

Energy & Store
Development Conference

2016
E+SD

Anticipating & Leading Market Disruptions

Opening General Session Keynote

Tony Seba

A STROLL DOWN
Memory Lane

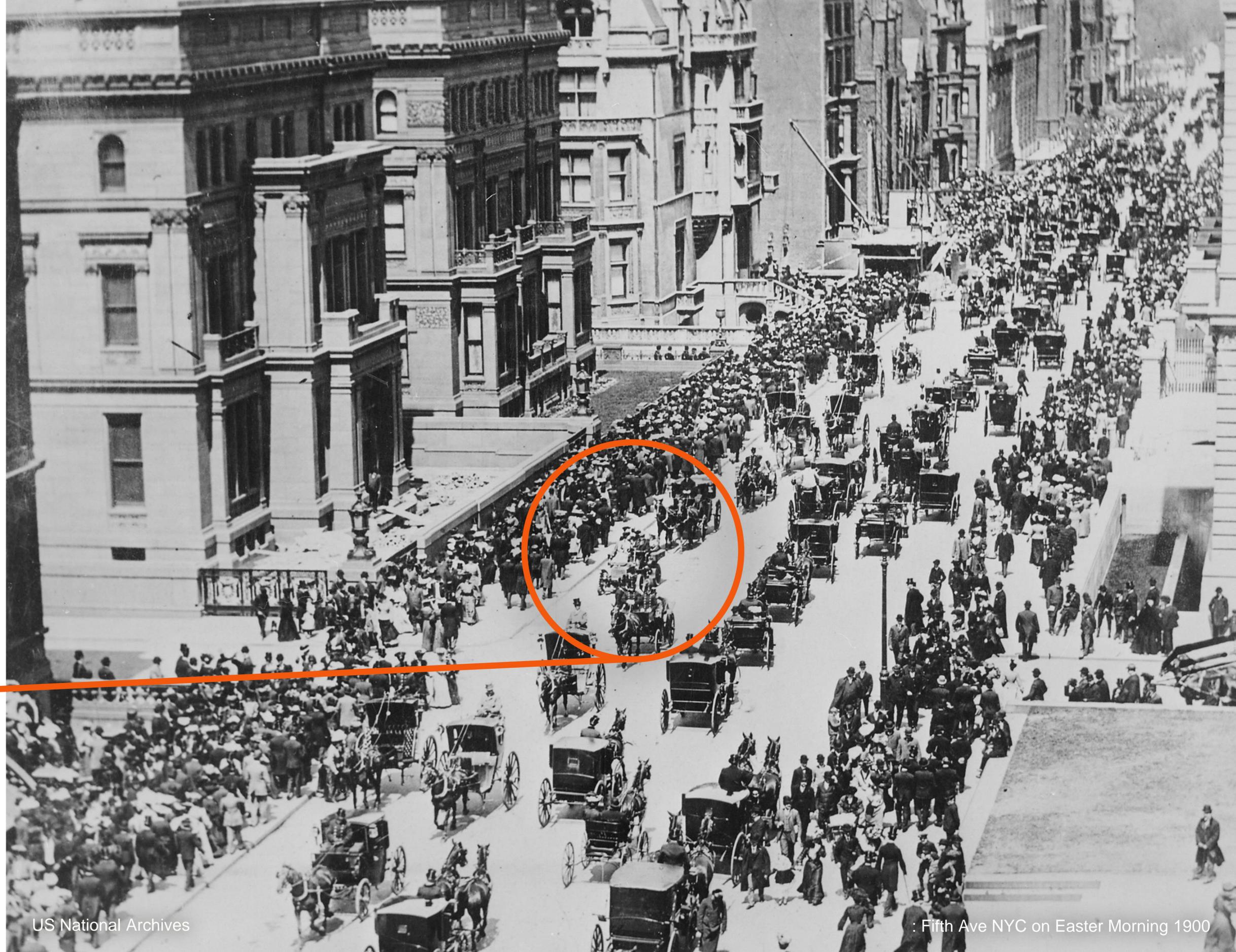
5th AVE NYC

1900

Where is

the

car?



5th AVE NYC

1913

Where is
the
horse?



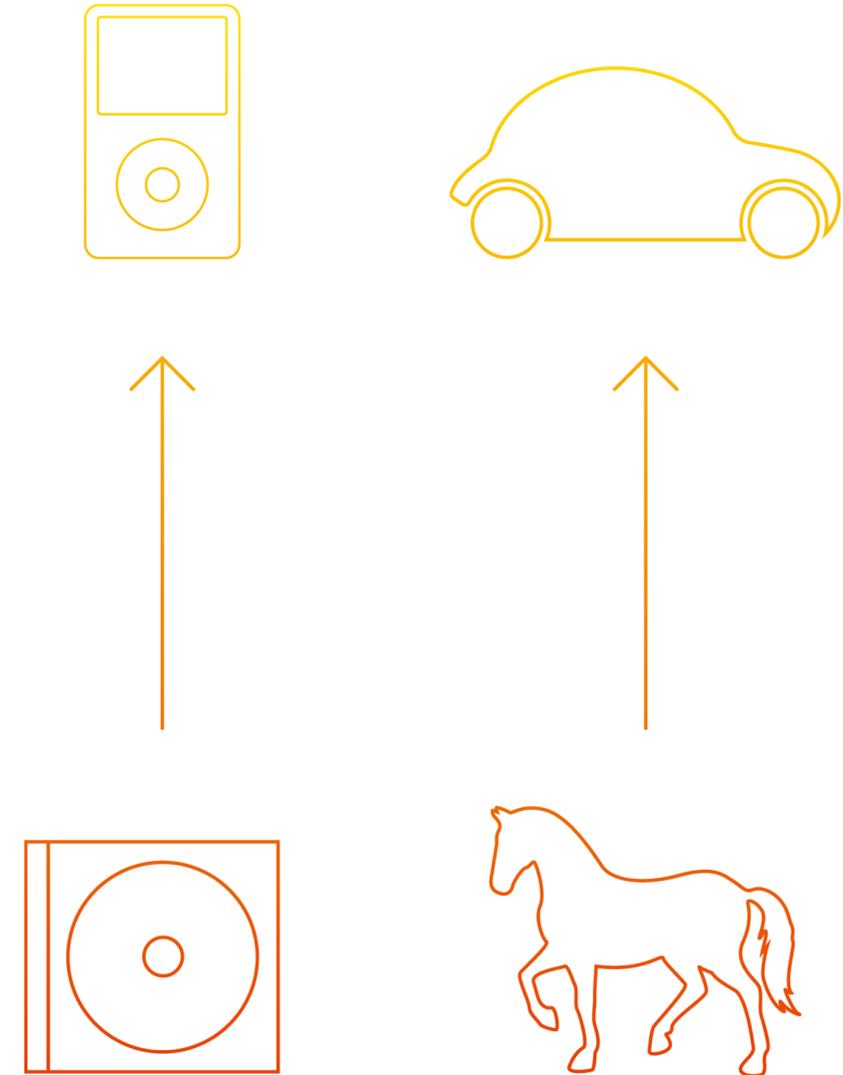
TECHNOLOGY BASED
Disruption



What is a Disruption?

WHEN A NEW PRODUCT OR SERVICE HELPS
create a new market

AND
**significantly weaken,
transform, or
destroy an existing product,
market category / industry**



FAST FORWARD TO 1985

▶▶ 1985



Image: GMAuthority.com

'Expert' Disruption Forecasts

In the mid-1980s AT&T hired McKinsey & Co to forecast cell phone adoption by the year 2000

THEIR (15-YEAR) PREDICTION

900,000

SUBSCRIBERS

THE ACTUAL NUMBER WAS

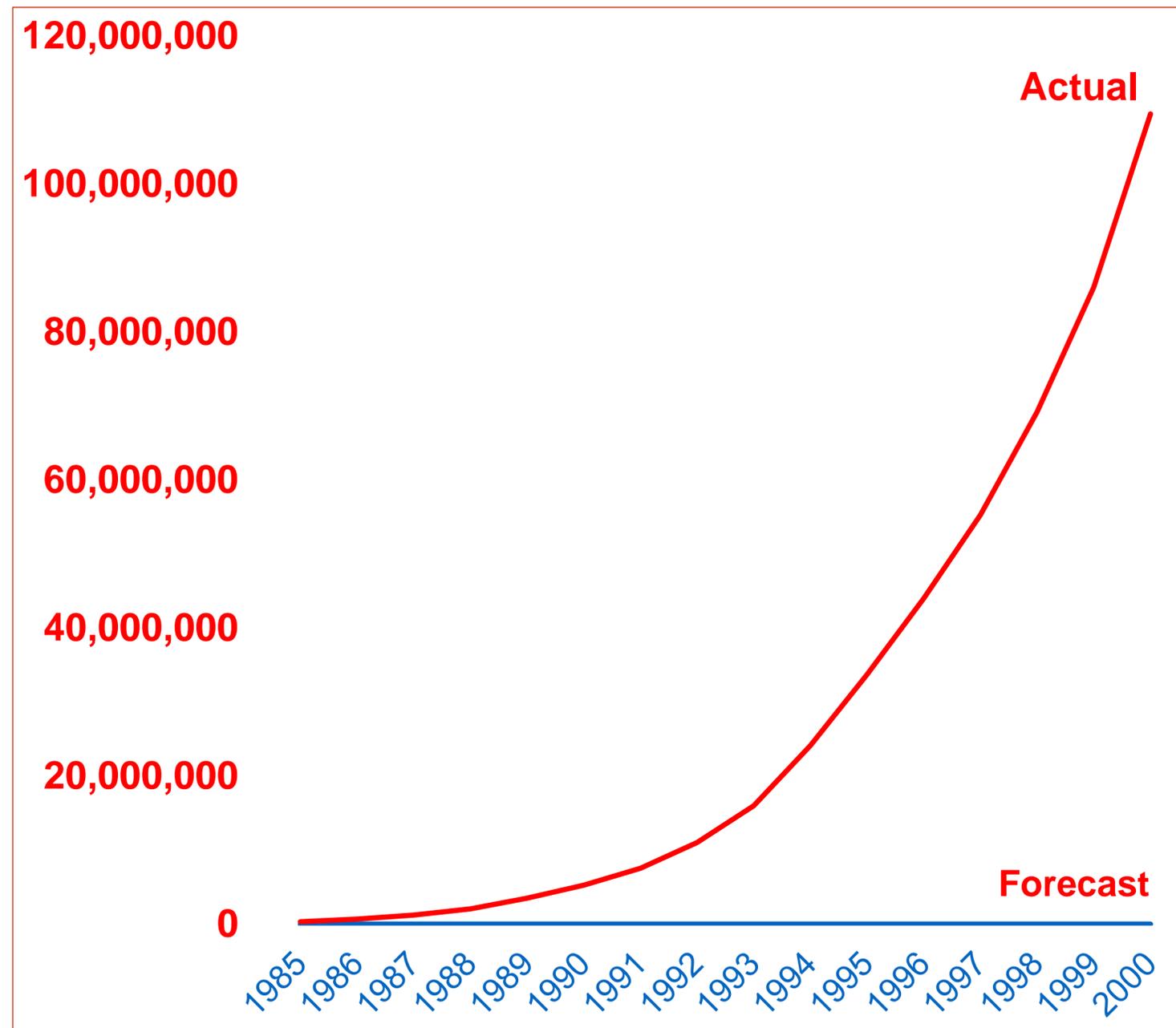
109 million

They were **off**
by a factor of:

120
X



AT&T Disrupted - while \$\$ Trillions Created



	Company	Home Country	Market Cap. (\$MM)
1	Apple	USA	\$763,567
2	Google	USA	373,437
3	Alibaba	China	232,755
4	Facebook	USA	226,009
5	Amazon.com	USA	199,139
6	Tencent	China	190,110
7	eBay	USA	72,549
8	Baidu	China	71,581
9	Priceline Group	USA	62,645
10	Salesforce.com	USA	49,173
11	JD.com	China	47,711
12	Yahoo!	USA	40,808
13	Netflix	USA	37,700
14	LinkedIn	USA	24,718
15	Twitter	USA	23,965
Total Market Cap of Top 15			\$2,415,867

- ▶ AT&T's **landline telephony** market was **disrupted**
- ▶ It **missed out** on **multi-trillion dollar** opportunities!

It's usually the 'experts' and 'insiders' who dismiss Disruptive Opportunities

"It's important that [Internet] expectations aren't cranked too high. The total number of users is still very small..."

Bill Gates, CEO Microsoft, 1994

"There is no reason anyone would want a computer in their home."

Ken Olson, CEO DEC, 1977

"The Internet will catastrophically collapse in 1996."

Robert Metcalfe, founder 3Com, 1995

FAST FORWARD TO 2000

▶▶ 20000



Kodak FY 2000: Record Results

- ▶ FY **2000** Financial Results:

- ▶ Revenues: \$14 B
- ▶ Operating Earnings: \$2.2 B
- ▶ Net Profits: \$1.4 B

"A great brand, a great balance sheet, cash flow. This is a very smart time to be in the picture business"

*Daniel Carp, CEO, Kodak
Letter to Investors, FY 2000*

- ▶ "Picture-taking at an **all-time high worldwide:**"⁽¹⁾

- ▶ **Record # of Pictures** taken: 80 billion.
- ▶ **Record # of Prints** ordered: 100 billion.

- ▶ **2012** - Kodak Filed for **Bankruptcy Protection**



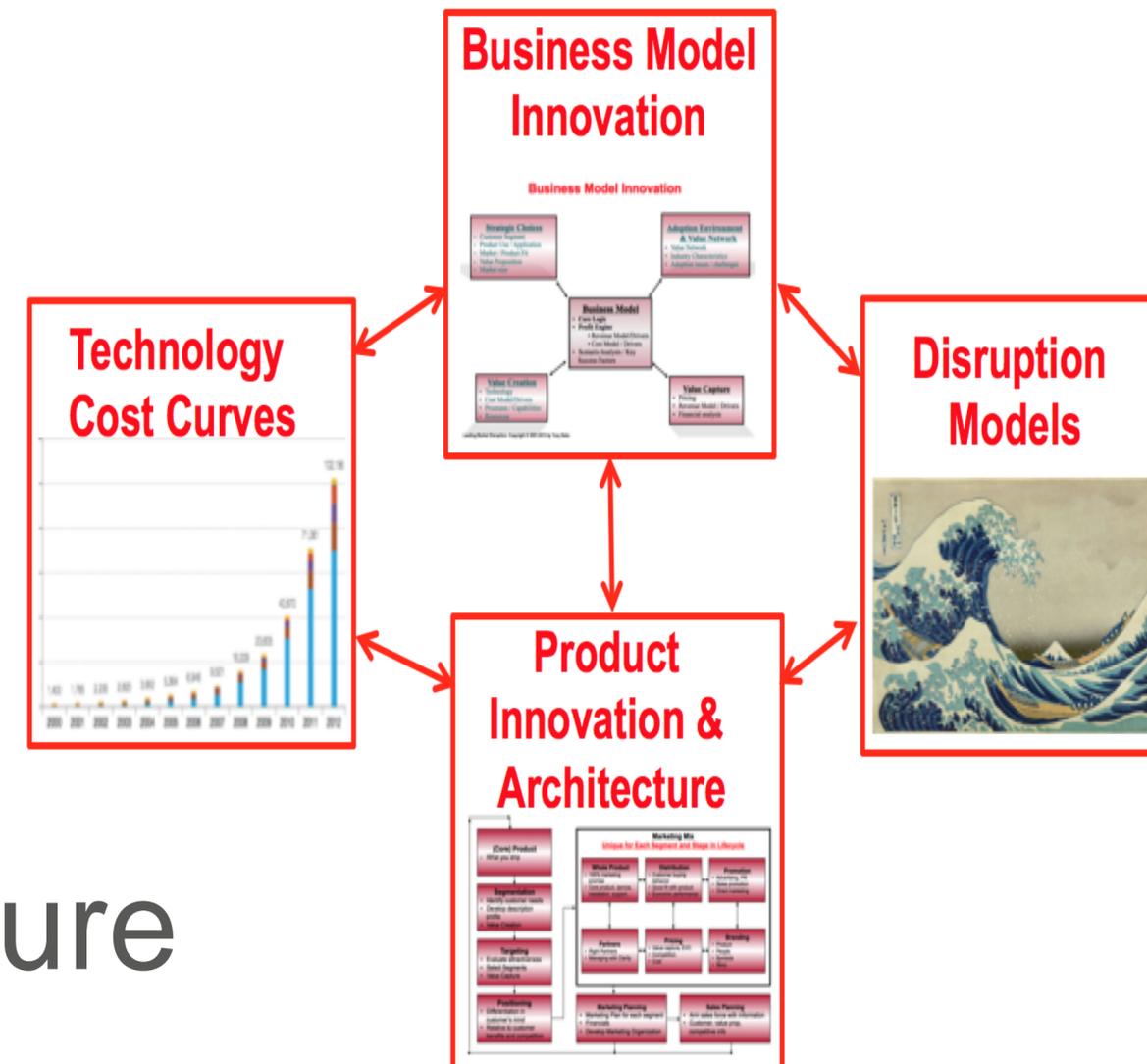
(1) Kodak, Annual Report 2000, Letter to Investors, Sources: Data and Image : Kodak

Why do smart people
at smart
organizations
consistently fail
to anticipate or lead
Market Disruptions?



Seba Tech Disruption Framework to Anticipate / Lead Market Disruptions

- 1 Disruption Models
- 2 Technology Cost Curves
- 3 Business Model Innovation
- 4 Product Innovation & Architecture

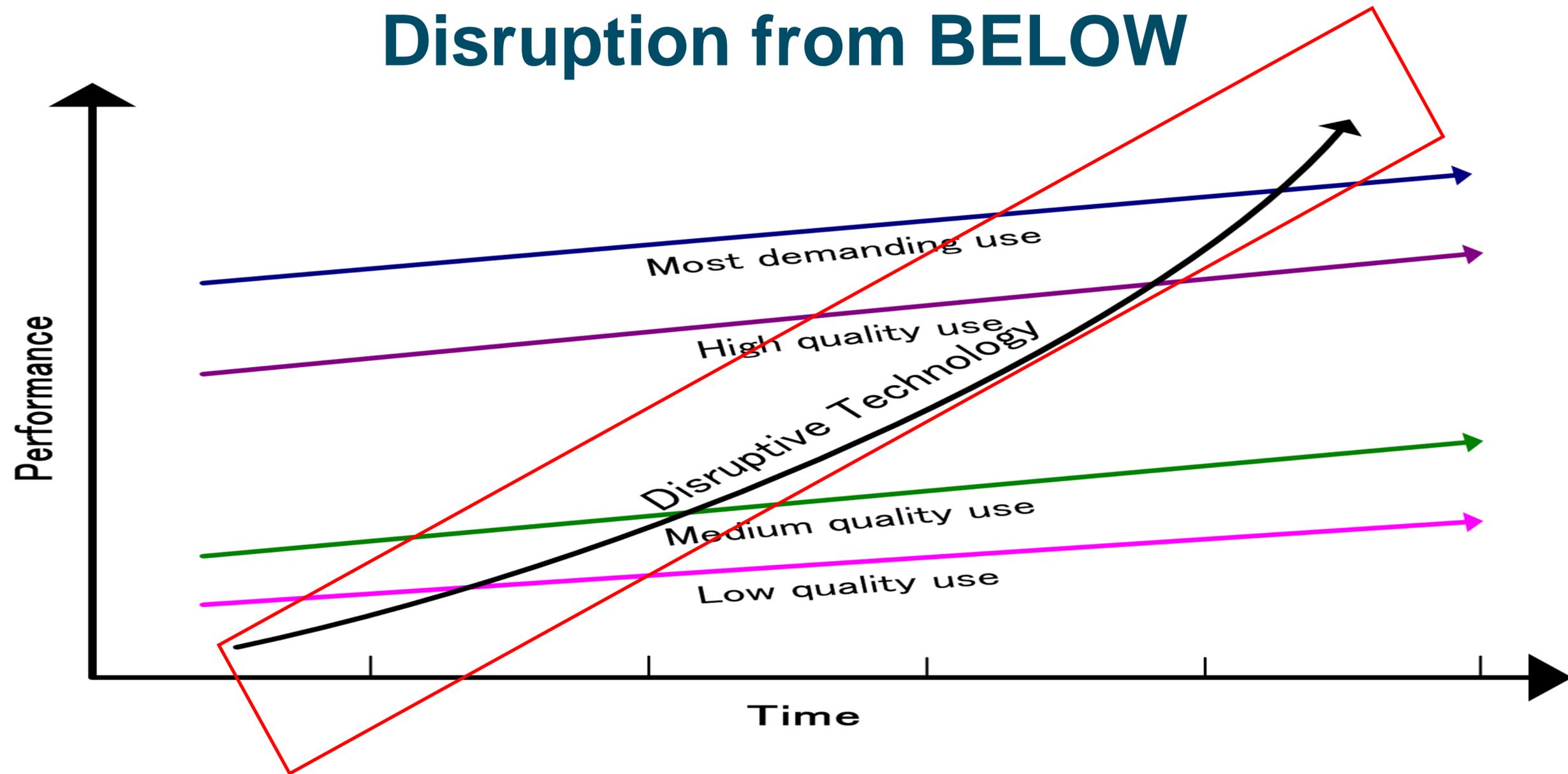


1 Disruption Models

CHRISTENSEN

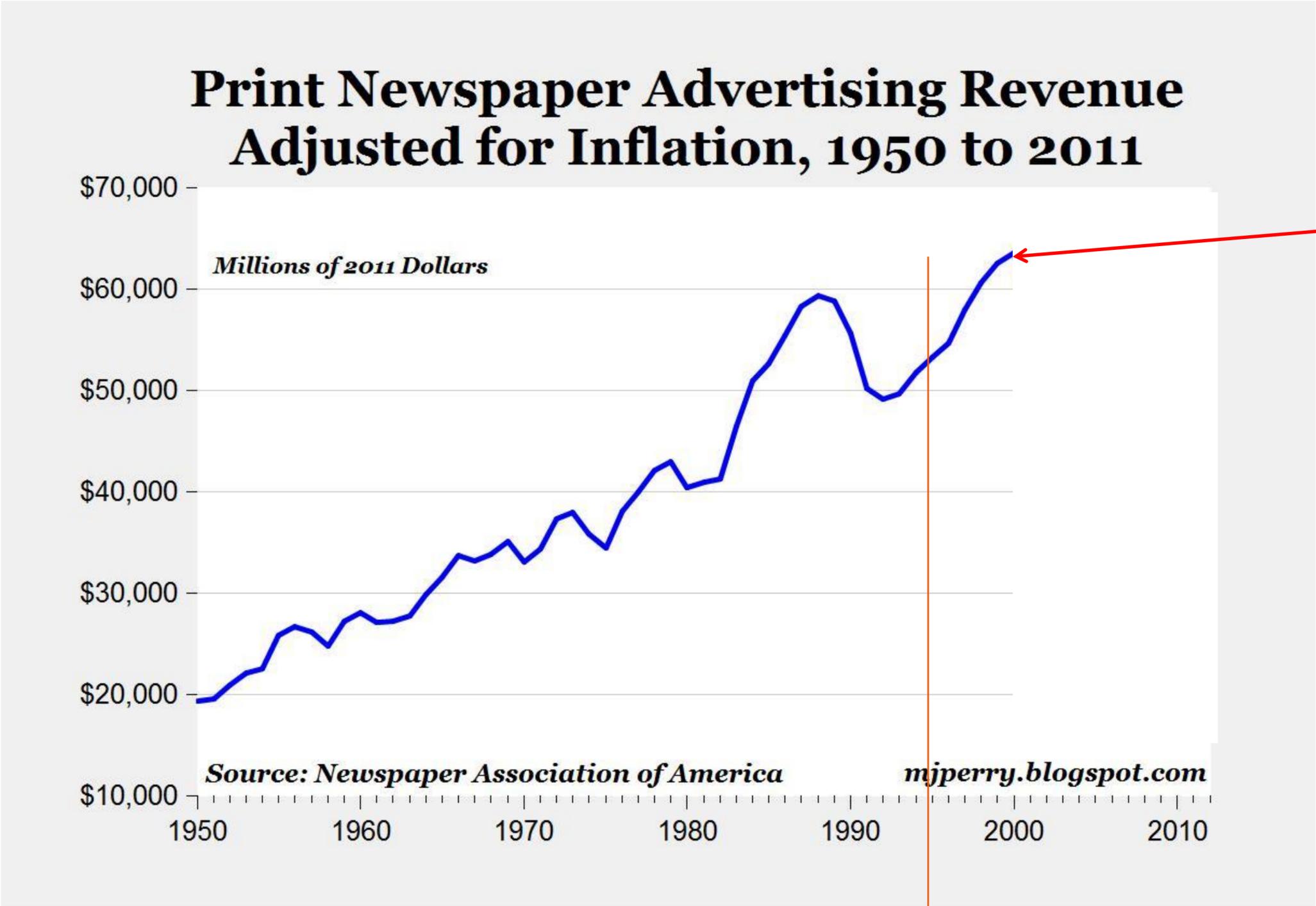
Disruption From Below

Disruption from BELOW



- ▶ Disruptive **products or services** that are **initially less capable** than what the existing mainstream markets are providing.
- ▶ They start out as '**inferior**' technology and are **dismissed** as "**low-quality**", "**toys**", or "**not good enough**".
 - ▶ Ex: **PCs, digital cameras, mobile phones, solar power**

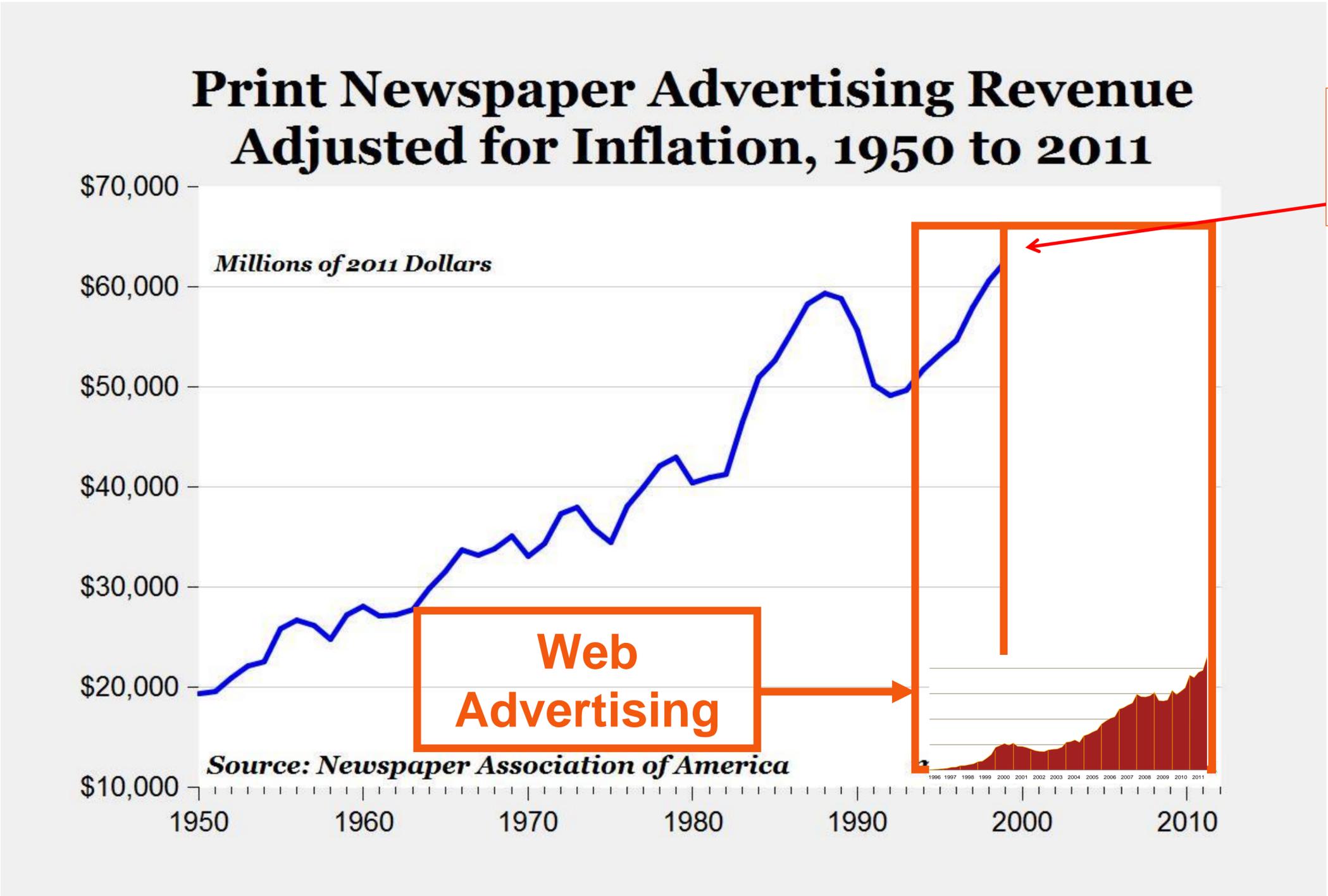
The Print Newspaper Industry ca. 2000



Record Revenues!

The Web

The Newspaper Industry after 2000



Record Revenues!

Web Advertising

SEBA

Disruption From Above

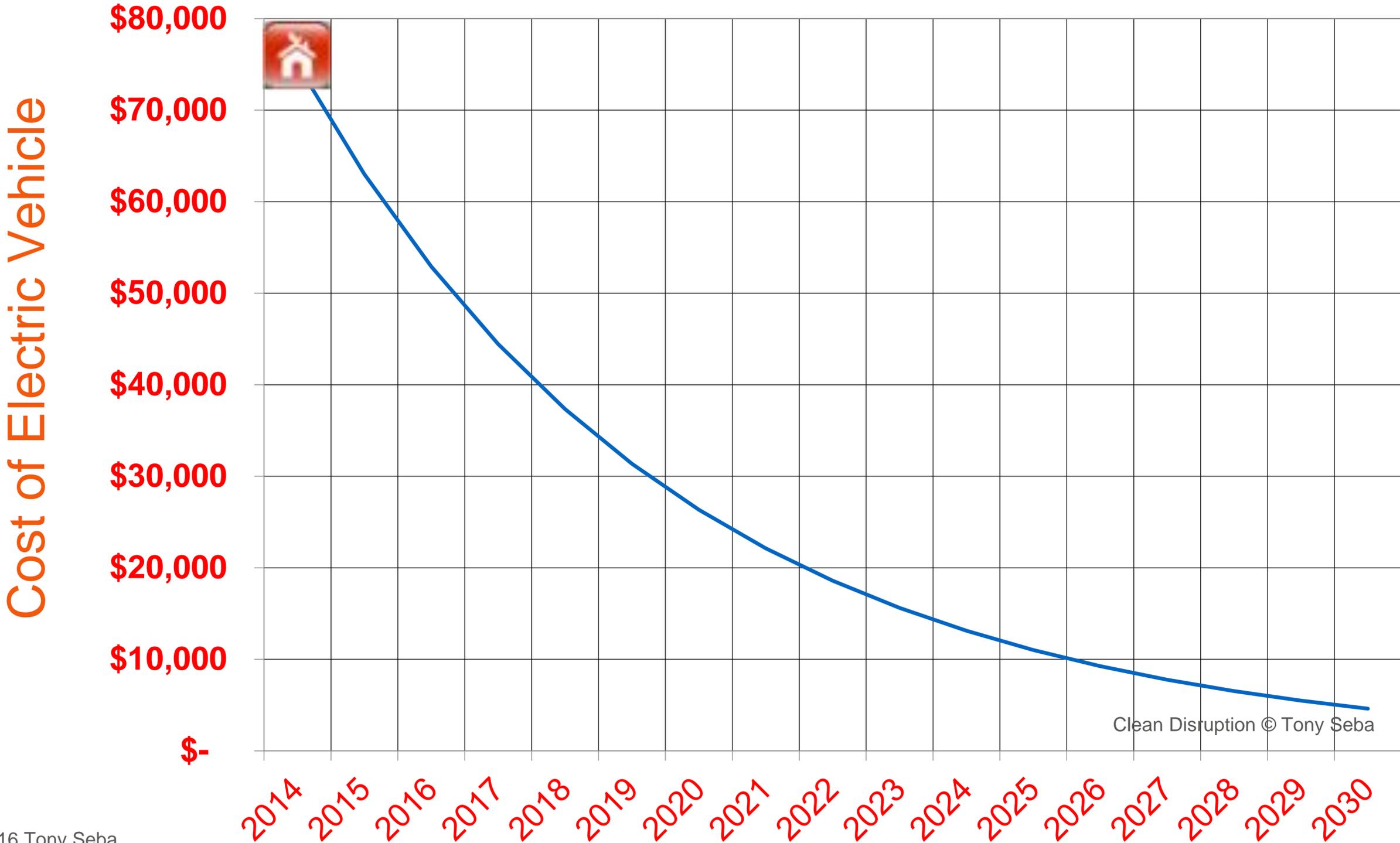
Disruption from ABOVE

- ▶ Start out with **superior** products and services that are much **more capable** but **more expensive** compared to what the existing mainstream market is providing.
- ▶ But their **technology cost curve** is on a **faster downward path** than the existing mainstream products.
- ▶ These products may be perceived as just **substitutes** for the existing mainstream products. However, they may have a **wider range of capabilities, uses, and applications.**



Disruption from Above

Projected Cost of EV with 200-mile (320 Km) range



DOWNES & NUNES

Big-Bang Disruption

Big-Bang Disruption

- ▶ Big-Bang Disruptive Products **start out** with
 - 1. Better Performance**
 - 2. Lower Price, and**
 - 3. More Customization**

- ▶ Ex:
 - ▶ **Google Maps with Driving Directions API**
 - vs Garmin & Tom-Tom GPS



Garmin: 2005-2010 Stock Price

Garmin Ltd. (GRMN) - NasdaqGS

[+ Add to Portfolio](#)

47.10 ↓ 0.10 (0.21%) 4:00PM EDT | After Hours : **47.10** 0.00 (0.00%) 4:02PM EDT - Nasdaq Real Time Price

Enter name(s) or symbol(s)

GET CHART

COMPARE

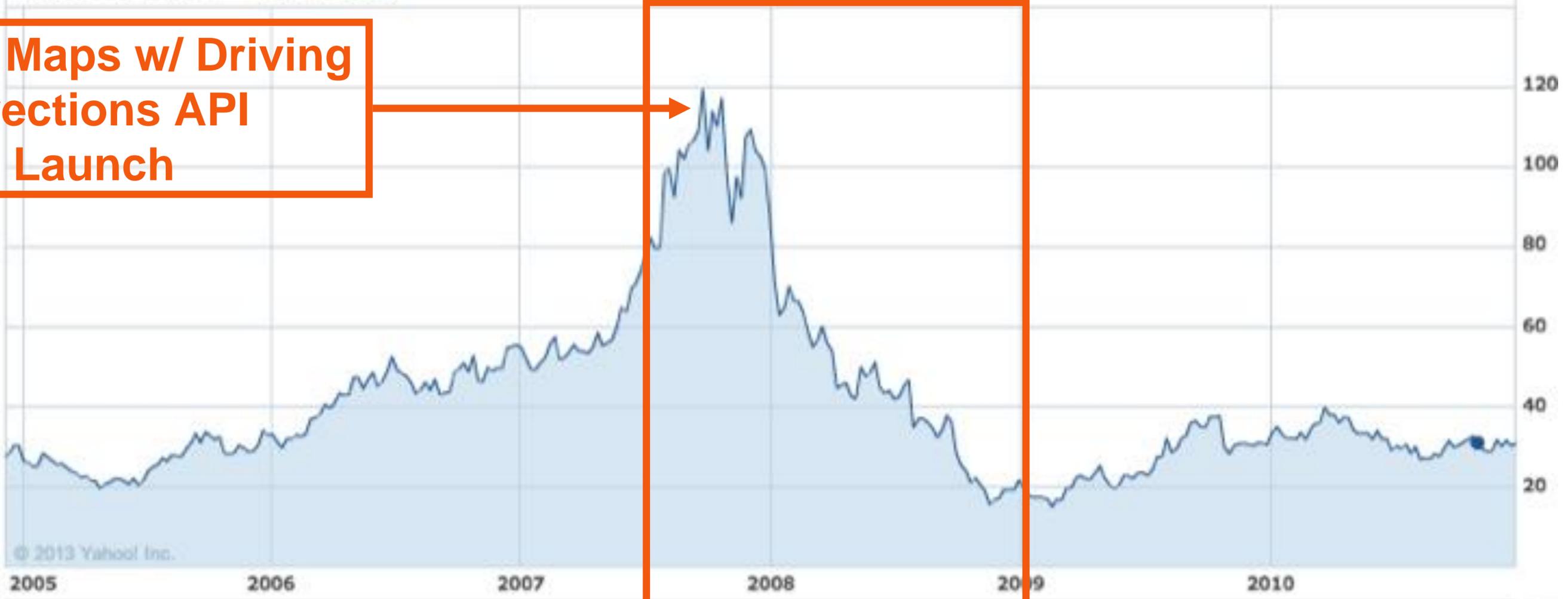
EVENTS ▾

TECHNICAL INDICATORS ▾

CHART SETTINGS ▾

RESET

Week of Nov 1, 2010: ■ GRMN 31.17



Google Maps w/ Driving Directions API Launch

How can NEW products
be Better and Cheaper?
And More
Customizable?



2 Technology Cost Curves

PC / Internet / Mobile Phone industries: Convergence of Exponential Technologies

- ▶ **Several Technologies improving at exponential rates**
- ▶ **Data Storage** – Kryder’s Law
 - ▶ Hard Disk \$ cost per bit down **50% every 18 months**
- ▶ **Digital Imaging** – Hendy’s Law
 - ▶ Pixels per \$ - **59% / year**
- ▶ **Network Capacity** – Butter’s Law of Photonics
 - ▶ The \$ cost of transmitting a bit decreases by **50% every 9 months**



Key Technologies

2016: Key Technologies

1. **Sensors / Internet of Things**
2. **Artificial Intelligence / Machine Learning**
3. **Robotics**
4. **Solar PV**
5. **Energy Storage**
6. **3D Printing**
7. **3D Visualization**
8. **Mobile Internet & Cloud**
9. **Big Data / Open Data**
10. **Unnamed Aerial Vehicles / Nano Satellites**
11. **eMoney / eFinance**

Sensors



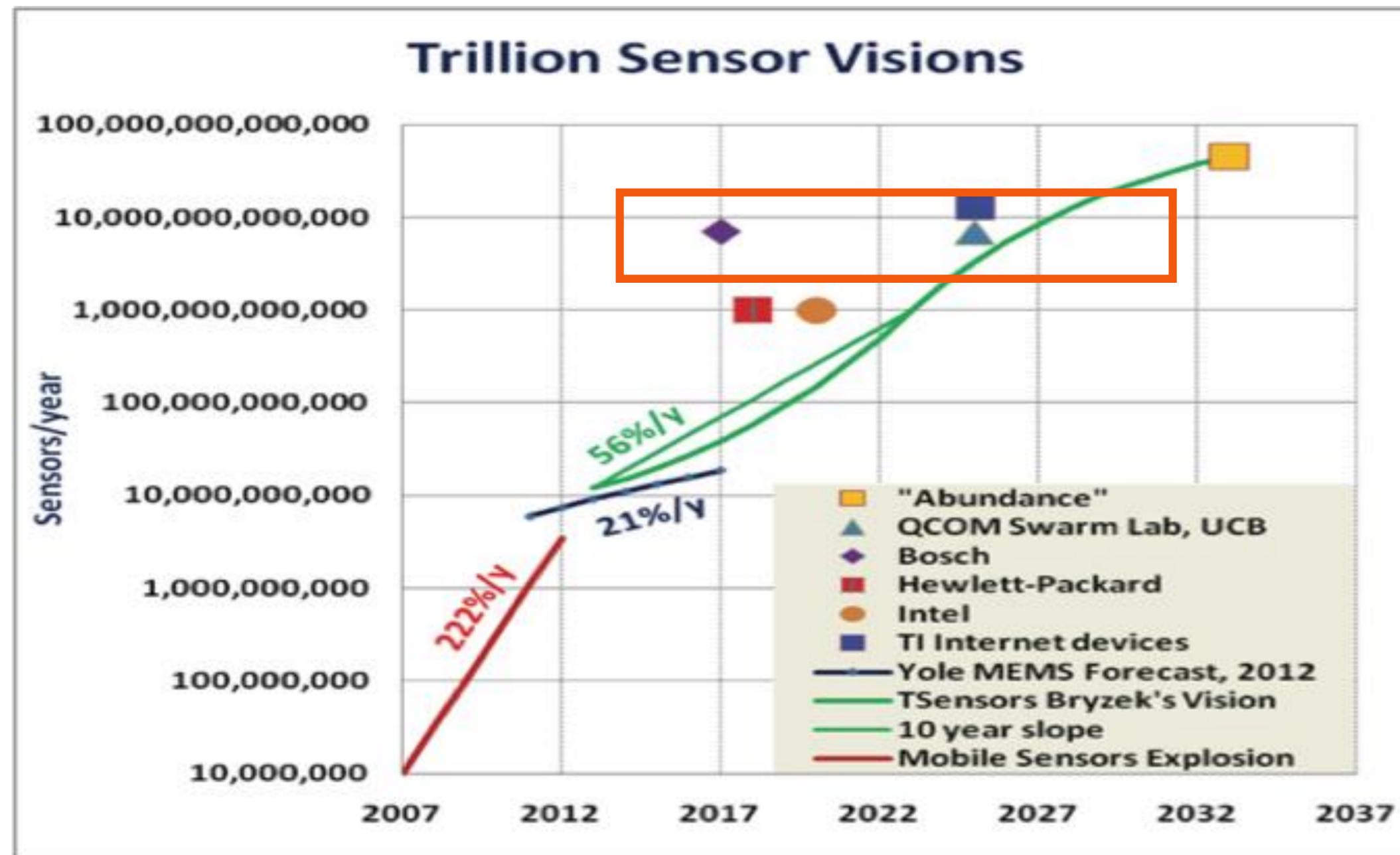
Sensors: 1,000X changes in 7 Years (2007 - 2014)

UNIT	CHANGE	COMMENTS
Number of Sensors	UP 1,000x 	From 10 million to 10 billion
Cost	DOWN 1,000x 	E.g., from \$250/axis for gyros to \$0.75 for three axis
Power consumption	DOWN 1,000x 	From W to mW and mW to μ W, depending on sensor
Physical Size	DOWN 1,000x 	E.g., gyro from 2,000 mm ³ to 2 mm ³ /axis
Number of Transistors	UP 1,000x 	From 1,000s per sensor to 1,000,000s/sensor

On the road to trillions of sensors: Exponential Unit Growth

Market: Trillions of Sensors in ~10 years

- ▶ TSensors: exponential growth from ~10 billion/yr to 10 trillion+/year over the next 10-15 years.



Everything will
have embedded
SENSORS...

Sports...

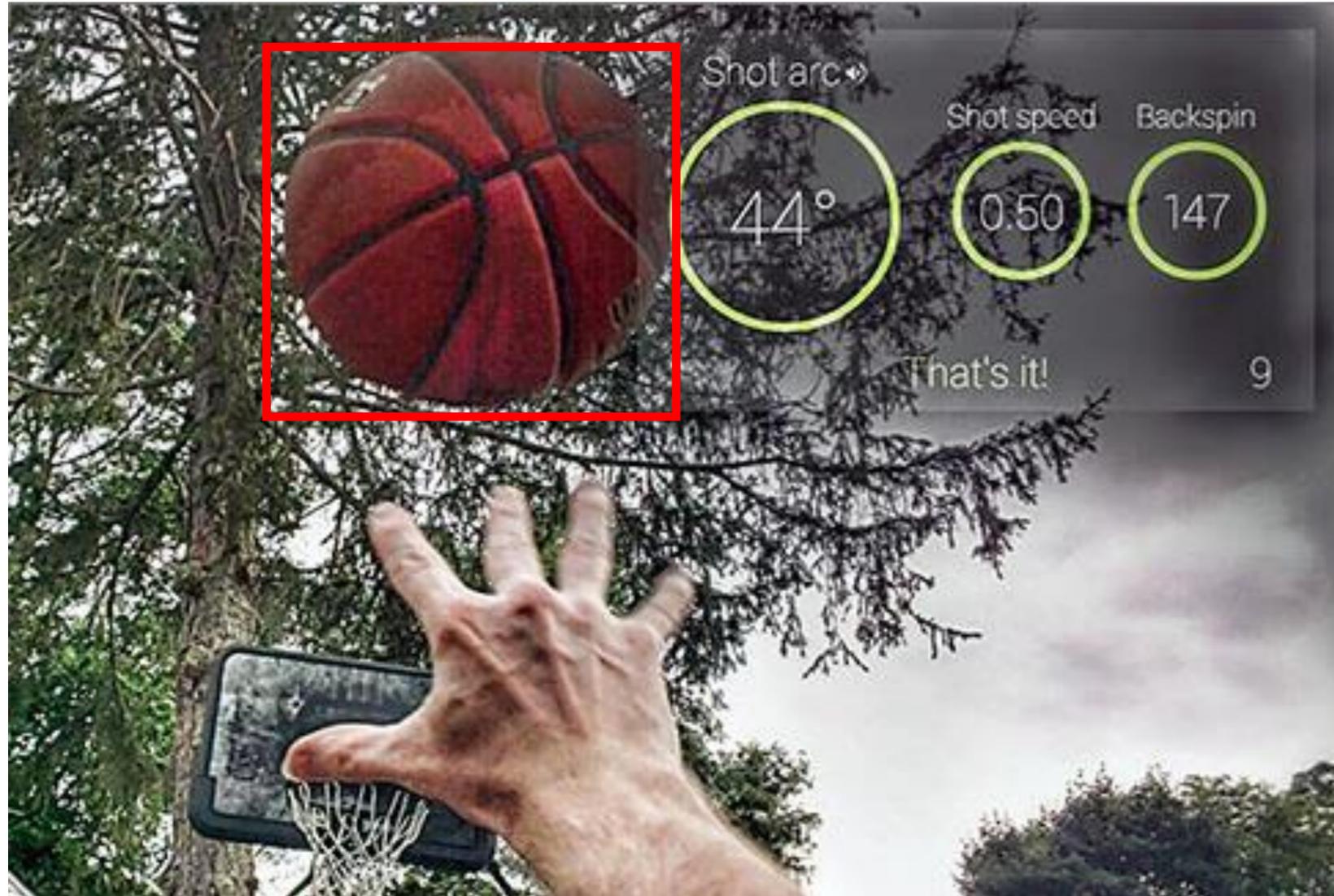
Sports: Swinging with Sensors...

- **Real-time, 3D Analysis of swings:** golf, tennis, baseball, softball...



Sports: Smart Sensor Basketball...

► Real-time, 3D Analysis of basketball.



Shooting Arc

Soften your shot for more consistency by learning to shoot with ideal arc.

▶ Watch it in Action



Dribble Intensity + Speed

Become more versatile by learning to dribble harder under pressure with either hand.



Shot Release Speed

Increase scoring with more shot attempts by always shooting at game speed.

▶ Watch it in Action



Shot Backspin

Improve accuracy by developing a strong wrist for better follow through and a shooters touch.

Energy...

Learning Thermostat



AROS GE Smart Air Conditioner

- ▶ Aros GE Intelligent Air Conditioner for ~ \$300
- ▶ Learns user usage and patterns and cools only when needed
- ▶ Open Innovation: designed by Crowd



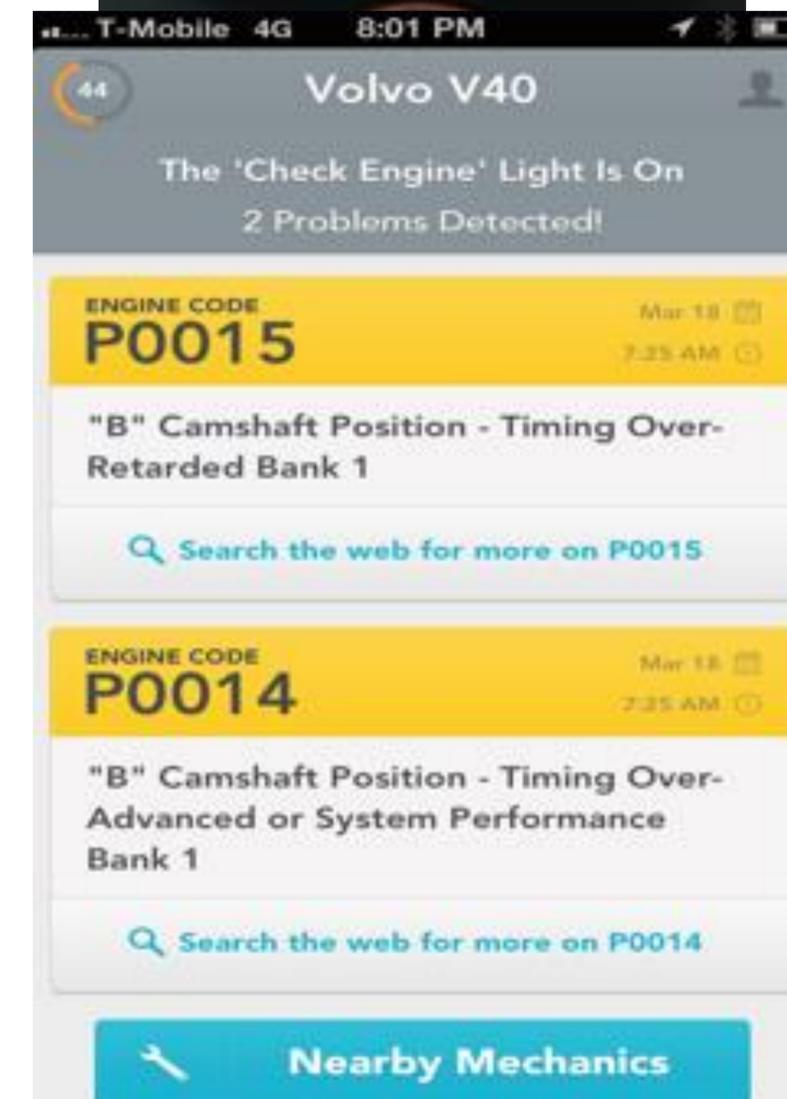
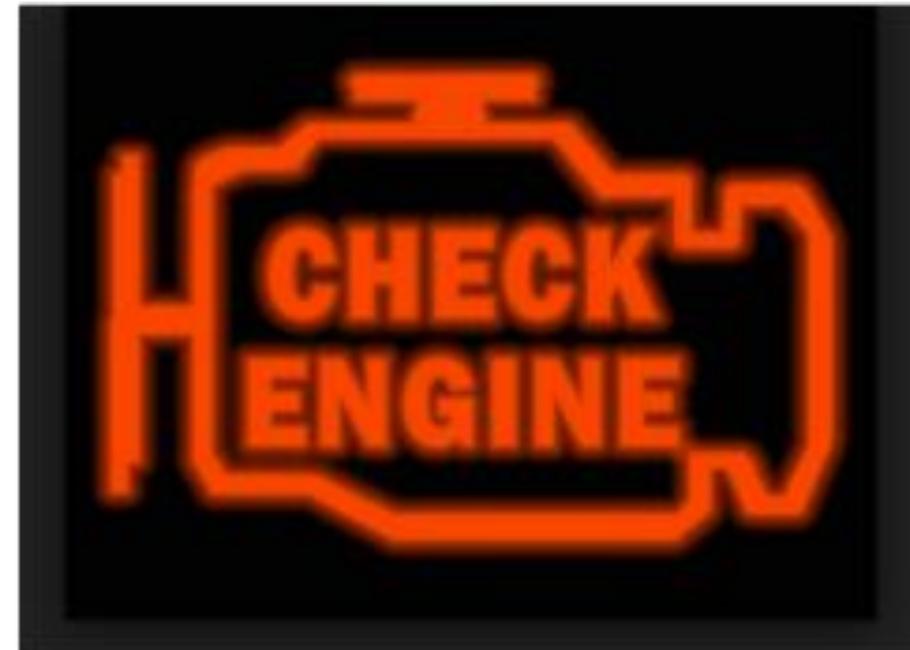
Smart Solar Trash Cans



Transportation...

Car Sensor Tech

- ▶ **\$99** auto accessory that connects to a car's "BLACK BOX" onboard computer and uses the smartphone's GPS sensors to provide driver with real-time info:
 - ▶ **"Check Engine"** light codes
 - ▶ **Trip Timeline**
 - ▶ **Driving information:** acceleration, braking, speeding
 - ▶ **Alerts** your contacts after "Crash Incident"



Convergence: Sensors + Mobile Disruption of Car Insurance

METROMILE		iPhone App	Per-Mile Insurance	Login
Features		 Device + App	 Device + App + Insurance	
Engine diagnostics		✓	✓	
MPG tracking		✓	✓	
Gas cost per trip		✓	✓	
Car locator		✓	✓	
Compare trips		✓	✓	
Automated street sweeping alerts (San Francisco only)		✓	✓	
Per-mile car insurance		-	✓	
24/7 service		-	✓	
Roadside assistance		-	✓	
		Sign up free	Get Insurance Today	

Intelligent, Connected Bicycles

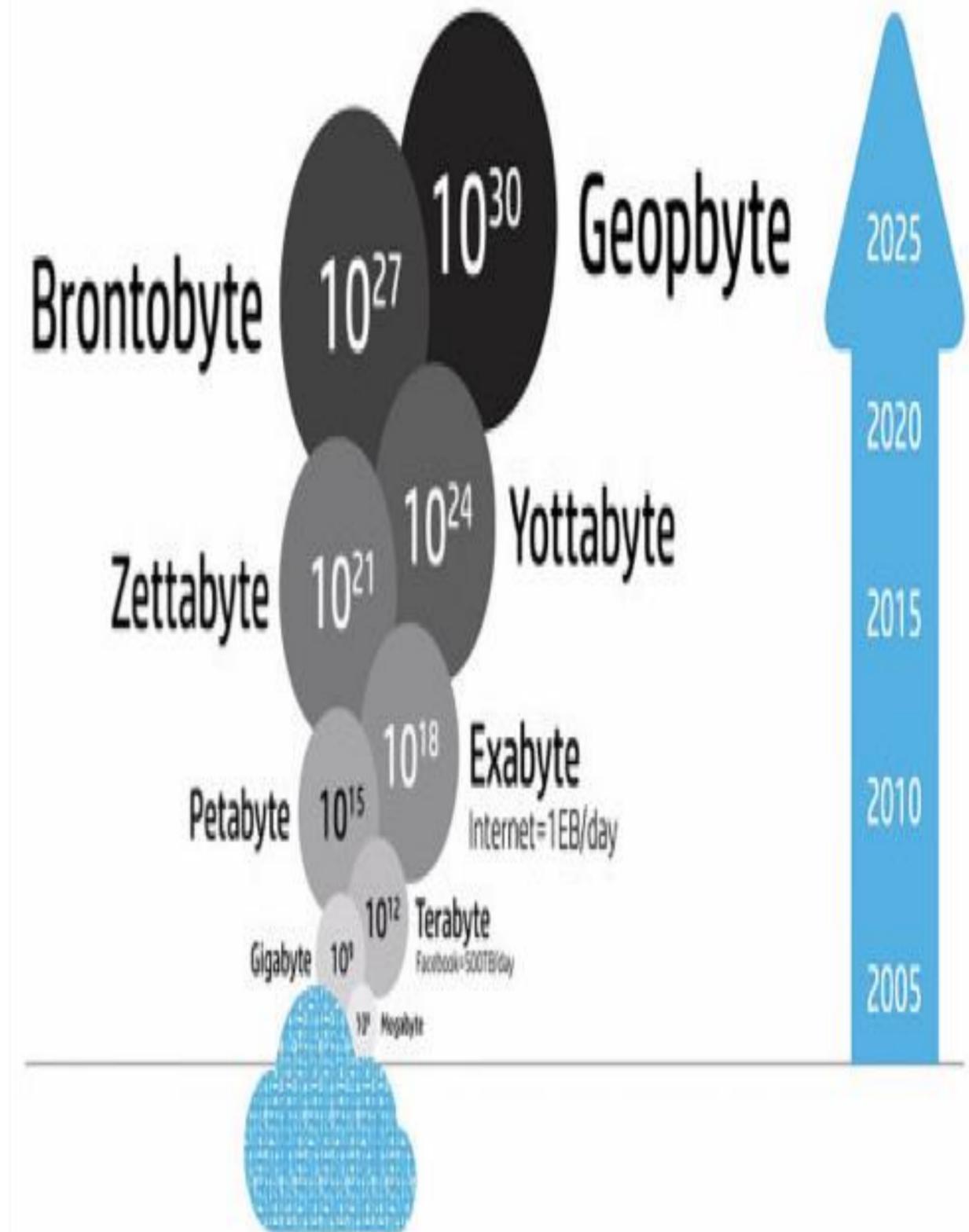


BIG DATA / OPEN DATA



Bronto-Data: The Internet of Things

- ▶ The # of **sensor-based** devices is increasing **exponentially**
- ▶ The # of **sensors within each device** is increasing **exponentially**
- ▶ The **amount of data that each sensor generates** is increasing **exponentially**
- ▶ The **# of connections** between those devices is increasing **exponentially**
- ▶ The result is a **COMBINATORIAL EXPLOSION** of data
- ▶ This is not BIG DATA, this is **BRONTO-DATA (10^{27})** or **EPTO-DATA**



Data-Ruption

DATA about Things is becoming more valuable than the Things themselves



- ▶ Data about money
- ▶ Data about energy
- ▶ Data about transport



UBER



heart rate



skin/core body temperature



SpO2 (oxymetry)



respiratory rate



blood pressure



ECG



emotional stress

Ex: UBER - Ride-Sharing

Companies disrupting private and public transportation.

- ▶ Connecting users with drivers
- ▶ Ex: Uber, Lyft, Didi
- ▶ **Uber** (started 2009):
- ▶ Est. **2015 Bookings = \$10 billion** (1)
- ▶ **1 million drivers** (global) (2)
- ▶ **Uber Valuation (\$64b) > BMW (\$54b)** (3)

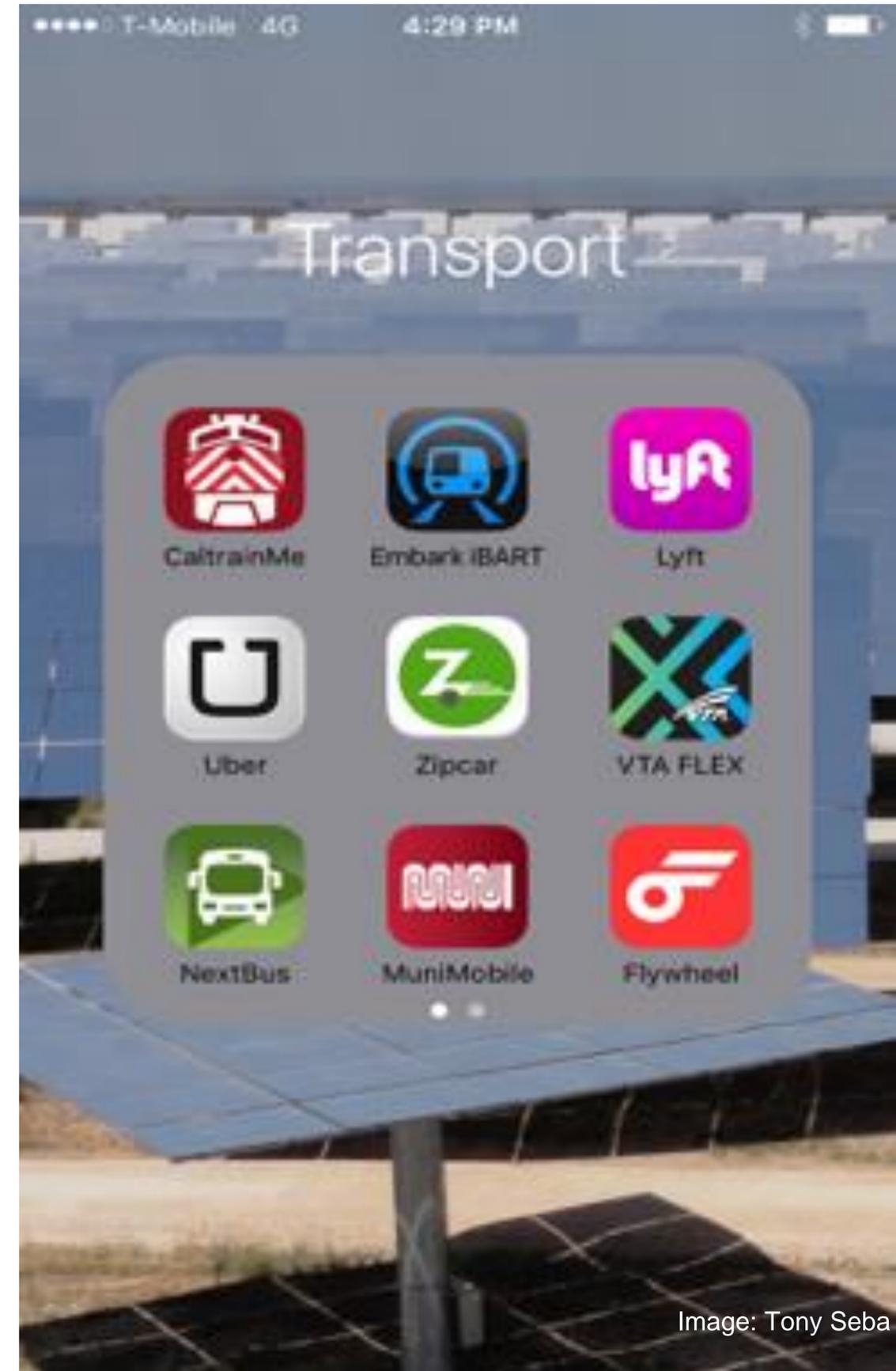


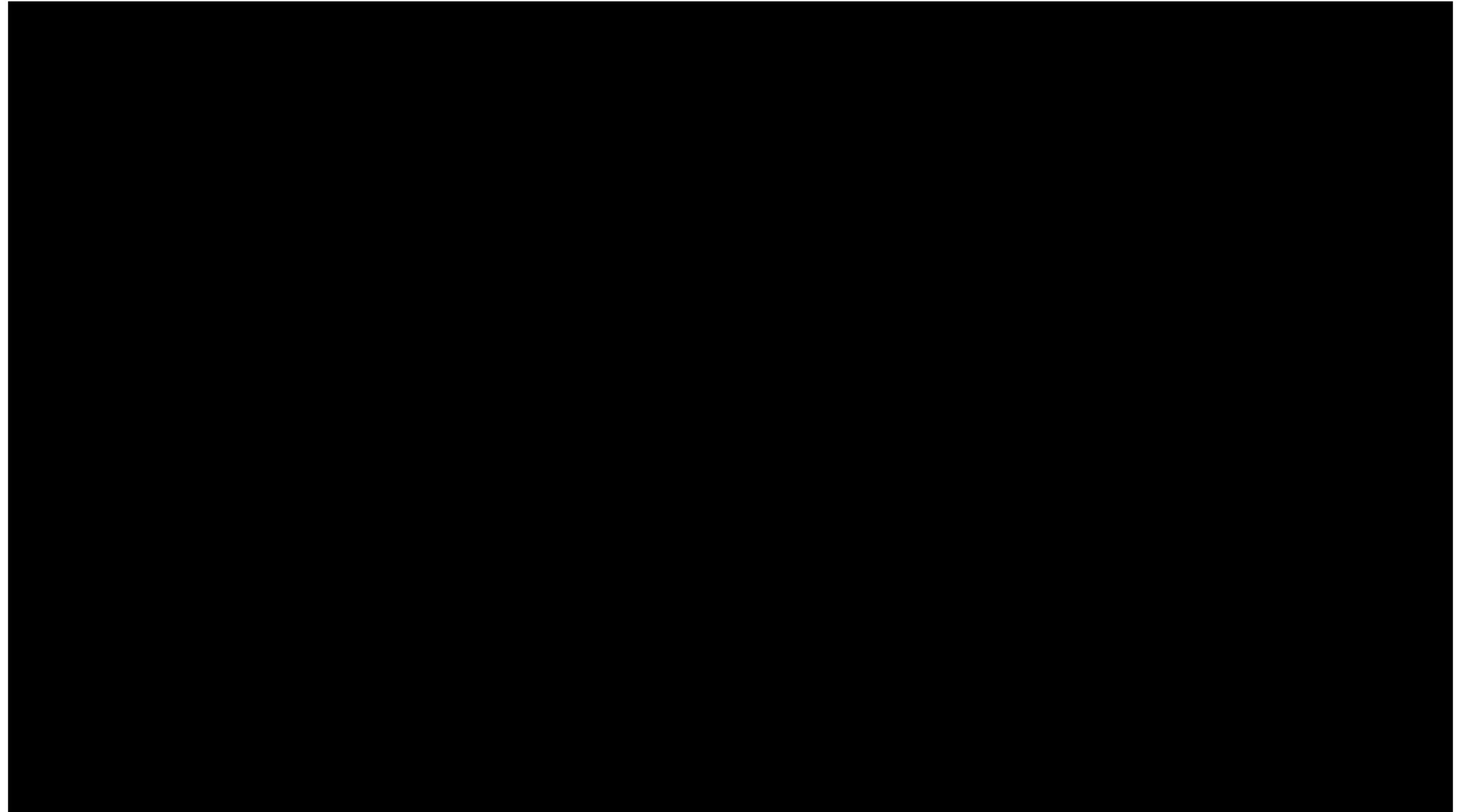
Image: Tony Seba

Robotics





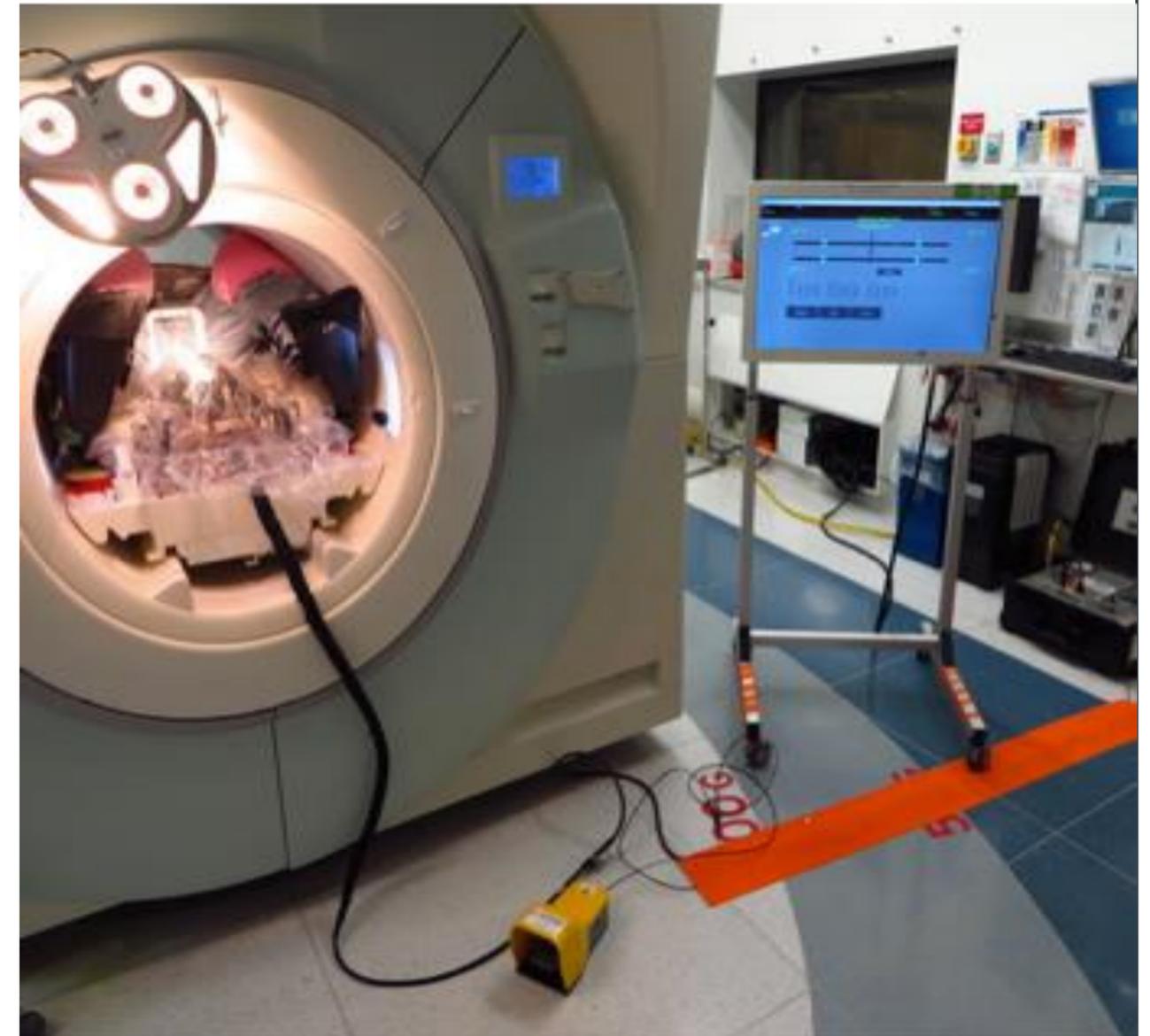
Robots: Improvements in One Year!



ROBOT PERFORMS PROSTATE SURGERY

With Robot: *“**The patient lies inside the MRI scanner** and the non-metallic **robot accesses the prostate** through the perineal wall.”*

*With Human Doctor Today: prostate biopsies are disparagingly called ‘the **blind biopsy**’.* “There’s no lesion targeted, the doctor inserts needles through the skin to get tissue samples. *It’s just: “**Let’s push a bunch of needles in and see what we get.**”*”



3D Printing



3D Printing: Toys & Jewelry?

The screenshot shows the Shapeways website interface. At the top, there is a navigation bar with the Shapeways logo, a 'Shop' button, a 'Make + Sell' button, a search bar, and links for 'Join' and 'Sign in'. Below this is a secondary navigation bar with categories: Art, Fashion, Home, Gadgets, Games, Jewelry, Maker/DIY, Miniatures, Make Your Own, Feed, Shops, Gifts, and Blog. A main banner reads 'Make, buy, and sell products with 3D Printing. How it works.' The main content area is titled 'Keepin' it Brassy' and features a grid of 12 product listings. Each listing includes an image of the product, its name, price, and the creator's name. On the left side, there is a 'SHOP' sidebar with a list of categories: Art, Fashion, For Your Home, Gadgets, Games, Jewelry, Maker/DIY, and Miniatures. Below the sidebar, there is a promotional box for 'More than a 3D Printing service' with an image of various colored 3D printed parts and the text 'Turn your ideas into products ='. The product listings are as follows:

Product Name	Price	Creator
6 Cufflinks	\$40.00	TMesservy
Bicycle Chaining Cufflinks	\$60.00	GothamSmith
Hypercube Pendant (33mm)	\$55.00	Bathsheba
Mechanical Ring 2	\$35.00	kspsho
Crania Anatomica Filigre (me...)	\$150.03	JoshuaHarker
Keychain Mini Crowbar Tool...	\$32.00	innovo
O. vulgaris	\$65.00	MuseumofSmallThings
Thomas Cufflink - Right Sleeve	\$65.00	ThreeFN
Ora Pendant	\$60.00	Bathsheba

3D-Printed Car



- ▶ Speed: 50 mph (80 kph)
- ▶ ABS Plastic, Carbon Fiber Reinforced – 49 parts total
- ▶ 100% Electric Vehicle

GE: 3D-Printing Turbine Parts

- ▶ The LEAP Jet Engine: 3D printed fuel nozzles, carbon fiber blades, and ceramic matrix composites
- ▶ GE expects to 3D print 100k parts by 2020

GE WORKS.

ADVANCED MANUFACTURING IS REINVENTING THE WAY WE WORK

PLAY VIDEO →

GE WORKS / BUILDING / ADDITIVE MANUFACTURING

100k

Additive parts will be manufactured by GE Aviation by 2020

\$6B

Amount GE invests in R&D worldwide each year

300+

3D printing machines currently in use across GE

SEE MORE STORIES



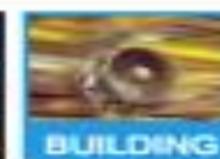
MOVING



CURING



POWERING



BUILDING

Forming manufacturing, one layer at a time

laser-powered 3-D printers, 3-D "inking" and "painting" machines, and other advanced manufacturing tools to make parts and products that were thought impossible to produce and

3D Printing Big Things: Houses

- ▶ 3D-Printing a House in Amsterdam



Machine Learning / Artificial Intelligence



Artificial Intelligence / Machine Learning

- ▶ **IBM Watson** is an **Artificial Intelligence** computer
 - ▶ Capable of answering questions in **Natural Language**
- ▶ In 2011, IBM Watson competed in the **TV Show Jeopardy**
 - ▶ **Against former winners** Brad Rudden & Ken Jennings
 - ▶ **Watson won the \$1m prize**
- ▶ In the **3 years** after it beat human contestants on Jeopardy, **Watson improved:**
 - ▶ **Performance:** by **25X**
 - ▶ **Speed:** by **24X**
 - ▶ **Size:** by **10X**

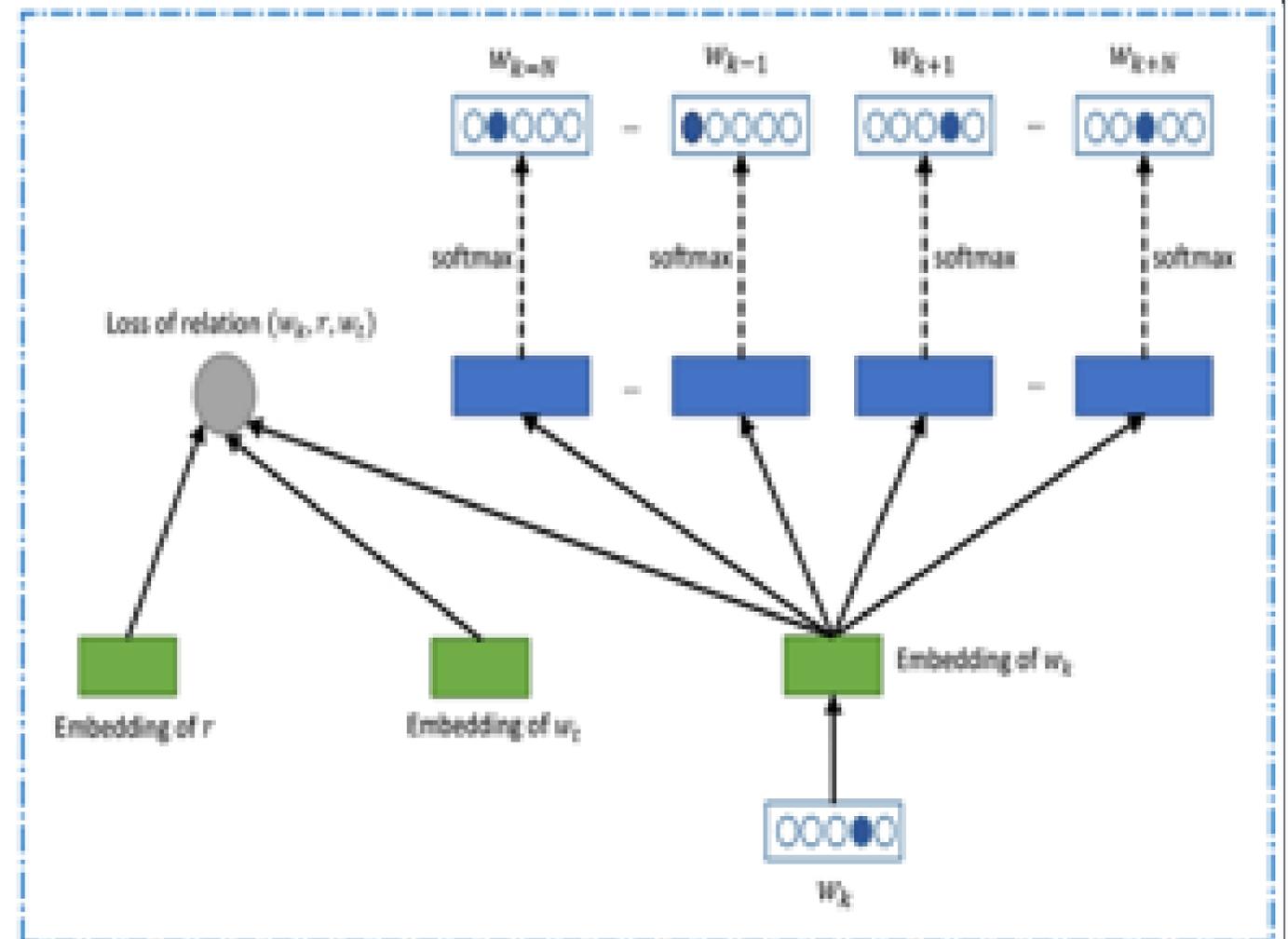


(from the size of a master bedroom 3 pizza boxes)

DEEP LEARNING MACHINE BEATS HUMANS IN IQ TEST

A new model developed by Huazheng Wang (University of Science and Technology, China) and Bin Gao (Microsoft Research, Beijing) “can reach the intelligence level between people with bachelor degrees and those with master degrees.”

“With appropriate uses of deep learning technologies, we could be a further step closer to true human intelligence.”

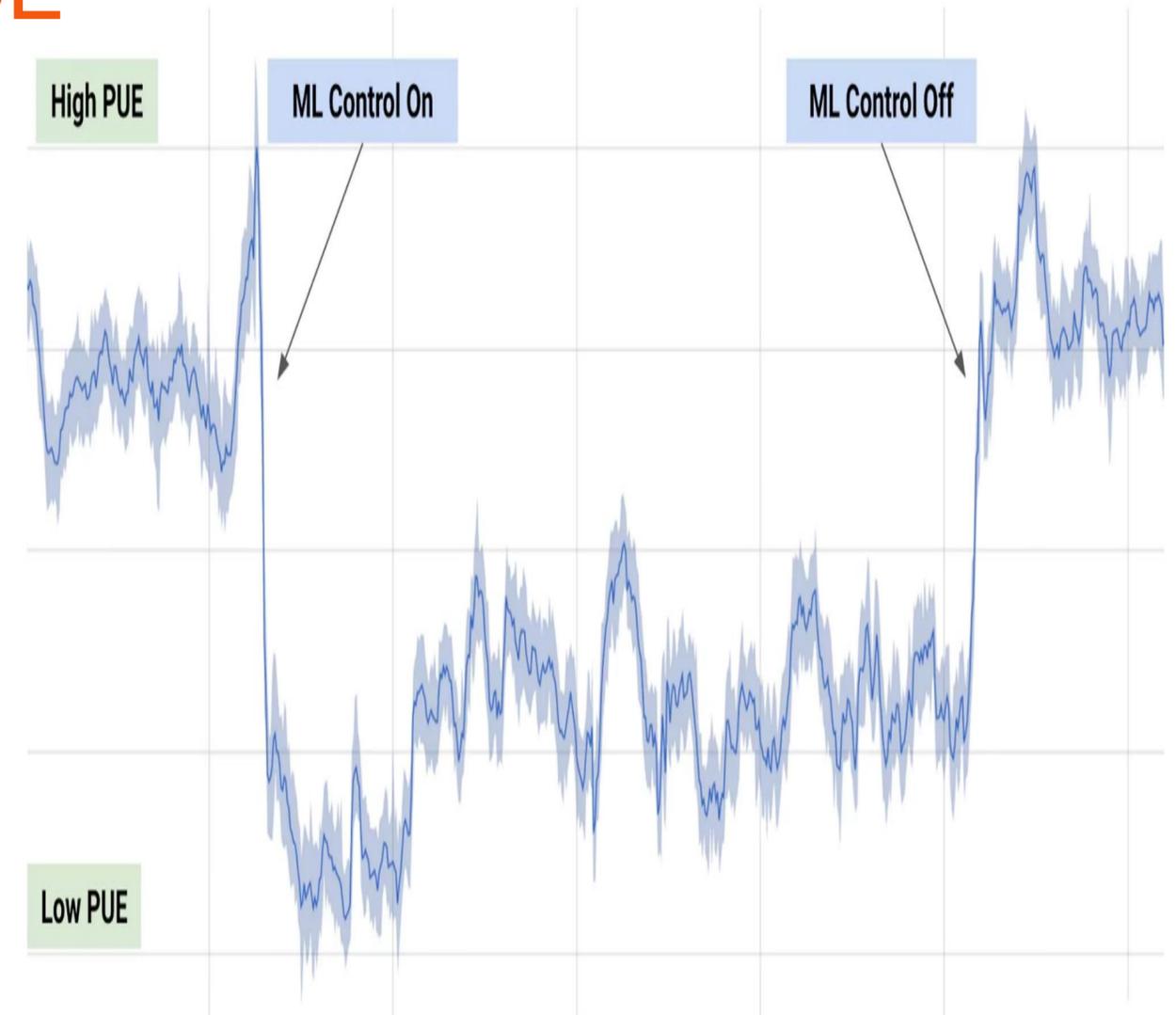


GOOGLE CUTS ELECTRICITY BILL WITH ARTIFICIAL INTELLIGENCE

Alphabet's DeepMind AI helped cut Google's Data Center Power Used for Cooling by 40% and Power usage Efficiency (PUE) by 15%.

The **AI manipulates 120 variables**. It controls how fans, cooling systems, windows, and computer equipment and changes how they **work** to lower PUE.

Google used 4.4 TWh of electricity in 2014. Any savings in usage can translate into hundreds of millions of dollars in savings.

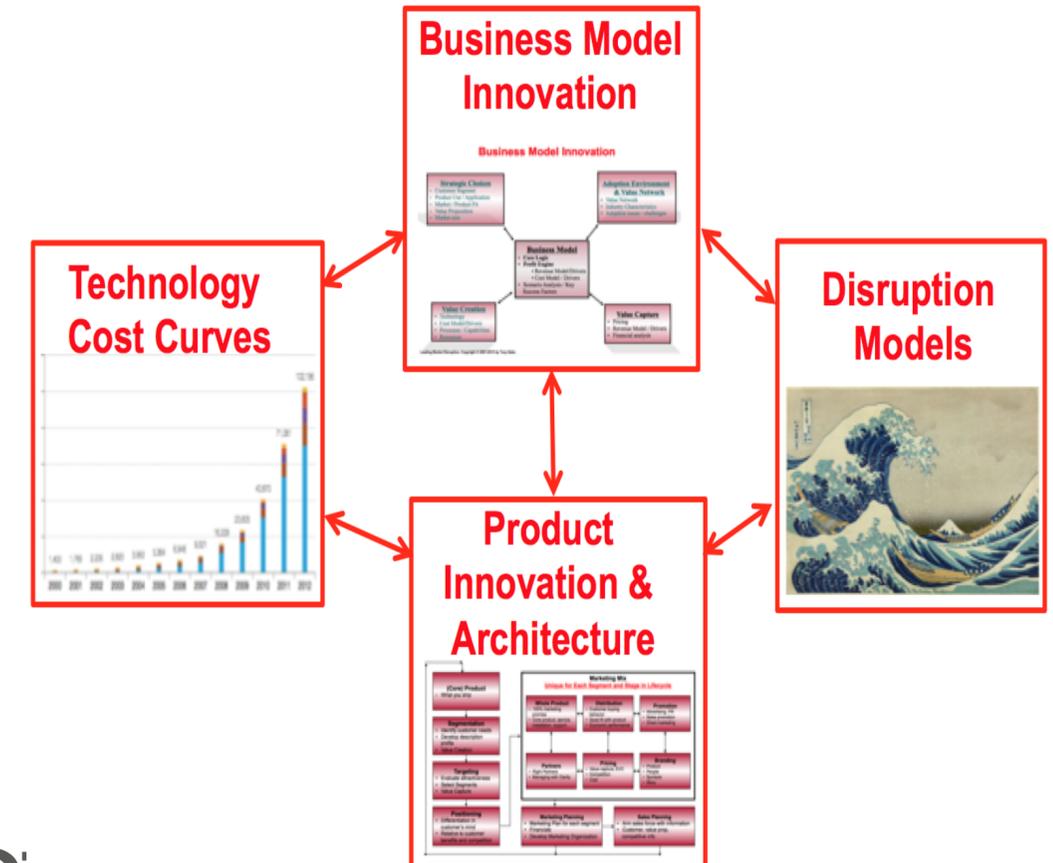


As seen in the graph, the data center's power consumption was cut by 40 percent when the machine learning controls were switched on

Graph Sources: Gizmag

How can WE Anticipate Market Disruptions?

- 1 Disruption Models
- 2 Technology Cost Curves
- 3 Business Model Innovation
- 4 Product Innovation & Architecture



Energy Storage



Li-on Battery costs dropping exponentially

- ▶ **Laptop Li-on battery costs dropped ~14% per year over 15 years.** (1)
- ▶ Investments in battery tech increasing dramatically:
 - ▶ **3 multi-trillion \$ industries investing:**
 1. IT/ Electronics
 2. Automotive
 3. Energy
- ▶ **Since 2010, battery costs have dropped at ~16%/year → ACCELERATING**

The Telegraph

Home News World Sport Finance Comment Culture Travel **Life** Women Fashion
Women Men **Motoring** Health Property Gardening Food Relationships Expert
News First Drives Manufacturers Festival of Motoring Goodwood Top Gear Alamy

HOME » MOTORING » CAR MANUFACTURERS » VOLKSWAGEN

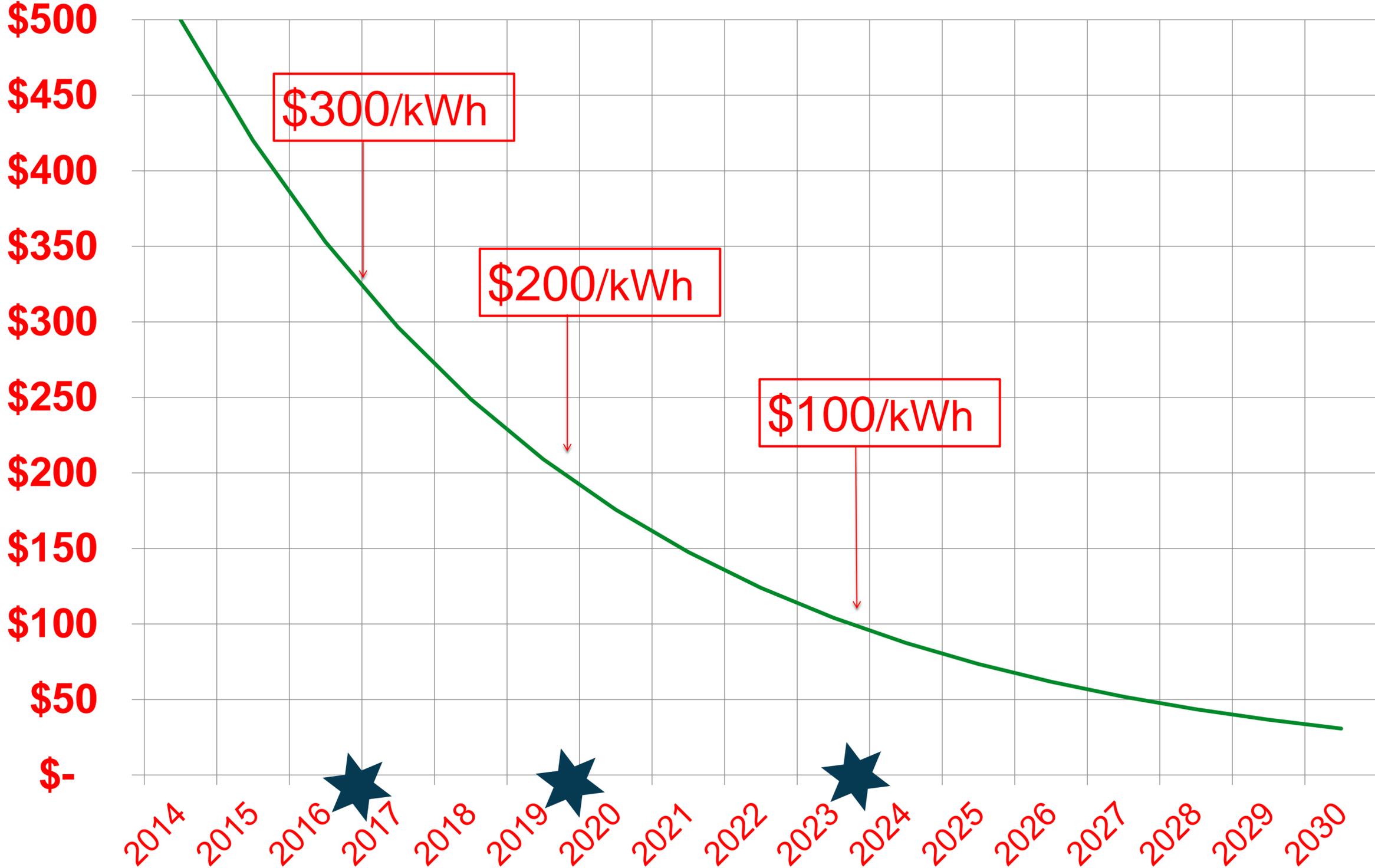
The battery tech that could change electric cars

Volkswagen is testing a new type of battery that it says could be four times as powerful as existing technology



Projected cost of Li-On Battery \$/kWh

Cost of Li-On Battery Storage (\$/kWh)



Tesla's Battery GigaFactory

- ▶ **\$5 Billion investment** (6,500 jobs)
- ▶ Battery pack output: 50 GWh year
→ **500,000 cars/year**
- ▶ **Double world battery production**

Reduce battery pack costs by

**30-50+
%**

Tech improvement. "Tesla expects to increase pack capacity by roughly 5% per year." (1)



Investments in Battery Megafactories increasing

- ▶ **BYD** could ramp up to **34 GWh** by 2020 - matching Tesla's **35 GWh** (1)
- ▶ **Foxconn** and **LG Chem** could add combined **22 GWh** (2)
- ▶ **Samsung SDI**, **Dyson**, Total, Bosch, Boston Power, TDK, Apple, Nissan, Daimler, VW, etc.
- ▶ **12+ Megafactories** expected to come online by 2020 (3)
- ▶ **Tesla** could **Triple** expected output to 105 GWh (cells) / 150 GWh (packs) (4)

Tech Cost Curve could accelerate!

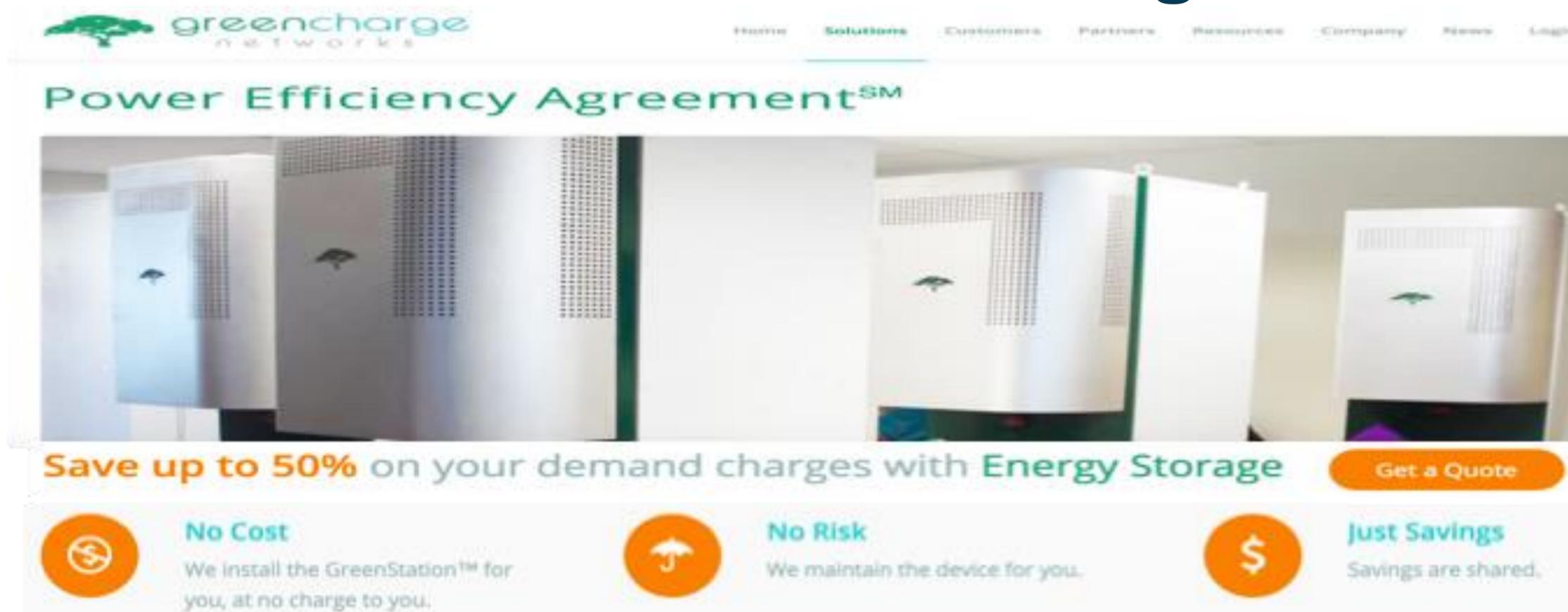


Image Source: Samsung SDI

ENERGY STORAGE

Business Model Innovation

Business Model Innovation: Storage as a Service



The screenshot shows the GreenCharge Networks website. At the top, the logo "greencharge networks" is on the left, and navigation links "Home", "Solutions", "Customers", "Partners", "Resources", "Company", "News", and "Login" are on the right. Below the logo is the heading "Power Efficiency AgreementSM". A large image shows several white energy storage units. Below the image is a banner that reads "Save up to 50% on your demand charges with Energy Storage" and a "Get a Quote" button. Below the banner are three key benefits, each with an icon in an orange circle: "No Cost" (dollar sign with slash) with the text "We install the GreenStation™ for you, at no charge to you.", "No Risk" (umbrella) with the text "We maintain the device for you.", and "Just Savings" (dollar sign) with the text "Savings are shared."

- ▶ Stem and GreenCharge Networks offering **storage-as-service** to reduce DEMAND CHARGES for businesses
 - ▶ **Zero-money down**, 10 years
- ▶ **Lower utility bills by 10-50%** (1)
- ▶ Storage also increases resiliency and may allow C&I businesses to participate in wholesale markets demand response programs.

Storage Disruption: Residential and Commercial

- ▶ Average American consumes 903 kWh/month → ~ 30kWh/day
- ▶ By 2020 it will cost **\$36.8/month (\$1.2/day)** for a full day of electricity storage

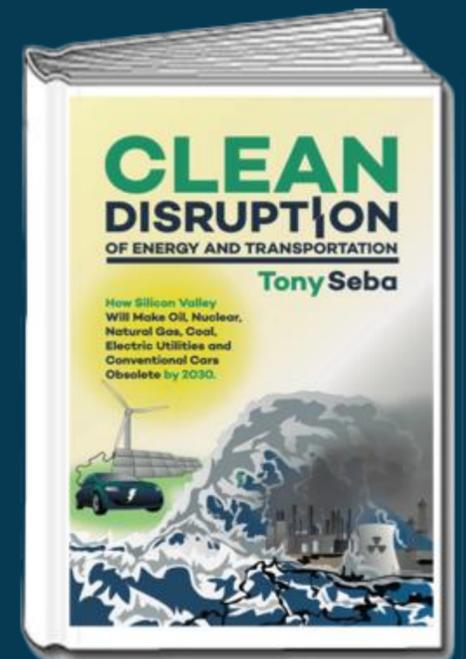
Monthly cost of residential storage		Target year ->		2014	2020	2024	2028	
Purchase cost of battery storage system (US\$/kWh) ->			\$600	\$500	\$300	\$200	\$100	\$50
SaaS services	Hours	kWh	Storage: Monthly Cost					
Demand response	1	1.25	\$4.6	\$3.8	\$2.3	\$1.5	\$0.8	\$0.4
Avoid peak, buy low & shift usage	4	5	\$18.4	\$15.3	\$9.2	\$6.1	\$3.1	\$1.5
Store all solar self-generation	8	10	\$36.8	\$30.7	\$18.4	\$12.3	\$6.1	\$3.1
Self-sufficiency	16	20	\$73.6	\$61.3	\$36.8	\$24.5	\$12.3	\$6.1
Full day	24	30	\$110.4	\$92.0	\$55.2	\$ 36.8	\$18.4	\$9.2

Every house, retail business,
warehouse, building, factory,
parking lot, device will have
smart, connected
BATTERIES...

The Electric Vehicle Disruption



Photo: © Tesla Motors



2013 CAR OF THE YEAR: TESLA MODEL S

\$ Best-selling high-end large luxury car in America! ⁽²⁾

U.S. Sales of Large Luxury Vehicles

MODEL	2015 Sales	2014 Sales	% Change
Tesla Model S	25,202	16,689	51.01%
Audi A7	7,721	8,133	-5.07%
Audi A8	4,990	5,904	-15.48%
BMW 6-Series	8,146	8,647	-5.79%
BMW 7-Series	9,292	9,744	-4.64%
Jaguar XJ	3,611	4,329	-16.59%
Lexus LS	7,165	8,559	-16.29%
Mercedes-Benz CLS-Class	6,152	6,981	-11.88%
Mercedes-Benz S-Class	21,934	25,276	-13.22%
Porsche Panamera	4,985	5,740	-13.15%
Total	99,198	100,002	-0.80%

Consumer Reports:
Best Car EVER! ⁽¹⁾





But who can afford an
Electric Vehicle?

IS THE ELECTRIC
VEHICLE

Disruptive?

(You always need to ask)



1. Electric Motor - 5X more Energy Efficient

Energy Efficiency



Internal
Combustion
Engine



Electric
Motor

2. EVs are 10X cheaper to charge/fuel

- ▶ It costs **\$15,000** to fill up a (**gas**) Jeep Liberty over **five years** (Consumer Reports)
- ▶ An **Electric** Jeep Liberty would cost **\$1,565** in electricity
- ▶ Improvements in power electronics will **increase this 10X**

Assumptions:

12,000 miles/year

Tesla Roadster: 4.6 miles per kWh.

Ave retail electricity in the U.S.: 12 ¢/kWh

5 year-cost = (60,000 miles * 0.12 \$/kWh) / 4.6 miles/kWh = \$1,565.



Image Source: jeep.com



Sources: Consumer Reports, DOE, Clean Disruption

3. Maintenance - Gasoline Car: 2,000+ moving parts (1)



3. EVs: 100X fewer Moving Parts

ICE (Gas) Vehicle

2,000+ moving parts ⁽¹⁾



Transmission, driveshaft, clutch, valves, differentials, pistons, gears, carburetors, crankshafts...

Electric Vehicle (EV)

18 moving parts ⁽¹⁾



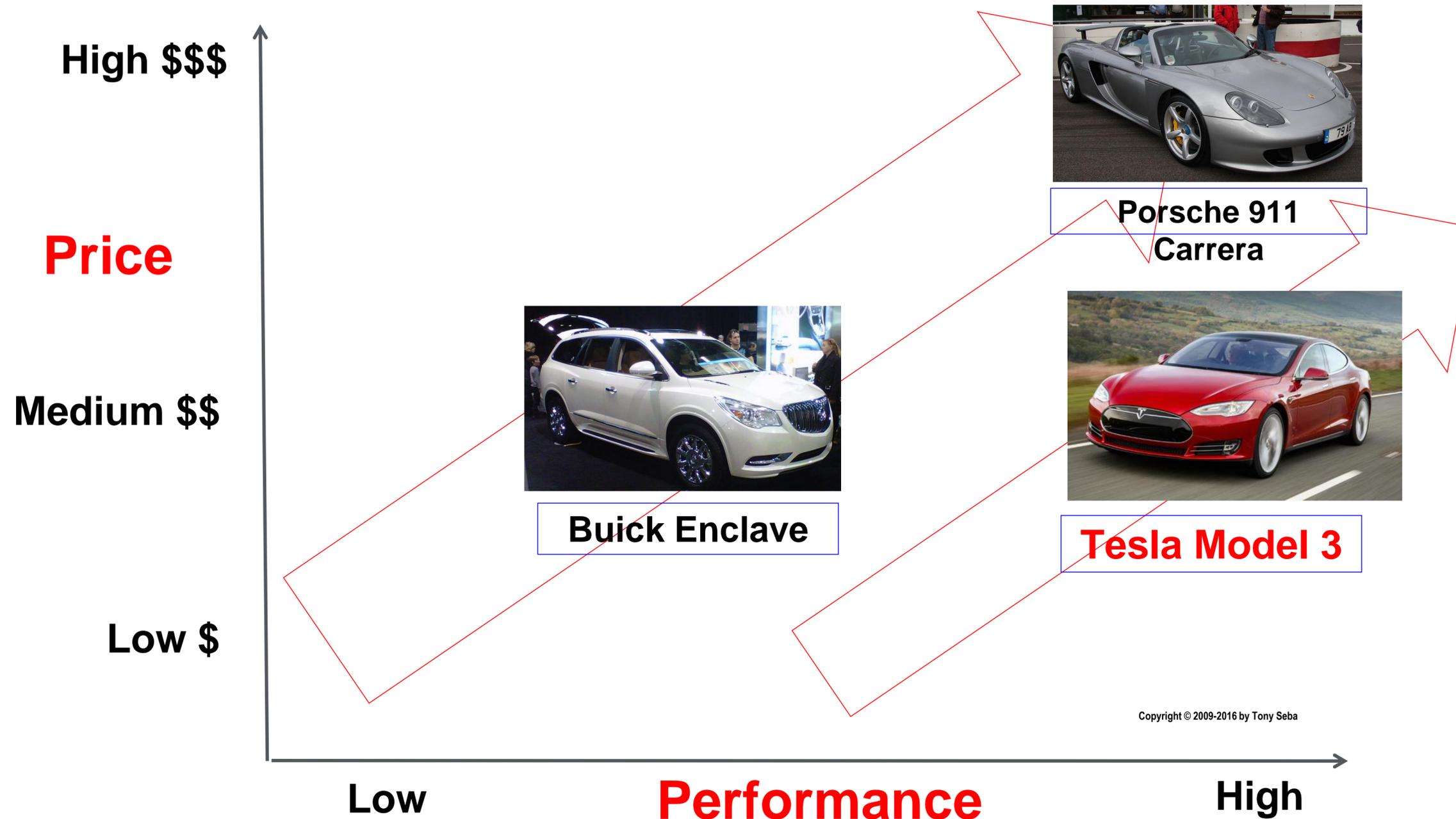
- ▶ EVs **10X-100X** cheaper to maintain!
- ▶ Tesla: **Infinite Mile Warranty!** ⁽²⁾

4 – EVs MORE powerful than ICE



“**University Student team** builds EV that breaks world acceleration record (0-100 Km/h in 1.51 sec) **beats the \$1m Porsche 918 Spyder** (2.2 sec)” (1)

EVs Shift the Price/Performance equation: Disrupt the BASIS of COMPETITION



EVs: Porsche performance for Buick prices!

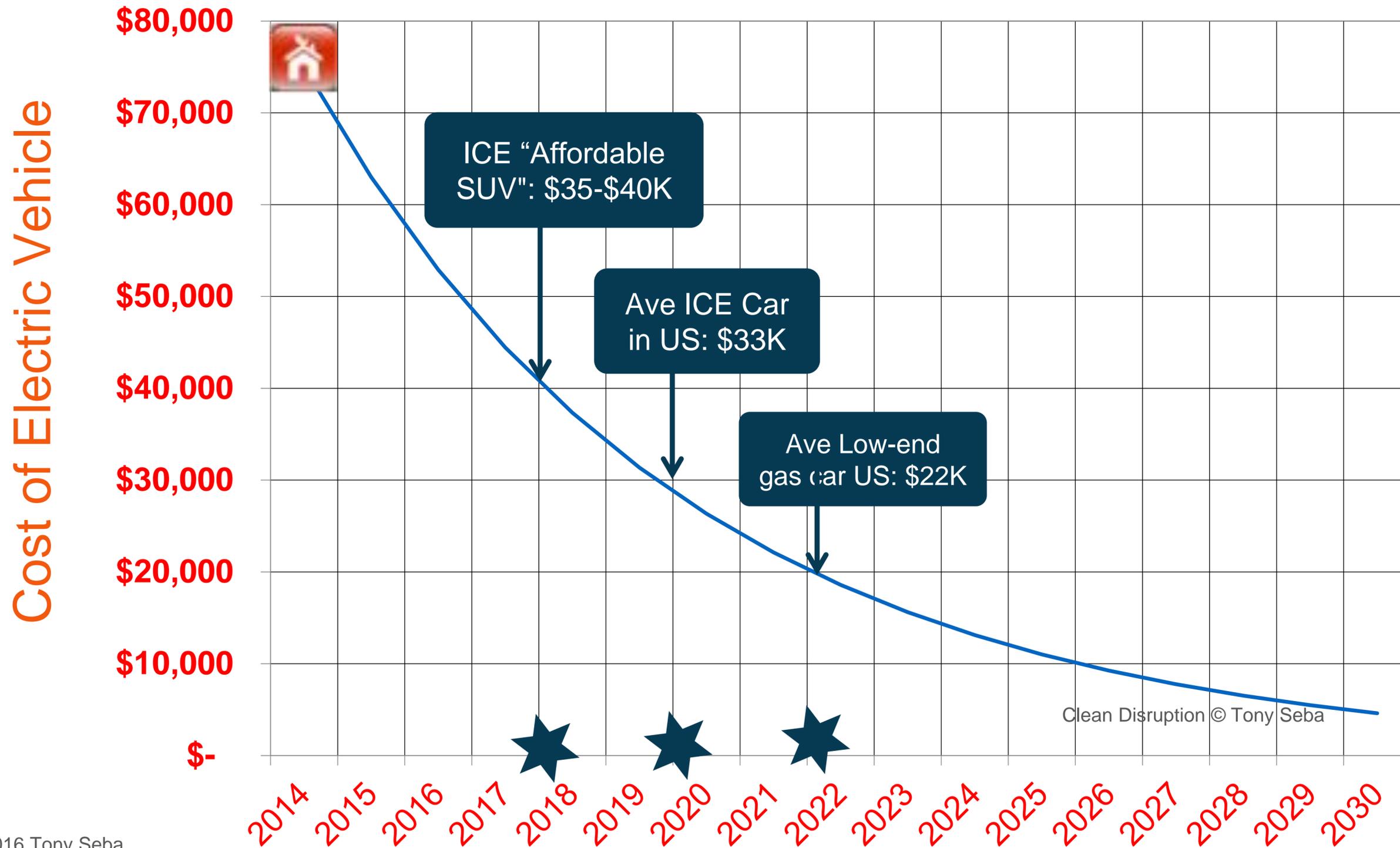
Copyright © 2009-2016 by Tony Seba

OK, SO THE EV IS DISRUPTIVE
How long will the transition
take?



Disruption from Above – Electric Vehicles

Cost of EV with 200-mile (320 Km) range



- Assumptions:**
- 4 miles/kWh,
 - 50kWh batteries,
 - 16% yearly battery cost improvement,
 - EV Cost = 3X battery

CEO BARRA UNVEILS BOLT EV @CES

2017 Chevy Bolt: **200-mile** range
Electric Vehicle for \$37,500
[unsub]

“It’s more than a car, it’s an upgradeable platform for new technologies.” (1)

“Car-sharing, new ownership models, automated driving... down the road.”



Image Source: Fortune

Tesla Model 3 – Record Single-Day Sales for any Product of Any Kind Ever!

Tesla Model 3

\$ 35,000

Unsubsidized

Autopilot (semi-autonomous)

215-mile range

0-60mph in < 6 secs

Market reaction:

180,000 cars

ordered / reserved **first 24h!**

>\$6.3b

pipeline **first 24h!**

Biggest Crowdfunding Event in History: \$400m & counting!



Image: Tesla

FOXCONN TO MAKE EV FOR \$15,000

“Foxconn, the maker of the Apple iPhone to invest \$811m to develop Electric Cars.”

“CEO Terry Gou said they are targeting EVs priced at \$15,000.”

(1)

“200+ Chinese startup EV companies developing 4,000+ models.” (2)



ELECTRIC VEHICLE / CHARGING

Business Model Innovations

(That can accelerate the Disruption)

Renault launched Elbnb, a P2P EV Charging Platform

ElBnb enables anyone's power outlets to become public Electric Vehicle Plug-In Stations.

"The home stations will be featured on a map accessible by EV drivers. Charging times and prices are determined by homeowners and drivers." ⁽¹⁾

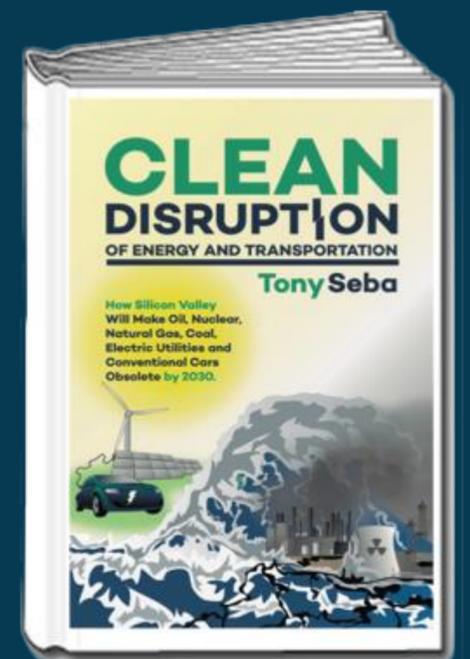


Image Sources: Renault

The Autonomous Vehicle Disruption



Image: Wikipedia



NEVADA APPROVES AUTONOMOUS TRUCKS



33 Corporations Working on Autonomous Vehicles



SELF-DRIVING CARS MAY HIT THE ROAD IN 2018: RENAULT-NISSAN CEO

PARIS Tue Jun 3, 2014 1:03pm EDT

0 COMMENTS | 



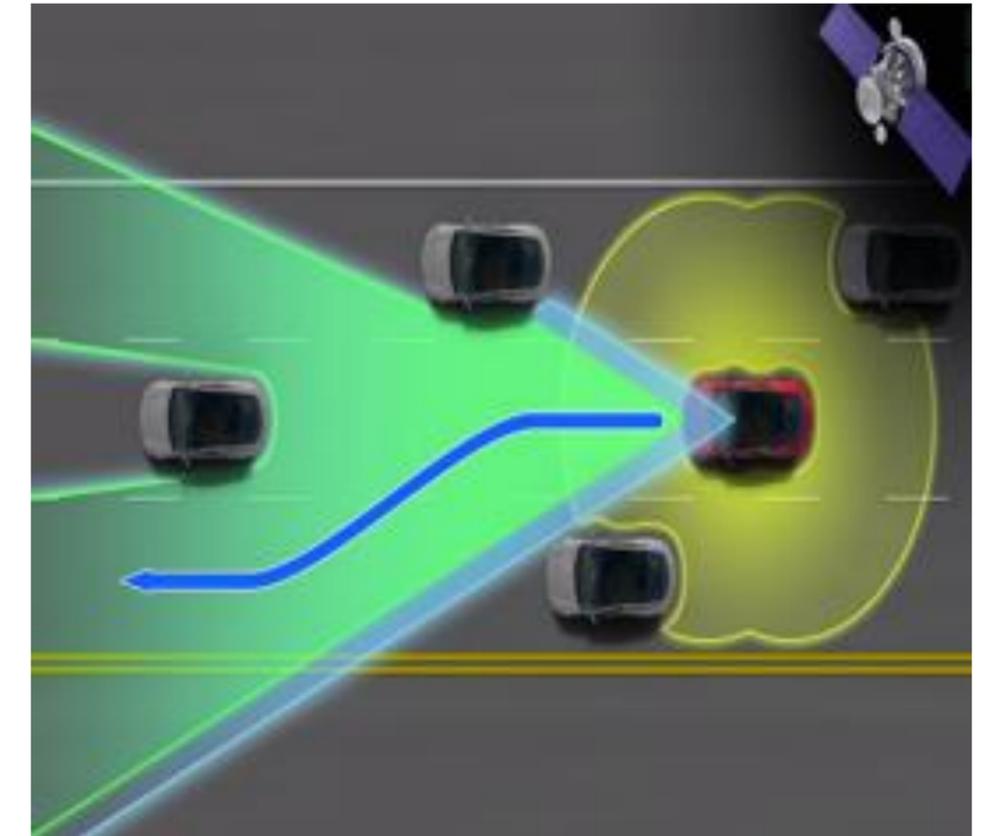
 Share this



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TESLA CAPABLE OF SELF-DRIVING 90% OF THE TIME



“90% Autonomous. For sure on highways.” (1)

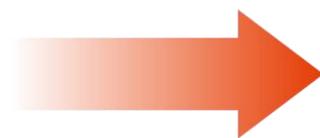
“Fully self-driving within 2 years.” (2)

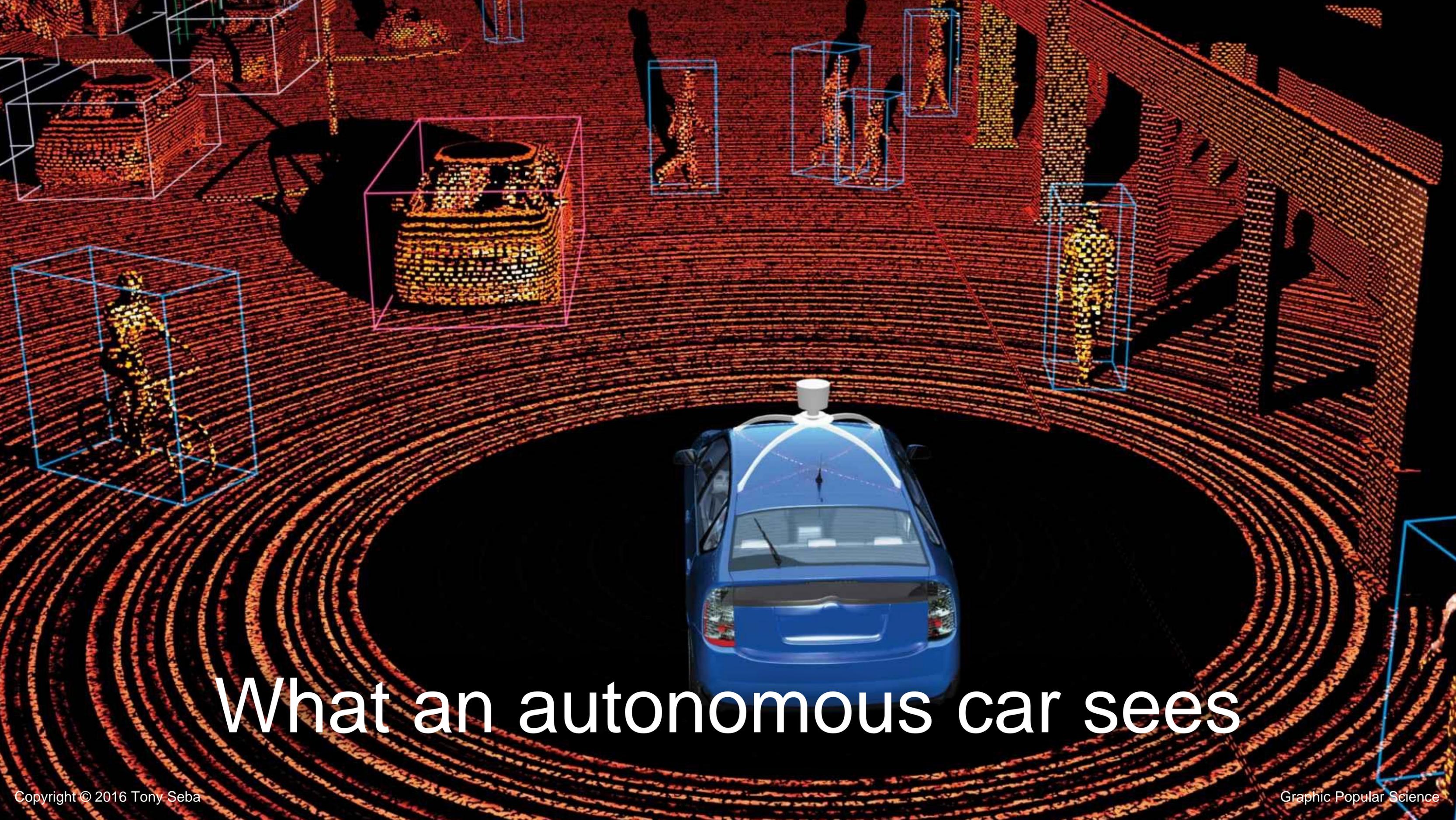
Elon Musk, Dec 2015

Autonomy Capability



WHAT ABOUT THE COST of Autonomous Vehicles?





What an autonomous car sees

Exponential Technologies: Machine Vision (LIDAR Sensors)

2012

Google announced that the cost of technology in its self-driving car was

~\$150k

LIDAR Sensor (for Machine Vision) was

\$70k

By the end of

2013

The next generation LIDAR was

\$10k

By Oct

2014

A SV Startup company announced LIDAR for \$1k



Image: Wikipedia

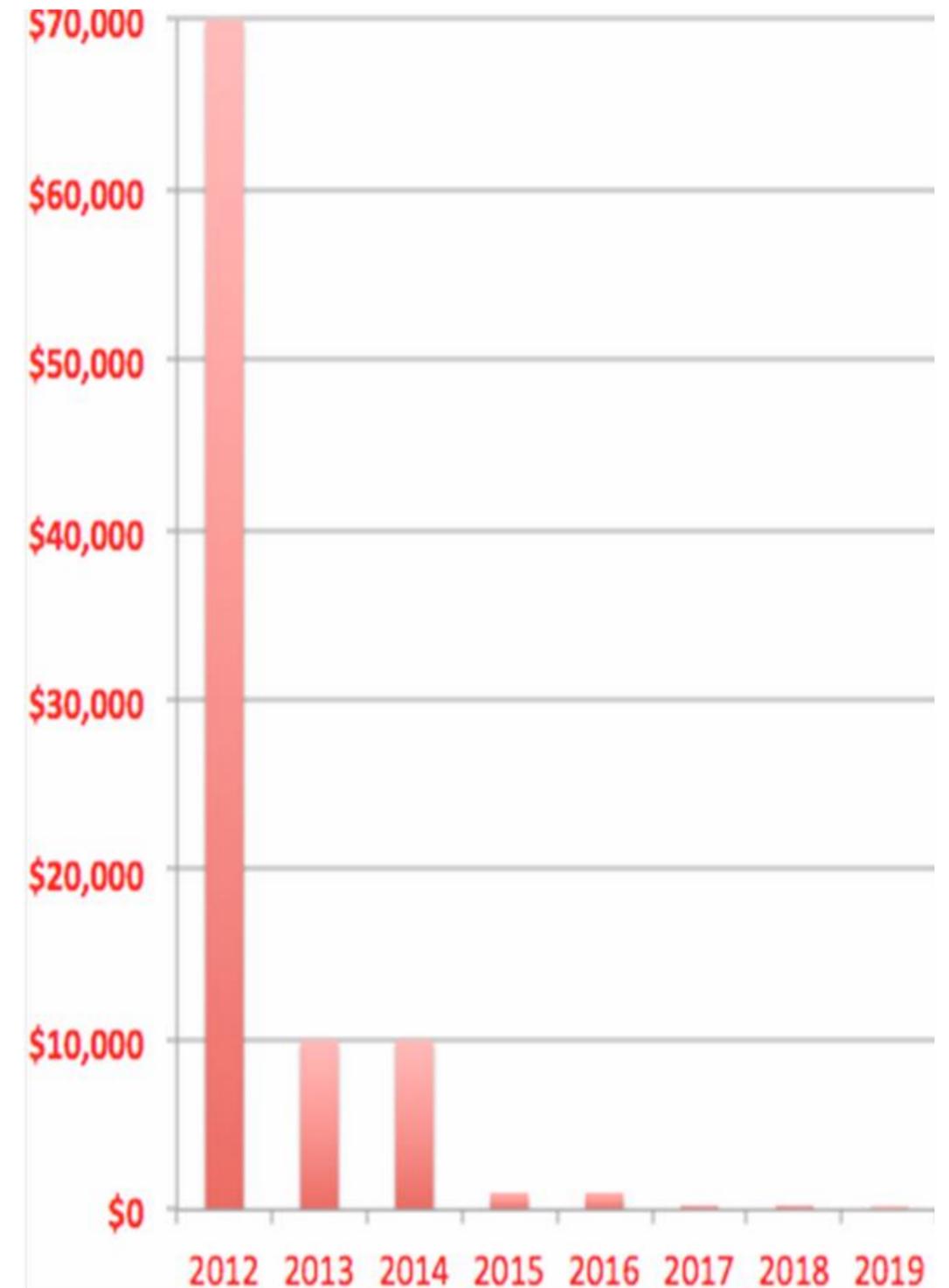
LIDAR: From \$70,000 to \$250

2015 GEN 1 LIDAR \$1,000

2016 GEN 2 SOLID STATE LIDAR \$250



GEN 3 (POSTAGE STAMP) \$90



Are we at the 'Garage' stage
of Autonomous Vehicles?



First Person To Build a Self-Driving Car in his GARAGE!

"George Hotz built a Self-Driving car with off-the-shelf parts with \$50,000 investment. He is taking on Google and Tesla by himself."

"The goal is to sell the self-driving package for \$1,000 per unit either to automakers or directly to consumers" (1)



Photo Sources: Bloomberg

Self-Driving Product Innovation: not just substitution!



- ▶ Not just substitution of existing modes of transportation.
- ▶ **Self-Driving Delivery units**
- ▶ Impact on food delivery?



Self-driving Scooter at SMART MIT

Cool! I can



and also



while NOT driving!

BUT WHAT'S THE

**Disruptive
Impact?**



BUSINESS MODEL
INNOVATION:

Car-as-a- Service



SELF-DRIVING + CAR SHARING:

Convergence of Technology & Business Model Innovation



My Smartphone: On-demand Car-as-a-Service

Plan & schedule All transportation needs with Apps

1. Buses: Muni, NextBus
2. Trains: CaltrainMe, iBART
3. **Car-Sharing: Zipcar**
4. **Ride-Sharing: Uber, Lyft**
5. On-Demand Bus: VTA Flex
6. Taxis: FlyWheel



Asset Utilization



© TonySeba 2015

Cars: Hugely Inefficient Use of Assets

- ▶ Cars = 2nd largest Capital Expense
- ▶ Ave. car costs = \$31k
- ▶ **Cars are parked 96% of the time!** (1)
- ▶ **4% Asset Utilization** is a disruption waiting to happen!



Photo: Tony Seba

Asset Utilization



UBER'S SELF-DRIVING FLEET ARRIVES THIS MONTH

*"Uber's Pittsburgh fleet, will consist of **100 modified Volvo XC90 SUVs**.*

*Uber riders are logging **100 million miles per day**.*

Uber can use the data collected from its app to quickly improve its self-driving mapping and navigation systems." (1)

*"When there's no [driver], the cost of taking an Uber anywhere becomes cheaper than owning a vehicle and then **car ownership goes away**." Uber's CEO (2)*



Tony Seba

GM TO LAUNCH SELF-DRIVING LYFT FLEET IN AUSTIN, TX

*“The first mainstream deployment of **autonomous** vehicles won’t be to customers but to a **ride-share** platform.” GM President Dan Ammann*

“This makes sense for GM:

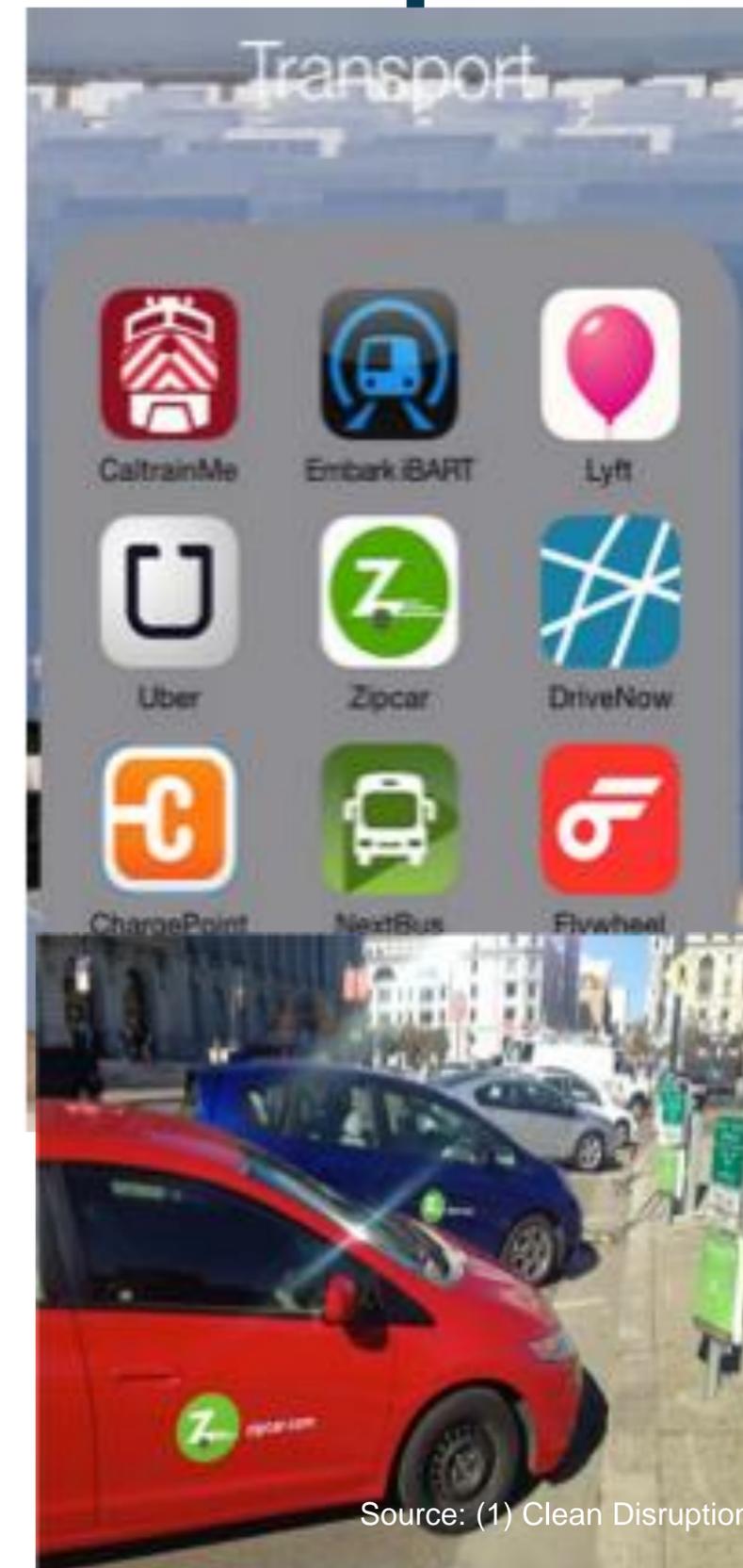
1. An **autonomous Bolt EV** will be in use **60-70%** of the **time**.
2. Easier to create a car that works in a known city within certain limits below 30mph.
- 3. Open up new markets.”**



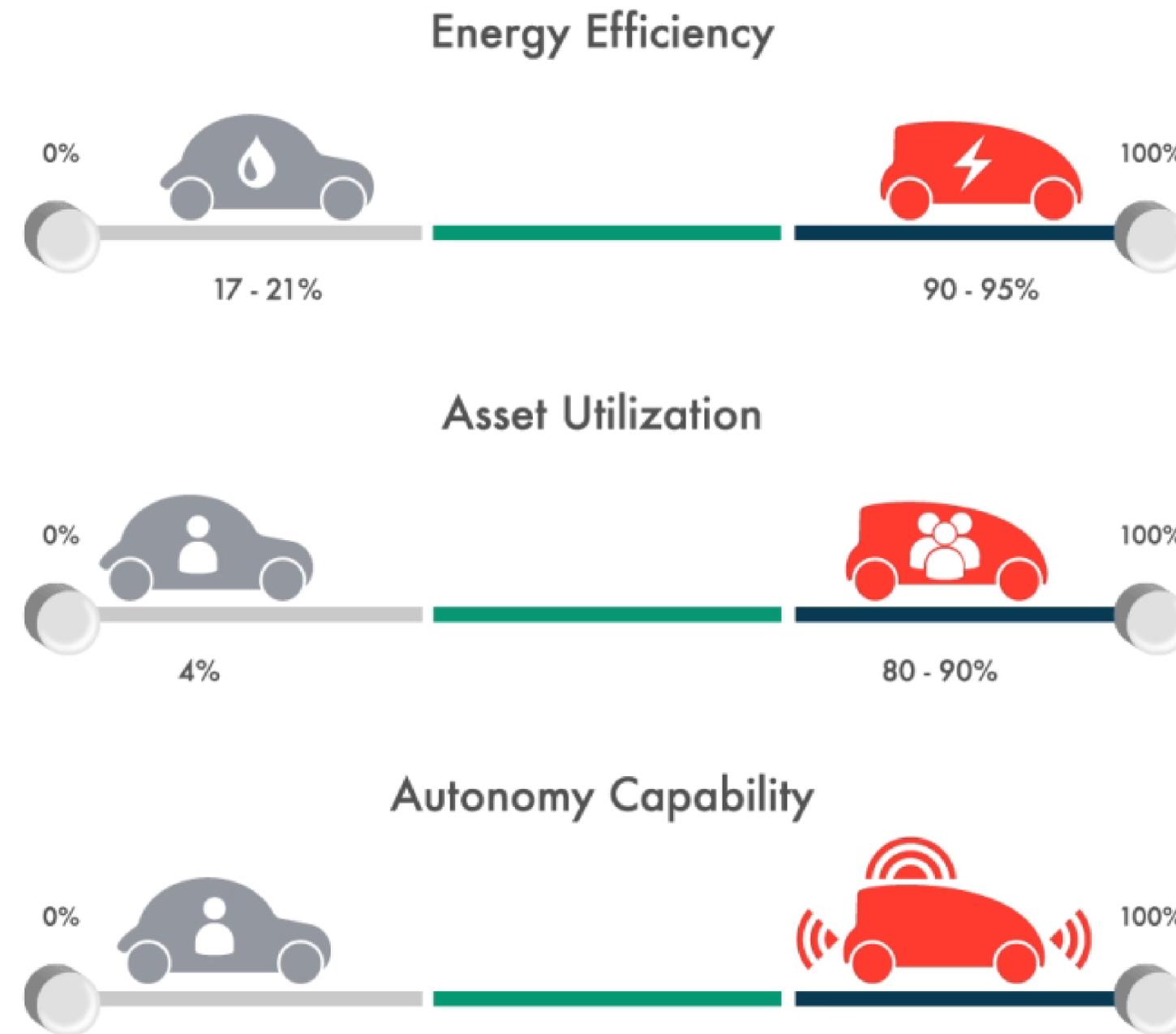
Car-as-a-Service: The End of Car Ownership

- ▶ Mobility on Demand / Car-as-a-service:
 - ▶ **Self-Driving** tech plus
 - ▶ **Car/Ride Sharing** biz model
- ▶ Vehicle Asset Utilization goes **UP 10X-20X**
 - ▶ From **4%** to **~80+%**
 - ▶ **Cost / mile ~10X cheaper**
- ▶ Car Fleet **~80% smaller**
 - ▶ 80+% fewer parking spots ⁽¹⁾

Asset Utilization



3D - CLEAN DISRUPTION OF TRANSPORTATION



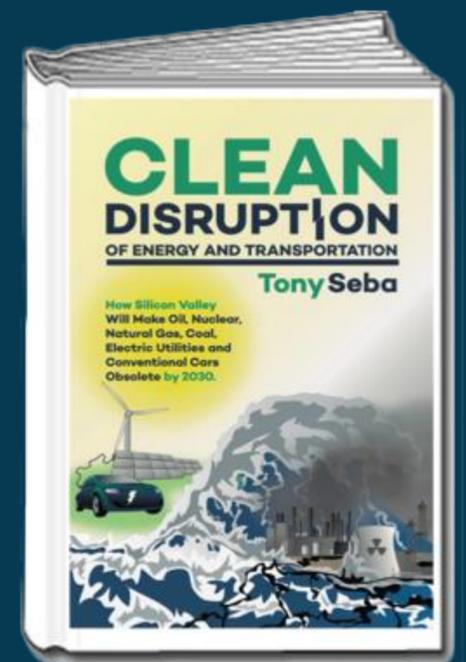
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- ▶ Car Market: From **B2C** to **B2B2C**

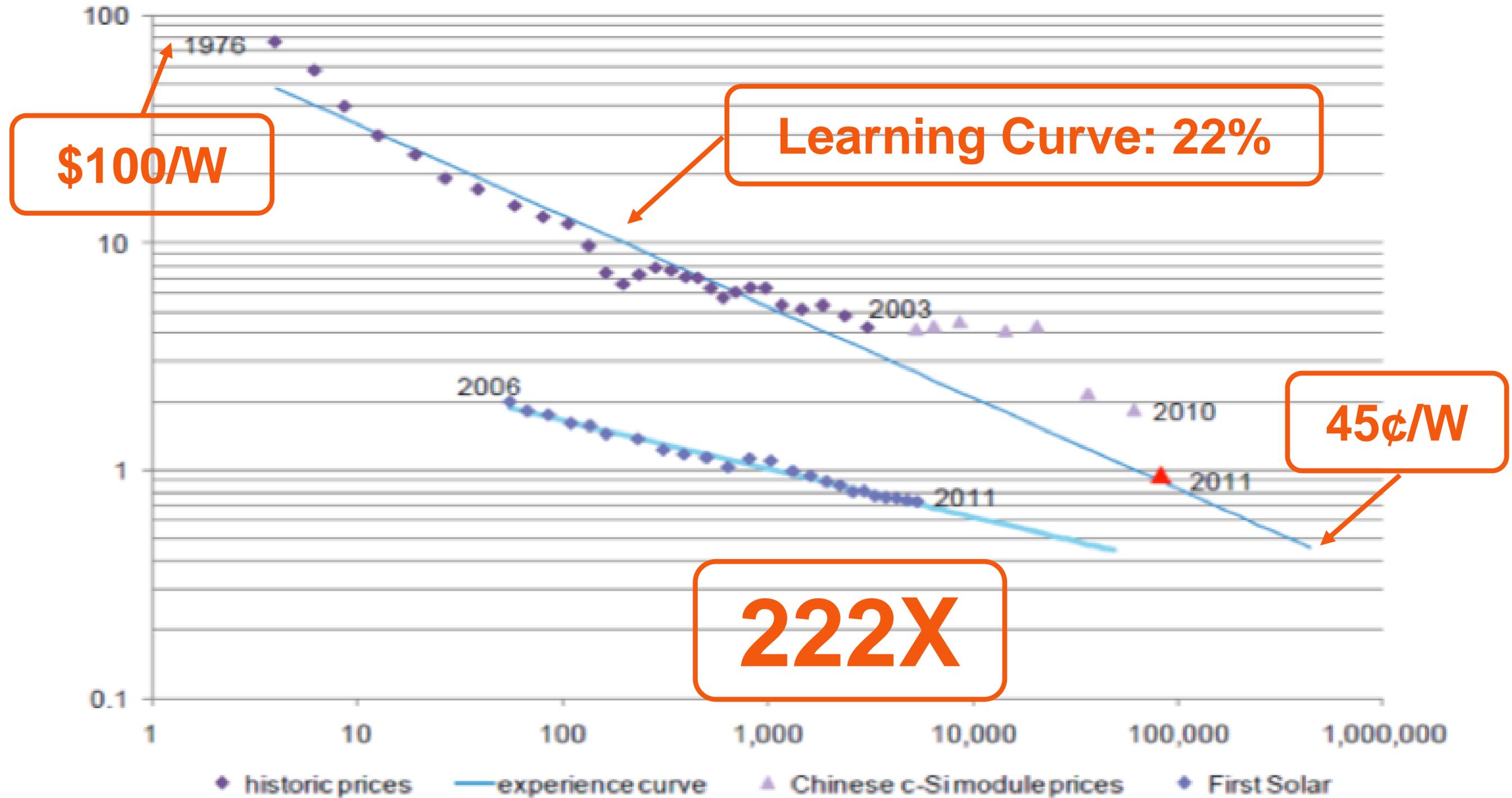
4 The Solar Disruption



Image: Tony Seba

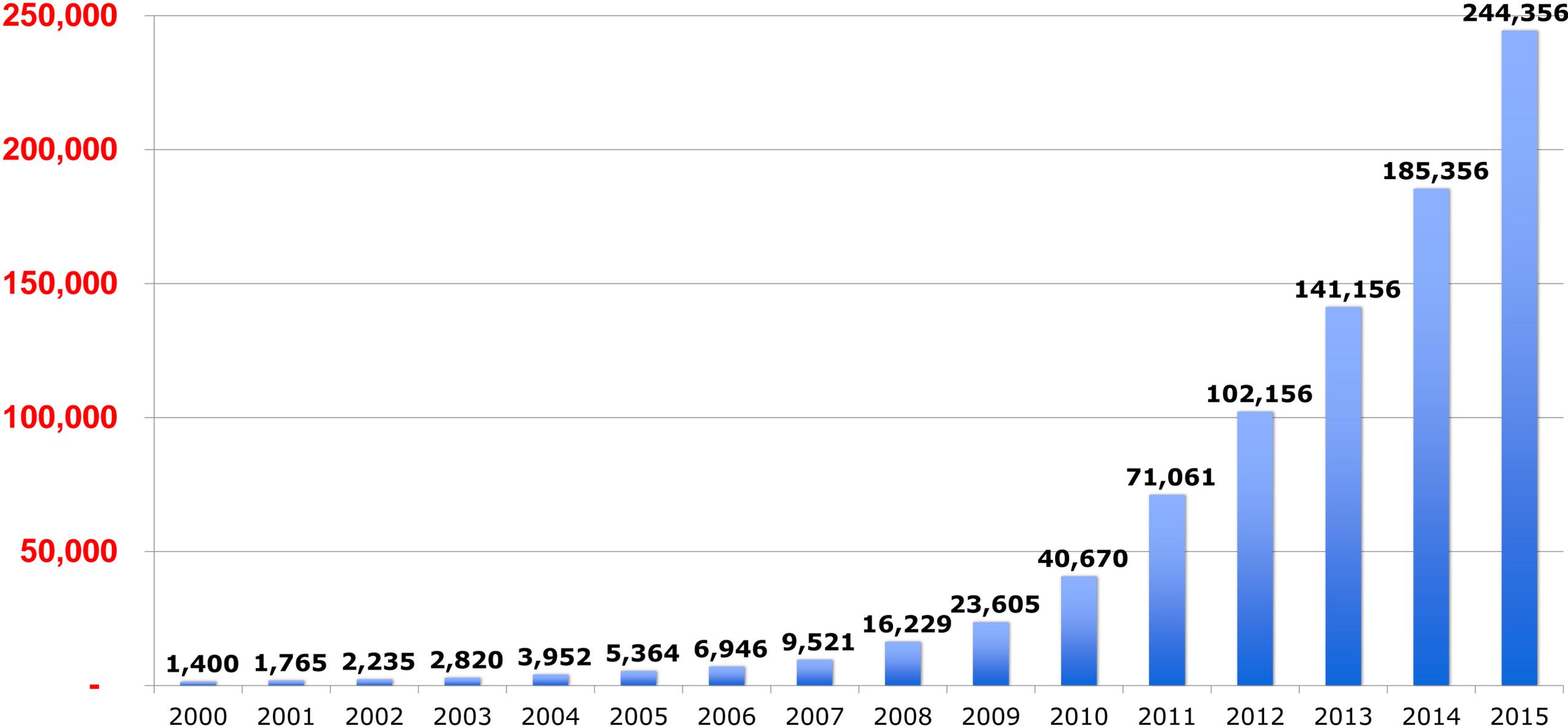


Solar PV Costs: DOWN 222X



Market: Solar PV Installed Capacity: UP 174X

Global Installed Solar PV (MW)



- ▶ Solar PV Market CAGR 2000-2015 ~41%
- ▶ Solar PV installed Capacity 2000-2015 Growth ~ 174X

Can Solar
Continue Growing
at this Rate?

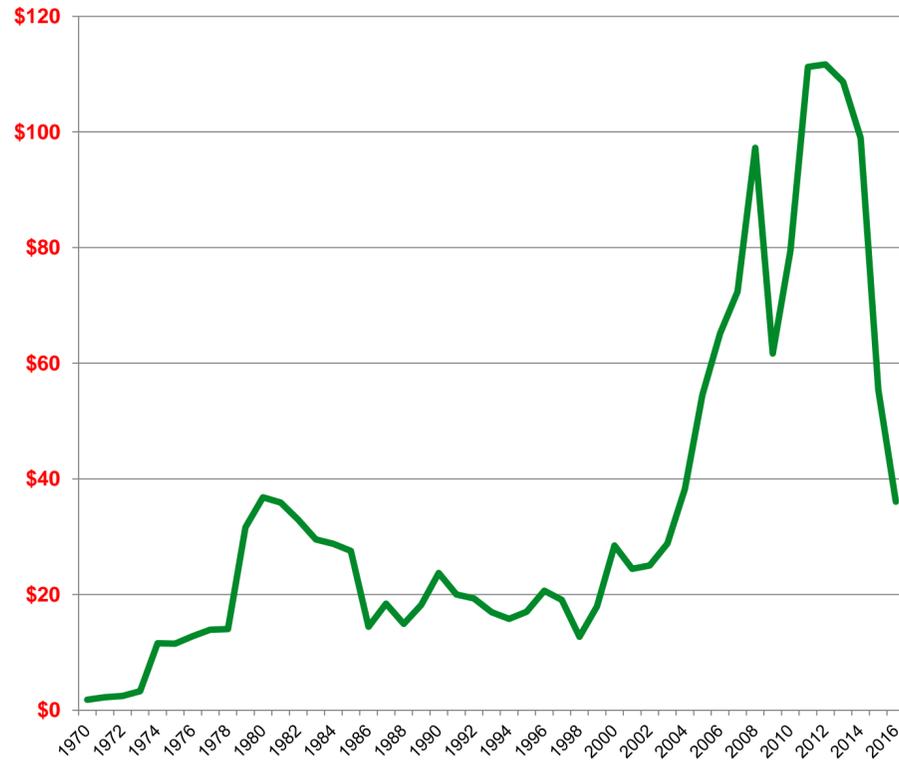


Solar Cost Trends

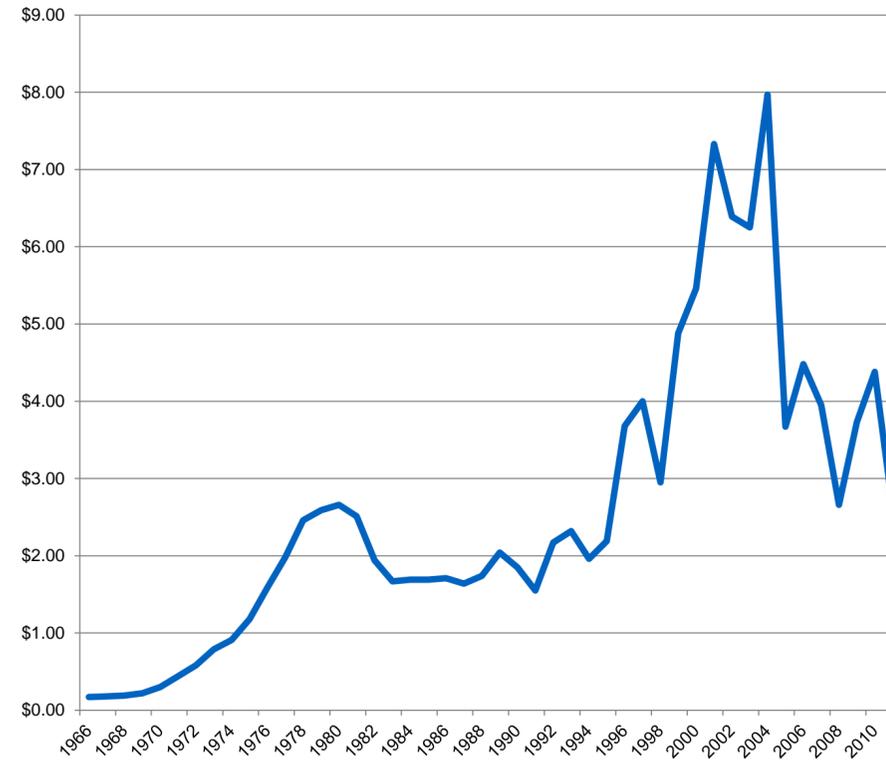
vs

Conventional Energy

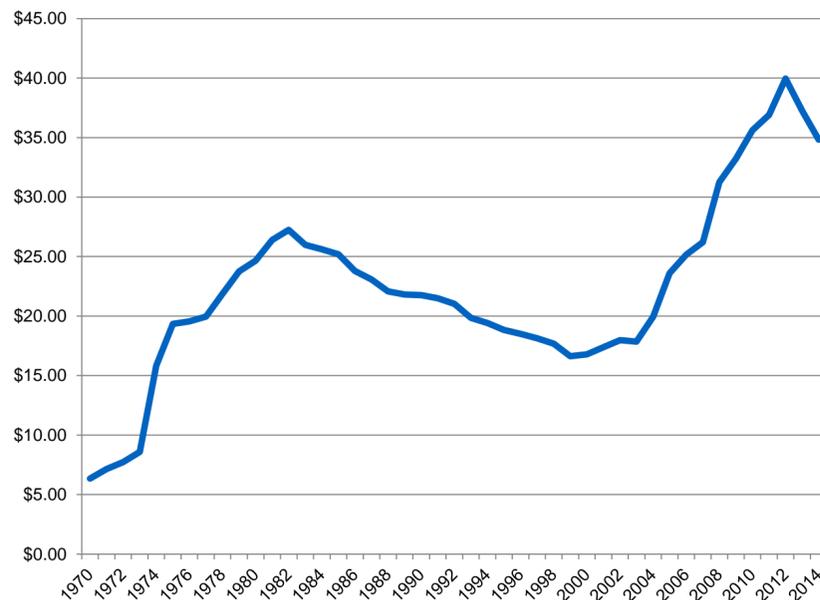
Since 1970 Prices for conventional resource-based energy sources are up 6X - 16X



Oil

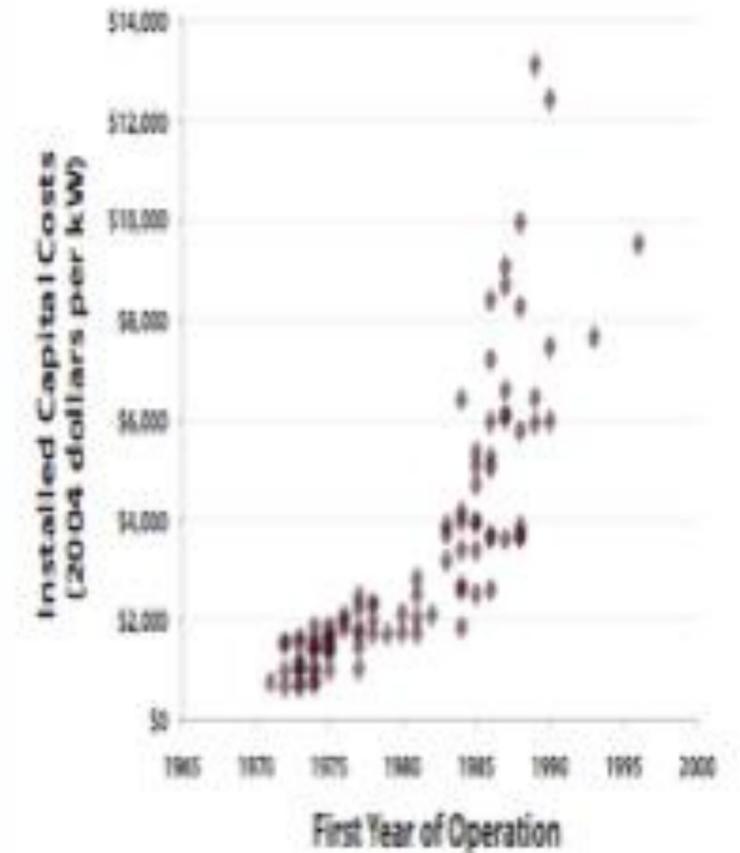


Nat Gas



Coal

Figure 8: Actual Capital Costs of Completed U.S. Nuclear Reactors (in 2004 Dollars)¹¹



Nuclear

Solar Cost Improvement vs. Conventional Energy

<u>Solar PV Cost Improvement</u> relative to:	<u>Times improvement</u> (1970-2016)
Petroleum	2,110x
Nuclear	2,929x
Natural Gas	3,284x
Coal	1,294x

Oil at \$30/bbl

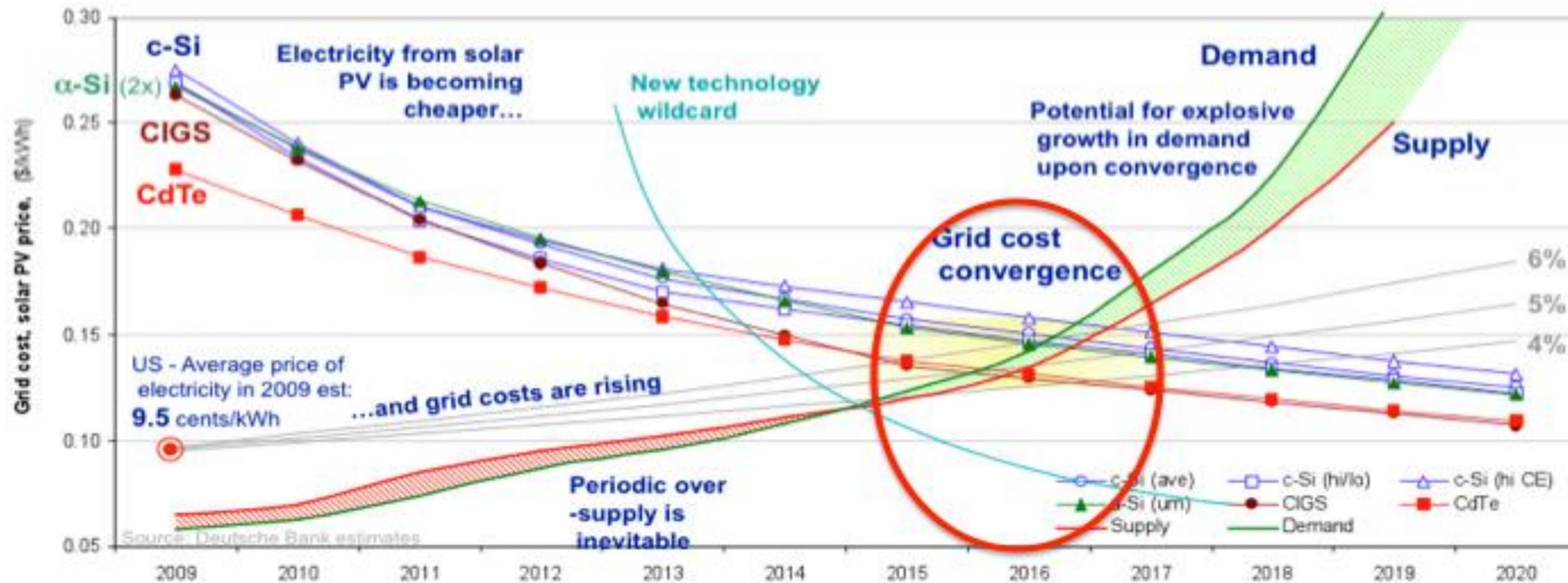
- ▶ Since 1970 Solar PV has improved cost by thousands of times relative to most conventional forms of energy
- ▶ Note: unsubsidized cost of solar PV

BACK TO SOLAR COST TRENDS:

1- Grid Parity, then
2 - God Parity?



DB: Grid Parity in 80% Global Markets by 2017

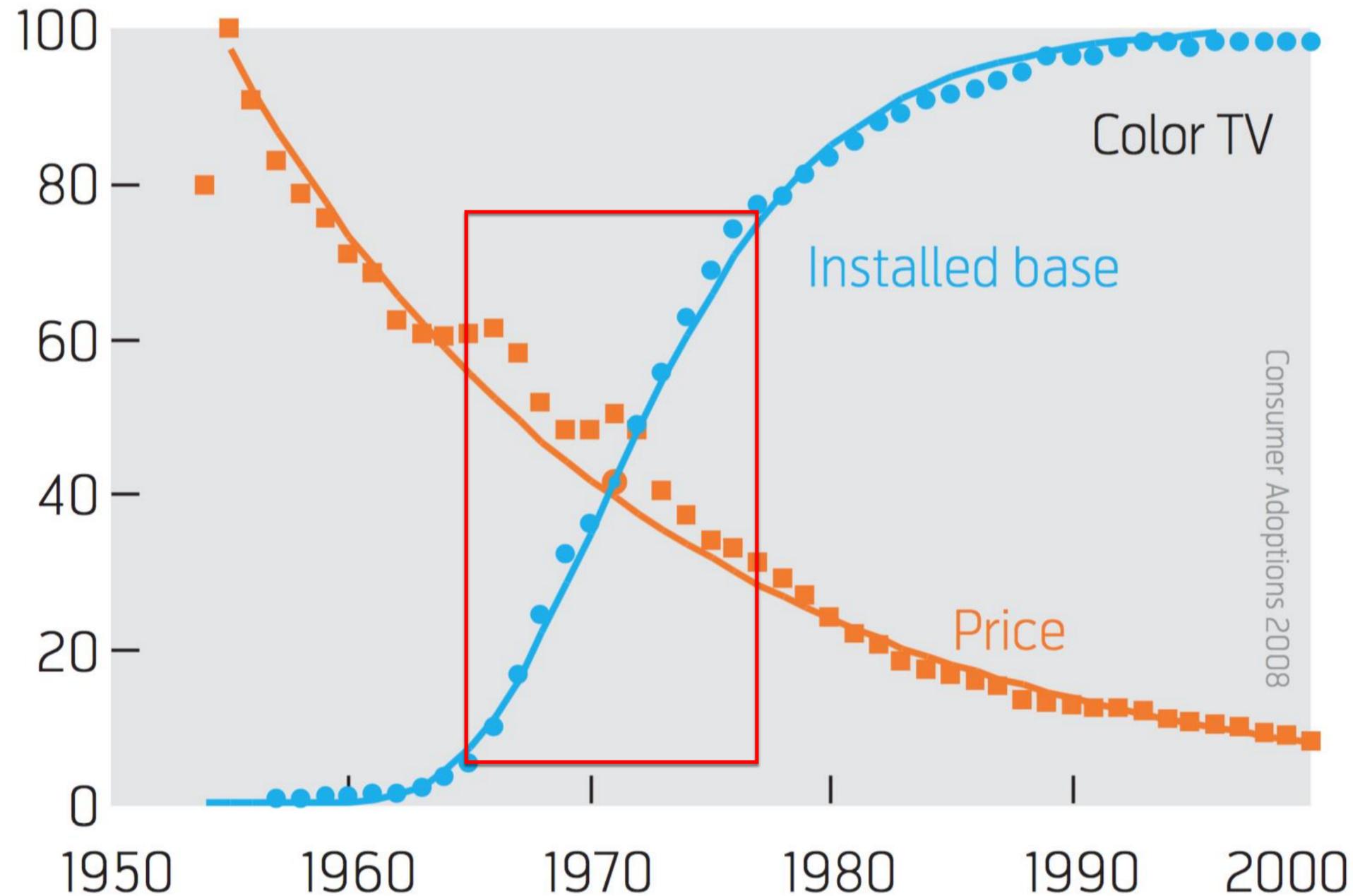


- ▶ Deutsche Bank: **Solar Below Grid Parity** in
 - ▶ 47 US states by 2016 (1)
 - ▶ **Up to 80% of Global market by 2017**
- ▶ PWC: **69% of Corporations** actively pursuing solar purchases (2)

Solar Growth Rate may Accelerate! (TECH S-CURVE)



Technology Adoption S-Curve (Color TV % US)

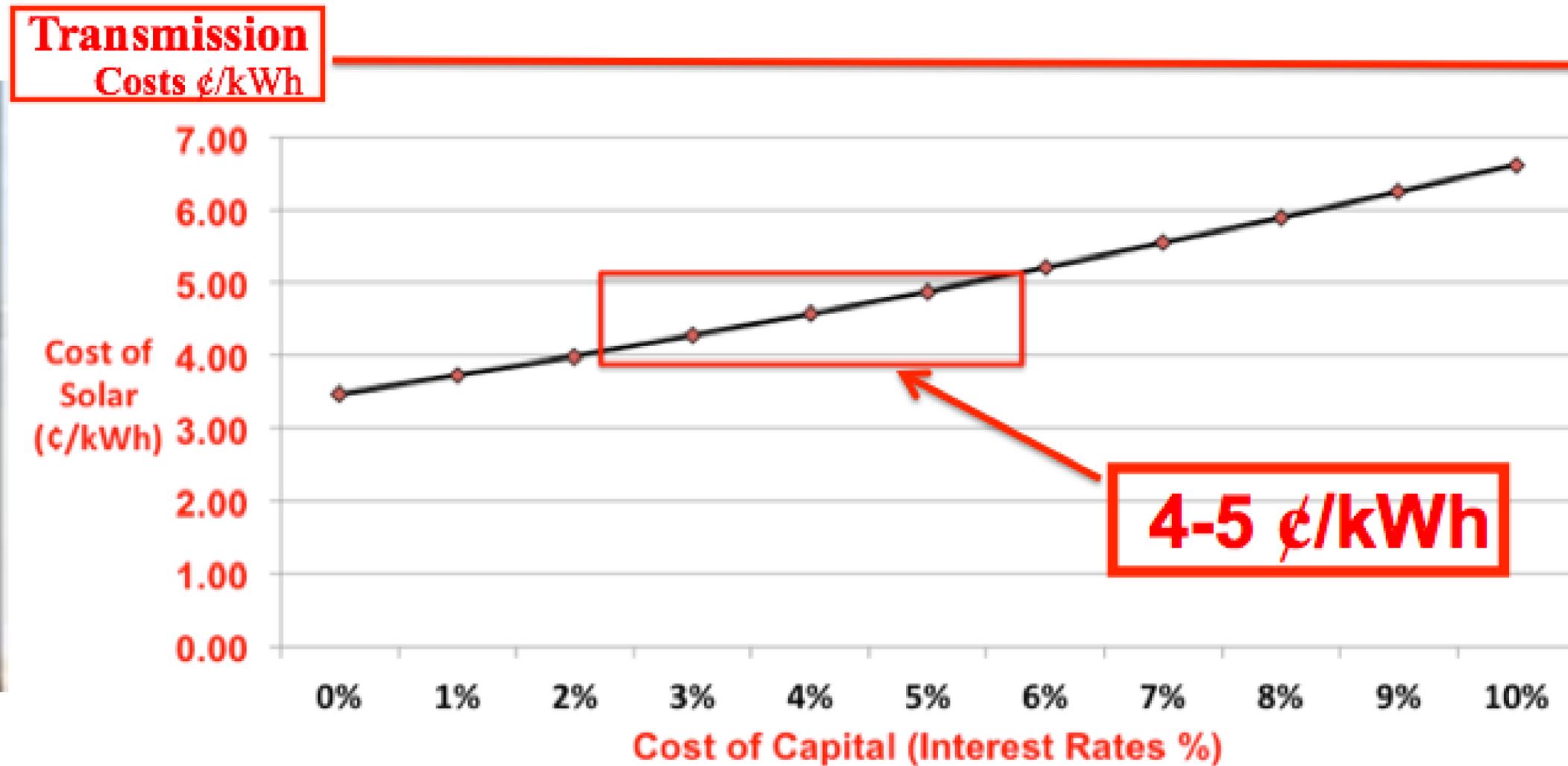


- ▶ **Solar PV** is a **technology**
- ▶ **Tech adoption** is not linear but follows an **S-Curve**



Solar GOD Parity
Point of No Return

God Parity by 2020 - \$ Rooftop Solar < \$ Transmission



- ▶ **God Parity: cost of (unsub) rooftop solar lower than cost of transmission!**
- ▶ Centralized Generation can't compete
 - ▶ Obsolete: Nuclear, Natural Gas, and Coal



Every home, retail business,
warehouse, building, factory,
shopping center, parking lot,
everywhere will have
SOLAR...

BUT NOT ALL POWER
GENERATION WILL BE ROOFTOP,
RIGHT?

What about **Utility Scale?**



Photo: Tony Seba



Rodin – Thinker
Photo: Tony Seba

Utility Scale Solar → Dropping below **~5¢/kWh**

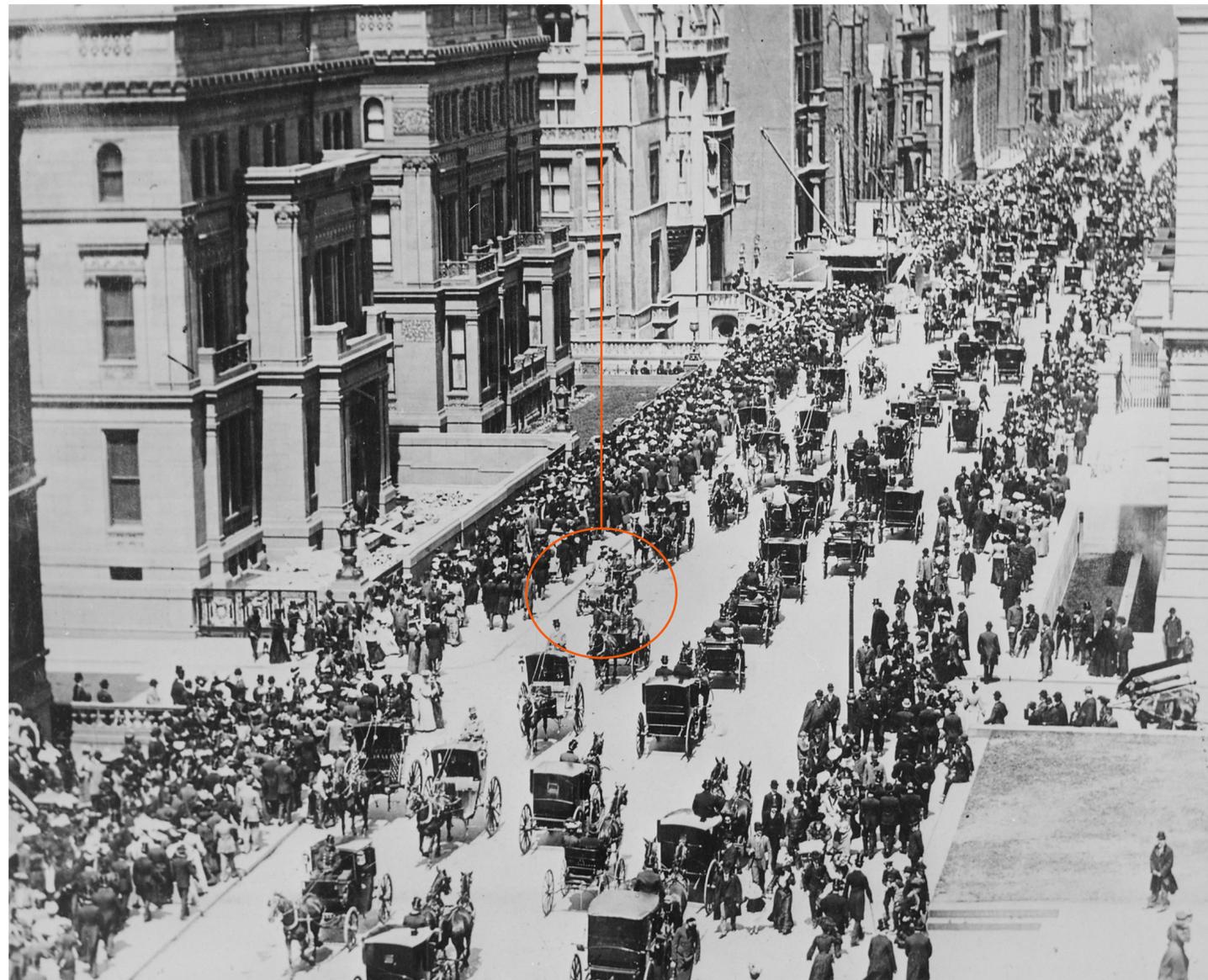


- ▶ 2015 USA PPAs **~5 ¢/kWh** (+/- 1¢/kWh) (1)
- ▶ “Solar at **5.8 ¢/kWh** is competitive with **oil** at **US\$10/bbl** and **gas** at **US\$5/MMBtu**” (2)
- ▶ 2015 Saudi Arabia PPA **4.9 ¢/kWh (unsub)** (Aug '15) (3)
- ▶ 2016 Chile PPA at **2.91 ¢/kWh (unsub)** (Aug '16) (4)

Back to the Future

On the Cusp of major Disruptions in Energy and Transportation

2016 We are here



2016 - Clean Disruption of Energy & Transportation

- ▶ The new tech-based architecture of energy and transportation will consist of **billions** of distributed, smart, mobile, connected devices - **generating, managing, consuming & trading energy**
 1. Energy Storage
 2. Electric Vehicles
 3. Self-Driving Cars
 4. Solar PV
- ▶ We will see **more changes** in energy & transportation over the **next 5-10 years** than we have seen in a century.

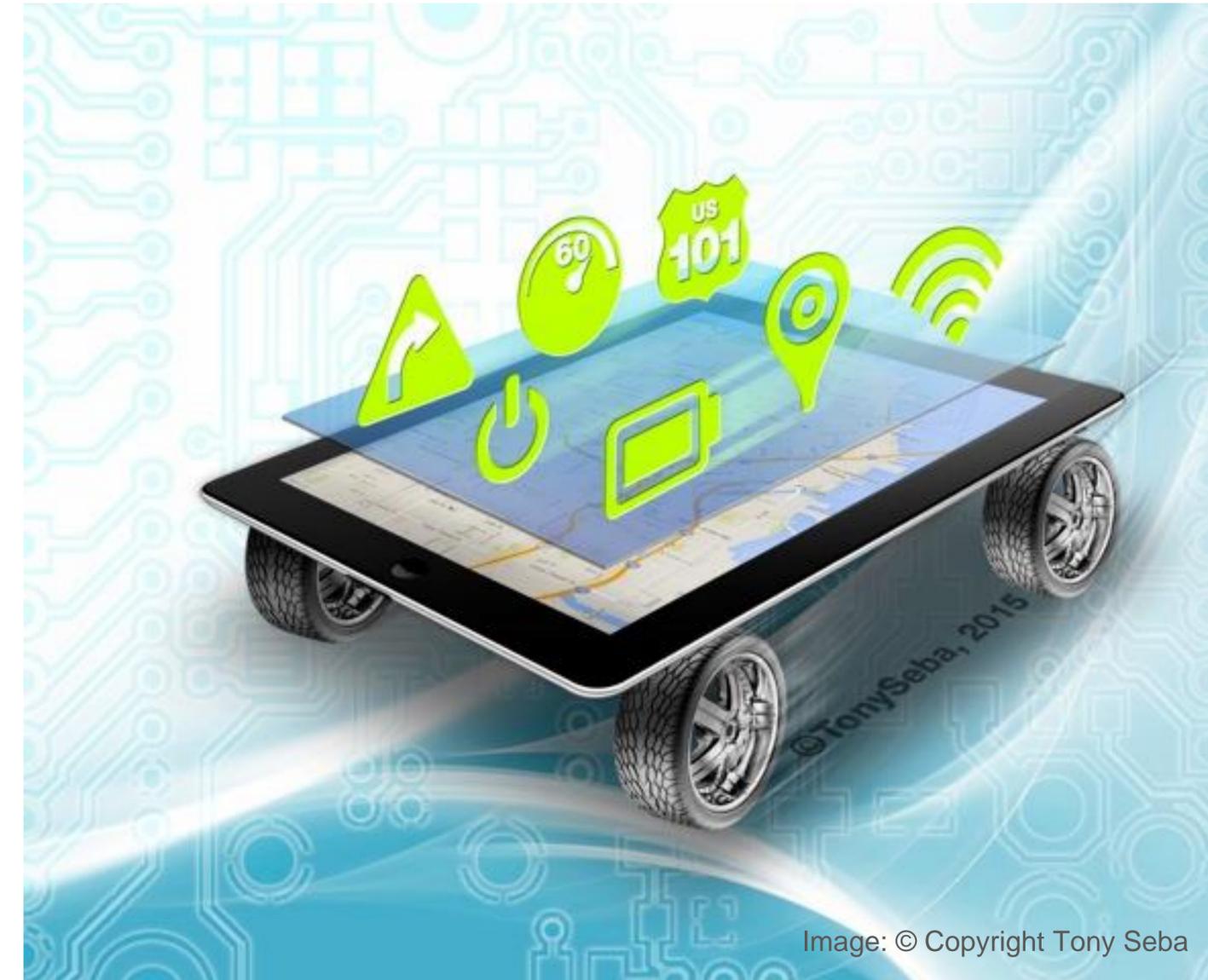
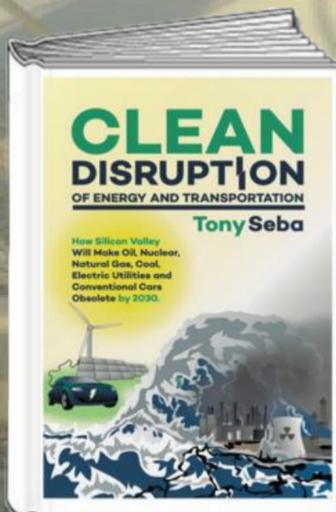


Image: © Copyright Tony Seba

This is NOT an Energy Transition This is a Technology Disruption



Thank You!

www.tonyseba.com

Energy & Store
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2016
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Anticipating & Leading Market Disruptions

Opening General Session Keynote

Tony Seba