



Center for Coal Technology Research
Located in the Energy Center at Discovery Park, Purdue University

Energy In Indiana

What Can We Expect?

**16th Annual Pollution Prevention (P2)
Conference and Trade Show**

September 25, 2013

Plainfield, Indiana

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Director

Center for Coal Technology Research



INDIANA BUSINESS DAILY
2012 ©



HOW ELECTRIC CARS WORK

www.investors.com/cartoons

Chevy Volt uses 3,800 BTU's of energy per mile (electricity) 5,800 miles per ton coal
Honda Insight uses 3,050 BTU's of energy per mile (gasoline) 41 MPG
Plug in works better if you calculate Miles/\$ not Miles/BTU.



Are Americans using too much Energy?

THE USA IS NOT THE PROBLEM, IT IS THE SOLUTION

It is not what you use, it is what you do with it.

	% World Population	Energy	GDP	Ratio \$/E
USA	4.5%	17.7%	21.4%	1.21
ROW	95.5%	82.3%	78.6%	.95

US population consumes **3.9 times** the energy of the average person in the Rest Of the World;
But we produce **5.2 times** the goods and services of the Rest Of the World.

\$GDP per unit of energy use (constant 2011 Ton of Oil Equivalent). Nuclear not added to TOE

USA	China	India	Japan	France	World
\$6,737	\$2,763	\$2,434	\$12,510	\$10,790	\$5,351

\$GDP per Tons of CO2

USA	China	India	Japan*	France*	World
\$2,844	\$953	\$1,010	\$5,215	\$5,659	\$2,328

*Note benefit from nuclear

Which economies are growing?

Leading Economies : Billion\$ Rank

USA	\$14,991.3	1
China	\$ 7,318.5	2
Japan	\$ 5,867.2	3
France	\$ 2,773.0	4
India	\$ 1,010.9	8

World Bank 2012

If the rest of the world consumed **energy as efficiently as the USA**
total World Wide Energy Consumption would be **reduced by 27.4%**



It is not what you use it is how you use it.

	<u>GDP</u>	<u>National Rank</u>
Durable Goods	15.0%	2
Non-Durable Goods	11.7%	2
Total Manufacturing	26.7%	2

- Total Manufacturing of 26.7% is the 2nd highest in the nation, 14% the national average, (1st is Oregon at 28%)
- Your CO2 Footprint is large in Indiana because we are a Manufacturing State:
- CO2 footprint measures your state's economic output, personal consumption is not relevant.

Indiana's industrial sector provides 26.7% of the state GDP & consumes 43.8% of total energy. Indiana consumes 35.7% more energy than average for Americans.

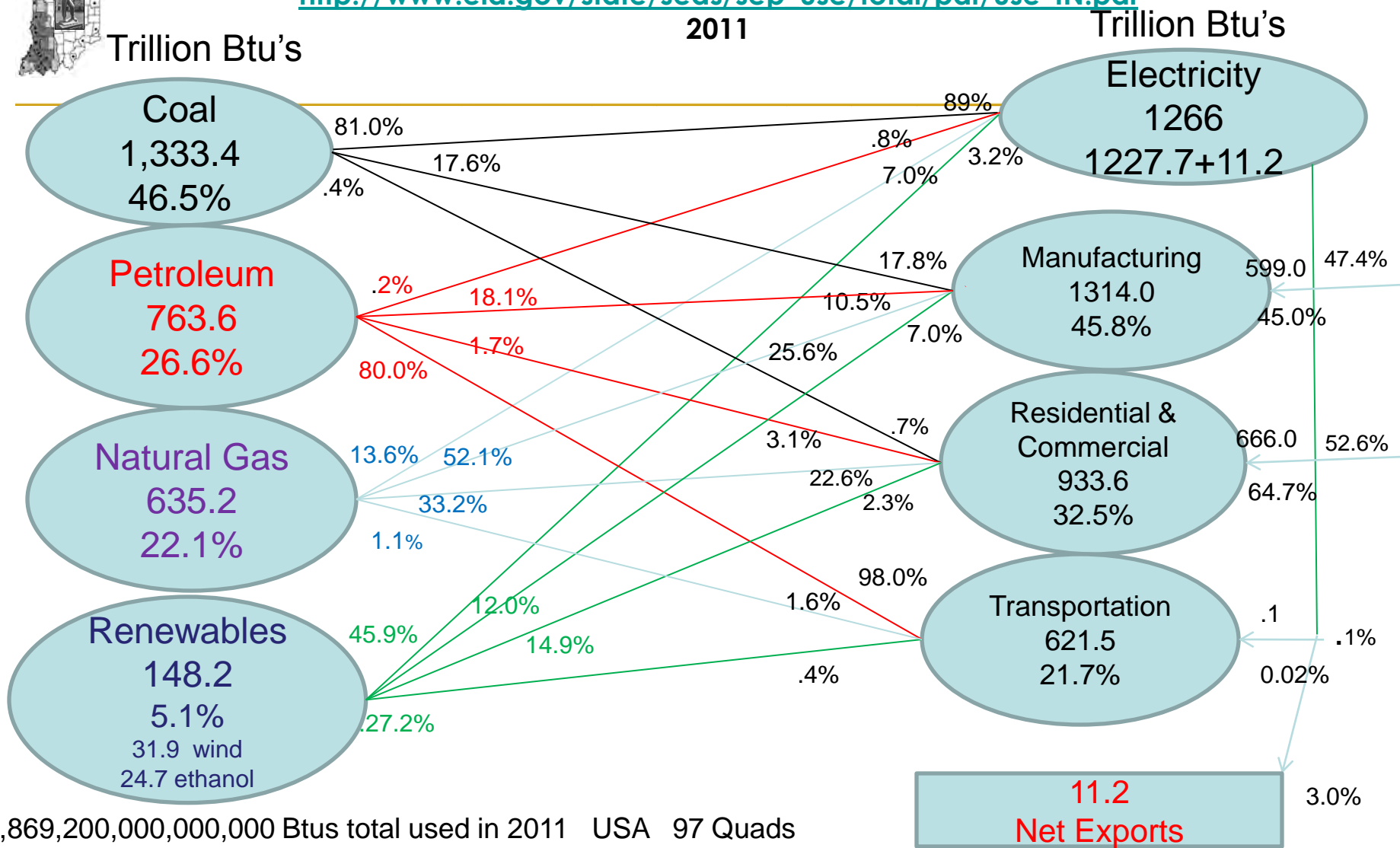
Reducing your carbon footprint by purchasing a Honda increases Indiana's carbon footprint



Indiana Primary Energy Consumption Source and Sector

http://www.eia.gov/state/seds/sep_use/total/pdf/use_IN.pdf

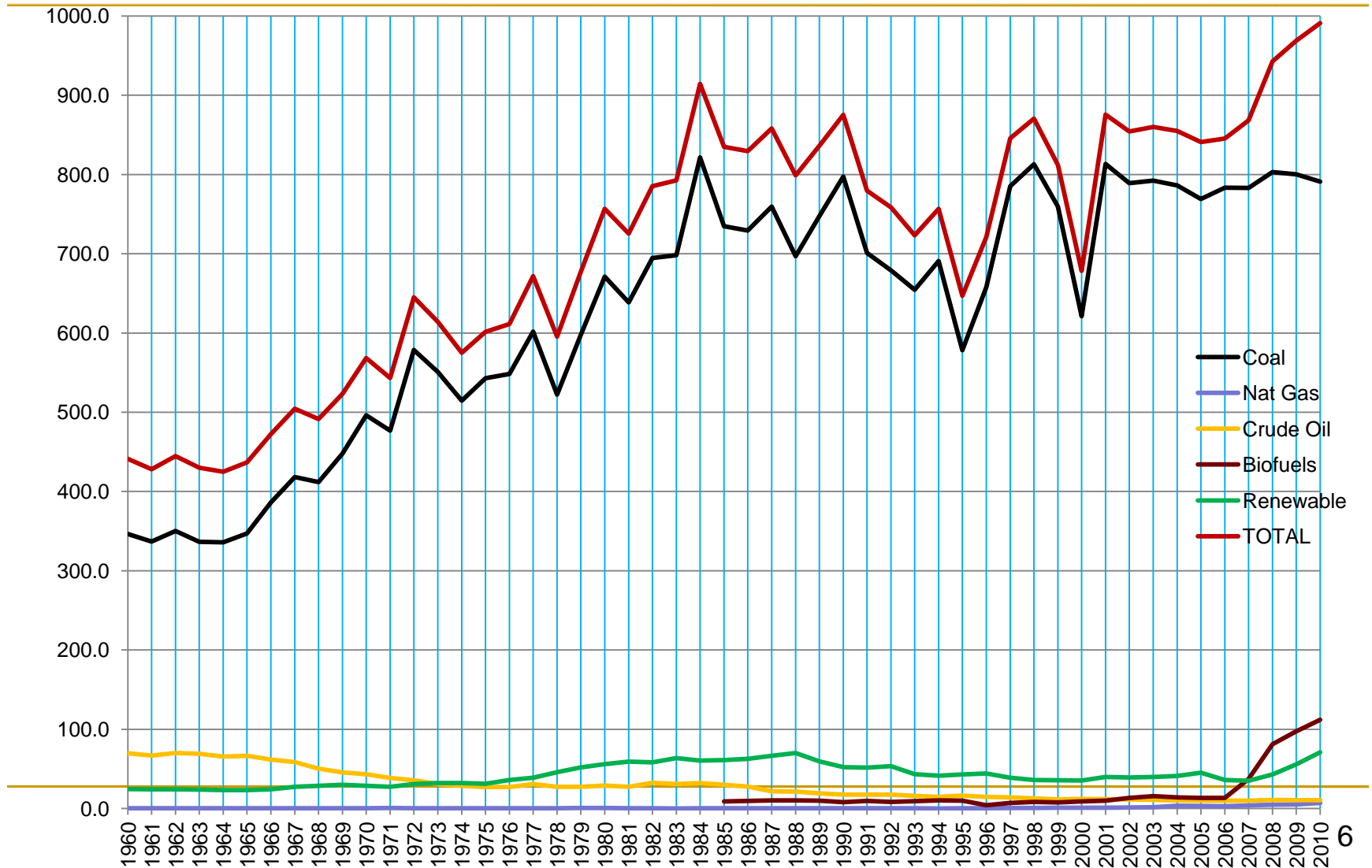
2011





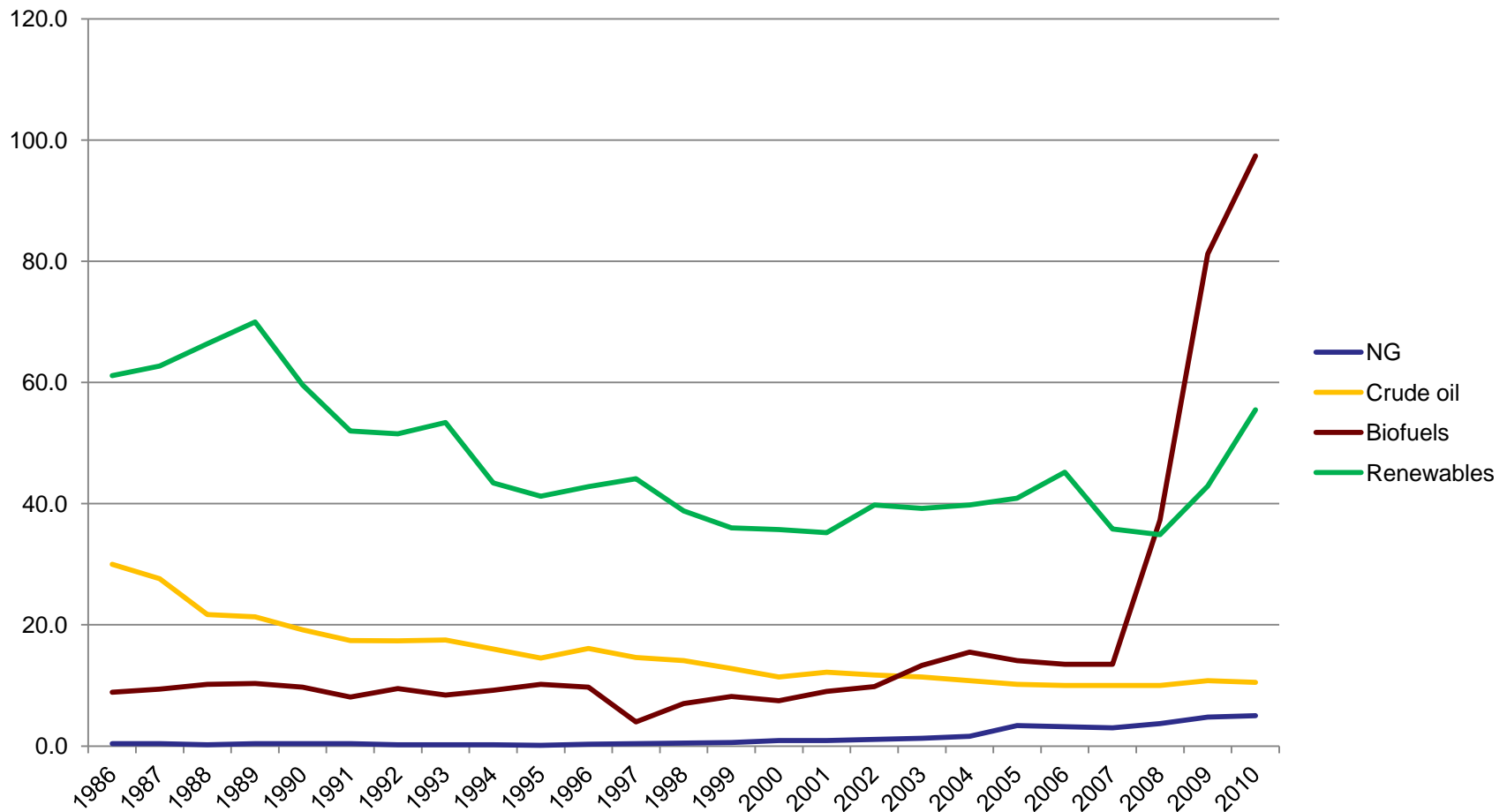
Indiana Energy Production

1960-2010 TBTUs





Indiana Non-Coal Energy production 1986-2010



Non coal energy production in 2010 was 20.1% of total energy production
Up from 12.1 % in 1986



2011 COAL DESTINATION: INDIANA

Indiana Consumed 52,041 : Produced 36,634 / Imported 23,560 / Exported 8,153

Wyoming: 9,855 Total
9,855 Electricity Generation
Rail

Colorado: 231 Total
Industrial Rail

Illinois: 3,793 Total
3,517 Electricity Generation
Rail 3,514 River 3 Truck 589
276 Industrial Plants
Rail

Western Kentucky: 810 Total
219 Electricity Generation
Rail 56 River 162
591 Industrial Plants
Rail 533 Truck 58

Eastern Kentucky: 1,336
609 Electric Generation
River 70, Truck 540
339 Coke Plant, Rail
387 Industrial 326 rail, 61 River

Alabama: 946
Total
221 Coke Rail

West Virginia: 4,820 Total
702 Electricity Generation
Rail 50 River 652 Truck 28
3,533 Coke Plants
Rail 3,533
585 Industrial Plants
Rail 530 River 55

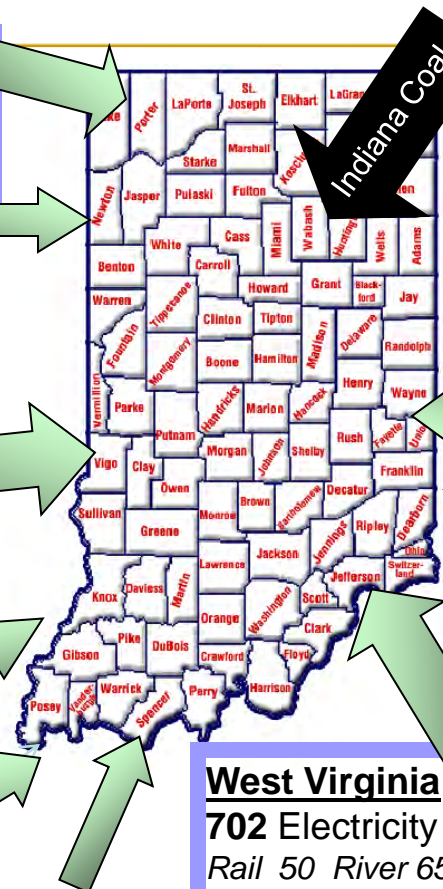
In state: 28,481 Total
27,200 Electricity Generation
Rail 20,381 River 316
Truck 6,503
1,010 Industrial Plants *Truck*
270 Residential-Commercial *Truck*
8.153 Exported

Ohio: 8 Total
8 Industrial Plants *Truck*

Pennsylvania: 1512 Total
1512 Electricity Generation
Rail 361 River 1151

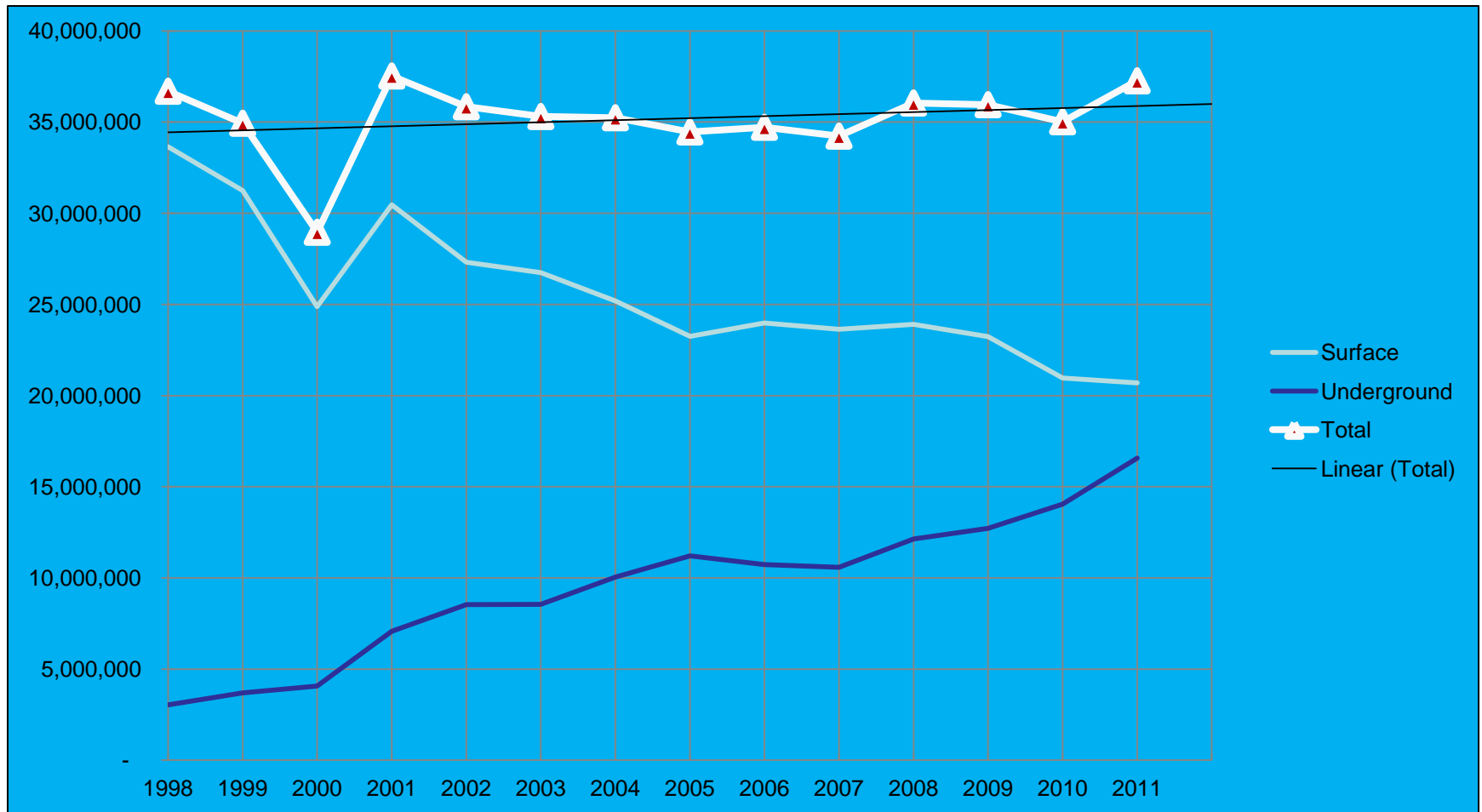
Virginia: 973 Total
704 Coke Plants *Rail*
268 Industrial rail

43,615 Power Generation
(9,300 from Synfuel)
4,797 Coke Plants
3,629 Industrial Plants
8,153 Export





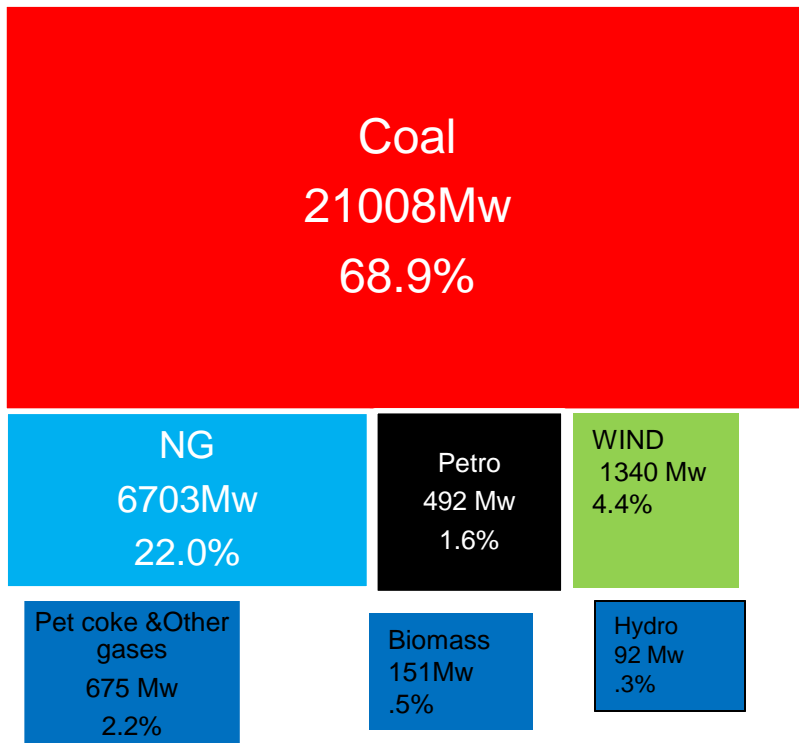
Coal Production in Indiana 1998-2011



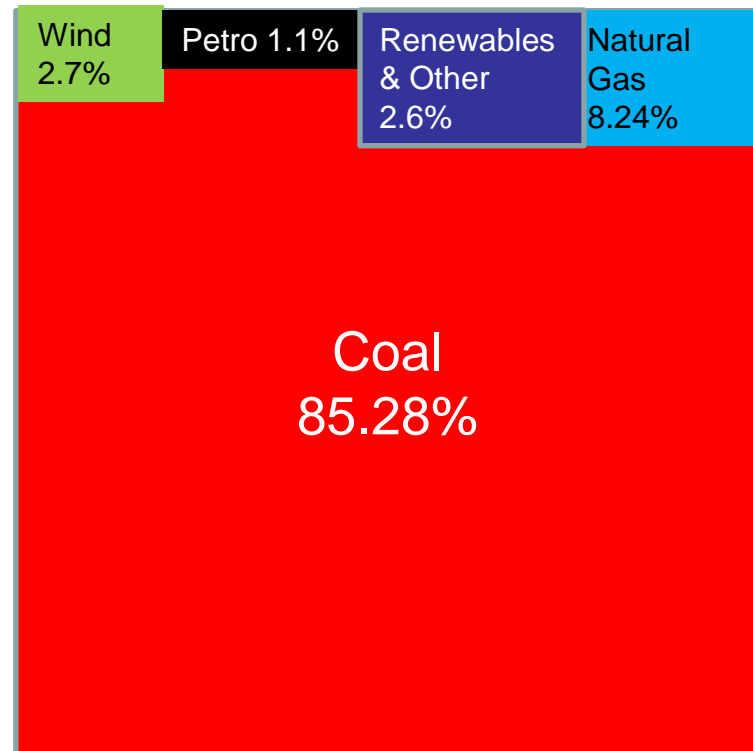


Coal, Natural Gas, & Renewables as Sources of Indiana Electricity Supplies Capacity vs. Generation 2011 Total State Wide Capacity

Indiana Electric Generation Capacity



Indiana Electricity Production:

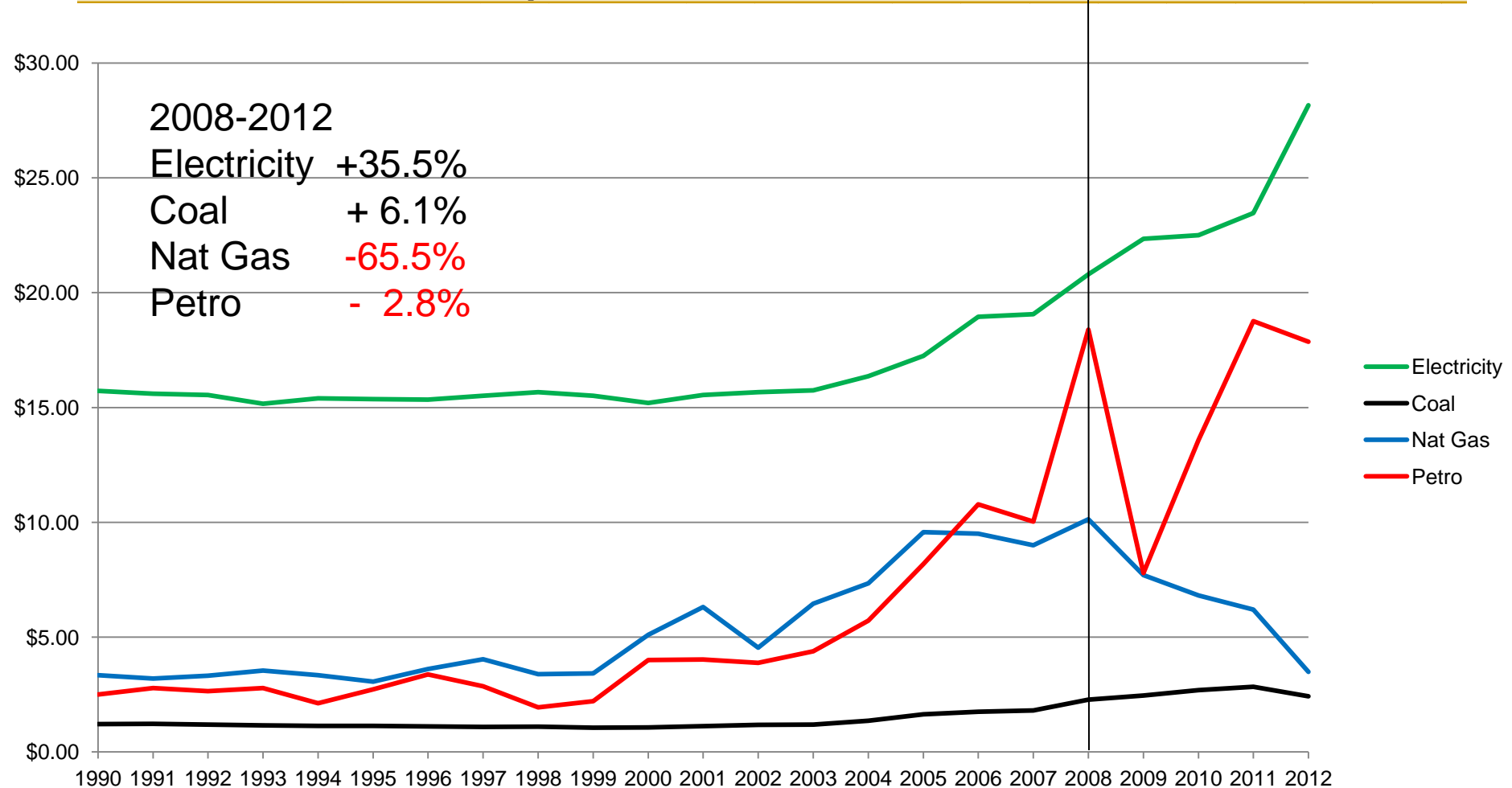


Airport Solar Project projected to be 100MW system able to supply an average of 13MW of power.



Indiana Energy Cost

\$/mmBTU 1990-2012



Recent electricity price increase (2008-2012) not related to cost of Primary energy Inputs



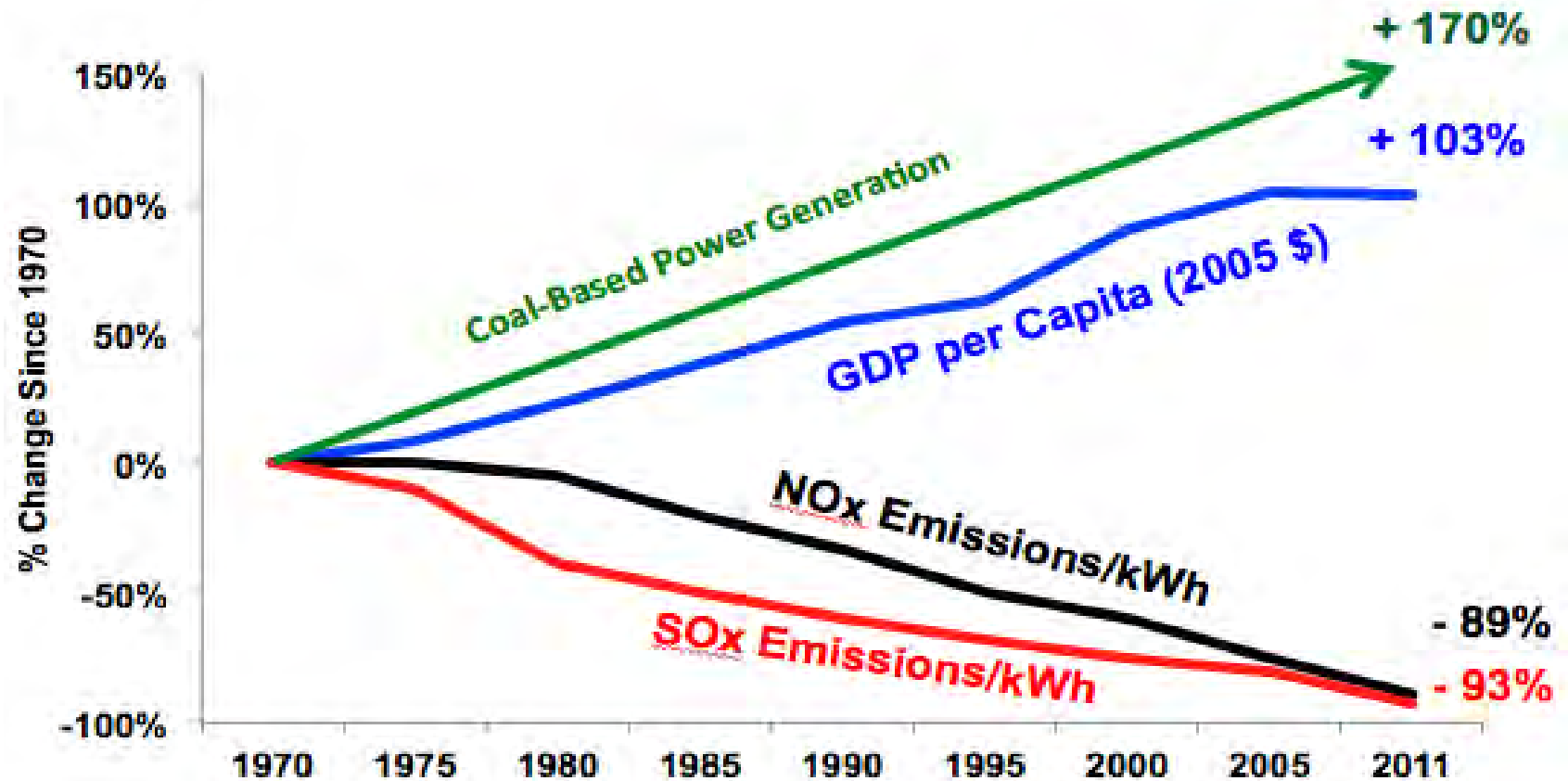
Indiana Energy Use and Expenditures 2002-2010

	2002	2010	
• Source	TBTU's	TBTU's	% Ch
• Coal	1,547.5	1,449.9	-6.3%
• Petroleum	890.7	787.6	-11.6 %
• Nat Gas	512.1	568.5	+11.0%
• <u>Renew</u>	<u>46.3</u>	<u>110.6</u>	<u>+138.9%</u>
• TOTAL	2,996.6	2,916.9	-2.6%
Homegrown	\$845.7 M	\$968.6 M	14.5%
Expenditures	\$16.0B	\$27.4B	71.3%
<i>\$/MMBTUs</i>	<i>\$ 5.35</i>	<i>\$ 9.47</i>	<i>77.0%</i>

- Using less but spending more
- IEA 2012



Pollution Emissions Decrease as Coal for Electricity Increased 1970-2011



PM reduction 96% per Kwh



Sources of Mercury

Source	Tons/year
• Nature: Volcanoes, Subsurface Ocean vents	9,000-10,000
• Chinese Coal and Oil Power Plants*	400
• Forest Fires	44
• USA Coal and Oil Power Plants*	44
• Human Cremations*	26
• CFLs*	2.2

*Less than 5% from Human activity Less than 1% from USA

- Most Expensive EPA rule ever issued

Annual Cost in 2016 --\$9.6 Billion above CSPAR

- EPA quantified benefits from 1985 to 2016 = \$33B-\$99B.
 - **Only between \$500,000 and \$6 Million of the quantified benefits are based on mercury reductions (1600 year payback period)**
-



EPA Impact on Indiana: Increase use of High Sulfur Coal and Reduced use of Renewables

• Current coal capacity	16,634.4 Mw	(baseload)
• Scrubbed	9,077.3 Mw	54.6%
• Unscrubbed	7,557.1 Mw	45.4%
• Immediate close	1,940.0 Mw	11.7%
• Mothballed Until a later date	1,145.1 Mw	6.9%
• Immediate retro fit (FGD)	4,472.0 Mw	*\$2619/kw, MISO 2012
Cost of retrofit est.	\$ 11.7 Billion*	
Western Coal Loss	6.98 Million Tons	
Indiana Coal Gain (net)	6.77 Million Tons	

“... in the current energy environment, increasing the amount of renewable energy , which now costs more than traditional forms of generation, must be balanced against other expected cost increases such as those necessary to comply with Environmental Protection Agency Mandates: IPL July 7, 2012



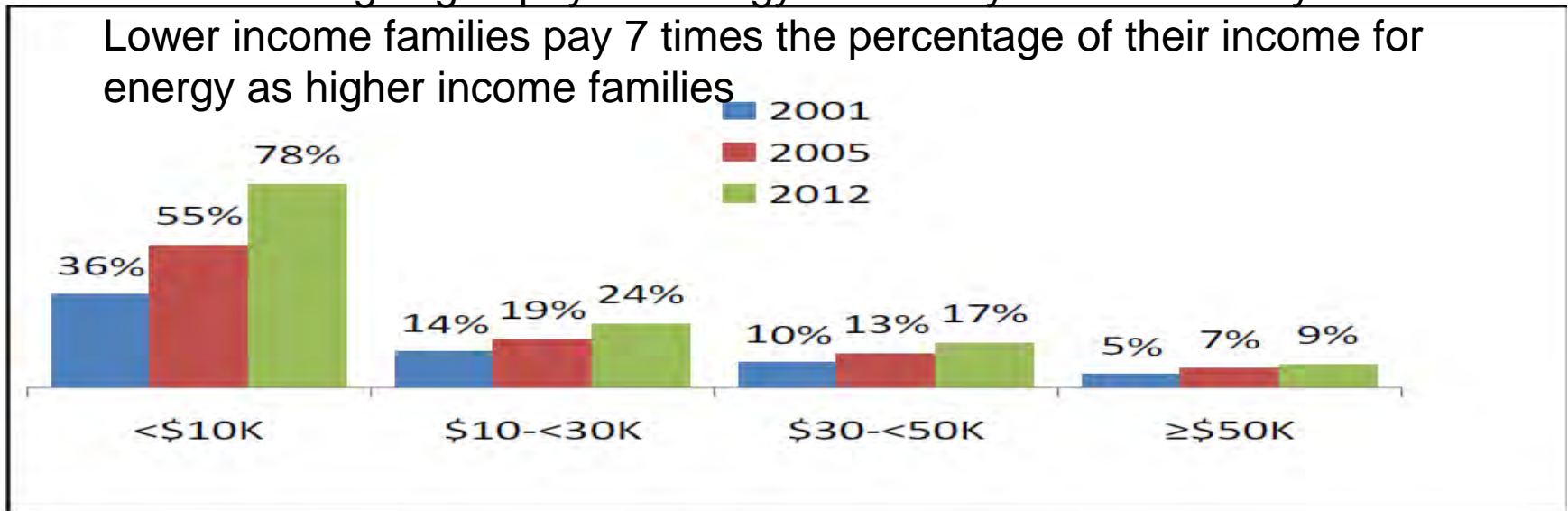
Energy is not a Luxury It is a Necessity

Energy Cost Impacts on American Families, 2001-2012

Not just a war on coal but, a war on affordable energy

% of income going to pay for energy has nearly doubled in 10 years

Lower income families pay 7 times the percentage of their income for energy as higher income families



Energy Costs as Percentage of Annual Household After-Tax Income



Energy Cost Affect Families Differently

- **Nearly 50% of US Households make less than \$50,000/year**
 - **These Households spend more on energy than they do on:**
 - Food
 - Twice as much as on healthcare
 - More on energy than on anything but Housing
 - **Government subsidies increase as price of energy increases.**
 - **Taxes increases further reduce a family's net income.**
Increase cost of energy result in increase taxes.
 - **It is imperative that we maintain a low energy cost not just for business and industry but for American Families.**
-



EPA CO₂ Rule Cost

- \$80 Billion to comply with new EPA rules.
 - 6,622.5 Trillion BTU's of new gas demand.
 - 11.6 times the amount currently consumed annually by Indiana every year.
 - 24% increase over 2012 total U.S. consumption
 - \$265 million in annual energy cost increases.
 - 3 years to comply with EPA rules, knowing that the EPA takes an average of 4 years to approve a New Source Permit.
-



What Does EPA say About Their Own Proposed CO2 Rules

The Agency does NOT anticipate any notable CO2 emission changes resulting from the Renewable Fuels Standard:

- “The standards would not even make a negligible contribution to a solution”
- “The Agency estimates that these standards will reduce atmospheric CO2 concentrations by 0.732 parts per million (equal to 1 part in 1.37 million), which in turn will avert an estimated warming of 0.004-0.012 Degrees C by the Year 2100.” “A change too small for scientist to distinguish from statistical noise.”
- As for the proposed CO2 emission for fossil-fuel power plants:
The Agency does not anticipate any notable CO2 emissions changes resulting From the standard.” And concludes: “There are no direct monetized climate benefits in terms of CO2 emission reductions associated with this rulemaking”



CO₂ Control Cost

Deployment Barriers for CO₂ Capture On New and Existing Coal Plants Today

1. Scale-up

- Current Post Combustion capture ~200 TPD
- 550 MWe power plant produces 13,000 TPD

2. Energy Penalty

- 20% to 30% less power output

3. Cost

- Increase Cost of Electricity by 80%
- Adds Capital Cost by \$1,500 - \$2,000/KW

4. Regulatory framework

- Transport — pipeline network
- Storage

5. Economies of Scale

- Land, power, water use, transportation, process components, ...



Utility Scale CC not available until 2025

National Energy Technology Lab, August 2011 Jared Ciferno



Local Impact

41% electric rate increase over next 8 years.

- **Western Coal Loss 6.98 Million Tons**
 - Reduces the export of energy capital by \$292 Million/year
 - **Indiana Coal Gain (net) 6.77 Million Tons**
 - Capital retained by \$237 Million (\$529 Million total economic benefit)
 - Adds 500 direct mine jobs +1500 ancillary jobs
 - **Increased use of Indiana coal will not be enough to offset the potential loss of manufacturing in Indiana nor the impact to Hoosier families due to the rate increases.**
 - **7% increase in average rates from fuel switching (CCTR)**
 - **20% COE to the State (SUFG 2011 forecast)**
 - **14% SUFG rate Increase for Compliance (SUFG 2011)**
 - **Manufacturing sector will need to switch from producing its own power to purchasing due to new MACT rules, making impact worse.**
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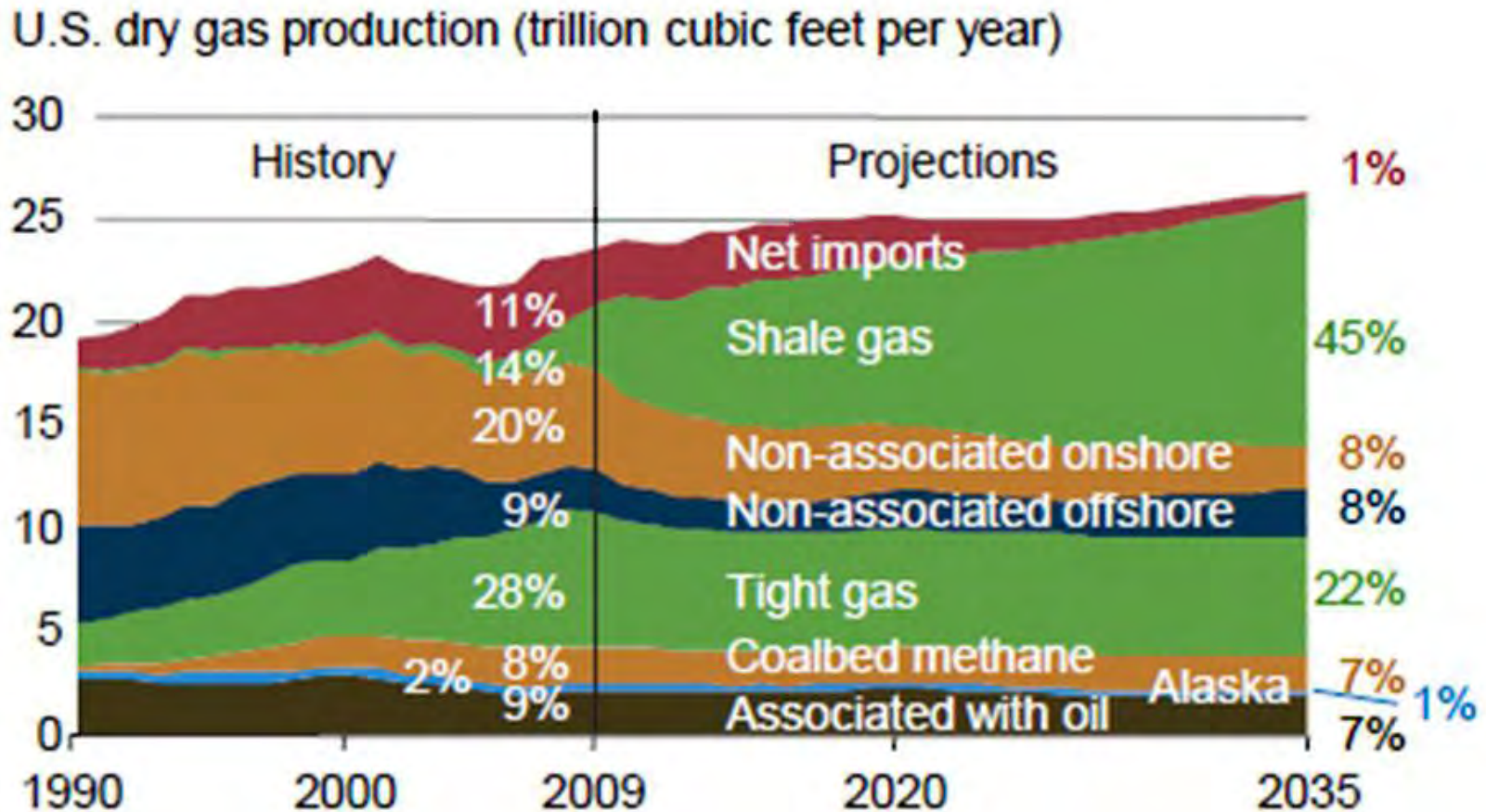


Natural gas is the answer! (Wanna Bet)

- Gas Turbine capacity in Indiana **6,003 Mw**
- Gas Turbine generation currently produce 4.6% (3.7 Billion KWH) peak demand
 - Will need to generate 14.4 Billion KWH. (4 fold increase)
- Natural gas can replace the 1940 MW of Coal capacity lost, with 1800 MW of turbines currently used as baseload, But:
- 1) Natural Gas is 2X the cost of coal
- 2) We have reduced our ability to meet peak demand by 32.3%
- Fuel cost for electricity goes up by 7 % across the board (this is in addition to the cost increase from adding scrubbers).
- We need to bring in **25% MORE NG** than is consumed in the entire state today from an infrastructure already operating at maximum levels. We need to build more pipelines going in a different direction than the ones used today.
 - There currently exist no source of NG that can produce that much additional supply plus what the other states that are doing the same will need, in the time frame dictated by the EPA.
- 67% of the gas from a Shale Oil well is produced in the first 3 years of well operation. We need to duplicate the number of wells we have today every 3^{23} years to stay even.



US Sources Of NATURAL GAS



April 2012 Natural gas \$2.43 MMBTUs, Shale Gas \$6.00 MMBTUs

3.0 Times as much gas from shale in next 25 years.

What will that do to price? If NG price stays \$2.43 overall Price 36% increase



Adding Value to a Lump of Coal

Coal is of no value until it is converted into something else

1 ton bituminous coal if gasified

1.27 Mwh electricity (\$95.25)

14 MM Btu Syngas (\$30.91)

.41 tons of CO₂ (capturable)

\$126.16

\$ 22.63 plus EOR value from CO₂

\$148.79

Pulverized
Coal

Combustion
No CO₂ control

FT CTL

Indirect Conversion
W/CO₂ capture

Direct CTL
(Catalytic)
w/ CO₂ capture

Electric Power Production

Products	Value
2.25 MWh Electric	\$168.75

FT Fuels and Power

Products	Value
120 KWH Elect	\$ 9.00
0.44 bbls Naphtha	\$ 53.24
0.57 bbls Diesel	\$ 80.88
0.012 Tons Sulfur	\$ 2.00
Total	\$145.12

Fertilizer, FT Fuels and Power

Products	Value
0.07 MWh Elect	\$ 5.25
3.52 bbl Diesel	\$ 499.49
0.25 tons ammonia	\$ 112.50
Total	\$ 617.24

1 ton of
coal

Coal @\$52/ton
Petroleum @\$92/bbl
Electricity @\$.075/KWh
Naphtha @\$121/bbl
Diesel @\$141.90 bbl
Ammonia @\$450/Ton



Conclusion

Do what we can now

- Put wind turbines where the wind blows (build grid connections)
- Put solar where the sun shines (local use not grid scale)
- Water companies to build close loop geothermal (most efficient way to heat and cool a house)
- Put gasifiers on coal fired power plant sites bypass coal fired boilers:
 - No new infrastructures needed
 - Meets EPA standards
 - Keeps coal job alive
 - Produces syngas when not producing power
 - Already able to capture CO₂ for EOR (no tech delay)
 - Enable wind turbine/gas turbine function (Indiana Coal report, SUFG 2009)
 - Mercury & SO_x separated in the process not emitted
 - NO_x not produced in the process
 - MSW can be blended to reduce landfill needs

The problem is we don't make these things anymore
We need to create the ability to build new technology



Renewable Energy System that Works





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