

How much will it cost to achieve an acceptable energy mix?  
Are costs among the various energy sources sufficiently different to  
justify unethical decisions?



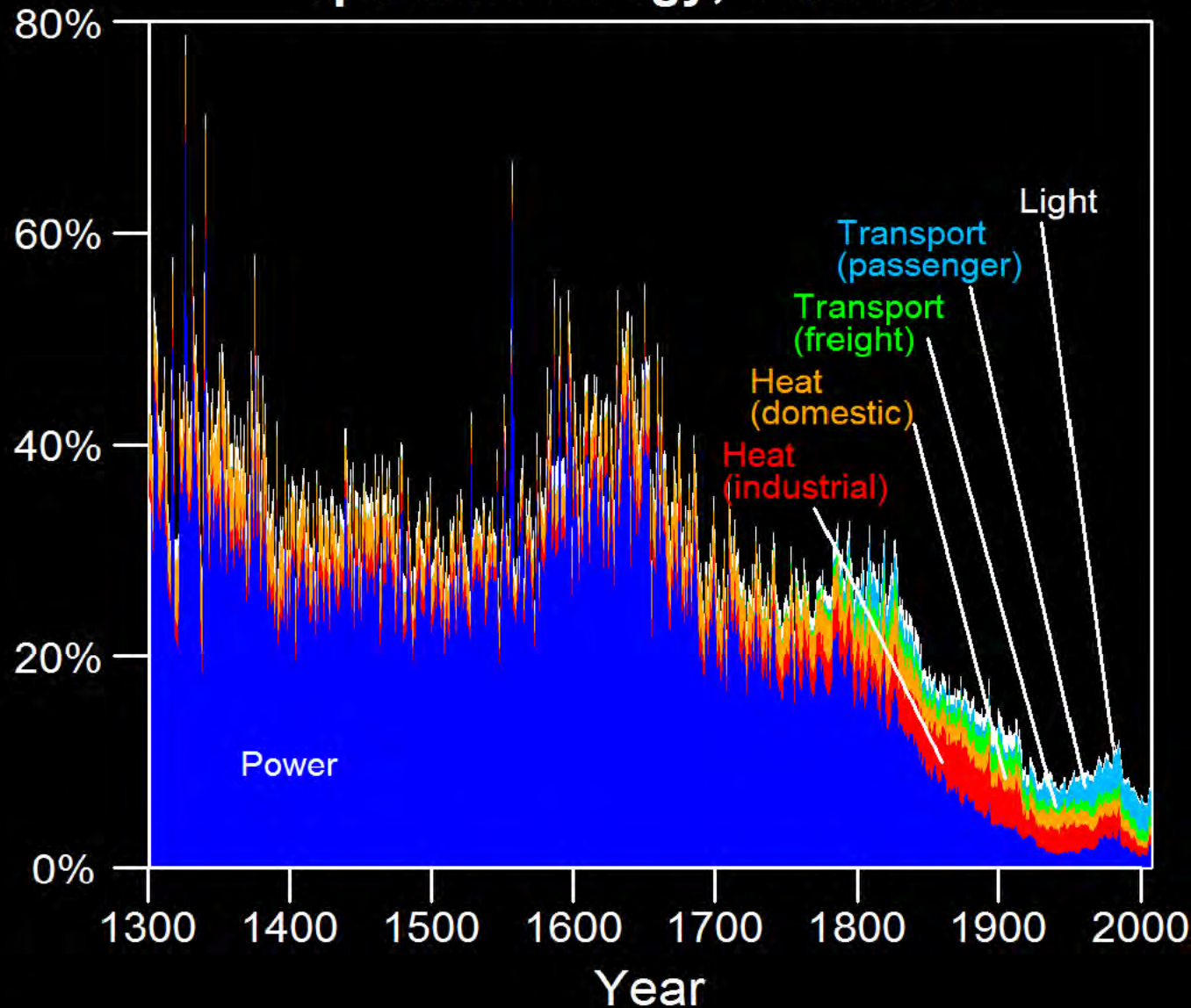


# Energy has never been cheaper than it is now

## Percent England/U.K. GDP spent on energy, 1300-2008

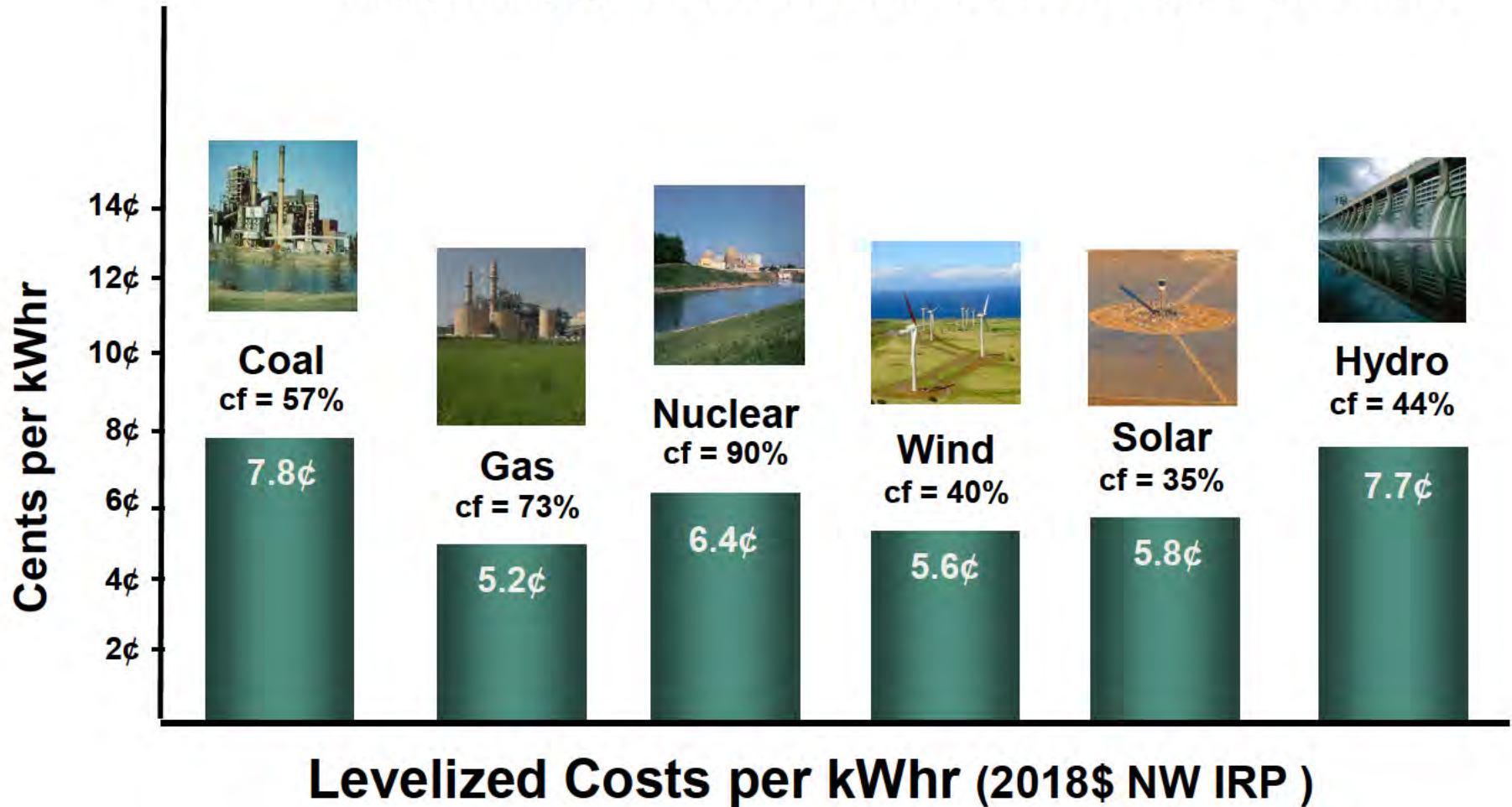
Spending on energy did not fall below 20% of GDP until the middle of the 1800's - the beginning of the fossil fuel age

In the preindustrial era, food was fuel for power as well as for life



***To produce 5 tKWhrs/year by mid-century in the United States  
with the 100% renewable-only mix will cost about \$20 trillion  
of which \$16 trillion is capital investment***

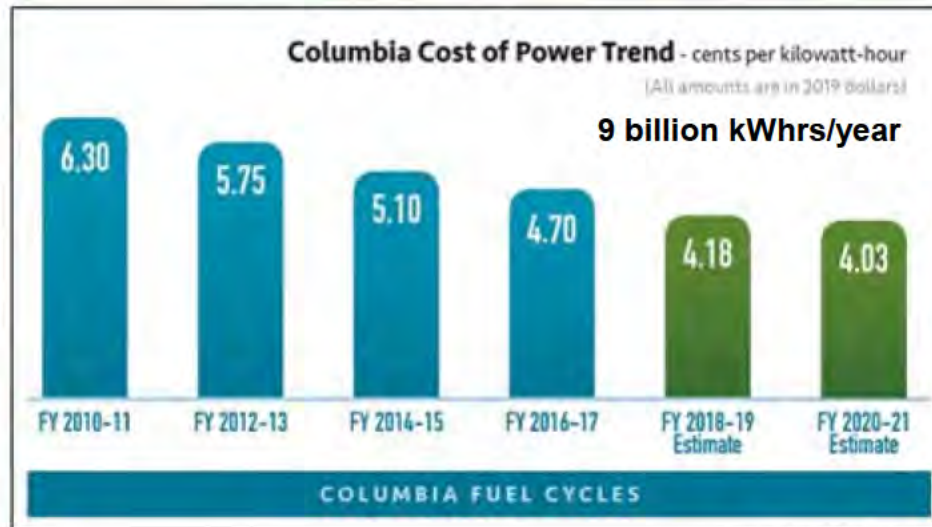
***This mix uses no fossil fuels (saves 4 billion tonsCO<sub>2</sub>/yr) ro  
but the health care savings from no fossil fuel (~\$4 trillion) over this nt  
time period pays for less than half of the extra capital investment***





# ~~Total Costs with DOE Energy Cost Solutions~~ ~~How Much Does Energy Cost So That We Can Wind~~

But costs are not actually lower for renewables, they're just shifted from the rate-payer to the tax-payer. Is this OK?



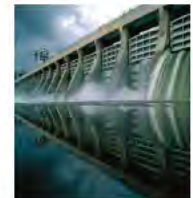
Ben Stewart graphic



cf = 40%  
**Wind**  
 5.6¢  
 2.8¢



cf = 35%  
**Solar**  
 5.8¢  
 3.0¢



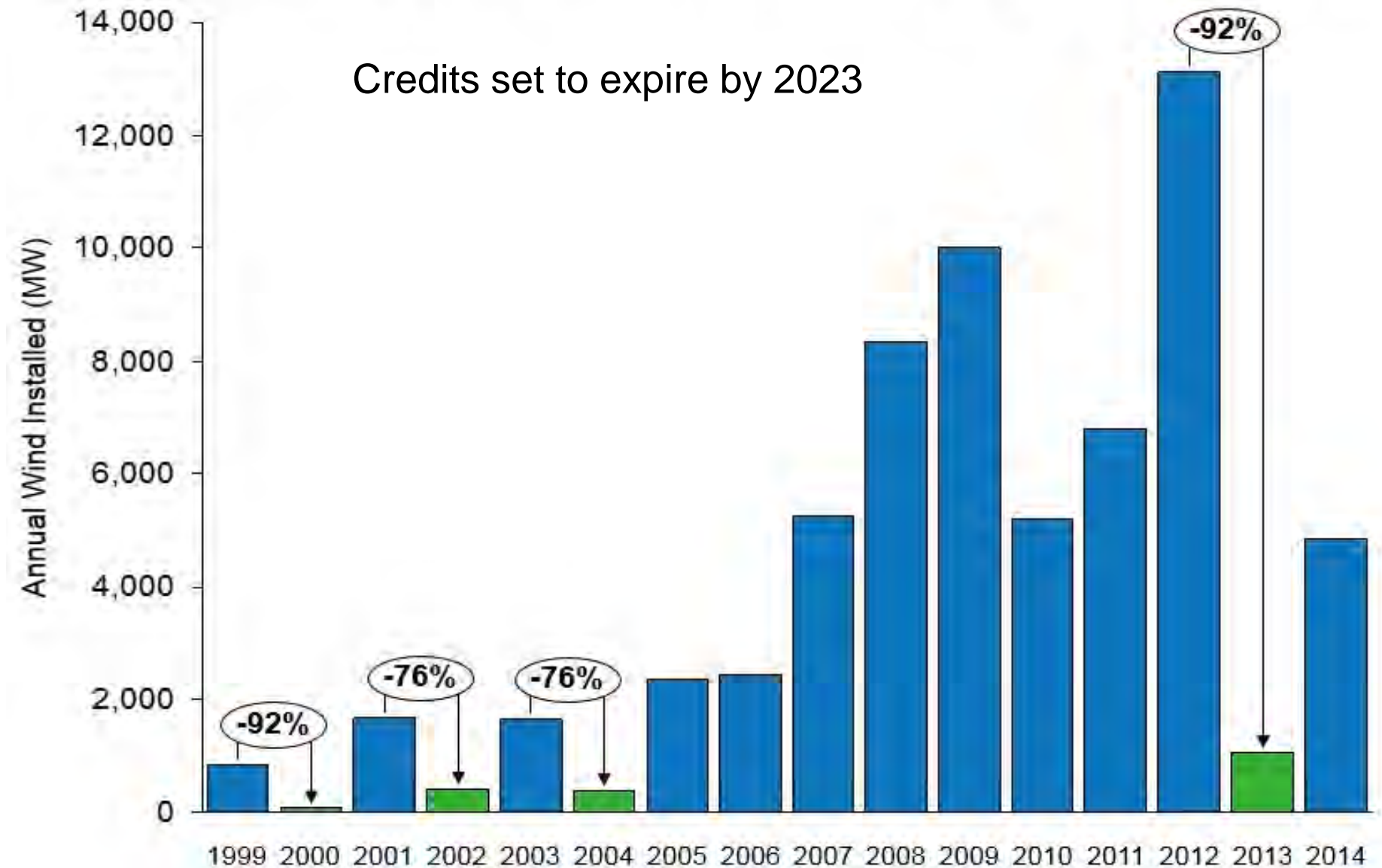
**Hydro**  
 cf = 44%



**kWhr (2018\$ NW IRP )**

Wind benefits more from Federal than State programs  
except where State mandates require specific percentages of renewables

## Historic Impact of Production Tax Credit (PTC) Expiration



# Low-Carbon Electricity Markets Are Fundamentally Different

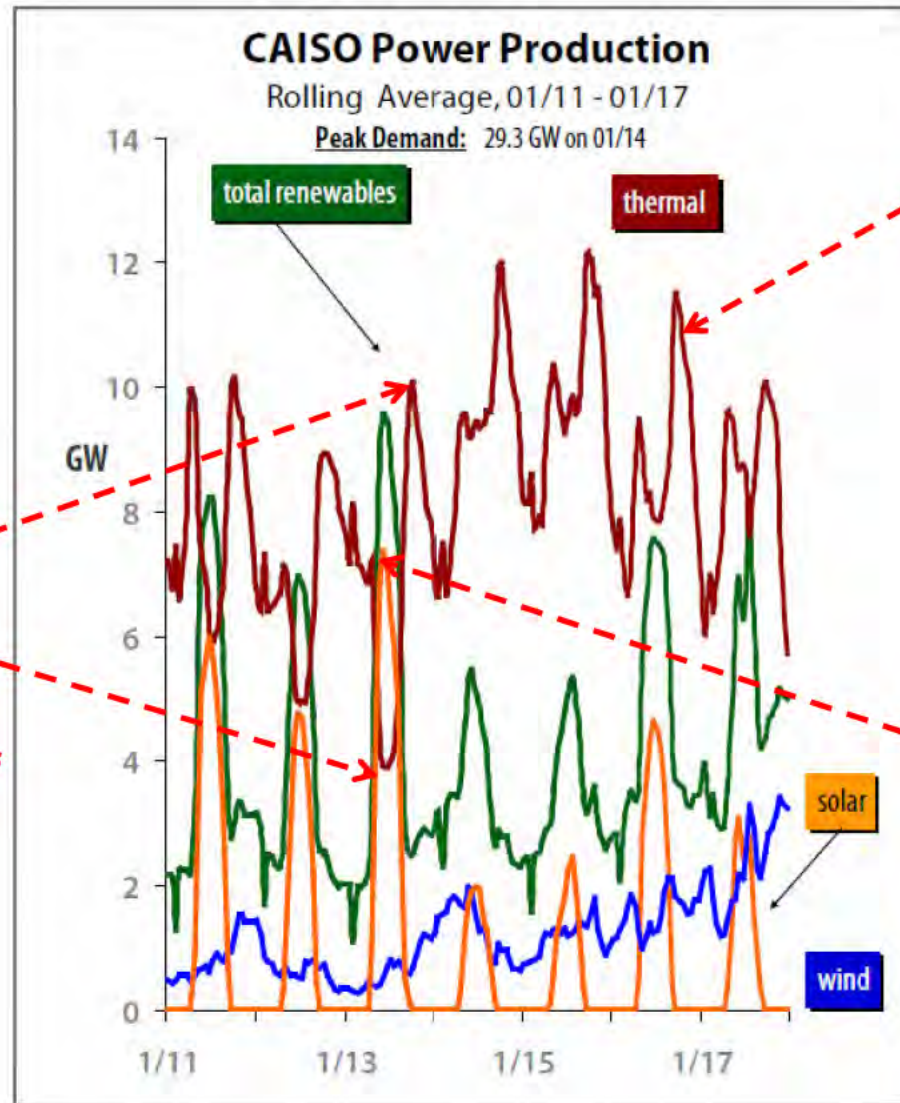
**Price Collapse Implies Large Quantities of Electricity at Less than Natural Gas Prices**



**Why Burn “Expensive” Natural Gas for Heat  
When Electricity Is a Cheaper Heat Source?**



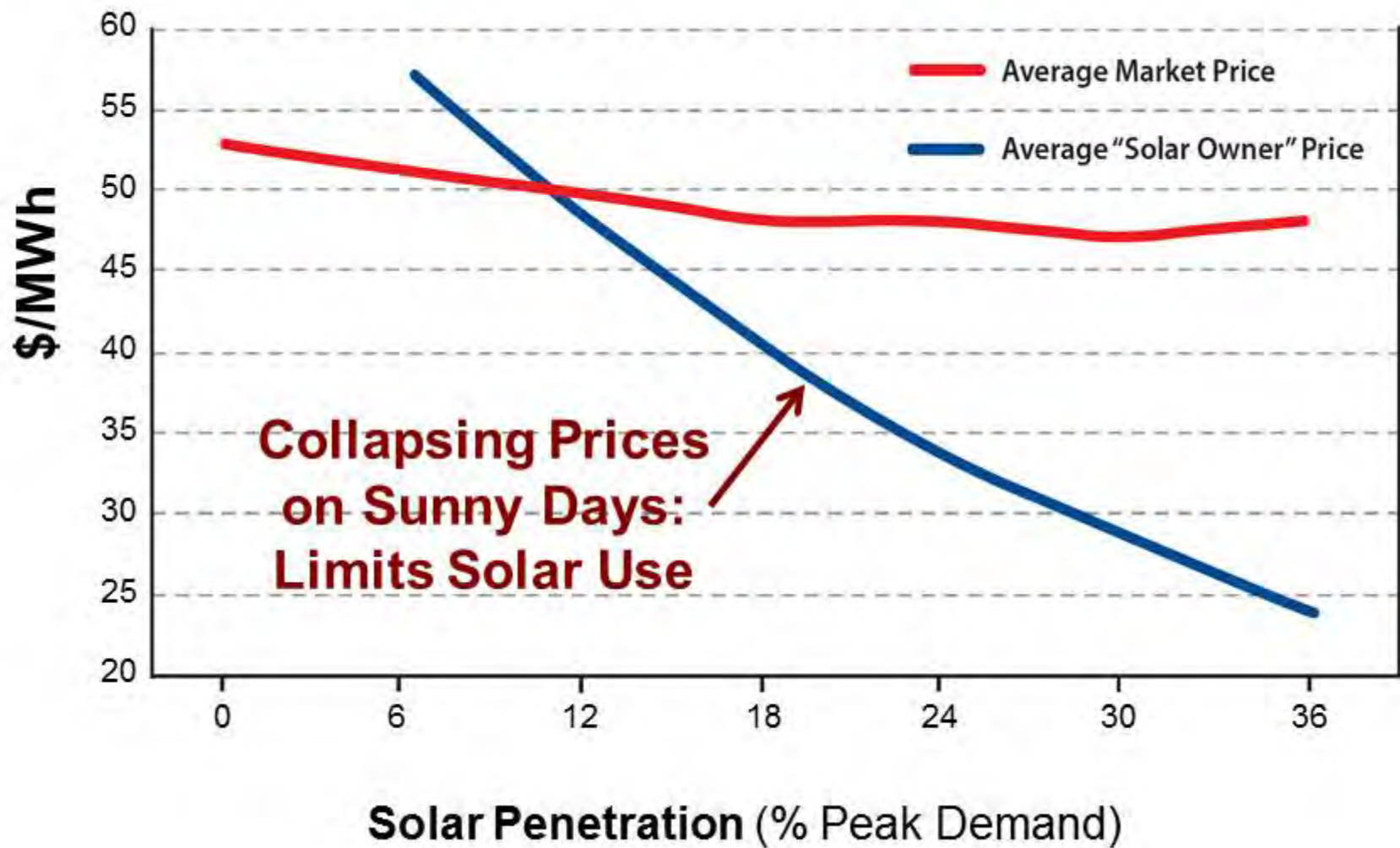
# Load & Resource Balance - California



*Thermal Plants Follow Load*

*Extreme Daily Ramping  
Requirements for Thermal  
Plants  
(Increased Mechanical  
Wear, increased C-emissions  
and Struggles to Recover  
Costs)*

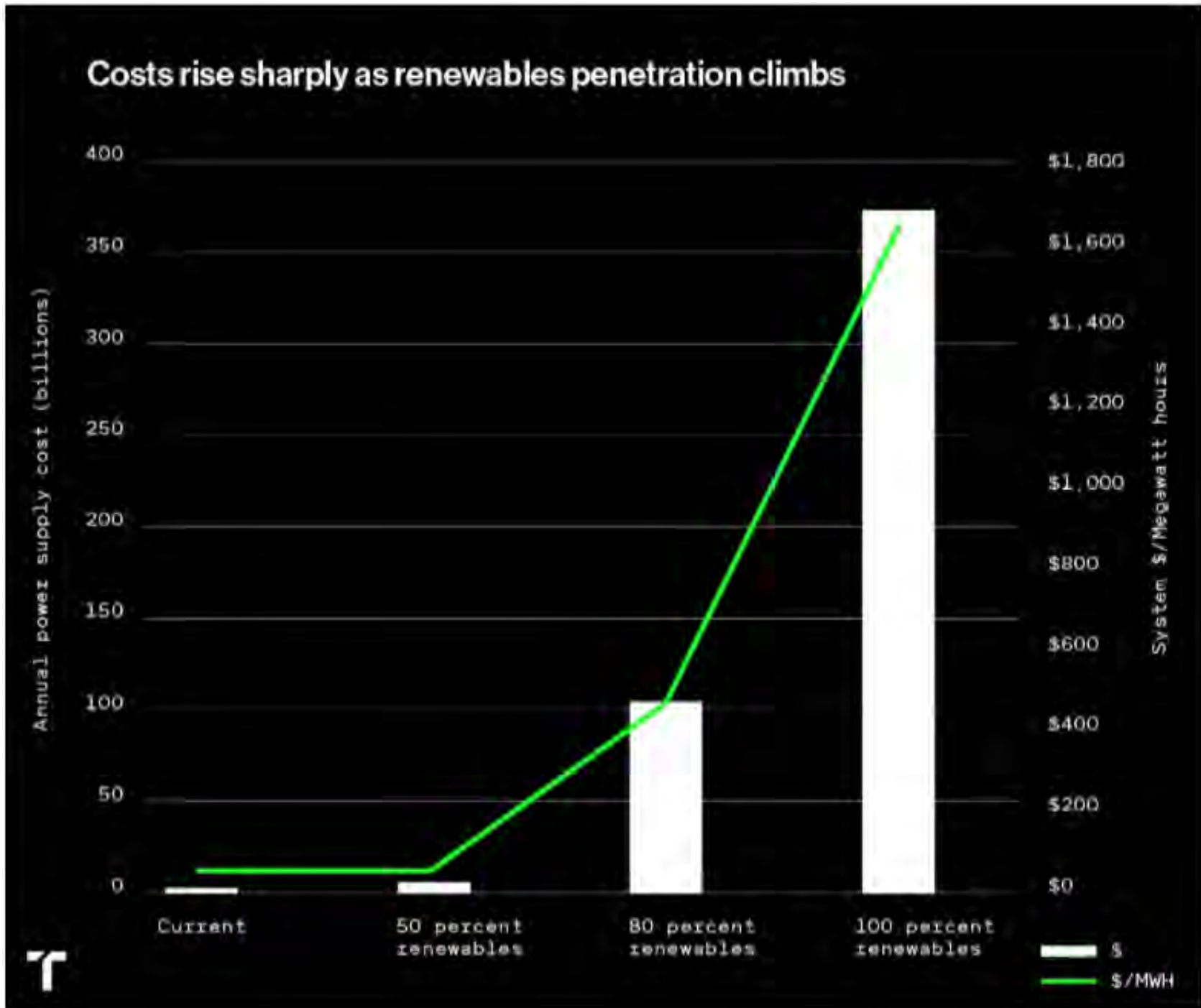
*Solar Production Maximum  
at Mid Day  
(Displaces Thermal Plant  
Energy Production)*



Solar PV Market Income and Average Wholesale Electricity Prices versus Solar PV Penetration.

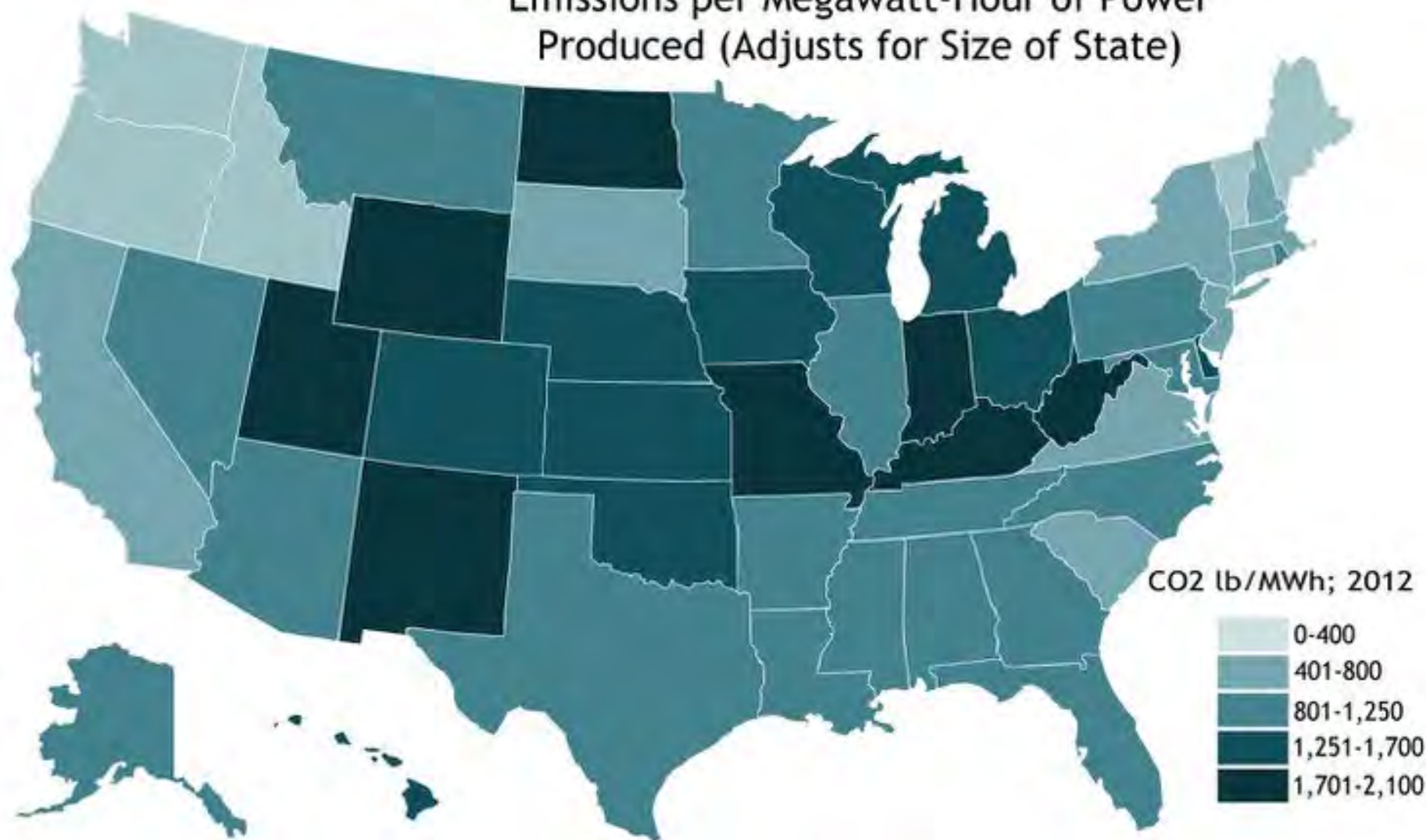


# CAISO Cost Projections for California

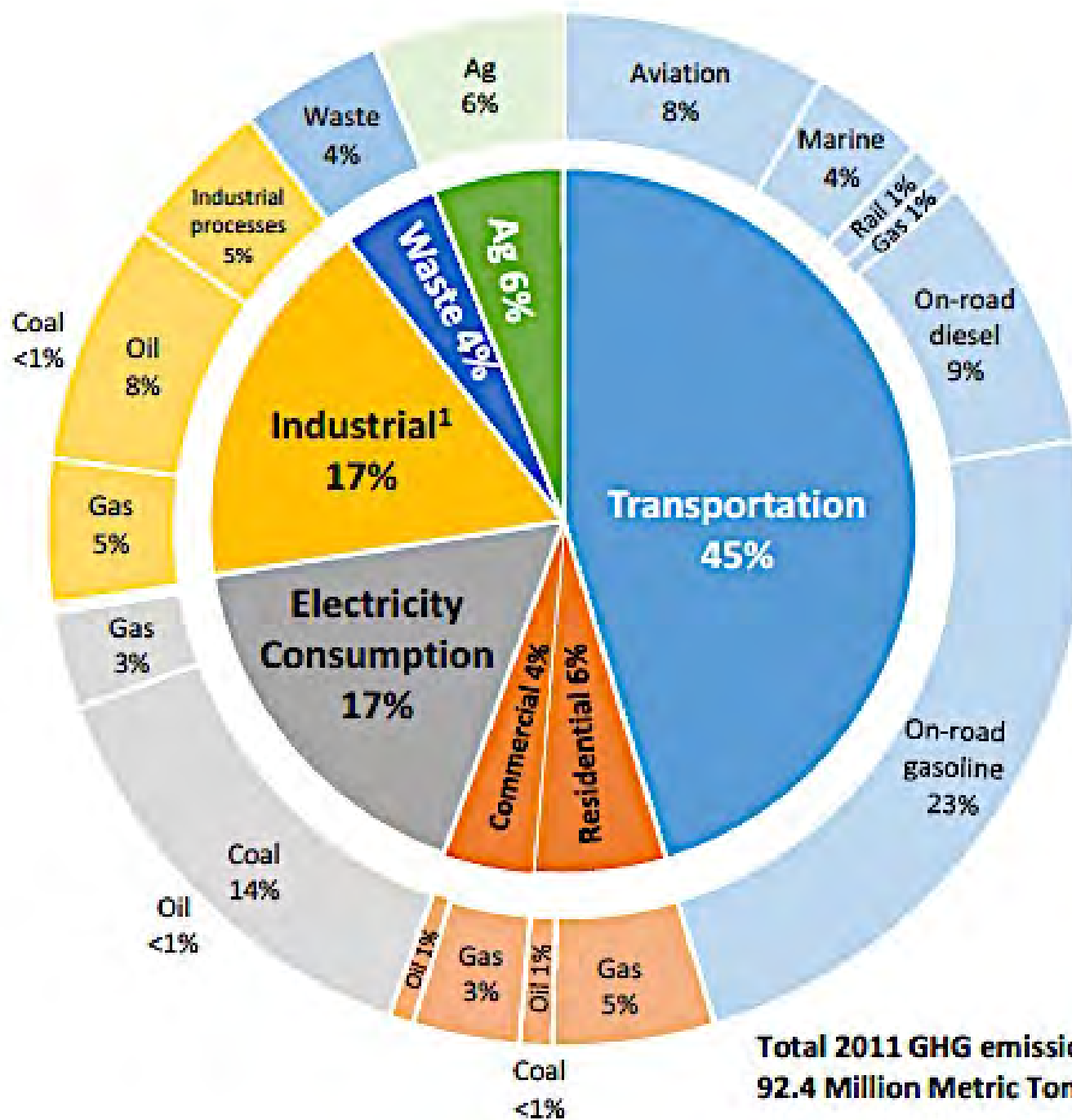


# State-by-State CO2 Emissions

Emissions per Megawatt-Hour of Power  
Produced (Adjusts for Size of State)







**Total 2011 GHG emissions:  
92.4 Million Metric Tons CO<sub>2</sub>e**





*A fully-electric vehicle in Washington State is really green, having the emissions equivalent of a gasoline vehicle getting over 1000 miles per gallon*

Electricity generation in WA State is over 90% non-fossil fuel because of hydro, nuclear and wind.

Electric vehicles in WA are *efficient*, equivalent to getting over 100 mpg.



2012 MODELS	MITSUBISHI "i"	FORD FOCUS EV	NISSAN LEAF	CHEVY VOLT
ELECTRIC EFFICIENCY (kWh/MILE)	0.3	0.32	0.34	0.36
ENERGY EFFICIENCY RATING (MILES PER GALLON OF GASOLINE EQUIVALENT)	112	105	99	94

*If America replaces 80% of our cars with electric from our transportation sector by 75% and require only an additional 75 billion kWhs*

Source: [www.fueleconomy.gov](http://www.fueleconomy.gov)