



Photovoltaic solar energy – a technical view

Professor Stuart Irvine,
Centre for Solar Energy Research
OpTIC Technium, Glyndwr University

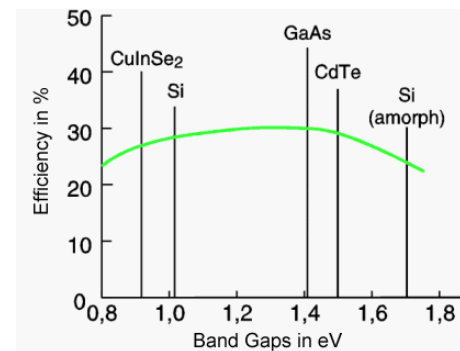
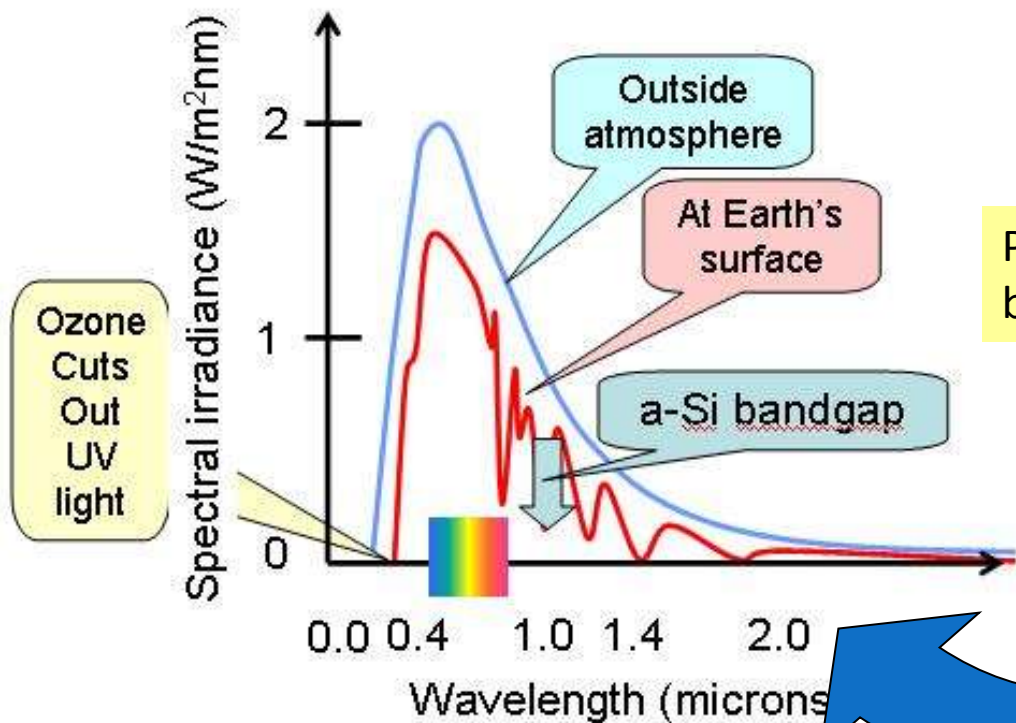


The sun radiates more than enough energy onto the Earth in just one day to provide enough energy for the population of 5.9 billion people for 27 years

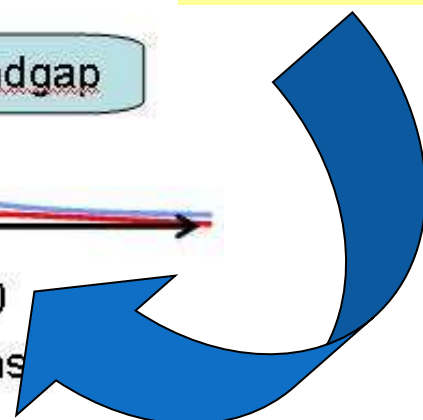
In Wales enough solar energy radiates onto just 1 square kilometre over a year to supply 10% of our electricity needs



Solar spectrum and potential for high efficiency solar cells



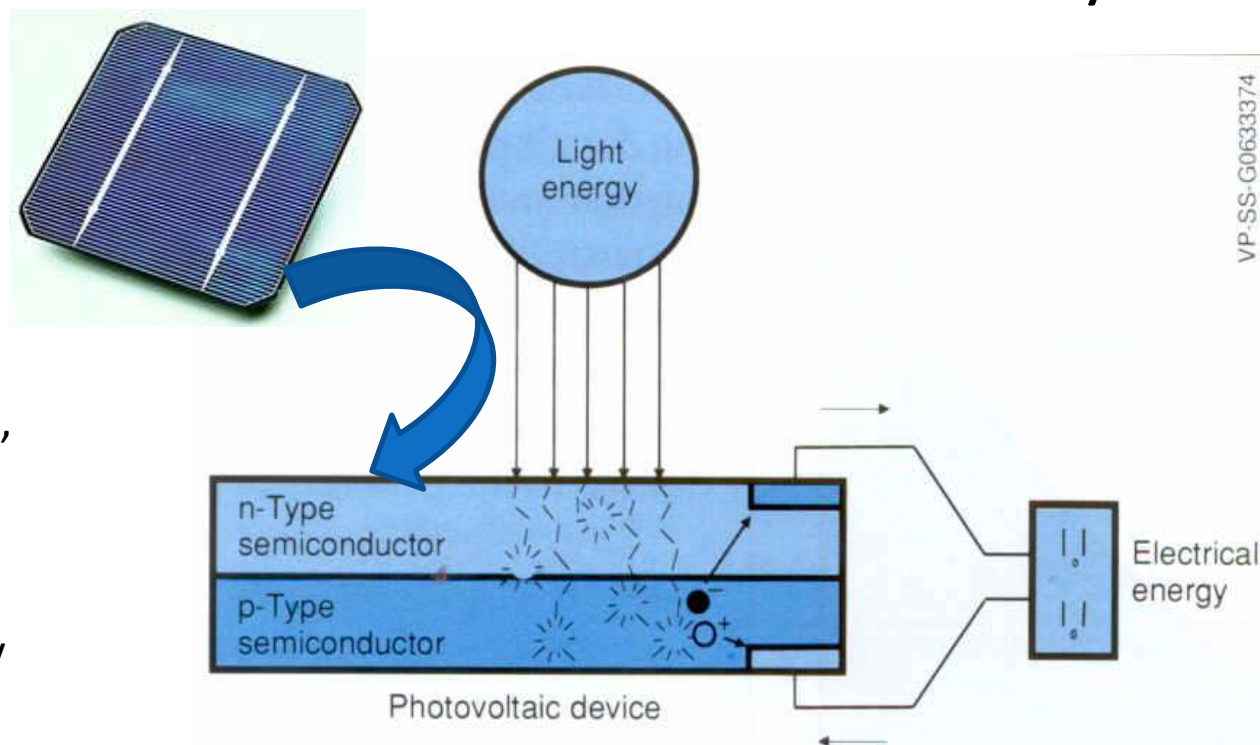
Potential for 30% efficient cells based on single junction PV





The photovoltaic effect is the conversion of light energy into electrical energy and needs a semiconductor material like silicon to absorb the solar radiation and convert it into electricity.

Unlike metals where electricity can only be conducted by electrons, semiconductors can conduct electricity with negatively charged electrons and positively charged “holes”





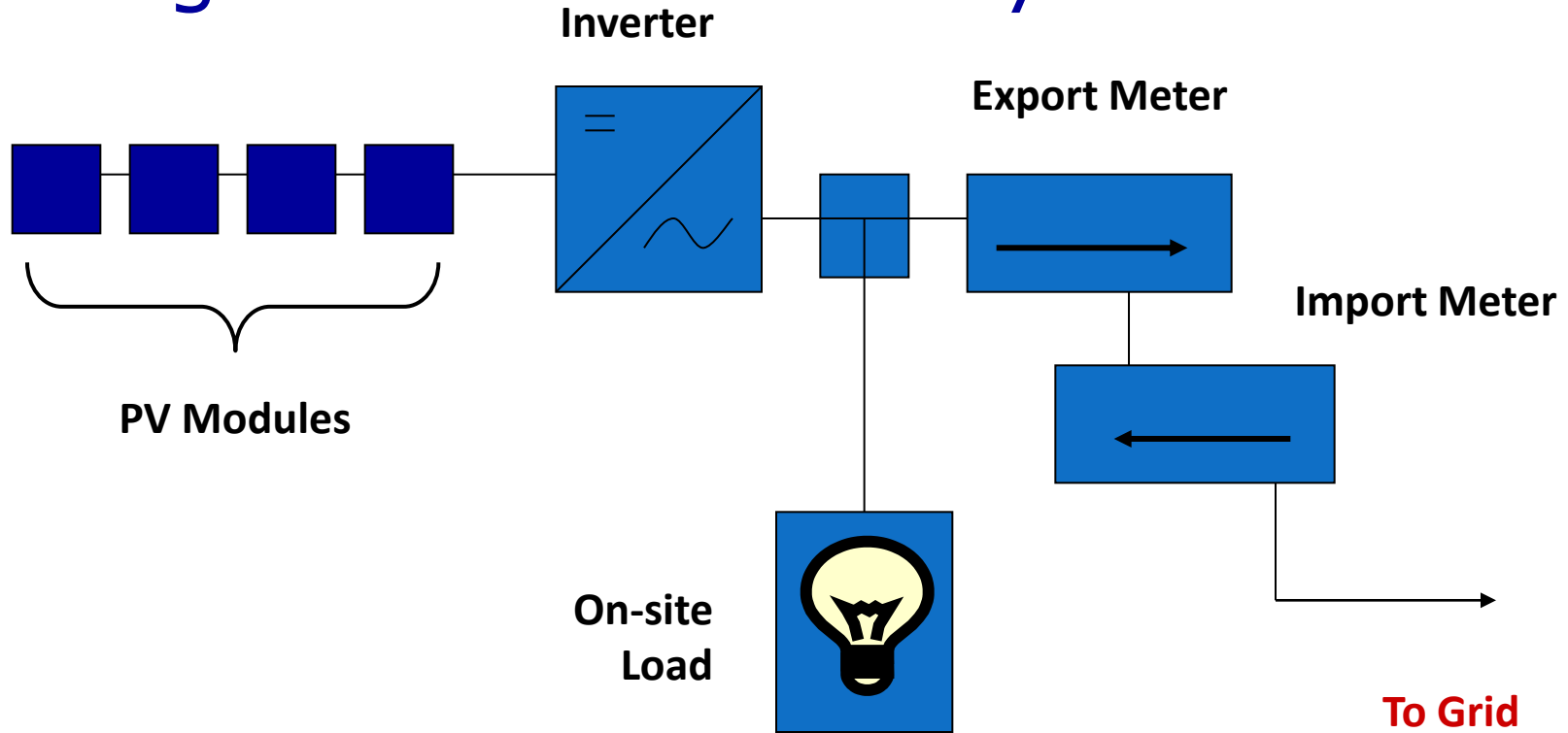
The Sharp module factory in North Wales is producing around 300 MW of PV panels a year using silicon cells



CIS tower,
Manchester



What are the components of a grid-connected PV system?

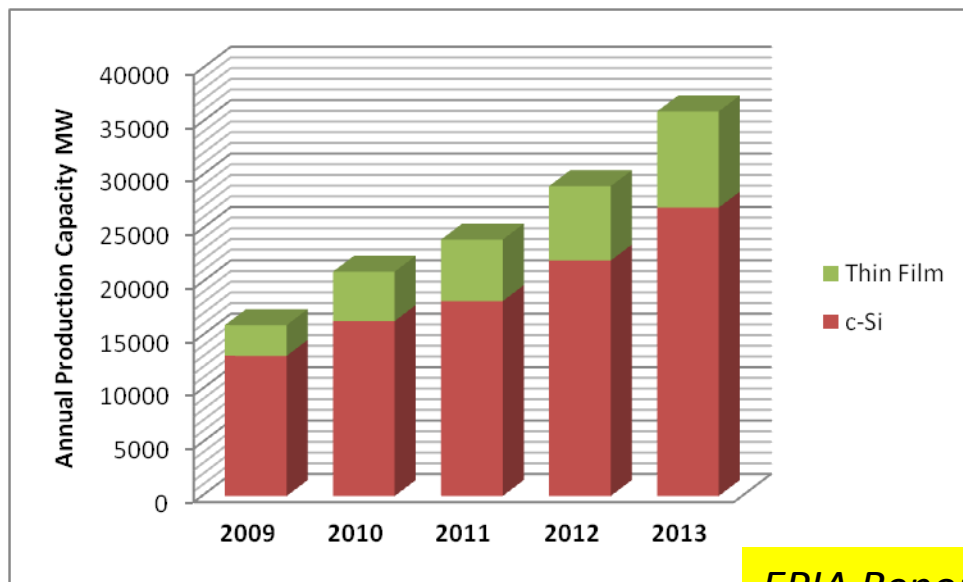




Market price and predicted capacity

Solar Buzz September '10 minimum prices

Lowest Mono- crystalline Module Price	\$2.17/Wp (€1.69/Wp)
Lowest Multi- crystalline Module Price	\$1.99/Wp (€1.55/Wp)
Lowest Thin Film Module price	\$1.07/Wp (€0.83/Wp)



Thin film PV (a-Si, CdTe and CIGS) will be a quarter of the market by 2013



PV modules can be made much cheaper with a thin film of semiconductor on a sheet of glass or sheet steel

First Solar Inc
Cadmium telluride cells

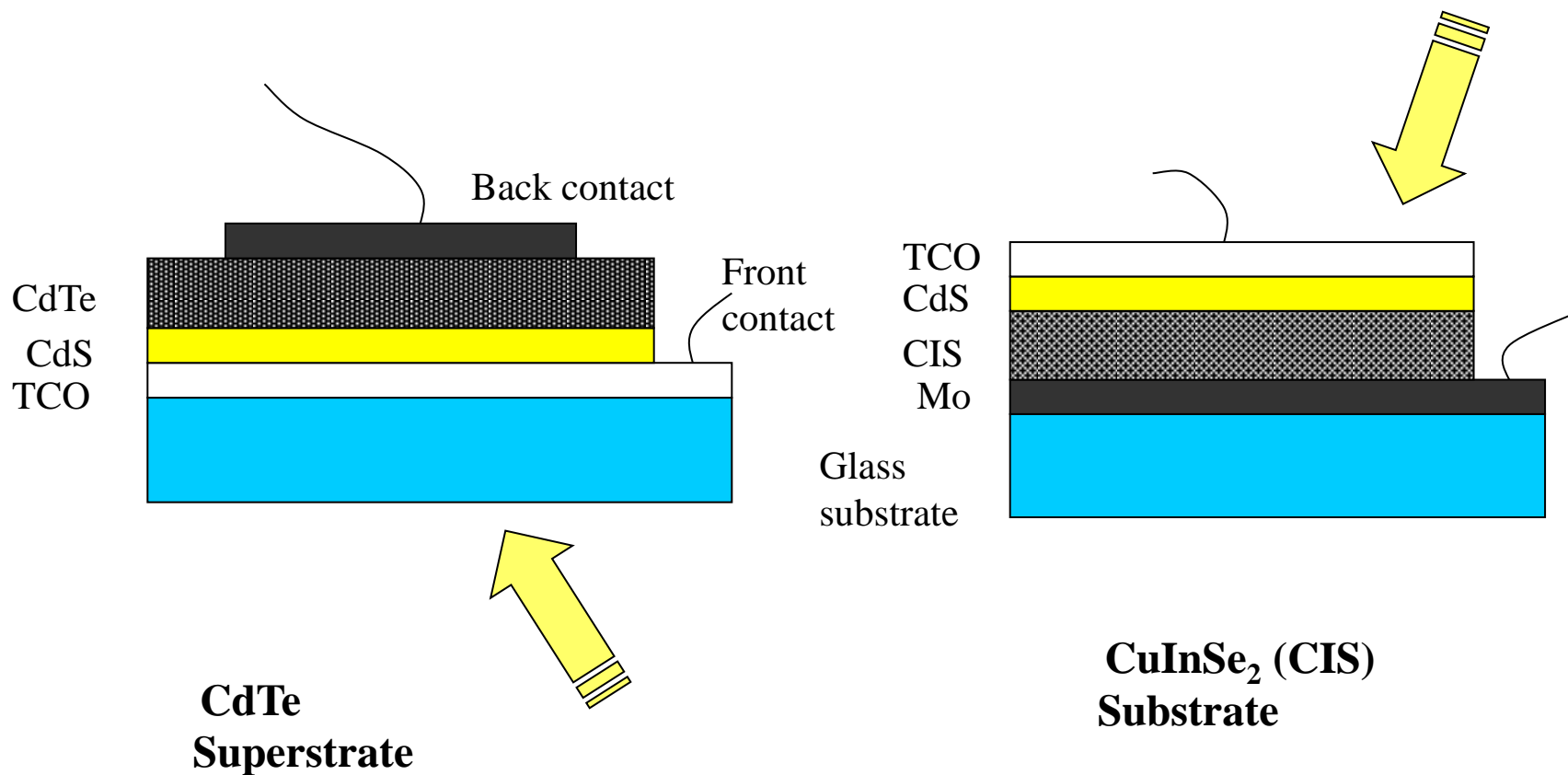


Würth Solar
CIGS cells





Thin film chalcogenide PV device configurations





The PV façade at OpTIC Technium, St Asaph demonstrates novel thin film CIGS technology

1000 m² generating up to 85 kWp of completely clean energy.

Largest of its kind outside US



In the first 12 months of operation a total of 65,000 kWh of clean electricity was generated, saving 28 tonnes of carbon emissions from fossil fuelled power stations



Considerations for thin film PV modules

- Inherently lower cost than crystalline silicon but conversion efficiency 8-11% compared with 15-20% for crystalline silicon.
- More uniform appearance suitable for architectural features.
- Partially transparent modules suitable for glazing.
- Flexible PV modules.
- Potential for much higher efficiency and lower cost with higher manufacturing volumes.



Key Materials Challenges

- Improve efficiency of energy conversion at module level.
- Reduce amount of costly semiconductor materials and efficient materials usage.
- Use cheaper materials.
- Cheaper and lower energy processing combined with high throughput.
- Improved durability and product life



Crystalline silicon

- low-cost solar grade silicon feedstock
- high-quality, low-cost crystallization
- high yield cutting of very thin wafers
- thin-film wafer equivalents



Sharp module factory near Wrexham producing over 300 MW/year



Thin film PV: a-Si, CdTe, CIGS

- Improving efficiency of thin film PV modules.
- Improve production throughput and yield.
- Implementation of in situ monitoring and process control
- Increase production scale.
- Better understanding of module lifetime issues.
- Increase materials utilisation.
- Incorporation of innovative materials.
- Improved characterisation techniques, in particular for thin film polycrystalline materials.

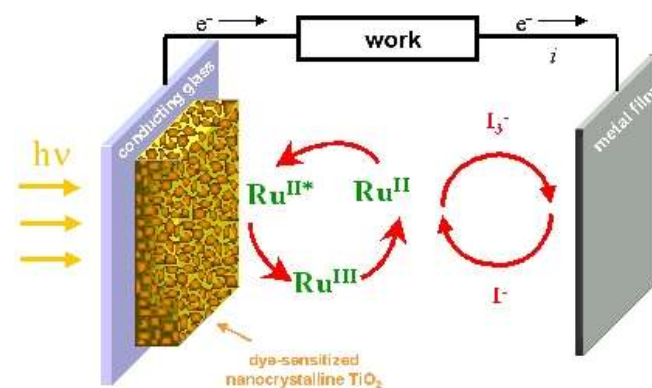


Excitonic PV

- Understanding the charge conduction (excitonic) conduction mechanisms.
- Replacing liquid redox couple with suitable polymer (development of new p-type polymers).
- Effective utilisation of the solar spectrum.
- Development and evaluation of new materials.



G24i DSC solar cells for mobile phones





Conclusions

- Brief overview of PV technology
- Different types of PV modules: crystalline silicon, thin film and dye sensitised (excitonic)
- Important technology drivers: cost per watt, conversion efficiency, durability, applications.
- Balance of system including the inverters and installation is about half total cost – opportunities for innovation.