RGA Labs, Inc.
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AGENDA

- *What IS Energy? Where does it come from?*
- *Solar Energy Technology*
- *Solar's Interrelation With the Larger Energy Mix*

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- *President and Founder of RGA Labs*
- *Degrees in Nuclear Engineering and AI*
  - ✓ Argonne National Laboratory
  - ✓ ComEd / Exelon
- *Mayor of Barrington Hills, IL*
- *Democratic Nominee for the US Congress in the 16th District*

Energy

- *What is Energy?*
  - ✓ $E=M*C^2$
- *Where does it come from?*
- *1. Our Star -- 2. Old Stars*
  - ✓ Fusion
    - ***Our Sun***
    - ***Thermonuclear fusion***
  - ✓ Fission
    - ***Heavy Elements from <u>other stars</u>***
    - ***Nuclear Reactors ➔ Electricity***

What Is Fuel? The Energy 'Store'

- *Energy Stores from Billions of Years*
  - ✓ Uranium, thorium, hydrogen, lithium – fission / fusion reactors
  - ✓ Geothermal
- *Energy Stores from 100's of millions of years*
  - ✓ Oil
    - ***Gasoline***
    - ***Diesel Fuel***
  - ✓ Natural Gas
  - ✓ Coal
- *Energy Stores from last year*
  - ✓ Ethanol
  - ✓ Bio-Diesel
- *Energy Stores from the last 8 minutes*
  - ✓ Sun light

How Do We Measure Energy?

- *BTU = The quantity of heat, which is a form of energy, necessary to raise the temperature of a pound of water from 39 to 40 degrees F.*

A Quadrillion is 1,000,000,000,000,000

A Quad = 10^{15} BTUs

A typical residential furnace is rated at 100,000 BTU/hour

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United States Energy Consumption 2004

In Quadrillion BTUs (Quads)

Coal	22.5	Solar	0.1
Natural Gas	19.3	Wind	0.1
Crude Oil	11.5	Subtotal	70.2
NGPL	2.5	Crude Oil Imp.	32.9
Nuclear Power	8.2	Adjustments	0.8
Hydro	2.7	Subtotal	103.9
Waste	2.8	Exports	-4.4
Geothermal	0.3	Total	99.5

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United States Energy Consumption 2004

In Industry Units

Fuel	Quads/Year	Yearly	Daily
Coal	22.5 Quads	1088.1 Million tons	2.95 Million tons
Natural Gas	19.3 Quads	19.6 Trillion cu ft	53.69 Billion cu ft
Crude Oil	11.5 Quads	1,955,000,000 Barrels	5,356,164 Barrels
NGPL	2.5 Quads	419,560,000 Barrels	1,149,479 Barrels
Pet. Imports	32.9 Quads	5,593,000,000 Barrels	15,323,288 Barrels
Pet. Imports		15,323,288 bbl/day = 643,578,096 gal/day	
Total Petroleum		21,828,931 bbl/day = 916,323,102 gal/day	

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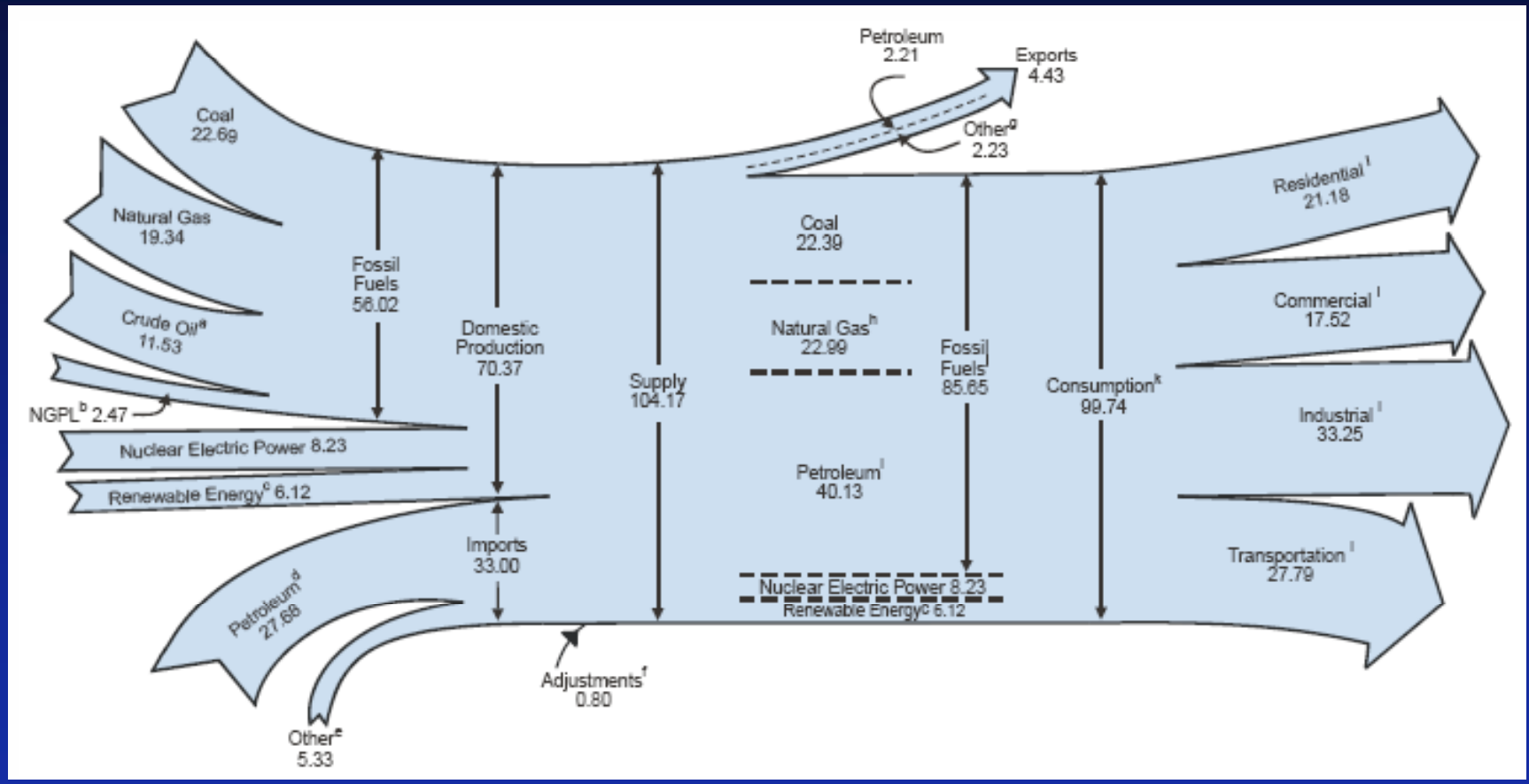
Where Does Energy Go?
2004 in Quads



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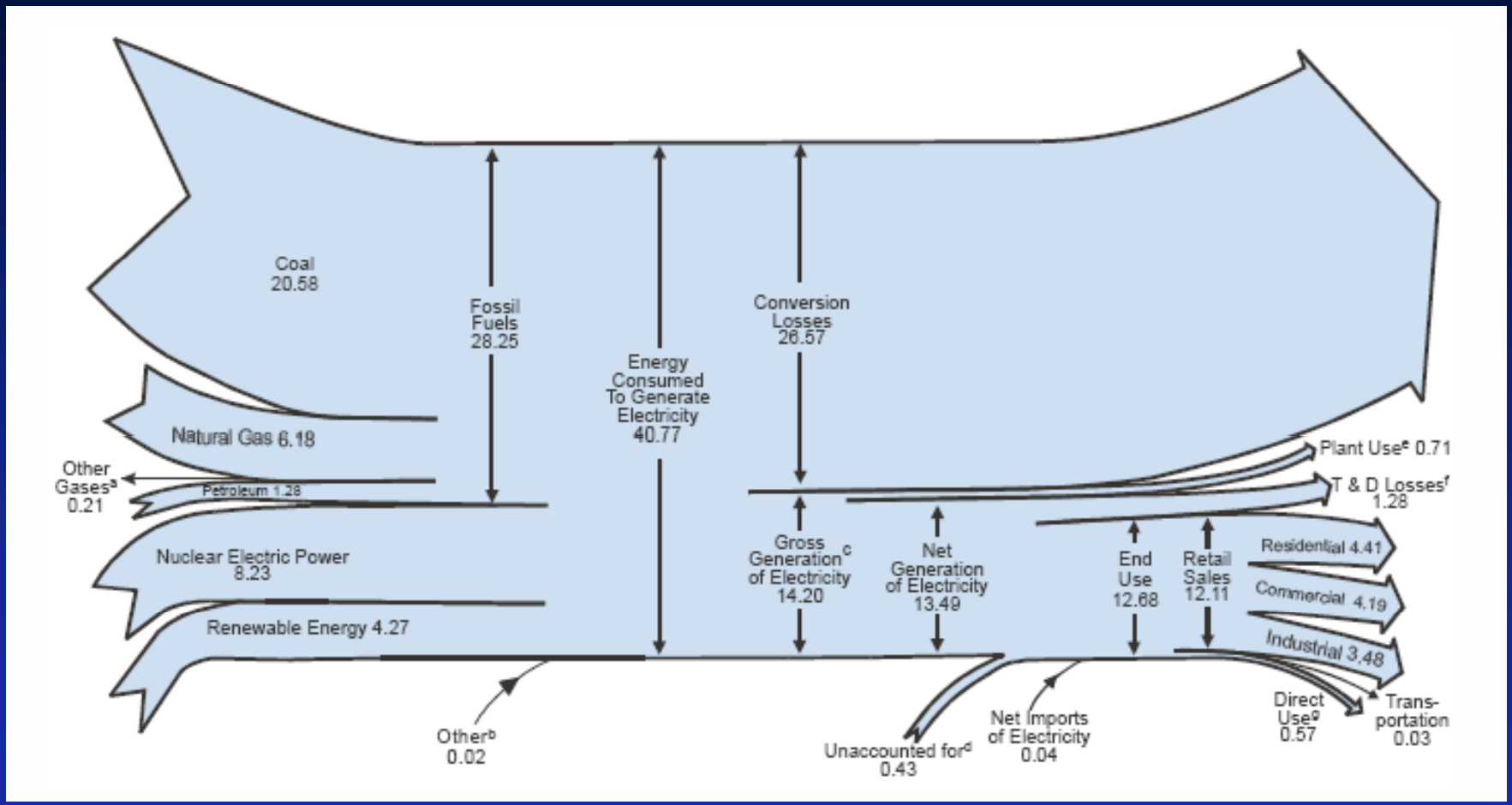
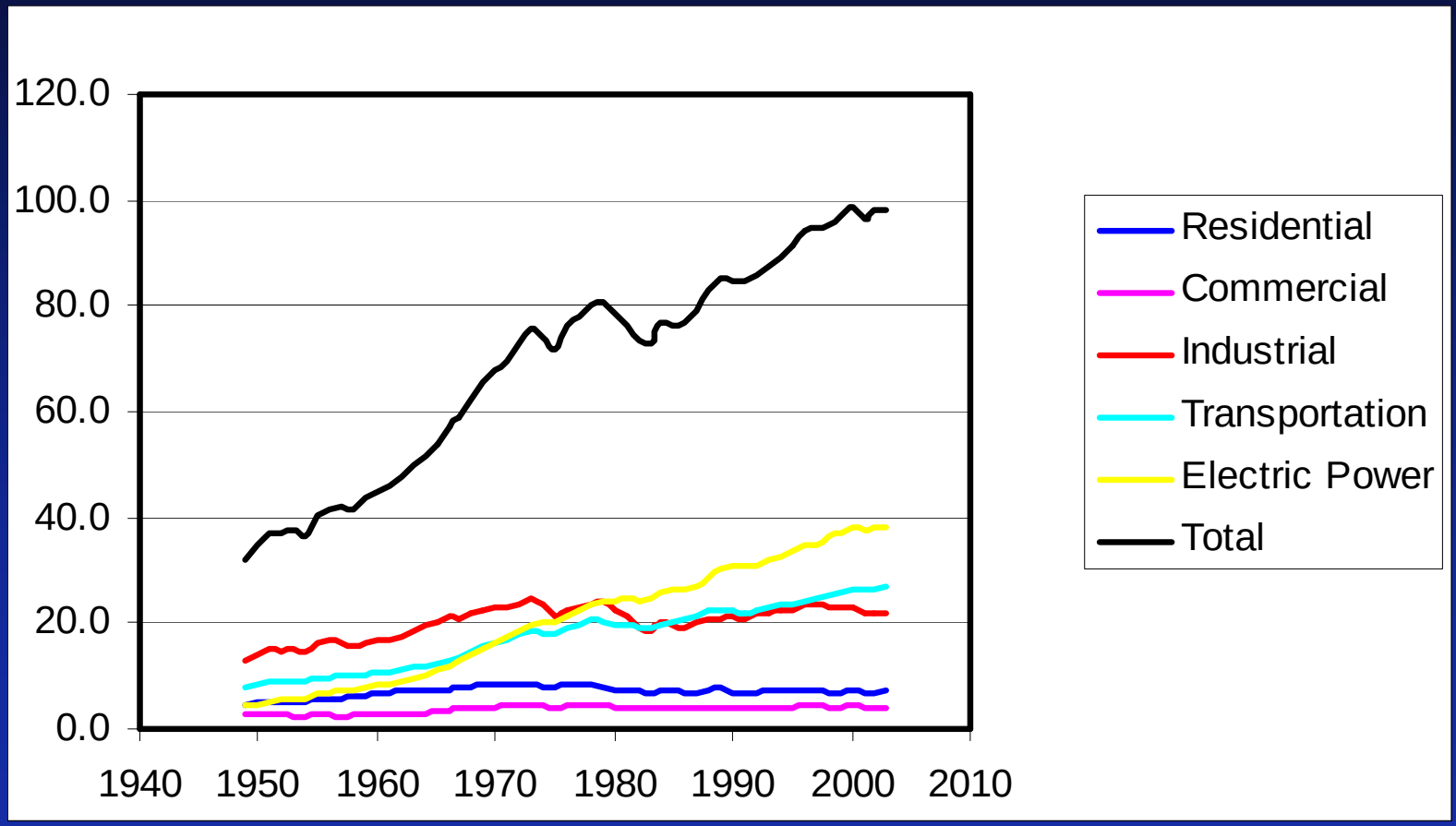
Electricity Production 2004 in Quads



Energy Demand – Reality Check

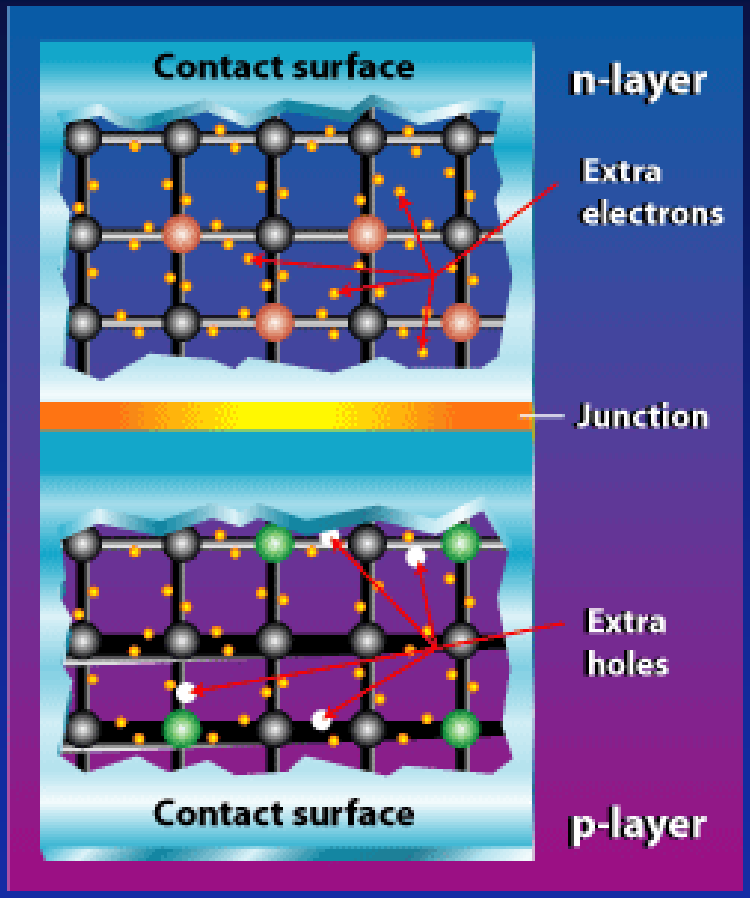


Solar Energy – What Is It

- *The conversion of sun light into a more useable form of energy*
- Electricity
  - ✓ Photo electric systems
  - ✓ Thermal electric systems
- Thermal
  - ✓ Building heating
- Distillate Fuels
  - ✓ Bio conversion (photo synthesis)
- Lighting
  - ✓ Direct use of light energy

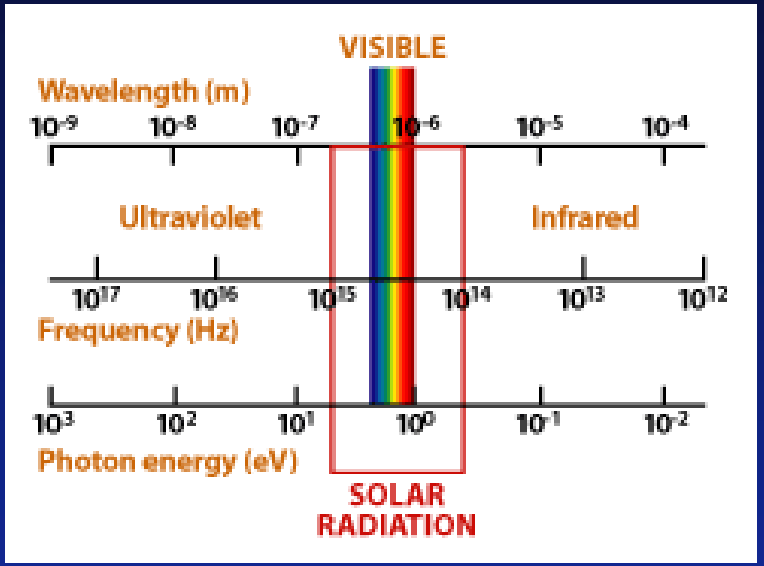
Photo Electric Cells

- p/n semiconductor junction
  - ✓ Electron transport
- Light conversion
  - ✓ Reflected
  - ✓ Absorbed – make electricity
  - ✓ Pass through
- Visible light
- IR or UV



Sun Light

- *The sun emits almost all of its energy in a range of wavelengths from about 2x10-7 to 4x10-6 meters*
- *Most in visible range*
- *Solar cells respond differently to the different wavelengths, or colors, of light.*



Devices – Cell Structures

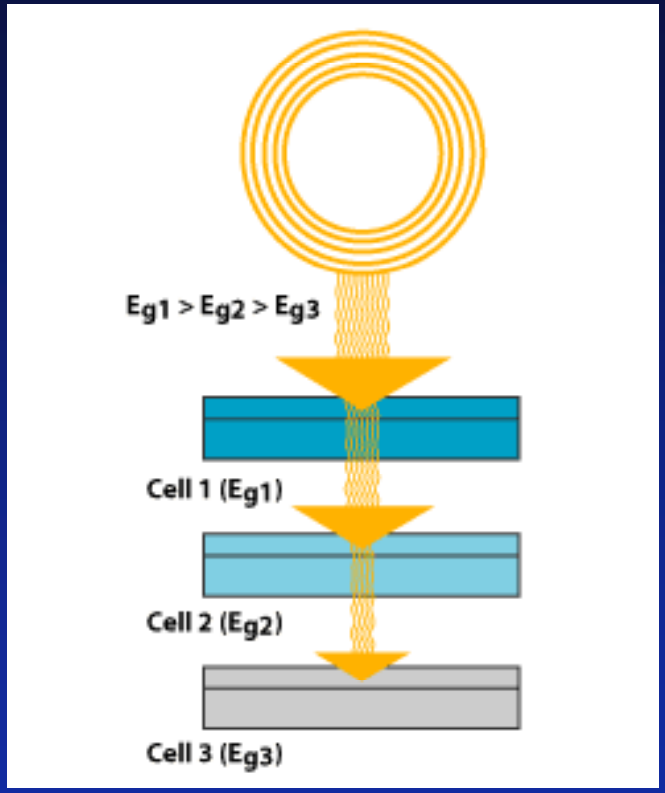
- *Homojunction Device*
  - ✓ Crystalline silicon is the primary example of this kind of cell. A single material—crystalline silicon
- *Heterojunction Device*
  - ✓ CIS cells, where the junction is formed by contacting two different semiconductors—CdS and CuInSe2. This structure is often chosen for producing cells made of thin-film materials that absorb light much better than silicon.

Devices – Cell Structures

- *p-i-n and n-i-p Devices*
  - ✓ Typically, amorphous silicon thin-film cells use a p-i-n structure, whereas CdTe cells use an n-i-p structure.
  - ✓ A three-layer sandwich is created, with a middle intrinsic (i-type or undoped) layer between an n-type layer and a p-type layer. This geometry sets up an electric field between the p- and n-type regions that stretches across the middle intrinsic resistive region. Light generates free electrons and holes in the intrinsic region, which are then separated by the electric field.

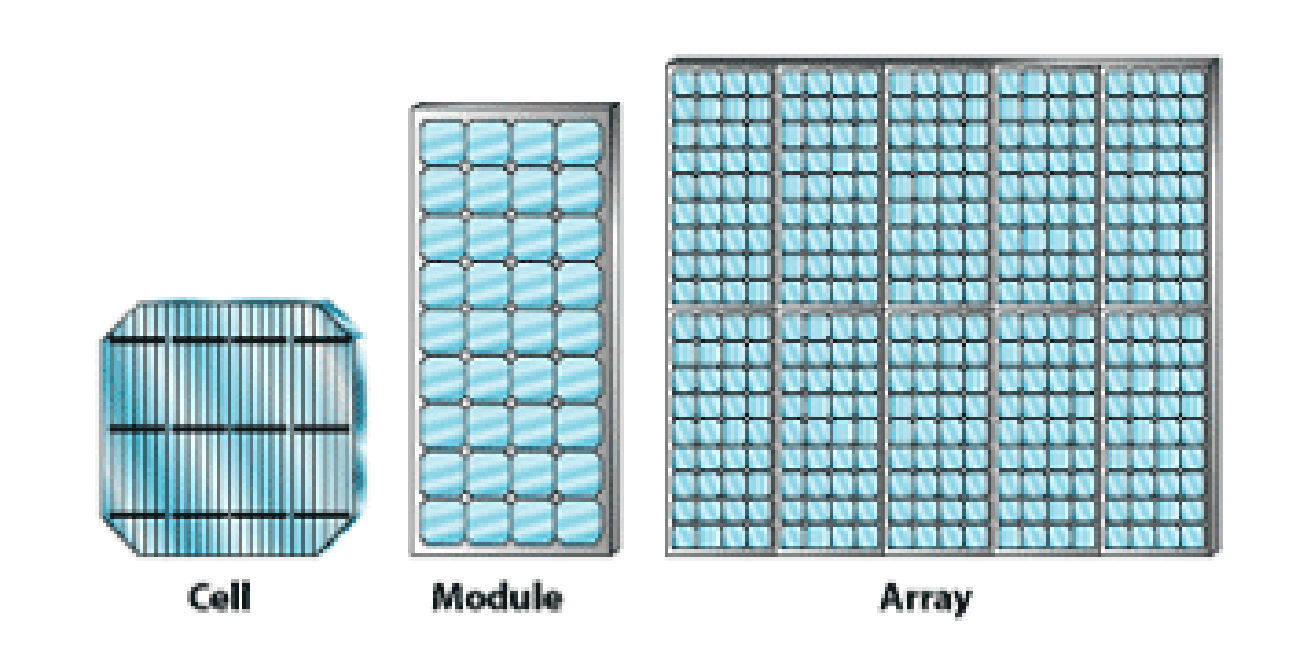
Devices – Cell Structures

- *Multijunction Devices*
  - ✓ Stack of individual single-junction cells in descending order of bandgap (Eg). The top cell captures the high-energy photons and passes the rest of the photons on to be absorbed by lower-bandgap cells.
  - ✓ Cascade or tandem cell, can achieve a higher total conversion efficiency by capturing a larger portion of the solar spectrum.



Systems

- *Build up cells into modules and arrays*



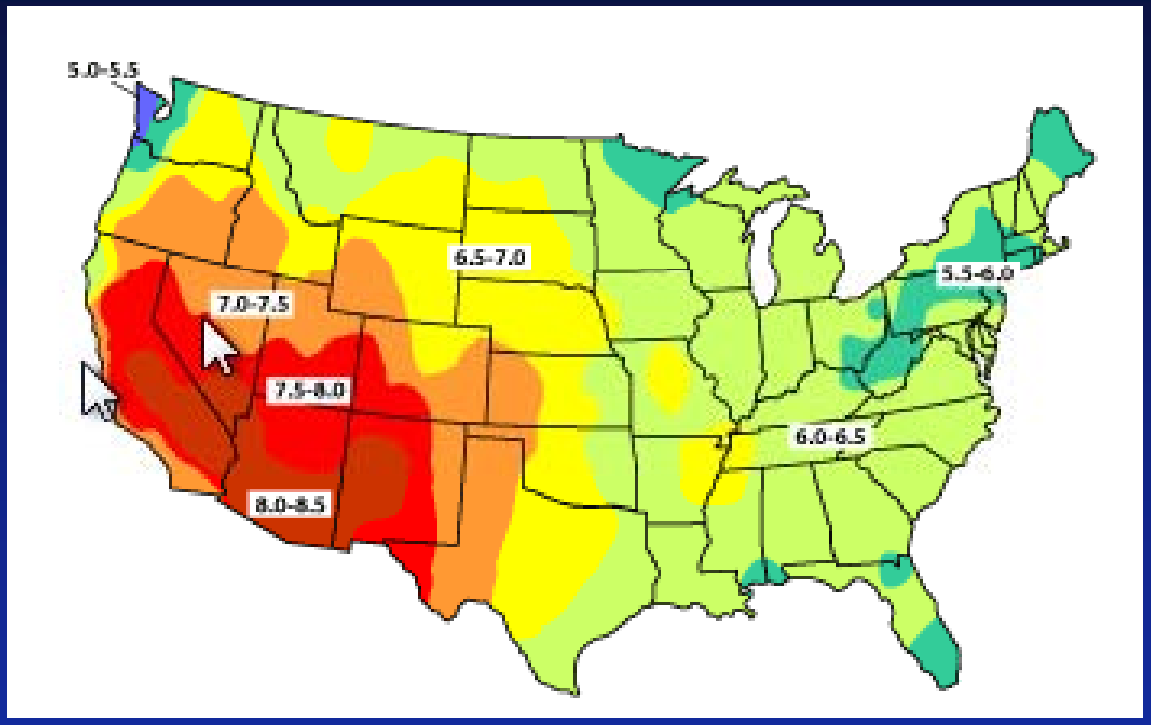
Systems

- *Inverters*
  - ✓ Convert power into usable form
    - ***Voltage***
    - ***Current***
- *Storage*
  - ✓ Batteries
- *Connection*
  - ✓ Metering
  - ✓ Switch gear
  - ✓ Protection

Applications

Solar Energy Availability

- *The yearly amount of energy striking almost any part of the Earth is vast.*
- *Problem is what is useable*



- *Shown is the average radiation received on a horizontal surface across the continental United States in the month of June. Units are in kWh/m^2/day.*

Costs

- *Overall costs are roughly 5-8 times utility power*
  - ✓ Including maintenance costs and depreciation
- *Utility systems are not yet competitive*
  - ✓ High costs of conversation and switching equipment
- *Small scales are competitive in 'remote' locations*
- *Solar is VERY cost effective when integrated into building designs for lighting and thermal management*

Cons – why isn't it every where?

- *Solar is non-dispatchable*
  - ✓ Requires alternate energy source or large scale storage
- *Requires large area use (kw/m^2)*
- *Typically not 4-quadrant capable*
  - ✓ Cannot provide VARS without significant electronics
- *Metering and other utility concerns*
  - ✓ Regulatory issues

Pros

- *Can be located in remote locations*
- *Not size dependant*
- *Low energies internally (safety)*
- *Flexible installation*
- *Good public accptance*

Future

- *Better technology*
  - ✓ Materials
- *Will have new federal support*
- *Limited grid application in next 50 years*
- *Expanded use in home systems*
- *Expanded use in small systems*
  - ✓ Systems require less and less energy

Questions