Building Integrated Photovoltaics -innovative concepts, policies & tools

Presenter:

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Context

- According to the Worldwatch Institute about 40% of the world's total energy usage is dedicated to the construction and operation of buildings.
- The building industry consumes 3 billion tons of raw materials annually -- 40 % of the total material flow in the global economy.
- Only about 0.003 % of earth's water is readily available as fresh water for human use (Miller, 1992). Building materials manufacturing, construction and operations consumes 16% of available fresh water annually
- Buildings account for about one-third of the emissions of heat-trapping carbon dioxide from fossil fuel burning and two-fifths of acid rain-causing sulfur-dioxide and nitrogen oxides.

•Space heating solar collector

Snapshot of emissions

- The threshold for dangerous climate change = +2oC
- Adding 1 trillion tonnes of carbon to the atmosphere = a warming of 2oC
- Amount emitted in the last 250 years = 500 billion tonnes
- Amount remaining to be emitted before +2oC reached = 500 billion tonnes
- Projecting current patterns of emissions, time to emit this amount = 40 years.

•Large-Scale Solar Thermal System

[NCCARF Data]

EU NEWS……..May 2009

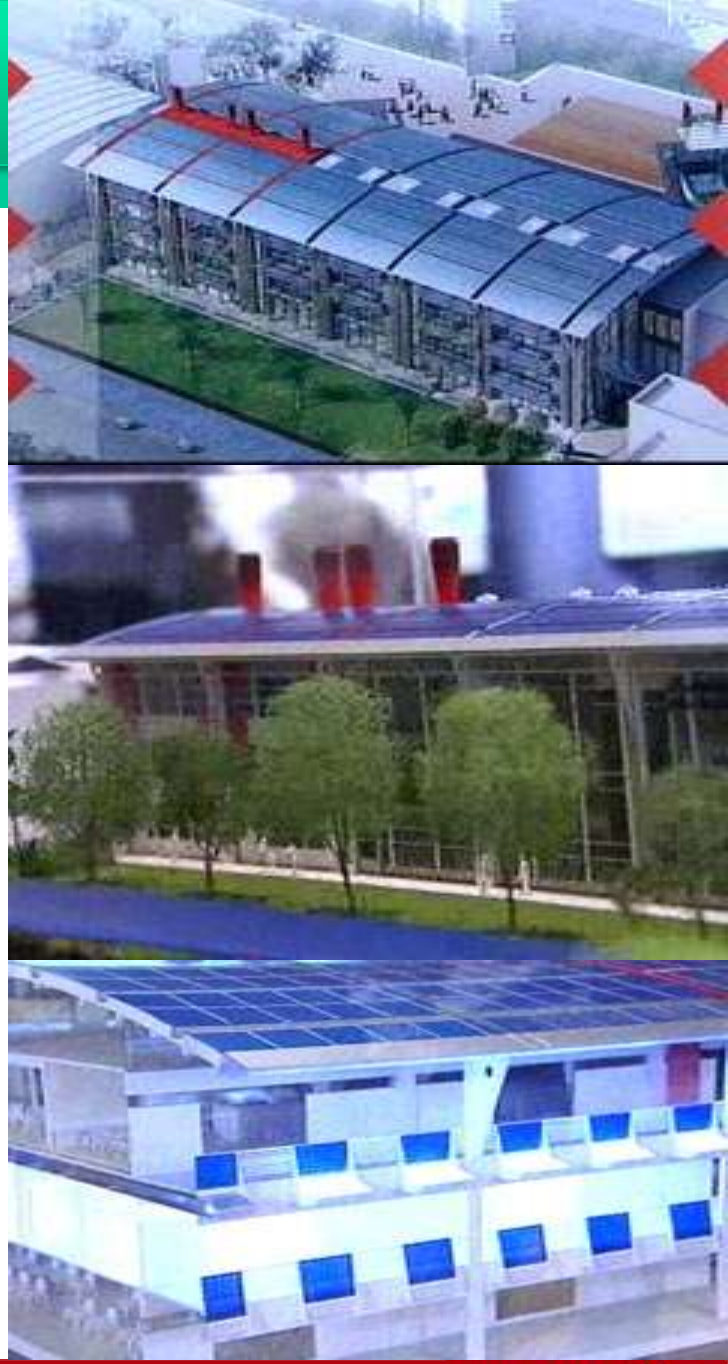
- ‘European Parliament voted for ‘zero energy buildings…. Zero Energy Buildings is a key element in the renewed EU legislation on buildings. During the last plenary session the Parliament adopted new legal requirements for Europe’s buildings and their energy performance
- From 2019 all new buildings in the EU will have to produce more renewable energy onsite for example by solar panels than they consume, the Parliament decided by recasting the Energy Performance Buildings Directive of 2002.
- These zero energy buildings will include energy efficient buildings whose overall annual primary energy consumption is equal to or less than the energy production from renewable sources on site. By 2015 national targets will be set to fix minimum percentages of existing buildings to be zero energy’ --*EU Media*

Zero Energy building - definitions

Authors	Definitions
U.S. Department of Energy Building Technologies Program (Torcellini, et al. 2006)	• **Net Zero Site Energy** : A site ZEB produces at least as much energy as it uses in a year, when accounted for at the site • **Net Zero Source Energy**: A source ZEB produces at least as much energy as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to generate and deliver the energy to the site • **Net Zero Energy Costs**: the amount of money the utility pays the building owner for the energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year •
Kilkis (2007)	• Balancing the "zero" both quantity and quality (exergy) of energy should be taken into consideration • **Net-Zero Exergy building** "… a building, which has a total annual sum of zero exergy transfer across the building-district boundary in a district energy system, during all electric and any other transfer that is taking place in a certain period of time".
Mertz et al. (2007)	• **Net-zero energy building (home)** : "… as a home, that over the course of year, generates the same amount of energy as it consumes • **Net-zero CO2 (CO2 neutral) building**: no CO2 is added to the atmosphere due to the operation of the building
International Energy Agency (IEA) (Laustsen , 2008)	"**Zero Energy Buildings** do not use fossil fuels but only get all their required energy from solar energy and other renewable energy sources" **Zero Net Energy Buildings:** buildings that over a year are neutral, meaning that they deliver as much energy to the supply grids as they use from the grids • **Zero Carbon Buildings**: buildings that over a year do not use energy that entails carbon dioxide emission

Singapore ZEB

- S$10 million spent to retrofit of an existing facility to incorporate some of the latest energy-efficient inventions
- The building is able to generate as much electricity as it consumes through renewable energy. This works out to a net energy consumption of zero over a typical year
- The solar panels which constitute about 15% of the building cost
- 60 percent of utility bills usually goes into air-conditioning. Sensors will detect the presence of users and will direct fresh air to their breathing zones. Recycled air will be used for ambient cooling



Zero Energy Office (ZEO) Building Kuala Lumpur

- The building is designed with energy index of 35-40 kWh/m2year, in comparison to typical conventional office building in Kuala Lumpur of 250-300 kWh/m2year. The energy consumption is reduced by various means of passive and active systems.

North View

Source: ZEO official website @ http://www.ptm.org.my/PTM_Building/Index.html; Access date: 15.05.2009

Adam Joseph Lewis Center for Environmental Studies--Oberlin College (Oberlin College Lewis Center)

•**Overview**

• Location: Oberlin, OH

• Building type(s): Campus, Higher education, Library, Assembly

• New construction

• 13,600 sq. feet (1,260 sq. meters)

• Project scope: 2-story building

• Completed January 2000

• Rating: Green Building Challenge

• Rating: Zero Energy Building

•An aerial view of the Oberlin College Lewis Center highlighting the PV arra

•**Zero Energy Building**

• Site ZEB: The Lewis Center is an all electric building that produces all energy on-site using PV.

• Source ZEB: Because the Lewis Center is an all electric site ZEB it also qualifies as a source ZEB.

• Emissions ZEB: The Lewis Center offsets any emissions for which it is responsible through its PV system which produces electricity with zero emissions.

BedZED & Eco-village Development

•**Overview**

• Location: Wallington, South London

• Mixed-use scheme

• 100 homes, community facilities

• and workspace for 100 people

• UK's largest new-build carbon-

• neutral development

•**BedZED Village Square**

•**Objectives**

• to produce a carbon neutral development

• to reduce environmental impact

• to help people to live more sustainably within their share of the earth's renewable resources, without sacrificing a modern, urban lifestyle

Alice Springs Hotel

- 305-kilowatt solar power system atop the roof of the Crowne Plaza Hotel in Alice Springs, Northern Territory
- expected to provide between 40 and 80 percent of the hotel's power requirements, depending on the time of year

PV as part of Building function

221kWp of blessed Vatican PV

Building integrated concepts for roof systems

Building integrated concepts for façades

13 kWp PV at Vocational School Tyrol, Austria

Building integrated concepts for façades

Solar Kogarah (AJC)

Kogarah SYDNEY 160 kWp

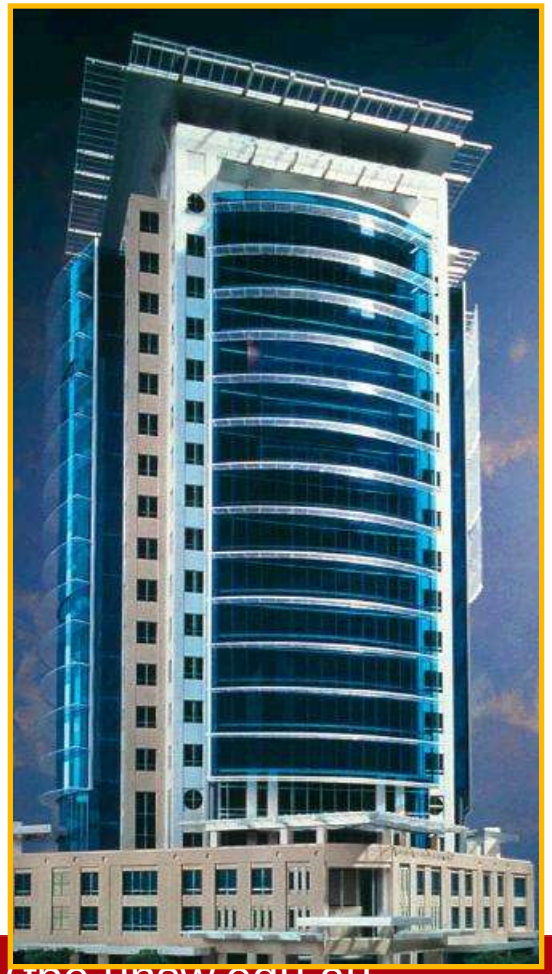
Australian showcase projects in major cities

Kogarah
SYDNEY
160 kWp

QV Markets
MELBOURNE
190 kWp

Melbourne
University
43 kWp

High Rise
BRISBANE
60 kWp



Original 629kWp

Olympic Village
SYDNEY

Additional 72kWp

Shade systems and balustrades

Innovative design

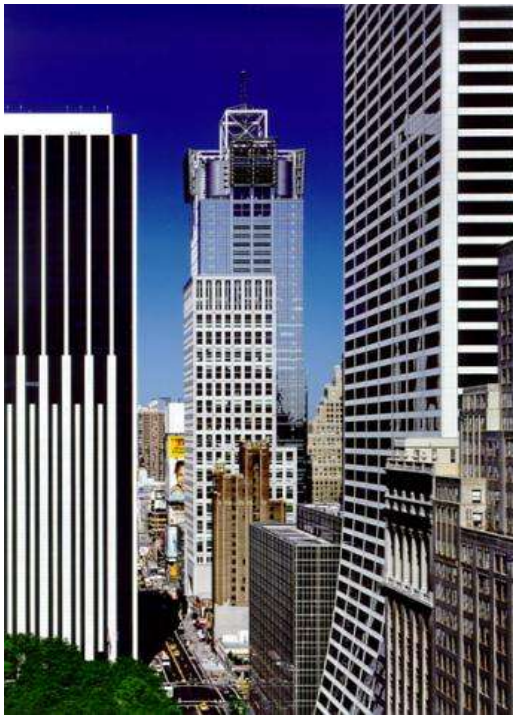
La-Vaguada entrance PV canopy 5.2kWp Madrid

Synergies with building materials

1MWp Mont-Cenis-Academy building, Herne Germany

Four Times Square, NY

- 48-storey skyscraper – 1st major office building built in NY in 1990s
- BIPV curtain wall from 37th to 43rd floor on south and east facades replacing spandrel glass.
- BIPV attached to building in same way as standard glass



Global examples – pergola

BIPV application : Pergola

Building name	:	*The Solar Pergola*
Location	:	*Spain, Barcelona*
Building type	:	*Pergola*
Completion	:	*2004*
PV application	:	*Roof integrated PV*
Type of PV :	*Monocrystalline silicone*	
Quantity	:	*449 kWp*
Yield	:	*1250 kWh/kWp*

General Description

The 50m height PV area is close to the size of a football pitch (112x50m2)

Source : http://www.isofoton.com/espaniol/forum.pdf

http://www.earthscan.co.uk/news/article/mps/UAN/226/v/3/sp/332244698595342568278

Global examples - Netherlands

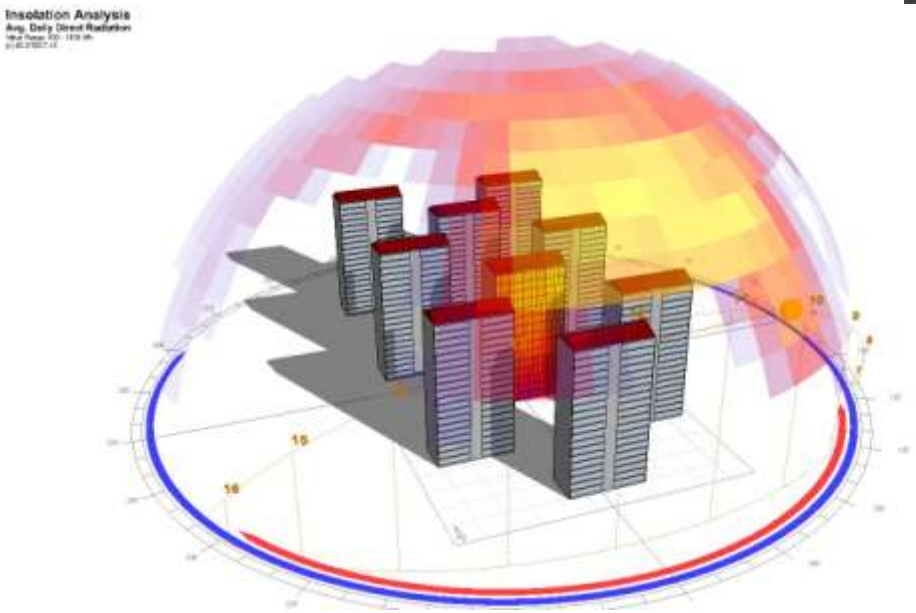
BIPV application : Roof

Building name:	Housing Area of Amsterfoot
Location:	Netherlands, Amsterfoot
Building type:	Residential
Completion:	1999
Type of PV :	Polycrystalline
Quantity:	1323 kWp on 500 houses
	900 solar hot water systems
	80% houses face SW-SE arc

Global examples – High rise

Korea

250kWp PV systems on roof mounted apartment blocks



Global examples - Japan

Ota, Gunma, Japan - over 500 houses totalling 2,16 MWp

Day lighting and power generation design control

BIPV Buildings in Beijing

Tianpu,Beijing Grid-connected system(50kWp)

•National Gymnasium Grid-connected system
•(100kWp) (In progress)

Volkswagen Beijing Service Center(43.2kWp)

•The new solar-powered Bus Stop Indicator in Beijing

Whole building solution - IEQ performance

Itoman City Government building, Itoman, Okinawa, Japan

Photovoltaic power generation

Shielding from intense sunlight

Photovoltaic power generation system making use of Okinawa's intense sunlight
Various exterior louvers matching the direction of insolation
Various exterior louvers for shading and ventilation

Northern face: vertical louvers
Shielding from summertime insolation effectively by reflection

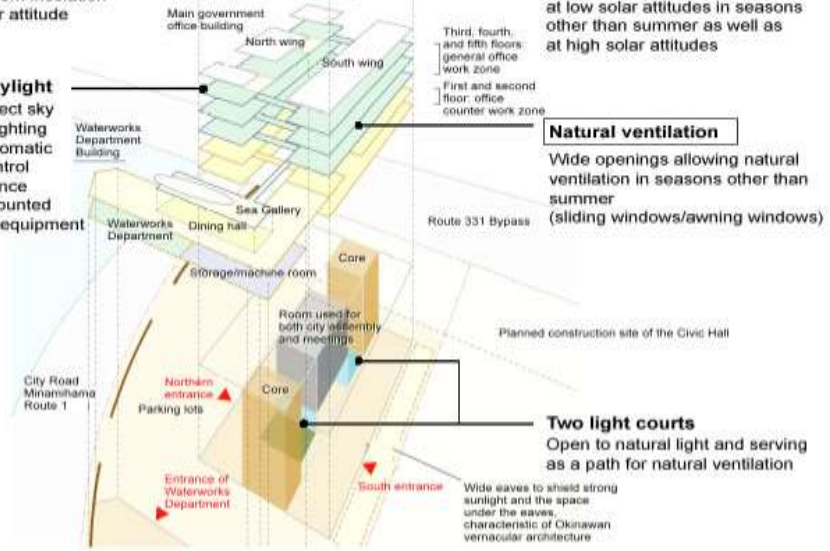
Rooftop: shelter incorporating solar cells
Generation capacity: 145.3 kW
Shielding from daytime insolation at high solar attitudes

Eastern and western faces: perforated PC panels
Reducing the opening ratio and shielding from insolation at low solar attitude

Southern face: louvers incorporating solar cells
Generation capacity: 50.3 kW
Shielding from daytime insolation at low solar attitudes in seasons other than summer as well as at high solar attitudes

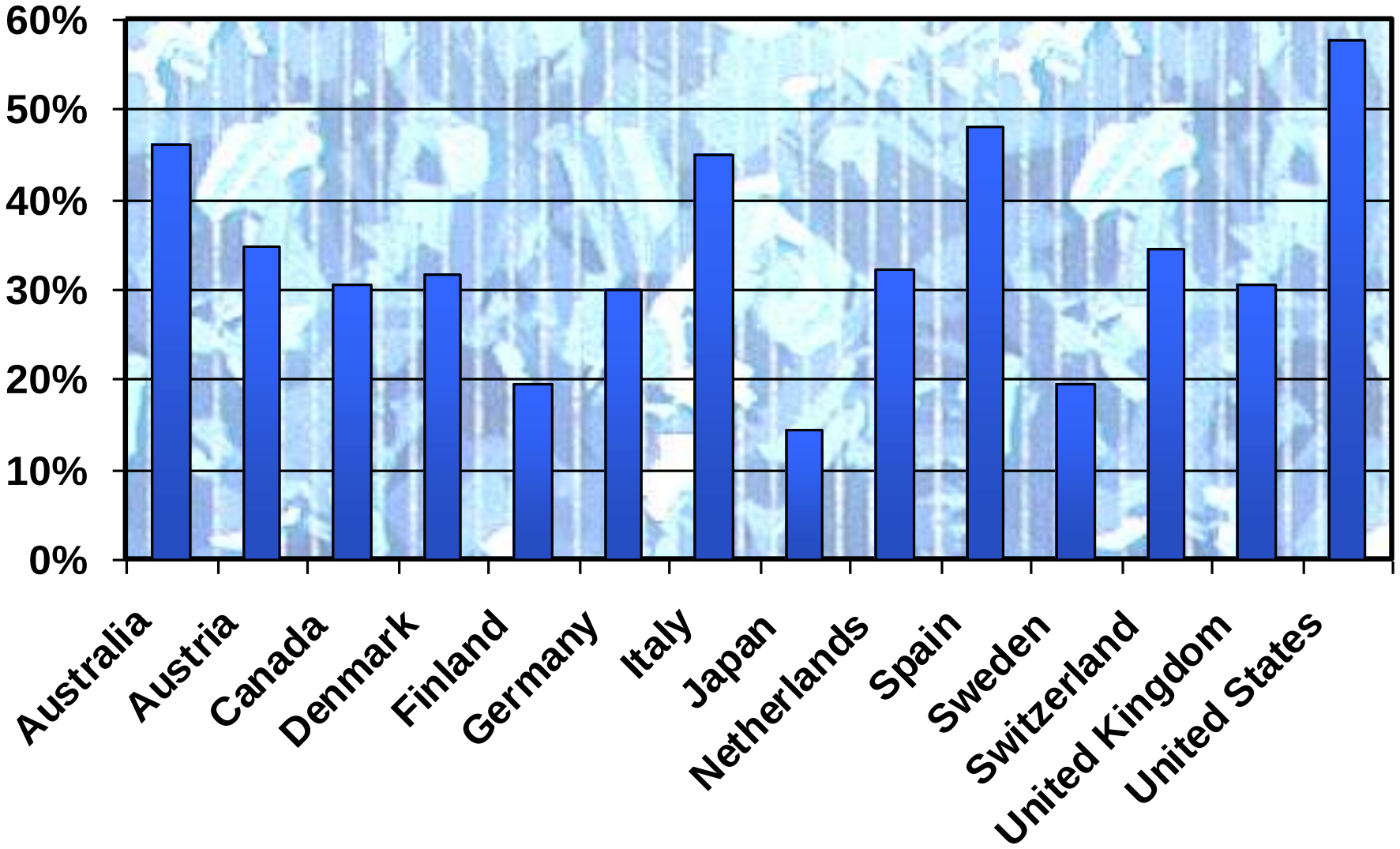
Use of daylight
Using indirect sky light as a lighting source Automatic lighting control by illuminance sensors mounted on lighting equipment

Natural ventilation
Wide openings allowing natural ventilation in seasons other than summer (sliding windows/awning windows)



Evolving form – wind integration - Bahrain

Achievable levels of PV power contributions to electricity consumption, using building surfaces with more than 80% of maximum output

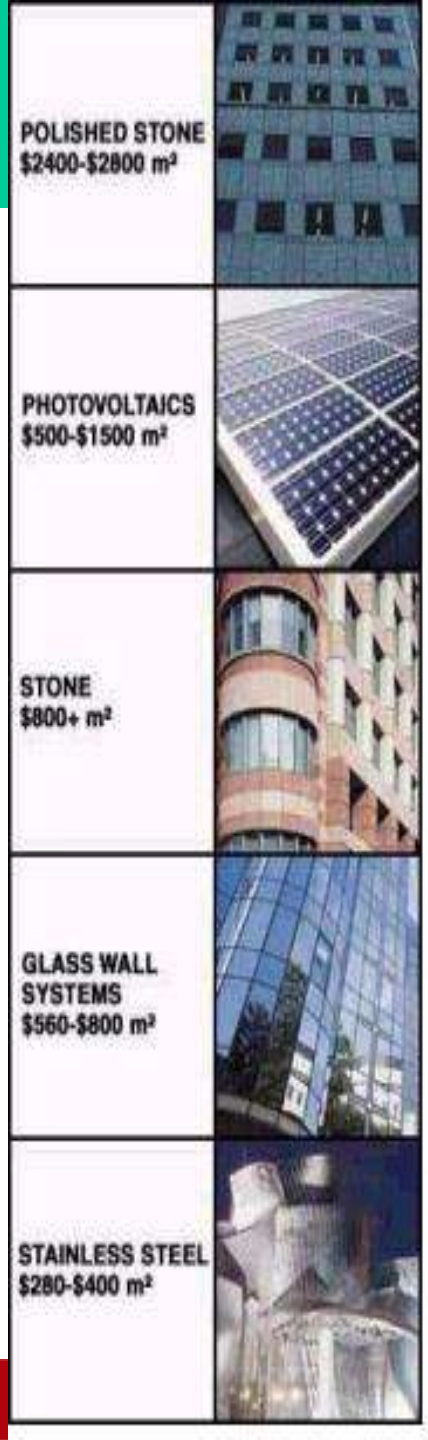


Challenges for Net-zero and Low-energy homes/buildings

- Integration of solar technologies with the architecture and with the envelope.
- Integration and optimization of solar with energy efficiency technologies – must not be separate.
- Thermal storage and passive solar design – what are the obstacles; need to integrate in standards
- Integrated control of energy and solar systems: reduction of peak loads will reduce need for new power plants.

Economic Challenge

- Link to property value
  - Why do we cost PV on buildings as a utility? It is a building material.
  - Value added benefits!
  - 5%-15% property value impact????
- Innovative financing.
- Who has lost money in developing, selling, owning a green building? Check Olympic site.



Australian Solar Feed in Tariff

- SA - 44 c/kWh, net export up to 10 kWp, for up to 10MW or until 2028
- Qld – 44 c/kWh net export, for up to 8 MW or until 2028
- ACT – 3.88x tariff (50.05c) gross 20 years for 10 kWp systems, 80% (40.04c) for systems between 10-30 kWp
- Vic - 60 c/kWh net export up to 3.2 kWp, for 15 years, ends 2024
- Energy Australia - 28 c/kWh net export, between 2-8pm
- Alice Springs Solar City – 45 c/kWh gross export 10 years, limit of $5 per day
- NSW – 60c/kWh net for 20 years up to 10kWp
- WA and TAS still to decide

Creating sustainable futures

•“Sophistication is not necessarily the product of highly developed machinery, nor intensive capital investment. It is more a way of using available equipment and resources with cunning and intelligence”

Reyner Banham The Architecture of the Well-tempered Environment 1984