Adaptive Charging Network

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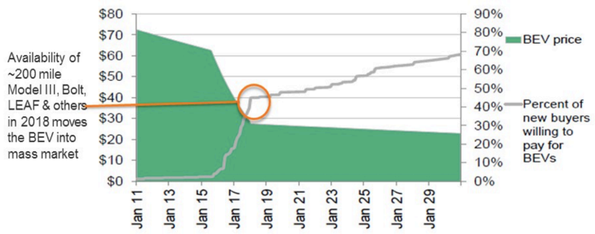
Opportunity



Tesla Model 3 (4/2016)

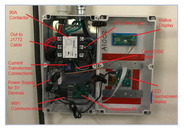
1st week reservation: 325K, $14B

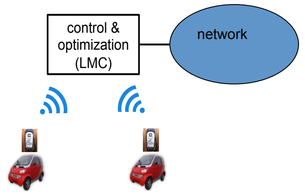
CA 2025 goal
- 1.5 million zero emission cars

Painpoint
- Overcrowding, EV shuffling nightmare

Adaptive charging network (ACN) values
- Provide target charging capacity at smaller infrastructure and operating costs (30%-60%)
- Provide ancillary energy services

Technology





Network of adaptive EV chargers
- Real-time sensing, communication, optimization

Scalable scheduling algorithms
- Optimally meet user energy demands
- ... without exceeding infrastructure capacity

Management software
- Real-time optimization and control
- Mobile app, monitoring, alert

$$\mathrm{LP}(t): \quad \min_{r \geq 0} \quad C_t(r)$$
$$\text{s.t.} \quad r_i(\tau) \leq \overline{r}_i(\tau), \qquad \tau \geq t$$
$$\sum_{\tau=t}^{T-1} r_i(\tau)\delta = e_i(t)$$
$$\sum_{\tau=t} r_i(\tau) \leq P(\tau), \qquad \tau \geq t$$

Online LP algorithm

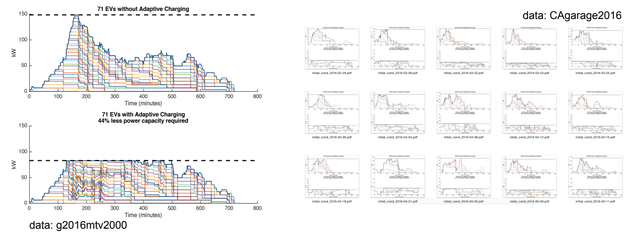
Suppose costs are uniformly monotone:

$$C(r) := \sum_t c_t \sum_i r_{it} \quad \text{with } c_t \text{ increasing in } t$$

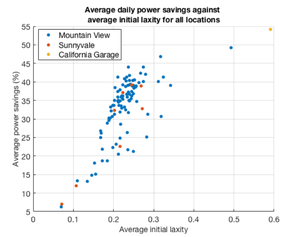
Theorem

Online LP attains offline optimal

Performance

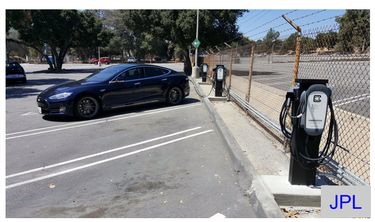


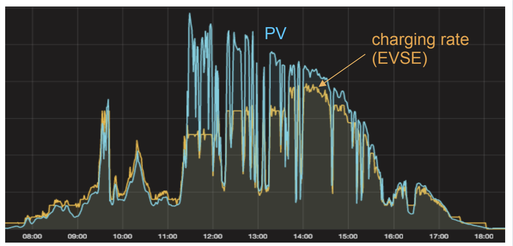
Real charging data
- Caltech, Google
- 52,362 charging sessions over 4,000 charging days at 104 locations
- significant power savings even at low laxity



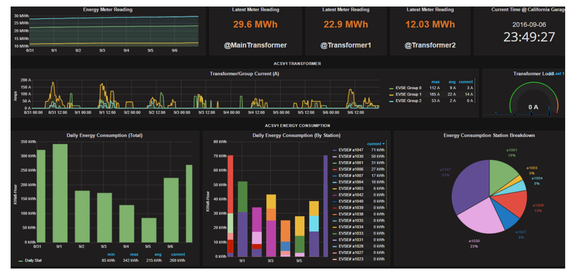
Daily peak power	Uncontrolled charging	ACN	Power savings
Caltech	85.3 kW	33.8 kW	60%
Mountain View	46.2 kW	28.4 kW	34%
Sunnyvale	94.0 kW	56.2 kW	29%

Deployment





ACN tracking PV generation in real time
- JPL demo, October 2016



Real-time monitoring

People

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