

# Climate Change Solutions : What you thought you knew is obsolete. Joe Romm

Introduction  
by Senator Tim  
Wirth



<https://youtu.be/P6ag3b1WCYc>

# Almost Everything You Know About Climate Change Solutions Is Outdated



Joe Romm

Wirth Chair Lunch  
September 9, 2016



<https://youtu.be/P6ag3b1WCYc>



“I’ve Learned A  
Lot Of What I  
Know About  
Energy  
Economics From  
Joe Romm.” –  
Paul Krugman, 2/16



<https://youtu.be/P6ag3b1WCYc>

## The New Energy/Climate Reality

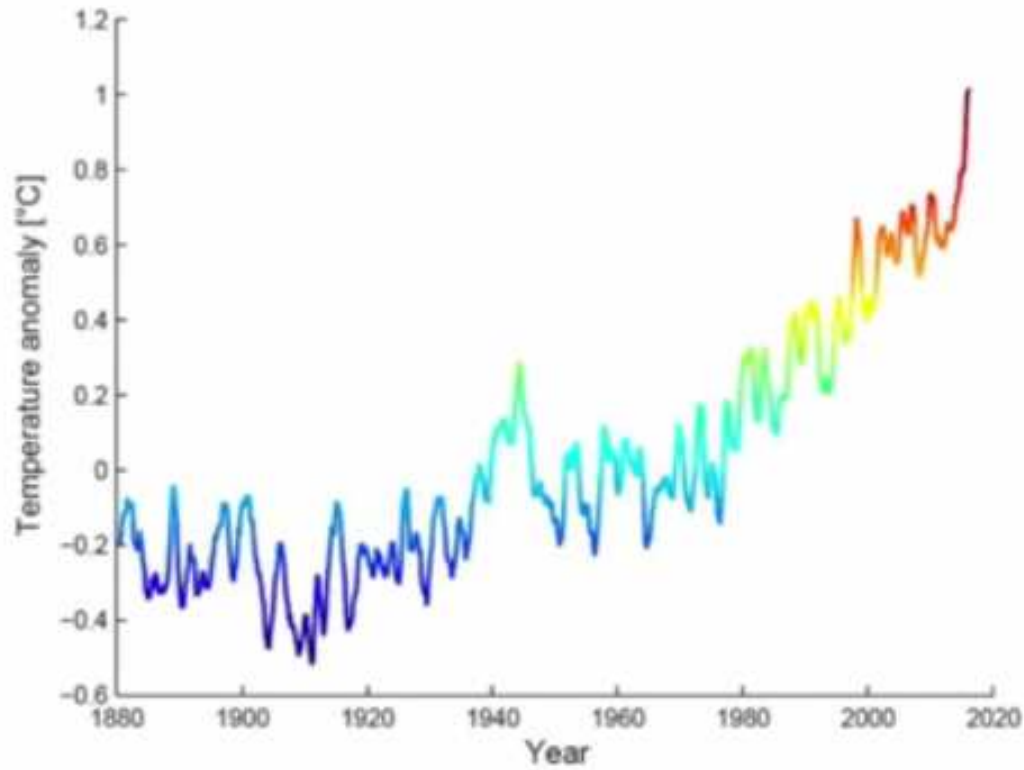
- Solar, wind, EV, battery, LED prices plummet
  - “Variablility” & integration issues solved\*
- Energy efficiency keeps demand flat\*
- Coal\*, gas “begin their terminal decline in less than a decade” (No G.A.G.)
- Oil begins its terminal decline by 2030
- Nuclear needs breakthrough + \$CO2 to compete
- Avoiding catastrophic climate change becomes organizing principle for humanity.



<https://youtu.be/P6ag3b1WCYc>

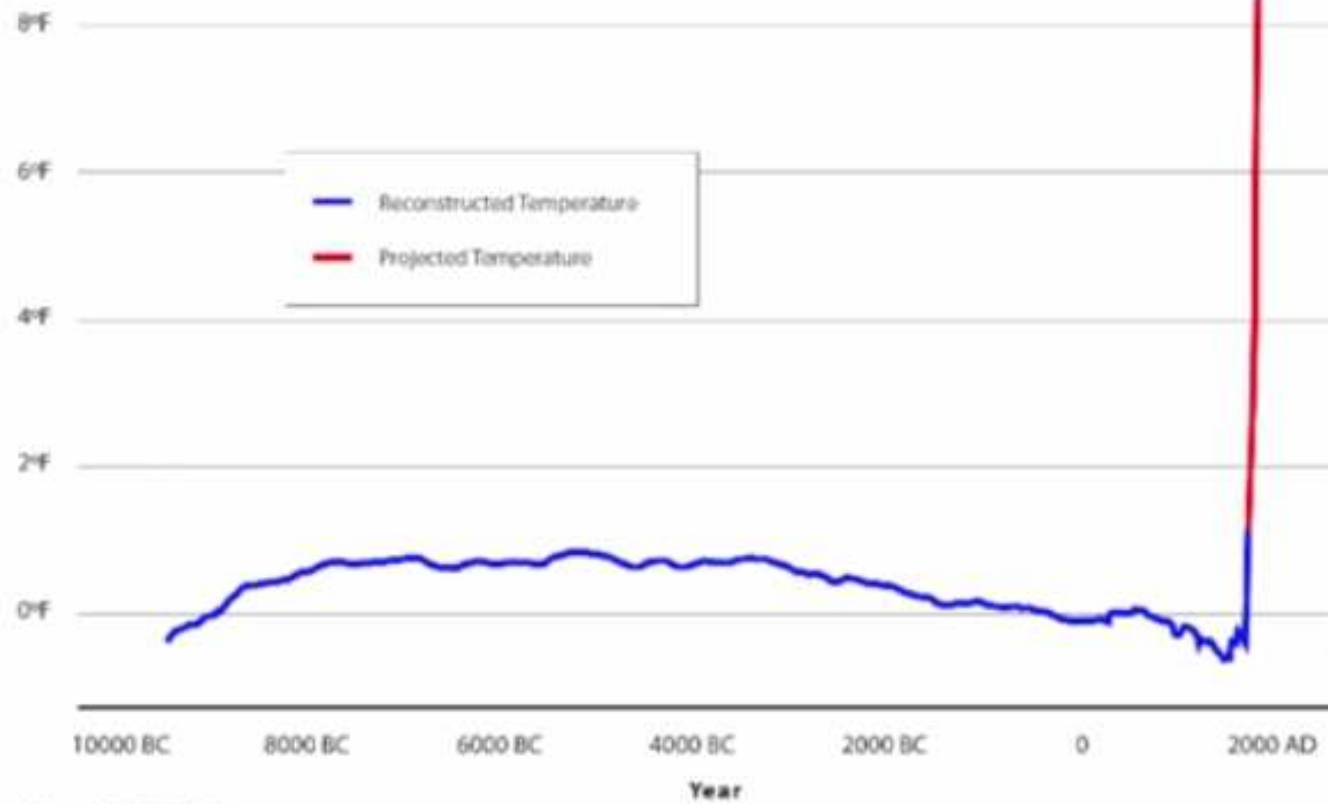
# We Keep Crushing Record For Hottest Year

## NASA: 12-Month Running Mean Global Temp



<https://youtu.be/P6ag3b1WCYc>

## Carbon Pollution Set To End Era Of Stable Climate



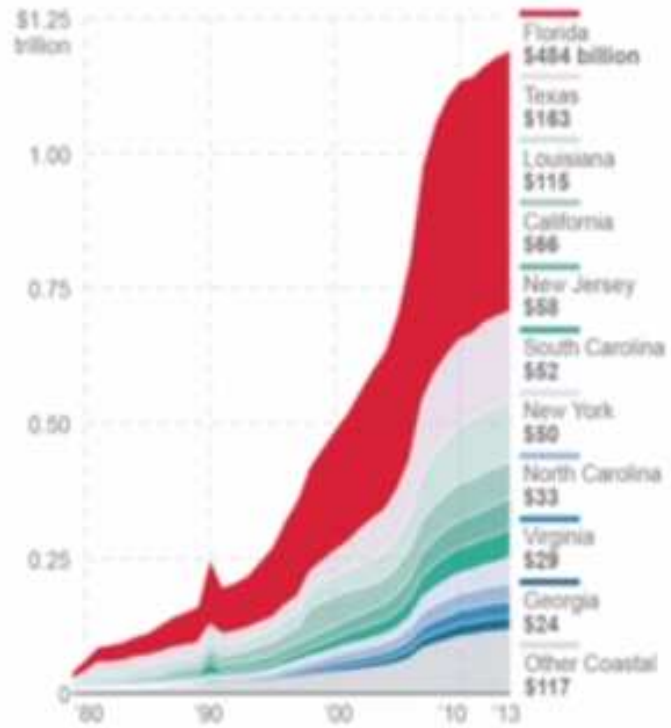
Science & ClimateProgress.org



<https://youtu.be/P6ag3b1WCYc>

## Safety net

Florida, Texas and Louisiana lead the nation in the value of property covered by the National Flood Insurance Program, often at below-market rates.

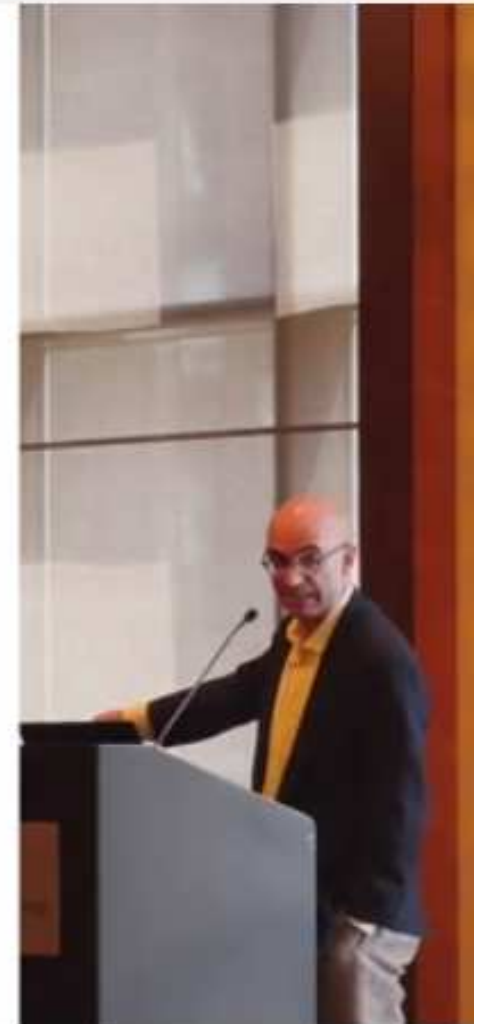
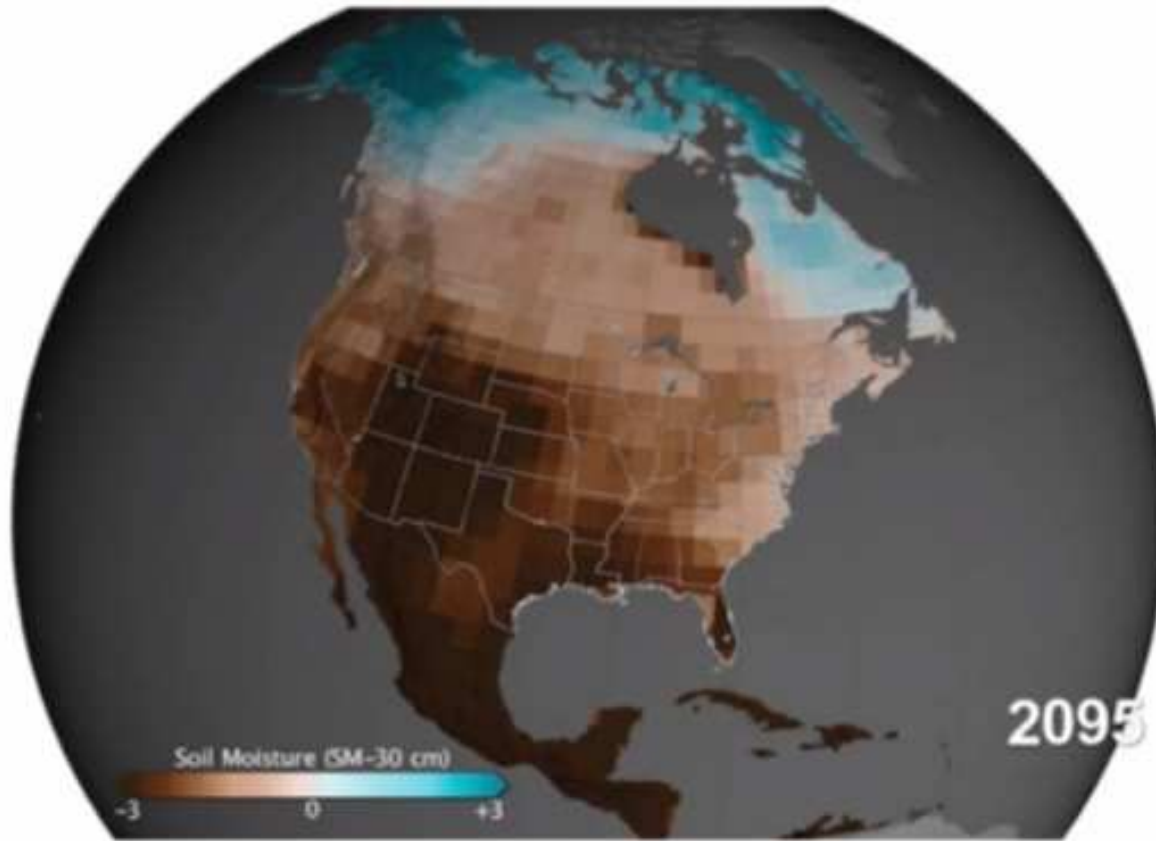


Note: Dollar values are nominal  
Source: Federal Emergency Management Agency



<https://youtu.be/P6ag3b1WCYc>

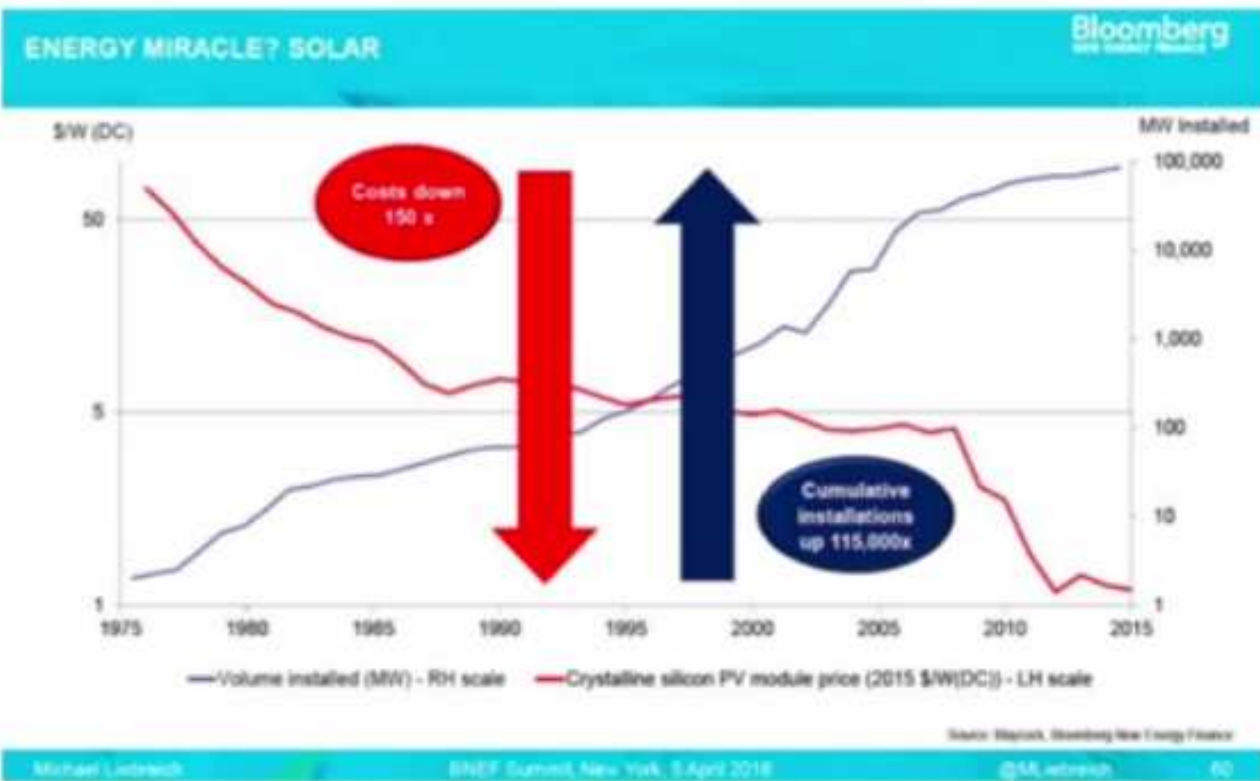
## NASA: Warming-Driven Dust-Bowlification



<https://youtu.be/P6ag3b1WCYc>



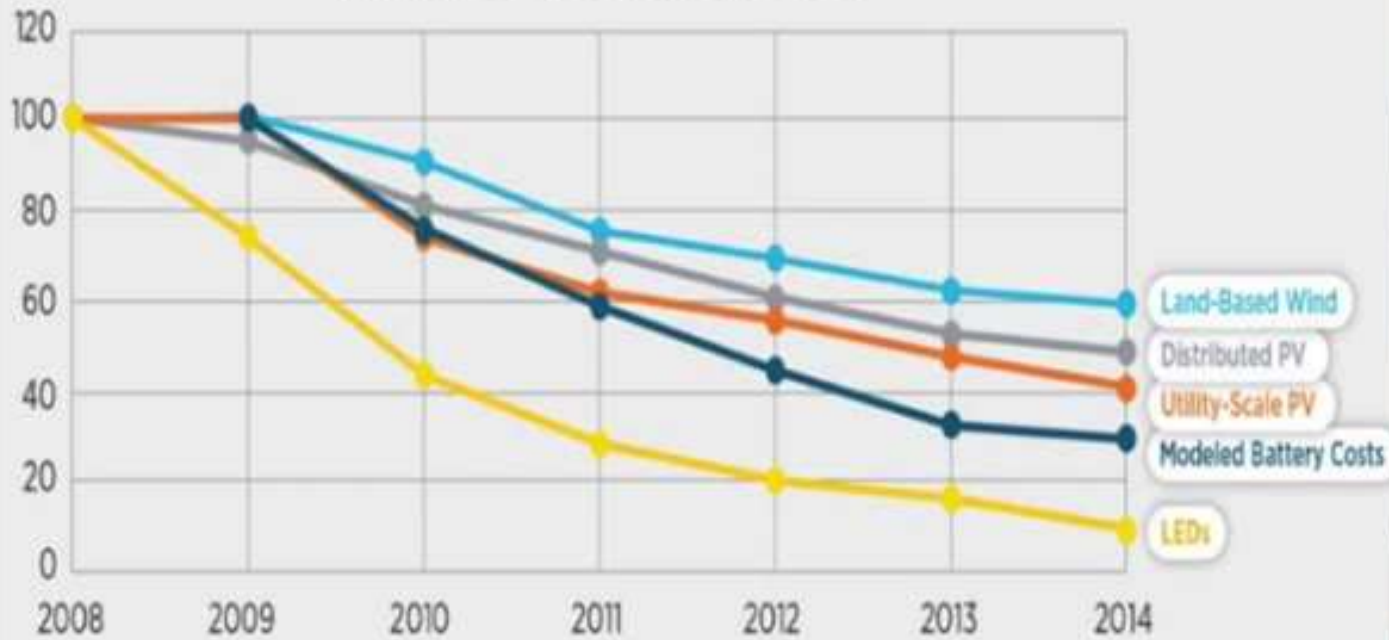
BNEF's Liebreich: "How much more miracle-y do you need your miracles to be"!



<https://youtu.be/P6ag3b1WCYc>

## Falling Costs for Clean Energy Technologies

### Indexed Cost Reductions Since 2008



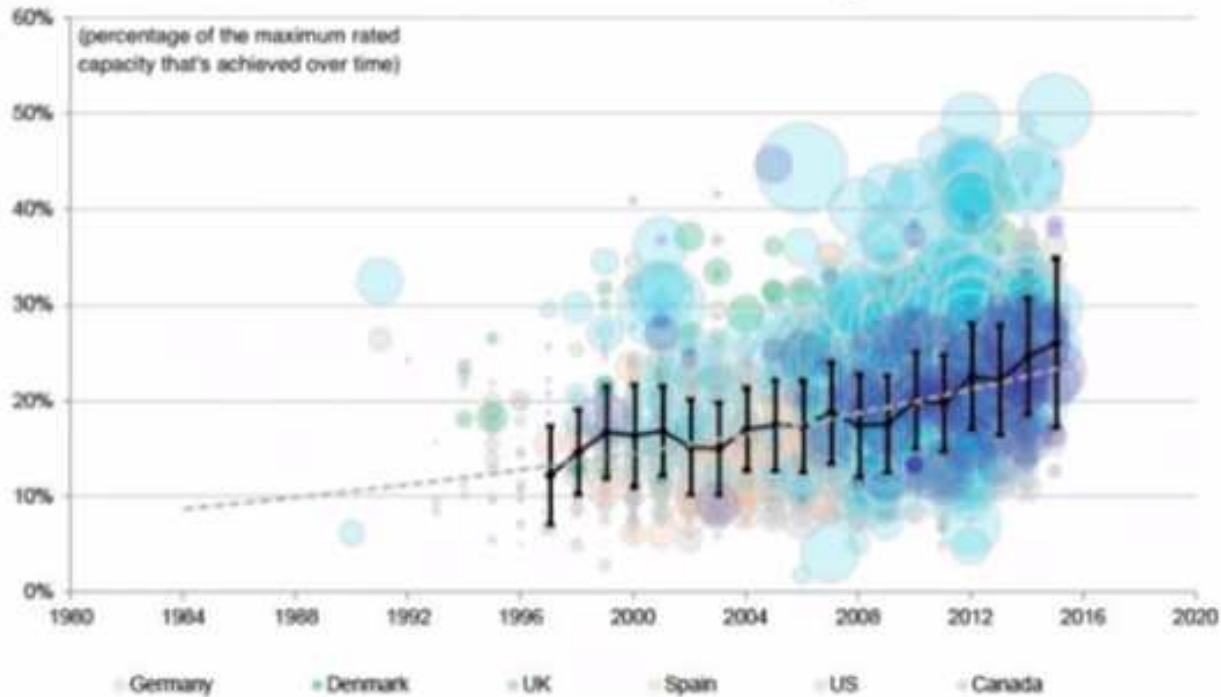
DOE, 2015



<https://youtu.be/P6ag3b1WCYc>

# The Technology Keeps Getting Better

Newer wind turbines are better at catching the breeze



*BNEF: Some wind farms generate full power the equivalent of half the time!*



# Solar Delivers Cheapest Electricity 'Ever, Anywhere, By Any Technology'

**WORLD RECORD: 3-CENT WIND, SUB-4-CENT SOLAR (UNSUBSIDISED)** 

ONSHORE WIND		SOLAR PV	
Location:	Morocco	Location:	Coahuila, Mexico
Bidder:	Enel Green Power	Bidder:	Enel Green Power
Signed:	January 2016	Signed:	March 2016
Price:	<b>US\$ 3.0 c/kWh</b>	Price:	<b>US\$ 3.6 c/kWh</b>

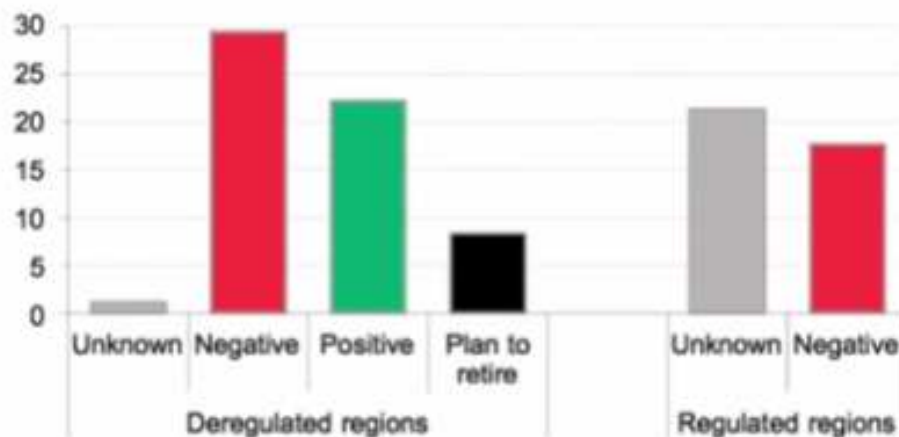
Source: Bloomberg New Energy Finance, ImageSource, Wikimedia Commons

Michael Liebreich  @MLiebreich 4



# Nuclear Power Is Losing Money At An Astonishing Rate

Figure 1: Profitability of US nuclear fleet, according to BNEF projections, 2016-19 (GW)



Source: Bloomberg New Energy Finance. Notes: Profitability is defined throughout as pre-tax earnings, based on our estimates of historical and forward power and capacity prices, and long-run costs of operating each plant.

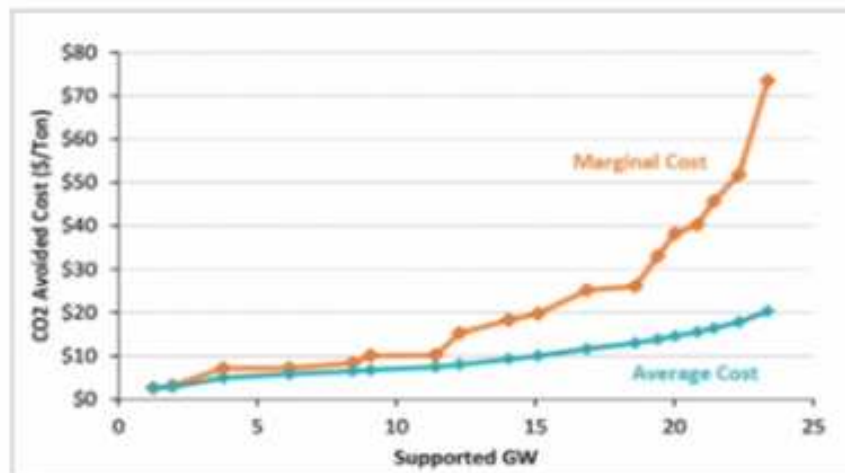


# A Small CO<sub>2</sub> Price Saves Nuclear Fleet

## Marginal and Average Cost of CO<sub>2</sub> Avoided

About half of the threatened nuclear fleet could be supported with an average cost per ton of CO<sub>2</sub> avoided below \$10/ton; while the most expensive reductions would be about \$75/ton, the average cost would be \$20/ton:

Costs of Avoided CO<sub>2</sub> From Retaining Merchant Nuclear Plants



# Nuclear Has Priced Itself Out Of Market

HINKLEY C PROJECTED POWER COST  
(GBP/MWH)

Bloomberg

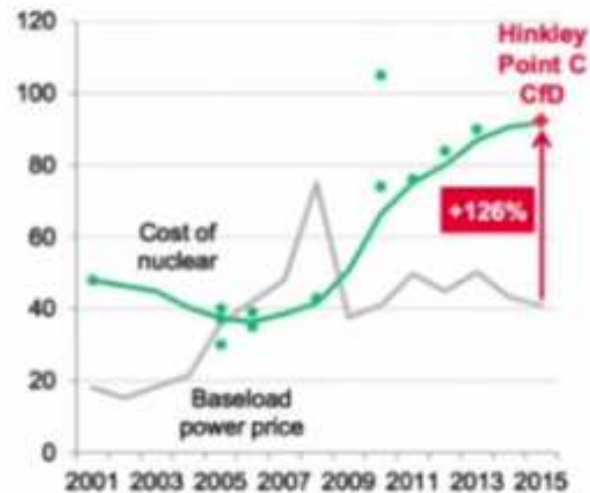


Image: EDF. Source: E.ON, Piersa Brinckerhoff, M&M, McDonald, E.ON, EDF, Centrica, Bloomberg New Energy F

Michael Liebreich

BNEF Summit, New York, 5 April 2016

© M. Liebreich

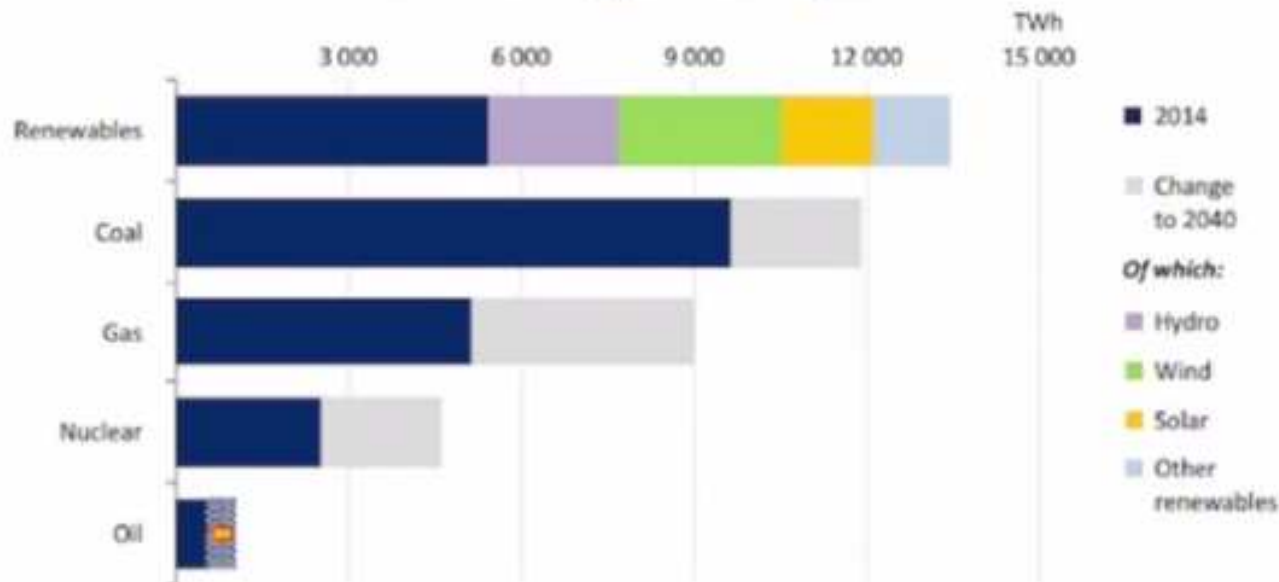
53

The French couldn't even build an affordable, on-schedule next generation nuke in their own nuclear-friendly country! **"Initially expected to cost €3bn and start operations in 2012, it will not start until 2018 at a cost of €10.5bn"**



# IEA: By 2030, Renewables Will Be The World's Primary Power Source

Global electricity generation by source



*Driven by continued policy support, renewables account for half of additional global generation, overtaking coal around 2030 to become the largest power source*





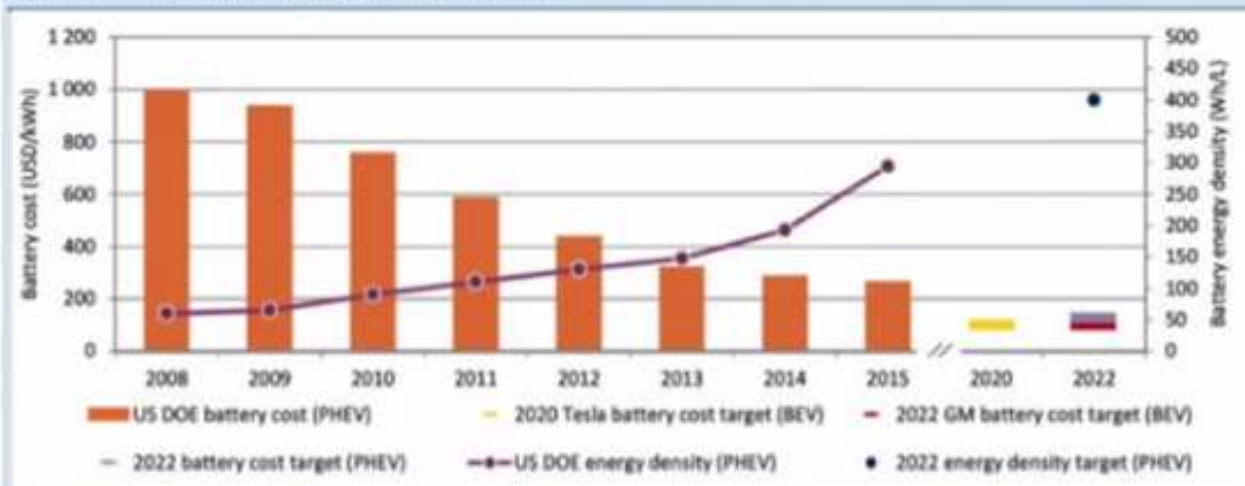
## Renewable 'Variability' & Integration Issues Solved With Existing Technology

- Transmission
- Day-ahead forecasting
- Demand response
- Large-scale storage (hydro, big batteries, CSP)
- Electric vehicles + load shifting
- Small-scale battery storage
- Large thermal storage
- Sure, keep some natural gas plants!



# The Battery Deployment 'Miracle'

Evolution of battery energy density and cost



Note: PHEV battery cost and energy density data shown here are based on an observed industry-wide trend, include useful energy only, refer to battery packs and suppose an annual battery production of 100 000 units for each manufacturer.



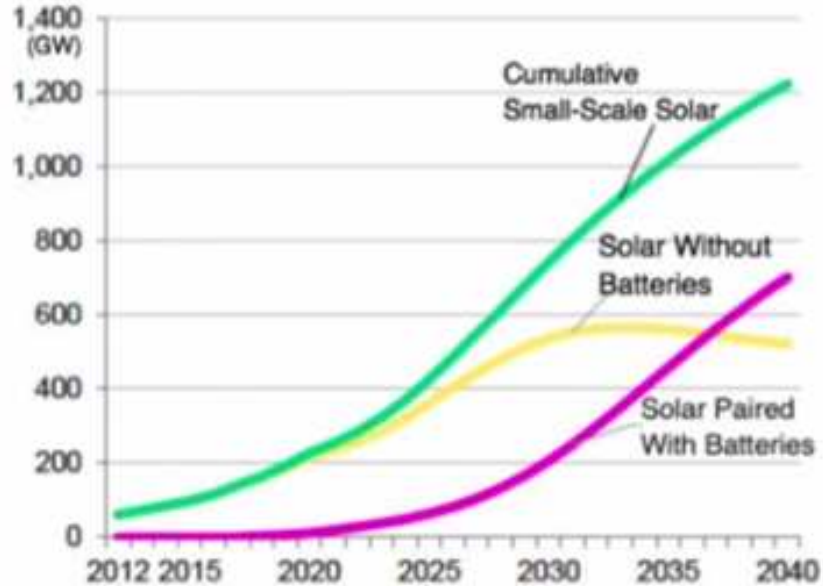
# The EV Deployment 'Miracle'



# Renewable Penetration With Small Batteries

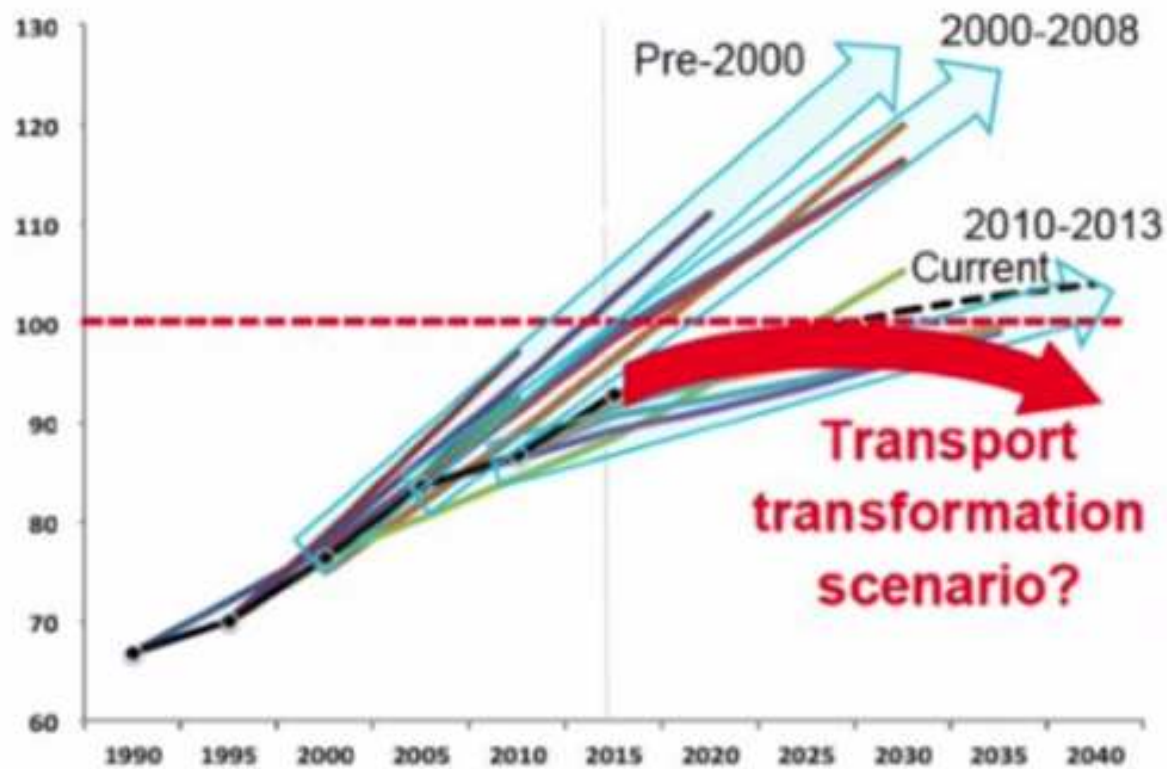
## Here Come the Batteries

Electricity storage will come standard with rooftop solar by the 2030s



# Peak Oil ... Demand

## Declining Prospects for Oil



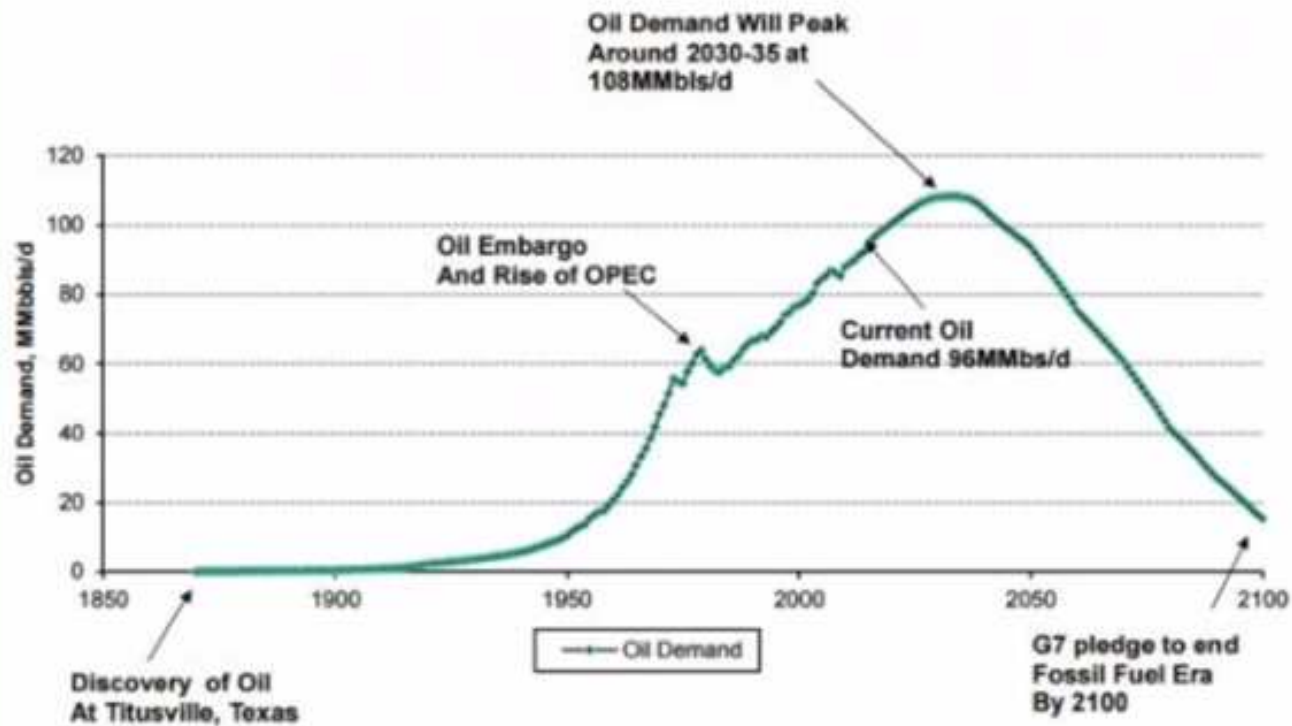
■ Forecasts in millions of barrels per day. Black line shows actual supply to date and 2014 IEA forecast. Source: IEA, 2012



# Peak Oil Demand

Exhibit 1

Oil Era Is Not Over – But The Peak Could Be In 15-20 Years

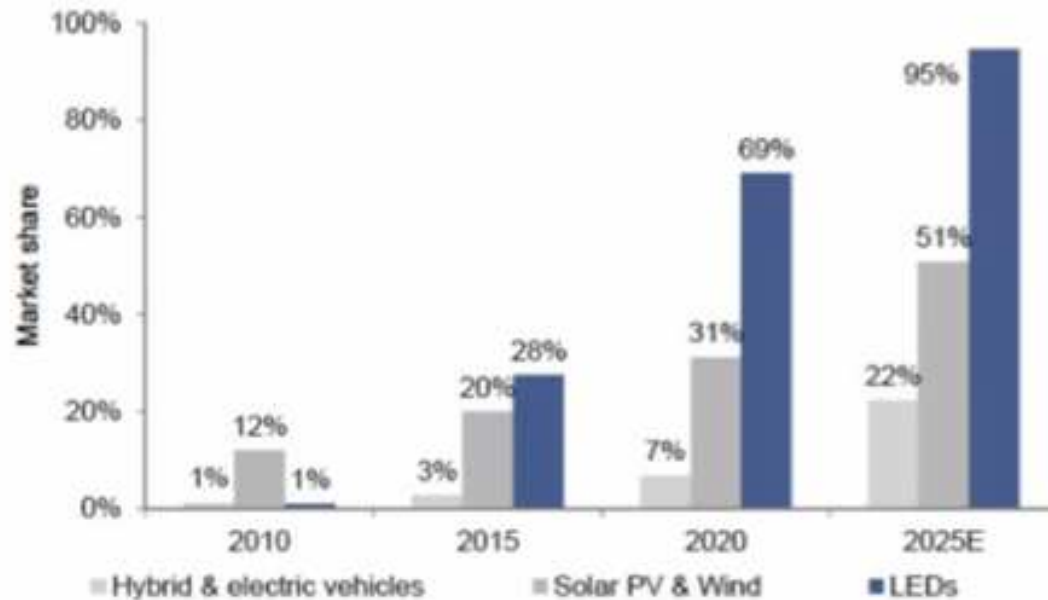


Source: BP Statistical Review, and Bernstein estimates (2016 and beyond) and analysis.



**Exhibit 19: The rapid adoption of LEDs in lighting marks one of the fastest technology shifts in human history.**

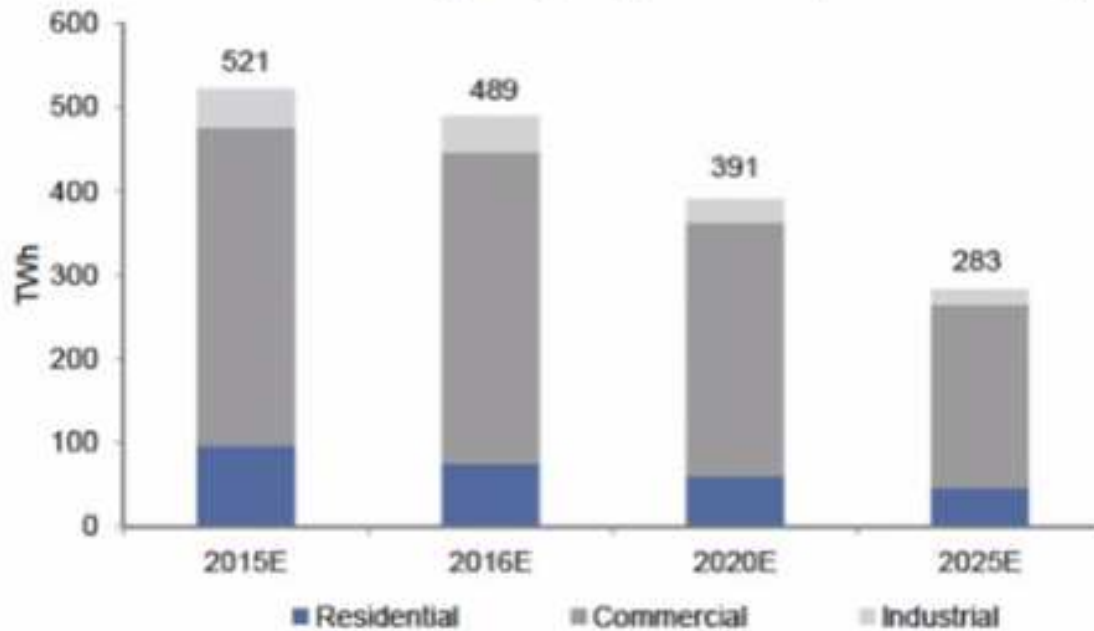
LEDs for general lighting were commercialized only recently, but will dominate sales by the end of this decade



Source: IHS, Company data, IEA, IRENA, BP, Goldman Sachs Global Investment Research.



**Exhibit 54: ...and are on track to cut power consumption for lighting (17% of total) by over 40%. As LED lighting rapidly penetrates the the installed base, US power demand for lighting begins to drop substantially**



*Source: Goldman Sachs Global Investment Research.*



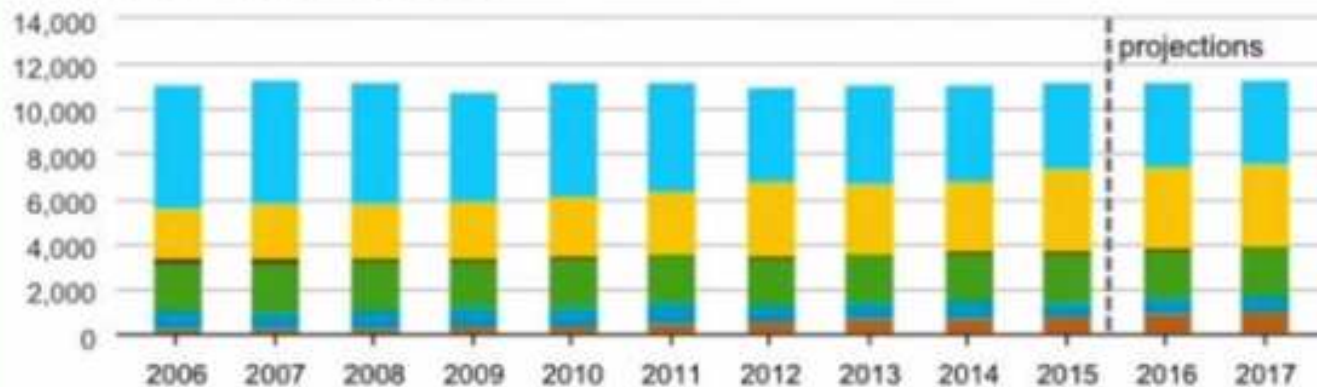


# Amory Lovins Was Right, Part 1: Electricity Demand Stays Flat For Foreseeable Future

## U.S. Electricity Generation by Fuel, All Sectors

 [DOWNLOAD](#)

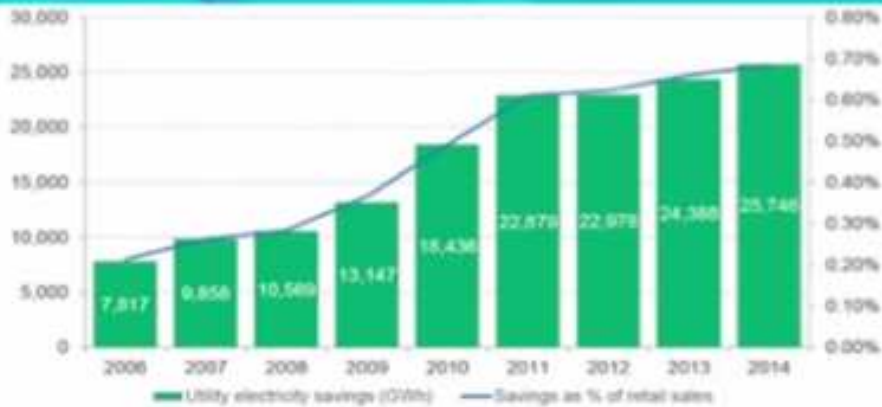
(thousand megawatthours per day)



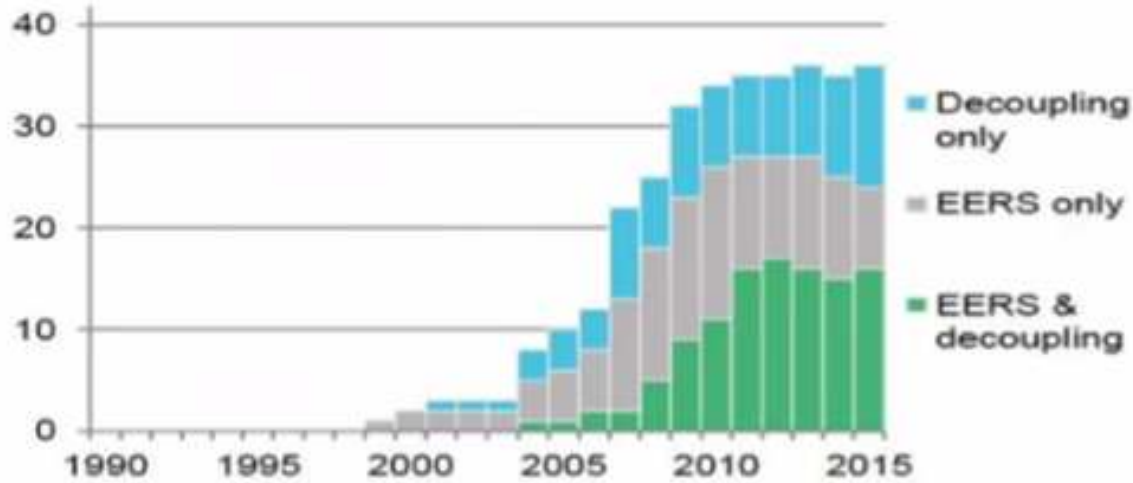
*Coal (blue), gas (yellow), new renewables (orange), nuclear (green)*



**Incremental annual energy efficiency achievements by electric utilities to date (GWh)** **Bloomberg**  
NEW ENERGY FINANCE

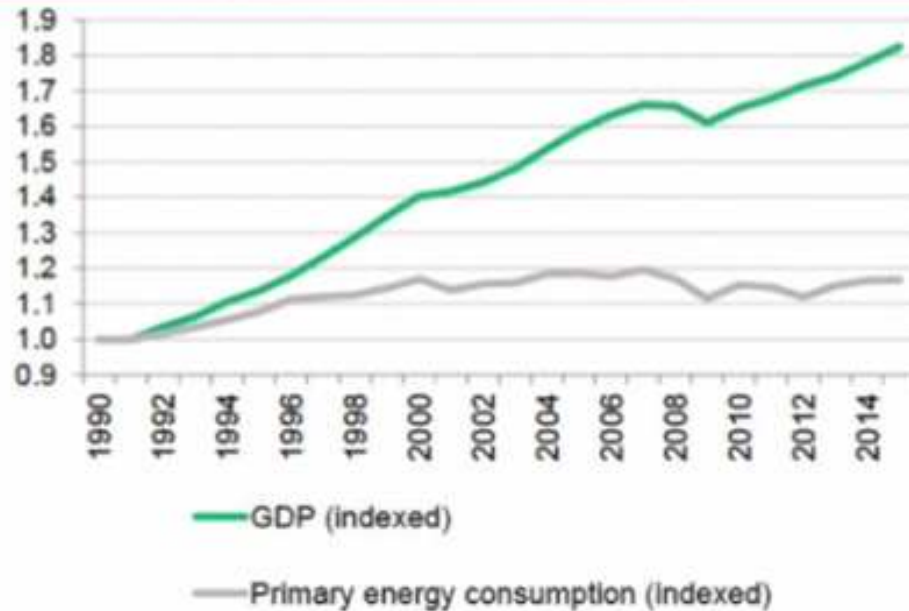


# of states

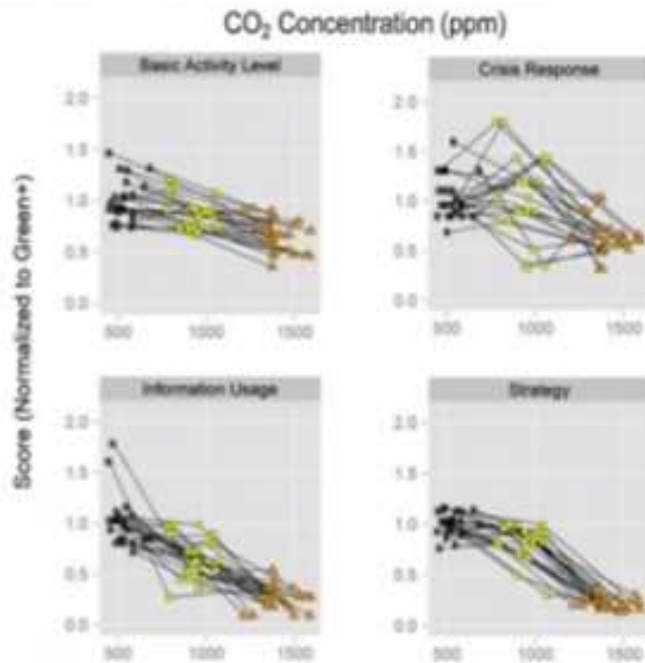


## Amory Lovins Was Right, Part 2 Energy Demand Decouples From GDP

US GDP and primary energy consumption  
(indexed to 1990 levels)



## How CO2 Levels Affect Human Cognition



Normalized cognitive function scores by participant and corresponding CO<sub>2</sub> levels in their cubicle. The Green+ case had CO<sub>2</sub> in the 500 ppm range due to high levels of outside air. It was compared to office settings in the 930 ppm range (yellow squares) and in the 1400 ppm range (orange triangles).

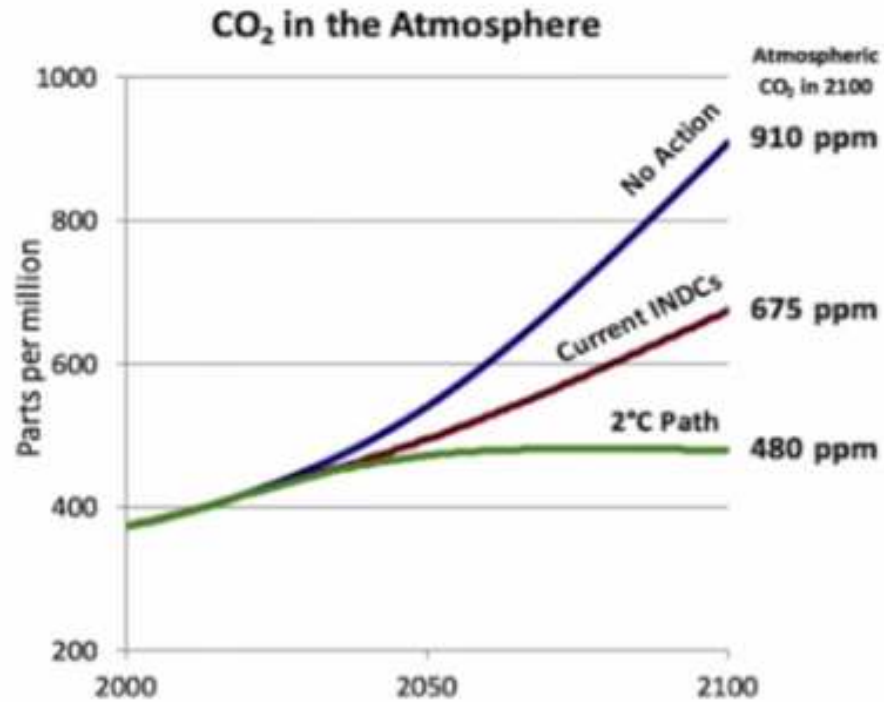
● Green+ ■ Medium CO<sub>2</sub> ▲ High CO<sub>2</sub>

Source: Allen et al (2016), Indoor Health Project

CLIMATEPROGRESS



# Why Climate Action Matters



Climate Interactive for ClimateProgress, 2015 | ClimateScoreboard.org



# #PUTAPRICEONIT

## *“Years of Living Dangerously,”* Season 2

### **Why do we need a price on carbon?**

When companies have to pay to pollute, they create less pollution.

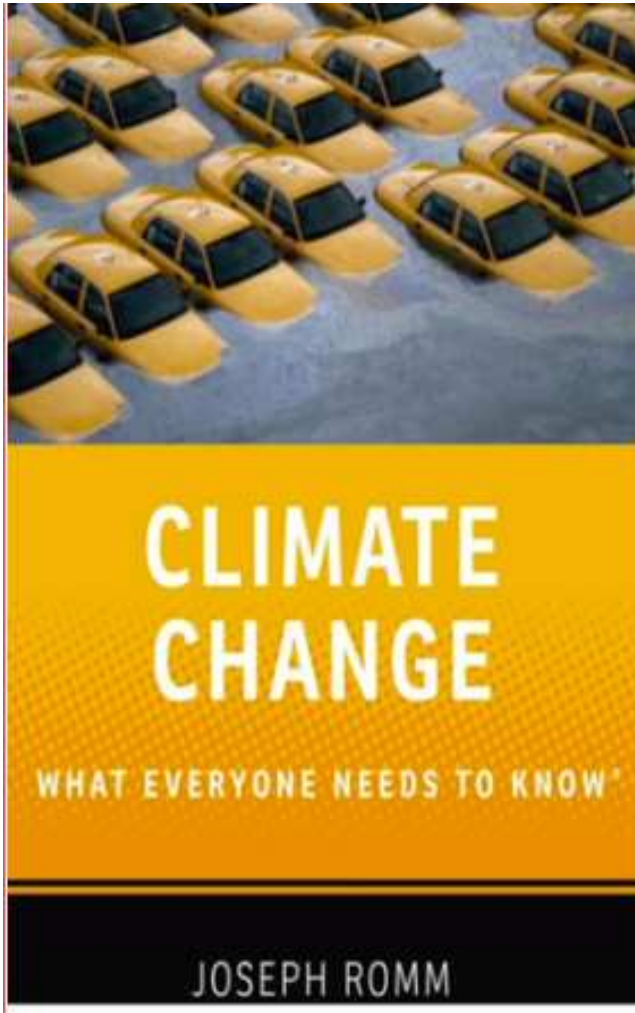
A price on carbon makes renewable forms of energy more affordable.

Anywhere you put a price on carbon you create jobs and generate revenue.

It's been proven to work in dozens of jurisdictions across the world.

**VISIT [THECLIMATESOLUTION.COM](http://THECLIMATESOLUTION.COM) TO JOIN  
STUDENTS ACROSS THE COUNTRY WHO ARE  
WORKING TO #PUTAPRICEONIT.**





Gore: “Cleantech  
revolution bigger than  
industrial revolution  
and information  
revolution combined.”

ClimateProgress.org



<https://youtu.be/P6ag3b1WCYc>

- Captured from youtube video <https://youtu.be/P6ag3b1WCYc>
- Strictly for educational purposes
- 
- Paul Belanger, Geologist/Paleoclimatologist, Ph.D.
- **For sustainability, climate and related issues, including solutions**
- **For those that say “it can’t be done” I say: Stay out of the way of those that are DOING IT!**
- <http://denverclimatestudygroup.com/> and on Facebook
- <https://www.facebook.com/denverclimatestudygroup/>
- [pebelanger@glassdesignresources.com](mailto:pebelanger@glassdesignresources.com)
- 21946 Panorama Dr
- Golden, CO 80401
- c. 303-249-7966; h 303-526-7996