

Ch. 15.4, 15.5 Notes

IV. Additional Renewable-Energy Options

A. geothermal energy (*geo-therm* = "Earth heat")

1) background info.

- a) *using naturally heated water for steam turbines to produce electricity*
- b) water is heated by *magma*
 - three categories

high temp. >150 °C medium temp. 100-150 °C low temp. < 100 °C

- c) used in over 30 countries

2) pros

- a) no radioactive waste products
- b) *can aid agriculture and aquaculture in cold climates*
- c) helpful to areas without access to fossil fuels
- d) some scientists believe *we have barely tapped into this power supply*

3) cons

a) *water issues*

- *water from watershed/waterways being depleted*
 - * *damming / diverting water flow*
- *water taken from reservoir*
 - * *subsidence*
 - * *salt water intrusion*
 - * *lowered water table*

b) *land issues*

- *loss of vegetation*
- *soil erosion / landslides*
- *ownership issues*

c) *waste (brine and condensate) disposal issues*

- *biological and chemical implications*

d) *re injection issues*

- *cooling of water*
- *possible seismic activity*

e) *air emissions*

- *fogging of the area*
- *slight heating of the area*
- *biological and chemical effects*

f) *noise pollution*

- *hearing loss*
- *nuisance/ disturbance*

from GEO – Geothermal Education Office

<http://geothermal.marin.org/http://geothermal.marin.org/>

- *"Aquifer* - a porous or fractured body of rock carrying cold or hot water.
- *Basin or Sedimentary basin* - a bowl-shaped depression in the earth filled with sedimentary rocks (rocks usually formed in water such as sandstone, limestone, etc.).
- *Fault* - a break in the earth's crust which extends a considerable distance (horizontally and vertically) along which relative (sliding) movement occurs.

- *Fumarole* - a flow of steam from the ground. Fumaroles can be weak or strong, noisy and superheated (temperature above boiling).
- *Hot spot* - a relatively small area of a plate heated by a rising plume of magma from deep within the mantle which produces local volcanic activity over a long time period.
- *Plate* - a rigid part of the earth's crust that moves relative to other plates. The map shows eight major plates and several minor ones.
- *Plate boundary* - where two plates meet.
- *Rift* - a part of the crust that has been pulled apart, usually bordered by faults. A rift zone is a rift with bordering faults. When rifting occurs, magma can move near the surface, forming volcanoes and geothermal systems. Rift zones may become plate boundaries.

U.S. Geothermal Energy Overview:

“The west coast boundary between the North American and Pacific plates is "sliding" along the San Andreas fault... from the Gulf of California up to northern California and subducting from the Cascade volcanoes north through the Aleutians. There are also volcanic hot spots under Yellowstone and Hawaii and intra-plate extension with hot springs in the Great Basin...

California generates the most geothermal electricity with about 824 MWe at the Geysers (much less than its capacity, but still the world's largest developed field and one of the most successful renewable energy projects in history), and ~800 MWe elsewhere in CA. There are also (geothermal) power plants in Nevada, Utah, and Hawaii, with plans in other states. Due to environmental advantages and low capital and operating costs, direct use of geothermal energy has skyrocketed to 3858 GWh/yr, including 300,000 geothermal heat pumps.

In the western United States, hundreds of buildings are heated individually and through district heating projects. Large greenhouse and aquaculture facilities in Arizona, Idaho, New Mexico, and Utah use low-temperature geothermal waters, and onions and garlic are dried geothermally in Nevada.”

Geothermal direct-heat usage:

(from <http://www.worldbank.org/html/fpd/energy/geothermal/>)

33%	space heating	12%	heat pumps	1%	snow melting; A/C
15%	bathing	10%	industry		
13%	aquaculture	3%	misc.		
12%	Greenhouses	1%	agricultural drying		

B. tidal power

1) *pros*

- a) *produces no liquid or solid pollutants*
- b) *little aesthetic impact*
- c) *acts as coastal shelters*
- d) *minimal difficulty to migrating fish*

2) *cons*

- a) *tidal difference is too close (usually less than 2 ft)*
- b) *only 30 places have the topography (land layout) to do this*

3) *locations*

- a) *Canada: Annapolis Tidal Generating Station*
 - *BEC - Blue Energy Canada, new projects*
- b) *France: Rance estuary in Northern France*
 - *largest tidal power station in the world*
 - *only one in Europe*
 - *built in 1966*
- c) *San Francisco Bay*

from http://www.pollutionengineering.com/CDA/ArticleInformation/features/BNP__Features__Item/0,6649,107271,00.html

“*Blue Energy California (BE-Cal) is pursuing the development of ‘The Brothers’ Tidal Fence concept to generate high-density, renewable energy adjacent to in Point San Pablo, City of Richmond (San*

Francisco Bay, north of the Richmond-San Rafael Bridge). The proposed 1000-foot long by 80-foot deep turbine array will generate some 70-100MW, or more than 1,170MWh per day.”

- 4) Tidal Electric, Inc. – proposals
 - a) UK (second-highest tidal range in the world)
 - b) Swansea Bay, China

C. Ocean Thermal Energy Conversion (OTEC)

- 1) experimental technology – most of the R & D work is done in Europe
- 2) Types of systems
 - a) *Closed-cycle systems*

From http://www.nrel.gov/learning/re_ocean.htm

“Closed-cycle systems *use the ocean's warm surface water to vaporize a working fluid*, which has a low-boiling point, such as ammonia. *The vapor expands and turns a turbine...*”

- b) *Open-cycle systems*

“...Open-cycle systems actually *boil the seawater* by operating at low pressures. This produces steam that passes through a turbine/generator.”

- c) *Hybrid systems* – use both methods

V. Policy for a sustainable energy future

Energy Efficiency and renewable-energy technology

- A. **Energy Star** and **Green Lights** programs—*government-backed programs to protect the environment through high energy efficiency*
- B. **PNGV - Partnership for a New Generation of Vehicles**
- C. **Global Change Research Program** (<http://www.usgcrp.gov/>)
- D. **Deregulation** of power companies—choose your provider
- E. *Net metering*—pay less if you have solar cells, etc.
- F. Commitments from oil companies to reduce Greenhouse gas emissions