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Alternative Fuel Vehicles and Utility Rate Design: *the devil's in the details.*

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- Introduction
- Fixed vs. Variable Charges
- Time of Use Pricing
- Block Rates
- Funding Renewable Energy
- Conclusions

Introduction

Introduction

- Utility rate design can have substantial implications for the economics of:
  - Alternative Fuel Vehicles
  - Energy Efficiency Investments
  - Renewable Energy Generation
- I will discuss different types of utility rate design and potential implications for different types of customers.

Note: examples shown are meant to be illustrative for purposes of discussing different tradeoffs between different rate design structures.

Introduction

- Utilities that provide electricity and/or natural gas to final consumers are “natural monopolies.”
  - In return for being protected from other firms competing in their service territory, utilities’ rates are set by regulators.
- Utilities are allowed to recover the cost of providing the service, plus an additional rate of return on their capital stock (i.e. their investment).
- Therefore, additional costs that a utility incurs by definition will flow through to ratepayers.

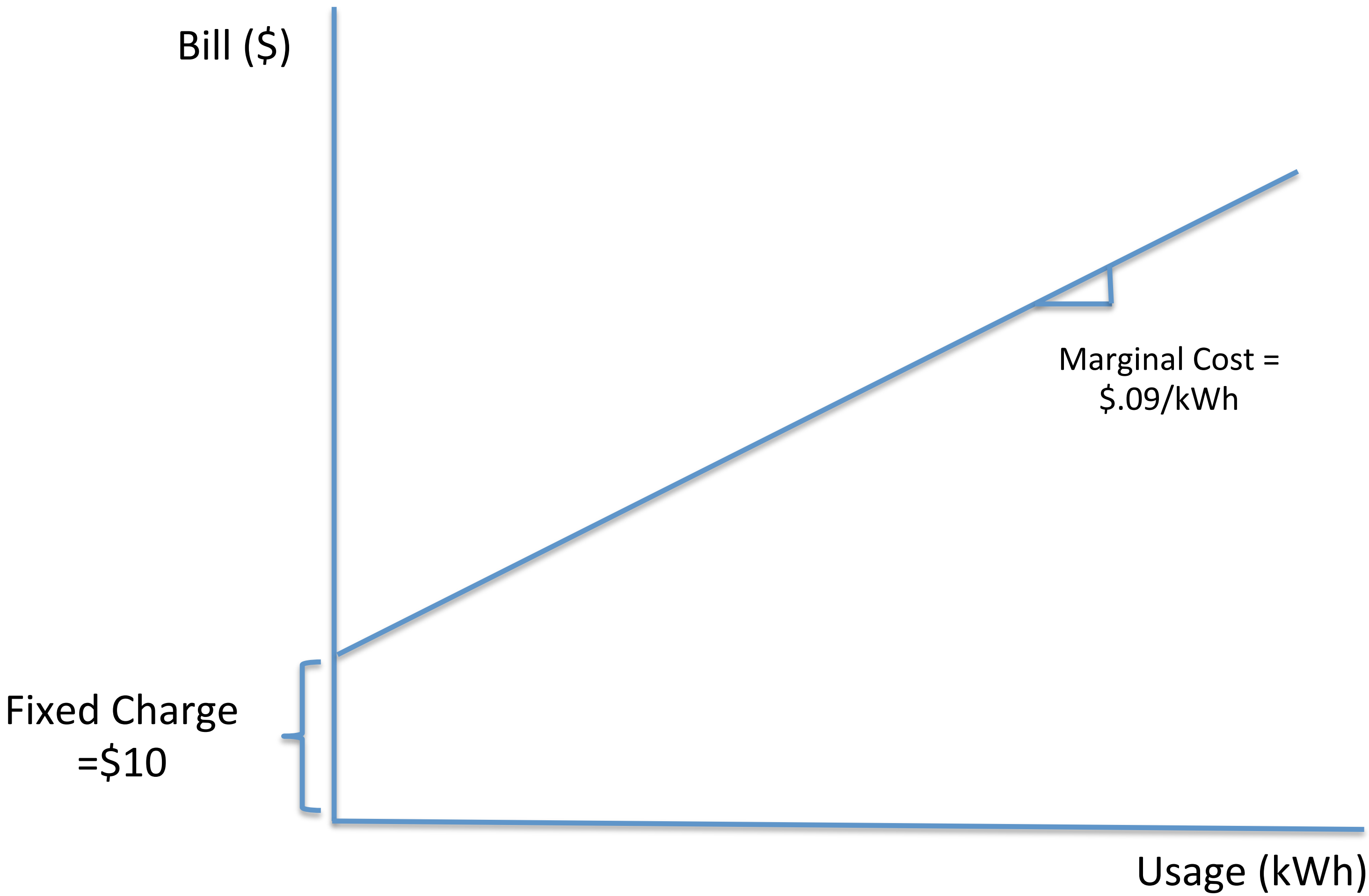
Introduction

- But there are different ways that rates can be set:
  - Fixed monthly charge plus variable charge per kWh
  - Time of use charges
  - Block rates (increasing or decreasing)
  - Incorporating renewable electricity generation

Rate design can impact the economic viability of different technologies asymmetrically. Thus, a solar customer might be impacted differently from one rate design regime than a EV customer, for instance.

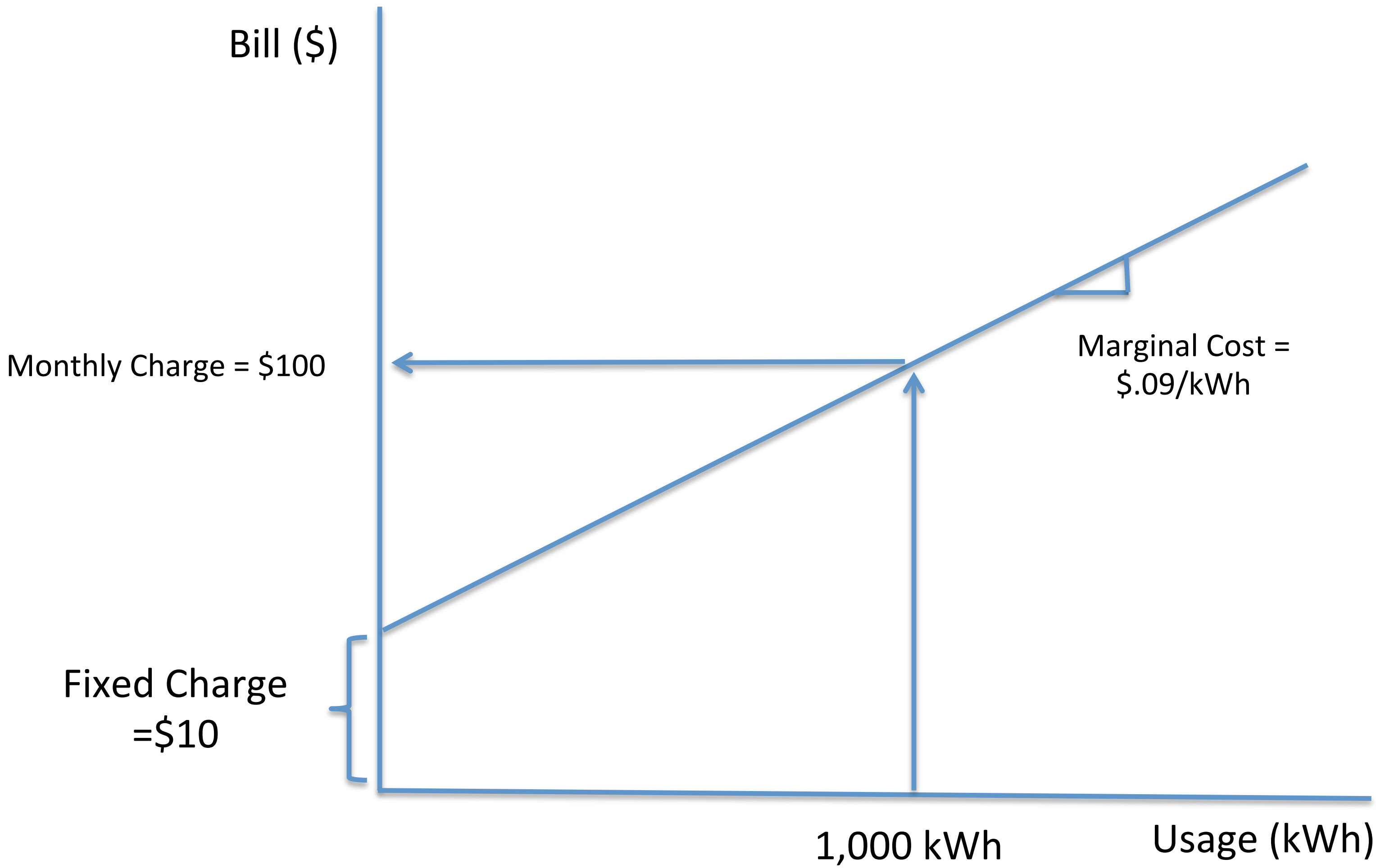
Fixed and Variable Charges

Representative Customer's Electricity Bill



Source: Author's Example. Note: Graph not drawn to scale.

Representative Customer's Electricity Bill



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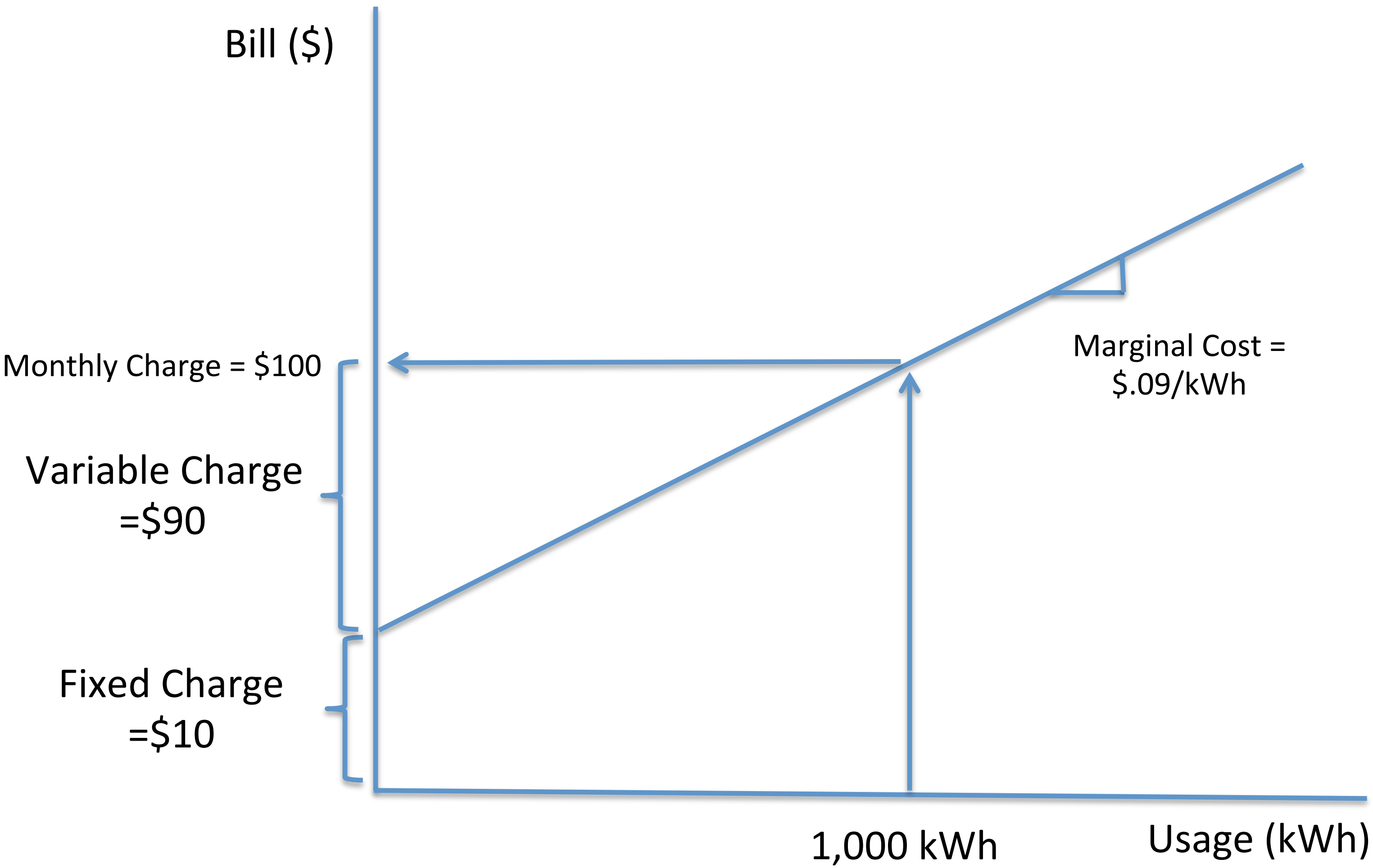
Representative Customer's Electricity Bill



Source: Author's Example. Note: Graph not drawn to scale.

Fixed and Variable Charges

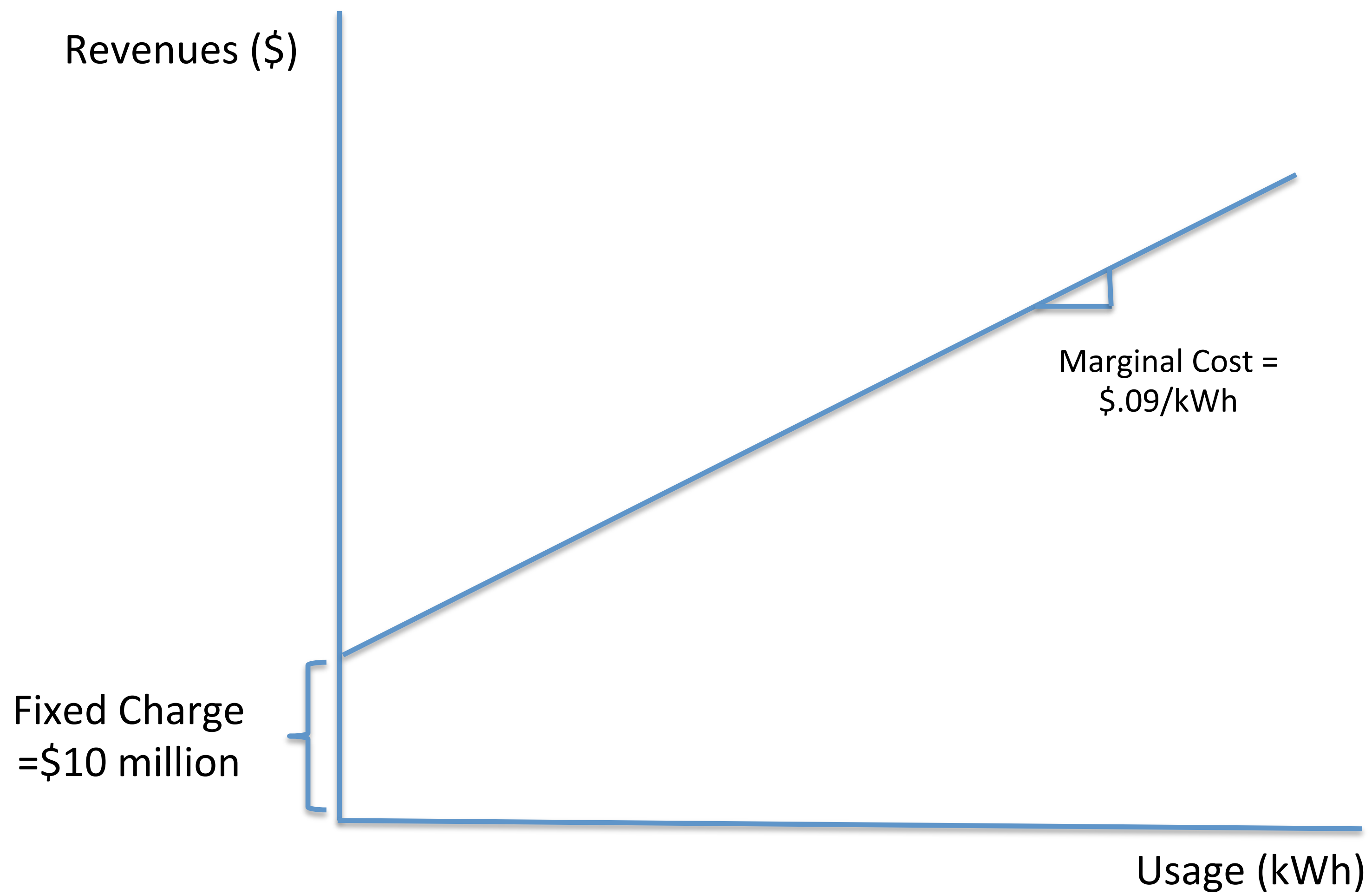
- Remember, that the sum of all customers' bills will approximately equal to the utility's revenue requirement.

$$RR = Customers \times (FC + MC*kWh)$$

- Therefore, the utility must choose FC and MC such that this equation holds.
- A utility could choose any combination of fixed and variable charges such that the revenue requirement is met (subject to the PSC's approval of course!)

Lets consider the revenues of this utility if it has 1,000,000 customers.

Revenue Requirement



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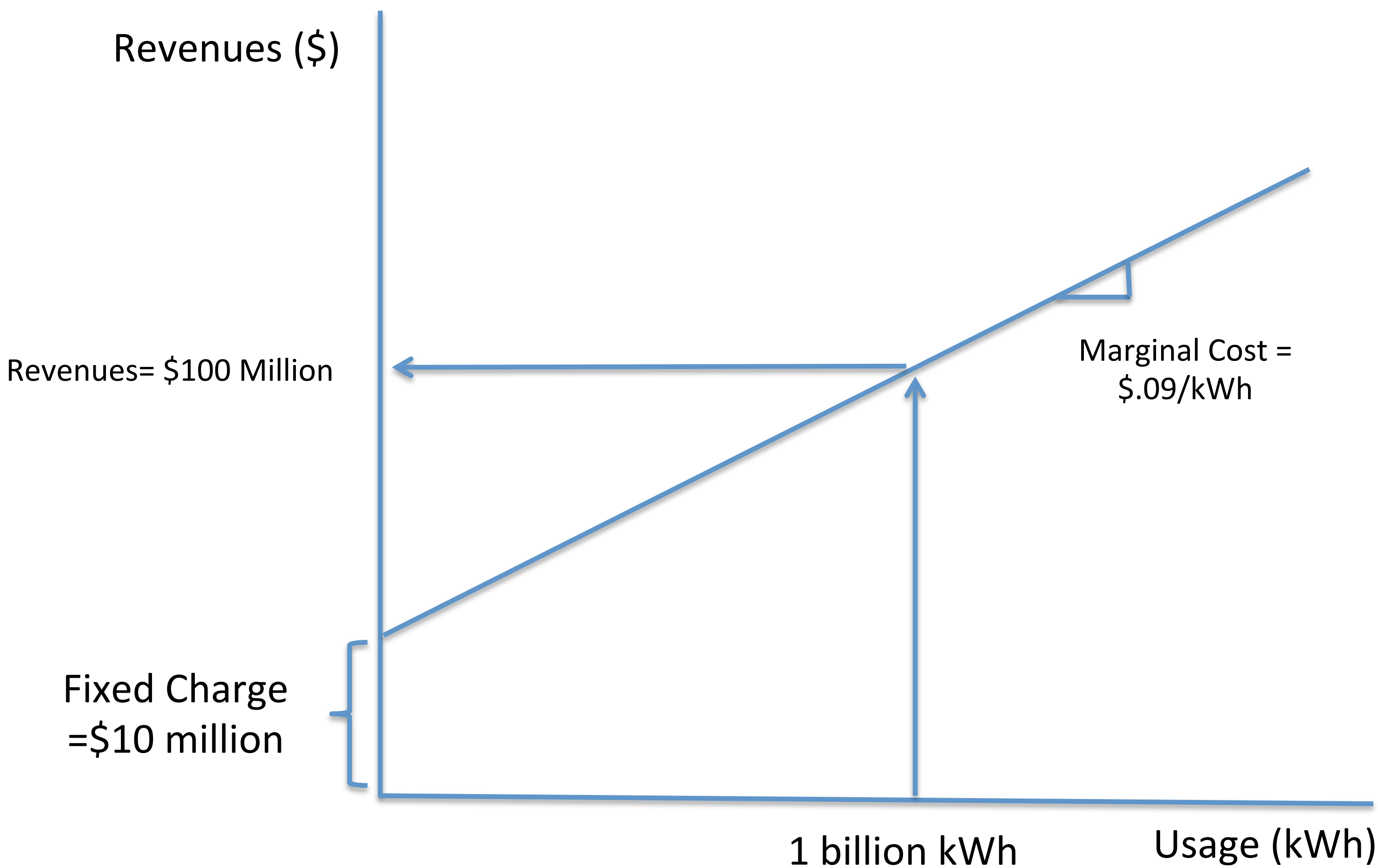
Revenue Requirement



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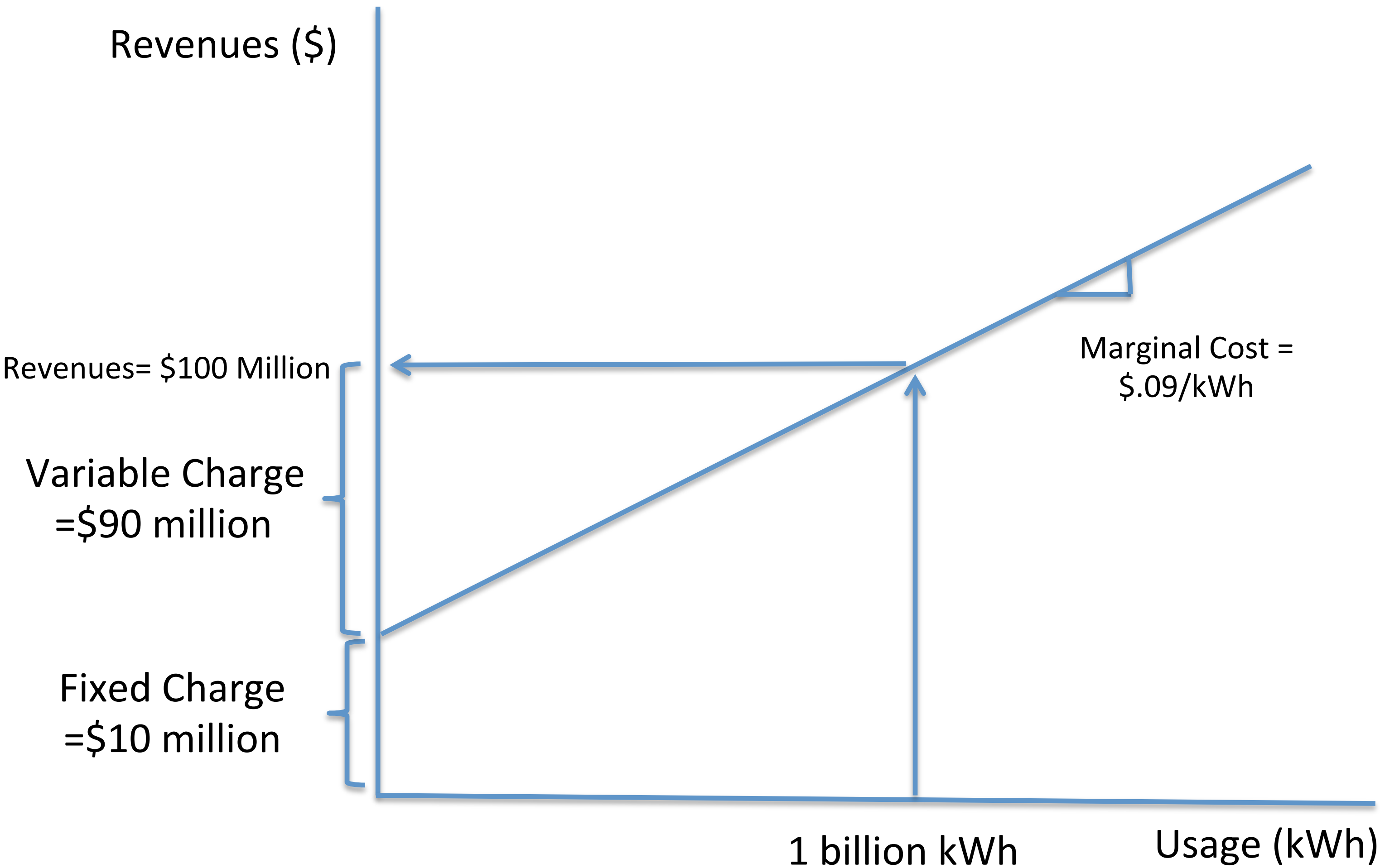
Revenue Requirement

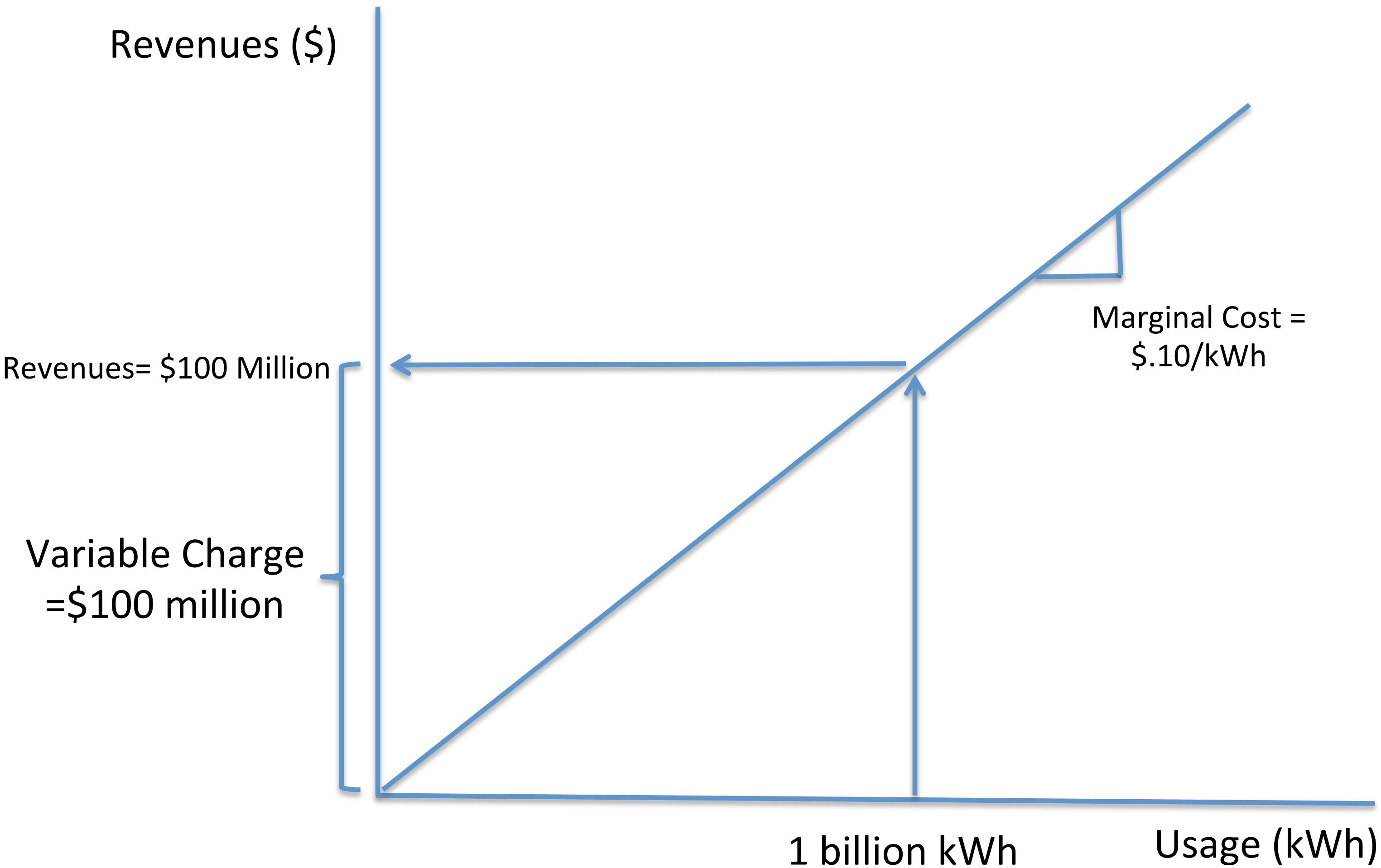


Source: Author's Example. Note: Graph not drawn to scale.

Fixed and Variable Charges

- But there are other combinations of fixed and variable charges that the utility could choose to meet its revenue requirement!
- Consider an example with zero fixed charge and all variable charge . . .

Revenue Requirement



Source: Author's Example. Note: Graph not drawn to scale.

Fixed and Variable Charges

In fact, there are many combinations that could be chosen:

Fixed Charge	Variable Charge
$0	$.10
$10	$.09
$20	$.08
$30	$.07
$40	$.06
$50	$.05
$60	$.04
$70	$.03
$80	$.02
$90	$.01
$100	$.00

Source: Author's Example.

High Fixed Charge and Low Variable Charge

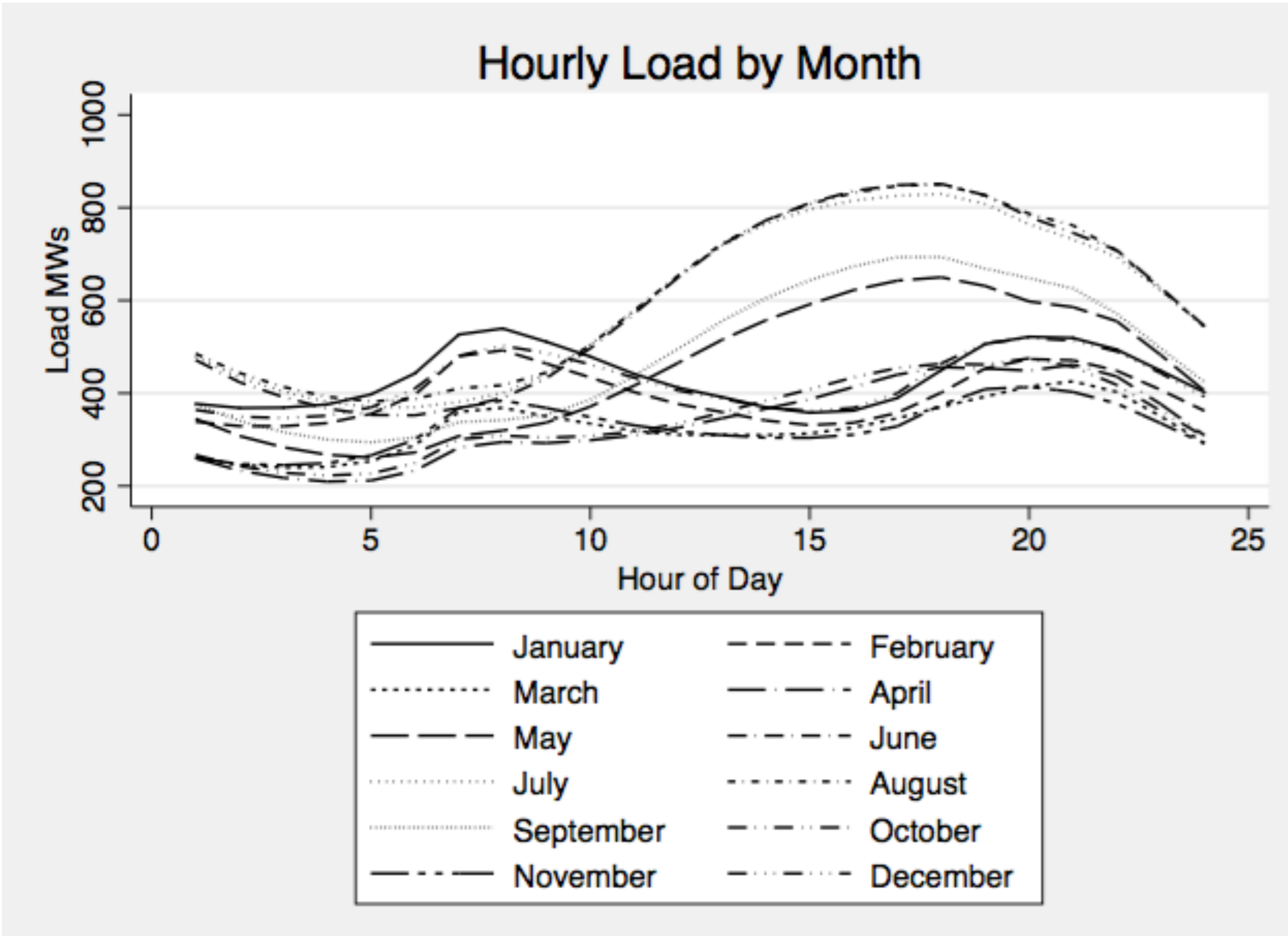
- **High** Fixed Charge, **Low** Variable Charge
  - Increases electricity bills for low usage customers, and decreases electricity bills for high usage customers.
    - Typically thought of as regressive.
  - Lower marginal cost means lower cost of charging electric vehicles.
  - Lower marginal cost means less incentive to abate usage:
    - Less energy efficiency investment
    - Less solar

Low Fixed Charge and High Variable Charge

- **Low** Fixed Charge, **High** Variable Charge
  - Decreases electricity bills for low usage customers, and increases electricity bills for high usage customers.
    - Typically thought of as progressive.
  - Higher marginal cost means higher cost of charging electric vehicles.
  - Higher marginal cost means more incentive to displace usage:
    - More energy efficiency investment
    - More solar

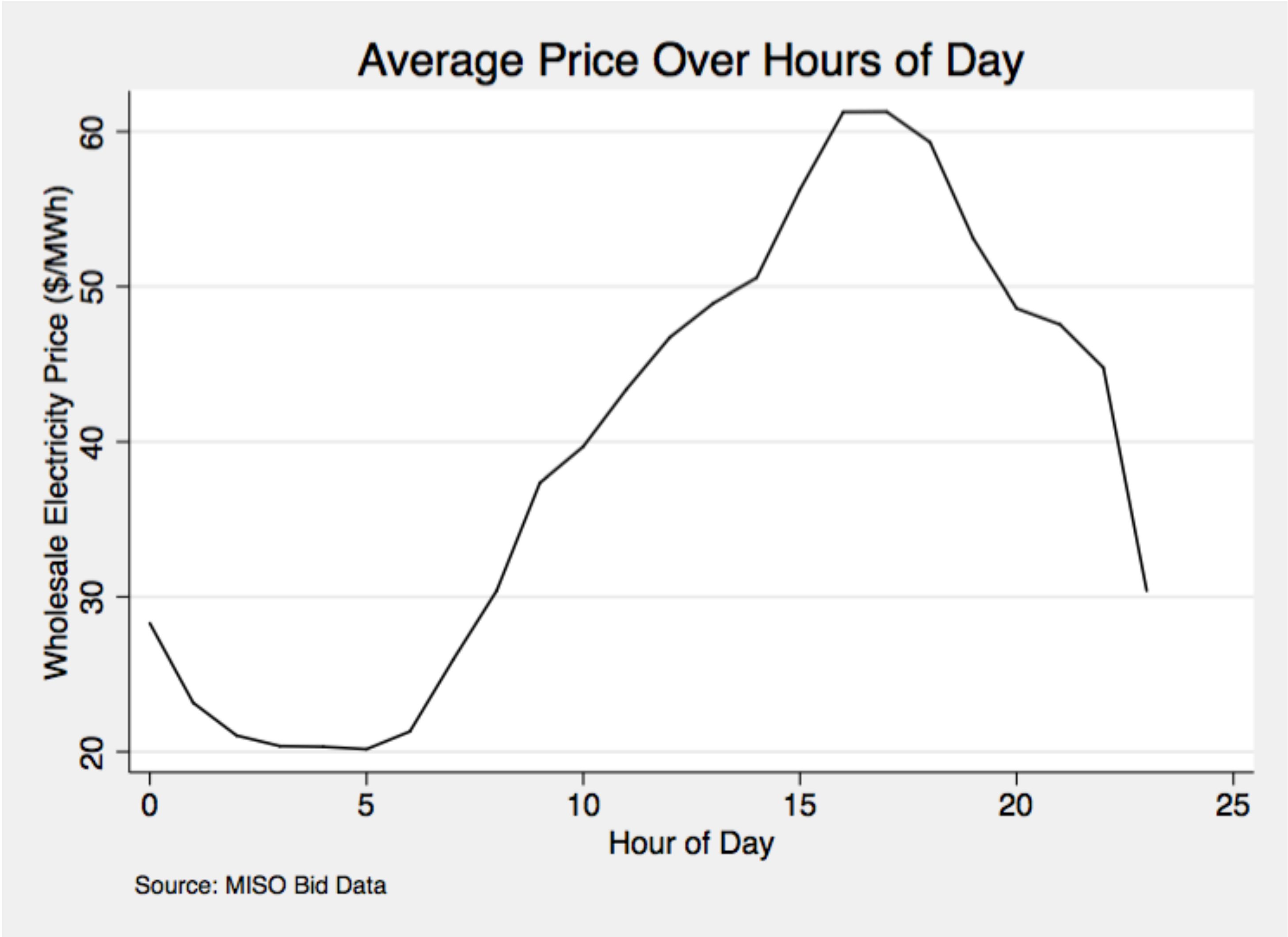
Time of Use Charges

Electricity Demand



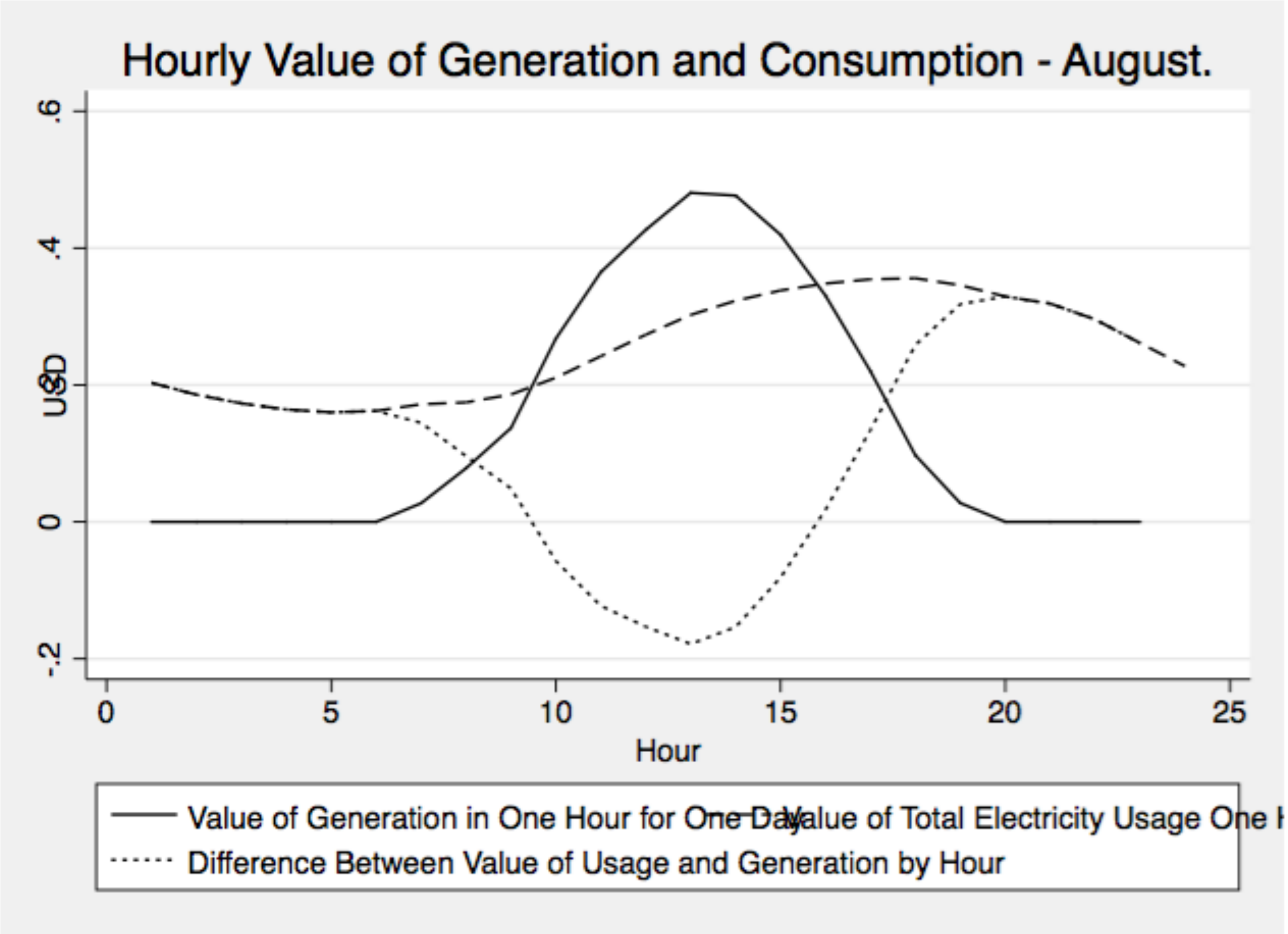
Source: Author's simulated data based on Louisiana utility.

Wholesale Electricity Price



Source: MISO Bid Data – Wholesale Market Prices

Wholesale Electricity Price



Source: Author's simulated data based on Louisiana utility.

Supply and Demand

1. Electricity demand is not constant throughout the day.
2. Wholesale electricity prices are not constant throughout the day.
3. Electricity prices and demand are positively related.

A utilities pays more for electricity during peak demand times.

Constant Price

- Constant Electricity Price
  - At **peak demand** times, the price that a customer faces can be **low** relative to the marginal cost observed by the utility.
  - Because the customer's price does not change throughout the day, an EV owner cannot save money by charging in off peak hours.
  - Solar customers are agnostic as to when their electricity is produced.

Time of Use Pricing

- Time of Use Electricity Price
  - At peak demand times, the customer faces a higher price.
  - EVs can be charged at low demand, and low price, times therefore reducing charging costs.
  - Solar generation peaks during the day, while prices peak in the evening.
    - Currently, solar panels are placed on the roof such that they **maximize total production**. With time of use pricing, this can incentivize panels to be placed on the west side of the house to balance **production** with **peak demand times**.

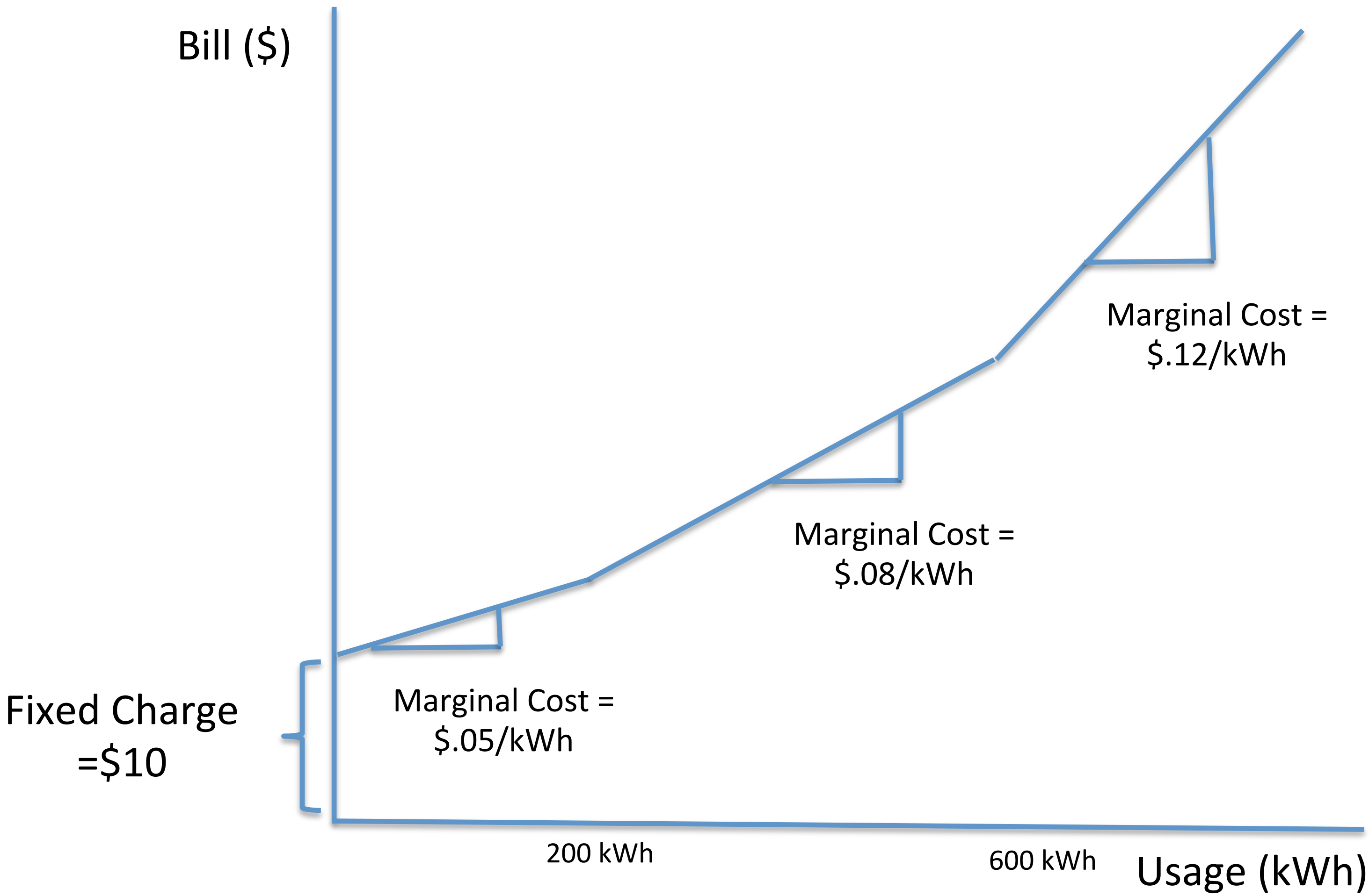
Block Rates

Implications for Solar and EVs

- Some utilities have moved towards increased block rates primarily for two reasons:
  1. To incent demand abatement.
  2. As a transfer payment from high to low income customers.

Increased block rates choose a marginal cost that is increasing with total monthly usage.

Representative Customer's Electricity Bill



Source: Author's Example. Note: Graph not drawn to scale.

Increasing Block Rates

- In this example:
  - 0 to 200 kWh ➔ $0.05
  - 200 kWh to 600 kWh ➔ $0.08
  - 600 kWh+ ➔ $0.12

Therefore, a customer who uses 1,000 kWh in a month will still have a total bill of $100.

Bill = $10 + (200×$.05) + (400×$.08) + (200×$.12)

Implications for Solar and EVs

- Increasing block rates will be beneficial for solar customers and energy efficiency investments as these will abate high marginal cost electricity.
- Increasing block rates will be bad for EVs, as the marginal electricity purchased for EV will cost a higher marginal cost rate.

Funding Renewable Energy

Funding Renewable Energy

Over the past two decades, the federal and many state governments have implemented a wide array of policies aimed at reducing CO_2 intensity of the electricity sector by increasing the market penetration of renewable technologies.

- Examples include:
  - Production tax credits
  - Property tax exemptions
  - Sales tax exemptions
  - Residential solar tax credits
  - Net metering

But, the fact is, renewable energy is simply more expensive than traditional fossil fuel based energy…

Comparison of Installed Cost

Technology	Overnight Cost ($/kW)	Variable O&M ($/ mWh)	Fixed O&M ($/ kW/yr.)	Capacity Factor
Advance Gas/Oil Comb Cycle (CC)	$1,017	$3.27	$15.36	48.2%
Coal	$2,917	$4.47	$31.16	59.7%
Adv Nuclear	$5,366	$2.14	$93.23	91.7%
Wind	$1,980	$0	$39.53	34%
Photovoltaic	$3,279	$0	$24.68	25.9%

Source: EIA AEO 2015. Table 8.2

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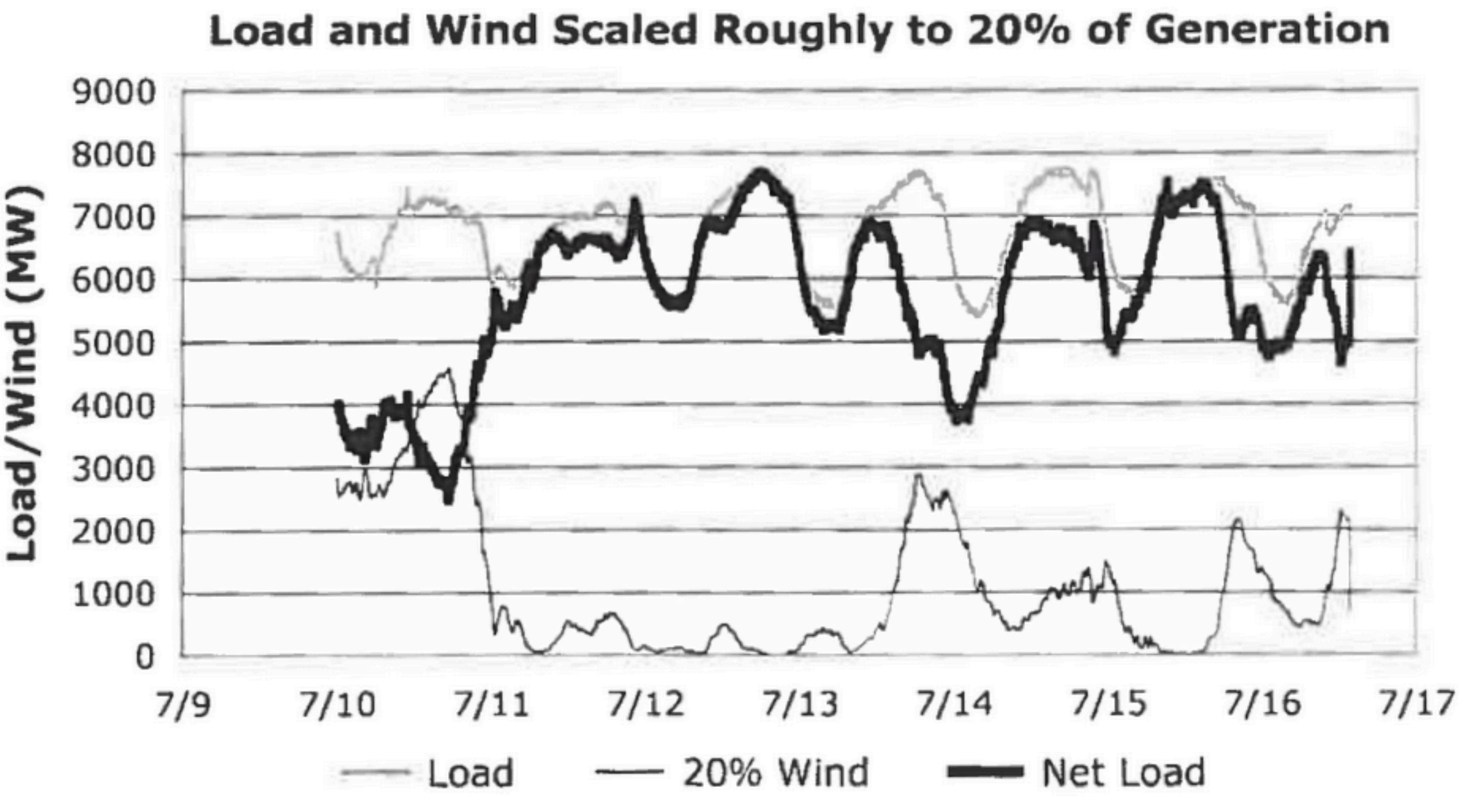
In addition to being more expensive, these renewables are **uncertain** and **variable**.

Source: EIA AEO 2015. Table 8.2

Wind as Large Share of System

During periods of peak wind generation, this will drive net load to low levels that might not be practical to accommodate. For instance, shutting down a thermal unit may result in it being unavailable for the next morning when the wind will likely die down.



Source: Dragoon, Ken. *Valuing Wind Generation on Integrated Power Systems.* Elsevier, 2010.

Negative Prices

- On September 20, 2015, the spot price of electricity in Texas fell below zero and hit -$8.52 per megawatt hour in the middle of the night.
  - The price hovered around zero or less until around 8:15 AM.
- Texas is one of the largest wind producing states—with 9 percent of its electricity generation coming from wind in 2014.
- During the night when power demand was low, wind production was high driving the price down to negative prices.

Source: Wall St. Daily. *Want Free Electricity? Move to Texas.* September 29, 2015.

Negative Prices

- Incorporation of renewable energy creates the need for improved transmission.
  - "Curtailments of wind generation on the Texas electric grid have steadily dropped since 2011 as more than 3,500 miles of transmission lines have been built."
  - "Occurrences of wind-related negative real-time electricity prices have similarly declined as CREZ transmission expansions have allowed wind power to flow to more electricity demand areas in the state. "
  - As of 2013, the scheduled program completion date, all of the CREZ projects had been energized, at a total cost of **$7 billion**."

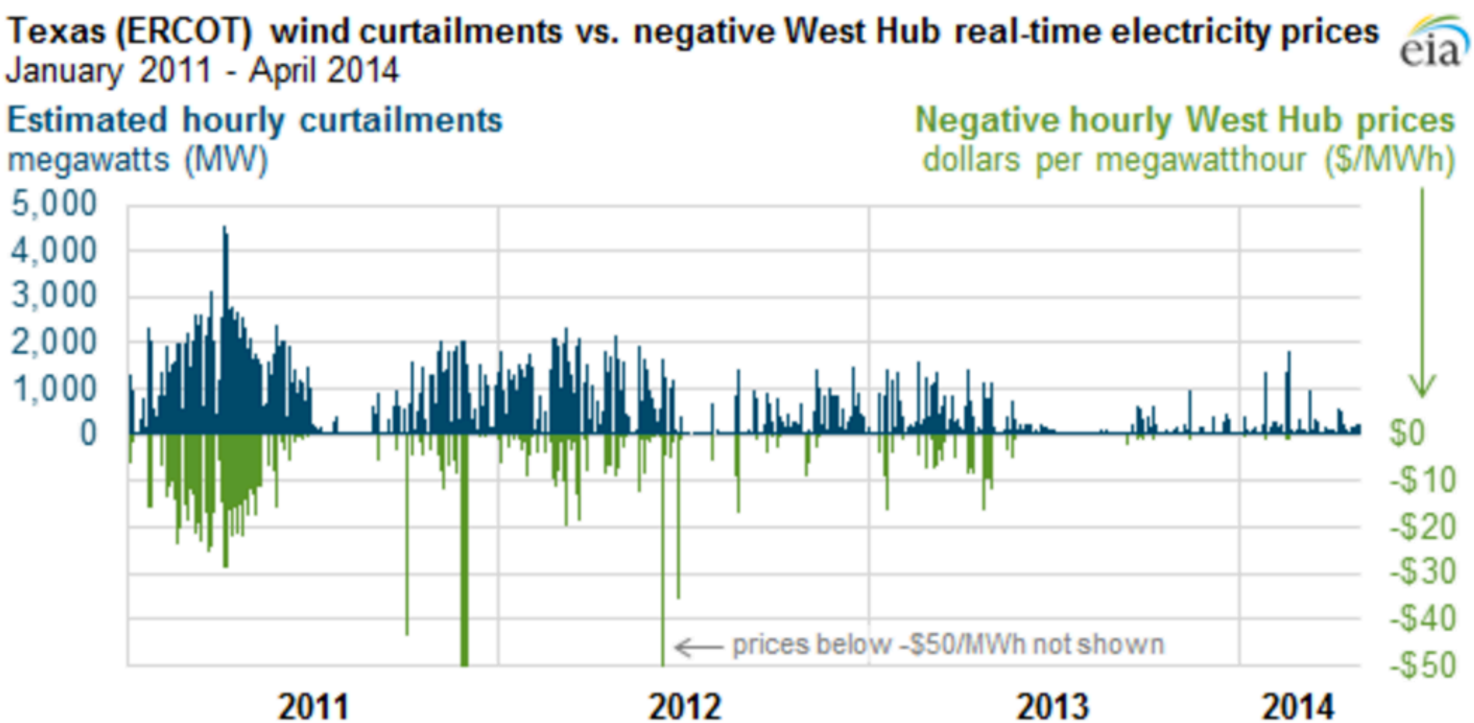
This comes out to a cost of more than $750 per household in Texas!
Upgrades can be made to accommodate higher levels of wind—but these are not cheap!

Source: EIA

Negative Prices

JUNE 24, 2014

Fewer wind curtailments and negative power prices seen in Texas after major grid expansion

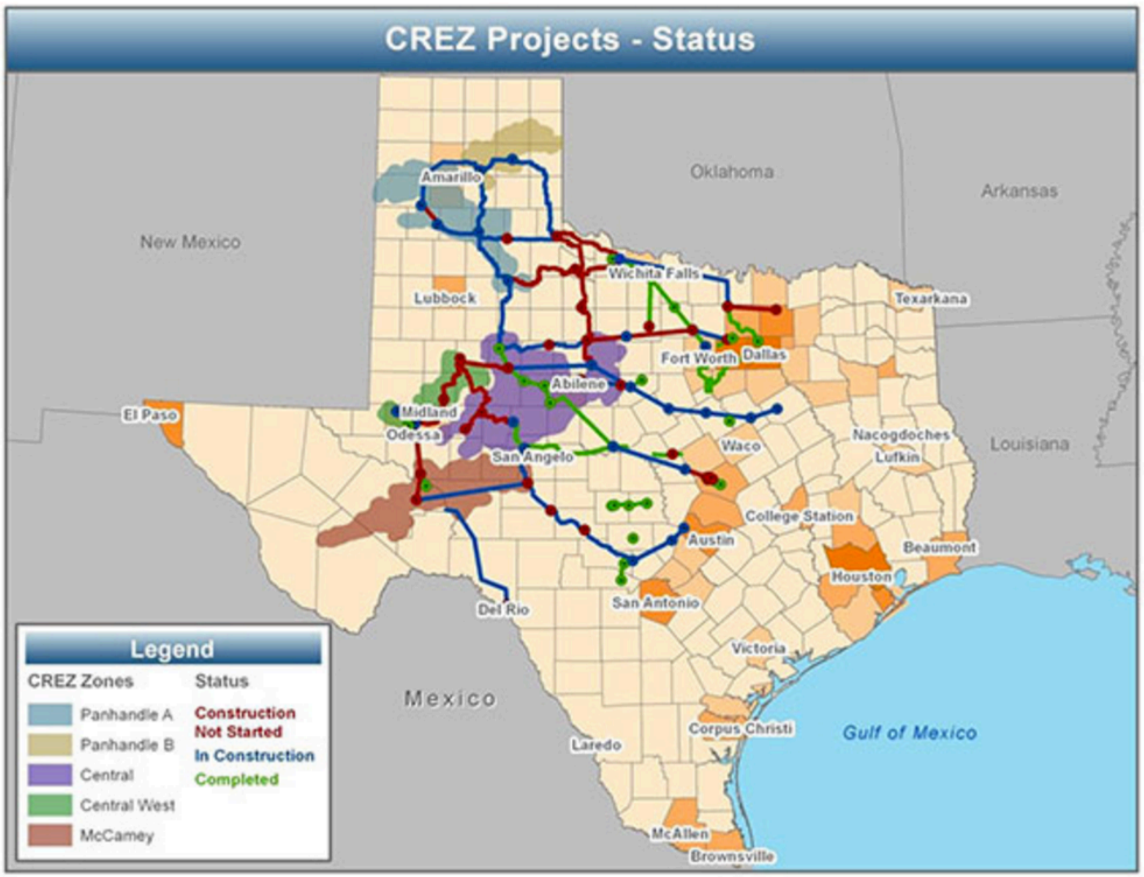


Source: U.S. Energy Information Administration, based on the Electric Reliability Council of Texas (ERCOT) for curtailments and SNL Energy for electricity prices

Source: EIA

Negative Prices

April 2014 | April 2013 | October 2012



Source: Public Utility Commission of Texas, October 2012 Competitive Renewable Energy Zones (CREZ) Program Progress Reports
Note: Click to enlarge.

Source: EIA

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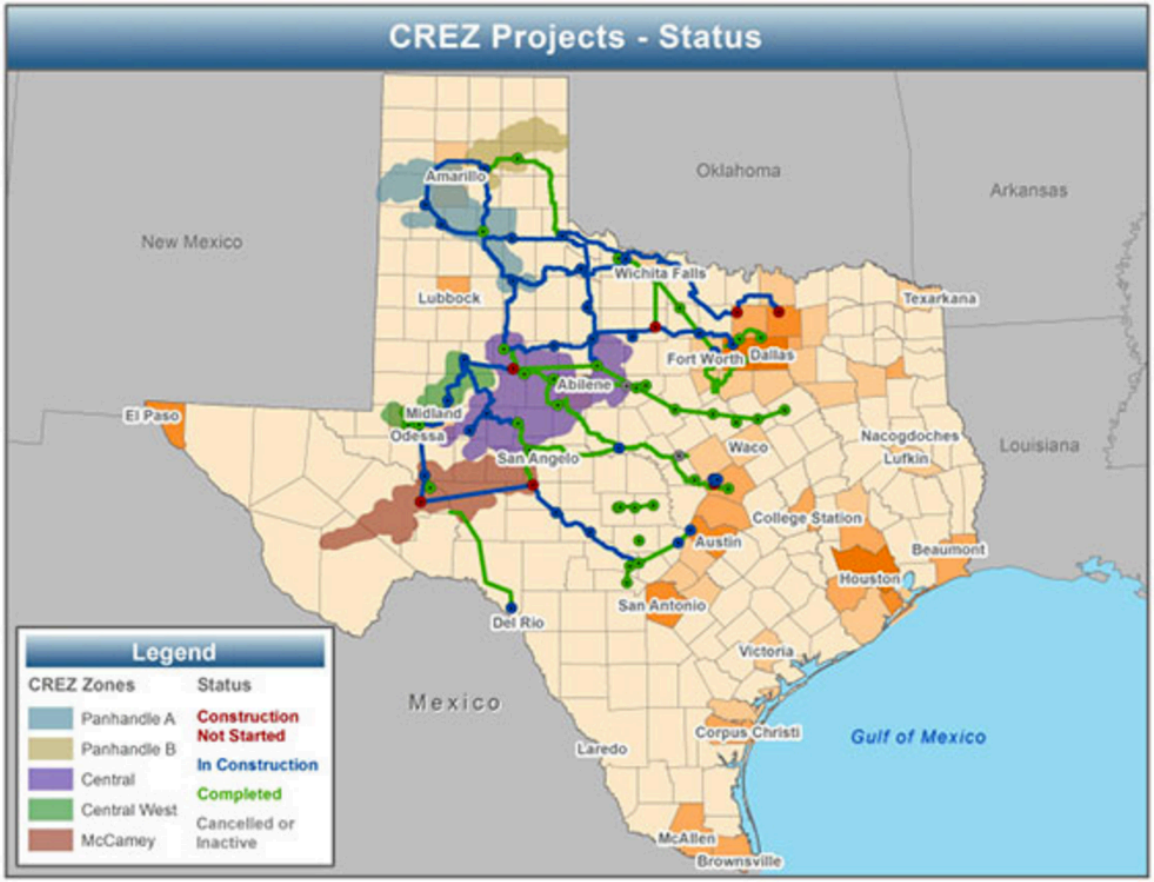

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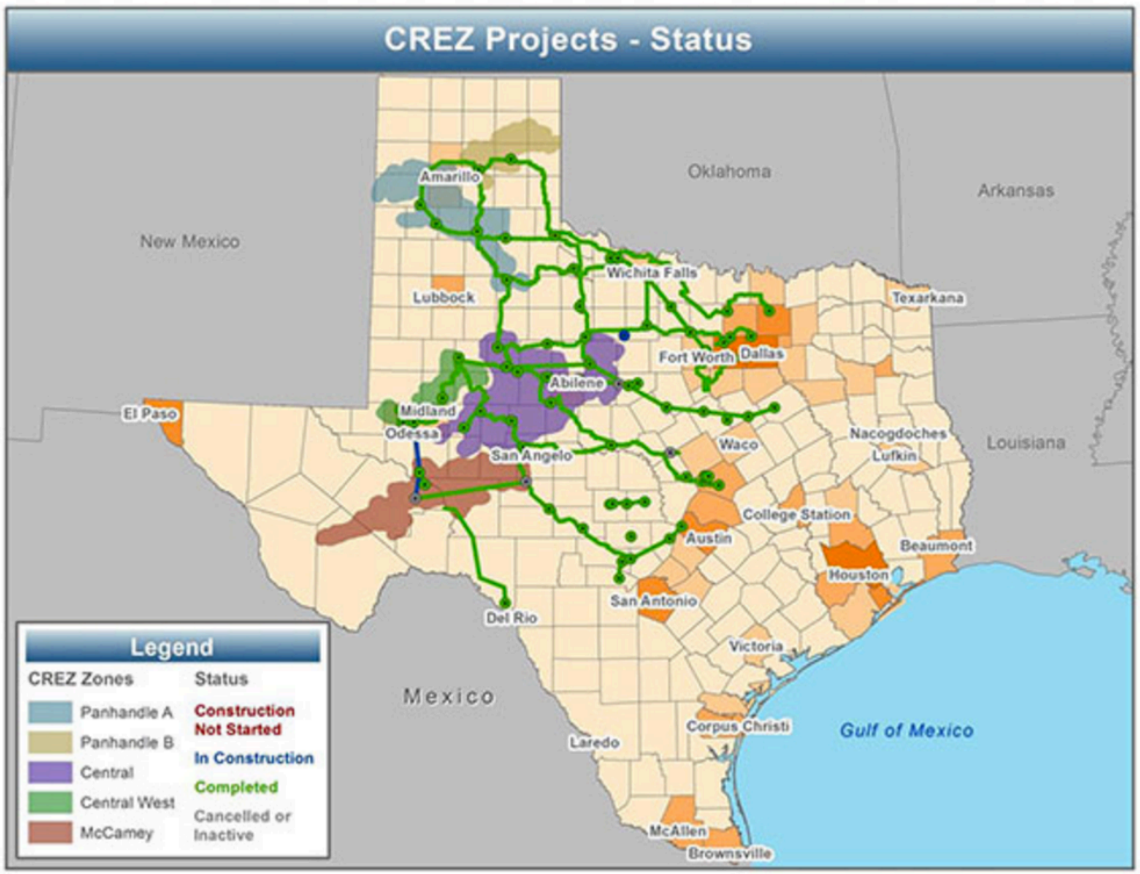

Source: Public Utility Commission of Texas, April 2014 Competitive Renewable Energy Zones (CREZ) Program Progress Reports
Note: Click to enlarge.

Source: EIA

Funding Renewable Energy

- So, can renewables be incorporated into the electricity grid? Of course they can!
- Can they lead to emissions reductions? If done intelligently, yes!
- But are they more expensive? Yes.
- There are two ways that society can choose to fund renewable generation:
  - Rate Increases
  - Taxing and Spending

Renewable Portfolio Standards

Renewable Portfolio Standards (RPSs) are state-level policies that legislatively mandate a portion of a state's electrical generation be produced by renewable sources by a specified future date.

RPS Policies commonly include a system of **renewable energy credits (RECs)** in which renewable producers generate one REC for every MWh of renewable electricity produced.

RECs can be bought and sold to help electricity providers meet RPS obligations. The vast majority of RECs nationwide have come from commercial scale wind energy.

RPSs are the most common state-level policy to promote renewable energy, as 30 states have adopted RPSs.

Source: Upton, Gregory B. and Brian F. Snyder. *Renewable Energy Potential and Renewable Portfolio Standard Adoption.*. Forthcoming *Utilities Policy.*

Renewable Portfolio Standards

TABLE 1—OVERVIEW OF RENEWABLE PORTFOLIO STANDARDS

State	Year	State	Year
Arizona	2001	Montana	2005
California	2002	Nevada	1997
Colorado	2004	New Hampshire	2007
Connecticut	1999	New Jersey	2001
Delaware	2005	New Mexico	2002
Hawaii	2004	New York	2004
Illinois	2005	North Carolina	2007
Iowa	1983	Ohio	2008
Kansas	2009	Oregon	2007
Maine	1999	Pennsylvania	2004
Maryland	2004	Rhode Island	2004
Massachusetts	1997	Texas	1999
Michigan	2008	Washington	2006
Minnesota	1997	West Virginia	2009
Missouri	2008	Wisconsin	1999

Source: Eastin (2014) and authors' independent research.

Source: Upton, Gregory B. and Brian F. Snyder. *Renewable Energy Potential and Renewable Portfolio Standard Adoption.*. Forthcoming *Utilities Policy.*

Renewable Portfolio Standards

- Empirical estimates suggest that RPS states have experienced an average of .9 ¢/kWh increase in electricity rates relative to non-RPS states with similar renewable energy potential, political environment, and prevalence of fossil fuel based industries.
  - Building renewable energy into the electricity price is **beneficial** for **solar customers** and **energy efficiency** investments.
  - Increased electricity prices make it **more expensive** to charge **EVs**.

Source: Upton, Gregory B. and Brian F. Snyder. *Renewable Energy Potential and Renewable Portfolio Standard Adoption.*. Forthcoming *Utilities Policy.*

Conclusions

Conclusions

- The **details matter!**
  - Sometimes a rate design mechanism that might promote renewables could make EVs less economical.
  - On the other hand, rate design that encourages EVs might make renewables less economical.

Utility rate design should be **agnostic** to **specific technologies**.

Instead rate design should provide an **equitable rate structure** that **aligns incentives** for all customers whether they choose to invest in renewable generation, demand reduction, electric vehicles, or choose to do nothing at all.

The goal of rate design should be to **internalize** the **externality**, not choose which technology is the winner and which is the loser.

Questions, Comments and Discussion

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