Rigid and Flexible Photovoltaic Systems for Terrestrial and Airborne Power

Dr. Sylvain Marsillac

Old Dominion University

OUTLINE

1 – Photovoltaic in a global context

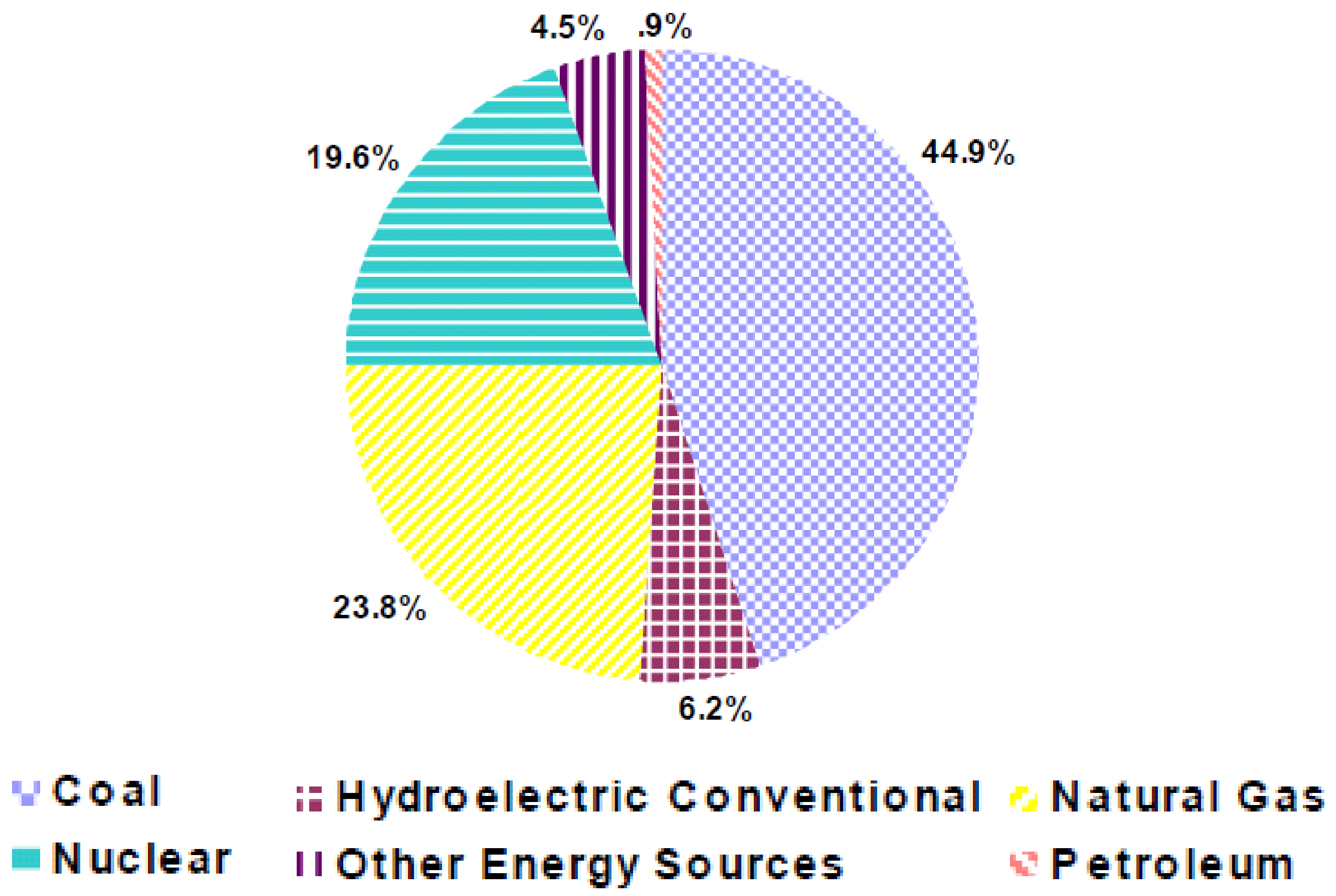
2 – Terrestrial applications

3 – Space applications

4 – Research at ODU

5 – Opportunities

US Net Generation Shares by Energy Source (2010)



www.eia.doe.gov

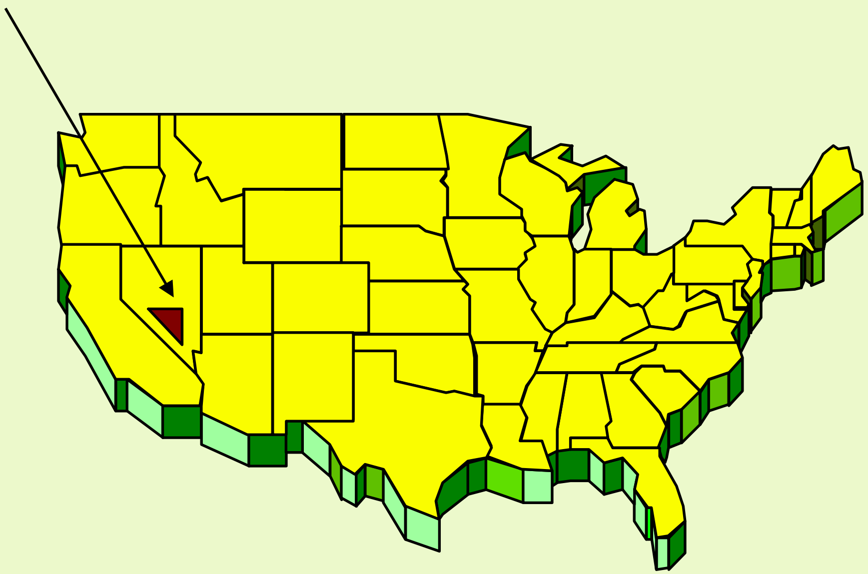
Photovoltaic: the unending resource!

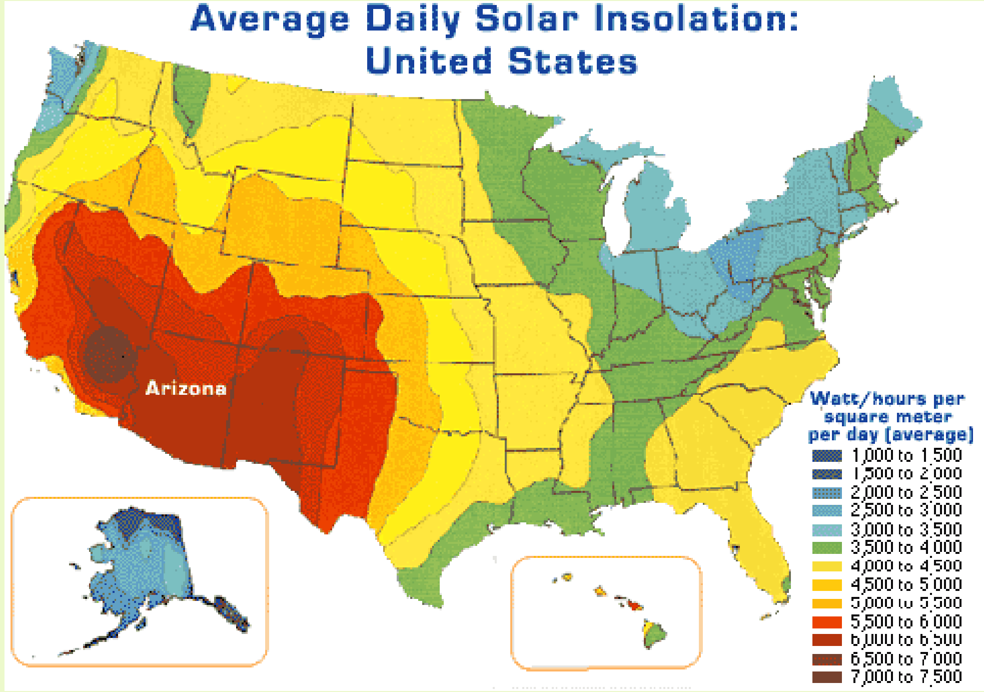
US Electric consumption: 3.8 TWh/yr 2009

Land required to generate

1TW of electric power

~20,000 km^2



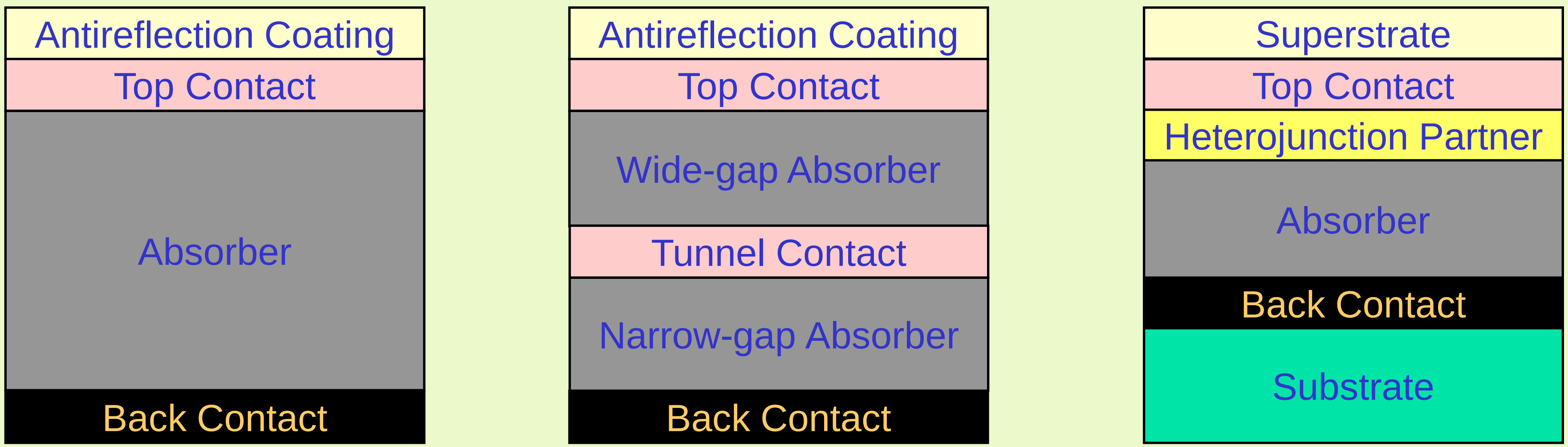


http://www.nrel.gov/gis/solar.html

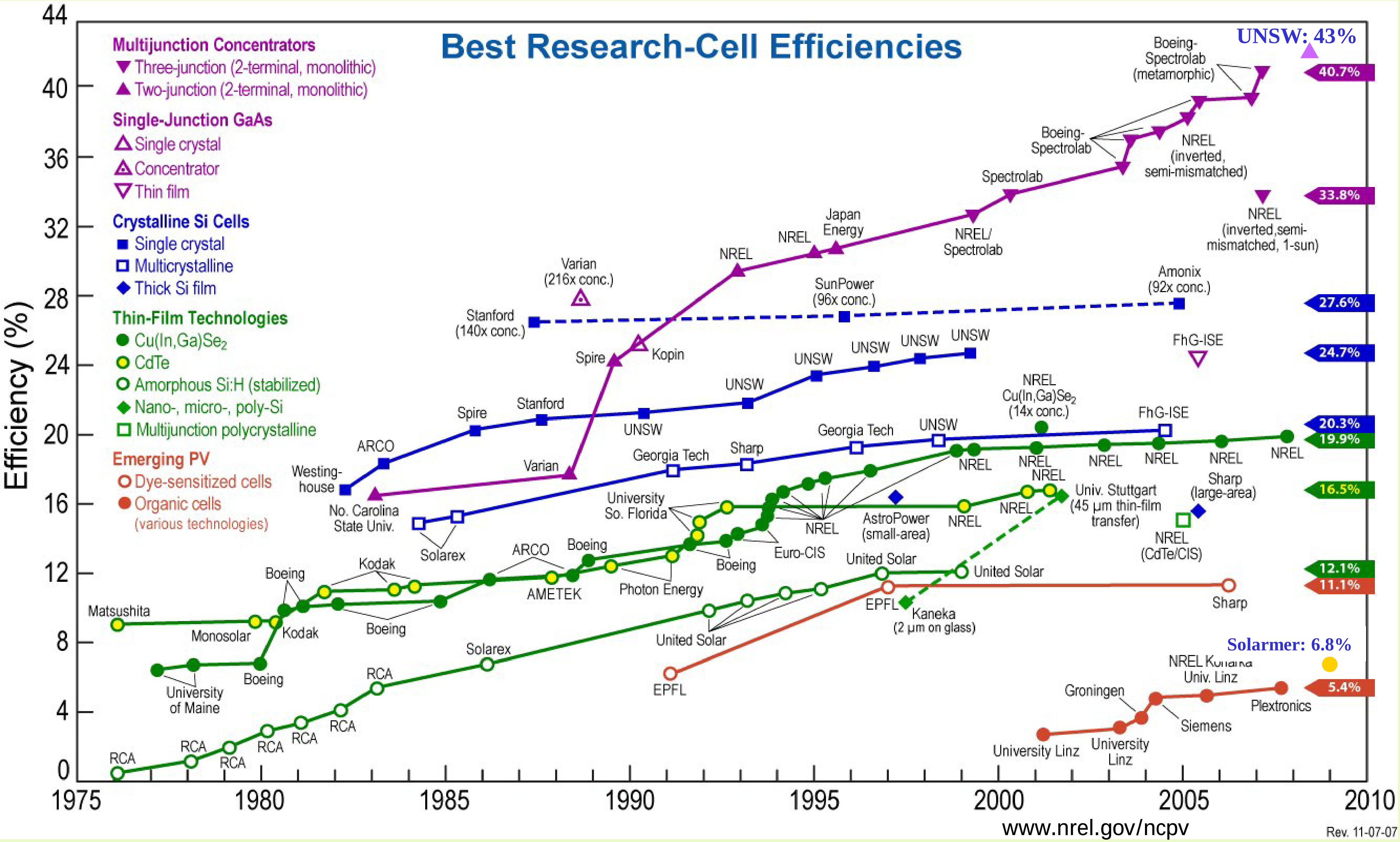
What do we need for Photovoltaic?

- Source of Photons

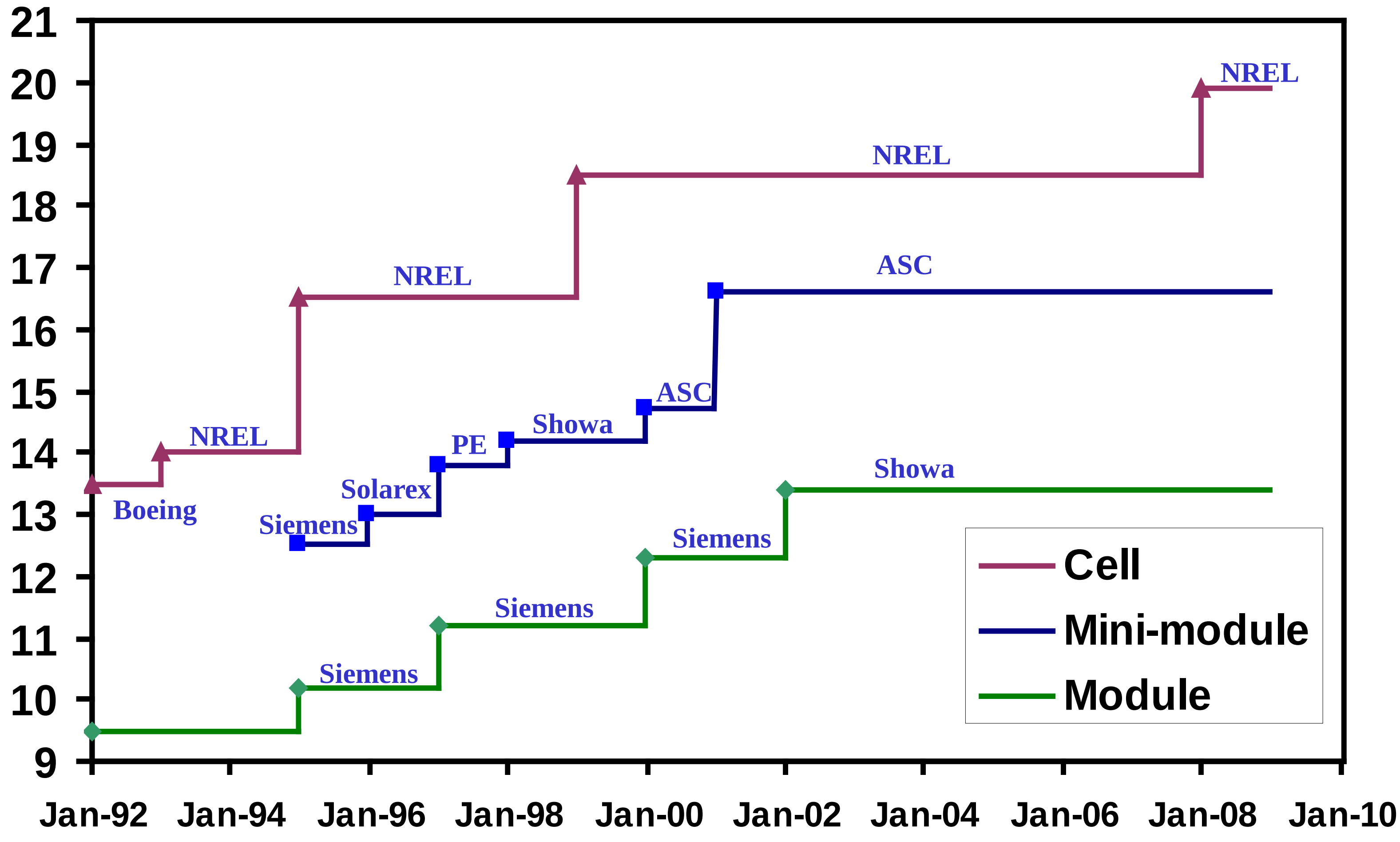
- Materials to absorb these photons and generate electrons
    - Inorganic, Organic, Mixture, Others
- Devices of various architectures



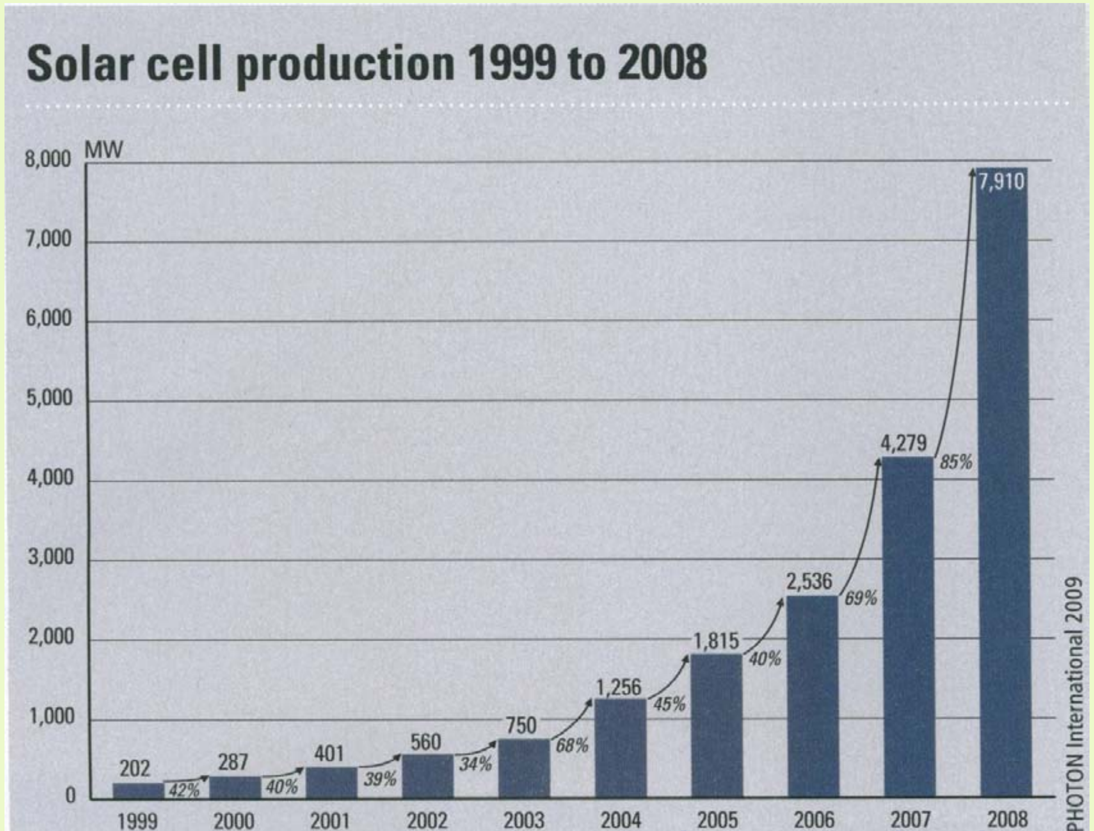
How Efficient are solar cells?



How about Module efficiency (example of CIGS)?



Worldwide PV Production

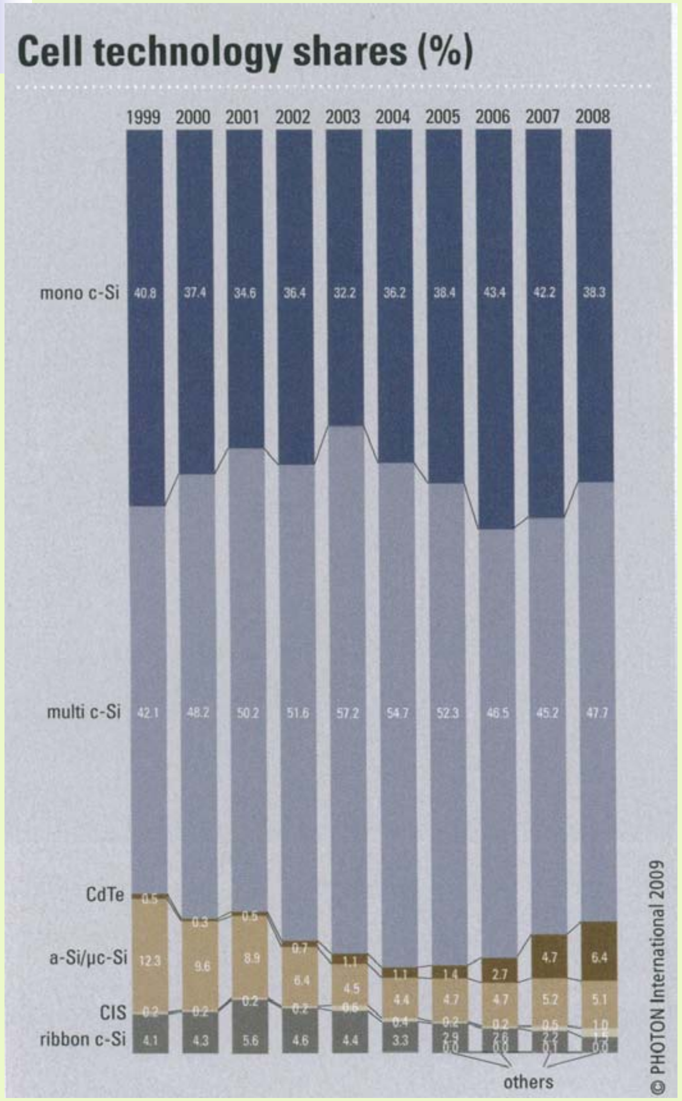


Photon International, March 2009

PV Market 2010 = 10 GW_p installed = $50 billions

(assuming $5/$W_p$ installation)

The market share in 2008

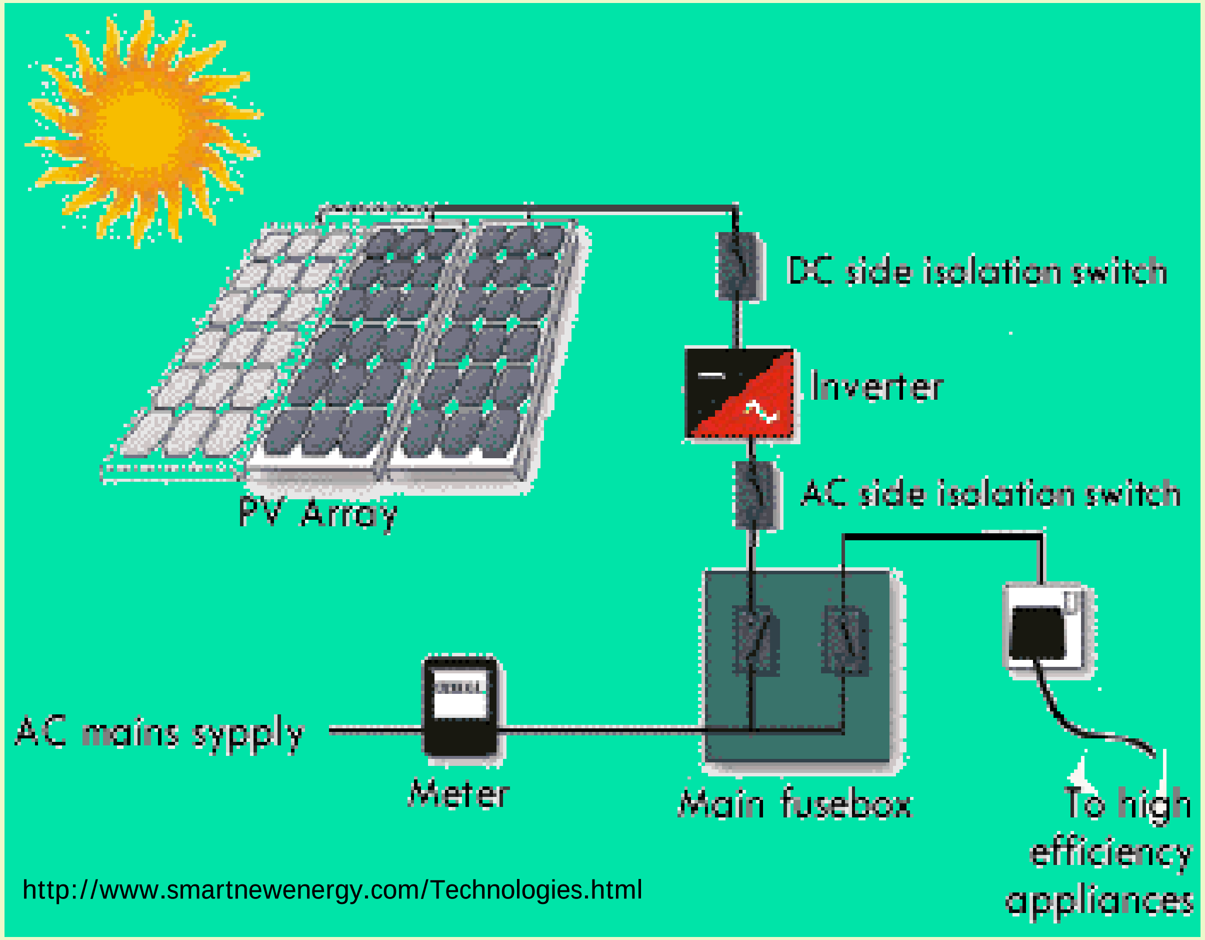


In 2008

Mono c-Si:	38.3
Multi c-Si:	47.7
CdTe:	6.4
A-Si/mc-Si:	5.1
CIGS:	1.5
Ribbon c-Si:	1.0
Others:	0.1

Photon International, March 2009

The terrestrial market: What do we need?



http://www.smartnewenergy.com/Technologies.html

The terrestrial market: large scale

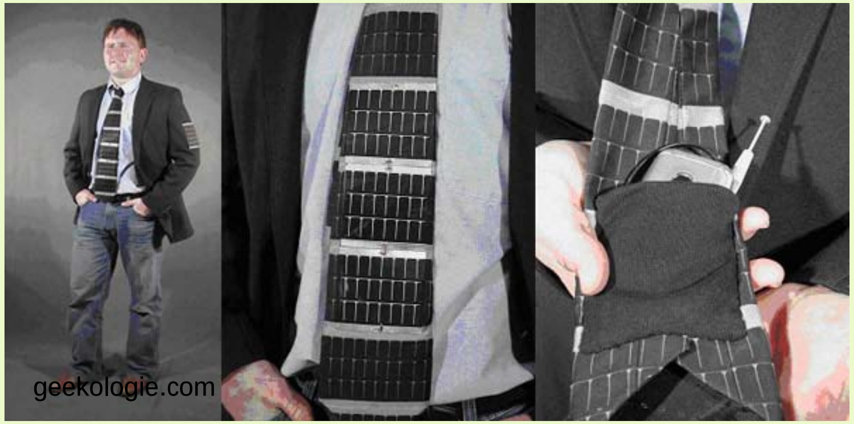
Terrestrial market: niche products

Thegloss.com

gadgetlite.com

military-solar-power.com

nrc-cnrc.gc.ca



geekologie.com

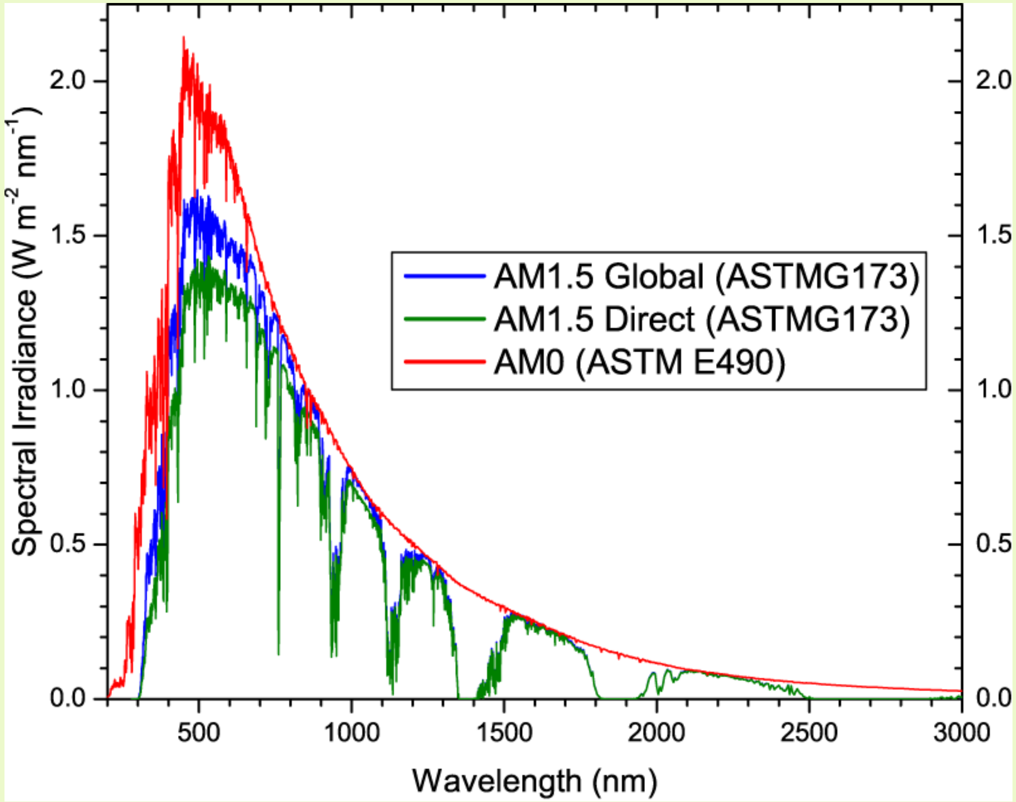
solarwares.com

Space Applications

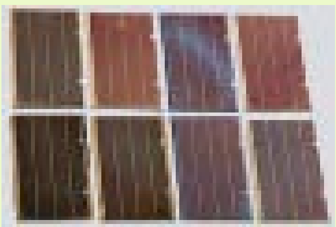
Space applications

Some constraints

- Weight
- Power
- Durability
- Radiation hardness
- Temperature
- Various orbits (LEO, MEO, GEO)



Space applications



Solar cell Techno	BOL efficiency (%)	Power density (W/m^2)	Specific Weight (W/kg)	Normalized to Si cost ($/W)
HE Si	14.1	169	676	1.00
3J III-V	23.9	**306**	360	1.22
CIGS	17	217	**1430**	**0.45**

Handbook of PV, Wiley, Luque and Hegedus

GEO conditions (60°C)- 1 MeV, $5e^{14}$ e/cm^2

What do we do at ODU?

Dr. Marsillac, Dr. Namkoong, Dr. Elsayed-Ali, Dr. Baumgart

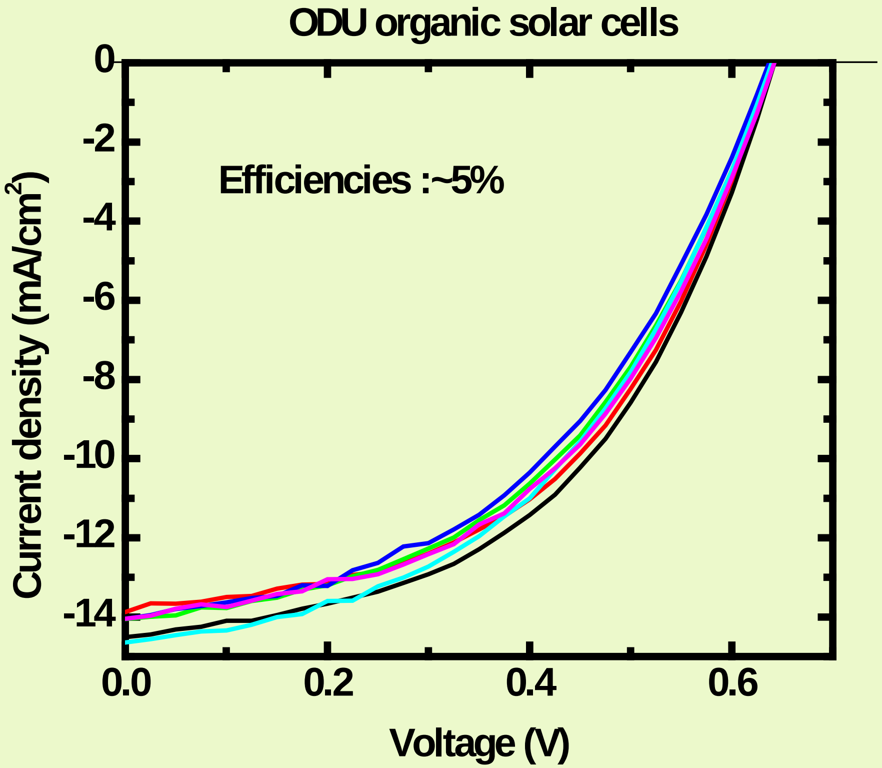
Two type of Issues:

1. Manufacture the current state of the art
2. Develop the next generation

- New materials: Absorber layers and Buffer layers
- Modification of deposition process: Enhancement or Development
- In-situ measurement

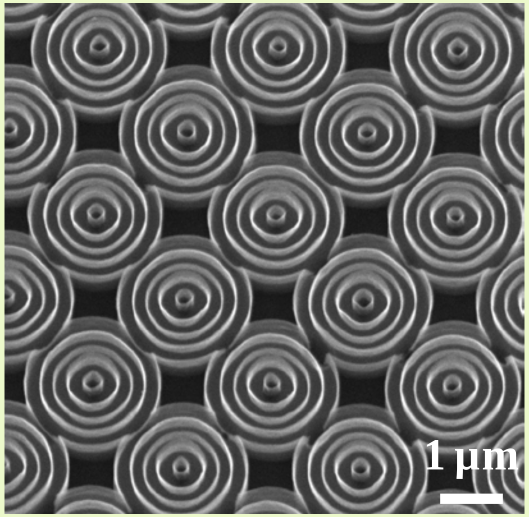
Organic/inorganic solar cells

Planar organic solar cell at ODU



ACS Nano Vol. 4, pp 753 (2010)
Nano Research, Vol. 4, pp 164(2011)
PSS RRL, Vol 5, pp 104 (2011)

Organic/inorganic solar cell



I-III-VI solar cells

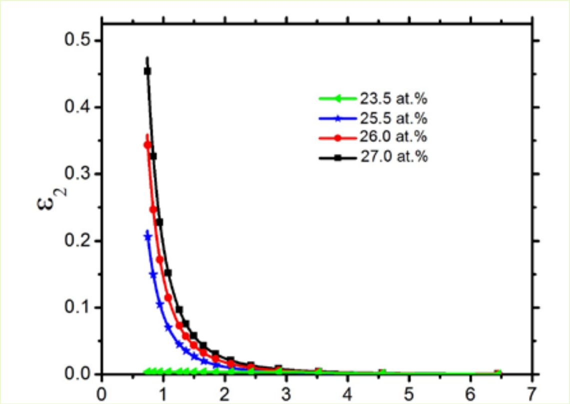


Figure 1 Drude oscillator as a function of Cu at.% in CIGS thin film

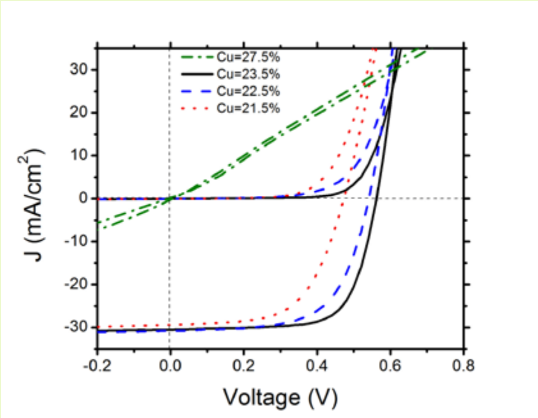


Figure 2 Current-voltage (J-V) characteristics curve for PV devices as a function of Cu at.% in the CIGS layer.

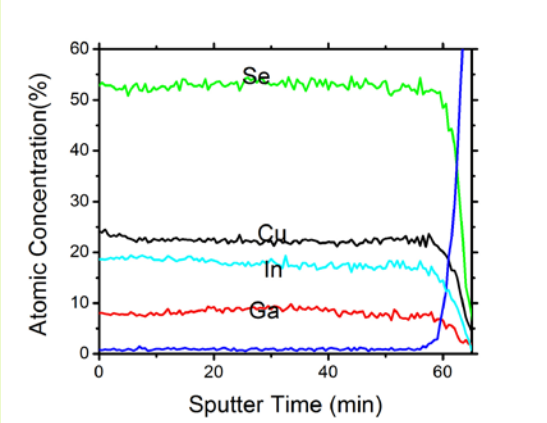


Figure 3 Auger spectroscopic spectra of CIGS thin film with 23.5 at.%, deposited by one stage process.

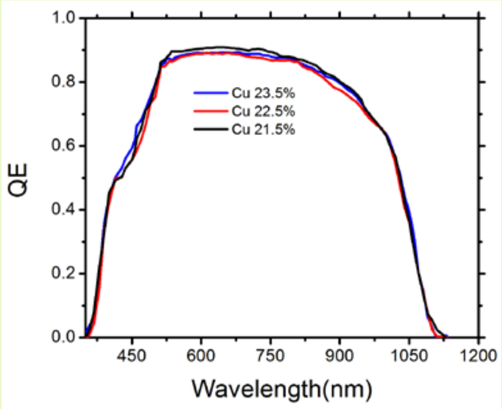
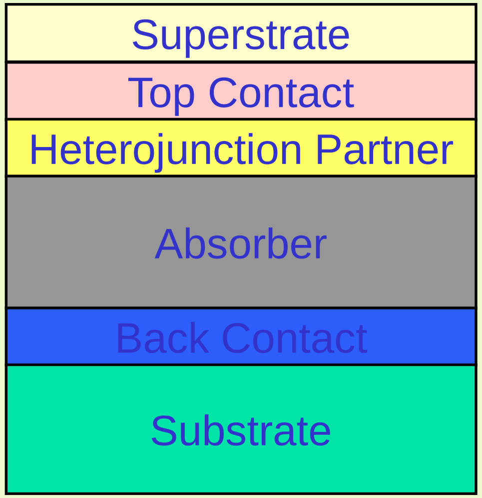


Figure 4 Normalized quantum efficiency (QE) curve for PV devices as a function of Cu at.% in the CIGS layer

Opportunities: Terrestrial

Every single component needs improvement!

- BOS: inverters, storage system (peak pb)
- Substrates: glass or polymer
- Materials:
  - new inks (material utilization)
  - Organic
  - Earth abundant materials
- Manufacturing process
- Encapsulation



Opportunities: Space and others

- Develop new multijunction solar cell
- Find new niche products
- Rapidly deployable power
- Floating solar system (reduce use of land)
- Disaster resistant power supply

THANK YOU!

ANY QUESTIONS?