Tidal Energy

MOST ATTRACTIVE WHEN USED IN COMBINATION WITH ANOTHER SYSTEM
- DESALINATION
- DEEP WATER MARICULTURE

A. Introduction

2. Ocean Thermal Energy (OTEC)

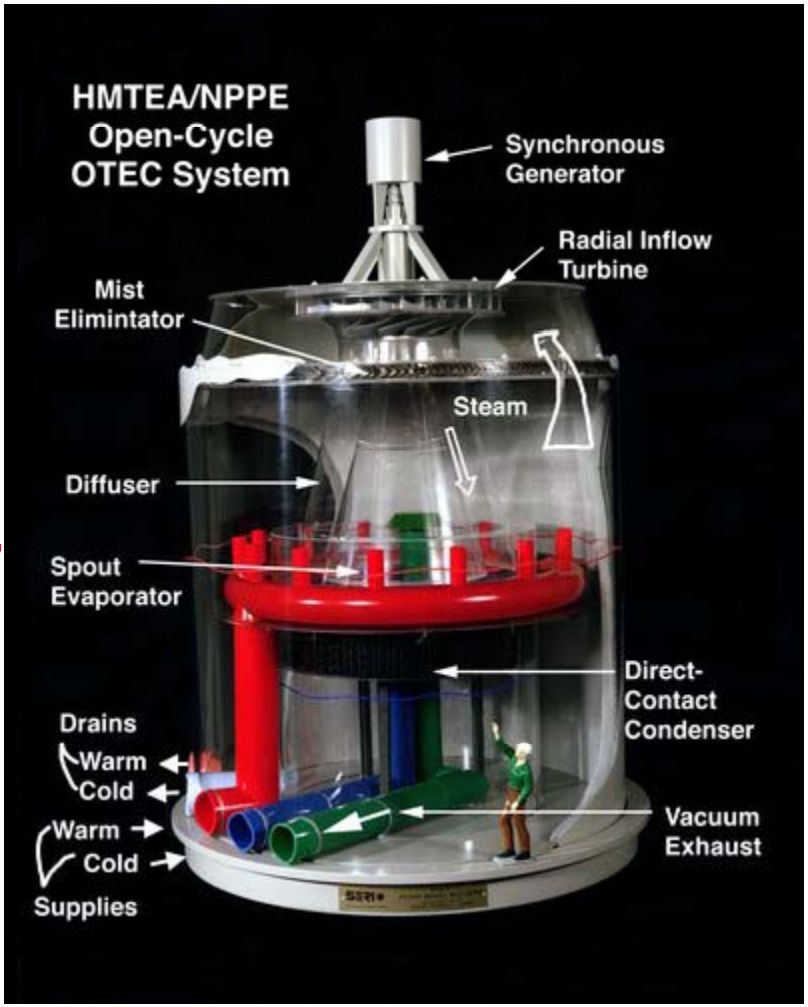
CONCLUSION

TEMPERATURE DIFFERENCE EXISTS BETWEEN
SURFACE 25°C
DEEP NEAR 0°C
↳ 500-1000 m DEEP

USE A HEAT ENGINE TO EXTRACT ENERGY

ADVANTAGES
VAST RESOURCE
ESPECIALLY ATTRACTIVE IN TROPICS

CHALLENGES
TEMP. DIFFERENCE IS LOW → LOW EFFICIENCY
PUMP REQUIREMENTS LARGE
↳ REDUCES NET ENERGY PRODUCED



Tidal Energy

A. Introduction

3. Tidal Energy

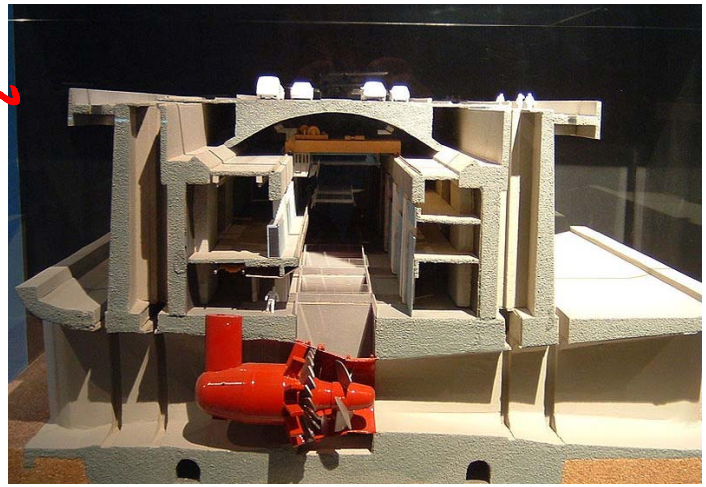
LEVEL OF WATER IN LARGE OCEANS RISES & FALLS

- REPEATING PERIOD 12 hr, 25 MINUTES
- HEIGHT CHANGES 0.5 m – 10 m
- PERIODIC CURRENTS NEAR LAND MASSES OF UP TO 5 m/s

RANGE POWER

CAPTURE WATER IN A TIDAL BASIN BEHIND A DAM

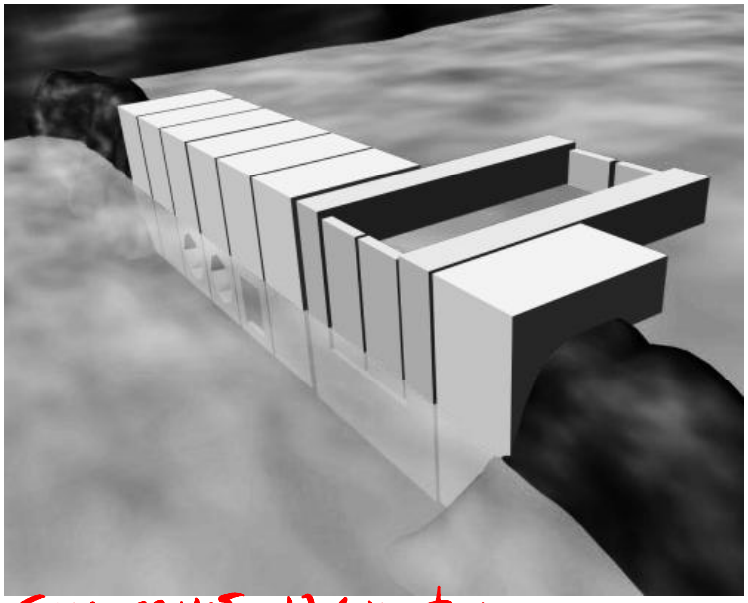
RUN WATER OUT THROUGH A TURBINE AT LOW TIDE



Tidal Energy

A. Introduction

3. Tidal Energy



RANGE POWER

$\bar{P}$ = AVERAGE POWER PRODUCED

$\bar{P} = \rho A R^2 g / (2\tau)$

A = BASIN AREA ρ = WATER DENSITY

R = RANGE – HEIGHT CHANGE BETWEEN SUCCESSIVE HIGH & LOW TIDES

g = GRAVITY τ = TIME BETWEEN TIDES

FOR $A = 10\ km^2$ $R = 4m$ $\tau = 12\ hr\ 25\ min$ $\rho = 1000\ \frac{kg}{m^3}$ $g = 10\ \frac{m}{s^2}$

$\bar{P} = 18\ MW$

NOTE: LARGE RANGE DESIRABLE

$\bar{P} \sim R^2$

Tidal Energy

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RANGE POWER

ADVANTAGES

TIDAL CHANGES WELL CHARACTERIZED & ACCURATELY PREDICTED

POTENTIAL USE FOR ENERGY STORAGE

- PUMP MEAL HIGH TIDE TO INCREASE HEIGHT

CHALLENGES

- MISMATCH BETWEEN TIDAL PERIOD & 24 HR DAY
- LONGER TERM CHANGES IN TIDES POWER OUTPUT VARIES
- HIGH VOLUME, LOW HEAD TURBINES
- LARGE CAPITAL COST
- LIMITED # OF LARGE RANGE SITES
- ENVIRONMENTAL IMPACTS

Moulin à marée de l'île de Bréhat (Bretagne, France).
Photographer: Flore Allemandou

Tidal Energy

A. Introduction

3. Tidal Energy

STREAM POWER

USE KINETIC ENERGY IN CURRENTS TO GENERATE POWER IN SIMILAR MANNER TO WIND TURBINES

POWER DENSITY IS STILL $\frac{1}{2}\rho u^3$

CONSIDER $u = 3\ m/s$ $\rho = 1000\ \frac{kg}{m^3}$

POWER DENSITY $13,500\ \frac{W}{m^2}$

CURS 7 WIND POWER IS $800\ \frac{W}{m^2}$ @ 50M

CURRENT VARIES WITH TIME IN MOST APPLICATIONS

RIVERS ALSO CONSIDERED → CURRENT VARIES WITH WATER AVAILABLE

EAST RIVER NYC

Tidal Energy

A. Introduction

3. Tidal Energy

STREAM POWER

ADVANTAGES — SIMILAR TO RANGE POWER

- HIGH POWER DENSITY – STRUCTURES CAN BE SMALLER THAN TYPICAL WIND TURBINE
- PREDICTABLE OUTPUT POWER: TIME & MAGNITUDE

DISADVANTAGES — SIMILAR TO RANGE POWER

- LIMITED TO LOCATIONS WHERE SUFFICIENT CURRENT EXISTS
- ENHANCED CURRENTS NEAR LAND MASSES
  - STRAITS
  - BAYS
  - INLETS

Tidal Energy

B. Tide Physics

BASIC MECHANICS OF TIDES ARE WELL UNDERSTOOD

DETAILS ARE NOT

→ TERRAIN FEATURES OF OCEAN/BAY

OCEANS HELD ON EARTH THROUGH EARTHS GRAVITY

IF EARTH HAS ONLY EFFECT, WATER SURFACE WOULD ALL LIE AT SAME DISTANCE FROM EARTH CENTER

GRAVITATIONAL ATTRACTION FROM MOON & SUN PERTURBS TIDE BALANCE

↳ FORMS BULGE IN OCEAN LEVEL

EARTH ROTATES BENEATH BULGE

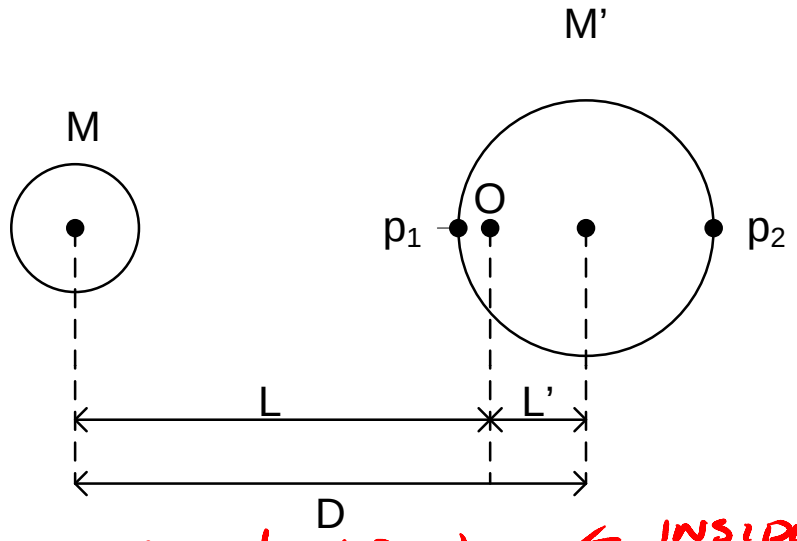
- EXPLAIN 24 HOUR PATTERN
- SOURCES OF BULGE MOVE → DEVIATION FROM 12 HOURS

TIDE POWER IS THUS DERIVED FROM EARTH'S ROTATION

Tidal Energy

B. Tide Physics

1. Lunar Tide



FROM ROTATING DYNAMICS

$ML = M'L'$

SUBSTITUTE TO SHOW

$L' = \frac{MD}{M'+M}$

SOLVE FOR L' USING NUMBERS $L' = 4670$ km ← INSIDE EARTH'S RADIUS

WE CAN APPLY DYNAMICS FROM

$\frac{GMM'}{D^2} = M\frac{V_M^2}{L}$ CONSIDER MOON ROTATING ABOUT EARTH AT $V_M = \omega L$

$= ML\omega^2$

← DETERMINES ROTATIONAL VELOCITY