Legislative Committee Briefing

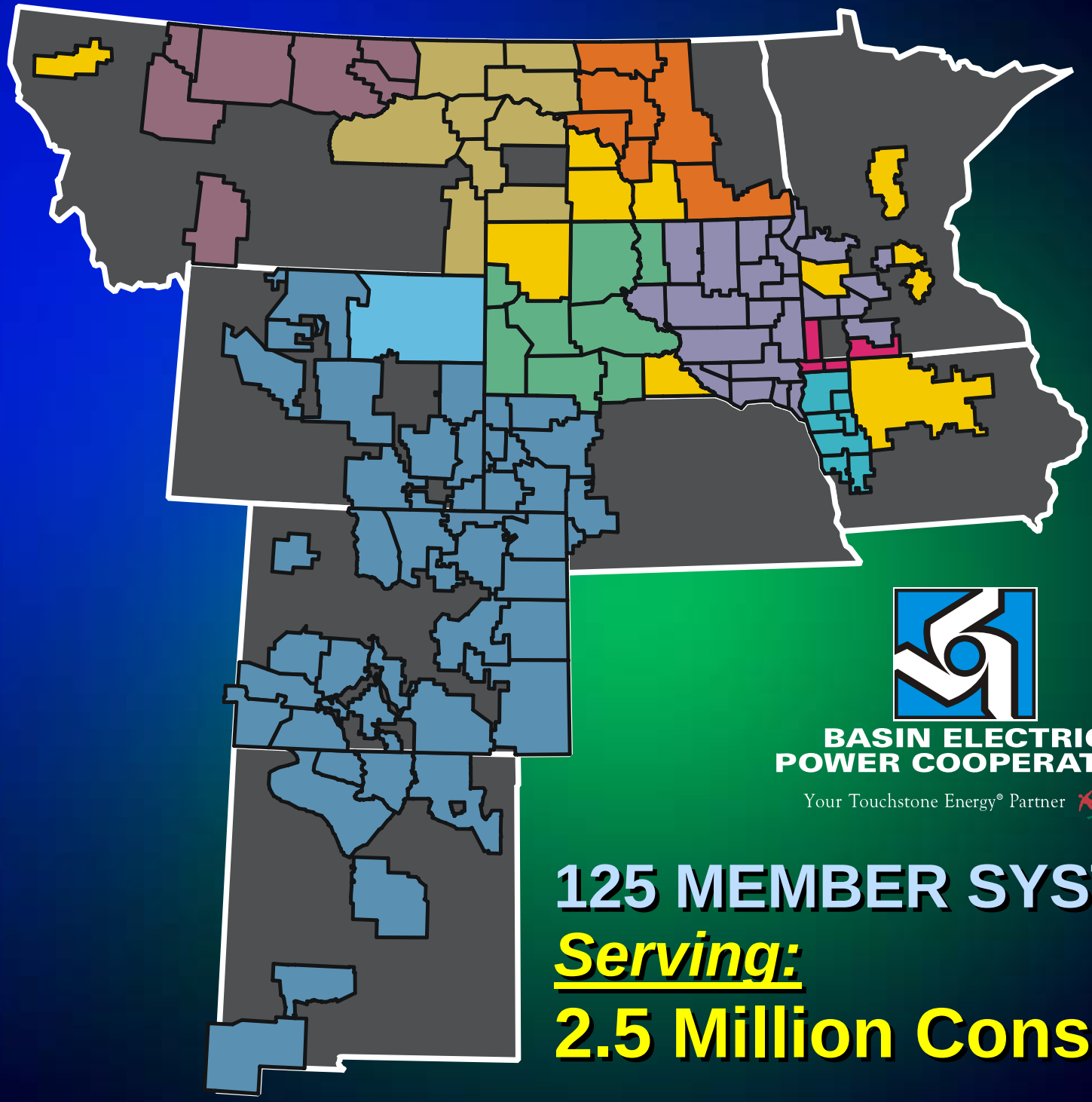
North Central Research Extension Center

March 5, 2008

BASIN ELECTRIC POWER COOPERATIVE

Your Touchstone Energy® Partner

Ron Rebenitsch, PE



BASIN ELECTRIC
POWER COOPERATIVE

Your Touchstone Energy® Partner

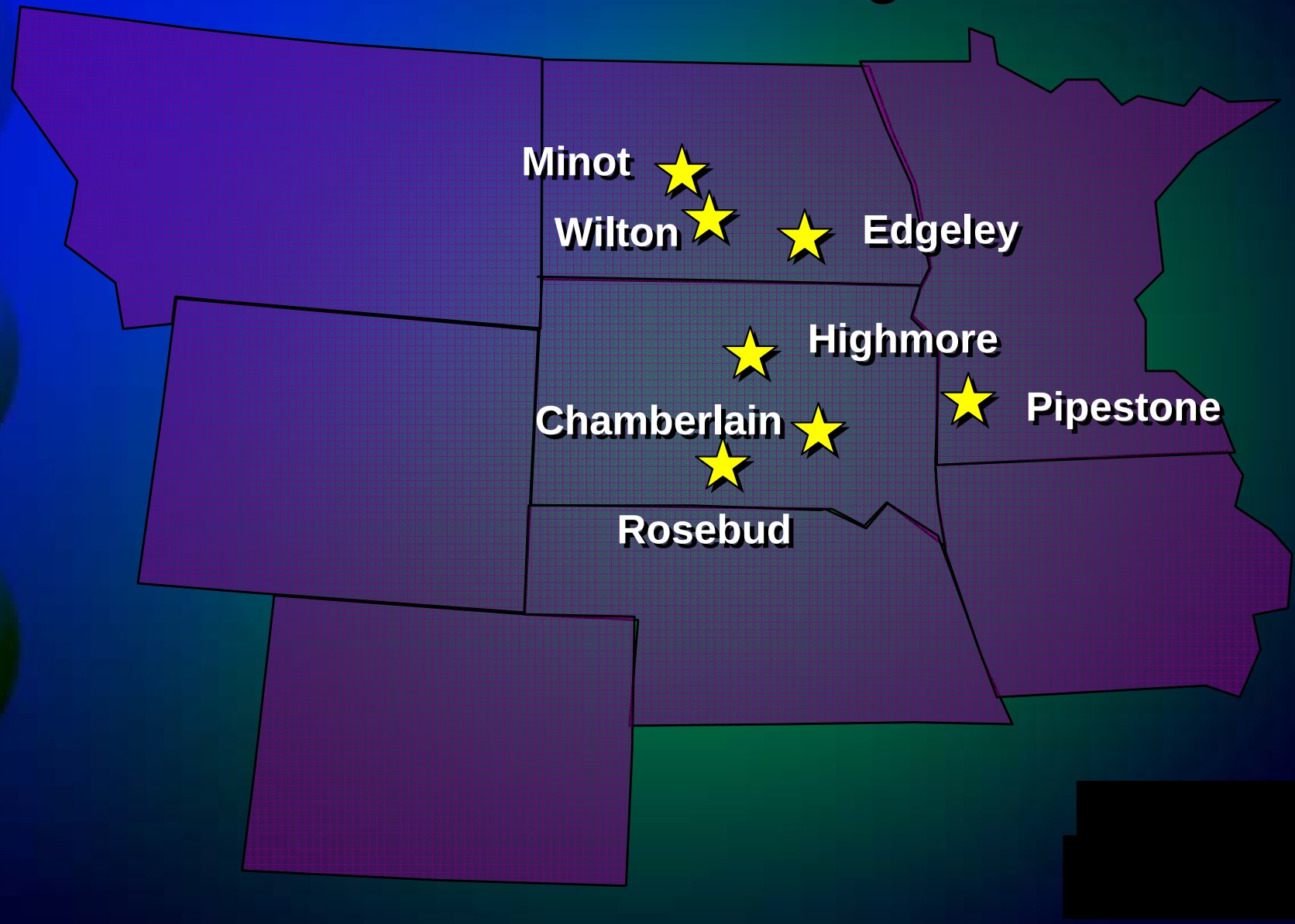
125 MEMBER SYSTEMS

Serving:

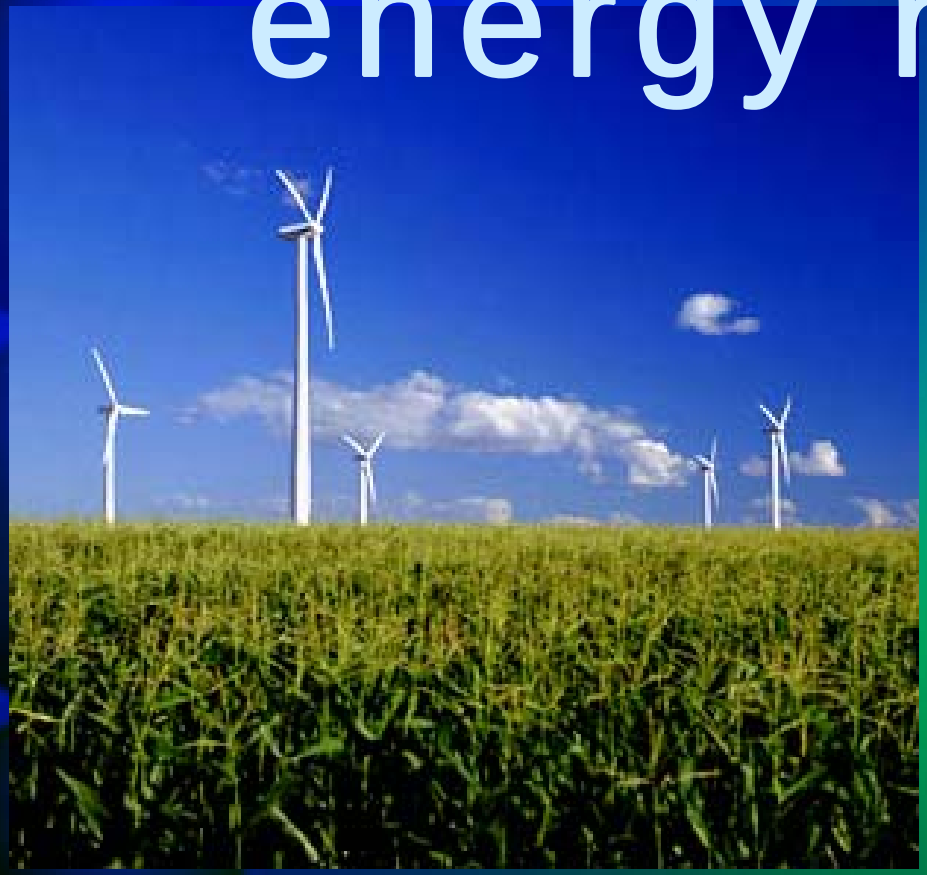
2.5 Million Consumers

Basin Electric's Wind

136 MW Existing



Wind offers a vast energy resource ...



The Great Plains can produce wind power at costs near 6-8¢/kWh

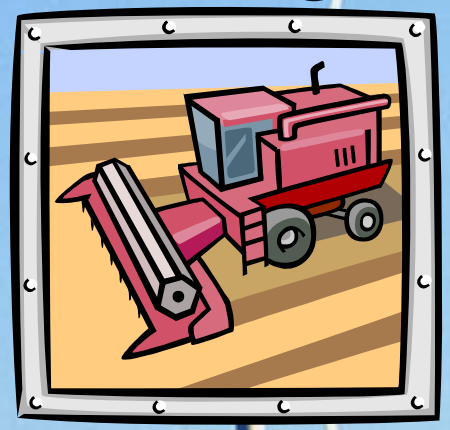
Aftertax: 3-5¢/kWh

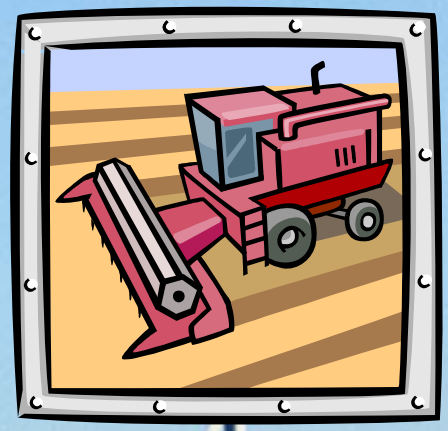
Why are we looking at Hydrogen?

- **Uses alternative resources**
- **Energy Security**
- **Clean fuel - Low emissions**
- **Feedstock for fuel cells**
- **Etc…**

Opportunity to store intermittent wind energy

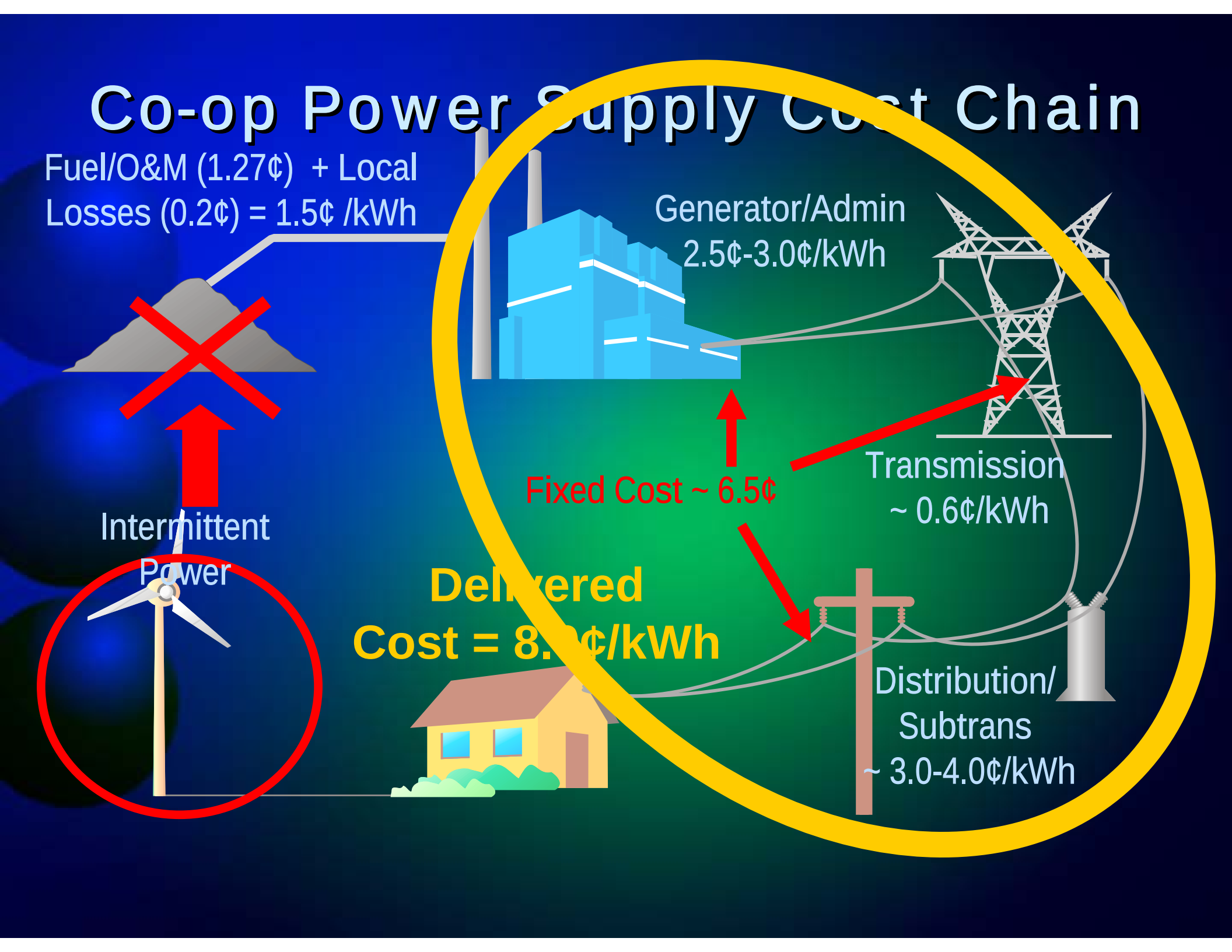
Harvesting the wind is feasible, but...





Economics drives decisions!

Co-op Power Supply Cost Chain

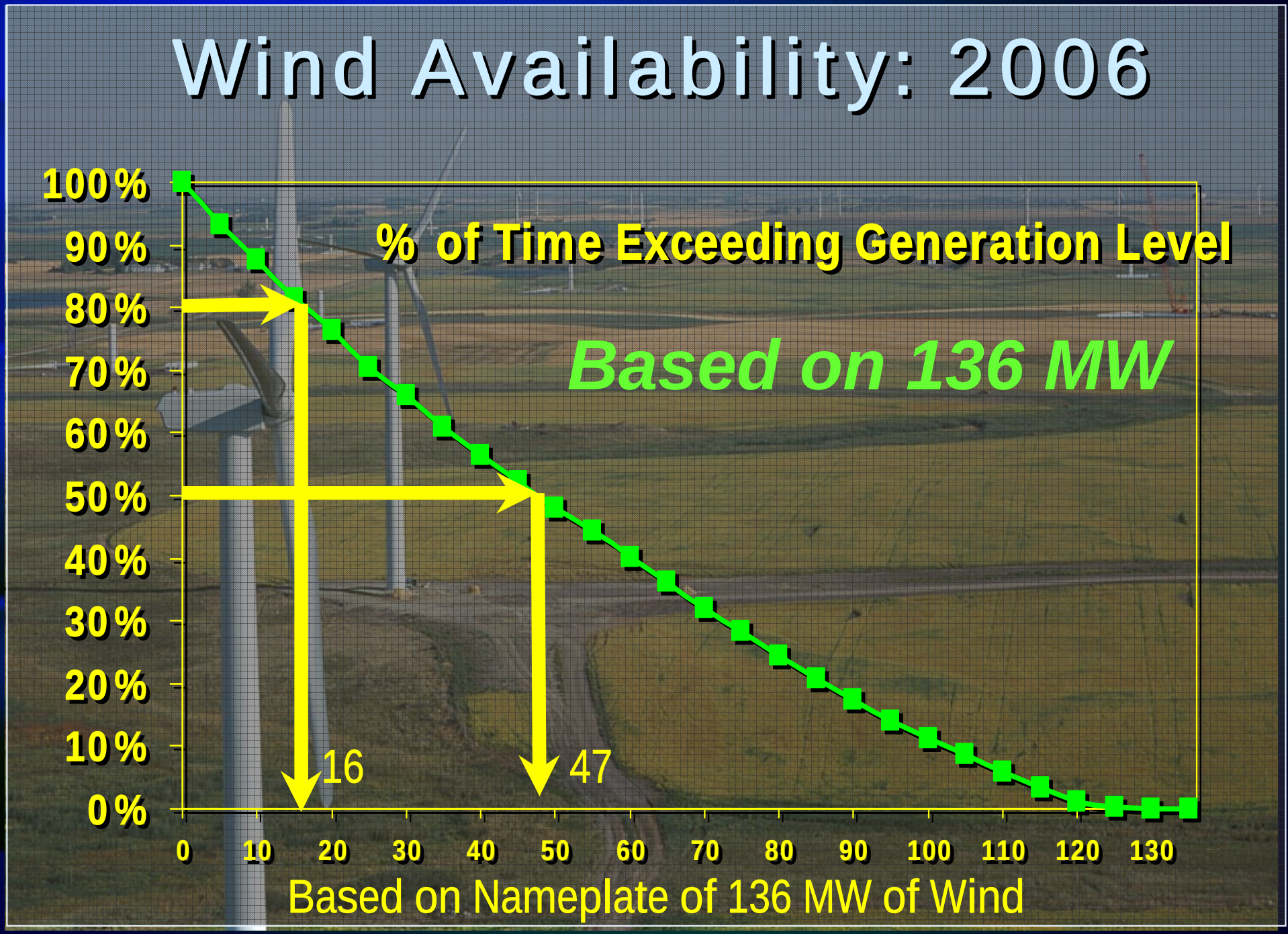


Net Metering Concern: Rates are *"Bundled"*

Over ½ the cost of power supply is "wires"…

Not electricity

Wind Availability: 2006



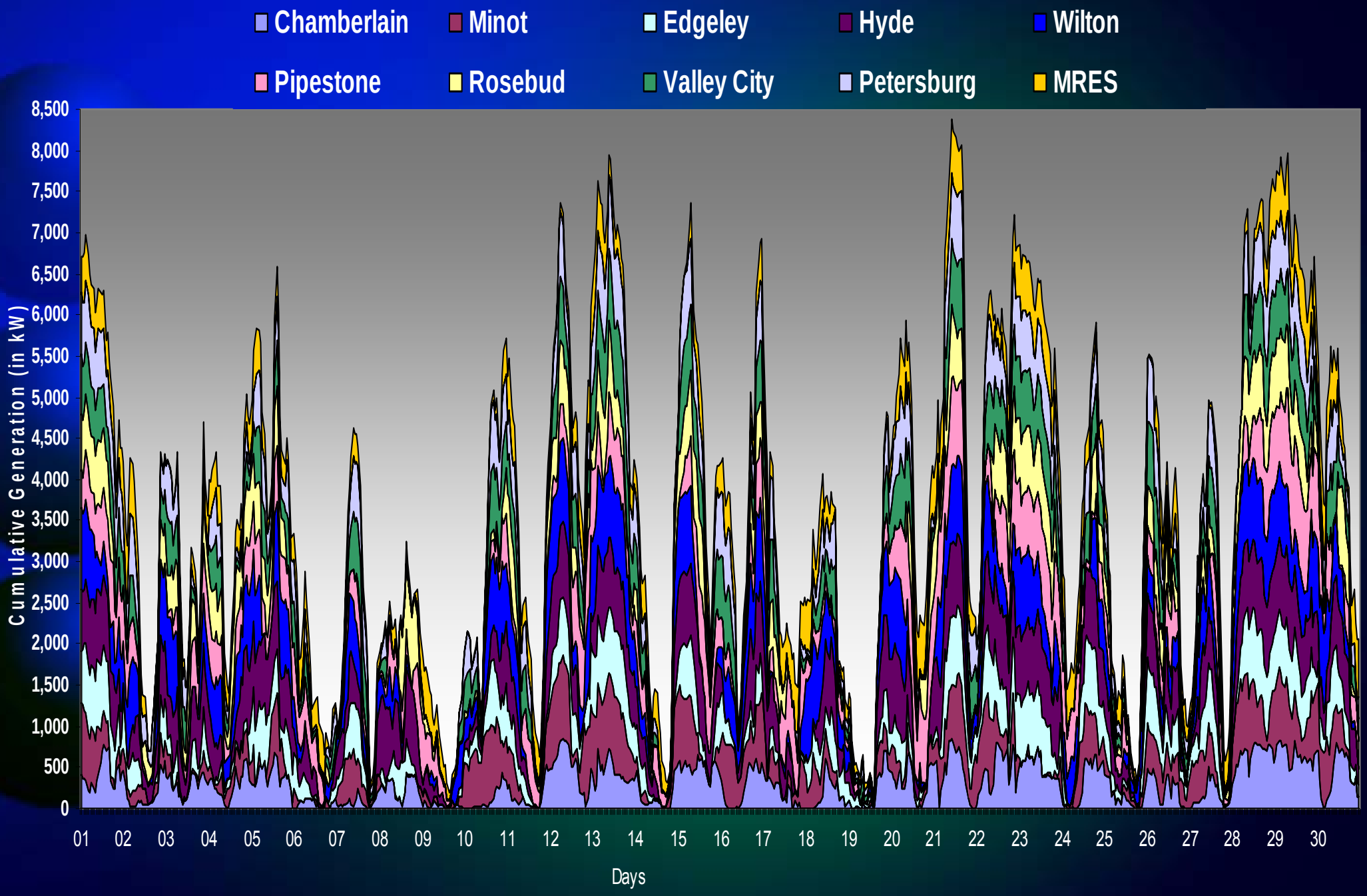
"Wind 2H2" Project:

Address Wind's Primary Hurdles:

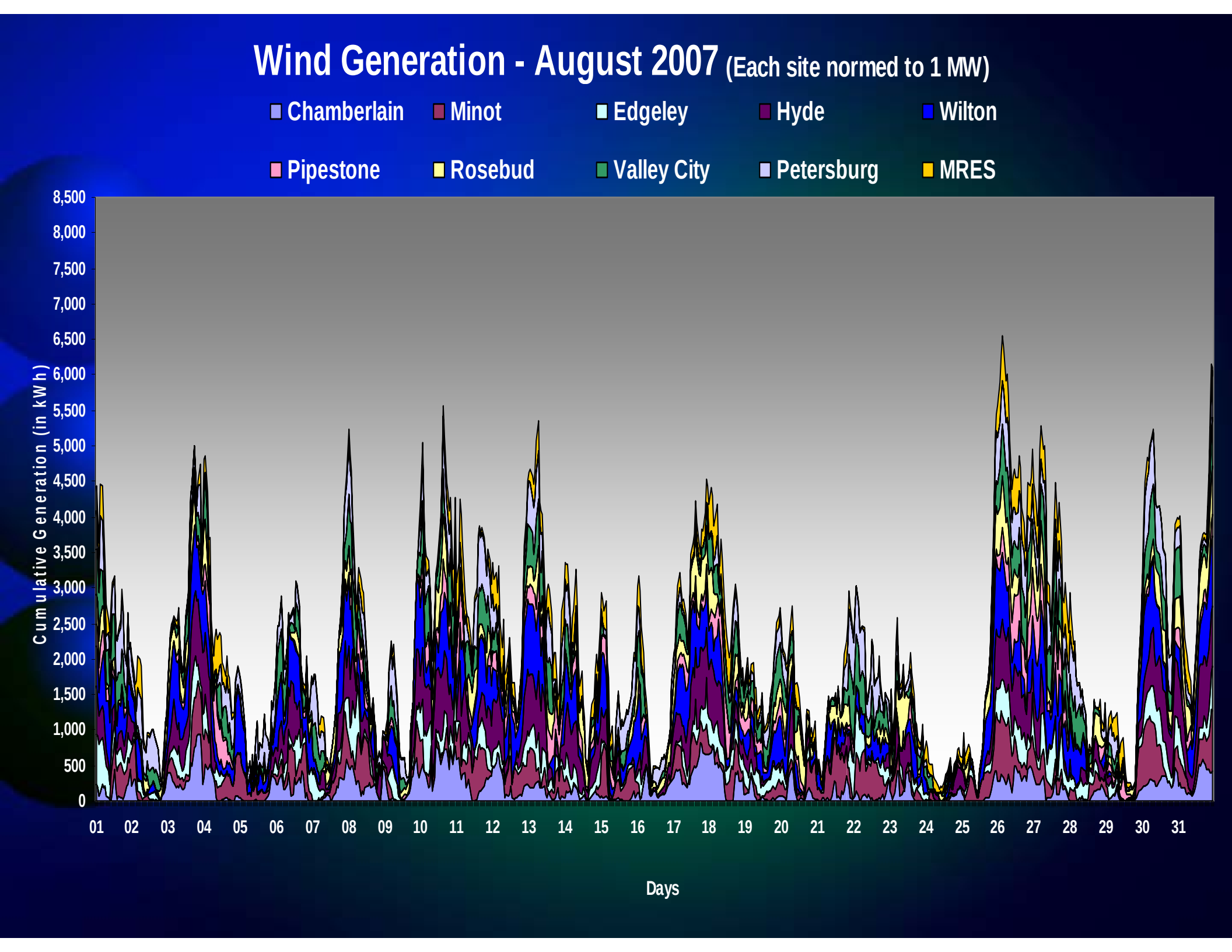
Transmission Congestion

Uncontrolled Variability

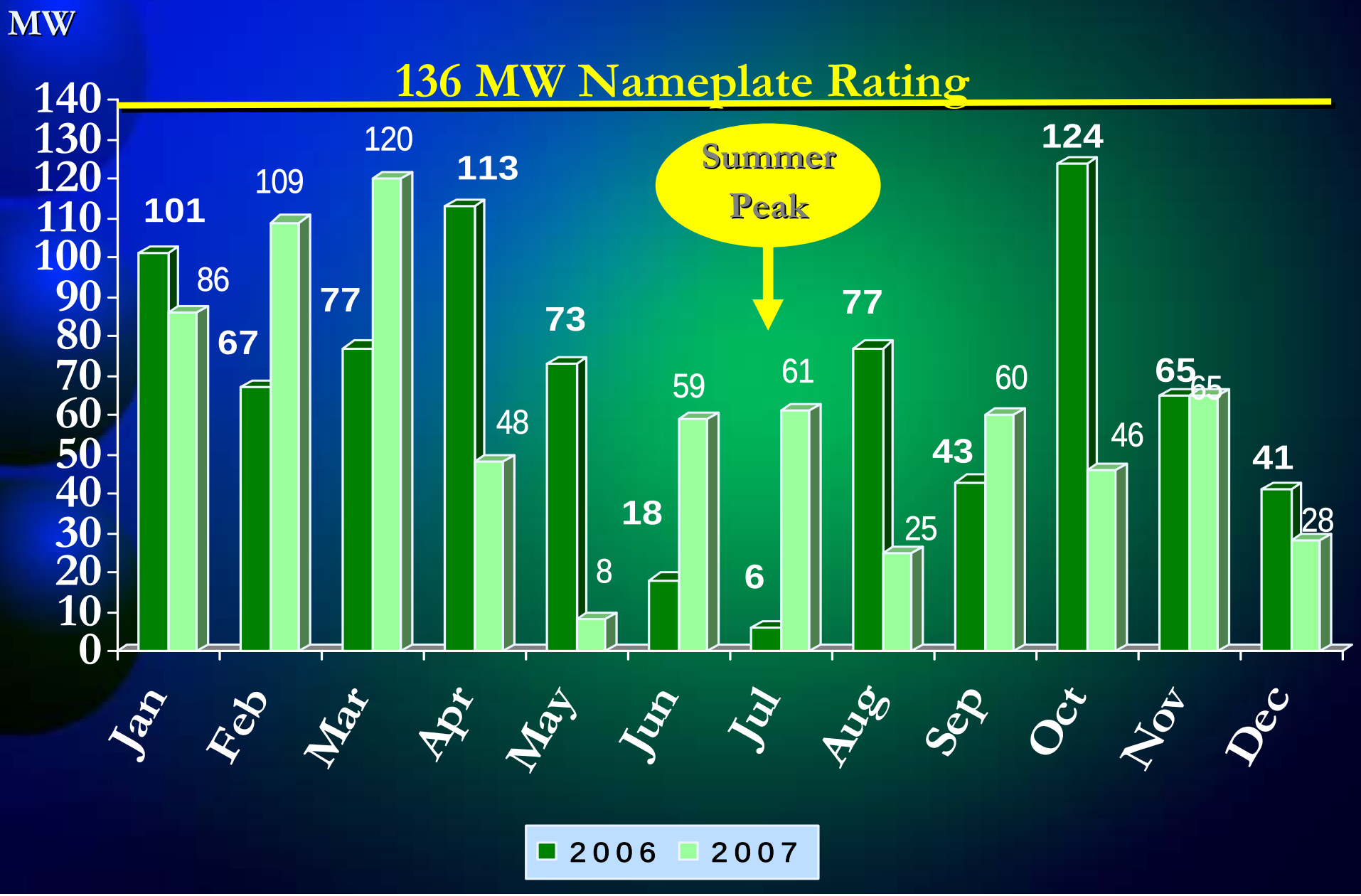
Wind Generation - Sept. 2007 (Each Site Normed to 1 MW)



Wind Generation - August 2007 (Each site normed to 1 MW)

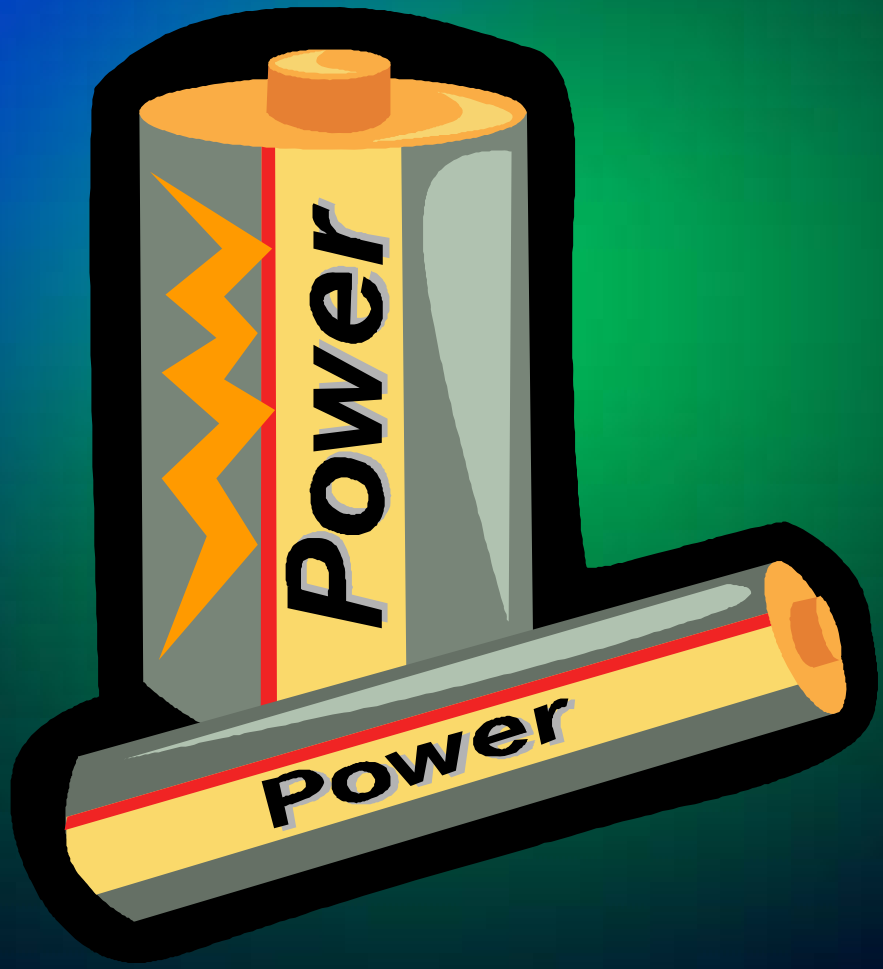


2006 & 2007
Generation During Monthly Peak HR

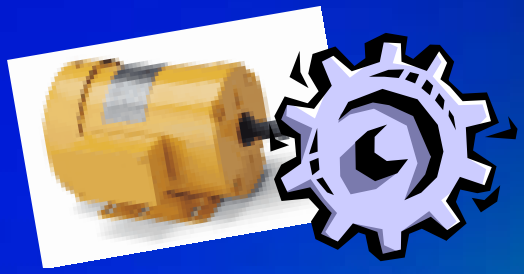


So, how do we get more value out of wind energy???

What's needed is "local use" or a "local battery"



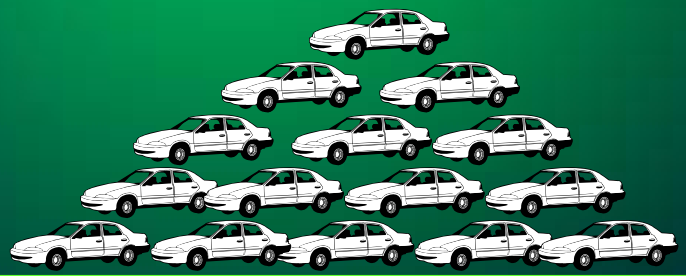
The energy in 1 kWH...



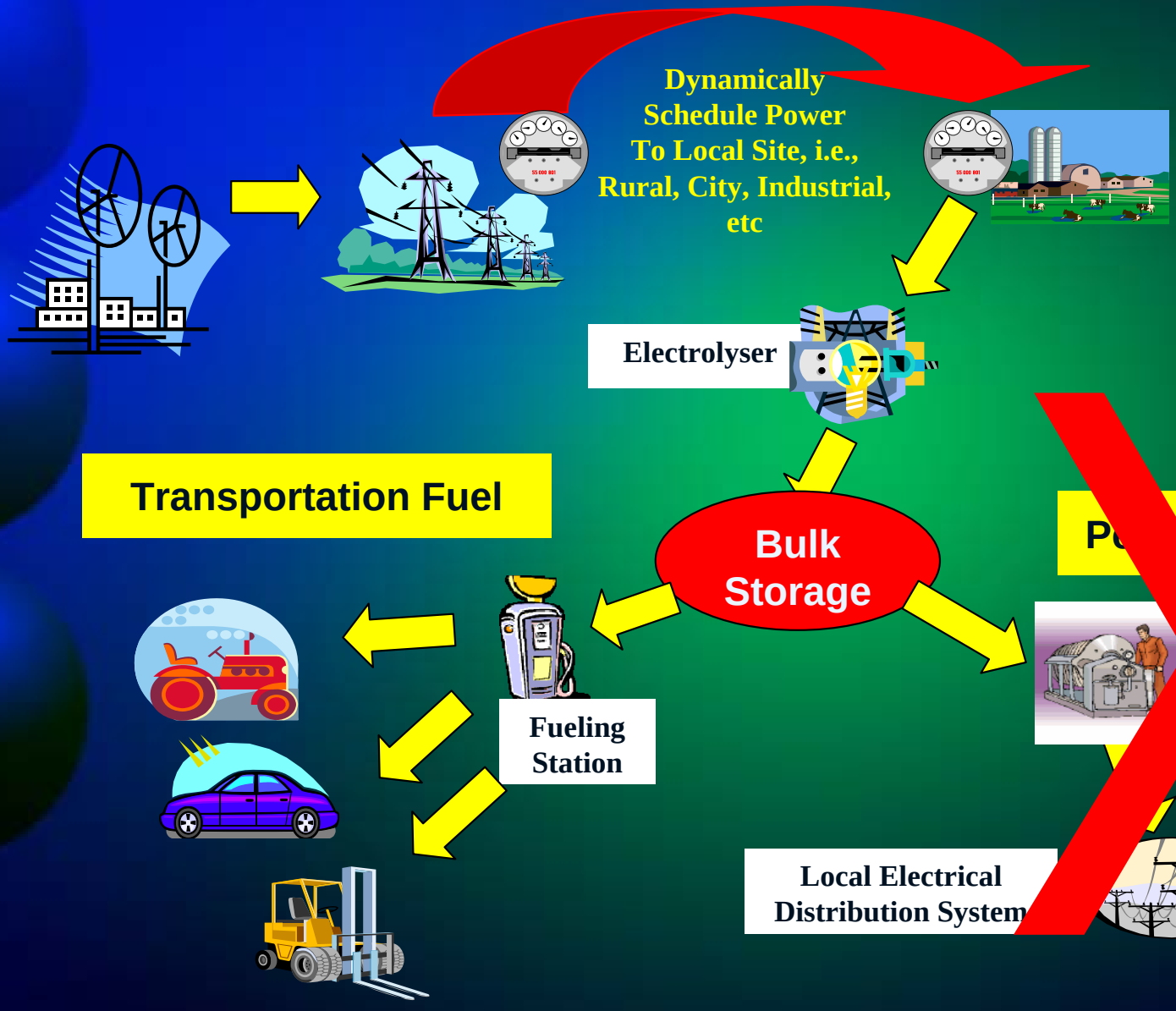
...is enough to lift

50,000 lbs up to

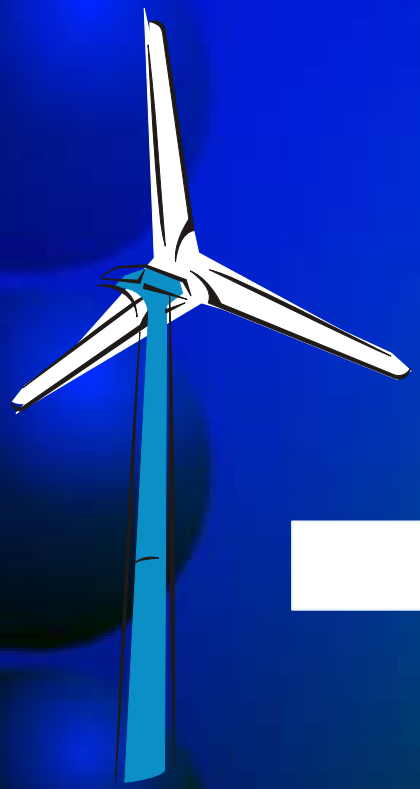
50 feet!

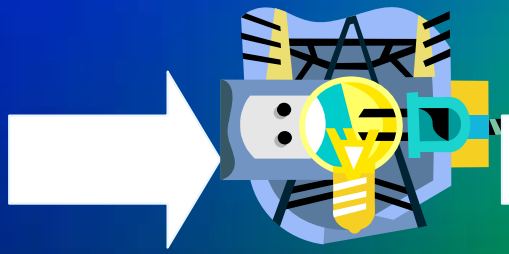


The Project...

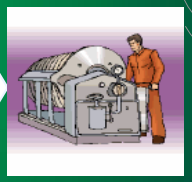

Dynamically Schedule Power To Local Site, i.e., Rural, City, Industrial, etc
Electrolyser
Transportation Fuel
Bulk Storage
Fueling Station
Local Electrical Distribution System

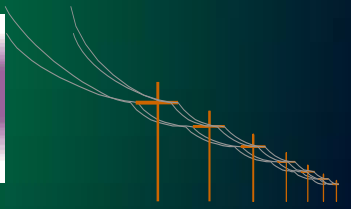
“Power Firming” has high losses!





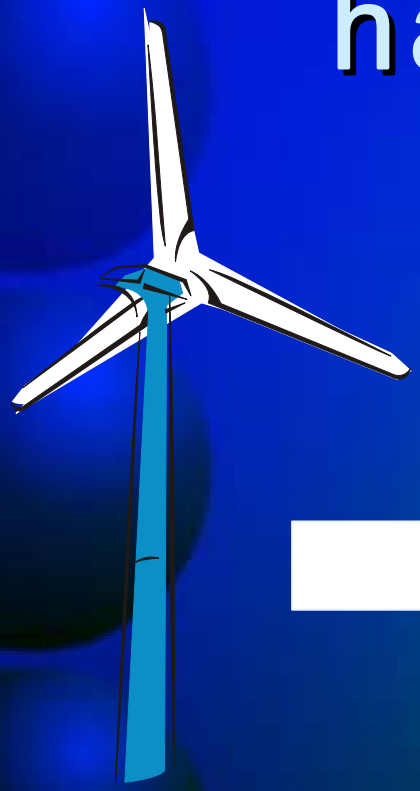
Compress & Storage

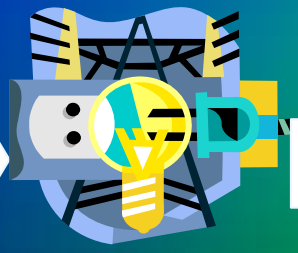




100 kWH 65% eff **65 kWH** 88% eff **55 kWH** 40% eff **22 kWH**

Transportation fuel has better potential





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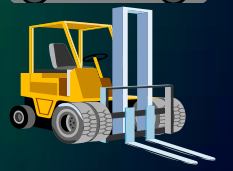
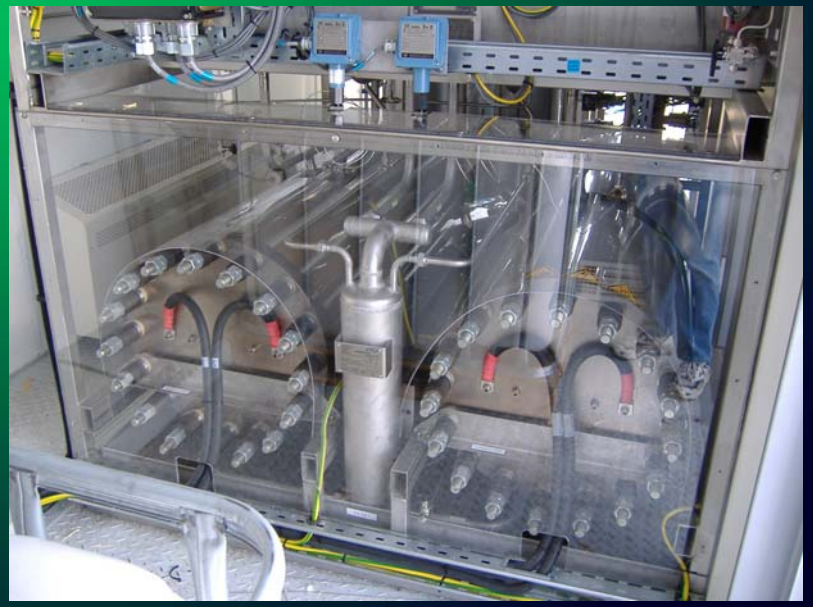


100 kWH 65% eff **65 kWH** 88% eff **55 kWH**

Electrolyzer Stats

- **Energy Input: 175 kW Electricity**
- **Energy Output: 2.7 kg/hr (30 NCMH) of H2**
- **Water Consumption: 0.264 GPM (15 GPH)**
- **H2 Pressure: ~6,200 psi**
- **H2 Storage: 80 kg**
- **Purity: 99.998%**



Electrolyzer Station

Vehicles Converted to H_2

Butler CAT

Tri-Fuel
Hydrogen
E85 Ethanol
Gasoline

Diesel/H2 Mix

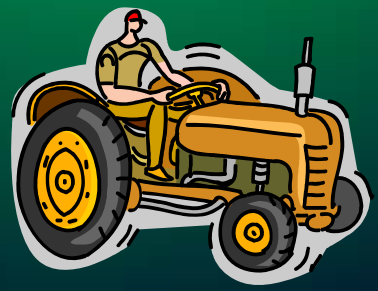
Why Not Fuel Cells?

Fuel Cells

- Limited Availability
- Very Expensive

Internal Combustion Engine

- Conversions available
- Much lower cost



Energy Content of Gasoline vs. Hydrogen

Rule of Thumb:

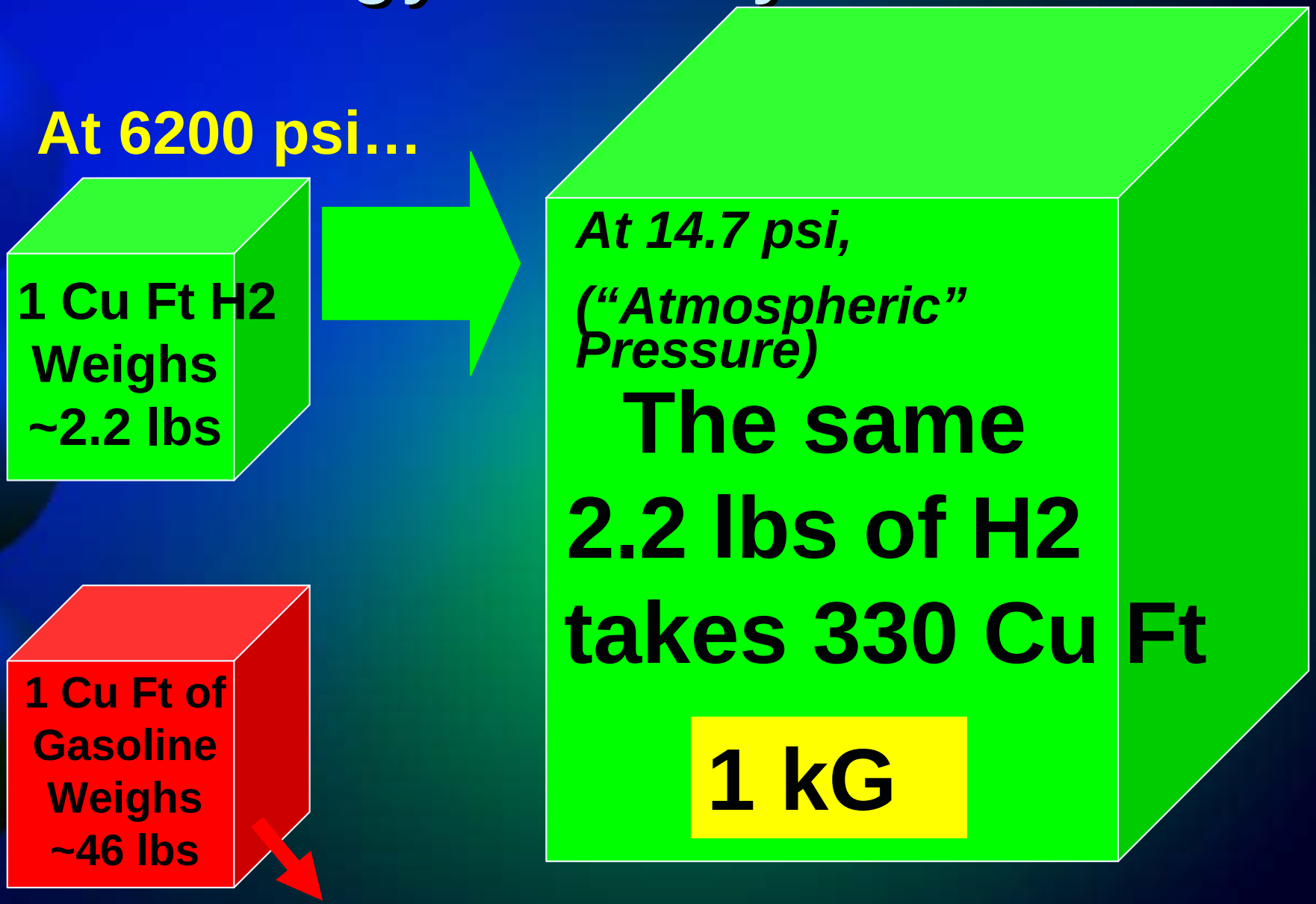
The energy in 1 kg of H2 is roughly equivalent to 1 Gal of Gasoline

Gasoline: ~123,000 BTU/Gal

Hydrogen: ~134,000 BTU/kg

Energy Density of H2…

At 6200 psi…



Almost 7 times as much energy

Expected Cost of "on-site" Wind Power to "Fuel" the Electrolyser...

It takes 60 kWh to make one kg of H_2

<u>Cost of power from a large wind project:</u>

~ 3.0-4.5¢ per kWh (after tax credits, etc)

<u>Energy cost to make hydrogen from wind:</u>

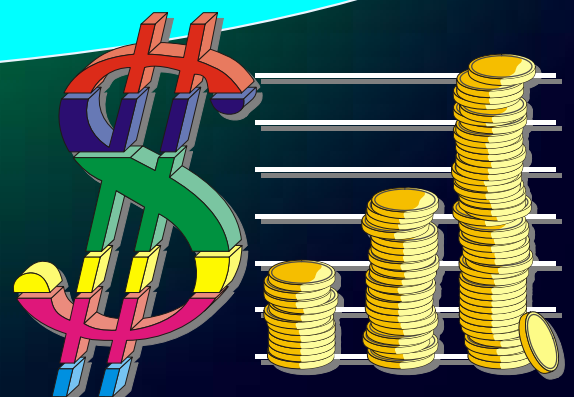
~$1.75 to $2.50/gal of gasoline

Capital costs (not energy costs) drive the economics

Installed Cost of Electrolyzer:

About $1.5 Million

Capital Costs are the biggest portion of hydrogen fuel cost



Some "*Back-of-the-Envelope*" Numbers

Annual Production:

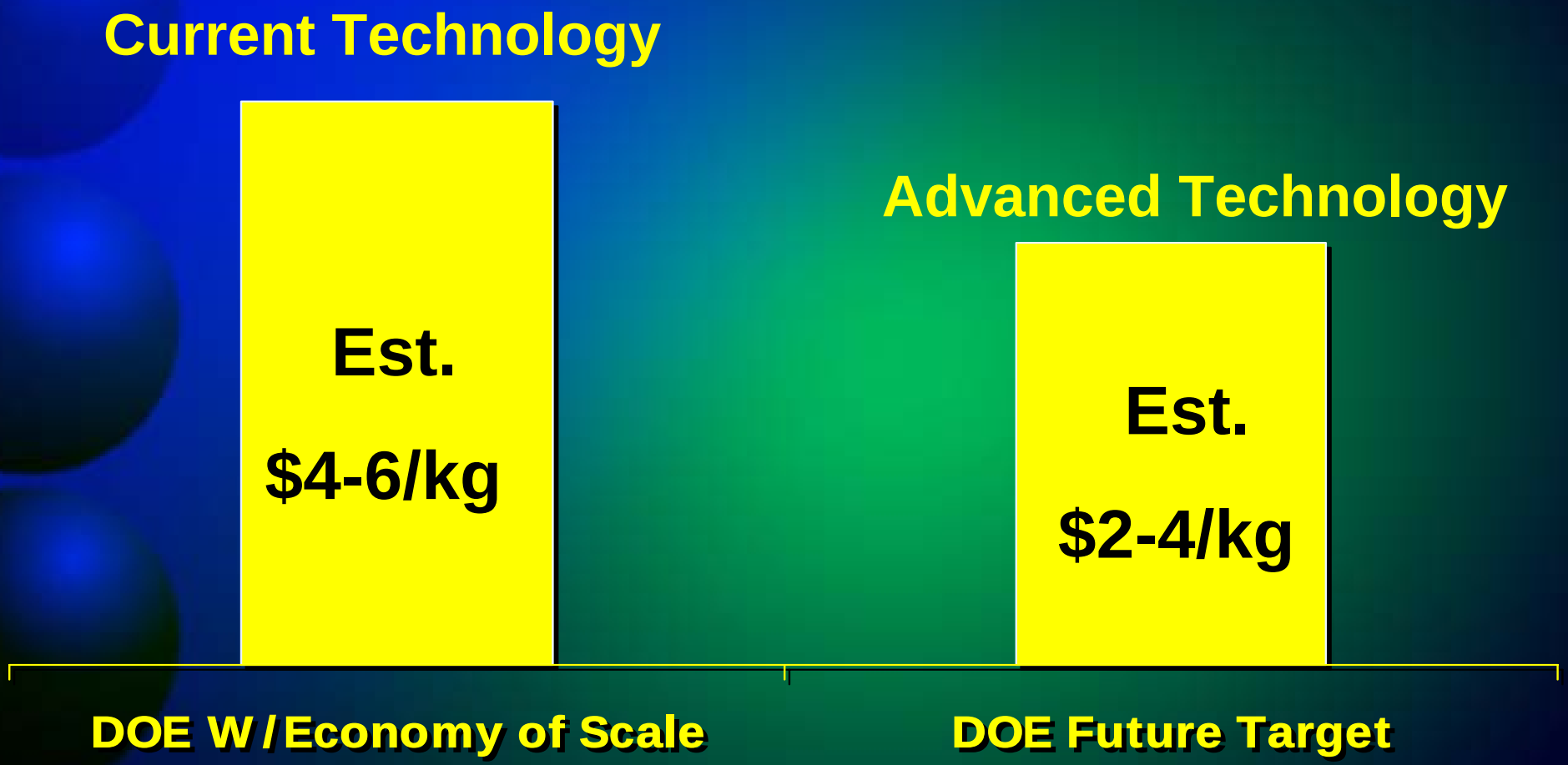
@ 83% Capacity Factor: 19,631 kg/yr

- **Capital Cost**
  ***($1,500,000, 6%, 10 yrs)*: $9.60/kg**
- **Electricity**
  (4¢/kWh, 60 kWh/kg): $2.40/kg

Total: Electrolyzer & Power $12.00/kg

Plus Misc. (O&M, parts, etc)

Economy of Scale Will Drive Costs Down...



Project: Lessons Learned....

- *Costs are higher than expected*
- *Not "Plug & Play"*
- *A H_2 design engineer is critical*
- *Expect schedule delays*
- *Infrastructure costs are high*
- *Internal combustion is here now*

Storage is key!

Technology is needed!

- Compression?
  - Volume/Weight Considerations
  - Not very cost effective
- Metal Hydrides?
- Nanotechology?
- New & Unknown Technology? (Hydronol?)

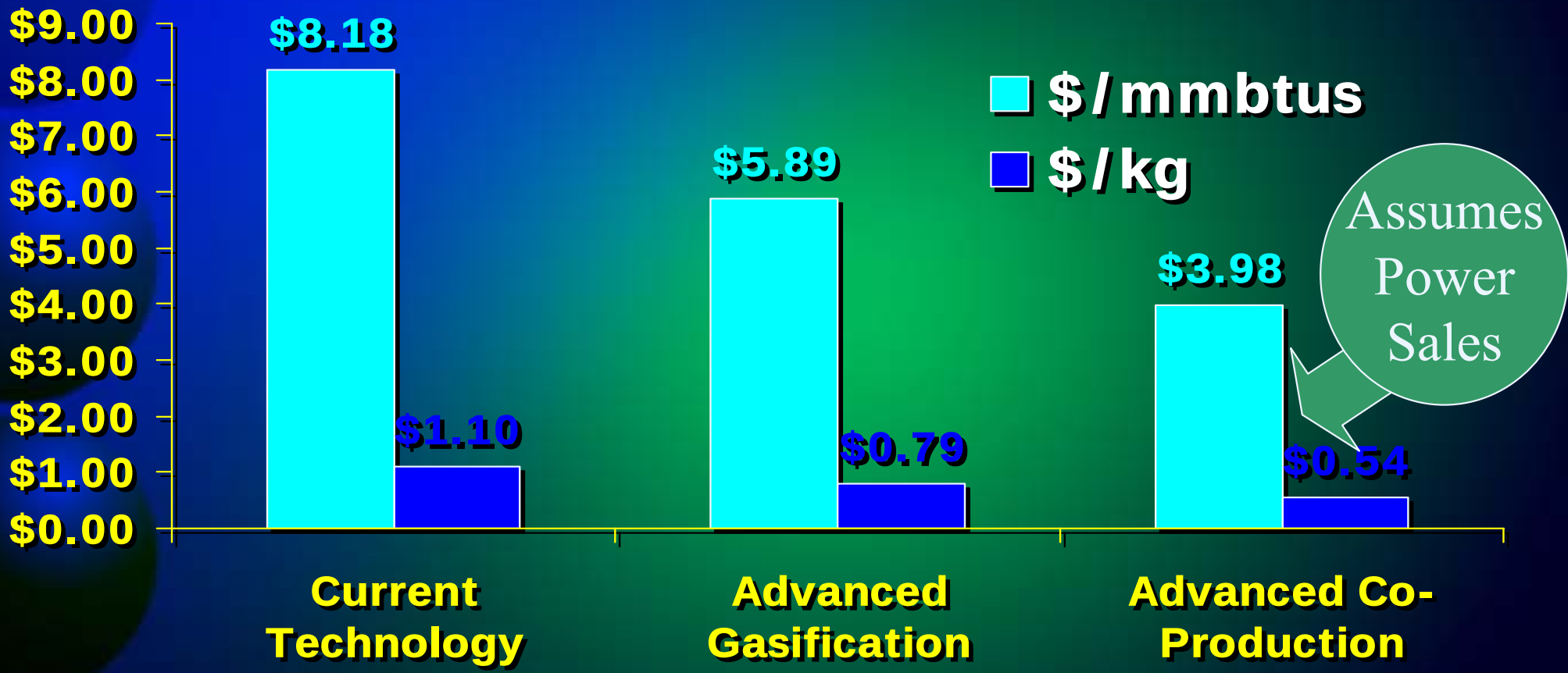
How does Hydrogen fit into the "Big" Energy Picture?

US Gasoline Consumption:
About 400 Million GPD

To replace all US gasoline with H_2 using electrolysis would require 900,000 MW of baseload generation

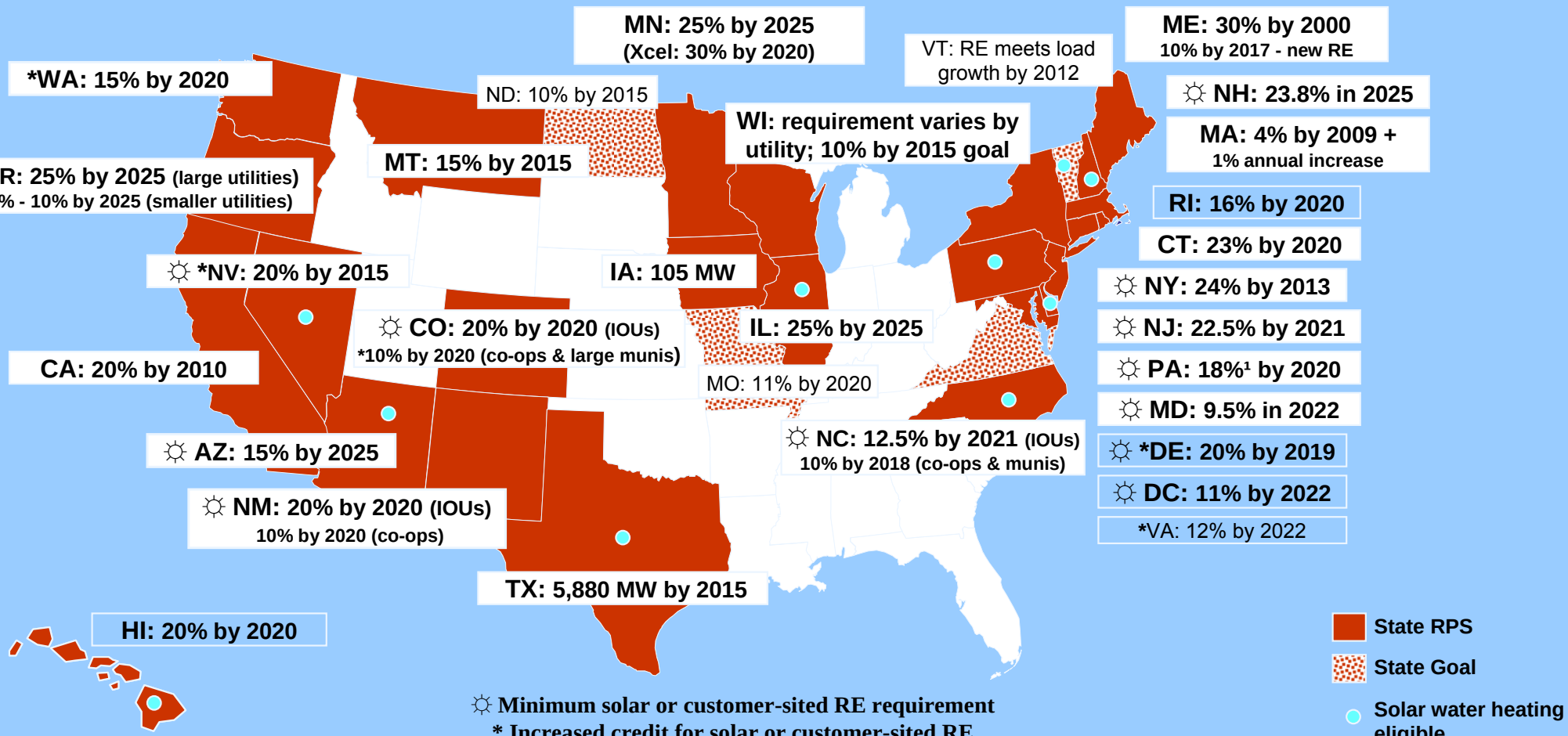
That is roughly equal to existing installed US generation capacity

DOE Projected H_2 Costs....



Data Source: DOE Office of Sequestration, hydrogen and Clean Coal Fuels, Edward Schmetz, Sept 8, 2004

Renewable Portfolio Standards



☼ Minimum solar or customer-sited RE requirement
* Increased credit for solar or customer-sited RE
[1]PA: 8% Tier I / 10% Tier II (includes non-renewables)

DSIRE: www.dsireusa.org

January 2008

2007 US Electricity Consumption

Over

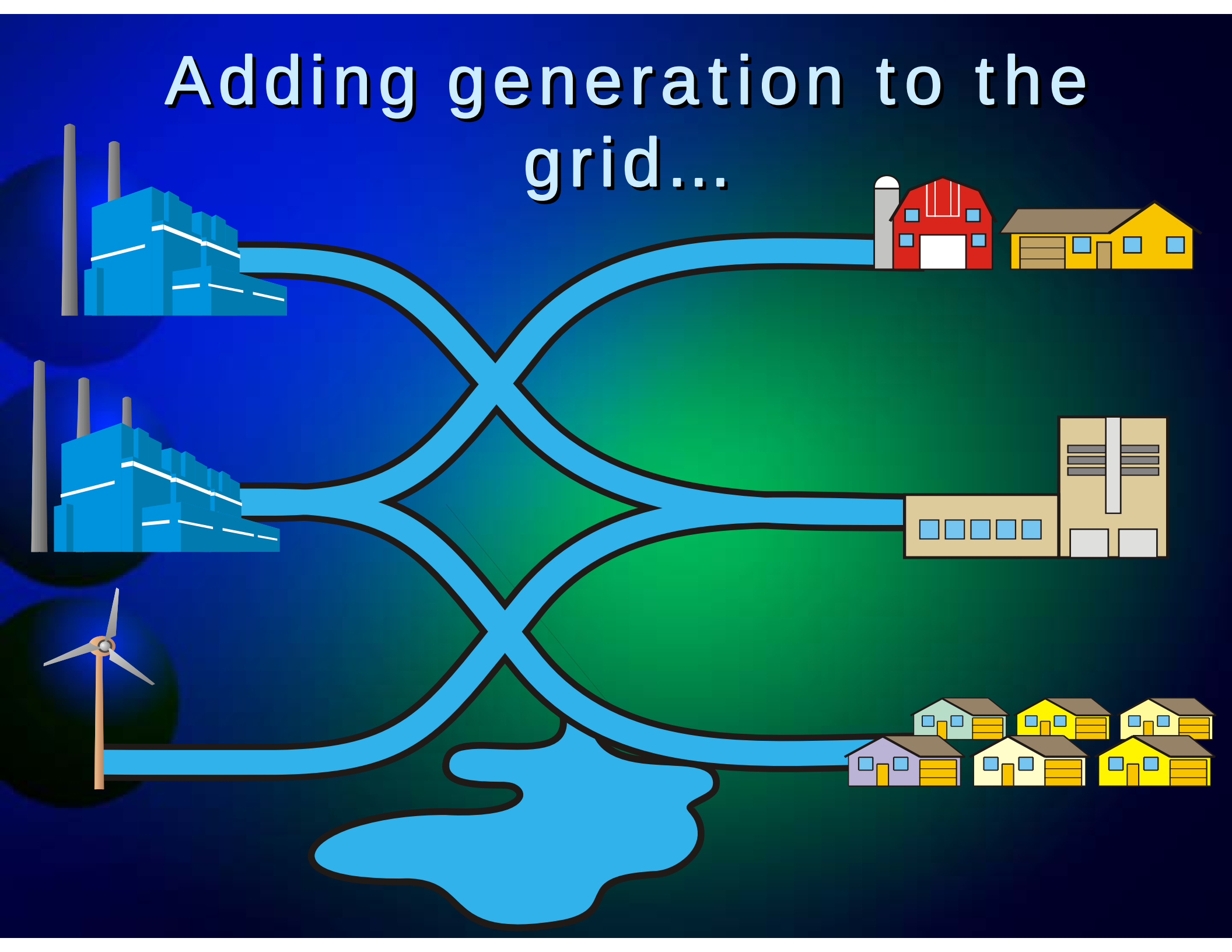
4,000,000,000,000 kWhs

A 15% by 2020 RPS would require ~250,000 MW of Wind

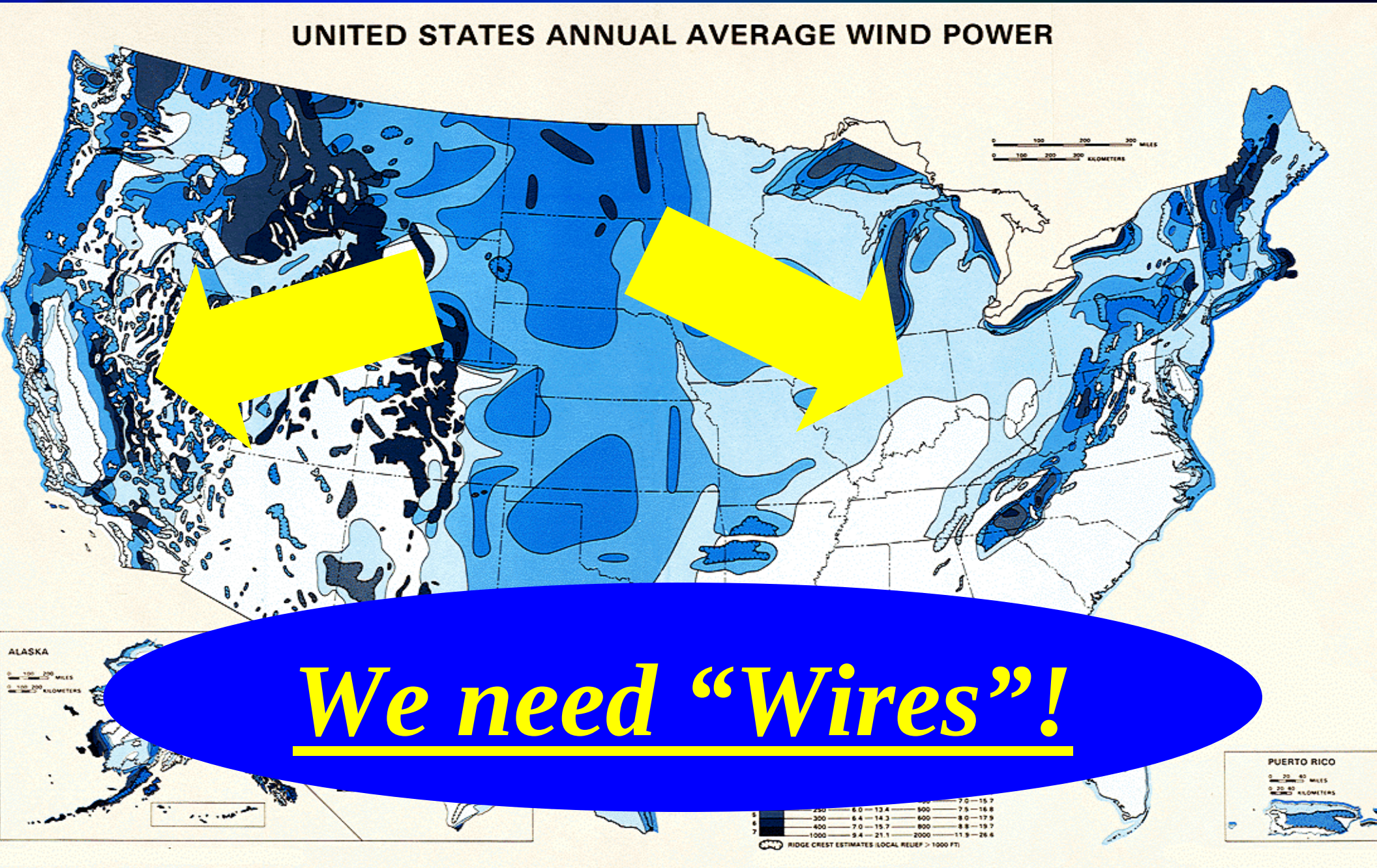
Will require building one 1.5 MW turbine every 45 minutes

Transmission is the key to any generation...

Adding generation to the grid...

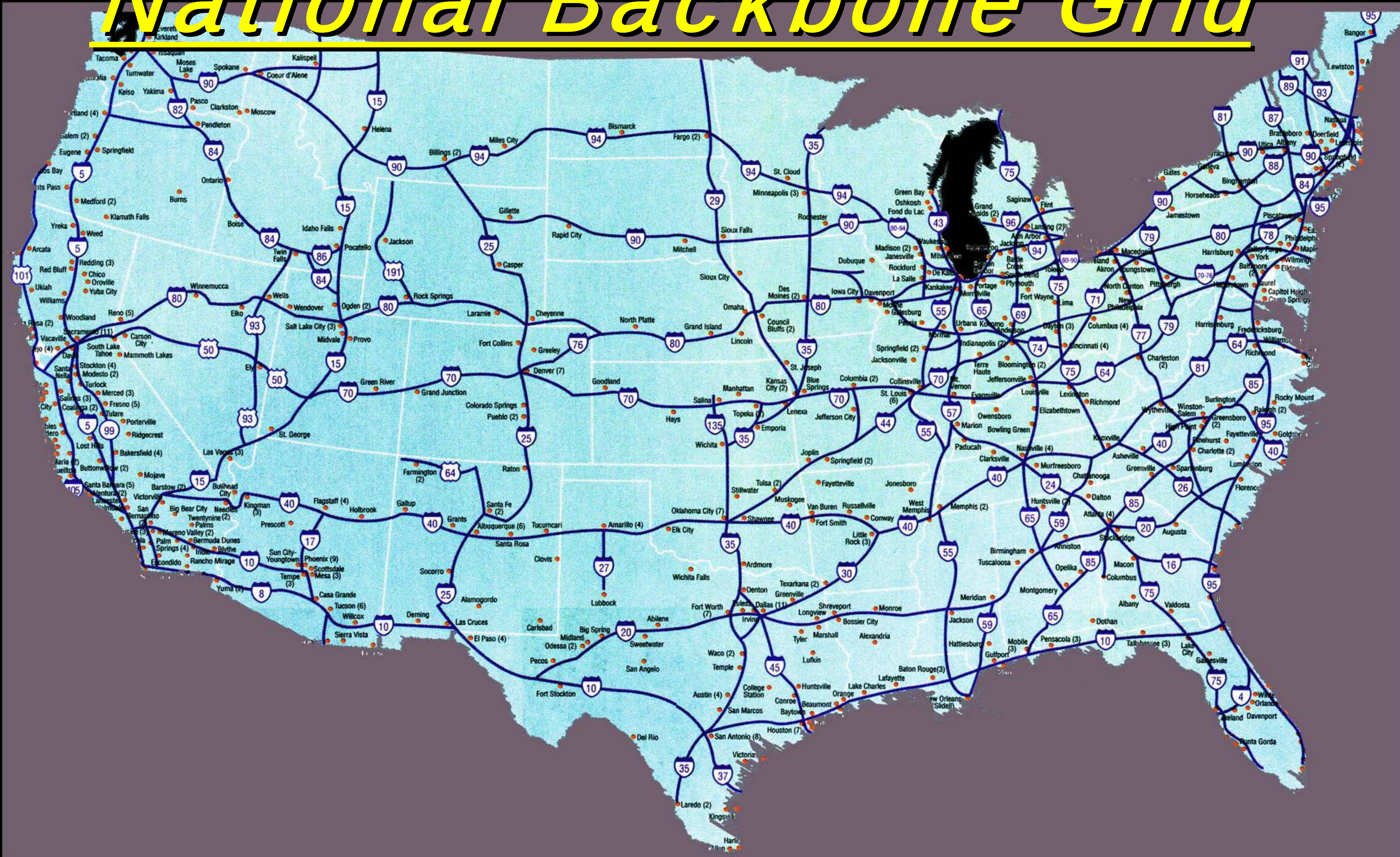


To move the product to market:



We need "Wires"!

A Long Term Vision… *__A National Backbone Grid__*

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