TELECOM Bretagne
Institut Mines-Télécom

Exploiting Electric Vehicles Mobility to Reduce Grid Dependency in Transit Areas

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Model description

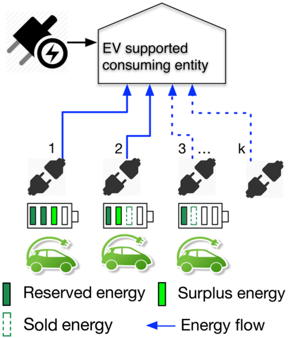

FIGURE: System setting

Input :

Average EV coming rate (λ/hour)

Average EV sojourn time ($\frac{1}{\mu}$hour)

Average surplus energy ($\frac{1}{\theta}$kWh)

On-peak electricity prices (g €/kWh)

Off-peak electricity prices (v €/kWh)

Facility power demand P_f kW

Output :

- Cost minimizing discharging power per EV
- Optimal number of dischargers

Where the problem lies ?

- Tradeoff on discharging power—P_0
  Power received by the facility, from discharging an EV at the power of P_0 kW is
  $$P = P_0(1 - \epsilon P_0) \quad (1)$$
  Money payed to the owner, for discharging its EV at the level of P_0 kW is
  $$P_0 v €/\text{hour}$$
- Tradeoff on number of dischargers—k
  Effective coming rate of EV is
  $$\lambda(1 - B(k))$$
  Each discharger has a fixed hourly cost
  $$A_d €/\text{h}$$

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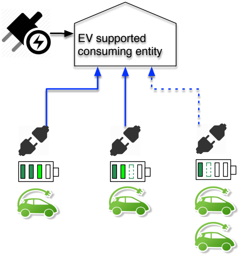
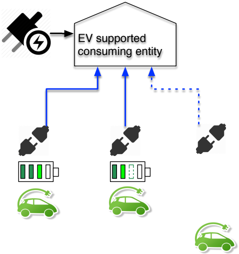
Unplugging the depleted ones at the price of U

No-unplugging : $\lambda(1 - B(k))$



Unplugging : $\lambda(1 - B'(k))$



Number of dischargers

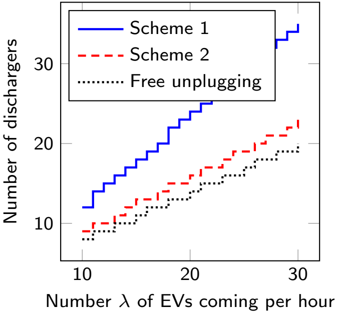


FIGURE: Optimal number of dischargers according to EV arrival rate $\lambda(\frac{1}{\theta} = 10)$

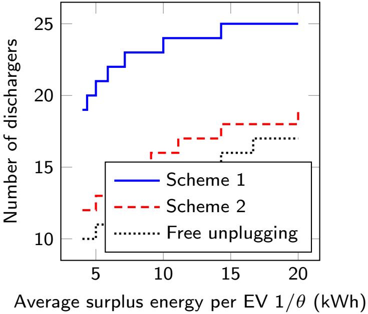


FIGURE: Optimal number of dischargers versus average surplus energy $1/\theta$ ($\lambda = 20$)

Cost savings

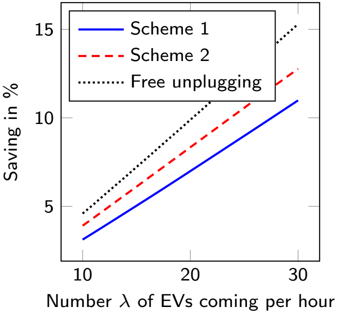


FIGURE: Variation of saving according to the EV arrival rate λ ($\frac{1}{\theta} = 10$)

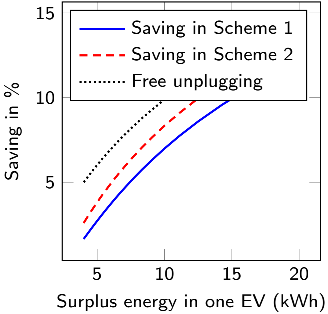


FIGURE: Variation of saving versus average EV surplus energy $1/\theta(\lambda = 20)$

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Q&A

Q : Are they willing to do that ? Is the discharging thing reliable in the first place ?

A : Good question, in fact we pay the owners 110% the energy we took, if they still decline to discharge, it's not our fault...

Q : How do you implement the unplugging ? Manually ? And where do you put the unplugged EVs ?

A : Frankly speaking, that depends on your imagination. E.g. there can be a large parking lot quite vacant, but not equipped with dischargers, more aggressively, when self driven cars hit the road we would have free unplugging.

Any other questions ?

Stochastic analysis—Markov chains

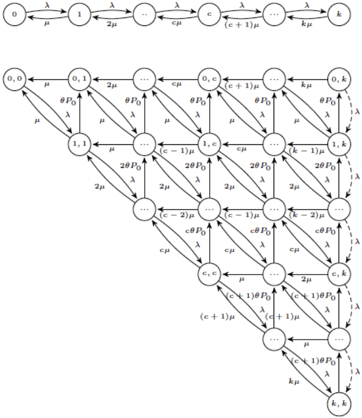

FIGURE: Evolution of the number of plugged EVs *(top)* and of (nb_discharging_EVs,nb_plugged_EVs) *(bottom)*.

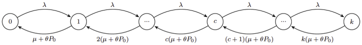

FIGURE: Transition diagram for the number of discharging EVs in the unplugging scheme

Cost analysis

- No-unplugging scheme :

$$C_{ost}(k,n) = nP_0v_0 + (P_f - n\underbrace{P}_{=P_0(1-\epsilon P_0)})g + kA_d \tag{2}$$

$$C_1(k) = \sum_{n=0}^{k} C_{ost}(k,n)\mathbb{P}_{\text{steady-state}}(n_t = n) \tag{3}$$

- Unplugging scheme :

$$C'_{ost}(k',n) = nP_0v_0 + (P_f - n\underbrace{P}_{=P_0(1-\epsilon P_0)})g + k'A_d + W(k')U \tag{4}$$

$$C_2(k') = \sum_{n=0}^{k'} C'_{ost}(k',n)\mathbb{P}'_{\text{steady-state}}(n_t = n) \tag{5}$$

Discharging power :

$$P_0(n) = \begin{cases} P_0^* = \frac{\mu}{\theta}(\sqrt{1+\frac{\theta}{\epsilon\mu}(1-\frac{v_0}{g})}-1) & \text{if } n \leq \frac{P_f}{P^*}. \\ \frac{1-\sqrt{1-4\epsilon P_f/n}}{2\epsilon} & \text{otherwise.} \end{cases} \tag{6}$$