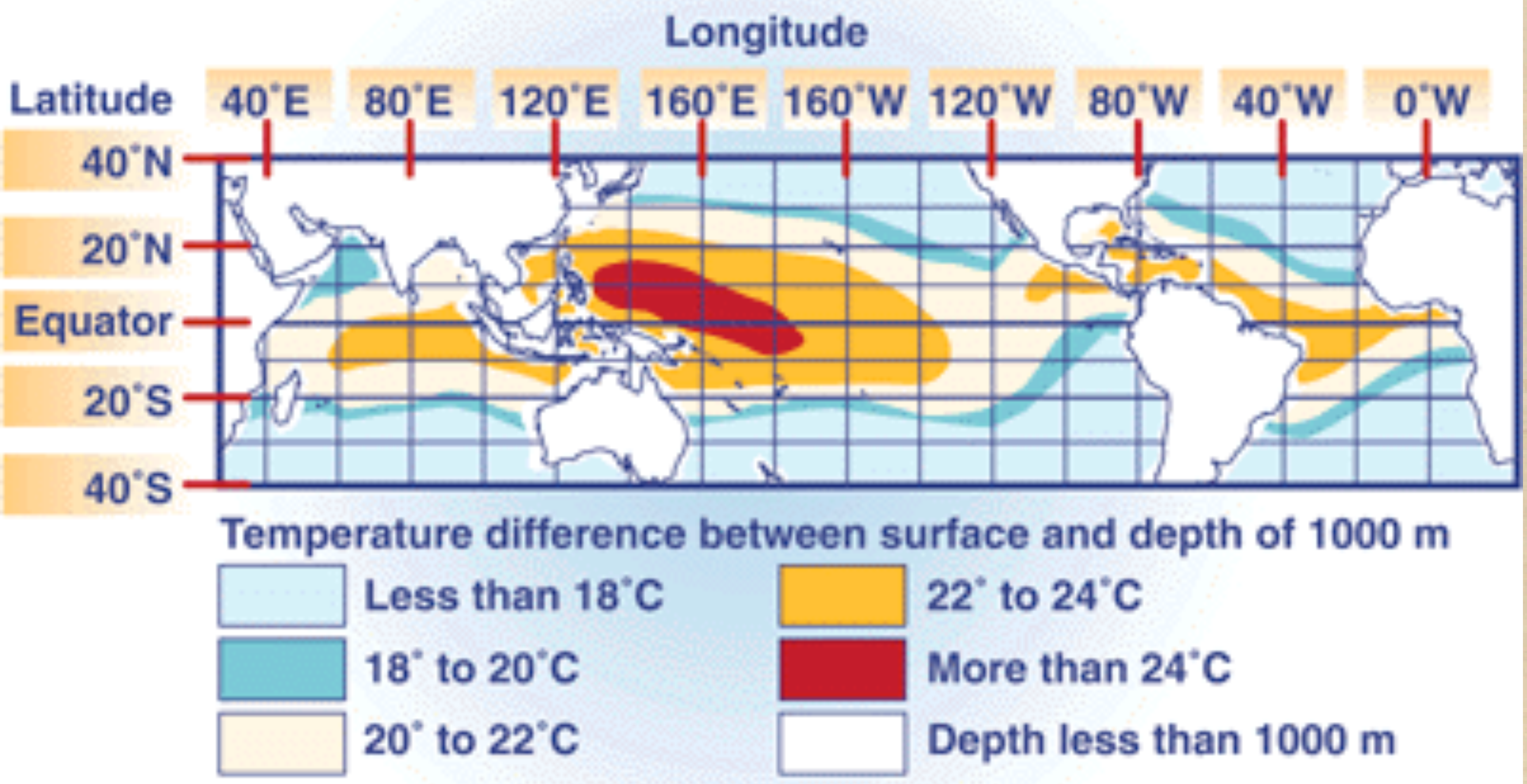
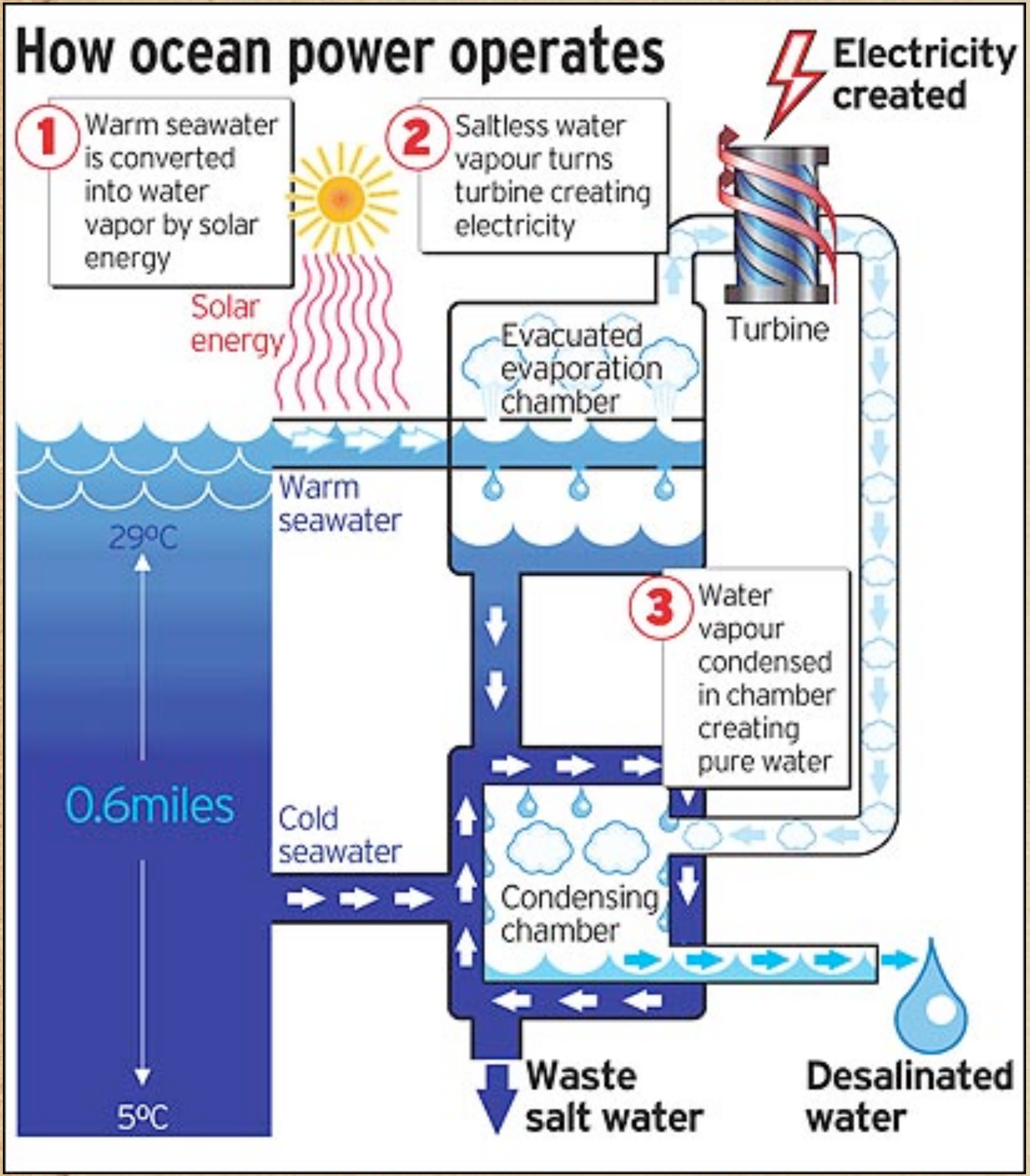
Lecture 24

May 30, 2012

OTEC
Ocean Thermal Energy Conversion



Water at surface is much warmer than water at 1000m depth. Can we use the temperature gradient of 20^{0}C?



$$\eta = \frac{T_H - T_C}{T_H}$$

$$\eta = \frac{15}{300} \sim 5\%$$

If we cool 1000 gallons of water by 2ºC, the power generated is 32 MW. At 5% efficiency this gives 1.6 MW output as usable power.

Offshore plants could produce Hydrogen that can be transported by ships..

Not a big player as yet, and rather cool response in US to this technology.

Biofuels/Biomass

Motivation

> All of a sudden, you know, we may be in the energy business by being able to grow grass on the ranch! And have it harvested and converted into energy! That's what's close to happening.
>
> GWB: Feb 2006

Ford T was built to run on either ethanol or petrol!!
And then we discovered the middle eastern oil fields!

Biomass

Photosynthesis

- 5 billion yrs ago, the atmosphere had H_2, He, N, CO_2, NH_3 and water but no oxygen
- 3 billion years ago we had oxygen and plant life, H_2 , He escaped the earth.
- Photosynthesis is key, anaerobic processes (no Oxygen required) created carbohydrates

$C_x(H_2O)_y$ are carbohydrates, e.g. $C_6H_{12}O_6$ fructose

Light= ENERGY

$$6\ CO_2 + 6H_2O + 674\ \text{kcal} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

Glucose

We may thus think of carbohydrate production by sunlight through this reaction.

A rough rule:
4300 cal energy needed to grow a gram of carb.

Respiration: opposite of PS

$$Carbodydrate + O_2 \rightarrow Energy\ (ATP)$$

Rate of carbohydrate production, agriculture, grains -> Alcohol-> Gasohol

We can say something quantitative about the total agricultural production on the basis of the solar constant!

$$Solar\ constant = 0.5 cal/min/cm^2$$

$$47\%\ reaches\ earth$$

$$\sim 500 cal/(cm^2 \cdot day)$$

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$$25\%\ correct\ wavelength\ for\ PS$$
$$70\%\ absorption\ by\ foliage$$
$$35\%\ light\ useful\ for\ PS$$
$$\sim 6\%\ of\ total$$
$$\sim 30\ cal/(cm^2 \cdot day)$$

Convert cal to grams using
a rough rule:
4300 cal per gram of carb giving
75 gm/(m² x day)

Experimentally one finds about 70 gm/(m² . day) of grain production averaged over many species

This comes out as ~5% of total energy, pretty close to our estimate of 6%!!

- Hubbert's data says total solar power available for PS is 40 TW.
- We can calculate the total potential production from this as $8\text{x}10^{16}$ gm/year on earth.

$$15\ tons/(acre \cdot year) \times 350 \times 10^6\ acres\ = 5.25 \times 10^9 Tons/year$$
$$at\ 4300\ (cal/gm) \sim 79 \times 10^{15} BTU$$

$$79 Quadrillion BTU\ versus\ 98 QBTU\ used!!$$

Gasohol: 10% ethanol + petrol. Good for combustion efficiency and is promising.

Nuclear Energy

- Vast possibilities
- Much worry about safety, partly based on experience
- Further ideas for safer harvesting
- Need to know the basics:

$$^{236}_{92}U \rightarrow ^{90}_{36}Kr + ^{143}_{56}Ba + 3n + \ 199 Mev$$

Fission reaction: Need to understand the symbols and concepts.

$E = m\ c^2$

General name	name	Charge	Mass	Mass x c^2
Nucleon Strongly interaction (Hadrons)	proton	+e	1.007 u	983 Mev
	neutron	0	1.008 u	984 Mev
Leptons	electron	-e	.00054 u	
	neutrino	0	~small	

$c = 3 \times 10^8\ m/sec$

u=1.66x10 $^{-27}$ kG

$1MeV = 10^6\ eV\ \ = 1.6 \times 10^{-13} J$

Nucleus

A nucleus consists of Z protons and N neutrons.
Its mass is close to (but not exactly) (A=N+Z) u.
Their nomenclature is as follows:

${}^{A}_{Z}(\text{Symbol})_{N}$

or sometimes simply as

${}^{A}_{Z}(\text{Symbol})$

Nomenclature:
A= Mass number
Z= Atomic (or proton) number
N= Neutron number
A=Z+N

Example of abundant oxygen

${}^{16}_{8}O_{8}$ or more simply ${}^{16}_{8}O$

In nature we also find other "isotopes" of Oxygen

${}^{17}_{8}O_{9}$

${}^{18}_{8}O_{10}$

${}^{14}_{6}C_{8}$

A few important nucleii, and their isotopes

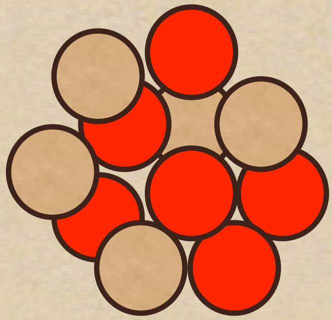
$Hydrogen\ {}^{1}_{1}H$ Stable hydrogen

$Deuterium\ {}^{2}_{1}H$ Stable heavy hydrogen

$Tritium\ {}^{3}_{1}H\quad halflife =\ 12\ years$

Helium	$^{4}_{2}\mathrm{He}$ $^{3}_{2}\mathrm{He}$	
Carbon	$^{12}_{6}\mathrm{C}$ $^{14}_{6}\mathrm{C}$	- 5600 yrs
Uranium	$^{238}_{92}\mathrm{U}$ $^{235}_{92}\mathrm{U}$	
Plutonium	$^{244}_{94}\mathrm{Pu}$ $^{239}_{94}\mathrm{Pu}$	

Radius of a nucleus ~ 10^{-15} m, i.e. a fermi



Strong interaction forces bind the nucleons together, overcoming their Coulomb repulsion by an even stronger attraction.

Binding energy and mass defect.

The reason a nucleus is stable is due to the binding energy. We can say:

$E_{nucleus} = E_{nucleons} - E_{Binding}$

or

$E_{Binding} = E_{nucleons} - E_{nucleus}$

$M_{defect} = E_{Binding} / C^2$

$$E_{Binding} = (Total\ energy\ of\ Z\ protons\ and\ N\ neutrons) - (total\ energy\ of\ nucleus)$$

$$\Delta m = (total\ mass\ nucleons) - (mass\ nucleus)$$

Example of $^{14}{}_{7}$ N nitrogen nucleus:

Nuclear Mass - 7 electron mass= 13.9992 u

Mass of nucleii (7 p + 7 n)= (.112356+ 13.9992)u

Mass defect = .112356 u

Binding energy = 1.004 10^{13} J

10 tons of this substance gives 98 QBTU !!!!