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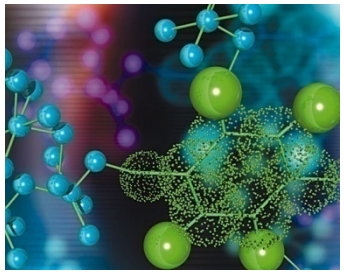


Barriers to Large Scale Grid Penetration of Renewables

High MW Electronics – Industry Roadmap Meeting

December 11, 2009

David J Prend

Managing General Partner, RockPort Capital Partners

Let's step back to late 1970s

Carter – "Moral Equivalent of War"

PV on the White House

David Prend

Engineer in Advanced Energy Technologies, Bechtel Corporation, 1980

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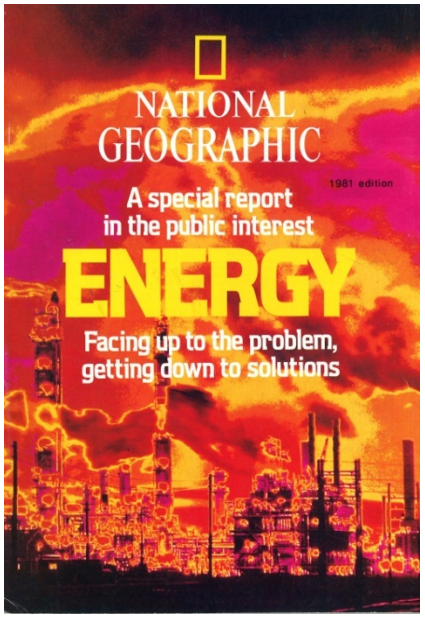
Is technology really the problem?

February 1981



"In the case of energy….often the obstacles are not technological but institutional."

November 2009

"The obstacles are primarily political, not technological."

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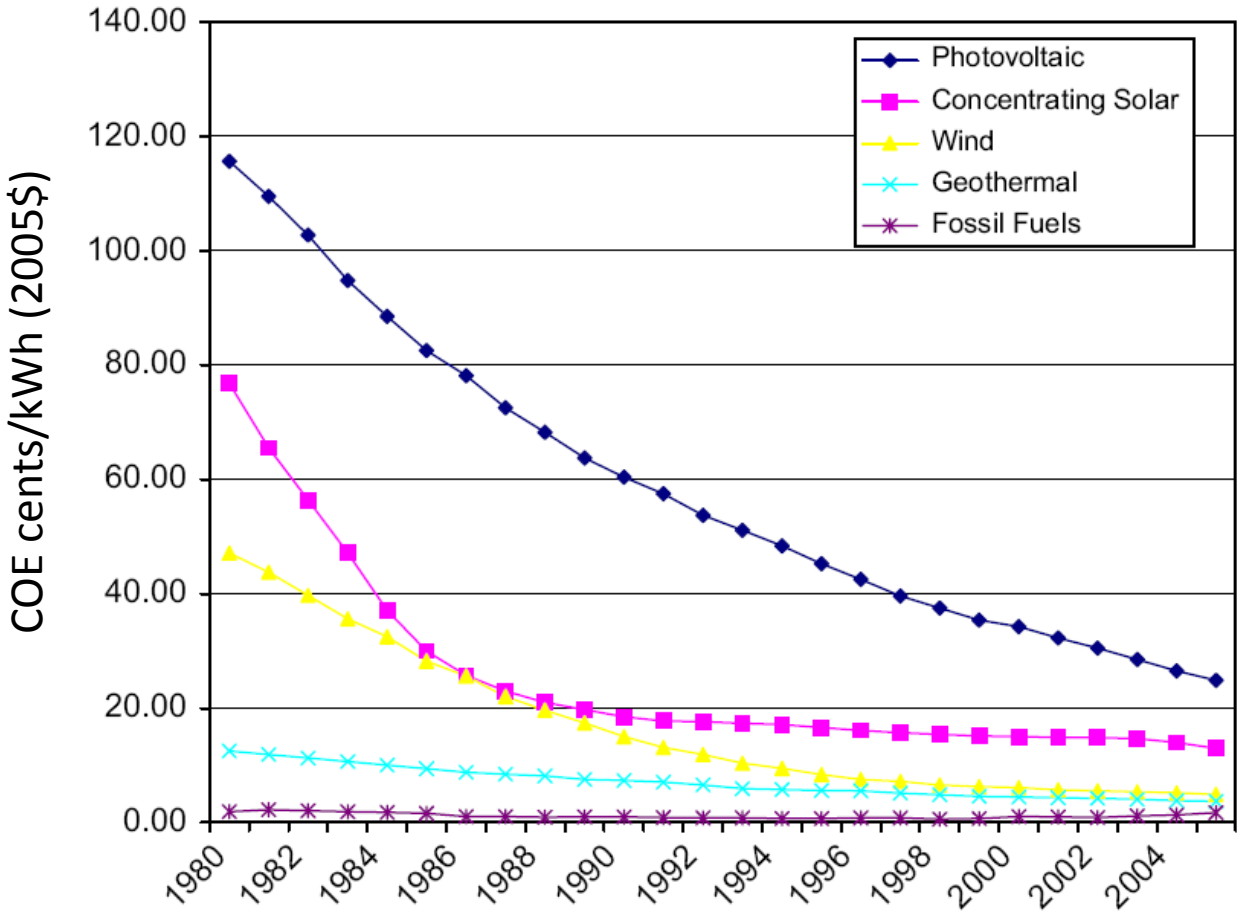
The importance of learning curves



Source: NREL and US Department of Energy

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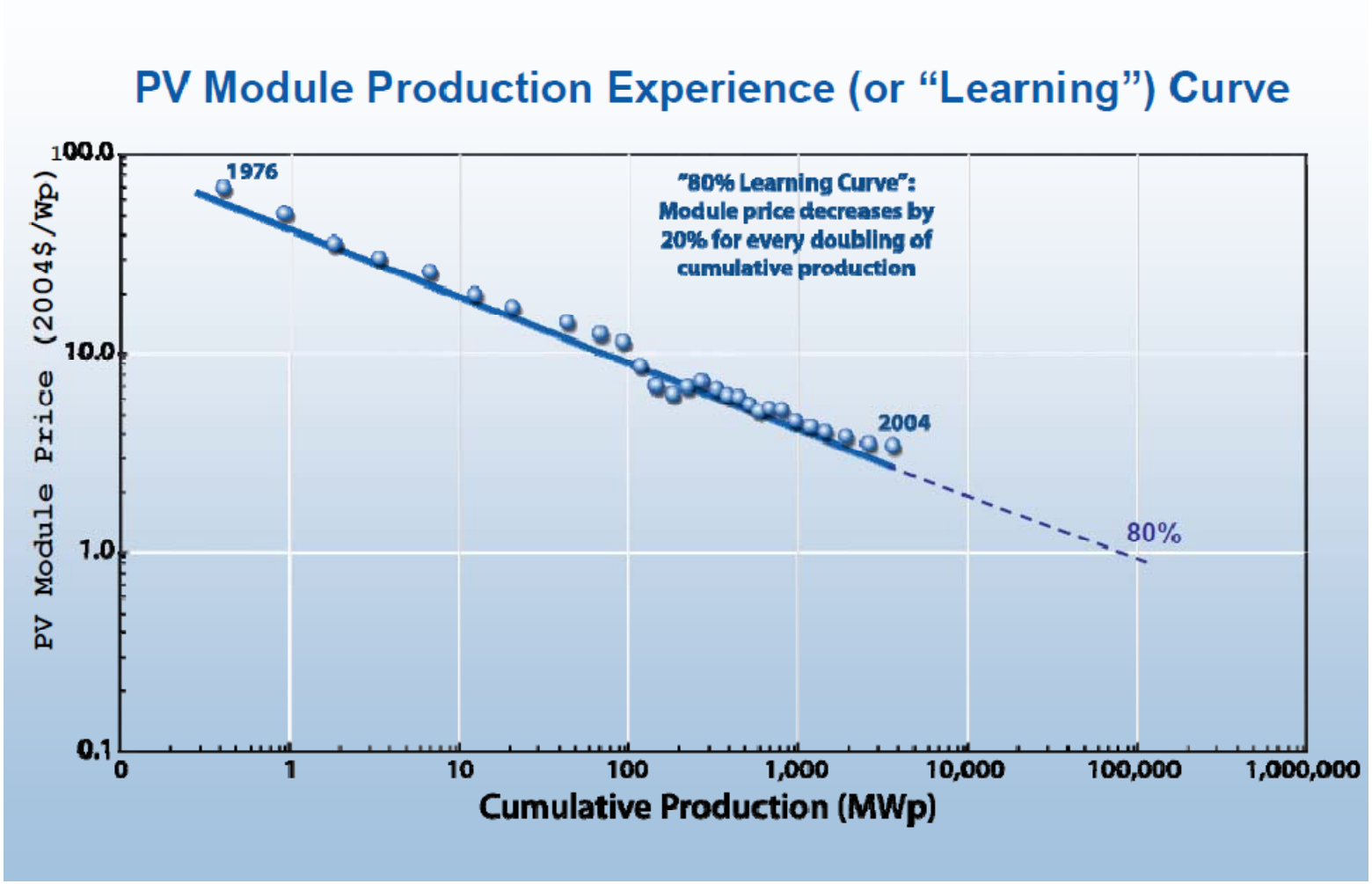
Solar learning curve



Source: NREL

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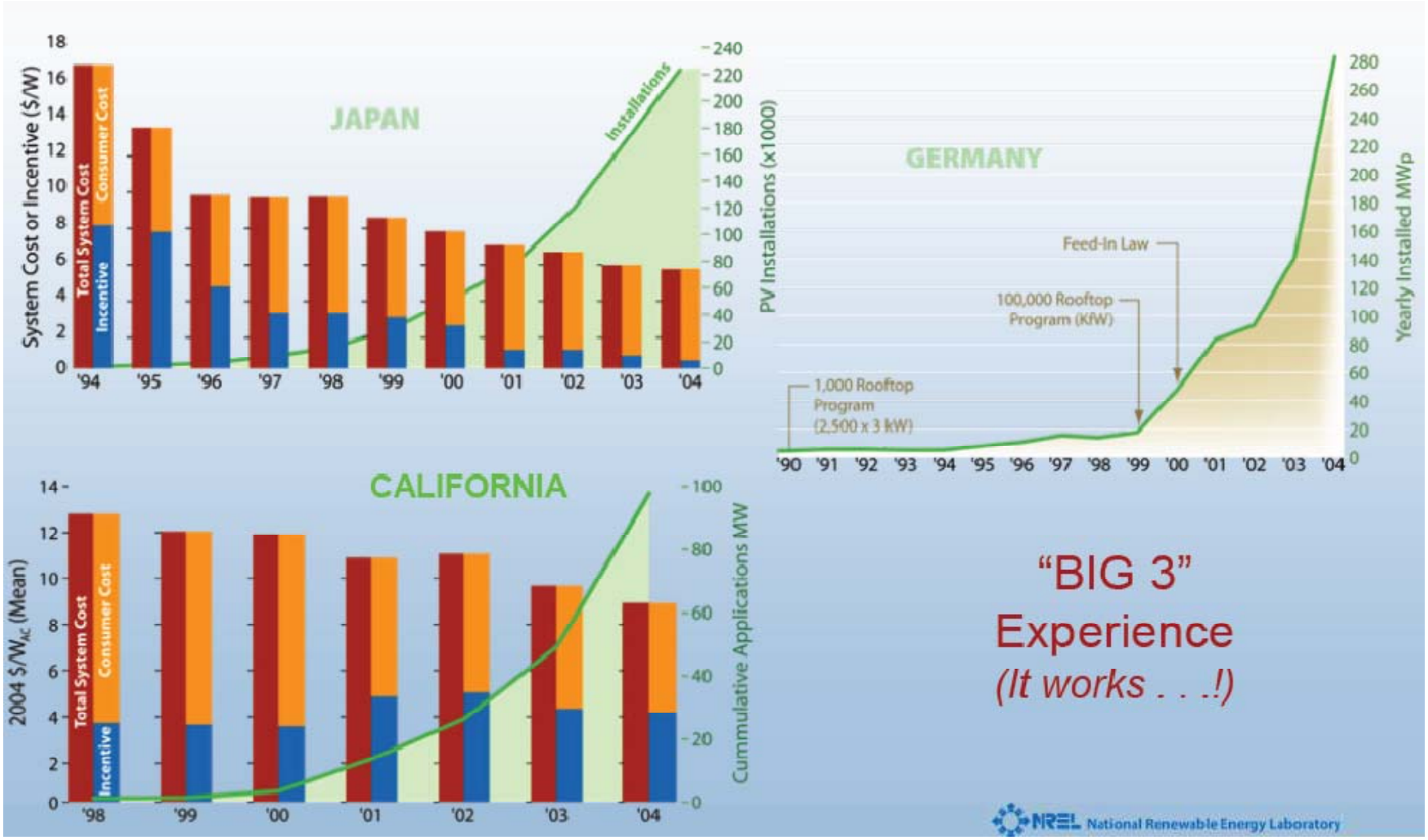
The impact of incentives



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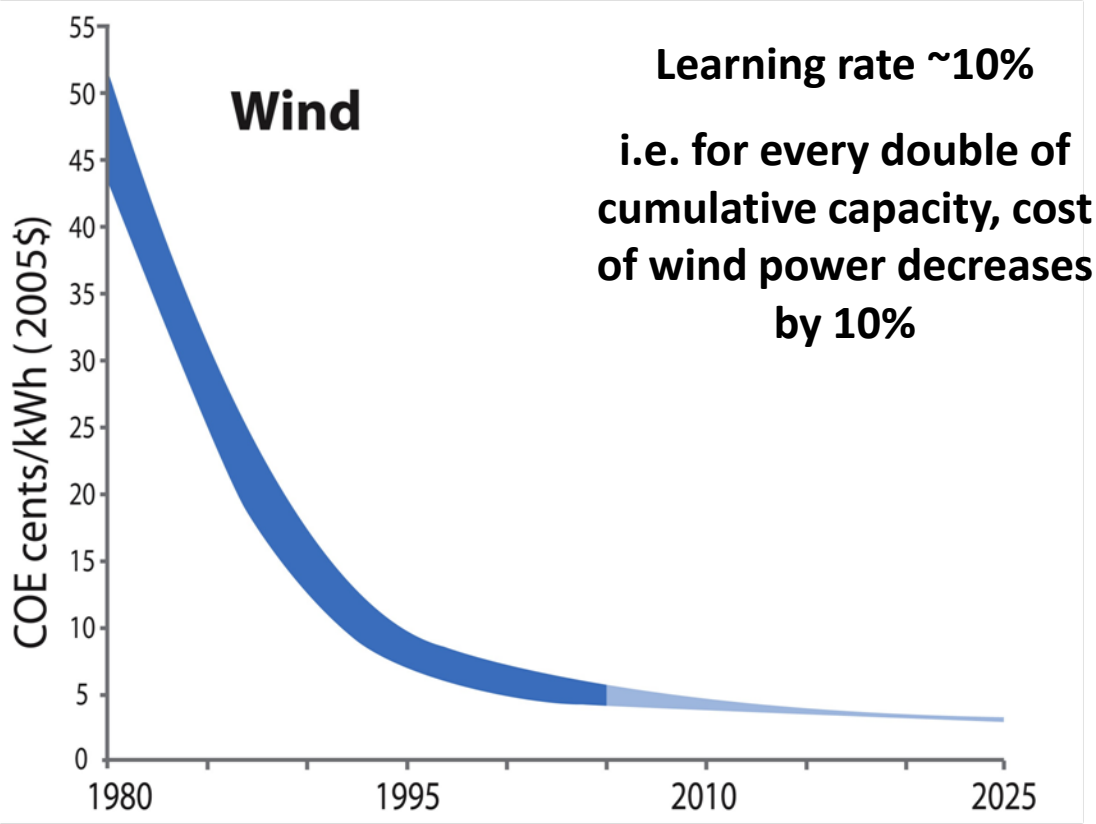
Wind learning curve



Source: NREL Energy Analysis Office (www.nrel.gov/analysis/docs/cost_curves_2005.ppt)

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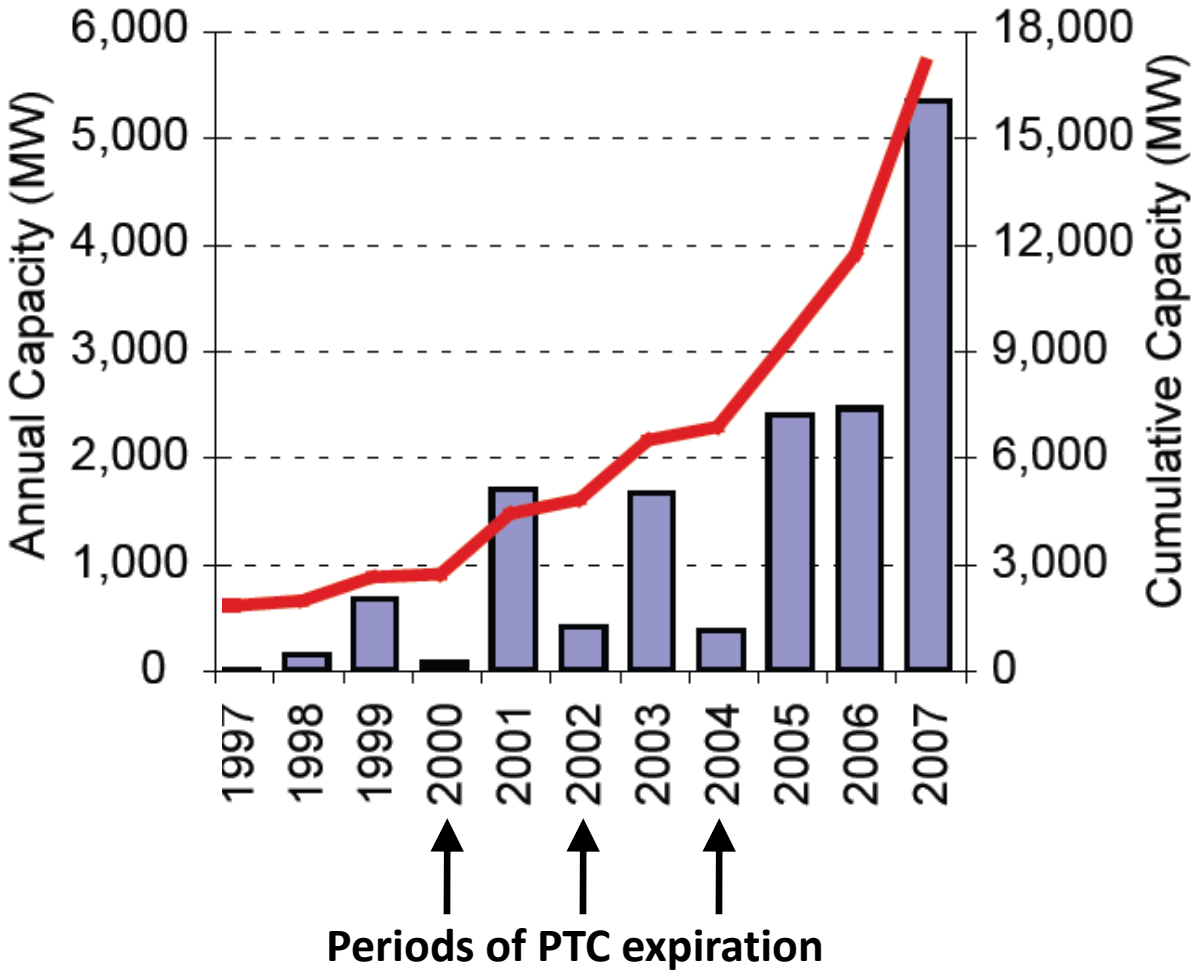
Incentive effects on US installed wind capacity



Source: AWEA

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Grid technologies currently exist

Grid

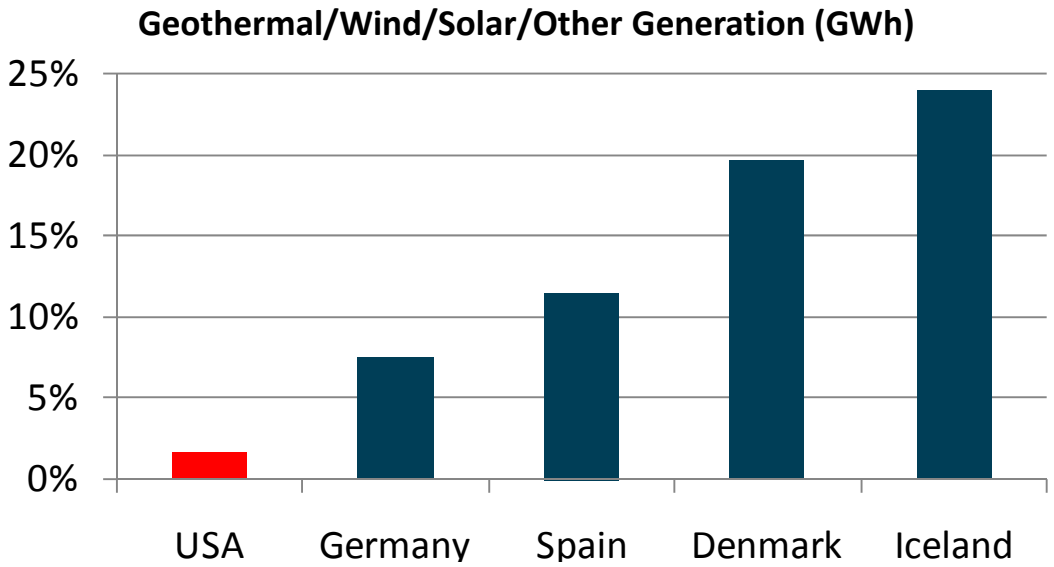
- Wide area networks
- Smart meters
- Substation automation
- Home area networks
- Real time monitoring and control
- Microgrids
- Demand management
- High MW power electronics

Storage

- Flow batteries
- Pumped hydro
- Compressed air
- Flywheels
- Electrochemical capacitors
- NAS batteries
- Lead-acid batteries
- Li-ion batteries

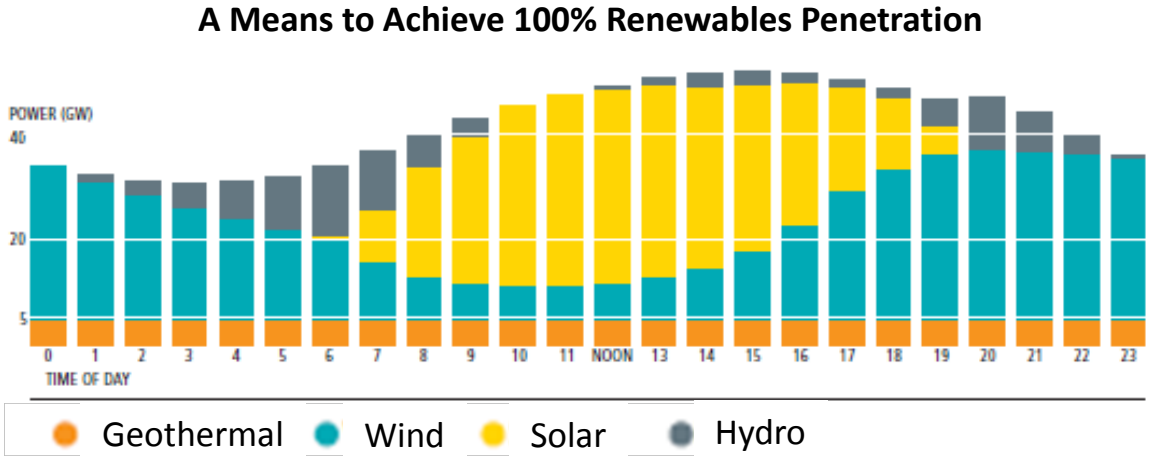
Large scale penetration is feasible

2008 Renewables Penetration



Source: IEA

2020 Model for California



Source: Scientific American, November 2009

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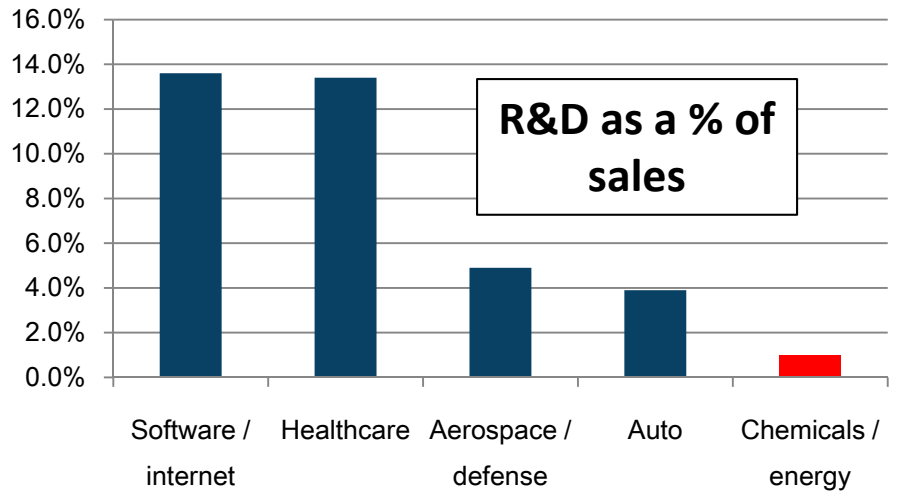
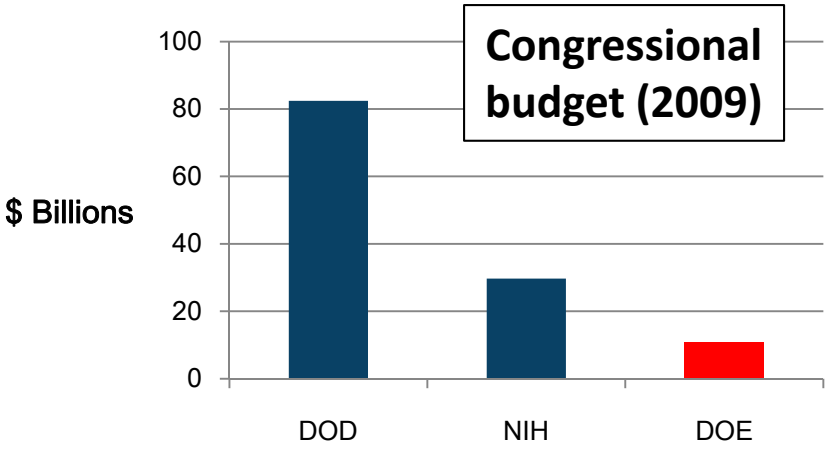
R&D spending on energy vs. other sectors

Industry



Source: Booz & Co

Government



Source: AAAS

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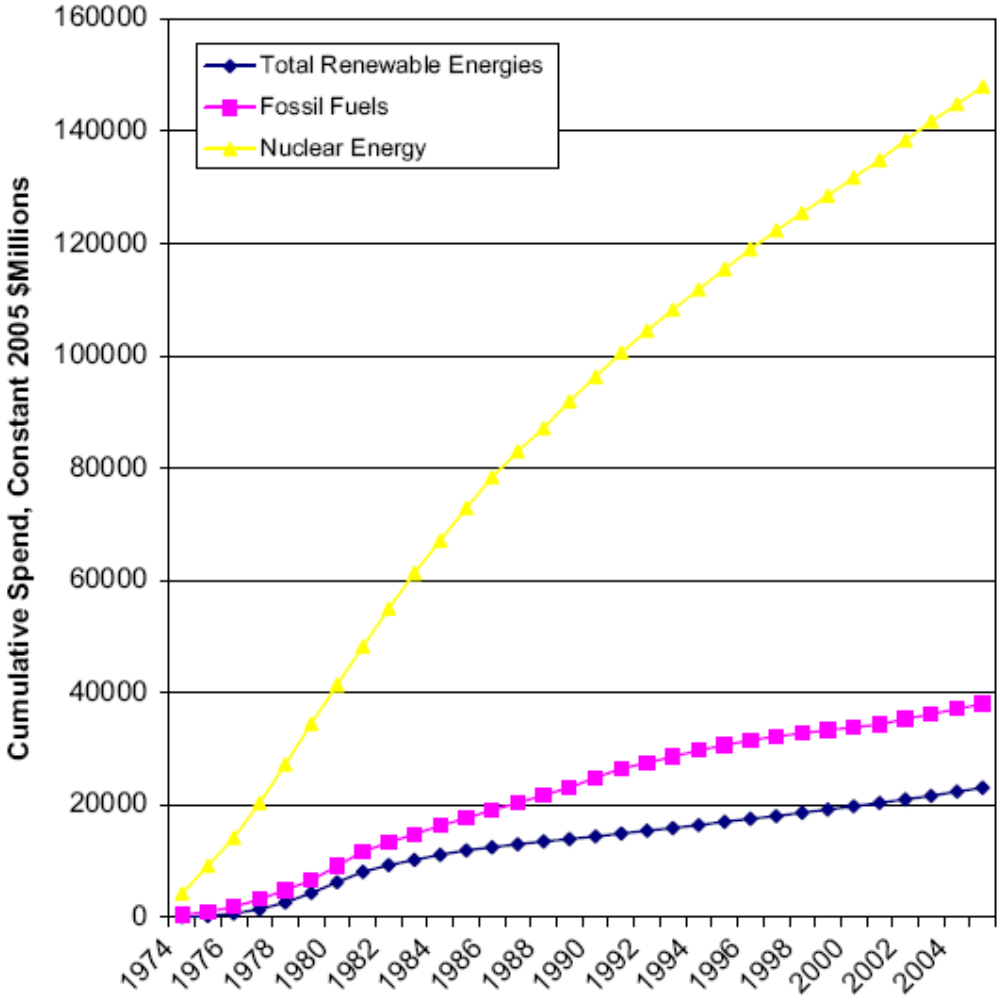
Global government spending on energy R&D



Source: Journal of Energy Policy, Schilling and Esmundo, 2009

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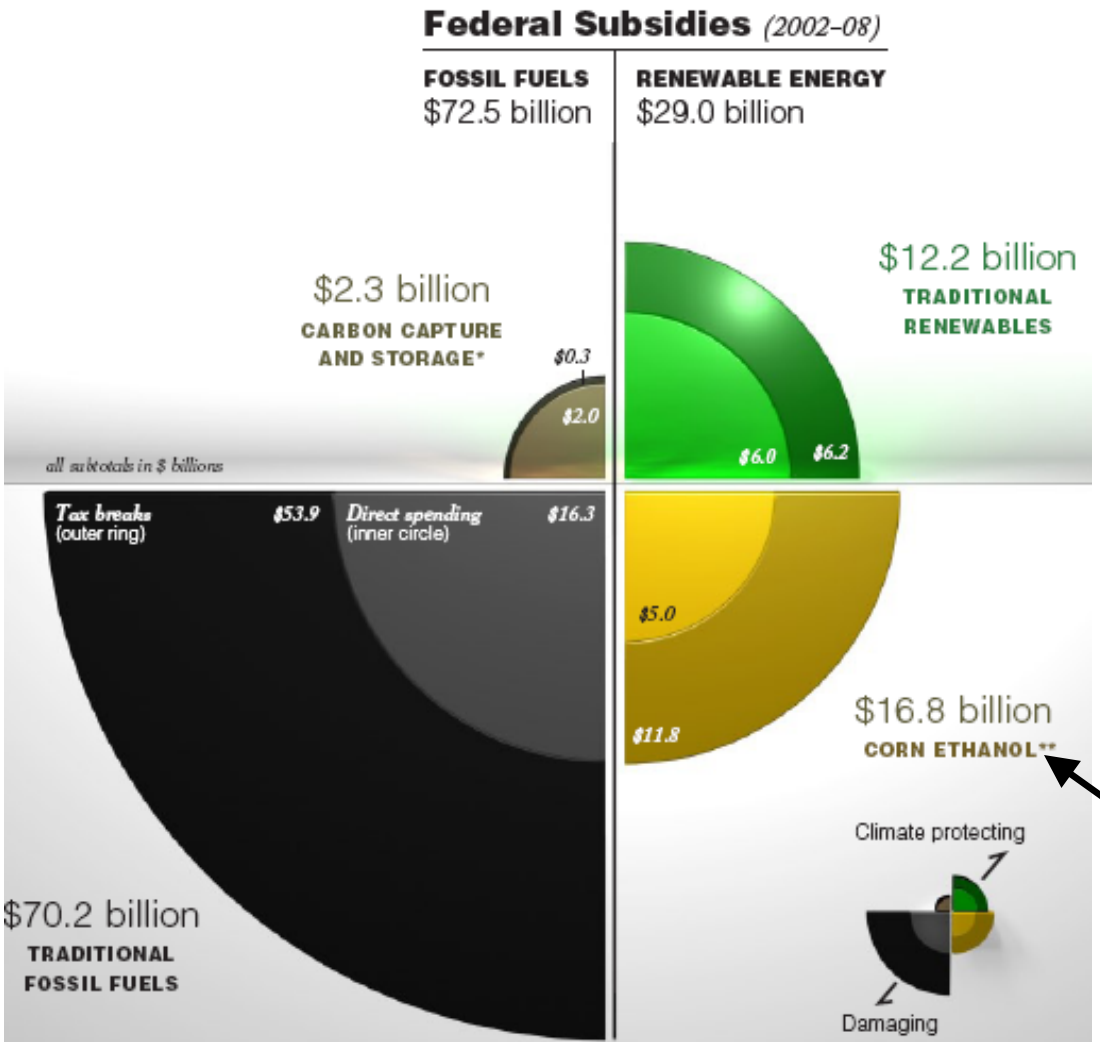
How level is this playing field?



Corn ethanol!

Source: Environmental Law Institute, 2009

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How level is this playing field?

$6.4B project in today's dollars

Federal Electricity Subsidies 2002-2007

(Billions of 2007$)

Direct Expenses		Tax Incentives	
Nuclear	$6.2	Nuclear [1]	$0.0
Fossil Fuel R&D	3.1	Fossil Fuel	13.7
Renewables R&D	1.4	Renewables	2.8
Transmission Improvements	0.8	Transmission and Other	1.7
Total:	**11.5**	**Total:**	**18.2**

[1] The GAO report excludes low cost loans, and the federal liability insurance program provided to nuclear operators, which significantly subsidizes their operations.

Source: Federal government statistics and the Government Accountability Office (Report GAO-08-102)

The real problem is demand…and financing

- **Question: how much capital investment would it take to increase (non-hydro) renewables from today's level to 20%?**

Total US electricity generation*	3,972,423,000	MWh	
Total (non-hydro) renewable generation*	130,516,000	MWh	3.3%
** Rolling 12 month total as of August 2009 (EIA)*			
20% of Total US electricity generation	794,484,600	MWh	
Additional generation from (non-hydro) renewables	663,968,600	MWh	

Capital investment required to reach 20% target (billions)

		Average capacity factor	
	$758	15%	20%
Installed Cost ($/W)	$2.50	$1,263	$947
	$3.00	$1,516	$1,137
	$3.50	$1,769	$1,326

- **Answer: More than a trillion dollars!**

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How do we access large pools of capital to fund deployment?

Feed in Tariffs

"United States of Gainesville"

Utilities

Cost recovery through "rate basing"

Conclusions

- Deal with demand side and supply will be there
- Focus on institutional barriers rather than technical barriers