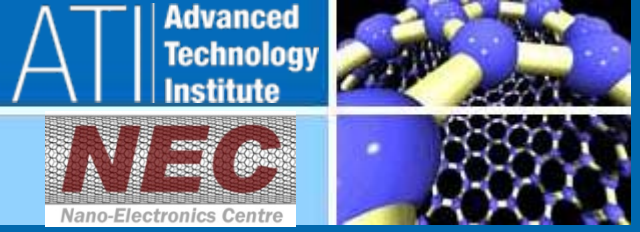

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Challenges in deploying large scale solar energy in India

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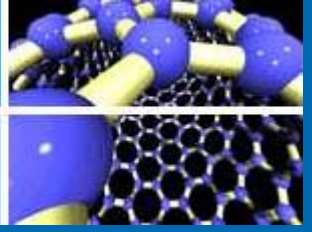

Science
AAAS

EDITORIAL

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Future Energy Institutes

THE LANDMARK ENERGY BILL WENDING ITS WAY THROUGH CONGRESS THIS SUMMER SEEKS TO reduce emissions of carbon dioxide and other greenhouse gases and supports the development of alternative energies, including solar and wind power. It's a bill that aims to create both a "green" U.S. economy and a sustainable environment. At this critical juncture, America must take an equally sustainable view toward investing in the brainpower required to confront the world's complex energy issues.

To harness a vast untapped intellectual pool to drive the new green revolution, Congress should enact legislation that provides long-term funding through the Department of Energy to support research and extension services focused on energy issues at specific universities selected through a competitive process. A one-time investment of $5 billion could fund the construction of new buildings and facilities, and a $30 billion endowment would generate $1.5 billion in federal funding per year to support programs on energy research. As with the land-grant program, federal

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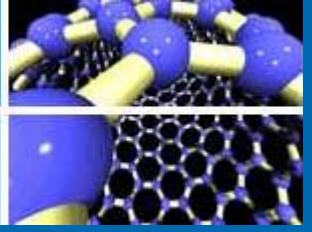

Energy Statistics

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and a small Snap-shot

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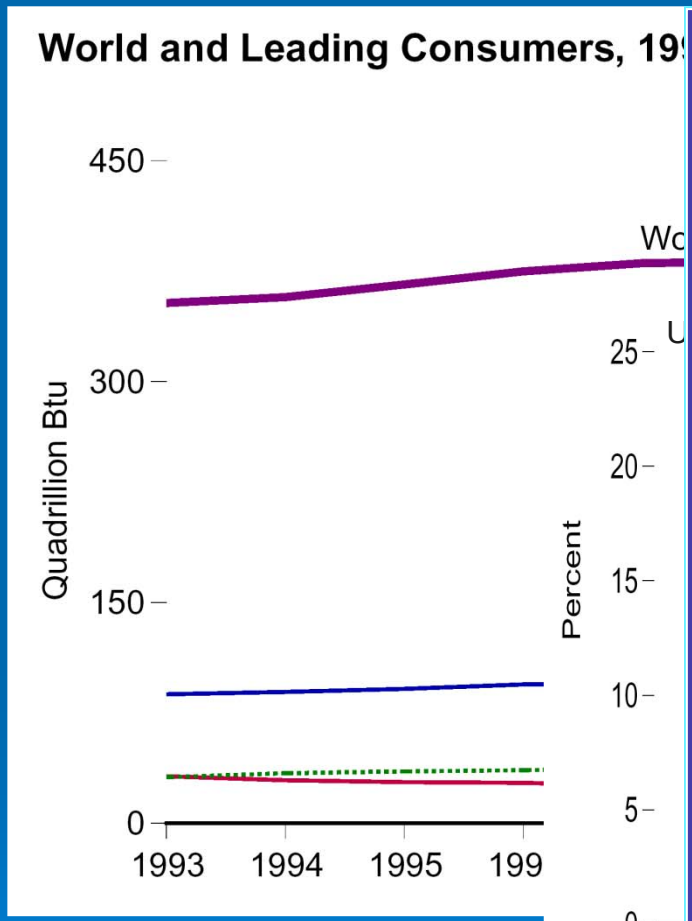
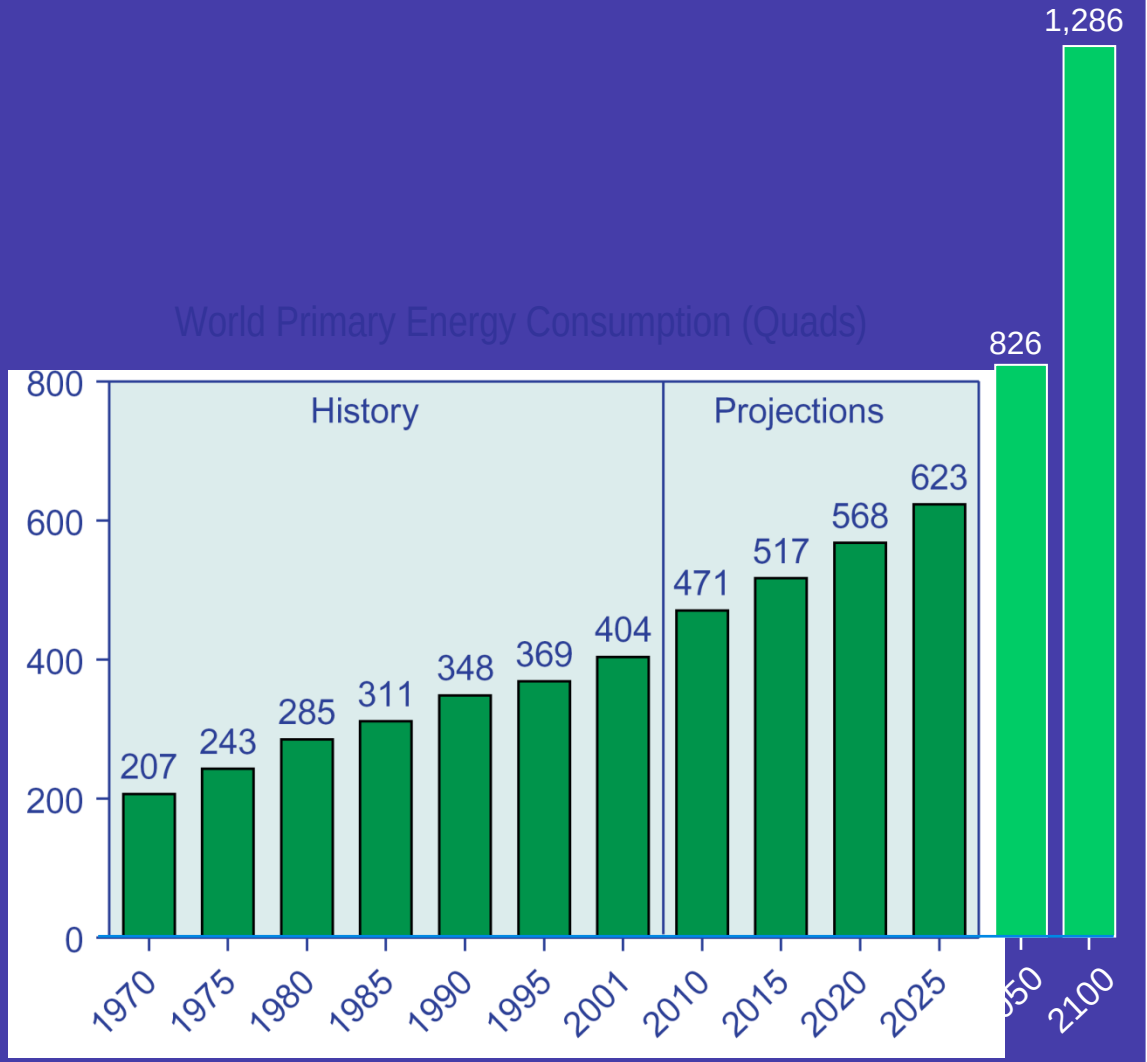
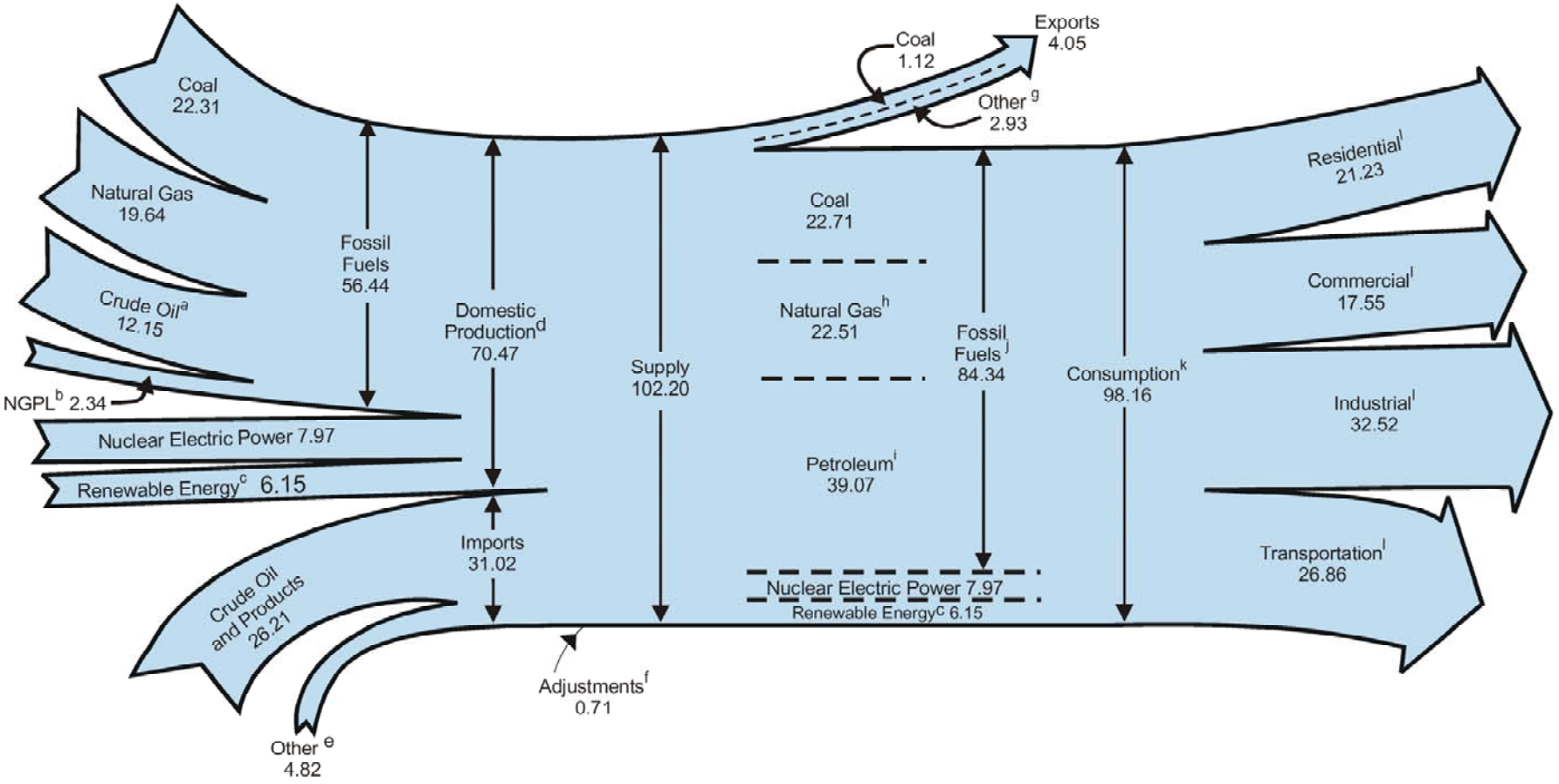
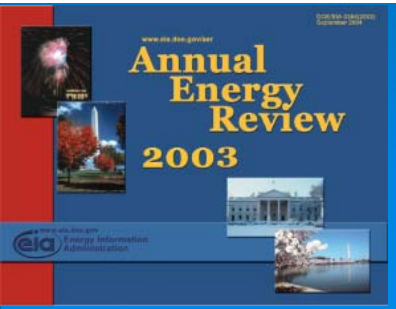




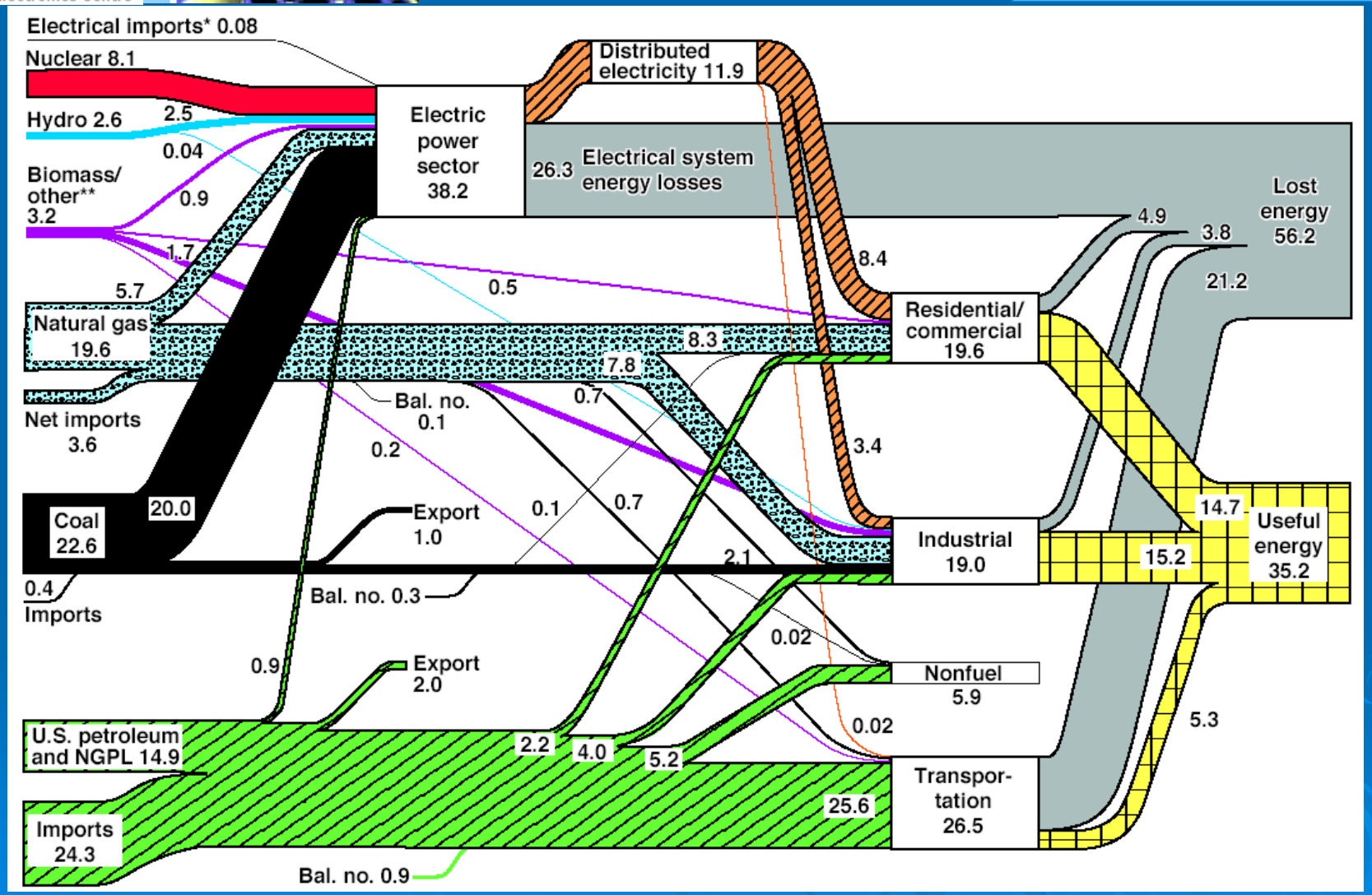
U.S. Energy Flow, 2003 (Quads)





- 85% of primary energy is from fossil fuels; 8% is from nuclear; 6% is from renewables. UK ~75% primary, 18% nuclear, 4% renewables.
- Most imported energy is petroleum, which is used for transportation.
- The end-use sectors (residential, commercial, industrial, transportation) all use comparable amounts of energy.

U.S. Energy Flow 2002 (Quads)



June 2004
Lawrence Livermore National Laboratory
http://eed.llnl.gov/flow

- 39% of primary energy goes toward electricity generation; 69% of that is lost energy.
- 80% of energy used in the transportation sector is lost energy.
- Overall, 58% of primary energy is lost energy.

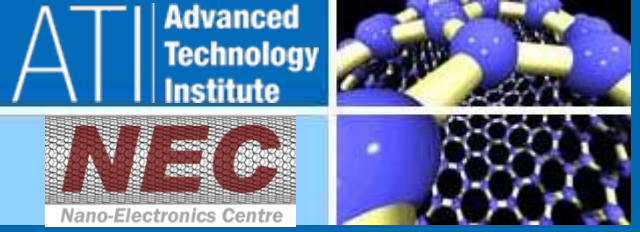
Energy Outlook in India

On Grid

Installed capacity ~150 GW
Renewable sources 13 GW, a third by wind
Solar: a few megawatts of grid-connected PV

Off Grid

Rural electrification
Solar water pumping
Lighting



Renewable Initiatives

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National Solar Mission to be soon unveiled- Reuters

20GW of solar energy (PV dominated?) by 2020!

1-1.5 GW as early as 2012

Incentives for production and installation as well research and development, and the plan offers financial incentives and tax holidays for utilities

Material challenges

Targets by 2020:

India 20 GW

China 20 GW

Japan 28 GW

EU/US Renewable commitments

2009 projected production 14 GW!

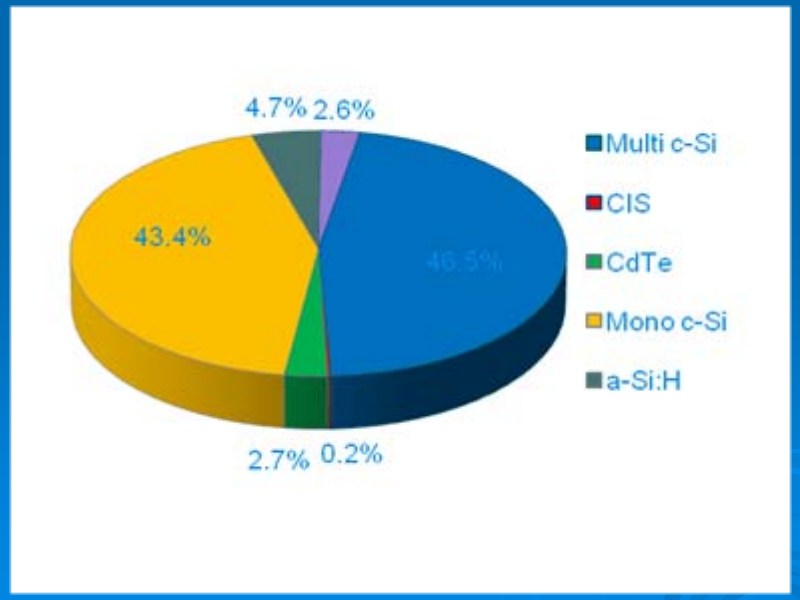
Worldwide demand for PV to drastically increase

60 MW_p

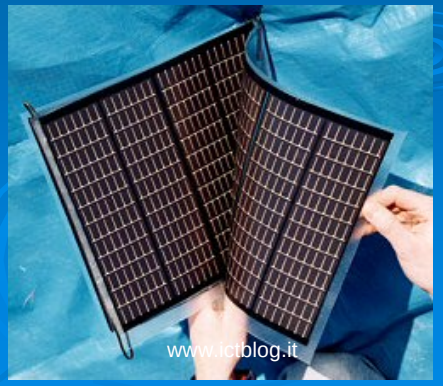
Olmedilla, Spain

Material Challenges

- We need all the technologies available
- Thin film technologies to spearhead production for spiralling demand



Amorphous silicon, Cadmium Telluride



Best Research-Cell Efficiencies

www.nrel.gov/ncpv/thin_film/docs/kaz_best_research_cells.ppt

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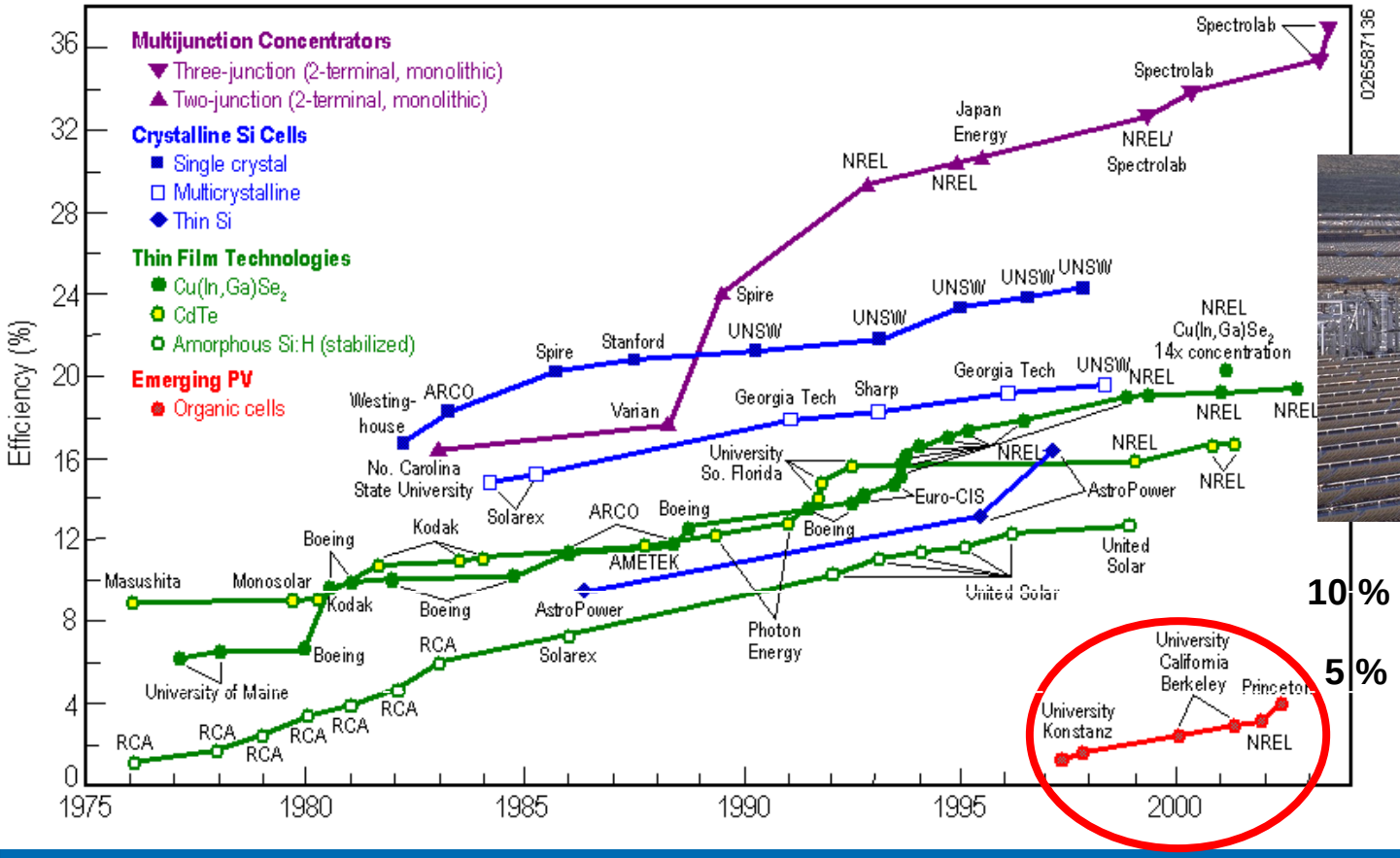

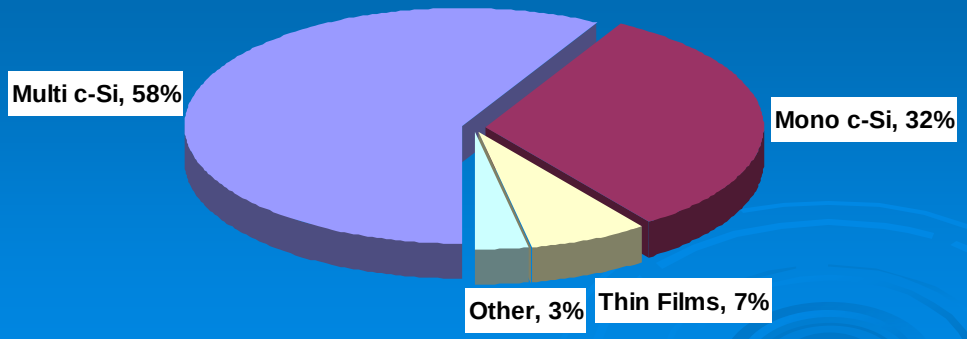

Silicon dominates the market at present, however manufacturing costs are still high.

Organic based cells at present have too low an efficiency to compete, but potentially offer a low cost alternative due to low raw materials costs and the ability to fabricate over large areas.

A vision for Photovoltaic Technology, European Commission Community Research, EUR 21242, 2005.

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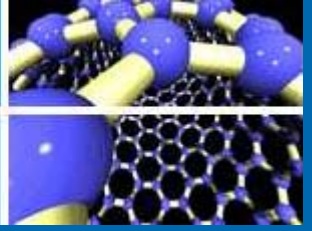

2, 3 & 4 G PV Devices

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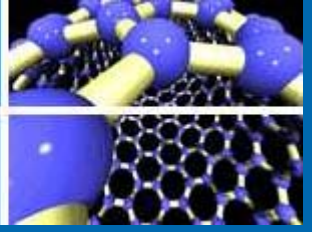

"Solar Paint"

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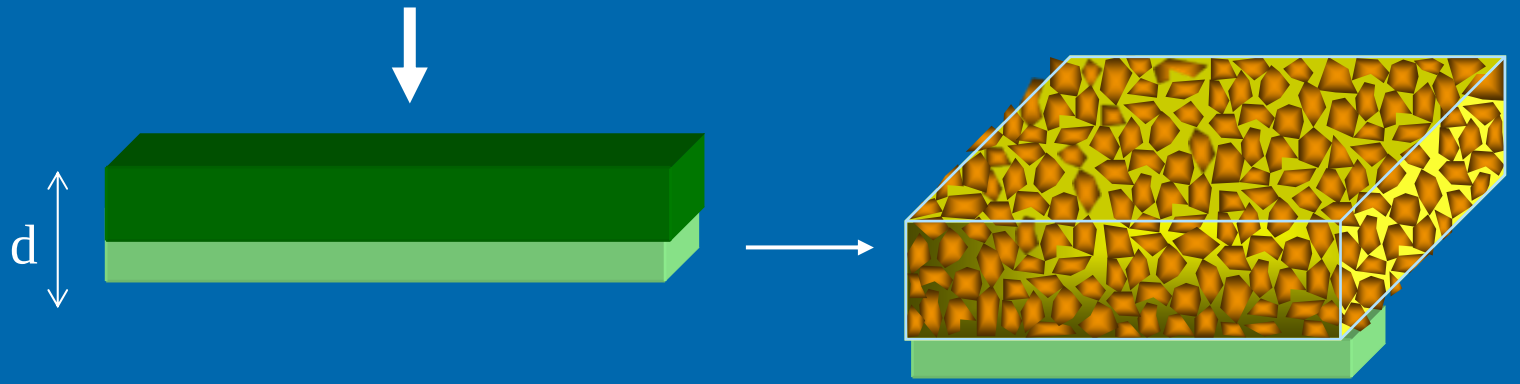
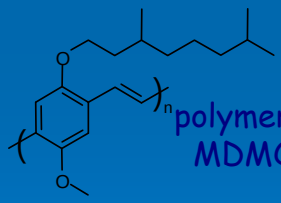
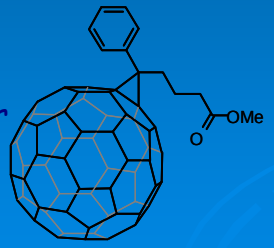


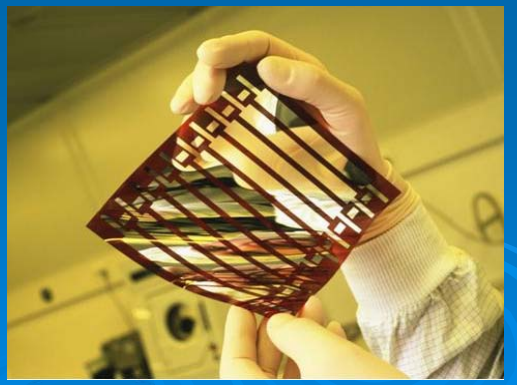
"Fooling "inexpensive particles into behaving as single crystals



polymer donor
MDMO-PPV



fullerene acceptor
PCBM



inexpensive processing, conformal layers

Material Challenges

- Mono crystalline silicon still faced with microelectronic industry competition.
- No longer the industry of microelectronics scrap
- R & D to alleviate obstacles for roll to roll processing

Success stories :
Uni Solar
Nano Solar?

Legislation Challenges

- Interests need to be commitments!
- Subsidies and incentives are a must for eventual grid parity
- Support industries will need government help as well

- Land availability
- Simplification of power purchase agreements for small producers to come in

Supply Challenges

- Capacity of support sectors such as inverters and structures
- Shipping costs?
- Local production to win?
- Emerging economies with cheaper labour such as India & China to benefit?
- Manufacturing requirements: Furnaces, Coaters, CVD equipment supply?

Xantrex PV150 system inverter

Tucson Electric Power Company

Reliability

- Of Technologies
- Of Systems

Last thing we need is unproven technologies/systems to falter after a couple of years

Guarantees, Performance , Testing

Support System Challenges

- Power system issues with large deployment of solar (20 GW is 8% of current Indian Installed capacity) such as spinning reserves and storage
- Balance of system development for PV such as inverters, which need to have commensurate price reductions with panel costs coming down
- BOS can be up to 50% of the cost of plant

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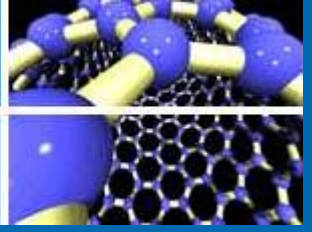

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Thank You

http://www.youtube.com/watch?v=35y2YSa9dV4&feature=channel_page
OR look for Nanotechnology for Green Energy Public Lecture by Ravi Silva on:
http://www.youtube.com/user/HongKongPolyU