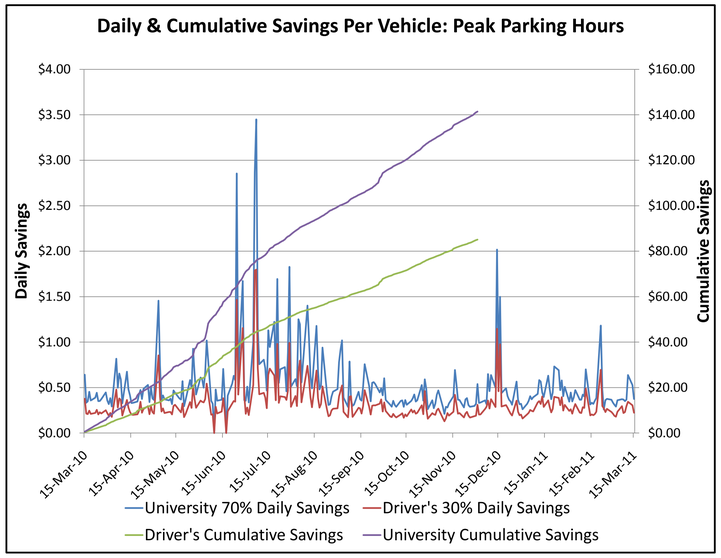
Energy Storage on the Campus of the University of Pennsylvania

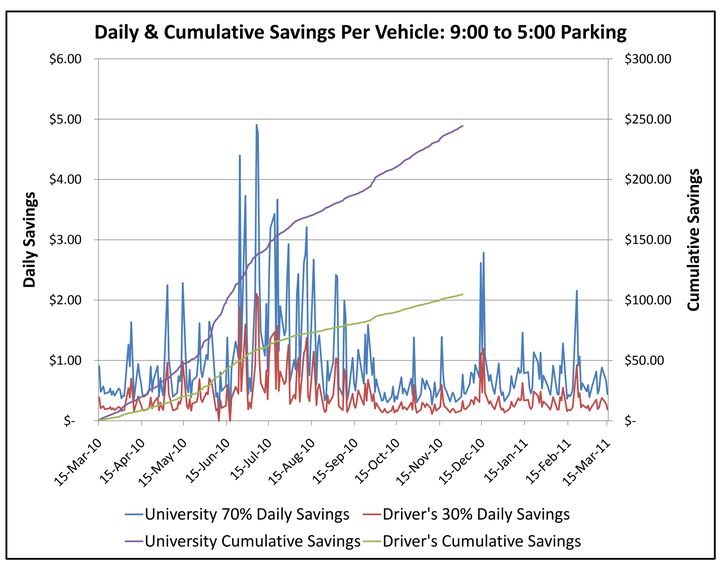


Above: Instantaneous and cumulative savings per vehicle when parked during peak parking hours of 11:00 AM to 2:00 PM.

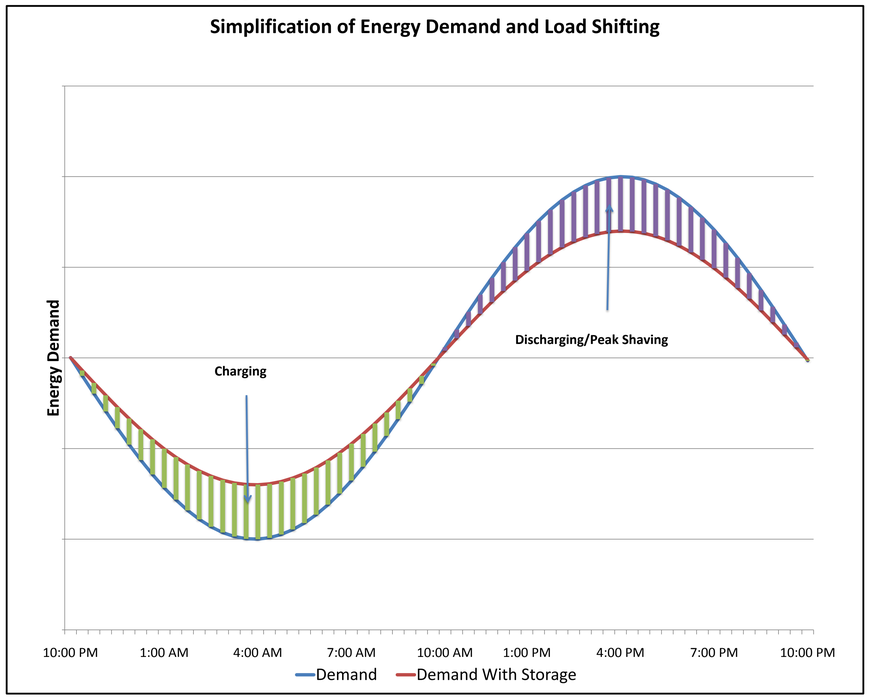
Individual Savings: By charging the EVs when electricity prices are lowest, and discharging them when the prices are highest, the EV owner and the University could take advantage of the energy arbitrage and reduce overall costs. The University, depending on the amount of time an individual vehicle is parked, could save between $140.00 and $240.00 per vehicle per year while the EV owner could save between $85.00 and $100.000 per vehicle per year.

Using a conservative, weighted average savings of $165.00 per year, the University could pay back the cost of a $2,000.00 charging station in just over 12 years which is less than the 25 year expected lifespan of the charging station.

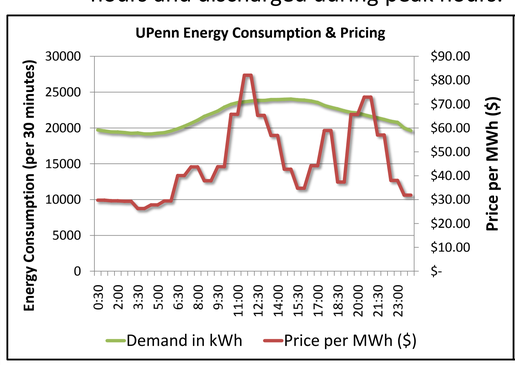
Below: Instantaneous and cumulative savings per vehicle when parked from 9:00 AM to 5:00 PM.

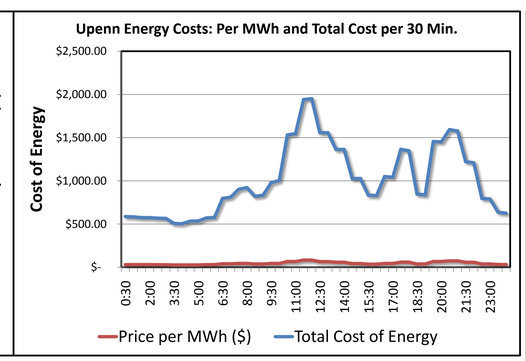


Electric vehicles (EVs) are on track to replace the internal combustion engine vehicle. These vehicles have many clear advantages, including zero direct emissions, which make them a desirable alternative. Other, less clear, advantages include providing a source of energy storage during off-peak hours. This is suitable for alternative and renewable sources of energy that do not operate on a cycle that revolves around the 9:00 to 5:00 work day, such as wind power and geothermal power. Another advantage, further discussed in this report, is the concept of load shifting or peak shaving.

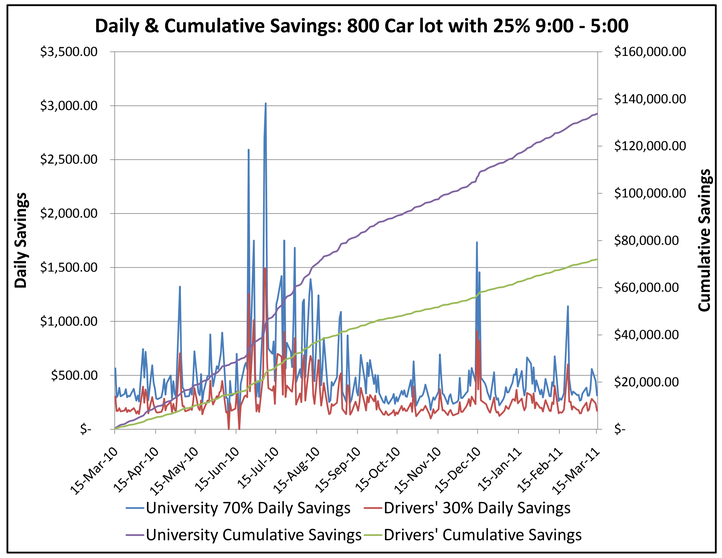


The above graph is a simplification of energy demand throughout a 24-hour period. When combined with a form of energy storage, such as pumped hydro, grid-scale batteries, flywheels, or electric vehicles, peak demand can be shifted to the off-peak hours. In the case of EVs, the batteries are charged during off-peak hours and discharged during peak hours.





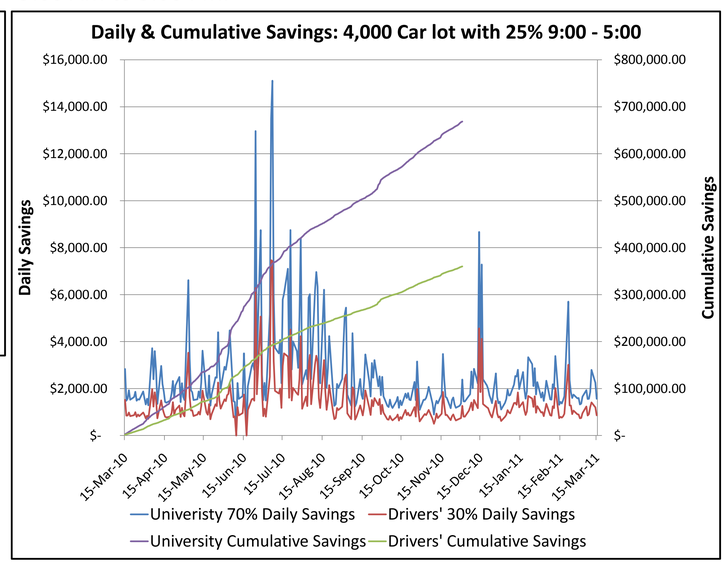
Above Left: This chart compares the energy demand of the University of Pennsylvania throughout one day to the instantaneous price of energy per megawatt-hour.
Above Right: This chart compares the total price of consumed energy (measured at 30 minute intervals) and the instantaneous price of energy per megawatt-hour. (Note: the red lines in both charts depict the same pricing data).



Above: Instantaneous and cumulative savings for 800 vehicles when 75% are parked during peak hours and 25% are parked from 9:00 AM to 5:00 PM.

Collective Savings: When applied to a single parking garage with a capacity of 800 vehicles, total savings for the University could reach nearly $140,000.00 per year. This assumes that 25% of vehicles park at 9:00 AM and leave at 5:00 PM and that 75% of vehicles park between 11:00 AM and 2:00 PM. With a capacity of 4,000 vehicles, total savings approach $675,000.00 per year.

Below: Instantaneous and cumulative savings for 4,000 vehicles when 75% are parked during peak hours and 25% are parked from 9:00 AM to 5:00 PM.



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