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Overview of
Wave and Tidal Current Energy
Research in the South Pacific

Presenter: **M. Rafiuddin Ahmed**

The University of the South Pacific
Laucala Campus, Suva, Fiji Islands



Overview of Wave and Tidal Current Energy Research in the South Pacific **AWTEC2012**

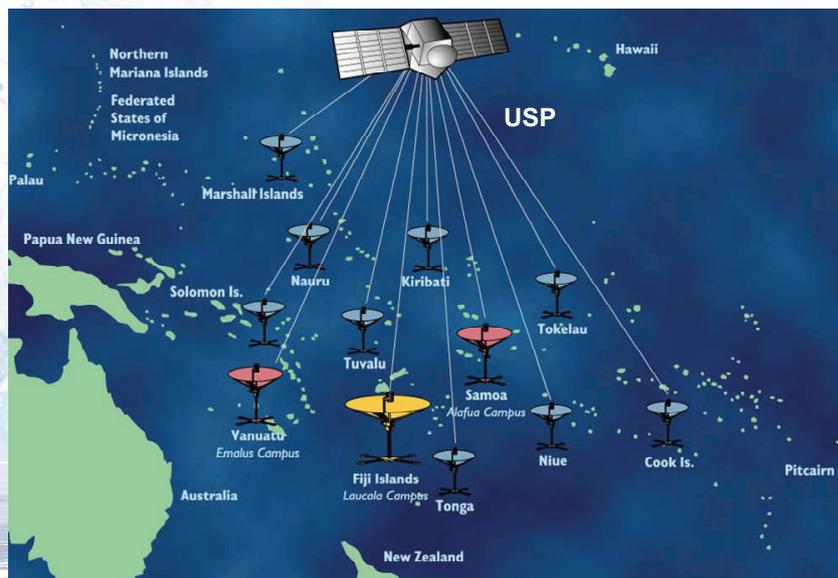
Background

- Climate Change impacts in the Pacific – very serious and will impact the lives and livelihoods of the people.
- Sea level rise is a major threat – need to help reduce carbon emission. One Pacific country Tuvalu is the first victim of rising sea level. Some of the leaders of Tuvalu have conceded defeat in the battle with rising sea, announcing they will abandon their homeland.
- Cost of buying fossil fuel – significant part of the countries' GDP.
- The need for sustainable solutions for survival.
- Geographical layout of Pacific (scattered islands and unavailability of power grid) needs tailor-made solutions that may differ from the rest of the world.

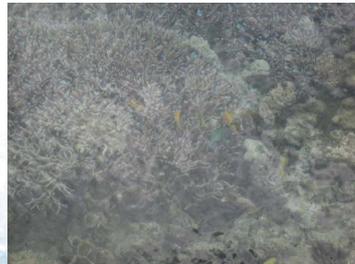
Background

- Most of these PICs have preserved their natural land and ocean resources, making them attractive tourist destinations and a major source of income.
- USP – the main University in the region - 33 million sq. km of ocean, an area more than three times the size of Europe.
- Total land mass is about equal to area of Denmark.
- A very high ratio of sea-area to land-area e.g. this ratio > 4000 for one country Kiribati.
- This unique nature of PICs makes offshore energy a clearly **ATTRACTIVE OPTION**.

Background



Background



Fiji and other PICs are rich in terms of natural resources.

Wave Energy

➤ There is good potential for wave energy extraction in PICs. Our ongoing work includes assessment of wave energy potential at selected locations as well as development of energy conversion devices.

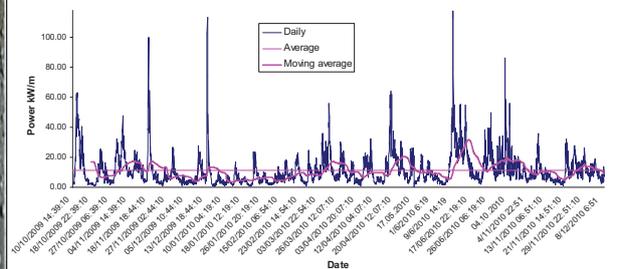
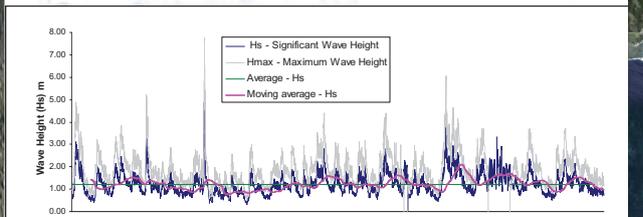
Country	Electricity Generation Potential (kW/m)	The U.S. Wave Energy analysis in 2003 using WEM Average WEM Power Output (kW)
Cook Islands	23 – 30	324
Fiji Islands	23 – 29	296
Kiribati	10 – 15	-
Samoa	16 – 25	253
Tonga	17 – 29	279
Tuvalu	15 – 20	-
Vanuatu	10 – 20	-

Sources: Ocean Wave Energy in the South Pacific – the resource and its utilisation; Country Reports by the US. Wave Energy

Wave Energy

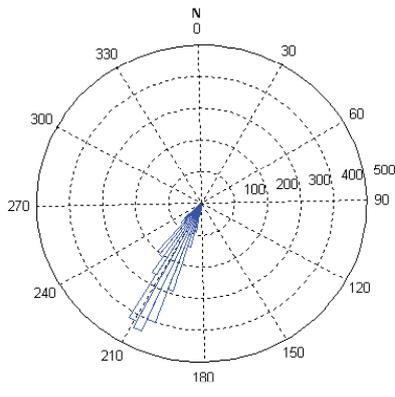
- Earlier works in PICs focused on deep waters as more energy is available in deeper waters, but now the focus is on near-shore and on-shore locations.
- Recently, completed projects on measurement of wave characteristics at two near-shore locations in Fiji.
- Recently, we acquired 3 waverider buoys from Datawell. One of them is deployed near Taveuni. One will be deployed near Kadavu (south) and the third one near Cook Islands.
- Apart from wave energy assessment, the buoys will provide the wave activity in the region and will be linked to the NOAA database.

Wave Energy



Wave heights and wave power at a depth of 15m west of main island.

Wave Energy



The results of wave measurements – wave Rose for mean incoming wave direction – Oct 2009 to Dec 2010.

Summary:

Avg. Wave Height = 1.23m.

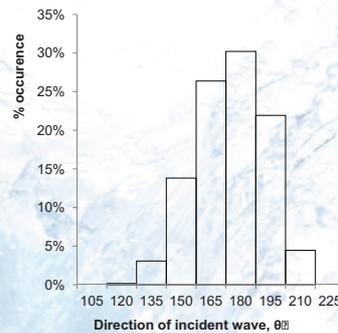
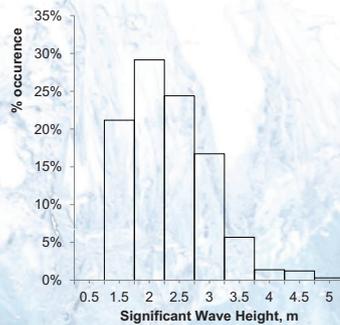
Avg. Power = 11.16 kW/m.

Mean direction: SSW – SW.

This is considered good potential for a depth of only 15 m. This depth is very practical for deploying WECs such as OWC.

Bathymetry & Geotechnical survey under progress.

Wave Energy

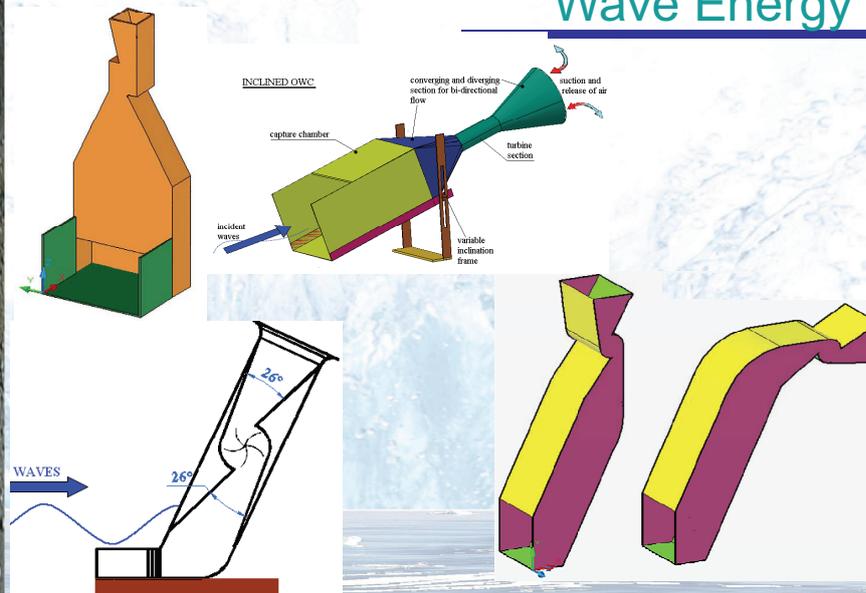


Wave measurement results at a depth of 18 m in the southern Fiji.

Wave Energy

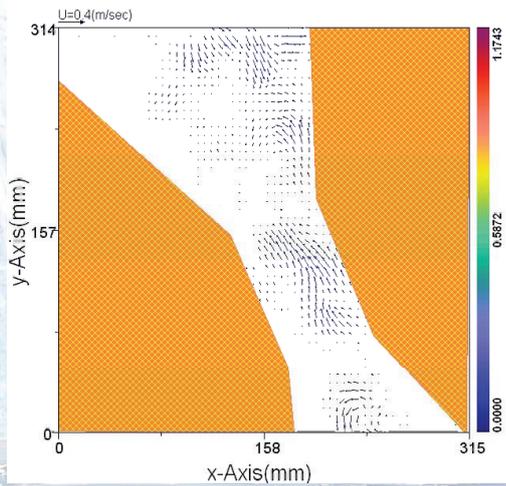
- We are also working on new WECs.
- An innovative concept of a rectangular OWC designed to direct bi-directional flow onto the blades of a Savonius rotor is successfully demonstrated.
- This has advantage of provision to increase width of chamber in practical systems and extract more power from waves by employing either a large rotor or a number of rotors in segments; this is not possible in circular OWC devices.
- Other advantage is ease of construction & operation of rectangular OWC devices as well as Savonius rotors.

Wave Energy



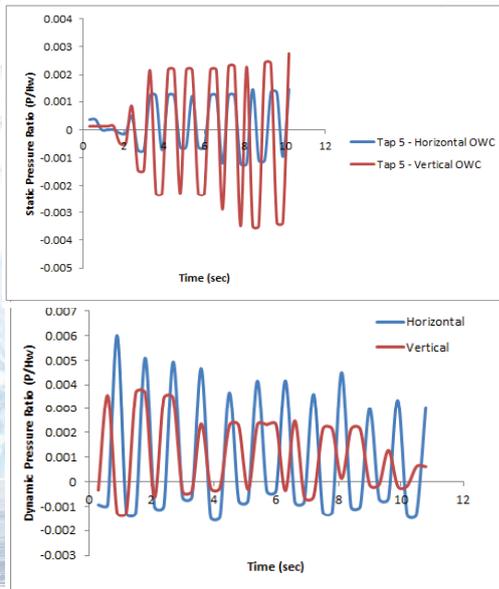
OWC devices tested in USP wave channel.

Wave Energy



Velocity vectors (video) for air in the inclined OWC device.

Wave Energy



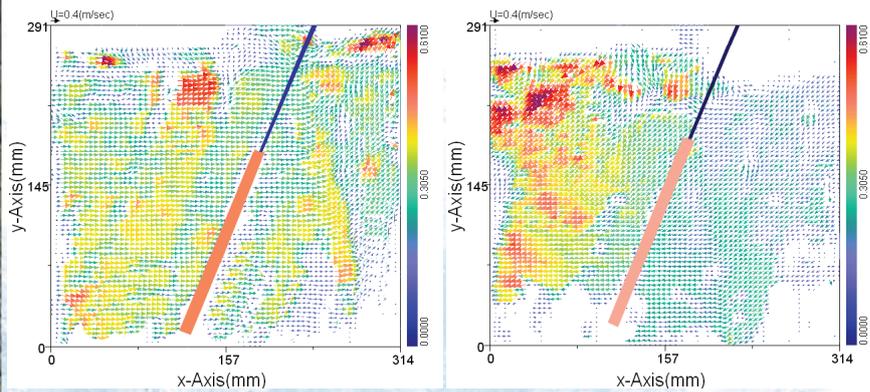
Comparison of the static and dynamic pressures of air in horizontal and vertical test sections of OWC devices.

Wave Energy

- Another device that is of interest to wave energy researchers is the pendulum, which oscillates due to the action of waves and the shaft rotation is converted to electricity.



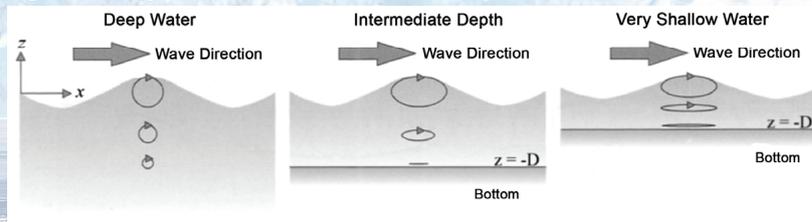
Wave Energy



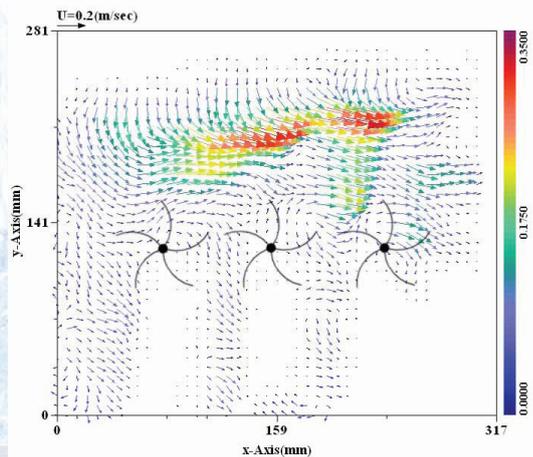
Velocity vectors around pendulum in forward & backward motions. Interestingly, the particles retained their paths even in presence of a big paddle.

Wave Energy

- In wave motion, water particles are known to follow orbital paths. This orbital motion was studied and a number of Savonius rotors that extract energy from the orbiting particles were built.
- The maximum energy is extracted when the rotor is placed close to the water surface at the minimum submergence. A large number of rotor configurations were tested experimentally and an optimum geometry obtained from the results.



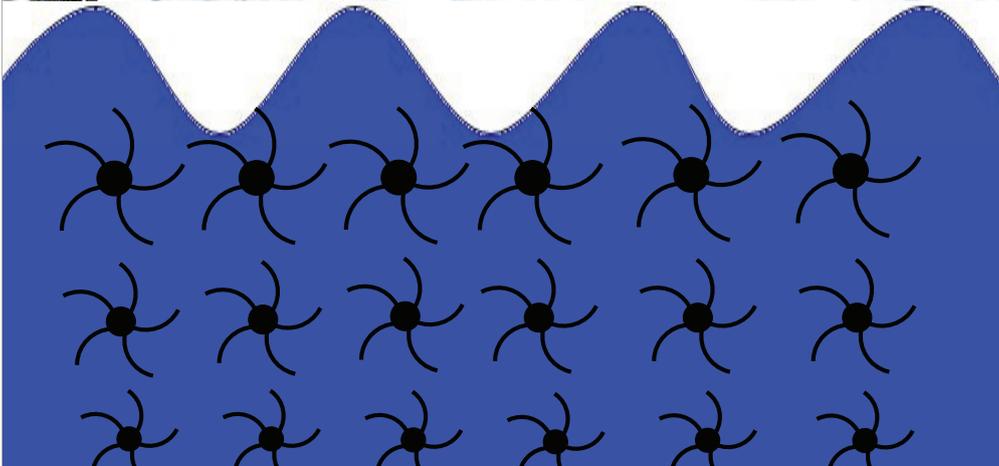
Wave Energy



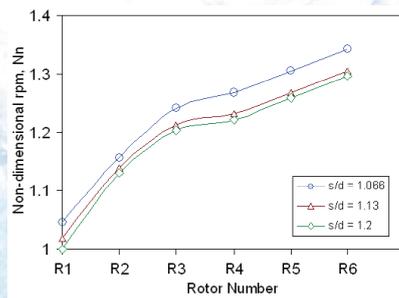
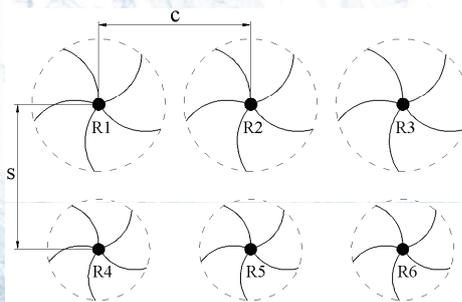
Rotors driven by the orbital motion of particles (video).

Wave Energy

- A number of rotors can be mounted in an array.
- There can be multiple arrays of rotors as shown (animation)



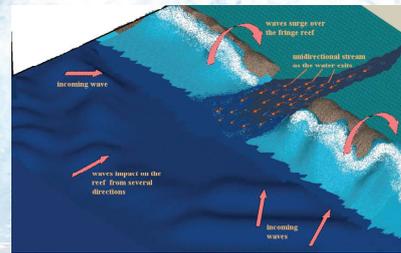
Wave Energy



Effect of spacing (vertical) on RPM of two arrays of rotors.

Tidal Current Energy

➤ A number of sites in Fiji and PICs have good tidal currents. Attempts are being made to quantify the tidal currents in the PICs at individual as well as organizational levels. We are working on two projects – one at national level and the other at regional level to do this assessment.



Some interesting sites where we did assessment.

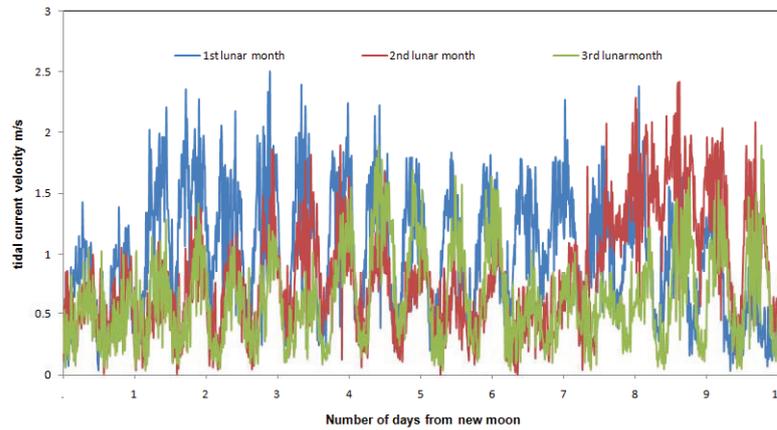
Tidal Current Energy

➤ Normally, if peak current speed exceeds 2 m/s, site is considered good for tidal current power generation. From the initial assessment, we have already identified more than 25 locations in PICs with good potential.

➤ Measurements are completed at 4 locations and currently underway at 2 more.

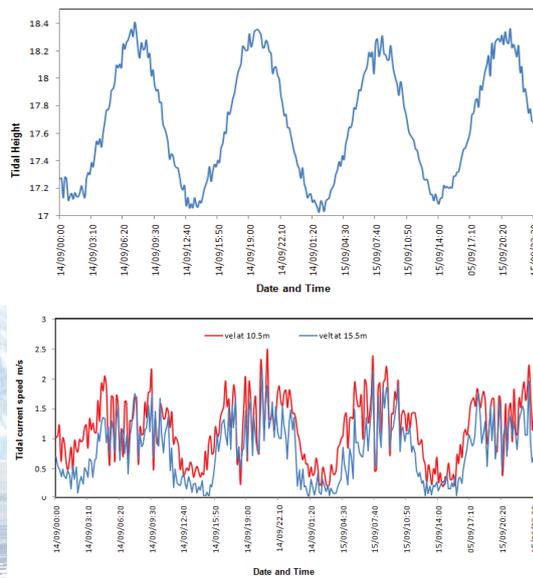


Tidal Current Energy



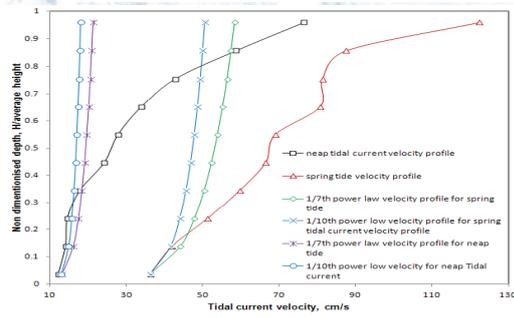
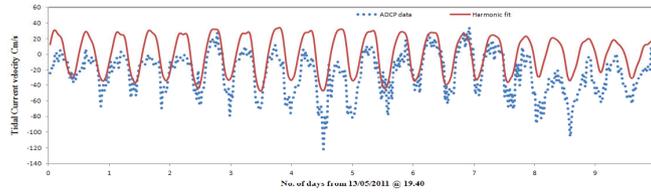
Current velocities for first 10 days of lunar month at a location in Fiji (Sigatoka).

Tidal Current Energy



Relation between tide height and tidal current velocities for a couple of days.

Tidal Current Energy

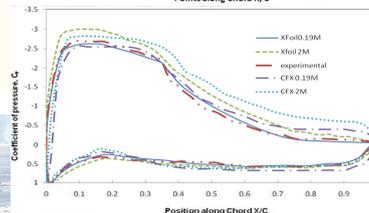
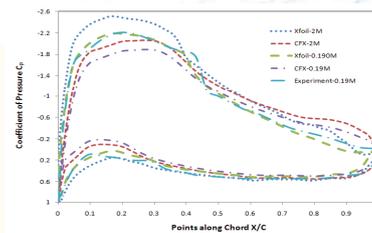
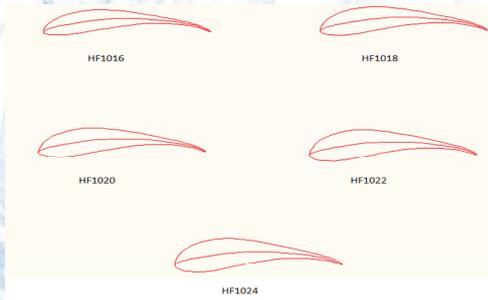


Harmonic fit (top) for another location in the west of Fiji (Wilkes passage).

Velocity profiles (left) and comparison with power laws profiles.

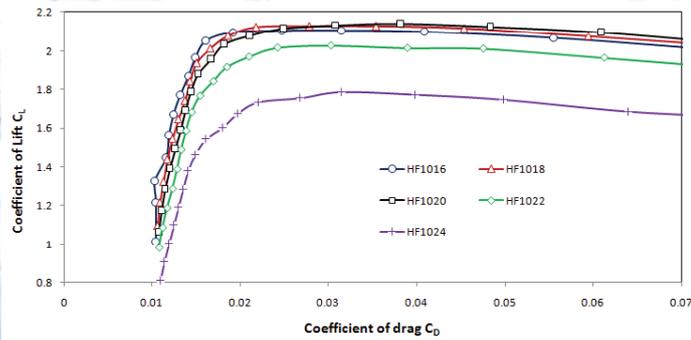
Tidal Current Energy

A horizontal HATCT is designed for the above location with varying thickness from tip to root region.



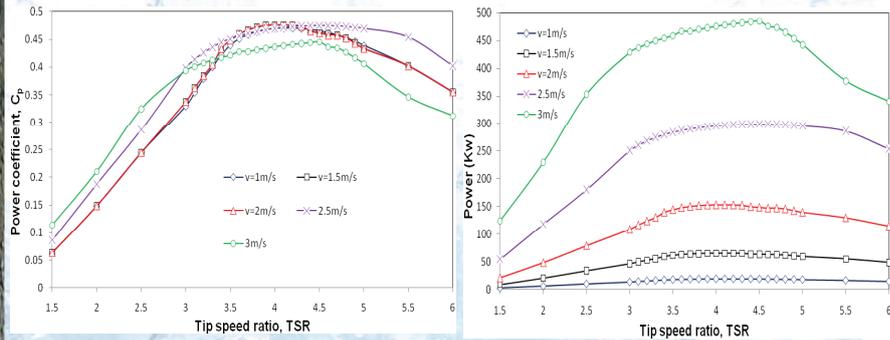
Profiles of the 5 sections and pressure distributions of the 20% thick section at angles of attack of 6° and 10°.

Tidal Current Energy



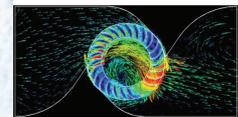
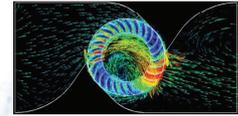
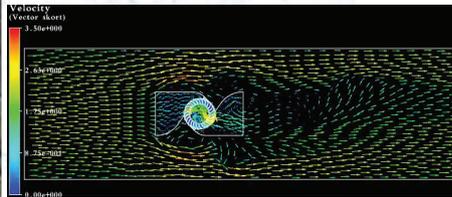
The drag polars for the five blade sections.

Tidal Current Energy

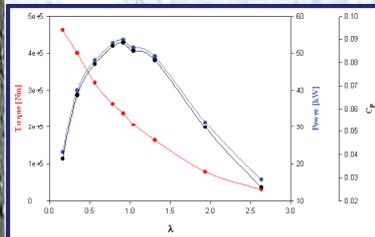


The power coefficient and power output of the 10m HATCT at different TSR.

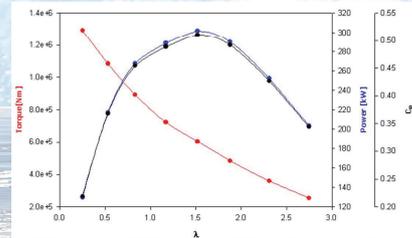
Tidal Current Energy



Performance of multiple cross-flow turbines occupying the channel width



Performance of a single cross-flow turbine in a wide channel



Summary

- There is an enormous potential for marine renewable energy extraction in the PICs, which exceeds the energy requirements. The available energy density is not as high as in some European countries, but then the requirement is also not large.
- Many islands with small populations will require only a few hundred kW to meet all their energy requirements, which can easily be met by a single WEC or HATCT.
- Another area the Government is looking at is wave-powered desalination, and some of our near-future measurements will be performed with this objective.

How Different is This?



A location where the depth is about 40 m (video).

**Thank You!!
Vinaka!!
Kamsa-hamnida!!
QUESTIONS & Comments???**