



Guest Lecture to HKU Department of Architecture  
[Arch 5305 – Sustainable Building Systems]




## Renewable Energy Systems

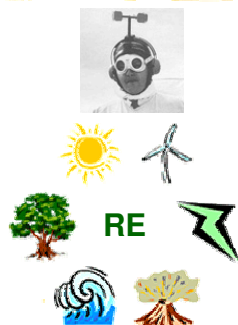
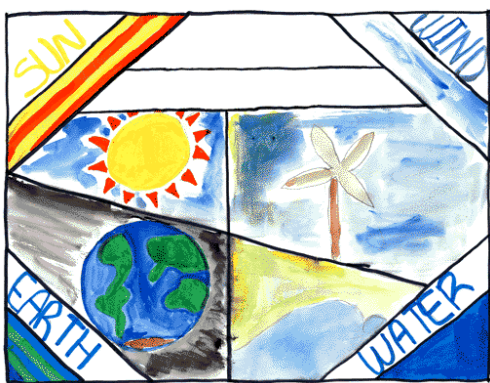


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- Basic Concepts
- Active Solar
- Photovoltaics
- Wind Energy
- Other Renewables





\* Artwork by Allison Allen Phillips, Grade 6, Thurston Middle School, Laguna Beach, California


## Basic Concepts



- Renewable energy
  - Energy that occurs naturally and repeatedly on earth and can be harnessed for human benefit
  - Such as solar, wind, biomass, energy from waste, geothermal, hydro, wave and tidal, ocean thermal
  - Most renewables are derived from the sun
    - Direct use of solar energy for heating or electricity
    - Indirect forms (e.g. wind, waves, running water)





## Basic Concepts



- Renewables for buildings
  - Solar energy
    - Passive (low energy architecture)
    - Active (solar thermal)
    - Photovoltaics
  - Other renewables
    - Wind (using buildings to harvest wind energy)
    - Geothermal (e.g. hot springs)
    - Small hydros (e.g. water wheels)
  - Hybrid systems (e.g. PV + wind + diesel)

多 因  
能 地  
互 制  
补 宜  
。

Passive solar (e.g. skylight)

Active solar (solar hot water)

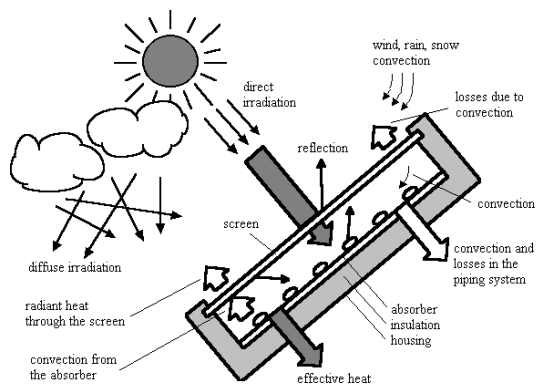
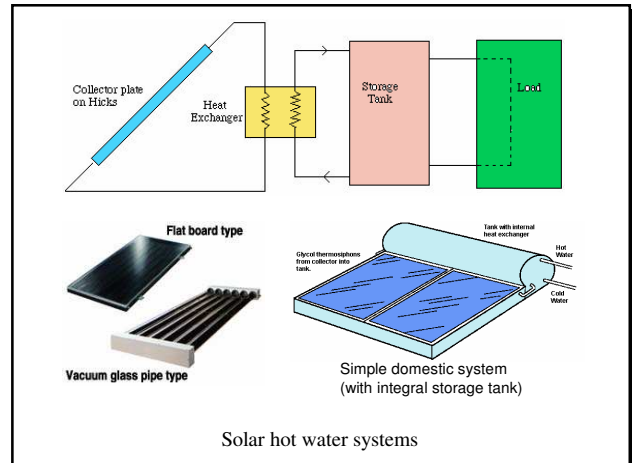
Photovoltaics

Integration of solar energy systems in buildings

## Active Solar



- Also called 'solar thermal'
- Common applications
  - Solar hot water (domestic or non-domestic)
  - Swimming pool heating
  - Space heating or air preheating
  - Solar air-conditioning
    - Using absorption or desiccant cooling system
  - Electricity generation
    - Using steam plant and concentrator



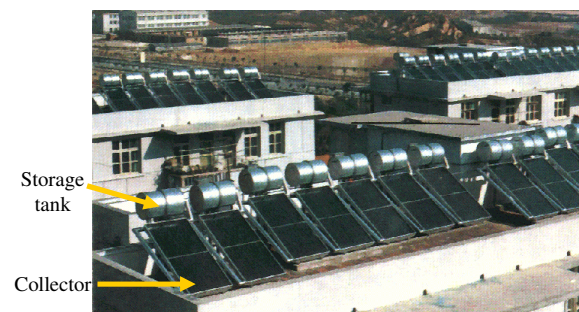
Heat transfer processes at a flat-plate solar collector



Solar hot water system in a hospital in Tuen Mun



Inclined Angle? Solar hot water for a school in Guangzhou



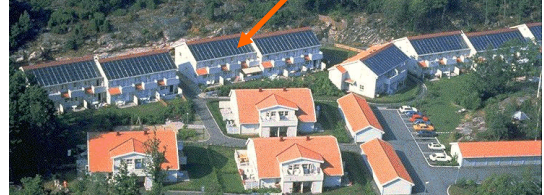
Solar domestic hot water system in Guangzhou



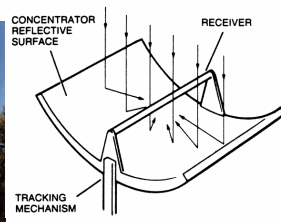
Evacuated-tube solar hot water system



Solar collectors integrated with roof

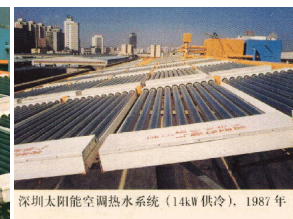


(a) Point focus



(b) Line focus

Focusing solar collectors  
(high temperature; can be used for  
generating electricity)



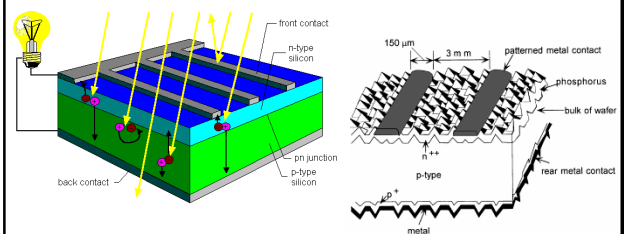
深圳太阳能空调热水系统 (14kW 供冷), 1987 年

A solar absorption cooling-hot water system in Shenzhen  
(using vacuum tube collectors)

## Photovoltaics

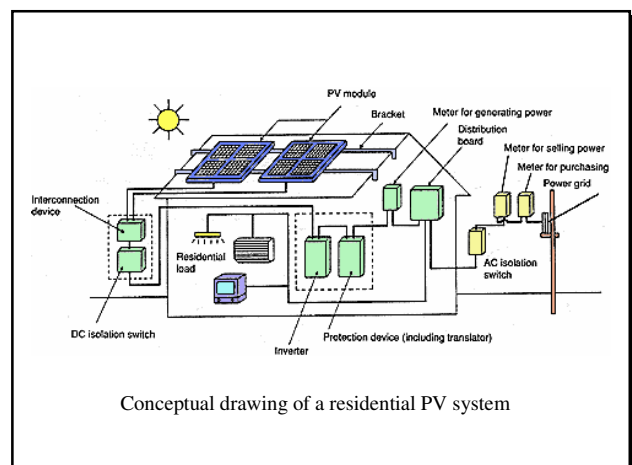
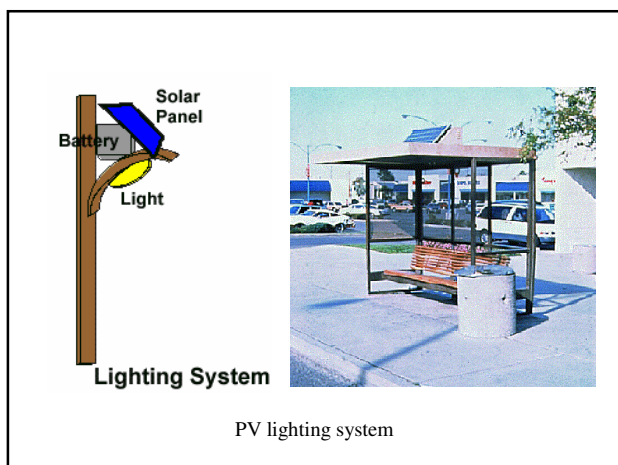
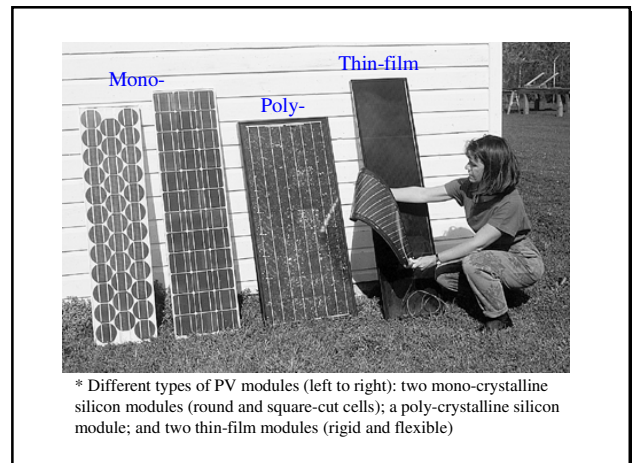
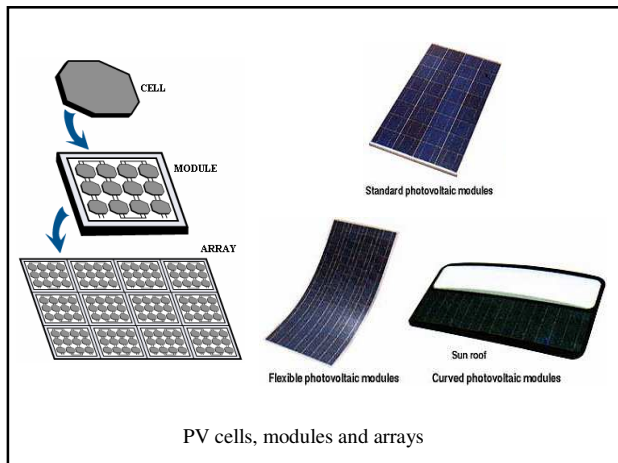


- Photovoltaics (PV)
  - Convert sunlight into direct current electricity using a semi-conductor device
    - Materials: crystalline and amorphous silicon (sand)
  - Applications:
    - Consumer products (e.g. calculator, radio)
    - Remote-site (e.g. remote telecom and weather station)
    - Central power generation
    - Building-integrated photovoltaic (BIPV) systems



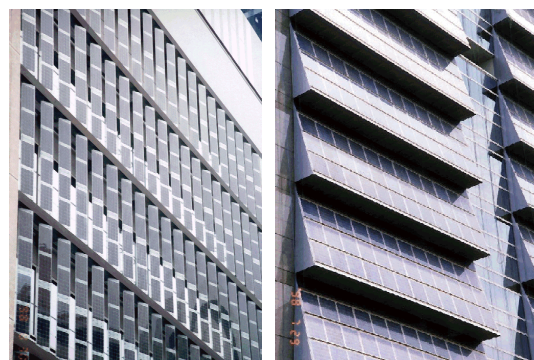
Principles of photovoltaic cells



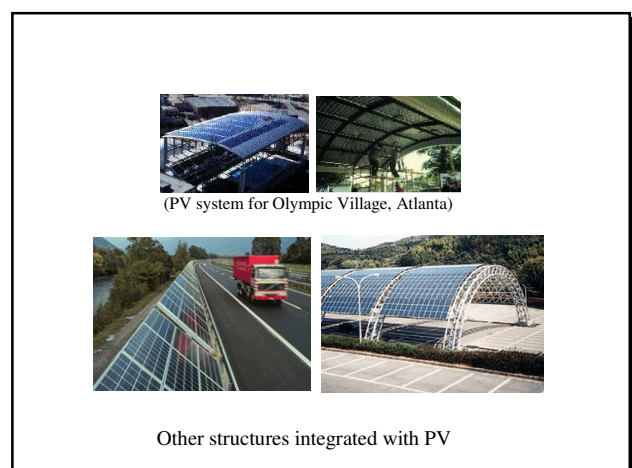
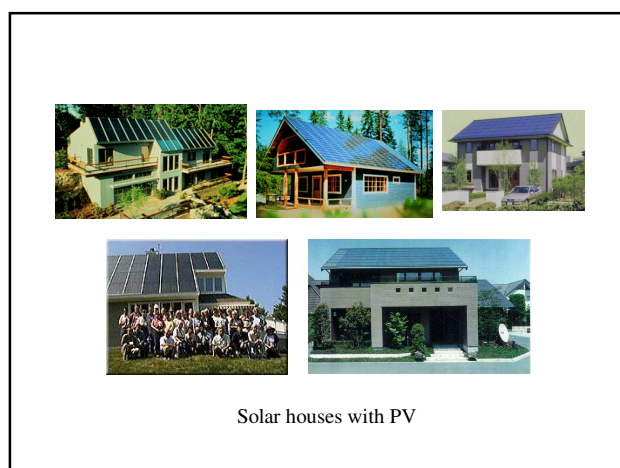
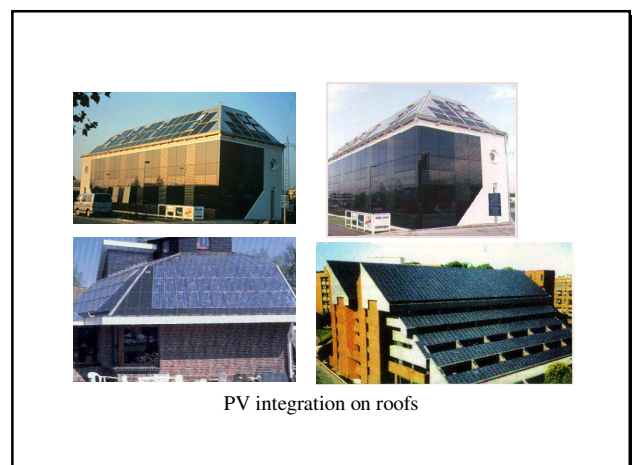
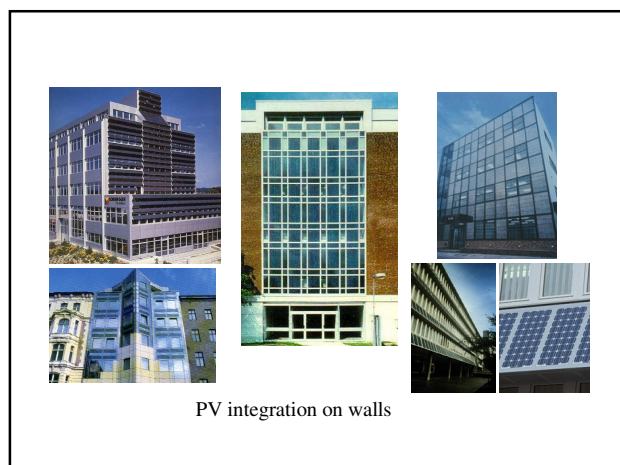
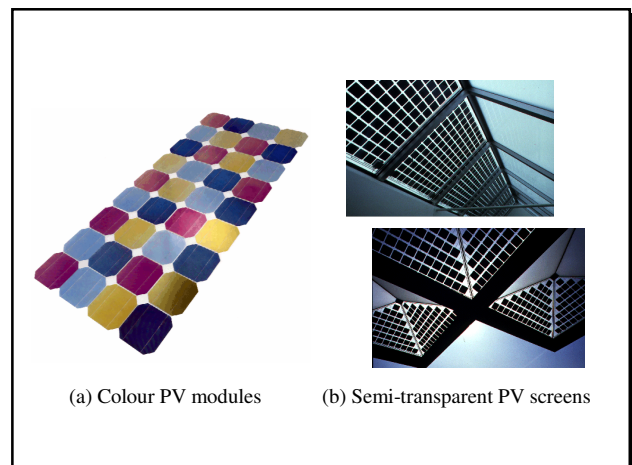
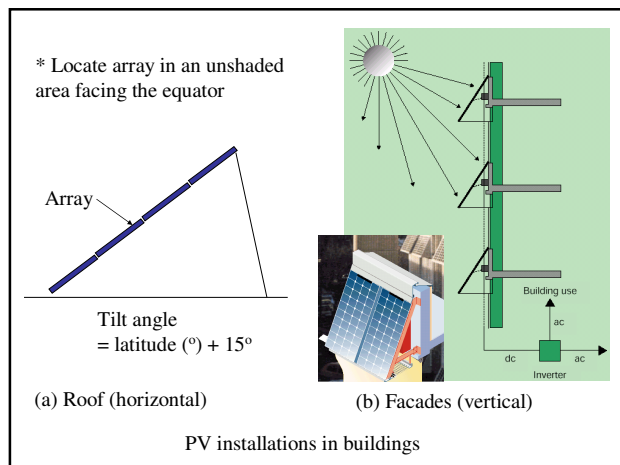


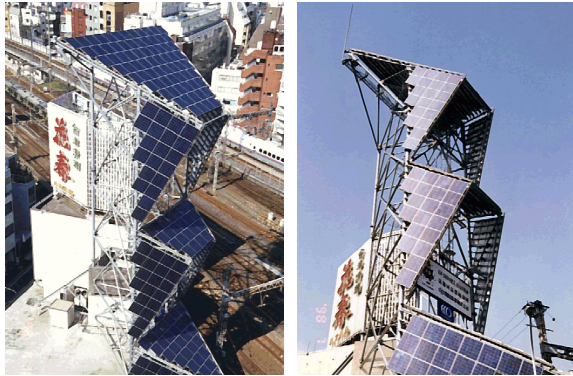
## Photovoltaics

- Building integrated PV (BIPV):
  - Improve cost effectiveness and functions
    - Dual use (PV + building envelope)
    - No need for extra land and support
  - Can be integrated with
    - Exterior wall panels, roof tiles
    - Exterior shading systems, parapet units
    - Skylights or atriums
    - Semi-transparent glass facades

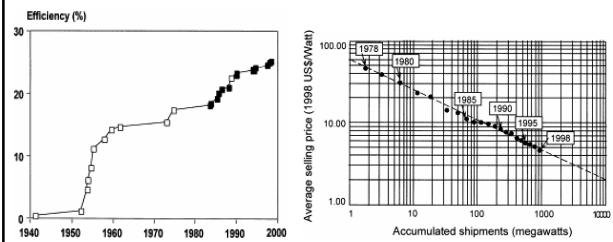


Architectural integration of PV modules on exterior walls



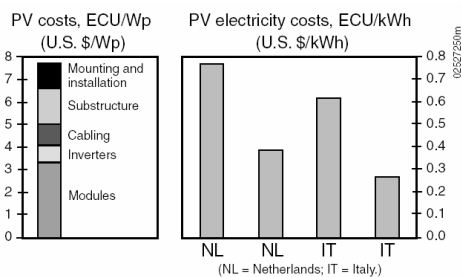


Solar Tower, Kanda (Tokyo, Japan)



Current price = US\$4-5/Watt  
(panel only; add 30-50% for accessories)

Efficiency and price of PV modules



**Figure 1. Overview of BIPV system costs in ECU/Wp (left) and the resulting PV electricity costs in ECU/kWh (right), for different countries and calculation methods (optimistic: maximum performance ratio, low interest rate; pessimistic: average performance ratio, high interest rate).**

Note: Currently, the ECU is equivalent to one U.S. dollar.

[Source: Eifert, P. and Kiss, G. J., 2000. *Building-Integrated Photovoltaic Designs for Commercial and Institutional Structures: A Sourcebook for Architects*, NREL, Colorado.]

## Wind Energy

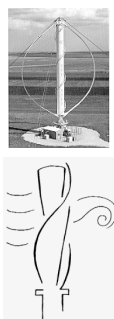
- Design factors
  - Location: inland or off-shore
    - e.g. wind farm
  - Wind turbines: horizontal or vertical axis
  - Wind speed
    - Cut-in = 3-5 m/s; shut-down = 25-27 m/s
- Environmental impact
  - e.g. noise, visual, electromagnetic interference



Wind turbines on inland or islands



Off-shore wind turbines



Vertical axis wind turbines

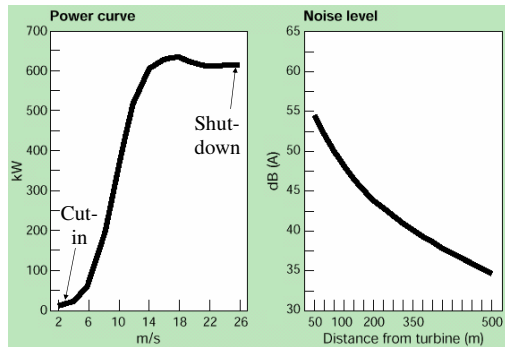


Dutch pavilion, EXPO 2000 Hannover



Project Zed - London

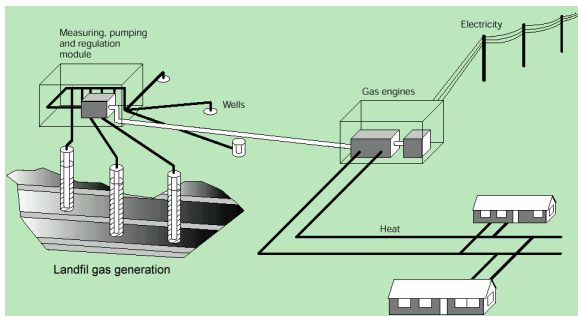




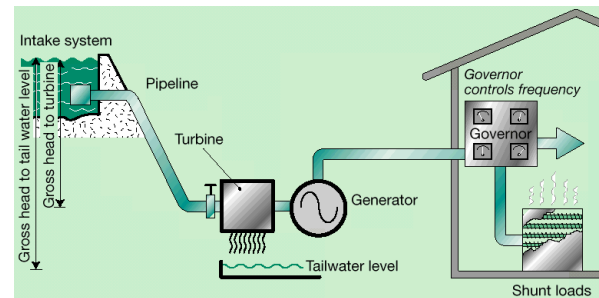
Power curve and noise level of wind turbines

## Other Renewables

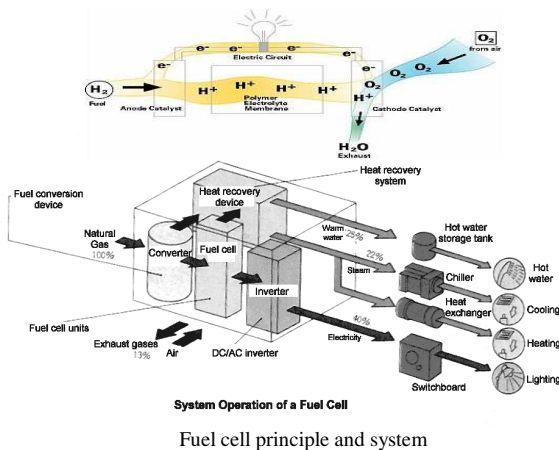
- Biomass
  - Using wood, agricultural residues as a fuel
  - Energy from waste incineration or digestion
  - Landfil gas, biogas and biofuel
- Small hydro
  - In mountain areas or river streams
- Geothermal - earth heat
- Wave, tidal, ocean thermal energy
- Fuel cell systems + Hydrogen



Use of landfill gas for electricity and heat



Small hydro system (example)



Fuel cell principle and system

## Examples

- Video presentation:
  - Turning Down the Heat [46 min.]
    - Solar energy in Holland, Japan, and California
    - Biogas in Denmark and Vietnam
    - Wind energy in Holland and India
    - Hydrogen fuel cells and ground source heat in Vancouver