



# Green Power for a Nation in the Red

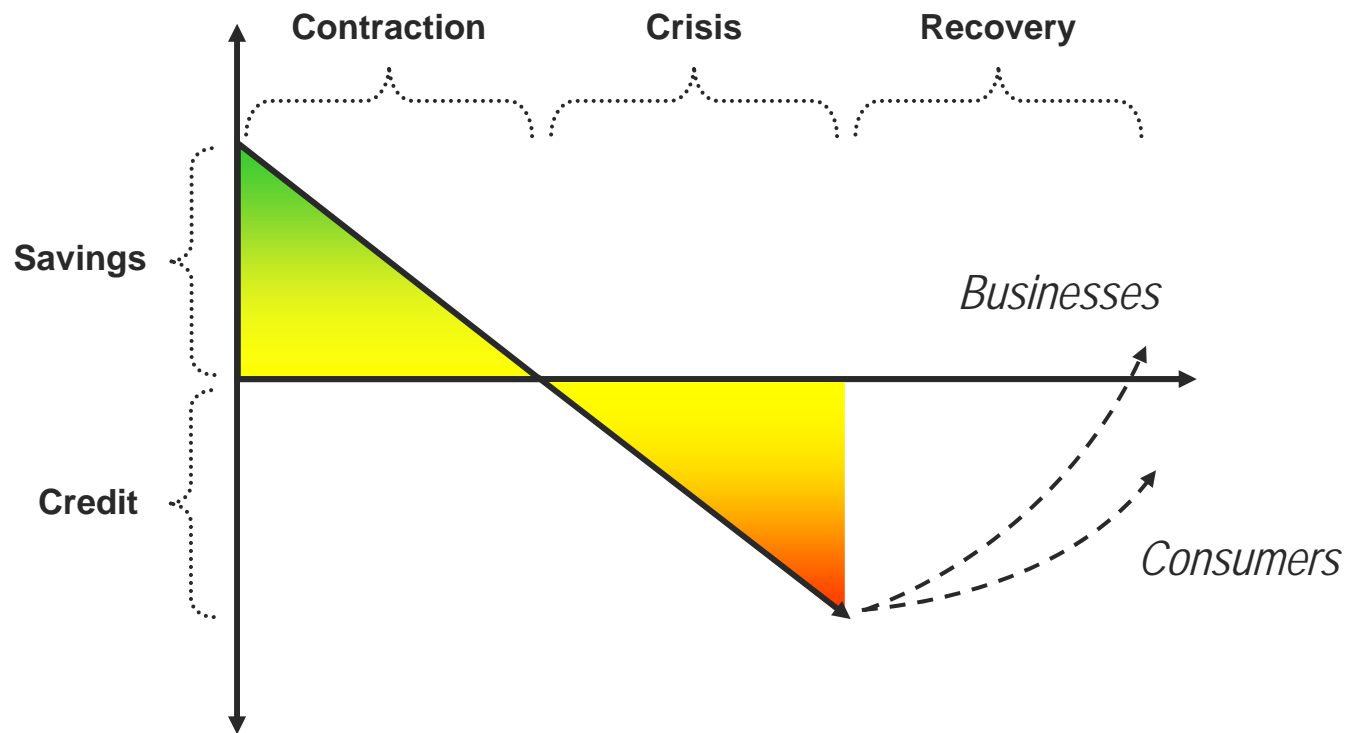
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Energy and Natural Resources : Energy Policy, Oil & Alternative Energy

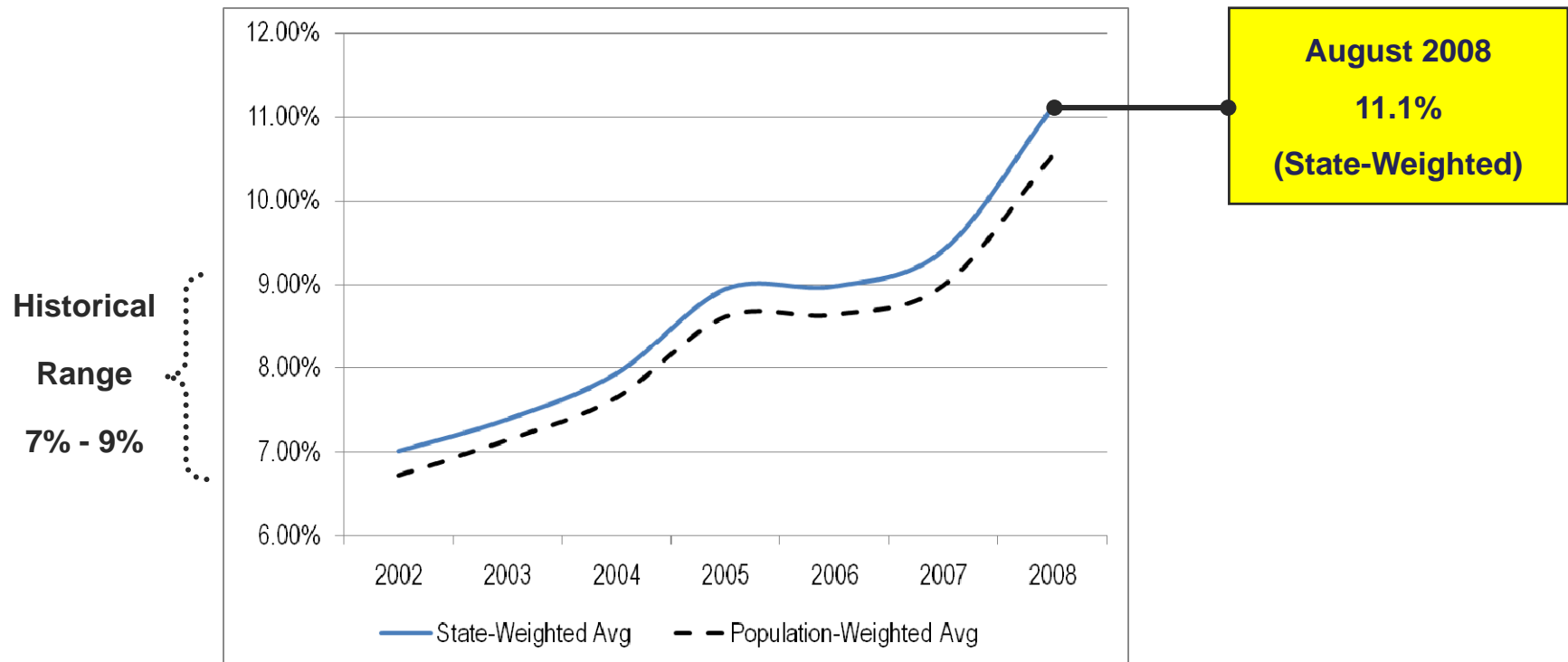
October 14, 2008

# A Word About the Energy Consumer



- ▶ **The household cash crunch didn't suddenly happen yesterday**
  - Consumers typically draw down cash reserves and credit before capitulating
- ▶ **The recovery won't instantaneously occur tomorrow**
  - Cash, discretionary spending and energy demand could lag macro recovery
- ▶ **Demand destruction will continue for years**
  - When energy users have the money to buy more efficient capital stock, they will

# FBR "Consumer Pain Index"



▶ **Typical Analysis:**

- Gasoline as a % of Personal Consumption Expenditures

▶ **The Consumer Pain Index: Household Energy Expenditures as a Whole**

- (Heat + Power + Gasoline) as a % of Disposable Personal Income

▶ **Rationale: Demand and Political Ramifications of High Prices**

- Consider how energy price influences perception of wealth/buying power/well-being

# First Economic Implication: GHG Emissions Prices?

Source	Projected, Legislated or Estimated "Social Cost" per Metric Ton of CO <sub>2</sub> e	Base Year	Annual Increase
William Nordhaus (Yale University)	\$ 2.50	n/a	n/a
MIT Future of Coal - Low Price	\$ 7.00	2010	5%
National Commission on Energy Policy	\$ 10.00	2010	Inflation + 5%
Bingaman-Specter Bill (S. 1766)	\$ 12.00	2012	Inflation + 5%
Intergovernmental Panel on Climate Change (IPCC)	\$ 12.00	2005	n/a
Larson Bill (H.R. 3416)	\$ 15.00	2008	COLA + 10%
MIT Future of Coal - High Price	\$ 25.00	2015	5%
Stern Review (U.K.)	\$ 85.00	n/a	n/a

▶ **Markets have spoken:**

- \$3.07/MtCO<sub>2</sub>e RGGI auction
- ~ \$40/MtCO<sub>2</sub>e (currency-adjusted) Emissions Trading Scheme

▶ **So have lawmakers, trade associations and scholars:**

- "Behavior change" begins at \$40/MtCO<sub>2</sub>e (economic reality)
- Carbon capture and storage begins in the \$85-125/MtCO<sub>2</sub>e range (EPRI)
- U.S. Senate Finance Committee: \$10/MtCO<sub>2</sub>e for EOR, \$20/MtCO<sub>2</sub>e for CCS

# The Value of Incumbency: Generation Costs from Conventional Fuels

Source	Capacity (MW)	Capacity Factor	Thermal Efficiency	Capital Cost/kW	Fuel Cost/Unit	Generation Cost/kWh
New Build Pulverized Coal	1,000	90%	35%	\$2,500.00	\$100.00	\$0.055
Legacy Pulverized Coal	500	90%	35%	\$0.00	\$100.00	\$0.042
New Build CCGT	500	90%	48%	\$1,000.00	\$7.00	\$0.062
Legacy Petroleum Boiler	500	90%	40%	\$0.00	\$63.00	\$0.074
Wind	250	28%	n/a	\$1,800.00	n/a	\$0.079
Farm-Scale PV, 30% ITC only	250	New ark 4.448 kWh/m2/d); 10%, 90% DC:AC/NoAxis; Unsub. Balance 100% Financed		\$5,000.00	n/a	\$0.210
Farm-Scale PV, 30% ITC, 15% State	250		\$5,000.00	n/a	\$0.178	
Farm-Scale PV, 30% ITC, 30% State	250		\$5,000.00	n/a	\$0.147	

- ▶ **In Principle, Either Surcharges or Subsidies Can Close the Gap**
  - Subsidized wind at \$0.059/kWh seems compelling (where it can be built), but transmission and dispatch issues can materially diminish economic benefits
- ▶ **Supply and Demand Dynamics Matter:**
  - CCGT falls to \$0.053/kWh at \$700/kW and \$6/mcf
  - Incumbent coal falls to \$0.032/kWh at \$75/ton and new build falls to \$0.044/kWh

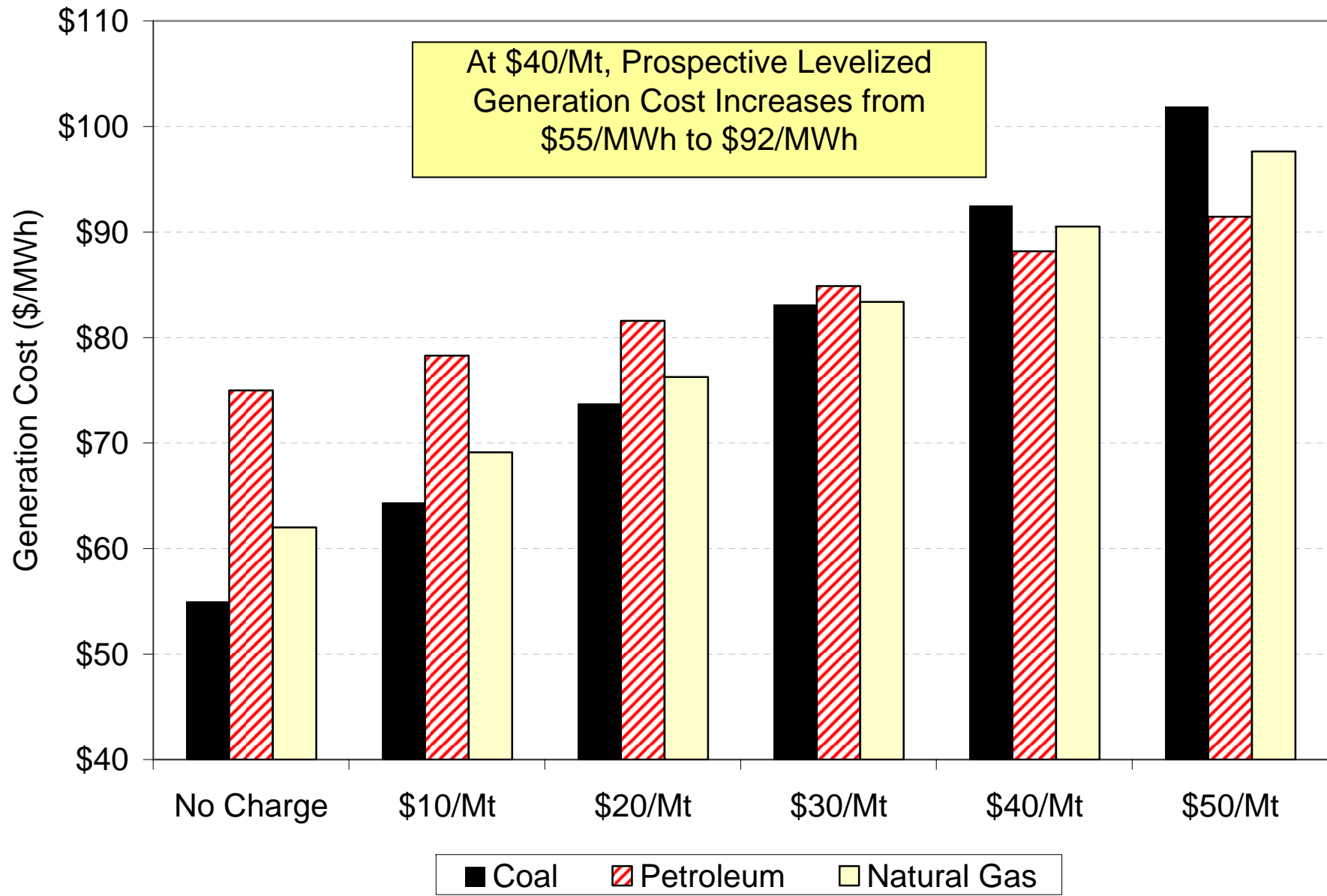
# Carbon Math 101: The Price of Compliance, by Fuel and Process

<b>Fuel</b>	<b>Coal</b>	10,500.00	Btu/pound	<b>Natural Gas</b>	1.03	MMBtu/mcf	<b>Middle Distillates</b>	5.82	MMBtu/bbl
		211.90	lbCO <sub>2</sub> e/MMBtu		116.98	lbCO <sub>2</sub> e/MMBtu		161.20	lbCO <sub>2</sub> e/MMBtu
		21.00	MMBtu/short ton						
		4,449.90	lbCO <sub>2</sub> e/short ton		120.49	lbCO <sub>2</sub> e/mcf		938.99	lbCO <sub>2</sub> e/bbl
		2.02	MtCO <sub>2</sub> e/short ton		0.05	MtCO <sub>2</sub> e/mcf		0.43	MtCO <sub>2</sub> e/bbl
<b>Process</b>	<b>Steam Turbine</b>	3.41	MMBtu/MWh	<b>Combined Cycle Gas Turbine</b>	3.41	MMBtu/MWh	<b>Steam Turbine</b>	3.41	MMBtu/MWh
		0.35	Thermal Efficiency		0.55	Thermal Efficiency		0.35	Thermal Efficiency
		9.75	MMBtu/MWh		6.20	MMBtu/MWh		9.75	MMBtu/MWh
		0.46	Short ton/MWh		6.02	mcf/MWh		1.67	bbl/MWh
		0.94	MtCO <sub>2</sub> e/MWh		0.33	MtCO <sub>2</sub> e/MWh		0.71	MtCO <sub>2</sub> e/MWh

► **For every \$10 per Metric Ton of CO<sub>2</sub>:**

- 10,500 Btu/lb coal @ 35% Thermal Efficiency → \$9.40/MWh
- Combined Cycle Gas Turbine @ 55% Thermal Efficiency → \$3.30/MWh
- Diesel/Distillate Generation @ 35% Thermal Efficiency → \$7.10/MWh

# Putting It Together: Climate Change Coal-Fired Generation Cost



# Carbon Surcharges on a National Average Basis: "Is That All?"

		Carbon Price (\$/MtCO <sub>2</sub> e)						
		\$1	\$5	\$10	\$15	\$20	\$30	\$40
Generation Cost Surcharge (\$/MWh)	Coal	\$0.94	\$4.69	\$9.37	\$14.06	\$18.74	\$28.11	\$37.48
	Petroleum	\$0.33	\$1.65	\$3.29	\$4.94	\$6.58	\$9.88	\$13.17
	Natural Gas	\$0.71	\$3.56	\$7.13	\$10.69	\$14.26	\$21.38	\$28.51
	National Average	<b>\$0.61</b>	<b>\$3.07</b>	<b>\$6.14</b>	<b>\$9.21</b>	<b>\$12.28</b>	<b>\$18.41</b>	<b>\$24.55</b>

Average per-capita power consumption (kWh/Y)	13,000
Average per capita disposable income	\$33,619
Effective tax rate	35%
Average gasoline consumption, per capita	600

			Carbon Emissions Price (MtCO <sub>2</sub> e)				
			\$10	\$20	\$30	\$40	\$50
Electricity	Annual surcharge per \$10/MtCO <sub>2</sub> e	\$79.80	\$79.80	\$159.59	\$239.39	\$319.18	\$398.98
	Disposable income effect per \$10/MtCO <sub>2</sub> e	0.237%	0.237%	0.475%	0.712%	0.949%	1.187%
	Effective tax per \$10/MtCO <sub>2</sub> e	0.365%	0.365%	0.730%	1.095%	1.461%	1.826%
Gasoline	Annual carbon surcharge per \$10/MtCO <sub>2</sub> e	\$52.69	\$52.69	\$105.38	\$158.07	\$210.76	\$263.45
	Disposable income effect per \$10/MtCO <sub>2</sub> e	0.157%	0.157%	0.313%	0.470%	0.627%	0.784%
	Effective tax per \$10/MtCO <sub>2</sub> e	0.241%	0.241%	0.482%	0.723%	0.964%	1.206%
Summary	Total disposable income effect		<b>0.394%</b>	<b>0.788%</b>	<b>1.182%</b>	<b>1.576%</b>	<b>1.970%</b>
	Effective tax		<b>0.606%</b>	<b>1.213%</b>	<b>1.819%</b>	<b>2.425%</b>	<b>3.031%</b>

## Second Economic Implication: No, That's Not All!

Winter 2008-2009 EIA Estimate (National Averages)			Carbon Emissions Price (MtCO <sub>2</sub> e)				
			\$10	\$20	\$30	\$40	\$50
Heating Fuel	Fuel Oil	604.7 gal	\$62.54	\$125.08	\$187.61	\$250.15	\$312.69
	Natural Gas	67.1 mcf	\$36.52	\$73.05	\$109.57	\$146.09	\$182.62
	Electricity	8,303 kWh	\$50.98	\$101.96	\$152.94	\$203.92	\$254.90
	Propane	675.7 gal	\$38.92	\$77.85	\$116.77	\$155.70	\$194.62
	<b>National Average</b>			\$47.24	\$94.48	\$141.73	\$188.97
Summary	<b>Total disposable income effect</b>		<b>0.141%</b>	<b>0.281%</b>	<b>0.422%</b>	<b>0.562%</b>	<b>0.703%</b>
	<b>Effective tax</b>		<b>0.216%</b>	<b>0.432%</b>	<b>0.649%</b>	<b>0.865%</b>	<b>1.081%</b>

- ▶ **To begin with, there is home heating.**
- ▶ **Then, there are costs borne across the economy:**
  - Inputs to industrial production
  - Logistics use of energy
  - New capital investment (ultimately should pay for itself)

# It Isn't Just Households: State Stabilization Funds are Shrinking, Too

Stabilization Funds as a % of Expenditures					
State	2007	2008	2009	Δ'08-'07	Δ'09-'08
Mississippi	11.6	8.8	0	-2.8	-8.8
Maine	1.2	0	0	-1.2	0
Arkansas	0	0	0	0	0
Wisconsin	0.5	0.6	0.8	0.1	0.2
Arizona	10.3	3.7	1.2	-6.6	-2.5
Michigan	2.9	2.3	1.2	-0.6	-1.1
New Jersey	8.5	4.4	1.8	-4.1	-2.6
Kentucky	9.2	3.1	2.4	-6.1	-0.7
Pennsylvania	4.7	4.2	2.8	-0.5	-1.4
Alabama	14.9	5.8	3	-9.1	-2.8
Illinois	3.6	3.7	3.5	0.1	-0.2
Rhode Island	2.6	0	3.5	-2.6	3.5
California	3.8	1.7	3.6	-2.1	1.9
Missouri	13	11.5	3.7	-1.5	-7.8
North Carolina	10.8	5.3	3.9	-5.5	-1.4
New York	5.9	4.9	3.9	-1	-1
Oklahoma	12.3	13.5	4.1	1.2	-9.4
Hawaii	10.3	8.8	4.2	-1.5	-4.6
Minnesota	14.1	8	4.4	-6.1	-3.6
Ohio	9.5	6.6	4.4	-2.9	-2.2
Delaware	17.4	13.8	4.7	-3.6	-9.1
South Carolina	16.5	4.1	4.8	-12.4	0.7
Vermont	4.8	4.8	4.9	0	0.1
Kansas	16.7	8.8	5	-7.9	-3.8
Colorado	7.3	4.6	5.2	-2.7	0.6

Stabilization Funds as a % of Expenditures					
State	2007	2008	2009	Δ'08-'07	Δ'09-'08
Oregon	26	-0.5	5.6	-26.5	6.1
Nevada	11.3	11.2	5.8	-0.1	-5.4
Washington	7.6	9.2	6.3	1.6	-2.9
Maryland	12.1	8.4	6.4	-3.7	-2
Montana	32.4	8.1	6.4	-24.3	-1.7
Idaho	14.6	11.3	6.5	-3.3	-4.8
Virginia	8.5	7.7	6.5	-0.8	-1.2
Tennessee	15.8	9.6	6.6	-6.2	-3
Utah	11.1	6.7	6.9	-4.4	0.2
New Hampshire	11	8.1	7	-2.9	-1.1
Florida	16.6	5.9	7	-10.7	1.1
Massachusetts	10.5	8.3	7.1	-2.2	-1.2
South Dakota	12.1	8.8	8.3	-3.3	-0.5
Indiana	10.5	10.1	8.9	-0.4	-1.2
Connecticut	9	9.9	9.5	0.9	-0.4
New Mexico	10.8	9.7	10	-1.1	0.3
Iowa	11.4	11.1	10.8	-0.3	-0.3
Georgia	14.5	12.5	12.4	-2	-0.1
Wyoming	16.5	16.9	13.1	0.4	-3.8
Louisiana	20.9	25.4	13.5	4.5	-11.9
West Virginia	25.6	15	16.4	-10.6	1.4
Nebraska	35.4	25.9	19.3	-9.5	-6.6
Texas	26	23	24.5	-3	1.5
North Dakota	48.9	47	30.8	-1.9	-16.2
Alaska	54.8	106.9	168.5	52.1	61.6

- ▶ **28 States' stabilization funds are diminishing significantly**
- ▶ **10 States' funds are due to zero out in FY09 (we already know two!)**
- ▶ **Every state (except Vermont) has a balanced budget amendment**  
(Vermont seems to be able to do just fine without one, thank you very much).

## Third Economic Implication: GHG Regulation as a Funding Source

<b>Regulated emissions (MTCO<sub>2</sub>e)</b>	6.1 billion
<b>Initial reduction target</b>	20% by 2026
<b>Phase into full auction over</b>	15 years
<b>Initial allowances as proportion of covered emissions</b>	50%
<b>Initial auction reserve price (\$/MtCO<sub>2</sub>e)</b>	\$10
<b>Maximum annual increase in auction price</b>	5%

	Year			
	2012	2013	2014	2026
<b>Allowances (linear decline)</b>	6.10	6.01	5.93	4.88
<b>Auction percentage</b>	0.50	0.54	0.57	1.00
<b>Allowances offered at auction</b>	3.05	3.22	3.39	4.88
<b>Maximum auction price</b>	\$10.00	\$10.50	\$11.03	\$19.80
<b>Government revenues from auction</b>	\$30.50	\$33.82	\$37.33	\$96.62
<b>15-Year Total (\$billion)</b>	\$901.21			
<b>Present value at 4.5% federal cost</b>	\$604.34			

# GHG Emissions “Lite”: A 20% LCFS for Carbon Fuels (\$15/Mt, 5%)

**20% “Low-Carbon Fuels Standard” Just for Motor Vehicle Transportation Fuels**

**= \$50 billion Over Ten Years**

<b>Assumption</b>	<b>Impact</b>
Lifecycle carbon-equivalent emissions, finished motor gasoline (average of all grades)	19.36 lbCO <sub>2</sub> e/gallon
Lifecycle carbon-equivalent emissions, Distillate fuel oil (average of all grades)	19.5 lbCO <sub>2</sub> e/gallon
2007 US finished motor gasoline demand	142,349,298,000 gallons
2007 US finished distillate fuel oil demand	64,323,336,000 gallons
Carbon footprint of surface transportation on wheels (e.g. no trains, barges, planes, etc.)	1,819,009,100 MtCO <sub>2</sub> e/Y - 2007
Demand growth (assumes conservation, slow economic growth)	0.50% ten-year average
Total nominal cost of 20% assuming no allowances	\$50.57 billion over ten years
PV at 4.5% federal cost of capital	\$36.78 billion over ten years

# If Not Coal, then What? A LOT of Natural Gas.

High estimate →	<b>40%</b>	thermal efficiency		
	1	cf	of gas	1034 Btu
	8530.00	Btu	of heat	1 kWh
	1	cf	of gas	0.1212 kWh
	8.25	cf	of gas	1 kWh
	1	kilowatt	capacity	8,760 kWh/Y
	1	kilowatt	capacity	72,266 cf/Y
Unbuilt Coal →	<b>100000</b>	megawatt	capacity	7,226,576 Mcf/Y
				<b>7,226.58</b> Bcf/Y
				<b>19.80</b> Bcf/d

# First Test of the Nation's Will: The Road Ahead for the (Expensive) PTC

## Wind Credit Caps Reveal a Senate Nod towards Fiscal Concerns and the House Stance on the PTC

Capital Costs	\$1,400	\$/kW
Capacity Factor	28%	
Cost of Capital	4.5%	
2009 Incremental Build	9,600	MW
Inflation Rate	3%	
Base Credit Amount	\$0.0210	per kWh
Base Year Capital Costs (Total)	\$13.44	Billion
PV of 10-Year Credit	\$4.57	Billion
Percentage	34.0%	

N.B.: reflects government discount rate

N.B.: assumption is arbitrary for calculation

	Year									
	1	2	3	4	5	6	7	8	9	10
PTC Amount per kWh	\$0.0216	\$0.0223	\$0.0229	\$0.0236	\$0.0243	\$0.0251	\$0.0258	\$0.0266	\$0.0274	\$0.0282
Generation (MM kWh)	23,547	23,547	23,547	23,547	23,547	23,547	23,547	23,547	23,547	23,547
Discounted Cost (\$MM/Y)	\$487.39	\$480.39	\$473.50	\$466.70	\$460.00	\$453.40	\$446.89	\$440.47	\$434.15	\$427.92

## A Second Test: What if it Works? A 30% ITC Could Cost Quite a Lot!

	2009	2010	2011	2012
Price Required to Unlock Implied Demand	\$5.63	\$4.48	\$3.66	\$2.95
Incremental MW	437.8	2,014.60	7,910.80	16,170.60
30% of Incremental MW at Price (\$MM)	\$739	\$2,708	\$8,686	\$14,311
PV at 4.5% Federal Funds Cost (\$MM)	\$22,799			
Projected cost over 10 years (\$MM)	\$3,236			

- ▶ **A “hockey stick”:** In February 2008, our “bottom-up” projected of implied U.S. solar demand suggested tremendous potential within both farm-scale and rooftop retrofit markets in the event that prices fell by more than 17% per annum from prevailing 2008 levels.
- ▶ **A much more restrained analysis** probably informed the Joint Committee on Taxation’s conclusion that extending the ITC to home and business applications for eight years at the 30% rate, without a cap, would cost the federal government approximately \$3.2 billion over ten years.
- ▶ **Our 16.1 GW of implied incremental demand is purely theoretical.** But it’s not impossible. This beggars the question of what might happen if outlays exceed expectations...

# Lessons Learned in Germany: In Tight Times, You Buy What You Need, Not What You Want

Project Size	2009 Decline Rate	2009 Credit Amount	2010 Decline Rate	2010 Credit Amount	2011 Decline Rate	2011 Credit Amount
<30 kW rooftop	8%	0.43	8%	0.40	9%	0.36
30-100 kW rooftop	8%	0.41	8%	0.38	9%	0.34
100-1,000 kW rooftop	10%	0.40	10%	0.36	9%	0.32
>1,000 kW rooftop	10%	0.33	10%	0.30	9%	0.27
Ground-based	10%	0.32	10%	0.29	9%	0.26

## What the German Parliament Did in June:

- **Biomass Power** (\$0.045 - \$0.08/kWh) → Increased Feed-In Tariffs
- **Wind Power** (\$0.08-\$0.10/kWh) → Kept Feed-In Tariffs the Same
- **Solar Photovoltaic Power** (\$.35-0.50/kWh) → Decreased Feed-In Tariffs

# Questions?

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## ▶As of the close of business October 16, 2008

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