Silicon Valley's Plan for the Energy Industry

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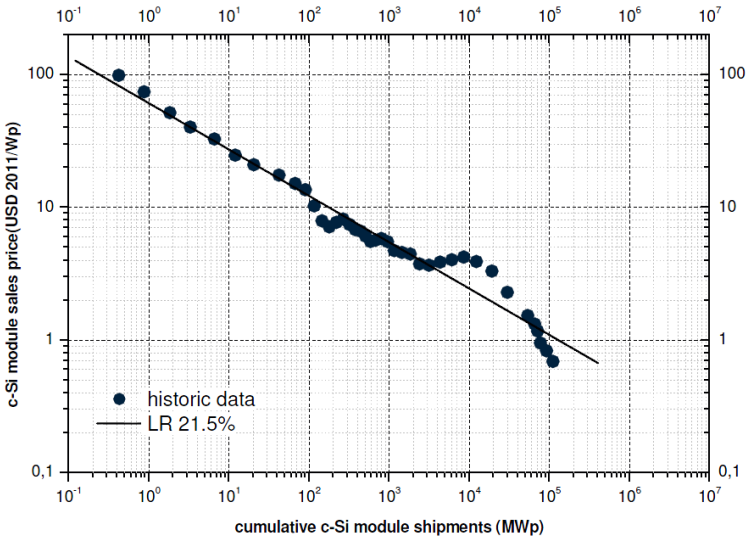
Columbia Gorge Bi-State Renewable Energy Zone meeting

December 5, 2014

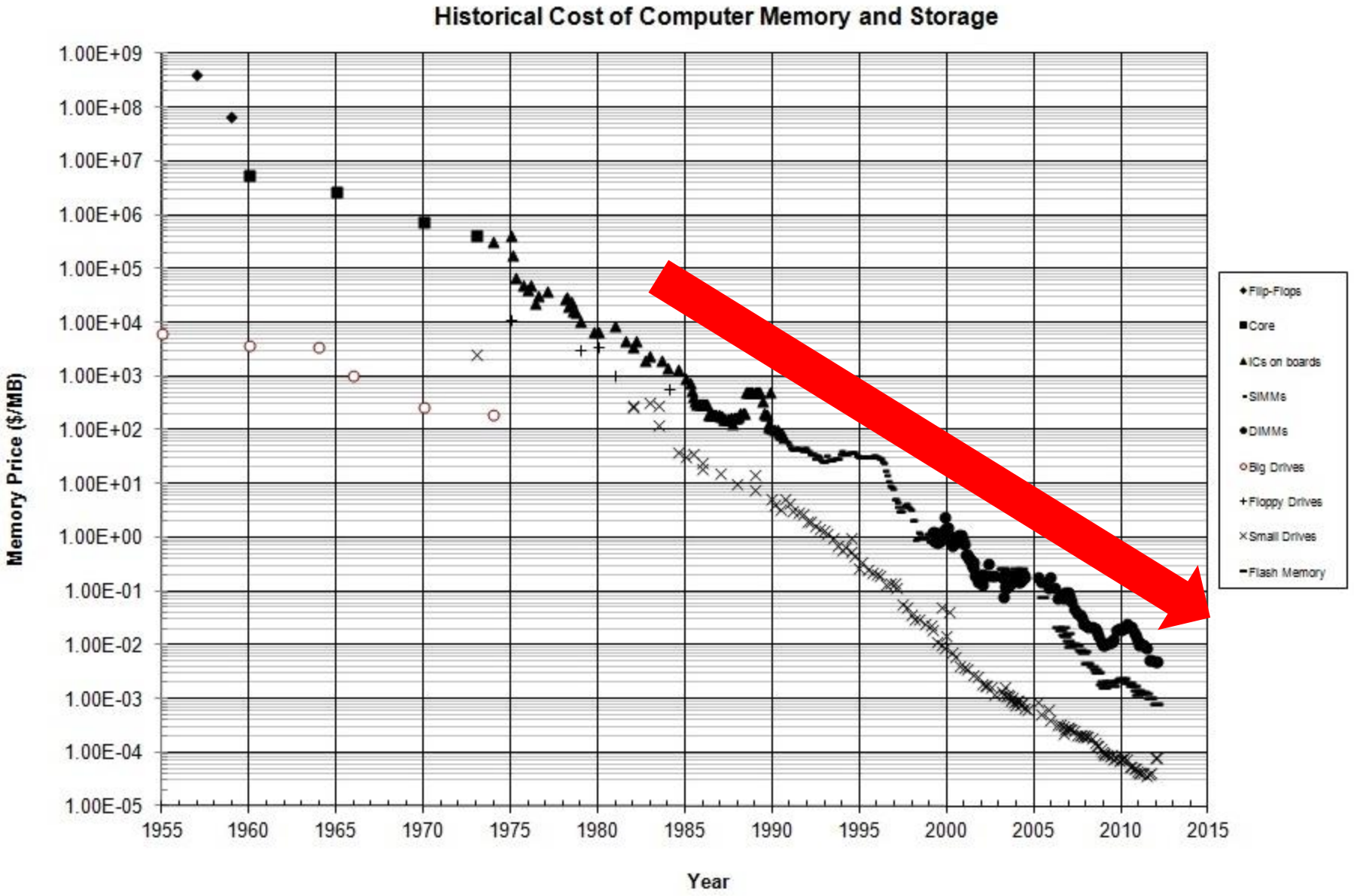
August 2013: “Game Over”

- PV panels on 21% learning curve
- EV batteries to drop from $500/kWh to $200/kWh by 2020



http://www.greentechmedia.com/articles/read/ferc-chair-wellinghoff-sees-a-solar-future-and-a-utility-of-the-future
http://reneweconomy.com.au/2014/say-investors-wake-solar-pro-sumers-24413

Semiconductors: “Extreme Business”

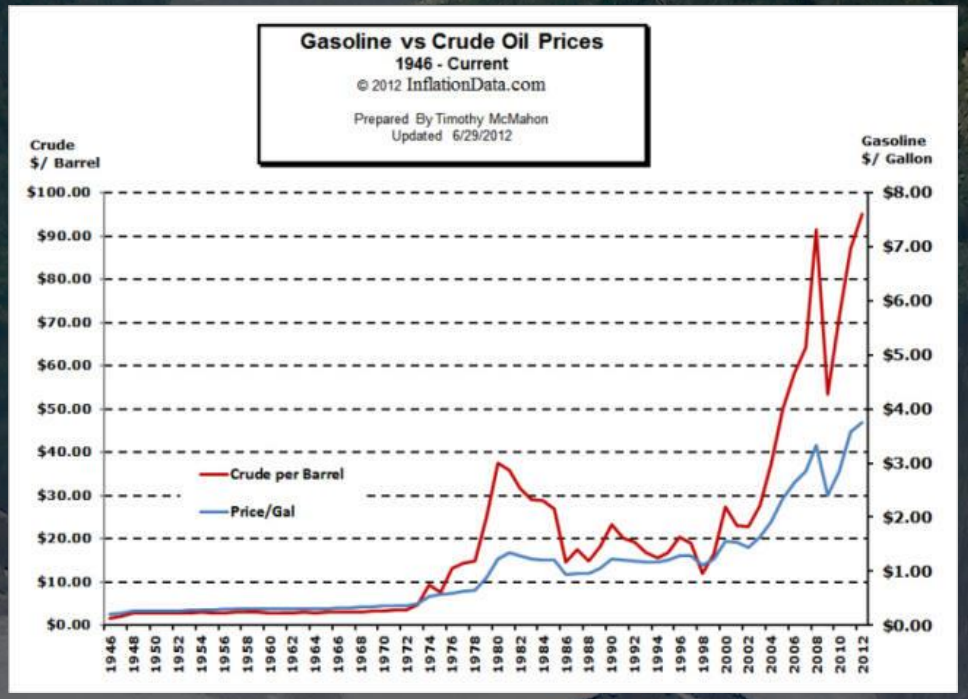


Managing Exponential Cost Reductions

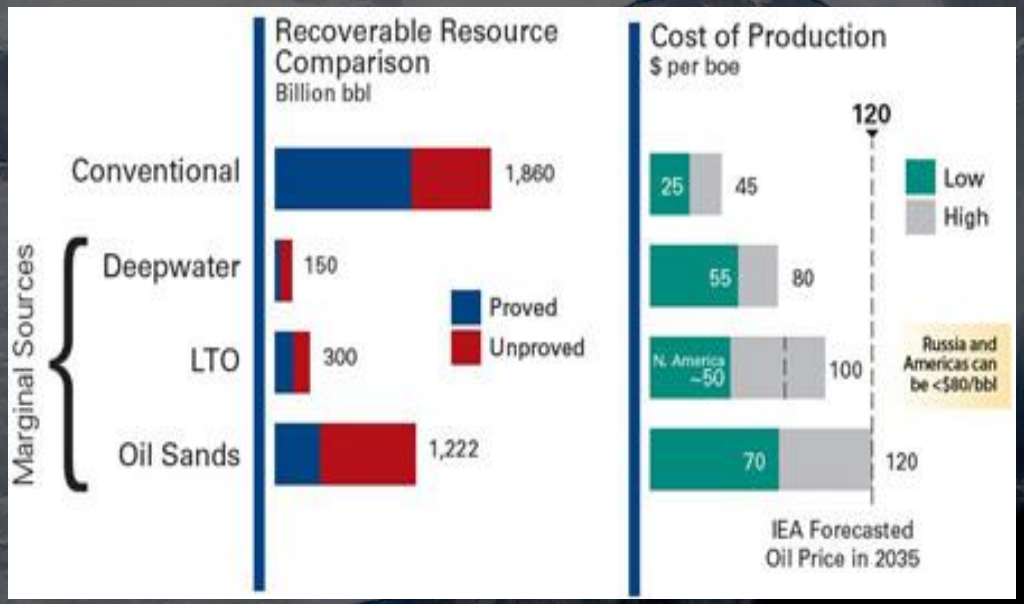
Today

- The phone in your pocket has about ten million times as much memory as the Apollo 11 flight computer
- You're paying more and more for gasoline
- A business plan built upon increasing material costs is not a good investment…

- You're paying more for gas

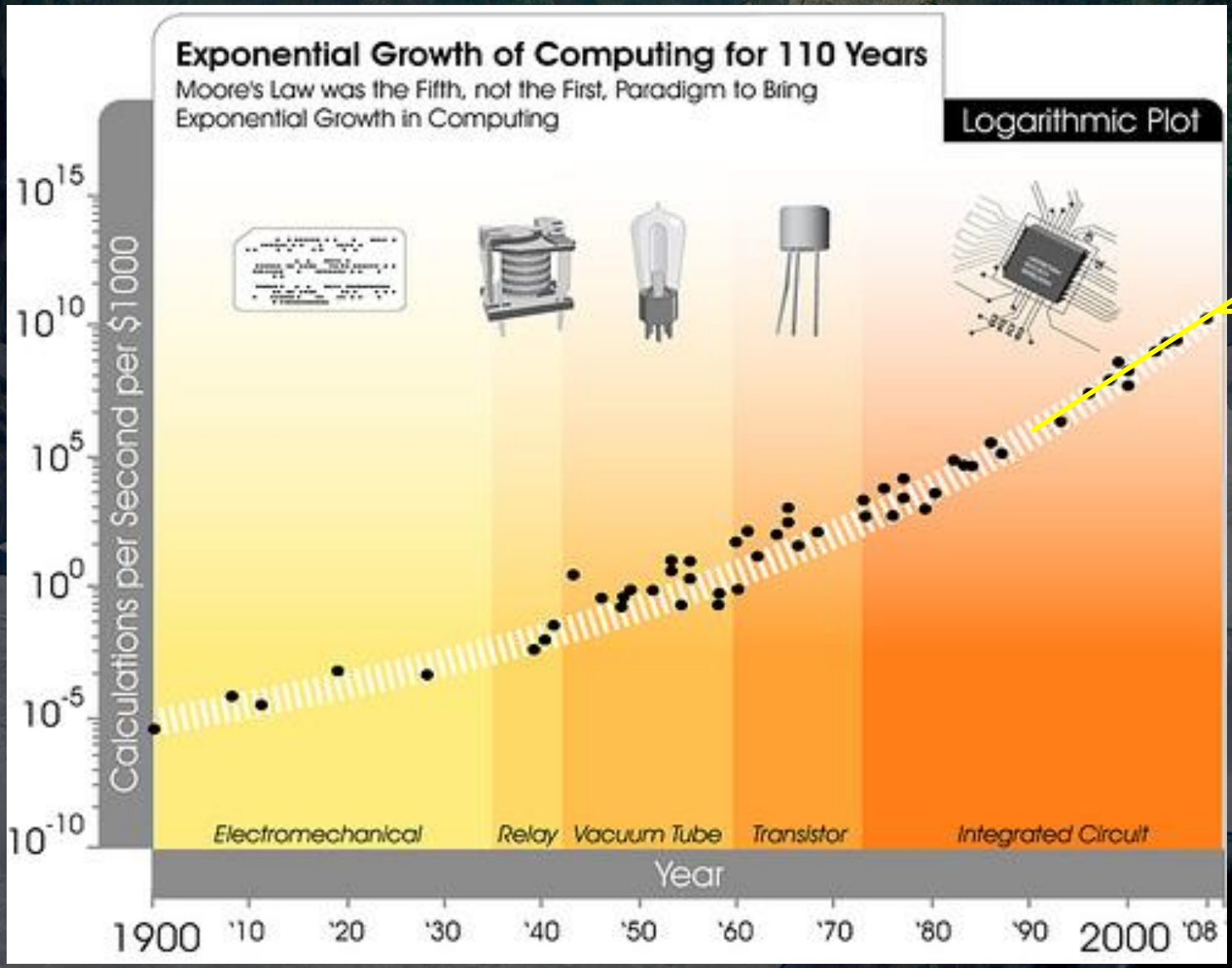


- Because oil is getting harder to find

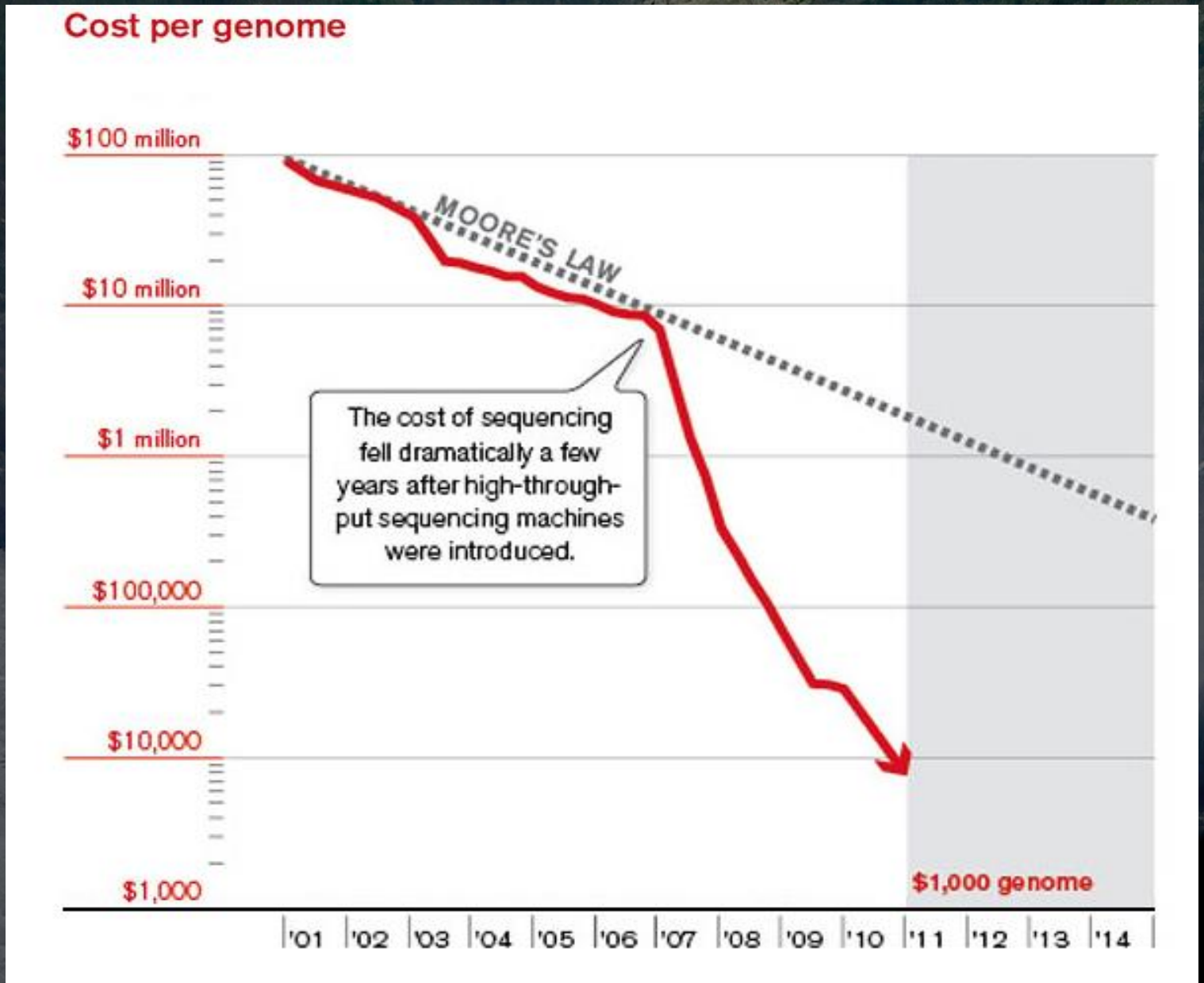


Source: Schlumberger Business

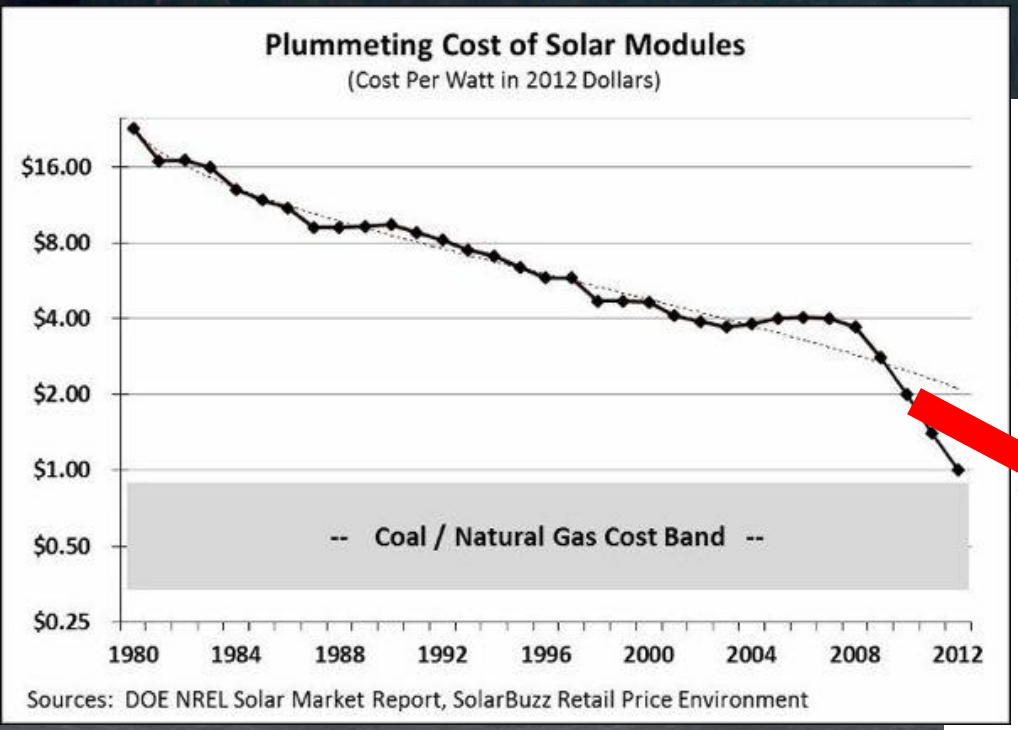
Contrast with Information Technologies

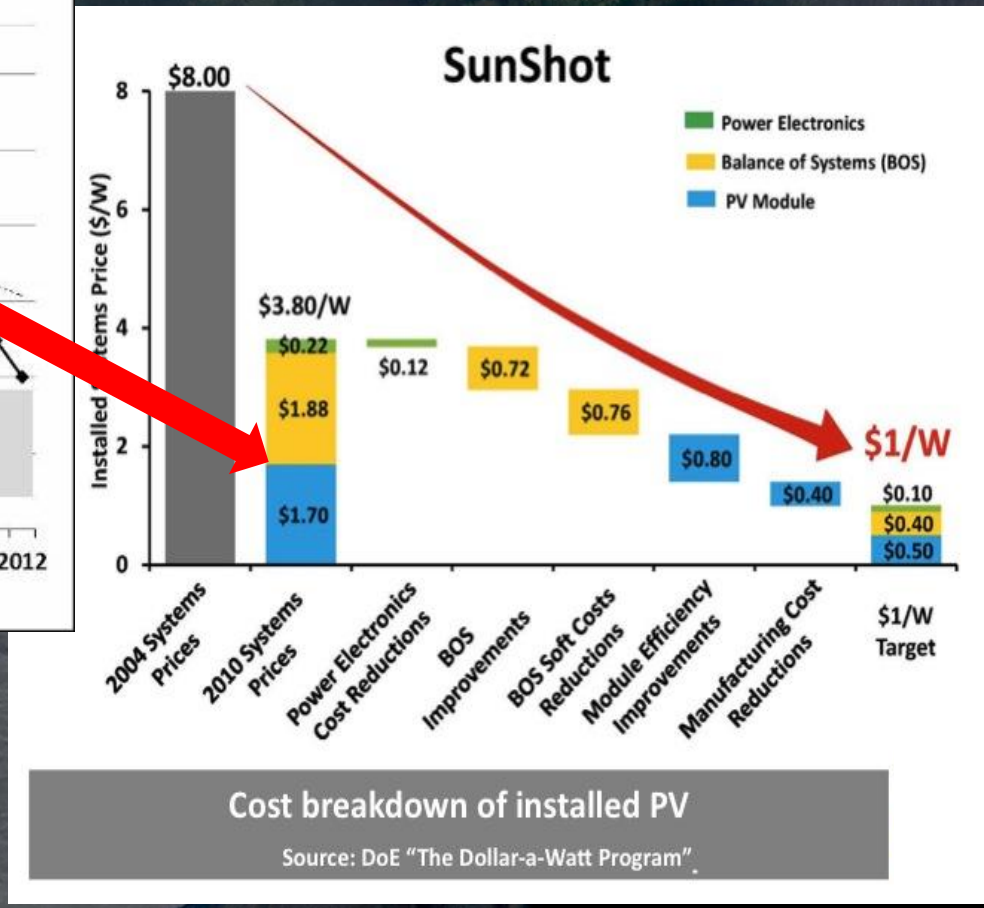


Genome Sequencing Costs Plummeting



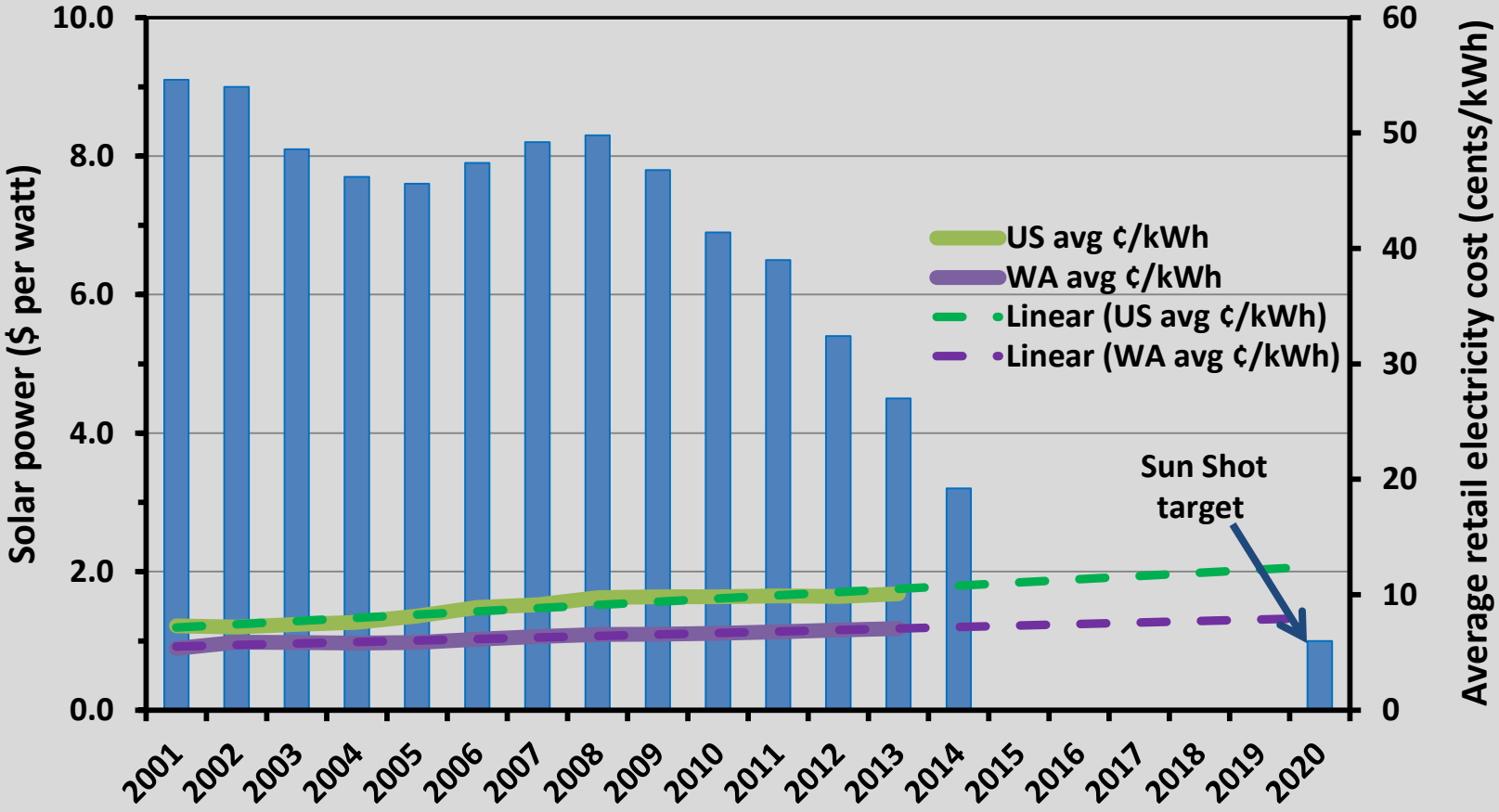
What Happens When the IT industry Meets the Energy Industry?





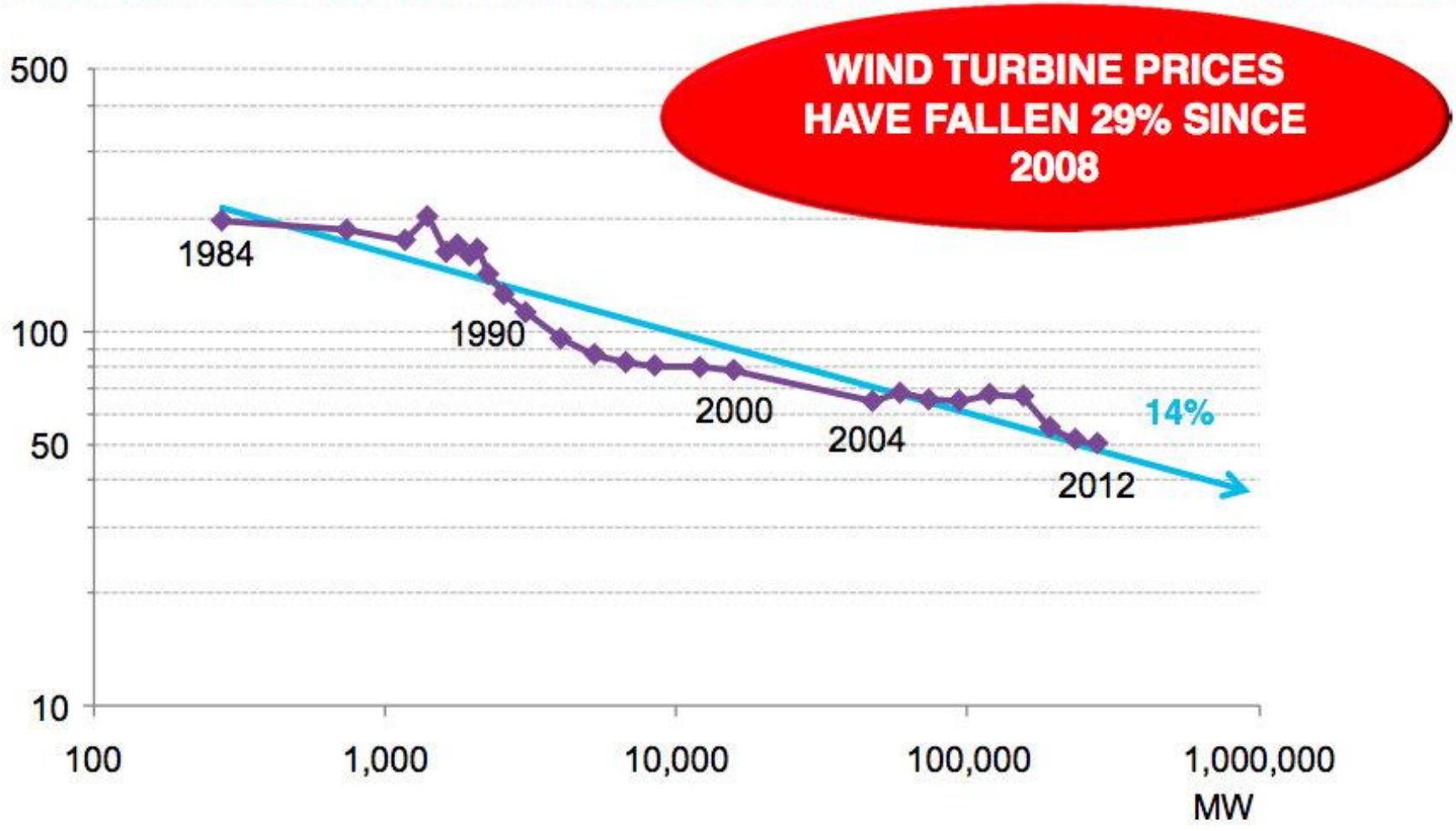
- **Learning curves**
- **Exponential mindset**
- **Technology roadmaps**

Average Costs of US Solar Power



NREL database; installed, pre-incentives

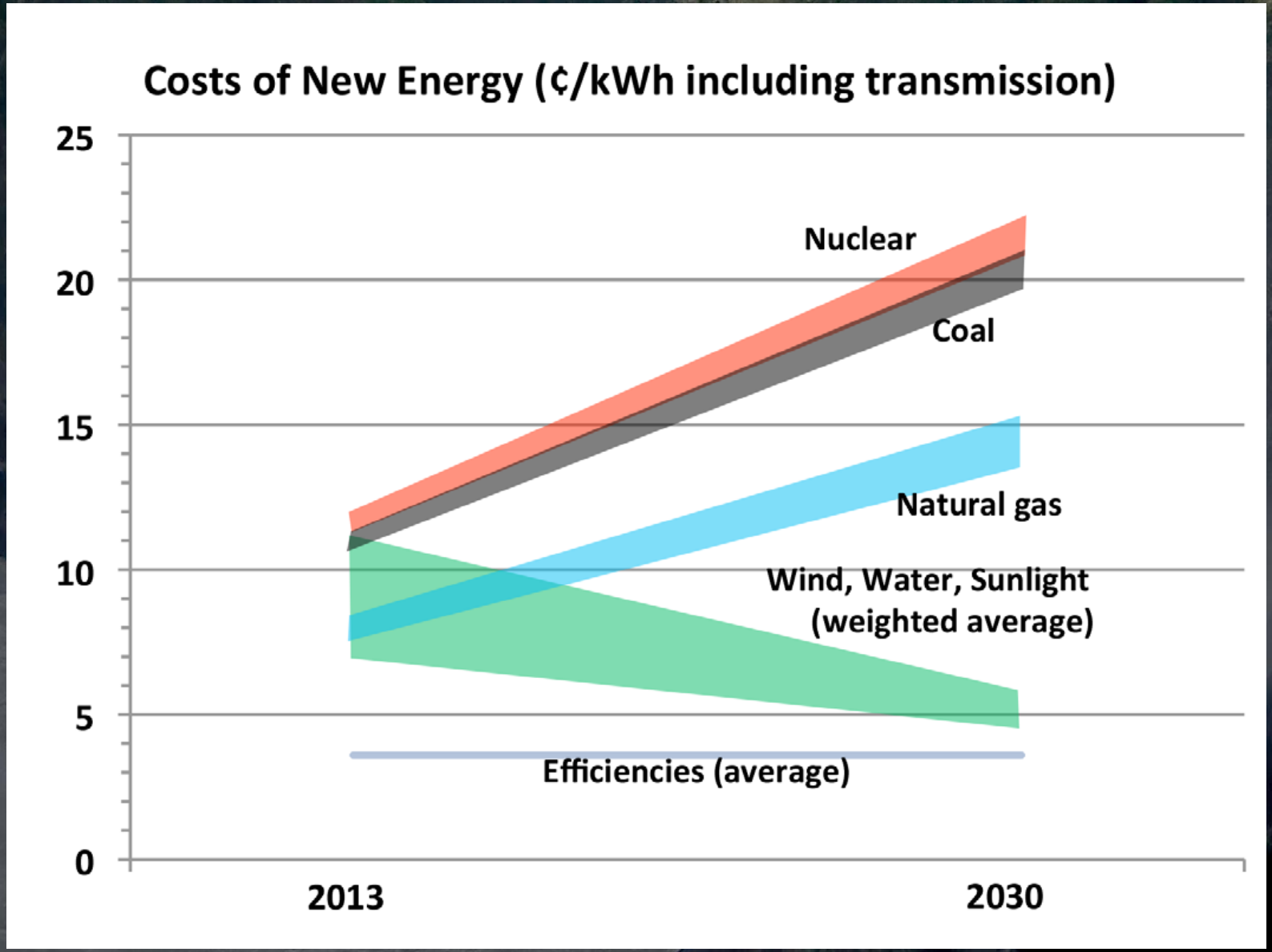
AVERAGE LEVELISED COST OF ONSHORE WIND, 1984-2012 (€/MWH)



Note: Learning curve (blue line) is least square regression: $R^2 = 0.88$ and 14% learning rate.

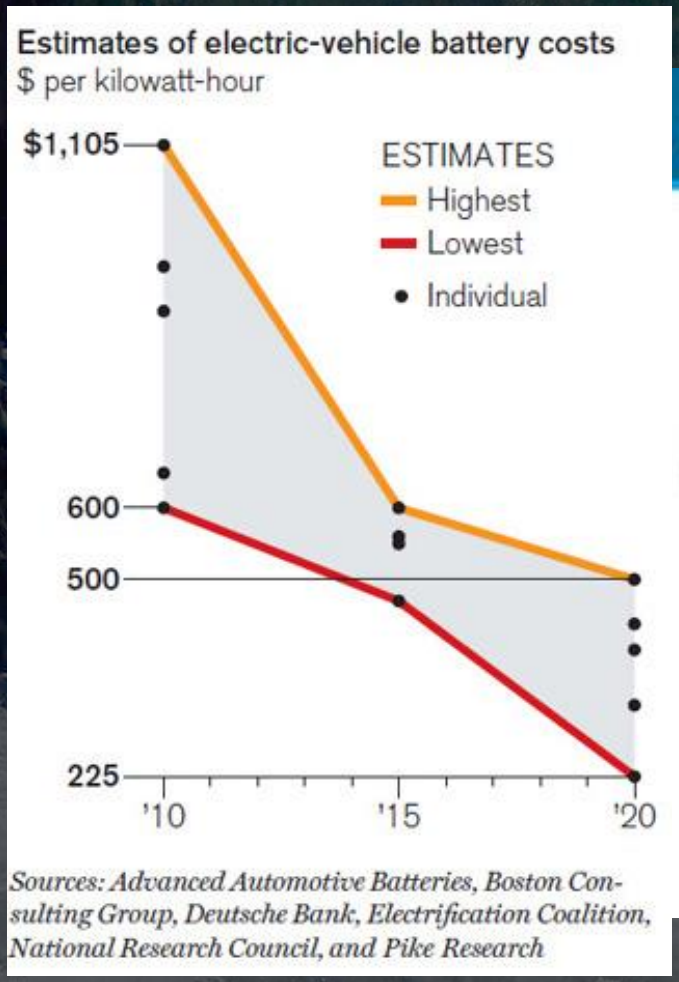
Source: Bloomberg New Energy Finance, ExTool

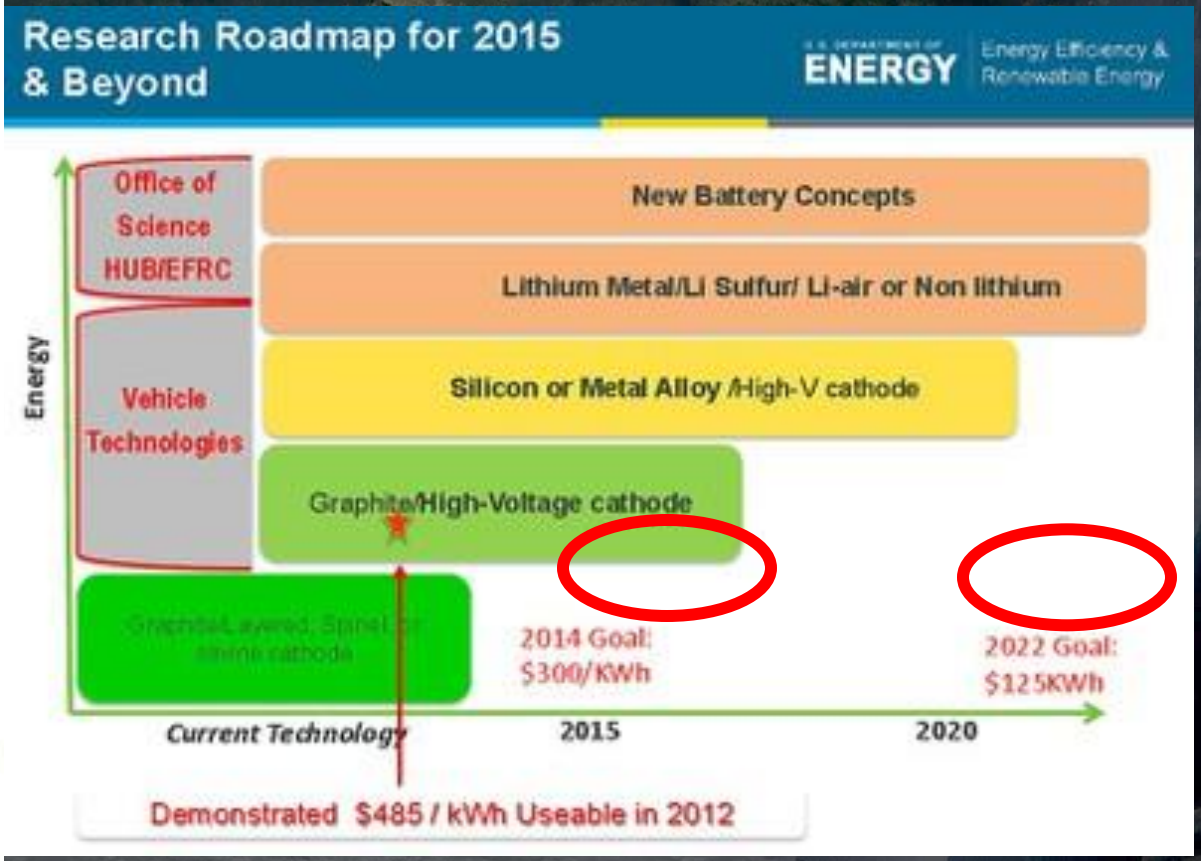
Cost Crossovers Everywhere



Source: Jacobson

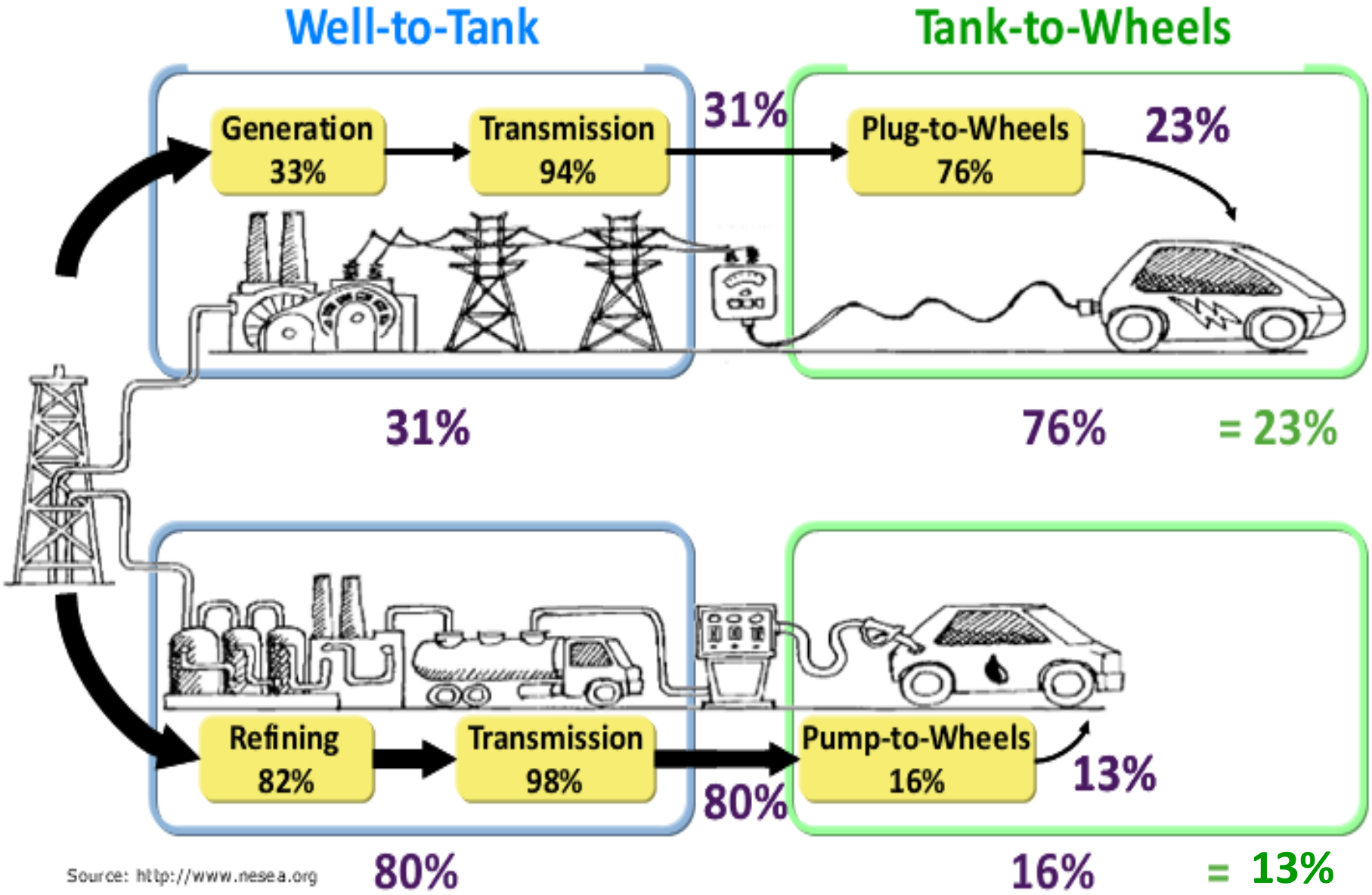
Plummeting Costs of EV Batteries





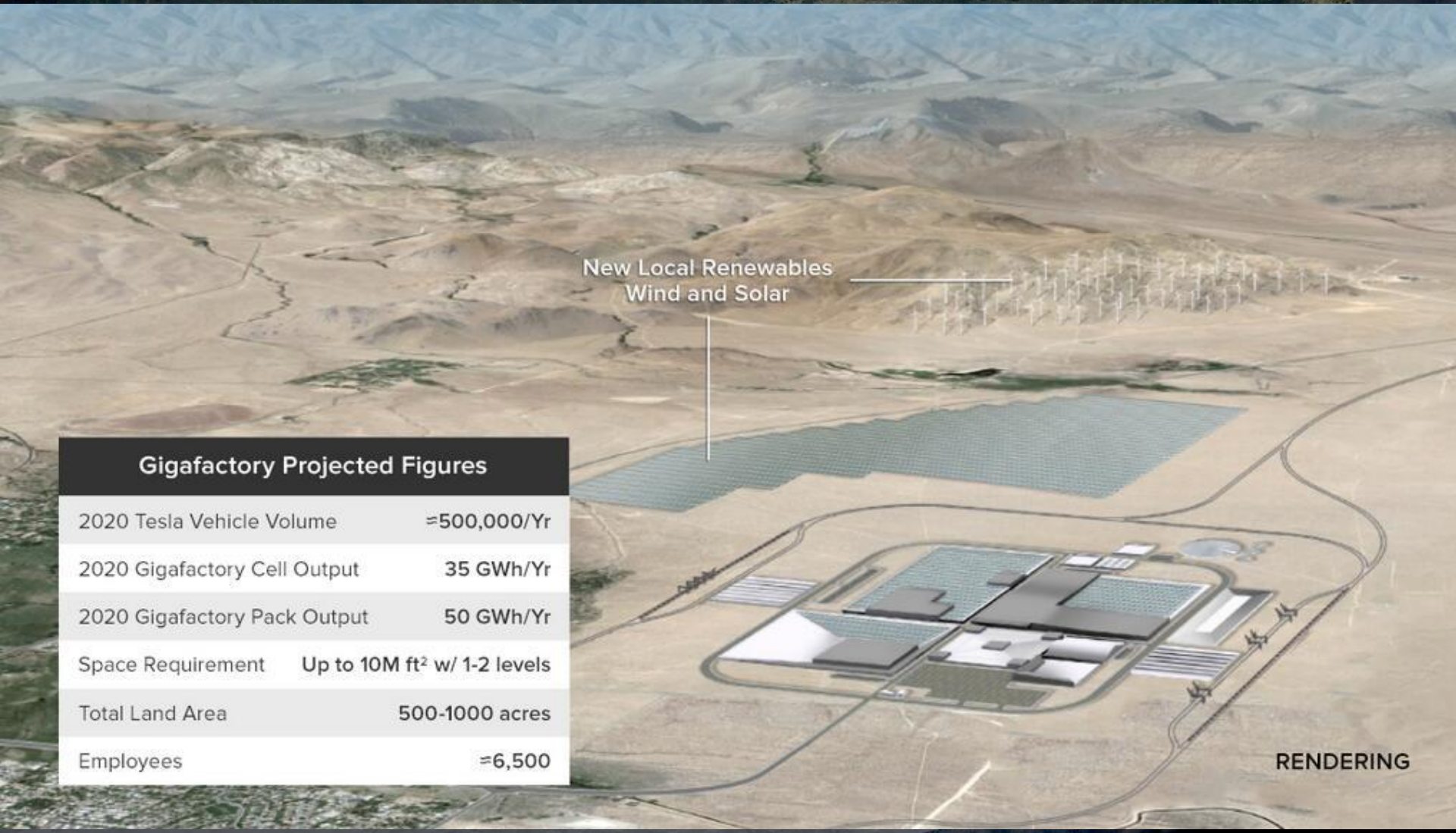
- Dozens of battery chemistries in development
- 75 battery companies in Silicon Valley!

Well-to-Wheels Efficiency



[http://www.nesea.org/]

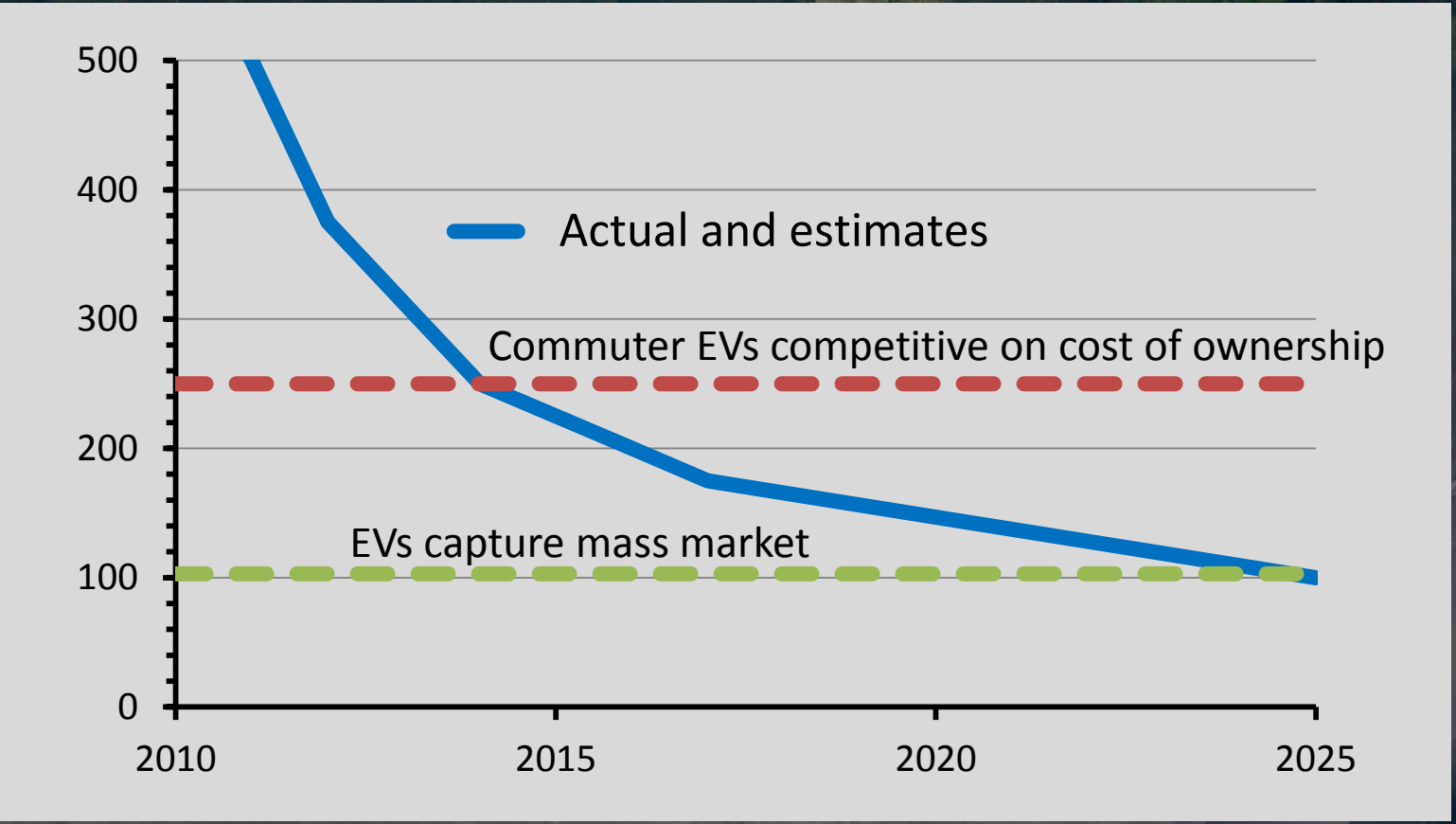
Pilot “Gigafactory” for Batteries



Gigafactory Projected Figures	
2020 Tesla Vehicle Volume	≈500,000/Yr
2020 Gigafactory Cell Output	35 GWh/Yr
2020 Gigafactory Pack Output	50 GWh/Yr
Space Requirement	Up to 10M ft² w/ 1-2 levels
Total Land Area	500-1000 acres
Employees	≈6,500

- Battery demand “semi-infinite”

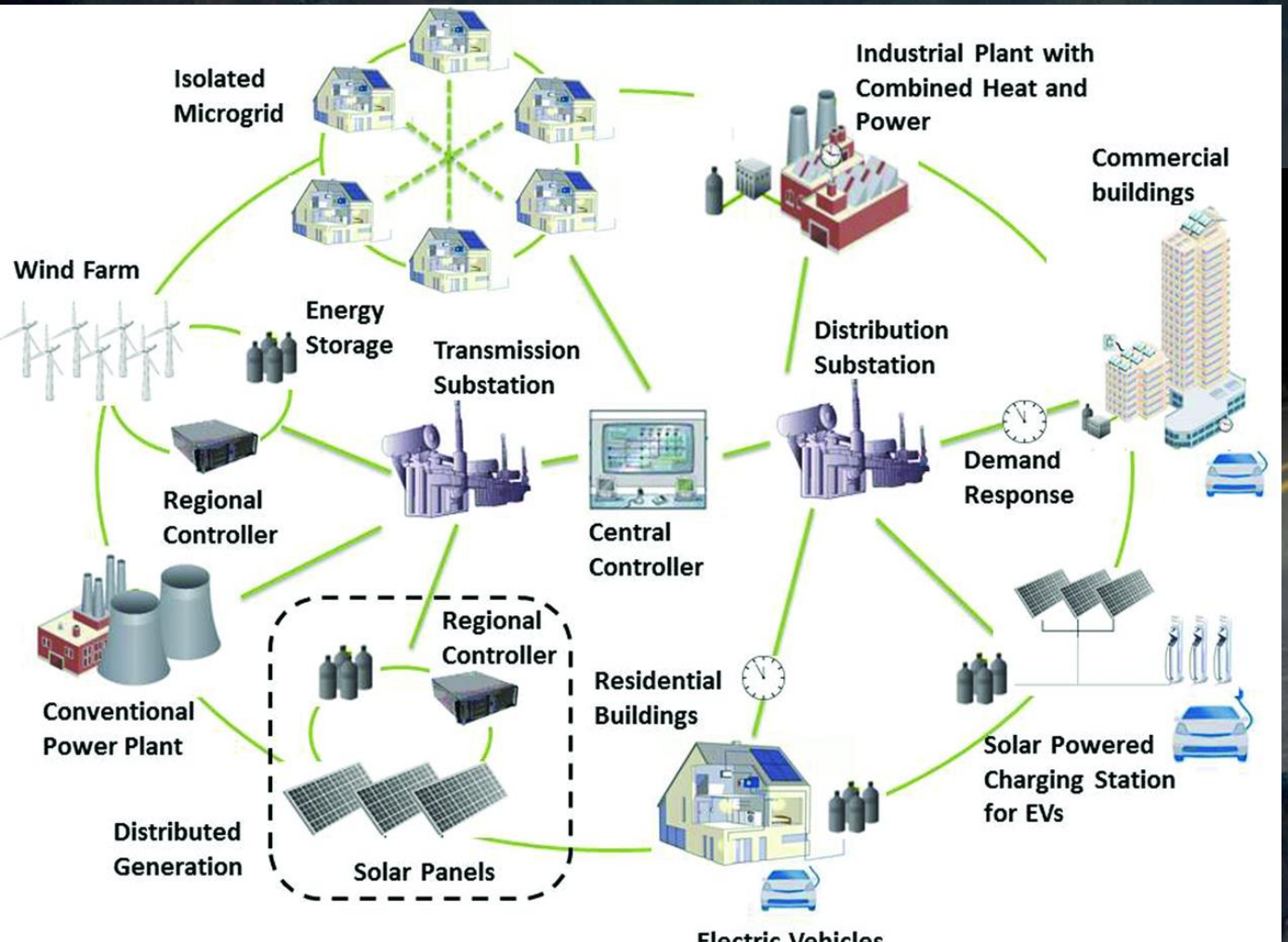
Prices of Li-ion Batteries ($/kWh)

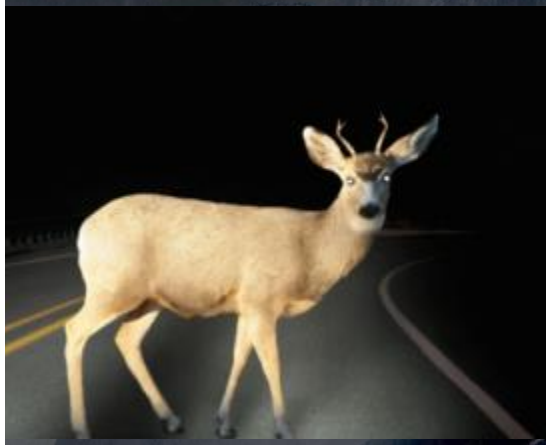


- Data from Tesla, Navigant, McKinsey, Sandia, BNEF, RMI
- Nissan Leaf is already the lowest cost commuter car

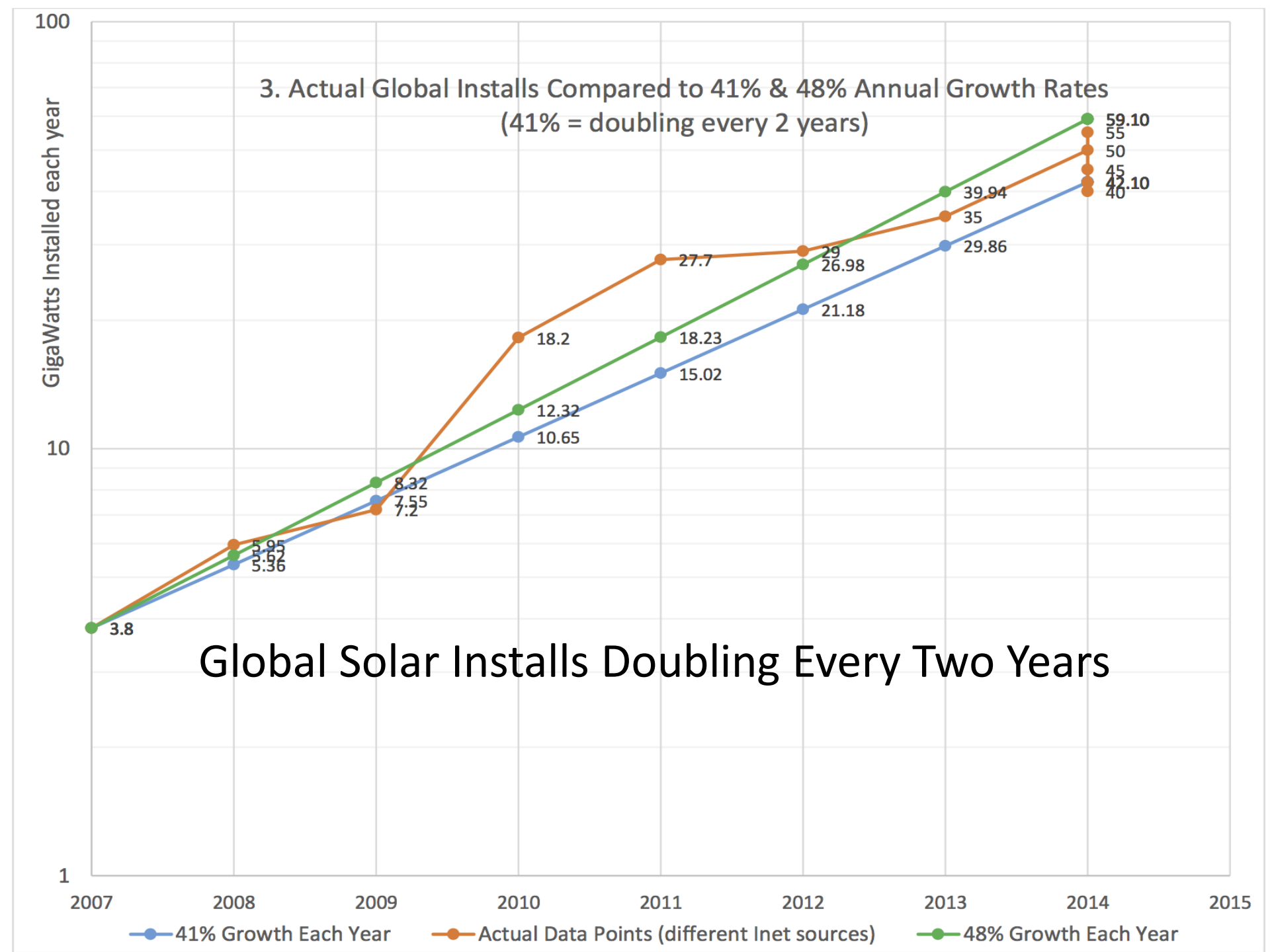
Smart Grid Will Reduce Cost, Increase Reliability

- Intermittent sources, distributed generation and storage
- New business models required!





Most utilities


3. Actual Global Installs Compared to 41% & 48% Annual Growth Rates
(41% = doubling every 2 years)
GigaWatts Installed each year
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
3.8
5.95
5.62
5.36
8.32
7.55
7.2
18.2
12.32
10.65
27.7
18.23
15.02
29
26.98
21.18
39.94
35
29.86
59.10
55
50
45
42.10
40
Global Solar Installs Doubling Every Two Years
41% Growth Each Year
Actual Data Points (different Inet sources)
48% Growth Each Year

Silicon Valley's Next Revolution

- PCs
- Internet
- Telecomm
- *Energy*

Creatively destroy the status quo with better cost-performance

Intermission

A Model of the Forces and Constraints

Analogous to software layers in a complex system

Governance Layer
Government, politics, legal controls

The governance layer must control the economics

Economic Layer
Daily commerce, business, employment

The economy is like a big computer finding lowest costs

Physical Layer
Science, technologies

The physical layer is our ecosystems and physical creations

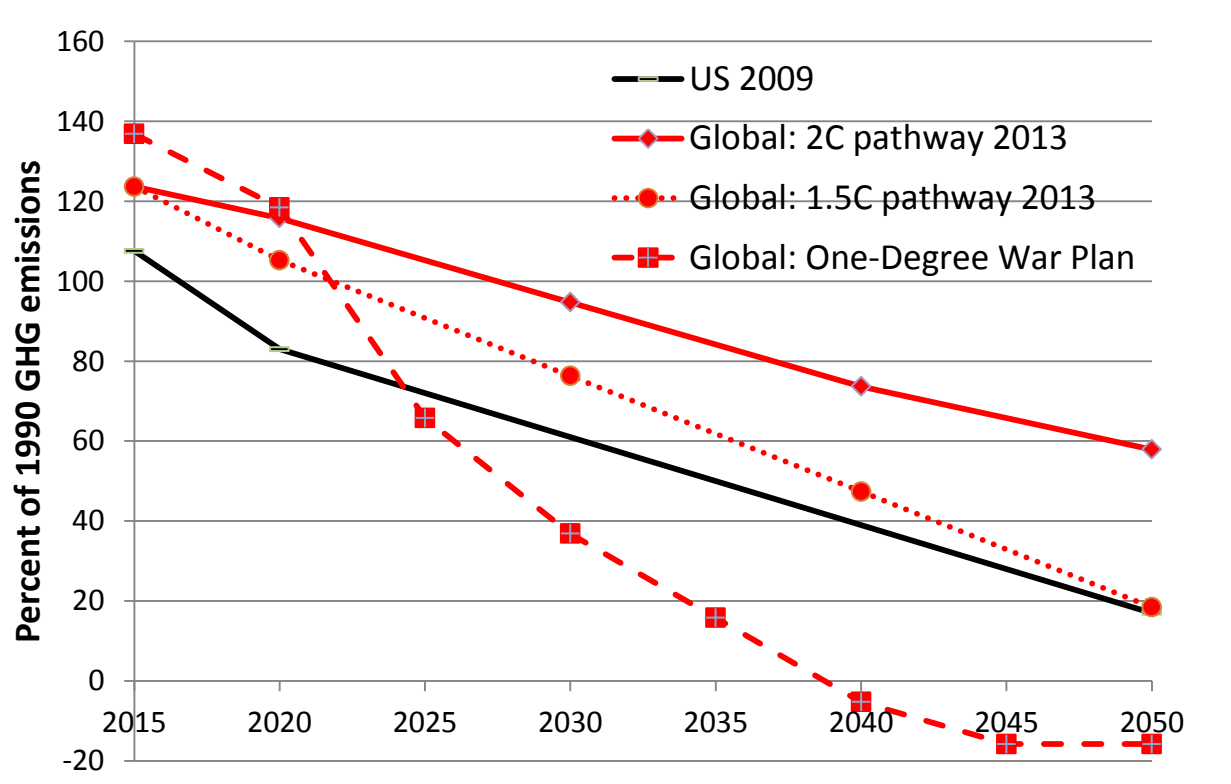
Moral/Spiritual Foundation
Earth Charter, religions, cultures,…

The foundation must respect life and our responsibilities

Every layer must work!

Physical Layer Implications

- Zero GHG emissions from energy sources
- Net zero emissions from agriculture
- Carbon-negative technologies and practices
- “Circular economy” recycles almost everything



Economic Layer Implications

- About 80% of people just buy the cheapest products that satisfy their immediate needs

  Therefore killer apps must compete at commercial cost

- Much more funding of R&D and deployment needed for high-risk/high-reward research
- Subsidies matter

US fossil fuel subsidies:

$500B

Oil spills or solar spills?

Governance Layer Implications

- George Schulz: A good federal energy policy would be a social cost on carbon plus some real R&D spending
- Government must attach the social costs of pollution or regulate pollution
- Renewables companies feel the fossil fuel subsidies but expect that *cost crossovers will happen before political change*

Implications

- For states
- For communities or families
- For utilities
- For businesses

Disclaimer: truth is stranger than fiction, and fiction is stranger than a logical forecast…

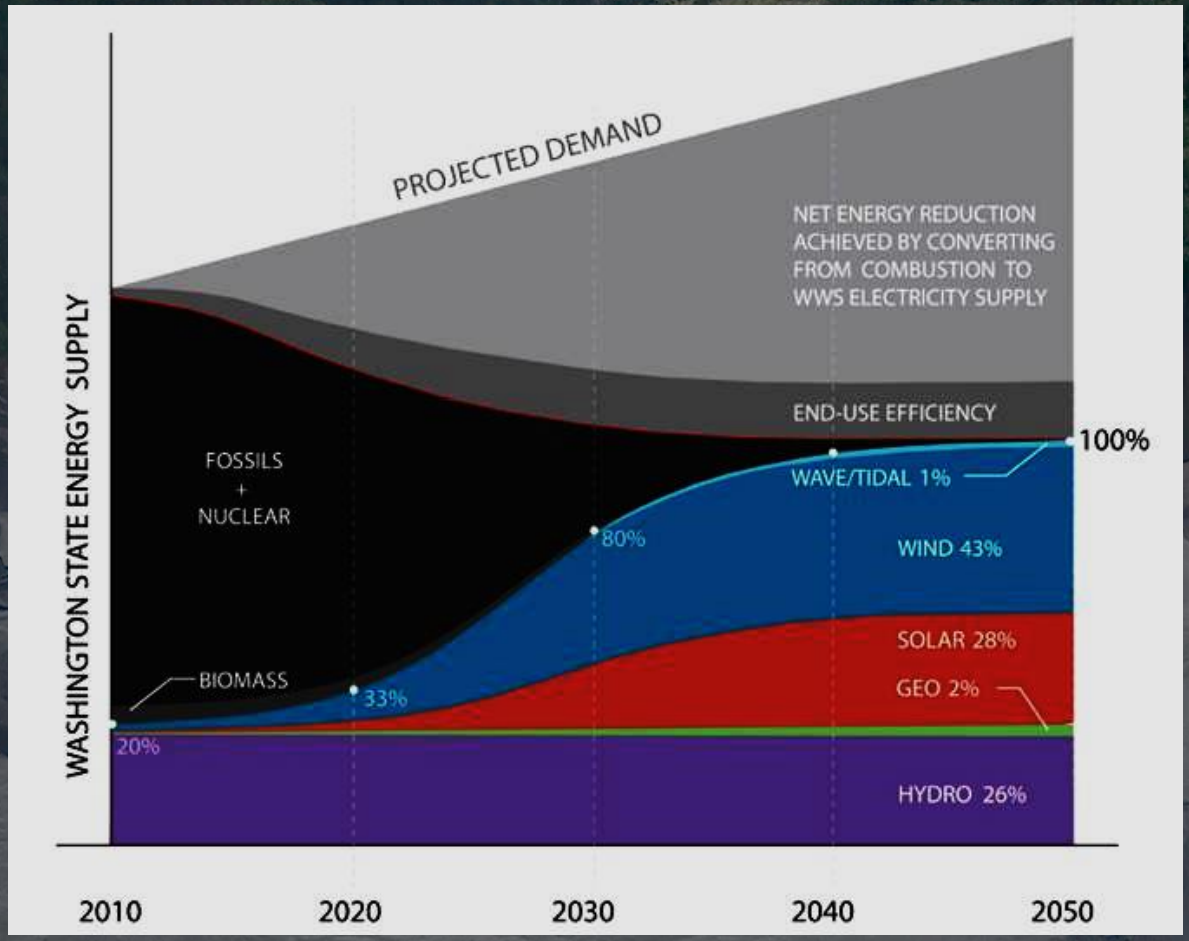
Implications for OR and WA

- WA/OR send $22B/$14B out of the state annually to buy fossil fuels
- Retooling with renewables would create thousands of jobs that can’t be outsourced
- Lower air pollution would enable massive savings in healthcare and climate social costs

Relevant Studies of Countries or States

- WA, CA, and NY states: Mark Jacobson
  - 100% renewables by 2050
- Germany: Fraunhofer Freiberg REMod-D
  - Can achieve GHG 80% less than 1990
  - Investment more than paid for by fuel savings
- 15 countries: Deep Decarbonization Pathway Project
  - Global pathways to 2C also reduce poverty
  - Requires global coordination of development & deployment
- US: NREL (2012)
  - 80% renewables feasible by 2050 with 2012 technologies and more transmission lines

Washington Study (Jacobson 2014)

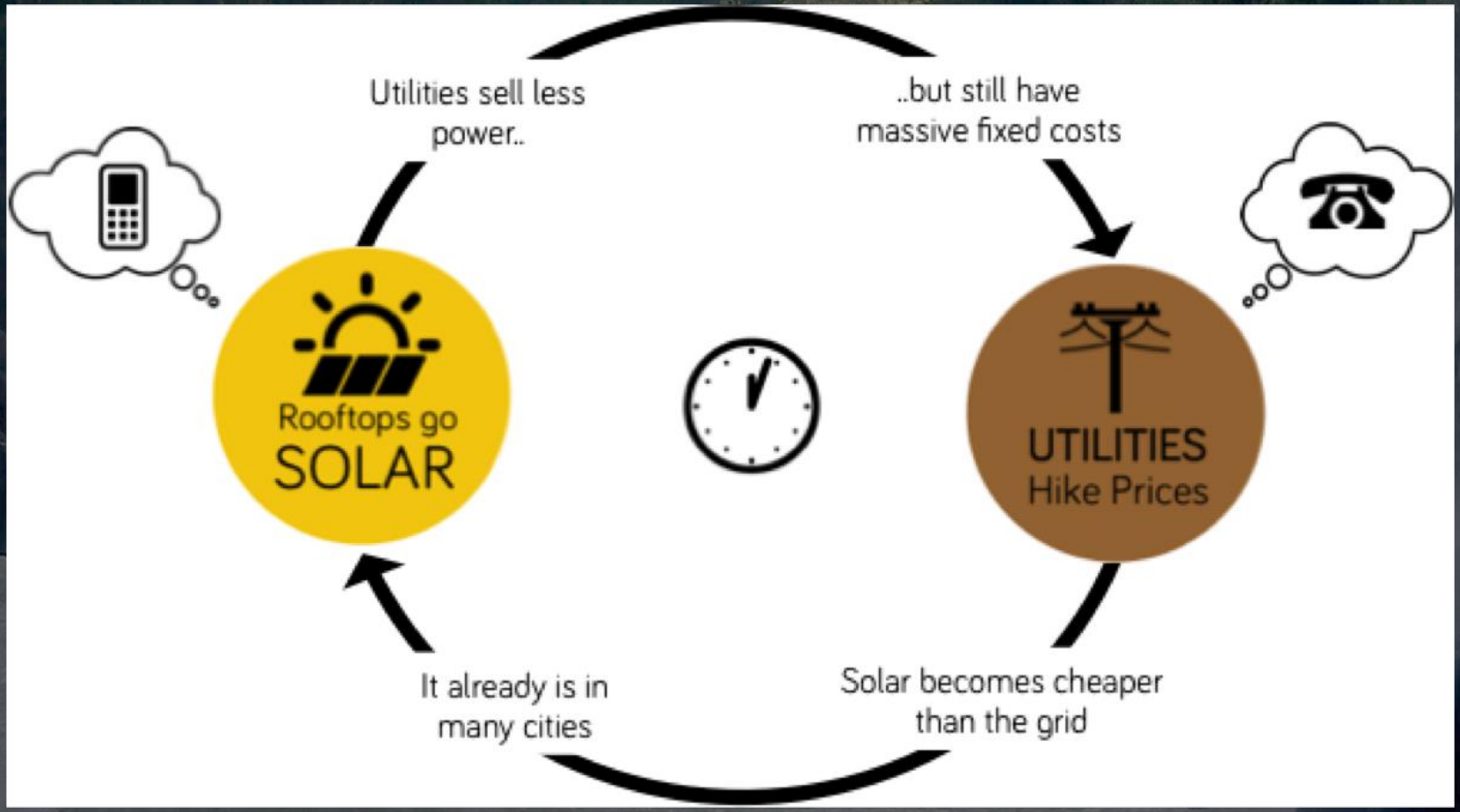


- 100% renewables by 2050; hydrogen storage
- Creates 40,000 permanent jobs net and saves 800 lives/year
- Requires ~$7.5B/year invested for 30 years
- $7.2B healthcare and $10B climate costs saved annually

Implications: Communities or Families

- Channel frustration into planning
- Calculate your carbon footprint and plan reductions
- Fix efficiencies now, buy renewables as affordable
- Stop buying or funding fossil fuel infrastructure
  - Autos & light trucks: buy EV or used
  - Oil and gas heating: replace with electric heat pumps
  - Fossil fuel terminals
  - Coal and oil transport costs
- Fossil fuel assets will become stranded soon
- Divest. “Fossil industry is the subprime danger of this cycle”

Implications: Utilities

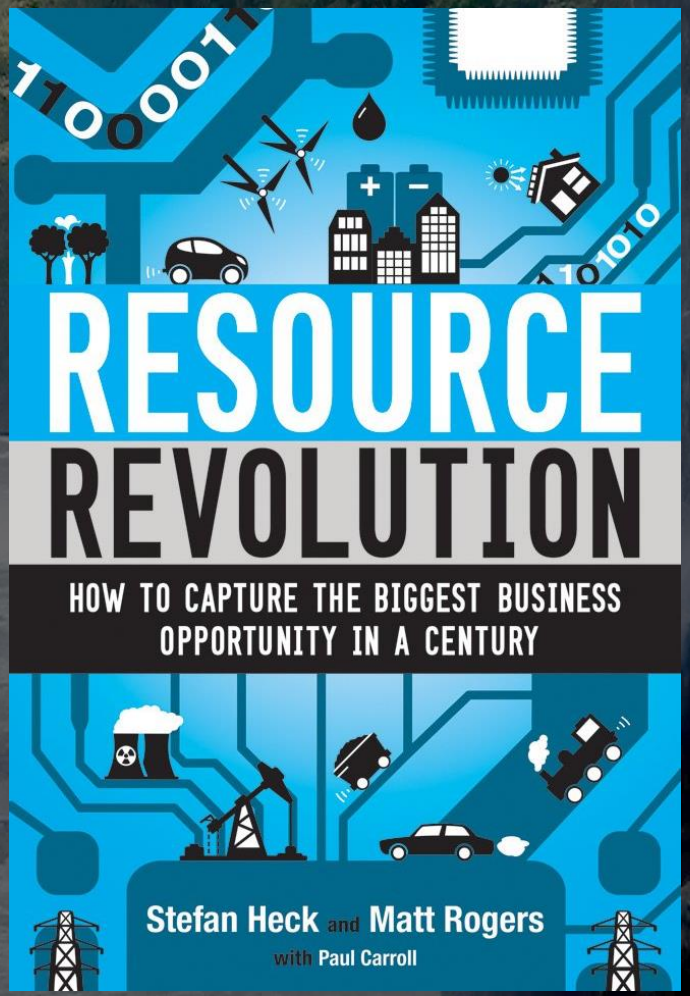


- Embrace the transition, don't resist it!
- OR and WA can wait and learn from others

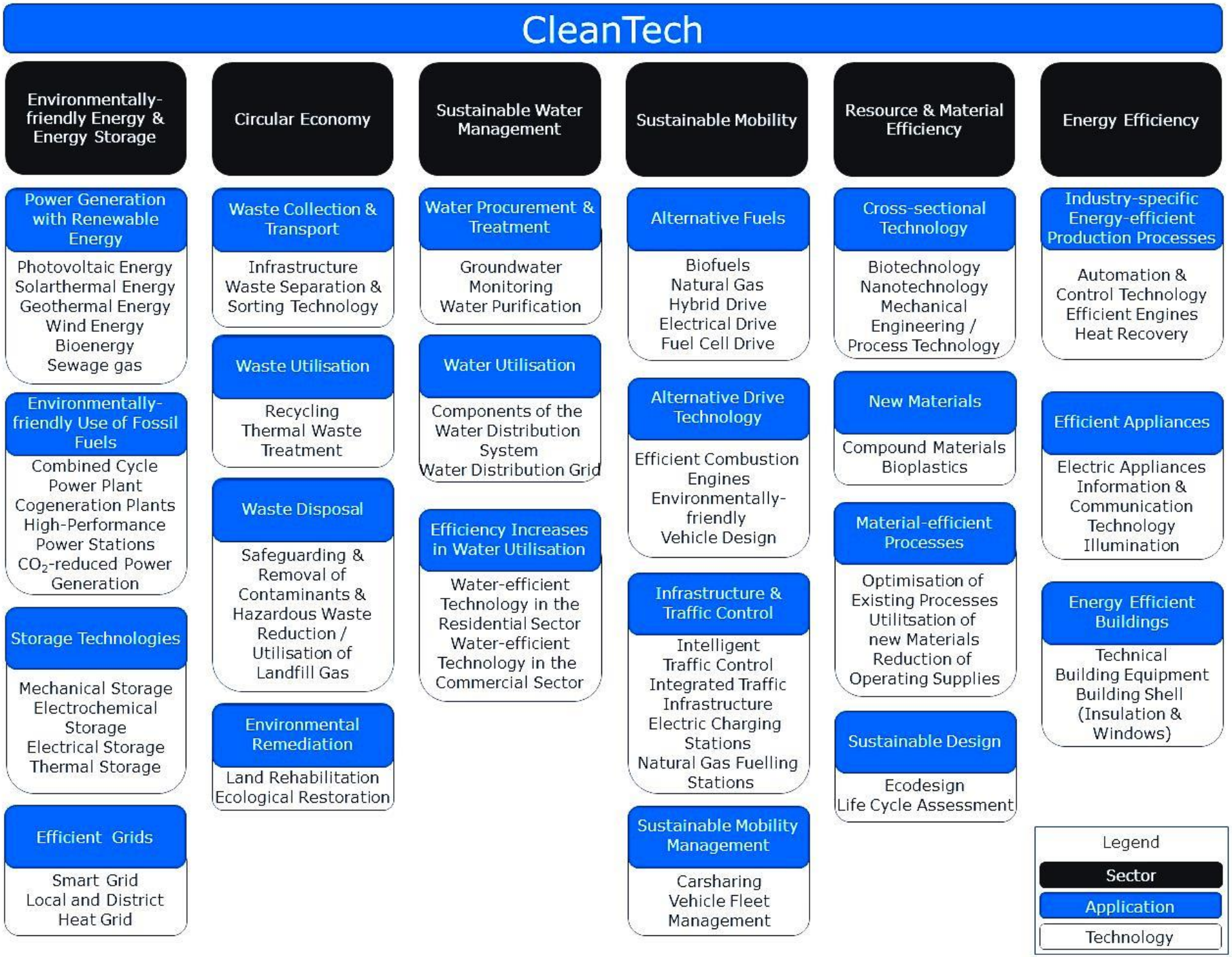
Implications for Business

New opportunities everywhere

- Wind, solar, smart grid
- Storage, batteries
- Energy and water efficiencies
- Biofuels, biochar, transport
- Recycling, waste recovery
- Integrating across silos
- New business models
- New financing models
- All the associated infrastructure
- Etc., etc.



Voice policy support: sign the Oregon Business Climate Declaration



For Entrepreneurs

- Unmet needs abound!
- What should be electrified next?
- What new infrastructure is implied?
- What will the new economics enable? (e.g., memory and radios are free today)
- What combinations of technologies will enable new benefits?
- If you're in a global market, how can you make this product the best in the world?
- Half-life of market research: ~12 months

More Examples

- Better efficiency in new construction, remodels, transport, and industrial processes—both products and installations
- Solar carports; PV integrated with roofing and siding
- Products that save both energy and water; products that report their status and/or control themselves
- Self-driving EVs on-demand; virtual trains on freeways
- Metrology infrastructure--such as a handheld non-contact DC voltage sensor for PV installations and maintenance
- Robots for forest and ag work
- Infrastructure that monitors itself & requires less maintenance

California Leads in Green Energy Technologies and Grid Deployments

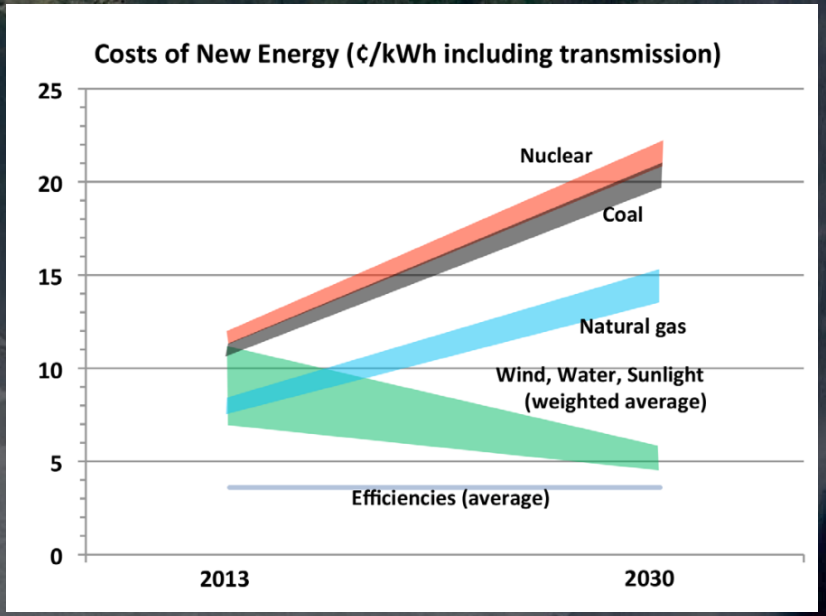
Distribution of Green Tech US Patents

WA?

OR?

Summary

- A massive energy transition is moving from pilot projects to deployment
  - Wind and solar now
  - Storage and EVs next
  - Low-carbon agriculture coming
  - Circular economy coming



- Huge opportunities for entrepreneurs
- Game-changing opportunities for WA and OR
- Divest from fossil fuels now and plan for next-gen infrastructure