Low carbon buildings – a pathway to lowering CO_2 emissions

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University of New South Wales

SPREE Seminar Series
March 14th, 2013 UNSW

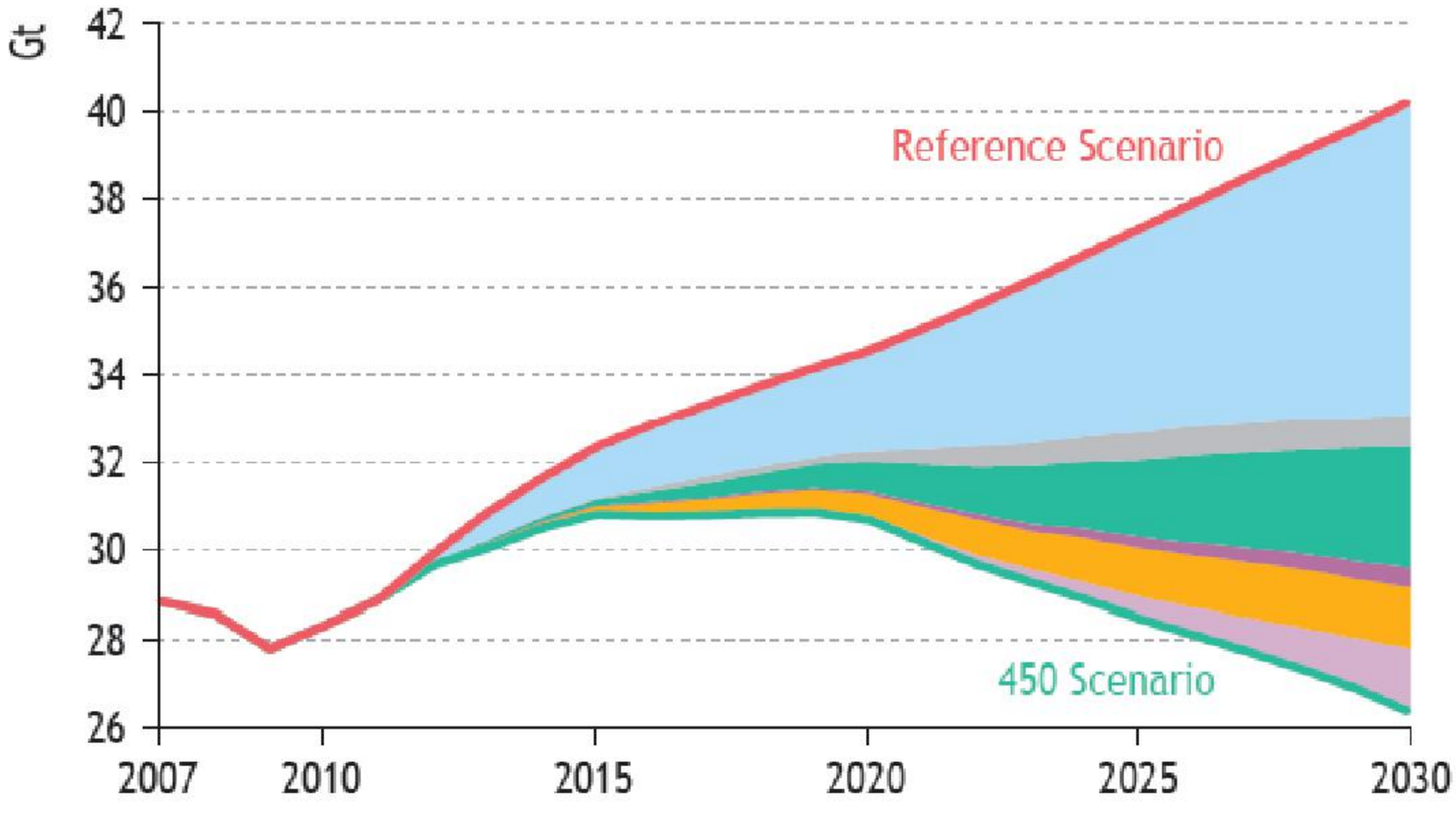
Low carbon cities?

- Energy efficiency
- Renewable energy & storage
- Integrated low carbon design (new and retrofit)
- Grid to suit above
- Low carbon behaviour


Energy efficiency

IEA : WORLD ENERGY OUTLOOK

Figure 5.8 ● World energy-related CO_2 emission savings by policy measure in the 450 Scenario

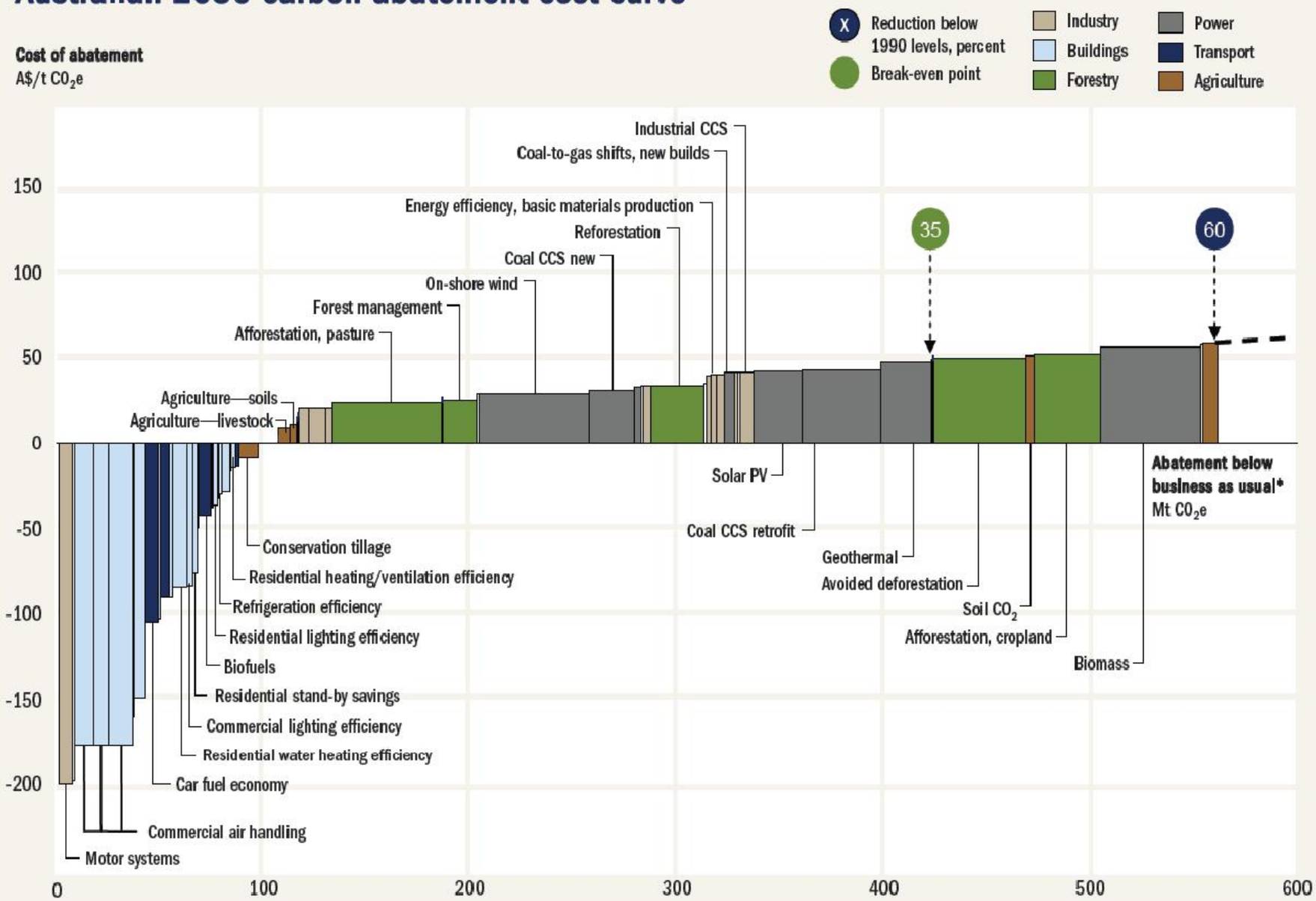


	Abatement (Mt CO_2) 2020	2030
Efficiency	2 517	7 880
End-use	2 284	7 145
Power plants	233	735
Renewables	680	2 741
Biofuels	57	429
Nuclear	493	1 380
CCS	102	1 410

http://www.worldenergyoutlook.org/

Exhibit 5

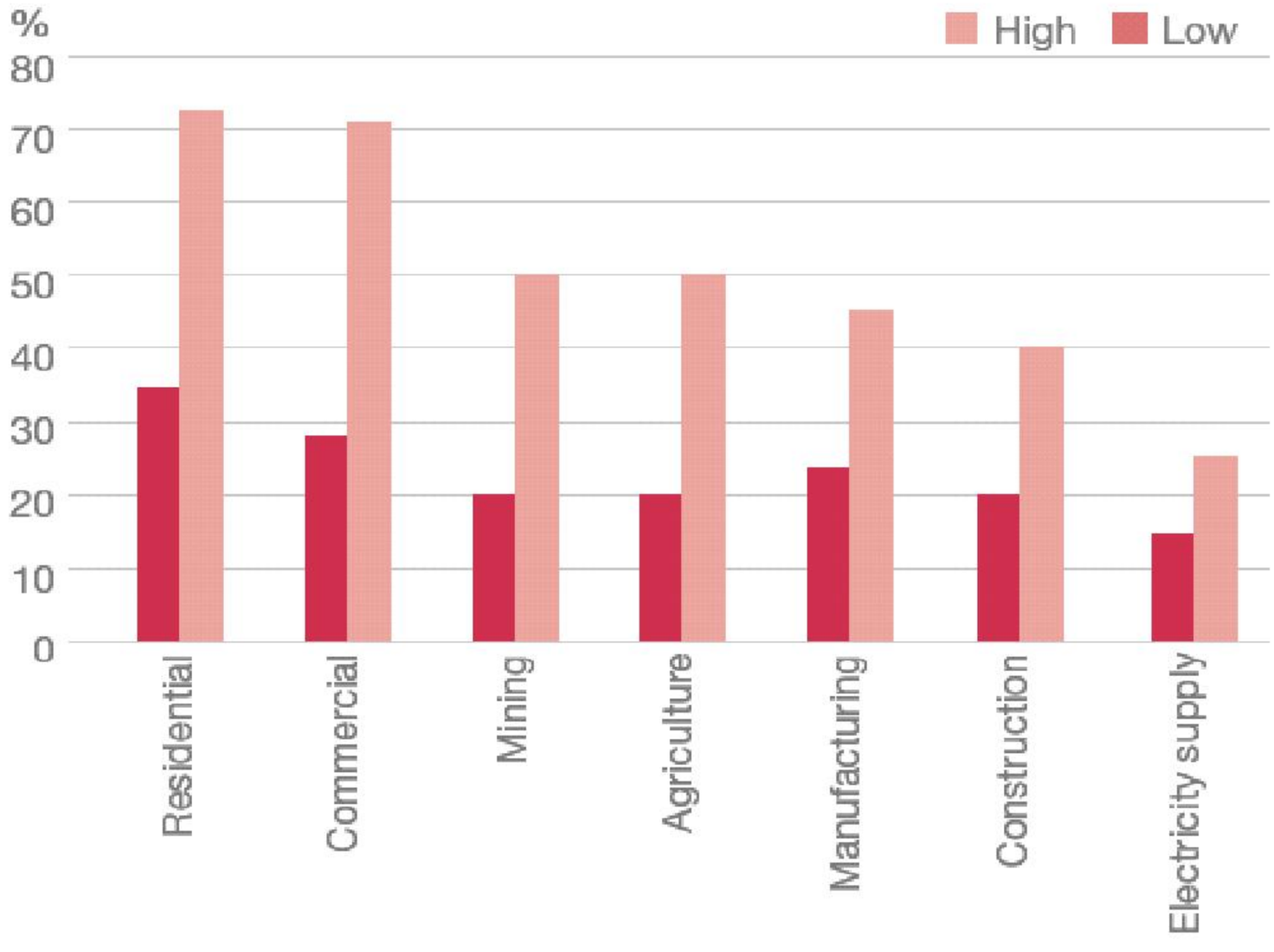
Australian 2030 carbon abatement cost curve



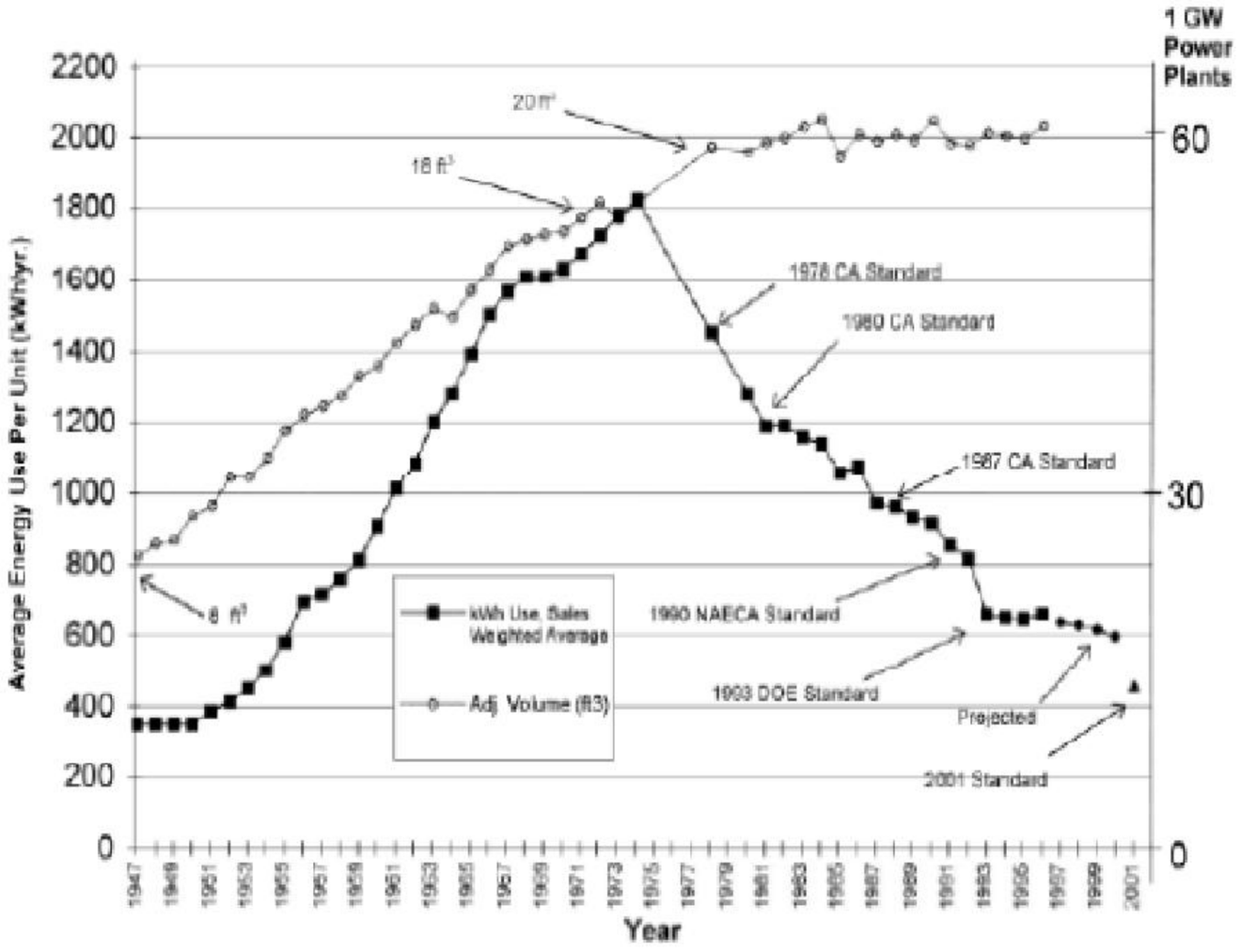
Note: Abatement opportunities are not additive to those of previous years

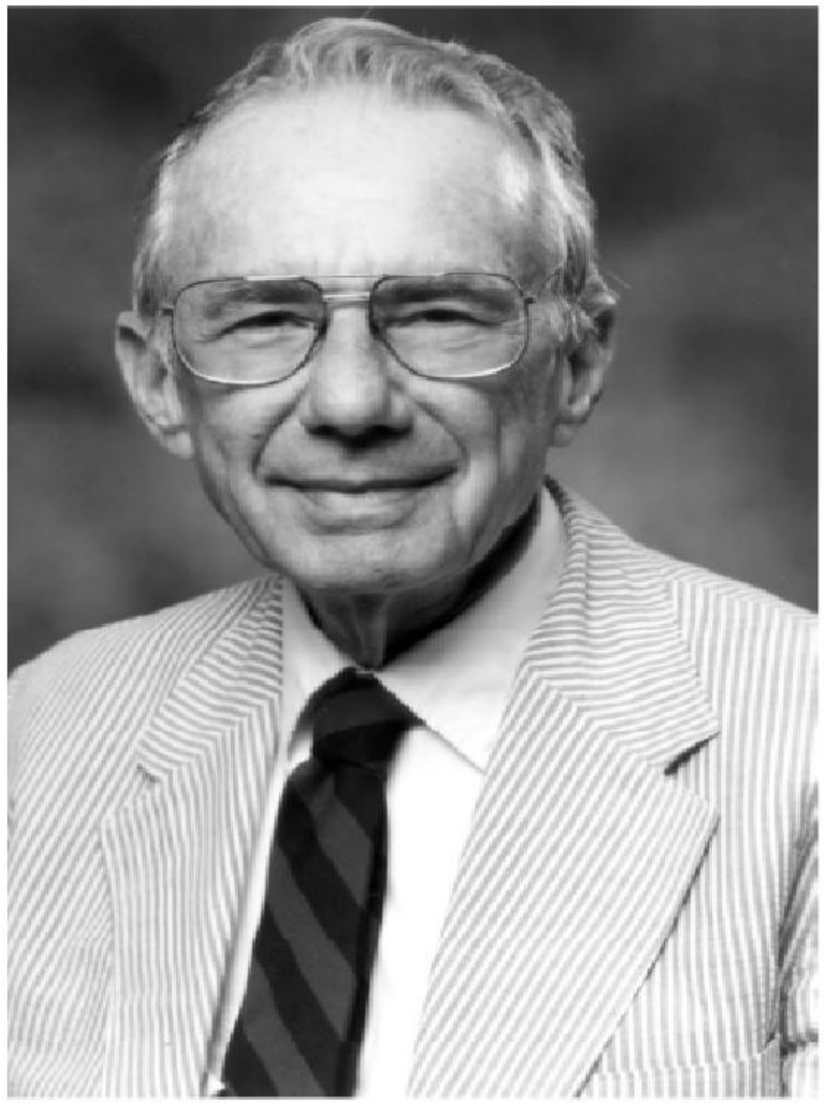
Source: McKinsey Australia Climate Change Initiative

Figure 4: Percentage cost–effective energy consumption reduction potential across different sectors.



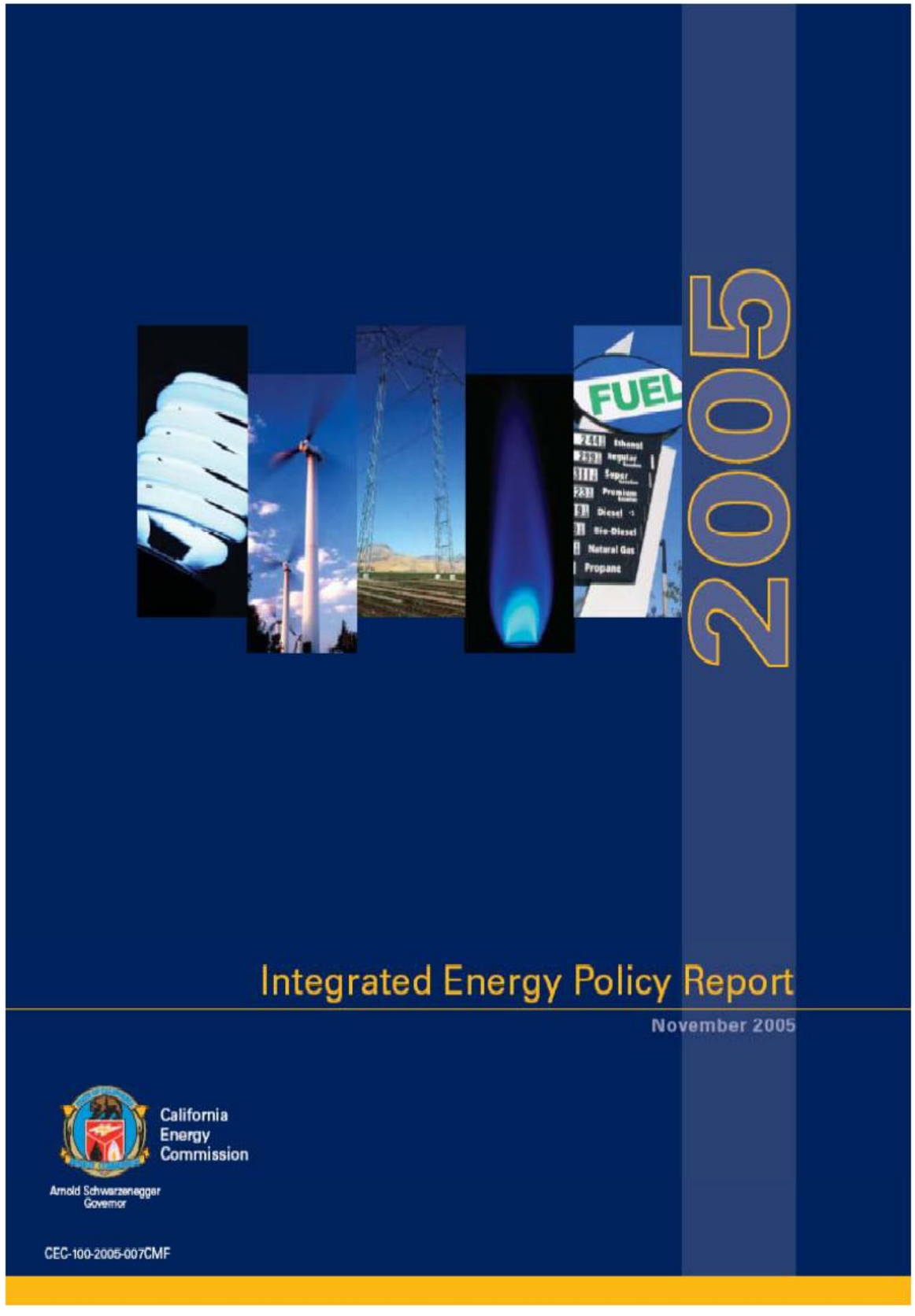
NFEE (2003) *Towards a National Framework on Energy Efficiency – Issues and challenges Discussion Paper*, National Framework on Energy Efficiency





Art Rosenfeld

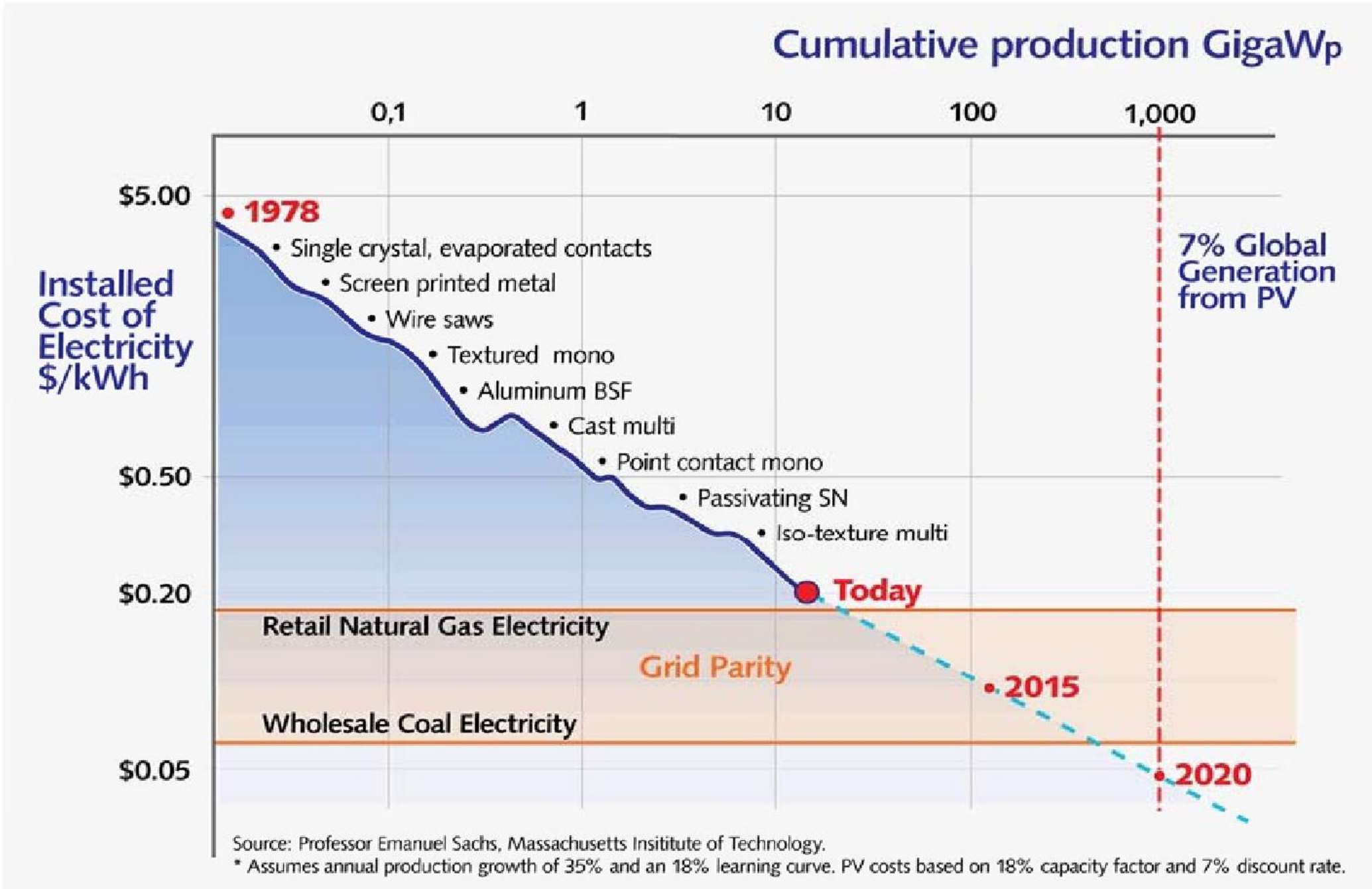
Figure 3 Electricity use by new U.S. refrigerators, 1947–2001. The *heavy line with dark squares* is the sales weighted average annual kWh use of new refrigerators, unadjusted for increasing volume. The volume growth, from 8 cubic feet to 20, is the *lighter line with open circles*. The right-hand scale shows the number of large (1 GW) base-load (5000 hours/year) power plants required to power 150 million refrigerators + freezers, each with the kWh use on the left scale. The difference between 1974 (1800 kWh) and 2001 (450 kWh) is 1350 KwH. The eventual saving from 1350 kWh/year × 150 million units is 200 TWh/year, equivalent to 50 avoided 1 GW plants. At 8 cents/kWh, the avoided annual cost is $16 billion.



"Reducing the demand for energy is the most effective way to reduce energy costs and bolster California's economy."


Renewables & storage

PV is growing fast and getting cheaper



Source: Professor Emanuel Sachs, Massachusetts Insititute of Technology.
* Assumes annual production growth of 35% and an 18% learning curve. PV costs based on 18% capacity factor and 7% discount rate.

Current Regulated Retail Tariffs and Charges

As of July 1st, 2012

Domestic All Time

Energy: cents/kWh	Ex GST	Inc GST
First 1,000 kWh per quarter^	24.4000	26.8400
Next 1,000 kWh per quarter^	25.5000	28.0500
Remaining usage per quarter	34.3000	37.7300
Service Availability Charge (cents/day/connection point)	62.8000	69.0800
NOTE: This tariff may not be applicable where capability supports Time of Use billing. ^based on an average daily quantity of 10.989kWh per billing day.		

Controlled Load

Energy: cents/kWh	Ex GST	Inc GST
Off Peak 1	10.1000	11.1100
Off Peak 2	13.3000	14.6300
NOTE: These tariffs are only available with a principal tariff.		

PowerSmart Home

Energy: cents/kWh	Ex GST	Inc GST
Peak: 2pm – 8pm on working weekdays	47.7700	52.5470
Shoulder: 7am – 2pm and 8pm – 10pm working weekdays and 7am – 10pm on weekends and public holidays	19.4000	21.3400
Off Peak: all other times	11.9000	13.0900
Service Availability Charge (cents/day/connection point)	74.7000	82.1700

http://www.ipart.nsw.gov.au/Home/Industries/Electricity/Reviews/Retail_Pricing/Changes_in_regulated_electricity_retail_prices_from_1_July_2012/25_Jun_2012_-_Energy_Australia_-_Approved_annual_pricing_proposals/EnergyAustralia_-_Regulated_Electricity_retail_tariffs_and_charges_for_201213

PowerSmart Business

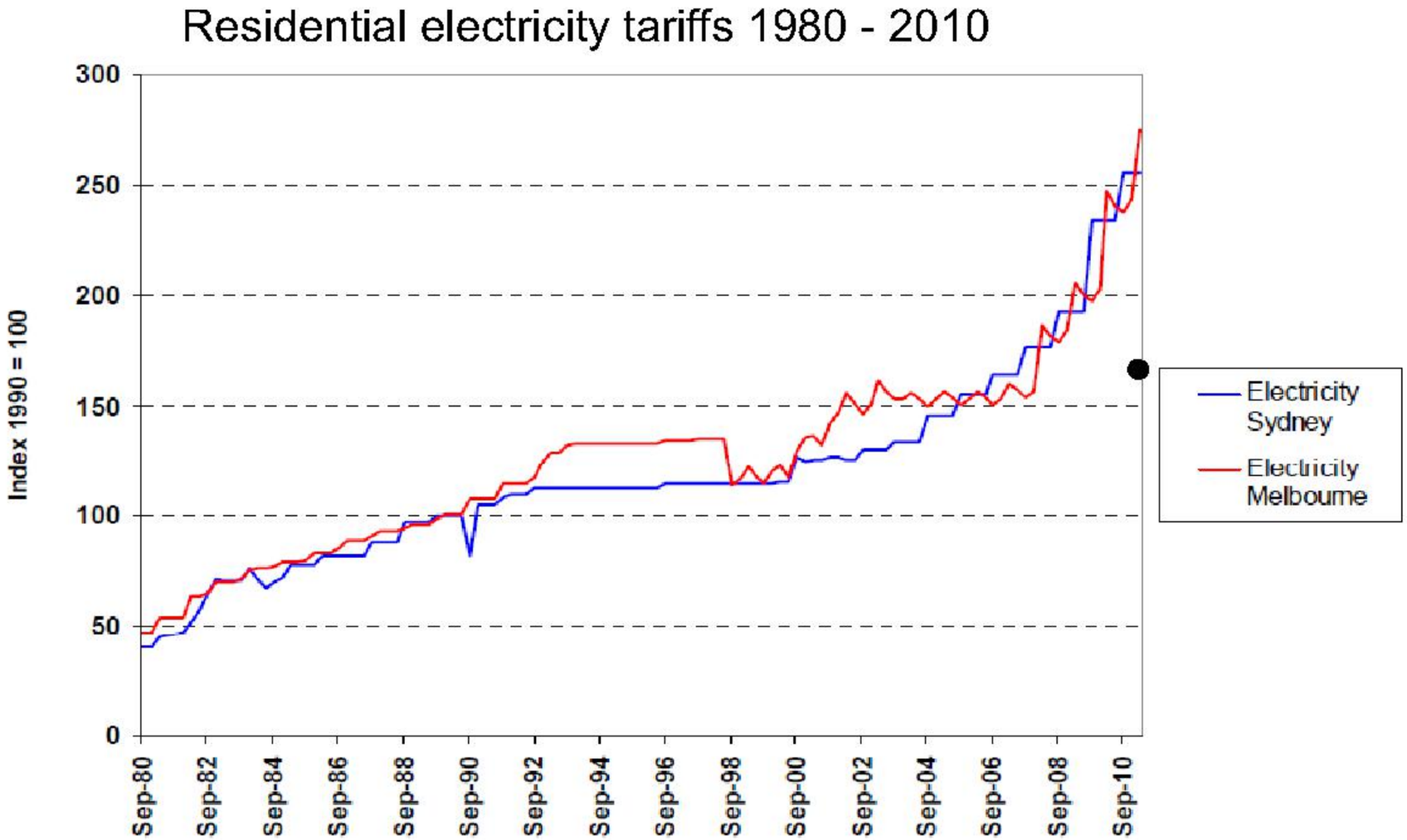
Energy: cents/kWh	Ex GST	Inc GST
Peak: 2pm – 8pm on working weekdays	44.3000	48.7300
Shoulder: 7am – 2pm and 8pm – 10pm working weekdays and 7am – 10pm on weekends and public holidays	20.7000	22.7700
Off Peak: all other times	11.6000	12.7600
Service Availability Charge (cents/day/connection point)	133.0500	146.3550

LoadSmart (Low Voltage)

Energy: cents/kWh	Ex GST	Inc GST
Peak: 2pm – 8pm on working weekdays	30.9000	33.9900
Shoulder: 7am – 2pm and 8pm – 10pm working weekdays	23.5000	25.8500
Off Peak: all other times	14.8000	16.2800
Service Availability Charge (cents/day/connection point)	550.0000	605.0000
Capacity Charge*: c/kW/day	**Ex GST**	**Inc GST**
Peak: 2pm – 8pm on working weekdays	33.0000	36.3000

Tariffs as of 1st July 2012 – for PowerSmart Business customers an average increase of 39% in three years, i.e. 13% per annum predominantly driven by peak demand upgrades to poles and wires

http://www.ipart.nsw.gov.au/Home/Industries/Electricity/Reviews/Retail_Pricing/Changes_in_regulated_electricity_retail_prices_from_1_July_2012/25_Jun_2012_-_Energy_Australia_-_Approved_annual_pricing_proposals/EnergyAustralia_-_Regulated_Electricity_retail_tariffs_and_charges_for_201213



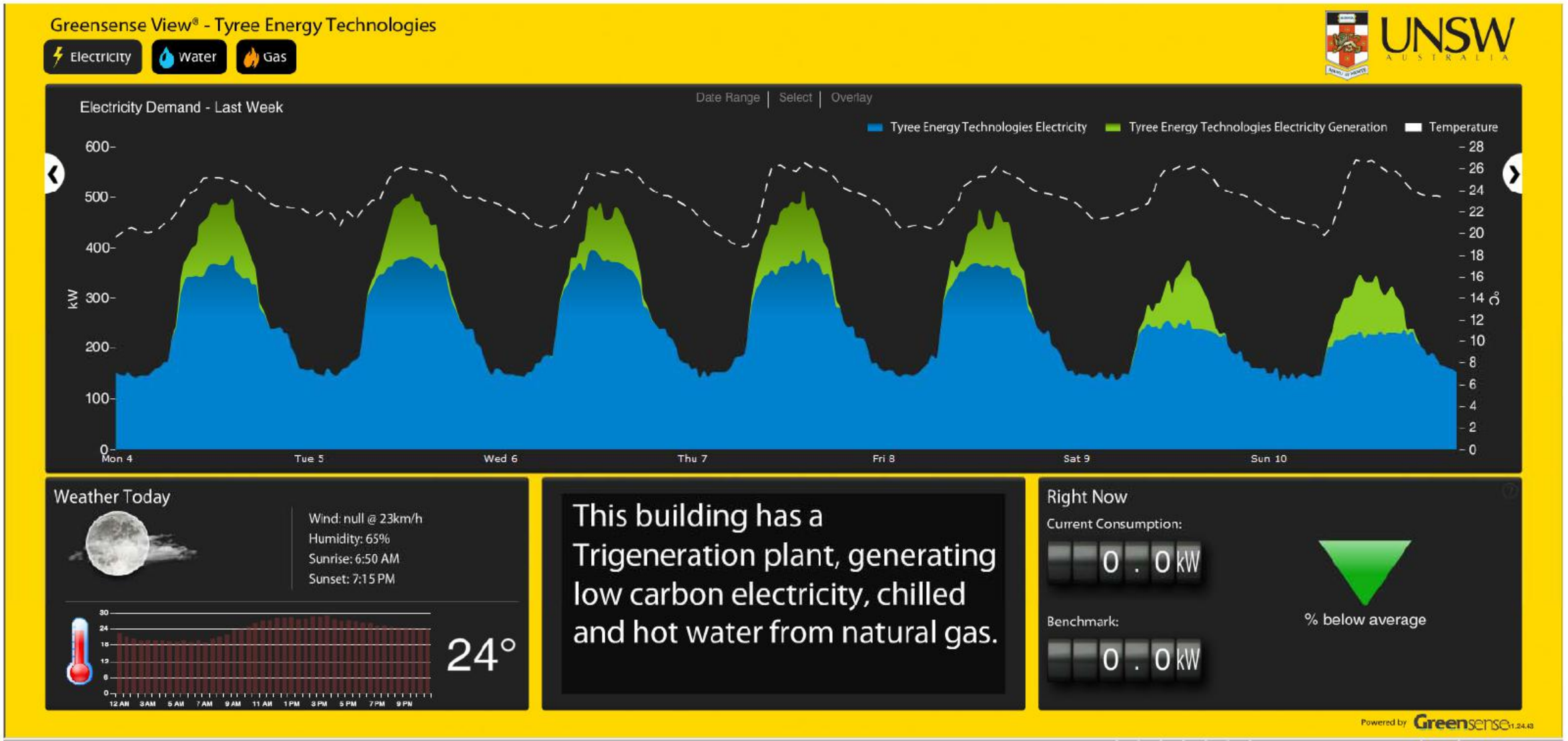
Most of the increase of electricity tariffs over the years has been in line with the CPI (average 4.4% p.a) **except** over the period 2007 – 2010, - electricity increases have been more like 14% p.a. (I have added a black dot to indicate the electricity price **IF** it had followed the CPI.

http://www.ausgrid.com.au/Common/About-us/Newsroom/Discussions/Syd-v-Mel-household-energy-bills.aspx


UNSW TYREE ENERGY TECHNOLOGY
BUILDING - 150 kWp PV ARRAY

UNSW TETB Electricity

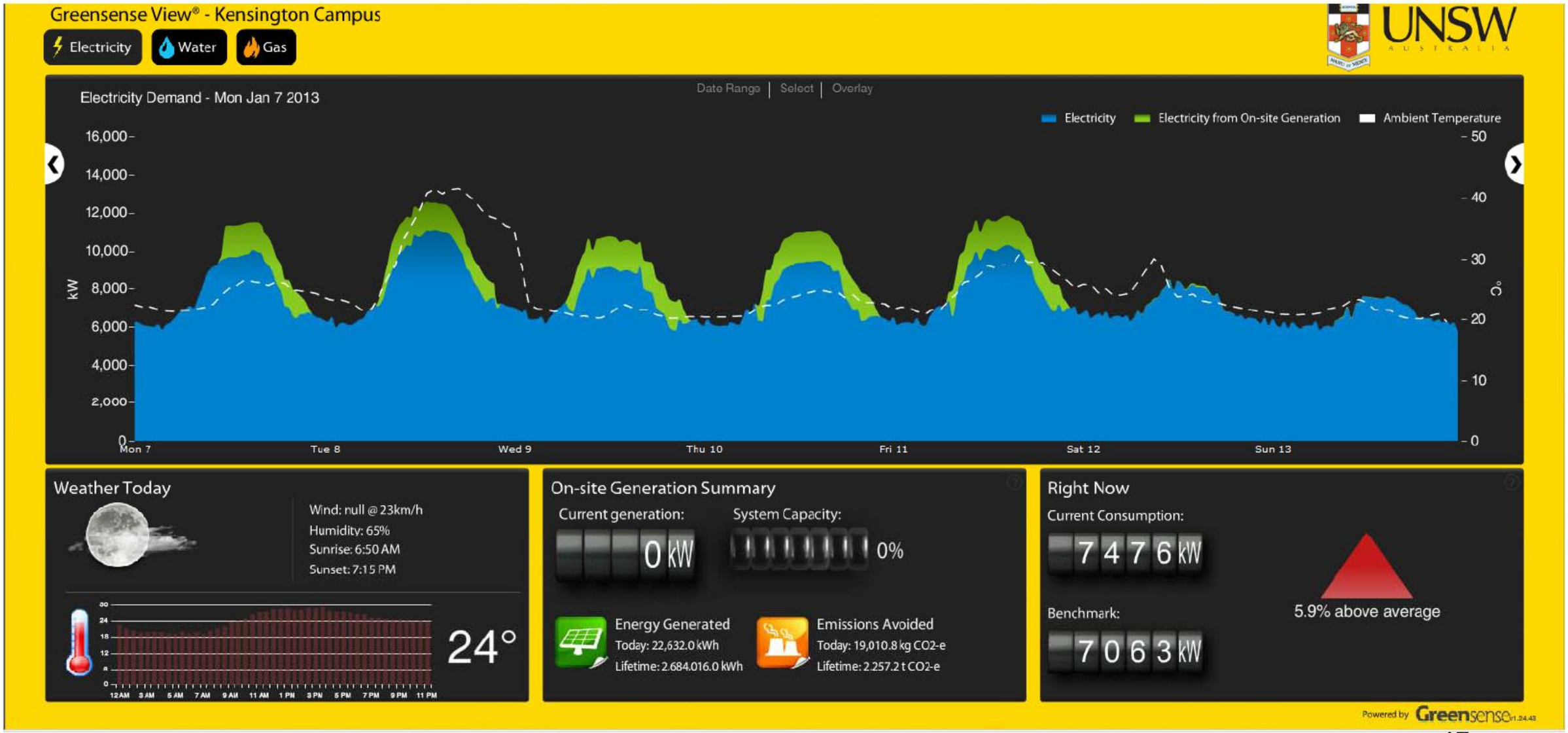
Mar 4 – 10, 2013



http://www.facilities.unsw.edu.au/campus-development/sustainability-campus/greensense-live-energy-project

UNSW Kensington Electricity

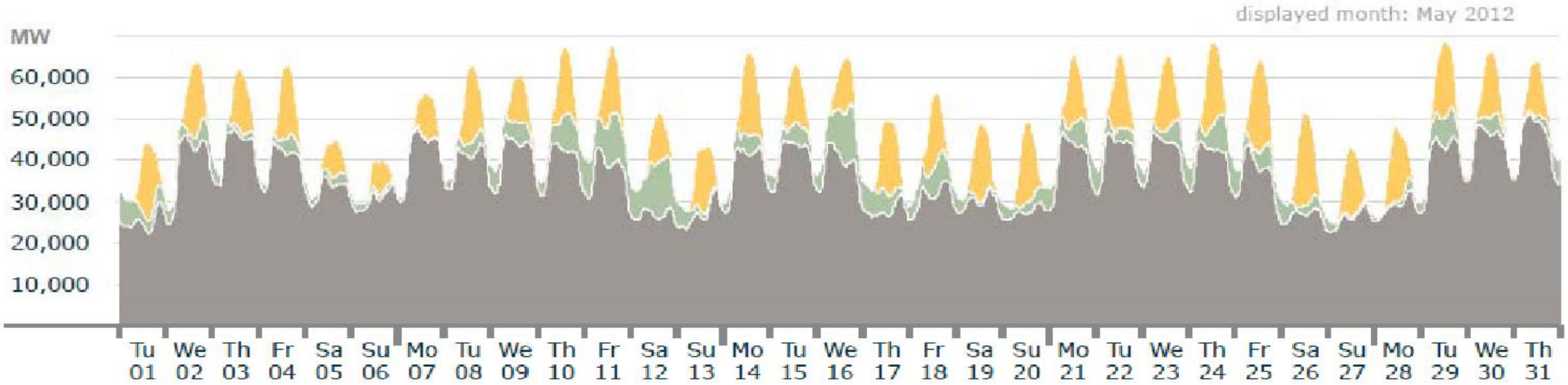
Jan 7 – 13, 2013



Wind energy

Electricity Production in Germany: May 2012

Actual production

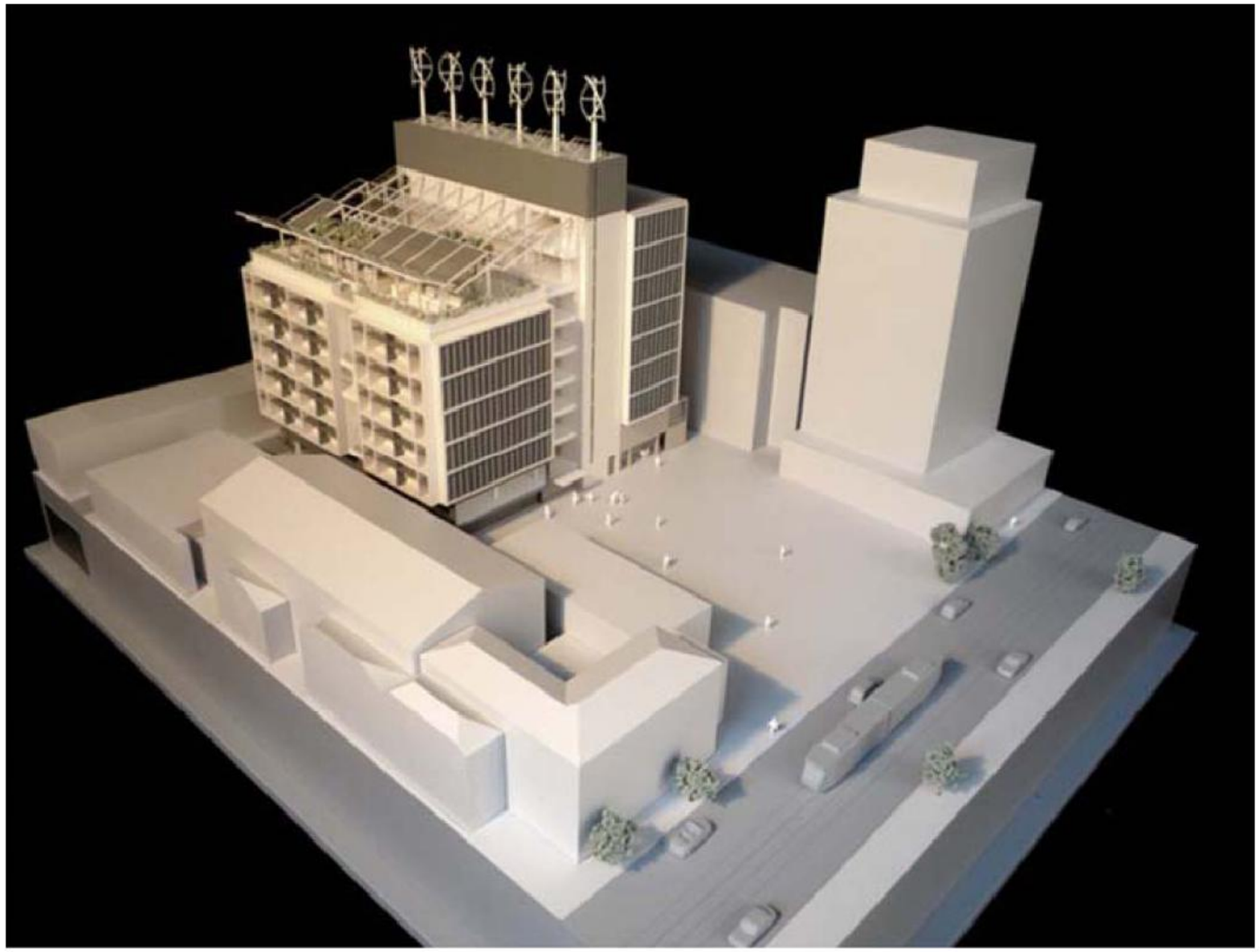


Legend: Conventional > 100 MW | Wind | Solar

- Solar: max. 22.4 GW; 4.1 TWh (Fr 25 May, 12:45)
- Wind: max. 14.1 GW; 2.9 TWh
- Conventional: max. 51.2 GW; 26.6 TWh

Graph: Bruno Burger, Fraunhofer ISE; Data: EEX, http://www.transparency.eex.com/de/

Fraunhofer ISE



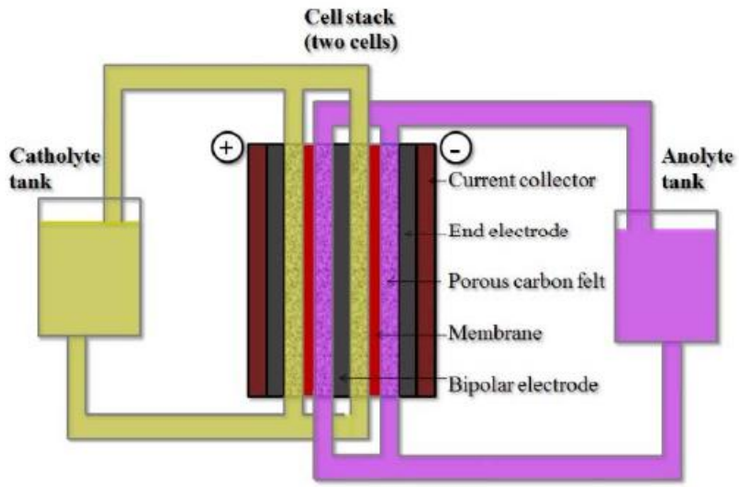
http://www.buildinggreen.com/auth/article.cfm/2009/4/29/The-Folly-of-Building-Integrated-Wind

http://www.temc.org.au/documents/51-101004_TEFMA-Presentation.pdf

http://www.windpods.com/pdf/Windpods_Brochure.pdf

Vanadium redox battery

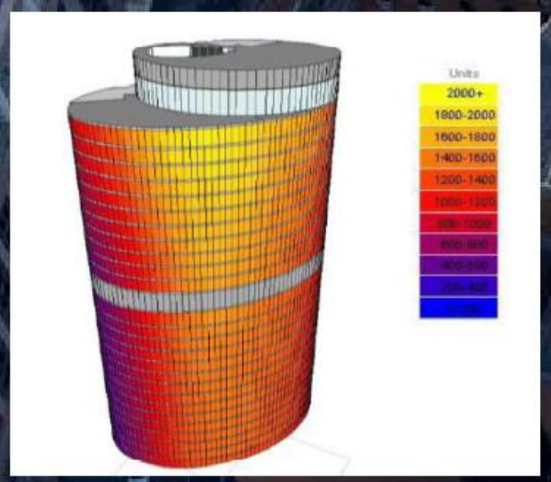
http://de.cellcube.com/index.htm



http://www.ceic.unsw.edu.au/centers/vrb/technology-services/vanadium-redox-flow-batteries.html

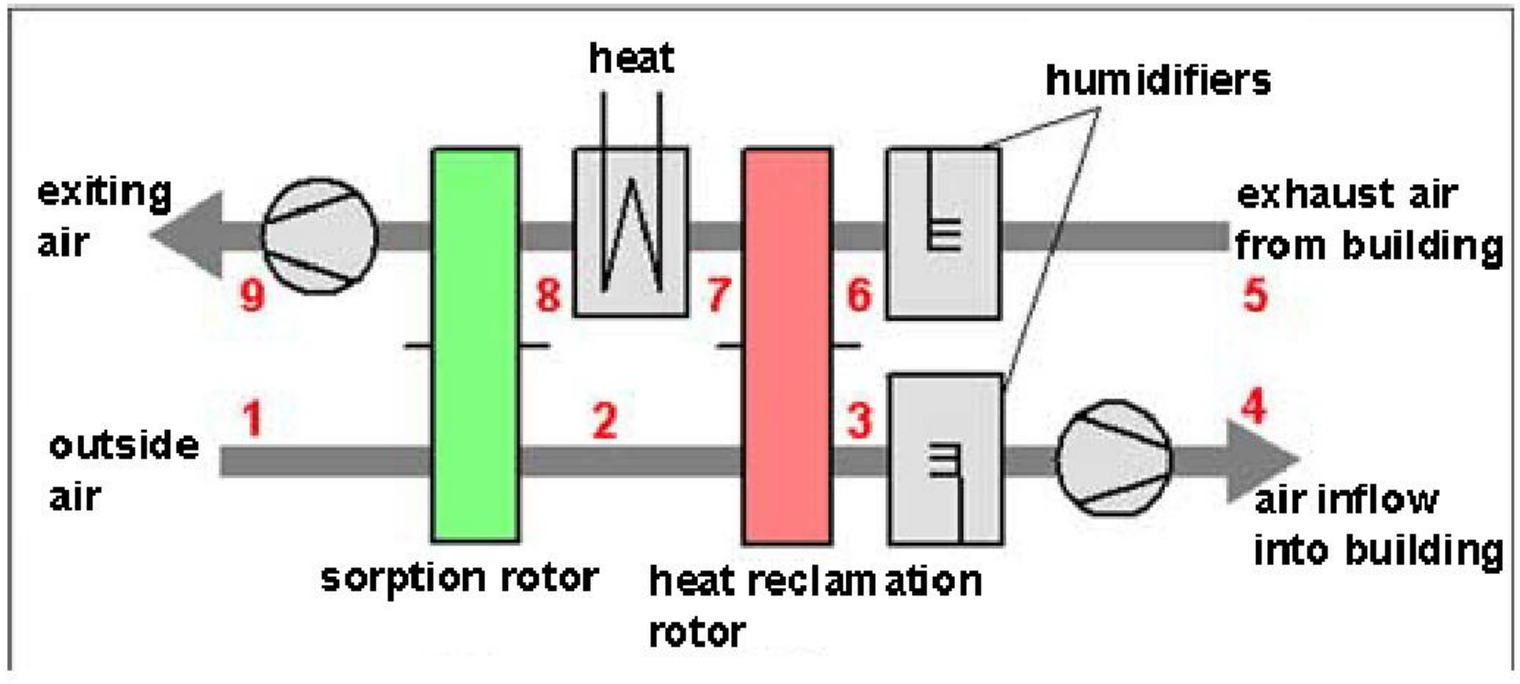

Low carbon design & integration

Low energy buildings need integrated low energy building systems

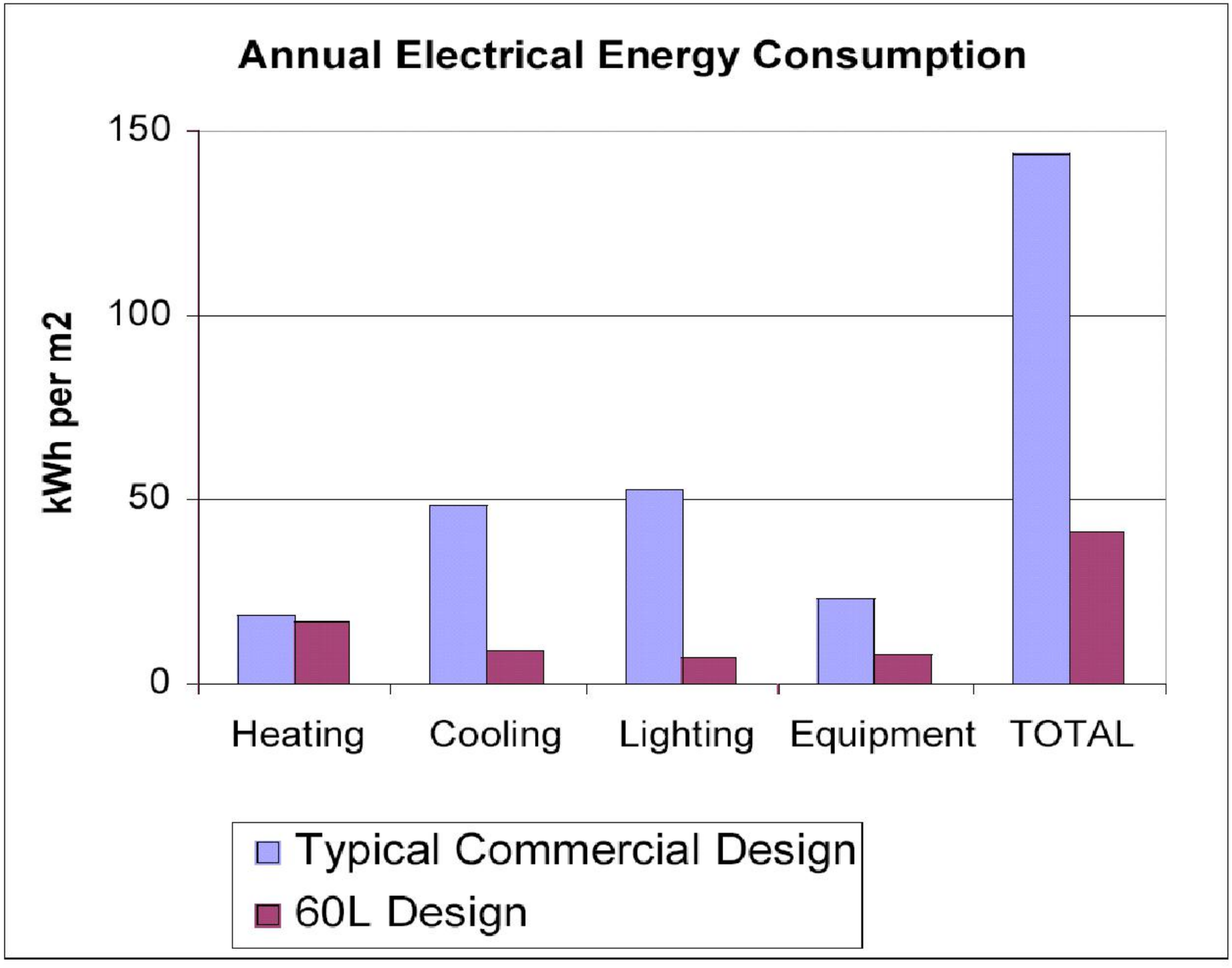


1 Bligh Street, Sydney
6 star office building

Solar cooling in Germany using adsorption air-cooling and solar heat.



- http://www.metaefficient.com/architecture-and-building/skyscraper-gets-covered-in-7000-solar-panels.html


Annual Electrical Energy Consumption
kWh per m2
150
100
50
0
Heating
Cooling
Lighting
Equipment
TOTAL
Typical Commercial Design
60L Design

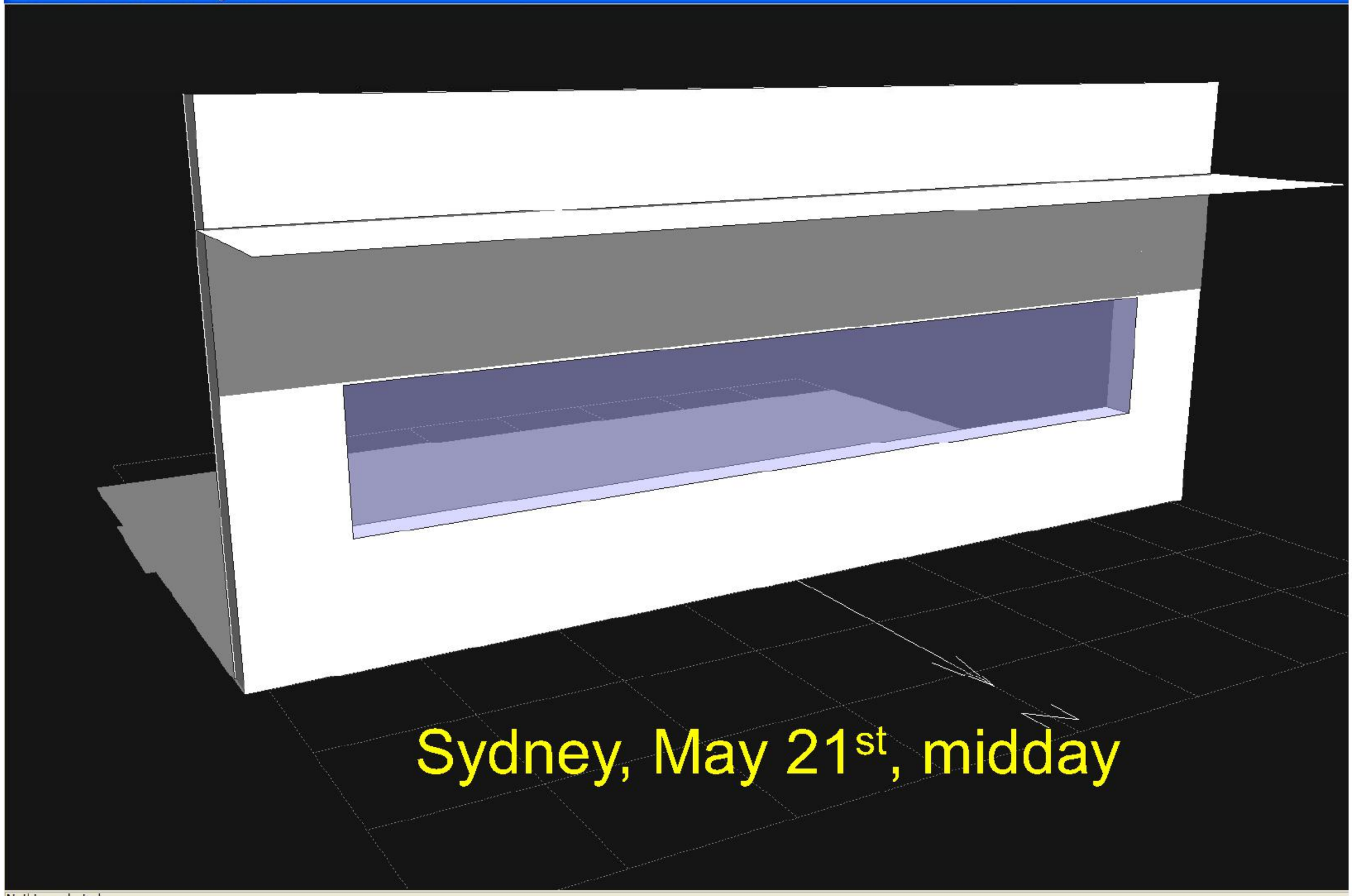
olar Tool: 3D Shading Model

Shading of windows

Sydney, March 21st, midday

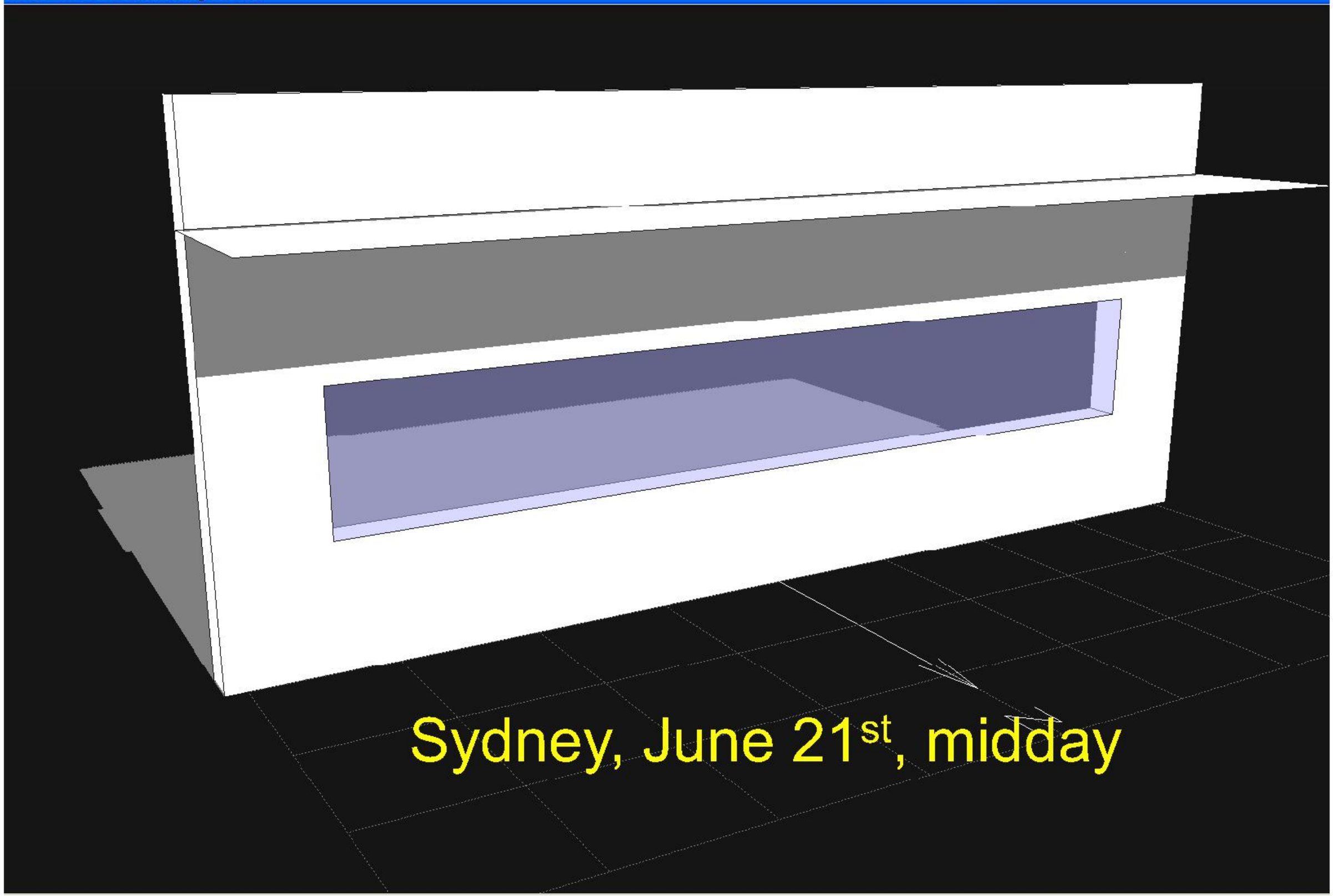
Wireless netv

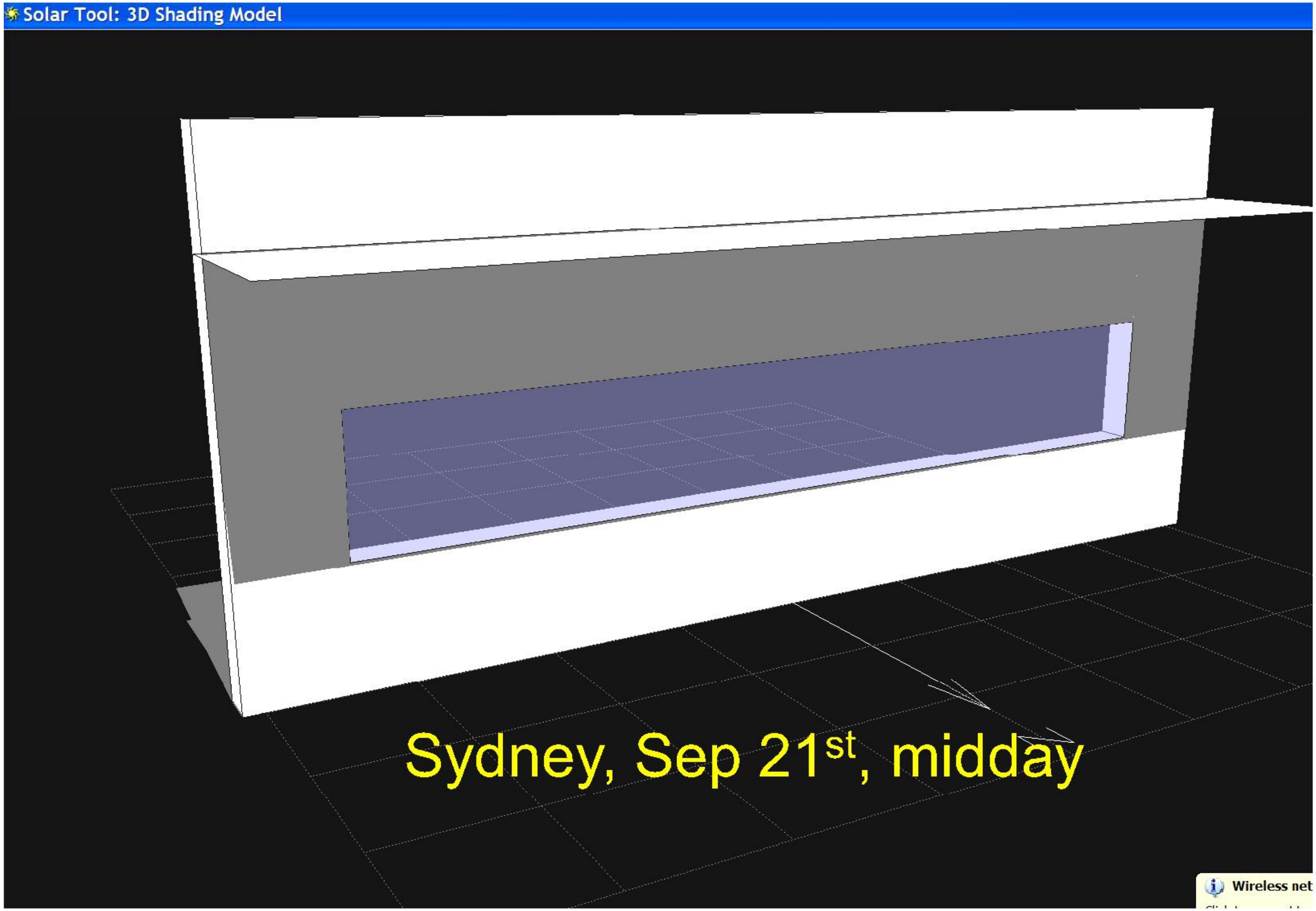
Solar Tool: 3D Shading Model



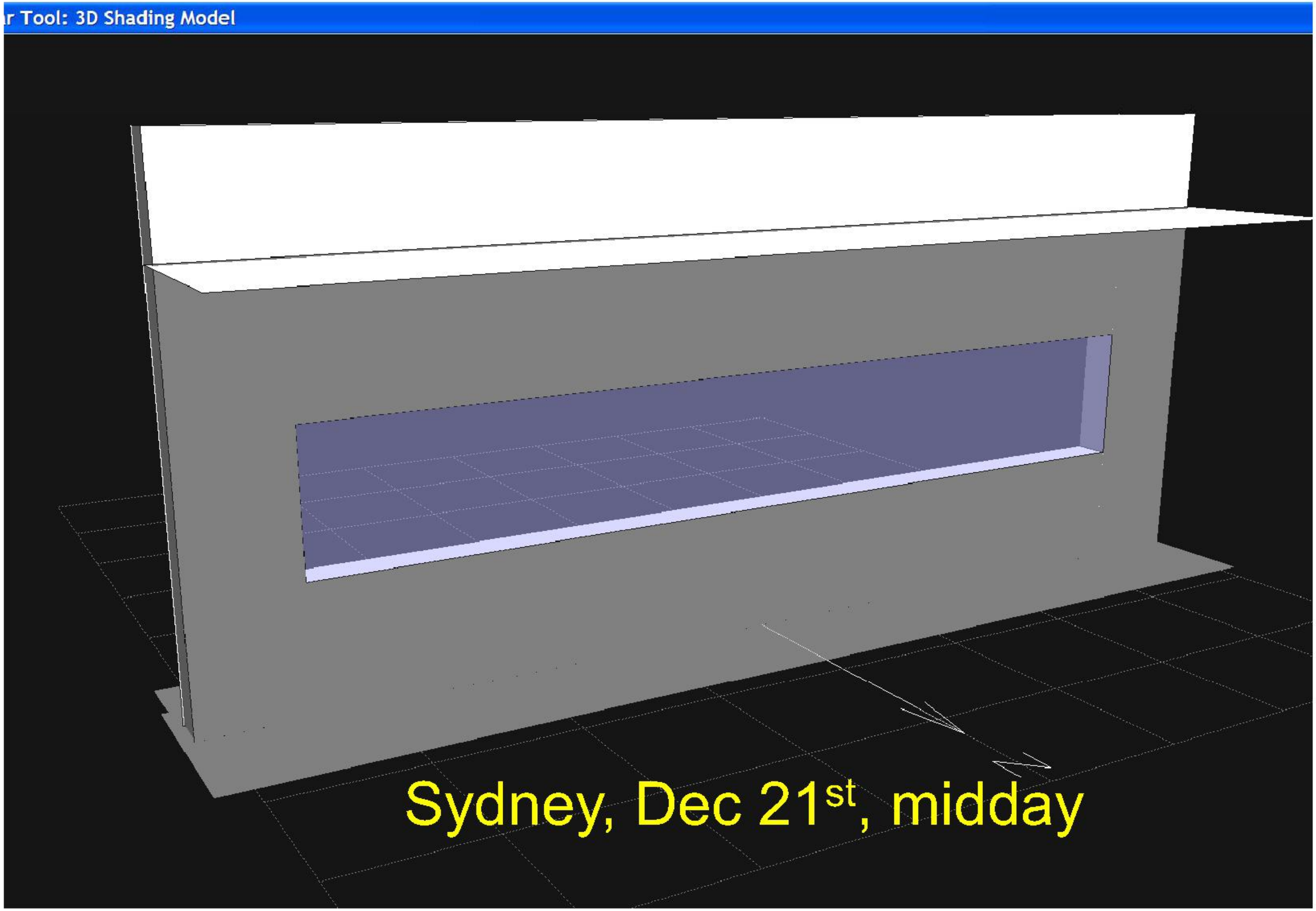
Nothing selected.

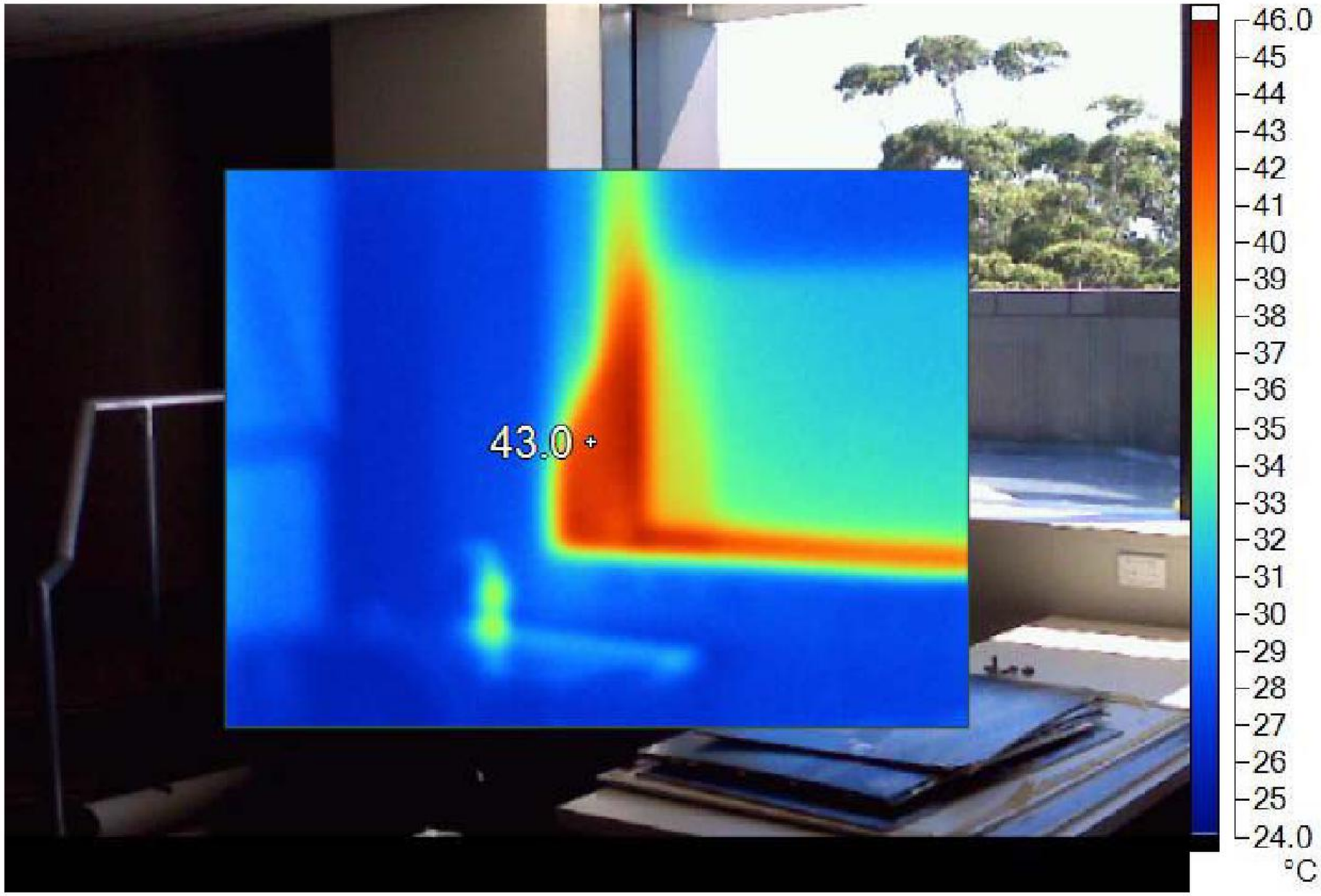
Solar Tool: 3D Shading Model




Solar Tool: 3D Shading Model
Sydney, Sep 21st, midday
Wireless net

r Tool: 3D Shading Model





March 13, 10:15 am, 2013 TETB Northern window. Sydney DBT = 28°C max.
Opportunity to improve external shading to exclude direct solar gain
(Sep 21st – Mar 21st)? PV panels - which currently have an installed system cost of ~ $250/m^2 may be the best option?

PV and Rooftops

PV and rooftops equals green electricity delivered to the customer offsetting electricity at retail prices.

PV modules can provide shading and lighting at no extra cost.

Conservatory ECN Building, Holland

PV roof at De Kleine Aarde

Conserval Engineering - SolarDuct PV/T, generates electricity *and* heat.

Halogen downlight nightmare

65 lamps @ 60W each ~ 4000 W of lighting

MORE PROFIT WITH LESS CARBON

BY AMORY B. LOVINS

Focusing on energy efficiency will do more than protect Earth's climate—it will make businesses and consumers richer

Amory Lovins – founder of the Rocky Mountain Institute - Energy Efficiency proponent and pioneer

MAP/Ming Visiting Professorship, Engineering School, Stanford University, 26 March 2007
CEE 173L/273L: Advanced Energy End-Use Efficiency

Public Lectures in Advanced Energy Efficiency:

1. Buildings

http://www.rmi.org/sitepages/pid231.php

Amory B. Lovins, Hon. AIA
Chairman and Chief Scientist
Rocky Mountain Institute
www.rmi.org

–44 to + 46°C with no heating/cooling equipment, *less* construction cost

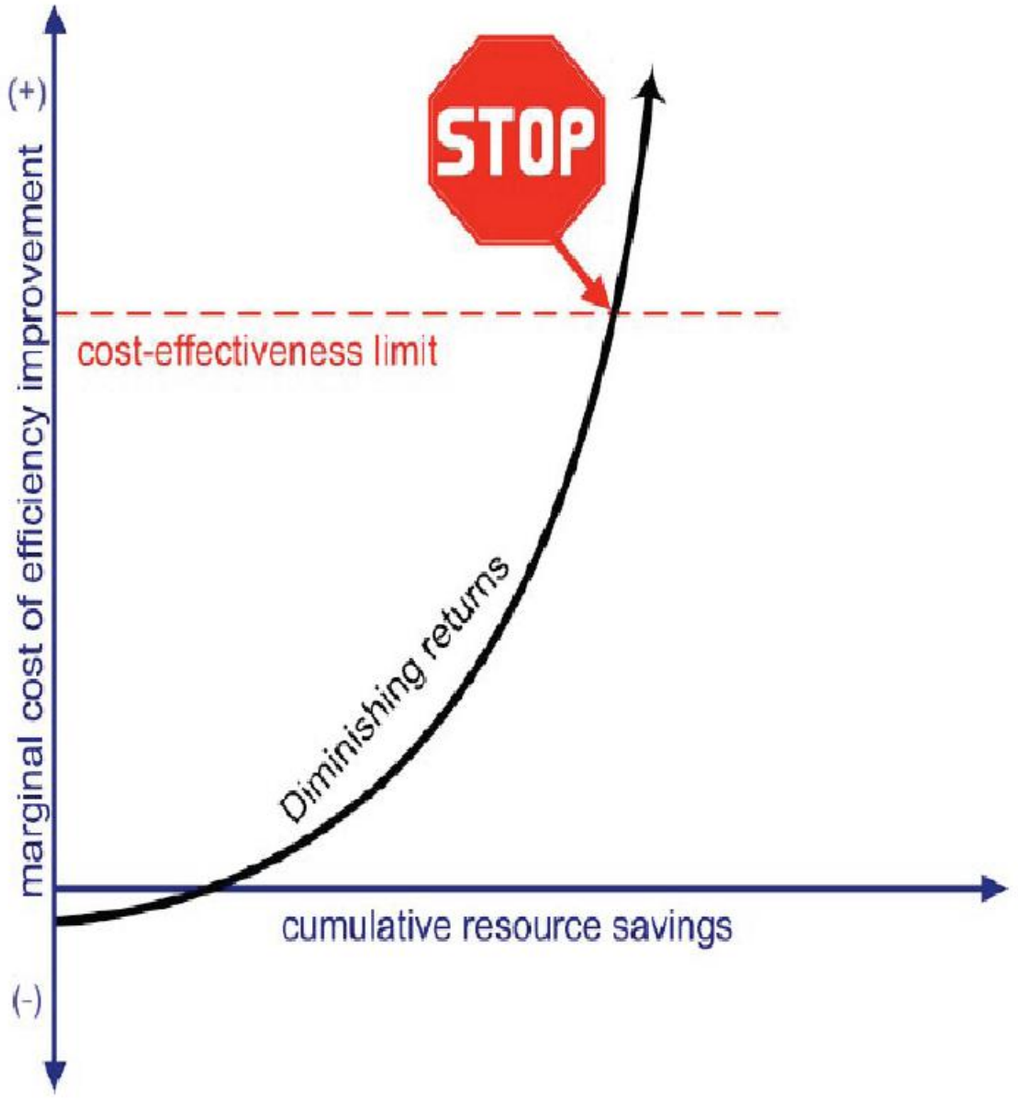
2200 m, frost any day, 39 days' continuous midwinter cloud…yet 28 banana crops with no furnace

Key: integrative design—multiple benefits from single expenditures

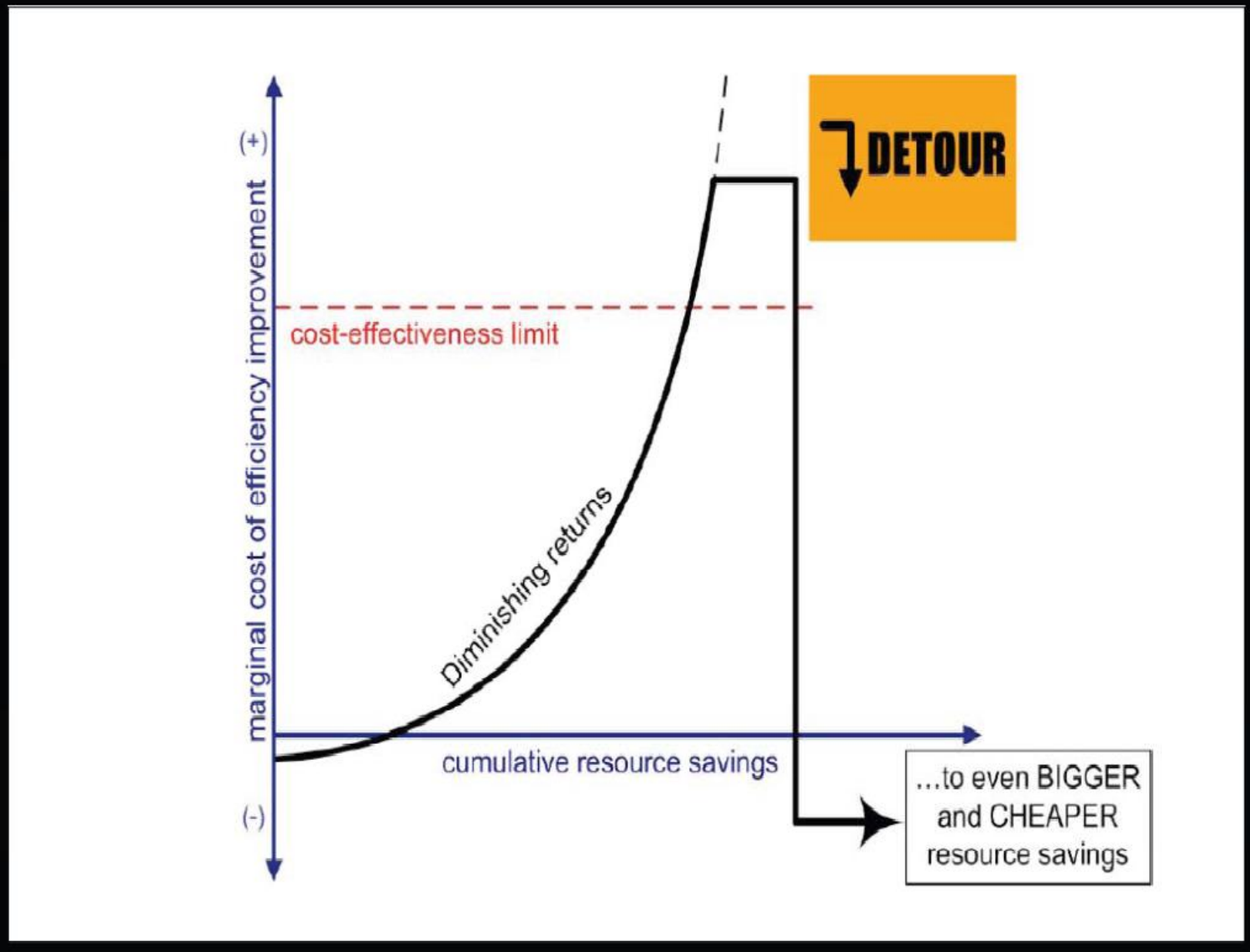
- Lovins house / RMI HQ, Snowmass, Colorado, '84
  - Saves 99% of space & water heating energy, 90% of home el. (372 m^2 use ~120 W_{av} costing US$5/month @ $0.07/kWh)
  - 10-month payback in 1983
- PG&E ACT²*, Davis CA, '94
  - Mature-market cost –$1,800
  - Present-valued maint. –$1,600
  - 82% design saving from 1992 Ca code, ~90% from U.S. norm
- Prof. Soontorn Boonyatikarn house, Bangkok, Thailand, '96
  - 84% less a/c capacity, ~90% less a/c energy, better comfort
  - No extra construction cost

*$18M experiment, 1990–97, 7 old & new bldgs, www.pge.com/003_save_energy/003c_edu_train/pec/info_resource/act2_proj.shtml

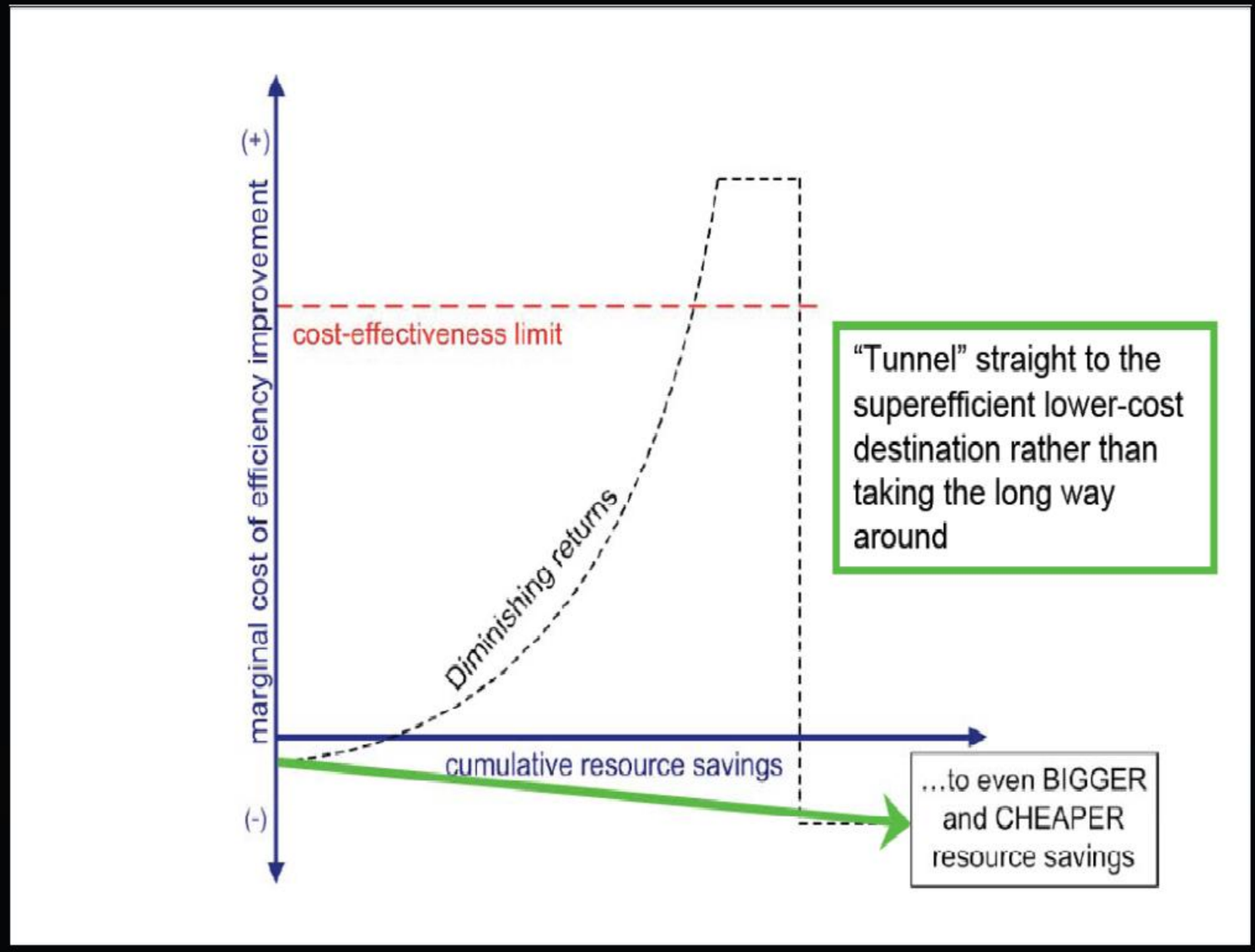
Old design mentality: always diminishing returns...



New design mentality: expanding returns, "tunneling through the cost barrier"



New design mentality: expanding returns, "tunneling through the cost barrier"



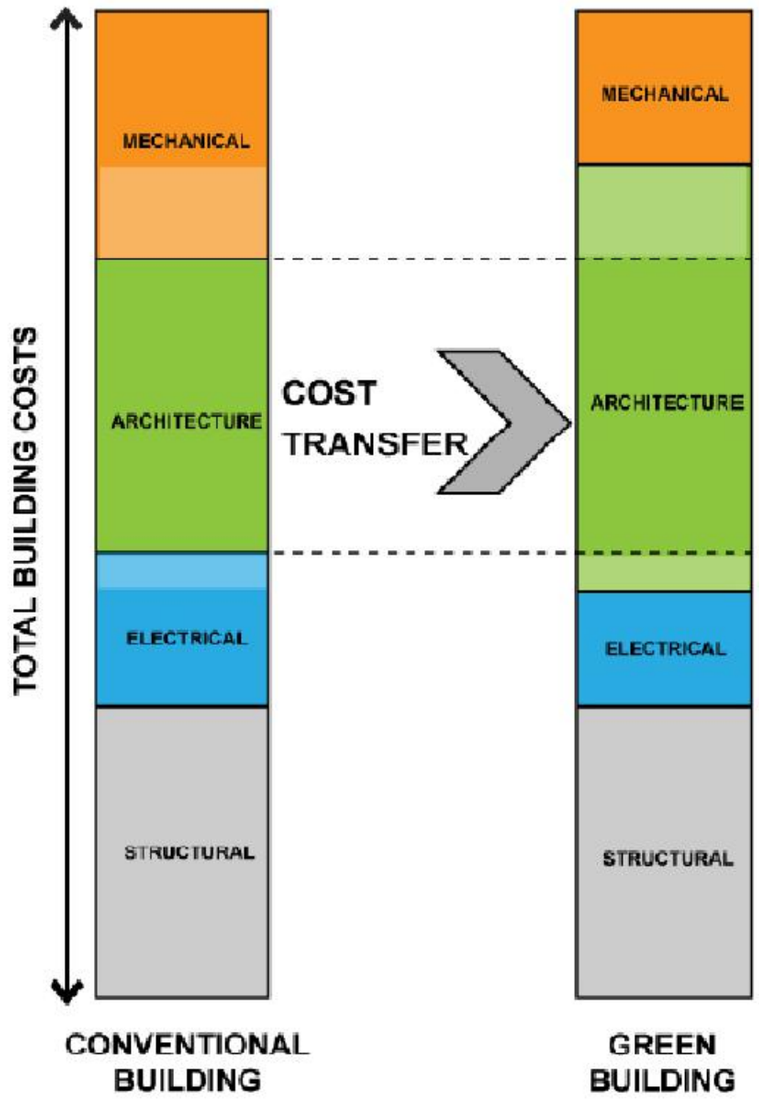
NREL's Zero Energy Building

http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/ns/webinar_rsf_03182010.pdf

Integrated Design

Cost Transfer

Transfer costs from mechanical and electrical systems to building architecture



http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/ns/webinar_rsf_03182010.pdf

Pumping systems

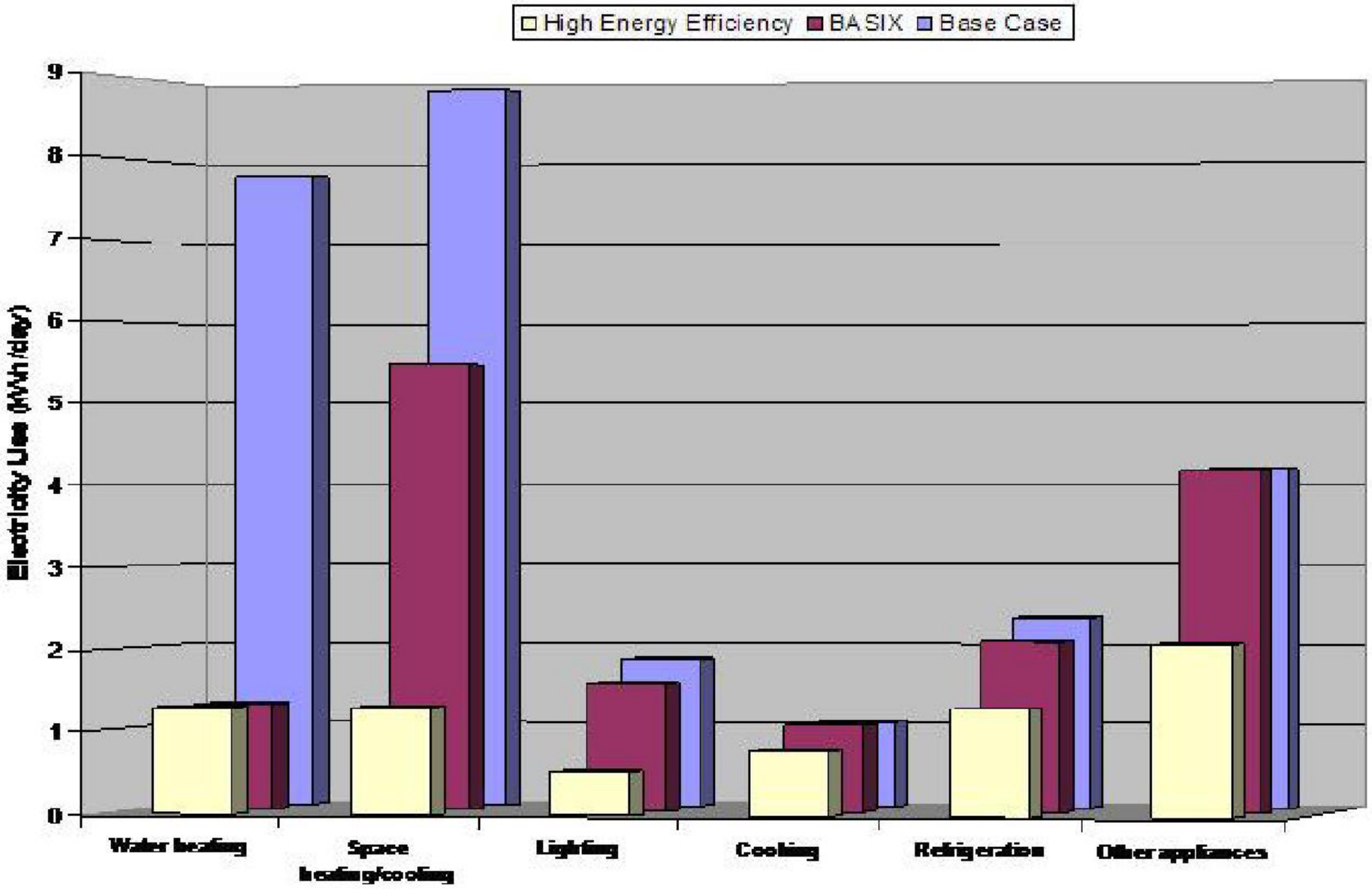
Redesigning a standard (supposedly optimized) industrial pumping loop cut its power from 70.8 to 5.3 kW (–92%), cost *less* to build, and worked better in every way. No new technologies — just two changes in the design mentality. Many other examples are in *Natural Capitalism*, free at www.natcap.org

1. Big pipes, small pumps (not the opposite)

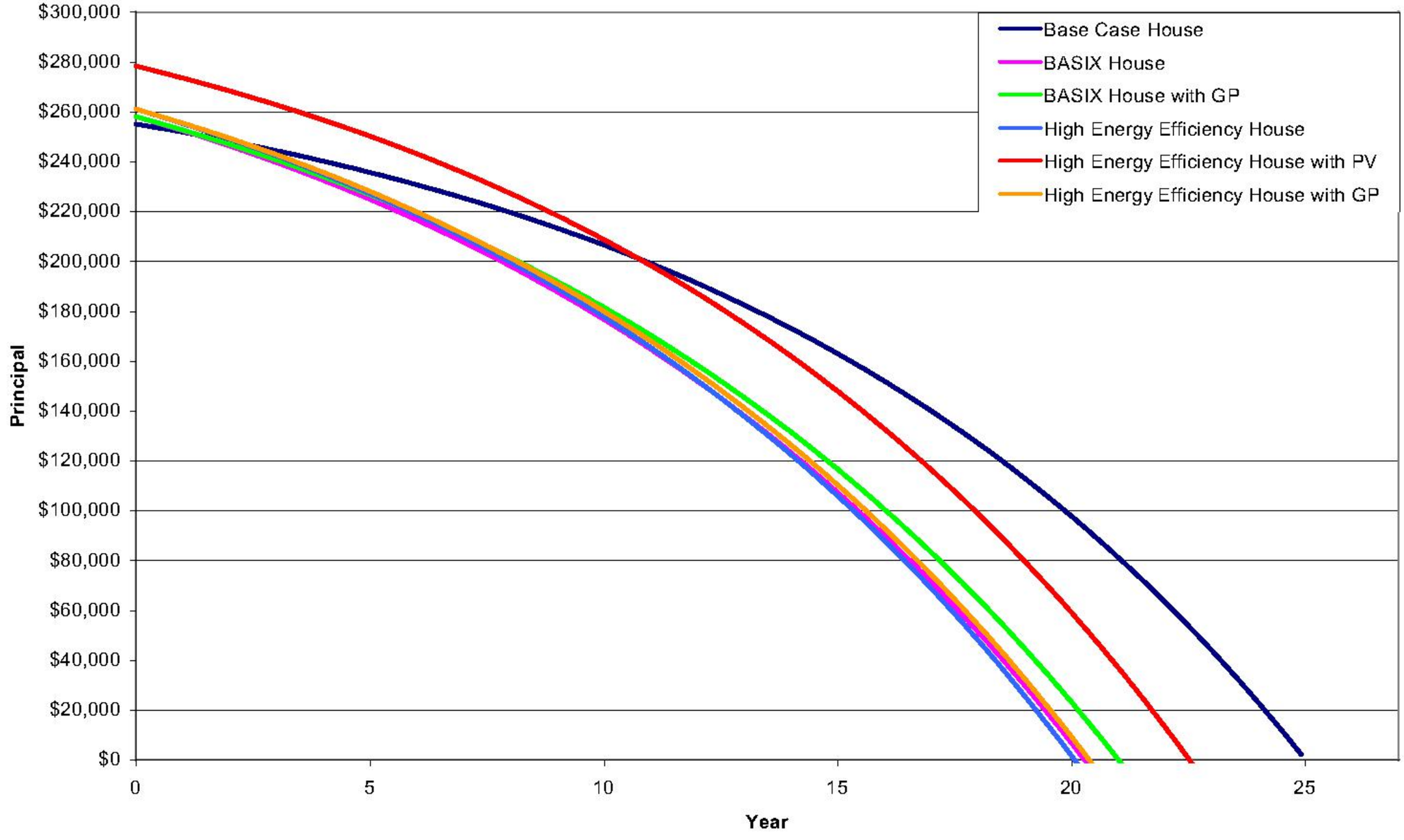
2. Lay out the pipes first, then the equipment (not the reverse).

LOWER PRESSURE =
LESS ENERGY LOSS =
ENERGY EFFICIENCY!

Carbon Neutral Homes



Expected breakdown of electricity consumption



Loan amortisation graph

Optimum energy design for a house in Sydney?

Table 2: Summary of house characteristics for simulation of typical and optimised house

	Typical House	**Optimised House**
Construction	Walls: Brick veneer, R1.5 Insulation Floor: Suspended timber floor, R1 Insulation Ceiling: Gyprock, R2.5 Insulation Roof: Steel roof	Walls: Reverse brick veneer, R5.7 Insulation Floor: Insulated concrete slab, R5.7 Insulation Ceiling: Gyprock, R5.7 Insulation Roof: Steel roof, R1 Insulation
Thermal mass	No internal thermal mass	Walls & Floor: 0.2m
Windows	Single glazed, unshaded with aluminium frames	Double glazed, shaded with timber frames
Ventilation	Normal ventilation: 2 ACH	Normal: 0.6 ACH Night ventilation: 10 ACH (summer) Heat exchange system

S.M. Bambrook, A.B. Sproul, D. Jacob, Design optimisation for a low energy home in Sydney, Energy and Buildings, Volume 43, Issue 7, July 2011, Pages 1702-1711,

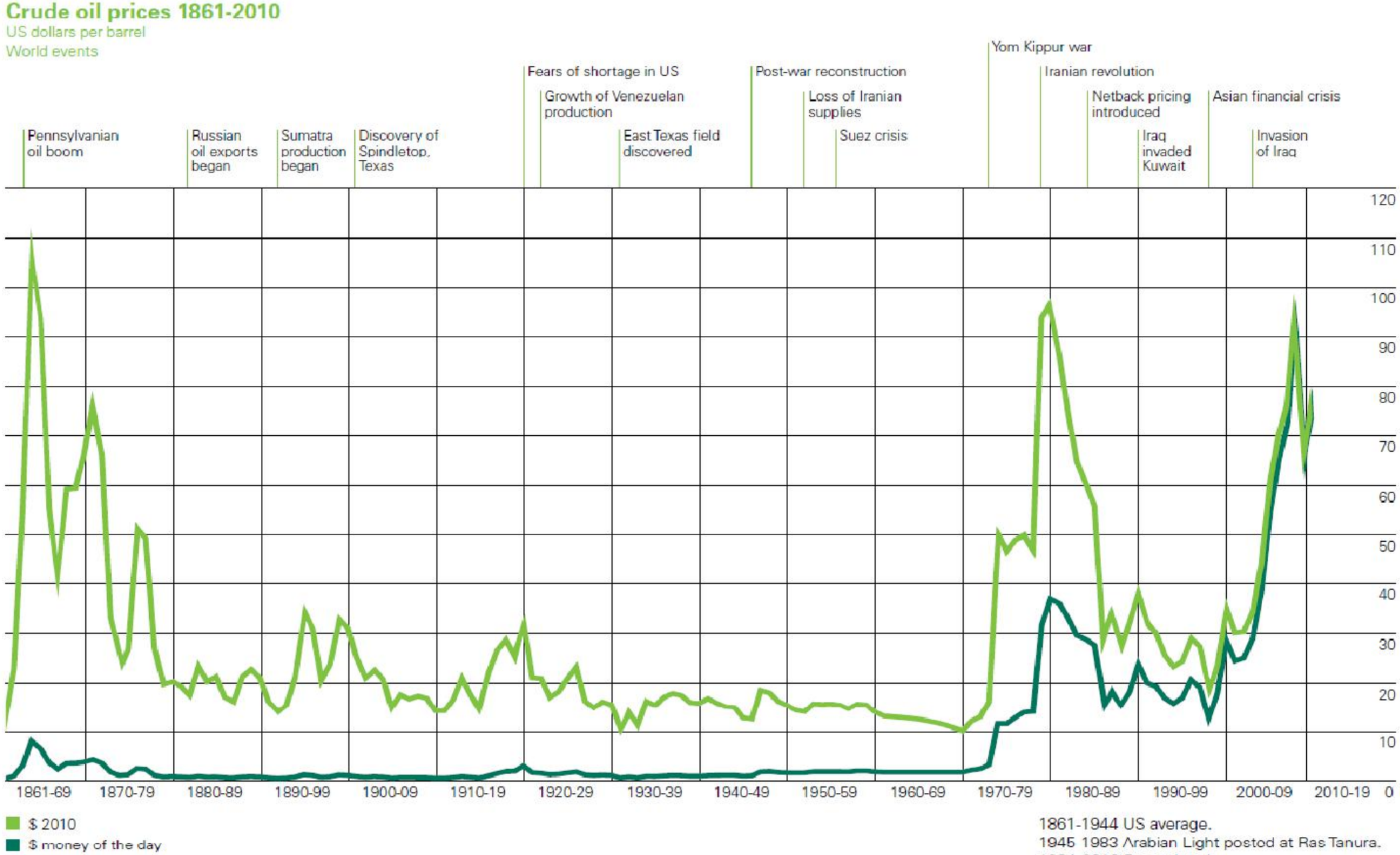
PV/T air systems

- Outlet temp suitable for space heating
- Array ventilation increases PV output
- Additional PV elec output > fan energy
- Good potential for residential application

S.M. Bambrook, A.B. Sproul, Maximising the energy output of a PVT air system, Solar Energy, Volume 86, Issue 6, June 2012, Pages 1857-1871


Transport

Chart of crude oil prices since 1861



BP Statistical Review of World Energy 2011

Increasingly electric vehicles/hybrids are becoming more widely available as the technology if offered to customers by a wider range of companies.

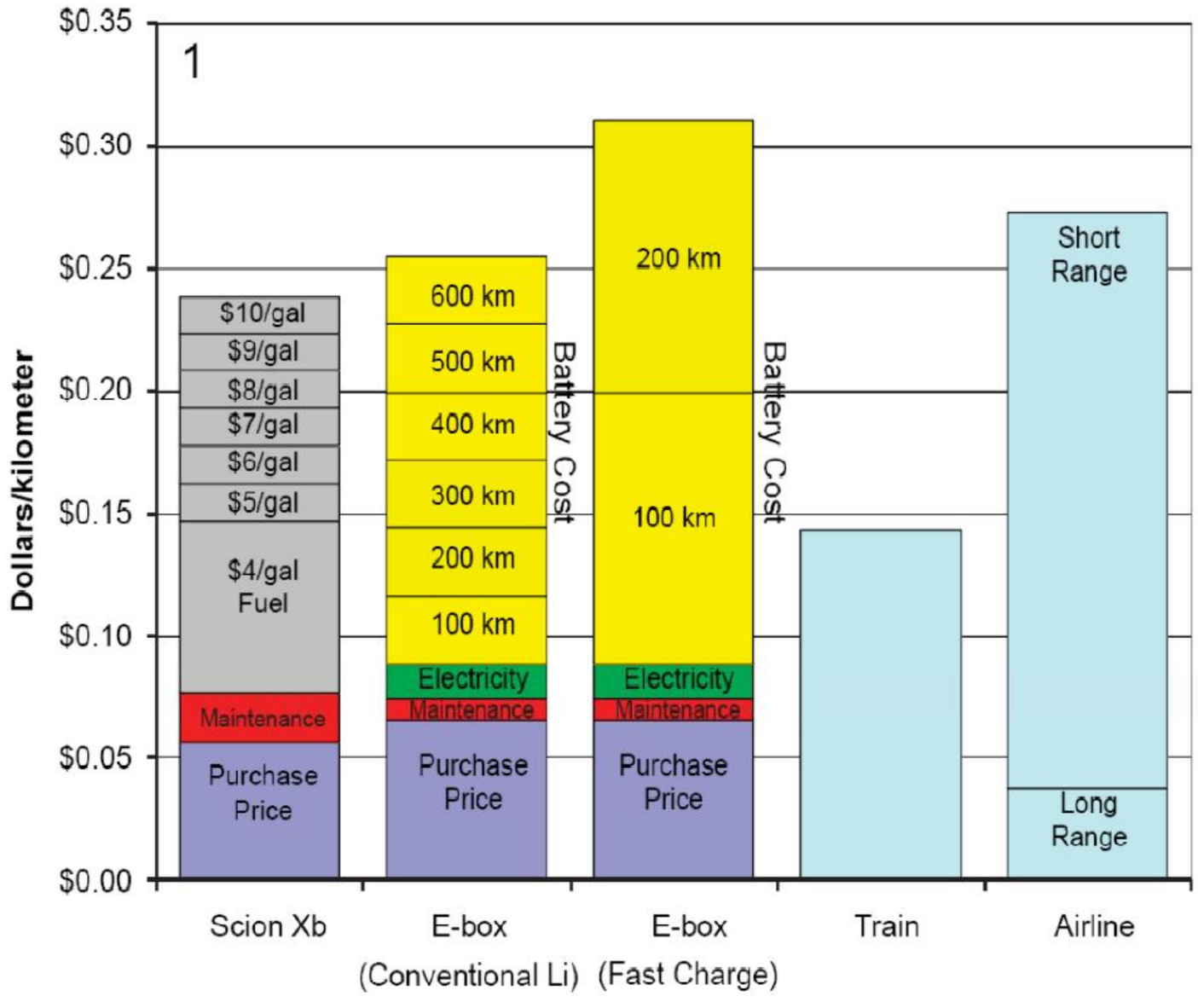
http://www.chevrolet.com/volt/

Batteries: Lower cost than gasoline?

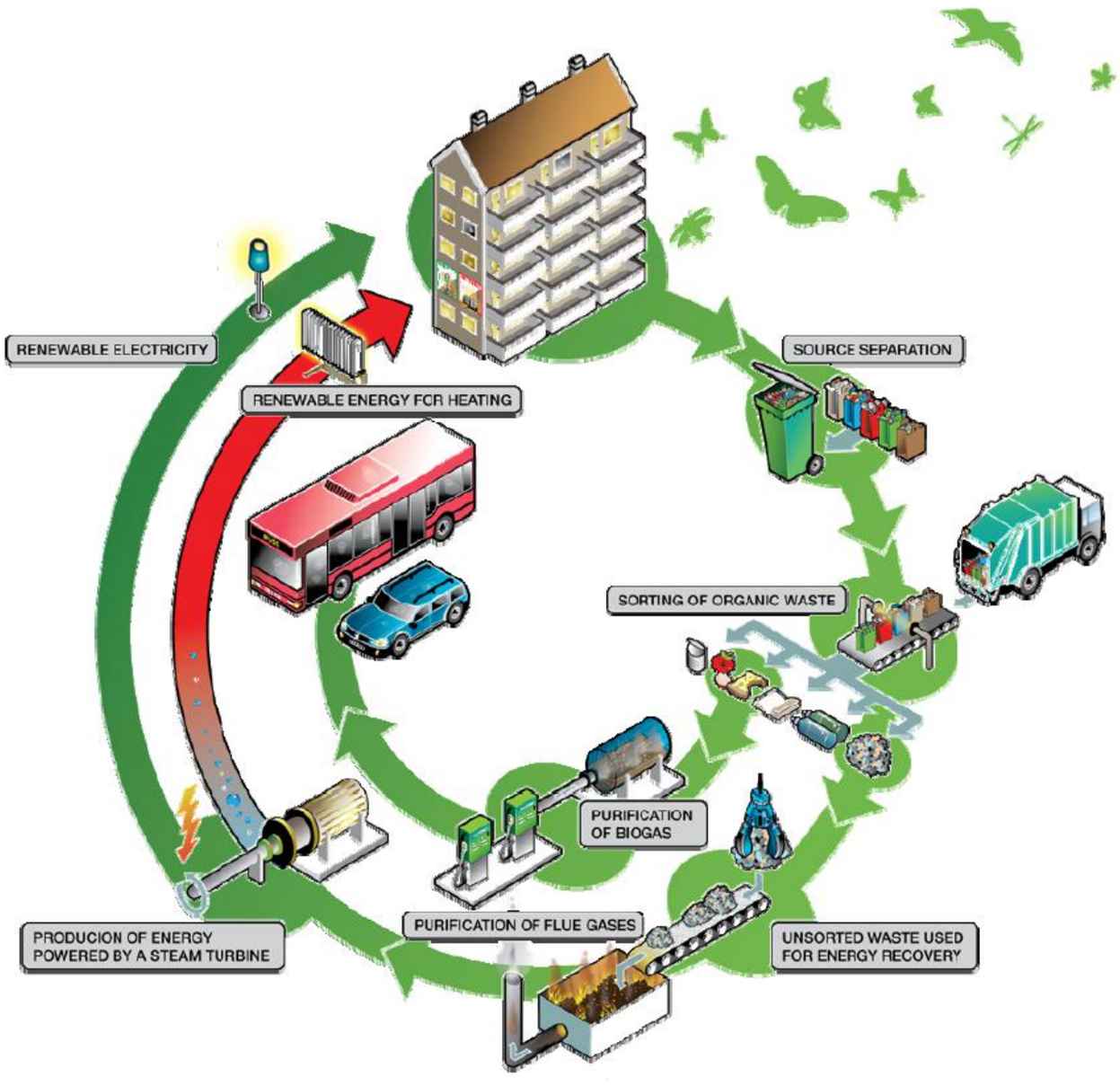
Mathew Werber, Michael Fischer, Peter V. Schwartz *

Cal Poly Physics Department, San Luis Obispo, CA 93407, United States

Energy Policy 37 (2009) 2465–2468



Oslo – plans to run all the city's buses on biogas produced from food waste.



http://www.bioenergy-news.com/index.php?/Industry-News?item_id=4826


Where to from here?


Termites don’t burn coal yet they have a low carbon built environment
“High rise” termite mound
Indoor climate control
Solar driven ventilation
Air-earth heat exchange
10 m high, maintains 31±1°C in 3–42°C for termites’ fungus-farming

CRC FOR
LOW CARBON LIVING

CRC FOR LOW CARBON LIVING

THE CRC PROGRAMS

✓ Integrated Building Systems

- **Integrated solar technologies for buildings**
- **Low carbon materials**
- **Integrated design, showcase, ratings and standards**

✓ Low Carbon Precincts

- **Digital information platform**
- **Integrated assessment of design**
- **Precinct level demand forecasting for distributed infrastructure networks**
- **Health and productivity co-benefits**

✓ Engaged Communities

- **Transition scenarios and affordability**
- **Drivers and barriers to community engagement**
- **Living laboratories**
- **Education and capacity building**

LOW CARBON LIVING CRC

LIVING LABORATORIES

- ✓ **Property developments**
  - → *Trialing new infrastructure solutions and technologies*
- ✓ **Community groups**
  - → *Trialing behaviour change, social engagement programs*
- ✓ **Making it real**
  - → *Research by doing*
  - → *Program delivery & cost by partner*
  - → *Ongoing metering and survey work by CRC*

First step to widespread adoption


Questions?