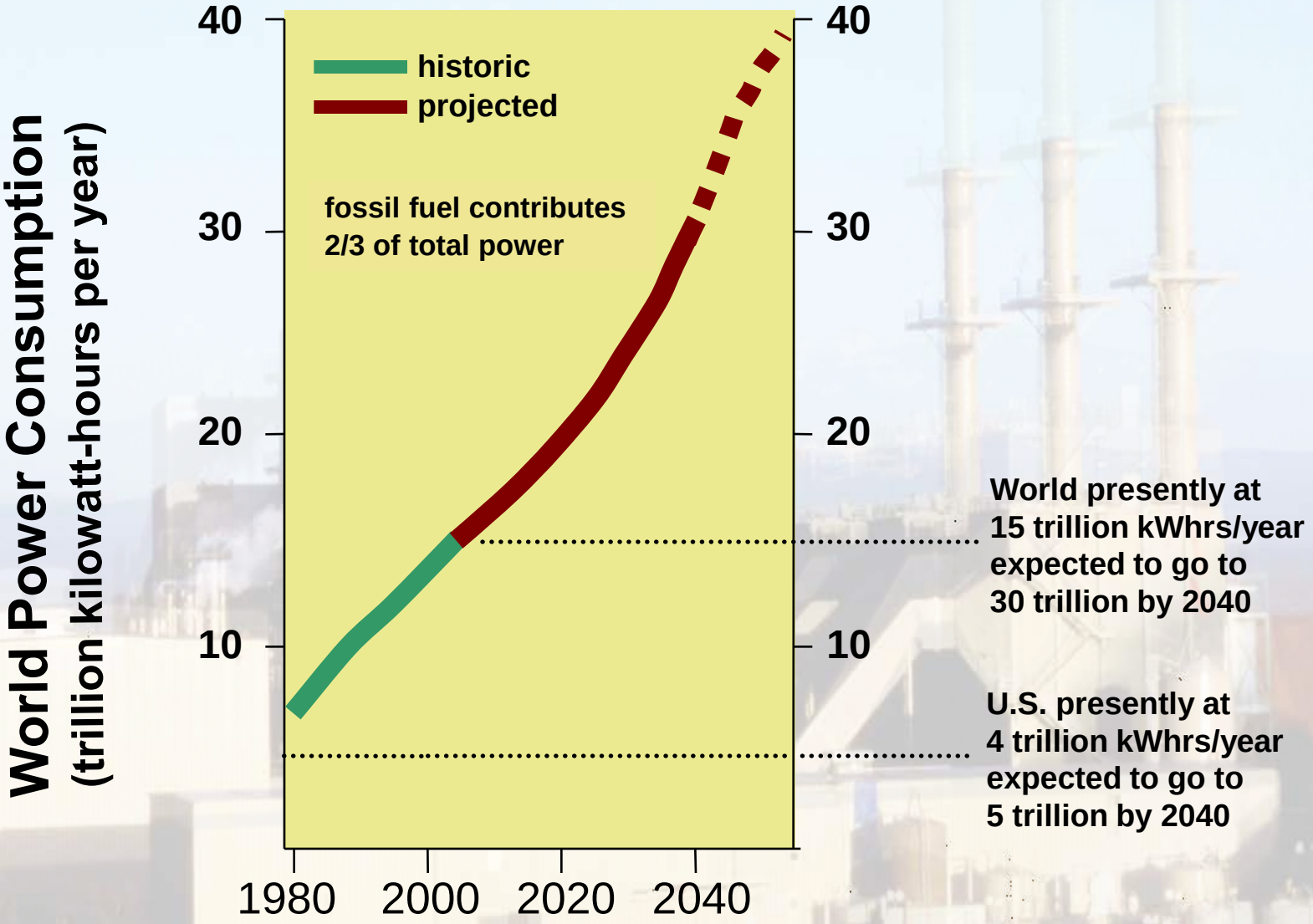
Baseload Generation and the Future Energy Horizon

- global shifts in generation and implications for U.S. carbon reduction goals

Dr. James Conca
UFA Ventures, Inc.
Richland, WA

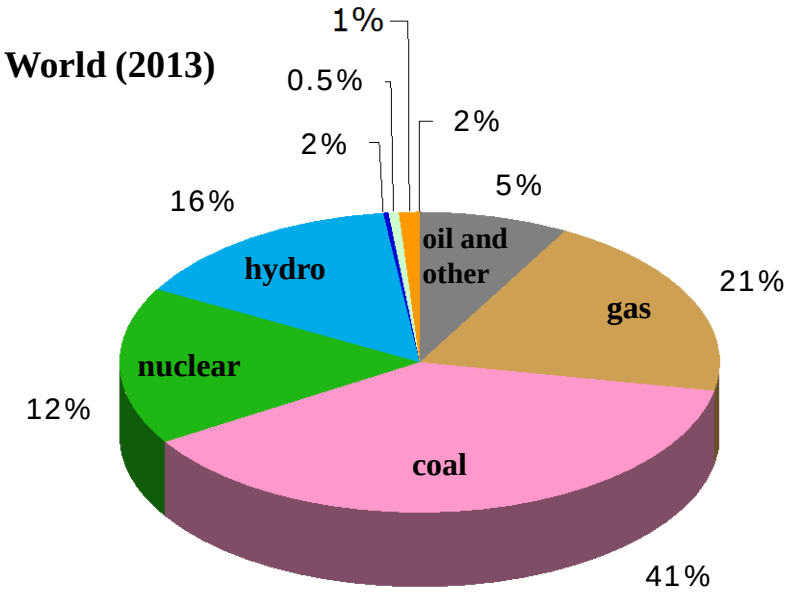
Member Forum XVII
Kennewick, WA
October 2014

http://www.forbes.com/sites/jamesconca/

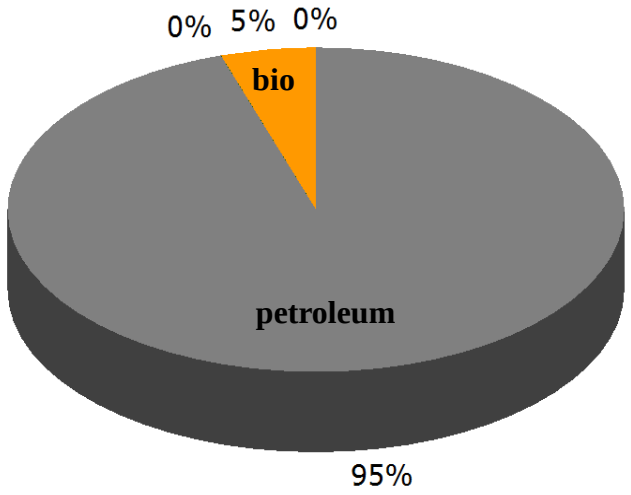

World Power Consumption
(trillion kilowatt-hours per year)
40
30
20
10
historic
projected
fossil fuel contributes
2/3 of total power
1980
2000
2020
2040
World presently at
15 trillion kWhrs/year
expected to go to
30 trillion by 2040
U.S. presently at
4 trillion kWhrs/year
expected to go to
5 trillion by 2040

Present Energy Distribution (Power)

World (2013)



Present Energy Distribution (Transportation)



- Oil
- Gas
- Coal (all types)
- Nuclear
- Hydroelectric
- Wind
- Geothermal
- Biofuels
- Solar
- Petroleum fuels (including H for fuel cells)
- Nuclear (H for fuel cells)
- Biofuels
- Solar (including H for fuel cells)

United States
39% coal
27% gas
19% nuclear
7% hydroelectric
4% wind 4% other

Washington	Kentucky	Illinois
4% coal	93% coal	43% coal
3% gas	4% gas	1% gas
8% nuclear	0% nuclear	49% nuclear
79% hydro	2% hydro	7% renew.
6% renew.	1% renew.	

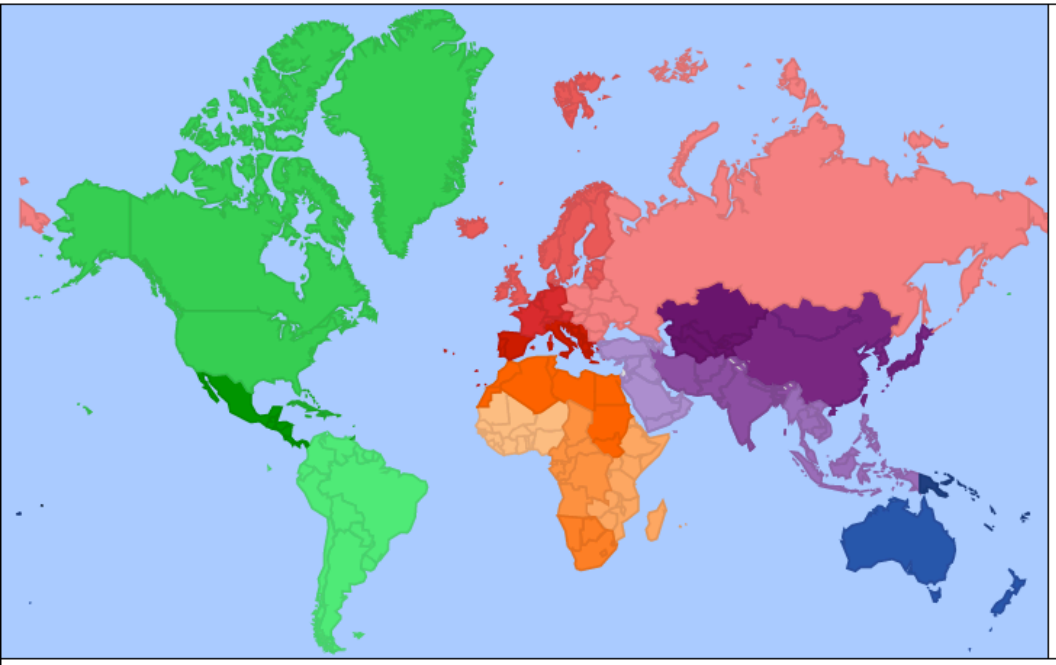
European Union
30% coal
20% gas
28% nuclear
9% hydroelectric
3% oil 10% renewables

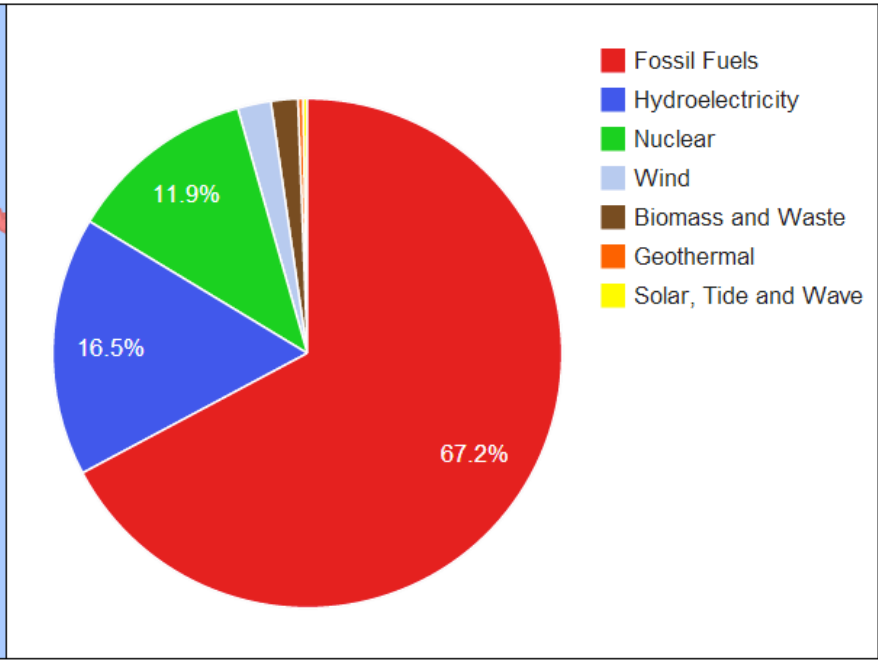
Korea
26% coal
23% gas
7% oil
36% nuclear
8% hydro + renewables

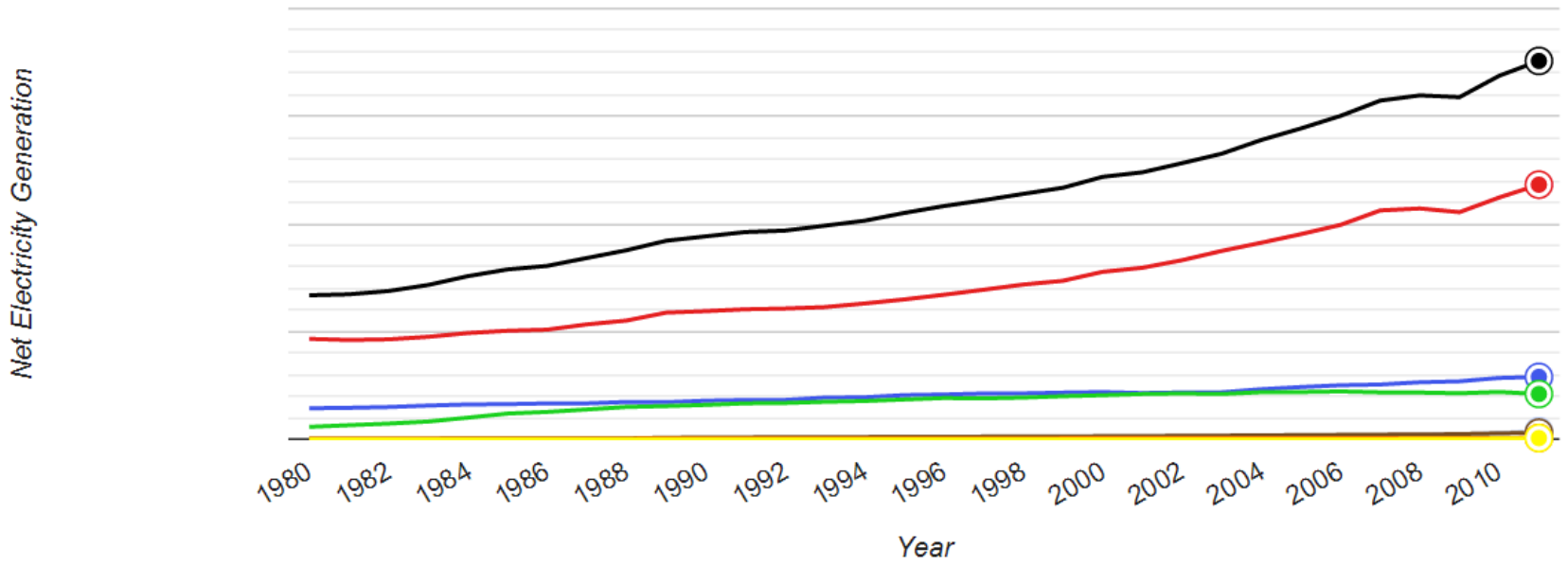
China
70% coal
3% gas
5% wind
1% nuclear
18% hydro 3% other

Location: World Year: 2011 Submit

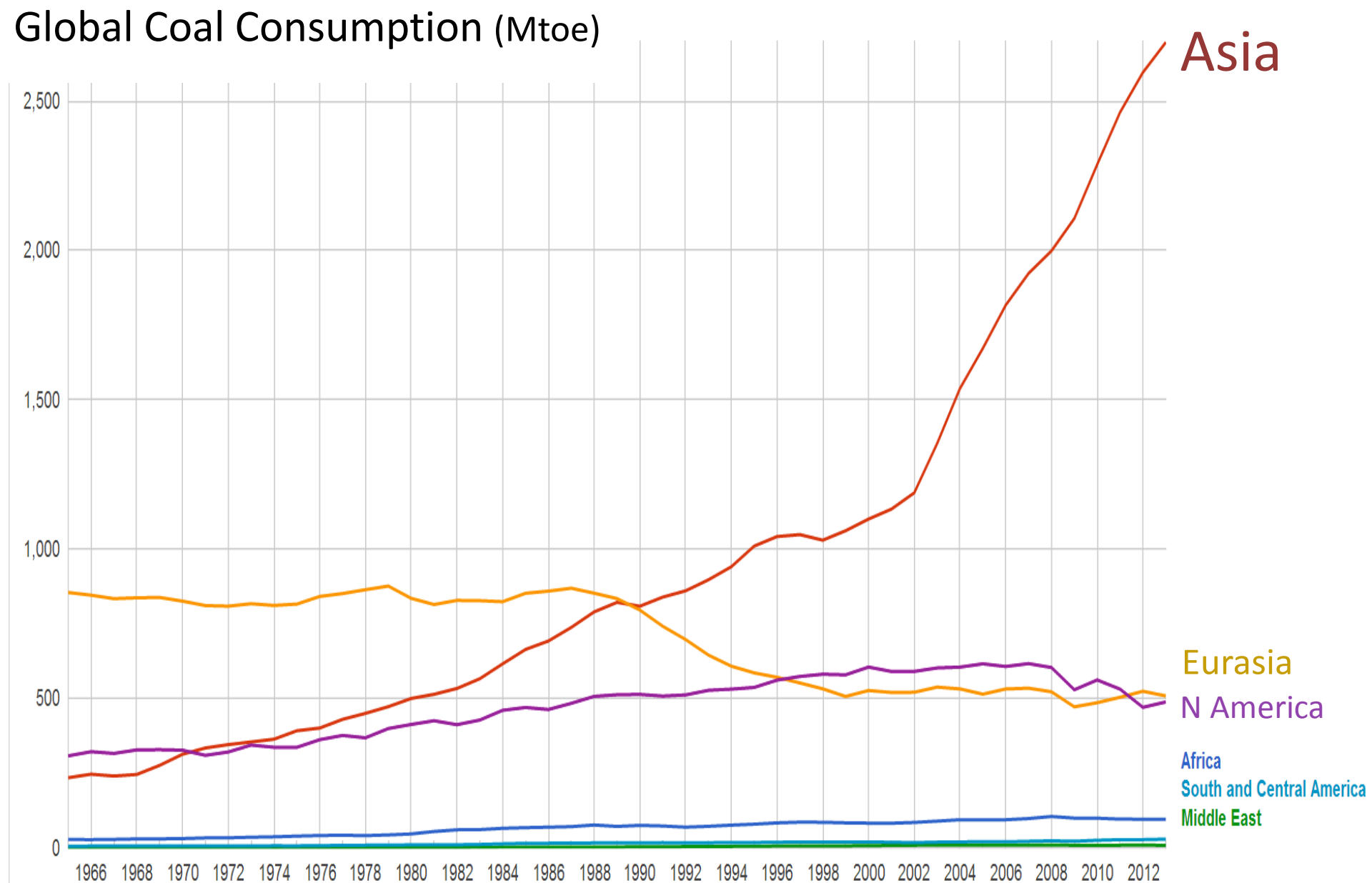
World Electricity Generation





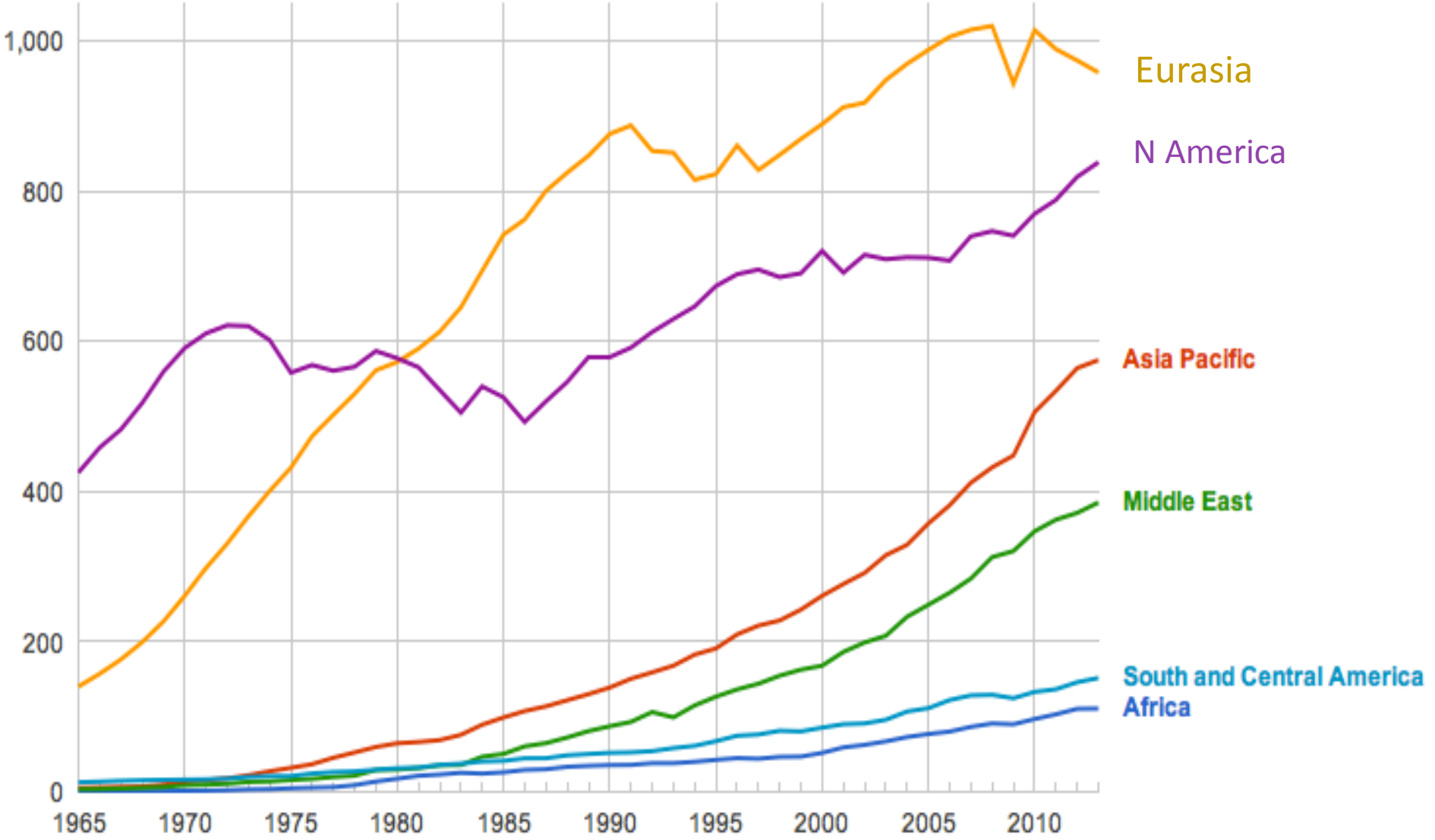


What is the fastest growing energy source?

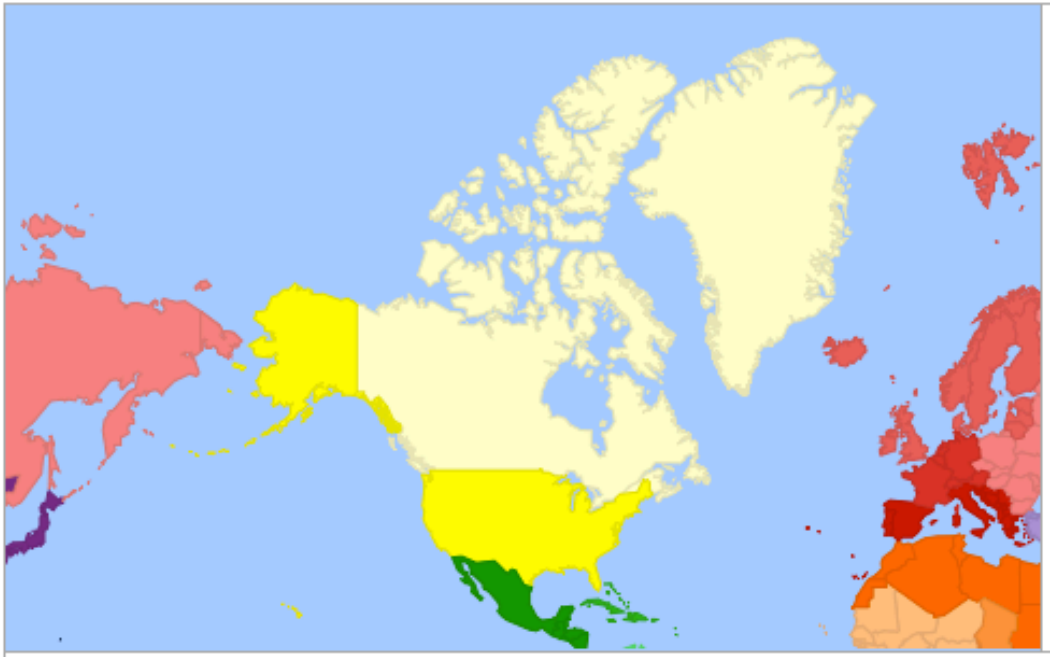


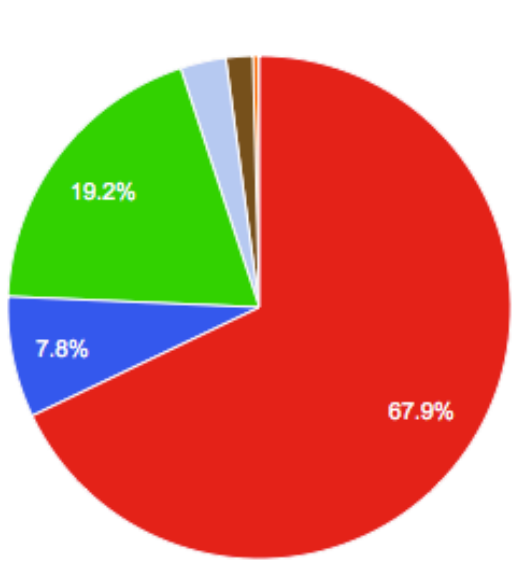
What is the next fastest growing energy source?

Global Gas Consumption (Mtoe)

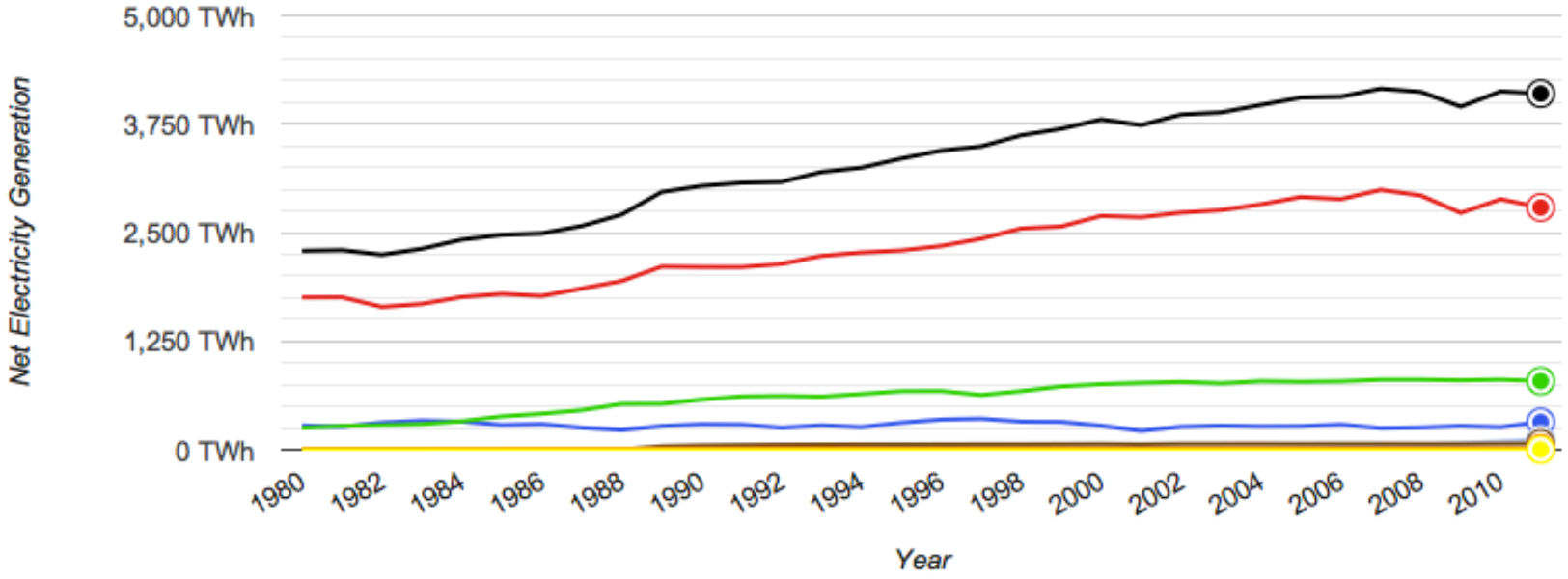


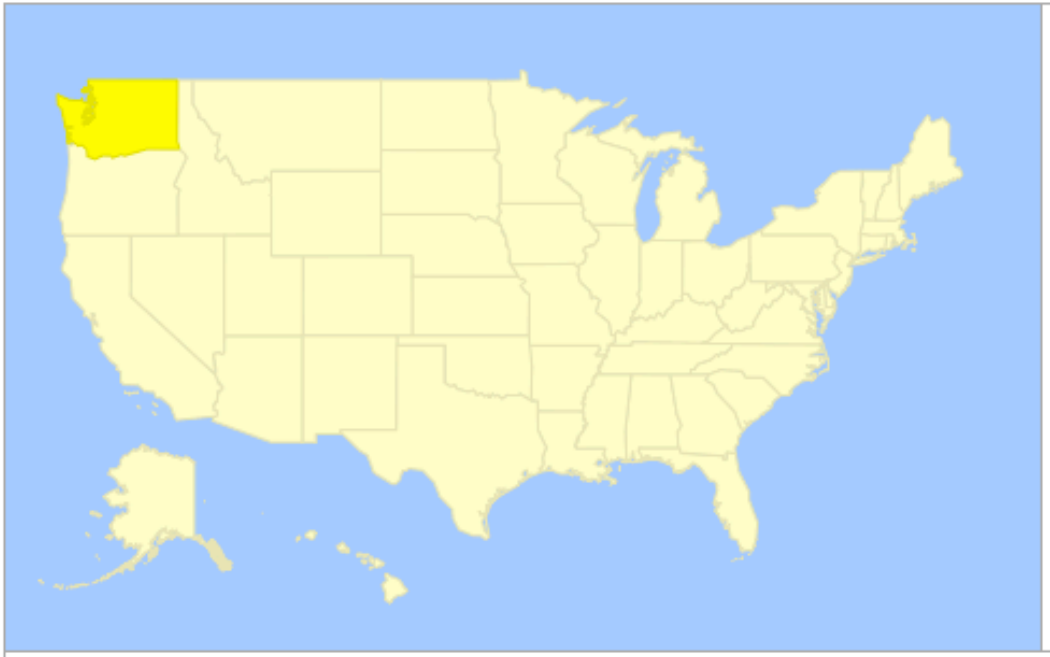
U.S. Electricity Generation

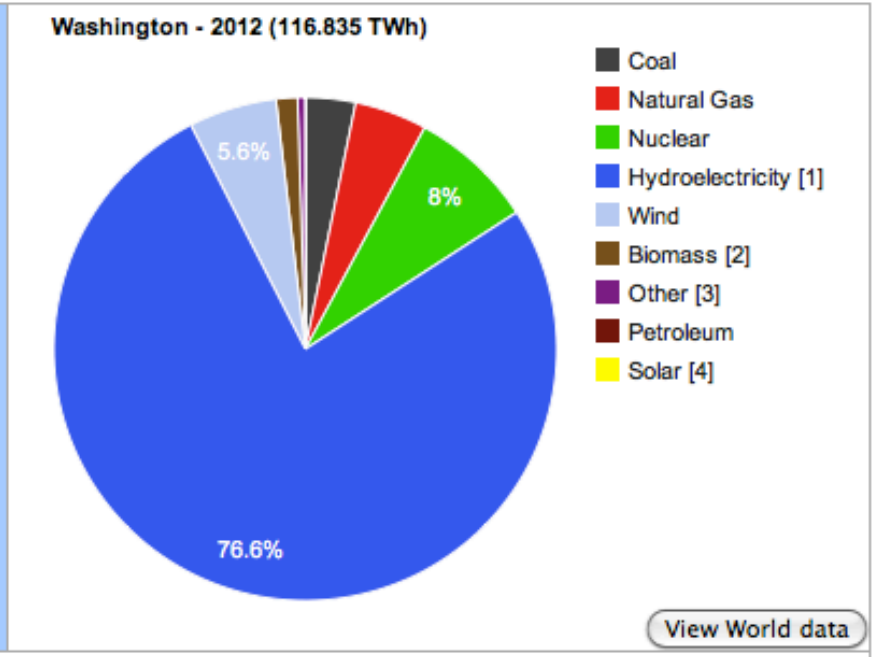


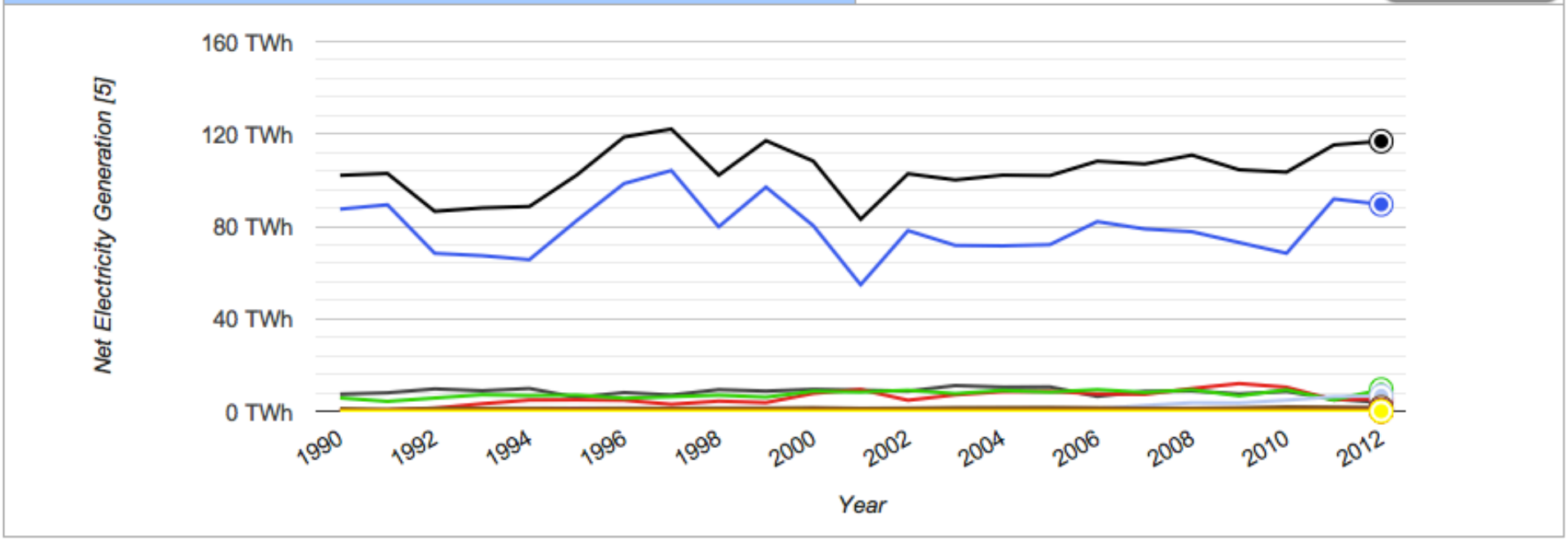


View detailed United States data

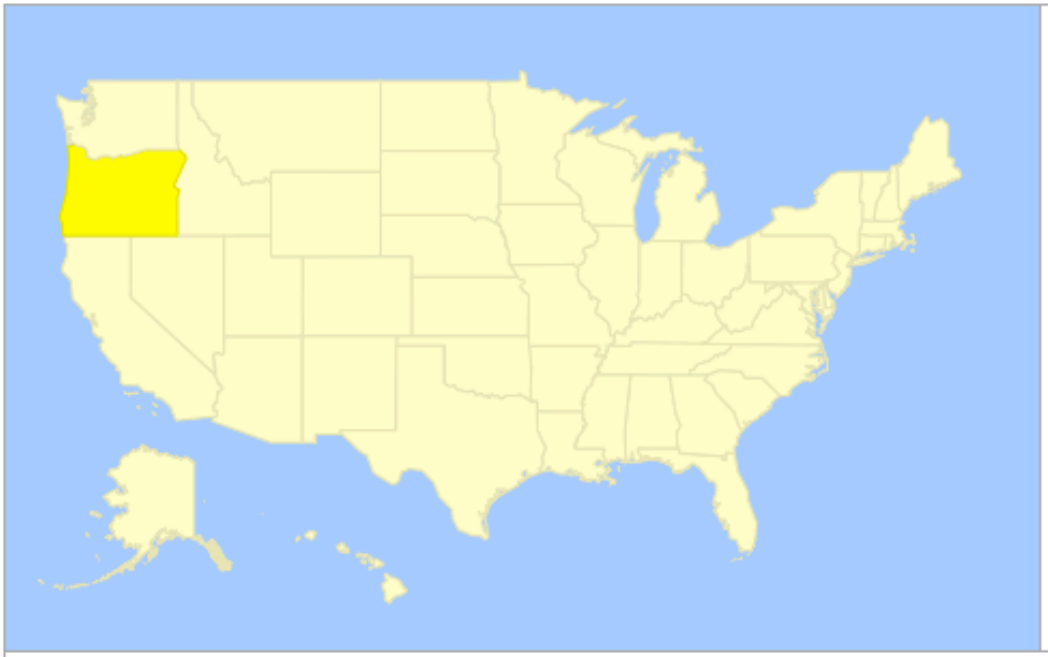


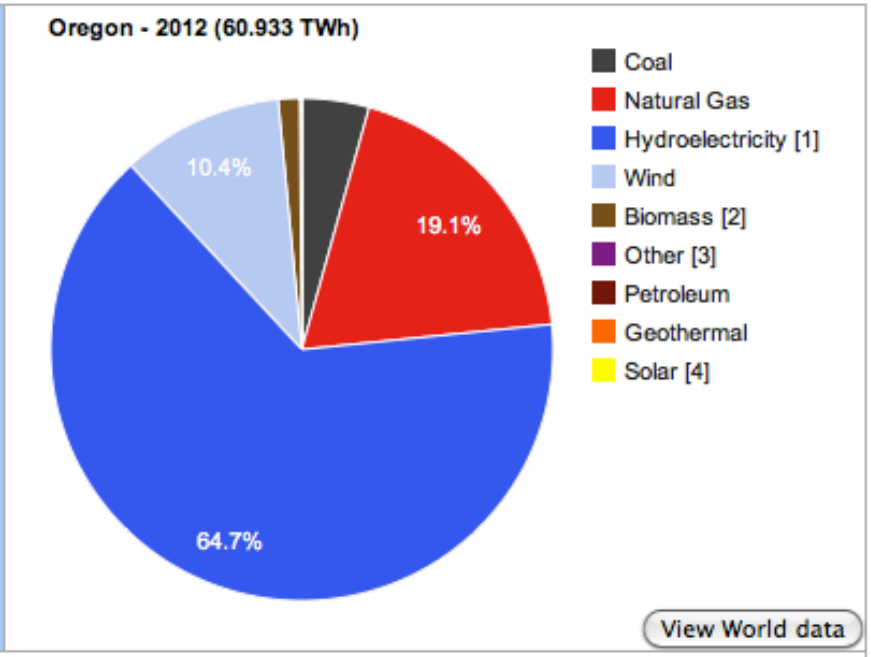


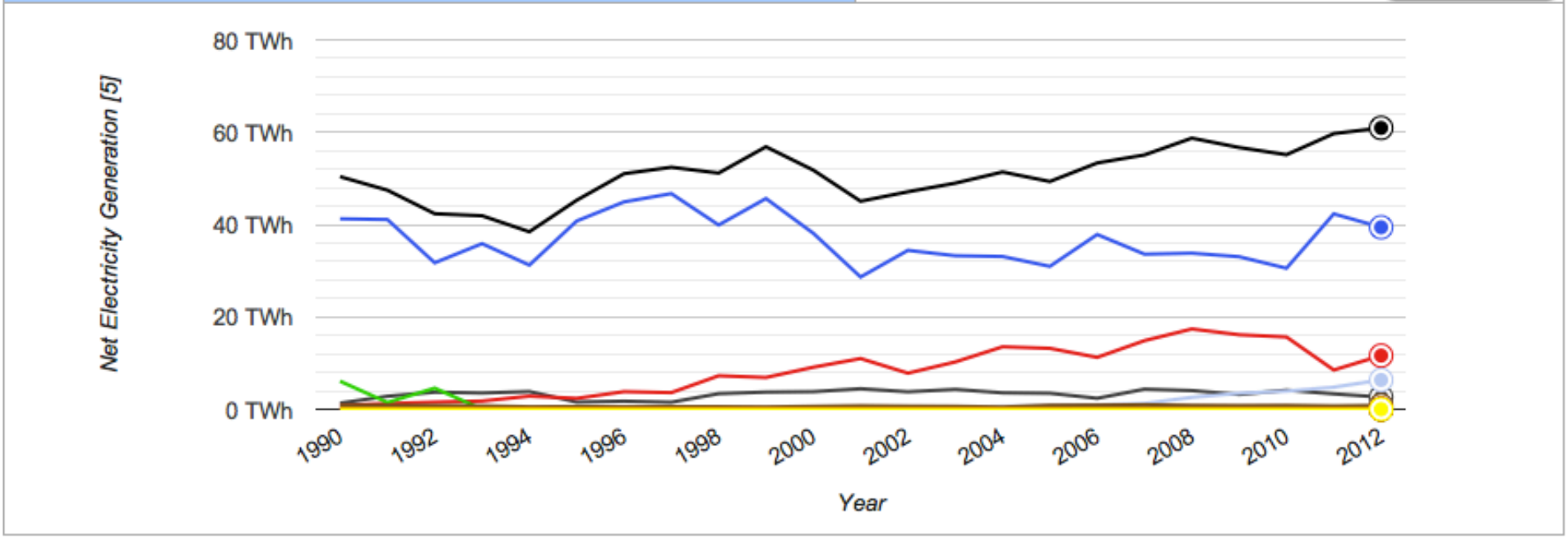


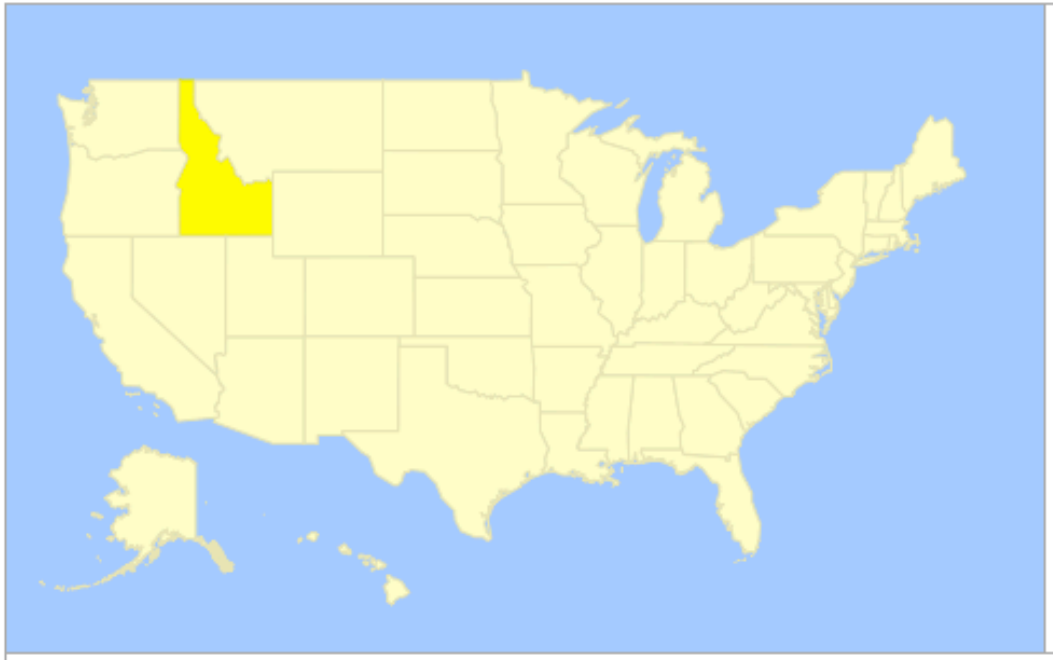


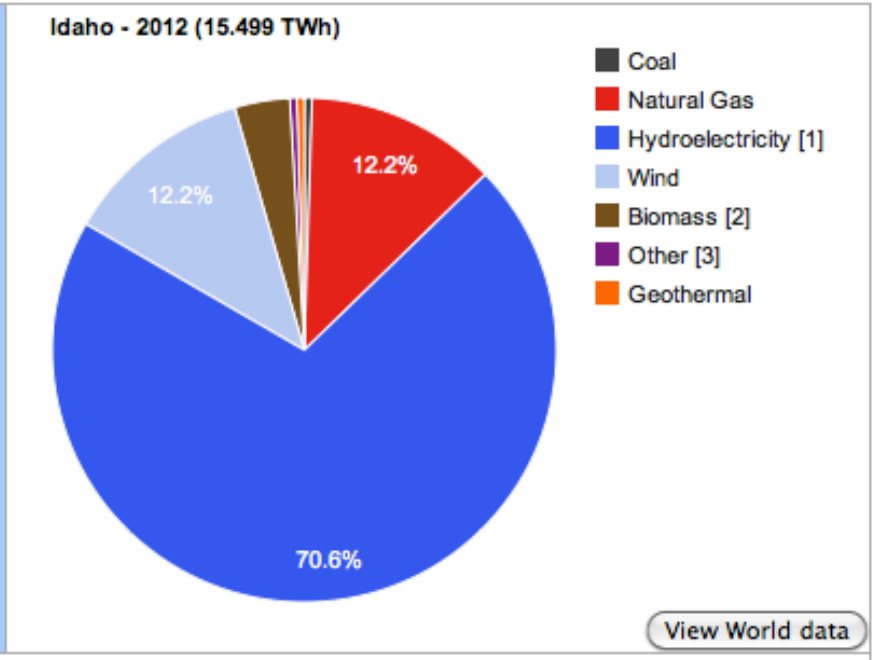
Data Source: U.S. Energy Information Administration. (2013). *Net Generation by State by Type of Producer by Energy Source* [Online]. Available:

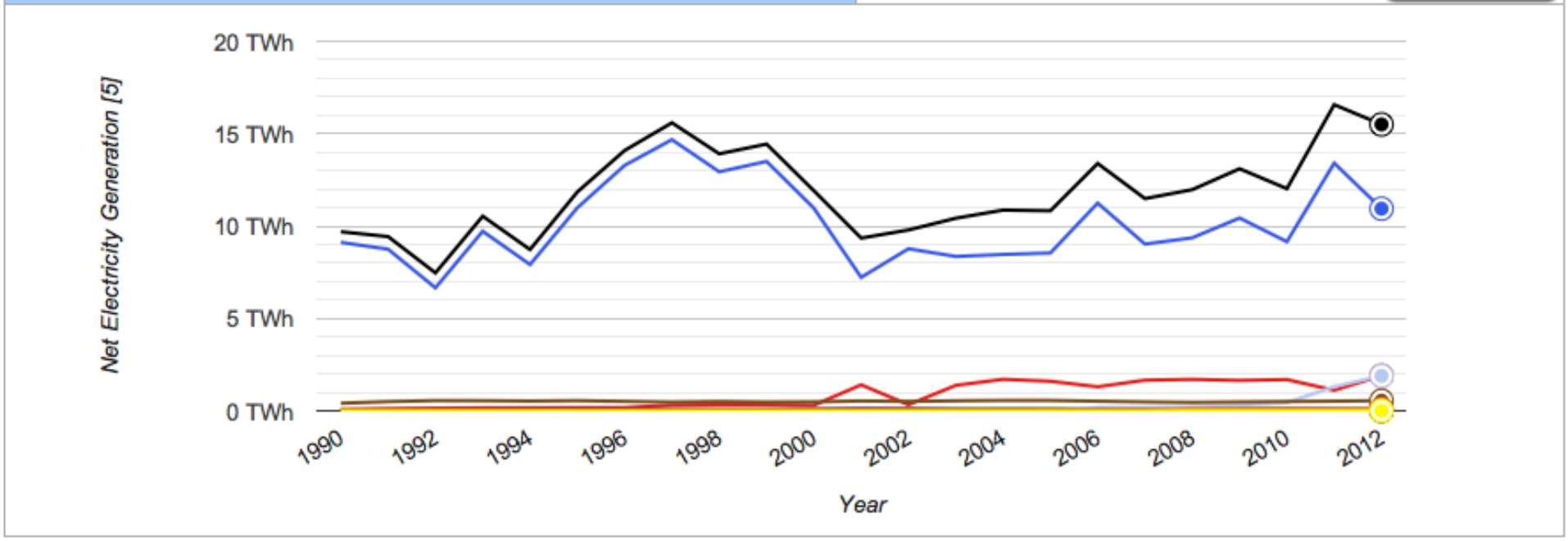


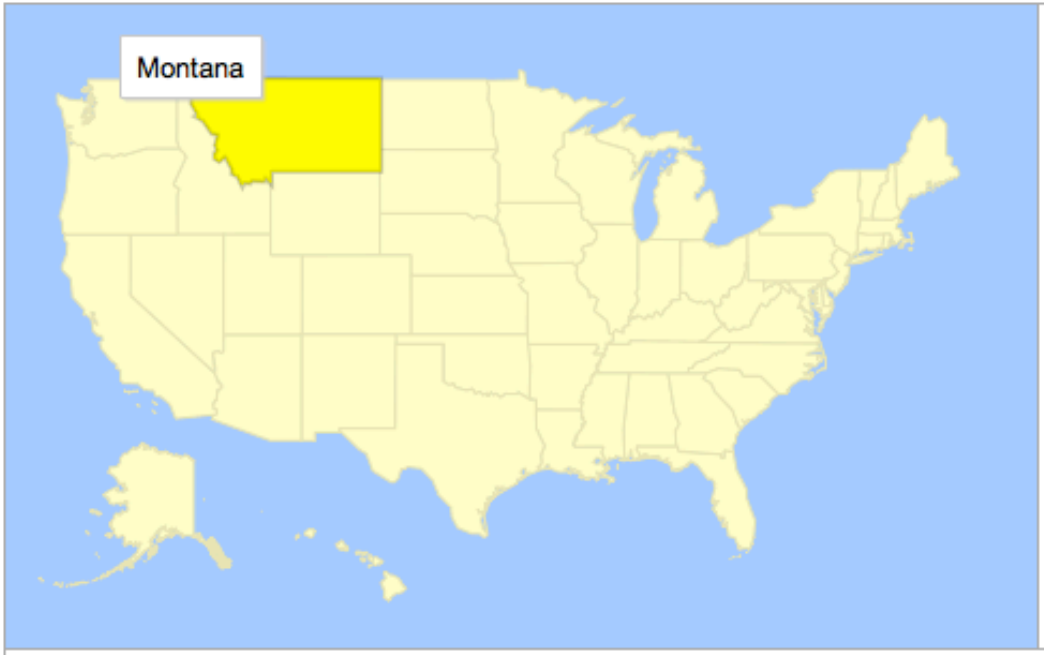

Oregon - 2012 (60.933 TWh)
Coal
Natural Gas
Hydroelectricity [1]
Wind
Biomass [2]
Other [3]
Petroleum
Geothermal
Solar [4]
10.4%
19.1%
64.7%
View World data

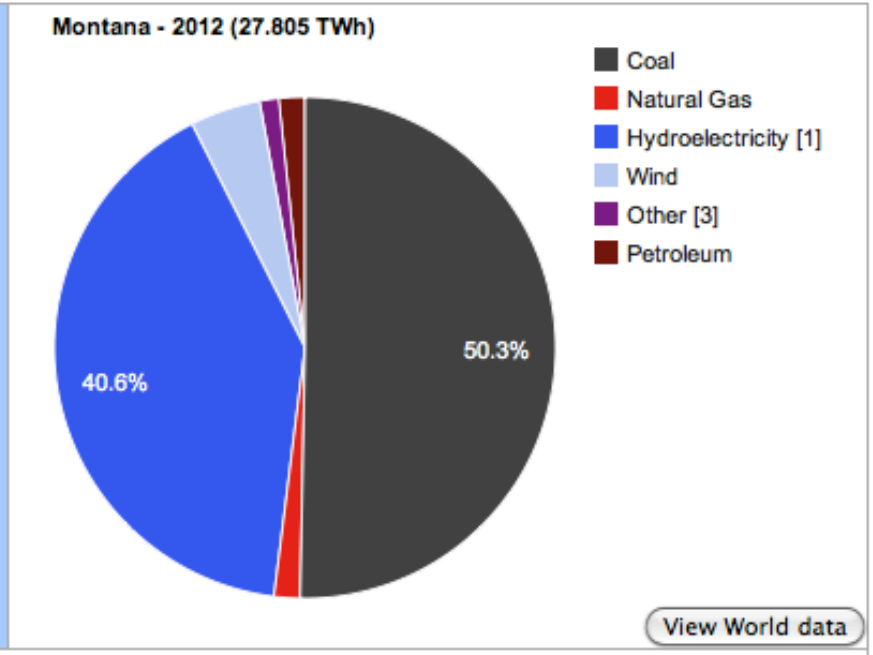

80 TWh
60 TWh
40 TWh
20 TWh
0 TWh
Net Electricity Generation [5]
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year

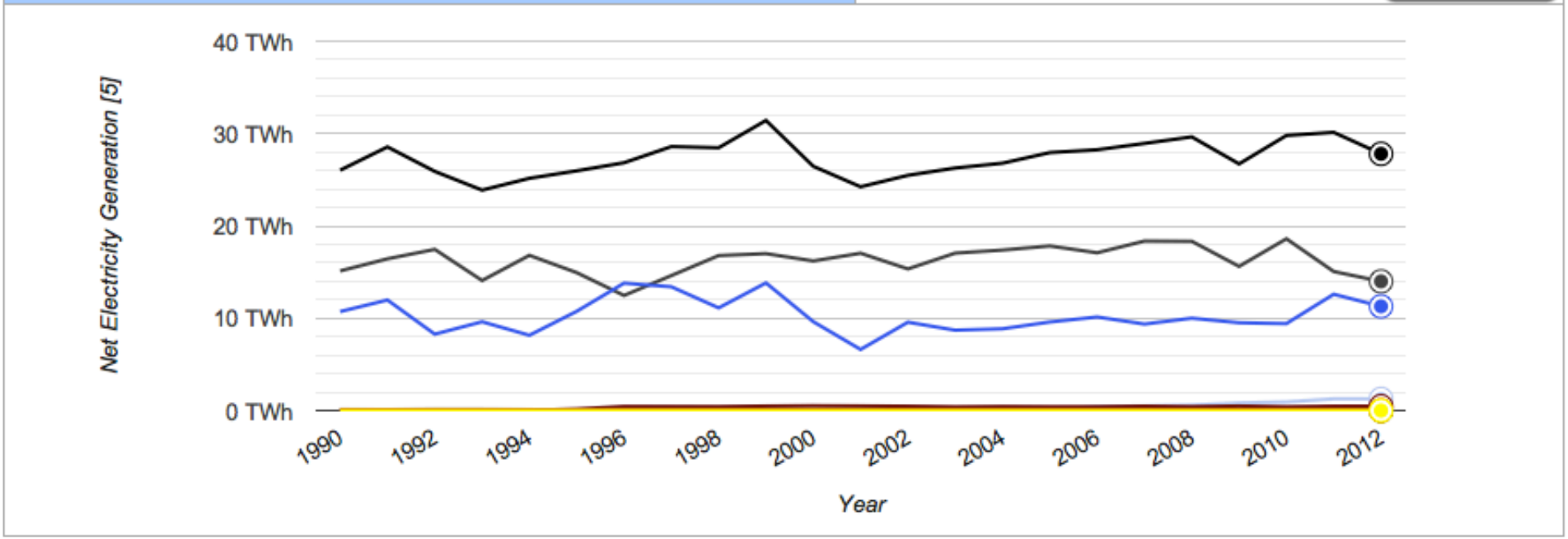


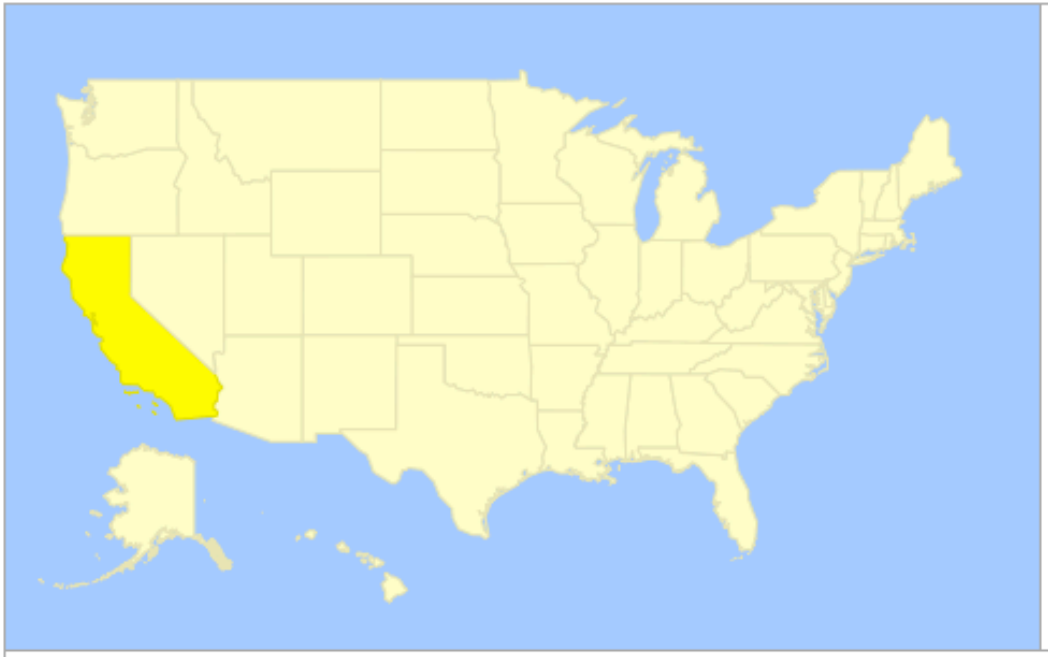

Idaho - 2012 (15.499 TWh)
Coal
Natural Gas
Hydroelectricity [1]
Wind
Biomass [2]
Other [3]
Geothermal
12.2%
12.2%
70.6%
View World data

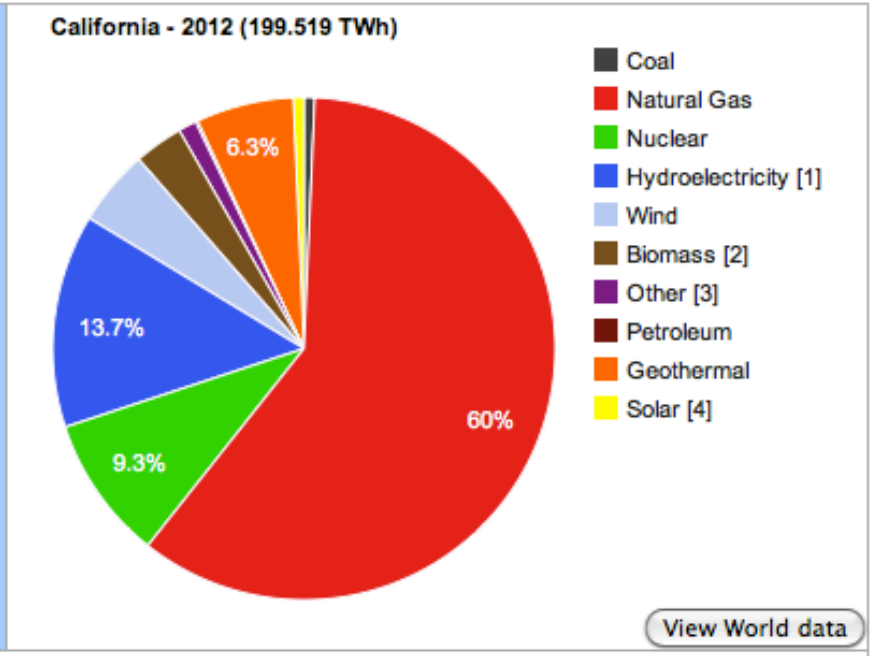

20 TWh
15 TWh
10 TWh
5 TWh
0 TWh
Net Electricity Generation [5]
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year

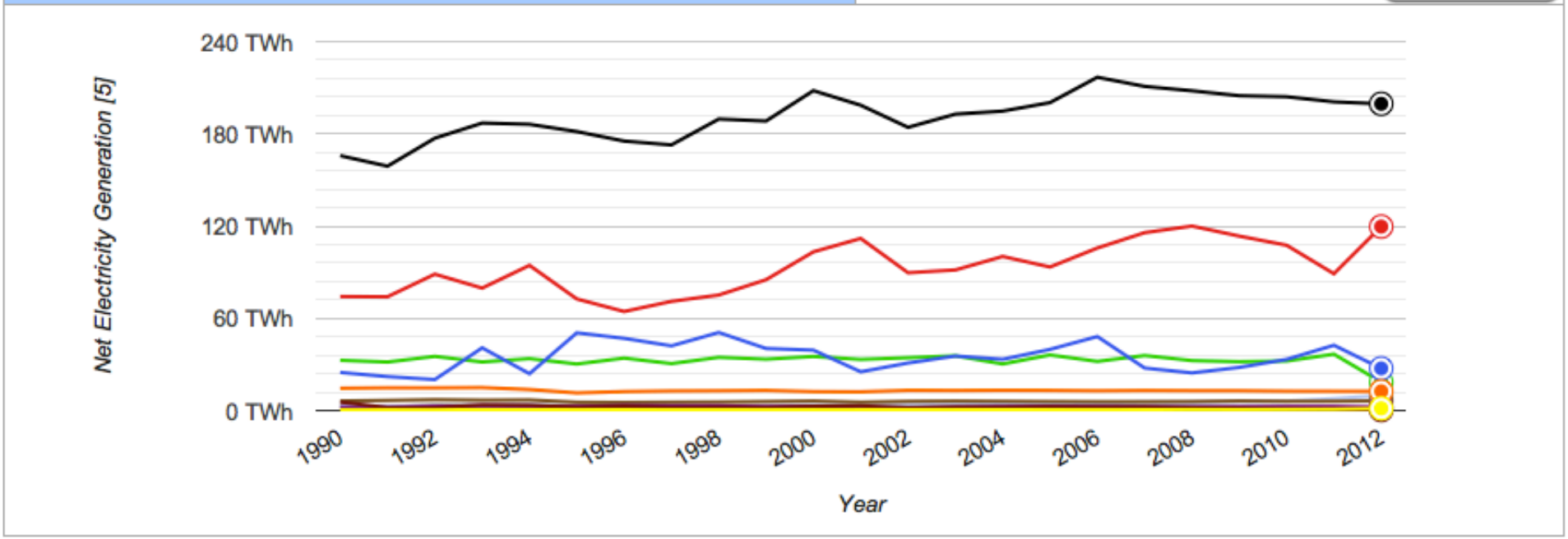

Montana


Montana - 2012 (27.805 TWh)
Coal
Natural Gas
Hydroelectricity [1]
Wind
Other [3]
Petroleum
50.3%
40.6%
View World data


40 TWh
30 TWh
20 TWh
10 TWh
0 TWh
Net Electricity Generation [5]
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year




California - 2012 (199.519 TWh)
Coal
Natural Gas
Nuclear
Hydroelectricity [1]
Wind
Biomass [2]
Other [3]
Petroleum
Geothermal
Solar [4]
60%
13.7%
9.3%
6.3%
View World data


Net Electricity Generation [5]
240 TWh
180 TWh
120 TWh
60 TWh
0 TWh
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year

The New EPA Carbon Rules

To reduce carbon emissions from American power plants by 30% over 2005 levels between now and 2030

(http://www.epa.gov/cleanpowerplan).

Rules allow States flexibility to meet these goals with any mix of

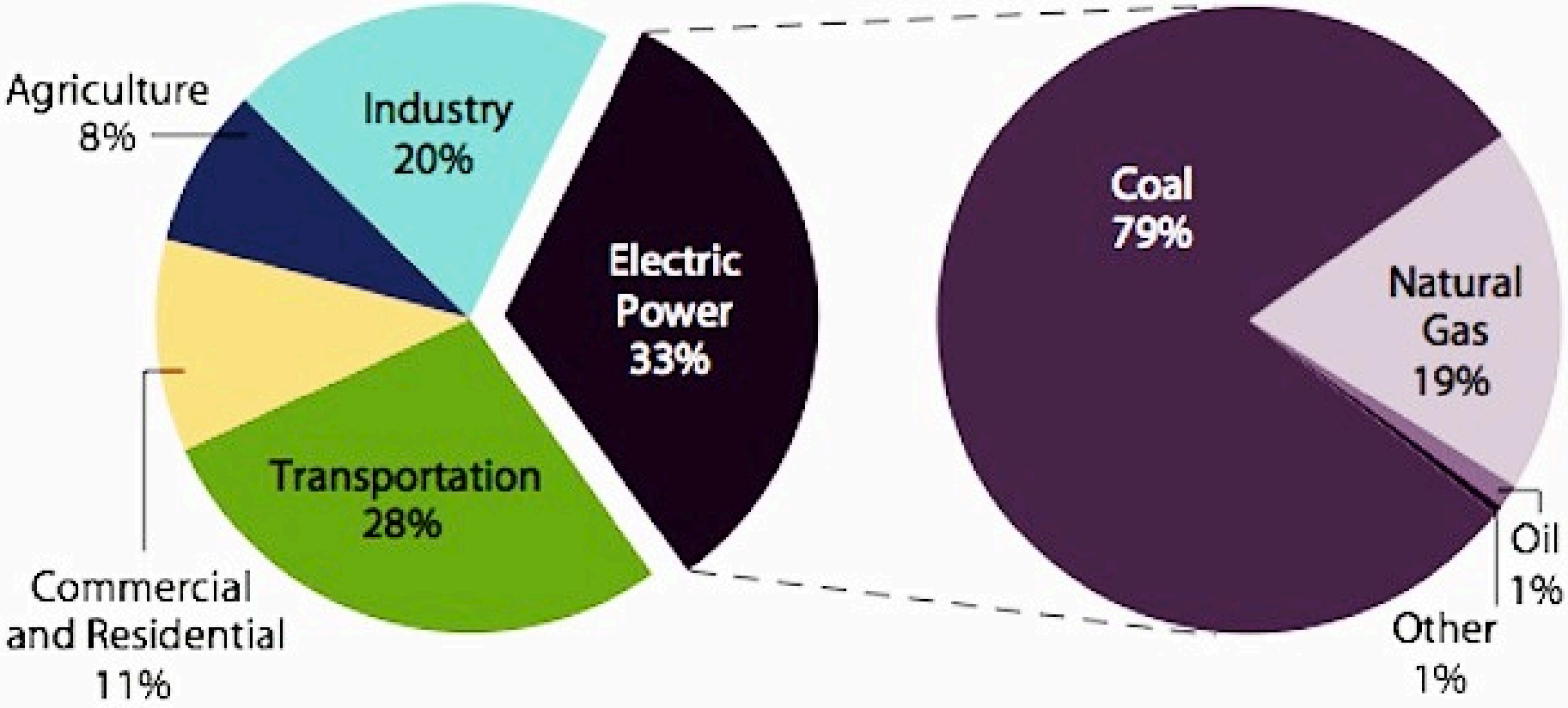
conservation
efficiency
renewables
retrofitting coal plants with gas
building new-design nuclear

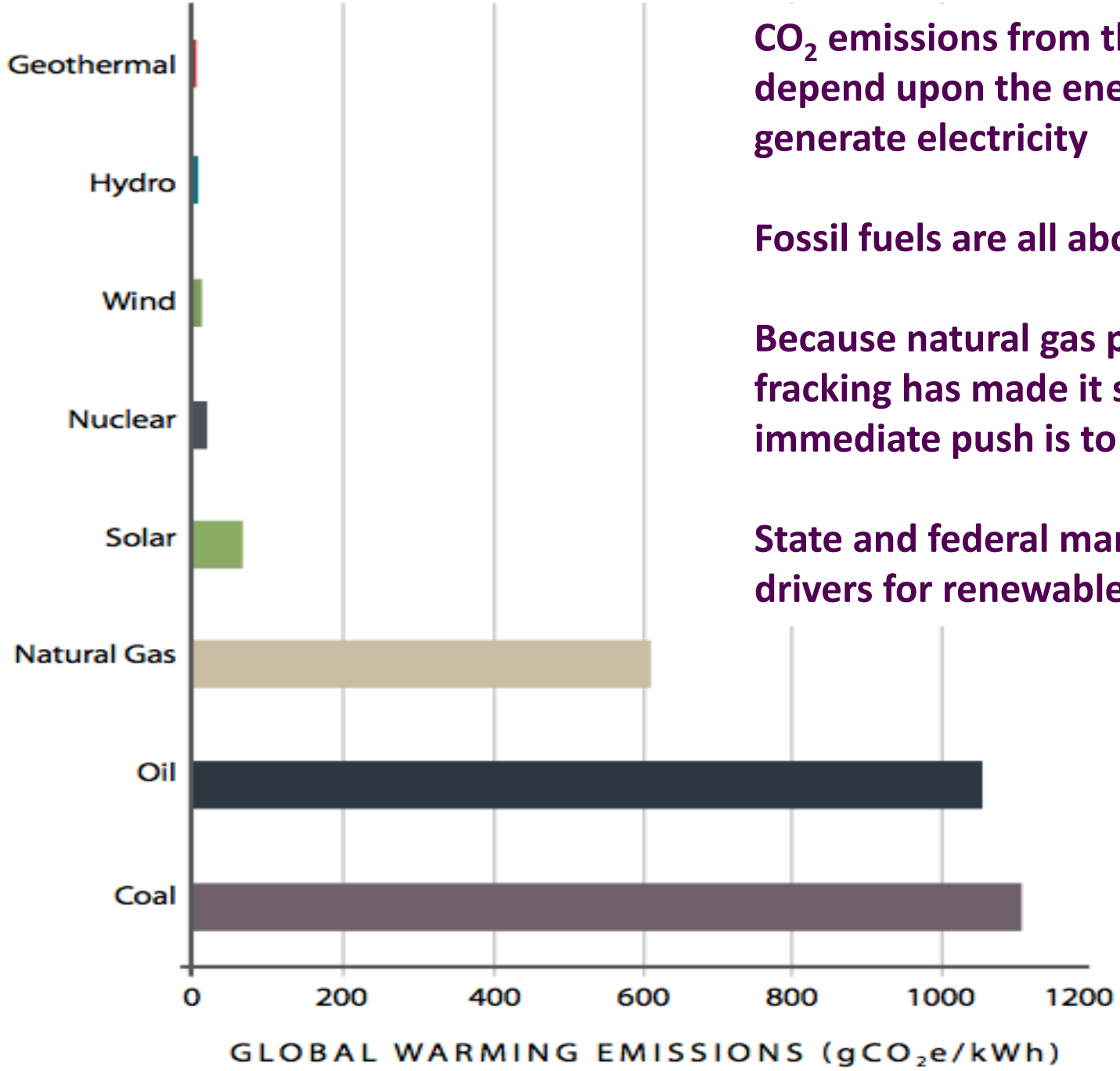
- With respect to nuclear power, the EPA Plan allows states, e.g., Georgia, South Carolina and Tennessee, to take credit for the carbon savings gained by new nuclear reactors under construction and for any future nuclear plant construction
- EPA has stated that premature closure of existing nuclear plants will make it difficult for the U.S. to meet its climate goals.
- Two-thirds of Americans support a new federal rule cutting carbon emissions from the nation's power plants

The Electric Power Sector is the largest source of carbon emissions in America and coal accounts for most of the share (EIA 2013)

Total U.S. Carbon Emissions by Economic Sector in 2011

Total U.S. Electric Power Carbon Emissions by Fuel in 2011





CO_2 emissions from the power sector depend upon the energy source used to generate electricity

Fossil fuels are all about carbon

Because natural gas prices are so low, and fracking has made it so abundant, the immediate push is to replace coal with gas

State and federal mandates are the main drivers for renewables

The Issues with Emissions – not just about climate, and not just about carbon

> "We all know this is not just about melting glaciers. This is one of the most significant public health threats of our time." - Gina McCarthy, EPA Chief

Long-term effects:

Climate Change - effects planet as a whole - agriculture, sea level, droughts, disease - will occur whether it's human induced or not – need to be ready – EP and EM

Short-term effects:

Human Health Effects - >1,000,000 people die each year from coal particulates, 20,000 in the U.S., >200,000 in China alone. The use of coal increases our health care costs by 10%, or $300 billion each year in the U.S.

Direct Environmental Harm – spills, pipeline breaks, coal impoundment failures, drilling and mining effects

Ocean Acidification – pH dropping through simple CO_2 dissolving in seawater to form carbonic acid.

- 4 days for upper layer of seawater to equilibrate with CO_2 in atmosphere
- 1000 years for entire ocean to equilibrate with atmosphere and carbonate rocks

Energy Source	Mortality Rate (deaths per trillion kWh)	
Coal – global average	100,000	(50% of global electricity)
Coal – China	170,000	(75% of China's electricity)
Coal – U.S.	15,000	(44% of U.S. electricity)
Oil	36,000	(36% of global energy, 8% of global electricity)
Natural Gas	4,000	(20% of global electricity)
Biofuel/Biomass	24,000	(21% of global energy)
Solar (rooftop)	440	(< 1% of global electricity)
Wind	150	(~ 1% of global electricity)
Hydro – global average	1,400	(15% of global electricity, 171,000 Banqiao dead)
Nuclear – global average	40	(17% of global electricity w/Chernobyl&Fukushima
Nuclear – U.S.	0.01	(20% of U.S. electricity)

Sources –World Health Organization; CDC; 1970 - 2011

What are the EPA Carbon Rules supposed to accomplish?

To benefit the economy, public health and the environment

- A recent Harvard study on the total effects of coal use in America concluded that coal costs us about $500 billion annually and any decrease in coal use has a direct benefit to the economy, public health and the environment.

- This summer, EPA Chief Gina McCarthy flatly stated:

> "The primary aim in implementation of moderately increased carbon cutback requirements is to kick-start the U.S. nuclear power industry"

This was echoed by previous EPA Chiefs

- Christine Todd Whitman, EPA Chief under Bush
- Carol Browner, EPA Chief under Clinton, and Director of Obama's Office of Energy and Climate Change Policy.

What are the EPA Carbon Rules supposed to accomplish?

For overall carbon emissions from the U.S. power sector

- Replace all existing coal with natural gas ➔ 20% reduction
- Replace all existing coal with new nuclear ➔ 60% reduction
- Replace coal with a 60/40 mix of gas and nuclear ➔ 30% reduction
- Replace existing coal plants as they die to minimize the disruption in jobs and supply

Support for nuclear is the smart choice

What About Our Existing Nuclear Fleet?

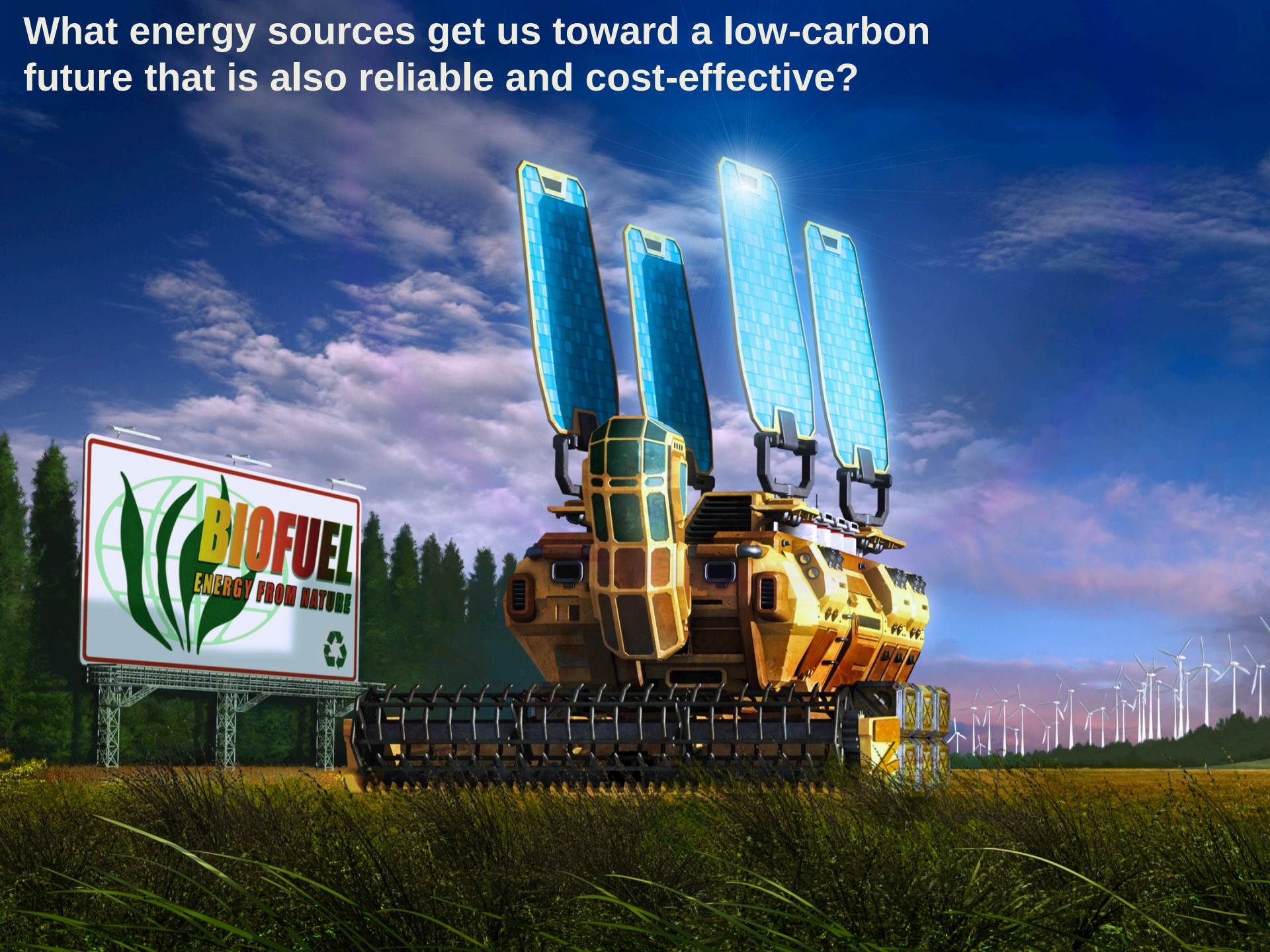
Our nuclear fleet offsets significant CO_2 emissions each year:

- 700 million tons if coal were used to produce the amount of energy
- 500 million tons if natural gas were used to produce that energy
- 350 million tons if new combined cycle gas turbine were used

There is no viable way to replace our nuclear fleet with any other mix of sources and maintain this level of carbon offsets. Even a 50/50 mix of CCGT and renewables, which would boost renewables beyond the levels imagined at present, would still result in an increase of about 250 million tons CO_2 emissions each year, which represents a 5% increase in total emissions.

This is why McCarthy and past EPA Chiefs are generally alarmed at the prospect of losing our fleet, the most recent symptom being the closing of the Vermont Yankee and Kewaunee nuclear plants.

What energy sources get us toward a low-carbon future that is also reliable and cost-effective?



The Business Model for a Low-Carbon Future

A recent Brookings Institute Report investigated the benefits of replacing coal and old-style natural gas plants with various low-carbon alternatives.

The ranking from most cost-effective to least cost-effective is:

- combined cycle gas turbine (CCGT)
- nuclear
- hydro
- wind
- solar

The Business Model for a Low-Carbon Future

Other conclusions were:

CCGT, hydro and nuclear have strong net benefits in cost and emissions.

CCGT is highly dependent on the price of natural gas

Wind and solar have much lower net benefits:

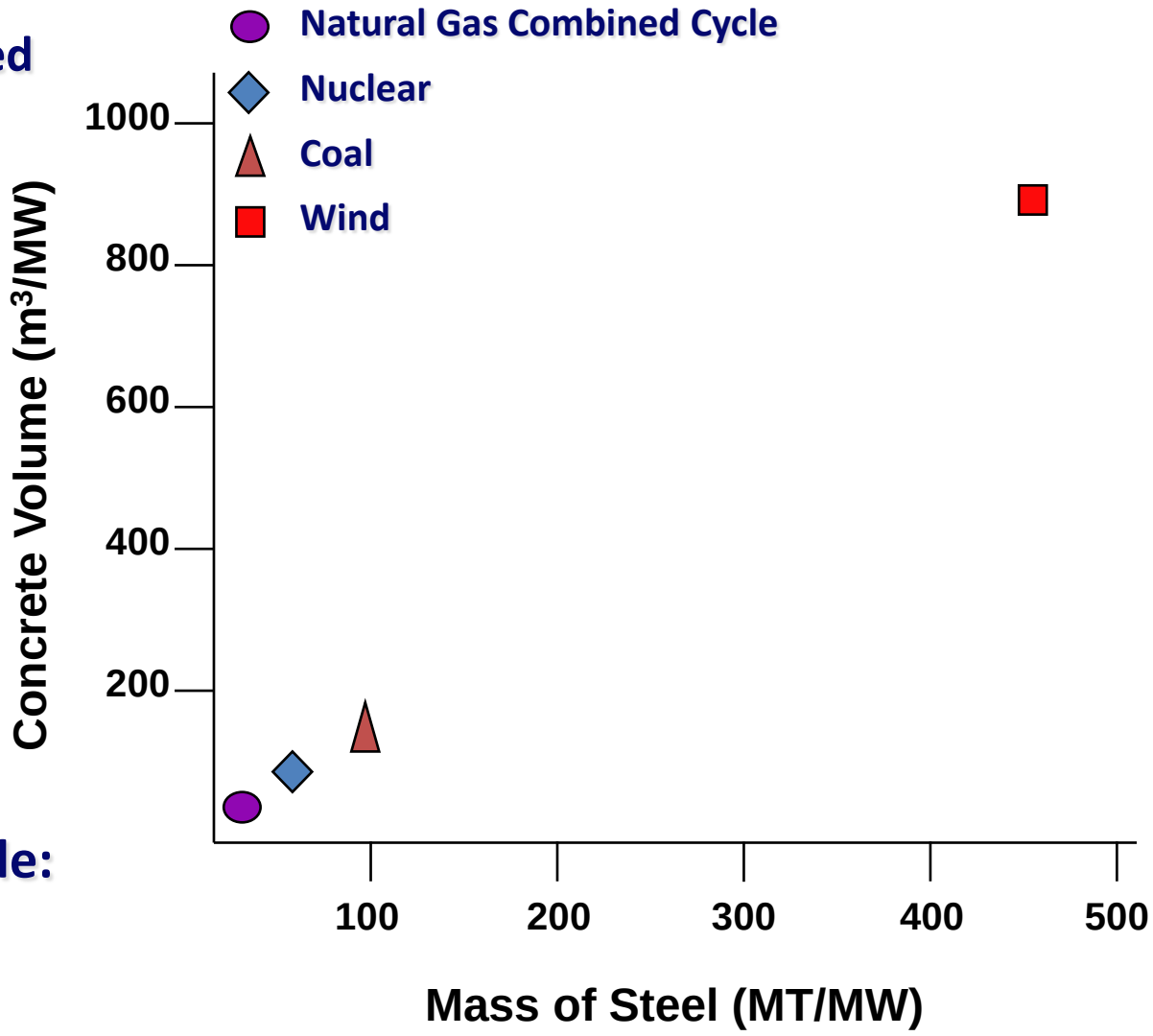
- *low capacity factor, requiring back-up sources*
- *high per-MW construction costs*
- *high intermittency*
- *high frequency variability*

A price on carbon is more effective than Cap&Trade, mandates or other incentives. The price on carbon must exceed \$50/tonCO_2emitted to be effective in targeting coal.

Materials, Resource and Capital Needs

Concrete + steel + copper are > 98% of construction inputs, and become more expensive in a carbon-constrained economy

- **Wind: 6.4 m/s avg wind speed**
  25% cap. factor
  - 460 MT steel/MW
  - 870 m^3 concrete/MW
- **Coal:**
  78% cap. factor
  - 98 MT steel/MW
  - 160 m^3 concrete/MW
- **Nuclear (LWR):**
  90% capacity factor
  - 40 MT steel/MW
  - 90 m^3 concrete/MW
- **Natural Gas Combined Cycle:**
  75% cap. factor
  - 3.3 MT steel / MW
  - 27 m^3 concrete / MW



How Do We Achieve a Low-Carbon Future for Washington State?

- WA State emissions have decreased since 1990, because of lower emissions in the agriculture and the industrial sectors.

- Our only coal plant is closing in 2025 and will eliminate almost half of our emissions from power sources.

- Electric vehicles are the most effective way in Washington State to address the petroleum fuel issue because the majority of electricity generated in WA State is from non-fossil fuel.

Conclusions

- The United States can easily meet EPA's Carbon Reduction Goals of a 30% reduction in CO_2 emissions by 2030 by replacing old coal plants, *as they die,* with gas, nuclear and renewables
- Washington State has already met these goals. WA should amend I-937 to make hydro a *clean* energy applicable to fossil fuel offsets, carbon and renewable goals
- We need long-term planning on what happens when nuclear and large hydro approach the end of their life expectancy
- Washington State could cut emissions over 40% just by going to a majority of electric vehicles by 2050
- Invest in charging stations every 70 miles along Routes 5, 90, 82, 395, 12, 97, 2, 101 and 14

Carbon Footprints

Do We Need A Carbon Tax Or A Cap&Trade Plan? Or Neither?

REMI Report for WA State

- Tax better than Cap&Trade for all sectors and fiscal results
  - jobs (+30,000)
  - GDP (+$700 million)
  - emissions (-50% by 2050)

Governor Inslee's Carbon Plan

- Cap&Trade (link to California)
- end coal generation (on track for 2025)
- ***reduction in vehicle emissions***
- increased funding for clean energy and ***energy efficiency***
- reduction in government carbon footprint

WA State Goals

- By 2020, reduce overall emissions of GHGs in the State to 1990 levels
- By 2035, reduce overall emissions of GHGs to 25% below 1990 levels
- By 2050, reduce overall emissions to 50% below 1990 levels

The Governor's office investigated, among other things, the effects of a straight carbon tax at two magnitudes:

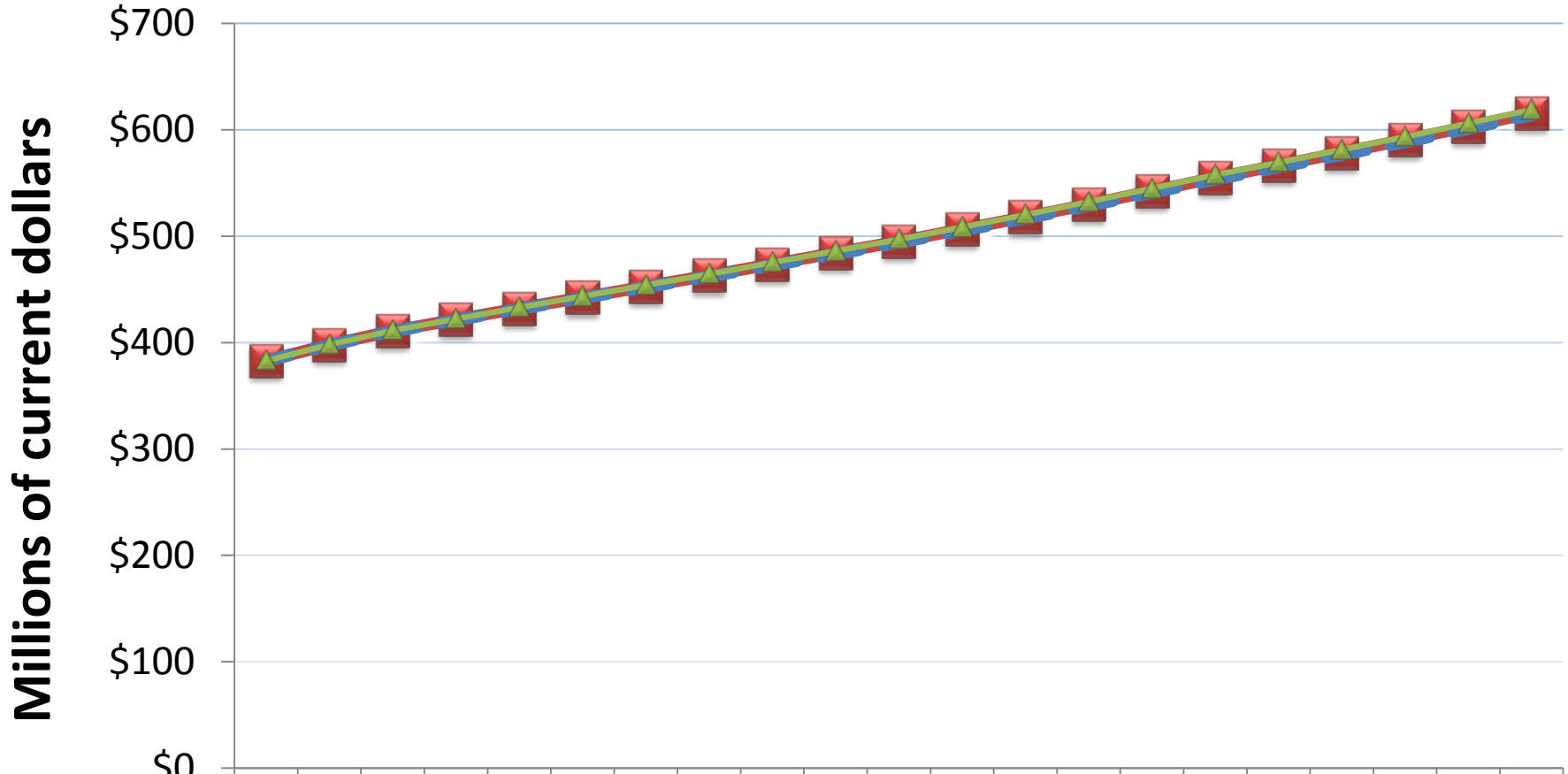
- a low carbon-price scenario of $12/metric tonCO2 in 2016
  - 60-cent-per-metric ton increase each year until 2020
  - increase by $2/metric ton each year thereafter.

- a high carbon-price scenario with the same $12/metric tonCO2 in 2016, but with an
  - $8/metric-ton increase each year thereafter.

This carbon tax would be on energy producers, not consumers, and the revenues would be spent as follows:

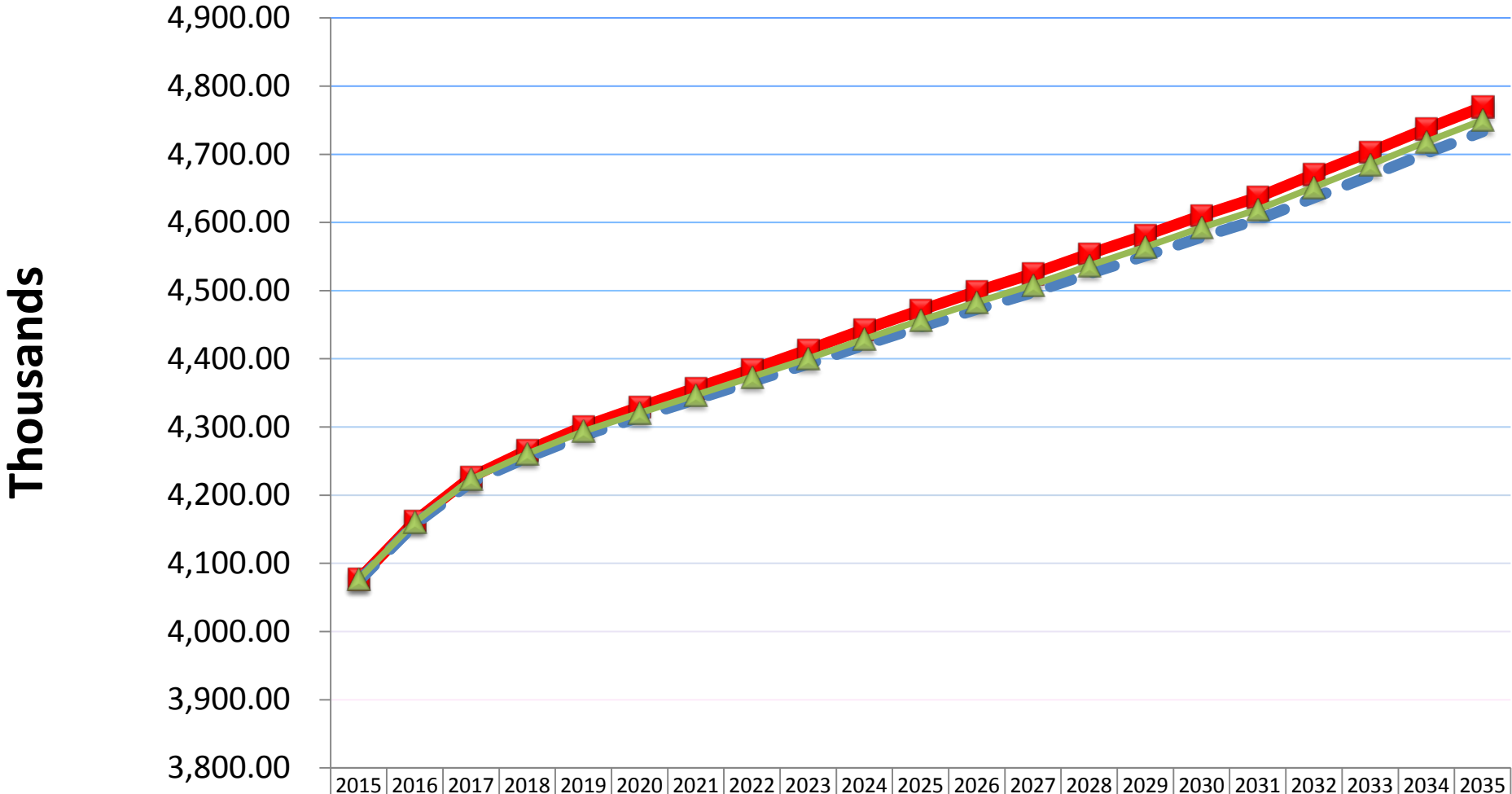
- 30% on lower income populations (the ones who need it the most)
- 15% on trade-exposed industries (highly impacted by the tax)
- 40% on transportation construction (this is the really good one)
- 10% on renewable electricity
- 5% on administration

Gross Domestic Product: No Effect
High & Low Price Scenarios



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
GDP Blnded Low Pr	382.	397.	410.	421.	432.	442.	452.	462.	473.	484.	495.	506.	517.	529.	542.	554.	566.	578.	590.	602.	615.
Baseline	382.	397.	410.	421.	431.	441.	452.	462.	472.	483.	494.	505.	516.	528.	540.	553.	564.	576.	588.	600.	613.
GDP High Pr	382.	398.	411.	422.	432.	443.	453.	464.	475.	485.	496.	508.	520.	532.	544.	557.	569.	581.	593.	605.	618.

Employment: No Effect
High & Low Price Scenarios



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Tot Emp High Pr	4,07	4,16	4,22	4,26	4,30	4,32	4,35	4,38	4,41	4,44	4,47	4,49	4,52	4,55	4,58	4,61	4,63	4,67	4,70	4,73	4,76
Baseline	4,07	4,15	4,21	4,25	4,28	4,31	4,34	4,36	4,39	4,42	4,44	4,47	4,49	4,52	4,55	4,57	4,60	4,63	4,66	4,70	4,73
Employment Blnded Low Pr	4,07	4,16	4,22	4,26	4,29	4,32	4,34	4,37	4,40	4,42	4,45	4,48	4,50	4,53	4,56	4,59	4,61	4,65	4,68	4,71	4,75

High Price Scenario:
Job Gains and Losses for Four Industries Overwhelmingly Positive

Construction – 7,630 jobs gained

Chemical Industry – 289 jobs gained

Natural Gas Industry – 19 jobs lost

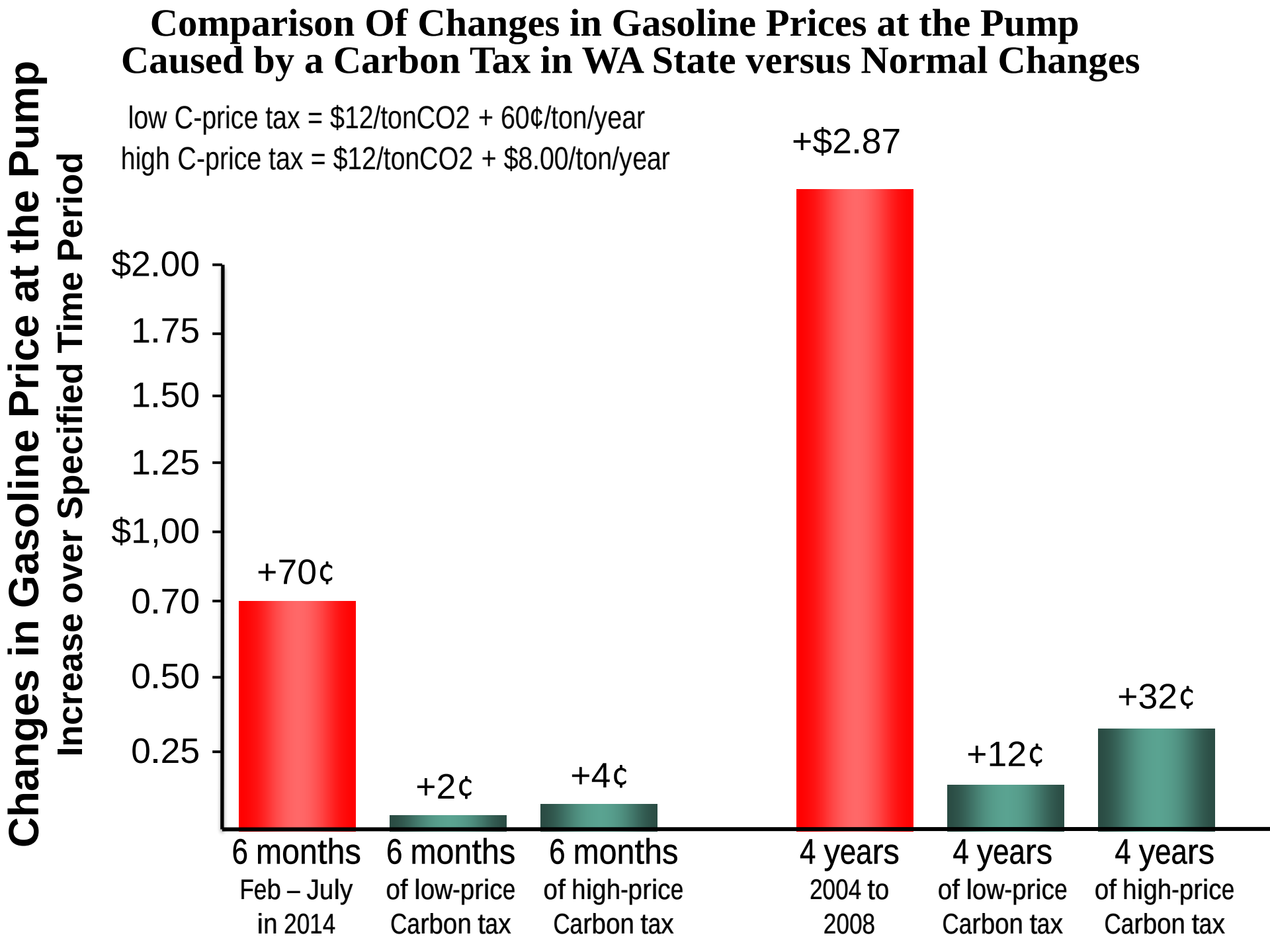
Textile Mills – 30 jobs lost

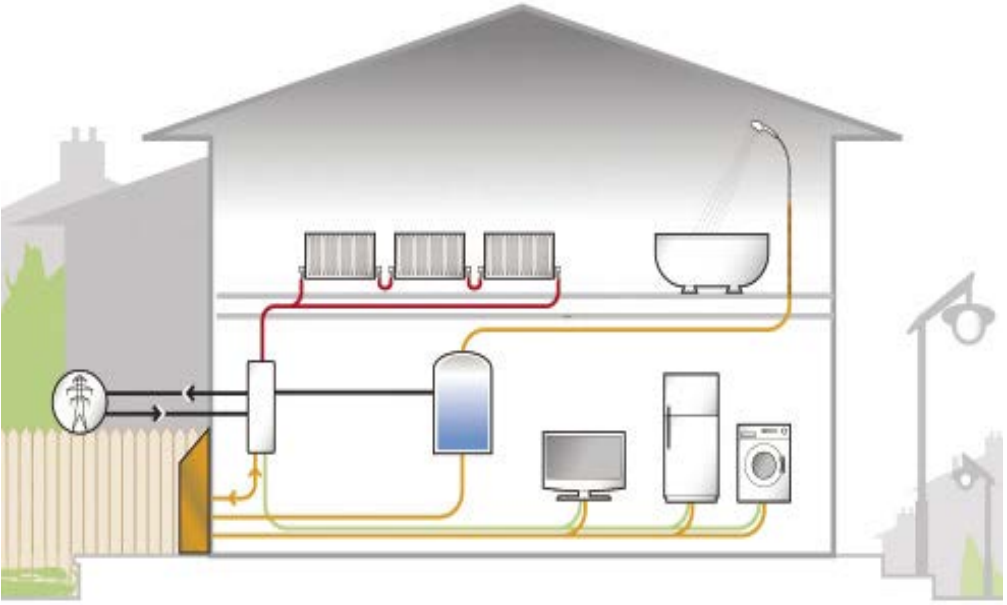
The Greatest Impact for Washington Citizens is the Effect of Each Tax on Gasoline Prices

Baseline*	2020: $3.25/gal
(gas production costs don't rise)	2035: $3.89/gal
	Net: $0.76/gal
Low Carbon Price	2020: +$0.13/gal
	2035: +$0.38/gal
High Carbon Price	2020: +$0.44/gal
	2035: +$1.46/gal

(*EIA Pacific Region, 2012 dollars, taxes included)

Comparison Of Changes in Gasoline Prices at the Pump Caused by a Carbon Tax in WA State versus Normal Changes





How Do We Achieve a Low-Carbon Future for Washington State?

The biggest sources of carbon emissions in Washington State are from:

- residential/commercial/industrial uses of fossil fuel

- gasoline and diesel fuels in vehicles

The Energy Source You Use to Charge Your Electric Vehicle (EV) Is Critical

A fully-electric vehicle in Washington State gets the equivalent of over 100 miles/gallon

Electricity generation in WA State is over 80% non-fossil fuel because of hydro, nuclear and wind. Electric vehicles in WA are *green,* equivalent to getting over 100 mpg.

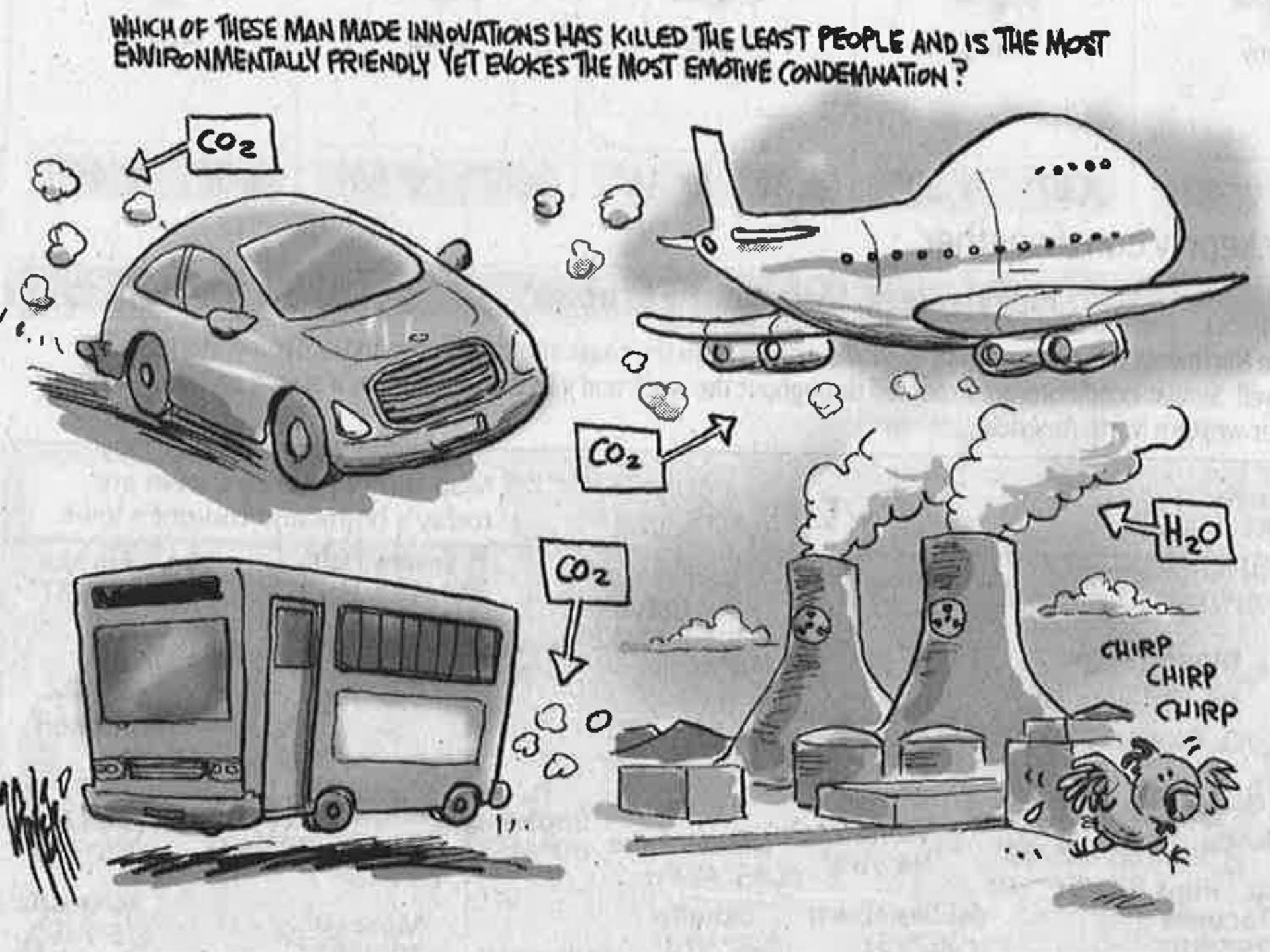
Electric vehicles charged in Indiana are no greener then ordinary cars using gasoline and getting 30 mpg because over 90% of their electricity is generated from coal.

If Washington State replaces 80% of our cars with electric vehicles by 2050 we would cut CO_2 emissions from our transportation sector by 75%

WA state consumer's would save $13,000 on average

Conclusions

- The United States can easily meet EPA's Carbon Reduction Goals of a 30% reduction in CO_2 emissions by 2030 by replacing old coal plants, *as they die,* with gas, nuclear and renewables
- Washington State has already met these goals. WA should amend I-937 to make hydro a *clean* energy applicable to fossil fuel offsets, carbon and renewable goals
- We need long-term planning on what happens when nuclear and large hydro approach the end of their life expectancy
- Washington State could cut emissions over 40% just by going to a majority of electric vehicles by 2050
- Invest in charging stations every 70 miles along Routes 5, 90, 82, 395, 12, 97, 2, 101 and 14


WHICH OF THESE MAN MADE INNOVATIONS HAS KILLED THE LEAST PEOPLE AND IS THE MOST ENVIRONMENTALLY FRIENDLY YET EVOKES THE MOST EMOTIVE CONDEMNATION?
CO_2
CO_2
CO_2
H_2O
CHIRP
CHIRP
CHIRP