FROM DEVICE TO SYSTEM EFFICIENCY: Examples from Buildings

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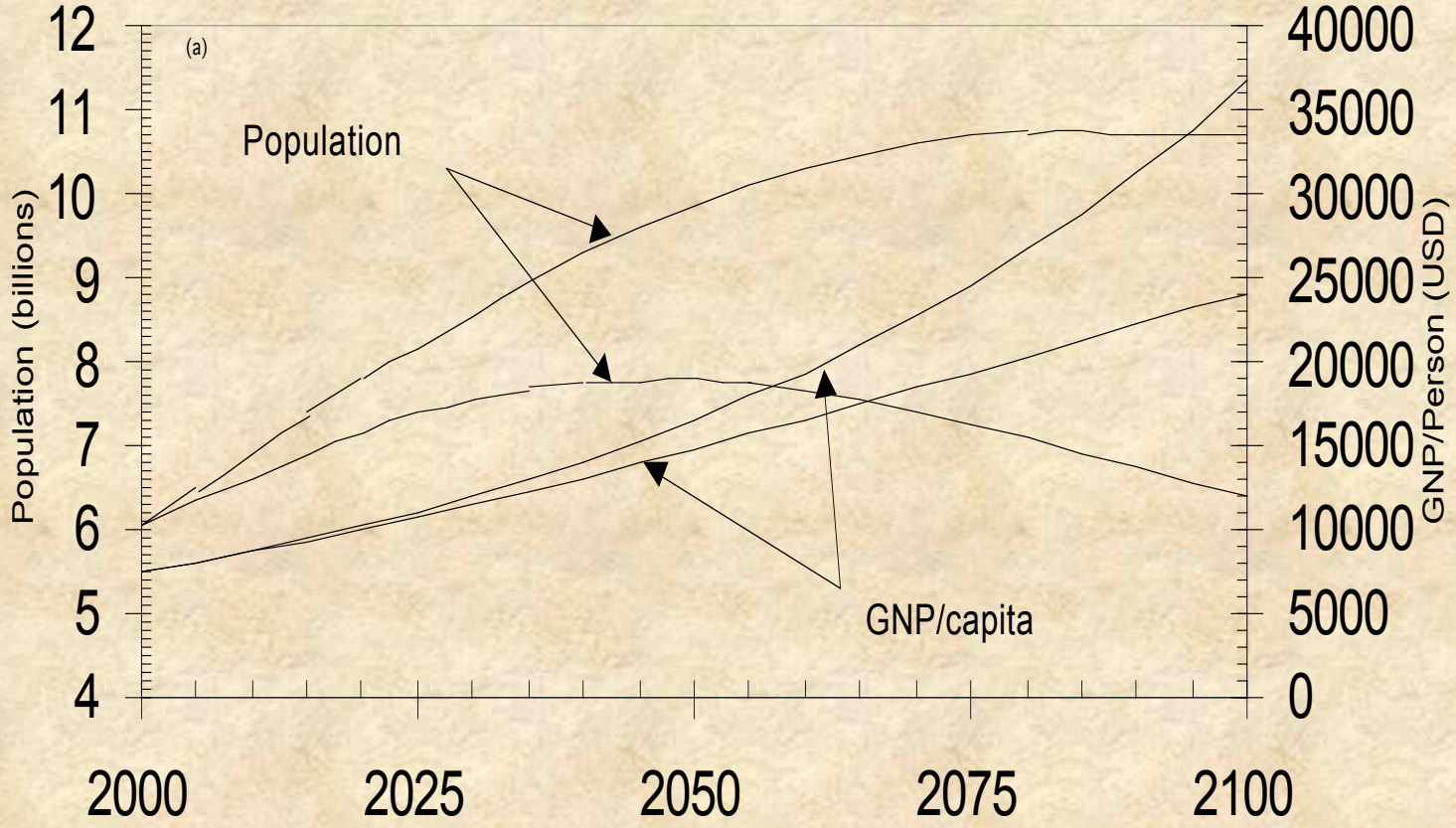
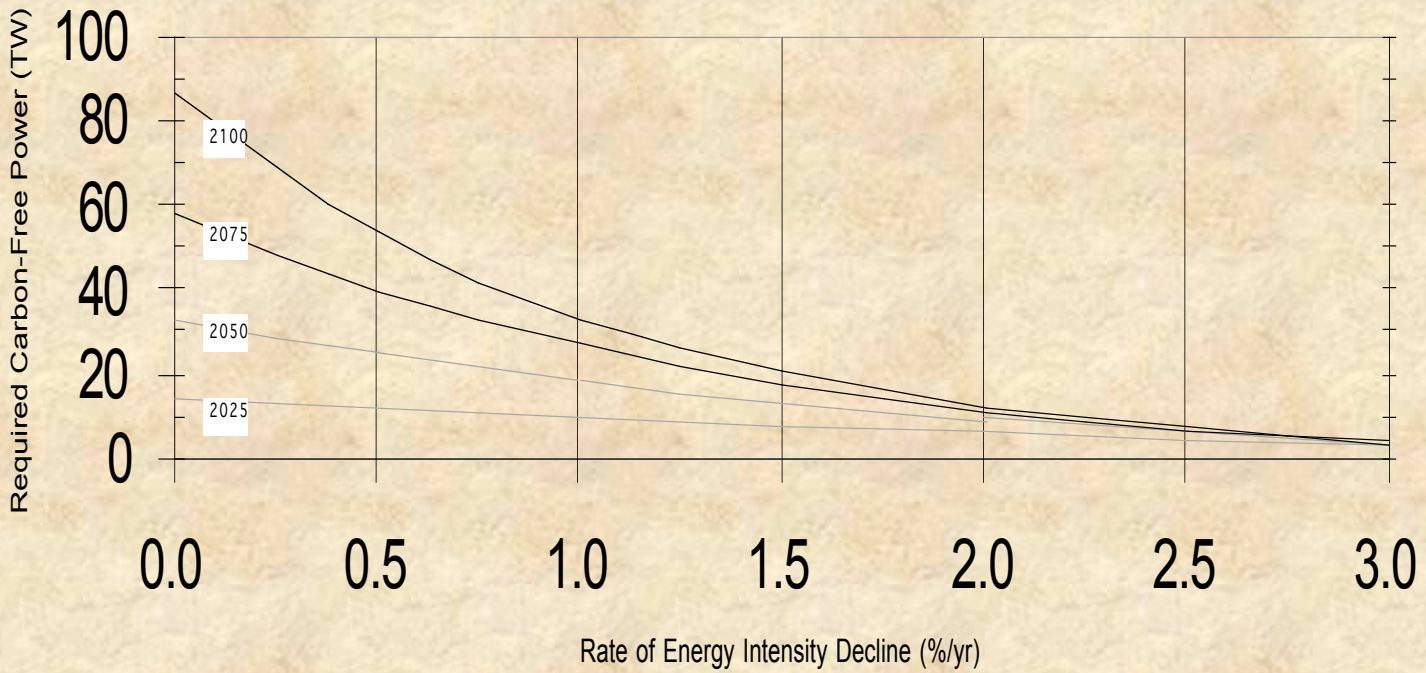
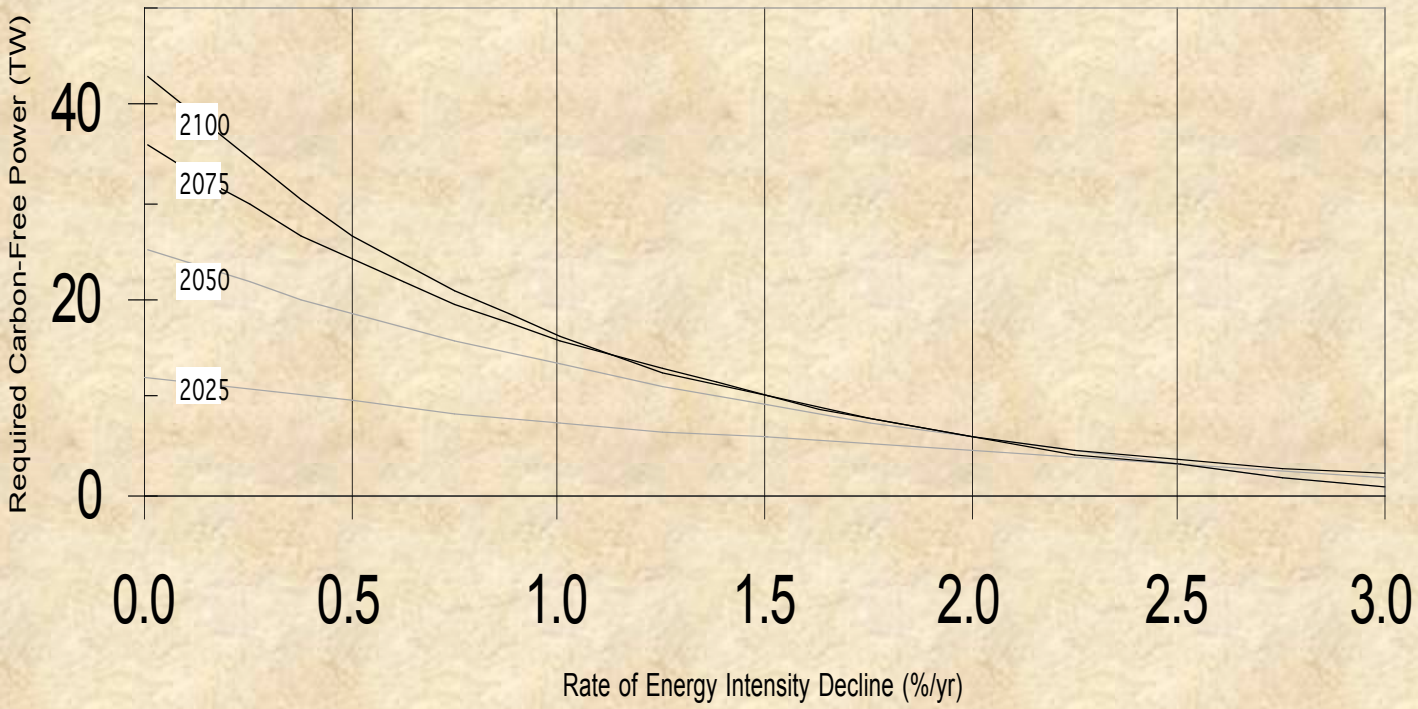
Alternative Population and GDP/P Scenarios



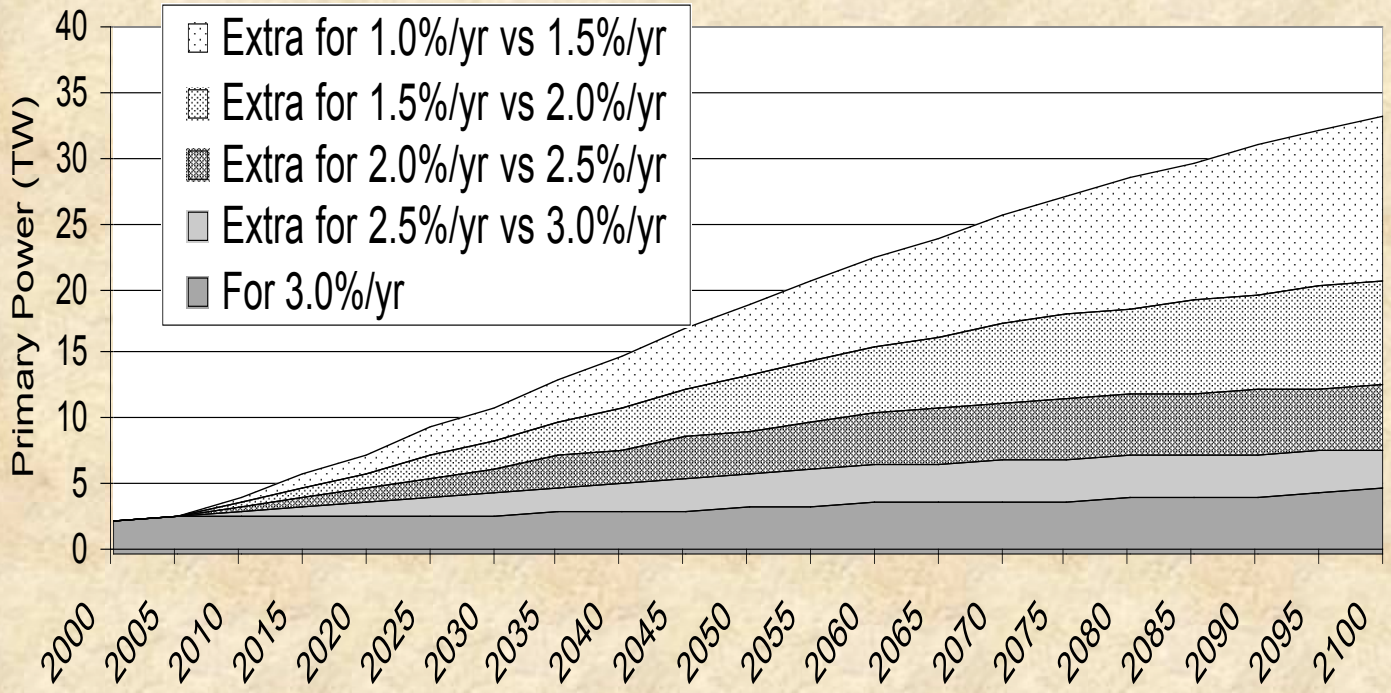
Medium Population, 1.6% per year growth of GDP per capita, 450 ppmv peak



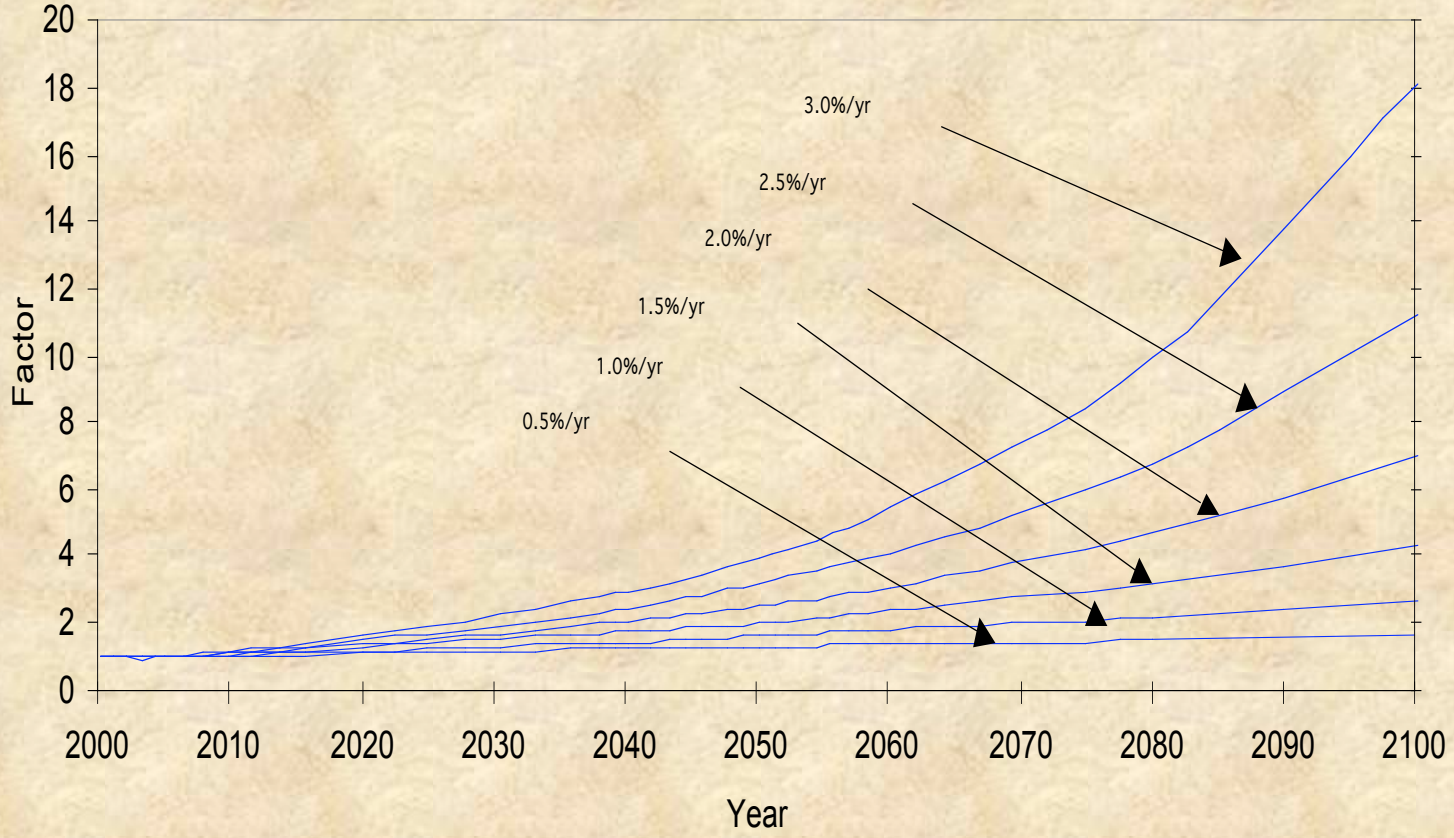
Low Population, Declining Rate of Growth in GDP per capita, 450 ppmv peak



C-Free Power (TW) required to stabilize at 450 ppmv CO2 for various rates of reduction in energy intensity, medium population and high GDP/P growth



Factor by which energy intensity decreases (relative to 2000) for various annual rates of decrease starting in 2000



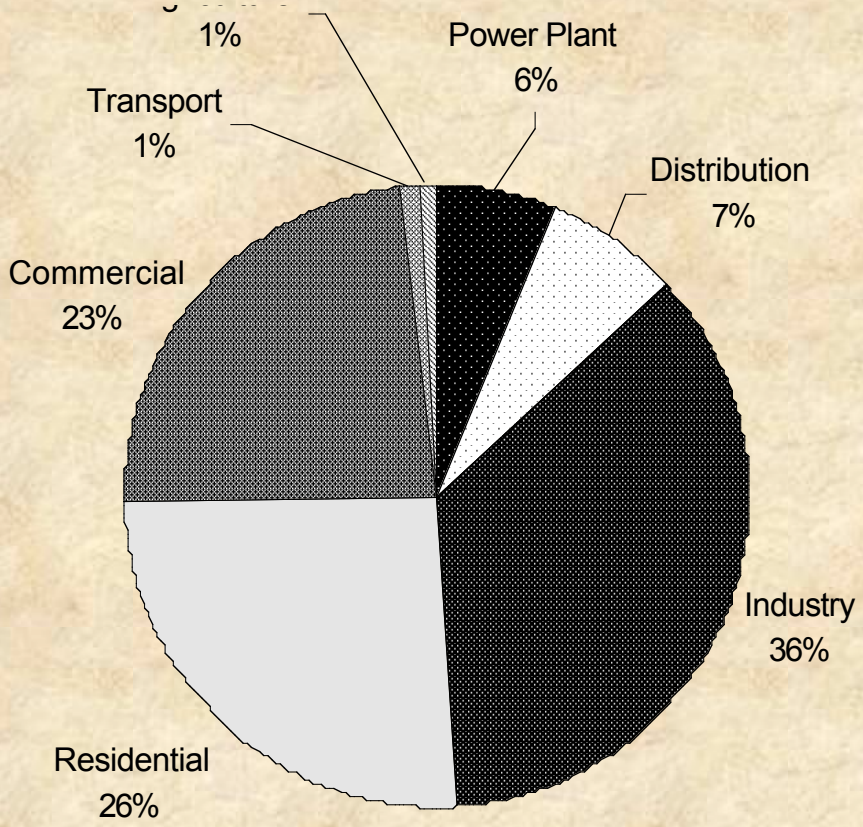
Energy and the New Reality: Facing up to Climatic Change

- Island Press (Washington), Spring 2005
- 160,000 words
- 225 figures+photos
- 130 tables
- 13 mathematical boxes

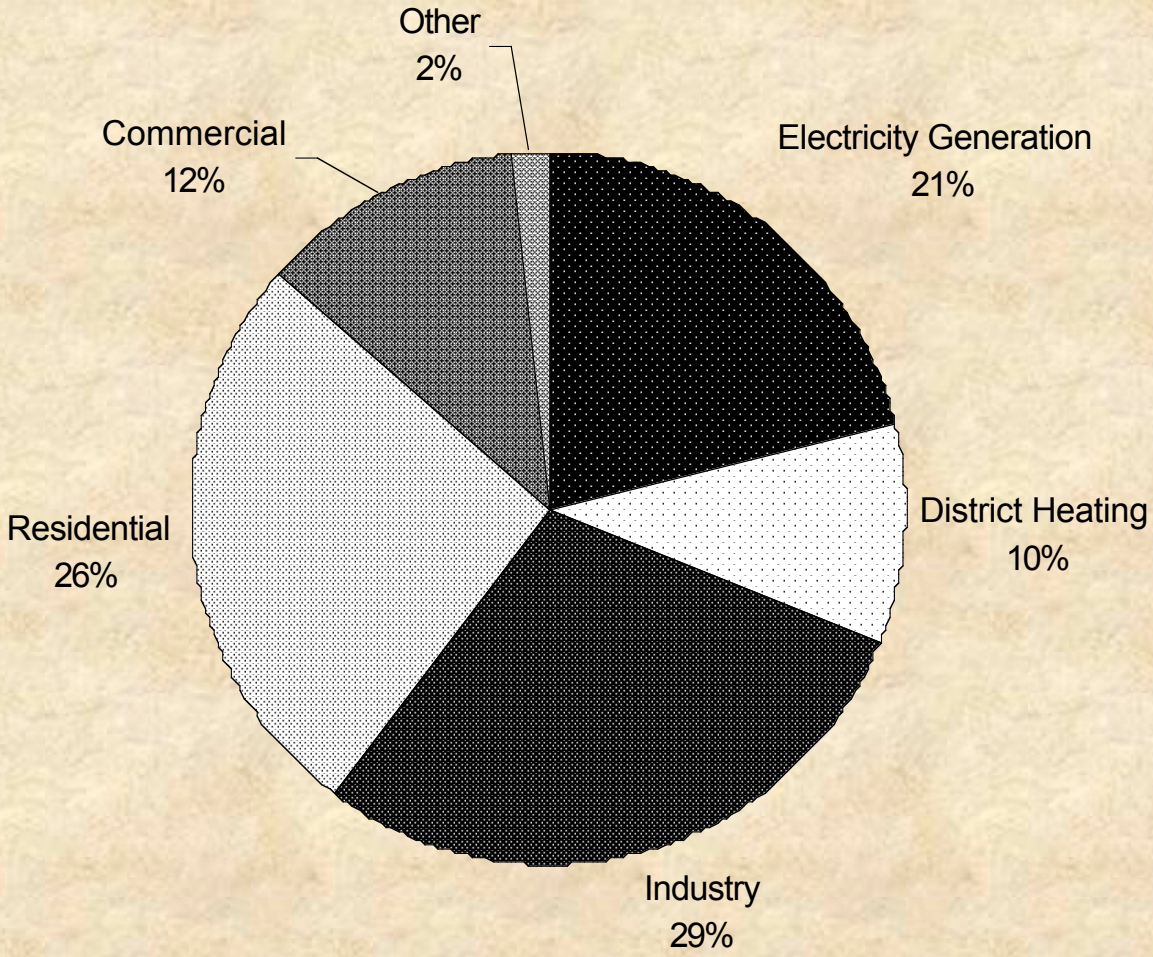
A Primer on Energy-Efficient Building Design and Retrofits

- Proposal to Island Press, Summer 2004 release
- 110,000 words
- 105 figures
- 60 Tables
- 15 mathematical boxes

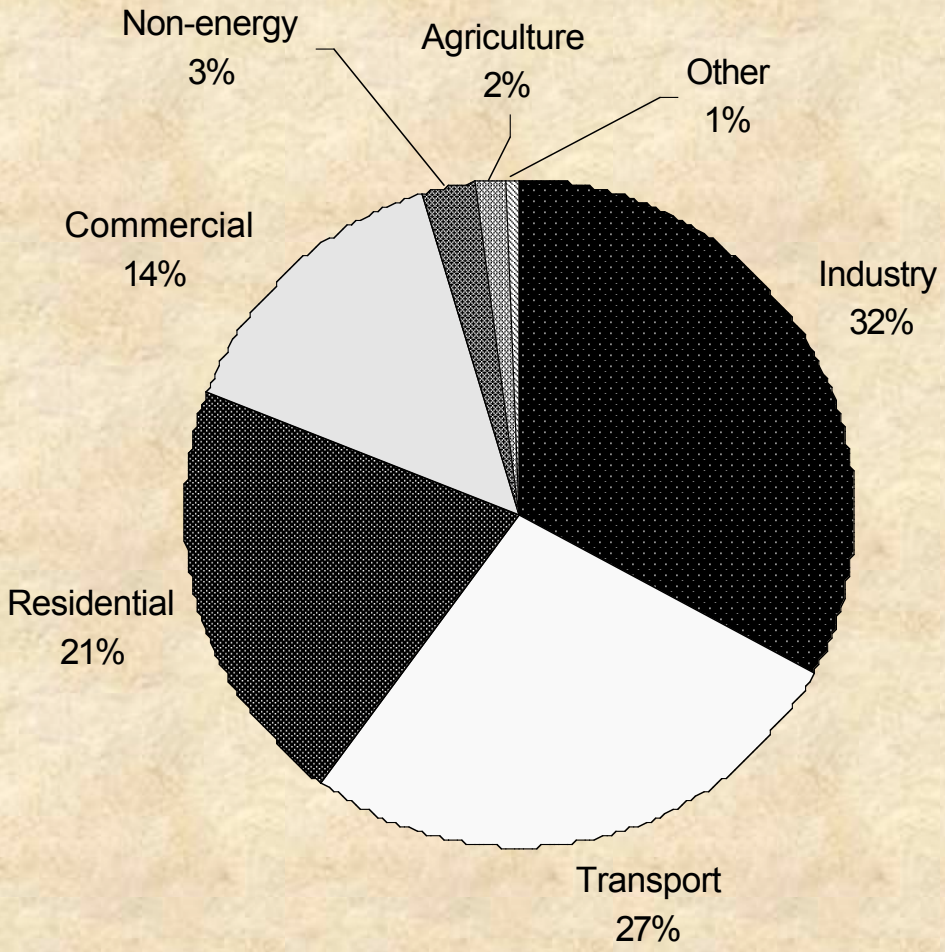
Electricity Use in OECD Countries



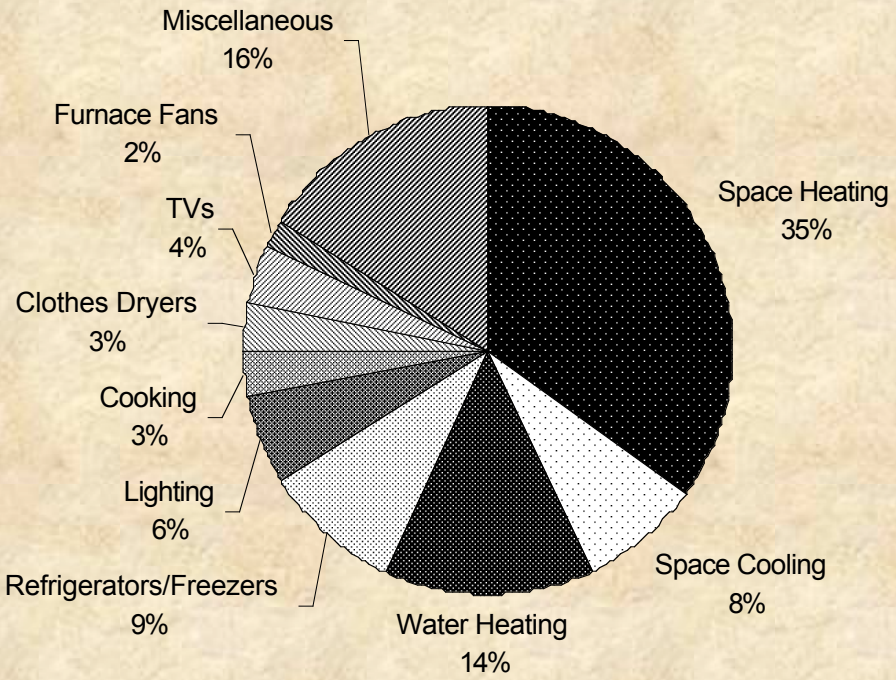
Natural Gas


Other
2%
Commercial
12%
Electricity Generation
21%
Residential
26%
District Heating
10%
Industry
29%

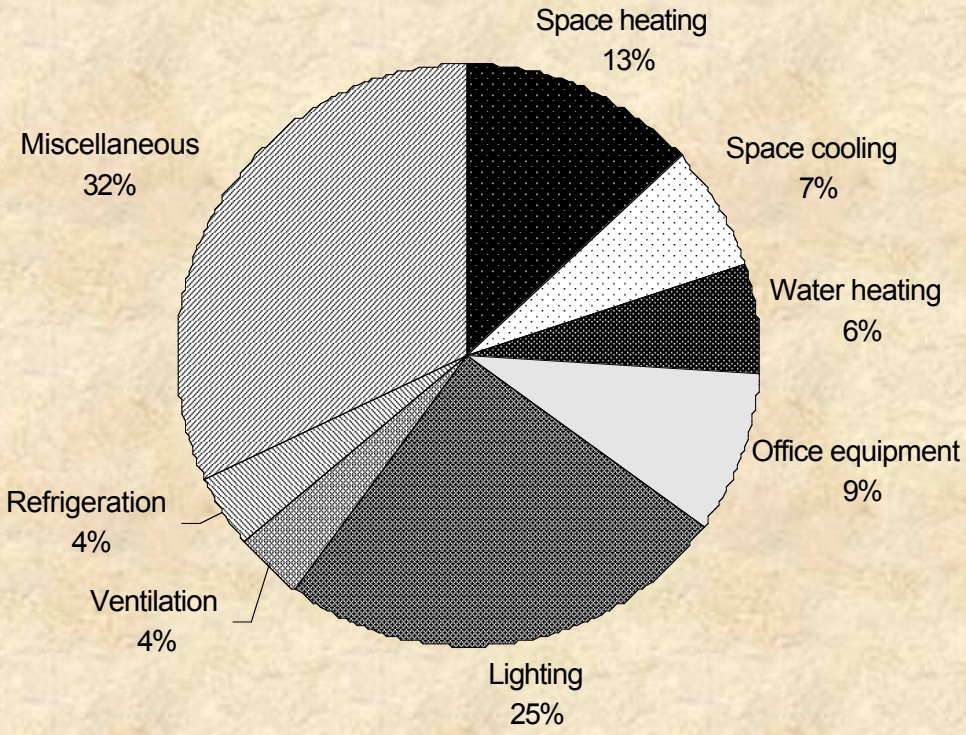
Primary Energy



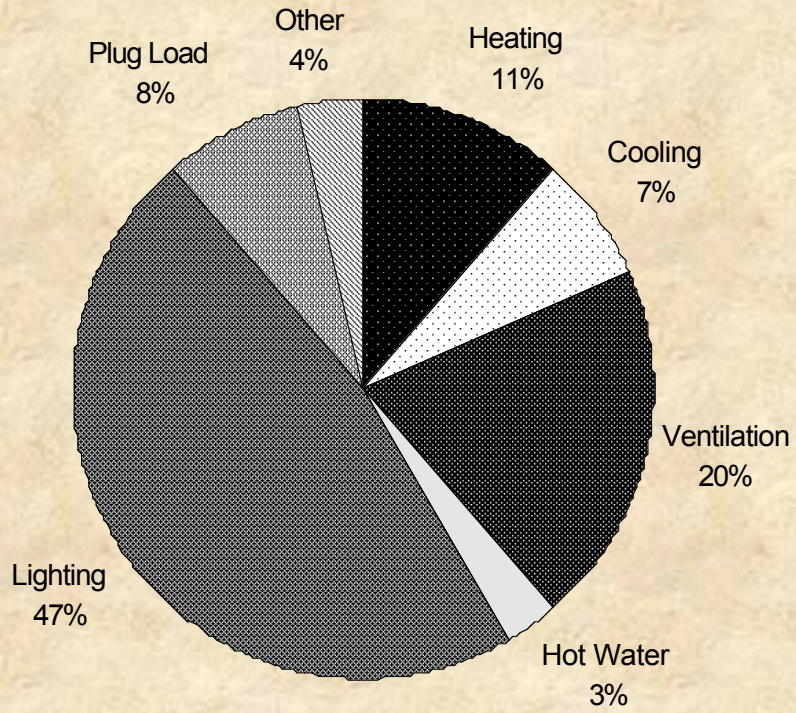
Residential Energy Use, USA



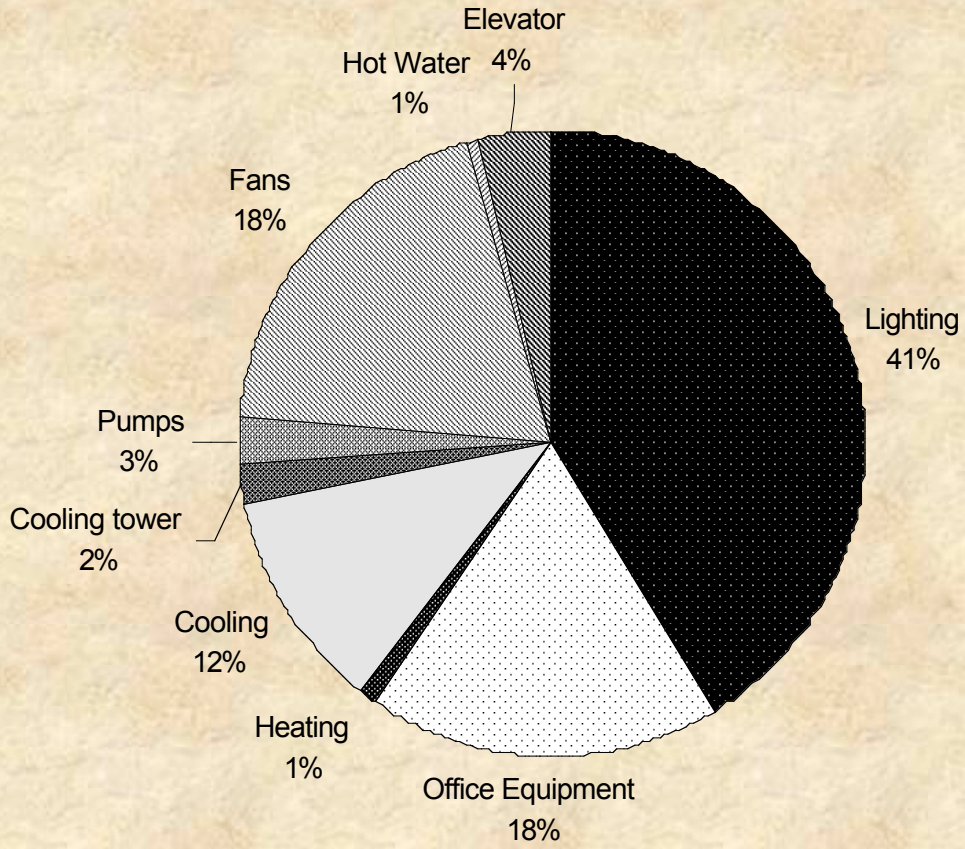
Commercial Sector Energy Use, USA



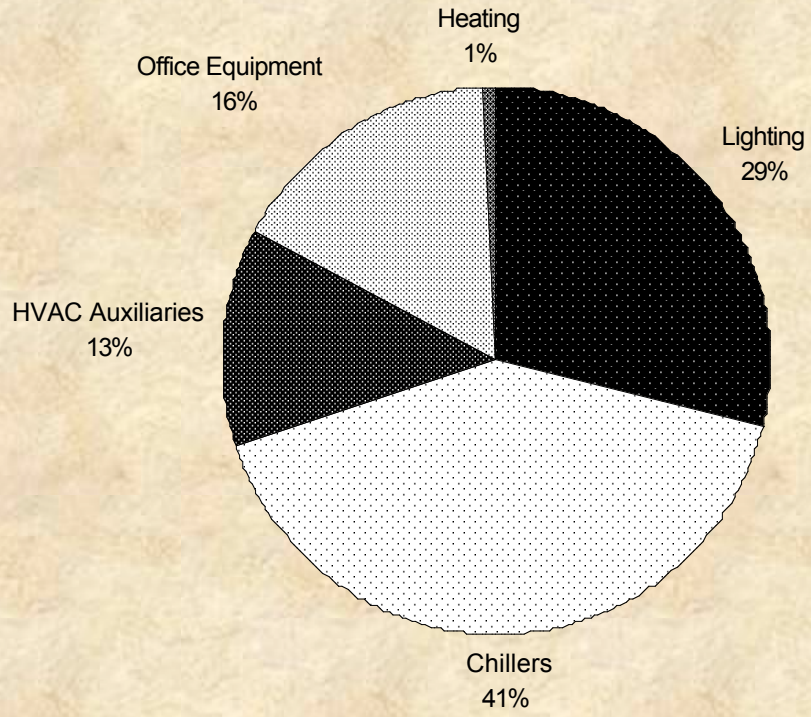
Commercial Sector Electricity Use, Toronto



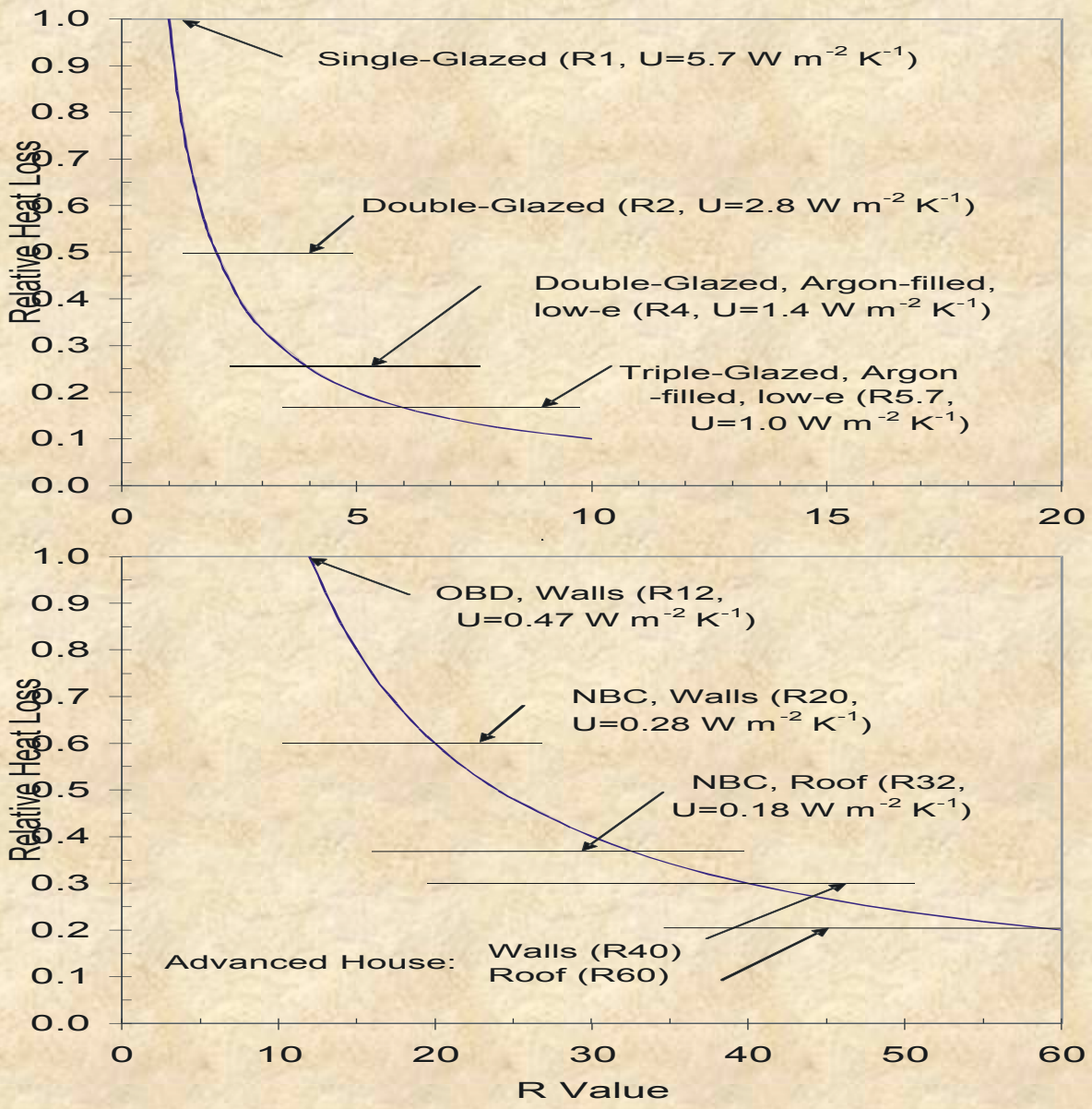
Electricity Use, 16-story New York Office Building



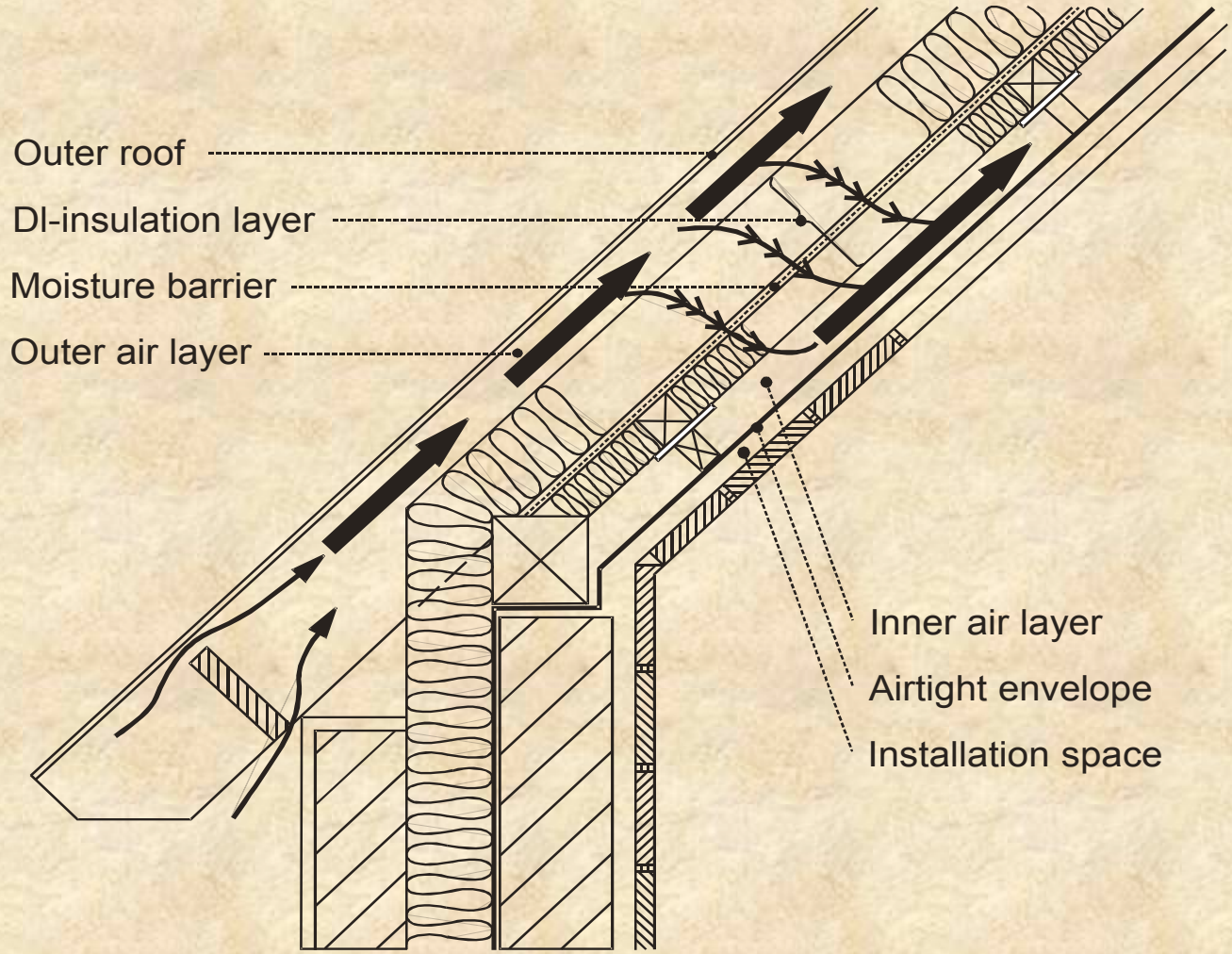
Electricity Use, Generic Hong Kong Office Building



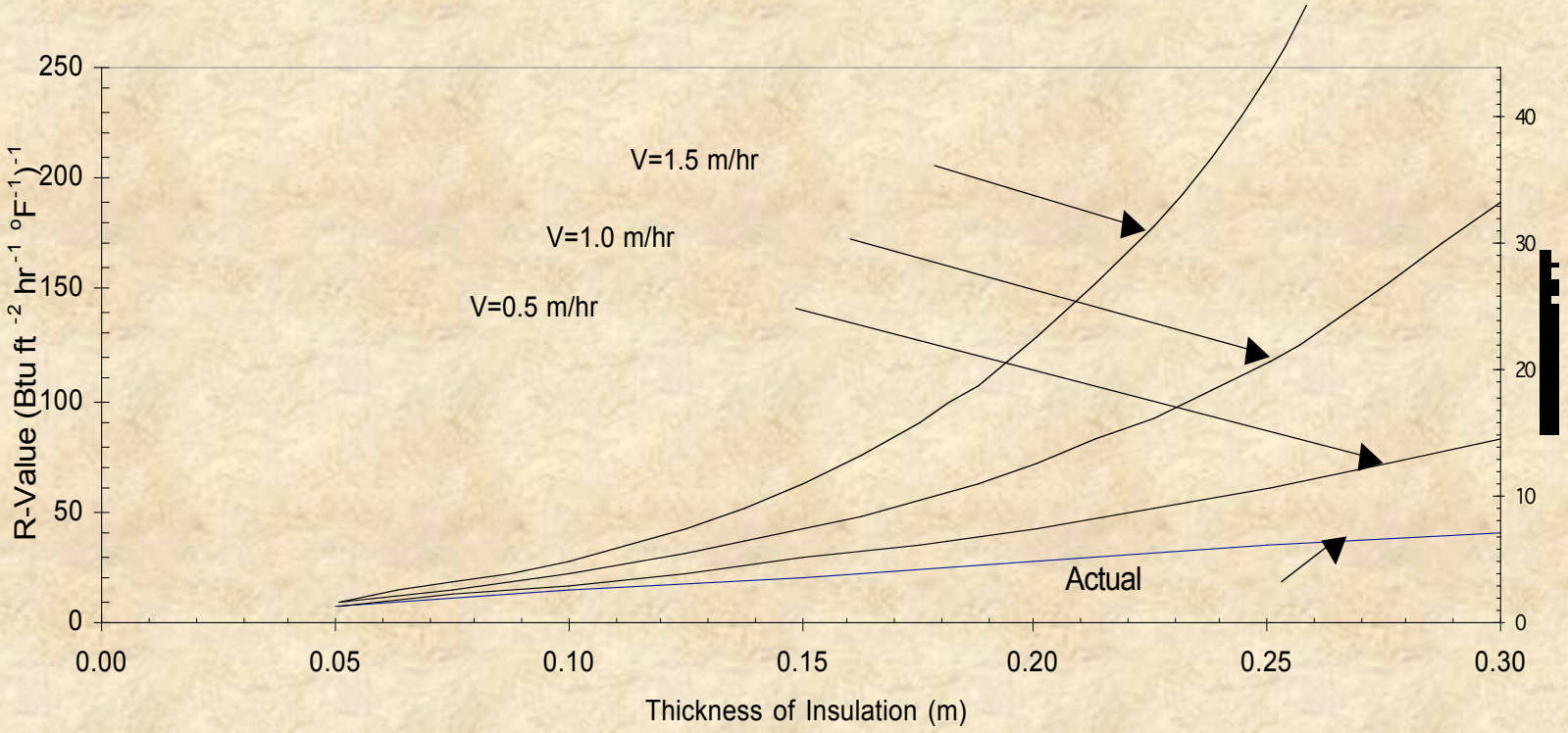
Envelope Heat Loss



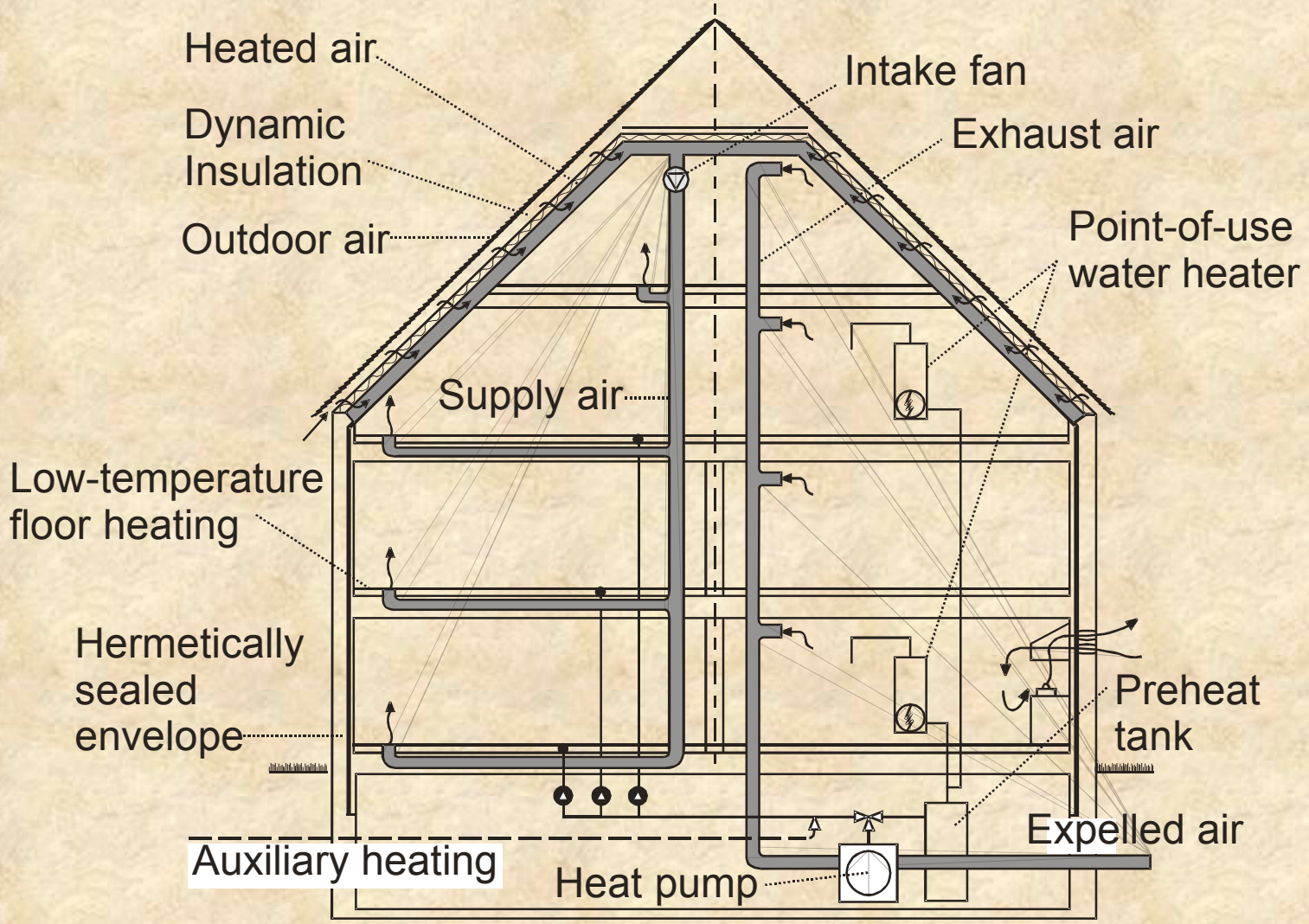
Dynamic Insulation



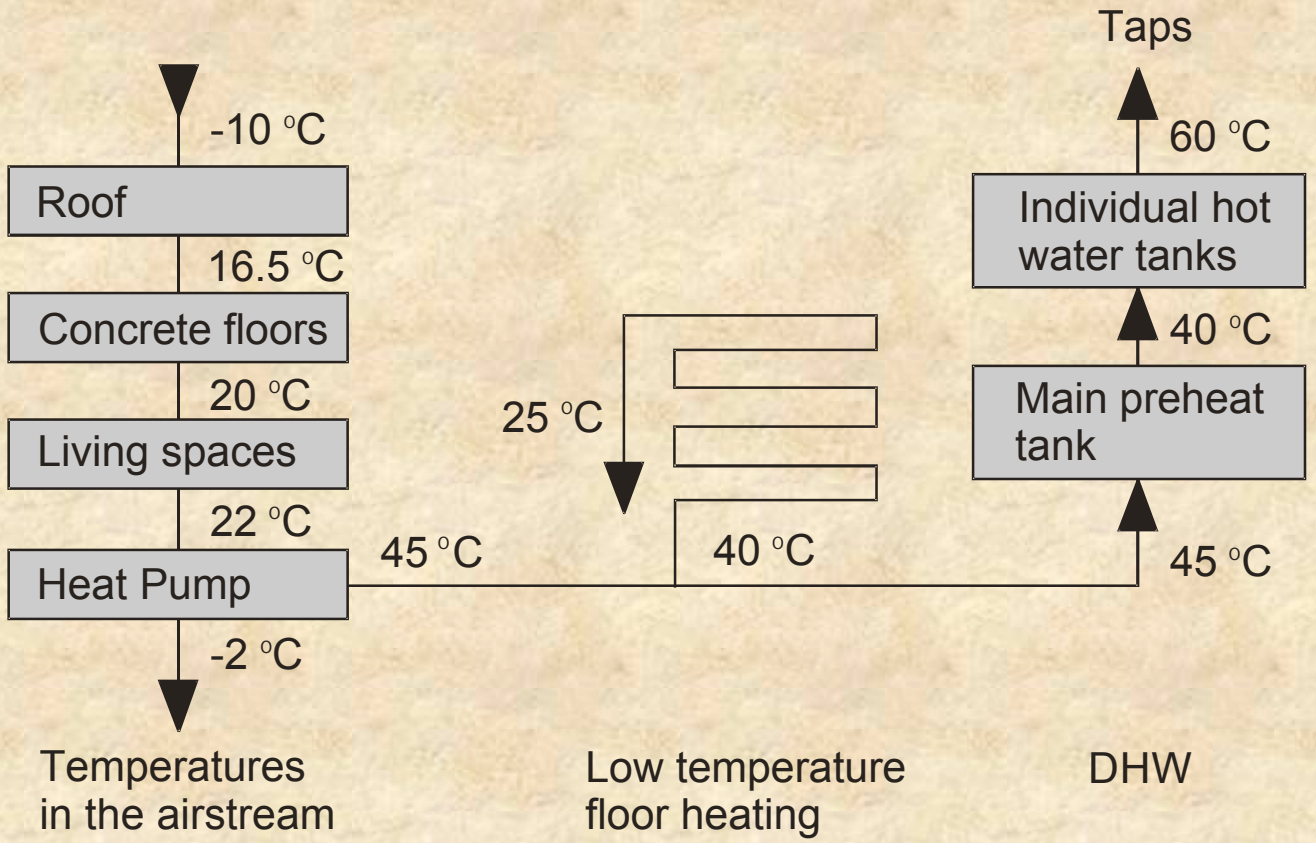
Effective R-values with Dynamic Insulation



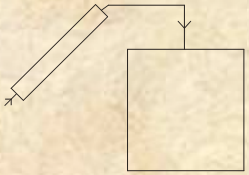
Advanced House in Switzerland



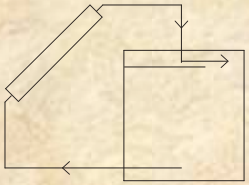
Temperatures in Advanced House



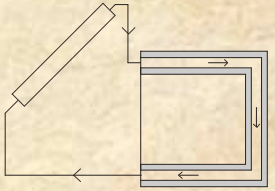
Solar-Air Collectors



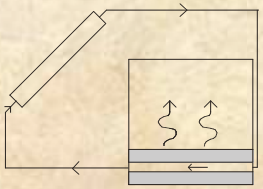
System type 1



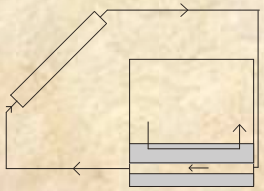
System type 2



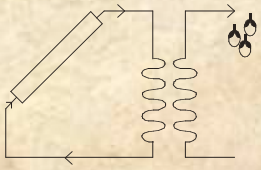
System type 3



System type 4

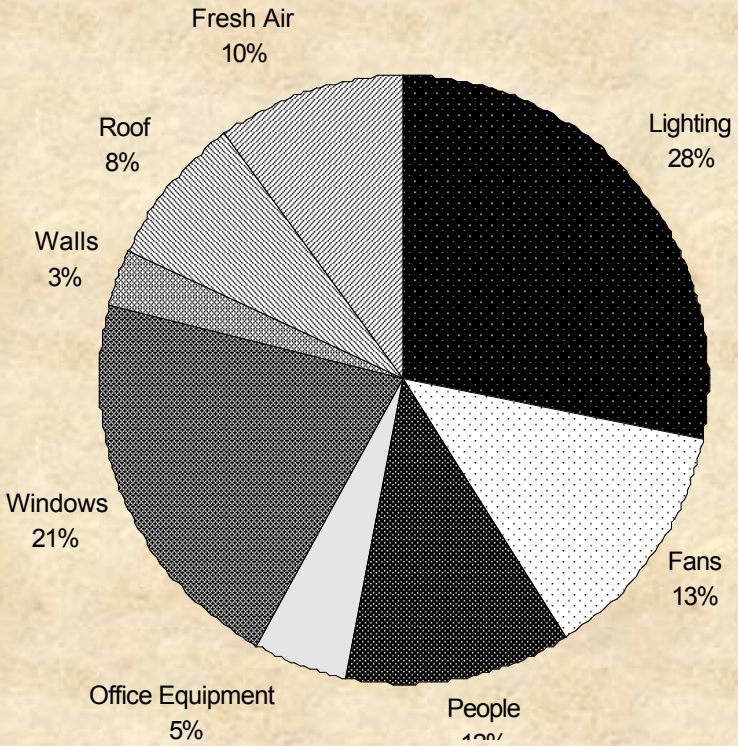


System type 5

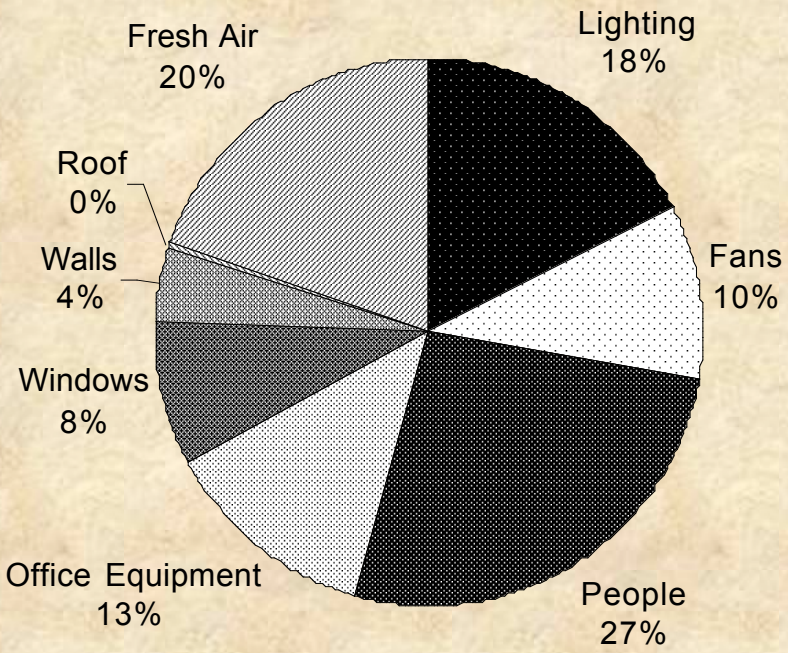


System type 6

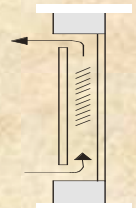
Cooling loads in a Los Angeles Office Building



Cooling Loads, Generic Hong Kong Office Building



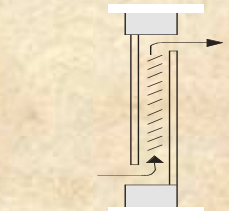
Air-Flow Windows



Window

Outdoor-Outdoor

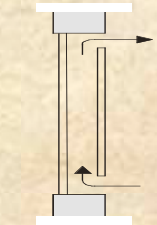
summer
cooling



Window, Wall,
Perforated Wall

Outdoor-Indoor

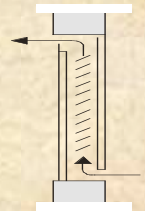
winter
heating



Window

Indoor-Indoor

winter
heating

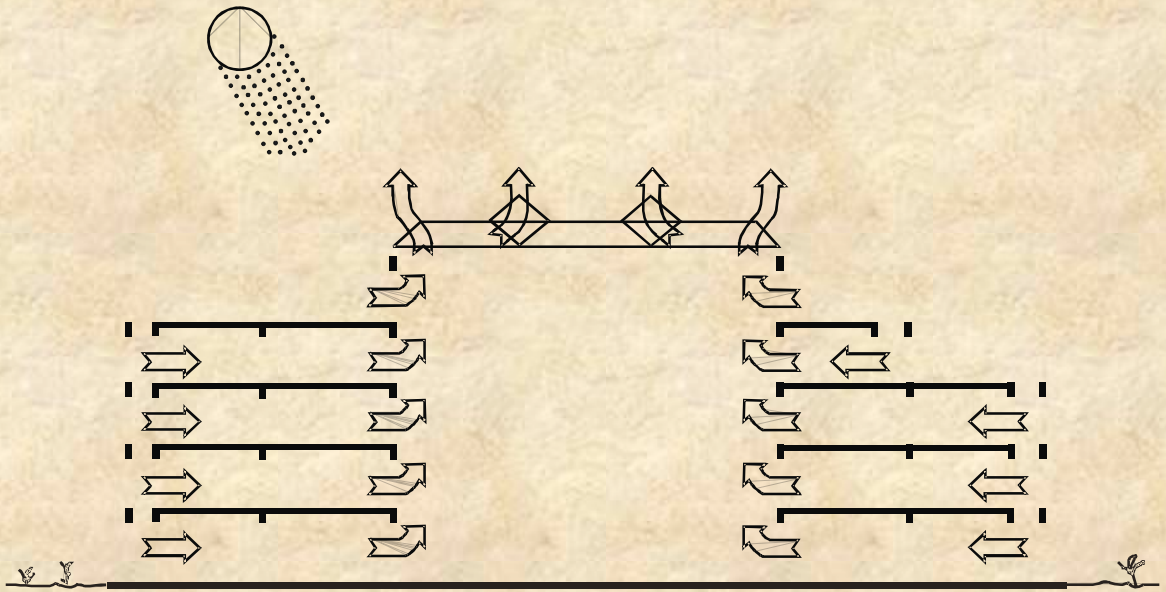


Window,
Wall

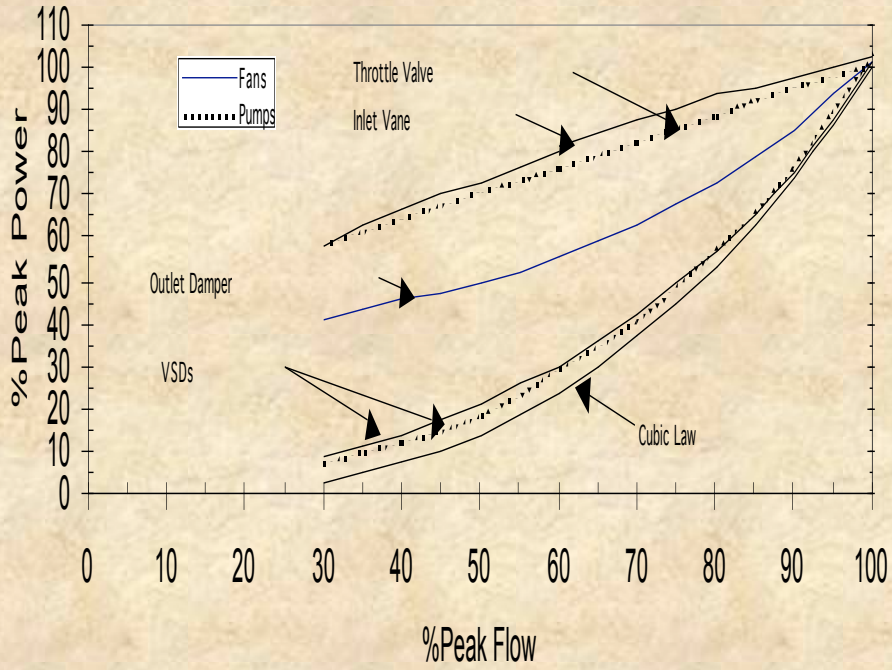
Indoor-Outdoor

summer
ventilation

Passive Ventilation

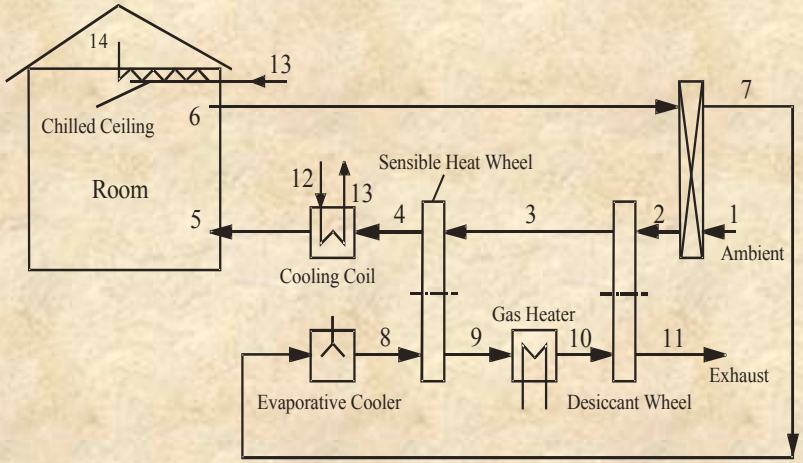


Pump or Fan Energy Use

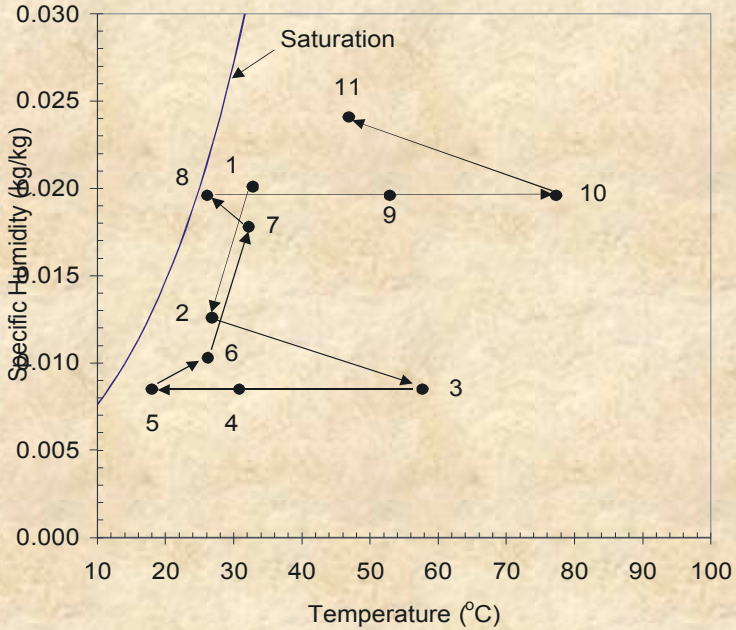


Solar-Powered Desiccant Dehumidification with Displacement Ventilation and Chilled-Ceiling Cooling

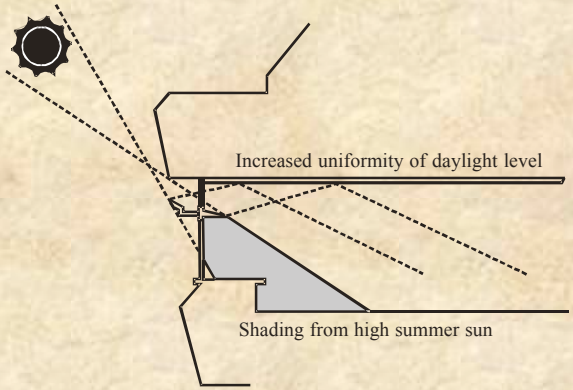
a)



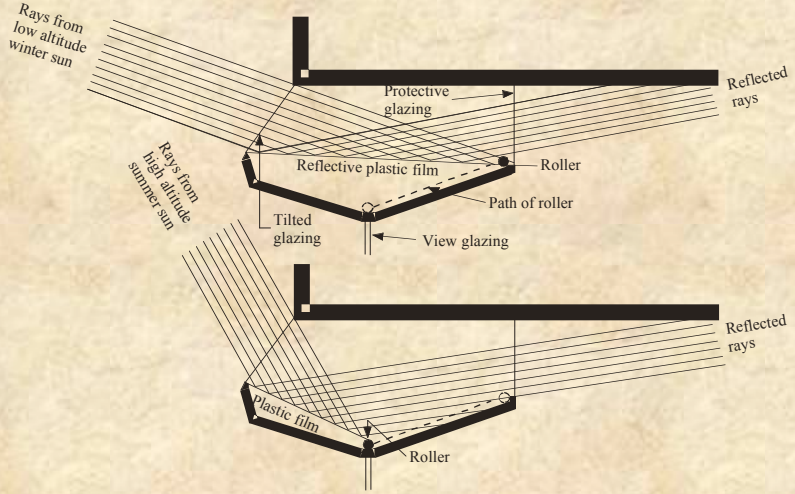
b)



Light Shelves

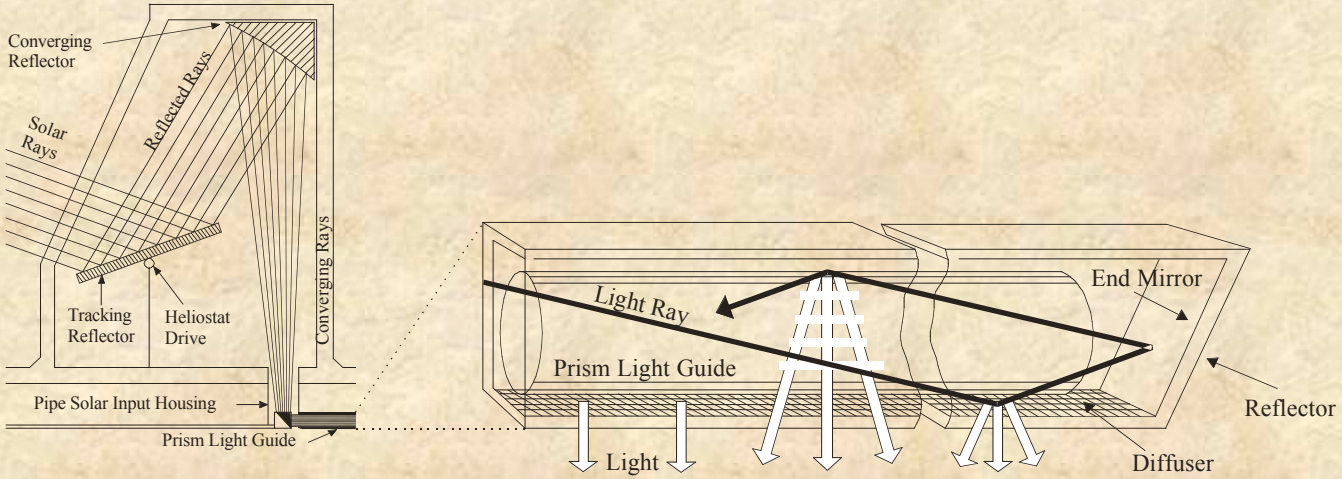


Fixed Light Shelf

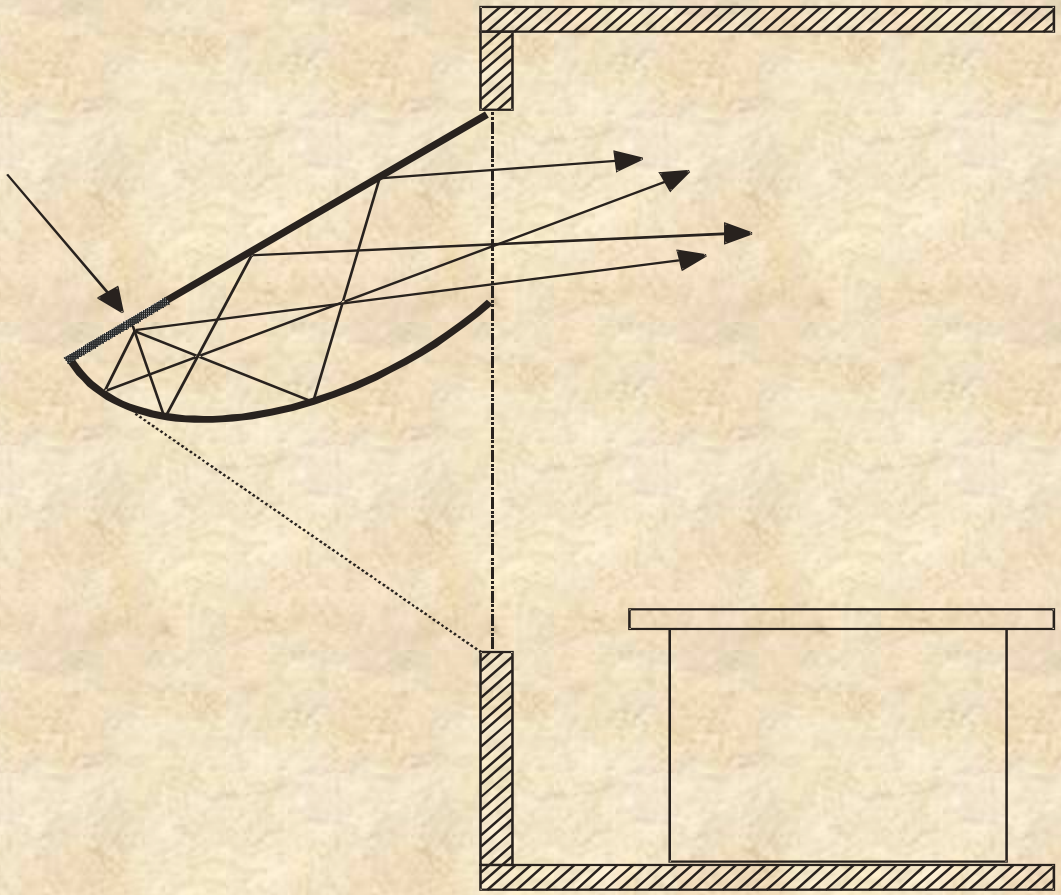


Adjustable Light Shelf

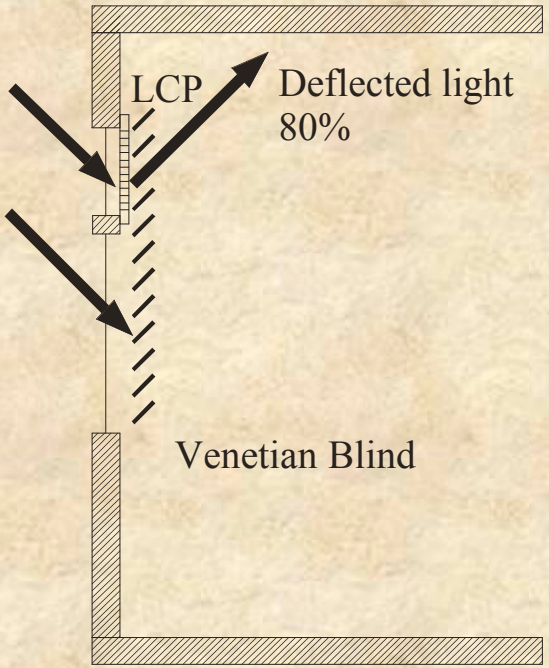
Light Pipes

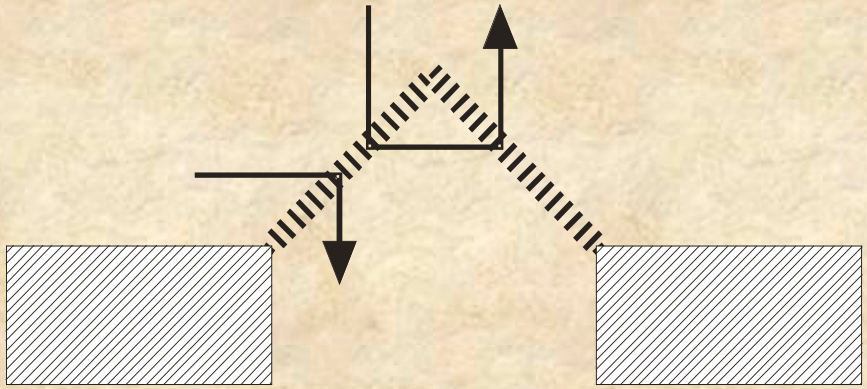

Converging
Reflector
Reflected Rays
Solar
Rays
Converging Rays
Tracking
Reflector
Heliostat
Drive
Pipe Solar Input Housing
Prism Light Guide
Light Ray
End Mirror
Prism Light Guide
Reflector
Light
Diffuser

Light-guiding Shades

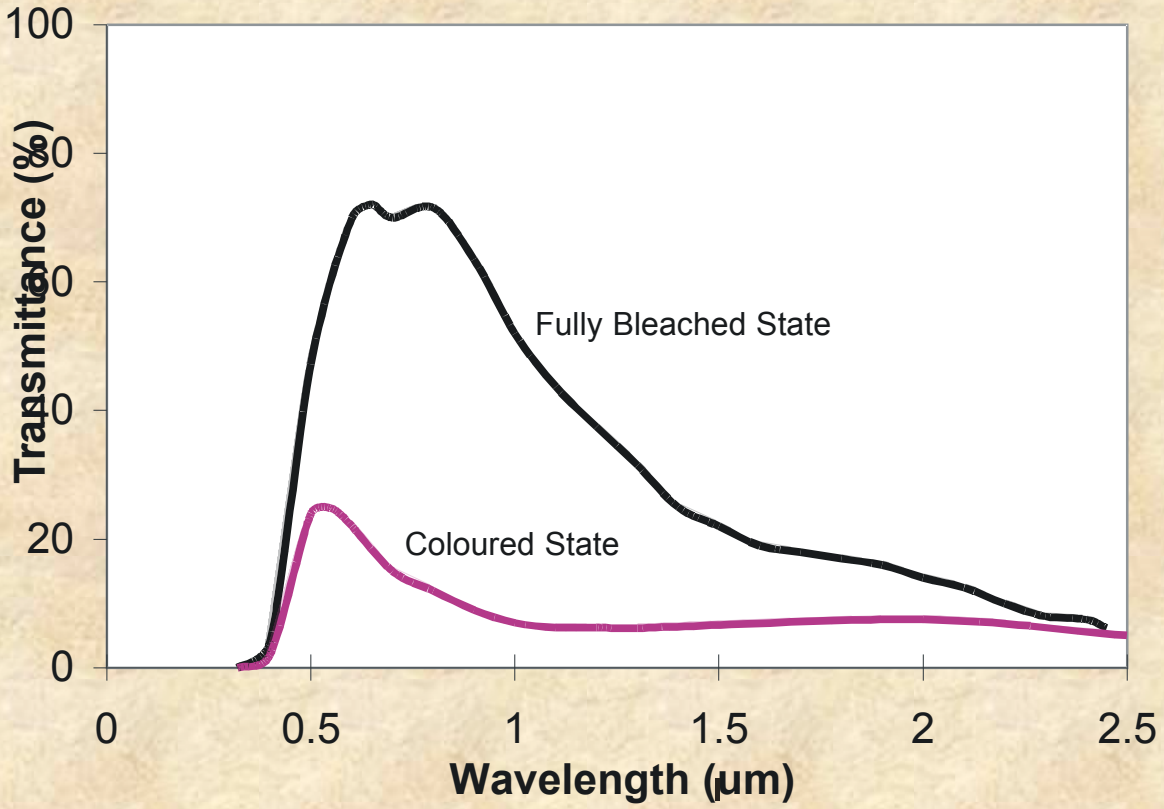


Laser-cut Panels

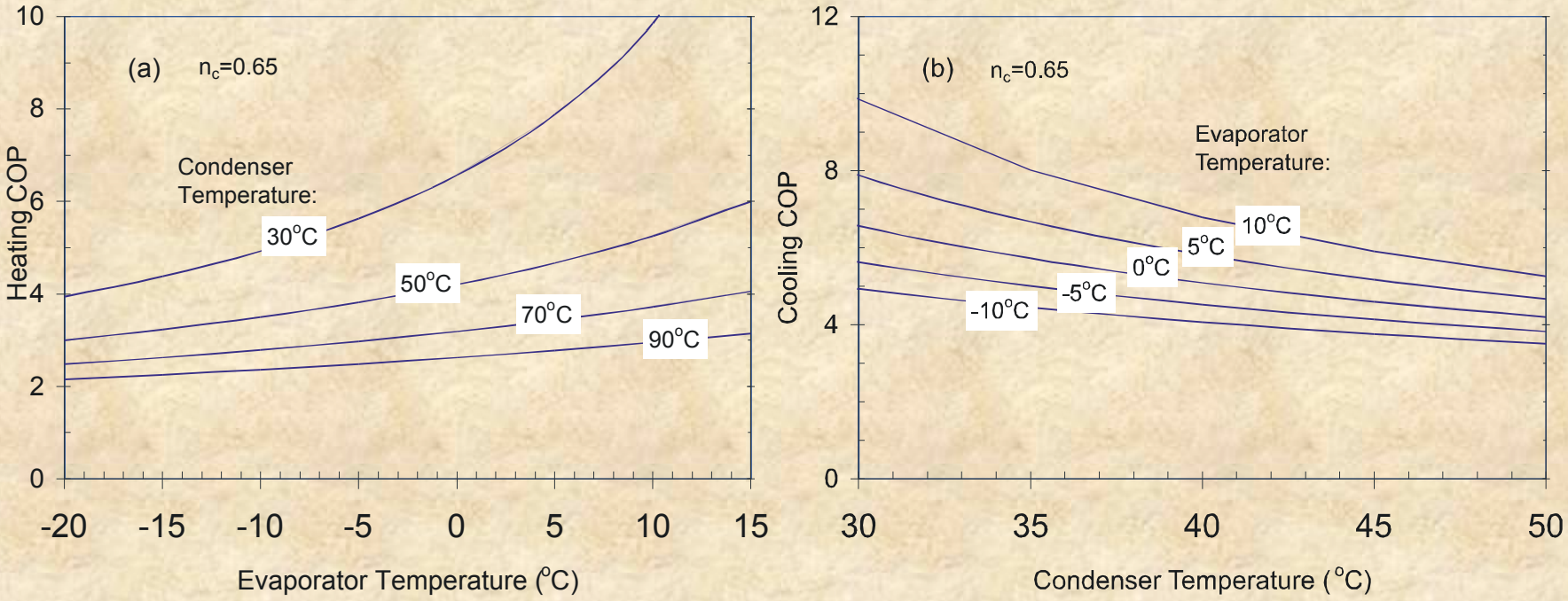




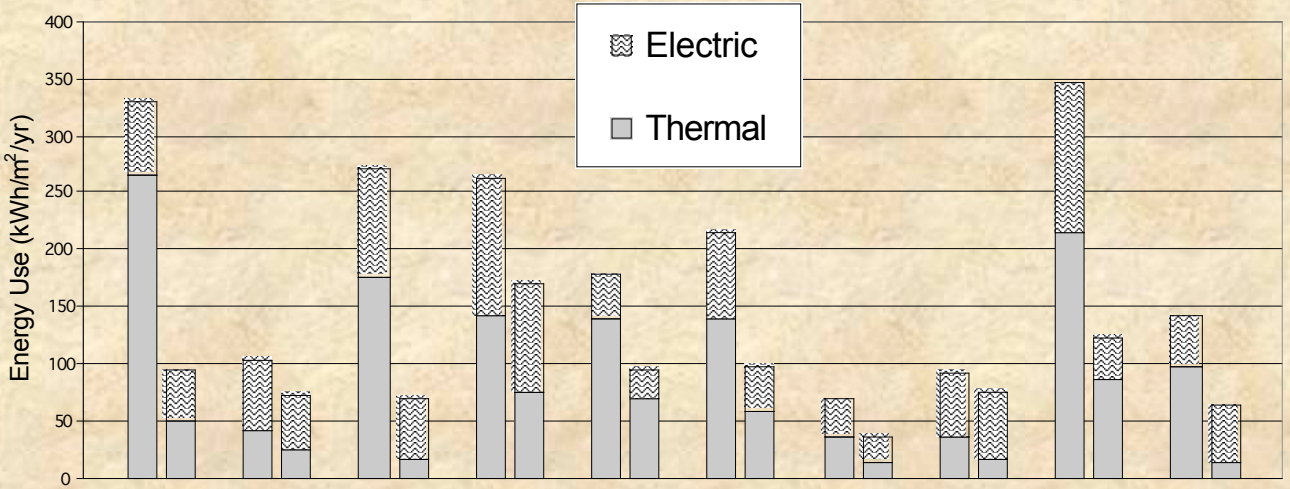
Electrochromatic Windows



Heat Pump Performance



European Office Retrofit Project



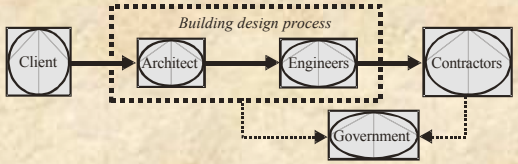
Country:	DN	SW	DE	NW	UK	CH	CH	IT	GR	FR
% Savings:	76	39	77	46	51	52	60	36	66	69

Apartment Retrofit Example: > 75% Savings in Primary Energy

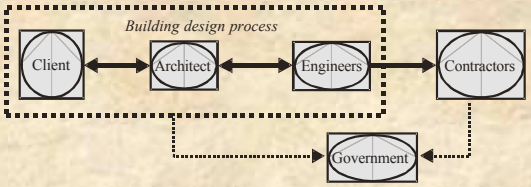
Table 14.1 Example of energy savings from retrofitting an apartment block in Switzerland. Given is energy use in units of MJ/m^2 per year. Source: Humm (2000).		
	Prior to retrofitting	After retrofitting
Conductive heat loss	473	216
Ventilation heat loss[a]	119	76[b]
Internal heat gain	114	108
Net heating requirement	478	184
Hot water requirement	108	100
Energy for space and hot water heating	**586**	**284**
Heating efficiency	0.85	3.2
Electricity demand		
Heat pump		89
Mechanical air circulation		6
Photovoltaic system (gain)		8
Secondary energy demand	690	87
Primary energy demand	**863**	**193**

Design Process

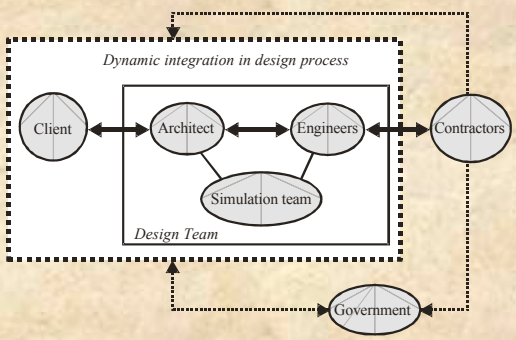
Level 1:



Level 2:



Level 3:



Summary:

- Much of the energy needs in buildings (lighting, ventilation, cooling, heating) can be achieved passively using solar energy and/or radiant techniques
- Buildings thus become the collectors and transformers of renewable energy
- Much of the remaining energy needs can be greatly reduced by putting together mechanical systems in a more intelligent fashion
- Device efficiencies tell us next to nothing about system efficiencies
- Improved design process alone can achieve savings of 50% in new buildings compared to common practice
- An integrated process combined with best (but currently available technologies) gives demonstrated savings of 75-90% in new buildings
- Retrofits that include solar features can often achieve savings of 40-75% in existing buildings