"Photovoltaics" → <u>def</u>: a method of converting solar radiation into DC electricity using semiconductors (or other materials) that exhibit the photovoltaic effect

1) <u>World Energy Sources</u>

a. So called "Fossil Fuels" - coal, oil, natural gas

* oil may be "slowly" renewable : carbonates into subduction zones

b. Nuclear

c. Geothermal

d. Solar

① <u>indirect solar</u>: bio-fuels, wind, wave (→ tidal?), hydro/hydroelectric

② <u>direct solar</u>: thermal, photovoltaics

2) <u>Energy from the Sun</u>

a. Solar "Power" reaching the Earth's outer atmosphere:

$$\sim 10^{17}\,W = 10^{8}\,GW\ !$$

→ <u>Solar Constant</u> → solar power reaching the Earth's atmosphere:

$$= 1366\ W/m^2 = 1.366\ KW/m^2$$

~30% is lost passing through the atmosphere

→ yields an <u>insolation</u> at Earth's surface of about $1000\ W/m^2$

→ Defined at sea level on a clear day

→ The accepted standard for "strong sunshine"

b. <u>Annual Mean Insolution</u>

→ Earth is a sphere with a circular solar footprint

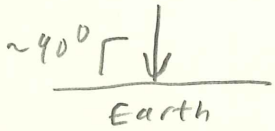
→ $A = \pi R^2$, $R \equiv$ Earth's radius

→ Earth is approx. a sphere: $SA = 4\pi R^2$, that spins

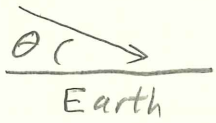
∴ annual mean insolation above the atmosphere is approximately $= 1366/4 = 342\ W/m^2$

→ However, it is shared very unequally

Over Equator



Near Poles



$\theta \ll 90°$

① <u>Atmospheric Losses</u> ~30%

→ absoption by atmospheric gases (wavelength dependent)

→ scattering by dust and other molecules *

→ clouds *

* vary with local climates

Ex. Avg. insolution at Earth's surface:

Sahara Desert ~ $300\ W/m^2$

Near Poles ~ $80\ W/m^2$

② If we know avg. insolation, use 8760 hrs to determine total energy received over 1 year

Ex: London/Berlin → avg. insolation $= 120\ W/m^2 = 1050\ KWh/m^2$

Sydney Aus. → " " $= 200\ W/m^2 = 1750\ KWh/m^2$

Note: averaged over night/day, summer/winter

∴ use with caution

→ May vary considerably from year to year

③ More data (from another book, different units: MJ/m^2-day

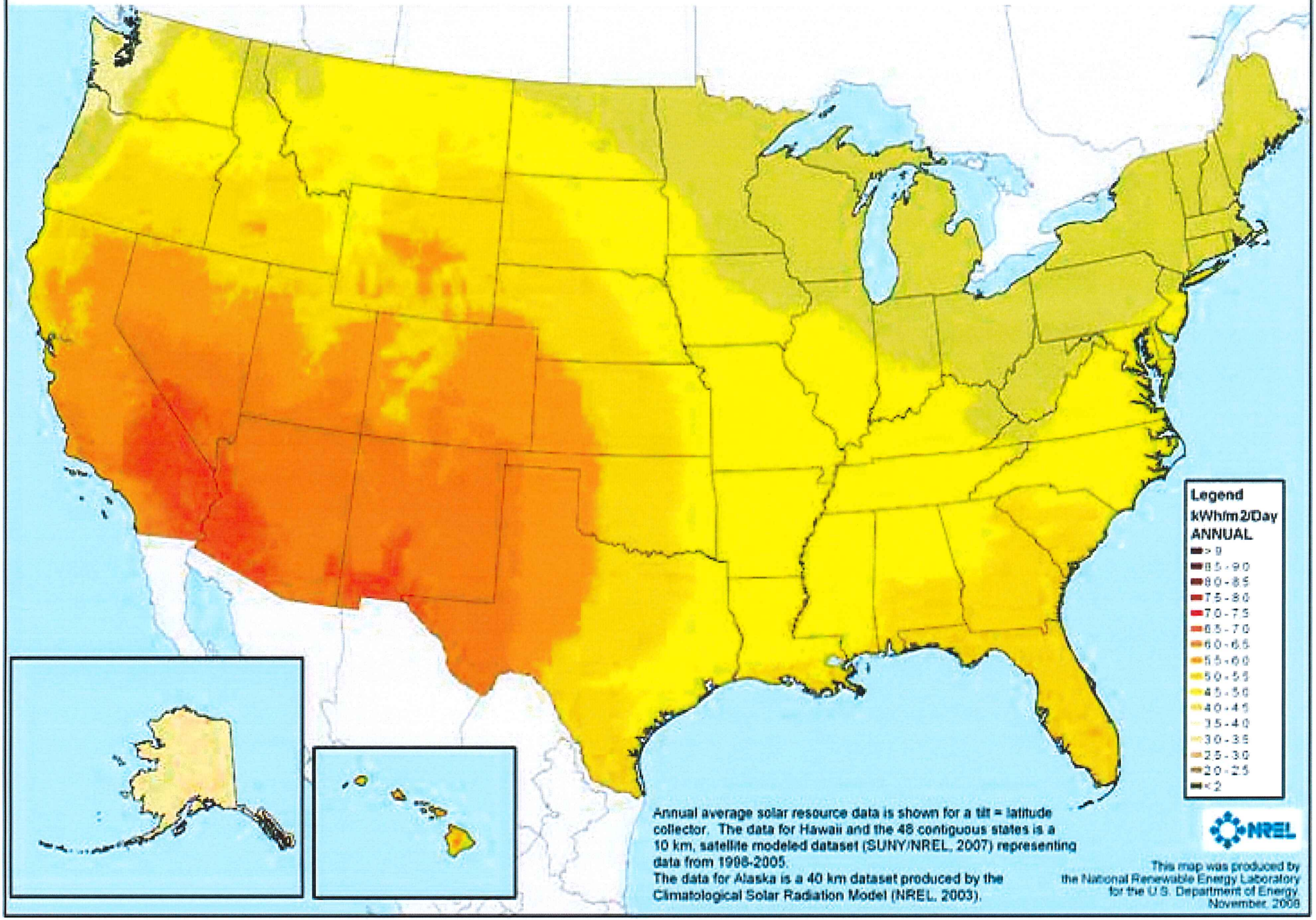
Montgomery, AL : Dec : 8.16 , June : 22.38

Phoenix, AZ : Dec : 10.58 , June : 31.09

NY, NY : Dec : 4.58 , June : 19.41

Photovoltaic Solar Resource: Flat Plate Tilted South at Latitude

Annual



Annual average solar resource data is shown for a tilt = latitude collector. The data for Hawaii and the 48 contiguous states is a 10 km, satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.
The data for Alaska is a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy. November, 2008

Best Research-Cell Efficiencies

NREL
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