

# IoT for Smart Transportation Systems

Sebastian Stein ([ss2@ecs.soton.ac.uk](mailto:ss2@ecs.soton.ac.uk))  
University of Southampton

Joint work with: Enrico Gerding, Valentin Robu, Keiichiro Hayakawa, Sofia Ceppi, Adrian Nedeia, Avi Rosenfeld, Mathijs de Weerd, Nick Jennings, Maciej Drwal

# Climate change needs to be mitigated

2016 hottest year ever recorded - and scientists say human activity to blame

- Final data confirms record-breaking temperatures for third year in a row
- Earth has not been this warm for 115,000 years

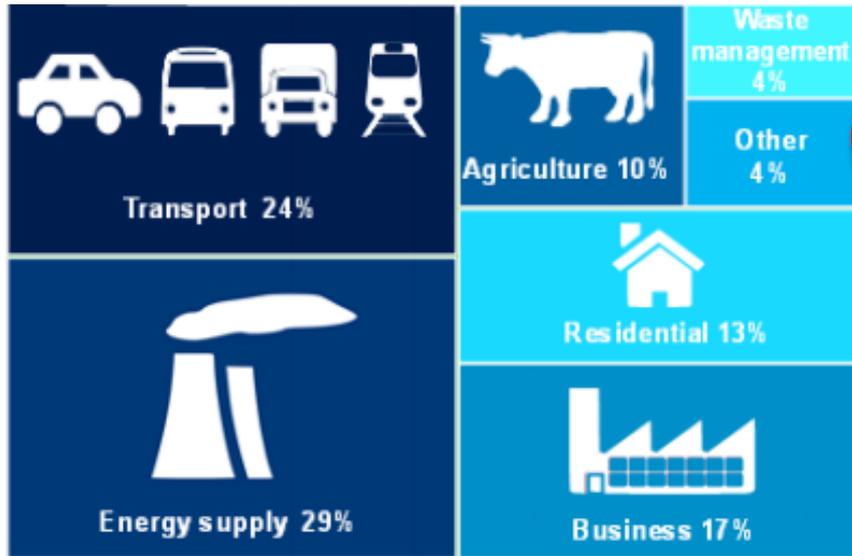


The natural El Niño climate phenomenon helped ramp up temperatures to “shocking” levels in early 2016.  
Photograph: P B Verma/Barcroft Images

2100?



# Transportation is a major contributor of greenhouse emissions



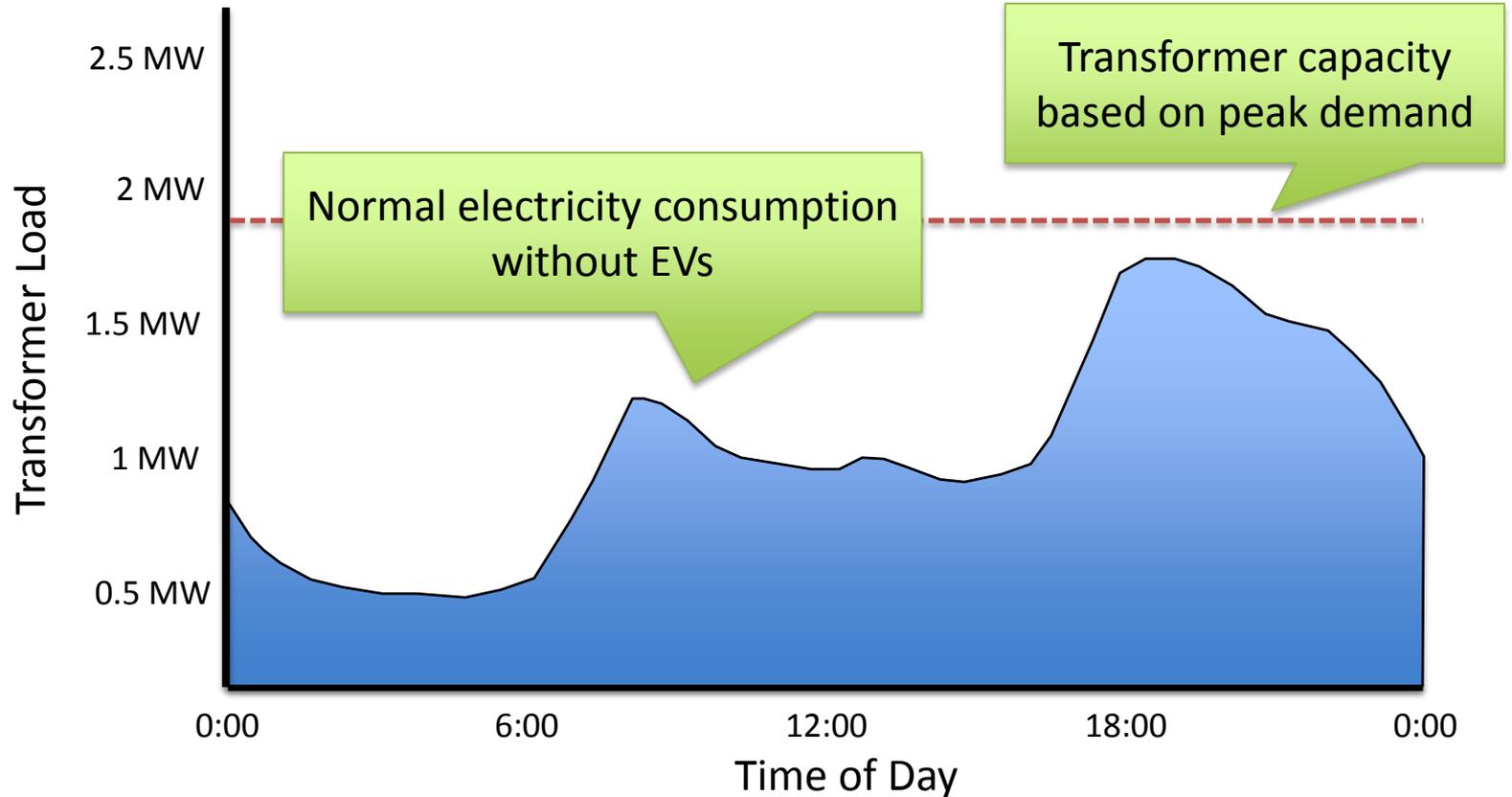
- Electric vehicles



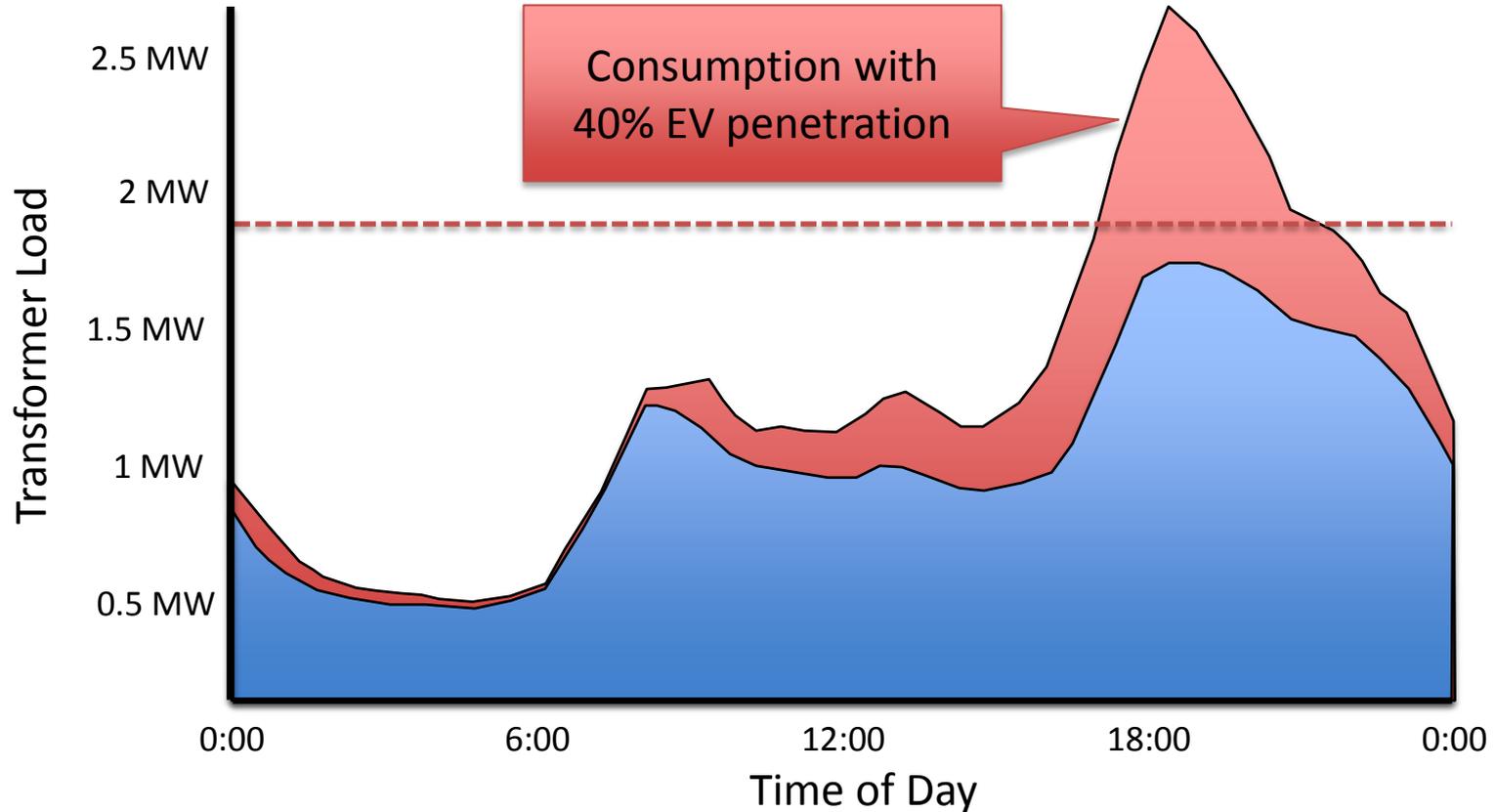
- New ownership models



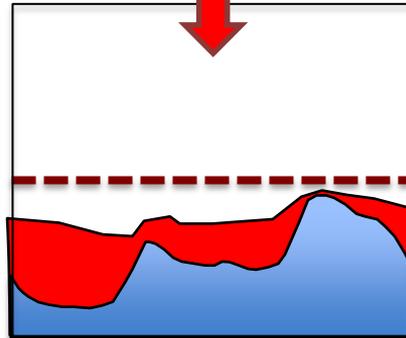
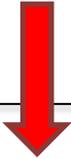
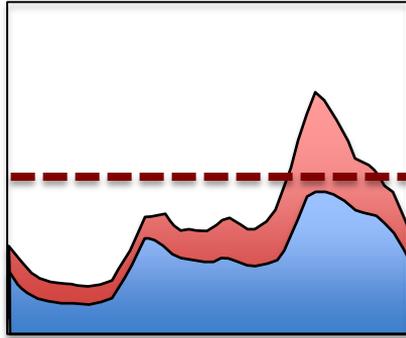
# Uncontrolled EV charging will cause considerable strains on grid



# Uncontrolled EV charging will cause considerable strains on grid



# We need to balance loads better



## Charge electric cars smartly to take pressure off national grid - minister

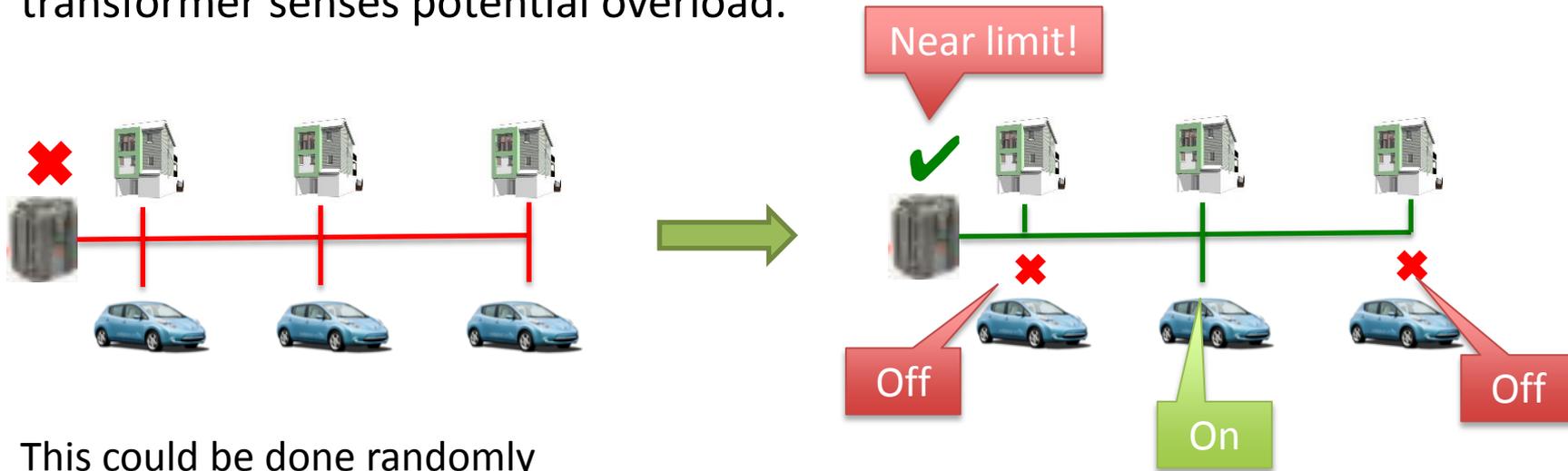
SSE trials 'demand-side response' where vehicles start charging a few hours after being plugged in, when demand is lower



An electric car is charged on a London street. Photograph: Miles Willis/Getty Images for Go Ultra Low

# IoT-based Smart Charging

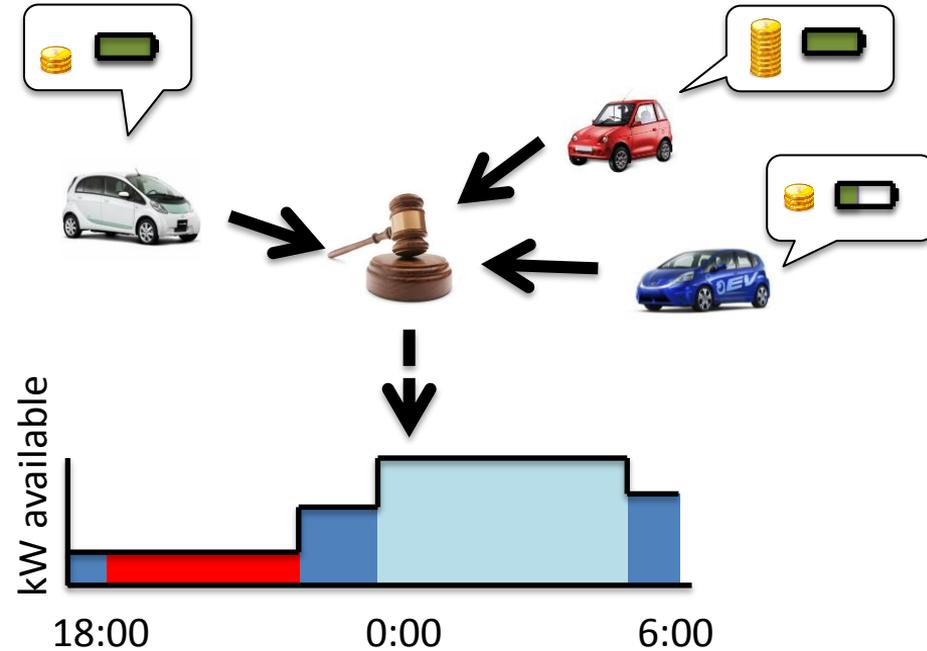
- Charging points are *connected* and switched off automatically when local transformer senses potential overload.



- This could be done randomly
- But: not based on drivers' requirements for charging, so can be very inefficient
  - Example: Everyone charges just too little for their journeys the next day

# Intelligent Incentive-Aware Smart Charging

- EV drivers **bid for electricity** when they plug in their vehicle (using an interface on their IoT-equipped chargepoint or a mobile app)
  - The bid includes both *requirements* (e.g., charging deadline and amount of energy needed by deadline) and maximum *willingness to pay*
- Charging is **coordinated centrally**, taking into account all drivers' constraints and their bids / valuations
- Payments are carefully designed using **game theory** to prevent strategic bidding. In particular, drivers have no incentive to:
  - overstate their requirements
  - understate their willingness to pay



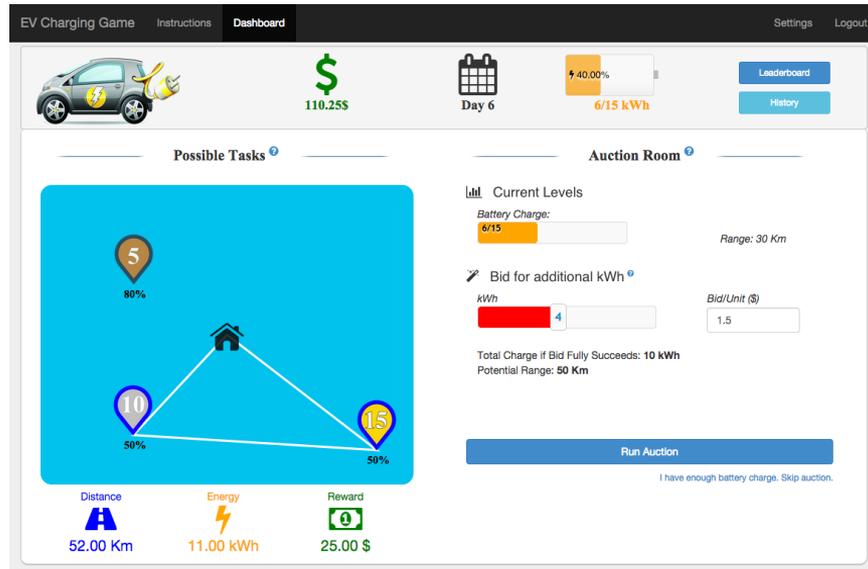
# Intelligent Incentive-Aware Smart Charging

- Benefits:
  - Charging is coordinated in real time, based on current transformer load
  - More flexible drivers are automatically deferred to less congested times
  - Drivers that urgently need electricity are prioritised
    - But may end up paying more if competition is high
  - Bidding can be delegated to intelligent software agents that learn a driver's travel patterns and willingness to pay
  - Experiments show we can sustain up to 40% more electric vehicles within a given set-up.
- But many challenges remain...

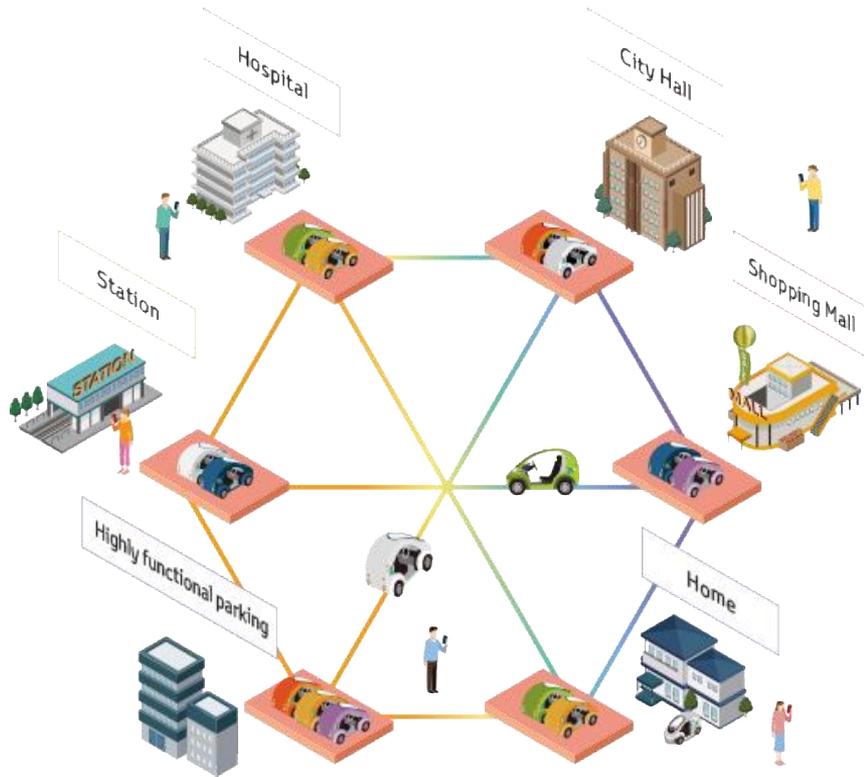


# Open Challenges

- Expense of real-world trials



# Carsharing



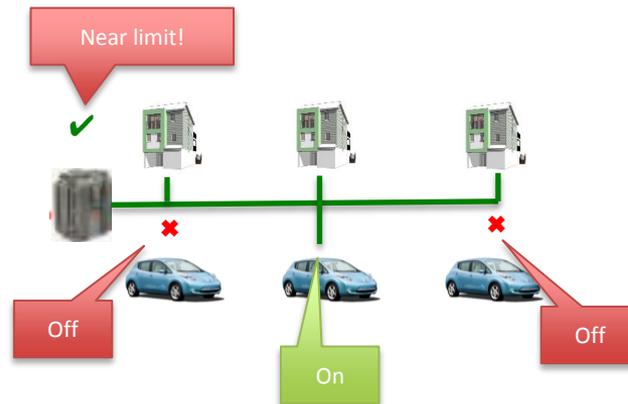
**TOYOTA**



- We use adaptive incentives to balance availability in real time within a carsharing system.

# Conclusions

- IoT technologies enable **smart EV charging schemes**.



- Their full potential is achieved using **intelligent** and **incentive-aware** algorithms

# Trends

