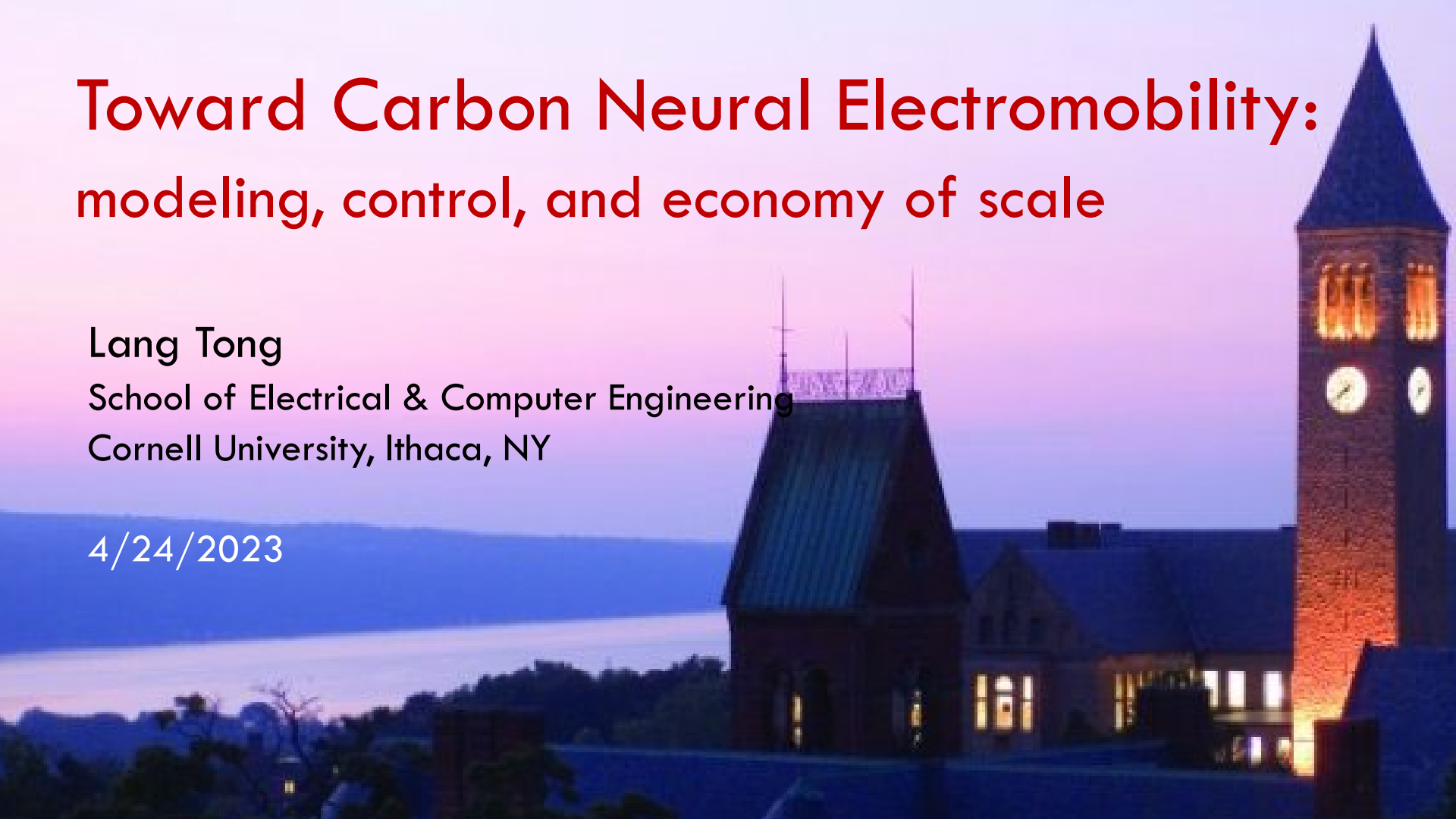


Toward Carbon Neural Electromobility: modeling, control, and economy of scale

Lang Tong

School of Electrical & Computer Engineering
Cornell University, Ithaca, NY

4/24/2023



Premises of discussion

- Electric power and transportation represent 60% of total energy consumption. Electrified transportation is a path toward carbon neutral electromobility.
- Electricity must (and will) be a clean (possibly scarce and not necessarily cheap) energy source.
- Upgrading the aging grid may prove to be far more expensive and far slower than that required to meet ambitious goals.
- A silver lining lies in the new **science and technology of electromobility** to induce positive feedback in investments in the electric and transportation infrastructure.



A Fresno streetcar stuck in traffic, in 1938. (Fresno Beehive)



Home > News > Cars & Auto

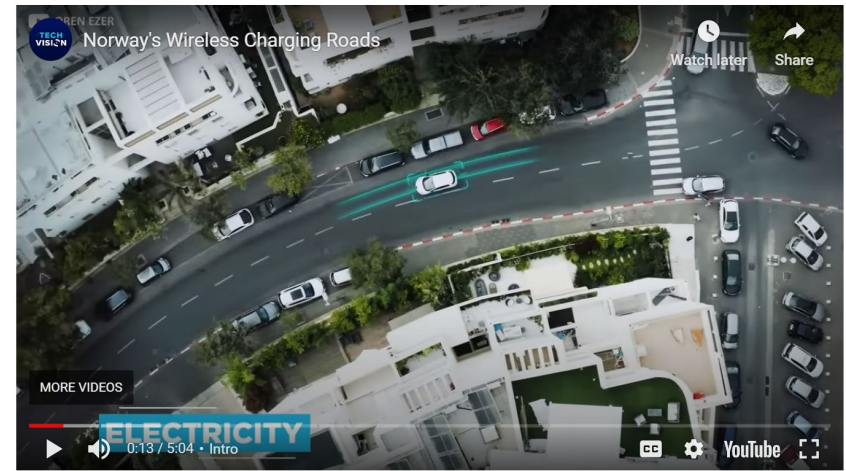
Michigan Plans 'First-in-the-US' Wireless Electric Vehicle-Charging Road

ElectReon has been tapped to build the mile-long section of road outside Detroit.



By Nathaniel Mott

February 5, 2022



The carbon footprint of batteries

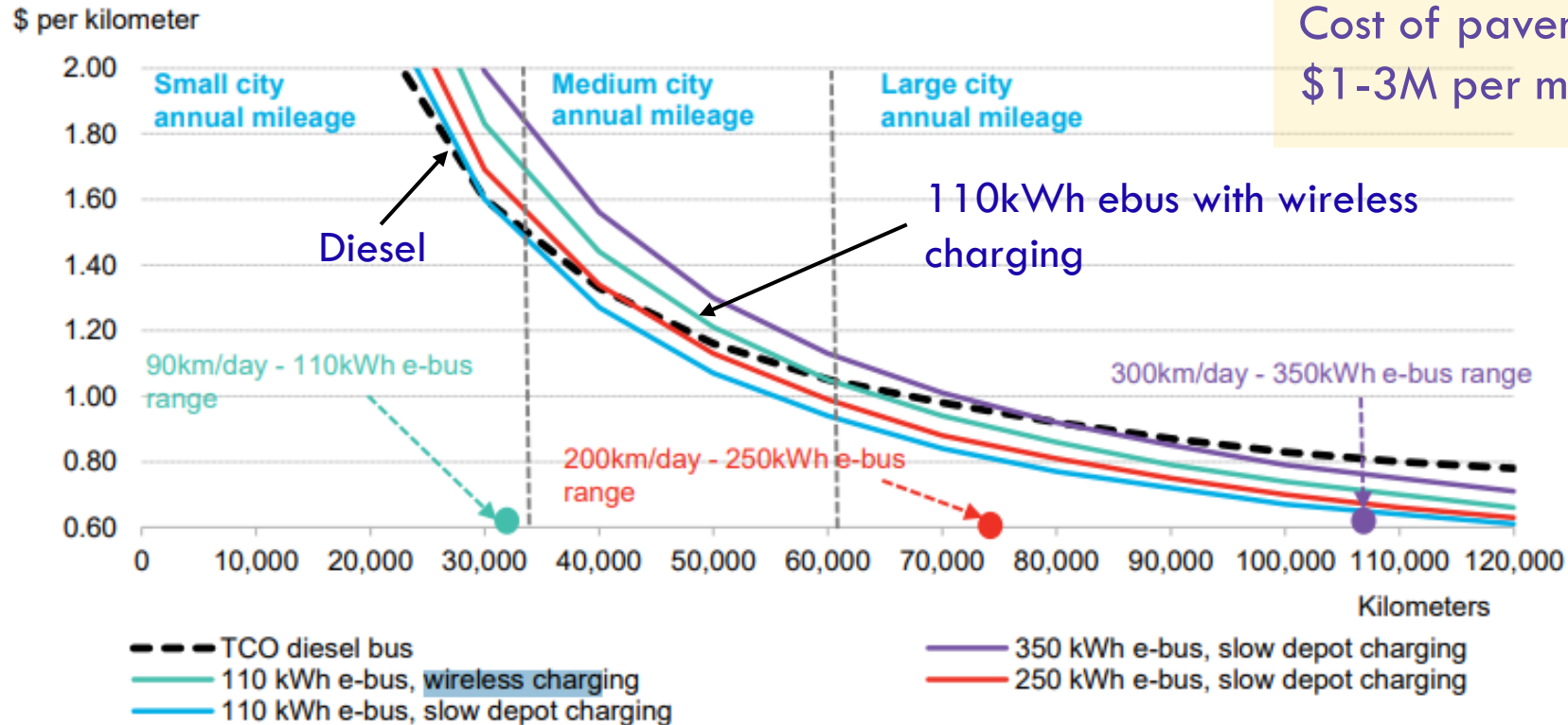
Manufacturing an 80kWh Li-ion battery of Tesla produces 2.5-16 metric tons of CO₂, equivalent to the emission of a gas-powered car driving 6K to 40K miles.

<https://climate.mit.edu/ask-mit/how-much-co2-emitted-manufacturing-batteries>

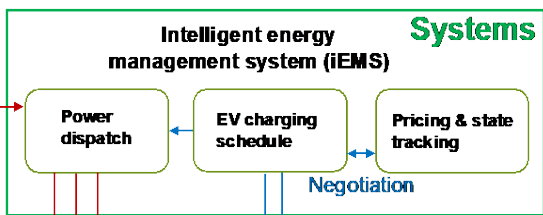


Economics of wireless charging

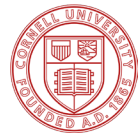
Figure 20: TCO comparison for e-buses and diesel buses with different annual distance travelled



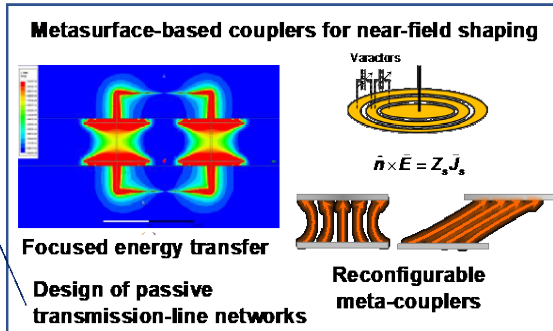
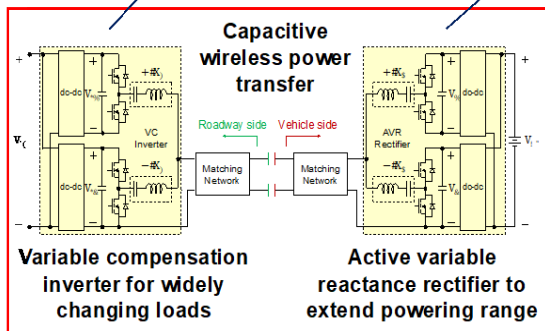
Source: Bloomberg New Energy Finance. Notes: Diesel price at \$0.66/liter (\$2.5/gallon), electricity price at \$0.10/kWh, annual kilometers traveled – variable. Bus route length will not always correspond with city size.



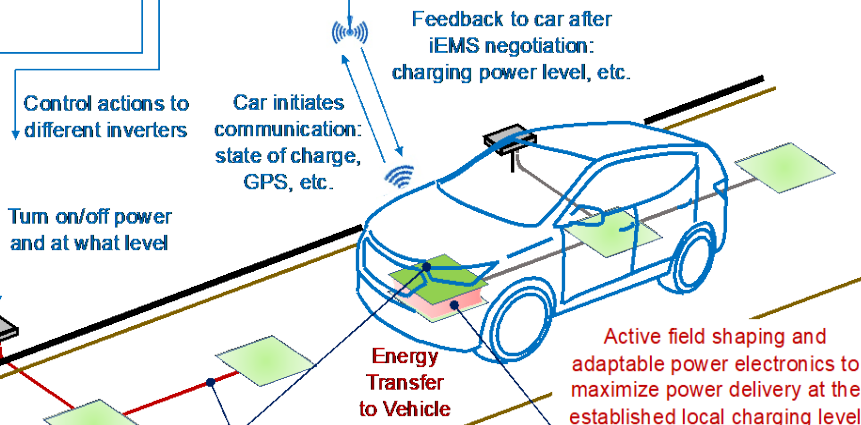
Dynamic Wireless Charging System for Electric Vehicles



Circuits

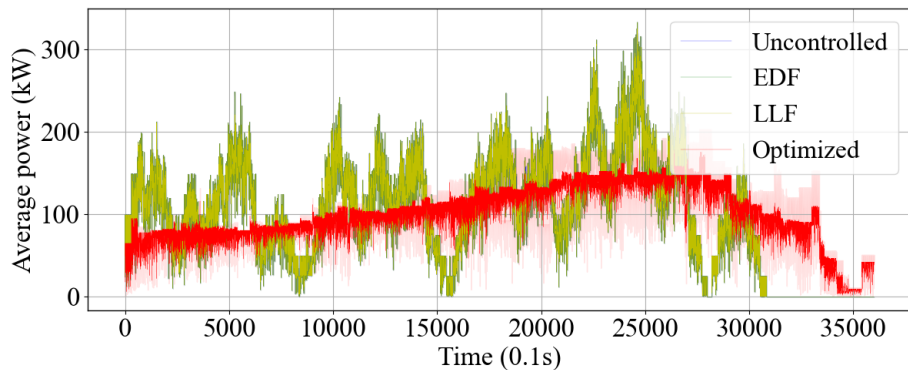
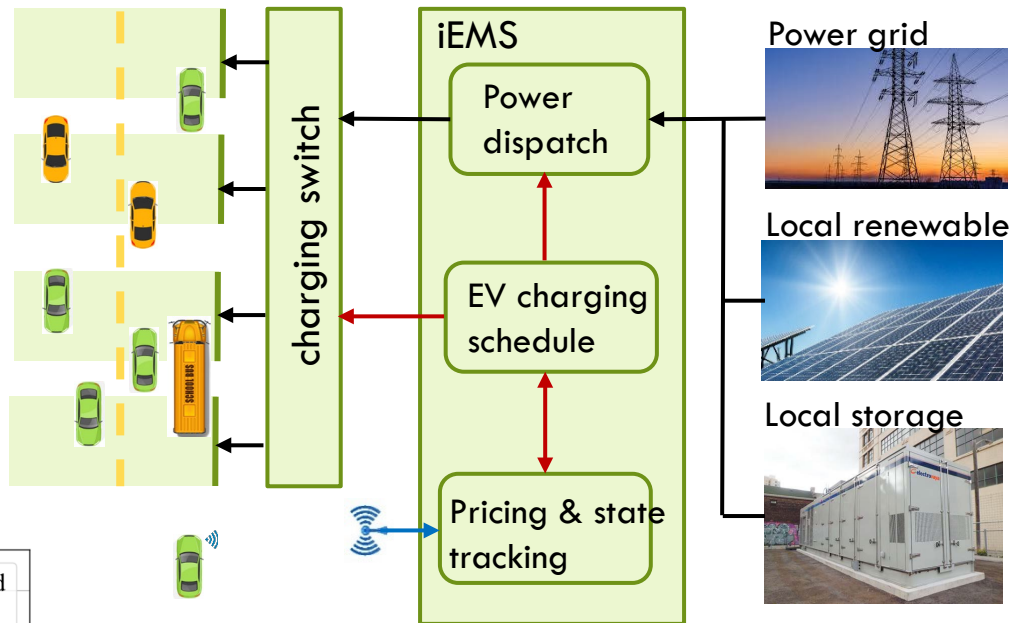
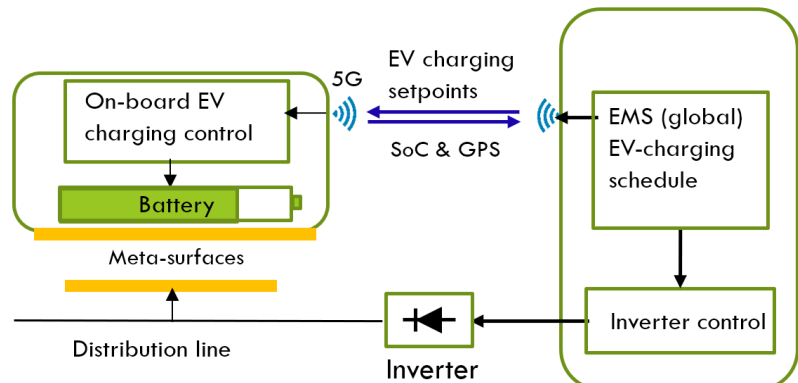


- 50kW dynamically capacitive charging with optimized power delivery profiles.
- Smart antenna: metasurface-based couplers for focused energy transfer.
- Hierarchical energy management
 - controls charging pad (millisecond)
 - dispatches resources (minute),
 - coordinates with traffic demands
 - Pricing signals and tiered quality of services



Fields

Intelligent Energy Management Systems



Transformer Rating (kVA)	200	400	600	800	1000
# AVR	3	6	10	13	16

Economics of EV charging

Demand: EV charging (including dynamic wireless charging) induces dynamic and stochastic electromobility; vehicle location, speed, and traffic volume produce complex and stochastic power flows, posing challenges in grid management.

Supply. A few profit-seeking integrated service providers

- Hierarchical energy management, QoS-based price incentives
- Coordination with DSO and participation in wholesale markets

Investments: who, policies, planning, ...

“The era of big government is over.” 1996, Bill Clinton