

Innovative Models for Utilizing Renewable Energy Technology for Remote Mining Projects – Introduction

Best Practices for Mining and Sustainable Development in the Arctic

Lulea, Sweden – October 14, 2016

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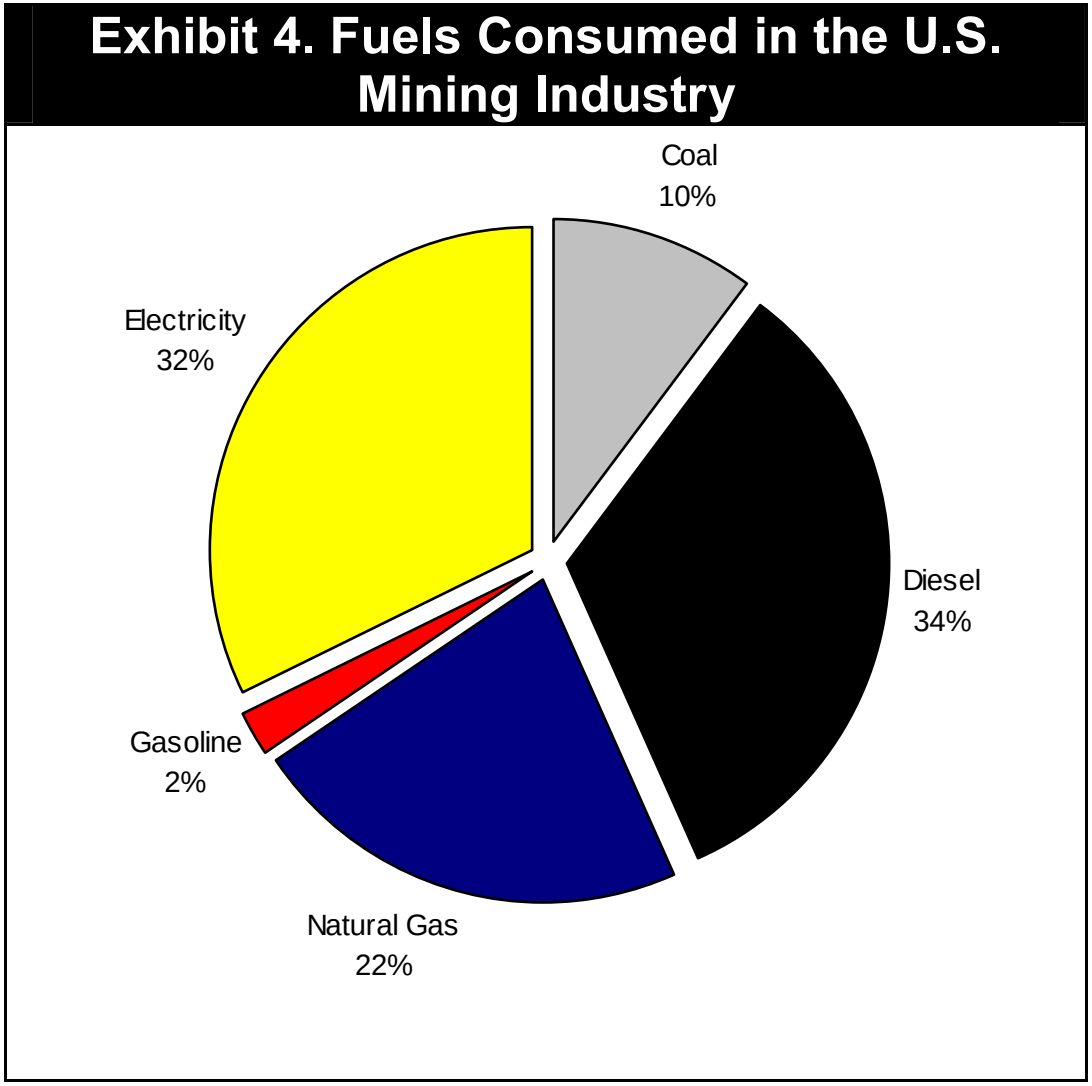
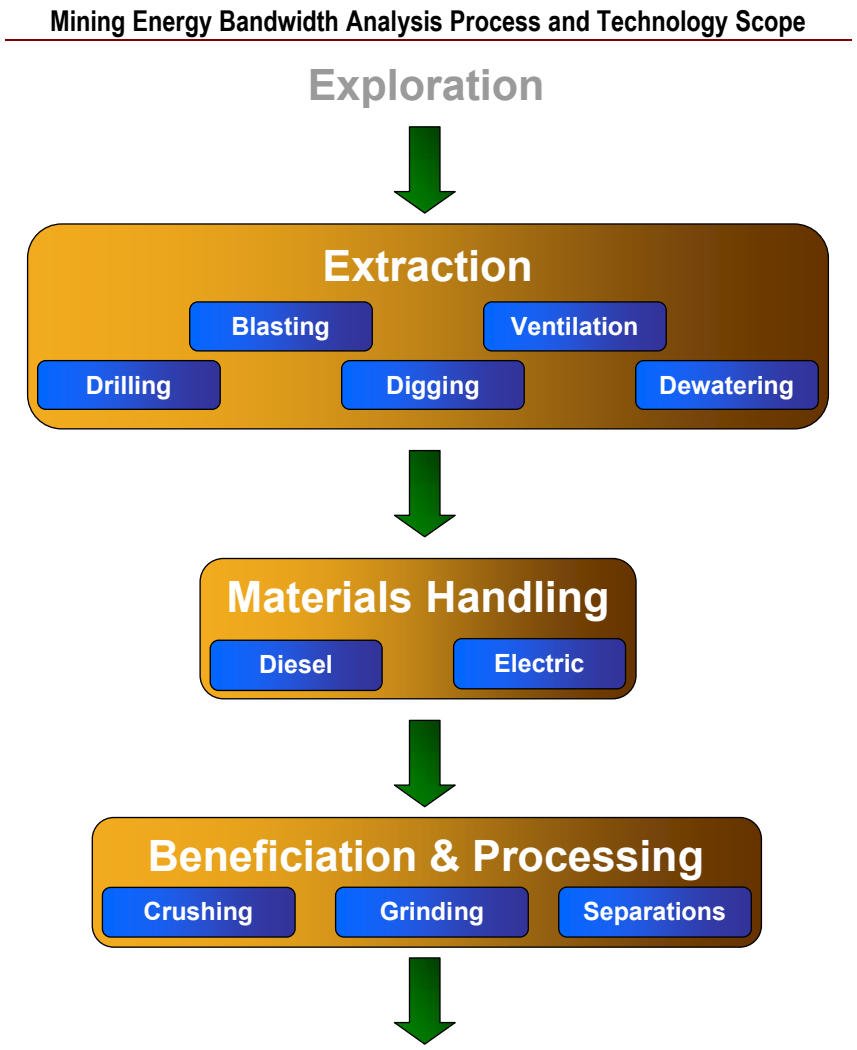
Fuels Used in US Mining



Mining Energy Bandwidth Study,, DOE, 2007

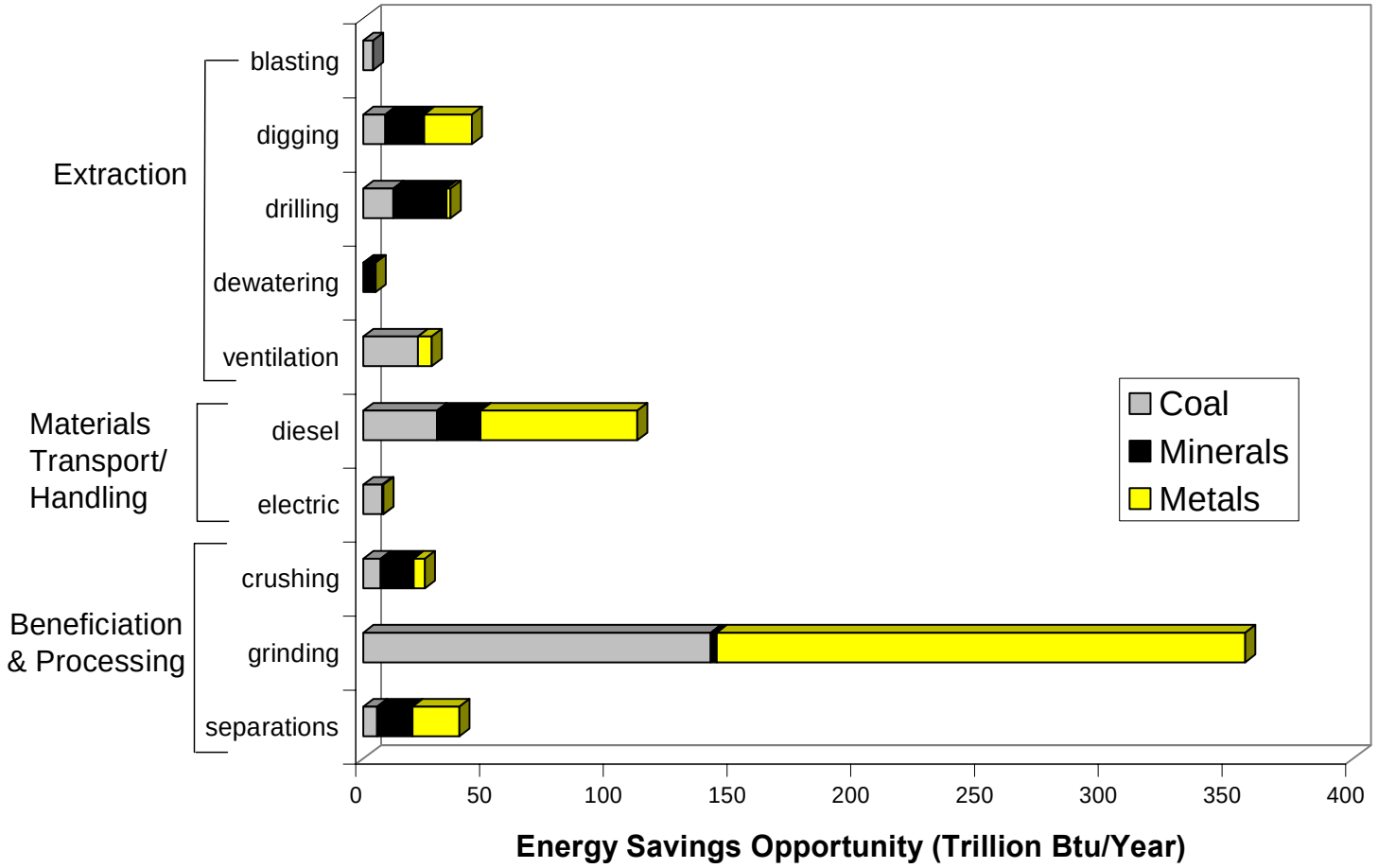
Mining Processes Have very Different Energy Requirements



Mining Energy Bandwidth Study,, DOE, 2007

Improving the efficiency and/or source of energy for grinding and materials Handling likely to provide the greatest benefit

Exhibit 19. Energy Saving Opportunity in U.S. Mining Industry for Top 10 Energy-Intensive Processes (includes energy savings from implementing best practices and R&D)



Mining Energy Bandwidth Study,, DOE, 2007



Mining and Renewable Energy in Alaska

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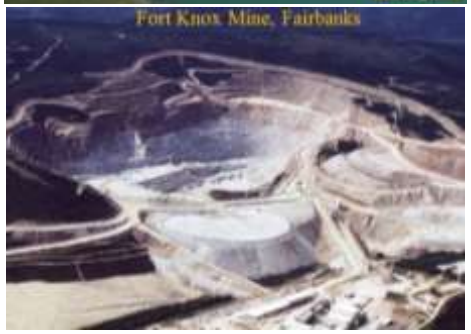
Large Mines in Alaska



Source: AKDNR

Large Mine Overview

Red Dog Mine

Operator: Teck Alaska Inc. (Teck Resources Ltd.)

Location: Approximately 82 miles north of Kotzebue on NANA Regional Corporation land (Alaska Native owned)

Principal minerals: Zinc and lead

Production: Opened in 1989. In 2014, milled approximately 4.3 millions tons of ore, producing 1.06 million tones of zinc concentrate (4 % of world's zinc supply) and 219,000 tones of lead concentrate.

Fort Knox Mine

Operator: Fairbanks Gold Mining Inc. (Kinross Gold Corp.)

Location: Approximately 25 miles northeast of Fairbanks on state and private lands

Principal minerals: Gold

Production: Opened in 1997. In 2014, produced approximately 387,000 gold equivalent ounces.

Source: AKDNR

Large Mine Overview

Pogo Mine

Operator: Sumitomo Metal Mining Pogo LLC (Sumitomo Metal Mining Co, Ltd. & Sumitomo Corp.)

Location: Approximately 38 miles northeast of Delta Junction on state land

Principal minerals: Gold

Production: Opened in 2005. In 2014, mined approximately 972,000 tons, milled 967,000 tons, and produced 342,000 troy ounces of gold

Kensington Mine

Operator: Coeur Alaska Inc. (Coeur Mining Inc.)

Location: Approximately 45 miles north of Juneau on U.S. Forest Service and private lands

Principal minerals: Gold

Production: Opened in 2010. In 2014, mined approximately 642,000 tons, milled 636,000 tons, and produced approximately 118,000 ounces of gold

Source: AKDNR

Large Mine Overview
Cont.

Greens Creek Mine

Operator: Hecla Greens Creek Mining Co.

Location: Approximately 18 miles southwest of Juneau on private and U.S. Forest Service lands

Principal minerals: Silver, zinc, lead, and gold

Production: Opened in 1989. In 2014, processed approximately 2,200 tons of ore per day, producing approximately 7.8 million ounces of silver.

Usibelli Coal Mine

Operator: Usibelli Coal Mine Inc.

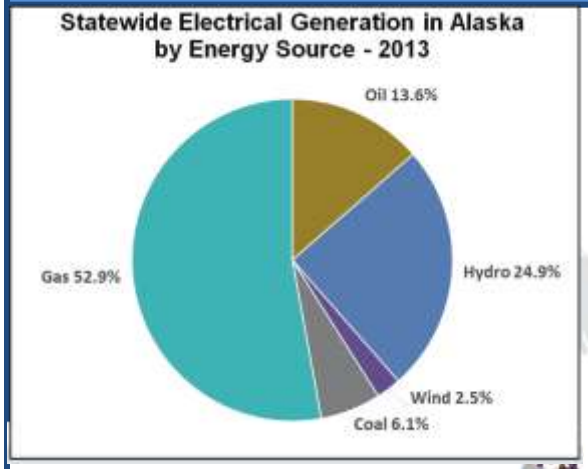
Location: 115 miles south of Fairbanks and 250 miles north of Anchorage on state land.

Principal minerals: Subbituminous coal

Production: Opened in 1943. In 2014, produced approximately 1.5 million tons of coal (500,000 tons exported to Pacific Rim).

Source: AKDNR

Energy Infrastructure and Sources in Alaska



- 150 stand-alone electrical grids
- 80% of AK electrical generation provided by rail belt (2000 MW installed capacity)
- State legislated goal of 50% renewable by 2025 established in 2010

Renewable Energy Atlas of Alaska, AEA, 2016

Existing Use of Renewables Where Mines Acquire Energy from a Larger Grid

Fort Knox (uses 33.5 MW of Electricity)

Pogo (uses 10 MW of Electricity)

Usibelli Coal

- Electric energy provided by utility – GVEA
- GVEA is committed to generating 20% of its peak electrical capacity from renewables – currently 6% of its power capacity comes from wind and 7% from hydro

Greens Creek (uses 7.5 MW of electricity)

- Draws up to 95% of its electricity mostly from hydro power produced by APE

Stranded Renewable Resources of Alaska, ACEP, 2012

Potential for Use of Renewables At Existing Mines

On the Grid

Fort Knox, Pogo and Usibelli Coal

- **Lower Carbon:** Increased use of natural gas for electrical generation through trucking LNG from Cook Inlet, HVDC from new North Slope natural gas power plant associated with Prudhoe Bay Field
- **Renewable:** Large scale hydro from the now mouth-balled large scale Susitna hydro project

Off the Grid

Red Dog Mine uses approximately 43 MW of electricity generated by diesel generators – Fair to good wind resources exist at or near mine site

Kensington Mine uses 6 MW of electricity from diesel generators. Multiple hydroelectric projects could provide electricity

Stranded Renewable Resources of Alaska, ACEP, 2012

Opportunities for Large Mines Currently Undergoing Permitting Processes

Donlin Gold Project

- Estimated to produce 1 million ounces of gold for 27.5 years
- Will use 157 MW of electrical power
- Project is planning a billion dollar, 315 mile, 14 inch natural gas pipeline from Cook Inlet with a capacity 73 million cf/day as the fuel source. Project considered but rejected biofuel, hydroelectric, small scale nuclear, and electrical intertie options during feasibility studies. Wind resources have been identified in the area.

Sources
Dolin Gold,
AK DNR,
and ADN

Creating the Grid Using HVDC and Stranded Gas

Projects have been proposed to generate additional electricity on the North Slope with natural gas, connecting it Anchorage and Fairbanks and possibly beyond to Kotzebue, Canada or the U.S. west coast with HVDC.

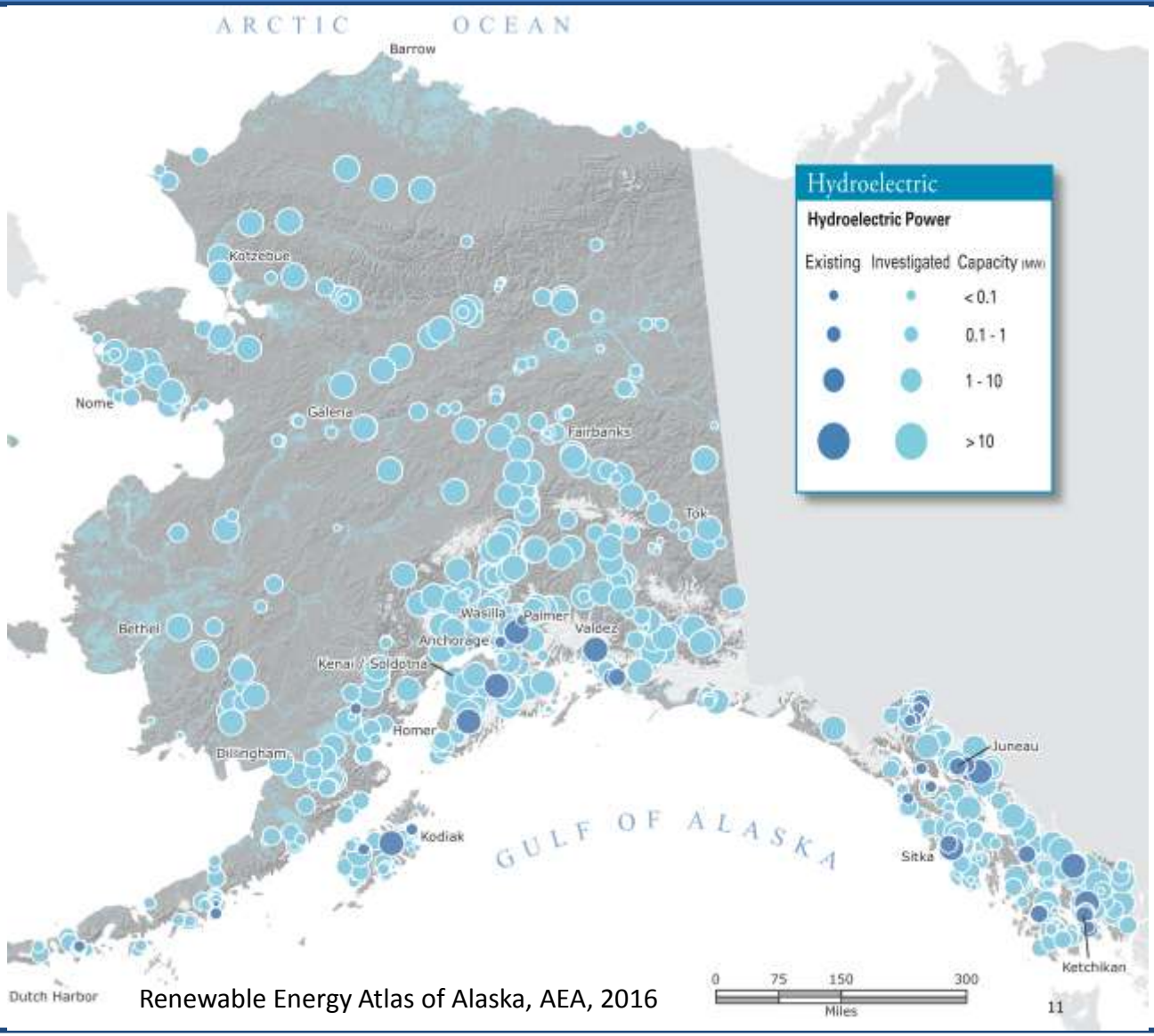
Example: "Alaska Power Backbone"

- 860 mike + - 500 kv HVDC line designed to transmit 1 GW
- Offloading in Anchorage and Fairbanks.
- Estimated cost $2.46 billion billion dollars
- Distribution cost of 3.7 cents per kWh.

An HVDC backbone could also connect renewable sources and mines

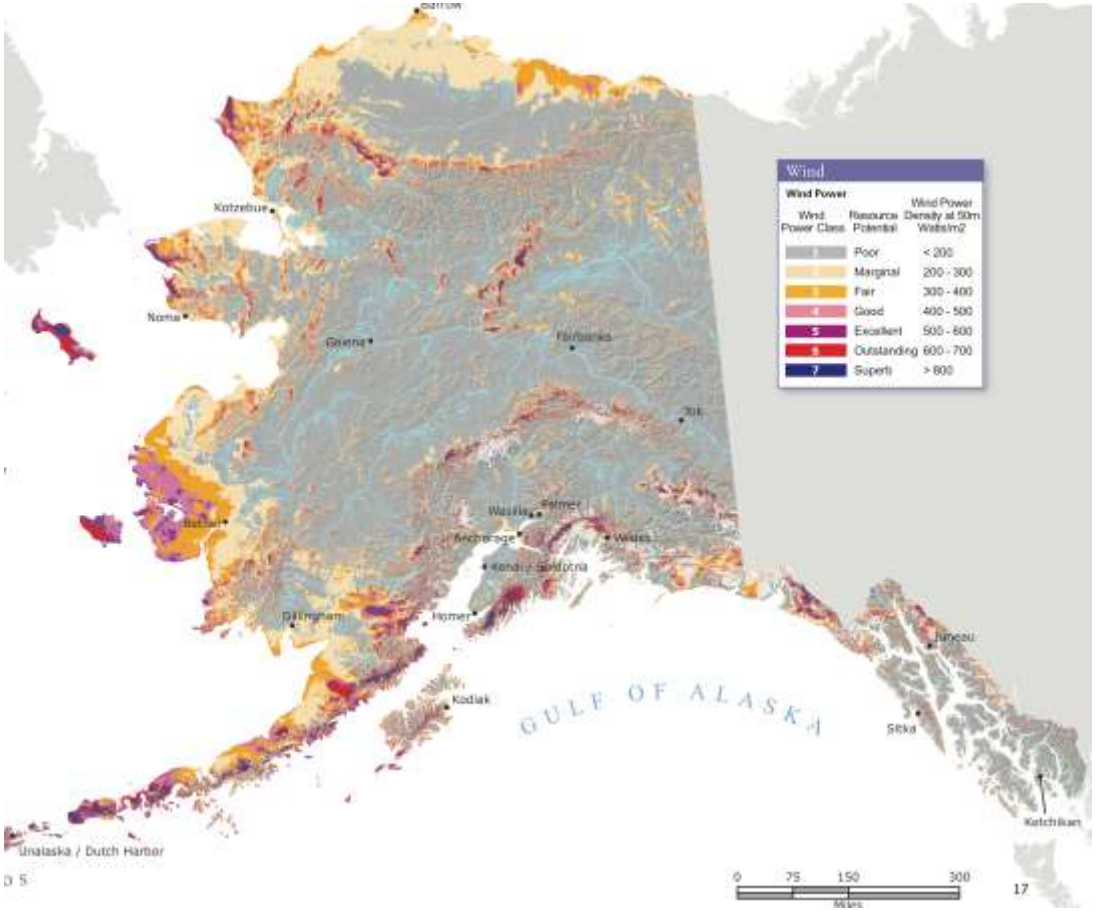
Stranded Renewable Resources of Alaska, ACEP, 2012

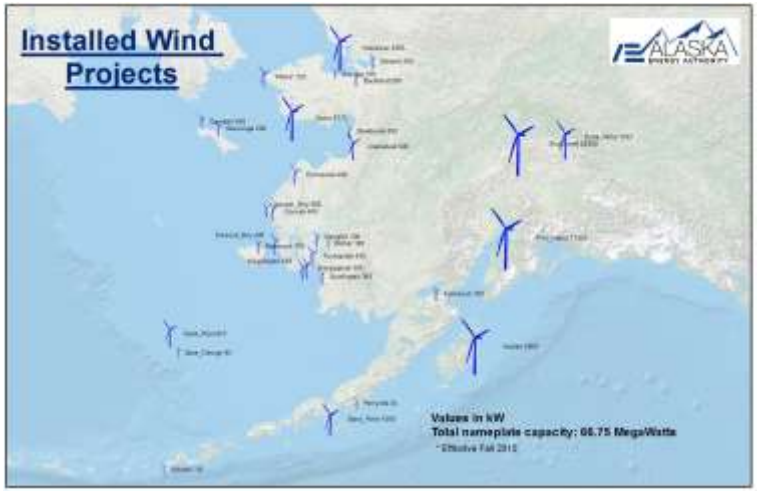
Alaska Hydroelectric – Existing and Potential



Renewable Energy Atlas of Alaska, AEA, 2016

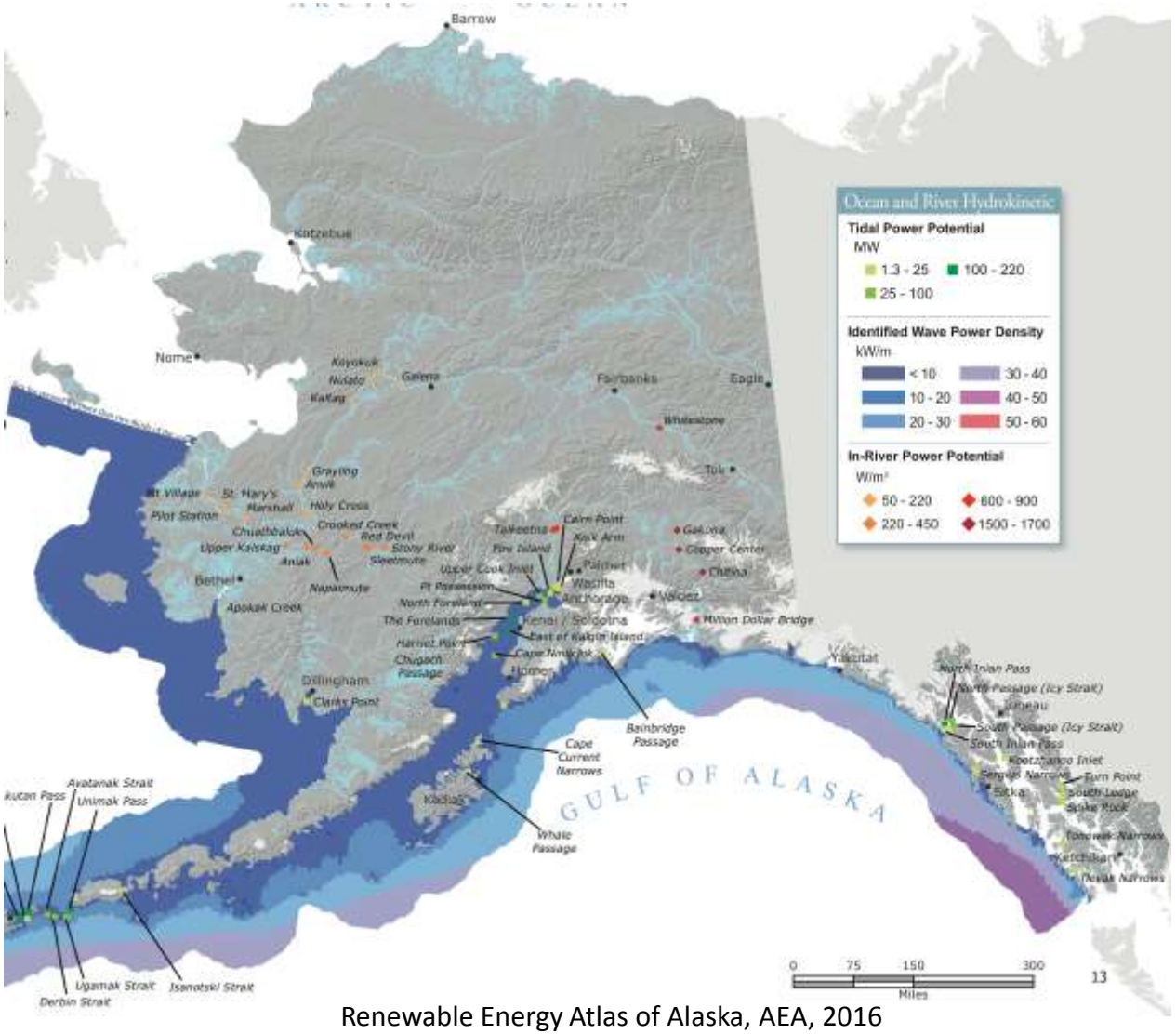
Alaska Wind Energy –Potential and Installed





Renewable Energy Atlas of Alaska, AEA, 2016

Tidal, Wave and River Hydrokinetic Power Potential



Renewable Energy Atlas of Alaska, AEA, 2016

Challenges and Opportunities for Additional Renewable Energy

- **Renewable energy has been integrated into Alaska mines that acquire electricity from regional grids, particularly hydroelectric and wind**
- **Alaska has huge distributed potential renewable resource base that could be exploited for mining and other high-intensity uses**
- **Includes hydroelectric, wind, tidal and river hydrokinetic**
- **Long-term large-scale investment would be needed for both generation and distribution facilities. Lack effective business and financing model**
- **Improvements in technology still needed in many areas including energy storage, integration with existing systems and sources, ability to operate reliably in arctic and sub-arctic conditions etc. In many cases technology is rapidly advancing but who takes the risk?**
- **Open question - Are businesses such as mining or other natural resource development companies willing to take on the regulatory burden and modest regulated rate of return associated with providing power or energy to communiites or utilities?**