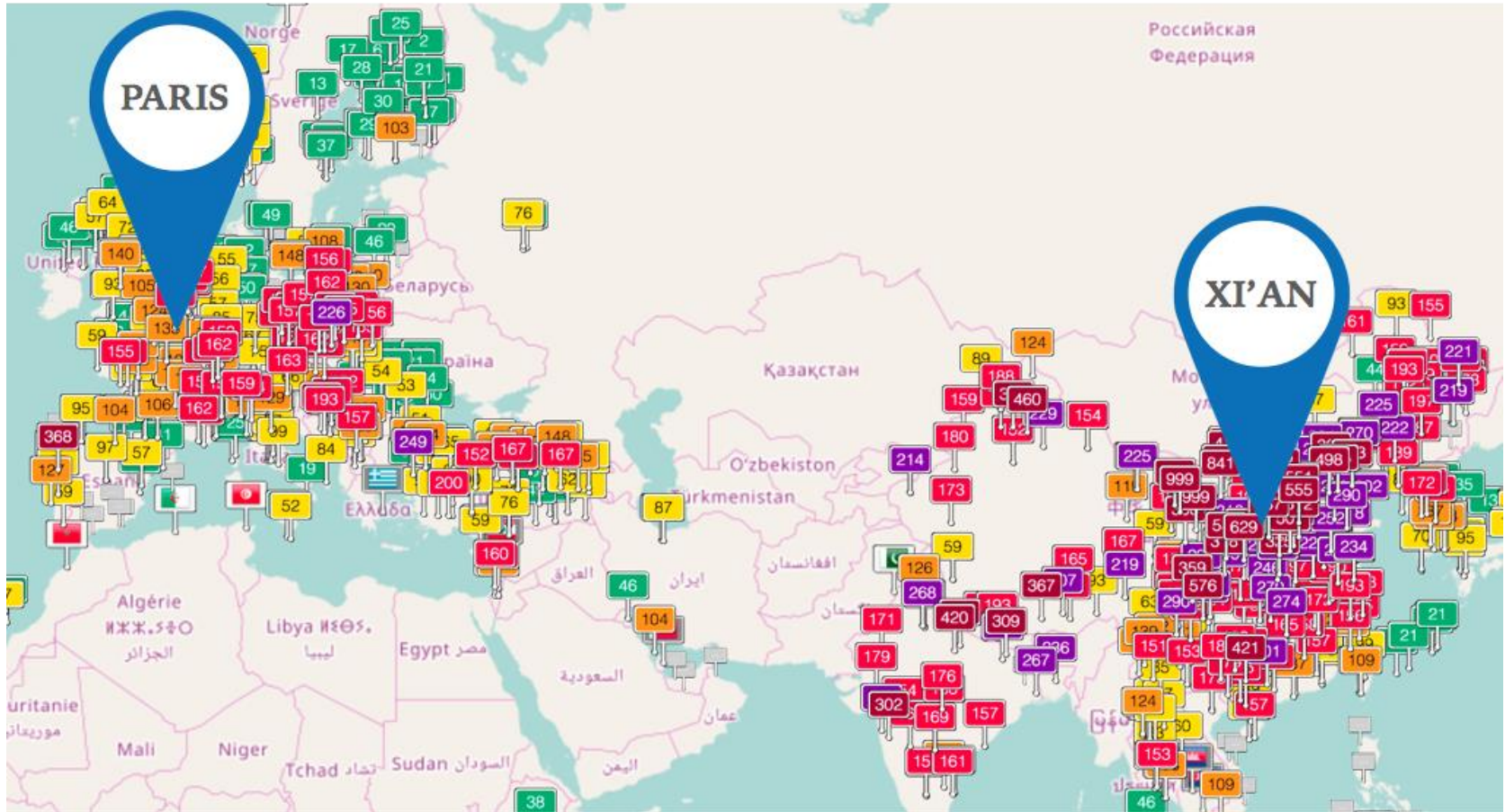


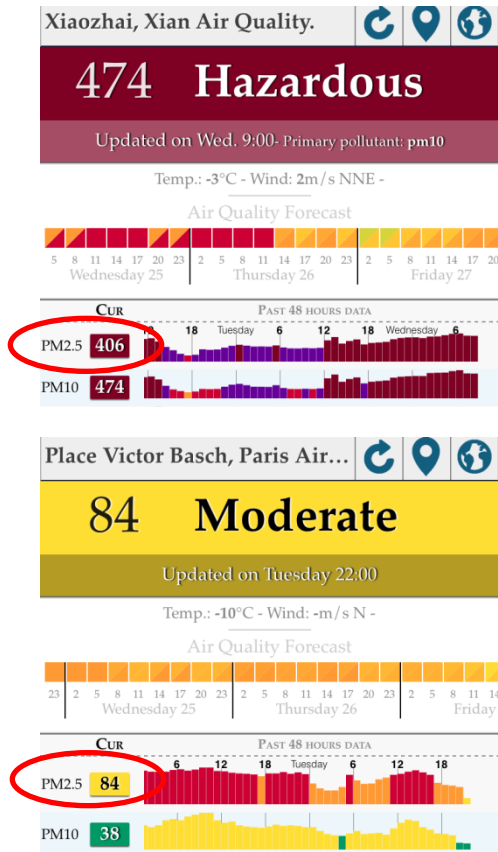


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away from haze, Driving

---Management of Electric Vehicle Systems with Self-interested Actors





How come?

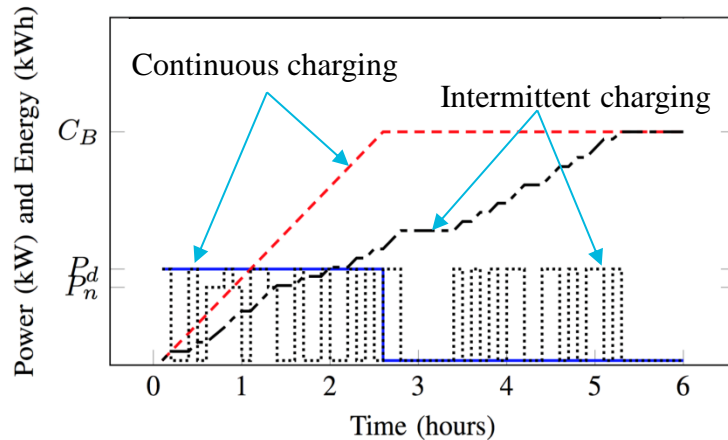
- ▶ Currently in Beijing, on-road **vehicles** account for **31%** of small particulate matter (PM_{2.5}) concentration. [1]
- ▶ ... Coal combustion in **power plants** contributes averagely **12%** (of PM_{2.5}) in North China.[2]

- [1] Vehicle emission control in Beijing. (2014) By Beijing Environmental Protection Bureau shared with The international council on clean transportation
- [2] Ma, Q., Cai, S., Wang, S., Zhao, B., Martin, R., Brauer, M., Cohen, A., Jiang, J., Zhou, W., Hao, J., Frostad, J., Forouzanfar, M. and Burnett, R. (2016). Impacts of Coal Burning on Ambient PM_{2.5} Pollution in China. *Atmos. Chem. Phys.*



Solutions?

- ▶ Currently in Beijing, on-road **vehicles** account for **31%** of small particulate matter ($PM_{2.5}$) concentration.
 - ---> *Transportation electrification*
- ▶ ... Coal combustion in **power plants** contributes averagely **12%** (of $PM_{2.5}$) in North China.
 - ---> *Renewable energy penetration*
- ▶ Coordinated charging of EVs.



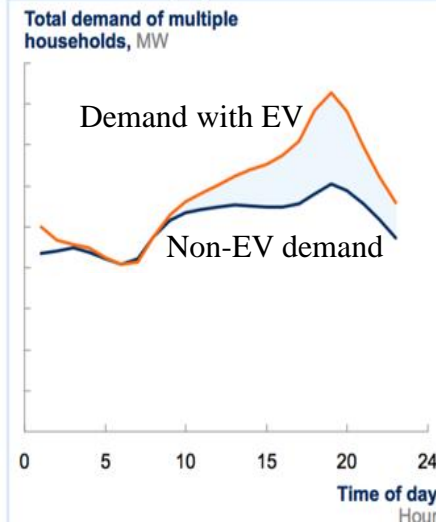
Opportunities:

- ▶ Vally-filling
- ▶ Smoothing renewable energy generation
- ▶ Arbitraging using real time electricity prices
- ▶ Revenue increasing through cooperatiion with grid operator
- ▶ ...

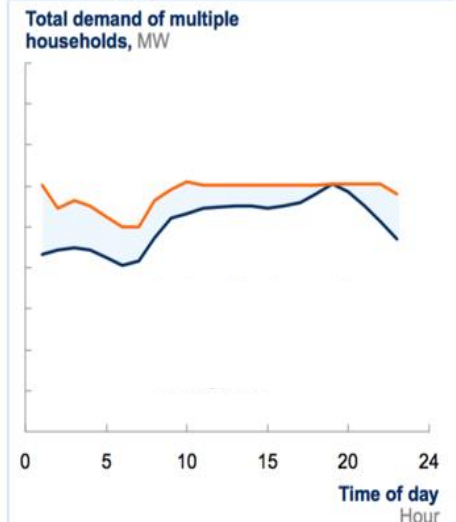
EV charging features:

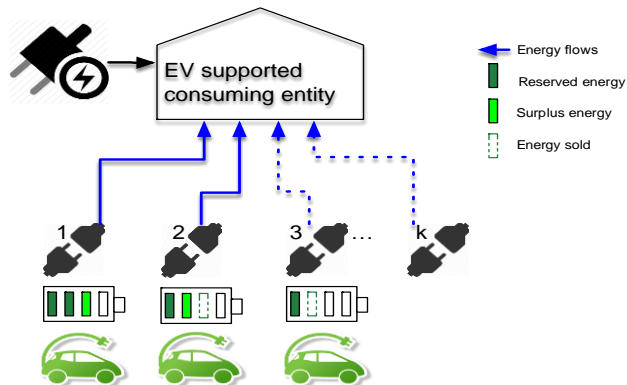
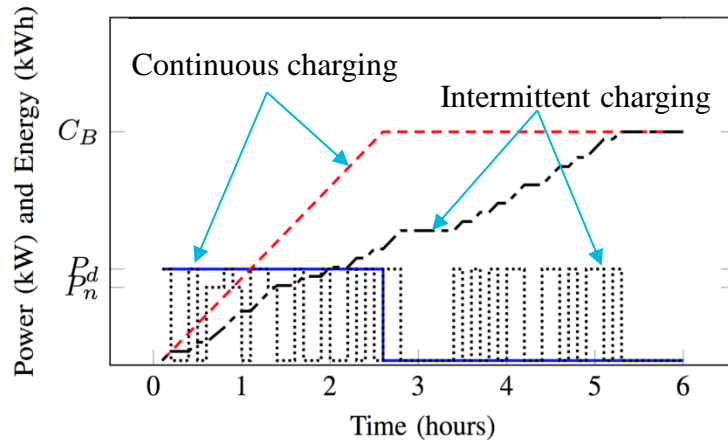
- ▶ Large battery
- ▶ Delay-able demand
- ▶ Long plug-in time
- ▶ Auto-Mobile
- ▶ Optional discharging (Vechie-to-Grid)

Uncontrolled charging



Smart charging





Our proposals:

- ▶ One charging station providing two types of charging services, i.e., Continuous and Intermittent, to EV owners at deferent prices.
 - -->> *Price discrimination increase station revenue and user utility*
- ▶ Two charging stations, each priding one type of charging service, compete for the users.
 - -->> *Competition brings down electricity price and attracts more EV owner accepting the grid-friendly, i.e., Intermittent charging service*
- ▶ EV owners selling surplus energy to a high volume user, making money from the price gap between peak time and night time.
 - -->> *A win-win for both seller and buyer*