

The Case of the Neglected Infrastructure

A detective story in three parts

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For ...

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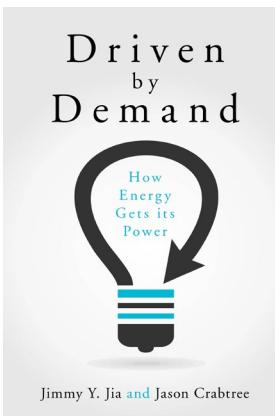
Hi! – I'm Jimmy



- CEO, Distributed Energy Management
- Board, Center for Sustainable Energy

- BS, MS, MIT Material Science
- MBA, Oxford University

- Author, *Driven by Demand*
- Speaker and Lecturer



- Energy pervades everything we do.
- How should we interact with it?

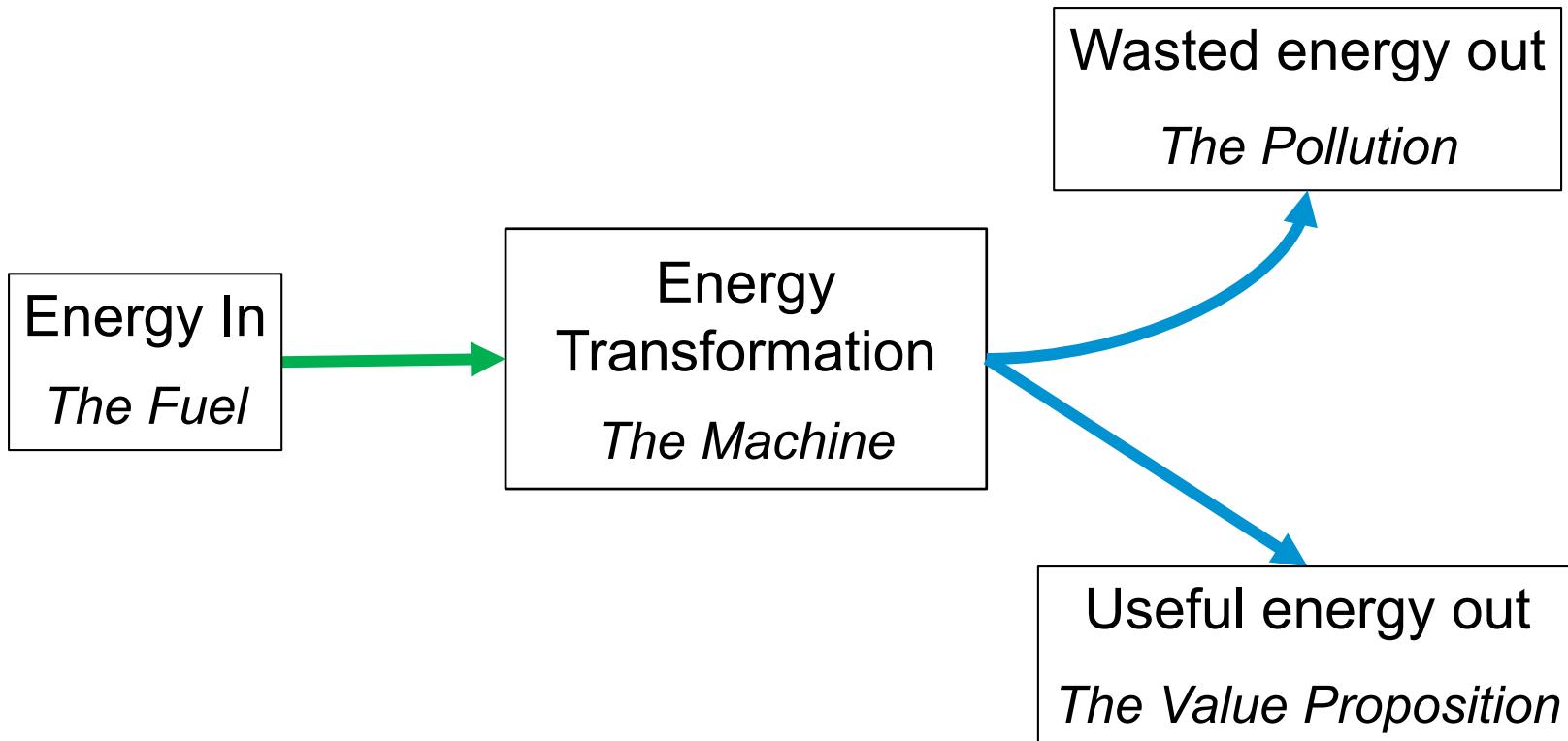
Agenda for tonight

- Introduction
- Three Actors
- Synthesis
- Quandaries

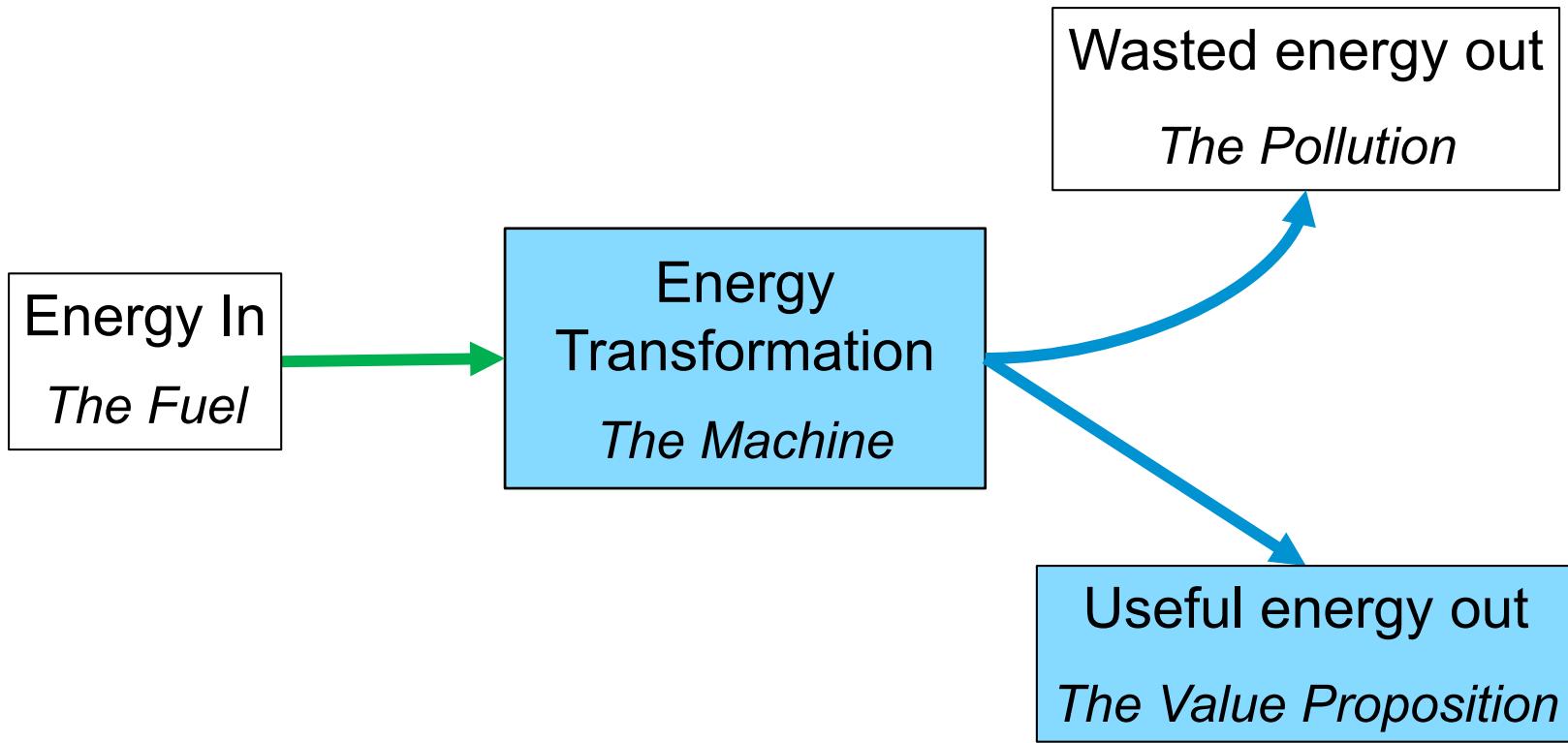
Introductions

- Name + short background.
- What expertise you bring to class.
- What is a question or quandary that you would like to have answered?

The Constrained Energy Ecosystem



The Constrained Energy Ecosystem



The Infrastructure:

Electric Grid →
Roads →
Telecom →

The Value Proposition:

Universal Access
Equal Access
Communication-as-a-service

Infrastructure Report Card



From: American Society of Civil Engineers

THE SUSPECTS

What is an Electric Utility?



Legally, an Electric Utility is:

- A company that is categorized as a ***commercial*** entity.
- This entity generates, transmits, and distributed ***electric*** energy.
- Its distribution is it sale to general public and/or industrial ***consumers***.
- The company ***owns*** and ***operates*** the equipment and facilities for this production.

Samuel Insull – Retail Regulations

- Realized he could serve 91 kW of load with a 29 kW transformer.
- *Diverse customer* usage meant larger the customer base, the less capital costs he needed.
- Promoted the regulated monopoly business model to bring electricity to the masses



But what about state borders?

- States could not regulate companies that delivered past state lines.
- Large, holding companies were formed to avoid state regulations.
- 1905, Wisconsin extended railway fare regulation to electric utilities.
- Federal Power Act of 1935 started the regulation of wholesale power



The Public's Pact with utilities

The government wants:

- Equal access for all citizens

Wall Street provides:

- Up-front capital to build infrastructure

In return, Wall Street receives:

- A local monopoly
- Guaranteed profit

The utility is charged with managing risk

- Financial risk of price spikes
- Physical risks of reliability

Statutory Framework – DUE PROCESS

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).*

If I was a developer...

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



If I was a developer...

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



Promise investors 8% return
per year for 10 years.

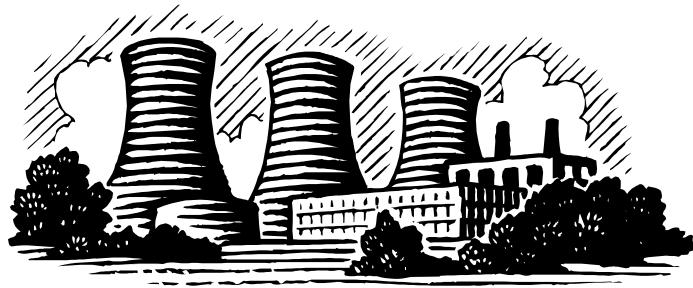
Earn \$3 M per year

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 Billion 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 Billion 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.

Access to the world's largest man-made machine

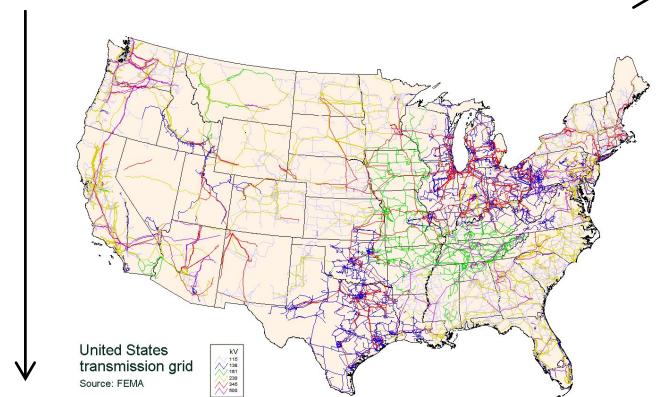
Our electrical grid works **99.98%** of the time for everyone in the USA

- ~ 1h of down time
- ~1 outage per year

Clothes Manufacturing: **98.5%**
Most reliable car: Prius at **97.8%**
Xbox/iPhone Reliability: **95-97%**

1,200 miles

2,800 miles



Financially, an Electric Utility is:

Wholesale:

Federal Regulations
that a utility MUST
buy on the
free market.

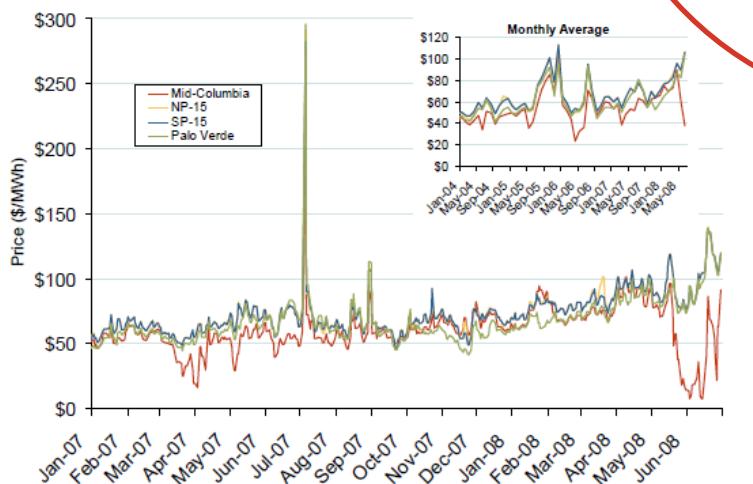
Utility:

Managing the
risk of cost
and price to
deliver a good
in a reliable
manner

Retail:

State regulations
that a utility MUST
sell at a fixed
price determined
by the public.

Western Daily Bilateral Day-Ahead On-Peak Price (\$/MWh)



Duke Energy

Small General Service

- Basic Charge: \$18.13/mo
- Demand Charge: \$3.7994/kW
- Energy Charge: \$0.116/kWh

Electric Summary and Tradeoffs

- Provide energy as a public service
- Allow for a Regional Monopoly
- Manage financial and physical risks of delivery reliable power
- Stymie innovations
- Prices are set based on due process
- A commission makes a determination after hearing evidence

What is a road?



Legally, a road is:

WA State Transportation Goals: RCW 47.04.280

- Economic Vitality
- Preservation
- Safety
- Mobility
- Environment
- Stewardship

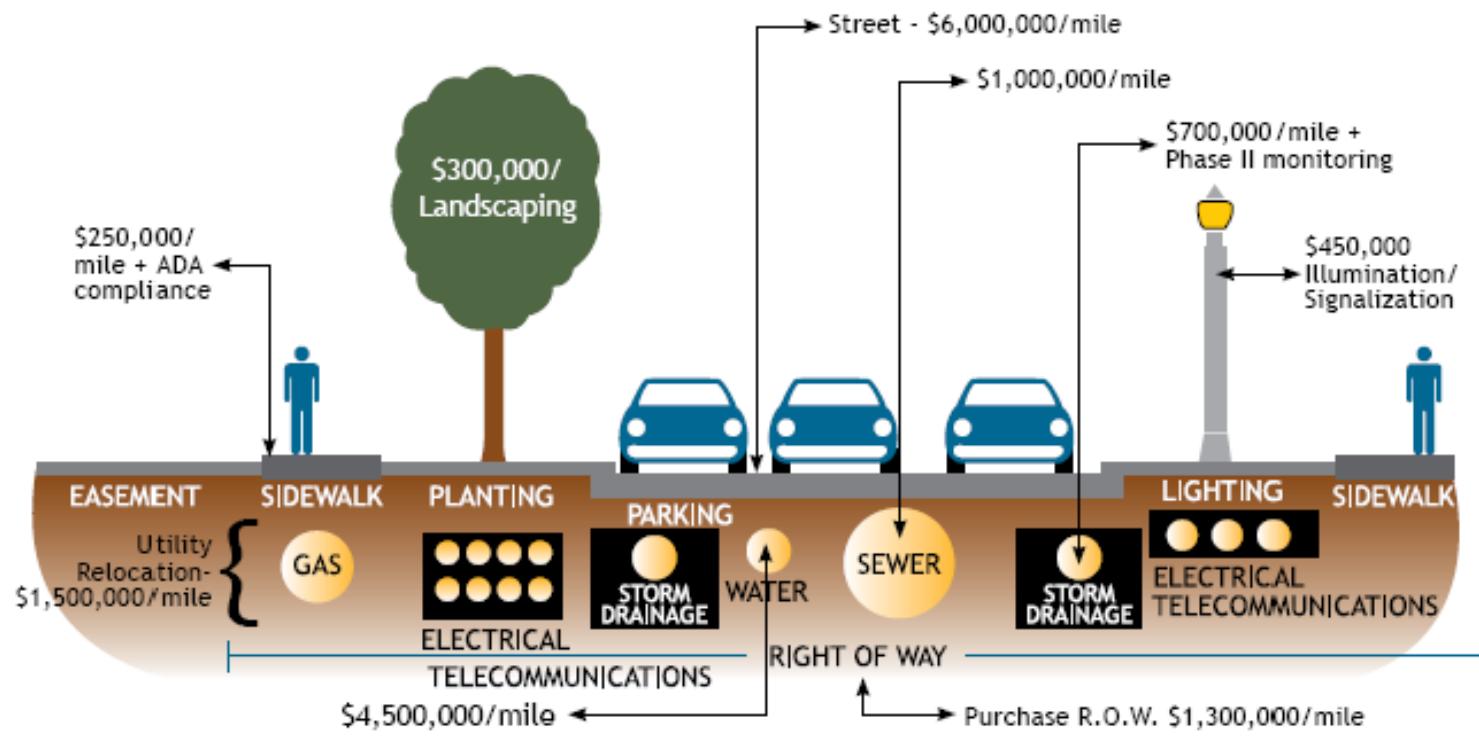
Physically, a road is:

Typical “Complete street” costs

Actual 2008 bid specs = \$15.7 million per mile

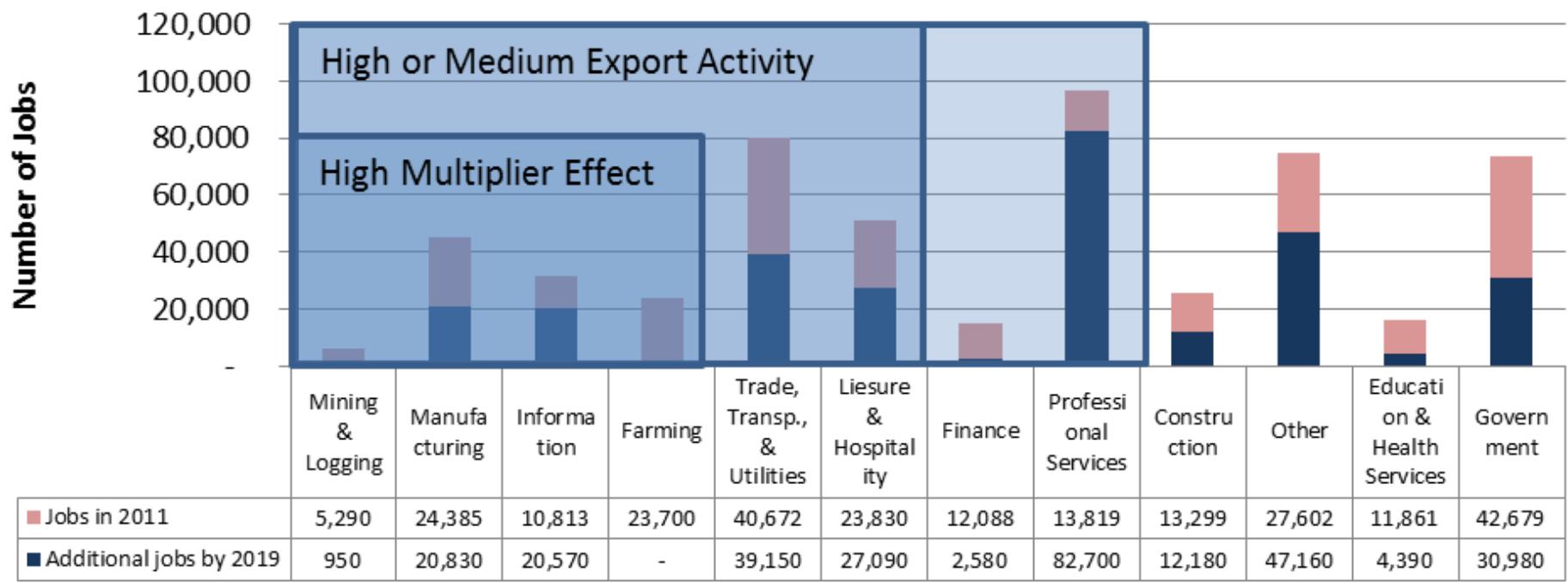
Typical City Infrastructure Costs Today

City streets are more than pavement.



Economically, a road is:

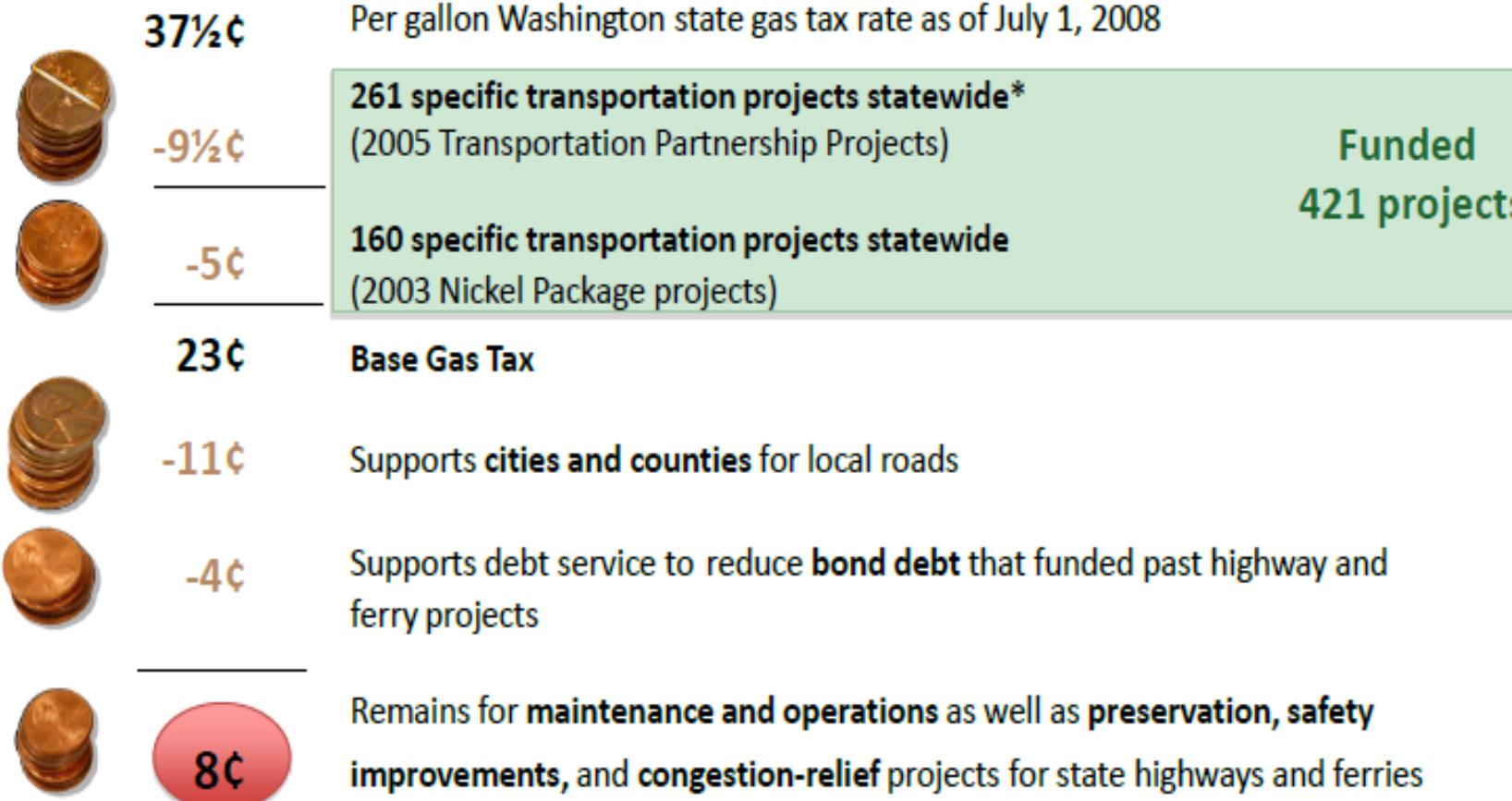
WA Jobs that are Dependent on Transportation



What is the Fuel Tax?

- Oregon institute a gas tax in 1919 to pay for roads for cars.
- An example of a user fee as a tax
- A ‘popular’ tax when it was created
 - People saw the improvements
- However, spending taxes on maintenance is less popular.

Collection and Distribution of the Fuel Tax (2008)



* Of the 9½ cents, 8½ cents is used by the state for highway projects, 1 cent goes to cities and counties for improvements to streets and roads.

Collection and Distribution of the Fuel Tax (2016)

49.4¢

~~37½¢~~



-9½¢



-5¢

23¢



-11¢



-4¢



8¢

Per gallon Washington state gas tax rate

11.9 ¢

2015 Connecting Washington Projects

\$16 B

261 specific transportation projects statewide*

(2005 Transportation Partnership Projects)

Funded
421 projects

160 specific transportation projects statewide

(2003 Nickel Package projects)

Base Gas Tax

Supports **cities and counties** for local roads

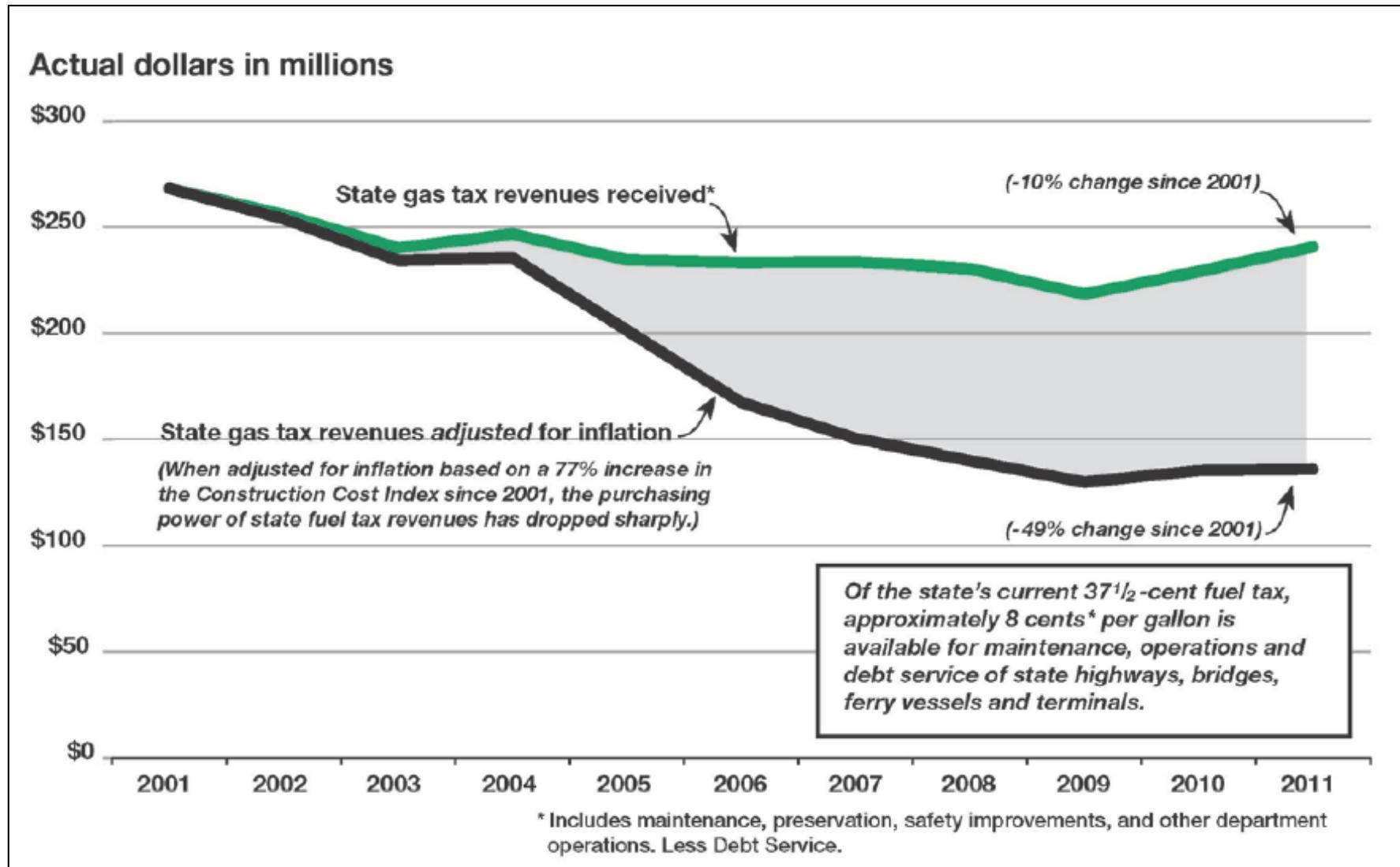
Supports debt service to reduce **bond debt** that funded past highway and ferry projects

Remains for **maintenance and operations** as well as **preservation, safety improvements, and congestion-relief** projects for state highways and ferries

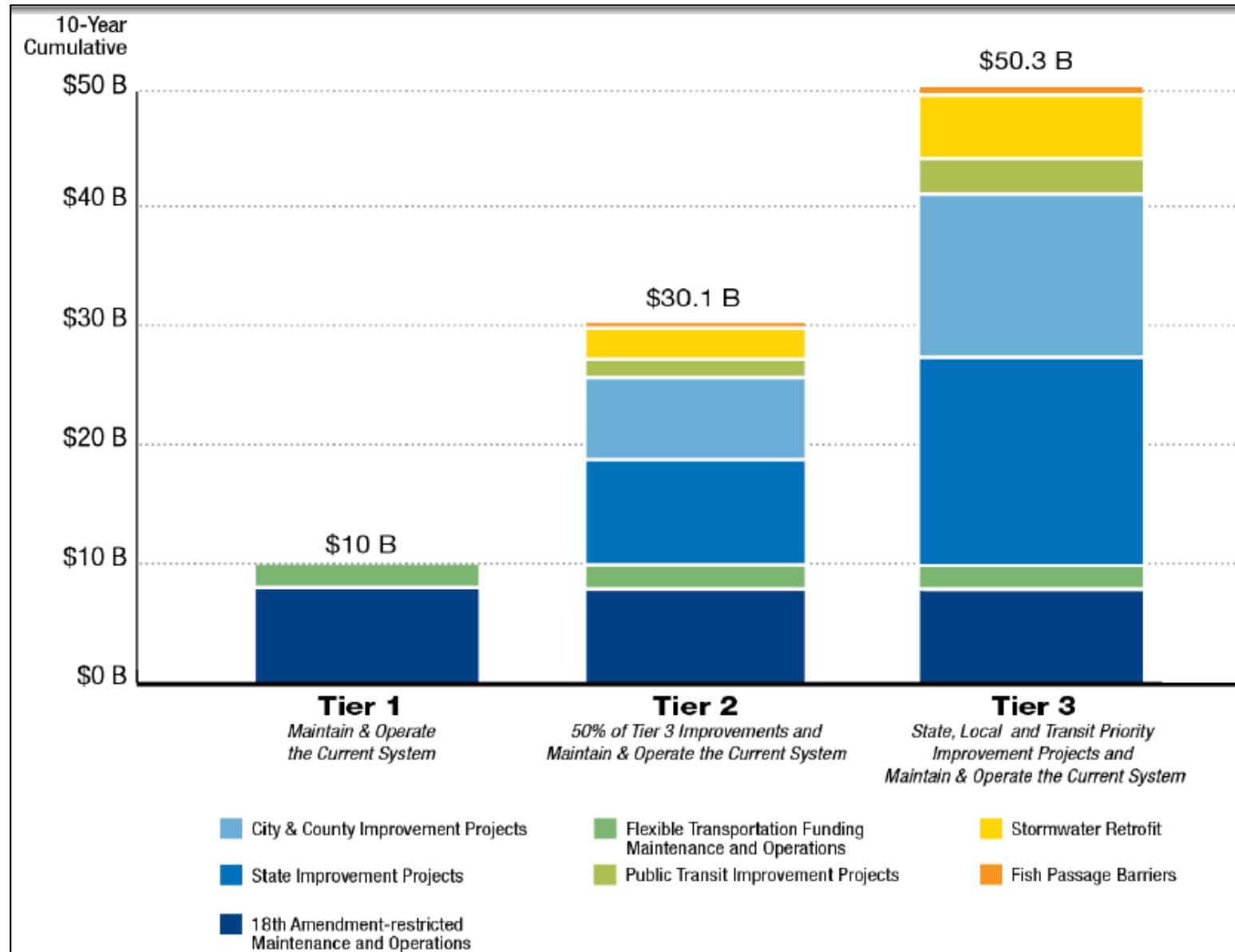
* Of the 9½ cents, 8½ cents is used by the state for highway projects, 1 cent goes to cities and counties for improvements to streets and roads.

Stayed the same!

Inflation has eroded purchasing power



WA Faces \$50B in road maintenance



Weight is the foe of transportation

	Vehicles		Cost Allocation of Damage		Federal Usage Fee Recovery	
	Number	Percent	\$ Millions	Percent	\$ Millions	Percent
Passenger Vehicles	2,495,056	92.60%	\$19,841	59.70%	\$22,285	67.10%
Single Units Trucks	83,100	3.10%	\$3,638	10.90%	\$3,142	9.50%
Combinations Trucks	115,689	4.30%	\$9,754	29.40%	\$7,806	23.50%

What's the goal – people or roads?

Jurisdiction	Where roads are		Where people are	
	Centerline Miles		Daily Vehicle Miles Traveled (1000's)	
Interstate	764.27	0.91%	41,937	21.33%
State	7,061.66	8.38%	86,179	43.84%
County	39,868.65	47.31%	24,928	12.68%
City	17,696.69	21.00%	41,522	21.12%
Other	18,877.85	22.40%	2,030	1.03%
Total	84,269.12	100%	196,596	100.00%

Equal services for *everyone*

Economic access for
Rural / Urban communities



Equal treatment for licenses



Roads Summary and Tradeoffs

- Rooted in Economical Development
- Everyone is treated equally at the same service level
- Attention is paid to new infrastructure
- Maintenance becomes a poor cousin to new construction
- Taxation revenue as a user fee
- Revenue and expenditures subject to political winds

What is telecommunications?



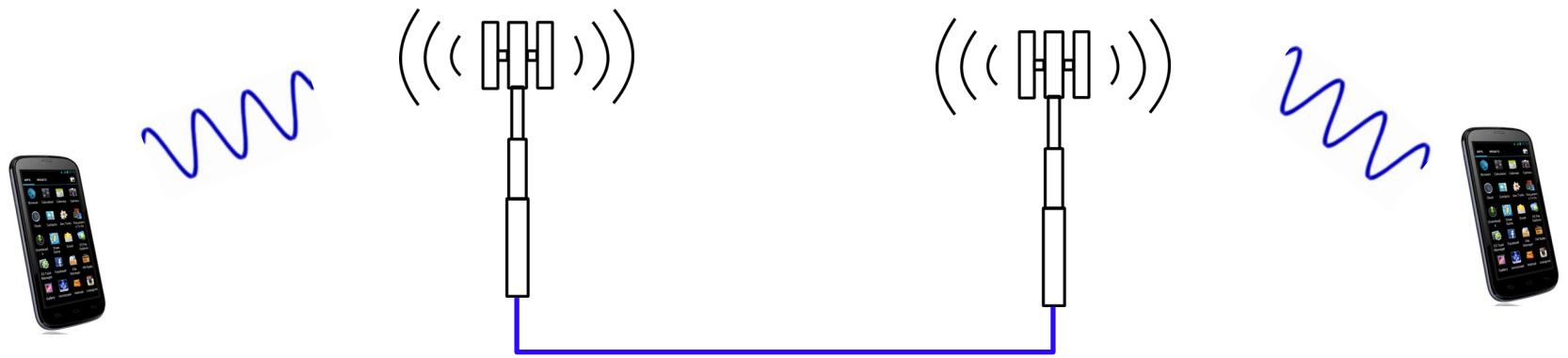
Legally, telecommunications is:

- (47 U.S.C. §151) is to "make ***available*** so far as possible, to all the people of the United States, without discrimination on the basis of race, color, religion, national origin, or sex, rapid, efficient, Nationwide, and world-wide wire and radio communication services with ***adequate*** facilities at ***reasonable*** charges."

FCC has 6 goals

- Broadband
- Competition
- Spectrum
- Media
- Public Safety and Homeland Security
- Modernize the FCC

Physically, telecom is:



Analog

Based on ***Spectrum***

Digital

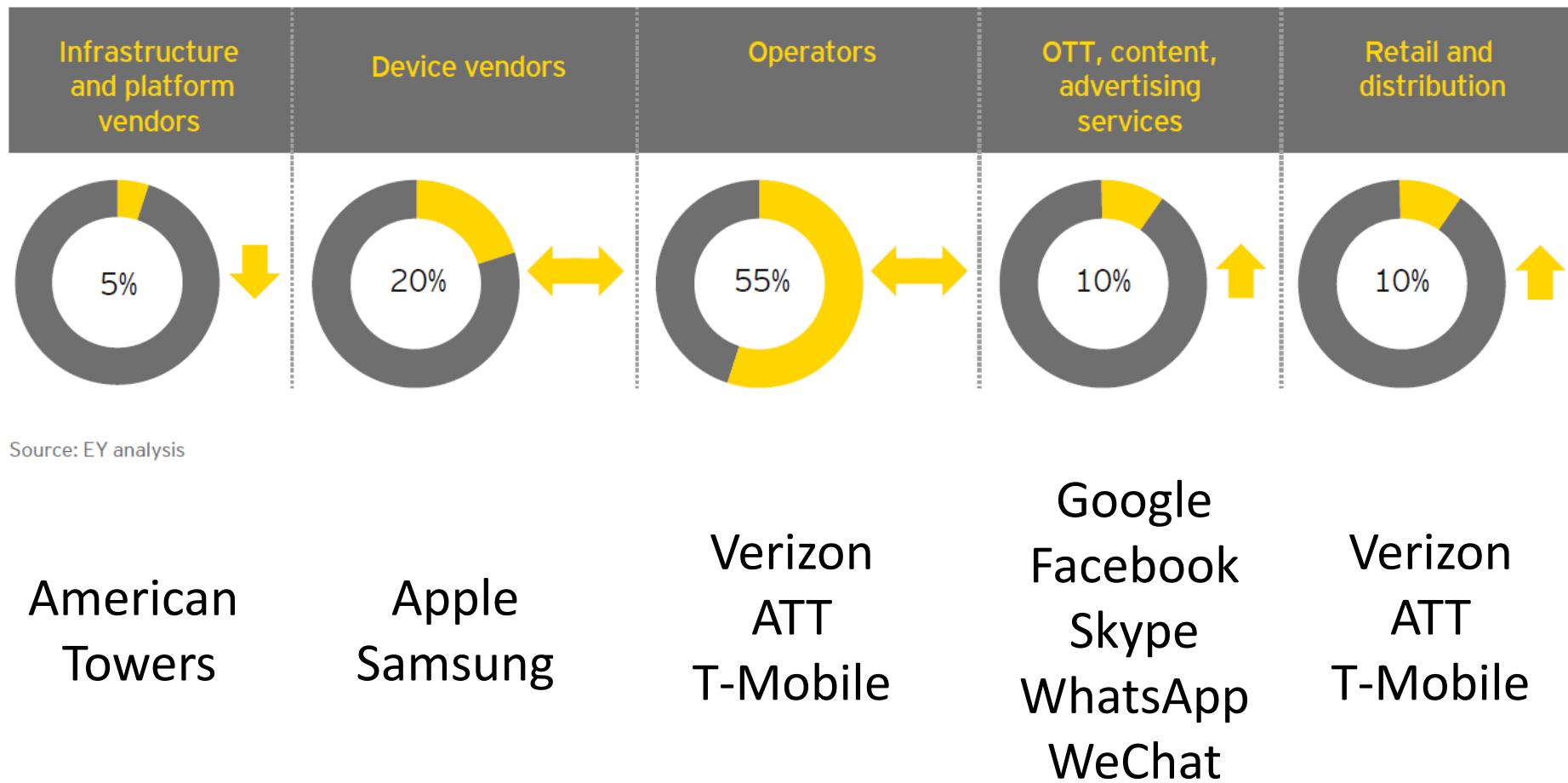
Based on ***Broadband***

Analog

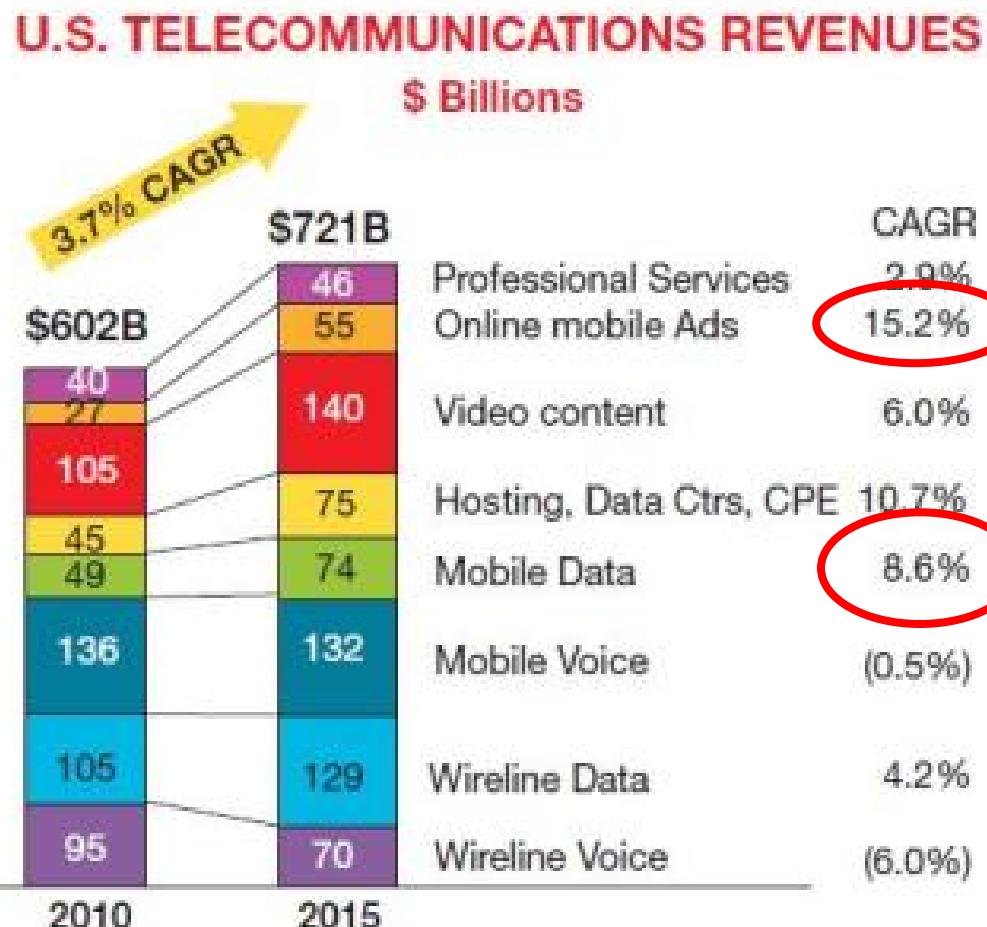
Based on ***Spectrum***

Financially, telecom sector is:

Figure 6: Telecommunications industry value chain – 2015 share of revenues by segment



Revenue Growth



Note: Numbers may not add due to rounding

*Source: S&P internal analysis based on composite industry forecasts
from Gartner and In-Stat*

Telco's growth

- Data services: 8.6%
- Mobile ads: 15.2%
- Is this high growth or low growth?

Data is growing at ~66% per year!

Who are the winners?

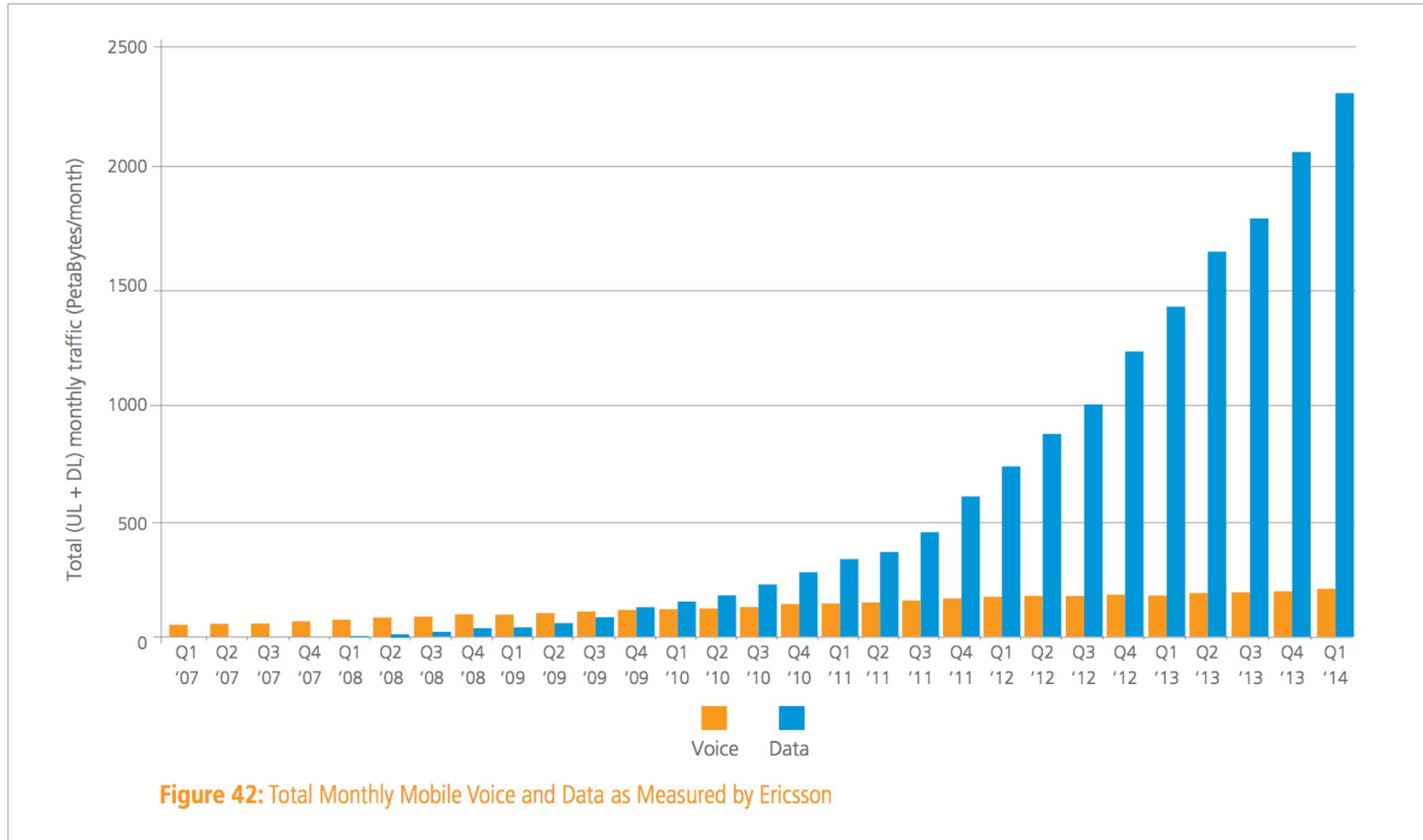
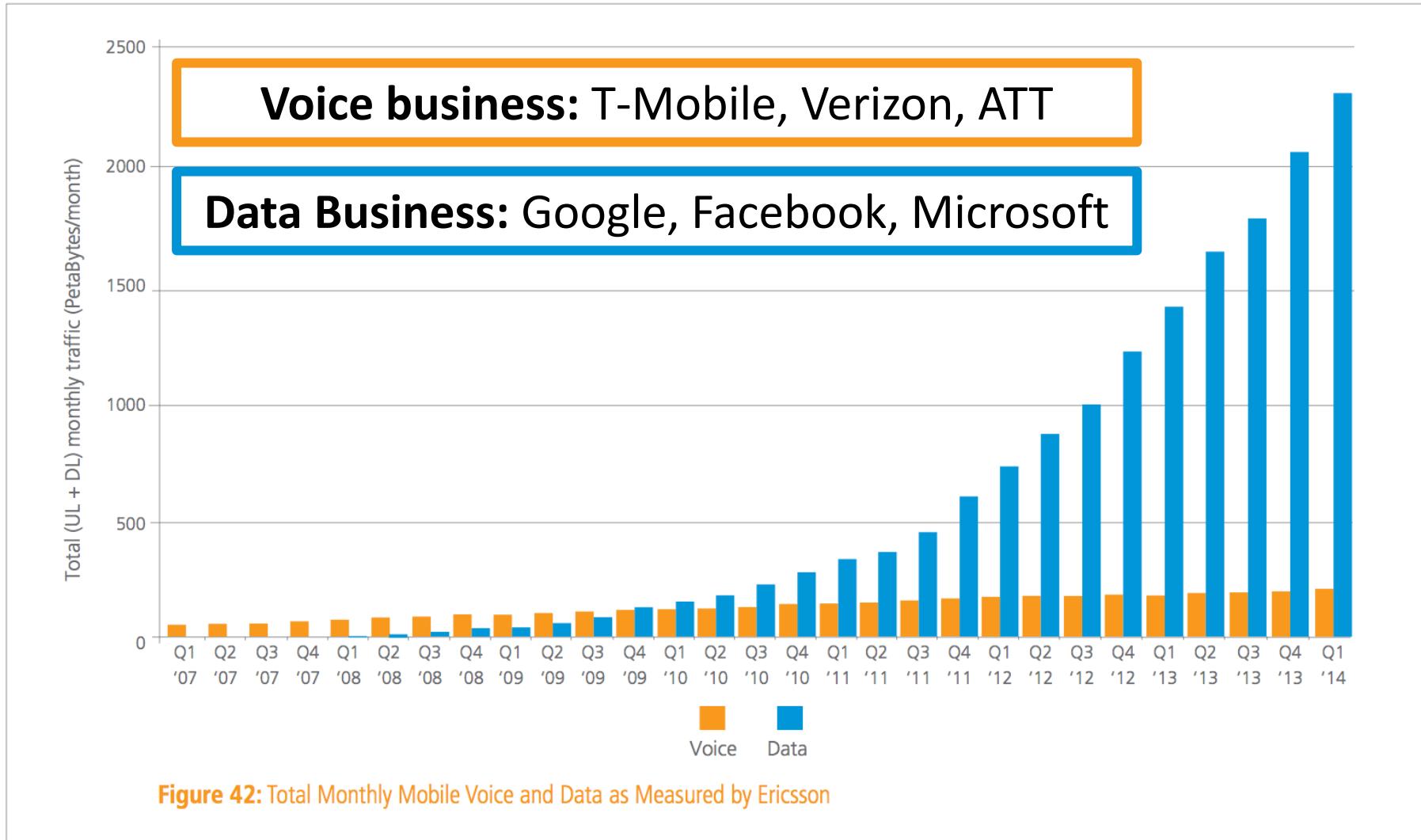


Figure 42: Total Monthly Mobile Voice and Data as Measured by Ericsson

Data is growing at ~66% per year!

What are the winners doing differently?

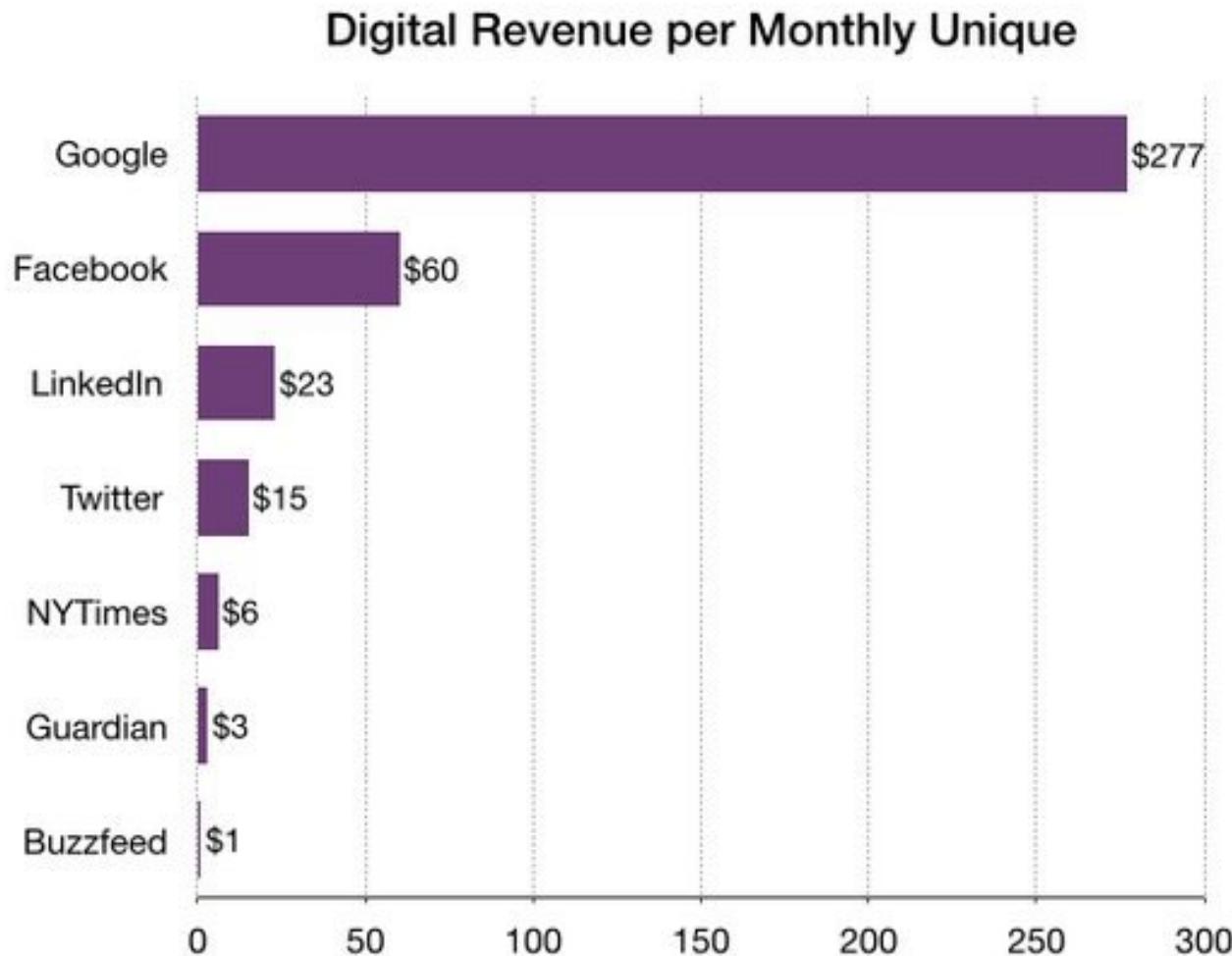


Pricing Model Telco: Revenue per cell phone

Data Amount	Verizon (unlimited text & minutes)				AT&T (unlimited text & minutes)			
	one phone	two phones	three phones	four phones	one phone	two phones	three phones	four phones
1GB	\$90	\$130	\$170	\$210	\$85	\$130	\$175	\$220
2GB	\$100	\$140	\$180	\$220	-	-	-	-
4GB	\$110	\$150	\$190	\$230	\$110	\$150	\$190	\$230
6GB	\$120	\$160	\$200	\$240	\$125	\$160	\$195	\$230
8GB	\$130	\$170	\$210	\$250	-	-	-	-
10GB	\$140	\$180	\$220	\$260	\$150	\$180	\$210	\$240
15GB	-	-	-	-	\$190	\$220	\$250	\$280
20GB	-	-	-	-	\$230	\$260	\$290	\$320
Data Amount	T-Mobile (unlimited text & minutes)				Sprint (ultd text & mobile-mobile min)			
	one phone	two phones	three phones	four phones	one phone	two phones	three phones	four phones
500MB each	\$50	\$80	\$90	\$100	-	-	-	-
2GB each	\$60	\$100	\$120	\$140	-	-	-	-
Unlimited	\$70	\$120	\$150	\$180	\$80	\$150	\$180	\$210

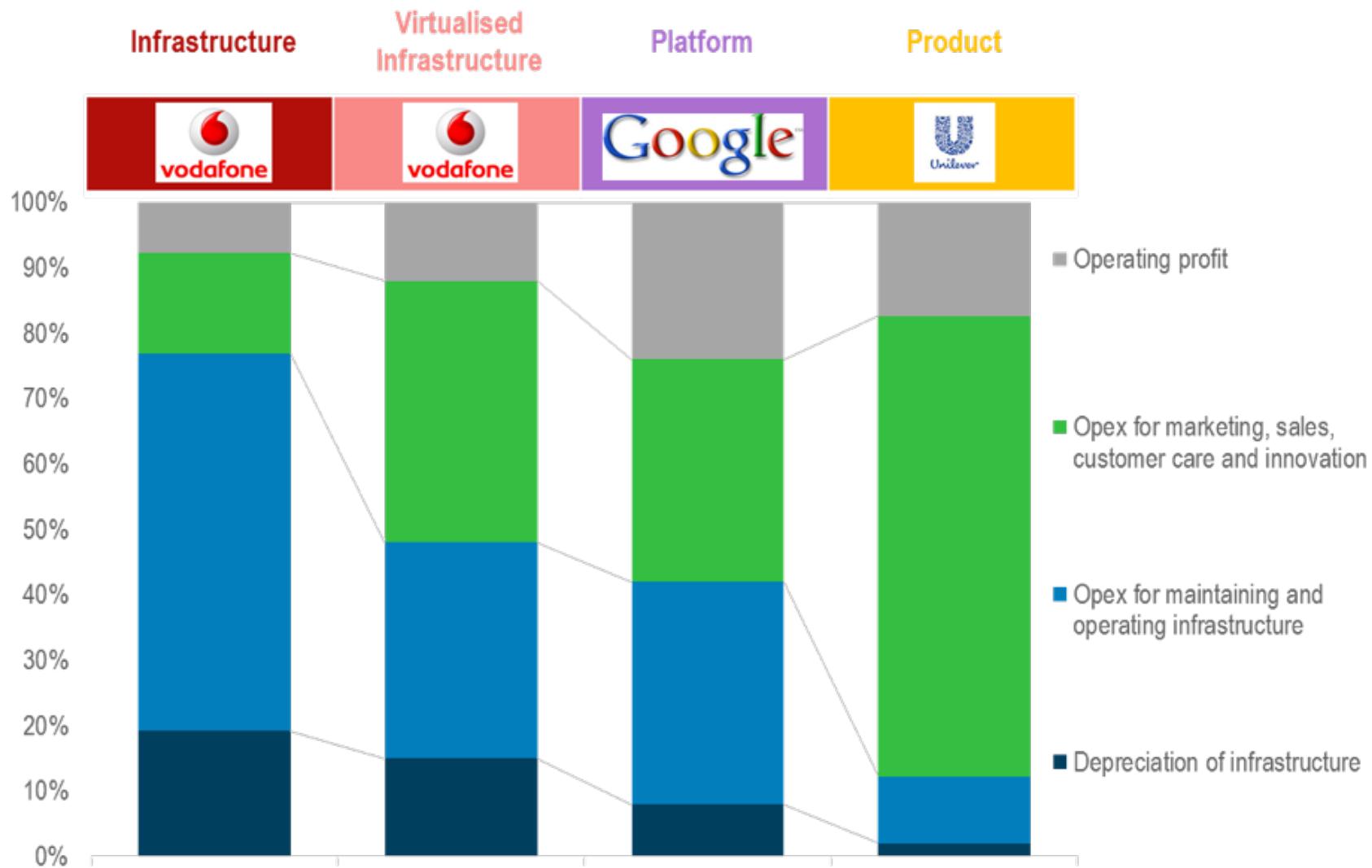
- 1) Services based on what you want to buy.
- 2) By definition, service levels are unequal for all users

Pricing Model OTT: Revenue per user

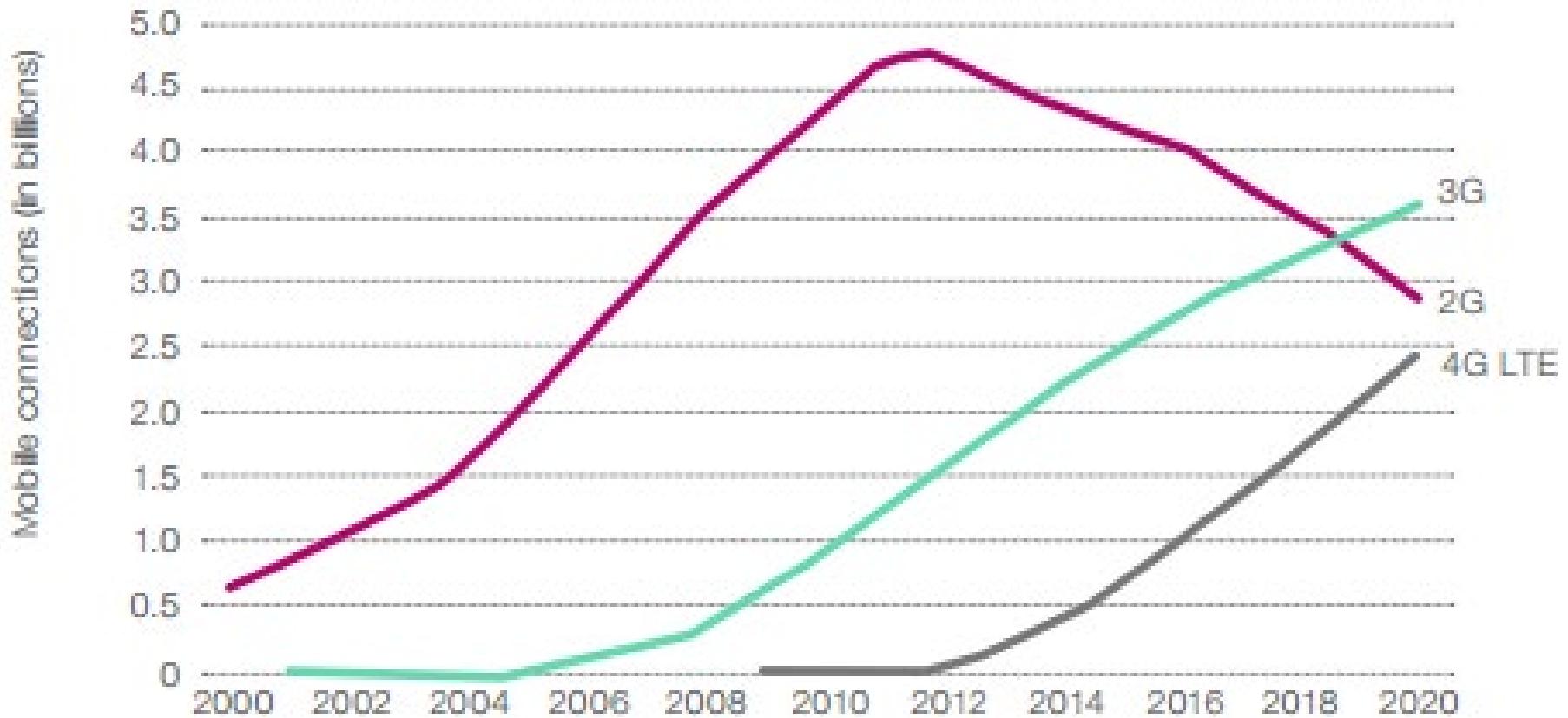


Google generates \$277 / user without the infrastructure costs of telcos!
Is that fair?

Cost Growth

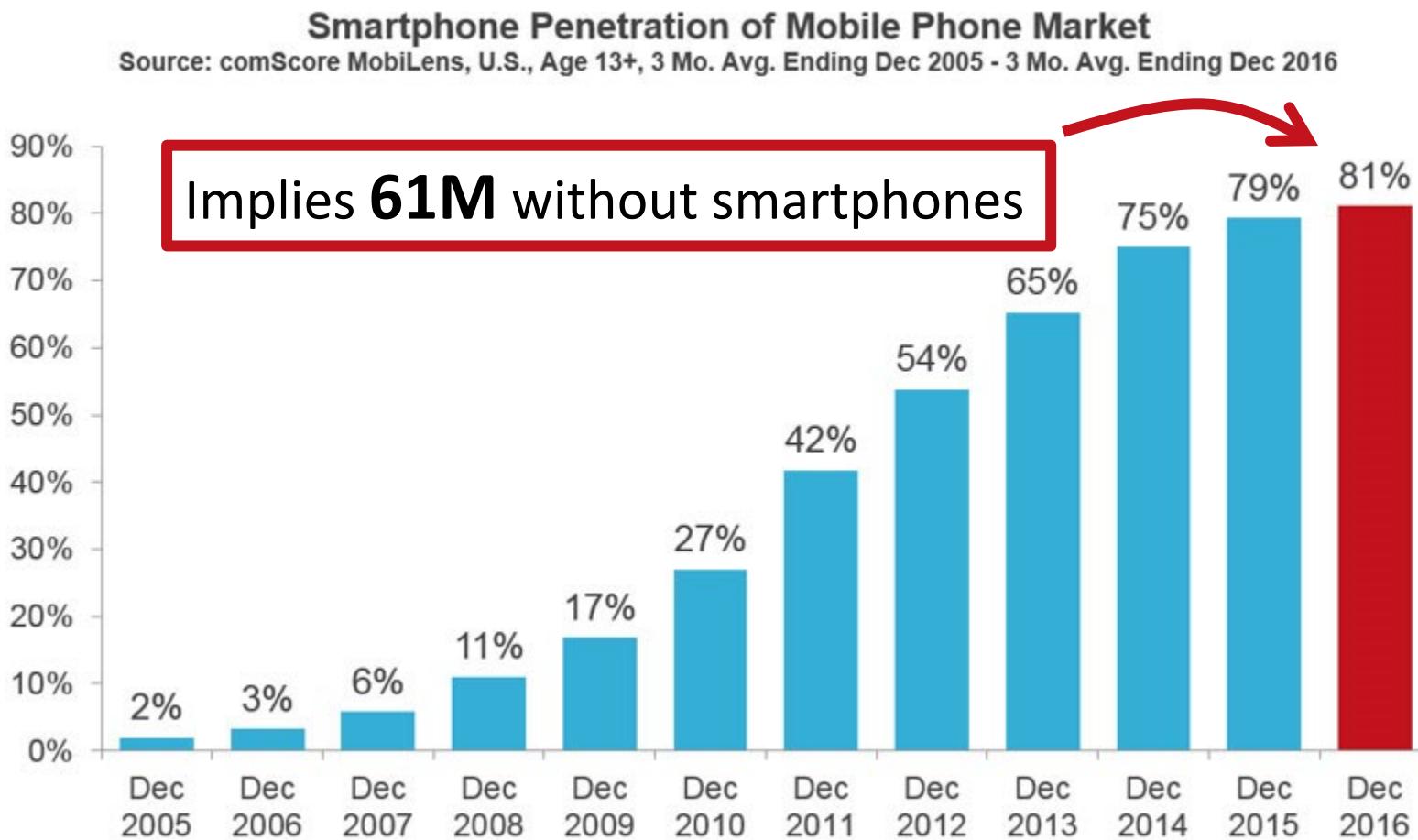


Lifecycle of Innovation



~ 10-20 year lifecycle for technologies
Already 5G is becoming available!

Penetration of cell phone service



Universal Service Fund

- Universal Service Fund is a federal fee paid out of your cell phone bill.
 - Lifeline is one of 4 programs that serves ~12 million low-income users.
 - Subsidizes phone costs at \$10 / month.
- Been dubbed the “Obamaphone”
- That still leaves 48M without access to smart phones.



Telecom Summary and Tradeoffs

- Rooted in promoting competitions
- Multiple players offering infrastructure, operations, services.
- Many innovations and rapid product lifecycles
- Leaves people behind – not 100% service level
- Revenue as a service fee
- Companies fight for competitive advantage

SYNTHESIS

The Wicked Problem

Coined by Prof. Horst Rittel and Melvin Webber in 1973*

- ‘Wicked’ meant to be opposite of ‘Tame’
- Tame – Solvable, ie math, chess, puzzles
- Wicked – Problems that lack simplistic or straightforward planning responses

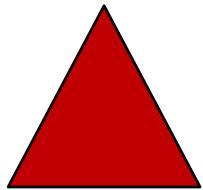
*Rittel H, and Webber, M. *Dilemmas in a General Theory of Planning* Policy Sciences 4 1973]

The 10 Characteristics

1. There is ***no definition*** of a wicked problem (defining wicked problems is itself a wicked problem).
2. Wicked problems ***do not ‘stop’*** being problems.
3. Solutions to wicked problems are not true-or-false, but ***better-or-worse***.
4. There is ***no test of a solution*** to a wicked problem.
5. There is no opportunity to learn by trial and error.
Every solution changes the problem.
6. Wicked problems do not have a describable set of potential solutions nor describable set of actions.
7. ***Every wicked problem is essentially unique.***
8. ***Every wicked problem is a symptom of another problem.***
9. The description of the problem is through a ***frame of reference***. Any proposed solution only meets the ***need of that frame***.
10. Planners are liable for the consequences of the actions they generate

The Clumsy Solution

Hierarchical
Process Driven

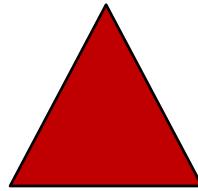


Competitive
Market determines 'best'

Egalitarian
For the common good



Hierarchical Process Driven



Competitive
Market determines 'best'



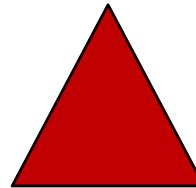
Egalitarian
For the common good





High reliability, low innovation
Reasonable profits are allowed

Hierarchical Process Driven



Competitive

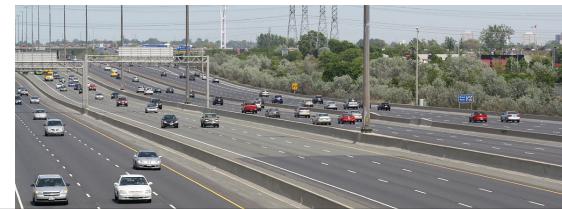
Market determines 'best'



Buy your level-of-service
Profit-driven motives

Egalitarian

For the common good

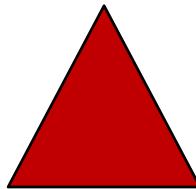


Equal treatment of all citizens
Revenue / expenses are politicized



High reliability, low innovation
Reasonable profits are allowed

Hierarchical
Process Driven



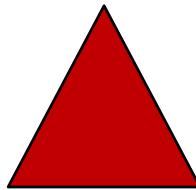
Competitive
Market determines 'best'

Buy your level-of-service
Profit-driven motives

De-regulation
Market Competition
Renewable Energy
Smart Grid
Real-time Pricing

Net Neutrality

No discrimination based on user, content, website, platform, application, equipment, method of communication



Competitive

Market determines 'best'



Buy your level-of-service
Profit-driven motives

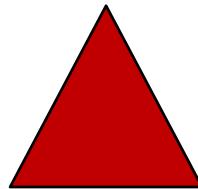
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For the common good

Equal treatment of all citizens
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Hierarchical
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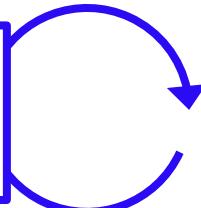


New Revenue Sources
Toll Roads
Congestion Fees

Egalitarian
For the common good



Tax Reform:
Vehicle-Miles Traveled



Equal treatment of all citizens
Revenue / expenses are political

In Synthesis

Policies affect the business models of how we pay for infrastructure



As *Ratepayers*

Reliability wins
Costs stay low
100% access

As *Taxpayers*

Equality wins
Ideally, user fee taxes
Political pressures

As *Customers*

Innovation wins
Pay-for-better-service
Not equally available

*Regardless of how, we have to pay for it.
There is no free lunch.*

THE DEBATE

Definitions

How does the purpose of the infrastructure affect their management?



- *Fair*
- *Just*
- Reasonable
- Sufficient

- ***Economic Vitality***
- Preservation
- Safety
- Mobility
- Environment
- Stewardship

- Broadband
- ***Competition***
- Spectrum
- Media
- Public Safety
- Security
- Modernize

Should they change?

Government

What should be the government's role in each of these three infrastructures?



Regulate
Price

Regulate
Revenues (taxes)

Regulate
Competition

Should they change?

Equality

*Is access to infrastructures a right or a privilege?
Does quality of access matter?*



100%
Penetration

100%
Penetration

80%
Penetration

Is this a problem?

Innovation

Should government be responsible for innovations in these sectors?



Beta ~0.38

Beta NA

Beta ~1.12

Beta is a measure of *financial* risk in the stock market.

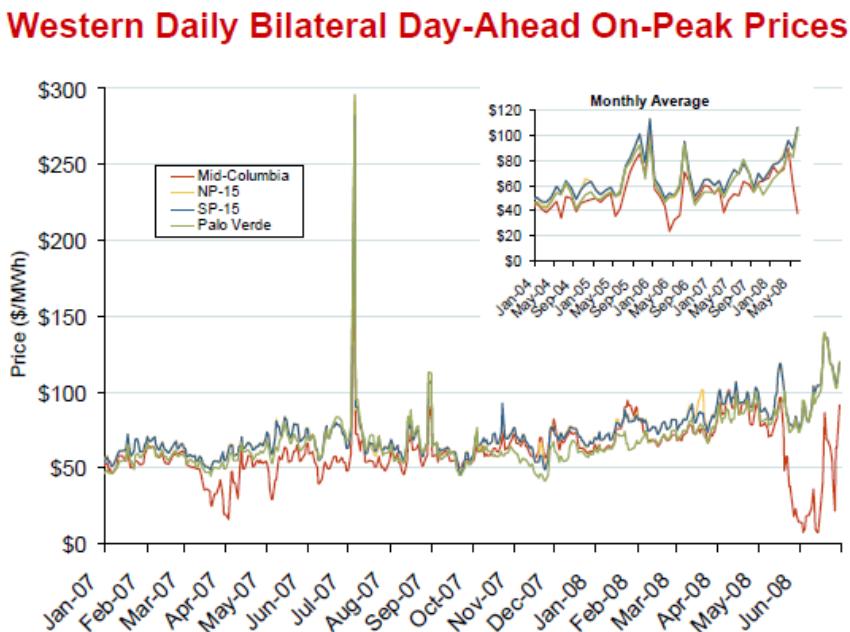
The stock market as a whole has a Beta = 1

Beta <1 is lower risk than the market and vice versa

Should we maximize reliability or innovation?

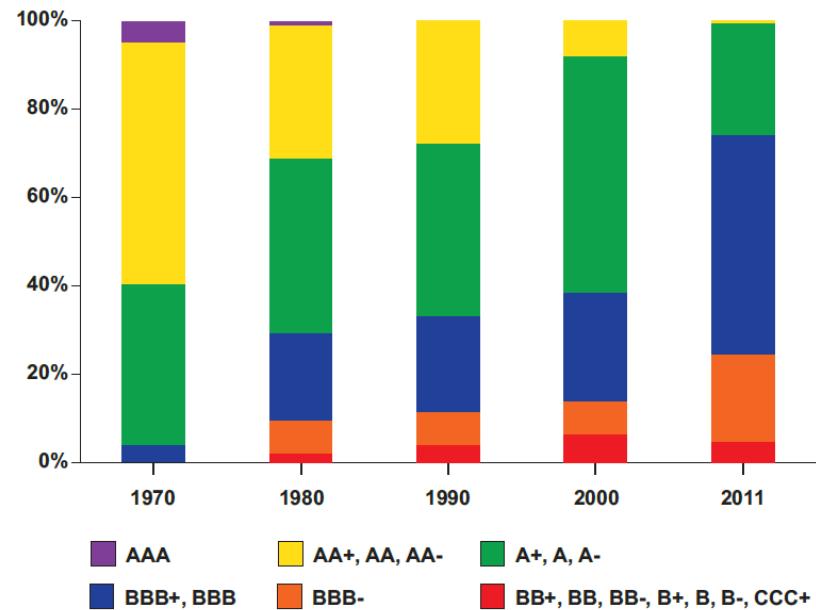
Utilities: Which regulator should respond?

(1) Resources: real-time peak prices can exceed \$300 / MWh (\$0.30/kWh)



(2) Wall Street: Credit ratings of Utilities are eroding.

Exhibit 2
Electric utility industry credit ratings distribution evolution
(S&P Credit Ratings Distribution, U.S. Shareholder-Owned Electric Utilities)



Source: Standard & Poor's, Macquarie Capital

Transportation: Which regulator should respond?

- Electric vehicles are becoming popular in our cities.
- Electric cars do not pay a gas tax that maintains the roads – they pay for cost recovery of the electric infrastructure.
- How should Department of Transportation respond to lower revenues with same level of service?



Telecom: Which regulator should respond?

- Telecoms want to get into smart grid – they want to use 3G 4G 5G to manage signals being sent to utilities.
- Utilities invest for 30-50 years.
- Telecoms invest for 10-20 years.
- How should they work together



Final thoughts

CA Aqueduct

Interstate 5

High Voltage
Transmission



THANK YOU