EELE408 Photovoltaics
Lecture 23: Summary

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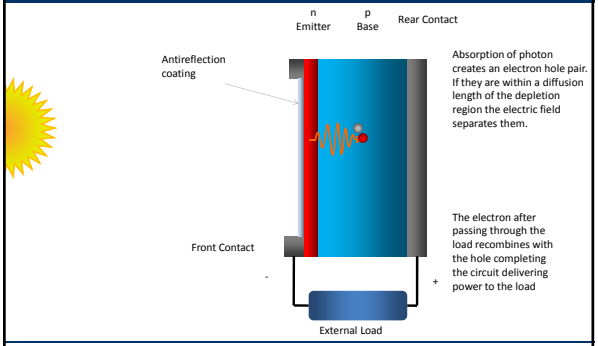
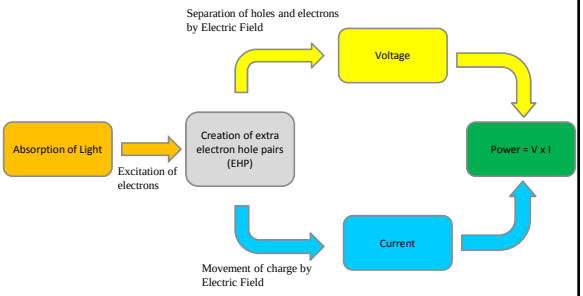
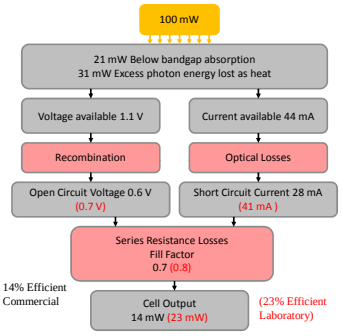
Solar Cell Operation



Photovoltaic Effect

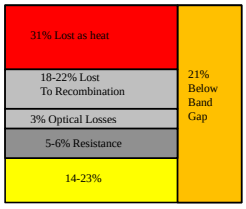


Efficiency



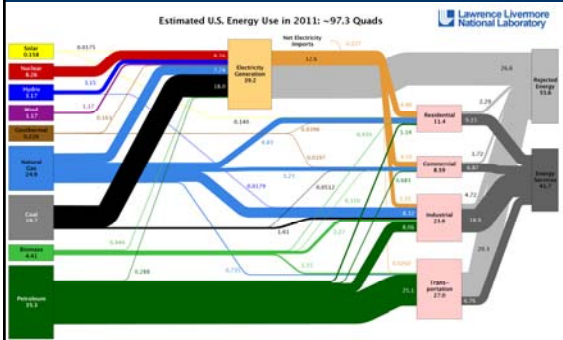
- Over half of energy lost initially due to mismatch in photon energy and gap energy
- Trade off between EHP recombination and optical absorption (thickness of cell)
- Almost half of potential lost to recombination

Percentage Losses

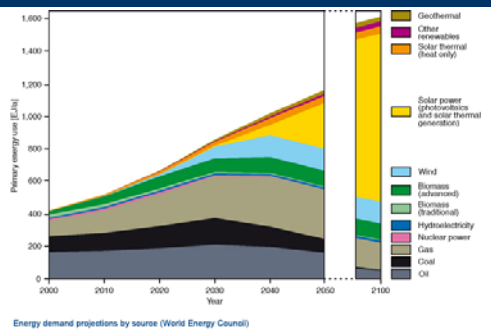


52% lost as heat or IR below the band gap

LLNL Energy Chart



Energy Demand Predictions

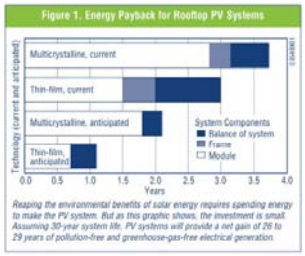


Energy demand projections by source (World Energy Council)

Photovoltaic Myths

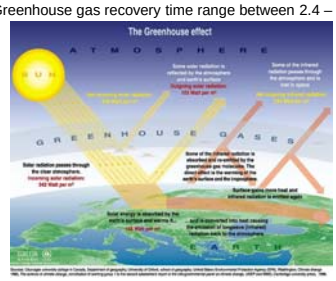
Photovoltaic Myth #1

- Solar modules consume more energy for their production than they ever generate.
  - Most frequent argument and just as incorrect
  - Monocrystalline silicon energy payback is 7.3 years (NREL 2004)
    - Lifetime of 25-30 years will generate over 3 times the energy of production
  - Thin-film modules energy payback is 3 years (NREL 2004)



Photovoltaic Myth #2

- PV produces more greenhouse gases than it saves
  - Same argument as energy production
  - Greenhouse gas recovery time range between 2.4 – 3.6 years

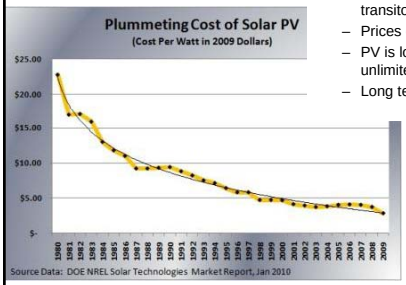


Photovoltaic Myth #3

- Grid-connected PV requires lots of back-up fossil power plants
  - PV energy production coincides largely with peak demand
  - Wind can meet some needs. It has a different and partly opposite time dependence
  - Smart Grid will become widespread in the future. Demand control can be adapted.

Photovoltaic Myth #4

- Photovoltaics is too expensive
  - Indeed it is expensive but this is a transitory situation
  - Prices continue to fall
  - PV is long lived, reliable & unlimited potential
  - Long term benefits undeniable



Photovoltaic Myth #5

- PV is not ready for marketing, more research is required
  - Improvements of technology is stimulated by interactions with markets
  - Market driven improvements continues
    - Example: cell phones, digital cameras, laptops
  - Lower costs will materialize with feedback from markets and technology improvements

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Photovoltaic Myth #6

- PV only makes sense in high insolation areas
  - Certainly true that PV modules can produce twice as much energy in high desert areas
  - But larger transmission costs and transmission losses
  - Distributed systems remove costs of transmission and metering, transmission losses, administration and taxes

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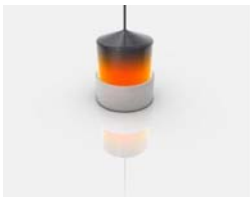
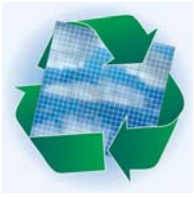
Photovoltaic Myth #7

- PV involves toxic materials
  - Minimal toxic materials in silicon solar cells, but used in the purification and processing
  - The silicon purification technology is well controlled based on decades of experience from the integrated chip industry
  - Future recycling of modules will further reduce environmental impact





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Photovoltaic Myth #8

- PV consumes valuable land area
  - Large projects use land that is not suitable for other applications
  - There is still a huge supply of unused roof, building, facade, and sound barrier space

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Solar Cell Land Area Requirements for the USA's Energy with Solar PV

- 100 miles by 100 miles in Nevada would provide the equivalent of the entire US electrical demand
- Distributed (to sites with less sun) it would take less than 25% of the area covered by US roads.

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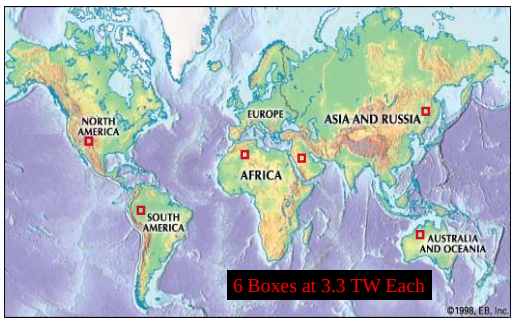
Solar Cell Land Area Requirements for the World's Energy with Solar



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Photovoltaic Myth #9

- PV competes for roof space with thermal collectors
  - Without question PV modules and solar thermal use the same southern roof space
  - Thermal collectors need only limited space due to higher efficiency (~70%)
    - For hot water 1 m² / person
  - Space heating only needed in winter
  - Thermal insensitive to partial shading → use in shadowing areas

Final Lab Report (Wafer Number)

- Background
  - Fabrication Sequence
  - Device Cross Section
- Measurements
  - N+ Final Sheet Resistivity
  - P+ Final Sheet Resistivity
  - Front Al Sheet Resistivity
  - Back Al Sheet Resistivity
  - Front Al Thickness
- Device Testing
  - IV curves (4)
    - Resistance Estimation
    - Fill Factor
    - Efficiency Estimations
  - Dark I-V curves (SDA)
    - Linear
    - Semilog
- Analysis
  - 4 solar cell data table
  - Series resistance calculations
  - Annealing impact
  - Class Data Table
  - 4 devices Variances
  - Comparison of Class Data
- Summary
  - Results
    - Maximum Voltage
    - Maximum Current Density
    - Maximum Fill Factor
    - Efficiency
  - Course recommendations

PV and BEV

Battery Electric Vehicle
4 miles/ kWh
kWh = 10¢
2.5¢/mile

Internal Combustion Engine (ICE)
30 mpg
$3.00/gallon
10¢/mile

Four times the savings
Reduces the payback time for PV system