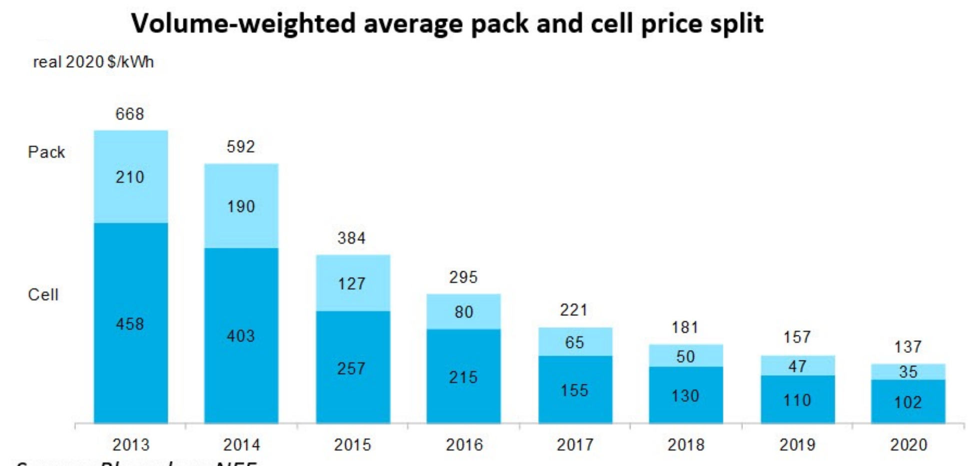
Unlocking the Value of Electric Vehicles as Grid Assets

Eilyan Bitar (eyb5@cornell.edu)
School of Electrical and Computer Engineering
Atkinson Center for Sustainability
Cornell University

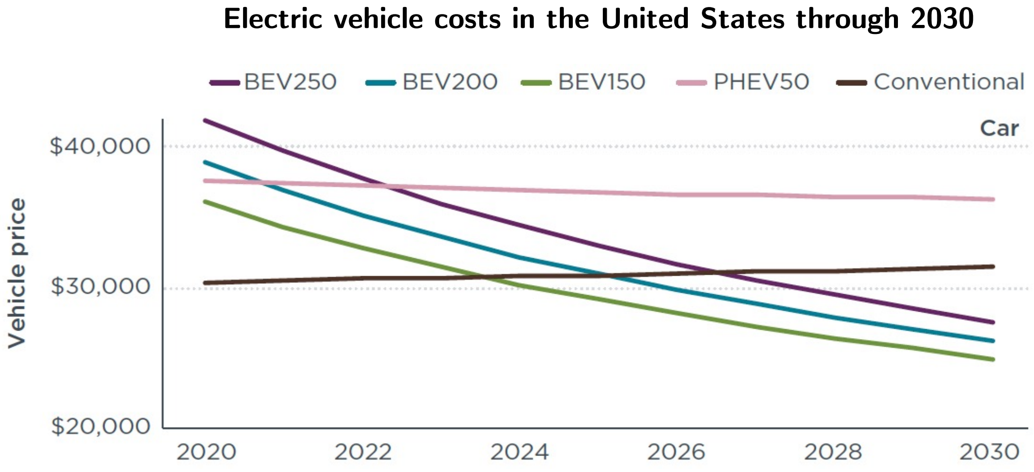
Electric Vehicles Are Coming

- Declining battery costs
- Progressive policy and incentives
- Automakers betting big on EVs
- Greenhouse gas emission reductions

But is the grid ready?



Source: BloombergNEF



Source: Lutsey et al. (2019)

Outline

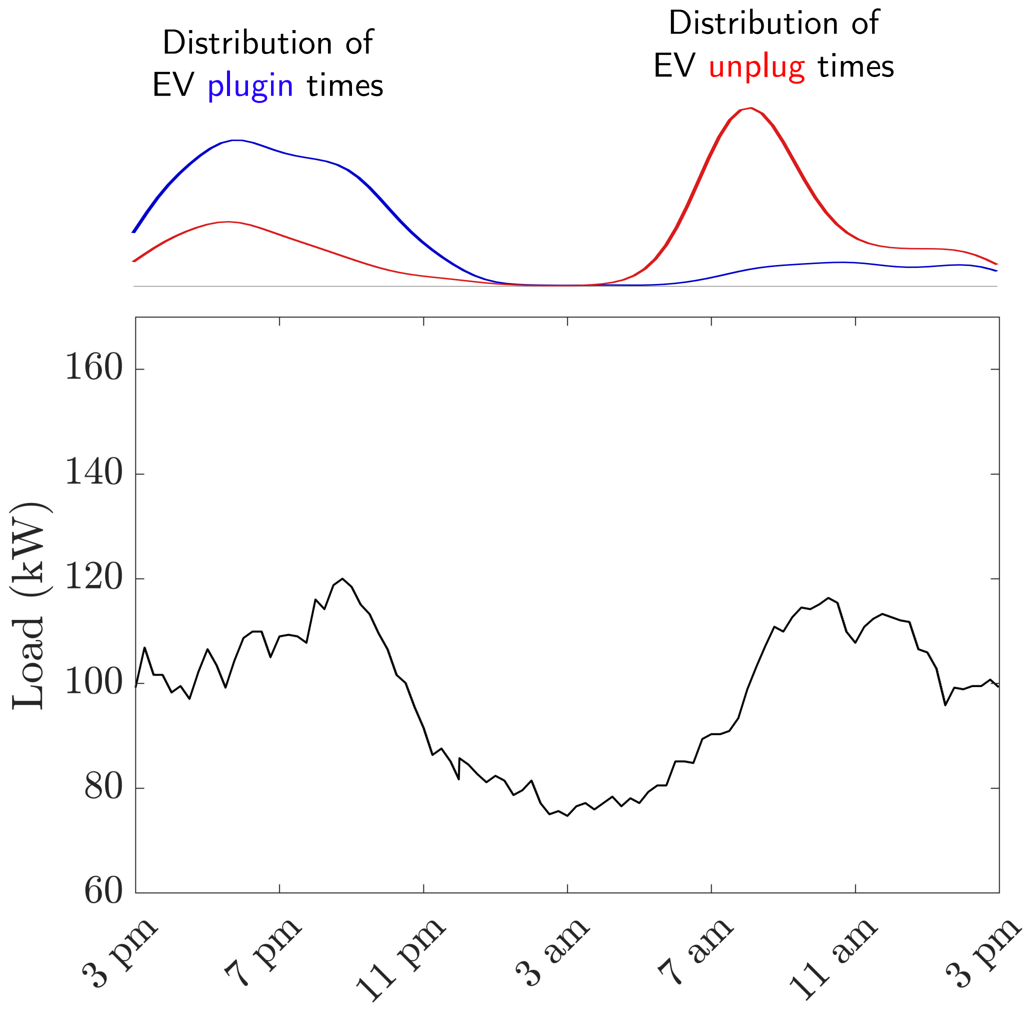
- A pilot study – OptimizEV (joint work with Polina Alexeenko)
- Grid impacts of unmanaged EV charging
- Harnessing the flexibility of EV charging to minimize strain on grid
- Decarbonizing the transportation sector (and why renewables need EVs)
- Other opportunities and risks...

NSF NEW YORK STATE OF OPPORTUNITY. NYSERDA NEW YORK STATE OF OPPORTUNITY. Department of Public Service NYSEG

A Real-World Pilot Study

- The OptimizEV pilot
  - Real-world study of residential EV charging patterns
  - 35 participants in Tompkins County, NY
  - Equipped with Level-2 chargers (7.7 kW max power)
  - Pilot ran from January 2020 – May 2021

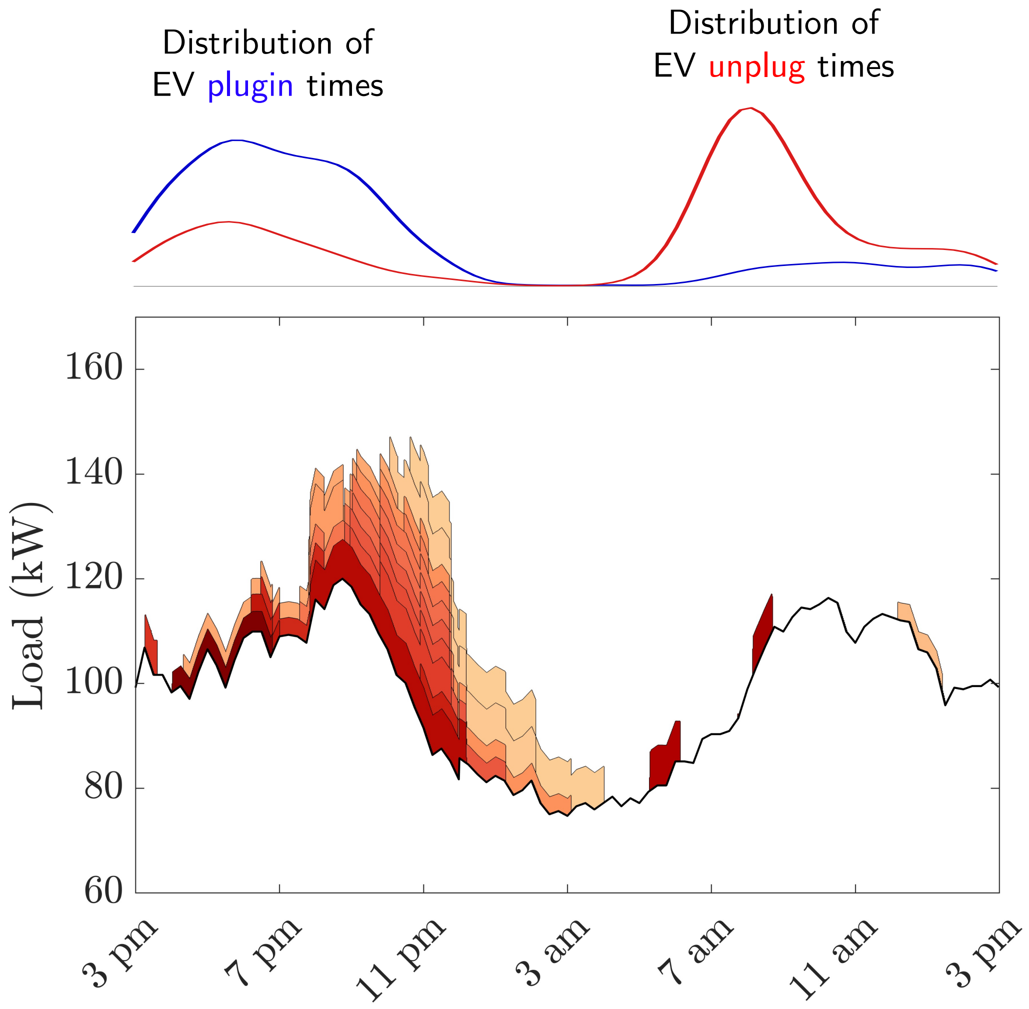
- Three scenarios studied:
  1. Unmanaged EV charging
  2. EV charging based on time-of-use pricing
  3. Optimized EV charging



Impact of Unmanaged EV Charging

- The OptimizEV pilot
  - Real-world study of residential EV charging patterns
  - 35 participants in Tompkins County, NY
  - Equipped with Level-2 chargers (7.7 kW max power)
  - Pilot ran from January 2020 – May 2021

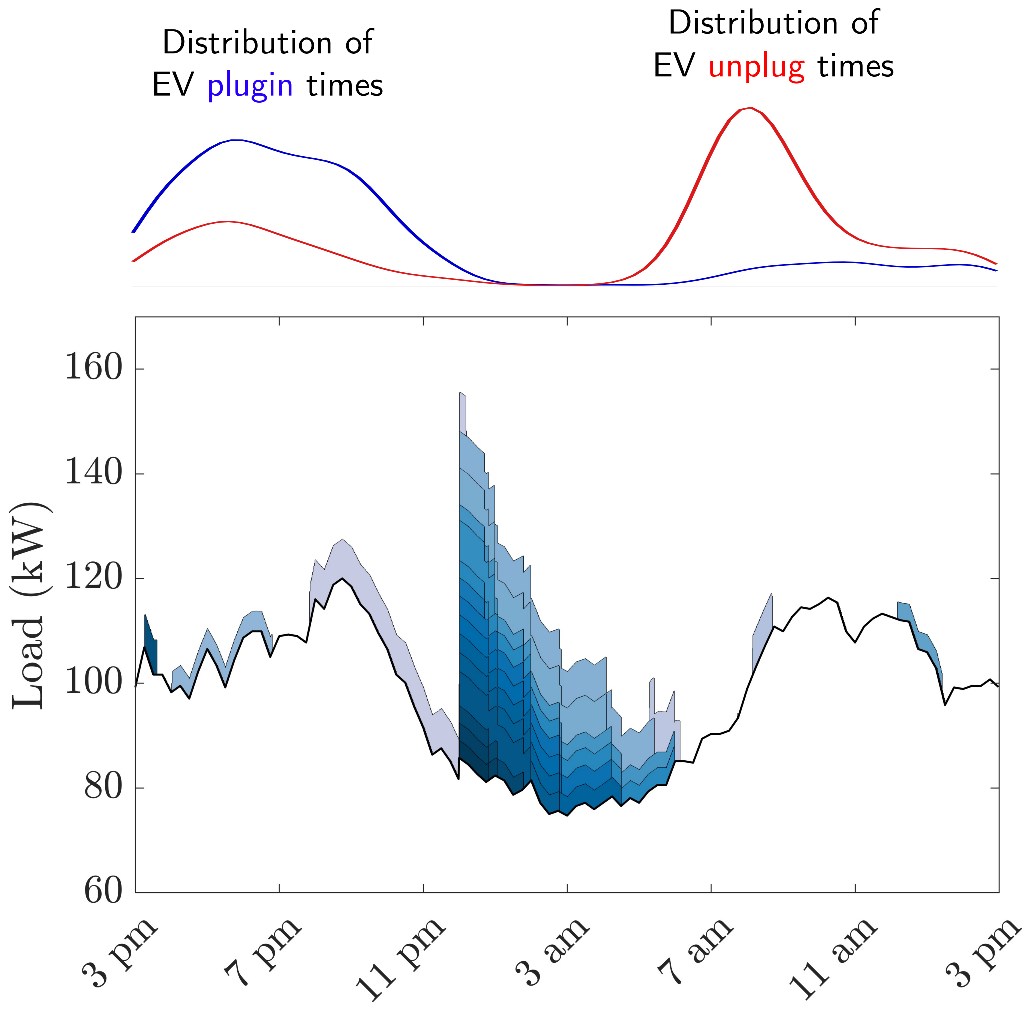
- Three scenarios studied:
  1. Unmanaged EV charging
  2. EV charging based on time-of-use pricing
  3. Optimized EV charging



Unintended Consequences of Time-of-Use Pricing

- The OptimizEV pilot
  - Real-world study of residential EV charging patterns
  - 35 participants in Tompkins County, NY
  - Equipped with Level-2 chargers (7.7 kW max power)
  - Pilot ran from January 2020 – May 2021

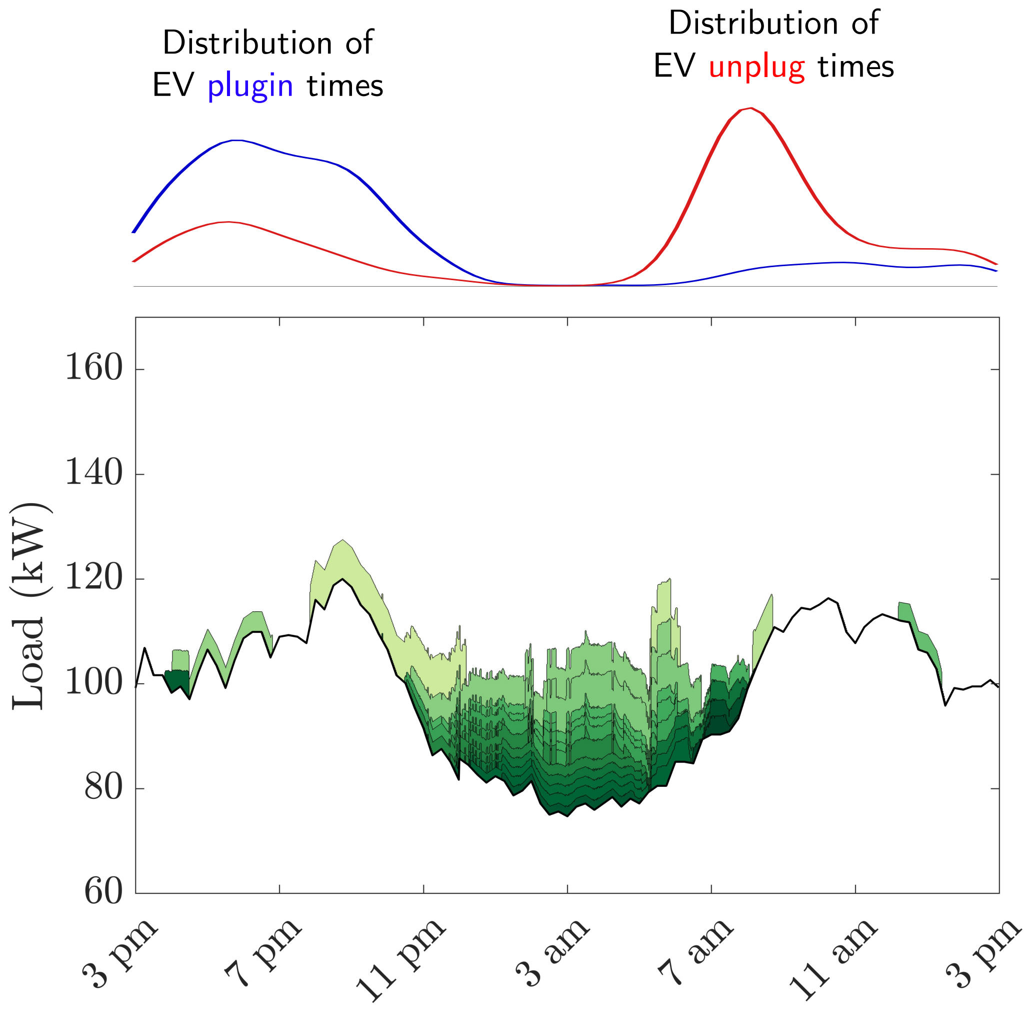
- Three scenarios studied:
  1. Unmanaged EV charging
  2. EV charging based on time-of-use pricing
  3. Optimized EV charging



Optimized “V1G” Charging

- The OptimizEV pilot
  - Real-world study of residential EV charging patterns
  - 35 participants in Tompkins County, NY
  - Equipped with Level-2 chargers (7.7 kW max power)
  - Pilot ran from January 2020 – May 2021

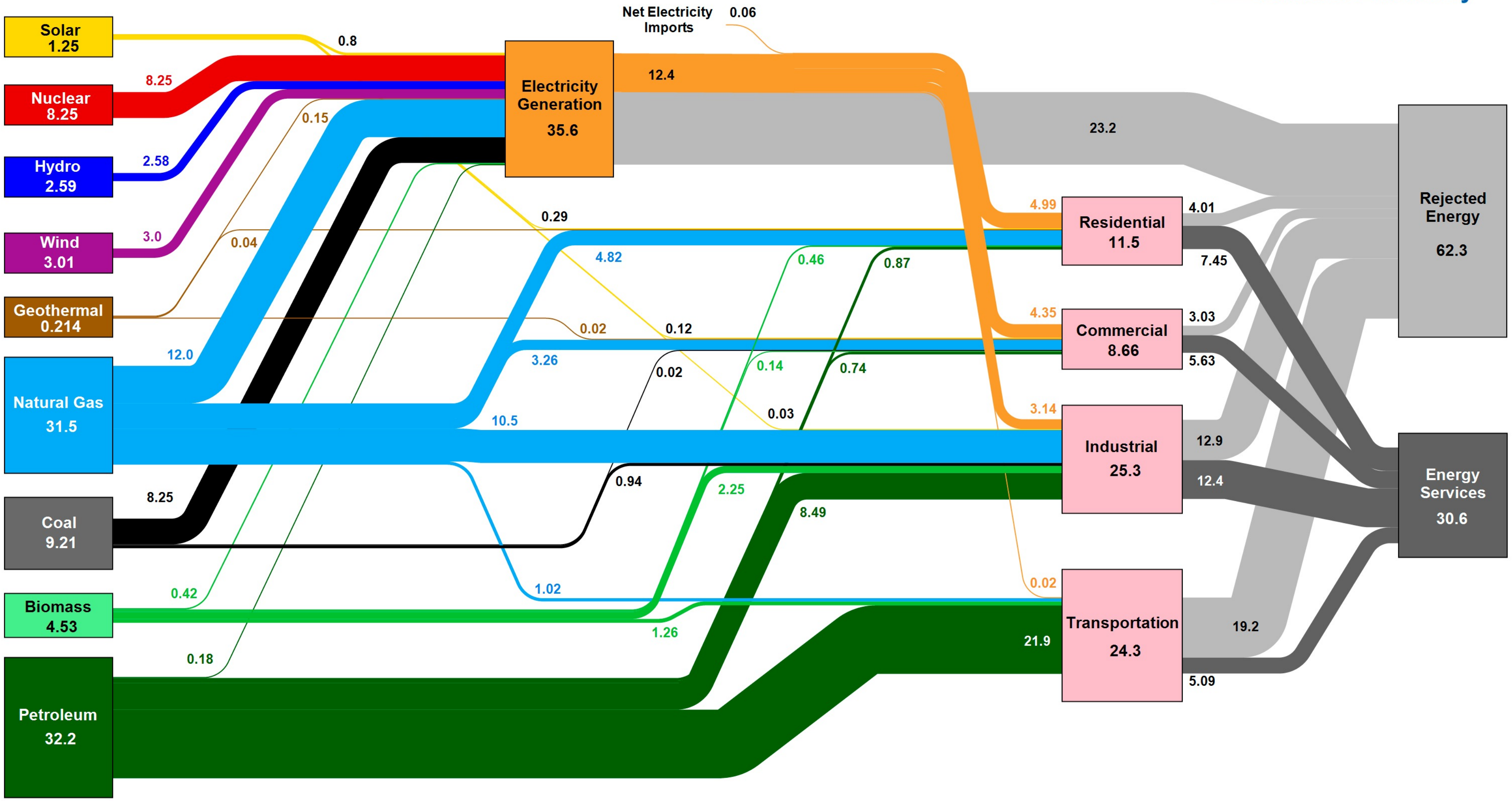
- Three scenarios studied:
  1. Unmanaged EV charging
  2. EV charging based on time-of-use pricing
  3. Optimized EV charging



The Decarbonization Potential of EVs

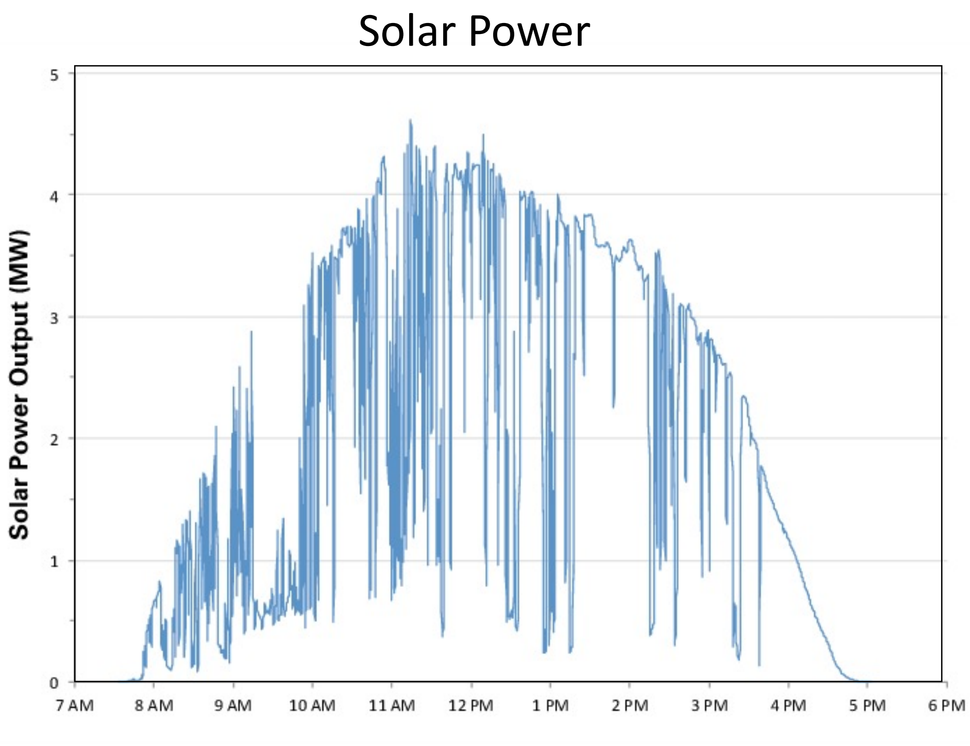
Estimated U.S. Energy Consumption in 2020: 92.9 Quads

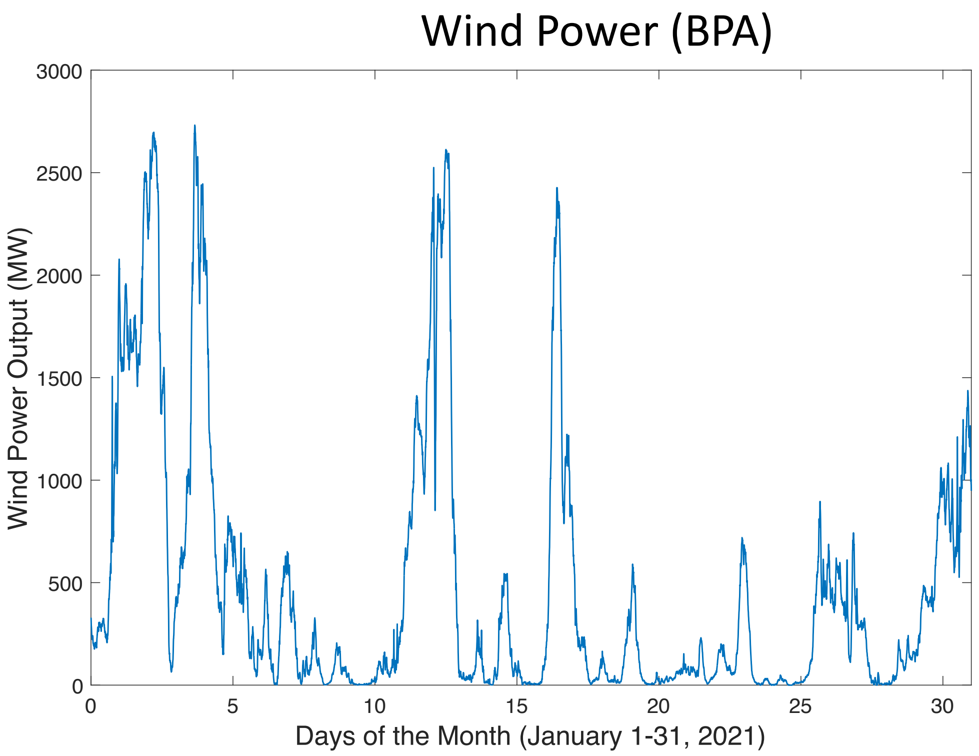
Lawrence Livermore National Laboratory



Source: LLNL March, 2021. Data is based on DOE/EIA MER (2020). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

A Symbiotic Relationship Between EVs and Renewables





- Wind and solar power are highly variable and notoriously hard to forecast
- Through optimized charging, EVs can balance this variability by acting like a giant battery (by absorbing and suppling power to the grid – V2G)

Key Takeaways, Opportunities, and Risks

- If left unmanaged, EVs will stress grid, requiring costly infrastructure upgrades
- However, EVs are inherently flexible
- Smart charging technologies (V1G/V2G) can tap this flexibility to:
  - Increase utilization rate of existing grid infrastructure
  - Balance intermittency of renewables
  - Provide energy and ancillary services to the bulk power grid
- EVs can increase resilience by providing emergency backup power during outages
- Increased visibility/control at the grid-edge comes with increased risk of cyberattacks

Eilyan Bitar
School of Electrical and Computer Engineering
Atkinson Center for Sustainability
Cornell University
Email: eyb5@cornell.edu
Website: https://bitar.engineering.cornell.edu/

Reading Material

- E. Bitar, *Prepare Grid Now to Power EVs*. Albany Times Union, April, 9, 2021.
- P. Alexeenko and E. Bitar, *Harnessing the Flexibility of Plug-in Electric Vehicle Charging with Incentives and Real-time Control: A Pilot Study*. Preprint, 2021. (Email for copy)