

“A Good Story Is a Miracle”

-- Stanley Kubrick

MIT Symposium on CCS Retrofit Technology

J. Wayne Leonard
Chairman and Chief Executive Officer
March 23, 2009



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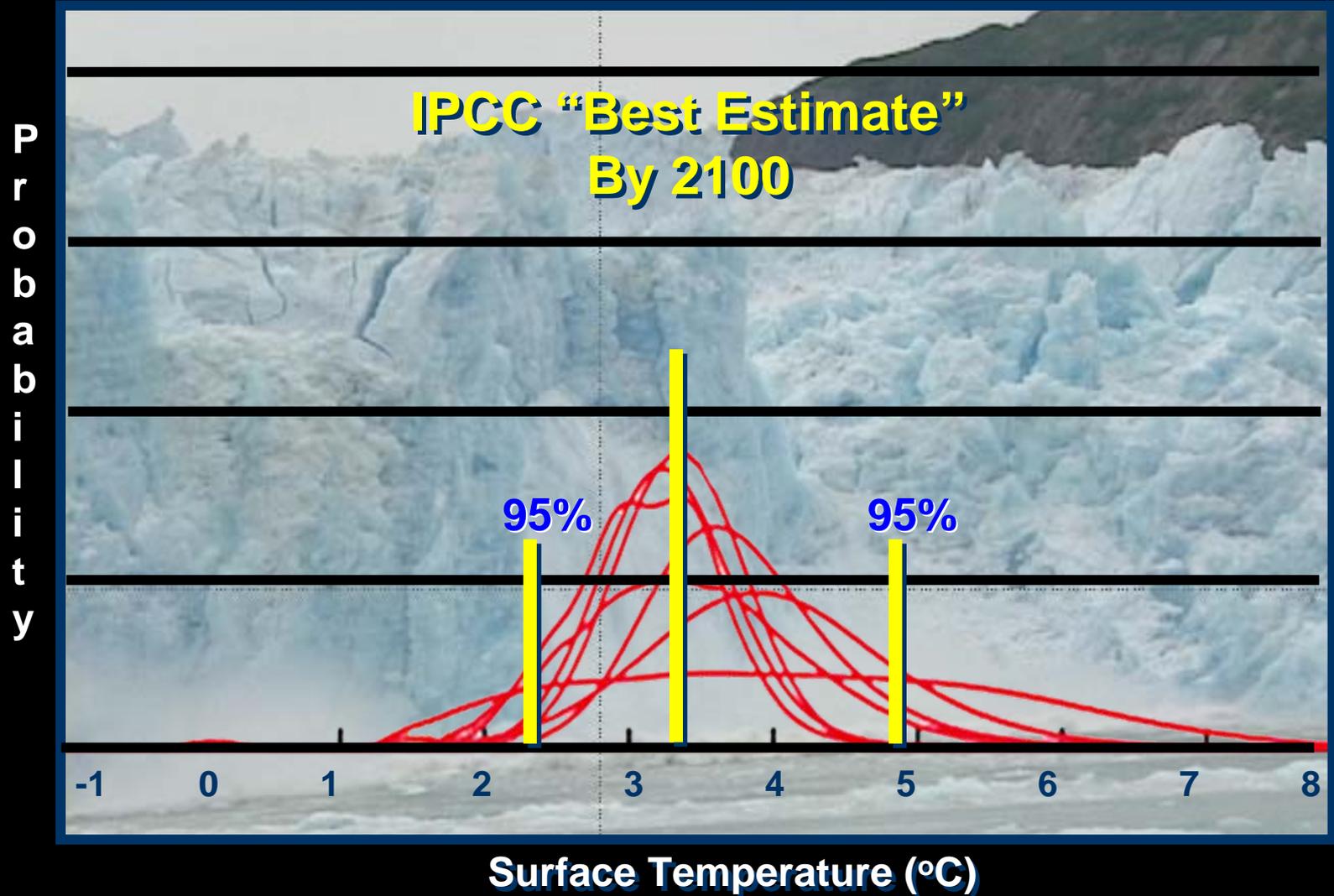
Forward-looking statements involve a number of risks and uncertainties. There are factors that could cause actual results to differ materially from those expressed or implied in the forward-looking statements.

The Princess Bride *As you wish.*



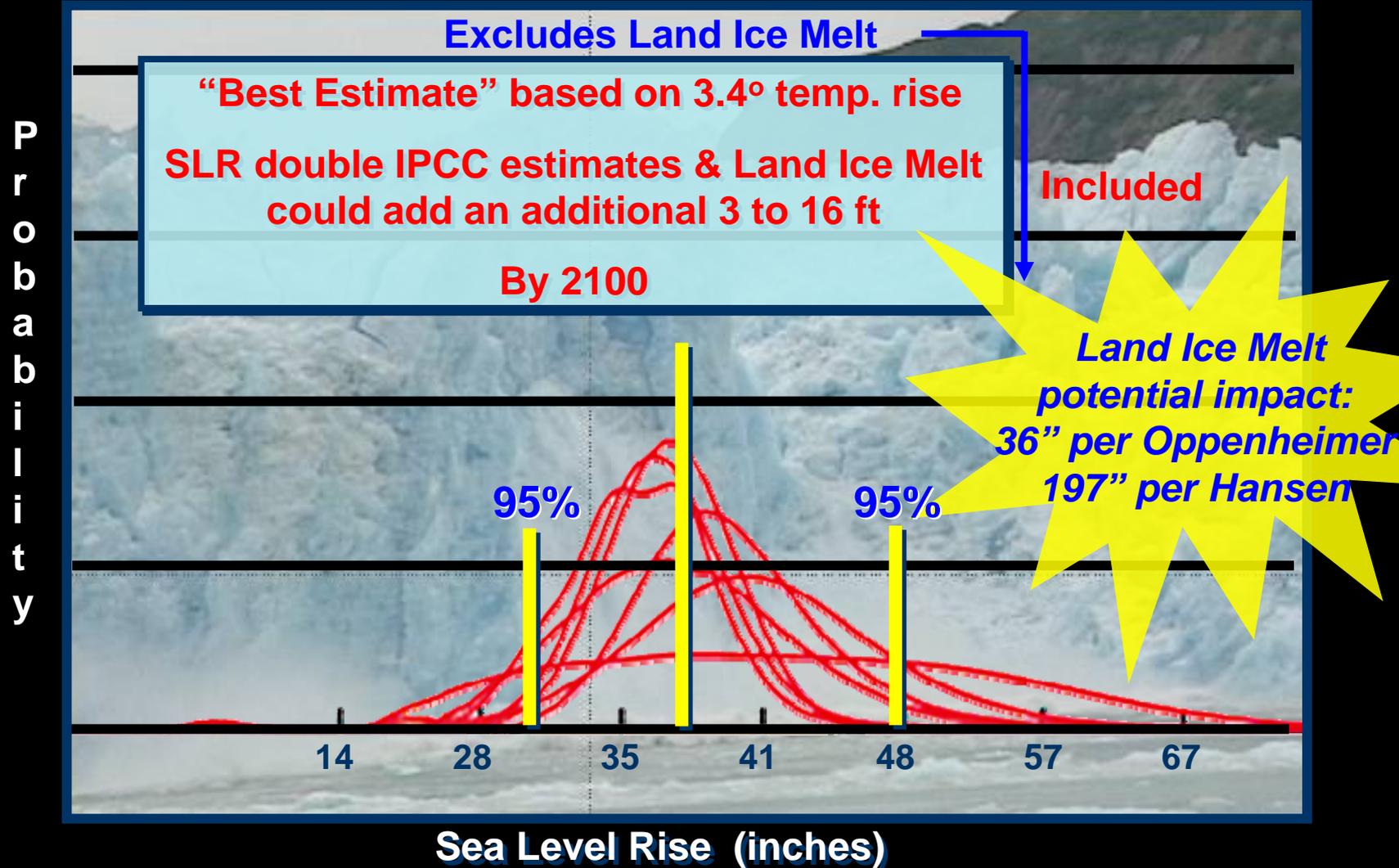
Since the invention of the kiss, there have been five kisses that were rated the most passionate, the most pure. This one left them all behind.

Fat Tails – Surface Temperature



Adapted from Intergovernmental Panel of Climate Change (IPCC) Fourth Assessment Report (AR-4) Fig SPM 5

Fat Tails – Sea Level Rise



IPCC AR-4 without land ice melting = 7” to 23” (Third Assessment Report (TAR) 4” to 35” from land ice melt)

Adapted from IPCC AR-4 Fig SPM 5 – Using Rahmstorf Empirical Formula (Rahmstorf, et al 2007)

Biodiversity

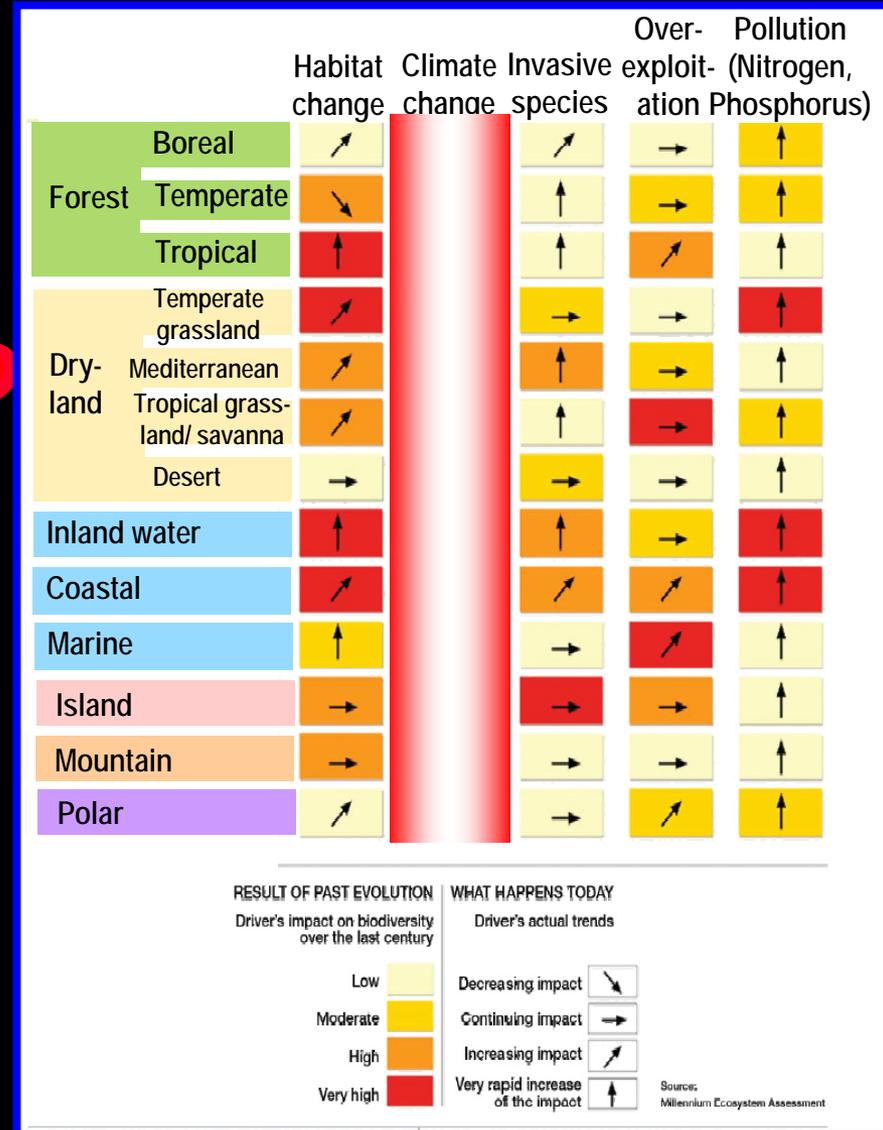


Every 20 minutes,
a species disappears

At current rates, one-half of all species of life on Earth will be extinct in 100 years

- Two primary and interlinked causes
 - habitat destruction, which already affects 90% of threatened species and
 - climate change which will accelerate future change
- There is a complex, delicate, evolved interrelationship between species and ecosystems
- Temperatures, onset of seasons, food and water availability are impacted by subtle changes in climate

Source: Millenium Ecosystem Assessment; IPCC



Security

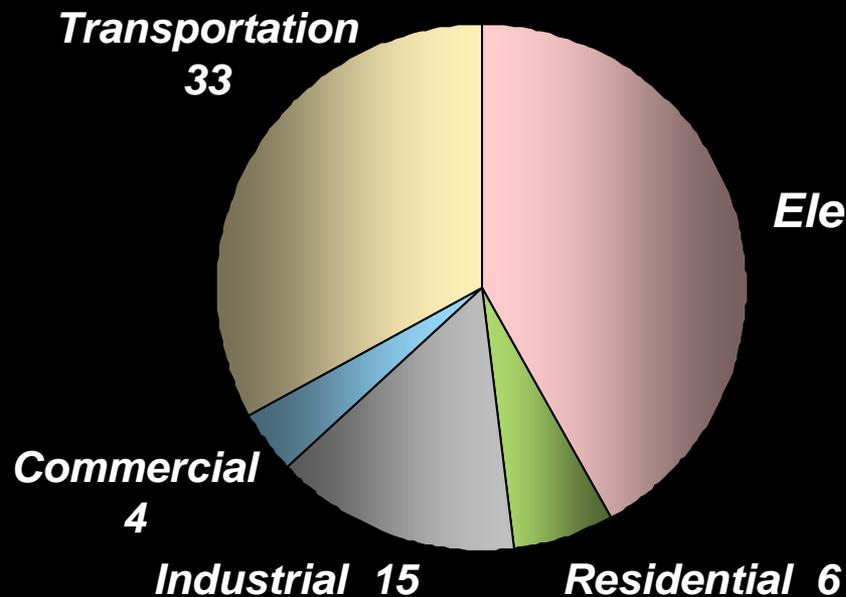
Testimony Before
Committee on Energy & Commerce
June 26, 2008

...Climate change acts as a threat multiplier
for instability in some of the most
volatile regions in the world.

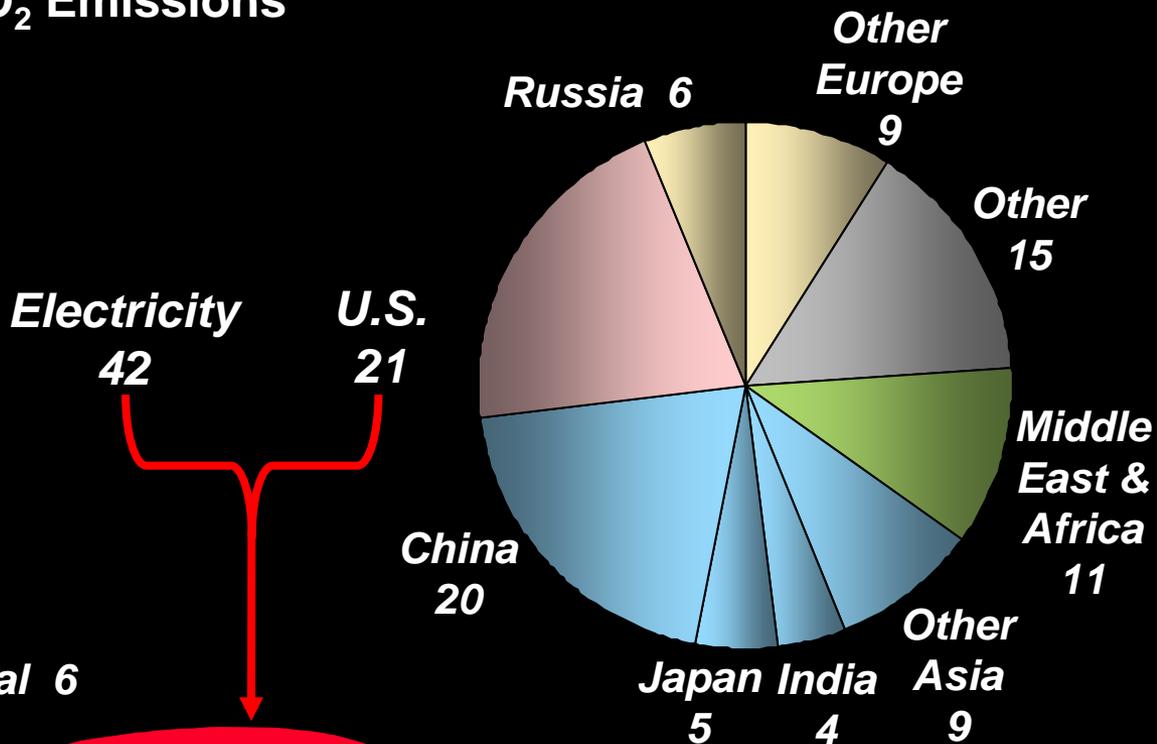
-- *Military Advisory Board*

Emissions

United States CO₂ Emissions % of total



World CO₂ Emissions % of total



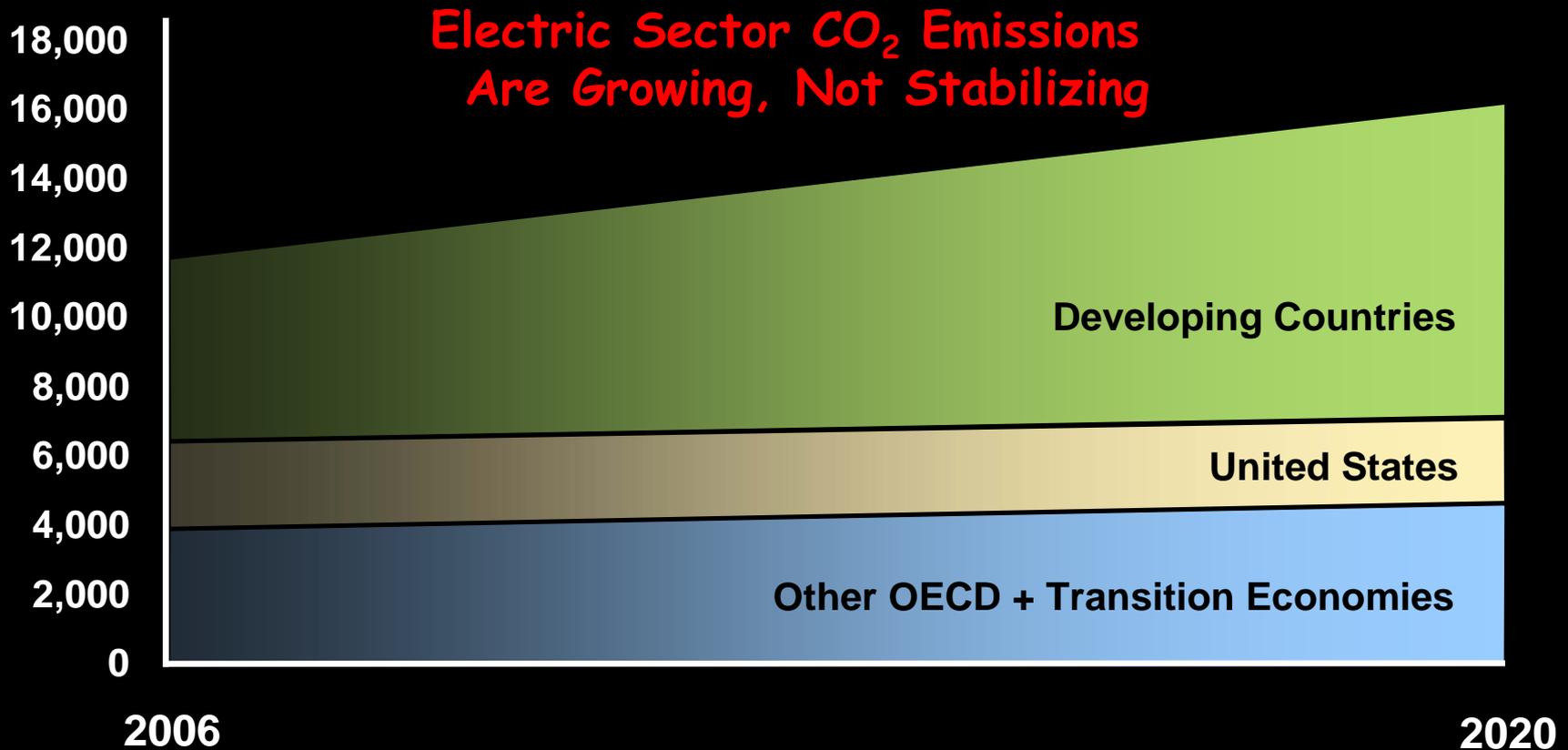
~9% of World's Emissions

Source: EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2007, Table ES-3

Source: Climate Analysis Indicators Tool (CAIT) Version 6.0. (Washington, DC: World Resources Institute, 2009)

A Little Short of Brotherly Love

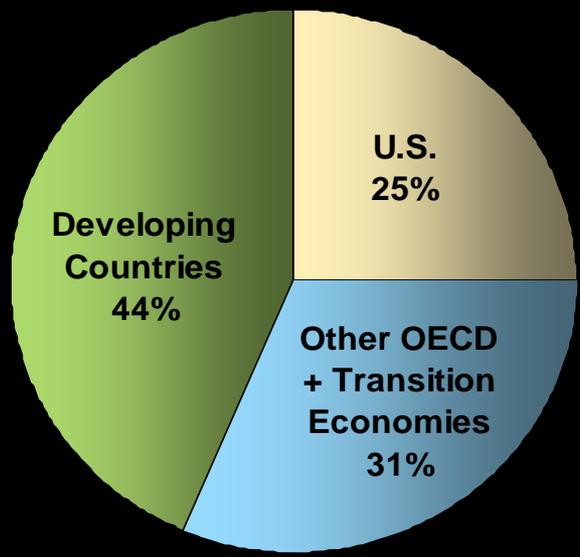
Global Electric Sector
CO₂ Emissions Forecast: BAU – No CO₂ Regulation
Million Metric Tons CO₂



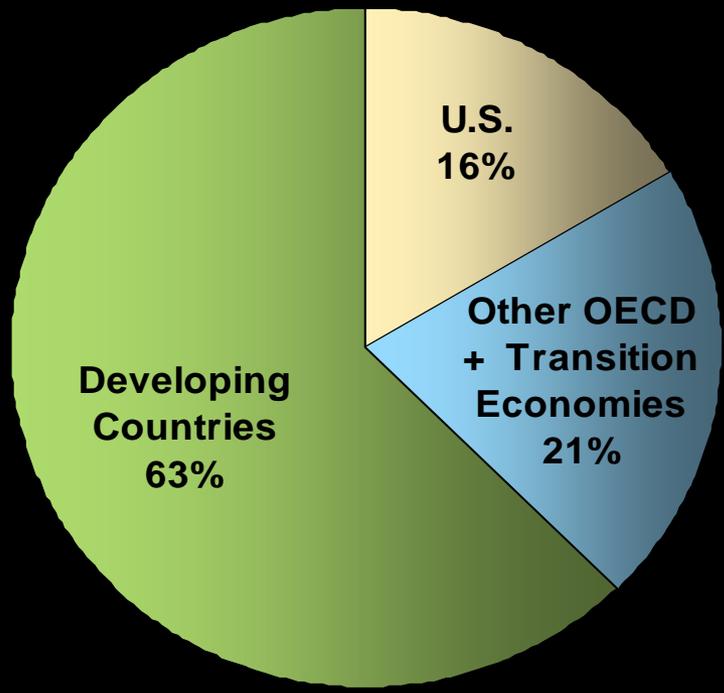
Source: IEA World Energy Outlook 2008 (Reference Case)

Growing Worldwide Coal Capacity Will Exceed 2 Million MW by 2020

New Coal Capacity in the Developing World Is Driving This Growth



2005: 1,333 GW

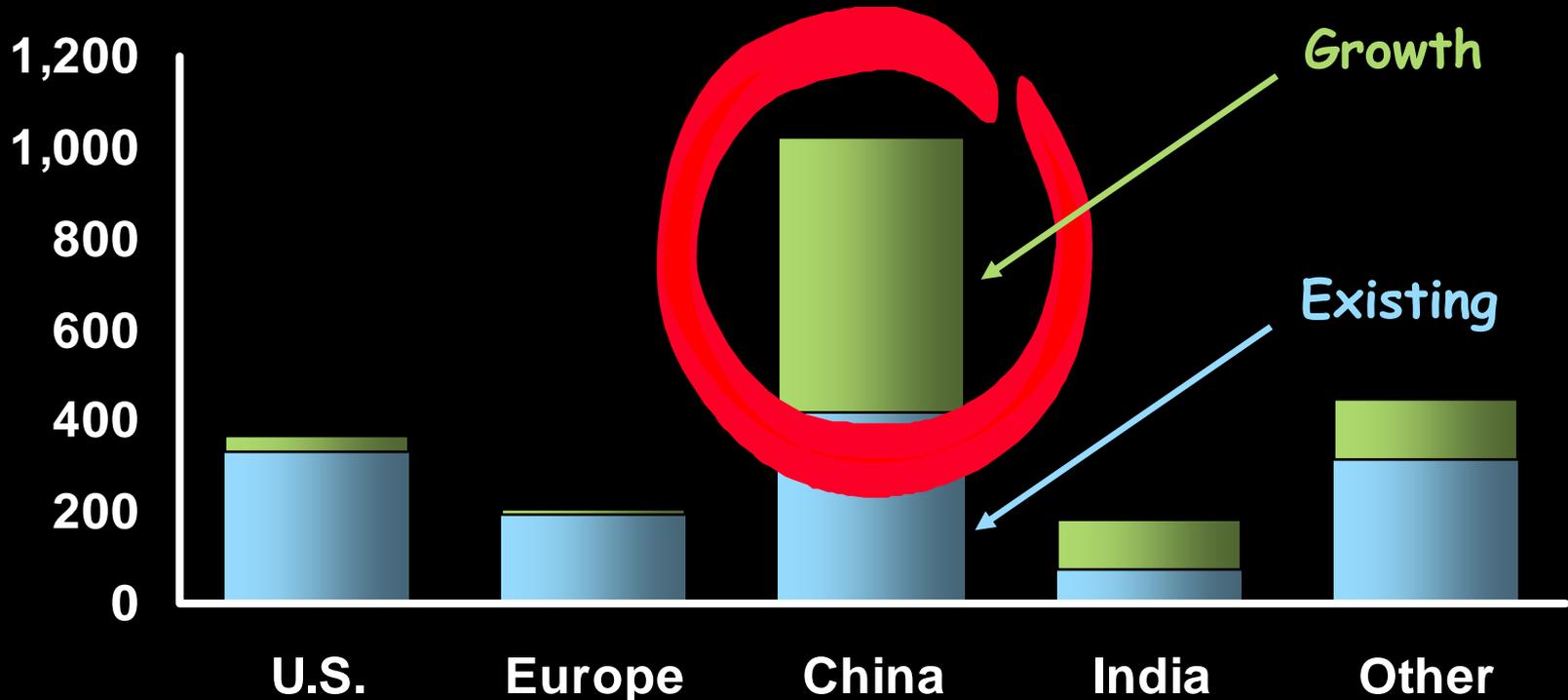


2020: 2,232 GW

Source: IEA World Energy Outlook 2008 (Reference Case)

We Can Fight or Give-up

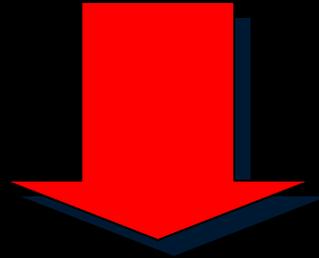
Installed Coal Capacity
2005 – 2020; GW



The China Test

The Challenge

We Don't Control Our Own Destiny



We Need to Plan Our Response with
the Developing World in Mind

Alternatives

Do Nothing

Go Slow(er)

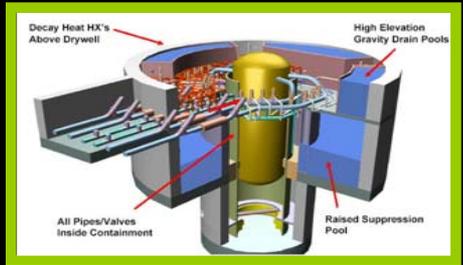
OR

Replace Coal With

Nuclear

Gas

Renewables



The Secret of Success... Prayer

Cost of Not Dealing With Climate Change Now:

- Creating a 5°C warmer world by 2100
- Irreversible commitment to sea level rise inundating low lying coastal areas
- Increased coastal flooding impacting up to 30 million people/year
- Increased damage from storms impacting up to 15 million people/year
- Global food shortages as adaptive capacity exceeded in low latitudes and yield decreases in higher latitudes
- Increased burden on health from malnutrition, cardio-respiratory and infectious diseases
- Water scarcity for up to 15 million people
- Catastrophic events

China test? Not a chance

Illustrative

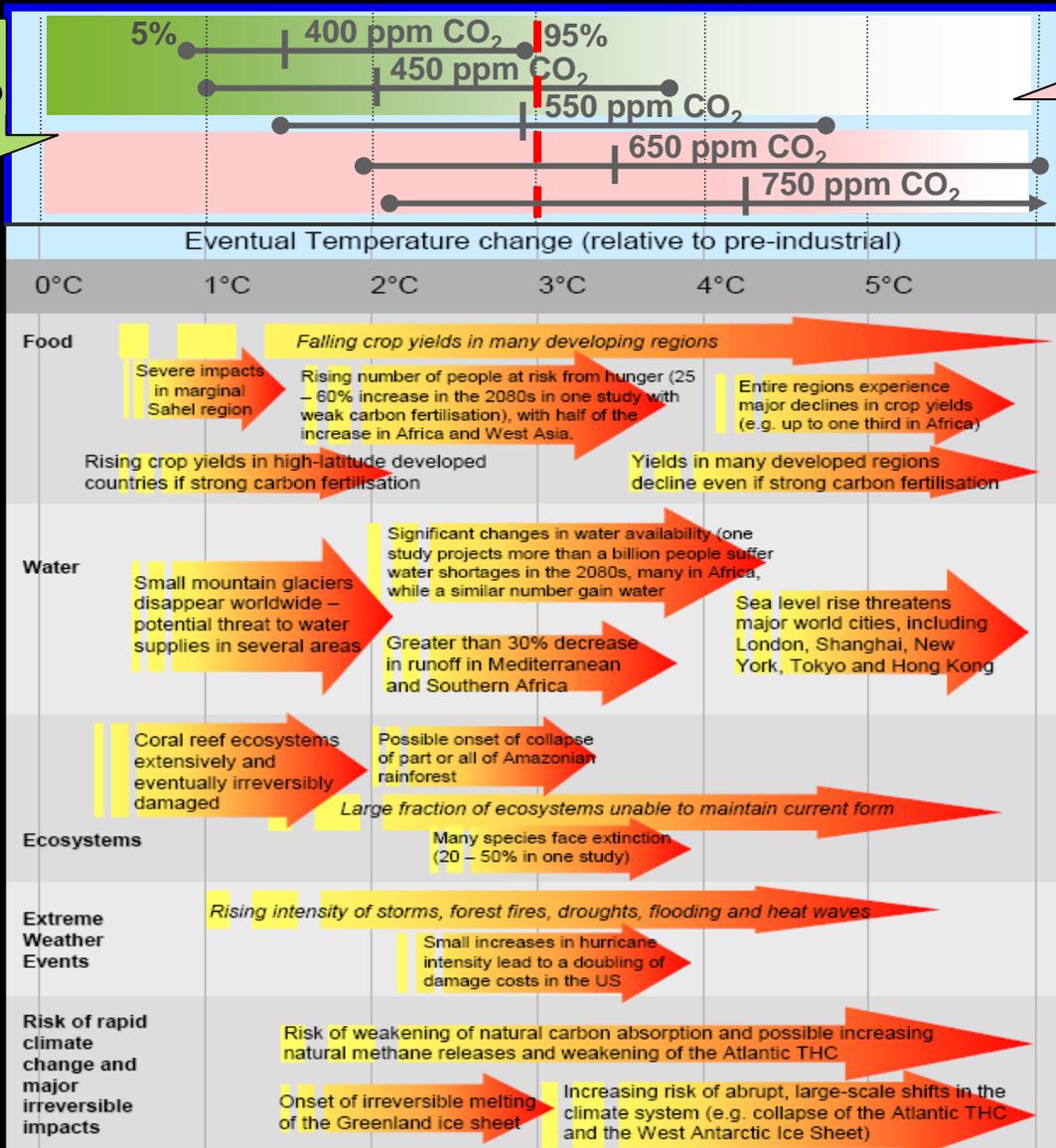
GDP Loss %



The Challenge - Alternatives

Go Slow(er)

Warner Lieberman 80% < ~3°



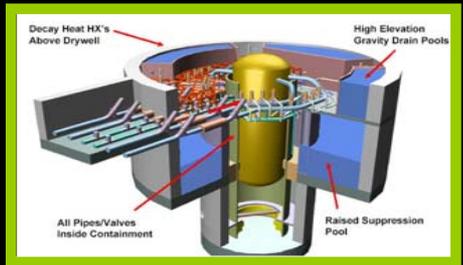
Illustrative
80% > 3° G8 Target

Source: Stern Review - Economics of Climate Change; Various Assumptions and Forecasts

Facing Economic Reality Two Million MWs of Existing Coal

Replace Coal With

Nuclear



Gas



Renewables

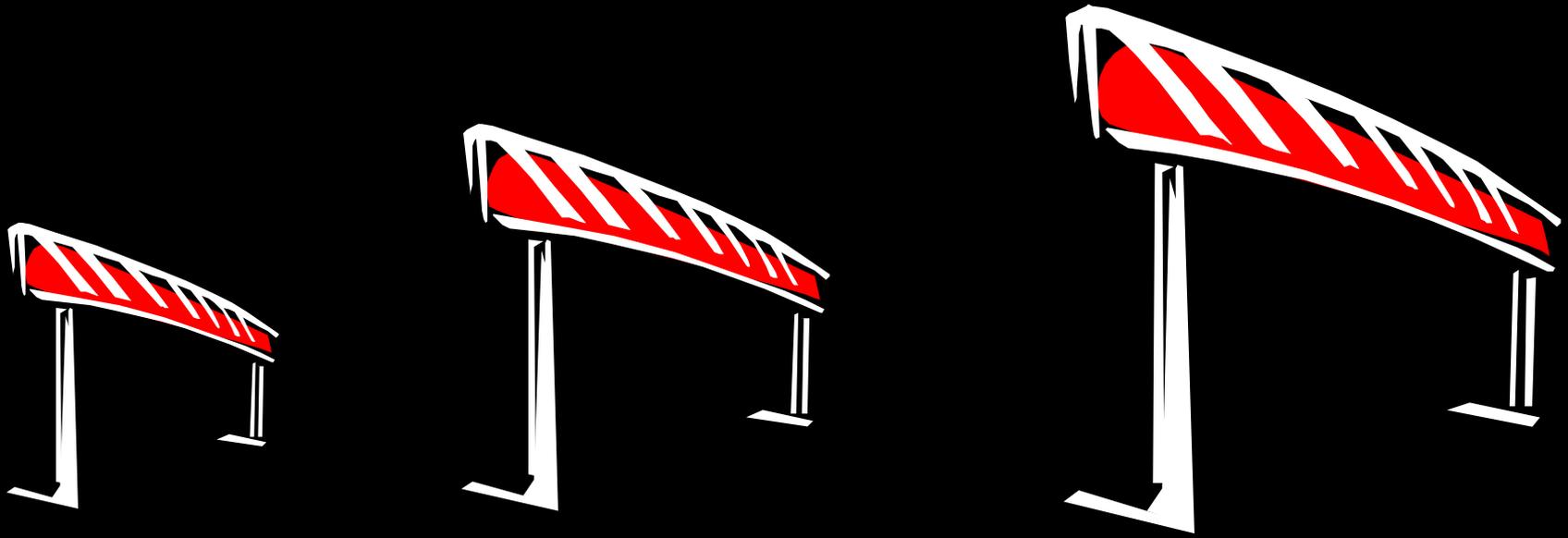


-- everything is harder than it used to be – you got to plan more, you got to prepare, you got to be damn sure what you're doing or you're dead.

It's Bad Business – If Every Job Lost Money

Basic Economics

The **Hurdle** to Replace Existing Plants –
Only the Marginal Costs Count

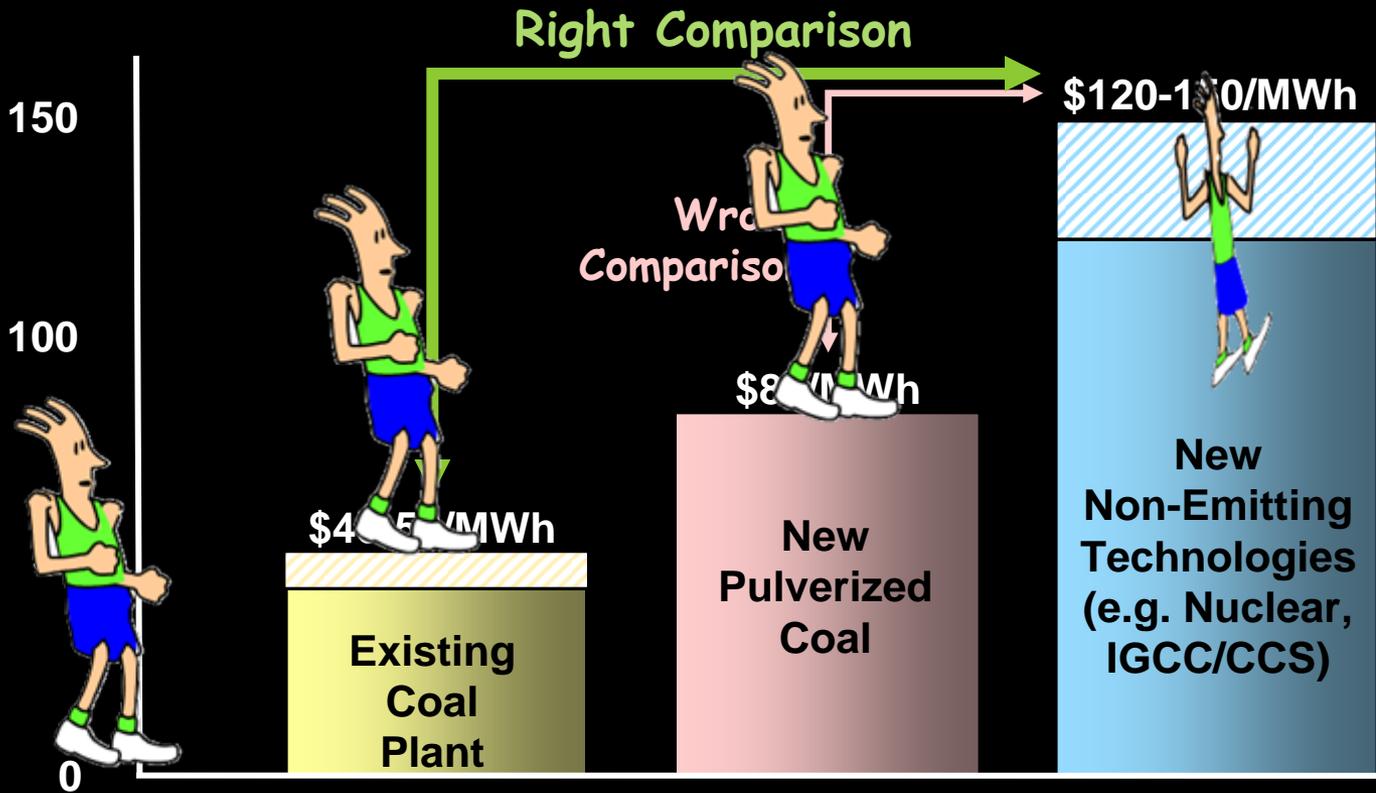


Every Day You Get Older – That’s a Law

Comparison of **“To Go”** Investment to Keep a Coal Plant Operating vs. All-In Cost to Replace It with New Capacity
Lifetime Costs in 2020 \$

But...

Coal Plants Don't Retire

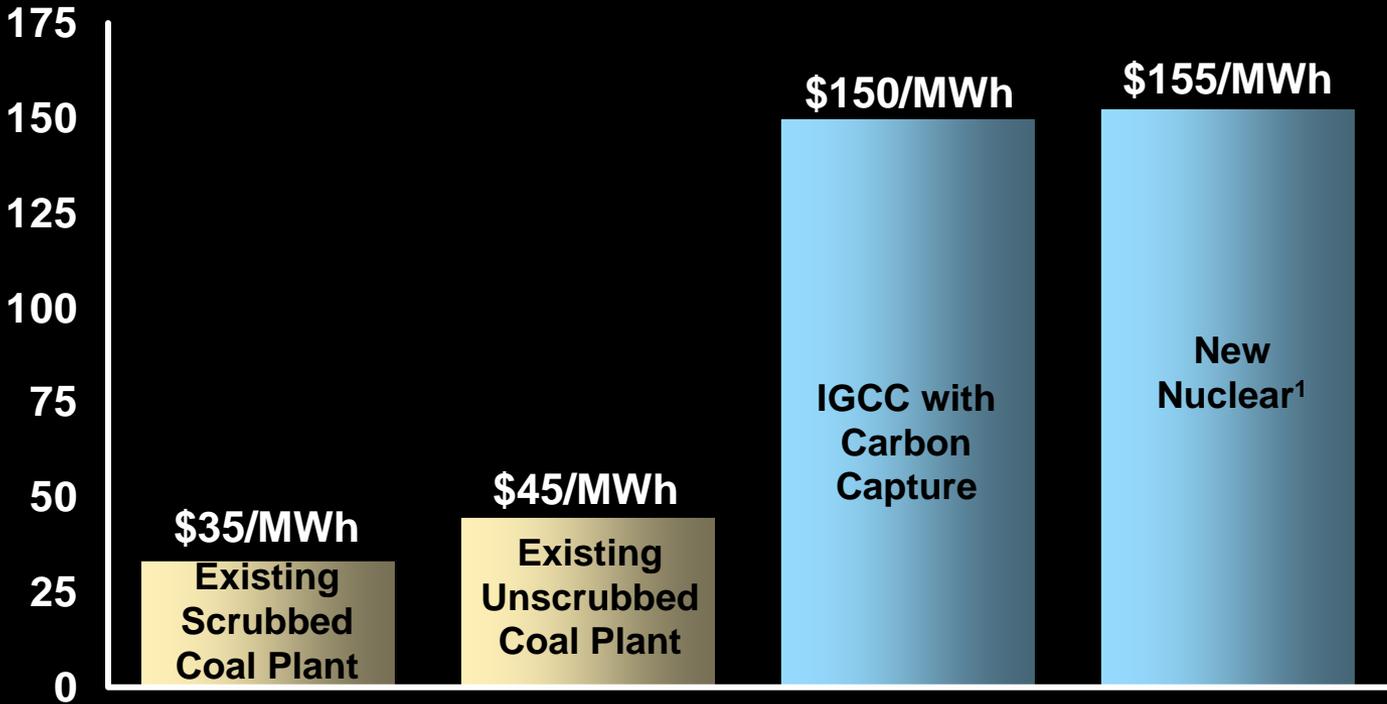


If we don't understand coal economics, we are unlikely to get the policies right

Source: NorthBridge Analysis

Replace Coal with Nuclear

Comparison of **“To Go”** Investment to Keep a Coal Plant Operating vs. All-In Cost to Replace It with New Capacity
Lifetime Costs in 2020 \$



The China Test

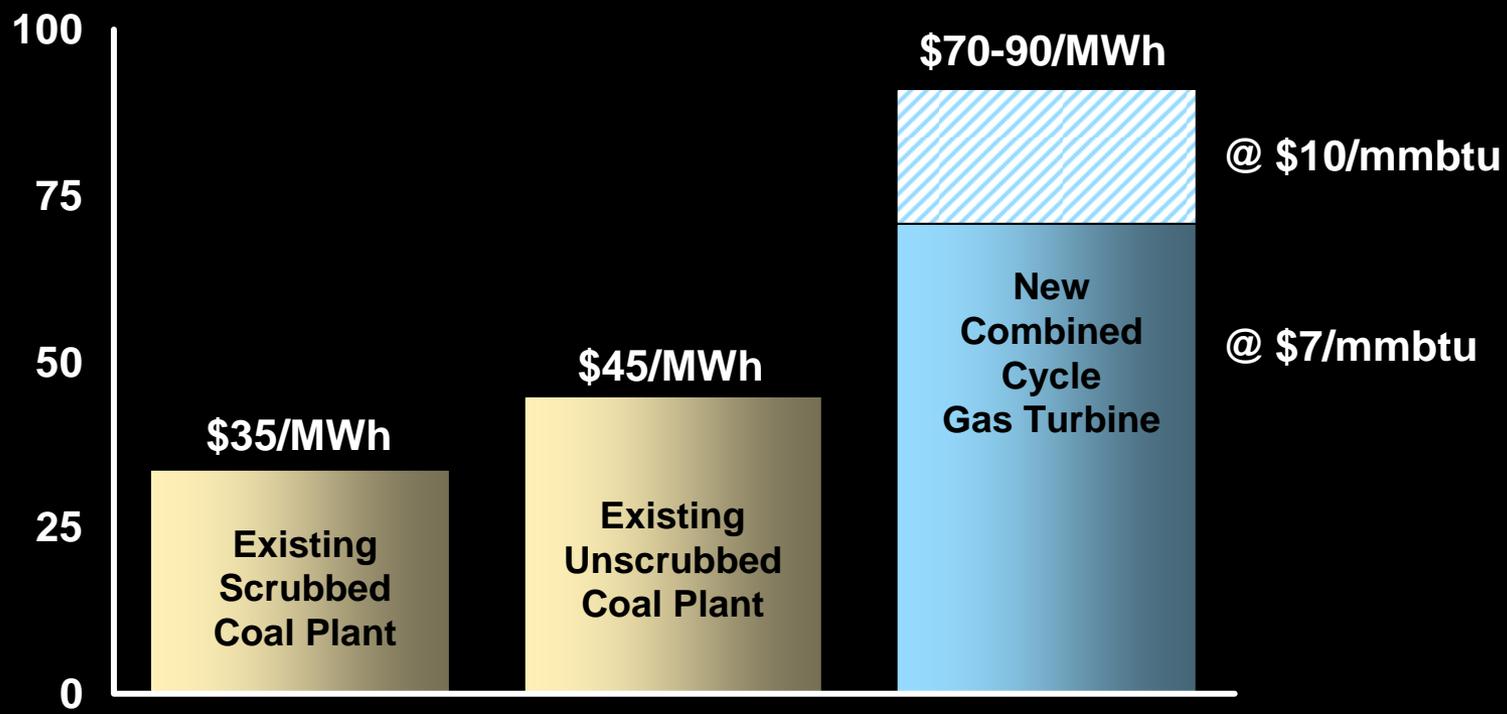
- Cost
- Doability – China plans already include **100** new nuclear plants before 2030

FAIL

Source: NorthBridge Analysis
¹ Assumes \$8,000 / kW installed cost in 2020

Replace Coal With New CCGT

Comparison of **“To Go”** Investment to Keep a Coal Plant Operating vs. All-In Cost to Replace It with New Capacity
Lifetime Costs in 2020 \$

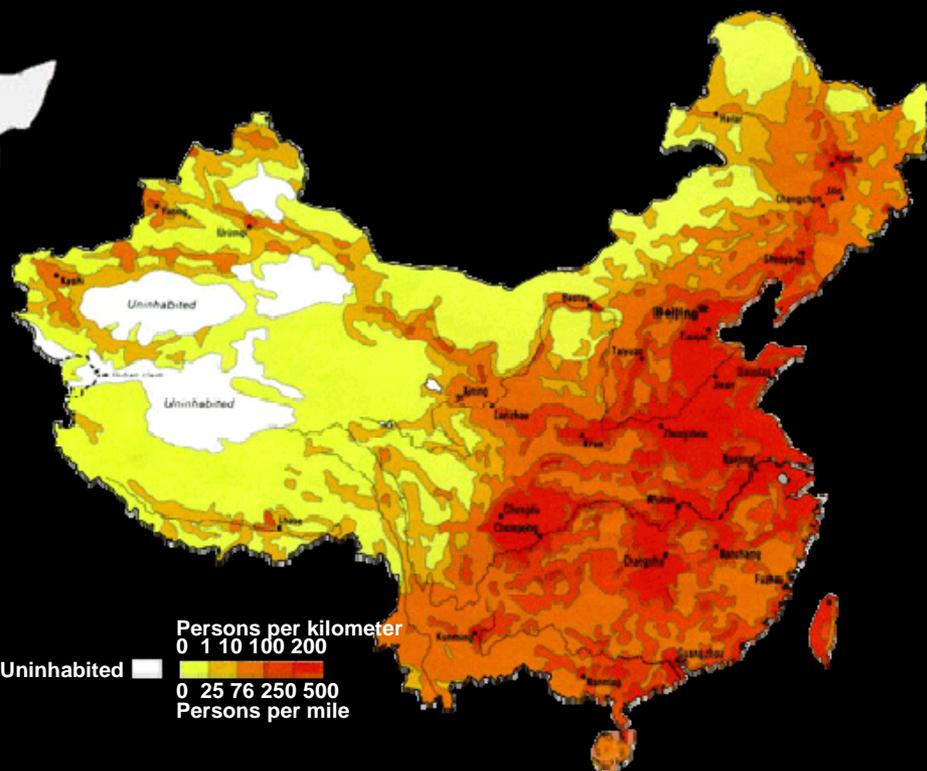
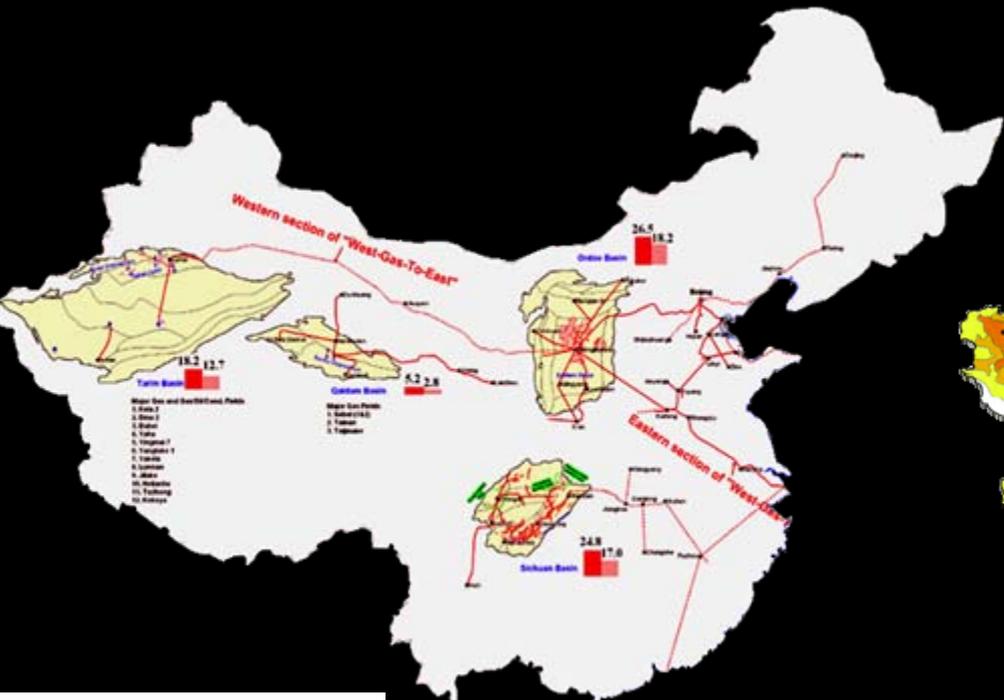


Source: NorthBridge Analysis

The Long (Distance) and Short (Reserves) of It

Gas Reserves

The Population



LEGEND

- Gas Field
- Gas Oil/Condensate Field
- Gas in Place, Tcf
- Recoverable Gas, Tcf
- Gas Pipeline in Operation
- Gas Pipeline under Construction
- Gas Pipeline Planned

Persons per kilometer
0 1 10 100 200
Persons per mile
0 25 76 250 500

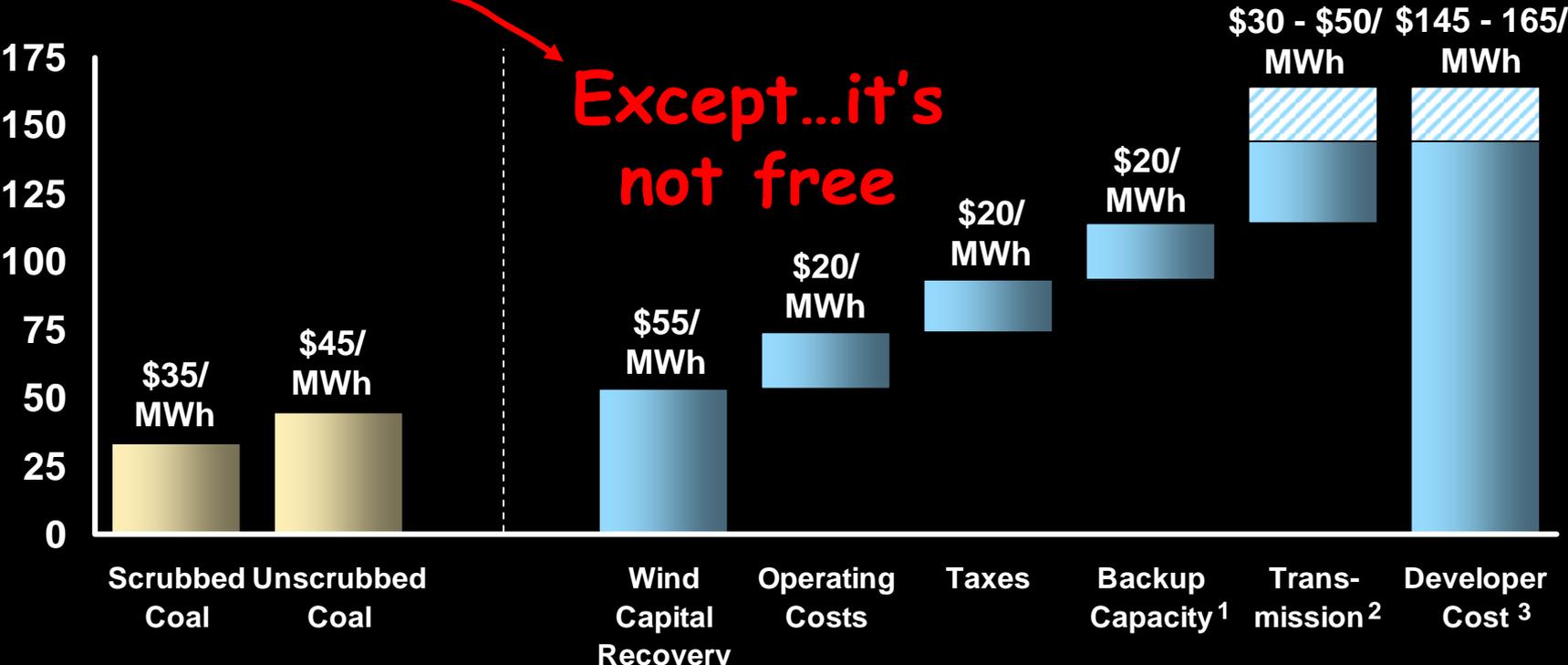
The China Test **FAIL**

Source: IEA

Source: Landing China.com

Replace 'Dirty' Coal with 'Free' Wind

Costs vary significantly; this example is based on Great Plains wind: relatively high quality wind resource, but far from load



Actual capital costs are confidential, but recent reports suggest that installed costs of ~\$2,000/kW are typical, with some projects costing more

Source: NorthBridge analysis

¹ Combustion turbine provides capacity and energy sufficient to utilize wind turbines as baseload resource at its average capacity factor

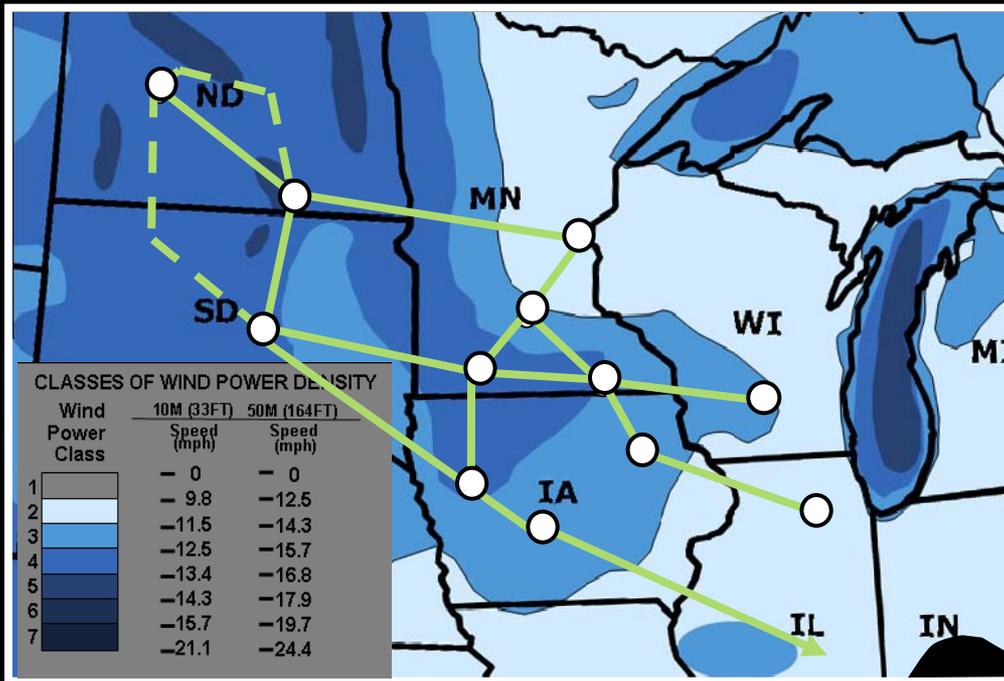
² Illustrative transmission expense of transmitting energy produced on the Great Plains to major load center

³ Does not include benefits of government subsidies or value of renewable energy credits

Replace 'Dirty' Coal with 'Free' Wind

Replace 'Dirty' Coal With 'Free' Wind

Wind - Isn't the Problem The Grid?



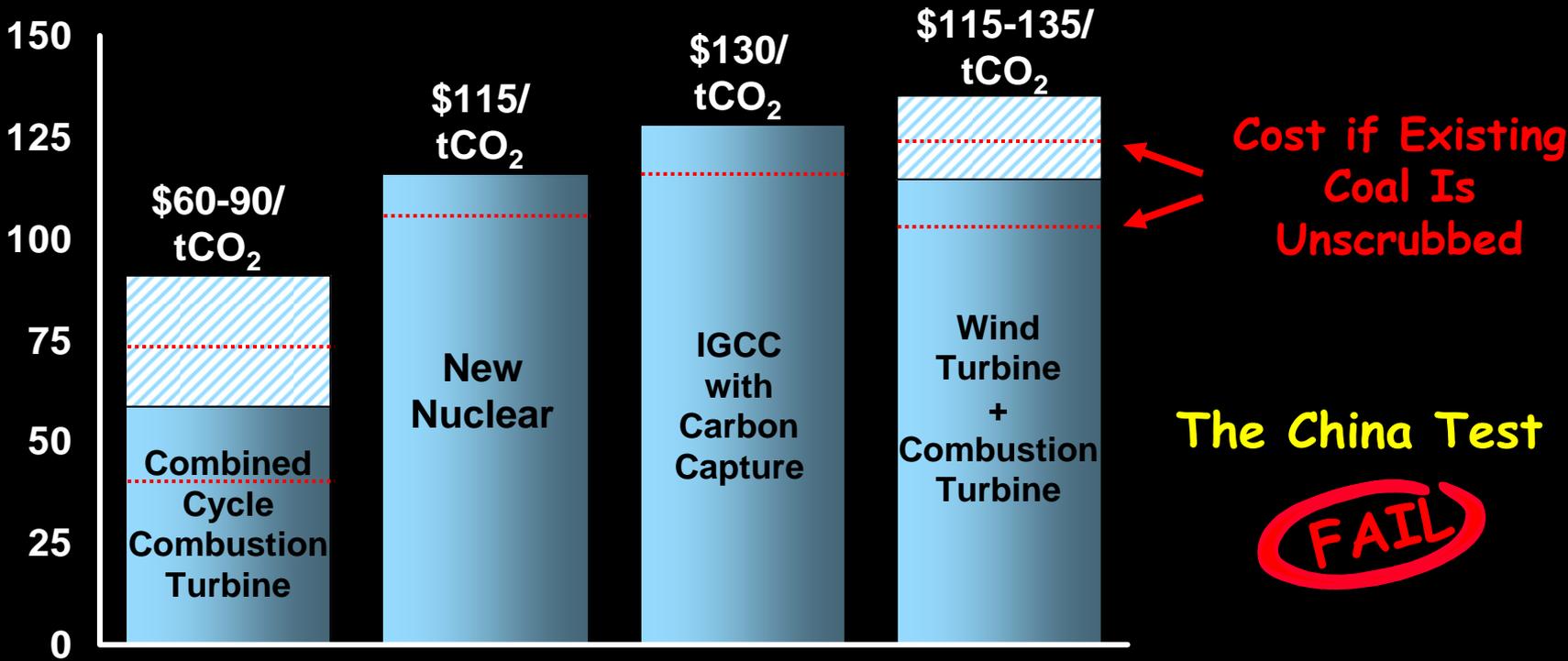
- Existing Station Site
- Green Power Express
- Conceptual Extension

Lack of Cost Transparency

- 2-3 explicit subsidies (50-80 MWh)
- Intermittent resources (back-up needed)
- Long way from population centers
- Best sites gone
- Increasing cost business?
- China test?

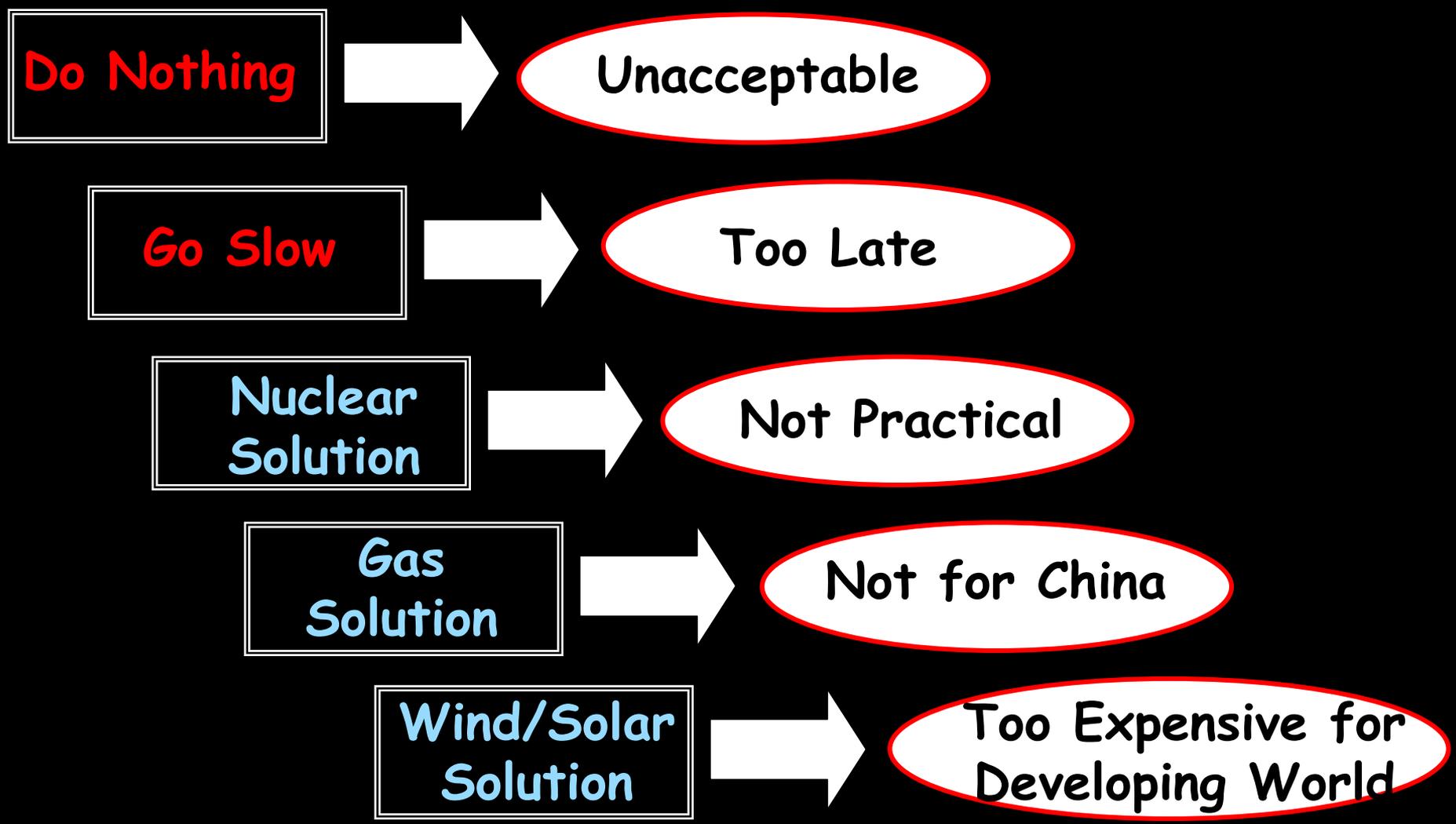
Economic, Political, International (China) Test

Implicit Cost of Replacing Existing Scrubbed Coal



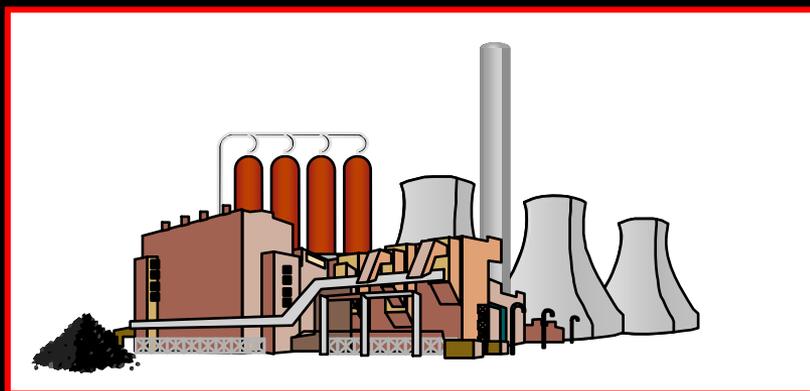
Source: NorthBridge Analysis

Summary



Coal Retrofit?

There is a missing link



Commercially viable
post-combustion capture and
sequestration technology,
something that can be
retrofitted on existing plants

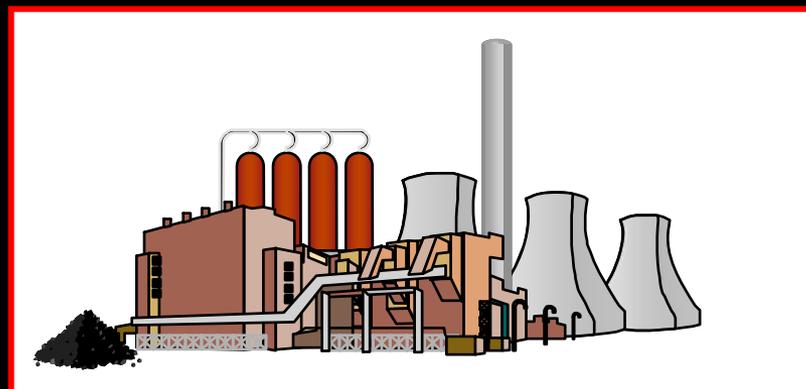
*Not Available
Today*

AND

- ✓ Huge market potential – enough to attract R&D
 - 1,300+ GW conventional coal capacity world-wide (growing to ~2,200 GW)
 - Credible estimates, i.e., could be commercially available for \$50-75/ton
- ✓ Government / industry underinvested in R&D
 - Pre-stimulus \$25M DOE spending on post-combustion capture

Early Cost Estimates; \$/metric ton CO2 Avoided

The Issue Is Cost, Not Doability
It Will Physically Work



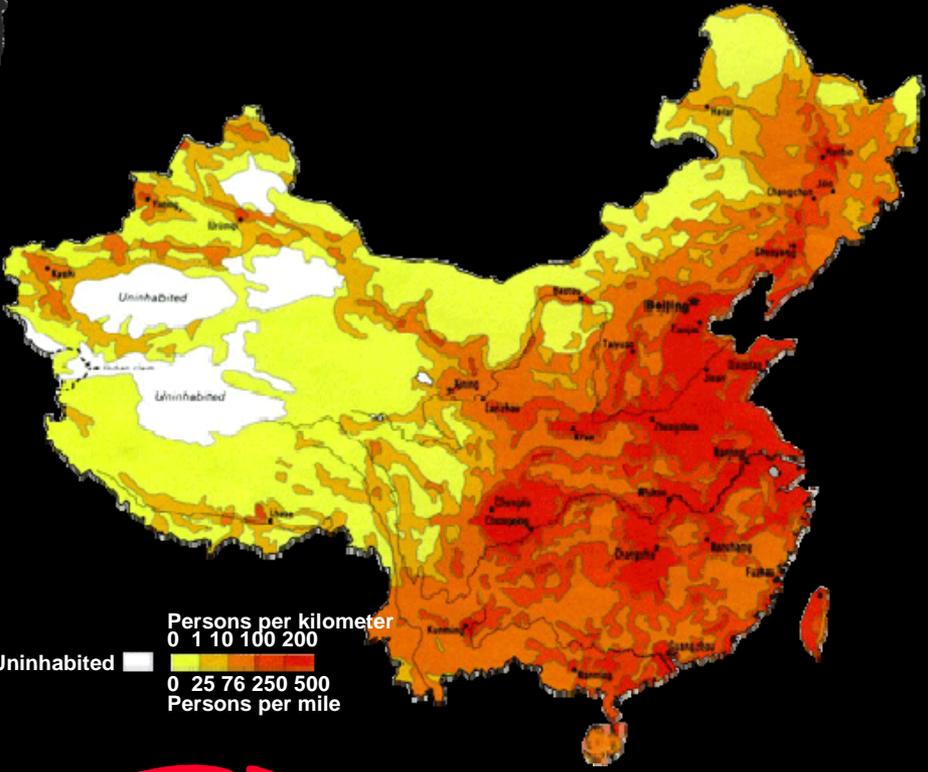
<p>EPRI 2008 \$50-74</p>	<p>McKinsey 2008 \$55-80</p>	<p>IEA 2008 \$50-95</p>
<p>Australia National Labs 2008 \$58-74</p>		
<p>MIT 2007 \$68-84</p>	<p>NETL 2007 \$70-101</p>	<p>ICF 2007 \$37-43</p>

¹ Includes capture, compression, transport and storage

The China Test

Coal Reserves
(World's 3rd Largest Reserves) NEAR

The Population



Persons per kilometer
0 1 10 100 200
Uninhabited
0 25 76 250 500
Persons per mile

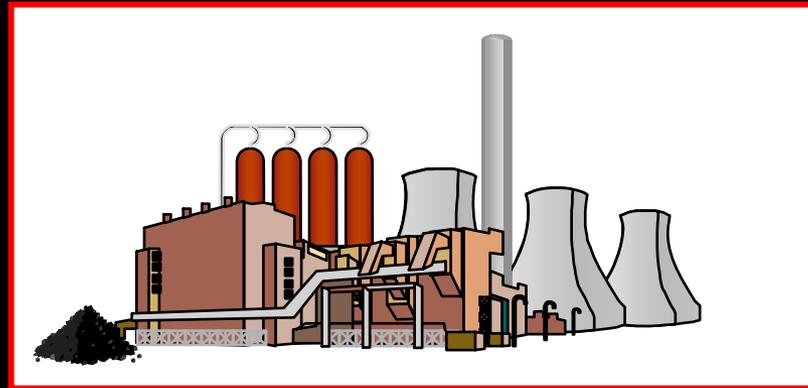
The China Test **PASS!**

Source: Maps of the World.com

Source: Landing China.com

Carbon Capture Retrofit on Existing Coal

Substantial Value

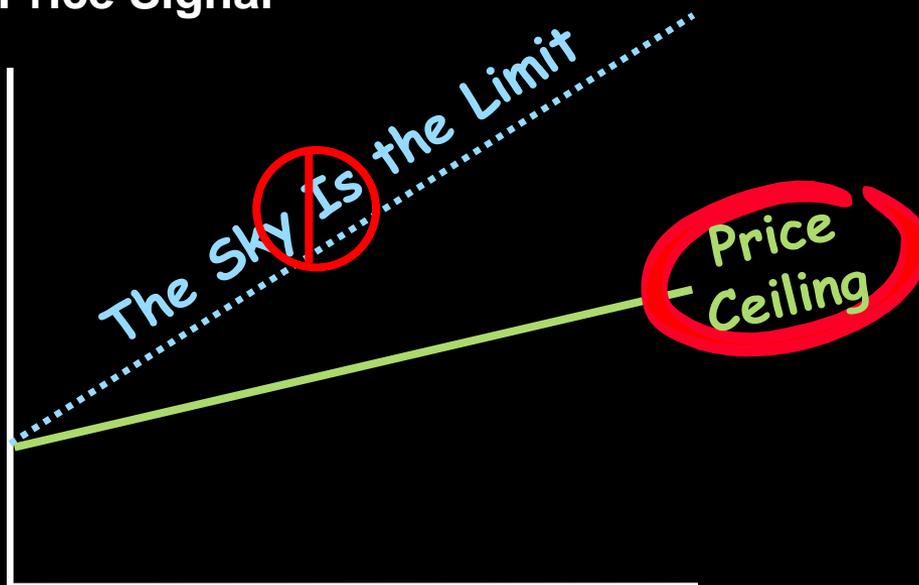


- ✓ U.S. compliance cost savings could be as high as **\$50-100B/year**
- ✓ More affordable ~~solution~~ for the rest of the world; savings could be as high as **\$400-600B/year**
- ✓ Frees up spending for other purposes
- ✓ A way to power PHEVS
- ✓ The China Test **PASS!**

Option Value Is?

Special Circumstances Call for Price Caps

Price Signal

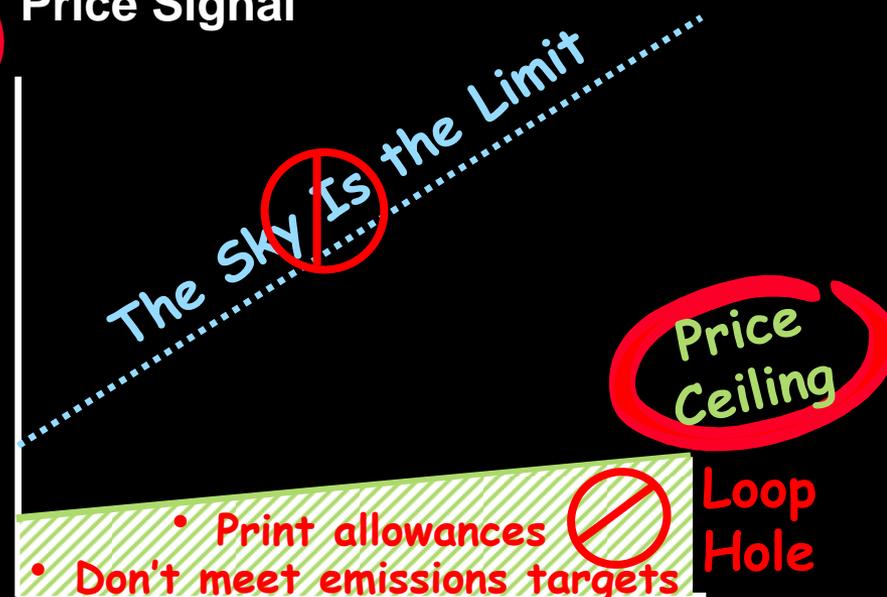


- ✓ Provides more political viability
 - Avoids backlash over 'No bottom line'
- ✓ Provides investor certainty
 - More certain price trajectory versus 'sky is the limit'

BUT

We can't set ceiling price too low

Price Signal



AND

*Price Caps Don't **Normally** Make Good Policy*



World-Wide Cap and Trade?

BUT

When benefits / costs are uncertain

AND

World-wide cooperation is critical

Best Approach Is Known, Price Cap Trajectory

Price Signals



Price Signals Alone Will Not Stimulate Needed R&D

The Reason: Uncertainty...

- Stay the course?
- Size of the market – Will China participate?
- Legal and technical issues associated with sequestration, here and abroad

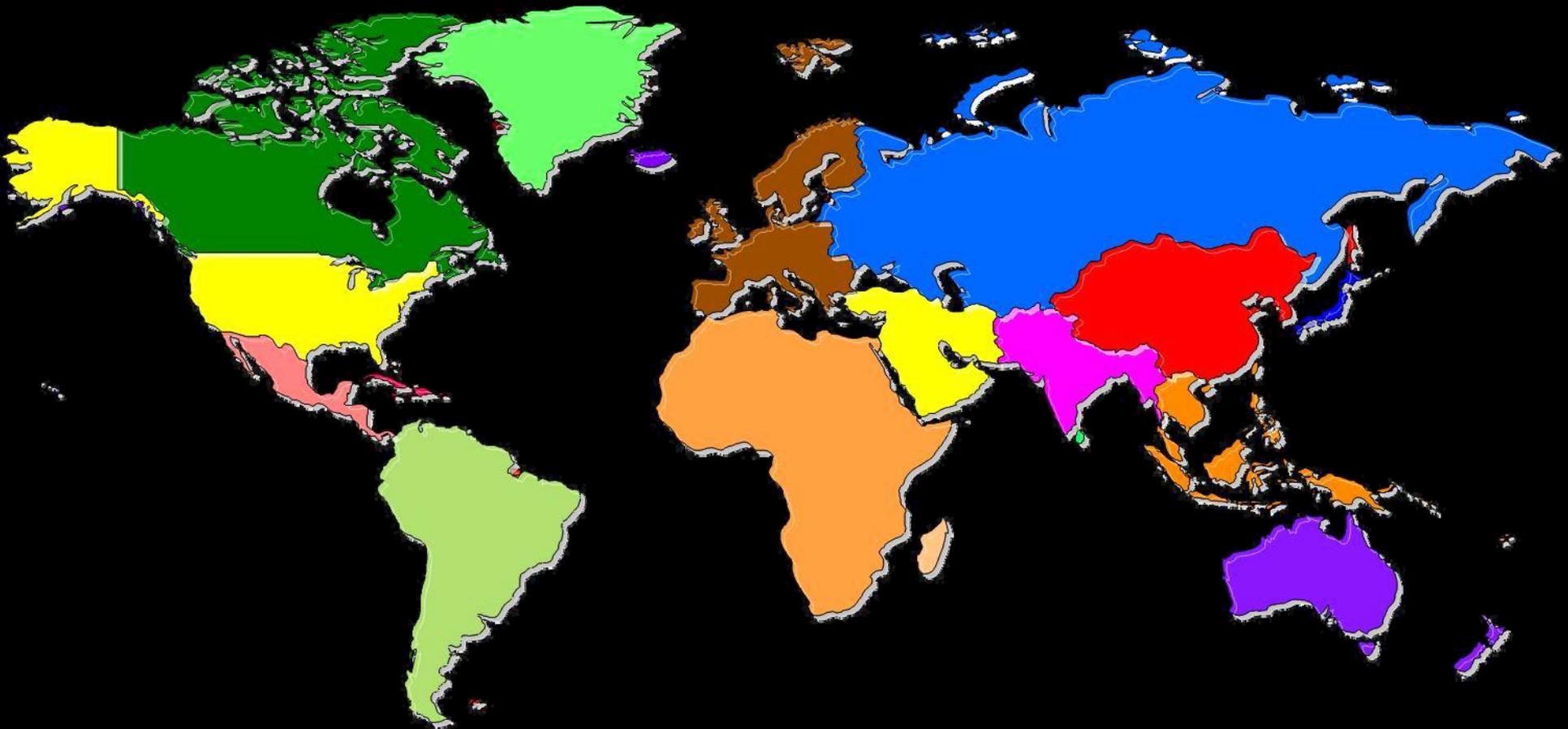
Past Delay Created
'Market Failure'
and
Now We Are Out of Time

...BUT, It **Won't** Be Easy

- Traditional **R&D is inherently risk averse**
 - Incremental scale up
 - Weed out “losers” early on before investing a lot of money
 - Conserve Scarce Funds
- An urgent problem requiring the fastest solution
- Demands a different approach to R&D

'Hard Truths'

The world's people share a common fate



The most significant threat in the electric sector has
a common solution

“A Good Story Is a Miracle”

-- Stanley Kubrick

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Appendix

Views on Climate Change



Entergy Guiding Principles

The risk is real; we need to act now to stabilize at 450 ppm: up to 80% reductions by 2050

Use an economy-wide, market based approach (preferably cap and trade or tax) to find most efficient solutions

We need to build in permanent low-income protection from the start, funded by CO₂ allowance sales or CO₂ tax revenues

- EITC or other rebates

Other Views

The science is too uncertain to justify the cost to the economy

We shouldn't act until the developing world agrees to limits

Income inequality should be dealt with separately, not through environmental legislation

Appendix

Views on Climate Change



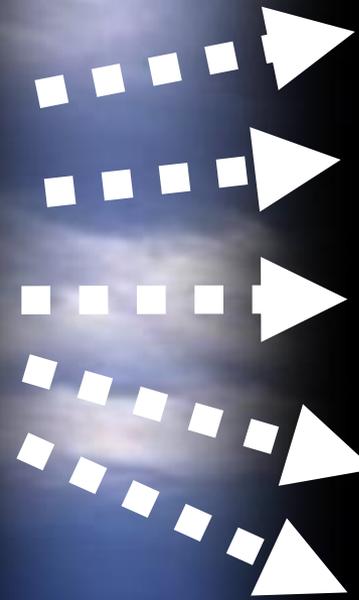
Entergy Guiding Principles

We need a strong but sustainable price signal to stimulate investment in efficiency and new technology

- Preferably cap and trade, with a high “price ceiling,” or a CO₂ tax
- Either way, \$50/ton by 2020-2025

U.S. policy must be informed by global reality

- Part of the solution will need to be a technology fix for existing coal plants
- Can't meet the goal through efficiency and/or renewables alone – or through new nuclear alone



Other Views

Don't set a price signal until we have the control technology

\$50 price is too high – it will kill the economy

\$50 may be too low – don't set a “price ceiling” at all

“Climate Fed” to set the price

This is a plan for Entergy to get rich with its non-utility nuclear plants

We can solve the problem relatively cheaply by investing in efficiency and renewables

We should build new clean coal (IGCC) and nuclear to replace existing coal