Outline

• Introduction to AHERC
• Hydrokinetic basics
• Economic basics
• Siting considerations
• Knik Arm site specifics
• Next steps
AHERC

- An applied research group within ACEP
- Jerry Johnson-AHERC Director
- Jeremy Kasper-Affiliated Researcher (physical oceanography)
- Antony Scott-Affiliated Researcher (economics)
- Marc Mueller-Stoffels-Affiliated Researcher (power systems integration)
- Andrew Seitz-Affiliated Researcher (fisheries oceanography)
- Jack Schmid-Research Engineer
- Paul Duvoy-Research Engineer
AHERC Goals

• Work closely with communities, industry, resource & regulatory agencies, utilities and power advocates to help communities make informed decisions

• Provide a statewide information and research resource
  • Marine and in-river resource assessments
    • Evaluate available power & biological resources that may be affected by hydrokinetic development
  • Evaluation of interactions between aquatic & socio-economic environments and marine and hydrokinetic energy development
    • Evaluate changes to river or ocean circulation or waves regimes that affect fisheries and marine organisms by altering habitat

• Develop and disseminate data and information needed by stakeholders to make informed decisions
AHERC Capabilities

- Economic Analysis
- Marine and river environment characterization (measurement & analysis)
  - Current velocity, power, turbulence
  - Wave height, frequency and direction
  - Fish populations and location
  - Debris and sediment transport
  - 2 & 3 dimensional modeling
  - Conversion efficiency of water power to electricity
  - Debris, fish, sediment, turbulence
  - Work collaboratively with other institutions to fill knowledge and skill gaps (e.g. marine mammal monitoring)

- Technology development
  - Anchoring, deployment, operations & debris mitigation

- Grid Integration
Hydrokinetic Energy Basics

- Underwater turbines convert ocean, tidal, or river currents into electrical power using the water’s kinetic energy
- Turbines are placed in relatively high-velocity currents
- Do not require dams or power houses
- Technology is considered pre-commercial—"emerging"
Hydrokinetic Power

The Power per unit of cross-sectional area:

$$P_{sp} = \frac{1}{2} d_w V^3$$

- $P_{sp}$ - specific power (W/m²)
- $d_w$ - density of water (kg/m³)
- $V$ - current velocity (m/s)
Hydrokinetic Devices

- Pulse tidal hydrofoil
- New Energy*: Ecurrent
- Marine Current Turbine*: VIVACE*: vortex induced vibration
- Ocean Renewable Power Company*

*Turbine images used with permission
Alaska’s Hydrokinetic Resource

90% of U.S. tidal current energy
High Energy Costs And Desire To Use Renewable Energy

- Alaska is attractive to hydrokinetic turbine and wave energy developers
  - High cost of energy in rural villages
  - Large number of villages next to major rivers
  - Tidal and wave resources near intertie grid

### Annual Average Cost of Power in Alaska (2010 dollars)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cost/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statewide</td>
<td>$0.22—$0.94</td>
</tr>
<tr>
<td>Railbelt</td>
<td>$0.14</td>
</tr>
<tr>
<td>Alaska Village Electric Corporation</td>
<td>$0.52</td>
</tr>
<tr>
<td>Continental U. S.</td>
<td>$0.09</td>
</tr>
<tr>
<td>Yakutat (2013)</td>
<td>$0.57</td>
</tr>
</tbody>
</table>
High Energy Costs And Desire To Use Renewable Energy

Costs of hydrokinetic power production at selected Alaskan locations (after power cost equalization adjustment)

<table>
<thead>
<tr>
<th>Location</th>
<th>Est. renewable cost/kWh</th>
<th>2010 Cost/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Igiugig (River)</td>
<td>$0.68</td>
<td>$0.73</td>
</tr>
<tr>
<td>Eagle (River)</td>
<td>$0.68</td>
<td>$0.47</td>
</tr>
<tr>
<td>Whitestone (River)</td>
<td>$0.19</td>
<td>$0.14</td>
</tr>
<tr>
<td>Knik Arm (Tidal)</td>
<td>$0.11</td>
<td>$0.14</td>
</tr>
<tr>
<td>Yakutat (wave)</td>
<td>$0.28</td>
<td>$0.31</td>
</tr>
</tbody>
</table>

Issued and pending preliminary FERC permits

FERC staff, March 13, 2012

ACEP
Alaska Center for Energy and Power
Factors Affecting Hydrokinetic Site Selection

- Tidal velocities [site location; economic viability]
  - Power density
  - Bathymetric and channel effects
  - Stratification
- Distance between resource and grid connections [economic viability]
- Turbulence [engineering design & power recovery efficiency]
  - Recoverable power
  - Infrastructure stress
  - Variation with currents, waves, bathymetry, stratification
- Beach or bank erosion
- Suspended & bed load sediment transport, Marine debris [operation & maintenance (O&M)]
  - Deposition and erosion
  - Infrastructure abrasion and clogging
  - Channel stability
  - Infrastructure integrity – bed scour, foundation stability
  - Damage to turbines or wave energy generators
Factors Affecting Hydrokinetic Site Selection

- **Debris [Site location; O&M]**
  - Type, size and frequency of occurrence, spatial location (lateral and depth)

- **Ice [O&M]**
  - Frazil ice accumulation
  - Depth & frequency of occurrence
  - Solid ice conditions

- **Fish, Marine mammals, sea birds [permit approval; site location; O&M]**
  - Seasonal populations and behavior
  - Spatial distribution
  - Need to understand why & how animals utilize an area before impact of new infrastructure can be determined

- **Vessel traffic (e.g. shipping)**

- **Recreational, subsistence and commercial uses (e.g. fishing)**
<table>
<thead>
<tr>
<th>Permitting Agencies</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Energy Regulatory Commission</td>
<td>In-water electric power generation (federal &amp; state waters)</td>
</tr>
<tr>
<td>U.S. Army Corps of Engineers (USACE)</td>
<td>Land use and navigable waterways (federal &amp; state waters)</td>
</tr>
<tr>
<td>Alaska Dept. of Fish and Game (ADF&amp;G)</td>
<td>Fish and habitat (state waters)</td>
</tr>
<tr>
<td>Alaska Dept. of Natural Resources (ADNR)</td>
<td>Land use (state lands)</td>
</tr>
<tr>
<td>NOAA National Marine Fisheries Service (NMFS)</td>
<td>Fish, marine mammal, and habitat conservation (federal waters)</td>
</tr>
<tr>
<td>U.S. Fish and Wildlife Service (FWS)</td>
<td>Fish (federal waters)</td>
</tr>
<tr>
<td>U.S. Dept. of the Interior Bureau of Ocean Energy Management (BOEM) / Bureau of Safety and Environmental Enforcement (BSEE)</td>
<td>Regulation and leasing (federal waters)</td>
</tr>
</tbody>
</table>
Knik Arm Site

# Knik Arm Site

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Knik Arm</td>
<td>17,000 kW</td>
<td>$123M</td>
<td>$0.11</td>
<td>$4.5M</td>
</tr>
</tbody>
</table>
Source: Polagye and Previsic, 2006
Theoretically available Cairn Point tidal power

Source: Polagye and Previsic, 2006
Yakutat Project Timeline

• 2009 EPRI Report
• 2012 C&B of Yakutat engages ACEP/AHERC for resource assessment
• Feb. 2013 Preliminary FERC Permit issued to Resolute Marine Energy
  – Marine mammal monitoring required by NMFS through the FERC process
• July 2013 CBY & AEA fund AHERC to conduct wave resource assessment (in-situ and modeling)
  – CBY’s contribution is eligible to serve as match for USACE to conduct “sea bed” survey (repeat bathymetric measurements)
  – CBY engages DGGS to conduct shoreline hazard analysis
  – RME proposal pending to DOE to conduct marine mammal & fisheries monitoring within the FERC permit area
Next Steps for Mat-Su Borough

• Contact Regulatory Agencies (specifically NMFS)
  • Update estimates from 2006 EPRI report
    – today’s dollars
    – economics of Port Mackenzie rather than Port of Anchorage
    – consider alternative hydrokinetic devices from original EPRI report
• Refine estimates of available power using NOAA’s model output
  • in-situ measurements
    – 1 year moored ADCP deployment (currents)
    – Repeat multi-beam SONAR surveys (sediment transport)
• Partner w/ company or issue an RFP for PPA
  • FERC permitting process
    – marine mammal acoustics
    – seabirds, fisheries, ????