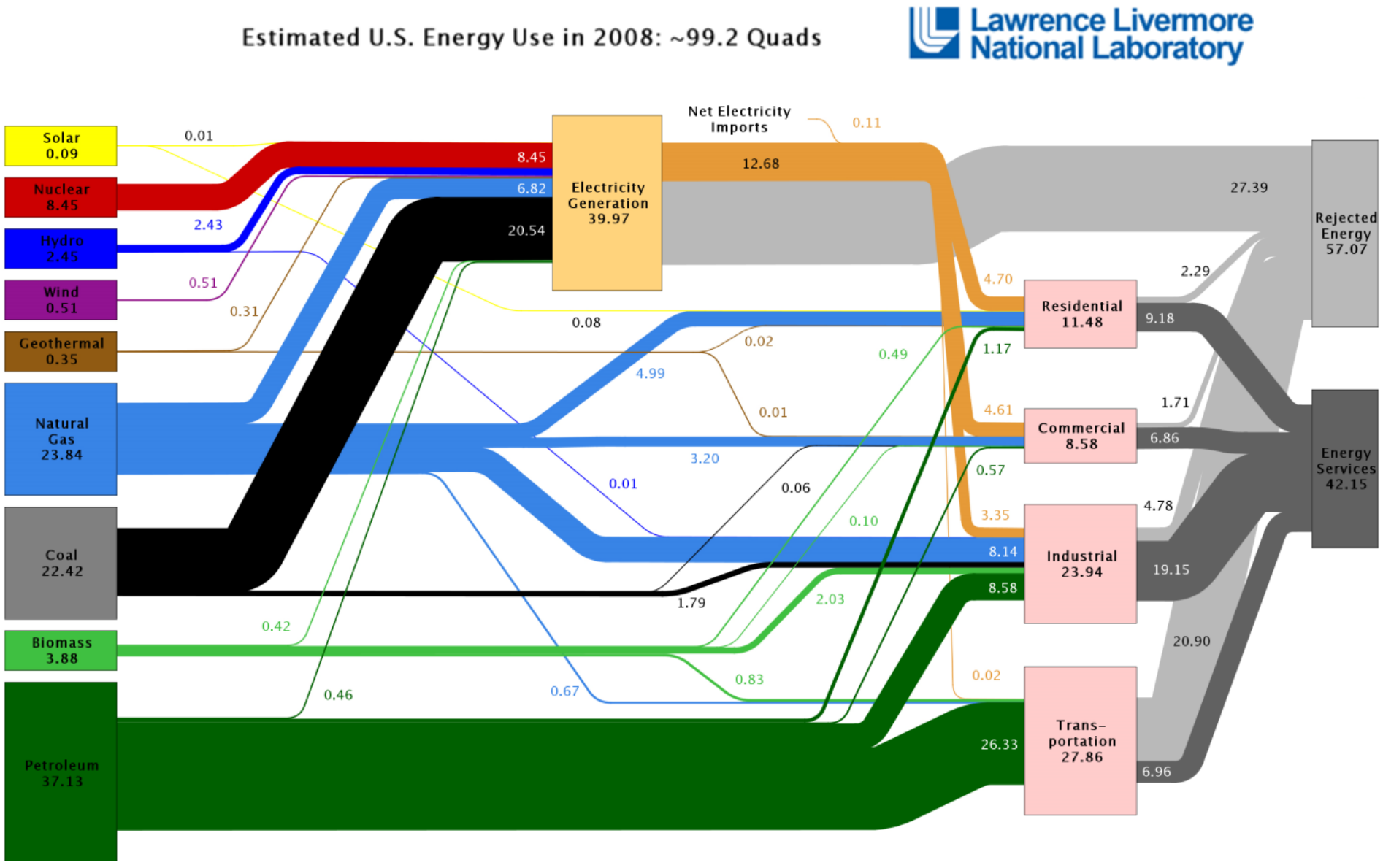
The Electric Utility's Business Model

or the taming of the shrew

Jimmy Jia
jimmy@jimmyjia.com
Last Edit: April 14, 2019

Energy Balance in the USA



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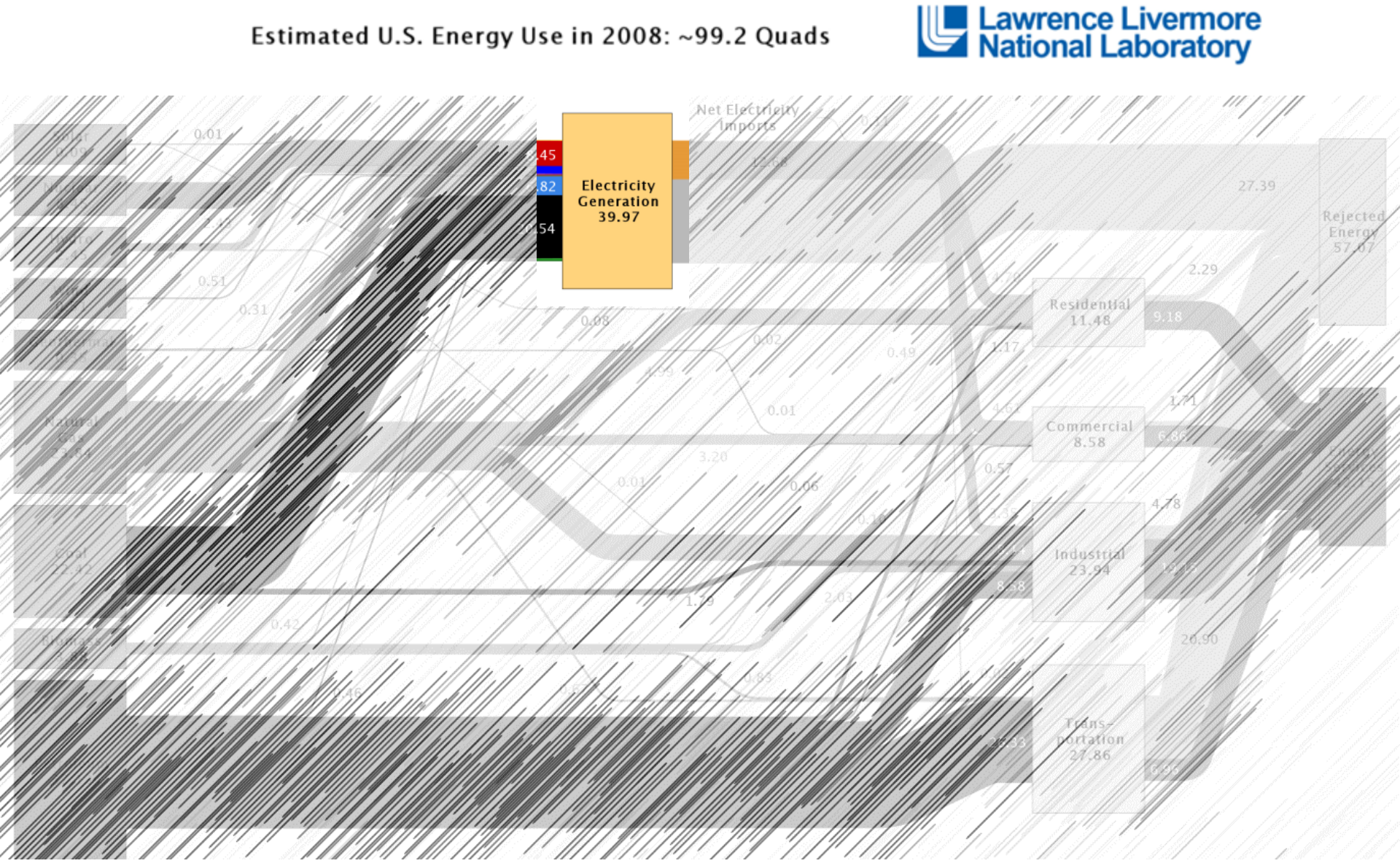


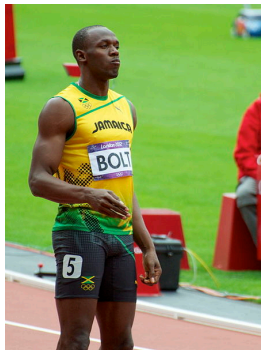
Energy vs. Power

Energy	Power
- Measures ability to do work	- Rate at which work is produced
- kWh; Joule; Calorie	- kW ; $\frac{\text{Joule}}{\text{time}}$
- How much water do we have?	- How fast is the water flowing?

Common Confusion #3:
Energy and Power are not the same thing.

Sprinter vs. Marathoner: who's the better athlete?

Usain Bolt



6'5"

38 mph

9.69 sec

Energy: 81.6 kJ

Max Power: 2620 W

Stephen Kiprotich

5'8"

12 mph

2:08:01 hours

Energy: 18,600 kJ

Power: 342 W

What are we buying?

Energy?

Power?

Electricity?

Access?

None?

All?

What do I care about?

Here's what we're buying

Safety Standards:

Waste and Lead Free:

Here's what we're buying:

- What about 60 Hz?
- What about 120 V?
- What about 2.0 A?
- What about availability 24/7/365?
- What about ∿ vs ⎓?

Anything seem missing?

Here's what we're buying

- What about 60 Hz?
- What about 120 V?
- What about 2.0 A?
- What about availability 24/7/365?
- What about ∿ vs ⎓?

NERC required Ancillary Services Products

1) Regulation
2) Load Following
3) Energy Imbalance
4) Operating Reserve – Spinning
5) Operating Reserve – Supplemental
6) Backup Supply
7) System Control
8) Dynamic Scheduling
9) Reactive Power and Voltage Control from Generation Sources
10) Real Power Transmission Losses
11) Network Stability Services from Generation Sources
12) System Black start Capability

$$\frac{Energy}{Time} = Power$$

Energy

Power

$$\frac{Energy}{Time} = Power$$

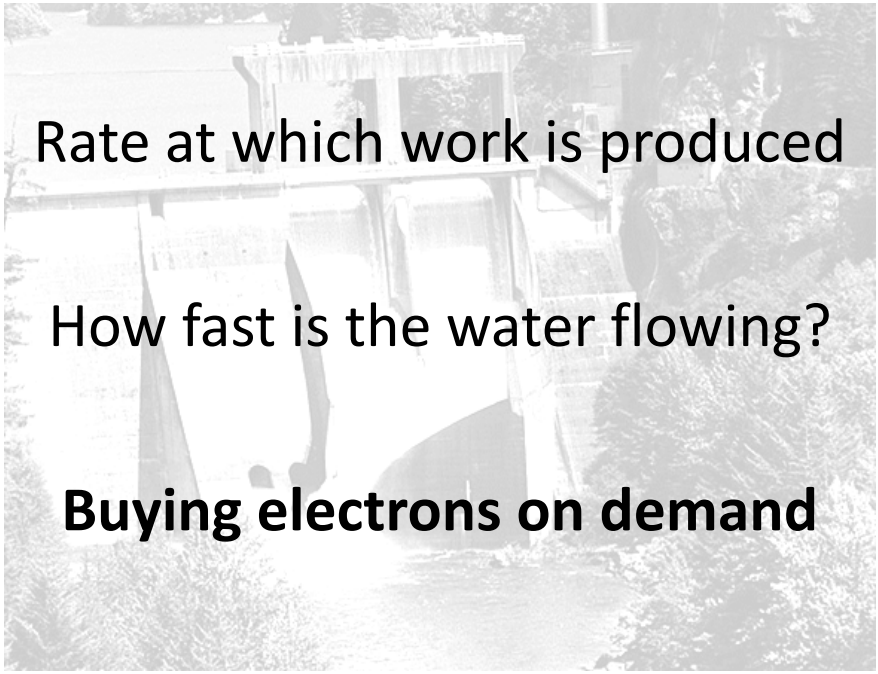
Energy (kWh)

Measures ability to do work

How much water do we have?

Buying electrons

Power (kW, hp)



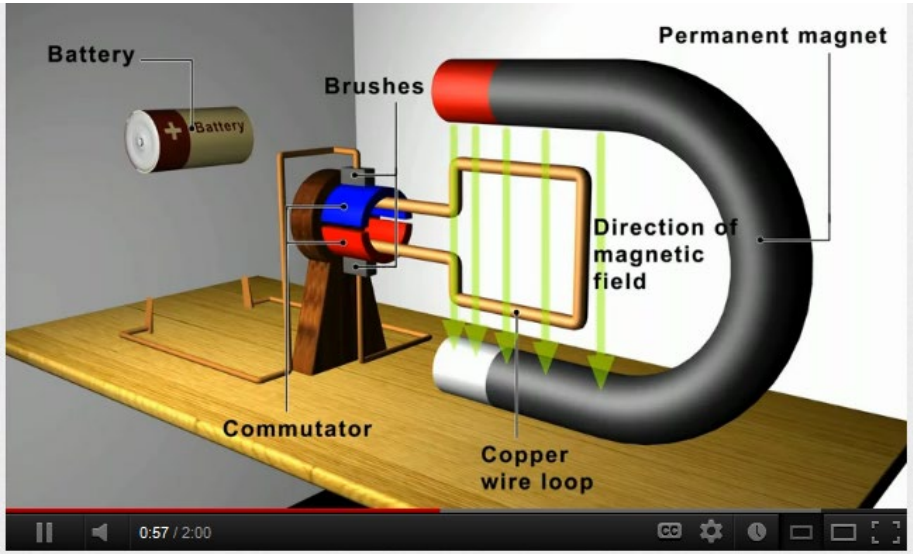
Rate at which work is produced

How fast is the water flowing?

Buying electrons on demand

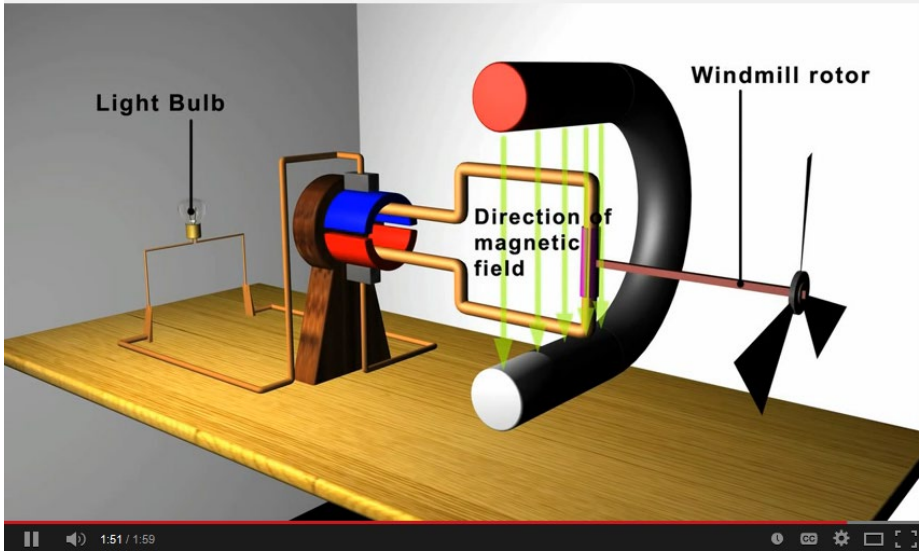
How do we create it?

Motor



Electricity + Magnet → Rotation

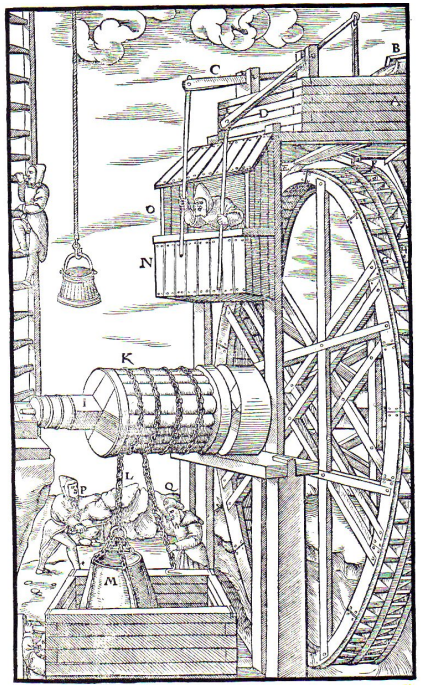
Turbine / Generator



Rotation + Magnet → Electricity

http://www.youtube.com/watch?v=d_aTC0iKO68

Turn the motor in a variety of mechanical ways



Water Power

Wind Power

Animal Power

http://www.youtube.com/watch?v=GI7AhajfhWE&feature=related

Then came chemistry!

Steam

http://www.youtube.com/watch?v=GI7AhajfhWE&feature=related

Energy System

Turn a motor to generate electricity

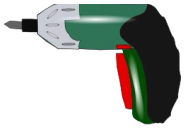
Use steam to turn a turbine

Boil water to create steam

Burn fuel to generate heat

Transmit electrons over great distances

Use electrons to light things



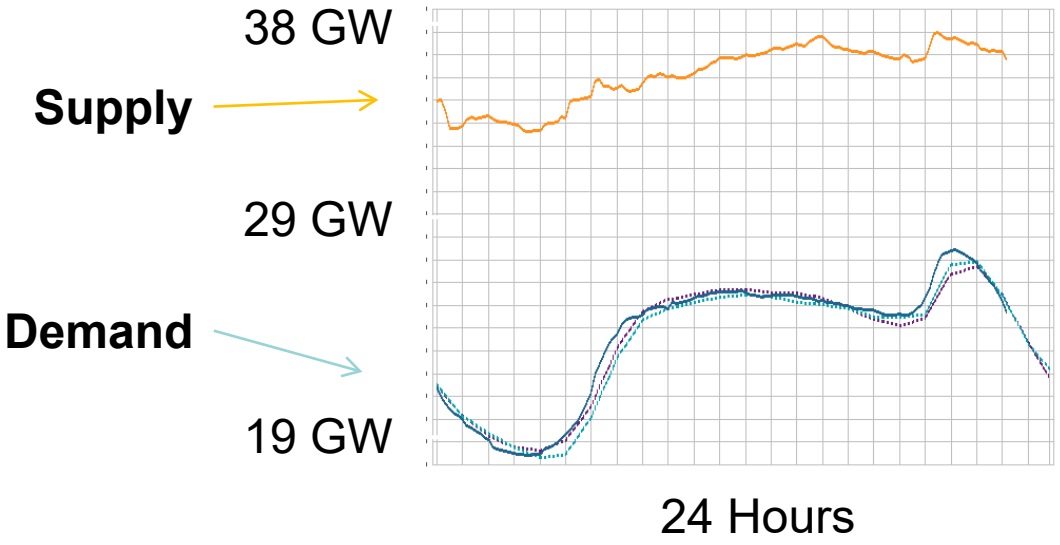
Use electrons to turn motors

Use electrons to power things

Use electrons to heat things

All images from openclipart.org

Capacity (kW) Constraints

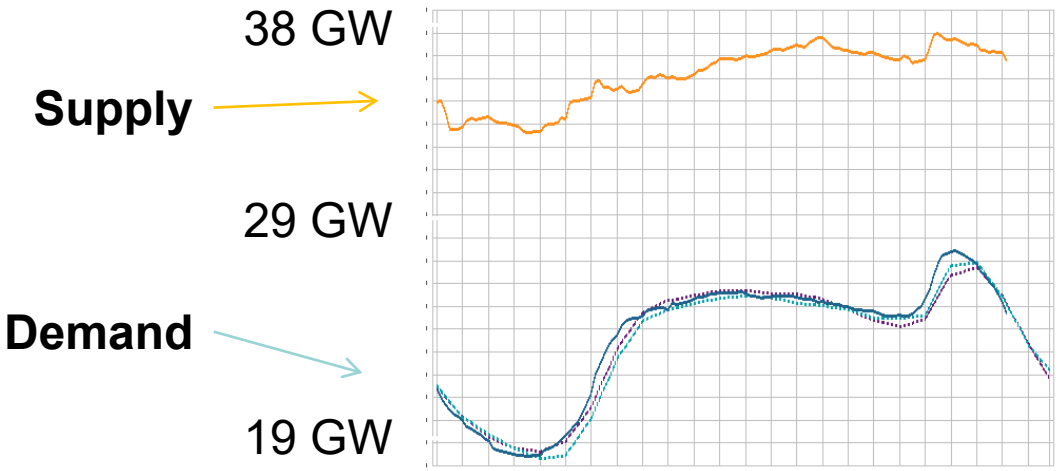


Common Confusion #4:
Electric energy is further constrained by TIME and LOCATION

See real time information at www.caiso.com
The California Independent System Operator

Capacity (kW) Constraints

Energy Storage:
Shifting Excess Generation to When it's Needed



Demand Response:
Shifting Peak Demand to When There's Surplus Energy

Common Confusion:
Electric energy is further constrained by TIME and LOCATION

Capacity (kW) Constraints

Energy Storage:
Shifting Excess Generation to When it's Needed

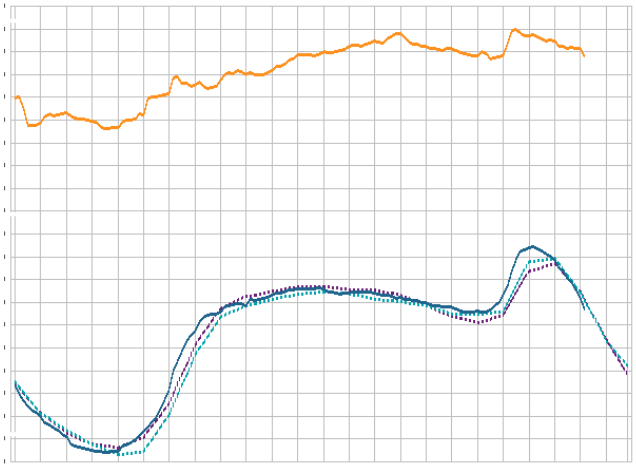
38 GW

Supply

29 GW

Demand

19 GW

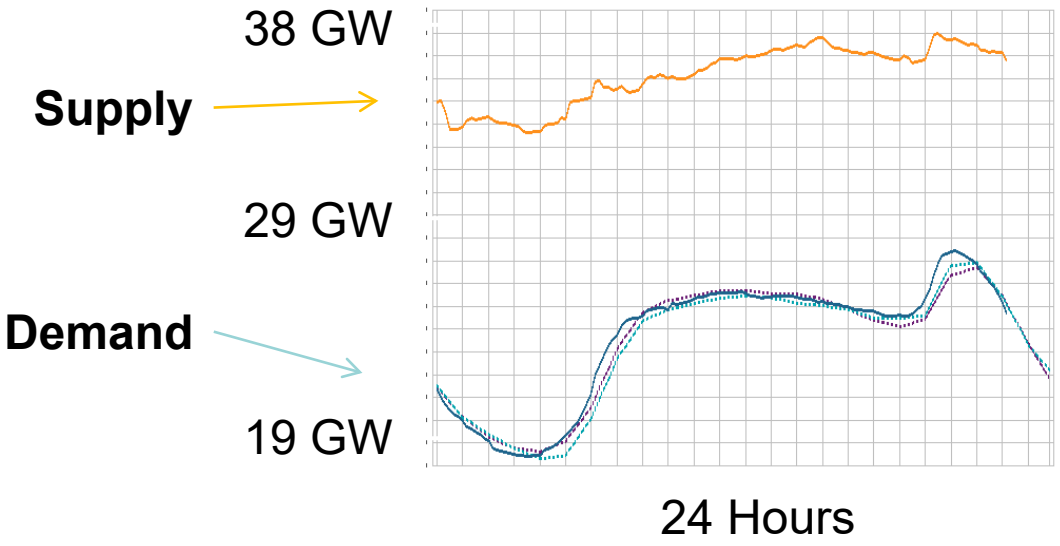


24 Hours

Demand Response:
Shifting Peak Demand to When There's Surplus Energy

ALERT:
We are already confusing energy and power!

Energy vs. Power



Energy Units:
kWh
BTU
Therms

Power Units:
kW
Horsepower

What is a Utility?

- An Example of why the exist
- How they made money (Cost Recovery)
- The actual role of utility in society

The Governing Laws of Utilities

Conservation of Energy

- What comes in must go out

Law of Supply and Demand

- Determines the equilibrium price of a good at a given time

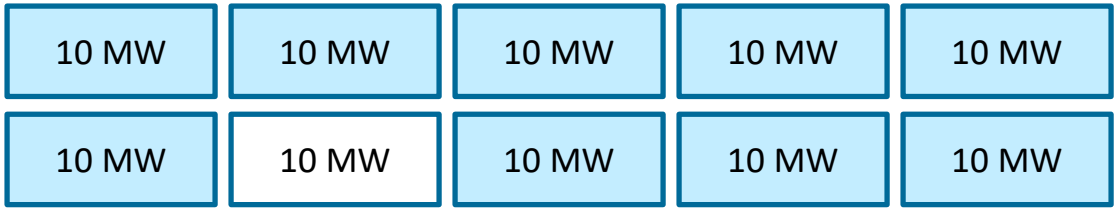
Market Distortion

- Intervention in a market by a governing body

… or by the laws of physics!

Supply and Demand in Power

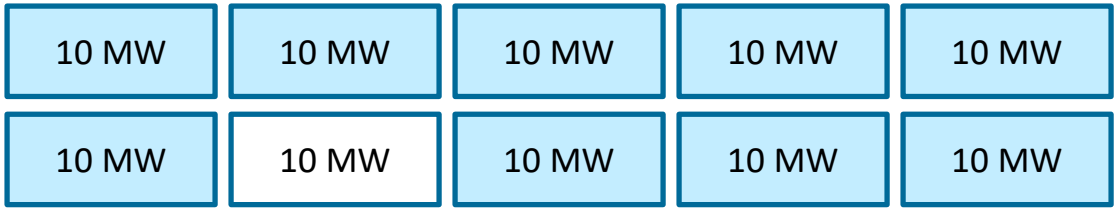
Scenario A: Demand is 90 MW and you have 10 power plants



Perfect competition – each plant will bid the lowest price to sell electricity to the market

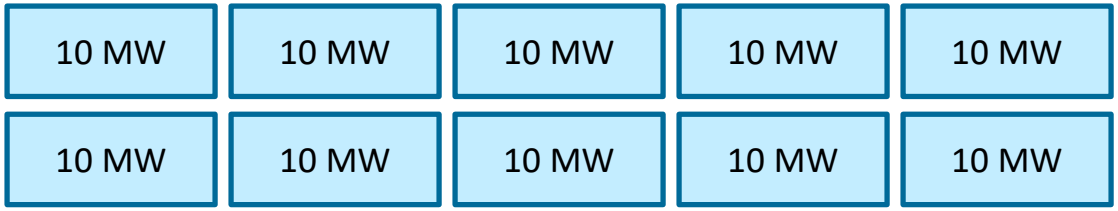
Supply and Demand in Power

Scenario A: Demand is 90 MW and you have 10 power plants



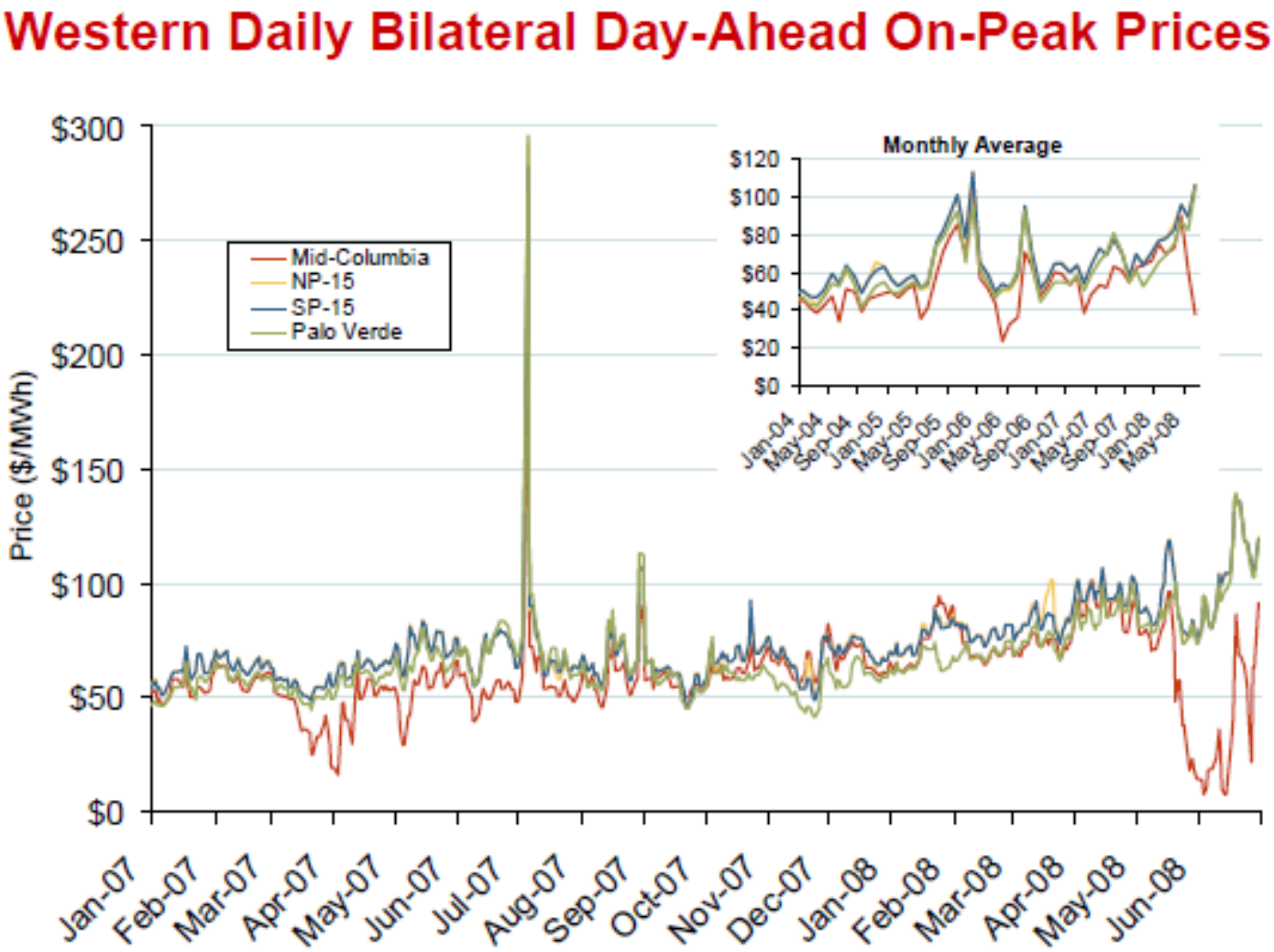
Perfect competition – each plant will bid the lowest price to sell electricity to the market

Scenario B: Demand is 91 MW and you have 10 power plants



Perfect monopoly – each plant is required to produce and each can charge a monopolistic price

Spikes in wholesale electricity markets



FERC Market Filings June 2008

Real Time Pricing (SCE RTP-2 Rate)

Hour

Temperature

TYPE OF DAY (WEEKDAY OR WEEKEND) AND APPLICABLE TEMPERATURE [1/]

HOUR ENDING @ PST	EXTREMELY HOT SUMMER WEEKDAY (>=95)	VERY HOT SUMMER WEEKDAY (91-94)	HOT SUMMER WEEKDAY (85-90)	MODERATE SUMMER WEEKDAY (81-84)	MILD SUMMER WEEKDAY (<=80)	HIGH COST WINTER WEEKDAY (>90)	LOW COST WINTER WEEKDAY (<=90)	HIGH COST WEEKEND (>=78)	LOW COST WEEKEND (<78)
1 a.m.	0.05067 (R)	0.05269 (R)	0.05132 (R)	0.04926 (R)	0.03930 (R)	0.04433 (R)	0.03897 (R)	0.05447 (R)	0.03881 (R)
2 a.m.	0.04370 (R)	0.04471 (R)	0.04323 (R)	0.04174 (R)	0.03211 (R)	0.03904 (R)	0.03498 (R)	0.04701 (R)	0.03112 (R)
3 a.m.	0.03881 (R)	0.03976 (R)	0.03900 (R)	0.03791 (R)	0.02925 (R)	0.03709 (R)	0.03336 (R)	0.04304 (R)	0.02764 (R)
4 a.m.	0.03731 (R)	0.03835 (R)	0.03770 (R)	0.03687 (R)	0.02847 (R)	0.03733 (R)	0.03421 (R)	0.04101 (R)	0.02609 (R)
5 a.m.	0.04143 (R)	0.04219 (R)	0.04108 (R)	0.04022 (R)	0.03254 (R)	0.04310 (R)	0.03990 (R)	0.04255 (R)	0.02725 (R)
6 a.m.	0.05366 (R)	0.05293 (R)	0.05107 (R)	0.05087 (R)	0.04324 (R)	0.05628 (R)	0.05242 (R)	0.04609 (R)	0.02983 (R)
7 a.m.	0.04810 (R)	0.04446 (R)	0.04365 (R)	0.04410 (R)	0.03999 (R)	0.06172 (R)	0.05921 (R)	0.04109 (R)	0.02279 (R)
8 a.m.	0.06131 (R)	0.05794 (R)	0.05597 (R)	0.05494 (R)	0.05070 (R)	0.06828 (R)	0.06284 (R)	0.04921 (R)	0.03081 (R)
9 a.m.	0.07944 (R)	0.08906 (R)	0.07199 (R)	0.06994 (R)	0.06250 (R)	0.07844 (R)	0.06753 (R)	0.05870 (R)	0.03912 (R)
10 a.m.	0.14602 (R)	0.13216 (R)	0.08432 (R)	0.08142 (R)	0.07284 (R)	0.11445 (R)	0.07151 (R)	0.06716 (R)	0.04593 (R)
11 a.m.	0.31691 (R)	0.26934 (R)	0.11506 (R)	0.09372 (R)	0.08485 (R)	0.19572 (R)	0.07270 (R)	0.07384 (R)	0.04944 (R)
12 noon	0.66339 (R)	0.40629 (R)	0.12644 (R)	0.09315 (R)	0.08381 (R)	0.25018 (R)	0.07414 (R)	0.07748 (R)	0.05174 (R)
1 p.m.	1.07190 (R)	0.58280 (R)	0.15711 (R)	0.10594 (R)	0.08968 (R)	0.36055 (R)	0.07512 (R)	0.08058 (R)	0.05323 (R)
2 p.m.	1.85452 (R)	0.92816 (R)	0.32889 (R)	0.11504 (R)	0.09673 (R)	0.55083 (R)	0.07674 (R)	0.08325 (R)	0.05432 (R)
3 p.m.	2.65796 (R)	1.17929 (R)	0.48718 (R)	0.13768 (R)	0.10104 (R)	0.68520 (R)	0.07668 (R)	0.08553 (R)	0.05496 (R)
4 p.m.	3.67292 (R)	1.48599 (R)	0.59713 (R)	0.16280 (R)	0.10274 (R)	0.79155 (R)	0.07592 (R)	0.08829 (R)	0.05617 (R)
5 p.m.	3.66475 (R)	1.36026 (R)	0.60574 (R)	0.15447 (R)	0.09909 (R)	0.65896 (R)	0.07600 (R)	0.09461 (R)	0.05950 (R)
6 p.m.	2.75863 (R)	1.06702 (R)	0.41738 (R)	0.12965 (R)	0.09503 (R)	0.36608 (R)	0.08108 (R)	0.10138 (R)	0.06358 (R)
7 p.m.	1.73653 (R)	0.55301 (R)	0.24346 (R)	0.11273 (R)	0.08802 (R)	0.27924 (R)	0.08111 (R)	0.09811 (R)	0.06386 (R)
8 p.m.	1.22751 (R)	0.37981 (R)	0.18066 (R)	0.10924 (R)	0.08507 (R)	0.27848 (R)	0.08080 (R)	0.09483 (R)	0.06537 (R)
9 p.m.	1.36084 (R)	0.60949 (R)	0.19153 (R)	0.09432 (R)	0.08939 (R)	0.32773 (R)	0.09195 (R)	0.09557 (R)	0.07139 (R)
10 p.m.	0.27989 (R)	0.24168 (R)	0.09611 (R)	0.07740 (R)	0.07196 (R)	0.14377 (R)	0.07332 (R)	0.08112 (R)	0.05810 (R)
11 p.m.	0.09457 (R)	0.12463 (R)	0.08762 (R)	0.07989 (R)	0.07716 (R)	0.09458 (R)	0.07065 (R)	0.07898 (R)	0.06343 (R)
Midnight [3/]	0.06797 (R)	0.06743 (R)	0.06405 (R)	0.05995 (R)	0.05613 (R)	0.06351 (R)	0.05447 (R)	0.06323 (R)	0.04840 (R)

Example from Southern California Edison

Real Time Pricing (SCE RTP-2 Rate)

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7 a.m.	0.04810 (R)	0.04446 (R)	0.04365 (R)	0.04410 (R)	0.03999 (R)	0.06172 (R)	0.05921 (R)	0.04109 (R)	0.02279 (R)
8 a.m.	0.06131 (R)	0.05794 (R)	0.05597 (R)	0.05494 (R)	0.05070 (R)	0.06828 (R)	[illegible] (R)	[illegible] (R)	0.03081 (R)
9 a.m.	0.07944 (R)	0.08906 (R)	0.07199 (R)	0.06994 (R)	0.06250 (R)	[illegible]	[illegible]	[illegible]	[illegible] (R)
10 a.m.	0.14602 (R)	0.13216 (R)	0.08432 (R)	0.08142 (R)	0.07284 (R)	[illegible]	[illegible]	[illegible]	[illegible] (R)
11 a.m.	0.31691 (R)	0.26934 (R)	0.11506 (R)	0.09372 (R)	0.08485 (R)	[illegible]	[illegible]	[illegible]	[illegible] (R)
12 noon	0.66339 (R)	0.40629 (R)	0.12644 (R)	0.09315 (R)	0.08381 (R)	[illegible]	[illegible]	[illegible]	[illegible] (R)
1 p.m.	1.07190 (R)	0.58280 (R)	0.15711 (R)	[illegible]	0.08968 (R)	0.36[illegible]	[illegible]	[illegible]	0.05323 (R)
2 p.m.	1.85452 (R)	0.92816 (R)	[illegible]	[illegible]	[illegible]	0.55083 (R)	0.07674 (R)	0.08325 (R)	0.05432 (R)
3 p.m.	2.65796 (R)	1.17929 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]520 (R)	0.07668 (R)	0.08553 (R)	0.05496 (R)
4 p.m.	3.67292 (R)	1.4859[illegible]	[illegible]	[illegible]	[illegible]	[illegible]155 (R)	0.07592 (R)	0.08829 (R)	0.05617 (R)
5 p.m.	3.66475 (R)	1.36020 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]896 (R)	0.07600 (R)	0.09461 (R)	0.05950 (R)
6 p.m.	2.75863 (R)	1.06702 (R)	[illegible]	[illegible]	[illegible]	0.36608 (R)	0.08108 (R)	0.10138 (R)	0.06358 (R)
7 p.m.	1.73653 (R)	0.55301 (R)	0.24340 (R)	[illegible]	[illegible]802 (R)	0.27924 (R)	0.08111 (R)	0.09811 (R)	0.06386 (R)
8 p.m.	1.22751 (R)	0.37981 (R)	0.18066 (R)	0.10924 (R)	0.08507 (R)	0.27848 (R)	0.08080 (R)	0.09483 (R)	0.06537 (R)
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Midnight [4/]	0.06797 (R)	0.06743 (R)	0.06405 (R)	0.05995 (R)	0.05613 (R)	0.06351 (R)	0.05447 (R)	0.06323 (R)	0.04840 (R)

$ 0.02609 / kWh

$ 3.67292 / kWh

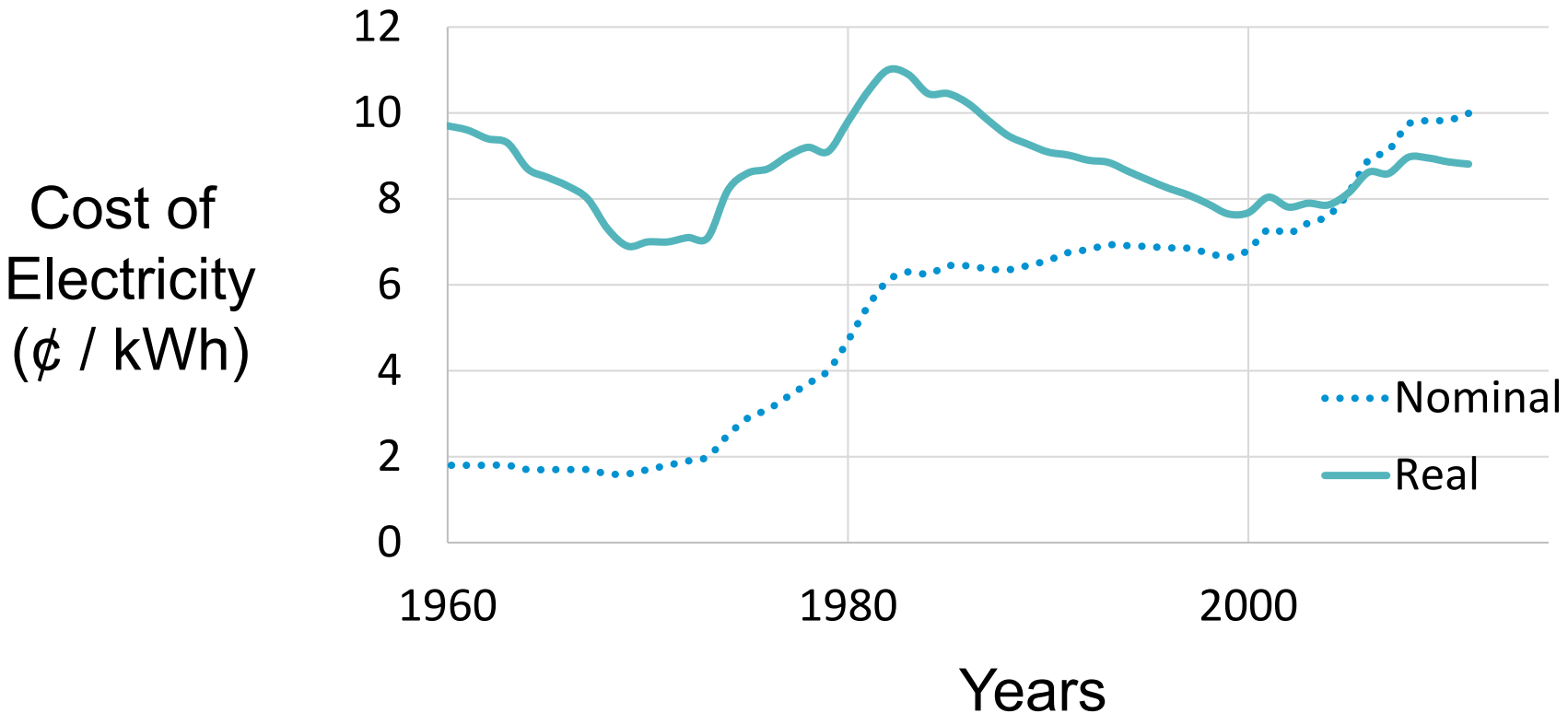
Example from Southern California Edison

Samuel Insull, CEO
Chicago Edison
Company

Served 91 kW of
customers

With a 29 kW
transformer!

Diversification of power → lowers cost to deliver load



BREAK

Statutory Framework

Under RCW 80.28.010, the WUTC must establish rates that are

"***fair*** to customer and to the Company's owners; ***just*** in the sense of being based solely on the record developed in the proceeding following principles of due process of law; ***reasonable*** in light of the range of possible outcomes supported by the evidence and; ***sufficient*** to meet the needs of the Company to cover its expenses and attract necessary capital on reasonable terms."

PSE General Rate Case, Docket UE-0-0904, Final Order, Order 11 (April 2, 2010).

Utilities Manage RISK

A utility is charged with managing risk

- Financial risk of price spikes
- Physical risks of reliability
- Equal access to all consumers

In return, they get

- A local monopoly
- Guaranteed revenue

If I was a developer…

How do I convince investors to give me $20 M to build an apartment?

If I was a developer…

How do I convince investors to give me $20 M to build an apartment?

Promise investors 8% return per year for 10 years.

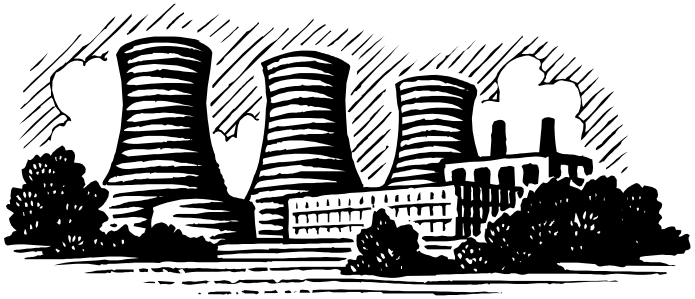
Earn $3 M per year

Capacity of 100 units

Therefore charge
$30,000 per year rent
$2,500 per month rent

If I was a developer…

How do I convince investors to give me $2 B to build a power plant?



Promise investors 8% return per year for 10 years.

Earn $300 M per year

Estimate 3.6 TWh/yr sold

Therefore charge
$0.08 per kWh wholesale
$0.24 per kWh retail

Are people happy with this number?

If I was a developer…

How do I convince investors to give me $2 B to build a power plant?

Time horizon	Annual Earnings	Est. Retail Cost
10-yr	$ 300,000,000	$ 0.24 / kWh
20-yr	$ 205,000,000	$ 0.17 / kWh
30-yr	$ 178,000,000	$ 0.15 / kWh

What can potentially affect a utility's earnings?

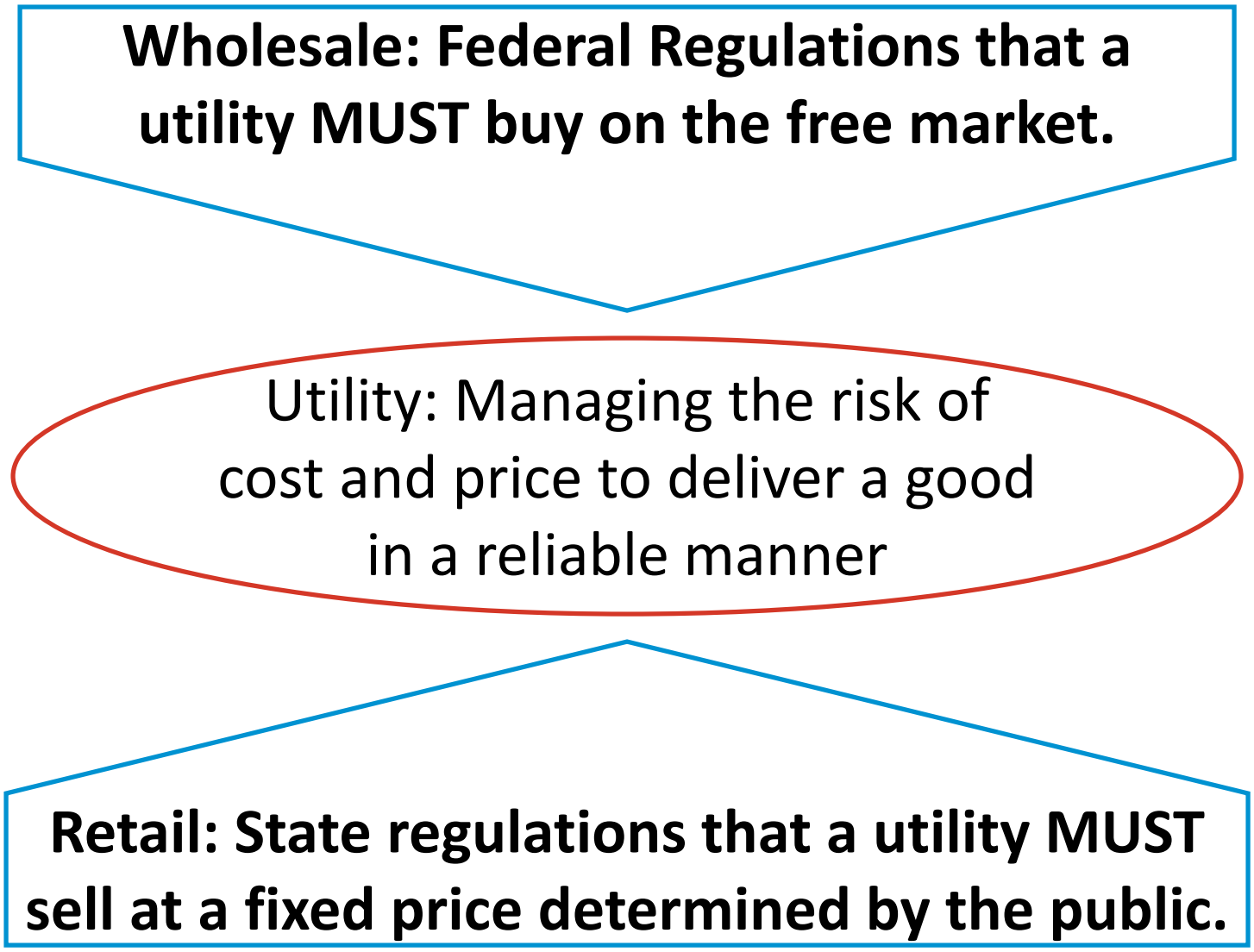
The concept of COST RECOVERY

In our example, the utility MUST earn $178,000,000 per year to meet their capital needs

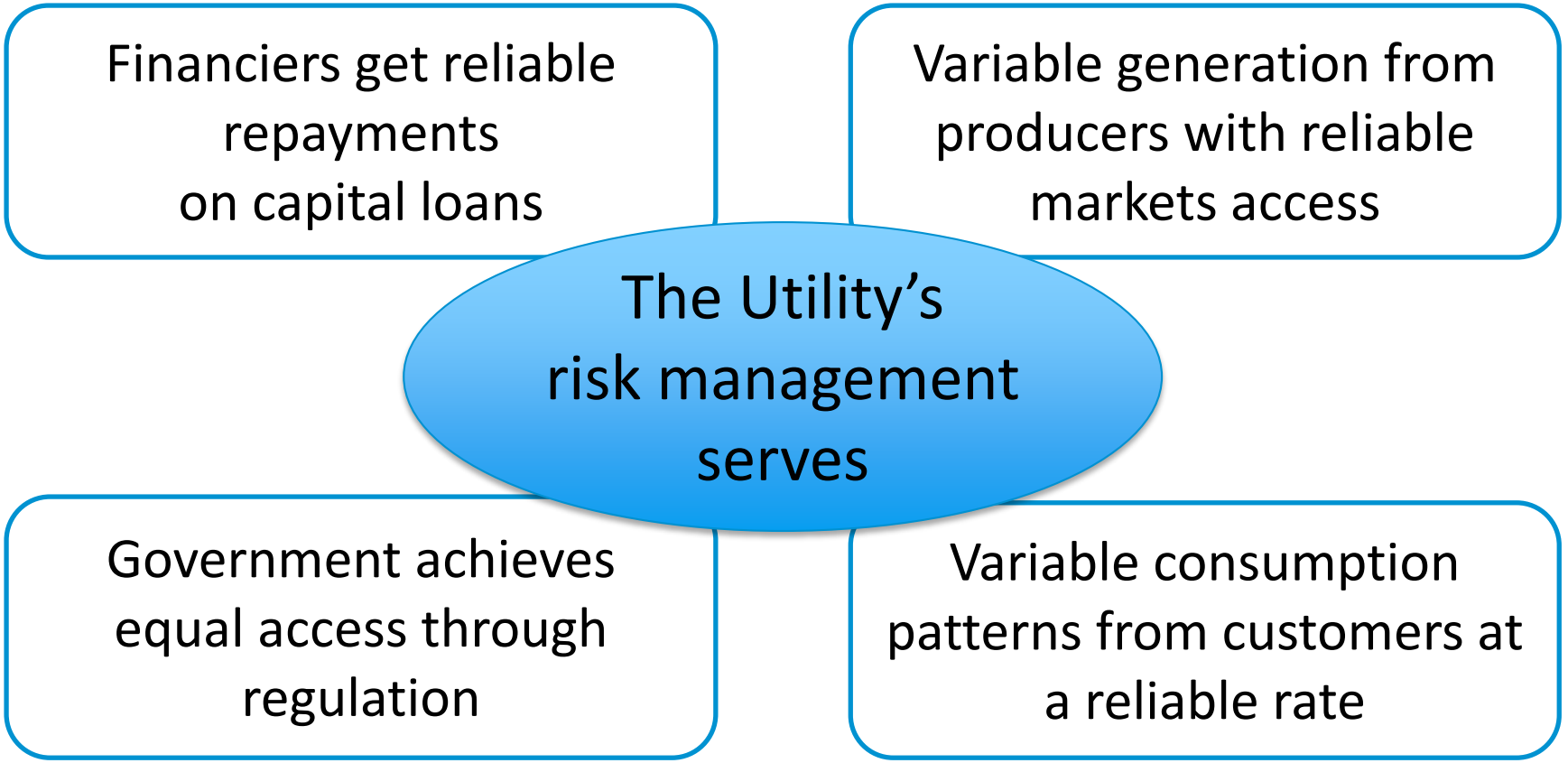
All electricity paid by consumers is used to ‘recover’ the capital cost of building the infrastructure.

This number INCLUDES an 8% interest repaid to investors.

Regulatory Environment



The Stakeholders in Utilities



Regulators

Figure 4-8:

2008 U.S. Retail Sales of Electricity By Type Of Utility

Type of Utility	Number of Utilities	Consumers	Sales (MWh)	2008 Revenue x $1000	Average $/kWh
Investor-Owned	211	94,996,996	2,229,654,009	$215,122,267	$0.096
Public	1,948	20,747,699	558,814,282	$49,178,880	$0.088
Cooperatives	938	18,167,208	392,103,539	$36,631,821	$0.093
Power Marketer	70	6,313,397	212,354,909	$25,331,745	$0.119
Total:	**3,159**	**140,225,380**	**3,392,926,739**	**$326,263,913**	**$0.096**

Source: USEIA 2008 Data

In Summary

- Energy, Electricity, Power – Keep your vocabulary consistent
- Time and Location – The constraints society cares about
- Utilities – Risk management is #1
- Public Service – Should energy be for the public good?