

BRIEFING

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Electric Vehicle Grid Integration in the U.S., Europe, and China

The ICCT and the Regulatory Assistance Project (RAP) jointly commissioned MJ Bradley & Associates to write a report on challenges and opportunities in integrating electric vehicles (EV) into the electrical grid in several world regions. This briefing paper summarizes their findings. The full report is available at <<http://www.theicct.org/electric-vehicle-grid-integration-us-europe-and-china>>.

OVERVIEW

Governments around the world are promoting electric vehicle deployment as part of their clean transportation and climate mitigation strategies. The U.S. has a target of 1 million EVs by 2015 and provides generous financial incentives for EV purchases and installation of EV charging equipment, while individual states have additional incentives. The EU supports EV deployment broadly through incentives in two major directives. Denmark, France, and Germany, which were examined in detail in this report, each have ambitious targets for EV adoption by 2020, supported by various financial incentives. China targets half a million EVs by 2015 and 5 million EVs by 2020, and provides subsidies and various financial and other incentives depending on region and city.

New EV models come online each year. At the time the report was written, 17 battery electric and plug-in hybrid electric vehicle models were available on the market, ranging in size from two-seaters to Toyota's RAV4 SUV. Still, none of these models are perfect replacements for conventional vehicles: the highest EV range potential (~ 200 miles for Tesla's Model S) is half that of a typical conventional vehicle, refueling time is far longer (from around 30 minutes to over 20 hours depending on the charging capacity), and EVs are still significantly more expensive.

The reason governments support EV deployment despite the above-mentioned drawbacks is that EVs offer attractive potential benefits. EVs have no tailpipe emissions, which immediately reduces harmful pollution in cities. And EVs have the

potential to reduce lifecycle greenhouse gas emissions – mitigating climate change – to the extent that their electricity is fueled by low carbon sources. Electric motors are much more efficient than conventional internal combustion engines, delivering direct savings.

On the other hand, electricity mixes such as China's, which relies heavily on coal, may cancel out the efficiency gains of EVs because coal produces roughly twice as much CO₂ per unit energy delivered as oil. Out of the focus regions in the U.S. and EU, California, Massachusetts, France and Spain have relatively clean grids (heavy on nuclear, renewables, hydro and/or natural gas), while Michigan, Denmark and Germany use substantial amounts of coal. Still, all the regions covered here are currently making efforts to increase the share of renewables in their electricity grids, and so climate mitigation benefits from EVs can be expected to rise in the future.

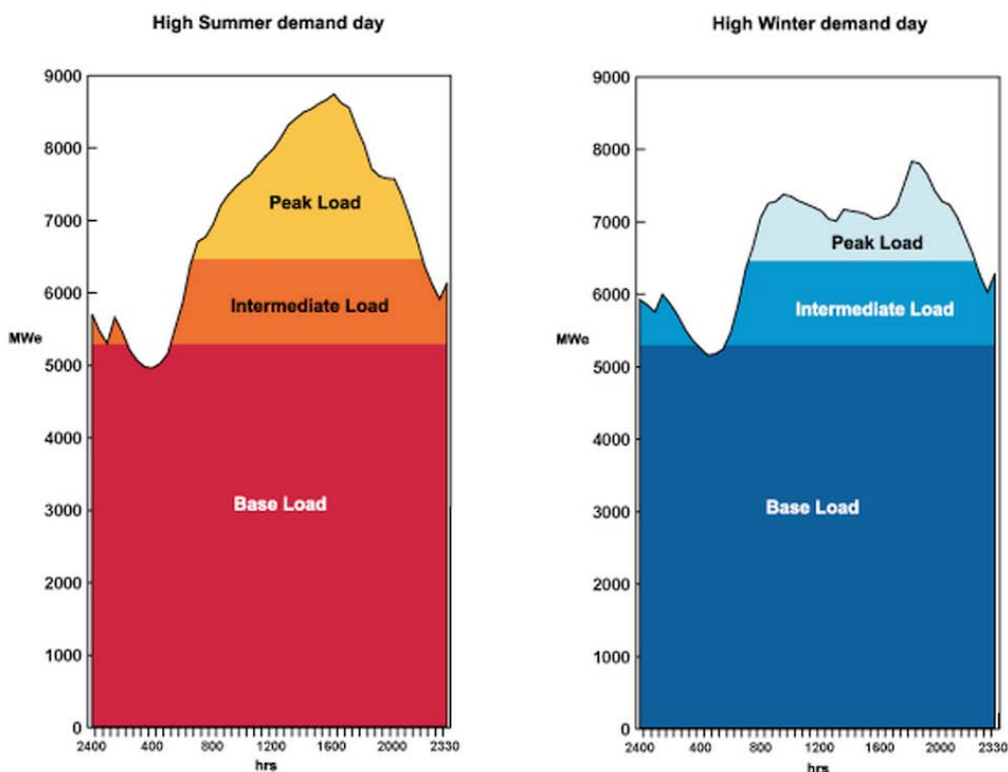
REGULATION OF THE ELECTRICAL GRID

The structure of the electricity market, and how it is regulated, varies considerably among regions. The U.S. has a fairly deregulated electricity market, in which consumers can choose electricity providers. In the three focus states, utility revenues are decoupled from electricity sales, so providers can recuperate infrastructure costs and improvements, such as smart meter installation. Most of Europe is still in the process of deregulation. In Germany, Spain and France, most electricity is provided by only a few companies, contributing to high electricity prices; this reduces cost benefits of EV adoption.

HOW COULD EVS IMPACT THE GRID?

ELECTRICAL LOAD

Electricity demand varies strongly by time of day, with lowest demand in the early hours of the morning and peak demand in the late afternoon (summer) or morning and evening (winter) (Figure 1). To supply these varying levels of demand, electricity providers need to bring some generators on and off line as the day goes on. This type of cycling is inefficient in terms of both carbon emissions and price, and is worsened by higher-than-normal peak loads (e.g., a very hot summer day when everyone turns on their air conditioners).

Figure 1. Idealized load curves in summer and winter. Source: IEA

If EV owners charge during peak-load periods, they increase demand and require more generators to be brought online. If instead, they program a smart charger to begin charging after peak hours, their EVs could help more efficient electricity management by reducing cycling. When EVs are charged matters a great deal to grid management and to their overall carbon footprint, and financial incentives like time-of-use electricity rates would help achieve better outcomes.

How EVs are charged matters as well. High-capacity chargers (both AC and DC) can better accommodate drivers' needs with a relatively quick charge when drivers are on the road. But imagine a scenario where many owners want to charge their EVs after work, on their way home: this would cause a spike in demand at peak load. Charging at 120-240 volts, using a typical household outlet, softens impacts on the electric grid, especially if it happens at off-peak hours.

Load pockets, or high load demand in local areas, are another concern. Because of their relatively short range, many EVs are purchased by urban dwellers for short city trips. Cities already have high electricity demand that can be difficult to manage; integrating EVs into these load pockets requires extra planning to prevent blackouts.

ANCILLARY SERVICES

EVs could potentially benefit the grid through additional services that help utilities manage load. For example, an EV that is plugged in all day could be used to store excess electricity during off-peak hours; the utility could later withdraw that electricity from the EV battery to supply peak load, avoiding some inefficient cycling of

generators. At the present, only electricity generators can provide ancillary services that help match changes in load. Regulations could be rewritten to allow EVs to participate as well. Owners could receive monetary compensation from the utility, which would also help offset the faster battery degradation that occurs with cycling.

BENEFITS TO CONSUMERS

In addition to the environmental benefits of EVs, the grid can offer EV owners monetary benefits. Electricity is cheaper than gasoline in all the focus regions discussed here, lowering fuel costs for consumers and partially offsetting the up-front price premium of EVs. EV owners may save even more money on electricity if charging at off-peak hours in areas with time-of-use charging. If consumers value time more than this cost savings, they can utilize the growing number of public high-capacity chargers that can charge a vehicle in as little as 10 minutes. Lastly, EV owners could potentially opt in to receive monetary compensation in return for providing ancillary services.

POLICY RECOMMENDATIONS

PRIMARY POLICY RECOMMENDATIONS

- » Create or amend rules to allow participation by EVs in electricity markets, so EVs can provide and be compensated for ancillary services.
- » Encourage time-of-use electricity pricing, to incentivize off-peak charging.
- » Allow cost recovery by electricity distributors, to encourage them to invest in smart meters and other infrastructure for EVs.
- » Adopt policies to control greenhouse gas emissions, which would incentivize EV adoption.
- » Decouple utility revenue from electricity sales, incentivizing lower energy use and keeping electricity prices low.
- » Establish a long-term strategy to integrate EVs into road-user fees, finding a way to implement a road tax after EVs no longer need purchase incentives.

SECONDARY POLICY RECOMMENDATIONS

- » Stimulate research and development into extending range and reducing cost of EVs.
- » Harmonize standards for EVs and chargers, and include advanced communication capability to allow owners and utilities to efficiently manage electricity demand and load.
- » Consider other financial incentives, besides time-of-use electricity rates, to encourage off-peak charging.
- » Establish customer relationship guidelines to reduce confusion among EV consumers about privacy and electricity rates.
- » Promote alternatives to high-capacity public DC charging that will encourage slow, off-peak charging of EVs.