Snohomish Power Needs

- Integrated Resource Plan (IRP) – Updated October 2013
  - covers the 15-year period from 2014 - 2028
  - expected 259 aMW load growth
  - target goal of 109 aMW of new cost-effective energy efficiency

- Need for renewable resources for load that exceeds aggressive conservation effort
  - 85% supply from BPA (BPA’s largest customer)
  - 9% from Market Purch
  - 6% from PUD Hydro
Tidal Energy

Why Tidal Energy?

• Clean, non-greenhouse-emitting, renewable resource
• Available locally
• Meets PUD policy focus (no greenhouse gas emissions)
• I-937 “Eligible” renewable resource
Tidal Pilot Project

• 10-Year Pilot license issued by the Federal Energy Regulatory Commission (FERC)
  – Install, operate and remove within 10-year license
  – Goal to collect 3-5 years of operational and environmental data

• Monitoring and Data Collection
  Objective is to generate relevant data to better evaluate the technical, economic, and environmental feasibility of tidal energy generation
Vicinity Map
Vicinity Map
1. CABLE LAY THROUGH HDD
2. HDD THROUGH SHORELINE ENVIRONMENT
3. TRUNK CABLE TERMINATED TO ONSHORE SWITCH VAULT

KEystone Harbor & Ferry Terminal

WSDOT Keystone Azimuth

Approx. High Water @ Shoreline

Keystone Conservation Area

Near Shore
On-Shore Details

OVERVIEW

1. SWITCH VAULT
2. TRANSFORMERS
3. POWER CONTROL & CONDITIONING BLDG. (PCCB)
4. BATTERY STORAGE SYSTEM
5. GRID CONNECTION EQUIPMENT
6. CONCRETE FENCED YARD
7. GRAVEL SURFACING
8. REVISED ACCESS APRON
9. REMOVAL OF EXISTING ACCESS
10. FLOODPROOFING PER FEMA
Power Conditioning and Control Building

1. NORTH ELEVATION
2. EAST ELEVATION
3. SOUTH ELEVATION
4. WEST ELEVATION
Functional One-Line

1 lunar day (~24 hrs) - Approx. Generator variable output

- 150 kW cap each

1 lunar day (~24 hrs) - Approx. Power to PSE Grid

- Variable Power 0-300 kW
- Constant Power 30 kW avg

Puget Sound Energy

- 7.2 kV - 1 Ø Overhead line

PSE Pole

- 240 VAC 1 Ø
- 7,200 VAC 1 Ø

Tidal Gen Controller Regenerative Drives

- Transformer 165 kVA

UL 1741 Grid Tie Converters

- 600 VDC BUS

- ~ 600 VDC in 240 VAC - 1 Ø - out

- 50 kVA

Batteries

- ~ 480 VAC 3 Ø in ~ 600 VDC out

Control Building

- 600 VDC max

Variable Voltage 0-480 VAC - 3 Ø

Constant Voltage 240 VAC - 1 Ø

Power and Voltage Conversion Functional Diagram

- Snohomish County PUD
- Admiralty Inlet
- Tidal Generation Project

- 0-400 VAC, 3 Ø
- 300 kW Nameplate each with 150 kW cap each

- Subsea Cable 2.2 km
- 0-4000 VAC, 3 Ø
- Voltage stepped up to reduce losses on cable
- Transformer 165 kVA

- 600 VDC BUS
- Batteries

- 600 VDC max
- 600 VDC - out

- 0-480 VAC, 3 Ø
- 0-480 VAC 3 Ø
- 240 VAC - 1 Ø
Project Permits

1. FEDERAL ENERGY REGULATORY COMMISSION (FERC)
2. HYDRAULIC PROJECTS APPROVAL (HPA) - WDFW
3. ISLAND COUNTY CONDITIONAL USE PERMIT (CUP)
4. ISLAND COUNTY BUILDING PERMIT
5. WASHINGTON ECOLOGY (401) – WATER QUALITY CERTIFICATE
6. NOAA FISHERIES CONCURRENCY – BIOLOGICAL ASSESSMENT
7. WASHINGTON STATE DOT (ACCESS)
8. WASHINGTON STATE DNR (AQUATIC EASEMETNS AND LEASES)
Construction

• Marine Operations effectively separated into 3-discrete operations with limited coordination:
  • Cable Installation (Qty-2)
  • Turbine Deployment (Qty-2)
  • Cable Connection (Qty-2)
Cable Installation
Cable Installation Concept

Cable Installation
1. 24-HOUR OPERATION
2. ROV Monitors Cable Installation
Cable-Lay Vessel (CLV) continues operation until it reaches Admiralty Bay. Vessel is arranged into a 4-point moor.

- Preset 4-Point Mooring Anchors & Lines
- Acoustic Release Buoy
Cable Installation Concept

CLV 4-Point Mooring
1. Two Tugs Leave Installation Site
2. Remaining Tug Provides Directional Control
3. HDD Pull Head (HPH) is Secured to the Shore-End of the Trunk Cable.
Commence Cable Installation

1. End of Main Export Cable is Removed from Dual Cable Pan
2. Additional Cable Needed for HDD is Paid out into Bay
3. Assist Vessel Tows End of Export Cable Towards Shore
Cable Installation Concept

Shore Cable
1. Assist Vessel Arrives at End of HDD at Shoreline
Cable Installation Concept

1. **Assist Vessel Arrives at Shoreline**
2. **Dynamometer Monitors Tension on CLV**
3. **Diver Monitors Installation at Bellmouth**

**Shore Cable**
- 1. Assist Vessel Arrives at Shoreline
- 2. Dynamometer Monitors Tension on CLV
- 3. Diver Monitors Installation at Bellmouth
Cable Installation Concept

1. Assist Vessel Removes Floatation Buoys as Needed
2. Diver Monitors Cable Catenary and Directs Cable through the HDD

Shore Cable
Shore Cable

1. Cable End Loop is Maneuvered Out of the Pan & Chutes
2. Excess Cable in Bay is Being Pulled Through HDD
3. Floatation Buoys are Being Removed at HDD End
Cable Installation Concept

Shore Cable
1. *Final Cable Loop is Lowered Over Cable Chute*
2. *Assist Vessels Continue Monitoring Installation*
Shore Cable

1. *Floatation Buoys are Removed at Each End.*
2. *Cable Catenary is monitored by Diver & Assist Vessels*
Shore Cable

1. *Cable is Installed on Seabed in Final Position*
2. *Remaining Buoys are Removed as Cable End is Pulled Through HDD*
3. *Diver Monitors Installation*
Shore Cable

1. Final Cable Position
2. Remaining Slack is Removed from Cable
3. Second Cable is a repeat performance
Turbine Deployment Operation
By OpenHydro

Tug

“OpenHydro Installer” Barge
OpenHydro Arrives on Station. Unit positioned over site & lowered.
OpenHydro Turbine Deployment

Fine timing of positions using tug tow line & 2-drives. Direction of tide & flow is measured & monitored closely as assembly approaches sea floor.
On bottom – Confirmation of positions, ensure unit is level & feet have not sunk. Release of hydraulics.
Recovery frame is now disconnected from the subsea base & raised back up to the barge.
Cable Connection Concept

Arrival Onsite
1. Barge Arrives During Weakening Flood
2. ROV is Deployed to Recover Line from Main Export Cable End
3. Modified Construction Barge Station Keeps
Cable Connection Concept

**Cable Recovery**

1. ROV Docks on Seafloor Next to Subsea Skid
2. ROV Recovers Line from Main Export Cable End
3. ROV Releases Dry Mate Housing from Skid
Cable Recovery

1. ROV Maneuvers Towards Construction Barge
Cable Retrieval

1. Linear Cable Engine (LCE) Winches in Cable End to the barge platform.
2. ROV Maneuvers Towards Subsea Base
Cable Connection Concept

Cable Retrieval
1. LCE Secures Cable End Aboard the Barge
2. System Health Check is Performed on Main Export Cable
3. Subsea Skid Remains on Seafloor for Future Use
Turbine Umbilical (TU) Retrieval

1. ROV Docks at the Subsea Base
2. ROV Releases the Cable End

Preinstalled Cable to Junction Bottle in Channel

ROV Docks at the Turbine Umbilical Storage Platform (TUSP)

Turbine Umbilical (TU) Retrieval
1. ROV Docks at the Subsea Base
2. ROV Releases the Cable End
Cable Tail Line Retrieval
1. ROV Releases cable from Integrated Capture Device (ICD)
2. ROV Recovers a Tag Line from the Cable Platform
Cable Tail Line Retrieval

1. Linear Cable Engine Winches Cable Tail Towards Barge
2. ROV Docks at Subsea Base & Monitors the Cable Recovery
Cable Tail Line Retrieval

1. Cable Tail is Brought Aboard the Barge
2. System Health Check is Performed on Cable Tail
Cable Connection Concept

Cable Redeployment
1. Barge Begins Lowering Cable in “S” Pattern
2. ROV Monitors Cable Placement on the Seafloor

Completed IPV Connection w/Bending Radius Protection
Cable Redeployment
1. Connector Housing is Deployed on Seafloor
2. ROV Monitors Final Placement
Monitoring Objectives

1. Those that are required for our FERC license mitigation
2. Those above and beyond the minimum that will add value to the future of Tidal Energy

All together can be summarized as:

- Studies evaluating Sea-Mammal Interactions
- Studies evaluating Turbine Noise
- Studies Evaluating the Impact to the Benthic Habitat – near field
- Water Quality
ENVIRONMENTAL MONITORING EQUIPMENT
ENVIRONMENTAL MONITORING EQUIPMENT

Optical Camera System

Acoustic Monitors
  1. Mammal Vocalizations
  2. Turbine Sound

Hydrophones
  1. Cetacean clicks
  2. Fish Tags

ADCP/Velocimeter

Water Quality Sensor

ADAPTIVE MONITORING PACKAGE (AMP)
ENVIRONMENTAL MONITORING EQUIPMENT

AMP and Delivery Vessel

Umbilical

Launch Platform

Current Direction
ENVIRONMENTAL MONITORING EQUIPMENT
6m EMEC Deployment
Contacts / Links

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PUD IRP & Tidal Power Development
• http://www.snopud.com/PowerSupply/irp.ashx?p=1161
• http://www.snopud.com/PowerSupply/tidal.ashx?p=1155

OpenHydro
• http://www.openhydro.com/technology.html

Ua Mau Ke Ea O Ka Aina I Ka Pono