Energy Potential of the Ocean vs. Available Technology in Nova Scotia

Topic #8b
Presented by Team #10

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PRESENTATION OVERVIEW

Introduction

- Background
- Topics for Comparison
- Technology

Ocean Energy Conversion Technology

- Tidal Power Generation
- In-Stream Power Generation
- Wave Energy Conversion

Recommendation

- In-Stream Power Generation

Conclusion

- Questions

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Background

- In 2010, the Nova Scotia government committed to increase the percent of renewable energy production from the 12% at the time to 40% by 2020.
- Nova Scotia has an enormous amount of energy at its disposal in its ocean resources. For example, the Bay of Fundy region.
- Nova Scotia is well set up to extract tidal power based on their existing infrastructure.
- Nova Scotia does not yet have a large amount of hydroelectric power, and has few grid connections to other cleaner energy sources outside the province.

Topics for Comparison

Ocean Energy Conversion Technology

- Technical overview
- Motivation for technology
- Environmental impact and sustainability
- Economic feasibility

TECHNOLOGY

Ocean Energy Conversion Technology

- Tidal Power Generation
- In-Stream Power Generation
- Wave Energy Conversion

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TIDAL POWER GENERATION

- Tidal barrage is built across the mouth of a large estuary
  - Sluice gates
  - Low-head hydroelectric turbines
- Single basin vs. Double basin
- Single basin
  - Ebb Generation
  - Flood Generation
  - Two-way Generation

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Tidal Power Generation

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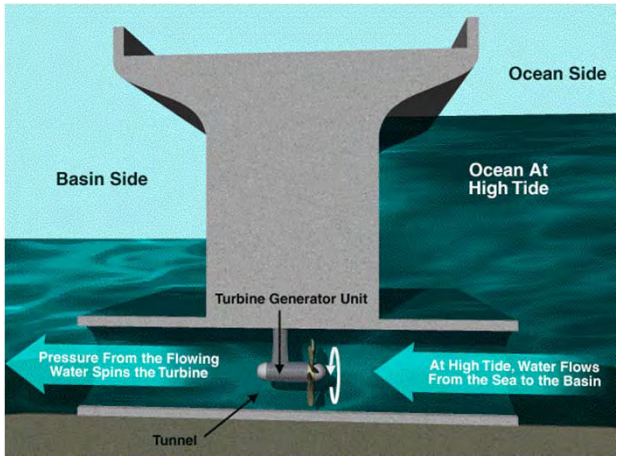
- Basic Principals



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Tidal Power Generation

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- Installations in Nova Scotia

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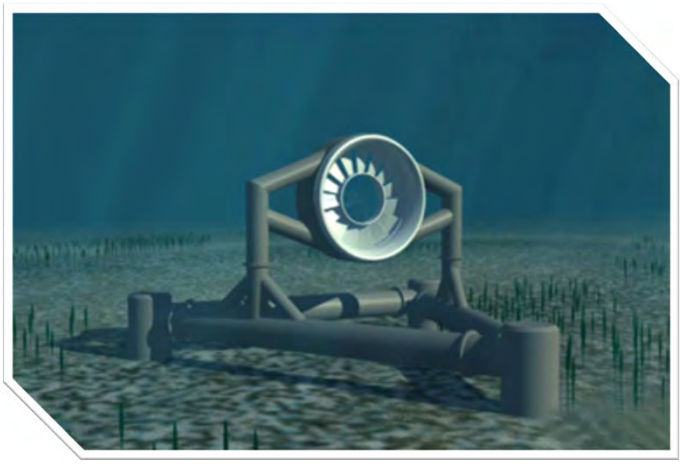
Tidal Power Generation

- Economics
  - Large capital costs
  - Long term payback
  - Averages around $0.10 / kWh
- Environmental considerations
  - Coastal regions
  - Migratory paths
  - Local economies

Tidal Power Generation

- Other Considerations
  - Integration with existing grid
    - Out of phase with solar cycle
  - Effect on local tourism
    - Link to NB / Maine
  - Potential for energy generation
    - Large tidal range
    - Comparatively small estuary areas

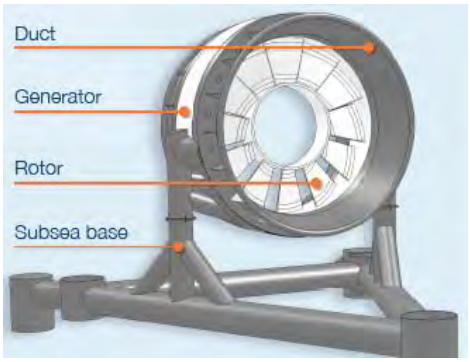
In-Stream Power Generation



In-Stream Power Generation

How does in-stream power generation work?

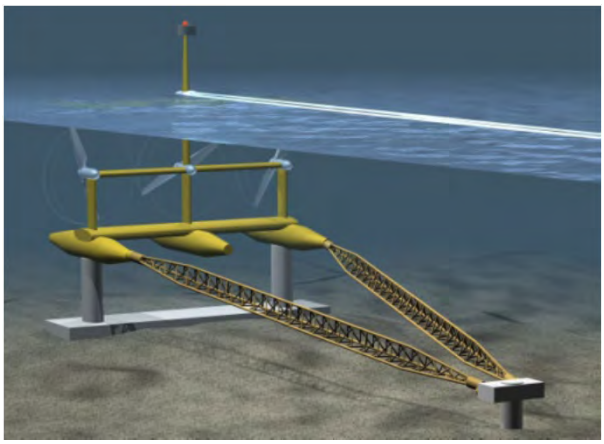
- Turbines are installed in fast-flowing water
- The water hits the turbine's blades, making it rotate
- The rotating turbine turns a generator, which produces electricity



In-Stream Power Generation

In-stream turbines take many different shapes

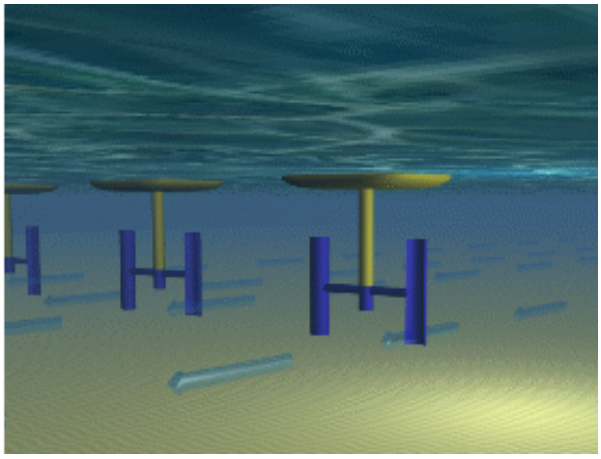
- Horizontal axis turbine



In-Stream Power Generation

In-stream turbines take many different shapes

- Vertical axis turbine



In-Stream Power Generation

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In-stream turbines take many different shapes

- Open center turbine

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In-Stream Power Generation

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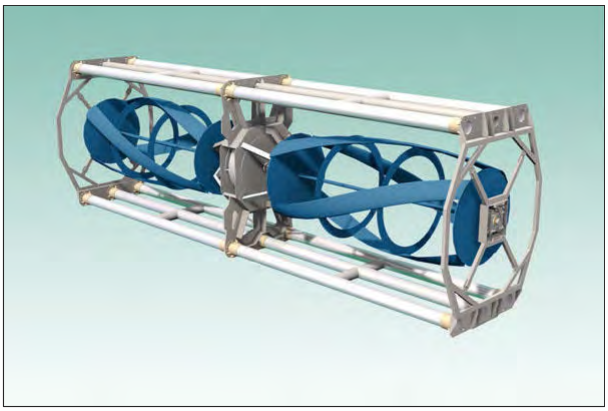
In-stream turbines take many different shapes

- Auger shaped, and many others



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In-Stream Power Generation

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Why use in-stream power generation in Nova Scotia?

- In-stream tidal power requires strong currents, the faster, the better
- Doubling the current speed increases power output by a factor of 8
- Nova Scotia's Bay of Fundy region sees a greater flow with each tidal cycle then all the rivers in the world combined
- Sites in both the Bay of Fundy and Cape Bretton have currents which reach speeds of 5m/s.

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In-Stream Power Generation

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Fundy Ocean Research Center for Energy (FORCE)

- Test site in the Minas Passage region of the Bay of Fundy. The 5km wide passage causes fast currents ideal for in-stream generation

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In-Stream Power Generation

Fundy Ocean Research Center for Energy (FORCE)

- 4 berths set up for testing in-stream tidal turbines, ready to be leased to private companies
- 1 major deployment has already taken place (OpenHydro).
- Two other major projects under development by an Alstrom and a partnership between MCT/Minas Basin Pulp and Power

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In-Stream Power Generation

Environmental Impact

- Overall environmental impact is low to non-existent
- Multiple environmental assessments have found no increase in mortality/injuries for fish, marine mammals, and other wildlife
- A FORCE study found that installation of Open Hydro turbine had no discernible impact on lobster distribution.

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In-Stream Power Generation

Sustainability

- Tidal power is renewable, its primary source of energy comes from the tidal force
- An estimated 300 MW of power could be safely extracted from the Minas Passage region alone.
- 300MW of clean, tidal energy would prevent 1 million tonnes of annual greenhouse gas emissions, the equivalent of taking 200,000 cars off the road

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In-Stream Power Generation

Economic Considerations

- Tidal power is currently expensive.
- A 1MW turbine carries a price tag of $10M
- The 11km of cabling required to set up the FORCE test site cost $11M to manufacture and install
- Current price of in-stream power: $0.35/kWh
- Better engineering and economies of scale could drop this price to $0.06/kWh, which is on par with energy from wind turbines

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Wave Energy Conversion

The Pelamis Wave Energy Conversion System

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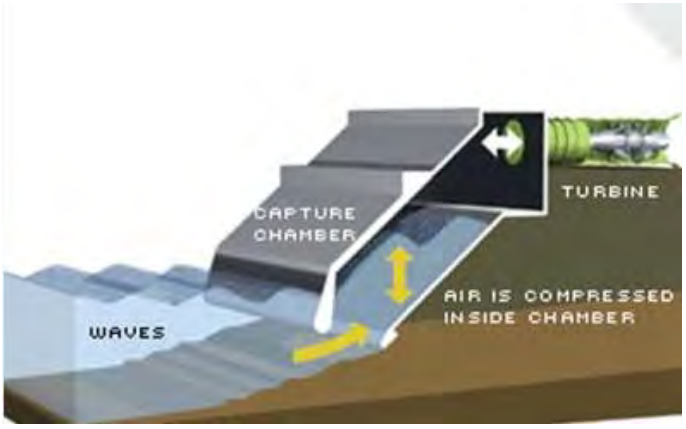
Wave Energy Conversion

The Limpet Power Station



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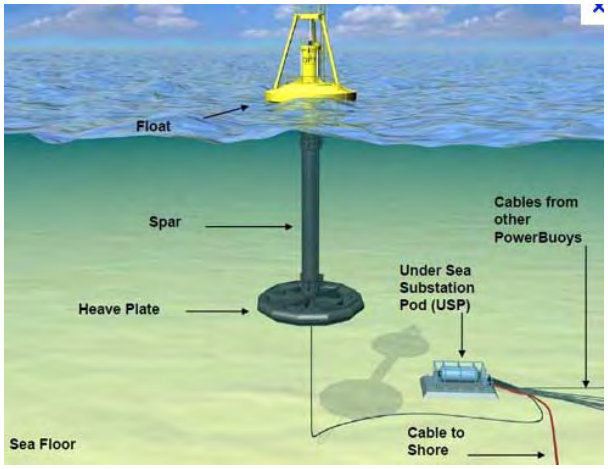
Wave Energy Conversion

The Powerbuoy



Wave Energy Conversion

Global Wave Energy Flux

Wave Energy Conversion

WEC Environmental Impacts

WEC Platform	Natural Envir. Impact	Economic Impact	Aesthetic Impact
Onshore	**Low** – only affects immediate region around the plant	**Low** - only affects immediate region around the plant	**High** – Highly visible change to existing coastline
Offshore	**Med** – Buoys and undersea cables are relatively static and only disrupt the environment due to there large area use	**High** – wave farms could displace traditional harvesting grounds and pose navigation risks	**Low** – does not disrupt the coastal aesthetics due to there location offshore

Wave Energy Conversion

WEC Economic Feasibility

Technology	Cost per unit ($CAN)	Price per kilowatt ($CAN/kWh)	Kilowatt Produced (MW)	Scalable
Pelamis	$1,000,000	0.29	1	Yes
Powerbuoy	$4,000,000	0.15	0.15	Yes
Limpet	$6,000,000	0.05	0.5	No
Average	**$3,700,000**	**0.15**		

RECOMMENDATION

Consideration	Tidal Power	In-stream	Wave Energy
Cost ($/kWh)			
Practicality in NS			
Environmental Impact			
Ranking			

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CONCLUSION

Ocean Energy Conversion in Nova Scotia

- Nova Scotia has a huge ocean resource
- In-stream power generation is the most suitable technology

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QUESTIONS

For More Information:

- Fundy Ocean Research Center for Energy (FORCE)
- Nova Scotia Department of Energy
- Nova Scotia Power – Annapolis Tidal Station

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