Energy in Alaska

"North to the Future"

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acep.uaf.edu

This project was funded in part through a grant from DOE EPSCoR

Discussion Items

- Some personal background
- Energy in Alaska
- About ACEP
  - Our team
  - Our work
- Collaboration?

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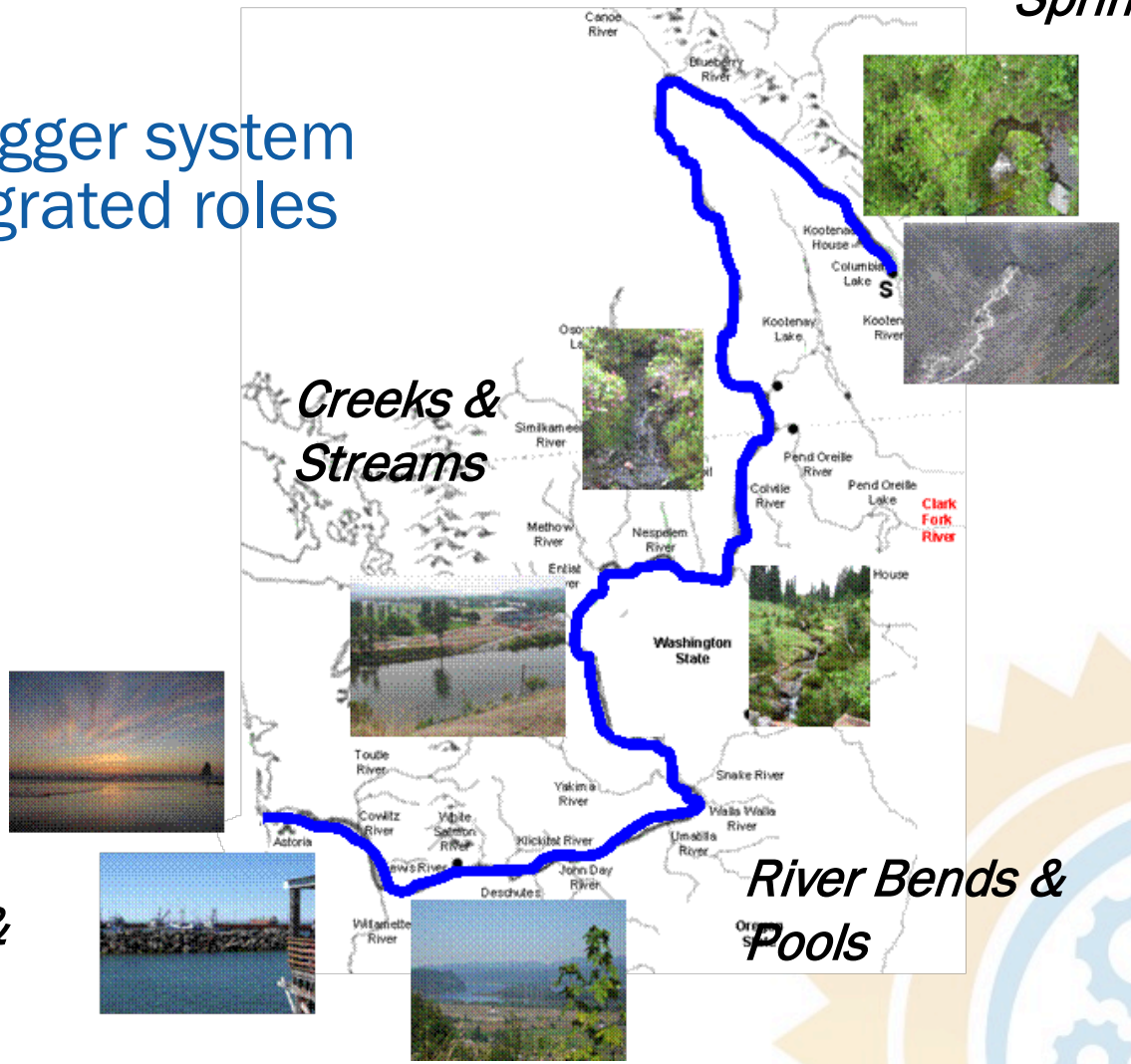
A River Runs Through It

- Part of (much) bigger system
- Individual & integrated roles (that change)

- Context
- Culture
- Capabilities
- Challenges
- Convictions
- Contributions



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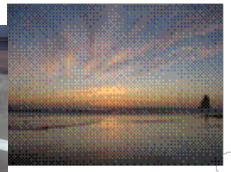
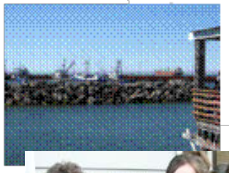
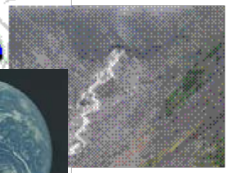
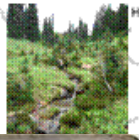
My River (so far)









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Engaging the culture, changing the world
Seattle Pacific UNIVERSITY

Alaska: Pioneers in ‘island’ energy systems

- Geographic isolation of population centers and significant trans-regional electrical intertie challenges.
- Wide-spread dependence on combustion-powered generators.
- High fuel costs establish strong incentive for operational efficiency & leverage of renewable energy resources.

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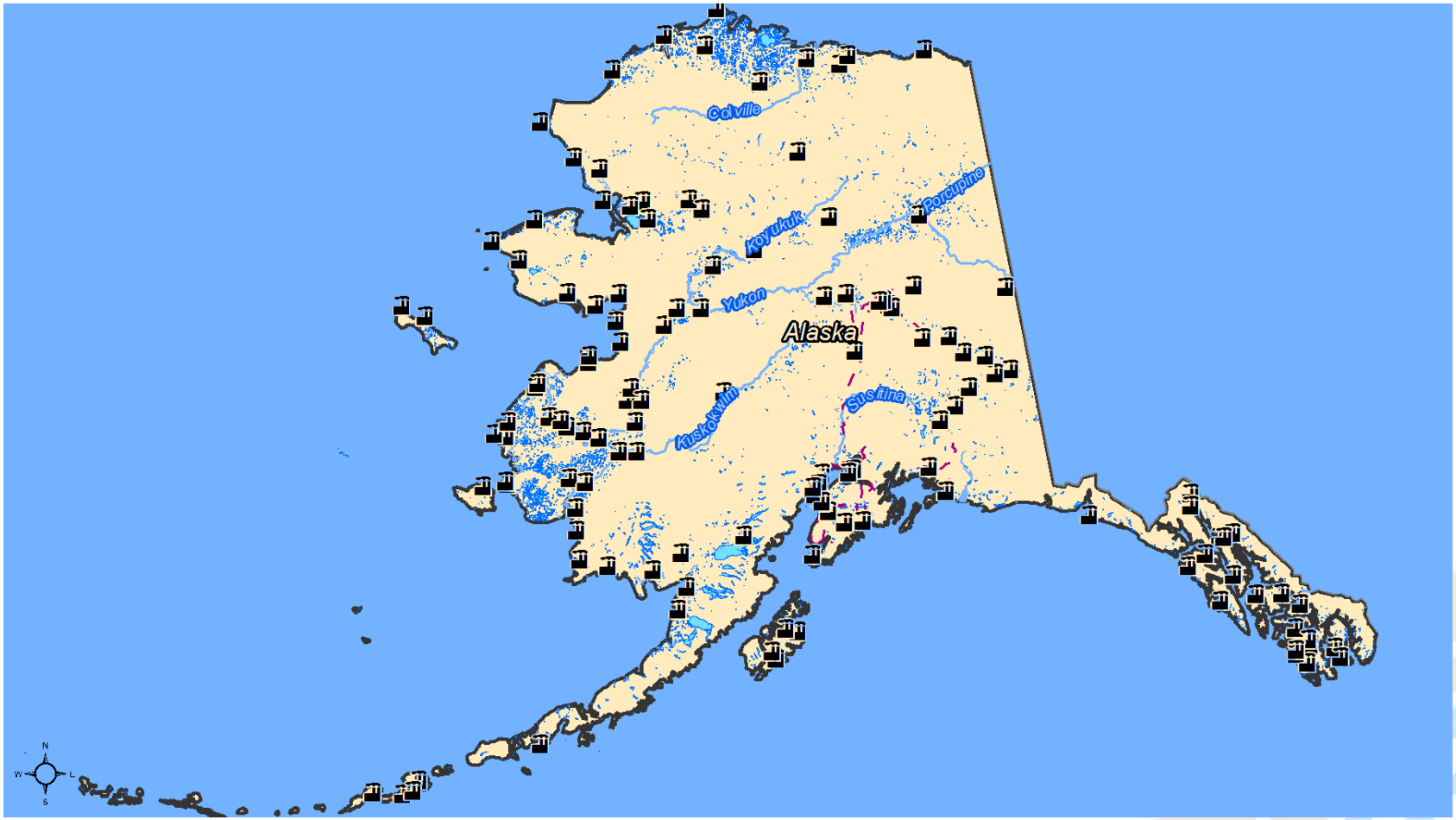
Ubiquitous Diesel Genset



Common challenge for Alaska communities and DoD assets in remote locations

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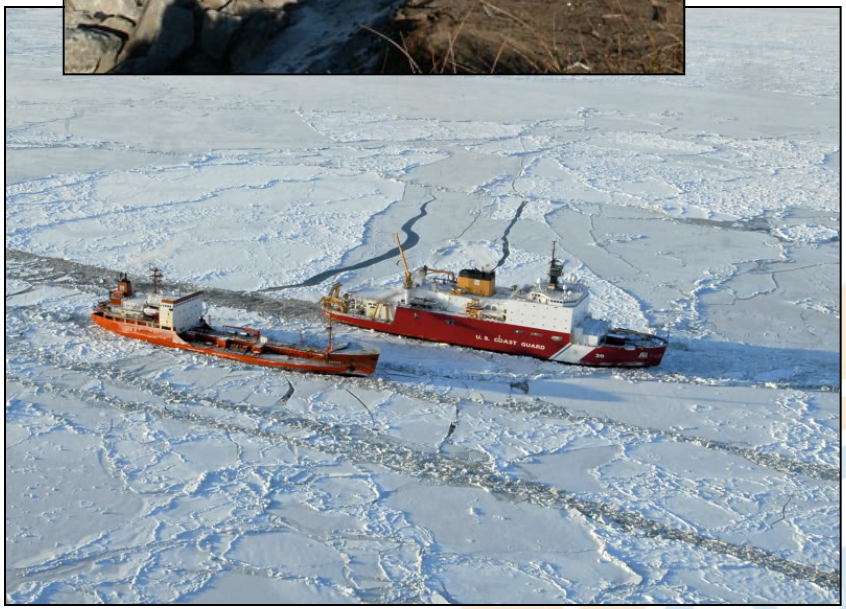
Alaska Realities

- High energy costs
- Fragmented electric grid
- Harsh climate
- End of supply lines
- Stranded resources
- Distributed population
- Limited road network
- Fiscal limitations
- Environmental impact

Erosion from fall storms - Shishmaref



Icebreaker supported fuel delivery to Nome

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ACEP Roles & Goals

Research –Move energy solutions from lab to market.

- *Discover. Develop. Remove barriers.*

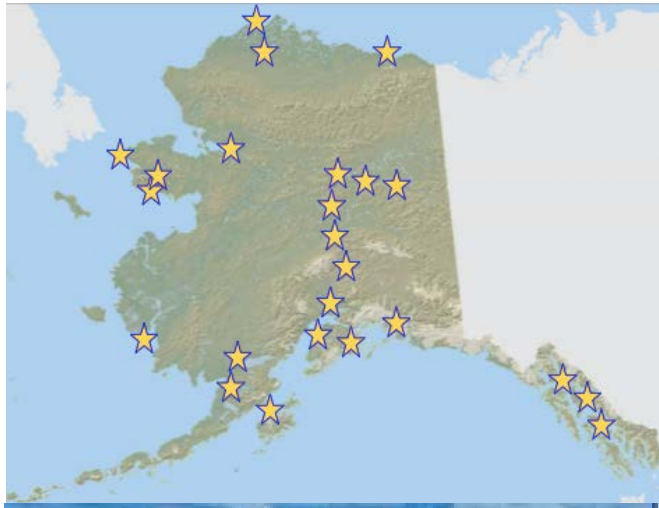
Outreach – Provide stakeholders with data and independent expertise needed to make informed decisions.

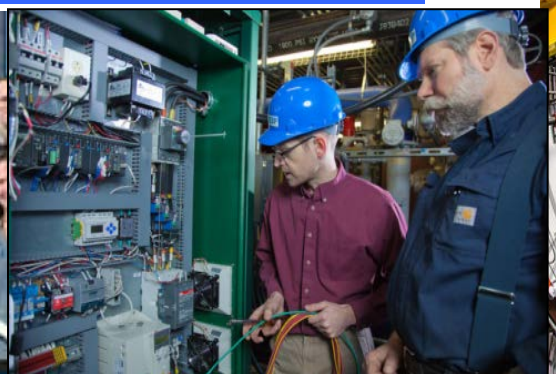
- *Disseminate. Advise. Connect.*

Academic – Leverage UA academic resources to meet energy workforce needs of Alaska and relevant global energy markets.

- *Involve. Teach. Train.*

ACEP enables, evaluates and integrates energy systems in islanded micro-grids.





Alaska Center for Energy and Power

ACEP Mission: Develop and disseminate practical, cost-effective, and innovative energy solutions for Alaska and beyond

Who we are:

- Organized 6 years ago under the Institute of Northern Engineering as 'Gateway' to Energy Research for UA
- Based at UAF with a satellite office in Anchorage
- 20 dedicated staff (mostly engineers)
- 35 affiliated faculty and 50 students
- Base funding of $750k through the UA budget

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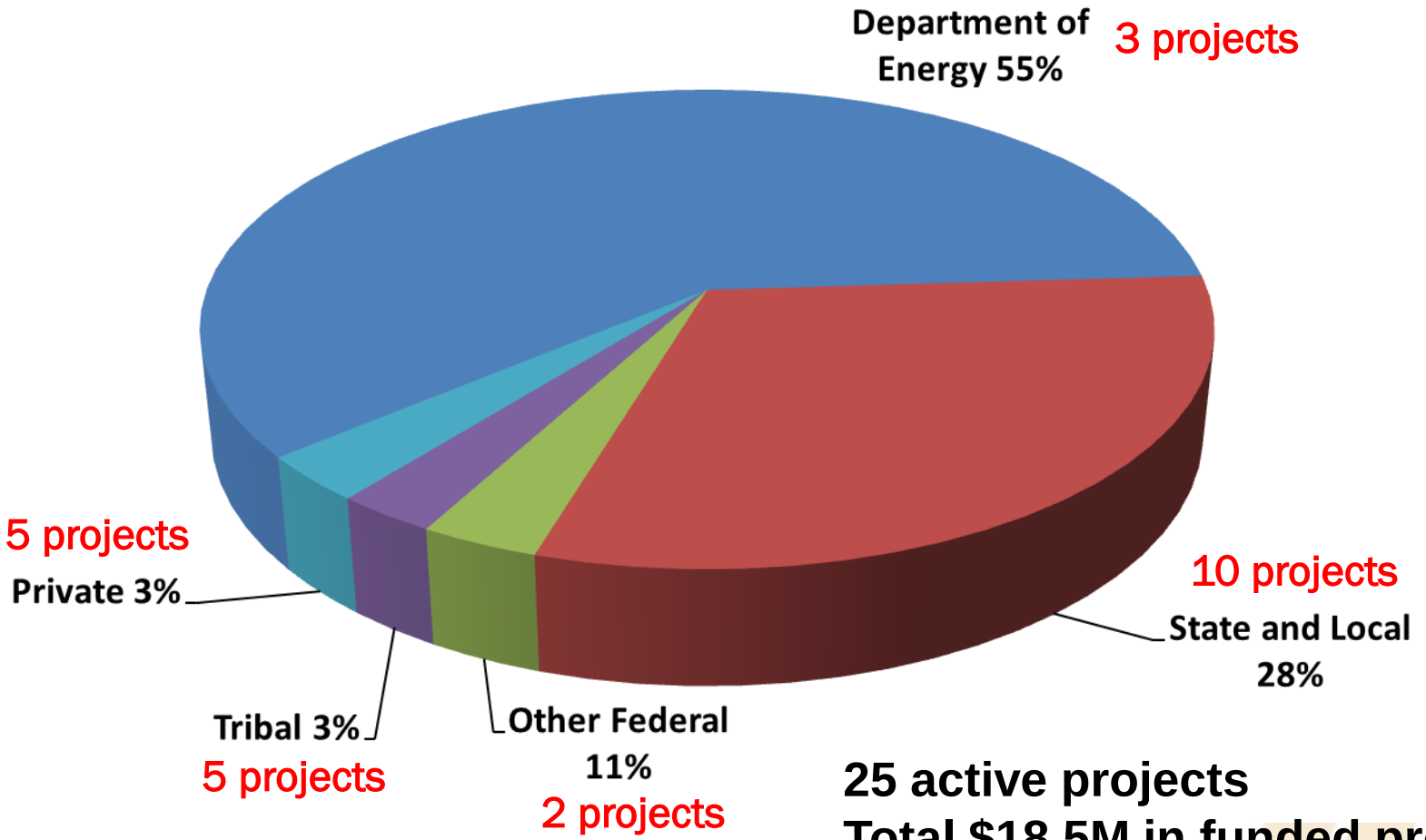
ACEP Funding Sources



25 active projects

Total $18.5M in funded projects

* some are multi-year
* does not include $750k in base funding

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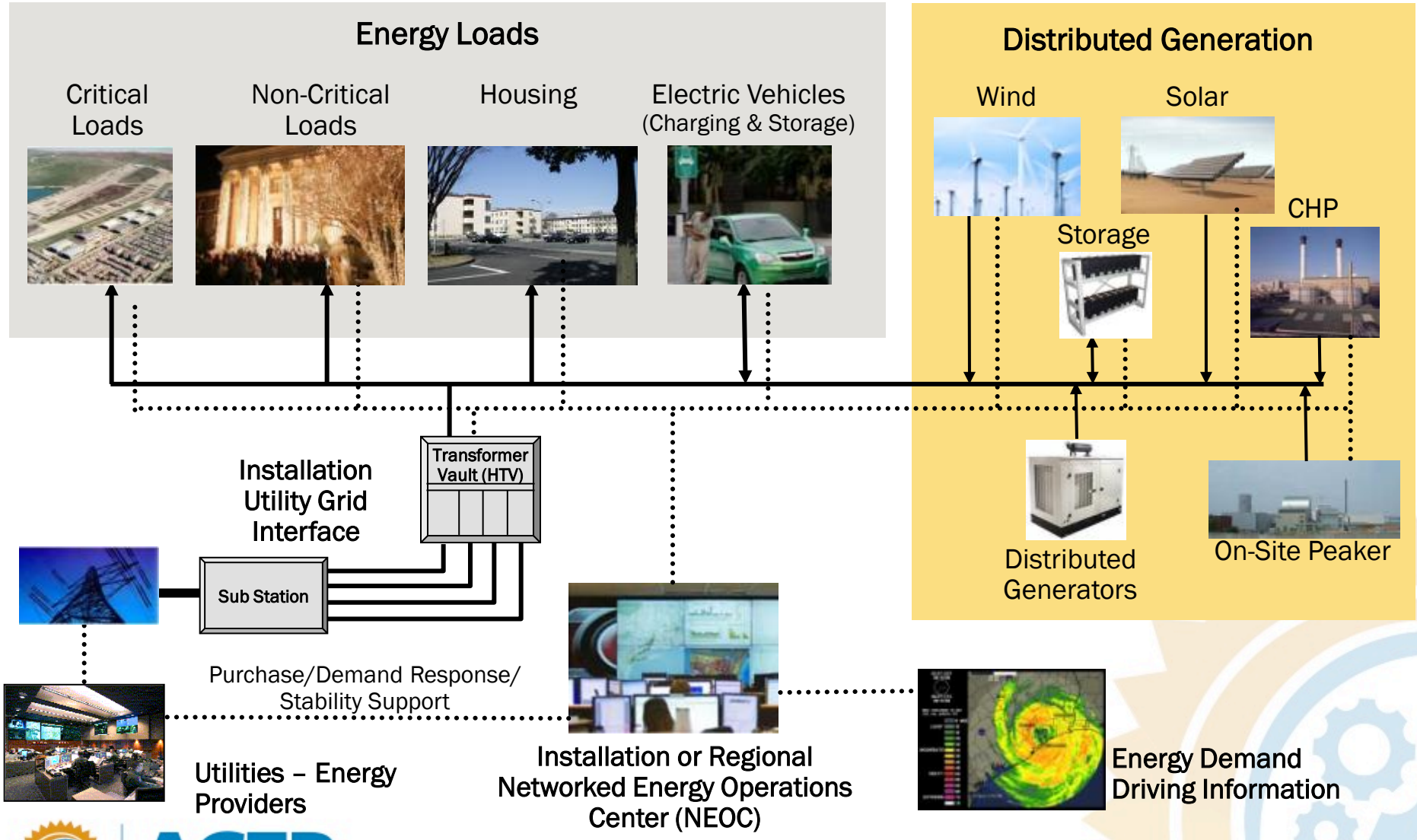
Intra-Grid & Inter-Grid Integration



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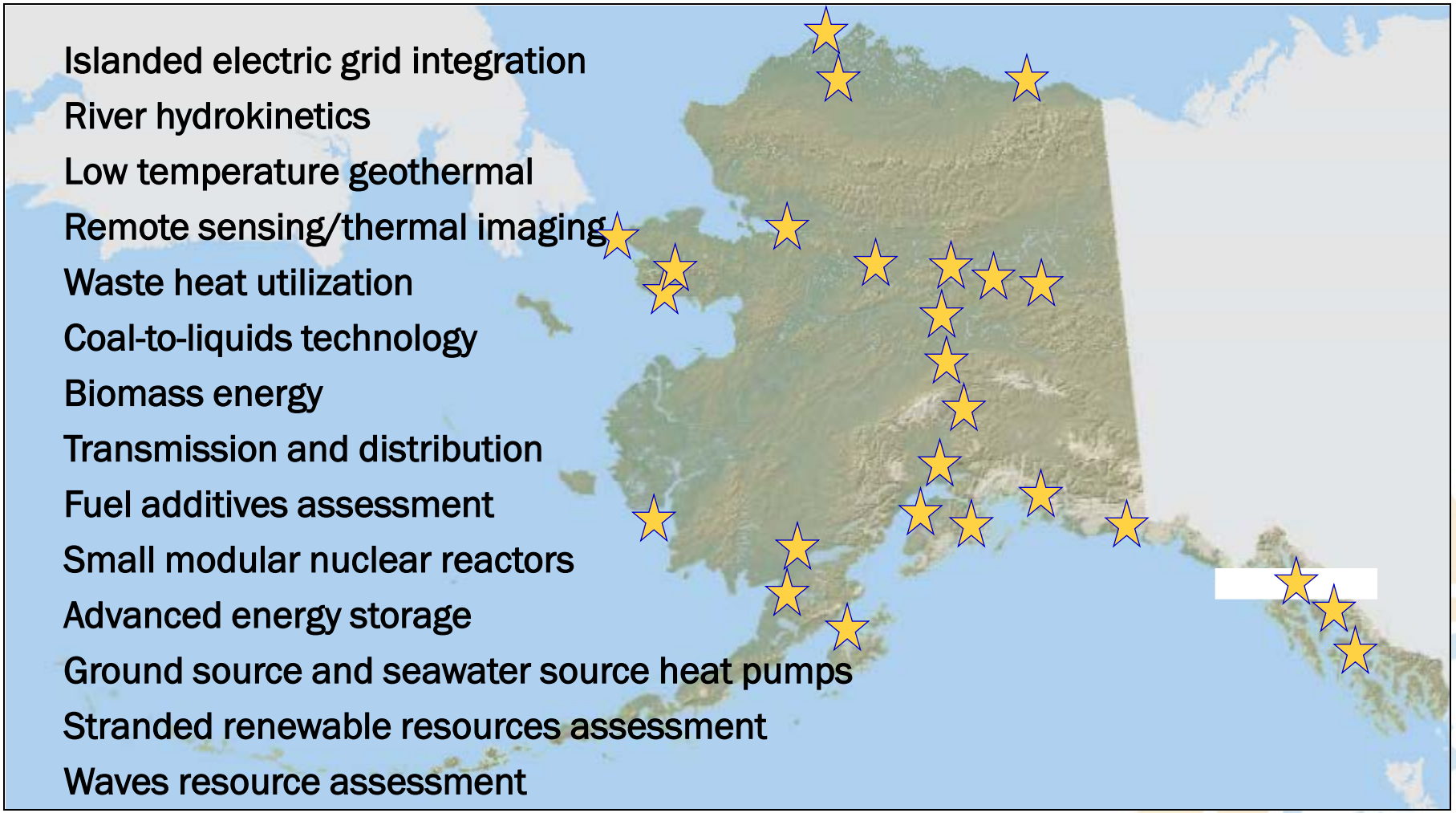
ACEP Projects are Statewide



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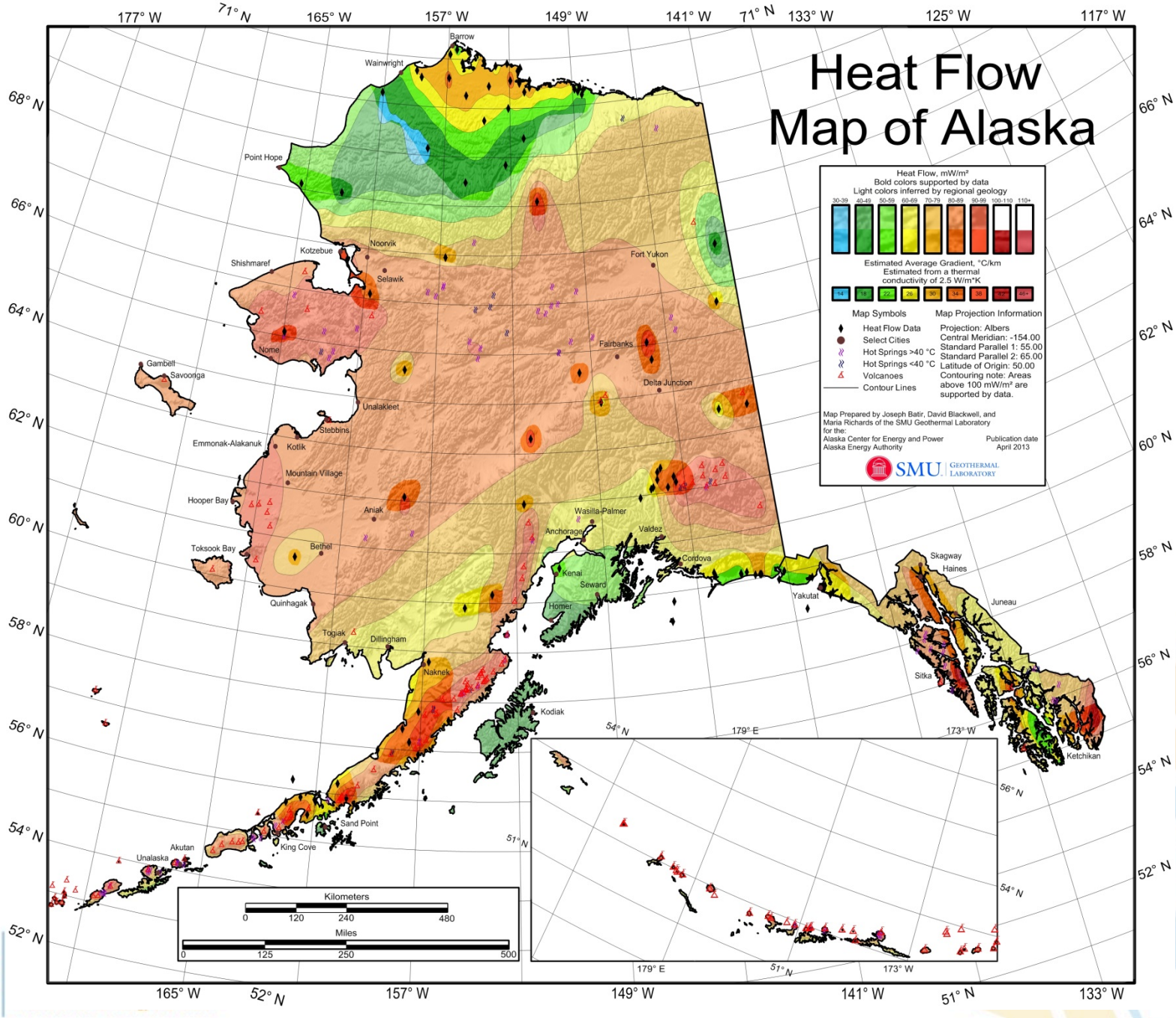
Key External Partners

Capitalizing on Niche Technology: Iceland

Iceland is a global leader in high temperature geothermal energy


Heat Flow
Map of Alaska
Heat Flow, mW/m²
Bold colors supported by data
Light colors inferred by regional geology
30-39
40-49
50-59
60-69
70-79
80-89
90-99
100-110
110+
Estimated Average Gradient, °C/km
Estimated from a thermal conductivity of 2.5 W/m*K
Map Symbols
Heat Flow Data
Select Cities
Hot Springs >40 °C
Hot Springs <40 °C
Volcanoes
Contour Lines
Map Projection Information
Projection: Albers
Central Meridian: -154.00
Standard Parallel 1: 55.00
Standard Parallel 2: 65.00
Latitude of Origin: 50.00
Contouring note: Areas above 100 mW/m² are supported by data.
Map Prepared by Joseph Batir, David Blackwell, and Maria Richards of the SMU Geothermal Laboratory for the:
Alaska Center for Energy and Power
Alaska Energy Authority
Publication date
April 2013
SMU GEOTHERMAL LABORATORY
Barrow
Wainwright
Point Hope
Kotzebue
Noorvik
Shishmaref
Selawik
Nome
Gambell
Savoonga
Unalakleet
Stebbins
Emmonak-Alakanuk
Kotlik
Mountain Village
Hooper Bay
Aniak
Toksook Bay
Bethel
Quinhagak
Togiak
Dillingham
Naknek
Kodiak
Akutan
Unalaska
Sand Point
King Cove
Fort Yukon
Fairbanks
Delta Junction
Wasilla-Palmer
Anchorage
Valdez
Cordova
Kenai
Seward
Homer
Yakutat
Skagway
Haines
Juneau
Sitka
Ketchikan
Kilometers
0 120 240 480
Miles
0 125 250 500
177° W
165° W
157° W
149° W
141° W
133° W
125° W
117° W
71° N
68° N
66° N
64° N
62° N
60° N
58° N
56° N
54° N
52° N
51° N
179° E
173° W

Niche: Low-Temp Geothermal

Binary plant testing at UAF

Chena Geothermal Project – lowest temperature commercial geothermal system in the world

First Organic Rankine Cycle power plant using geothermal energy *in the world* operated at **Manley Hot Springs** in 1980.

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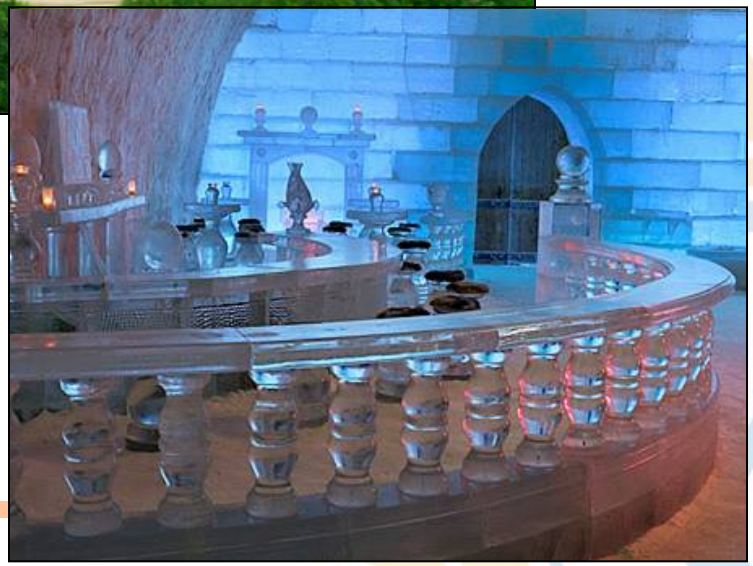
Niche: Low-temp Geothermal



Images from Chena Hot Springs Resort

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Why Low-Temp Geothermal is Economic in Alaska (versus Iceland)

- **High energy costs**
  (typically over 50cents/kWhr in rural areas)
- **Non-integrated electric grid**
  (communities have their own generation sources)
- **Cold climate** (improves cycle efficiency)

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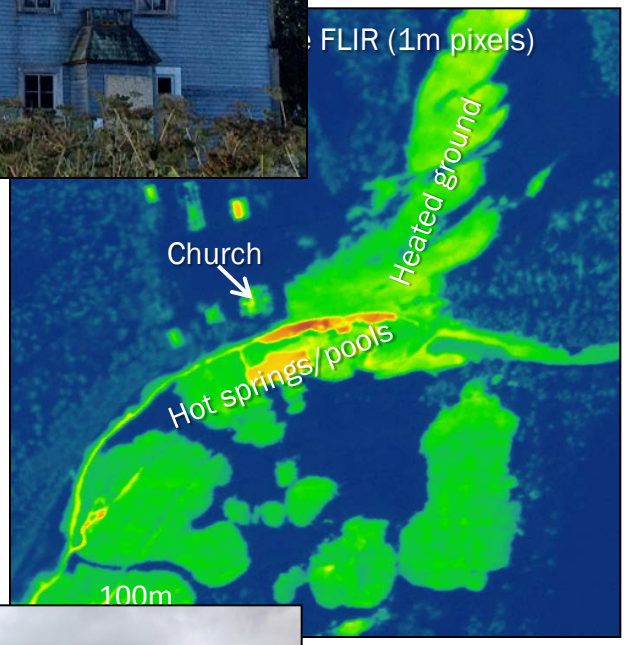
Innovative Geothermal Exploration Techniques



- Optical and infrared (FLIR) cameras
- Potential for rapid, low-cost mapping and quantitative assessment
- Funded through DOE and State of Alaska
- Verification using standard geothermal exploration techniques

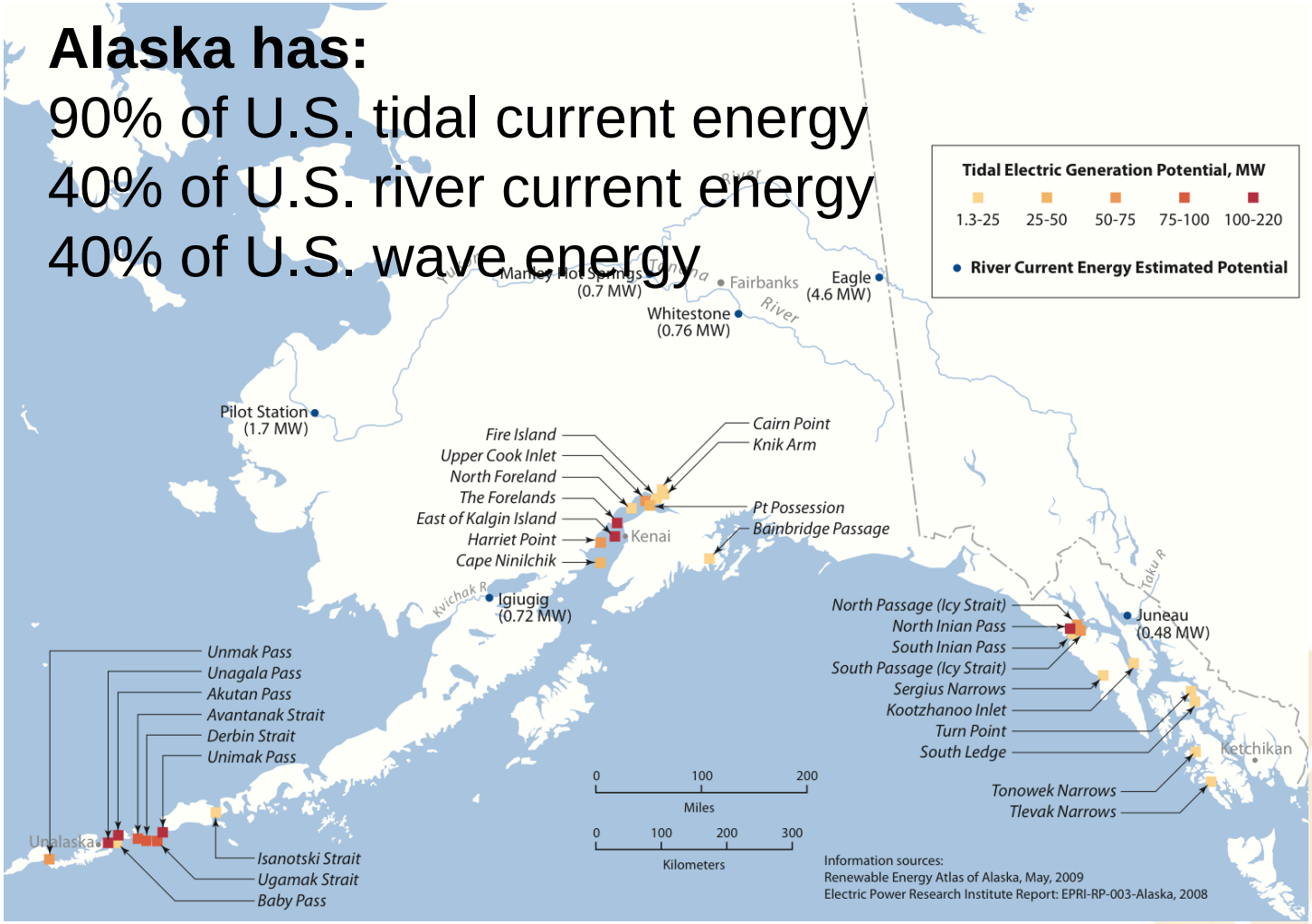
Opportunities

Alaska has:

90% of U.S. tidal current energy

40% of U.S. river current energy

40% of U.S. wave energy



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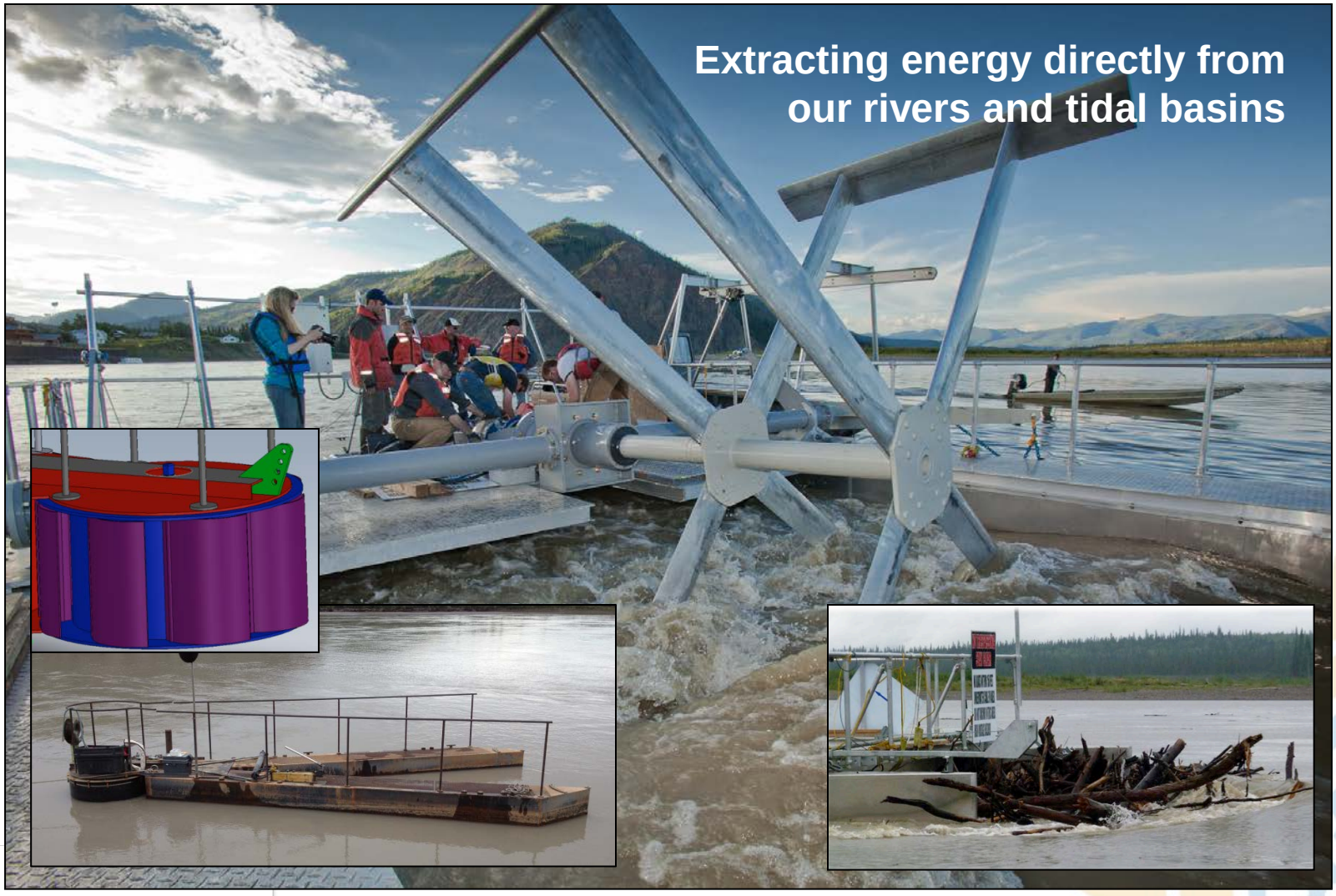
Niche Technologies - Hydrokinetics

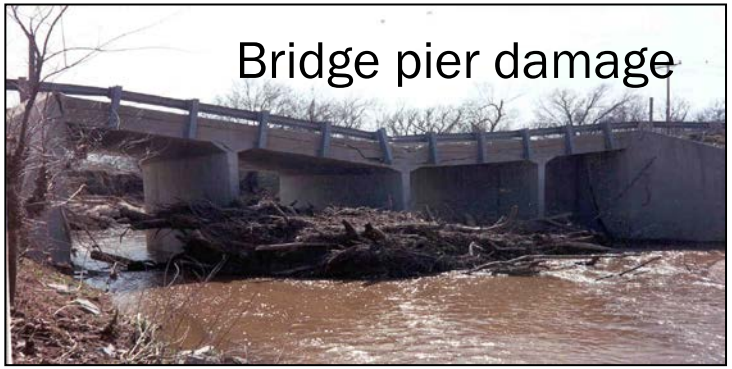


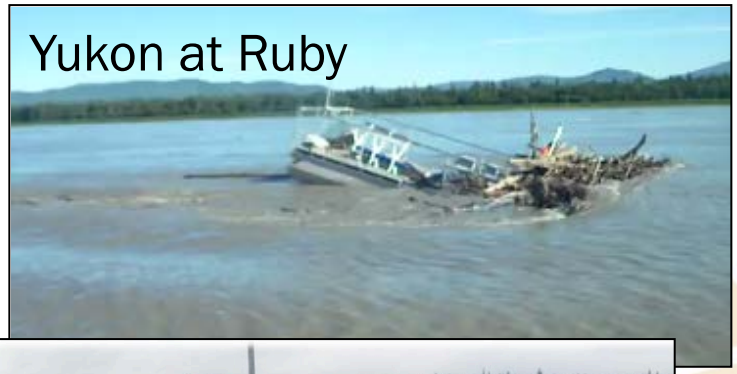
Debris Challenges

Debris accumulation damages infrastructure, disrupts operations, and creates maintenance and safety issues.

Examples:

- Ruby 5 kW turbine demonstration
- Eagle 25 kW AP&T Demonstration
- Fort Simpson 25 kW New Energy demonstration





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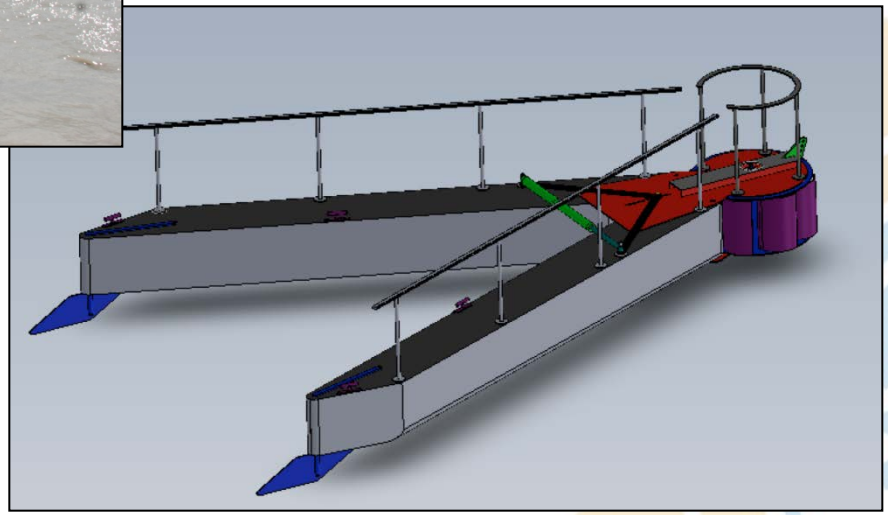
AHERC research focused on enabling technologies



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Niche: High Contribution Renewables

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System Performance Data

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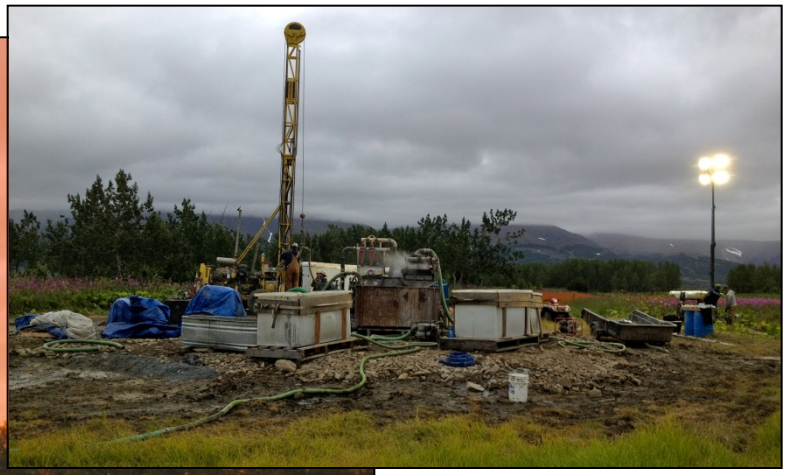
Nome, AK: Pilgrim Hot Springs



Nome Energy Facts

Current Energy Status

Electric Utility (Estimated)

Cost of Electricity (Residential)	0.37	kWh	Annual Community Energy Sales	28,588,475	kWh/Year
Average Community Load	3,264	kW	Annual Diesel Electricity Generated	31,260,682	kWh/Year
Estimated Peak Load	7,252	kW	Wind Turbine Electricity Generated	0	kWh/Year
Electrical Intertie?	N		Hydroelectric Electricity Generated	0	kWh/Year
Primary Diesel Power Locations(s):			Natural Gas Electricity Generated	0	kWh/Year
Hydroelectric Plant Location(s):			Annual Electricity Purchased	0	kWh/Year
Communities on the Intertie:			Source Data Note:	5 yrs:FY04-08	

.37/kW

Note: Power plant (station service), transmission, and distribution losses account for the difference between power generation and sales.

Diesel Power Generation (Estimated)

Annual Diesel Electricity Generated	31,260,682	kWh/year				Estimated Local Fuel Cost @ $107.50/bbl	$3.71
Annual Diesel Fuel Consumption	1,955,713	gal/year	Fuel Cost	$0.23	/kWh	Projected Fuel Cost /year	$7,255,696
Average Diesel Efficiency	15.98	kWh/gal	Non-Fuel Cost	$0.13	/kWh	Non-Fuel Costs /year	$4,022,659
			Diesel COE	$0.36	/kWh	**Total Electric**	**$11,300,000**

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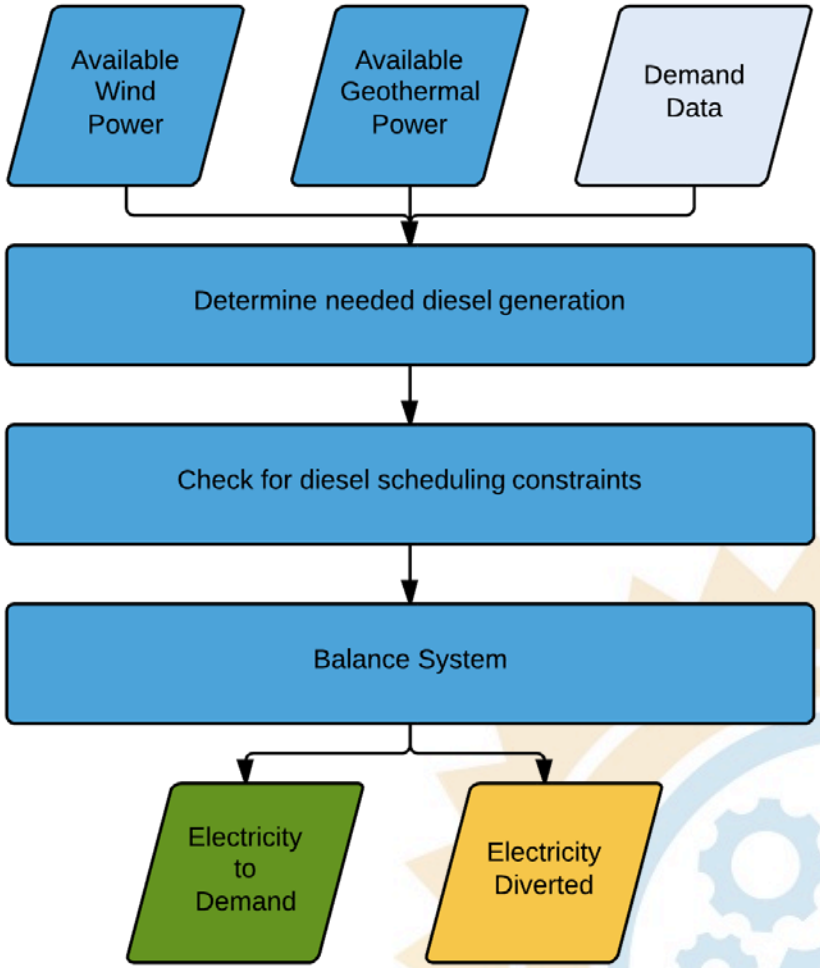
Integration Modeling for City of Nome

- How does 2 MW of geothermal generation interact with existing wind and diesel generation sources?
- Is this project economic under reasonable cost projections?



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Enabling High Penetration Renewable Energy

- Limits to Wind/PV (RE) integration dictated by system sophistication
- No control: very little RE possible
- Control over generating assets increases RE limits
- Load management increases RE limits

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Energy Storage Technologies

- Pumped hydro
- Compressed gas
- Batteries
- Ultracapacitors
- Flywheels
- Rail cars
- Energy liquids
- Thermal (hot and cold)

Alaska Experience & Background Information at ACEP & Alaska Energy Wiki sites

http://www.uaf.edu/acep/

http://energy-alaska.wikidot.com/energy-storage

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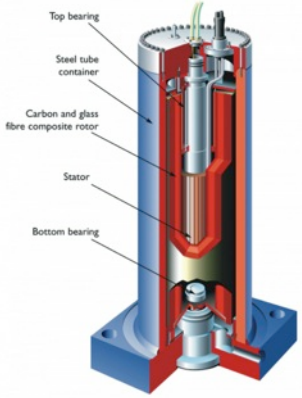
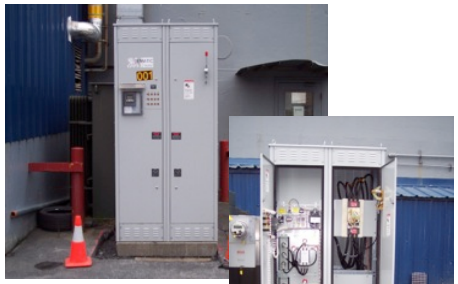
Alaska Electrical Energy Storage Experience

Flywheels: in-service & in-work



Utility Battery Energy Storage Systems On-line

Flow Battery Research



Capacitors Installed

Technical Literature at ACEP webpage & Alaska Energy Wiki site

http://www.uaf.edu/acep/

http://energy-alaska.wikidot.com/energy-storage

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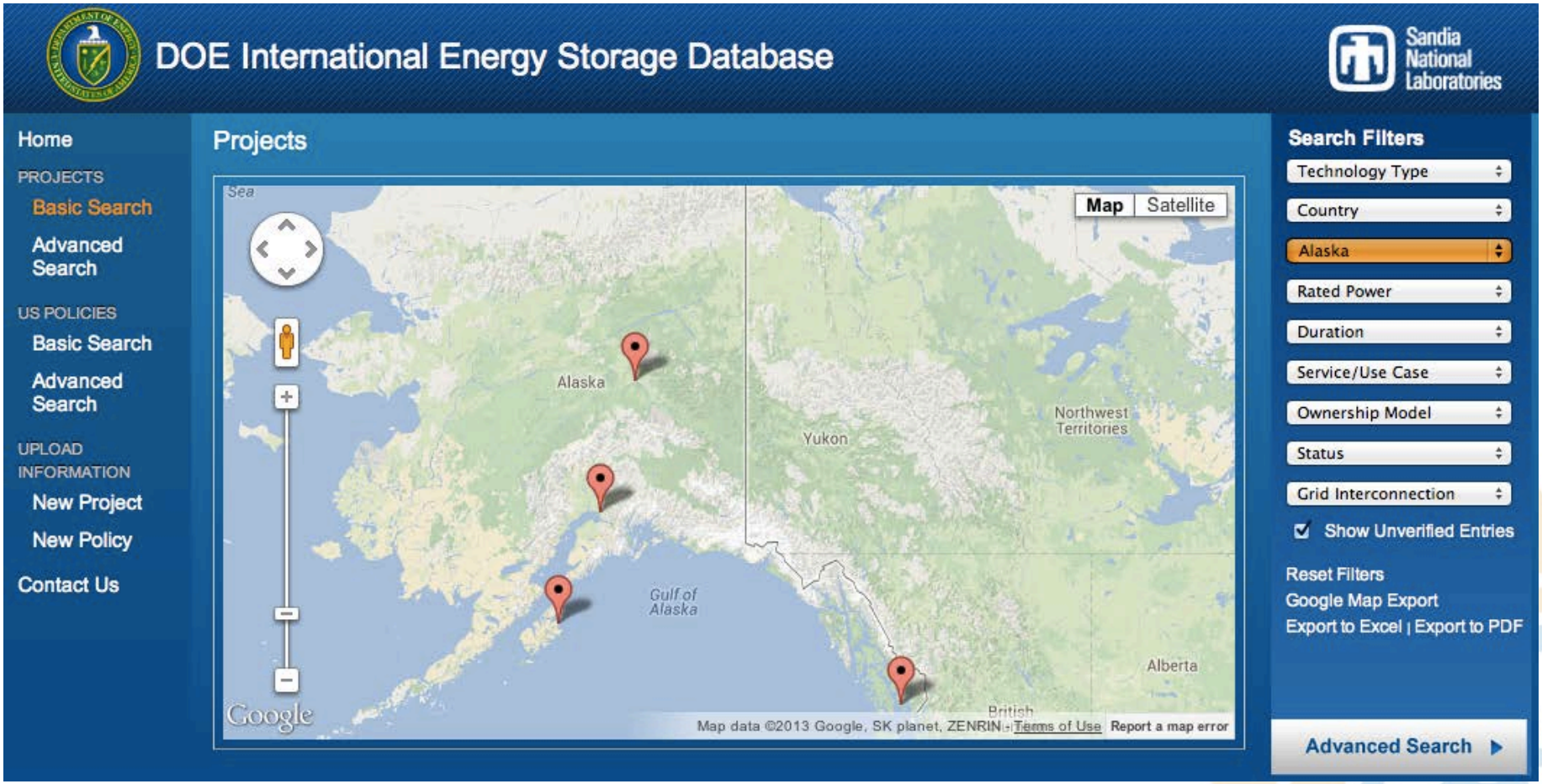
DOE Energy Storage Repository



http://www.energystorageexchange.org

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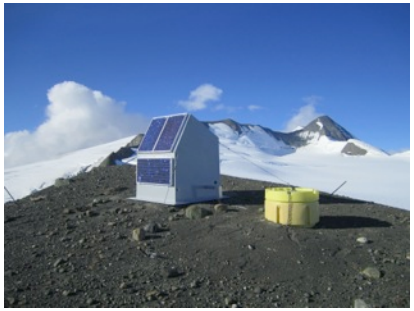
Alaska Electrical Energy Storage Opportunities

- Geophysical sensors
- Border security
- Communication systems
- Off-grid renewable energy
- High-penetration gridded renewables
- Diesel-off facilitation
- Uninhabited vehicles
- Transportation



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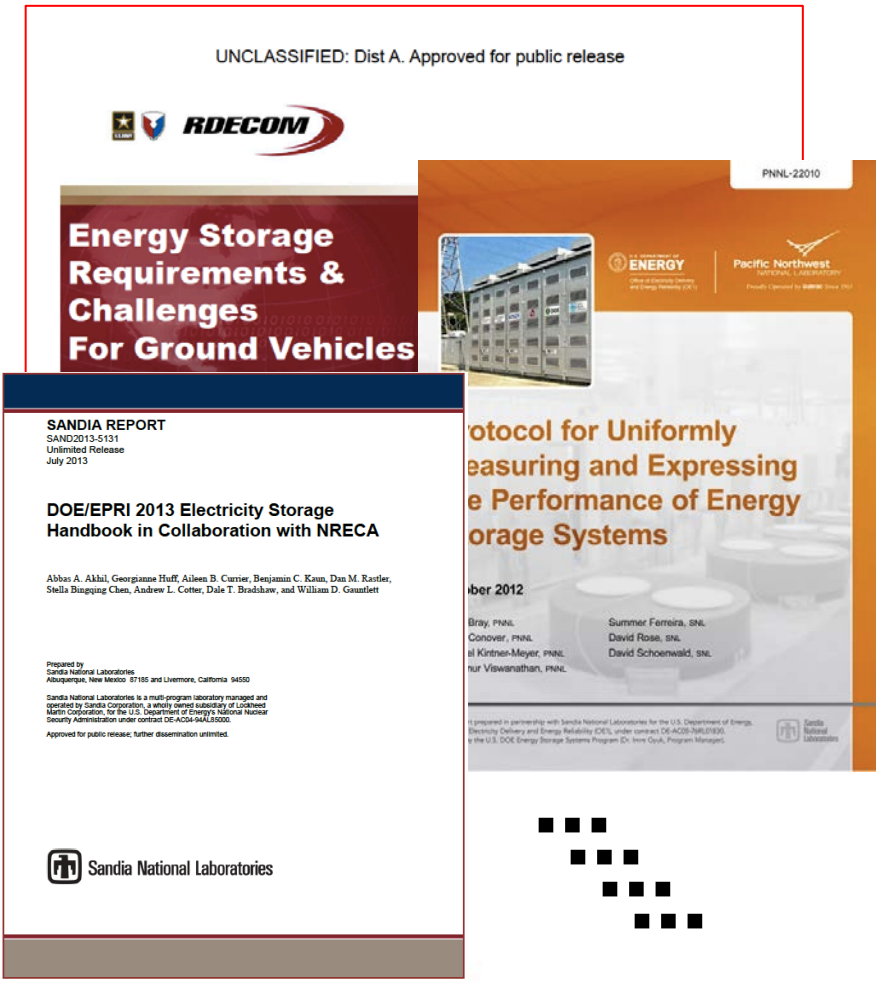
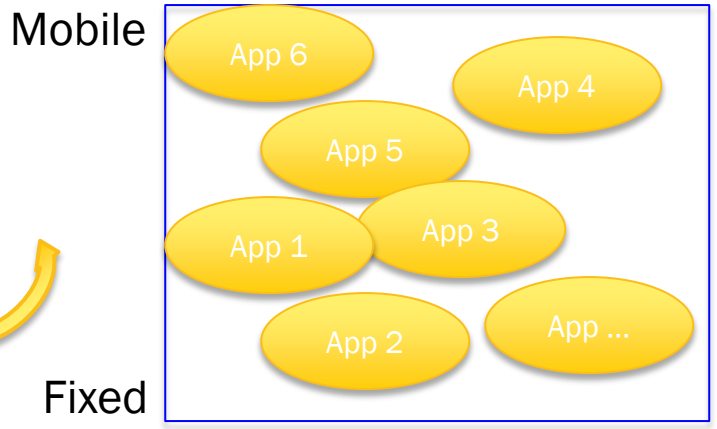
Identifying Arctic Electrical Energy Storage Challenges

Application-specific Requirements Aggregation



Requirements Comparison



Arctic-related Technology Needs

- Reliability
- Temperature
- Transportability
- Affordability
- State of health
- End of life
- ...

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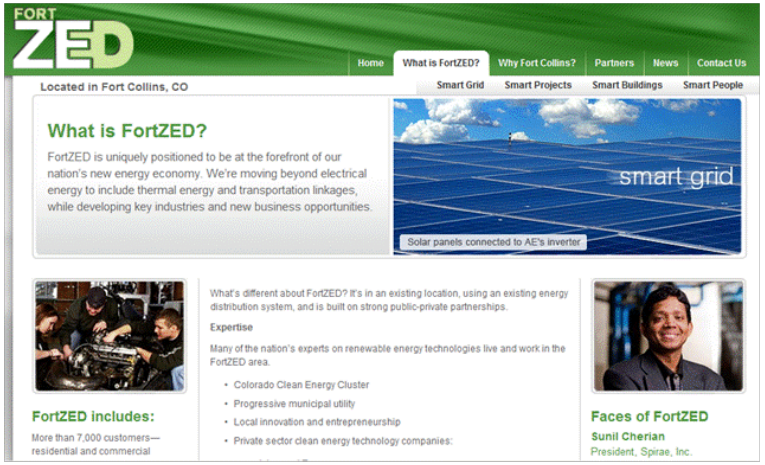
“Net Zero” Synergies?

✓ DoD

Air Force – Army - Marine Corps - Navy

✓ Communities



http://fortzed.com/

Campuses?

ILISAGVIK COLLEGE

UAA UNIVERSITY of ALASKA ANCHORAGE

UAF UNIVERSITY OF ALASKA FAIRBANKS

UAS UNIVERSITY OF ALASKA SOUTHEAST

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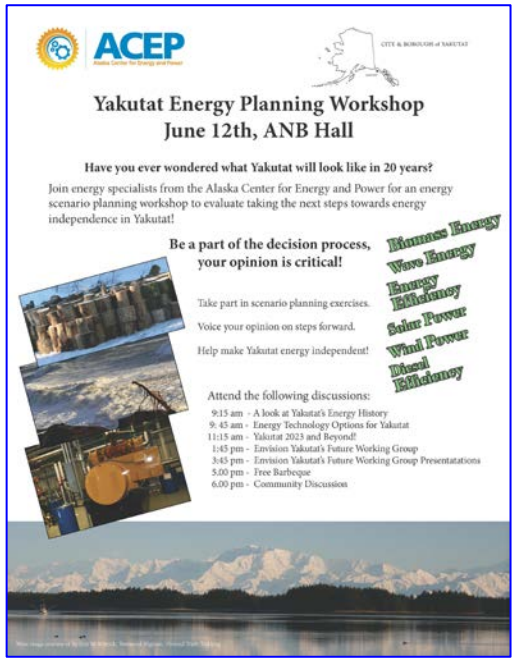
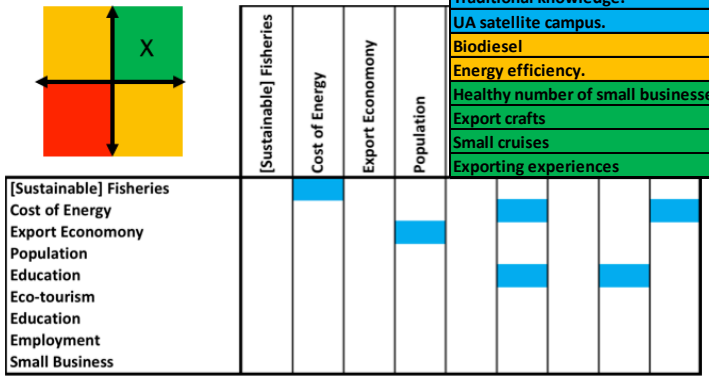
Yakutat Workshop



Themes	[Sustainab	Cost of Ene	Export Eco	Population	Education	Eco-tourisr	Employme	Small Busir
Under-utilized species, aquaculture, crab hatchery.	X		X		X	X		X
Shrimp and crab	X		X			X	X	X
Oysters	X		X			X	X	X
CQE programs	X				X		X	
Wood shop, art, and trade classes		X	X		X			
Career technology education (vocational schools)	X	X	X		X		X	X
Train local EMT, diving training, aquac								
Traditional knowledge.								
UA satellite campus.								
Biodiesel								
Energy efficiency.								
Healthy number of small businesses								
Export crafts								
Small cruises								
Exporting experiences								



The Yakutat of the future will be a sustainable and thriving community, honoring and leveraging its cultural heritage, demographic diversity, and natural resources

- Pillar Attributes:
  - Sustainable fisheries
  - Thriving local economy
  - Ecotourism
- Key Enablers:
  - Affordable energy
  - Strong education system

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VISION: Alaska leading the way in innovative production, distribution, and management of energy

What does this mean?

- We are maximizing production of our oil and gas resources
- We are developing local resources wherever practical
- We are using innovative financing mechanisms to incentivize private sector investment in Alaskan project
- Diesel-off is common place in our rural communities
- Experience gained by solving Alaska's energy challenges is exported (knowledge-based economy)

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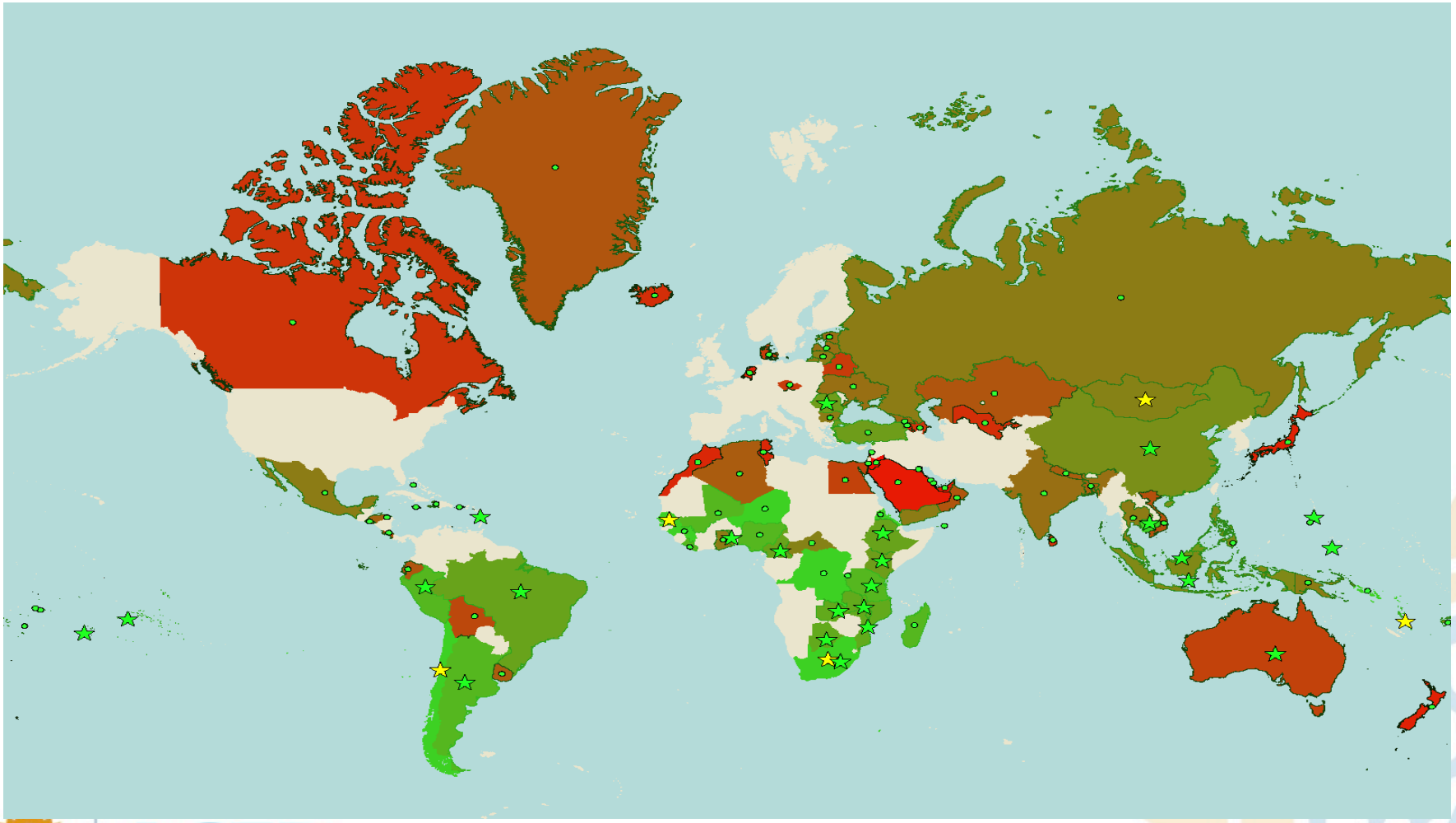
Sustainable energy – a global challenge



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Alaska's Rural Energy Applications

- Characterized as islanded microgrids
- Predominantly reliant on diesel electricity generation
- Increasingly susceptible to volatile fuel costs and supply interruptions
- Seeking energy provision that is affordable, cost-stable, reliable, and secure

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Islanded Microgrids: Rare in US

- Globally, islanded microgrids are/will be common, in particular in the developing word
- Similar circumstances in energy provision
  - long and vulnerable energy supply chains, expensive and volatile energy costs, minimally developed infrastructure, and rugged geographic and environmental conditions.
- Global activity to address these circumstances
  - access to affordable, cost-stable, reliable, and secure energy is a cornerstone to human and economic development.

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Program Motivation

- Assess the global opportunities for trade surrounding the use of energy systems in islanded grids
  - Develop a robust Alaska knowledge economy that can be exported globally
  - Create synergy with global entities in the development of solutions and strategies in mitigating barriers to affordable, cost-stable, reliable, and secure energy.

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Step 1: “GAP Matrix”

- Create a multi-dimensional evaluation tool to conduct a market assessment
- Methodology:
  - Define “ideal market”
  - Identify the criteria that serve as indicators
  - Develop and apply scoring system
  - Identify countries
  - Apply series of filters to identify countries for further investigation

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Ideal Market Characteristics

- Low population density
  - Communities that are isolated from urban centers by large distances or difficult terrain
- Problems associated with supply lines
  - Limited availability of infrastructure to access the region, or transport goods within it
- No electrification or be dependent on a non-integrated grid powered by diesel generators
- Area government/international community pursuing initiatives to improve energy supply and security
- Positive economic trajectory that could help drive and finance energy projects

Defining Criteria

- 4 requirements
  - Correlation with “Ideal Market”
  - Differences between countries
  - Easily quantifiable
  - Single credible source
- Qualitative Example: Business Environment
  - Classifies the country’s overall business climate, using data that indicates the complexity and cost of their regulatory environment as well as the strength of their legal institutions. For this qualitative assessment, the World Bank’s Doing Business rankings were used.

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Results

- 100 countries and territories
- Literature review
- Regional selections
- Reviewer input

#	Country	Final Score
1	South Africa	59.0
2	Vanuatu	58.5
3	Chile	57.5
4	Senegal	57.5
5	Mongolia	57.0

- Strengths
  - Surprises
  - Filtering out of unrelated nations
  - Broad range of possibilities
- Weaknesses
  - Regional challenges
  - Cohesion of data
  - Unavailable data

Step 2: Initial Country Review

Senegal: Synergies with Ideal Market

- Rapid electrification
- Comparable village sizes
- National and international programs
- Reliance on imported oil
- Rapid expansion hybrid micro-grids

Vanuatu: Unexpected National Priorities

- Bulk fuel delivery and storage throughout the country
- Data collection regarding energy use and the performance of the energy sector
- A national renewable energy atlas and wind resource assessments

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Program Status

- Two initial country reviews complete
  - Refine GAP Matrix
  - Connect with key regional/country stakeholders
  - Finalize reporting and documentation
- SIDS investigation, journal review
  - Formal work in comparative Alaska/SIDS investigation
- UNU Program Development
  - Low-grade heat short course development
  - Curriculum development for Iceland program
  - Alaska site visit by UNU Iceland
- Develop funding strategy and program partnerships
  - Develop program white paper
  - Dependent on findings from initial country reviews
  - Communicate program activities and findings
- Investigate similar initiatives and tailor GAP vision / plan accordingly
  - Idaho, NREL, EDIN, etc.
- Validate/refine GAP initiative with key Alaska stakeholders
  - State of Alaska
  - Private sector partners

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Increasingly Electrified Transportation

POWER ELECTRONICS (Si, SiC, GaN

- SEMICONDUCTOR SWITCHES
- CAPACITORS
- CIRCUITRY
- OTHER COMPONENTS

ENERGY STORAGE

- BATTERIES
  - MAINTENANCE FREE
  - CHEMISTRIES
- FLYWHEELS
- SUPERCAPACITORS

THERMAL MANAGEMENT

- ACTIVE VS. PASSIVE
- HEAT PIPES
- "ELECTRIC" AIR CONDITIONING
- STORAGE
- RECOVERY

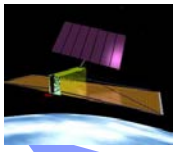
POWER GENERATION / UTILIZATION

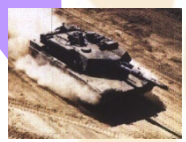
- MOTOR TYPES
  - SWITCHED RELUCTANCE
  - INDUCTION
- STARTER / GENERATORS
- COOLING
- MAG BEARINGS
- CONTROLLERS
- ELECTRIC ACTUATION

POWER DISTRIBUTION / SYSTEM INTEGRATION

- VOLTAGE TYPE
- HIGH VOLTAGES, FREQUENCY
- QUALITY / STABILITY
- EMI
- MODELING
- DEMONSTRATIONS
- SIGNAL CONTROLS
  - ELECTRIC
  - PHOTONIC

More Electric Platforms





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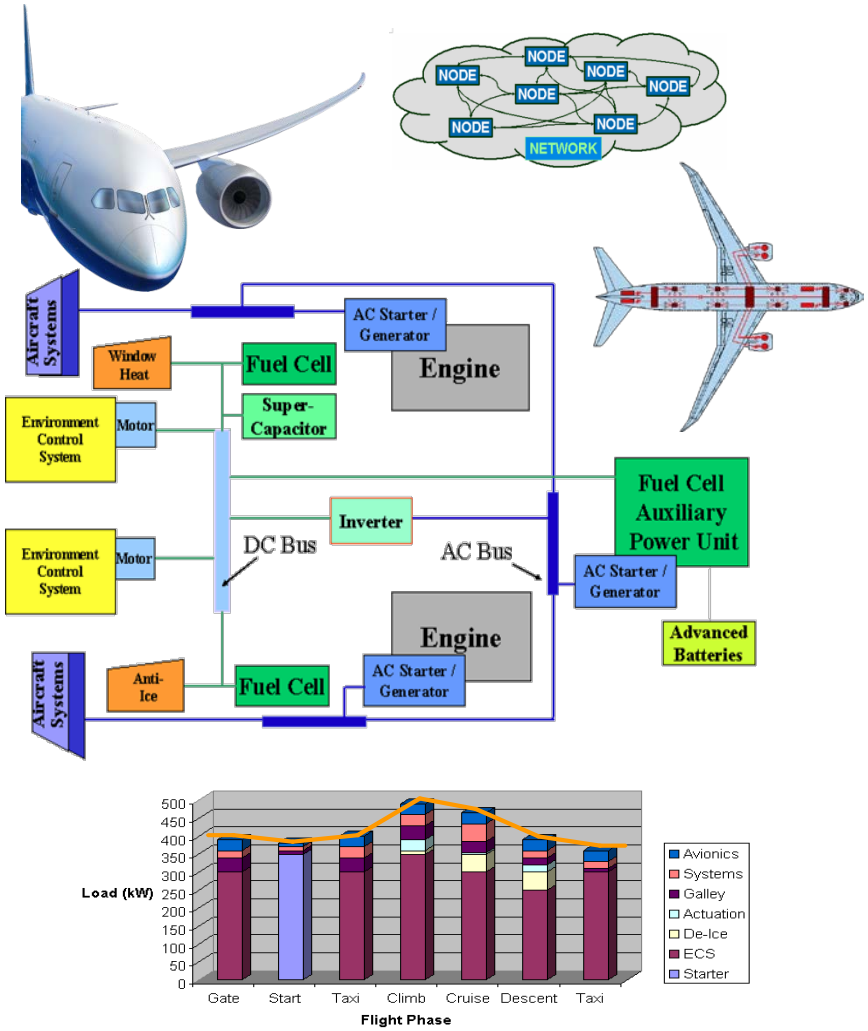
Grid-like Aircraft Power Systems



- Power system flexibility & utility
- Graceful, graduated failure modes
- Reduced power extraction
- Lower wire weight
- Improved efficiency
- Greater dispatch availability

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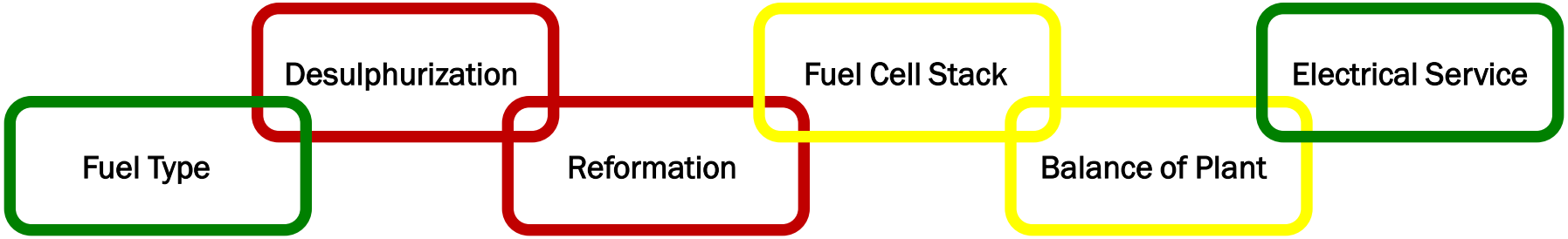
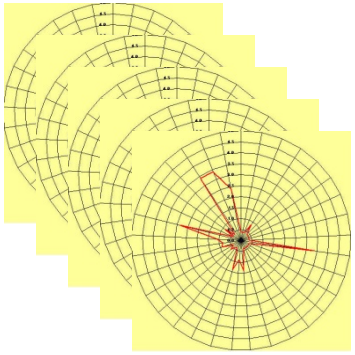
System Capability & Development Needs Assessment for Priorities & Staging



Immaturity				
	3	4	5	6
	2	3	4	5
	1	2	3	4
		1	2	3
		Criticality		

Immaturity				
	3	3	6	9
	2	2	4	6
	1	1	2	3
		1	2	3
		Criticality		



- **Ground support**
- **Power pod**
- **Aircraft utility**
- **Factory power**
- **Maritime**
- **…**

- Identify critical elements & associated attributes / risks
- Evaluate elements, identify "weak links"
- Compare applications to identify synergies & situation-unique items

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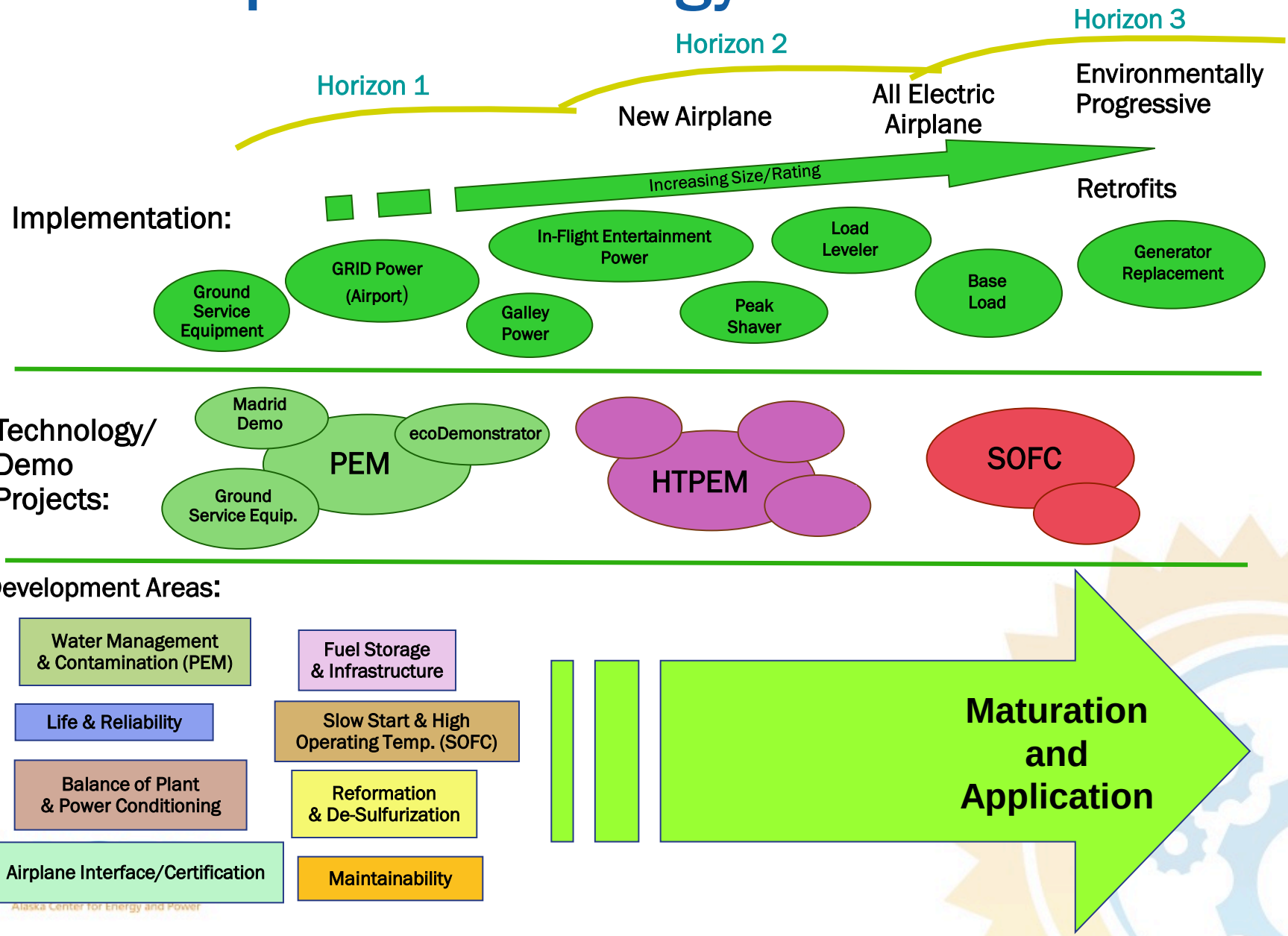
Roadmap for Technology Collaboration



Many Shared Technologies

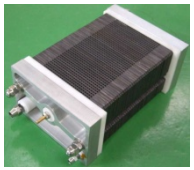
Red: Technology Maturation Needed
Black: Industry is Relatively Mature

Hydrogen Storage

Fuel Tank

Fuel Reforming

SOFC Stack

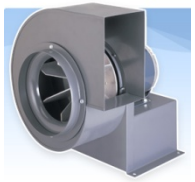


PEM/HT PEM Stack

Electrolyzer Stack

Power Electronics and Controls

Batteries / Capacitors



Air Blower

Turbo Compressor

Pumps

Heaters

Sensors

Valves and Plumbing

Water Reservoir

Filters

Water Separator/Collector

Steam Generator HEX

Heat Exchangers

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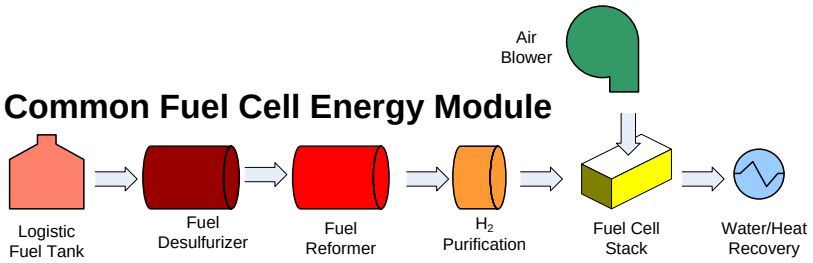
Fuel Cell Energy Sources Can Facilitate "Green" Ground Support Equipment (GSE)

Potential Fuel Options for "Green" GSE With Logistic Fuels (e.g. Jet A or Bio-Fuel)



Option 2
Use Hydrogen

Hydrogen Could Be Generated Onsite by Electrolysis Using Solar/Wind/Grid Power

Photo by: Las Vegas Valley Water District

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Examples of Airport GSE

Ground Power Unit

Aircraft Tractor (Tug)

Lower Deck Loader

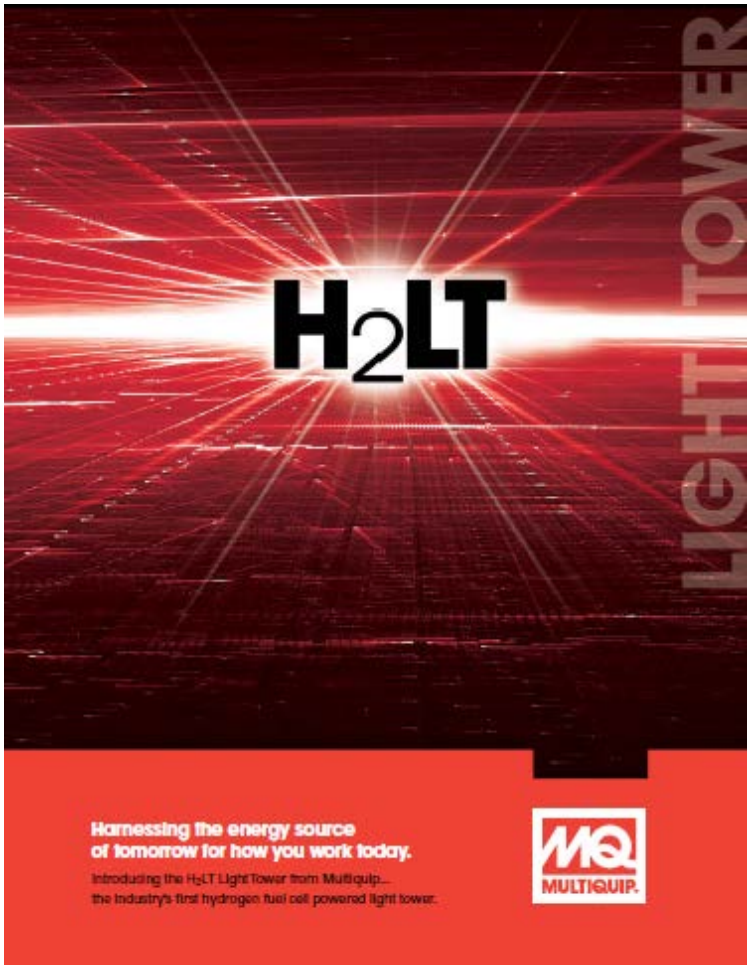
Airport Passenger Steps

Mobile Light Stands

Aircraft Heater

Airport Baggage Handling

A Success Story!



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Organizational & Regional Collaboration

- Technology development
- Modeling
- Test
- Demonstration
- Scaling
- …

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Collaboration Opportunities?

- Seasonal thermal energy storage
- Waste heat recovery
- Geothermal direct use enhancement
- Biomass
- Transportable waste-to-energy
- Non-traditional energy storage / transport
- Fuel cells – spent deicing fluid / coolant processing
- Arctic-suitable electrical energy storage technologies
- Standardized small scale renewable energy packages
- Community energy collaboration initiatives
- Renewables integration
- Diesel-off enablement
- Stranded renewable energy resource access
- Distributed resource energy grids optimization
- Unattended sensor energy source
- UAV / UUV energy system and support system energy
- Electric vehicle enablement – land, water, air
- …

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Be Careful of

Earth | Energy | Water | Air | Plants & Animals | Waste | People

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Your Footprints

Serve to Lead, Lead to Serve

(from www.aerospaceweb.org accessed 19 September 2011)

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Remember You're Being Followed

(personal photograph, GF Roe, used with permission)

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Quotes

“Twenty years from now you will be more disappointed by the things you didn't do than by the ones you did do. So throw off the bowlines, sail away from the safe harbor. Explore. Dream. Discover.” (Mark Twain)

"Heaven doth with us as we with torches do, not light them for themselves. For if our virtues did not go forth of us, 'twere all alike as if we had them not." (William Shakespeare)

“Action springs not from thought, but from a readiness for responsibility.” (Dietrich Bonhoeffer)

“Do what you can, with what you have, where you are.” (Theodore Roosevelt)

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