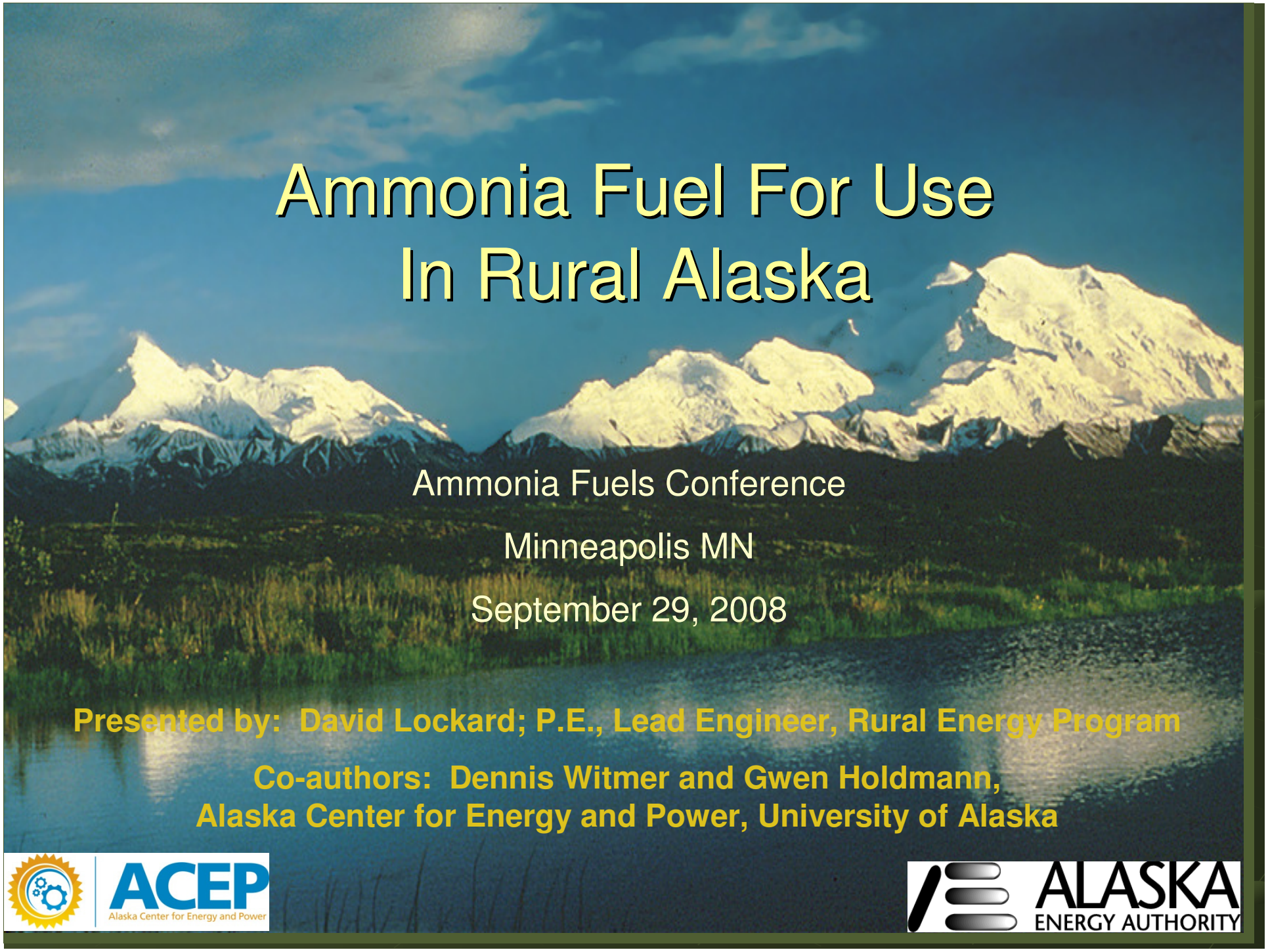

Ammonia Fuel For Use In Rural Alaska

Ammonia Fuels Conference

Minneapolis MN

September 29, 2008

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Co-authors: Dennis Witmer and Gwen Holdmann,
Alaska Center for Energy and Power, University of Alaska

ACEP
Alaska Center for Energy and Power

ALASKA
ENERGY AUTHORITY

Problem and Proposal

- Problem: Stranded energy resources and expensive fuel for power generation
- Proposal: Produce ammonia fuel and transport it to remote sites by barge?
- Possible Applications
- Economics
- What Next?

Typical Rural Alaska Power Generation

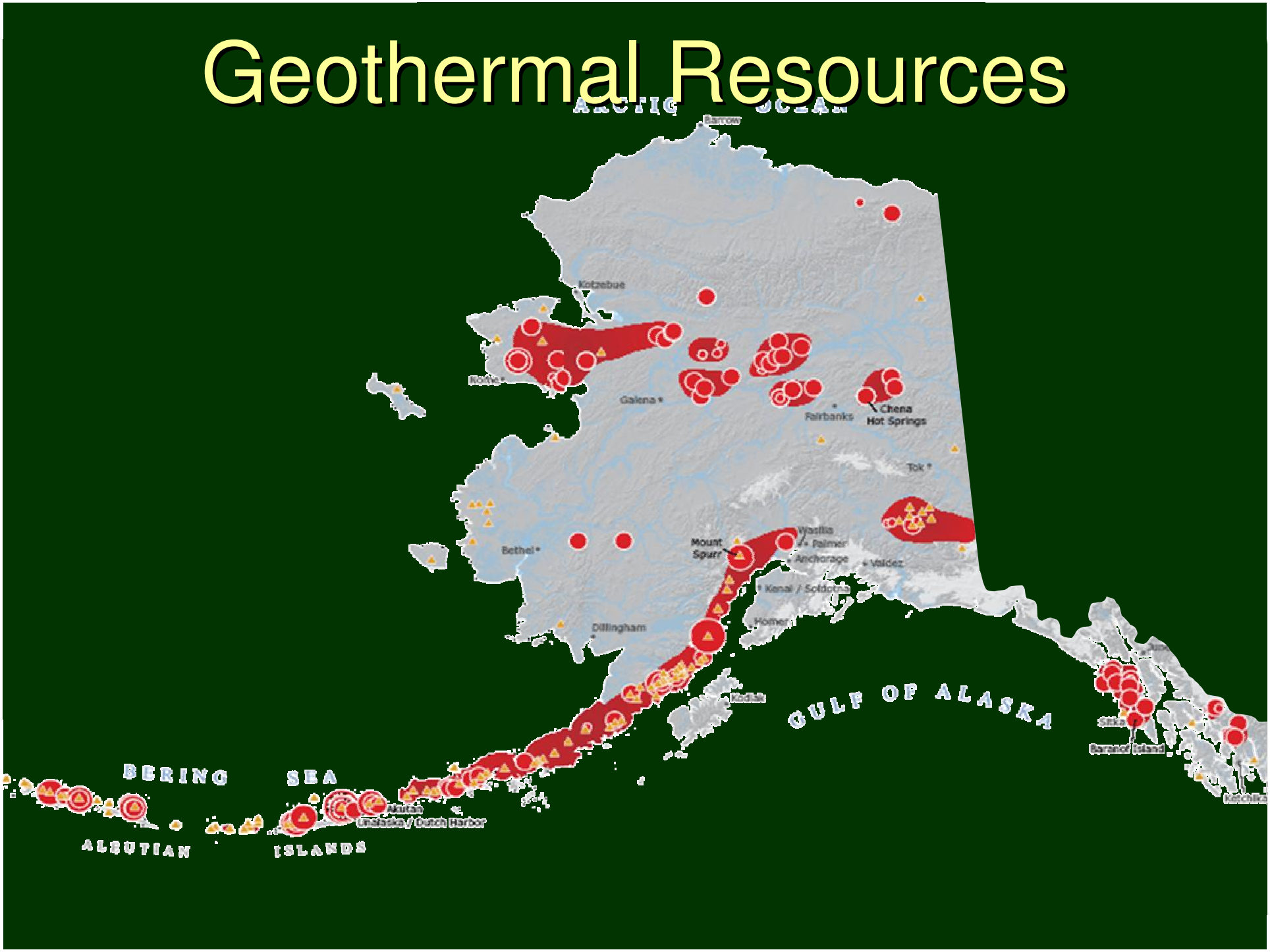
- Diesel reciprocating engines
- 12-15 kWh/gallon
- $4-10/gallon today
- Barge delivery
- In some cases, seasonal fuel storage
- New power plants have electronic fuel injection, automatic paralleling switchgear, fuel-oil blending, SCADA


NC
DANGER
HIGH VOLTAGE

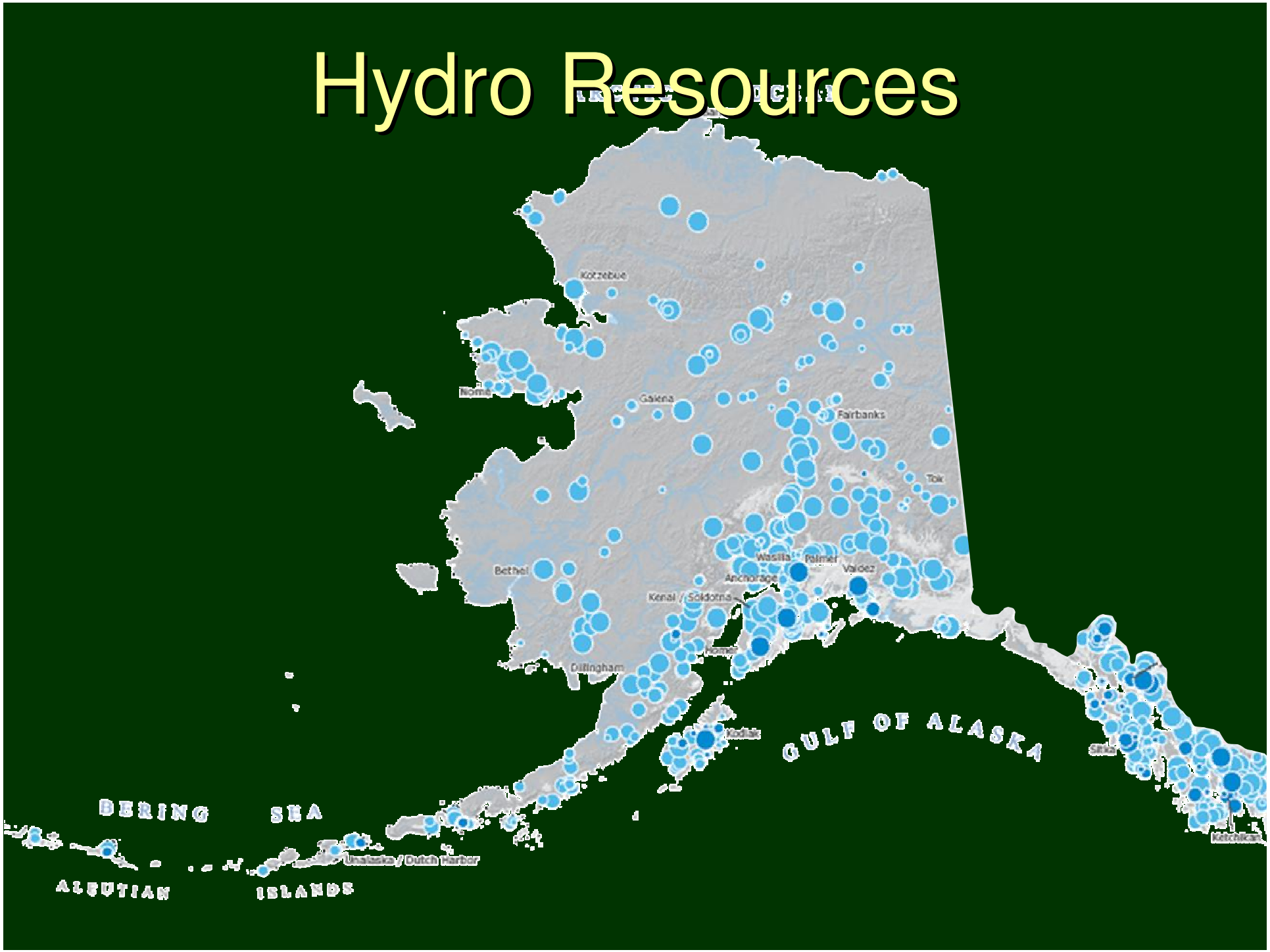
Stranded Renewable Energy Resources

- Many Megawatts of Power Potential
- Typically Only Economic In Large Scale
- Prohibitive Transmission Costs
- Regional Need To Reduce Diesel Fuel Consumption
- Possible Application Where Local Electrical Need Is Significantly Less Than Resource Potential (Makushin)

Geothermal Resources



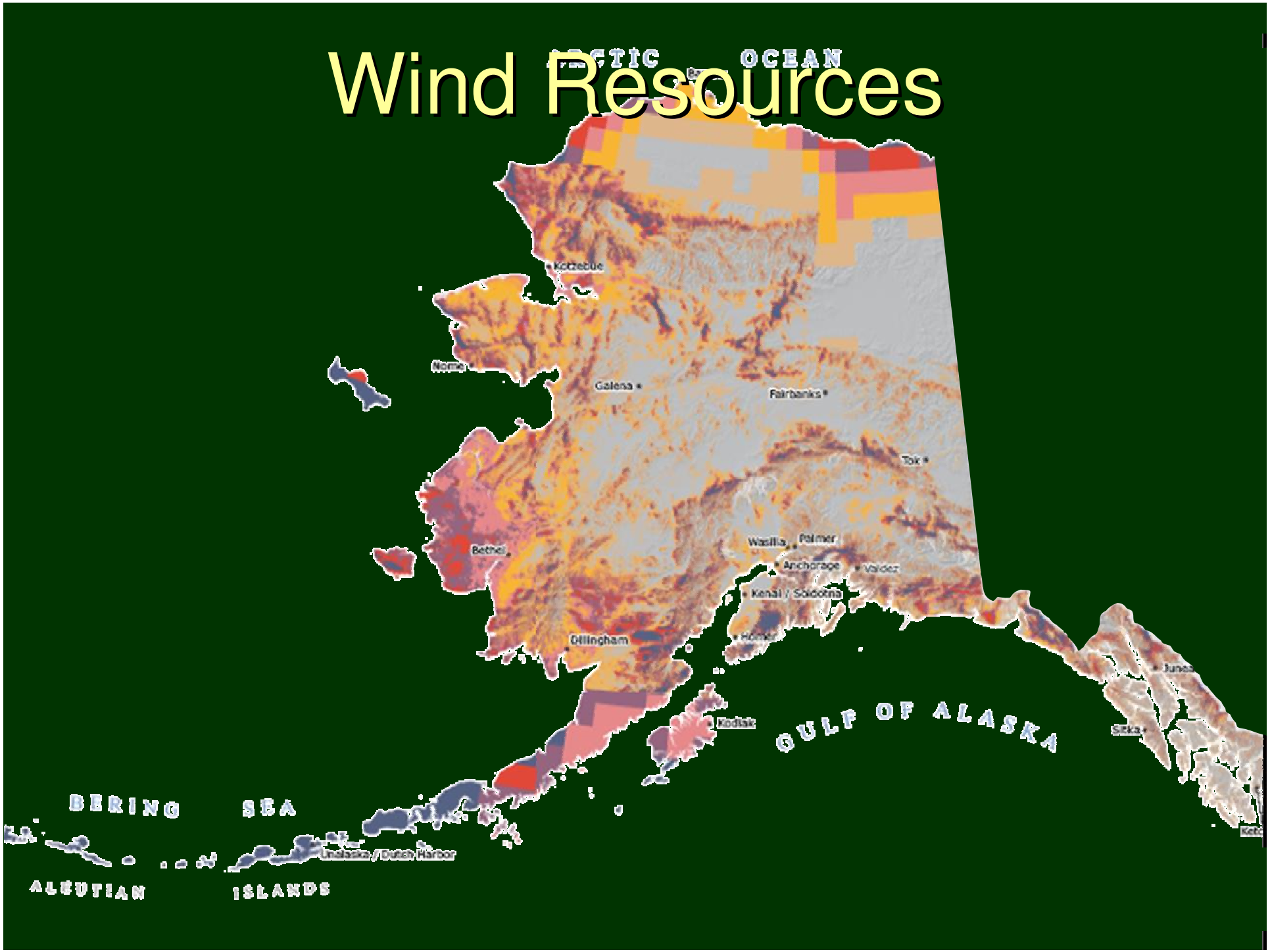
Hydro Resources



Bradley Lake Hydro

Tidal and Wave Resources

Wind Resources



Ammonia Fuel

- Chemical Formula: NH3
- 2006 Worldwide Production: 146m tons
- Used to power Belgian buses in WWII
- 1981 Chevy Impala converted to run on ammonia
- 9,690 Btu/lb
- 5 pounds per gallon at 60degF
- Combustion products: nitrogen and water
- Can also be produced from natural gas (Agrium plant process)
- Can fuel internal combustion (spark and compression ignition) engines and fuel cells

Possible Applications

- Diesel Powerhouses
- Commercial Fishing Boats
- Cargo Ships
- State Ferries
- Fish Processors
- Mines

Why Ammonia Rather Than Hydrogen?

- Higher energy density
- Stores at temperatures and pressures closer to atmospheric
- Existing infrastructure for handling, storage, and transportation
- Does not require exotic storage materials
- Existing industry standards and regulations
- Also valuable as fertilizer

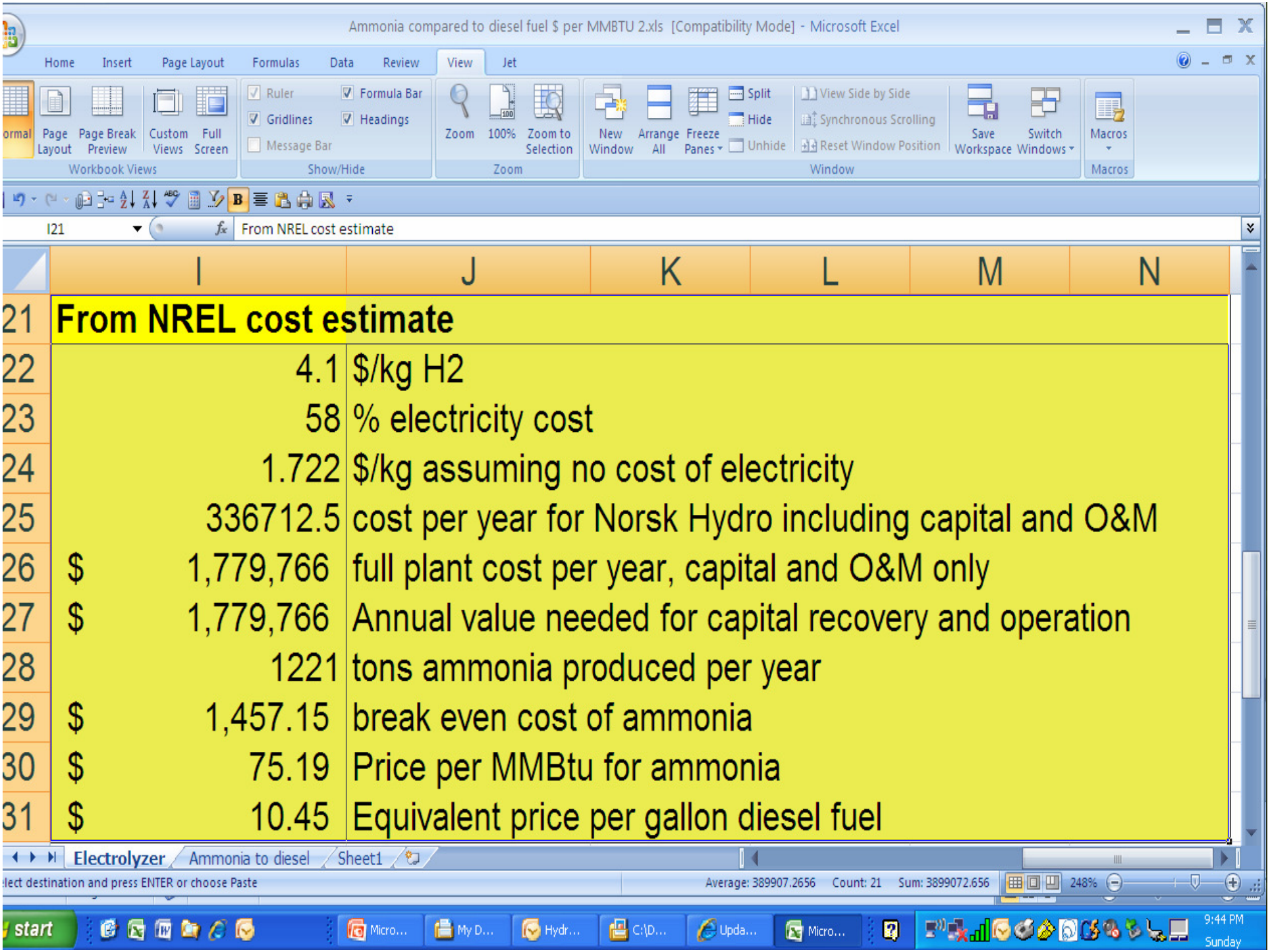
Fuels That Can Be Produced From Other Alaskan Resources

- Ammonia from natural gas or coal
- Hydrogen from natural gas or coal
- Liquid Synfuels from coal, natural gas, or biomass using Fischer-Tropsch process

Back of the envelope…

- Power cost: 20 cents/kWh
- Conversion efficiency: 60%
- Ammonia plant cost subsidized
- Negligible O&M costs

- $13.48 diesel equivalent cost


Ammonia compared to diesel fuel $ per MMBTU 2.xls [Compatibility Mode] - Microsoft Excel
Home Insert Page Layout Formulas Data Review View Jet
Workbook Views Show/Hide Zoom Window Macros
I21
From NREL cost estimate
From NREL cost estimate
4.1 $/kg H2
58 % electricity cost
1.722 $/kg assuming no cost of electricity
336712.5 cost per year for Norsk Hydro including capital and O&M
$ 1,779,766 full plant cost per year, capital and O&M only
$ 1,779,766 Annual value needed for capital recovery and operation
1221 tons ammonia produced per year
$ 1,457.15 break even cost of ammonia
$ 75.19 Price per MMBtu for ammonia
$ 10.45 Equivalent price per gallon diesel fuel
Electrolyzer Ammonia to diesel Sheet1
Average: 389907.2656 Count: 21 Sum: 3899072.656
248%
start
9:44 PM
Sunday

Questions Remaining

- Is Ammonia Fuel From Stranded RE Resources The Best Option?
- What Are The Economics?
- Does The State Want To Commit To Developing Ammonia Fuel Production, Storage and Transportation Infrastructure?
- Can ammonia take the place of new transmission lines?