Beneficial Electrification and EVs

Building Energy Boston--Next Generation Energy Efficiency

Presented by David Farnsworth, Associate
Regulatory Assistance Project

March 08, 2017

- The Regulatory Assistance Project (RAP) is a global, non-profit team of energy experts, mostly veteran regulators, advising current regulators on the long-term economic and environmental sustainability of the power and natural gas sectors. (www.raponline.org)

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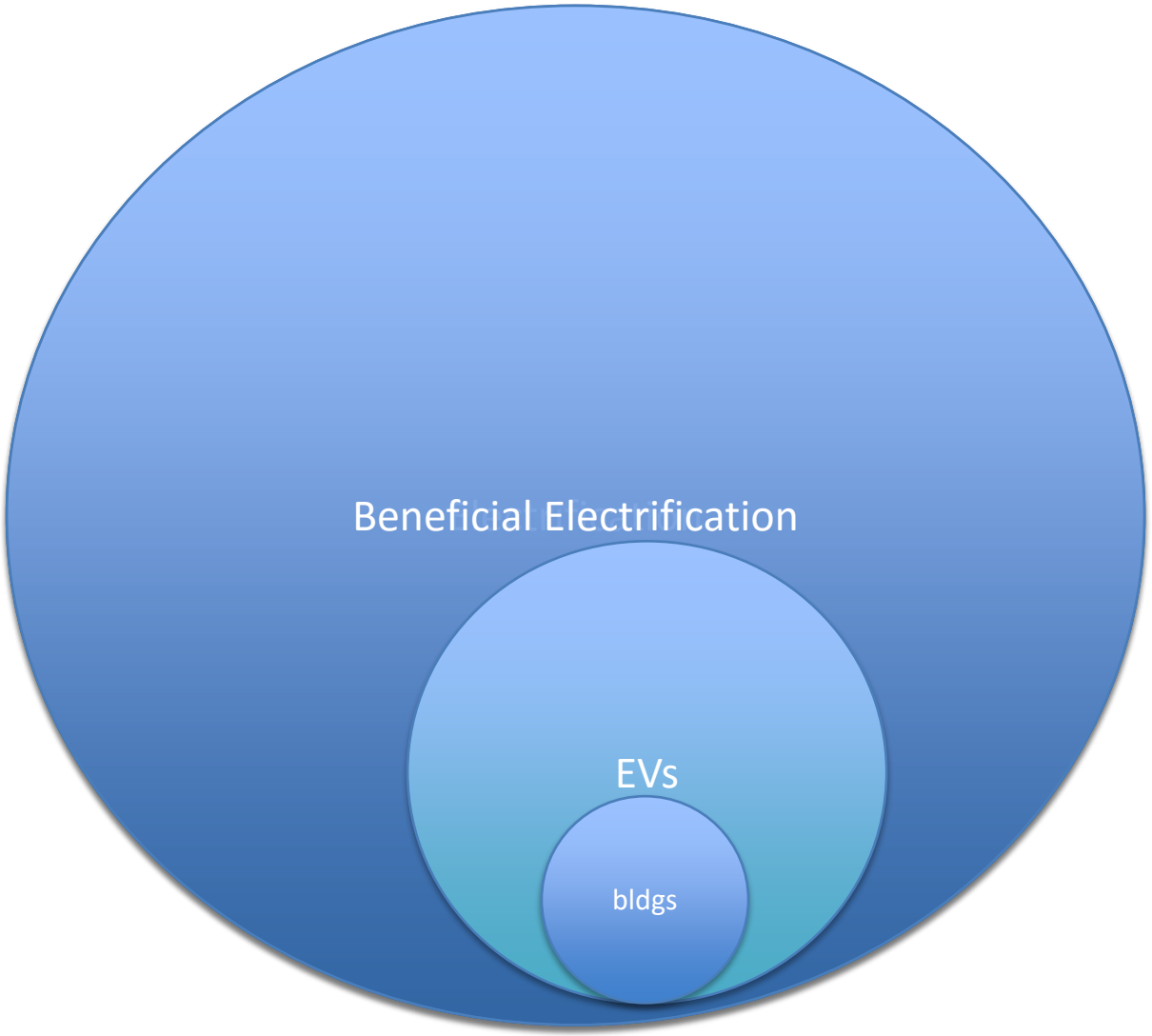
Outline



What is Beneficial Electrification or “BE”?

- Fueling with electricity, appliances and machines that would otherwise be powered by fossil fuels.

What is Being Electrified?

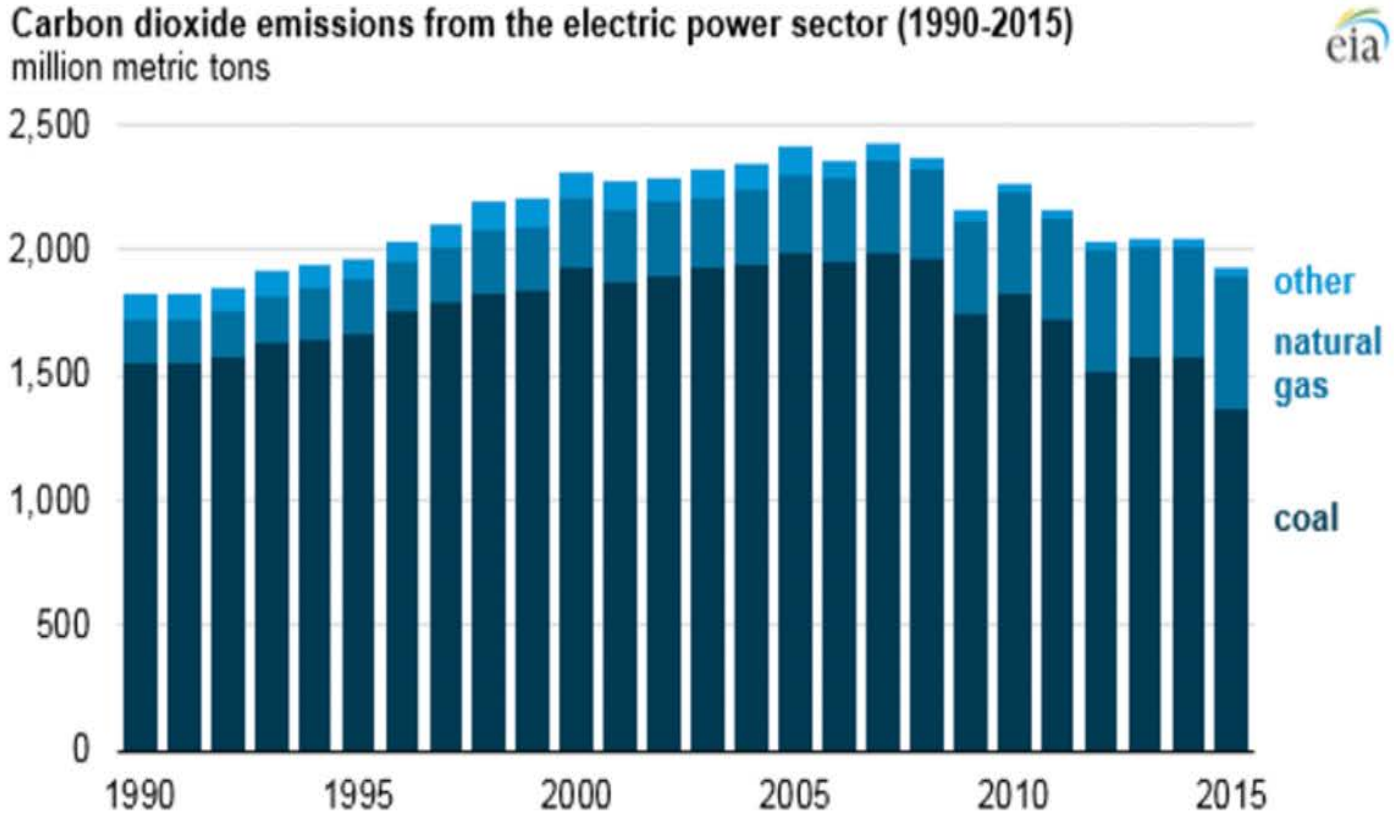
Why is BE Possible?

- GHG Reduction Goals
- Declining Electricity Sector GHG Emissions
- Increased Efficiency of End-Use Equip.
- Technology Advances in Other Sectors
- Need for Flexible Demand to Integrate RE

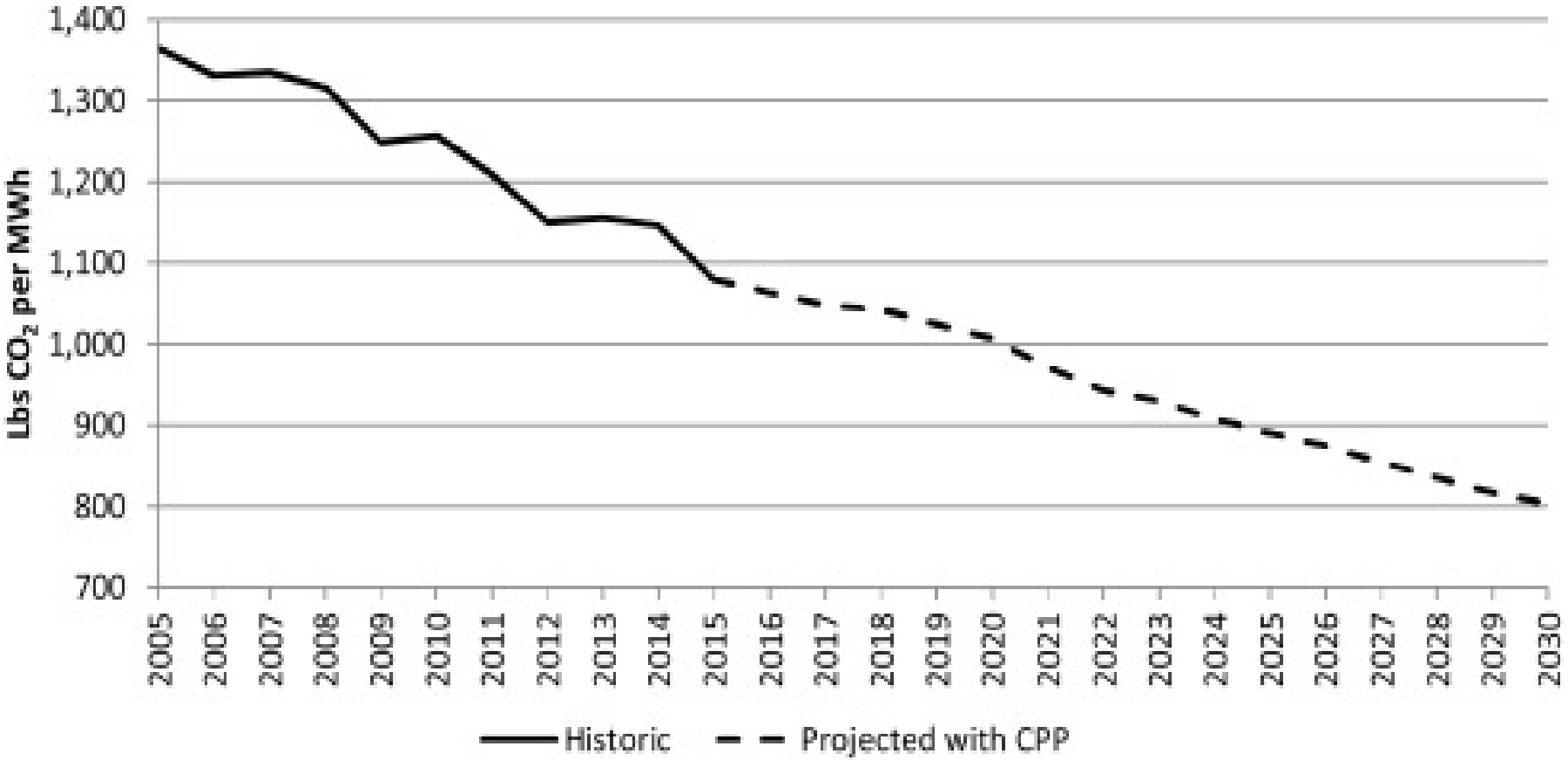
Why is BE Beneficial?

- It's about reducing overall emissions.
  1. Avoiding emissions by moving away from fossil fuels;
  2. Accounting for emissions from the electric system supporting your change; and
  3. Understanding the net result.

CO2 Accounting and Emissions Efficiency



Carbon Intensity of US Electric Sector Generation 2005-2030



Wiman, Channele. 2016. "Carbon Dioxide emissions from Electricity generation in 2015 were lowest since 1993". *Independent Statistics and Analysis, U.S. Energy Information Administration*.

2016 New Generation Capacity Additions by Fuel Source (Source EIA)

Type	New Capacity (GW)	2015 Average Capacity Factor	Estimated Generation (MWh)	Emissions Rate (Short Tons/MWh)	Emissions (Short Tons)
Solar	9.50	28.6%	23,800,920	0.00	0.00
Natural Gas	8.00	56.3%	39,455,040	0.45	17,754,752
Wind	6.80	32.5%	19,359,600	0.00	0.00
Nuclear	1.10	92.2%	8,884,392	0.00	0.00
Petroleum and Other	0.30	1.3%	34,164	1.08	37,068
Hydro	0.30	35.9%	943,452	0.00	0.00
Total	**26.00**	**40.6%**	**92,477,568**	**0.19**	**17,791,820**

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Environmentally beneficial electrification: The dawn of 'emissions efficiency'☆,☆☆

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1. Introduction

The nature of the electricity grid is changing dramatically, as are our nation's environmental goals, so our policy thinking needs to change profoundly, too. Mounting research suggests that aggressive electrification of energy end uses – such as space heating, water heating, and transportation – is needed if the United States and the world are to achieve ambitious emission reduction goals for carbon dioxide. This concept, the electrification of energy end uses that have been powered by fossil fuels (natural gas, propane, gasoline, diesel, or fuel oil) in order to reduce greenhouse gas emissions, is called "environmentally beneficial electrification."[1]

Achieving the greenhouse gas emissions reductions possible through environmentally beneficial electrification will require routinely revisiting and updating prevailing energy efficiency metrics and accounting methodologies in order to maximize gains. Specifically, it is timely to consider whether reduced electricity consumption (i.e., kWh) is the optimal compass with which to navigate the path to a low-carbon future when, in fact, substitution of electricity for fossil fuels may in some cases *increase* electricity consumption.

Policy goals are shifting from the simple energy conservation focus of yesteryear toward achieving greenhouse gas (GHG) reductions. Therefore, we need to assess the GHG emissions associated with various ways to power end uses, as opposed to simply the number of kilowatt-hours consumed. To that end, we submit that "emissions efficiency"[2] may be as or more important than "energy efficiency" moving forward.

Beyond ensuring that our efficiency metrics and policies promote positive environmental outcomes and produce less CO_2, it is also imperative that they not create *disincentives* to achieving GHG emissions reductions through the electrification of loads that are less carbon-intensive than existing practices. Replacing a fuel oil heating system in a single-family residence with electric heat pump technology, for example, would typically reduce emissions, improve comfort, and save the owner money. But such replacements may not be encouraged under the Clean Power Plan (CPP) due to the statutory constraints the U.S. Environmental Protection Agency (EPA) faces implementing it under section 111(d) of the federal Clean Air Act (CAA). This article expands upon environmentally beneficial electrification, introduces the concept of emissions efficiency, and considers how the design of the CPP could impede opportunities for environmentally beneficial electrification. Because environmentally beneficial electrification is necessary to achieve our nation's GHG emission reduction goals, states must find ways to encourage it. Notwithstanding the uncertain judicial future of the CPP at this time, several steps to boost environmentally beneficial electrification reflect "no regrets" strategies that should be encouraged and implemented even in the absence of a clear regulatory regime.

2. Growing consensus for environmentally beneficial electrification

Consensus is growing that meeting aggressive GHG reduction goals will require electrification of end uses such as space heating, water heating, and transportation. A recent report by Environmental and Energy Economics (E3) states that "critical to the success of long-term GHG goals" is "fuel-switching away from

☆As the U.S. works to meet carbon reduction goals, 'environmentally beneficial electrification' will be required. Rather than focusing solely on reducing energy consumption, we must generate electricity using more resources that emit little or no CO_2 and power more end uses with electricity. To this end, 'emissions efficiency' may be an important and effective metric for the electric sector moving forward.

☆☆This article and the opinions within are the responsibility of the authors and do not necessarily represent the opinion of their respective organizations.

*Corresponding author.

[1] Dennis, K. 2015. "Environmentally Beneficial Electrification: Electricity as the End-Use Option." Electricity Journal 28(9): 100–112.

[2] The term "emiciency" could be used as a newly coined word and applied as a short-hand term for "emissions efficiency." Greater emissions efficiency reflects fewer emissions created per unit of useful output of an energy-consuming service. For example, fewer pounds of CO_2 emitted per mile traveled by a car or fewer pounds of CO_2 emitted per gallon of hot water provided by a water heater.

http://dx.doi.org/10.1016/j.tej.2016.07.007

Emissions Efficiency

Supply & Loads are Movable

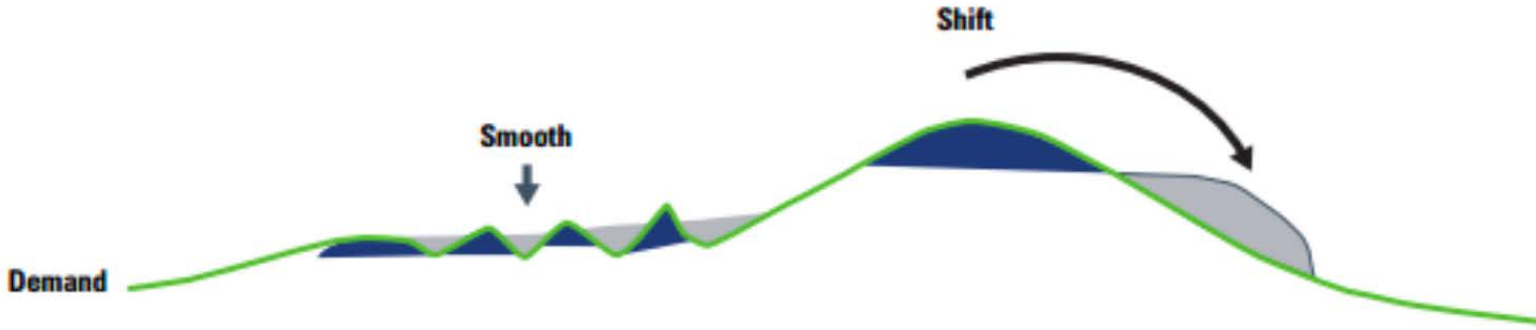
- Wind & solar energy are variable resources
- Variability is nothing new for the grid
- Demand for power from customers is also variable and always has been.
- Timescales of RE variability and demand variability (customer loads) can be handled in comparable ways

See, Mark Ahlstrom's https://www.uvig.org/commentary-uvig-president-responds-economist-feature-renewable-energy/

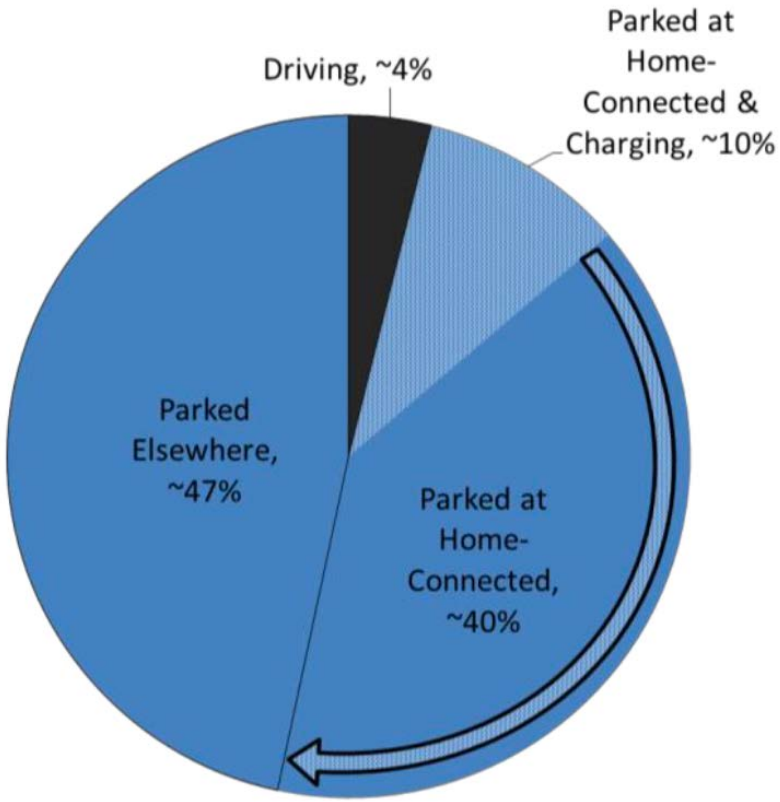
Why is BE Beneficial? Cont.

- Environmentally beneficial plus BE practices can be used by power companies to **manage** their **grids**
- EVs can serve as grid resources
  - Making power grids more flexible by moving load to reduce peaks and absorb production of renewable energy:
    - E.g., CA/AZ charge EVs in the middle of the day when the sun is shining on PV arrays;
    - in MA/ND charge at night when the wind energy is available and everyone is asleep
  - Getting greater use existing grid resources and returns on investments

When You Can Move Load

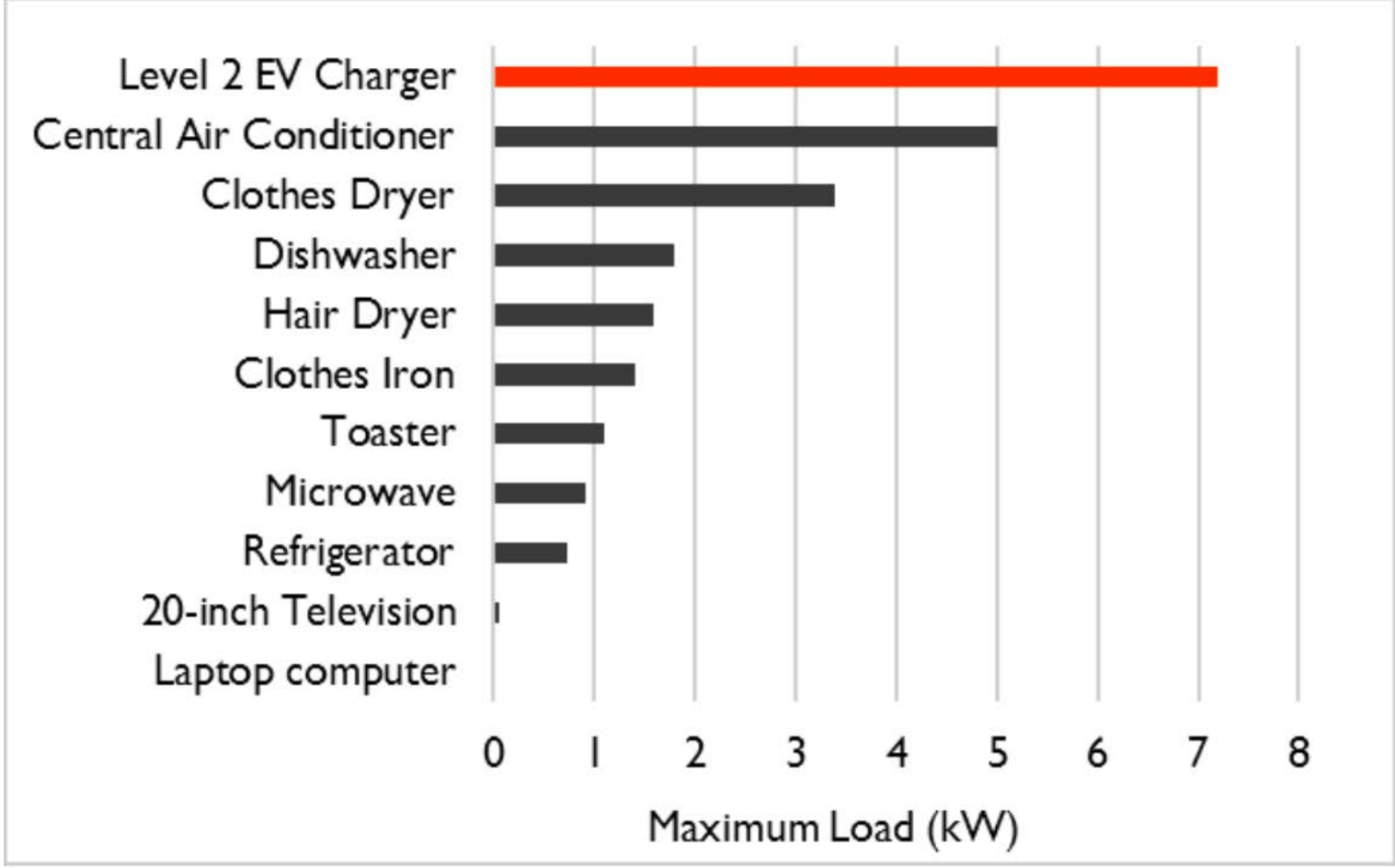


EVs as Grid Resources



- Vehicles –
  - low capacity utilization,
  - idle over 95% of the time, and
  - need to charge only about 10% of the time
- Provide operational flexibility as “load” or “generation.”
- Communications and actuation technology – DR

Relative Load of Level 2 EV Charger



Sources: Consumer Reports Wattage Calculator; Bosch Electrical Vehicle Solutions.

One Key: Rate Designs

GHG reduction

Grid Management.

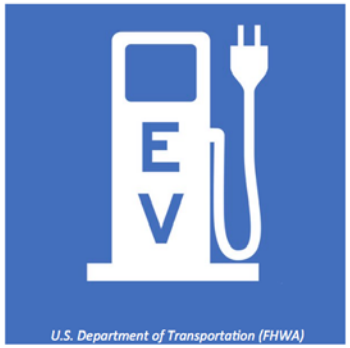
Will Rate designs be barriers or enablers?

Synapse Energy Economics

A Plug for Effective EV Rates

By Avi Allison and Melissa Whited *March 2, 2017*

The Case for Supporting EVs



U.S. Department of Transportation (FHWA)

Electric vehicles (EVs) provide a tremendous opportunity to reduce greenhouse gas (GHG) emissions and save money at the same time. In the United States today, EVs generally result in substantially fewer GHG emissions compared to gasoline-powered internal combustion engine (ICE) vehicles.[1] EVs are also typically cheaper to operate than ICEs. A recent Synapse analysis found that replacing ICEs with EVs powered by renewable energy is one of the most cost-effective ways for states in the Northeast to cut GHG emissions.[2]

However, the environmental, health, and economic benefits of EVs are not guaranteed. When powered primarily with coal-fired electricity, EVs can *increase* emissions of GHGs and local air pollutants.[3] And charging EVs during times of peak electricity demand could result in higher electric system costs, potentially outweighing the operational energy savings associated with EVs. It is therefore well worth encouraging EV owners to charge their vehicles at times when electricity is cheap and clean.

The Role of Rate Design

Electricity rates play a crucial role in fostering the adoption of EVs and encouraging existing EV customers to charge their vehicles in an environmentally and economically efficient manner. Unfortunately, standard electricity rates do little to encourage EV adoption or optimal charging times. In fact, current time-invariant rates and demand charges may even directly discourage efficient charging practices.

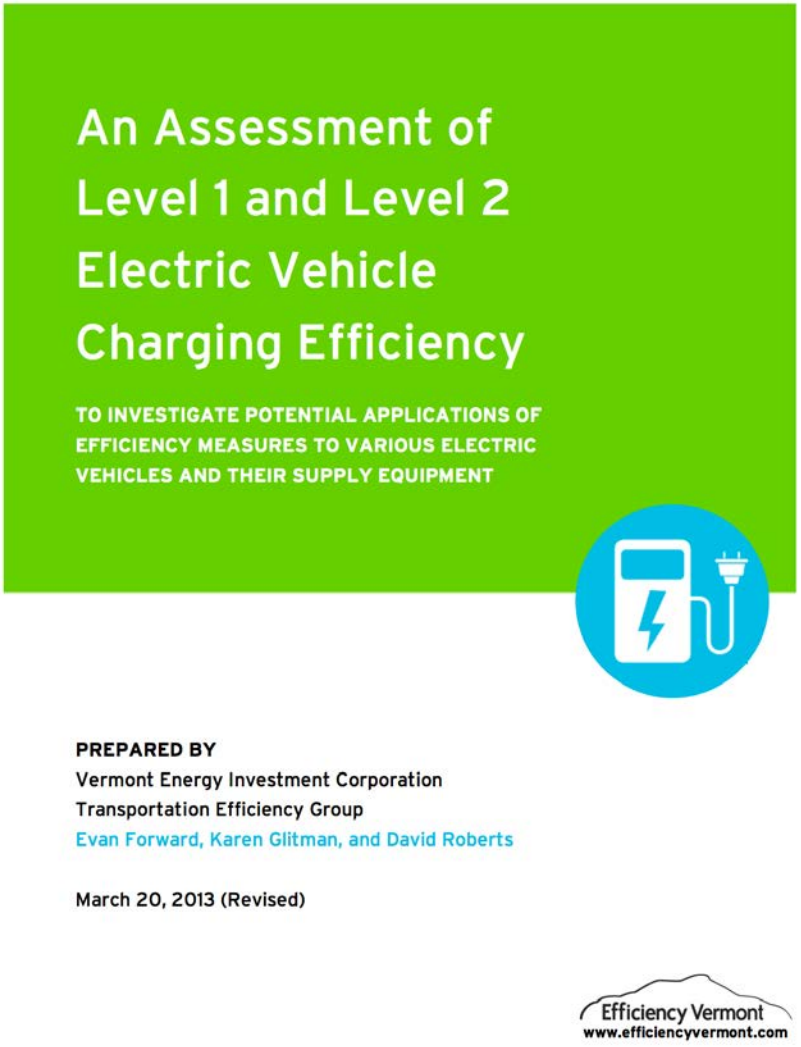
Rethinking Rates for EVs

In addition to their potential to cut costs and emissions, EVs have at least two important characteristics that set them apart from most other uses of electricity. First, they represent relatively large loads. As shown in Figure 1, home EV charging systems can draw nearly 50 percent more power than even the most energy-intensive residential appliances. If charged during a time of peak demand with a standard Level 2 charger, an EV's load is roughly equivalent to that of an entire household.[4]

Second, EVs are effectively storage devices. When EVs draw electricity from the grid, that electricity is not immediately used to propel the vehicle. Instead, the electricity is stored in the vehicle's battery for later use. Most people do not care so much about precisely when and where their EV gets charged, as long as the battery works when it is needed. This is very different from most major residential electricity uses (think of air conditioning) and opens up the possibility of encouraging efficient charging without inconveniencing consumers.

http://www.synapse-energy.com/sites/default/files/A-Plug-for-Effective-EV-Rates-S66-020.pdf

Don’t Forget the Efficiency of Technologies



Charger Efficiency

- **High-Energy** Charging Events – Level 2 chargers are **2.7%** more efficient than Level 1 chargers.

- During **Low-Energy** Events – L2 chargers are **12.8%** more efficient than L1 chargers.

Low-Energy event defined – charging less than 2kW, i.e., 40 minutes or less w/L2 charger (e.g., while you are in the store)

Brattle's *Electrification – Emerging Opportunities for Utility Growth*

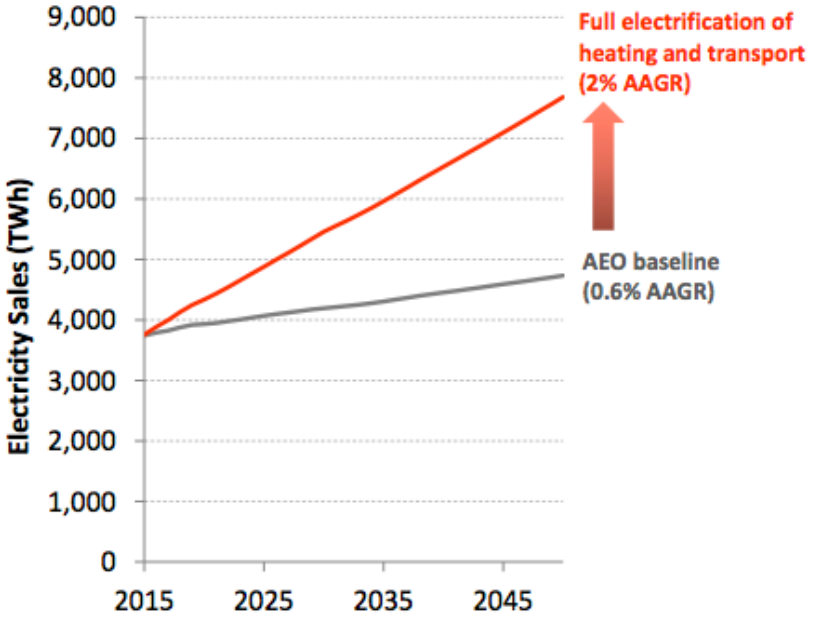
- Modeling technical potential suggests that electricity sales could double from 2015 levels by 2050 if the heating and transportation sectors were to switch from their current fuel mix to 100 percent electricity.

- Coupling electrification of heating and transport with significant decarbonization of the power sector and modest reductions in other energy sectors could lead to more than a 70 percent reduction (from 2015 levels) in U.S. energy-related GHG emissions

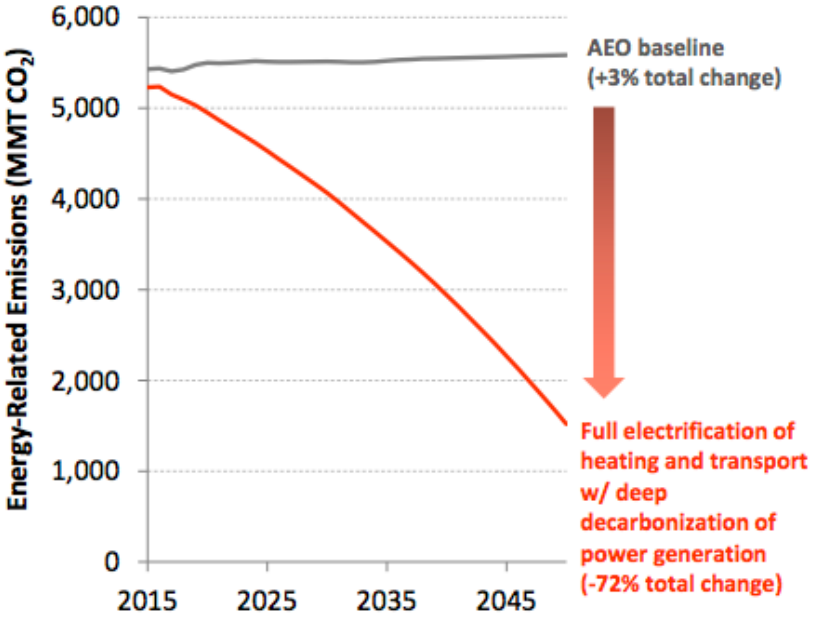
http://www.brattle.com/system/news/pdfs/000/001/174/original/Electrification_Whitepaper_Final_Single_Pages.pdf?1485532518

Brattle's *Emerging Opportunities* cont.

Impact on Electricity Sales



Impact on GHG Emissions



Source: The Brattle Group analysis based on EIA AEO 2015 data

Some Next Steps

- GHG accounting should recognize that the emissions intensity of the grid is changing
  - DOE and EPA update "Source" emissions factors
- Electrification projects should account for impacts that result from direct combustion of fossil fuel
- Emissions efficiency should be considered in addition to energy efficiency (i.e., kWh saved) as a metric for projects targeting emissions reductions.

Remember

- Electrification is beneficial when it produces net emissions reductions
  - "Emiciency" – the grid is getting cleaner, but metrics are important to ensure clarity regarding net emissions.
- BE can be an important to grid management
  - Utilities will need to adopt effective rate designs and smart charging programs.

We Have a History of Rapid Transformation

Source: Tony Seba

5th Avenue, NYC
Easter Parade, **1900**
See any automobiles?

We Have a History of Rapid Transformation

Park Avenue, NYC
Easter, **1913**
See any horses?

Source: Tony Seba

Thank You
Q&A