losses: building and EV components.

Component	AC current (A)	Percentage losses (%)	
		Charging	Discharging
EV Battery	10	0.64	0.64
	40	1.69	1.91
EV PEU	10	6.28	16.67
	40	5.77	19.23
EVSE	10	0.10	1.42
	≈40	0.29	1.39
Breakers	10	0.00	2.80
	≈40	1.30	0.60
Transformer	10	10.20	14.60
	≈40	3.33	6.65
Total	10	17.22	36.13
	40	12.38	29.78

V2G APPLICATIONS

Frequency Regulation (Now/Near Future)



'Carbitrage' (Long Term)