# 24th Annual Conference on the Environment

## Carbon Neutral Generation

**November 12, 2009**

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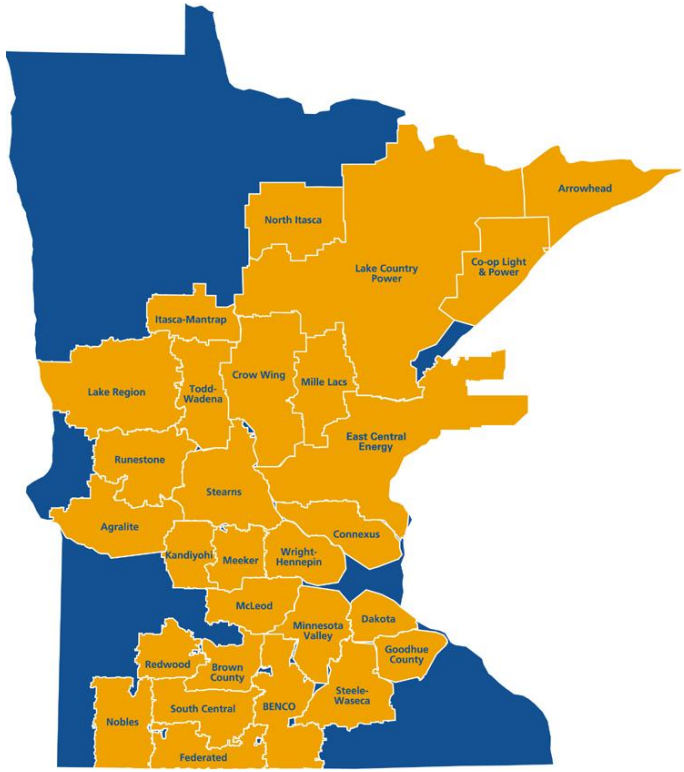
# Great River Energy

- Generation & Transmission (G&T) Cooperative
- 28 member distribution cooperatives
  - 630,000 members
- Sales - 60% residential; 40% C&I
- 2,600 MW Peak (summer)

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# Some foundation…

# Energy/Climate Legislation

- Federal Climate Change
- Federal RPS

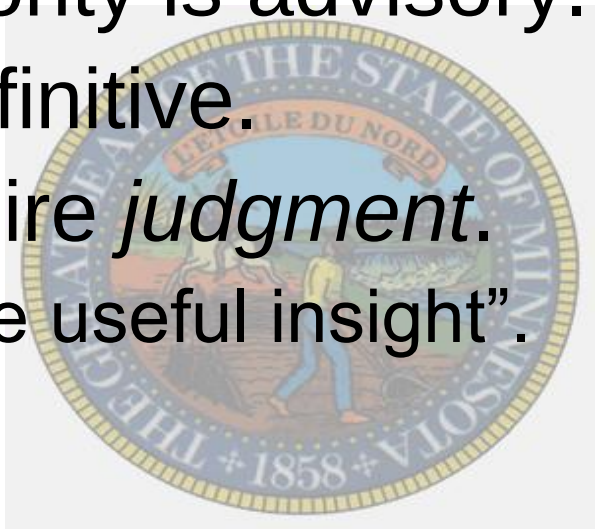
- 2007 - MN's Next Generation Energy Policy Act
  - 1.5% annual energy savings (goal)
  - Renewable Energy Standard
    - 25% Renewables by 2025 (mandate)
  - GHG reduction (goal)

# Energy Policy Motivations

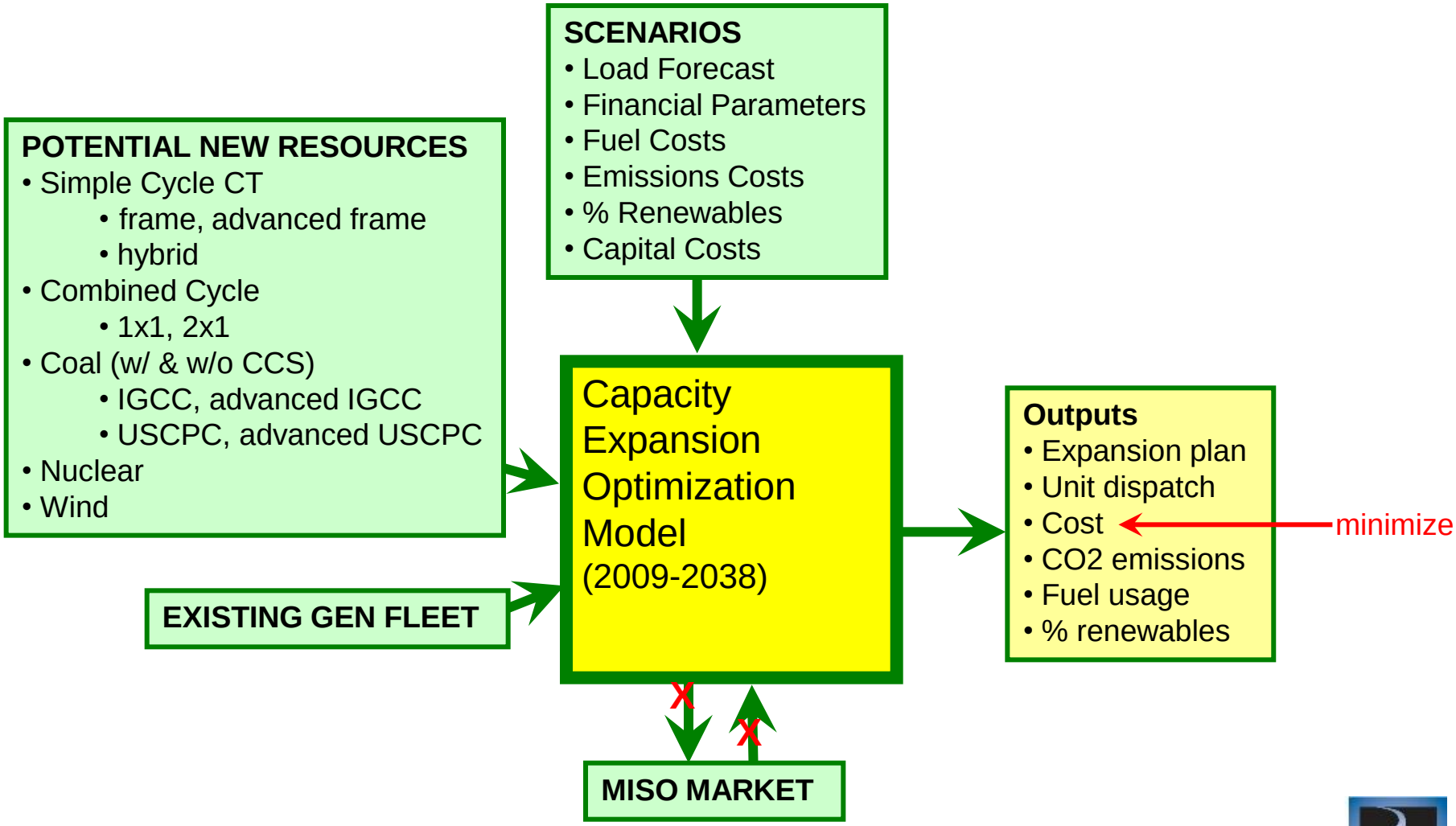
- Fossil fuels are a finite resource
  - Valuable for other purposes – plastics…
  - Save them better uses…
- We're interested in security of energy supply
  - Even if available somewhere in the world, we may not want to partner with undesirables
- It's very probable that using fossil fuels changes the climate
  - Even if human activities aren't to blame, legislation (and costs) will be here soon

# Resource Planning in MN

- Continuous process, incorporating new information.
- Must report to PUC at ~two-year intervals.
- For coops, PUC's review authority is advisory.
- Approach:  Informative, not definitive.
- Models are *guides.* Plans require *judgment*.
  - "All models are wrong, some give useful insight". (Bob Thresher, NREL)



# Capacity Expansion Modeling

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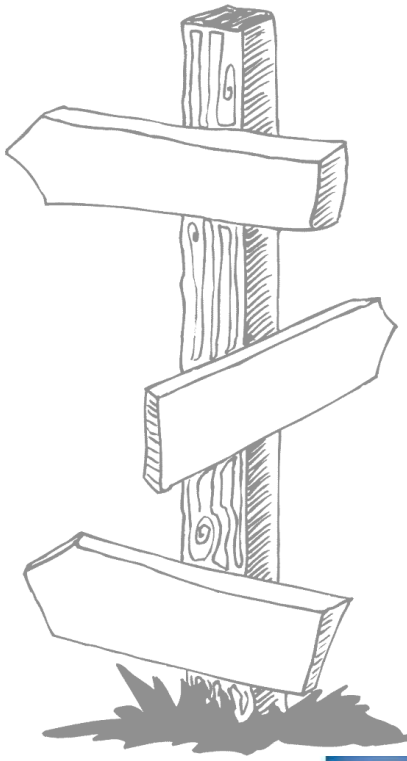
# Benchmark Scenario - Assumptions

- Meet MN conservation goal.
- Meet or exceed MN Renewable Energy Standard.
- Generators added in fractional shares.
- Transmission cost adders included.
- $10/ton CO2.
- Wind Production Tax Credit until 2012.
- No retirements of existing plants.
- Contracts expire at end of terms.
- No net market transactions.



# Other Scenarios

- "Status Quo" - no new wind, conservation, $CO_2$=$0
- $CO_2$ = $0, $4, $10, $30, $50, $70
- Higher gas prices
- Higher wind costs
- Higher loads

# Capacity Expansion Modeling Conclusions

- Wind and gas (CT & CC) sufficient thru ~10 years.
  - Existing peakers reduce need for new gas to accommodate wind.
- Wind is very sensitive to wind price (including PTC).
- Need baseload ~2020.
  - Nuclear, Coal w/ carbon capture, hydro all possibilities.
- At high CO2 costs (≥$30/t):
  - Existing coal plants no longer are baseloaded
    - suggests need to retire, repower, or add carbon capture
  - nuclear or coal w/ carbon capture more cost effective than gas
  - costs (rate impacts) increase dramatically unless offset

# Carbon Neutral Generation

Traditional Renewables

- **Wind**
- **Solar**
- **Biomass**
- Hydro
- Geothermal
- Wave
- Tidal

Other Options

- Natural Gas
- Coal w/carbon capture
- Nuclear
- **Energy Storage**

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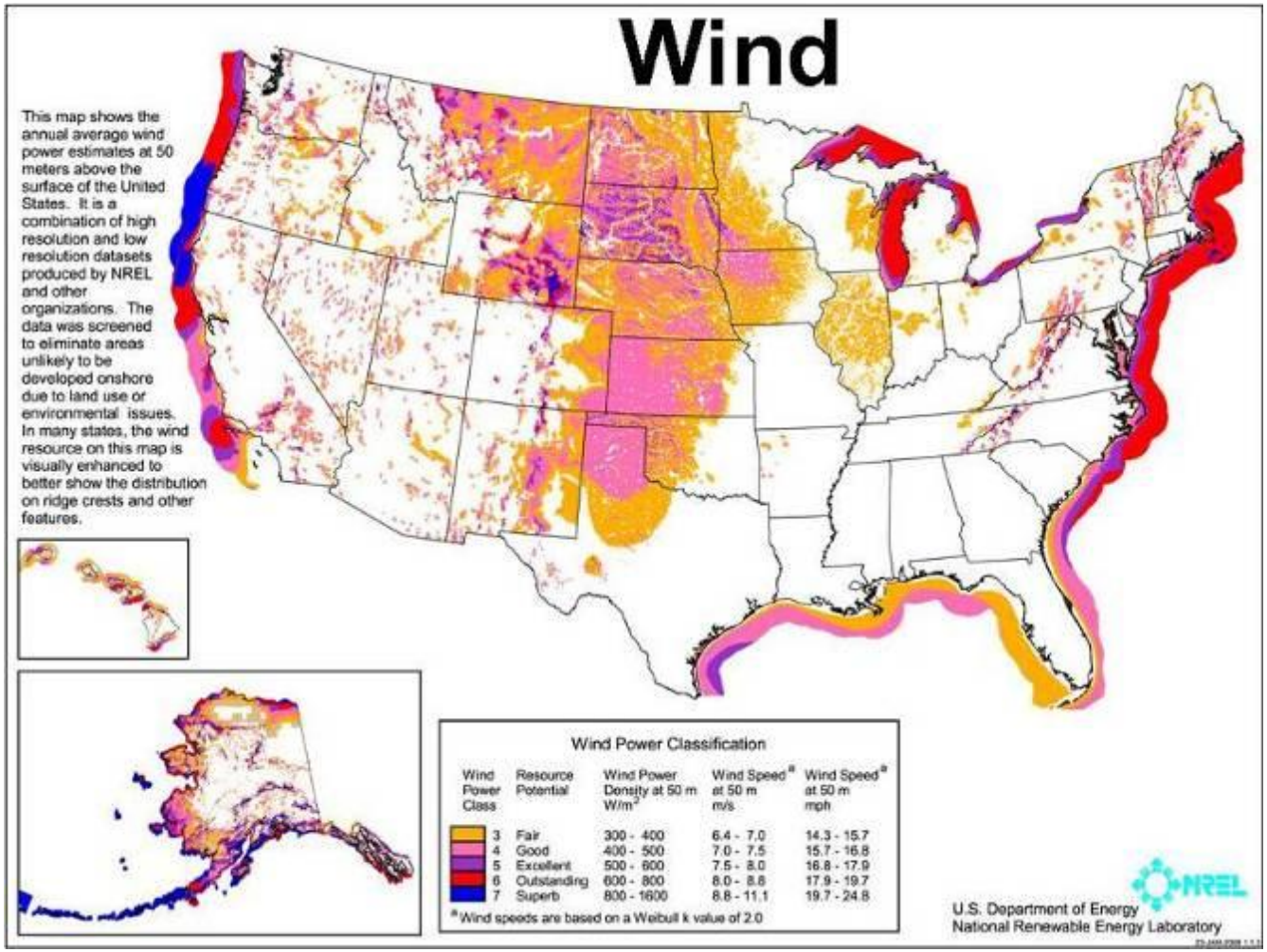
# Resource Assessment

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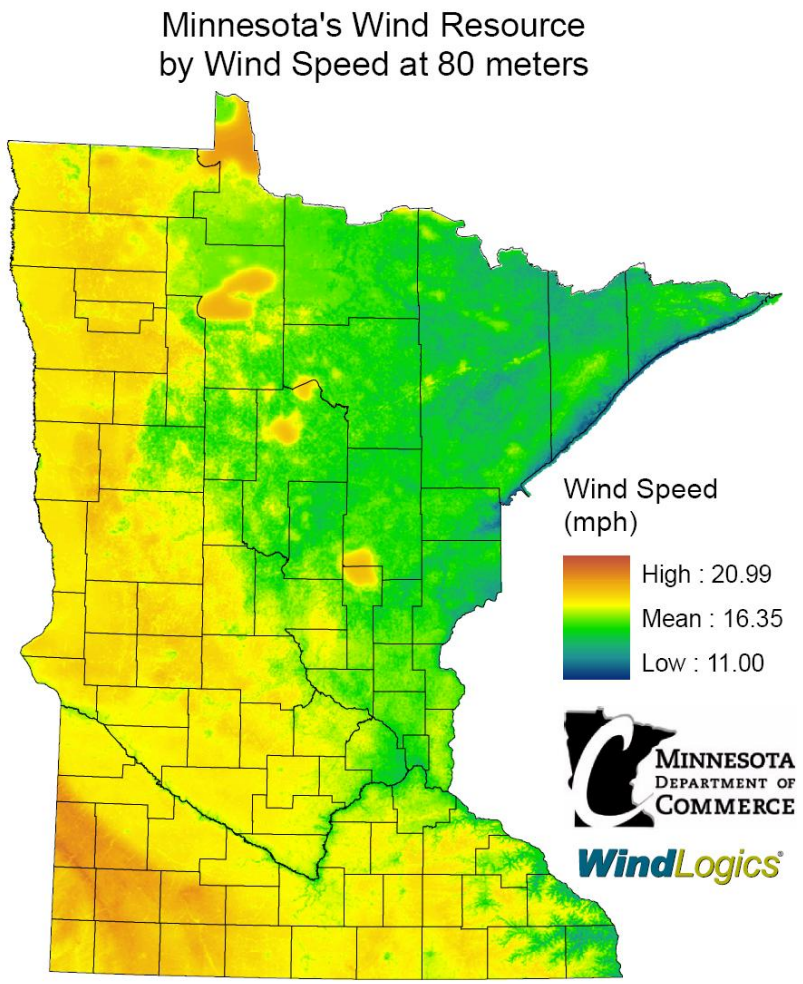
# Minnesota's Wind Resource




## Minnesota

- 9th best wind resource
- 4th installed capacity
- 2nd % energy from wind

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# U.S. Wind Ranking

- 2008 Additions = 8,500 MW
- Total wind power capacity = 25,300 MW
- United States has largest amount of wind capacity in world
  - Overtaking Germany in 2008!

# 100 Megawatts of Wind Power

- 67 typical wind turbines (1.5 MW rating)
  - 340,000 MWh/yr carbon free energy
  - Annual energy needs of 29,000 homes
- 8,000 – 12,000 acres of land
  - <5% needed for turbine, foundation, roads
- $225 million capital investment

# The 20% Wind Energy Scenario

- Primary Assumptions:
  - U.S. electricity consumption grows 39% from 2005 to 2030 -- to 5.8 billion MWh (Source: EIA)
  - Wind turbine energy production increases about 15% by 2030
  - Wind turbine costs decrease about 10% by 2030
  - No major breakthroughs in wind technology
- Primary Findings:
  - 20% wind electricity would require about 300 GW (300,000MW) of wind generation
  - Affordable, accessible wind resources available across the nation
  - Cost to integrate wind modest
  - Raw materials available
  - Transmission a challenge

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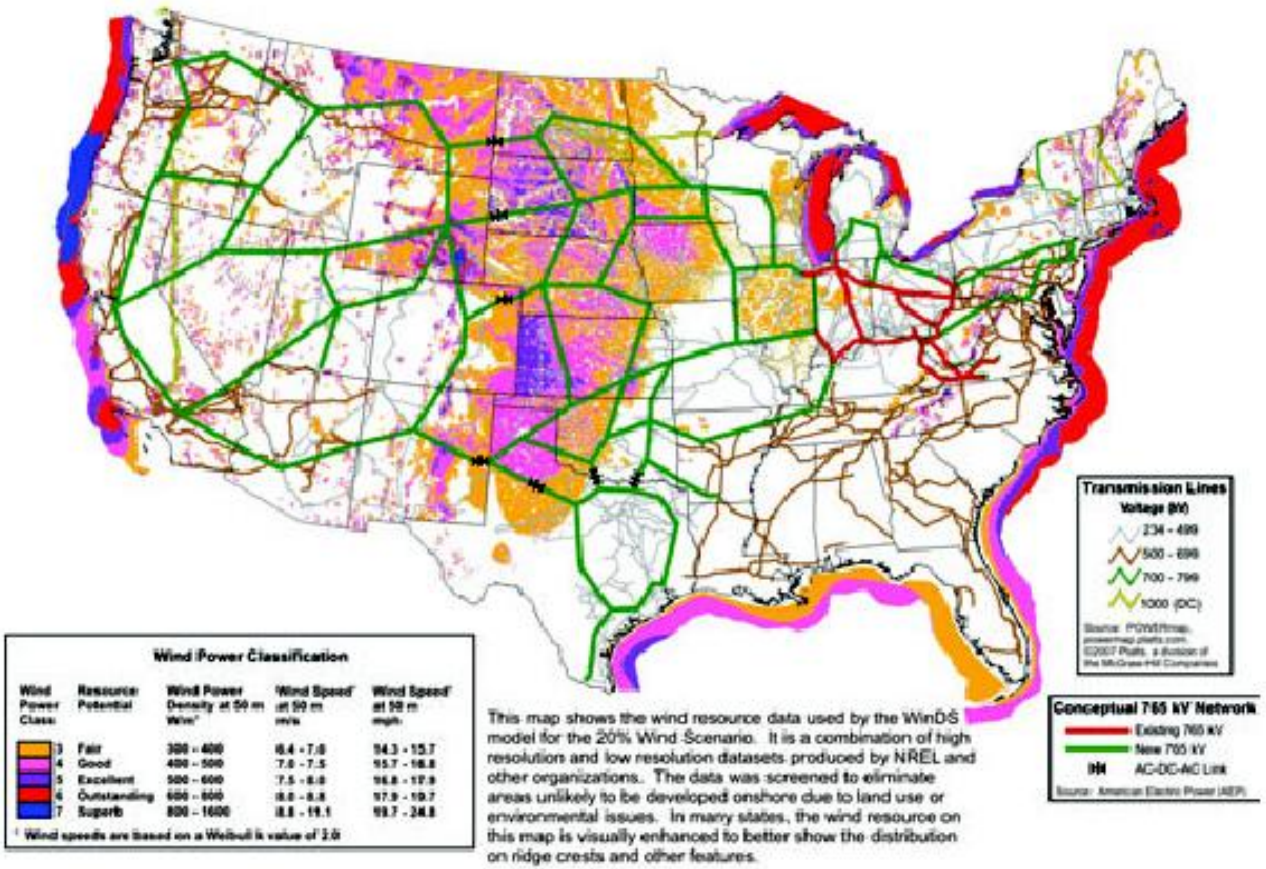
# Future Transmission Needs

Figure ES-10. Conceptual transmission plan to accommodate 400 GW of wind energy (AEP 2007)




This map shows the wind resource data used by the WinDS model for the 20% Wind Scenario. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.

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# Concern:  Siting for Turbines & Transmission


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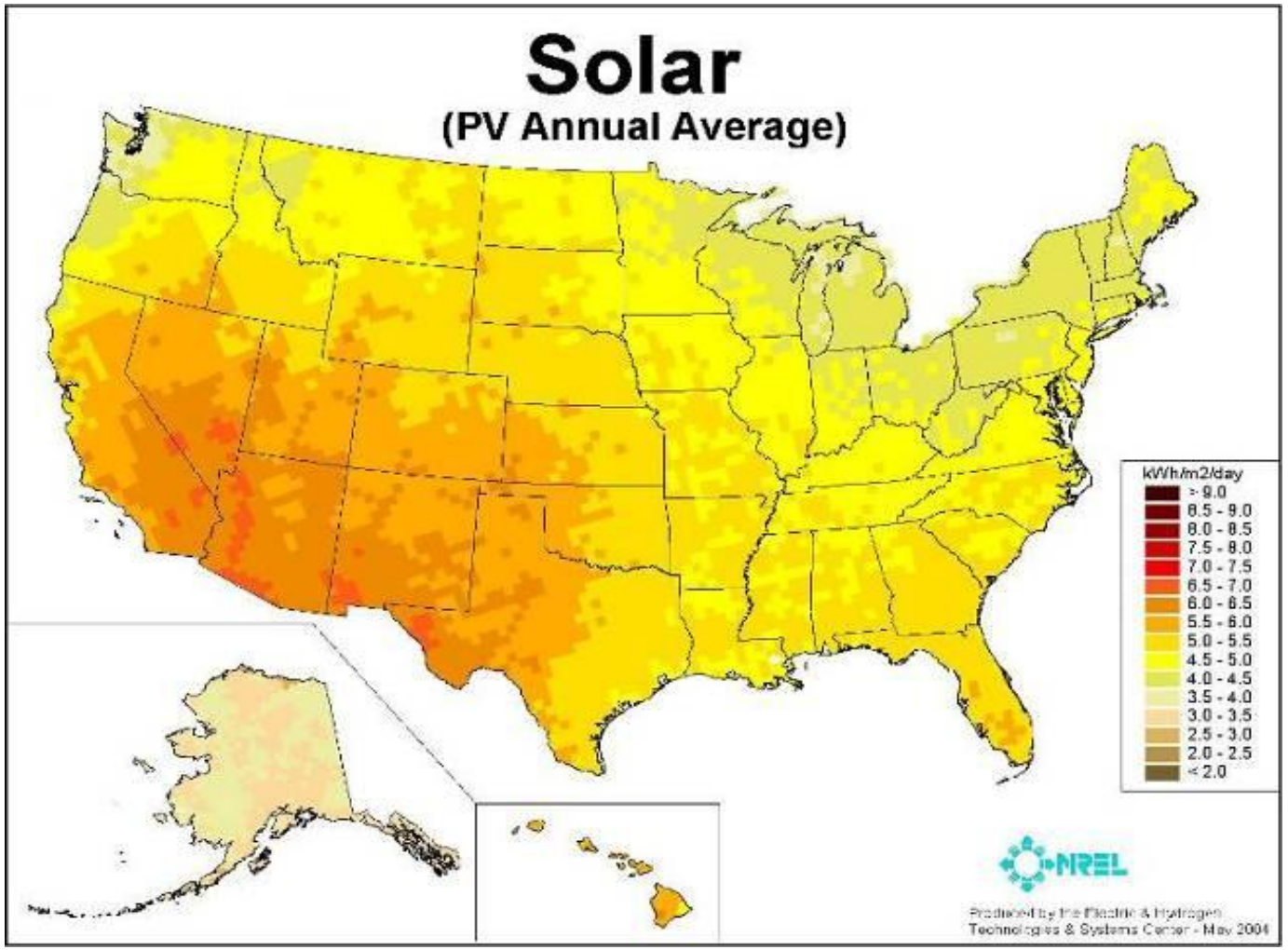
# Resource Assessment

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# Solar Energy Potential

- Solar PV
  - Silicon, Thin films
  - Fixed, tracking, building integrated
  - 10% of U.S. energy by 2030
- Solar Thermal
  - Hot water for space heat & domestic hot water needs
  - Steam generation for electricity production
  - 100% of U.S. electricity supply if 92 square miles in desert SW had these…

- Solar Biomass
  - Trees, algae, corn etc.

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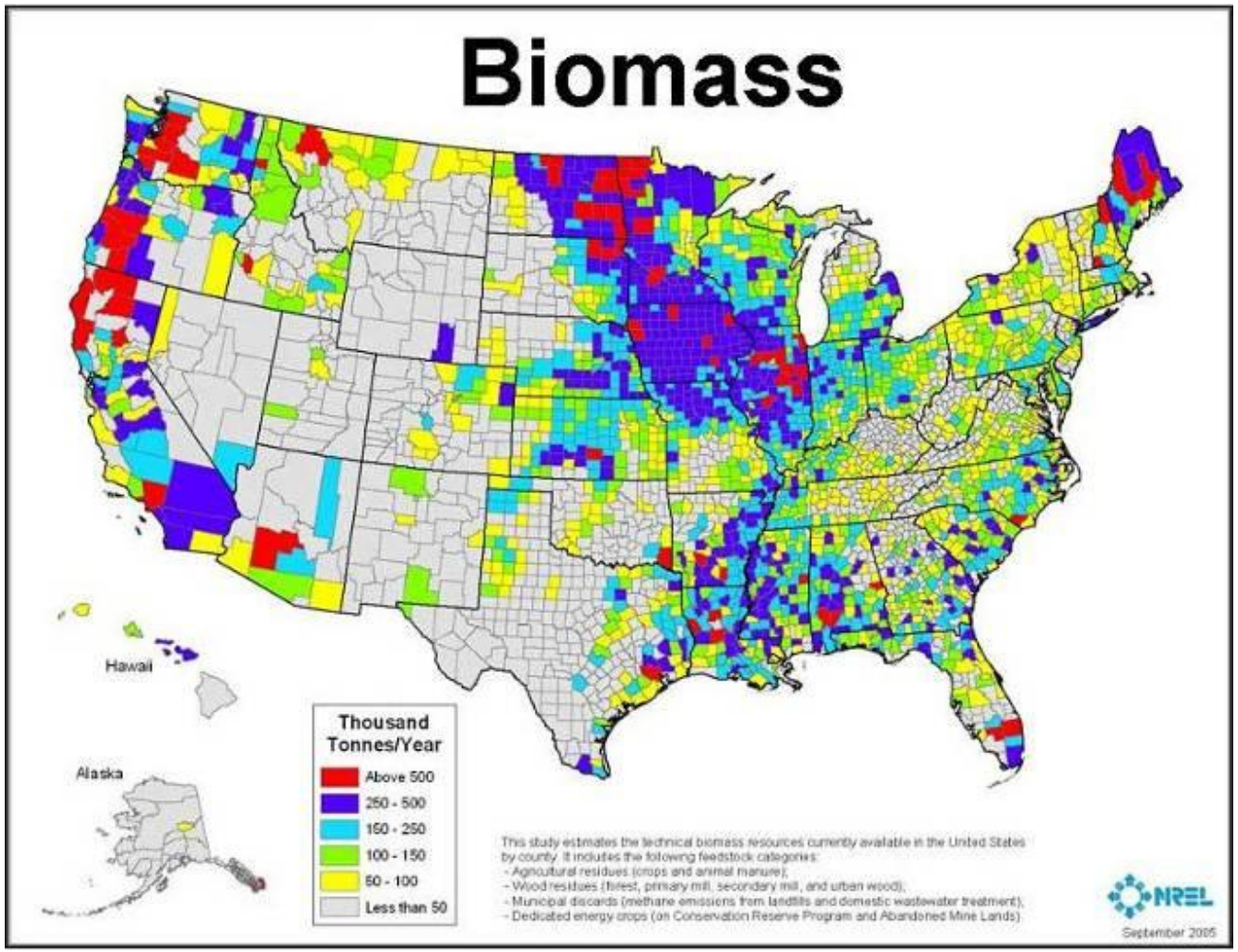
# Resource Assessment

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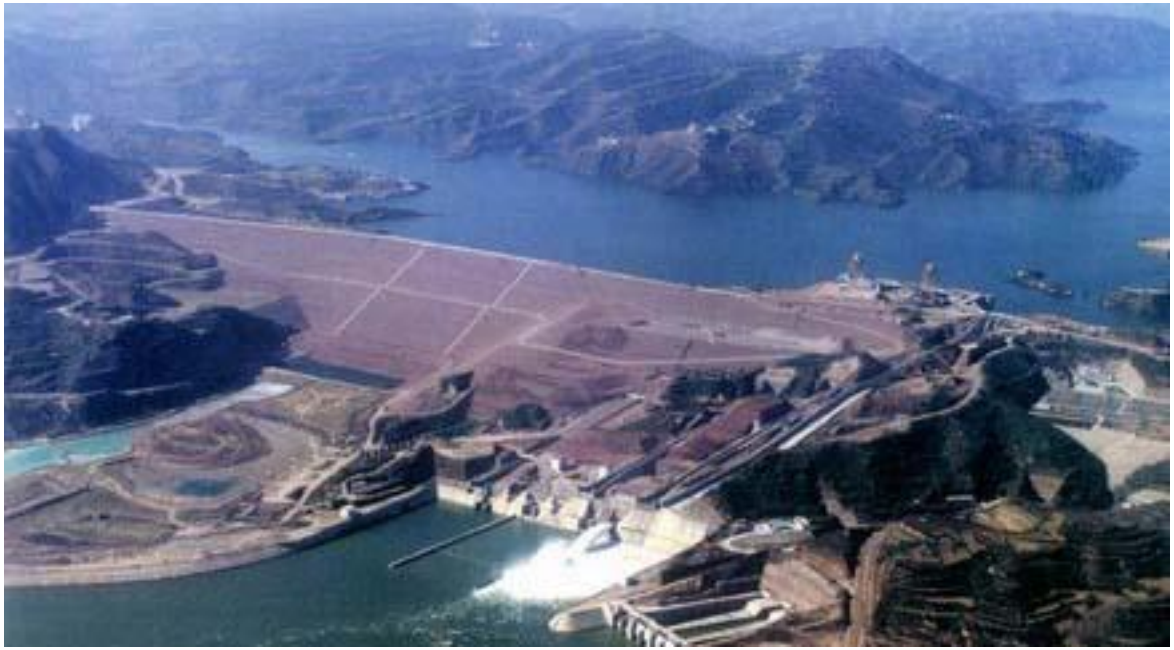
# Biomass

- Grow specially chosen plants for fuel and burn them to make heat or electricity
  - Coal substitution
- Use by-products of agricultural activities
  - Burn them
  - Digest them
- Use household wastes
  - Process and burn them – reduces landfill volumes
  - If already landfilled, capture methane for electricity production

# Large Hydro



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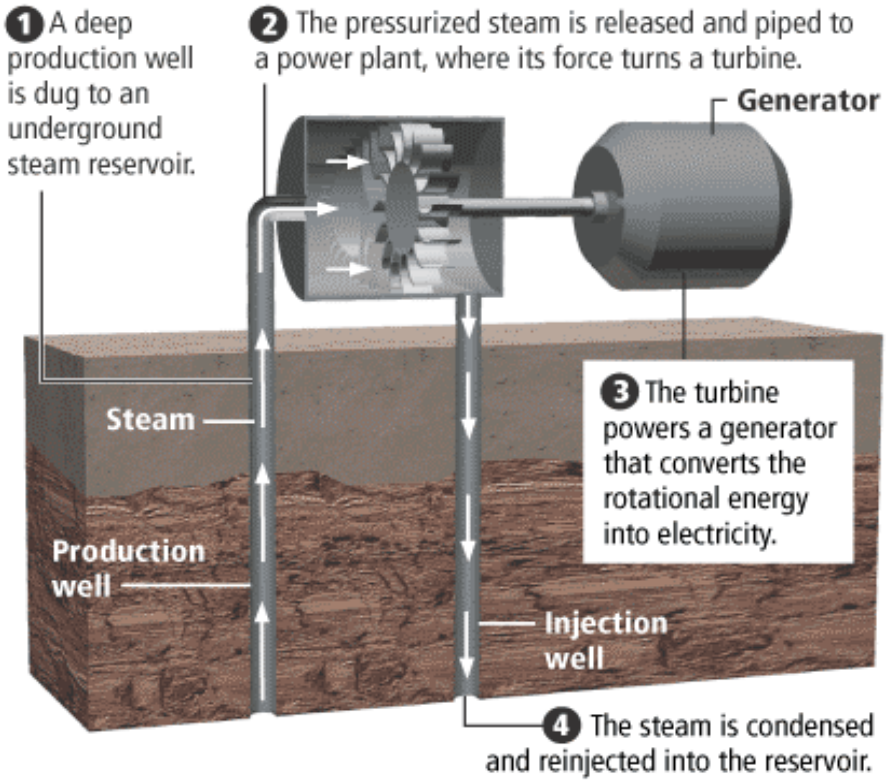
# Geothermal

## HARNESSING GEOTHERMAL ENERGY

Geothermal power could theoretically satisfy all the world's energy needs. Trouble is, it's expensive to do the deep drilling necessary to tap the heat.

### HOW IT WORKS




Source: U.S. Department of Energy

SEATTLE P-I

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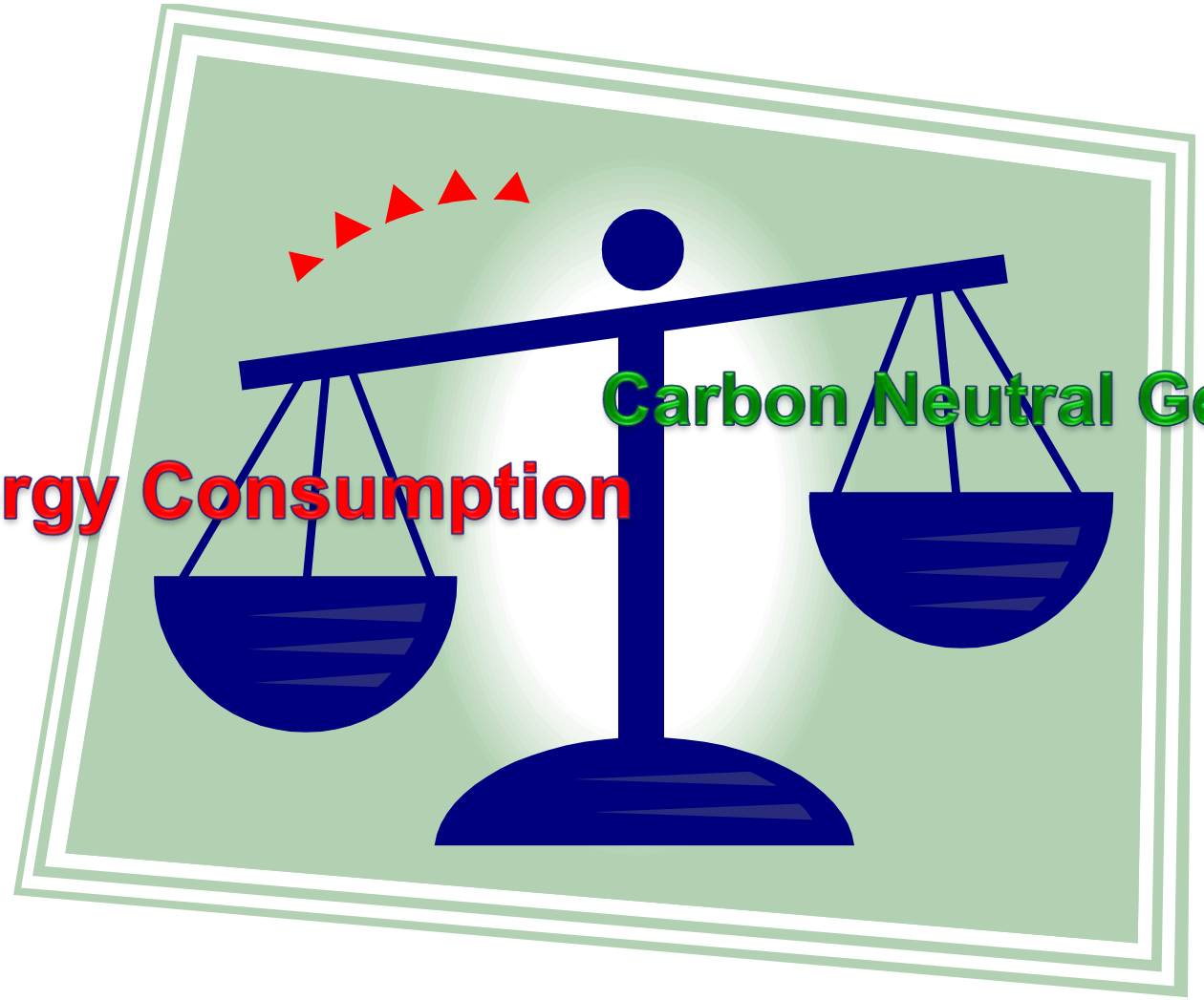
# Can we find a balance?

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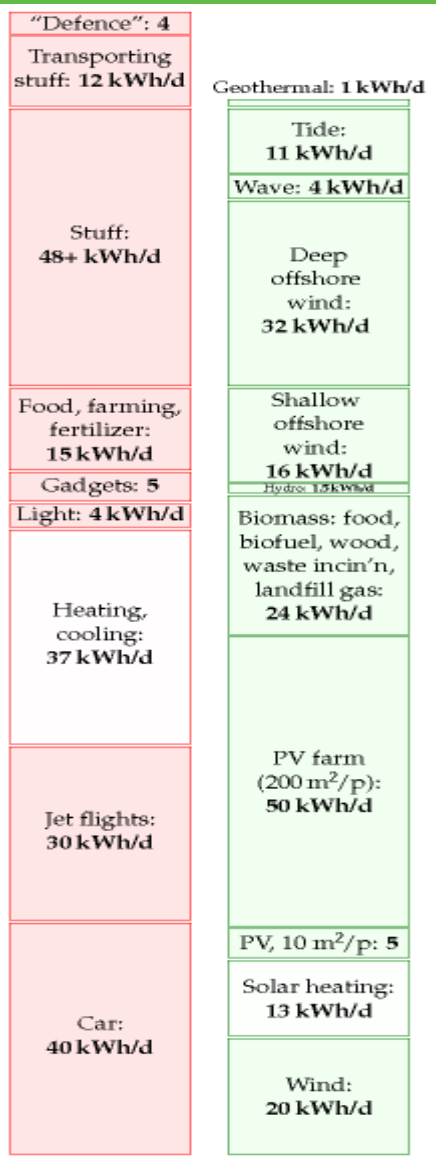
# Can we live on renewables?

Consumption
195 kWh/d/p




Traditional Renewables Potential
180 kWh/d/p

**No economic, social or environmental constraints!**

Sustainable Energy - without the hot air
David JC MacKay/Physics Professor, University of Cambridge

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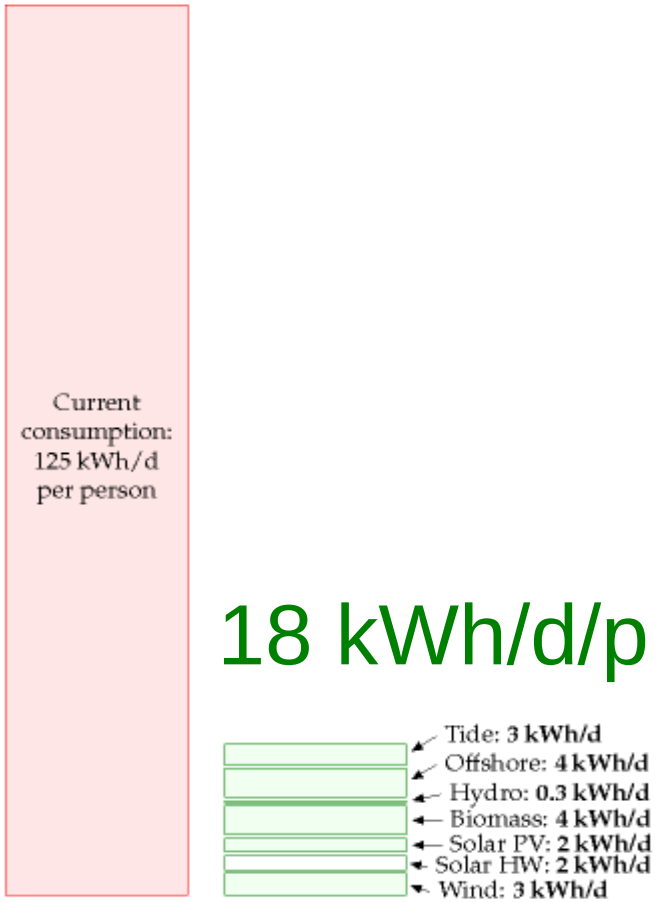
# After public consultation…




*After the public consultation.* I fear the maximum Britain would ever get from renewables is in the ballpark of 18 kWh/d per person. (The left-hand consumption number, 125 kWh/d per person, by the way, is the average British consumption, excluding imports, and ignoring solar energy acquired through food production.)

- Technology too immature!
- Too expensive!
- Not near my radar!
- Not near my birds!
- Not in my valley!
- Not in my countryside!
- Not on my street!
- Not in my backyard!
- Too expensive!

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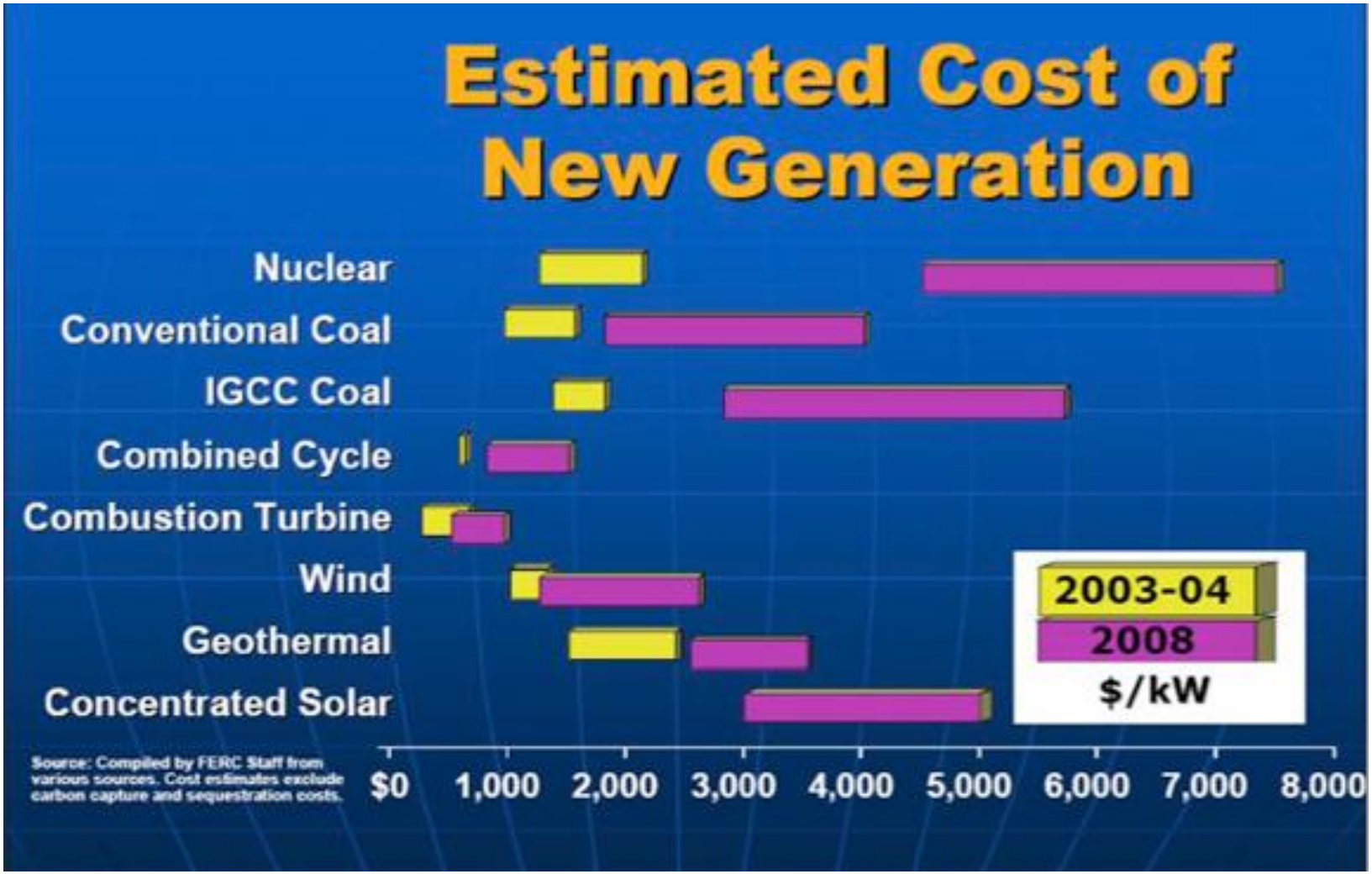
# New Electric Generation Costs

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# In Summary

- Policy
  - Energy Efficiency
  - Renewables
  - Carbon reduction goals
- Potential
  - Wind – 25%, Solar 10%
  - Need all resources to meet future energy needs
- Progress
  - Renewables are a major % of new resources
  - Development of storage technologies
  - Development of carbon capture & storage technologies


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RENEWABLE ENERGY SOURCES
HARVESTING THE WIND

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