Lecture 22

May 23, 2012

Important table

Electric power statistics from DOE

Thousand MHW= 10^9 WH

Description	2009
Net Generation (thousand megawatthours)	
Coal[1]	1,755,904
Petroleum[2]	38,937
Natural Gas[3]	920,979
Other Gases[4]	10,632
Nuclear	798,855
Hydroelectric Conventional[5]	273,445
Other Renewables[6]	144,279
Wind	73,886
Solar Thermal and Photovoltaic	891
Wood and Wood Derived Fuels[7]	36,050
Geothermal	15,009
Other Biomass[8]	18,443
Pumped Storage[9]	-4,627
Other[10]	11,928
All Energy Sources	**3,950,331**

Thousand thousand megawatt hr=
10^{12} watthour= TWH
where T=Tera

1 Quad= 293 TWH
100 Q= 29700 TWh

Total Generation = 3950 TWH
=134 Quad
Coal = 1755 TWH

Solar Thermal + PV = .891 THW

Fusion ideas 2010 Livermore Labs

Could This Lump Power the Planet?
Newsweek Nov 2009 and last year
Scientists at Lawrence Livermore National Lab are betting $3.5 billion in taxpayer money on a tiny pellet that could produce an endless supply of safe, clean energy.

This target chamber is 10 meters in diameter and weighs 287,000 pounds.
It contains small pellets of radioactive material (deuterium-tritium fuel) that are to undergo fusion.

More prosaic but very useful applications for airconditioning airports in sunny cities

Heliodynamics @ Albequerque, NM

The Albuquerque International Sunport is a world-renowned, full-service airport facility that welcomes more than six million travellers per year. The Sunport Car Rental Center houses a number of major car rental companies which service the majority of the Sunport users.

We were commissioned to design and install a solar air-conditioning system which would provide both cooling and heating to the facility. With no available ground area for solar collection we placed our collectors on top of carports in the parking lot area. The system we designed and installed consisted of eighteen HD16 solar collectors. These feed heat to either an absorption chiller providing cooling or provide space heating to the facility.

Installed Capacity: 216 kW
Application: Air conditioning
Completion Date: Dec, 2009

HelioDynamics

ENERGYMIXX

Case Study - 2009

Albuquerque, USA

- 216kW
- Solar Air Conditioning
- Heating
- HD16 (18 modules)
- Roof mounted

General Idea behind solar cooling

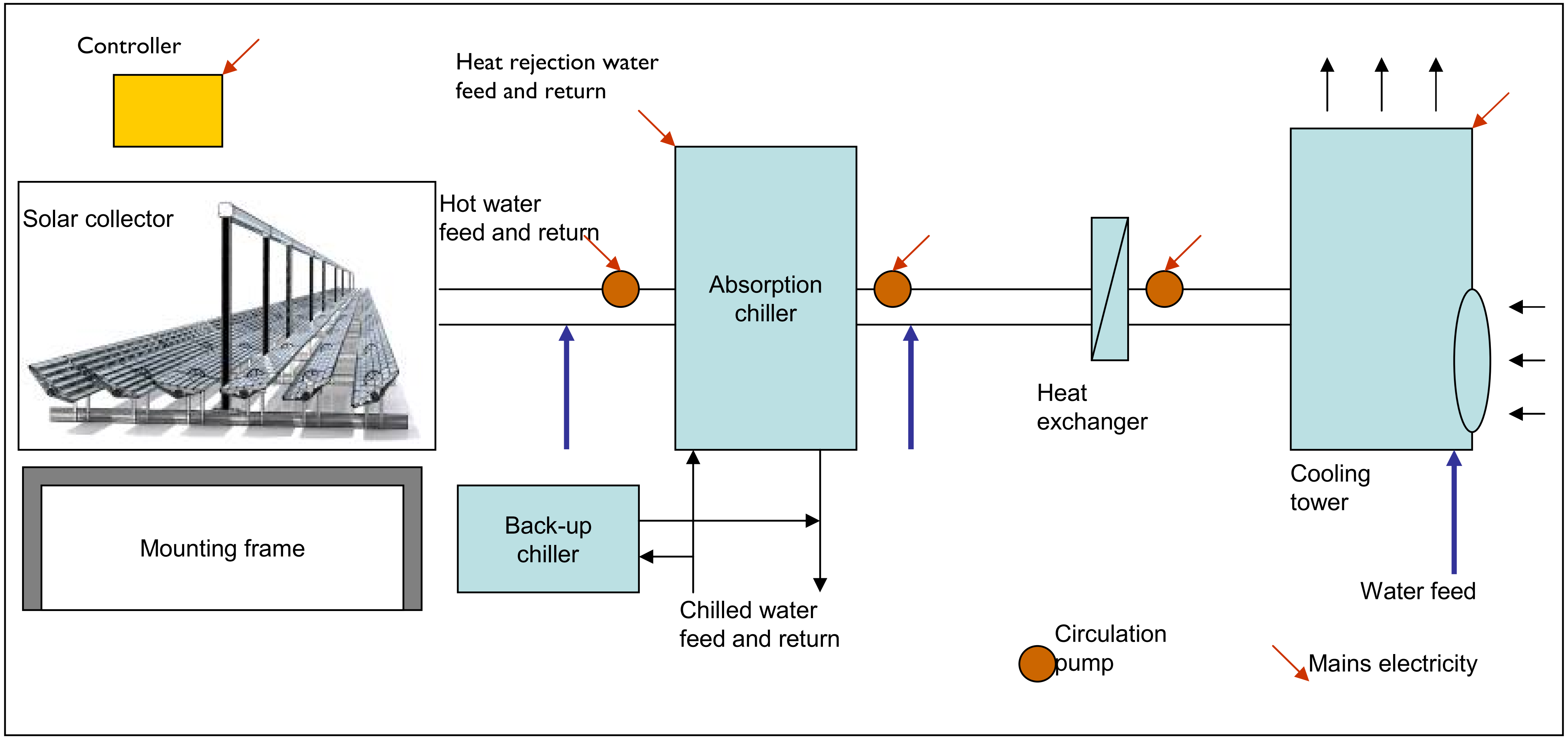
Exploit evaporative cooling cycles
i.e. Desert Coolers

Active solar cooling wherein solar thermal collectors provide input energy for a desiccant cooling system:

Air can be passed over common, solid desiccants (like silica gel or zeolite) to draw moisture from the air to allow an efficient evaporative cooling cycle. The desiccant is then regenerated by usin solar thermal energy to dry it out, in a cost-effective, low-energy-consumption, continuously repeating cycle. A PV system can power a low-energy air circulation fan, and a motor to slowly rotate a large disk filled with desiccant.

The potential for near-future exploitation of this type of innovative solar-powered desiccant air conditioning technology is great.

Solar chillers…

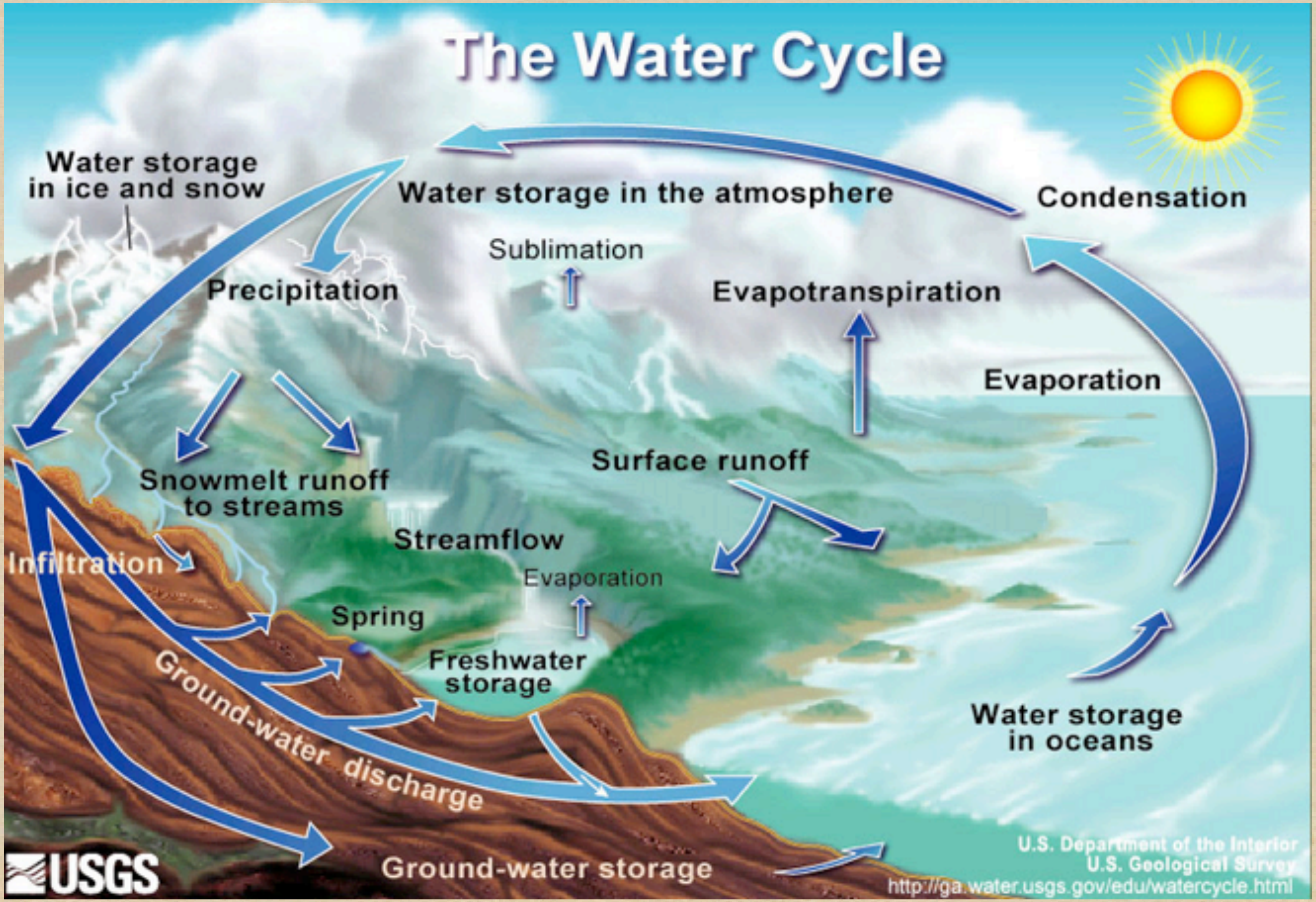


Renewable Energy sources

- Hydroelectric power
- Ocean derived power
- Tidal energy
- Wind power
- Geothermal energy
- Biomass

Hydroelectric power

- Hydel power per se
- Pumped storage systems
- Dead sea project and other examples



Water power is conversion of potential energy of water to electrical energy, e.g. by turning a turbine.

- 80% to 90% efficient
- Cyclical and weather (precipitation) dependent
- In USA currently less than 7% of total usage from 30% in post war years

Head= "h" the height of water

Potential energy of water

$$E = Mgh$$

$$g = 9.8 \text{ meter}/\text{sec}^2$$

Example: Water drops in a hydel project with a head of 90 meters. How much water flow is needed to produce 10 kW power, assuming 80% conversion efficiency?

Let x liters of water flow per second.

Hence mass flow is x kg/sec (using density of water - d =1 kg/Liter)

Power = energy /time = M gh/t = (M/t) g h

$$Power = x(kg/sec) \times 9.8(m/sec^2) \times 90m$$

$$= x \times 882\ kg\ m^2/sec^3$$

$$= x \times 882\ watts$$

$$\text{Watt} = \text{kg}\ meter^2/\text{sec}^3$$

Next equate these:

$$0.8 \times x \times 882\ watts = 10^4\ watts \qquad x = 14.17\ Litres\ /sec$$

River discharge rates:

Amazon = 219 Million Litres/sec

= 219,000 m^3 /sec (1 m^3= 10^3 L)

Ganges = 42 Mil L /sec

St Lawrence = 10 M L/s

Ohio - Missisippi = 8 ML/s

Problem:

If we can drop the Ohio river by 10 meters, what is the generated power?

$$Power = 8 \times 10^6 \ (kg/sec) \ \times 9.8 \times (m/sec^2) \ \times 10(m)$$
$$= 0.8 \times 10^9 \ Watts$$

$$Total\ energy\ per\ year = Power \times 365 \times 24\ Watt\ hour$$

$$Total\ energy\ per\ year = 5.6\ TeraWatt\ hour$$