Designing for Resilience

Green Architecture Day: Health and Buildings

5th April 2014,

Sallis Benney Theatre, University of Brighton

www.brightonpermaculture.org

Professor Susan Roaf

Professor of Architectural Engineering at Heriot Watt University, Edinburgh,

Email: s.roaf@hw.ac.uk

What Does a Building Do?

How warm / cool does it have to keep you ?

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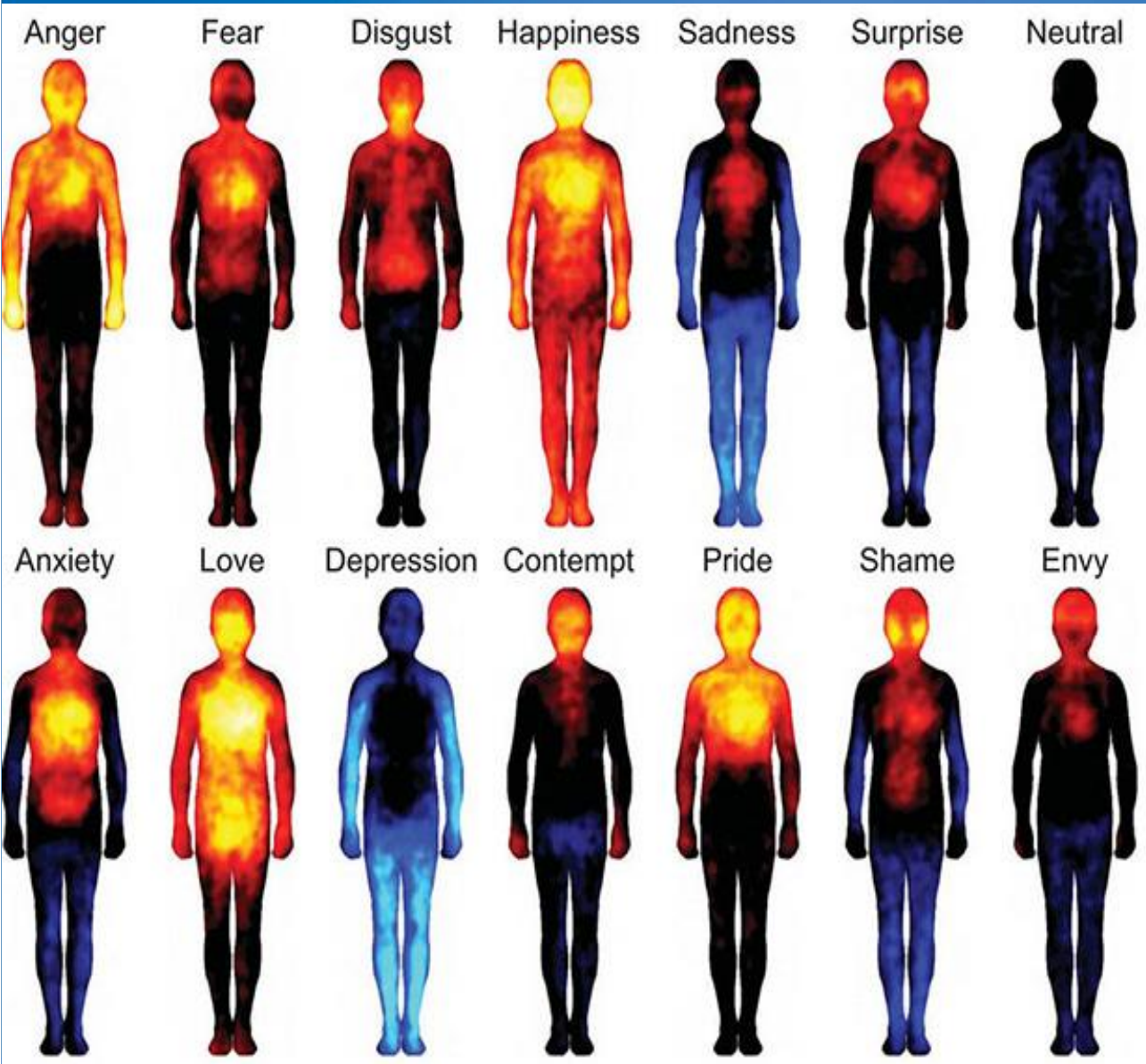
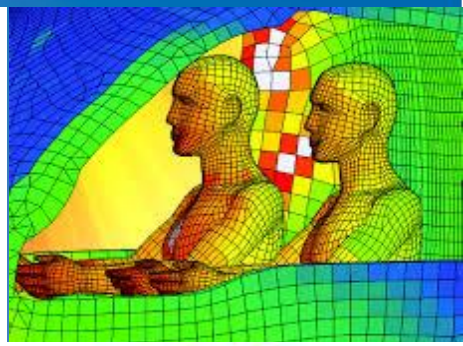
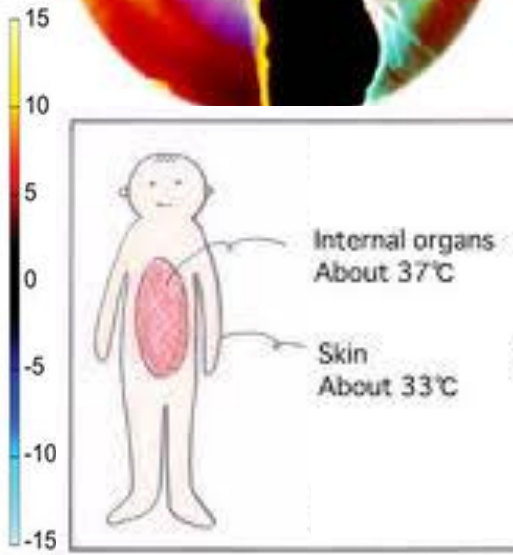






Mechanisms to keep body temperature constant at about 37°C

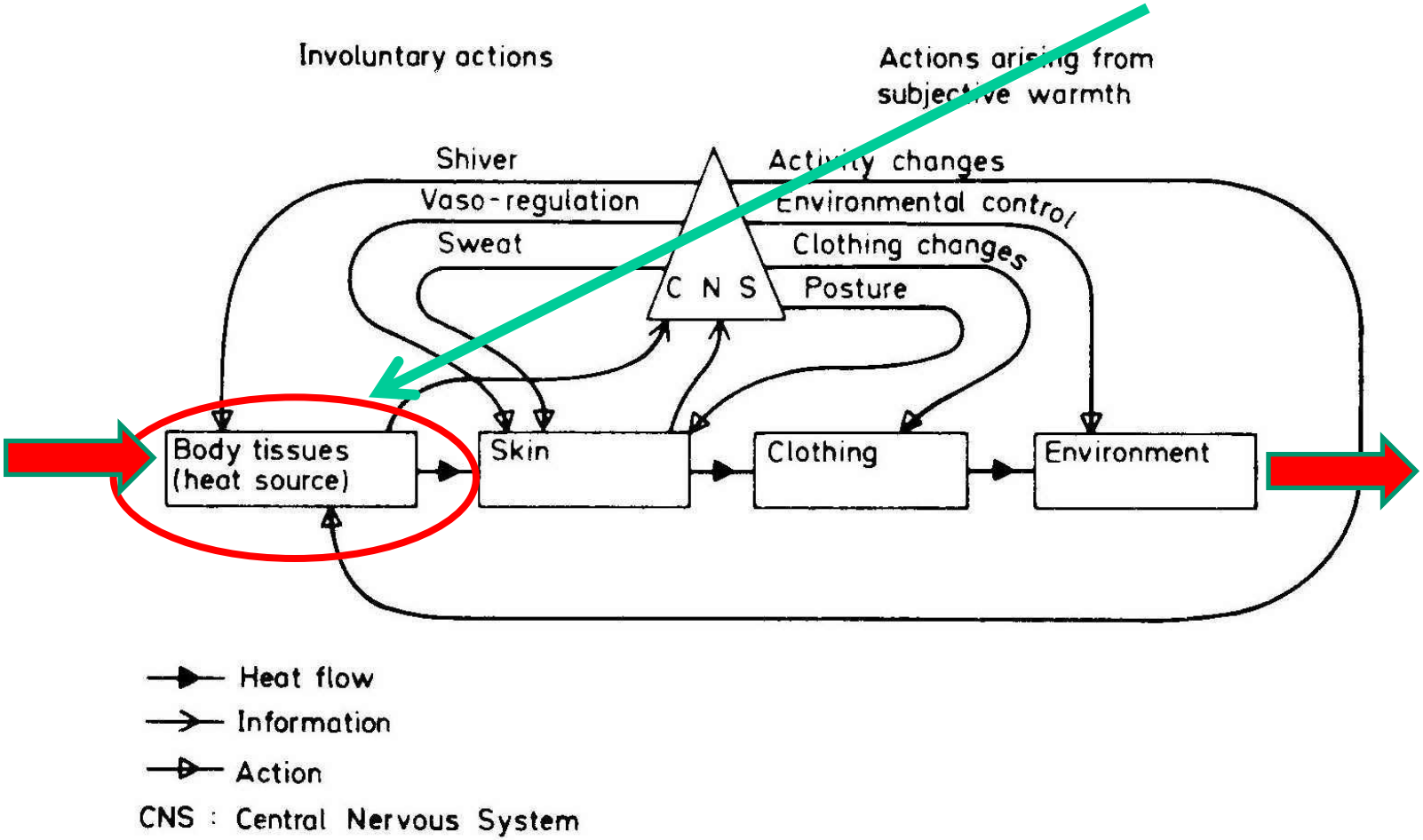


Figure 2. *The thermal regulatory system.*

Source: Nicol & Humphreys 1972

1) The physics

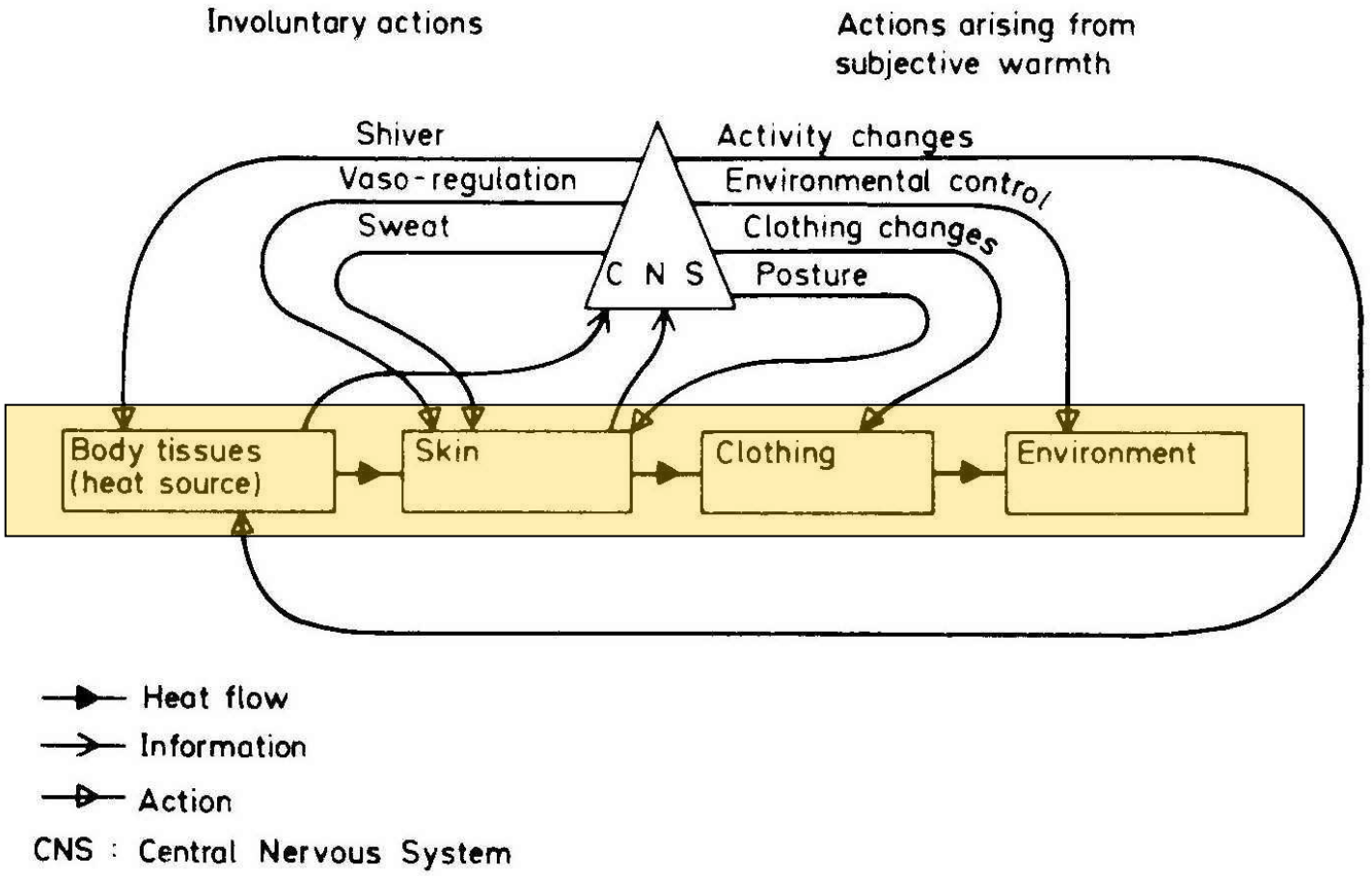


Figure 2. *The thermal regulatory system.*

2) The physiology

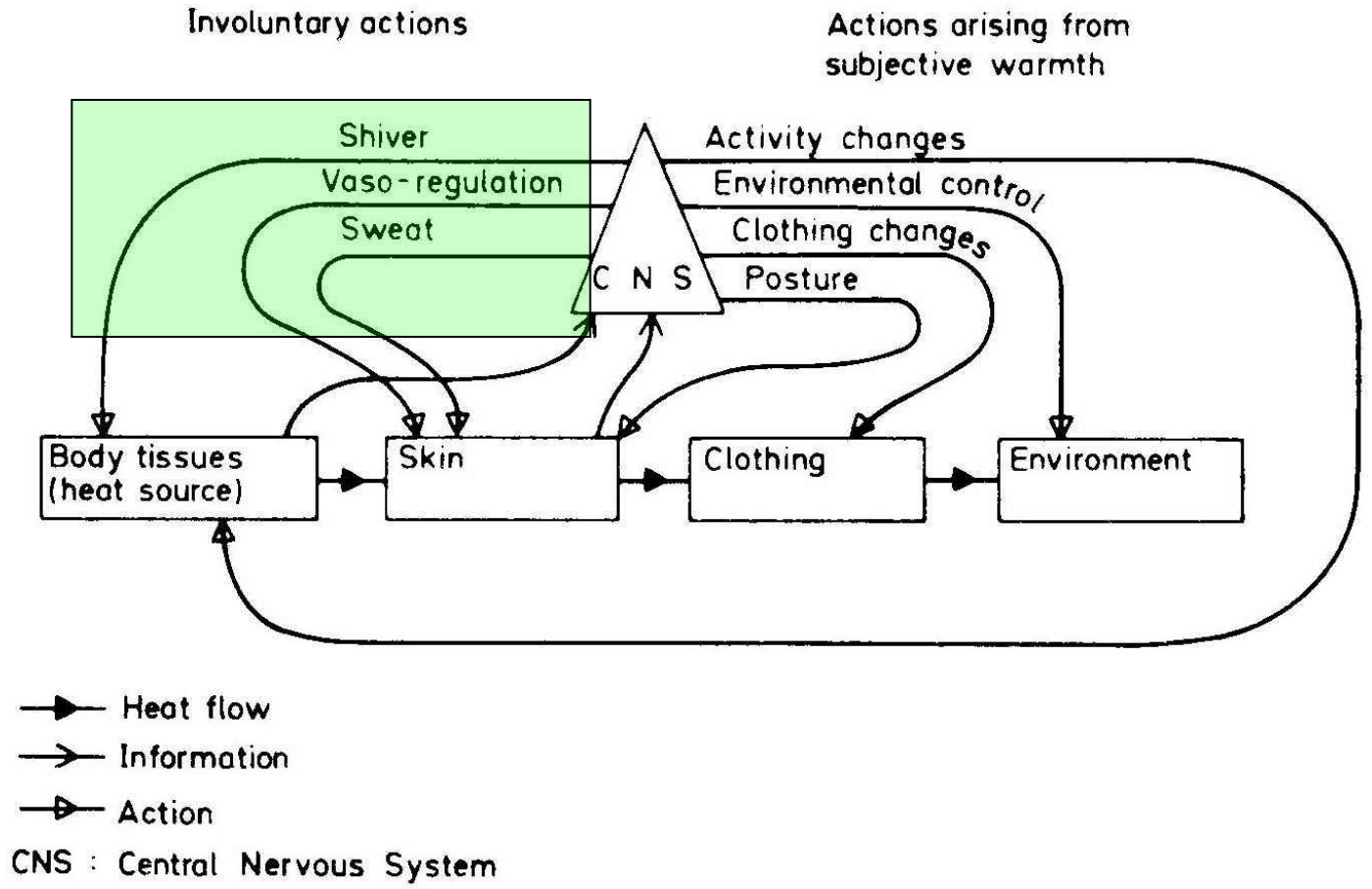


Figure 2. *The thermal regulatory system.*

3) Behaviour is also an essential component

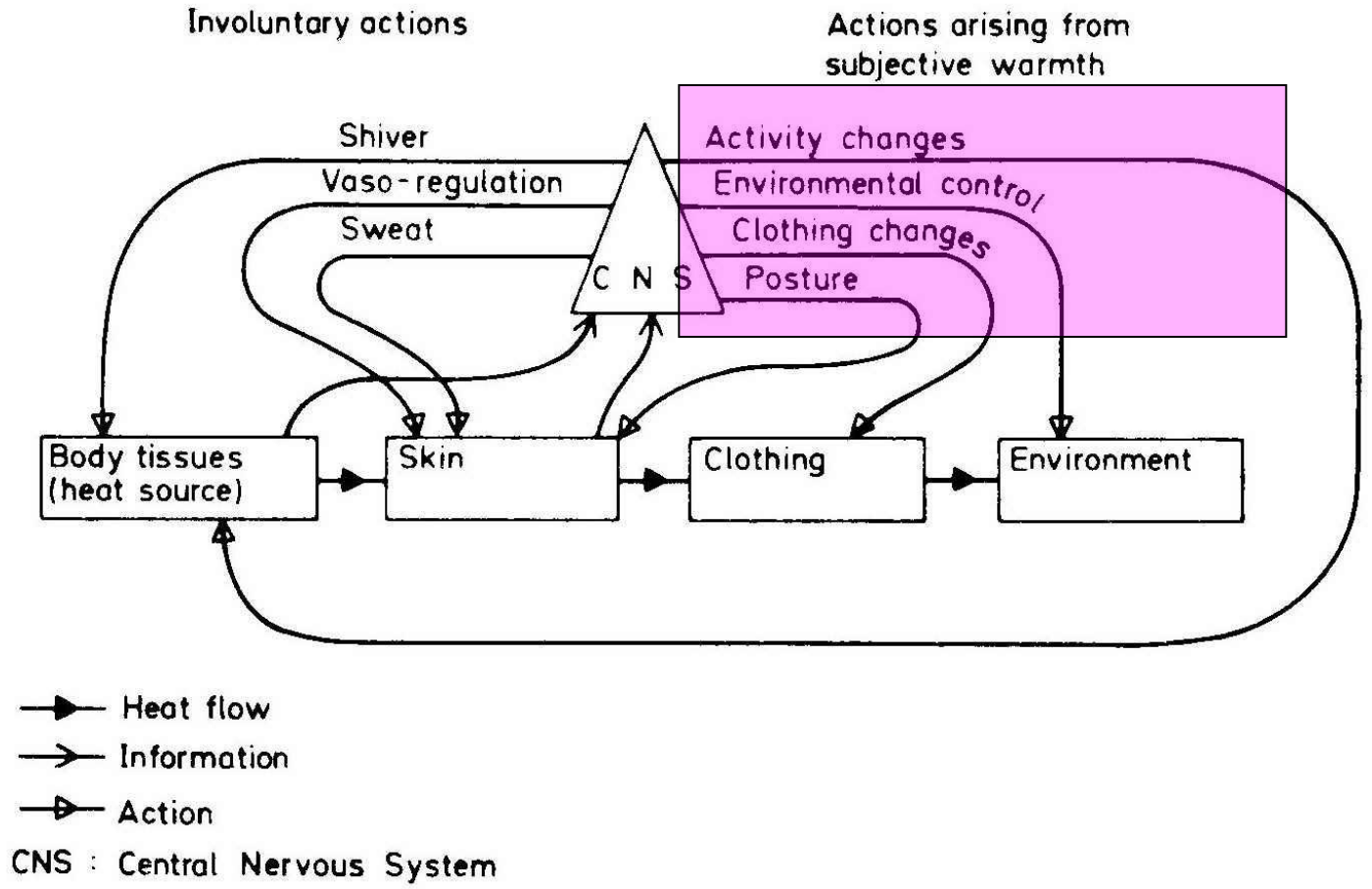
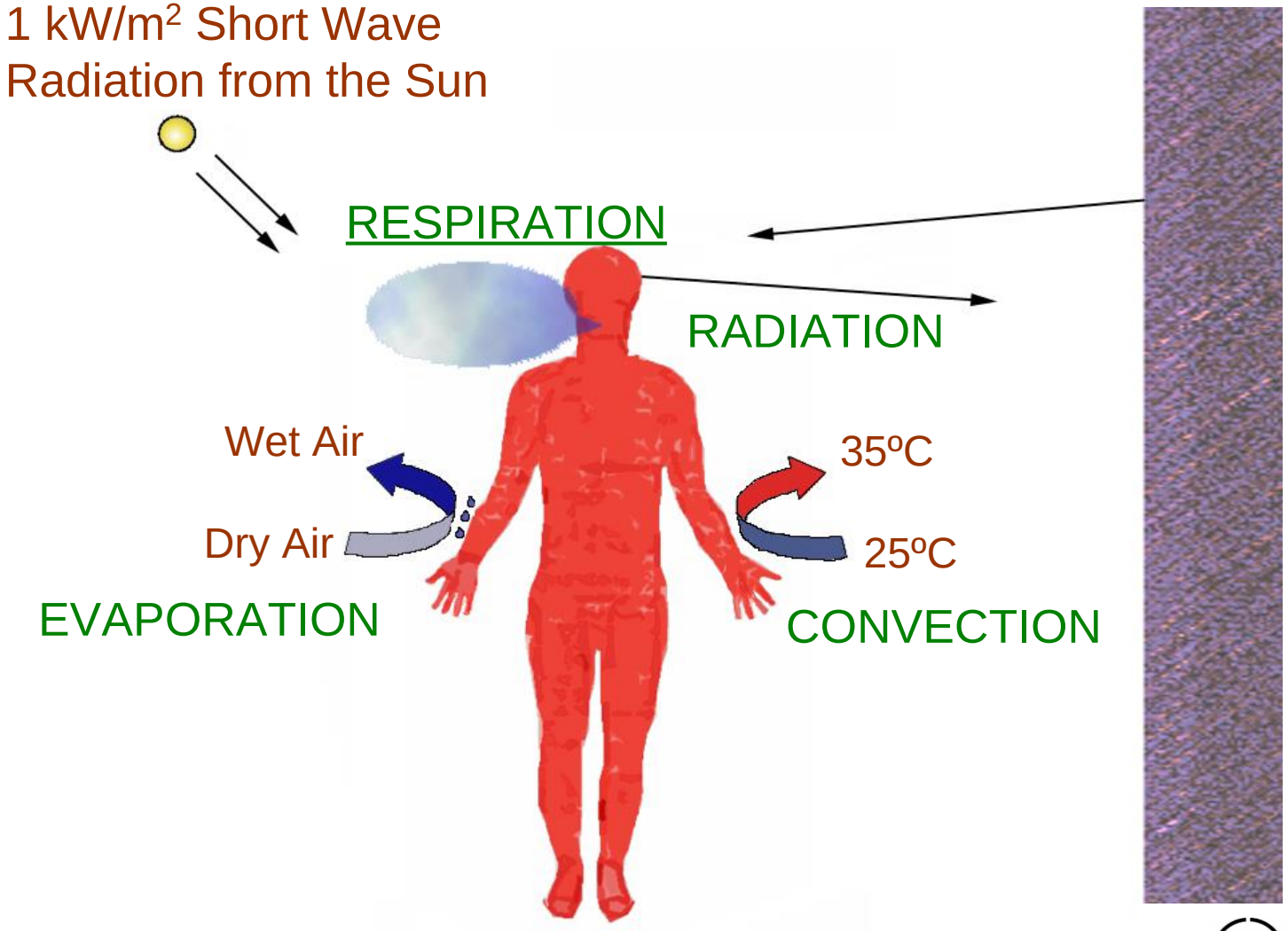


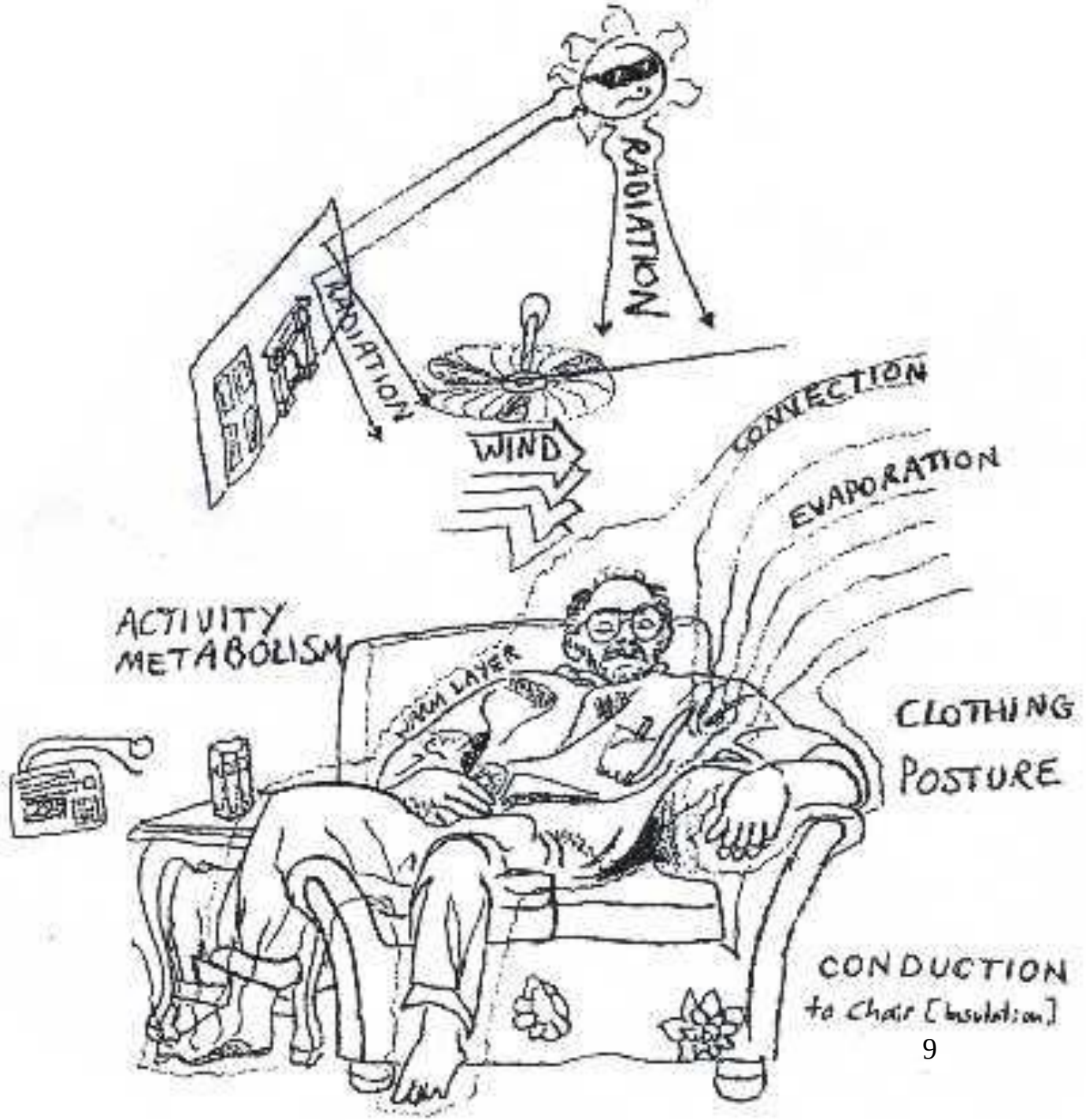
Figure 2. *The thermal regulatory system.*

Heat Exchange of the Body with the Environment



Courtesy Max Fordham

MFP



Picture: Sab Ventris

What is the function of a Tea Pot?

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?

What is the perfect temperature for tea?

Tea Pots: The Basic Principles

Milk in First to
Keep it hotter?

?

Tea Pots: The Basic Principles

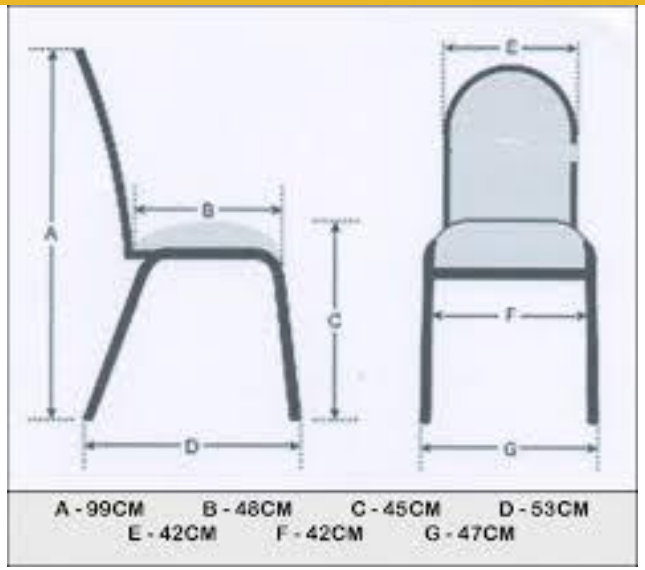
Delta Δ T

The difference between the Tea and the Air temperatures

MIF wins

Chairs: Theory and Practice

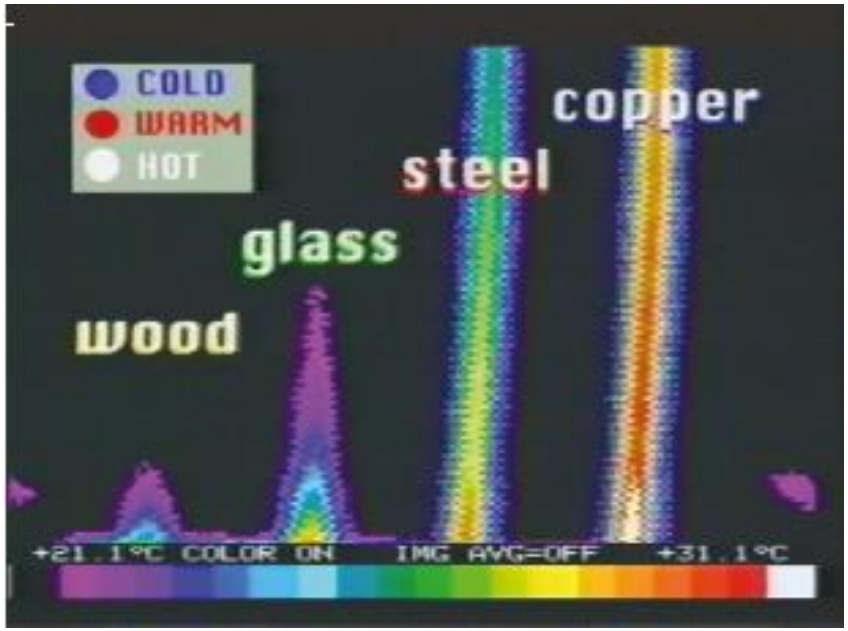
Which Chair is most thermally comfortable ?



Which Part of Your Chair is warmest ?

Chairs: Conduction

They all have the same surface temperatures
the materials conduct the heat away from your hand at different rates



The Rate of Heat Loss is Key

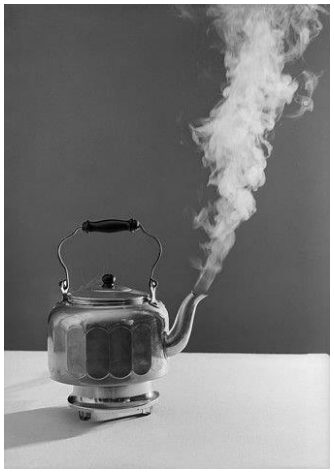
Overcoats for Chairs ?

Tea Pots: The Basic Principles

?

Which is the Best Tea Pot Material ?

What WORK does a Teapot do ?



TEA POT WORK

M **Moves** Hot **WATER** from Kettle to consumer and

A **Allows WATER** to be poured into a Cup but

S **Stops WATER** and **ENERGY** from escaping and

S **Stores** the Heat **ENERGY** till it is needed

Tea Pots: Radiation

?

How do you keep the tea in these glass pots hotter for longer ?

Tea Pots

Remove the cold bridge

?

Fill them up

Heat them
With a
candle

Insulate them

Tea Pots: The Basic Principles

?

How did they keep tea hot in a silver teapot hot ?

Tea Pots: The Basic Principles

Regularly top it up
From a heated
Samovar

Make the whole
Pot heavier and
Warm the pot first

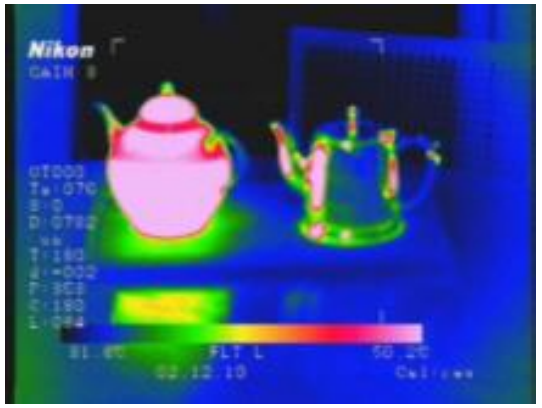
Heat it constantly
Over a flame

Place an insulating
tray beneath it

Tea Pots: Emissivity

Surface Material	Emissivity Coefficient - ε -	Surface Material	Emissivity Coefficient - ε -
Black Body Matt	1.00	Iron polished	0.14 - 0.38
Black Enamel Paint	0.80	Marble White	0.95
Cast Iron, turned and heated	0.60 - 0.70	Mild Steel	0.20 - 0.32
Concrete	0.85	Porcelain, glazed	0.92
Concrete, rough	0.94	Silver Polished	0.02 - 0.03
Concrete tiles	0.63	Stainless Steel, polished	0.075
Copper Polished	0.023 - 0.052	Water	0.95 - 0.963
Glass smooth	0.92 - 0.94	Wood Beech, planned	0.935
Glass, pyrex	0.85 - 0.95	Wood Oak, planned	0.885
Ice rough	0.985	Wood, Pine	0.95

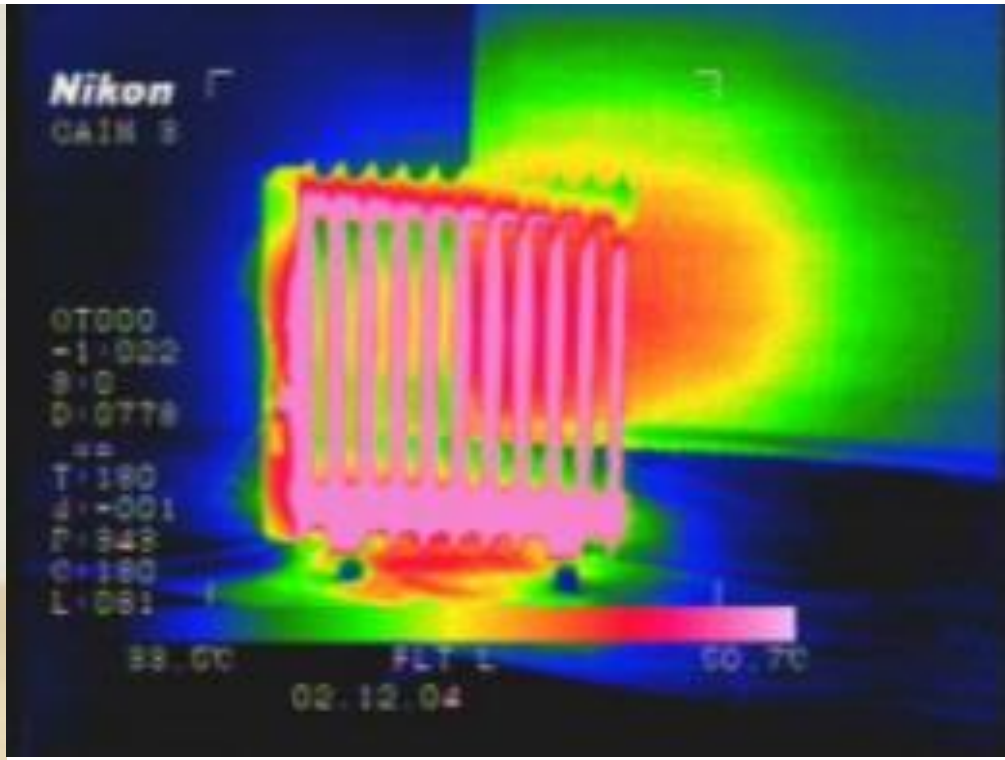
Tea Pots: Emissivity



http://www.ips-innovations.com/new_paints_ref.htm

EMISSSIVITY

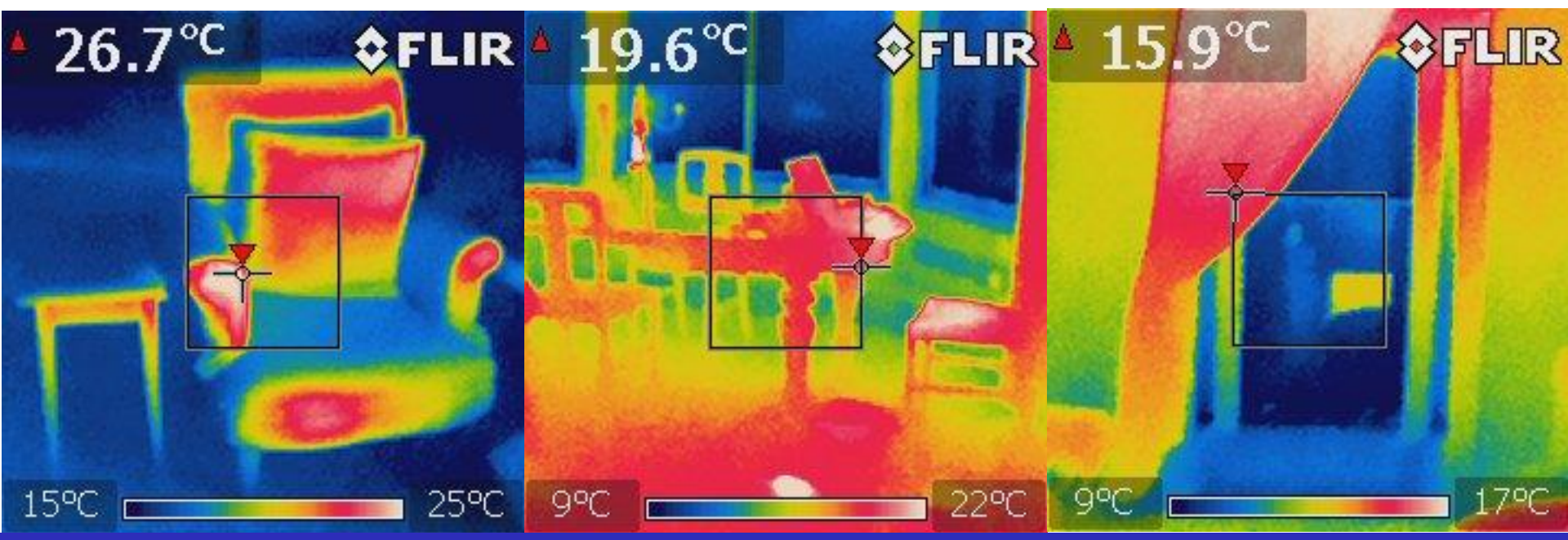
New Low Emissivity Wall Paints which keep the heat in the house during winter and keep it out in summer. The right side of the wall behind this heater is painted with a low-e wall paint, which reflects part of the heat back into the room before it is lost through the wall. In the winter a low-e wall paint on an inner wall decreases heat loss. In summer on an outer wall it reflects heat back into the environment saving energy. (www.sova-online.dewww.thermalin.de



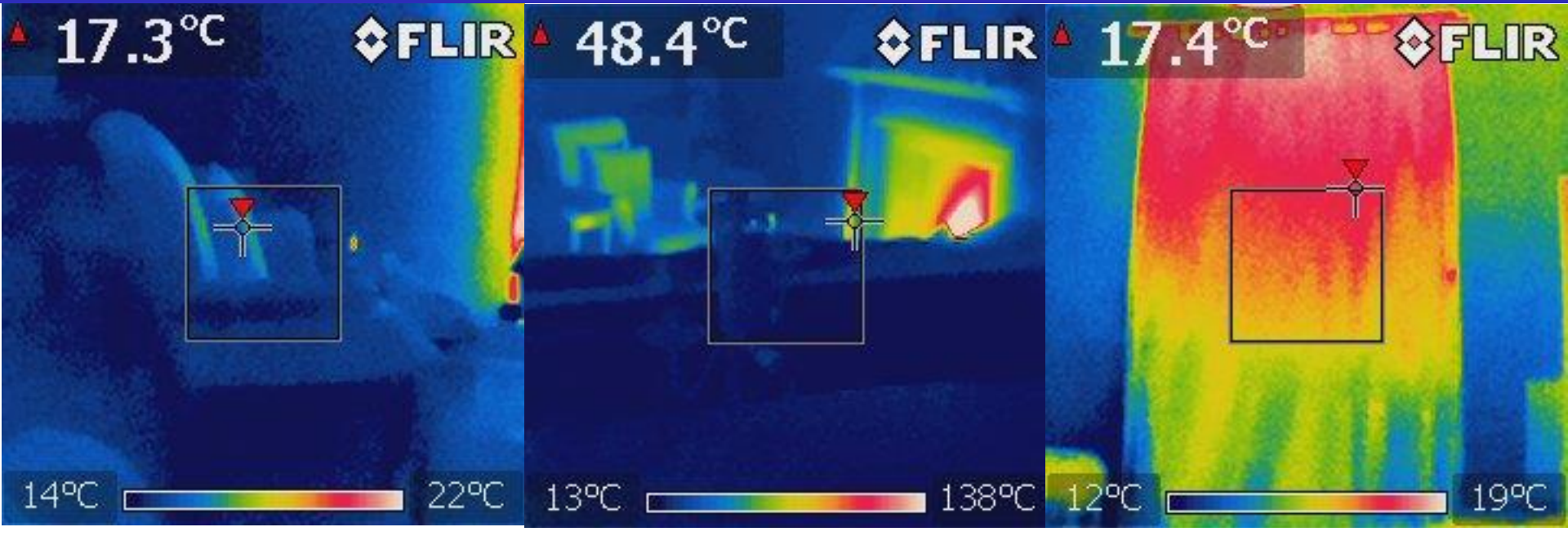
http://www.ips-innovations.com/new_paints_ref.htm

Story - Calorific Cascades – Dynamic Environments

Abra Kadabra ……

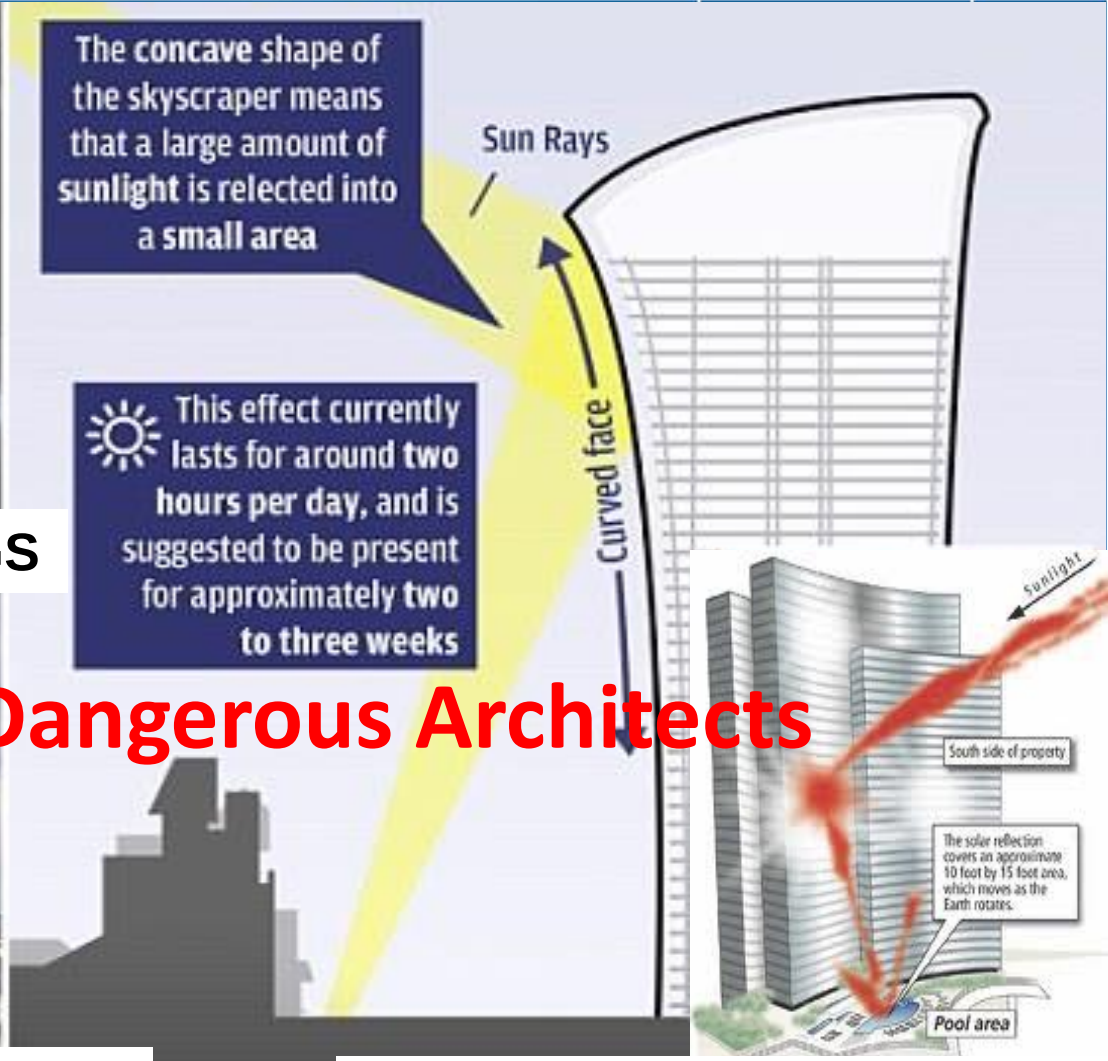


Complex Thermal Landscapes in Rooms



AVOID DANGEROUS BUILDINGS

London 2013The Cheese Grater



Avoid Dangerous Architects

Vedara Hotel Las Vegas 2010

Tea Pots: The Basic Principles

So how do you keep tea hotter longer in a

ceramic tea pot

?

Best Form: Minimise the Surface Area

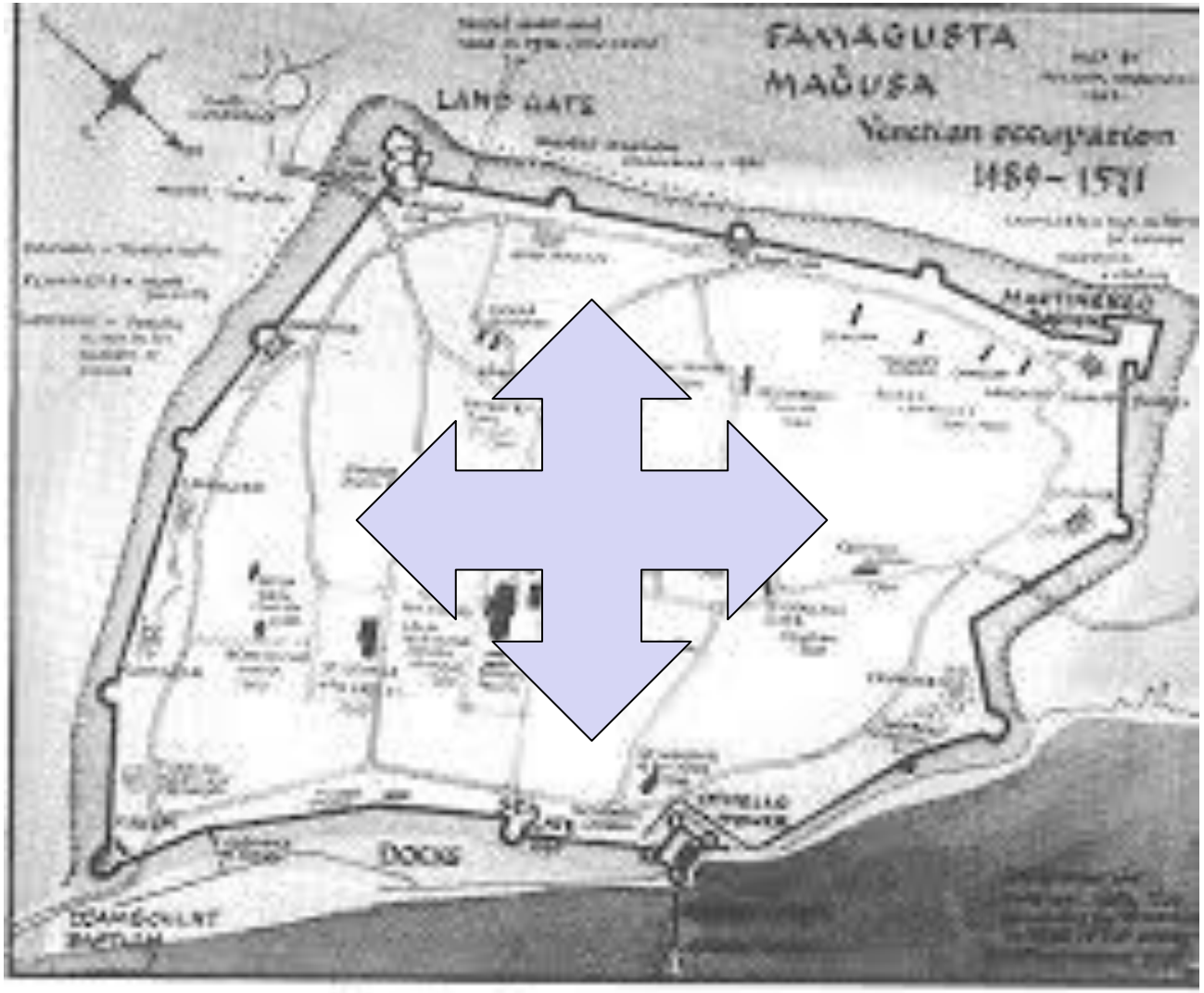
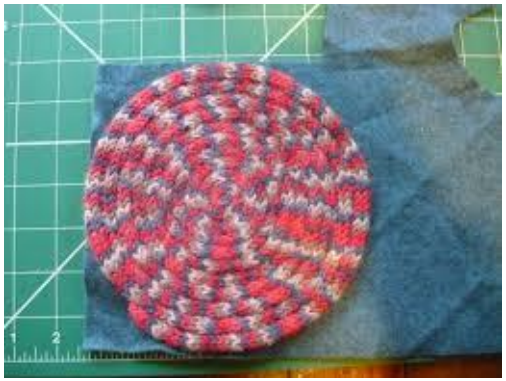


Fig. 1. Map of Famagusta within the walls.

Tea Pots: Insulation



Heat Pot first
Fill it up
Insulate it
Heat it

Tea Pots: Convection

?

Cold Bridging Problems ?

Maximising heat loss
From exposed surfaces ?

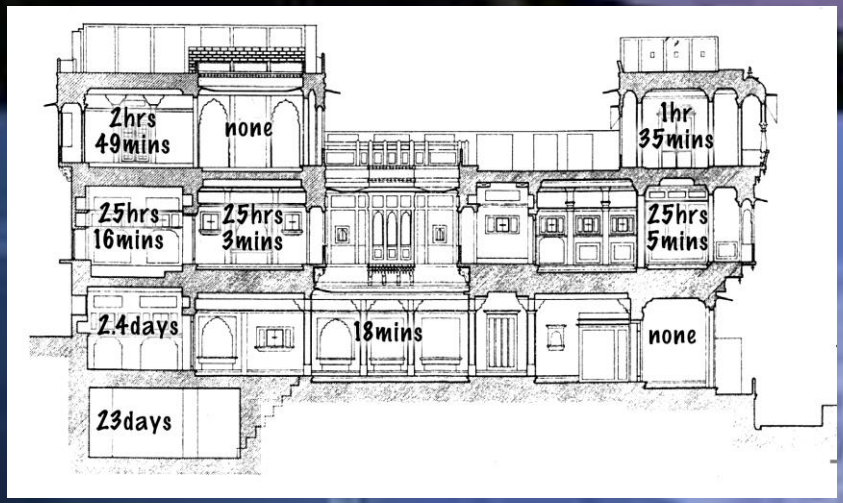
Tea Pots: Buildings

Meis - Glass and Metal

Traditional – cosy - sheltered

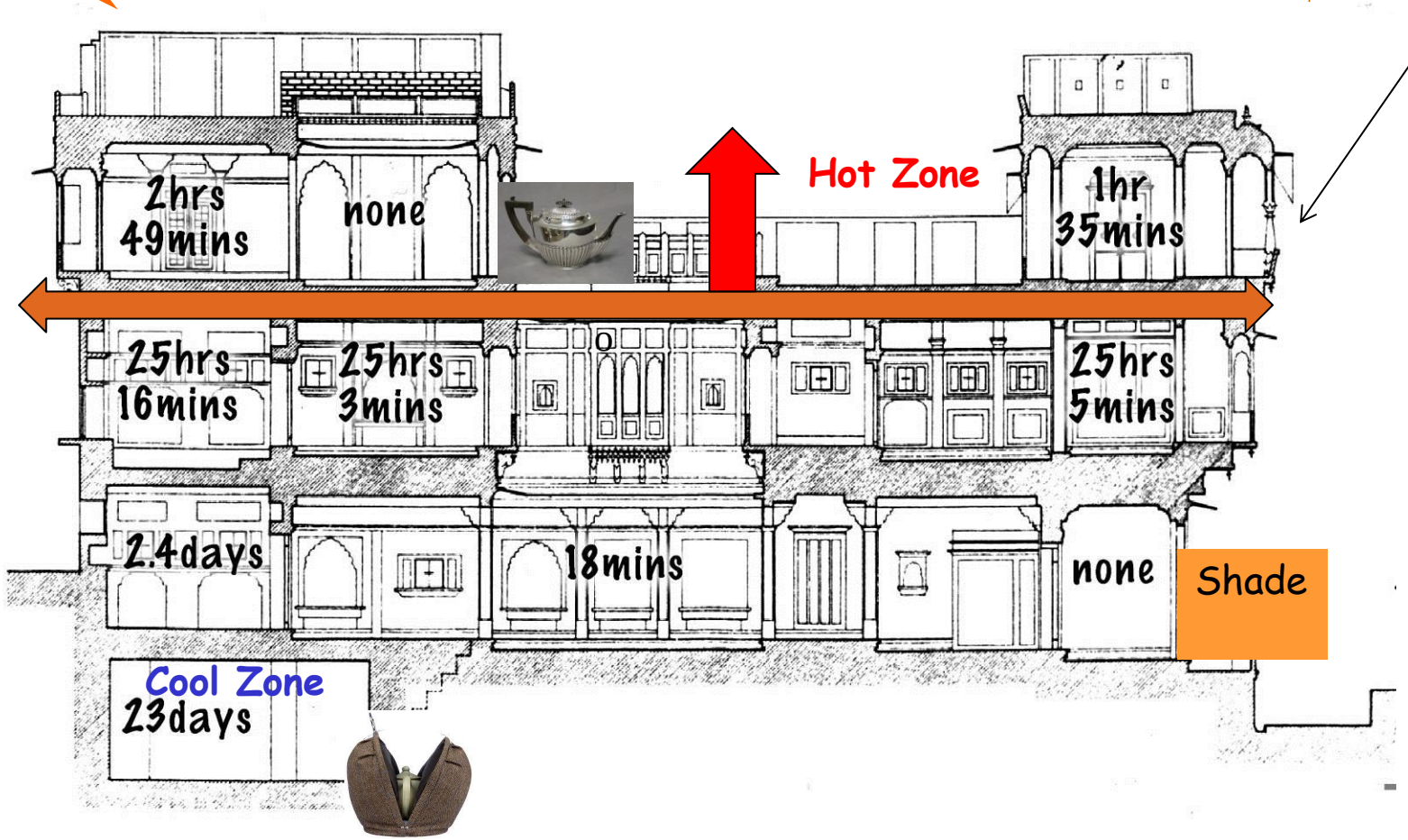
Corb – suspended Concrete

Different Pots for Different Climates ?



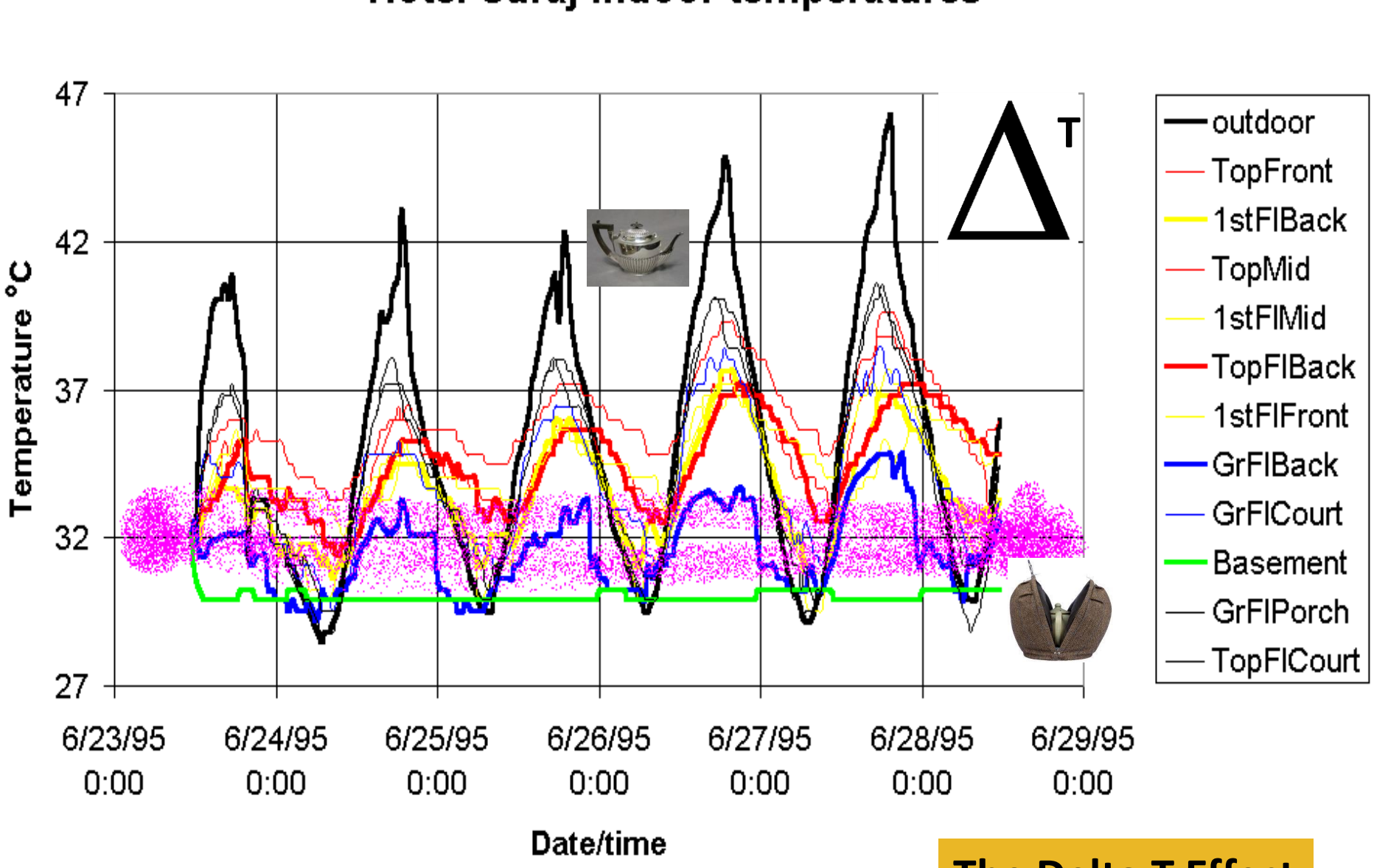
ΔT

Different Pots for Different Places ?



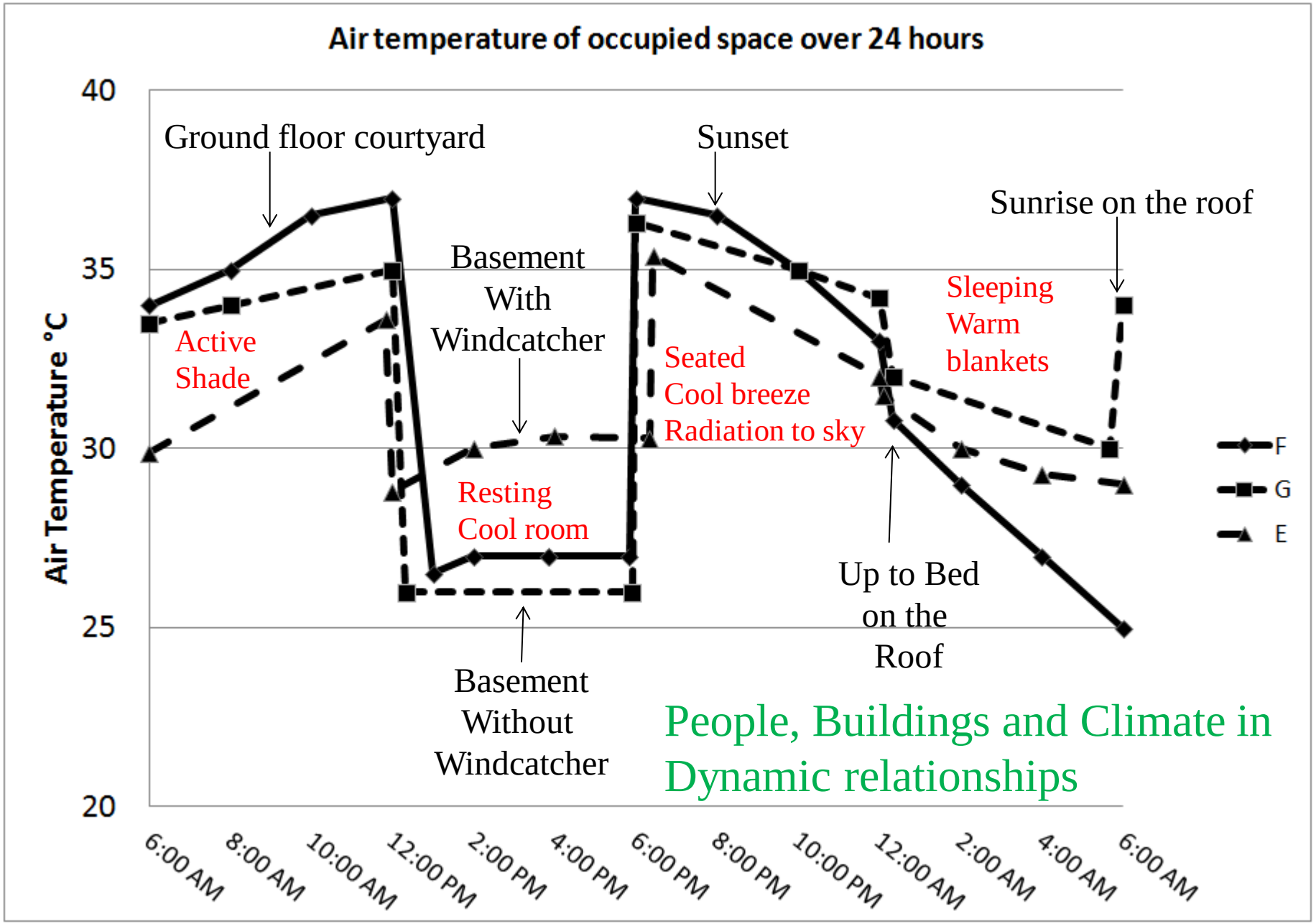
5°-10°C temperature differences found in different rooms in the same house

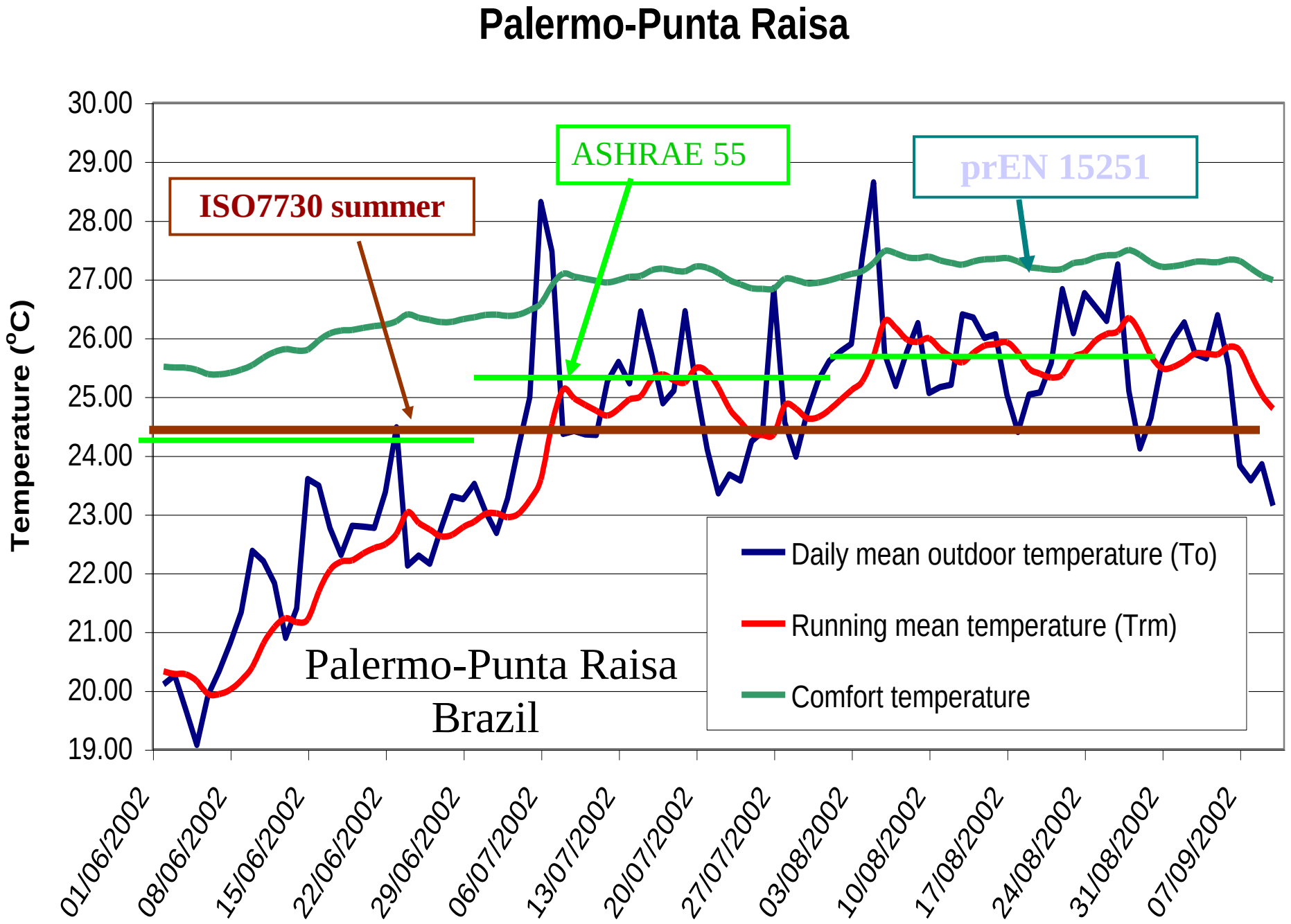
Source: Jane Matthews



The Delta T Effect

Understanding Time: 24 Hour Thermal Histories of Yazdi Housewives




Palermo-Punta Raisa
ISO7730 summer
ASHRAE 55
prEN 15251
Temperature (°C)
30.00
29.00
28.00
27.00
26.00
25.00
24.00
23.00
22.00
21.00
20.00
19.00
Daily mean outdoor temperature (To)
Running mean temperature (Trm)
Comfort temperature
Palermo-Punta Raisa
Brazil
01/06/2002
08/06/2002
15/06/2002
22/06/2002
29/06/2002
06/07/2002
13/07/2002
20/07/2002
27/07/2002
03/08/2002
10/08/2002
17/08/2002
24/08/2002
31/08/2002
07/09/2002

Different choices for season, places, people and occasions?

The snug

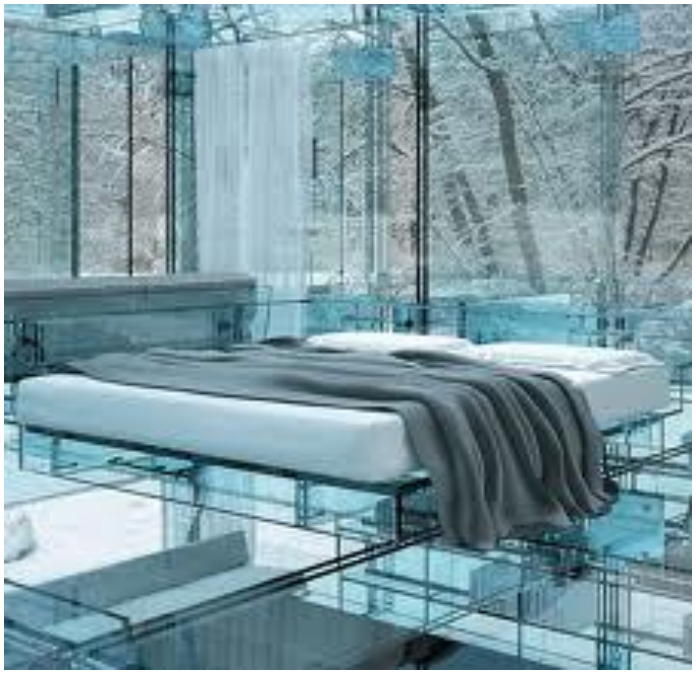
ΔT

Cold Kitchen

Warm Sunny Kitchen

The Veranda

We do need to train Architects to be part of the Solutions Not be the problem …..Fit for Purpose in a Changing World

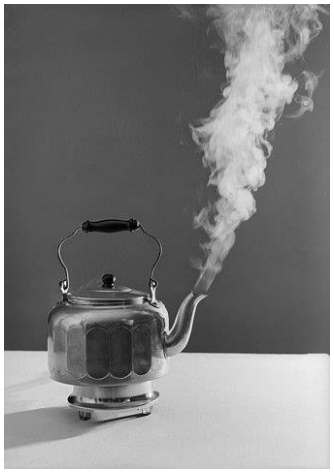


Which is the Best Tea Pot ?

Answer = It All Depends what Work it needs to do
And how many 'Adaptive Opportunities' are available

Can we adapt Teapot thinking for other Uses?

YES



BUILDING WORK

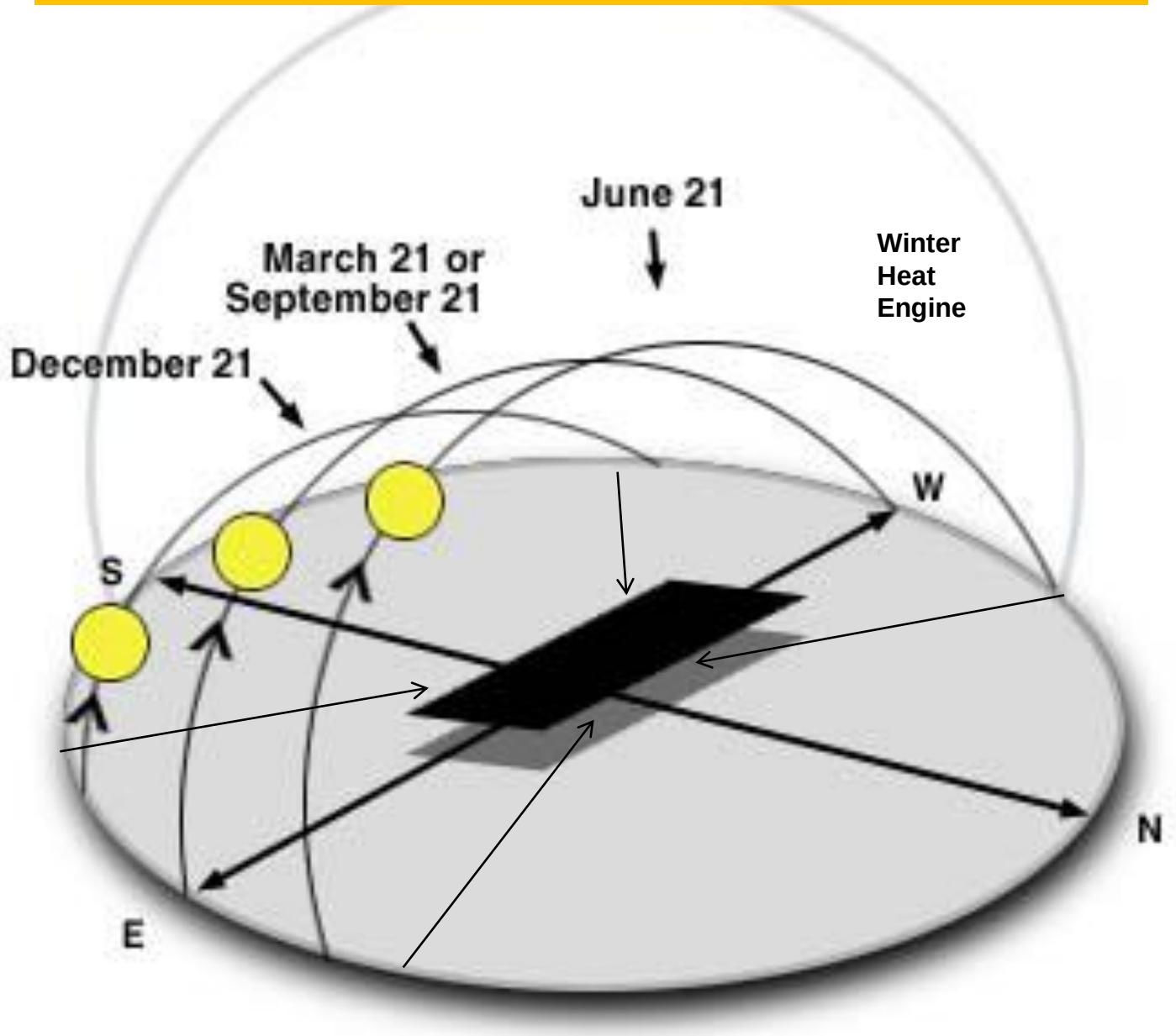
M **Moves HEAT or COOLTH** from where it is made to where it is needed

A

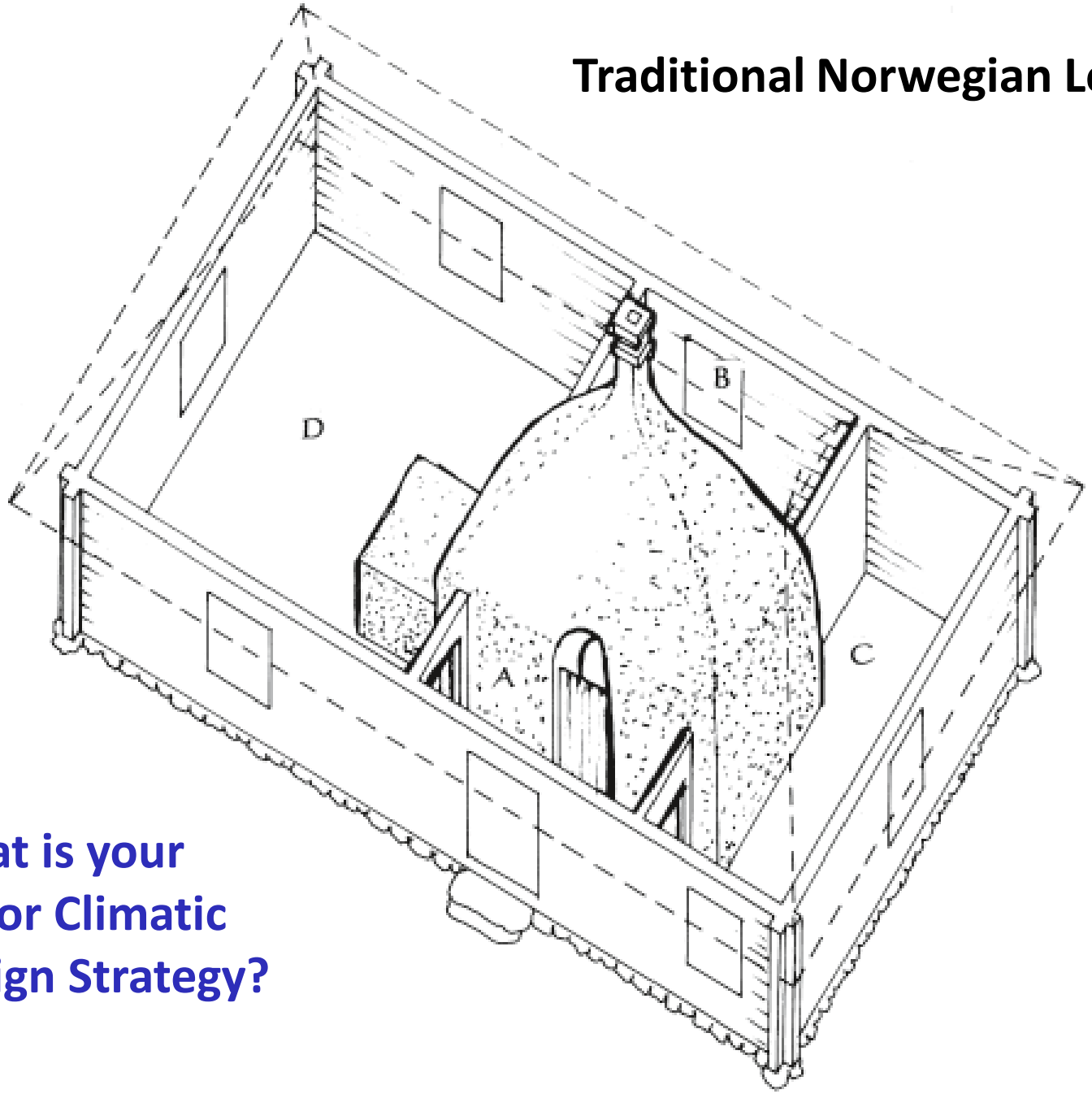
S **Stops HEAT OR COOLTH** from entering or escaping

S **Stores HEAT or COOLTH** till it is needed

1st Important Decision: Solar Orientation

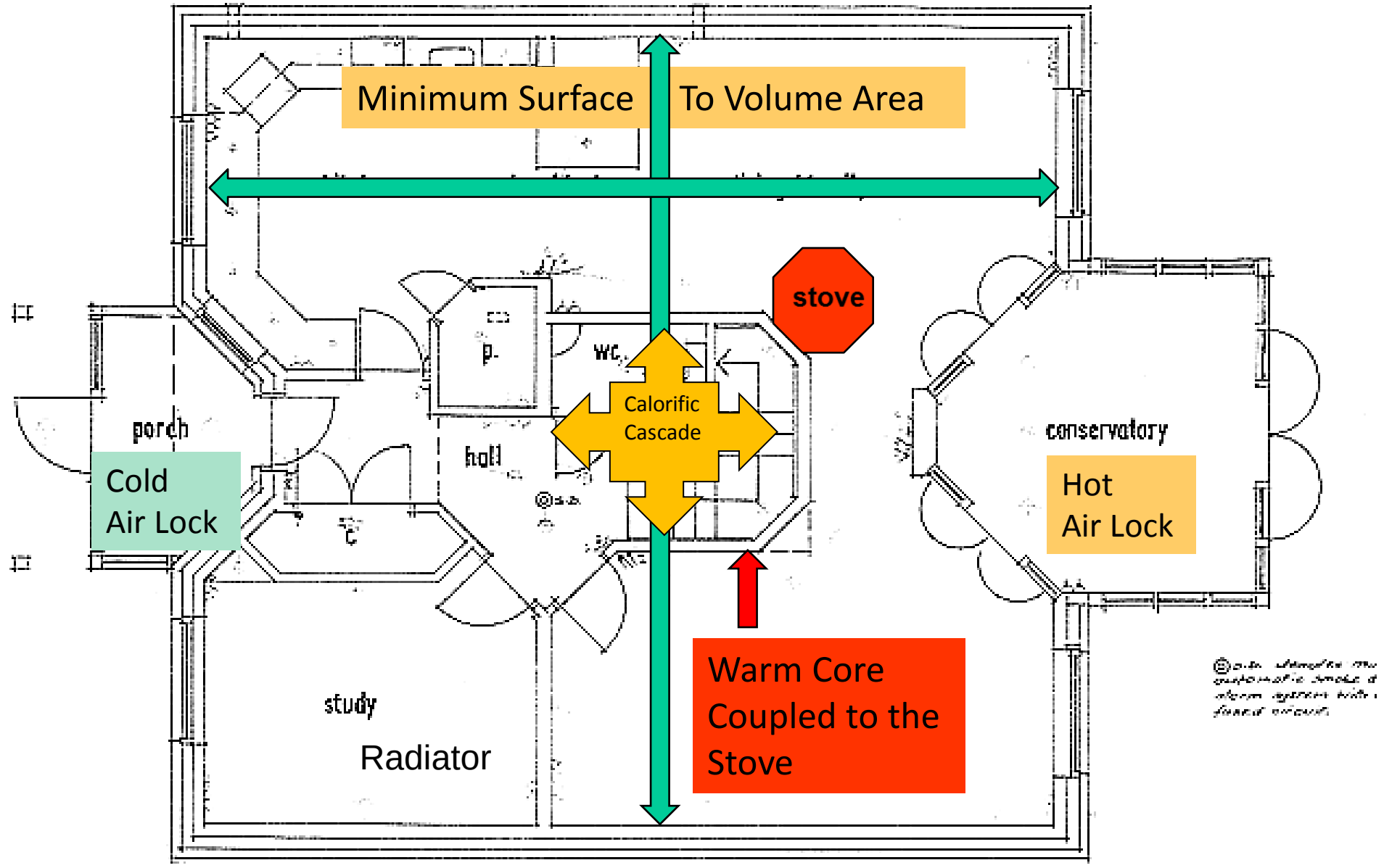


Traditional Norwegian Log House

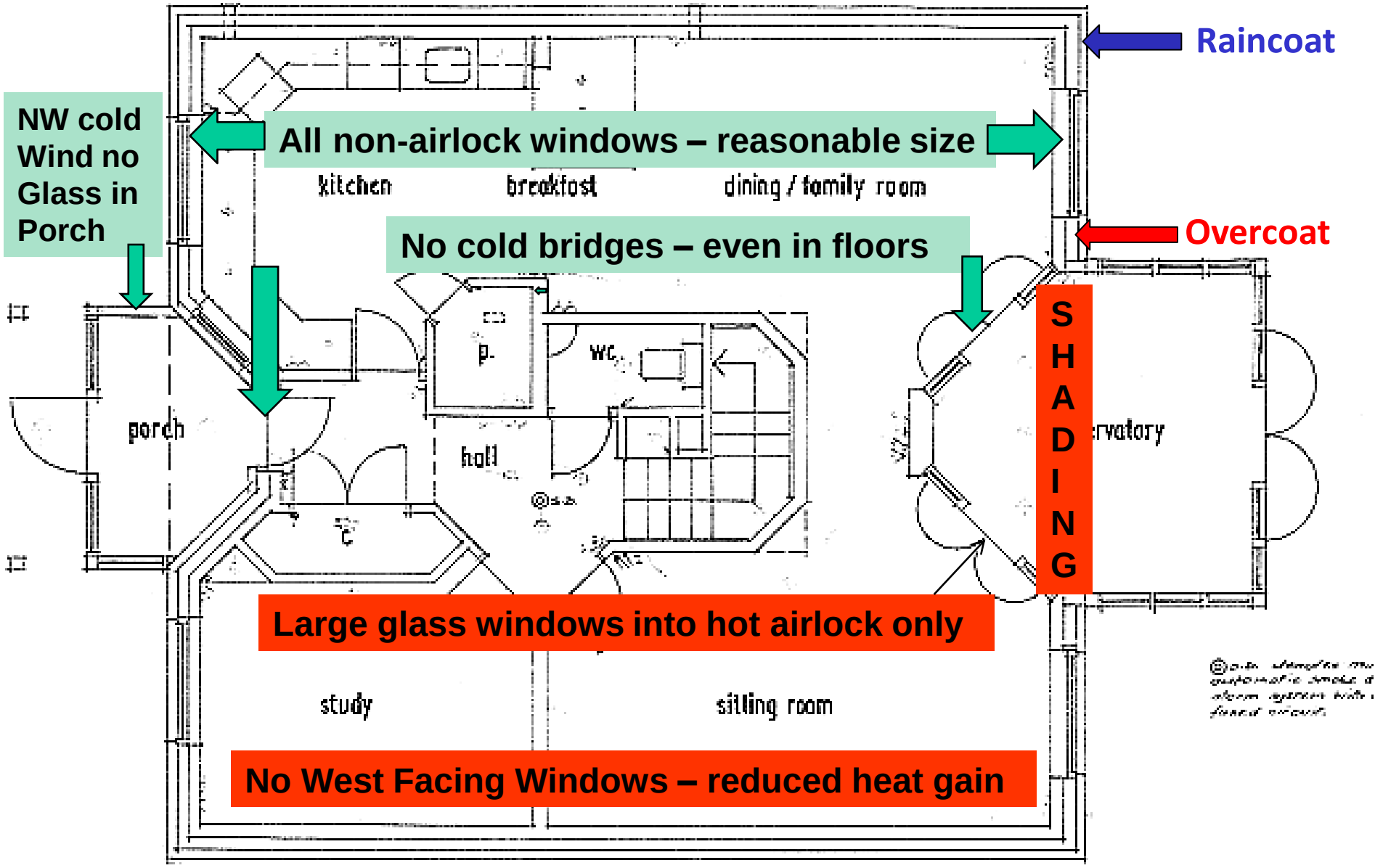


What is your Major Climatic Design Strategy?

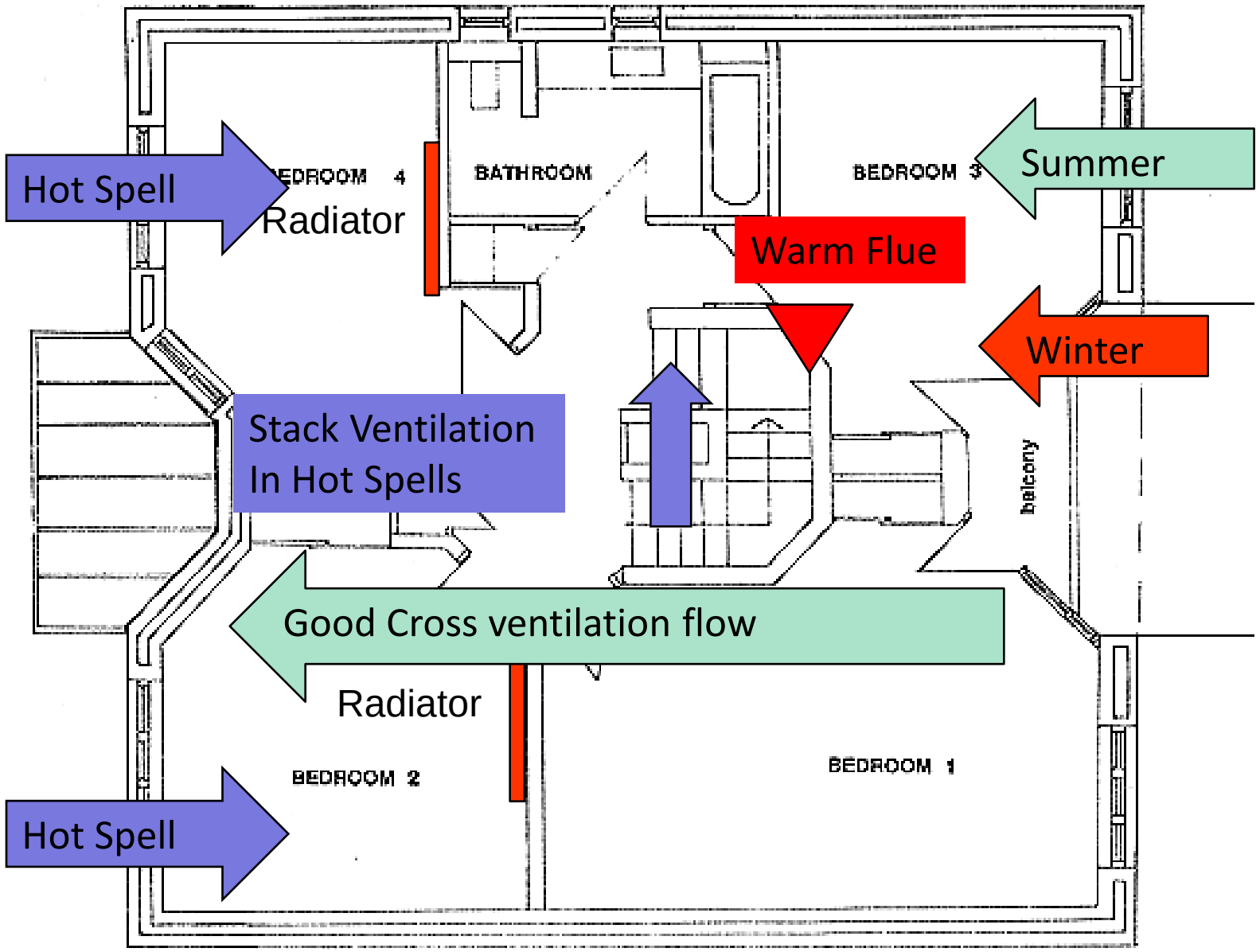
2nd Important Design Decision: Building Form



3rd Important Design Decision: Envelope Choices



4th Selective Cooling Ventilation Strategies




Opening Doors and Windows in mid-winter

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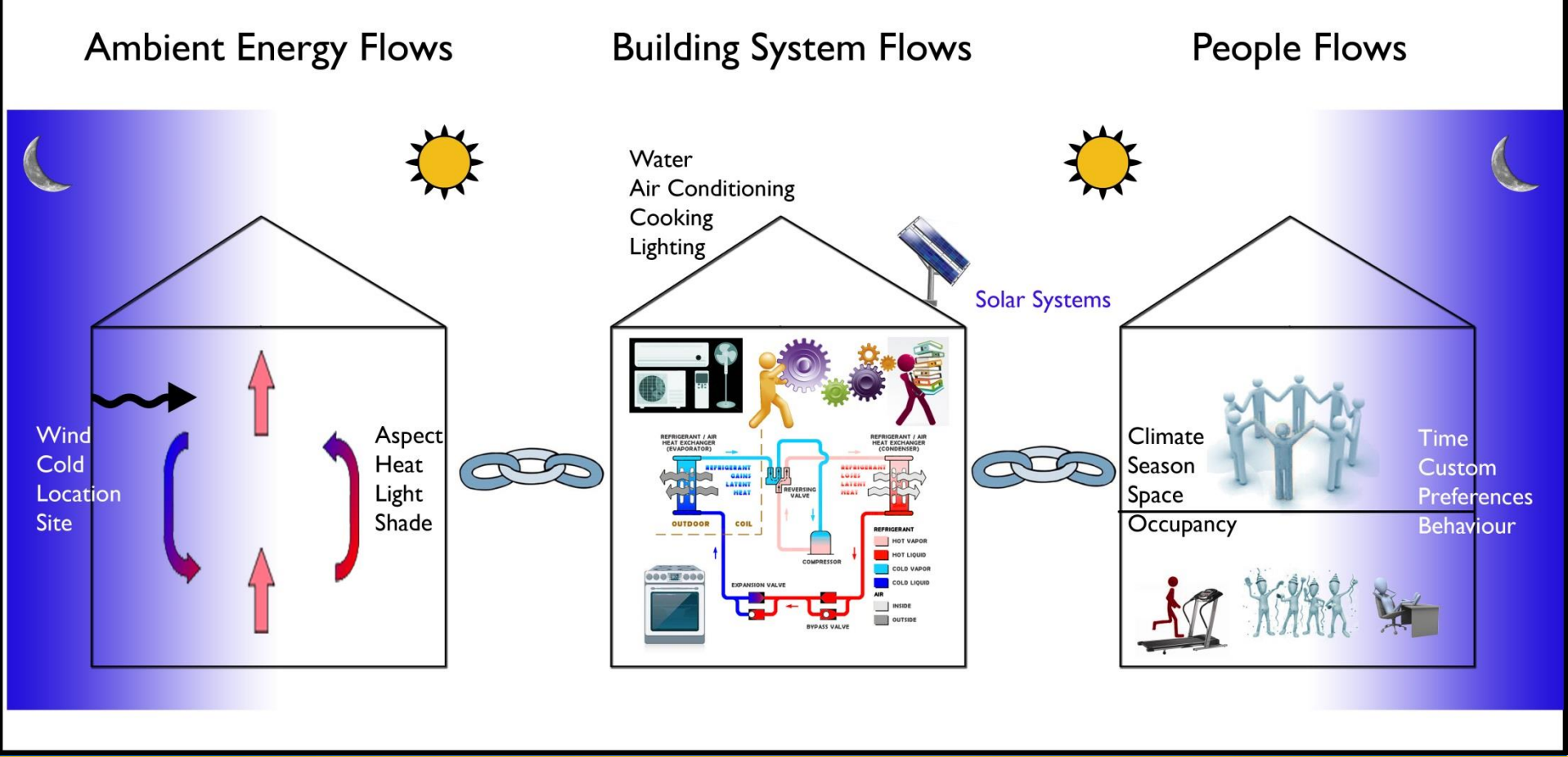
What Else Does a Building Do?

Much More than a Teapot



What sweeps through a building ?

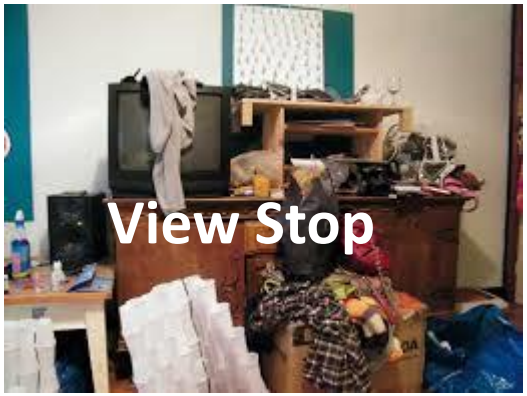
Sound	S
Water	W
Energy	E
People	P
Sight	S

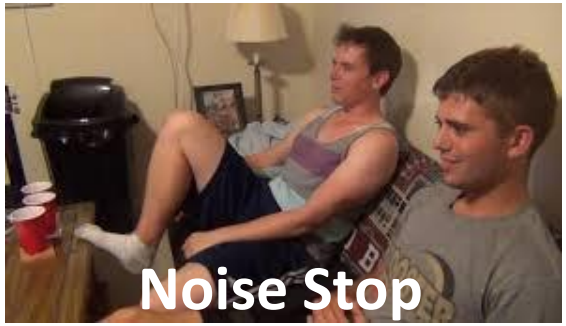
Raincoat

Overcoat

Water, Energy, Sight – Move / Allow / Stop / Store

Student Halls – Complex links through walls to Ecosystems

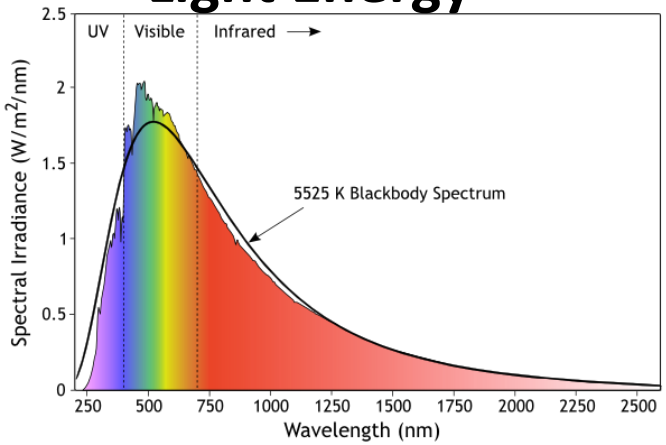


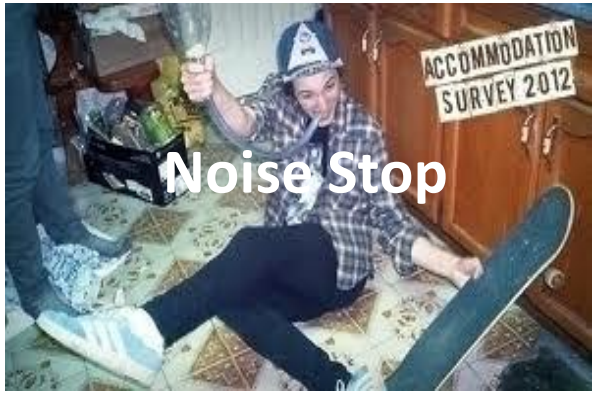


Light Energy

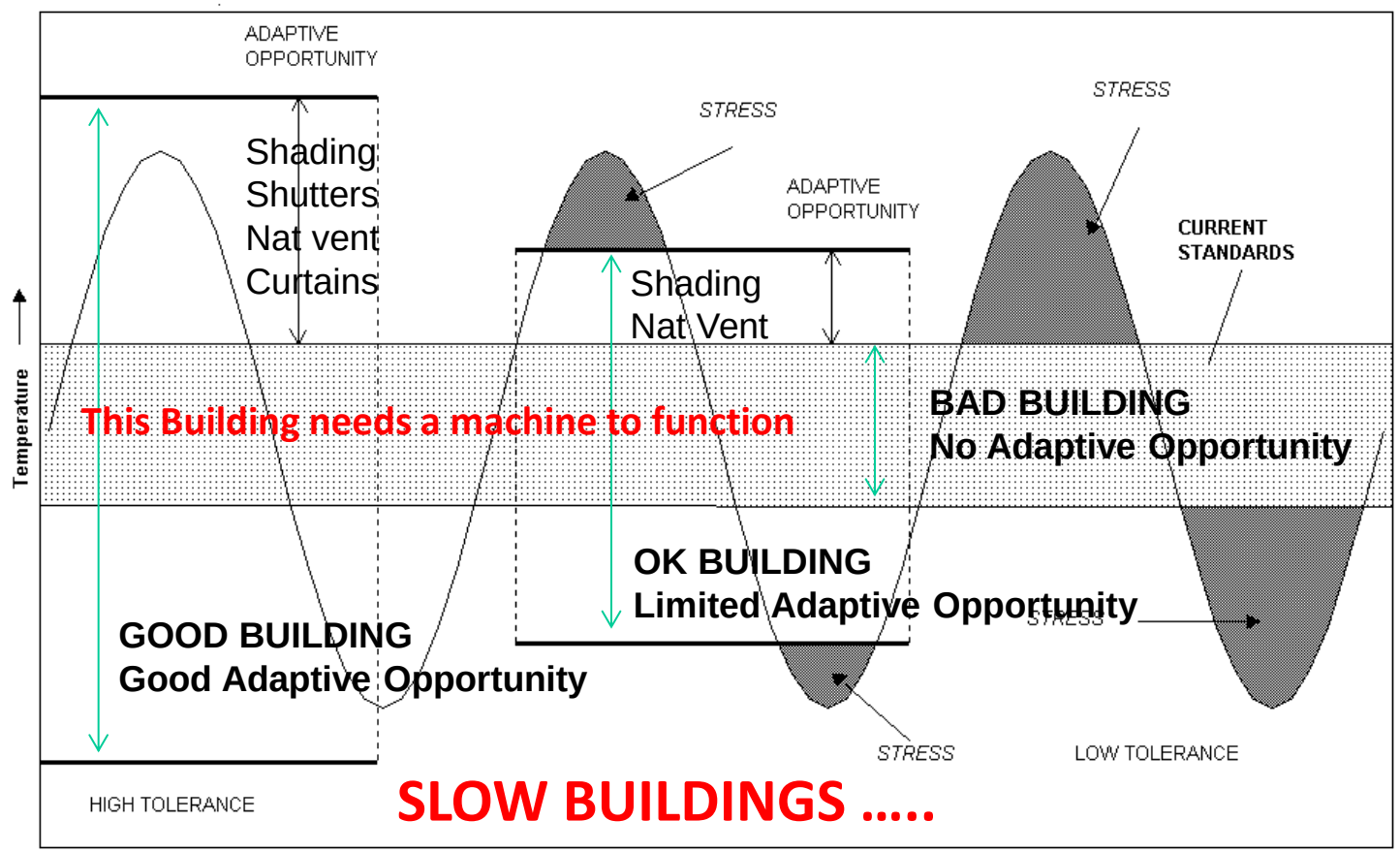
Sound

Sight



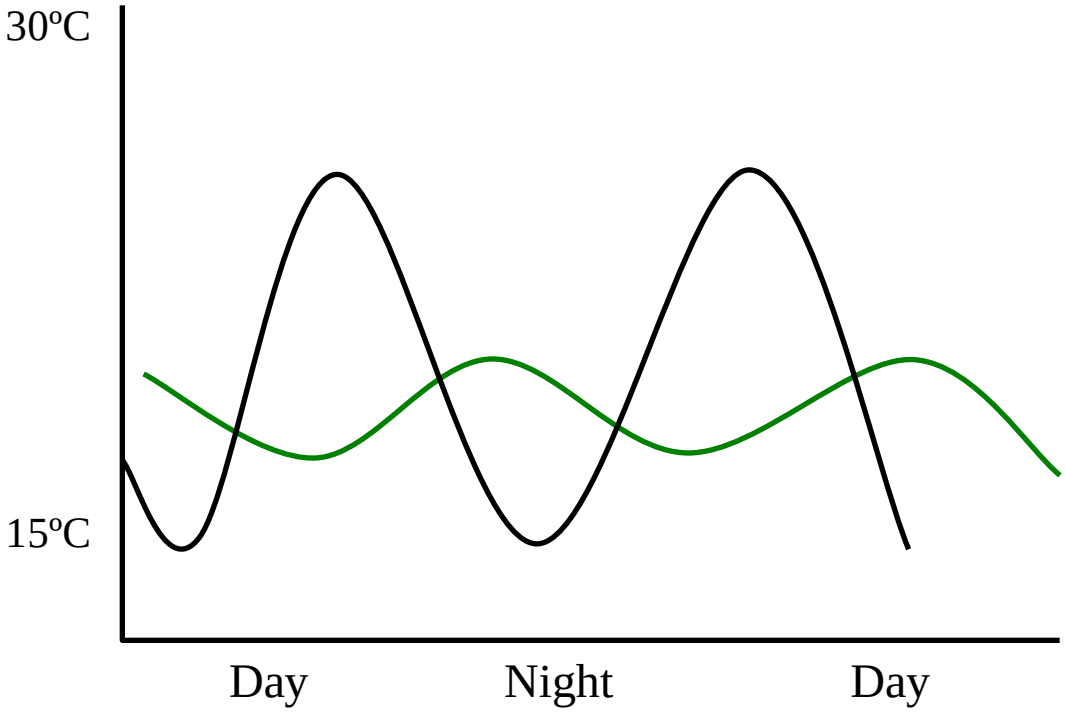


BUILDING FUNCTIONALITY: Adaptive Opportunity – using a wide range of Materials Dynamically Diurnally and Seasonally and Occasionally



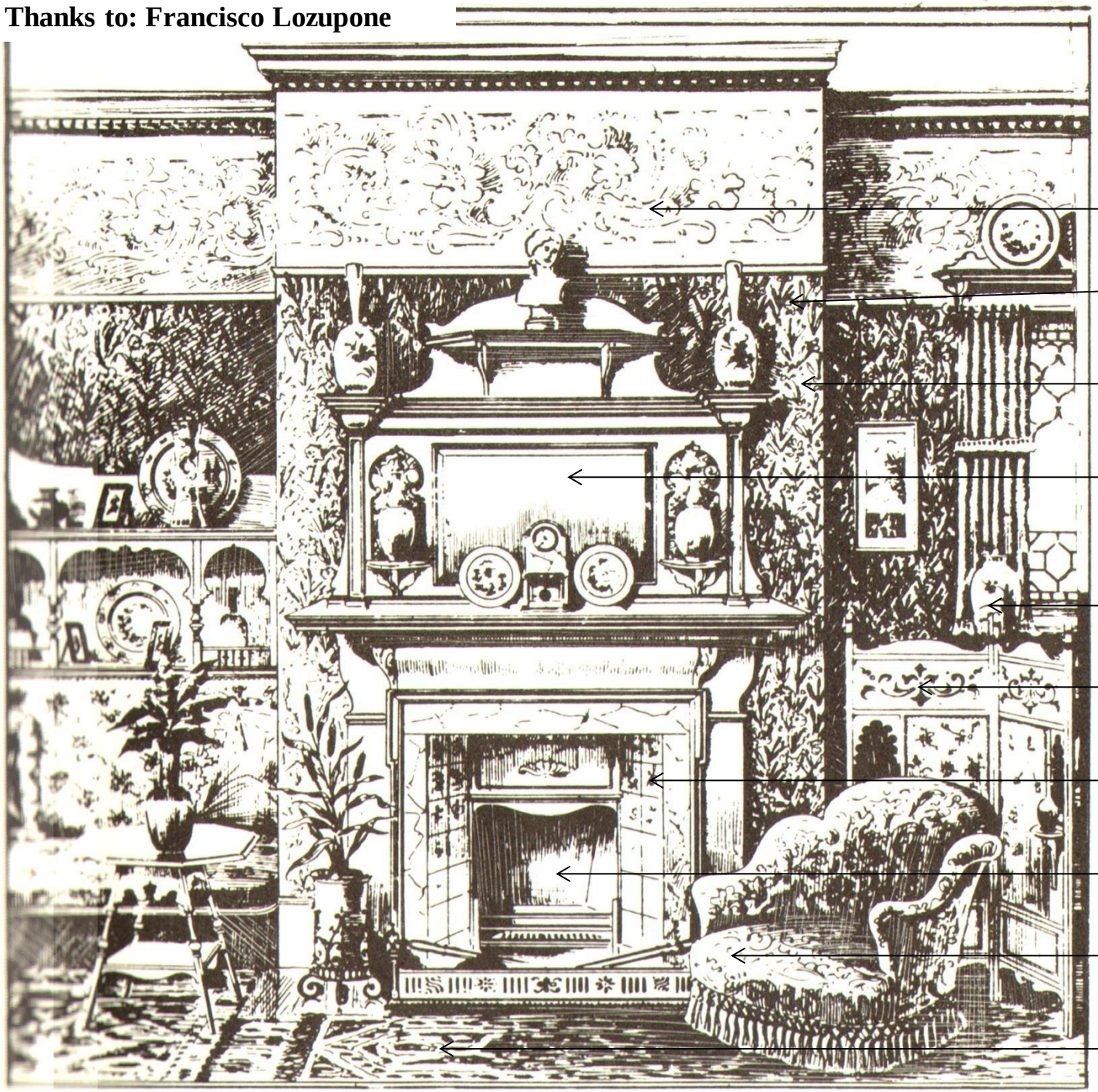
Energy Storage – Dampens Peaks

High Thermal Mass Building in Summer



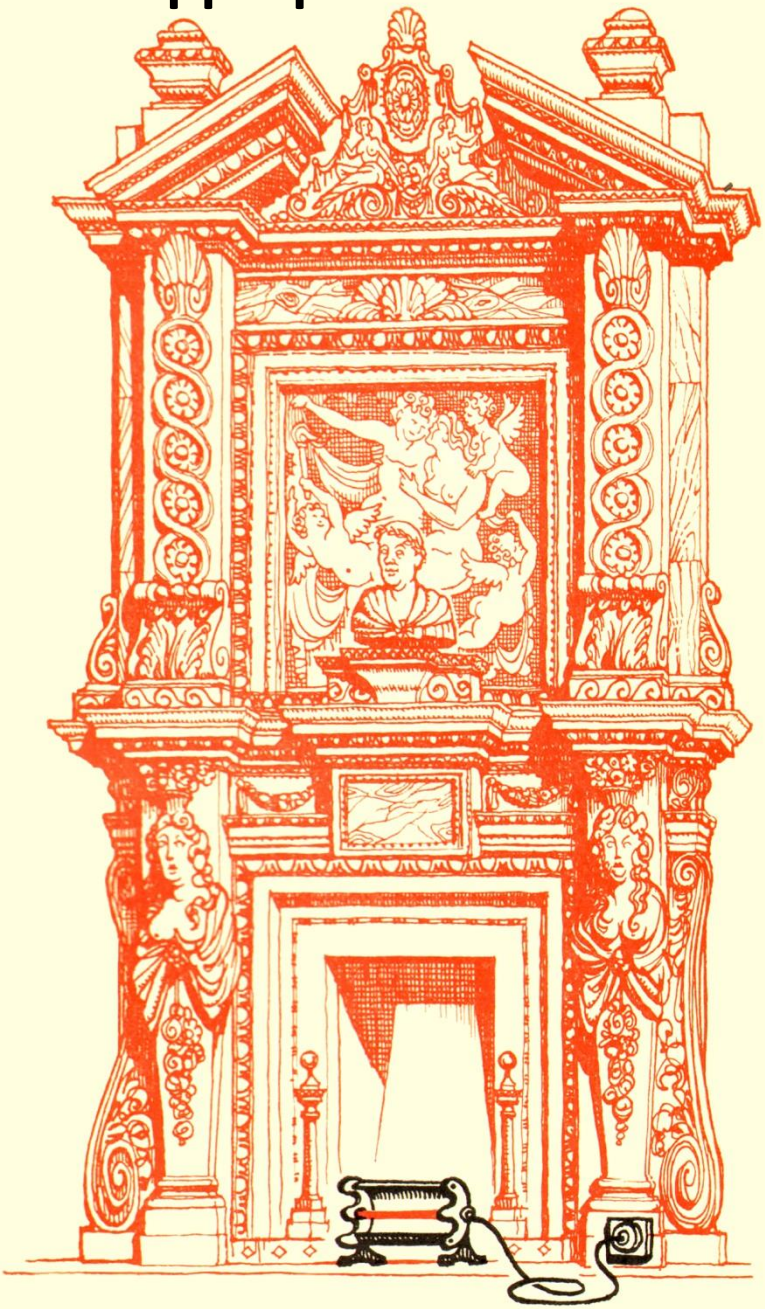
Thanks to: Francisco Lozupone

19 C. Product Opportunities



- Flock Wall Paper
- Heavy Mass Chimney
- Wet Plaster Finish
- Light reflecting Mirrors
- Nick Nacks – mass
- Screens
- Ceramics - mass
- Wood / Coal
- Expensive Chairs
- Carpets

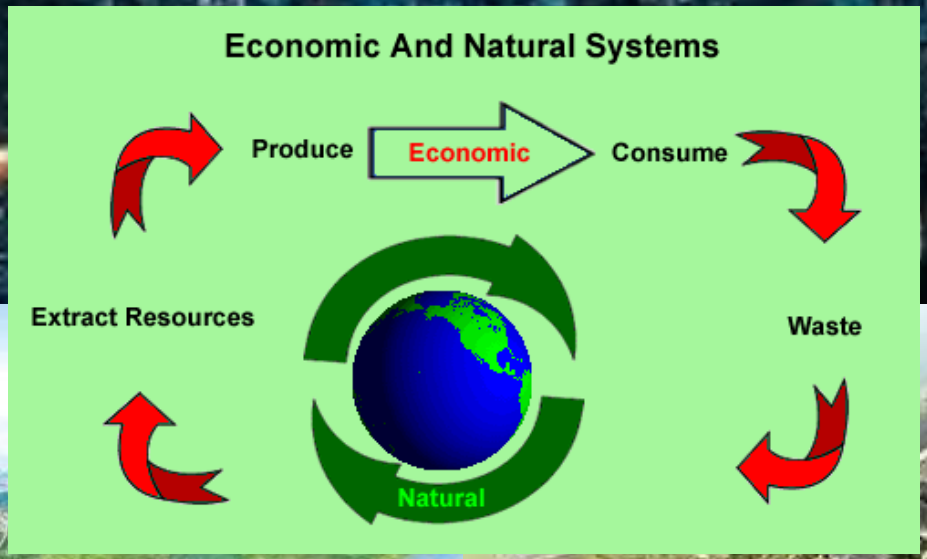
Inappropriate Architecture for an Energy Austere Future ?



Personal Environmental Controls: PETs

Source: Edward Arens, UC Berkeley, Windsor Conference 9-11 April 2010.

New Seoul: from the film ‘Elysium’ 2013



Guji Myeon, Dalseong County, South Korea

Solar Valley, Dezhou, China


2100 ?

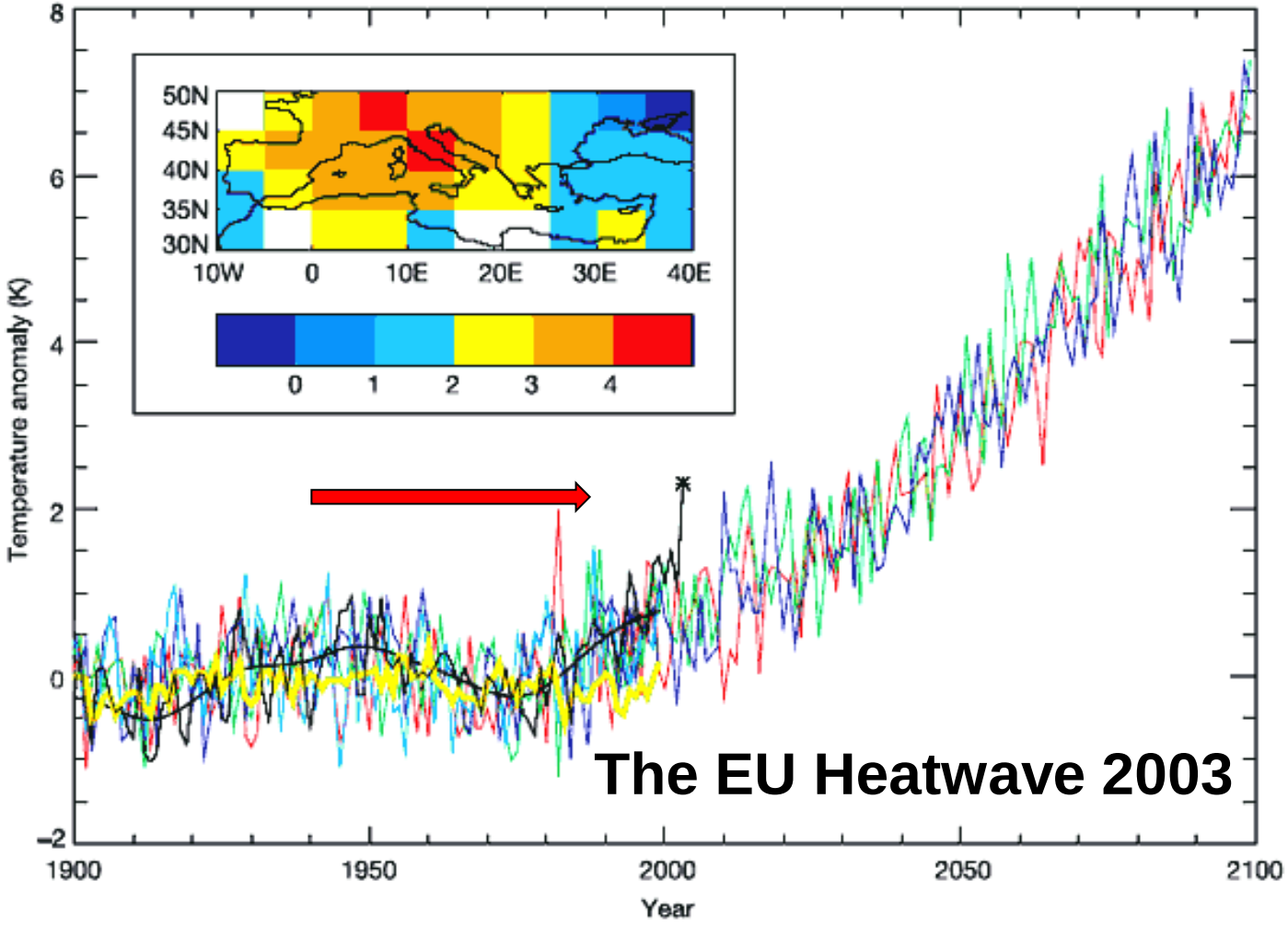


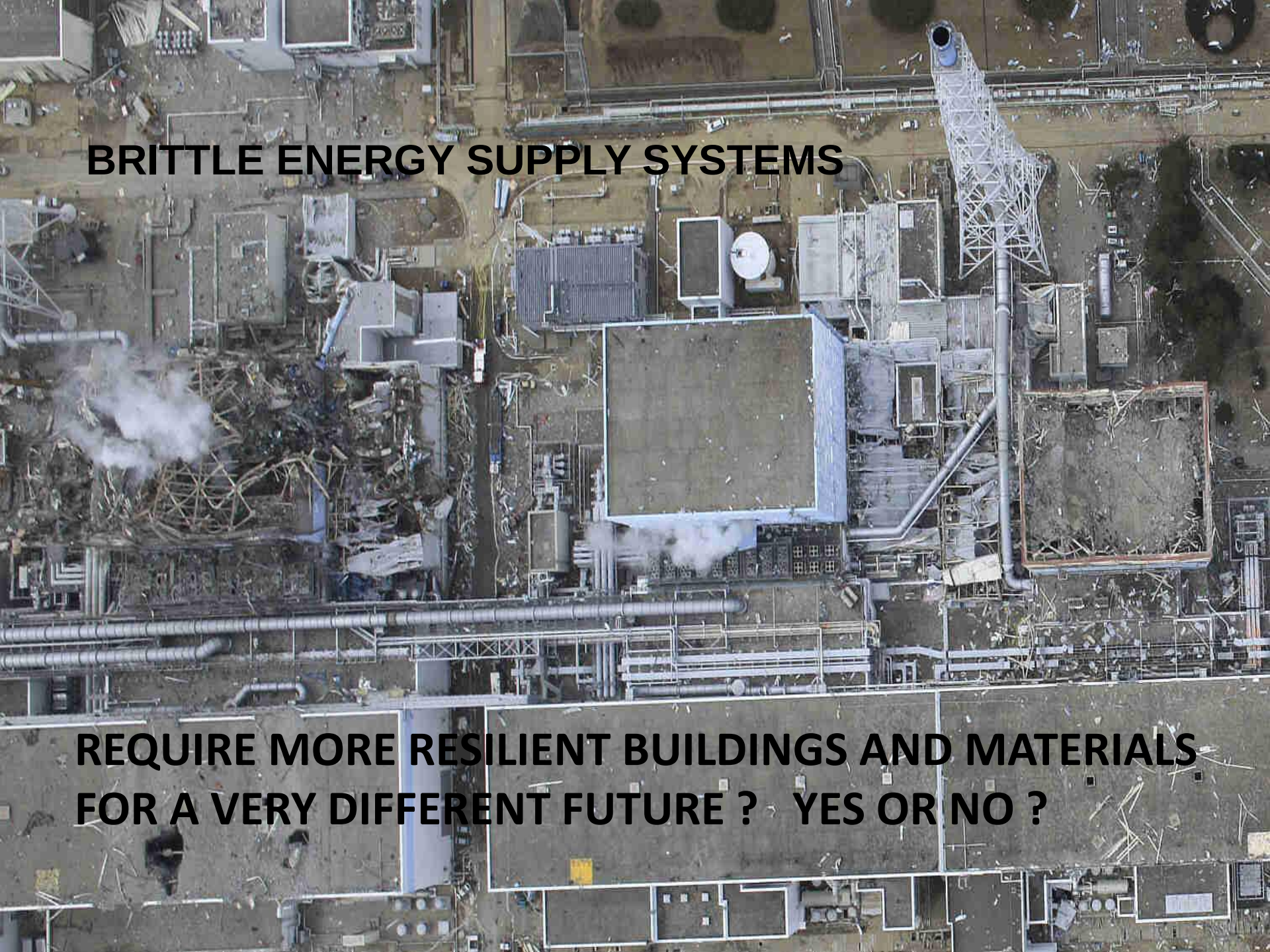
Figure 2. The extreme summer of 2003 may well occur ever second year by 2030 and by 2050 will be a cool year. This figure shows the June-August anomalies (relative to 1961-90 mean in K) over the region shown inset. Shown are observed temperatures (black line, with low-pass-filtered temperatures as the heavy black line), modelled temperatures for four HadCM3 simulations including both anthropogenic and natural forcings to 2000 (red, green blue and turquoise lines), and estimated HadCM3 response to purely natural forcings (yellow line). The observed 2003 temperature is shown as a star. Also shown (red, green and blue lines) are three simulations (initialized in 1989) including changes in greenhouse gas and sulphur emissions according to the SRES A2 scenario to 210022. The inset shows the observed summer 2003 temperature anomalies in K).

Nakicenovic, N. and R. Swart (2010). Special Report on Emission Scenarios, Cambridge University Press, Cambridge, UK.

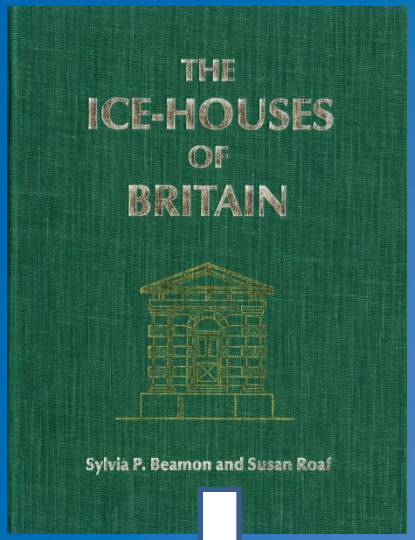
January 2014 Flooding : destroying Infra-structures

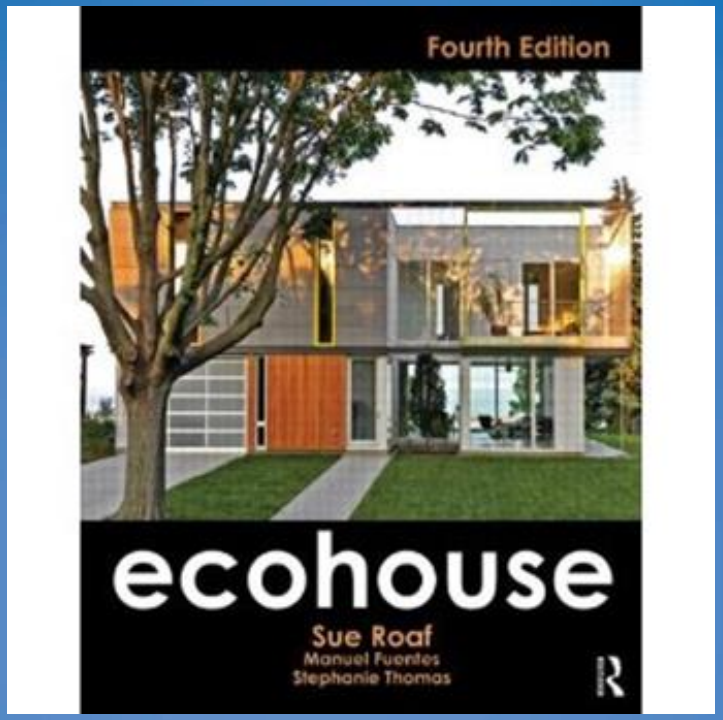
January 2014 Flooding : destroying Lives

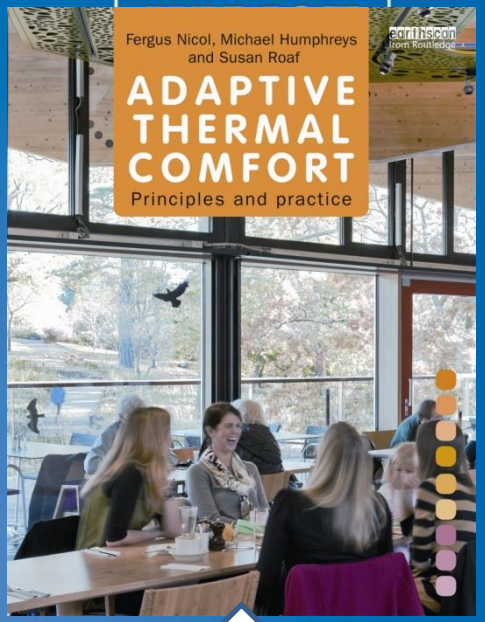

WELCON
TO
TACLOBAN CITY

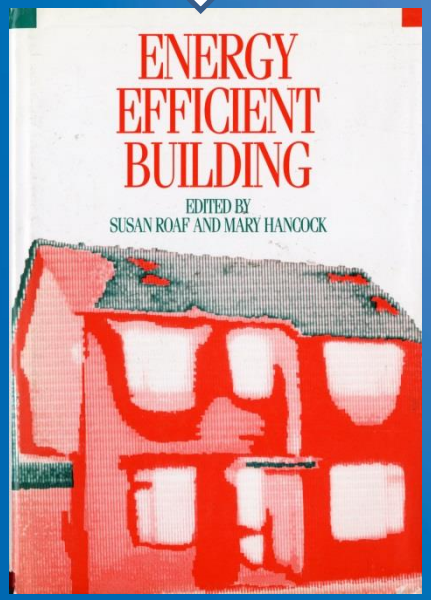

BRITTLE ENERGY SUPPLY SYSTEMS
REQUIRE MORE RESILIENT BUILDINGS AND MATERIALS
FOR A VERY DIFFERENT FUTURE ? YES OR NO ?

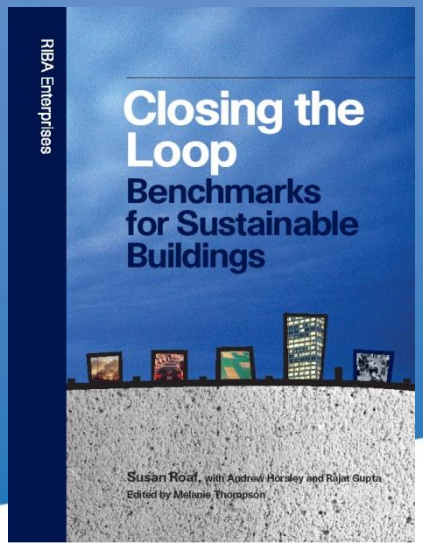
Rapid Changes in the Building Sector

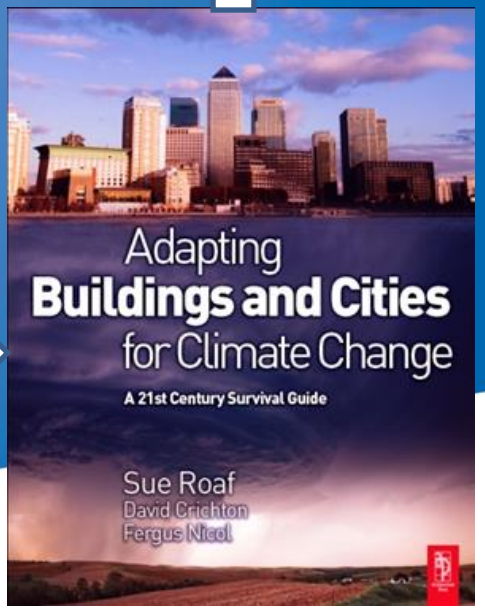




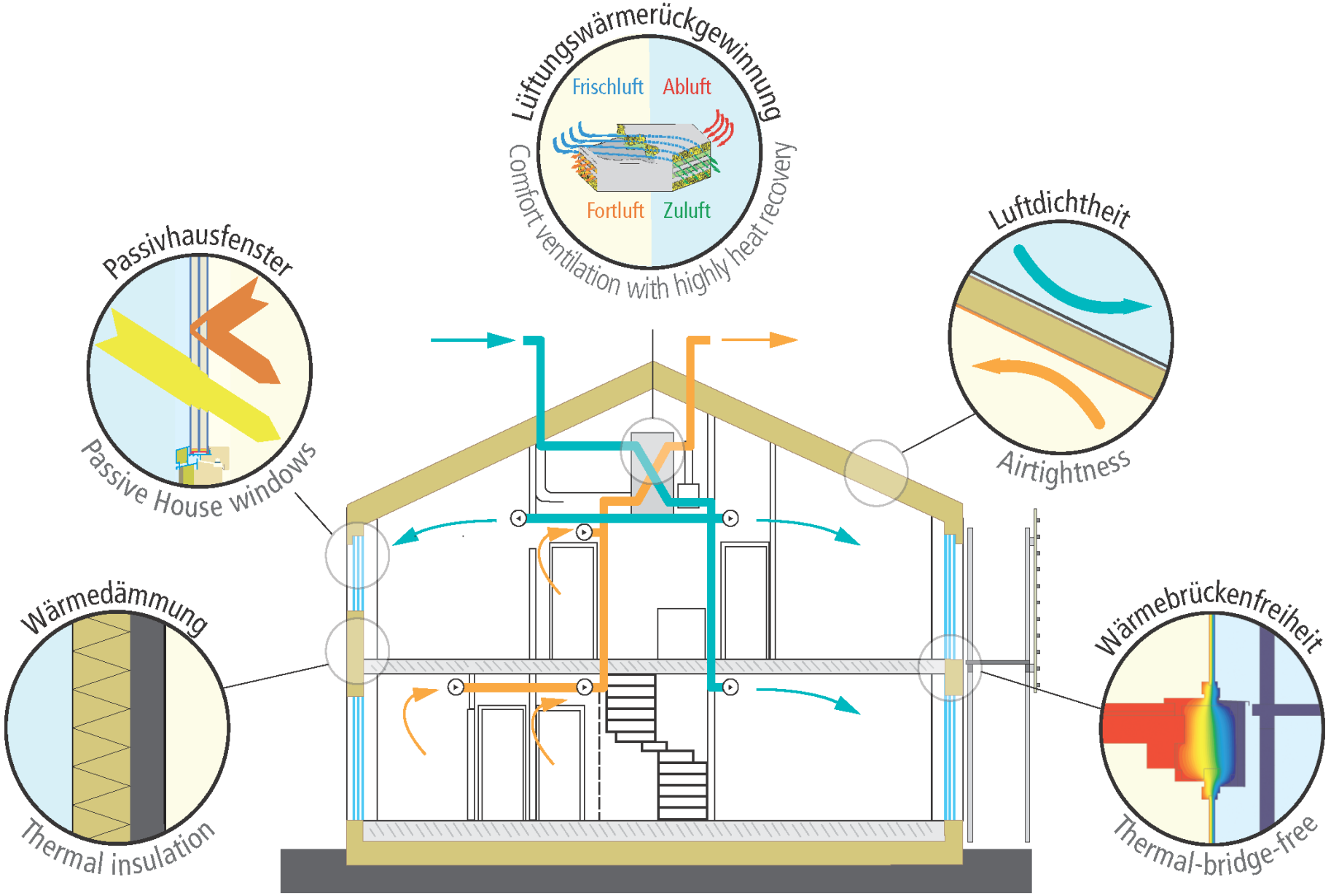


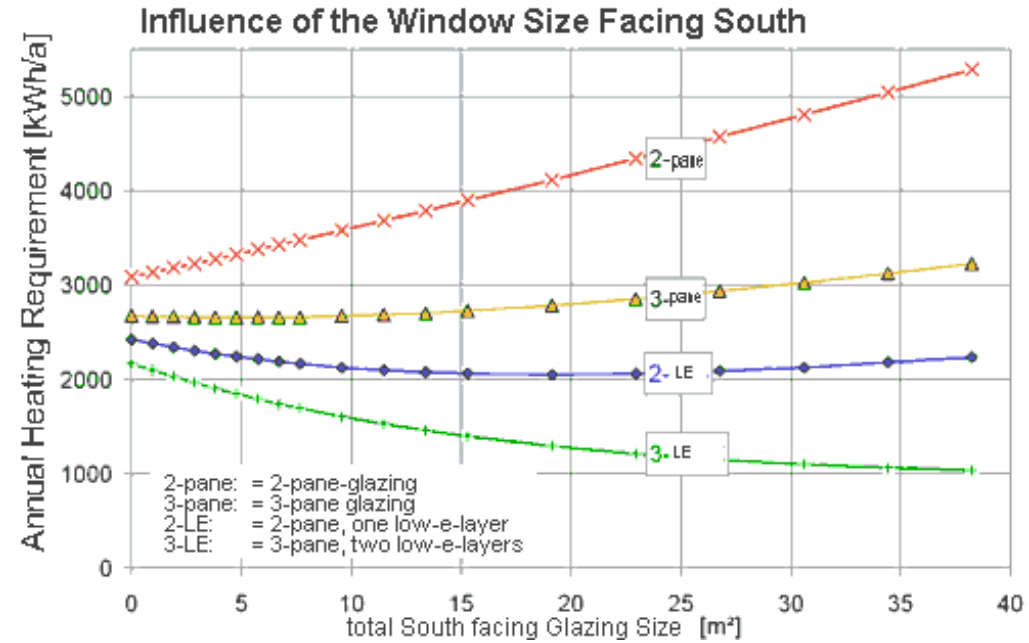


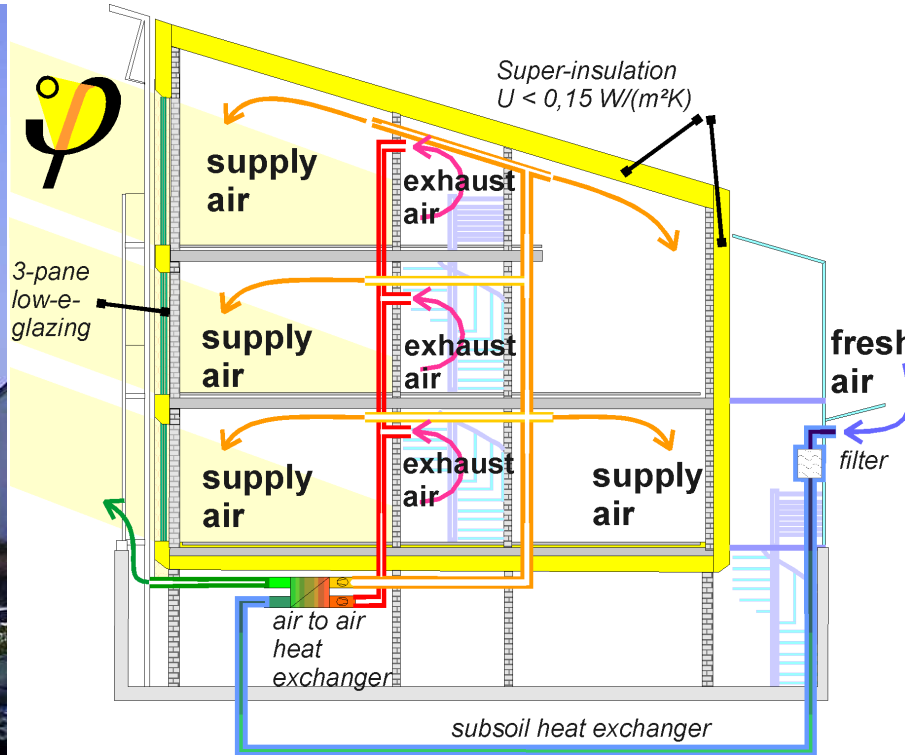


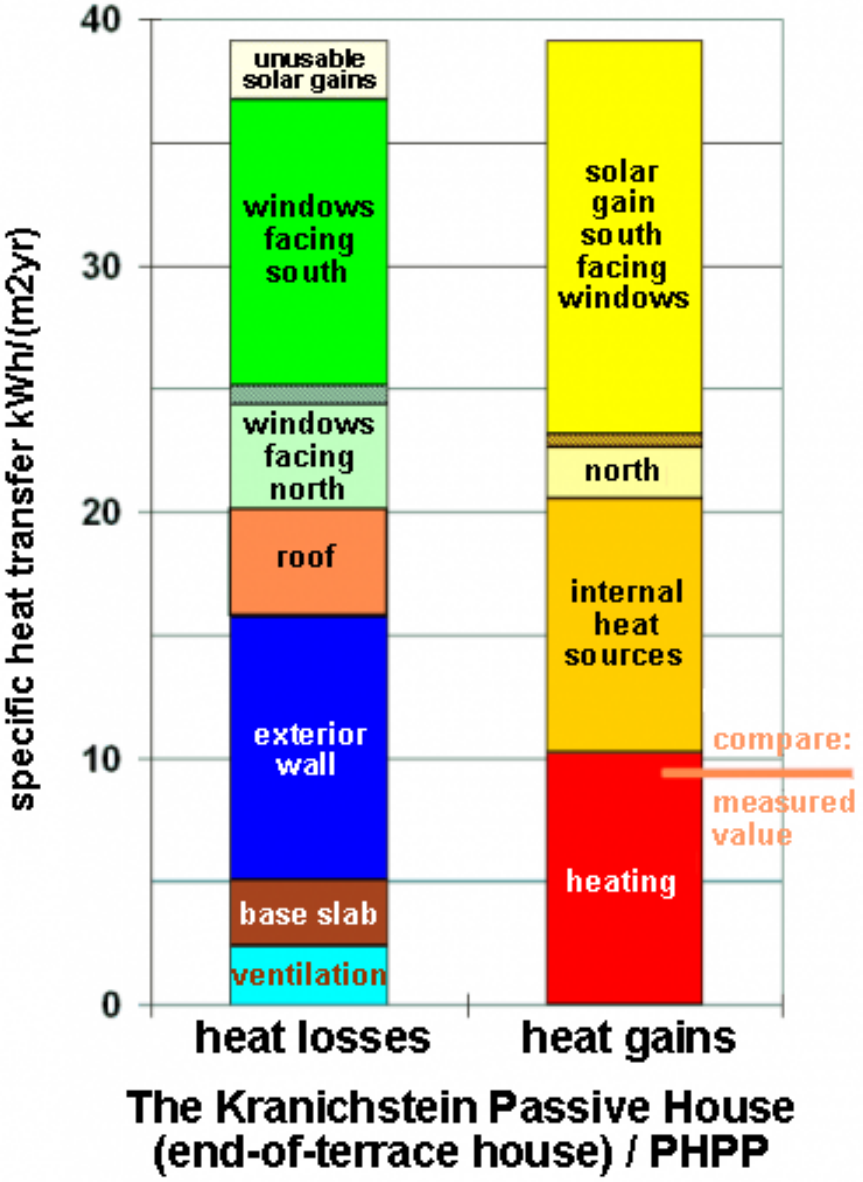


PASSIVE HOUSES: 1990s



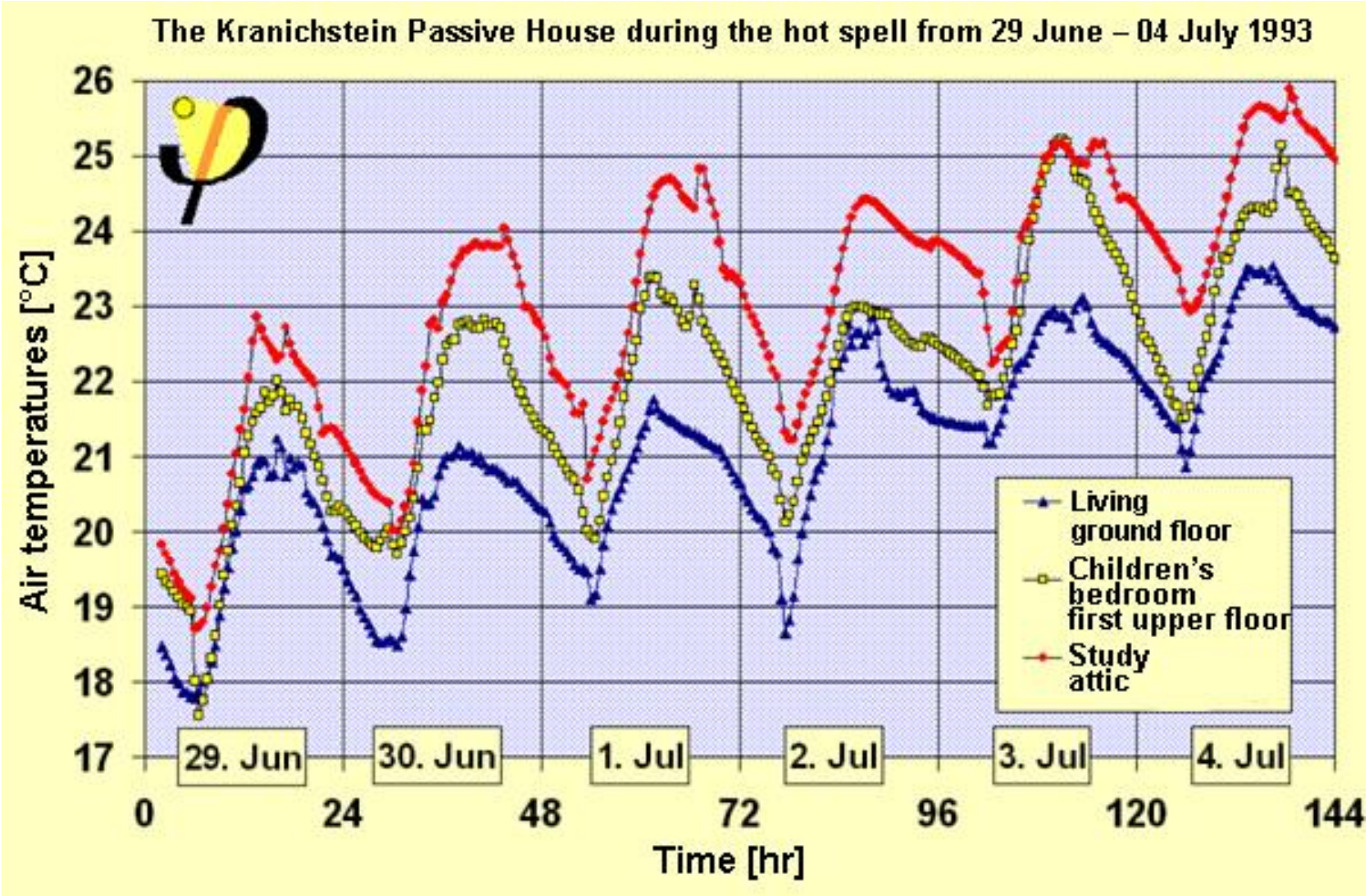

Influence of the Window Size Facing South
Annual Heating Requirement [kWh/a]
5000
4000
3000
2000
1000
0
2-pane
3-pane
2- LE
3- LE
2-pane: = 2-pane-glazing
3-pane: = 3-pane glazing
2-LE: = 2-pane, one low-e-layer
3-LE: = 3-pane, two low-e-layers
0
5
10
15
20
25
30
35
40
total South facing Glazing Size [m²]


Super-insulation
U < 0,15 W/(m²K)
supply air
exhaust air
3-pane low-e-glazing
supply air
exhaust air
fresh air
supply air
exhaust air
supply air
filter
air to air heat exchanger
subsoil heat exchanger



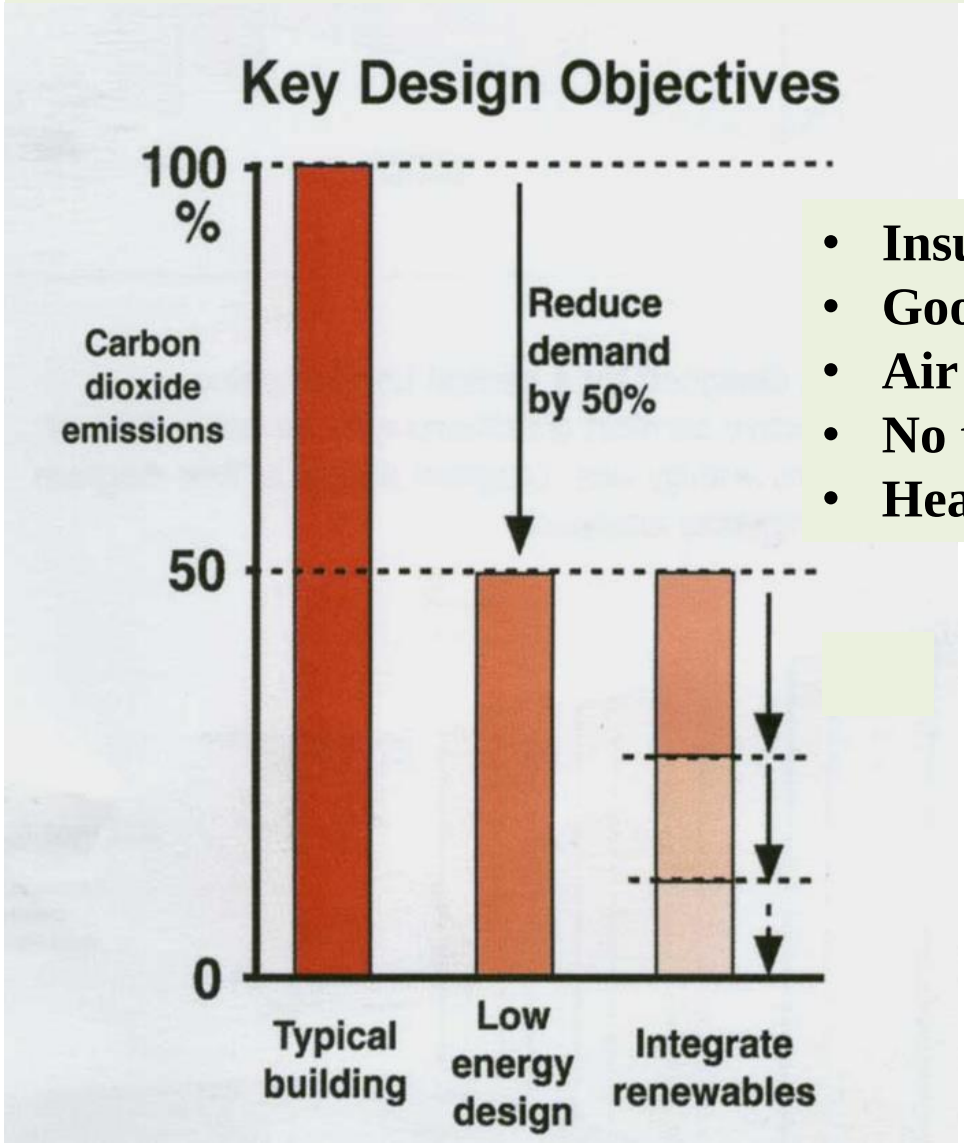
www.byggmeister.com

Passive Houses and Overheating



http://passipedia.passiv.de/passipedia_en/_detail/picopen/gemessene_sommertemperaturen.png?id=basics%3Asummer

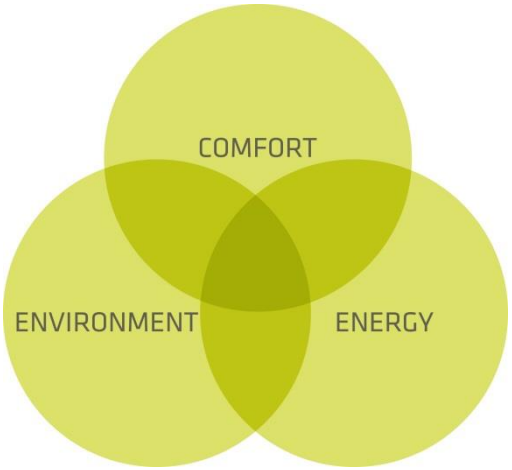
Passive House: Energy Efficient Approach



- **Insulation**
- **Good Windows**
- **Air Tight**
- **No thermal bridging**
- **Heat Recovery**

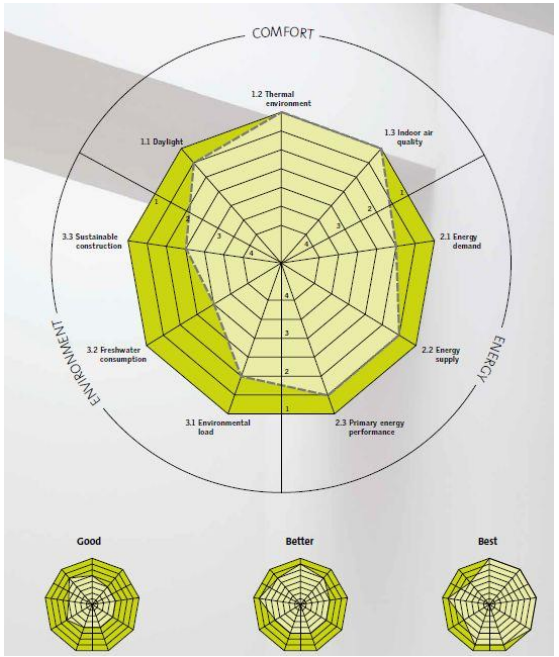
The Active House, yet another green building standard, comes to North America:

ACTIVE HOUSE: 2000s



ENERGY- *Contributes positively to the energy balance of the building*

INDOOR CLIMATE - *Creates a healthier and more comfortable life for the occupants*



ENVIRONMENT - *Has a positive impact on the environment*

http://www.treehugger.com/green-architecture/active-house-yet-another-green-building-standard-comes-north-america.html

Andrew Purcell, The Guardian,

Thursday 21 May 2009

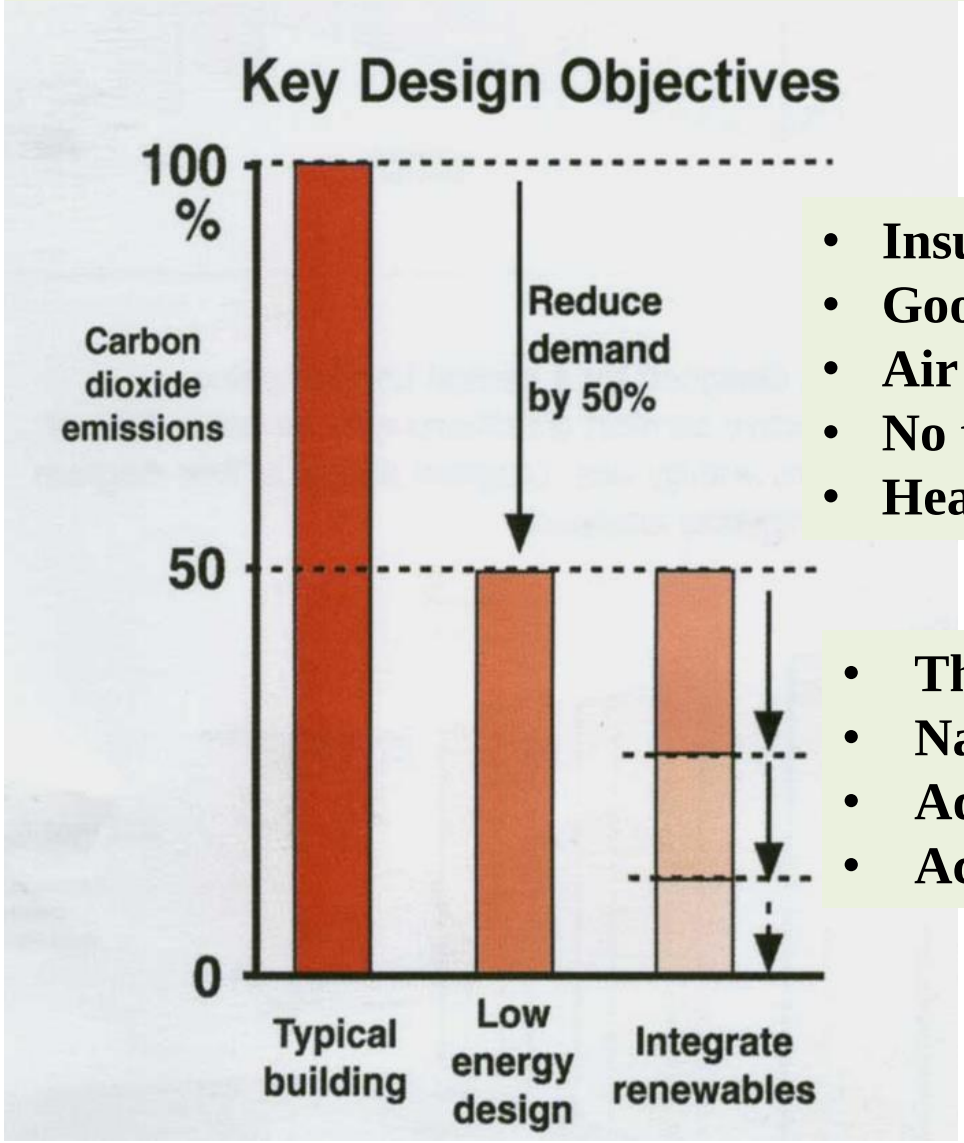
Zero-carbon eco home is light years ahead

The dream of zero-carbon living is being realised on an estate in Denmark. Andrew Purcell takes a tour of the world's first Active House

'Conceived as a more comfortable and user-friendly response to the Passive House, which has set the standard for sustainable living in the last decade'

http://www.theguardian.com/environment/2009/may/21/active-house-denmark-zero-carbon

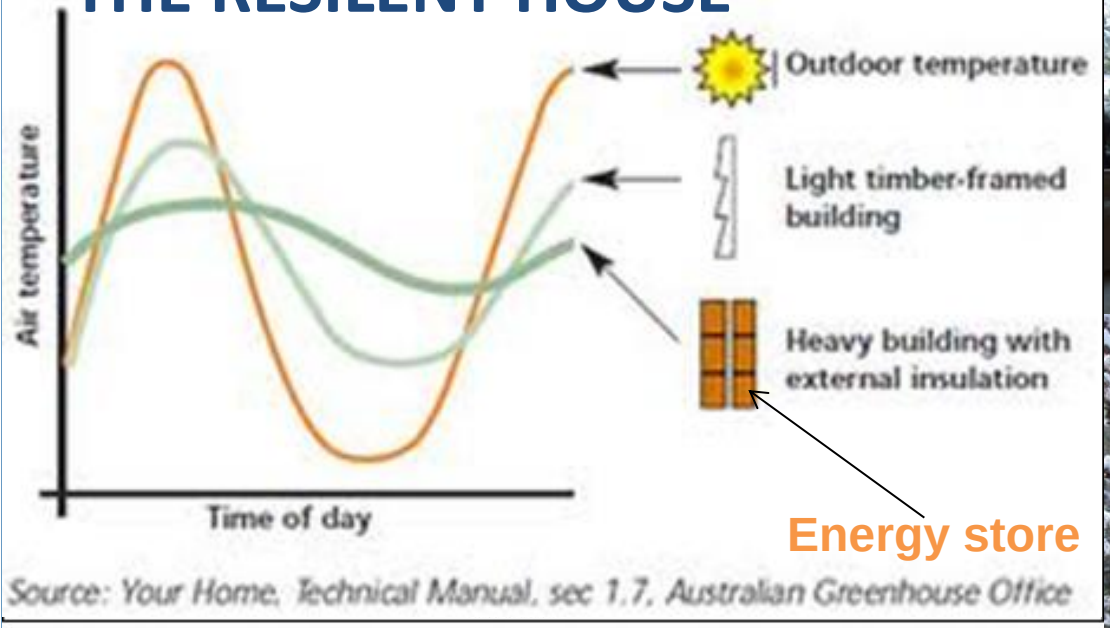
Active House: The Environmental Approach



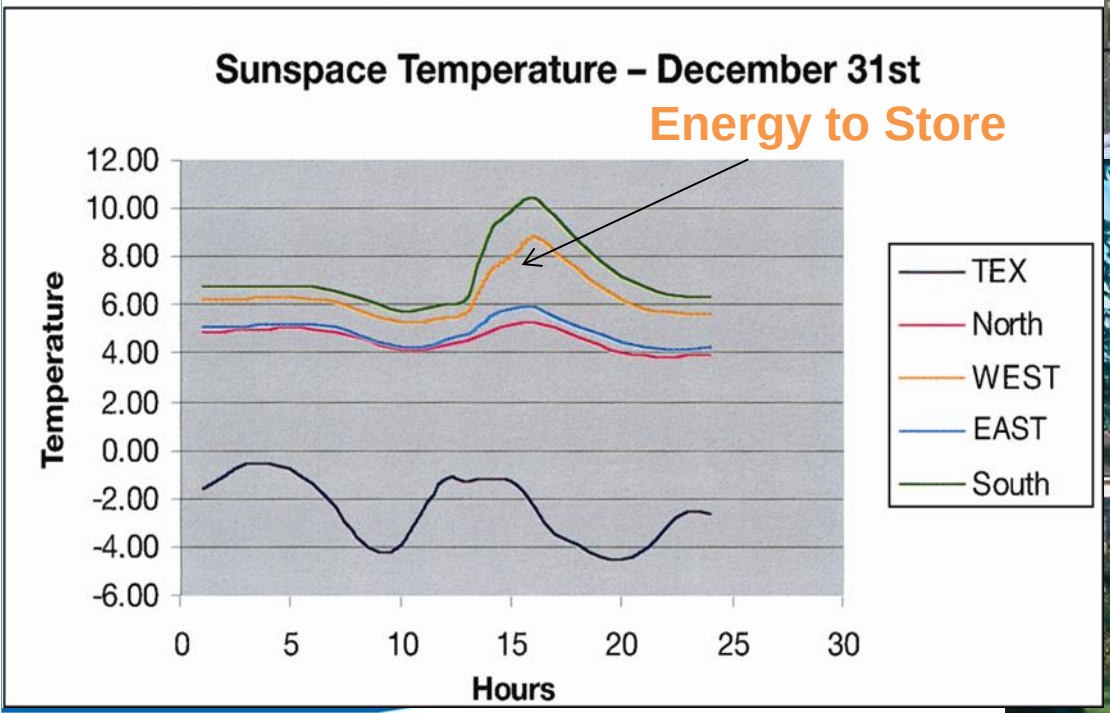
- Insulation
- Good Windows
- Air Tight
- No thermal bridging
- Heat Recovery

- Thermal Storage
- Natural Ventilation
- Adaptive Envelope
- Active solar systems

THE RESILENT HOUSE

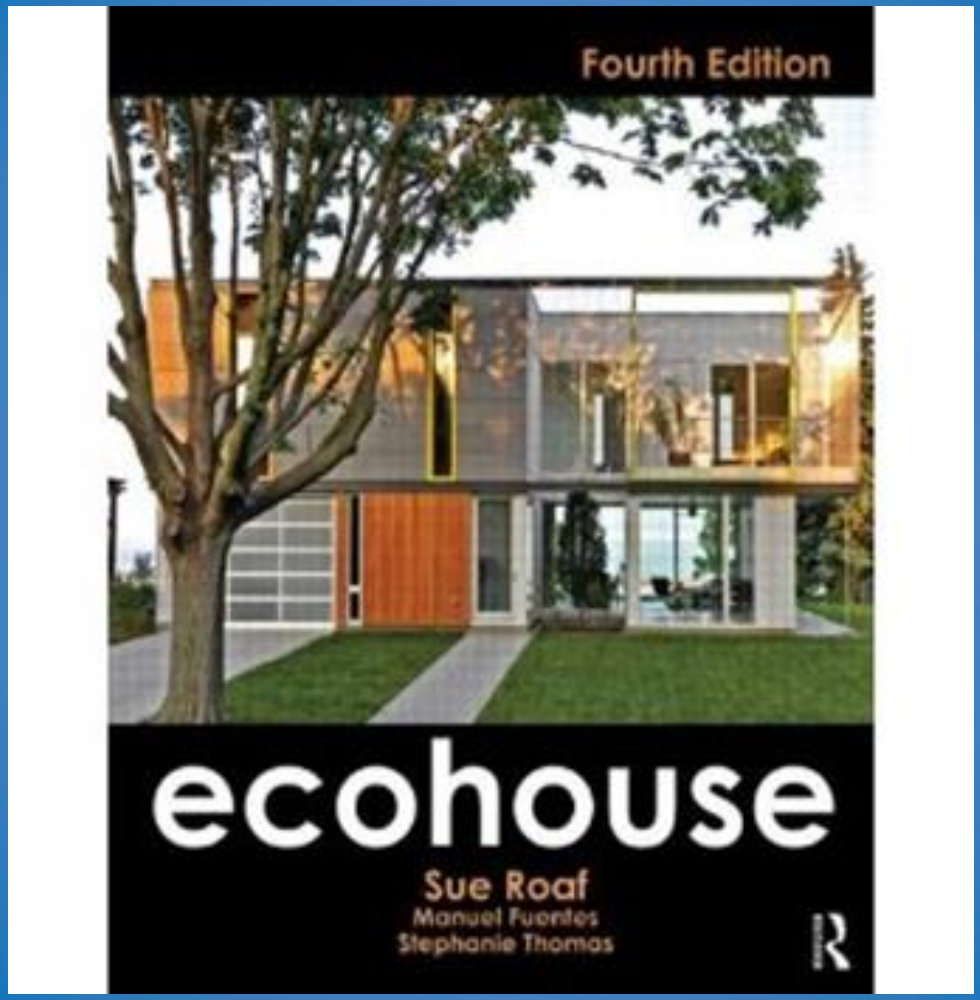


Source: Your Home, Technical Manual, sec 1.7, Australian Greenhouse Office



Future-Proofing through Resilient Design

www.resilientdesign.org



Meeting the Needs of a new generation of PROSUMER Clients

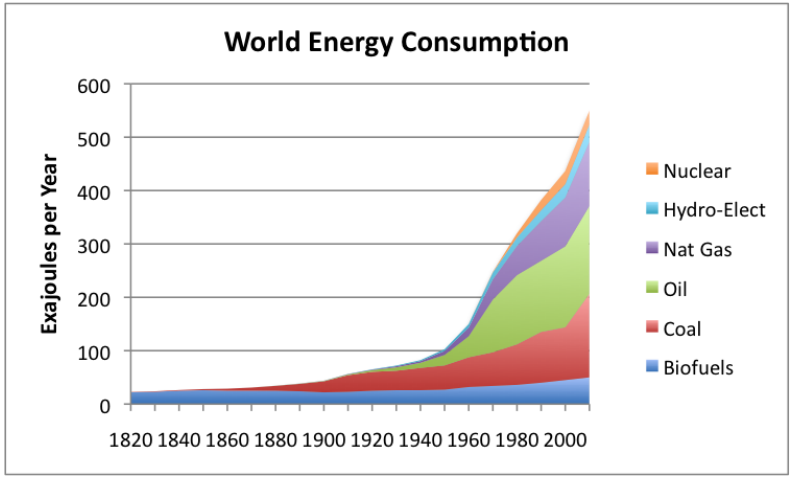
With buildings that Generate and Consume Energy

20th Century Buildings

Poor Climatic Design – Unaffordable – Without Cheap

The solution is
Not a machine

We are connected
To the climate



Building is
Not a box

throwing energy away is not longer an option

LEED Platinum / BREEAM / Energy Star Excellent Driving change or Business As Usual ?








Is the Solution a LEED Building like these? NO

21st Century Buildings

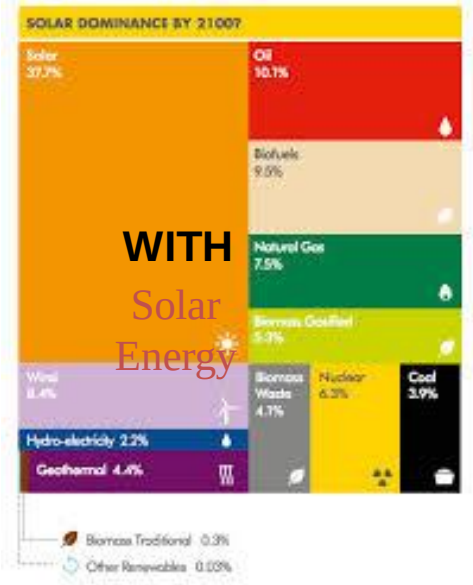
Design for People

Time

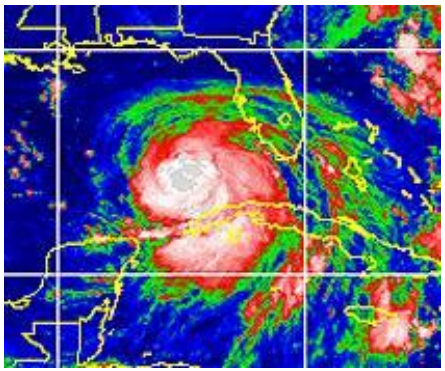
Place

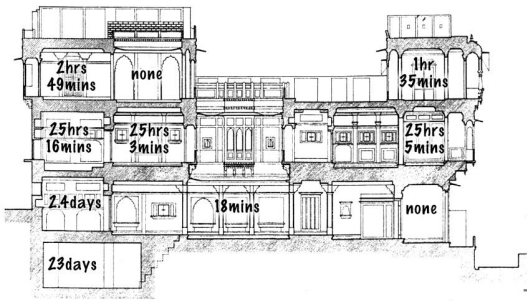
Design with Nature And Climate

Buildings run on Renewable energy



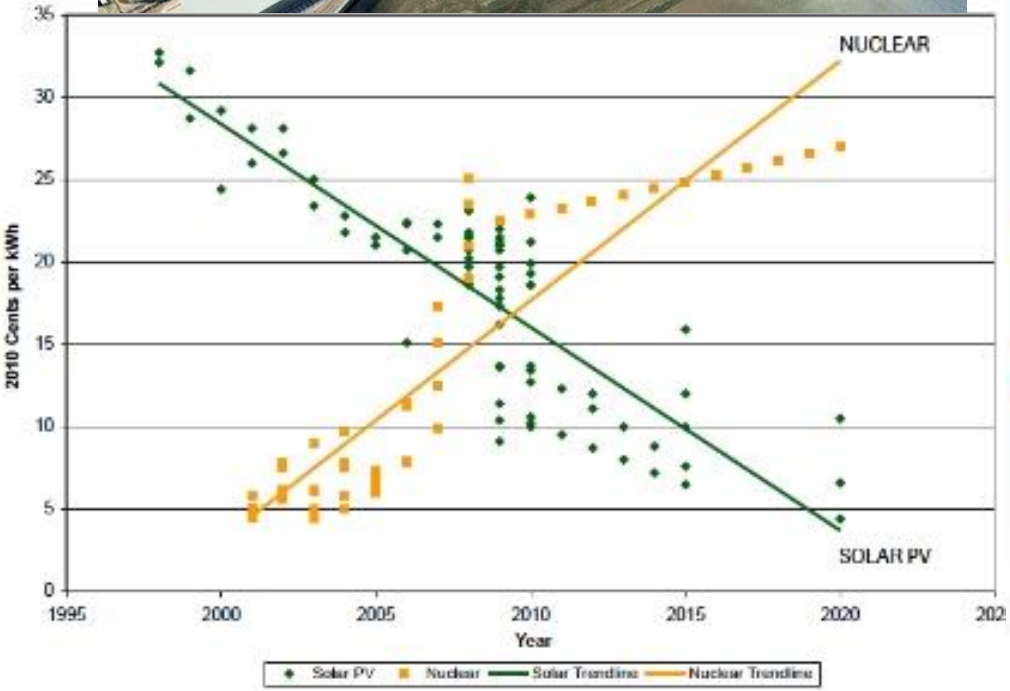
WITH
Solar Energy

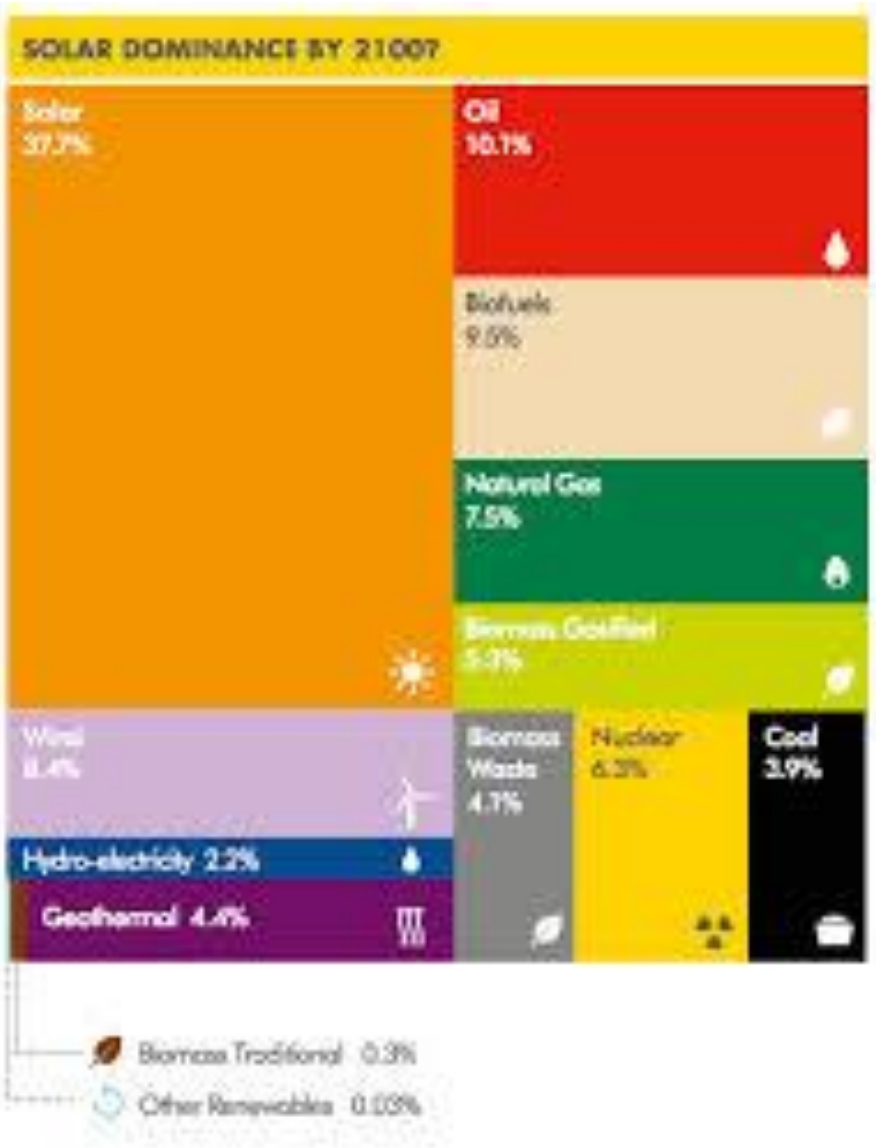




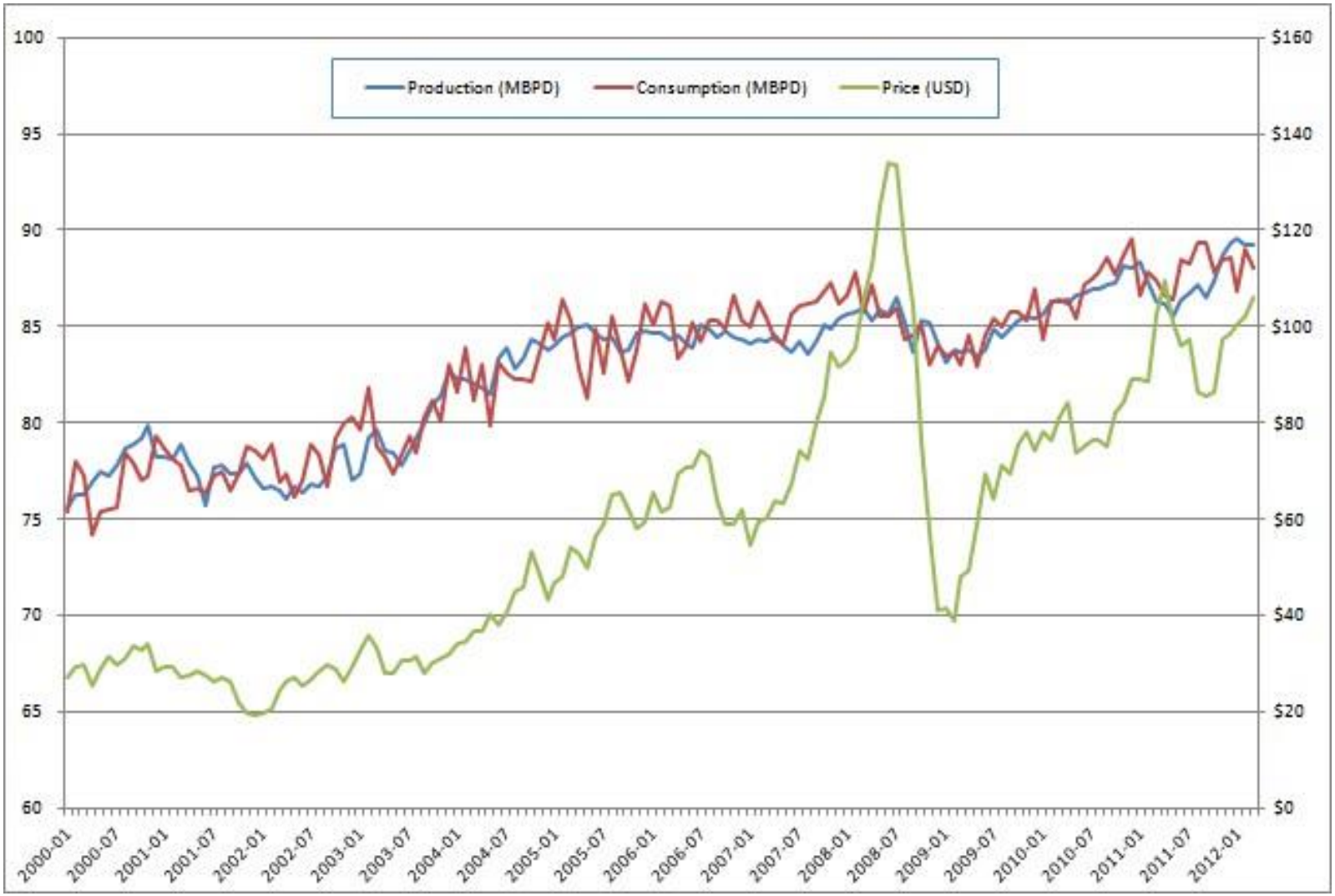
Architecture

20thC buildings were designed in an Age when Energy was dreamed would be 'Too Cheap to Meter'





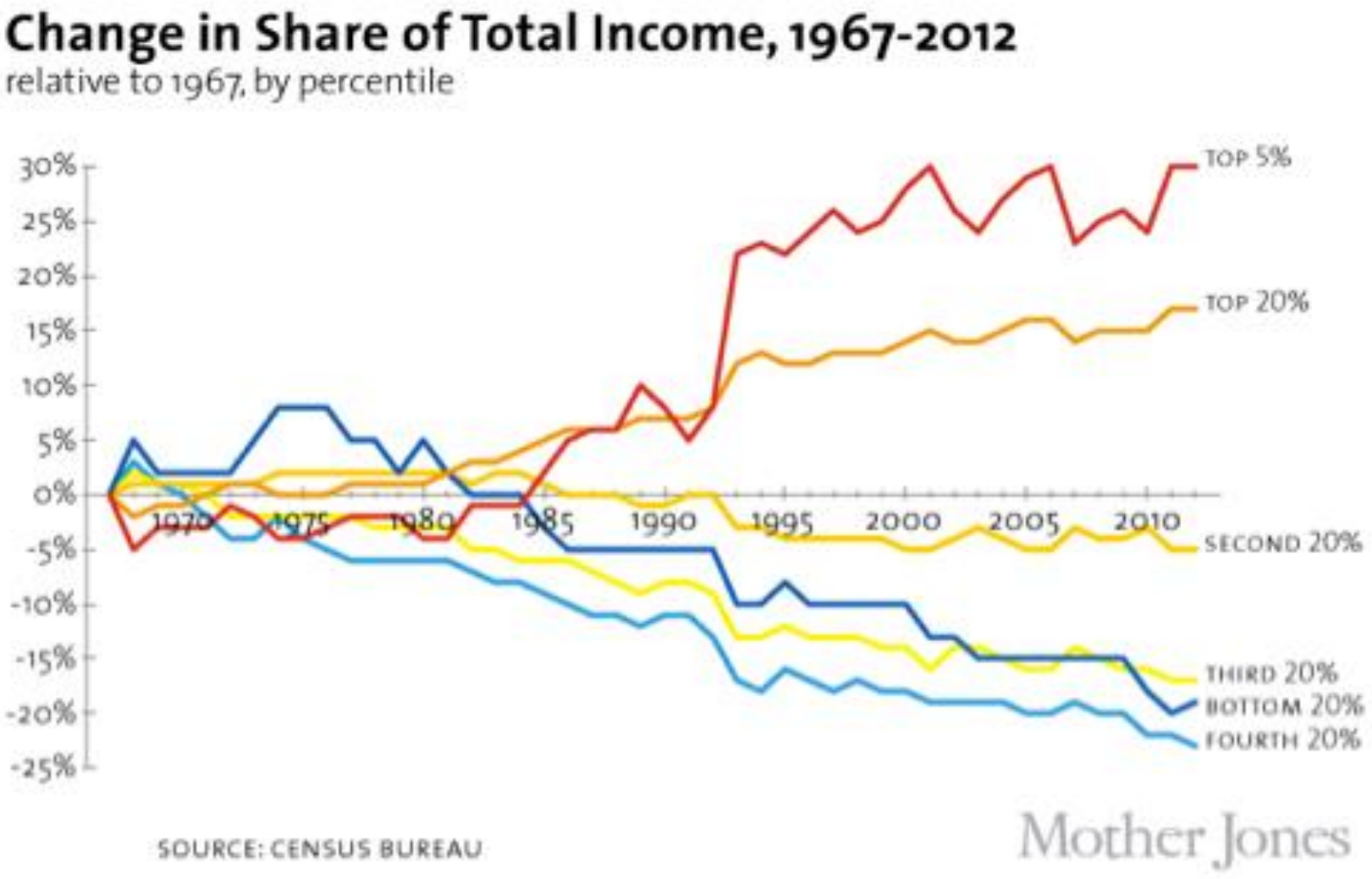
Not for a Future of soaring energy costs?



Global Oil Production, Consumption and Price 2001 - 2012

http://www.eia.gov/ers

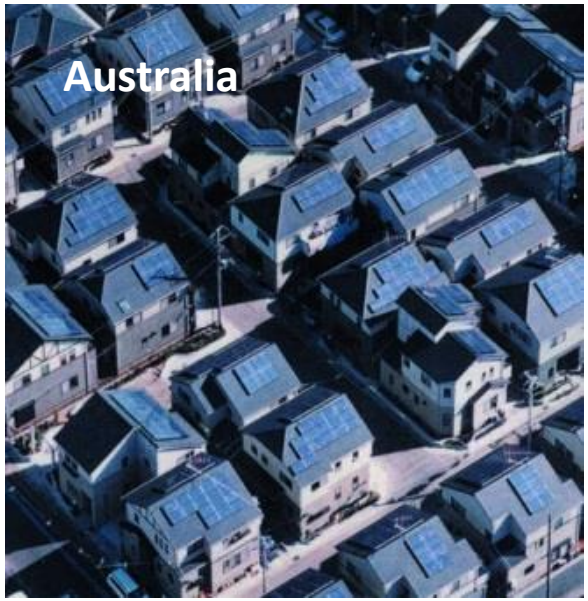
And Disappearing Middle Classes?



The US Census in 2012 evidence of the widening income gap between the rich and poor, prolonging the trend of the last 40 years http://www.eia.gov/ers

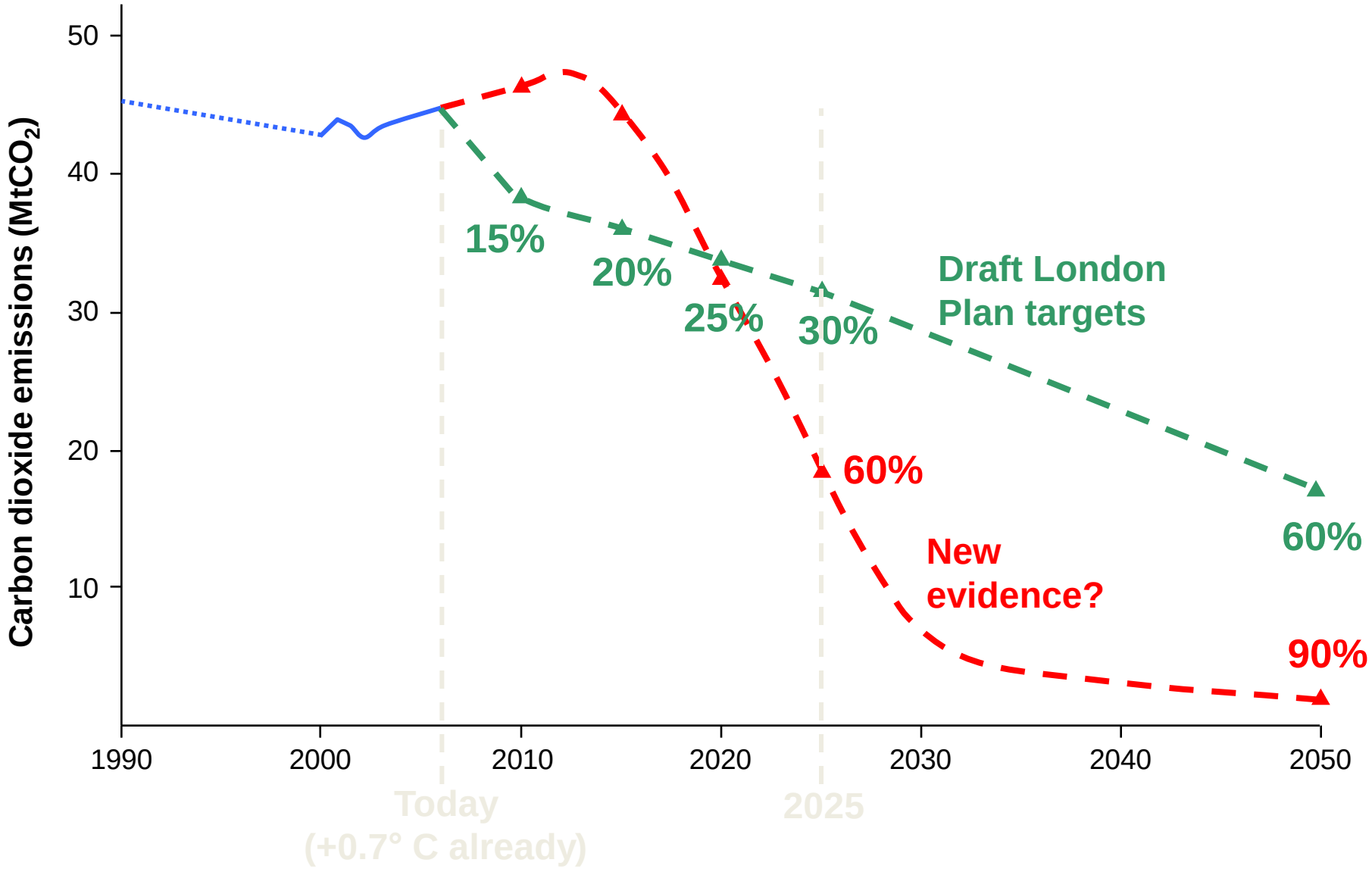
There are lots of new Opportunities - like new ways of doing Work ……..

New Ways of Powering Buildings and Cities

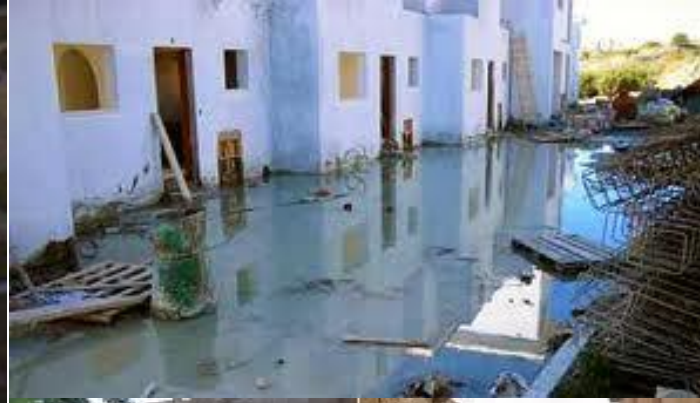


All different
All appropriate

Buildings will increasingly be driven by Targets



And by Markets..



And the Changing World around us

?

Tea Pot Wisdom

Apply the underlying principles wisely

?

Δ

T^{0}C