Alaska Hydrokinetic Energy Research Center (AHERC)

Jeremy Kasper

University of Alaska Fairbanks (UAF)

Institute of Northern Engineering (INE)

Alaska Center for Energy and Power (ACEP)

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Palmer, August 2013

Outline

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

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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**

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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

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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**

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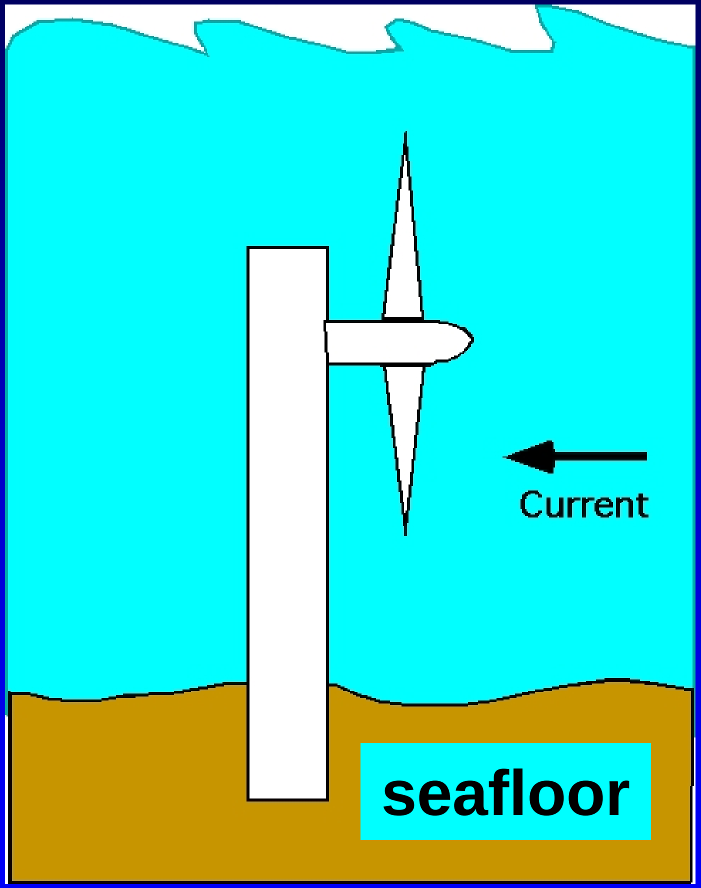
Hydrokinetic Energy Basics

- 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"

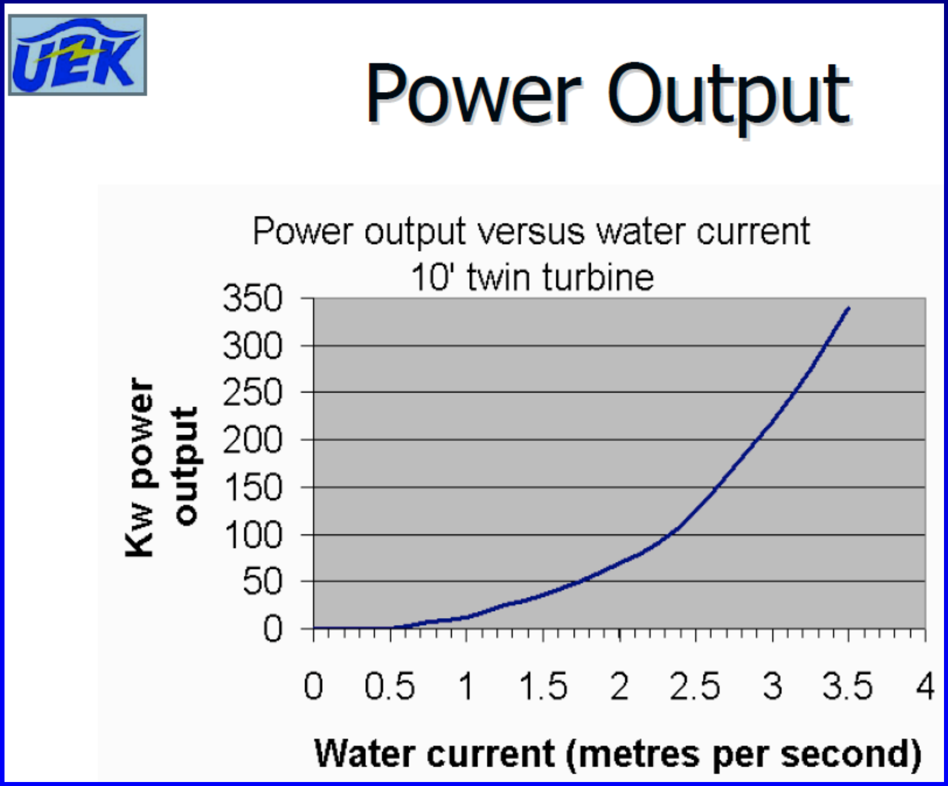


Hydrokinetic Power

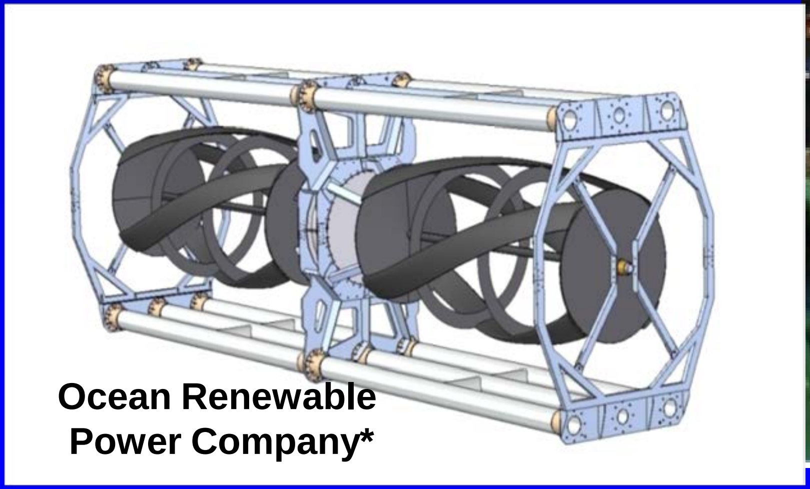
The Power per unit of cross-sectional area:

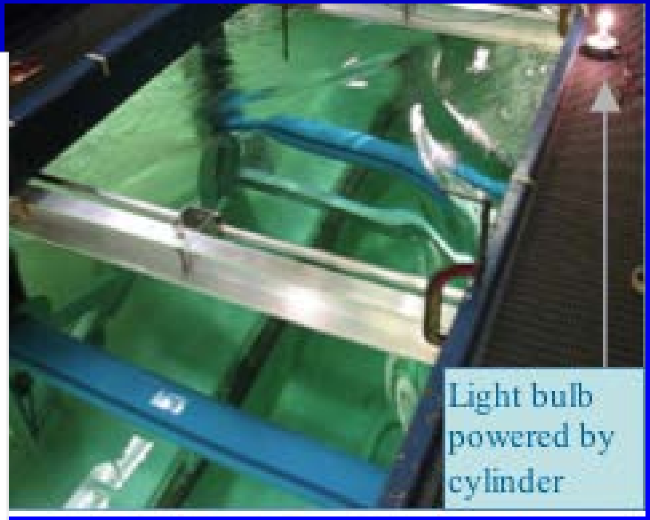
$$P_{sp} = \frac{1}{2} d_w V^3$$

- P_{sp} - specific power (W/m^2)
- d_w - density of water (kg/m^3)
- V - current velocity (m/s)



Hydrokinetic Devices

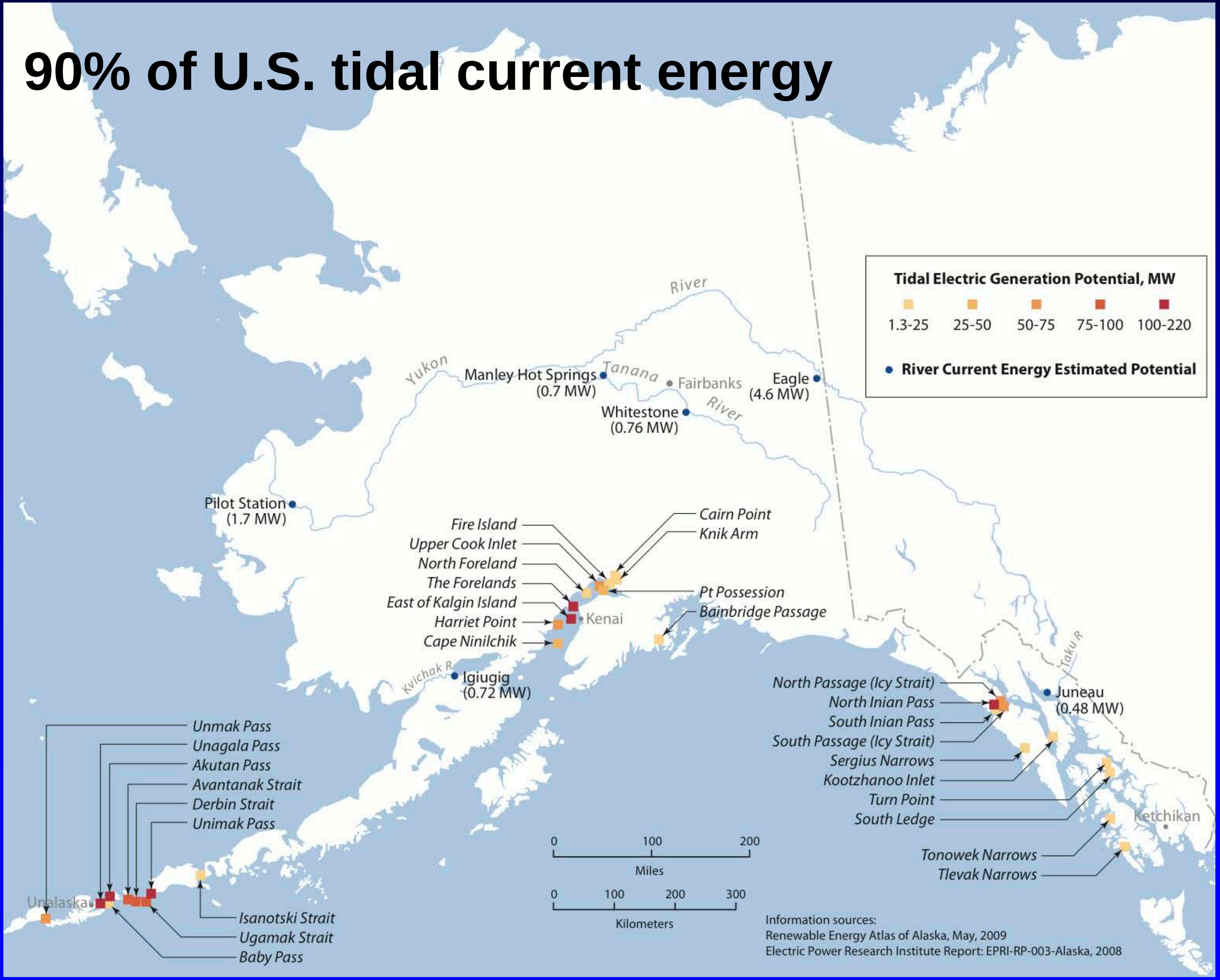




VIVACE*: vortex induced vibration

*Turbine images used with permission

Alaska's Hydrokinetic Resource



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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)	
Location	Cost/kWh
Statewide	\$0.22—\$0.94
Railbelt	\$0.14
Alaska Village Electric Corporation	\$0.52
Continental U. S.	\$0.09
Yakutat (2013)	\$0.57

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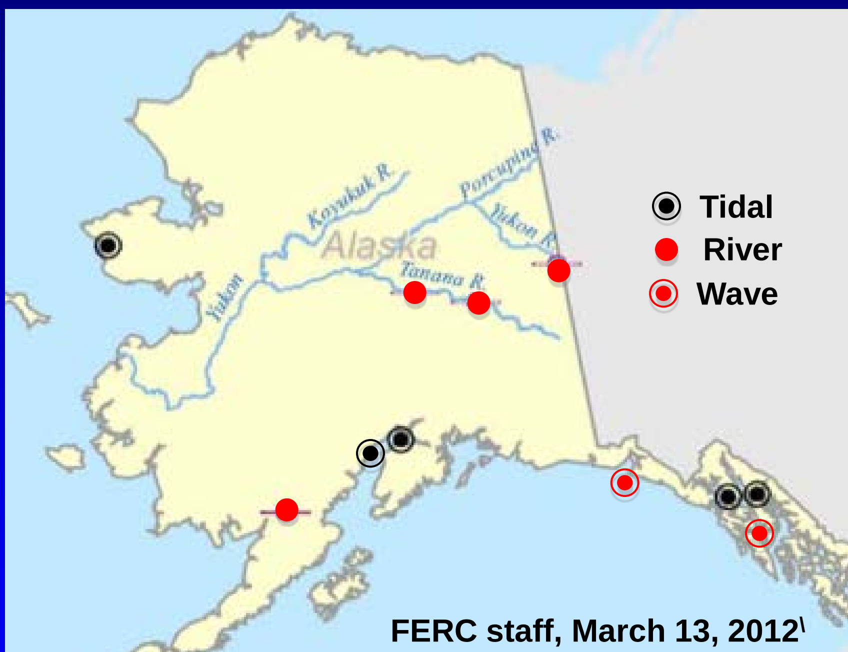
High Energy Costs And Desire To Use Renewable Energy



Issued and pending preliminary FERC permits

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

Location	Est. renewable cost/kWh	2010 Cost/kWh
Igiugig (River)	$0.68	$0.73
Eagle (River)	$0.68	$0.47
Whitestone (River)	$0.19	$0.14
Knik Arm (Tidal)	$0.11	$0.14
Yakutat (wave)	$0.28	$0.31

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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**

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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)**

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Regulatory Agencies

Permitting Agencies	
Federal Energy Regulatory Commission	In-water electric power generation (federal & state waters)
U.S. Army Corps of Engineers (USACE)	Land use and navigable waterways (federal & state waters)
Alaska Dept. of Fish and Game (ADF&G)	Fish and habitat (state waters)
Alaska Dept. of Natural Resources (ADNR)	Land use (state lands)
NOAA National Marine Fisheries Service (NMFS)	Fish, marine mammal, and habitat conservation (federal waters)
U.S. Fish and Wildlife Service (FWS)	Fish (federal waters)
U.S. Dept. of the Interior Bureau of Ocean Energy Management (BOEM) / Bureau of Safety and Environmental Enforcement (BSEE)	Regulation and leasing (federal waters)

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Knik Arm Site

- Johnson, J., and Pride, D. 2010. River, Tidal, and Ocean Current Hydrokinetic Energy Technologies: Status and Future Opportunities in Alaska, ACEP.
- Polagye, B., and Previsic, M. 2006. System level design, performance, cost, and economic assessment – Knik Arm Alaska tidal in-stream power plant. EPRI-TP-006-AK (http://oceanenergy.epri.com/streamenergy.html), 128 pp.
- Smith et al., 2005. Tide and Current Measurements and Analyses in the Vicinity of the Proposed Knik Arm Bridge (http://knikarmbridge.com/documents/App.1Smithetal2005)

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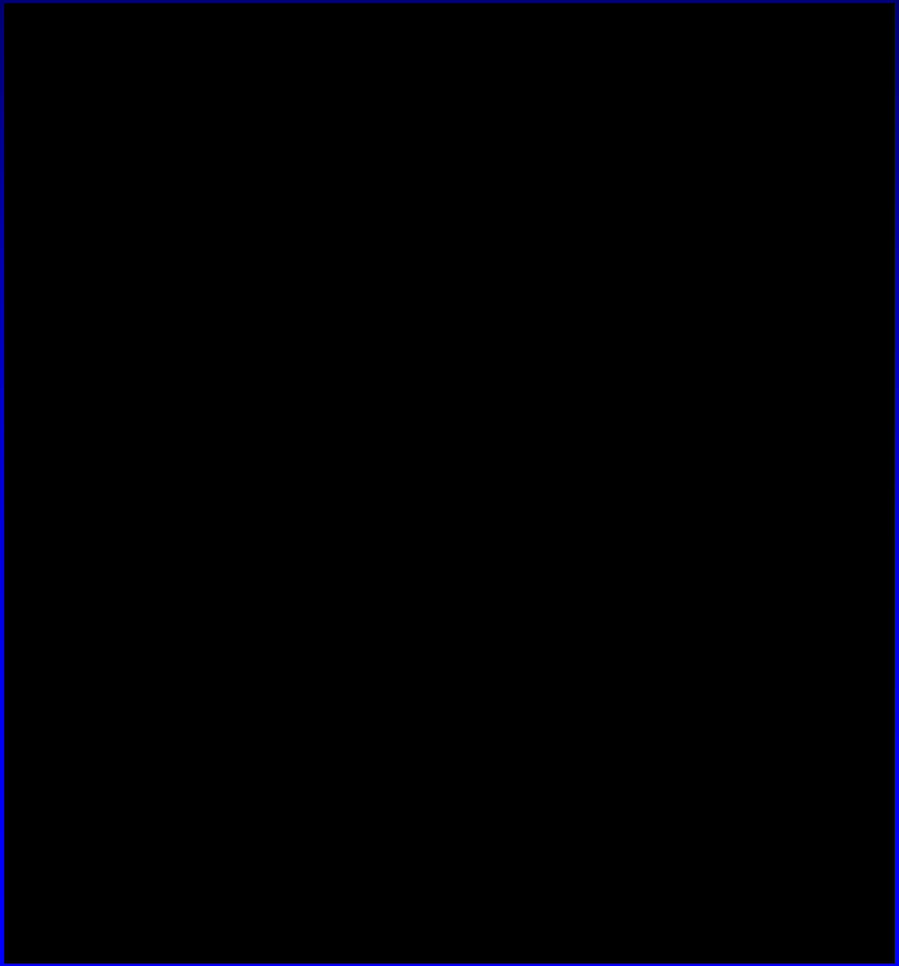
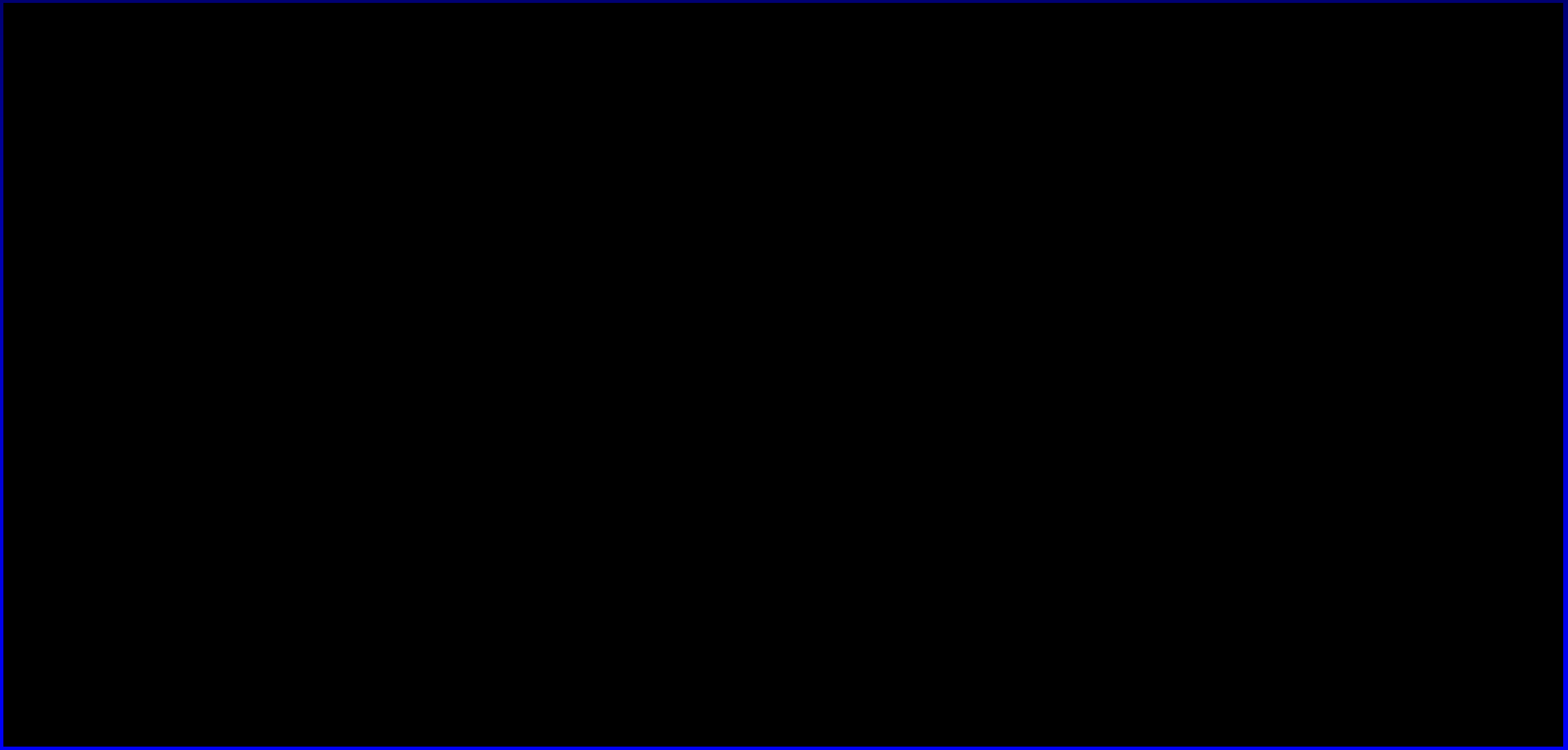
Knik Arm Site

	Power Production (kW)	Capital Cost (2010 $)	Cost per kWh (2010 $)	Annual O&M Costs (2010 $)
Knik Arm	17,000 kW	$123M	$0.11	$4.5M



Source: Polagye and Previsic, 2006



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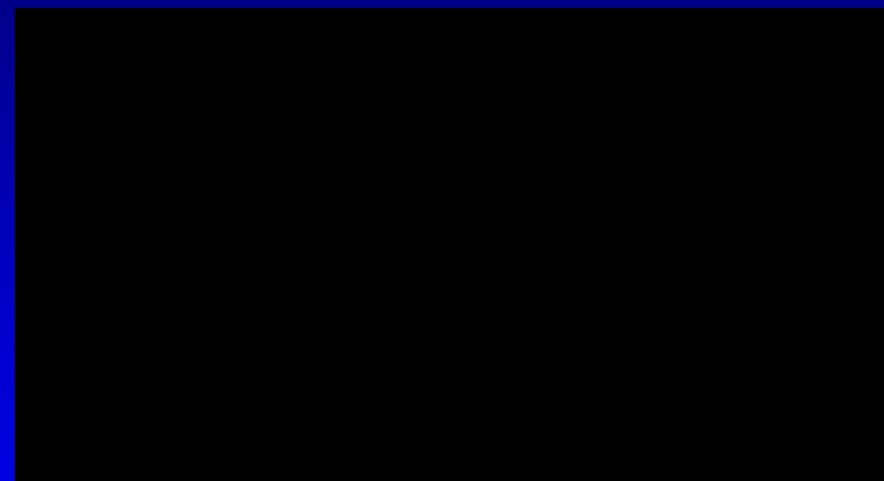
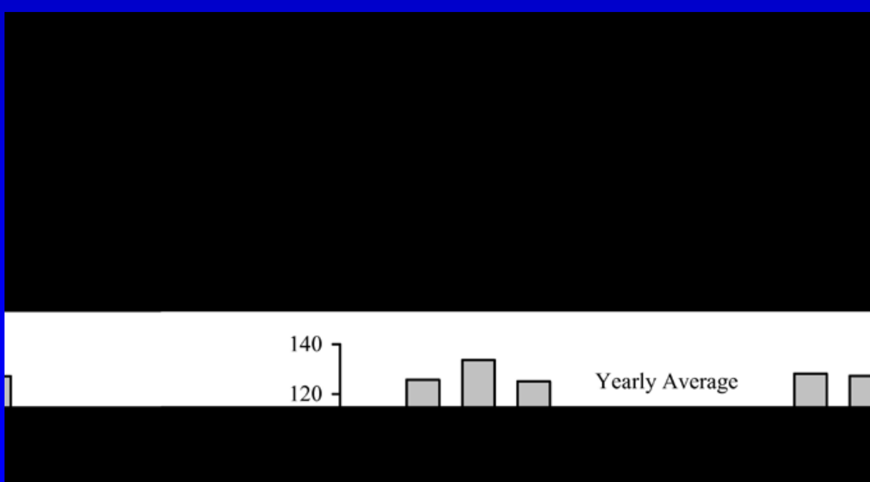
Theoretically available Cairn Point tidal power





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

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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, ???

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